THE DIGITAL ELEVATION MODEL 1:25.000 (DEM 25) FOR THE FEDERAL REPUBLIC OF GERMANY

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ABSTRACT

The fusion respectively the homogenisation of the digital terrain models of the federal states (Länder) of Germany to a nationwide digital elevation model for Germany is described. The aim is a nationwide, consistent, at the moment not yet existing, digital elevation model with an accuracy of ± 1 to ± 3 m. The incoming data from the states have different grid sizes, techniques and dates of data acquisition and, of course, different accuracies. These different accuracies range from the quality of laser scanning or high resolution photogrammetry to the quality of digitalisation of contour lines. For checking the quality of each incoming database the differences in the overlapping areas adjoining the neighbour state are calculated. Regions showing great differences (errors) are checked by field measurements using a DGPS-method (SAPOS). After checking the data the error-free DTM-Data will be merged with algorithms that depend on the data accuracy. Possible height steps in the data will be prevented using a distance-depending adaptation. After the flooding catastrophe of the river „Elbe“ in the year 2002 Germany has an urgent demand for high resolution digital elevation models with respects to possible flooding areas. Therefore, the DEM25 will be supplemented with a high resolution DEM with an accuracy of 0,5 m and better in these regions.

KURZFASSUNG

Die Landesvermessungsämter erstellt gemeinsam mit dem Bundesamt für Kartographie und Geodäsie (BKG) bis zum Jahre 2004 ein die Bundesrepublik abdeckendes, homogenes digitales Geländemodell (DGM, Rasterweite kleiner/gleich 50 m) in mittlerer Genauigkeit (d.h. geländetypabhängig ± 1 bis ± 3 m). Vorhandene Datenbestände der Länder werden hierzu genutzt. Die Eingangsdaten der Länder unterscheiden sich hinsichtlich Gitterweite, Erfassungsarten und -zeitpunkt und somit der Genauigkeit jedoch stark. Die Genauigkeiten reichen von der Qualität des Laserscannings oder hochgenauer Photogrammetrie bis zur Qualität der Digitalisierung von Höhenlinien. Zur Qualitätsuntersuchung werden Differenzenmodelle der Überlappungszonen der Eingangsdaten berechnet. Regionen mit großen Differenzen werden durch Feldmessungen mittels DGPS (SAPOS) geprüft. Nach der Qualitätskontrolle werden die Daten genauigkeitsabhängig fusioniert. Mögliche Höhenstufen werden durch eine distanzabhängige Anpassung angeglichen. Aufgrund der Flutkatastrophe der „Elbe“ im Jahre 2002 besteht eine erhöhte Nachfrage nach hochgenauen digitalen Geländemodellen in Deutschland. Aus diesem Grund wird das flächendeckende DGM25 durch hochgenaue DGMe (Genauigkeit 0,5 m und besser) in überflutungsgefährdeten Gebieten ergänzt werden.

1 INTRODUCTION

At the moment there is an urgent need for digital terrain models and, respectively, digital elevation models. One reason for this demand is, for example, the flooding catastrophe of the river „Elbe“ and its tributaries that occurred in August 2002. For calculating flooding predictions a precise DEM is needed. The growing market of mobile telephone systems is another reason. The mobile telephone companies are using elevation models for planning the best locations for their aerial masts.

The Federal Agency for Cartography and Geodesy (Bundesamt für Kartographie und Geodäsie = BKG) of Germany offers three nationwide digital elevation models for the mapping scales 1:50.000 to 1:1.000.000 with a minor accuracy of about ± 20 m. Further, the federal states (Länder) of Germany have digital elevation models for the mapping scales 1:5.000 to 1:50.000 for their areas with an accuracy of ± 0.3 to ± 5 m. But presently there is no nationwide elevation dataset, which fulfils the needs of many customers of BKG. For this reason a new digital elevation model is just being calculated. The DEM is built up for the mapping scale 1:25.000 and will have an accuracy of ± 1 to ± 3 m.

2 DECISION OF THE ADV

The Working Committee of the Surveying Authorities of the States of the Federal Republic of Germany (Arbeitsgemeinschaft der Vermessungsverwaltungen = AdV) decided in Mai 2003 that the states shall build up a new digital elevation model of Germany (Decision 112/12). According to this resolution the BKG is responsible for the homogenisation and the fusion of the datasets of the states. The first release of the elevation model was terminated for the year 2004. Furthermore, the accuracy of the model was specified with ± 1 to ± 3 m. The accuracy depends on the terrain type. In plain areas the accuracy has to be 1 m and in moun-

tain areas a lower accuracy of 3 m is allowed. Generally the grid width of the model is set to 50 m.

The AdV specified that the states will deliver their datasets to the BKG. The fusion and homogenisation have to be calculated by the BKG.

3 DTM/DEM DATABASES OF GERMANY

In Germany the responsibility for surveying is regulated by law. The states, for example Bavaria, are concerned with the map scales 1:500 to 1:50.000 for their respective areas. The BKG is responsible for the map scales 1:100.000 to 1:1.000.000 for the whole of Germany. In the field of DEM/DTM production there was an analogue border of responsibility. Many states now have a DEM or DTM with a good accuracy and resolution. An overview of the DEMs or DTMs of the states and the BKG is given below.

3.1 DEM DATABASES OFFERED BY BKG

In table 1 the DEMs offered by the BKG as nationwide datasets are described. Because of the low accuracy and the fact that there is no updating, the demands for the datasets decrease.

	DEM1000	**DEM250**	**DEM50**
Scale	1:1.000.000	1:250.000	1:50.000
Grid width	30”x50”	200x200m	1”x1”
Accuracy	?	±20 m	±20 m
Planned Updates	no	no	no
Method of data acquisition	Digitalisation of contour lines	Resampling of DEM50	Digitalisation of contour lines

Table 1: DEM-Datasets offered by BKG

3.2 DTM DATABASES OFFERED BY THE STATES

Figure 1 depicts the best available DEM/DTM data from the states in the year 2001 (AdV, 2001). The states in the western part of Germany offer mostly DEM5 quality, which has an accuracy of about ±0,5 m. In the eastern part of Germany there is mainly DEM25 quality available, which is precise to about ±2 m. In some states, for example Baden-Württemberg, the surveying authorities have planned or executed projects for building up a high resolution DEM for special regions or the whole state.

4 TASKS OF BKG

The main part of the work for building up the DEM25 for Germany is the fusion of the datasets of the states. The datasets have mostly an overlapping zone at the boundary between two states. The homogenisation is another work-intensive item for the BKG.
Furthermore, the quality control of the datasets of the states and the final DEM are important points for building up the DEM25.

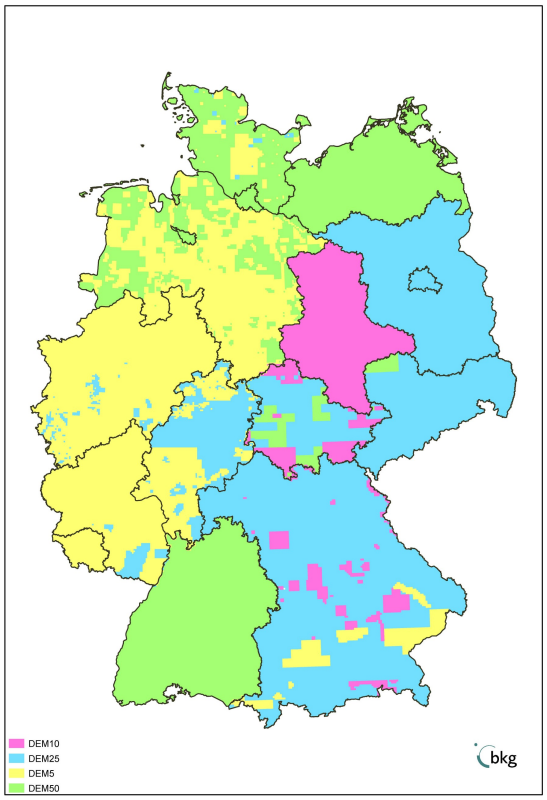

Figure 1: DEMs offered by the states

4.1 FUSION

The datasets of the states were delivered to the BKG in the years 2002 and 2003. The first task was the inspection of completeness of the datasets. The data should cover the whole area of each state, but often the states had collected height information beyond their boundaries. The next step was the transformation of the coordinates into a uniform coordinate projection and height system. Then the calculation of differences at the overlapping boundary areas was done. This is the main part of the fusion work, because these areas are covered by two or sometimes three datasets. Because of different data acquisition methods and for other reasons differences have to be expected. The methods of data acquisition are mainly :

- Laser scanning
- Photogrammetry (for example profiling or measuring contour lines)
- Digitalisation of analogue map contour lines

The datasets will be merged after inspecting and eliminating the differences. Therefore, the datasets should be calculated depending on the input data accuracy. Possible height steps in the data will be prevented using a distance-depending adaptation. Another point of the work will be the homogenisation of the datasets. The final dataset will

be covering the whole of Germany with a Universal Transverse Mercator projection (Gauß-Krüger) in the third strip (9° East) and will have a consistent grid width of 50 m.

Table 2 lists the quality and the grid width of the input datasets of the states. Because of data acquisitions being still in progress there are datasets of lower quality in the list. This data will be replaced with precise elevation data during the next year.

Quality	Accuracy	Grid width	Percentage
DEM5	±0,5 m	≈ 5-10 m	24
DEM10	±1,0 m	≈ 10-20 m	6
DEM25	±2,0 m	≈ 20-50 m	54
DEM50	±4,0 m	≈ 50 m	16

Table 2: DEM Quality delivered from the states to build up the DEM25

4.2 QUALITY CONTROL

Quality control of the incoming datasets is another task of BKG. For this inspection a method was developed (Hovenbitzer et al., 2004), which was based on the DGPS technology SAPOS. The height information is tested on site by walking or driving through the test areas. When a point is measured the survey controller of the GPS receiver calculates the difference to the DEM or DTM data in real time, so that the field staff can evaluate the correctness of the tested dataset.

5 PRACTRICAL EXPERIENCE

For varying reasons there are differences in the overlapping areas of the DEM/DTM datasets. The main causes are :

- Different dates of data acquisition
- Different methods of data acquisition
- Different grid widths of the data
- No use of morphological information for building up a DEM

Figure 2 shows a garbage dump, which was measured at two different times. The contour lines in the figure depict the ongoing dumping of waste in the north of the garbage dump. To solve this difference problem we have to cut off the older measuring points, so that the current data will appear in the final dataset.

In figure 3 great differences in a quarry are determined. The reason is again a different date of data acquisition. Because of the digging in the quarry the surface has changed between the two dates of data acquisition.

A narrow valley is shown in figure 4. The reason for the differences in this case is a different grid width of the two overlapping datasets. The raster points of the grid with the lower spacing cannot model this narrow valley correctly.

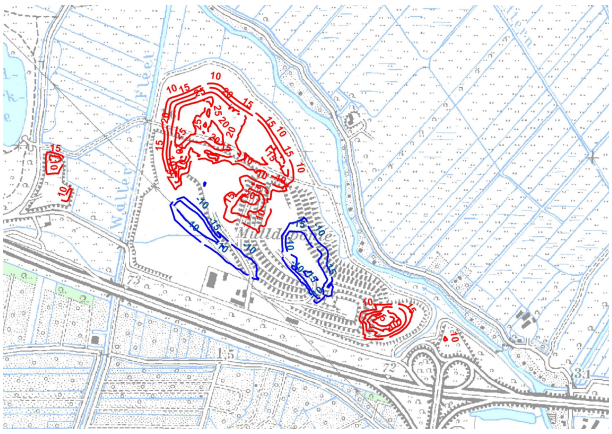

Figure 2: Contour lines of differences in an overlapping zone of two states (garbage dump)

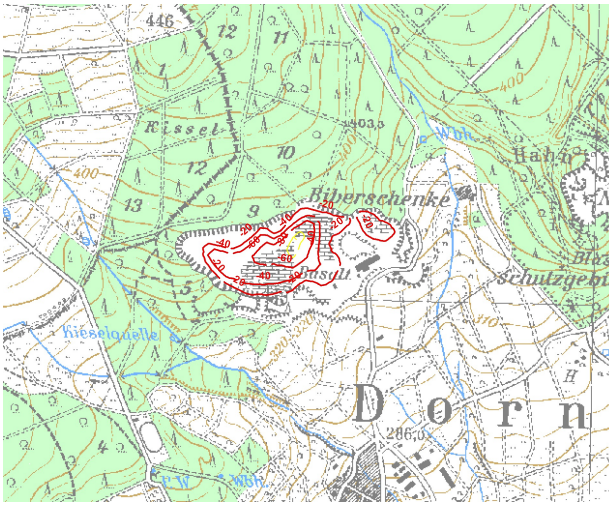

Figure 3: Contour lines of differences in an overlapping zone of two states (quarry)

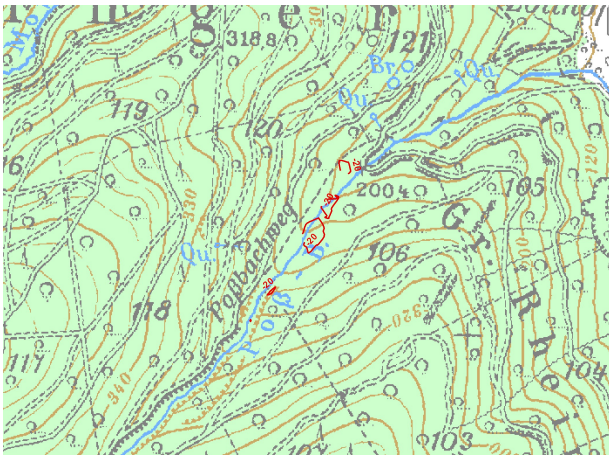

Figure 4: Contour lines of differences in an overlapping zone of two states (different grid widths)

6 CONCLUSION AND OUTLOOK

The DEM25 has to be available in the year 2004. Therefore, a first release of the DEM is terminated for the third quarter of the year. The release will solve the biggest difference problems, but because of some data acquisition still in progress there are regions with a lower accuracy than the accuracy aimed at of ± 1 to ± 3 m. Within the next years the DEM will be improved more and more, because of promised updates of the states.

For calculating flooding predictions it is planned to supplement the DEM25 with a high-resolution DEM with an accuracy of at least 0,5 m for these possible flooding regions. But for this project the specifications of the flooding areas and the accuracy needed have not been defined as yet.

REFERENCES

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