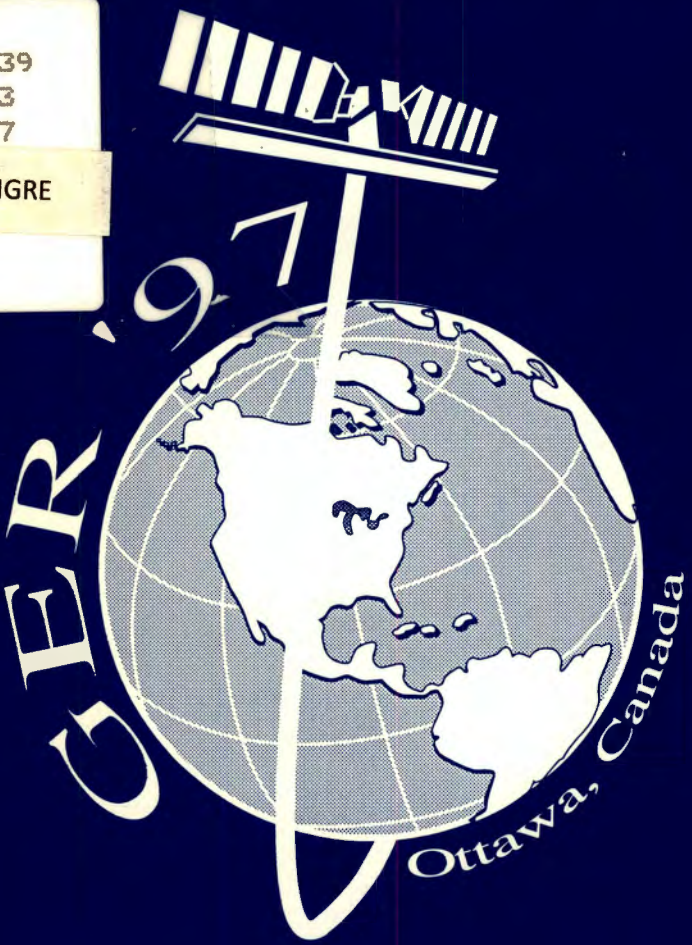
ABSTRACTS

GEOMATICS IN THE ERA OF RADARSAT



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LA GÉOMATIQUE À L'ÈRE DE RADARSAT

ABSTRACTS

GEOMATICS IN THE ERA OF RADARSAT

May 25 - 30, 1997

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LA GÉOMATIQUE À L'ÈRE DE RADARSAT

Du 25 au 30 mai 1997

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Analysis of geological styles of deformation using Radarsat data: examples from the southwestern Grenville province of Quebec.

Analyse des patrons de déformation géologique à l'aide de données Radarsat, examples du sud-ouest du Grenville au Québec.

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Abstract

Understanding crustal evolution through studies of highly eroded orogens such as the Grenville province is a current scientific challenge world-wide. Radarsat satellite imagery is well suited to this task as it provides synoptic views of regional structures with sufficient detail to link field observations with interpretations derived from imagery. Our Radarsat study is part of a regional mapping project by the GeologicalSurvey of Canada in the Mont-Laurier area of the southwestern Grenville province of Quebec. The marble and quartzite sequences and gneiss complexes of the area represent a collage of rheologically contrasting lithotectonic domains affected by successive orogenic and magmatic events. The intrusive bodies, grouped into distinct suites, represent regional markers essential to the tectonic reconstruction. At the initial stage of the field work, radar imagery was used for reconnaissance mapping of faults, folds and intrusives, therefore optimizing planning of field efforts. Later, image analysis led to the delineation of intrusive bodies, zones of ductile deformation, and fold interference patterns. The Radarsat imagery shows deformation domains recording distinct styles of deformation with structures at scales of hundreds of meters to kilometers. The gneiss complexes record early Grenvillian convergence (pre-1.19 Ga) characterized in the imagery by variable patterns of the regional foliation which are attributed to kilometer-scale fold interference patterns. At 1.165 Ga emplacement of the Lac Chevreuil intrusive suite concentrated along N-S corridors marked the onset of renewed orogenic activity. Many of the intrusions from this suite have a unique topographic signature which can be delineated on the Radarsat imagery. Following the magmatic activity, late compressive deformation in the ductile regime was focussed along the N-S corridors. The style of this deformation is characterized by a regional N-S foliation and coaxial anastamozing shear zones (NE-SW

dextral; NW-SE sinistral) which were delineated in the radar imagery and confirmed using field kinematic indicators. The Radarsat imagery provides a view of the extent of this deformation event and corroborates field and petrological studies indicating that during this event the gneiss complexes were rigid crustal domains and remained relatively unaffected by the deformation.

ROCK STRUCTURE EXTRACTION IN SATELLITE IMAGES BY ART2-A NEURAL NETWORKS

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ABSTRACT

RADARSAT can provide distinct remote images for exploiting the distribution of mineral deposits. One of main tasks for mine exploration is to find out about mineral characteristics that involve landforms, rock-types, and rock structure (folds, faults, fractures). This information can provide clues to the distribution of mineral deposits. In this paper, a fast neural networks ART2-A, an expansion of adaptive resonance theory (ART2) for both analog and binary input, is introduced to detect the rock structure features of satellite images. Network inputs come from the results detected by a Sobel operator. Feature nets consist of eight selective functional-link nets. Each of these nets associated with particular orientation generates rectilinear, non-symmetrical, curvilinear and "h" type patterns. In the rock structure detection subnets, the ART2-A neural networks are used and summarized.

[1]RADARSAT Investigation of a Circular Feature in East Central Jordan

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ABSTRACT

A typical ring-like feature located in east central Jordan ~ 150 km southeast of Amman, is very obvious on RADARSAT images. Four concentric circles but only two perfect ones, were discriminated, ranging in size from ~ 6 km to ~ 1 km. From the first glance, this feature greatly resembles an ideal impact structure.

Previous geological studies, geophysical investigations and field observations proved the presence of a domal structure which incorporates lower Cretaceous sandstones at the core and successively surrounded by a highly fractured and steeply dipping sequence of Cretaceous and lower Tertiary carbonates and chert. The principal faults and lineaments in the region follow the northwest, northeast and ~ east-west trends, the intersection of which acts as a preferable place for the implacement of an igneous body in the post Eocene which causes the domal uplift and the associated ring faults at Jabal Waqf as Suwwan.

Interpretation of aerial photographs at 1:60,000 scale and the 1:50,000 topographic maps clearly show two concentric rings of ~ 6 and 1 km in diameter and these coincide with the presence of steep dissected ridges of Eocene chert and carbonates. Tectonic interpretation of gravity data show the presence of five concentric ring like faults which greatly coincide with RADARSAT imagery interpretation and field evidence. Magnetic data suggest the presence of either a dense non-magnetic igneous intrusion, a carbonatite body or an anhydrite dome. Seismic data, on the other hand, confirmed the presence of a highly fractured ~ 6 km wide zone.

Merging RADARSAT with LANDSAT TM data enables discrimination of surficial deposits, chert and chalk and illustrates certain geological structures and drainage segments. Replacement of RADARSAT standard 7 image for intensity and hue in the IHS transformation and PCI of selective LANDSAT TM bands is useful. Image inversion, filtering and stretching enhancement operations were employed.

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[1] To be presented at the Mid-term Symposium for ADRO, Ottawa, May 24-30, 1997

A Lake Beneath the Selima Sand Sheet, Southwest Egypt: Evidence from RADARSAT Data

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ABSTRACT

In this paper we investigate the relationship between sand accumulations and groundwater potentials in the Selima Sand Sheet along the border between Egypt and Sudan in the Eastern Sahara. The latter is the driest place on Earth, where the received solar radiation is capable of evaporating over 200 times the amount of rainfall. However, there is geographical, geological and archeological evidence of wetter climates in the past: its sand sheets and dune fields are largely enclosed in topographic depressions; numerous dry channels of palaeo-rivers and streams lead into these depressions; and several prehistoric human habitation sites have been identified in the region.

From these observations, it has been concluded that, over time, rain and surface water seeped through the underlying rocks to be stored in porous layers and fracture zones. Such water may first have accumulated in inland depressions forming lakes. The sediments that were carried by the rivers and streams would have served as the source of the sand that was later shaped into dunes by aeolian activity.

We have analyzed both Landsat Thematic Mapper (TM) and RADARSAT images of the region to look for indications of a relationship between the location of sand accumulations and palaeo-drainage channels. One area just west of the Selima Sand Sheet shows indications of palaeo-draining (a few in TMs 178/177 45 and many in a RADARSAT image centered on 21°N and 26°E). Radar has the ability to sense up to a few meters beneath the surface in desert environments; hence, reveal any sub-surface features that may exist. Sub-surface penetration is a rare phenomenon because a set of circumstances must operate in order for it to occur. These are: the cover material must be radar smooth, fine grained and homogeneous relative to the wavelength (as in the case of desert sand relative to the 5.6 cm radar wavelength); and the cover material must be dry (as in the case of the hyper-arid environment of the Eastern Sahara).

The results show much evidence of past fluvial activity, with channels trending from the Gilf Kebir Plateau southeast toward the Selima Sand Sheet. This fluvial activity probably formed a lake that is now covered by sand. Two phases of activity are clearly observable: the first as large wadis, about 15 km wide, and the second as later, superposed drainage networks of smaller wadis. Both trend directly from the plateau to the sand sheet and their

morphologies imply a change from flash-flood conditions to periods with extended surface runoff. The wadis are strongly controlled structurally as shown by numerous straight segments that trend in a west-northwest-east-southeast direction.

Thus, RADARSAT data indicate that an ancient lake may exist beneath the Selima Sand Sheet, in the southern part of the Western Desert of Egypt and the adjacent desert in northwestern Sudan. Further, the drainage features observed may have acted as the source of the sand that was brought into the lake and was subsequently shaped by aeolian activity after the climate changed and dry conditions prevailed. The proposal of a palaeo-lake in the area has implications to ground-water potentials. Much of the lake water would have seeped into the underlying porous sandstone layers to be stored in acquifers, some of which may be confined to fracture zones, as indicated by the structural control of the wadi systems.

GUIDELINES FOR THE SELECTION OF RADARSAT BEAM MODES FOR GEOLOGICAL MAPPING.

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The paper presents the results of the use of various RADARSAT beam modes for geological mapping in different terrains. Our results have shown that SAR viewing geometries are significant for the delineation of geological structures, lithological units, landforms and terrain types.
RADARSAT has 25 different beam and incidence angle positions with spatial resolution varying from 10 - 100m. In order to maximize its use it is necessary to evaluate the various beam modes and report on their suitability for geological and geomorphological mapping. This guide is aimed at assisting geoscientists in planning their RADARSAT image acquisition for geological mapping.
The study areas were selected to represent different terrain types and surfaces. The terrain types represent low, moderate and high relief. Selected surfaces are vegetated, non-vegetated, rocky and sandy. These surfaces are typical of glaciated, vegetated precambriam terrains, desert landscapes and tropical forested areas. The interpretation of the appropriate RADARSAT beam modes and their significance to surficial geological mapping, and geohazard assessment is presented.

DETECTION AND MAPPING OF WETLANDS FROM MULTI-TEMPORAL POLARIMETRIC DATA

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ABSTRACT

The detection and mapping of wetland regions is important as they may offer good habitats for certain types of wildlife and waterfowl, a possible source of peat and a source of cattails that could be used as an economic source of cattle feed. The goal of this projects is to verify the capabilities of polarimetric SAR for wetlands mapping and to determine the optimum period and the polarization for a best detection and classification of wetland areas. An algorithm will be developed for wetlands mapping of the Mer Bleue by means of C-band SAR.

The backscattering behaviour of the wetlands is investigated based on five C-band polarimetric SAR images of the Mer Bleue bog, situated some 20 km east of Ottawa, Canada (centre latitude 45°24'N, centre longitude 75°36'W). These images have been obtained at important points in the hydrological cycle of wetlands: April 18, 1995 (spring melt and runoff); May 25, 1995 (spring flush for vegetation); July 6, 1995 (mature growth stage for vegetation); October 3, 1995 (leaf-off for vegetation); February 22, 1996 (frozen, dry winter scene). These polarimetric images are calibrated. We investigate the signature of different classes of wetlands as a function of incidence angle and we evaluate the separability between classes in order to develop a classficiation procedure including the best polarimetric parameter.

INTÉGRATION DE DONNÉES MULTISOURCES ET PROPAGATION DES ERREURS DANS UN MODÈLE HYDROGÉOLOGIQUE

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RÉSUMÉ

Dans le cadre du volet hydrogéologique du programme PREDIR (Projet de recherche sur l'exploitation des données Images Radar) conduit par le centre de recherche en géomatique de l'Université Laval en collaboration avec MIR télédétection, un modèle de vulnérabilité de la nappe d'eau souterraine a été implanté sur ArcInfo. Il s'agit du modèle DRASTIC, initialement développé aux États-Unis et maintenant reconnu par les agences gouvernementales canadiennes et américaines. Le présent projet de recherche se veut une poursuite du travail amorcé dans le volet hydrogéologique de PREDIR. Son objectif est d'évaluer la propagation des erreurs spatiales dans le modèle. DRASTIC fournit une carte de vulnérabilité pour un territoire donné, à partir de l'évaluation de 7 paramètres, soient la profondeur d'eau, la recharge annuelle, le milieu aquifère, le type de sol, la topographie, l'impact de la zone vadose et la conductivité hydraulique du matériel. Pour une région homogène donnée, l'indice est calculé par la somme des cotes attribuées à chacun des paramètres, selon les chartes DRASTIC. Chaque élément de la sommation est pondéré selon l'influence qu'exerce le paramètre sur la vulnérabilité. Les données nécessaires à l'évaluation de chaque paramètre du modèle proviennent de diverses sources; données ponctuelles de forages, cartes digitalisées, modèle numérique de terrain, classification d'une image satellitaire, etc. Pour chacun des paramètres, l'incertitude spatiale doit être représentée par des modèles d'erreur différents selon la provenance de l'information et les manipulations impliquées. De façon générale, chacune des couvertures utilisées pour le calcul de l'indice pourrait être caractérisée par un des deux modèles suivants; le modèle polygonal et le modèle de la variable interpolée. Pour gérer l'incertitude, ces modèles requièrent des approches différentes, soient l'utilisation des probabilités dans le cas de la variable interpolée et la théorie des sous-ensembles flous dans le cas du modèle polygonal. La combinaison de ces deux approches permet d'élaborer un modèle d'erreur adapté qui fournit une valeur d'incertitude associée à l'indice calculé par le modèle DRASTIC.

Radarsat Applications in Watershed Management

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Estimates of hydrological parameters such as soil moisture, snow conditions and water levels are of prime importance to water resource management. The use of traditional remote sensing technology (Landsat, SPOT, aerial photography) has shown potential for providing environmental information but is often constrained by time or hampered by weather conditions.

RADARSAT, is a potential new tool for water resource management. RADARSAT's Synthetic Aperture Radar (SAR) is an active microwave system which provides for all-weather acquisition independent of solar illumination. It is particularly well suited to hydrology applications due to the sensitivity of microwave energy to the presence of water.

This paper assesses the potential of Radarsat to extract information hydrological variables such as soil moisture, snow and wetlands over the Mississippi River (Ontario) Watershed. Radarsat data collected during the fall, winter and spring periods were analyzed in relation to ground observations, weather radar and meteorological conditions. These use of these derived parameters as input to a distributed hydrological model for the Mississippi River were then evaluated.

Monitoring Wetlands in Northern Australia Using RADARSAT

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ABSTRACT

This research is based on radar's unique ability to detect and image water under trees. RADARSAT data will be used sequentially over a period of three years to map the pattern and changing distribution of flooding in the wetlands of the Alligator Rivers region of Kakadu national Park occasioned by seasonal climatic conditions and human impact.

While many wetlands in Northern Australia have been relatively undisturbed by human activities in the past, increasingly they are coming under threat from saltwater intrusions, invasion by exotic weeds, degradation by feral animals, increased pollution from agriculture and recreational use. This baseline study will provide the environmental knowledge and methodologies for assessing and monitoring other wetlands in Australia.

Hydrologic, geomorphic and ecological field and reference data will be collected at successive stages in the pattern of floodwater recession and floodplain drying out and stored in a GIS relational data base at Environmental Research Institute of the Supervising Scientist (ERISS). This information will be correlated with the radar data and used to characterize the aquatic conditions and associated tree stands and assess the extent of change occurring in these environments.

This paper reports on the analysis of the first RADARSAT data acquired in November 1996.

TECHNOLOGY TRANSFER, EDUCATION AND TRAINING: THE CHANGING SHAPE OF GEOMATICS

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ABSTRACT

The paper commences with an overview of the more important factors affecting surveying and mapping industries recently - institutional, economic and technological. Various structural shifts in the relevant institutional arrangements are noted, especially with the advent of cost-recovery and user-pay regimes. These, when coupled with an over-increasing emphasis on productivity, innovation and competitiveness, have altered the public-sector/private-sector landscape markedly. Here, as elsewhere in the paper, the experiences of Australian and New Zealand economic reforms are used to provide examples in the surveying-mapping nexus.

Some specific impacts of technological change are then explored to determine the degree to which the nature of the work itself has altered and, in particular, whether this process is proving to be competence-enhancing or competence-destroying for the disciplines, professions and the wider industry. In turn, this leads to consideration of core issues including: the accelerating obsolescence of knowledge, especially for technical professions; changes in the marketplace for professional skills; and the interesting move in some professional quarters away from strong demarcation between disciplines/subjects towards a more collaborative and integrated approach.

The paper then turns to the key matters of providing education and training and the various changes taking place in this particular arena. Several themes are used to explore these issues. First, there is commentary on the rather transparent repositioning by a number of university education providers (especially professional surveying departments) in their adoption of the Geomatics banner. This trend is examined as to justification, cause and effect.

Secondly we take up the issue of an emerging, and arguably more relevant, professional educational model. Even at undergraduate level, this post-technocratic model places more emphasis on identification, acquisition and recognition of genuine professional competences rather than simply using qualifications per se. Apart from the benefits of more neatly integrating pure and applied knowledge with professional practice, it brings with it the valuable lesson that professional competencies are highly likely to become far more contestable and contested.

Finally, there is the very real challenge of reaccreditation to be met. Occupations generally, and professions especially, have grappled with the demise of a once for-all-time educational accreditation and many have moved strenuously towards tangible and verifiable Continuing Professional Education (CPE) for refreshment and updating. The significant implications for formal providers, such as the universities, are assessed here particularly the emergence of new providers such as the professional associations and other private and public

organizations. The use of alternative delivery mechanisms, e.g. short duration courses with a deliberate vocational focus, are examined.

To conclude, increased and changing demands have emerged for both initial and continuing education in the surveying and mapping fields especially in higher education. The results of these pressures have in some cases resulted in departments changing their names in an effort to reposition themselves for an ongoing changing environment where certainty no longer exists and where the concept of profession and identity have been radically altered.

GEOMATICS EDUCATION AND RESEARCH AT THE DEPARTMENT OF GEOGRAPHY, UNIVERSITY OF LETHBRIDGE

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ABSTRACT

New research and teaching initiatives recently established in theDepartment of Geography, University of Lethbridge, are presented Geomatics curricula include introductory and advanced courses in air photo interpretation, digital remote sensing, geographical information systems, and cartography leading to the Bachelor and Master of Science Degrees in Geography. Research interests involve innovation in the fields of remote sensing, GIS, and Earth System Science modelling to derive important biophysical and geophysical parameters for studies of environmental change. Current attention is focused on boreal forest ecosystems (BOREAS, NASA COVER Project) and mountainous terrain (Alberta Rockies, Colorado, Yukon), with a secondary research interest in tropical ocean coral reefs (Fiji). A unifying aspect of these diverse applications is the development of new algorithms and software to achieve individual project goals. Together with these new research initiatives, strong collaborative ties have also been established with several international agencies and global change projects.

Critical Mass Human Resources Development Requirement in Africa in the Field of Earth Resources and Environmental Information - Opportunities and Constraints and the Critical Role of RECTAS.

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ABSTRACT

The assessment of a country's economic status is now by a system of its natural resources evaluation on the basis of what is there, how much is used, the pressures on it, and the optimum utilization desirable for sustainable development. This requires a powerful tool of Natural Resources and Environmental Information System.

African mapping organisations are already under severe pressure to develop National Spatial Data Infrastructures (NSDI) as part of the national utilities for their socio-economic development and to satisfy the current needs of their clients for multispectral applications in various areas of human endeavours. The main constraint is appropriate human resources development.

Education and Training are the means for successful human resources development on a critical mass level to meet these requirements.
This paper evaluates and discusses the current African situation under the various opportunities available for human resources development at the three levels of manpower requirements and the numerous constraints. The implications of Education and Training ranging over such issues as who to train and educate, what type of education/training, where it should be delivered, the duration, who should pay and how the trained/educated could be retained/educated to have a critical mass for a successful management of National Spatial Data Infrastructure. The relationship of these to the implementation of Agenda 21 on Earth Resources and Environmental Information are also discussed.

The critical role of the Regional Centre for Training in Aerospace Surveys (RECTAS) Ile-Ife, Nigeria under the auspices of the U.N Economic Commission for Africa (UNECA) is playing and is expected to play in future among others for the accelerated, orderly growth/development and economic recovery of African countries on a sustainable basis are discussed.

Conclusion and recommendations are made including measures to take that would have these desired impact for the development of African countries on a sustainable basis.

Socio-Cultural Considerations for Geomatics Training

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Preferred Session: Education and training, Oral Session

Socio-cultural factors often have a greater influence on the process of learning than the content of the course. Canadian companies are offering geomatics training in a wide variety of socio-cultural settings - throughout Canada, and worldwide. More attention needs to be given to socio-cultural differences in planning training services and products. Simply translating training packages from one language to another is not sufficient in today's marketplace. Canadian industry is very aware of this fact, but currently few in the geomatics sector are making a conscious effort to take these factors into account.

Research was done to identify the key factors influencing training effectiveness in different social and cultural settings. For the purposes of this study 'training' was divided into:

- short term sessions and workshops offered to clients from a cross-section of socio-cultural backgrounds,
- on-the-job technical training of foreign professionals in Canadian companies and organizations done with the intent of transferring technology back to their home countries, and
- on-the-job training as part of a cooperative technology transfer project.

All these three types of training are essential for continued professional development and are job function or project focused. Longer term career development training offered at academic institutions is also influenced by socio-cultural issues. Therefore, the findings may also be of interest to educators in these institutions.

Information on socio-cultural factors was collected from existing knowledge data bases, organizations such as CIDA, and from people with first hand knowledge and experience of training in different socio-cultural settings. A survey of training courses offered by Canadian companies and organizations was done to determine their experience in different socio-cultural settings, and to identify specific socio-cultural factors influencing training effectiveness. People who have received technical training in Canada were canvassed in order to discover their views on the effectiveness of the training they received.

This session will provide ideas on how training products and services can be adapted to better meet requirements for training worldwide. A large market for training services exists at this time. The success of Canadian trainers depends on the quality (as perceived and evaluated by trainees) of training services and products they can offer.

Are You Ready for the Digital Image Revolution

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Over the past four or five years there has been a virtual explosion of Digital Image data products for GIS. In the next four or five years we will be flooded with data from High Resolution Satellites that are scheduled to begin operations as early as 1997. The companies that are putting up the satellites claim that their data will revolutionize the way GIS users view the world and will enable many new applications. These claims may be achievable but there are still many issues to be addressed before these data become commonly accepted by the user community. User acceptance will depend on the same basic elements as for any data set; What does it cost? When was it created? How and when can I get it? What can I do with it? How can I use it on my system? This paper will look at the issues that remain to be addressed before the users will readily embrace the results of these new data collection technologies. It will also look at some practical examples of how high resolution image data have been integrated into functional GIS applications.

Some of the technical issues are; spatial accuracy, geometric corrections, data management (including formats, file structure, access and retrieval), effective data delivery mechanisms and integration within GIS applications. Some of the non technical issues are; cost, suitability, usability and availability.

Providing more data to a user is a benefit only if the user spends less effort (cost) to get a solution to their problem. Linnet has pioneered the use of Digital Orthophotography (DOI) as a reference data set for GIS applications. To date over 120,000 sq. km of 2 m imagery have been produced in Manitoba. At Linnet we have successfully built over fifteen GIS applications that provide non technical users the capability to easily access and manage data and perform complex GIS functions as part of their normal work routine.

These systems are designed to take advantage of these future data sources without putting an extra burden on the user. Some of the tools that are required to minimize this effort are already available. Most of the scientific tools are typically found within proprietary software that has been designed for the technical user. However, regular users require easy to use data management tools contained within their business applications to gain any benefit from the data.

A New Adaptive Speckle Filter for SAR Images

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Abstract:

"Speckle" is the name given to the noise in SAR images resulting from Raleigh fading in the coherently reflected and detected radar signals. The coefficient of variation (or fading value) of the speckle can be theoretically predicted. Previous adaptive speckle filters (Lee, Frost, Kuan, etc.) use this statistic as a measure of local homogeneity, to control a weighted averaging of pixels within a fixed, rectangular area around each pixel. (These filters vary from each other primarily by how they apply the weighting). The filter introduced in this paper takes a different approach to applying this statistic. The coefficient of variation is used to determine an irregular, homogenous area around each pixel, such that the coefficient of variation for that area is less than or equal to the predicted value. This results in an adaptive speckle filter with a number of advantages over previous filters. The filter provides near-optimal smoothing in large homogenous areas, while still preserving small details. Edges are enhanced, regardless of direction and curvature. The filter is robust and is not controlled by empirical variables, such as damping factors or rectangular dimensions. Comparative results are presented using RADARSAT imagery. The performance of the old and new filters are largely equivalent for large homogeneous areas and for small features. In areas of transition (edges) however, the new filter exhibits much superior performance, by reducing speckle across features while maintaining their sharpness.

A LEAST COMMITMENT APPROACH TO SAR IMAGE FILTERING

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ABSTRACT

The conflicting goals of SAR image filtering are the removing of the speckle noise by smoothing while preserving the image structures such as specular spots, lines and region boundaries. The Box filter calculates the mean value over a square window to reduce the signal variance. However, this also blurs the lines and region contours. Adaptive filtering uses statistical testing to decide if the window covers a homogeneous area or not. The objective is to reduce the smoothing when we come closer to an edge. This assumes that the decision process can correctly detect the presence of edges of other structures in the image. Unfortunately, the importance of the speckle noise makes this decision process unreliable.

This paper examines the decision process from a computer vision point of view and proposes a new SAR image filtering technique. We have considered the different kinds of decision processes that can be applied. The "minimum commitment" rule states that we should first apply the most reliable ones. An unreliable decision should therefore be postponed until enough confidence is accumulated. The characteristics of radar signals have been carefully studied by many authors and for a given application, we know the probability density function of the speckle, hence, the gamma distribution is generally used. If we assume that we know the mean backscattering intensity of a region, then we can define a decision process to decide if an observed pixel value belongs to the region or not. We should however use a very conservative approach. We should decide that the pixel belongs to the region only if the observed value is very close to the region mean value. Hence, we define a small interval around the mean value corresponding to a confidence coefficient of 50% to 85%. For low filtering, we use the smaller interval (50%). Moreover, to confirm the decision that a pixel belong to a homogeneous region, we should examine the neighboring pixels, i.e.., we should exploit the spatial information. In a homogeneous region, a large number of the pixels will belong to the decision interval. The pixels outside the interval will be randomly distributed over the region, and the pixels inside the interval will be connected together. If a pixel is close to the region boundary, it will be connected only to pixels of the same region. The new filtering technique, therefore, does not calculate the mean value over all the pixels of the window. Instead, we calculate the mean value only of the pixels inside the interval and connected to the central pixel of the window. The connected pixel criterion results in the self-adaptation of the filtering to the shapes and sizes of the image structures. However, since we cannot assume that we know a priori the mean backscattering values of the image regions, we must examine all the possible mean values and for each pixel define the most appropriate value. For each pixel, we select the mean value producing the largest connected area around the pixel. Hence, if a pixel is on a line structure, the mean value of the line will be selected and only the pixels of the line will be used in the calculation of the filtered value.

Good results have been obtained for agricultural and forest areas. We will present the results for a forest area. The technique performs an important filtering of the speckle while preserving the image structure. The selection of the decision interval size allows a good control of the amount of filtering performed and in all cases, results are meaningful.

X-SAR Backscatter Slope and Aspect Dependence

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ABSTRACT

X-SAR data over New Zealand from the SIR-C/X-SAR mission flown in October 1994 has been analyzed to characterize the dependence of backscatter on local slope and aspect. A high resolution digital terrain model was generated from 20 m contour information and used in the analysis of the orthorectified X-SAR image. Areas effected by layover or shadow effects are pre-calculated and excluded from the analysis.

A correction, previously developed by the authors to normalize pixel backscatter for the variation in distributed scatterers, is used in this study. As was found in a previous study using JERS-1 L-band imagery, this correction works well over a wide range of slope/aspect geometry's provided there is no shadow or layover in the pixel.

Residual angular dependence of backscatter is assumed to be target type specific. Backscatter angular variation is analyzed for two target types, namely, grass and trees. Unlike the previous study using L-band, the X-band signal exhibits a much smaller variation in angular effects between the target types. Backscatter is more isotropic for the smoother grass targets than was the case with L-band imagery. This result is explained by the much shorter wavelength being small with respect to the roughness of most natural ground cover types.

CONTROL SYSTEMS PRINCIPLES APPLIED TO SPECKLE FILTERING AND TO THE RETRIEVAL OF GEOPHYSICAL PARAMETERS THROUGH RADARSAT AND ERS BAYESIAN DATA FUSION

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ABSTRACT

Some important issues of interest in the field of multi-channel SAR images processing remain still open. Among them, the introduction of A Priori knowledge or A Priori guess which implies the use of Bayesian methods in the processing of multi-SAR's images. So far, the case of multi-channel detected SAR images has not yet been studied with this approach.

Two new Bayesian vector speckle filters are developed for multi-channel SAR images. These filters incorporate statistical descriptions of the scene and of the speckle in multi-channel SAR images. These models account for the scene and system effects which result in the presence of a certain amount of correlation between the different channels. Since the non-linear system and scene effects are taken into account by these Bayesian restoration processes, the filtering operation can be considered as a controlled restoration of the radar reflectivity where A Priori knowledge controls the inferential restoration process.

These new established Bayesian speckle filters present the structure of control systems. In the case of multi-SAR's image series, the speckle filtering process proceeds as a data fusion process, since the information content of the whole image series is exploited to restore the individual images. This offers very wide possibilities for further choice and design of additional commands (statistical or physical very wide possibilities for further choice and design of additional commands (statistical or physical models). In this view, speckle filtering should be regarded as the first step of integrated application oriented control systems, rather than processing chains, for multi-temporal SAR or multi SAR's series.

So far, such a control system allowing the retrieval of soil roughness and soil moisture as well as the identification of snow covered areas from ERS and RADARSAT SAR images through Bayesian data fusion has been developed. These geophysical parameters are important for agriculture applications of radar remote sensing.

Results obtained over the Netherlands in the framework of Pilot Projects ERS PE-FRNE2 and RADARSAT ADRO#581 illustrate the performance of the new techniques introduced above for a variety of SAR combinations. These results show that: 1) the new speckle filters present convincing performances for speckle reduction as well as for texture preservation and for small and/or thin scene objects detection; 2) the retrieval of soil roughness and soil moisture, as well as the identification of snow covered areas through Bayesian data fusion of ERS and RADARSAT data provides valid results.

Measuring Clearings and Tree Heights with Stereo RADARSAT Data in a Tropical Forest Environment

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RADARSAT, Canada's first Earth observation satellite can provide stereo coverage of a geographical area using a variety of beam modes, positions and two Earth-relative look directions. This capability provides a unique opportunity to extract information from a stereo pair. Along with the flexibility of RADARSAT image products, comes a range of geometric and radiometric characteristics that must be addressed if each image and the stereo pair are to be used successfully for geoscientific applications.

In the tropical rain forest environment of Brazil, there is an enormous need for mapping and monitoring of renewable and non-renewable resources. In fact, the increase in deforestation needs to be monitored on a regular basis. In this environment, where near-perpetual cloud cover often prevents optical data from being used to monitor vegetation change, RADARSATdata are a valuable source of information.

Most of the time, the canopy of the rain forest can be clearly discriminated from the clearings on a single radar image. It is more difficult to discriminate between different types of clearings, such as active pastures or various levels of overgrown pastures. In this context, a third dimension (3D) enhances one's ability to interpret two dimensional imagery. The "naturalness" of 3-D representation has major advantages in this tropical rain forest environment:

- qualitatively because by combining information from the stereo-pair and the radiometry of each image, a better and more confident determination can be made between primary forest and different clearings; and
- quantitatively, because the surface of clearings and tree heights can be measured on the stereo-pair, without using a DEM.

This presentation will demonstrate the applicability of stereo RADARSAT data in a tropical rain forest environment by interpreting and measuring some physical characteristics of the forest. The method and the system used for the stereo-interpretation and measurements are presented first, and then the results of this specific application using other data sources are evaluated.

SAR Interferometry With Radarsat Data Over An Alpine Terrain

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Abstract

A large magnitude of remote sensing SAR image data nowadays are available from the ERS, JERS-1 and Radarsat instruments. This data promises significant applications in the Earth sciences of which SAR interferometry is one. Although satisfactory results concerning the validation of interferometrically derived digital elevation models (DEM) from Radarsat data have been reported in the literature, a comprehensive analysis of these data, as in the ERS case, has not been widely presented. Therefore, in this paper results of a comprehensive analysis of interferometrically derived DEMs from Radarsat data are given together with a detailed quality analysis in comparison to reference DEM data. These are, a DEM generated from ERS interferometric data as well as a DEM derived from topographic maps. The test site is the area around the city of Graz in Austria which consists of a complex terrain, with flat areas along the Mur river valley and some mountainous regions covered with mixed alpine forest.

The selected Radarsat data are interferometrically processed and the elevation information generated. For the validation of results the ERS comparative data as well as the reference DEM generated from the maps are already available in a specified cartographic system. As by-products, multilook interferometric data, such as amplitude images, interferograms, gray value fringe and coherency images, will be analyzed and presented as well.

Coherency of the ERS interferometric data is mostly good in the non-forested area, with the temporal difference between most of the data sets being only one day, i.e. ESR tandem data. Good rms height error of values below 9 meters were achieved for the ground control points used in the DEM generation from the ERS data. Whereas, the standard deviation of the difference DEMs for these data on average was about 10 meters, with the relatively larger baseline giving the best accuracy. The horizontal accuracy, i.e. residuals of the Easting and Northing of the ground control points, were within half a pixel on average (24 meters) with a pixel resolution of 40 x 40 square meters.

Geometric and Radiometric Calibration of RADARSAT Images

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ABSTRACT

Interpretation of SAR images in areas with significant relief requires rigorous calibration considering local incidence angle effects if one is to be able to perform meaningful multitemporal analysis using images acquired with different geometries. Given the large swaths made available by Radarsat, even comparison of the near vs. far range sections of the same image requires such calibration.

We present here results from geometric and radiometric calibration of single and multiple beam mode Radarsat SAR images, as applied to data provided under the ADRO programme. A high resolution elevation model is used first to terrain-geocode the data from ground range radar coordinates into the reference map coordinate system. Tiepoints are used to coregister both the slow and fast-time axes to a global Earth-centred rotating coordinate system.

Radiometric calibration is performed by compensating for effects of local incidence angle on the local backscatter. In particular, the effects of multiple DEM slopes ("facets") within a single radar geometry pixel (which can grow to over a kilometre in steep terrain!) are considered. The antenna gain pattern is retrieved from the image header and integrated into the compensation in the above step.

The utility of the SAR data for thematic interpretation is presented, both before and after calibration. The impact of the calibration is illustrated using a selection from forest and snow-cover discrimination and land-use classification applications.

Estimating Flow Rates of the Lowell Glacier with Satellite InSAR Data

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It has been shown that one of the most important applications of satellite interferometric SAR is to measure small displacements or flow rates of geophysical features on the earth's surface. One such application demonstrated recently has been the measurement of flow rates of Alpine glaciers.

In this paper, we extend these results by analysing new data from the Lowell Glacier in the Yukon. ERS SAR measurements have been taken from two directions, from ascending and descending passes, and this allows us to project the satellite-measured flow rates more accurately onto the glacier surface. The InSAR processing steps are outlined, and the geometric transformations used to combine the ascending and descending data vectors are explained. It is shown that glacier flow rates can be measured with an accuracy of approximately 4 cm/day from a C-band satellite SAR.

GÉOMATIQUE ET AMÉNAGEMENT EN MILIEU MUNICIPAL COMPARAISON FRANCE/QUÉBEC

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RÉSUMÉ

À l'heure où un nombre grandissant de municipalités adoptent la géomatique, l'étude des implications humaines et sociales liées à l'utilisation des SIG, et plus précisément à la représentation spatiale qu'ils génèrent, apparaît comme un axe de recherche prioritaire. La diffusion des SIG au sein des municipalités et l'appropriation sociale qui en résulte ne sont pas sans conséquences sur les processus de réflexion aménagistes. L'objectif du projet de recherche présenté ici est de comparer l'influence de la géomatique sur la réflexion et la négociation aménagiste en milieu municipal, en France et au Québec, en tentant d'éclairer les phénomènes d'appropriation sociale des SIG par le système d'acteurs qui intervient au sein des projets d'aménagement. La méthode utilisée s'articule autour de trois outils méthodologiques différents, mais complémentaires (quatre études de cas exploratoires, une enquête et une analyse des politiques institutionnelles de développement de la géomatique). Cette démarche repose sur une approche multidisciplinaire, à la croisée des préoccupations de la géographie sociale, de la géomatique et de la sociologie des organisations. Les résultats attendus devraient permettre, outre d'éclairer le phénomène d'appropriation sociale des SIG par les acteurs de l'aménagement et milieu municipal, d'évaluer les effets induits par l'utilisation des SIG sur le processus de réflexion et de négociation aménagiste, et de mieux cerner le rôle de l'information géographique.

GEOMATICS AND MUNICIPAL PLANNING COMPARISON BETWEEN FRANCE AND QUÉBEC

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Abstract

At a time when a growing number of municipalities equip themselves with geomatics technologies, the study of the human and social implications related to the use of GIS, and more specifically, to the the representation of space they generate, appears as a major research direction. The spreading of GIS within municipalities and the consequent social adaptation are not without consequences with regard to planning process. The main goal of the project presented in this paper is to compare the influence of geomatics techologies on the municipal planning decision-making process, both in France and Quebec, by trying to throw light on the social adaptation phenomena to GIS achieved through the system of local collaborators, which intervenes at the heart of planning project. The method used is connected with three different, but complementary methdological tools (four exploratory case studies, a survey questionnaire and an analysis of the institutional development policies of geomatics). This process lies on a multidisciplinary approach at the junction of the concerns of social geography, geomatics and sociology of organizations. The awaited results will not only give information on the social adaptation phenomena to GIS, but they will also estimate the effects entailed by the use of GIS on decision-making and communication process, and define more precisely the role of geographical information.

APPLICATION OF REMOTE SENSING AND GIS WITH LOCATION ALLOCATION MODELLING

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ABSTRACT

This study investigates how remote sensing and geographic information systems (GIS) can be used with location allocation modelling to reduce the errors inherent in aggregation of population within urban enumeration areas. Remote sensing provides the tools necessary for classification of SPOT urban satellite imagery to better locate built-up areas within man-made geographical boundaries. GIS provides an environment within which base data, classified imagery, intermediate data sets, and location-allocation analysis can be readily integrated. In better identifying population centers within enumeration areas, location-allocation modelling is provided with data of higher quality. The goal is to more efficiently locate facilities and allocate demands based on real world locations of urban population centers. The integrating nature of the study demonstrates the benefits of using a multifaceted approach to problem solving.

CONCEPTION D'UN SIG-TRANSPORT DE PROSPECTIVE DE LA DEMANDE

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RÉSUMÉ

Bien qu'il existe des SIG dédiés aux transports, la plupart de ces systèmes sont surtout axés sur l'offre à un niveau spatial très détaillé et sont mal adaptés pour la planification de la demande à long terme fondée sur une vision globale (Madituc, Emme^2, TransCad). L'objectif de notre projet est de concevoir un SIG prospectif de la demande en intégrant une approche pluridisciplinaire qui utilise les facteurs structurels (démographie, aux tendances du marché du travail, au cycle de vie, etc.) comme variables explicatives dans la détermination de la demande future en transport. La modélisation de la prospective se servira des données de l'enquête Origine-Destination (O-D) de la région de Puebla au Mexique (1994). Un tel SIG devrait être conçu de manière à pouvoir s'appliquer tant au niveau des villes du Nord qu'aux villes du Sud moyennant une calibration différenciée des paramètres. Dans une première étape, le système doit générer les matrices O-D sur la base d'une discrétisation des données socio-économiques par cohortes d'âge, de sexe, etc. Par la suite, le système sera dopé de modèles d'analyse des comportements, de simulation de patterns des déplacements futurs et d'évaluation de l'impact de la diffusion de divers moyens de transport (Bussière, Madre, etc.).

Le développement du système nécessite, au préalable, la résolution de certains problèmes d'ordre méthodologique. Les données de l'enquête existent déjà dans des fichiers en format dBase (modèle physique). Mais, le choix d'une approche ascendante d'ingénierie de logiciel n'est conseillée que si l'on peut reproduire avec succès le modèle logique et le modèle conceptuel de données. Adopter une approche descendante signifie le *re-engineering* des tables existantes au risque d'une perte de l'intégrité et de la cohérence des données. Le choix d'une stratégie de développement rapide de modules de traitements pose un autre défi. En effet, autant le développement à partir de rien *(from scratch)* que l'utilisation des langages des SIG ou le couplage de logiciels *(components software)* comportent des avantages et des inconvénients qu'il faut évaluer sérieusement. Dans notre papier, nous analyserons l'espace des solutions et nous présenterons les premiers extrants visuels du prototype du système (graphiques et cartes).

USING GEOGRAPHIC INFORMATION SYSTEMS FOR ELECTRIC UTILITY LOCAL INTEGRATED RESOURCE PLANNING

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ABSTRACT

This paper presents "lessons learned" from the development of a Geographic Information System designed for use in local integrated resource planning. Utilities have not fully explored the use of GIS for this purpose and so this project represents a ground breaking study. This fact has been recognized by Natural Resources Canada's Geographic Information Systems Development Program and by Ontario Hydro, both of whom have made financial contributions towards the fulfillment of this pilot study.

Local integrated resource planning has become the commonly accepted means by which electric utility planners evaluate the wide variety of options open to them for supplying their customers with energy services (heat, light and motive power). Integrated Resource Planning refers to the process by which supply and demand management options are consistently planned, implemented and evaluated to provide energy services at a cost that appropriately balances the interest of all stakeholders. The term "cost" has generally been expanded to include economic, social and environmental costs.

Ottawa Hydro and Ontario Hydro began a local integrated resource planning study of the region early in 1995. A preferred strategy for meeting the electricity service needs of customers at the lowest cost in the Ottawa area over the next 15 years was developed. The study identifies that area of downtown Ottawa served by the King Edward Transformer Station (TS) for priority action because the station is currently overloaded. Options being considered for alleviating the problem include upgrading the existing transformer station, transferring electrical load to other stations, reducing the demand for electricity through customer demand management programs or contracting for private sector standby generation.

In order to adequately evaluate each option's potential for reducing overloading at the transformer station, and the associated costs of doing so, a GIS will be used. A consistent problem with implementing demand management programs is forecasting customer participation. Success is highly dependent upon the program's ability to address both utility and customer needs. Potential participants must be identified based on their location, their electrical end-uses and demand patterns, and their options in terms of fuel switching, load shifting or increasing energy efficiency. By allowing planners to clearly identify potential participants, GIS can increase the likelihood of success for demand management programs. GIS is the only means by which different scenarios involving a mix of supply and demand management options can be adequately assessed and presented to decision-makers and the public for final evaluation and approval.

INTEGRATION OF REMOTE SENSING AND GEOGRAPHIC INFORMATION SYSTEM FOR CASSAVA MONITORING, NORTHEAST THAILAND: PROBLEMS STILL EXIST

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ABSTRACT

The integration of remote sensing and geographic information system for cassava monitoring was conducted for the Northeast Thailand where it has the most extensive cassava cultivation area. Cassava, the second major export commodity of Thailand is ranked after paddy rice. Since 1965, cultivation of cassava has been greatly increased due to the high demand in foreigner markets, easy to grow, less pest damage and drought tolerant. The increasing trend of planted area was fluctuated due to the unstable farm gate price of cassava. The cassava yield declines rapidly after a few years of cultivation from clearing forest land. However, the cassava yields vary according to soil fertility status, physical characteristics and suitability. Remote sensing and GIS are considered as effective tools for resource inventory and monitoring. But, little work has been carried out in Thailand with regard to large area crop monitoring and yield forecasting. This study employs visible and IR remotely sensed data to map cassava planted areas. GIS is employed to create Dbase i.e. administrative boundaries, soils, topography land use, and cassava yield. The NOAA-AVHRR data, 1.1 km were used for crop monitoring and yield forecasting. The satellite data were found to be useful only when cloud free during the harvest period. Since, harvesting is farmers dependent, it is hardly to have full area coverage of cassava in the dry season. So far, there is no chance to receive cloud-free data during the full mature stage in September-October. GIS on the other hand is proved to be a very useful tool for cassava yield estimation. The available SAR data may be of interest for further study.

RADARSAT SAR Azimuth Ambiguity Patterns - The Ghost Fleet of Halifax Harbour and Implications for Applications Work

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ABSTRACT

Common electrical engineering measures of radiometric accuracy in satellite synthetic aperture radar (SAR) imagery include signal dependent noise, peak impulse response sidelobes and ambiguities. While most users of SAR imagery are largely unaware of ambiguity signal noise, its occurrence in extreme cases can lead to visible artifacts which, if ignored, cause incorrect analysis results and misinterpretation. This paper reports on the occurrence of azimuth ambiguity patterns detected in SAR imagery obtained from the Canadian RADARSAT system in Standard Mode 7 on October 19, 1996 over the Halifax Harbour area in Nova Scotia, Canada. First order analysis of the real targets, the 'aliases' and their spatial separation shows that actual measurements of azimuth and range displacement agree well with theoretical values. Illustrations of actual targets and their ambiguities are provided. Implications for practical applications work are briefly discussed with reference to RADARSAT SAR data of coastal regions.

Operational Marine and Coastal Information from the ERS SAR

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*Under contract to ERS Data Utilisation Section ESA-ESRIN

ABSTRACT

One of the aims of the ERS mission was to demonstrate the viability of operational and commercial applications based on microwave remote sensing. To this end, a number of data exploitation programs were initiated by ESA with the aim of allowing organizations to develop such services based on the ERS instruments. Various additional exploitation programs have also been set up at national levels within the ESA member states. Such programs allowed the extensive validation of products and services intended for governmental and commercial customers. As a result, operational and pre-operational applications of ERS data have progressed considerably, particularly in the marine and coastal information sectors over the last 12-18 months.

This paper will highlight particular examples where commercial or operational services, derived at least in part from ERS data, are now being provided on a routine basis, giving an overview of the service provision, the use of the ERS data within the product or service provided and the developments currently ongoing aimed at further exploitation and development of such services. The main focus will be the provision of bathymetry maps to the oilfield support industry and organizations involved in coastal protection and sediment transport monitoring, including a description of an operational bathymetry assessment system currently available, the level of accuracy attainable, the benefits from using such a system, how the performance of such a system meets particular user requirements and some conclusions regarding further exploitation.

In addition to bathymetric information, the paper will discuss a second application area in the offshore oil and gas exploration market sector, highlighting the capability of the ERS SAR in the detection of surface slicks arising due to seepage from sub-sea hydrocarbon deposits. One example of a commercial service currently available to hydrocarbon exploration companies will be discussed, focusing on the incorporation of ERS SAR data, coupled with information derived from the radar altimeter, into the analysis of the exploitation potential for new basins. This paper will conclude with some points looking forward to the availability of Envisat ASAR data.

Merging LANDSAT TM and Airborne SAR for Generating Maps of Louisiana's Coastal Zone to Facilitate Oil Spill Cleanup

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ABSTRACT

Coastal zones throughout the world are highly productive, extremely fragile and increasingly at risk. Pollution from oil spills represents one of the more important risks, and the risks increase as oil and gas exploration, extraction and transportation expands with growing demands brought about by both population growth and increasing standards of living. Oil spills will happen; however, up-to-date maps of the areas at risk will help facilitate oil spill cleanup and reduce environmental damage.

Even when compared to other coastal zones, the Louisiana coastal zone is a very dynamic, complex and fragile environment. The complexity and dynamic nature of the Louisiana coast prohibits the utilization of traditional surveying and photogrammetric techniques for updating coastal maps at the necessary time interval. Historically, aerial photographs have been used in coastal surveys, and although they provide very high spatial resolution information, the cost of the required periodic over-flights and the analysis of the photography is often prohibitive. Remote sensing data and image processing techniques provide a possible solution to this mapping problem. Recently acquired LANDSAT TM and airborne X-band synthetic aperture radar (SAR) made it possible to evaluate techniques to generate accurate and up-to-date image-based maps suitable for use by field personnel in preparation for, during and following an oil spill on the Louisiana coast.

The completion of this project required the melding of the "high tech" aspects of remote sensing/digital image processing with the logistical needs/preferences of the oil spill field personnel. The generation of the image-based maps required georeferencing the data sets, selection of the optimum LANDSAT TM bands and experimenting with a variety of merging techniques to "come up with" a suite of LANDSAT TM/SAR image options. The final selection of the "best" image-based map was based on input from the potential users of the product. Oil spill personnel from the oil industry, the oil spill cleanup industry and state and government agencies assisted in the evaluation and selection of the image products generated for use by personnel charged with planning, monitoring and undertaking oil spill containment and cleanup operations.

This presentation will discuss the major tasks and conclusions of this project. More specifically the topics covered will be:

1. selection of the study areas,
2. selection of the LANDSAT TM dates and bands,
3. importance of the SAR data,
4. image processing and merging techniques,
5. selection procedures for the best image-based maps,
6. evaluation of the merged images,
7. problems encountered, and
8. conclusions.

RADARSAT Ocean Feature Workstation

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The RADARSAT SAR imaging system has selectable beam modes that provde the flexibility of acquire images of marine areas of interest with various resolutions and incidence angles. To serve the Department of Fisheries and Oceans (DFO) operational requirement for near real time environmental and vessel information, DFO implemented a RADARSAT Ocean Feature Workstation (ROFW) processor with analysis algorithms. The RFW operates in an unattended mode at the Gatineau Receive Station. ROFW products are available within three hours of the RADARSAT pass and are sent electronically to Marine Environmental Data Service (MEDS) for distribution to the regional management centres. MEDS archive the products for later scientific user access. The results from this system are being evaluated using various SAR modes and incidence angles. The fishing vessel information centres verify the RADARSAT observations with aircraft and vessel observations. The early results from the initial trials of fishing vessel detection on the Grand Banks will be discussed. The algorithms for environmental information are being validated under contract and will be complete by March 1997. To test the fishing vessel and ocean environment surveillance capabilities of RADARSAT, large areas of the Grand Banks and Scotia Shelf are being monitored. The user selects a SAR image mode with adequate resoltuion to detect fishing vessels with sizes ranging from twenty meters to the large trawlers of sixty meters. Theoretical studies indicate the far beams, with shallow incidence angles, can provide the best signal to noise for ship detection. Ocean wave and feature monitoring required SAR beams with steep incidence angles and adequate spatial resolution.

Station de travail RADARSAT sur les particularités océaniques

En permettant de varier les paramètres du faisceau du radar télédétection, le système RADARSAT offert beaucoup de flexibilité au niveau de la prise d'images des zones maritimes d'intérêt aux résolutions et angles d'incidence qui conviennent le mieux. Afin de satisfaire ses besoins opérationnels en matière de renseignements en temps réel sur l'environnement et le déplacement des navires, le ministère des Pêches & Océans (MPO) a conçu un processeur pourvu d'algorithmes d'analyse pour sa station de travail RADARSAT sur les particularités océaniques (STRPO). La STRPO fonctionne de façon sont disponibles trois heures après le survol du satellite et sont acheminés part voies électronique au service de données sur l'environnement marine (SDEM) pour diffusion aux centres régionaux de gestion. Le SDEM met également ces produits en archives pour fins de recherches ultérieures. On procède présentement à l'évaluation de ce système sous divers modes d'opération du radar et d'angles d'incidence. Les centres de renseignement sur les vaisseaux de pêche comparent ces observations RADARSAT celles obtenues au moyen d'avions ou de navires. Le conférencier fournira les premiers résultats des essais de détection de vaisseaux de pêche sur les Grands Bancs. Pour ce qui est de l'algorithme pour les reseignements environnementaux, un contrat est en voie d'exécution pour en valider l'utilisation. Ce travail sera complet d'ici mars 1997. Une surveilance intensive de vastes zones des Grands Bancs et du plateau Scotia est présentement effectuée afin de vérifier la capacité de surveillance de RADARSAT. L'utilisateur peut choisir les paramètres du faisceau du radar et la résolution nécessaire pour détecter des vaisseaux de pêche dont les dimensions vont de 20-60 mètres. Des études théoriques démontrent que pour la détection de vaisseaux, les faisceaux affleurants peuvent donner les meilleurs résultats. Pour ce qui est des vagues sur l'océan et de l'observation des praticularités océaniques, il faut que l'angle d'incidence des faisceaux soit élevé et la résolution spatiale adéquate.

GULF OFFSHORE SATELLITE APPLICATIONS PROJECT DETECTS OIL SLICKS USING RADARSAT

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ABSTRACT

The Gulf Offshore Satellite Application Project (GOSAP) is an ADRO program. Being undertaken by members of the petroleum, marine, and environmental industries to determine how best to use remote sensing technologies for Offshore Exploration. The project will evaluate the ability of remote sensing systems, primarily RADARSAT SAR, to detect oil seeps and spills in the Marine environment; investigate the influence of sea temperature geological, geochemical, and biological factors on natural seep rates; relate the slick morphology to its dispersion history; demonstrate the use of RADARSAT data in shallow littoral waters to derive wave and current information; and establish and evaluate operational criteria for RADARSAT commercial products for these applications.

In the winter of 1996 GOSAP-ADRO acquired the first RADARSAT images over our Gulf of Mexico test site and observed spills plus natural oil slicks using all of the major beam modes, Special processing problems were resolved, and a system for image rectification was developed and deployed operational criteria for RADARSAT image selection and acquisition are being evaluated for routine image purchases.

Use of SSM/I 85 GHz Passive Microwave Data for Investigating Great Slave Lake ice Freeze-up/Break-up Variations

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Preferred Session: CRYSYS
Presentation Mode: Oral

Freshwater ice seasonally covers most lakes in Canada. Previous studies have shown lake ice formation and decay are closely correlated to climate variables, such as air temperature, and thus variations in ice freeze-up and break-up may be useful indicators of regional climate variability and change. Conventional measurements of lake ice freeze-up and break-up have typically been shore-based visual observations. For large lakes, such as Great Slave Lake in the Northwest Territories, shore-based observations are not representative of conditions over the entire lake. Satellite remote sensing provides the means to observe lakes on a daily basis and thus determine the ice cover conditions over the entire lake surface. This paper will present results of an ongoing investigation into the use of passive microwave satellite data to determine spatial and temporal characteristics of lake ice formation and decay for Great Slave Lake.

Since 1992, Special Sensor Microwave Imager (SSM/I) data have been acquired in near real-time during the ice freeze-up and break-up periods for Great Slave Lake. From this data set, it has been shown that 85 GHz brightness temperatures, with a spatial resolution of 12.5 km, can be used to discriminate between areas of ice and open water over the lake surface. By acquiring SSM/I data daily, it is possible to observe spatial and temporal patterns of ice formation and decay over the entire lake, thus providing more representative dates of complete freeze-over and ice-free conditions. Annual variations in ice conditions are also being investigated using several years of acquired SSM/I data. The variability in timing of events, such as the onset of ice formation and decay and complete freeze-over and ice-free conditions, will be presented. Trends and variations in the spatial patterns of ice cover formation and decay will also be noted. Using historical SSM/I data, it is possible to generate a time series of Great Slave Lake ice freeze-up and break-up from 1987 to the present, and document the variations over a ten year period. The potential use of such a time series for analysis and modelling of climate variations will be discussed.

The development of methodologies and algorithms for deriving lake ice information using SSM/I data is part of "CRYSYS", a Canadian interdisciplinary investigation within NASA's Earth Observing System (EOS) Program. The availability of higher resolution passive microwave data with the planned launch of AMSR (Advanced Scanning Microwave Radiometer) on the EOS-PM platform in the year 2000, should extend the capability to observe lake ice conditions over much smaller lakes in Canada.

THE CRYOSPHERE: AN INDICATOR OF CLIMATE CHANGE?

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ABSTRACT

The cryosphere (snow, sea ice, glaciers and ice caps, lake ice and permafrost), something to which all Canadians can all relate, can also serve as an indicator of climate change and variability. CRYSYS - "Use of the Cryospheric System to Monitor Global Change in Canada" - is a Canadian Government and university contribution to NASA's Earth Observing System which utilizes remote sensing, modelling, field studies and data integration to provide improved capabilities for monitoring the state of the cryosphere, and greater understanding of processes and variability. This presentation will provide our scientific strategy, highlight key results to date, show some of the products being developed and discuss how the team's work can make contributions to education and policy.

La cryosphère (neige, glace de mer, glaciers et calottes glacières, glace des lacs et permafrost), un sujet assez familier aux Canadiens, peut aussi servir en tant qu'indicateur du changement et de la variabilité du climat. Le programme CRYSYS, qui consiste en l'utilisation du système cryosphérique pour observer le changement climatique au Canada, *est la contribution du gouvernement canadien et des universités canadiennes* au système de la NASA pour l'observation de la Terre. Ce système utilise la télédétection, la modélisation, les études sur le terrain et l'intégration des données afin de fournir une capacité améliorée pour le suivi de l'état de la cryosphère, et une plus grande compréhension des processus et de la variabilité cryosphériques. Cette présentation montrera notre stratégie scientifique; elle mettra en évidence les résultats obtenus jusqu'à maintenant, montrera certains des produits en développement et discutera de la façon dont le travail de l'équipe contribuera à l'éducation et au développement de politiques.

ESTIMATION OF LARGE SCALE SEA ICE MOTION FROM SSM/I 85.5 GHz IMAGERY

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ABSTRACT

This presentation will describe the application of an automated cross correlation technique to pairs of 85.5 Ghz SSM/I images to obtain ice motion over the entire Arctic Basin for a continuous two-month period December 1993 to January 1994. Although the surface ice information in the imagery is coarse and noisy, the area cross correlation method is quite successful in picking up ice motion information. The accuracy of 85.5 Ghz SSM/I derived ice motions is evaluated by comparing results with Arctic buoy drift. Over 390 comparisons with buoy drift estimates of ice displacement were made with an overall correlation of .75 and an average vector magnitude error in ice velocity of 3.5 km-day-1. The main difficulty with the automated technique is the tendency to overestimate ice displacement compared to buoy data by about 14%. Two detailed examples of ice motion are presented. One case study occurred in December 1993 when a major westward shift in the ice pack occurred in the Canada Basin. This opened up a very large lead off Banks and Prince Patrick Islands. The second example occurred in January 1994 when an intense anti-cyclone over the Canada Basin produced a strong Beaufort Gyre.

PERMAFROST MAPPING NEAR CHURCHILL, MANITOBA, USING OPTICAL AND SAR DATA

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ABSTRACT

In recent years there has been a renewal of interest in the utilization of satellite remotely sensed data to map permafrost in North America. With the availability of TM and SPOT imagery, in particular, attempts have been made to map both the presence/absence of permafrost and active-layer thickness in the discontinuous permafrost zone. Some degree of success has been achieved over some areas, but no methods have yet shown to be transferable to other regions. The main reason for this is that permafrost is a subsurface phenomena and, as a result, mapping its distribution can only be done using indirect means. A land cover map is the usual product derived from remote sensing data, which is then combined with digital topographic data to map the spatial distribution of permafrost. In the continuous zone, on the other hand, remotely sensed data are often used to map phenomena indicative of permafrost agradation or degradation (e.g. polygonal ground, active layer detachment slides, thaw slumps, etc.).

In this paper we will present results of a study on the use of Landsat TM and multitemporal ERS-1 SAR data to map active-layer thickness in an area of continuous permafrost near Churchill, Manitoba. Landsat TM data and surface-based measurements were utilized to map surface albedo, terrain types, and snow depth. Ground surveys of snow depth confirm that the terrain types have clearly distinguishable snow retention properties, ranging from an average of 11 cm for upland lichen-heath to 41 cm for open spruce forest and willow-birch wetland. Information on soil moisture conditions and the seasonal freeze/thaw cycle of the landscape was obtained using the ERS-1 multitemporal data set. The combination of data products derived from the two types of imagery allowed to produce a preliminary map of active-layer thickness categories for the Churchill area. The next stage will be to test the map against ground-based data which have been collected for a number of terrain types and a number of years.

A COMPARISON OF AGGREGATED OBJECT AND SINGLE PIXEL METHODS FOR SLOPE UNIT CLASSIFICATION

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ABSTRACT

A hypothesis test is conducted to determine whether identifying and classifying geomorphological units from digital elevation and remote sensing data is more accurate if the complete objects are described in comparison to a single pixel classification approach. Using an existing geomorphological theory, an automated method has been developed for extracting geomorphological objects called slope units from downslope profiles. The digital database is segmented on the basis of a geomorphometric consideration, the location of breaks of slope in profile, instead of segmentation based on the variation of reflectance values in the remote sensing image. Each aggregated slope unit object is described with a list of shape, topographic, and spectral reflectance variables and submitted to classification using discriminant analysis. For a baseline comparison in the hypothesis test, corresponding single pixels are also classified.

The hypothesis test is conducted for a study area in southwest Yukon, Canada. The new aggregated method of slope unit classification is compared with the single pixel method in two steps. First, only variables describing aggregated slope unit objects that are comparable to the single pixel variables are used for classification training. Second, an expanded list of variables generated to describe slope units is used for training. In both cases, the slope unit method produces higher overall classification accuracy than the single pixel method, because the description of slope units is more detailed. The study demonstrates the benefits of database segmentation prior to classification, in particular for the identification and discrimination of geomorphological landscape units.

MORPHOSTRUCTURAL ANALYSIS OF THE SOUTH EAST OF TUNISIA USING INTEGRATED TOPOGRAPHIC, BATHYMETRIC AND REMOTE SENSING DATA

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ABSTRACT

In this work, the morphostructure on and off shore of the SE of Tunisia is analyzed using topographic, bathymetric and remote sensing data.

In the first step, image processing Erdas software is used to enhance TM and Spot data, extract morphology of the studied area, tectono-lineaments and to describe channels in the bottom of main lagoons bordering the coast.

In a second step, GIS Arc/Info has been used to:

- construct DEMs from topographic and bathymetric data, extract and analyze the drainage pattern (surfaces, morphometric and morhogenetic analysis)
- harmonize multi-source data (geometric correction)
- integrate cartographic and remote sensing data to produce a final morphotectonic document.

Regarding the spatio-temporal repetition of tectonic's elements and their styles, three morphostructural zones in the studied region were carried out and genesis of lagoons of El Boughrara, El Maleh and El Biban is precised.

Mapping Debris Flows in Banff National Park.

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Abstract

Debris-flows are defined as the rapid movement of water, rock debris and vegetation, down a predefined ephemeral channel. After examining these channels, reviewing historical documents and talking with experts and eyewitnesses, it was deemed that their potential for destruction and relatively high recurrence rate, poses a significant danger to the increasing number of visitors entering Banff National Park. A GIS database of these channels is being developed to help identify hazardous areas which are a potential threat to lives and/or property within the park. A recurrence interval model would calculate the number of years between successive high magnitude debris-flows at a particular site.

Over 45 debris-flow tracks were studied between July and September, 1996 in Banff National Park. A GPS unit was used to collect site location information in three dimensions, and general characteristics and measurements were also noted. GIS maps will be used as base maps for the database. The GPS coordinates of each site, will be digitized onto a raster base map and linked to a database created in MSAccess. The database will contain information about each debris-flow channel gathered from field research, digital aerial photos and an ecological atlas of the park. Information such as the length, width, slope, aspect, vegetation type, ecological zone and proximity to developed areas will be included. These characteristics will be displayed when the appropriate site is selected on the GIS map. The possibility of linking a digital aerial photo of a site to its database entry is also being explored.

The recurrence interval model relies on 9 variables to compute the number of years between successive, high-magnitude debris-flows at a given site. The calculations are being carried out in MSExcel using data derived from field observations, digital aerial photos and journal articles. The Bootstrap algorithm is being proposed as the method by which the variance, or error, of each variable involved, can be estimated. The model is based on current measurements of channels, theoretical channel shape, accepted erosion rates and other morphometric data. Because rainfall is the primary release mechanism in this environment, a threshold value, above which failure is extremely likely, would have to be determined from historical records. This would give park personnel the information required to make responsible decisions about the hazards posed by these failures to the park visitors.

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The coastal region of northeastern Brazil are major economic and recreational areas. In these areas, low income population in small fishing villages, "favelas" and expanding urban areas, are affecting the sensitive coastal ecosystems. At the same time, the coastal zone is been eroded by the frequency and intensity of storm events which also destroy the marginal ecosystems. Because of the permanent cloud cover in these coastal areas, no optical image exist to assist in geological and environmental mapping.

In this study we use RADARSAT data to interpret the structural geologic and geomorphic processes and their relationships to coastal erosion. Our results show the following:

- There is a good correlation between the radar image-interpreted lineaments in the coastal areas and the Pre-Cambrian and Post-Cretaceous geological structures in the interior areas.
- The coastline is structurally controlled with lineament directions of $NE40^0 \pm 5^0$ (dextral strip slip and normal/gravitational faults), $NW20^0 \pm 5^0$ (sinistral strip slip and normal/gravitational faults) and $NS \pm 5^0$ (inverse sub-vertical faults, with E-W overlaps).
- The areas with high vulnerability to erosion (almost 300m of coastal loss, in 25 years), are characterized by flat Quaternary sediments (alluvial and sandstone surfaces). In these areas, increasing coastal erosion is related to the increase in the frequency of lineament directions. These directions are $NE25^0 \pm 5^0$ (inverse sub-vertical faults, with W-E overlaps) $NW20^0 \pm 5^0$ and $NW35^0 \pm 5^0$ (sinistral strip slip and normal/gravitational faults).
- The areas with low vulnerability to erosion are characterized by accretion and by Tertiary/Quaternary sandstone cliffs. In these stable regions, the frequency of the lineament directions decreases. These directions are $NE40^0 \pm 5^0$ and $NW60^0 \pm 5^0$, and represent sinistral strip slip and normal/gravitational faults.
- The standard RADARSAT image with incidence from 36-42 degrees was useful to improve geological and geomorphic mapping from existing 1:1 000 000 to 1:100 000 scale maps.

DETECTION OF STRUCTURAL CHARACTERISTICS THROUGH SPACEBORNE SAR IN NINGMING BASIN , GUANGXI ZHUANG AUTONOMOUS REGION , CHINA

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Detection and study of geological structural characteristics in Niming basin, GuangXi zhuang Autonomous Region, China, have been conducted through space-borne SAR acquired in Oct. 1996. As south-eastern part of the big-names YouJiang rift basin during Herecynian, this district had experienced continually evolution from Calidonian to Herecynian. The basin became part of the folding belts during Herecynian orogenic movement. The molasse formation with great thickness was developed in foreland basin during Indosinian to Yanshanian.

The detection and study to geological structure in the district have great significance of understanding basin and orogenic dynamic evolution and explorating of gold , manganese deposit and coalfield etc. The study of lithological types, structural imagery features, genetical mechanics and ore-bearing characters of basin have been conducted through geometric correction, noise removing , textual analysis and visual interpretation to SAR image. Research results display that the spaceborne SAR imagery is a useful means for detecting geologic structure.

Keywords: Spaceborne SAR, Detection , Structural characteristics.

The use of RADARSAT SAR images in neotectonic studies in the Eastern Great Lakes regions

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Abstract
The integration of RADARSAT SAR data into our ADRO project (No. 58), a multidisciplinary study of intraplate seismicity and neotectonics in the Eastern Great Lakes region, will help us to address two critical issues regarding possible seismic hazard and risk in that particular region. These issues would be, 1) whether known microseismicity and historical major seismic events in the region are demonstrably associated with reactivated, deep-seated basement faults, and 2) whether major basement faults in the region are in some way linked to the St. Lawrence Fault Zone, which is recognized as a region prone to major earthquakes and abundant microseismicity.

RADARSAT SAR data will be used to increase our ability to delineate major fault lineaments in our study area by, 1) tracing the extent of known reactivated basement faults into regions where their surface expression is less pronounced due to cover of Quaternary sediments, or by vegetation, and 2) identifying other lineaments that may represent important faults that have not been previously recognized. In order to enhance the RADARSAT image products and to highlight the spatial associations of prominent lineaments within these images, RADARSAT data will be integrated with ancillary remotely sensed imagery and available geological, geophysical and geomorphological data. This approach will allow linkage of various lineaments that appear to be discontinuous in one or several data sets, but that are obviously segments of a larger scale structural feature when viewed in integrated radar images.

The great advantage of using RADARSAT SAR data in this study lies in the high resolution of the images that can be generated, and in the high incidence angles that can be achieved using the steerable beam on the satellite. These unique RADARSAT attributes lend themselves well to the mapping of structural lineaments in regions of subdued topography such as in the Eastern Great Lakes region.

RADARSAT Imageries Interpretation for Geological Mapping on the Vietnam-China Border Region

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ABSTRACT

The use of radar data for geological mapping is a well established technique due to the sensitivity of radar backscatter to surface features and geological structure. Both VTGEO from Vietnam and IRSA from China are using RADARSAT data from GlobeSAR to evaluate its suitability for various geological mapping and exploration activities.

A joint project was also established on the Vietnam/China border region in order to compare methods and results for generating a geological map. Wide mode (beam 3) RADARSAT imagery of the border region were acquired from both ascending and descending orbits during the rainy (August) and dry (January) seasons to support this effort. The objectives fof the study being conducted by VTGEO are:

1. To produce a geological map of the Vietnamese side of the study site using the RADARSAT wide mode imagery and compare it to existing maps and a field validation effort;

2. To evaluate the information content of the RADARSAT imagery as a function of season and look direction; and,

3. To combine the output with the chinese geological map and produce a unified map of the border region.

The imagery was corrected for geometric and radiometric image quality prior to visual interpretation. A field visit was conducted to provide validation of the map output. These results were then compared and merged with the Chinese map in order to produce a unified product. The results of this study will be presented at the meeting.

A CROP INFORMATION SYSTEM INCORPORATING MULTI-PARAMETER SATELLITE RADAR DATA: APPLICATIONS IN THE U.K. AND PARAGUAY

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Abstract

The capability of satellite radar to acquire images independently of cloud coverage or daylight conditions is of major significance in the context of agricultural applications, which are time critical. The accurate identification of crop types depends on the availability of images acquired within specific time windows through the growing season when there are marked differences in the appearance of particular crop types on remote sensing images. Despite the progress which has been made towards operational applications, experience shows that high resolution optical satellite sensors cannot always provide the desired information due to constraints related to cloud cover and revisit schedules.

This paper describes the analysis techniques which have been developed to extract agricultural information from RADARSAT S7 and ERS SAR PRI images. The RADARSAT imagery acquired in standard beam mode 7 (i.e. 45° - 49° incidence angle and C-IIII polarization) gives a different imaging configuration compared to the ERS data (i.e. C-VV polarization and 23° incidence angle). The use of such multi-parameter SAR data for crop discrimination and classification has been investigated. The focus is on field-based extraction of image statistics (parcel means) and crop classification using a Remote Sensing Crop Information System (CROPINS) with special capabilities for integrated handling of optical and radar data.

Results of synergistic use of optical and multi-parameter satellite radar data for crop classification using temporal spectral signatures will be presented for test sites within the UK and Paraguay. In the UK, the work focuses on two MARS Activity B sites, Driffield and King's Lynn, which show differences in topography, soils, cropping and management practices. In Paraguay information is required on 4 major crops - soya, wheat, cotton and maize. Approximately 80% of the national soya and wheat crops are grown in the *departmentos* of Alto Paraná and Itapuá and for this reason analysis has concentrated on these areas.

MOVING TOWARDS REGIONAL SCALE MONITORING OF AGROECOSYSTEMS IN SOUTHERN ONTARIO

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ABSTRACT

The success of agriculture is dependent on many variables such as crop type, soil moisture, nutrient availability, and soil type. Remote sensing data for monitoring these variables and providing accurate, up-to-date information on a regional scale will be available in a few years. This capability depends on Radarsat and the impending launch of up to 10 new satellites by the end of 1998. With fusion of satellite data, the potential to provide a continuum of accurate agricultural data over the entire growing season (from snowmelt to snowfall) is improved.

Providing accurate agricultural information to the end-user requires objective ground truthing that is cognizant of spatial and temporal variations that occur on a regional scale. For example, two corn fields separated by 300 kilometres do not have the same spectral properties due to a variety of environmental and management factors. Using one corn field as opposed to several fields to "train" the satellite data would decrease the accuracy of the classification. It is in this context that all large agricultural fields (those greater than 15 ha in size) were identified in southern Ontario.

To facilitate the identification of large fields from Landsat TM data, a rigid unsupervised classification procedure was developed. The spatial resolution of Landsat data was found to be limiting in the identification of large fields. Using a stratified random sampling scheme a small number of individual fields were randomly selected within each strata to be used for ground validation and training of satellite data. Stratification of the study area was achieved using the 15 major physiographic regions found in southern Ontario as strata. The sample sites/fields were integrated with a digital road network to allow rapid and efficient ground validation of satellite data over southern Ontario. The resulting sampling scheme has been synthesized to provide an objective training framework for those intending to monitor agriculture on a regular basis.

USING EXTENSIVE LANDSAT IMAGERY AND GIS TO VERIFY GRAIN TRANSITION PAYMENTS ACROSS WESTERN CANADA

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ABSTRACT

Over 100 Landsat TM images (acquired between October 1993 and June 1995) were used to classify land cover on up to 77.6 million acres of crop land across western Canada, as part of the Western Grain Transition Payments Program (WGTPP). Using GIS, this information was integrated with survey data to create a final product that conformed to the mapping standards of western provinces. The resultant land cover product contributed significantly in the verification required to provide compensation for lost shipping benefits to some 242,000 landowners on over 700,000 parcels of land.

To be eligible for a payment, land had to be seeded to annual grains or oilseeds in 1994. Remote sensing agencies and value-added contractors provided the land cover classification from satellite imagery. Mapping categories included cultivated land, forages, grassland, trees, wetland and water. Additional data bases that were used to verify the accuracy of eligibility claims included crop insurance contracts, and municipal assessment information.

Classification accuracy ranged fro 75 - 90%, depending on the quality, timing and number of satellite scenes available, level of field verification and availability of other data bases. Land cover mapping was originally received in raster format and converted to polygonal coverage in ArcInfo. Resulting units were analyzed on a parcel basis to develop a land cover data base of over 1.3 million land parcels, encompassing the smaller application data base. GIS challenges included the significant effort required to reconcile the definition of land parcels as used by the landowner, agricultural agencies, municipal governments and Crown survey.

RADARSAT In Rice Monitoring Applications

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Abstract

SAR sensors and RADARSAT in particular, hold considerable potential for the monitoring of rice crops. Rice, wheat, and maize account for more than 50% of the calories consumed by the human population. Although, wheat is the leader in area harvested (232 million ha, compared to 148 million ha and 129 million ha respectively for rice and maize) human consumption accounts for 85% of the rice production compared to 60% for wheat and 25% for maize. In addition, it is estimated that rice production will have to increase by 70% over the next 35 years to meet the expected demand associated with the increase in population. Hence, it is important to address the need for reliable and timely rice production information. Presently, there are several initiatives underway within the Canada to address this important application.

This paper will describe a multifaceted approach to the development of the methodology and tools to monitor this crop. It will describe the joint work that is underway between the Canada Centre for Remote Sensing (CCRS) and the International Rice Research Institute (IRRI) and between CCRS, RADARSAT International Inc. and the Institute of Remote Sensing Applications (IRSA) in China and give several examples of the early results from the analysis of RADARSAT data. In addition, this paper will describe some of the work that is being funded through the RADARSAT User Development Program to develop the necessary tools to integrate RADARSAT data with other data sources within an information system.

SAR IMAGE FOR RICE MONITORING

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Abstract

Rice is the major food product in China and mainly planted in three southern regions Pearl River delta, yangtze River delta and Jianghan Plain, where the optical remote sensing data is very difficult to acquire.
Our study show that SAR image is capable of monitoring rice. Zhaoqing test site was firstly imaged by the Canadian CV-580 airborne SAR system under the GlobeSAR program. After the launch of RADARSAT on November 4, 1995, it was imaged during the early and late rice growing season. This paper presents the rice identification results based on SAR image, the relationship between the rice growing status and the radar backscatter. Many vegetation can be discriminated by SAR image.

Tropical Agriculture Monitoring and Determination of Agricultural Crop Type with Radarsat Imagery over South Sulawesi, Indonesia.

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Abstract

The use of imaging Radar on tropical agriculture studies has a great potential for crop monitoring where cloud coverage is a severe limitation. Furthermore, microwaves are sensitive to geometrical and dielectrical properties of the vegetation and provide specific complementary information as compared to optical remote sensing. Realizing 70% Indonesian population employee work in agricultural sector, the government has priority to develop food crop (rice, maize,etc.) and industrial plantationto support food diversification and to establish self sufficient food policy. The Radarsat multitemporal imagery is applied to identify the type of agriculture crop and separability based on digital and visual analysis for monitoring purpose.

The studies further are to analyze the ability of Radarsat single date to know the discrimination of backscatter value of crop type, soil and water. Requiring multi-date acquisition is very important, in relation with the crop growth cycle.

Multifrequency and Multipolarization Radar Data for Estimation Forest Volume over Zhaoqing Area of Southern China

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Abstract

Forest monitoring is an ambitions objective of the remote sensing community for the future years. Many environmental problems of increasing importance, such as desertification, climatic change, carbon dioxide concentration, etc., are related to forest extension and condition. A large amount of experimental efforts are being carried out to investigate radar sensitivity to forest parameters. Radar is one of the most potential tools for mornitoring forest change in the tropic and sub-tropic regions, while visible and infrured remote sensing technology meets fatal problems caused by heavy precipitation, cloud coverage etc. C/X band and multipolarization SAR data over Zhaoqing test site in south of China using the Centre of Canada Remote Sensing's airborne SAR system onboard a CV-580 have been acquired in Novermber, 1993, as part of the GlobeSAR program. On the other hand, the field inventory data were collected by the local departments. In the test site, more than 80% of the trees are pine, and tree ages are mostly 10-15 years. The GlobeSAR data were firstly performed the antennna pattern correction geometric rectification and reduced speckle noise. Then the collected ground measurements and SAR data were used to study the relationships between the radar backscatter intensity and stand height, the backscatter and stand trunk dbh(diameter at breast height), and the backscatter and tree density. The study shows that there is almost no relationship between the radar backscatter and the tree density. But the backscatter increase as the stand dbh and tree height. The SAR data are sensitive to the tree structure and can be used to estimate the forest volume. Therefore, a regression model was established between the SAR data and the forest volume by the multipe linear regresssion method. On the base of the model, the forest volume were estimated and a comparison of radar predicted estimates of forest volume with forest inventory estimates in the test site was carried out. The radar predicted estimates are close to the forest inventory estimates. The study suggests that it is a economical and useful method to estimate the forest volumes using multiband and multipolarization SAR data.

Texture Anaylsis For Forested Scenes

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Abstract

Texture analysis plays an important role in the study of forested imagery. Radar images (satellite or airborne) can hold forestry related information such as location and size of logged or burned areas, limited species and age discrimination, roads, rivers, and topography. Evaluating scene attributes from radar images of forested environments is a task suitable for texture analysis methods. The interaction of microwaves and the forest canopy, forest floor, tree branches and tree trunks is a complex phenomenon which yields varied image texture from one forest environment to another. The textural content of radar images of forested areas have been found to dependent on a number of imaging aspects. This paper explores the role of texture analysis for forested images and discusses aspects of imaging which influence texture measurements, like incidence angle, wavelength, resolution and polarimetric differences.

THE EFFECT ENVIRONMENTAL INFLUENCES ON RADARSAT IMAGES OF FOREST LAND

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ABSTRACT

C-band radar and RADARSAT are not "all weather" in terms of forestry applications. Analysis of ERS-1 and RADARSAT images over a forest test site (Petawawa Research Forest and CFB Petawawa) in eastern Ontario indicate significant changes in the contrast between clearcuts and various forest types depending upon environmental conditions. Dry or wet vegetation and surface soil conditions and dry or wet snow cover are key factors. Relative backscatter among forest types remains similar. There is generally a trend of increasing backscatter from low values for red pine, intermediate for jack pine, to high for spruce. The influence of environmental factors has important implications regarding marketing of RADARSAT data to forestry clients.

Radar Imaging Natural Systems (RAINS)

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Symposium Paper Sub-title: Stumps and Dead Trees
ADRO Project No. 384

ABSTRACT

Fine 2 and standard 4, ascending RADARSAT data were recorded during December 1996, night time, stormy weather, of the study area on Northern Vancouver Island. The images were examined for interpretable features relevant to forest management, operations, and stand features and referenced to normal colour air photos. Image evidence indicates that: 1) recent clearcut are clearly depicted; 2) riparian zone leave strips are detectable in some circumstances; 3) tree crowns give texture to stand images, with dark images from fine textured canopies; 4) image patterns of old growth cedar stands (coarse textured) are different from hemlock stands (fine textured); 5) regenerated stands are separable from new cutovers; and, 6) new road extension not in evidence on the air photos are evident on the RADARSAT images. On the Fine 2 mode image, single dead tree crowns in the midst of forest stands gave a strong radar return, which made them separable from the surrounding stand canopy. Analysis of image pixel data indicates that different cover types have different pixel frequency distributions.

CAPABILITIES OF RADARSAT DATA FOR LAND USE/LAND COVER ANALYSIS IN SW AMAZONIA (TEST SITE ACRE, BRAZIL).

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The area under study, located in SW Amazonia, Acre State, Brazil, in the vicinity of the city of Rio Branco, has been studied in the last few years using optical (TM-Landsat) and microwave (airborne C-band SAR, ERS-1, SIR-C) remote sensing data. Recently data from RADARSAT in both Standard and Fine mode beams were acquired.

The objective of this research is data to determine the capabilities of RADARSAT and merged RADARSAT/Landsat TM images for land use and land cover discrimination. Two distinct periods of the tropical hydrological cycle, i.e. at the end of the rainy season (April/May) and at the end of the dry season (September/October) were investigated. The main features discriminated were: variations in pasture land, recent forest burning, and changes in regrowth patterns. Also, the separation of small clearings (50-100 ha) and large clearings (200 to several 1000 ha) is also feasible. The smallest clearings (the "colocações", or clearings of the rubber tappers) are under investigation, and are the smallest features of interest for discriminated by radar.

Furthermore, a stratification of primary forest and regrowth is also in progress. Finally geomorphological features along the larger rivers (such as abandoned meanders, river scars, lakes, etc) are being analysed, to set up criteria for mapping the floodplain area of these rivers. The RADARSAT products used were various Standard and Fine mode beams ranging from April to October, 1996. The preprocessing performed at CCRS consisted of scaling the data from 16 to 8 bit real integers, antenna pattern correction, attenuation of speckle and linearly contrast stretch. The RADARSAT data was then registered to Landsat TM Bands 3,4 and 5 with IHS/RGB transformations to integrate the data. This study is supported by both color aerial photographs (scale 1:20,000) and physiognomic-structural profiles of the natural vegetation. The concept behind the use of Standard and Fine mode RADARSAT data integrated with Landsat, is to analyse the feasibility for systematic mapping of similar land use/land cover in tropical rainforest areas.

Using RADARSAT Data for Identification and Assessment of the Deforestation in the Imataca Forest Reserve, Bolivar State, Venezuela

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ABSTRACT

The main objective of this project will be to establish the applicability of RADARSAT data to identify and assess the extent and magnitude of the deforestation and mining activities occurring in the Imataca Forest Reserve in southeastern Venezuela.

The study area lies in the southern part of the Orinoco River. A somewhat isolated region with scarce population and other infrastructure (the only roads available are those intended to make it possible for the logging activities). Both high precipitation and temperature are the main characteristics of the region. For localization purposes, the image is centered at 08° 07' north and 61° 21' west.

Standard mode data at 30 m resolution acquired in the ascending mode with an incidence angle of 46.9° (S-7) and a HH polarization was acquired.

RADARSAT data will be digitally processed to make it possible an optimum identification and evaluation of the damage produced to the original forest. First of all, the data will be compressed from 16 to 8 bits to be able to handle a 256 level histogram. Secondly, a geometric rectification will be performed using the five pairs of coordinates provided with the scene (four corners and the center). The lack of cartographic information better than 1:500,000 as well as logistical difficulties make it unfeasible for the collection of ground control points by GPS.

Additionally, contrast stretching, filtering and IHS will be applied, to improve the visual quality of the image.

Visual interpretation of the deforestation and mining activities, as well as the geomorphology of the study area at the scale of 1:100,000 will be performed using a PROCOM-2 system. A digitization process will make it possible for the georeferencing of it onto the corrected radar file.

"On screen" interpretation of the corrected image will be done by defining polygons and referring them to a database.

A field verification will be carried out afterwards to try to make validation between the interpretations and the field. A qualitative comparison between both the visual and the digital interpretation will be attempted.

Finally, optical satellite data (LANDSAT TM scene 233/054 acquired on February 12, 1992) will be used as ancillary information for a multitemporal analysis. Field data and thematic information produced by the Venezuelan Forestry Service as well as by Cartografia Nacional will be useful pieces of information which will also be taken into consideration during the whole process.

ANALYSIS OF THE INFORMATION CONTENT IN RADARSAT, ERS-1 AND JERS-1 DATA FOR CONTINENTAL SCALE MONITORING OF TROPICAL VEGETATION

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ABSTRACT

This paper presents a preliminary analysis of SAR images of the Africa tropical forest acquired by RADARSAT, ERS-1 and JERS-1. The images are part of three different projects of which the common objective is the monitoring of tropical forest. The first is the CAMP (Central Africa Mosaic Project) project led by ESA-JRC. The second is the GRFM (Global Rain Forest Monitoring) project led by NASDA. The third is an ADRO project for development of RADARSAT applications. The coverage of Central and west Africa tropical forests for all projects is within the TREES project coordinated by the MTV (Monitoring Tropical Vegetation) unit of Space Application Institute at the Joint Research Center of the EC in Ispra, Italy.

The objective of the present paper is the preliminary evaluation of the information content of mono-temporal RADARSAT images for continent-wide forest and vegetation monitoring.

The information content of RADARSAT SCANSAR data are analyzed in a test sit in Congo, where SAR data from ERS and JERS satellites are also available. Tonal differences between different Savannah types are visible in RADARSAT SCANSAR data acquired at shallow incidence. The same tonal differences can also be seen in JERS data while ERS data these differences are masked y topography-induced variation in the SAR data.

A new technique multiscale analysis - based on the wavelet transform - is applied to RADARSAT standard mode data on a test site in Ivory Coast. The technique allows mapping of images onto different scales for texture analysis. Qualitative assessment of different targets and land cover types is presented.

MONITORING LANDSCAPE MODIFICATION IN ICELAND AS A CONSEQUENCE OF THE NOVEMBER 1996 CATASTROPHIC GLACIER OUTBURST FLOOD (*JOKULHAUP*) VIA RADARSAT SAR

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ABSTRACT

Landscape modification occurs at anomalously rapid rates and over broad spatial scales in Iceland where the simultaneous interaction of volcanic, glacio-fluvial, and sub-arctic weathering processes are observed. A sub-glacial volcanic eruption in October of 1996 beneath the 8300 km^2 Vatnajokull ice cap resulted in widespread modification of a portion of the largest ice cap in Europe. On the basis of almost continuous cloud-cover obscuration in the Iceland region of the sub-arctic, orbital synthetic aperture radar (SAR) imaging is the only mechanism for routinely observing catastrophic ice surface and landscape modifications. Furthermore, subglacial eruptions in Iceland frequently catalyze enormous catastrophic glacier outburst floods or jokulhlaups as a consequence of the melting and subsequent release of cubic kilometers of water from beneath major ice caps such as Vatnajokull. Thus, one of the primary objectives of our three-year study of landscape dynamics in the Iceland region is to quantify the effects of any "natural hazard events" in this area using a time-series of RADARSAT SAR images. Extremal hydrologic events such as jokulhlaups occur several times per century in Iceland, and capturing the impact of such events on well characterized landscapes could provide valuable boundary conditions for flood hydrologists attempting to infer details of fluid mechanics of the jokulhlaup process.

A relatively large jokulhlaup was predicted by Icelandic scientific experts as the Oct. 1996 subglacial eruption concluded and the water level in the major sub-glacial caldera (*Grimsvotn*) atop the ice cap continued to rise over 50 meters above its traditionally stable levels. During the early stages of the eruption, a pair of RADARSAT Standard Beam (beams 1 and 5) images were acquired on the vent area, as well as of the broad glacier outwash plain that extends in a wedge-like pattern south of the Vatnajokull ice cap and the eruption site. This area is knows as the Skeidararsandur and is commonly the locus of jokulhlaups issued from the Grimsvotn caldera. It extends over 50 km in an East to West direction and over 20 km from the terminus of the Skeldararjokull outlet glacier southwards to the Atlantic Ocean. In June of 1996, NASA scanning airborne laser altimeter surveys in this area revealed a broadly convex flood plain with only 5-6 m of total relief in an East-West direction, and consisting of anastomosing drainage fans. Only 1-2 m of local relief variations are observed, predominantly as higher-standing flood deposits from the last major jokulhlaups. The 1938 jokulhlaup was the most recent extreme hydrologic event to impact the Skeidararsandur. Our Oct. 5 (beam 1, ascending) and Oct. 7 (beam 5, descending) RADARSAT images reveal the relatively unchanged textural patterns of the Skeidararsandur during the middle stages of the subglacial eruption that began on 1 Oct. and concluded by 14 Oct., 1996. These SAR images clearly delineate the evolving pattern of surface deformation associated with the eruption, including the development of a new

canyon in the ice cap extending NNW from Grimsvotn. Subtle changes in the SAR backscatter intensity along the course of the Skeidararjokull outlet glacier are also observed.

The jokulhlaup event finally occurred on 5 November 1996 with an estimated peak discharge rate of 45,000 to 50,000 m3/8, involving the drainage of over 3 km^3 of water from beneath Skeidararjokull out across the Skeidararsandur. By 7 November, all of the flooding was effectively concluded. The bridge that crosses the sandur was destroyed and megablocks of ice tens of meters in scale were rafted onto the Skeidararsandur after being detached from the rapidly deforming terminus of the Skeidararjokull glacier. RADARSAT SAR images were acquired on 9 November and 10 November in standard beam mode, just after the jokulhlaup had officially terminated. Of greatest interest is the 9 Nov. Standard Beam 2 image (ascending pass), because it is geometrically most similar to that acquired on 5 October. We have registered the 5 Oct. and 9 Nov. RADARSAT SAR images to our 90 m resolution DEM of the region, in order to facilitate detailed geomorphic comparisons. Preliminary analysis illustrates the development of new alluvial fan deposits over ten km in width at the western margin of the Skeidararsandur, and extremely high radar backscatter features are observed within this new feature, suggesting that the largest megablocks of ice may be detectable from orbital SAR. Modifications of the alluvial fan deposits on the eastern side of the Skeidararsandur are also observed, and the course of the Skeidara river was apparently modified by the jokulhlaup. From the RADARSAT images it is clear that the entire terminus region of the Skeidararjokull glacier was devastated, and further that the existing proglacial lake drained catastrophically to the southwest by carving a new channel that first extended westwards, before turning to the south to follow the topographic gradient to the Atlantic ocean. Over 50% of the surface area of the Skeidararsandur was modified by the catastrophic flood event, with the development of major new channelways and the eventual deposition of texturally distinctive materials, including numerous megablocks. We are continuing to document the evolving geomorphology of the Skeidararsandur using RADARSAT in both standard and fine beam modes. Fine beam mode images were acquired on 24 and 28 November in order to characterize the distribution of megablocks transported by the flood. Starting in late December of January (1997), routine monthly ScanSAR and Standard Beam mode imaging of Iceland and the jokulhlaup deposits will commence.

Monitoring Snow and Ice Conditions Using a Normalized Difference Index Based On AVHRR Channels 1 and 2.

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Developing methods to monitor changes in the Earth's cryosphere is considered important from both a scientific and an operational perspective. In terms of investigating environmental change, sea ice has been identified as a high leverage parameter in the short and long term modulation of our climate. Of specific concern is the monitoring of energy fluxes over the seasonal sea ice surface and the identification of climatically significant events such as the onset of melt and ice breakup. Operationally, economic activities (e.g. shipping, hydrocarbon exploration/mining) within ice-infested waters require accurate knowledge of current sea ice conditions. Of primary importance here is the identification of ice type, thus allowing it to serve as a proxy indicator of ice thickness. Many identify satellite remote sensing as the only viable way of monitoring sea ice variability over its inherent wide range of spatial and temporal scales. Towards this, Advanced Very High Resolution Radiometer (AVHRR) satellite data is currently used by both scientists and operational personnel to monitor sea ice conditions.

In this paper, we propose the use of a simple normalized index, identical in form to the common Normalized Difference Vegetation Index (NDVI), to monitor the condition of the sea ice cover. In this case, the index will be used as a normalized difference snow and ice index or NDSII. AVHRR channels 1 (AVHRR 1:0.58-0.68 μm) and 2 (AVHRR 2:0.73-1.1 μm) will be used to compute the index. The index has the advantage of being simple in both implementation and interpretation. NDSII values were extracted from a multitemporal image dataset collected during the 1993 Sea Ice Monitoring and Modelling Site (SIMMS) experiment in the Canadian Archipelago. Index magnitude and variability were compared to *in situ* observations of sea ice characteristics. In order to aid in the interpretation of the derived indices, NDSII values for typical sea ice surfaces were predicted using theoretical and observed surface albedo spectra along with the spectral response functions of AVHRR 1 and AVHRR 2. Results indicated that increases in NDSII captured the onset of melt conditions in the study area. The highest index values were found over melt pond surfaces. Simple thresholding based on reflectance values allowed the distinction between areas of dry snow and open water, both of which possess similar NDSII values. Consideration of calibration drift and atmospheric attenuation in the two AVHRR channels was found to be critical in the interpretation of the derived NDSII values.

Glacier flow field measurement using satellite SAR interferometry: An assessment

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ABSTRACT

The ERS-1/ERS-2 tandem mode mission provided C-band SAR imagery over the same site with 24 hour intervals between observations. Furthermore, the orbit was controlled such that a suitable interferometric baseline was available for the majority of imagepairs considered. This data set is considered to be ideal for interferometry applications such as DEM generation, measurement of glacier flow field, and terrain subsidence.

In this paper, we consider tandem mode interferograms over 2 test sites. In both cases the ERS interferometric imaging geometry is reconstructed using accurate orbit data and a digital elevation model (DEM) obtained from the CCRS airborne interferometric SAR (InSAR) system, which when subtracted from the tandem interferogram creates a differential interferogram. The first test site, Bathurst Island in the Northwest Territories, serves as an ideal site for estimating the residual phase noiseof the differential interferogram. This in turn is used for assessing the application of satellite interferometry for measurement of the flow field of the Saskatchewan Glacier, a mid-latitude alpine glacier in Alberta.

The Bathurst Island site is a test area for RADARSAT SAR interferometry. It is an arid and rocky region of the Canadian Arctic where relatively high coherence can be obtained through a large part of the year, and represents an ideal site to test processing algorithms for orbit geometry reconstruction and terrain-induced phase compensation. Seven pairs of ERS tandem mode data were collected over the test site. In most cases the residual rms phase noise of the differential interferogram is small. In some cases a larger different pattern of residual phase remained and was not compensated. The residual phase is likely related to atmospheric propagation heterogeneities which developed due to the differences in atmospheric properties between the two passes, introducing a phase error of up to 1 radian on scales of 1 to 10's of km. These phase errors may impact on the accuracy of differential flow field estimation and of extracted topography, depending on the baseline.

The Saskatchewan Glacier site has been the focus of previous studies in which the ascending pass data were used to satisfactorily measure the glacier's flow rate, as validated by in situ point surveying measurements. In this work, we extend the data set to also consider the descending passes. It was believed that combination of the ascending and descending pass measurements would allow more accurate flow field determination.

However, it is now evident that the descending pass geometry is worse (the projection of the motion vector along the radar line of site for the descending passes is less accurate) and an assumption about the flow vector direction is still required to derive a unique 3-D flow field. Even two observations with different geometries is not adequate to improve the accuracy of the 3-D flow field measurements over that carried out with the ascending passes alone.

* Under contract from Intermap at CCRS

SUIVI DU COUVERT NIVAL À L'AIDE DES DONNÉES DE RADARSAT

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RÉSUMÉ

Ces dernières années, l'INRS-Eau a mené une étude pour évaluer le potentiel des données RSO (ERS-1) pour estimer l'équivalent en eau du couvert nival dans la région de la Baie James. L'étude a effectivement démontré qu'il était possible de dériver un algorithme pour estimer l'équivalent en eau à partir d'une image hivernale et d'une image automnale. Deux exemples de cartes d'équivalent en eau ont aussi été produits pour le secteur du Lac des Voeux. Ces résultats ont encouragé le Société Hydro-Québec à poursuivre l'étude avec les données de RADARSAT dans le cadre du programme ADRO.

Cette étude vise donc à adapter aux données de RADARSAT les algorithmes empiriques développés à partir d'ERS-1 afin d'extraire l'équivalent en eau de la neige au sol, ainsi que d'autres variables reliées au suivi du couvert nival. Les deux objectifs de l'étude sont :

1) Estimation de la distribution spatiale, à une date donnée, de plusieurs variables nécessaires à la prévision hydrologique pour la gestion des stocks énergétiques, la planification de la production hydroélectrique et la détermination des risques d'inondation. Les variables retenues sont : a) l'étendue du couvert de neige (neige vs pas de neige); b) l'équivalent en eau du couvert nival; c) l'étendue de la neige humide (neige sèche vs neige humide); d) l'étendue du sol gelé;

2) Détermination du produit ou de la combinaison de produits du satellite RADARSAT susceptible(s) de fournir les estimations définies ci-dessus avec la précision souhaitée.

Nous avons retenu deux modes d'acquisition pour les données RSO, le Mode Standard (faisceaux S1 et S7) et le SCANSAR. Afin d'évaluer l'équivalent en eau de la neige, on déterminera les coefficients de rétrodiffusion du couvert nival et par conséquent, dans la mesure du possible, les images seront étalonnées et géocodées. Des campagnes de terrain sont aussi prévues, en conjonction avec l'acquisition des images. Ces campagnes de terrain permettront de recueillir les données de contrôle nécessaires à l'établissement et à la validation des algorithmes.

Cette communication présentera les résultats préliminaires de l'étude suite à l'acquisition et au traitement d'images RADARSAT à l'automne 1996 et à l'hiver 1997.

USING IMAGES IN A MULTI-SOURCE GEOGRAPHIC DATA ENVIRONMENT

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ABSTRACT

Inherent relationships between natural occurrences exist in the landscape. Generally, these natural occurrences are represented by several data sets, each of which are typically obtained using different surveying methods. Spatial data managers are increasingly compiling multi-source geographic databases and applying integrated spatial analysis techniques, within Geographic Information System (GIS), to understand the spatial patterns and processes which exist in the landscape.

Image analysis technology is used for spatial information management, in part, because remotely sensed images provide a synoptic view of the landscape and can be collected at various temporal, spectral and spatial resolutions. Recent advances in computer aided technologies have allowed for the integration of remote sensed imagery with traditional GIS by improving on the methods used, by the GIS, to present geographic information to the user. The use of this system in soil mapping applications will also be presented.

FORECASTING SNOWMELT RUNOFF USING RADAR MAPS

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Multi temporal radar observation have been acquired for three different areas in Canada -- Arctic tundra, Rocky Mountains and Prairie wetlands. The radar sequences show changing patterns of both low and high backscatter, which respectively resemble changes in wet snowcover and in soil moisture distribution. Twenty-five Arctic image sequences were acquired by ERS-1 satellite; Four Rocky Mountain wide-beam and five Prairie wetland narrow-beam sequences were acquired by Radarsat. The ERS-1 images were part of an RDDP study while the Radarsat images are part of ADRO project 409 ("Forecasting mountain runoff using wet-snow radar maps") and ADRO project 406 ("Monitoring wetland water-area with fine resolution radar"). In the Arctic, there was found to be large areas with intermediate-backscatter levels, indicating either unresolved partial-snowcover in mixed-pixels or less-wet, snow-free pixels. Methods of both single-image and multi-temporal analysis were examined and compared. For the Arctic study site near Inuvik, single-image snow/no-snow discrimination required a power-ratio threshold of 1.5. In contrast, Rocky Mountain alpine sites in the upper Bow River valley requires a power-ratio threshold of less than one, for wet snow discrimination. Power-ratio images are those from which radar-beam topographic effects have been largely removed by ratioing to a standard winter scene. Multi temporal radar was found to unambiguously separate the effects of partial-snowcover and soil moisture, in Arctic tundra. This multi temporal procedure gave interpretations consistent with expected topographic effects. The procedure is bases on a dual-variable five-level classification scheme developed for snow and soil moisture in areas of thin snowpack and very-wet soil. The suitability of modifying this scheme to deep snowpacks in Rocky Mountain areas, will be discussed for Alpine areas and forest clearings. Prairie wetland radar-satellite observations are compared with water level observation measured at twenty-five ponds. These ponds are located in the St-Denis National Wildlife Refuge, near Saskatoon, and consist of a large range in pond sizes and exposures, in both natural grassland and cropped fields. The correlation between fine-beam radar backscatter and pond level, is used to demonstrate pond survival monitoring, during the drying season.

Oral presentation

Any session dealing with terrestrial applications, it would be suitable for the snow and ice session as suggested

COMPLEX INTERGRAM UTILIZATION FOR INTERFEROMETRIC SAR APPLICATIONS

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Abstract

Interferometric synthetic aperture radar (INSAR) has been one of the highlighted issues in the remote sensing community these years. In this paper, utilization of complex intergram, the median product of INSAR data, is addressed. The significance of intergram in INSAR data manipulation can be understood from the information flow viewpoint. While general steps of INSAR data processing, namely interferometric image pairs acquisition, image registration, intergram formation, phase unwrapping, and DEM orthorectification, are well established both theoretically and practically, there do exist some tradeoffs among these steps, and consideration on cost efficiency is a must for overall performance. Thus, the complex intergram utilization problem is defined, and some guidelines for solving this problem are put forward.

Intergram utilization advocated in this paper brings some advantages and/or convenience for INSAR data applications. First, intergram performance can be seen as the index of the quality of INSAR data and thus the index of accuracy of the final DEM output, it is the case at least to some degree. The two aspects of complex intergram-fringe visibility and coherence image immunity (from noise), which can be easily measured by the end user, directly reflects errors from imaging process, time / baseline decorrelation, and other factors as the scenario on the ground. Second, with the aid of information from the intergram, the burden on phase unwrapping is greatly reduced. While the underlying theories and algorithms for phase unwrapping are straightforward, and satisfactory results can always be obtained for simulation data sets, it is another thing when it comes to the real world INSAR data. This is just why nowadays there are so many papers discussing the robust phase unwrapping problem. Emphasis might be put on what is ready to be phased unwrapped, i.e. the characteristics of the complex intergram input. Third, as a median product of INSAR data, the intergram itself can be informative to the end users of INSAR data.

The above mentioned work is analyzed with specific examples from two-pass SIR-C/X-SAR data over China. Some conclusions are made in the final section. Considerations on further work conclude the paper.

Comparison of a Precision DEM with Elevations Derived by Interferometry from X-SAR Images of New Zealand

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Abstract

Three X-band SAR images were acquired of the South Island of New Zealand from the SIR-C/X-SAR instruments flown on the SRL-2 mission in October 1994. One pair of images in this region shows a Doppler difference of +/-50Hz over the length of the scene and was chosen as a candidate for interferometry. The scenes were registered using a hybrid method of complex cross-correlation, for coarse matching, followed by the method of maximum spectrum, for finer matching. Magnitude and coherence estimate images were generated and ortho-rectified to theNew Zealand Map Grid for field verification. A high resolution digital elevation model, and fine scale slope and aspect maps were also generated as aids in field interpretation. Finally, for those areas where the coherence estimate was sufficiently high, the resulting interferogram between the two images was formed and an unwrapped version generated. Height difference, slope and aspect error images were generated as comparison products.

A supporting field study was undertaken determine the reasons behind the changes in coherence visible in the combined dataset, as well as the areas where large height and slope errors were detected. The study areas covers a variety of terrain, from bush to alpine cover, with a variety of vegetation density. Significant layover and shadow was observed within the scene to contaminate the result. Once these latter areas were excluded, the remaining areas showed coherence values that were cover-class dependent, and this dependence was detected to some extent in the height, slope and aspect errors.

The suitability of RADARSAT's orbit for repeat pass SAR interferometry

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The capability of the RADARSAT synthetic aperture radar (SAR) for repeat pass interferometry has been demonstrated for several test sites. It is well known that the SAR's fine beam mode allows use of rather large baselines due to use of a large chirp bandwidth and the available large incidenc angles. However, the RADARSAT orbit position is not accurately known or well controlled. This is a consequence of the mission objectives not including interferometry, which has stringent orbit control and knowledge requirements. This limited control, combined with the 24 day repeat pass interval, has meant that only a few image pairs with useful interferometric baseline have so far been acquired.

A typical RADARSAT orbit maintenance scenario involves orbit boosts at periodic intervals separated by roughly 90 days. Around the middle of the inter-boost time frame, the orbit reaches maximum height and minimum longitudinal drift rate. The boost period is driven by the specification of +/-5 km maximum longitudinal excursion. This envelope is generally too large to provide interferometric baselines for an arbitrary 24 day interval. The proposed interferometry strategy is to centre the acquisitions, separated by 24 days, on the time of minimum longitudinal drift. This minimize the baseline and reduces baseline decorrelation.

In this paper, we present an analysis of RADARSAT definitive orbit data which demonstrates the validity of the proposed acquisition strategy. The scale of expected interferometric baseline and the time with respect to orbit boost and minimum longitudinal drift events is delineated. RADARSAT orbit predictions are validated by comparing predicted drift plots with definitive orbit data. It is shown that, although there there can be significant errors in orbit drift prediction, the predicted drift curves are adequate to determine the time of the minimum longitudinal drift rate event and to allow time to plan RADARSAT interferometry acquisitions.

RADARSAT repeat-pass SAR interferomtry: Results over an arctic test site

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Abstract

The potential of using RADARSAT SAR data for repeat-pass interferometry (InSAR) is demonstrated over an arctic test site. The test site over Bathurst Island was chosen since it provided dry, barren conditions during the wintertime, which maximizes the potential of conserving scene coherence over the 24 day repeat orbit interval. Several pairs of fine resolution beam mode RADARSAT SAR data for which we found suitable interferometric baselines, taking into account the satellite drift rate, have been processed and analyzed. It is shown that useful scene coherence can be retained over a 24 day interval, thus demonstrating the feasibiliy of InSAR in the RADARSAT case for some terrain types. We discuss particularly the interferometric processing methodoloy required for generation of RADARSAT interferograms and for estimation of the scene coherence. The methodology includes image co-registration, spectral filtering of the complex data in both azimuth and range, estimation of the interferometric baseline, and correction of the interferogram with respect to the "flat earth" phase contribution.

Use of Spaceborne Interferometric SAR data to measure land subsidence caused by oil exploitation

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Abstract

In addition to its DEM generation abilities, Spaceborne SAR repeat-pass interferometry (INSAR) is receiving much attention as a means of providing maps of large scale deformation with unprecedented accuracy (cm or mm level). A very promising application area for the oil industry is the monitoring of oil exploitation sites. Worldwide there are many examples of large scale deformation and deformation rates can vary from just cm's per year to as much as 1 meter per year. The impact of the subsidence can be very significant. It gas affect the ability to extract oil or gas from a site and can damage the infrastructure and affect the water management. It is in the interest of oil companies to implement techniques and procedures to obtain this information.

In this paper deformation maps generated from ERS-1 interferometric SAR data will be shown. The area of interest in California (USA) has been visited many times by ERS-1 and is being monitored by RADARSAT. The ERS and RADARSAT deformation maps will be compared with in-situ measurement of deformation and records of oil extraction in the area of interest.

Information Content of InSAR in Northern Terrain: Preliminary ADRO Results from the Schefferville Digital Transect

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ABSTRACT

The study examines the information content of interferometrically processed, initially ERS-1 and, later RADARSAT, Synthetic Aperture Radar (SAR) images for northern terrain at the Schefferville Digital Transect (SDT). The SDT is located at 54°53'N, 67°08'W in the transition zone from boreal forest to alpine tundra and was initially established for snowcover and permafrost modelling purposes. A geographic snow information system (GSIS) has been developed and, as a result of this work, topography, hydrography, vegetation, microclaimate, surficial geology, periglacial geomorphology, snow cover and permafrost conditions are well known and available in digital form.

We use the GSIS to examine the information content of a sequence of ERS-1 SAR images obtained during the winter 1993-94 while the satellite was orbiting the SDT at three-day intervals. Our results show that interferometric SAR (InSAR) is a new, powerful tool for the study of snowcover dynamics. A composite image, produced from 24-day coherence images closely replicates a permafrost map previously produced by the Iron Ore Company of Canada, suggesting a new tool for delineation of discontinuous permafrost. A composite image, produced from 3-day coherence images maps zones of deep and shallow snow accumulation and also exhibits a signal correlated with vegetation cover properties. The ensemble of information obtainable by InSAR also provides a new means for quantitatively examining the environmental context of periglacial phenomena, for examining lake ice cover dynamics and for study of wintertime processes in subarctic wetlands.

SAR Interferometry With ERS Missions: Key Results & Future Perspectives

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ABSTRACT

This presentation will give a high-level overview of the key results obtained to date through the technique of SAR interferometry with the ERS-1 and ERS-2 missions in the major application areas of Earth surface topography, surface motion and land cover. In particular, recent results from the ERS-1/ERS-2 Tandem mission will be reviewed.

There are a number of factors which impact the usability of repeat pass spaceborne data for interferometric applications. This presentation will cover ESA's current initiatives in investigating new services to encourage enlarged commercial exploitation of the ERS mission data. First results of an on-going ESA study to assess the market-based requirements for a future dedicated SAR interferometry mission will be presented.

IMAGE MAPS:
A COST EFFECTIVE METHOD OF COMPLETING THE CARTOGRAPHIC COVERAGE OF CANADA AT 1:100 000 SCALE

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ABSTRACT

The Centre for Topographic Information of Geomatics Canada, Natural Resources Canada, has the mandate to evaluate the production of image maps of the Canadian North at a scale of 1:100 000 for the land areas not covered by monochrome 1:50 000 maps. Diminishing resources and leaner economic times have prompted the Centre to look into lower cost alternatives to the standard 1:50 000 monochrome line map of the National Topographic System (NTS) mapping program to cover low demand areas of the High Arctic. In cooperation with the private sector, the Centre produced a prototype of this image map to evaluate production costs and potential client interest . The image maps are generated from either an ortho-rectified Landsat TM image of bands 3, 2 and 1, or an ortho-rectified panchromatic SPOT image. The ortho-rectified image is overlaid with vector topographic, cadastral, toponymic and cartographic information originating from the 1:250 000 National Topographic Data Base data set. This poster paper will describe the production approach. The new image map will be presented and participants will have an opportunity to provide their input to this new product.

LES CARTES-IMAGES : UNE MÉTHODE PEU DISPENDIEUSE POUR COMPLÉTER LA COUVERTURE CARTOGRAPHIQUE DU CANADA À L'ÉCHELLE DE 1/100 000

RÉSUMÉ

Le Centre d'information topographique de Géomatique Canada, Ressources naturelles Canada a été mandaté pour évaluer la production de cartes-images du Nord canadien à l'échelle de 1/100 000 pour les régions ne possédant pas de couverture cartographique monochrome à l'échelle de 1/50 000. En raison de la conjoncture économique difficile ainsi que des ressources restreintes, le Centre a décidé d'explorer des alternatives moins dispendieuses que la carte monochrome à 1/50 000 du Système national de référence cartographique (SNRC) pour le programme de couverture cartographique des régions à faible demande de l'Arctique. En coopération avec le secteur privé, le Centre a produit un prototype de cette carte-image afin d'évaluer les coûts de production et l'intérêt potentiel de clients. Les cartes-images sont générées à partir, soit d'images ortho-redressées des bandes 3,2 et 1 du capteur TM de Landsat, soit d'images SPOT panchromatiques. On superpose, à l'image ortho-redressée, de l'information vectorielle topographique, cadastrale, toponymique et cartographique provenant d'ensemble de données de la Base nationale de données topographiques à 1/250 000. Cette présentation par affichage décrira l'approche de production et présentera la nouvelle carte-image; de plus, on profitera de l'occasion pour recueillir des commentaires et des réactions face à ce nouveau produit.

REMOTE SENSING AND GIS ANALYSIS OF THE ST. MARYS BASIN, CENTRAL NOVA SCOTIA

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ABSTRACT

Remote Sensing and GIS analysis in combination with geological mapping have been used to interpret the geological history of the St. Marys Basin and surrounding areas. Various images, including optical, radar and shaded relief elevation, have been integrated with magnetic and gravity geophysical data to assess the geology of the basin and the Meguma/Avalon terrane boundary. Data were interpreted at a regional scale and in detail at three selected study sites. Based on these interpretations and geological constraints a model has been developed for the evolution of the St. Marys Basin. The model proposes the basin formed as a northeast-trending belt of rocks adjacent to the Meguma Terrane in the Late Devonian-Early Carboniferous and was subsequently deformed and dismembered as a result of dextral motion between the Avalon and Meguma terranes in the Middle Carboniferous.

A positive gravity anomaly in the eastern part of the basin appears to continue north of the Chedabucto Fault and possibly correlates with the deeper crust of exposed Devonian volcanic and sedimentary rocks of the Guysborough block. Two possible correlative units to the Fall Brook and Barrens formations of the St. Marys Basin have been identified north of the Guysborough block. The Guysborough block is interpreted to represent a positive flower structure associated with dextral motion on the Chedabucto Fault. Lineament analysis of the shaded relief and radar images has identified a major northeast-trending lineament in the Stewiacke River area corresponding to a regional anticline, and several northwest-trending lineaments that are interpreted to be fractures.

A MEASURE OF THE THREAT TO BIODIVERSITY USING GIS TECHNOLOGY

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ABSTRACT

The work presented in this paper was supported by Environment Canada and Natural Resources Canada. The objectives of the work were to investigate the potential inputs to a model that would measure the threat to biodiversity, design and populate a GIS database that would measure threat to biodiversity and that could evolve as new data became available, and to develop an integrated GIS model that incorporates information on pressures on biodiversity, environmental sensitivity, and the degree of protection currently available. A number of government agencies were interviewed to determine what data are available and if they were suitable for input into the biodiversity database. Data were collected and processed for entry into the database which was based on the 2q7 ecoregions of Canada. Currently thirteen layers of information are used in the model which has produced a map of Canada that shows the areas where the greatest threats to biodiversity exist and the amount and level of protection provided by legislation. A second part of the work was to package the database with the Tydac OBSERVER software to permit quick and easy access and analysis of the data over the Environment Canada Network and possible the Internet. The results of the work are 1) a dynamic GIS database that will evolve as new data become available, 2) a GIS model of the threat to biodiversity that can quickly be modified to address special case scenarios, and 3) a user friendly package that permits easy access to the database and model by scientists.

GIS DATABASE UPDATING FROM REMOTELY SENSED IMAGES

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ABSTRACT

Images are a major source of data for keeping geographic data bases current. This operation can be greatly facilitated if pertinent spatial and attribute information which resides in a geographic information system (GIS) relational database plays an active roll in the image analysis.

Image analysis schemes are proposed in this paper for detecting and monitoring changes which are confined to certain geographic or land use boundaries, stored in a GIS. These schemes are based on the assumption that the changes or no change can be, at least partially, anticipated. The essence of the monitoring operation is then to confirm the expectations or detect and resolve the deviations. The analysis of the image is performed by either a standard per pixel image classification or by relying solely on image statistics generation. The heart of the monitoring schemes is a polygon-by-polygon assessment of the results that follow the image processing, to separate those polygons which match the apriori expectations within a preset threshold range. Polygons which do not pass the test are subjected to further examination, assisted by information stored in the database, to resolve the deviations. An immediate revision of the attribute files concludes the process.

The proposed schemes for detecting and monitoring changes significantly reduce the problems of multi-classification and misclassification due to overlaps of spectral signatures, which often plagues standard image classification. The concept of the polygon specific monitoring schemes will be illustrated by examples.

Geomatics Partnerships and Cooperative Technology Development

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Over the past several years, several factors have contributed to the growth of partnerships and cooperative projects between government, the private sector, universities and consortia. Most important among these has been increased budgetary reductions and calls for prioritization of research and development expenditure that have lead to alternative means to develop technology and participate in research and development. Several additional factors include the pace of change driving technology development, the potential for synergy between the development participants, and growth of the Internet and networking of geomatics data and services.

For Geomatics Canada the response has involved expansion of a number of mechanisms, programs and government/industry partnership arrangements that promote cooperative development and/or sponsorship of research and development activities. Expanded use of partnership mechanisms has provided both intended and unexpected results. This paper addresses several of the factors affecting geomatics technology development and explores several mechanisms used by Geomatics Canada to promote and build technology using partnership arrangements. In exploring the results of expanded partnerships, the case of the Geographic Information Systems Development Program is used to provide an example and discussion of technology development through cooperative projects.

ANALYSIS OF CZCS IMAGES OF ANNUAL AND SPATIAL PATTERNS OF PIGMENT CONCENTRATION ON THE CONTINENTAL SHELF OF CHINA

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Abstract

The combination of a population of more than 1.2 billion people in China and rapid industrialization in recent years has placed very heavy burdens on the coastal environment. Algal blooms are occurring with increasing frequency and intensity and red tides pose a serious threat to public health and the fishing/fish culture industry. Therefore, a thorough examination of the variation in pigment concentration on a large scale is necessary.

This study examines the annual and geographic variations of pigment concentration on the continental shelf of China from November 1978 to June 1986. All the available Coastal Zone Colour Scanner (CZCS) images (2139 scenes) from Nimbus satellite covering the research area were screened and examined. A total of 76 monthly composite images and 8 annual composite images were generated. Annual pigment concentrations were examined for three transects along the shelf. Significant geographic variation of pigment concentration are revealed. A distinct high concentration belt of about 50 km wide existed along the coastline of China, with a large plume of high pigment concentration extending nearly 500 km to the east from the Yangtze River. High values occurred in the Taiwan Strait, the Gulf of Tonkin and the Luzon Strait. A large anticyclonic gyre appeared in the center of the Yellow Sea in April 1986. Significant interannual variation in the study area are also revealed. Annual pigment concentration increased from 1979 and reached a peak in 1981, just prior to a strong El Nino, and it then decreased in the following years. Generally, annual pigment concentrations were relatively higher and more variable in inner shelf and in the northern area, whereas lower and less variable in outer shelf and in the southeast region, it decreased seawards and south eastwards.

Nutrients and water temperature, which are related to river discharge, upwelling, water mass distribution and climate, are two of the most important factors affecting variation of pigment concentration.

INTÉGRATION DES IMAGES RADAR DANS UN SIG POUR ÉTUDIER L'ÉVOLUTION CÔTIÈRE À GRANDE ÉCHELLE DU DELTA DU NIL

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RÉSUMÉ

Les deltas, comme celui du Nil en Égypte, sont modifiés par des facteurs naturels et humains. Du point de vue sédimentologique, il est possible de quantifier les phénomènes naturels tels l'augmentation du niveau marin et la subsidence. Notre étude s'intéresse principalement à l'évolution des lacs et lagunes qui bordent le delta du Nil. L'analyses de carottes sédimentaires du delta du Nil, obtenues par le Smithsonian Institution, semble indiquer que la subsidence ne soit pas constante et serait plus importante dans la région de Port Said où elle atteindrait 4 mm/an alors qu'elle est d'environ 2 mm/an pour l'ensemble du delta. Une conséquence possible serait un déplacement latéral des lagunes. Pour être capable de quantifier un déplacement potentiel, l'utilisation de la géomatique est un outil intéressant. Les Systèmes d'information géographique (SIG) nous permettent de superposer des cartes anciennes avec des photos aériennes et des images satellitaires afin d'estimer les changements du trait de côte, des lacs et des lagunes. Trois images radar : RADARSAT (mode SN1), ERS-1 et SIR-C sont superposées sur des cartes récentes et anciennes pour déterminer les changements du littoral. Pour l'analyse spatio-temporelle, on estime la superficie des lagunes à plusieurs époques, on calcule le taux d'érosion et on détermine le déplacement de leur centre de masse pour chaque lagune. Il devient alors plus facile de discriminer les effets humains occasionnés par le remblayage, l'irrigation et l'industrialisation.

THE INCORPORATION OF SPATIO-TEMPORAL INFORMATION INTO AN ENVIRONMENTAL SENSITIVITY INDEX.

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Abstract

Coastal environments are often numerically classified or rated for their sensitivity to oil using an Environmental Sensitivity Index (ESI). An ESI is usually based on an inventory of plants and animals and the potential consequences to them of an oil spill. ESI's also attempt to take into account the physical processes occurring on the coastline, such as wave action, and the geomorphology of the region, as these factors influence the persistence of the oil. The ESI ratings fail to consider the spatio-temporal nature of a coastal environment ecosystem. The biota of a coastal region is often seasonal and so for parts of the year the sensitivity of these species may be zero. Species that are prevalent throughout the year may also exhibit sensitivity to oil that varies with their biological cycles. The incorporation of such spatio-temporal factors would improve the accuracy, reliability and usefulness of ESI's.

Where ESI's are used to develop a risk assessment model for groups involved in planning and development or potential disaster mitigation, the lack of a spatio-temporal component weakens the value of the risk assessment model. The use of geographic information systems and an understanding of spatio-temporal relationships will enable the development of better ESI's. This will lead to improved risk assessment models for use in planning and development decisions and should enhance the capability of organisations to react more effectively to oil spill events.

The paper will consider current Environmental Sensitivity Indexes, their apparent shortcomings and the incorporation of spatio-temporal information in the development of a modified ESI. An area in south-eastern Australia known as Westernport will be used to develop the modified ESI. This area was chosen because it is a diverse and complex ecosystem and a coastal resource atlas for the region has recently been completed.

INTEGRATED COASTAL ZONE MANAGEMENT: SOVEREIGNTY AND SECURITY APPLICATIONS OF RADARSAT-1/2

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Abstract

The origins of the RADARSAT Program are closely linked to the surveillance of Canada's extensive coastal and ocean exclusive economic zones. In this context the demonstrated ability of RADARSAT-1 to provide valuable data products to resource and environmental professionals around the world should come as no surprise.

This paper provides an overview of ongoing multi-agency efforts aimed at demonstrating the operational capabilities of RADARSAT-1 and opportunities to enhance RADARSAT-2 for a number of other sovereignty and security application areas. Lessons learned as part of the interdepartmental RADARSAT Evaluation are described, and operational demonstration plans for the summer/fall of 1997 are outlined.

An Evaluation of CASI Imagery for Mapping Coastal Wetlands in the Great Lakes

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ABSTRACT

The aim of this study is to determine the extent to which Compact Airborne Spectrographic Imager (CASI) data can provide information on vegetation species within coastal wetlands. On September 1, 1996, CASI imagery was acquired over part of the eastern shoreline of Lake St. Clair. The data consisted of eight bands of imagery recorded with a pixel size of 2.5 m by 2.5 m. After initial processing and production of imagery, field checking was undertaken in the Lake St. Clair National Wildlife Area (NWA) operated by the Canadian Wildlife Service of Environment Canada. Colours and patterns of colours observed in the imagery were related to the major vegetation types and conditions encountered within the NWA. In addition, in situ spectrometer readings were recorded over different vegetation species and communities using an Analytical Spectral Device (ASD) instrument. These data are being analyzed to aid in identifying the most appropriate parts of the electromagnetic spectrum within the range of 400 - 900 nm for differentiating specific vegetation species.

Initial results indicate that it is possible to identify at least thirteen different species of vegetation which can be grouped into four classes of tall, intermediate, emergent, and submergent aquatic communities. The extent to which CASI imagery with a pixel size of 2.5 m by 2.5 m can meet the mapping and monitoring information needs of coastal wetland specialists is being evaluated.

INFORMATION FROM RADARSAT FOR OFF-SHORE RESOURCE DEVELOPMENT OPERATIONS MONITORING AND MANAGEMENT

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ABSTRACT

A pilot project assessing RADARSAT imagery for the management of off-shore resources was conducted in the fall of 1996. The project acquired 16 scenes in both fine and standard mode beams over the same continental shelf ocean region. The purpose of the project was for the demonstration of the detection and monitoring of ocean features information relevant to the offshore operations activities of the local client. The acquired scenes proved to be rich in information content ranging from sea surface signatures reflecting meterorological and underlying bathymetric structures to point target signatures from ships at sea and distributed targets such as slicks. The project demonstrated the ability of desk-top personal computers and off- the shelf software to process and extract information from RADARSAT scenes to effectively support the management of off-shore resource development operations. This paper outlines the processes used to extract, organize and present the information, graphic and tabular examples of the data are also presented.

Identification of Forest and Landuse Activities in Thailand Coastal Resources from GlobeSAR Data

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ABSTRACT

The west and east coasts of southern Thailand are selected as study areas for monitoring coastal resources under the Thailand GlobeSAR project. The objective is to study how RADARSAT data of C-band with HH polarization can be used to identify forest and landuse activities in coastal zones.

The dataset used in the study includes RADARSAT simulated digital data of C-band with HH polarization which was taken on November 5, 1993, LANDSAT TM and RADARSAT SAR acquired on June 3, 1996, September 7, 1996 and November 18, 1996.

In the preliminary data processing, forest and landuse activities could be identified from a single simulated RADARSAT data. Uniformly high backscatter of major landuse types such as paddy fields, paddy fields with sugar palm and aquaculture features can be easily classified. Difficulties arise in the case of standing tree features including mangroves, swamp forest, mixed orchards and rubber plantations. To obtain more information, the simulated RADARSAT is combined with optical LANDSAT TM data. This, in particular was designed to separate mangrove forest from brackish swamp forest. The results show that those two classes can be clearly distinguished.

However, it was found that most difficult to separate rubber plantation and mixed orchard of which the SAR backscatter values are nearly the same. To further verify coastal forest and landuse change classification, multitemporal RADARSAT SAR was applied for monitoring purposes. Results were promising, indicating that mangrove forest was replaced by shrimp farming.

In future work, March and April RADARSAT images which are the period when rubber trees shed their leaves will be used to seek an effective means for separating rubber plantation from mixed orchard.

La diffusion commerciale des applications des technologies satellitaires: Le cas de RADARSAT I pour la gestion des barrages

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Conçues à l'origine pour répondre à des besoins spésifiques dans le secteur de la défense, la plupart des technologies satellitaires suscitent, au fur et à mesure du développement des techniques de transmission, de stockage et de décodage de l'information, des initiatives pour la promotion de nouvelles applications civiles L'émergence de nouvelles applications pour ces technologies, quel que soit leur intérêt économique apparent, n'entraîne pas nécessairement leur diffusion sur les marchés. En fait, la diffusion réussie d'une technologie, développée sans souci particulier des besoins exprimés sur les marchés, ce que l'on convient d'appeler la « poussée technologique», dépend de plusieurs facteurs qui contrôlent son acquisition par les utilisateurs potentiells. La diffusion de ces technologies est souvent compromise par leurs coûts de développement ou encore par leur faible utilité socio-économique.

On peut alors se poser les questions suivantes: Comment peut-on évaluer le potentiel de diffusion d'une technologie satellitaire? Quels facteurs interviennent comme freins ou comme incitatifs à la diffusion de ses applications potentielles? Comment configurer les applications potentielles en vue de faciliter leur diffusion commerciale? Quels actions les gouvernements doivent-ils envisager pour mettre en valeur leur potentiel économique?

Dans la présente communication on réponde à ces questions, sur la base de la théorie socio-économique. Cela permet de mettre en évidence les stimulants et les freins à la diffusion, notamment dans le cadre d'une situation de «poussée scientifique». Cette théorie tient compte des besoins exprimés sur les marchés, de l'intégration ou de la capacité de substitution aux techniques déjà en utilisation, ainsi que de l'intérêt des gouvernements à supporter les transferts vers des applications du domaine privé ou public.

La configuration des technologies constitue l'élément central établissant son potentiel de diffusion. Au cours du développement d'un projet qui implique des produits technologiquement innovants, l'activité générée vise à réduire des incertitudes sur les plans technique, technologique et commercial afin de mettre le produit dans des conditions de lancement favorables. L'analyse du marché doit permettre de déterminer les paramètres de configuration qui conditionneront la diffusion des produits.

Enfin, plusieurs facteurs économiques et structurels interviennent dans la diffusion des technologies Ceux qui doivent être pris en considération dans le politiques

gouvernementales sont, notamment, les coûts de configuration et de transfert, les risques élevés inhérents a la poussée scientifique, la concurrence internationaly résultant d'investissements publics, etc. En conclusion, on propose des éléments de solutions pouvant être intégrés à une politique de soutien à la diffusion de ces technologies.

Notre analyse se concentre principalement sur RADARSAT I et sur son utilisation éventuelle pour le mesure de l'équivalent en eau du couvert nival des bassins en vue de gérer les réservoirs d'eau et la production hydroélectrique.

Principal Components Analysis of Arctic Ice Conditions Between 1987 and 1995 as Observed from the SSM/I Data Record

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Preferred Session: CRYSYS
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Climatologists are increasingly convinced that the Arctic sea ice cover is inextricably linked with the global climate system hence it can be used as a proxy indicator of climate change. We are interested in contributing to this theory by documenting the natural variability of ice concentrations in the Northern Hemisphere: to establish the norms from which changes can be measured. Principal Components Analysis (PCA) is an image analysis tool which has been used with remote sensing imagery to enhance the visual interpretability of the data, improve classification speeds and accuracies, reduce the dimensionality of a multi-channel data set, and more recently, to identify periodic and change events in temporal image sequences.

In this paper PCA is used to examine Arctic sea ice concentrations derived from the SSM/I passive microwave radiometer over the eight year period, 1987-1995. The spatial and temporal patterns of ice concentrations are highlighted and reveal both known and anomalous patterns of inter-annual variability. These patterns are compared with those which emerged from a similar study of SMMR passive microwave data between 1978 and 1987

EVEN "GREAT" GLACIERS CAN SLIP TO DEMISE

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ABSTRACT

The volume, flow and terminus position fluctuations of the Saskatchewan, Athabasca and Illecillewaet Glaciers are examined for the last century, with a focus on data obtained in the last 50 years. Relevance to basal sliding and net ice loss are discussed. Field survey data is compared to that obtained from digital elevation models derived from a variety of sources. Recently field studies at Columbia icefields have been augmented by SAR interferometric analysis using CCRS-Convair plane and ERS 1/2 data (Cummings et al., 1995; Vachon et al., 1996). The SAR data has allowed spatial mapping of glacier flow and topography across expansive areas during 1995-96. Ice velocity fluctuations in recent years have been derived from both ground and satellite measurements. These show that the three Glaciers appear very sensitive to variations in glacier water input, and seasonally slide at their bed.

Accelerated motion of Saskatchewan and Athabasca glaciers observed during 1995 summer is attributed to exceptionally high rainfall and high water input to the glaciers. Not only are these glaciers sensitive to variations in water input, but they also are sensitive to minor changes in the present snowline. This is because they possess large accumulation areas at relatively high elevations. The glaciers at Columbia icefield continue to maintain relatively high velocities despite the fact that they have thinned considerably in their accumulation and terminus regions. The Illecillewaet Glacier appears to advance in sudden pulses, and then slowly thin. At the present time all the glaciers are retreating. The glaciers sensitivity to water input has tended to keep the terminii from retreating as quickly as it might have otherwise done. It is possible that increased basal lubrication from increased water input enhanced the dramatic advance of Illecillewaet Glacier, while contributing to the thinning in the accumulation area during the recent advance of 1960-1990. Projections are made as to the lifetime of these glaciers based on possible future mass balance, temperature and precipitation patterns related to global warming. If the present trends continue, it appears to be all downhill from here for the glaciers.

MONITORING ICE FREEZE-UP AND BREAK-UP OF SHALLOW TUNDRA LAKES AND PONDS USING ERS-1 SAR DATA

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ABSTRACT

While low resolution passive microwave and optical imagery have been used with some success to monitor ice freeze-up and break-up over large water bodies in both southern and northern Canada, little work has been conducted on the utilization of high-resolution active microwave imagery to study this phenomenon. In the Arctic and Subarctic, where vast areas of the land are covered by lakes, multitemporal SAR imagery could provide valuable information on whether or not a given lake 1) was suitable as a year-round source of water or 2) should be considered as a site where permafrost may be deeply thawed due to the thermal effect of the year-round presence of a water body. As well, monitoring ice freeze-up and melt of shallow ponds would be useful in studies examining regional methane exchange from northern wetlands.

In this paper results of an investigation on the use of multitemporal ERS-1 SAR data to monitor ice freeze-up and break-up of shallow tundra lakes and ponds found in the Hudson Bay Lowlands, near Churchill, Manitoba, will be presented. A map of lake bathymetry produced using a Landsat TM image and field measurements of lake depth, which was registered to the SAR data set, allowed to relate changes in radar backscatter to various stages of ice formation and to determine when and whether or not the lakes and ponds found in the study area freeze to the bottom. Examples of backscatter changes associated with ice thickening, freezing to the bottom, the inclusion of bubbles, and ice break-up will be given using a series of ERS-1 images acquired between November 1992 and June 1993.

ESTIMATION OF SNOW WATER EQUIVALENT IN THE BOREAL FOREST USING PASSIVE MICROWAVE DATA

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ABSTRACT

Current Canadian snow water equivalent (SWE) algorithms, based on passive microwave data, and derived from non-vegetated prairie landscapes, have been shown to underestimate SWE in forested areas. This paper presents the results of recent algorithm development to estimate SWE specifically in the boreal forest landscape. Airborne microwave data and ground-based measurements of snow cover were collected during the BOREAS (Boreal Ecosystem Atmosphere Study) winter field campaign held in February 1994. Airborne microwave brightness temperatures were acquired by three radiometers operating at 18, 37 and 92 Ghz in vertical and horizontal polarizations, over a set of lines in the BOREAS northern and southern study areas. These lines sampled a range of forest cover types including deciduous, coniferous and regeneration areas. Extensive ground snow surveys were conducted along calibration segments of the lines to measure snow cover characteristics including SWE. Land cover information for the flight lines was derived from the BOREAS Landsat-TM classification maps.

Analysis of the experimental dataset shows that the microwave vertically polarized difference index (MPDI) for 18 and 37 Ghz, which is currently used for prairie SWE retrieval, can also be used to estimate SWE in a forested environment. However, this index is strongly sensitive to land cover characteristics. For an equivalent amount of snow on the ground, deciduous sites are characterized by lower MPDI values as compared to coniferous sites. As the conifer stands become more open, the microwave index increases towards the values generally found in the non-vegetated prairie region. As a result, two different linear algorithms were developed for deciduous and coniferous forest types respectively. A third algorithm, designed for areas of more open forest cover, is intermediate between the coniferous and prairie algorithms. The different linear algorithms appear almost parallel to each other, which may be explained by the canopy densities associated with the various forest types in the study areas. The potential use of optical remote sensing data to investigate the influence of canopy density on the passive microwave retrieval of SWE will be discussed.

The applicability of algorithms developed from airborne data at regional scale to satellite data will be addressed. As spaceborne microwave radiometers are coarse spatial resolution sensors (~25 km at 37 Ghz), a pixel may contain a mixture of several land cover types. SWE for a pixel or a grid point can be calculated by weighting the SWE values obtained from each land cover algorithm according to the percentage of the land cover type within the pixel. Advantages and limitations of this method will be discussed. Results from initial application of these algorithms to SSM/I EASE-GRID data are very encouraging and examples evaluating the algorithms for other years will be included.

Quantitative Aspects of the Radiometric Normalization of Multi-Temporal Satellite Scenes in the Creation of Large Area Image Mosaics

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Abstract

The generation of large area mosaics from multiple satellite images presents unique problems not normally encountered in the fusion of aerial photographs. Low revisit cycles of satellites combined with high incidence of cloud cover over most of the Earth's land areas necessitate the merging of scenes acquired over a broad temporal window, typically on the scale of months to years. As a result, one must deal with problems of integrating partially overlapping scenes which exhibit diverse atmospheric and possibly thematic characteristics into a visually seamless image product. Traditionally, a host of empirical and largely cosmetic procedures have been employed to achieve radiometric continuity. Usually, one scene is selected as a reference and the radiometric scales of all other scenes are modified to match it through, for example, grey level mean/variance normalization. Additional local operations, such as scene blending in overlap regions, are used to further suppress inter-scene seams. While these approached have been successful in producing visually pleasing mosaics, they fail to provide quantitative measures of radiometric and underlying thematic continuity, information which is crucial if useful landscape information is to be derived from this type of image product.

In this paper we describe a unified normalization methodology which is based on a detailed analysis of grey level scattergrams from regions of overlap between scenes. Based on a clustering technique in this 2-D radiometric space, we are able to address a number of relevant issues including;

a) the identification and editing out of disparate inter-scene information. This 'outlier' data can arise from the presence of cloud cover in on the scenes or a significant change in thematic cover.

b) the derivation of normalization coefficients from grey level properties of clusters found in the edited datasets.

c) the estimation of inter-scene thematic continuity based on cluster characteristics such as correlation and orientation in this grey level space.

d) the selection of preferred reference scene candidates.

The proposed methods have been developed and evaluated with Landsat MSS imagery acquired as part of a Canadian contribution to the NASA Landsat Pathfinder program. This work has resulted in the creation of a proto-type mosaic of the Great Lakes watershed.

The Extraction of Planimetric Features from High Resolution Satellite Imagery Using Image Segmentation and Spatial-Based Reasoning

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Abstract

The next 5 years will witness the launch of a series of civilian satellites carrying sensors capable of generating digital imagery with resolutions on the scale of 1 to 5 meters. A major benefactor will be the mapping community, since these data should be adequate for detailed, worldwide topographic mapping from space. Since current remote sensing image analysis methods have been tailored to a different environment, namely the processing of images of low spatial resolution (typically 10 to 1000 meters) but high spectral dimensionality, they will not be sufficient to fully exploit the spatial information content of these new images. On the other hand, in parallel with conventional information extraction research, there has been considerable 'image understanding' research directed at the analysis of high resolution monochromatic aerial photos; however, until recently, this work has been largely driven by military applications. The key characteristics of image understanding are its segment as opposed to per-pixel based image processing and its reliance on spatial attributes and spatial context reasoning to interpret or classify image features as physical objects. Many of these concepts and technologies are of potential value in analyzing this new generation of high resolution satellite image data.

This paper presents some early results of research conducted at the Canada Centre for Remote Sensing to develop a comprehensive suite of image understanding tools to automate the extraction of common planimetric features. While image partitioning is achieved based on an edge-based segmentation approach first proposed by Perkins, we have greatly expanded upon this methodology to allow for the creation and integration of a hierarchy of segmentations since no single segmentation is suitable to provide adequate delineation of all objects of interest (e.g. roads, buildings, forests etc) without excessive image fragmentation. In addition, we employ the same edge measures, used in the segmentation process, to quantify intra-segment spatial attributes such as texture, thereby providing a coherent and consistent set of image characteristics throughout all image processing stages.

A key function in planimetric feature extraction and the creation of a consistent scene interpretation is the accurate delineation of the road network. Conventional road finding on low resolution images has generally been based on 'line finding and following' algorithms. At high resolution more elaborate techniques are required since detailed characteristics of the road are clearly visible (e.g. road width, texture). Such methods can be complex, for example employing cross-road radiometric profile matching and tracking. We present an alternative which is based on the identification and fusion of 'road-like' segments and the employment of image morphological operators to define road characteristics such as centre-line trajectory and road width.

Example results and performance measures will be presented based on the analysis of 2-meter resolution aerial photography.

IDENTIFICATION ET CARTOGRAPHIE DES ZONES DE REBOISEMENT À L'AIDE DES DONNÉES LANDSAT TM ET RADARSAT DANS LA VALLÉE DE COCHABAMBA, BOLIVIE

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RÉSUMÉ

Ce projet a été développé pour tirer profit des avantages qu'offrent la télédétection et les systèmes d'information géographique en complémentarité aux méthodologies traditionnelles de gestion des ressources naturelles et d'aménagement du couvert forestier dans les Andes boliviennes. Cette recherche appliquée répond à un problème réel en fournissant rapidement et aux moments opportuns des cartes identifiant les différentes espèces végétales. Ce projet s'inscrit dans un plan national pour diriger le développement économique et social de la Bolivie. Dans cet esprit, le gouvernement du pays a adopté la politique du développement durable. Le but est d'améliorer les conditions de vie de la population actuelle, sans mettre en péril les besoins fondamentaux des générations futures.

Plus en détail, ce projet vise à contrôler les problèmes de classification et de cartographie de la forêt de la vallée centrale de Cochabamba, située dans la région andine de la Bolivie. En comparant et en évaluant l'évolution et l'état qualitatif de la forêt, à l'aide des informations fournies par les images multi-échelles et multi-temporelles de capteurs différents (Landsat TM et Radarsat) ainsi que de données d'inventaire recueillies au terrain, l'aboutissement de cette recherche se traduira en une application qui permettra de classifier et de cartographier le couvert forestier. Ceci permettra de suivre et de contrôler l'évolution des conditions environnementales des plantations et permettra la mise à jour régulière de l'état des reboisements qui, dans le contexte actuel, évolue rapidement.

La zone d'étude se situe dans la vallée de Cochabamba à plus de 2 500 m d'altitude, avec un climat semi-aride. La ville est la troisième plus importante du pays en terme de population (600 000 habitants) et d'activités économiques. Tout autour de la ville se trouve une section de la cordillère andine de l'est. La vallée centrale est un site expérimental pour un projet de reboisement depuis environ 20 ans et elle possède une grande diversité d'espèces végétales. De plus, la distribution florale hétérogène complique l'opération de classification et de gestion. L'équilibre de cet environnement peut être menacé par des opérations d'aménagement non contrôlées et la destruction de cette forêt peut avoir des conséquences catastrophiques à plusieurs points de vue.

Ce projet est réalisé par la collaboration entre le Centre d'applications et de recherches en télédétection (CARTEL) de l'Université de Sherbrooke et le Centro de Investigación y Servicios en Teledetection (CISTEL) de l'Universidad Mayor de San Simón à Cochabamba, Bolivie.

ANALYSE DE TEXTURE D'IMAGES ROS

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RÉSUMÉ

Les images ROS permettent d'obtenir des informations, en particulier sur la rugosité en liaison avec les reliefs et l'humidité des sols en milieu semi-aride. Après avoir expérimenté plusieurs de ces méthodes d'analyse de texture d'images ROS aéroportées dans le cadre du projet GlobeSAR - Tunisie, la communication présente l'application de ces méthodes à des données RadarSat acquises dans le cadre du programme RVP, le 20 mars 1996, en bande C et polarisation HH, de la région de Sebkhet El Kalbia en Tunisie Centrale.

Trois approches différentes seront discutées :

1) l'analyse par la transformée de Karhunen-Loeve (TKL), qui consiste en une phase d'apprentissage à l'aide de bancs de filtres adaptés à chaque texture de l'image puis en une phase de décision dans laquelle l'image est classifiée à l'aide des caractéristiques déduites de chaque texture, selon un critère d'optimisation.
2) l'analyse par classification non supervisée s'appuyant sur la logique floue, qui consiste en une étape permettant d'estimer les caractéristiques des différentes classes qui serviront à classifier l'image dans une deuxième étape.
3) l'analyse combinant une classification non supervisée et l'utilisation des matrices de cooccurrences qui ne font intervenir que les cooccurrences de niveaux de gris de l'image globale et celles du voisinage du pixel.

À l'aide des matrices de cooccurrences, des signatures texturales sont calculées puis transformées et classifiées. La présentation se termine par une étude comparative. Les résultats obtenus par chacune des trois approches et concernant les mêmes textures sélectionnées, considérées comme représentatives d'un milieu semi-aride, seront présentées.

IMPACT DES MÉTHODES D'INTERPOLATION SUR LA PRÉCISION DES MODÈLES NUMÉRIQUES DE TERRAIN

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RÉSUMÉ

Les modèles numériques de terrain (MNTs) sont actuellement présents dans tous les domaines des sciences de la terre (cartographie numérique, génie civil, télédétection, etc.). Un MNT est restitué à partir des données altimétriques obtenues, entre autres, par procédés photogrammétriques, levé topographique direct, courbes de niveau et points cotés numérisés et intégrés dans un système d'information géographique (SIG). Cette restitution nécessite souvent l'utilisation d'une méthode d'interpolation en raison de la faible densité des données (courbes de niveau et points cotés). Toutefois, il existe différentes méthodes d'interpolation de résolution de ce problème rendant la tâche délicate pour le contrôle de la qualité des MNTs et par conséquent le choix d'une méthode d'interpolation pour une application donnée. Dans la présente étude nous analysons l'impact de trois méthodes d'interpolation sur la précision des MNTs en fonction de la densité des données altimétriques et de la résolution spatiale du MNT à élaborer. Les trois méthodes retenues sont: I) les moyennes pondérées, ii) les différences finies et, iii) les polynômes ajustés par moindres carrés. Les données altimétriques sont numérisées à partir des courbes de niveau d'une carte topographique à 1/50 000 de la région de Sherbrooke (Québec) selon deux équidistances différentes (10 et 20 mètres). Ainsi, pour chaque méthode d'interpolation et chaque équidistance, les MNTs ont été rééchantillonnés selon trois résolutions spatiales (10, 20 et 30 mètres). Indépendamment de la densité des données et de la résolution spatiale des MNTs, les résultats obtenus montrent que la méthode *des moyennes pondérées* est moins précise que les deux autres méthodes. Globalement, la restitution des MNTs à d'une équidistance de 10 mètres permet une précision meilleure que pour une équidistance de 20 mètres. Pour une équidistance de 10 mètres et quelle que soit la résolution spatiale, la méthode *des différences finies* se démarque par une précision meilleure par rapport à la méthode *des polynômes ajustés par moindres carrés*. Par contre, pour une grande équidistance (20 mètres), ces deux méthodes engendrent presque la même précision. Dans cette étude nous présentons les méthodes d'interpolation étudiées, la méthodologie suivie et les résultats obtenus.

RETRIEVAL OF SPECTRAL SIGNATURES OF TROPICAL CORAL THROUGH ANALYSIS OF THE DIFFUSE ATTENUATION COEFFICIENTS FOR IRRADIANCE AND RADIANCE THROUGH THE WATER COLUMN

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ABSTRACT

Landsat Thematic Mapper and SPOT satellite image data have been used in a qualitative manner to map the spatial characteristics of tropical reef systems. Recently, data available for shallow corals have been studied to determine a "Living Madrepora Index" that may form the basis for quantitative analysis of ecosystem viability. This may be of particular importance in studies of coral bleaching events that may be caused by climate variability or change, and/or pollutant stress. The challenge is to adjust the digital imagery for the optical attentuation through water to greater depths with corrections that will vary with the density of intervening sediment or plankton.

In this paper we report on a study in Fiji in which we measured the vertical profiles of the diffuse attenuation coefficient for the downwelling irradiance and upwelling radiance in the SeaWIFS channels. We have over forty profiles over coral reefs, debris surfaces, and sand surfaces, as well as 'blue water' with depths far beyond the range of the 100 metre cable for the dropsonde radiometer. We discuss the properties of these coefficients and the applicability of radiative transfer models to retrieve the spectral characteristics of submerged surfaces.

RADARSAT IMAGES OF THE EASTERN SAHARA

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ABSTRACT

Radar images are most useful for mapping structural and morphological features, as well as the tone and texture of rock types. Additionally, in desert environments, radar has the ability to sense up to a few meters beneath the surface. This is a rare phenomena because the cover material must be dry, radar smooth, fine grained and homogenous relative to wavelength in order for it to occur.

Three radarsat scenes have just been received at the Center for Remote Sensing, at Boston University. They cover parts of the eastern Sahara at the southern reaches of the Great Sand Sea, straddling the borders of Egypt, Libya and Sudan. Data were collected in standard modes 4 and 5 with incidence angles ranging between 34° and 42°; sufficiently high to optimize sub-surface imaging (owing to roughness and incidence angle effects). These data are currently being processed and analyzed to map ancient sub-surface river beds that may be buried there, as part of a project to investigate the relationship between sand accumulation and groundwater in the eastern Sahara. Since it can not be determined whether imaged features are surface or subsurface based on a radar image alone, Landsat data is also being used for this study. Results shall be presented at the symposium.

REMOTE SENSING OF BALSAM FIR FOREST VIGOR

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ABSTRACT

Practical indices of forest health are needed so that the impact of various stress agents can be measured and ecosystem response to such threats as climate change, air pollution, and large scale disturbance by insects can be predicted. We have designed a study which uses controlled experimental manipulations of forest stands to assess the potential for monitoring forest vigor at a variety of scales by remote sensing tools and techniques. We chose four 'vigor' levels to represent a wide range of growing conditions in balsam fir ecosystems. In order of increasing vigor, the manipulations were: root pruning (RP), control (C), thinning (T) and thinning in combination with fertilization (TF). This paper reports on the spectral separability of the vigor plots at the leaf-branch level using reflectance data acquired by a field portable spectroradiometer with a spectral range from 350 - 2500 nm. Initial results demonstrate that foliage samples collected from each vigor plot can be discriminated with a high level of accuracy using the reflectance data and a combination of factor and discriminant analysis techniques. Further work will (i) determine relationships between vigor and stand biochemical and biophysical characteristics and (ii) determine the sensitivity of canopy level reflectance measurements to differences in stand vigor. This research is in support of future use of airborne and satellite remote sensing data for input to process-based models of ecosystem functioning.

HIGH SPECTRAL RESOLUTION REMOTE SENSING OF BALSAM FIR INFESTED BY BALSAM WOOLLY ADELGID (*ADELGES PICEAE*)

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ABSTRACT

Monitoring the area and severity of forest damage caused by insect pests is an important prerequisite to estimating productivity and to sustainable forest management. Herein, we report progress in the use of high spectral resolution remote sensing for discriminating forest damage caused by the balsam woolly adelgid, *Adelges piceae*, an important pest of true firs in eastern and western Canada. Reflectance data were acquired by a field portable spectroradiometer with a spectral range from 350 - 1050 nm. A combination of derivative and logistic regression analyses were used to discriminate foliage from damaged and undamaged balsam fir trees in pre-commercially thinned and unthinned stands. Stepwise regression techniques were used to relate raw and derivative spectra to chemical constituents in foliage. Overall classification accuracies of logistic regression models based on 3 optimal channels were at least 80% correct in discriminating foliage from damage and undamaged trees. Classification improved with the calculation of first and second-order derivative spectra. The spectral reflectance data predicted concentrations of chlorophyll a, b and total nitrogen and phosphorus reasonably well, however, selected wavelengths were not consistent with those selected for discriminating damage and probability of damage was only weakly correlated with concentrations of chlorophyll and nitrogen. Spectral analysis of foliage at the leaf-branch level is an important step towards future use of airborne and satellite hyperspectral remote sensing data for damage detection and analysis of foliar chemical constituents associated with damage by forest pests.

Comparison of Multidate Radar and Multispectral Optical Satellite Data for Wetland Detection in the Great Lakes Region

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ABSTRACT

This paper evaluates the performances of multidate ERS-1 radar and multispectral optical satellite data for wetland detection and classification in the Great Lakes Region. One of the limitations of using Landsat TM and SPOT satellite data is data availability due to cloud cover and the relatively long repeat cycle of the high resolution optical sensors. Recently, radar satellite SAR (Synthetic Aperture Radar) data become available, such as the European Remote Sensing Satellite (ERS-1) and the Canadian Radarsat Satellite. Due to the all-weather, day or night capabilities of SAR, images will be available on a regular and timely basis. This advantage over optical satellite data can be utilized in wetland identification and classification. The results of this study show that although single channel ERS-1 images produced poor results, the performances of multidate ERS-1 radar data were comparable with those of Landsat TM data. Classification results which were derived from four-channel combination ERS-1 data have achieved the overall landuse classification accuracy of over 80% and the overall wetland vegetation classification accuracy of over 80%. The cloud free capability of radar data makes it a potential alternative to the optical satellite data.

GIS for Natural Disaster Monitoring and estimation in Mongolia

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Abstract

Mongolia is situated in the northern part of the Great Gobi desert of Central Asia and frequently experiences natural disasters such as drought and fires. In Mongolia main economic branch is agriculture and livestock (about 40 per cent of GDP) which is closely related to natural disasters. Natural disasters cause not only economic losses but also seriously affect to the environment. Multiple sources of data have been used for natural disaster monitoring and fire management. These sources of data includes the following:

* satellite remote sensing
* ground measurement and agro-meteorological post observations

In this research we are used NOAA/AVHRR data and Global Vegetation Index (GVI) data. Analysis of the data has shown a good correlation between vegetation biomass and the normalized vegetation index, also between the normalized vegetation index and rainfall. Because of this good correlation the NDVI can be used as a good indicator for drought conditions.

In order to clarify the possibility of using NDVI data for drought studies we have compared NDVI data for drought and non-drought years. From complex analysis of NDVI, drought index and ground observed data we get NDVI values corresponding to different summer conditions and drought. Result showed these NDVI values are really different and varied by space and time.

For fire monitoring were used drought index which show air dryness and NOAA/AVHRR criteria of fire such as:

1) CH3 > 313 k
2) CH3 > CH4+10 k or CH5+10 k
3) CH4 > 250 k or CH5 > 250k
4) CH1(2) < 10%

Also was estimated forest and steppe fire influence to environment by measurement CH4, CO2 and other components and calculation in total. Forest fire estimation includes using satellite data on fire developed days and then we have overlay it with geographic map of location forest resources, roads and settlement areas. Using results of this GIS analysis we have suggested sample examples for decision making on optimal measures fire prevention and to extinguish the fire .

From global climate change view we compared precipitation and temperature dynamic with NDVI, drought area and fire and drought occurrences number.

The results of this studies shown remote sensing technology can provide wide area, operative and cost effective information on fire and drought prevention and estimation. It is very useful for Mongolia, which has vast territory, weak economic capacity and sparse population. The results of the research will be used for estimation of damage for environment caused by nature and economic development.

L'Implementation du standard SDTS pour les problemes du cadastre en Roumanie.

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RESUME

Dans les conditions dans lesquelles en Roumanie le probleme du cadastre foncier est prioritaire, on peut valoriser l'experience et les capacites de l'Institut National de Recherches Aerospatiales "Elie Carafoli" par la creation du Centre de Transfert Technologique dans le domaine de la Teledetection, dans le cadre de l'Institut.

La preoccupation des presentateurs se rapporte a l'introduction et l'utilisation, pour la premiere fois en Roumanie, des standards concernant le transfert des donnees de teledetection, SDTS, proposees par U.S. Geological Survey, que nous avons contacte.

L'expose comprend le projet pour l'implementation de ces standards dans les problemes specifiques de la Roumanie; les programmes nationaux concernant la teledetection, l'implication de la Roumanie dans des programmes internationaux (le projet MARS).

COMPLÉMENTARITÉ ENTRE RADARSAT ET ERS-1

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RÉSUMÉ

Les actions de lutte contre la désertification doivent s'appuyer sur des études de base capables d'évaluer le milieu sous ses différents aspects aussi bien physique, écologique que socio-économique et de faire le suivi de son évolution. Si les méthodes traditionnelles d'investigation reposent sur une approche quantifiée, leurs résultats restent partiels et n'intègrent pas tous les facteurs responsables. Ainsi, la télédétection permet d'apporter une contribution importante à ces études et au suivi de ces phénomènes évoluants dans le temps et dans l'espace.

Dans le cadre d'un projet mené au Centre National de Télédétection, une étude est en cours, sur le site de Menzel Habib (sud-est tunisien) afin d'évaluer l'apport des données Radar à l'étude des différentes formes de dégradation présentes dans la région. Pour ce faire, nous avons utilisé une image radar aéroportée (simulation de RadarSAT acquise dans le cadre du programme GLOBESAR) de polarisation HH et une image ERS-1 de polarisation VV. Nous avons procédé à une étude quantitative de la variation radiométrique des zones identifiées par photo-interprétation et/ou par classification dans les deux images radar correspondant à : zones dégradées, parcours, zones mises en défens (zones protégées et interdites au pâturage), champs labourés et zones d'arboriculture.

Les résultats obtenus montrent que :
- la variation radiométrique est plus importante dans l'image aéroportée que dans l'image ERS-1;
- certains thèmes sont plus facilement identifiables sur l'une des deux images que sur l'autre;
- l'utilisation simultanée des deux images radar dans la classification permet d'obtenir des résultats meilleurs que dans le cas de classification séparées;
- l'utilisation d'images radar à paramètres d'observations différents permet une exploitation optimale des informations contenues dans les deux images.

RADARSAT ET LA CARTOGRAPHIE ÉCOLOGIQUE : APPLICATION À L'ÎLE D'ANTICOSTI (QUÉBEC)

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RÉSUMÉ

Le but de cette recherche est de déterminer le potentiel d'application de RADARSAT pour l'utilisation en cartographie écologique. La cartographie écologique est un système hiérarchique de perception et d'expression écologique du territoire. L'inventaire écologique est une subdivision (cartographie) de l'espace en territoires écologiques, unités identifiées et caractérisées par les composantes biophysiques les plus permanentes de l'environnement, qui reflètent le mieux les perspectives d'utilisation du milieu naturel. Le système de classification écologique du territoire, utilisé par le ministère des Ressources naturelles du Québec (MRNQ), comporte cinq niveaux de perception écologique : la région (1 : 1 000 000), le district (1 : 250 000), le système (1 : 125 000), le type (1 : 20 000) et la phase (1 : 10 000). Ce type de cartographie est un document de synthèse qui est facilement utilisable, entre autres, pour la planification touchant à l'inventaire et à l'aménagement des milieux forestiers. Actuellement, les techniques utilisées pour sa réalisation sont la photo-interprétation et le travail sur le terrain. La télédétection radar permet, entre autres, d'identifier la topographie, la géologie et l'hydrologie qui sont des composantes de ce type de cartographie. De plus, sa répétitivité d'acquisition des données est un élément important et permettrait donc à RADARSAT d'être un outil complémentaire aux méthodes actuelles. Actuellement, on ne connaît pas le potentiel ni les contraintes du radar pour la cartographie écologique.

La zone d'étude de ce projet est l'Île d'Anticosti, qui est située à la limite nord-ouest du golfe du Saint-Laurent. Les images utilisées ont été acquises par RADARSAT et sont en mode F2 et F4 (Descendant) et couvrent la partie centrale de l'île. Les données utilisées comprennent aussi des cartes géologiques, de dépôts de surface, topographiques et forestières. Certaines d'entre elles ont été numérisées afin d'apporter une information complémentaire aux images. De plus, les deux images permettront d'utiliser la stéréoscopie. La légende retenue pour la cartographie est la même que celle proposée et utilisée par le MRNQ. Le traitement des images numériques portera sur l'analyse de texture car l'ajout d'information texturale augmente de façon significative la séparabilité des classes spectralement confondues.

Les résultats obtenus à ce jour ont permis d'identifier quelques structures géologiques. Les talus d'érosion ainsi qu'un front de cuesta ont été identifiables à certains endroits. Les zones marécageuses sont facilement repérables sur l'image de RADARSAT de même que quelques falaises mortes. Dans la partie nord-est de l'image, on peut identifier des routes. De plus, l'encaissement des rivières est assez visible.

ON THE HAUSDORFF DISTANCE CONCEPT USED FOR THE EVALUATION OF SEGMENTATION OUTPUTS IN REMOTE SENSING

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ABSTRACT

Broadly defined, image segmentation consists in partitioning an image into distinct regions that are uniform. Although there exists hundreds of segmentation techniques in the literature, few attempts have been done to develop methods for the quantitative evaluation of segmentation results. This communication concerns the comparison of segmentation outputs with a reference partition (e.g. ground truth). It is noteworthy that, among the few methods available for segmentation evaluation, the majority of them focus on measures related to the number of misclassified pixels in the segmentation output. Such approaches neglect boundary information. This represent an obvious deficiency since human evaluation of segmentation outputs, which is considered by many as the ultimate test for output quality, is certainly influenced by boundary information. Since methods based on boundaries information are rare, we have evaluated a measure that is conceptually simple to understand and which is based on spatial proximity: the Hausdorff distance. This measure possesses the advantage of being trivial to compute. The Hausdorff distance represents a measure of the spatial distance between two sets of points. A known extension of the Hausdorff distance is the partial (directed) distance based on ranking. This measure can be used to establish the number of points in an image, e.g. the ground truth boundary points, that are each within a specified distance of some points in another image, e.g. the segmentation output boundary points. This measure possesses thus the potential power to quantify the proximity of the boundary points in a segmentation output compared to a reference partition. In this paper, we explore the potential of the Hausdorff concept of distance for segmentation evaluation. The mathematical framework is first introduced. Then, the method is illustrated with a case taken from the literature. Finally, the strengths and the weaknesses of the method are discussed.

L'EXTRACTION DE L'INFORMATION FORESTIÈRE DES DONNÉES RAS
PROJET ADRO #83; RÉSULTATS PRÉLIMINAIRES

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RÉSUMÉ

Le site d'étude du projet est la forêt Montmorency qui est située 75 km au nord de la ville de Québec. Depuis plusieurs années, ce site fait partie de notre programme d'étude sur l'application des données images radar en foresterie.

L'ensemble des données du site inclu des données de l'inventaire forestier ainsi que des données radar du ERS-1, JERS-1 et RADARSAT.

Les premières données RADARSAT ont été prises en août (mode standard) et en octobre (mode fin) 1996. Cette communication présentera les résultats préliminaires de l'analyse des données RADARSAT. De plus, nous allons comparer le contenu de l'information extrait des données RADARSAT aux résultats obtenus lors de l'analyse des données ERS-1 et JERS-1. Nous porterons un intérêt particulier aux facteurs qui influencent la visibilité des coupes et l'aspect de l'analyse multi-temporelle.

Understanding RADARSAT Data in Stereo

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Not so long ago, a hill top view provided the largest vista from which to observe the Earth's surface. Today, Earth observation satellites such as RADARSAT orbit our planet allowing us to observe, understand, plan for, and monitor the world's resources as never before.

In order to depict the three dimensionality of land features, mapmakers traditionally used rendering techniques such as shading, overlapping and perspective views. In the last 200 years, many advances in representing the third dimension have been made.

It is important to convey the third dimension because humans have a natural ability to see in 3-D. The 'naturalness' of a 3-D representation enhances the ability to interpret 2-D imagery. Depiction of the third dimension supplies important information about relationships between land structures, slopes, water ways, vegetative growth and other ground cover. Cartographers, engineers, geologists, hydrologists, and other scientists use 3-D viewing methods, such as stereo viewing of aerial photos and satellite images, in order to better understand the Earth's surface.

RADARSAT, Canada's Earth observation satellite is able to provide stereo coverage of a geographical area. The ability of RADARSAT to acquire data from a variety of beam modes, positions and two Earth relative look directions allows users a wide variety of possible stereo image pairs. However, viewing RADARSAT images in stereo is more complex than viewing aerial photographs or VIR satellite image pairs.

Depth perception is a combination of physiological and psychological cues. To this day little is known of how these cues are combined in our brains. The physiological cue of binocular disparity predominates over other cues when viewing optical/VIR imagery in stereo. When viewing RADARSAT and other SAR imagery, binocular disparity is important but other cues have a strong impact. It may take our brains time to assimilate new information RADARSAT images present. However, practice makes "perfect" and with experience, RADARSAT image pairs can be viewed in stereo as easily as aerial photographs or VIR satellite image pairs.

In order to better understand and control the different cues and parameters which impact the stereo-viewability of RADARSAT data, this presentation will:

- examine the basics of depth perception and stereo, and
- address parameters related to sensor, satellite, and the Earth which affect stereo viewing.

These considerations enable us to decide on how to generate the best stereo pair for a given application. Furthermore, when parasitic problems on a stereo image pair occur, simple image processing techniques are evaluated to enhance the stereo-viewability. Various examples will illustrate these different factors.

EARTH SURFACE TOPOGRAPHY MAPPING USING MULTIFREQUENCY INTERFEROMETRIC PROCESSING OF SIR-C/X DATA

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Abstract

The report represents results of researches devoted the questions of digital terrain maps creation using multifrequency SAR interferometric imagery. As initial data the images received by SIR-C/X SAR in test site of Moscow region, Russia in three wavelength bands L, C and X were used. For this test site the quite authentic and exact terrain maps are available, and the results of researches are checked easily with use of the ground measurements.

The digital map created with use of a hierarchical method, including three stages. At the first stage the interferometric pairs of L-band were used for formation of a rough digital map on all region. At the second and third stages the interferometric data obtained by C and X radar channels were used in order of sequential specification of an initial produced DEM for those areas where interferogrames did not contain of a phase noise with critical level. For X-band phase images such areas appeared more less than for C-band ones, however the accuracy of relief restoration for X frequency data is better. In the report a overall technique used for interferometric data processing is resulted. All stages of processing was carried in temporary area without use of frequency transformations and FFT algorithms.

Also the used algorithms of phase unwrapping are considered for areas of test site with low and high levels of phase noise. For sites with a low level of phase noise a Laplacian based algorithm was used, ensuring fast processing with rather high quality. For sites where the level of phase noise exceeds value 2Pi a LMS Non-Iterative algorithm was used, requiring of the significant temporary expenses and machine computing resources. In the report the main features of the offered algorithms are discussed.

For recalculation of an absolute phase values (in radians) to relief topographic heights two methods was used consistently.In the first method for rough account as the basic input data parameters of platform orbit and surveylances characteristics, contained in the accompanying information to the images were used. At the second stage for exact recalculation a ground control points with well known heights over a reference surface were used.

The results of processing show good efficiency of the used methods for the decision of a topographic tasks as one of possible application of the SAR spaceboard imagery.

SMALL SATELLITES: A NEW SPACE VIEW ON THE TROPICAL ENVIRONMENT

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ABSTRACT

In this paper, we will introduce a concept for a small satellite mission to provide data which is complementary to the radar data which is becoming available from the radar system. It is well known that the major interest of radar imagery to the remote sensing community resides in the 24 hour and all-weather availability of SAR images. Radar digital data enhances certain features important to end users for application in forestry, agriculture etc. Radar data have the advantage of being intrinsically related to the internal properties (water content, dielectric constant etc.) of each target. Consequently, they are the ideal complement to the optical data, which is usually related to surface properties, to provide a very appropriate tool for the mapping and identification of terrain features. Spar Aerospace, in collaboration with university and potential end users, has conducted initial investigations which have identified the potential of small optical remote sensing satellites to fulfill tropical region missions as a complement to radar missions. Following this investigation, Spar has established a small satellite mission concept, fully dedicated to resource management, specifically forest covers in tropical regions. This mission has the following characteristics: precision, data reliability, repetitivity and in particular, economy which allows the data to be affordable and accessible to end-users. The system baseline is to supply precise operational vegetation cover measurements while minimizing extraneous effects due to atmosphere, optical properties of bare soils etc. The radar/optical combination opens new avenues for the study and the understanding of environmental problems and the management of vegetation covers in particular for the tropical regions. In those regions, the climate is characterized by particular conditions, combining heavy rainfalls with high level of humidity. These climatic conditions, on one hand, favour vegetation growth, while, on the other hand, limit the usefulness of optical satellites due to the high probability of obscuration by cloud. In this paper, we will present the spatial, spectral and orbital characteristics of the new system which, by providing an additional source of optical data, will make a significant contribution to improving the availability of optical data for the tropical regions. The problems related to radiometric and atmospheric calibration as well as potential applications and complementarity to radar data will also be presented.

LES PETITS SATELLITES : UNE NOUVELLE VUE DE L'ESPACE SUR L'ENVIRONNEMENT TROPICAL

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RÉSUMÉ

Nous présentons dans ce papier un concept de petit satellite optique complémentaire aux données radar qui sont devenues disponibles à partir des satellites radar. En effet, l'intérêt majeur de la télédétection radar réside au niveau de l'observation de nuit comme de jour indépendamment de la couverture nuageuse et des précipitations. Les données radar augmentent certainement l'intérêt des utilisateurs de ce type de données numériques pour les applications forestières, agricoles, etc. Ainsi, les données radar ont l'avantage d'être beaucoup plus liées aux composantes internes de la cible observée (teneur en eau, constante diélectrique, etc.). Par conséquent, elles constituent un ajout très pertinent aux données optiques (qui se limite aux propriétés de surface de la cible) pour former ensemble un outil très approprié pour la cartographie et l'identification des objets sur le terrain. En collaboration avec le milieu universitaire et les usagers potentiels de la télédétection, une première investigation a permis à Spar d'identifier le potentiel des petits satellites pour remplir certaines missions de télédétection optique dans les régions tropicales pour la complémentarité des données radar. À la lumière de cette étude, Spar Aérospatiale a mis au point le concept d'un petit satellite dédier à la gestion des ressources terrestres, principalement les couverts forestiers dans les régions tropicales. Les caractéristiques de ce petit satellite sont la précision, la fiabilité des données, la répétitivité et surtout, le facteur économique qui doit être abordable et accessible aux utilisateurs. Le concept de base de ce satellite est de fournir des mesures précises et opérationnelles sur les caractéristiques des couverts végétaux en minimisant les effets extérieurs (atmosphère, propriétés optiques des sols nus, etc.) sur le signal issu de la végétation. La combinaison radar/optique ouvre des perspectives pour l'étude et la compréhension des problèmes environnementaux et la gestion des couverts végétaux en particulier dans les régions tropicales. Dans ces régions, le climat se caractérise par des particularités qui lui sont propres, des pluies abondantes combinées à des taux d'humidité très élevés. Ces conditions climatiques, d'une part, contribuent à la prolifération des couverts végétaux et, d'autre part, limite l'observation par satellite optique. Dans cette étude, nous présentons les caractéristiques spatiales, spectrales et orbitales de ce nouveau système qui sera une autre source des données optiques pour les régions tropicales. En outre, nous discutons les problèmes d'étalonnage radiométrique et atmosphérique, et nous présentons les applications potentielles et la complémentarité avec les données radar.

TECHNOLOGICAL RESEARCHES AND DEVELOPMENTS, REGARDING THE USE OF SAR-ERS DATA INDEPENDENTLY AND THE INTEGRATION OF THIS DATA WITH OTHER TYPES OF AERO-SATELLITE AND GROUND INFORMATION, AS WELL AS DETERMINING THEIR COMPLEMENTARITY; PERSPECTIVES TO USE RADARSAT DATA; CASE STUDY: DANUBE DELTA AND THE CONTINENTAL PLATFORM OF THE BLACK SEA

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ABSTRACT

We will make use of the unique characteristics of the RADARSAT data - mainly its adjustable viewing angle (we intend to use for our first studies a 23 deg. viewing angle, for comparison with the ERS-SAR data, already studied) and the HH polarization, having in view the following general ideas:

- the measurements - determinations taken over general and specific zones.
- working effectively in the pluri - and inter-disciplinary teams.

1. Making use of RADARSAT data independently, we will perform the following studies:
   - General and thematic mapping of the areas, including the enhancement B/W and color, thematic oriented;
   - Evaluate the vegetation indices, in real time system, for the specific deltaic vegetation, with large homogeneous surfaces, to determine the radiation's penetration (e.g. for reed, rush, by modifying the incidence angle);
   - Evaluate the moisture degree of the terrains and drought phenomenon in the diked areas,
   - Evaluate the land slides which occur on large areas and affect large zones;
   - Characterize the temporal changes detected in RADARSAT data backscatter for different classes;
   - Monitor the coastal and marine pollution;
   - We also have in view to study natural calamities, such as floods, earthquakes, land slides, etc.
2. Integration of the RADARSAT data with other types of data, by registration, synergism (fusion) and compatibilisation of these data;
3. Assessment of the degree of complementarity between the whole of the data, together with the determining of the intrinsic dimensionality for different thematics;
4. Some contributions regarding the data calibration / validation problem.

The Basic ideas consists of intensive radiometric measurements, taken as system profiles over sample areas with Exotech 100AX Radiometer (provided with Landsat MSS & TM filters, and we hope also with SPOT filters), linked with a PC 486DX computer with color display, for reducing to a minimum the number of satellite images needed; this aspect is of

great importance for East European countries, and of course for Romania; That is, contributions to remote sensing technology, adapted to restricted means.

The field and airborne radiometric profiles, taken at convenient times (seasonal data would be most convenient) must be positioned on aero-satellite images (seasonal data base) using different platforms and systems: towers, captive balloons, micro-airplane and in the future mainly manned airborne platforms provided with differential GPS (Global Positioning System) - kinematic mode.

Our main goal is to detect the changes inside of the homogeneous ecosystems, seasonal monitoring using repetitive aero-satellite recordings together with in-situ radiometric measurements.

The multiband and multipolarisation characteristics of the RADARSAT recordings may be a good complementary for multispectral LANDSAT - TM and SPOT to a better and more efficient thematic mapping.

The paper contains a rich illustration B/W and color.

In fact, our activity in the frame of the paper to be presented, is the result of our **ADRO proposal ID no 254.**

Establishment of a Relationship Between RADARSAT Imagery and Soil Moisture

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Abstract

Soil moisture is a key hydrologic state variable. For streamflow simulation it is a major unknown that must be inferred from observed streamflow and precipitation. The estimated soil moisture field tends to reflect errors in both these data sets. This seriously restricts the reliability of hydrologic model calibration and is an impediment to the application of the advanced hydrologic models needed for current water resources problems.

SAR imagery is often proposed as a potential source of soil moisture. Early truck mounted scatterometer studies showed strong relationships between soil moisture and backscatter for bare surfaces. The series of OXSOME experiments showed that this correlation exists in C-band imagery. Our pervious work has confirmed this for ERS-1 C-VV imagery. During this experiment we hope to demonstrate that a similar relationship exists between soil moisture and backscatter in RADARSAT imagery.

Our study area is located in the Upper Grand River watershed upstream of Cambridge, Ontario. The land cover is generally low relief agricultural land with a highly variable vegetative surface cover, with forest, barren land, crops, marsh, water areas and urban centres. We have identified 16 pasture fields in the basin which are being used as index fields. These are horse and cow pasture which have relatively uniform roughness characteristics over the basin. They are generally not subject to crop rotation and are suitable long term targets.

Our initial expectation was to gather 18 images for the period from April 1 to November 20, 1996 in order to study a broad range of moisture conditions. However, we were only able to acquire 6 images from September 8 to November 19. Hence the images all represented times when the soil condition was very wet and we will have to supplement our study with images from next year when the soil is dry. During the dates of the imagery we carried out ground surveys in the index fields using grab samples and TDR systems to establish soil moisture.

Preliminary within scene relationships between soil moisture and backscatter are presented. If calibrated imagery becomes available, between scene results will also be shown. The current results are compared to those using 1993 ERS-1 imagery of the same fields.

Based upon the imagery received to date we can conclude that a correlation exists between soil moisture and the RADARSAT imagery. However, refinement of this relationship will have to be established when imagery collected under a broader range of moisture conditions is available.

Investigation of Influence of Radar Sensing Parameters on the Radar Reflection Characteristics of Moscow Region Forests.

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Abstract

The decision of problems of determination of parameters of forests the account of regional peculiarities is required. Important factor is a choice of parameters of radar sensing and in particular of a angle of sensing. In work the radar reflection characteristics of wood of national park Losiniy ostrov and Schelkovo region are investigated. The data base of forest parameters for this sites are used. The SIR-C SAR images for various polarizations and incidence angles are considered. The calibrated radar data are received from JPL, NASA . A problem about a choice of optimum parameters of radar sensing for the decision of problems of determination of wood parameters are considered.

Image Modelling of Forest Changes Associated with Acid Mine Drainage using a Cellular Automata Transition Model - KamKotia Mine Site, Timmins, Ontario.

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Preferred Topic: Environment and Climate
Preferred Format: Poster

Abstract
A planar cellular transition model is proposed as a predictive methodology for modelling tree population dynamics along a chemical contamination gradient. A brief review of raster modelling is provided, showing how non-deterministic automata through the incorporation of cell neighbourhood regions are a natural extension of Markovian models. The advantage of automata modelling is that during iterative derivation and application of temporal transitions it conceptually maintains continuity of structure (edge and contagion) amongst the raster cells. This characteristic is a necessity for the modelling of dynamic phenomena such as disease spread, forest blow down, and competitive growth. This stochastic approach was applied to a mixed forest area proximal to an unconfined, abandoned acid mine tailings in an attempt to model effects from acid drainage, airborne contamination, and wind fall. Data for the model consisted of black and white photography from the period 1946 to 1991 at scales from 1:15,840 to 1:70,000. The images were scanned to produce a ground pixel size of 0.42m and then tonally segmented to identify tree clumps. A population estimate was then extracted at varying diffusion distances from the de-vegetated fringe. The trees and their closest neighbour configurations were compared between image dates and tallied to generate a transitional probability matrix indicative of new growth, death, and steady state transitions. Transitional estimates were then modelled for differing iteration intervals and the resulting distributions were compared to reference imagery for each period of forested areas affected only by natural succession. Preliminary transition results between image dates show that tree population stability decreases and canopy openness increases as distance from the tailings edge decreases. Possible enhancements to the modelling process such as cell neighbour distance weighting and normalization by a hypothetical maximum regeneration interval density are discussed.

DETERMINATION OF MIXED BOREAL FOREST STAND BIOPHYSICAL STRUCTURE USING LARGE SCALE AIRBORNE DIGITAL CAMERA IMAGERY

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Preferred Topic: Environment and Climate
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Abstract. Forest biophysical parameters such as plant area index (PAI), canopy openness, stand basal area, stand height, and species composition are important descriptive measures for quantifying forest structure. Previous attempts to model stand biophysical structure using remote sensing have been limited to relatively homogenous stands of black spruce (*Picea mariana*) or jack pine (*Pinus banksiana*) and have tended to use imagery with lower resolution than the individual tree level (e.g. 1-30 m). However, in many boreal regions a more typical mixture of the boreal dominants: trembling aspen (*Populus tremuloides*), black spruce, white spruce (*Picea glauca*), balsam fir (*Abies balsamea*) and jack pine often occurs rather than pure (homogenous) stands. This mixed forest situation presents a much different scenario for model development.

Using airborne colour infrared digital camera data with 0.25m and 0.5m pixels, a model was developed for determination of the relative areal proportions of the radiometric fractions: sunlit canopy, sunlit background, shadowed canopy, and shadowed background. Fifteen structurally diverse 400m^2 plots were analyzed from several view angles using both visual interpretation and digital techniques. Statistical relations between the area proportions of the radiometric fractions and the measured forest stand parameters of PAI, canopy openness, stand basal area, stand height, and species composition were determined.

Results from this study support the use of stand radiometric fractions as a potential method to infer stand structure in a mixed forest situation. High resolution digital camera data can aid in the delineation of the relative aerial proportions of the radiometric fractions, which are traditionally very difficult to determine in a mixed forest stand. This research demonstrates that low cost airborne digital camera imaging coupled with simple modeling of image structure is a viable alternative to more expensive multiband remote sensors and sophisticated spectral modeling for determination of mixed boreal forest stand structure.

CARTOGRAPHIE DES CHAMPS THERMIQUES DANS L'ENVIRONNEMENT DES STATIONS MÉTÉOROLOGIQUES À PARTIR DES IMAGES NOAA-AVHRR

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RÉSUMÉ

La température de l'air sous abri est une importante variable climatologique et l'information sur sa distribution spatiale est d'un grand intérêt pour divers disciplines scientifiques. La faible densité spatiale des stations à l'intérieur des réseaux météorologiques entraîne des erreurs relativement grandes durant l'interpolation des données et rend difficile la délimitation du patron spatiale des températures.

La présente étude vise à évaluer les possibilités de cartographier la distribution spatiale de la température de l'air autour des stations météorologiques de surface à l'aide NOAA-AVHRR images.

L'analyse a portée sur 25 stations météorologiques et un ensemble d'images NOAA-AVHRR pour les années 1989, 1990 et 1992 ainsi que pour un ensemble d'images et d'un contrôle terrain en décembre 1996 pour l'Andalousie en Espagne. L'environnement de chacune des stations a été décrit dans le détail. L'analyse spatiale de la température maximum de l'air (Ta) et de la température de brillance de la surface (Ts) a été effectuée pour des fenêtres image de 11 x 11 Km^2 centrée sur la station. L'hypothèse alors retenue est que la température de l'air autour de la station est fortement reliée à la température de brillance (Ts) dans l'environnement autour de la station.

L'advection d'énergie en provenance des surfaces environnentes au point de mesure ainsi que la nature des échanges convectifs liés aux conditions atmosphériques vont conditionner la température de l'air. Ainsi la représentativité spatiale de la température de l'air mesurée en un point du territoire va être conditionnée par le cadre environnemental (altitude, type de surface, orientation de la station de mesure, morphologie du territoire et position du poste de mesure par rapport a un plan d'eau, zone urbaine, etc.) et synoptique (origine des masses d'air, vent dominant, conditions atmosphériques).

Considérant que les données disponibles ne sont pas directement intereliées, il est alors important de trouver une façon de les rendre compatibles contenu du fait qu'elles peuvent expliquer individuellement les variations spatio-temporelles de la température de l'air.

Il est donc important de considérer dans un premier temps la mise en conformité spatiale des données en fonction de la variabilité spatiale observable de Ta. Pour nous aider a déterminer cette échelle nous avons eu recours aux images satellitaires NOAA-AVHRR au niveau des bandes thermiques. La tenpérature de brillance (Ts) qui est alors extraite des

images représente les conditions thermiques apparente au niveau du sol pour une échelle spatiale correspondant à la taille des pixels soit 1 km.

La représentativité spatiale des températures de l'air mesurées à la station a ensuite été effectuée en considérant l'influence de la topographie et le cadre environnemental et météorologique. Cette analyse à alors permis de générer des cartes de représentativité spatiale des stations de surface pour la température de l'air pour le sud de l'Espagne en Andalousie. Le défi actuel demeure la régionalisation spatiale de Ta à partir des réseaux de mesure.

IMPORTANCE DES DONNÉES SATELLITAIRES POUR LA RÉGIONALISATION ET L'OPTIMISATION DES RÉSEAUX MÉTÉOROLOGIQUES DE SURFACE

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RÉSUMÉ

L'utilisation d'outils géomatiques permet une meilleure intégration spatio-temporelle des données météorologiques au sol ainsi que celles acquises, en provenance d'autres sources et de format différent comme les données satellitaires NOAA et GOES, les données physiographiques (cartes, MNT, et autres), les sorties des modèles météorologiques (MC2, CGCM), et autres. La modélisation spatio-temporelle des données météorologiques et environnementales pour l'optimisation des réseaux de mesure implique l'estimation des paramètres agrométéorologiques en tout point du territoire. La géomatique par l'intermédiaire de la télédétection, des systèmes d'information géographique (SIG) ainsi que les systèmes à référence spatiale s'avère être la meilleure voie pour l'optimisation et la régionalisation des réseaux météorologiques.

La présente étude vise à démontrer qu'à l'aide de la géomatique (télédétection, SIG et la cartographie) et en se basant sur le cadre environnementale et l'utilisation du territoire ainsi que sur l'ensemble des stations météorologiques (manuelles et automatiques) existantes, nous pouvons en optimiser l'utilisation et mieux régionaliser les mesures autour de la station. D'autre part, l'intégration des différentes sources de données à l'intérieur d'un SIG nous permet en combinaison avec les prévisions météorologiques de mieux actualiser celles-ci à une échelle régionale et locale.

Plusieurs études ont portées sur la régionalisation des besoins et des caractéristiques des variables météorologiques. Cependant en raison de la faible densité des réseaux météorologiques et la grande variabilité spatiale des variables météorologiques les techniques traditionnelles s'avèrent plus ou moins efficaces. L'intégration de l'information satellitaire avec les bases de données météorologiques issues des modèles et des réseaux de surface à l'intérieur d'un système d'information à référence spatiale (SIRS) pour fin de modélisation s'avère une avenue intéressante pour la régionalisation et l'optimisation des réseaux. Les paramètres météorologiques qui ont été considérés dans la présente étude sont la température de l'air minimum et maximum mesurée sous-abris. Au total 120 stations manuelles et 60 stations automatiques du réseau québécois, localisées dans la vallée du Saint-Laurent, ont été utilisées. Les données alors utilisées couvrent une période normale de 15 à 30 ans pour les stations manuelles alors que les données en provenance des stations automatiques ne couvrent que l'année 1994.

Afin de s'assurer d'une représentativité spatiale et temporelle uniforme des données nous avons considéré l'utilisation de descripteurs pouvant êtres extrait ou combinés aux images soit : la topographie, la végétation (classes, NDVI), la pente et l'utilisation du sol ont été retenus. Deux types d'images satellitaires ont été considérées soit NOAA-AVHRR et GOES. Ces images sont alors calibrées, corrigées et transformées pour obtenir la température apparente de la surface, l'albédo, la biomasse (NDVI), et les classes d'utilisation du sol à une échelle spatiale de 1 km. Leurs usages a été limités aux journées claires, sans nuages. Les mesures de surface ainsi que les paramètres extraient des images ont été combiné au modèle météorologique régional MC2 d'Environnement Canada. Cette intégration a rendu possible l'évaluation du réseau météorologique québécois de mesure, son optimisation ainsi que la régionalisation des paramètres mesurés. Les résultats ont aussi démontré que l'actualisation des prévisions météorologiques à une échelle régionale et locale est possible avec l'utilisation combiné des images satellitaires NOAA et GOES, et les modèles météorologiques

Nous vous présentons ici le système qui a été développé ainsi que les résultats que nous avons obtenu pour le Québec.

REGIONALISATION OF AIR TEMPERATURES USING SURFACE TEMPERATURES FROM NOAA AVHRR IMAGES TOGETHER WITH TERRAIN AND LANDCOVER DATA

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ABSTRACT

Air temperature is an important meteorological parameter, in particular in applied meteorology like for example in agrometeorology. Currently, various methods of spatial interpolation are used to retrieve this parameter for every point of a given area. These methods, however suffer from the low density of meteorological stations. In consequence, reported errors range from 1 to 3 K. NOAA AVHRR images, to the contrary, provide a complete spatial sampling of the surface skin temperature for pixels of about 1.1 km. The current research aims to investigate the potential use of these images in the retrieval of the air temperature field.

The study region is Andalusia in southern Spain. Some first analyses concentrated on a regression analysis between air temperatures (Ta) and surface temperatures (Ts) for 3 years of data. A mean number of 44 meteorological stations and 158 NOAA AVHRR images were used per year. The results showed that in 80% of the cases, we could predict Ta with a reasonable accuracy using Ts as an independent variable. The mean absolute error obtained with these regressions is in the order of 2 K. Subsequently, a cross-validation analysis was done and the mean absolute error for the prediction is in the order of 2.5 to 3 K. For some stations, the regression and the prediction from the cross-validation are both good. For some others, however, this is not the case, pointing to a specific local climate at these stations.

Since other variables like, for example, the altitude and the terrain form have an influence on the air temperature they should be considered. In order to explain part of the remaining error, we therefore try to predict the air temperature using not only the surface temperature but also additional information concerning the terrain, such as altitude, landcover, slope and aspect. The method applied is a multiple regression analysis between these variables. The results will give better information on the influence of these variables on the air temperature. The maps of air temperatures obtained from the resulting prediction model are compared with maps obtained from traditional interpolation method.

ANALYSE MULTI-ÉCHELLE DE LA DISTRIBUTION SPATIALE DE LA VÉGÉTATION D'UN MILIEU DE TOUNDRA ALPINE

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RÉSUMÉ

Les biômes alpins, sont particulièrement sensibles aux changements climatiques. Dans le contexte actuel de changements globaux, à l'échelle de la planète, il devient important de prévoir l'impact qu'auront ces changements sur la distribution spatiale de la végétation de la toundra alpine de Niwot Ridge, au Colorado. Nous tenterons de préciser l'importance de chaque variable environnementale (pente, orientation, convexité des pentes, etc.) sur la distribution spatiale de la végétation et d'identifier les combinaisons de variables qui permettraient de simuler l'impact d'un changement climatique sur la végétation de toundra alpine, pour une courte période de temps. Par ailleurs, nous tenterons de vérifier si l'introduction de sites d'entraînements, seulement, permet d'obtenir des résultats similaires à l'utilisation des images complètes comme variables d'entrée. L'étude tentera aussi d'évaluer si une certaine résolution spatiale est plus appropriée pour l'analyse de ces variables environnementales.

Les bases de données des systèmes d'information géographiques sont maintenant couramment exploitées pour les études multivariées et l'analyse d'informations écologiques à caractère spatial. Le logiciel PEGASE, basé sur la théorie de l'information mutuelle, est utilisé pour déterminer la relation végétation-variables environnementales. Les variables sont réorganisées en classes et introduites dans PEGASE. Plusieurs essais, permettront de s'assurer que le nombre de classes utilisées n'introduit pas de biais. Nous utiliserons des résolutions de 30-m, 20-m, 15-m et 10-m afin de déterminer l'influence de la résolution spatiale sur les résultats obtenus, selon l'information supplémentaire qu'elle apporte, la qualité des résultats et les similarités entre les combinaisons de variables sortantes. Dans un premier temps, les images entières sont utilisées, alors que dans un deuxième temps, on introduit quelques sites d'entraînements seulement. Les résultats des analyses seront comparés à une carte des communautés végétales de la toundra alpine de Niwot Ridge. La connaissance de ces variables environnementales permettra aux analystes de développer des modèles de plus hautes précisions, afin de visualiser le déplacement de la végétation dans l'espace, advenant un éventuel changement climatique.

L'INDICE DE DÉVELOPPEMENT CARTOGRAPHIQUE (I.D.C.) APPLIQUÉ AUX PAYS EN VOIE DE DÉVELOPPEMENT

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RÉSUMÉ

Les pays en voie de développement (P.V.D.) connaissent diverses difficultés en matière de cartographie et ce à des degrés différents. Que ce soit par exemple au niveau de la disponibilité des documents cartographiques, de la désuétude, des échelles disponibles, de la superficie couverte, de la dépendance étrangère, du personnel affecté, des budgets disponibles, ou encore de la diversité des thématiques abordées. Certains ouvrages présentent une description de la situation, nous pouvons mentionner à titre d'exemple les travaux des Nations Unies (La Cartographie Mondiale), de Larsgard (1991), de Parry et Perkins (1987), de O.S. (1996), ainsi que ceux de Böhme et Anson (1991). Ces derniers offrent un portrait cartographique par pays ou encore par continent, par contre ils ne permettent pas de classifier systématiquement les pays entre eux.

L'objectif du présent projet repose sur le développement d'une approche méthodologique permettant la caractérisation en matière de cartographie par la création d'un indice de développement cartographique (I.D.C.). Cet indice, quoique différent de l'I.D.H. (indice de développement humain) de part sa vocation, se veut un outil permettant de caractériser adéquatement l'état de la situation d'un pays en matière de cartographie dans le but d'établir des comparaisons et ainsi offrir une meilleure compréhension de la cartographie des PVD.

Ainsi dans le cadre de travaux antérieurs nous avons inventorié, à partir des sources mentionnées, l'ensemble des documents cartographiques produits et ce en y intégrant au-dessus de trente paramètres. Cet inventaire a été réalisé pour l'ensemble des pays du continent africain et sud-américain, pour ce qui est du continent asiatique celui-ci devrait être achevé durant l'année 1997. De l'inventaire produit nous avons été en mesure d'identifier quatre paramètres jugés prioritaires en matière de cartographie, soit les échelles disponibles, le pourcentage de superficie couverte, le nombre de thématiques abordées ainsi que les dates de parution. De plus ces paramètres ont été pondérés afin de tenir compte des caractéristiques propres des pays traités.

Par la suite en combinant ces quatre paramètres il a alors été possible d'en arriver à un système de classification caractérisant plus finement l'état de la situation en cartographie. Il importe de mentionner que ces quatre paramètres ne peuvent être traités de façon indépendante, en fait une relation étroite existe entre ces derniers.

Nous croyons que cet apport méthodologique permettra d'identifier plus adéquatement les pays où l'aide pour le développement cartographique devra être soutenue et amplifiée.

MISE SUR PIED D'UN SYSTÈME D'INFORMATION GÉOGRAPHIQUE SUPPORTANT L'ÉCOLOGIE INDUSTRIELLE, DANS LA RÉGION DE SOREL-TRACY, QUÉBEC

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RÉSUMÉ

Les déchets industriels peuvent être réintégrés à la production pour éviter d'être rejetés dans l'environnement. On appelle "écologie industrielle" le principe selon lequel la vente ou l'échange de résidus de fabrication ou de consommation constitue une source de revenus additionnelle pour une industrie et une façon de diminuer les impacts néfastes de la production sur l'environnement. L'écologie industrielle aborde les problèmes environnementaux sous une approche systémique, s'inspirant des écosystèmes naturels, de façon à optimiser les cycles de vie des matériaux et des sources d'énergie. Dans la pratique, cela se traduit par un réseau d'industries, dans lequel les rejets des unes deviennent la matière première des autres.

D'une façon globale, notre projet vise à mettre en place un outil pour la planification, l'implantation et la gestion d'un réseau de producteurs industriels. La dimension spatiale dans l'établissement d'un tel réseau étant prépondérante, la convergence des SIG et de l'application des principes de l'écologie industrielle s'avère toute naturelle.

Le système d'information sert à identifier les fabricants qui pourraient s'échanger, sur une base de vente et achat, des matériaux en fonction des produits fabriqués ou utilisés dans la production. Il sert à déterminer le meilleur emplacement pour un nouveau fabricant selon les potentiels d'échange et des critères économiques. Il doit enfin pouvoir tracer le meilleur parcours routier ou ferroviaire en fonction des contraintes à la circulation et des coûts.

Le système d'information traite des échanges à l'intérieur de la MRC du Bas-Richelieu et fonctionne dans un environnement Arc/Info. Sa mise sur pied se déploie en deux phases principales : la constitution de la base de données et le développement d'outils d'analyse. Au cours de la première phase, les données structurées sur des composantes spatiales et non-spatiales sont incorporées au système d'information. Les premières localisent, entre autres, les entreprises, les réseaux de transport, le réseau hydrographique, les aires peuplées; tandis que les secondes concernent les matières et produits.

Dans la deuxième phase, nous élaborons des outils pour procéder aux analyses multicritères pour les choix d'emplacement et aux analyses de réseaux pour des choix de parcours. Pour ce faire, nous développons de nouvelles méthodes algorithmiques intégrant des critères géographiques, économiques, environnementaux et sociaux. Le système proposé pourra être utilisé lors de la reconception de procédés et la construction de nouvelles usines ou encore pour trouver de nouveaux usages à des infrastructures inutilisées, dans l'optique de maximiser les bénéfices économiques et environnementaux.

BILAN SPATIAL DE LA BIODIVERSITÉ DU SAINT-LAURENT À L'AIDE D'UN SYSTÈME D'INFORMATION GÉOGRAPHIQUE

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RÉSUMÉ

L'inventaire spatial de la biodiversité constitue l'un des objectifs du programme «Bilan de la biodiversité» du Plan Saint-Laurent Vision 2000 d'Environnement Canada. Afin de réaliser cet inventaire, nous avons réuni des données, provenant de diverses sources existantes, et les avons intégrées dans un système d'information géographique. La base de données est composée de trois segments principaux : l'information topographique, l'information sur le vivant et l'information sur le milieu physique. Elle concerne trois milieux : aquatique, côtier et terrestre (bordier).

Sept feuillets topographiques à l'échelle du 1 : 1 000 000 provenant de la carte numérique *Digital Chart of the World* ont été assemblés et découpés pour servir d'assise à la base géographique. Les données sur le vivant ont été obtenues de diverses sources : bases de données numériques existantes (base sur les poissons de fond de Pêches et Océans Canada, base EPOQ sur les oiseaux, etc.), études scientifiques sur le Saint-Laurent, études d'impacts, etc. Les données retenues ont été saisies selon deux modes : leurs composantes spatiales ont été localisées par numérisation cartographique tandis que leur composantes descriptives (espèce, abondance, date, qualité de l'information, etc.) ont été placées dans un tableau de données relié aux cartes par un système d'identifiant unique.

Les données sur le milieu physique ont également été produites à partir de diverses sources. Trois type de découpages territoriaux ont résultés de l'analyse de données topographiques, géologiques, géomorphologiques et climatiques selon une approche de cartographie écologique : les unités physiographiques terrestres, les éléments de trait de côte et les paysages marins. Chacune des unités est décrite par les variables ayant servies au découpage et à partir également de variables complémentaires comme la salinité, la température des eaux, etc.

Toutes ces données ont été analysées selon deux modes. D'abord, nous avons cherché à caractériser la biodiversité actuelle selon deux types de découpages spatiaux : arbitraire (cellules carrées de dimension variable) et systématique (selon les divers découpages issus de la cartographie écologique) par le biais d'analyses statistiques qui serviront à identifier les «points chauds» de la biodiversité actuelle du Saint-Laurent. Par ailleurs, d'autres analyses serviront à caractériser la diversité écologique d'après des critères physiques. Nous explorerons de plus les liens entre diversité écologique et biodiversité. MapInfo et

CARTOGRAPHIE FORESTIÈRE AUTOMATISÉE À PARTIR D'IMAGES SATELLITALES D'UNE RÉSOLUTION DE UN ET QUATRE MÈTRES ET DE DONNÉS AUXILIAIRES

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RÉSUMÉ

Au moins trois nouveaux capteurs satellitals fourniront dès 1997-1998 des images de un et quatre mètres de résolution, respectivement dans les modes panchromatique et multispectral. L'exploitation automatisée de l'information accrue apportée par ces images pour des fins de cartographie forestière ne sera possible que si des méthodes de traitement adaptées à ces résolutions sont mises au point. Pour en tirer plein profit, nous avons donc développé une approche de traitement basé sur l'analyse spectrale et texturale, ainsi que sur la modélisation écologique à partir d'un système d'information géographique.

Notre approche intègre à l'heure actuelle trois composantes de traitement, une analyse spectrale basée sur la classification par maximum de vraisemblance et l'interpolation pour identifier les espèces forestières, une analyse texturale basée sur le calcul du demi-variogramme directionnel pour estimer la taille des arbres et la densité des peuplements, et une analyse de la carte topographique numérique au 1 : 20 000 afin de dériver la pente, l'azimut des versants, la situation topographique et la distance à partir des étendues d'eau dans le but de générer des probabilités d'occurrence à priori pour chacun des types de peuplements forestiers.

La présente étude a consisté à appliquer cette approche intégrée à des données-image simulées. Nous avons, pour générer ces dernières, recréé une maquette informatique tridimensionnelle des arbres formant les peuplements d'une secteur forestier situé en Abitibi, Québec. La carte forestière numérique au 1 : 20 000ième de cette zone a été utilisée afin guider la plantation des arbres virtuel. Une image multispectrale ainsi qu'une image panchromatique ont été générées à partir d'un modèle d'illumination et de la maquette informatique. Les algorithmes d'identification des espèces et d'estimation des paramètres de structure de la forêt ont été appliqués à ces images de synthèse. Un modèle de prédiction du type de forêt en fonction des caractéristiques écologiques stationnelles a de plus été construit à partir du modèle numérique d'altitude de la zone d'étude et de la carte forestière. Les trois composantes de l'approche ont été intégrées afin de produire une carte forestière «déduite» qui a été comparée à la carte forestière «vraie» ayant servi à générer les images de synthèse. Les résultats démontrent que les nouvelles images satellitales contiendront une information qui facilitera la réalisation de cartes forestière à grande échelle.

COASTAL CHANGE DETECTION THROUGH RADARSAT IMAGERY

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ABSTRACT

On September 5, 1996, Hurricane Fran struck the North Carolina coast at Cape Fear (34°N, 78°W). The storm caused widespread damage to low-lying areas and significant modification to the shoreline and nearshore morphology. We acquired a RADARSAT ascending Fine 5 mode single look complex image of the coastline 100 km north of the centre of the storm track on June 7, 1996, and again on October 5, 1996 in an identical imaging geometry. Examination of these figures shows evidence of much shoreline erosion, sandbank migration, flooding and destruction of shoreline structures such as piers and wharves.

Standard image processing techniques for change detection fail to work efficiently on this pair of images due to the automatic gain control on the satellite. We discuss the problems encountered with the traditional approach of histogram modification and subtraction and show how a pseudo-colour methodology allows both a qualitative and quantitative assessment of the change between the images.

Image differences are attributable to three main causes: changes which are a direct result of the disaster, expected changes due to natural processes unrelated to the hurricane, and those due to the statistical variability of microwave backscatter. We show how, in principle, it is possible to separate these three causes and therefore use image pairs such as these for disaster assessment.

AUTOMATISATION DES PROCÉDURES DE MISE À JOUR DU RÉSEAU ROUTIER : RECALAGE DE LA CARTE SUR L'IMAGE À L'AIDE D'UN RÉSEAU DE NEURONES

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RÉSUMÉ

L'incorporation de procédures automatiques de mise à jour des cartes topographiques est nécessaire afin d'en réduire les coûts.

L'application d'une procédure développée au laboratoire de télédétection du département de géographie de l'Université de Montréal consiste à utiliser une vieille carte et une image SPOT panchromatique plus récente du même site. Deux étapes distinctes sont requises :
1. la mise en congruence des routes de la carte et de l'image; et,
2. la détection des nouvelles routes le long du réseau extrait à l'étape précédente.

Puisque des décalages non-systématiques pouvant aller jusqu'à trois pixels sont observables entre les routes de l'image et de la carte, la mise en congruence ne peut pas s'effectuer par une simple superposition de la carte sur l'image géoréférencée. L'accent a donc été mis sur l'élaboration de méthodes afin de réaliser cette étape essentielle de recalage. Tous les tests sont effectués en utilisant une image SPOT panchromatique de Charlesbourg, Québec et la carte correspondante à l'échelle du 1 : 50 000.

Dans un premier temps, une revue des travaux antérieurs porte sur une procédure employant des paramètres de l'image tels des valeurs de niveaux de gris, d'arêtes linéaires calculées perpendiculairement à la direction locale de la route et de stabilité relative de niveau de gris calculé dans la direction locale de la route.

Puisque ces paramètres sont difficiles à ajuster pour tenir compte de tous les cas possibles, une deuxième approche de recalage utilisant un réseau de neurones à rétro-propagation de l'erreur a été développée et mise à l'essai.

Cette procédure comprend quatre étapes :
1. L'entraînement d'un réseau de neurones en utilisant une centaine d'exemples et de contre-exemples, respectivement des fenêtres 5 par 5 de routes et d'éléments autres (sol à nu, forêt, maisons, etc.);
2. l'utilisation de la base de données cartographiques pour regrouper les routes afin de définir la forme de chaque intersection;
3. la recherche des intersections correspondantes sur l'image; et
4. le retraçage des routes selon les valeurs de décalage trouvées.

La recherche des intersections s'effectue comme suit. Chaque intersection de la carte est le centre d'une fenêtre 7 par 7 sur l'image. La forme définie par la carte est appliquée à chacune des 49 positions. Les pixels situés sous cette forme sont fournis individuellement au réseau de neurones qui produit une valeur d'activation pour chacun d'eux. Leur moyenne est ensuite calculée. Puisque le réseau a été entraîné à reconnaître les routes, l'emplacement réel de l'intersection correspond à celle des 49 positions possédant la plus forte moyenne.

EVALUATION OF RADARSAT DATA FOR COASTAL ZONE SENSITIVITY MAPPING IN NOVA SCOTIA, CANADA

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ABSTRACT

The project was initiated by AERDE under EOP3 in cooperation with the Government of Nova Scotia's Geomatics Centre and the Environmental Protection Branch of Environment Canada. The data for this project is part of a set of 17 RADARSAT S7 scenes acquired under the Federal-Provincial RADARSAT Memorandum of Understanding. We were able to identify and select a very low-tide data acquisition window for selected areas of the Bay of Fundy. RADARSAT promptly acquired the data at low tide regardless of cloud cover which tends to frustrate optical data acquisition efforts in time-critical situations such as capturing low tidal cycles. The evaluation of Standard Mode S7 data for several test sites along the Fundy and Atlantic coast was guided by information requirements established in Environment Canada's coastal zone sensitivity mapping (CZSM) program. Several ground reference data sets, including 1:10,000 color aerial photography, shoreline classification maps, assisted in the shoreline analysis. We also tested the ability of RADARSAT S7 data to detect the following features of interest to CZSM: human use/socio-economic resources; development wharves, breakwater, jetties (e.g. industrial sites, weirs, dams anchorages, marinas, slipways); recreation (recreational beaches); natural areas; extraction (e.g. fishing, shellfish harvesting, aquaculture, logging booms, logging access, agriculture); and urban (e.g. urban residential, shipping, transport). This paper details our digital image analysis approach which involved enhancement and classification procedures, as well as the development and execution of an evaluation procedure. Our discussion of the results highlights strengths and shortcomings of RADARSAT S7 data for CZSM in the geographic context of Nova Scotia.

MISE AU POINT D'UN INDICE CONTINENTAL D'ÉVAPOTRANSPIRATION APPARENTE ADAPTÉ AUX RÉGIONS INTERTROPICALES AFRICAINES

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RÉSUMÉ

L'évapotranspiration est un paramètre critique, à la base de l'équilibre hydrique, et, sous la forme d'énergie utilisée pour l'évaporation, de l'équilibre énergétique. Beaucoup de méthodes existent permettant de l'extraire à une échelle locale à partir de données météorologiques, mais seule la télédétection permet de l'évaluer à une échelle régionale. L'objectif de ce projet est de mettre au point un indice continental d'évapotranspiration apparente entièrement basé sur les données satellitaires et plus spécialement adapté aux régions intertropicales africaines. La méthodologie retenue a consisté en l'étude et la comparaison d'indicateurs déjà existants au niveau théorique suivi du choix d'une de ces méthodes, en fonction des données disponibles, de l'application ainsi que de l'objectif du projet. Différents modèles, tant partiellement (JACKSON, SEGUIN *et al.*) que totalement satellitaires (SØGAARD, CASELLES *et al*), ont été étudiés. L'approche de CASELLES *et al* a finalement été retenue car elle répondait le mieux aux objectifs de ce projet.

La région qui a servi de test pour cette étude est la partie centrale de l'Afrique de l'ouest. Les données satellitaires utilisées étaient les données NOAA-11-HRTP, couvrant de façon presque journalière cette zone pour l'année 1991. Les données-terrain, permettant la calibration de la méthode, étaient constituées d'une base de données météorologiques pour un ensemble de 35 stations réparties uniformément à travers la zone.

L'évapotranspiration potentielle a été calculée pour chacune des stations à partir des données météorologiques selon la méthode proposée par PENMAN. Les paramètres satellitaires correspondants ont été extraits sur 24 images réparties à travers l'année, de façon à couvrir le maximum de conditions climatiques possible. Des tests de corrélation et d'analyse des résiduelles ont été effectués montrant un faible corrélation entre l'évapotranspiration calculée aux stations et celle estimée à partir des données satellitaires. Cette faible relation s'explique principalement par le manque d'homogénéité du territoire, l'échelle utilisée, la représentativité limitée des données, la faible précision de la température de surface causée par le manque de données sur l'émissivité des sols ainsi que par l'importance de certains facteurs climatiques, comme le vent, qui ne peuvent être modélisés à partir des données satellitaires.

MULTIPLE INCIDENCE ANGLE RADARSAT DATA FOR TROPICAL FOREST MAPPING IN COLOMBIA

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ABSTRACT

Multiple incidence angle Radarsat data of the Murindo region of the Bajo Atrato province of Colombia are used to discriminate various forest types by their relative brightness versus incidence angle signature. The region is characterized by tropical rain forests. Studies are directed toward assessment of Radarsat potential for forest inventory and monitoring of natural and human environmental changes. Multiple incidence angle Radarsat data composite was created and compared with Multi-temporal ERS-1 data and SAR airborne data. The results indicate that different forest species may be better discriminated using multiple incidence angle Radarsat than multi-temporal ERS-1. This paper describes the methodology used to process and analyze the Radarsat images in order to extract the required information to create a forest cover map.

Wheat Yield Estimation in the Canadian Prairie using Climatic and Satellite data : An investigation into forecasting techniques

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Abstract

Wheat yield, in the Canadian Prairies, largely depends on the regional weather, which is characterized as drought-prone and is the main reason for high fluctuation (20 to 30 million tonnes) in annual wheat production. This high degree of variation poses difficulty in determining reasons for high fluctuation (20 to 30 million tonnes) in annual wheat production. This high degree of variation poses difficulty in determining export wheat price in an international market, which depends on the pre-harvest estimates of the production. Presently, the Canadian Wheat Board uses a regression model to forecast yield using temperature and precipitation data. This paper investigates the performance of other forecasting techniques such as time series analysis and pattern recognition, using both climatic and satellite (NOAA) data. The analysis presented in the paper finally leads to development of a practically viable and an improved technique to forecast pre-harvest wheat yield.

The Physical and Dielectric Properties of Wheat and Canola

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Abstract

The interpretation of SAR data for crop condition assessment requires a thorough understanding of the physical and dielectric properties of crop canopies. Intensive weekly physical sampling of wheat and canola canopies was conducted near Altona, MB. during the 1996 growing season (from emergence to harvest). Crop canopy sampling was stratified into four layers adapted to each crop type. Parameters measured per layer included, green and brown leaf area, wet and dry biomass (per plant component per layer), the measurement of individual plant components (lengths, widths, diameters), plant geometry and percent cover. Soil surface roughness and weekly volumetric soil moisture measurements were obtained. Complementary soil temperature data and all the components of the surface radiation and energy balance were collected at 15 minute intervals throughout the growing season. In this paper we present the results of these detailed physical observations and modelled electrical properties from the perspective of microwave scattering at 5.3 GHz. We review the salient physical and electrical characteristics of canola and wheat crops in Prairie Canada which give rise to the time series scattering as observed with RADARSAT and conclude with a description of how this research will be continued within the field seasons of 1997 and 1998.

On Links Between Snow and Ice Temperature Profiles and the Physical and Electrical Properties on Snow Covered First-Year Sea Ice

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Abstract

This paper characterizes the seasonal evolution of a snow covered sea ice temperature profile and its relationship to changes co-occurring to the physical and electrical properties of the volume. Snow and ice physical property data were collected from the Seasonal Ice Monitoring and Modelling Site (SIMMS'95) and the Collaborative-Interdisciplinary Cryospheric Experiment (C-ICE'96) near Resolute Bay, NWT during the 1993-1996 spring period. The snow/ice temperature profile is controlled primarily through the complex interaction of ambient air temperature, snow depth, snow density, thermal conductivity of the snow as a function of snow wetness and temperature, and ice thickness. In this paper we address the issues of characterizing the thermodynamic behavior of the snow/sea ice system for estimating the physical and electrical response of a snow covered sea ice volume. Specifically, the discussion focuses on developing a classification of the snow and ice temperature profile based on observed snow and ice temperature data during the seasonal transition. The rationale for this approach is so that we can begin to identify those physical mechanisms responsible for the seasonal migration of the profile. The physical basis for using the time series evolution of the microwave scattering coefficient (s=A1) from a synthetic aperture radar (SAR) for remotely estimating sea ice strength is then discussed. Results indicate that the profile is a highly dynamic phenomenon on both diurnal and seasonal time scales. Percent water volume in the snowpack and snow depth appear to be the most important variables in determining the timing of physical and electrical changes within the profile for wet and dry conditions, respectively.

Applying Variograms to the Modelling of the Spatial Patterns of Snow Distribution over Sea Ice.

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Abstract

Extensive research has been conducted on the snow distribution patterns over terrestrial landscapes, while surprisingly little research has focused on the snow patterns over an icescape. Snow distribution over different types of sea ice (first-year, multiyear and rubble ice in particular) has significant consequences on the physical, biological and climatological components of the marine cryosphere. The depth and distribution of snow controls much of the thermodynamic characteristics of the icescape as well as the radiative exchanges between the atmosphere and ocean.

In this study we model the snow distribution patterns over sea ice using snow depth data collected during the Seasonal Sea Ice Monitoring and Modelling Site (SIMMS'95) and the Collaborative Interdisciplinary Cryospheric Experiment (C-ICE'96) field experiments. Snow depth was collected at a spacing of 1 m in a 100 m x 100 m sampling grid. A geostatistical technique known as the variogram was used to model the snow distribution within the three different ice types. Variograms are used to estimate the spatial pattern of snow distribution using the theory of a regionalized variable. Our objectives were to determine the statistical pattern of snow distribution within these ice types, segment the ice types within synthetic aperture radar (SAR) images of sea ice, and then apply the variogram model of snow distributions to the segmented image.

Preliminary results show that all the first-year sea ice sites (FYI) snow distributions were modeled using a wave (hole-effect) model, which is the most appropriate model due to the periodicity in the snow drifts. For the multiyear (hummock/melt pond) and rubble sea ice sites (MYI (H/MP) and MYI (Rubble) respectively), the most appropriate models were a combination of a spherical and gaussian model. These models were the most appropriate because of the irregular snow distribution pattern produced by the irregular sea ice topography. Most of the models for all the sites were able to model more than 70% of the variability found within the data set, having nugget values less than 0.3 for the standardized variograms. We conclude this paper with a description of how we intend to segment the SAR images of sea ice so that modelled variograms of snow distribution may be applied at a regional scale.

Passive Radiometry and Snow Water Equivalence Estimation in the Arctic Archipelago.

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Abstract

This paper outlines the predictive capabilities of passive microwave radiometry in estimating snow water equivalence (SWE). Geophysical snow data and in situ passive microwave signatures were collected in the Canadian Arctic Archipelago during 1995 and 1996 under the Seasonal Sea Ice Monitoring and Modelling Site (SIMMS) and the Collaborative-Interdisciplinary Cryospheric Experiment (C-ICE). Surface based radiometer measurements were collected at 10GHz in 1995, and 19, 37, and 85GHz in 1996 (both vertical and horizontal polarizations). SSM/I data were obtained for the C-ICE'96 field season.

Results from this work show that the theoretical underpinning for estimating SWE from passive microwave signatures lies in dielectric theory. As the SWE increases (either through densification or added snowfall) the permittivity of the snow will increase, resulting in a decrease in emissivity. This in turn will lower the apparent brightness temperature recorded by the radiometer. Results with the surface based radiometer indicate a high degree of correlation between the passive signature and the SWE. Results from SSM/I indicate lower correlations. We conclude this paper with suggestions on how to improve the operational ability of SSM/I to forecast SWE within the marine cryosphere.

The use of SAR in defining ringed seal distribution and population indices

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Abstract

The most abundant Arctic marine mammal is the ringed seal, Phoca hispida. It is the smallest species of its genus, and has evolved physiological and behavioral adaptations that allow it to maintain a large Arctic geographic distribution (Smith et al. 1991). The aquatic phase permits foraging and mating, while the ice surface is required for birth and nursing. In addition, these nursing lair are situated within deep snow drifts which provide a moderate thermal environment for the pups. Often, these drifts are closely associated with deformational ridges. The ability to escape into the aquatic or surface medium provides additionalprotection against predation. Seals are capable of feeding on a variety of prey, and consequently their population distribution reflects oceanic productivity. Overwintering population densities of seals are also skewed towards landfast and stable first-year ice areas.

Systematic field surveys were conducted in Admiralty Inlet, NWT (April 2 - June 9, 1992) and in Barrow Strait, NWT (April 5 - May 8, 1995). Synthetic Aperture Radar (SAR) data were provided by the Canada Centre of Remote Sensing (CCRS) using the airborne platforms STAR-2 and the Convair-580. Physical measurements were collected on seal lairs to describe and quantify the nature of the ringed seal habitat, including snow depths, distance to the nearest ridge and the height and thickness of these associated features. In this work we evaluate the utility of SAR (in particular RADARSAT) as a means of developing a habitat suitability index (HSI) based on the morphology, consolidation andkinematic structure of sea ice in the Canadian High Arctic.

Submission to GER '97, *Geomatics in the Era of Radarsat*,
May 24-30, 1997, Ottawa, Canada

Spatial dependence characteristics of multi-scale remotely sensed imagery

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Preferred Session: New technologies, software, image processing
Preferred Presentation Mode: Poster

Since remotely sensed images are inherently spatial, examination of properties of local spatial dependence can provide insights into the characteristics of image data not revealed by traditional texture measures.

When spatial heterogeneity occurs, the characteristics observed within a window change systematically. for example, as the result of the presence of trend in the data or due to a change in the variance. In such circumstances, the nature of inter-pixel relationships can vary considerably. One way of examining such variation is to use local indicators of spatial association (LISA) measures.

One such statistic, the Getis statistic, $G_i(d)$, measures the extent and nature of the concentration of the sum of values associated with variable X in the region under study. By calculating the Getis statistic for a series of different distance values, it is possible to assess the degree of spatial heterogeneity at locations within an image.

When applied in remote sensing, LISA statistics may provide for the identification of anomalous regions within image space. The Getis statistic is tested upon Landsat and *casi* data to provide an indication of the extent of local spatial dependence in forest scene image data. In particular, the Getis statistic highlights image regions with significant spatial dependence with may then be assessed further. The Getis statistic may potentially act as a spatially dependent measure of image texture.

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Refinement of GIS forest polygon content with classified remotely sensed image data

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Leaf area index (LAI) is often estimated from remotely sensed spectral values using regression formulas based upon LAI as the dependent variable and a vegetation index as the independent variable. These regression formulas are created specifically for dominant cover types due to the differing spectral characteristics of the cover types. Knowledge of the forest cover type present in a particular image region allows for the selection of the most appropriate formula to be chosen to compute an LAI value to represent that location.

Forest polygon data in a geographic information system (GIS) enables refinement of the methodology of estimation of LAI. Forest stand polygon data may be overlain with geocoded spectral information from remotely sensed sources which enables the selection of a formula based upon the current species composition of a given polygon.

Use of forest polygon data has been shown to be poorly related to actual ground coverage which is in evidence in current remotely sensed imagery. Polygons are created to represent areas of homogeneity, which may involve mixtures of species. The spectral information which is extracted to represent the polygon therefore may not capture the actual species coverage characteristics. Accordingly, there is significant variability in estimates of LAI based upon how the polygon data is related to the remotely sensed imagery.

Data extraction from the GIS forest cover polygons may be increased in utility through integration of a supervised multispectral classification of the digital imagery. Introduction of a precisely geocoded cover type map produced from the supervised classification process to the GIS will allow for information at the sub-polygon level to be extracted. Spectral and textural information is collected to represent each cover type found in each polygon which allows for the assignment of the most appropriate equation in the estimation of LAI. An increase in the accuracy of LAI estimates is demonstrated with the sub-polygon cover type information utilized to suggest the most appropriate estimation equation.

High Resolution Sea Ice Albedo as Determined Using Low Level Aerial Photography and Surface Reflectance Measurements

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Session: Ice and oceans applications
Poster presentation preferred

The Arctic sea ice surface is extremely heterogeneous, especially during the spring melt season when the fractional coverage of melt ponds and residual snow cover are under constant evolution. Since regional scale albedo values can be influenced by local variations in ice type, snow cover, melt pond distribution and depth, high resolution imagery is necessary to accurately quantify variations in albedo.

In this study we use a coupled sampling scheme of low level aerial photographs and surface spectrometer measurements to investigate the surface heterogeneity of sea ice albedo through the spring melt period. A tethered balloon was flown at an altitude of 300 metres over a study site composed of both first-year and multiyear ice, collecting a time series of infrared photographs from June 6 to June 17. Coincident surface reflectance measurements were made at 20 revisited surface sites with an Analytical Spectral Devices Personal Spectrometer II. Spectra were separated into visible (400 to 700 nm) and near infrared (700 to 1000 nm) bands and surface albedo was derived. The albedo from each surface site was related to a pixel value from the corresponding aerial photographs, with the general relationship between pixel value and albedo isolated using regression analysis. This allowed the conversion of the pixel gray scale values to albedo which were then contoured to show the spatial variability of surface albedo inherent within one image. The entire time series of photographs were contoured to show change as melt progressed. Average image albedo was also calculated.

Results indicate an evolution in visible albedo values over first-year ice from 0.8 to 0.5 for residual snow cover, and 0.6 to 0.3 for melt features through the time series. Near infrared albedo values are consistently lower by approximatley 0.3 units. Multiyear ice albedo undergoes a transition similar to that of first-year ice, although the presence of deeper multiyear melt ponds can lower specific pond albedos significantly. The range of albedo values in one image was observed to narrow through the final stages of melt.

"IMAGE QUERY ASSISTANT"
UN OUTIL LOGICIEL D'AIDE À LA DEMANDE D'IMAGES

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RÉSUMÉ

Le concept IQA (Image Query Assistant) développé par Aerospatiale est celui d'un outil logiciel d'*aide à la décision* dans le domaine de l'imagerie spatiale.

L'objectif est de proposer un ensemble de solutions en terme d'images, produits et traitements, pour répondre à une demande d'information liée à un domaine d'application.

Le logiciel IQA est interrogé dans une terminologie liée au(x) domaine(s) d'application (l'environnement par exemple), en indiquant les informations thématiques recherchées. En outre, différentes contraintes peuvent compléter la demande (délais, coût, ...).

Le logiciel réalise alors une *analyse thématique*, dont le but est de définir des types de produits ou d'images qui permettraient de répondre à la demande. Les solutions potentielles sont évaluées selon un ensemble de critères thématiques.

La possibilité d'acquérir les données de chaque solution est ensuite analysée, en prenant en compte les contraintes de délai. Une *planification* indicative complète alors les solutions faisables. Elle permet d'estimer le temps minimum nécessaire pour obtenir les informations.

La fonction d'analyse thématique s'appuie sur la connaissance des applications et des potentialités de la télédétection spatiale. Elle est implantée par un système à base de règles. La fonction utilise une modélisation des missions d'acquisition. Elle est réalisée par une planification sous contraintes.

Un outil de ce type est particulièrement utile en contexte multisystèmes, pour proposer des solutions adaptées et innovantes, lorsqu'on dispose de différents types de capteurs, embarqués sur des porteurs différents. Aerospatiale a ainsi développé un prototype couvrant un large domaine de systèmes d'observations, mais pour une application restreinte.

La seconde partie de l'article propose une nouvelle adaptation du concept IQA, pour le choix des modes RADARSAT.

Le concept IQA, qui part du besoin thématique et non du besoin image, s'adapte particulièrement bien à ce problème, compte tenu de la richesse des produits proposés par RADARSAT d'une part, et de la méconnaissance qu'ont les utilisateurs des potentialités du radar d'autre part.

Dans ce contexte monosystème, les modèles utilisés sont dédiés au système, tant pour la thématique que pour la mission d'acquisition.

Poster Subject: Images of the Great Lakes Region of Africa

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Several of the RADARSAT-1 images acquired during the pre-mission and mission planning stages of the Canadian led humanitarian mission to the Great Lakes region of Africa will be presented in a manner that demonstrates the capabilities of RADARSAT-1 for terrestrial applications.

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Development of a GIS based Biodiversity Atlas for the littoral region of Lake Malawi, Africa.

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Abstract

The purpose of this study is to develop a digital biodiversity atlas for the nearshore area (NSA) of Lake Malawi, Africa as part of the Lake Malawi Biodiversity Conservation Project (LMBCP). This GIS based biodiversity atlas and its supportive relational database will provide a vehicle to understand, model, and extrapolate the spatial patterns of nearshore fish biodiversity through the integrated study of fish, fish habitat, and the physical processes which form and maintain nearshore habitat pattern and structure.

Due to Lake Malawi=D5s large size, a GIS modeling approach has been developed to achieve continuously distributed habitat and species maps for the entire nearshore area (0-34 m. depth). To produce the models which can facilitate such predictions, two types of field studies are being implemented. The first, called calibration studies, integrates data regarding substrate habitat structure, benthic primary productivity, and fish ecology data, and are implemented coincident in space and time. The second sampling protocol, called the extensive survey, focuses on the collection of site data around the lake's perimeter. As the emphasis for these surveys is spatial coverage, fewer sampling variables are collected.

In this research we report on the development of the biodiversity atlas. We describe the techniques used to integrate satellite remote sensing data for on shore habitat; acoustic sonar data for substrate habitat; and GIS models of fetch distance to estimate wave energy parameters. In-lake collections provide the benthic primary productivity and fish species diversity data. We conclude this paper by discussing the production of a series of models which statistically predict spatial biodiversity estimates (with associated probability maps) and explore measures of biodiversity and their interpretation at several spatial and taxonomic scales within the overall context of the Lake Malawi Biodiverisity Conservation Project.

Digital Elevation Modelling in Malawi

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Abstract

One of the requirements of the Lake Malawi Biodiversity Conservation Project (LMBCP) is to link terrestrial processes to near shore biodiversity within Lake Malawi. As a component of this requirement we require accurate estimation of terrestrial topography as an input to modelling erosion potential within all the watersheds of the Lake. In a natural resource spatial database, elevation, slope, and aspect are among the most important units because errors in elevation models will propagated through the database. The accuracy of these three units is evaluated for two digital elevation models (DEM) centered on Cape Maclear which separates Monkey Bay and Kasankha Bay at the Southern end of Lake Malawi, Malawi. The first DEM was constructed by manually digitizing contours from a 1:50,000 map of the Cape Maclear region published in 1986 by the Malawi Department of Surveys. The second DEM was produced from a 20 m Spot multispectral stereopair using the PCI Ortho and DEM package. The PCI DEM engine computes the geometry of the two images and then measures the displacement of matching pixels in the images. DEM accuracy was assessed for both models through the comparison of computer generated elevation values with field survey values collected using a Trimble Global Positioning System. Elevation error mean, average, and standard deviation were calculated for the digitized and stereo determined elevation models, and this data was compared to determine the more accurate model construction method. We conclude this paper with a description of the utility of DEM generation within a multidisciplinary study being conducted to assess the impacts of human activity on the biodiversity of Lake Malawi, Africa.

Cross-calibration of AVHRR with Landsat MSS data for suspended sediment mapping in large lakes.

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Abstract

Landsat MSS, Landsat TM or SPOT are commonly used in suspended sediment mapping because their high spatial resolution is appropriate to the scale of most lakes. However, where ephemeral sediment plumes are created by seasonal events like the spring runoff in temperate latitudes or the rainy season runoff of tropical regions, the high temporal resolution of the NOAA series is more likely to produce a usable series of cloud-free data. For large lakes, at 1.1 km at nadir spatial resolution, purchasing and processing costs are much lower for AVHRR data than for the 12 to 50 times higher resolution Landsat and SPOT data. However the lower spatial resolution of AVHRR data dictates a different sampling strategy for calibration studies.

In this study, Landsat MSS data previously calibrated on Southern Indian Lake, Canada, are used to develop sediment concentration relationships for mapping sediment from NOAA AVHRR data. At-satellite reflectances in the 0.6-0.7 um range for MSS data are correlated with suspended sediment concentrations at sample sites in a sub-basin of Southern Indian Lake and then used to map concentrations throughout the lake. The resulting MSS-derived sediment map is used to develop a correlation with at-satellite reflectances calculated for AVHRR 0.58-0.68 um data. Consistency of the relationship is tested by mapping of Lake Winnipeg sediments with both MSS and AVHRR data. We conclude this paper with a description of the utility of sediment plume mapping using AVHRR data within a multidisciplinary study being conducted to assess the impacts of human activity on the biodiversity of Lake Malawi, Africa.

PRELIMINARY ANALYSIS OF SPACEBORNE RADAR IMAGERY INTEGRATED WITH GEOSCIENCE DATASETS FOR CENTRAL NOVA SCOTIA

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ABSTRACT

The purpose of the project is to evaluate ERS-1, JERS-1 and Radarsat SAR imagery for geological information content for central Nova Scotia. In preparation for Radarsat imagery as part of an ADRO investigation, a regional digital dataset consisting of geophysics, elevation, geological and base GIS layers have been processed and integrated. The regional study area is significant because of a major geological terrane boundary of the Appalachians, Avalon to the north and Meguma to the south. The Carboniferous basins which overstep and flank the terrane boundary area (Kennetcook and Shubenacadie Basins) are the focus of detailed analysis. The basins have subsequently been deformed as a result of Late Paleozoic fault movement.

Upon the receiving of Radarsat data, ortho-rectification, mosaicking, and filtering are planned for four descending S2 scenes. A manual lineament analysis has been conducted on ERS-1, JERS-1, and a variety of different angles on shaded relief elevation data (1:50,000); the same procedure is planned for the Radarsat data. These lineaments will be used to conduct a quantitative comparison of the datasets. Frequency, length, and orientation will be evaluated and compared. Preliminary analysis reveals two main lineament trends: northeast and northwest. The northeast trends are parallel to major fault systems probably related to the terrane boundary. The northwest trends range from kink-folds to extensional fractures. The shaded relief and radar imagery have been merged with the geophysical (magnetic, gravity, radiometric, elevation) and geological data utilizing the IHS integration method. Similar hybrid geophysical images and lineaments have been used to interpret the geological and tectonic history of the St. Marys Basins and terrane interaction.

A mineral potential model aimed at Carbonate hosted base metal deposits will be constructed in a GIS for the detailed study area. The layers to be used in the model include: interpreted lineament and fault intersections, bedrock lithologies and specific geological

contacts, anomalous geochemical areas, and possibly geophysical parameters. The significance of each layer will be based on an exploration model and also by the spatial relationship to known mineral deposits in the area. It is hoped that the comparative analysis and interpretation of the radar imagery will lead to a better understanding of the utility of Radarsat data for geological applications.

INTEGRATION OF DIFFERENT RADAR AND OPTICAL DATA TO STUDY GEOLOGY AND PETROLEUM PROSPECTS OF SUBARCTIC AREAS OF RUSSIA

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ABSTRACT

The study of geology and petroleum prospects using different radar and optical data was carried out on the test site chosen to execute the Radarsat project. It is situated at the north-east of the Russian European part of Timan-Pechorian petroleum province in the tundra zone and covers the area of several petroleum traps with high petroleum potential. The integration of radar (Russian ALMAZ, Japanese JERS-1 SAR), multispectral (Russian RESURS - F and JERS-1 OPS), aerial photographies and geoscience data was made using technology and software developed at VNIIKAM for IBM-PC. The technology includes the creation of a Data Base, different operations with radar and multispectral images (production of color compositions, rationing, principal component analysis, classification), extraction and processing of landscape elements, such as different type of lakes, lineaments, which give an indication of geological structure, comparative analysis and correlation of the data. Radar data has become a significant tool for geological application especially at subarctic areas because it provides information regardless of weather and illumination conditions.

The results of analysis of radar imagery on its own as well as integrated with multispectral data have allowed to extract a new information on distribution of glacial Quaternary sediments, to correlate glacial boundaries with tectonic structure, to reveal framework faults and blocks controlling petroleum traps distribution, to study the expression of petroleum structures on the satellite data and to predict the location of prospective objects. The information on this test site will be supplemented by RADARSAT data.

INTÉGRATION DES DONNÉES MULTISOURCES (IMAGES TM, MNT, RÉSEAU HYDROGRAPHIQUE, LITHOLOGIE, VÉGÉTATION ET OCCUPATION DU SOL) POUR L'ÉTUDE DE L'ÉROSION DANS UN CONTEXTE SUBHUMIDE (TUNISIE DU NORD)

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RÉSUMÉ

Dans le cadre de l'aménagement intégré d'une zone montagneuse située dans les Hédils (Tunisie du Nord) les données de la télédétection spatiales (images TM multidates) ont été intégrées dans un système d'information géographique (SIG) avec un modèle numérique de terrain et ses différents dérivés afin de qualifier, quantifier et suivre les phénomènes de l'érosion hydriques amplifiés par un relief imposant (très accidentés) et une lithologie meuble et friable. Le couvert végétal assez dégradé ne joue pas pleinement son rôle de stabilisation. Aussi le caractère violent et irrégulier des précipitations ne fait qu'aggraver les conditions du décapage du sol.

L'intégration des données lithologiques, hydriques et topographiques ainsi que celles de l'occupation du sol ont permis de réaliser des cartes des zones à risques appelant une intervention urgente.

STUDY OF KIMBERLITES BY REMOTELY SENSED DATA PROCESSING AND INTERPRETATION

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The investigated area is well-known Arkhangelsk kimberlite region located in conjunction zone of Baltic shield and Russian plate. Kimberlite pipes here are covered by sedimentary rocks with thickness up to tens meters.

We carried out integrated analysis the following data :

- Russian satellite ALMAZ digital radar data (winter and summer seasons);
- Japanese satellite system JERS-1 OPS (7 bands);
- Russian satellite photographic system RESURS-F;
- topographic, geological and geophysical dataset.

To study role and place of kimberlite-forming stage at the geological history of the region a special technique of satellite images computerized processing and interpretation was elaborated.Integrated analysis of different spectral range RSD allows to obtain new improved structural information.

Morphostructural analysis allows to emphasized subtle delicate landscape reflection of kimberlite fields by separation of certain landscape elements. The scheme of density of landscape indicators inferred from images and topographic maps shows that all known kimberlite fields occure into area of higher summarized density oflandscape indicators.

Special purpose lineament analysis was applied. The general factor controlling kimberlite field location are different rank faults, some of them are latent and weakly reflected by landscape indicators and geological features. However the zones of dynamic influence of latent faults clearly reflect on combined characteristics of lineament fields and magnetic field features, which are stipulated by interaction of fold and fault deformations.

Circular structure with diameter about 50 km controlling more then 80 % known pipes was distinguished at Arkhangelsk region by special processing of field of certain lenght lineaments.

Relationship of kimberlite fields and isotropy characteris-

tics of lineament fields was distinguished. Analysis of azimuthal distribution trend of certain lenght lineaments by technique of round "moving window" reveals narrow relations between kimberlite field and sites of the crust with isotropic structure. Under analysis of isotropy degree of lineament field the N-W-trending rift-like zone with width about 35-40 km is clearly revealed. This zone play important role as kimberlite controlling factor but it was not distinguished by visual interpretation.

At the more detailed level kimberlite are controlled by small amplitude folds of sedimentary cover reflected deep-seated folded deformations.

The Application of Integrated Imagery and Geological Data in an Environmental Geoscience Mapping Program, The Oak Ridges Moraine, Southern Ontario.

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Abstract

The ORM Aquifer Complex in south-central Ontario is currently the focus of a multi-disciplinary, multi-agency environmental geoscience mapping project lead by the Geological Survey of Canada and the Ontario Geological Survey. Extensive digital geo-referenced thematic maps, satellite image products, a Digital Elevation Model, and surface and subsurface geoscience databases have been developed and forms an integral part of the geological mapping process.

To assist the materials mapping and landform analysis of this region, numerous image and thematic map integration techniques have been employed including, enhanced perspective views, chromostereo enhancements and IHS colour space enhancements. Specifically this paper will show examples demonstrating the geological mapping advantages of enhanced and integrated Landsat, RADARSAT, DEM and geology map composites.

DEM generation from stereoscopic SAR data

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Abstract

It has been established for many years that elevations can be calculated from stereoscopic SAR images. Leberl in particular has generated DEMs from aerial SAR images and from Shuttle Imaging Radar. A limitation of this procedure has been the problems of automatic correlation of the SAR data in order to generate a sufficiently dense elevation model. Work at University College London has developed automatic correlation algorithms to a point where 85% coverage can be obtained and by a careful study of the geometry and of the effect of errors in the raw data, an accurate DEM can be generated. This has been demonstrated with ERS data and currently RADARSAT data is being tested using the same algorithm.

The method used for stereomatching automatically determines seed points in the top layer of an image pyramid, these are then matched using the Gruen adaptive least squares algorithms in the top layers of the pyramid whilst in the finer layers the Otto-Chau region matching algorithm, developed from the Gruen approach, is used.

The final stage is the transformation of disparities to 3-D data. In the current work the method uses the range and Doppler equations for the two images to determine the co-ordinate vector of the ground point, using known satellite position and the satellite velocity. An uncorrected DEM produced by this method is of rather poor quality but the application of a constraint condition in the object space removes a large proportion of the error and produces a DEM with a root mean square error of about 20m in Z. A further refinement which can be applied is the use of a coarse DEM such as a one with a 1km spacing. This allows a good initial approximation to be used and hence a better final elevation. These results can be obtained without ground control points if accurate orbit data is available. If it is not then ground control can be used to improve the accuracy.

The method has been tested with ERS PRI and RTM (roll-tilt mode) data with good results and is now being tested with RADARSAT data which offers a much greater potential because the availability of variable incidence angles and the fine resolution data. Results will be presented from the matching and elevation determination with RADARSAT data over the CEOS test area over the Aix, Marseilles area in SW France and over areas of tropical forest in SE Asia.

Radargrammetric Evaluation of Radarsat SAR Data With Regard to Cartographic Applications

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Abstract

Satellite remote sensing data has been used in many investigations related to environmental mapping and monitoring. But, until now many of these applications are mainly in an experimental manner only. A major reason for this is due to the wide spectrum of image information to be analysed and the lack of appropriate processing methods and algorithms. This in particular concerns the treatment of image data acquired from SAR sensors, which have frequently rather peculiar geometric and radiometric characteristics.

Concerning cartographic applications, Radarsat seems to be a more promising tool in comparison to the steep looking ERS sensors, as it provides multiple imaging modes in different incidence angles and pixel resolutions. SAR layover effects should therefore be less severe in Radarsat scenes, at least in the more shallow imaging modes. Hence, these data should also be better suitable for mountaineous terrain applications, such as evidently present in the Austria alps.

In this paper, the potentials of Radarsat SAR data for high mountain applications are presented. Emphasis is put onto the analysis of the performance of the different imaging modes with respect to mountaineous terrain. The geometric as well as the radiometric performance of Radarsat data for stereoscopic applications shall be evaluated and compared to the one of other sensors like typically ERS-1/2, JERS-1 and SIR-C/X-SAR. Digital elevation models (DEMs) shall be generated from stereo measurements extracted from Radarsat image pairs by automatic image correlation techniques.

Based on the SAR stereoscopy derived DEMs and a map-derived reference DEM being available, geocoded images as well as other "value-added" products like simulated SAR images or layover and shadow masks are generated. An intercomparison of the various DEMs, of georeferenced data sets, and of the value-added products and real SAR data shall serve to comprehensively analyze the quality of the cartographic products generated from the Radarsat SAR data.

Relief Restitution by Radargrammetry Using RADARSAT Images: Examples in Indonesia and in French West Indies

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Adro Project # 274

ABSTRACT

Relief restitution by Radargrammetry is definitely operational using aircraft SAR images, nevertheless the use of satellite SAR images to obtain DEM by this method was not up to now fully satisfactory. This is due to the satellite features which were not dedicated to provide stereoscopic capabilities.

For example, in the case of ERS-1 and ERS-2, the low incidence angle (23°) generates layover, and shows stereoscopic effect only in the overlapping area (40% of overlap surface) of two images acquired on parallel orbits. The incidence angle difference is about 3° and then the theoretical height accuracy is not better than 30 meters. With the launch of RADARSAT, Radargrammetry using satellite SAR images will be more efficient and operational. However, this satellite has real stereoscopic capabilities, as a wide range of incidence angles are available (range from 20° to 60°). This allows to create large scale DEM (nearly 100 km by 100 km), with a theoretical height accuracy of better than 10 meters.

We developed in GEOIMAGE a Radargrammetric module, organized in five major steps: calibration of the data, i.e. we projected both images in an epipolar reference, radiometric improvements (global dynamic stretching, local contrast enhancement,...), matching of identical points in the two images in order to create a disparity map. (We developed an original correlation algorithm based on hierarchical correspondence of the characteristic structures shown in both images.) Finally, we converted the parallax difference in height and projected the DEM in a cartographic reference.

Two test sites were selected with a tropical forest cover. One is located in the north of Sumatra Island, Indonesia; the other in the Guadeloupe Island (French West Indies). On these sites there are few optical images available due to the dense cloud cover, and there is no accurate map or DEM over some Indonesian areas. We used two RADARSAT stereoscopic pairs combining an image with an incidence angle of 20° and an image with an incidence angle of 41°. We have computed two very coherent DEMs in order to assess in a final step the resulting accuracy. The associated ortho images were also computed.

RADARSAT images will give a new lease of life for the Radargrammetry, all the more that interferometry for relief restitution with repeat pass seems to reach a limit due to atmospheric perturbations.

SYSTEMATICAL CARTOGRAPHY OF THE NATIONAL TERRITORY AT 1:250,000 SCALE CORDILLERA PATAGONICO-FUEGUINA

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ABSTRACT

Within the framework of the National Program of Geological and Thematic Maps of Argentina, the basic geological cartography of the country at the scale of 1:250,000 is being performed, using topographic maps of the Military Geographical Institute. Particularly, in the Andean Cordillera between 40° and 55 ° LS (Patagonia and Tierra del Fuego), the existing rain forest coverage and the roughness of the area, hamper recognition of geological units. Due to these difficulties the remote sensors' data such as airborne geophysical (magnetometry -- radiometry), optical and radar satellite images are required.

It has been programmed airborne geophysics to be done during 1997, to cover the Cordillera Fueguina and partially the Cordillera Patagonica.

The analysis of the information from RADARSAT images, jointly with the analysis of the TM images will allow identification of main lithological units as well as structural features to reach an important degree of precision in the geological mapping of the area.

In addition to the stratigraphic and structural information, detection of target areas with mining possibilities, will be improved.

On the other hand, given the resolution of the radar information, it will be possible to accomplish a characterization of the potential geological hazards that could impact over economic projects and therefore produce the corresponding thematic maps applied to territorial planning.

ANTARCTIC NAUTICAL CHARTS UPDATING WITH SAR IMAGES

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ABSTRACT

Marine navigation in Antarctica requires updated and detailed nautical cartography. Satellite microwave technology allows to make precise mapping during all the year and in all-weather conditions. Synthetic Aperture Radar (SAR) produces images, where the relief results enhanced, and consequently little details, as obstacles and navigation risks turn up more evident. This Project try to integrate the bathymetric information (provided by hydrographic surveys) with SAR images, in order to obtain a better cartographic product. Coastal details, small islands, rocks and other perils will be mapped. This task requires a previous orbit schedule to select the opportunity of the data collection simultaneous with low tide situation. Two Antarctic zones are selected, according to Navy Hydrographic Service function and International Hydrographic Organization (IHO) planification : Palmer Island (W of Antarctic Peninsula) in 1:100.000 scale in a first stage, and Deception Island in 1:50.000 scale later. The image processing will contain speckle filtering, image geo referencing, image merging and overlapping of cartographic data. Two images of the same area are required for a good view of western and oriental coasts. Output charts will be incorporated in a Geographic Information System (GIS) to provide the geographical reference for antarctic environmental studies.

FOREST AND LAND COVER MAPPING FROM C-BAND SAR: APPLICATION FOR LARRACHE CORK-OAK FOREST, MOROCCO

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EXTENDED SUMMARY

Morocco's potentially rich natural resources have not yet been adequately mapped and classified for sustainable development. The country is presently designing various long terms strategic plans for natural resources development and environmental management purposes (agro-ecological national reforestation plans, etc.) This planning effort has been limited by the low production and spatial analysis of resource and environmental information which have not developed to the desired level. This situation is more critical in the mountainous regions and the remote rangelands. The conventional methods, bases on the use of aerial photography and extensive field survey, for land use mapping and monitoring are still very costly and time consuming. To meet this pressing demand for resource information Moroccan scientists have undertaken an intensive adaptive research program to determine the extent to which new remote sensing and GIS technologies can be used to assist the planners and the managers of the agricultural lands., especially the forests and the rangelands (over 85% of the country). The Moroccan GlobeSAR is one of these programs aiming to assess the most effective way of using satellite radar data for land use and forestry survey. This paper presents the preliminary result of this research project and which is connected to the international GlobeSAR project, a worldwide program of airborne SAR data collection, simulations, data analysis and training which supported the development of RADARSAT data applications in many countries including Morocco.

Using the C-Sar airborne instrument operated by the CCRS, SAR data (4.31m resolution) were obtained on the 16th of December 1993 over a large area (8060Km^2) of north-western Morocco with a variety of land cover and physiographic diversity. For the evaluation the study area was represented by the natural oak (Quercus suber) forest located 1 km south of the port city of Larache. This 2000 ha forest plays an important environmental, economical and recreational role for the province of Larache. Unfortunately, this forest has been subject to adverse transformation and degradation due to overgrazing, deforestation and planting with different non-indigenous species (eucalyptus, pine). The forest will be soon dissected by the Rabat-Larache freeway and therefore requires precise monitoring. A recent survey of this forest was conducted in 1994 using aerial photography (forest maps at 1/20 000 SCALE) and a management plan

was proposed. The forest offered an excellent experimental site for this radar data application; it lies on the quaternary coastal plateau with sandy soils and some microtopography that should be well depicted by SAR data.

Prior to digital and visual image processing and interpretation airborne SAR data were processed for geometric (georeferencing) and radiometric corrections and enhancements (antenna pattern corrections, image filtering, etc.). Visual interpretation was performed on a set of black-and -white prints at a scale of 1/35000 and colored computer printouts (1/25000) were produced and used for field interpretation. The first result consisted in the easy masking of the forested area which was clearly separated from the surrounding irrigated and rainfed agricultural and urban landunits. All map manipulations were done in GIS environment.

Using the computer interactive display of the EASI-PACE* image analysis system as well as the black-and-white prints, training areas were identified and delineated on the airborne SAR imagery which were representative of the six major land covers (vegetation) types (cork oak or *Quercus suber* alone, 37% of the area; cork oak with tea in a agroforestry system, 19.1%; old eucalyptus plantation, 33.4%; young eucalyptus plantation, 4.2%; pine or *Pinus pinea* plantation 4.7%; baresoil, 1.2%). Discrimination between these landunits and the roads and villages was very good, which facilitated the integration of the image into the GIS and the existing map features. The visually interpreted image was then classified and overlapped in the GIS with the existing ground and vegetation types on the ground and enhanced more details on the structure of some trees with regular planting density. But the backscatter was different for the newly planted and the old plantation. This will facilitate the monitoring of the reforestation and the clearcutting programs. Preliminary results indicate that the controlling factor of the variation in backscatter is a combination of the canopy top surface roughness, due to trees' density and their canopy form and the moisture, but the influence of the surface roughness is greater. The accuracy of the airborne SAR imagery visual analysis as compared to the ground truth map represented by the low altitude, vertical aerial photographs supported with field survey is excellent (>95%) and demonstrate the usefulness of SAR images for land use mapping in this part of Morocco.

A RADARSAT-1 image was acquired (RVP program, CCRS) for the same area on the 23 of March 1996 (Standard mode S7, 45^0 - 49^0) and was analyzed for the same objectives of forest mapping. The preliminary results from the study provide evidences that RADARSAT-1 imagery has the ability to discriminate the major forestry environments and detect the changes that will affect them.

If the use of GIS was valuable in extracting more information and presenting the results of the mapping, the typical digital image analysis techniques (supervised and unsupervised classification, density slicing, etc.) did not give satisfaction as that obtained with spectral data except for the texture analysis. At this time the study focuses on the assessment of the RADARSAT-1 imagery a and theirs combined analysis with other satellite data

(Landsat -TM and SPOT) for their ability to discriminate the major forestry environments and to detect land cover changes in Northern Morocco.

* Trademarks of PCI inc. Richmond, Ontario, Canada

CLASSIFICATION OF FLOODPLAIN HABITATS (LAGO GRANDE, BRAZILIAN AMAZON) WITH RADARSAT AND JERS-1 DATA

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ABSTRACT

Constant cloud cover and dense forest canopy prevent the application of optical remote sensing for the classification of floodplain habitats in the Amazon Region. Although several attempts have been made for using Thematic Mapper, the reported results are still incomplete.

Multitemporal (May an August 1996) RADARSAT and JERS-1 radar images were used to investigate the potential of using multi-incidence angle and multiwavelengh radar data for increasing visual and digital classification accuracy. Floodplain habitats that are of interest for a preliminary classification are open water, flooded forest, non-flooded forest, aquatic plants and landuse/landcover. Subsets of the Lago Grande scene were selected for a preliminary assessment of the methodology and the classification accuracy.

Raw radar data had to be converted into a near-normal distribution by applying a filtering procedure on each dataset. RADARSAT, JERS-1 and a combination of both images were submitted to a segmentation process using different thresholds according to pixel number and similarity. After this procedure, each segmented image had a Bhattacharya distance classification algorithm applied. The results were then verified with aerial photographs and ground truth information that had been collected concurrently with the radar image acquisitions. Preliminary results obtained for the May data set are encouraging.

Factors Affecting Clearcut Mapping Accuracy from Single-Date RADARSAT images

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Forest inventory update has been identified as one of the most promising applications of RADARSAT data for forestland management in Canada. Foresters are particularly interested in having timely information to enable them to update their maps for new roads and clearcuts. While the visibility of clearcuts and some roads has been demonstrated with RADARSAT data, questions remain about the accuracy of mapping which can be achieved with RADARSAT data, and the conditions under which the best results can be obtained. As part of a comprehensive evaluation of RADARSAT data for forestry applications under the ADRO program, the Canada Centre for Remote Sensing and the Canadian Forest Service are cooperating to address these questions. In this study we address the following questions:

1. What clearcut mapping accuracy can be expected from single-date RADARSAT Fine Mode data under typical Canadian boreal forest conditions, in an area with rolling terrain?

2. How does the contrast between the clearcut and its surroundings affect the mapping accuracy?

3. What are the predominant factors affecting this contrast?

Two single-date RADARSAT Fine Mode scenes, acquired March 5 and April 5, 1996 were orthorectified to the Alberta provincial base map, using roads and streams as ground control points and the Alberta digital elevation model (a component of the base map) to correct for topographic distortions in the RADARSAT images. Spatial filtering was used to reduce radar speckle, and the data were contrast stretched and printed at a scale of 1:20 000 for interpretation by foresters who were experienced in photo interpretation but who had no experience with SAR imagery. Two interpreters interpreted a sample of 54 clearcuts which had been chosen to provide 18 samples from each of three classes of contrast classes (provisionally labeled as high, medium, and low). Their interpretations were digitized and compared with the boundaries of the same clearcuts mapped using first order stereo photogrammetric procedures from 1:20 000 scale aerial photography.

The differences in boundary placement between the photogrammetrically mapped clearcuts and the clearcuts mapped from the RADARSAT images were analyzed to assess the magnitude of the errors to be expected from RADARSAT. These errors, in turn, were evaluated as a function of clearcut contrast, and factors affecting clearcut contrast were assessed.

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Initial Results From the Dendron Resources ADRO on the Application of RADARSAT Data in Forest Resource Management

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In order for the forestry sector to utilise RADARSAT data two important elements must be provided. The first is proof that the product is cheaper and/or better than existing means of addressing specific and relevant forest management tasks. The second is that tools are required to perform the analysis of the data by operational personnel.

Dendron Resource Surveys Inc. is working with hardware and software companies developing a feasible approach for using RADARSAT data to facilitate operational forest management. The ADRO program provided RADARSAT data of five operational forest test sites - 4 in Canada and 1 in the tropics for this project. The four Canadian test sites (two in B.C. and one each in Alberta and Ontario) and the tropical site in Ecuador were selected to cover the broad range of requirements which must for an operational system. In order to test RADARSAT for monitoring changes in the cut blocks and provide examples of seasonal affects, three temporal RADARSAT acquisitions were acquired from the spring of 1996, summer of 1996 and the winter of 1997.

This paper reviews an operational procedure for using RADARSAT data for forest updates. The paper also reports on the accuracy of RADARSAT data for forest updating, compared with traditional photogrammetric and GIS methods.

Potential of RADARSAT for Assessment of Forest Regrowth State

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The assessment of forest regrowth through satellite SAR data has been inadequately studied. Presently, the primary potential use of RADARSAT for forest management is clearcut mapping. It is an important objective to go beyond the mapping of clearcut boundaries, to assessing the forest regrowth state with the same data.

There is a general trend where radar backscatter increases with increasing age of clearcut to approach and overlap the radar backscatter of mature forested area. The signal in C-band saturates through volume scattering of the upper portion of the tree crown. It is an important complement to clearcut mapping, to examine the variability of the signal before it reach the state of saturation due to crown volume scattering. This study will examine the first 15 years of the forest regrowth which may present scattering from all tree components and ground floor. We will also discuss a case where environmental effect had reduced significantly the interpretability of the image.

OPERATIONAL CALIBRATION FOR RADARSAT DATA

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ABSTRACT

The RADARSAT Image Data Calibration System was developed to provide operational RADARSAT imagery meeting relative radiometric accuracy and geometric requirements as described in (Parashar, 1993).

This paper will present RADARSAT calibration and image quality performance achieved to date from the Canadian Data Processing Facility.

RADARSAT BEAM PATTERN DETERMINATION

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ABSTRACT

The operational RADARSAT Image Data Calibration System was developed to provide RADARSAT imagery meeting relative radiometric accuracy and geometric requirements as described in (Srivastava, 1995). Critical elements include the antenna beam patterns in azimuth and elevation.

This paper describes the methodology used and the determination of the azimuth and elevation beam patterns for RADARSAT during the Radiometric Calibration Phase.

RADARSAT SYSTEM INTEGRATION AND COMMISSIONING - RIDE ON A ROLLERCOASTER

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ABSTRACT

The preparation of the RADARSAT system for service presented significant challenges in view of the system's technical scope, its development nature, the number and diversity of the agencies and contractors involved, and the schedule and fiscal constraints imposed by today's economic climate. This paper reviews the key activities and highlights of the system integration, operations preparation, and commissioning of the Ground and Space Segments.

A brief overview of the system and its external interfaces is provided along with the challenges facing the team responsible for its integration, early operation, and commissioning. The overall planning for system integration, operations and Ground Segment preparation, along with highlights of the campaign is presented. Key decision points, results, priorities and replanning are discussed.

The main achievements of the early flight operations and the strategy and results of system commissioning, are summarized. These included the early orbit deployments and configuration of the Spacecraft for imaging operations, functional and performance testing of the space and Ground Segments including calibration activities, the incremental introduction of system elements and progressive build-up of system activity, problem and anomaly resolution, and the transition of the system and staff to routine operations. Some of the highlights included:

- The Launch and first orbit activities
- SAR Antenna deployment
- The first day of imaging
- The S-Band Transmitter anomaly
- Qualification of the Canadian Data Processing Facility (CDPF) and Image Data Calibration Systems (IDCS)
- Start of Routine operations at the Mission Control Centre.

Some lessons learned for follow-on missions are presented.

THE GERMAN REMOTE SENSING DATA CENTRE SAR FACILITY IN THE ERA OF RADARSAT

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ABSTRACT

One of the major tasks of the German Remote Sensing Data Centre (DFD), located at the German Aerospace Research Establishment DLR Oberpfaffenhofen, is the operational acquisition, processing and archiving of ERS-1 / ERS-2 SAR data (under ESA contract as D-PAF) as well as the processing and archiving of X-SAR data (X-band sensor from the two SIR-C N A S A missions, under DARA contract). DFD operates receiving stations in O'Higgins / Antarctica and Neustrelitz / Germany as well as transportable stations in Libreville / Africa and Cordoba / Argentina.

At this time, D-PAF is upgrading its operational SAR facilities to meet the challenges of a new generation of highly flexible SAR sensors operating in a variety of modes including ScanSAR, among which RADARSAT is the first one being operational. The major receiving chain upgrade is the integration of a transcription system with which SAR raw data can be transcribed in real-time onto computer-readable tapes using a software programmable frame synchronizer. The kernel of a new operational SAR processor based upon the chirp scaling algorithm and running completely in a standard UNIX environment is under completion. An operational InSAR processor for the generation of digital elevation models is under development and already pre-operational for ERS data. The transcription system as well as both processor systems will be able to handle RADARSAT data and provide the necessary data products for a DFD ADRO proposal with respect to RADARSAT interferometry.

This paper describes the DFD SAR facility, especially with respect to the included RADARSAT functionality. Furthermore, it gives detailed results on all tests to be performed with respect to RADARSAT data acquisition and processing in the next months.

RADARSAT I EXPERIENCE POINTS THE DIRECTION FOR FUTURE MISSIONS

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Up until launch, it was not known which of RADARSAT's imaging modes would be in greatest demand from users, and which aspects of imaging performance would prove to be most important. After more than a year of operations, some clear trends are emerging, and in several respects they are not what had been anticipated in advance. This paper identifies these trends, and considers their implications for the designs of future satellite SAR missions.

The original imaging requirements for the RADARSAT SAR were derived from a survey of the key applications anticipated for the data. The specified images, covering swaths of 100km with resolution of 25m, were seen to meet the essential requirements in all areas. During the system design process, Spar offered the additional imaging capabilities with finer resolution and wider coverage as alternative modes which could be provided with essentially the same hardware, and these were subsequently added into the system specifications. During the first year of operations, it has been notable that the two types of image which have been in greatest demand have been from these two modes: ScanSAR and Fine Resolution. This suggests several conclusions which are important for future missions:

These two modes represent the extremes in the trade-off between swath width and resolution. Their popularity indicates that certain aspects of performance are key for each application, and users in that area want the best available performance in that respect, even if they are restricted in some other respect.

Different applications require widely different types of data. A system can be designed either to be very versatile in its operations so as to meet all needs, or to be of minimal complexity (and cost) in satisfying the specific needs of a particular application.

With the important exception of emergencies, users generally prefer to have a specific type of image, rather than accept another type which would be available sooner. All capabilities should therefore be provided over as wide an angular range as possible so as to minimise access time, and maximise potential use.

The RADARSAT experience has also indicated aspects of the design where relaxations in the specification will enable enhancement in more critical aspects of performance without any adverse impact for users. An illustration is provided by the Extended High Incidence Beams, which allow good quality imaging over a considerably increased coverage region, with no apparent impact from the significantly degraded ambiguity performance.

Preferred session and presentation mode: New technologies (sensors), oral

ANALYSE COMPARATIVE DES MODÈLES DYNAMIQUES DES ÉCOSYSTÈMES TERRESTRES

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RÉSUMÉ

L'étude des changements climatiques suscite énormément d'intérêt de la part de communauté internationale et plusieurs modèles décrivant les interactions terre-atmosphère ont été développés. Ces modèles ont clairement démontré que la végétation est un attribut de la surface de la terre qui influence grandement le climat. Les modèles de végétation impliquent généralement la description de paramètres morphologiques (indice foliaire, surface fractionnaire,..), physiques (albédo, résistance aérodynamique,..) et physiologiques (résistance stomatale, déficit en vapeur d'eau,..). L'étude présente l'analyse comparative de divers modèles des écosystèmes terrestres disponibles actuellement (BETHY, BIOME3, BIOME-BGC, CARAIB, CASA, CENTURY, DOLY, EMU, GLO-PEM, HRBM, HYBRID, IBIS, MAPSS, MUSE, PLAI, SLAVE, TEM,..). Parmi ceux-ci on distingue des modèles intégrant les images satellite car celles-ci permettent de dériver certaines caractéristiques de la végétation ou servir de source de validation et/ou calibration des modèles des écosystèmes terrestres. Cette étude a été réalisée via l'envoi d'un questionnaire aux différents groupes de chercheurs. L'objectif est de fournir un constat sur la modélisation des écosystèmes terrestres afin de sélectionner un modèle de végétation à l'échelle continentale bien adapté à l'intégration des images satellite et des systèmes d'information géographique. Le but de l'étude n'est pas de comparer les résultats des modèles mais bel et bien d'évaluer et de comparer les modèles sur la base des processus incorporés.

L'enquête fournit une description détaillée des modèles selon leurs caractéristiques spatiales (taille de maille, résolution, domaine,..) et temporelles (pas de temps, horizon de simulation,..). De plus l'analyse identifie de façon détaillée les données d'entrée (contraintes environnementales, valeurs initiales et variables de mise à jour), les données de sortie (paramètres écologiques, biogéochimiques, climatiques et hydrologiques) et les processus incorporés (biologiques, échanges d'énergie, en eau, carbone et les perturbations externes). Il permet de mettre en évidence les points forts et les points faibles des modèles. Une partie spéciale est réservée à l'évaluation des liens effectifs ou potentiels avec les images satellite. On y distingue le type de capteur, les traitements numériques (calcul d'indices de végétation, de température de surface, ...), les caractéristiques de la végétation (LAI, SLA, biomasse,..) et des indicateurs des activités biologiques (FPAR, PSN, NEP, NPP, ET,..). Finalement l'enquête indique si le modèle a été intégré dans un SIG et comment. Les résultats de l'analyse s'expriment sous la forme d'une analyse comparative permettant de confronter les modèles selon divers critères d'évaluation (simplicité, réalisme, exactitude et évaluation). Une performance est ainsi attribuée à chaque modèle en fonction du but recherché.

Estimating Regional-Scale Biophysical Parameters in BOREAS using Spectral Mixture Analysis Coupled with Radiative Transfer Models

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ABSTRACT

Boreal forest biophysical structure can be estimated from spectral mixture analysis and geometrical optical reflectance models applied to remotely sensed optical image data. The approach works by computing areal fractions of fundamental scene components of sunlit canopy, shadow, and sunlit background, and relating these fractions to forest biophysical parameters such as biomass density, leaf area index (LAI), and net primary productivity (NPP), which are important inputs to regional scale models of ecosystem process and terrestrial carbon flux. In this paper, we present results from a forest stand-level validation experiment where linear regression analyses showed r2 values in excess of 0.80 between spectral mixture fractions and LAI, biomass and NPP. Following this, we present a new algorithm for applying these ideas to the regional scale of the Boreal Ecosystem Atmosphere Study (BOREAS) area. The algorithm uses a linked, two-stage approach in which land cover stratification and biophysical parameter estimation are performed simultaneously through the combined use of a knowledge-based classifier coupled to canopy reflectance models and spectral mixture analysis fractions. The paper concludes by comparing results obtained from conventional NDVI approaches to show the theoretical and empirical advantages of the new methods presented here.

VEGETATION/SPOT for Northern Applications: preliminary results

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ABSTRACT

VEGETATION is an optical sensor to be launched early 1998 onboard of SPOT-4. It will provide daily global coverages at a spatial resolution of 1.1 km, similar to AVHRR (Advanced Very High Resolution Radiometer). However, compared with AVHRR, it has the advantages of (1) fixed spatial resolution invariant with look angle, (2) better geometrical and radiometric accuracies, (3) additional blue and shortwave infrared bands, and (4) "zooming capability" when combined with SPOT data.
VEGETATION/SPOT for Northern Applications (VESNA) is a collaborative project funded by the European Commission. It is directed specifically towards exploring the usefulness of the VEGETATION/SPOT system for vegetation monitoring in the boreal environment. It has the following objectives: (1) to extend and refine the methodology previously developed for processing AVHRR data to the VEGETATION/SPOT system, (2) to assess the advantages of VEGETATION spectral bands in deriving biophysical parameters over the existing AVHRR, (3) to investigate the usefulness of VEGETATION/SPOT for vegetation carbon budget estimation, and (4) to investigate the operational use of VEGETATION as a substitute for AVHRR for crop and forest fire monitoring. The investigation is divided into pre-launch and post-launch periods. During the pre-launch period, the investigation will be based on a simulated data set produced using TM data, and field data will be acquired in central and eastern Canada regions. In this period, biophysical parameter algorithms and carbon budget and productivity models will be developed and refined for the use of VEGETATION/SPOT data. During the post-launch period, the algorithms and models will be applied to the actual VEGETATION/SPOT data set to generate products for Canada.

In this presentation, we report preliminary results of this project. A simulated VEGETATION data set has been produced using 4 Landsat TM scenes covering agricultural and forested areas near Prince Albert, Saskatchewan. The advantages of the simulated data set over AVHRR data over the same area are being investigated. The results showed improved accuracies in the retrieved leaf area index and the photosynthetically active radiation absorbed by the vegetation. Field measurements of spectral signatures in various types of vegetation are used to investigate the usefulness of the blue and mid-shortwave infrared bands in distinguishing moss type and moisture condition in boreal forests. The moss layer is expected to play an important role in the boreal carbon and water cycles.

UTILISATION DES IMAGES STÉRÉOSCOPIQUES RADARSAT DANS LA CARTOGRAPHIE ÉCOLOGIQUE DE GRANDS TERRITOIRES À PETITE ÉCHELLE

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Résumé

Le ministère de l'Environnement et de la Faune du Québec (MEFQ) réalise depuis 1992 des travaux de cartographie écologique à petite échelle en se basant sur des caractéristiques permanentes du milieu physique, telles que la physiographie, la géologie, l'hydrographie et la géomorphologie. Ces travaux s'insèrent dans un système hiérarchique d'informations écologiques à référence spatiale dans lequel on retrouvent aux niveaux supérieurs les régions naturelles et les ensembles physiographiques. Ce sont des unités écologiques de grande superficie (respectivement de l'ordre de 10^4 et de 10^3 km^2) cartographiées aux échelles allant de 1:1 000 000 à 1:500 000. Les images Landsat MSS et TM de même que les images SPOT-HRV sont fréquemment utilisées par le MEFQ pour la délimitation et la description de ces unités écologiques.

L'objectif général de ce projet ADRO est d'évaluer les possibilités et l'apport des images RADARSAT en mode stéréoscopique pour la délimitation et la caractérisation des grandes unités écologiques (i.e. régions naturelles, ensembles physiographiques). Plus spécifiquement le projet servira à déterminer le caractère unique des données RADARSAT par rapport aux autres types de produits satellitaires, en particulier Landsat et SPOT, ainsi qu'à identifier la meilleure des combinaisons de «mode RSO/résolution/angle d'incidence» offertes par RADARSAT.

À cette étape-ci du projet, deux paires d'images stéréoscopiques prises en mode ascendant et descendant ont été analysées. L'une d'elles est en mode RSO Scansar Narrow 1 (SN1) et l'autre, en mode SN2. Chaque scène couvre une superficie de 300 km x 300 km avec un pixel à 50 m et leur partie commune en stéréoscopie représente environs 70 % et 50 % des 90 000 km^2 respectivement. Les images ont été rehaussées et géoréférencées et ensuite imprimées à l'échelle de 1:1 000 000 et de 1:500 000.

Parmi les résultats préliminaires obtenus, nous retenons en particulier les points suivants :

1. Les images RADARSAT offrent plus d'informations sur la structure géologique du territoire (SGT) que celles de Landsat et de SPOT. La résolution spatiale des images SN est acceptable pour interpréter la SGT. Le fait que les images stéréoscopiques proviennent du mode ascendant et descendant assure aussi une interprétation plus complète.
2. Les images stéréoscopiques SN à l'échelle de 1:1 000 000 permettent d'obtenir une vue globale de la physiographie sur une très grande superficie, ce qui est unique parmi les produits satellitaires actuellement disponibles. L'exagération verticale du relief est suffisamment importante tant dans le mode SN1 que dans le mode SN2. Ces images semblent donc convenir à la révision des limites des régions naturelles et à la reconnaissance des ensembles physiographiques.
3. Les images SN à l'échelle de 1:500 000 offrent une vue stéréoscopique plus détaillée et plus nuancée qu'à l'échelle de 1:1 000 000. Leur qualité est inférieure à celle des images stéréoscopique SPOT à même échelle. Ceci est cependant compensé en partie par une fenêtre de vue stéréoscopique plus grande des images SN. Ces images semblent donc mieux convenir à la délimitation finale des ensembles physiographiques.
4. Finallement, les images SN acquises en 1996 présentent des problèmes radiométriques, ce qui engendrent une fausse perception du relief dans certaines parties de territoire.

Utiliser en complémentarité avec les autres sources d'information, notamment le modèle numérique d'élévation, nous estimons que les images stéréoscopiques RADARSAT en mode SN peuvent fournir des informations distinctes des autres types images satellitaires, et qu'elles sont utiles à des fins de cartographie écologique à petite échelle. En effet, l'analyse a été mise à profit dans le cadre du programme fédéral-provincial de Vision Saint-Laurent 2000 et les résultats ont grandement contribués à la révision de cinq régions naturelles ainsi qu'au découpage des ensembles physiographiques.

Projet ADRO ID588

Cartographie des milieux naturels montagneux à l'aide des images RADARSAT

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L'objectif ultime de notre projet ADRO est le développement d'un guide d'utilisateur des images RADARSAT pour la cartographie des milieux naturels montagneux dans différentes zones climatiques. Trois régions à travers le Québec ont été choisies présentant une grande variabilité au niveau de la géologie, de la géomorphologie et de la végétation: le parc de la Gaspésie, la rivière aux Mélèzes au Nouveau Québec et les Monts Tomgats au Labrador. Pour les deux premières régions des images RADARSAT multi-angulaires, à visée opposée et à deux résolutions différentes ont été acquises l'été 1996. Pour la troisième région l'acquisition d'images est prévue pour cet hiver et l'été 1997. En Gaspésie une campagne d'acquisition des données terrain a été effectuée en synchronisme avec le passage du satellite, tandis qu'une campagne de reconnaissance a été effectuée dans la zone des Monts Tomgats également cet été. La zone de la rivière aux Mélèzes fait l'objet d'une étude géomorphologique depuis les trois dernières années incluant des campagnes sur le terrain, la photo-interprétation et les analyses des images ERS-1. Les analyses préliminaires effectuées avec les images RADARSAT disponibles nous ont démontré que:

a) L'orthorectification des images à l'aide d'un modèle numérique de terrain de grande précision est nécessaire pour obtenir une mise en commun sans ambiguïtés des images RADARSAT diachroniques entre elees et avec d'autres images de télédétection. Un test a été effectué en Gaspésie avec des petits réflecteurs portatifs pour baliser des points de contrôle avec des résultats prometteurs.

b) Le contenu en information au niveau de la couverture du sol est limitée à trois out tout au plus quatre classes de tonalité. En territoire forestier (Gaspésie) il est même très difficile de reconnaître les zones ayant un couvert végétal bas (régénération) des ceux ayant un couvert végétal haut. Seuls certaines zones de brûlis se différencient de leur voisinage selon l'angle de visée. En territoire de taïga (Mélèzes) quelques anciens deltas ressortent très bien avec une tonalité très foncée à foncée ainsi que des brûlis relativement récents. À angle de visé profond, les lacs sont difficilement discernables de leur voisinage.

c) Bien que certaines variations de texture soient apparentes qui pourraient constituer la base de développement d'une clé d'interprétation visuelle ou numérique des images, le bruit de chatoiement surtout en mode fin rende la reconnaissance despatrons de texture

incertaine. La prise en considération de ce bruit est nécessaire. Les filtres adaptatifs ne semblent pas avoir un bon rendement ni en mode fin, ni en mode standard.

d) Le relief topographique est l'élément dominant qui module la tonalité générale des images. Le macro-relief domine peu importe l'angle de visée tandis que le micro-relief divient plus apparent à angle de visée profond. Ceci pourrait constituer la base d'une méthode de différentiation de la structure géologique de la géomorphologie locale.

Notre communication a pour but de présenter les résultats des analyses qui nous ont conduit à ces conclusions préliminaires ainsi que l'approche qui sera suivie pour développer notre guide.

Estimating Snow Thickness Distributions on Sea Ice using Microwave Remote Sensing

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Abstract:

Snow cover on sea ice is highly variable both spatially and temporally. It occurs as an integral component of the atmosphere-sea ice-ocean system; both affecting and being affected by forcing variables acting across this interface. Microwave scattering and emission from snow covered sea ice is influenced by the presence of the snow cover both as a result of direct (scattering inclusions) and indirect (thermodynamic effect on ice surface dielectrics and inclusion structure) effects. The potential to maximize existing operational orbital remote sensing platforms such as SSM/I and Radarsat is premised on the notion of understanding the interrelationships amongst the geophysical, electrical, and scattering potential of the snow layer medium.

In this paper I develop a theoretical framework for the estimation of snow thickness classes using the dielectric contrast across the snow/sea ice interface under varying atmospheric forcing conditions. Results from in situ field observations, dielectric mixture and forward scattering models are used to investigate the microwave response which results from varying snow thicknesses over first year sea ice. I conclude this paper with an overview of the significance of this research for climate related studies within the marine cryosphere.

The Use of Remote Sensing in a One-Dimensional Thermodynamic Sea Ice Model

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Abstract

The use of numerical models for studying Arctic sea ice processes and forecasting has been applied over the past few decades with a fair degree of success. Remote sensing technology for observing Arctic sea ice has greatly improved our ability to monitor and extract meaningful physical quantities and processes of the ocean-sea ice-atmosphere interface. The first step of incorporating remote sensing information into a sea ice process model is conducted with the intent of improving the model's ability to simulate Arctic sea ice evolution. A one-dimensional thermodynamic sea ice model is used to investigate the critical parameters and processes that control sea ice evolution to elucidate those parameters and processes in which remote sensing can be most useful. A series of sensitivity tests were performed on the model where several key parameters and processes have been identified. In addition, the same relevant remote sensing derived parameters and processes have also been identified. Six years of in situ measurements from the SIMMS and C-ICE experiment near Resolute Bay region will be used to force the model and to link it with the remote sensing data to provide more realistic comparisons and model simulations. This is a critical first step for the incorporation of remote sensing into numerical sea ice models to improve our ability to simulate Arctic sea ice processes.

FLOATING ICE MONITORING TO ANTARCTIC NAVIGATION

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ABSTRACT

Floating sea ice is a potential hazard to the marine navigation in Antarctica.

Satellite Synthetic Aperture Radar (SAR) image gives the opportunity of monitoring floating ice types, independently of weather and light conditions.

The Project intends to use images of 2 levels of resolution:

1) Low resolution (ScanSAR, 500 km., pixel 100x100m) to provide near-real time sources to support the vessels trips operations.

2) High resolution (50 km. pixel 10 m.) to perform sea ice parameters correlated with simultaneous in-situ campaigns.

The research will require a previous orbit schedule to program the simultaneous satellite and ship data collection.

The main goals expected are:

* with low resolution:
  - sea ice extension and edges
  - sea ice concentration
  - open water, features and leads identification

* with high resolution:
  - sea ice classification
  - iceberg identification
  - ship detection

The output maps will be composited with nautical charts into a Geographic Information System to study the dynamic mapping of the Antarctic sea ice features.

UTILIZATION OF RADARSAT DATA

IN THE CANADIAN ICE SERVICE

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ABSTRACT

The Canadian Ice Service (CIS) is the Canadian Government Agency responsible for providing ice information over Canada's offshore areas for marine operators. the launch of RADARSAT in November, 1995, has provided a major new input to this program. Data from the on-board C-band HH-polarized SAR sensor is acquired in near real time from the Canadian Data processing facility (CDPF) at Gatineau, Québec via a T1 digital link. Ice information products are then developed at the Ice Centre in Ottawa and transmitted to marine clients. The major client is the Canadian Coast Guard who receive the imagery and derived products on board their icebreaking vessels and at the Ice Operations Offices, and display them on Windows NT systems known as Ice-Vu.

This presentation will describe the end-to-end system that has been developed for acquiring RADARSAT digital imagery, producing ice data products and transmitting them to marine clients in near real time. The process for analyzing the data and providing ice information the Coast Guard and other marine clients will be presented and examples of ScanSAR imagery as it related to ice information extraction will be discussed and examples of field experiments to validate ice signatures will be presented.

Recently, automatic ice information extraction algorithms are being developed in order to fully exploit the data. An Ice Tracking system, which calculates ice displacements from coincident RADARSAT image pairs, is now running at the Ice Centre in an operational sea ice classification system has been undergoing testing. These two algorithms will be described, along with a Marine Information System)MAST) which will incorporate these and other algorithms into a suite of tools for marine information analysis on a variety of data sources.

SEASONAL MAPPING OF FLOODING EXTENT IN THE VICINITY OF THE BALBINA DAM (CENTRAL AMAZONIA) USING RADARSAT AND JERS-1 SAR DATA

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ABSTRACT

The Balbina Dam was built in 1987 on the Uatumã River to supply electricity to Manaus (capital of Brazil's State of Amazonas). This research is part of the Amazon Basin RADARSAT Evaluation Project led by CCRS, INPE, and RSI and the JERS-1 Global Rain Forest Mapping Project led by NASDA. Its objective is to assess the multitemporal use of RADARSAT and JERS-1 SAR for mapping seasonal variations in the spatial extent of flooding, which is a critical factor for the environment monitoring of the Balbina Dam.

The area flooded in the Balbina Dam is not precisely known, despite the apparent precision of maps made in 1984 by ELECTRONORTE (the governmental power company in northern Brazil). The topographic information on the maps (1:50,000 scale) is based on aerial photographs. These remote sensing products are not acquired in a repetitive fashion and therefore portray only the environmental conditions prevailing during acquisition, which prevents their use for seasonal monitoring. Furthermore, aerial photographs record the level of the treetops, not the ground underneath, which is a source of small errors on the topographic map. Considering that a substantial part of the reservoir may be only a meter or two deep, these small errors can easily alter the final estimate of flooding extent.

The present investigation is carried out in the following steps: (a) data samples are extracted from selected portions of geocoded and coregistered RADARSAT (Standard Mode, Beam S3) and JERS-1 SAR images (in both low and high water periods), in order to analyse the semivariogram behavior of open water bodies, macrophyte stands, upland vegetation and flooded forest; (b) image classification is performed based on the unique statistical fingerprints described by the semivariograms for the different cover types selected in (a); the algorithm to be used in the semivariogram textural classifier (STC); (c) STC - classified images are merged on a mosaic in order to provide seasonal maps of

floodable areas in the vicinities of the Balbina Dam; (d) a Digital Terrain Model (DTM) is built based on the topographic maps made by ELETRONORTE in 1984; such a DTM is then used to estimate the surface extent of flooding taking into account stage height readings at the Balbina Dam corresponding to RADARSAT and JERS-1 SAR acquisition dates; (e) discrepancies between area estimations obtained in (c) and (d) are identified and field checked.

MORPHOLOGIC DYNAMIC OF AMAZON RIVER - IQUITTOS, PERU

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ABSTRACT

The Amazon River crosses the Amazonia by more than 10,000 km. and has permanent changes in its course, drifting hundred of meters year by year.

In the last years, IQUITOS, an important City near the Amazon river has a problem with this drift. Economic impact occurs due the permanent maintenance that is necessary to develop in the boundary and in the ship attendant facilities.

Remote Sensing technology is a good tool to develop a multi-temporal study using different source data as aerophotographic products, old MSS LANDSAT products and SPOT and RADARSAT data.

The multi-temporal study tries to understand the Amazon drift to make a possible future trajectory to prevent a social and economic disaster.

OBJECTIVES

- Measurement of the real displacement of the river in the last 40 years.
- Analyze the actual 100 km. before IQUITOS attitude of the river.
- Evaluate and deforestation surrounding IQUITOS an its impact over the river attitude.

HYDROGEODYNAMICS OF THE WETLANDS IN THE BOLIVIAN AMAZON BASIN

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ABSTRACT

The Amazon Basin region is continuously covered by clouds and contains vast isolated areas difficult to access. In the framework of the Canadian ProRADAR program designed to evaluate RADARSAT data for the monitoring of the Amazon region, a study has been undertaken to analyse the dynamics of floods in the Bolivian Amazon which affect from 100.000 to 150.000 km^2 during four months of the year. Lack of information on these phenomena impedes the sustainable management of the natural resources of this part of the country, the optimization of cattle rearing which constitutes presently 47% of the Bolivian bovine production, as well as the proper delivery of rescue services.

The overall objective is to evaluate the use of C-band data, comparing HH and VV polarizations, for flood monitoring and identification of risks areas, with a view to improving the management of natural resources, enhancing the animal breeding activity and facilitating the work of emergency preparedness, as well as for vegetation mapping.

This paper presents preliminary results obtained in the Trinidad area, around the Mamore river, using ascending ERS-SAR (VV polarization) and RADARSAT data (HH polarization) from dry and wet seasons, water levels from hydrometeorological stations and simultaneous field checks. Several SAR-TM colour composites are being used to integrate and evaluate the respective contributions of optical and microwave data with distinct polarizations: RGB-IHS transformation has been used, using the Intensity component from TM as the Hue input; TM classification with difference RADARSAT and ERS images and with HH and VV from each season.

KEYWORDS: *Radar, Flood monitoring, Vegetation mapping, Amazon basin, Bolivia*

Flooding Risk Evaluation and Humid Zones Mapping in the Red River Delta, Vietnam

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ABSTRACT

The Red River Delta is highly populated and frequently affected by flooding. This area is often hidden by the cloudy coverage during the rainy season when flooding is mostly extended and is, therefore, one of the test sites of a joint research project between the Center VTGEO in Vietnam and the CARTEL in Sherbrooke, Canada. Various positions of the Delta have been chosen for this analysis.

Combining the radar and optical remotely sensed data with other sources such as topographic data and the dike system in a GIS makes it possible to evaluate the land cover of the Delta and then to associate it to the different humidity zones or potentially flooded zones. The processing used is based on a multi-source data modelling approach. In this model, optical images (TM and JERS-1) are used to identify the seasonal land use types as an indicator of different humidity and flooding conditions. The RADARSAT standard mode images were acquired in different periods (before, during and after the flooding) and are used to follow the spatial extension of the humidity and flooded zones. Topographic data at 1:25,000 scale (DEM) are used to evaluate natural humid or flooded areas in comparison with irrigated areas. The dike system is entered into this modelling as a controlling factor of the flooding risk.

Some main results are presented and discussed in this paper.

1. Flooded zones and their spatio-temporal extension of 3 characteristic sectors: South of Hanoi City, eastern and western sectors of the Red River Delta.
2. Evaluation of land cover types affected by flooding in these studied areas.

3. Evaluation of the information on humid and flooded zones provided by three RADARSAT and one JERS-1 image with different wavelengths and by the fusion of radar and optical data and evaluation of potential flooding risk in the studied areas.

ÉTUDE DES INONDATIONS DANS LE DELTA DU FLEUVE ROUGE AU VIET-NAM A L'AIDE D'IMAGES RADARSAT ET JERS-1

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ABSTRACT

(French version)

Le delta du fleuve Rouge est situé au nord du Viet-nam. Il possède un écosystème fragile et complexe influencé par des facteurs naturels et humains. C'est une région rizicole dotée d'un aménagement hydraulique développé. Notre zone d'étude, le district de Nam Thanh de la province de Hai Hung, se situe à l'est du delta. Il est entièrement entouré par des cours d'eau dont le fleuve Thai Binh, un important défluent du fleuve Rouge. Cette région est caractérisée par un climat de mousson qui sépare l'année en deux saisons. Durant la saison des pluies (mai à septembre), la quantité et l'intensité des précipitations provoquent la crue de fleuve Rouge et de ses défluents, qui peut ensuite engendrer des inundations. La télédection radar constitue un outil privilégié pour obtenir des images satellitaires de cette région malgré la présence du couvert nuageux.

Cette étude s'inscrit dans le cadre d'un projet de coopération s'inscrit dans le cadre d'un projet de coopération internationale (SIE-Delta) subventionné par le CRDI. De plus, le Prgramme ADRO du Projet RADARSAT nous a permis d'acquérir des images (en mode F4, S4 et S7) de notre zone d'étude lors d'une campagne de terrain qui s'est déroulé du 17 au 22 aout 1996. En aout 1995, une première visite sur le terrain a été effectuée, de même que l'acquisition d'une image JERS-1.

Le but de cette étude est de voir dans quelle mesure les images radar peuvent contribuer à l'étude des inondations dans la plaine du delta du fleuve Rouge. L'approche méthodologique consiste à collecter des données de terrain au même moment que le passage du satellite. De cette façon, nous pouvons identifier les états de surfaces discernés sur l'image en fonction des observations faites sur le terrain. L'interprétation visuelle des images multidates nous permet e comparer l'effet des différents paramètres d'acquisition, comme la longueur d'onde, l'angle d'incidence et la résolution spatiale, sur la rétrodiffusion des ondes radar pour une même zone.

Une première analyse visuelle des images permet de discerner des rizières à divers stades de croissance. La rétrodiffusion observable sur les images est influencée par le stade phénologique du riz, c'est-à-dire l'âge des plants (hauteur et densité), par le niveau d'eau dans les parcelles et par la situation topographique de ces dernières. Certaines scènes comportent des rizières complètement submergées par une inondation catastrophique et d'autres permettent de bien identifier les villages-jardins et les vergers. Des analyses multidates et multiparamétriques permettent ainsi de caractériser les différentes zones qui composent cette région rizicole. De plus, la superposition d'images permet une interprétation plus complète du paysage rural vietnamien. Enfin, des techniques de filtrage et des analyses de texture sont effectuées afin de réaliser une cartographie de l'utilisation du sol de la zone d'étude.

ABSTRACT

(English version)

The Red river delta is located in northern Vietnam. It has a fragile and complex ecosystem influenced by natural and human factors. It is a rice-growing region with well developed hydraulic resources. Our study area, the district of Nam Thanh, is located in the eastern portion of the delta. It is completely surrounded by river systems such as the Thai Binh river, an important distributor of the Red river. The region is characterized by a monsoon climate which divides the year into two seasons. During the rainy season (from May to September), the quantity and intensity of precipitation provoke the rising of the Red river waters and its distributors which can eventually lead to flooding. Radar remote sensing constitutes a useful tool for obtaining satellite images of the region in spite of cloud cover.

The study is part of an international cooperation project (SIE-Delta) funded by IDRC. The RADARSAT ADRO program also enabled the acquisition of images (in F4, S4 and S7 modes) of our study area during the ground campaign which was conducted from August 17 to 22, 1996. In August 1995, a first visit was make to the area and JERS-1 image was acquired.

The objective of the study is to determine to what extent radar images can contribute to the study of floods in the Red river delta plain. The methodological approach consists in collecting ground data at the time of satellite overpass. In this way, we can identify surface states observed on the image in relation to ground observations. Visual interpretation of the images permits the comparison of the effects of the different acquisition parameters, such as wavelength, incidence angle, spatial resolution, as well as changing surface states on radar backscatter over a given area.

Preliminary visual analysis of the images permits the determination of large homogeneous areas in the rice paddies. Homogeneity appears to be a function of the phenological state of rice, i.e. the average plant age (height, density) and in relation to the water level in the land plots as well as topography. On certain scenes, it is possible to discriminate different rice growing stages, while on others it is possible to observe rice paddies completely submerged by a catastrophic flood or even to clearly identify garden-village and orchards. Multi-temporal and multi-parametric analyses make it possible to characterize the areas affected before and after the flood. Furthermore, the superimposition of the images permits to carry out a more thorough interpretation of the Vietnamese agricultural landscape. Finally, filtering techniques and texture analyses are used to produce a land use map of the study area.

4NR Project - Spatial Data Resources Inventory, Sampling and Integration:

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Spatial data resources in Canada's Federal Government vary widely in content and format, and can be used for many different applications - natural resource management, business geographics, and public education are but a few. In an era of improving communications and the internet such data represent a significant resource that should be more fully utilized. However, access, sampling and integration of spatial data remains a common problem for scientists, researchers and the general public. Add the dimension of many different agencies and the absence of a coordinated effort and integration of data becomes even more difficult.

Many of these challenges will be remedied through the development of the Canadian Spatial Data Infrastructure (CSDI). In building an initial component of the CSDI, the 4NR project developed a prototype WWW site to address improved access, sampling and integration of spatial data in Canada's Federal Government. The project was conducted in partnership with the Canadian Forestry Service and the Geological Survey of Canada.

The paper describes the project, development of prototype web site, inter-action with participant agencies, and planned developments. It will also describe access to spatial data resources through four different "windows" on the web site: 1) by agency, 2) search by subject, 3) data sampling, and examples of data integration; and 4) a simple list of databases and subjects. Users can discover national scale spatial data resources, understand the data producing agency and its activities, view maps of the data and inter-actively sample its integration potential using the NAISMap on-line GIS system. Directed examples of scientific queries and data integration are also provided, along with guidance to data producing agencies, publications and reports and related WWW sites.

The prototype site can be accessed at: http://nais.ccm.emr.ca/4NR.

CIQS - A New Web Tool for Accessing CCRS's Image Library

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ABSTRACT

Over the past 25 years, the Canada Centre for Remote Sensing (CCRS) has accumulated more than 14,000 images acquired by various imaging satellites and airborne instruments. These images have been used for research and development and to promote the use of remote sensing in environmental monitoring, agriculture, ice reconnaissance, hydrology, geology and many other applications. They are stored on various types of media ranging from computer compatible tapes, to CD-ROM disks, to Exabyte cassettes, which are usually located in the CCRS Tape Library. However, in some cases the images are kept in the individual libraries of the project investigators. When undertaking a new project, there is often a need to able recover all previously acquired relevant images before initiating any new data acquisition. The CCRS Inventory Query System (CIQS) satisfies this need by storing information about all CCRS's current image holdings in a relational database and by providing access to that database using only a standard World Wide Web (WWW) browser.

Cyberspace Research was commissioned, under the open bidding process, to create the CIQS software package to allow CCRS users to search or browse any processed or unprocessed (raw) images in the CCRS Image Library. Using the latest web technology, CIQS archives the image information as structured metadata and facilitates searching using database, geographic and temporal navigators. A CIQS user can perform queries on any of the following metadata fields to locate an image: project number, satellite track, scene number, geographic location (in latitude and longitude), NTS number, time of acquisition, satellite, sensor, degree of processing, and chief investigator. In addition, any other database fields can be searched and displayed using a WWW browser, or data can even be updated or entered, as long as the user has been authenticated, and has the appropriate authorization level required to gain access. All CIQS data access is strictly controlled through a data access security layer, and using a secure communication protocol.

Although it has been developed initially for use within the CCRS Intranet, CIQS will eventually become a node within CEONet. The CIQS software is easily extensible and customizable, and could be readily adapted to provide WWW access to any image library.

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ABSTRACT

Using the WWW to Enhance Collaboration within the BOREAS Project
by J.D. Dunlop[1]

York University and the Earth Observations Lab (EOL) of the Institute for Space and Terrestrial Science (ISTS) have a mandate to supply Compact Airborne Imaging Spectrometer (CASI) data to the BOREAS research collaborators and to disseminate the knowledge learned about the Boreal forest ecosystem's functioning to the wider research community. New cooperative information system (CoopIS) technologies, emerging out of the Conseil Européen pour la Recherche Nucléaire's (CERN) World Wide Web (WWW) and the National Centre for Supercomputer Applications' (NCSA) Mosaic initiatives, have made this type of collaboration and dissemination easy and reliable. Since the participants in BOREAS are all linked via the Internet they can exploit any available Internet tools in order to exchange data and information. It was a natural conclusion that the Earth Observations Lab should employ WWW technology to enhance collaboration within the BOREAS project.

The BOREAS research, conducted primarily during 5 intensive field campaigns in 1994, is focused at two major study sites in and around Prince Albert National Park in Saskatchewan and near Nelson House, Manitoba, and were chosen because they represent typical conditions of the northern and southern extremes of the Boreal forest. Much of the BOREAS data must be provided in a structured and logical manner to ensure the comprehensive data inventory is effectively managed. However, BOREAS is a research project wherein concepts and ideas will be developed and the methods used to effectively communicate these ideas may require not just words, but also images, graphics and animations. Rather than strict traditional hierarchies, the links will take the form of an interconnected web of data and data relations.

It is an important concept to recognize that not only the data stores themselves have value, but also the fine-grained relationships between them that can only be produced by an expert community. A critical requirement of any collaborative system is that it encourages community participation to provide new, original data and information, to peer-review what is already available, and to help develop new linkages between existing documents. The word document is used here to mean any shared, network addressable entity, and may actually contain any type of static or dynamic data file, data query or web application.

This paper will present a short review of the tools that were used by the Earth Observations Lab to enhance collaboration within the BOREAS project and then discuss the experience and improvements in collaboration that resulted. Since the WWW is rapidly changing the face of all information technology, a new vision for collaborative research in the "Era of Radarsat and the WWW", based on our BOREAS experience, will be presented.

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Tori: Web-based Analysis and Visualization of Time-Series RS Imagery

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Abstract

Tori is a Web-based Java applet which allows for the analysis and visualization of time-series RS imagery. Users can use Tori to select, display, animate and analyze image data stored remotely. The interface includes animation controls (forward/reverse/stop/slow), image filters (speckle reduction, edge detection, smoothing), change detection, frequency histogram display of all image time-slices, and the ability to select specific regions to apply specific methods.

Tori includes a meta-data database on its different datasets, which can be perused remotely. Being an Java applet, all processing of data is on the local host, allowing for a more intuitive, interactive interface, in contrast to more traditional, unwieldy CGI-based Web applications.

Experience in Using a Low-Cost Virtual Reality Tool

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ABSTRACT

The paper is about a project using the virtual reality (VR) technology to create an interactive multi-media presentation for tourist attractions. This technology can be used to simulate the three-dimensional world and enables users to interact and explore a photographic scene in a computer.

A recent development by Apple Computer Inc., Quick Time VR (QTVR), is used to transform a panoramic picture taken at a node into a virtual reality presentation. The user can then visit each site on the computer, browse the panoramic view, and walk to other nodes. Hot spots leading to still pictures, video clips, and sound clips can also be included.

LITHO EXPERT SYSTEM FOR INTERPRETATION OF ROCK COMPOSITIONS BASED ON REMOTELY SENSED DATA

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ABSTRACT

Numerous practical works in the area of remotely sensed data (RSD) interpretation allow VNIIKAM to accumulate wide experience on detection of material characteristics of lithological complexes. On this basis expert system for native rock compositions deciphering was elaborated. The system is capable of supporing a data base including airborne and satellite images classification data set, their description and interpretation scheme as well as a knowledge base as rules on RSD analysis and conditions their of their application.

Expert Systems includes user's interface, data base, knowledge base and instruments. The main functions of the user's interface are: review of images included in system's data base and user's materials; choice of images, satisfying to requirement of the tasks; forming of image description for interpretation and receipt of the expert's system conclusion; receipt of interpretation background made by system; review of interpretation rules (description), which used by ES in the process of logical conclusion.

The knowledge base consists of theoretical and methodical elaborations on this problem description of rock's composition indicators and their interpretation signs. Knowledge base supports the interpretation signings set for different conditions of interpretation objects classification, logical inference procedures to obtain conclusion on rock type based on interpretation signs and explanation procedures to ground made conclusion. Description scheme includes the following subdivisions: geological bodies structure; relief; drainage; vegetation; tone (color) of photographic image. The whole native rocks are divided in 11 groups and each of them includes one or several rock varieties with similar indicators of physical/mechanical properties, defining a stability of the rocks to weathering and denotation. These last circumstances define reflection of the rocks in landscape (in the first hand in relief) that allows to distinguish and define rocks on the images.

Data base of elaborated expert system includes unificated characteristics of standard images of rocks accordingly to divisions; name and age of the rock; geostructure, form of the bodies, dislocation degree, exposure degree, climate, technical specification of image, time of survey and some other data.

Instrumental means are languages of knowledge description and auxiliary utilities providing the following possibilities: operation with unmetric data, execution of logical inference based on both unclear knowledge and unclear data; presentation of conclusions in unclear form; graphical language form of snow edge presentation which permits to expert use under models construction only notes from his subject area; definition of minimum necessary signs set and automatic construction of the rules for receipt of required conclusions.

The Geological Monitoring System for Yamal Peninsula with ground-based and satellite technology.

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Abstract

The academic and practical organization pay attention on Yamal peninsula as the most valuable and prospective region of Russia in view of the natural gas and oil deposits. The local users and administrative bodies create the demand in the contemporary geoecological monitoring system. Such system must be oriented toward the control of the terrestrial applications and hazardous events. The location of Yamal peninsula in auroral zone also lead to needs in the information about geomagnetic disturbances its influence on technological systems. The complex task will possible to solve in the frame of modern monitoring systems based on the ground-based network and remote sensing satellite date.

As the first approach in present time we use the AVHR receiving station in Salekhard and a few points of observations of Yamal peninsula. The regular data formed in the data management system used for monitoring purposes. The dynamics events such as vegetation process, ice conditions, floods, oil spills, forest fires are detected well. The monitoring system, include Arc/Info GIS, pack with data base (maps) on the agroecology, geocriology, geology, geomorphology, mineral deposits, ecology and living species. The output products varies from mesoscale to landscape scale. As we know we own the first regional data base for real Arctic region in Russia.

There are no substitutes for direct satellite measurements, so the future improvements in our geoecological monitoring system we expect due to involvement in the RADASAT's Application Development and Research Opportunity program featuring innovative data application for Yamal peninsula and adjacent seas.

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Practical Considerations for Geological Investigations using RADARSAT-1 Stereo Image Pairs in Tropical Environments

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Stereo image viewing of landforms provides geologists with a three dimensional perspective which enhances the interpretability of geological features. Our case study from Sarawak, Malaysia presents a mountainous, tropical rainforest environment characterized by a complex fold-thrust belt system. We investigated several beam modes (Fine, Standard, Extended) over a range of beam positions (incidence angles) and concluded that a wealth of additional information is gained through stereoscopic interpretation of fold and fault structures whose interrelationships are often difficult to elucidate from any single SAR image

There are four factors that influence the selection of suitable RADARSAT-1 image pairs :
1. Radar look-direction is fairly constant at 82° azimuth for ascending passes; 279° azimuth for descending passes, and therefore the passes should be chosen according to the morphology of the terrain. Images compared from opposite look directions, however, often contain complementary information. We have consistently observed that geological features are more clearly discernible on the far-range slope of mountains, whereas the near-range mountain face is frequently saturated by high backscatter and foreshortening effects.
2. Same-side stereo (i.e., ascending/ascending or descending/descending) image pairs are generally recommended for all terrain types. Opposite-side image pairs (ascending/descending) provide higher vertical exaggerations, but are only recommended for areas of low relief.
3. Overlap between beam positions is not complete, particularly at equatorial latitudes. For example S1/S6 followed by S2/S7 provide the maximum stereo coverage (over 90%), whereas S3/S4 provides only a 30% overlap. In Fine mode, F1/F4 and F2/F5 yield over 90% overlap, however all other pairs have less than 50% overlap, or none at all. Ten new Fine beam positions have been introduced for the second year of operation. The benefits of improved Fine beam overlap will be presented.
4. RADARSAT-1 incidence angles range from 10° to 59° and beam positions with the largest incidence angles minimize (single image) terrain distortions. Also, the greater the angle between incidence angles of each image in the stereo pair, the greater the perceived vertical relief.

Investigations with Fine, Standard and Extended High beam modes reveal that with a minimum of image manipulation and processing, excellent stereo image pairs can be created and viewed with traditional optical stereoscopes. The structural information interpreted from the imagery is greatly improved to that obtained from single images alone.

Radar Images as a Source of Geological Information in Northern Barren Environments

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Geological mapping programmes in remote regions can benefit from an integrated use of remotely sensed data throughout the life of the project. The wide area, synoptic coverage of satellite images provides (1) an overview of the major structures and general subdivisions at the initial planning stages, (2) complements aerial photographs for planning specific field activities, and (3) aids in the development of the geological map during the compilation stage.

Mapping in the Whitehills-Tehek Lake area (65°N / 096°W, north of Baker Lake, NWT) by the Geological Survey of Canada and field investigations of radar image characteristics by the Canada Centre for Remote Sensing were carried out in July and August, 1996. Radar data used in this study were acquired in April 1995 from the CCRS airborne C-band SAR and in September 1996 from RADARSAT-1 (Standard 7).

Results indicate that airborne and satellite SAR images reliably differentiate between areas of bedrock or felsenmeer (block fields produced by intense freeze-thaw cycles), which appear as bright tones on SAR images, against dark tones typical of heath-covered tundra. Texturally similar bright zones on SAR images broadly correlate with regional lithological units. Quartzite units of the Woodburn Group are particulary recognizable by very high radar backscatter. Exposures of felsic gneisses also exhibit high backscatter, whereas exposures of metamorphosed iron formations, metavolcanics and associated metasediments have somewhat lower backscatter. In the airborne SAR data, actual bedrock often exhibits a slightly higher backscatter than areas of only frost-heaved blocks. This provides an important distinction for mapping which is not easily made from the vintage of aerial photographs available for the area. This distiction is not resolved in RADARSAT Standard Mode, however in Fine Mode it may be possible. SAR images combined with aeromagnetic data has proven especially useful for locating outcrops of iron formation and mafic to ultramafic units whose distributions are generally inferred from their high magnetic signatures. New fault zones revealed from field mapping are recognized in SAR images and can be extended beyond their observed locations with greater confidence.

Évaluation des images RADARSAT pour la détection des linéaments structuraux et glaciaires dans les secteur de la Rivière aux Mélèzes

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Les méthodes traditionnelles de cartographie et d'interprétation des linéaments peuvent être parfois fastidieuses et coûteuses lorsqu'on veut détecter des formes à plus petite échelle dans les régions difficiles d'accès. La télédétection radar est une solution de rechange, puisqu'elle permet d'obtenir des images d'une perspective globale et ce, dans toutes les conditions atmosphériques.

Cette étude s'insère dans le cadre du projet ADRO qui a pour but de développer des méthodologies afin d'évaluer le potentiel du satellite RADARSAT-1. Par conséquent, l'objectif général de cette recherche est de détecter, de façon optimale, les linéaments structuraux (failles, fractures, contacts lithologiques) et les formes glaciaires (drumlins, eskers) dans une région nordique. L'objectif spécifique est de comparer des images prises à différents modes d'acquisition (orbite, résolution), angles d'incidence et de faire une discrimination des linéaments structuraux et des linéaments glaciaires. La région d'étude correspond au secteur de la rivière aux Mélèzes, situé au sud-ouest de la Baie d'Ungava. Le choix du secteur se justifie par la possibilité d'obtenir des données brutes et traitées provenant d'autres capteurs (LANDSAT-TM, ERS-1), ainsi que des photographies aériennes et la carte glaciaire du Canada. Du plus, cette région est caractérisée par le géosynclinal du Labrador et par des évidences du passage de la callote glaciaire.

Dans le cadre du projet, les techniques de détection des linéaments, développés pour les images ERS-1, seront appliqués aux images RADARSAT-1. Les images RADARSAT présentent des attributs variables dus à la variabilité des angles d'incidence et de visée, des modes d'acquisition et la variabilité des angles d'incidence et de visé, des modes d'acquisition et à la possibilité de leur fusionner des information complémentaires (LANDSAT-TM, modèle numérique d'altitude). La méthode d'extraction comporte plusieurs étapes. La première, consiste à appliquer les correction géométriques et de lisser les donnés, afin de réduire les distorsions spatiales et les bruits des images radar. L'application des techniques de détection sur l'ensemble des images constitue la seconde étape. La troisième est la comparison des résultats entre eux et une caractérisation visuelle du milieu dans le but d'effectuer la discrimination.

Ce projet fournira un outil complémentaire à la cartographie des structures de la Fosse du Labrador et des linéaments à directions multiples, à la compréhension des flux glaciaires laurentidien par la séparation des types de linéaments (Structural opposé à galciaire) et aux développements de stratégies de prospection minière.

ÉVALUATION DE LA GÉOMÉTRIE DES IMAGES RADARSAT : PREMIERS RÉSULTATS

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En tant que premier satellite canadien d'observation de la Terre, RADARSAT procure une source d'information importante pour une gestion effective et un suivi régulier des ressources naturelles de la Terre. En effet, 25 types d'images sont disponibles à l'utilisateur, de jour comme de nuit : chacune variant en fonction du mode d'acquisition, de l'angle de vue et de son orientation, mais aussi du terrain imagé.

Afin d'utiliser efficacement ces différentes images, à savoir les fusionner, les intégrer avec d'autres données multi-sources et multi-format, et en extraire de l'information cartographique, il est nécessaire de comprendre leur géométrie et d'évaluer les contraintes et les paramètres qui affectent le traitement géométrique des données, en mono- ou en stéréoscopie. Ainsi, une évaluation qualitative et quantitative de ces paramètres doit être effectuée : à savoir le mode, la résolution, les angles de vue, d'intersection et de convergence.

Le site d'étude est la zone d'essai à Sherbrooke (Québec, Canada), qui comprend un grand nombre de données cartographiques de grande précision. Ces données sont utilisées comme vérité-terrain pour l'évaluation. Les données RADARSAT disponibles ont été acquises en mode fin, standard, et étendu avec différents angles d'incidence (de 10° à 59°). Les logiciels utilisés sont ceux de traitement géométrique disponible au Centre canadien de télédétection, pour la création d'ortho-images ou la restitution stéréoscopique d'un couple.

Après avoir présenté les aspects théoriques sur le traitement géométrique et la restitution stéréoscopique, la présentation analysera les résultats du traitement géométrique en fonction des différents paramètres étudiés, sur le site d'étude.

Cette analyse permettra de mieux comprendre les phénomènes physiques reliés au traitement géométrique et à la restitution stéréoscopique, mais aussi donnera aux utilisateurs des données RADARSAT des outils et des informations pratiques pour choisir leurs images et couples stéréoscopiques en fonction :

- du terrain et de son relief;
- des données auxiliaires (points d'appui, MNA, etc.);
- de la précision recherchée;
- de l'information à extraire; et
- de l'applications envisagée.

A Training Package on: "How to use RADARSAT data in stereo"

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Throughout history, humans have tried to represent what they saw and understood through images. Maps have been one way to show the relationship between humans and their environment. Mapmakers have always sought ways in which to represent both the location and three dimensional shape of land. Drawing techniques such as shading, overlapping and perspective views were traditionally used to give an impression of three dimensionality.

In the last 200 years, many advances in representing three dimensions have been made. Stereomodels, anaglyphs, chromo-stereoscopic images and holograms can provide three-dimensional (3-D) information about our planet that flat, two-dimensional (2-D) images can not.

Why is it important that the third dimension be conveyed? Humans are naturally able to see in three dimensions. The 'naturalness' of a 3-D representation of reality enhances our ability to interpret 2-D imagery. Cartographers, engineers, geologists, hydrologists, and other scientists use 3-D viewing methods in order to better understand the Earth's surface. Representation of the third dimension supplies important information about relationships between land shape and structure, slopes, water ways, surface material and vegetative growth.

Stereo viewing of two 2-D images has been used since the mid 1800's. Stereoscopes are still widely used throughout the world. They are less expensive and more portable than computer hardware and software. Although automatic methods to extract quantitative information from a stereo pair have been developed, qualitative interpretation is best done by people skilled in stereo viewing. For many users and applications, a stereoscope and a stereo pair represent the most efficient way of getting a large amount of information about an area of the Earth quickly and cheaply.

The is a presentation of a training package designed to demonstrate the potential and feasibility of stereoscopy with respect to RADARSAT data. The intent of this package is to illustrate the use of a stereoscopic apparatus to view and interpret RADARSAT data in stereo. Data sets, mainly from RADARSAT, but also from other sources will be used as examples to show:

- three different methods of representing depth information,
- possibilities of creating stereo image pairs from different data sources,
- different look directions, beam modes and beam positions of RADARSAT data available to the user,
- effects of ground cover and geographical location on RADARSAT image pairs, and
- different image processing techniques that enhance the viewability of RADARSAT stereo pairs.

Users of this package will gain a practical understanding of the differences between different data sets. Furthermore, it will enable users to generate the best stereo pair according to the data set, study site and thematic application.

DEM GENERATION FROM SPOT IMAGERY IN A DIGITAL PHOTOGRAMMETRIC WORKSTATION

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ABSTRACT

Although stereoscopic SPOT imagery has been used for mapping for over a decade, most of this work has been performed in analytical plotters. The introduction of digital photogrammetric workstations (DPW) has created a new environment and opened new possibilities for the metric analysis of the images. It is therefore important to ascertain what impact this new technology has on the photogrammetric processing of SPOT data. Such study is in progress at the University of New Brunswick.

This paper will review the procedures followed and the strategies used for generating a digital elevation model (DEM) from SPOT imagery in a DPW. A complete scene, with a base to height ratio of 0.4 was available for the test. DEMs were generated by automatic image correlation at 50 m grid spacing for eight, 8.0 km by 5.5 km each, test sites. These sub-scenes represent various terrain topography and land cover. The SPOT DEMs were compared with the provincial digital DEM files which were collected in a precision analogue stereoscopic plotter from 1:35,000 scale aerial photographs. The results indicate that the standard deviation of less than 9.5 m can be obtained for the SPOT DEM, which can be reduced to less than 8.0 m by editing. The procedure employed for blunder detection and editing will also be presented. A comparison of contours generated automatically from the SPOT and the check DEMs is in progress and the results will be included in the paper.

USE OF RADARSAT IMAGERY IN CARTOGRAPHY

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ABSTRACT

IGN Espace is a production unit of IGN-France, the french mapping organization, which is specialized in topographic mapping based upon satellite imagery (SPOT, LANDSAT, ERS). In order to complement the range of our image data sources, we have decided to adapt our production line to RADARSAT imagery. In this paper, we present the first step of our evaluation of RADARSAT imagery: orthoimage production through space triangulation techniques and the evaluation of the various locating precisions.

The geometric quality of cartographic products (orthoimages and Digital Elevation Models) depends on the location quality of the images, which can be improved using ground control points. Space triangulation is the technique used at IGN Espace to register satellite images: both absolute and relative locations are simultaneously optimized on a whole block of images. In order to adapt this modelization technique to RADARSAT imagery, ground control points identified on RADARSAT images are used to improve the knowledge of image acquisition geometry. It enables us to choose and validate the appropriate physical correction model. From this, we can deduce the precision of point identification (absolute location), the precision of image to image matching (relative location) and the appropriate number of ground control points required. It is also possible to quantify the precision of location without ground control points (this precision is linked to the quality of ancillary data): the use of descending/ascending pairs of ERS images enables the locating of terrain features without ground control points, with a precision better than 50 meters. This use of ERS imagery is very useful in cartography; it is therefore important to measure RADARSAT capability in this field.

TOPOGRAPHIC MAPPING FROM RADARSAT

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ABSTRACT

Image processing techniques readily allow the operational use of radar satellite for cartography. The recent availability of Radarsat data, which is the only system that has the capability to electronically steer the radar beam to efficiently collect data with the required stereo geometry for digital terrain extraction, offers a great potential for this kind of application. In this context, a project has been launched to carry out a demonstration of the capability of RADARSAT for the production of topographic maps at scale of 1:100 000 in tropical environments on a pilot site in Colombia.

To achieve this, RADARSAT stereopairs will be acquired for a representative site in a specific zone where data capture using optical sensors is difficult because of cloudy conditions. Topographic information will be extracted from the images, then integrated into the existing cartographic information system at the national institute of cartography, and compared to current data as well as cartographic norms at a scale of 1:100 000. Analysis of results will be done in close collaboration with national institute of cartography thus allowing for the evaluation of capability and accuracy of RADARSAT data as it relates to this cartographic application. In light of the results obtained, a technical and economic feasibility study of RADARSAT data integration to an existing national institute of cartography production facilities will be undertaken. This paper presents the preliminary results of the study.

USING RADARSAT-1 SAR IMAGERY TO MONITOR THE RECOVERY OF THE IRVING WHALE OIL BARGE

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ABSTRACT

The salvage operation of the sunken oil barge Irving Whale in the Gulf of St. Lawrence presented an opportunity to demonstrate the operation of the RADARSAT-1 system for acquisition and delivery of timely SAR image data in the event that a spill should occur. The project was initiated by the Alliance for Marine Remote Sensing (AMRS), the Canada Centre for Remote Sensing (CCRS) and Environment Canada. AERDE Environmental Research conducted the bulk of the work under subcontract to AMRS. Funding was provided through the EOP3 and EODS programs which are administered by CCRS as part of Canada's Long Term Space Plan (LTSP II). The paper summarizes design and execution of this demonstration pilot project to detect and possibly monitor oil spills using RADARSAT-1 SAR data. Implementation issues are also addressed. Several benefits have been identified for using RADARSAT in oil spill detection exercises. These include: (I) increased effectiveness of surveillance activities through larger area coverage and through better inspection frequency of high risk areas; (ii) increased effectiveness and cost savings through complementary use of a RADARSAT-based oil spill detection and alert method and aircraft-based site investigation and positive identification; and (iii) improved documentation and statistical data collection for managing marine environments, environmental impact assessment, or oil drift model validation.

SHIP DETECTION WITH RADARSAT SAR

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ABSTRACT

RADARSAT, equipped with a C-band, HH-polarized SAR has the potential for operational ship traffic monitoring through the use of user-programmable beam modes and incidence angles. Seven beam modes provide swath widths from 50 km to 500 km, resolution from 10 m to 100 m and an incidence angle range from 10° to 60°. Ship traffic monitoring with RADARSAT is enhanced with the realization that the probability of detecting a ship increases with increasing incidence angle, and is better with HH-polarization which is less sensitive to ocean-surface roughness.

In one of the first quantitative assessments on the use of RADARSAT for ship detection, RADARSAT Wide mode (30 m resolution) imagery of the Strait of Georgia, British Columbia, was acquired January 13, 1996. Ground truth information was provided by the Canadian Coast Guard (CG), who monitor the Strait of Georgia with shore-based radars. Ship traffic is updated continuously, and includes a vessel identification tag and vessel position. In addition, wind direction was obtained from meteorological stations around the Strait. The position of ships, as tracked by the CG, was compared to ship targets in the RADARSAT image. Within the geographic extent of the RADARSAT image, eighteen vessels were tracked by the CG, and all eighteen vessels were detected. Ship lengths ranged from 14 m to 140 m, and detection occurred in both cross-wind and upwind directions, and for ships traveling both perpendicular and parallel to the radar look-direction. Wind speeds ranged from 4 m/s to 10 m/s. A second RADARSAT image of the Strait of Georgia was acquired January 24, 1996, in Fine mode (10 m resolution). Results from a comparison of the backscatter characteristics of two ships, identified in both the Fine and Wide mode images, are also discussed.

The Extraction of Ocean Surface Information from SAR Imagery

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Abstract

Near global coverage of the oceans is now available from satellite based synthetic aperture radars (SARs) such as those on board ERS-2 and RADARSAT. In principle, it is useful to extract ocean surface data from each SAR scene. Scene statistics, calibrated backscatter, image spectra, and inter-look cross-spectra can all play a role in determining the wind and wave conditions present in the scene. These, in turn, affect the detection of targets such as ships and slicks on the ocean surface. Quantitative analysis of data from ERS-1, ERS-2, and RADARSAT, along with in situ measurements of wind and wave conditions at the time the data were acquired, can be combined to validate several information extraction techniques which apply to each of these C-band sensors. The techniques include the use of low wavenumber image spectra to resolve wind direction and the combination of these directions with calibrated ocean backscatter to resolve wind speed. Wave spectra can be derived from SAR image spectra and the inter-look cross spectral technique can be used to reduce speckle noise contributions to the SAR image spectra and to resolve the wave propagation direction. Wind speed and significant wave height can also be related to the azimuth cutoff wavelength. Finally, scene statistics such as skewness, kurtosis, and the K-distribution order parameter can be computed and combined with the wind and wave information to predict the detection performance of the SAR for ships and other targets with unusual statistical properties. While the potential exists to obtain a detailed snapshot of many aspects of the ocean surface and the targets on it with the SAR data alone, ancillary data may be required to fully resolve the wind direction and to supply wave information outside of the azimuth passband. Synergistic use of wind and wave field predictions together with the SAR imagery, allow a more complete picture of the ocean to be developed than would be possible with either information source alone.

The Ocean Feature Workstation: Experience gained with RADARSAT

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ABSTRACT

One of the main advantages with a satellite imaging sensor sch as the RADARSAT SAR. is the ability to cover large areas of the Earth's surface in a short time. The challenge in using this sensor over the oceans, is to reduce vast amounts of collected data into useful information in a short enough time to be useful in the rapidly changing ocean environment. The Ocean Feature Workstation (OFW) has been developed to extract information in RADARSAT images collected over the ocean. The system is designed to use state of the art algorithms for retrieval of wind and wave information, the location of major ocean and atmospheric features, as well information on vessels. The extracted information is formatted into products designed for ease of interpretation and for transmission to operational centres on land and at sea.

RADARSAT has now been in orbit for more than a year. During this year, significant experience has been gained, both in satellite operations, data acquisition, and in processing data with the OFW. The SAR has been shown to provide high quality imagery. The many beams and modes of the radar allow the user significant flexibility in acquiring marine environmental information. The OFW has been used for ship detection, for wind measurements and for estimates of wave conditions. This paper will discuss our experience, and relate it to RADARSAT data characteristics and the OFW performance.

Wind, Wave, and Current Signatures in RADARSAT

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ADRO # 11, Oceans and Ice Applications

ORAL Presentation

ABSTRACT

As a part of ADRO Project # 11, we have been collecting sets of ascending narrow ScanSAR passes separated by three-day intervals over the NW Atlantic. The passes intersect the US East Coast between Cape Hatteras and the Gulf of Maine, and extend southward past the Gulf Stream. In the narrow ScanSAR mode, with a swath width of 300 km, successive passes overlap slightly. The resulting mosaic has dimensions of 800 km to 1000 km in each direction, and theoretically can be collected every 24 days. We have collected two such sets in October and January, and expect to collect two more sets in February and March. The overall objective of the work is to explore the potential of RADARSAT for monitoring properties of the surface wind field, the wind-generated wave field, and the surface current dynamics. We are especially interested in the following questions, related to each of the three classes of signatures:

1. How often do wind direction signatures appear, either as wind rows or otherwise? Using some surface manifestation of direction, can the narrow ScanSAR mode be sufficiently well calibrated to yield a robust estimate of wind speed with spatial resolution of 25 km or less? What is the effect of boundary layer stability on the SAR signatures?

2. Does the spatial evolution of the wind-generated wave field signature reveal further details about the practical limitations of high-altitude SARs for monitoring storm waves? In particular, how severe is the azimuth fall-off problem in RADARSAT?

3. Can RADARSAT, in its narrow ScanSAR mode, reveal the current boundaries of the Gulf Stream and lesser coastal currents with enough confidence to become a useful adjunct to the cloud-plagued AVHRR and similar instruments? Is the resulting time/space sampling sufficient to help fill in the present gaps in coverage?

There are also two more practical issues that bear on those above:

1. How stable in time (scale of months) and space (distance across swath) is the RADARSAT transfer function? Can we expect to maintain relative calibration across the entire narrow ScanSAR swath to within 1 dB?

2. Can the RADARSAT imagery be processed, disseminated, and analyzed rapidly enough to support a useful real-time web site? Could such a web site, for selected regions off the US coast, be updated within a day of collection?

In this talk, we will summarize our current progress and future plans in each of the above areas.

Mode Selection and Image Optimization for Coastal, Ocean and Ice Applications of RADARSAT Imagery.

Submitted as an abstract for ADRO Project # 160.

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As the incidence angle increases across the RADARSAT accessibility swath, the radar backscatter contrast will also increase for mixed land, ice and water scenes, due primarily to high slope of the open water backscatter curve. Depending on a number of parameters, including the position and size of the low backscatter region in the swath, this may create problems in the resulting imagery. In particular, Doppler centroid estimation may be compromised, and analog-to-digital (ADC) saturation may take place. Both problems can lead to visible image artifacts and problems with image interpretation.

In this paper we review the mode choices for different ocean and ice applications of RADARSAT data. For some applications and modes it is unlikely that image degradation will occur. However, for other applications the optimum mode choice will be those for which it is possible to get radiometric problems arising from ADC or Doppler centroid problems. The scene conditions (the gross arrangement of high contrast regions in relation to the satellite track) which can lead to problems will be explained and some examples of imagery which have been corrupted by these problems will be shown. The discussion will aim to help users identify whether radiometric problems have occurred, and address one approach to correct the radiometric degradation which accompanies ADC saturation.

On the Use of the Wavelet Transform for Sensitivity Analysis of ERS-1 SAR Data Applied to Multiscale Structures in the Tropical Forest.

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The work presented here is part of the TREES ERS-1 Central Africa Mosaic project. The goal of the TREES project (Tropical Forest Ecosystem Environment Monitoring by Satellites) is to establish an operational tropical forest monitoring system.

This paper will focus on the use of Wavelets for the analysis of multiscale texture in ERS-1 SAR images of the tropical forest. Previous work has shown that the main features responsible for texture in forested environmentsare effects due to microtopography in the forest canopy. In the case of ERS-1 images of the tropical forest, these features are not resolvable. We are therefore interested in analysing structures at larger scales. Since structures can exist at different scales, a multiscale approach is needed in order to measure the resulting multiscale texture. In this paper texture is considered as a scale dependant image characteristic.

The paper describes the analysis methodology which is based on the wavelet transform. The SAR image is decomposed into its different scales in order to identify those scales at which observable structure exists. Once the image has been decomposed we compute the histogram distribution at the different inherent scales. The analysis then consists of fitting a non-linear function to the histograms. This allows identification of the parameters and target peculiarities, which can be used for classification of the forest features in the image.

The methodology was first tested on a data set composed of 18 images of the same area. Based on the temporal stability of the tropical forest a simple average can be applied to this data which results in a quasi noise free composite image.

The textural structures detected and observed in the ``noise-free'' image, were than analysed on a single PRI format radar image. However, the PRI images are heavily blurred by radar speckle. A method is describe for the assessment of the contribution of the speckle noise to the Wavelet Transform. An assessment of the speckle contribution permits the definition of a detection threshold and a signal to noise ratio for structures and intrinsic image texture.

Preliminary results show that the Wavelet component first order distribution fitting, permits texture analysis. In addition, structures responsible for the multiscale texture are most readily detectable at scales larger than 100 meters.

Using RADARSAT's Imaging Versatility to Improve Fine Resolution MappingCapabilities

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Abstract

The Synthetic Aperture Radar (SAR) on Canada's RADARSAT Earth observation satellite offers high resolution all weather imaging using its Fine Resolution imaging mode. This imaging mode, providing better than 9 metre resolution over a swath width of 37 to 57 km, has proven to be the most popular commercial imaging mode in RADARSAT's first year of operation. However, the initial offering of 5 beam positions over an accessible swath of 210 km could not fully exploit RADARSAT's high resolution potential for mapping in the commercially important equatorial regions. To improve coverage capabilities, improveflexibility, and improve coverage efficiency, an additional 10 Fine Resolution Beam positions have been added by making use of the imaging flexibility inherent in the RADARSAT instrument.

Before being implemented into the operational system, the modifications required to provide enhanced coverage were analysed theoretically (and found to be simple), tested under controlled circumstances, and validated through examination and analysis of the image products. In this paper, the 10 new positions are defined and the improvements in coverage capability, flexibility, and efficiency are illustrated. Images produced with these new beam positions meet the image quality specifications for the original positions.

This is an example of how the instrument versatility can be utilised to expand the range of imaging capabilities. Some other potential ways in which this versatility could be exploited are presented and discussed in the paper. If these prove as satisfactory after analysis and testing as the augmented Fine Resolution Beams, it is hoped that they can be incorporated into the operational capabilities of the system.

Adaptive Compensation of RADARSAT SAR Analogue-to-Digital Converter Saturation

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Abstract

Dark rangeward bands sometimes appear in RADARSAT synthetic aperture radar (SAR) imagery of the coastal zone. These bands are usually visible over land or ice when water is in the near range. This artifact arises since the automatic gain control (AGC) is set by the near half swath alone, while the far half swath could return more power than the near half swath, depending on scene content. If the gain is inappropriately set too high for the far half swath, then the radar's 4-bit analogue-to-digital converters will saturate, one effect of which is a loss in power and the appearance of the image banding.

We have tested a simple correction methodology to improve image radiometry under these circumstances. Based upon measurement of the signal data standard deviation and the power loss properties of a 4-bit ADC, under the assumption of a Gaussian input to the radar a gain parameter is determined which is used to scale the signal data and recover the lost power. The methodology has been implemented for our workstation-based SAR processor. We show that artifacts with power loss as large as 8 dB can be reduced to less than a 1.5 dB residual, while power loss on the order of 2 dB can be nearly perfectly compensated. Furthermore, ADC under flow for low backscatter regions can also be corrected.

The method does not address possible corruption of image texture due to ADC saturation. Also, there is the possibility of small signal suppression in the coastal zone, even if the power loss correction is carried out.

It should be noted that some degree of ADC saturation and power loss could occur even if the gain is held constant during image data acquisition. While the image banding is eliminated by this type of compensation, for quantitative use of the data the power loss should still be compensated. A similar situation arises for ERS-1 SAR images over the ocean for moderate to high wind speeds. The proposed procedure of scaling the signal data also applies to this situation.

Implementation of this method in the Canadian Data Processing Facility (CDPF) would serve to improve the quality and radiometry of images derived processed from archived RADARSAT signal data.

Radar Image Modeling of natural surfaces with undulated topography.

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Abstract:

In order to understand the radar image formation process of natural terrain with undulated topography, we developed a model divided into three main parts. First, the radar beam is modeled using a 2-D point spread function (PSF) simulated with a 2-D gaussian modulated with a cosine. Second, the radar receiver is modeled with a sampling operation of the backscattered signal occuring at fixed time intervals. Third, the observed natural surface is modeled with scatterers randomly distributed in 3-D undulated space. The radar image formation process consists in convolving the slant-range axis projected 3-D natural surface with the 2-D PSF and sampling the resulting signal with respect to time (slant-range axis), to produce each pixel in the radar image. This type of model is useful to study the parameters and stochastic processes involved in radar image formation. Moreover, it will help to choose the best set of features (first and second order statistics) to allow representation of particular undulated natural surfaces. Preliminary results of radar images simulated with our model are presented for diverses conditions of undulated natural surfaces.

Algorithms for Processing RADARSAT ScanSAR Data

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Quite a few papers have been published in the last several years on phase preserving SAR processing algorithms, including the classical range/Doppler, modified range/Doppler, SPECAN (de-ramp and FFT), and chirp scaling. These algorithms work well on continuous-mode SAR data, such as Radarsat's regular beams, but must be modified when applied to burst-mode data, such as Radarsat's ScanSAR modes. This is because the spectrum of the data collected in burst-mode varies with time.

With the recent interest in interferometry, it is important that SAR processing algorithms be phase preserving. However, the time-varying spectrum of burst-mode data inherently introduces phase variations, and special modifications must be made to the processing algorithms to regain the correct phase properties of the received data. This paper will discuss the required modifications, and recommend the best algorithm for processing Radarsat ScanSAR data.

First, an ideal compressed point target is generated as a reference, which is obtained by tuning the matched filter to this particular target only. Second, another compressed point target is obtained by tuning the matched filter to the whole ensemble of burst-mode point targets. Then, compression with di references. In the paper, we also distinguish between phase distortions due to the processor and due to the way the data is acquired, keeping in mind the inherent phase properties of burst-mode data.

Each algorithm is examined to see how it deals with the azimuth varying discontinuous Doppler spectrum of the received data, and how it affects the phase and radiometry of a compressed target. For interferometric applications, each algorithm is further investigated to quantify its susceptibility to misregistration between bursts. Finally the efficiency of each algorithm is studied. The analysis is supported by simulation experiments and experiments with Radarsat ScanSAR data.

SETTLEMENT DETECTION AND URBAN LAND USE MAPPING FROM RADARSAT IMAGERY

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ABSTRACT

This paper presents the preliminary results of a project designed to investigate applications of Radarsat imagery in settlement detection, population estimation, and urban land use pattern analysis and sponsored by the Canadian Space Agency under the Application Development and Research Opportunity Program (ADRO Project ID: 348).

Although the distribution of Radarsat data was delayed by several months and images for most of the originally selected sites are not yet available, images of fairly good quality for part of the northern China plain, part of the north central States of the U.S. and Sun City of Arizona have been received recently. Data analysis has already begun. This paper uses these images to demonstrate the capabilities of Radarsat data for settlement detection and urban land use mapping.

Specifically, results of defining the minimum size of settlements for their accurate detection and the overall accuracy of detection of settlements of various sizes will be presented. The results are based on the analysis of four images acquired over part of the northern China plain in the Fine Resolution mode and one image acquired over part of the north central States of the U.S. in the Wide ScanSAR mode. The types of urban land use and land cover mappable from Radarsat data and the level of classification accuracy achievable are based on the detailed study of the image of Sun City, Arizona acquired in the fine Resolution mode. Effects of climatic regions, cultural environment, look direction and spatial resolution on the detectability of settlements and the image classification accuracy will also be discussed.

EFFECTS OF IMAGING GEOMETRY ON SETTLEMENT DETECTION AND URBAN LAND USE MAPPING

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ABSTRACT

This paper presents part of the results of a project designed to investigate the applications of Radarsat imagery in settlement detection, population estimation, and urban land use pattern analysis and sponsored by the Canadian Space Agency under the Application Development and Research Opportunity Program (ADRO Project ID: 348).

Although the distribution of Radarsat data was delayed by several months and images for most of the originally selected sites are not yet available, images of fairly good quality for part of the northern China plain, part of the north central States of the U.S. and Sun City of Arizona have been received recently. Data analysis has already begun. This paper uses these images to demonstrate the effects of imaging geometry on settlement detection and urban land use mapping.

Radar imaging geometry consists of five basic elements: radar look direction, radar incidence angle, feature orientation on the ground, slope of the terrain surface, and the geometric shape of ground targets. The interplay of these elements determines whether vertical structures or aligned trees, rows of crops and other similar surface features or objects will cause corner reflection which often becomes the dominating factor of image brightness pattern and seriously complicates the procedure of automated radar image classification. A clear understanding of the interplay of these elements and the ability of quantifying the effects of these elements on corner reflection are of critical importance to radar image interpretation and design of effective radar image classifiers.

Radarsat can acquire images in either ascending or descending mode, giving two possible look directions. The incidence angle of the Radarsat imaging system can vary from 10 to 60 degrees. The potential variability of feature orientation is 360 degrees although most cultural features are oriented in the cardinal directions and symmetrical. The geometrical symmetry reduces the variability of cultural features to 180 degrees. The theoretical range of variability of terrain slope is between a flat surface and a vertical cliff. Obviously, the practical range, at least as far as cultural features are concerned, is much smaller because very few vertical structures are built on extremely steep slopes. The geometrical shape of ground targets can also vary widely, particularly for natural features. It is these highly complex geometrical shapes that had promoted the development of fractal geometry. On the other hand, it should be possible for us to produce an finite list of regular geometrical shapes for cultural features. As a first step, we will model the effects of buildings whose footprints are square, rectangular or circular and roofs are either horizontal or tilted planar surfaces.

DEPARTMENT OF NATIONAL DEFENCE MILITARY UTILITY EVALUATION OF RADARSAT DATA

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ABSTRACT

The Directorate of Space Development managed an evaluation of the military utility of RADARSAT data in support of the Department of National Defence's (DND) space-based surveillance requirements. The evaluation started while the RADARSAT spacecraft was in commissioning phase and was completed in Dec. 96. The article describes the scope of the evaluation and the scenarios which comprised the evaluation plan. Each scenario was assigned to a DND agency which was responsible for the analysis of the data. In addition to DND resources, the evaluation made use of imagery analysis capabilities and on-going research in the field of maritime applications by the Canada Centre for Remote Sensing (CCRS), Department of Fisheries and Oceans (DFO), and other Government departments. The scenarios assessed the ability to detect, identify and/or classify point targets in a land, marine and air environment taking into account local environmental factors and seasonal effects. They also included the recognition and extraction of geomatic features and marine conditions that affect the conduct of military operations. The technical evaluation identified the RADARSAT imaging modes and image processing modes that are best suited to the targets of interest to DND. Finally, the evaluation identified enhancements that may be applicable to RADARSAT II and/or ground-based image recovery and image processing facilities. The lessons learned from the management and planning of the evaluation are summarized.

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Radarsat and TM data fusion for urban structure analysis

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Abstract:

Improvement of data quality for urban structural analysis by fusion of Radarsat and TM images is focused. Three objectives are settled as;

(1) Vegetation in urban structure

Fused image between Radarsat and Landsat/TM has an advantage in vegetation distribution analysis in the urban structure. Only Landsat/TM data do not give satisfaction for the interpretation of vegetational segments in the urbanized area. Landsat/TM data give the spectral pattern of the land surface but no details of the urban structures as roads, rail roads, or the town blocks. Whereas, Radarsat image gives the town structure as above listed but no spectral signature. Combination of two kinds of satellite data makes the possibility to give the spectral and structural analysis.

What kind of combination is the best for this purpose. There are various purposes in urban analysis. For example, a case requires to argue vegetation distribution in urbanized area. In another case, some optimal solution for planting tree in a street is required. Investigation of existing relationship between street trees and street structure is anticipated. For the final skeleton, it might be required how to plant street trees for the street size, length and types etc..

The authors present a method of data fusion for this purpose with an example combining Tokyo data sets; a fine mode data of RADARSAT of December 31, 1995 (ascending, UTC 8:48, Incidence angle: 46.2°and Heading 346.34 A), and Landsat/TM April 13, 1993.

(2) Change detection

Change detection is an important subject for urban monitoring. Two examples of change in Tokyo are shown by fusing the data combination of (1) Radarsat fine mode F2 of Tokyo on December 31, 1995 (ascending) and F5 of Tokyo on October 14, 1996 in the ascending at 8:48:04 UTC in evening. Grassland change can be detected in this fused imagery. Another change is the settlement of seaweed bed in front of the river mouth of Edogawa in Tokyo Bay. Seaweed bed can be seen in the December image but not in the October one.

(3) Comparison of street direction

Looking the urban structure, an important thing is the direction of street because street direction is related with the direction of housing. Houses facing the south is preferred rather in Japan traditionally because of the warming in winter season and the drying in rainy season. Discrimination of street direction is tested in Tokyo down town area using two kinds of data acquired in evening and morning; a fine mode F5 of Radarsat, with heading:350.71°, on October 14, 1996, at 8:48:04 UTC (Ascending - Evening), and a fine mode F3 of October 8, 1996 (descending - Morning). These two data have different beam directions. This enables us to extract two kinds of town difference in street direction inside the down town of Tokyo.

RISK MANAGEMENT: THE PREDICTION IMPERATIVE

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ABSTRACT

An information revolution is in progress, fuelled by the availability of remotely sensed data from a growing number of commercial Earth observation satellites. Some of these systems have the capabilities required to contribute to a broad spectrum of disaster monitoring and mitigation applications, as demonstrated by recent experience with RADARSAT-1.

This paper provides an overview of the risk management prediction imperatives identified using RADARSAT-1 as an information source for the Canadian led humanitarian mission to the Great Lakes region of Africa. Collection, analysis, dissemination, and research lessons learned are reviewed in the disaster management context.

Evaluation of the Radarsat imagery for the operational mapping of sea ice around Greenland

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ABSTRACT

As part of the ADRO-503 project a total of seven Radarsat images; six ScanSAR Wide (SCW) and one ScanSAR Narrow (SCN) with corresponding swath widths of 500 km and 300 km. respectively, in the waters around Greenland have been evaluated. Of these seven images, three (two SCW and one SCN from 12th., 13th. and 16th. March 1996, respectively) were off Cape Farwell (60 °N, 44 °W), three SCW (18th. - 20th. April 1996) off Disko Bay (70 °N, 55 °W) and one SCW (7th. August 1996) was from Scoresby Sound (71 °N, 24 °W). The images were compared with near simultaneous photographs, video recordings and the ice charts produced by the ice patrol using visual observations and the mapping radar on board the aircraft. The results of the comparison showed that for waters off Cape Farwell, which are navigationally most important and which are characterised by thick ice floes of size < 100 m, SCW and SCN images from the 12th. and the 16th. March were excellent. There was almost one-to-one correlation between the ice features (ice floes, icebergs, icebelts) observed in photographs and those imaged by the Radarsat. However, the SCW image from the 13th. March was difficult to interpret. In this image the regions of ice with concentration ≤ 3/10 were very difficult to distinguish from the open water regions. The main reason for this was that in some areas the wind caused the radar backscatter from the water regions to be of the same order of magnitude as that from the ice. In the Disko Bay region and Scoresby Sound, which are characterised by floe sizes > 500 m, SCW images were excellent at mapping the sea ice. In these regions, practically all the features in the observational data could be identified in the images.

Filtering based on the Power-to-Mean-Ratio (PMR) was found to be excellent at identifying icebergs and was also very helpful at distinguishing between the open water and the ice regions. However, PMR filter is ambiguous in strong (≥ 20 m/s) and, more importantly, variable (i.e., multi - directional), wind conditions such as those for example experienced on the 13th. March.

Based on the limited data set used so far it can be concluded that Radarsat images are very good (out of the total of seven images evaluated only one was difficult to interpret) at mapping the sea ice when the winds are not variable. The ice information that could be obtained from the images was on six out of seven occasions better than that available from the ice charts obtained from the ice patrol based in Narsarsuaq. The preliminary results are thus very encouraging which means that the Radarsat images should allow the number of aerial reconnaissances in the Cape Farewell waters to be significantly reduced. In particular, the aircraft may not have to be available with the same high priority as hitherto and the aerial reconnaissances may take on the character of "ground control flights". The latter are currently carried out according to the navigational needs about 2 - 3 times per week. However, to confirm these initial conclusions it is imperative to evaluate more images; ideally for at least one full season. In particular, the ability of the Radarsat to image the sea ice at different surface temperatures i.e., melting and freezing, and for an annual set of typical wind conditions needs to be thoroughly investigated.

Towards an operational use of satelite SAR for winter navigation- prelim. results

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Abstract

Since 1988 the potentials of SAR for sea ice applications have been studied in several experiments involving airborne SAR and later on ERS SAR in the Baltic Sea and in the Arctic. Within different ESA Programs, application and demonstration experiments have been realized. As for sea ice monitoring and icebreaker operations the following conclusions can be made: * SAR data are beneficial both as complementary information for sea ice monitoring and as a new source for small-scale, tactical information. * Operational use of SAR data demands a coverage of the area in interest about once a day and an access of the information within, at the most, 2 - 3 hours. * Image pixelsizes of some 50 to 200 meters are sufficient and segmentation or other image processing techniques (apart from some smoothing) are not essential for the interpretation.* The full potential of the information can be utilized only provided that the images are presented in a form that really suits the needs of the end-users (i.e. geocoded etc).

With the launch of Radarsat, the potential for an operational use of SAR for sea ice applications is at hand. The differences in characteristics between the ERS1/2 SAR and that flown by Radarsat, however, must be considered. The wide swath width (300-500 km) possible with the Scan SAR Wide/Narrow is an advantage compared to the ERS, particularly so as the pixelsizes of 50 to 100 meters are still sufficient. The HH polarization is expected to damp the backscatter from open water surface waves compared to the VV polarization, giving a better contrast between ridges and level ice. The large variations in the incidence angles over the image can cause some interpretation problems as a specific ice features may show up in different ways depending on its location in range direction.

Experiences with Radarsat data from the 'Swedish Arctic Ocean 96' expedition in July-September 1996 will be presented. Some results from Radarsat use in the Baltic Sea from the ice season 1997 - an ADRO project - will be presented as well.

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ICEMAP - An Interactive Ice Charting Application for Ice Servives

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ABSTRACT

The ICEMAP, an application developed by VTT for interactive design of ice charts, is now in operational use at the Finnish, Swedish and German Ice Services, providing valuable information for winter traffic navigation in the Baltic Sea. The users of ICEMAP are able to produce high quality icecharts based on satellite images interactively in a short time. ICEMAP reads preprocessed geocoded AVHRR images from the NOAA satellites as well as radar satellite images from the RADARSAT and ERS satellites. Information about the ice (concentration and thickness) and sea surface temperature can be output as a grid-file for input to meteorological forecast models or for statistical analysis. The geocoded icechart is sent digitally to the Finnish and Swedish icebreakers and can there be viewed as an overlay on satellite images using the on-board ICEPLOTT system.

ICEMAP is based on an innovative polygon network philosophy, i.e. the areas representing different types of ice are polygons with common, shared borderlines. The user draws the border between the different types of ice using BÚzier curves, from which ICEMAP then automatically determines the intersections and the new areas (polygons) that are produced. Thus only the changed parts of the ice edges have to be redrawn. This speeds up the production of a revised chart, because usually only part of the ice edges have changed since the last edition of the chart. The user can then select the areas interactively and give them the proper hatching. The non-overlapping polygons also provide a good structure for useful operations such as accurate calculation of the area of the ice cover and registration of ice area attributes.

ICEMAP supports interactive drawing of standardized ice chart symbols as well as normal graphics and text. In the paper the polygon network philosophy, image processing principles and isotherm generation method is described. The possibilities for using ICEMAP as a tool for generating customer tailored detailed ice charts and as part of an advanced information system to support ships in winter traffic, is discussed.

OPERATIONAL USE OF RADARSAT IMAGERY TO SUPPORT 1996 M.V. ARCTIC SHIP OPERATIONS IN THE CANADIAN ARCTIC

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ABSTRACT

A key application for RADARSAT is to provide Near-Real Time (NRT) delivery of imagery to support shipping operations in ice-covered waters in polar regions. During the late summer and early fall of 1996, RADARSAT imagery was provided to the M.V. Arctic to support its voyages to the Bent Horn oil terminal on Cameron Island in the Canadian High Arctic. NRT processing of selected images at the Gatineau ground station previously ordered by the Canadian Ice Service of Environment Canada, combined with processing and delivery via the ENFOTEC TRIDENT IceNav Bulletin Board Information Service ensured the imagery was delivered on board the vessel within hours of reception. These images were an important input for strategic and tactical decisions concerning the operation and routing of the vessel.

This paper will focus on three main areas. The first area will discuss the parameters that can be extracted from RADARSAT imagery that are relevant to ship navigation in ice. The second area will describe the ground system infrastructure that was set up to obtain the data from Gatineau, including the operational procedures to take advantage of data previously ordered by the Canadian Ice Centre, and deliver imagery to the M.V. Arctic in NRT. Finally, the key issues to be addressed to expand this particular case to the general case for operational NT delivery of imagery will be discussed. Some of these issues include the ground-infrastructure required, the ordering process for imagery and required data compression effects on image interpretation for ice.

Ocean and Ice Feature Detection Using the ERS SAR Browse Images

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ABSTRACT

A very small proportion (about 10%) of the ERS SAR raw data is actually converted in SAR images because of the lengthy processing time associated with the generation of high resolution products. In order to overcome this weakness, ESA has developed a SAR browse processor capable to generate low resolution images (resolution around 200 metres) corresponding to the totality of an acquired SAR segment. The first purpose of the availability of the browse images is to promote the use of high resolution data (by identification of scenes to be processed at high resolution). However, this also allows new applications for SAR data, in particular for detection of large scale phenomena in oceanography and sea ice studies.

This paper will provide examples of features detection using the SAR browse images such as: ice edge determination in the Arctic Ocean; and current shears, eddies and bathymetric signatures in Northern Europe seas. Several mosaics of browse images covering Northern Europe will also be presented.

CONSTRUCTION D'UN MODÈLE DE TERRAIN POUR LA SIMULATION HYDRODYNAMIQUE DE CRUES MAJEURES : INTÉGRATION DE DONNÉES DE SOURCES ET DE DATES MULTIPLES

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RÉSUMÉ

Une simulation hydrodynamique bidimensionnelle nécessite a priori la connaissance de la topographie du lit mineur. Celle-ci s'obtient généralement à partir de relevés ponctuels sur le terrain par arpentage ou par une technique utilisant l'écho-sondeur. Un modèle numérique de terrain est alors élaboré à partir de ces relevés. Dans le cas de crues majeures, ce modèle numérique de terrain n'est plus suffisant. La rivière déborde largement et c'est alors une grande partie de la vallée qui devient le lit du cours d'eau. Plusieurs problématiques se posent alors : Comment compléter le modèle de terrain pour incorporer toutes les zones touchées par la crue, comment intégrer adéquatement les différentes sources d'information pour obtenir un modèle de terrain homogène et comment faire évoluer ce modèle pour qu'il tienne compte des changements progressifs du lit de la rivière qui seraient survenus entre le début et la fin de la crue?

Cette étude décrit les méthodes utilisées pour construire une topographie intégrée du lit majeur de rivières soumises à une crue extrême, comme ce fût le cas au Saguenay (Québec, Canada), en juillet 1996. On discute d'abord de l'utilisation de la photogrammétrie et des données provenant de sections transversales (type dam break ou HEC2) ou de semis de points. On détaille la construction d'un maillage d'éléments finis flexible qui reçoit les données topographiques de sources et de dates multiples et qui sert de base aux simulations hydrodynamiques. On décrit ensuite l'approche utilisée pour faire évoluer la morphologie du lit durant la crue.

RECENT-FLOOD MAPPING IN THE PEACE-ATHABASCA DELTA USING MULTI-SOURCE DATA

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ABSTRACT

THE PEACE-ATHABASCA DELTA (PAD) is one of the world's largest inland freshwater deltas covering approximately 3900 km^2. It is formed by the Peace, Athabasca, and Birch rivers at the western end of Lake Athabasca in north-eastern Alberta. three lakes (Claire, Baril and Mamawi) occupy much of the area but are relatively shallow, normally less than 3 m in their deepest parts. Smaller lakes at elevations higher than the channel network are referred to as *perched basins*, which are the most biologically productive habitat in the delta. Like most deltaic ecosystems, the PAD relies on periodic flooding to support its habitat and it is only though large overland floods that the perched basins are effectively recharged.

Regulation of the Peace River in 1968 caused severe drying of the delta and initiated significant changes to the regions hydrology, vegetation and related wildlife. Over the past two decades early successional forms of vegetation (e.g. sedge, grasses, and willow) have enroached into the perched basins and other areas which regularly experienced flooding. However, in the spring and summer of 1996, 22 years after the last flood, the Peace River spilled its banks and flooded most of the PAD.

The remote nature, lack of representative data, and sheer size of this flood necessitated the use of remote sensing to assist in understanding the geophysical and historical changes and to provide a tool for environmental monitoring of this region. Remote sensing data immediately after the flood was acquired from three different sensors: RADARSAT (C-band SAR, HH polarization), LANDSAT-TM (all 7-bands) and low altitude aerial photography. Image analysis of both electro-optical data sets show that flooded areas which are vegetated (which comprise most of the delta) cannot be delineated unless the sensor is at the specular angle. However, these regions are immediately evident on the Sar imagery. Flooded areas populated by young willow show very high back-scatter as a result of multiple reflections between the tree structures and the underlying water surface. Emergent grasses are mostly penetrated and therefore give a low return, similar to open water. The optical imagery, cross-referenced with field data, allows us to verify the spatial distribution of vegetation in order to interpret the back-scatter mechanisms responsible for the different flood are returns.

USING RADARSAT DATA TO MONITOR FLOOD CONDITIONS IN BANGLADESH - AN ASSESSMENT OF EARLY RESULTS

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ABSTRACT

This project was initiated by the Environmental GIS (EGIS) Project under ADRO, in cooperation with AERDE and the Bangladesh Space Research and Remote Sensing Organization. The goal is to monitor the very extensive monsoon floods. RADARSAT successfully acquired data during peak floods regardless of cloud cover, the influence on very heavy monsoon rainfall on the radar backscatter was noticeable at a few locations. The ability to acquire synoptic data of monsoon floods was demonstrated. The project was repeatedly affected by technical difficulties (AGC, RADARSAT acquisition failure) and administrative problems (ADRO communication, delays in data delivery). In this paper we investigate the use of RADARSAT Fine Mode and ScanSAR data, digital image processing and GIS integration methods to combine and analyse SAR imagery, ground reference data and mathematical flood model results. We outline a simple methodology for monitoring flood conditions in Bangladesh with satellite SAR data. Then we demonstrate and illustrate the usefulness of multi-temporal image analysis during the 1996 flood season for selected test areas. Early results indicate that RADARSAT products are a potentially very useful data source for water surface delineation during monsoon flood conditions. When used in conjunction with flood model results and topographic data, satellite SAR can provide valuable information about localized as well as regional, i.e. nation-wide, flooding conditions.

HYDROGEODYNAMICS OF THE WETLANDS IN THE BOLIVIAN AMAZON BASIN

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ABSTRACT

In the framework of the Canadian ProRADAR program designed to evaluate RADARSAT data of the monitoring of the Amazon Basin region continuously covered by clouds and with vast isolated areas difficult to access, a study has been undertaken to analyse the dynamics of floods in the Bolivian Amazon which affect from 100 000 to 150 000 Km ^{2} during four months of the year. Lack of information these phenomena impede the sustainable management of the natural resources of this part of the country, the optimization of cattle rearing which constitutes presently 47% of the Bolivian bovine production, as well as the proper delivery of rescue services.

The overall objective is to evaluate the use of C-band data, comparing HH and VV polarization, flood monitoring and identification of risks areas, with a view to improving the management of natural resources, enhancing the animal breeding activity and facilitating the work of emergency preparedness, as well as for vegetation mapping.

This paper presents preliminary results obtained in the Trinidad area, around the Mamore river, using ascending ERS-SAR and RADARSAT data from dry and wet seasons, water levels from hydrometeorological stations and simultaneous field checks. Several SAR-TM colour composites are being used to integrate and evaluate the respective contributions of optical and microwave data with distinct polarization: RGB-IHS transformation using the Intensity component from TM as the Hue input; Tm classification with difference RADARSAT and ERS images and with HH and VV from each season.

KEYWORDS: Radar, Flood monitoring Vegetation mapping, Amazon basin, Bolivia

Flood Extent Monitoring with RADARSAT:
Experience with the California Flood of 1997

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RADARSAT is a nearly ideal sensor for flood extent monitoring by virtueof its all-weather imaging capability, relatively frequent revisit, and excellent ability to distinguish open water and flooded vegetation from land classes. These benefits derive from RADARSAT's wide field of view, the relatively long wavelength of the C-band radar, horizontal transmit and receive polarization of the signal and the large range of incidence angles available for imaging.

The recent floods in Northern and Central California that took place in late December of 1996 and early January of 1997 forced massive evacuation of people and livestock, and wreaked damage which is estimated to exceed $1.6 billion USD. RADARSAT acquisition planning, programming, processing and analysis was accomplished in emergency mode, resulting in a large set of high quality data over three interesting sites. The data and subsequent analysis clearly demonstrates operational potential for monitoring dynamic flood extent over time, including unpredictable events such as levee breaks. This has applications in litigation support, calibration of flood extent prediction models, and flood mitigation activities.

This paper describes the planning, acquisition, processing, and analysis of the data and the operational value of the resulting information in the context of US federal and state level activities. This paper also discusses the concept of a Flood Monitoring Workstation which can perform cost-effective, highly automated analysis resulting in products which can be integrated into future operational flood management activities.

FLOOD MONITORING AND DAMAGE ASSESSMENT IN BANGLADESH USING RADARSAT DATA

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ABSTRACT

Bangladesh is a flood prone country. Almost every year, the country is visited by floods, some of which often become severe. The most recent one was in 1988 when about two-thirds of the country went under water. Being situated at the flood plain of the mighty ricers like the Ganges, Brahmaputra and Meghna, the country becomes most vulnerable to flood disasters. In order to minimize the effects of floods, development of better flood monitoring and damage assessment technique is urgently needed. The optical remotely sensed data are not of much use because of heavy cloud cover during the flood period, i.e., during the South-West monsoon period when floods usually occur. The microwave satellite data like those of RADARSAT are considered to be very appropriate for flood monitoring and disaster assessment in Bangladesh. The present work examines the possibility of using RADARSAT data for such purposes and gives preliminary results regarding the processing and use of RADARSAT data for flood monitoring in Bangladesh.

To start with, a pilot area has been selected. The RADARSAT data are being provided free of cost by RADARSAT International under the ADRO project. This preliminary study is based on flood period RADARSAT imagery of 11 August and 4 September 1996. These two dates do not correspond to flood situation in 1996 as there was no flood but inundation during this time. As such the images of these two dates are used for developing a methodology capable of identifying and quantifying the fluctuation in water areas (a crucial condition for flood monitoring). The study area was overcast with heavy clouds during the period of data acquisition on both the dates that prevented effective surface observation in the optical region as is evident from GMS satellite data acquired at almost the same time (as that of RADARSAT data) in the visible band, at the Meteorological Satellite Ground Station of SPARRSO. contrarily, by comparison, an excellent cloud penetration capability of RADARSAT data was observed.

The primary concern in monitoring flood is to obtain pre-flood and flood condition data layers having proper geographic orientation, so that flood extent can be identified up to the smallest administrative unit (Thana) in the country. Effectiveness of flood monitoring depends on real or near-real time generation of flood condition data layer. For generating

flood and pre-flood condition data layers in digital level, water area must be separable from land in RADARSAT images. Due to presence of noise, land/water separation in raw RADARSAT images using conventional methods of separation (Training based, clustering and thresholding) was found to be not satisfactory. Average filtering was applied to raw RADARSAT images for removing noise. It was found that a '5 x5 window' gave best bi-peak distribution of the pixels in the image histogram, and made it possible to separate water from land using the method of thresholding.

Geometric correction (GC) of RADARSAT images to a map projection was found to be a bit difficult in respect of getting control points. However, it was found that high back scattering from corner reflection of the permanent physical structure made it very easy to mutually register RADARSAT images acquired from the same look direction. Therefore, GC of the best image (in respect of getting control points) to the used map projection, and then mutual registration of the other image with the corrected image, made it possible to geometrically correct both the images in the data set with acceptable accuracy

The processed RADARSAT images show a distinct separation between land and water. The results of land/water separation in RADARSAT images were compared with the reference layer created from available maps and LANDSAT TM images for normal river condition and were found to be reasonably accurate. Mutually superimposing the images of pre-flood and flood periods, it was found that water area fluctuation between the two images was detectable and comparison between the pre-flood and flood period data can provide estimation of the flood affected areas and as such, RADARSAT data seems to be effective for flood monitoring.

The study will be continued with more RADARSAT data (after receiving them from RADARSAT International) to capture the nature and extent of the flood and subsequently work will be conducted for damage assessment.

ANALYSE DU POTENTIEL DE L'APPROCHE «DATA WAREHOUSE» POUR L'INTÉGRATION DE MÉTADONNÉES PROVENANT DE DIFFÉRENTS GÉORÉPERTOIRES SUR INTERNET

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RÉSUMÉ

L'utilisation grandissante de l'Internet comme véhicule de diffusion des données spatiales a permis la création d'une multitude de sites spécialisés en géomatique. Parmi ces sites, on retrouve les géorépertoires, lesquels permettent de connaître quels sont les documents (cartes, photos aériennes, images satellite, etc.) disponibles sur un territoire donné ainsi que les métadonnées s'y rattachant. Le nombre sans cesse croissant de géorépertoires (plus de 27 en novembre 1996 en Amérique du Nord) pose certains problèmes aux usagers en raison de l'hétérogénéité des données disponibles sur ces sites. Par exemple, les métadonnées que l'on retrouve ne respectent pas les normes établies, l'interface est différente pour chaque site, un même type d'objet peut avoir un nom différent d'un site à l'autre, etc.

Face à cette problématique, quelques solutions peuvent être envisagées afin d'améliorer la situation. L'utilisation d'un data warehouse est l'une d'entre elles. L'utilisation de cette technologie permettrait de créer un site qui agirait à titre de guichet unique, les usagers n'auraient donc pas à parcourir l'ensemble des sites pour trouver l'information recherchée. L'utilisation d'un outil de transformation, d'intégration et de synthèse des métadonnées permettrait d'intégrer les métadonnées provenant des différents géorépertoires sous une base commune. L'analyse des différents documents s'en trouverait donc facilitée.

L'utilisation d'un data warehouse offre donc un potentiel intéressant pour concevoir une application de type guichet unique. Cependant, à notre connaissance, cette approche n'a jamais été testée et nous voulons donc en évaluer la faisabilité opérationnelle et technique. L'objectif principal de cette recherche de M. Sc est d'analyser le potentiel de l'approche data warehouse, incluant la transformation, l'intégration et la synthèse des métadonnées géomatiques pour produire un guichet unique pour l'ensemble des géorépertoires disponibles sur Internet.

Cette présentation vise à expliquer le projet dans son ensemble, c'est à dire une brève description de la technologie data warehouse, un aperçu des problèmes liés à l'hétérogénéité des sites géorépertoires ainsi qu'une démonstration du prototype partiel du système optimal de sélection des documents spatiaux (SOSDS) développé au cours des derniers mois.

Data Warehousing for Spatial Data: Research Issues

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ABSTRACT

Canadian organizations involved in forestry, agriculture, geology, environment and urban planning annually spend hundreds of millions of dollars to acquire, manage and integrate data about the land. Most of these data have been stored in disparate and partially redundant systems, both within and across organizations. Most of the time, these geographic data have also been isolated from other corporate data. One resulting problem is the difficulty to find, select, integrate and process the best data for cross-system applications. This paper will present how the data warehouse approach may help to solve such problems and what research issues remain to be solved to be a more effective solution.

L'architecture "Data warehouse" pour les donnés spatiales: défis de recherche

RÉSUMÉ

Les organisations canadiennes impliquées en foresterie, agriculture, geologie, environnement et urbanisme dépensent annuellement des centaines de millions de dollars pour cueillir, gérer et intégrer des données sur le territoire. La plupart de ces données sont conservées dans des systèmes disparates et partiellement redondants, tant à l'intérieur des organisations qu'entre celles-ci. La plupart du temps, ces données spatiales sont également isolées des autres données corporatives. Il en résulte une grande difficulté pour trouver, sélectionner, intégrer et traiter les meilleures données pour les applications plus globales impliquant plusieurs systèmes. Cet article présente comment l'architecture "Data warehouse" peut aider à résoudre de tels problèmes et quel défis de recherche doivent être relevés pour développer des solutions plus efficaces.

The Canadian Hydrographic Service Bathymetric Data Warehouse

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The Canadian Hydrographic Service (CHS) has adopted new digital data collection systems for bathymetry which provide the capability for 100% bottom coverage. A three month survey conducted with a Simrad EM3000 Swath system generates approximately 2800 million depth measurements and approximately 280 Gigabytes of bathymetric information to manage. The use of these new collection technologies has resulted in a dramatic increase in the size of digital bathymetric data sets and the requirement for new techniques for compressing and managing this information.

The CHS has addressed this problem by designing a bathymetric Source Data Base to manage this information in a relational data base environment. The CHS developed techniques for storing, analyzing and retrieving dense data sets using HHCode (Helical Hyperspatial Code). This technology was transferred and incorporated in the Oracle Corporation's RDBMS and is currently marketed as the Oracle Spatial Data Option (SDO) product.

This paper describes the use of Oracle SDO and data conditioning utilities to compress and manage spatial data sets in excess of one terabyte that have the potential to grow over the next five years to multi-terabytes. The data model described includes data partitioning and compression techniques. Data set status indicates if the information is currently stored on-line, near-line or off-line. The capability to perform horizontal and vertical datum transformations on data query are also addressed. The metrics (time versus data volume) for conditioning, loading and querying the dense spatial data sets are described.

Preferred Session: Geospatial Data Warehousing Special Session

Presentation Mode: Oral

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Geospatial Data Warehousing: an Architecture

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Abstract

The challenge for geospatial data users is to access accurate data, trusted information in support of their specific needs. This paper describes the architecture for geospatial information access based on a data warehouse driven by an open data access interface. Requested datasets, in vector, raster, matrix and textual formats are accessible through on-line network gateways, compliant with international, national, industry and government standards for exchange.

Within a 'data warehousing' architecture, a database populated with a basic set of feature data provides the framework. Intensification or vertical integration can be performed through access to 'federated' databases in a seamless design. The main components of an architecture are presented and discussed within the implementation of an end-to-end prototype. The development is carried out within the concerted efforts of the Mercator Alliance.

Human Activity and Environmental Change modelling within the Lake Malawi Biodiversity Conservation Project (LMBCP)

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Abstract

Lake Malawi, the third largest lake on the continent of Africa, is important in that it is a major source of protein and water for the country of Malawi in addition to having one of the largest and diverse populations of Cichlididae in the world. To protect its ecological health, the Lake Malawi Biodiversity Conservation Project was established. The aspect of the project that the members of the Centre of Earth Observation Sciences are concerned with include the examination of the following areas:

- the biodiversity of Lake Malawi;
- the factors reducing the level of biodiversity;
- the causes of those factors;
- why those causes occur and how they can be stopped.

The factors adversely affecting biodiversity are caused by an increase in human activity to the point where the viability of the lake has been seriously threatened. Without human activity, the lake =D5s diversity would likely not be in danger. As the ultimate goal of the overall project is the preservation of biodiversity, it is important to examine the wide array of causative factors leading to the deleterious ecological changes. The =D4 reasons =D5 for these activities are the basis for a complex series of interactions which are examined from a structuralist perspective.

Our purpose in the project is to establish the athropogenic foundations of change through the examination of the agricultural strategies and technologies being utilized in the Lake Malawi watershed. In order to do this we have examined both the historical and current social, political and economic situations within the area; choosing a number of social, economic, and agricultural variables that will become part of the GIS database which this project is developing. The variables chosen, help to identify current landuse practices which are detrimental to the lake and its biota and allow an estimation of potential future activity and disturbance.

Both directly and indirectly the agricultural systems and practices influence the rate of top-soil erosion and associated water run-off affecting the lake. This aspect of the project dovetails with the others, such as mapping landcover/landuse and sediment distribution within thelittoral zone of the lake, and will ultimately allow the production of asequence of causal events.

Time Series Analsysis of Riparian Habitat: A Fractal Texture Analysis.

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Abstract

The Assiniboine River watershed in Manitoba, from Beaudry Provincial Park to south of St. Francis Xavier Manitoba has been the site of intensive agricultural activities for many generations. The original riparian forest (or gallery forest) was removed, during the colonial expansion of the mid to late 1800s, to supply building materials and to provide access to the Assiniboine River transportation route. The riparian forest in this area is now comprised of secondary growth and is still affected by agricultural development. Beaudry Provincial Park is one small area of this re-growth, which has been protected from further development by the Manitoba Provincial Government.

The remaining forested areas provide critical functions: facilitating river bank stabilization, providing wildlife with essential habitat, and protective corridors for travel. Further reduction in habitat creates the potential risk of increased frequency and intensity of river flooding, bank instability and loss of critical wildlife habitat. Measuring fluctuations in the areal extent of the riparian habitat would assist river management by providing types and rates of anthropogenic change.

Aerial photography has the necessary resolution to accurately measure changes in the areal extent of riparian habitat along the Assiniboine River; however, as traditional aerial photography uses only one band of visible light, it is very difficult to quantitatively classify the habitat types. Fractal analysis might provide a solution to the quantification problems associated with single-band aerial photography. Much of the information contained within aerial photography is stored as textures. Simply, a tree canopy can be identified by the human eye because of we are capable of interpreting the pixel variance found in the tree canopy as leaf texture. The heterogeneity of pixel values found in a tree canopy is in contrast to the homogeneity of pixels values present in an agriculture landscape (e.g. mature wheat). Fractal dimensions may provide a quantitative measure of the previously stated homo and heterogeneity of pixel values found in aerial photography.

Eastern Antarctic as a test site for evaluation of relief measurements from RADARSAT SAR repeated orbits inteferometry.

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Abstract

Spaceborne SAR repeated orbits interferometry is a modern tool, allowing possibility of the relief measurements with high spatial resolution and good vertical accuracy. For a development of the reliable techniques of relief measurements from repeated orbits interferometry data it is desirable to have reliable ways of evaluation of techniques and validation of obtained measurements.

Temporal decorrelation of the backscatter because of precipitations and other events corrupts the measurements. For the shorter radar wavelengths and longer period of orbits repetition influence of temporal decorrelation is higher. In the case of RADARSAT with 5.6 cm wavelength and 24 days of orbits repetition it is necessary to select area of surface with small level of surface modification (level of precipitations). In our report we propose to use Sovetskoye plateau in the Eastern Antarctic as a test site for RADARSAT SAR repeated orbits interferometry observations.

Sovetskoye plateau is the area of Antarctic, suitable for the development of the relief extraction algorithms. Low annual level of precipitations (50 mm per year) is good in the sense of possible temporal decorrelation of the reflected signals. Existing set of topography data from previous missions (ERS-1 altimetry data), stereo observations from RADARSAT Antarctic Mode operation and other might serve as a source of the data for comparison of the relief measurements and efficiency of different techniques and instruments.

Mapping Rainfall Distribution Using Radarsat Data
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The unique relationship between SAR backscatter and the dielectric properties of water provides an excellent opportunity for mapping the spatial distribution of rainfall. Since the magnitude of backscatter is directly proportional to the dielectric properties of the target material, rainfall distribution can be derived from backscatter. In general, the higher the water content in the soil or vegetation, the greater the radar backscatter.

To investigate this capability, RADARSAT data were collected over southern Manitoba in May and October of 1996. Coincident with each satellite acquisition were ground weather radar and modelled estimates of soil water. Four ScanSAR wide scenes were acquired during May and four during October. For those dates where rainfall had occurred over any part of the site, visual identification and demarcation was performed on the ScanSAR image and compared with weather radar information for the same period. A rainfall distribution map was created and analyzed to assess the extent to which SAR imagery could delineate and quantify the amount of precipitation. Preliminary results of this work are presented in this paper.

Evaluation de la constante dielectrique et de l'indice foliaire pour caracteriser le coefficient de retrodiffusion des cultures de mais, bande C

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Resume

Les modeles empiriques simulant le resultat de l'interaction de signal radar sur les cultures agricoles utilisent peu la constantedielectrique foliaire comme parametre intrant contrairement aux modeles theoriques, a cause de la difficulte a mesurer cette constante dielectrique. Notre projet porte sur la technique et la mesure in situ de la constante dielectrique foliaire. Puis, nous avons evalue le potentiel d'explication de la variation du coefficient de retrodiffusion d'un signal radar, en bande C, sur une culture de mais par les parametres tels la constante dielectrique, l'humidite gravimetrique et l'indice de surface (LAI) des feuilles de mais. Nos analyses ont demontre que la partie reelle dielectrique foliaire expliquait mieux la variation du coefficient de retrodiffusion que l'humidite gravimetrique des feuilles de mais. Les resultats de regression multiple ont conduit a l'elaboration d'un modele simple, fonction de la partie reelle dielectrique, de LAI et de l'angle d'incidence. Le modele explique de 60% a 90% la variation du coefficient de retrodiffusion. Cependant, l'observation des resultats indique qu'il manque un terme geometrique fonction de l'angle de visee, par rapport aux rangs de culture, pour la configuration de polarisation VV.

La constante dielectrique a ete mesuree directement sur le feuilles, sans perturber leur etat naturel, a l'aide d'une sonde experimentale. Le procede technique etant different des etudes anterieures (perturbation de l'etat des feuilles), l'intensite de nos constantes dielectriques mesurees est inferieure a celle des modeles existants. Cela s'expliquerait par une difference d'energie potentielle de l'eau libre, contenu dans l'echantillon, entre les deux etats. C'est-a-dire une variation de la quantite de molecules d'eau disponibles pour interagir avec l'energie d'excitation du signal radar. Des etudes futures reliant la constante dielectrique avec l'energie potentielle de l'eau libre des feuilles permettraient de mieux comprendre le phenomene d'interaction interne du signal radar avec la vegetation.

Semi-Automated Oil Spill Detection

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ABSTRACT

Oil spill classification using SAR data is an area of research where automation has not yet been successfully achieved. However a trained operator can differentiate relatively easily between oil spills and other dark ocean features. We have developed a semi-automatic oil spill detection software toolkit that allows a user to process a large number of images using several different detection algorithms, including adaptive threshold, local statistics and unsupervised minimum distance classification. The detection algorithms have been tested with several SIR-C and a few Radarsat scenes. Results are shown. Once automatic detection is performed, the user can view results and either accept them, modify them or reject them as false alarms. Statistics can be gathered on the areas automatically detected, or on a user-specifiable area or class. Statistics gathered include aerial coverage of oil slick, mean, variance, standard deviation, skew, kurtosis, second and fourth moment, median, minimum and maximum digital number. Scatter plots of one statistic versus another can be plotted to characterize oil spills for a given sensor or data product.

Fisheries Habitat Assessment Using Airborne Imaging Spectrometry

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Abstract

With the exception of the Fraser River estuary, the state of fisheries habitat in the Strait of Georgia, British Columbia, is poorly understood as is the impact of human population growth and industrial pressures upon them. Only poor or limited baseline information is available, and very little of the area has been mapped in recent times.

As part of an ongoing effort to establish a mechanism for fish habitat mapping, assessment and monitoring, Fisheries and Oceans undertook an airborne remote sensing campaign in the Strait of Georgia. Two sets of multispectral, fine spatial resolution imagery optimized for marine vegetation were collected using the Compact Airborne Spectrographic Imager (casi). One data set was collected in September 1994, the second in March 1995. Field observations in support of the airborne campaign were undertaken as were ground-based geometric measurements. Both data sets were radiometrically corrected to radiance values, geometrically corrected, georegistered and mosaicked. Apart from a subjective comparison of the two data sets however, this paper deals only with the imagery collected in March of 1995.

Following separation of the emerged and submerged image areas, both supervised and unsupervised classifications were undertaken. Raster to vector conversions were then made to allow for export to a Geographic Information System (GIS).

The classification results were not as detailed as hoped due to the complexity of the study area, instrument limitations and problems associated with the data collection. Nevertheless, this approach shows promise and work is ongoing to fully evaluate the results. Further work in this area is justified.

THE USE OF NOAA-AVHRR DATA AS AN INPUT DATABASE FOR MESOSCALE COMPRESSIBLE COMMUNITY MODEL (MC2)

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ABSTRACT

Satellite thermal infrared measurements have been introduced to provide estimates of sea surface temperature since the late 1960's. With the help of the improvement of satellite sensor techniques, the Advanced Very High Resolution Radiometer (AVHRR) can produce higher quality land surface data at a high spatial resolution (1.1 km). the Mesoscale Compressible Community (MC2) model was developed based on the full-elastic non-hydrostatic model of Robert, Tanguay and Laprise (1990). The model solves a full set of Euler equations on a limited-area Cartesian domain of the polar projection with time-dependent nesting of the lateral boundary conditions supplied by a larger-scale. Many studies have demonstrated that simulations of surface climate by a general circulation model are very much dependent on the formulation of its land surface scheme. The Canadian Land Surface Scheme (CLASS) was recently developed for the Canadian General Circulation model (CGCM) by Verseghy ct al. (1991, 1993). This paper reports some preliminary experiments of MC2/CLASS run.

The experiment domain is a 40 x 30 km square. It centres at 46.2 N and 72.8 W, and Quebec City and Montreal are situated on the upper right corner and lower left corner, respectively. The numerical resolution for this horizontal plane is primarily at 10 km. Two sub-winders with resolutions of 1 km and 5 km respectively, were opened inside the simulation domain in order to explore more detailed physical phenomenon.

AVHRR data were used to clarify the vegetation type coverages and provide the values of ground surface albedo in the simulation domain. In order to access the performance of MC2/CLASS model, six cloud free processed AVHRR satellite images were selected from summers of 1993 and 1994. Each image provides a snapshot of surface temperature field for the integration area. In addition to satellite data, screen air and ground surface temperatures, wind speeds and directions, relative humidity and soil temperatures and moisture contents have been made available for 30 different locations from ground surface meteorological stations within the simulation area.

The comparison was made primarily on the surface temperature fields obtained from AVHRR images and from MC2/CLASS model simulations. Particular emphasis was paid on the general and specific patterns of the two temperature fields. The result shows that in general, all six AVHRR images are matched well by their respective MC2/CLASS model simulations except in some mountain areas, and with the increase of horizontal spatial

resolution, this difference can be reduced to a minimum value. Also the temperature variances between the two fields are very much similar. The mean temperature anomalies between AVHRR and MC2/CLASS model simulations are about 3 to 4 C. While the result of stationary comparisons for surface temperature, wind speed and direction, and relative humidity time series values are not very encouraging. This is simply because a stationary value represents the point value, but MC2/CLASS model gives a grid averaged value depending on the horizontal spatial resolution.

Évaluation du radar pour le suivi des teneurs en eau et des cultures en sols organiques

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Résumé

Le potentiel des capteurs actifs à hyperfréquences, et plus particulièrement de RADARSAT, pour le suivi des cultures et des teneurs en eau en sols organiques a été étudié à l'aide d'un diffusomètre monté sur un camion. Le protocole visait à établir une relation entre les teneurs en eau du sol et le signal radar puis à évaluer l'interaction de la biomasse et la structure foliaire, ainsi que l'impact de la pratique culturale sur cette relation. Une collecte hebdomadaire de données fut menée dans un sol organique à la ferme expérimentale de Ste-Clotilde (Québec) entre juin et septembre 96. Les mesures ont été acquises dans quatre parcelles de sol nu, deux parcelles de carottes et deux parcelles d'oignons. Les données recueillies furent l'humidité du sol à 3cm, 5cm, 10cm et 15cm, la biomasse, la rugosité et le coefficient de retrodiffusion radar en bandes C et L, dans quatre polarisations et quatre angles d'incidence. Des propriétés physiques du sol comme la conductivité hydraulique et la courbe de rétention d'eau ont aussi été échantillonnées. Le protocole expérimental et des résultats préliminaires sont présentés.

Evaluation of radar for soil water and crop monitoring in organic soils

Abstract

The potential of active microwave sensor, especially RADARSAT, for crop and water content monitoring in organic soil was studied with a scatterometer mounted on a truck. The experiment was designed to establish a relation between the soil water content and the radar signal, and to evaluate the interaction of the biomass and the leaf structure on this relation as well as the impact of the crop practices. A weekly data collection was conducted in organic soil at the Ste-Clotilde experimental farm (Québec) from June to September 1996. The measurement were taken from four bare plots, two carrot and two oignon plots. The data collected is the soil moisture at 3cm, 5cm,10cm and 15cm, the biomass, the surface roughness and the radar backscatter coefficient in C and L-Band in four polarizations and four incidence angles. The soil physical properties such as hydraulic conductivity and water retention curve were also sampled. The experimental protocol and the preliminary results are presented.

A Case of Education and Training for Remote Sensing Application with Personal Computer in Japan

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Abstract:

Many satellite images appear recently on the Internet in the world. By using,the Internet system on a personal computer, the authors created an educational,system for teaching the principle of remote sensing and exercising th,applied,technology. There is a server machine connecting with 24 WINDOWS/NT,machines,for the network system in our machine room. The contents of learning exercise is derived through a small scale Local Area Network (LAN) from the server machine to the client terminal in the classroom. In addition, various useful information on the Internet supplied by various organizations can be read by the server machine. Once the data read, each client machine can access to the data of the Internet at the same time.

Landsat/TM data for individual local governments, as cities, towns, and villages in Japan, are experimented as the menu that are provided by our server machine to the public domain. The data is defined in two sizes of 512 x 512 pixels or 1024 x 1024 pixels in GIF format for each local government. This unit image can be obtained by pointing the position on the location map. Using this satellite image data, the methods looking the area and analyzing the land cover, for example, can be learned with combining the Geographical Information System (GIS) data as well.

Remote sensing satellites in new age are launched in these years frequently. Those are the Indian IRS-1C having high spatial resolution capability, the RADARSAT with its unique sensor functions, and the ADEOS sensors for the variety of its functions. These data can be obtained easily through the Internet.

Merits, demerits, and usefulness of the data obtained in such a way, are discussed by taking them experimentally using our facilities. Followings are some results; 1. Sensor and satellite dimensions involved in the data fulfill an important role at the comparison of the respective data. 2. Original data quality should be reproduced for the right analysis or the right comparison of the data.
3. Analyzed data are important and useful in some cases.

Many institutes expose the information through the Internet, and so the newest information can be taken easily. Furthermore, these data have high quality and can be supplied directly as a educational materials. Faster, easier, and high quality of the served data on the Internet from the providers are most important factors for the well-teaching system. Many of examples can be known to be used with no modification or no explanation. Linking these data source from the outside of campus with our newly developed system, the educational efficiency might increase more in the subjects of remote sensing and environment.

Using RADARSAT to Map Tillage and Residue on Agricultural Fields

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The frequency of tillage, as well as the type of tillage implement applied, can significantly impact the health and erodibility of agricultural soils. Mapping tillage characteristics, and the corresponding crop residue cover, is important for monitoring conservation tillage adoption and for quantifying wind and water erosion.

Different tillage practices can create varying degrees of surface roughness. Since microwaves are sensitive to these perturbations, radar may be useful in indentifying and mapping tillage practices. Crop residue cover, if present in significant amounts, may also impact the magnitude of radar backscatter. To investigate this potential, RADARSAT data were collected over Altona, Manitoba in October of 1996. Across the study site, approximately 200 fields were characterized for type and amount of crop residue, tillage type and frequency, as well as tillage direction. Six RADARSAT scenes, including 4 standard mode and 2 extended high beams, were acquired over the study site during a 3 week period. Incidence angles for these acquisitions ranged from approximately 25° to almost 60°. Analysis of the data will address the potential of C-HH SAR to identify tillage and residue classes. In addition, the study will examine the optimal RADARSAT mode under which these classes can be separated, and the impact of moisture conditions on residue and tillage identification. This paper will present early results from the analysis.

Diurnal Effects on Rice Paddy Backscattering
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The population of Asia accounts for approximately 60% of the global population, about 92% of the world's rice production, and 90% of global rice consumption. With such a large population and high levels of rice consumption, an effective rice crop monitoring tool is needed. The unique capabilities of SAR (synthetic aperture radar) to penetrate clouds, haze and darkness allows for efficient and timely data collection which is useful for applications such as rice crop monitoring. RADARSAT, Canada's recently launched earth observation SAR satellite, orbits on a dawn/dusk cycle allowing data to be collected both day and night. As plant moisture levels change with respect to the sun's orbit, it is important to consider the effect that time of day might have on radar backscatter. Microwave sensitivity to plant moisture content may produce significant differences between daytime and nighttime data acquisitions. For this paper, six RADARSAT images were acquired over a study area in Guangdong Province in Southern China. These scenes make up three ascending/descending image pairs taken at three different stages in the plant growth cycle. Analysis of this data, along with land cover maps and ground data, will address the unique properties of diurnal microwave backscatter. Environmental effects caused by rain and dew will also be considered and the implications of these effects on radar backscatter of rice crops will be discussed.

Quality Control and Refinement of the Positional Accuracy of Records in Ontario s Water Well Data Base using Automated GIS Techniques

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Abstract

The Ontario Ministry of Environment and Energy (MOEE) is the custodian of a digital database of the water wells log drilled in the province. The lithological, material properties and hydrogeologic information contained in this database is utilized extensively in geotechnical and hydrogeologic site investigations and for geologic and terrain studies. The utility of this database is however restricted, owing in part to planimetric and elevation inaccuracies associated with these records.

An automated process has been developed to flag positional errors in this database using GIS processing techniques. An area encompassing the municipalities of the Greater Toronto Area (GTA) was selected for the development of this technique. All records in the database are spatially referenced by UTM coordinates, Lot, Concession, and elevation. For each water well within the GTA, its UTM coordinates were spatially compared to its Lot and Concession coordinates. Where discrepancies between the two planimetric geo-referenced sources were encountered the record was flagged as being locationally inaccurate.

To verify the surface elevations of these same records, a high quality Digital Elevation Model (DEM) was constructed, providing a continuous surface elevation datum. The surface elevation of each well within the GTA was then compared to the DEM and where differences of 10 metres or greater were encountered, the record was flagged as having a locational error. The results of these processing steps, produced a refined waterwell database for the GTA of 40,147 records, an elimination of almost 30 percent of the original records.

MESURE D'ERREURS D'UN RÉSEAU DE DRAINAGE GÉNÉRÉ DANS UN SYSTÈME D'INFORMATION GÉOGRAPHIQUE EN MODE MATRICIEL

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RÉSUMÉ

À l'aide d'un système d'information géographique (SIG) de type matriciel, il est actuellement possible de modéliser le cheminement de l'eau superficielle sous l'action de la gravité selon la ligne de plus grande pente, ce qui s'avère très utile dans les sciences de l'environnement. Pour la plupart des algorithmes de drainage, la donnée de base requise est un modèle numérique d'altitude (MNA), éventuellement de source satellitaire (SPOT, RADARSAT); il faut par la suite procéder à l'ajustement d'un paramètre de superficie minimale de drainage pour contrôler la densité du réseau final. Or, comme c'est souvent le cas présentement en géomatique, l'erreur associée à un résultat cartographique est rarement déterminée, du fait de la complexité des algorithmes appliqués, en particulier la structure hiérarchique de la procédure de drainage.

Grâce à la détermination des distances de drainage, on a pu établir une mesure d'erreurs permettant de quantifier, globalement ou tronçon par tronçon, la concordance spatiale entre un réseau généré et le réseau de référence. Par rapport aux comparaisons plus conventionnelles des statistiques hydrographiques telles que le nombre de tronçons internes/externes, la longueur des tronçons, la superficie de drainage, la densité de drainage, la sinuosité des tronçons, les rapports de bifurcation, de longueur, de pente, de superficie, ce critère a l'avantage de tenir compte de la localisation spatiale des réseaux de façon plus adéquate que la matrice de confusion habituellement utilisée pour les résultats de classification.

Cette mesure d'erreurs a été testée sur le bassin versant de la rivière Boyer situé à 25 km au sud-est de la ville de Québec et couvrant une superficie d'environ 220 km^2. L'algorithme de drainage de Martz et Garbrecht (1995), adapté et complété, permet de tenir compte du relief peu accentué de cette zone dont les altitudes s'échelonnent entre 250 mètres à l'amont et 10 mètres à l'exutoire dans le fleuve Saint-Laurent. Le MNA de référence a été généré avec le logiciel IDRISI à partir de la source la plus précise disponible : les courbes de niveaux numériques issues des cartes au 1/20 000 du gouvernement provincial. Une des applications utiles du critère d'erreurs a consisté à déterminer une résolution optimale pour les opérations de drainage.

SYGET

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RÉSUMÉ

Les besoins des pays de l'europe de l'est pour la géomatique de gestion territoriale peuvent être satisfaits grâce aux technologies développées au Canada. Le projet présentement en cours fait intervenir des organismes publics et privées du Canada et de la Roumanie. Le projet qui s'intitule SYGET propose la modernisation du système de gestion du territoire en faisant appel aux outils de télédétection, de cartographie numérique et des systèmes d'information géographique. Les tâches du SYGET incluent la numérisation de la cartographie existante afin de créer un noyau de cohérence géomatique pour le suivie des activitées agricoles et autres. Une composante importante de l'information utilisée provient des images RADARSAT et autres sources TD.

STUDY OF LANDSCAPE CHANGES IN THE AREAS OF INTENSIVE PETROLEUM EXPLOITATION USING REMOTELY SENSED DATA

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ABSTRACT

To study landscape changes in the areas of intensive petroleum exploitation the Data Base was formed which includes multispectral satellite data from Russian satellites RESURS-F (cameras KFA-1000 and MK-4) radar data from Japanese satellite JERS-1, airborne radar data with different wavelength (centimeter and meter bands) and aerial photography acquired in the period since 1974 (before the development of petroleum fields) to recent time when intensive exploitation of the fields is executed. The Data Base contains also the data layers dealing with different aspects of the natural environment. It will be supplemented by RADARSAT data within the RADARSAT project. This Data Base is a consistent source of information on landscape changes.

The area under study is situated at Timan-Pechorian petroleum province in forest-tundra zone and covers the large petroleum fields Usinskoe and Vozeiskoe and the part of oil pipeline where there was an accident in October, 1994. The exploitation of these fields especially accidents on the pipeline strongly affected the natural environment.

New processing tools to extract useful information and techniques of analysis have been developed. This analysis has permitted the comparison of multitemporal satellite data and the evaluation of the effectiveness of different radar data for detection of landscape changes as a more promising tool for subarctic areas with extreme climatic conditions, and choosing a more informative combination of data, to map the landscape changes and oil pollution connected with development of petroleum fields and accidents on oil pipeline.

STUDY OF KIMBERLITES BY REMOTELY SENSED DATA PROCESSING AND INTERPRETATION

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The investigated area is well-known Arkhangelsk kimberlite region located in conjunction zone of Baltic shield and Russian plate. Kimberlite pipes here are covered by sedimentary rocks with thickness up to tens meters.

We carried out integrated analysis the following data :

- Russian satellite ALMAZ digital radar data (winter and summer seasons);
- Japanese satellite system JERS-1 OPS (7 bands);
- Russian satellite photographic system RESURS-F;
- topographic, geological and geophysical dataset.

To study role and place of kimberlite-forming stage at the geological history of the region a special technique of satellite images computerized processing and interpretation was elaborated.Integrated analysis of different spectral range RSD allows to obtain new improved structural information.

Morphostructural analysis allows to emphasized subtle delicate landscape reflection of kimberlite fields by separation of certain landscape elements. The scheme of density of landscape indicators inferred from images and topographic maps shows that all known kimberlite fields occure into area of higher summarized density oflandscape indicators.

Special purpose lineament analysis was applied. The general factor controlling kimberlite field location are different rank faults, some of them are latent and weakly reflected by landscape indicators and geological features. However the zones of dynamic influence of latent faults clearly reflect on combined characteristics of lineament fields and magnetic field features, which are stipulated by interaction of fold and fault deformations.

Circular structure with diameter about 50 km controlling more then 80 % known pipes was distinguished at Arkhangelsk region by special processing of field of certain lenght lineaments.

Relationship of kimberlite fields and isotropy characteris-

Crop Identification Using Multi-polarization SAR Data
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Crop classification using single date, single polarization and single frequency Synthetic Aperture Radar (SAR) can be difficult even when image acquisition is well timed for a specific purpose. The use of additional polarizatons (ie. HH and VV) can often improve classification capabilities, as is the case in agriculture. Presently there is no opportunity to analyze the potential for improving crop discrimination through the use of additional polarizations from a single spaceborne sensor. Therefore analyses are limited to airborne platforms or multiple satellite systems.

During the summer of 1995, a multi-polarization airborne SAR dataset was acquired over a site near Winnipeg, Manitoba to evaluate the information content through the use of additional polarizations (HH, HV and VV). Preliminary results suggest that at some time intervals during the growing season multitemporal data may allow better discrimination between similar crops than a multipolarized dataset. Since the crop phenology changes rapidly with time this needs further investigation. This work will present the results of single channel and multichannel polarization combinations.

Application of Regularization Methods to Retrieval Problems in Atmospheric Remote Sensing using Microwave Radiometry

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Abstract

Passive remote sensing of the atmosphere is used to determine the atmospheric state. A radiometer measures microwave emissions from earth's atmosphere and surface. The radiance measured by the radiometer is proportional to the brightness temperature. This brightness temperature can be used to estimate atmospheric parameters such as temperature and water vapor content. These quantities are of primary importance for applications in meteorology, climatology and environmental sciences.

Depending on the range in the electromagnetic spectrum being measured by the radiometer and the atmospheric quantities to be estimated, the retrieval or inverse problem of determining atmospheric parameters from brightness temperature might be linear or nonlinear. In most applications, the retrieval problem requires the inversion of a Fredholm integral equation of the first kind making this an ill-posed problem. The numerical solution of the retrieval problem requires the transformation of the continuous problem into a discrete problem. The ill-posedness of the continuous problem translates into ill-conditioning or ill-posedness of the discrete problem. Regularization methods are used to convert the ill-posed problem into a well-posed one.

In this paper, we present some results of our work in applying different regularization techniques to atmospheric temperature retrievals using brightness temperatures measured with the SSM/T-1 sensor. Simulation results are presented which show the potential of these techniques to improve temperature retrievals. In particular, no statistical assumptions are needed and the algorithms were capable of correctly estimating the temperature profile corner at the tropopause independent of the initial guess.

Synergistic Use Of Multispectral Spaceborne Passive Microwave Data For Monitoring Sea Ice Cover

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The spaceborne scanning passive microwave imagers in orbit at the present time provide global observations at several microwave frequencies. The measured brightness temperature for a target area containing mixture of sea ice and open ocean is a function of contributions from the sea ice, open ocean, and the atmosphere. The success of sea ice cover information retrieval depends on the accuracy of interpreting these contributions. The sensitivity of the observed brightness temperature to the changes in the surface and atmospheric conditions for each of the observing frequencies. The large contrast between microwave emission from an ice-covered ocean and ice-free waters is one of the factors responsible for the effectiveness of microwave radiometry in monitoring seasonal and spatial changes in the sea ice cover of the world oceans. The sea ice cover parameters which are inferred from passive microwave sensors are the concentrations of sea ice, and, with some seasonal/regional limitations, ice type (old, first year or young). Since the identification of the ice type is based on the microwave spectral differences, the uncoupling of the effects of the atmosphere from the surface contributions is crucial. This implies simultaneous implementation of the retrievals of atmospheric and ocean surface information. In this work we discuss a sea ice cover information retrieval technique that synergistically combines atmospheric and ocean surface algorithms. In addition, we present and evaluate the results of using this method for the Hudson Bay, Labrador Sea, and other ice covered seas.

ÉTUDE DES GÉORISQUES PAR TÉLÉDÉTECTION RADAR : EXEMPLE DU KARST DE L'ÎLE D'ANTICOSTI (QUÉBEC)

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RÉSUMÉ

Les roches carbonatés contiennent des proportions importantes de carbonate de calcium, facilement attaquable par les eaux de précipitations et de ruissellement. En effet, l'eau s'infiltre dans les orifices de la roche et la dissout, forçant l'agrandissement des fissures, des diaclases et des joints entre les strates. Dans ce type d'environnement géologique, le réseau de drainage souterrain est particulièrement bien développé. On y retrouve des cavités de dimensions variées et à la surface, le terrain est très accidenté. Mais étant donné que l'érosion chimique est très active, le profil topographique des régions calcaires peut évoluer rapidement. Il arrive même que le toit de certaines cavités s'effondrent, laissant des trous béants à la surface. Évidemment, cela rend difficile l'implantation de bâtiments et d'infrastructures là où le karst s'est développé. De plus, la présence d'un réseau de drainage souterrain vient mettre un frein à la construction sous terre, en plus d'être un type de réseau souvent méconnu et difficile à contrôler.

Ce projet fait partie d'une étude sur les géorisques par télédétection radar dans le cadre du programme ADRO de l'Agence spatiale canadienne. L'objectif principal est d'utiliser certaines caractéristiques de l'imagerie radar (télédétection dans le domaine des hyperfréquences, images multidates) pour aider à identifier et à surveiller les zones à risques élevés. Mais une revue exhaustive de la littérature ne nous à pas permis de déterminer avec certitude la capacité du radar à détecter un karst. Le but principal de ce projet est donc de vérifier si l'imagerie radar est suffisamment sensible pour cartographier les structures karstiques de surface.

La méthode proposée consiste à effectuer une comparaison entre la cartographie d'une zone karstique, faite à partir du traitement d'images radar aéroportées (SAR 580) et spatiales (RADARSAT), et une vérité terrain. L'île d'Anticosti, situé dans le Golf du Saint-Laurent, a été choisie comme site d'étude parce qu'elle constitue un cas typique puisqu'elle est composée de roches calcaires avec un karst bien développé. De plus, un nombre important d'études a été effectué sur l'île. Il s'agit donc d'un endroit bien connu à partir duquel il est facile d'effectuer la vérité de terrain.

Land cover of Canada: a new, nationally consistent, satellite-derived product

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ABSTRACT

Whether one is interested in land management, resource inventory, process studies, modelling or simply communication with stakeholders, land cover type is the single most important environmental information. It has long been recognized that remote sensing techniques are most effective when applied to mapping land cover and other surface characteristics. However, it has heretofore been impossible to map land consistently over large areas, such as the landmass of Canada. Recent advances in the processing and analysis of medium (1-2km) resolution optical data have led to the demonstration that such land cover maps can be produced consistently and with a minimum of operator intervention. This paper describes a new land cover map of Canada, produced at a spatial resolution of 1km. The map is based on multitemporal data obtained by the Advanced Very High Resolution Radiometer during the entire 1993 growing season. The presentation will briefly describe the data set employed; preprocessing methods; the classification approaches used; and the information content of the map including the accuracy and deficiencies of the procedure in relation to specific cover types, such as glaciers and snowfields.

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Multidata Integration Using RADARSAT Images: Studies of Geological, Geomorphological, Land Use, Urban Occupation and Remote Sensing Datasets from Manaus Region, Amazonas, Brazil

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Poster Presentation

ABSTRACT

The purpose of this investigation is to carry out analyses of the performance and advantages of using digital RADARSAT images to improve the knowledge about an area located in the Amazon Region, Brazil, where the frequent cloud covering is a common problem. The selected test area is situated in the neighborhood of the city of Manaus, in the Amazonas State (northern Brazil), with lat/long at S 3° 15'/S 2° 30' and W 59° 45'/W 60° 30'. This is a rainforest region with large rivers and irregular urban occupation.

The RADARSAT images will be submitted to geometric and radiometric correction, and thereafter co-registered with topographic map in the 1:50,000 scale. Field reports, vectors, point data and raster data from other sensors are all merged to maximize and improve the informational final document. The resulting merged products will be analyzed and interpreted in order to build up general thematic maps of the studied area, such as vegetation, deforested areas, soil and geologic maps, flood limits and surrounding land use, and urban occupation maps.

It is expected that RADARSAT imagery becomes a valuable and important tool to enable a continuous and more detailed study of forested areas, such as the Amazon Region.

Used RADARSAT Data: Stereo and multitemporal data by acquiring S7D (on September/October, '96) and S2D (on May/June, '97) beam modes.

SUIVI DU CYCLE SAISONNIER DE GEL ET DÉGEL DE LACS THERMOKARSTIQUES DE LA RÉGION D'OLD CROW, NORD-OUEST DU YUKON, PAR IMAGERIE RADAR

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RÉSUMÉ

L'étude du climat a toujours occupé une place importante dans le monde de la recherche scientifique. Aujourd'hui, plus que jamais, à cause des activités anthropiques et du réchauffement global qui en résulte et des conséquences appréhendées à long terme, la compréhension du système climatique global revêt plus que jamais un intérêt particulier pour la communauté scientifique. En climatologie, il est reconnu que les éléments de la cryosphère constituent des indicateurs intéressants pour faire l'étude des changements climatiques. Ainsi, une meilleure connaissance du cycle de gel et de dégel des lacs ainsi que la répartition et l'épaisseur de la glace sur chacun d'eux peut être importante afin de mieux comprendre par exemple les liens précis entre les périodes de froid extrême et l'expansion imprévisible des glaces.

Dans notre exposé nous présenterons les résultats d'un projet ayant pour but d'évaluer le potentiel de l'imagerie radar ERS-1 dans le suivi de l'évolution spatio-temporelle du cycle de gel et dégel de lacs thermokarstiques situés dans le nord-ouest du Yukon. Le radar semble, à ce jour, être le meilleur outil pour l'étude de l'épaisseur et de la structure de la glace étant donné sa capacité de pénétration importante. Certains travaux effectués sur le sujet ont fait état d'une réponse radar sensible à la composition de la glace. Ainsi, la présence de bulles rondes et/ou tubulaires ainsi que la présence de couches d'eau interstitielles à l'intérieur de la glace peut occasionner un double rebond du retour radar, ce qui a pour effet de générer un retour radar maximum. Un modèle suggère que lorsque la glace est composée de bulles d'air, quelques centimètres suffisent pour provoquer un retour radar maximal au milieu de la saison de gel. De plus, les lacs gelés jusqu'au fond provoquent un faible retour radar car on présume qu'une bonne partie des ondes émises par le radar sont absorbées par le lit du lac.

Evaluating Glacier-Related Hazards on an Active Volcano: Popocatepetl Volcano, Mexico City

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ABSTRACT

The presently erupting Popocatepetl volcano is located within about 40 km of Mexico City and is the target of an intensive investigation by Mexican University and Government researchers including UNAM Geophysics (seismology, volcanology, and geophysics) and the Mexican Centre for Natural Disaster Prevention (CENAPRED). The past geologic record on the volcano indicates that it has been frequently and violently active. Volcanic mudflows (lahars) and pyroclastic surges in the past have devastated heavily populated areas formerly occupied by the prehispanic people, and presently threaten a number of major population centers surrounding the volcano. In the past, glaciers and heavy snowfalls on the upper slopes of the volcano have apparently triggered tremendous lahars reaching more than 40 km from the volcano, and the deposits of these flows presently underlie several major population centers of several hundred thousand people. A concerted effort was implemented by the Mexican government to aid Mexican investigators in studying the volcano to improve predictive capability, and to reduce the hazards presented to the surrounding populations, industry and local economy. Recently, field measurements high on the cone have been minimized or eliminated due to the extreme hazard presented by the volcanic activity, and SAR interferometry remote sensing methods are being explored with Fred Campbell of the Canada Centre for Remote Sensing to improve deformation, magma movement and ice stability monitoring.

The glacier hazards presented by the volcano have been assessed through surface surveys, aerial photographic investigations, digital elevation model development, flow response measurement and modelling, ice depth sounding and ice volume analysis. The glaciers have shown greatly increased crevasse development since the eruption began in 1994. The ice velocity data obtained on poles inserted into the glacier in 1995 show a remarkable pattern of the entire glacier slowing down from September 1995 to June 1996, with the lower glacier moving as a block much faster than the heavily fractured upper glacier. This situation indicates that the glacier is probably sliding at its bed, and that the lower glacier is capable of failure as a major ice block avalanche. There is strong indicating the glaciers on Popo volcano accelerate seasonally due to lubrication at the bed. If this is the case reactivation of the glacier "block-stollen" motion may have occurred in the summer of 1996. The slip-stick motion of the glaciers on Popo may be mistaken for harmonic tremor. The glacier crevasses present additional hazards since if the cracks continue to enlarge, water can more easily reach the glacier bed and lubricate the block of lower glacier ice comprising the

ablation area. This would allow the ice block near the terminus to further accelerate towards a major rock cliff just below the present terminus. Previous glacier advances on the mountain have been preceded by enhanced crevassing in upper slopes, but none so dramatic as what has occurred between spring 1995 and fall 1996.

The presence of a heavily crevassed glacier surface will allow a better transfer of heat to melt the glacier particularly if the surface is overrun by a pyroclastic flow, lava flow or a hot lahar. For a glacier-related lahar initiated form the upper most slopes of the volcano, there would be a high initial energy and high momentum generated due to gravitational potential. The erosive capability of a glacier fed lahar would be greatly increased and the viscosity greatly decreased by water lubrication as well as probably acoustical fluidization. Such a flow could reach the greatest distances from the volcano and overrun population centers downstream of the glaciers within less than an hour of flow initiation. Thus it is critical that the simation of glacier stability be understood and the predictive capability of glacier related lahars be improved at Popocatepetl volcano. If there is a failure of the volcanic cone or an intrusion of magma into water saturated slopes, then the potential of a major explosion of the volcano is increased. Much like Mount St. Helens, such a phreatic explosion could trigger a change in the much larger magma chamber at depth and lead to a major eruption. A summary of results to date at Popocatepetl is given in this paper and success of new methods used to aid hazard evaluations are discussed.

AN INVESTIGATION OF THE SPATIAL MODES OF SNOW WATER EQUIVALENT OVER CENTRAL NORTH AMERICA USING PASSIVE MICROWAVE DATA

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ABSTRACT

Snow cover has a considerable local and regional scale influence on energy exchange with the atmosphere through both a high surface albedo, and low thermal conductivity. It is therefore important to characterize the changing distribution of snow cover through the seasonal cycle of snow accumulation and ablation. Passive microwave derived measures of snow water equivalent (SWE) provide an excellent means of monitoring snow cover because of a broad spatial resolution, daily orbital coverage, and all weather imaging capabilities. In this study we utilize a time series of five day averaged (pentad) Special Sensor Microwave/Imager (SSM/I) passive microwave derived SWE images to characterize the seasonal evolution of snow cover during winter 1988, over a validated study scene extending from the Canadian Prairies into the American Great Plains.

Principal components analysis (PCA) was used to identify the dominant modes of snow water equivalent distribution. Component loadings indicate the relative strength of time series images to the pattern characterized by each component. Results indicate that the first 3 SWE components account for over 90% of the variance in the original data. Subsequent components explain only a fraction of the variance in the data, however, they may still track valid geophysical processes. A second PCA was performed on pentad imagery of the entire continent of North America in order to investigate the sensitivity of the analysis method to a more varied geography. Although SWE algorithm performance has not been validated over boreal, montane, and other terrestrial surfaces, the goal of the second PCA was to track the signal of SWE over the Prairies amidst surrounding image data, and to note any changes in the dominant modes of snow cover.

ANALYSE PRÉLIMINAIRE DE L'ÉMISSION DE LA NEIGE À L'AIDE DE DONNÉES DE MICRO-ONDES PASSIVES SSM/I : LE CAS DU BASSIN VERSANT DE LA RIVIÈRE LA GRANDE (QUÉBEC)

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RÉSUMÉ

Plusieurs études effectuées à partir des données provenant de NIMBUS-5 et 6 ESMR (Electrically Scanning Microwave Radiometer) et de NIMBUS-7 SMMR (Scanning Multichannel Microwave Radiometer) ont démontré le potentiel des micro-ondes passives pour l'étude du couvert nival. En effet, pour des fréquences supérieures à 15 GHz, l'émission de la neige tend à diminuer au fur et à mesure que le couvert de neige augmente. La diminution de l'émission de la neige est directement reliée à la redistribution de l'énergie causée par la diffusion de volume des grains de neige.

L'objectif de cette étude consiste à réaliser le suivi du couvert nival pour un secteur de la Baie James à partir des données de micro-ondes passives issues du capteur Special Sensor Microwave/Imager (SSM/I). Le secteur considéré est le bassin versant de la rivière La Grande. La base de données utilisée comprend des données SSM/I et une image NOAA, de même que plusieurs données de terrain pour les mois de février et mars de l'année 1994 et 1995. Précisons que depuis septembre 1995 nous acquérons aussi une série temporelle de données SSM/I (tous les mois) pour l'hiver 1995/96 et 1996/97. Les relevés d'épaisseur et d'équivalent en eau du couvert nival (EEN) ont été complétés par une simulation de l'accumulation de la neige au sol pour les périodes où l'information était manquante.

Une analyse préliminaire montre que les températures de brillance de la neige diminuent au fur et à mesure que le EEN augmente. Toutefois, lorsque le EEN est supérieur à 18 cm, la relation devient positive. Cette situation est directement liée au pourcentage de gros cristaux présent dans la neige, ceux-ci étant directement responsables de la forte diffusion de volume de la neige. En effet, lorsque les couverts de neige sont peu épais, on remarque une baisse de l'émissivité de la neige, puisque le fort gradient de température favorise la formation rapide d'une neige à gros cristaux (± 4 mm). Par ailleurs, lorsque le EEN est supérieur à 18 cm, le pouvoir de pénétration de l'onde diminue et l'émission de la neige provient surtout de la surface du couvert nival. Dans le cas de la Baie James la pénétration moyenne était de 60 cm. Cette situation explique donc la relation positive entre la température de brillance et les EEN supérieurs à 18 cm. Découlant de cette analyse, on a utilisé deux régressions différentes pour évaluer le EEN des couverts de neige épais et peu épais. Cette approche s'est avérée plus efficace pour la cartographie du couvert nival puisqu'elle considère les conditions particulières de la neige.

A GIS METHODOLGY FOR GEOLOGIC CHARACTERIZATION OF A CANADIAN SHIELD TERRAIN

by

Robert G. McGregor[1], Vern Singhroy[2] and Peter Bruton[2]

ABSTRACT

New approaches to the manipulation of spatial data have become evident with the advent of the use of GIS. This paper describes a methodology for determining the geologic characterizatics of a Canadian Shield terrain, incorporating remotely-sensed data, a DEM, and ground-based data within a GIS environment.

Since 1978 AECL has investigated methods to characterize the geologic conditions of plutonic rock bodies of the Canadian Shield in order to assess their potential suitability for the disposal of nuclear fuel waste in an underground vault . Recently this has included investigation the use of remotely sensed data and other digital data sets to assist in understanding the geologic conditions. As an example of this approach, RADARSAT S7 and F5 beam mode imagery, together with Landsat TM, airborne geophysics and geological data from ground based mapping studies have been integrated within a GIS to characterize the geology of a plutonic intrusion in Northwestern Ontario. Characteristics such as ground cover, elevation and mapped geology were combined with lineament analyses, to define features required for developing a geologic model of the site. This work was performed for the Canadian Nuclear Fuel Waste Managment Program in cooperation with the Canadian Centre for Remote Sensing and GeoAccess Canada and is jointly funded by NRCan, AECL and Ontario Hydro under the auspices of the Candu Owners Group.

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Application of High Resolution Optical Imagery to Precision Agriculture

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Significant spatial variations in crop yield often occur across agricultural fields. Much of this variability in yield is attributable to soil nutrient and moisture variability, topographic variations, as well as insect and weed infestations. Precision agriculture combines a number of technologies - GPS, GIS, remote sensing and variable rate technology - to site specifically manage this spatial variability. Pilot studies have demonstrated that with this approach, crop production can be optimized with minimum inputs of chemicals, and a corresponding minimum impact on the environment.

Within the context of precision agriculture, GPS technology is used in the creation of spatial yield variability maps from continuous yield sensors and in the geo-referencing of field measurements. Variable rate technology is used to apply the within field variability information collected from site samples, remote sensing inputs and variable yield monitors. GIS is the technology used to manage and integrate the geo-referenced data.

The role of remote sensing in precision agriculture is to supply repetitive information on the condition and spatial variability of soil and crop attributes, including crop condition and crop infestations. The high spatial resolution associated with soon to be launched commercial optical satellites, such as EarlyBird and QuickBird, suggests that these satellites will be a valuable data source for input into the precision agriculture system.

To evaluate the potential of these high resolution satellites for use in precision agriculture, a number of datasets were collected over study sites in Manitoba during 1996. These data included the collection of CASI airborne multispectral data and air photographs during crop emergence, as well as the collection of CASI data during crop vegetative growth. At the time of image acquisition, ground data were collected in selected fields to characterize weed growth and crop biomass. These datasets will be analyzed to determine the potential of the high resolution satellite sensors to identify weed location and weed type, and to provide information on crop biomass and variability in biomass across agricultural fields.

An hybrid approach for forest regeneration assessments from high resolution aerial images

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The assessment of forest regeneration success is an essential aspect of forestry practice and an intregral part of most allowable cut quota systems.

An hybrid approach of regeneration assessment from high resolution aerial images (10-100cm/pixel) was developed. It detects the young trees and for given stands produces information such as stem density, average tree spacing and stocking. It can also pinpoint areas of under or overstocking. If stands are not known apriori, a method has also been developed to regroup the trees into stands of uniform densities and produce the regeneration assessment.

The hybrid approach is based on previous work directed at mature forest in medium resolution images. This older approach detects local maxima and considers them to represent the "tree tops" of conifers. It is generally appropriate for dense stands where every tree is surounded by shade. However, its use on sparse stands generates numerous false positives on the ground between the trees. A modification of the algorithm to take into consideration the presence of a specific shadow for every tree aleviates the problem. The hybrid algorithm is capable of switching from one mode of operation to the other based on a pre-computed local directionality factor.

The new hybrid approach and a simple stand delineation method are describ= ed. Preliminary results on regeneration stands of various ages and densities are presented.

MAPPING AREAS OF COASTAL EROSION IN THE STATE OF PARAÍBA, BRAZIL FROM RADARSAT DATA

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The coastal region of northeastern Brazil are major economic and recreational areas. In these areas, low income population in small fishing villages, "favelas" and expanding urban areas, are affecting the sensitive coastal ecosystems. At the same time, the coastal zone is been eroded by the frequency and intensity of storm events which also destroy the marginal ecosystems. Because of the permanent cloud cover in these coastal areas, no optical image exist to assist in geological and environmental mapping.

In this study we use RADARSAT data to interpret the structural geologic and geomorphic processes and their relationships to coastal erosion. Our results show the following:

- There is a good correlation between the radar image-interpreted lineaments in the coastal areas and the Pre-Cambrian and Post-Cretaceous geological structures in the interior areas.
- The coastline is structurally controlled with lineament directions of $NE40^0 \pm 5^0$ (dextral strip slip and normal/gravitational faults), $NW20^0 \pm 5^0$ (sinistral strip slip and normal/gravitational faults) and $NS \pm 5^0$ (inverse sub-vertical faults, with E-W overlaps).
- The areas with high vulnerability to erosion (almost 300m of coastal loss, in 25 years), are characterized by flat Quaternary sediments (alluvial and sandstone surfaces). In these areas, increasing coastal erosion is related to the increase in the frequency of lineament directions. These directions are $NE25^0 \pm 5^0$ (inverse sub-vertical faults, with W-E overlaps) $NW20^0 \pm 5^0$ and $NW35^0 \pm 5^0$ (sinistral strip slip and normal/gravitational faults).
- The areas with low vulnerability to erosion are characterized by accretion and by Tertiary/Quaternary sandstone cliffs. In these stable regions, the frequency of the lineament directions decreases. These directions are $NE40^0 \pm 5^0$ and $NW60^0 \pm 5^0$, and represent sinistral strip slip and normal/gravitational faults.
- The standard RADARSAT image with incidence from 36-42 degrees was useful to improve geological and geomorphic mapping from existing 1:1 000 000 to 1:100 000 scale maps.

Enhancement of the Geologic Mapping of Anticosti Island using SAR data

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The uninterrupted and undeformed carbonate shelf sequence of Anticosti Island, in the Gulf of St.Lawrence, eastern Canada is one of the best exposed and most complete sections in the world spanning the Ordovician-Silurian boundary. Although the succession is well exposed in numerous cliff sections along the coast and inland rivers, most of the island surface is covered by an extensive vegetation cover. Airborne C-band radar data of the entire island were collected with the CCRS Convair-580 aircraft. These data are providing new and more complete information on surface and bedrock geology of the study area including i) a more precise delimitation of most member and formation boundaries across the island, including the O-S boundary; ii) a better visual interpretation of the bedrock topography beneath the vegetation cover showing a pronounced cuesta morphology in the eastern and western parts of the island; iii) an accurate measurement of surface linear features (joints, minor faults); iv) the presence of gentle open folds and of more widespread thoeliitic dykes of Jurassic age in the eastern and central parts of the island respectively; and v) a complement for mapping Quaternary glacio-marine and marine deposits (moraines, eskers, raised littoral beaches and erosional cliffs). The results of this airborne SAR study is providing easily interpretable products and cost-effective way to improve geological mapping in vegetated terrains.

Sea Surface Evaluation by Using Radarsat Imagery Relating to Meteorological and Morphological Conditions over Ambon and Jakarta Bay, Indonesia

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Abstract

The ocean is a complicated system with movement and variability in a time and space scales. Remote sensing is an alternative tool to obtain a time series data at a fixed point and a synoptic chart. Radar satellite remote sensing, such as Radarsat, is an invaluable tool to overcome optical remote sensing due to independence of of solar illumination, penetration of cloud and produce different information than that availale in an optical of a spectrum. Sea surface roughness pattern in radar image due to the presence of wind, bottom topography, man made structures and vessels, surface film and slick will be evaluated by real-time field data acquiring. Multi-temporal and multi-beam mode of Radarsat images are used to analyze surface roughness radar pattern.

The objectives of the program are to verify Radarsat image for identification of sea surface roughness of radar pattern and to evaluate its capability for sea surface pattern related to wind, bottom topography, artificial causes, surface films and slicks.

Optimal Path Delineation to Multiple Targets Incorporating Analysis of Fixed Cost Distance

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Poster format and should preferably be part of the GIS Software topic

ABSTRACT

This paper introduces a new concept of distance measurement and a corresponding method of calculating minimum cost surfaces. These cost surfaces also require an enhanced pathway analysis function in order to delineate least cost paths. Fixed cost distance is defined as the cumulative costs associated with the creation of a path linking two or more points. This is in contrast with those costs associated with the effort of movement between two or more points. The costs included in each distance measurement are mutually exclusive. Costs associated with both distance measurements may be combined when performing a cost surface analysis with a single target since the goal of each distance measurement is to arrive at an optimal path joining an origin and a target. However, for multiple targets, the goals of effort distance and fixed cost distance measurement vary. For calculation of the costs associated with effort distance, an algorithm solves for the cumulative costs of each optimal path joining an origin with a target. Since the costs of movement are not included with the fixed cost distance, the goal of the algorithm is to solve for the optimal path that joins all targets to the origin without regard for minimizing the costs associated with joining the origin to a target in isolation. Preliminary surfaces using the conventional method and a method designed for calculation using fixed cost distances reveals a twenty to thirty percent decrease in "minimum cost". For larger images, decreases in minimum cost are expected to be greater than seventy percent. Potential applications for fixed cost surface measurement include remote road construction to mine sites or forest stands and power line construction involving multiple targets.

AirSAR Data Use and Limitations: A Case Study of a Mountainous District of Uganda

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ABSTRACT

GlobeSAR was conceived as a preparatory project for the 1995 launch of the Canadian RADARSAT satellite. In essence, the user community is prepared for the operational use of radar data from 1995 onwards and into the next century through the transfer of the Canadian experience and expertise in the field of Synthetic Aperture Radar (SAR) technology worldwide.

SAR technology is claimed to provide data for several environmental and natural resource applications. This research, however, concentrated principally on the potential application of SAR data for the detection and discrimination of the Earth's surface and sub-surface features in a rugged and mountainous part of Mbale district in Uganda.

This area presents a formidable challenge to planners, decision-makers and managers of natural resources and human environment. Attempts to map or monitor the area from space by the conventional photographic and multispectral scanning systems are always futile as it experiences near to perpetual cloud cover and rain, especially at higher elevations of Mt. Elgon. Since radar can "see" through these adverse weather conditions and is an all-day imaging system, SAR technology appears to be a logical remote sensing tool for gathering data about the human environment and natural resources in the area.

Interpretation of the AirSAR (airborne) image of the area was based on reference data such as surface ground truth, local knowledge, existing topographic maps, and a wealth of experience in the visual interpretation of aerial photographs and optically/infrared-sensed satellite images. In addition to this visual interpretation approach, machine or digital image classification of the image was attempted.

The major land use/land cover categories identified in the image were: banana plantations, forest types (natural forests, degraded and un-degraded bamboo), bare rock surfaces, mountain slopes and valleys, built-up areas (infrastructure), water (drainage channels/rivers), and extensive intercropped subsistence agriculture on heavily fragmented plots on the slopes of rides and in valleys.

Concerning machine unsupervised digital image classification of the image, only a handful of land cover classes was discernible when the result was printed on a black and white laser printer. Supervised hybrid classification based on the conventional image classifiers such as minimum-distance-to-means, parallelepiped (box) and maximum-likelihood algorithms, on the other hand, was not applicable to the single C-band SAR image dataset and no meaningful result was produced. This result points to a need for the development of new approaches to classification which take full advantage of SAR technology Density slicing of multi-temporal SAR images could possibly lead to better classification result.

The single spectral dimensionality of SAR imagery and absence of multi-temporal SAR or optical/infrared images; lack of up-to-date "true" ground truth map nor a provision for incorporating topographical information using digital terrain models or through interferometry; foreshortening and layover effects due to relief displacement; speckle and inappropriate timing of field work were the main constraints to this research endeavor.

The Application of SAR Data for Land Cover Change in North Tibet

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ADRO Project # 591

ABSTRACT

Northern Tibet, located in Western China, is the highest plateau in the World, with an average elevation of more than 5,000 metres. In November 1996 the TM data and SAR data (eight scene tapes) supported by ADRO was used to analyze land cover changes. Based on imagery processing and GIS several conclusions have been reached: (1) in recent years with the increasing Earth temperature, the snow line in study area retreated; (2) the desert study area also shows enlarging, thus, the environment change should be paid more attention; (3) provide a series of suggestions to protect the environment.

Resolving Projection Issues Using Canadian NTS Digital Data

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ABSTRACT

The application of GIS technology has reached a level of maturity such that exchange of map related data in digital format is now commonplace. This is true of municipalities, utilities, resource management agencies and many other organizations in both the public and private sectors. This paper describes experiences in dealing with data exchange and map projection issues in the resource management sector, where the 1:50,000 Canadian NTS sheets are often used as a base on which other data are overlain.

In Ontario there are two common sources of base mapping. the 1:10,000 OBM sheets are available in digital format in NAD 27, May 1976 correction, while the digital 1:50,000 NTS maps are available in NAD 83. Conversion between these projections is conceptually straightforward, and many GIS packages provide the capability to convert data to and from a variety of projections. Geomatics Canada also provides national transformation grid files for conversion between NAD 27 and NAD 83, with a subset of the database applicable to Ontario's May 1976 correction.

The issues described in this paper came to light while completing a project to prepare digital resource mapping that was based on NAD 27 1:50,000 hard copy. The data were to be delivered in NAD 83 to be overlain on the digital 1:50,000 NTS data. When the NAD 27 data were converted to NAD 83 using the Version 2 grid shift files from Geomatics Canada, there was a systematic error in all the converted data. Map neatlines and other common features such as water bodies and roads showed an offset from the NTS digital files that was the same sign in both the easting and northing. The same results were found when the data were converted using projections built into the GIS package employed to create the data. This was unusual because the easting and northing changes are usually of opposite sign when converting between NAD 27 and NAD 83.

Allowing for the fact that the 1:50,000 NTS data were prepared from conversion of scanned NAD 27 hard copy, the discrepancies still could not be resolved, and prompted further investigation to determine the reasons. A NAD 27 hard copy 1:50,000 NTS sheet was used to prepare a digital file from which a number of projection transformations were used to

generate data to compare to the 1:50,000 NTS NAD 83 base. The outcome of these efforts indicated that there appeared to be no latitude or longitude shift applied to the digital NAD 83 1:50,000 base when converted from NAD 27 to NAD 83.

While this experience may be an isolated incident, it could provide valuable assistance to those who must deal with data from a number of different mapping sources and experience problems with apparent errors when converting to a common projection.

Delivering Geomatics Technology to Russia

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ABSTRACT

Linnet is leading a team of canadian companies to deliver a modern state of the art digital mapping and geographic information system to Moscow Aerogeodetic Enterprise and the City of Ryazan. This paper will deal with the experiences of overcoming the delivery issues and putting new Canadian technology into the hands of inexperienced technology users. The project was funded by CIDA and was done with the support of Geomatics Canada.

MONITORING MANGROVE RESOURCES WITH RADARSAT IMAGERY

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Abstract

This study contains an analysis of a series of RADARSAT images acquired over mangroves in the northern Pacific coast of Nicaragua, and on the southern Pacific coast of Costa Rica. The objectives are (a) to demonstrate RADARSAT's utility for monitoring of mangroves and (b) to evaluate different acquisition modes for feature detection within the mangroves and surrounding areas. The images were acquired in May, 1996. In the case of the mangroves of Estero Real in Nicaragua, we used ground reference data, SPOT panchromatic imagery and aerial photographs. In the case of the mangroves of Terraba Sierpe in Costa Rica, we are using a detailed vegetation map elaborated from aerial photographs of 1988 as well as a high resolution airborne C-band imagery acquired in 1992.

The utility of the imagery for the delineation of shrimp ponds and natural lagoons is recognized for all acquisition modes studied, being the Fine 5, Standard 1, Standard 7 and Extended 6. Monitoring of shrimp ponds is of primary importance because of occasional un-authorized pond enlarging or the establishment of new ponds. The natural lagoons in Nicaragua's Estero Real are traditionally used by the local population for shrimp gathering, and are respected as such by the government. Proper mapping of these lagoons by means of radar can contribute to prevent land use conflicts caused by the planning commercial shrimp establishments in these areas. The images were also useful for delineating banana plantations and rice paddies in the surroundings of the mangroves, which can be matter of concern if large amounts of agrochemicals are being used.

A preliminary analysis of the images suggests that large incidence angles are preferable to identify certain features such as shrubby vegetation. In Nicaragua, the image acquired with a small incidence angle (Standard beam 1) showed a bright return for wind-roughened water, which could be confused with the return from shrubby mudflats. The data also showed no signifcant difference in tone between a large area of bare cotton fields and adjacent fields with mixed vegetation.

In turn, data acquired with larger incidence angles (Standard 7 and Extended beam 6) easily detected the bare fields, and allowed a sharper distinction between areas of low shrubs, adult tree strips in the mangroves, mudflats and/or water. Further investigation is under way to determine if rainfall has contributed to the poor detectability of the bare cotton plots in the Standard 1 image. Results from previous research suggest that under dry conditions, the contrast in C-band SAR between bare soil and vegetated areas increase with larger incidence angles.

Sediment yield in the watershed is one of the factors which most affect mangroves. The possibility of identifying bare fields at the beginning of the rainy season is a very important issue. This problem is difficult to address with electro-optical remote sensing imagery, which is sensitive to cloud cover. The detection of low shrub areas in the mudflats of the Estero Real is also a crucial issue. In certain areas, the shrubs are thought to be regenerated vegetation associated with flats which may have been the result of massive sediment yields during the "cotton boom" period thirty to forty years ago. The shrub vegetation does not appear on the maps currently used for the planning of shrimp concessions. Although mangrove vegetation is protected by law, the extent of shrub vegetation is not known and is not taken into account for planning purposes.

For these applications, the RADARSAT Fine Mode imagery does not seem to offer any major advantages over the Standard Mode data, because of its single look configuration. It will not be possible to use the SAR imagery from either data acquisition mode for the purpose of identifying vegetation species. In the case of Terraba-Sierpe in Costa Rica, the high resolution airborne imagery was more successful in distinguishing general vegetation classes; in many cases, bright SAR returns and shadows indicated the limits of taller stands of trees or areas colonized by ferns or low shrubs.

APPORT DES IMAGERIES LANDSAT-TM & RADARSAT-1 A L'ANALYSE MORPHOSTRUCTURAL: CAS DE LA ZONE DE MANZLA (RIF OCCIDENTAL MAROC)

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RÉSUMÉ

La présente étude met en évidence l'apport des images radar et multispectrales à l'analyse morphologique et structural, don l'objectif essentiel est de tester la nouvelle génération des satellites canadien RADARSAT. La zone d'étude, sur laquelle a été portée travail est la zone de Manzla qui présente une superficie de 20 km ^{2} à l'ouest du bassin de Tahadart-Hachef. Cette zone fait partie des bassins néogène et quaternaire littoraux, comme celui, de Ghercif sur la côte méditerranéenne et celui, de Gharb sur la côte atlantique. Ces bassins sont allongé E-W suggérant un contrôle neotectonique dans leur formation. La zone de Manzla montre une variation topographique très marquée et se rattache géologiquement à la chaîne rifaine dont les formation dominantes sont des flyshs gréseux numidiens, formant les principaux reliefs et les dépôts plio-quaternaires à des altitudes relativement basses.

Deux couvertures d'images satellitales de différentes résolutions spatiales et spectrales Landsat-TM (30x30m) et Radarsat-1 (12.5x12.5m) ont subi différents traitements géométriques et radiométriques. La sélection des meilleures représentations des bandes spectrales de TM a été basée sur les méthodes statistiques (Moik, Oif, Index) et la procédure visuelle. Trois canaux ont été sélectionnés pour l'extraction de l'information géologique et géomorphologique qui sont TM3,TM5 et TM7.

La compression et l'intégration des données TM3/TM5/TM7 et RADARSAT-1 a permis un réhaussement des principales structures morphotectoniques de la région d'étude. Grâce à cette reconnaissance, nous avons pu extraire un grand nombre de discontinuités linéaires (linéament). L'analyse statistique révélée par la rosace directionnelle de ces discontinuités a montré l'importance de deux direction majeures NE et NW. La direction NW montre la direction des bancs gréseux et pelitiques métriques numidiens et un ensemble

d'escarpements de même direction qui sont généralement interrompus par des cluses, des vallées et des failles de direction NE.

Les résultats obtenus ont été conformes aux travaux de terrain révélées par les études antérieures à 'échelles régionales, malgré que la présente étude a porté sur une zone relativement réduite.

INTÉGRATION DES DONNÉES RADAR A UN SIG DE SUIVI DE LA DYNAMIQUE D'OCCUPATION DES SOLS IRRIGUÉS: APPLICATION AU PÉRIMETRE IRRIGUÉ DU LOUKKOS

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RÉSUMÉ

La présente étude a porté sur l'évaluation de l'apport des images radar (ROS) à l'identification et la cartographie de l'occupation des sols dans le périmètre irrigué du Loukkos (Maroc). Il avait pour objectif secondaire l'intégration des ces données radar dans un Système d'Information Géographique (SIG) du périmètre, pour servir d'aide à 'a décision de sa gestion et son fonctionnement.

Les données radar utilisées sont celles acquises le 16 décembre 1993 dans le cadre du programme de recherche Globe SAR-Maroc. Les différents traitements et analyses effectués sur l'image couvrant la zone d'étude ont permis de discriminer entre les trois principales classes d'occupation du sol rencontrées en mois de décembre. La méthode de seuillage a été aussi testée. L'erreur commise par cette dernière méthode de cartographie est d'environ 25%. Elle est supérieure à celle commise par interprétation visuelle, qui est d'environ 15 à 20%. Les structures linéaires présentes dans le secteur choisi ont été, également, identifiées sur l'image

L'établissement du noyau d'un SIG intégrant le résultat de la cartographie, a consisté tout d'abord à l'apport de la carte issue de l'interprétation visuelle de l'image radar. Ensuite cette carte a été superposée à la carte de parcellaire pour constituer une carte d'occupation du sol reliée à une base de données des cultures et des parcelles.

MANAGEMENT OF SUSTAINABLE COASTAL AQUIFER SYSTEM OF A WATERSHED, TAMILNADU, INDIA

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ABSTRACT

Satellite remote sensing techniques are employed increasingly to solve problems relating to water management both at various scales, national and local. Using IRS 1B LISS II 5 X FCC AND LANDSAT 5TM 5X FCC, geomorphic units and land uses of the watershed in question have been studied for the purpose of assessing the sustainable nature of the coastal aquifer system. The coastal aquifer, especially in the geomorphic area of coastal deltaic plains, is contaminated also by the practice of aquaculture all along the coast, taking advantage of the sea inlets and backwaters The area under aquaculture has been clearly identified, using the images, enabling an assessment of the nature of contamination of salt water in the coastal aquifer.

The study area falls under the delta plain with a tree crop (prosopis) on a sedimentary terrain. Lithology as such plays a major role in the salt water intrusion and the quality of groundwater. This is an elongated basin with low rainfall and it drains into the Bay of Bengal. The huge deposition of Cretaceous and Tertiary formation is adjacent but interior to the coastal alluvium. Depth to bedrock in the deltaic plain region is from 100m to 250 mm with reference to mean sea level and is under low resistivity zone. Lateritic uplands can be sharply identified from the remotely sensed data and have good quality groundwater. The depth to bed rock and low resistivity zones can be correlated towards identifying the locations for drilling. Deep vertical electrical sounding conducted in the coastal terrain revealed that the sediments overlying the basement have resistivities ranging from 10 ohm. M to 110 ohm. M and in certain areas 1 to 15 ohm. M. There is not much variation in the quality of groundwater in east and in the southeastern parts of the area. In the region characterized by the laterite and sandstone at the top and overlying the basement, the resistivity ranges from 10 to 150 ohm. M, due primarily to good quality groundwater. In the ridge area of Tertiary formation, groundwater is comparatively small in quantities with EC values ranging between 1250 and 2150 microsiemons/cm and the groundwater is suitable for irrigation. Low resistivity zones in the coastal sediment tracks are indicative of thick clay and the aquifer containing saline water. The aquifer conductivity in the Cuddalore Sandstone is followed by crystalline basement in the area adjoining Karaikudi and Devakottai and they are entirely of freshwater.. It is concluded that the Tertiary formation should not be disturbed and in fact the saline aquifer should be sealed to prevent the freshwater aquifer from being contaminated. The area with a big tank known as Rajasingamangalam tank appears to be a paleao lagoon which plays a major role and controls the flow in the Kottakariyar joining the sea. Salt water intrusion is however high in the areas adjacent to the sea, with EC values ranging from 5000 to 15000 microsiemons/cm. It is particularly severe in this area as the saltwater intrusion is fast in

this zone as well. The studies using remotely sensed data and the water quality analysis have shown the options there are for a sustainable use of the coastal aquifer: the simplest strategy we should adopt being prevention of salt water intrusion through continued withdrawal from the aquifer and expanding aquaculture. The paper elaborates the options as regards sustainable aquifer use and coastal zone development without much disturbance.

Soil Surface Stoniness Assessment for Agricultural Uses

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ABSTRACT

The agricultural area in Egypt is rather limited and the area per capita share decreases as the population increases. The government devotes a lot of investments as well as efforts to bring the desert land into production. A major development plan has been formulated for Sinai because its potential natural resources including vast prospective land for agricultural uses.

The soil surface of some areas is covered by gravel, cobbles and/or stones. These surface coarse fragments may influence the tillage conditions and the capacity to retain nutrients as well as water. Moreover, workability of the land depends mainly on surface stoniness, and thus is considered as a limiting factor for agricultural practices.

The study area is located at the Gulf of Suez in Sinai between latitudes 29^0 00' and 29^0 32' N and longitudes 32^0 40' and 33^0 15'. The area is formed of some deltas, wadis and plains.

Landsat image analysis was employed to assess the stoniness of the soil surface. Spectral reflectance and image texture were two parameters used in the analysis.

The output classified image shows different stoniness percentages of surface coverage categories.

APPLICATIONS OF REMOTE SENSING TO VOLCANIC PHENOMENA IN THE SYRIAN ARAB REPUBLIC

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ABSTRACT

Satellite Remote Sensing is a widely used and potentially powerful tool in the mapping of large-scale volcanic phenomena. Landsat-5TM Thematic Mapper, Radar-SIR-A (LFC) Large Format Camera, MKF6M, Kate 140 and RBV data have been used to map volcanic phenomena and the pronounced margin of the lava flows which have been traced clearly TM provides nearly as much information as high-altitude aerial photograph, especially in areas with extensive lave cover. Radar imageries have proved useful for detailed interpretation of volcanic structures. The brightness of the Radar returns from the lava surfaces shows significant local variation. Bright and dark returns represent rougher and smoother flows. These contrasts are less clear on the Landsat imagery. This paper presents the results of Remote Sensing investigation based on various imageries. Visual and digital images processing interpretation have been applied to study the volcanic phenomena.

The purpose of this paper is to evaluate the capabilities and limitations of spaceborne Thematic Mapper data and associated image processing techniques for volcanic phenomena in the Syrian Arab Republic. Landsat 5 Thematic Mapper data have been used to map the volcanic was employed. Digital image processing of TM data gives more information than with B/W photographs, especially in areas with extensive volcanic cover. The image processing utilized consist of generation of color composites. TM imagery has proved useful for detailed interpretation of geological structures. Compared with MSS

POTENTIAL OF RADARSAT DATA FOR GEOLOGICAL APPLICATIONS IN THE TROPICAL RAIN FOREST ENVIRONMENTS: FIRST RESULTS FROM CARAJÁS MINERAL PROVINCE, BRAZILIAN AMAZON REGION

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ABSTRACT

As part of the ADRO Program, RADARSAT data has been acquired in the Carajás Mineral Province, easternmost border of the Brazilian Amazon. The Province encompasses the world's largest iron deposits and important Brazilian deposits of Salobo (Cu-Au-Mo-Ag), Pojuca (Cu-Zn), Azul (Mn), Bahia (Au-Cu) and Vermelho (Ni), among others. Despite the great volume of previous geological data, the geology of the Province is not completely known and has not been fully mapped. The area is related to an Archean Shear belt, with metasediments, metavolcanics, gneisses and granulites. Anorogenic granites with Middle Proterozoic ages are scattered throughout the region.

The vegetation is typical of tropical upland rain forest communities with complex and multilevel canopies with numerous species of trees and plants. Previous investigations with CCRS SAR 580 (SAREX' 92) have shown that airborne C-band SAR data provided an effective data source for geological mapping and is consistent with published large scale maps. New information on structures and lithologies were obtained and provided improved information for current geology of the area. Although these findings were obtained under airborne conditions, it is expected that RADARSAT will provide similar results for systematic geological mapping, mineral exploration, monitoring and the environmental control of the mining activities in the area.

The main objectives of the ADRO project are: (1) to evaluate the performance of the various modes of RADARSAT (ScanSAR, Fine and Standard beams) aiming at tectonical/structural analysis and geological mapping; (2) to develop RADARSAT digital integrated products with ancillary data (Landsat TM and aerogeophysical) for mapping in heavily-vegetated tropical rainforest terrain; (3) to evaluate the potential of RADARSAT High Resolution data (Fine Beam) in the mapping of surficial laterite units related to iron mineralizations.

The main regional litho-structural domains in the Carajás area have been distinguished through visual analysis and these are: (1) the southern domain or Serra dos Carajás imbricated sinistral shear zones with rocks related to the Xingu Complex, Pium Complex, Plaquê Granitoids and Sapucaia Group; (2)

the central domain with a transcurrent nature, with thrusting records represented by the several rock systems (Serra dos Carajás, Cinzento , Tapirapé and Buritirama) and (3) the northern domain characterized by overthrusting of mainly granulitic rocks tectonically mixed with portions of the Xingu Complex

A 55 kilometre square area in the Central Carajás Mountain Range was selected for the digital integration of RADARSAT with Landsat TM and Airborne gamma ray (Total Count, U, Th). The SAR data was radiometricly corrected (Antenna Pattern) and orthorectified with speckle suppression filtering (Fgamma) The Landsat TM was also orthorectified and a 30 m pixel size was chosen for the geological digital integration The integration was based on IHS/RGB transformation. The combination of RADARSAT with Landsat TM shows geobotanical controls, i. e., spectral variations closely related to vegetation responses and displayed in gradations of hue while radar enhances the relief. The integration of RADARSAT with isolated gamma ray channels has favored insights between terrain (morphology/bedrock) radiometric properties and lithological units, rock types and also hydrothermal metasomatic processes The first results of this investigation emphasize the importance of using digital integration based on RADARSAT data as an effective tool in systematic geological mapping in the Amazon Region

Experimental Design for RADARSAT Ground Data Acquisition in Tucuruí Reservoir and Lago Grande Floodplain, Brazilian Amazon.

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In order to validate the RADARSAT data acquired as part of the ADRO program, an experimental design was conceived to collect ground information for aquatic and floodplain ecosystems. The ground data collection is oriented to answer scientific questions regarding the application of RADARSAT data for accomplishing the following tasks: 1) to understand the interaction between microwave radiation and aquatic plant features; 2) to estimate the area occupied by different ground classes found in those ecosystems; 3) to understand the seasonal dynamics of these ecosystems as a response to the hydrocycle. The objective of this research is to report the methodological aspects of the experimental stage to support ADRO program investigations.

Ground data were collected concurrently with RADARSAT acquisitions during the following months of 1996: May (high water) August (falling water) and November (low water). During the May campaign, aerial photographs at the scale of 1: 10 000 and 1:20 000 were also obtained. The data collection was divided into three segments: 1) a qualitative survey including the acquisition of ground control points, hand held photographs and descriptions of selected areas for the sample sites. Qualitative information on weather conditions were obtained for each sampling site; 2) a quantitative survey consisted of measuring macrophyte canopy features (wet and dry weight, height, leaf area index, average inclination, inclination range, percent of ground cover at different viewing angles, biomass, canopy roughness, and the dominant genera in the stand); 3) ancillary data collection which consisted of water sampling for methane emission and reduced dissolved gases. Water column properties such as pH, temperature, maximum depth and transparency were also taken.

Pre-processing of RADARSAT Images of Tucurui Reservoir and Lago Grande Floodplain, Amazon.

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Several acquisitions of RADARSAT data were programmed as part of the ADRO project for the Lago Grande floodplain and the Tucurui reservoir areas in the Amazon Basin of Brazil. The general objective of the projects was to evaluate multiangle RADARSAT imagery. The evaluations were based on detecting seasonal dynamics of different habitats and to understand the relationship between C-band backscattering and aquatic plant variables.

To accomplish these tasks RADARSAT images were acquired in three periods of the hydrological cycle; high flood water, rising flood water and low water. The acquired images have the following characteristics; CEOS RADARSAT format, single beam detected product, 16 bit unsigned data, SAR georeferenced fine resolution (SGF), standard mode with different incidence angles and resolution, 12.5 by 12.5 m pixel spacing; and 1(range) by 4 (azimuth) looks.

Image pre-processing techniques for correcting radiometric and geometric distortions of RADARSAT imagery are necessary. To retrieve relative radiometrically calibrated data it is required to apply the reverse process of output scaling by altering the gain and offset factors. The output scaling process is performed at the Canadian Data Processing Facility in order to ensure optimum utilization of the available output dynamic range. The offset is a fixed value and the gain is range dependent. The CEOS Radiometric Data Record provides the values for the scaling factors, allowing the conversion of the digital numbers to sigma nought.

The second step in pre-processing is geometric calibration. The images were ortho-rectified by integrating the complete viewing geometry, the characteristics of the Earth and the cartographic projection. Maps with a scale of 1:100 000 were used for the collection of ground control points to complete the registration.

RADARSAT Relative Backscatter and Macrophyte Canopy Variables: Preliminary Results for the Tucuruí Reservoir and Lago Grande Floodplain Sites of the Brazilian Amazon.

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This study is part of the ADRO program and discusses the preliminary results of the relationship between RADARSAT C-band backscatter and macrophyte stand variables. The variables of interest are wet and dry weight, biomass, moisture content, range of vegetation height, leaf area index, average inclination, range of inclination, canopy roughness and the percent of canopy cover at simulated RADARSAT viewing angles.

Field work was performed concurrently with RADARSAT acquisitions that were acquired throughout the year of 1996. The present results refer only to the data collected during the high water season for the Tucuruí reservoir and Lago Grande floodplain ecosystems. During this mission a total of 20 samples were collected at Tucuruí and 18 at the Lago Grande test site.

Both relative backscatter and macrophyte canopy variables were subjected to statistical analyses to assess the relationship between the variables. Preliminary results for Tucuruí indicate that if all macrophyte types are included in the analyses, the only statistically significant relationship with C-band backscatter is given by the mean inclination. When the samples are split according to morphological type (grass-like or forb-like), the mean inclination, wet and dry weight and the height become statistically significant. For Lago Grande, the same pattern was not observed. If all macrophyte genera were analysed, there was no significant relationship between canopy variables and relative C-band backscatter. Although, when the data were split by morphological type, a statistically significant relationship between relative backscatter and the height, leaf area index, wet and dry weight of the samples was observed. These differences found between the ecosystems are related to the differences in their macrophyte community structure.

Seasonal Dynamics of the Amazon Floodplain through RADAR Eyes: Lago Grande de Monte Alegre Case Study.

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There is a lack of information on the seasonal dynamics of floodplain habitats in the Amazon regions of Brazil. This lack of information is due to the large size of the Amazon, persistent cloud cover and difficult access to do field campaigns. Radar data from RADARSAT will provide multitemporal data over these cloudy tropical regions which will result in increased information. As part of the ADRO program, this research investigates the preliminary results of assessing the synergism of multitemporal and multifrequency radar data for the Amazon. This assessment will allow for the understanding of seasonal floodplain dynamics in tropical environments.

RADARSAT and JERS-1 images were acquired throughout 1996 for the Lago Grande test site in Brazil. Three periods of the hydrological cycle were imaged, these being high water, receding flood water and low water stages. The present evaluation is the preliminary results of the two first stages with the third stage still under investigation. Images for these stages were calibrated, orthorectified and filtered allowing for the integration of multitemporal and multifrequency data.

These results show that the synergism of multitemporal and multifrequency (C and L band) data provides the best combination of microwave information to discriminate among the floodplain habitats. C-band data is more sensitive to aquatic plants whereas L-band data is more effective in distinguishing between flooded forest, non-flooded forest, pasture, and aquatic plants. The combination of the two wavelengths increased the spectral separability of different classes, and allowed for monitoring of the seasonal floodplain dynamics.

Evaluation of RADARSAT Data For Geological Exploration

Berger, Z. and R.E.L.I. Cartwright

Abstract

The evaluation of RADARSAT data for geological exploration requires an extensive study of the optimum data acquisition modes available. This paper presents the preliminary results of a RADARSAT User Development Program (RUDP) project awarded to INTERMAP Technologies and Image Interpretation Technologies for the evaluation of remotely sensed imagery for petroleum and coal exploration. The study sites include the Western Canada Basin, the Middle Magdelena Basin (Colombia) and Papua New Guinea for which detailed surface and subsurface information is available. The auxiliary data is used to constrain the interpretation of remote sensing data in these areas and compare the surface/structural mapping capabilities of new RADARSAT data with the more conventional surface mapping tools.

RADARSAT image products, from all modes evaluated, provide significant geological information and appear to overcome the serious limitations associated with shadowing (airborne systems) and layover effects (ERS-1 satellite systems). An evaluation of look-direction, resolution, incidence angle and stereo-imaging is presented. The optimum operational modes of RADARSAT imagery for exploration in mildly, moderately, and highly deformed areas are provided. Suggestions for stereo pair acquisition using a variety of be RADARSAT beam modes in variable topography are also presented.

ANALYSE DE LA TEXTURE D'UNE IMAGE RADARSAT POUR LA MISE 'A JOUR DE LA CARTOGRAPHIE GÉOLOGIQUE DANS LA FORET ÉQUATORIALE DE NGOUTOU, EST DU GABON

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RÉSUMÉ

A partir de l'image radar de la région de Ngoutou situé à l'Est du Gabon et acquise par le satellite RADARSAT-1 (image: 184km x159km; faisceau W1; orbite descendante; 25/8/96, 4h55mm TU), l'approche méthodologique employée ici consiste en une application des filtres de texture en utilisant le système de calcul des matrices de co-occurence des niveaux de gris (GLCM) dans une fenêtre de convolution 9 par 9 (pixels). L'objectif à atteindre est d'établir d'une cartographie automatique des contrastes spectraux résultant des différences zones texturales ont été ensuite confronté à la carte géologique regionale de Ngoutou (au 1/50000 ème) afin de pouvoir associer la réponse des contrastes texturaux avec la répartition des unités lithologiques.

Les résultats de cette analyse de texture montrent une assez bonne corrélation entre la réponse des contrastes spectrales et les grandes unités lithologiques régionales. Cette analyse permet en particulier de discriminer et de corriger avec une assez bonne précision les incertitudes et les extrapolations des zones de contacts entre trois ensembles; au nord, les terrains archéens du massif Nord-Gabon; au sud, le bassin sédimentaire du Francevillien et entre ces deux formation, le massif intrusif de Ngoutou.

L'analyse de texture met aussi en évidence des axes structuraux majeurs (failles et filons de dolérite) qui affectent aussi bien le substratum archéen que les sédiments franceviliens susjacents.

L'analyse des contrastes texturaux présente donc des perspectives nouvelles et intéressantes dans l'extraction indirecte de l'information géologique en forêt équatoriale à partir des images radar recueillies par le capteur à antenne synthétique (RAS) du satellite canadien RADARSAT-1.

Produits à valeur ajoutée et premières analyses des données de RADARSAT en matière de géomorphologie structurale : le cas de la région de Charlevoix, Québec

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RÉSUMÉ

Dans le cadre du projet ADRO no. 107, nous avons obtenu des images en modes standard et fin de la région de Charlevoix, au Québec. Cette étude est réalisée non seulement dans une optique de recherche fondamentale, mais aussi sous une vision appliquée. Elle permet d'abord de bien circonscrire la délimitation des zones séismogéniques, de voir et de comprendre l'organisation et l'évolution structurale d'une région dont une partie a été fortement altérée par une météorite qui a percuté le sol il y a 350 million d'années. Ce territoire perturbé est communément appelé "l'Astroblème de Charlevoix".

Du point de vue séismique, c'est une des régions les plus actives en Amérique du nord. On y dénombre en moyenne 12 tremblements de terre perceptibles par année. D'un point de vue appliqué, nous pouvons mieux percevoir des éléments hydrogéologiques du socle rocheux (approvisionnement en eau et cheminement possible de matière liquide contaminée). Enfin, il peut être utile de bien connaître l'organisation structurale d'un territoire dans une perspective de prospection minière.

Dans cette recherche, nous allons estimer comment les données de RADARSAT peuvent servir à identifier et à comprendre l'organisation des linéaments géologiques autour et dans l'Astroblème de Charlevoix. A cet effet, nous avons réalisé différentes ortho-images en utilisant des données multisources (MNA, RADARSAT, ERS, LANDSAT). De plus, nous avons généré des produits à valeur ajoutée tel que des images chromo-stéréoscopiques qui offrent une vision tridimensionnelle du terrain pour faire ressortir le relief et en quelque sorte, ses particularités géomorphologiques.

La communication aura d'abord pour but de présenter brièvement la méthode utilisée pour en arriver à créer ces produits. Par la suite, différentes combinaisons des ortho-images de RADARSAT, ERS et LANDSAT permettront entre autres de créer des compositions colorées qui seront comparables entre elles. Tous ces produits à valeur ajoutée seront donc analysés dans une perspective de niveau d'efficacité dans la reconnaissance des linéaments. Une validation sera possible grâce a des informations aéroportées (RADAR) ainsi que d'une vérité-terrain provenant des recherches issues de la photo-interprétation et de relevés de terrain.

Comparison of geomorphological features in the Canadian Shield as obtained from RADARSAT FINE mode Beams 1, 3 and 5.

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Abstract

RADARSAT is providing the geologist with a wealth of information regarding the morphology of the terrain. Until now, few studies have focused on the information content of the SAR images as a function of the incidence angle of the microwave beam. Geologist are interested in knowing what incidence angle will provide them with the richest and most reliable information on ground morphology as this will lead into more reliable geological information extraction. Geomorphological information from a SAR image is in fact a complex process involving the effect of local incidence angle, interaction between the incident beam and the vegetation canopy and the apparent surface roughness. RADARSAT has a large variety of incidence angles ranging from 10? (Extended Low mode) to 59? (Extended High mode) and users should be aware of the capabilities of the various incidences angles for their own specific use. The RADARSAT images used for this study were acquired in FINE mode beam 1 (37 - 40? incidence angle, dated June 1, 1996), FINE mode beam 3 (41 - 44? incidence angle, dated June 8, 1996) and FINE mode beam 5 (45 - 48? incidence angle, dated June 15, 1996). This study will present the preliminary results of a study using three FINE mode images of the Sudbury Basin in Ontario, a large impact crater (1.8 billion years old) located near

the southern fringe of the Canadian Shield and hosting some of the largest nickel deposits in the world. The objective of this study is to understand how the morphology of the terrain varies with the incidence angle and which incidence angle gives the best rendition of geomorphological features. To attain this goal, the three images were orthorectified using the sensor s orbital parameters and a 1:20 000 DEM. Using a subset of the original scene and the shaded DEM, the geomorphological features are compared in areas where the forest cover is uniform. The study is completed by an analysis of several radiometric profiles obtained from the SAR images and from the shaded DEM.

Radarsat SAR Data Assessment of oil lakes in the Greater Burgan Oil Field, Kuwait

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An infamous catastrophe bequeathed to Kuwait's desert environment during the 1990-91 Arabian Gulf War was the formation of oil lakes. Approximately 300 oil lakes covering an area of more than 49 km2 were created in Kuwait's oil fields when Iraqi forces set ablaze several producing oil wells and damaged others. Twenty-one million barrels of oil was recovered and exported, but one million barrels of unrecoverable oil was left in the oil fields. Since then some of the oil had either evaporated, dried up to form tarmats, or been covered by a veneer of sand and are no longer seen on the surface. The oil lakes pose environmental hazard to humans, animals and plants and therefore require continuous monitoring. More than 90% of the oil lakes were formed in the Greater Burgan oil field, consisting of Ahmadi, Magwa and Burgan oil fields. The Greater Burgan oil field, with proven reserves of 70 billion barrels of oil, is second largest onshore oil field in the world. Due to the digital format, availability, and relatively inexpensive data sets, analysis of satellite remote sensing image data offer an unparalleled technique to map and monitor any surficial, spatial and temporal changes associated with the oil lakes. The changes can be recorded in pictorial forms that are not possible using any other method. Five RADARSAT images recorded in different beam modes and acquired between October and November 1996, were processed and used to assess the oil lakes in the Burgan oil field. The images were geometrically registered to each other and used as input to a change detection program. The main interest was to map and differentiate between the oil lakes, tarmats, vegetation, buried oil lakes, and also to evaluate the usefulness of RADARSAT's beam modes in characterising such features. The ability to map the oil lakes and environs is essential in monitoring the resilience of the contaminated areas and to recommended environmental-friendly remedial measures. The results from the RADARSAT imagery analysis were compared to similar studies using optical and SIR-C/X-SAR data.

Estimating Soil Moisture Profile in Root Zone from Intermittent Remotely Sensed Surface Moisture Contents

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ABSTRACT

Soil moisture in the root-zone is of great importance in agricultural, hydrological and meteorological applications. Conventional methods for soil moisture determination, are not only time and labor consuming, but also difficult to make at the regional scale. Microwave remote sensing on the other hand offers a possible way to measure soil moisture over large area. However, the present technology of microwave remote sensing can only provide an estimation of soil moisture within the top 10cm layer. This study is conducted to evaluate the possibility of extrapolating remotely sensed surface moisture contents to the root zone, by integrating soil water modeling with remote sensing. The Soil-Water-Atmosphere-Plant (SWAP, the most recent version of SWACROP) model is evaluated and tested by comparing simulated ans measured soil moisture profile distributions in mineral and organic soils. Model adaptations to be evaluated include: (1) input of daily or weekly surface soil moisture contents to be used directly as the upper boundary condition; (ii) a subroutine in which the flux through the top of the soil surface is calibrated according to measured and simulated surface moisture contents; and (iii) a calibration subroutine in which the soil physical and sink term parameters are adjusted on a weekly or monthly basis according to differences in measured and simulated surface soil moisture contents.

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Résumé

L'humidité du sol dans la zone des racines est d'une grande importance en agriculture, en hydrologie et en météorologie. Les méthodes conventionnelles pour déterminer les teneurs en eau sont non seulement fastidieuses et longues mais aussi difficiles à réaliser à l'échelle régionale. La télédétection dans le domaine des hyperfréquences offre la possibilité de mesurer l'humidité du sol sur de grandes surfaces. Cependant, la technologie actuelle de la télétection hyperfréquence ne fournit un estimé des teneurs en eau que sur les dix premier cm de sol. Cette étude vise à évaluer la possibilité d'extrapoler à la zone des racines, l'information sur les teneurs en eau de la surface, et ce, en intégrant la télédétection et les modèles de bilan hydrique des sols. Le modèle SWAP (Soil Water Atmospher Plant, la version la plus récente de SWACROP) est évaluée en comparant des distributions de profils hydriques estimés et mesurés dans des sols minéraux et organiques. Les adaptations du modèles qui seront évaluées incluent: (i) l'utilisation des teneurs en eau de surface journalières ou hebdomadaires comme condition frontière limite au modèle; (ii) une routine dans laquelle le flux à travers la surface du sol est calibré avec des teneurs en eau observées et mesurées; et (iii) une routine de calibration dans laquelle les paramètres de pertes et les propriétés physiques des sols sont ajustés sur une base hebdomadaire ou mensuelle en fonction des différences entre les teneurs en eau de surface mesurées et observées.

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Réponse électromagnétique des sols organiques au printemps dans les hyperfréquences, le visible et le proche infrarouge

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Résumé

Les satellites sont des outils potentiellement intéressants pour la gestion des productions maraîchères en sol organique. Cependant, le comportement du signal électromagnétique dans ces sols a été peu étudié jusqu'à présent. En mai 96, une étude a été menée dans les régions de Sherrington et de Ste-Clotilde (Québec) afin de déterminer la sensibilité des capteurs hyperfréquences, visible et proche infrarouge aux variations des teneurs en eau et des caractéristiques pédologiques des sols organiques au printemps. Des données d'un capteur passif à hyperfréquences ont été acquises à l'aide d'un radiomètre SLFMR monté sur un avion de type C-GCJX. Des images dans le visible et le proche infrarouge ont été prises simultanément par un spectromètre imageur CASI (*Compact Airborne Spectrographic Imager*) monté en parallèle avec le radiomètre. Une image en mode haute résolution fut aussi acquise avec RADARSAT. Des données d'humidité du sol et de constante diélectrique furent prises dans une vingtaine de champs au moment du passage de l'avion (26 mai 96) et de RADARSAT (30 mai). Des mesures de réflectance au sol ont aussi été acquises le 26 mai. Nous présenterons la méthodologie et les résultats préliminaires d'une étude comparative.

Electromagnetic signal of organic soils in spring in the microwave, visible and near infrared regions

Abstract

The satellites are potentially useful tools for organic soil marshland production management. Meanwhile, few studies have been conducted on the electromagnetic signal behavior in these soils until now. In May 96, a study was undertaken in the Sherrington and Ste-Clotilde (Québec) area in order to determine the sensibility of microwave, visible and infrared sensors to the variation in water content and organic soil physical parameters in spring. The passive microwave data were acquired by a radiometer (SLFMR) mounted on an aircraft C-GCJX. The visible and near infrared images were taken simultaneously with a CASI (*Compact Airborne Spectrographic Imager*) mounted on the aircraft beside the radiometer. A fine resolution mode image was also acquired by RADARSAT. The soil moisture and the dielectric constant data were taken over some twenty fields during the flight of aircraft (May 26, 96) and the overpass of RADARSAT (May 30, 96). Ground reflectance measurement were also taken on May 26. The methodology and the preliminary results of the comparative study will be presented.

The Research on the Method of Monitoring the Soil Moisture of North China Plain Based on NOAA-AVHRR Data

Yu Tao andTian Guoliang

Abstract

After an introduction of the development of dynamic monitoring of the soil moisture based on NOAA-AVHRR remote sensing data, the paper gives a full and particular account of research method and its application on North China Plain.

The main aim of this paper is to investigate the possible method that can be used to monitor the bare soil moisture changes immediately and quantitatively during spring season when the drought often happens in North China. In this study, to monitor the soil moisture immediately, the method takes advantage of remote sensing data as more as possible, in the mean time, reduces the reliance on local in situ data; to monitor soil moisture quantitatively, the method is built on the mathematical and physical basis other than on the statistical basis. Except some necessary supposing and simplification, the main results are derived from analytical method, Fourier series and finite element simulation.

The method of this study is numerically simulating water and energy transfer/ exchanges at the upper soil layer (bare soil in spring season with no rain condition) and near-ground site, particularly divide into 4 parts: (1) finding the relations between moisture and thermal inertia of different kind & style soil, (2) finding the relations between remote sensing data and soil thermal inertia to remotely sense the upper layer soil moisture , (3) simulating the soil temperature and moisture changes with the initial and boundary conditions obtained from remote sensing data and local field experiment result which mainly concerns the local stable relations, (4) expending this method to large areas in North China Plain with the help of GIS.

Results are given in the end of the paper which shows that the way of this study is promising.

APPORT DES DONNÉES RADARSAT A L'ÉTUDE DES PROPRIÉTÉS HYDROLOGIQUES DES SOLS D'UNE ZONE SIMI-ARIDE: CAS DU BASSIN VERSANT DE TELATA NORD DU MAROC)

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RÉSUMÉ

La tendance actuelle dans l'utilisation de modèles hydrologiques s'oriente de plus en plus vers l'intégration de données de télédétection pour, au moins des fins de classification de la couverture du sol.

La présente étude avait comme objectif d'évaluer la possibilité d'utiliser le signal rétrodiffusé de la band C (3,75-7,5 cm) du capteur satellitaire RADARSAT pour l'identification des unités de sols en fonction des propriétés hydrologiques du bassin versant de Telata.

Le bassin versant de Telata, situé au nord du Maroc, couvre une superficie de 18,000 ha. Il est caractérisé par une topographie très accidentée et un processus d'érosion hydrologique très intense.

Pour cette étude, une base de données composée d'une image RADARSAT, d'une image optique, d'une carte pédologique et d'un modèle numérique de terrain a été utilisée. Les images RADARSAT et Landsat TM ont été acquises en saison humide: 23 mars et 25 mars respectivement.

- L'image Landsat TM a été utilisée pour l'identification des différents thèmes d'occupation des sols.
- La carte pédologique a servi pour la délimitation, sur l'image radar, des différentes unités hydrologiques définies par la méthode SCS (Soil Conservation Service).
- Le modèle numérique de terrain a été utilisé pour la détermination de la carte des pentes d'aspect et de l'angle d'incidence local. L'ensemble de ces paramètres a été utilisé

pour le calcul de coefficient de rétrodiffusion et la réduction de l'effet du relief sur le signal radar.

Dans le bassin versant de Telata, trois classes hydrologiques (B, C,D,) ont été identifiées en fonction de la texture granulométrique de la surface du sol et de son potentiel de drainage. L'analyse de la relation existante entre le coefficent de rétrodiffusion et les différentes classes hydrologique montre une régression linéaire en fonction de la capacité de drainage de chaque classe. La variabilité spatiale du coefficient de rétrodiffusion, à l'intérieur de chaque classe, est sans doute reliée à la variabilité de la pente et du niveau d'humidité. Enfin cette possibilité d'identifier facilement des thèmes hydrologiques ouvre des champs d'applications multiples pour les données RADARSAT dans le domaine d'étude d'érosion hydrologique.

Initial observations on the characterization of soil moisture conditions along the Oak Ridge Moraine using RADARSAT data and field measurements.

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Abstract

Estimating soil moisture conditions using radar backscatter is known to be complicated by several factors, including those of topographic relief, surface roughness, material texture and landcover. Further, it is believed that changes in soil moisture through time will be a function of material type slope, aspect and landuse/landcover. In response to this, a digital database was prepared using ARC/INFO, MapInfo and IDRISI which characterized the geographic extent of variations in these phenomena. From these data, fifteen field sample locations were selected based upon results of a constraint analysis. For each of the sample locations, representative material samples were acquired and described.

During each satellite overpass, soil samples where acquired at 5cm intervals for a 0.5m vertical profile in three randomly selected positions at each of the sample locations. Soil moisture was then derived using standard formula. These data were also included in the digital database. Ground data were then subjected to hierarchical cluster analysis in an attempt to assess the degree of similarity with respect to soil moisture and environment between sample locations. The selected groupings were then tested using discriminant analysis to see if the resultant clusters were statistically different from one another. The groupings were then used as a basis upon which investigation of the radar imagery was predicated.

Initial sampling of the radar imagery was undertaken using the PCI image analysis system and was initially restricted to locations coincident with the sample locations on the surface. The assumption being that radar backscatter should be similar for locations deemed to be statistically similar in environment and soil moisture. As a preliminary test, the groupings of the sample locations isolated using the field data were again submitted to hierarchical cluster analysis using the radar backscatter values as the sole means of discrimination. Initial results are promising with reasonable agreement being observed on sample groupings differentiated on field and radar backscatter data.

Future planned investigations will test the strength of this association, as this initial segment deals solely with data acquired under saturated conditions. Characterization of the strength of these results under several soil moisture conditions will allow the assesment of the reliability of any relational model which will subsequently be developed from this research.

THE USE OF REMOTE SENSING DATA FROM NOAA SATELLITES TO DETECT FOREST FIRES

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Abstract:

Expeditious detection of forest fires is a crucial environmental control activity. This applies particularly to huge stands of forest in sparcely populated regions of Siberia and the Far East. The use of aircraft in these regions requires considerable material costs.

We believe that it would be juditious to employ when detecting fires the data from AVHRR instrument (Advanced Very High Resolution Spectrometer) installed aboard the satellites of the NOAA series (USA). This instrument measures self-radiation and the radiation reflected from the terrestrial surface in five spectral channels (0.58--0.68 mcm, 0.725-1.1 mcm, 3.55-3.93 mcm, 10.3-11.3 mcm, and 11.5-12.5 mcm) with 1 km spatial resolution. The image covers a belt on the ground about 2500 km wide along the satellite flight.

It is known that the main decoding signature of the site of origin for fire is provided by its infra-red radiation, whose maximum corresponds to the spectral range 3.1-3.7 mum /1/, i.e., to the third channel of the AVHRR instrument; consequently, this channel can be used to detect fires, whose size is significantly smaller than the spatial resolution limits. Information supplied by the other spectral channels is helpful in the discrimination of clouds, which is very important because in the third spectral channel the response of clouds illuminated by the Sun is comparable to and sometimes exceeds the response from fire.

During the fire-hazardous periods of 1994 -1996 the Institute of SolarTerrestrial Physics carried out observations of environmental conditions in Irkutsk and lake Baikal Regions with the purpose of promptly detecting forest fires. Our obtained data were compared with data of aircraft protection of forests against fires. A three years observing run showed that on the clouds free regions we detected 70% of forest fires with a minimum area 0.01 hectar.

A METHODOLOGY FOR PLANTATIONS MONITORING USING THEMATIC MAPPER DATA

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ABSTRACT

Effective plantation management requires frequent assessment of the divergence between expected and actual plantation development. A monitoring system based on the satellite data collection can provide adequate information to address the above issue. The objectives of this study were to develop a monitoring system using the contrast between understory and overstory reflectance. This contains traditionally deemed "noise," changes over time in response to shifts of dominance of these two layers. This study has utilized this noise in such a way that canopy closure of plantations can be estimated, plantation disturbances and their locations can be displayed to plantation managers.

The proposed method was tested in a case study of planted black spruce (*Picea mariana* Mill) in good and poor quality sites. Shrubs and herbs were the constant understory features against which the development of forest attributes was assessed. In this investigation, canopy closure was successfully correlated with thematic mapper (TM) digital numbers (DNs). TM bands 1,2, and 3 were unsuitable for this purpose because of their small DN range. TM band 4 had a very weak or non existent relationship at less than 60% canopy closure, and an inverse relationship greater than 60% canopy closure. TM band 5 indicated a greater DN range and a stronger inverse correlation with canopy closure than the five other TM bands. TM band 7 revealed a strong inverse relationship with canopy closure. This band also revealed some potential for estimating canopy closure.

The canopy closure/DN relationship of poor quality sites, for all TM bands, followed the same general trends as the canopy closure/DN relationship of good quality sites.

This study has demonstrated that the Landsat TM imagery is a valuable data source for monitoring forest plantations based on the contrast between understory and overstory reflectance.

DÉVELOPPEMENT D'UN SYSTÈME À BASE DE CONNAISSANCES POUR LA MISE À JOUR DES CARTES FORESTIÈRES À PARTIR DES IMAGES DE TÉLÉDÉTECTION

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RÉSUMÉ

La présente recherche est réalisée en collaboration avec le Centre de Recherche Informatique de Montréal (CRIM) et a pour but la conception d'un système à base de connaissances (SBC) permettant la mise à jour des cartes forestières à partir de données de télédétection.

Le SBC développé ici se base sur des règles de décision pouvant s'adapter aux données que l'utilisateur fournit au système. Ces données peuvent provenir des capteurs Landsat-TM ou SPOT-HRV. De plus, le système peut intégrer des données numériques topographiques (MNÉ).

Afin de standardiser l'utilisation du SBC et de traiter des images satellites de différentes dates, il est nécessaire d'enlever les effets atmosphériques qui influencent la mesure des objets au sol. Pour ce faire, l'inversion de l'algorithme 6S est utilisée ce qui permet de travailler avec les valeurs de réflectance.

Le développement et l'écriture des règles de décision ainsi que l'incorporation de l'incertitude et de la logique floue se fait à l'aide du logiciel FuzzyCLIPS développé par le Conseil National de Recherche du Canada (CNRC) et qui est une modification de CLIPS développé par le NASA's Johnson Space Center.

Un premier essai du système utilisé avec un bande XS2 de SPOT de la région du Lac St-Charles, Québec a permis de détecter les différents types de coupes forestières présentes avec des résultats satisfaisants. Un deuxième essai permettra de tester le système sur le secteur des Monts Chic-Chocs en Gaspésie à l'aide de données Landsat (TM3, TM4 et TM5) ainsi que des données topographiques.

Les résultats de ce deuxième essai seront présentés sous forme orale, en français lors de la session sur les systèmes experts.

Remote Sensing - GIS Integration: Defining a Conifer Understorey Classification System for use with Landsat TM Data

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Abstract

A current forest landscape problem in boreal mixedwood management is to ascertain the presence and spatial distribution of conifer understorey within deciduous and mixedwood stands. Current efforts to meet this need involves interpretation of leaf-off aerial photographs and field surveys, but these methods are expensive and time-consuming to undertake. A research program was created to determine the extent by which digital satellite data, such as from the Landsat Thematic Mapper (Landsat TM), could be used to map the location and extent of conifer understorey stands. A land cover classification system needs to be defined that is appropriate for the resolution of image data to be employed, and the output classes must have informational value to the forest manager. Conifer understorey was photo interpreted and mapped from 1:10,000 color infrared aerial photographs, and incorporated into a Geographic Information System (GIS) database that consisted of forest cover polygons for the study area. An integrated remote sensing-GIS approach was used by overlaying the understorey polygons from the GIS onto a spatially-registered, multitemporal Landsat TM data set. Four sets of land cover classes, which consisted of overstorey stand structure and varying amounts of understorey, were assessed for their spectral separability with contiguous a understorey classes that incorporated crown closure had higher separability values because these polygons incorporated the influence of stand structure on Landsat TM spectral response. Random pixel sampling also produced larger, but more representative spectral variances that better meets the statistical assumptions of the Bhattacharyya distance algorithm. A proposed land cover classification system for conifer understorey is presented and will be evaluated with future work.

UNE STRATÉGIE MULTI-ÉCHELLE POUR MESURER L'INDICE DE SURFACE FOLIAIRE DANS ECOLEAP

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RÉSUMÉ

Une groupe de scientifiques du Centre de recherche des Laurentides au Service canadien des forêts, a initié un programme de recherche sur l'écophysiologie de la productivité forestière : ECOLEAP (Effort Concerté pour Lier l'Écophysiologie À la Productivité forestière). Le projet ECOLEAP est né du besoin grandissant d'outils permettant l'évaluation de la productivité intrinsèque des sites forestiers ainsi que de l'effet de facteurs externes au site sur cette productivité. Ce projet comporte deux volets. Le premier volet est basé sur la modélisation des processus de croissance de l'arbre, modélisation alimentée et validée à partir d'études détaillées d'architecture et d'écophysiologie sur le terrain. Le second volet est dédié au développement d'outils d'extrapolation spatiale à partir de bases de données sur systèmes d'information à référence spatiale et d'imagerie multi-spectrale satellitaire. Les objectifs visés par ce projet sont à la fois théoriques et pratiques. Ils comprennent le développement de méthodologies permettant de suivre la productivité forestière à une échelle régionale, et l'amélioration des méthodes actuelles d'inventaire forestier.

L'indice de surface foliaire (LAI) constitue un paramètre essentiel pour les deux volets du projet ECOLEAP. Une approche multi-échelle fut donc établie pour mesurer et extraire le LAI par quatre moyens privilégiés : (1) par l'échantillonnage destructif sur le terrain, (2) par diverses mesures indirectes de capteurs optique tel que la photographie hémisphérique, le LAI-2000 ou le TRAC, (3) par des capteurs aéroportées fournissant des photographies à haute résolution spatiale ou des images numériques, et (4) à partir d'images satellitaires. Cette approche a l'avantage de fournir des mesures très fiables au niveau du sol, permettant de valider les procédures indirectes d'extraction du LAI par des capteurs de résolution spatiale et spectrale très variable. La mesure efficace de valeurs du LAI est une étape essentielle pour trouver la quantité de biomasse présente dans les site forestiers. En plus de valider les procédures de mesures indirecte du LAI de scènes forestières, notre étude adresse le effets de la grande variabilité spatiale de ce paramètre.

L'apport de la géomatique et des méthodes d'aide à la décision dans la gestion des paysages forestiers

La gestion des ressources naturelles et le développement durable sont sans conteste des domaines d'application privilégiés des technologies géomatiques. L'analyse des situations problématiques et la réalisation de plans d'aménagement intégrant plusieurs ressources ne sauraient se passer d'informations fiables ni des nouveaux moyens informatiques mis à la disposition des gestionnaires du territoire, particulièrement dans un contexte de certification environnementale. Cependant, tout ces moyens et données ne seront vraiment efficaces que s'ils sont utilisés dans le cadre d'une démarche décisionnelle cohérente.

L'aménagement des paysages forestiers ne fait pas exception. L'utilisation d'une démarche multicritère (incontournable dans ces circonstances) nécessite cependant de bien saisir les mécanismes et particularités inhérents aux différents niveaux de planification. En effet, il faut bien comprendre que, si aux niveaux supérieurs de la planification des activités forestières (long terme et moyen terme), la prise en compte des paysages forestiers peut être considérée très souvent sur une base purement quantitative et globale (superficie, localisation grossière, etc.), au court terme, on doit inévitablement recourir à une évaluation de type qualitatif (aspect des coupes, formes, orientations, etc.).

Sur ce point, certains travaux menés au Centre de recherche en géomatique ont abouti au développement d'un outil de visualisation des paysages sous forme d'image de synthèse. L'utilisation de ces images ont donné des résultats intéressants notamment dans le cadre du projet de gestion intégrée des ressources mené au Gouvernement du Québec.

La présente contribution illustrera ce propos par la description des principales phases de planification considérées et de leurs caractéristiques, et la présentation concrète des images de synthèse obtenues et de leur rôle dans la planification à « court terme » des aménagements forestiers.

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Land Cover Information Content of Polarimetric SAR Data of a Boreal Forest, Central Yukon Territory

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Abstract

AIRSAR is a polarimetric radar imager operating at the P-band (0.45Ghz), L-band (1.26 GHz), and C-band (5.31 GHz) frequencies. Each frequency channel has the capability of simultaneously collecting like-polarized (HH and VV) and cross-polarized (HV and VH) backscatter data. The spatial resolution of AIRSAR data is approximately 6.7 m in the range direction and 12.1 m in the azimuth direction. In recent years, we have seen an increase in the utilization of polarimetric SAR data in various fields of application, such as forestry, agriculture, geology, and hydrology.

In this paper the land cover information content of multifrequency/multipolarization SAR data acquired by the NASA/JPL AIRSAR system over a study area near Mayo, central Yukon, on May 4, 1991, will be presented. This date corresponds to the snowmelt/ice break-up period at this high-latitude boreal forest study site (63.5oN) A Landsat TM image acquired an hour after the time of polarimetric SAR data acquisition was used to provide information on surface conditions (e.g. dry, wet, snow or ice covered). A land cover map produced using TM data acquired in August 1990 and medium to large scale aerial photographs (1:8 000, 1:10 000, and 1:40 000 scale) were utilized to extract subareas within the AIRSAR imagery for analysis. A surficial geology map available for the study area was also used as a complementary source of information in the analysis of the polarimetric SAR data.

An Evaluation and Demonstration of Mapping Africa Using RADARSAT for the UN-FAO AFRICOVER Project

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ABSTRACT

This paper discusses the results of a RADARSAT User Development Program (RUDP) project entitled "An Evaluation and Demonstration of Mapping Africa Using RADARSAT", for the UN-FAO AFRICOVER Program. This project was conducted between April 1996 and June 1997. The objective of the RUDP project was to demonstrate the value of RADARSAT for the AFRICOVER project to the UN-FAO and major international development institutions. The AFRICOVER project goals and objectives were to:

- Establish for the whole of Africa, a digital geo-referenced land cover database and geographical reference at 1:200,000 to 1:250,000 scale;
- Reinforce and build up national and regional capabilities to create, update and operationally use the maps and geographic database;
- Prepare this geographic information to complement existing environmental programs in Africa; and
- Implement in six African sub-regions.

In this project, ten study sites were chosen that were representative of most ecological contexts within the African continent. These included five sites in Nigeria, along with one each in Senegal, Angola, Tanzania, Kenya and Senegal. The principle partners in this project were Geomatics International (project execution and management), along with Photosur Geomat Inc., as well as the UN-FAO and the UN Global Environment Fund (GEF).

The benefits of RADARSAT to the AFRICOVER project were that RADARSAT imagery filled in data "holes" that resulted from out-of-date optical imagery (i.e. more than 5 years old), and/or adverse climatic conditions that have allowed no optical imagery to be collected. Furthermore, RADARSAT imagery was shown to be a valuable, cost effective and in some cases, the only option for remote sensing imagery, particularly in tropical areas such as those encountered in the AFRICOVER project.

The deliverables for this project were:

- RADARSAT imagery archives;
- Printed maps;
- Derived statistics on land cover;

- Training products:
    - Interpretive keys;
    - Manuals on the techniques and methodologies to produce RADARSAT interpretations according to the AFRICOVER program guidelines; and
    - Seminars for the users of AFRICOVER products and databases.

- Summary report which focuses on the evaluation of RADARSAT for land cover interpretation, along with methodologies and techniques.

While this demonstration of RADARSAT'
s land cover mapping capability has been completed, the promotion and commercialization of this capability are on-going. The results of this project will: convincingly demonstrate the use of RADARSAT for land cover mapping in many terrains; showcase the SAR remote sensing expertise of the project team; build an accessible knowledge base on SAR land cover mapping and processing; and assist in the creation of a sustainable remote sensing and land use monitoring capability in Africa.

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Prairie Ground Cover Classification; Techniques and Practices

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Abstract - The world's largest digital land cover data base was developed at the Saskatchewan Research Council to facilitate the Western Grain Transition Payments program for the Federal entity Prairie Farm Rehabilitation Administration. Remote Sensing (RS) and Geographical Informational Services (GIS) has become the de facto recognizant of Canada's resources. Through refined and newly modeled RS methodologies, the prairie regions have been classified to provide ground cover information to serve the needs of a vast range of government departments. Content of the digital information ranges in use from quantification to overall geographic understanding. These considerations must be meet with exceptional commitment to details surrounding the geographic location, ground cover as it relates to land use, climate, local geographic understanding and utilizing the tools of RS and GIS to their fullest capacity. A quality digital RS data base depends on the integration of the aforementioned, knowledge of the land combined with knowledge of RS is critical, but one must also bring the willingness to access and incorporate the knowledge of others who represent science and experienced land use practices.

Our data base is made up of 328, 1:50,000, NTS map sheets in digital form. The satellite data was geometrically corrected using a refined method of ground control points (GCP's) and classified after correction using a supervised classification method. More than one system was used and the final product is a blending of several image analysis software packages along with final formatting in GIS. In conjunction with the Manitoba Remote Sensing Centre the methodologies used in the production of this data base were shared and modified depending on the RS operator. The following is an account of the practices employed to develop our agricultural data base.

Landsat TM and Topographic Map Data in a Stratified Approach for Vegetation Mapping in Sweden

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ABSTRACT

Knowledge about the areal distribution of vegetation cover and the possibilities to detect changes over time are central for the modelling and understanding of our complex ecosystems, as well as for planning and resource management. In this context the remote sensing techniques have proven to be valuable tools for providing data for different applications. One such application is the production of vegetation maps, which in Sweden are currently based on airphoto interpretation. However, airphoto interpretation is both expensive and time-consuming when large areas are to be covered, and the airphotos soon become out of date. Therefore, satellites are of interest, offering possibilities to obtain data with high repeatability and coverage of large areas to a relatively low cost.

This paper presents a method for vegetation mapping based on multitemporal Landsat TM and topographic map data. Twenty-eight vegetation and landuse classes, closely following a classification system normally used for airphoto-based vegetation mapping, have been tested and evaluated in an area in central Sweden. The study includes 13 forest classes, 9 mire classes, 2 meadow classes, arable land, built-up areas, harvested peat-bog and sand/stone quarry. The method used is based on a stratified approach where information from the topographic map is used to create masks for classification in steps where only a limited number of classes are allowed. This provides a possibility to reduce the number of potential misclassifications between classes or, when more than one recording date is used, to use an optimal band combination for the actual classes. Of central importance for the result is the selection of training areas and the recording dates. The result was evaluated using 840 randomly selected points and comparison was made with an airphoto-based vegetation map available for the area. The paper describes the main steps in the proposed method and discusses the thematic content obtained with the satellite-based method compared to the airphoto-based.

INTEGRATION OF NEIGHBOURHOOD CONTEXT TO A WEIGHTING PROBLEM USING VORONOI DIAGRAMS

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ABSTRACT

The basic task of GIS analysis is to combine multi-source spatial data for exploration or evaluation purposes. In a general sense the technical and social constraints of a given project are embedded in the different data layers of the GIS. These data layers need to be weighted in such a fashion as to account for their diversity as well as their functional and spatial interrelationships in al three dimensions of the GIS. It is then essential to adapt the weighting procedures to the spatial context. We have in particular studied the effect of the neighbourhood on the weights given to the multiple spatial features. A methodology is presented which integrates the spatial dimension into the weighting process. The algorithm developed is adapted to the problem of the optimal choice of a path for power lines. The impedances of the network for which we seek the optimal path are derived from weights given by a contextual weighting procedure. The methodology is based on two major steps. First, we define the appropriate weighting function that best fits the nature of the data in use. Three functions were tested for a set of artificial thematic images differing by their statistical distribution and representing technical and environmental spatial constraints induced by power lines. Each spatial feature of the images had an evaluation score that reflected its resistance from a technical or environmental point of view. These scores are generally the result of a multicriteria evaluation. The principal difference between the functions is the way they discriminate between high and low scores of the spatial features. In the second step, we have adapted the weighting functions to the spatial neighbourhood in a Voronoi diagram. An algorithm known as the quaternary incremental method was employed to generate and update the Thiessen polygons. The weights are calculated for each spatial feature by taking into account other features which are neighbours in a Voronoi sense. We have used the raster version of the Dijkstra shortest path algorithm; each pixel of the weight layer is considered as a node. The objective is to minimize the length, the environmental and the technical cost of power lines. The contextual weighting is compared to global weighting for which neighbourhood relations are not considered in the weight calculation. Shortest path retrievals applied to the artificial images demonstrated that the most universally cost effective weighting function is that function which permits one to simultaneously account for the contextual impact of evaluation scores.

CONCEPTION D'UN OUTIL D'AIDE À LA DÉCISION UTILISANT LES TECHNOLOGIES GIS ET GPS POUR LES MISSIONS DE RECHERCHE ET DE SAUVETAGE AÉRIENS (SAR)

Dans le cadre d'un projet de recherche d'études de deuxième cycle, le Centre de recherche en géomatique de l'Université Laval s'intéresse au potentiel de l'utilisation combinée des technologies GIS et GPS pour les missions de recherche et de sauvetage aériens.

Sérabec est la branche québécoise d'un organisme civil national - CASARA - qui a pour tâche d'effectuer des recherches et des sauvetages aériens lorsque des personnes sont portées disparues sur le territoire québécois. Pour effectuer ses missions de recherche et de sauvetage, Sérabec dispose d'avions légers, de cartes aériennes, de quelques récepteurs GPS et de bénévoles possédant une formation spéciale, mais n'utilise pour l'instant aucune technique géomatique. En effet, l'intégration et l'utilisation efficaces des techniques GIS et GPS dans ce type de contexte n'ont pas fait à ce jour l'objet de recherches approfondies. Il est en particulier nécessaire d'identifier le rôle de ces technologies dans les activités de SAR, le niveau de précision des données nécessaires, les logiciels et fonctionnalités nécessaires.

Pour concrétiser la démarche scientifique et pour obtenir des résultats conformes à la réalité, un plan de vol a été réalisé par un spécialiste des missions de recherche et de sauvetage ; sur cette base, une mission de recherche a ensuite été simulée dans le territoire de la réserve faunique des Laurentides, afin de pouvoir enregistrer par GPS la trajectoire suivie par l'avion effectuant les observations. Les positions obtenues par GPS ont ensuite été intégrées à un GIS possédant un module d'analyse de visibilité afin d'identifier les zones non-observées durant la mission.

En conclusion, les technologies géomatiques sont de plus en plus accessibles car les coûts d'acquisition diminuent toujours et ces outils deviennent de plus en plus performants. Lorsque ces technologies répondent à des besoins clairement définis et qu'elles sont utilisées de façon efficace, on peut s'attendre à une augmentation du taux de réussite des missions de recherches et de sauvetages.

Lors de la conférence, les résultats suivants seront présentés:

- analyse de la qualité du positionnement absolu et relatif avec des mesures de code en les comparant aux résultats de la technique de résolution des mesures de phase en mouvement (approche On The Fly);
- comparaison entre le plan de vol et la trajectoire effectivement suivie par l'avion en fonction des différents modes de positionnement;
- résultats obtenus avec l'analyse de visibilité en fonction de la trajectoire suivie, du relief du terrain et de la hauteur des peuplements forestiers;
- impact du type de positionnement GPS sur l'analyse de visibilité (positionnement absolu vs relatif).

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Session désirée	Travaux de R&D, nouvelles technologies
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UTILITY MAPPING WITH GPS

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ABSTRACT

In today's world of high technology, Geographic Information Systems are fast becoming a mainstay of any municipality's arsenal of tools to stay informed and properly manage resources. As many users find out in short order - a GIS is built, not bought, and in today's world of 'needed it yesterday' a fast and accurate method of mapping underground utilities such as pipelines and cables is mandatory to protect lives and investments.

Presently, utility mapping of buried pipe and cable has, in general, been inadequate, inaccurate and behind the times due to rapid growth of many municipalities. Field personnel locate the buried utilities and place marks on the ground to be transferred to paper maps at a later time. Quite often these older maps are then brought into the GIS resulting in good news, bad news scenario of 'new GIS/old data'. Also, given the fact that information of this nature is captured 12 months out of the year, our winter climate provides additional challenges to physically marking and recovering cable locations, which can result in inaccurate transfer of utility locations. Additionally, these utilities may not be referenced to the geographic reference frame used in the GIS.

Enter Trimble GPS and Radiodetection.

A simple and effective way of producing accurate maps of buried pipes and cables has been developed through the combination of Trimble's GPS mapping products and Radiodetection's pipe and cable location equipment. The combination of these two technologies has resulted in a system which will accurately and precisely locate the position and log the depth of a buried pipe or cable simultaneously, and in a digital format. This information can then easily be transferred directly to most commercial GISs on the market today, thus significantly increasing the efficiency and accuracy of mapping these utilities while reducing costs.

The goal of this paper is to outline a series of case histories which successfully demonstrate the combined application of these two technologies. Radiodetection, a supplier of tools, instruments and procedures to locate and provide information about all types of buried utility pipes and cables and Trimble Navigation Ltd., the American manufacturer of high precision GPS equipment, are world leaders in their respective fields. These examples consist of actual contracted work completed by multiVIEW Geoservices Inc., a Canadian firm specializing in sub-surface imaging and mapping technologies. The GPS expertise and equipment for this project was provided by Cansel Survey Equipment, the exclusive distributor of Trimble Survey and Mapping Products in Canada.

Using Global Positioning Sistems for verify the location of ground control points used in satellite remote sensing

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Abstract.

Global Positioning System (GPS) has high potential for use with satellite remote sensing. GPS can be very useful for accurately determining the location of Ground Control Points (CGPs); if it is used correctly, can rapidly and accuratly determine a location almost anywhere on earth and at most times of the day. For satellite remote sensing purposes the maximum allowable error for a positional fix is generaly one half the spatial resolution of the acquired image. Simple comercial GPS civil users worldwide use the Standard Positioning System (SPS) without charge or restrictions. Most receivers are capable of receiving and using the SPS signal.Satellites sensors determine the spatial resolution of the acquired image and this defines the minimum acceptable accuracy of the GPS system. User's needs define data requirements and usually require conversion between geodetic datums and map projection.

However for determining precise location of GCPs there are a number of factors that may limit the suitability of GPS data for remote sensing purposes. The ultimate accuracy of GPS solutions is determinated by the sum of several sources of error as: atmospheric and ionospheric delays, ephemeris errors, receivers errors, satellit clocks, S/A (Selective Avaibility) and multipath reception [TRIMBLE]. The contribution of each source of error may vary depending on atmosferic and equipment condition. Some of these errors can be eliminated with mathematics and modeling but some configuration of satelites in the sky can magnify the other errors in the system. The accuracy of the 2-D or 3-D position solution depends by the accuracy of the pseudo range measurement and the PDOP (position dilution of precision) parameter.

Consideration must be given to hardware limitations, site characteristic and GPS operation parameters. Successful integration of these techniques requires careful planning. It can result in better ground truth and an improved final product. This paper presents an experimental aproach of the GPS reception characteristics features of a district as Chianti using data derived from commercial GPS; it regards the study of the coverage capabilities of the Florence zone territory of some comercial GPS receivers working in different operative conditions (countryside, urban areas, etc), in order to estimate the characterics of precision of GPS position data

THE RADARSAT USER DEVELOPMENT PROGRAM: THE FIRST TWO YEARS

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ABSTRACT

The RADARSAT User Development Program (RUDP) is designed to help the Canadian value-added GIS/remote sensing industry to develop products and services that will be commercially successful, and that will lever RADARSAT data sales. The RUDP funding profile has now completed its second year of operation.

The RUDP program objectives, proposal criteria, administrative structures, evaluation mechanisms, and partners of the programs are described.

Brief descriptions of the contracts awarded to date, preliminary results of the projects are presented, as well as statistics of number and value of contracts awarded. The status of RFP's and a cooperation agreement in progress is also discussed.

Future plans of the RUDP are briefly described. Suggestions from Canadian industry are welcome and are solicited.

THE USE OF REMOTE SENSING AND GEOGRAPHICAL INFORMATION SYSTEMS IN ANALYZING LANDSCAPE CHANGES OF THE NORTHWESTERN ARID COAST OF EGYPT

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ABSTRACT

Remote Sensing (RS) systems and Satellite Image Processing have been widely used to map land cover in different regions of the globe. However, due to the complexity of the dynamic aspect of the landscapes, few studies were taking into consideration biophysical and socioeconomic factors simultaneously in order to explore its nature. Therefore, the present study proposes a combination between the output of RS and the Geographical Information Systems (GIS) techniques to reveal changes of arid coasts landscapes. the northwestern coastal zone of Egypt has been selected due to the important landscape changes that have occurred during the period between 1949 and 1992. Four landscape characteristics (land use diversity, pattern indices (e.g. shape indices, proportion of land-cover types, mean size of patches ...etc.), economic activities, and population densities) were extracted for four different dates. Available data consisted of sets of aerial photographs for 1949 and 1977, and SPOT satellite images (XS and Panchromatic) for 1987 and 1992. Socioeconomic data was collected from census data for the specified periods.

The study was carried-out in four main phases: (1) classification and (2) extraction of landscape characteristics for each date, (3) comparison and change detection, and (4) relating change factors that explain landscape dynamics. The combined techniques of RS and GIS were powerful tools in revealing the interrelationships between changes in different landscape characteristics and their driving factors which lead to a comprehensive understanding of their evolution. Different guidelines and recommendations are traced in order to assist in the decision-making processes in planning and management of arid coasts landscapes.

GLOBESAR-II RADARSAT APPLICATION REVIEW

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ABSTRACT

GlobeSAR-II is a RADARSAT training, technology transfer, and applications development program being conducted in 12 countries in Latin America by the Canada for Remote Sensing (CCRS) and RADARSAT international Inc. (RSI), with Canadian International Development Agency (CIDA) and International Development and Research Centre (IDRC) support. The program goals are:

1) to provide the basic background and understanding of how to use SAR imagery in general and RADARSAT products in particular;

2) to provide the necessary data and analyses tools to support application development and demonstration; and

3) conduct collaborative detailed studies on a wise range of application. This talk will briefly describe the GlobeSAR-II program, highlight the training approach being implemented for the program and review the initial results from a variety of application for each participating country.

Land Cover Database and Map of Africa (Africover).

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ABSTRACT

Food and Agriculture Organization of the United Nations (FAO) is starting implementation of one of the most ambitious mapping project based on remote sensing: production of digital land cover database and associated hard copy map for the whole African continent. The overall project objective is to provide reliable land cover information required for the sustainable management of natural resources, environmental protection, and planning of international development projects. An equally important objective is to strengthen the capacities of participating African regional and national organizations for managing the Africover database, monitoring land cover changes, and initiating land cover projects at larger scales. The Africover mapping scales are 1:200 000 or 1:250 000 (depending on the scales of topographic maps in respective countries) and 1:1 million. Land cover classification system, map legend and formats, structure of digital database, mapping methodology and standards for geometric and thematic accuracies have been developed with the involvement of experts from industrialized as well as African developing countries. Applicability of satellite SAR imagery is being tested in pilot projects sponsored by the Canadian Space Agency (RADARSAT) and European Space Agency (ERS). The United Nations economic Commission for Africa (UNECA), and the selected African regional and national mapping organizations are participating in project implementation. Although it is a regional project, its implementation was divided into subregional and national modules, in order to accommodate the preferences of funding organizations. However, the mapping methodology and standards remain the same regardless of the implementation mode. The first phase of the Africover project, funded by Italy, is being implemented in East Africa. It is the largest project module, comprising 12 countries with a total area of 9.6 million sq.km. The project team for this module is located at the Regional Centre for Services in Surveying, Mapping and Remote Sensing in Nairobi, Kenya. The Africover is a truly pioneering project for land cover mapping based on remote sensing.

HIERARCHICAL ALBERTA VEGETATION INVENTORY (AVI) CLASSIFICATION USING AERIAL DIGITAL FRAME CAMERA DATA

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ABSTRACT

Aerial multispectral digital frame camera imageries were acquired at 32 by 25 cm resolution from approximately 150 m above a mature forest ecosystem near Barrier Lake in Kananaskis Country, southwestern Alberta in July 1996. Alberta vegetation Inventory data, including species composition and crown density, were collected at 40 plots scattered throughout several pure and mixedwood deciduous and coniferous stands. A test was conducted to determine image classification accuracy using existing classification technique applied in a hierarchical fashion to these data and to AVI class labels at decreasing levels of detail. Initial accuracy was low, but use of a hierarchical decision process suggested in earlier work, by which image classes were merged eliminated, or accepted, increases average accuracy to over 60% across a wide rage of AVI class labels for this region. The high spatial detail in the frame camera data combined with the known deviations from the statistical assumption required by the maximum likelihood classier were identified as the primary problems in image classification. An optimal method of image separate individual features such as tree crowns, understory, shadows resolved in the image data; then, contextual classifier could be used to reconstruct the AVI label at the required label of precision.

OBJECT-ORIENTED ANALYSIS / DESIGN SYSTEM FOR SATELLITE IMAGE PROCESSING AND MANAGEMENT

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ABSTRACT

The data from satellite systems such as RADARSAT and Landsat Thematic Mapper (TM) represents most suitable satellite images for use in digital cover mapping mineral deposits, oil and gas, agriculture, forestry and so on. However, there has been a geometric increase in the volume of the satellite images in recent years. The usage of the images has created a greater need for image processing and management.

FUZZY NEURAL NETWORKS APPLIED TO MINERAL DATA CLASSIFICATION

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ABSTRACT

Fuzzy neural networks have fascinating prospects in remote technique applications of mining exploration. In this paper, mineral characteristics such as folds, faults, and fractures are extracted by adaptive resonance theory neural networks. Another algorithm detects additional features such as curvature points that are valuable clues to represent mineral areas. A fast spatial gray-level dependence method can extract image texture characteristics.

SEMIVARIANCE MOMENT TEXTURE IN THE ASSESSMENT OF FOREST STRUCTURE

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ABSTRACT

Remotely sensed images inherently contain spatial information. The ability to extract the spatial information contained in remotely sensed imagery in a quantified and consistent manner would increase the utility of remotely collected information. Texture is a method which attempts to characterize the spatial variation in the digital numbers of remotely sensed images.

Image texture has been a successful means at the extraction of the spatial characteristics of digital imagery. Problems with many textures processing algorithms are related to considerations such as the window size and quantization level. An attempt at resolving or minimizing some of these problems is to apply moments of the semivariance response curve form as textural indicators.

The directional variogram is proposed to generate e values to represent image locations in the form of a local texture. An attempt to capture the variance surrounding a pixel is to compute semivariograms and record significant points of the semivariance response. The nugget represents the initial variance, the sill represents the maximum semivariance, the range relates the number of lags required to reach the sill, the mean semivariance represents the average magnitude of the variance between nugget and sill, and the slope of the semivariance response variogram represents the rate of change of the variance between nugget and sill, computed from sill divided by the range. These values relate to the typical semivariance response forms, such as the classic, periodic, aspatial, periodic-classic, multi-frequency, and horizontal forms.

The information content, theory, and utility of semivariance moment texture on high resolution *casi* data is demonstrated in this study.

Classification or enhancement: a new method for digital analysis of multichannel raster data

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ABSTRACT

This paper presents a new method for the digital analysis of multispectral (or multichannel) images. The method is suitable for data sets for which neither the structure of the multidimensional space, nor the correspondence of thematic classes and their multichannel expression, are known. Termed Classification by Progressive Generalization (CPG) the procedure employs features of visual interpretation, digital enhancement, and unsupervised clustering. CPG does not make any assumptions about the structure of the multidimensional space, is executed automatically with a minimum number of control parameters and, until the last classification step, is run automatically. Unlike most unsupervised classification algorithms it is unidirectional. Because of these attributes it is particularly suitable for projects covering large regions with limited understanding of the land cover spectral characteristics. In this presentation we describe the principles and basic steps of the procedure, compare it with other supervised and unsupervised classification methods, and illustrate its performance with TM and AVHRR satellite data.

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ANALYSE DE L'APPORT DE L'INDICE DE VÉGÉTATION À LA CLASSIFICATION DANS LES MILIEUX HÉTÉROGÈNES

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RÉSUMÉ

Le but de la présente étude est une analyse statistique de l'apport de l'indice de végétation à la précision de la classification pour la cartographie thématique dans les milieux hétérogènes. L'impact du changement des résolutions spatiale et spectrale sur cette précision sera aussi analysé. Les indices NDVI et TSARVI sont retenus pour réaliser cette étude; le premier est l'indice le plus utilisé et le plus populaire, alors que le second est un nouvel indice qui caractérise convenablement la végétation moyennement dense dans les milieux hétérogènes indépendamment des effets des sols nus et des variations spatiotemporelles de l'atmosphère. Différents schémas de classifications ont été réalisés à l'aide de l'algorithme du maximum de vraisemblance. La précision propre à chaque classe individuelle ou celle relative à chaque schéma de classification a été déterminée respectivement par les coefficients Kappa conditionnel et de concordance. À cette fin, nous avons exploité deux images, une satellitaire du capteur TM de Landsat et l'autre aéroportée de résolutions spatiale (7 m) et spectrale (30 nm) étroites du capteur MEIS-II (Multi-detector Electro-optical Imaging Scanner) du Centre canadien de télédétection (CCT). Les deux images ont été acquises la même journée sur le territoire de l'île de Montréal (Québec) et ont été étalonnées radiométriquement et corrigées atmosphériquement, et géométriquement. Les résultats obtenus ont mis en évidence les limites de l'apport de l'indice de végétation pour une amélioration significative de la classification globale de l'image. Quant aux classes individuelles, le taux de succès de la classification est variable d'une classe à l'autre en fonction de l'indice intégré et de l'image utilisée. Pour les classes individuelles où il y a une mixture entre le sol nu et le couvert végétal, le TSARVI prouve son avantage par rapport au NDVI en discriminant mieux ces classes est par conséquent améliore significativement la précision de la classification. En outre, nous montrons que la précision de la classification varie en fonction des résolutions spatiale et spectrale du capteur utilisé et qu'une augmentation de ces résolutions ne signifie pas une amélioration automatique de la précision de la classification dans les milieux hétérogènes.

METEOROLOGICAL EVENTS RELATED TO THE USE OF RADARSAT DATA FOR CROP DISCRIMINATION

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ABSTRACT

In Canada, agricultural surveys are conducted annually, to gather information and associated statistics on crops, rangelands, livestock, and other agricultural resources. Agricultural agencies within municipal, provincial, and federal governments require this information to formulate policy, determine crop insurance rates, develop marketing strategies and provide input into agricultural decision support systems. Data requirements include, total cropland, crop type, crop vigor, crop yield, planting dates, harvesting dates, chemicals used, crop damage, etc. Research has demonstrated that certain types of crop information can be extracted from radar data in a timely fashion (Brown et. al. 1994).

In this study, RADARSAT - 1 data were acquired in both ascending and descending mode on August 3rd. and 27th., 1996 for a test site near Miami, Manitoba, referred to as South Tobacco Creek. These data were used to investigate the effect of meteorological events such as dew, temperature and rain on identifying agricultural crop types. Ground data were collected for various crop types within the test site. Meteorological data (precipitation and temperature) were also obtained for the times of RADARSAT acquisition. The RADARSAT-1 data were geometrically registered. Transformed divergence statistics (TDS) were calculated for each crop pair. This statistical analysis technique identified crop separability and the significance of meteorological events to radar backscatter. The results demonstrate the effects of using dawn/dusk data for determining the impact of meteorological events on crop separability.

MULTITEMPORAL SPACEBORN SAR DATA FOR CROP CLASSIFICATION: A SEQUENTIAL-MASKING APPROACH

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ABSTRACT

Spaceborne SAR is an important data source for agricultural applications since it satisfies the basic agricultural requirements for reliable and frequent imaging throughout the crop growing season. Before the launch of the long-duration spaceborne SAR systems, airborne studies had demonstrated that multitemporal SAR data could enhance the ability to distinguish between various crop patterns. However, comparatively few datasets have been available for study due to the increased cost and logistics of generating multitemporal SAR data with airborne platforms. With the launch of ALNAZ-1, ERS-1, JERS-1, and RADARSAT, world-wide spaceborne SAR data are now routinely available. They provide researchers with an excellent opportunity for developing multitemporal SAR agricultural applications.

The sequential-masking classification procedure is an interactive human/computer interface patterned after photo-interpretation techniques in which the most distinct image features are labelled (classified) first. Image analysis is then carried out on the less-interpretable image features until the entire image is classified. Sequential masking employs image-processing techniques and GIS operations simultaneously to classify multitemporal images. Although sequential-masking techniques were developed using satellite VIR data for land-use mapping, the potential has not been fully explored due to lack of datasets. The availability of multitemporal Spaceborne SAR data makes it possible to investigate sequential-masking techniques for crop classification.

The objectives of this study are evaluate early- and mid-season multitemporal ERS-1 SR data for crop classification using sequential-masking techniques. Nine dates of the ERS-1 C-VV SAR data were acquired over an agricultural area in Oxford County, Ontario, Canada during the 1993 growing season. Extensive ground data were collected on each satellite overpass including crop type, growth stage, percentage cover, canopy height, row spacing, row direction and plant condition.

Based on the temporal back scatter profiles, early- and mid-season multitemporal SAR data for crop classification using sequential-masking techniques were evaluated. It was found that winter wheat could be easily identified using an early-season single-date SAR image (June 16). Soybeans could be classified with some degree of success using June 16 SAR data. After masking out wheat and soybeans, barley/oats could be easily classified on July 5 and July 21 (mid-season). Again, after masking out wheat, soybeans and barley/oats, corn can be successfully separated from alfalfa/hay on July 21 (mid-season). These results clearly indicate that crop classification can be carried out successfully using sequential-masking techniques with early-and mid-season multitemporal SAR data,

INFORMATION PROCESSING OF MULTIPOLARIZATION AIRBORNE SAR DATA FOR EARLY SEASON CROP DISCRIMINATION

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ABSTRACT
In this study, multipolarization airborne SAR data are examined for their capability to discriminate agricultural crop classes during early season crop development. Narrow-swath C-band SAR data with HH, HV and VV polarizations were acquired on July 10, 1990 over an agricultural area I southwestern Ontario, Canada, at spatial resolutions of 6 m by 6 m. Linear discriminant analysis techniques are applied to SAR tone and texture features to determine the potential of multipolarimetric SAR data for assisting in the discrimination of agricultural crop classes early in the growing season. Techniques for generating texture features include the Neighbouring Grey-Level Dependence Matrix (NGLDM) and the Grey-Level Co-occurrence Matrix (GLCM). A variety of texture features is extracted from the NGLDM (e.g., large number emphasis, second moment) and the GLCM (e.g., contrast, mean, angular second moment, correlation). In addition to texture statistics, processing parameters that are examined include window size and grey-level threshold for the NGLDM. The evaluations are based on the discrimination of agricultural crop types using tonal and textural features derived from georeferenced C-HH, C-HV and C-VV SAR data. In this paper, the effects of polarization and textural parameters on the separability of crop types recorded on airborne SAR data are reported. The results of this study will assist in the selection of appropriate polarizations and texture processing techniques for crop classification with SAR data.

INVESTIGATING THE RELATIONSHIP BETWEEN CROP RESIDUE COVER AND RADAR BACKSCATTER

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ABSTRACT

(English version)

Post-harvest agricultural surfaces have varying amounts of crop residue cover, with the amount and type of cover determining, in part, the erodibility and health of the topsoil . If RADARSAT is to be used to map residue and/or tillage in order to monitor soil conservation practices, an understanding is required of the relationship between residue and radar backscatter.

During the fall of 1996, an experiment was run on plots set up at the Agriculture and Agri-Food Canada Central Experimental Farm in Ottawa. The experiment was designed to address the importance of residue type (corn and barley), residue moisture content and residue amount to radar backscatter, and to examine the effect of look direction on radar response. Scatterometer measurements (Ku, C and L-Band with 4 linear polarization) were made over corn and barley plots with treatments varying by residue amount and moisture level. Soil and residue moisture data were collect during 9 days of scatterometer acquisitions. This paper will describe the experimental setup and will provide preliminary results on the relation ship between residue characteristics and C-Band radar backscatter.

French version

ÉTUDE DE LA RELATION ENTRE LE COUVERT DE RÉSIDUS VÉGÉTAUX ET LE COEFFICIENT DE RÉTRODIFFUSION RADAR

Différentes quantités de résidus sont laissées dans les champs après la récolte. La quantité et le type du couvert de résidus déterminent en partie l'érodibilité et la santé du sol de surface. Il est important de comprendre la relation entre les résidus et le signal rétrodiffusé, si l'on veut utiliser RADARSAT pour cartographier les résidus et/ou les pratiques culturales dans le but de faire un suivi des pratiques de conservation des sols.

Une expérience a été menée à l'automne 1996 sur des parcelles établies à la ferme expérimentale d'Agriculture et agroalimentaire Canada à Ottawa. L'expérience a été conçue pour déterminer l'importance du type de ((maïs et orge), du contenu en eau des résidus et de la quantité de résidus sur le signal radar rétrodiffusé, et pour étudier l'effet de l'angle de vue sur la réponse radar.

Des mesures avec un diffusomètre (bandes C et L, avec quatre polarisations linéaires) ont été faites sur des parcelles de maïs et d'orge. Les traitements variaient par la quantité de résidus et leur niveau d'humidité. Les données d'humidité du sol et des résidus ont été recueillies conjointement avec les données du diffusomètre à neuf occasions. Ce papier présentera le protocole expérimental et des résultats préliminaires sur la relation entre les caractéristiques des résidus et le signal radar rétrodiffusé en band C.

OBJECTIVE TRAINING SITE SELECTION FOR REGIONAL SCALE SATELLITE DATA VALIDATION

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ABSTRACT

The success of agriculture is dependent on many variables such as crop health, soil nutrient status, soil moisture, and soil organic matter. These variables in agriculture vary over time and space. The aim of this research project is to account for spatial and temporal variability when selecting training sites to be used in the supervised classification of remotely sensed data over a regional scale.

The ground validation of satellite data is one of the least systematized aspects in remote sensing projects. A wide range of methods exist when selecting training sites for satellite data. Many of these methods are subjective and consequently may reduce the classification accuracy with non-representative, biased training sites.

An objective, systematic method is proposed to improve the accuracy of classifications by reducing user bias and accounting for spatial and temporal variability when selecting training sites. The sampling scheme utilizes a stratified random sampling design. The study area is 11 counties located in southern Ontario. All large agricultural fields (fields greater than 15 ha in size) were identified in southern Ontario. This area has been divided into 15 strata based on physiographic regions. These major physiographic regions demarcate more homogeneous regions within southern Ontario. Within each strata 15 to 20 agricultural fields were randomly selected in clusters to be used as sample sites. The selected fields were then integrated with a digital road network of the study area to facilitate ground truthing.

This sampling scheme will enable the remote sensing industry to provide classified satellite data with an improved accuracy to the end user. With regular ground monitoring the sampling scheme will also enhance our understanding of the relationship between ground events and satellite data.

SHORTWAVE INFRARED CONTRIBUTION TO THE DETECTION OF CROP RESIDUES AND DRY VEGETATION OVER DIFFERENT SOIL BACKGROUNDS

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ABSTRACT

Crop residues and dry vegetation are generally confused with bare soils by vegetation indices using only visible and near infrared channels. But the evaluation of soil protective cover by residues or dry vegetation is of considerable importance for soil protection against erosion. It has been previously shown, by using rain simulators on experimental plots, that a residue cover of 20% can reduce erosion rates by 80% during the non-vegetative season on corn fields. Similar effects can be observed in semi-arid landscapes due to the protective effect of wheat stubbles in zones of pluvial agriculture.

In order to evaluate the ability of TM, SPOT 4 SWIR and other shortwave infrared sensors to estimate residue cover rate, we made a series of radiometric measurements over soils of different colours which were covered by increasing amounts of dry residues. The results show that visible and near infrared derived indices alone do not bring a reliable residue detection, but a big improvement in residue detection is obtained by combining shortwave infrared and near infrared channels. This combination has been done by two approaches:

- a soil adjusted index approach with different versions of the Soil Adjusted Crop Residue Index (SACRI) developed previously by our team

- a linear spectral unmixing approach using the most significative bands of the spectra to define spectral endmembers such as various soils, the residues and the shades of the residues over the different soils.

The results obtained by the index approach are satisfactory for low cover rates up to 30% while the unmixing approach is adequate for a wider range of coverages. Both are reliable enough to be used for a semi-quantitative assessment of anti-erosive agricultural practices.

MONITORING OF FIELDS WITH HYDRIC EROSION CONTROL STRUCTURES

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ABSTRACT

The Province of Buenos Aires, in the Argentine Republic, has a very important part of its territory affected by hydric soil erosion processes.

The hydric erosion by rain water flow is particularly evident in ondulate lands, which are dedicated to agriculture. The erosion reduces the water infiltration and the productive surface soil layer, reducing the crop yields.

One of the most effective control practices, when the terrain slope is higher than 3%, is the structure named "terrace." All the farmers belonging the same hydrographic bassin must share an efficient control task.

In order that the farmers get involved in the subject, the government must promote these techniques. So, it is necessary to have an adequate and updated land-terraces mapping.

By mean of RADARSAT SAR image processing, land with terraces will be mapped. The identification of these lands will be made with" ground truth," using soil taxonomy, meteorological data, terraces and land cover surveys, soil moisture measures and topographic maps.

In order to analyze the backscattering with different geometry, roughness (land cover, crop types) and soil moisture conditions, four images of different seasons of 1997 will be employed.

The further integration of the expected results of the Project into a Geographic Information System would make possible, using multitemporal studies, the monitoring of the hydric erosion control promotion government policy.

EVALUATION OF LAND DEGRADATION IN SEMIARID INTERMOUNTAIN VALLEYS WITH RADAR DATA

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ABSTRACT

Land degradation surveys are needed to establish conservation practices in the Calchaquies valleys of Argentina. However, a major barrier to this survey in this region is logistical difficulty in obtaining ground data quickly, cheaply, and with an appropriate level of accuracy. That's why the radar data would be an useful tool for this purpose. Our fields studies (Navone et al 1989) indicate that several factors and processes contribute to "Land degradation" . From the point of view of their quantitative importance, the following processes can be mainly identified: wind and water erosion. Both problems decrease land productivity. Changes due to human action develop fast over short time intervals. A management plan for this basin should be made on the basis of a proper description and diagnosis of the different levels of erosion present in the area.

The objective this study was conducted to determine whether land degradation map units can be extracted from a radar scene of this semi-arid region in Argentine. Different products should be obtained from processing radar data. It should be very important to discriminate the earlier stages of actual and potential wind and water erosion in each region. Sample areas were chosen in each of them from three up to five test sites (plots of 3 x 3 pixels) were located according to the size of the areas and their homogeneity. Geomorphology, soils, vegetation and land management was studied as factors that affect land degradation. After field work, erosion map units were defined by "Land degradation method" (FAO-PNUMA,1984). The analysis of radar data should be done and its interpretation.

RESULTS:

There are twelve map units with different degrees of water erosion in this area. Only in three of them there are wind erosion. Near Cafayate town the dunes are really magnificent (map unit 1 and 9). In unit 3 wind erosion degree is moderate, in both map units there is no water erosion. Some creeks could be described in " Los Quilmes " area (map unit 8), with severe water erosion. In map units 5,6,8 and 10 we found soils with fine superficial texture and low vegetation cover, water erosion degree is severe. Intensive agriculture was done in the river terraces (map units 2,4 and 7) There is no water or wind erosion in these areas. In the alluvial fans (map unit 11) there is severe degree of water erosion. In flood areas (map unit 12) near Amaicha town there in no water or wind erosion. It is very important to find methodological approach for the monitoring of degradation processes usable by extensionists, experts or governments.

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USE OF OPTICAL AND THERMAL INFRARED NOAA-AVHRR DATA AS INPUTS IN THE CANADIAN FOREST FIRE DANGER RATING SYSTEM

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ABSTRACT

Our study is involved in a research program which has the objective to study the potentiality of optical, thermal infrared and radar images for spatially and temporally monitoring forest fire hazard. In Canada, daily forest fire danger of the major Canadian forest types is operationally predicted using the Canadian Forest Fire Danger Rating System (*CFFDRS*) which combines, through simulated indices, weather, fuel, topography and ignition parameters. One of the important input parameters of this system is the foliar moisture content (*FMC*) which affects the crown fire behaviour. In the current *CFFDRS*, *FMC* is indirectly and empirically estimated in function of the number of days from the date of minimum *FMC*. This data is a regional constant computed from elevation, latitude and longitude, without taking into account yearly weather variations. Also, equations to calculate *FMC* are derived from data gathered on sites which are located under 60° Lat. N. An alternative method would use satellite images that offer the advantage of larger sampling areas, lack of destruction of the studied resource (trees), gathering data on less accessible areas and representing, in essence, the integrated response of vegetation to factors influencing vegetation stresses. Furthermore, thermal infrared data are physically related to vegetation water status, whereas optical data are a good indicator of vegetation ground cover types and rates. In our study, optical and thermal infrared *NOAA-AVHRR* data are related to ground-measured *FMC* of white spruce, black spruce and jack pine stands, which are located in Northwest Territories, between 60° Lat. N. and the Northern tree limit. On each stand moisture content of coniferous needles at three different ages as well as understory vegetation was weekly measured in the 1994 summer and in the same day as the satellite overpass. Preliminary results show that the *FMC* of the overstory is more sensitive to the needle age than to the site, the date of measurement or the species. Overstory *FMC* are better estimated in the case of southern-located stands, probably because these stands are more homogeneous and have a higher tree density which induce a lower influence on the satellite signal, of disturbing factors like lichen, moss and understory reflectances. Limits and possible improvements of our study are also discussed, among others related to the operationality of the developped method to daily estimate *FMC* in the perspective of forest fire behaviour prediction.

Mapping Forest Clearcuts Using Optical and Radar Digital Remote Sensing: The Canadian Experience

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ABSTRACT

Annual forest map updating is required by various Forestry Acts of the different Canadian provinces. It includes clearcut mapping, which is currently done mainly by photo-interpretation of aerial photographs having various scales. An alternative method would use data provided by digital sensors that offers the advantage of larger surveyed areas, of working in other wavelengths than the visible ones, and of providing routinely lower-cost images in digital format that are easier to process. Our paper documents the state of practice in the use of optical and radar digital images for mapping forest clearcuts, with a particular emphasis on the Canadian experience. A literature review on the use of optical satellite images shows that the performance of clearcut mapping from optical satellite images is highly related to the pixel size of these images. Indeed, the best mapping accuracy was obtained using summer SPOT-HRV panchromatic images which has a 10 m pixel size. Clearcut mapping from such images is five times less expensive than the one performed from 1:15 000 airphotos. Weather and illumination conditions mostly limited the availability of optical satellite images, but not of radar images. Some radar images were also tested for clearcut mapping. It seems that images acquired in longer-wavelength bands and in cross-polarized modes are more suitable for clearcut mapping as well as for regeneration assessment. Some factors badly influence clearcut detection and mapping on radar images, among others the incidence angle and the topography. For this reason, clearcut mapping was not highly accurate on radar images, even on images with higher spatial resolution. Most of the reviewed optical and radar studies were based on summer imagery, although optical winter imagery has been demonstrated to be better for estimating forest stand parameters and radar winter imagery, for clearcut identification. Multi-date images are also more suitable than single-date images. Other open areas such as wetlands, grasslands or agriculture lands, must be masked before mapping, because of possible spectral confusion with clearcuts. Sources of mapping errors are related to the spatial resolution of the sensor as well as to the reference map, which has a different nature and sometimes a different scale than the map derived from the image. In the mapping procedure, the geographic information system database is updated using the clearcut boundaries extracted from the digital image and is also used for example in the masking procedure or as reference in the mapping

accuracy assessment. Despite the cost and time benefit of using digital imagery, its operational use for clearcut mapping is limited by lack of fully automated mapping system. However, LANDSAT digital imagery is operationally used for general land cover mapping, since 1980 in Ontario and between 1993 and 1995 in Quebec as well as since 1992, for clearcut mapping of private woodlots in Quebec. In the future, clearcut mapping from digital imagery will use methods based not only on spectral analysis, but also on spatial analysis, which is more efficient with high spatial resolution images, such as SPOT-HRV PLA-mode images. Also, because partial cuts are progressively replacing total cuts, harvested area mapping will become a bigger challenge because of spectral confusion of the remaining vegetation with the surrounding stands.

Fire Monitoring in Boreal Forest Region

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Fire is an intrinsic part of the boreal forest ecosystem. It has a fundamental role in the growth and development of forest stands and their distribution across the landscape. This paper provides initial results of an investigation of the extent and dynamics of forest fires in and around the BOREAS Region during the 1994 growing season, one of the most active fire seasons on record. Both ground and satellite data were employed to obtain the statistics of the fire activities. Ground data were based on reports by fire management agencies in Saskatchewan and Manitoba. AVHRR satellite data from NOAA-11 were analyzed both as single date images and as 10-day composites using two methodologies that detect current active fires and cumulative burned area repectively. Most fires in 1994 occurred in the transitional forest to the north and northwest of the BOREAS Region. The results indicate discrepancies in the numbers of fires and areas burned between the three methods. They are attributed to several factors, including the accuracy of each technique; the difficulty in establishing a correspondence between satellite and surface observations; and varying capability of detecting different fire attributes by the two satellite methods. The daily satellite detection approach can be as effective as, or even more effective than, ground observations provided that cloud cover did not pose a problem. Overall, there are 99 fires of approximately 2 million hectares found over an area of 800X700 km^2 around the BOREAS study region in the summer of 1994. Some of them had a significant impact on the BOREAS measurements of various fluxes. The satellite data showed that fire evolution is not uniform in time and space.

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Cartographie du couvert forestier en Gaspésie à l'aide des images de télédétection des satellites Landsat-5 et RADARSAT-1

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L'objectif est d'étudier le potentiel des images RADARSAT-1 pour la cartographie de la forêt au Québec. La région d'étude située en Gaspésie a été choisie pour sa diversité écologique de cinq domaines forestiere (érablière à bouleau jaune, sapinière à bouleau jaune, pessière noire, pessière blanche et la toundra alpine). Les images radar disponibles ont différents angles de visé (20 à 46 degrés), différentes résolutions (30 m et 8.5 m) et sont acquises en orbite ascendante et descendante.

L'orthorectification des images a été effectuée à l'aide d'un modèle numérique d'altitude (MNA). La qualité du MNA est importante pour la correction et celui utilisé pour ce projet est basé sur les cartes topographiques 1:20 000. Les images radar ont été ensuite filtrées pour réduire le chatoiement. Une image multispectrale (TM) a été aussi combinée avec les images radar et différents essais de classification ont été entreprise.

Le but de cette communication est de présenter les résultats de classification pixel par pixel à l'aide du maximum de vraisemblance et un réseau de neurone à rétroprogagation de l'erreur. G"Enéralement, le réseau de neurone a montré une plus grande capacité à s'adapter là la texture des images radar. Cependant, les classes différentiables restent générales. Une autre approche est nécessaire pour permettre l'extraction des classes qui ont plus grande signification pour le forestier.

ABSTRACT
(Oral presentation requested for the symposium.)

CALIBRATION/VALIDATION, STABILITY MONITORING, AND QUALITY ASSURANCE IN REMOTE SENSING: A NEW PARADIGM

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In the larger sense, calibration/validation (cal/val) includes all of the steps required to convert raw sensor data into accurate and useful geophysical or biophysical quantities that are verified to be self-consistent. Interest in the cal/val aspects of terrestrial remote sensing has been on the rise and significant resources are being devoted to relevant areas of research and development. Nevertheless, the challenge to provide operational data products with proper cal/val has only partially been met.

The paper attempts to relate advances in cal/val technology to the needs of users and introduces the concept that cal/val can play an essential role in bringing remote sensing products to mainstream consumers in an information-based society, provided market-oriented, quality-assurance elements are a fundamental component of the development strategy. A market model for the specific case of remote sensing technology is suggested. Initiatives are proposed in terms of quality assurance and standardization.

The paper goes on to present an action proposal to help present-day users while waiting for cal/val technology currently under development to become operational and for the quality assurance perspective of the future to evolve. The concept involves the routine and systematic monitoring of quality assurance and stability reference (QUASAR) sites and the timely dissemination of results. Hyperspectral data sets acquired for the monitoring sites will be used to generate results in the spectral bands of commonly used sensors and make them available on the Internet world-wide web on a rapid and frequent basis. These efforts can be important first steps towards ensuring that cal/val is transparent to mainstream users and standardized on an international scale, as well as being a routine and integral part of the quality assurance of Earth observation products and algorithms.

Submitted to the 19th Canadian Symposium on Remote Sensing (GER'97), to be held in Ottawa, May 1997.

AN ACCURACY STUDY OF A LOW-COST DIGITAL CAMERA

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ABSTRACT

Digital cameras were originally designed and developed for journalism. On the other hand, they have found many applications in photogrammetry because of the practical advantages they provided over their traditional film-based counterparts. Thus, various research projects on metric applications of digital cameras are underway. Usually, the price of digital cameras employed primarily for photogrammetric measurements is quite high, which makes the adaptation of digital cameras impractical to a wide range of industrial and engineering applications.

The objective of this paper is to describe an accuracy study of a low-cost, off-the-shelf digital camera, the Fujix DX-10. Digital images of a well-controlled, three-dimensional testfield were captured with the digital camera in a multi-station, multi-exposure convergent imaging configuration. The Digital Video Plotter (DVP) was used to measure the image positions of the test points. The data reduction was based on three different methods, namely two self-calibrating bundle adjustment methods (UNBASC2 and GEBAT) and the Direct Linear Transformation (DLT). The two self-calibrating bundle adjustment methods differ in the modelling of systematic errors of the imaging system and imaging process. While UNBASC2 and the DLT solutions gave very close results, GEBAT did not perform as well in this study. The attainable relative accuracy of 1:6000 suggests that a low-cost digital camera can be applied for situations where a medium level of accuracy is required, provided that the camera is well calibrated and the imaging configuration is appropriately designed.

ESTIMATION DE CARACTÉRISTIQUES DE SURFACE AU NIVEAU SOUS-PIXEL À PARTIR DE DONNÉES SIMULÉES DES FUTURS CAPTEURS VÉGÉTATION ET HRVIR DU SATELLITE SPOT-4

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RÉSUMÉ

Le suivi des variations temporelles de surface sur les grands bassins hydrologiques requiert des fréquences d'observation que ne peuvent fournir des capteurs à haute résolution spatiale, mais à couverture spatiale restreinte et surtout à fréquence de passage peu élevée. À l'automne 1998, un consortium européen devrait lancer le satellite SPOT-4 avec à son bord le capteur Végétation plus adapté au suivi des surfaces terrestres que les capteurs AVHRR et de pratiquement même résolution spatiale (1050m) et temporelle. Le satellite comprendra aussi un capteur haute résolution HRVIR, ce qui permettra l'acquisition simultanée de données haute et moyenne résolution.

Les objectifs du projet sont (a) l'estimation des caractéristiques de surface (comme l'albédo) des classes d'occupation du territoire présentes dans les pixels mixtes à cette résolution spatiale et de la distribution spatiale du couvert de neige au sol au niveau sous-pixel et (b) l'estimation la plus précise possible de la localisation géographique de l'image pour des fins de suivi multitemporel et l'utilisation dans un modèle hydrologique discrétisé.

Dans cette communication, après présentation de la méthodologie de simulation des données VGT et HRVIR à partir de données TM, nous discuterons des images VGT et HRVIR simulées en insistant sur les principales caractéristiques de surfaces identifiables sur ces images, bande par bande et en composé couleur. Des caractéristiques linéaires comme les rivières peuvent être identifiées sur les images VGT dans l'infrarouge. De même, identifiables sur les bandes individuelles, les patrons principaux d'occupation du territoire sont encore mieux identifiés sur le composé couleur.

La méthodologie de traitement de ces images pour en tirer des informations sous-pixel sera aussi expliquée. On analysera la détérioration des estimations de réflectance résultant d'une détérioration progressive de la précision de localisation de l'image et on montrera comment cette méthodologie peur aider à améliorer la précision de localisation. L'analyse de la variation des erreurs d'estimation des réflectances avec l'augmentation de l'imprécision de localisation indique que s'il est possible de localiser l'image à l'intérieur de 150m de la position vraie des objets au sol, les estimations de réflectance ne seraient pas trop affectées. Il est utile de savoir que l'imprécision maximale de localisation prévue par les concepteurs du capteur est de l'ordre de 300m. De plus, la méthodologie que nous utilisons semble indiquer qu'il serait possible de localiser effectivement l'image avec une précision de 100 à 150m de la position des objets au sol.

Vicarious Calibration of NOAA 12's AVHRR Channel 1 and Channel 2 Using Snow-Covered Sea Ice

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As scientists begin to examine the issues of environmental change, greater emphasis is being placed on the fidelity of remotely sensed data. In particular, scientists require absolute measurements of reflected and emitted solar radiation from the Earth-atmosphere system. Towards this, a determined effort is underway to monitor the calibration of satellite sensors that measure upwelling energy in the visible and infrared regions of the electromagnetic spectrum. The Advanced Very High Resolution Radiometer (AVHRR) carried by the NOAA TIROS-N satellites continues to amass a considerable land-ocean dataset that is now being examined in the context of monitoring environmental change. Unfortunately, onboard calibration is not available for AVHRR channel 1 (AVHRR 1: 0.58-0.68 μm) and AVHRR channel 2 (AVHRR 2: 0.73-1.1 μm). As such, the prelaunch calibration of these channels has been shown to drift significantly after launch. Unfortunately, there is currently no information regarding the status of the NOAA 12's pre-launch calibration for AVHRR 1 and 2.

This paper updates the pre-launch calibration of AVHRR 1 and 2 onboard the NOAA 12 satellite. NOAA 12 AVHRR data were collected over snow-covered sea ice during the Seasonal Sea Ice Monitoring and Modelling Site in 1993. Surface-based reflectance measurements were used to estimate the amount of radiation within AVHRR 1 and AVHRR 2 reflected from the surface at the bottom of the atmosphere. *In situ* measurements of atmospheric conditions and the 6S radiative transfer model were used to predict the at-sensor radiance at the top of the atmosphere (TOA). Using the raw satellite data, the appropriate gain was then determined for each channel. An error budget for the procedure is calculated. Results indicate that, like others in the series, both AVHRR 1 and AVHRR 2 has experienced significant losses of sensitivity. As of April 1993, AVHRR 1 calibration decreased by 9%., while AVHRR 2 decreased 25%. This significant loss in fidelity underscores both the importance of regular updates to the AVHRR sensor series and the considerable hurdles to utilizing this archive for long term measurements of environmental change.

The AEROCAN Sunphotometer Network: a component of a CAL/VAL strategy for
consistent image correction

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AEROCAN is a Canadian wide sunphotometer network initiated by the Canada
Center for Remote Sensing to support calibration procedures for the atmospheric corrections of data acquired by satellite and airborne sensors over Canadian scenes. This network is one of a number of strategic CAL/VAL iniatives defined by the Canadian LTSP (Long Term Space Plan) and is, as well, a subnetwork of a worldwide sunphotometer network (AERONET) developed
by NASA to support its Earth Observation strategies.

Currently, efforts in atmospheric corrections of any Canadian scenes involve the employment of a variety of techniques with a variety of protocol standards (including the option of simply ignoring atmospheric effects). A principal objective of AEROCAN is to support the establishment of a standardized Canada wide operational strategy for the spatial estimation of the key optical paramters required for atmospheric corrections (optical depth and the Angstrom parameter). These parameters will be available on a regular basis for the specific AEROCAN sites (3 at present and 3 to be implemented before the fall of 1997) while synoptical techniques, trajectory analysis and satellite imagery will be employed to extend the applicability of the local sunphotometer sites. In this communication we present some preliminary results from AEROCAN along with
an analysis of the difficulties encountered or to be encountered in transforming this initiative into an operational Canadian CAL/VAL tool.

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ABSTRACT

It is a commonplace that GIS works best by integrating data across an organisation. For this reason most organisational strategies aim to adopt one corporate GIS. GIS suppliers set out to sell their products as complete solutions to companies, and to have their system adopted as THE corporate GIS for the whole organisation. This paper questions this approach on the basis of experience in Edinburgh City Council. It argues that multiple GIS from several manufacturers can, under the right circumstances, be more appropriate than a corporate solution.

Edinburgh has a wide range of GIS technologies, but the key to their success is that they fulfill the needs of those who use them. Often the suppliers were prepared to invest in the development of a particular application as a pilot, or existing systems had strong links with a particular GIS technology. It is more important to obtain a truly customised application, or a system closely linked to particular business needs than to impose a universal technology.

The principal reason for insisting on corporate technology is the difficulty in achieving a seamless transfer of data. Whilst this is still a problem it is less so than when many of the ideas about corporate GIS development were suggested in the 1980s. Technological developments have brought GIS to the PC, with consequent exchangability of data.

The other mechanism driving improved exchange of data is standardisation. In Britain the Assoc for Geographic Information and the Local Government Management Board have had several successes in agreeing formats for data. The real test of legitimacy of such instruments is their adoption by national agencies. The next GIS standards will undoubtedly be fought for on the Internet. In the future GIS professionals will have to decide between Java and Active X.

The presentation will enlarge upon these ideas with reference to the many GIS implemented at Edinburgh Council, and their partners in government and the private sector. The council has found relatively cheap solutions to the problems of data exchange between its systems, and the above developments will ensure that the task of integrating GIS becomes easier and easier.

Mapping of Radionuclide Data Fields using GIS

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ABSTRACT

This paper introduces the results of implementation of the joint research project of European community countries and Russia, Ukraine and Belarus on the creation of "Atlas of deposition of European territory by Cs137 in the result of Chernobyl accident", paying attention to the materials created directly or under active participation of Ukrainian side.

The atlas became the first document showing a coherent and comprehensive picture of the deposition over the whole territory of Europe having gathered and integrated data from more than 30 European countries on the same GIS platform (ArcInfo).

The content of the Atlas is briefly presented in the paper showing the most significant results.

The paper also discusses data sets available, standardization and unification approaches, methodologies of preliminary data analysis.

Proposed mapping methodologies are based on the possibilities of joint analysis for different nature data and modelling techniques in GIS, statistical and structural (variographical) analysis of spatial data. Examples are given.

Within the framework of the project Ukrainian participants have created the system for different scale mapping of Chernobyl radionuclide deposition fields and building on this base high quality maps of radiological situation of contaminated territories and calculation of economically important indicators describing degree of contamination of territories and elements of ecosystems whose initial source of contamination is soil.

Work of the system is shown on the series of examples. Map of the deposition of Ukrainian territory by Cs137, scale 1:2000000 is presented along with large scale maps (1:500000, 1:200000) of territories for highly contaminated regions (so named occasional control zone and strict control zone). As one of examples of the system application the map of wood contamination on the Ukrainian territory is presented. Quantitative information on soil and wood contamination is presented in tables and gives idea on the damage scale in the result of Chernobyl.

LE SYSTÈME MIG, UN SYSTÈME ASSISTÉ DE TRANSFERT ET DE TRAITEMENT DE DONNÉES GRAPHIQUES POUR LA CRÉATION, LA DIFFUSION ET L'UTILISATION DE BASE DE DONNÉES SPATIALES

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RÉSUMÉ

MIGNOT INFORMATIQUE GRAPHIQUE Inc. propose un système de traitement de données spatiales basé sur une nouvelle approche pour le transfert et la conversion automatique de documents graphiques vers les systèmes d'informations géographiques.

Cette approche fait intervenir l'expertise humaine pour assister les processus automatiques utilisant les technologies du scanner, du traitement d'image, de la reconnaissance d'objets et de la conversion raster/vecteur.

Elle est caractérisée par l'utilisation d'un langage symbolique programmable intégrant au document brut des instructions et des guides. Ceux-ci assistent le logiciel de traitement pour identifier automatiquement le document, identifier les actions à prendre et les paramètres à appliquer. Ils orientent le processus de reconnaissance et de conversion.

Cette approche permet de traiter automatiquement de très grandes quantités de données avec un taux de réussite maximale sans plus nécessiter d'édition manuelle subséquente.

Un prototype du système de traitement MIG a été développé, testé et intensivement utilisé pour la numérisation rapide de cartes topographiques imprimées et la production de terrains numériques nécessités par les projets de télécommunications.

Le concept sera étendu à la diffusion et à l'échange de documents et de données à contenu spatial suivant une philosophie de traitement distribué et de conversion «juste à temps».

La méthode est exposée, appuyée par différentes applications pratiques dont la numérisation de cartes topographiques. Les concepts principaux du système prototype de traitement MIG lui-même sont présentés et discutés. L'implantation du concept dans un environnement internet/intranet pour la diffusion et l'échange de données spatiales est esquissé.

Research and Development Issues Related to Interoperability Among Spatial Datasets

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Abstract

In North America and Europe, activity has dramatically increased in initiatives associated with the development of interoperability among spatial databases. Interoperability is generally defined as the "development of software components operating reciprocally to overcome batch conversion tasks, import/export obstacles, and distributed resource access barriers imposed by heterogeneous processing environments and heterogeneous data" [OGIS Guide Chapter 4]. In creating 'access' to spatial datasets, questions must be posed concerning what users will wish to do with spatial data that they cannot do or readily achieve at present, assuming interoperability is forthcoming This paper addresses some of the key research issues associated with the use of spatial and thematic information from different sources.

Design and Implementation of Algorithms for ARC/INFO to Delta-X Conversion

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ABSTRACT

There is an ever increasing demand from GIS users to move spatial data across the platforms without a lot of overhead. This is due to the choice of GIS packages they are using and the need to convert the data from other packages whenever the need arises. This demand is addressed by various vendors in the form of Export or Save As options. The choice depends on the popularity, proprietary obligations as well as the availability of the packages. Delta-X is a federated multidatabase system designed to provide inter-operability between different database management systems. Delta-X is positioned to create a platform for a seamless exchange of spatial and attribute data amongst several GISes like ARC/INFO, SPANS, VISION, CARIS, etc.

A typical GIS application can have points, lines and polygons representing various georeferenced features either in isolation or in combination. All the features are tied with the help of tics used for registering the coordinate system in ARC/INFO. Some of the facilities available in the package include exporting the required parameters into other GIS and CAD packages.

All commercially available GISes use their propriety data organization to represent points, lines and polygons spatially. The current research focuses on data made available to the user to build a database that forms a hub for the exchange of data. Facilities available to extract ASCII are used extensively to extract the information as much as possible and the coding was done in embedded SQL with C as a host language.

The proposed paper addressed the issues involved in the conversion of geo spatial data related to points (including label points, nodes, tics, etc.), lines and polygons. Some of the challenges in the translation include, handling of polygons within the polygons, one of the sides in a polygon terminating on one of the sides of an encompassing polygon, nested polygons, etc. The paper also highlights some of the interesting challenges encountered, like two point polygons (which incidentally may occur in ARC/INFO ungenerate functions) and ways to handle them. Conversion algorithms are demonstrated with the help of case studies.

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SUSTAINABLE CITIES PROGRAMME FOR UNCHS (HABITAT II) - URBAN MANAGEMENT PROGRAMME - THE CASE OF SUSTAINABLE IBADAN PROJECT (SIP) IN NIGERIA - REVISED BASE MAP PRODUCTION FOR RECTAS

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ABSTRACT

The World Bank, the United Nations Centre for Human Settlements (UNCHS) Habitat, the World Health Organization (WHO) with the support from the United Nations Development Programme (UNDP) have launched an Urban Management Programme (UMP) with the principal goal of providing Planners, Managers and Decision-Makers with improved capability to deal with the challenges of Sustainable Urban Development. The Sustainable Cities Programme (SCP) an operational arm of UMP has been actualized in twelve cities throughout the world of which Ibadan, Oyo State, in Nigeria is one of the representative demonstration City Projects in this group from Africa. This Sustainable Ibadan Project is christened (SIP). These projects were presented at the World Summit or Habitat II Conference/Exhibition under "**Best Practices**" in Istanbul, Turkey in June 1996.

The Environmental component of this project requires the use of Geographic Information System (GIS) as a very important tool. An essential requirement of the GIS is an up-to-date and accurate working base map (preferably in both digital and analogue/hard copy form) for the Urban Information System.

For the Ibadan project, the Regional Centre for Training in Aerospace Surveys (RECTAS) Ile-Ife, Nigeria was commissioned to carry out a Map Survey Situation of Ibadan and then to compile a special up-to-date map revision edition at two scales: 1/50,000 and 1/25,000 and also produce a digital map at the same scale (using SPOT data in panchromatic mode and also multispectral mode to enhance interpretation) to be used as the baseline data for sustainable Ibadan Management Programme

This paper describes the process/methodology used by RECTAS to execute the job in collaboration with a local private survey firm "Niger Surveys & Consultants". Based on the experience gained comments, conclusions and recommendations are made on the importance of involving indigenous capabilities in such projects in future and collaboration with local private organizations to encourage efficient utilization of built-up critical capacity for African countries with International Technical Cooperation Assistance funding under Regional Cooperation and integration for sustainable growth and accelerated/orderly development of Africa. The strategic role of RECTAS a Regional Centre for Training and Consultancy Services in the Natural Resources sector operating under the auspices of the U.N. Economic Commission for Africa (UNECA) is highlighted.

La télédétection et la cartographie appliquées au suivi environnemental et de la croissance urbaine au Zaïre: le cas de la région minière de Mbuji-Mayi

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Résumé

L'intérêt des données satellitaires multidates représente un potentiel d'analyses urbaines, régionales et même nationales que plusieurs études mentionnent (C. Collet, 1992 et P. Dumolard, 1993). Malgré leur profusion, ces informations hautement technologiques restent peu accessibles aux pays principalement francophones du Tiers-monde par leur coût élevé et le problème de formation en ressources humaines dans plusieurs institutions d'enseignement. L'intégration de ces données dans un système d'information géographique (SIG) par le biais de la géomatique nous semble une voie à explorer. Pour faire face au problème réel de mise à jour de la cartographie en général dans de nombreux pays africains depuis les indépendances (autour des années 1960), la géomatique permet d'atténuer certaines carences. L'analyse de milieux urbains et régionaux au niveau de leur dynamique spatiale et environnementale au Zaïre entreprise ici, tente de démontrer comment ces informations organisées grâce à la géomatique peuvent être mises à contribution dans le défi du développement de ce pays. Notre recherche concerne Mbuji-Mayi (Kasai Oriental), capitale régionale de plus de 500 mille habitants et pour laquelle de nombreux documents cartographiques manquent. Cette carence a plusieurs implications: difficulté dans l'élaboration de schémas d'aménagement en ce milieu karstique et sablonneux, organisation de transports en commun délicate, gestion foncière cahotique et extrêmement conflictuelle, précarité fiscale municipale de cette ville pourtant mondialement reputée "capitale diamantifère du Zaïre"! L'objectif de cette étude est double: scientifique et pratique. D'une part, étudier les modalités de la croissance démographique et des développements inégaux qui provoquent de grandes transformations du milieu naturel suivant la théorie de la forme urbaine (G. Ritchot et C. Feltz, 1985) qui allie les rapports villes/campagnes en matière d'aménagement. D'autre part, établir une série de documents cartographiques et synthétiques indispensables à la gestion municipale et régionale dans leur globalité. La recherche vise avant tout à fournir une référence géographique (cartographique) homogène et précise indispensable en aménagement du territoire. Notre démarche méthodologique consiste à analyser les premiers plans de la cité minière érigée par la MIBA (Minière de Bakwanga) pour loger ses travailleurs de l'exploitation du diamant et les étapes de sa bouleversante transformation depuis l'indépendance (1960). Elle examinera également quelques photos aériennes (1959, 1977) et des images satellites SPOT multispectrales de 1989 et 1995 pour venir combler le manque d'informations en matière de cartographie et d'analyse spatiale urbaine et régionale.

International Earth remote sensing project "PRIRODA"- scientific program of land surface exploration.

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Abstract

International Earth remote sensing project PRIRODA is developed with use of the special module. PRIRODA module was launched in April 1996 and docked to the MIR orbital station. The PRIRODA project, having research character, is aimed at the development of observation and interpretation means of space monitoring data. Due to great number of different types of remote sensing equipment used, covering practically whole EM radiation spectrum (from UF wavelengths to decimeter of microwave band), various types of the practically all nature objects investigations are possible. So, the PRIRODA complex is capable of solving two problems: comprehension of remote sensing methods and investigation of nature processes as well. For working out scientific program of PRIRODA project experiments and designing scientific equipment a plenty of organizations were engaged. Description of the equipment and scientific program of land surface exploration with preliminary schedule of planed experiments in 1997-1998 will be presented.

The role of Geomatics Technologies in the Lake Malawi Biodiversity Conservation Project (LMBCP)

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Abstract

The Lake Malawi Biodiversity Conservation Project (LMBCP) is a multiyear, multidisciplinary research project funded by the World Bank and the Canadian International Development Agency (CIDA). The project is part of the Global Ecological Faculty (GEF) programme of the World Bank. The GEF framework calls for the identification and conservation of planetary ecological diversity. Lake Malawi was selected as one of the GEF sites because of the unique aspects of biodiversity within the lake and the potential for significant anthropogenic impacts on this biodiversity.

The principal scientific output of this project will be a strategy for the conservation of biodiversity of Lake Malawi which ensures sustainability of the fisheries. This strategy is to be presented in a Biodiversity Atlas and Management Plan, supported by a Guide Book to indigenous species. The project documents call for biodiversity surveys to identify the taxa and to define their geographic distribution and habitat requirements. The conservation strategy also needs to identify threats to biodiversity, develop a predictive capacity and propose protective measures. The principal scientific disciplines in which the project is to achieve its goals are: taxonomy, ecology, limnology and water quality studies, geography and remote sensing, conservation and parks planning.

In this paper we focus on the role of Geomatics Technologies within various aspects of this interdisciplinary project. We will introduce the primary science objectives and specifically address how various components of the Geomatics field (e.g., remote sensing, GIS, GPS, computer modelling and mapping) are being used to address specific objectives. We will conclude with an overview of the relative strengths and weakness of using the emerging tools of Geomatics within a large international science program such as the Lake Malawi Biodiversity Conservation Project.

RADARSAT APPLICATIONS RESEARCH IN CENTRAL AMERICA: THE GLOBESAR PROGRAM IN COSTA RICA

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ABSTRACT

In March 1995, staff from the International Development Research Center (IDRC) and the Canada Centre for Remote Sensing (CCRS) met in San José, Costa Rica with delegates from several designed institutions of Panama, Honduras, Nicaragua and Costa Rica, determining their needs, priorities and capabilities in remote sensing technology, to consider the potential technical cooperation and technological transfer to spread the utilization of radar satellite data as applied to environmental studies at each country. Two years later, in February 1997, started a **Central America Regional RADARSAT Project,** including only three of those countries.

The main objective of the Regional Project is to develop a research capability in use and application of radar satellite imagery of Costa Rica, Honduras and Panama, through the transfer of geospace technology and the promotion of applied researches for evaluating and monitoring their natural and physical resources. The Costa Rica principal coordinator institution have been considered for their Project three general objectives;

1. To develop remote sensing space technology with satellite radar in various laboratories and institutions of Costa Rica.

2. To investigate the applications of this technique for studies of natural resources in several areas of the country.
3. To train a group of costarrican professionals in the management and digital analysis of radar remote sensing data.

The Project is very important with regard to promote space information technology and its potential in sustainable development projects. Modern techniques, digital methods and data dissemination for planning, monitoring and evaluation purposes are critical to the long-term growth and development of Costa Rica In particular it can be emphasized that:

a) It is necessary to modernize existing systems for the acquisition and processing of radar and other satellite data for environmental monitoring and planning purposes.
b) It is necessary to bring about a greater spread of the use of remote sensing satellite space technology.
c) There is very little professional training in modern techniques of digital radar data. analysis.
d) The use of other techniques for research and monitoring natural resources must be promoted.

During the two years length of the Project (1997-1998), a number of activities will be conduced for organization, acquisition, training, field work, research, digital processing and dissemination of results. Five areas of Costa Rica has been selected for the RADARSAT imagery acquisition and conducting the diverse applied researches. Those areas were chosen with consideration to institutional interest, the type of possible applications, and the radar data potential related with topographic and geographic conditions. The potential applications for the RADARSAT data in Costa Rica are quite diverse, according to the arcas selected and the research centres participating in the Project.

LAND-COVER CLASSIFICATION IN SAR IMAGES BY MEANS OF A BACKPROPAGATION NEURAL NETWORK CLASSIFIER AND THE FUZZY c-MEANS CLUSTERING ALGORITHM

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ABSTRACT

With the advent of airborne and spaceborn synthetic aperture radar (SAR) systems, land-cover classification from SAR images has become an important research subject. Since gray tone alone has proven to be of limited capability in differentiating land covers types in SAR images, texture has naturally become an attractive avenue to explore. A large number of spatial feature extraction methods were developed during the past 20 years. The effectiveness of each method has been assessed in different studies using different data. However, there have been few application-oriented studies made to evaluate the relative powers of these methods in a particular environment. In this study, three spatial feature extraction methods have been compared in the land-cover classification of an ERS 1 SAR image of the mangrove forest in the vicinity of Douala (Cameroun). The first method is the well-known Spatial Dependence Grey Level Matrix (SDGLM) method, the second one is the Grey Level Run Length Method (GLRLM), and the third one is the Texture Spectrum (TS) method which was developed recently. Three sets of spatial features were derived using these methods. Combinations of features from each of these sets were used in the classification of about twelve land-cover types by means of a backpropagation neural network classifier. A method based on the fuzzy c-means clustering algorithm was used to generate sample data while training the neural network. This study has established the superiority of the Spatial Dependence Grey Level Matrix method over the other ones.

NEURO-VISION SYSTEM FOR RADARSAT: IMAGE CLUSTERING AND RECOGNITION

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ABSTRACT

RADARSAT as the first satellite using synthetic aperture radar is playing a leadership role in remote sensing technology around the world. To assure RADARSAT's internationally competitive position, advanced application software available to RADARSAT data should be developed. In this paper, a large-scale intelligence software package called neuro-vision system (NVS) is described to provide reliable strategies to practical applications of the RADARSAT data such as mine exploration.

CARTOGRAPHIE DU PARCELLAIRE À L'AIDE D'IMAGES RADARSAT : ESSAI D'ALGORITHMES DE CLASSIFICATION SPECTRALE ET CONTEXTUELLE

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RÉSUMÉ

La superficie des espaces occupés par divers types de culture est un paramètre important qui entre dans le modèle de prévision des récoltes et dans le processus d'évaluation par les agences d'assurance-récoltes (Agences AR). Quand la cartographie du parcellaire est réalisée par télédétection, elle exige des méthodes particulières de discrimination des cultures et d'extraction de chaque parcelle agricole (superficie). Le problème de fond demeure d'une part, la difficulté imposante de la caractérisation de l'information texturale des données radar à ouverture synthétique, et d'autre part l'intégration de cette information dans une méthode cognitive appropriée en vue de la cartographie du parcellaire.

Cette communication résume les essais sur des images RADARSAT et LANDSAT d'algorithmes de classification développés au CARTEL. Ces algorithmes sont : les méthodes ICM multibande et contextuelle axées sur la théorie markovienne et la transformée par ondelette, l'architecture neuromimétique intégrant la procédure des k-moyennes, et la technique de classification entité par entité utilisant l'algorithme de segmentation à optimisation séquentielle. Ces mêmes images sont aussi traitées à l'aide d'algorithmes conventionnels tels le maximum de vraisemblance et ISODATA en vue d'effectuer une analyse comparative dont les données de référence ont été collectées dans la région agricole de Champlain au Québec. D'une part, cet article décrit les conditions d'expérimentation et l'analyse des résultats de cette étude comparative; d'autre part, il suggère quelques recommandations aux utilisateurs des données RADARSAT dans le domaine de l'agriculture.

RADARSAT Reception and Processing at RSSGS in China

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The Remote Sensing Satellite Ground Station (RSSGS) was formed in 1986 in order to supply the growing user demand for earth observation data in China. It has also been receiving satellite Synthetic Aperture Radar (SAR) data from the ERS-1/2 and JERS-1 platforms since 1993. This capability, as well as the GlobeSAR program, have helped develop radar applications in China although the majority of data requests are still from the optical satellites. The recent launch of RADARSAT by Canada and the development of a reception and data distribution agreement between RSSGS in China and CSA/RSI in Canada means RADARSAT data and products will also soon be available.

The upgrade to RSSGS in order to receive and process RADARSAT data is in progress through a contract with MacDonald Dettwiler and Associates (MDA). It is expected that RADARSAT reception and processing capabilities at RSSGS will be fully operational and on-line by the end of 1996. Due to the growing demand created by the successful ERS-1/2, JERS-1, and SIR-C research investigations, as well as the GlobeSAR program, many users are already eager to obtain RADARSAT data. Thus RSSGS wishes to become operational as soon as possible.

This talk will describe the upgrade to RSSGS in order to receive and process RADARSAT data. Some additional details on products and services available from RSSGS will also be presented.

OPEN GEOSPATIAL DATASTORE INTERFACE (OGDI)

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ABSTRACT

One of the main problems in today's spatial or geographic information management framework is geospatial data conversion and integration. Very often, GIS developers and users need to import geospatial data from different sources. This task has proven to be difficult and time consuming. Industry experts believe that 60% to 85% of the total cost of implementing GIS is data conversion. Geospatial data products are offered in a large variety of different and incompatible formats, possibly in different coordinate systems or cartographic projections. Typically suppliers have developed versions of geospatial data products for several software packages

Geospatial data format standardization is one solution to this problem. However, it is very unlikely that the industry will move to a single standard. At least half-dozen important standards can be expected besides all the proprietary commercial data products already gaining momentum in the marketplace. This means those standardization efforts alone will not solve the geospatial data conversion and integration problem by itself.

This paper proposes a solution called Open Geospatial Datastore Interface (OGDI) to leverage and to accelerate this standardization effort. OGDI is an application programming interface (API) that sits between a GIS software package (the application) and various geospatial data products using a standardized access method. OGDI uses a client/server architecture to facilitate the dissemination of geospatial data products over any TCP/IP network and a driver-oriented approach to facilitate access to several geospatial data products and formats. OGDI provides a solution for some of the most difficult geospatial data integration problems

These solutions include:

- Conversion of various formats into a uniform transient data structure
- adjustment of coordinate systems and cartographic projections
- retrieval of geometric and attributes data
- access to a growing number of geospatial data products and formats and
- use of the Internet as a medium to distribute geospatial data products.

The OGDI has been contributed to the public domain (including source code) in order to improve interoperability of GIS software. Its use in GRASSLAND GIS is demonstrated, highlighting the direct (on-the-fly) access to several geospatial data formats such as GRASS, VRF, ADRG and DTED.

Operational Concept Modeling of Command and Control Spatial-Based Decision-Aids

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ABSTRACT

With the continuous development of the geomatics technology and the rapidly increasing computer power available to the end user, Geographic Information System (GIS) and geospatial information are nowadays an intrinsic part of most information systems. However, the spatial analysis capabilities of GIS are still largely unexploited, assuredly because of a lack of appropriate geospatial data but also because of the complexity of the tools.

The Department of National Defence is involved in a requirements definition project called Chameleon to model and prototype advanced functions for Land Force command and control information systems. These functions include spatial-based decision-aid tools that exploit the georeferenced, topographical and temporal nature of spatial information and that provide a simple and intuitive user interface. Among the most interesting tools are: a movement planner with an animated playback capability, terrain analysis tools (e.g. trafficability, shortest path, intervisibility), change detection using satellite or aerial imagery, diagnostic tools, alert definitions.

This paper provides an overview of the Operational Concept Modeling approach and the rapid application development tools used in Chameleon, and describes the spatial-based decision-aids and advanced command and control concepts that have been prototyped.

Data Discovery and Access in the Canadian Spatial Data Infrastructure.

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Abstract:

The Canadian geospatial data infrastructure is being defined as a collaborative effort between the federal and provincial governments. The principal elements of the geospatial infrastructure are: enabling data collection and data sharing agreements, recommended standards and protocols for metadata creation and data exchange, framework data sets, and interoperable systems for data discovery and access. To ensure broad, international interoperabilty for Canadian users, the data discovery and access element is based on the ISO Z39.50 protocol adopted by the U.S. Federal Geographic Data Committee. It will, however, also support a number of other widely used standards such as the Catalogue Interoperability Protocol being developed by the Committee on Earth Observation Satellites. The Canadian approach to the infrastructure addresses the diverse roles of the various data, product and service providers. In particular it recognises the importance of the private sector and the need to accommodate a number of different business models in the transactions that will take place within the data discovery and access element. Thus, it includes tools and services to bring metadata and data holdings on-line, support for e-commerce transactions, and the exchange of data and services. This latter will permit many small organisations to participate in and benefit from the infrastructure by making their specialised products and services as visible and interoperable as those of the larger suppliers.

Networks and Roadmaps:
Agency Issues of the Canadian Geospatial Data Infrastructure

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Development of the Canadian Geospatial Data Infrastructure (CGDI) is ongoing across several different Federal Government Departments, and within several different initiatives and projects. In combination, partnership and cooperation, these development efforts take different forms, have many industrial, government and consortia participants, and exist under several names in fulfillment of different organizational objectives and missions.

This paper discusses recent decisions by the Canadian Council on Geomatics (federal-provincial geomatics agencies) and the Inter Agency Committee on Geomatics (federal agencies using geomatics) to work together to develop a more cohesive Canadian Geospatial Data Infrastructure. The primary topics of the paper include the elements of the initiative, the philosophy behind it and the plans for the next year.

Building Bridges to Global Geospatial Information Infrastructure: Mercator Alliance, OGDI and Standards

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The emerging Global Geospatial Information Infrastructure involves significant participation of several agencies and a wide variety of stakeholders, requires significant development of enabling technologies and demands the coordination of effort. The pressures and potential of rapid change technical change , reduced resources and a greater sophistication of users further calls for linkages of effort to map the future of global geospatial data and services in the next century.

The Mercator initiative, the Open Geospatial Datastore Interface (OGDI), and focused standards efforts are key components towards the development of networked solutions for the delivery of accurate, timely and needed geospatial products and services. Related are national and international forums to disseminate and harmonize positions concerning the direction of GGII policy and development efforts. In combining a climate of participate input, common interests and the leveraging of enabling technologies, these activities bridge the delivery of better geospatial products and services into reality. The purpose of this paper is to further describe the coordination of efforts, and activities enabling the GGII to develop, while defining the future of continued coordination for the GGII.

RELATIONSHIP BETWEEN RADARSAT FINE MODE DATA AND WHEAT CROP PARAMETERS

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ABSTRACT

Satellite remote sensing data play an important role in providing information about agricultural crops on a routine basis for management decisions. The Canadian satellite, RadarSat, is providing data with a great potential for crop conditions monitoring. For areal estimates of crop conditions, the relationship between SAR (Synthetic Aperture Radar) data and the crop/soil biophysical parameters need to be developed. This will lead to a better assessment of the temporal and spatial variability of crop conditions at the field scale for precision farming requirements.

For this study, RadarSat fine mode 5 and 1 data were acquired on August 12 and 22, 1996, respectively, on an agricultural site near Delisle, Saskatchewan. Supporting ground data including soil moisture and biomass were collected from wheat stubble and summerfallow fields almost simultaneously with the SAR data. The analysis of RadarSat data in relation to soil moisture and wheat biomass and the response of the two fine modes to the farming practices will be discussed. Simulation of RadarSat data using the MIMICS (Michigan Microwave Canopy Scattering) model adjusted to the agricultural context will also be examined.

PRELIMINARY INVESTIGATION OF HIGH RESOLUTION, LATE SEASON NDVI AND IMPLICATIONS FOR SITE SPECIFIC CROP MANAGEMENT (SSCM)

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ABSTRACT

In late summer/fall of 1996, CASI images (4 m resolution) were acquired over 40 sites in southern and eastern Ontario. Normalized difference vegetation indices (NDVI) were generated for field study sites participating in the OMAFRA site specific crop management program. These sites exhibited a variety of crop types and growth extents. High resolution DEMs were also generated using a dual frequency DGPS unit for each of the sites associated with OMAFRA program.

The NDVIs tended to be skewed toward the high positive side reflecting the maturity of the crops at the time of acquisition. The values of the NDVI varied depending on crop type, with soybeans showing a strong correlation to topography. It is suggested that this is indicative of the differential dry down of the crop due to moisture conditions within the field. Corn showed little variation in NDVI values across the field, indicative of the full canopy development of the crop.

Initial yield data showed little correlation with the late season NDVI, suggesting an earlier acquisition date is required before any quantitative yield/NDVI relationships can be resolved. Based on this study, it is suggested that remotely sensed products, specifically high resolution vegetation indices, may provide valuable information in a site specific context.

Identification and Monitoring of Shifting Cultivation in the Rio Padamo, Amazonas State, Venezuela

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ABSTRACT

The main objective of this project will be to test the applicability of RADARSAT data for detecting clearings in tropical rainforests due to shifting cultivation by the indigenous Yanomani population.

The study area is located along Rio Padamo, which flows southward into the Orinoco River, approximately 45 km southeast of the settlement of La Esmeralda, in the Amazonas State in southern Venezuela. The only transportation facilities in the region are provided by the Orinoco River and two landing strips for the use of small planes.

Fine beam data at 10 m resolution acquired in the ascending mode with a nominal incidence angle of 42.7° (F-3) and a HH polarization was acquired. For localization purposes the image is centered at 3° 13' north and 65° 20' west.

RADARSAT data will be digitally processed to make it possible an optimum identification of clearings. First of all, the data will be compressed from 16 to 8 bits to be able to handle a 256 level histogram. Secondly, a geometric rectification will be performed using the coordinates provided with the scene (four corners and the center). The lack of cartographic information better than 1:500,000 as well as logistical difficulties make it unfeasible for the collection of ground control points by GPS.

Contrast stretching, filtering and IHS will be applied, to improve the visual quality of the image. Likewise visual interpretation of clearings, as well as the geomorphology of the study area at the scale of 1:50,000 will be performed using a PROCOM-2 system. A digitization process will follow to make the georeferencing of it onto the corrected radar file.

"On screen" interpretation of the corrected image will be done by defining polygons and referring them to a database.

A field verification will be carried out afterwards to try to find some validation between the interpretations and the ground truth. A qualitative comparison between both the visual and the digital interpretation will be attempted. Finally, optical satellite data (LANDSAT TM scene 002/058 acquired on March 20, 1988) will be used as ancillary information for a multitemporal analysis. A qualitative comparison between the visual and the digital interpretation will be attempted. A comparative analysis will be carried out using the study done by Ahern, Kux, Salcedo and Pietsch, where 6 meter resolution, narrow swath, airborne SAR-C data was used. This data was acquired in April 1992, during the South American Radar Experiment (SAREX'92) project.

Preliminary Results of Analysis of RADARSAT Standard Mode Beam 7 Data for Agricultural Crop Identification in India

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ADRO Project No. 349

ABSTRACT

RADARSAT standard mode beam 7 data acquired on November 11, 1996 over Saharanpur district, Uttar Pradesh state, India was analyzed for identification and classification of field crops mainly sugarcane. The geometric characteristics or the image observed after image to map registration showed the image dimension in range direction as 111.53 km and in azimuth direction as 99.30 km. The nominal pixel dimensions in range and azimuth directions were computed to be 7.99 and 8.01 metres, respectively. The scene centre is estimated as 30°01'34" N and 77°42'14" E. The angle from UTM northing (zone 43 R) observed for pixel and scan directions were 98.11° and 118.54°, respectively. The internal accuracy of the image, after registration with 1:50,000 scale base maps, was observed to be around 60 meters.

The image was predominantly over an agricultural area, where field crops occupied more than 50 per cent area and orchard, mainly mango, is the other dominant cover. The image statistics indicated that the distribution of gray values is highly negatively skewed and highly leptokurtic. Performance of various speckle suppression filters with different window sizes were carried out before classification. Two filers, viz., enhanced Lee and enhanced Frost filters, with window size of 5x5 were found to be optimum. Using this filter, the standard deviation of classes reduced by 50 per cent, while the mean remained almost the same. The observed entropy in Lee and Frost filter were 9.1451 and 9.1461 respectively. Similarly no significant difference was observed in the signal to noise ratio and edge retention performance of both the filters.

Sugarcane is the dominant crop of the area and the objective of this was mainly to identify and classify this crop. The crop was in fully mature stage by November and ready for harvest in many locations. The other crops were potato, mustard, jowar and fodder crops like lucerne, oat, etc. Rice crop was just harvested and fields were either fallow or ploughed for sowing of wheat. Six test sites of 8x6 km area spread over the image had been selected, where field level ground data on various classes were collected synchronous to date of pass. Field boundaries were digitized and stored as vector data base for training signature generation. Pixels from these sites were used to generate signature in 16 bit amplitude range.

Low value was observed for clear water and highest from villages. In all cases, it was observed that sugarcane shows different signature from crops like mustard, lucerne, potato, villages and permanent tree vegetations. The major misclassification was observed with that of mango orchards. The mean values of sugarcane classes (different moisture and agronomic stages) varied from 8400 to 10000. The mean value of mango orchard lay between 10000 to 10700. The standard deviation of these classes were between 700-1000. This indicates that, a second date data corresponding to a different phenological stage of sugarcane crop will improve the separability of these classes and help in classification.

Moisture status of the crop canopy was found to significantly affect the radar backscatter. In the case of Jowar and sugarcane crops, the difference in values observed for the yellow maturing canopy and the green canopy were between 500 and 900. The row effect was also observed in the case of potato crop. The potato fields on this date had around 40-50 per cent ground cover resulted very high backscatter, appearing the brightest among all the field crops (DN > 12000).

Assimilating optical reflectance data to correct a coupled crop growth and reflectance model for sugar beet yield estimation.

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Difficulty is experienced with using ecophysiological crop growth models to estimate crop yield over large areas due to the variability of field-specific crop parameters and model initialising conditions. Regionally, emergence conditions are quite variable due to soil conditions, climate, and cropping techniques, all having important consequences on crop establishment. At the local level, parameters describing early growth may be measured and used to function the crop model. At the regional level, it is hardly feasible to determine early growth parameters for each field through direct measurement and therefore must be estimated to improve simulation results.

Periodic remotely sensed optical data, early in the growth cycle, provides crop growth characteristics which may be assimilated into a coupled crop growth and reflectance model (SUCROS+SAIL). Assimilation is the process of incorporating external data into the model, using this data to correct the functioning of the model by adjusting certain parameters. The crop model is recalibrated through adjustment of early growth parameters in such a way as to minimise the difference between measured reflectance and reflectance simulated with the coupled models. The assimilation of reflectance measurement improves seasonal reflectance, growth, and yield simulations, as well as the determination of early growth parameters of the model.

This growth model correction technique was tested at the local level under a specific agronomic situation where two sugar beet crops in northern France were seeded in different seedbeds. The test crop had delayed and reduced seedling emergence compared to the reference crop. Therefore, reference crop model parameters were in default for the test crop. Reflectance was measured four times during early growth using a hand-held radiometer in green, red, and near infrared wavebands. The methodology developed here incorporated this series of measurements, and by adjusting selected early growth parameters, fitted simulated canopy reflectance to measured reflectance. Results showed improved simulation of leaf area evolution and yield, as well as good estimation of early growth parameters. Root yield estimation error was 2.2%, down from 25.5% if growth parameters of the reference crop were used.

This technique is a promising application of remotely sensed data for a large scale agricultural monitoring system, illustrating the possibility of estimating field level yield. Field measurements have been acquired by airborne and satellite imagery for future methodology validation on fields supplying sugar beets to two sugar factories.

Improvement of RADARSAT Image Localization

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ABSTRACT

This paper summarizes the RADARSAT design for transmitting the ephemeris to the image processor for precise image localization. For fast delivery, the ephemeris predicted on the ground are uplinked to the spacecraft and passed to the user through the image data, or by ground link. Location accuracy results using single site ranging obtained during RADARSAT commissioning are described. Improvement of current scheme is investigated, in particular, architecture and location accuracy improvement by using a GPS receiver on board are discussed. The RADARSAT design for the orbit determination system and for the distribution of ephemeris data to the data processing facilities is presented.

The orbit ephemeris are computed using ranging data collected from RADARSAT tracking sites at St-Hubert and Saskatoon. The transmission of the ephemeris to the end user is performed using two separate mechanisms: a ground transmitted ephemeris; and a spacecraft ephemeris uplinked daily and downlinked with the image data. The ground ephemeris comprises Cartesian earth centered inertial (ECI) state vectors and is passed to the data processing facility by ground link. The vectors are reconstructed using an interpolation scheme. The spacecraft based ephemeris transmitted to the payload computer consists of mean equinoctial elements which are pre-computed in the flight dynamics system and forwarded to the processing facility as a part of the image data for fast delivery products.

The osculating elements are obtained by adding the short periodic variations to the mean elements. RADARSAT requirements for predicted and definitive orbit data are presented, and compared to the results obtained during the design through analysis, and by measurements during commissioning. The current system design neglects earth tides and high order terms in the geopotential field. Current location accuracy can be partially improved by adding ranging data to the orbit solution and by upgrading current models. Alternatives using GPS data for fast delivery products are investigated. Several architecture using ground or spacecraft based GPS processing are discussed.

A COMMON EVALUATION APPROACH OF SMOOTHING AND FEATURE PRESERVING FOR SAR IMAGE FILTERING

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ABSTRACT

SAR image filtering has two conflicting goals: The removing of speckle noise by smoothing and the preservation of image features such as specular spots, lines and region boundaries. An intensity SAR image, I (= R x F), can be viewed as a stochastic process with two components: an informative part, R (the mean backscattering signal), and a random part, F (the noise). A gamma distribution is generally used for the multiplicative noise F. The image filtering consists then in the estimation of R, $\mathbf{R}$=E(R).

The filtering process can be evaluated by comparing the estimated value $\mathbf{R}$ with the through value R. In statistics, the quality of an estimator is measured by its bias and its dispersion around the mean value. the bias measures the difference between the mean value of the estimator, E($\mathbf{R}$), and the through mean value, R. the variance of the estimator, var($\mathbf{R}$), measures its dispersion around the mean value. In SAR image application, the coefficient of variation, C (=variance$^{1/2}$ /mean), is used instead of the variance.

The Box filter is used in homogeneous area, i.e., area with constant R value. It calculates the average value of I over a NxN window. In this case, the bias should be null and the variation coefficient of the estimator, $C_{\mathbf{R}}$, is related to the variation coefficient of F, $C_{\mathbf{R}}=C_F/N$. the filtering consists then in smoothing the data and the amount of smoothing is related to the reduction of the variance or the variation coefficient.

The evaluation of filters for heterogeneous area has not yet received a uniform and scientific sound definition. the main aspect is that the area will consist of at least two distinct regions with R values and that the filtering process will blur the edges between them. A good filter should preserve these edges or features. Ad hoc evaluation technique could then use the slope at the edge point as an estimation of the introduced blur. The displacement of the edge position could also be employed.

We propose to use the bias and the variance of the estimator to evaluate the preservation of features or edges. The blurring or displacement of the edge introduces an important bias in the estimator. The bias value is higher at the edge point and decreases as the distance to the edge increases. An edge displacement will produce an asymmetric decrease of the bias. Stronger blurring results in a slower decrease of the bias. Therefore, the bias contains the most important information about the edge preservation.

We should also consider the reduction of the variation coefficient of the estimator, $C_{\mathbf{R}}$. Some techniques do not perform filtering at edge point in order to obtain a null bias. However, this maintains the original value of the variation coefficient, C_F. A filter design can then be viewed as a choice between a low bias and a reduction of the variation coefficient.

The evaluation should also consider the contrast between regions at edge points. Adaptive techniques try to detect the presence of edges, but this becomes difficult when the contrast is low. However, real data contains regions of varying size and contrast. Good filters should be able to process these different cases correctly.

The paper will present the results produced by the Box filter, the Kuan filter, the Gamma filter and a new Least Commitment based filter. The results agree with previous ones and stress the advantages and limitations of each other.

A new method for extracting linear features from SAR images*

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Linear features are important components of images as they may represent surface features such as geological or geomorphological structures, lines of communication or ship wakes. Some of them also make up a major structural component of an image, supplying important clues for visual interpretation, and they can be used for precision geocoding or registration of images.

At the moment visual interpretation is by far the most efficient method for mapping such features, but while this gives good results it is tedious, requires expert training and is subjective. There is therefore a need for alternative methods. The literature abounds with algorithms for automatic extraction of features from a wide range of some types of images, which could be adapted to attempt to extract lineaments from SAR images. However, there are two very important problems in doing so. Firstly these methods were developed for images of high signal-to-noise ratio and perform badly in very noisy images. Secondly they usually can only cope with one type of feature, whereas in this kind of problem there is a diversity of features that need be extracted. Moreover, the appearance of a single feature differs from image to image because of conditions such as look angle, shadowing, surface cover and geometric distortions. At present, modelling approaches cannot cope with such a range of possibilities, and the successful extraction rate is usually low.

In this paper we review some of these methods and propose a new semi-automatic method; the two most important steps of which are segmentation and segment tracing of lines using least squares. The method is demonstrated using an ERS-1 SAR image around Kendal, Northern England, and ERS-1 and Radarsat images of an area around Larch river, Northern Quebec. The results of this semi-automatic mapping are then compared to the output of photointerpretation.

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IMAGE GEO-REFERENCIATION WITHOUT TERRESTRIAL CONTROL POINTS

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ABSTRACT

RADARSAT image georeferencing is being performed as is standard practice with space sensors, by means of a set of terrestrial control points, whose geographical coordinates are precisely known.

In the case of an open sea image or terrestrial areas without enough precise control pints, the alternative will be to use the satellite orbital information, the time of the image acquisition, and the operation mode at the time, for precise georeferenciation.

The proposal is to study and develop the necessary algorithms for such a case, and estimate the positioning errors to this method as compared with the terrestrial control points' one, based on the available satellite information.

The possible inclusion of "learning ability" to the system is being considered, as it might provide an extra advantage of refinement in the correction. This stage must be accomplished with the inclusion of control points when available, in order to increase the system ability and accuracy.

USING A CALIBRATED DIGITAL CAMERA TO INVESTIGATE DIRECTIONAL EFFECTS OF VEGETATION CANOPIES

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Abstract

Performing accurate assessments of vegetation condition and trend using remote sensing is fraught with difficulties. For off-nadir viewing sensors, the primary difficulty is the variation of canopy reflectance with view direction. As the off-nadir view angle increases, so does the canopy brightness. The sun position also has an effect as the canopy appears brighter near to the anti-solar point. To correct for these effects, we need to have measurements of canopy brightness as a function of view direction and sun position for many vegetation types. Researchers generally use non-imaging radiometers to view reflecting surfaces from many different directions. With this method it is difficult to sample all directions before the sun's position changes. Organizing data acquisition from the different view directions also poses significant logistical difficulties. In contrast, a calibrated digital camera fitted with a wide-angle lens can capture canopy brightness measurements over many directions in an instant. The vegetation canopy just needs to be large and homogeneous in extent.

The radiometric response of a digital camera was determined at the focal point and then extended to the full CCD array by using averaged images of clear blue sky. The wide-angle lens was calibrated for lens fall-off and radial lens distortion using standard laboratory techniques. Once calibrated, the camera was used to capture directional radiance measurements of commonly occurring vegetation in New Zealand: pine forest (*Pinus radiata*), pasture (*Lolium spp*), beech forest (*Northofagus fusca and Northofagus menziesii*), and manuka (*Leptospermum scoparium*).

The calibrated camera provides densely sampled radiances with respect to view direction. This allows radiance as a function of view direction to be separated into the product of two empirical functions: one a function of off-nadir view angle, and the other a function of phase angle. The function of off-nadir view angle represents the proportion of sunlit canopy seen by the observer; and the phase angle function represents the average radiance of sunlit leaves. This separation into the product of two functions explains the proportion of radiance variation by over 95% for three of the four vegetation types, and facilitates analysis of directional radiance measurements by turning a two dimensional function into two, one dimensional functions.

The method presented here is quick, uses inexpensive equipment, and measures radiance patterns to a precision of 7%. The simplicity of the method allows radiance measurements of many vegetation types to be made. These data are very detailed, and should provide more opportunities for canopy radiance modelling and testing.

Sensitivity Analysis of Forest Reflectance using the Modified Forest Light Interaction Model

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ABSTRACT

The project Monitoring and Assessment of Resources in Europe-Forest (MARIE-F) is funded by the European Commission under its Space Techniques Applied to Environmental Monitoring Programme. The principal aim of this work is to develop and test an objective methodology for estimating forest characteristics from TM and SPOT data. The emphasis of the project is on physical modelling of forest reflectance and model inversion. The Forest Light Interaction Model (FLIM, Rosema et al. 1992) is the primary model being used in the work.

As part of the forest modelling effort it was necessary to determine the how terrain slope and aspect modulated stand reflectance, and thus to determine to what extent these effects would need to be incorporated in the inversion of the FLIM. Previous reports on the detailed effects of terrain on stand reflectance are limited and have shown mixed results. The FLIM was modified to take into account the effects of terrain on stand reflectance. The modifications included the mutual shadowing effects that exist between tree crowns at relatively large solar (or viewing) zenith angles but also on moderate to steep slopes. A sensitivity analysis of the model is then carried out to determine the sensitivity of stand reflectance to slope and aspect relative to the other stand characteristics included in FLIM (stand density and structure, leaf area index, leaf angle distribution, component reflectances).

This presentation will introduce the project, focus on results of sensitivity analysis of the model, and discuss inversion strategies to be tested during the summer field campaigns of 1997 and 1998.

KNOWLEDGE-BASED INVERSION FOR MULTIANGULAR REMOTE SENSING

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ABSTRACT

The inversion of ground surface features from remotely sensed data is one of the most important research areas in remote sensing and has received much attention from remote sensers over the years. One of the major tasks of remote sensing is to establish the relationship between the structure of surface features and remotely sensed data. Traditional nadir remote sensing neglects the anisotropical nature of ground objects and attempts to establish the direct relationship between Leaf Area Index (LAI) and Vegetation Index (VI). This approach has been proved to be problematic by many researchers. Multiangular remote sensing is specifically developed to tackle the problem of anisotropy of surface features and represents the best approach for extracting information on the structure of ground features. Many successful BRDF forward physical models have been developed. However, many of these models are not invertable and others are only partially invertable. The invertability of a BRDF physical model depends on not only the model itself but also the bidirectional reflectance data and the parameters to be inverted. In this paper we will first analyze the various reasons for the lack of invertability of existing models, and then provide a new inversion mechanism incorporating the background knowledge of existing spatial databases, spectra of ground objects measured in the laboratory or in the field, and the empirical observations of remote sensing experts. The first step is to determine what inversion parameters can be derived from raw remote sensing data. For different inversion parameters components from different BRDF models will be selected and integrated into a new model. Mathematical programming method will be used for model inversion. Quantitative and qualitative results of model inversion will be presented.

On the Performance of Hybrid BRDF Models over Boreal Forest Stands

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The dependence of reflectance on viewing geometry has been widely recognized as a function of three angles, namely, solar zenith (SZ), viewing zenith (VZ) and relative azimuth (RA). The function is often referred to as bidirectional reflectance distribution function (BRDF) which delineates the varying intensity of the solar radiance reflected in different viewing directions by the sensed target. In addition to providing an unique attribute of the target, BRDF is often used to infer reflectance at angles not measured and to compute an hemispheric albedo from a reflectance measurement. The ensuing reflectance of a common geometry usually serves to monitor the changes. Determination of albedo is often needed for geophysical applications, as it measures the loss of solar energy in all directions due to reflection. Various BRDFs have been put forward from radiative transfer models, experimental observations and their hybrid. Kernel-driven BRDF (KDB) is a popular hybrid model which is being increasingly employed. The kernels generally result from simplified treatments of the physical processes of radiative transfer, while the coefficients of the KDB are usually tuned from actual measurements. The objective of this study is to assess the performance of various kernels that have been used so far. The bidirectional reflectance measurements were made with the PARABOLA instrument mounted over a trim over several boreal forest stands during the international Boreal Ecosystem Atmosphere Study (BOREAS). The assessment addresses the following questions.

(1) How well does a KDB simulate the dependence of reflectance on AZ and SZ? This question is raised because of the dearth of samples in the viewing domain by most satellites.
(2) How much error may incur in the derivation of an albedo using a BRDF tuned to a typical satellite viewing geometry?
(3) How does the atmosphere influence the performance of these kernels?
(4) Which kernel performs better than others for each of the boreal scene types under study?

Since boreal forest is the major component of the northern ecosystem, evaluation of the potential errors in the satellite-based estimates of albedo inferred from reflectance measurements is of significance for many remote sensing applications.

Supervised Classification Techniques for Hyperspectral Remote Sensing Data

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Abstract

The recent development of more sophisticated remote sensing systems enables the measurement of radiation in many more spectral intervals than previous possible. An example of this technology is the AVIRIS system, which collects image data in 220 bands. The increased dimensionality of such hyperspectral data provides a challenge to the current techniques for analyzing such data. As the number of bands increases it is expected that the capability to detect more classes and the classification accuracy increase as well.

The understanding of high dimensional space characteristics will enable the analyst to take advantage of the capability of hyperspectral data. Human experience in three dimensional space tends to mislead one's intuition of geometrical and statistical properties in high dimensional space, properties that must guide our choices in the data analysis process. In this paper some high dimensional space properties and their implication for high dimensional data analysis are studied in order to illuminate the differences between conventional spaces and hyperdimensional space. Among the characteristics, three are relevant for high dimensional data analysis. The first characteristic is that most of the high dimensional space is empty. The second is that as the dimensionality increases most of the low dimensional linear projections have the tendency to be normal. Other characteristic is that the required number of training samples for supervised classification is linearly related to the dimensionality for a linear classifier and to the square of the dimensionality for a quadratic classifier. In terms of nonparametric classifiers the sample size for training the classifier needs to increase exponentially with the number of dimensions.

The characteristic mentioned previously and empirical results tell us that that the present algorithms used for supervised classification are not enough to retrieve the information from hyperspectral data. An algorithm for dimensional reduction named Parametric Projection Pursuit is presented in this paper. This particular method takes into consideration high dimensional space properties. With this algorithm applied as a preprocessing procedure we were able to increase the classification accuracy of supervised classifiers such as Maximum Likelihood and ECHO. The first one is a spectral classifier and ECHO is a contextual-spectral classifier. Parametric Projection Pursuit was compare with other techniques of feature extraction such as Discriminant Analysis and Decision Boundary. In all the experiments Parametric Projection Pursuit performed better than the other methods in terms of classification accuracy.

DÉTECTION DE LA TENEUR EN OXYDE DE FER ET EN CARBONATE DES SOLS À L'AIDE DE LA HAUTE RÉSOLUTION SPECTRALE ET D'UNE SIMULATION SPECTRALE TM, POUR L'ÉVALUATION DE LA DÉGRADATION DES SOLS EN MILIEU MÉDITERRANÉEN

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RÉSUMÉ

La dégradation des sols en milieu méditerranéen est le résultat de plus de 2000 ans de mise en culture et d'exploitation intensive des ressources dans un contexte de climat semi-aride. Il a été montré que les propriétés spectrales des sols reflètent cette situation et que la signature spectrale peut donc servir d'outil de diagnostic de l'état de dégradation dans des régions à substratum marno-calcaire en Ardèche, France (Hill et al., 1995). Dans le cadre du travail présenté ici, la comparaison entre l'analyse physico-chimique des sols, prélevés dans le bassin de Guadalente, sud-est de l'Espagne, et leur réponse spectrale met l'accent sur les caractéristiques des sols ayant une influence au niveau des propriétés spectrales, comme la teneur en carbonates et en oxyde de fer.

La méthode utilisée pour quantifier les bandes d'absorption des différents constituants consiste dans un premier temps à tracer la courbe-enveloppe (Galvão et Vitorello, 1995) de la courbe générale du spectre, mesuré en laboratoire à l'aide du spectroradiomètre GER S-IRIS. Par la suite, le rapport entre les valeurs de réflectance de la réponse spectrale des sols et de la courbe-enveloppe permet d'estimer la profondeur, la largeur et l'aire des bandes d'absorption des oxydes de fer, centrée à 900 nm, et des carbonates, centrée à 2300 nm. De plus, une simulation des bandes spectrales de TM est effectuée en rééchantillonnant les bandes du spectroradiomètre à la résolution spectrale de TM. Quant aux échantillons de sols, ils ont été analysés à l'Université de Trèves, en Allemagne.

Les résultats de l'analyse statistique par régression multiple montrent un potentiel des caractéristiques de la bande d'absorption pour la prédiction de la teneur en oxydes de fer et en carbonates. Les variables de l'aire de la bande d'absorption, centrée à 900 nm, et la bande spectrale TM4 expliquent plus de 80% de la variation de la teneur en Fe_2O_3 des échantillons de sol. Quant à la prédiction des carbonates, nous atteignons plus de 90% de la variation expliquée en introduisant les variables de la bande spectrale TM7 et l'indice de coloration $IC_{3,2}$ (Forest, 1996).

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New Software Technology for Repeat Pass Spaceborne Interferometric SAR (InSAR) Processing

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Abstract

In the last decade SAR repeat-pass interferometry has been the subject of intensive research. Although it is still at a research stage today, it has been recognized as a technique that yields highly quantitative information, for example height, large scale deformation and (subtle) change. It has the potential to routinely provide Digital Elevation Models (DEM's), maps of deformation and change, and to allow a full geocoding of SAR imagery. A growing number of applications have become feasible, and even more are being researched. Perhaps the most exciting new application of SAR interferometry is the 2-dimensional mapping of deformation with very high accuracy (mm- to cm- level). Applications include earthquake deformation detection and monitoring, monitoring of crustal movements, volcanic movement, land slides and land subsidence. Results have been published by for example Massonnet [Massonnet et. al 1993] who used ERS-1 data. The RADARSAT offers unique opportunities for this type of interferometric monitoring with its variable incidence angle geometry and fine beam mode. Another interesting area of research is the use of phase coherence for classification and change detection.

Under the RADARSAT User Development Program of the Canadian Space Agency, Atlantis has developed a software product called the EarthView InSAR Workstation. It provides both research and operational users of spaceborne InSAR data with the opportunity to process and interact with data of varying quality and from various platforms and sources.. The software contains the full chain of steps necessary for interferometric processing including image coregistration, interferogram generation, coherence products generation, interferogram enhancement, phase unwrapping, DEM / deformation map generation, geocoding and mosaic generation and maintenance.

The InSAR workstation is implemented in the EarthView image analysis and function development software framework. The workstation approach features state of the art interferogram enhancement and filtering. The dataset geometry is characterized in terms of master and slave state vectors and an accurate orbital propagator. Toolkit functions will provide the opportunity to refine inaccurate state vectors. Several phase unwrapping algorithms have been implemented that offer the user the possibility to optimize the phase fidelity. Toolkit functions are available to compensate for potential data quality limitations.

In this paper, we present the algorithmic and processing approach and results obtained by the first release of the software. It is shown that applications specialists who are not experts in SAR technology can with only limited training produce interferometric image products. Example results using RADARSAT, ERS-1, ERS-1/2 Tandem Mode, and JERS-1 SAR sensors will be shown demonstrating the capability of this new technology for making digital elevation models, ground subsidence measurements, and fine scale classification using coherence.

Hyperspectral Information Extraction Techniques Applied to Agricultural *casi* Data for Detection of Within-Field Variations

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ABSTRACT

With the advent of the imaging spectrometer, a fundamental new data set became available to the remote sensing community for information extraction purposes. Due to the high spectral dimensionality and complexity of such data, new techniques are required to fully take advantage of the spectral content of imaging spectrometer data. Accordingly, specific techniques have been developed for classification mapping and estimation of quantitative parameters.

To exploit the potential of imaging spectrometer data using new information extraction techniques, a number of 96-band casi data sets, together with ground reference information, were collected during crop emergence and vegetation growth over test sites in Manitoba in 1996. Spectral matching and unmixing analysis techniques will be applied for classification purposes to identify within-field variations with respect to crop density and the location of weeds. Plant liquid water concentration as a stress indicator will be estimated across the fields using a combination of regression and physical models to characterize the 980 nm liquid water absorption feature. Ground reference information will be used to validate the retrieved data products.

Site Characterization of Mine Tailings at the INCO Copper Cliff Mine using *Casi* Imagery

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The reduction of acidic drainage from mine tailings sites and their environmental restoration is a growing concern for many mine operators. The characterization of mine tailings sites and their monitoring are two necessary steps towards site restoration. The objective of this paper is to evaluate the usefulness of high spatial and spectral resolution data and techniques for characterizing and monitoring such sites.

High spatial and spectral resolution *casi* imagery in the visible and near infrared are used to characterize mine tailings at the INCO Copper Cliff mine. This site was chosen because it contains a large variety of mine tailings and different levels of vegetation regrowth and is well documented. Flight data was acquired in late August in spatial (15 bands) and spectral mode (72 bands) along with a detailed ground survey. The ground survey included a visual characterization of the site and the collection of ground truth spectra using a GER 3700 spectrometer operating between 400nm and 2500nm. Different surface types were measured such as tailings (different composition and level of oxidation) and areas of vegetation regrowth (different levels of regrowth and state of health). Images will be classified using hyperspectral classification techniques including spectral matching and unmixing. The classification results will be validated using the ground reference information.

SUPPORT TO DEFENCE AND HUMANITARIAN OPERATIONS: THE RADARSAT USER AWARENESS AND TRAINING DIMENSION

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ABSTRACT

The important contribution that space-derived information can have in supporting a broad range of defence and humanitarian operations is emerging in the lessons learned from many recent international peace and security related missions. However, many user awareness and training issues need to be addressed before the capabilities of the growing number of commercial Earth observation systems can be fully realized to support these operations.

This paper provides an overview of the user awareness and training issues associated with the use of Synthetic Aperture Radar (SAR) data available from RADARSAT-1. Lessons learned using RADARSAT-1 as an information source during the interdepartmental RADARSAT Evaluation, and recent experience during the Operational Demonstration of RADARSAT-1 scheduled to occur during 1997 will be reviewed.

POTENTIALS FOR SAR APPLICATION IN LANDCOVER AND GEOLOGICAL MAPPING IN MALAYSIA

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ABSTRACT

In recent years, the country has participated in several collaborative projects with Australia, Canada (GlobeSAR), EC (EC-ASEAN ERS-1) and Japan (JERS-1 Research Programme) to assess the potentials of SAR data for land cover and geological applications. Complementing SPOT MLA with airborne SAR (X-band - HH polarized) data has resulted in improvement of visual reparability of some land cover features. Temporal ERS-1 and JERS-1 data have potentials for land cover change detection, making them effective for updating digital land cover database derived from optical data. GlobeSAR data has shown promise for land cover classification using fractal analysis and neural network techniques and has also enhanced visual understanding of lithology and geological structures.

REMOTE SENSING PROGRAM IN THAILAND

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ABSTRACT

Satellite Remote Sensing Program of Thailand was initiated in 1971 with the prime objective to participate in the NASA Earth Resources Technology Satellite (ERTS) Program. Since then, satellite remote sensing activities have been widely promoted with the participation of various agencies concerning with natural resources and environment monitoring. Subsequently, the ground receiving station was set up in late 1981 to acquire Landsat MSS data within the area of 2,500 kilometers of radius from Bangkok. Being upgraded continuously since then, the station is at the moment capable to receive and process various satellite data including Landsat TM, SPOT HRV, MOS MESSR, NOAA AVHRR, ERS-1 and JERS-1 SAR and OPS. Currently, the Thai ground receiving station is being upgraded to receive RADARSAT SAR and IRS-1CPAN and LISS-111. Furthermore, the Ministry of Science, Technology and Environment of Thailand (MOSTE), is conducting, under the MOU on cooperation in space technology and applications with the Canadian Space Agency (CSA), Thai Remote Sensing Small Satellite Program. The first Thai Earth Resource Satellite, with Canadian Technology, was planned to be launched by the 2000.

INTERNATIONAL REMOTE SENSING OVERVIEW: 1980-2007

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ABSTRACT

The field of space-based remote sensing is evolving from one that contains purely governmental and military standalone systems of high complexity and expense to one that includes an increasing number of hybrid government/commercial systems, fully commercial systems focused missions using small satellites, international proliferation, and an increasing emphasis on the production of end user products. 1997 represents a landmark year in the evolution of the field. As of three years ago, seven countries had flown free-flying Earth remote sensing satellite systems. Projections are for this number to more than double by three years from now. Civil and commercial spaceborne systems with increasingly high spatial resolutions from 30 to 6 meters in the visible spectrum have been flown over the last 15 years by the USA, France, Japan and India (Landsat, SPOT, ADEOS, and IRS-1C, respectively). In 1997, the first commercial three meters and one meter systems are scheduled to become a reality with the launches of Clark EarlyBird, and Carterra. In 1997, the number of spectral bands available in a spaceborne remote sensing instrument is scheduled to increase dramatically with the flight of the hyperspectral sensor on Lewis. In the smallsat arena, the number of remote sensing commercial minisats' missions are scheduled for 1998 and beyond, including ones from Brazil, Israel, Italy, South Korea, Taiwan, Thailand, and the USA. Commercial ocean color imagery is also scheduled to become a reality in 1997, with the launch of SeaStar. In the microwave portion of the spectrum, commercial synthetic aperture radar (SAR) systems became a realty with the launch of the Canadian RADARSAT in 1995, with significant International proliferation projected through 2007. In the conference presentation, the lessons learned from 1980-1997 will be summarized, and projections for the evolution of the field over the coming decade will be made.

One result of the proliferation of Earth remote sensing systems and data are a growing need for improved methods of data processing, interpretation and archiving. Needs are seen for improved graphical user interfaces (GUIs), image processing software, geographical information system (GIS) software, image compression tools for archival storage, images browse software, and advanced computer hardware to support it all. Also needed are trained scientists and engineers who can understand the data and bring an end-to-end systems perspective to the burgeoning field of Earth remote sensing.

AUTOMATED EDGE DETECTION IN RADARSAT IMAGES

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ABSTRACT

The Radar Data Exploitation Group within the Aerospace Radar and Navigation Section at the Defence Research Establishment Ottawa (DREO) is investigating the possibility of automatically coregistering a spacebased SAR image, such as from RADARSAT, with an image from the same or a different sensor (SAR or Electro-optical (EO)) or a digitized map. The intended purpose of this work is to improve image analysis in the areas of change detection, target classification and image fusion.

Solutions to the image coregistration problem may have to deal with the following issues: images from different sensors; images taken at different times; images taken from different perspectives; images that do not fully overlap; images at different spacial resolutions; and images with different radiometric properties, such as SAR and EO (e.g. layover, shadowing and reflections). The solutions to the automated image coregistration problem can be divided into three general classes of techniques. The first class involves performing detailed geometric (using ephemeris data) and radiometric corrections to align both images. This class of techniques suffers from inaccuracies in the ephemeris data and orbital modelling, as well as a lack of elevation data (needed for radiometric corrections) for all areas of interest. The second class involves using a Digital Elevation Model (DEM) to simulate geocoded images of the area of interest which match each of the real images to be coregistered, warping the real images to match the simulated images, and then overlaying both real images. This class of techniques suffers from the lack of available DEMs for all areas of interest. The third class involves performing an approximate geometric correction between both images based upon a georeferenced point in each image, finding "tie points" (e.g. well defined ground control points (GCPs)) in each image, matching corresponding tie points, and then warping one image to match the other. This class of techniques requires a large computational load. However, of the three classes, this one has the potential to provide the most accurate coregistration of a pair of images, but which are not necessarily geocoded, and has thereby been selected as the one to pursue. The scope of this third class is very large, so the discussion in this paper focusses on the problem of finding the tie points in SAR images only, and the topics of matching and warping are left for future work and discussion. Popular types of tie points

include: well defined points such as intersections, straight line segments, straight and/or curvilinear edge segments, and regions defined by closed boundaries and/or homogeneous areas. For the work described here, edges have been used, as every image has them, but every image does not necessarily have distinguishing points, straight lines or complete regions.

This paper discusses the various algorithms used to attempt automatic edge detection in both simulated data and RADARSAT images, and presents some of the key test results. The simulated data is used to isolate the particular algorithm required to best find edges in SAR images. The simulated data contains both straight and curvilinear edges with various signal-to-noise ratios. The noise is a simple multiplicative noise model having exponential first-order statistics. This model simulates the presence of speckle in SAR images. The algorithms tested are based upon computing the ratio of various brightness (e.g. mean) and smoothness (e.g. standard deviation) measures within neighbourhoods (i.e. subimages centered on a potential edge pixel) in the image data. Both simulated amplitude and intensity data are tested to determine which provides better results. In addition, tests are conducted on the simulated data using overlapping, adjacent and offset neighbourhoods, as well as neighbourhoods oriented at different angles to better match the orientation of an edge. Furthermore, some edge management is required to remove small, probably noise related, edge segments. Since the eventual goal of this work is to perform coregistration, it is not necessary to retain all edges in an image, only the more evident or key edges. Hence, removal of edge segments is justified. Unfortunately, the simulated data does not mimic the edge variations/roughness (e.g. a shoreline is not a straight edge) found in a real image. Hence, RADARSAT images are used to test for optimum neighbourhood size since this attribute is very dependent on the true appearance of an edge. The results of testing the automated edge detector for numerous RADARSAT images are given.

A COMPARISON STUDY OF DATA FROM RADARSAT, LANDSAT, A MULTISPECTRAL CAMERA, A FIELD-PORTABLE SPECTROMETER AND A HIGH RESOLUTION UV-VIS--NIR SPECTROMETER

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ABSTRACT

A project to improve search and rescue operations with the use of satellite imagery is currently in progress at RMC. As part of this program, new dyes and pigments have been investigated for their potential to improve the likelihood of detection by remotely sensed imagery. Research into the chemistry of dyes is normally performed in a laboratory situation, using standard laboratory data to assess thheir spectral characteristics. In an effort to validate the ability of laboratory data to correctly predict the imagery obtained from remotely sensed targets, we have obtained RADARSAT and Landsat imagery, video CCD imagery from a Xybion multispectral camera as well as reflectance spectra using a field portable, ocean Optics spectrometer and a Cary 5 UV-visible-NIR laboratory spectrometer. All imagery and spectra were obtained from the identical target. This paper compares and contrasts the information obtained from the various sensing techniques.

The Integration of an Imaging Spectrometer and a Laser Terrain Mapper

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Abstract

Airborne imaging spectrometers of the pushbroom variety have proven to be extremely useful in in many applications where fine resolution, hyperspectral imagery is required. But in those applications where precision geometry and positioning is critical, imagery from pushbroom spectrometers is of limited value unless it first undergoes costly manipulation or is merged with supporting data.

This project deals with the integration of the Compact Airborne Spectrographic Imager (casi), with the Airborne Laser Terrain Mapper (ALTM). The casi is a pushbroom scanner capable of generating digital, multi-spectral imagery. The ALTM is an airborne laser device equipped with INS/GPS. It can operate in either profiling or scanning mode to generate highly accurate data for digital elevation modeling and other mapping purposes.

The two instruments are mounted together and operated simultaneously. INS/GPS data from the ALTM is used to geometrically correct the casi imagery which is then tied to the digital elevation model generated by the ALTM. The result is a fine resolution, multi-spectral data set corrected for position, internal geometry, and terrain effect.

A variety of data sets showcasing the capabilities of the sensor combination will be displayed together with a discussion of the operational, processing and application considerations.

THE LOCAL ENVIRONMENTAL APPLICATIONS PROGRAM AT THE CANADA CENTRE FOR REMOTE SENSING

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The Canada Centre for Remote Sensing (CCRS) of the Department of Natural Resources has realigned its research and development strategy with market studies showing the high growth areas for geomatics technology in the coming decade. As a result of three consultative workshops involving other government agencies, universities and representatives from the geomatics industry. It was recommended that CCRS conduct a series of demonstrations of geomatics technology in the area of environmental assessment which was identified as the major growth area in the market studies. The objectives of LEAP are as follows.

1 To demonstrate the usefulness and effectiveness of remote sensing technology in environment-related activities.

2 In collaboration with the Canadian environmental and geomatics industry, government agencies, and Universities, perform applied research and development related to local environmental applications in order to improve the accuracy and efficiency of remote sensing methods and algorithms. Initial emphasis will be placed on high resolution digital data and on algorithms to monitor and identify environmentally sensitive parameters.

3 To establish a cooperative relationship with the geomatics and environmental industry regarding the use of high resolution digital data for local environmental applications, and to provide technical support to the development of market niches domestically and internationally.

Current demonstrations focus on environmental impact assessment in the context of the new mining development at Voisey's Bay, Nfld., the flooding disaster in the Saguenay region of Quebec and the monitoring of pipeline right-of-way in Alberta. In this paper, we will present the specific objectives of each of these projects with preliminary results obtained to date and will outline future research trusts. Currently available data sets will be described.

Identification of Agro-Ecosystem Indicators using Optical and SAR Remote Sensing Data

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ABSTRACT

A national set of agro-ecosystem indicators has been developed by Agriculture and Agri-Food Canada to provide information on the status an trends of sustainable agriculture in Canada. The aim of this study is to determine how integrated optical and radar remote sensing data ca contribute to improved identification and monitoring of agro-ecosystem indicators. The study site is located in Oxford County, southwestern Ontario. SPOT-XS and ERS-1 data, acquired on June 15, 1992, were used for the identification of indicators in the early part of the growing season. For comparison, the identification of indicators was also completed using Landsat TM and ERS-1 data acquired on August 6, 1992. Field data were collected at the time of data acquisition.

The agro-ecosystem indicators were classified using Maximum Likelihood Classification (MLC) and K-Nearest Neighbour (K-NN) per-field classification using the mean and the modal values. Biomass, as a surrogate for crop yield, was measured using the Normalized Difference Vegetation Index (NDVI).

Results of the study show that indicators for soil degradation risk, agro-habitat and biomass can be successfully identified using optical and SAR remote sensing data. All indicators were better detected using June data; however, a multitemporal approach may be beneficial in the determination of soil degradation risk. The K-NN per-field classification method using modal values provided the best results for all indicators. A per-pixel classification approach was more appropriate for biomass determination.

Classification of Reservoir Habitats in the Brazilian Amazon Using RADARSAT Multi-incidence Data.

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Incidence angles are key variables in the interaction between radar radiation and ground targets. Without multifrequency data, multi-incidence angle data can be used as surrogate for multipolarisation or multiband imagery with same success. In this investigation, multi-incidence angle RADARSAT images (S1 and S5) were used to develop a methodology for the classification of the following reservoir habitats: open-water; grass-like macrophytes (*Scirpus* and *Typha*); forb-like macrophytes (*Eichhornia*); dead-tree trunks (*paliteiro*) and forest.

A sub-set of the reservoir data (Pucurui sub-scene) was selected to assess the methodology and check the accuracy of the classification used. A filtering process was performed to convert the radar data to a near-normal distribution. RADARSAT S1,S5 and a combination of the two were submitted individually to a segmentation procedure which considers the pixel number and the similarity among pixel thresholds. The Bhattacharya classification algorithm was then applied to the segmented images for producing individual classes. The resulting classifications were then compared with aerial photographs and ground truth information for accuracy assessment. The accuracy of the results are still being assessed.

Multifrequency Versus Multiangle Radar Data for Ground Target Discrimination: Tucuruí reservoir, Amazon.

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In this study we compare the information content of multifrequency radar data with that provided by multiangle radar data for aquatic vegetation discrimination. At present, multifrequency radar information is available through the combination of JERS-1 L-band data and RADARSAT C-band data. Multiangle RADARSAT images with varying incidence angles provide steep to shallow scene viewing for increased information content. In theory, the incidence angle is the most important system variable affecting radar backscatter and the multiangle images allow better discrimination among the ground targets.

Both JERS-1 and RADARSAT imagery were acquired over the Tucuruí reservoir study site. The RADARSAT data was acquired in Standard Mode beams with three different viewing angles: S1 (20 to 27 degrees), S5 (36 to 42 degrees) and S6 (41 to 46 degrees). The JERS-1 and S6 RADARSAT were acquired concurrently with a May ADRO field campaign in Tucuruí and the S1 and S5 images were acquired with a August field campaign.

RADARSAT S1 and JERS-1 imagery, with almost identical viewing angles, were used to select sets of ground samples. Examples from both May and August were used to assess the effect of radar frequency on class discrimination. The cross-effect of frequency and viewing angle for data acquired on similar dates (S6 and JERS-1) and different incidence angles (RADARSAT S1 and S5) were also investigated for class discrimination. Preliminary results show that there is a great deal of information provided by various data sets which can be used to discriminate aquatic vegetation classes.

Can RADARSAT Improve Methane Emission Estimations in Tropical Floodplains and Reservoirs: Tucuruí Reservoir and Lago Grande, Amazon?

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Methane is a greenhouse gas whose concentration in the atmosphere is increasing at a rate of 1.5 to 2.0 % per year. Wetlands are regarded as significant natural sources of methane and during the last two decades there has been several attempts to quantify their contribution to the global carbon budget. Methane fluxes are high for the floodplains and reservoirs of the Amazon region. The focus of this research was to measure methane fluxes in three different environments: open water, macrophyte beds and flooded forests.

However, there is still little information about the extent of these environments. During the early eighties there were some attempts to quantify the area of these habitats using remote sensing techniques. Cloud cover and the seasonal variability of these environments made it impossible to produce accurate numbers on the proportion of each habitat in the floodplains and reservoir. The availability of multitemporal RADARSAT data will provide multitemporal data over the Tucurui reservoir and Lago Grande floodplain.

The objective of this research is to present a methodology for integrating radar data and methane ground measurements. The data integration will provide more accurate methane estimation of these ecosystems. During 1996, as part of the ADRO program, water and gas samples for methane concentrations were collected concurrently with RADARSAT acquisitions. These acquisitions were during three different hydrological stages: high water, receding flood waters and low water. First results indicate that the information provided by RADARSAT was crucial for an increased understanding of the methane produced from the seasonal dynamics of these ecosystems.

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A Comparison of ERS-1, JERS-1 and RADARSAT Modes S-7 and S-2 for Lineament Analysis for Central Nova Scotia

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ABSTRACT

Several descending spaceborne radar images have been processed for central Nova Scotia. The study area is located within the Carboniferous St. Mary's Basin which oversteps a major geological terrain boundary separating the Avalon terrain to the north from the Meguma terrain to the south. An initial analysis of the ERS-1 and JERS-1 data indicated the steeper incidence angle and shorter wavelength (C-band) of ERS-1 was superior for enhancing subtle topographic features within the basin. A Digital Elevation Model (DEM) was constructed from 1:10,000 contour lines and used to calculate the Local Angle of Incidence (LAI) for ERS-1 and JERS-1. The LAI indicated that a larger area of low values (maximum backscatter) was represented by the ERS-1 system over the JERS-1 system. Two RADARSAT standard mode images (S-7 and S-2) were acquired for the same area and compared for lineament analysis. As expected from the ERS-1 and JERS-1 experience the S-2 imaging mode was found to be superior for this terrain.

The main lineament trends in the area consist of a significant northeast-trending feature intersected by several northwest-trending features. Geological fieldwork was carried out to determine the origin and significance of these structures. The northeast-trending lineament corresponds to the axial trace of a regional anticline. While the northwest-trending lineaments correspond to extensional fractures. The overall fold and fracture pattern is interpreted to results from dextral motion between the Avalon and Meguma terrains in the Late Carboniferous. The northeast-trending lineament appears to rotate to a north-northwest trend at its southern limit. The strike of local bedding in this area appears to be rotated from a typical northeast trend to north-northwest trend, parallel to the lineament. This area has been interpreted to represent a second phase of deformation associated with

fault movement in the Shubenacadie Basin to the south. This study has identified and explained several significant lineaments within the St. Mary's Basin and has used elevation data to explain and predict the best incidence angle for lineament analysis based on the local terrain conditions.

The Radar Based Earth Resource Information System: A Tool for Mineral Exploration and Resource Management

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Abstract

Over the past 10 years the mineral exploration industry has been faced with increased competition for mineral deposits in an expanding "global market place". New deposits are becoming more and more difficult to locate, and consequently, the exploration cost associated with them is escalating. The increased competition has stimulated exploration companies to actively seek out alternatives to conventional exploration methods designed to reduce the costs associated with mineral exploration and also to improve the likelihood of success. One of these alternatives has been to investigate the use of remotely sensed data from various satellite platforms such as Landsat, SPOT, and ERS-1 for exploration applications. The value of these data for mineral exploration applications has been variable and is dependent on a number of factors including: geologic terrane, climate, geography, and exploration strategy. The enormous challenge of locating an economically viable mineral deposit requires a tremendous variety of data including: geology, geochemistry, and geophysics in addition to satellite remotely sensed data. The key is the ability to integrate all the various data layers that are required and to extract information from them. Most mineral exploration companies have been exposed to the potential advantages that can be gained from the use of computer based data processing applications and many have begun to implement them in their operations. However, despite the advantages offered by these technologies, many companies have underestimated their complexity and have been unable to maximize the extraction of information from their data. In response to this current situation, a Radar Based Earth Resource Information System (RBERIS) has been developed. The RBERIS is a digital information system featuring value-added, integrated Radarsat SAR products in conjunction with a suite of complementary earth resource data layers designed to support earth resource and mineral exploration applications. The province of Nova Scotia was selected as the site for the development of the prototype system because of the availability of a substantial quantity of digital geoscience data, the diverse geology and geography, and the presence of world class mineral deposits. The RBERS comprises 4 major components: (1) regional Narrow ScanSAR/Standard Beam value added Radarsat mosaic products, (2) detailed large scale products featuring Fine Resolution Beam Data, (3) a comprehensive geoscience database, and (4) a low cost, windows-based display and query graphics system. Development of the RBERIS has been funded in part by the Radarsat User Development Program of the Canadian Space Agency.

RADARSAT Imagery of Oceanographic Features During the Coastal Mixing and Optics Experiment

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ABSTRACT

The year-long Coastal Mixing and Optics (CMO) experiment sponsored by the US Office of Naval Research was begun in the summer of 1996 on the continental shelf south of Cape Cod. The goal of CMO is increased understanding of processes that govern mixing and sediment transport over the continental shelf, and the effect of these processes on optical transmission through the coastal water. Extensive in situ data were collected in the CMO experimental area from four mooring arrays and numerous ship-board sensors during the course of the first phase of the experiment in the late summer of 1996. These data included measurements not only of optical transmission properties, but also of density and current profiles as well as surface wave spectra, wind velocity, and atmospheric soundings. In support of these ground-truth measurements, we have obtained a sequence of RADARSAT SAR images centered over the CMO area between May and October 1996. A total of 16 RADARSAT images, provided to us as part of the Canadian Space Agency's Application Development and Research opportunity (ADRO) program, have been collected during this time period. Many of these images along with some of the supporting in situ data may be viewed on our CMO Web page (http://fermi.jhuapl.edu/cmo_index.html).

In our presentation, we will briefly discuss many interesting features observed in the SAR imagery, and give possible explanations for their appearance based on the available in situ data and our current understanding of the imaging physics. Such features include internal waves generated at the sharp bathymetry gradients around Block Island as well as at the continental shelf break, wave-current interaction effects over the Nantucket Shoals as a function of the tidal cycle, and surface features related to atmospheric processes such as convective cells and wind rows caused by an unstable marine boundary layer. Furthermore, during the last few days of August and the first few days of September 1996, Hurricane Edouard traveled north along the US east coast reaching the vicinity of the CMO experimental area on 2 September, and then veering to the northeast into the North Atlantic where it eventually dissipated. We have three SAR images, on 30 August and 2 and 3 September, 1996, during the passage of Edouard near the CMO site. The availability of three SAR overpasses separated by only a day or so during such a high wind event with the concurrent extensive ground truth measurements described above represents an extremely rare opportunity for the testing and validation of many ideas about how SAR responds to high wave conditions.

The combination of in situ data from the CMO experiment and national Data Buoy Center buoys in the area and sea surface temperature estimates from AVHRR imagery (also downloaded and processed at JHU/APL) with our sequence of SAR images provides a unique opportunity to improve our understanding not only of the generation and dissipation processes responsible for the seasonal cycle of coastal internal waves, but also of the physics that governs their imaging with microwave SAR systems. This combined data set is therefore of great benefit to both the oceanographic and remote sensing communities.

CLASSIFICATION AND MONITORING THE TAPAJÓS NATIONAL FOREST REGION USING SAR (RADARSAT - STANDARD MODE AND SAREX - WIDE SWATH MODE) AND LANDSAT THEMATIC MAPPER DATA

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The use of SAR data for monitoring the Amazon region has been increasing in this decade due to the availability of this kind of information provided by satellite sensors. These information sources are very important for this region, where the frequent cloud cover has restricted the use of optical data provided by Landsat and SPOT sensors in an operational way. Each RADARSAT standard mode image covers a large area on the ground allowing maping and monitoring large regions such as Amazonia. In this study, the region comprising the Tapajós National Forest and its surroundings, with large number of small plots occupied for agriculture activities and abandoned areas with secondary forest, was selected. This area is located in Pará State, between the coordinates 55° 30' W to 54° 36' W and 2° 30' S to 4° 18' S. For this area, several remote sensing data sets (e.g. Landsat TM, SAREX, RADARSAT) are georeferenced. For this study, Landsat TM acquired in 1988, SAREX wide swath mode acquired in 1992, and RADARSAT standard mode acquired in 1996 are used. The shade fraction image derived from TM data shows very clearly the contrast between forest (high amount of shade - bright) and non-forest (low amount of shade - dark) areas. The SAREX wide swath mode image has showed useful for differentiating the forest and non-forest areas due to the pseudo topography showed by forest and baresoil and/or secondary vegetation. The analysis o RADARSAT standard mode (S7D) image shows very clearly the recent clear cut areas due to its high incidence angle. The RGB color composite images formed by the combination of these data will be explored for mapping forest types and to monitor changes occurred between 1988 and 1996 when these different images were obtained. Also the image segmentation technique will be tested on these images for classifying the forest and land cover types.

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Landscape Analyses of Representativeness in the Serra da Mesa Hydroelectric Reservoir, Brazil

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The Serra da Mesa Hydroelectric Reservoir is being built on the Tocantins River in Central Brazil. The dam was closed in October 1996, and when completely filled in 1998, it will have flooded an area of 1784 km^2 of mostly *cerrado* savanna vegetation, riverine forest, tropical dry forest, and agricultural lands. The lake will contain nearly 300 islands ranging in size from less than 0.03 km^2 to over 40 km^2.

The purpose of this project is to assess the representativeness of the island and lake edge habitats in relation to the original mix of habitats present in the reservoir area. The analysis combines RADARSAT with Landsat TM data to provide a landscape classification before and after creation of the lake. Integration with Landsat TM provides complementarity, with RADARSAT coverage showing the relief and TM coverage documenting the vegetation classes.

The study area is large, with hilly terrain and many small rivers and streams. Large ridges occur in a NW-SE direction. We documented the relief with a RADARSAT image obtained on 25 September 1996, standard 4 beam mode, descending orbit, centered at S 14-01 / W 48-25. We also performed a preliminary analysis of landscapes in the RADARSAT image. Agricultural landscapes in bottomlands, including apparently bare fields, were easily identified. River drainages and gallery forests were also evident. However, natural savannas and dry forests on slopes could not be characterized, or separated from pasturelands. At the dam construction site, buildings were evident, but the disturbed areas in the environs were not clearly visible.

The next steps in the project are to correlate field data on the biological communities of the islands with the landscape classification by remote sensing. An additional RADARSAT image will be taken in March/April 1997, when most islands near the dam site should already be formed.

Evaluation of RADARSAT Data for Phyto-ecological Mapping at Medium Scale in the Test Area of Itacoatiara, Amazonas, Brazil

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This project involves the evaluation of RADARSAT data obtained at two distinct seasons, October 1996 (summer) and May, 1997 (winter). We have selected a study area of 4620 km^2 located along the shore of the Amazon River, municipality of Itacoatiara, Amazonas State. The study area is a rectangle, extending between latitudes 2° 45' and 3° 15' South and 58° 00' and 58° 45' West. This area is characterized by three physiographic enviroments typical of the Amazon: uplands (Terra Firma), floodplains (Várzea), and swampland (Igapó), a climate supporting evergreen broadleaf forest, and undulating relief. The objective of this study is to identify, analyze, and evaluate the phyto-ecological environments, settled areas, land use, and the road and stream network. Therefore, we carefully verify what will be the degree of contribution which a RADARSAT image product will provide to the photointerpreter during the process of image interpretation. The method employed is visual interpretation of a paper print of a Standard Beam 6 image acquired during a descending pass. To extract the information the data will be processed on the GIS system produced by INPE (Instituto Nacional de Pesquisas Espaciais). When this step is finished, we hope that the results obtained will be positive, and that RADARSAT data will help overcome the cloud cover problem typical of the region, and allow us to integrate all of the remote sensing data available to date. Then RADARSAT will become one more tool to aid in regional planning with a wide and dynamic view of the area affected by human settlement.

Analysis of RADARSAT fine mode images for forest application: Tapajós National Forest, Brazilian Amazon

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When mapping and/or monitoring the Amazon tropical forest, the frequent cloud cover in the region is a major problem. It requires the use of remote sensing data provided by sensors which can obtain information even with cloud cover. Because of the nature of its radiation, radar images constitute a valuable tool to perform this task. This paper describes part of the activities developed in the ADRO Project (INPE/CCRS) evaluating the potential of RADARSAT images for application in tropical forest areas. The study site comprises the Tapajós National Forest, Pará State, Brazil. Tapajós National Forest is rich in trees of commercial value and is under a management program (National Institute of Renewable Resources - IBAMA) to explore these forest resources. Two RADARSAT fine mode images were used: SGF- F2, acquired on May 20, 1996 and SGX-F5 acquired on May 05, 1996. In these images the relative image calibration and ortho-correction using geometrical modeling and the digital elevation model (DEM) were applied. Three speckle filters: (average, Lee and gamma) were tested over the images, with different window sizes. The TM/Landsat (WRS 227/62) scene (channels 3, 4, and 5) obtained on August 07, 1995 was merged with RADARSAT images using an IHS transformation. The image integration was useful for class discrimination and for defining the field work sampling procedure. To infer the forest canopy structure and cover roughness, information about location, species type, and height of trees with diameter (DBH) greater than 40 cm were obtained for the two predominant forest types (low plateau and high plateau). Different forest types and land use classes were analyzed in the RADARSAT images: low plateau forest, two types of high plateau forest, disturbed forest, clear-cut and water. Since no significant difference between power average values for each class was observed, semivariogram analyses were performed to evaluate the spatial variability of the various classes . Although semivariograms varied according to the resampling procedure during speckle filtering, they were considered an useful tool for discriminating land cover classes on RADARSAT images.

Utilization of RADARSAT Images in the Evaluation and Monitoring of the Amazonian Environment

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The study area is located at the extreme southeast of the territory of Colombia, between 3° 20' and 4° 20' north latitude and 69° 42' and 70° 42' west longitude. It occupies an area of 10,000 km^2 in the department of Amazonas, a region of great importance for its biodiversity, natural resource potential, and ecological complexity.

The objectives of the study are:

- Obtain and evaluate information on the biophysical characteristics of Amazonia;
- Analyze the dynamics of the vegetation cover and land use;
- Integrate RADARSAT data with data provided by other remote sensing instruments;
- Establish a methodology for monitoring the environmental resources of Amazonia.

The methodology employed is based on visual interpretation and digital processing of RADARSAT images obtained in the S2 beam mode. With the intention of making the best use of RADARSAT data, these have been integrated with data from other satellites, utilizing the capabilities offered by geographic information systems.

The possibility to interpret a complete and recent coverage with images from RADARSAT presents us with an opportunity to acquire, standardize, and synthesize information on the biological and physical diversity of the region, permitting us a global vision of the actual state of Amazonia, which has not been possible up to now.

JOINT AND LINEAMENT PATTERNS IN SOUTH CENTRAL ONTARIO REVEALED BY RADARSAT AND LANDSAT TM IMAGERY

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ABSTRACT

Landsat TM and Radarsat data are used in combination with aeromagnetic data interpretation and field studies in order to investigate the distributions, orientations and intensities of fractures in Proterozoic basement and Paleozoic cover rocks in an E-W trending area in south - central Ontario extending from Georgian Bay to Kingston. Of principal interest is the influence that major Grenville-age structures in the Proterozoic basement may have had during the Paleozoic to Recent tectonic evolution of the region. Joints and related lineaments in flat-lying Paleozoic sedimentary rocks are potentially sensitive indicators of basement structure reactivation and the Paleozoic to Recent deformation history of the region. Topographic features and boundaries between surface cover materials are the most common causes of geological lineaments detectable in the satellite imagery. The most prominent lineament trends in the western part of the study area are NNE (peak at 028o) and SE (peak at 124o). Results for the western part are not yet available. Several major basement structures are discernible in the Proterozoic basement underlying the Paleozoic cover as linear magnetic anomalies. NNE-trending magnetic lineaments are the dominant structural feature in the basement and their peak orientation of 026o coincides with the orientation of satellite lineaments to within 3 degrees. Field measurements of over 5000 joints show that ENE- and SE- trending vertical joints occur throughout the region. A well defined NNE- trending set also occurs in the western part of the area, being the most or second most abundant set. However, this trend is absent in the eastern part where it appears to have been replaced by a NE- trending set, which would imply a rotation of ~20o degrees. This observation and the appearance of two anomalous NS- and ENE- trending sets in the Kingston region indicates a subtle W-E change in joint population across a possible structural break in the Belleville area.

Regionally, the trends of joints in the Proterozoic basement coincide with the orientation of joints in the Paleozoic areas where they can both be observed. Strike directions are maintained even at the outcrop scale where joints in granitic Proterozoic basement rocks extend across the unconformity into flat lying Paleozoic sediments. This observation, together with the coincidence of magnetic and satellite lineaments suggests that structures in the Paleozoic cover rocks are strongly controlled by structures in the underlying Proterozoic basement.

STRUCTURAL STUDY AND GEOLOGICAL REINTERPRETATION PROJECT, SW GRENVILLE PROVINCE IN QUÉBEC (ADRO 504a3)

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Following our proposal, submitted to the Canadian Space Agency, to participate in the ADRO Program we have received RADARSAT images for an area over 65 000 km^2 covering nearly entirely the Central Metasedimentary Belt of the southwestern Grenville Province in Québec. The images were acquired in the Standard Beam Mode - S1 and S6 - both during the descending orbits during the month of August, 1996. In addition, a ScanSAR Narrow Mode (SN1) image englobing the same area was also acquired during the same month. The images were processed at the Canada Centre for Remote Sensing and at MRNQ. The outstanding feature of the RADARSAT imagery is manifested in the capacity of the images acquired in Standard Beam Positions S1 and S6 to provide excellent stereoscopic view which further facilitates the work of lineament identification during the geological structural interpretation. Furthermore, S1 and S6 images have proven to be complementary because certain structures are always better defined either on one image or the other. Due to limited time the structural interpretations for only the western one-third of the area covered by the images has been completed. The observed lineaments and structures are classified as ductile and brittle structures. The ductile structures include folds, shear zones, zones of intense deformation, lithological boundaries, structures induced by plutonic emplacement etc. Some of the brittle structures are related to the Ottawa-Bonnechère graben system, while others represent local faults, fractures, joint systems etc. Some of the lineaments and structures observed may be correlated with the known lithologies and structures, the extents of the known structures become much better defined, whereas others were previously unrecognized. The identification of new lineaments and structures must require field verification before their significance is fully understood.

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Land Resource Information: Application of Radar Data

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ABSTRACT

Information on land resources especially land use, land cover and related statistics such as areas covered by agricultural crops is essential for planning for national development. In Kenya, like in most developing countries, this information is lacking or limited, hence the need to evaluate possible effective methods for obtaining this information.

Airborne radar data of Nakuru in Kenya has been interpreted and land use and land cover information derived as a land use map. The derived map has input into a Geographic Information System (GIS) for spatial analysis.

Use of RADARSAT Data in the Design and Implementation of Sustainable Development in the Kayapó Indigenous Area, Pará, Brazil

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Efforts to design and implement sustainable management plans in the Kayapo Indigenous Area of southern Pará, Brazil are hampered by a lack of baseline information. Key gaps include information on the spatial distribution of resources and past extraction activities, and the ecological impacts of extraction activities. Satellite (Landsat, RADARSAT, and AVHRR) data are being used in combination with ground-based research to remedy this situation. Mahogany (*Swietenia macrophylla* King) is a valuable resource in the area, but ecological factors determining the distribution and regeneration of this tree species are not understood. Preliminary surveys suggest that groves are located in both floodplain and headwaters regions and that patterns of regeneration may vary between the two habitat types. Use of remote sensing information to map the distribution and intensity of past logging activities is being examined by overlaying satellite information and detailed maps of logging activities at several sites. Research on the ecological impacts of these extraction activities is focusing on the edge effects created by logging roads and other canopy openings.

In this paper we report on the use of RADARSAT data, alone and in conjunction with Landsat data, to provide information to aid in the location of potential mahogany habitats. We explore and demonstrate the use of the combined data product to aid in both geomorphological and vegetative stratification of the study area.

In addition, biodiversity monitoring will be structured around natural ecological gradients in the landscape as identified from remote sensing data. These gradients will be used to design "natural" (or mensurative) experiments to test ideas about of how ecological process in the landscape drives patterns of biodiversity.

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Initial Evaluation of Multitemporal RADARSAT Data for General Forest Cover Mapping

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Previous studies with airborne SAR data have shown a very significant increase in information when using multitemporal data, compared to the best single-date data sets. In particular, land cover information similar to that available from Landsat Thematic Mapper images appears to be present in four-date, single polarization images of the Petawawa National Forestry Institute and the CCRS boreal forest test site north of Whitecourt, Alberta. These studies also demonstrated conifer species discrimination capabilities superior to Landsat data. In these studies, principal components analysis was shown to be a very powerful tool for extracting the maximum information from multitemporal SAR data.

Because of its wide-area, cloud-free coverage, RADARSAT ScanSAR mode offers a very attractive data source for wide area vegetation mapping projects. An ambitious study of multitemporal data was accepted as part of a joint CCRS-CFS ADRO investigation. The study was to employ four ScanSAR mode images (one for each season) approximately 500 x 750 km in size for each of two study areas, on in Alberta, and the other in Ontario and Québec. Because of various problems, suitable ScanSAR data was not available, and the initial investigation was reoriented to use Standard Mode RADARSAT images of the Whitecourt boreal forest test site.

Four season RADARSAT images were combined and subjected to principal components analysis. In this paper we will discuss the problems involved in registering multitemporal RADARSAT data, and provide a preliminary assessment of the information content of the resulting data set. We will also discuss the opportunities and problems involved in extending this technique to ScanSAR data.

RADARSAT SAR INVESTIGATIONS OF SOUTH COAST OF KOREA FOR COASTAL MANAGEMENT: PRELIMINARY RESULTS

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ABSTRACT

Effective coastal zone monitoring has been an important issue for sustainable development along the south coast of Korea in order to keep balancing both industrial and aqua-culturing activities. Aqua-culturing in this area is solely seasonal dependent: active only in winter. Recently coastal reclamation on a large scale has been being carried out over the study area. Therefore seasonal change detection of aqua-culture site as well as change in land use along coastal zone is focused in this study.

We have planned to acquire multi-seasonal and multiple beam mode RADARSAT SAR data over the study area with specific purpose of detecting seasonal changes in aqua-culturing sites and land use. Although summer scenes of RADARSAT SAR data are successfully obtained during August of 1996, winter scenes are yet to be acquired. The preliminary results of this investigation, combined with Landsat TM data, shows that RADARSAT SAR provides excellent rendition of changes in land use. Speckle noise in fine resolution mode, however, may lead to difficulties in change detection of aqua-culturing structures and land use in some case. In order to reduce this problem, we have adopted a data fusion technique using the fine and the standard beam mode of RADARSAT SAR data as well as applying speckle noise removal filter. Change vector analysis has also been conducted using multi-seasonal and multiple beam mode RADARSAT SAR data as well as Landsat TM data for monitoring changes in land use in coastal zone and aqua-culture site. The results demonstrate that the RADARSAT SAR data acquired in multiple beam mode are very promising for monitoring changes in coastal zone and for aqua-culture monitoring.

Interpretation and Preliminary Texture Analysis for RADARSAT Imagery of the Barnes Ice Cap Margin

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ADRO Project 303

ABSTRACT

Accurate monitoring of ice masses requires regular and detailed mapping of ice margin position. When mapping such areas remotely, similarities in lithology make it difficult to distinguish between supraglacial debris, moraine, bedrock outcrops and outwash plain material. These are thus complicating factors in the delimitation of the extent of the ice mass.

Initial interpretation of a RADARSAT image of the southeast margin of the Barnes Ice Cap is made using TM LANDSAT imagery and geomorphological information from air photos. An investigation of the suitability of the texture analysis technique for identification of ice marginal features is undertaken and the preliminary results of first and second order texture measures are presented.

Finally, a fieldwork strategy for the collection of training data to coincide with the acquisition of an August 1997 RADARSAT image of the Barnes ice margin is presented. The collected data will be used to test the accuracy of the different classifying techniques and determine the best technique or data source combination for developing land cover classifiers for radar imagery of ice marginal zones.

WWW Distance Learning As a Tool to Support Sustainable RADARSAT Technology Transfer

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Abstract

Sustainable transfer of Radarsat technology to the user community will be an essential ingredient in the success of the Radarsat program. To be effective and sustainable, the initiatives which transfer Radarsat technology must be designed to manage the risks inherent in the physical, technologic, institutional and human dimensions of the process of adoption of this new technology. Needs-based training is one of the most important initiatives in achieving sustainable technology transfer. It contributes to the overall goal by:

- Introducing the new technology
- Developing a community who know how to use the new technology productively
- Building the confidence necessary to use it in practice
- Enhancing the knowledge base which must be in place for local applications development, and
- Fostering the management the awareness and commitment that are required for long term support of the infrastructures associated with the new technologies.

Traditional training methods, however, often are not fully effective in contributing to sustainability. The reasons for this include:

- Training and learning are interactive processes and should include monitoring and feedback activities. These opportunities are lost when hardcopy curricula are reproduced and distributed as the primary mechanism for training.
- Hardcopy training curricula are expensive to create, reproduce and distribute; and are difficult and expensive to update and reproduce. These factors make it inherently difficult for the curriculum content to evolve quickly in response to problems, issues and training needs as they arise in a dynamic field like geomatics.
- In many parts of the world, the cost of event-based or one-off training activities are very high and the impact is reduced due to high rates of staff and management attrition/turn over.
- It is often difficult to recruit the most appropriately qualified trainers to deliver training directly due to demand and challenges of scheduling and travel to remote locations.
- To manage costs, on site workshops often involve delivery of high volumes of curriculum which are delivered very quickly. Also, the resources available to trainers often do not permit delivery in the first language of the recipients.
- Supporting reference material may not be easily assessable and are often not available for consultation following the on-site training encounter.
- Attendance at technical conferences may be impractical for the learners with the greatest need due to location and cost and internal regulations regarding attendance at such events.

The Authors recognize the continuing value of a balanced approach to training delivery involving both on-site and remote delivery of training. Increasing emphasis is being placed on the merits and challenges of Distance Learning. This paper seeks to demonstrate that the WWW can be used as an effective distance learning tool that, through careful design and delivery can address many of the above issues and thus contribute directly to sustainable technology transfer. The RADARSAT Training and Resource Centre (RTSC) at www.radarsatinaction.com, a project supported by the User Education and Training Initiative and private industry, is a demonstration of WWW-based distance learning which will form an important part of the successful transfer of this new technology to users in the world community.

Estimation of Applications of Microwave Remote Sensing in Forestry: A Case Study of Halong Area-Vietnam

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ABSTRACT

Forestry investigations of various types use conventional remote sensing methods as a very important part of the methodology. Because of cloud cover in the mountainous areas of Vietnam, those methods may be limited. The application of microwave remote sensing is used to solve this situation. The aim of this study is to develop a methodology to create a forest map using microwave remote sensing data.

The RADARSAT wide mode image of the Halong area, Vietnam was chosen to be processed for this study. First, filters (Lee, Frost, Median) were applied to reduce the noise and enhance the image quality. Then, using data fusion techniques such as PCA (Principal Component Analysis) and Color Composite (IHS), the radar image was combined to SPOT and LANDSAT MSS imagery. After that a supervised classification was applied to the result of the data fusion to generate a forest map separating forest and non-forest areas and to identify different types of forest. A DEM of the area was also used to add more information to the forest type mapping because the distribution of forests often follows the elevation.

At last, the forest map was compared to the standard forest map created by FIPI based on a detailed field investigation. From the comparison, the results of the study were estimated. Hence, the role of RADARSAT data for this application can be estimated.

Residential Mapping with RADARSAT: A Case Study in Tienbai, Red River Delta, Vietnam

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ABSTRACT

In Vietnam, the development of residential areas is increasing and needs to be monitored. Optical remote sensing data is a valuable contribution, but additional information on resident areas can be extracted from radar data. In particular, the villages of the Red River delta residential areas are often confused with other land use types with optical data. RADARSAT imagery may help in mapping these residential areas.

In this study, we apply filtering (Lee, Frost, Median) and a data fusion technique (PCA) for RADARSAT, SPOT, LANDSAT and JERS-1 data from various dates. Two interpretation methods, manual and numeric processing, were done in parallel. Afterwards, in order to evaluate the approach, the results (statistics, thematic maps) will be compared with each other, with existing maps, and the field data.

From this study, we evaluate the ability for RADARSAT for mapping residential areas and propose a methodology for radar processing for this application in Vietnam.

Most of the data used for this study are provided by both IDRC project with CARTEL, Sherbrooke University and the ADRO project with CCRS.

Seasonal Peatland Monitoring Using RADARSAT C Data

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ABSTRACT

A study of the seasonal changes in the peatlands of the Hudson Bay Lowland, northern Ontario, Canada is being conducted with RADARSAT data. The aim is to determine the effectiveness of RADARSAT imagery for detecting and monitoring the temporal and spatial distribution of snow, ice and open water in northern peatlands.

With data collection complete, a total of 20 images will have been used in this study. Images were collected in both the Fine and Standard Beam Modes offered by RADARSAT corresponding to resolutions of 10 m and 25 m respectively. During the spring of 1996, images were collected at approximately 1 week intervals in both of the beam modes in order to capture the rapid changes which the peatlands were experiencing due to melting of the snow and ice. The remaining summer and fall seasons were monitored at approximately 1 to 2 month intervals in both of the beam modes.

The images have been converted from slant to ground range, geometrically corrected and radiometrically calibrated. They were georeferenced in order to allow for image to image registration. Enhancements performed on the images includes noise removal using 5 x 5 Enhanced Lee Filter. The images were scaled from 16 bit to 8 bit. For visual improvement of the images, a nonlinear radar Drieman contrast stretch was applied.

It was then necessary to identify areas of ice, snow, open water and vegetation. This was accomplished through in depth knowledge of the area aiding in visual identification as well as use of digital numbers. Analysis of temporal change throughout the study area can be done through the generation of a composite image using the Red, Green and Blue channels. By inserting into each of the 3 channels an image of a different (e.g. April 24 Red, May 8 Green, May 14 Blue), it is possible to visualize and determine when and where ice and snow are disappearing, open water is appearing and where vegetative cover is growing or changing with season.

Preliminary results show that the seasons are easily discernible. Winter and spring peatland scenes tend to show much higher backscatter returns. Winter peat bog areas tend to show higher digital numbers than do winter fen areas. This possibly suggests that ice or frozen ground is interacting with the vegetation to produce corner reflections. Areas of low elevation such as those within drainage patterns tend towards higher digital numbers in winter while the same areas tend to the lower digital numbers in summer and fall scenes. This may suggest corner reflections in winter resulting from frozen streams interacting with the bank levees. In the summer moisture is probably producing the dark returns.

Comparison of Electromagnetic Sea Ice Thickness Measurements with RADARSAT Imagery Off the Canadian East Coast

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ADRO Project No. 380

ABSTRACT

Sea ice thickness profiles were collected using a helicopter-borne electromagnetic sensor in the Gulf of St. Lawrence and off the Labrador coast in February - March 1996. These measurements are used to validate SAR signatures of ice observed in RADARSAT imagery. The ice thickness and RADARSAT data were co-registered using satellite-tracked ice beacons deployed on drifting ice floes. Some of the ice beacons were equipped with GPS receivers and provided hourly positions with an accuracy of about 30 m; these positions were used to estimate ice convergence. At several sites, direct measurements of ice thickness were obtained through augured ice holes, and ice salinity samples were collected.

In the Gulf of St. Lawrence, strong westerly winds on march 4 and 5 compressed the ice against the western shore of the Magdalen Islands and resulted in convergence of the ice beacons. Ice thickness measured with the EM sensor to the southwest of the Magdalen Islands on March 6 were relatively low, with many leads and no large ridges. This corresponded to an area on the March 6 ScanSAR Narrow image where the ice appeared bright (pancake ice) or fine-textured. To the north, many large dark floes (> 1 km diameter) surrounded by brighter areas were visible in the ScanSAR imagery. Ice thickness measured by the EM sensor over the large floes were about 40 cm, but many thickness of over 1 m were present in the surrounding ice where ridges were observed. The largest peak in ice thickness (3.4 m) was observed about 14 km northwest of the Magdalen Islands where the ice was compacted against the shore.

Along the Labrador coast, offshore winds in early March resulted in low ice thickness and concentrations close to shore. The inshore edge of the main pack off Cartwright appeared bright in the March 10 ScanSAR Wide image, and corresponded to relatively high ice thickness measured by the EM sensor. Between the shore and the main pack, bright lines extended southeast (downwind) of small islands. These lines corresponded to ice rubble which appeared as peaks of 1-2 m in the ice thickness data.

Ecological Land Classification Using RADARSAT Data in a Mountainous Arctic Environment: Preliminary Results

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ADRO Project No. 013

ABSTRACT

The primary objective of this project is to determine the suitability of RADARSAT data for ecosystem mapping in mountainous, Arctic environments. At the "ecodistrict" level (1:250,000), surficial material and vegetation are two of the dominant variables that characterize a land unit, whereas regional geomorphology and physiography contribute to its delineation. It has previously been demonstrated that surficial material and vegetation exert control over radar backscattering and possess predictable relationships in arctic ecosystems. Also, they have been successively classified through visual interpretation of SAR imagery. Therefore, it is expected that RADARSAT data will enhance the accuracy of ecological land classification in arctic environment.

The results presented relate to the preprocessing of the RADARSAT image and preliminary analyses which were designed to extract information relevant to ecological land mapping. Results are presented on three aspects of the project, as follows: 1) selection of an appropriate speckle filtering algorithm and parameters; 2) image interpretation of land cover categories known from aerial photograph interpretation; and 3) preliminary image analysis to identify texture and backscattering signatures corresponding to various surficial materials and landforms.

The study area comprises an east-west transect, 28 km wide by 65 km long, from the Labrador coast to the dissected upland plateau of the Torngat mountains. The preliminary analysis is applied to an area located at the upper reach of the Rivière Koroc valley in Québec (63.75° W, 58.75° N). Geometric distortions such as radar shadow, layover, or foreshortening are minimal due to the relatively simple topography of the valley floor and the orientation of the valley relative to the radar beam look angle. Aerial photographs at a scale of 1:60,000 are used as a reference to identify the surficial material units and landforms of interest, including: bedrock, scree slopes, till blanket and veneer, glaciofluvial sediments, deltas, alluvial fans, sand bars and water in river beds.

First Cut Results on RADARSAT Data Analysis for Monitoring and Evaluation of Irrigation Projects in Monsoon

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ADRO Project No. 460

ABSTRACT

Monitoring and evaluation of irrigation projects all over India especially during summer season using Optical Remote Sensing has been carried out successfully but monitoring of monsoon crops is hampered to a great extent due to persistence of clouds almost throughout the season. Microwave data (from ERS) which can penetrate clouds has been employed to separate paddy using multitemporal data and the attempts were successful mainly due to water background in paddy fields. Now, in addition to ERS SAR data, the availability of multilook angle SAR data of different swaths and resolutions from RADARSAT has raised hopes for separating individual crops and for estimating soil moisture, enabling monitoring and evaluation of irrigation projects even under cloud cover conditions. Under RADARSAT-ADRO project, an attempt is being made to classify individual irrigated dry and wet crops using multitemporal, multilook angle and multipolarization SAR data in C-band from RADARSAT and ERS, for further evaluation of irrigation system performance in Bhadra project, Karnataka, India.

RADARSAT data of different dates in shallow and steep angles and concurrent ERS-SAR data are being processed and analyzed for possible discrimination of individual irrigated dry crops. Paddy could be isolated from ERS-SAR data acquired during transplantation period. It is hoped to achieve better crop separability from multilook angle data as well as from polarization index (multipolarization data) from ERS and RADARSAT. Using handheld GPS receiver, representative sample sites for soil moisture sampling were identified accurately and soil moisture samples were also collected at different depths to correlate the moisture values with radar backscatter. If made operational, soil moisture estimation (from microwave data) is of immense help in irrigation monitoring and scheduling. In this paper, first cut results of crop classification and soil moisture estimation using RADARSAT/ERS-SAR data and GPS are discussed.

Remote Sensing Studies of Dykes and Faults Related to Groundwater

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ADRO Project No. 190

ABSTRACT

We present the results of an investigation to test a method using remote sensing data that might be useful for identifying types of favorable locations for groundwater exploration in areas of basement rock in relatively dry terrains. The ability to store and conduct water in basement areas depends on the secondary porosity and permeability of fissures caused by faulting, dyke emplacement and subsequent weathering. These processes have linear surface expressions which can often be identified on aeromagnetic and satellite images. Faults may act as channels for groundwater or reservoirs depending on the hydraulic head distribution in the surrounding area. Dykes may act as dams blocking the flow of water, or, less frequently reported, as channels or reservoirs if wide and fractured. The purpose of this study has been to identify dykes and faults from aeromagnetic data and to correlate these geological features with vegetation enhancements after rainy periods which may indicate in some cases the presence of groundwater. The study area is in Zimbabwe (270 km sq.) east of The Great Dyke and south of Harare. Aeromagnetic data (provided by the Geological Survey of Zimbabwe) was downward continued to the surface, reduced to the pole, and filtered to remove noise and a regional trend and converted to shaded relief to accentuate linear features related to dykes and faults. A multitemporal approach was taken to identify areas of persistent vegetation enhancement. Two full scene LANDSAT TM images were processed, one from the end of the dry season, the second shortly after the end of the wet season after the peak growing season of rainfall-fed vegetation. NDVI (normalized difference vegetation index) images were generated for each season. The most effective method for defining areas of change related to vegetation was one in which a multitemporal vegetation window was superimposed on a LANDSAT colour composite in which image intensity is varied by the aeromagnetic data. We show examples of vegetation enhancements aligning with magnetic lineaments and falling preferentially on one side, as the vegetation window is widened the range of vegetation enhancement increases and eventually appears on both sides of the magnetic lineament. The integration of RADARSAT into the project, with a multitemporal analysis of vegetation patterns using fine and standard beam data, will be completed once we receive the requested January wet season image. Fine and standard beam RADARSAT images have been assessed as a tool for locating edges of lineaments related to faults and dykes. Despite the associated reduction in resolution after filtering to reduce speckle, these images appear as accurate as the LANDSAT images in this type of application.

Test Site TH 6
Using RADARSAT Data to Detect Land Use and
Land Cover in Doi Tung, Chiang Rai

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Abstract :

GLOBESAR Program is a project of the Canada Center for Remote Sensing (CCRS). The workshops started in 1993, which has conducted an airborne SAR data collection in many countries for the frame work of the CLOBESAR Program. Such data will be evaluated in this project and will be used to guide for satellite data. The RADARSAT satellite data was acquired on December 2, 1996. In order to get the best collected data and application development project, workshops for research training and technology transfer activities start from 1993-94 to 1996-97. The technology transfer will help develop all staffs from various agencies which can make use of the SAR data.

The study area is located in Chiang Rai and Pha Yao Provinces. It is bounded by latitudes 19. 19.0 - 19. 50.7'N and longitudes 99. 27.4' - 99. 32.5' E and is 93 km. wide and 110 km. long. The landscape of the area is characterized by mountainous and narrow plain topography. The climate by Koppen's classification is Tropical Savanna. The precipitation is started from 1,200 mm. on the low land to 1,800 mm. on the high land. Rainy season starts from May to October. The lowland is mainly occupied by paddy field, while the upland is fieldcrops mainly cassava, corn and beans. The highland was formerly covered by Hill Evergreen forest, Dry Everygreen forest and Mixed Deciduous forest. Most of the forest area has been cut down and changed into shifting cultivation, orchard and other activities.

Using aerborne SAR data, the result showed that SAR data can be used to identify for some land use types, namely, water body, wet land, irrigated paddy and urban area. Ground survey and reference data are needed to support the analysis.

The astellite data of TH-6 acquired on December 02, 1996 in CD-ROM and hard copy, standard mode (s6), approximate resolution 30 m. Digital and hard copy Radarsat data acquisition and anlysis. RADARSAT data and LANDSAT-T.M identification will be carried out to study the efficiency of SAR data. Field investigation is verified the results that obtained from data interpretation.

RADARSAT data requirement :
March and July 1997, standard mode.
October 1997 fine mode.

SUIVI DU COUVERT DE GLACE À L'AIDE DE L'IMAGERIE SATELLITAIRE RADARSAT-1

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Résumé

Hydro-Québec, dans le cadre de la conception de ses ouvrages, doit connaître les risques d'embâcles et de débâcles liés à ses ouvrages et pour ce faire une bonne connaissance de l'état du couvert de glace et de son évolution au cours de l'hiver est nécessaire. La présente étude a pour but d'évaluer le potentiel de l'imagerie RADARSAT-1 pour faire le suivi du couvert de glace en eau douce. Elle vise plus spécifiquement à distinguer les glaces des zones d'eau libre sur une rivière étroite, à évaluer la qualité des données en mode fin, à analyser les structures des glaces sur les réservoirs à partir de ces images et, enfin, à identifier les paramètres du radar les plus performants pour analyser le couvert de glace sur les réservoirs.

Dix images RADARSAT ont été octroyées à Hydro-Québec dans le cadre du programme ADRO. Deux images ont été analysées en 1996; une image de la rivière Mitis et une image du complexe Outardes. Divers tests de filtrage ont été effectués sur l'image de la rivière Mitis et évalués quant à leur efficacité à réduire le chatoiement et à préserver les arêtes. Le filtre Lee amplitude qui affiche une bonne performance a permis d'améliorer considérablement la discrimination de la glace et de l'eau libre. L'image RADARSAT acquise en mode fin s'est donc avérée un outil efficace pour distinguer l'eau libre de la glace sur une rivière étroite. Pour Hydro-Québec, cette méthode d'observation pourrait devenir essentielle dans le cas de rivières difficiles d'accès.

Une analyse visuelle des réservoirs des complexes Outardes et Manicouagan a permis de constater que le capteur ROS du satellite RADARSAT est sensible aux structures de la glace. Par conséquent, ces images offrent la possibilité d'obtenir une compréhension

globale des structures des glaces sur les réservoirs. Toutefois, l'analyse préliminaire des données semble indiquer que les valeurs de rétrodiffusion ne sont pas suffisantes pour déterminer à elles seules l'état du couvert de glace. Néanmoins, plusieurs hypothèses peuvent être émises quant à la nature des glaces, plus particulièrement quant au processus de formation des glaces.

Test Site TH 2
Evaluation of the SAR Data for Agricultural Land Use

By : C. Mongkolsawat
Chokchsi Rodprom
P. Thirangoon

Abstract :

The study area is located in Amphoe Nong Song Hong, Khon Kaen Province, having an area of 22 km. wide 30 km. long. The major landscape of the area is gently undulating topography with sparse trees and isolated patches of forest remnants. The lower lands are extremely flat plains of alluvial origin and restricted to rice cultivation. A Typical feature of rice field is the presence of scatted isolated trees and shrubs with in the paddies.

The upper land is retricted to upland crops mainly cassava and sugar-cane in association with irregular patches of trees. Mean annual rainfall is relatively low with an average of 1,100 m.m. Climatic constraints, principally the timing and amount of rains vital to agriculture, are then permanent concern in this area.

Satellite data acquired on December, 1996, standard mode.
SAR data identification will be conducted to evaluate for agricultural land use in this area.

Data requested : March, July and October, 1997, fine mode.

Test Site TH 3
Evaluation of SAR Data for Land Use and Forestry
in Nakhon Si Thammarat

By : Mr. Damrong Buapradabkul, LDD
Mr. Adisak Phetcharas, NRCT

Abstract :

The study on the evaluation of SAR data for land use and forestry is taken in Nakhon Si Thammarat Province, southern part of Thailand. The study area is located between Latitudes 8. 07' - 8. 40'N and Longitudes 99.25' - 99.43'E covering 22 km. wide and 60 km. long. The topography is comprised of footslope and steep hills, the forest on this area has been cut and changes into agricultural area, mostly rubber plantation. The gently sloping area is covered with mixed orchard. The flood plain along Tapee river is paddy field.

The result from the airborne SAR data showed that, SAR data can be used to classify agricultural area and forested area at general level. In order to identify crops, more ground truth and reference data are needed to support the analysis.

The satellite data of TH-6 has already acquired on December 1996 in CD-Rom and hard copy, standard mode, approximate resolution 30m.. Satellite data identification will be carried out to evaluate for land use and forest in this area.

Data requested : March, July and November 1997, fine mode.

Application of Radar Images to Study on Geology and Archaeology in Thailand

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ABSTRACT

Two case studies were carried out using airborne radar images as a tool to study geology and archaeology in Thailand. Visual interpretation are basic techniques used for both case studies. The first case, geomorphology and geology of the Chaiyaphum area in northeastern Thailand were mapped with limited field check. Seven geomorphic units, six rock units and four units of unconsolidated sediments are classified based on different surface expression, lithology and its resistance, and relation of units. These characteristics control appearance on the images. Structure such as curvilinear features, lineaments are bedding are examined.

The second case, geomorphology and archaeological features in the upper part of the Chao Phraya central plain are determined. Mountainous terrain, colluvial slope, terrace and meandering plain are remarkably recognized on the images. In terms of archaeology, the moat of an ancient city and an ancient irrigation canan are prominent as well.

Comparison of the radar images to other available remotely sensed dated used for these studies is made.

TOWARDS A NEOTECTONIC AND HAZARDS EVALUATION OF THE ISRAEL-JORDAN ARAVA VALLEY USING RADARSAT REMOTE SENSING.

Yaacov Arkin,[1] Arnon Karnieli,[2] Charles Ichoku.[2]

1. Geological Survey of Israel, Jerusalem.
2. Remote Sensing Lab. Ben Gurion University, Sede Boqer.

The Arava Valley forms the segment of the Syro-African Rift between the Dead and Red Seas. It is a N-S trending valley some 160km long, separated into two basins by a drainage divide of an elevation of 290m above sea level. The northern basin is some 70km long and 12-20km wide, descending northwards to -408m in the Dead Sea. The elevations of the shoulders reach 1641m on the eastern side in Jordan and 300m on the western side in Israel. The southern basin is some 90km long and 7-10km wide, descending to the Red Sea level. The elevations on the eastern side reach 1727m and on the western side 472m. This general EW asymmetry is also seen in the stratigraphy as expressed by Cretaceous sediments in the west and Precambrian and Cambrian to Cretaceous rocks in the east. It is further expressed in the tectonics as step faulted blocks exposed in the shoulders and en echelon sedimentary basins in the valley floor. These geomorphologic features support the sinistral wrench fault movement of some 105km considered to have taken place along the rift.

The aridness of the area and sparseness of vegetation in a relatively flat valley floor form optimum conditions for Radar Remote Sensing. Synthetic Aperture Radar acquired by Radarsat is used as the primary data source for structural study of the area. Adapted digital image processing and analysis reveal valley floor tectonics and geomorphology. These are expressed as lineaments and different surface roughness related to the distribution and density of sand, pebbles, boulders and vegetation on the surfaces. Relative dating of these surfaces and topographic measurements based on the techniques of digital elevation modeling (DEM) and interferometry may be used to evaluate neotectonic movements and seismic hazards in the Arava.

Hydrological Mapping of Wadi Araba from RADARSAT Images

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ABSTRACT

Wadi Araba has the priority to be developed, where this area is considered as a promising area and it has an economic importance for agricultural production.

Wadi Araba is located at the south western part of Jordan, it extends from south of the Dead Sea to the Gulf of Aqaba. It is about 240 km long, and located between Jordan and Israel.

The methodology of this study was performed in two steps; first, RADARSAT S1 and S3 were used for mapping hydrogeological units, based on lithology and geomorphology. S1 standard beam images, pixel size 12.5 m, was used for mapping dissected hills unit and alluvial fans. While S3 was used for mapping badlands (silt and clay) unit and the different types of alluvium deposits related to hydrogeological units.

Second step, RADARSAT images were integrated with TM LANDSAT image bands 7, 5, 4 using IHS technique to create an image, providing more scientific data to be used for hydrogeological mapping.

The result of this study is to produce hydrogeological maps thus to delineate water recharge zones and to assist in ground water exploration. This study helps in the management of surface water and land use development. The area was divided into three major units: Araba hills (dissected basement plateau), Wadi Araba escarpment that includes dissected erosional escarpment and basement complex rocks (sandstone and calcareous), and Wadi Araba (region) flood plane which consists of different sub-units of alluvium and lisan marl.

This study shows clearly the benefits of using RADARSAT imagery for the identification of hydrogeological units that depend on lithology and geomorphology.

Managing Desertification of Amman Region (Madaba) from RADARSAT Imagery

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ABSTRACT

Natural resources in the arid and semi-arid areas are declining in productivity and require a special attention due to the expansion of urban area and the decreasing rainfall. So Madaba Region is considered one of the regions in Jordan that suffers from the decrease in the agricultural production, and there is an urgent need to manage the agricultural process to stop the decreasing of land productivity that leads to desertification.

The study area is located in the southern part of Amman, and covers about 1200 km^2. To achieve our objectives, we used RADARSAT images standard beams 7, 4 pixel size 12.5 m which were very useful especially in creating lineament sheet, soil moisture sheet and soil sensitivity for erosion sheet. Also we used LANDSAT TM images* to create land use, land cover sheet. The main factors in this study were: soil moisture, soil sensitivity for erosion, rainfall, soil salinity. Then an integration was made between all of these factors by using the GIS techniques, so as to obtain the intersection between all of these factors. Then we delineated the areas which were effected by desertification, after that they were classified in four categories according to the United Nations Desertification Conference which was held in Nairobi, Kenya, 1977, as follows:

1. Areas of slight Desertification
2. Areas of Moderate Desertification
3. Areas of Severe Desertification
4. Areas of Very Severe Desertification.

* **In different data and in different seasons - TM 1983, 1987, 1994**

[1]The Use of RADARSAT Imagery for Mapping Groundwater Recharge Zone in the Madaba Area

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ABSTRACT

Jordan is one of the countries that has a serious water deficiency due to the weak intensity of rainfall and having a sizable part of its land under arid and semi-arid conditions.

Managing of existence water resources and looking for more resources of water are the most important goals at this time. Remote sensing is considered as one of the best tools to help water resources management. RADARSAT standard beam-7 image is used in this study.

The methodology of this research is based on the interpretation of enhanced and geocorrected RADAR imagery; this image is used for lineament extraction and discrimination and for creation of a map of lineament density and a map of drainage network. LANDSAT TM data was used to create the erosion susceptibility map and the landuse map for the definitive suitable dam site. Other data such as 1:50,000 geological, 1:50,000 topographic maps, which are stored in the database, were integrated with the RADARSAT and TM image.

This procedure underlines the good capability of RADARSAT imagery to define the ground water recharge zone in the study area.

[1] GER' 97 - the first major conference to examine the results from RADARSAT. Held May 24-30, 1997 in Ottawa, Canada.

[1]Geological Interpretation of East Central Jordan from RADARSAT Images

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ABSTRACT

This study has been designed to evaluate the utility of RADARSAT images for revision of geological interpretation of east central Jordan. The geological interpretation is concerned with: 1) rock type discrimination; 2) identification of structural features; 3) water harvesting investigations; and 4) geomorphological interpretation. The study area has a considerable interest in its geology for its distinctive location as part of one of the main discharge zones in Jordan, which is the Azraq Basin. Moreover, it is considered as a part of the limestone plateau in eastern Jordan. The northern part of it is covered by volcanic rocks. The rocks outcropping within the area range in age from Turonian to recent. Structurally the area is tectonically active and dominated with NW-SE, E-W and N-E faults. Generally speaking, two major structures affected the area, the Fuluk in the northeast and Sirhan in the south.

The study involves visual interpretation of three RADARSAT images of different looks and modes of beam to identify the most suitable mode for optimum extraction of geological information. The visual interpretation will be carried out in parallel with image processing comprising contrast stretching, linear enhancement, and principal component analysis (PCA) using ERDAS image 8.2. The interpretation approach is based on sufficient correlation between the images and the ground surface appearances.

RADARSAT images were acquired by the Canada Centre for Remote Sensing in November 7, march 17 and March 15, 1996 as part of the ADRO program. Acquisition parameters include C-HH, 4 looks with varying incidence angles. speckle has been reduced using 5 x 5 F-GAMMA filters. A LANDSAT Thematic Mapper quadrant image of path/raw 173/38 will be used in parallel with the RADARSAT images. A synergy image will be produced from the fusion of RADARSAT image and the LANDSAT TM image using the IHS transformation method to extract more geological information from the high spatial resolution of the RADARSAT image and the spectral resolution of the TM.

From a preliminary inspection of the two datasets of the study area linear features and drainage network are easily identified on the RADARSAT images, than on the TM image. On the other hand, the TM image provides more information as concern land cover discrimination. Therefore, production of a synergy image is a good approach. However, further data integration is recommended to resolve local ambiguities in the identification of some stratigraphic units and the origin of some lineaments

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[1]To be presented at the Mid-term Symposium for ADRO, May 24-30, 1997

Creative Uses of the Third Dimension in GIS Analysis

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ABSTRACT

Geoscientists are often confronted with data, such as lake sediment geochemistry data or elevation points that are affected as much by the studied phenomenon as they are by the spatial variation of this phenomenon. Geographical information systems provide the analysis tools required to study these continuous variables by representing them as a third dimension on a geographic surface. Three different uses of the third dimension are presented to emphasize the additional information provided by this type of surface analysis.

1. A Digital Elevation Model (DEM) of the bedrock surface was required for the Oak Ridges Moraine area, southern Ontario. Constructing a bedrock surface differs from a traditional DEM of topographic features as source data are not readily available. In this compilation, waterwell records were the most common input source, providing an inconsistent distribution of samples. Accuracy was controlled through GSC boreholes, rock outcrops and a hydrologically sound DEM of topographic features. Various methods for interpolation, correcting and filtering were used to ensure a quality surface representation.

2. A second DEM representing the topographic surface was generated for this same area. The hydrological properties of the DEM allow accurate hydrogeological studies, such as drainage analysis. This model was used to produce a map of the major drainage basins covering the area. This work was based on an adequate stream ordering for the complete drainage network. Secondly, the model was used as a tool to improve the understanding of the landforms found around the Oak Ridges Moraine.

3. Mineral exploration in large areas of Canada is made difficult because the bedrock is blanketed by thick layers of glacially derived sediments. Comparison of the concentrations of chemical elements in these sediments and in the vegetation aids in identifying the underlying bedrock composition. In the Cape Breton area, till and bark samples, analyzed for their trace element contents, were combined to produce correlation surfaces. These three-dimensional surfaces were then used as the basis for the generation of hillshaded models incorporating the bedrock geology and the surficial geology. This technique provides a powerful visual tool allowing easy analysis of the relationship between the quality of the till-bark correlation and the geology.

TEMPORAL SOIL MOISTURE MONITORING WITH MULIT-INCIDENCE ANGLE RADARSAT DATA

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Knowledge of soil moisture distribution is important in hydrology, climate and agricultural applications. The difficulties related to acquiring spatial measurements of this variable using traditional methods make the integration of soil moisture in geophysical models rather complex and inaccurate. The limitation of point sampling methods are mainly due to the high spatial and temporal variability associated with soil moisture.

Many studies have observed a relationship between surface soil moisture and radar backscatter. However surface characteristics such as cover type, soil surface roughness, and soil texture influence radar backscatter. The contribution of these parameters are difficult to separate from the soil moisture contribution using one image with a single imaging configuration. Additional data may be needed to complement the information content brought by a single SAR image. As such, multi-date approaches using different imaging configurations may provide a better understanding of the relationship between surface soil moisture and radar backscatter.

A RADARSAT soil moisture experiment was conducted during October, 1996 over a test site located in southern Manitoba, Canada centred roughly on the Town of Altona. This site has been used as a test site by CCRS for a number of years and was most recently used during the SIR-C/X-SAR mission in 1994. The project was a co-operative venture amongst the Canada Centre for Remote Sensing (CCRS), the University of Sherbrooke and the University of Winnipeg. Over the period of October (post harvest) four RADARSAT Standard Beam Mode and one Extended High Mode data acquisitions occurred over the site covering a range of incidence angles From 24° to 59°. During each RADARSAT acquisition 20 fields, selected to cover a wide range of soil textures were sampled for soil moisture and surface roughness characterization.

One of the overall objectives of these experiments is to evaluate the capabilities of multi-date RADARSAT Standard Beam Mode data acquired over a range of incidence angles to estimate soil moisture in an agricultural environment and to provide a first order incidence angle correction factor for use of Standard mode data from different beams. A sensitivity analyses for estimating soil moisture from RADARSAT Standard mode scenes will also be presented.

ANALYSIS OF RADARSAT IMAGES WITH DIFFERENT INCIDENCE ANGLES AND MODES RECORDED OVER AN AGRICULTURAL TEST SITE, SOUTHERN ONTARIO, CANADA

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ABSTRACT

Four RADARSAT images were acquired over a period of five days in late summer for part of Oxford county in southern Ontario. Details of the acquisition are as follows:

August 1, 1996 - standard beam 4, ascending orbit;
August 2, 1996 - fine beam 2, descending orbit;
August 4, 1996 - standard beam 7, ascending orbit;
August 5, 1996 - standard beam 1, descending orbit.

The fine-beam image was registered to the UTM coordinate system. In turn, each of the standard-beam images was co-registered to the fine beam image. A field-boundary file, derived from digitizing a georeferenced spot multispectral image within ARC/INO, was also overlain on the images. The GIS database associated with the fields enables the crop types to be readily identified. Using standard image-overlay enhancement techniques, evaluations have been made of several different image combinations. Theses were designed to compare the effects of incidence angle, fine-beam versus standard-beam modes, and differences between ascending and descending orbits. Visual interpretation of the colours permits conclusion to be drawn about the variation in backscatter between the different images. The images are of relatively poor quality when compared with other RADARSAT images; reasons for this are suggested, even so, variations in colour permit interpretation of the images to be undertaken.

L'acquisition des données terrain en regard avec l'analyse des images RADARSAT

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Dans le cadre du projet ADRO réalisé par l'équipe de l'université de Montréal, il est essentiel de procéder à l'échantillonnage des caractéristiques physiques du terrain en fonction des régions tempérées et sub-arctiques ont été choisis: les Monts Chics-Chocs en Gaspésie, le secteur nord de la fausse du Labrador et les Monts Tomgats. Pour des raisons d'accessibilité, seul le site en Gaspésie a fait l'objet d'un tel échantillonnage.

La méthodologie d'acquisition des données terrain est articulée autour de trois étapes de travail:

1) **Le positionnement** des sites d'échantillonnage d'intérêt est effectué, pour la correction géométrique des images, en combinant la technologie SPS (deux unités) avec celle d'une station-totale de haute précision. Afin d'optimiser les mesures de positionnement, des points géodésiques servirent de base pour les mesurers GPS en mode différentiel tout en assurant un rattachement au système de coordonnées UTM.

Quelques sites bien dégagés ont servis de points de contrôle et des réflecteurs en coin furent installés sur certains d'entre-eux. Le positionnement de ces derniers à fait l'objet d'une attention particulière compte-tenu de leurs influences sur les corrections géométriques ainsi que leurs grand potentiel de repérage sur les images RADARSAT.

2) **L'échantillonage** concerne chacun des sites et peut être effectué en tout temps. La méthodologie d'échantillonnage est guidée par un formulaire pré-établi. Dans ce formulaire, conforme aux exigences d'échantillonnage du Centre Canadien de Télédétection, on retrouve des caractéristiques décrivant les conditions de la topographie, de la végétation, du sol et des types de dépôts présents.

3) **L'échantillonnage fait pendant l'acquisition des image RADARSAT** concerne des renseignements sur les conditions climatiques et d'humidité du sol. Ces mesures ont été récoltées dans un délai d'une heure avant et après le passage du satellite. Lors de ces périodes d'échantillonnage, nous avons constatés la présence d'un important couvert de givre à la cime des conifères (zones denses de conifères) ainsi qu'une forte rosée au sol. L'analyse des images RADARSAT en considérant les effets de ces particularités climatiques pourrait s'avérer des plus pertinente.

Understanding Multi-Dimensional False Color Radar Imagery

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ABSTRACT

Since the development of "natural" color film, the use of color to present and display multi-dimensional, usually multispectral, data sets has been common place. With the successful launch of several spaceborne imaging packages (SIR-B, SIR-C/XSAR, JERS and RADARSAT), a plethora of easily rectified multi-dimensional (multi-frequency, multi-polarized, multi-look angle and multitemporal) digital radar data sets became available to the scientific community. Prior to the accessibility of this multi-dimensional data, most of the imaging radar data were collected in an analog format and presented as black and white images since the data were primarily collected in a single band, single polarization format. The color radar images were actually "colorized black and white" images based on one band/one polarization and were NOT "true color" radar images based on the combination of three unique layers of data. With the availability of radar data to generate "true color radar" or, more correctly, multi-dimensional false color radar imagery, the image interpreter is now presented with a powerful visual color display of spatial information. However, dangerous pitfalls exist that may result in misinterpretations.

Image interpreters familiar with visible/near infrared false color composites are likely to be confused when presented with a multi-dimensional false color radar imagery. Even radar analysts accustomed to interpreting single channel, black and white radar images may be confused by the colors and their meaning. It is imperative that image analysts interpreting multi-dimensional false color radar data sets be cognizant of 1) the type (multi-frequency, multi-polarized, etc.) and number of data sets being combined; 2) the colors assigned to each data layer; 3) basic color theory; and 4) the physical processes that influence target/signal interaction. This is in addition to having an in-depth knowledge of 1) the study area, 2) the appropriate earth science (oceanography, geomorphology, etc.) and 3) image analysis techniques.

Although a vegetation community, a snow or ice type, or land cover unit may be delineated on multi-dimensional false color radar images without understanding WHY these color patterns occur, this lack of understanding limits the interpreter to mere observation and prohibits progressing to the "explanation and prediction phase" so important in the process of discovery. The purpose of this paper is to provide a better understanding of multi-dimensional false color radar images by: 1) discussing some of the common models of multi-dimensional radar data sets; 2) presenting possible models for standardizing the assignment of colors to multi-dimensional false color radar composite images; 3) discussing some of the system and target parameters that influence radar backscatter; and 4) interpreting the colors on several multi-dimensional false color radar images.

DEFINITION OF THE DRAINAGE NETWORK IN WET AND DRY SEASONS IN THE PLAIN (PENILLANURA) OF THE CASIQUIARE RIVER, IN THE STATE OF AMAZONAS, VENEZUELA

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Since the first Amazon Nations Workshop at INPE in Sao José dos Campos, Brazil, the following project has been elaborated. Its primary objective is to evaluate the utility of RADARSAT data in the definition of the plain (Penillanura) of the Casiquiare River, in the State of Amazonas, Venezuela in the wet and dry seasons. This area is a poorly drained swampland which connects the Amazon and Orinoco river watersheds.

Due to the permanent cloud coverage existent in this region, optical sensors are severely limited. In this study our objective is to prove that RADARSAT data is a reliable alternative for the cartographic interpretation, mapping and cartographic updating.

RADARSAT images of the 10,000 square kilometre study area have been acquired during the rainy season in September 1996 and during the dry season of January 1997. For the definition of the drainage network, the RADARSAT images of the study site have been visually interpreted using the Procom-2, an optical device which allows the data in the form of a photographic transparency to be enlarged and overlayed on existing maps. We were able to generate a digital thematic map which contained information on forest, flooded forest, savannas, flooded savannas and hydrology.

APPORT DES DONNÉES RADARSAT A L'ÉTUDE DES PROPRIÉTÉS HYDROLOGIQUES DES SOLS D'UNE ZONE SIMI-ARIDE: CAS DU BASSIN VERSANT DE TELATA NORD DU MAROC)

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RÉSUMÉ

La tendance actuelle dans l'utilisation de modèles hydrologiques s'oriente de plus en plus vers l'intégration de données de télédétection pour, au moins des fins de classification de la couverture du sol.

La présente étude avait comme objectif d'évaluer la possibilité d'utiliser le signal rétrodiffusé de la band C (3,75-7,5 cm) du capteur satellitaire RADARSAT pour l'identification des unités de sols en fonction des propriétés hydrologiques du bassin versant de Telata.

Le bassin versant de Telata, situé au nord du Maroc, couvre une superficie de 18,000 ha. Il est caractérisé par une topographie très accidentée et un processus d'érosion hydrologique très intense.

Pour cette étude, une base de données composée d'une image RADARSAT, d'une image optique, d'une carte pédologique et d'un modèle numérique de terrain a été utilisée. Les images RADARSAT et Landsat TM ont été acquises en saison humide: 23 mars et 25 mars respectivement.

- L'image Landsat TM a été utilisée pour l'identification des différents thèmes d'occupation des sols.
- La carte pédologique a servi pour la délimitation, sur l'image radar, des différentes unités hydrologiques définies par la méthode SCS (Soil Conservation Service).
- Le modèle numérique de terrain a été utilisé pour la détermination de la carte des pentes d'aspect et de l'angle d'incidence local. L'ensemble de ces paramètres a été utilisé

pour le calcul de coefficient de rétrodiffusion et la réduction de l'effet du relief sur le signal radar.

Dans le bassin versant de Telata, trois classes hydrologiques (B, C,D,) ont été identifiées en fonction de la texture granulométrique de la surface du sol et de son potentiel de drainage. L'analyse de la relation existante entre le coefficent de rétrodiffusion et les différentes classes hydrologique montre une régression linéaire en fonction de la capacité de drainage de chaque classe. La variabilité spatiale du coefficient de rétrodiffusion, à l'intérieur de chaque classe, est sans doute reliée à la variabilité de la pente et du niveau d'humidité. Enfin cette possibilité d'identifier facilement des thèmes hydrologiques ouvre des champs d'applications multiples pour les données RADARSAT dans le domaine d'étude d'érosion hydrologique.

Evolution morphologique du littoral de Tettouan : apport de l'imagerie radar et optique

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RÉSUMÉ

Le Littoral Nord-Méditerranéen du Maroc, s'étend sur environ 40 Km de côte
entre Sebta et Martil. Celui-ci est considéré comme zone sensible, formée de plages fragiles sur laquelle est implanté des aménagements portuaires et se pratique une grande activité balnéaire. La variation morphologique annuelle et multi-annuelle du trait de côte nécessite un suivi permanent et une cartographie adaptée. La télédétection à travers l'imagerie satellite de haute résolution permet de répondre à certains de ces exigences, par l'utilisation d'imageries Radar (Radarsat), Spot XS et Landsat. L'étude rentre dans le cadre du programme Globesar Maroc qui a bénéficiée de compagne in-situe et de données radar et optique. Des données cartographiques et thématiques est également été prises en considération afin de mettre en évidence les tendances d'évolution.

CHANGE MONITORING FOR ONTARIO -- A STATE OF THE RESOURCES REPORTING METHODOLOGY -- EARTH OBSERVATION DATA SETS PROGRAM PROJECT

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ABSTRACT

The Ontario Ministry of Natural Resources has recently released a business plan that establishes priorities in 5 key areas:

1) Natural Resource Management
2) Crown Land Management
3) Public Safety and Enforcement
4) Parks and Protected Areas
5) Geographic Information

Consistent with all 5 business areas is the requirement for a "State of the Resources" reporting methodology which would consist of the following:

1) A baseline database about the state of the resources at a given time
2) A regular and sustainable monitoring cycle for detecting changes to the resource
3) Sufficient detail for identifying significant changes to various different resource types
4) An assessment of the nature and magnitude of change to an appropriate level of accuracy
5) Information in a comprehensive, timely and cost-efficient manner readily available to our client base

The Ontario Land Cover Database is on such resource that was initially derived from Landsat Thematic Mapper data and now serves the Ministry as an information source that describes the state of the resources at a given time. Orbital earth imaging satellites provide data at a regular and repeatable cycle for detecting changes to the base. Radar data from the RADARSAT satellite may provide sufficient detail at an appropriate level of accuracy in a cost-effective and timely manner.

The objective of the proposal was to develop a "State of the Resources" monitoring methodology for Ontario using the Ontario Land Cover as a reference and use RADARSAT data to detect changes to the Land Cover in a timely, accurate and cost-effective manner. A pilot project was proposed where the monitoring methodology could be developed. An area in Simcoe County immediately north of Metro Toronto was selected. This is an area of dynamic growth where the changes are expected to be extensive.

A complete range of RADARSAT data sets with varying modes and beam positions for the project area have been acquired. This data has been processed and evaluated for change monitoring capability. The feasibility of using RADARSAT for change monitoring will be discussed.

Flood hazard mapping in del plata watershed and it's incorporation to the National Hydrological Warning & Forecast System

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Related to the ***GlobeSAR 2 Project*** it will be analyze and evaluate the effective of RADARSAT images in the field of flood hazard mapping specially in flat areas landscape.

GlobeSAR 2 is planned as a 2-year project involving CCRS,CIDA,IDRC, and several organizations in each participating country, and is being developed to prepare users to use RADARSAT data.

Central and South America countries were invited to participate through host country institutions and governments to presents specific programs related to management and environmental monitoring. Finally, Argentina and this study were included as a part of the ***GlobeSAR 2 Project.***

To carry out this research proposal was selected an area where flood occurs periodically and important cities are located, along the Parana river in Argentine's territory.

RADARSAT and LANDSAT IMAGES, hydrological information (water levels and discharge values), and topographic maps were selected to fulfill the requirement of the investigation.

Remote Sensing technics and GIS methodologies will be implemented to establish the main guidelines to delineate flood hazard mapping thus to evaluate the social and economic effects of the flooding events. The results will be included in the National hydrological Warning & Forecast system of del Plata basin.

Urban and Agricultural Analysis with RADARSAT fine resolution images in the city of Rosario-Argentina, and surrounding agricultural areas.

Principal investigator: Architect Carlos Cotlier[1]

Co-investigators: Architect Mirtha R. Fuentes[2], *Ing. Agronom. Nestor Mori*[3], *Tech. Alejandro Ravenna*[4]

Information concerning urban (big cities including regional level) and agriculture, in countries like Argentina requires nearly continuous acquisition of data to formulate and monitor governmental, provincial and municipal programs. Several of these data needed are well served by satellite image interpretation.

WHAT IS TO BE INVESTIGATED AND EXPECTED RESULTS:

A) Corner reflection in relation of different urban height and density of Rosario dwelling;
B) Urban texture;
C) Geometrical characteristics;
D) Urban pattern by RADARSAT images;
E) Urban and agricultural land cover;
F) Crops identifications by color composite
G) Urban intrusion over agricultural areas;
H) Deforestation;
I) Slum growing areas;

MULTISOURCE AND MULTIDATE SATELLITE DATA FOR CROP DISCRIMINATION AND EARLY ACREAGE ESTIMATION

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ABSTRACT

The main agriculture area of Argentina "the pampcana region" comprises 60 millions of hectares. The winter and summer crops vary their proportion each year due to different reasons. The southeast part of Buenos Aires province was taken as a site of study. Crop inventory in this area and in Argentina in general presents a lot of difficulties because of the extremely complex mix of land uses, land covers and different filed sizes.

The area under study presents one principal winter crop: wheat and four summer crops: corn, sunflower, soybean and potatoes. Pastures alternate each year during the agriculture rotation. Nowadays optical satellite images are using operationally for crop inventories and crop development monitoring. However, Synthetic Aperture Radar of Radarsat satellite offers the opportunity to obtain cloud-free imagery at the appropriate time.

From the perspective of increasing our understanding of the uses and possibilities of SAR data, the agricultural research with GLOBESAR II Argentine Program is focused on the following objectives:

1) To assess the temporal and spectral complementary of Landsat and Radarsat data to improve crop discrimination during the growing season,
2) To analyze the possibility to produce early area estimation certain agricultural crops through their temporal backscatter characteristics.

The methodology to be carried out will emphasize the following point:

- Preprocessing methods of Radarsat standard mode
- Strategies to data fusion of Landsst and Radarsat images for land use and crop identification using close and far dates in the growing season
- Different classification and segmentation techniques (at pixel and parcel level) to crop identification using temporal backscatter profiles

This research would result in a great help to the Argentinean agricultural official authorities and the private sector, assuring the continuity of operational aorecage estimations of agricultural crops.

APPLICATIONS OF THE RADARSAT IMAGE TO EVALUATE AND MONITORING AGRICULTURAL RESOURCES AND FLOODED AREAS

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ABSTRACT

The principal aim of this project is the training in the analysis and interpretation of Radarsat image in interest themes' relation with the productive sector of Buenos Aires Province, Argentina.

The applications will be oriented to the knowledge and evaluation of agricultural resources and flooded areas in cases of state of emergency by climate adverse conditions.

The study area is located in the south-east of Buenos Aires Province, where there are important crops (wheat, sunflower, corn, potatoes). Moreover, this is the principal forestry region in our province.

The thermatic results will be oriented to identify and monitoring water bodies, assess the usefulness of Radarsat images for land use mapping, identification of agricultural areas and pastures, to compare microwave data with optical data and to obtain forest inventory information.

The results will serve to the Ministerio de Asuntos Agrarios for take decisions and tasks of provincial planning.

POLYMETALLIC MINERAL DEPOSITS PROSPECTION IN LAGO FONTANA AREA, CHUBUT PROVINCE, ARGENTINA. RADARSAT/SAR IMAGES AS A TOOL FOR LITHOLOGICAL AND STRUCTURAL ANALYSES.

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ABSTRACT

The Lago Fontana area, located in the South-western par of Chubut province, Argentina, is a good geological target for the search of new polymetallic mineral deposits. The geological and structural mean features of the region are similar to some nearby Chilean districts, where already performed exploration works established very good mining expectations. The Lago Fontana area is geologically placed in the Patagonian Andes, which geological frame includes an intense volcanic activity of Jurassic-Cretaceous age which has several metallic mineralization evidences. Sedimentary clastic episodes are intercalated within the main volcanic event. Hydrothermal mineralizations related to this volcanic-sedimentary sequence have been recognized in the area, such as La Ferrocarrilera, El Finadito, Las Chapas, Susana Y Estrella Gaucha.

The principal aim of the present research is to determine precious metals. (Au-Ag) and polymetallic (Au-Ag-Cu-Zn-Pb) mining targets in the area of Lago Fontana. The first stages of the research project comprise the employment of satellite images for the easier identification of the geological units and the structural features as well as a field checking with an expeditious sampling .This methodology will lead to prepare a 1:50.00 geological-structural map and to make the first select of areas to apply the following steps (geology, geophysics, geochemistry). The goals of the project include to evaluate and make use of RADARSAT/SAT images analysis to complement the information obtained from optical images and aerial photographs in order to identify hydrothermal alteration zones and the possible related structures hosting quartz lodes.

LAND USE AND LAND COVER MONITORING IN THE AGRICULTURE LUJAN RIVER BASIN AREA BY MEANS RADAR DATA

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OBJECTIVES:

The aim of the present project is to determine the potential use of radar data for monitoring of land use and land cover in the Lujan river basin, evaluating the effect of the different incident angles, as well as to compare the use of radar data with other remote sensing systems, as Landsat TM, to evaluate natural resources.

MATERIAL AND METHODS

The studied area is located in the Lujan river basin Northeast of Buenos Aires Province, in the so called "Pradera Pampeana" situated between 58 30' and 59 58' W and 34 50'S, which includes nearly 230 000 hectares.

This is mainly an agriculture area, which carries out different activities, such as: winter crops, specially wheat, summer crops, like corn and soybean and cattle raising.

This area is being studied by means of Landsat TM data , so it will be convenient to evaluate it using other information systems as Radarsat, comparing both of them.

For the development of this project it will be necessary to get data by means of: Operational Beam Mode Standard with Beam Positions S1, S4, and S7; and Fine Positions F1 and F5.

The methods to be used are based on:

- Radiometric and geometric corrections through digital radar data processing
- Special photographic products generation through enhancement image techniques
- Thematic Map generation by radar data supervised classification
- Thematic Map generation by visual interpretation of radar image (Special photographic products)
- Comparison of the results got by means of different methods (visual & digital)
- Comparison of optical and microwave rage data
- Data integration by a Geographic Information System (GIS)

THE CENOZOIC VOLCANISM OF THE PUNA REGION (ARGENTINA) AND ITS RELATED MINERAL POTENTIAL

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ABSTRACT

As part of the thematic cartography that accomplished the Geological and Mining Survey of Argentina is being executed a study of the Puna region (Jujuy, Salta and Catamarca) with special emphasis in the evaluation of its geological and mineral resources.

The geological investigation of border areas with partial financing of CIDA started recently in cooperation with the Geological Surveys of Bolivia, Chile and Peru. Additional works will be undertook in order to study mineral resources liked with the Cenozoic volcanism

The selected areas have a poor economic development whose improvement depends almost exclusively on their mining potential. The new geological information will contribute to their general economic growth.

The use of radar images in this project will provide a significantly advance in the cartography of volcanism sequences and their stratigraphy.

The combined use of radar images and other remote sensing methods, such as airborne geophysics - magnetometry and radiometry - and TM images interpretation will make possible the mining targets' detection and the identification of geological hazards that could impact over economic projects. This will contribute to the programming of infrastructure works.

LAND USE AND LAND COVER MAPPING OF THE ARTIFICIAL IRRIGATED ZONES CULTIVATED IN THE PROVINCES OF SAN JUAN AND MENDOZA IN ARGENTINA

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ABSTRACT

This study is part of the research project "Land use and land cover of the irrigated zones cultivated in the provinces of San Juan and Mendoz in Argentina" included in the GlobeSar2 Program 1997-1998. Here are shown the results obtained after the completion of the first stage where the objectives were :1) evaluation of the look direction for land cover mapping using beam S3 ascending pass and beam S4 descending pass, and 2) evaluation of resolution for land cover mapping using beam Fine 3 and Beam S4.

The importance of this project lies in the development of a methodology which allows to incorporate SAR images to crop discrimination using a multitemporal study (images as to the phenological) cycle of the main crops) and a multi-sensor one, using optical images(Landsat and Spot) to discriminate crop types and conditions.

The area under study is the Central Western Region of Argentina, located at the East of the Precordillera mountain rage, with arid-semiarid climate -- approximately 150 mm annual rainfall regime -- which included zones belonging to the Provinces of San Juan and Mendoza.

The sites test, in Tulum valley of San Juan Province, involves approximately 100,000 ha of cultivated land. The main crop is gravewine and the annual crops of tomatoes, garlic and onions, even when represent a smaller proportion, are important as well.

The irrigation system used are: Furrow and Inundating artificial irrigation (95%) and Pressured irrigation dripping and microsprinkling irrigation (5%).

In previous studies, it was observed that SAR images are sensitive to land roughness and allow to detect those soils which are being prepared for cultivation which should have water driving furrows in the parcels. In addition, it was observed the SAR images allow the detection of grapevine crops using the driving system consisting in "cuyano type" vine arbor of 1.90 m high and separated at a distance of 90 cm each row.

CONTRIBUTION OF LOW RESOLUTION SAR IMAGES TO STUDY THE OCEAN DYNAMICS IN THE SOUTH TROPICAL CONVERGENCE REGION.

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ABSTRACT

The South Atlantic ocean is characterized by two important currents: the Brazil and the Malvinas currents. The Brazil current is an extension of the Atlantic South Equatorial warm currents which divides between latitudes 7 and 17=BAS, depending of the year, and flows southwest parallel to the Brazilian coast.

The Malvinas is a cold current that originates mainly from Cape Horn current in the northern part of the Drake Passage. After passing through a strait, the current sets north bordering Malvinas islands and follows the coast of South America until it joins the Brazil current. The confluence of this two currents, situated near the entrance of La Plata River estuary, is characterized by strong seasonal temperature changes and large spatial fluctuations at the border of the two currents.

The geographic location of the currents confluence is about 24=BAS in May-July and about 36=BAS in February and their variability is very important for different scientific and economic aspects, such us: oceanographic, climatologic and fisheries Due to their importance, the confluence of both currents has been largely studied by different authors with NOAA-AVHRR data. This satellite observes the area four times per day in the visible and near and far infrared. But, during large periods of time the region is covered by clouds, and there are no images free of clouds available.

The objective of this work is to use low resolution SAR images to monitor the area and to determine the possibility of using this data as a complementary information to the AVHRR data, particularly during the cloudy season. To achieve this objective, RADARSAT low resolution images of the indicated area have been required for different times of the year. The first image has just been received, processed and analyzed. This paper presents the results of this processing and also a comparison with AVHRR information of the same region.

Satellite Observations of the Delta of Parana River in Argentina. Possible contributions of Radarsat images.

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ABSTRACT

This work is presented within the frame of Globsar2 projects. It describes the possible contribution of optical and radar satellite data in the study of a large wetland region of Argentina, the Delta of Parana River.

The area is characterized by:

1. It is located very close to major cities such as Buenos Aires
2. It is the only one of the large deltas that forms in an estuary and does not have the direct influence of sea waters
3. The hydrologic regime is mainly determined by the lunar tides of the De La Plara River waters.
4. Natural vegetation communities and forest plantations cover the area
5. It constitutes a mitigation system for flooding produced by Parana and Uruguay rivers.

The possible contribution of optical and radar data to discriminate:

* Natural forest from afforestation
* Different types of afforestation
* Ecotone areas between forest and marshes
* Secondary succession forest (abandoned afforestation) versus active forests is discussed.

The presentation is based in the use of TM and ERS-1 images, and in the potential contribution of Radarsat images.

CONTRIBUTION OF SATELLITE DATA TO THE STUDY OF THE RIO DORADO BASIN IN THE PROVINCE OF SALTA, ARGENTINA

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ABSTRACT

The study of this area is within the frame of the world Bank Project "Native Forests and Protected Areas" which includes the component "National Inventory of Native Forests and Protected areas, and development and management of the Corresponding data Base.". Phase 1 addresses the utilization of optical satellite systems as the basic tool for the tasks defined in the project.

The Rio Dorado basin is located in the Department of Anta, Province of Salta, it has a subtropical climate with a dry season. This region is characterized by a important climatic, topographic and fitogeographic diversity. Satellite images of Landsat/MSS (1984) and of Landsat/TM (1987) have been used to discriminate between different forest types and to determine the forest stand areas. The main goal of this work was to obtained a quali-quantitative analysis about the localization and extension of the natural forest of the region in order to help to the sustainable use of its natural resources. According to topography, natural vegetation types and state of the forests, 12 classes were identified and the corresponding thematic maps obtained.

Due to meteorological conditions (cloud cover), the availability of cloud free images is quite limited. It is expected that SAR images could constitute an interesting alternative to the use of optical bands. This presentation describes the basic characteristics of the region and discusses the potential contribution of RADARSAT images in the development of the National Inventory.

GEOMORPHOLOGY AND LATE CENOZOIC GEOLOGY OF THE NORTHERN SIDE OF TANDILIA RANGE, BUENOS AIRES PROVINCE, ARGENTINA

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ABSTRACT

The study area is located in the southeastern part of Buenos Aires province (38^0 06'S, 57^0 40"W) which belongs to the "pampas Plain" region of Argentina. Tandilia Range is a block-mountain system with altitude reaching 270 m asl. Late Cenozoic sediments cover the intermoutain and plain areas, and sometimes the horizontal summits of the ranges. This Late Cenozoic succession is composed of both depositional facies (loess) and postdepositional facies (paleosols and calcretes). Most of the loess is eolian or reworked silt of volcaniclastic origin derived from the Andean region immediately to the West (about 1100 km length).

The Ranges consist in a group of table-like hills of flat summit. These elevations are composed of subhorizontal quartzite strata of Lower Paleozoic age. The surrounding plain is characterized by a relictic landscape formed by an assemblage of longitudinal and parabolic silty dines and deflation ponds. The parabolic dunes are U or V shaped and they are mainly oriented in an SW-NE direction. A drainage system makes up of short and subparalell streams is superimposed to that landscape. This large stabilized dune field which is now completely vegetated and inactive, must have been active as recently as the last full glacial. Intervals of more active loess transport may be correlated with periods of dune formation. Present climate is characterized by temperate conditions which means annual precipitation of 800 to 900 mm and an annual temperature of about 15^0 C. The soils, mostly Argiudolls, have been intensively managed since of the beginning of last century.

Image analysis techniques appear to be one of the best tool for geomorphological mapping in the area since the main landorms (paleodunes and drainage features) are barely visible on the ground because of their low relative relief and dense grass cover.

The main objective of this project is to generate information to make a model of the present and past geomorphology of the area. In this context, paleoclimatic markers (litofacies, paleosols, calcretes, paleosurfaces, etc.) must be investigated. Moreover, modern dating methods promise a significant resolution of loess stratigraphy and better correlation models.

The knowledge of soil-geomorphology relationship will provide criteria in order to get a better land-use planning as regards specific requirements of a productive system.

Finally, we intent to stablish the climatic oscillation in the region during the Late Cenozoic and correlate glacial and interglacial intervals as well as stadials and interstadials' periods.

Paleoclimatic data will provide accurate information to the understanding of the global change.

RADARSAT Validation Activities for Ocean Applications

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Abstract

RADARSAT, Canada's first satellite for operational environmental monitoring, was successfully launched on November 4, 1995. RADARSAT is a C-band, HH polarized SAR system capable of imaging the earth's surface day or night with a repeat cycle of 24 days. Repeat coverage in shorter time intervals is also possible because of flexible swath-width and imaging modes that are unique to RADARSAT. The key marine applications areas for RADARSAT include ship detection, measurement of ocean wave spectra, wind retrieval, oilspill detection and ocean signatures. Initial validation and calibration work undertaken at CCRS since January, 1996 shows that RADARSAT is well suited to meet operational maritime surveillance requirements.

As part of the validation campaign for RADARSAT, CCRS has initiated quantitative analysis of RADARSAT data from all image modes to assess image quality, to verify application-specific processor scaling functions, and to determine optimum image modes for specific information requirements. The aim of this work is to quantify RADARSAT capabilities and to stimulate early acceptance of RADARSAT data by industry and other government agencies.

In the summer of 1996, a demonstration trial was initiated to assess RADARSAT capabilities for ship detection. Participating government agencies included the Department of Defence (DND), Canadian Coast Guard (CCG), Department of Fisheries and Oceans (DFO), Canadian Space Agency (CSA), and CCRS. The demonstration trial used the Ocean Feature Workstation (OFW) to receive RADARSAT image data from the central processor at the Gatineau Satellite Station for processing into a ship location product. The OFW presently runs on a UNIX SUN workstation but will be ported to an SGI workstation in May, 1997 for faster and more efficient throughput. The OFW was developed by Satlantic Inc. under the Supply and Services Environmental Innovation Program (EIP).

Over 200 images were processed with only 18 images having coincident ship and wind validation data. The OFW successfully detected a range of vessel sizes under low to moderate wind speeds. The smallest identified vessel was 46m and the largest was 280m. The maximum wind speed encountered was 11.2m/s. Dedicated field programs will be undertaken in the summer of 1997 to try and image smaller vessels under higher wind conditions so as to determine experimentally the minimum ship size detectable by RADARSAT for each beam mode, for a range of wind conditions. This will also enable a more complete assessment of the

capability of the OFW to meet the operational needs of DND and the DFO Conservation and Protection Branch.

In addition to the ship trials, validation work on wind retrieval has been on-going. A field program was conducted from January to March 1997 to obtain coincident RADARSAT and in-situ directional wind speed data over the Grand Banks and Labrador Sea. The results of this experiment will be used to refine the current wind retrieval algorithm and an operational version will be implemented on the OFW.

This poster will present the results of the validation campaigns and highlight the marine parameters that may be extracted from the RADARSAT data under a variety of sea states and environmental conditions.

SPATIAL VARIABILITY OF SOIL MOISTURE AND TEXTURE: MAPPING WITH AIRBORNE C-BAND RADAR

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ABSTRACT

C-band airborne SAR (SAR 580) data was acquired on mixed farming sites to study the possibility of using radar data to assist in mapping agricultural soil types. In particular the study focuses on soil moisture and textural properties of the soils in the Woodstock - Florenceville area. Multipolarisation C-band data were acquired in April 1994 at sample areas located on the two principal soil associations in the region. The Caribou Soil Association covers 15 000 ha and has a silt loam texture and 3% organic matter, the Carleton soil Association covers 17 000 ha in the area and has a coarser loam to silt loam texture and 3.5% organic matter on average.

Using detailed field sampling of the volumetric water content and windows centred on the field sample sites, a series of correlation analyses were made to develop empirical relation between the soil moisture and radar backscatter values. In the analysis the variations in land cover conditions (height and density) as well as the relative or apparent roughness was evaluated as ancillary data.

Results showed the strongest significant relationships of backscatter with the soil moisture in the Carleton Soil Association. It was evident that land use and land cover are important contributors to backscatter, however, there was insufficient sampling to determine the full extent of the contribution. Inversion of the model and examination of the resultant soil moisture maps and various percentage intervals (5% to 1%) reveals very subtle differences in the moisture content and therefore in the drainage characteristics of the soils. Further work in progress to compare the soils texture characteristics based on detailed field mapping and the radar data.

CONTRIBUTION ENVISAGEABLE EN MATIERE DE TECHNOLOGIES GÉOMATIQUES ET DE MÉTHODOLOGIES D'AIDE A LA DÉCISION AU SERVICE DE LA CONSERVATION DES EAUX ET DU SOL

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ABSTRACT

La gestion des eaux et du sol et par le fait même l'application des politiques de gestion relatives à ces ressources constituent un difi de taille pour les pays semi-arides, qui font face actuellement à de graves problèmes de désertification d'érosion et de salification. C'est dans ce contexte que le gouvernement Tunisien, en collaboration avec 'École Nationale d'Ingénieurs de Tunis, le Ministère de l'Agriculture de Tunis, le Centre de Recherche en Géomatique de l'université de Laval à Québec et le Centre de Recherche pour le Développement International canadien, cherche à développer des mécanismes et des outils permettant de mieux gérer ces ressources.

Les méthodes de travail existantes de même que les moyens technologiques disponibles actuellement sont cependant mal adaptés à la prise en compte simultanée de ces facteurs.

Le gestionnaire du territoire doit maintenant composer avec des projets qui tentent de concilier, sur une même base territoriale, les préoccupations de gestion de plusieurs intervenants, en tenant compte, à chacun des stades de projets, d'un ensemble de facteurs biophysique et socio-économiques respectant les spécificités régionales. Le constat, à l'heure actuelle, est à l'effet qu'il n'existe pas de structure ni de mode de planification qui permettent de prendre en compte efficacement les préoccupations inhérentes à chacune de ces multiples ressources qui, par essence, visent des objectifs souvent conflictuels. Devant la complexité de la situation, le nombre et la diversité des parties prenantes et la multiplicité des facteurs à considérer, la recherche d'une solution optimale (au sens strict du terme) est illusoire: il faut rechercher la solution de compromis "la plus acceptable" pour l'ensemble des intervenants, ce qui conduit tout naturellement vers une approche de type multicritère, dans une démarche de planification globale, cohérente et intégrée.

Tout au long de cette démarche de planification, on constate que les intervenants ont de plus en plus besoin d'outils non traditionnels capable de répondre à leurs sans cesse grandissants, d'information très variées, fournies sous les formes les plus diverses : les outils dits "multimédia" offrent à ce titre des perspectives intéressantes. La présente contribution décrira les principaux aspects des problématiques abordées, des solutions méthodologiques esquissées, et des moyens techologiques envisagés, le tout illustré par la présentation d'une maquette utilisant des moyens multimédia et hypermédia.

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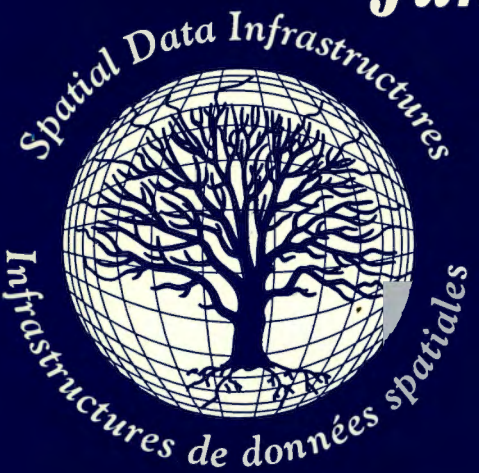

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