Ontario

User Guide For Ontario's Radar Digital Surface Model

LIO Data Class

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Additional Information

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Executive Summary

Key Words

Ontario Radar Digital Surface Model, Digital Surface Model, Digital Elevation Model, Digital Terrain Model, Elevation, Spaceborne, Interferometric Radar, C-Band, Shuttle Radar Topography Mission.

Abstract

This user guide details the specifications for the Ontario Radar Digital Surface Model (ORDSM). The Ontario Radar DSM was constructed using radar data collected during an eleven day mission in February 2000 by the Space Shuttle Endeavour.

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List of Acronyms

CVGD28: Canadian Vertical Geodetic Datum 1928

DEM: Digital Elevation Model

DSM: Digital Surface Model

DTM: Digital Terrain Model

EGM96: Earth Gravitational Model 1996

GCS: Geographic Coordinate System

IfSAR: Interferometric Synthetic Aperture Radar

LCC: Lambert Conformal Conic

LIO: Land Information Ontario

LPI: Local Polynomial Interpolation

MNRF: Ministry of Natural Resources & Forestry

MSL: Mean Sea Level

NAD83: North American Datum of 1983

ORDSM: Ontario Radar Digital Surface Model

SDI: Spatial Data Infrastructure

SRTM: Shuttle Radar Topography Mission

USGS: United States Geological Survey

1. Product Description

The source data used for generating the Ontario Radar DSM was from the Shuttle Radar Topography Mission (SRTM), which collected Interferometric Synthetic Aperture Radar (IfSAR). The Space Shuttle Endeavor mission performed a single pass radar interferometry from two antennae mounted 60 m apart with a swath width of 225 km. Orbiting the Earth 176 times during the 11 day mission, the SRTM successfully captured radar data for over 80% of the Earth's land surface (Fig. 1). A more detailed description of the SRTM mission, including publically available data, can be found at USGS.gov (https://lta.cr.usgs.gov/SRTM1Arc).

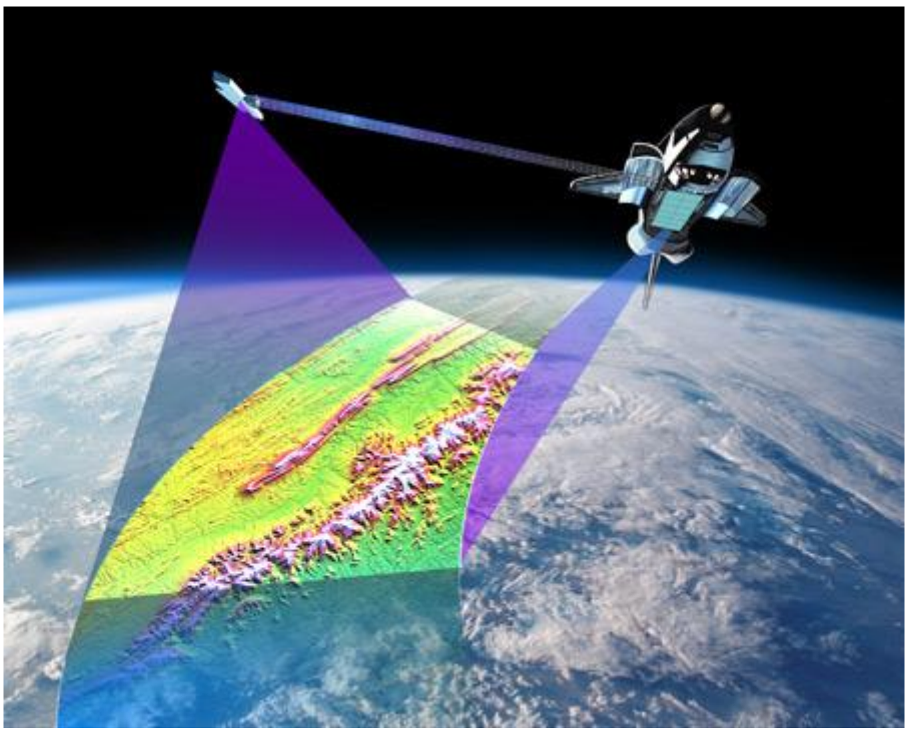

Figure 1: SRTM Collection

1.1 Geographic Extent

The horizontal extent of the Ontario Radar DSM provides continuous spatial coverage between the southern-most extent of the province and north to 57 degrees latitude. The bounding extent for the Ontario Radar DSM in the province is:

- West-bounding coordinate: -96 degree longitude
- East-bounding coordinate: -74 degree longitude
- North-bounding coordinate: 57 degree latitude
- South-bounding coordinate: 41 degree latitude

1.2 Horizontal Reference System

The horizontal coordinate system of the Ontario Radar DSM is converted from a Geographic Coordinate System to MNRF Lambert Conformal Conic projection. The horizontal datum of the Ontario Radar DSM is North American Datum of 1983 (NAD83). Projection parameters are as follows:

- False Easting: 930000
- False Northing: 6430000
- Central Meridian: -85.00
- 1st Standard Parallel: 44.50
- 2nd Standard Parallel: 53.50
- Latitude of Origin: 0.00
- Linear Unit: meters

1.3 Vertical Reference System

The elevation vertical datum of the Ontario Radar DSM is based on two different systems:

- Canadian Geodetic Vertical Datum 1928 (CGVD28), which is the current national and provincial elevation data standard. GRS80 for NAD83 is used as the reference ellipsoid.
- Earth Gravitational Model 1996 (EGM96), which is used by the source data. WGS84 reference ellipsoid is used.

2. Product Details

The Ontario Radar DSM has been interpolated at a consistent linear spatial resolution and geospatial coordinate system similar to other MNRF elevation products, which allows for seamless integration. The elevation vertical datum was transformed from EGM96 to CGVD28 to make the Ontario Radar DSM conform to the national and provincial elevation data standards.

2.1 Data Processing

A Digital Terrain Model (DTM) measures the heights of the bare earth's surface at a given x y location. Numerous technical approaches have been created and used to capture the average topography and generalized geomorphology (Junlin Zhao, Kent Todd, Adam Hogg and Frank Kenny, 2008). The SRTM data used in this project attempts to acquire earth coordinates of the reflective surface, resulting in a DSM. The SRTM tiles were then used to create the Ontario Radar DSM (Fig. 2).

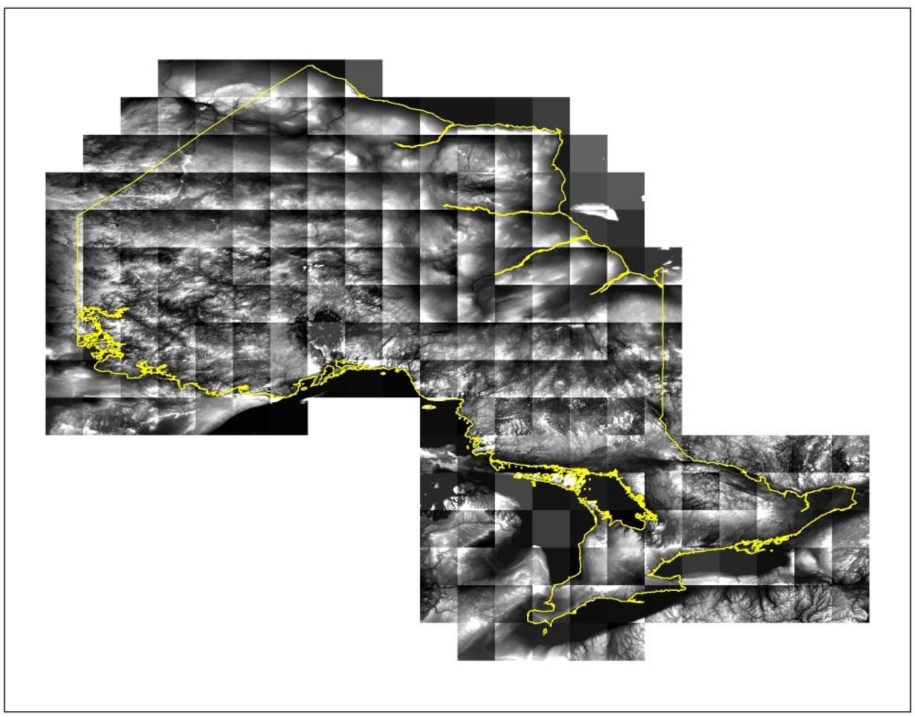

Figure 2: SRTM Tiles Used to Create the Ontario Radar DSM

The steps to generate the Ontario Radar DSM are as follows:

1. Extract elevation vector points from raster SRTM. In order to keep full precision of original SRTM data, the raster data is converted to vector points before projection.
2. Mosaic 211 tiles of vector point into three shape files based on the hardware and software processing capacities.
3. Project the vector point shape files from Geographic Coordinate System (GCS) to MNRF standard Lambert Conformal Conic (LCC) projection.
4. Interpolate the projected point data into raster grids using ESRI's Local Polynomial Interpolation (LPI) algorithm. For more detail on this process see Appendix A
5. Control cell origin to align with current provincial DEM standard.
6. Merge three sub-region raster data together to form a one-piece provincial elevation model. There is a one degree overlapping in latitude to avoid edge effect and ensure the data consistency. Figure 3 shows the three sub-regional raster datasets in their own grey scales respectively.
7. Convert the elevation vertical datum from EGM96 to CGVD28.

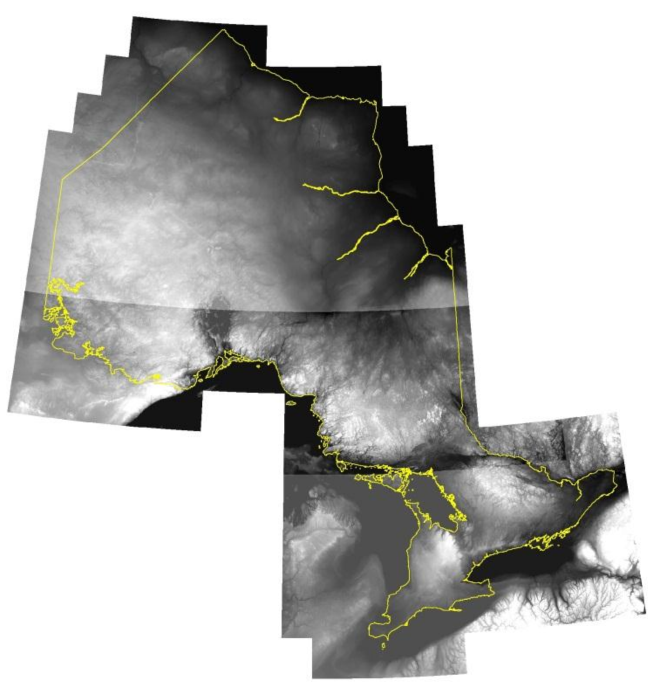

Figure 3: Sub-regional Raster Datasets

A 30 meter spatial resolution elevation distortion surface was created for elevation vertical datum transformation. The elevation distortion between CGVD28 and EGM96 elevation datum (Fig. 4) indicates the elevation distortion range is about 2 meters across the province.

This elevation distortion surface can be used to transform elevation vertical datum between CGVD28 and EGM96 bi-directionally. The CGVD28 product has only been packaged for distribution; however, the EGM96 product and the elevation distortion surface are available upon request.

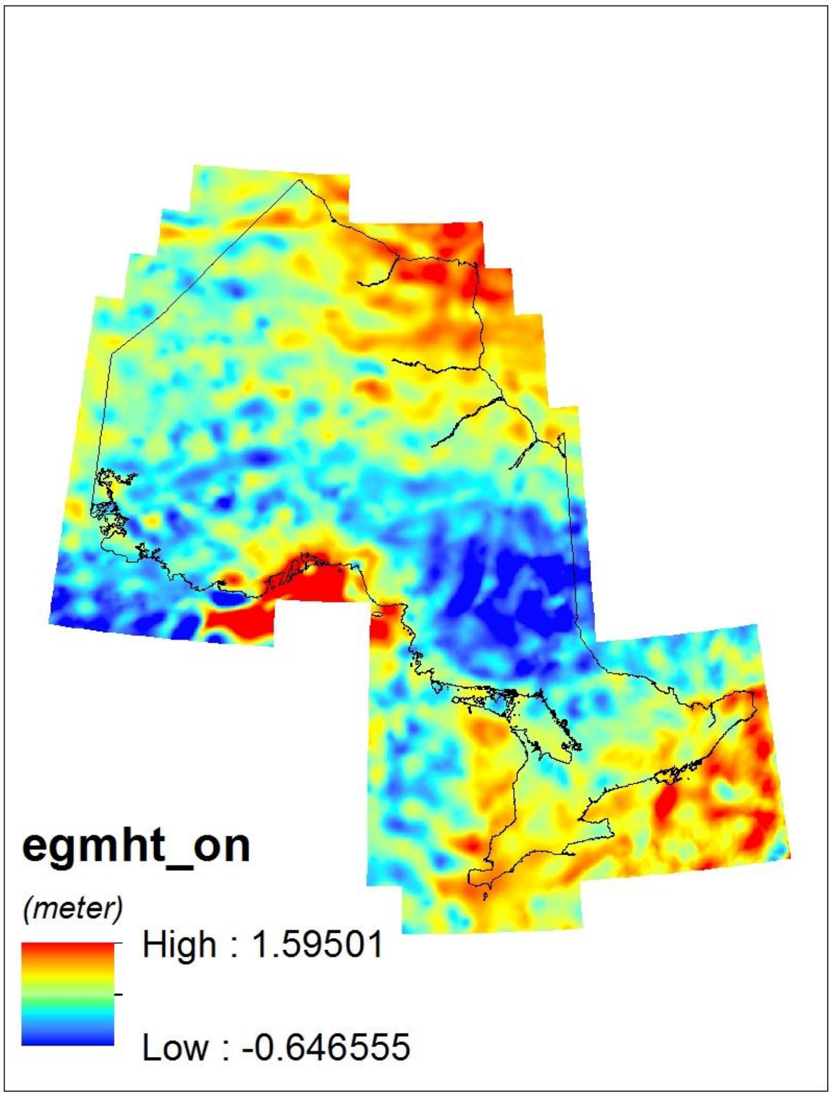

Figure 4: Elevation Distortion between CGVD28 and EGM96

2.2 Elevations

Elevations are orthometric and expressed in reference to Mean Sea Level (MSL). Both vertical and horizontal units of measure (coordinate system axis units) for all raster cells in the Ontario Radar DSM are expressed in meters (m).Product Limitations

Elevation values in the original SRTM data represent the reflective surface of earth. It is a DSM, and should not be considered as a true bare earth DTM. Northern Ontario is heavily forested including deciduous forest, coniferous forest, mixed forest, sparse forest, treed fen and treed bog. Elevation values will be influenced by the vegetative cover in these respective areas.

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2.4 Accuracy Assessment

An accuracy assessment has been conducted on the Ontario Radar DSM to better understand the limitations and suitability of use for the product. This accuracy report seeks to create accuracy metrics for the DSM based on the United States National Digital Elevation Program (US NDEP) guidelines and discusses the suitability and limitations of the elevation data. For further information regarding the accuracy assessment please contact Spatial Data Infrastructure at sdi@ontario.ca.

3. Data Delivery Format

The Ontario Radar DSM is available to be downloaded on the metadata record. It is split into two packages (North/South):

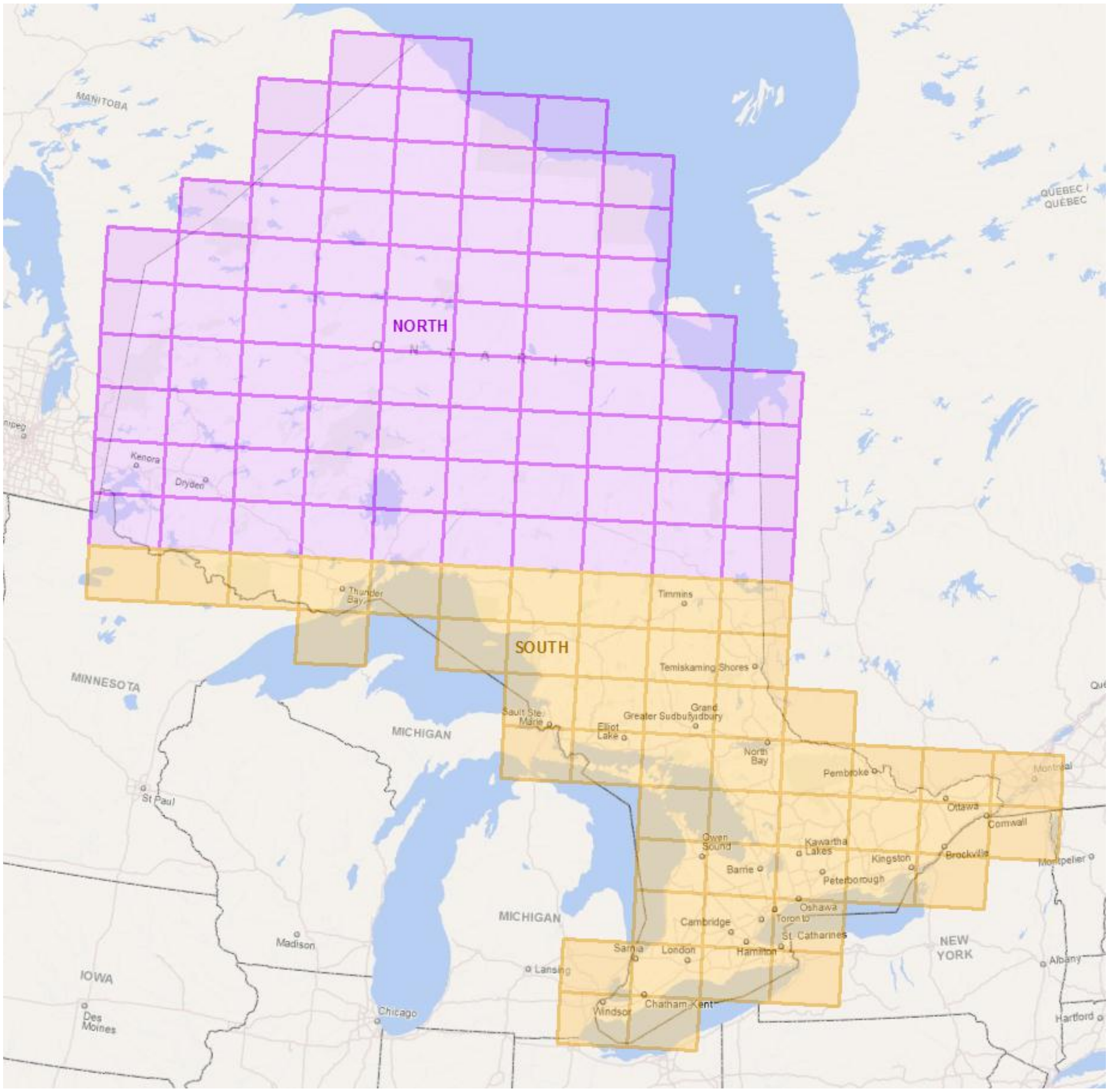

Figure 5: North and South Tiles

Each package contains 32-bit ESRI GRID format files:

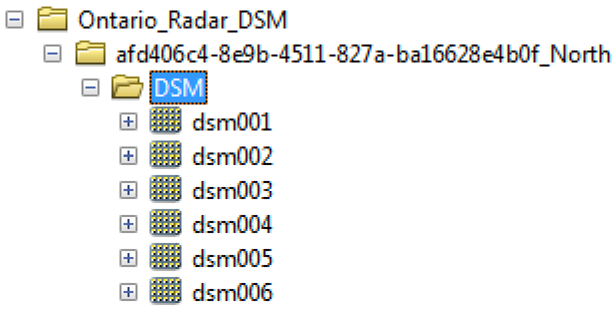

Figure 6: Package Structure

The north package contains 77 tiles and the south package contains 59 tiles. Please refer to Appendix B for the Ontario Radar DSM tiling index. For tiles beyond the index system, requests can be made to Land Information Ontario.

4. Product Use Restrictions

The Ontario Radar DSM is Open Data and has no restrictions.

5. References

ESRI, Feb. 11, 2011: How local polynomial interpolation works http://help.arcgis.com/en/arcgisdesktop/10.0/help/index.html#//003100000027000000.htm

Kevin Johnston, Jay M. Ver Hoef, Konstantin Krivoruchko, and Neil Lucas, 2001: Using ArcGIS Geostatistical Analyst, ESRI geostat_analyst (http://dusk2.geo.orst.edu/gis/geostat_analyst.pdf).

APPENDIX A: Geostatistics

Geostatistical algorithms are often used for advanced surface modeling (Kevin Johnston, et al, 2001). In general, surface fitting using Geostatistical method involves three key steps:

- Exploratory analysis of spatial data
- Structural analysis of spatial properties of source data
- Surface interpolation and assessment

Global Polynomial Interpolation is usually used to identify long-range trends in the dataset and to create a smooth surface across the entire area of interest using a single polynomial. However, in the situation of simulating a terrain surface, the variation of earth surface elevation usually has short-range variation in addition to long-range trend.

To capture the short-range elevation variation, Local Polynomial Interpolation is used to re-construct the SRTM based DSM. Local Polynomial Interpolation fits many polynomials, each using points only within the specified overlapping neighborhoods. The search neighborhoods overlap with each other, and the interpolated elevation value used for each prediction is the value of the fitted polynomial at the center of the neighborhood (ESRI, Feb. 11, 2011).

Two assumptions are made when re-constructing the SRTM based DSM using Local Polynomial Interpolation:

1. The elevation points of the SRTM data are equally spaced;
2. The elevation values, within the searching neighborhood, are normally distributed.

The first assumption is true in the space of the Geographic Coordinate System, as elevation points of the source data are posted at the spatial resolution of 1 arc second by 1 arc second for the area below 50 degree latitude, and 1 arc second by 2 arc second above 50 degree latitude. However, in this project, the local polynomial interpolation is applied in the space of Lambert Conformal Conic (LCC) Projection System. The elevation points of the source data in LCC space is not perfectly equal spaced, but still can be considered evenly distributed. The second assumption is hard to conform too strictly. However, the elevation values are roughly normal-distributed.

The output of Local Polynomial Interpolation algorithm is heavily dependent on the search neighborhood, which can be defined by using the size and shape, number of neighbors, and sector configuration. There is a consideration here for defining the search neighborhood. If the search neighborhood is too large, the output will be less sensitive to short-range elevation variation. If the search neighborhood is too small, the output will be less representative to elevation variation trend, and even create empty areas (voids) in the prediction surface. In this project, both major semi axis and minor semi axis are set to 150 m with angle setting 0. Gaussian distribution is used as kernel function with power setting 2 and smooth factor 0.5.

The software used to generate elevation surface was ESRI ArcGIS 9.4 beta version. Two different Beta versions of ArcGIS 9.4 were available and both were used in this project.

APPENDIX B: Ontario Radar DSM Tile Index