

# THE EUROPEAN DEM (EURODEM) - SETUP AND HARMONISATION

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## ABSTRACT:

The fusion, respectively the homogenisation, of the digital terrain models of the countries of Europe to a Europe-wide digital elevation model with a vertical accuracy of 8 to 10 m is described. EuroGeographics, an association of nearly all European National Mapping and Cadastral Agencies (NMCAs), decided to build up a digital terrain model for the whole of Europe containing the datasets of the member countries. The technical management and the harmonisation work was done by the Federal Agency for Cartography and Geodesy, Germany (BKG). The incoming data varied in different coordinate systems, grid widths, techniques and dates of data acquisition and, of course, showed different accuracies. To check the quality of each incoming dataset its discrepancies in elevation to the neighbouring states' dataset were calculated in the overlapping areas. Regions with great differences (errors) are cross-checked against contour lines of topographic maps or SRTM-height values. After the quality check the edited DTM data was merged with an average algorithm taking into account the distance to the national border of the member's state. Other quality checks were done by the cross-validation of the height of single points of the levelling network in Europe and interpolated points of the harmonised dataset. Another verification was the localisation and elimination of peaks and gaps in the dataset. The final product will have a grid width of two arcseconds and will be available in May 2008.

## KURZFASSUNG :

Beschrieben wird die Fusion, beziehungsweise die Harmonisierung, der digitalen Geländemodelle der Staaten Europas zu einem europaweiten digitalen Geländemodell mit einer vertikalen Genauigkeit von 8 bis 10 m. EuroGeographics, eine Vereinigung fast aller nationalen Kartographie- und Katasterbehörden in Europa, beschloss den Aufbau eines digitalen Geländemodells für ganz Europa aus den einzelnen Datensätzen der Mitgliedsstaaten. Die technische Leitung und die Fusions- und Harmonisierungsarbeiten wurden vom Bundesamt für Kartographie und Geodäsie (BKG) übernommen. Bezüglich Georeferenzierung, Gitterweite, Erfassungsmethode und -zeitpunkt, sowie der Genauigkeit variierten die gelieferten Datensätze. Zur Kontrolle der Qualität der nationalen Datensätze wurden in den Überlappungszonen zu den Nachbarländern Unstimmigkeiten der Höhen aufgedeckt. Regionen mit großen Differenzen (Fehlern) wurden mittels Höhenlinien aus topographischen Karten bzw. Höhenwerten der SRTM-Mission überprüft. Nach der Qualitätskontrolle wurden die bearbeiteten Datensätze durch einen Mittelwertalgorithmus zusammengefügt, der mittels des Abstands zur Landesgrenze gewichtet wurde. Weiterhin wurden die Höhen von Punkten des europäischen Nivellementsnetzwerks und des harmonisierten Datensatzes verglichen. Die Lokalisierung und Elimination von Ausreißern und Datenlücken wurde ebenso im Rahmen der Qualitätskontrolle durchgeführt. Das Endprodukt wird eine Gitterweite von zwei Bogensekunden aufweisen und im Mai des Jahres 2008 zur Verfügung stehen.

## 1. INTRODUCTION

### 1.1 Motivation

The demand for geodata, especially digital terrain or elevation models, has risen enormously over the last years as a consequence of the growing importance of applications with geospatial reference. There is a strong need for a digital terrain model for the area of Europe. In the moment there is no dataset covering the whole of Europe with an accuracy better than the freely available SRTM data. Also the SRTM dataset covers not the whole of Europe, because the area north of 60 degrees latitude is not captured by the SRTM mission.

Because of these facts EuroGeographics decided at the beginning of the year 2007 to build up a digital terrain model for Europe with a better accuracy and grid width than the SRTM data. This digital terrain model, named EuroDEM, is a mosaic of national elevation data. It is provided from the

national databases by the National Mapping and Cadastral Agencies (NMCAs') of Europe. The production, respectively the harmonisation, was managed by the Federal Agency for Cartography and Geodesy (in German: Bundesamt für Kartographie und Geodäsie -BKG).

### 1.2 EuroGeographics

EuroGeographics (EuroGeographics, 2008) represents nearly all European National Mapping and Cadastral Agencies. Currently the association EuroGeographics has 50 members from 46 countries, as you can see in figure 1. The vision of EuroGeographics is to achieve interoperability of European mapping and other geoinformation data and thus build the European Spatial Data Infrastructure (ESDI).



Figure 1. Member countries of EuroGeographics

On the way to this goal EuroGeographics offers currently three European vector datasets, compiled out of the datasets of its members :

- EuroBoundaryMap

The EuroBoundaryMap is a pan-European reference database of the administrative units and administrative boundaries from the local up to the state level and has been designed for applications in the 1:100 000 scale.

- EuroRegionalMap

EuroRegionalMap is a multifunction pan-European topographic reference dataset of mean resolution (1 : 250.000). The object themes reach from administrative boundaries, hydrography, traffic network to settlements and vegetation.

- EuroGlobalMap

EuroGlobalMap has nearly the same object themes like EuroRegionalMap, but has only a low resolution (1 : 1.000.000).

These products will be supplemented in May 2008 with a fourth product, named EuroDEM. This is a digital terrain model for Europe, a fusion on the basis of the national datasets of the countries in Europe.

## 2. THE PRODUCT EURODEM

### 2.1 Description and Specifications

EuroDEM is a digital representation of the ground surface topography of Europe. It is a pan-European height dataset in a scale of approximately 1:100.000 and consists of regularly distributed terrain points. Using the official national databases EuroDEM was produced in cooperation by the National Mapping and Cadastral Agencies of Europe. The Federal Agency for Cartography and Geodesy (BKG) plays the leading

role for this project and is responsible for the organisation, data merger and quality check. EuroDEM is seamless and harmonised at the borders of the countries. Because the product EuroDEM is a mosaic of the national elevation data the specification of the grid width and the vertical accuracy is a compromise within the range of these specifications of the original datasets. The reference systems were chosen according to the standards of the other products of EuroGeographics. Table 1 shows an overview of the general specifications of the product.

Data Type	Raster
Reference date	May 2008
Resolution	2 arc seconds (approx. 60 m in meridian direction)
Vertical Accuracy	+/- 8 – 10 m
Elevation Resolution	Height values in meters (Integer values)
Geo-referencing	ETRS89
Elevation Reference	EVRS
Coordinate System	Geodetic : arc seconds

Table 1. Technical specifications of the product EuroDEM

EuroDEM covers the 27 EU countries and the 4 EFTA countries as well as Albania, Bosnia-Herzegovina, Croatia, Kosovo, Macedonia, Moldova, Montenegro, Serbia and the Kaliningrad area (see figure 2).

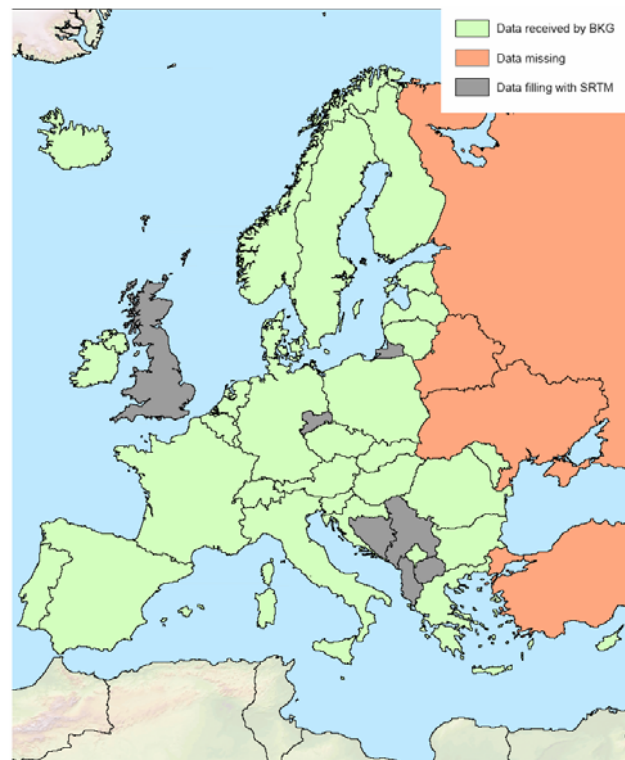


Figure 2. Extent of the product EuroDEM

For the grey areas in figure 2 only SRTM data (SRTM, 2008) with a lower quality of +/- 15 m is used in the dataset EuroDEM. These are the countries or areas of Albania, Bosnia-Herzegovina, Great Britain, Macedonia, Montenegro, Saxony in

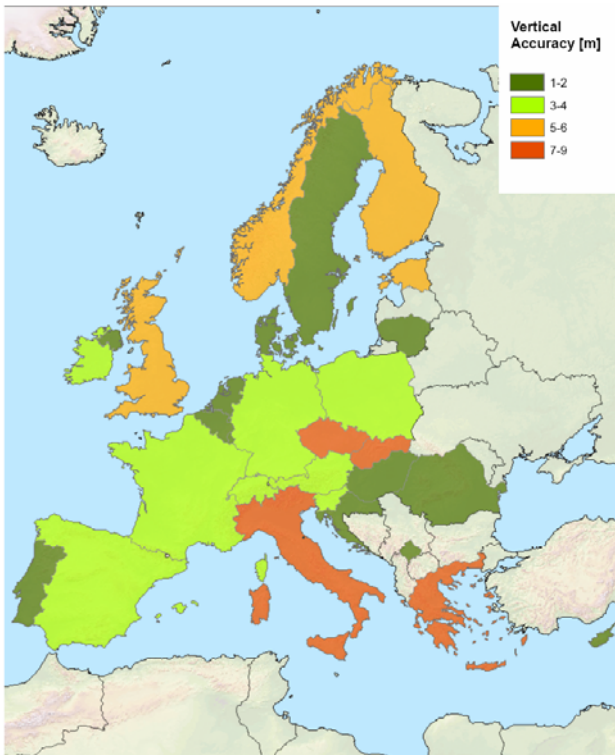


Figure 3. Vertical accuracy of the national height datasets of the European countries.

Germany, Serbia (except Kosovo) and the Kaliningrad area. In figure 3 the vertical accuracy of the national datasets of the European countries is depicted. The grid width of the national datasets is shown by figure 4. In certain cases the national dataset was not used for building up the product EuroDEM, because of legal problems (for example Great Britain). As shown in these figures the range of vertical accuracy lies between 1 and 9 meters. The best delivered grid width was 5 meters and the worst 100 meters.

## 2.2 Delivery and Formats

EuroDEM has a seamless coverage of Europe. However, the product has adopted a tile partition, which is delimited by degree graduation of longitude and latitude. The tiles have a spatial extent of 1 x 1 degree (3600 x 3600 arc seconds). The only saved value is the elevation at this coordinate, no further attribute is attached.

EuroDEM will be licensed according to two standard product options:

1. Full European coverage including all countries
2. A predefined set covering one of the following 4 European regions:
  - Northern Europe
  - Western Europe
  - Central Europe
  - Eastern Europe

The coverages of the European regions overlap each other so that a country may be included into several regions. There is no possibility to license a single national dataset of a country. However, single national datasets can be licensed in addition to a European region on condition that they create a seamless

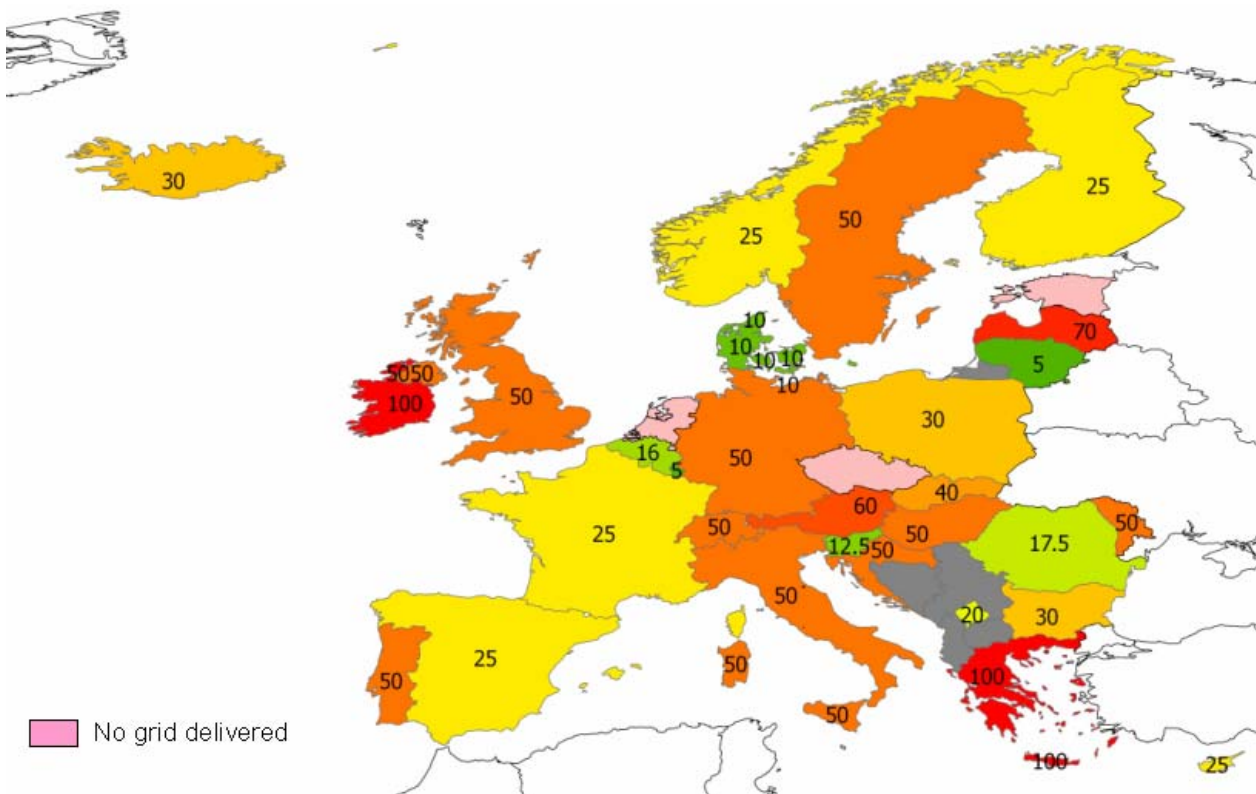


Figure 4. Grid width of the national height datasets of the European countries.

coverage and constitute a neighbouring country of the region.

Full Europe and the European regions can be provided in the following formats:

- ESRI Grid
- ESRI Grid Ascii
- GeoTiff
- XYZ-File (Ascii)

### 2.3 Harmonisation Work

The general production process consisted of the following stages :

- Collecting the national datasets.
- Transforming the elevation data into a uniform projection and height system.
- Resampling of the elevation data to a uniform grid width.
- Eliminating differences resulting, for example, from different dates and methods of data acquisition, in overlaps at national boundaries.
- Merging of the dataset by applying an average algorithm.
- Controlling data quality of the end product.
- Changing format and tiles with respect to the EuroGeographics' licensing requirements.

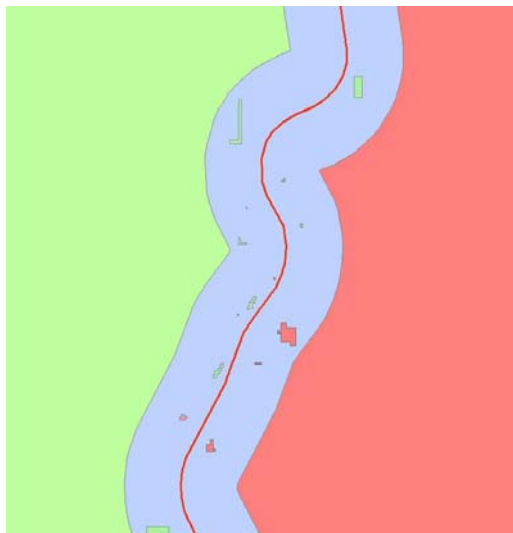


Figure 5. Result of the manual checking in an overlapping region (in grey).

For the harmonisation work the software ESRI ArcGIS was used, so that the transforming and resampling was done with the standard tools of ArcGIS. The time-consuming part of the harmonisation was the editing of the differences in the overlaps at the national boundaries. To check the quality and correctness of each incoming dataset its discrepancies in elevation to the neighbouring states' dataset were calculated for the overlapping areas. Regions with great differences were cross-checked against:

- Contour lines of topographic maps
- or SRTM height values

As mentioned in (Hovenbitzer, 2004) the reasons for these differences are :

- Different dates of data acquisition
- Different methods of data acquisition

- Different grid widths of the data

These areas were marked with a polygon and the information which dataset is correct in this area is stored (see figure 5). After this manual checking the datasets were merged with an average algorithm taking into account the distance to the border of the overlapping region and the edited polygons. The weight of the averaging is calculated as shown in figure 6. If the height value in the middle of the overlapping region was calculated, the height values of the countries in general had the same influence. A point in the proximity of the border of the overlapping region of country A had been influenced strongly by the heights of country A and slightly by the heights of country B.

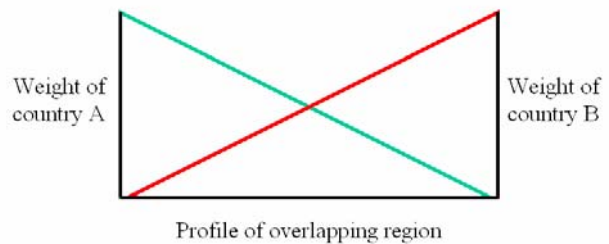


Figure 6. Weight of the averaging in the overlapping areas.

### 2.4 Quality Control

By the cross-validation of the height of single points of the levelling network in Europe and interpolated points of the harmonised dataset a quality check was done. As a result of this check the vertical accuracy of the product EuroDEM was confirmed. Another verification was the localisation and elimination of peaks and gaps in the dataset.

## 3. CONCLUSIONS

EuroDEM is useful for a wide range of applications, including ortho-rectification of imagery, watershed analysis, flight simulations, cartographic publishing and so on, or in combination with other datasets for rendering three-dimensional visualisations, for instance. The product EuroDEM will be available in May 2008 and will fill the "elevation" gap of the products of EuroGeographics. For the future it is planned, that the horizontal resolution and the vertical accuracy will be enhanced depending on dataset updates from the European countries.

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