SATELLITE INFORMATION FOR LANDCOVER OF CANADA (SILC)

WORKSHOP REPORT

August 14-15, 2000
Ottawa, Ontario

B. Guindon (Editor)

With contributions by

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1. Project Overview

This report describes the major results of a planning meeting for a project entitled 'Satellite Information for Landcover of Canada (SILC). It is a companion document to a series of presentations that are provided separately.

SILC was proposed to NASA in September 1999 as a response to an announcement of opportunity. It was selected in as one of 32 projects under the LCLUC (Land Cover and Land Use Change) Program.

The overall goal of the SILC project is to identify, develop and validate satellite image-based land cover products that can be used to improve our understanding of carbon and hydrological cycles. The six specific objectives are:

1. To develop an objective, robust, operational method for producing forest and other land cover information at the regional level using fine resolution (10-50m) satellite data or daily coarse resolution (200-1000m) satellite coverage.
2. To produce land cover maps over the 1993-2001 period using coarse satellite data.
3. To develop methods for quantifying the content of coarse resolution land cover maps using fine resolution satellite data (10 –50 m) or other information sources.
4. To prepare a database of wetland distribution for Canada using a combination of remotely sensed data and other data types.
5. To obtain statistics for land cover distribution at national, provincial and sub-provincial level using optimum combinations of coarse and fine resolution data.
6. To derive land cover information for creating higher level products and to study surface-atmosphere interactions and the role of land cover in carbon and hydrological cycles.

While forests are the most important vegetation type, the project is concerned with all land cover types and characteristics that occur in Canada.

2. Workshop Objectives

The initial project meeting was designed to review and discuss major research and methodological issues involved in the proposed project. The following workshop objectives were defined:

1. To review project objectives and policy/program drivers for land cover work.
2. To refine objectives for the proposed research and development.
3. To identify specific issues/questions
4. To identify and characterise new data products. To identify new algorithms and data sources that will be needed to support new product development and current product refinement.
5. To develop plans for quantitative validation of existing and proposed products.
6. To prepare a program schedule including milestones and task assignments.

3. Information requirements and methodological issues

3.1 Information requirements

3.1.1 Forest inventory and sustainable development

The mission of the Canadian Forest Service (CFS) is ‘to promote the sustainable development of Canada’s forests and competitiveness of the Canadian forest sector for the well-being of present and future generation of Canadians’. Land-cover remote sensing provides a synoptic and repeatable means of monitoring of Canada’s forest s over time. Currently, the CFS has the mandate to produce the National Forest Inventory (NFI) for Canada. To accomplish this goal, provincial inventory statistics are harmonize and reported upon nationally. Remotely sensed data is used in the context of the NFI to aid in the inventory of remote locations. Canadian Space Agency funding has been secured to enable a partnership with the CFS to develop a space-based forest monitoring system, operating with fine spatial resolution satellite data, called Earth Observation for Sustainable Development of Forests (EOSD). With this system we will be able to produce full satellite coverages representing different time periods, or use the imagery to sample and report upon Canada by region of interest. The forest monitoring system developed for EOSD will aid the NFI by providing data to enhance the inventory. As EOSD is concentrating on fine spatial resolution satellite data, synergy with coarse spatial resolution land-cover products is highly desirable. For instance, use of complementary land-cover legends will aid in reporting and scaling. Additionally, holes in the Landsat coverage may arise and could be compensated for using coarse resolution coverage. The high temporal coverage available with coarse resolution remote sensing may also aid in the quality of fine spatial resolution products. The key drivers for fine spatial resolution land-cover mapping are the NFI, Kyoto Protocol reporting and C and I reporting (local level and certification at the national level).

More detail is provided in M. Wulder’s presentation.

3.1.2 Carbon budget modelling

The major land cover requirements for carbon budget modelling are:
Species composition and its changes (every ~ 5 years), resolution 30 – 1000 m
Age class or height and changes, resolution 30 – 1000 m
Land cover transformation/transition, resolution 30 – 1000 m
Afforestation, reforestation, and deforestation areas, 5-30 m.
More detail is provided in W. Chen’s presentation.

3.1.3 UN FCCC reporting

A key issue involves meeting the reporting challenges under the United Nations’ Framework Convention on Climate Change (UNFCCC) and its Kyoto Protocol in the land-use, land-use change and forestry sector. Current limitations include (a) incomplete activity data, (b) the existence of several carbon pools that are unaccounted for, (c) information that is not spatially explicit and (d) inadequate spatial and temporal tracking of land-use and land-use change. Initial national land cover information is required at 1-km resolution with updates approximately every 5 years. There are a number of specific years of interest (1990, 2008 and 2013). Wetland characterisation is also of particular importance since wetlands account for more than 50% of Canada’s terrestrial C storage (150 Gtons). Descriptors of interest include (a) non-peatlands vs.

peat-accumulating wetlands, (b) wetland type (bogs, fens, marshes, swamps, shallow water), (c) surface cover/use (e.g. forest, grassland, tundra, etc.).

For Kyoto reporting, an information system is required to track, store and report on spatially explicit information on past and current changes in C-stocks of specific parts of the forest land-cover. Its components should include data acquisition (from remote sensing, inventories, flux towers and ground measurements); land use activity reporting storage and modelling; parameter databases; and reporting and verification tools. Current reporting systems will need significant enhancements to address Kyoto reporting needs. Until the detailed requirements for Kyoto reporting are defined, focus should be placed on more accurate national reporting to UNFCCC.

More detail is provided in D. Blain's presentation.

3.1.4 Canadian environmental statistics

Statistics Canada's Environment & Natural Resource Accounting initiative involves maintaining a System of National Accounts (SNA). Among these are Environment and Resource Accounts which are dealt with by the Environment Accounts and Statistics Division. Statistics on land cover and land cover changes are a very important part of reporting on Land Accounts which have five layers (physical infrastructure, land cover, land use, land potential, land value). The Land Account is currently compiled at 1:1million scale. Regarding land cover change, ideally a land cover transition matrix is needed.

The land cover information is used to report on stocks of Canada's natural resources and for the development of environment-economy indicators and SD indicators. If a land cover change matrix were available, it would also be used to meet an OECD reporting requirement.

More detail is provided in D. Trant's presentation

3.2 Methodologies

The following presentations on methodological topics were made:

J. Beaubien, ' ECM: Enhancement-Classification Method and Results'.

R. Fernandes, ' Satellite-Based Land Cover Mapping of Wetlands'.
' MODIS Data Status'.
' TM Data Status'.

R. Fraser, ' Burnt Area Mapping Across Canada'.
' Review of Sub-Pixel Land Cover Classification'.
' Proposed Strategy for Sub-Pixel Land Cover Classification over Canadian Boreal Forests'.

R. Latifovic, ' Land Cover Characterisation and Change Detection for Environmental Monitoring of Canada'.

B. Guindon, ' Processing Issues Related to Fine Scale Land Cover Mapping'.

M. Wulder, 'Land Cover Information Requirements: Sustainable Development/C&I/NFI'

These presentations are provided as separate documents in digital form (??reference, link?).

4. Existing Products and Methodological Issues for Product Improvements and Actions

The objectives listed in Section 1 are to be met through the development of a series of national and regional products. These products are listed in Table 1 along with a summary of their broad characteristics. Some products, primarily those at coarse resolutions, currently exist and planned activities associated with them emphasize refinement and validation. At fine scales, product development is currently immature and hence more fundamental issues related to classification strategies and multi-scene integration are to be addressed.

Table 1: Summary of major product types and their characteristics[1]

Product	Classification legend[3]	Source imagery	Pre-processing methodology	Classification strategy	Validation
A- Coarse	Hard	VGT 1998 (+2000)	ABC3V2[2]	ECM/CPGcs	TM
B- Coarse	Fractions	VGT 1998 (+1999)	ABC3V2	New	TM
C- Coarse	Wetlands	MODIS, perhaps +JERS-1; wetlands data base	TBD	TBD (blended product)	Air photos, TM, maps
D- Coarse	Fuzzy	MODIS500+250m	ABC3V2	New (see above)	TM
E- Coarse	Cover change	AVHRR/VGT	TBD	TBD	TM, field
F- Fine (scaling)	Hard/scale hierarchical or continuous fields (GOFC)	TM	TBD (Radiom.correction +intra-scene normalisation)	ECM/CPGcs or MFM-5scale?	Maps, field
G- Fine (mosaic)	MRLC/land cover change	MSS/TM	TBD (Radiom.correction +intra-scene normalisation)	TBD	Maps, field

1) LEGEND:

2) ABC3V2: Coarse data calibration processing (Cihlar et al., 1997, in prep.)

3) Classification legend:

Hard: conventional approach where a single class label is assigned to each pixel, presumably corresponding to the dominant cover type.

Fractions: approach to estimate class proportions within a pixel (i.e. pixel 'un-mixing').

Scaling/continuous fields: physical modelling approach to classification involving matching observed reflectances to predicted values for a range of surface parameters. The goal is to retrieve a parametric description of terrain (e.g. in a forested area this might include specie, percent cover, under-story characteristics, etc.). This approach is compatible with the classification legend proposed for GOFC (Appendix 2; Ahern, 2000).

A summary of the detailed discussion of each product type is presented below.

Product A:

This product will replace the existing reference product, the Land Cover of Canada based on 1995 AVHRR data (Cihlar et al., 1997). Classification is to be undertaken with the 1998 VGT composites using the same approach as previously (with the 1995 AVHRR data) to derive national land cover. A 45-class set will be employed. The result will be compared with the 1995 product. Accuracy assessment will be conducted using a set of representative TM scenes.

In addition, there is a tentative agreement that SILC will contribute to the Millennium Assessment Project <http://www.ma-secretariat.org/> through the VEGA 2000 initiative <http://sirius-ci.cst.cnes.fr:8080/vgtprep/000526AO.html>. This global mapping exercise will be carried out for the year 2000.

Follow-up: Beaubien, Latifovic

Products B, D:

The principal direction of future research in this area will be in the development of new methods to infer class fractions within the 'coarse' pixels. Early work in the development and assessment of fuzzy classifiers and neural networks has been undertaken and will be built upon. The development of a consistent class set for VGT and MODIS was discussed but further study is needed, especially if consistency is to be extended to fine resolutions as well.

MODIS presents further challenges since the team has limited experience working with this data type. Of particular interest are the daily reflectance images and the 16-day composites. Products have tagged geo-locations and have to be converted to conventional raster. Classification testing is to be carried out with a range of MODIS products to select an optimum spatial resolution mode.

Follow-up: Fraser, Fernandes, Latifovic

Product C:

The purpose of this product is to provide a map of the spatial distribution of wetland types across Canada. The criteria are that the map provide as much spatial detail as feasible with the existing data, and that it be produced within 1-2 years. The starting point of this activity is a 1:1 M scale map of wetlands which is being compiled from existing cartographic information in a separate project led by C. Tarnocai (Cihlar and Tarnocai, 2000). The objective in this product is to refine the map based on satellite image interpretations both to improve delineation of boundaries of existing map wetland areas and to identify small-scale wetland features not currently captured. A number of approaches were discussed including: (a) blending the existing map with coarse land cover products and ancillary data (e.g. StatsCan census and land account polygons) within a rules-based classification scheme, (b) using 'local' training of TM imagery on known wetlands to locate spectrally similar small scale features, and (c) combining the 1:1 M map with the land cover map of Canada derived from AVHRR or VGT. Validation will be undertaken with human interpretations of TM imagery or aerial photography, and possibly also the use of detailed wetland maps from specific projects.

Follow-up: Fernandes, Tarnocai

Product E:

This product will portray changes in land cover that have taken place across the Canadian landmass during the satellite observation period. Preliminary change detection testing has been carried out AVHRR composites. The near-future challenges include validating 'major' changes, understanding the nature of the more subtle changes with a view to estimating confidence limits for setting change/no change thresholds. Besides observed 'local', abrupt changes (e.g. those due to fires), there appear to be subtle large-scale regional changes or trends. These are potentially of great interest but need further investigation. Once the methodologies are completed, products showing changes over various periods will be produced and validated (primarily using TM imagery).

Follow-up: Latifovic, Fernandes

Product F:

This product is based on high resolution satellite data, typically TM, produced in support of coarse resolution product generation or validation. These could consist of isolated scenes or mosaics of adjacent scenes. Previously, hard classification approaches have been developed that are ready for routine use (ECM, Beaubien et al., 1999; CPGcs, Cihlar et al., 2000). However, continuous fields are of great interest and will be the principal product for GOFC (GOFC Design Team, 1999). An initial progress in this direction has been made by using reflectance model simulations of cover type response to label spectral clusters over a limited area of a TM sub-scene (Peddle et al., 2000).

The processing implications of a model-based classification for large area (i.e. multi-scene) mapping were discussed. Classifying mosaics rather than a set of distinct scenes is attractive from a computational efficiency point of view; however model-based labelling puts much more stringent requirements on mosaic radiometric fidelity than conventional 'empirical' radiometric normalization. First it is imperative that within-scene variations in atmospheric haze be suppressed without compromising effects such as BRDF. With the exception of a few papers (e.g. Richter, 1996), there is very little work in the atmospheric literature that is of practical use and further research is needed. Second, there can be significant differences in acquisition dates among scenes comprising a mosaic which in turn can impact both spectral cluster characteristics as well as model-based reflectance prediction. In effect, one has to take into account scene lineage within the mosaic and this brings into question the need for creating the mosaic in the first place other than eliminating redundant coverage. Research should be done to assess the level of inter-scene radiometric variability due to atmospheric effects but that decisions on the strategy for radiometric normalization await the 5-scale sensitivity test results.

Methods will be investigated to correct for spatially-varying haze within scenes beginning with an analysis of Richter's (Richter, 1996) methodology. The conventional approach to large area mapping (e.g. the US Multi-Resolution Land Cover mapping program, MRLC) involves first mosaicking scenes together then classifying the mosaic as a single entity. Given the stringent radiometric requirements, it is doubtful that this approach is applicable if modelled classes exhibit significant seasonal variations in reflectance. Decisions on an overall processing flow require a clear definition of the class set and its parametric descriptors and the significance of temporal influences.

Follow-up: Guindon, Peddle, Du

Product G:

This product represents land cover maps of large areas produced from multiple, adjoining high resolution images. It is being developed within the context of a joint project with the US EPA to derive synoptic land cover of the Great Lakes basin using archival Landsat MSS imagery. The principal processing issues to be addressed include utilisation of inter-scene overlap regions to improve classification, quantification of the spatial variations in product accuracy, and intra-scene radiometric normalisation. A 'hard' classification approach is being employed. The class set will be compatible with the legends used for other hard products.

Follow-up: Guindon

5. Other Issues and Actions

5.1 Classification Legend(s)

This is a critical issue that was discussed but requires further serious consideration. An 'ideal' legend should meet the following criteria:

(a) Provides necessary information layers to support carbon and hydrological modelling requirements of in-house and external clients (e.g. StatsCan, Environment Canada, CFS, GOFC, etc.).
(b) Provides consistency across spatial resolution regimes (e.g. a nested hierarchy).
(c) Provides consistency across labelling regimes (i.e. hard vs. continuous fields).

The way forward involves a comparison of existing legends (for coarse and fine resolution products) with those proposed for NFIS and GOFC.

Follow-up: Cihlar, Beaubien, Wulder, Trant, Blain, Chen, Latifovic

5.2 Validation

(a) Participants agreed that the selection of high resolution scenes for supporting the coarse resolution product development should be based on the Purposive Selection Algorithm (Cihlar et al., 2000a, b). It was noted, however, that the TM scene subset selected by applying PSA within each of the 15 ecological zones exhibits some regional gaps, especially in the high Arctic and Quebec. New scenes (one from each of these regions) have been identified and ordered and will be added to the current complement bringing the national total to about 34 scenes a number which is near the limit of processing feasibility.

Action: Fernandes, Beaubien, others (TBD)

(b) Validation requires precise alignment of the TM scenes within national coarse composites. An approach, based on image correlation matching, will be developed.

Action: Latifovic

(c) Once registration is complete, the TM scenes will be classified and labelled using a suite of 10-15 classes. JB will do quality check and accuracy assessment of these products.

Follow-up: Latifovic, Beaubien, others (TBD)

5.3 Insect Damage

An investigation is to be undertaken to determine if coarse resolution data can be used to detect damage due to spruce budworm. Change detection analyses are to be conducted on coarse products such as LAI. CFS test sites in B.C. are to be used.

Follow-up: Latifovic, Wulder, Fraser

5.4 Model-Based Classification

Since D. Peddle was not able to attend the workshop, a separate discussion involving him and several workshop participants took place on the occasion of the 21st Canadian Symposium on Remote Sensing in Victoria, BC in late August, 2000.

1. D. Peddle demonstrated the MFM-5Scale software. The command line version was demonstrated although a window's version with the same functionality exists. The demonstration included an example of parameterising a MFM run for 5-Scale, and execution of MFM-5-Scale in forward mode to build up a look-up-table. There was insufficient time to demonstrate an inversion example.

2. D. Peddle described the approach for matching forward model trajectories and observed reflectances. Essentially, there are three cases:
   i. No matches – currently the solution here is to increase the range or resolution of 5-Scale parameters to attempt to populate the look up table to ensure matches. A large number of no match cases may indicate errors in parameters or land cover not considered in the 5-Scale conceptual model.
   ii. Single match – here the observed reflectance matches one of the many MFM forward modelled reflectances. In this case MFM identifies a key in a database containing records consisting of 5-Scale inputs and forward modelled reflectances.
   iii. Multiple matches – here the observed reflectance matches two or more MFM forward modelled reflectances. In this case MFM identifies a key to each match. Multiple matches often occur within the same land-cover class and can also be dealt with based on frequency of occurrence, spatial context and by measures of central tendency applied to derived physical values. The observation can be considered a mixed pixel if the context of the matched MFM runs applied.

   D. Peddle reported that more than two matches are very rare although it was also suggested that this was a function of the discreteness of the look up table in terms of reflectance intervals.

3. The issue of calibration of images or the modelled LUT in the face of errors in estimated reflectances was discussed in some detail. One suggestion was to run MFM-5-Scale in forward mode over known targets and adjust MFM reflectances to ensure a matching inversion (i.e. training MFM-5-Scale). The effectiveness of this approach lies in the variability in land surface reflectances between the calibration and classification data sets. It was agreed that the Boreas mosaic would be a good test whereby MFM-5-Scale could be calibrated in one TM scene and applied to other scenes.

4. The issue of spatial scale and mixing was also discussed. Essentially, it may be the case that a "pure" land cover class (e.g. LAI 2 wet conifer) will have the same reflectance as a mixed class (e.g. bare ground over 50% of a pixel and LAI 5 wet conifer over the other 50%). In this case the inversion algorithm will report a match for the first land cover and not the mixture since an explicitly mixed class will not be used in training. Once again, working with the Boreas mosaic can help us quantify this problem and determine if MFM-5-Scale needs to include trajectories of explicitly mixed classes.

The model-based approach has implications for input data quality, pre-processing, and other aspects. They include:

Extending 5-Scale to encompass 4 axes: leaf type, crown density, canopy height and fraction or woody vegetation and under-story. If the model is to be used for a broader class set than coniferous forests, seasonal variability in reflectance needs to be taken into account.

It is imperative that an extensive sensitivity analysis be undertaken of these parameters taking into account the effects of the radiometric resolutions of the TM sensor bands in conjunction with the limiting scan angle geometry. This would in turn determine the suitable parameter quantization levels and provide insight into inter-parameter/inter-class ambiguities.

Additional activities are needed to validate the interpretation of observed TM spectral response. For example, one might take 1:25000 aerial photos of test areas and, based on visual interpretation, derive model estimates on a fine scale (e.g. 5m x 5m cells). The model could then be run to predict 5m pixel reflectances which in turn could be convolved with the TM IFOV to generate spectral surfaces. These surfaces could then be directly compared with corresponding real TM coverage. Activities involving the converse process (i.e. real spectral surface to model parameter distribution) are also required.

If one of the long term goals is to attempt to quantify 'historic' burn activity based on archival satellite data (e.g. GEOCOVER MSS scenes from the 70's), it would be of interest to develop temporal-spectral profiles for re-generation scenarios. These might then be useful in estimating characteristics of burn areas observed in imagery within the context of the image-model spectral space matching methodology.

Follow-up: Peddle, Guindon, Fernandes, Cihlar

6. Detailed List of Milestones

A detailed list of proposed milestones is presented below.

6.1 Classification Legends

6.1.1 Review (a) user needs and (b) the existing legends in use by CFS, CCRS, NASA and GOFC to come up with a schema that can be used over a range of spatial resolutions, generalizations and LC/LU applications (March 2001).

6.1.2 Using a selected set of images, assess the performance of a range of image data types in the identification of classes at the proposed legend levels. Update the performance results throughout the course of the project as new products are generated (September 2002).

6.2 Coarse Land Cover Classification and Validation

6.2.1 Identify a set of representative TM scenes, approximately 45 in number, and procure these from NASA and CCRS archives (completed).

6.2.2 Complete fuzzy classification analyses for the BOREAS region (December 2000).

6.2.3 Develop and apply a robust method to accurately register full TM scenes to local portions of coarse composites. A registration accuracy of 200m should be sought (March 2001).

6.2.4 Generate classifications for the set of TM scenes using methods such as ECM and CPG (June 2001).

6.2.5 Generate VGT fuzzy classifications for all of Canada, stratified by ecozone (November 2001).

6.2.6 Generalize TM classifications to coarse resolution scales and undertake a statistical assessment of the accuracy of the coarse resolution land cover product(s) (December 2001).

6.2.7 Generate fraction estimates from co-registered TM scenes for a range of classification levels (e.g. land-water, fraction forest cover, etc.). Use a subset of scenes for training. Generate national fraction products. Assess product accuracy using the remaining TM scenes. Compare percent forest results with the De Fries global product (March 2002).

6.2.8 Complete implementation of an operational system for fractions classification (June 2002).

6.2.9 Generate provincial/regional statistics (September 2002).

6.3 MODIS Processing

6.3.1 Receive and archive Level 3 500m data and 250m reflectance data for Canada (on-going).

6.3.2 Develop and test a method for BRDF correction of MODIS (December 2000).

6.3.3 Create a national MODIS composite (500m data) (April 2001).

6.4 National Wetlands Mapping

6.4.1 Prepare a national wetlands database at 1:1M scale from existing sources of information (January 2001).

6.4.2 Select those TM scenes that encompass a representative sampe of wetland types. Develop methodologies to utilize the database as a form of rudimentary training to assess the spectral uniqueness of local wetlands. In cases where wetlands appear to be spectrally distinct, develop and apply methods to improve the delineation of existing database features and to detect wetland candidate areas that are below the MMU of the database. Assess the results of these operations using visual interpretations of high resolution satellite images and aerial photography (April 2001).

6.5 Fine Scale Land Cover Mapping

6.5.1 Develop a processing methodology and proto-type system to generate seamless synoptic land cover maps from individually classified scenes (March 2001).

6.5.2 Develop accuracy assessment methods and tools to characterize intra-product accuracy variations based on analyses of classification results in scene-to-scene overlap regions (March 2001).

6.5.3 Produce Landsat TM classifications of representative scenes using fuzzy classification techniques (May 2001).

6.5.4 Generate a synoptic land cover map of the Great Lakes watershed using early 90’s Landsat MSS data (March 2001).

6.5.5 Generate similar maps using MSS imagery from the mid 70’s and mid 80’s epochs (March 2002).

6.6 Model-Based Image Classification

6.6.1 Develop a robust method for haze removal from fine resolution imagery that is image-based. Determine its effectiveness as a pre-processing step in the creation of radiometrically-controlled iamge mosaics (March 2001).

6.6.2 Undertake sensitivity analyses to assess the effects of sensor limitations, atmospheric contamination and seasonal variations on class separability and modelling resolution limits (June 2001).

6.6.3 Extend the model reflectance databases to include seasonal and non-forest factors. Undertake test classifications of the BOREAS mosaic and representative TM scenes of Quebec and western Canadian forest regions (June 2001).

7. References

Ahern, F. 2000. Global Observation of Forest Cover: Synopsis of the Project and its Proposed Products for Carbon Budget Modeling. In: Cihlar, J., Denning, A.S., and Gosz, J. (Eds), Global terrestrial carbon observation: requirements, present status, and next steps; Report of a Synthesis Workshop, 8-11 February 200, Ottawa, Canada: 94-99.

Beaubien, J., Cihlar, J., Simard, G., and Latifovic, R., 1999. Land cover from multiple Thematic Mapper scenes using a new enhancement - classification methodology. Journal of Geophysical Research 104 (D22): 27909-27920.

Cihlar, J., Ly, H., Li, Z., Chen, J., Pokrant, H., and Huang. F., 1997. Multitemporal, multichannel AVHRR data sets for land biosphere studies: artifacts and corrections. Remote Sensing of Environment 60: 35-57.

Cihlar, J., Latifovic, R., and Beaubien, J. 2000. A comparison of clustering strategies for unsupervised classification. Canadian Journal for Remote Sensing (accepted).

Cihlar J. , Tarnocai C. 2000. Wetlands of Canada and Climate Change: Observation Strategy and Baseline Data. Report of a Workshop, Ottawa, Ontario, 24-25 January. 67 p.

Cihlar, J., Latifovic, R., Chen, J., Trishchenko, A., Li, Z., Du, Y., and Guindon, B. Systematic corrections of AVHRR image composites data for temporal applications. In preparation.

Cihlar, J., Latifovic, R., Chen, J., Beaubien, J., and Li, Z. 2000. Selecting representative high resolution sample images for land cover studies. Part 1. Methodology. Remote Sensing of Environment 71: 26-42.

Cihlar, J., R. Latifovic, J. M. Chen, J. Beaubien, Z. Li, 2000. Selecting representative high resolution sample images for land cover studies. Part 2: application to estimating land cover composition. Remote Sensing of Environment 72: 127-138.

GOFC Design Team. 1999. A strategy for global observation of forest cover. Version 1.2. 50p. Available at http://www.gofc.org/gofc/docs.html

Peddle, D., R.L. Johnson, J. Cihlar, S.G. Leblanc, and J.M. Chen. MFM-5-Scale: A Physically-Based Inversion Modeling Approach for Unsupervised Cluster Labeling and Independent Landcover Classification and Description. Proceedings of the 21st Canadian Remote Sensing Symposium, Victoria, B.C. 12p.

Richter, R.. Atmospheric correction of satellite data with haze removal including a haze/clear transition region. Computers and Geosciences 22: 675-681.

Boreal Land Information Survey from Space

Project Kick-Off meeting

Dates:
August 14-15, 2000

Venue:
Room 301
Canada Centre for Remote Sensing
588 Booth Street
Ottawa, ON
K1A 0Y7

OBJECTIVES:

The goals of this 2-day meeting are:

1. To review objectives and policy/program drivers for the land cover work
2. To review and refine objectives of the proposed research and development
3. To identify specific issues/questions we must answer to meet the proposed objectives
4. To identify new data products to be generated
5. To identify algorithms and data sources to be used/developed/refined
6. To develop validation plans for the data products
7. To agree on tasks, assignments, schedule

DRAFT AGENDA

DAY 1:
08:30

1. (10') Workshop introduction and objectives J. Cihlar

1. (4x15') Land cover information requirements
   - 1.1 Carbon budget studies W. Chen
   - 1.2 Challenges of Kyoto reporting D. Blain
   - 1.3 State of Canada's environment D. Trant
   - 1.4 Sustainable development/ C&I M. Wulder

2. (15') Project review J. Cihlar

3. (6x20') Existing satellite-derived products for Canada: products, methods, strengths, weaknesses

3.1 Coarse scale	R. Latifovic, R. Fraser, C. Tarnocai
3.2 Fine scale	J. Beaubien, D. Peddle, M. Wulder

Lunch: (60')

4. SATELLITE-BASED STRATEGY for developing new products: discussion with introductory presentations

4.1 LAND COVER

4.1.1 (6x20') Data pre-processing, classification/analysis, and validation strategy:

- Fine resolution — B. Guindon, M. Wulder, D. Peddle
- Coarse resolution — R. Fraser
- Wetlands — R. Fernandes

4.1.2 (150') End-to-end methods and products generation (discussion): coarse

Input data — All

- Tasks, responsibilities, plans — All

DAY 2:
0830:

4.1.2 (150') End-to-end methods and products generation (discussion): fine

- Input data — All
- Tasks, responsibilities, plans — All

4.2 LAND COVER CHANGE

4.2.1 (90') Change Detection Review — R. Latifovic, R. Fernandes

4.2.2 (60') Product generation (discussion):

- Input data — All
- Tasks, responsibilities, plans — All

5. (60') Action plan, tasks, AOB — J. Cihlar

Appendix: GOFC classification scheme

Table 3. Revised GOFC Land and Forest Cover Classification Scheme*

Land Cover		• Compatible with highest level of FAO Africover classification • More detail will be needed if GOFC expands to include all vegetation			
Water					
Snow and Ice					
Barren or sparsely vegetated					
Built-up					
Croplands					
Grasslands					
Forest	**Class name**	**Continuous field variable**	**Variable Range**	**Initial Accuracy**	**Ultimate Accuracy**
	Leaf type	Broadleaf/needle-leaf ratio	0 – 100%	~ 25%	~10%
	Leaf longevity	Evergreen/deciduous ratio	0 – 100%	~ 25%	~10%
	Canopy cover	% canopy cover	0 – 100%	~ 25%	~10%
	Canopy height	height	0 – 100 m	~ 3 m	~ 1 m
Forest special theme: flooded forest					
Spatial resolution: 1 km → 250 m (coarse) and 25 m (fine)					
Update cycle: 5 years * coarse, all land area * fine, "priority" areas ("priority" to be defined)					

Table 5. Revised Forest Change Classes (unofficial)*

	Coarse	**Fine**
Resolution	1 km initially 250 m as soon as possible	~25 m
Cycle	Annual wall-to-wall	5 year wall-to-wall 20% - 30% annual
Classes	"Significant" change in one or more continuous field variables ("significant" to be defined)	"Significant" change in one or more continuous field variables ("significant" to be defined)
Special Products	Burned forest	Fragmentation Forest change occurrence

* From: Ahern (2000)