Modeling and Correction Analysis of Regional Ionospheric Modeling

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***Abstract*—The Global Navigation Satellite System (GNSS), due to its all-weather lobal monitoring and high precision, makes it possible to use GNSS observation data to accurately extract the total electron content (TEC) of the ionosphere and to study ionospheric activities. At the same time, the delay error caused by the ionosphere to GNSS signals is also one of the main sources of error in GNSS positioning. For regional users, using as few stations as possible to establish an ionospheric TEC model within the region has higher efficiency and range practicability. This paper realizes the establishment of a regional ionospheric TEC model based on spherical harmonics, and establishes an ionospheric TEC model in the 15~45°N and 105°~135°E regions, which is compatible with IGS (International GNSS Service, IGS) and CAS (Chinese Academy of Sciences, CAS), the overall difference is more than 70% within ±3TECU.**

Key words—ionosphere; regional modeling; TEC; spherical harmonic function

I. INTRODUCTION

The ionosphere is a near-Earth space environment that includes a large number of free electrons [1]. Electromagnetic waves propagate through the ionosphere and will cause refraction and other effects, which will cause the signal speed and propagation path to change, and even cause communication interruption [2]. In the process of global satellite navigation and positioning, the ionospheric delay can cause positioning errors of several meters or even hundreds of meters, which is an important error that must be considered [3]. The total electron content of the ionosphere (TEC) is an important physical parameter describing the properties of the ionosphere. Polynomial function models, trigonometric series function models, spherical harmonic function models, etc. are common methods for calculating and analyzing TEC [4].

The ionosphere is divided into global ionospheric modeling and regional ionospheric modeling according to different modeling ranges [5]. For regional users, establishing regional ionospheric TEC model and analyzing its application range and accuracy is particularly important for regional users to improve navigation and positioning accuracy. Section 6 studies the establishment of a regional ionospheric model based on a polynomial model, and analyzed its application in China's wide-area differential system. Section 7. studies the principles and methods of using dual-frequency GPS pseudo-range observations to establish a regional ionospheric model. Section 8 proposes an inter-station divisional grid method to establish a regional real-time ionospheric delay correction model.

This paper uses the fourth-order spherical harmonic function to establish a regional ionospheric TEC model, and establishes a regional ionospheric TEC model in eastern China, and compares it with the global ionospheric TEC products of IGS and CAS to analyze the accuracy of the regional ionospheric TEC model.

II. REGIONAL IONOSPHERIC TEC MODELING METHOD

In the TEC modeling of the ionosphere, it is assumed that the free electrons in the ionosphere on the propagation path of the GNSS signal are concentrated on the extremely thin ideal sphere, and the sphere height is 450km. Using GPS dual frequency observation data, the ionospheric Slant Total Electron Content (STEC) is calculated by using the carrier phase smoothing pseudo range method. According to the Mapping Function(MF), STEC is transformed into Vertical Total Electron Content (VTEC). The equations are formed according to the observation data during the observation time, and the least square method is used to solve the model parameters in each time period.

The GNSS pseudo-range observation equation is as formula (1):

$$P_i^k = \rho_i^k + \frac{40.28}{f_n^2} TEC + V_{trop} + (B^s - B_r) + \delta p_i + \delta m_i + \varepsilon \tag{1}$$

ρ_i^k is the geometric distance between the satellite and