AN IDEAL MAP PROJECTION FOR GLOBAL GIS OUTPUT

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This paper specifies the deficiencies of the present system of projections available for global data presentations, and demonstrates the need for a new projection suitable for the portrayal of global environmental data. As the answer to present needs, created by advancements in space and computer technologies, the novel general purpose map projection is proposed for use as the base cartographic representation for Global GIS output. It is a minimum error cartographic representation of the globe, which simultaneusly minimizes the distortions in equal-area, conformal, and equidistant properties of the resultant world map. Several advantages of this Tri-Optimal World Projection are described, which make it the best candidate for use as the general coordinate system for Global GIS displays and analysis. The most important features of this new projection are: minimum error property; best compromise among equal-area, conformal, and equidistant projections; contiguous display of the entire Earth's surface; special shape of polar regions which creates an illusion of the perspective view of the globe; and simple mapping equations.

Key Words: Cartographic, Minimum Error Projection, Compromise Representation, Global GIS

INTRODUCTION

The present selection of map projections suitable for portrayal of global phenomena is not satisfactory for many reasons:

-- Most projections in current use were developed long ago, when the main objective was to minimize map distortions over the habitable continental areas only, which were accessible for direct terrestrial measurements,
- Classic projections' equations were developed before massive numerical calculations became practical with the advent of computers,
- The geophysical measurments in the pre-satellite era were lacking global perspective,
- Scientific awarness of global connectivity of environmental factors was very low, and
- Public interest in protecting the global environment was not yet developed.

Present advances in space technology, global environmental science, and growing public interest in protecting the environment at the planetary scale call for the development of the new general purpose world map projection to facilitate Global GIS analyses and global data visualizations.

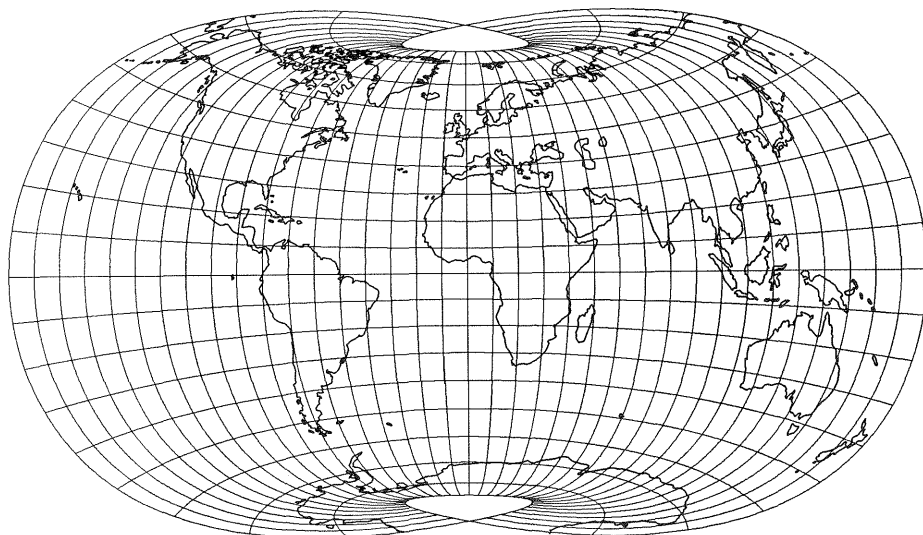## TRI-OPTIMAL WORLD PROJECTION

Figure 1. Continental shapes.

Global GIS will become an important tool for analyses and presentations of world-wide environmental data. The presentation layer of Global GIS will require that the data of planetary extent be represented on a contiguous map projection of the world with the minimum amount of distortions and in the form which enhances both scientific understanding and the process of communication of spatial relations to the general public. Global GIS needs a projection with the property of minimum distortion for accurate statistical analyses and with the appearance which gives an impression of roundness of our planet and its unity, without interruptions or sharp corners, to allow for visual comparisons of the portrayed phenomena among remote areas.

The present speed of computers and the recent development of new analytic techniques (Laskowski, 1991a) makes it possible to quantify all the above requirements for global data presentations, and to reach for the analytically optimal solution to these new demands: a general purpose cartographic representation of the world for Global GIS (Fig.1).

THE TRI-OPTIMAL WORLD PROJECTION

The Tri-Optimal World Projection (Fig.1) fulfills all the above criteria for the ideal cartographic representation of Global GIS output. It is constructed to simultaneously minimize the deviations from equal-area, conformal, and equidistant representations of the globe, resulting in the best compromise among equal-area, conformal, and equidistant world projections. Furthermore, the inevitable distortions in polar regions are arranged to mimic the perspective view of the globe (see Fig.1) and to create an illusion of viewing simultaneously the front and the back side of the Earth – a feature important for visualizations and animations of global phenomena. Very simple polynomial mapping equations guarantee fast processing (both raster and vector) for real time spatial displays and analyses.

The theoretical foundation which led to the development of Tri-Optimal World Projection was described by Laskowski (1991a & 1991b). This development is an extension of the ideas of Airy (1861), Gilbert (1974), Tobler (1977), Canters(1989), and others. Here it suffices to say that the new projection is based on the concept of the "triple balance of errors" which results in the best possible compromise among equal-area, conformal, and equidistant representations of the globe. The projection depicts the entire surface of our planet as an uninterrupted oval, with a smooth outline (Figure 1). However, its main potential for use as a general purpose cartographic base map for Global GIS arises from the following set of analytical properties:

- Minimum-error projection of the world: This mapping has the smallest possible geometric distortion among all projections which can be represented by a 5-th degree polynomial in longitude and latitude and which seek the best compromise among equal-area, conformal, and equidistant representations of the globe. This property is most important for the spatial analysis layer in Global GIS, and for accurate visual data assessments.
- The best compromise among equal-area, conformal and equidistant projections: Because of this property this projection offers a general purpose coordinate system for use with Global GIS and visualizations of planetary data.
- Simple mapping equations (in the form of a 10-parameter polynomial, given in (Laskowski,1991a)), guarantee fast numerical processing and displays. Parameters are invariant with respect to rotations about the polar axis – an important advantage for animations of global phenomena and for temporal analyses in GIS.
- The entire surface of the globe is represented without interruptions: This feature is important in the presentation layer of GIS: it allows for continuous viewing of environmental data of global extent, preserving spatial connectivity of the spherical surface as much as possible.
- Finally, the polar regions are shaped to simulate the perspective view of the globe and to create an illusion of viewing simultaneously the front and the back side of the planet. In the presentation layer of Global GIS this feature may enhance understanding of spatial phenomena, especially in the communication to general public. As it was pointed out by Bertin (1967, p.290), this perspective-like appearance stimulates a 3-dimensional effect and helps to translate some of the distortions in polar regions into the impression of third dimension.

Although it may still be true that there is no best single projection for all possible purposes, it is nevertheless possible to achieve the best compromise among projections by blending the right features needed for global data presentation and analyses. The Tri-Optimal World Projection is one such solution. It is not perfectly equal-area, not perfectly conformal, and not perfectly equidistant, but it deviates the least from any one of these basic characteristics. To give an example, Figure 2 shows the distribution of distortions in areas.

CONCLUSION

The Tri-Optimal World Projection was constructed in response to the need of an effective presentation and visualization of growing volumes of world-wide environmental data. None of the existing projections had all the necessary features of a universal coordinate system suitable for visualization of variety of environmental data of planetary extent.
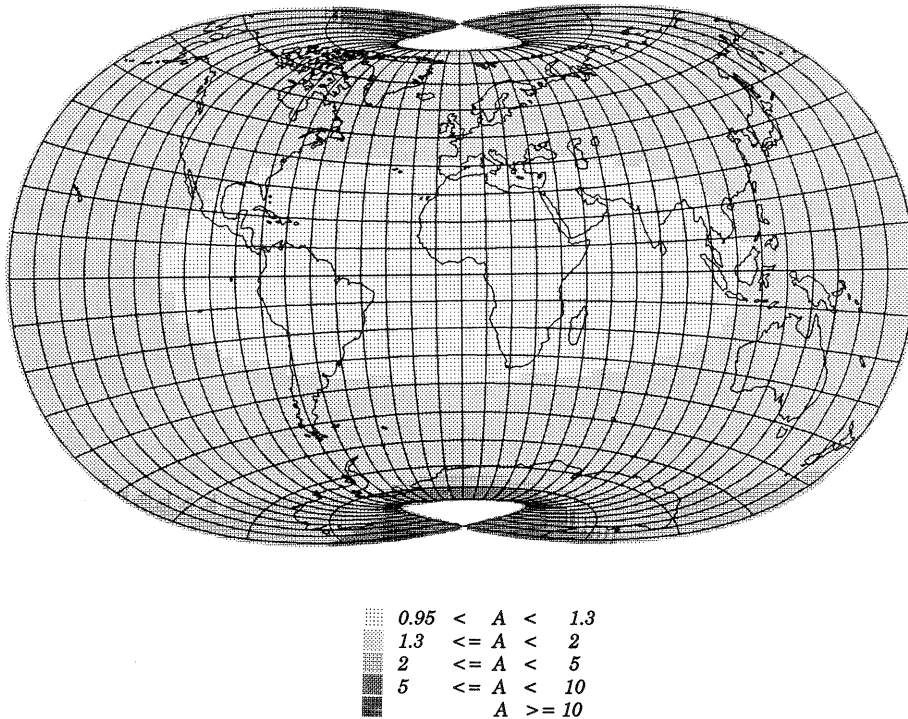
TRI-OPTIMAL WORLD PROJECTION

0.95 < A < 1.3
1.3 <= A < 2
2 <= A < 5
5 <= A < 10
A >= 10

Figure 2. Area distortion pattern (A — the areal scale factor).

The Tri-Optimal World Projection offers one solution to this problem. The main features of Tri-Optimal World Projection were presented in the context of their usefulness for Global GIS analyses and displays. This new projection has a unique blend of analytic and visual characteristics which make it an ideal candidate for a base cartographic representation of Global GIS output. It is a minimum error projection and the best compromise among equal-area, conformal, and equidistant representations of the globe, and as such it may become a general utility in Global GIS.

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