MAPS ON VIRTUAL GLOBES FOR GEOGRAPHIC EDUCATION: APPROACHES AND IMPLEMENTATION IN THE "SWISS WORLD ATLAS INTERACTIVE"

Philipp Marty
marty@karto.baug.ethz.ch

Juliane Cron
cron@karto.baug.ethz.ch

Hans Rudolf Bär
baer@karto.baug.ethz.ch

Christian Häberling
haeberling@karto.baug.ethz.ch

Lorenz Hurni
hurni@karto.baug.ethz.ch

Institute of Cartography, ETH Zurich
8093 Zurich, Switzerland

Abstract

Teachers and students at the secondary school level have need of maps on virtual globes as there are several advantages in comparison to planar 2D maps. It is important that these maps complement the curriculum of geographic education. However, existing globe applications (e.g. Google Earth) are not exactly suited for teaching purposes. This paper dwells on the reasons and discusses how to close the gap by creating thematic and topographic maps for a virtual globe application which are most appropriate for education and follow the necessary cartographic principles. Besides the preparation and display of the map tiles, the focus lies on an appropriate placement of map labels that considers the dynamic projection of virtual globes. The presented ideas originated from the ongoing development of a new digital school atlas, the "SWISS WORLD ATLAS interactive".

1 Virtual Globes as Teaching Aids

In recent years, virtual globes such as Google Earth, NASA World Wind, or Microsoft Virtual Earth have become very popular and have greatly attracted public interest. They are attractive, versatile, easy to operate and the usage is mostly free of charge. It is obvious to use these globe applications also for geographic education at the secondary school level since virtual globes offer several advantages compared to planar 2D maps in current printed school atlases. These advantages include the unlimited spatial navigation, assistance in visual thinking and new not necessarily north-oriented views. In contrast to a planar map, a globe is representing the three-dimensional shape of the original without distortion (Riedl 2000).

Virtual globes, especially Google Earth, have been suggested as teaching aids (Schultz et al. 2008, Green and Mouatt 2008) and undoubtedly, they should be part of certain geography lessons. However, Google Earth, NASA World Wind and Microsoft Virtual Earth are not always well suited for general teaching purposes, because they do not meet the specific demands of a curriculum. According to Weber et al. (n.d.), the following problems can be identified:

- Teachers prefer ready-to-use maps that complement the curriculum. They usually do not have the time to search data nor the skills to compose custom maps that are easy and unambiguous to read.
- Google Earth as well as most other virtual globes are not atlases with a predefined collection of cartographic maps. Every user can contribute spatial data. This may lead to interesting representations (figure 1 left), but these are often not appropriately generalized and symbolized or have little attractive design. Furthermore, the completeness, accuracy, and reliability of user-generated data are frequently undocumented. According to that, such overlays can be rather difficult to read for students and other novice map users.
- A lot of the functionality in virtual globes is not required for teaching, and can be deflecting or confusing to students.
- It seems that virtual globes, and especially Google Earth, are mostly viewed at a large scale, where its aerial images and 3D renderings of the digital elevation model are most impressive. There are relatively few worldwide overlay maps available that are sufficiently generalized showing a synthesis of a global phenomenon (figure 1 right). Indeed, it seems that most users see the globe as a navigation tool that allows them to quickly plunge into detailed aerial images (Schöning et al. 2008).

It is not the main goal of common virtual globes to be well suited for school use. They aim at other purposes such as advertising revenues or the development of business applications including their license business (Rech 2008, Schweikart et al. 2009). However digital globes find their ways into geographic education (Allaway et al. 2006). It can be expected, that the usage and the influence of virtual globes will still increase. Part of this tendency is the fact, that certain printed school atlases, such as Diercke Weltatlas (Diercke 2008), have already been published with its own virtual globes.

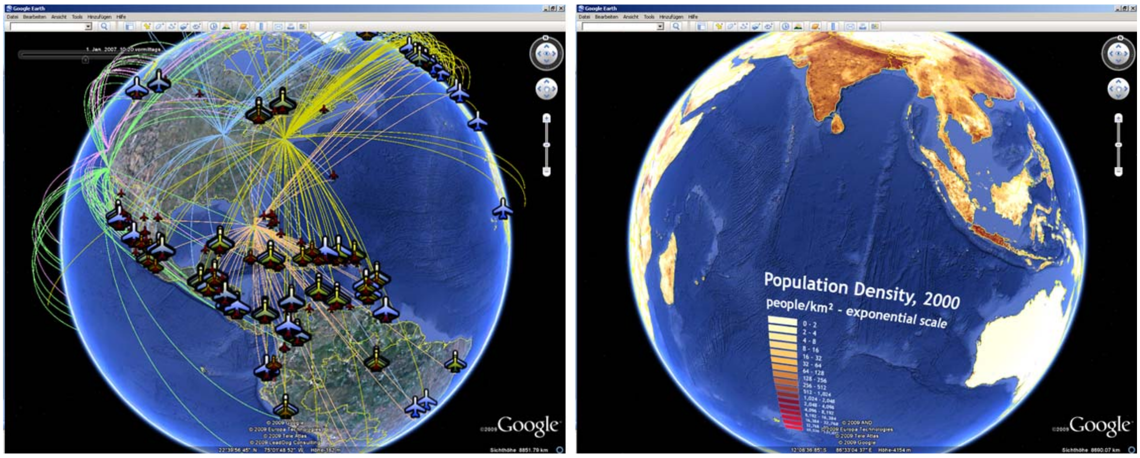

Figure 1. Thematic overlays for Google Earth (Google Earth 2009).
Left: International Flights Animation.
Right: World Population Density.

2 Cartographic Maps on Virtual Globes

2.1 Orientation to Teaching Purposes

Until now, only a few globe applications use topographic or thematic maps instead of aerial images for the surface texture. However, especially these map textures would be interesting in globes for teaching purposes. Such virtual globes are supposed to complement existing printed school atlases and to enhance the attractiveness of working with maps.

This paper intends to raise the usability of virtual globes at the secondary school level by replacing aerial images with thematic and topographic maps for teaching purposes. To further promote and establish the use of virtual globes at schools it is indispensible to provide a number of convincing map examples. Therefore, this paper also discusses methods to improve the readability and cartographic appearance of the maps.

2.2 Enhancing the SWISS WORLD ATLAS with a Virtual Globe

The below mentioned implementation of a virtual globe is part of the "SWISS WORLD ATLAS interactive", a web-based school atlas, which will complement the already existing printed atlas version (SWISS WORLD ATLAS 2008). Besides globes, the new digital atlas will also include block diagrams and planar 2D maps.

Using the open source NASA World Wind Java library, the authors developed an application to integrate cartographic maps in a virtual globe and extended it by an adaptive and easy to read label placement. NASA World Wind is a free, open source virtual globe that is developed by NASA and an open source community (NASA 2008).

The functionality and the data overlays are very similar to Google Earth. It is a useful base for the development of a customized globe.

2.3 Preparation and Display of Map Tiles

Several working steps have to be done to integrate own maps into World Winds' virtual globe application. In our case, the original map data consists of different Freehand and DGN files, optimized for printing of a given map scale. First of all, the vector and raster data has to be transformed to an equirectangular projection (plate carrée). Then the data is symbolized and optimized for screen displays. Afterwards, the map is rasterized with different resolutions and divided in quadratic tiles. The naming scheme and directory structure for the raster tiles have to follow strictly the specifications of the virtual globe software.

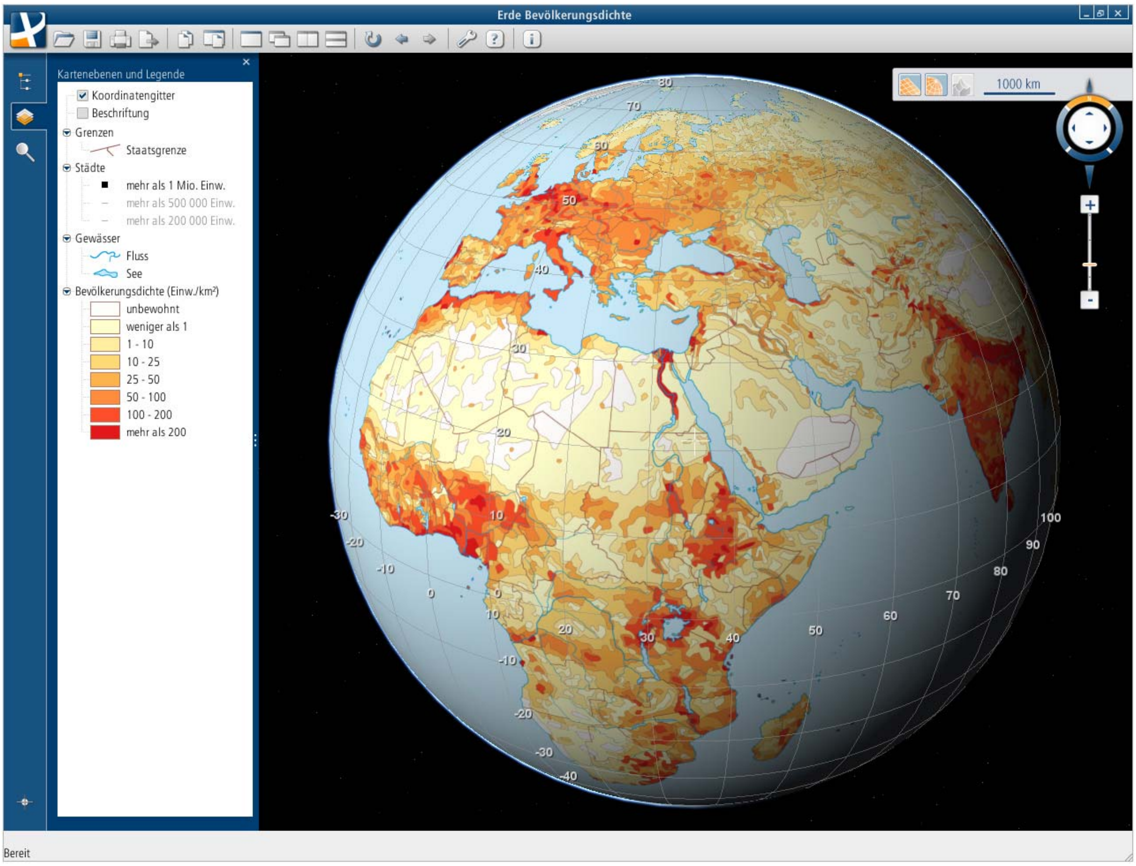

Figure 2. The virtual globe of the "SWISS WORLD ATLS interactive", textured with a thematic map about the worldwide population density.

The World Wind library performs the mapping of the raster tiles on the virtual globe. Figure 2 shows a screenshot of the resulting globe with a worldwide map about the population density, embedded in the graphical user interface of the "SWISS WORLD

ATLAS interactive”. Different map resolutions are used, depending on the scaling of the globe. This enables a fast download of the tiles and an optimal display. Since maps are originally designed for a given scale, the zooming range must be limited. This range can be extended if there are additional maps with the same thematic content but with different degrees of generalization.

2.4 Placement of Map Labels

Map labels are handled separately since they would only be readable partly when projected on a sphere. The current implementation of World Wind treats every label as an attribute of a coordinate pair, with its position at the centre of the related feature. The coordinates including their label attributes must be written to an XML file which can be read by the globe application.

Figure 3. Label classes for different zoom levels on the virtual globe of the “SWISS WORLD ATLS interactive” (textured with a thematic map about the worldwide landcover).

The implemented labeling approach is placing and keeping the names always horizontally and slightly hovering above the raster tiles. It supports different label positions which are kept when rotating, tilting the view or zooming in and out. World Winds’ default label position is on top of an anchor point, which is partly suitable for area features and line features. For the labeling of point features (symbols) and small area features (e.g. islands), the authors enhanced the World Wind code with further possible label positions: top right, bottom right, top left or bottom left. Furthermore, different scale ranges can be specified at which certain label classes will be shown. This guarantees an optimal density and readability of labels at any map scale. For this purpose, all the labels had to be grouped from a cartographic point of view, with the result that superior label classes will be shown earlier (figure 3 left) than minor ones when zooming in (figure 3 right).

2.5 Challenges and Alternative Approaches

The high-performance display of the map tiles on the virtual globe is promising. The raster tiles keep their graphical quality especially at the equator and in the mid-latitudes of the globe (figure 4 left). However, the quality is noticeably decreasing poleward due to the increasing lateral compression of the tiles. This leads to unpleasant artifacts like distortions of stroke widths (figure 4 right). When mapped from a plate carrée, meridians near the poles are rendered invisibly thin, growing to their full size when entering the equator region. One idea is to compensate this distortion during line rasterization by scaling the pen according to Tissot's indicatrix. The stroke width then is no longer constant but a function of line direction and latitude. Another approach would consider other intermediate projections than the currently used plate carrée. Instead of square map tiles for instance, trapezoidal-shaped map tiles will then be used to render the virtual globe. A third alternative to avoid distortions of stroke widths would be the usage of KML files, at least for linear features (e.g. coastline). The authors have not integrated KML so far, due to performance reduction, especially when using complex geometries.

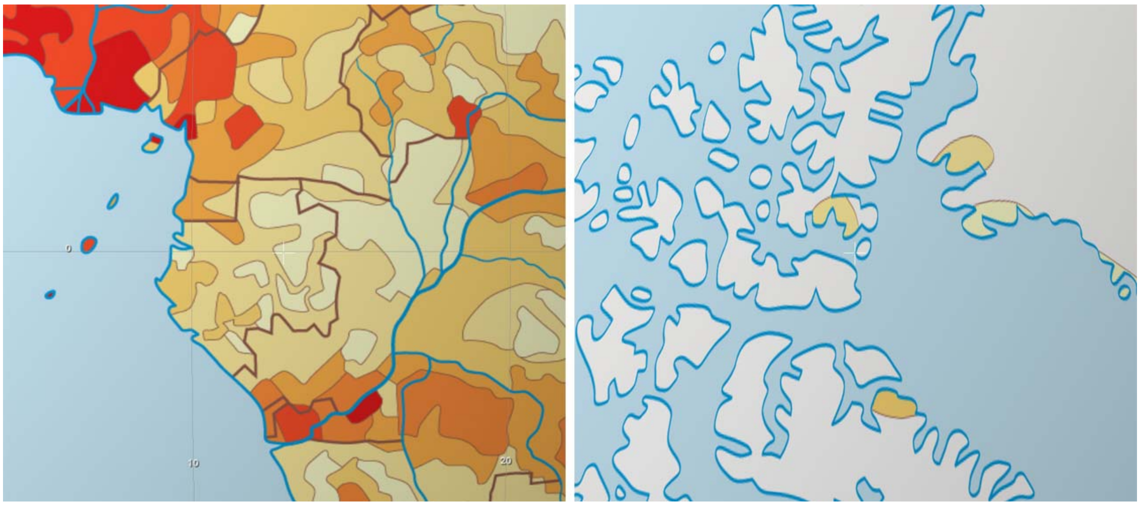

Figure 4. Zoomed map sections on the globe of the “SWISS WORLD ATLS interactive” (textured with a thematic map about the worldwide population density).
Left: Good quality at the equator.
Right: Increasing distortions of stroke widths poleward.

The current implementation for labeling achieves easy to read maps in most cases. The method is especially suited for the labeling of point features and rather roundish area features (e.g. “Mato-Grosso” in figure 5 left). It is less suited for line features and rather elongated area features (e.g. “Anden” in figure 5 left). In the latter cases, the proposed horizontal label placement does not always meet the cartographically postulated labeling along the direction of the feature (e.g. “Kordilleren oder Anden” in figure 5 right). In the future, an additional approach will consider labels along any desired path.

Figure 5. Sections of a thematic map about the worldwide landcover.
Left: Horizontal label placement on the virtual globe.
Right: Labeling along the direction of line features and rather elongated area features on the 2D map.

3 Conclusion and Outlook

The presented approaches and implementations were realized within the ongoing development of a new digital school atlas, the “SWISS WORLD ATLAS interactive”. The integration of thematic and topographic maps for teaching purpose on a virtual globe and the enhancement with an adaptive labeling that considers cartographic aspects is promising and is expected to meet the demands of the curricula in geographic education. In the near future the usability and the acceptance of maps on the virtual globe will be evaluated by different user groups. Simultaneously, the authors will proceed with further improvements of cartographic contents on virtual globes.

References

Allaway, R., Hong, C., Jin, D. (2006): Using Google Earth. In: Teaching Geography. 10/2006, S. 110-111.

Diercke; Bildungshaus Schulbuchverlage (2008): Diercke Weltatlas. Westermann Schroedel Diesterweg Schöningh Winklers GmbH. Braunschweig.

Google Earth (2009): Google Earth. http://earth.google.com/ (accessed 1st july 2009).

Green, D. R., Mouatt, J. (2008): The digital globe – Using Google Earth for virtual fieldtrips of coastal environments. In: Digital Geography: Geospatial Technologies in the Social Studies Classroom, ed. by Milson, A. J. and Alibrandi, M., p. 147–165, Information Age Publishing, Charlotte, U.S.

NASA (2009): NASA World Wind. http://worldwind.arc.nasa.gov/ (accessed 1st july 2009).

Rech, A. (2008): Der Horizont ist offen. In: GIS-Business 2/2008, S. 6-7.

Riedl, A. (2000): Virtuelle Globen in der Geovisualisierung. In: Kretschmer, I. & Kriz, K. (Hrsg.): Wiener Schriften zur Geographie und Kartographie, Band 13, Wien 2000.

Schöning, J., Hecht, B., Raubal, M., Krüger, A., Marsh, M., Rohs, M. (2008): Improving interaction with virtual globes through spatial thinking: helping users ask “why?”. In: Proceedings of the 13th International Conference on Intelligent User Interfaces IUI 08, Gran Canaria, Spain, January 13–16, 2008. ACM, New York, p. 129–138.

Schultz, R. B., Kerski, J.J., Patterson, T. C. (2008): The use of virtual globes as a spatial teaching tool with suggestions for metadata standards. In: Journal of Geography, 107(1), p. 27-34.

Schweikart J., Pieper J., Schulte B. (2009): Virtuelle Globen: Entwicklungsgeschichte und Perspektiven. In: Kartographische Nachrichten 3/2009, S. 129-136.

Swiss World Atlas; Schweizerische Konferenz kantonaler Erziehungsdirektoren EDK (Publ.) (2008): Schweizer Weltatlas – Atlas Mondial Suisse – Atlante Mondiale Svizzero. Lehrmittelverlag des Kantons Zürich. Zurich.

Weber, A., Jenny, B., Wanner, M., Cron, J., Marty, P., Hurni, L. (n.d.): Cartography meets gaming: navigating globes, block diagrams and 2D maps with gamepads and joysticks. In: The Cartographic Journal [accepted for publication].