

# Thematic Maps on Virtual Globes

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**Abstract.** With the emerge of virtual globes several new visualization methods appeared, taking advance of the possibilities of this new media. Just like it happened in web-mapping, where thousands of ugly new „maps” was born without any consideration of the traditional cartographic design criteria, everybody started to fill Google Earth with prism maps, graduated 3D symbols and animations with sometimes questionable results.

This paper tries to summarize the types of thematic maps on virtual globes, the possible software solutions and to give some hints about cases when such a visualisation is desirable as well as those when it should be avoided.

**Keywords:** Virtual Globes, Thematic Maps, Visualization

## 1. Introduction

Virtual globes offer several possibilities for geographic visualization. As nowadays it is very easy to assemble such “thematic maps”, the Internet is full with these kind of artefacts and it is obvious that their creators often lack of any previous cartographic knowledge.

Although there are several occasions when these visualizations are really useful, the presence of very poor solutions leded to strong critical voices, even suggesting that there is no need of such thematic maps on virtual globes at all (e.g. Harrower 2009).

The author’s opinion is, however, that there are several pros and contras of putting our thematic maps to virtual globes, and it is advisable to take everything into account before taking sides.

First of all it is important to clarify the aims of thematic maps. These maps always represent the spatial (and sometimes temporal) distribution of value(s) or objects. Their main usage is to help quickly understanding spatial aspects and relations of various phenomena, therefore maybe their most

important aim is to give an overview impression at a glance, while making it possible to examine the details or, according to Cuff and Mattson (1982), „the concern is for a sound presentation of the essence of some distribution”.

Another important aspect is attractiveness. There is a huge amount of information reaching people every day and if the presentation of a message is not enough „eye-catching“, it may remain invisible.

What are the limits of flat maps compared to globes? They have edges – they aren’t capable of showing connection stretching over the edges. Although one may say that when examining globes, only one hemisphere is visible at one time, but as we can change the viewing position (or turn the globe around), it is not really a problem.

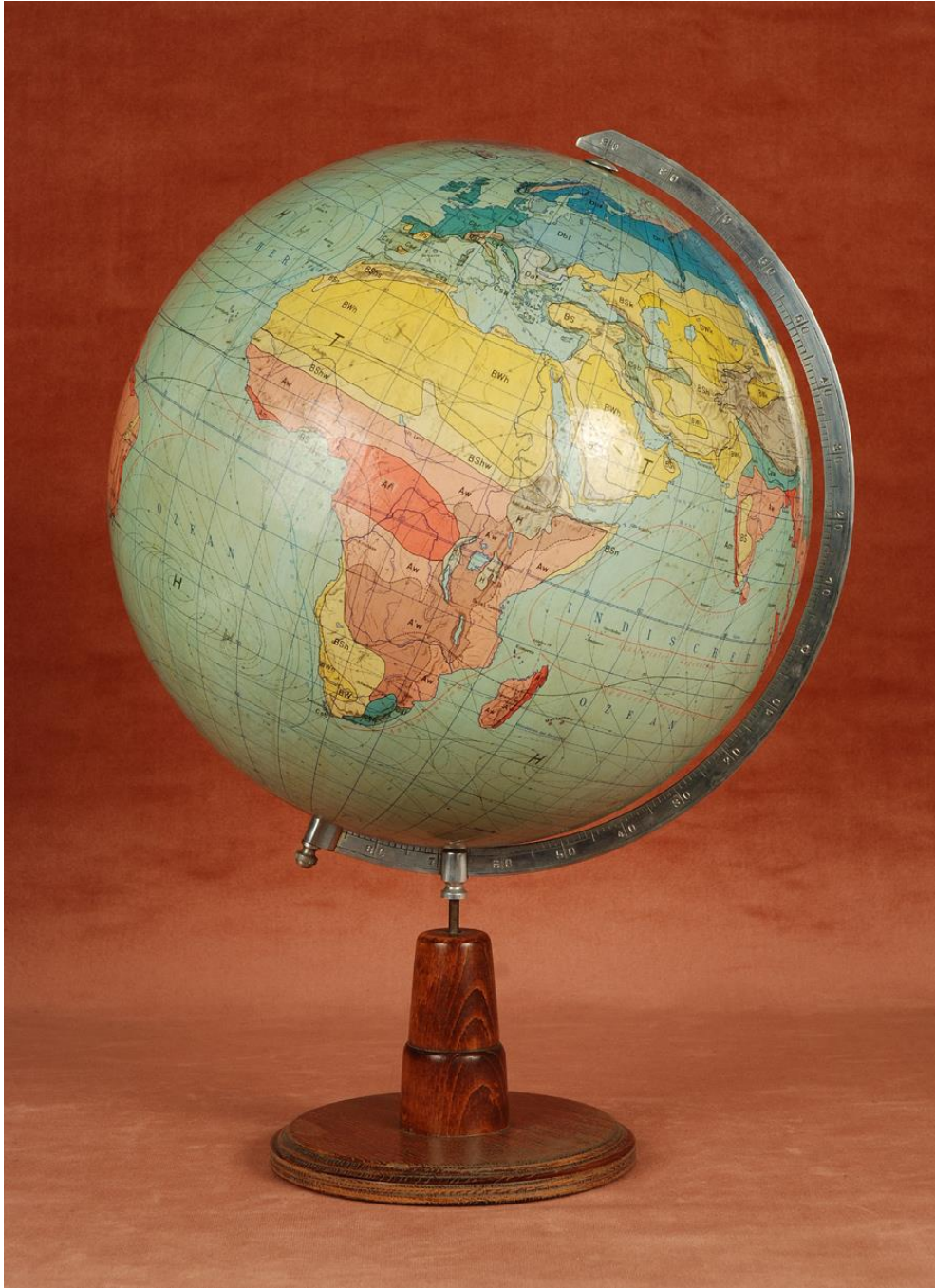
The big advantage of (even traditional) globes and other 3D visualizations is their attractivity. And even if there are some problems with the solutions applied, it is still better to have an imperfect map viewed by many people than a masterpiece that remains unnoticed in the plethora of information.

The following sections show various thematic visualization methods for globes, also mentioning the most important pros and cons of them.

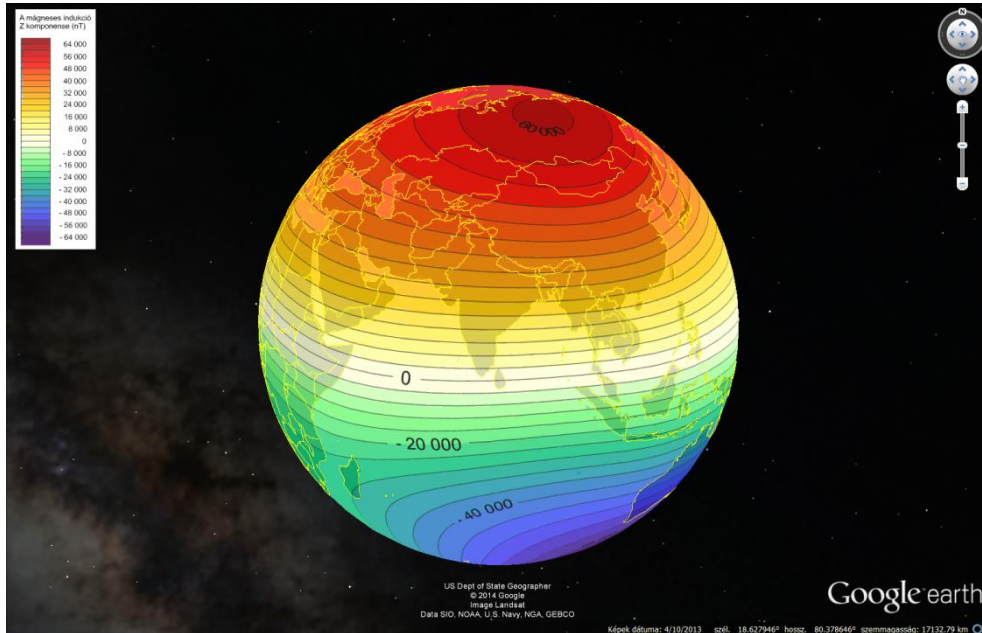
## **2. Traditional thematic visualizations on globes**

An obvious solution of displaying thematic maps on globes is to design a traditional thematic map to the spherical surface. This is not a new idea: there are several examples of such thematic globes such as the Klima-Globus of Georg Jensch (Jensch 1970, *Figure 1*). The only problem is the map legend: on flat maps there is always some place for the legend outside the map while in the case of the globe the legend will hide the map content (usually somewhere in the middle of the Pacific Ocean) or it has to be a separate object – e.g. a booklet for traditional globes or a hideable screen overlay for virtual globes (*Figure 2*).

As in this solution the map is still a static, 2D image (only not in the Euclidean plane), any kind of traditional thematic visualization methods (e.g. isolines, choropleths, dot densities) can be used, even combined.



**Figure 1.** The Klima-Globus of Georg Jensch (image from the Virtual Globes Museum, <http://vgm.elte.hu>)



**Figure 2.** Map of geomagnetic induction in Google Earth with legend as a screen overlay (from Balázs 2013)

A special case of thematic globes is a dismountable structural-morphological earth model made in Hungary (*Figure 3*). The globe consists of two parts, showing additional information on its inner surfaces such as several historical structural models, the value of various physical variables (pressure, temperature, density) as a function of depth and a map legend (Kovács & Márton 1989).



**Figure 3.** Dismountable structural-morphological earth model (image from the Virtual Globes Museum)

The common character of these globes is the global and seamless nature of their theme: putting the information to any kind of flat world map would separate neighbouring objects to the opposite edges of the map, that's why it is worth to show it on a sphere.

The usual solution of creating such a map is to draw one global image in a particular projection (which is usually Plate Carrée) and to drape it to the globe. Following this way, we should always pay attention to the distortions of the rectangular image when it is transformed to sphere. The width of lines that are along meridians will shrink on higher latitudes, and the same happens with any symbols and labels: their east-west dimension will be reduced, the objects will be distorted. Therefore, the rectangular map should contain „pre-distorted“ lines, symbols and labels to solve this problem.

A simpler solution is described e.g. in (Hargitai & Gede 2009): there are separated maps depicting the northern and southern higher latitudes in Azimuthal Equidistant projection. In these regions the distortions of this projection are low so the map content does not need to be modified to eliminate them.

### **3. New possibilities using virtual globes**

#### **3.1. Interactivity**

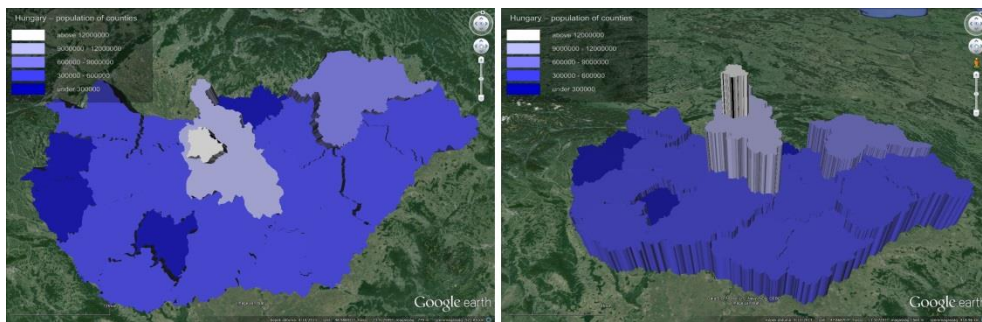
Virtual globe applications offer various interactive features: clicking on features may result pop-up windows with detailed information; hyperlinks pointing to related websites can be added; visibility or opacity of elements (or element groups) can be modified, therefore different themes can be examined together.

#### **3.2. Multiple levels of detail (LODs)**

It is possible to show elements only in a specific zoom interval. This feature allows us to create more and more generalized views of maps. As an example, when displaying information about national parks of a country, point symbols can represent the parks at lower zooms, while polygons may appear when the scale of the view makes it possible. LODs can also be used to create multi-resolution ground overlays also called “super-overlays“, which makes viewing large raster overlays faster and less resource intensive.

### 3.3. Using the third dimension

Map objects are not necessarily clamped to the globe surface. Their height can be used to display numeric attributes. Alternatively, it is possible to put more than one object to a specific location using different heights. These methods, however, should always be used with precaution: variable height in itself reflects only the difference of a specific attribute. If the absolute value is also important, it should be indicated using numeric labels or a colour scale. Other problems are that raised symbols may obscure other objects, and the colour of a surface may alter with the change of the point of view (*Figure 4*).



**Figure 4.** Surface colours change with the viewing angle.

### 3.4. The fourth dimension: time

It is possible to alter the content as time is changing. The usual implementation of this feature is that a time slider control appears on the screen to explicitly set the current time and/or a play/pause button to start/stop time passing. Map objects may either have a specific temporal validity i.e. a time interval when they exist, so they will be visible only in that time or their position, orientation or size may vary as the function of time. These features facilitate the visualization of temporal dynamics as animations.

## 4. Virtual globe applications

Nowadays there are several applications for displaying virtual globes, falling into three major groups: standalone geobrowser applications, browser plug-ins and web application programming interfaces (APIs) not requiring a plug-in.

#### 4.1. Google Earth

Probably the most popular among the standalone applications is Google Earth. Its markup language, KML, provides tools for all kind of thematic mapping representations (Google 2014b):

- Raster images can be stretched to the globe as *ground overlays*. This can be the solution in most cases when some kind of traditional thematic map is adapted to the globe. Taking advantage of multiple level of details (LODs), generalized, less detailed versions of the globe map can be shown at smaller zoom levels. Disadvantage of this solution that (not counting the multiple LODs) the map is totally static, and rotating the globe may cause labels turned upside down. (One may say, however, that this is not a disadvantage as we can turn the globe back.)
- *Point placemarks* can be used as scaled symbols. It is possible to set the size, height and heading of the icons. We should keep in mind that icons always show their faces, regardless the viewing angle. The size of the icons does not change with zooming in or out while viewing height does not exceed 3000 km. Above this height the size of icons shrinks.
- *Linestrings* and *polygons* for vector drawings. Mind the different behavior of tessellated (draped to the ground) polygons and polygons with specified height. While the tessellated ones are rendered similarly to raster ground overlays and their colour is constant, the surface colour of other polygons change with the viewing angle as seen on *Figure 4*. Vertically raised polygons can be used for prism maps. As the vertices of a polygon may have various heights, it is also possible to create shapes in tilted or vertical planes.
- Scalable *3D models* as symbols. This feature should be used with consideration, as the visual size of models (unlike point placemarks) change with zoom, therefore it should not reflect numeric information.
- Objects with temporal restrictions (*timespan/timestamp*) for temporally dynamic maps.

#### 4.2. Google Earth plug-in

The plug-in version of Google Earth provides all the possibilities of the desktop version embedded into a website (Google 2014a). As its API supports the manipulation of the plugin in several ways, it is even possible to create custom controls and functions that are not present in the desktop version. On the other hand, its obvious drawback is the need of active internet connection (the plugin cannot work in offline mode) and the plugin nature itself – a website using this plugin will work only on computers having the appropriate plugin installed.

### 4.3. Open source WebGL virtual globes

Recently several open source WebGL-based virtual globe libraries emerged. Their common advantages are the open source nature, and the possibility of offline mode. One of those is the *Cesium.js* (Cozzi 2013) which also offers tools for thematic mapping purposes.

- Images can be draped to the surface just like ground overlays in KML. Either single images or tiled image pyramids (according to the TMS standard) can be used.
- Scaleable point placemarks
- Linestrings, polygons (also vertically raised)
- 3D models
- Time-dynamic features using Cesium Language (CZML)

Examining its features, it is clear that Cesium has most of the functionality of Google Earth (either desktop or plugin version). There are some drawbacks, however: in most cases, Google provides higher resolution imagery, and higher bandwidth to reach them. But these issues are not present when we are using our own data.

Apart from Cesium, there are other WebGL virtual globe libraries, such as OpenWebGlobe, created by Swiss researchers (Christen, Nebiker, Loesch 2012), but these have limited features compared to Cesium.

### 4.4. X3DOM

X3DOM is a WebGL-based Javascript library that integrates declarative 3D content (X3D code) into the HTML Document Object Model (Fraunhofer 2014). Among its several uses, we can use it to display globes as well - globes in the Virtual Globes Museum (<http://vgm.elte.hu>) are also visualized this way. As all the 3D content can be manipulated from Javascript, virtually all kind of 3D thematic representations (including various animations) can be presented with this tool.

A drawback of this solution that some features that are obvious in geobrowsers (e. g. icons that are always showing their faces regardless the viewing angle, symbols or labels with zoom-independent scale) can be implemented with considerable programming work. Therefore, in some cases we can save worktime by using geobrowsers instead of defining the whole 3D scene from scratch.



## 5. Conclusion

The previous sections showed that there are several ways and tools for displaying thematic maps on globes. However, we should always consider the following thoughts:

- Sometimes the “less is more”. If the information to be delivered can be easily represented on a traditional 2D map, then let it be. In the case of global content an alternative can be a globe.
- When using 3D symbols, prisms, etc., features may become hidden behind other objects from some viewing angles.
- In contrary to the first point (“less is more”), we should not forget the power of the third dimension and interactivity in raising attention – much more people will examine a rotatable-zoomable 3D scene than a 2D map simply because they can “play” with it.

## 6. Acknowledgements

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