Canada

THE CANADA CENTRE FOR REMOTE SENSING

Energy, Mines and Resources Canada
Énergie, Mines et Ressources Canada

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LANDSAT MSS image with nominal 80 m resolution, from July 3, 1981, covering an area of 185 km by 185 km, including much of Prince Edward Island. This type of image can be used to study cropland distribution, general land use and regional geography.

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Remote sensing is the observation of the earth and its resources from a distance. It is a space age answer to longstanding problems in natural resources management — problems that are particularly challenging to a country like Canada. The challenge, inherent in the vastness of the country, has increased with population growth, industrialization and northern development.

With the possibilities offered by remote sensing for surveying and monitoring these vast and largely uninhabited areas, it is not surprising that Canada has embarked on an ambitious remote sensing program. The Canada Centre for Remote Sensing (CCRS), a branch of Energy, Mines and Resources Canada, is the central agency in the nationwide remote sensing program. A major objective of the program is to ensure that available data and facilities are used to Canada's maximum benefit.

Through the endeavours of CCRS, Canadians are receiving, processing, distributing and using data from satellites and from specially equipped aircraft. Facilities are available at CCRS for computer analysis and enhancement of these remotely sensed data.

Consulting, data analysis and data interpretation services, airborne data acquisition facilities and satellite and airborne data are available on a countrywide basis, either directly from CCRS or from its contracting firms.

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WHAT IS REMOTE SENSING?

Earth observation satellites and airborne data collection systems are elements of remote sensing technology, and allow us to observe and measure our environment from a distance.

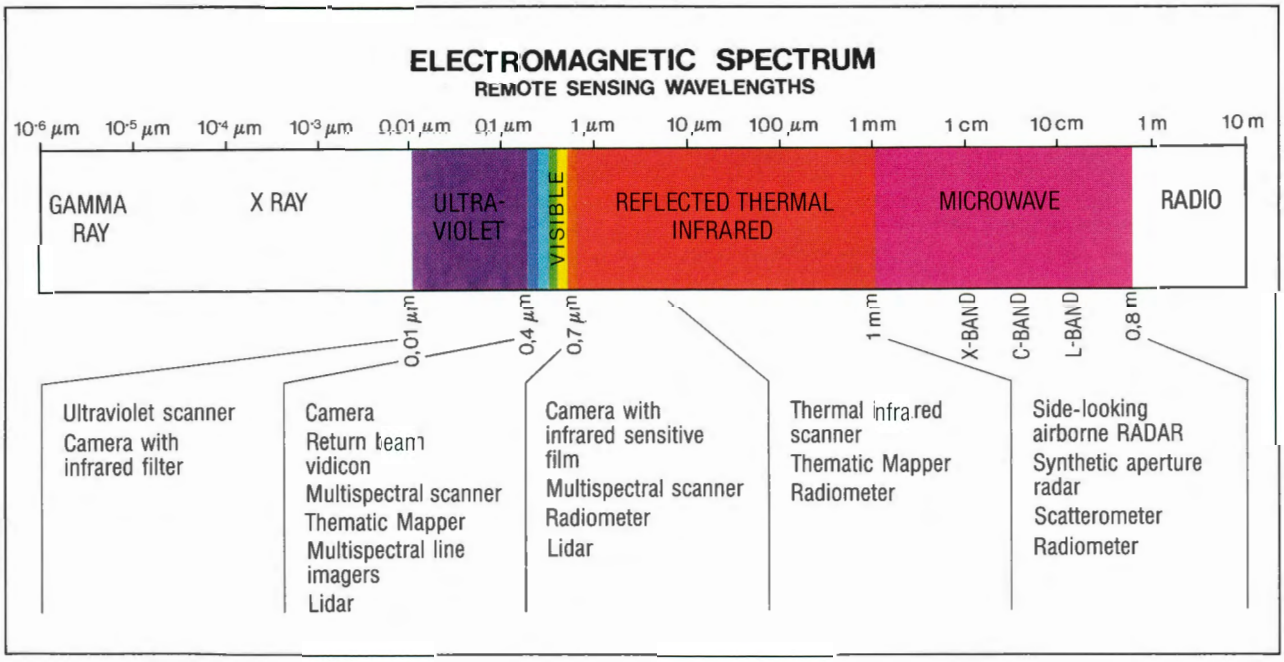
The eye is sensitive only to a very small portion of the electromagnetic spectrum, the 'visible' region. Cameras are sensors that operate in the visible region and produce a permanent record of what the eye sees. Other sensors have been developed that can 'see' in those parts of the spectrum that lie above the visible region (the ultraviolet region) and below the visible region (the infrared and microwave regions). Special photographic films, sensitive to the near infrared region; infrared scanners, which can record the temperature of an object at a distance; and radar devices, which can see through clouds, are examples of sensors that operate in the nonvisible portions of the spectrum.

Satellite data provide a broad perspective and repeated observations that cannot easily be achieved by other means. For example, one satellite image of Baffin Island covers 34 000 km² of a remote area. To obtain comparable coverage by aircraft would require many hours of flying time and the assembly of approximately 100 separate images. Some would be taken at times significantly different from others so that, because of varying light, cloud cover and perspectives, one part of the mosaic could not be accurately compared with another.

On the other hand, satellite data have the disadvantage of lower resolution (the ability to 'see' detail) than aircraft data. In addition, at times data may be required more frequently than is available from the fixed cycle of a satellite. When fine detail and frequent observation are required, airborne data must be used, either alone or as a supplement to satellite data.

To gain maximum benefit from vast quantities of remote sensing data collected by satellite and aircraft, ordinary visual methods of interpreting photos must be supplemented by automated methods that can handle masses of data in a fast, accurate and repeatable way.

Interesting exploratory projects are continually being conducted at CCRS in order to discover new and better methods of collecting, analyzing and applying remotely sensed data.



August 1975 LANDSAT MSS image of Baffin Island. It can be used to evaluate and map the coastal tundra wetland area, which is important for bird nesting. Sediment being carried into the Foxe Basin is evident.

THE CENTRE

Remote sensing is being applied in Canada to help manage our resources and monitor environmental changes. To further the development and use of this technology the Canada Centre for Remote Sensing was established in 1972 as the central element in a national program on remote sensing.

To help ensure that Canada's remote sensing program is truly interdepartmental and national, the following two advisory committees have been established:

The Interagency Committee on Remote Sensing is the senior coordinating body for the national program on remote sensing. It is chaired by the Assistant Deputy Minister, Research and Technology Sector, Energy, Mines and Resources Canada, and it has members, at the assistant deputy minister level, from interested Government of Canada departments and agencies. It advises on policy and financial matters.

The Canadian Advisory Committee on Remote Sensing consists of representatives from each province and the two territories, the chairpersons of some 12 applications and technology-oriented working groups, the heads of specialty centres and representatives from certain other organizations. Several provinces have set up provincial or regional remote sensing centres with full-time staff; other provinces have representatives to coordinate activities within the province and act as a liaison with CCRS.

The activities of the Centre can be divided into five categories:

Applications. New uses for remote sensing data are developed and demonstrated. Projects are undertaken in cooperation with users.

Satellite Operations. Satellite data are received, processed and distributed.

Airborne Operations. Three specially equipped aircraft are operated for Canadian scientific investigators.

Research and Development. New data analysis methods, new sensors and data acquisition systems are developed.

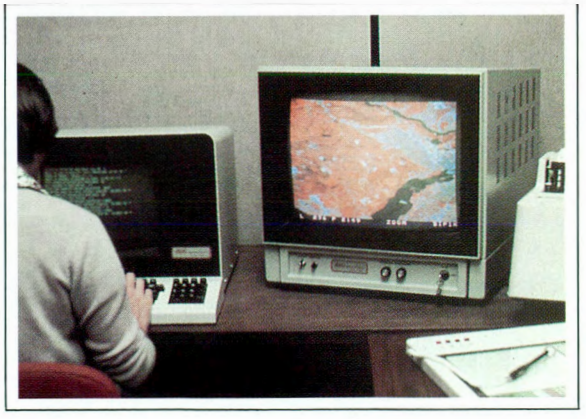
User Services. Facilities and technical information are made available to the user on a routine basis.

Applications

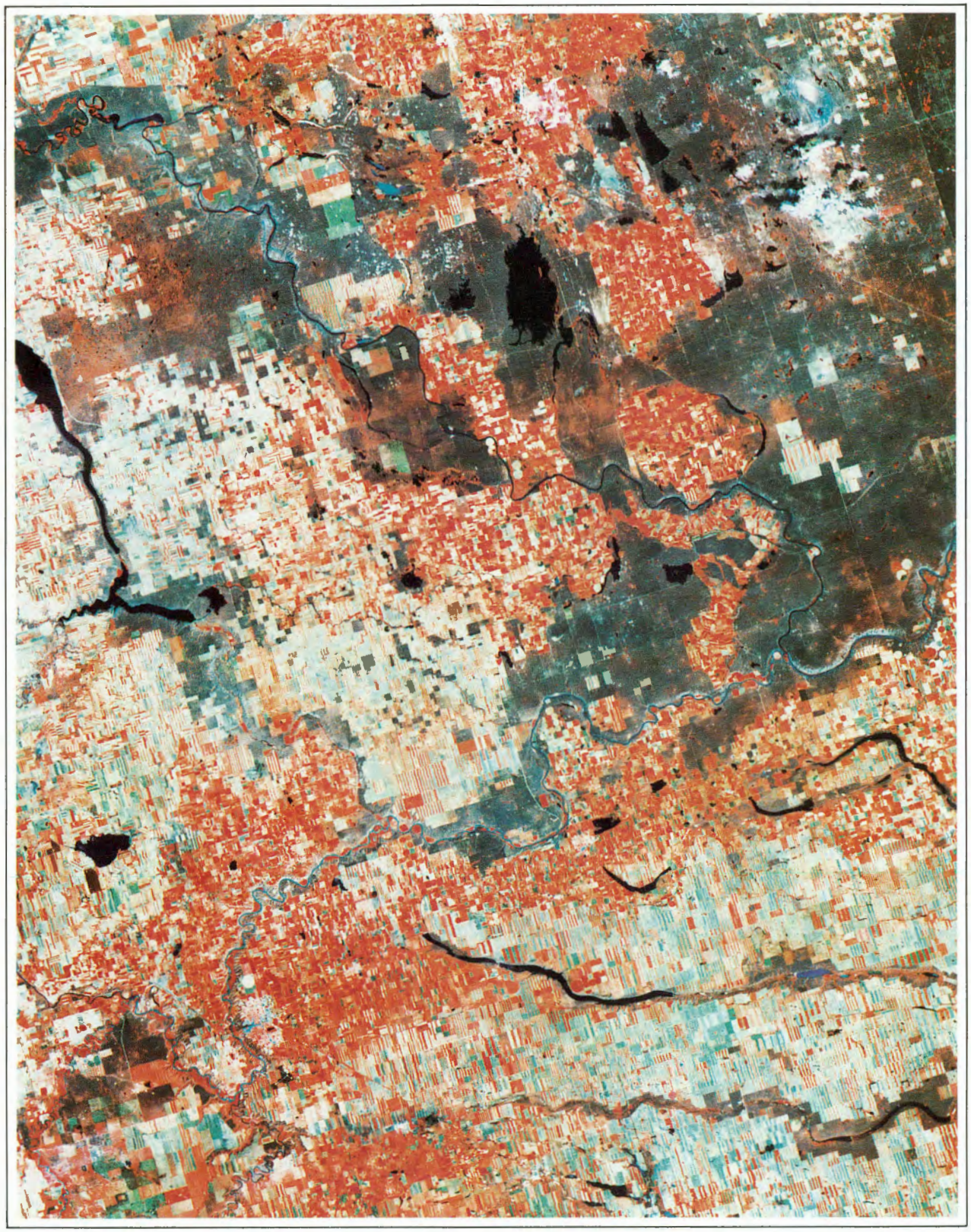
CCRS scientists cooperate with a number of user agencies to develop suitable ways of applying remote sensing data to the management of Canada's natural resources. Applications in forestry, agriculture, land use, water resources, mineral exploration, oceanography, Arctic ice reconnaissance and the environment are currently being developed and demonstrated.

Working space, where managers and scientists can use the most up-to-date and sophisticated analysis equipment, is provided at the Centre's data analysis laboratories. These laboratory facilities are available to all users, provided similar equipment is not routinely available through private industry. Interested agencies, both government and private, may second personnel to the Centre for both short- and long-term periods. These 'visiting scientists' work closely with the scientific and technical staff at CCRS.

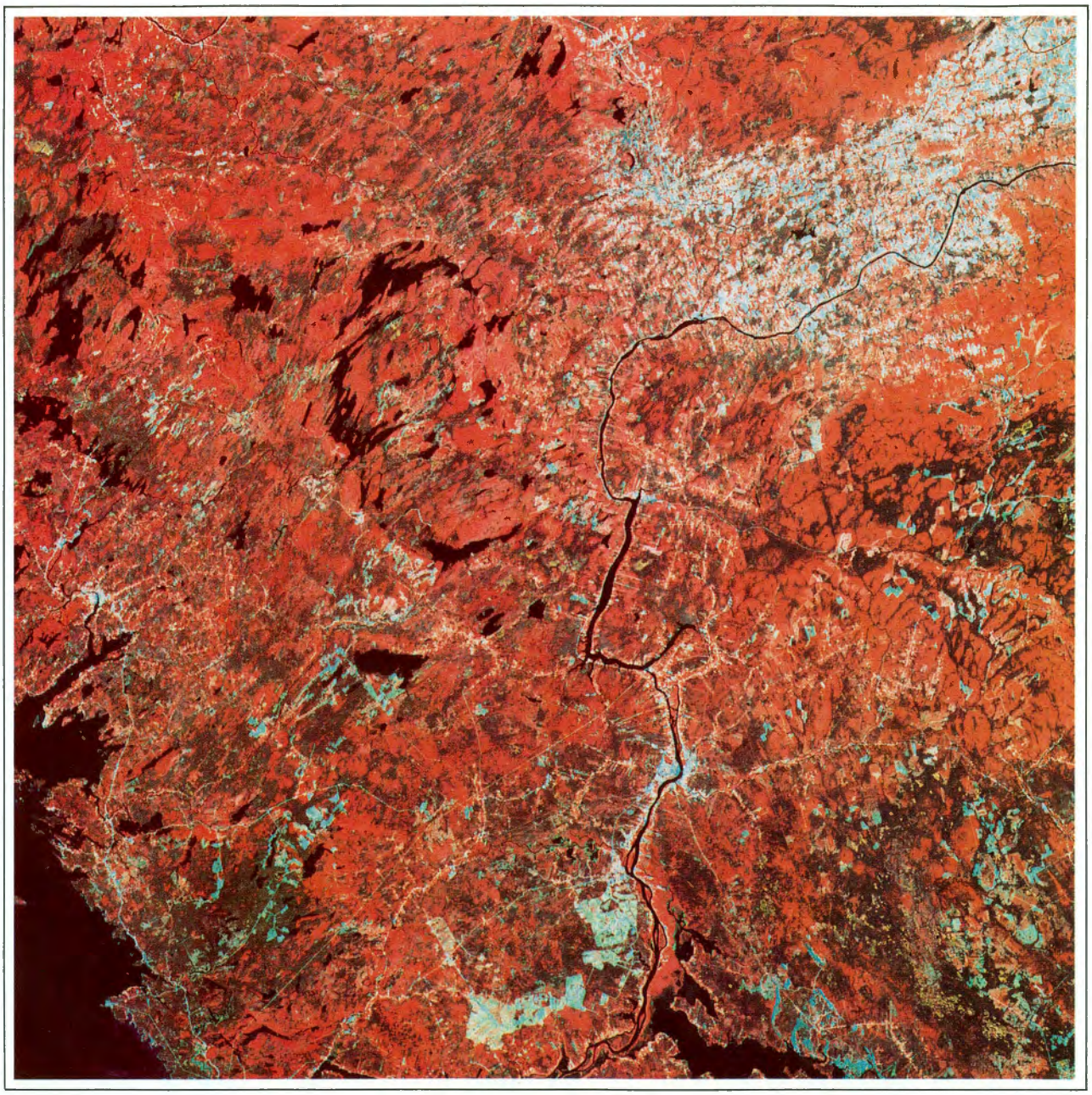
Equipment available in the Centre's analysis facility consists of both conventional analogue photointerpretation equipment and complex computer-controlled systems for the analysis of satellite and airborne data.



ARIES II Digital Image Analysis System.



LANDSAT MSS images can be enhanced to bring out details specific to rangeland. This mid-June image near Vauxhall, Alberta, is typical of the type now being used by ranchers and range managers to assess grazing conditions. Good rangeland appears a dark blue-grey; poorer range is lighter grey, often tinged with a subtle red due to invading, undesirable vegetation.



LANDSAT images such as this one from June 18, 1981 of the St. John River Valley in New Brunswick can be enhanced to provide details in forested areas. This enhancement for mixed woods can be used for updating maps of clearcuts and logging roads in both the hardwoods (red) and softwoods (dark reddish brown). This imagery can also be used to identify cropland, which is indicated by bright bluish green in this image.

Satellite Operations

The Canada Centre for Remote Sensing operates a ground receiving station located in Prince Albert, Saskatchewan. The ground station receives signals from American earth-observation satellites, notably from the LANDSAT and NOAA (National Oceanographic and Atmospheric Administration) series. Preparations are also being made to receive data from the French SPOT satellite and the European Space Agency's ERS-1 satellite.

LANDSAT'S Multispectral Scanner

The first satellite of the LANDSAT series was launched by the United States NASA (National Aeronautics and Space Administration) in July of 1972. LANDSAT-1 and all its successors carried a multispectral scanner (MSS), which senses the electromagnetic radiation from the earth's surface in four specific regions of the electromagnetic spectrum, bands 4 through 7.

BAND	WAVELENGTH (μm)	PART OF SPECTRUM
4	0.5 – 0.6	blue-green
5	0.6 – 0.7	red-orange
6	0.7 – 0.8	infrared
7	0.8 – 1.1	infrared

Images produced by the multispectral scanner each cover an area of 185 km by 185 km or approximately 34 000 km^2. The sensor's ground resolution, which is the size of the smallest detail it can observe, is 80 m.

Prince Albert, Saskatchewan LANDSAT receiving station and processing facility.

The first 30 m resolution LANDSAT-5 Thematic Mapper image of Ottawa. On photographic print, individual subdivision roads and larger buildings are clearly discernible. This type of image can be used for land use, land cover, forestry, wildlife habitat and related mapping and monitoring applications.

The Thematic Mapper

LANDSAT-5, launched in March 1984, carries a Thematic Mapper (TM) sensor, in addition to the MSS. The Thematic Mapper senses the electromagnetic radiation reflected by the earth's surface in seven specific regions or bands of the spectrum, each band having its own usefulness:

Band 1: 0.45-0.52 μm. Used for water body penetration, making it useful for coastal water mapping. It is also useful for differentiation of soil from vegetation, and deciduous from coniferous flora.

Band 2: 0.52-0.60 μm. Used to measure visible green reflectance peaks of vegetation for vigour assessment.

Band 3: 0.63-0.69 μm. A chlorophyll absorption band important for vegetation discrimination.

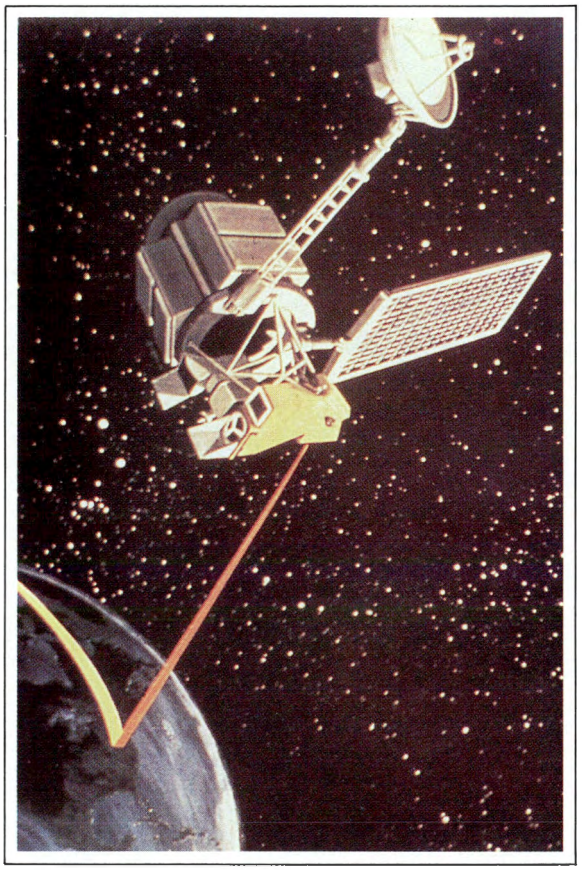
Band 4: 0.76-0.90 μm. Useful for determining biomass content and for delineation of water bodies.

Band 5: 1.55-1.75 μm. Indicates vegetation moisture content and soil moisture. Also useful for differentiation of snow from clouds.

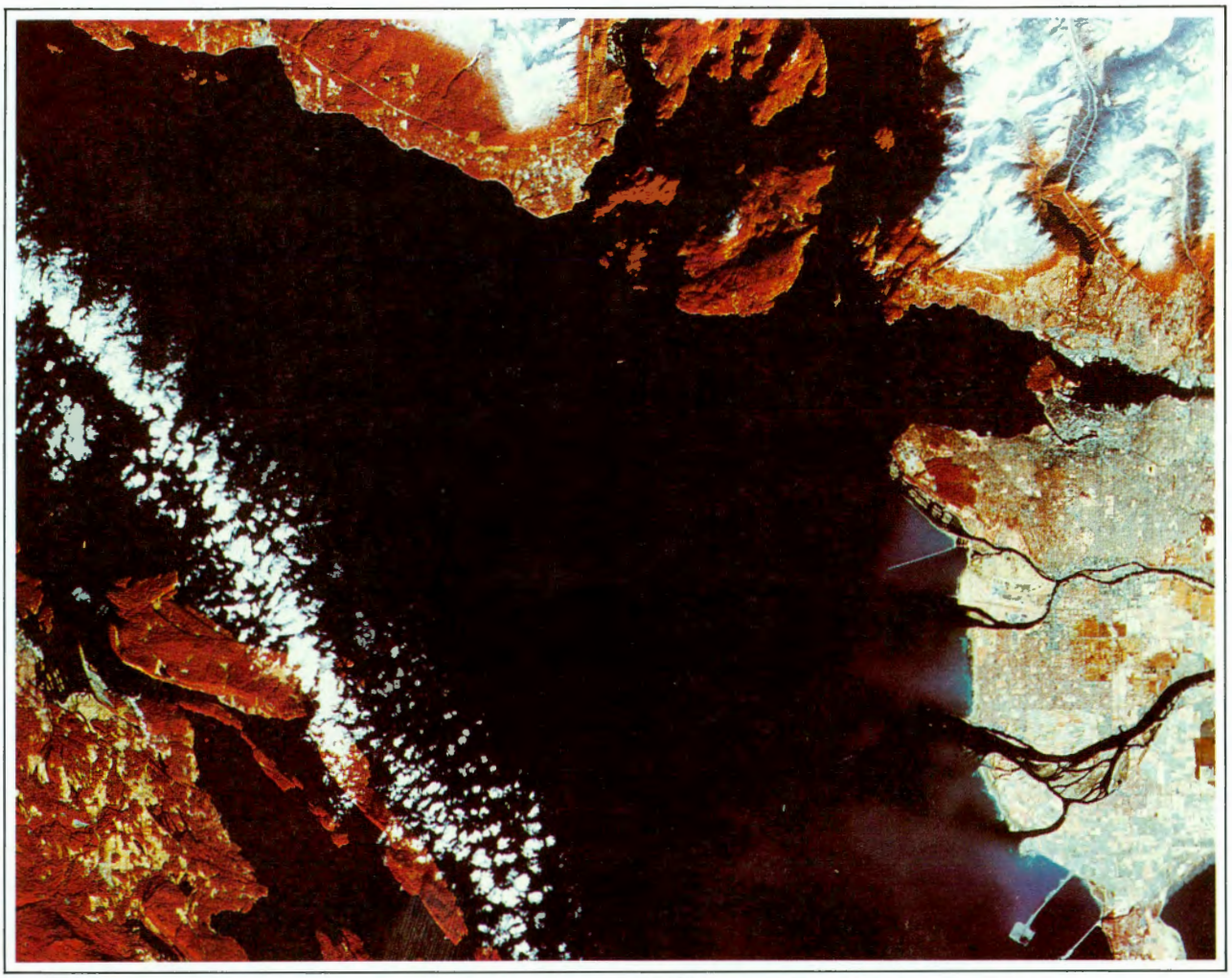
Band 6: 10.4-12.5 μm. A thermal infrared band of use in vegetation stress analysis, soil moisture discrimination and thermal mapping.

Band 7: 2.08-2.35 μm. A band selected for its potential for discriminating rock types.

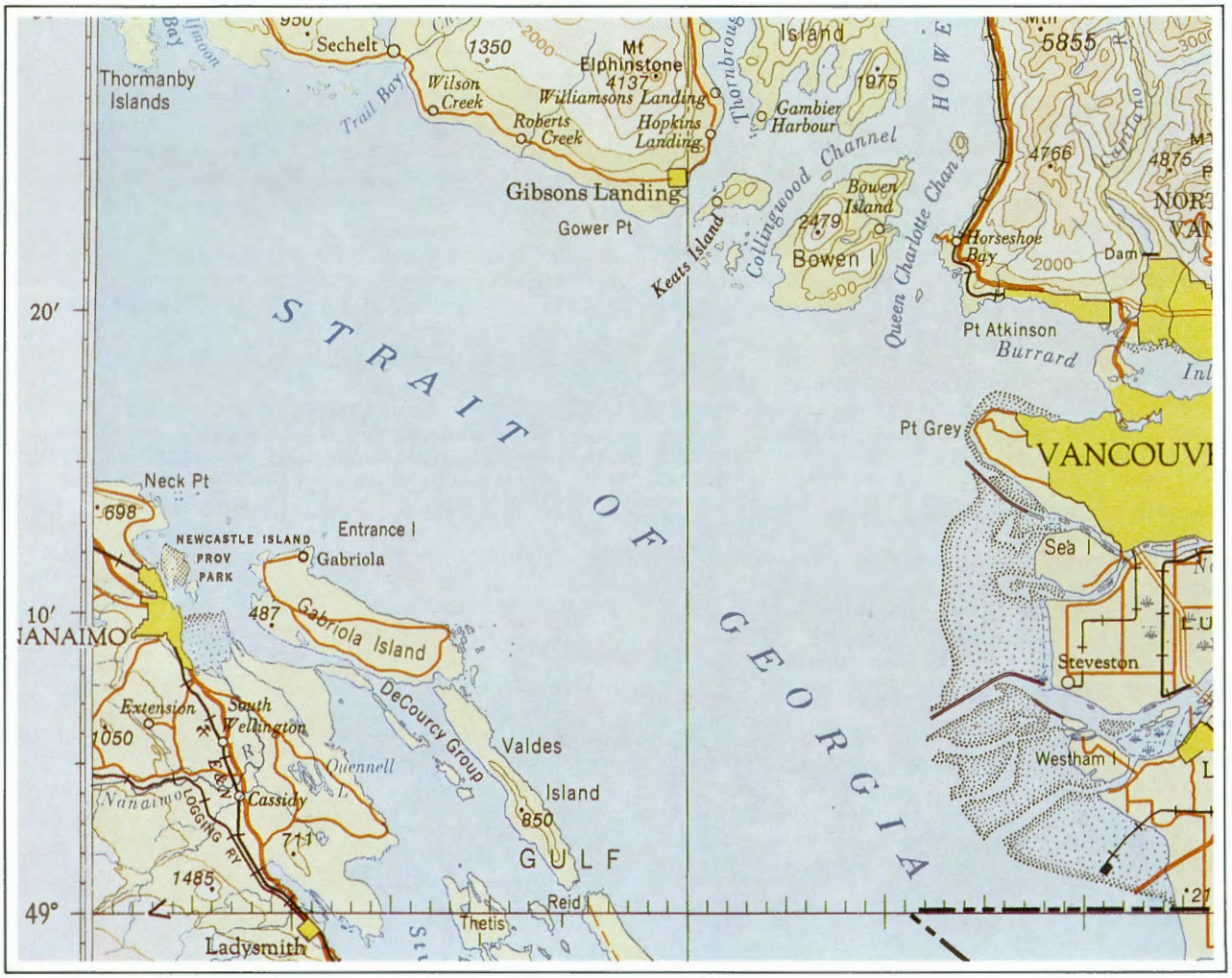
LANDSAT-5 operates from an altitude of 705 km, scanning the earth's surface between the latitudes of 78° N and 78° S. The satellite is in a sunsynchronous orbit, which means it always crosses a particular latitude at the same local time, for instance 11:20 am for the latitude of Prince Albert, Saskatchewan.



LANDSAT-5.



December 27, 1982 Thematic Mapper image received by the CCRS Prince Albert satellite station and later processed by MacDonald, Dettwiler & Associates Ltd. of Vancouver into a geocoded format. This image can be used for regional planning studies, forest cutover mapping or snowline mapping.



The image on the opposite page has been geocoded to correspond to the above map. The scale of the original map is 1:500 000. The map was reproduced from National Topographic System map sheet 92 SE. Map courtesy of EMR.

Satellite Data Products

CCRS receives and processes satellite data into photographic image or digital computer form, and distributes these products to users. Examples are the following:

Black and white or colour images. Typical products include black and white images of any one of the spectral bands. Colour composites, which combine three of the spectral bands into one colour image, are also available.

Digital data. Data are provided in digital form on magnetic tape, which is usually compatible with the user's computer. This is known as a computer-compatible tape or CCT.

Geocoded products. For users wishing to superimpose satellite data directly over conventional maps, the satellite image is projected onto a flat surface using the standard map projection of the National Topographic System of Canada. A high-precision product known as a 'Geocoded CCT' is produced. The product can be readily entered into a digital data base or can be used to generate a map-compatible image.

Geocoding also facilitates the comparison of images of the same site obtained at different dates, so that any change from image to image can be detected and analyzed. Geocoding now allows the combination of data from as many sensors as desired, each sensor providing its own type of information.

Enhanced products. Users interested in the visual analysis of satellite data can have images processed to bring out specified features. Enhancements have been produced for forestry, geology and rangeland applications.

Other Satellite Programs

In addition to data from LANDSAT and NOAA, CCRS will receive, process and distribute data from the SPOT satellite, scheduled for launch by the French Space Agency in 1985. SPOT will carry two push-broom scanners with a swath width of 60 km each and a resolution of 20 m in each of three bands, or 10 m in panchromatic mode. A steerable mirror will allow the sensors to look to the side of the orbital track, thus providing the opportunity to revisit sites more frequently than would otherwise be possible and also to obtain stereoscopic views at selected sites.

CCRS's ground receiving station is being updated by Canadian industry to include the most advanced readout and digital processing facilities for major new optical and radar resource management satellites, including ERS-1 and RADARSAT.

SPOT simulation of Sherbrooke, Quebec, which integrates the 10 m resolution panchromatic band and the 20 m multispectral data. This image was produced from airborne digital multispectral scanner data acquired by CCRS in November 1982. It is expected that topographic map revision and detailed land cover mapping will be significant applications of SPOT data. Photo courtesy of Sherbrooke University.

Digital image of the Petawawa Forest Research Institute acquired by the CCRS solid state Multispectral Electro-optical Imaging Scanner (MEIS) from 1750 m. Pixel size is 1.2 m by 1.2 m. Pixels (for 'picture elements') are the smallest constituents of an image. This type of digital imagery can be used for forest regeneration and inventory work.

Airborne Operations

The Canada Centre for Remote Sensing operates, in cooperation with industry, a fleet of three aircraft equipped with sophisticated optical, radar and laser sensors. The aircraft are fitted with special navigation and data management systems to record and annotate the output of several sensors.

The fleet includes a Falcon Fan-Jet, which can operate at altitudes of 12 000 m; a long-range, radar-equipped Convair 580; and a DC-3, which is used for low-level operations and for testing new sensors. All aircraft are flown and operated by Innotech Aviation of Montreal. Sensor operators and technicians are provided through a subcontract by Intera Technologies Limited of Calgary.

Aircraft are used for the acquisition of airborne data requested by users and for the development and demonstration of new sensors. User requests may be either research or operational in nature. Research proposals with good potential for future operational use are flown under a plan that assists the development of new applications by reducing the user's cost. In contrast, operational users cover all incremental costs associated with their project through a preestablished leasing arrangement.

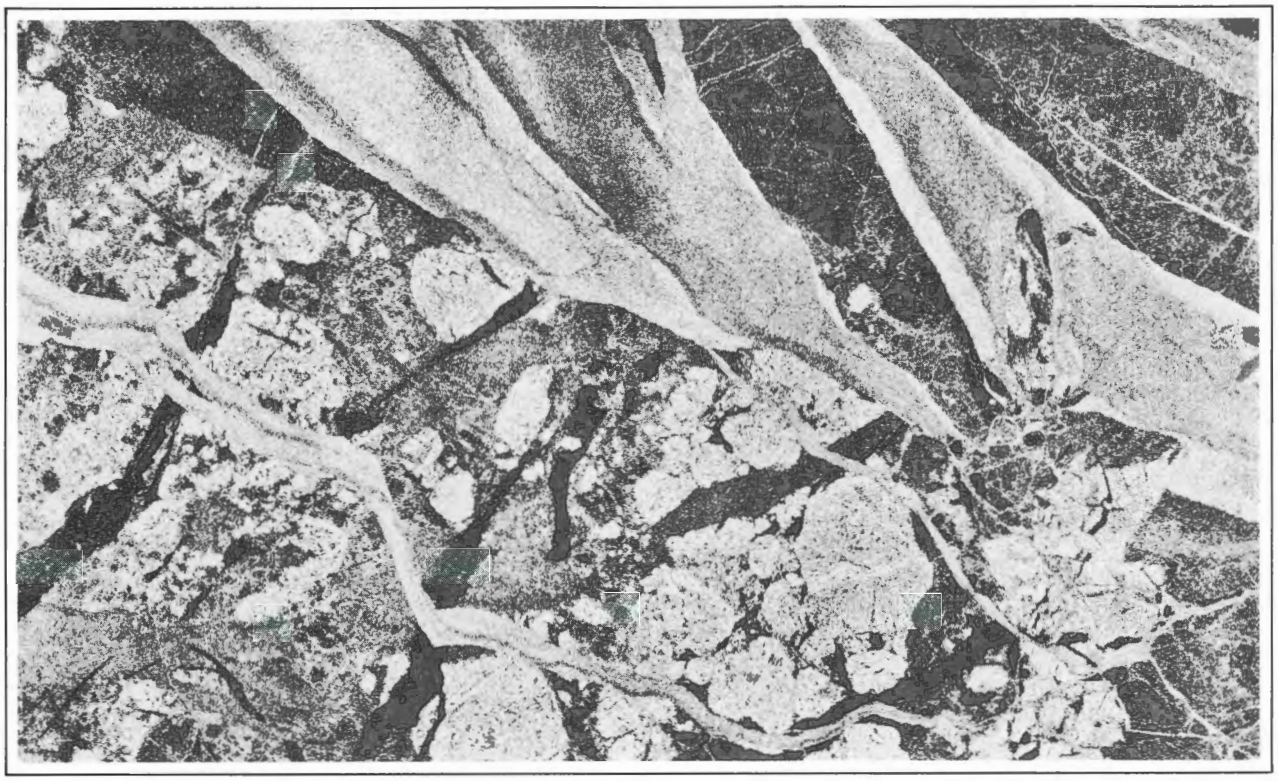
Depending on the nature of the sensors used, the data obtained can appear in electronic or photographic form. Data from electronic sensors are recorded on magnetic tape and processed at CCRS. Master tapes are archived at CCRS and copies are provided as computer-compatible tapes or in hard-copy form. Films from photographic cameras are processed by the National Air Photo Library Reproduction Centre. Master negatives are placed in the National Air Photo Library; copies of the data can be acquired through that agency.

The number and type of sensors carried by the aircraft may vary according to the requirements of the mission to be flown and the capability of the aircraft.

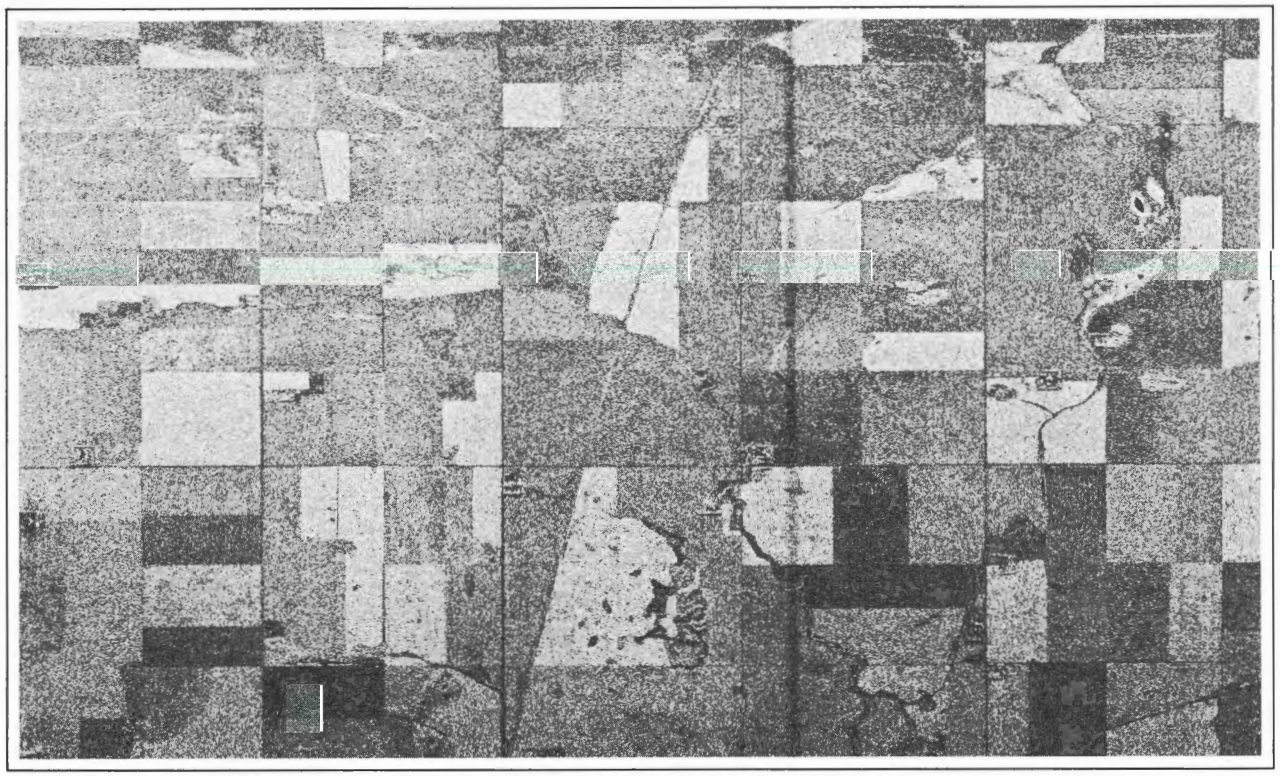
A complete description of the aircraft, sensors, flight operations and procedures for flight requests is available from the Airborne Operations Section of CCRS.

Falcon Fan-Jet.

Convair 580.



High-resolution X-band SAR image of sea ice in the Beaufort Sea, acquired during April 1983. The top half of the image shows hardened first-year ice (dark) and large strips of young ice (grey). Multiyear ice floes occupy the lower half. Such imagery is useful in planning Arctic navigation.



C-band synthetic aperture radar (SAR) image of an area near Melfort, Saskatchewan. Bright fields are rapeseed (canola) in bloom, dark fields are summerfallow, medium are grains. In addition to its all-weather capability, SAR data have the potential to improve crop recognition early in the season because of the SAR's sensitivity to plant structures.

Research and Development

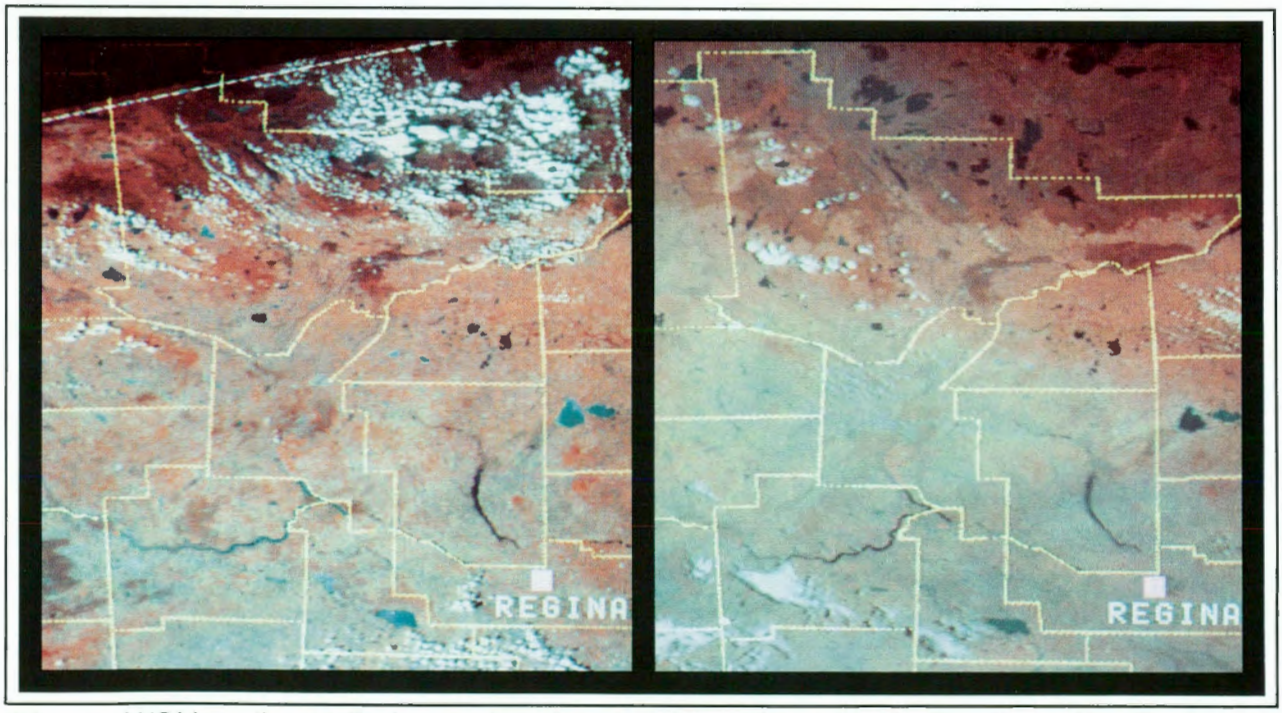
CCRS maintains a strong research effort in data acquisition systems and sensor development, data processing, data analysis and applications development. Research work is usually conducted in cooperation with industry.

Sensor research includes the development of microwave (radar) devices capable of providing ice reconnaissance information for Arctic and offshore operations in fog, cloud or darkness. Other work is concerned with the development of electronic sensors capable of providing high-resolution images in the visible and infrared part of the spectrum. Laser devices associated with sophisticated navigation equipment are also developed for use in charting shallow coastal waters.

The Centre's major effort in data processing research is the development of systems capable of transforming new data obtained by airborne or space sensors into standard products, readily compatible with the user's operating procedures and traditional sources of data. A system called the MOSAICS allows a satellite image to be directly superimposed over conventional topographic maps.

In the area of image analysis, the Centre is developing computer systems capable of storing and manipulating large amounts of remote sensing and traditional data (soil maps, land use maps) in order to extract and update valuable information for interpretation purposes.

CCRS carries out research and development projects seeking new ways of applying remote sensing data to the management of Canada's natural resources and environment. These projects are conducted in association with potential end users, and often receive the support of interested federal and provincial agencies. Industry participation is encouraged, to facilitate the commercial development of promising applications. Areas of interest include agriculture, forestry, geological exploration, surveys and mapping, ice reconnaissance, fisheries, water resources and environmental monitoring.



This pair of NOAA weather satellite images shows how drought has advanced on the Canadian prairies. The August 1983 image (left) displays green vegetation (red), especially at lower left, which has disappeared in the August 1984 image (right). The lines are crop reporting district boundaries.

A LANDSAT MSS softwood enhancement of part of the Cariboo plateau region of interior British Columbia. The Fraser River flows south along the eastern edge. Lodgepole pine stands appear dark green, with varying amounts of red depending on deciduous vegetation present. The imagery can be used for cutover mapping (small, often rectangular yellow-orange areas) and general forest inventory.

User Assistance and Marketing Unit.

User Services

The main contact between the outside user and CCRS is the User Assistance and Marketing Unit. This unit is responsible for providing information on the Centre and its activities and facilities, assisting with orders for all CCRS products, answering enquiries and receiving complaints and suggestions.

User services also include the CCRS Technical Information Service (TIS), which has a library of remote sensing books, reports, reprints, slides, films and reference material, as well as a large collection of LANDSAT imagery.

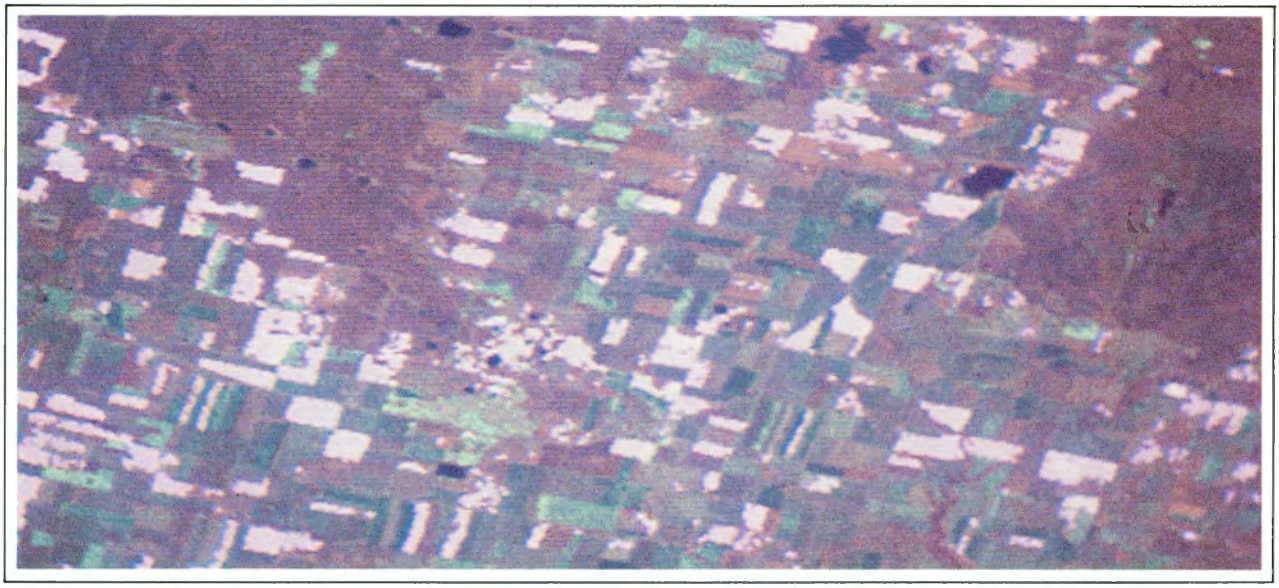
Most of these library resources are catalogued in computerized systems so that users anywhere in Canada with access to a computer terminal may use the information. Documents on remote sensing applications and techniques, in English and French, may be located through the Remote Sensing On-Line Retrieval System (RESORS).

LANDSAT imagery can be located through an on-line computerized catalogue. Users may obtain a list of images corresponding to any Canadian geographic area of interest, qualified by degree of cloud cover and spectral band quality.

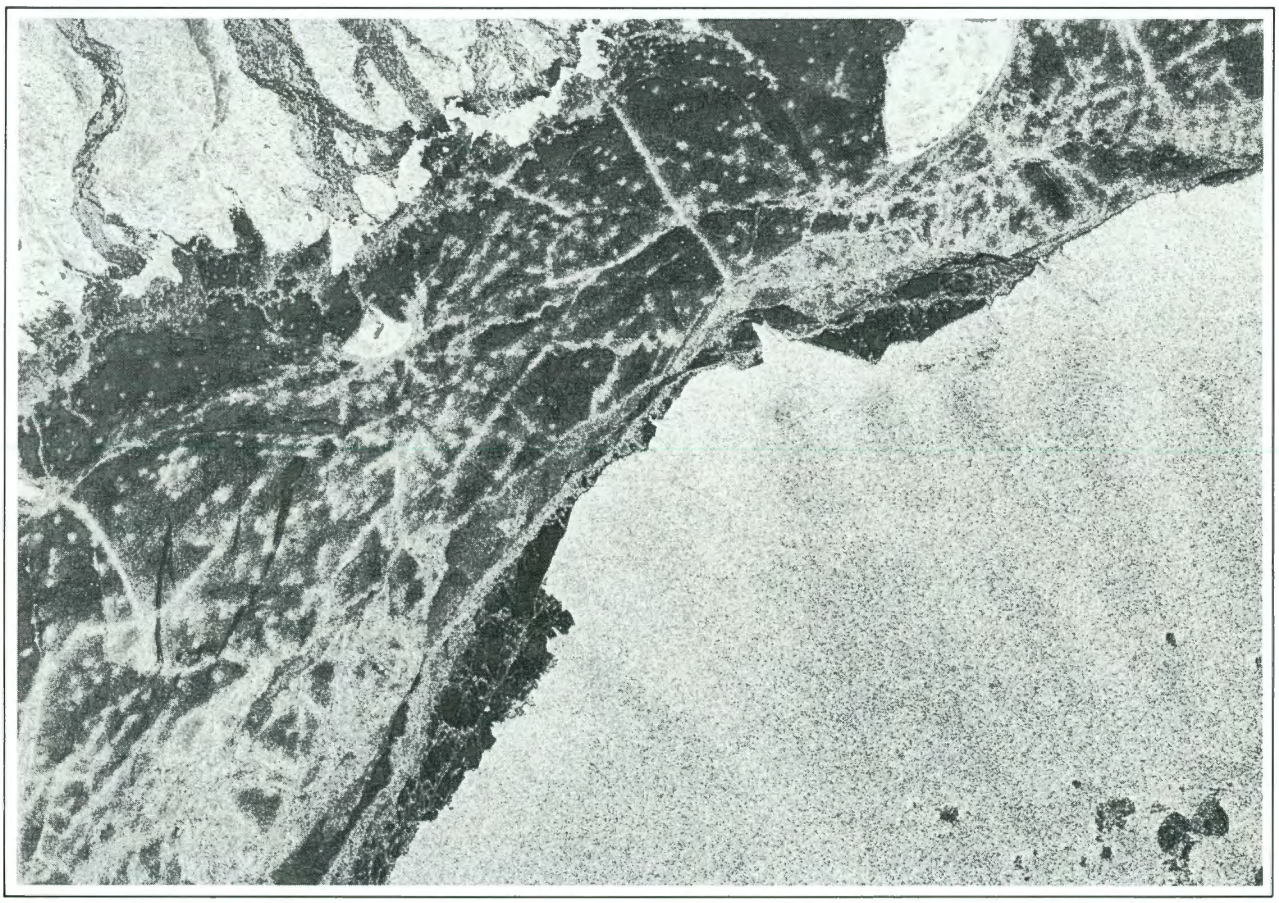
TIS also maintains a manual microfiche index to LANDSAT imagery.

Other products on file include a selection of Skylab and NOAA imagery, airborne flight line index maps and a visual library containing documentation and sample imagery from completed projects. An international microfilm file, excluding the United States, is also maintained so that Canadian users can determine which satellite imagery is available for other parts of the world. International data must be ordered from the Eros Data Centre in Sioux Falls, South Dakota, U.S.A., 57198.

Anyone wishing to use the above services or to make further enquiries should contact the User Assistance and Marketing Unit at 717 Belfast Road, Ottawa, Ontario, K1A 0Y7.



An agricultural area in Manitoba where rapeseed (canola) is the major crop. A classification of the crop by spectral signature has been done, and fields where canola is in bloom are a bright pink colour. The total hectares of canola can be easily estimated using these data in conjunction with sample data acquired by ground survey. Photo courtesy of Statistics Canada.



Synthetic aperture radar image from the SEASAT mission, July 1978, showing a portion of Banks Island, NWT, in the top left corner. Smooth, shore-bound ice along the coastline reflects the microwaves emitted by the radar away from the sensor, and therefore appears dark. Open water, because it is rippled, reflects part of the incident energy towards the radar, and therefore appears grey. Such imagery is used in studies of ice as well as for navigation. Digital Processing: MacDonald, Dettwiler & Associates Ltd.

INTERNATIONAL COOPERATION

From inception, the Canada Centre for Remote Sensing has been ready to share its knowledge and experience with other agencies worldwide.

A unique feature of the Canadian remote sensing program is the thorough integration of technological know-how with user needs, resulting in the development of low-cost but highly effective systems, well adapted to the users' operational requirements.

This close integration of effective technology with user needs is a direct result of the considerable challenge facing Canadian resource managers responsible for the development of vital natural resources in a vast country, often under adverse terrain and weather conditions. As a result of this responsiveness to user requirements, many of the systems and approaches developed in Canada have found worldwide acceptance. Noteworthy are low-cost, high-performance ground receiving stations, image analysis systems and radar data acquisition and processing systems.

LANDSAT ground receiving station in Australia built by MacDonald, Dettwiler & Associates Ltd.

A LOOK TO THE FUTURE

RADARSAT

To date, Canada has concentrated its remote sensing activities on the ground segment of satellite remote sensing systems (ground stations, processing and analysis systems and applications), supported by a vigorous airborne program. This thrust will be maintained and enhanced through the development of the RADARSAT program, a Canadian contribution to the remote sensing space segment.

RADARSAT, to be launched in the early 1990s, will be equipped with a synthetic aperture radar as its main sensor. The radar will operate in the C-band (approximately 10 cm wavelength), with a ground resolution of 25 m and a swath width of 200 km in all weather conditions. Its beam will be steerable to provide stereo radar capability.

RADARSAT's ability to 'see' through cloud, storm and darkness will make it particularly useful to support Arctic and offshore operations, and it will be invaluable for applications in geology, forest management, agricultural production and water resources, and for oil, gas and mineral exploration.

In addition, Canada is cooperating with the European Space Agency in the development of the ERS-1 satellite, scheduled for launch in the late 1980s. ERS-1 will carry a C-band synthetic aperture radar for ocean applications.

CONCLUSION

Today, through earth observation from satellites and aircraft, Canadians have a valuable tool to better understand and manage their country's resources.

The Canada Centre for Remote Sensing will continue to concentrate its efforts on improving the quality and usefulness of remotely sensed data, in order to meet the needs of an increasing number of users in Canada and abroad.

COVER ILLUSTRATION

This is an artist's concept of the RADARSAT satellite, a sophisticated new remote sensing satellite being developed by the Canada Centre for Remote Sensing. Scheduled for launch in 1990, RADARSAT will carry an advanced radar technology, Synthetic Aperture Radar (SAR), which can 'see' day and night in any kind of weather and will have hundreds of uses. SAR is especially effective in forecasting northern ice conditions, and can also be used for crop monitoring, oil spill detection and resource exploration.