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GÉO info
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Modelling: A Prime Planning Tool within the Ministère des Transports du Québec

Pierre Tremblay

The Ministère des Transports du Québec (MTQ) uses modelling to develop transportation policies, optimize road development, and assess opportunities and impacts of major infrastructure projects as part of the planning process.

Transportation models are information systems that use spatially referenced data, statistics, rules, and specialized software to represent and analyze transportation supply and demand. In other words, they represent who people and merchandise move along Québec's transportation network, while providing the means for predicting how this movement may change over time.

The sound use of transportation models contributes to a rigorous, structured analysis of the impacts of transportation projects of the Ministère and its partners based on miscellaneous scenarios. Constant updating is critical for information currency and taking advantage of the new technological tools available.

In order to achieve structured representation of transportation systems of transport, modelling requires the use of research operational methods, in particular to establish optimal roads and stimulate flow along road networks. These methods involve two classes of base data centered on fine spatial reference, namely transportation supply and demand.

Demand

The entire territory modelled is divided into homogeneous areas based on flow generation or attraction. Demand can then be presented in the form of tables referred to as flow matrices, between the originating location and destination. The data from these matrices come from regional origin-destination survey that make it possible to sketch an accurate picture of traffic demand at a given moment. Supply projection models are then used to predict flow on the medium and long terms.

Supply

Current and future traffic supply is represented by geocoding of transportation networks in which intersections are represented by nodes and road segments by curves. Collective transportation services are coded according to the itinerary of nodes used.

Models for Each Type of Transportation

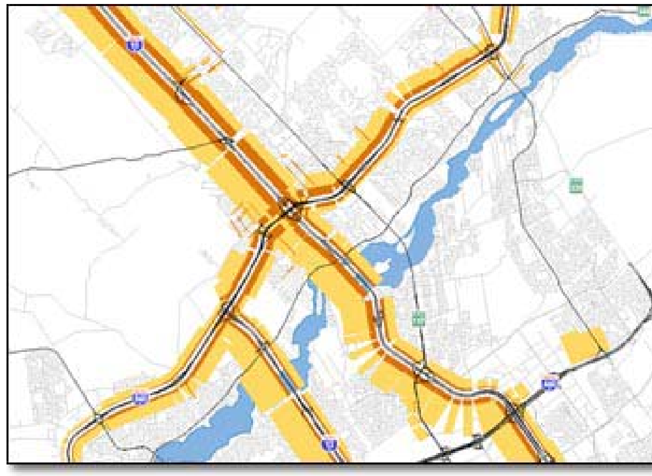
The MTQ uses models for three classes of transportation issues, namely urban mass transit, intercity freight, and road traffic.

Furthermore, the Ministère has regional models for the province's five main built-up areas (Montréal, Québec, Sherbrooke, Trois-Rivières, and Gatineau) used in analyzing urban transportation issues. These models are regularly updated as new regional origin-destination surveys are carried out. These models are used in

EMME/2 (http://www.inro.ca/) and MADITUC (http://www.transport.polymtl.ca/), both of which are software applications developed in Québec universities.

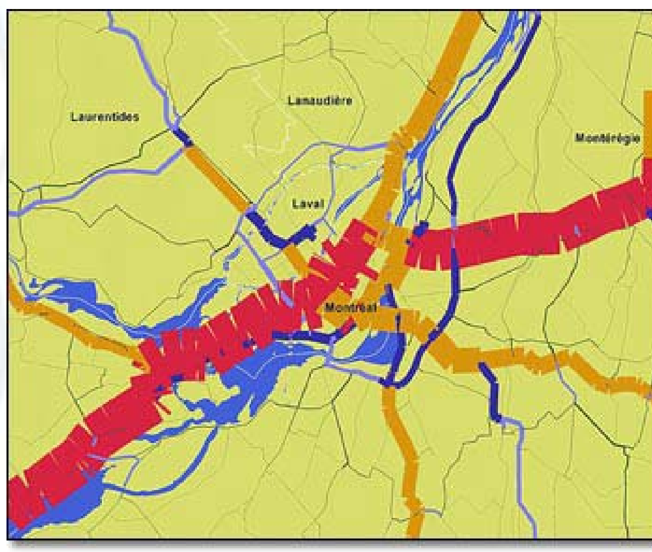
The MTQ also has a flow simulation model for intercity heavy trucks using Québec's road network. It was developed with Transcad software and the results from the pan-Canadian trucking surveying carried out in 1999. This model makes it possible to produce simulations for the entire North American road network.

As for road traffic, smaller-scale problems are examined with microsimulation models. MTQ has acquired the AIMSUN (http://www.aimsun.com/) microsimulator, which can analyze the operation of complex intersections and interchanges or even optimize geometric layouts within major transportation corridors.



Proportion and origin of ramp users on the A-15 / A-640 interchange during morning rush hour (between 6 AM and 9 AM)

Microsimulation of vehicle movement at the A-40 / Acadie interchange in Montréal.



Intercity heavy truck flow in the Montréal area in fall 1999.

Information Accessible to Partners

MTQ develops, uses, and updates transportation models that respond primarily to department needs. Nevertheless, MTQ allows its partners (other departments, municipalities, public transportation agencies, research and study organizations, etc.) to use various transport modelling products, in particular:

- Simulation network traffic (flow maps)
- Analysis of flow rate (isochronous curves)
- Estimates of polluting emission from mobile sources
- Projections of transportation demand

The next issue of *GÉOinfo* will present the multimodal network model of Québec, which is another MTQ modelling tool that makes it possible to calculate travel time and distances between Québec localities.

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Next-Generation Technologies Club/Club de la prochaine génération de technologies

A new pathway for exchanging and disseminating information in the fields of geomatics and Earth observation

Gino Desrosiers

Relax. The Next-Generation Technologies Club/Club de la prochaine génération de technologies (NGTC/CPGT) isn't a *new club* for die-hard *Star Trek* fans. Instead, it's a group of students from different universities involved in the fields of geomatics and Earth observation.

The NGTC/CPGT was founded in September 2002 by four students (Guy Aubé, Julie Gaudreau, Nicolas Gignac, and Rima Mohammed) to foster the acquisition, exchange, and dissemination of information about new technologies. In the current context of overinformation, getting access to genuine innovations in areas of advanced technology can sometimes be difficult. The club was therefore created to respond to a student need. Among other things, the group helps transfer knowledge between governments, industry, scientists, and the student communities in various fields, which is essential to ensuring innovation both in Québec and Canada.

Targeted Objectives

NGTC/CPGT members have the following objectives:

- Have a clear vision picture of the market, current innovative projects, and potential of the geomatics industry on the provincial, national, and international levels.
- Acquire, exchange, and disseminate information about advanced technologies (Earth observation, geographic information systems, geopositioning, wireless telecommunications, etc.).
- Seek the means to stimulate the emergence, convergence, and merging of new technologies by putting them at the service of the general public, private-sector companies, and governments, while preserving the physical and human environments.
- Create a discussion forum developed by and for university students in many related fields (such as agriculture, biology, geography, geology, hydrology, spatial engineering, oceanography, telecommunications).
- Promote the emergence and development of a network of contacts in fields of advanced technology.

Forum for Exchange

The NGTC/CPGT board meets every months to exchange information about new innovative technologies. Each board member is responsible for current information about the sectors of activity to which they have been assigned. The board meetings deal with a variety of themes that include real-time management of emergencies and natural disasters, mobility, and marine geomatics.

The current theme is *Galileo: the Future of Geopositioning*. Galileo, a joint initiative of the European Space Agency (ESA) and the European Community, is the future navigation and positioning satellite system that will provide a highly accurate, guaranteed global positioning service. One of its capabilities is providing real-time positioning for air, marine, and road traffic as well as for agriculture, forestry, and public safety. The system will be deployed in 2008 and comprise 30 satellites. On October 8, the Canadian Space Agency (CSA) became a partner in this project. NGTC/CPGT members are now looking at system operation, possible applications, benefits, and the like.

In order to preserve group dynamics and the development of innovative ideas, the NGTC/CPGT board is fully dissolved and reformed every four months (January, May, and September every year).

The Future GALILEO System

Partnership

On April 2003, the NGTC/CPGT received a grant from the Natural Sciences and Engineering Research Council (NSERC) through the Vice Rector for Research at the University of Sherbrooke to implement a Web site.

The NGTC/CPGT also had the financial support of the Centre d´Applications et Recherches en Télédétection (CARTEL) and the Institut National de Recherche Scientifique - Eau, Terre et Environnement (INRS-ETE).

NGTC/CPGT Web Site.

In June, the NGTC/CPGT became an official partner of the Association Québécoise de Télédétection (AQT). Specifically, the NGTC/CPGT took part (display and conference) in the 11th AQT conference, which took place concurrently with the 25th Canadian Symposium on Remote Sensing in Montréal last month. Moreover, the European Space Agency (ESA) invited the NGTC/CPGT to the 54th International Astronautical Federation (IAF) conference, held in Bremen, Germany, in October and the NGTC/CPGT presented a poster about new technologies.

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NUMÉRIMAGE

Canada-Quebec Agreement on the Development of RADARSAT Data

This article presents the results of a project carried out for the Canadian Space Agency's Earth Observation Application Development Program (EOADP) and the Canada-Quebec Agreement on the use of RADARSAT data. This agreement was initially signed in 1998 and renewed for three years in June 2002. It is co-managed by the Canadian Space Agency, the Ministère du Développement économique et régional, and of the Ministère des Ressources Naturelles, de la Faune et des Parcs. Subsequent issues of articles GÉOinfo will describe the projects carried out under the Canada-Quebec Agreement.

Assessing Wind Power Potential with Satellite Images

Gino Desrosiers

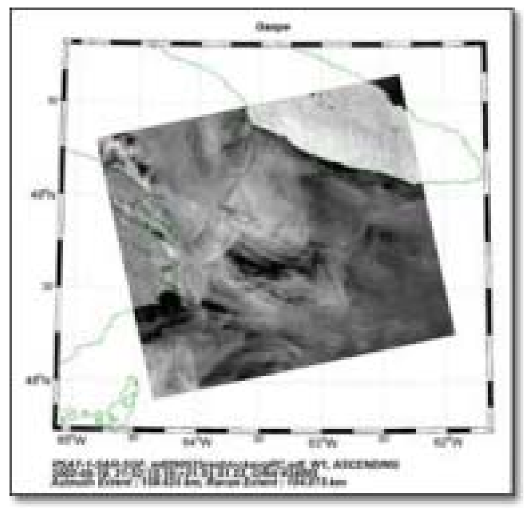
Can satellite images be used to assess the wind power potential of coastal regions? Helimax has attempted to provide an answer to this question putting this new method for estimating wind velocity to the test. This, of course, involves images provided by the RADARSAT-1 satellite.

Recent Use

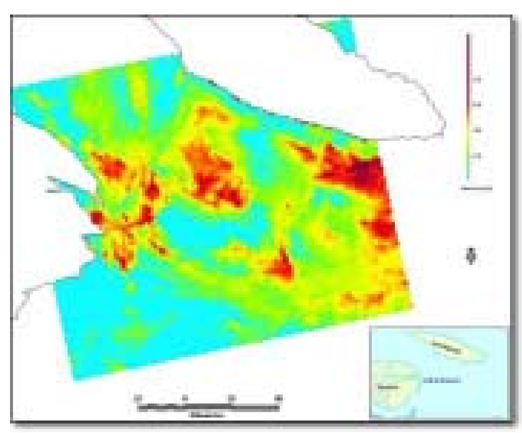
Satellite imagery has been in the oceanographic sciences for nearly two decades. But the scientific community has only been taking a closer look at this technology for studying wind velocity over seas and oceans since the beginning of this century.

Various physical phenomena affect the return recorded by a radar satellite, include the surface roughness of water. Consequently, wind velocity directly affects wave intensity. Therefore, it was posited that satellite images might preserve some trace of the wind's action.

While there is a variety of approaches that can be used to assess wind velocity from radar images, the researchers have preferred that developed by CCRS (Canada Centre for Remote Sensing) involving a radar satellite, namely RADARSAT-1. This approach is based on a semi-empirical



Satellite image captured by RADARSAT-1 on May 10, 2002.



Example of wind velocity fields derived from satellite images opposite using CCRS software.

hybrid numerical model that is the basis for CCRS internal software and Ocean Monitoring Workstations (OMWs). The software used makes it possible to extract velocity fields 10 m above the sea surface.

It's common knowledge that the Gaspésie region has a very high potential for wind energy. And that's why Helimax researchers decided to set up their laboratory in this corner of the province along the Gulf of St. Lawrence, specifically at Pointe-Saint-Pierre in the municipality of Percé.

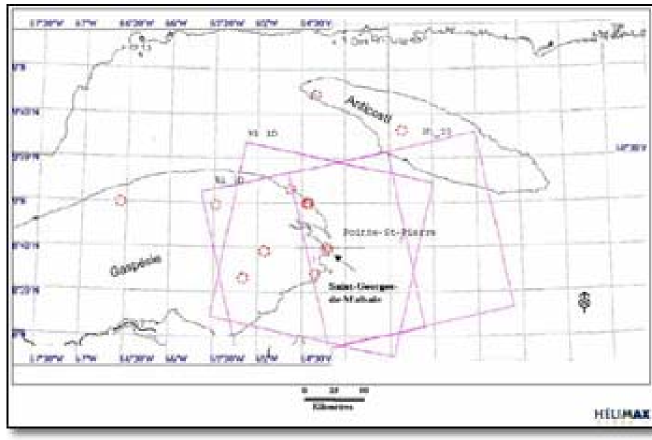
Over a period of 24 days, the test region is captured by RADARSAT-1 operating in W1 mode (recommended by the CCRS for the study) in three passes. This scan mode yields about one image of the sector per week. A total of 39 satellite images have been collected and analyzed over the twelve-month course of the study (the times when the gulf was frozen over were excluded from the sample).

The wind velocities derived from these satellite images were compared to those measured 10 m above the ground on masts erected at least 100 m from the shore. The purpose of the comparison was to establish the degree of correlation between the two types of measurement.

Inadequate Findings

Another series of comparisons was carried out involving measurements taken from masts erected at 1 km, 2 km, and 3 km offshore. The results, however, were unsatisfactory. Indeed, the wind velocities derived from the satellite images yielded a correlation of about 55% with the measured velocities. The measurements recorded 1 km offshore yielded the weakest correlation (52%). The derived velocities were probably skewed by fetch effect, which is the distance at which waves do not increase in height under offshore wind conditions.

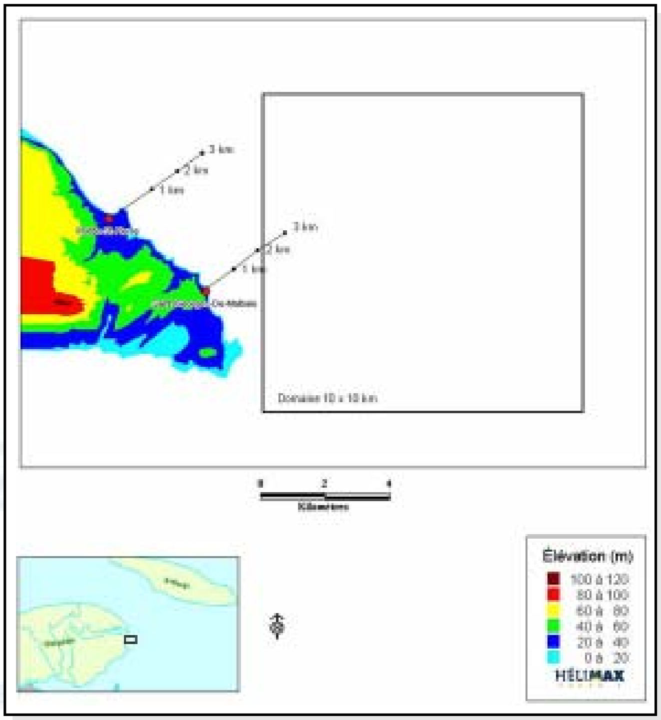
In order to compensate for this shoreline effect and, consequently, improve the degree of correlation between the measurements, the researchers also compared two series of velocity measurements derived from satellite images covering an area of measuring 10 km by 10 km offshore. The results were equivalent to those in the first series of comparisons: 57%.



Coverage of the Pointe-Saint-Pierre study area yielded by the three RADARSAT-1 passes.

Characteristics of the **W1 mode** (wide beam mode)

- Incidence angle: 20° to 31°
- Resolution: 30 m
- Area covered: 164 km by 185 km



Maps of the comparison locations and the 10 km by 10 km test area.

Partners:
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It is interesting to note that the velocity comparisons took into account wind direction. The correlation results were even weaker (49% and 35%, respectively) when the wind was offshore or onshore. A very high correlation (98%), however, was returned when the wind direction was parallel to the shore. It should be noted that the wind velocities from this group could only be measured on six images.

The final phase of the project consisted in initializing the WAsP (Wind Atlas Analysis and Application Program) wind atlas analysis and application program for mapping wind velocities over water. This made it possible to make an absolute comparison between these velocities and the velocities derived from radar images. Once again, the correlation was fairly weak (43%).

A Glimmer of Hope

The Helimax study made it possible to conclude that, for the time being, the new technology for estimating wind velocity based on radar imagery cannot effectively assess the wind-power potential of coastal regions. Consequently, it cannot be immediately used by the wind-power industry. Nevertheless, higher rates of correlation could be obtained if the effect of various meteorological phenomena (such as wind direction and atmospheric stability) on the quality of velocities derived from satellite imagery were better defined.

A great deal of hope is held out for using radar imagery in assessing wind-power potential in coastal regions. Indeed, CCRS is pursuing its research in order to perfect this new method.

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3D/3G Solutions

Remote Sensing Breaks into the Cell-phone Industry

Gino Desrosiers and Chantal Seuthé

The growth of cities is complicating the management and planning of urban environments. Having accurate knowledge of these spaces is especially important in telecommunications, with the arrival of third-generation cellular telephony, which requires a greater number of antenna in order to constitute one of the most effective networks. What could be better for studying and modelling wave propagation, thereby optimizing antenna location, than a 3-D model of the region obtained from satellite imagery?

The 3D/3G Solution

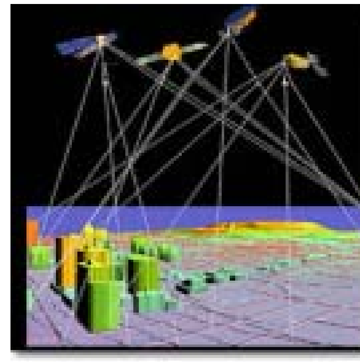
Telecommunications companies are now looking for three-dimensional digital terrain models (DTMs). The rush is due to the arrival of third-generation cellular telephony. Increasing the capacity to carry information (bandwidth) requires in-depth knowledge of the area's topography (ground DTM) as well as infrastructure location and height (ground-surface DTM).

Up to now, the main sources for DTMs have been aerial photographs and vector data from topographic maps. Unfortunately, these data are not always available or current.

VIASAT GeoTechnologies implemented the 3D/3G Solutions project to assess the stereoscopic potential of satellite images produced by different Earth observation systems in designing three-dimensional digital terrain models.

The Meaning of 3D/3G Solutions
The term derives from *three-dimensional* and *third-generation cellular telephony*.

The project assesses both stereoscopic data sensors and multisensor stereoscopy, which refers to combining two images from two different sensors. For example, this could mean combining an aerial photograph with a Landsat image or a radar image with a SPOT image. The revisit capabilities provided by using different sensors to acquire images and the potential for combining images considerably increases the capacity for producing current data.



Some Vocabulary

Photogrammetry:	The science of obtaining reliable spatial measurements from imagery.
Radiometry:	Measurement of the intensity of electromagnetic radiation, which is displayed as greyscale or on satellite imagery.
Stereoscopy:	Process that gives the appearance of relief when two images of the same object are taken from different viewpoints at the same time.
Stereoplotting:	The process of using a stereoplotter to record and convert measurements made from a stereoscopic model into a drawing or map (hardcopy or digital).
F1 mode:	Fine-beam acquisition mode (10 m of resolution) with an incidence angle of 37 to 40 degrees.
F5 mode:	Fine-beam acquisition mode (10 m of resolution) with an incidence angle of 45 to 48 degrees.
Adjacent looks:	Said of two images taken from the same direction but at different angles.
Adjacent looks:	Said of two images taken from opposite directions, one to the right of the track, one to the left.

Method

In order to achieve multisensor stereoscopy, the team heading up the project successfully integrated satellite image rectification models developed by CCRS (Canada Centre for Remote Sensing) into the Helava environment. This made it possible to model geometric distortions, the merging of images, stereoplotting, interpolation, the production of three-dimensional digital terrain models, quality control, and error correction in 3-D mode.

The stereopairs likely to yield the best results are selected according to three criteria: stereoscopic geometry, given by the image incidence angle; radiometry, given mainly by the image capture date; and the rendition of image elements. Inadequate geometry, which occurs when the incidence angle between the two images is too small, translates into inadequate hyperverticality and alters the depth perception when the object is plotted in three dimensions. Too much disparity in the radiometry of the two images in the stereopair or too much time between the capture dates will affect the three-dimensional plotting by making it difficult to identify the same feature in both images. Lastly, the ability to recognize features in the images viewed in stereo, such as the hydrographic network, road network, or buildings, will determine the DTM's scale and type.

Results

A preliminary analysis of each stereopair brought out the following:

- A radar image can only be combined with another radar image. The radiometric disparity in Landsat or SPOT optical images is too great to ensure adequate 3-D viewing. Moreover, radar images can only be used to produce ground DTMs because the spectral response of surface geometric objects, such as buildings, produce significant backscatter (corner reflection) that hinder building identification and depth perception. The same phenomenon has been observed in areas of dense vegetation. In any event, ground DTMs produced from radar images are of very good quality. Viewing stereoscopic of axial highways makes intersections readily identifiable; in certain cases, it can yield DTMs greater than 5 m in accuracy.

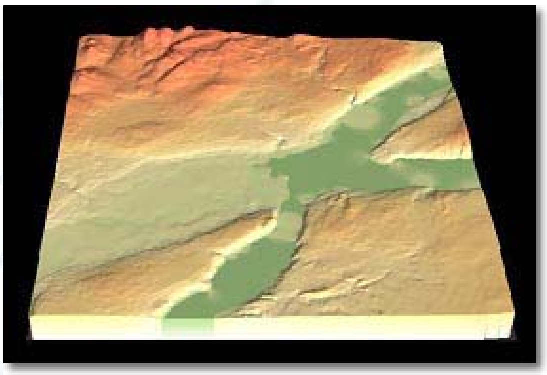
- Using Landsat images was discarded due to the periodic geometric noise probably introduced during initial processing before being purchased. This noise translates into three-dimensional ghost waves when displayed stereoscopically.

- Three-dimensional viewing is not enhanced by merging a high-resolution image with a low-resolution image.

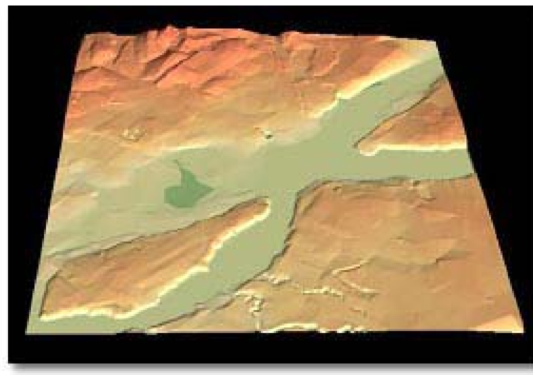
Based on initial assessment, the stereopairs that met quality criteria were processed to yield a three-dimensional digital model. Two approaches were used for each of the pairs: a semiautomatic correlation approach and a photogrammetric approach (entirely manual). Afterwards, the accuracy level of the resultant DTMs was estimated quantitatively.

A Regional Analysis

The project team had four RADARSAT images in F1 and F5 modes for the Québec study area, designated for the production of DTMs at the regional (1:100 000) and urban (1:50 000) scales. An assessment of DTM accuracy revealed a relationship between accuracy and relief. Regardless of the pair used, the error was larger with terrains with high relief than with flat terrain. Moreover, it appears that relief plays a determining role in selecting a radar pair for producing a DTM. Using an image pair with adjacent looks yields better results with high relief, whereas a combination of images with opposite viewing angles is more appropriate for flatter relief.



DTM produced from BDTA hypsometric data



Ground DTM produced from an image pair RADARSAT in F1 and F5 modes

Urban Analysis

As for downtown Montréal, which was selected as being a high-density urban area, the ground and ground-surface DTMs were produced from various combinations of optical (SPOT, aerial photos, Quickbird) and radar sensors. There is good correlation between sensor resolution and the accuracy of the stereoscopic plotting. Consequently, the higher the image's resolution, the easier it is to plot objects on the 3-D image. It also appears that a pointing on the ground is more accurate than on a high building.

Generally, high-spatial resolution optical pairs yield the most faithful ground-surface DTMs. That being said, combining images taken at different times can lead to errors in perception, since the occupancy in certain portions of the downtown area have changed, leading to building demolition or construction.

Promising Conclusions

The project led to several significant conclusions pertaining to the production of ground and ground-surface DTMs in an urban area. As a result, Helava automatic correlation of radar images and high spatial resolution optic images remains a difficult process in urban areas. Adequate correlation is built on having images with highly similar radiometry. The geometry offered by the stereopair is not always adequate or available, depending on the relief, spatial resolution, and object type. In such cases, using a pair of mixed scenes can be a very effective solution. Nevertheless, the use of scenes from different sensors increases radiometric disparity and, consequently, reduces the effectiveness of correlation, while increasing the difficulty in perceiving images in three dimensions.

Taking all this into account, it appears that using stereoscopic scenes acquired nearly simultaneously along the track of high-resolution satellites (IKONOS, QuickBird and SPOT-5) should be the preferred approach. In addition to bringing together optimal radiometry and geometry conditions as well as adequate cartographic accuracy, this acquisition method offers a satisfactory revisit frequency for producing updated DTMs in dense urban areas.

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