

## Research on Mathematical Model and Spatial-Temporal Geodesic Reference of 'Digital Earth'

Jing Li<sup>1</sup> ChunPing Zhou<sup>2</sup> LianwangYin<sup>3</sup>

<sup>1</sup>*Institute of Remote Sensing & GIS, Peking University, Beijing, China, 100871*  
Tel: 86-10-62757394, Fax: 86-10-62757394  
Email: [jingl@263.net](mailto:jingl@263.net)

<sup>2</sup>*Beijing Remote Sensing Institute, Beijing, China, 100011*  
Tel: 86-10-66747976  
Email: [zcp1688@263.net](mailto:zcp1688@263.net)

<sup>3</sup>*Institute of Remote Sensing Applications, Chinese Academy of Sciences*  
P.O. Box. 9718, Datun Road, Beijing, China, 100101  
Tel: 86-10-64889215, Fax: 86-10-64889876  
Email: [yinlw@yeah.net](mailto:yinlw@yeah.net)

**ABSTRACT** 'The Digital Earth', as a new high science and technology, has become a trend of Information Age. This paper, according to the systematic model of digital earth, has proposed a series of related mathematical models and techniques, including the intelligent referenced ellipsoids of the Earth, the geodesic system of digital earth in spatial-temporal multi-dimensions and multidimensional spatial-temporal data agent based on WebGIS.

**KEYWORDS** Mathematical models of 'Digital Earth', geodesic system in spatial-temporal multiple dimensions, multiple spatial-temporal data agent

### 1. Introduction

This paper aims to research and inquire into the aspects of mathematical reference system of "digital earth", its contents consist of geometric model of the earth, spatial—temporal geodesic reference and multidimensional space data information agent mechanism and so on, So that we can provide united and standardized geodesic platform of "digital earth".

### 2. Key Research Contents

**2.1. Referenced Geometric Model of "Digital Earth"**  
"The intelligent referenced ellipsoids of the earth" we proposed aims to fully research formation feature of the earth surface, and according to regional and global mathematical model of ellipsoids of the earth, we can compute a referenced geometry of earth suitable for require of "digital earth". It contains not only conventional referenced ellipsoids of the earth, but transform coordinates among referenced ellipsoids of the earth in different countries and regions, besides, it also can automatically select optimal referenced geometry of the earth in accordance with specific applications of users.

**2.2. The Geodesic System of "Digital Earth" in Multiple Spatial-Temporal Dimensions**  
According to referenced ellipsoids of the earth in every countries (or region), we can set up united,

normative and standardized multidimensional geodesic system in space and time (including time order and attributes), meanwhile establish transformation model among temporal referenced frames of every countries and region and among international temporal referenced frames. Through "intelligent geodesic system of multiple spatial-temporal dimensions", we can determine optimal geodesic system of multiple spatial-temporal dimensions.

#### 2.3. The Intelligent Projection System

1. General map projection models  
Transform coordinates from geodesic latitudes and longitudes to various kinds of map projections such as Mecator, Mollweide and etc.
2. Projection transformation models  
Transform coordinates among different types of map projections, for example, from Mecator to Mollweide projection.
3. Projection distortion analytic models  
Every projection has distortion compared with its original geographic coordinates, but different projection causes different distortion in orientation, distance and area shape. If we can know the various degree of distortions in terms of numeric value from analytic models, it is convenient for user to choose the proper kind of projection in specific application.
4. Optimal projection selecting models  
Based on projection distortion analytic models,

one or more best (optimal) projection to user's application by analyzing some features as theme, map scale, area size of geographic region, shape of the region etc. For example, Mecator can be said best projection for navigation as there is no distortion of orientation while the equal angular orientation projection is the best for aviation.

#### *2.4. Multiple Spatial-Temporal Data Agent Mechanism of "Digital Earth"*

Just as Al. Gore said that 'Now we have an insatiable hunger for knowledge. Yet a great deal of data remains unused'. We can get a vast amount of geospatial data, but we don't know where they are and how to use them. Multiple spatial-temporal data agent mechanism is one solution to discover the geographic information user need in worldwide distributed data servers. This is just like data mining and knowledge discovery of databases, we can quick search useful data by user's conditions as theme, region, scale, projection, data format and time the data got etc from various databases distributed in the world via internet.

### **3. Application of "Digital Earth"**

After setting up geometric model and space temporal system of "digital earth", we can provide united, normative and systematized basic mathematical referenced platform. Its function can be illustrate by following application.

#### *3.1. The Space Data Position of "Digital Earth"*

Through "intelligent referenced ellipsoids of the earth" and "Geodesic system of multiple spatial-temporal dimensions", we can dynamically choose data source suitable for referenced ellipsoids of the earth and temporal system in a large amount of spatial information, according to the conditions about the application of concrete geoscientific application, map scale, geographic area etc. Which users propose, so as to meet the

need of multiple spatial-temporal dimensions data information share and spatial-temporal coordinates transformation of different geographical theme.

#### *3.2. The Spatial-Temporal Data Transformation of "Digital Earth"*

Through "digital earth projection intelligent system", it can dynamically accord with specific projection user choose to change plane coordinates of spatial data, and draw corresponding projection net by latitude and longitude, distortion ellipsoid and equal distortion graph, meanwhile system can automatically analyze distortion of different projection, so as to determine referenced projection type with lest distortions of orientation, distance and area.

#### *3.3. Multiple Spatial-Temporal Data Agent*

In order to realize the aim of "digital earth", we must solve two basic questions. First, how to select the data from existing different areas, different temporal referenced systems. Second, how to meet the infinite need of data from the limited data available. through "multiple spatial-temporal data information agent mechanism", system can organize, manage vast amount of spatial information with multiple spatial-temporal dimensions, and according to the need, automatically analyze the data, information and knowledge available.

### **4. Conclusion**

Data and information that "digital earth" can provide will be widely used in many fields, as education, sustainable development decision making, landuse planning, agriculture, military, global change, environment and disaster, population and resources, and so on. Mathematical model and spatial-temporal geodesic reference is the foundation of "digital earth", which is the core in managing various information resources.