



Monitoring an Antarctic Ice Shelf

During the fall of 2000, the second RADARSAT-1 mission to map Antarctica, the Modified Antarctic Mapping Mission (MAMM), was successfully completed. This project focused on obtaining fine and standard mode data suitable for interferometry. RADARSAT-1 maintained its right-looking position for MAMM and thus coverage was only obtained for the area of Antarctica north of 80°S latitude. Scientists at the Canada Centre for Remote Sensing (CCRS), Natural Resources Canada have processed some of the collected data. Using the speckle tracking interferometry technique, developed initially at CCRS to measure ice motion using AMM data, current velocities of the Brunt Ice Shelf have been mapped in unprecedented detail.

The background image in Figure 1 is a perspective view of the Brunt Ice Shelf with ice velocities shown as a colour overlay. This illustration uses mosaic and digital elevation data with vertical exaggeration to emphasise the transition between floating and grounded ice. Velocities are the combined results from the analysis of three interferometric pairs. Speeds vary from less than 100 meters per year (blue), to as much as 1500 meters per year (purple) near the front of the ice shelf.

The British Antarctic Survey Halley Base has been situated on the Brunt Ice Shelf as of the mid-1950s. Halley Base and its supply route from the ocean are clearly visible in the inset image of Figure 1. The interferometric velocities of this area are approximately 750 meters per year (yellow/green). These speeds are in agreement with measurements taken at Halley Base.

The Brunt Ice Shelf imagery provides a good example of Antarctic change. Figure 2 shows the central area of the ice shelf with a

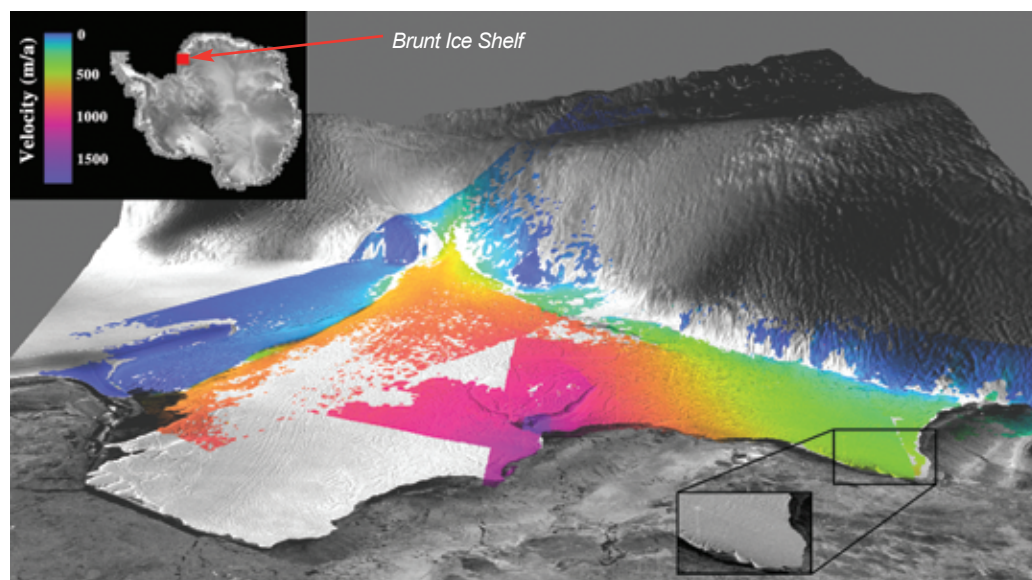


Figure 1. A perspective view of the Brunt Ice Shelf with ice velocities shown as a colour overlay.

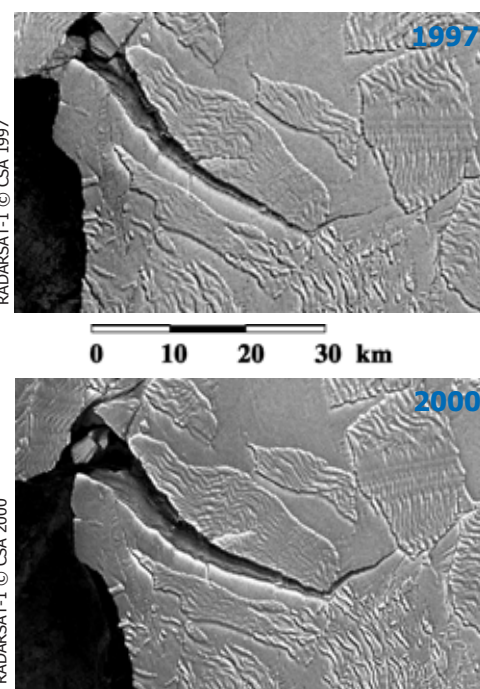


Figure 2. Fracture in Brunt Ice Shelf.

significant fracture in 1997 and in 2000. The fracture has widened and lengthened noticeably over the three-year period. Continued use of RADARSAT-1 imagery will be an important tool for monitoring the stability of Antarctica.

The author wishes to acknowledge Dr Ken Jezek of The Ohio State University for the digital elevation model and an early copy of the RADARSAT-1 mosaic.

For more information regarding the speckle tracking technique developed at CCRS please see *Remote Sensing in Canada*, Volume 28, Number 1.

More details available on the CCRS Web site.

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"Remote Sensing in Canada"

A national newsletter providing a comprehensive view of remote sensing activities, programmes and products co-ordinated by the Canada Centre for Remote Sensing, Natural Resources Canada. CCRS works in co-operation with other agencies of the Government of Canada, provincial governments, Canadian industry and Canadian universities. CCRS includes the National Atlas Information Network.

For more information about CCRS please consult our Web site at: <http://www.ccrs.nrcan.gc.ca/>

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Preview the application potential associated with RADARSAT-2 type Synthetic Aperture Radar data.

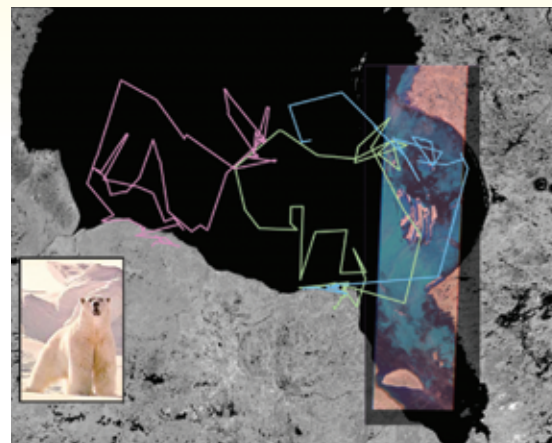
Kids, Space, and Species

A partnership between the Canadian Space Agency, the Canada Centre for Remote Sensing, the Canadian Wildlife Service, the Canadian Wildlife Federation and several Canadian corporations has resulted in an innovative learning resource for Canadian school children. Space for Species (SFS) is an interactive Web-based initiative that enables students to learn about wildlife conservation using technologically advanced tools such as satellite telemetry and remote sensing.

By logging-on to

<http://www.spaceforspecies.ca/>

students access migratory data of selected species at risk of extinction in Canada; observe habitats from space using satellite imagery and astronaut photography; monitor daily and seasonal climatological conditions that affect movement; and evaluate threats along migratory routes. For example, ice imagery is useful for monitoring Polar bear (*Ursus maritimus*) movement since this species uses sea-ice habitat for travelling and hunting prey. CCRS's expertise in Earth observation technology and its application have contributed significantly to the space technology content of the SFS programme.



RADARSAT-1 layer © CSA, 2000



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Committed to the goal of revealing to students the relevant challenges in environmental and Earth sciences, SFS provides materials and supporting resources for improving science literacy in Canada. Space for Species opens a window to the exciting opportunities of combining Earth observation technology with wildlife and habitat conservation.

More details available on the CCRS Web site.

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On the Move

After more than twenty-five years of service with the Government of Canada, **Dr. Edyrd Shaw**, Director General, has retired from the Canada Centre for Remote Sensing. Considered "the father of RADARSAT", Ed has been an integral part of Canada's remote sensing programme and CCRS since 1973. **Ron Brown** and **Bob O'Neil** have taken up the Director General responsibilities on a rotational basis until an official appointment is made. **Jeff Labonté** has been appointed Director of GeoConnections, reporting directly to the Assistant Deputy Minister of the Earth Sciences Sector, **Dr. Irwin Itzkovitch**. **Christine Hutton** has been selected to fill the Management Trainee position within the Director General's Office.

Radiometric Calibration of the Landsat Data Record

One goal of the Landsat program is the cross collaboration of the Landsat 7 Enhanced Thematic Mapper Plus (ETM+) and the Landsat 4 and Landsat 5 Thematic Mapper (TM) sensors on a comparable radiometric scale. Doing such will allow the possibility of examining a continuous, near-global data set from 1982 for monitoring global and regional land dynamics at a 30 m scale where both natural and anthropogenic disturbances can be assessed.

A co-ordinated effort on the part of several agencies has led to the specification of a definitive radiometric calibration record for the lifetime of the Landsat 5 TM anchored to the same radiometric scale as the Landsat 7 ETM+. A cross-calibration methodology

to anchor the Landsat 5 TM radiometric calibration to that of Landsat 7 ETM+ has been formulated and implemented using image pairs from the Landsat 7/Landsat 5 tandem configuration period in June 1999. It is expected that a similar analysis can be completed for the Landsat 4 TM.

New time-dependent calibration processing equations and procedures applicable to newly processed Landsat 5 TM data have been specified. Data provider implementation considerations are currently being examined. The merits and feasibility of placing the Landsat Multispectral Scanner series on the same radiometric scale need to be assessed before undertaking any significant calibration effort. Equations and procedures have also been specified for recalibration of some existing processed TM

data sets in a Canadian context. The algorithm and related user documentation should be available from the Canada Centre for Remote Sensing soon.

The Landsat Project Science Office, NASA/GSFC, along with CCRS, has sponsored the research and development of these Landsat calibration activities. Contributors to this work include NASA's Goddard Space Flight Center, South Dakota State University, the University of Arizona, the United States Geological Survey EROS Data Center, the Rochester Institute of Technology, Jet Propulsion Laboratory, TerreVista Earth Imaging, MacDonald Dettwiler and Associates, and RADARSAT International.

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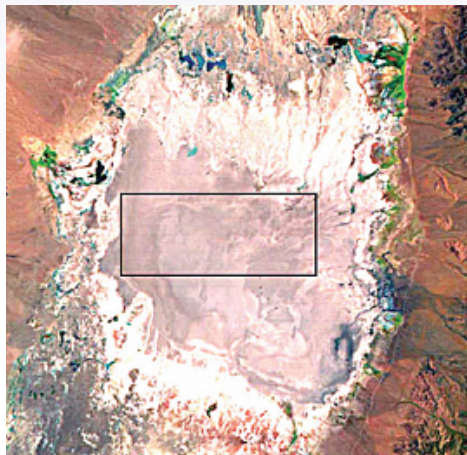
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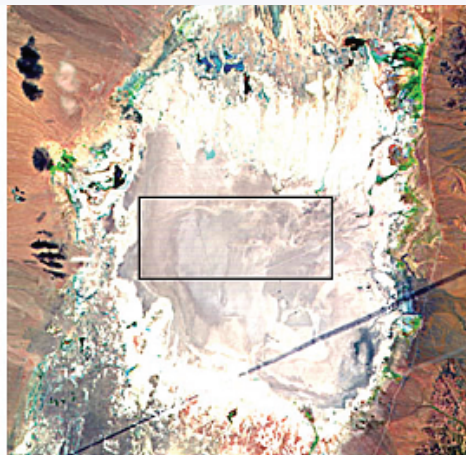
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Landsat Cross Calibration Data Sets

Railroad Valley Playa, Nevada, WRS 4/33, June 1, 1999



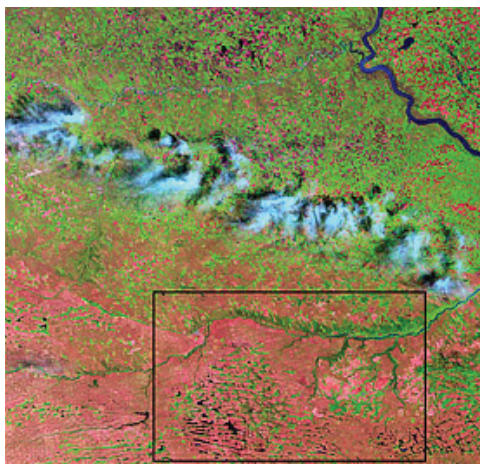
Landsat 5



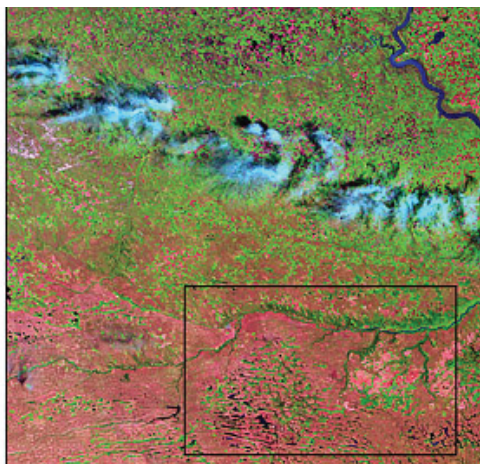
Bands 5,4,2

Landsat 7

Niobrara, Nebraska, WRS 31/30, June 2, 1999



Landsat 5: 12:02:14 CDT



Bands 5,4,2

Landsat 7: 12:16:59 CDT

Hurricane Watch

Synthetic aperture radar (SAR) images of the ocean's surface often show the imprints of marine atmospheric boundary layer processes that modulate the near surface wind field. In the case of hurricanes, RADARSAT-1's ScanSAR Wide (SCW) mode images can show features such as boundary layer rolls, precipitation, eyewall features, wind speed, and wind direction effects. Hurricane Watch, a collaboration between the Canada Centre for Remote Sensing (CCRS); the Canadian Space Agency (CSA); and the National Oceanic and Atmospheric Administration (NOAA), has routinely acquired RADARSAT-1 SCW images of hurricanes during the Atlantic Basin hurricane season, normally August through October, for the past three years.

SAR images provide the potential for offshore precipitation observation, valuable when hurricanes are beyond the range of coastal Doppler radar. The large spatial extent of boundary layer rolls in hurricanes was first revealed in RADARSAT-1 images. The image of Hurricane Floyd, Figure 1, is characterized by a series of distinct striations that are aligned with the nominal wind direction. These striations are the SAR image expression of boundary layer roll processes.

Coastal Doppler radar has permitted the correlation of dark bands in SAR ocean images of hurricanes with heavy rainfall. Studies suggest that turbulence generated in the upper few centimetres of water surface by droplet impact tends to dampen small-scale roughness. However, depending on duration and intensity impact can produce roughness. Under high rain rate conditions, rain volume attenuation can also be a factor in lowering observed radar backscatter.

While SAR images of hurricane eyes over the ocean are still rather rare,

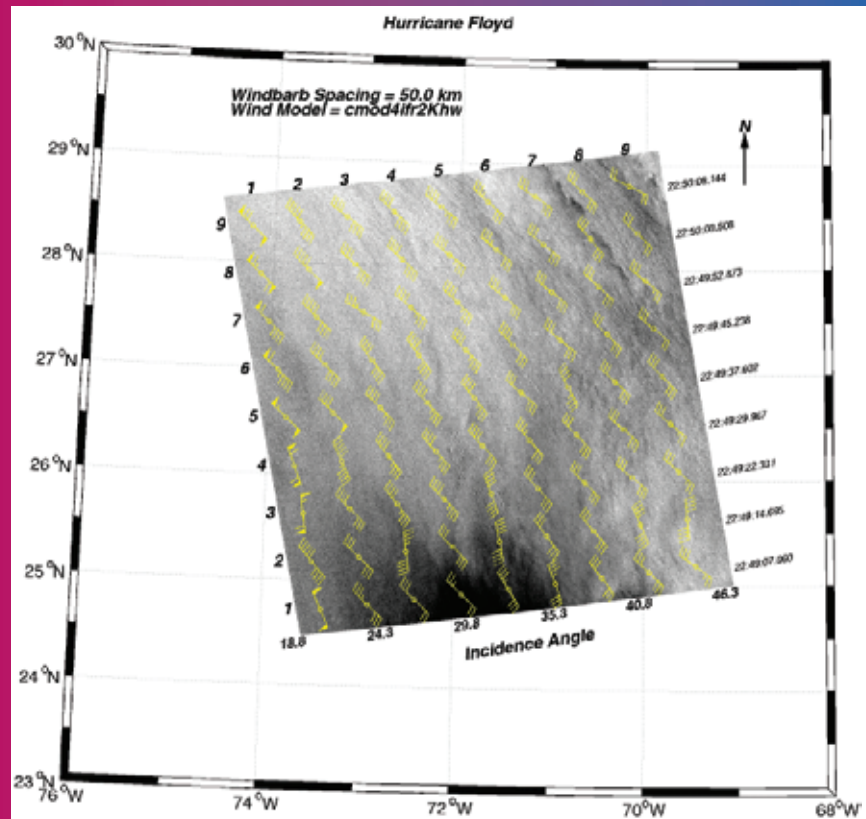


Figure 1: RADARSAT-1 SCW image of Hurricane Floyd on 1999-09-04, covering 500 km from left-to-right (© CSA 1999). Note the striations across the image corresponding to boundary layer rolls. The corresponding image spectrum (bottom) indicates that the striations have a scale of 3.5 km.

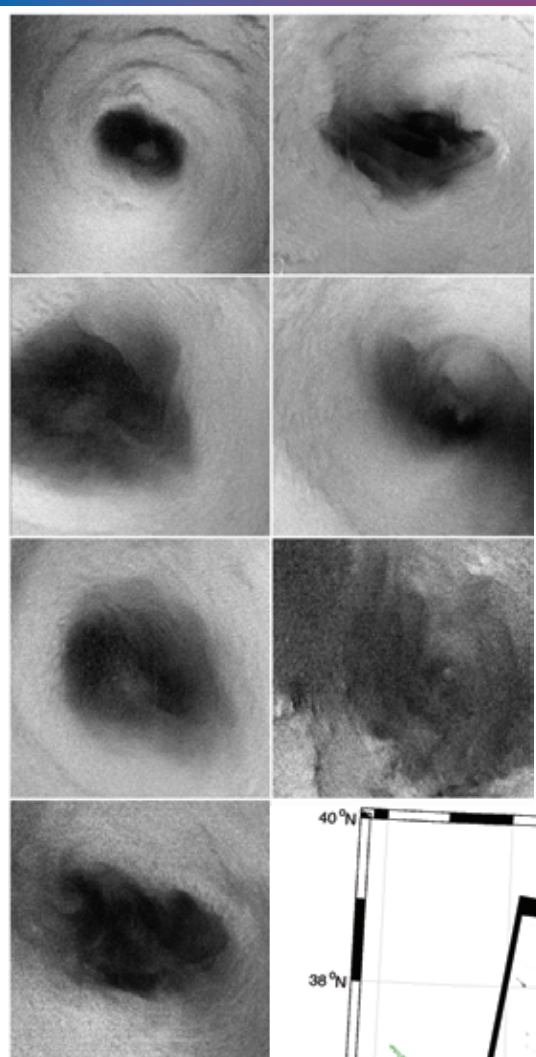
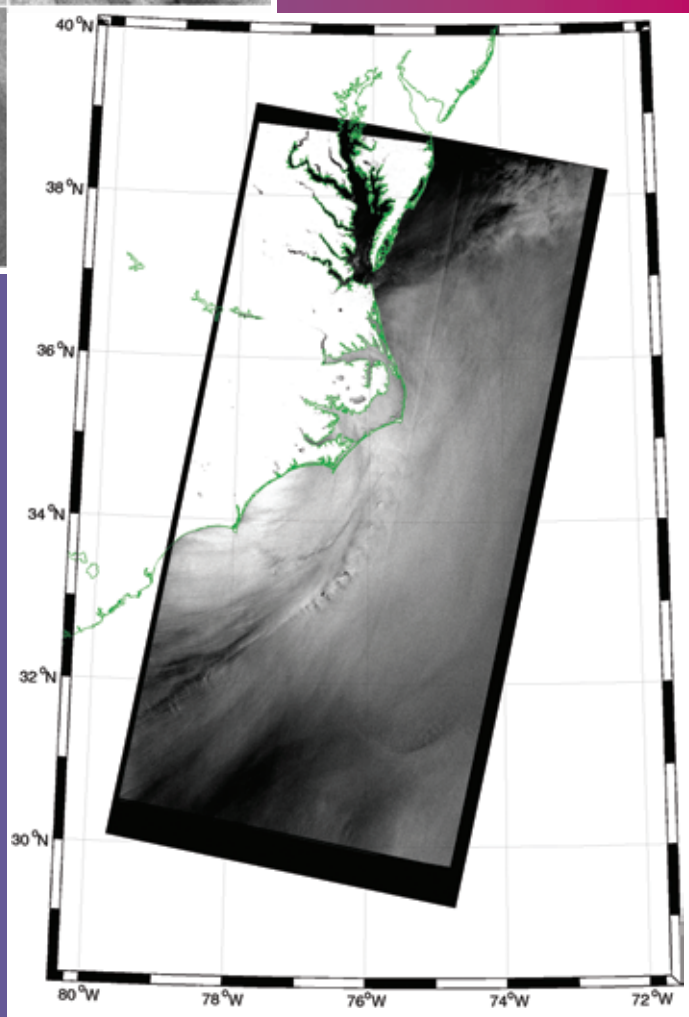


Figure 2: RADARSAT-1 ScanSAR Wide mode images of hurricane eyes: Danielle (upper-left, 1998-08-31); Dennis (upper-right, 1999-08-27); Dennis (1999-08-29); Dennis (1999-08-31); Floyd (1999-10-15); Tropical Storm Alberto (2000-09-17); Florence (lower-left, 2000-10-13). Each subscene spans 100 km from left-to-right. (© CSA 1998, 1999, 2000)

Figure 3: RADARSAT-1 SCW image of Hurricane Bonnie on 1998-08-27 covering 500 km from left-to-right (© CSA 1998) along with WSR-88D coastal precipitation radar data. Note that the dark regions in the SAR image correspond to regions of intense precipitation.



they often show eyewall mesovortex features. The image of Hurricane Dennis on 1999-09-27, Figure 2, shows a protrusion of higher backscatter curling into the eye from the northeast. This feature corresponds to a "super cell" that developed within the eyewall, which that was also observed by a NOAA P3 research aircraft circling upwind along the eyewall shortly after the SAR pass. Similar features observed in Hurricane Dennis on other days and in other hurricanes, possibly signal changes in storm structure and perhaps provide clues to intensity change.

Hurricane Watch is presently focusing on obtaining supporting observations to study boundary layer rolls in hurricanes by acquiring NOAA P3 aircraft measurements at the times of RADARSAT-1 hurricane acquisitions. A better understanding of the evolution of these rolls as hurricanes develop could lead to more precise predictions of hurricane intensity change. Validation of wind speed and SAR-derived wind fields is also the subject of ongoing research.

Acknowledgement

Many colleagues and organizations have contributed to the acquisition and analysis of the RADARSAT-1 SAR images referred to in this article. The author thanks S. Parashar, S. Srivastava, K. Lord, A. Mahmood, R. St-Jean, G. Burger, L. Patten, P. Voumard, K. MacDonell, et al. at CSA; J. Cranton, L. Wu, J. Wolfe, A. Deschamp, et al. at CCRS; P. Clemente-Colón, W. Pichel, K.S. Friedman, X. Li, et al. at NOAA/NESDIS; and K.A. Katsaros, P.G. Black, P. Dodge, E. Uhlhorn, et al. at NOAA/AOML.

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Ground Station Operations and Satellite News

NEW LANDSAT-7 DATA DISTRIBUTOR

Resource GIS and Imaging Ltd. (RGI) of Vancouver, British Columbia was appointed to the CCRS LANDSAT-7 distributor network in September 2001. The acceptance of RGI as a CCRS distributor of LANDSAT-7 data will increase and enhance the availability of remote sensing data and value added products. RGI joins RADARSAT International Inc. (RSI) as a CCRS LANDSAT-7 distributor. For more information on RGI see <http://www.rgi.ca/>. For more information on RSI see <http://www.rsi.ca/>.

NOAA AVHRR

The NOAA-16 satellite experienced payload difficulties resulting in the degradation of transmitted signal on September 28, 2001. Corrective action was implemented by NOAA on October 9, 2001 and resulted in a change in downlink frequency. Routine NOAA-16 reception resumed at the Prince Albert Satellite Station as well as DFO-Mont. Joli for East coast coverage.

ENVISAT ASAR

According to the European Space Agency (ESA), the ENVISAT launch can be envisaged by 2002, week 8. The CCRS ENVISAT ASAR Ground Segment development continues according to schedule and will be able to support the ENVISAT ASAR High Rate data reception, archiving, processing, and delivery operations as well as ESA's ASAR payload commissioning phase, if required by ESA.

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First Nation Communities Gather to Study Remote Sensing

The Canada Centre for Remote Sensing (CCRS) and the Sustainable Communities Initiative (SCI) of GeoConnections hosted a 5-day "Introduction to Remote Sensing"

workshop as a response to a request for a practical training session in the fundamentals of remote sensing. SCI helps Aboriginal, rural, and northern communities in Canada use geospatial information to make decisions about their economic, environmental, and social development. Representatives from the First Nation communities of Tr'ondek Hwech'in, Yukon; Little Salmon Carmaks, Yukon; Wikwemikong, Ontario; Wahnapiatae, Ontario; and Eel Ground, New Brunswick gathered in Ottawa in May 2001 to complement the GIS training received as part of their SCI projects.

The workshop was designed to facilitate opportunities for these community representatives to compare and discuss needs, to share experiences, and to consult with instructors regarding practical solutions and project designs. The curriculum was created by enhancing the extensive Internet and multimedia materials developed at CCRS, integrating it with imagery examples, and delivering it in a manner that was sensitive to Aboriginal needs and traditions of land stewardship. All participants deemed the training session a success, and commented on the future usefulness of remote sensing for their land management projects. The workshop also contributed to strengthening connections within the growing network of SCI communities, providing valuable insight into how operational needs can meet community needs.

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University Co-op Student Receives Award

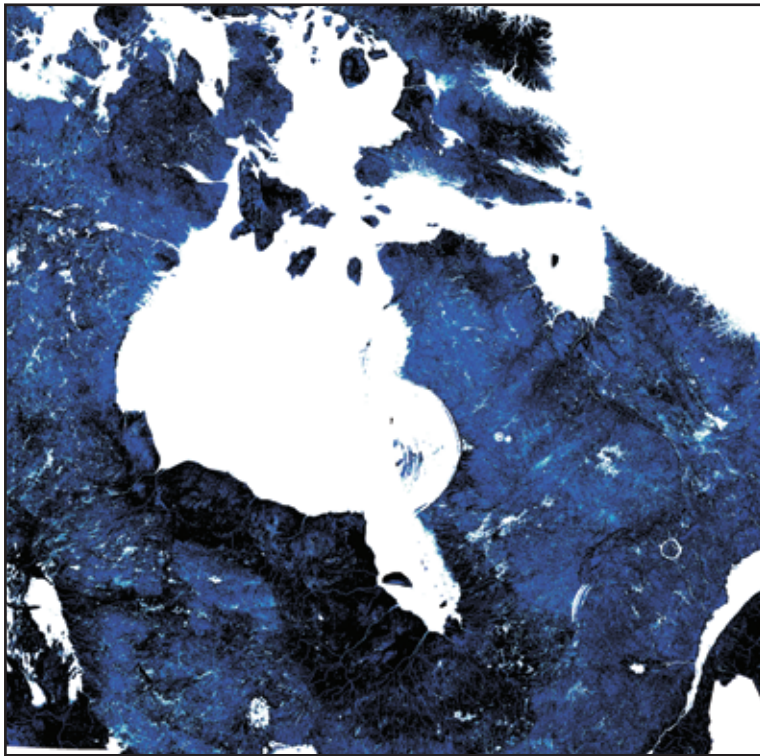
Troy Tennant has been awarded the Xerox Research Centre of Canada Work Report Award for writing an outstanding work term report. A co-operative education student from the University of Waterloo, Mr. Tennant was employed at the Canada Centre for Remote Sensing from September 2000 to May 2001. Entitled "Crusade Mission - Analysis of Ship Based Data" his work term report provided summary information on the time-varying records from sensors (wind, ship motion and position, sea temperature etc.) located on participating vessels in a large airborne radar campaign off the coast of Newfoundland in March 2000. His report also provided details on sea, wind, and ship parameters that complement the radar signatures. Led by the Canadian Department of National Defence, Defence Research Establishment Ottawa the CRUSADE mission was aimed at measuring polarimetric radar signatures from ships at sea.

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Water Fraction Database of Canada

Canada has the third largest renewable water resource stock of all countries reporting to the United Nations. According to Statistics Canada, freshwater covers 891,163km², or just less than 10% of Canada's landmass. Knowledge regarding the spatial distribution of freshwater across Canada is required for a wide range of purposes including modelling national carbon and water cycles, correcting and interpreting satellite imagery, as well as regional and climate forecast models. Currently, national hydrographic coverage in vector format derived through the revision and generalization of 1:1,000,000 scale VMAP: Level 0 hydrographic information from the United States is available via GeoConnections (<http://geoconnections.org/>).

To support the generation of raster products using satellite data for the modelling of carbon and water cycles, scientists at the Canada Centre for Remote Sensing have prepared the first water fraction database of Canada. This new raster product represents the area of water for each grid cell as reported in the Canadian 1:50,000 scale (or 1:250,000 scale if 1:50,000 data was unavailable) National Topographic Database (NTDB). Initially to be available at 1km grid resolution this information can be used in combination with the available vector hydrography layer to provide a national synopsis of both hydrological networks and freshwater areas with accuracy limited only by the NTDB source data.

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Geospatial Data Gateways

The former Canadian Earth Observation Network (CEONet), a geospatial data search engine, is now named "GeoConnections Discovery Portal" (<http://geoconnections.org/>). This portal currently offers access to more than 9,000 products (maps, satellite images and publications), 1,600 organizations and 300 services, plus provides searches of more than 265 databases from Canada and around the world with Z39.50 connectivity.

The CCRS Earth Observation Catalogue (CEOCat), (<http://ceocat.ccrs.nrcan.gc.ca/>), a satellite image archive, will soon have direct online ordering capability between registered clients and receiving stations.

GeoGratis (<http://geogratias.cgdi.gc.ca/>), a web and file transfer protocol (ftp) site, has over 50,000 geospatial data files accessible for free download. Vector mapping data, as well as several types of full resolution satellite imagery are available in scales ranging from 1:50,000 to 1:30,000,000 in a variety of file formats. Rail, hydrology, and administrative boundary framework layers are also offered. Work continues on drainage basin, road network, parks, and census sub-divisions framework layers.

In co-operation with federal and provincial governments, GeoGratis is also distributing full resolution orthorectified Landsat 7 and Level 1-G imagery for all of Canada. The imagery is available to registered users free of charge with "on-the-fly" format translation, projection selection (LCC and UTM), scene sub-setting, and compression choice (WinZip, Unix Gzip). The orthoimage dataset is being created with the most accurate control data available. The imagery has been corrected with either (provincial) aerial triangulation data, or if not available, the most accurate National Topographic Database data. The L1-G product is a radiometrically and systematically corrected Level Zero-Reformatted (LOR) image. Resulting products from the orthorectified and Level 1-G imagery are intended to complement federal and provincial mapping programmes, as well as provide a valuable resource for the remote sensing, geomatics, and educational communities. Acquisition and orthorectification of all data for this project is expected to take three years.

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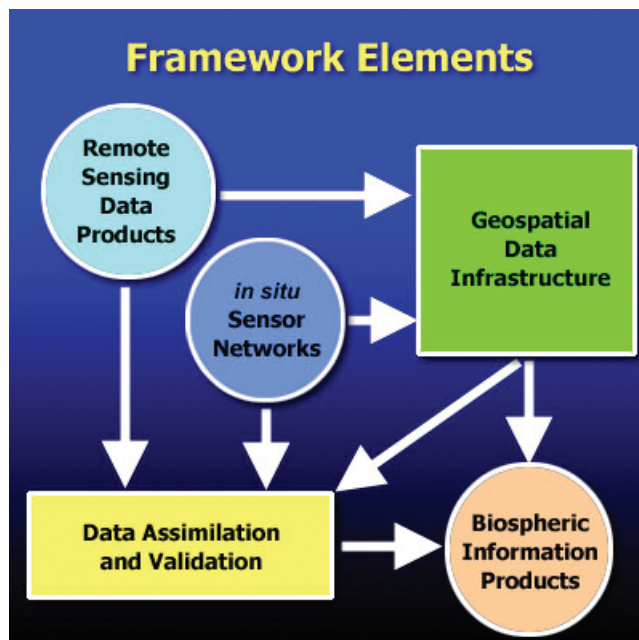
in situ Sensing



Given the increasing importance of *in situ* data and their assimilation into models that also use remote sensing data, the Canada Centre for Remote Sensing has initiated an *In Situ* Sensor Measurement Assimilation Programme (issmap).

The goal of issmap is to make significant advancements in the practical use of Earth observation data by developing intelligent *in situ* measurement capabilities that open new pathways towards the generation of quantitative biospheric information products. Since many independently managed *in situ* sensor networks and data archives currently exist, activities will be carefully focused and existing infrastructures will be used wherever possible. The scope of activities will initially conform to a five-element framework centred on biospheric information products, remote sensing, *in situ* sensor networks, geospatial data infrastructures, as well as data assimilation and validation.

issmap is seeking research and development partnerships and strategic alliances to focus on the development of intelligent sensor networks for *in situ* data acquisition; methods to assimilate *in situ* and remote sensing data into models; and the integration of *in situ* sensor data into geospatial data infrastructures.



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Imagery and Gridded Data Components - Round 2

The International Standards Organization Technical Committee 211 (ISO/TC 211) on Geographic Information/Geomatics Project 19124: Imagery and gridded data components that is being led by the Canada Centre for Remote Sensing, has defined five components and developed two new standards projects. The defined components are Data Model, Metadata, Encoding, Services, and Spatial Registration. The two newly accepted standards projects are ISO 19129: Imagery, gridded and coverage data framework and ISO 19130: Sensor and data models for Imagery and gridded data.

Project ISO 19129 will define the content and the relationship between the five components defined in ISO 19124. ISO 19129 is a technical specification that combines a number of well-defined content structures, such as grids, tillings, trees, and traversals according to ISO 19123: Geographic information - Schema for coverage geometry and functions with metadata, sensor and other aspects into a framework. At the Content Model level this framework will foster a convergence of existing imagery, as well as gridded and coverage data while allowing for backward compatibility with existing standards. This project will also include the definition of an application schema for products such as remote sensing imagery.

Project ISO 19130 focuses on the development of data models for remote sensing imagery including the definition of metadata elements for different sensors. ISO 19130 will also include a Sensor Model Language, permitting the fusion and portrayal of several remote sensing imageries over an Internet client-based browser.

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