Canadian Digital Elevation Model
Product Specifications

Edition 1.1

2013-04-01

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RELEASES HISTORY

Date	Version	Description
2013-04-01	1.1	Plane coordinate projection option upon data extraction

ACRONYMS

CDED	Canadian Digital Elevation Data
CGVD28	Canadian Geodetic Vertical Datum of 1928
DEM	Digital Elevation Model
FGDC	U.S. Federal Geographic Data Committee
GDB	Geospatial Data Base
ISO	International Organization for Standardization
MHWL	Mean High Water Level
MSL	Mean Sea Level
NAD83 (CSRS)	North American Datum of 1983 (Canadian Spatial Reference System)
NHN	National Hydro Network
NTDB	National Topographic Data Base
NTS	National Topographic System
SRTM	Shuttle Radar Topographic Mission

TERMS AND DEFINITIONS

Canadian Geodetic Vertical Datum of 1928 (CGVD28)

Official height reference system in Canada The reference frame for the CGVD28 is the 1928 mean sea level at six tide gauges located on both the Pacific and Atlantic Oceans as well as on the St-Lawrence River.

CDEM Mosaic

Dataset corresponding to a subset of the CDEM, as extracted for a pre-defined or user-defined extent.

Contour line

An imaginary line on the ground connecting an infinite number of points of equal elevation recorded in metres or feet relative to mean sea level based on the North American Datum 1983 horizontal reference datum.

Digital Elevation Model (DEM)

A digital representation of relief composed of an array of elevation values referenced to a common vertical datum and corresponding to a regular grid of points on the earth's surface. These elevations and can be either ground or reflective surface elevations.

Mean high water level (MHWL)

The Nova Scotia coastline, oceans, and estuaries are depicted at the MHWL which has varying elevations across the province. All MHWL elevation values are with reference to the Canadian Geodetic Vertical Datum 1928.

Mean sea level (MSL)

The average sea level for a particular geographical location, obtained from numerous observations, at regular intervals, over a long period of time.

Metadata

Information about the source data used to produce CDEM. The information is formally structured according to the *North American Profile of ISO 19115:2003 – Geographic information – Metadata*.

North American Datum 1983 (NAD83)

The horizontal control datum for the U.S., Canada, Mexico and Central America, based on the Geodetic Reference System 1980 (GRS80) geocentric reference ellipsoid. The Canadian Spatial Reference System (CSRS) reflects the integration of the Canadian geodetic network to the NAD83.

National Topographic System (NTS)

Official division and identification system for the base topographic maps of Canada.

NHN Work Unit

Polygon which delimits the drainage area covered by a National Hydro Network (NHN) dataset.

Orthometric elevation

Height of a point related to the geoid, usually determined by horizontal levelling and gravimetry, and presented in general as an MSL elevation.

TABLE OF CONTENTS

1.   Overview

These product specifications apply to the Canadian Digital Elevation Model (CDEM). The CDEM is part of Natural Resources Canada's altimetry system designed to better meet the users' needs for elevation data and products.

The CDEM stems from the existing Canadian Digital Elevation Data (CDED). The latter were extracted from the hypsographic and hydrographic elements of the National Topographic Data Base (NTDB) at the scale of 1:50 000, the Geospatial Database (GDB), various scaled positional data acquired by the provinces and territories, or remotely sensed imagery.

In the CDEM data, elevations can be either ground or reflective surface elevations.

A CDEM mosaic can be obtained for a pre-defined or user-defined extent. Derived products such as slope, shaded relief and colour shaded relief maps can also be generated on demand.

The coverage and resolution of a mosaic varies according to latitude and to the extent of the requested area (see Sections 3.3 and 3.4 for further details). The North American Datum 1983 (NAD83(CSRS)) is used as the reference system for horizontal coordinates.[1] Elevations are orthometric and expressed in reference to mean sea level. (Canadian Geodetic Vertical Datum of 1928 (CGVD28)).

The CDEM plays the same role as contours and relief shading on conventional paper maps. The CDEM serves as key primary data in a range of applications critical to achieving sustainable development. These applications include environmental and ecological impact assessments, water flow and water quality analysis, climate change studies, forest regeneration planning and wildlife habitats. In addition, the CDEM can be used in the generation of three-dimensional graphics displaying terrain slope, profiles and lines of sight. Non-graphic applications include geoid calculations, terrain modelling, flood simulations and telecommunication studies.

2.   Data Identification

2.1   Spatial Resolution

Spatial resolution within the CDEM data varies according to latitude and to the extent of the area requested by the user. For each of the three geographic areas shown in Figure 1, Section 3.3, there exists a base resolution.

The **base** resolution for CDEM is 0.75 arc seconds along a profile in the south-north direction and varies from 0.75 to 3 arc seconds in the west-east direction, depending upon the geographic location. However, because of file size constraints, resolution be lower than that of the base resolution, at the time of extraction, depending on the extent of the region to be extracted. See Section 3.4 for further details.[2]

2.2   Language

NOT APPLICABLE

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[1] The CDEM data are stored in geographic coordinates but can be converted to a plane coordinate projection at the time of extraction.

[2] When a user chooses a plane coordinate projection at the time of extraction, the data are resampled using a regular grid approaching the resolution of the selected area in geographic coordinates. Refer to table 2, section 3.4 for more details.

2.3   Character Set

NOT APPLICABLE

2.4   Topic Category

According to the Global Change Master Directory thesauri, CDEM data can be classified into science key words structured using a 4-level hierarchy: Category>Topic>Term>Variable

CDEM data are classified by:

Science Keywords > Land Surface > Topography> Contours

Science Keywords > Land Surface > Topography> Terrain Elevation

Science Keywords > Land Surface > Topography> Topographic Relief

2.5   Geographic Box

The geographic box or minimum-bounding rectangle delineating the CDEM coverage is:

- West-bounding coordinate: 142° West   (or -142°)
- East-bounding coordinate: 52° West   (or -52°)
- North-bounding coordinate: 84° North   (or 84°)
- South-bounding coordinate: 41° North   (or 41°)

2.6   Geographic Description

The geographic area comprises lands and waters falling under Canadian jurisdiction.

2.7   Extent

The vertical domain of the dataset identifies the lowest and highest vertical extent contained within the data. The vertical extent is expressed in metres and can vary from -226 to 5,959 metres (Mount Logan) in Canada.

2.8   Supplemental Information

2.8.1   Elevations

Elevations are orthometric and expressed in reference to mean sea level (Canadian Geodetic Vertical Datum 1928 (CGVD28)). CDEM elevations are recorded as either ground or reflective surface elevations. The metadata supplied with CDEM mosaics specify whether the elevations are reflective surface or ground.

2.8.2   Waterbodies

Canada's coastline, oceans and estuaries at mean sea level, are assigned an elevation value of zero metre.

However, the Nova Scotia coastline, oceans, and estuaries are depicted at the mean high water level which has varying elevations across the province. All mean high water level elevation values are with reference to the Canadian Geodetic Vertical Datum 1928 (CGVD28).

For CDEM data produced using ground elevations, waterbodies are considered as naturally occurring areas of constant elevation (lakes) or having a small slope (rivers). Waterbodies are assigned their known or estimated elevation. Lakes are represented flatter and lower than the surrounding terrain and the shore is made clearly discernible. In general, a waterbody of unknown elevation is assigned an interpolated

elevation that is lower than the contour elevation surrounding its shoreline. Rivers and streams are continuous (no gaps), have constant water flow and a descending order of z-values.

For CDEM data produced using reflective surface elevations, waterbodies (lakes) may not have a constant elevation. They may have a small slope to indicate the direction of the water flow.

2.8.3   Void Areas

Void areas (areas where there is no data) are represented by elevation values of -32,767.

CDEM data contain void areas when they include lands or waters outside Canada's borders.

CDEM data are clipped to within plus or minus one (±1) pixel of resolution along the international boundary.

The international boundary, available on the GeoBase portal, is used for the purpose of clipping or merging CDEM data.

2.8.4   Quality Control

Quality control assures that the CDEM data is smooth within the grid and continuous from one elevation point to the next, except at natural break points such as streams, cliffs, and craters.

The CDEM quality control process ensures that the watercourse direction of flow and the flatness of the water surface and surrounding area are considered. In addition, anomalies with regards to drainage are eliminated.

3.   Geospatial Characteristics

3.1   Spatial Representation Type

A grid format is used to represent the elevation data.

3.2   Spatial Representation

CDEM mosaics contain a variable number of nodes (elevations), depending on the extent of the selected area and the chosen resolution. Hence, each mosaic holds a variable number of profiles. All profiles are oriented south-north.

3.3   Coverage and Continuity

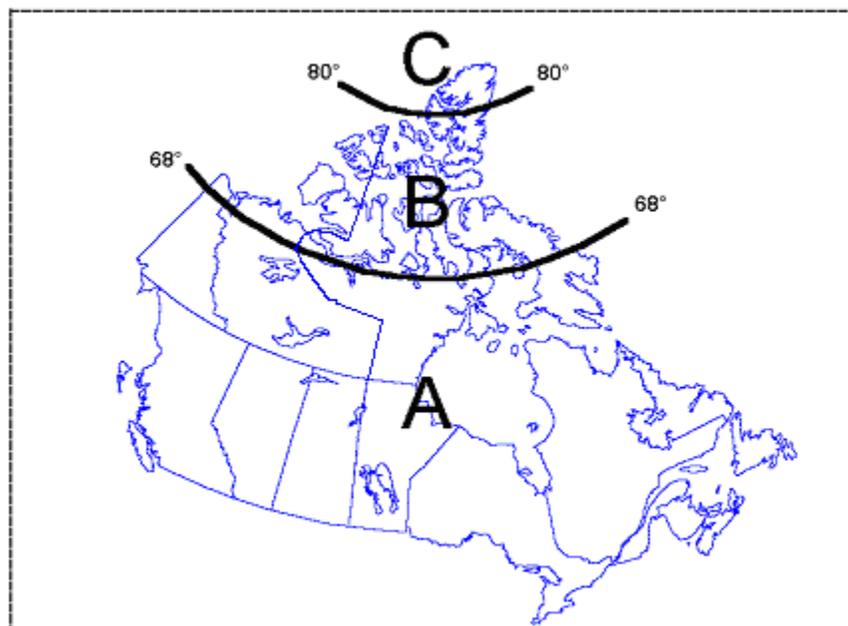The CDEM provides a complete coverage of the entire Canadian landmass.

Figure 1: The Three Geographic Areas

3.4   Resolution

Resolution within the CDEM varies according to geographic location as is shown in Figure 1, section 3.3. The base resolution is 0.75 arc second along a profile in the south-north direction and varies from 0.75 to 3 arc seconds in the west-east direction, depending upon the geographic location.

At the time of extracting a CDEM mosaic, another resolution can be selected if desired (see Table 1 hereafter). However, because of file size constraints, resolution upon extraction may be lower than the desired resolution, depending on the extent of the region to be extracted. In the event where the region to be extracted overlaps two of the geographic regions shown in Figure 1, the best of both possible resolutions will be retained for the extracted region.

GEOGRAPHIC AREA		A (Lat. < 68°)	B (68° < Lat. < 80°)	C (80° < Lat. < 90°)
RESOLUTION **(latitude and longitude** **in arc seconds)**	**Base:**	0.75" x 0.75"	0.75" x 1.5"	0.75" x 3.0"
		1.5" x 1.5"	1.5" x 3.0"	1.5" x 6.0"
		3.0" x 3.0"	3.0" x 6.0"	3.0" x 12.0"
		6.0" x 6.0"	6.0" x 12.0"	6.0" x 24.0"
		12.0" x 12.0"	12.0" x 24.0"	12.0" x 48.0"

Table 1 – Resolution of CDEM Data Based on Geographic Area

Furthermore, although CDEM data are stored in geographic coordinates, they can be converted to a plane coordinate projection at the time of extraction. In the case where the users chooses this option, the data are resampled using a regular grid approaching the resolution of the selected area in geographic coordinates.

	Base:	20 m
		50 m
RESOLUTION		90 m
		200 m
		400 m

Table 2 – Resolution of CDEM data in plane coordinates

3.5   Data Segmentation

NOT APPLICABLE

4.   Data Model

NOT APPLICABLE

5.   Data Dictionary/Feature Catalogue

NOT APPLICABLE

6.   Reference System

6.1   Horizontal Reference System

North American Datum 1983 (NAD83 (CSRS)).

6.1.1   Horizontal Coordinate System

Data is stored in geographic coordinates (longitude (λ) and latitude (φ)). However, it can also be offered in a plane coordinate projection (X and Y) at the time of extraction. Definition for the coordinate system can be found in the metadata.

6.1.2   Horizontal Unit of Measure (coordinate system axis units)

The unit of measure for storing horizontal data is decimal degrees. Meters will be used, however, if a plane coordinate projection is selected at the time of extraction.

6.2   Vertical Reference System

Elevations are orthometric and expressed in reference to mean sea level (Canadian Geodetic Vertical Datum 1928 (CGVD28)). Exception: Nova Scotia shoreline as noted in section 2.8.2 Water Areas.

6.2.1   Vertical Unit of Measure (coordinate system axis units)

The unit of measure for storing vertical data is the metre. In general, elevations are expressed as integers. They are expressed as floating point whenever available.

7.   Data Quality

7.1   Scope

NOT APPLICABLE

7.2   Lineage

The source digital data for the CDEM are the existing Canadian Digital Elevation Data (CDED). The latter were extracted from the hypsographic and hydrographic elements of the National Topographic Data Base (NTDB) at the scale of 1:50 000, the Geospatial Database (GDB), various scaled positional data acquired by the provinces and territories, or remotely sensed imagery.

The horizontal reference system is the North American Datum of 1983 (NAD83 (CSRS)); the vertical reference system is the Canadian Geodetic Vertical Datum of 1928 (CGVD28)).

Metadata describing the source data and the product generation process is made available when extracting a CDEM mosaic.

7.3   Completeness

NOT APPLICABLE

7.4   Logical Consistency

NOT APPLICABLE

7.5   Positional Accuracy

Please see the CDEM metadata record for the horizontal and vertical positional accuracy reports.

7.6   Temporal Accuracy

NOT APPLICABLE

7.7   Thematic (attributes) Accuracy

NOT APPLICABLE

8.   Metadata

Each CDEM mosaic has a corresponding metadata record that complies with the *North American Profile of ISO 19115:2003 – Geographic information – Metadata*, The metadata is supplied at the time of extracting a CDEM mosaic.

The CDEM mosaic metadata contain the following information:
1. Identification Information
2. Data Quality Information
3. Spatial Data Organization Information
4. Spatial Reference Information
5. Entity and Attribute Information

6. Distribution Information
7. Metadata Reference Information

9. DATA Portrayal/Data Transfer Format/Physical Model

NOT APPLICABLE

10. Data Capture and Maintenance

NOT APPLICABLE

11. CDEM Data Delivery

11.1 Format Information

The digital data exchange format for the CDEM data is GeoTIFF. The GeoTIFF format specification can be obtained from: http://www.pubdoc.org/fileformat/rasterimage/tiff/geotiff.pdf and http://geotiff.maptools.org/spec/geotiffhome.html.

11.2 Medium Information

NOT APPLICABLE

11.3 Data Use and Restrictions

Information regarding the use of the data is defined in the Open Government Licence Agreement for Unrestricted Use of Digital Data which can be found at: https://open.canada.ca/en/open-government-licence-canada.

11.4 Data Extraction

CDEM data can be extracted in the form of mosaics. A CDEM mosaic can be obtained for an extent defined by the user through a web interface or for a pre-defined extent such as an NTS sheet, an NHN Work Unit or a Landsat image ground trace.

11.5 Derived Products

Besides digital elevation models per se, CDEM data can be extracted as one of the following derived products:

11.5.1 Shaded Relief (or Hillshade)

A relief representation which enhances the illumination and shadow variations, according to elevation and slope, as created by a light source located at a specified height and in a specified direction. The resulting 8-bit greyscale raster image provides a realistic terrain visualization.
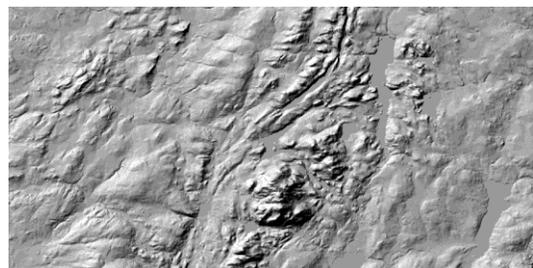
Optional parameters

Azimuth   Direction of light source, between 0 and 360, measured in degrees, clockwise from the north.

Defaults to 315.

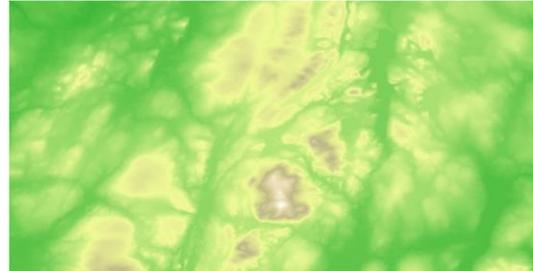Altitude   Vertical direction of light source, from 0 (horizon) to 90 degrees (zenith).

Defaults to 45.

zFactor   Vertical exaggeration factor.

           Defaults to 5.

11.5.2 Color Relief

A relief representation in which the elevations are assigned different colours according to their value. The resulting product is a 3-band (RGB) raster image where the colours are blended gradually to depict elevations, according to a pre-defined correspondence table.

11.5.3 Color Shaded Relief

A relief representation combining a Color Relief image, in which the elevations are assigned different colours according to their value, and a Shaded Relief image, in which lighting enhances elevation and slope. The resulting product is a 3-band (RGB) raster image where colour intensity varies to provide a realistic terrain visualization.

Optional parameters

Azimuth   Direction of light source, between 0 and 360, measured in degrees, clockwise from the north.

           Defaults to 315.

Altitude   Vertical direction of light source, from 0 (horizon) to 90 degrees (zenith).

           Defaults to 45.

zFactor   Vertical exaggeration factor.

           Defaults to 5.
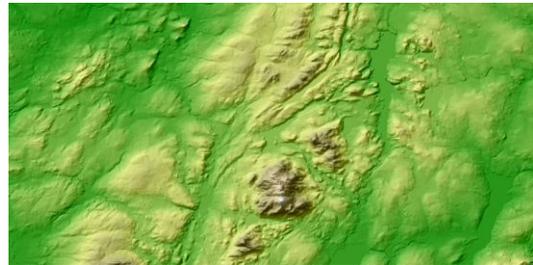
11.5.4 Slope Map

A relief-derived representation in which every pixel is attributed the value of the greatest slope (the measure of change in elevation over distance, in degrees from the horizontal or as a percentage) at the corresponding point of the represented surface. The resulting product is a 32-bit raster image of slope values.

Optional parameter

Slope type :   Choice of degrees or percent slope.

           Default : degrees.
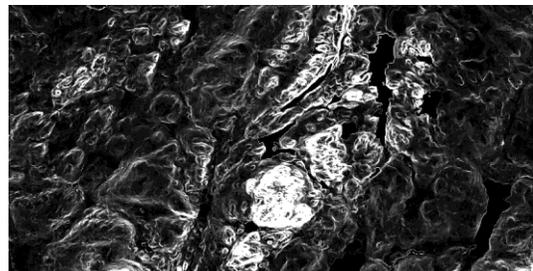
11.5.5 Aspect Map

A relief-derived representation in which every pixel is attributed the value of the azimuth which the slope is facing. Such azimuth value is comprised between 0 and 360, measured in degrees, clockwise, from the north. The value -9999 can also be used in flat areas where the slope value is zero. The resulting product is a 32-bit raster image of azimuth values.
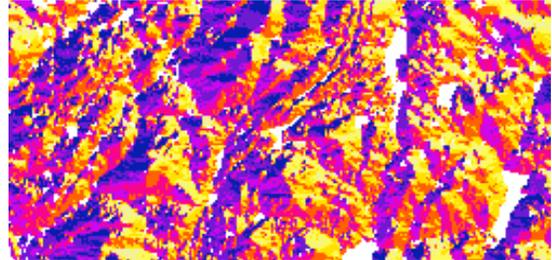
11.5.6 Point Data

Point data consist of sets of elevation points extracted from cells, or pixels, of digital elevation or digital surface data. They correspond to the coordinates (x, y) and altitude (z) of the center of every pixel from the elevation data for the chosen area. The resulting ASCII file is in CSV format and is composed of three columns: x, y and z. The column separator is a comma.
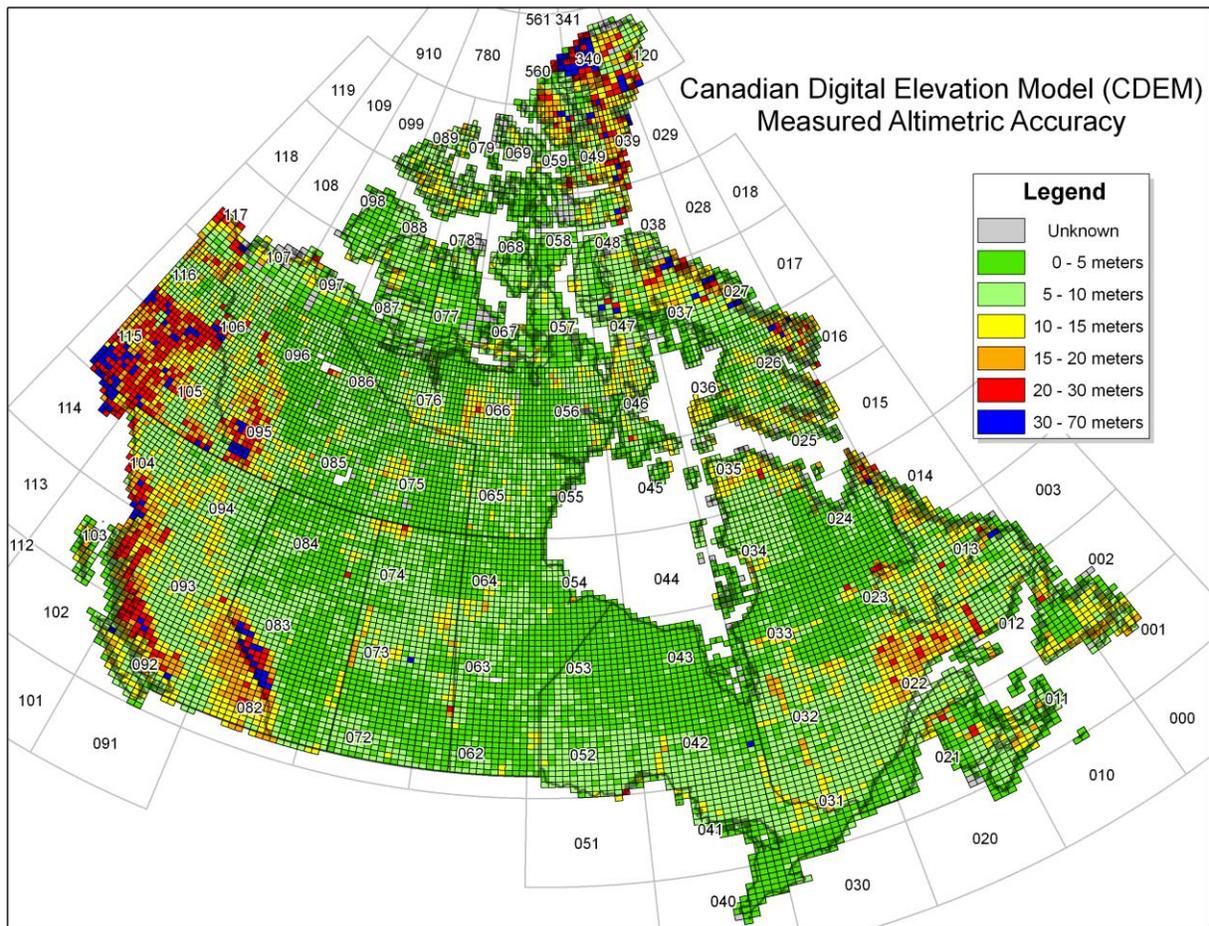
12. Accuracy Index

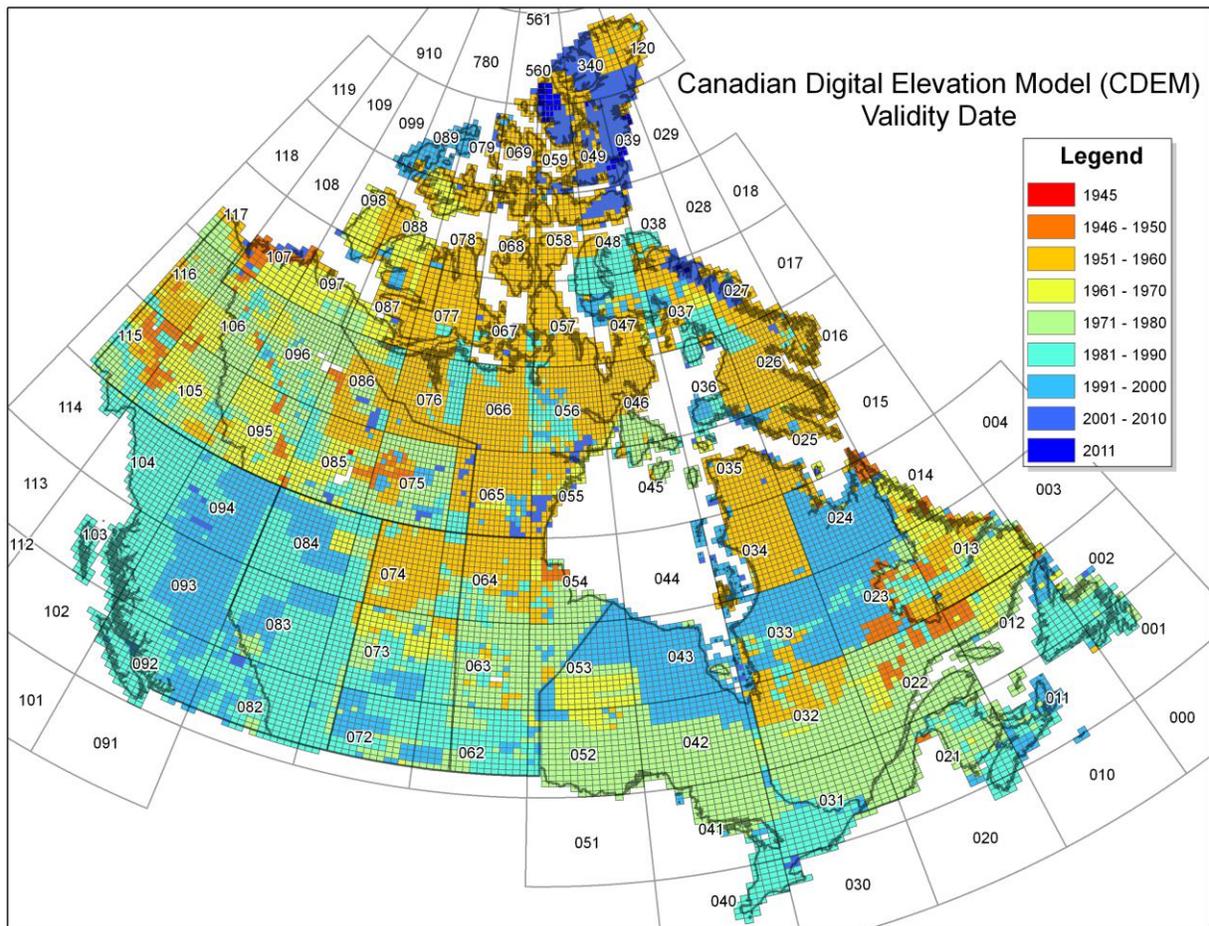**Figure 2: Measured altimetric accuracy per NTS map sheet**

13. Validity Date Index

Figure 3: Validity date per NTS map sheet