Chapter XII
Overview, Classification and Selection of Map Projections for Geospatial Applications

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ABSTRACT

There has been a dramatic increase in the handling of geospatial information, and also in the production of maps. However, because the Earth is three-dimensional, geo-referenced data must be projected on a two-dimensional surface. Depending on the area being mapped, the projection process generates a varying amount of distortion, especially for continental and world maps. Geospatial users have a wide variety of projections too choose from; it is therefore important to understand distortion characteristics for each of them. This chapter reviews foundations of map projection, such as map projection families, distortion characteristics (areal, angular, shape and distance), geometric features and special properties. The chapter ends by a discussion on projection selection and current research trends."

INTRODUCTION

Recent automation and increasing user-friendliness of geospatial systems (such as Geographical Information Systems -GIS) has made the production of maps easier, faster and more accurate. Cartographers have at present an impressive number of projections, but often lack a suitable classification and selection scheme for them, which significantly slow down the mapping process. Map projections generate distortion from the original shape of the Earth. They distort angles between locations on Earth, continental areas and distances between points. Distortion, although less apparent on a larger-scale map (because it covers a smaller area and the curvature of the Earth is less pronounced), misleads people in the way they visualize, cognize or locate large geographic features (Snyder, 1993). Map projections have been devised to answer some of the distortion issues, preserving selected **geometric** properties (e.g., conformality, equivalence, and equidistance) and **special** properties. Ignoring these distortion characteristics may lead to an unconsidered choice of projection framework, resulting in a disastrous map, thereby devaluating the message the map attempts to communicate. It is urgent for users of geospatial technologies to acquire a map projection expertise before interacting with any cartographic software.

THE MAP PROJECTION PROCESS

The Earth is essentially spherical, but is approximated by a mathematical figure –a datum surface. For the purpose of world maps, a sphere with radius R_E = 6371km is a satisfying approximation. For large-scale maps however (i.e., at the continental and country scale), the non-spherical shape of the Earth is represented by an ellipsoid with major axis *a* and minor axis *b*. The values of *a* and *b* vary with the location of the area to be mapped and are calculated in such a way that the ellipsoid fits the geoid almost perfectly. The full sized sphere is greatly reduced to an exact model called the *generating globe* (see Figure 1). Nevertheless, globes have many practical drawbacks: they are difficult to reproduce, cumbersome for measuring distances, and less than the globe is visible at once. Those disadvantages are eliminated during the map projection process, by converting the longitude and latitude angles (λ,ϕ) to Cartesian coordinates (Canters and Decleir, 1989):

$$x = f(\varphi,\lambda),\ y = g(\varphi,\lambda) \qquad (1)$$

CLASSIFICATION OF MAP PROJECTIONS BY FAMILIES

Three major projections classes are named after the developable surface onto which most of the map projections are at least partially geometrically projected. All three have either a linear or punctual contact with the sphere: they are the cylindrical, conical and azimuthal. The advantage of these shapes is that, because their curvature is in one dimension only, they can be flattened to a plane without any further distortion (Iliffe, 2000). The pseudocylindrical, pseudoconic, pseudoazimuthal and pseudoconical projections are based on the three aforementioned families (Snyder, 1987; Lee, 1944).

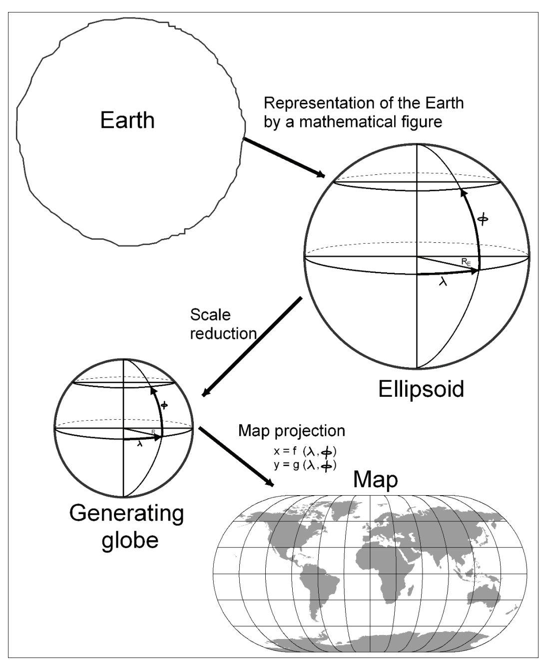
Conical Projection

When a *cone* wrapped around the globe is cut along a meridian, a *conical projection* results. The cone has its peak -also called apex- above one of the two Earth's poles and touches the sphere along one parallel of latitude (Figure 2a). When unwrapped, meridians become straight lines converging to the apex, and parallels are represented by arcs of circle. The pole is either represented as a point or as a line. When the cone is secant to the globe, it bisects the surface at two lines of latitude (Figure 2b).

Cylindrical Projection

A *cylinder* is wrapped around the generating globe, so that its surface touches the Equator throughout its circumference. The meridians of longitude are of equal length and perpendicular to the Equator. The parallels of latitude are marked off as lines

Figure 1. The map projection process: the sphere, approximated by a mathematical figure is reduced to a generating globe that is projected on a flat surface. (after Canters and Decleir 1989)



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