TERRAIN REPRESENTATION IN SMALL-SCALED MAPS

Michael Heuberger
Karel Kriz

University of Vienna, Department of Geography and Regional Research
Cartography and GIS
heubm@atlas.gis.univie.ac.at ; karel.kriz@univie.ac.at

Abstract: *There is extensive knowledge on how to represent terrain using various relief depiction methods, such as hill shading and cliff drawing in cartographic products using large-scale maps. However, the relevance and correct use of topographic information nowadays in small-scale maps does not seem to be of high priority. This information that is frequently poorly depicted in such products can be crucial for the general acceptance of a map and more often determines whether the cartographic representation is beneficial. Therefore all possibilities of terrain visualization in these scales must be considered. The correct scale dependent use of digital and/or analog terrain information such as hill shading, cliff depiction, land cover and land use, as well as availability of elevation data must be examined as well as judged from a cartographic constructive and design perspective.*

This contribution gives an overview about existing visualization methods and approaches for small-scale maps with a focus on the experience and production process during the creation of an overview map of Europe (scale 1:5 Mio.) and the topographic overview map for the Hydrological Atlas of Austria (scale 1:1 Mio.).

INTRODUCTION

A major objective of terrain representation is to give the map user a comprehensive overview of a distinct region with significant capabilities for orientation. Relief depiction serves above all to emphasize the third dimension and is frequently applied in middle and large-scale maps by using area-related depiction methods such as analytical hill shading. This representation procedure has the task of depicting the terrain by using combined graphical shadowing techniques in order to emphasize the topographic situation. In connection with labeled height points, relief depiction is a suitable way of representing terrain in the scale of 1:1 million without using isolines. The method used in the Hydrological Atlas of Austria underlies a combination of digitally adapted shadowing and slope representation techniques.

Utilizing techniques to emphasize the morphological structure of mountainous regions in small-scale maps is a challenge in cartography. Due to the fact that dominant features such as steep rock cliffs are not presentable in these scales other procedures to bypass these problems must be taken into consideration. The method of pseudo rock representation using graphical manipulation and texturing is one approach that was tested for a small-scale overview map of Europe (scale 1:5 Mio.).

In order to create a small-scale cartographic terrain representation it is essential to have sufficient information of the region that is to be depicted. In earlier days this was a tedious task that more often became an artistic defiance as opposed to a constructive approach. However many famous cartographers such as Imhof, Imfeld and Wenschow were in poses of such talents and produced outstanding examples. In the past large scale depiction of a mountainous area as shown in figure 1 of the Schneeberg region was mainly based on the interpretation of aerial photographs and isoline maps that showed the morphological situation in great detail. The “cartographic artist” then just had to amalgamate his impression and imagination using a constructive approach. The smaller the scale the more artistic the output became.

Nowadays it is feasible to make use of digital elevation data to achieve the same task, however often at the cost of design. Not always does a hill shading algorithm solve the desired problems. Depending on the quality and availability of the base data the output can differ tremendously. Due to efficient computer based operation methods digital hill shading is getting easier to use and more and more significant. The bases for such analytical hill shading methods are digital elevation models (DEM). Since these models are now globally available and in some circumstances freely accessible, the importance of relief depiction in all scales is growing.

The overview map of Europe for the terrain representation of the Alps at a scale of 1:5 million used a digital elevation model based on a resolution of 1x1 km. Furthermore, the conception of the map was to emphasize the morphological structures of the Alps using hypsometric tinting with pseudo rock depiction. The topographic overview map of the Hydrological Atlas of Austria at a scale of 1:1 million utilized a digital elevation model with the resolution of 250x250 meters. The main objectives of the topographic overview map were to offer both a profound topographic and a morphologic overview of Austria to the interested hydrological user.

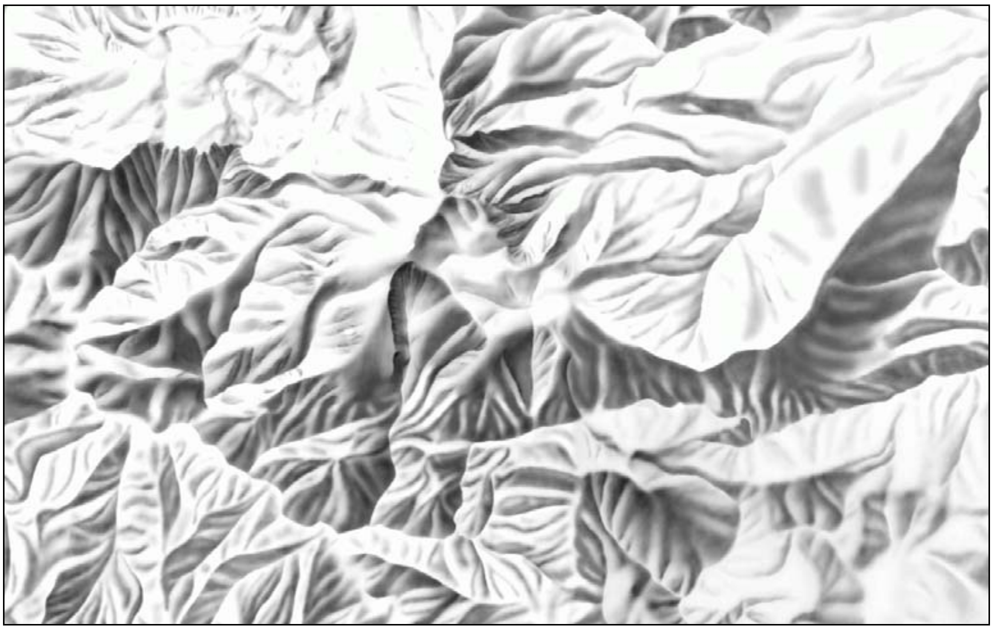

Figure 1: Relief shading of the Schneeberg Region (reduced)

AVAILABLE DATA

Since high resolution global digital elevation data can be nowadays downloaded from the Internet at affordable costs various kinds of terrain representations in all scales are experiencing a tremendous upturn. But free availability does not always coincide with high cartographic quality. Not only can the data be inconsistent or inaccurate, but in many cases the methods of production can also be very coarse or inadequate. Results are often of low quality and the cartographic output is inefficient to communicate terrain information.

The following link is a useful starting point for available digital elevation data in the Internet:
http://edc.usgs.gov/products/elevation.html

The following digital elevation models were used to some extent for both examples described in this paper:

SRTM
The Shuttle Radar Topography Mission (SRTM) is a joint project between the National Geospatial-Intelligence Agency (NGA) and the National Aeronautics and Space Administration (NASA). The objective of this project is to produce digital topographic data for 80% of the Earth's land surface (all land areas between 60° north and 56° south latitude), with data points located either every 1-arc second (approximately 30 meters) or 3-arc second (90 meter) on a latitude/longitude grid. The absolute vertical accuracy of the elevation data will be 16 meters (at 90% confidence).
http://srtm.usgs.gov/

ASTER
Another high resolution elevation dataset is the collection of the Advanced Spaceborne Thermal Emission and Reflection Radiometer called ASTER which is carried on the Terra satellite of the NASA. The resolution is up to 25meters. ASTER data is also free, but has to be ordered. Ordered tiles are about 25 MB file size and cover an area of 60 km x 60 km. The resolution of the image is 30 meters and has a dimension of 2500x2500 pixels.
http://edcdaac.usgs.gov/aster/ast14dem.asp

GTOPO30
Global 30 Arc-Second Elevation Data Set (GTOPO30) is a global raster Digital Elevation Model (DEM) with a horizontal grid spacing of 30 arc seconds (approximately 1 kilometer). The resolution of data is about 1km near the equator, and about 650 meters in alpine areas. GTOPO30 was derived from a variety of raster and vector sources. The data is expressed in geographic coordinates (latitude/longitude) and is referenced to the World Geodetic Survey (WGS) system of 1984 (WGS84). The files are available in generic binary (16-bit signed integer) format and are distributed on DVD and File Transfer Protocol (FTP).
http://edc.usgs.gov/products/elevation/gtopo30/gtopo30.html

METHODS OF PRODUCTION OF DIGITAL SHADED RELIEF

In order to produce cartographic terrain representation efficiently it is important to understand the methods of production that utilize digital elevation data. There are many ways to produce digital shaded relief. One approach is shown in figure 2 that explains the workflow of how both examples in this paper were produced.

Starting with available digital elevation data it is at first important to choose the correct resolution for the given scale. As a rule of thumb the ratio [(map scale / 4) m] can be assumed - The result for a map scale of 1:1 million =

250m and for 1:5 million = 1.250m. The next step includes the adoption of the raw data utilizing a Geographic Information System (GIS). This step includes the preparation of the data, data analysis and creation of exchangeable data formats for further processing. Due to the fact that small scale maps do not need high vertical accuracy it is sufficient enough to produce an 8-bit DEM (256 grayscale image). This is practical and easier to handle for further image manipulation. If the refined elevation data is to be manipulated with special functionalities it must be transformed to fit the image processing methods. These can incorporate various procedures such as degradation, color conversion and filter effects. Besides these issues basic hill shading actions such as northwest illumination or slope coloring effects can be produced.

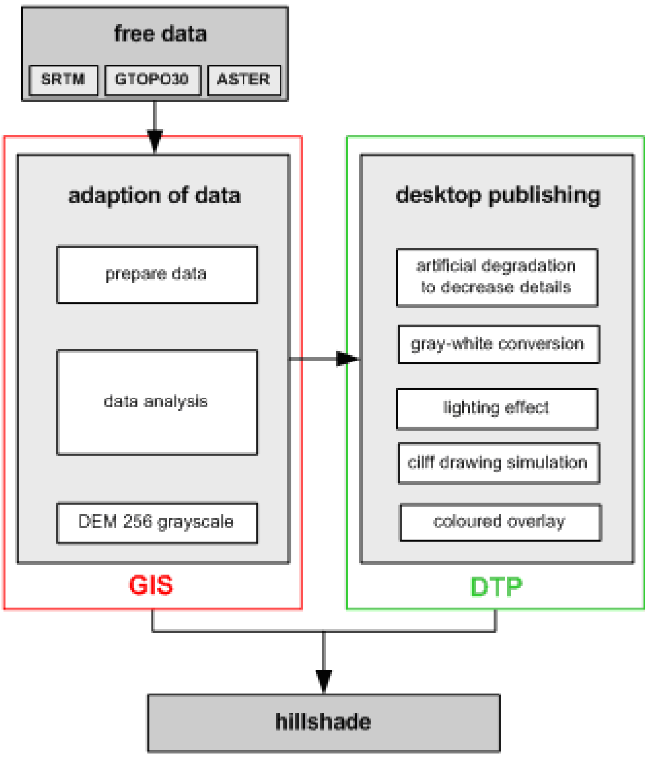

Figure 2: Hill shading process using digital elevation data

OVERVIEW MAP OF EUROPE (scale 1:5 Mio.)

The overview map of Europe in a scale of 1:5 million takes advantage of the method of pseudo rock representation. This approach utilizes graphical manipulation and texturing techniques. The digital elevation data used for this map was derived from free available GTOPO30 data. The elevation data was extracted from three tiles, imported into a GIS, georeferenced and converted into an 8-bit grayscale TIFF image. In order to achieve the pseudo rock representation three graphical manipulation and texturing steps had to be undertaken: hill shade creation – pseudo cliff drawing – hypsometric tinting.

At first a grayscale image was produced utilizing northwest shadowing (hill shading) and degradation. The manipulated hill shading image was then blurred. Thereafter level and filter options were applied in order to down sample the sharpness. The goal was to produce a very simplified smooth terrain representation. The process of pseudo cliff drawing uses a gamma adjusted copy of the simplified smooth terrain representation that emphasizes steep areas. The dark areas in the result resemble rock and give the image an overall impression of a generalized "pseudo" cliff drawing. Finally to polish up the image hypsometric tinting was applied. This supports the map reader to conceive the third dimension more easily and understand the morphological structure of the region in a better way.

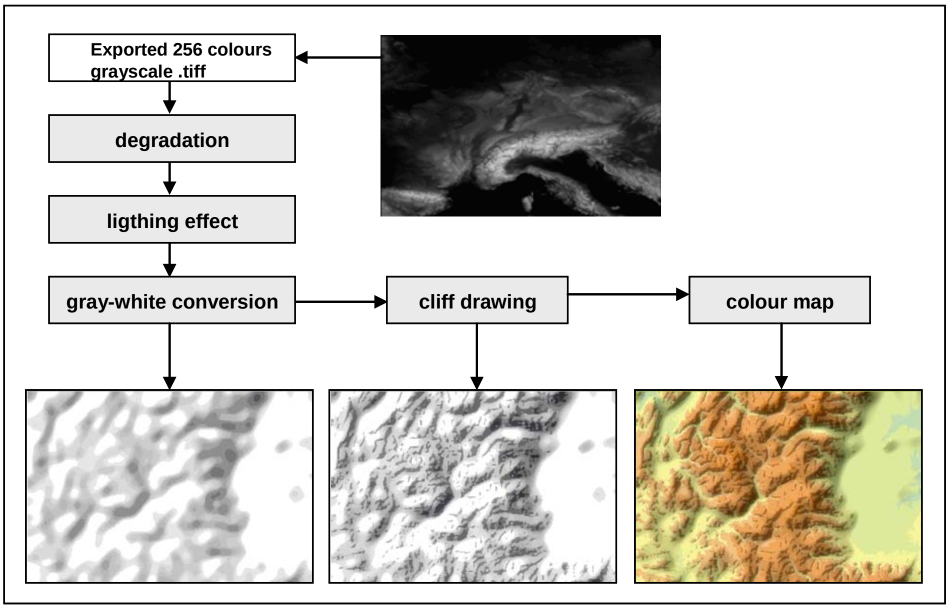

Figure 3: Method of pseudo rock representation using graphical manipulation and texturing

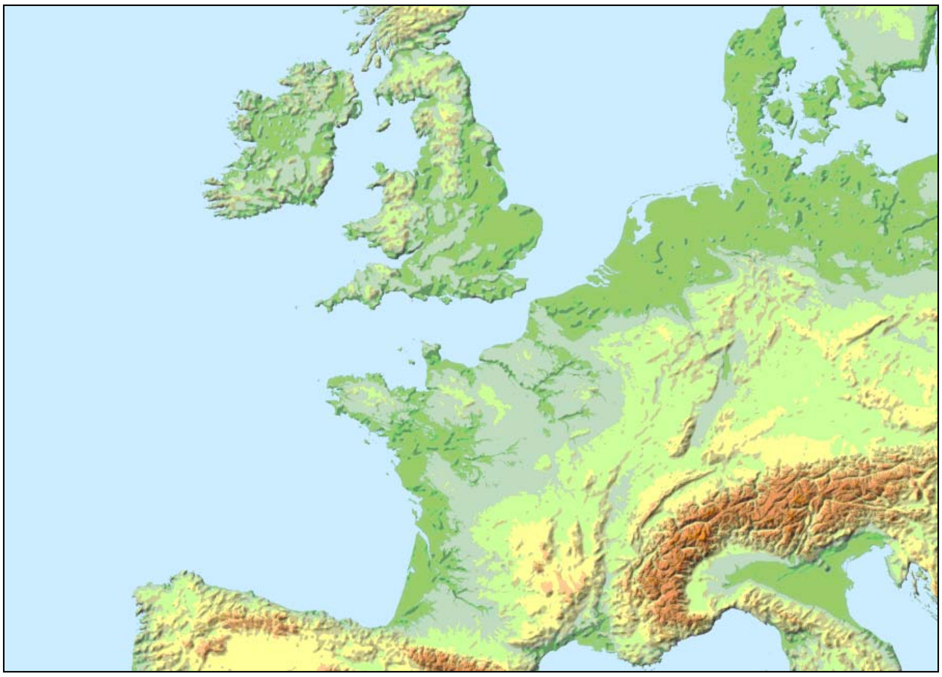

Figure 4: Section of the overview map of Europe 1:5 Mio (reduced)

TOPOGRAPHIC OVERVIEW MAP OF HYDROLOGICAL ATLAS OF AUSTRIA (scale 1:1 Mio.)

The Hydrological Atlas of Austria (HAA) is a collection of thematic maps containing hydrologic information in the scale of 1:1 million and 1:2 million. Special emphasis was given to the visualization as well as to the distinction of the manifold topographic objects and their designation for hydrologic utilization.

Cartographic object selection for the general topographic map was primarily done according to hydrological-geographical aspects. The most important objective therefore, was to highlight water, the atlas' main theme, in every map including the topographic overview map. For all objects, simplification and scale dependent processing were necessary. This required content related selection as well as graphical generalization in order to emphasize the thematic and cartographic elements in the map. Such accompanying measures allow readability and rapid identification of essential features.

Above all relief depiction serves to emphasize the third dimension and is very frequently applied in middle- and large-scale maps by using area-related depiction methods such as analytical hill shading. This representation procedure has the task to illustrate terrain by using combined graphical shadowing techniques in order to emphasize topography. In connection with labelled spot heights, relief depiction is a suitable method of representing terrain in a scale of 1:1 million without using isolines. The relief depiction, as used in the atlas, is a combination of digitally adapted shadowing and slope representation techniques and was then manipulated and optimized by an image-processing program.

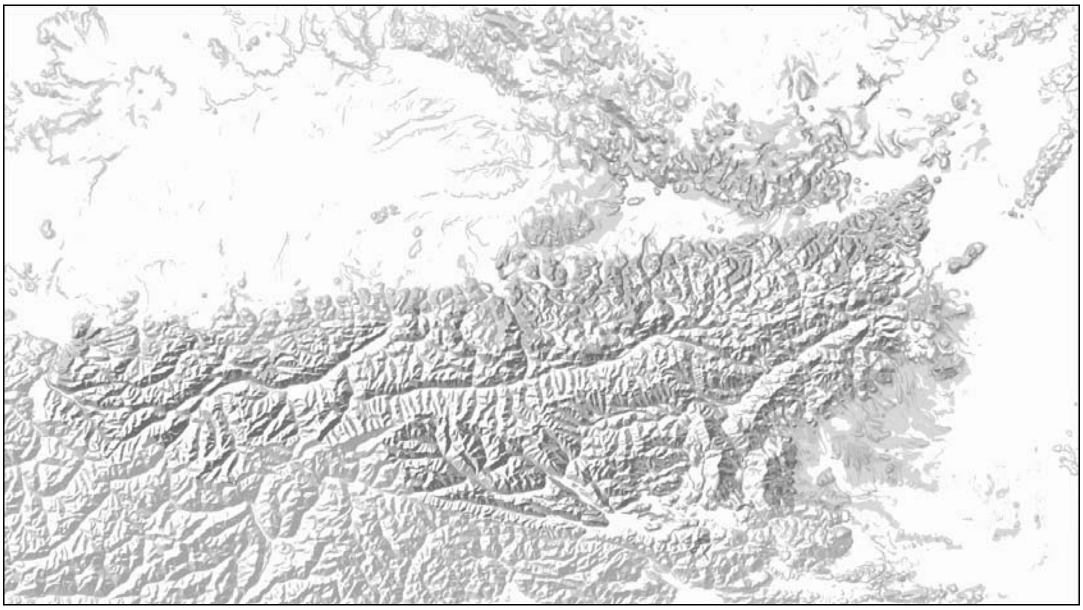

Figure 5: Hill shading of the Hydrological Atlas of Austria (reduced)

Figure 6: Section of the topographic overview map of the Hydrological Atlas of Austria (reduced)

CONCLUSION

Terrain representations in smaller scales are becoming an important issue in cartography, especially when mountainous regions are involved and more over when the cost of production is affordable. Furthermore, the use of global accessible elevation data is essential as both examples illustrate. Finally, the significance of aesthetics, readability and spatial orientation is fundamental to assist the map reader to understand the correlation between topographic as well as geographic information in a holistic way.

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Biography of Authors

Mag. Michael M. Heuberger
University of Vienna, Department of Geography and Regional Research
Cartography and GIS
Universitaetstr. 7, A-1010 Wien, AUSTRIA
Phone: (+43 1) 4277 48659 Fax: (+43 1) 4277 48649
E-mail: heubm@atlas.gis.univie.ac.at
AUSTRIA

Michael Heuberger was a staff member of the Institute of Hydrology and was involved with the production of the Hydrological Atlas of Austria for three years. His current area of interest is using GPS for data collection. Since December 2005 he is employed at the Department of Geography and Regional Research, Cartography and GIS.

Ass. Prof. Dr. Mag. Karel KRIZ
University of Vienna, Department of Geography and Regional Research
Universitätsstraße 7
1010 Vienna
Austria
Tel: +43 (1) 4277 48641 Fax: +43 (1) 4277 48649
karel.kriz@univie.ac.at
AUSTRIA

Karel Kriz, born 1962, studied geography and cartography at the University of Vienna and graduated in 1989. For 3 years he worked in the fields of digital cartography, GIS and computer science developing various scientific and commercial applications. Since 1992 he is an Assistant Professor at the Department of Geography and Regional Science at the Department of Geography and Regional Research. In 1994 he completed his PhD on the topic of "Requirements on Digital Cartographic Systems". His major areas of interest lie in web-based cartography, GIS and thematic aspects of mountain cartography.