# Preparing Billions of Points for Archaeological Use

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**Abstract:** High resolution DEM data is available now for almost the whole area of Saxony. To get presentations of that raw data, like hillshades and 3D-views, over 4.6 billion points within about 5200 tiles had to be processed. While the methods are clear in theory, there were some challenges in processing large amounts of 3D-data in practice, mainly regarding processing capacity and memory.
Based on solutions with ArcGIS 10 Model Builder hillshades and ArcGIS Terrain Models were created with tolerable effort. They provide presentations without sheet divisions and support an easy generation of TIN and 3D-views. The focus of the project was rather an efficient handling of mass data then a scientific innovation. The method supports the practice of heritage protection not only for a small project region but state wide for the entire region of Saxony.

**Keywords:** archaeological base data, remote sensing, digital elevation model, heritage protection.

The surveying department of Saxony issued high resolution DEM data. The airborne laser scans of about 18 415 km² will be finished in 2011. The standard DTM "ATKIS-DGM2", a set of interpolated data with 2m-grid and an accuracy of +/- 0,2 m consists of over 4.6 billion ($10^9$) points within about 5200 tiles. In combination with raw data and primary classified data the DEMs consist of about 80 billion points. This treasure should be provided for daily archaeological use. But archaeologists don't use original DEM data; they expect a visualized presentation like hillshades or 3D-views. The raw data have to be prepared.

While the methods are clear in theory, there were some challenges in processing large amounts of 3D-data in practice. The GIS used was ArcGIS 10 (ArcEditor with 3D Extension) on an Intel Core2Duo (E4800, 3 GHz) machine with 8 GByte RAM and Windows XP. Previous projects (with ArcGIS 9) showed, that 3D processing needs considerable amounts of processing capacity and memory, some tasks needed several minutes for processing, other tasks ended with a crash. Hence the first tests were made to estimate processing time and reliability of the necessary tools.

As a result we found, that version 10 of ArcGIS is more stable in 3D processing then version 9. The creation of hillshades and other raster datasets worked with a standard DTM tile (2*2 km², 1 million points) and raw data (up to 20 million points). Only the production and visualisation of large TIN models made problems, to preserve system operability about 300 000 points shouldn't be exceeded. The processing time of single processing tools, referred to one tile, ranged from some seconds to over 30 minutes. Considering the number of over 5000 tiles, it is recommended to carefully prepare an optimised processing sequence.

Two ways proved successful as visualisation in former projects. Hillshades are easy to handle, even without GIS, and they provide a good overview and many details of the terrain. To obtain more attractive

presentations, 3D models like TINs should be used. They allow much interactive handling and sights from various viewing positions up to flight simulations. Depending on the available resources a preparation of all DEM data was not possible. So we decided to pre-process all ATKIS-DGM2 data into an ArcGIS Mosaic Dataset of hillshades and into a Terrain Dataset. Additional requirements, such as the use of higher resolution raw data or the creation of TIN at specified regions have to be met operative.

Subsequently several variations of processing queues were investigated. The tasks were designed and performed by ArcGIS Model Builder. At the end we decided in favour of 4 models:

- Model 1 creates hillshades (as TIF) from the original ASCII DEM data. Intermediate products are ArcGIS Feature Classes with the 3D information; they are preserved for further operations.
  → Whole Saxony was pre-processed (duration about 50 hours for 5000 tiles).
- Model 2 organises the hillshades in an ArcGIS Mosaic Dataset. In this way all of the individual raster datasets can be accessed en bloc (like a mosaic).
  → Whole Saxony was pre-processed (duration about 1 or 2 hours for 5000 tiles).
- Model 3 uses the Feature Classes from model 1 to create an ArcGIS Terrain Dataset. Terrain Datasets are able to save and organise large amounts of 3D data as the entire dataset of ATKIS DGM2 of Saxony.
  → Part of Saxony was pre-processed (duration about 4 hours for 500 tiles).
- Model 4 can be used to create TINs from Terrain Dataset using the current display extent. This model is not useful for large regions, so reasonable project regions (<1 km²) have to be used.
  → Tested with several project regions (duration some minutes).
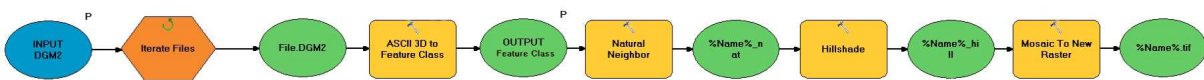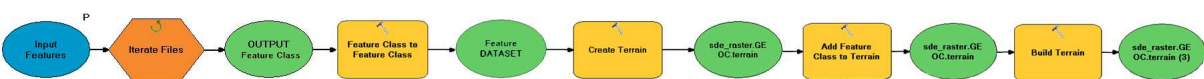


Model 1: Create Hillshades from ASCII-DEM



Model 2: Create Mosaic Dataset

Model 4: Create TIN from Terrain



Model 3: Create Terrain from Feature Classes

Final results are the Mosaic Dataset of hillshades and the Terrain Dataset, both are free of sheet divisions and easy to use within ArcGIS. The hillshades are also available as TIF images that can be accessed by a simple image viewer. Unfortunately the Mosaic Dataset cannot be presented as web map service without an extra license. The Terrain Dataset supports the easy generation of TIN and 3D-views of selected and limited regions. The attempt to export a TIN into VRML and present it with independent software didn't succeed yet. The amount of data increased to about 3 TeraByte including the processed data without temporary files.

The focus of the project was rather an efficient handling of mass data than a scientific innovation. The methods support the practice of heritage protection not only for a small project region but state wide for the entire region of Saxony.

### References

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ATKIS-DGM2. *Digital Terrain Model*. Archaeological Heritage Office of Saxony (internal data). © Staatsbetrieb Geobasisinformation und Vermessung Sachsen.
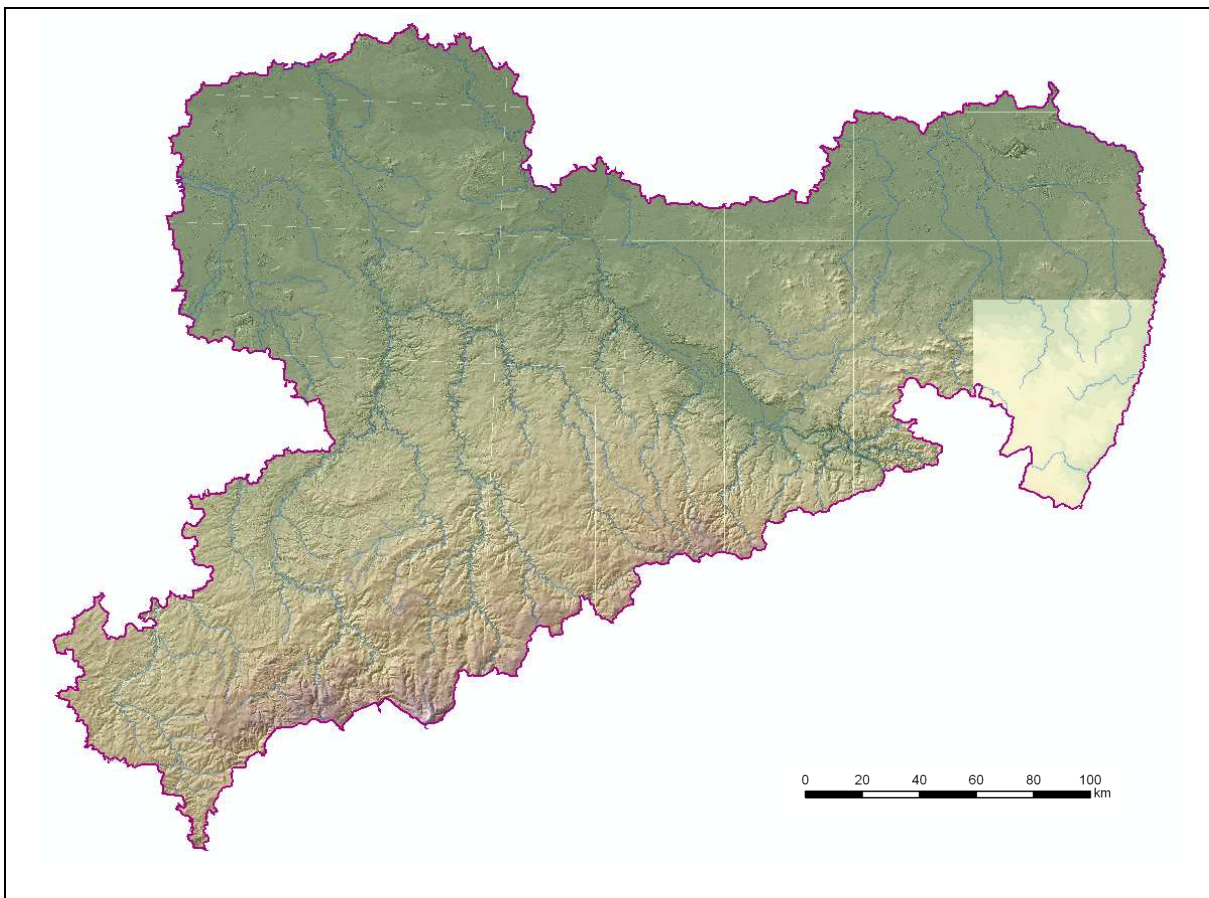
Fig. 1 – Overview of available high resolution DEM in Saxony (09/2011).
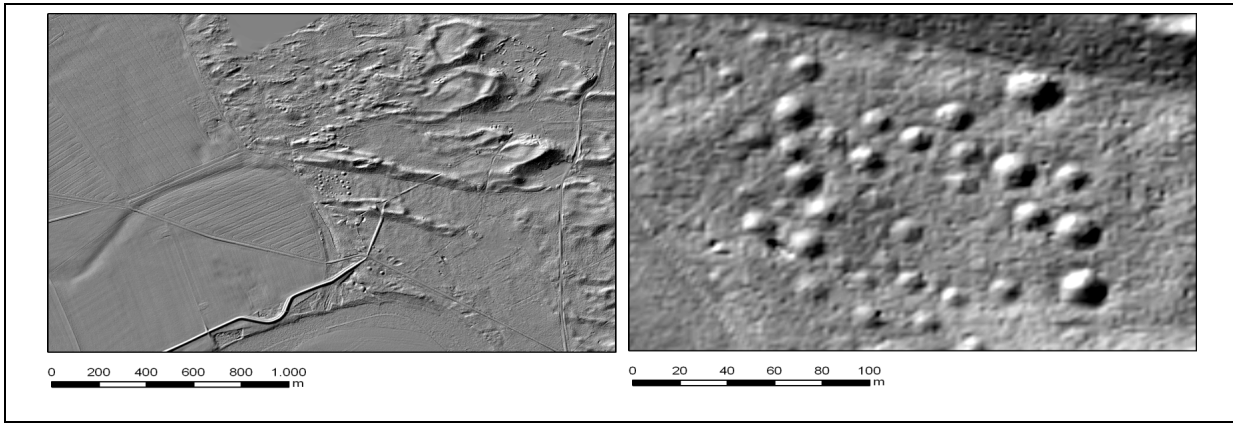
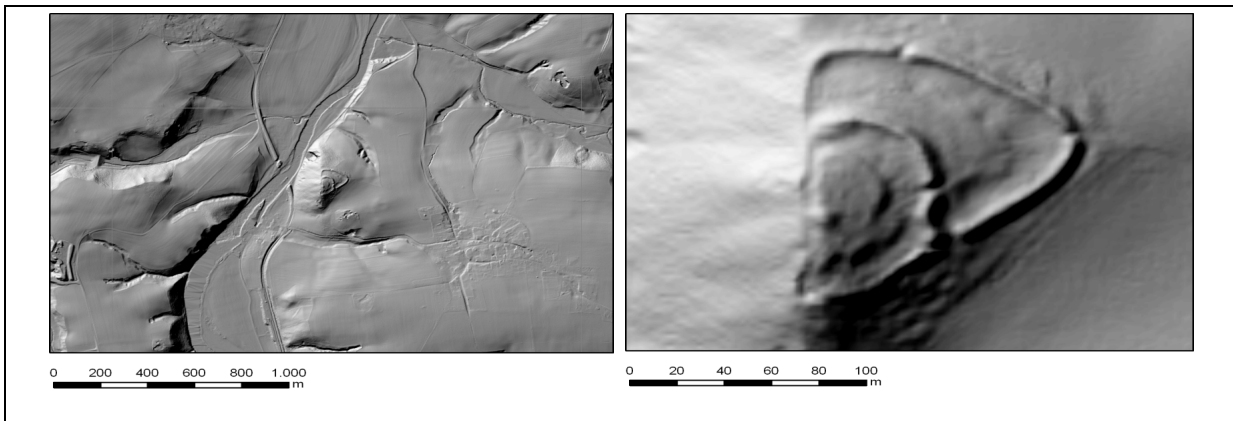Fig. 2 – Hillshades of grave mounds at Rosenfeld (situation and details).



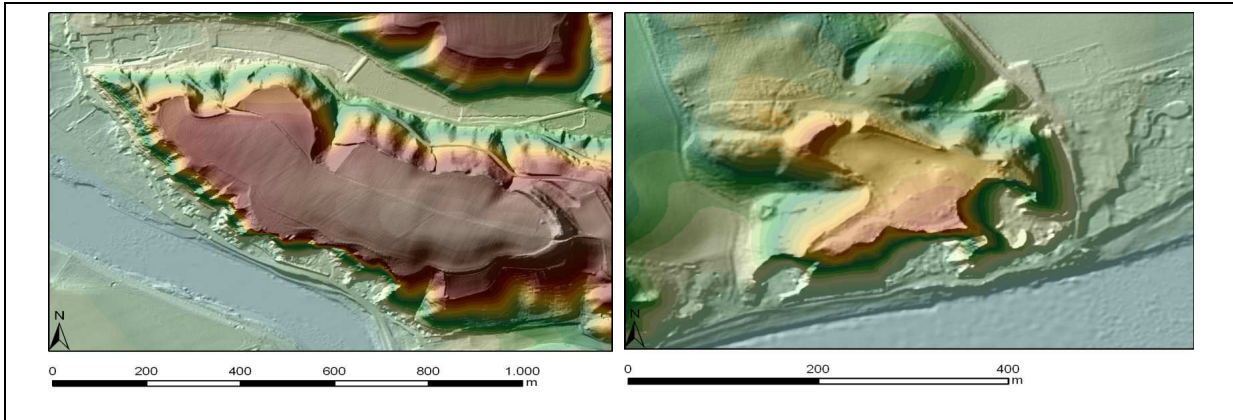Fig. 3 – Hillshades of walls at Lastau (situation and details).
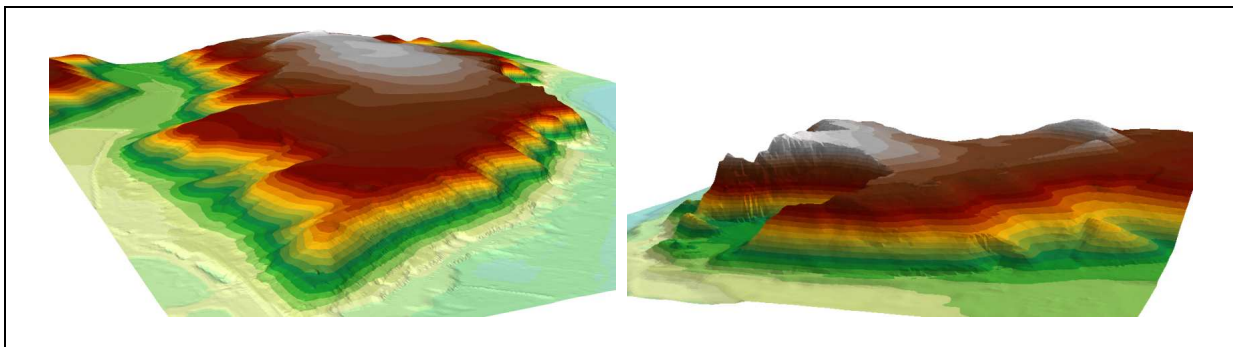


Fig. 4 – Coloured hillshades of ancient fortifications (Seußlitz, Göhrisch).



Fig. 5 – 3D-views from TIN (same regions as in fig. 4).