Atlas of Map Projections: the technology of creation on the basis of program-analytical complex

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Abstract. In the article we present the methodology of automated selection and construction the elements of the mathematic basis of maps. We discuss the functional possibilities and basic steps of work the program-analytical complex in implementation of the presented methodology. As a result of the work «The Atlas of map projections for the main regions of the Russian Federation» is presented.

Keywords: atlas, map projection, program-analytical complex (PAC)

1. Introduction

Despite that there is a developed theory of the selection the map projections in the mathematic cartography this selection for the most classes of maps (except the unified systems) was not implemented in the software. As a result when you want to develop the new kind of map you have to take the projection of the original cartographic material or any of projections which offer the software. Very often this selection is not optimal.

The most complicated task which stands the GIS-user in the process of map design is to select the optimal map projection to fulfill the task of the future map.

To minimize the time on the selection of the optimal map projection for the different kid of the geographical maps we can use Atlases of the map projections. Such Atlases are to have the recommended map projection and the parameters of map projection for the different kind of the mapping territories, which give possibilities to use the map projection recommendations at once, without additional calculations of the map projection parameters.

To add more, the GIS-users are not always professional cartographers. The Atlases of the map projections can become the link between the cartographers and the wide range GIS-users. But the development of such Atlases on traditional bases is very laborious and there is a real need to automate this service and make it easy for users.

To fulfill this idea we work out the technology of forming the Atlases of the map projections based on program-analytical complex (PAC). Below we discuss all the stages of the methods, which were realized in this complex.

2. Methods of automated selection and construction of elements for mathematical basis of maps

The methods in the whole are presented on Figure 1.

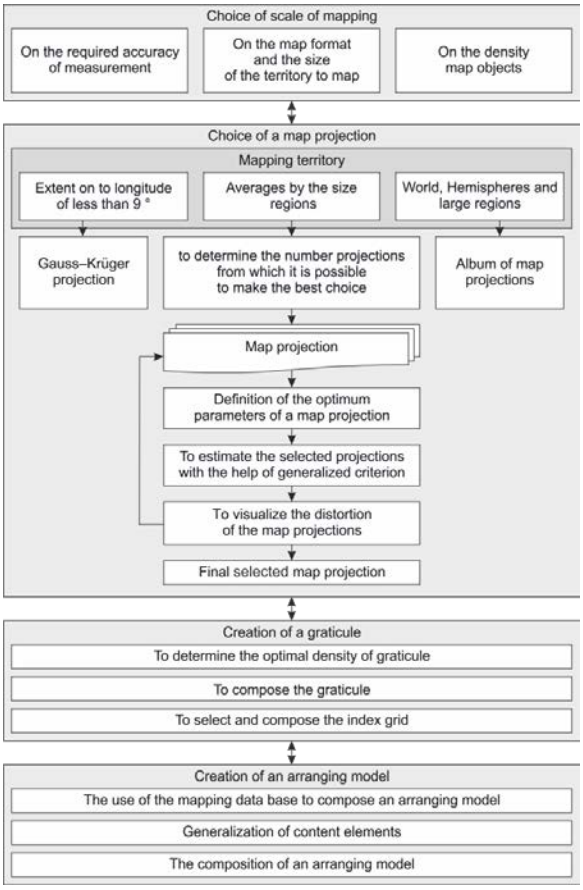

Figure 1. A methods of automated selection and construction for the elements of the mathematical basis of maps

3. The program-analytical complex (PAC)

The program-analytical complex (Figure 2.) provides the automation of processes for the all elements of the mathematical basis, which includes: the definition of the scale of mapping, the choice of the optimal map projection and its calculation, and construction of graticule and a layout.

The main functional characteristic of the PAC are follow:

- import/export of geo-spatial data
- the computer-aided choice of a map projection
- use of atlas of map projections
- analysis of map projections
- definition of the optimum parameters of a map projection
- the computer-aided process of definition the scale of map
- the computer-aided process of creation a graticule
- the computer-aided process of creation an arranging model
- analytical transformation of raster map
- a comprehensive characterization of the projection in any point of the map (geographical, spherical polar and rectangular coordinates, the magnitude of distortion of all kinds)

The PAC works with vector and raster graphics and allows interacting with all basic geographic information systems (GIS) and graphics programs.

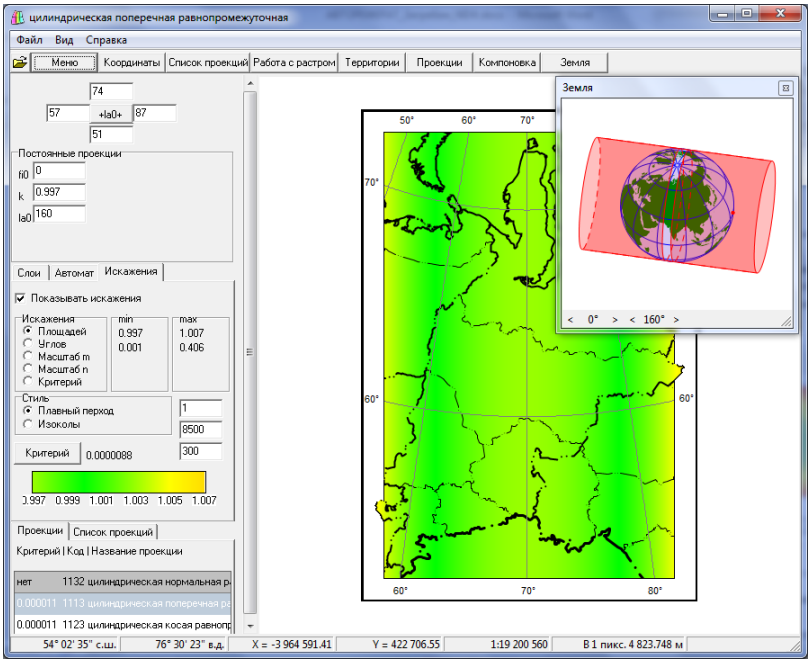

Figure 2. The window of the PAC

The choice of the map projection depends on the size of the mapping area. For the maps which cover the World, Hemisphere, Continents and Russia the range of the map projections was already defined. That is why to automate the process of selection of the map projection for these areas we use the Atlas of map projections as a Library of projections.

In the future this Library can be added with the new map projection for other often mapping areas.

The selection of the optimal map projection for the middle-size areas, which is not included in the Library, we can do with the methods of the automated selection the optimal map projection. The middle-size areas are the next – the territories of the states/countries and its provinces, nature and economic areas. The map projection selection performs step-by-step.

The specification of the mapping area. To figure out what area need to be mapped one can use the map database (the layer of borders and coastline) or assign the margins according the graticule, map border, free outline or using the Zenith distance from the center of map window. When mapping the administrative unite (state, administrative subjects of the Russia Federation, etc.) you need to select the needed area according the name or code. In this case the PAC will make the selection from the map database automatically. When we want to make the World map we can use the graticule as the margin for the mapping area and the PAC has option to assign the margin according the graticule and one can make a request on any extend values of latitude and longitude lines. It gives possibility to make any map composition, including those with the difference in extend longitudes more than 360°. For the Map of Hemispheres on the oblique aspects is the best way to determine the mapping area according the Zenith distance. For the mapping of the Nature areas and other territories which does not have the strict borders, it is possible to define them according free outline, to put it on the visualized cartographic basis. Herewith the PAC automatically defines the margins of the area in rectangular and geographic coordinates.

The specification of the optimal map projection. The PAC-user, after when set the mapping area, has to ask several questions: *Position*, *Area Shape* and *Kind of Distortions*. On the tab *Projection* will be reflected the suitable map projection for the selected area, which will be also generalized on the mathematical criterion. By default the projections in the top of the list will be chosen. In most of the cases it will be the optimal projections for the selected area. The user also can pick up the other map projection from the list and compare them with the optimal.

The specification of the parameters of the projections. The searching and decision on the main latitudes in the Conical and Cylindrical projections,

central points of the oblique coordinate system are performed automatically on assumption of minimality for generalized criterion. To fulfill this option one's needed to figure out the value of parameters based on shape and place of the mapping area, also on the basis of minimality for generalized criterion.

The visualization of distortion and the final selection of the map projection. To finalize the decision about the map projections one's need to calculate and construct the model of the graticule with the distortion for each type of map projections on the monitor screen (Figure 3.). The construction of the graticule model with the distortion gets a great importance when the user receives several models of projections as the result of analysis mentioned above and the generalized mathematical criterion values of them are very close to each other. It is possible to show the distortion by line of equal distortion or colors. In this case the minimum values of distortion according which we can make the most accurate measurements will be shown in green. Less accurate measurements will match with the yellow and orange colors. The red and purple colors match the areas with largest distortions and in this case the PAC-user can only visually estimate the model without possibility to make any measurement.

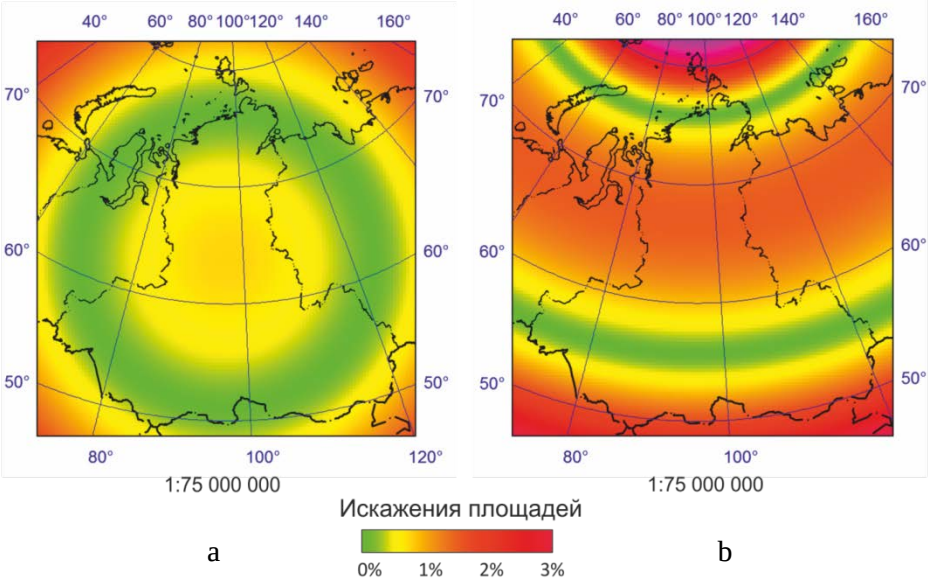

Figure 3. The Siberian Federal Okrug. The model of the graticule with shown distortion (a – Oblique Azimuthal Equidistant projection, b – Conical Equidistant projection)

4. «The Atlas of map projections for the main regions of the Russian Federation»

The Program-analytical Complex (PAC) was tested on the Russian Federation territory as example for production the Atlas of Map Projections for Federal Okrugs and Military Okrugs.

Atlas designed on basis of Atlas of Map Projections ZNIIGAiK (Ginzburg & Salmanova 1957), not duplicate it, but supplement the previous.

The Atlas consists of two parts. In the first part, the methodology of automated choice of map projection is described. According to this method, the optimal cartographic projections, which meet the requirements for minimum distortion of mapping areas, were selected for eight Federal Okrugs and four Military Okrugs. In the second part for the each Okrugs a separate page presented the name of projection and its parameters; also a brief explanation and a graticule are given as well as the distortion of areas and the maximum distortion of the corners (Figure 4.).

Also for each area are given the parameters of coordinate in different GIS systems.

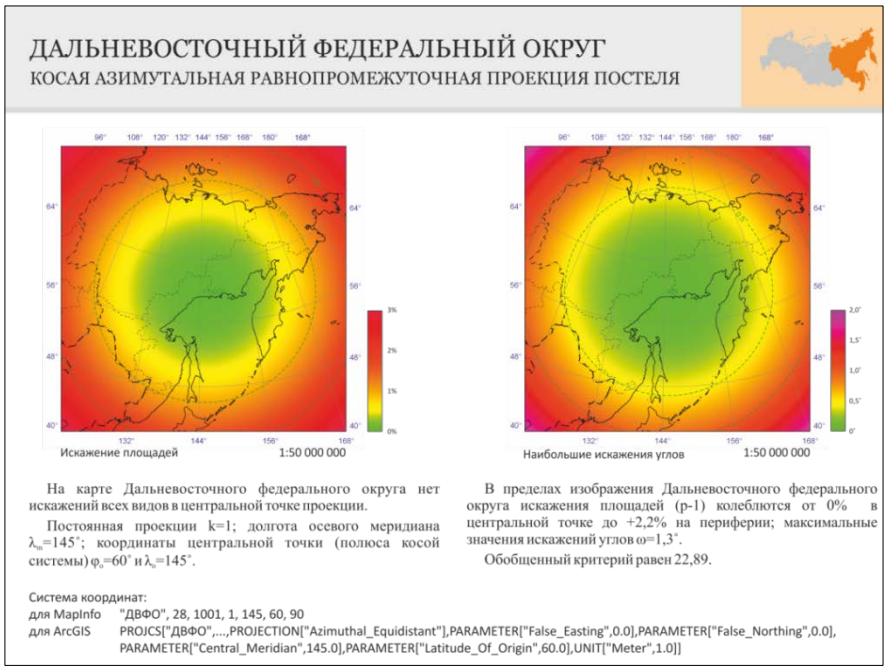

Figure 4. Page from «The Atlas of map projections for the main regions of the Russian Federation»

The Atlas has A4 paper size, album position. The maps presented in two scales: 1:25.000.000 and 1:50.000.000. The graticule step for map scale 1:25.000.000 is 4° on latitude and 6° on longitude. The model of graticule has the coastline, state border, borders the Subjects of the Russia Federation.

All the projections showed in the Atlas are implemented in modern GISs. Projections' parameters can be easily installed by using the corresponding text line describing the coordinate system from the Atlas.

Atlas of Map Projections also implemented in electronic form as Library for GIS-set for MapInfo and ArcGIS.

5. Conclusion

The discussed above methodology and developed on its base the program-analytical complex (PAC) give possibility to create the Atlases of projections for any areas of the Earth. Such Atlases can be used by the professional cartographers and also GIS-users who have not the vocational education as cartographer. The Atlases can be in paper and also in electronic form. «The Atlas of Map Projections for the Main Regions of the Russian Federation» will allow optimizing map making process both for state and for private cartographic companies.

The PAC together with the methods automation of generalization, which was developed in the Moscow State University of Geodesy and Cartography under the scientific supervision of Professor, Doctor of Engineering Anatoly Ivanov, provides the possibility of making the derivatives digital map bases on given territory, in given map projection and scale.

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