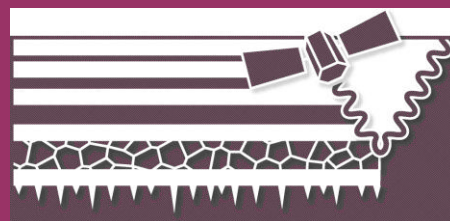


ESA DUE Permafrost



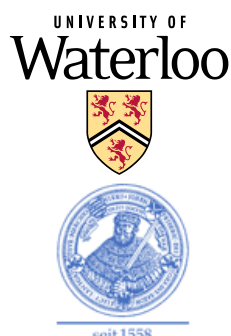
# Pan-Arctic DEM V1 product guide



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# 1 Product overview

This document describes the database of DEMs provided by GAMMA Remote Sensing for the DUE Permafrost project. A brief introduction on elevation data available to generate a global DEM suitable for the scope of the project and related specifications are provided in the document “Global DEM test product guide”. As a result of a preliminary screening of data therein listed, it was decided to use elevation information from the following datasets:

- SRTM-3 DEM (Shuttle Radar Topography Mission)
- RTM (Russian Topographic Maps)
- CDED (Canada Digital Elevation Data)
- U.S. Geological Survey DEM (for Alaska)

All datasets have been downloaded and checked for coverage and quality before further processing. For each dataset, description of image specifications, processing applied and quality control is provided below in related Sections. It should be noted that the original elevation values have been kept in the native format in case of large areas of no-data values. Gap fill in case of local voids has been considered as option; nonetheless, it could be observed that this was never the case since all datasets did not present voids.

## 2 Sources

### 2.1 SRTM

The Shuttle Radar Topography Mission, SRTM, DEM is an elevation dataset available for all land masses between 60 degrees N and South. For the DUE Permafrost project the 3-arcsec version 4.1 provided by the Consultative Group on International Agricultural Research / Joint Research Centre (<http://srtm.csi.cgiar.org>) is used. This is a void-filled version of the version 2.0 dataset provided by NASA JPL. The data is available in tiles of 5×5 degrees, in equiangular projection, at 3 arcsec spatial resolution. Quality reports are provided in (Rabus et al., 2003) and on the CGIAR website.

For the DUE Permafrost project, the 1×1 tiles have been extracted from the original CGIAR 5×5 deg tiles with the Gamma Software program `dem_trans`. No further processing was needed.

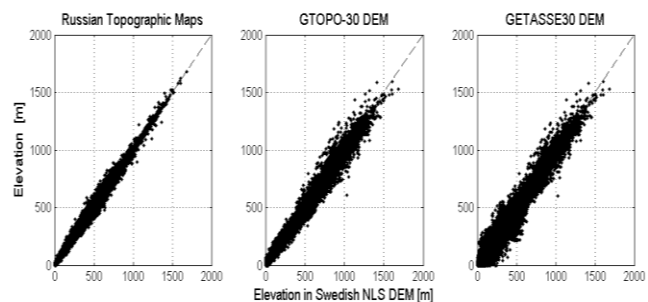
### 2.2 RTM

The dataset of Russian Topographic Maps stems from digitized maps at 1:200,000 scale, available at <http://www.viewfinderpanoramas.org>. The dataset covers all land masses above 60 deg N, with the exception of North America. The DEMs are provided as SRTM-like tiles (version 2), i.e. covering 1×1 deg, with 3-arcsec posting. By the time of compilation of the elevation dataset for the DUE Permafrost project, the coverage had been completed. There are no official reports on data quality and accuracy, however the data producer ensures the highest possible quality and provides examples on the quality of the dataset on the website.

A comparison with the National Land Survey (NLS) elevation dataset of Sweden is displayed in Figure 1 (Santoro & Cartus, Deliverable 3 of the STSE-BIOMASAR Project, 2009). The scatterplot compares elevation from the NLS dataset with elevation from the RTM datasets and from two global DEMs (GTOPO30 and GETASSE-30) for 100,000 samples in northern Sweden. All datasets, if necessary, have been resampled to 3 arcsec posting. The agreement was best in the case of the Russian topographic maps. The low-resolution DEM datasets performed slightly worse, in particular several outliers were noted in the case of the GETASSE dataset. The average elevation difference was 1.4 m, -1.4 m and -7.6 m for respectively the Russian topographic maps, the GTOPO-30 DEM and the GETASSE30 DEM. The corresponding standard deviations were 16.6 m, 24.0 m and 35.3 m. Visual comparison confirmed the high quality of the RTM dataset. Only very local mismatches in form of shifts of the order of a couple of hundred meters were noticed.

For the DUE Permafrost project, no additional processing was needed since the dataset is already available as SRTM-like tiles (version 2).

Figure 1. Scatterplots of elevation reported in the Russian topographic maps (left), the GTOPO-30 DEM (centre) and the GETASSE30 DEM (right) with respect to the Swedish National Land Survey DEM. County of Västerbotten, Sweden.



## 2.3 CDED

The Canadian DEM dataset consists of maps at 1:250,000 extracted from the hypsographic and hydrographic elements of the National Topographic Data Base (NTDB) or various scaled positional data acquired from the provinces and territories (<http://www.geobase.ca/geobase/en/data/cded/index.html>). The time period covers the years 1945-2010. The horizontal accuracy is related to the data source(s) used to generate the CDED. A comparison with SRTM-3 data has been carried out when preparing the Global DEM database for latitudes where both elevation datasets are available. The agreement was high in the horizontal and the vertical direction. This however does not imply that the accuracies are similar for the entire CDED dataset. Visual analysis of the dataset however did not reveal particular artefacts.

The CDED data is available with the following pixel spacing (lat × long):

- 3 × 3 arcsec for lat < 68 deg
- 3 × 6 arcsec for 68 deg < lat < 80 deg
- 3 × 12 arcsec for lat > 80 deg

The data is in equiangular projection, North American Datum 1983 (NAD83) and ellipsoid GRS80. Data is provided in tiles of different size depending on latitude (1×1, 1×2 and 1×4 deg), ASCII format and little endian byte order.

For the DUE Permafrost project, the original CDED tiles were reformatted as follows:

1. Conversion of each CDED tile from ASCII to plain binary (with GDAL tool `gdal_translate`);
2. Conversion of each CDED tile from little to big endian (`swap_bytes` tool of Gamma Software);
3. Mosaicing of individual CDED tiles (`mosaic` tool of Gamma Software);
4. Checking for voids and gap filling (`replace_values` and `interp_ad` tools of Gamma Software);
5. Transformation to output map projection with a bilinear interpolation method and extraction of 1×1 deg tile (`dem_trans` tool of Gamma Software).

## 2.4 USGS DEM (Alaska)

The elevation dataset is produced by USGS and provides coverage in  $1 \times 1$  degree blocks with 3 arcsec resolution for all of the contiguous United States, Hawaii, and most of Alaska. The basic elevation model is produced by or for the Defense Mapping Agency (DMA), but is distributed by the USGS, EROS Data Center, in the DEM data record format. In reformatting the product the USGS does not change the basic elevation information. 1-degree DEM's are also referred to as "3-arc second" or "1:250,000 scale" DEM data ([http://www.webgis.com/terr\\_us1deg.html](http://www.webgis.com/terr_us1deg.html) and <http://edc2.usgs.gov/geodata/index.php>). The topographic features (e.g., contours, drain lines, ridge lines, lakes, and spot elevations) are first digitized and then processed into the required matrix form and interval spacing.

The data is available with the following pixel spacing (lat  $\times$  long):

- $3 \times 6$  arcsec for  $50 \text{ deg} < \text{lat} < 70 \text{ deg N}$ ;
- $3 \times 9$  arcsec for  $\text{lat} > 70 \text{ deg N}$

The data is in equiangular projection, with WGS-84 system. Data is provided in tiles of different size depending on latitude ( $1 \times 1$  deg corresponding to  $1201 \times 601$  and  $1201 \times 401$  pixels respectively). All tiles are in ASCII format and little endian byte order.

The accuracy of the 1-degree DEM data, together with the data spacing, adequately support computer applications that analyze hypsographic features to a level of detail similar to manual interpretations of information as printed at map scales not larger than 1:250,000 scale.

The quality check of the USGS dataset revealed:

- There are data gaps in the data from USGS
- Lat: 68/69 N, Long: 149/147 W;
- Lat: 64/65 N, Long: 164/163.5 W;
- The tile covering Lat: 61/62 N, Long: 163/162 W looks as stretched along the N-S direction.
- In correspondence of several coastal areas and river deltas, the USGS DEM presents 0 m height whereas there are clear land features (although terrain seems very flat). It should be noticed that 0 means 0 m elevation. No data values are generally reported as very negative values (-9999).

For the DUE Permafrost project, the original tiles were reformatted as follows:

1. Conversion of each USGS tile from ASCII to plain binary (with GDAL tool `gdal_translate`);
2. Conversion of each USGS tile from little to big endian (`swap_bytes` tool of Gamma Software);
3. Mosaicing of individual USGS tiles (`mosaic` tool of Gamma Software);
4. Checking for voids and gap filling (`replace_values` and `interp_ad` tool of Gamma Software)
5. Transformation to output map projection with a bilinear interpolation method and extraction of  $1 \times 1$  deg tiles (`dem_trans` tool of Gamma Software)

## 3 Product specification

The database of elevation provided to the DUE Permafrost project consists of tiles with following specification

- Latitude coverage: > 55 deg N
- Longitude coverage: full
- Elevation: as in original datasets (see related documentation on individual DEM sources)
- Projection: equiangular, i.e. latitude/longitude
- Ellipsoid/datum: WGS-84
- Elevation data on the integer degree lines (all four sides) overlap with the corresponding profiles on the surrounding eight blocks.
- For each tile the SRTM standard tiling system (version 2.0) has been used
  
- Tile coverage:  $1 \times 1$  deg
- Posting: 3 arcsec = 0.0008333333 deg (i.e., approximately 90 m at Equator)

File name coding:

1. NyyWxxx.hgt (western hemisphere)
2. NyyExxx.hgt (eastern hemisphere)

where “xx” and “yyy” refer to the digits of latitude and longitude respectively of the bottom left corner (centre of pixel) of the tile.

The extension “hgt” does not indicate a specific kind of file but only indicates the content of the file, i.e. elevation.

File format:

- Plain binary
- Short integer
- Byte order: big endian
- Width: 1201 pixels
- Length: 1201 pixels
- given in xxx, xxx and xxx

Tiles have been grouped according to the DEM origin and geographic location in related directories

- Alaska (USGS)
- Cded (Canada, lat > 55 deg N)
- Rtm
- Eurasia (lat > 60 deg N)
- Greenland (lat > 60 deg N)
- Srtm3\_v4\_1
- America (55 < lat < 60 deg N)
- Eurasia (55 < lat < 60 deg N)



## 4 Data access and contact information

The Circumpolar DEM product can be accessed via PANGAEA (<http://doi.pangaea.de/10.1594/PANGAEA.780111>) and should be cited as:

Santoro, Maurizio; Strozzi, Tazio (2012): Circumpolar digital elevation models > 55° N with links to geotiff images, GAMMA Remote Sensing, doi:10.1594/PANGAEA.779748

In: DUE Permafrost Project Consortium (2012): ESA Data User Element (DUE) Permafrost: Circumpolar Remote Sensing Service for Permafrost (Full Product Set) with links to datasets. doi:10.1594/PANGAEA.780111

The product is alternatively stored at GAMMA Remote Sensing and the Institute of Photogrammetry and Remote Sensing (TU Wien) FTP server which can be accessed via the DUE Permafrost data portal ([www.ipf.tuwien.ac.at/permafrost](http://www.ipf.tuwien.ac.at/permafrost)). The dataportal includes a WebGIS for visualization. Login information is available on request.

For login access to the dataportal, contact [Annett.Bartsch@tuwien.ac.at](mailto:Annett.Bartsch@tuwien.ac.at).

For questions about the product, contact [santoro@gamma-rs.ch](mailto:santoro@gamma-rs.ch).

For ESA's technical officer, contact [Frank.Martin.Seifert@esa.int](mailto:Frank.Martin.Seifert@esa.int).

Additional information on the ESA DUE Permafrost project can be found at the web - site: <http://www.ipf.tuwien.ac.at/permafrost>