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Technical Note / Note technique

Landsat-7 ETM+ orthoimage coverage of Canada

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Abstract. The Centre for Topographic Information (CTI) of Natural Resources Canada is currently producing a complete set of cloud-free orthoimages covering the Canadian land mass using data from the Landsat-7 satellite (under a project called Ortho-7). The project is being undertaken in partnership with GeoConnections, the Canada Centre for Remote Sensing (CCRS), provincial and territorial agencies, and other federal government departments. In addition to financial support, partners are providing topographic control data to assist in producing orthoimages of high quality and accuracy. The creation of a national coverage with Landsat-7 orthoimages will provide an up-to-date fundamental geospatial framework for Canada. These products will serve as an excellent reference for map updating, and their geometric integrity will facilitate data integration from other map and image sources. The inherent information content of the imagery will also serve as a rich baseline for characterizing the Canadian land mass. Image acquisition for this initiative began in 1999 and will continue until complete coverage of Canada is obtained (scheduled for completion in 2004). Of the estimated 750 scenes required to cover the Canadian land mass, 400 images have already been identified as suitable for production. The primary criterion is that the imagery must be cloud and haze free. The ortho-correction is being done in partnership with Canadian industry and is proceeding as scheduled. This note is intended to provide details about the Landsat-7 orthoimage data specifications, production, and delivery model.

Résumé. Le Centre d'information topographique (CIT) produit actuellement une couverture d'ortho-images pour l'ensemble du territoire canadien à partir du satellite Landsat-7. Ce projet est rendu possible grâce à la participation de GeoConnexions, du Centre canadien de télédétection (CCT), de la grande majorité des gouvernements provinciaux et territoriaux ainsi que des autres ministères fédéraux intéressés à la géomatique. En plus de leur participation financière, les organismes possédant des données de contrôle sont invités à les fournir afin de produire des ortho-images les plus précises possible. Par la création d'une couverture nationale d'ortho-images produite à partir des données de contrôle des divers partenaires, le présent projet mettra sur pied une structure nationale d'informations géographiques qui permettra d'intégrer diverses données provenant de différentes organisations. La participation des provinces et des autres partenaires dans le projet contribue à rencontrer les objectifs de GéoConnexions, soit l'établissement d'une structure géospatiale commune favorisant l'intégration de données et l'élaboration d'applications. L'acquisition des images a débuté à l'été 1999 et se poursuivra jusqu'à l'obtention d'une couverture complète du territoire canadien (prévue pour 2004). Parmi les 750 scènes Landsat-7 requises, plus de 400 sont déjà disponibles pour la production des ortho-images. Les scènes choisies doivent être sans nuage ni voile atmosphérique. Une grande partie des fonds investis dans ce projet sont redistribués sous forme de contrats à l'industrie canadienne de la géomatique. Cet article présente le processus de production, les spécifications techniques des données produites et le modèle de partenariat établi pour le projet.

Background

The Centre for Topographic Information (CTI) of Natural Resources Canada is responsible for the acquisition, management, and dissemination of topographic information for the Canadian land mass. The CTI location in Sherbrooke (CTI-S), Quebec, is leading the project to create orthographically correct Landsat image coverage for Canada.

The CTI will be using the orthoimages for updating themes of the National Topographic Database (NTDB). These themes include, but are not limited to, the hydrographic network, built-up areas, vegetation classes, and wetland regions. In addition, these data, along with those acquired through partnership agreements and outsourcing (road network, rail network, etc.), will be used to populate the new CTI geospatial database (GDB). The CTI will use the GDB to offer customers a new range of digital topographic products, which will be more accurate and up-to-date than the current NTDB.

The CTI-S has designed and implemented the production environment necessary for achieving the orthoimage coverage for Canada, including the image acquisition, contract production, quality control, product distribution, and overall

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project management for this initiative. Through GeoConnections, the CTI was awarded funding to produce the orthoimage data for Canada. These funds largely support contracting out of the ortho-production process. The various partners are providing funds, primarily for image data acquisition. Partners are also contributing ground-control data that facilitate the development of orthoimages with as high accuracy as currently achievable with the available resources, as the best available positional data for each Canadian region are being utilized. As the accuracy of the positional ground control varies nationally, the orthoimages will be of variable positional accuracy nationally. This project will also yield a metadata and control-point database, appropriate for use in future orthoimage production projects.

The ortho-corrected Landsat-7 Enhanced Thematic Mapper Plus (ETM+) data are being provided to all acquisition partners on compact disks (CD-ROM) as the data become available. Each CD-ROM contains information about the image ortho-rectification specifications and metadata on the ingest and output data. It also includes the ortho-corrected image data in a GeoTIFF format. A web-based distribution environment has also been established using the GeoGratis web site (<http://geogratis.cgdi.gc.ca/frames.html>) and the CTI on-line purchasing web site (<http://www.ctis.nrcan.gc.ca>). Thus, a broad distribution policy has been developed to ensure wide availability of this particular product opportunity. In doing so, it is anticipated that the high-quality data being provided will stimulate interest from less traditional users and thereby contribute to fostering greater interest in geomatics data and its potential applications.

CTI Landsat data collection consortium

With the support of GeoConnections and the Canada Centre for Remote Sensing (CCRS), the CTI-S established agreements with the larger stakeholders in the field of geomatics in Canada (federal, provincial, and territorial levels). Funding from these partners is primarily intended for data acquisition, since some 750 Landsat-7 scenes will be required to complete the project. Of the 10 Canadian provinces, nine are full participants, and all three territories are participating. The participating federal government agencies are Agriculture and Agri-Food Canada, Canada Centre for Remote Sensing, Canadian Forest Service, Canadian Heritage (Parks), Canadian Transportation Agency, Department of Indian and Northern Development, Department of National Defense, Elections Canada, Environment Canada, Fisheries and Oceans Canada, and Statistics Canada.

CTI contracting and production methodology

In undertaking the ortho-rectification of the imagery, digital elevation models (DEM) and geo-referenced control points are required. Ideally, control points that meet the CTI-S specifications must be used for each image. Since the source and dates of control points vary, so to may the accuracy of the resulting products. Sources of control include provincial or federal vector data and photogrammetric models from the Aerial Survey Database (ASDB). The work for delimiting the entities used for image control prior to the ortho-rectification is contracted out to the Canadian geomatics industry. The work involves the delimitation of image entities on the raw image, the delimitation of control entities based on the control source, and the establishment of a relationship between the two entities. Contractors carry out the entity delimitation that enables the CTI to make the final selection of points for image correction.

According to the standard CTI production model, the CTI-S relies on private industry for production and processing of the geomatics data while CTI staff address issues of quality control, management, and distribution of the data. As for most of its activities, a qualifying process is required to become a supplier to the CTI-S. In this specific case (ortho-production contracts), only the basic structuring qualification (BSQ) is required. The testing, or qualification process, consists of learning and applying data format conversion and structuring specifications. There are currently over 10 companies that are certified as qualified contractors to the CTI-S. Once the contractors have delivered the control-point selection and delineation, the CTI-S audits the procedures and ensures control-point quality, identification and removal of gross errors, geo-correction model calculation, and automatic ortho-correction processing.

Image data description

Landsat-7 ETM+ was launched on 15 April 1999 (Goward et al., 2001). Since then, the CTI has been monitoring the quality of images collected over Canada and purchasing those that meet seasonal and atmospheric criteria. The Landsat-7 imagery is collected from May to October. Only those images judged visually to be without haze or cloud are purchased.

A brief description of the Landsat-7 orthoimage production plan is available on a web site at the CTI (<http://www.ctis.nrcan.gc.ca>). The Ortho-7 web site is comprised of three sections:

(1) The first section provides production progress on a per province or per region basis, showing the orthoimages produced, those currently in production, and the image availability for ortho-correction (cloud free). A list of the selected images is available on-line. In **Figure 1**, for example, the production strategy for British Columbia is shown.

(2) The second section provides the theoretical planning for Landsat-7 coverage of Canada. The Worldwide Referencing System (WRS) is used to define the acquisition and collection of Landsat imagery. A summary of the WRS, and specifically how it relates to Canada, can be found in Wulder and Seemann (2001). The overlap of Landsat frames is approximately 40% at

Canada's southern border, increasing to greater than 80% in northern Canada. Using thinning rules to maintain all images at <60°N latitude, every second image from 60°N to 68°N and every third image above 68°N results in a theoretical coverage of 650 images. Prior to thinning of the WRS, over 1200 images cover Canada's land mass.

(3) The third section shows graphically the progress of the project (**Figure 2**). Cloud-free images acquired from May to October are eligible for purchase for the orthoimage. To date, over 140 orthoimages have been produced and distributed to partners. Another 60 orthoimages are currently in production and should be available for distribution by the fall of 2002. The production schedule is established according to availability of cloud-free imagery (where possible with contiguous scenes), availability of sources for control, and stakeholders priorities.

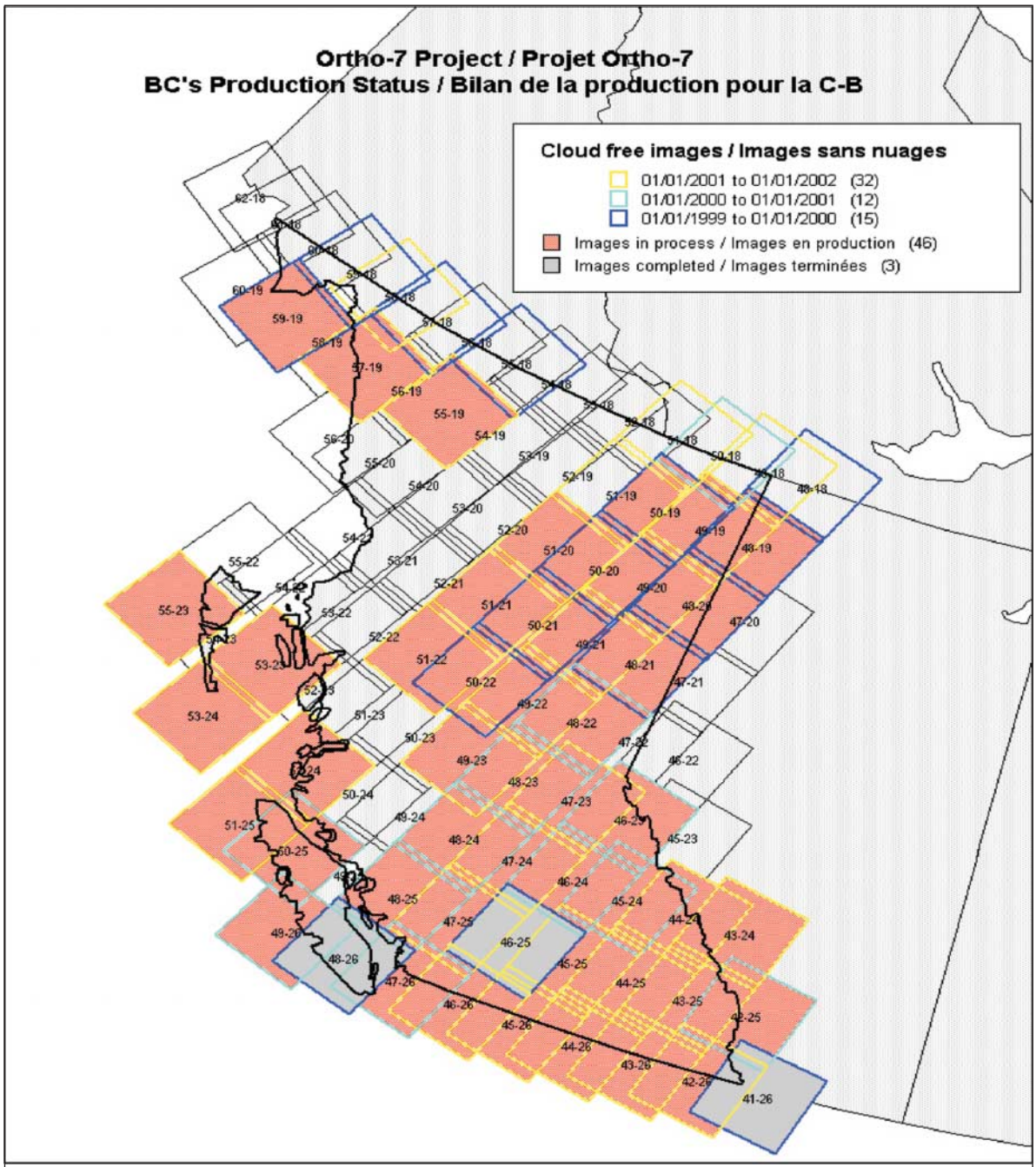

Figure 1. Landsat-7 images selected for the CTI production block 6, British Columbia. The map shows images in production and images identified as cloud free and appropriate for production. Other images, not yet identified as appropriate for production (no fill), are monitored for purchase eligibility on a regular basis for cloud- and haze-free status.

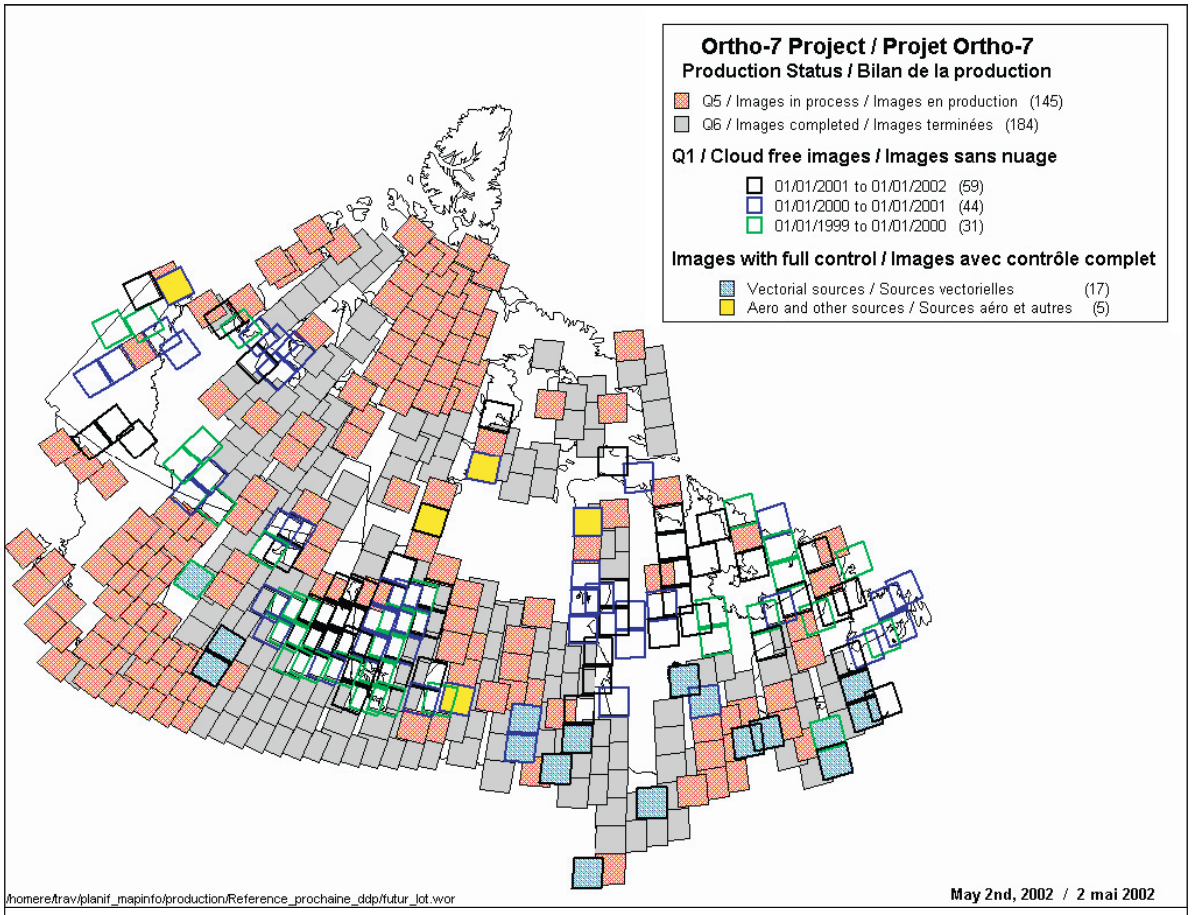

Figure 2. Coverage and status of Landsat-7 images obtained since 1999.

The data are geocoded to the Universal Transverse Mercator (UTM) format in the NAD83 datum. The image data are resampled using a cubic convolution algorithm (Toutin, 1995). The image radiometry is altered using the gain and offset values appropriate for the date of image acquisition. The metadata for the imagery contain information on scene centre, sun elevation, sun azimuth, and time to allow for additional radiometric adjustments (e.g., Richter, 1990).

Conclusions

This national Landsat-7 coverage of Canada, enabled through GeoConnections funding, the CTI, and the CCRS leadership, is providing an invaluable resource for characterizing the state of the Canadian land mass. The sharing of these data with partners and availability via the web provide an unprecedented opportunity for the characterization and assessment of the Canadian land mass and in so doing provide baseline documentation for the status of our terrain circa 2000.

The integrity of the ortho-corrected imagery allows for a common geometry between the Landsat-7 scenes and other geographic data of Canada. The successful partnerships brought to bear in this initiative are an excellent example of a working framework for future opportunities.

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