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Free Data Use for Designing GIS-Projects in the Ecology Students Training Course

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Abstract: The objective of this research is the study of the problem of the lack of high-quality geospatial data needed for designing customized GIS projects. It is suggested to solve the problem by using free network resources of vector and raster data with diverse spatial resolution and area coverage which are in open access. The study describes the largest free sources of geodata, the use of which allows to solve the problem of the lack of spatial information as regard to those regions where measurement of desired characteristics has not been performed or owing to some reasons is in accessible. The study presents specific examples of compatibility of heterogeneous spatial characteristics, received from various sources in the unified coordinate space of the environmental GIS project. The algorithm for research projects creation with the help of various methods of data interpolation for the spatio-temporal analysis of environmental characteristics is presented. The conclusion is drawn that the use of free data in the training course designed for ecology students provides wide opportunities for further inter disciplinary researches.

Key words: GIS technologies, free data, training, analysis, data interpolation, elevation digital values, designing environmental GIS projects

INTRODUCTION

Geoinformation Systems (GISs) are computer systems designed to collect, test, integrate and analyze spatial information. The main task of the first GIS Versions was visualization of geographical data but overall mathematization of knowledge in all fields could not but affect them. This was followed by gradual saturation of GIS applications with new models and methods of data processing. Mathematical tools in modern GISs allow to not ably facilitate the analysis of spatially-connected characteristics, essentially eliminate manual labor and significantly simplify user's calculations. That is why so far a GIS can be described as aspecific set of software products of the same level as database management systems or programming languages. The use of GIS technologies allows to boost work agility and quality almost in every field of activities, particularly where it is necessary to generalizeand analyze spatially-distributed information (Pivovarova, 2014). Among all the diversity of traditional fields of geo information system utilization notably dominates the environmental one as GISs allow to model ecological changes in various environments as well as to investigate the dependence of the ecosystem condition on weather conditions or characteristics of pollution sources.

EXISTING PROBLEMS IN GIS DESIGNING

The result of keen interest to GISs is that nowdays only in the USA alone >50 thousand students of various specializations take at least one course annually on the foundations or applied aspects of this technology. GIS training classes regularly take place in approximately, 1000 higher educational institutions in many countries and the total number of universities and colleges where GIS is used is approaching 3.5 thousand. In Russia teaching ecology students to GIS technologies is enshrined in the standards of the Ministry of Education. GISs are widely usednot only in educational process but in the work of university research centers and laboratories as well. However, very of ten educators and students face the problem of lacking the data needed to design GIS research projects this problem particularly concerns spatial information for large areas. A big problem is to find for the area of interest and desirable scale high-quality vector data such as hydrographic, topographic, social and economic infrastructure which are suitable for solving spatial problems. Access to many topographic and environmental data is chargeable while that is often unacceptable for educational institutions as GIS Systems by themselves are a quite expensive software product. Attempts to exchange data among various

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administrative departments encounter difficulties as well, arising from incompatibility of data from different sources in a unified information environment. One of the main problems is the lack of a coordinate system and projection parameters description, caused by various reasons while without them data compatibility in a unified coordinate space is impossible. The other problem stems from the lack of unambiguous understanding and interpretation of topographical information being caused by semantic incompatibility of the data, retrieved from different sources as they are heterogeneous on their structures, encoding methodsand/or information representation. Therefore, researchers often have to perform tasks beyond their duties by digitizing study maps that takes a lot of time and prevents them from performing their main tasks. Quite often available digital topographical maps are suitable at most, only for visual reproduction of their study sources and are no good at all from the topological correctness point of view. A lot of effort and time is required to adjust these data to be used in practice. All the aforesaid does not attract students' interest both in geo information technologies and in research studies as a whole.

EXAMPLE OF ENVIRONMENTAL MONITORING SYSTEM DEVELOPMENT BY MEANS OF GISS

The study presents the examples of free network resources utilization for the needs of environmental GIS project designing. The first task was to develop a digital model of surface water pollution within the area of the Oka River basin located in the central region of the Russian Federation. Terrain elevation data on the area in question served as a topographical base for further insering the matical layers. Digital values of underlying surface elevations have been imported from the Consortium for Spatial Information (CGIAR-CSI) site (http://srtm.csi.cgiar.org/). They are available on the NASA official site as well (http://www2.jpl.nasa.gov/srtm/). These data are distributed free of charge by the United States Geological Survey and are the result of radar interferometric survey of the Earth's surface (Shuttle radar topographic mission), performed in February 2000 from the board of the space shuttle. The SRTM data of high resolution (30-90 m), provided by the CGIAR-CSI are arranged in 5×5°C tiles, everyone of which is named according to its left bottom corner coordinates, e.g., N60E032.hgt-60°C of the Northern latitude and 32°C of the Eastern longitude. Files with .hgt extension can be easily downloaded into Global Mapper GIS without any additional processing. An absolute error for the elevation data is 6.2 m for Eurasia while a relative elevation error is 8.7 and all errors being within a confidence limit of 90% (Description and retrieval SRTM data. http://gislab.info/qa/srtm.html#.D0.98.D0.BC.D0.BF.D0.BE.D1.80.D1.82_.D0.B4.D0.B0.D0.BD.D0.BD.D1.8B.D1.8). The topographical relief of such high degree of detail and accuracy provides a good basis for any GIS project. In our case, the algorithm for further actions was the following:

- Creation of the vector layer with a hydrographic site plan of the catchment basin
- Correction of water objects to adjust them to the topographical relief
- Creation of a unified working space "topographical relief+creeks"
- Marking of point objects with settlements and industrial enterprises
- Contouring of polygons with the highest degree of their catchment area pollution (Fig. 1)

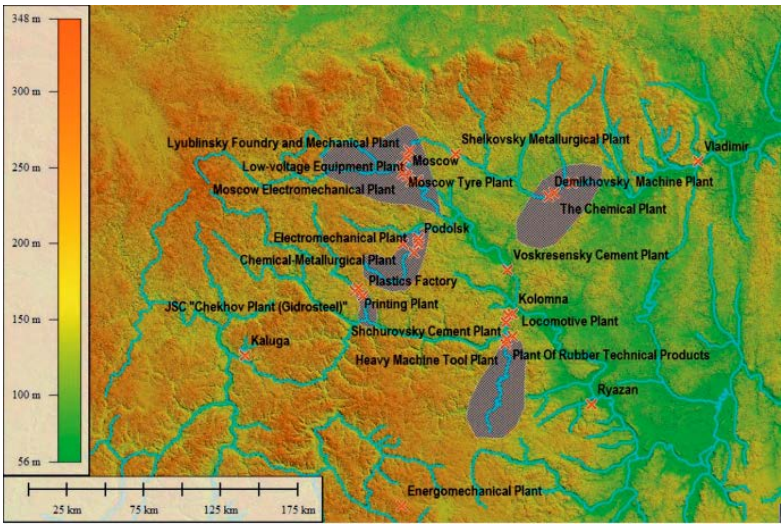

Fig. 1: Maximum pollution areas

Data on polluting substances occurence in wastewater of the enterprises in the region in question are freely accessible in the reports of government organizations on hydrometeorology and environment monitoring (http://ecomos.ru). In truth, it has to be noted that such information concerning remote regions of Russia is quite difficult to be found. However, in our case by using only free data sources the ecology students have gained experience in creation customized GIS projects covering various areas and with varying space resolution by using both raster and vector data models have studied the tools for marking areal, linear or point objects as well as the possibility for their spatial characteristics determination.

EXAMPLE OF THE USE OF GIS SPATIO-TEMPORAL ANALYSIS FUNCTIONS

Along with a powerful graphics platform, GIS Systems include various mathematical algorithms for geo information processing. Therefore, a the matical project development, comprising electronic maps, tables and graphs for a spatio-temporal analysis of the content of polluting substances in the atmosphere of the European Union countries is exemplified below as the second example of environmental GIS designing. The students were offered to use official data on sulfur oxide emissions for a decade period from 2001-2010 provided by the statistics service of the European Union (http://epp.eurostat.ec.europa.eu). The tabular data were processed by using MS Excel and imported into the GIS Map Info.Grid-themes including both interpolated pollution data for the time period of 2001-2010 years and changes in characteristics in question for the same time period were created (Fig. 2). It has to be noted that Map Info offers various methods for data interpolation designed to create the matical surfaces. The main methods among them are: IDW-a Method of inverse distance weighting (a weighted average of the values available at the neighbor points by the given number of neighbors or within the limits of the given radius); Kriging (a multi-step process of fitting a mathematical function at a given number of points or at the points within the limits of the given radius in order to propagate dependencies upon all points); natural neighbor (this can find a subset of input objects closest to the point in question and use against them weighted values based on proportional areas in order to interpolate the value) (Mitchell, 1999); bilinear (bilinear interpolation where a point value in a new imagery is determined by means of linear interpolation among the values of four nearest points); TIN (a method according to which all reference points are connected

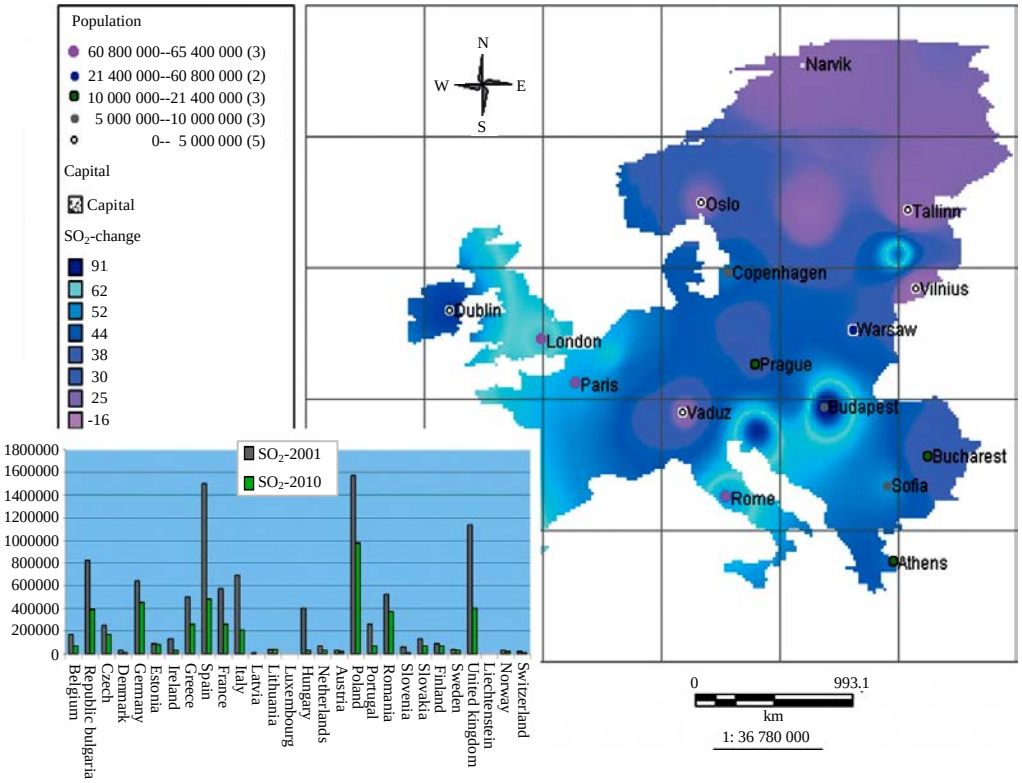

Fig. 2: Changing the Sulfur Oxides (SO_2) over the 10 years

by triangles forming triangulated irregular networks) (Zeiler, 1999). However, in case the Vertical Mapper module is not embedded in the main Map Info program version, then only two methods, TIN and IDW are accessible. The IDW Method has proved to be more suitable for solving the given task as it processed large mounts of initial data quite well and displayed the result in a human oriented form. A thematical layer depicting the population distribution has been inserted into the project where the field of values was classified according to their level of increase. Thus, in the course of performing the task, the students have learned to create digital layers by marking objects and spatial dependences have considered data interpolation methods used forthe analysis of distribution, interconnections and spatial characteristics trends on the selected territory. And what is the most important, visualization of tabular data in the form of the matical maps and calculation of statistical characteristics for various years have allowed to identify source areas of pollution and to detect temporal trends in the change of polluting substances content in the environment. These maps clearly demonstrate that sulfur dioxide reduction in atmospheric air averaged 30-40% in the countries of the European Union for the decade period this fact being an evidence of significant work carried out to improve environment protection laws in the EU. The created electronic GIS maps can be automatically changed after introducing new characteristics or time period adjustment. The Eurostat, possessing a large data bank in different fields of human life and activities, affords an opportunity of inserting into the environmental project of new digital layers on other polluting substances, discharges of industrial enterprises, power systems, motor transport, etc.

CONCLUSION

In case of complex approach that is typical for environment protection studies it is acommon practice to base upon general characteristics of the environment requiring in turn, the amounts of initial information sufficient on a minimum level to be large. Otherwise validity of decisions or/and actions to be taken would be hardly reached. These data should be easily accessible and systemized to meet the users' needs (Trifonova *et al*., 2005). Network resources described in this study meet all these requirements. Digital elevation data provided by the SRTM are a dramatic break through in the field of digital Earth mapping and a big leap forward as regard the accessibility to high-quality elevation data for a considerable part of tropics and other hard-to-reach areas of the world (http://srtm.csi.cgiar.org/). The use of Eurostat data in designing GIS projects provides wide opportunities for interdisciplinary researches as well. For example, the analysis of interrelations between population health and various (natural, demographic, economic, environmental) factors; quantitative estimation of the influence of environmental parameters on the conditions of local or regional ecosystems and their components; determination of landowners' incomes depending on dominant types of soil, climate, remoteness from cities, etc. Also, among the largest free sources of spatial information the following ones are:

- Data catalog of the United Nations Environment Programme. Its online database holds >500 different variables as national, subregional, regional and global statistics or as geospatial data sets (maps), covering themes like Freshwater, Population, Forests, Emissions, Climate, Disasters, Health and GDP (http://geodata.grid.unep.ch/)
- Data of the Stanford Geospatial Center, Stanford University (https://lib.stanford.edu/GIS/data) where students and educators involved into researches have access to digital mapping services to the rich collection of databases and also to references to on-line sources of geospatial information

In conclusion, it should be noted that the use of accessible network resources of GIS data allows not only to solve the problem of the lack of geospatial information on those regions where meausurements of characteristics in question were not performed either because of those areas being hard to access or because of complicated political or economic situation but as well it allows a researcher to feel him/herself a part of the world informational and scientific community. And popularization of geospatial education promotes the development of students' spatial imagination, teaches them to process large information amounts and undoubtedly, develops analytic capabilities and intellectual potential of the person.

REFERENCES

Mitchell, A., 1999. ESRI Guide to GIS Analysis: Geographic Patterns and Relationships. ESRI, Redlands, California, Pages: 190.

Pivovarova, I., 2014. Evaluation of spatial uniformity of hydrological characteristics. J. Eng. Appl. Sci., 9: 268-272.

Trifonova T.A., N.V. Mishchenko and A.N. Krasnoshchekov, 2015. Geoinformation Systems and Remote Sensing in Environmental Studies: Manual for Higher Schools. Akademicheskiy Proyekt, Moscow, Russia, Pages: 352.

Zeiler, M., 1999. Modeling our World: The ESRI Guide to Geodatabase Design. ESRI, Inc., Redlands, California, Pages: 254.