Landsat 7 Orthorectified Imagery over Canada, Level 1 Product Specifications

Edition 1.1

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REVISION HISTORY

Date	Version	Description
January - 2003	1.0	Original version
March - 2008	1.1	BSQ and PIX formats not available anymore

Please note the CanImage release in February 2008 at the scale of 1:50,000 for the Canada is the last one. It is no longer subject to data discrepancy corrections and will remain a static data collection.

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ACRONYMS AND ABBREVIATIONS

CCRS	Canada Centre for Remote Sensing
CDED	Canadian Digital Elevation Data
CTI-S	Centre for Topographic Information – Sherbrooke
DEM	Digital Elevation Model
FTP	File Transfer Protocol
GCMD	(NASA) Global Change Master Directory
GeoTIFF	Georeference Tagged Image File Format
GPS	Global Positioning System
GRS80	Geodetic Reference System of 1980
LCC	Lambert Conformal Conic
NAD83	North American Datum of 1983
NTDB	National Topographic Data Base
NRN	National Road Network
UTM	Universal Transverse Mercator

TERMS AND DEFINITIONS

Orthorectified Image / Orthoimage

An image derived from a conventional perspective image by simple or differential rectification to remove image displacements caused by sensor tilt and relief of terrain.

1 Overview

Landsat 7 orthoimages are stored as raster data and comprise 9 spectral bands: a panchromatic band with a pixel size of 15 metres, 6 multispectral bands with a pixel size of 30 metres and 2 thermal infrared bands with a ground resolution of 60 metres. They were produced in accordance with NAD83 (North American Datum of 1983) using the Universal Transverse Mercator[1] (UTM) projection.

The orthoimage data sets were created with the most accurate control data available at the time. A variety of sources were used for image correction, the most accurate were given priority. The usual priority ranking was: GPS source for the National Road Network (NRN), provincial vector data, accurate National Topographic Data Base (NTDB) data, federal aerotriangulation data, and other sources. The accuracy was evaluated for each orthoimage data set. The control data, which was extracted from sources as mentioned above, could consist of road intersection vector data or lake/island centroids. In some cases the intersection of the centre line of a surficial river might were used. The control points were distributed homogeneously within the image in specific sectors. Sectors were located in the image surround, in the area of the image with the lowest and highest elevations, and in all other areas in which overlapping image base sectors were located.

The objective of the national orthoimage project was to produce a complete set of cloud-free (less than 10%) orthoimages covering the Canadian landmass using Enhanced Thematic Mapper (ETM+) data from the Landsat 7 satellite. The purpose is to promote the use of geomatics and educate by providing a Web site and file transfer protocol (ftp) site that distribute Canada's geospatial data.

Data (choice of spectral bands) are available for download in GeoTIFF format using either Lambert Conformal Conic (LCC) or Universal Transverse Mercator (UTM) projection.

2 Data Identification

2.1 Spatial resolution ("scale")

The spatial resolution, or the spatial dimension on the earth covered by the size of a pixel (nominal ground sample distance), varies according to each spectral band in Landsat 7 orthoimages.

Landsat 7 Band No.	Spectral Location	Wavelength (in µm)	Resolution (pixel size in m)
1	Blue-green	0.450 – 0.515	30
2	Green	0.525 – 0.605	30
3	Red	0.630 – 0.690	30
4	Infrared (IR)	0.750 – 0.900	30
5	Mid infrared I (MIR 1)	1.550 – 1.750	30
6L	Thermal IR (Low gain)	10.400 – 12.500	60
6H	Thermal IR (High gain)	10.400 – 12.500	60
7	Mid infrared II (MIR II)	2.090 – 2.350	30
8	Panchromatic	0.520 – 0.900	15

Each band has 8-bit radiometry (values from 0 to 255). Each Landsat 7 orthoimage covers an area approximately 183 km by 170 km.

[1] A description of the UTM projection can be found at: http://cartes.RNCan.gc.ca/maps101/nts.html.

2.2 Language

The language used in the dataset is English.

2.3 Character set

The character coding standard used for the dataset is UTF8.

2.4 Topic category

The main topic category of the Landsat 7 orthoimage dataset is image base maps Earth cover. According to the GCMD[2] (Global Change Master Directory) thesauri, imagery can be classified into science key words structured using a four-level hierarchy: category > topic > term > variable. The following list indicates which were retained for Landsat 7 orthoimages.

CATEGORY > TOPIC > TERM > VARIABLE

- EARTH SCIENCE > ATMOSPHERE > RADIATION BUDGET > ALBEDO
- EARTH SCIENCE > RADIANCE OR IMAGERY
- EARTH SCIENCE > RADIANCE OR IMAGERY > INFRARED WAVELENGTHS > INFRARED IMAGERY > ENHANCED INFARED IMAGERY
- EARTH SCIENCE > RADIANCE OR IMAGERY > INFRARED WAVELENGTHS > INFRARED IMAGERY > NEAR INFRARED ALBEDO
- EARTH SCIENCE > RADIANCE OR IMAGERY > INFRARED WAVELENGTHS > INFRARED IMAGERY > NEAR INFRARED BANDS
- EARTH SCIENCE > RADIANCE OR IMAGERY > INFRARED WAVELENGTHS > INFRARED IMAGERY > NEAR IR
- EARTH SCIENCE > RADIANCE OR IMAGERY > ULTRAVIOLET WAVELENGTHS
- EARTH SCIENCE > RADIANCE OR IMAGERY > VISIBLE WAVELENGTHS > VISIBLE IMAGERY
- EARTH SCIENCE > RADIANCE OR IMAGERY > VISIBLE WAVELENGTHS > VISIBLE IMAGERY > VISIBLE REFLECTANCE
- EARTH SCIENCE > AGRICULTURE > FOREST SCIENCE > REFORESTATION
- EARTH SCIENCE > AGRICULTURE > FOREST SCIENCE > FOREST YIELDS
- EARTH SCIENCE > AGRICULTURE > FOREST SCIENCE > FOREST PROTECTION
- EARTH SCIENCE > AGRICULTURE > FOREST SCIENCE > FOREST PRODUCTS/COMMODITIES
- EARTH SCIENCE > AGRICULTURE > FOREST SCIENCE > FOREST MENSURATION
- EARTH SCIENCE > AGRICULTURE > FOREST SCIENCE > FOREST MANAGEMENT
- EARTH SCIENCE > AGRICULTURE > FOREST SCIENCE > FOREST FIRE SCIENCE
- EARTH SCIENCE > LAND SURFACE
- EARTH SCIENCE > LAND SURFACE > LAND USE/LAND COVER > LAND CLASSES
- EARTH SCIENCE > LAND SURFACE > LAND USE/LAND COVER > LAND COVER
- EARTH SCIENCE > LAND SURFACE > LAND USE/LAND COVER > LAND MANAGEMENT
- EARTH SCIENCE > LAND SURFACE > LAND USE/LAND COVER > LAND PRODUCTIVITY
- EARTH SCIENCE > LAND SURFACE > LAND USE/LAND COVER > LAND RESOURCES
- EARTH SCIENCE > LAND SURFACE > LAND USE/LAND COVER > LAND TENURE
- EARTH SCIENCE > LAND SURFACE > TOPOGRAPHY > LANDFORMS > TERRAIN MAJOR LANDFORM
- EARTH SCIENCE > LAND SURFACE > TOPOGRAPHY > LANDFORMS
- EARTH SCIENCE > HYDROSPHERE

2.5 Geographic box

The geographic box or minimum bounding rectangle (MBR) delineating the coverage of all existing Landsat 7 orthoimages in Canada is:

[2] Information on NASA Global Change Master Directory (GCMD) can be found at: http://gcmd.nasa.gov.

- West Bounding Coordinate: 141° West (or -140°)
- East Bounding Coordinate: 52° West (or -52°)
- North Bounding Coordinate: 85° North (or 85°)
- South Bounding Coordinate: 42° North (or 42°)

2.6 Geographic description

The Landsat 7 orthoimages cover the entire Canadian landmass with less that 10% of cloud.

2.7 Extent

Landsat 7 images used to produce this data set were captured between 1999 and 2003.

2.8 Supplemental information

Landsat 7 data are collected from a nominal altitude of 705 kilometres in a near-polar, near-circular, sun-synchronous orbit at an inclination of 98.2º, imaging the same 183-km swath of the Earth's surface every 16 days. Each frame is denoted by a sequential Path and Row determined by the 16-day repeat cycle. Landsat sensors require 233 orbits. The Rows, indexed east/west, are generated by partitioning each Path into 23.92 seconds of spacecraft time in both directions at the equator, resulting in 248 Rows per complete orbit. The Landsat sensors continuously collect data which are segmented post-collection on the ground, using telemetry ephemeris data, into individual framed scenes. The orbital tracks can drift over time due to a variety of factors and are adjusted when necessary. The framing is unique for each orbit. Accordingly, the frame locations are not exact, but are within a tolerance of movement off the original satellite orbit. The satellite orbit results in a coverage side overlap of a minimum of 7.3% at the equator increasing to approximately 85% at 80º of latitude.

3 Geospatial Characteristics

3.1 Spatial representation type

The method used to spatially represent a Landsat 7 orthoimage is raster data.

3.2 Spatial representation (VD) (GD)

Landsat 7 orthoimages are composed of thousands of pixels. Each pixel of information covers a portion of the Earth's surface according to its spatial resolution (spectral bands). The pixels are located in a column (north/south) and row (east/west) axis reference system.

3.3 Coverage and continuity

The Landsat sensors continuously collect data, which are segmented post-collection on the ground, using telemetry ephemeris data, into individual framed scenes. The orbital tracks can drift over time due to a variety of factors and are adjusted when necessary. The framing is unique for each orbit. Accordingly, the frame locations are not exact, but are within a tolerance of movement off the original satellite orbit. The satellite orbit results in a coverage side overlap of a minimum of 7.3% at the equator, increasing to approximately 85% at 80 degree of latitude.

3.4 Data segmentation (VD)

NOT APPLICABLE

4 Data Model (VD)

NOT APPLICABLE

5 Data Dictionary / Feature Catalogue (VD)

NOT APPLICABLE

6 Coordinate Reference System

Landsat 7 orthoimages are available in two projected coordinate reference systems: Lambert Conformal Conic (LCC) and Universal Transverse Mercator (UTM).

6.1 Horizontal reference system

The horizontal reference datum used is NAD83CSRS (North American Datum of 1983 for Canadian Spatial Reference System) and the Geodetic Reference System of 1980 (GRS80) ellipsoid served as a reference.

6.1.1 Horizontal coordinate system

Data are in metres.

6.1.2 Unit of measure (coordinate system axis units)

The data are stored in 2 dimensions for both projections (LCC and UTM): there are 2-coordinate system axis (north-south and west-east).

The unit of measure for data coordinates in X (north-south) and Y (west-east) axis is metres adjusted to the spatial resolution (pixel dimension) of each spectral band (15, 30 or 60 metres).

In Canada, for LCC projection, the standard parallels are 49º North and 77º North, the latitude of projection origin is also 49º North and the longitude of central meridian is 95º West. The false easting and the false northing are both equal to 0 (zero) metre.

For UTM projection in Canada, the scale factor at central meridian is 0.9996, the longitude of the central meridian is determined with the formula (180° – λ) / 6° + 1), where the latitude of projection origin is 0 (zero), the false easting is 500 000 metres, and the false northing equals 0 metre.

6.2 Vertical reference system

NOT APPLICABLE

7 Data Quality

7.1 Scope

The data quality information applies to each Landsat 7 orthoimage dataset.

7.2 Lineage

Orthoimages were produced from control points located in sectors in the image corners and in the middle of the east and the west boundaries (6 base sectors). Additional sectors were used in minimum and maximum elevation areas within the image. The theoretical limit of overlapping images was used to create additional sectors (where projected base sectors of overlapping images were located). A minimum of 3 control points by sector was selected. The Digital Elevation Model (DEM) accuracy had a small impact on orthoimage accuracy (tan 7 * DEM accuracy). Elevations attached to entities used as control points were derived from provincial DEMs, federal DEMs, or from aero-triangulation models. Various DEMs could have been used for rectification depending on availability. The horizontal accuracy given for the orthoimage used the worst DEM accuracy in the calculation. The DEM used could be provincial, NTDB data at the 1: 50,000, or NTDB data at the 1: 250,000, depending on availability. The process used a provincial DEM, if available, to complete the gaps with DEMs derived from NTDB 1: 50,000 contours; remaining gaps from DEMs derived from 1: 250,000 contours were then completed. Since DEM accuracy had little impact on image accuracy, the worst DEM accuracy (including slope impact) served in assessing orthoimage accuracy. At the end of the process, all valid control data and image entities were and still kept in a database.

The originator and the source data used to produce Landsat 7 orthoimages were U.S. Geological Survey (raw image); Centre for Topographic Information - Sherbrooke (National Topographic Data Base (NTDB)); CTIO (aerotriangulation); and provincial data, specifically British Columbia: provincial vector data and provincial DEMs; Alberta: provincial vector data and provincial DEMs; Saskatchewan: NTDB data; Manitoba: federal aerotriangulation and GPS road network; Ontario: provincial vector data and federal aerotriangulation; Quebec: provincial vector data and federal aerotriangulation; New Brunswick: provincial vector data; Nova Scotia: NTDB data; Prince Edward Island: NTDB data.

When the source was provincial data, digital vector data and DEMs (in some cases) were used as control data. If the source was federal or multisource, federal (National Road Network (NRN), NTDB, aerotriangulation) and/or provincial data were used. Orthoimage accuracy was computed in reference to the control data used. The control points were derived from road and river intersections and lake/island centroids.

7.3 Completeness

The data set is derived from Landsat 7 raw image level L1G. It was processed using control points based on the most accurate control available data in the country. The methodology ensures homogeneous distribution of control points within the image. The parametric model was developed by Dr. Thierry Toutin at the Canada Centre for Remote Sensing (CCRS), Natural Resources Canada. This model is based on principles related to orbitography, photogrammetry, geodesy, and cartography. It reflects the physical reality of the complete viewing geometry and corrects distortions that occur due to platform, sensor, Earth, and cartography projection. The Digital Elevation Model (DEM) is the most accurate source available as of the date of orthorectification. It can be a combination of provincial data, Canadian Digital Elevation Data (CDED) at the 1: 50,000, or at the 1: 250,000.

7.4 Logical consistency

Control points were chosen in predefined areas in the image to ensure good and equitable distribution. The image area planned for control-point selection was reduced by 4.5 km in the east and west boundaries of the image. This reduction ensured that the same control points were reused in the next image update. Tests were done on 3 images to determine the best location for control points in an image in order to achieve greater accuracy. These images contained various types of terrain and were very representative of the Canadian landmass. Various control-data types and accuracy were used for these images. The tests concluded that control points in 6 base sectors in the image surround and in the minimum and maximum elevation sectors delivered the best accuracy. Overlapping images were considered and corresponding base sectors were added. These additional sectors (between 4 to 10) did not improve the accuracy, but ensured that the same control points were reused in image overlaps. When accurate control (sub-pixel) was used, the correction model was a good indicator of the derivation of the orthoimage's accuracy.

7.5 Positional accuracy

Orthoimage planimetric accuracy depends on control data, the digital elevation model (DEM), and the method used to extract the positions of the control points in the image. The best sources of control data available **in Canada** were used to generate the orthoimages. A number of control sources were used to correct the Landsat 7 images, namely provincial vector data, roads resulting from the global positioning system (GPS), data from the National Topographic Data Base (NTDB), and geometrically corrected aerial photography (orthophotos). The control points extracted from the sources generally represent road intersections and centres of mass of lakes or islands. Different DEMs also served in generating these orthoimages: provincial DEMs and Canadian Digital Elevation Data (CDED) at the 1: 50,000 and the 1: 250,000 scales. Planimetric accuracy is obtained by analyzing the parametres of the geometric correction model (SRIT), the accuracy of the source data used to correct the image, and DEM accuracy. Once all errors were combined, the accuracy is calculated to a level of confidence of 90% (Circular Map Accuracy Standard (CMAS) (CCSM, 1984)).

The planimetric accuracy for the orthoimages in Southern Canada is about 20 metres, compared to about 30 metres in the northern part of the country. It should be noted that only control data within Canada was used. The planimetric accuracy of the part of the image located outside of Canada may therefore be lower. Each orthoimage has a different planimetric accuracy.

7.6 Temporal accuracy

There is no temporal attribute for Landsat 7 orthoimages besides the date of image capture.

7.7 Thematic (attributes) accuracy

Six (6) multispectral bands are available with a resolution of 30 metres. A panchromatic band 8 was added, with a resolution of 15 metres. Band 6 now has high-gain and low-gain bands with a resolution of 60 metres.

8 Metadata

There are 2 levels of metadata to describe Landsat 7 Orthorectified Imagery, as shown in following figure: collection and product/dataset. The higher level of metadata covers the entire data collection: it applies to the series of available datasets (group of features), database, etc. The other level, called product or dataset level metadata, gives specific information about each dataset.

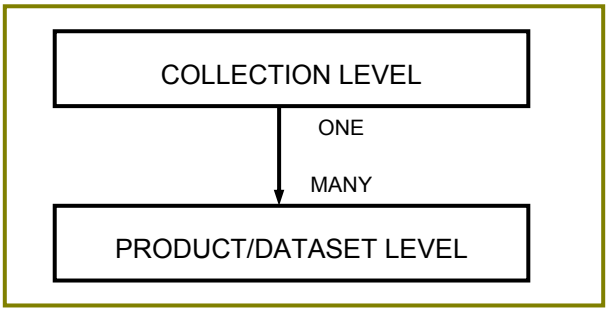

Figure 1: Metadata Levels

The Landsat 7 Orthorectified Imagery metadata are available via GeoBase Portal (in the Data/Satellite Imagery section at http://www.GeoBase.ca) and GeoConnections Discovery Portal (in the Satellite Imagery section at http://geodiscover.cgdi.ca).

9 Data Portrayal / Data Transfer Format / Physical Model

NOT APPLICABLE

10 Data Delivery

10.1 Format information

The format for GeoBase Landsat 7 Orthorectified Imagery product is GeoTIFF. Note that all files require image enhancement for best viewing. The 743 composite images have had histogram clipped linear enhancement applied.

The GeoTIFF[3] is a Tagged Image File Format. The georeferencing tag permits the addition of geographic information such as projection, datum, and coordinate parametres to imagery or other raster-based data. Adobe Systems (http://www.adobe.com/) holds the copyright for TIFF specifications. GeoTIFF is a highly flexible and platform-independent format supported by numerous software packages. The format specifications for GeoBase Landsat 7 orthorectified imagery in GeoTIFF are uncompressed, 8-bit, band-separated. The enhanced 743-color composite image is not band separated.

If your viewing software does not recognize one of the tags, the component is simply ignored and the image will be displayed. GeoTIFF files can be viewed using the widest range of software packages and is recommended for non-geomatics professionals.

PKZIP compression software is used to reduce file size.

A complete Landsat 7 orthoimage is about 400 Mb in size, which can take a fair amount of time to download.

10.2 Medium information

The Landsat 7 orthoimage datasets are available on-line via a FTP site.

10.3 Constraints information

The constraints information for data access and data use are defined in the GeoBase Unrestricted Use Licence Agreement (http://www.GeoBase.ca/ - Home page/Use and Restrictions section).

11 Data Capture and Maintenance

The Landsat 7 raw image must be cloud-free (less than 10% of coverage) in Canada before being orthorectified.

[3] Information about the GeoTIFF standard can be found at: http://www.remotesensing.org/geotiff/geotiff.html.