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DEFENCE AND SPACE

# Copernicus DEM

## Copernicus Digital Elevation Model

# Product Handbook

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AIRBUS

## DOCUMENT PREPARATION

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## DOCUMENT CHANGE CONTROL

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| Version | Date | Chapter | Changes |
|---|---|---|---|
| 1.0 | 28.11.2019 | all | First issue |
| 2.0 | 11.05.2020 | 1.2.5.5<br>1.3.2 | Correction of section 1.2.5.5 regarding minimum number of ICESat points<br>Faroe Islands added to EEA39 coverage |
| 2.1 | 25.06.2020 | 1.2.3<br>3.1 / 3.2 | Disclaimer on hydrological consistency for reduced resolutions added<br>New structure:<br>Chapter 3.1. "Product Editing Parameters"<br>Chapter 3.2. "Product Generation Process |
| 3.0 | 09.11.2020 | 1.2.5.2<br>1.2.9 & 3.2.2.5 | New fill source: Norway DEM<br>New chapter added: "Special geocells for Ocean" |
| 4.0 | 03.06.2022 | 1.2.5.2<br>various | New fill source: Spanish DEM<br>New coordinate reference system implemented for EEA-10 INSPIRE instance |

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# Reference Documents

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|---|---|
| [RD-01] | WorldDEM Technical Product Specification, Version 2.5, April 2019 |
| [RD-02] | INSPIRE Infrastructure for Spatial Information in Europe D2.8.II.1 Data Specification on Elevation – Technical Guidelines, Version 3.0, December 10 2013 |
| [RD-03] | DLR Document: TD-GS-PS-0021; DEM Products Specification Document, Version 3.2, May 07, 2018 |
| [RD-04] | PERFORMANCE SPECIFICATION DIGITAL TERRAIN ELEVATION DATA (DTED), MIL-PRF-89020B, May 23, 2000 |
| [RD-05] | DGWIG: Defence Gridded Elevation Data Product Implementation Profile (DGED); Version 1.0; June 02, 2016 |
| [RD-06] | Grohman, Kroenung, Strebeck: Filling SRTM Voids: The Delta Surface Fill Method, 2006 |
| [RD-07] | Copernicus DEM Validation Report (DEL-04), Version 3.0., November 2020 |
| [RD-08] | Copernicus DEM Product Handbook (DEL-08), Version 4.0., June 2022 |

# Acronyms and Abbreviations

| | |
|---|---|
| CE | Circular Error |
| DEM | Digital Elevation Model |
| DGED | Defence Gridded Elevation Data |
| DLR | Germany Aerospace Agency |
| DSM | Digital Surface Model |
| DTED | Digital Terrain Elevation Data |
| EC | European Commission |
| EDM | Editing Mask |
| EEA | European Environment Agency |
| EGM | Earth Gravitational Model |
| ESA | European Space Agency |
| FLM | Filling Mask |
| GLO | Global |
| GSHHG | Global Self-consistent, Hierarchical, High-resolution Geography |
| ICESat | Ice, Cloud and Land Elevation Satellite |
| InSAR | Interferometric Synthetic Aperture Radar |
| INSPIRE | INfrastructure for SPatial InfoRmation in Europe |
| ISO | International Organization for Standardization |
| LAEA | Lambert Azimuth Equal Area |
| LE | Linear Error |
| MMU | Minimum Mapping Unit |
| NGA | National Geointelligence Agency |
| QC | Quality Control |
| RD | Reference Document |
| SAR | Synthetic Aperture Radar |
| UTM | Universal Transverse Mercator |
| WBM | Water Body Mask |

# 1 Copernicus DEM: Product Specification

The Copernicus DEM is a Digital Surface Model (DSM) which represents the surface of the Earth including buildings, infrastructure and vegetation. This DEM is derived from an edited DSM named WorldDEM™, i.e. flattening of water bodies and consistent flow of rivers has been included. Editing of shore- and coastlines, special features such as airports and implausible terrain structures has also been applied.

The WorldDEM product is based on the radar satellite data acquired during the TanDEM-X Mission, which is funded by a Public Private Partnership between the German State, represented by the German Aerospace Centre (DLR) and Airbus Defence and Space.

The Copernicus DEM is provided in 3 different **instances** named EEA-10, GLO-30 and GLO-90. The Copernicus DEM instances have:

- varying geographical extent
  - global coverage or
  - area of the EEA member states and the 6 cooperating countries (EEA39)
- varying resolution (0.3 to 3.0 arc seconds)
- varying format
  - DGED (see [RD-05])
  - DTED (see [RD-04])
  - INSPIRE (see [RD-02]):



Figure 1 (below) provides an overview of the Copernicus DEM instances.

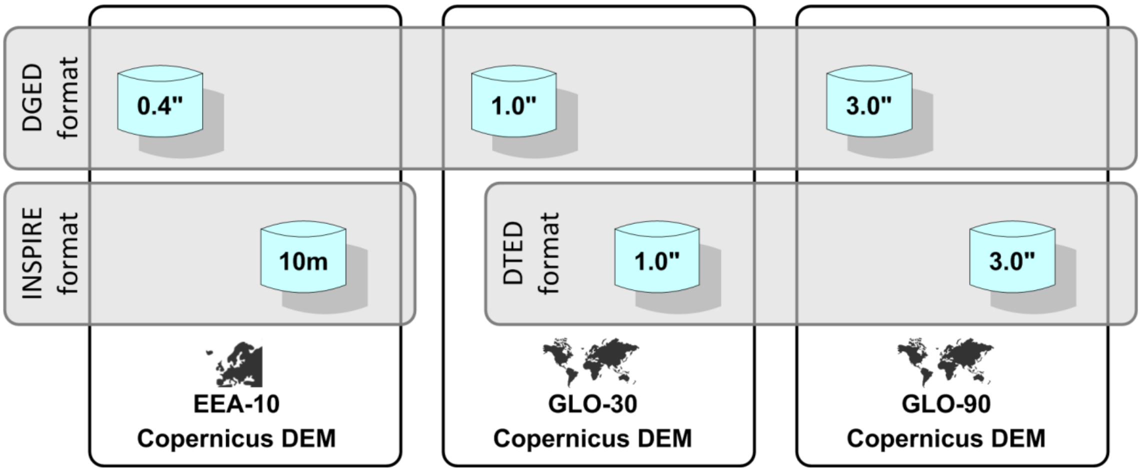



**Figure 1: Overview of Copernicus DEM instances**

The Copernicus DEM instance with INSPIRE format was specified with a grid spacing of 0.3" and geographic coordinates until end of 2021 (see [RD-08]). This has been adapted to a projected coordinate system (LAEA, UTM) with a fixed grid spacing of 10 meters for the INSPIRE instance with the beginning of 2022. The outdated INSPIRE format with geographic coordinates will still be available for a limited transition period.

A visual impression of the Copernicus DEM instances is provided in the Figure 2 below.

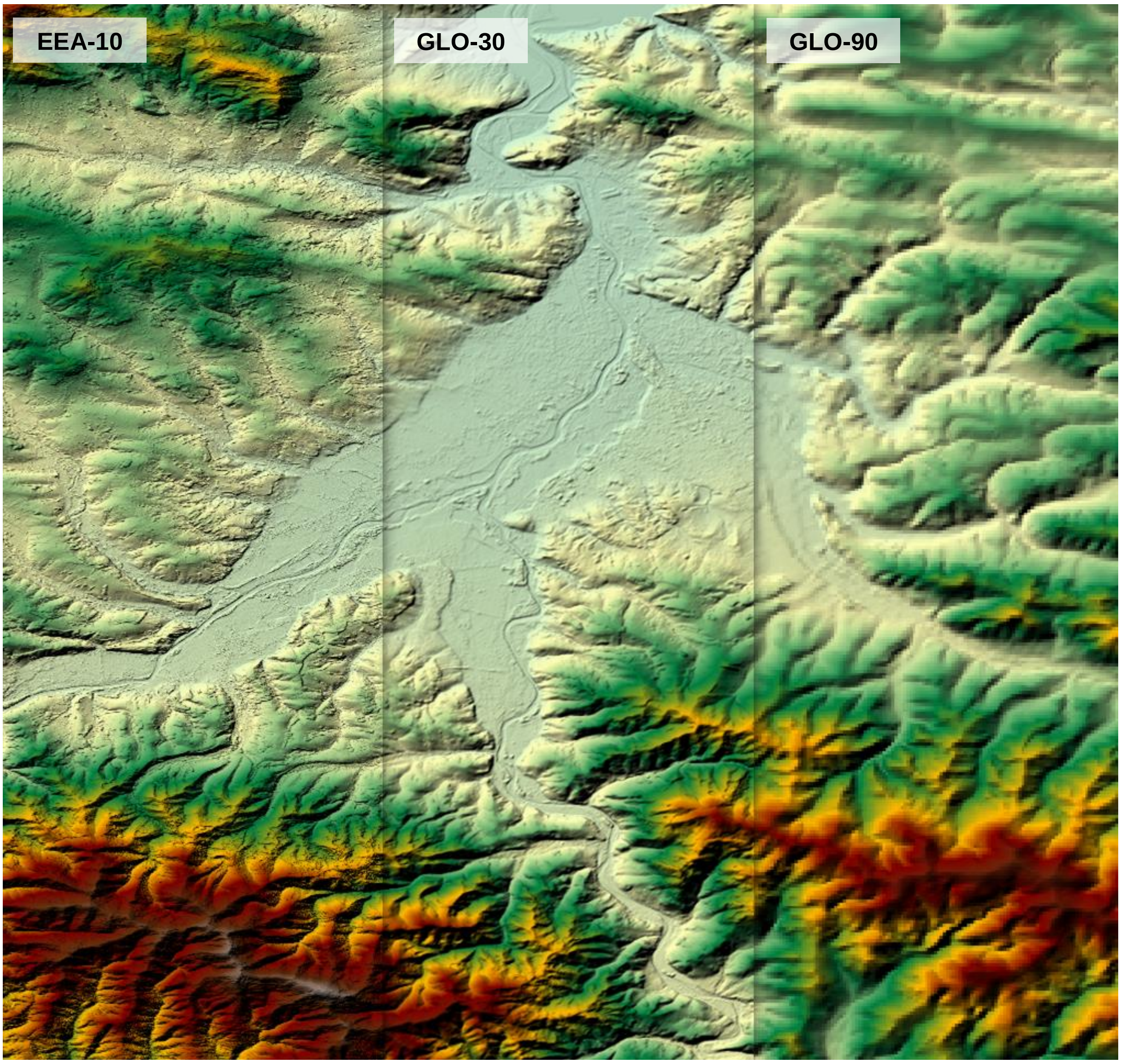



**Figure 2: Visual comparison of Copernicus DEM instances**
**(left: EEA-10 | centre: GLO-30 | right: GLO-90)**

## 1.1 Overview

The technical specification for the Copernicus DEM instances EEA-10, GLO-30 and GLO-90, that are provided in DGED and DTED format, is summarized in the Table 1 (below).

**Table 1: Copernicus DEM specification parameters (DGED and DTED format)**

| Specification Parameter | | Value | | |
|---|---|---|---|---|
| File Format | | GeoTIFF \| DTED | | |
| File Data Type | | 32 Bit, floating point (DGED) or<br>16 Bit, signed integer (DTED format) | | |
| Delivery Unit / Tiling | | 1°x1° latitude/longitude | | |
| NoData Value | | -32,767 (EEA-10 only) | | |
| Projection | | Geographic Coordinates | | |
| Coordinate Reference System | Horizontal | WGS84-G1150 (EPSG 4326) | | |
| | Vertical | EGM2008 (EPSG 3855) | | |
| Grid Spacing | Latitude direction | **Format** | **DGED** | **DTED** |
| | | EEA-10 | 0.4" | |
| | | GLO-30 | 1.0" | 1.0" |
| | | GLO-90 | 3.0" | 3.0" |
| | Longitude direction | variable (depending on latitude, see chapter 1.2.3) | | |
| Vertical Unit | | meters | | |
| Absolute Vertical Accuracy [1) 2) 3)] | | < 4m (90% linear error) | | |
| Relative Vertical Accuracy [2) 3)] | | < 2m (slope ≤20%)<br>< 4m (slope > 20%)<br>(90% linear point-to-point error within an area of 1° x 1°) | | |
| Absolute Horizontal Accuracy [1) 2) 3)] | | < 6m (90% circular error) | | |

1) Validation results based on TanDEM-X DEM/ WorldDEM ICESat GLAS reference points (TanDEM-X Mission Goal: < 10m; global arithmetic mean value)
2) Excluding Antarctica and Greenland (physical reflection properties differ between WorldDEM and reference data in regions with permanent snow/ice cover)
3) Due to the global coverage of the TanDEM-X DEM / WorldDEM / Copernicus DEM, all accuracy statistics and values stated in this document are calculated as an arithmetic mean. Local deviations can occur.

The technical specification for the Copernicus DEM instances EEA-10, that is provided in INSPIRE format, is summarized in the Table 2 (below).

**Table 2: Copernicus DEM specification parameters (INSPIRE format)**

<table>
<tr><th colspan="2">Specification Parameter</th><th>Value</th></tr>
<tr><td colspan="2">File Format</td><td>GeoTIFF</td></tr>
<tr><td colspan="2">File Data Type</td><td>32 Bit, floating point</td></tr>
<tr><td colspan="2">Delivery Unit / Tiling</td><td>100km x 100km</td></tr>
<tr><td colspan="2">NoData Value</td><td>-32,767 (EEA-10 only)</td></tr>
<tr><td colspan="2" rowspan="2">Projection</td><td>Continental Europe<br>Lambert Azimuth Equal Area (see [RD-02])</td></tr>
<tr><td>Overseas Territories (e.g. French Guiana)<br>Universal Transverse Mercator</td></tr>
<tr><td rowspan="3">Coordinate Reference System</td><td rowspan="2">Horizontal</td><td>WGS84-G1150 (EPSG 4326)</td></tr>
<tr><td>ETRS89-GRS80</td></tr>
<tr><td>Vertical</td><td>EGM2008 (EPSG 3855)</td></tr>
<tr><td colspan="2">Grid Spacing</td><td>10 meters</td></tr>
<tr><td colspan="2">Vertical Unit</td><td>meters</td></tr>
<tr><td colspan="2">Absolute Vertical Accuracy 1) 2) 3)</td><td>< 4m (90% linear error)</td></tr>
<tr><td colspan="2">Relative Vertical Accuracy 2) 3)</td><td>< 2m (slope ≤20%)<br>< 4m (slope > 20%)<br>(90% linear point-to-point error within an area of 1° x 1°)</td></tr>
<tr><td colspan="2">Absolute Horizontal Accuracy 1) 2) 3)</td><td>< 6m (90% circular error)</td></tr>
</table>

1) Validation results based on TanDEM-X DEM/ WorldDEM ICESat GLAS reference points (TanDEM-X Mission Goal: < 10m; global arithmetic mean value)
2) Excluding Antarctica and Greenland (physical reflection properties differ between WorldDEM and reference data in regions with permanent snow/ice cover)
3) Due to the global coverage of the TanDEM-X DEM / WorldDEM / Copernicus DEM, all accuracy statistics and values stated in this document are calculated as an arithmetic mean. Local deviations can occur.

The appropriate UTM zone is selected based on the geographic location of the Overseas Territories (see chapter 1.3.2, Figure 15).

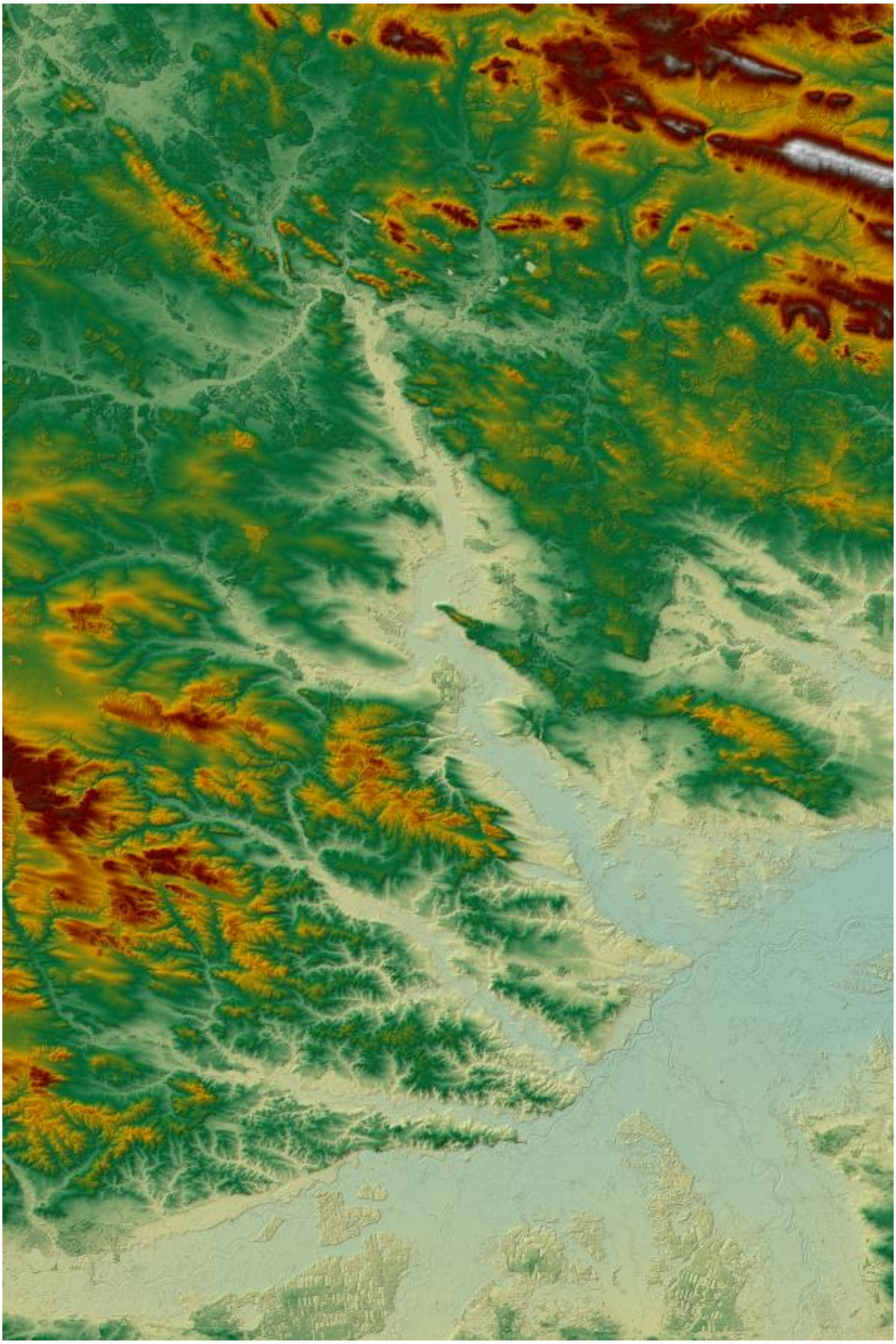


**Figure 3: Colorized display of the Copernicus DEM for the region of Krakow/Kielce (Poland; geocell N50E020)**

## 1.2 Detailed Specification

### 1.2.1 Coordinate Reference System

The Copernicus DEM instances are available in Geographic Coordinates (DGED and DTED format) and the corresponding horizontal reference datum is the World Geodetic System 1984 (WGS84-G1150; EPSG 4326). In addition, the Copernicus DEM is available in INSPIRE format with projected coordinates (Lambert Azimuth Equal Area for continental Europe) with horizontal reference datum ETRS89-GRS80; Universal Transverse Mercator for French Overseas Territories (DOMs) with horizontal reference Datum WGS84-G1150).

The vertical reference datum is the Earth Gravitational Model 2008[1] (EGM2008; EPSG 3855).

### 1.2.2 Format & Grid Definition

The Copernicus DEM data is available in 3 different formats, each following a different DEM profile as a basis.

1. DGED format: EEA-10, GLO-30, GLO-90
2. DTED format: GLO-30, GLO-90
3. INSPIRE format: EEA-10



The main format follows the DGED Product Implementation Profile [RD-05] which covers all available resolution levels of the Copernicus DEM. The DEM data within DGED is provided as 32-bit floating data in GeoTIFF file format including the corresponding XML metadata and quality layers.

The DTED versions of the Copernicus DEM are available as 16-bit signed integer data in DT1 file format (GLO-90) resp. DT2 file format (GLO-30), following [RD-04]. Corresponding XML metadata is included.

The INSPIRE format of EEA-10 provides the height information in 32-bit floating data in GeoTIFF file format with a grid spacing of 10 meters (see [RD-02]).

Figure 1 provides a graphical overview on the available formats per Copernicus DEM instance.

A NoData value (-32,767) is used for pixels where the elevation information is not provided.1°x1° geocells of the EEA-10 DGED instance and 100kmx100km tiles of the EEA-10 INSPIRE instance with continental landmass outside the extent of EEA39 or unavailable input height information (i.e. WorldDEM) contain pixels set to -32,767. This value is applied for the area outside the outer boundary of the nations belonging to EEA39. An additional buffer of 250m outside the nations' boundary is included.

The vertical unit for measurement of elevation height is meters.

The Copernicus DEM standard grid definition refers to the data item GTRasterTypeGeoKey in the GeoTIFF specification. This item is defined as *RasterPixelIsPoint* for the DGED and DTED format and represents a point in the real world, e.g. point oriented information like an elevation sample at an XY point coordinate. The coordinates of the centre of the corner pixels of a DEM tile always refer to integer values in latitude and longitude. Grid points coincide with the centres of cells of the geographical grid. With the establishment of the *RasterPixelIsPoint* definition, the Copernicus DEM is following the DGED, DTED as well as INSPIRE profile. Figure 4 displays the detail of the alignment of the DEM grid to the geographic grid.

In contrast, the GTRasterTypeGeoKey item is defined as *RasterPixelIsArea* for the EEA-10 INSPIRE instance. Grid points coincide with the upper left corner of cells of the projected grid (LAEA, UTM).

[1] Earth Gravitational Model 2008 (EGM2008 geoid undulation values with respect to WGS 84) retrieved from https://earth-info.nga.mil/GandG/wgs84/gravitymod/egm2008/egm08_wgs84.html

Therefore, the tile dimension of the EEA-10 INSIPRE instance is 10.000 columns (X) and 10.000 rows (Y), without any overlapping pixel in adjacent tiles.

DTED File Tag information is adapted when deriving the DTED formatted version of the Copernicus DEM GLO-30 and GLO-90 instances from the WorldDEM input data.

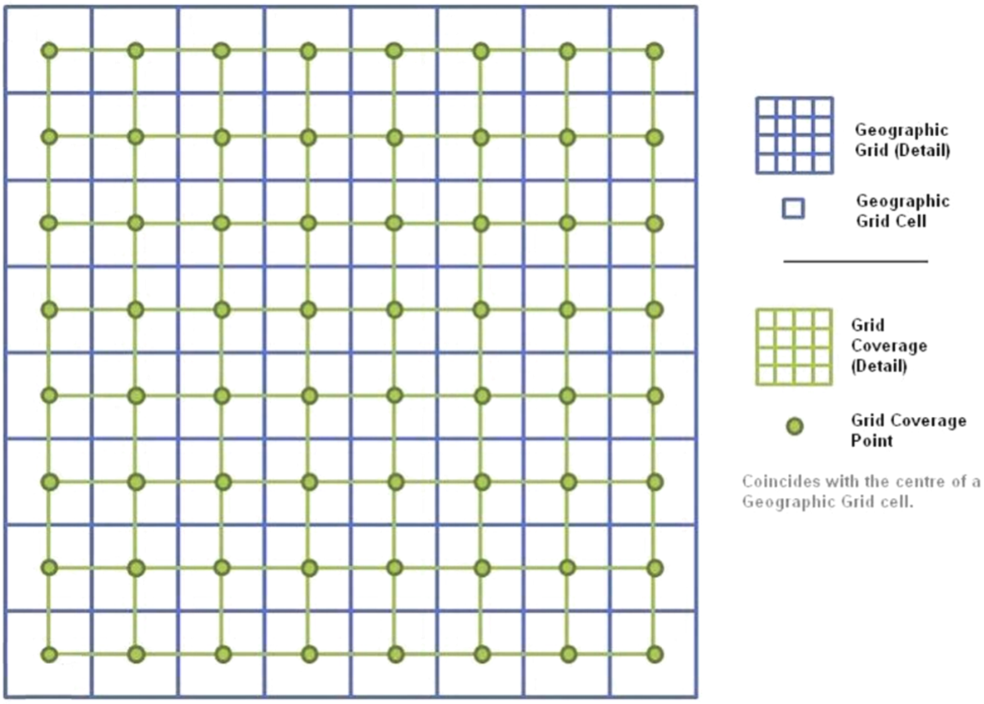



**Figure 4: Copernicus DEM grid definition (DGED and DTED format)**
**(GTRasterTypeGeoKey = *RasterPixelIsPoint*; figure adapted from [RD-02])**



For the Copernicus DEM formats in DGED and DTED format, the number of grid posts per geocell is equal to the number of intervals per geocell plus one (e.g. 9001 pixel columns and rows for a Copernicus DEM geocell with 0.4 arc seconds grid spacing in latitude and longitude direction). Subsequently, overlapping posts (in both directions) of adjacent geocells have identical elevations, in case of coincident pixel centre coordinates. The identical elevations are not ensured in the case of a change of the longitude grid spacing between adjacent cells (i.e. change of latitude band).

### 1.2.3 Grid Spacing

The instances of the Copernicus DEM vary in grid spacing. The high-resolution instances of the Copernicus DEM (EEA-10) are available for the extent of EEA39, with a latitude grid spacing of 0.4 arc seconds (DGED format) as well as 10 meters in projected coordinates (INSPIRE format). The GLO-30 datasets have a latitude grid spacing of 1 arc second, while the GLO-90 datasets have a latitude grid spacing of 3 arc seconds.

For gridded data with geographic coordinates, the effect of convergence of meridians is mitigated with variable longitude grid spacing. The longitude grid spacing is related to the latitude grid spacing based on a reduction factor for each affected latitude band.

A visual impression on the level of detail of the three Copernicus DEM instances (EEA-10, GLO-30 and GLO-90) is displayed in Figure 2 above.

The hydrological consistency of WorldDEM cannot be ensured for Copernicus DEM (EEA-10 INSPIRE, GLO-30, GLO-90) due to the resampling process and the possibility of aggregation of hydro features close to each other.

Table 3 presents the grid spacing for the Copernicus DEM following the DGED profile.

**Table 3: Copernicus DEM grid spacing and longitude reduction factors following DGED format (dep. on latitude)**

| | | WorldDEM (0.4") | | DGED format | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Level 3 | | Level 2 | | Level 1 | |
| **Copernicus DEM instance** | | | | **EEA -10** | | **GLO-30** | | **GLO-90** | |
| **LAT spacing** | | 0.4" ~12.4m | | 0.4" ~12.4m | | 1.0" ~30.9m | | 3.0" ~92.8m | |
| **LON spacing** | 0° - 50° | 0.4" ~12.4m - ~8.0m | 1x | 0.4" ~12.4m - ~8.0m | 1x | 1.0" ~30.9m - ~19.9m | 1x | 3.0" ~92.8m - ~59.8m | 1x |
| | 50°-60° | 0.6" ~12.0m - ~9.3m | 1.5x | 0.6" ~12.0m - ~9.3m | 1.5x | 1.5" ~29.9m - ~23.3m | 1.5x | 4.5" ~89.6m - ~69.8m | 1.5x |
| | 60°-70° | 0.8" ~12.4m - ~8.5m | 2x | 0.8" ~12.4m - ~8.5m | 2x | 2.0" ~31.0m - ~21.2m | 2x | 6.0" ~93.0m - ~63.6m | 2x |
| | 70°-75°<br>75°-80° | 1.2" ~12.7m - ~6.5m | 3x | 1.2" ~12.7m - ~6.5m | 3x | 3.0" ~31.8m - ~16.2m | 3x | 9.0" ~95.5m - ~48.5m | 3x |
| | 80°-85° | 2.0" ~10.8m - ~5.4m | 5x | 2.0" ~10.8m - ~5.4m | 5x | 5.0" ~26.9m - ~13.5m | 5x | 15.0" ~80.8m - ~40.6m | 5x |
| | 85°-90° | 4.0" ~10.8m - ~0.2m | 10x | 4.0" ~10.8m - ~0.2m | 10x | 10.0" ~27.0m - ~0.5m | 10x | 30.0" ~81.1m - ~1.6m | 10x |

An overview map of the latitude bands following the DGED format is provided in Figure 5 below.

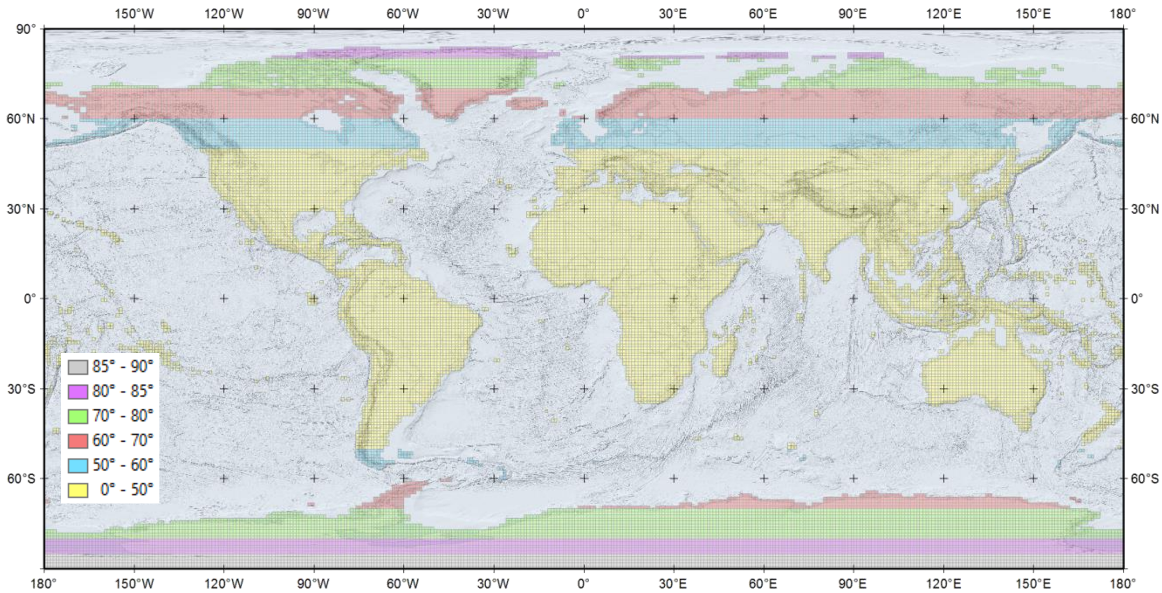



**Figure 5: Overview map of latitude bands for the DGED format**

**Table 4: Copernicus DEM grid spacing and longitude reduction factors following DTED format (dep. on latitude)**

<table>
<tr><th colspan="2" rowspan="2"></th><th colspan="2" rowspan="2">WorldDEM (0.4")</th><th colspan="4">DTED format</th></tr>
<tr><th colspan="2">Level 2</th><th colspan="2">Level 1</th></tr>
<tr><td colspan="2">Copernicus DEM instance</td><td colspan="2"></td><td colspan="2">GLO-30</td><td colspan="2">GLO-90</td></tr>
<tr><td colspan="2">LAT spacing</td><td>0.4"<br>~12.4m</td><td></td><td>1.0"<br>~30.9m</td><td></td><td>3.0"<br>~92.8m</td><td></td></tr>
<tr><td rowspan="7">LON spacing</td><td>0° - 50°</td><td>0.4"<br>~12.4m - ~8.0m</td><td>1x</td><td>1.0"<br>~30.9m - ~19.9m</td><td>1x</td><td>3.0"<br>~92.8m - ~59.8m</td><td>1x</td></tr>
<tr><td>50°-60°</td><td>0.6"<br>~12.0m - ~9.3m</td><td>1.5x</td><td rowspan="2">2.0"<br>~29.9m - ~23.3m</td><td rowspan="2">2x</td><td rowspan="2">6.0"<br>~119.5m - ~63.6m</td><td rowspan="2">2x</td></tr>
<tr><td>60°-70°</td><td>0.8"<br>~12.4m - ~8.5m</td><td>2x</td></tr>
<tr><td>70°-75°</td><td rowspan="2">1.2"<br>~12.7m - ~6.5m</td><td rowspan="2">3x</td><td>3.0"<br>~31.8m - ~16.2m</td><td>3x</td><td>9.0"<br>~95.5m - ~48.5m</td><td>3x</td></tr>
<tr><td>75°-80°</td><td>4.0"<br>~32.1m - ~21.6m</td><td>4x</td><td>12.0"<br>~96.3m - ~64.6m</td><td>4x</td></tr>
<tr><td>80°-85°</td><td>2.0"<br>~10.8m - ~5.4m</td><td>5x</td><td rowspan="2">6.0"<br>~32.3m - ~0.53</td><td rowspan="2">6x</td><td rowspan="2">18.0"<br>~97.0m - ~1.0m</td><td rowspan="2">6x</td></tr>
<tr><td>85°-90°</td><td>4.0"<br>~10.8m - ~0.2m</td><td>10x</td></tr>
</table>

An overview map of the latitude bands following the DTED format is provided in Figure 6 below.

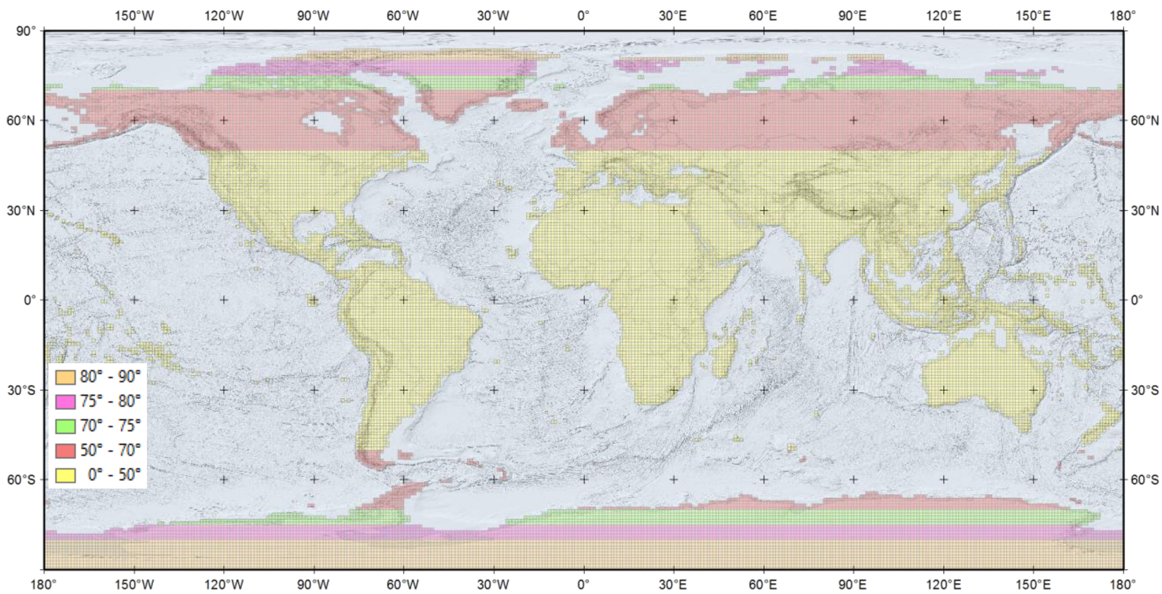



**Figure 6: Overview map of latitude bands for the DTED format**

### 1.2.4 Product Delivery Unit

The Copernicus DEM following the DGED and DTED profile for the area of EEA-10, GLO-30 and GLO-90 is available with standardized extent of 1°x1° geographic degree. The Copernicus DEM following the INSPIRE profile for the area of EEA-10 is available with standardized extent of 100km by 100km. The Copernicus DEM data product includes the corresponding elevation dataset and metadata files.

The Copernicus DEM following the DGED and INSPIRE profile contain additional quality layers as well.

### 1.2.5 Quality Layers

Quality layers are auxiliary information masks that are generated during the Copernicus DEM production process and are available as raster data in GeoTIFF format. Table 5 highlights the quality layers that are part of the Copernicus DEM data product. All quality layers are available for the instances of the Copernicus DEM with DGED & INSPIRE format. The grid spacing corresponds with the DEM data (see Table 5). Quality layers provided with a data format of 8 Bit unsigned integer are available with LZW compression; quality layers with a data format of 32 Bit floating point are uncompressed.

All available 8 Bit data (EDM, FLM, WBM) are obtained from the auxiliary information of the edited WorldDEM™ (grid spacing: 0.4”) by applying a majority value resampling. A consistent coding of thematic classes throughout all 8 Bit data has been taken into account.

**Table 5: Copernicus DEM Quality Layers**

| Quality Layers | | Data Format |
|---|---|---|
| Editing Mask | EDM | 8 Bit unsigned integer, GeoTIFF |
| Filling Mask | FLM | 8 Bit unsigned integer, GeoTIFF |
| Height Error Mask | HEM | 32 Bit floating point, GeoTIFF |
| Water Body Mask | WBM | 8 Bit unsigned integer, GeoTIFF |
| Source Data Layer | SRC | KML vector file |
| Accuracy Layer | ACM | KML vector file |

#### 1.2.5.1 Edit Data Mask (EDM)

The Edit Data Mask (EDM) indicates all DEM pixels that were modified during the terrain and hydro editing process (see [RD-01]). The EDM represents the last editing process that was applied to a pixel.

The meaning of the pixel values is displayed in Table 6.

**Table 6: Edit Data Mask – Pixel Values**

| Pixel Value | Meaning |
|---|---|
| 0 | Void (no data) |
| 1 | Not edited |
| 2 | Infill of external elevation data |
| 3 | Interpolated pixels |
| 4 | Smoothed pixels |
| 5 | Airport editing |
| 6 | Raised negative elevation pixels |
| 7 | Flattened pixels |
| 8 | Ocean pixels |
| 9 | Lake pixels |
| 10 | River pixels |
| 11 | Shoreline pixels |
| 12 | Morphed pixels (series of pixels manually set) |
| 13 | Shifted pixels |



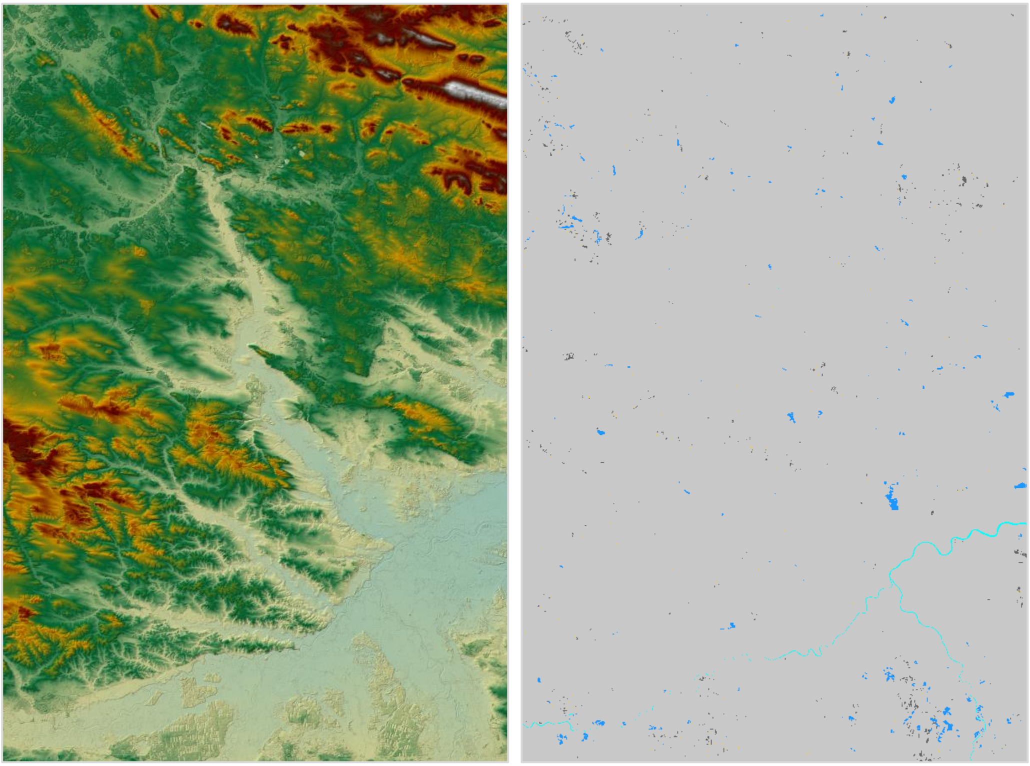


**Figure 7: Colorized quicklook of the Copernicus DEM and the corresponding Edit Data Mask for the region of Krakow/Kielce (Poland; geocell N50E020)**

### 1.2.5.2 Filling Mask (FLM)

The Filling Mask (FLM) is created primarily during the terrain editing process (Chapter **Fehler! Verweisquelle konnte nicht gefunden werden.**). All edited and filled pixels are flagged in this mask. For filled pixels, the fill source is specified. Table 7 shows the meaning of the pixel values of the Filling Mask.

**Table 7: Filling Mask – Pixel Values**

| Pixel Value | Meaning |
|---|---|
| 0 | Void (no data) |
| 1 | Edited (except filled pixels) |
| 2 | Not edited / not filled |
| 3 | ASTER[2] |
| 4 | SRTM90[3] |
| 5 | SRTM30[3] |
| 6 | GMTED2010[4] |
| 7 | SRTM30plus[5] |
| 8 | TerraSAR-X Radargrammetric DEM |
| 9 | AW3D30[6] |
| 100 | Norway DEM[7] |
| 101 | DSM05 Spain[8] |



Data resources used to enhance licensed data material (void filling):
[2] ASTER Global Digital Elevation Map retrieved from https://asterweb.jpl.nasa.gov/gdem.asp, NASA/METI/AIST/Japan Space Systems, and U.S./Japan ASTER Science Team
[3] STRM Digital Elevation Data retrieved from http://earthexplorer.usgs.gov/ and http://srtm.csi.cgiar.org/ U.S. Geological Survey, https://lta.cr.usgs.gov/sites/default/files/Data%20Citation_1.pdf
[4] GMTED2010 Elevation Data retrieved from http://earthexplorer.usgs.gov/ produced by the U.S. Geological Survey, https://lta.cr.usgs.gov/sites/default/files/Data%20Citation_1.pdf
[5] NASA LP DAAC, 2013, NASA Shuttle Radar Topography Mission Global 1 arc second, Version 3.0. NASA EOSDIS Land Processes DAAC, 2013 USGS Earth Resources Observation and Science (EROS) Center, Sioux Falls, South Dakota (https://lpdaac.usgs.gov), accessed May 2nd 2017 at https://doi.org/10.5067/MEaSUREs/SRTM/SRTMGL1.003.
[6] ALOS World 3D-30m (AW3D30) provided by Japan Aerospace Exploration Agency (JAXA) retrieved from https://www.eorc.jaxa.jp/ALOS/en/aw3d30/data/index.htm
[7] Norway DEM retrieved from https://hoydedata.no/, processed and produced by Statens kartverk (Norwegian Mapping Authority)
[8] Digital Surfaces Model (DSM05) Spain, available at http://centrodedescargas.cnig.es/CentroDescargas/locale?request_locale=en

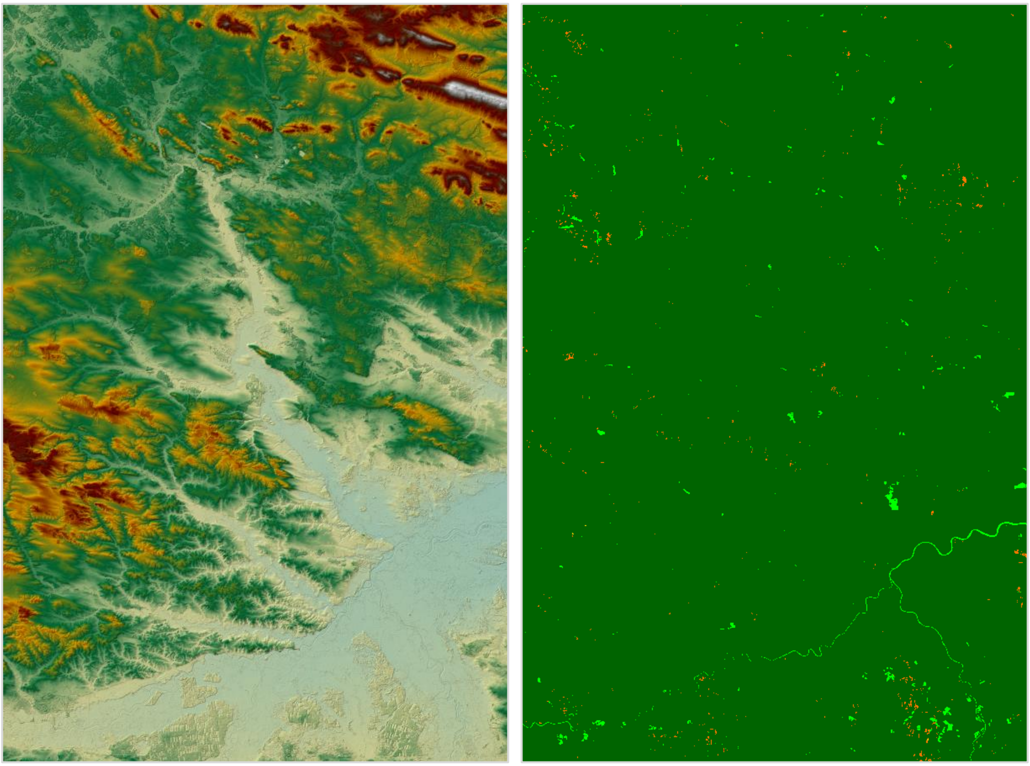


**Figure 8: Colorized quicklook of the Copernicus DEM and the corresponding Filling Mask for the region of Krakow/Kielce (Poland; geocell N50E020)**



#### 1.2.5.3 Height Error Mask (HEM)

The Height Error Mask (HEM) represents the corresponding height error for each DEM pixel in the form of the standard deviation derived from the interferometric coherence and geometrical considerations. The HEM represents errors in the interferometric phase determination and the combination of different coverages [RD-03]. These are random errors and do not include any kind of systematic errors, such as elevation offsets related to erroneous orbital parameters. Phase unwrapping errors are not represented here.

The Height Error Mask (HEM) is congruent to unedited DEM pixel as the edited regions are coded to the pixel value -32,767 in this mask. The Editing Mask as well as the Filling Mask support the interpretation of the HEM for areas coded with -32,767.

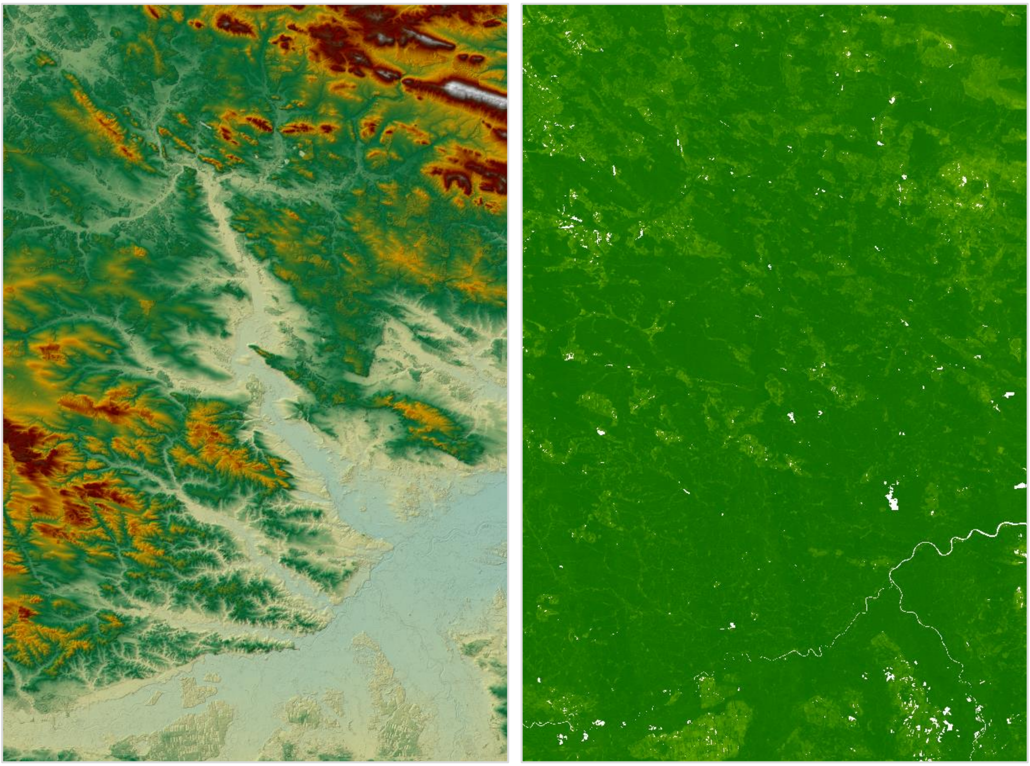


**Figure 9: Colorized quicklook of the Copernicus DEM and the corresponding Height Error Mask for the region of Krakow/Kielce (Poland; geocell N50E020)**



#### 1.2.5.4 Water Body Mask (WBM)

The Water Body Mask (WBM) shows all DEM pixels which are classified as water and edited according to the categories Ocean, Lake or River. Table 8 shows the meaning of the pixel values.

**Table 8: Water Body Mask – Pixel Values**

| Pixel Value | Meaning |
|---|---|
| 0 | No water |
| 1 | Ocean |
| 2 | Lake |
| 3 | River |

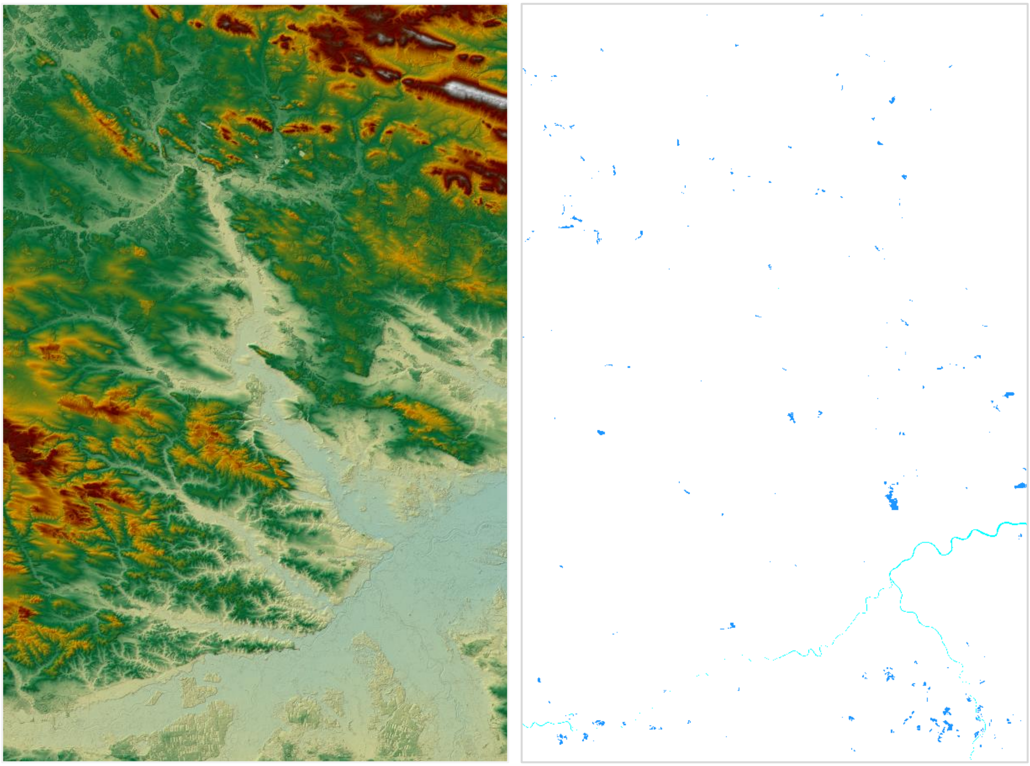


**Figure 10: Colorized quicklook of the Copernicus DEM and the corresponding Water Body Mask for the region of Krakow/Kielce (Poland; geocell N50E020)**



#### 1.2.5.5 Accuracy Layer (ACM)

Accuracy information is determined from the WorldDEM input data of the Copernicus DEM (0.4 arc seconds resolution). This information is derived for those 1°x1° geocells, where at least one ICESat GLAS[9] reference point (dataset GLA06, version 33, provided by the US National Snow and Ice Data Centre) was available. A filtering procedure on the ICESat GLAS data has been applied to derive reliable reference information in generally flat terrain with no features subject to temporal changes (e.g. vegetation and urban areas). The Accuracy Layer provides the absolute, vertical accuracy information expressed in the estimated mean (68%) and maximum (90%) vertical accuracy per delivery unit as a vector file (KML format). The absolute, vertical accuracy is provided as linear error (68% and 90% confidence levels, respectively). The number of available ICESat GLAS points used for determination of accuracy values is provided as a 3rd attribute. Accuracy information with a sufficient number of at least 200 points per geocell are considered as reliable.

For the EEA-10 INSPIRE instance with projected coordinates and delivery units of 100km by 100km, the ACM dataset represents a combination of the input statistics of the incoming 1°x1° geocells of WorldDEM.

[9] GLAS/ICESat L1B Global Elevation Data, Dataset GLA06 Version 33 retrieved from https://nsidc.org/data/GLAH14, National Snow and Ice Data Center, U.S.

#### 1.2.5.6 Source Data Layer (SRC)

The Source Data Layer (SRC) is a vector file (kml) containing the information of the data scenes used for DEM processing. This file includes information about the acquisition ID, data scene number, data acquisition date and time as well as information about the height of ambiguity of the data scenes.

### 1.2.6 XML Metadata

The XML metadata contains information on the acquisition period, input products, data processing and post-processing systems, statistical parameters and general information for all delivered product components.

### 1.2.7 Quicklook Information

Quicklook images are provided with the Copernicus DEM product package (DGED & INSPIRE format). All raster data (DEM, Quality Layer) are available as colorized 8 Bit data in GeoTIFF format. The spatial resolution of the input data is reduced by a factor related to the resolution of the Copernicus DEM (method: averaging; see Table 9). The reduced information is then processed to colorized 8 Bit data.

**Table 9: Quicklook reduction factors**

| Resolution level | Quicklook reduction factor (approx.) |
|---|---|
| EEA-10 | 10 |
| GLO-30 | 5 |
| GLO-90 | 3 |



Two DEM quicklooks are provided, which are refined to colorized shaded reliefs:

- Representing absolute DEM values:
  colour table with respect to a global elevation range (between -450m and 9000m)
- Representing relative DEM values:
  colour table adapted to geocell statistics (min/max)

A kml file linked to the colorized quicklook information is delivered with the data for easy visualisation in GoogleEarth and/or GIS platforms.

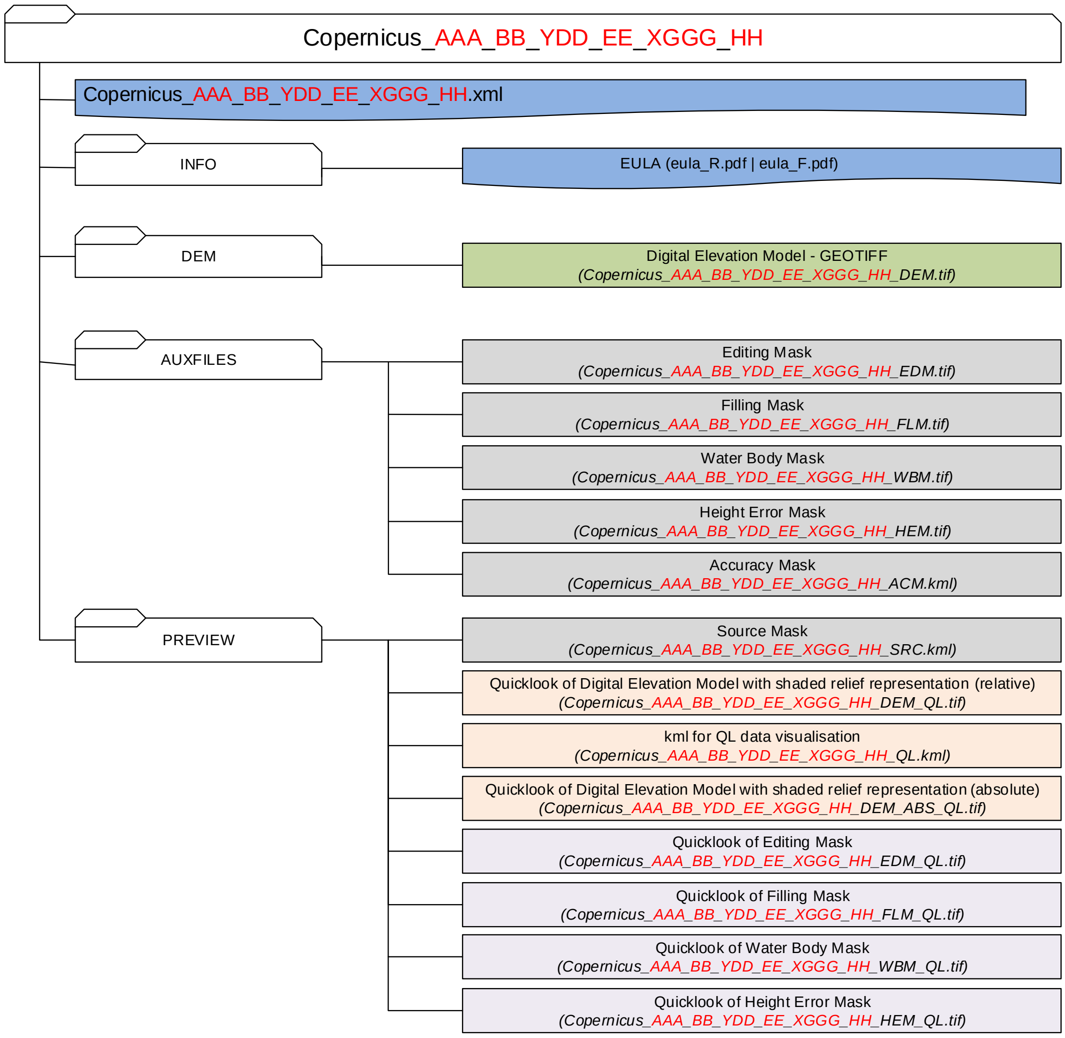
### 1.2.8 Product Structure / Naming Convention

The following chapter provides the product structure and naming convention for all Copernicus DEM product instances.

#### 1.2.8.1 DGED profile

Figure 11 (below) provides a graphical overview of the Copernicus DEM product structure in DGED format format. The product naming convention is displayed as well.

**Copernicus DEM – DGED Product Structure**



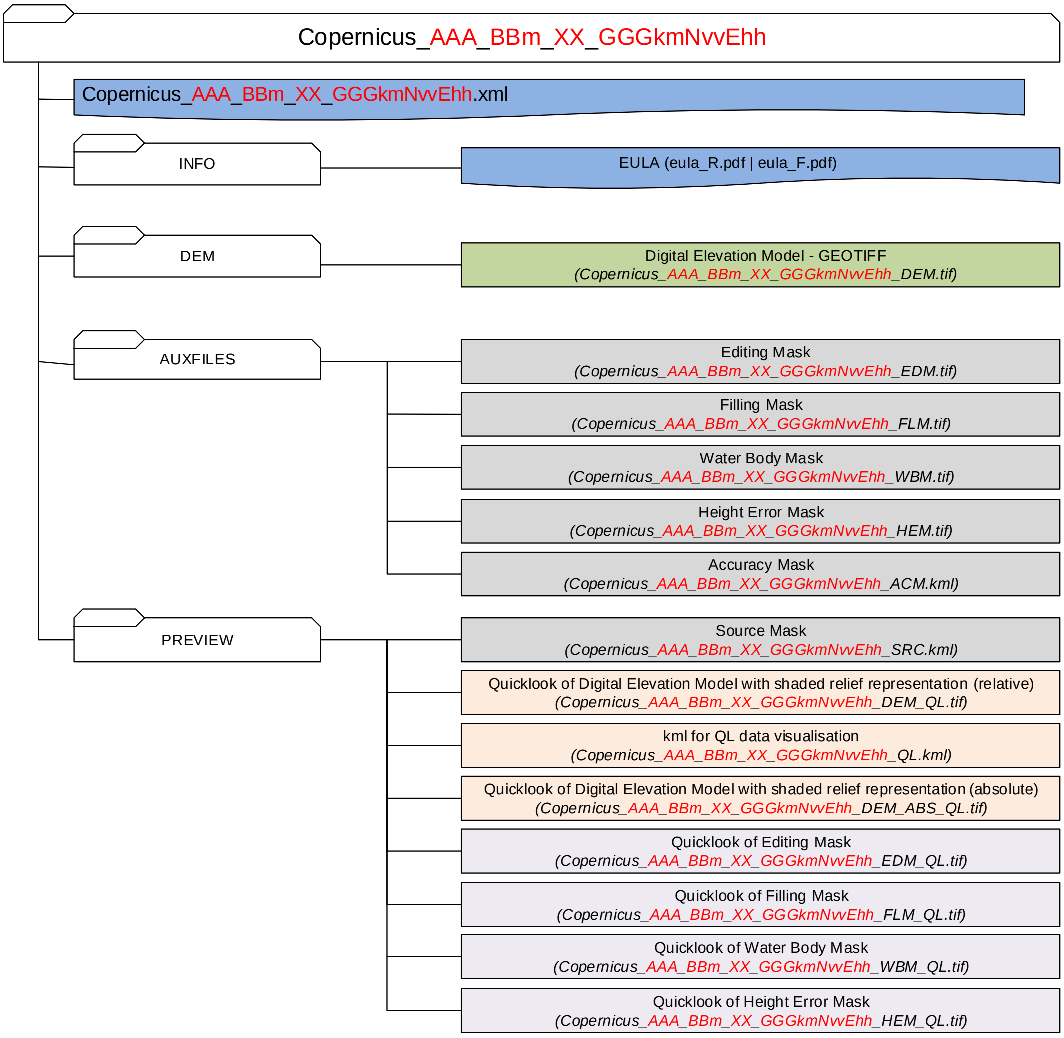

**Naming convention:**
**AAA** = DEM Product Level
**BB** = Spacing. 03: 0.3-arcsecond grid, 04: 0.4-arcsecond grid, 10: 1-arcsecond grid, 30: 3-arcsecond grid
**YDD_EE_XGGG_HH**= Geolocation of LL corner in decimal deg. (eg. N20_00_W120_00)
*Y = N (North) or S (South); DD = Latitude in Degree (Range: 0 – 90); EE = Decimal Latitude Degree (Range: 0 – 99); X = W (West) or E (East)*
*GGG = Longitude in Degree (Range: 0 – 180); HH = Decimal Longitude Degree (Range: 0 – 99)*
**DEM Product Level Naming:** DSM = Copernicus DEM - Digital Surface Model (edited)

**Figure 11: Copernicus DEM product structure (DGED)**

### 1.2.8.2 INSPIRE profile

Figure 13 (below) provides a graphical overview of the Copernicus DEM product structure aligned to the INSPIRE profile. The product naming convention is displayed as well.

**Copernicus DEM – INSPIRE Product Structure**



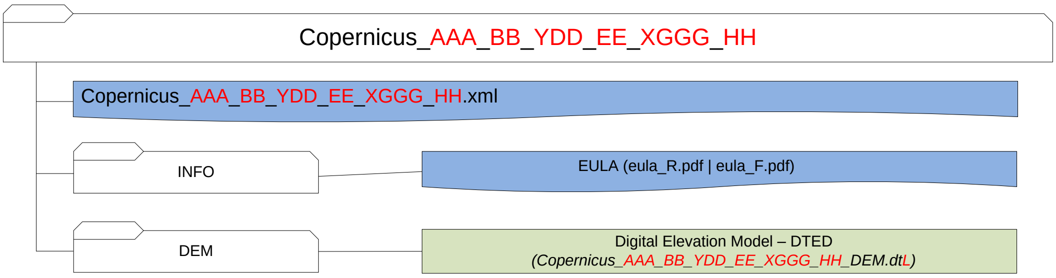

**Naming convention:**
**AAA** = DEM Product Level
**BBm** = Spacing. 10m: 10 meters grid, or analogue with different spacing
**XX** = Name of CRS; *ETRS89LAEA = ETRS-89 LAEA; WGS84UTMxy[N/S] = WGS1984 UTM, Zone xy, North or South, (*e.g. UTM40S*)*
**GGGkmNvvEhh** = Geolocation of LL corner in Specific metric system. (eg. N76E03, belonging to UTM40S); GGG = width of each geocell in km; *N = Northing; vv = Vertical distance from coordinate origin in km/100; E = Easting; vv = Horizontal distance from coordinate origin in km/100*
**DEM Product Level Naming:** DSM = Copernicus DEM - Digital Surface Model (edited)

**Figure 12: Copernicus DEM product structure (INSPIRE)**

### 1.2.8.3 DTED profile

Figure 13 (below) provides a graphical overview of the Copernicus DEM product structure aligned to the DTED profile. The product naming convention is displayed as well.

**Copernicus DEM – DTED Product Structure**




**Naming convention:**
**AAA** = DEM Product Level
**BB** = Spacing 10: 1-arcsecond grid, 30: 3-arcsecond grid
**L** = DTED Level 1: 3-arcsecond grid, Level 2: 1-arcsecond grid
**YDD_EE_XGGG_HH**= Geolocation of LL corner in decimal deg. (eg. N20_00_W120_00)
*Y = N (North) or S (South); DD = Latitude in Degree (Range: 0 – 90); EE = Decimal Latitude Degree (Range: 0 – 99); X = W (West) or E (East)*
*GGG = Longitude in Degree (Range: 0 – 180); HH = Decimal Longitude Degree (Range: 0 – 99)*
**DEM Product Level Naming:** DSM = Copernicus DEM - Digital Surface Model (edited)

**Figure 13: Copernicus DEM product structure (DTED format)**

### 1.2.9 Special Geocells for Ocean

5 special geocells of 1°x1° exist for the global coverages of Copernicus DEM (GLO-30, GLO-90) which are globally distributed. The geocells have not been acquired and produced as TanDEM-X DEM by DLR due to the lack of expected landmass.

Airbus expanded the global coverage by adding these 5 special geocells based on the exploitation of available fill sources and application of filling processes (see chapter 1.2.5.2). The corresponding quality layers and metadata information are provided for these special geocells as well. The quality layers and metadata information are adapted to these circumstances.

**Table 10: Special geocells for ocean areas (IDs)**

| Global distribution |
|---|
| N06W163,<br>N15W079,<br>N23E037,<br>N24E036,<br>S20E164 |



### 1.2.10 Special Geocells for Large Lakes

17 geocells of 1°x1° exist for the global coverages of Copernicus DEM (GLO-30, GLO-90) which are located in the Caspian Sea (Asia, 16 geocells) and Lake Superior (North America, 1 geocell) and do not cover any landmass. Consequently, the quality layer and metadata information are adapted to these circumstances.

The geocells have not been acquired and produced as TanDEM-X DEM by DLR due to the lack of landmass. Airbus expanded the global coverage by adding these 17 special geocells, by exploitation of the neighbouring geocells of edited WorldDEM of the nominal TanDEM-X DEM coverage. The corresponding quality layers and metadata information are provided for these special geocells as well.

**Table 11: Special geocells for large lakes (IDs)**

| Caspian Sea<br>(Asia) | Lake Superior<br>(North America) |
|---|---|
| N37E051, N37E052, N38E050, N38E051, N38E052, N39E050, N39E051, N40E051, N41E050, N41E051, N42E049, N42E050, N43E048, N43E049, N44E048, N44E049 | N47E087 |

## 1.3 Coverage

### 1.3.1 GLOBAL (GLO-90, GLO-30)

The Copernicus DEM GLO-30 and GLO-90 instances cover the full global landmass of the time frame of data acquisition (2011-2015). Each instance covers 148.5 million square kilometres of land surface (including inland water bodies). Figure 14 (below) provides an overview map of the coverage of landmass of the Copernicus DEM instances GLO-30 and GLO-90.

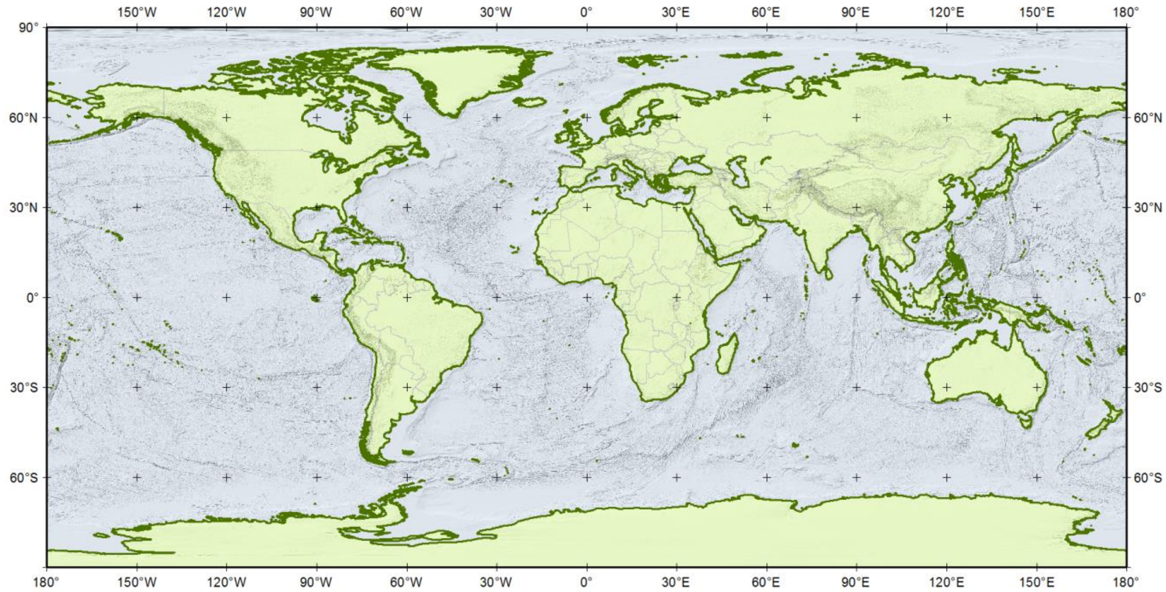



**Figure 14: Land surface coverage within Copernicus DEM – GLO-30 & GLO-90**

### 1.3.2 EEA39 (EEA-10)

The Copernicus DEM EEA-10 instance is available for the countries and regions of EEA39. The European Environmental Agency (EEA) has 33 member countries (status: 2019) and six cooperating countries. European microstates such as Andorra, Monaco, San Marino and the Vatican City state are included in the coverage of the Copernicus DEM EEA-10 instance.

The 1°x1° geocells of the EEA-10 DEM instance (DGED profile) and 100kmx100km tiles of the EEA-10 DEM instance (INSPIRE profile) with continental landmass outside the extent of EEA39 or unavailable input height information (i.e. WorldDEM) contain pixels set to -32,767. This is applied for the area outside the outer boundary of the nations' belonging to EEA39 as well as the ocean areas. An additional buffer of 250m outside the nations' boundary is implemented.

The 1°x1° geocells of the EEA-10 DEM instance (DGED profile) and 100kmx100km tiles of the EEA-10 DEM instance (INSPIRE profile) with continental landmass fully inside the extent of EEA39 or fully available input height information (i.e. WorldDEM) are provided with full coverage (i.e. no pixels set to -32,767).

Data tiles of the EEA-10 INSPIRE instance, that touch the ocean/open sea and are not fully covered with 1°x1° input geocells are partially coded with -32,767. This is applicable to the regions outside of the 1°x1° input geocells and is based on processing reasons.

EEA39 includes the following countries and regions:

Albania, Austria, Belgium, Bosnia and Herzegovina, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Kosovo under the UN Security Council Resolution 1244/99, Latvia, Liechtenstein, Lithuania, Luxembourg, Malta, Montenegro, the Netherlands, Norway, Poland, Portugal, Republic of Macedonia, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey, United Kingdom [including all islands of those countries, e.g. Azores, Madeira, Canary, Baleares, Greek islands, Corsica, Sardinia, Faroe Islands etc.]. French Overseas Departments: French Guiana, Martinique, Guadeloupe, Mayotte and Reunion.

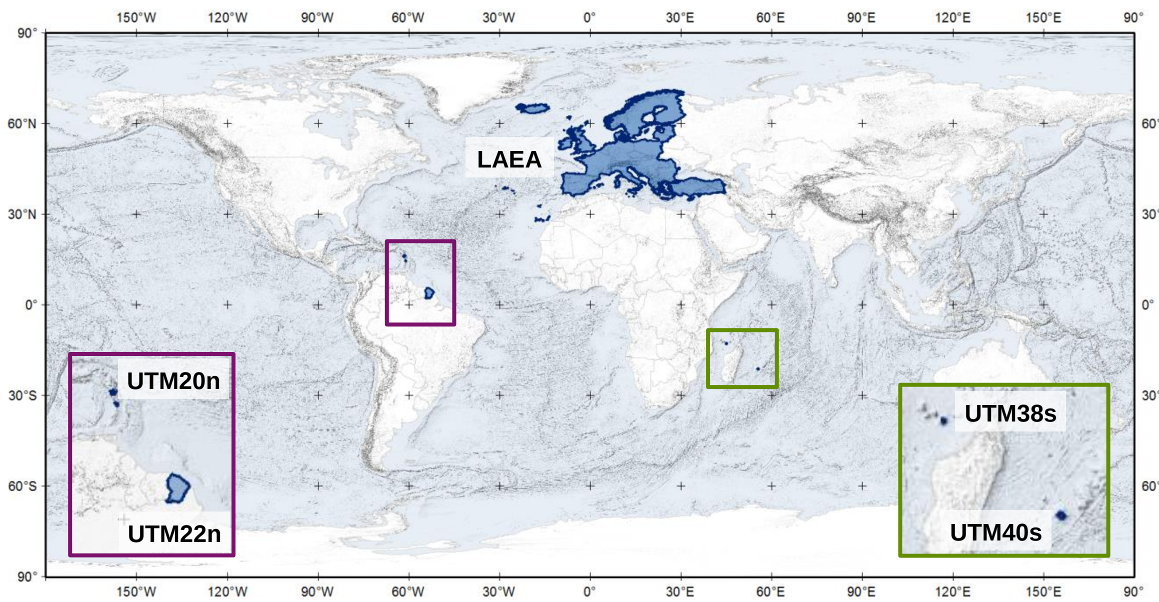



**Figure 15: Land surface coverage within Copernicus DEM – EEA-10**

# 2 Copernicus DEM: Product Quality Performance

The vertical accuracy is specified as absolute and relative accuracy.

Due to the global resp. Pan-European coverage of the Copernicus DEM, all accuracy statistics and values stated in this document are calculated as an arithmetic mean on global level. Local deviations occur.

## 2.1 Absolute Vertical Accuracy

The absolute, vertical accuracy value describes all random or systematic uncertainties of a pixel, in vertical direction, with respect to the vertical datum used. The error is expressed as linear error at a 90 percent confidence level and based on the global product (97% of expected global landmass acc. to GSHHG).

The given absolute, vertical accuracy has been assessed by DLR using ICESat GLAS[10] reference points (dataset GLA14, version 31, provided by the US National Snow and Ice Data Centre). ICESat GLAS laser altimetry data provides accurate and reliable reference data on a global scale. The reliability decreases in case of the presence of slope and/or forest or man-made structures within the ICESat GLAS footprint of ~ 50x70 meters. Therefore, a filtering procedure based on attributes provided with each ICESat GLAS reference point has been developed by DLR and applied.

The footprints of ICESat GLAS reference points cover multiple resolution cells of TanDEM-X/WorldDEM. A distance-based average elevation of the covered TanDEM-X/WorldDEM height values is calculated for comparison with the ICESat GLAS height value.

The basis for the accuracy statistics in Table 12 are the values derived by DLR (geotile basis with extents of 1°x1°, 1°x2°, and 1°x4° depending on latitude), which are based on the comparison of unedited TanDEM-X/WorldDEM data with ICESat GLAS reference points. They refer to the absolute vertical accuracy ($LE90_{ABS}$) of full geotile extents.

The radar signal penetration of TerraSAR-X and TanDEM-X into dry firn snow prevents a direct comparison with ICESat GLAS data which represents a signal reflection at the top surface of dry firn snow. Additionally, the ICESat GLAS reference point data was acquired between 2003 and 2009 whereas the TanDEM-X/WorldDEM has been acquired between December 2010 and January 2015. This represents a temporal decorrelation of the two datasets and potential elevation changes of the areas with permanent snow/ice cover (e.g. seasonal variation within a 1-year timeframe; decrease of the ice shield over the years 2003 to 2015) would affect the accuracy statistics of the TanDEM-X/WorldDEM data. Therefore the statistics were separated into areas with and without permanent snow/ice cover (see Table 12). The clipping of TanDEM-X/ WorldDEM data (variable extent depending on latitude) to WorldDEM/Copernicus DEM geocells of 1°x1° does not affect the vertical accuracy of the global dataset.

The provided accuracy statistics in the accuracy layer (ACM, see Chapter 1.2.5.5) are separated from the consolidated statistics in this chapter as these are derived by using a different reference dataset of ICESat (dataset GLA06, version 33, provided by the US National Snow and Ice Data Centre).

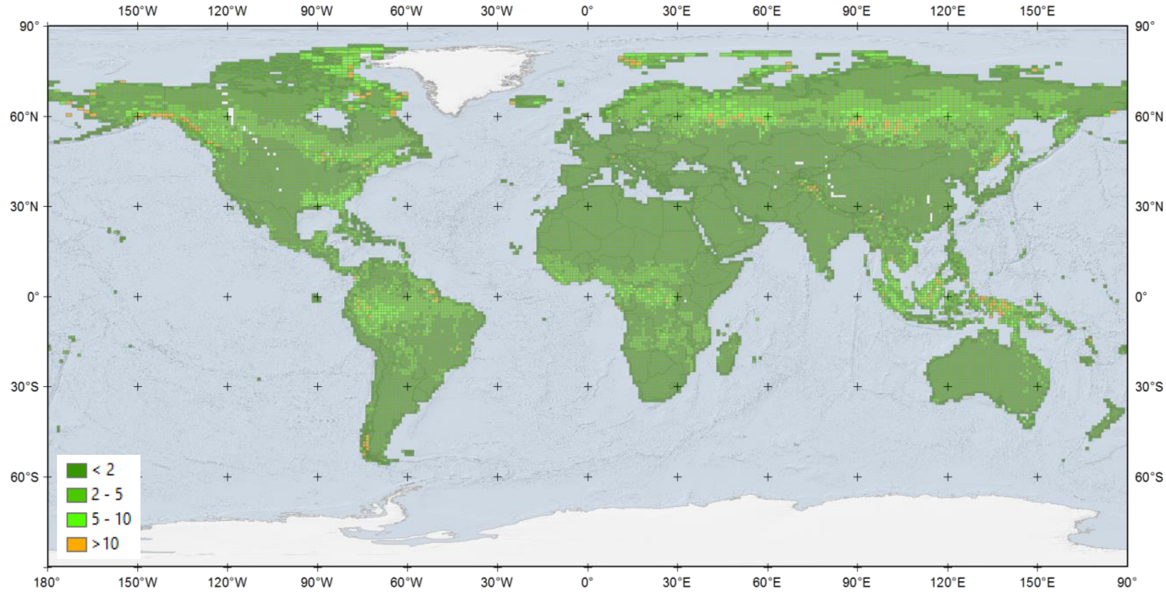


[10] GLAS/ICESat L1B Global Elevation Data, Dataset GLA14 Version 31 retrieved from https://nsidc.org/data/GLAH14, National Snow and Ice Data Center, U.S.

**Table 12: $LE90_{ABS}$ – Statistical result of comparing TanDEM-X/WorldDEM data with ICESat GLAS reference points (basis: DLR $LE90_{ABS}$, geotile extents)**

| | | Number of geotiles | Percent of geotiles | Area of landmass | Percent of landmass |
|---|---|---|---|---|---|
| **1 Global** | | | | | |
| **$LE90_{ABS}$, by DLR** | **Mean** | **2,57** | | | |
| | | 19,389 | 100 % | 148,537,202 $km^2$ | 100 % |
| **1.1 Global area excluding Greenland and Antarctica** | | | | | |
| | | 16,363 | 84.4 % | 132,363,663 $km^2$ | 89.1 % |
| **Absolute, vertical accuracy ($LE90_{ABS}$, by DLR)** | **Mean** | **1.92** | | | |
| | < 2m | 10,881 | 56.1 % | 96,173,522 $km^2$ | 64.7 % |
| | 2 - 5 m | 3,339 | 17.2 % | 27,562,136 $km^2$ | 18.6 % |
| | 5 - 10m | 863 | 4.4 % | 6,822,927 $km^2$ | 4.6 % |
| | > 10 m | 184 | 0.9 % | 1,210,823 $km^2$ | 0.8 % |
| | n/a * | 1,096 | 5.7 % | 594,317 $km^2$ | 0.4 % |
| | **1.1.1 Area of EEA39** | | | | |
| | | 1,089 | 5.6 % | 6,400,363 $km^2$ | 4.3 % |
| | **Mean** | **1,66** | | | |
| | < 2m | 808 | 4.2 % | 5,094,202 $km^2$ | 3.4 % |
| | 2 - 5 m | 183 | 0.9 % | 1,174,727 $km^2$ | 0.8 % |
| | 5 - 10m | 23 | 0.1 % | 76,123 $km^2$ | 0.1 % |
| | > 10 m | 9 | <0.1 % | 37,170 $km^2$ | <0.1 % |
| | n/a * | 66 | 0.3 % | 18,141 $km^2$ | <0.1 % |
| | **1.1.2 Area outside of EEA39** | | | | |
| | | 15,274 | 78.8 % | 125,963,301 $km^2$ | 84.8 % |
| | **Mean** | **1,95** | | | |
| | < 2m | 10,073 | 52.0 % | 91,079,319 $km^2$ | 61.3 % |
| | 2 - 5 m | 3,156 | 16.3 % | 26,388,949 $km^2$ | 17.8 % |
| | 5 - 10m | 840 | 4.3 % | 6,746,623 $km^2$ | 4.5 % |
| | > 10 m | 175 | 0.9 % | 1,172,233 $km^2$ | 0.8 % |
| | n/a * | 1,030 | 5.3 % | 576,176 $km^2$ | 0.4 % |
| **1.2 Greenland and Antarctica** | | | | | |
| | | 3,026 | 15.6 % | 16,173,539 $km^2$ | 10.9 % |
| **Absolute, vertical difference ($LE90_{ABS}$, by DLR)** | **Mean** | **6,17** | | | |
| | < 2m | 73 | 0.4 % | 267,608 $km^2$ | 0.2 % |
| | 2 - 5 m | 965 | 5.0 % | 5,699,087 $km^2$ | 3.8 % |
| | 5 - 10m | 1,549 | 8.0 % | 9,332,554 $km^2$ | 6.3 % |
| | > 10 m | 144 | 0.7 % | 535,578 $km^2$ | 0.4 % |
| | n/a * | 295 | 1.5 % | 338,712 $km^2$ | 0.2 % |

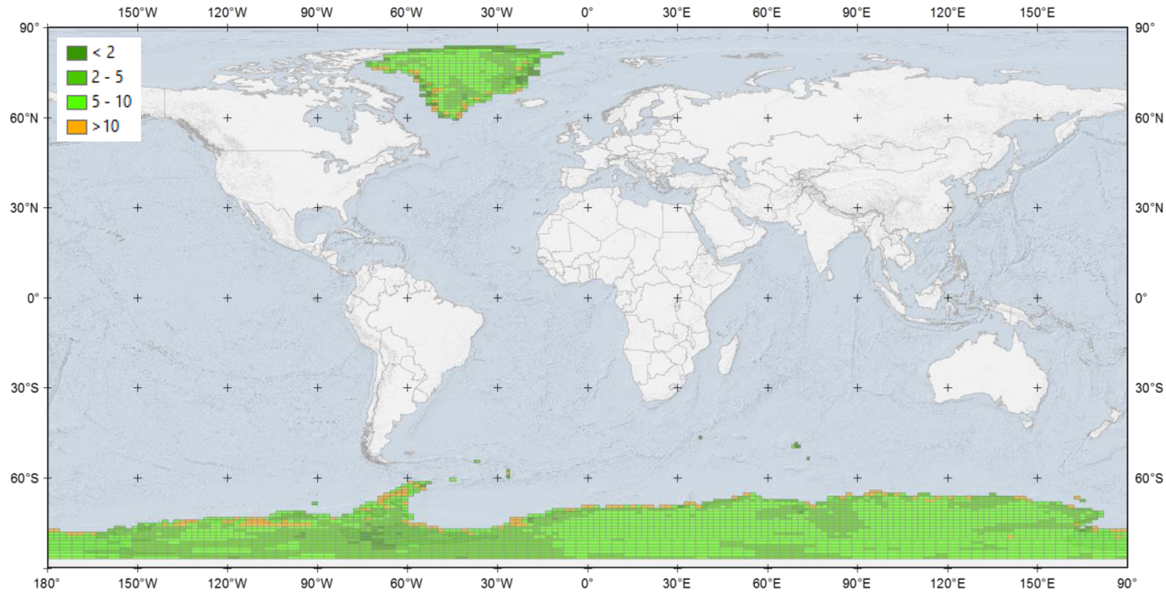
* No ICESat GLAS data available (e.g. geotiles at the land-ocean-boundary)




Background information from Global Insight Version 2014.2 | (C) 2014 Europa Technologies Ltd. | www.europa.uk.com www.viaeuropa.uk.com

**Figure 16: Spatial distribution of absolute, vertical accuracy statistics ($LE90_{ABS}$, from DLR, geotile basis, excl. Antarctica & Greenland)**






Background information from Global Insight Version 2014.2 | (C) 2014 Europa Technologies Ltd. | www.europa.uk.com www.viaeuropa.uk.com

**Figure 17: Spatial distribution of absolute, vertical difference analysis for areas with permanent snow & ice cover ($LE90_{ABS}$, from DLR, geotile basis, Antarctica & Greenland)**

## 2.2 Relative Vertical Accuracy

The relative accuracy describes the consistency of the digital elevation modelling. The relative accuracy is specified as uncertainty between two DEM pixels caused by random errors. The relative uncertainty is expressed as linear error at a 90 percent confidence level.

The relative, vertical accuracy has been assessed by DLR using the interferometric coherence, which serves as input for the height error map (HEM). The HEM dataset provides relative, vertical accuracy information in form of the standard deviation of the interferometric phase error. The approximation of the relative, vertical accuracy is based on the average deviation of coherence values (resp. height error values) compared to an assumed horizontal reference surface. The relative, vertical accuracy of TanDEM-X/WorldDEM is specified with <2m for areas with slope ≤ 20%. The accuracy is specified with <4m for areas with slope > 20%. The derivation of slope information is based on the incoming DEM which is reduced to a horizontal sampling of 3” (~90m). The relative, vertical accuracy value is provided in percent and represents the accumulated area of fulfilled relative, vertical accuracy (2m for slope ≤ 20%; 4m for slope > 20%) compared to the overall area of a geotile.

The analysis in Table 13 is based on the relative, vertical accuracy assessment from DLR (geotile basis with extents of 1°x1°, 1°x2°, and 1°x4° depending on latitude). The approximation of the relative, vertical accuracy for forested as well as for snow/ice covered regions is partially overestimated due to the microstructure of forest and ice/snow covered regions that lead to a radar signal penetration of TerraSAR-X and TanDEM-X into the observed object. Therefore, the area of Greenland and Antarctica are separated in Table 13 (aligned to Chapter 2.1, Table 12).

**Table 13: $LE90_{REL}$ – Relative vertical accuracy statistics for TanDEM-X/WorldDEM (basis: DLR $LE90_{REL}$, geotile extents)**

| | | Number of geotiles | Percent of geotiles | Area of landmass | Percent of landmass |
|---|---|---|---|---|---|
| **1 Global** | | | | | |
| **$LE90_{REL}$, by DLR** | **Mean** | **94,4%** | | | |
| | | 19,389 | 100 % | 148,537,202 km² | 100 % |
| **1.1 Global area excluding Greenland and Antarctica** | | | | | |
| | | 16,363 | 84.4 % | 132,363,663 km² | 89.1 % |
| **Relative, vertical accuracy ($LE90_{REL}$, by DLR)** | **Mean** | **96.8%** | | | |
| | > 98% | 9,992 | 51.5 % | 85,979,789 km² | 57.9 % |
| | 95-98% | 3,014 | 15.5 % | 23,180,057 km² | 15.6 % |
| | 90-95% | 2,072 | 10.7 % | 14,938,760 km² | 10.1 % |
| | 80-90% | 1,041 | 5.4 % | 7,428,763 km² | 5.0 % |
| | <80% | 244 | 1.3 % | 836,295 km² | 0.6 % |
| | **1,1,1 Area of EEA39** | | | | |
| | | 1,089 | 5.6 % | 6,400,363 km² | 4.3 % |
| | **Mean** | **96.8%** | | | |
| | > 98% | 596 | 3.1 % | 3,629,670 km² | 2.4 % |
| | 95-98% | 254 | 1.3 % | 1,468,591 km² | 1.0 % |
| | 90-95% | 182 | 0.9 % | 1,086,065 km² | 0.7 % |
| | 80-90% | 46 | 0.2 % | 215,052 km² | 0.1 % |
| | <80% | 11 | 0.1 % | 984 km² | <0.1 % |
| | **1,1,2 Area outside of EEA39** | | | | |
| | | 15,274 | 78.8 % | 125,963,301 km² | 84.8 % |
| | **Mean** | **96.8%** | | | |
| | > 98% | 9,396 | 48.5 % | 82,350,119 km² | 55.4 % |
| | 95-98% | 2,760 | 14.2 % | 21,711,466 km² | 14.6 % |
| | 90-95% | 1,890 | 9.7 % | 13,852,695 km² | 9.3 % |
| | 80-90% | 995 | 5.1 % | 7,213,711 km² | 4.9 % |
| | <80% | 233 | 1.2 % | 835,311 km² | 0.6 % |
| **1.2 Greenland and Antarctica** | | | | | |
| | | 3,026 | 15.6 % | 16,173,539 km² | 10.9 % |
| **Relative, vertical accuracy ($LE90_{REL}$, by DLR)** | **Mean** | **81.9%** | | | |
| | > 98% | 270 | 1.4 % | 1,580,228 km² | 1.1 % |
| | 95-98% | 359 | 1.9 % | 1,886,470 km² | 1.3 % |
| | 90-95% | 502 | 2.6 % | 2,619,120 km² | 1.8 % |
| | 80-90% | 855 | 4.4 % | 4,617,225 km² | 3.1 % |
| | <80% | 1,040 | 5.4 % | 5,470,496 km² | 3.7 % |

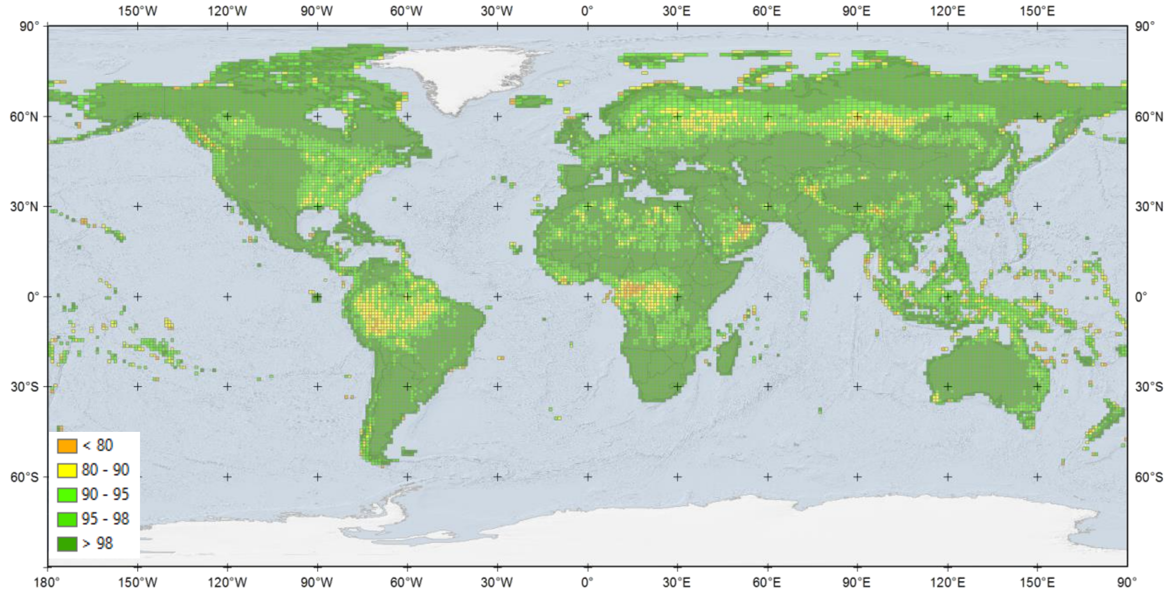



**Figure 18: Spatial distribution of relative, vertical accuracy statistics ($LE90_{REL}$, from DLR, geotile basis, excl. Antarctica & Greenland**

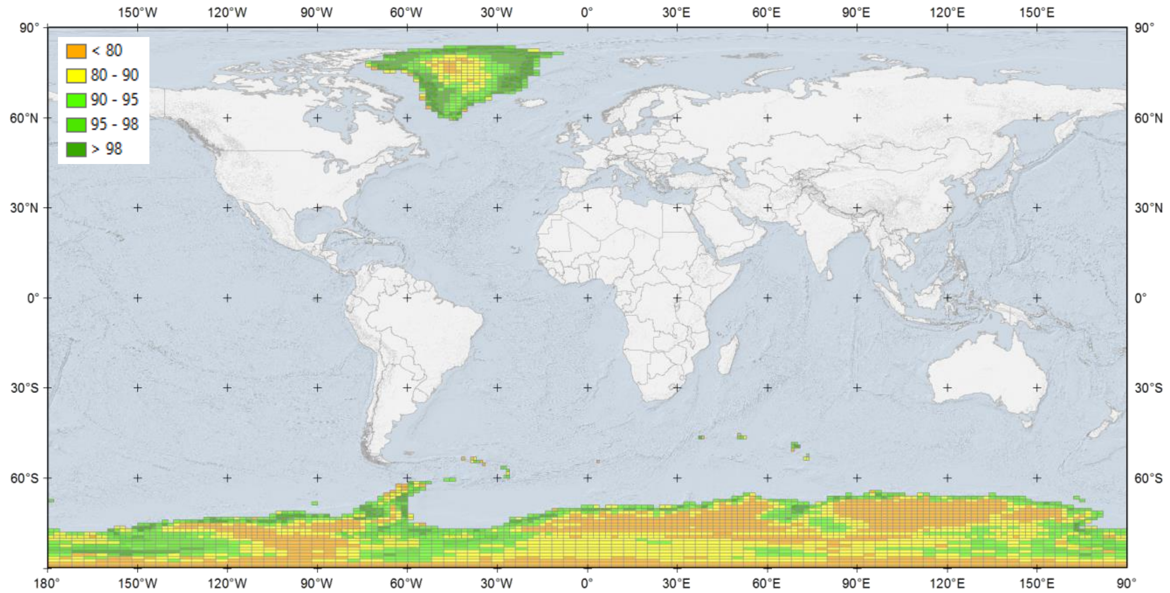



**Figure 19: Spatial distribution of relative, vertical accuracy statistics for areas with permanent snow/ice cover (Antarctica & Greenland, $LE90_{REL}$, from DLR, geotile basis)**

## 2.3 Absolute Horizontal Accuracy

The absolute horizontal accuracy value describes all random or systematic uncertainties of a pixel, in horizontal direction, with respect to the horizontal datum used. The error is expressed as circular error at a 90 percent confidence level and based on the global product.

The absolute horizontal accuracy is influenced by 2 effects:

1. The positional accuracy of the individual DEM scenes.
   This correlates with the accuracy of TerraSAR-X Basic Products for imagery which is less than 30cm
2. Absolute, vertical error of the DEM data that is projected to a horizontal displacement.

The absolute, horizontal accuracy can be determined from the absolute vertical error which is stated with an arithmetic mean of $LE90_{ABS}$ < 4m for the global product. The horizontal accuracy is specified with circular error of <6m (90% confidence level).

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