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## 1. Introduction

TITLE: CCRS Proposal for Evaluating LANDSAT-4 MSS and TM Data

Investigation Number: LANDSAT-4, F-2

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Organization: Canada Centre for Remote Sensing (CCRS)

Type of Report: Third Progress Report

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## II. Technique

The following LANDSAT-4 imagery was used in the study: 3 MSS scenes and 2 TM scenes.

| Sensor | Path/Row | Identification | Date | Data Type |
|---|---|---|---|---|
| MSS | 16/24 | Mistassini, Que. | 21/06/83 | raw |
| MSS | 16/28 | Ottawa, Ont. | 24/10/82 | geocoded |
| MSS | 16/28 | Ottawa, Ont. | 07/07/83 | geocoded |
| TM | 28/25 | Dryden, Ont. | 26/09/82 | CCT-P |
| TM | 23/35 | NE Arkansas | 22/08/82 | CCT-P |

## III. Accomplishments

The objectives of the Canadian proposal are:

(1) to quantify the LANDSAT-4 sensors and system performance for the purpose of updating the radiometric and geometric correction algorithms for MSS and for developing and evaluating new correction algorithms to be used for TM data processing;

(2) to compare and access the degree to which LANDSAT-4 MSS data can be integrated with MSS imagery acquired from earlier LANDSAT missions;

(3) to apply image analysis and information extraction techniques for specific user applications such as forestry or agriculture.

During the reporting period the accomplishments toward these objectives have been:

(1) completion of interband registration error study in raw LANDSAT-4 MSS data, (Reference 1).

(2) completion of multitemporal registration error between two LANDSAT-4 MSS geocoded products, and between one LANDSAT-2 and two LANDSAT-4 MSS geocoded products, (Reference 2).

(3) radiometric enhancement of TM data for forestry applications, (Reference 3).

## IV Problems

TM application studies based on the Lac St. Jean (14/26) and the Sorel (14/28) scenes acquired on October 10, 1982 have been delayed because the data recorded on high density tape in the NASA Martin Marietta format could not be processed until the Martin Marietta recorder had been returned to the Prince Albert station for the launch of LANDSAT-5. This data is currently being analyzed.

TM information extraction studies based on the Webster County scenes 27/31 have also been delayed for the same reason. These data are currently being transcribed.

## V LANDSAT-5 TM Workshop

J. Murphy from CCRS participated in the LANDSAT-5 TM Workshop that took place at GSFC on April 5-6, 1984.

# LANDSAT-4 MSS INTERBAND REGISTRATION

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Interband registration on raw LANDSAT-4 MSS data has been measured in the four MSS bands of the Mistassini scene (path-row 16-24, June 21, 1983). Statistical comparison between line-pixel locations of uniformly distributed ground control points in the four different bands permitted quantitative measures of the offset over the entire scene. The statistical distribution of the offset measures has also permitted to evaluate the standard error on the mean values, giving confidence on their precision.

In order to achieve precise offset measures, two different methods have been used to localize the control points. These are the manual GCP (Ground Control Point) extraction done on the CCRS Digital Image Correction System and the digital band-to-band correlation adapted from a digital stereographic correlation algorithm. The correlation matrix has been set to 13 lines by 13 pixels and different tests have been made on the correlation peak in order to prevent false correspondence.

The following table summarizes the results obtained from both methods. All band misregistrations are relative to band 1. Units are given in nominal interpixel and interline spacing of 57 m by 82.7 m. The pixel misregistration values are compared to the published figures (NASA).

**TABLE 1. Interband line-pixel misregistration**

| BAND "N" RELATIVE TO BAND 1 | LINE MISREGISTRATION ($L \pm \sigma_L$) | |
|---|---|---|
| | MANUAL GCP'S (SAMPLE SIZE) | DIGITAL CORRELATION (SS) |
| BAND 2 - BAND 1 | 0.10 ± 0.03 (98) | 0.09 ± 0.02 (208) |
| BAND 3 - BAND 1 | 0.10 ± 0.03 (98) | 0.15 ± 0.01 (1681) |
| BAND 4 - BAND 1 | 0.10 ± 0.03 (98) | 0.17 ± 0.01 (1622) |

| | PIXEL MISREGISTRATION) ($P \pm \sigma_P$) | | |
|---|---|---|---|
| | MANUAL GCP'S (SS) | DIGITAL CORRELATION (SS) | POST LAUNCH OFFSET (NASA REV 7) |
| BAND 2 - BAND 1 | 1.91 ± 0.05 (98) | 1.92 ± 0.01 (412) | 1.95007 |
| BAND 3 - BAND 1 | 3.97 ± 0.04 (98) | 4.01 ± 0.01 (2648) | 3.89084 |
| BAND 4 - BAND 1 | 5.77 ± 0.04 (98) | 5.74 ± 0.01 (1966) | 5.84091 |

From these results, the following conclusions can be made.

- There is an agreement within $2\sigma$ between results obtained from the two line-pixel localization techniques. In all cases the digital correlation method gave the best offset measure due to the large sample size.

- There is line misregistration up to 0.20 pixel between bands.

- There is a divergence of 0.12 pixel (band 3) and -0.10 pixel (band 4) between the experimental pixel misregistration results and the published figures (NASA). No significant divergence has been found for band 2.

**REFERENCE**

NASA Goddard Space Flight Center, LANDSAT-4, To Ground Station Interface Description, Revision 7, August 1983, Page B-2.

# LANDSAT-MSS MULTITEMPORAL REGISTRATION

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The multitemporal registration of LANDSAT-4 MSS products has been tested for two different geocoded subscenes acquired October 24, 1982 and July 7, 1983. They have also been compared with LANDSAT-2 MSS geocoded data acquired August 17, 1981. The geocoded subscenes correspond to the Ottawa area as DICS (CCRS Digital Image Correction System) products being geometrically corrected and resampled to 50 metre square pixels projected on the UTM grid. The subscenes extend over four 1: 50000 scale National Topographic system maps. Each image is identified as:

L4A:LANDSAT-4 MSS, path-row 16-28 Oct. 24, 1982

L4B:LANDSAT-4 MSS, path-row 16-28 July 07, 1983

L2: LANDSAT-2 MSS, path-row 17-28 Aug. 17, 1981

Statistical comparison between line-pixel locations of uniformly distributed ground control points in the three geocoded products permitted quantitative measure of the offset over the sub-scene. The statistical distribution of the offset measures has also permitted to evaluate the standard error on the mean values, giving confidence on their precision.

In order to achieve precise offset measures, two different methods have been used to localize the control points. These are the manual GCP (Ground Control Point) extraction done on the CCRS Digital Image Correction System and the digital band-to-band correlation adapted from a digital sterographic correlation algorithm. The correlation matrix has been set to 13 lines by 13 pixels and different tests have been made on the correlation peak in order to prevent false correspondence. Bands 2 and 4 have been used for the manual GCP extraction and band 4 only for the digital correlation.

The following table summarizes the results obtained from both methods. Units are given in resampled 50 metre square pixels.

**TABLE 1. Multitemporal line-pixel misregistration**

| LANDSAT M RELATIVE TO LANDSAT M | LINE MISREGISTRATION ($L \pm \sigma_L$) | |
|---|---|---|
| | MANUAL GCP'S (SAMPLE SIZE) | DIGITAL CORRELATION (SS) |
| L4A - L4B | -0.17 ± 0.16 (21) | +0.18 ± 0.02 (792) |
| L4A - L2 | -0.21 ± 0.13 (21) | -0.11 ± 0.02 (1077) |
| L4B - L2 | -0.04 ± 0.15 (21) | -0.33 ± 0.01 (1513) |
| | PIXEL MISREGISTRATION ($P \pm \sigma_P$) | |
| | MANUAL GCP'S (SS) | DIGITAL CORRELATION (SS) |
| L4A - L4B | -0.89 ± 0.15 (21) | -0.75 ± 0.05 (625) |
| L4A - L2 | -0.41 ± 0.22 (21) | -0.23 ± 0.05 (817) |
| L4B - L2 | +0.46 ± 0.17 (21) | +0.52 ± 0.02 (1092) |

From these results, the following conclusions can be made.

- There is an agreement within $2\sigma$ between results obtained from the two line-pixel localization techniques. In all cases the digital correlation method gave the best offset measure due to the large sample size.

- There is a line misregistration

  . of +0.18 pixel between LANDSAT-4A and 4B geocoded products
  . of -0.11 pixel between LANDSAT-4A and 2 geocoded products
  . of -0.33 pixel between LANDSAT-4B and 2 geocoded products

- There is a pixel misregistration

  . of -0.75 pixel between LANDSAT-4A and 4B geocoded products
  . of -0.23 pixel between LANDSAT-4A and 2 geocoded products
  . of 0.52 pixel between LANDSAT-4B and 2 geocoded products

These line and pixel misregistrations are mainly due to local residual offsets as the geometric correction model is adjusted not only to the geocoded product area but to the entire LANDSAT scene.

# FORESTRY APPLICATIONS OF TM DATA

**D.N.H. Horler and F.J. Ahern**
**Canada Centre for Remote Sensing**
**4 May 1984**

A LANDSAT-4 Thematic Mapper image of Dryden, Ontario (Path 28, Row 25, 26 September 82) has been studied in detail for forestry applications as a logical continuation of work on simulated TM imagery reported by Horler et al (1983). The aims of the work have been to understand the forestry information available in the data and to develop procedures for generating enhanced image products. The research has concentrated on the spectral information content of the imagery. The methodology consisted of the following steps:

(1) The scene was previewed and stratified, and subscenes were selected.

(2) Forest stand maps at 1:15 840 scale and additional information from Provincial forestry officers were obtained for the selected subscenes.

(3) Training areas were selected to represent the major cover types (about 45 classes were selected).

(4) A subscene of the Arkansas image (Path 23, Row 35, 22 August 82) was used to provide a spectral signature of hardwoods in mid-summer.

(5) An attempt was made to atmospherically correct the Dryden and Arkansas scenes and to calibrate the data in reflectance units.

(6) The radiometric statistics (means and co-variances) of each class in each band were computed after checking the statistics of each class for Gaussian distribution.

(7) The data from step 6 was used to study the forestry information content of the spectral features, specifically with respect to (a) broad cover type discrimination, (b) ages of clearcuts and burns, and (c) age, density and species discrimination of softwoods.

(8) The information, combined with statistical tests of class separability, was used to select spectral features for colour image display.

(9) Selected training areas were used to generate an eigenvector transform, and the transformed images were evaluated in the same way as the original bands.

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(10) A colour display space optimised for visual perception was tried in addition to RGB display of spectral features.

(11) Enhanced images were generated, and evaluation in the laboratory and in the field is in progress.

Some conclusions can be drawn at this stage. The fundamental TM spectral data space appears similar to that proposed by Crist and Cicone (1984), in which the first two eigenvectors represent Brightness and Greenness features and the third is a contrast between the shortwave infrared (TM 5 and 7) and the first four bands. Less than 5% of the total scene variance was present in the third eigenvector in our data set, the first two eigenvectors accounting for over 90%. The SWIR bands are of good quality, with good dynamic range and low noise, and contain a great deal of useful information (although much of this information is also present in bands 1 to 4). For example, clearcut information is present in visible and SWIR bands, but TM 5 may be preferable to TM 2. TM 2 is equivalent to LANDSAT MSS 5, which is commonly used for clearcut monitoring.

Extension of the study to include TM images from other parts of Canada and other times is planned, as well as the collection of further ancillary information in the field. The further work will result in a more complete understanding of the information content of the data, particularly with respect to the blue and SWIR bands. Publication of the work is also in preparation.

**References**

Crist, E.P. and Cicone, R.C. (1984). A physically-based transformation of Thematic Mapper data - the TM Tasseled Cap. IEEE Transactions on Geoscience and Remote Sensing, May.

Horler, D.N.H. et al (1983). Development of LANDSAT Thematic Mapper enhancements for forestry applications. Proceedings of International Conference on Renewable Resource Inventories for Monitoring Changes and Trends, Corvallis, Oregon, 15-19 August, p. 471-475.