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A complete orthorectified Landsat-7 mosaic of the Canadian Arctic Archipelago

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This new mosaic of the Canadian Arctic Archipelago comprises the best data available for the Canadian Arctic acquired under snow-free conditions between 1999 and 2002 and is now available for free download through GeoGratis.

By using more than 9000 ground control points and 1500 conjugate tie points, the equivalent of approximately 280 images were assembled to create the mosaic by using methodology developed at the Canada Centre for Remote Sensing.[1] All of the multispectral bands are registered to the panchromatic band, and the positional accuracy of each pixel is approximately 7.5 metres (m) RMS, relative to the control points used. This level of accuracy represents a maximum position error of approximately 20 m (at 90 percent confidence level) anywhere within the mosaic.

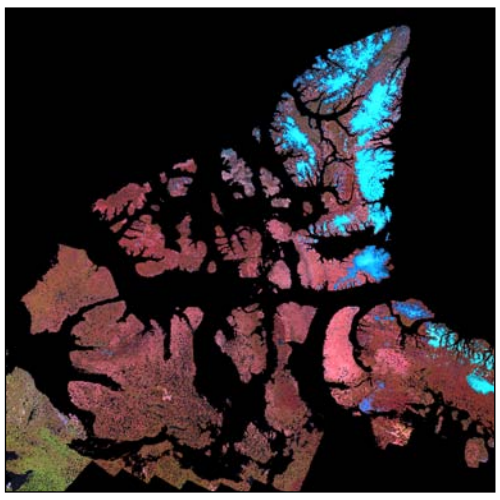

Figure 1. Landsat-7 mosaic of the Canadian Arctic islands
Map projection parameters:
Lambert Conformal Conic (LCC)
Central meridian: 95°W
Projection origin: 0°N
First standard parallel: 49°N
Second standard parallel: 77°N
Ellipsoid model: WGS84

The Landsat-7 mosaic of the Canadian Arctic archipelago is a seamless geographic image data product accurately registered to better than 1:50 000 scale. The processed data includes all the multispectral bands at 30-m resolution. This regional compilation contributes supporting thematic terrain information to serve geographic baseline needs, resource mapping efforts and environmental applications.

Data selection

The best cloud-free data for creating the mosaic were selected from acquisitions collected during the snow-free periods in the summers of 1999 to 2002. In contrast to the traditional "square scene" data delivery of 185 by 185 kilometre Landsat frames, the photogrammetric adjustment process employed long strips of data along an orbital track. Each of the 115 tracks is as long as one to seven (typically three) standard scenes.

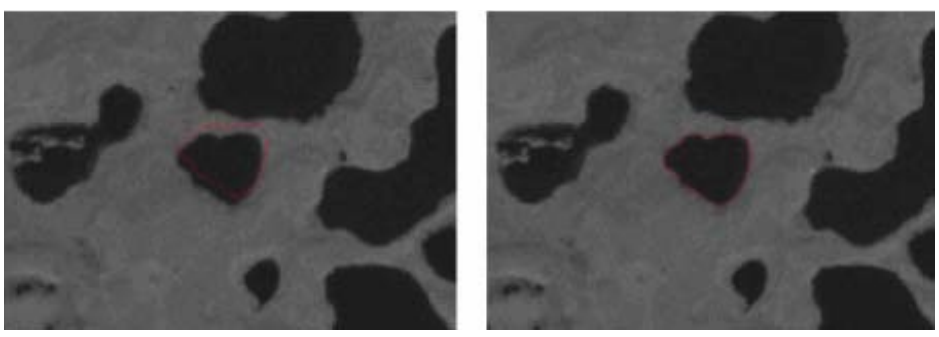

Figure 2. Geometric accuracy test, before (left) and after (right) orbital adjustment process

In the pair of images in Figure 2, the left side is a Level 1G product that exhibits the nonconformity of the image with the vector outline of a known lake location shown in red. The image on the right side is the result following the ortho-rectification procedure. The image location of the lake matches well with the red vector outline in this product.

Data processing methodology

The uniform error distribution throughout the mosaic was achieved by applying a simultaneous block adjustment of multiple acquisition paths that each contain multiple scenes. In contrast to these results, the traditional approach of adjusting each scene individually produces variable position accuracy for each scene as a function of the control points used.[2] As a result of adjusting the satellite ephemeris and attitude data before resampling the data, the final result also succeeds in preserving the radiometric integrity of the data.

The new procedure minimized the accumulation of planimetric errors that accompanies traditional resampling, orthorectification and geographic registration steps. This procedure preserves the radiometric integrity of the spectral data. The technique employed produces products that are based on a single resampling step.

Procedure

A correction for the satellite ephemeris and attitude parameters (e.g. roll, pitch, yaw, position and velocity) is calculated to minimize residual errors for all the ground control points (GCP) and conjugate points (CNJ). The method of solving for the correction of the ephemeris and attitude values is to use the co-linearity condition for the GCP measurements and the co-planarity condition for the CNJ measurements to derive a least-squares equation. The solution of the equation is used to update the ephemeris and attitude values of each orbit path.

Figure 3. Kanguk Peninsula, Axel Heiberg Island, Nunavut - a view of a 500 by 500 pixels Landsat-7 mosaic at full 30-m resolution

The GCP and CNJ measurements were determined by using the Phase Correlation technique that employs two-dimensional Fast Fourier Transform routines to determine the spatial phase difference between the images being compared.

The comparison of a GCP image and the satellite image begins with an image patch sized 512 lines by 512 pixels; each patch dimension is further reduced by a factor of two in each step. The process is complete when the patch size reaches 16 lines by 16 pixels. At this level, relative geographic positions are computed for further evaluation. The residual errors for the Arctic mosaic are given in the following table.

Measurement type	Number of measurements	X error RMS (m)	Y error RMS (m)	Intersection uncertainty RMS (m)
Ground control points	9100	7.5	7.6	–
Conjugate points	1500	–	–	3.8

Summary

A new orthorectification procedure was successfully applied to Landsat-7 data for creating a large area mosaic of the Arctic islands. Results indicate that RMS planimetric positional errors are 7 to 8 m for GCP and 3 to 4 m for CNJ. With available GCP limited to approximately 5 m known accuracy, these seamless map products can be considered accurate to approximately 20 m, or less than one image pixel. An early version of this mosaic was described by J. Gibson,[3] and all digital data of this final version, including some three-band composite images, are now available for free download through GeoGratis. Landsat-7 is currently the best spatially and radiometrically accurate Landsat product for the Canadian Arctic.

Acknowledgements

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[1] Gibson, J.R. and S. Nedelcu. 2008. "An improved approach for the production of satellite-based geospatial reference imagery." *International Journal of Digital Earth.* vol. 1, no. 2, pp.221-239.

[2] Ibid.

[3] Budkewitsch, P., Nedelcu, S., Gibson, J., MacGregor, R., Dewing, K. and D. James. 2007. "A Complete Ortho-rectified Landsat-7 Mosaic of Arctic Canada." First International Circumpolar Conference on Geospatial Sciences and Applications, Yellowknife, N.W.T., 21-24 August, 2007. CDROM Proceedings, 1 p. BudkewitschP_North2007_A.pdf.

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