Analyses of Visualization Methods of the Earthquake Catalog Mapping for Educational Purposes

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Abstract. The aim of the study is to find possible solutions to represent earthquake catalog data and design maps which can help students to identify those places where earthquakes occurred frequently. The goal is to visualize all available catalog data sets in a complex way on a single map, displaying the long-term recurrence times of earthquakes. Therefore, raw data and aggregated data were combined with different cartographic visualization techniques to test the applicability of earthquake maps. Preliminary research demonstrates that aggregation can improve the process of retrieving information from earthquake maps and 3D visualization is useful to define the largest earthquakes. A second result is that 3D visualization is not effective in the comparison of quantities of released energy and the number of earthquakes.

Keywords: Visualization, Earthquake Catalog, 3D mapping

1. Introduction

As major earthquakes have occurred recently (Stein et al. 2011; Chen&Wang, 2011), an extensive discussion developed among seismologists concerning the discrepancy between the earthquakes and prediction maps (Kerr, 2011). Researchers analyzed the problem and they realized that these maps have to be retested and the communication with the local communities must be enhanced,

Although Hungary is not typically of the home of large earthquakes, the analysis of the several smaller ones, on which data is stored in the Hungarian Earthquake Catalog, would be useful to indicate future ones. The Earthquake Catalog indicates significantly higher seismic activity on certain areas, where other earthquakes are expected in the future by seismologists (Tóth et al 2008). The Hungarian Earthquake Catalog contains about 25 000 earthquakes dated from 456 A.D. until present.

The authors have already made the first attempts to find the optimal visualization technique for representing the data of the Hungarian Earthquake Catalog (Pődör&Kiszely, 2011).

The problems in the visualization of the data sets are as follows. (1) The amount of data is large, representing a catalog of a 1500-year-period; therefore, the symbolization of all the data on a single map is very complicated. (2) Another problem is the data quality, as data were not gathered two hundred years ago in the same way as today; nowadays, scientists gather instrumental and macroseismic earthquake data and deal with definition of earthquake focal parameters too. (3) The determination of the exact location of the epicenters is not uniform either throughout the Catalog.

2. Material and Methods

2.1. Experimental design

In the fall semester 2012, 97 BSc students from land surveying and 12 BA students from public administration management participated in the Information Technology course and the introductory course of Geographical Information Systems.

In visualizing earthquake data, there are several attributes which can be important: (1) date, (2) coordinate (epicenter or the hypocenter), (3) magnitude or intensity. Traditionally, the magnitude is one of the most important attributes in visualizing earthquakes, but the authors found that showing the released energy and the number of events can be just as important as presenting magnitudes. Examining the possible generalization with a help of a Borland C++ Builder program, the authors divided the study area into small grids (**0.1° x 0.1°**), and the program counted how many earthquakes occurred within one grid, and how much energy was released during the earthquake ($E = 10^{(1.5M + 4.8)}$ joules, where M = magnitude of the earthquakes).

The aggregated data for these unified cells can be easily drawn on the map. 3D visualization was also implemented as a way of representing the catalog. This method for aggregation can handle and reduce the problem of inconsistency of the Catalog (Pődör&Kiszely, 20

2.2. Preparation of the test maps experimental tasks

Further theories (Bertin, 1967, Mersey, 1990, Potash 1977, Robinson, 1953) and tradition (graduated symbols, isarithmic method) were fully considered by the authors of the present article while designing the test maps.

The original database with all the data of the Hungarian Earthquake Catalog was used on each map, but the data was handled differently. The authors also created and tested maps applying various cartographic methods.

The purpose of the test was to simulate the experimental phases when students studying about seismicity.

The participants conducted the experiment in a computer lab. The maps were prepared in ArcGIS at 1 : 2 million scale. The test generally lasted for 45-60 minutes. It consisted of 39 questions related to 11 maps. Each question was connected to one map indicated at the end of the question. The questions were focused on (1) how well students could estimate where the biggest earthquakes were, (2) how well they could compare the magnitude and the number of earthquakes and the extent of released energy, and (3) how well they could prepare an ascending sequence of earthquakes of regions in Hungary.

3. First results

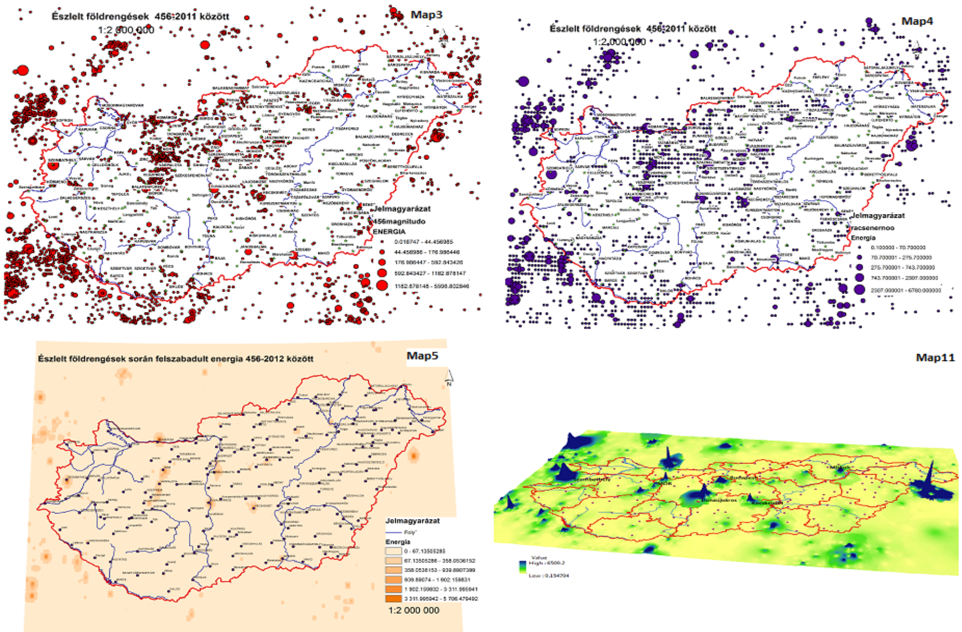

Figure 1. Some test maps showing the released energy

The simplest task proved to be the determination of the location where the largest earthquake occurred. In this task, the best result was connected to the using of 3D map. Preparing the ascendant sequence of energy release was the most difficult assignment for the students, though 3D maps seem to be very effective in this task also. A second finding is that 3D visualization is not effective in defining the exact number of earthquakes and released energy, so in the visualization of earthquake catalog one should be careful about applying 3D visualization. These findings clarify that 3D mapping can be an effective tool if scaling and proper visualization are improved.

4. Conclusion

Comparing different visualization methods for representing Earthquake Catalog data, the aggregation method designed by the authors proved to be a useful tool in analyzing and processing large data for the students. Although 3D visualization was also analyzed, the result clearly shows that this method in defining differences of quantities was not very efficient but, on the contrary, in defining the highest and the lowest values of number of earthquakes and released energy proved to be very effective. The findings of the present study would be a good basis of making high quality prediction maps by choosing appropriate visualization methods for communicating earthquake hazards to the community.

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References

Bertin J (1967): Semiology of Graphics: Diagrams, Networks, Maps. University of Wisconsin Press, 1983 (first published in French in 1967, translated into English by Berg W.J. in 1983)

Chen, Q.-F., Wang, K. (2010): The 2008 Wenchuan earthquake and earthquake prediction in China. Bulletin of the Seismological Society of America 100, 2840-2857.

Gooding M (1998): Studying Seismic Activity Using ArcView GIS and 3D Analyst http://www.esri.com/news/arcuser/1098/quake.html ArcUser Online Accessed 9 June 2011

Kerr, R.A. (2011): Seismic crystal ball proving mostly cloudy around the world. Science 332 912-913.

Kiszely, M. Pődör, A.: (2011): A földrengések eloszlásának statisztikai vizsgálata – két esettanulmány, GEOMATIKA XIV:(1) p. 111. (2011)

Mersey, J. E. (1990): Colour and Thematic Map Design. The role of Colour Scheme and Map Complexity in Choropleth Map Communication.Monograph 41.Cartographica 1990/27/3. pp. 5–33.

Pődör A, Kiszely M (2010): Földrengések térképen történő ábrázolásának 200 éves története. Magyar Geofizika 50. évf. 4.

Pődör A, Kiszely M (2011): Visualization problems of the Hungarian Earthquake Catalog GeoViz: Linking Geovisualization with Spatial Analysis and Modelling, 10-11 March 2011, Hamburg, Germany

Potash, L. M. (1977): Design of Maps and Map-Related Research. Human Factors 1977/19/2. pp. 139–150.

Robinson, A. H. (1952): The Look of Maps. Madison, Wisconsin 1952. The University of Wisconsin Press. pp. 105.

Stein S., Liu, M. (2009): Long aftershock sequences within continents an implications for earthquake hazard assessments 462,.nts. Nature 87-89

Tóth L., Mónus P., Zsíros T., Kiszely M., Czifra T., 2002, 2003, 2004, 2005, 2006, 2007, 2008,2009, 2010: Hungarian Earthquake Bulletin. – GeoRisk MTA GGKI, Budapest

Tóth L, Mónus P, Bus Z, Győri E. (2008): Seismicity of the Pannonian Basin, In: E.S. Husebye (ed.), Earthquake Monitoring and Seismic Hazard Mitigation in Balkan Countries, Springer Verlag, NATO ARW Series, Vol. 81, pp. 97-108.

Zsíros T. (2000): A Kárpát-medence szeizmicitása és földrengésveszélyessége: Magyar földrengéskatalógus (456-1995) /Seismicity and seismic hazard of the Carpathian Basin: Hungarian earthquake catalogue (456-1995)/. MTA FKK GGKI. Budapest. 495 pp. ISBN 963 8381 15 9