Medium Resolution Digital Elevation Model (MRDEM)

– CanElevation Series – Product Specifications

Edition 1.0

2024-02-28

Government of Canada
Natural Resources Canada

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RELEASES HISTORY

Date	Version	Description
2024-02-28	1.0	Original version

ACRONYMS

CGVD28	Canadian Geodetic Vertical Datum of 1928
CGVD2013	Canadian Geodetic Vertical Datum of 2013
COG	Cloud Optimized GeoTIFF
DEM	Digital Elevation Model
DSM	Digital Surface Model
DTM	Digital Terrain Model
HRDEM	High Resolution Digital Elevation Model
ISO	International Organization for Standardization
Lidar	Light Detection and Ranging
MRDEM-30-DSM	Medium Resolution Digital Surface Model
MRDEM-30-DTM	Medium Resolution Digital Terrain Model
MRDEM-30-DTMS	Medium Resolution Digital Terrain Model Source
NAD83 (CSRS)	North American Datum of 1983 (Canadian Spatial Reference System)
NRCan	Natural Resources Canada
WCS	Web Coverage Service
WMS	Web Map Service

TERMS AND DEFINITIONS

Canadian Geodetic Vertical Datum of 2013 (CGVD2013)

The Canadian Geodetic Vertical Datum of 2013 (CGVD2013) is the reference standard for heights across Canada. This system has replaced the Canadian Geodetic Vertical Datum of 1928 (CGVD28). For more information on CGVD2013, visit the following resource: https://www.nrcan.gc.ca/maps-tools-and-publications/tools/geodetic-reference-systems/canadian-spatial-reference-system-csrs/9052

CanElevation

Series of elevation products created in support of the National Elevation Data Strategy implemented by NRCan.

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 can be either ground or reflective surface elevations.

Digital Surface Model (DSM)

A representation of the earth’s surface including vegetation and man-made structures. The Digital Surface Model (DSM) provides the height of the vegetation, canopies and structures relative to the vertical datum.

Digital Terrain Model (DTM)

A representation of the bare ground surface without any objects such as vegetation and man-made structures. The Digital Terrain Model (DTM) provides the height of the ground relative to the vertical datum.

Lidar

Stands for Light Detection and Ranging. It is a remote sensing method that uses light in the form of a pulsed laser to measure ranges (variable distances) to the Earth.

North American Datum 1983 CSRS (NAD83(CSRS))

The North American Datum of 1983 CSRS (NAD83(CSRS)) is the official geometric reference system in Canada. NAD83(CSRS) is a dynamic 3D representation of NAD83(Original) adapted for Canada. NRCan maintains NAD83(CSRS) aligned to the North American plate using plate motion estimation. For more information on NAD83(CSRS), visit the following resource: https://www.nrcan.gc.ca/maps-tools-and-publications/tools/geodetic-reference-systems/canadian-spatial-reference-system-csrs/9052

Orthometric Height (elevation)

It is the elevation of a point above the geoid. It is measured along the plumb line, which is perpendicular to the equipotential surfaces.

Lidar Point Cloud

This is the primary data product of a lidar instrument. In its crudest form, a lidar point cloud is a collection of range measurements and sensor orientation parameters. After initial processing, the range and orientation associated with each laser pulse is converted to a position in a three-dimensional frame of reference. In its final form, the points in the lidar point cloud are classified according to various classes such as ground, noise, buildings and bridge structures. This spatially coherent cloud of classified points is the base for further processing and analysis. The raw point cloud typically includes first, last, and intermediate returns for each emitted laser pulse.

Web Map Service (WMS)

Standardized service interface allowing the visualization of data in the form of a static map. This service only allows the visualization of data. The detailed information of the data is not available.

TABLE OF CONTENTS

1. Overview

1.1 Title

Medium Resolution Digital Elevation Model: Product Specifications

1.2 Reference Date

2024-02-28

1.3 Product Responsible

Natural Resources Canada
Strategic Policy and Innovation Sector
Canada Centre for Mapping and Earth Observation
Client service

Telephone : +01-819-564-4857 / charge free : 1-800-661-2638 (Canada and United-States)
Fax : +01-819-564-5698
Email : geoinfo@nrcan-nrcan.gc.ca
URL : https://open.canada.ca/en/open-maps

1.4 Language

Languages in which the product specifications are available according to the ISO 639-2 standard :
fra – French
eng – English

1.5 Informal Product Description

These product specifications are for the Medium Resolution Digital Elevation Model (MRDEM-30) which provides a continuous representation of elevation data available, at a 30 metres resolution, across the country.

Elevation data is a core theme that has been provided by Natural Resources Canada (NRCan) to Canadians as essential geographic information. Since 2015, NRCan has implemented the National Elevation Data Strategy which aims to increase Canada's coverage of high-resolution elevation data and increase the accessibility of the products. Although this effort is still ongoing, there was a need for a medium resolution elevation product that could serve as a replacement for the legacy Canadian Digital Elevation Model (CDEM) that is no longer supported. Users involved in large-scale analysis often lack of a good, continuous and up-to-date elevation source data to cover their needs.

This new offering provides a Canada-wide and up-to-date elevation data at a 30 metres resolution. It is a multi-source product that integrates elevation data from the Copernicus DEM[1] acquired during the TanDEM-X Mission (AIRBUS, 2022), and the High Resolution Digital Elevation Model data derived from airborne lidar. The product offers both a DSM (MRDEM-30-DSM) and a DTM (MRDEM-30-DTM).

The MRDEM-30-**DSM** is based on the GLO-30 version of the Copernicus DEM[1] (hereafter named GLO-30). Since elevation values from the GLO-30 are referenced to the EGM2008 geoid model, they were

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transformed to the Canadian Height Reference System of 2013 (CGVD2013), using the CGG2013 geoid model.

The process to generate the MRDEM-30-**DTM** is more complex and involves different sources. Where available, the HRDEM Mosaic derived from lidar was used since it already provides reliable terrain elevation values. The HRDEM Mosaic data used was resampled from 1m to 30m. Elsewhere, the processing workflow combines a forest removal model and a settlement removal model that is applied to the GLO-30 values in order to estimate the terrain elevation values. More details on the methodology can be found in the technical specification document.

To help users identify which source is use at any given point of the MRDEM-30-DTM, we provide a source asset which indicates the underlying source of the elevation data used. This resource is referred to as the Medium Resolution Digital Terrain Model Source (MRDEM-30-DTMS).

The MRDEM-30 is disseminated through the Data Cube Platform, implemented by NRCan using geospatial big data management technologies. It is available from Web Map Services (WMS) and as a single COG GeoTIFF file. Accessible data includes the MRDEM-30-DSM, MRDEM-30-DTM, MRDEM-30-DTMS and derived products such as the shaded relief, slope and aspect. It is referenced to the CGVD2013 which is the reference standard for orthometric heights across Canada.

2. Data Identification

2.1 Spatial Resolution

The spatial resolution of the product is 30 metres.

2.2 Language

NOT APPLICABLE

2.3 Character Set

NOT APPLICABLE

2.4 Topic Category

According to the Government of Canada Core Subject Thesaurus, the MRDEM product is classified according to the following keyword :

- Digital elevation data

Free text keywords:

- Color relief map
- Digital elevation model
- Digital surface model
- Digital terrain model
- Medium resolution Digital Elevation Model
- Shaded relief map

2.5 Geographic Box

The MRDEM-30 covers, at a minimum, the following geographic box or minimum-bounding rectangle:

- West-bounding coordinate: 145.9° West (or -145.9°)
- East-bounding coordinate: 52.5° West (or -52.5°)
- North-bounding coordinate: 83.5° North (or 83.5°)

- South-bounding coordinate: 40.3° North (or 40.3°)

2.6 Geographic Description

The geographic area is comprised of land and water that fall within the Canadian jurisdiction. In some cases, the spatial extent extends to other jurisdictions, where needed, to provide cross-border coverage in support of hydrological studies and applications. Please refer to section 3.3 for additional details.

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 the maximum elevation is 5,959 metres (Mount Logan) in Canada.

2.8 Supplemental Information

2.8.1 Elevation

The elevation values in the DTM datasets represent the bare ground surface without any objects such as vegetation and man-made structures.

The elevation values in the DSM datasets represent the surface above the vegetation (canopies) and man-made structures.

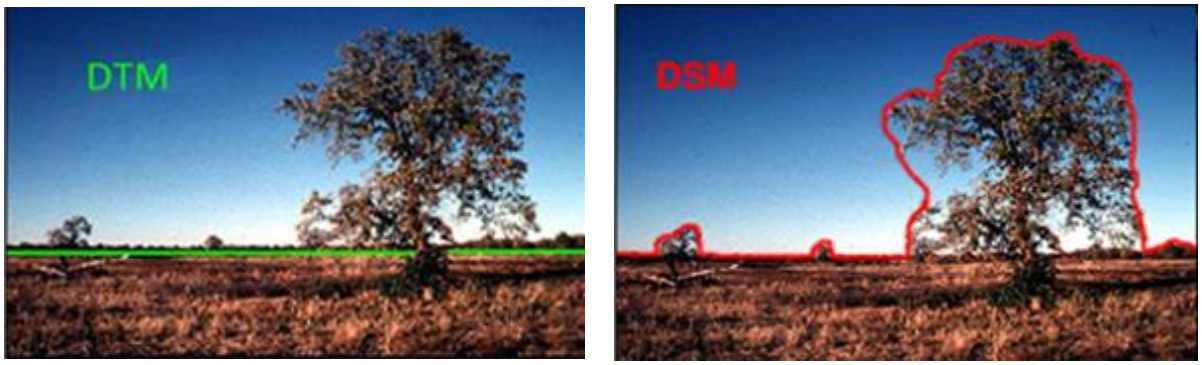

Figure 2: DTM and DSM representations (source: Wikipedia)

2.8.2 Waterbodies

Waterbodies are processed differently depending on the source. Here are some additional information for every source:

GLO-30 source data

The GLO-30 is based on an edited version of the WorldDEM™[2] which included flattening of waterbodies, introducing consistent flow of rivers, and editing of implausible terrain structures, among others (AIRBUS, 2022).

HRDEM Mosaic source data

Due to the properties of the lidar used, the pulses are absorbed by water, reducing the point densities in water areas. The DEMs derived from lidar points, generated without breaklines, depict water surfaces with artifacts and void data resulting from the interpolation and void filling processing affecting accuracy.

For the MRDEM-30-DTM processing, since both source data are blended together, the waterbodies should not contain any void data. For MRDEM-30-DSM, only the GLO-30 is used.

2.8.3 Void Areas

For MRDEM-30-DTM and MRDEM-30-DSM elevation layers, the empty areas (for which there is no data) are represented by elevation values of -32 767.

For the hillshade layers and the MRDEM-30-DTMS layer, the empty areas are represented by a value of 0. These void pixels are mostly present on very large waterbodies such as the Great Lakes and the Hudson Bay.

2.8.4 Quality Control

Technical details about the quality control process will be published shortly in a separate document.

3. Geospatial Characteristics

3.1 Spatial Representation Type

A grid format is used to represent the elevation data.

3.2 Spatial Representation

The MRDEM-30 is represented by raster data that contains a variable number of pixels corresponding to elevations depending on the extent of the selected region and the source of the data.

3.3 Coverage and Continuity

The boundaries of the MRDEM product are based on the National Hydro Network work units along with USGS Watershed Boundary Dataset, level 8 (HU08), which share a border with Canada and/or contribute to flows into Canada. A 5 kilometres buffer is applied to the resulting coverage to compensate for errors that might have occurred during the delineation of these units.

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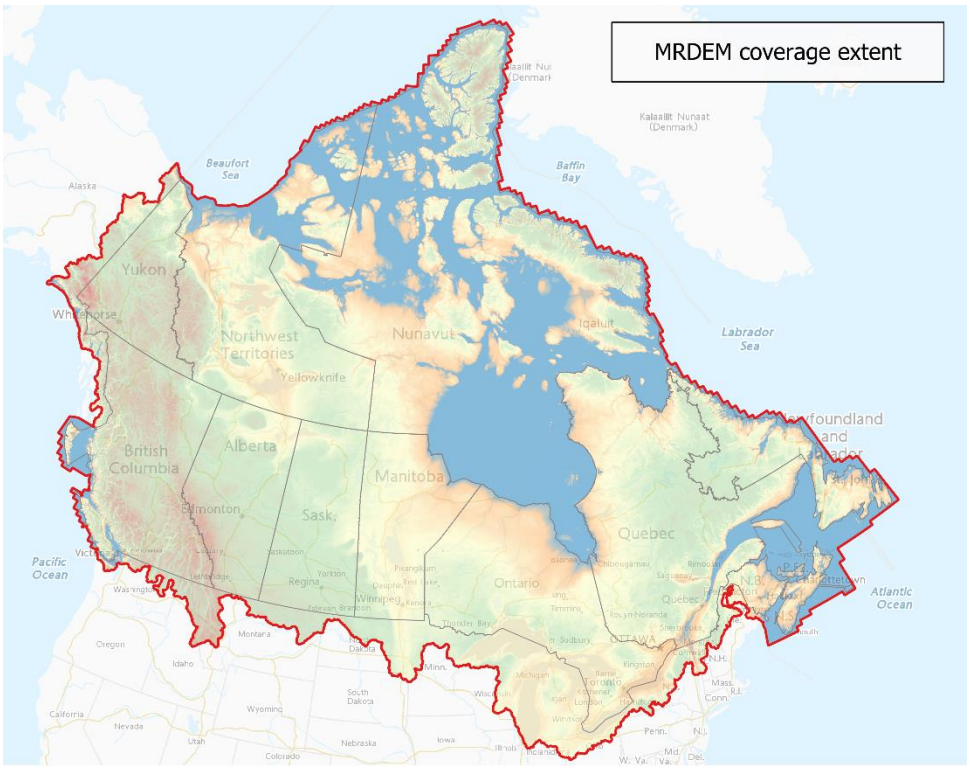

Figure 1 : Map showing the coverage of the MRDEM product

3.4 Resolution

The MRDEM-30 product data is available at a 30 meters resolution.

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

6.1.1 Horizontal Coordinate System

The planimetric coordinate system used is the Canadian Spatial Reference System (NAD83 (CSRS) / Canada Atlas Lambert) (EPSG:3979). It is also available under the following projections for WMS and WCS services:

- WGS 84 / World Geodetic System 1984 (EPSG : 4326)
- WGS 84 / Pseudo-Mercator (EPSG : 3857)

Several other projections are available for the WMS service. The information is available with the following GetCapabilities query from the web mapping service.

https://datacube.services.geo.ca/ows/mrdem?request=getcapabilities&service=wms

6.1.2 Horizontal Unit of Measure (coordinate system axis units)

Metric is used and represented in metres.

6.2 Vertical Reference System

Elevations are orthometric and expressed in reference to the Canadian Geodetic Vertical Datum of 2013 (CGVD2013) (EPSG : 6647).

Source: https://www.NRCan.gc.ca/earth-sciences/geomatics/geodetic-reference-systems/9054.

6.2.1 Vertical Unit of Measure (coordinate system axis units)

The unit of measure for storing vertical data is metres. Elevations are expressed as floating points.

7. Data Quality

7.1 Scope

NOT APPLICABLE

7.2 Lineage

GLO-30 source data:

The GLO-30 is a digital surface model (DSM) and contains buildings, vegetation and infrastructure in its representation of the surface of the earth (AIRBUS, 2022). It is based on an edited version of the WorldDEM™(3). The data used to create WorldDEM™(3) is radar satellite data acquired during the TanDEM-X Mission, which is a funded public[3] private partnership between the German State and Airbus Defence and Space. To produce this dataset, two satellites, TerraSAR-X and TanDEM-X operated as a single-pass SAR interferometer (InSAR) using the bi-static InSAR StripMap mode (AIRBUS, 2020). The data collection period is 2011 to 2015.

HRDEM Mosaic source data:

The HRDEM Mosaic is a compilation of the available HRDEM datasets implemented by NRCan as part of the CanElevation Series. To generate the MRDEM-30-DTM, only the digital terrain model derived from lidar is used, which provides the bare-earth terrain data needed. The underlying data of the HRDEM mosaic has been acquired through multiple lidar acquisition projects and different partners.

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Other data:

Many different sources are used to create the MRDEM-30-DTM such as the The World Settlement Footprint (WSF) layer and the Canadian Forest Heights layer. Technical details will be published shortly in a separate document.

7.3 Completeness

NOT APPLICABLE

7.4 Logical Consistency

The processing workflow includes a blending process for parts where both GLO-30 and HRDEM Mosaic pixels are used. However, marked differences in elevation can be observed in the HRDEM Mosaic where multiple lidar sources, acquired at different dates, were integrated together.

7.5 Positional Accuracy

As the MRDEM-30-DTM contains data from two different sources, the accuracy validation was completed in two ways. To assess the accuracy of MRDEM-30-DTM in areas where HRDEM provides elevation values, we compared it against Real-Time Kinematic (RTK) check points. Additionally, for areas where buildings and forests were removed from the DSM to generate the DTM values, we compared the resulting values to HRDEM DTM values. Table 1 shows the results of the comparison.

	MRDEM-30-DTM (derived from DSM-GLO30) compared to HRDEM DTM data		**MRDEM-30-DTM (derived from HRDEM) compared to RTK data**	
	RMSE	LE90	RMSE	LE90
Vegetated areas	3.28	5.26	1.44	2.34
Non-vegetated areas	0.98	1.60	1.31	2.12

Table 2 RMSE and LE90 results for the accuracy assessment, in meters.

7.6 Temporal Accuracy

HRDEM Mosaic source data: 2006 – Ongoing. *As of May 2024, the median year of lidar projects in the product is 2018.*
GLO-30 source data: 2011 – 2015

7.7 Thematic (attributes) Accuracy

NOT APPLICABLE

8. Metadata

The MRDEM product has a metadata record that complies with the *North American Profile of ISO 19115:2003 – Geographic information – Metadata*.

The MRDEM-30-DTM source dataset (MRDEM-30-DTMS) used for every pixel are part of a distinct asset. See Section 11 for details.

9. Data Portrayal/Data Transfer Format/Physical Model

NOT APPLICABLE

10. Data Capture and Maintenance

NOT APPLICABLE

11. MRDEM-30 Product Data Delivery

11.1 Format Information

The product is available as a web mapping service (Web Map Service (WMS) and as Cloud Optimized GeoTIFF (COG) files compliant with Open Geospatial Consortium (OGC) standards (https://www.ogc.org/standards).

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 - Canada (http://open.canada.ca/en/open-government-licence-canada).

Legal notice

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The organisations in charge of the Copernicus program by law or by delegation do not incur any liability for any use of the Copernicus WorldDEM-30.

11.4 Data Extraction

The data can be directly access using the COG files. Direct use of the COG file is an efficient way to access the raw elevation values.

DSM:

https://datacube-prod-data-public.s3.ca-central-1.amazonaws.com/store/elevation/mrdem/mrdem-30/mrdem-30-dsm.tif

DSM hillshade:

https://datacube-prod-data-public.s3.ca-central-1.amazonaws.com/store/elevation/mrdem/mrdem-30/mrdem-30-dsm-hillshade.tif

DTM:

https://datacube-prod-data-public.s3.ca-central-1.amazonaws.com/store/elevation/mrdem/mrdem-30/mrdem-30-dtm.tif

DTM hillshade

https://datacube-prod-data-public.s3.ca-central-1.amazonaws.com/store/elevation/mrdem/mrdem-30/mrdem-30-dtm-hillshade.tif

11.4.1 Directory tree

The directory only contains documents related to the product and technical specifications. These can be found in the following download directory:

https://ftp.maps.canada.ca/pub/elevation/dem_mne/MRDEM_MNEMR

The directory contains the elements below:

- CanElevation-MRDEM-Product-Specifications.pdf
- CanElevation-MNEMR-Specifications-Produit.pdf

11.4.2 Tile identifier

NOT APPLICABLE

11.5 MRDEM-30-DTM source asset (MRDEM-30-DTMS)

A distinct asset has been created to help users identify which source was use at any given pixel of the MRDEM-30-DTM.

The MRDEM-30-DTMS asset is a raster which has three unique values. Every distinct value represents the source and treatment of the underlying elevation data. The dataset largely contains values of 1 and 10. The blended area represents a buffer on the extents of the HRDEM projects used to minimize the vertical differences between the elevation values derived from GLO-30 and the HRDEM Mosaic.

Value	Source

1	MRDEM-30-DSM (adjusted COP GLO-30 data)
5	Blended area
10	HRDEM Mosaic

https://datacube-prod-data-public.s3.ca-central-1.amazonaws.com/store/elevation/mrdem/mrdem-30/mrdem-30-dtm-source.tif

11.6 Derived Data

Products derived from the DTM and DSM are also available. This section describes derivative products that are accessible via the WMS web mapping service. Information about these products is available with the following GetCapabilities queries from the web mapping service:

WMS: https://datacube.services.geo.ca/ows/mrdem?request=getcapabilities&service=wms

11.6.1 Hillshade Map

A relief representation which enhances the illumination and shadow variations, according to elevation and slope, is created by a light source located at a specified height and in a specified direction. The resulting 8-bit greyscale raster image provides realistic terrain visualization. This derivative product is available for both DTM and DSM.

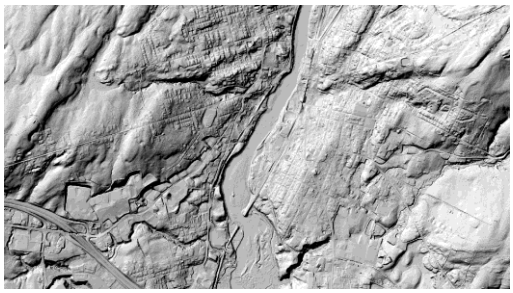

Figure 3: Relief Representation of a DTM

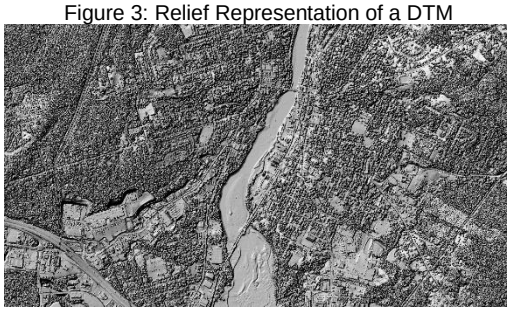

Figure 4: Relief Representation of a DSM

Parameters

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

Default: 315.

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

Default: 45.

zFactor: Vertical exaggeration factor.

Default: 5.

11.6.2 Color Relief Map

A relief representation in which the elevations are assigned different colours according to their value. The resulting product is a raster image where the colours are blended gradually to depict elevations, according to a pre-defined correspondence table. This layer is provided for both DTM and DSM datasets.

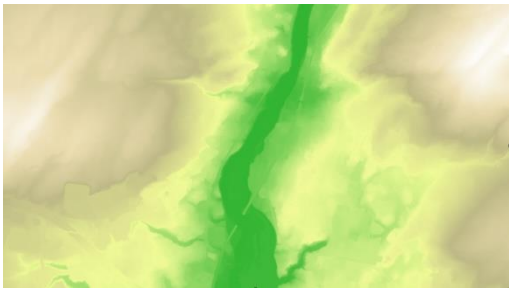

Figure 5: Color Relief Map representation of a DTM

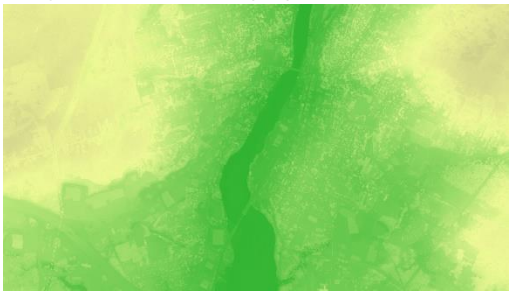

Figure 6: Color Relief Map representation of a DSM

11.6.3 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) at the corresponding point of the represented surface. This layer is provided for both DTM and DSM datasets and available through the WMS.

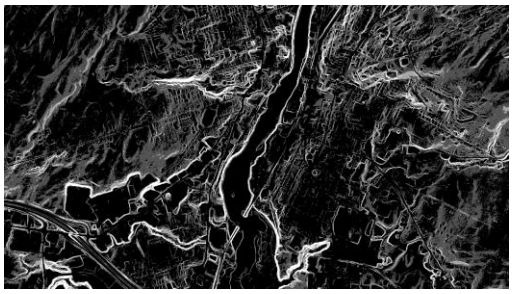

Figure 7: Slope Map Representation

11.6.4 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 -1 can also be used in flat areas where the slope value is null. This layer is provided for both DTM and DSM datasets and available through the WMS.

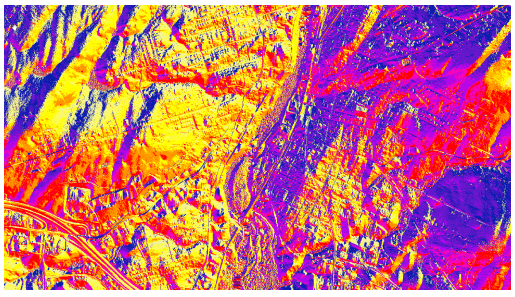

Figure 8: Aspect map Representation