1. Introduction

As responsible of the International Terrestrial Reference Frame (ITRF) determined in Latin America, SIRGAS uses this network to compute regional maps of horizontal and vertical Total Electron Content (TEC) for the area that is referred to the community through the SIRGAS webpage. SIRGAS networks perform an empirical model of the Earth's ionosphere, which allows modeling the data, but not the empirical model, so that:

\[ \text{TEC} = f(x, y, z, \phi, \theta, h) \]

evaluates the errors that are produced when the model is used to reproduce the ionosphere scenario.

2. The ionospheric model

The whole ionosphere is represented by spherical annular thinness at a height, \( h \). The start TEC (\( TEC_s \)) along a given satellite-to-receiver line of sight (LOS) is related to the vertical TEC (\( TEC_v \)) at the ionospheric parameters (IIP) by:

\[ TEC_s = TEC_v \left( \frac{h}{h_s} \right) \]

where \( h_s \) is the height, \( \alpha \) the angle at the IPP and \( \beta \), \( \gamma \) the parameters. The TEC, \( TEC_v \), is parameterized as a function of time, \( t \), and geographic latitude, \( \phi \), and longitude, \( \lambda \), the IPP:

\[ TEC_v(t, \phi, \lambda) = TEC_v(t) \]

which is the dual-frequency ionospheric observable and \( \gamma(t) \) the associated observational error. The TEC is estimated from the orbit of the satellite, which is modeled with steps of 25 km.

3. Numerical simulations

The TEC distribution in the SIRGAS region is characterized by several magnetic parameters caused by the geomagnetic field. The ionosphere is represented by a spherical layer ionospheric model. The following magnetic scenario is considered:

- \( \text{TEC} \)
  - The IIP is a GNSS satellite orbiting the 350 km ionospheric layer.
  - The magnetic field and the solar activity are modeled with the standard deviations of the magnetic field, \( \sigma \).

The variation with the height of the ionospheric layer, \( h \), of the systematic error on the TEC estimation is 100 km, 300 km, 400 km, 500 km, and 600 km. The results of this study are presented in Figs. 4 and 5.

4. Assessment of the mapping function error

The TEC error due to the use of the mapping function is:

\[ \Delta \text{TEC} = \text{TEC}_{\text{model}}(x, y, z, \phi, \theta, h) - \text{TEC}_{\text{true}}(x, y, z, \phi, \theta, h) \]

The systematic component of the error is characterized by the errors of the satellite and receiver inter-frequency bias (FFB) due to the propagation of the mapping function errors to the satellite.

\[ \Delta \text{TEC} = \sum_{i=1}^{n} \Delta \text{TEC}_{i} \]

where \( \Delta \text{TEC}_{i} \) is the dual-frequency ionospheric observable and \( \gamma(t) \) the associated observational error.

5. Assessment of the fitting in the TEC and PFI estimation errors

The TEC error due to the mapping function, the systematic error on the TEC estimation is 100 km, a 350 km, 400 km, 500 km, and 600 km. The results of this study are presented in Figs. 4 and 5.

The first experiment consists in adding to the TEC and the PFI estimation error due to the use of the TEC model:

\[ \Delta \text{TEC} = \sum_{i=1}^{n} \Delta \text{TEC}_{i} \]

The standard deviation of the residuals, \( \sigma \), is estimated from the TEC estimation for 100 km, 350 km, 400 km, 500 km, and 600 km. The results of this study are presented in Figs. 4 and 5.

The last experiment consists in adding to the TEC and the PFI estimation error due to the use of the TEC model:

\[ \Delta \text{TEC} = \sum_{i=1}^{n} \Delta \text{TEC}_{i} \]

The standard deviation of the residuals is estimated from the TEC estimation for 100 km, 350 km, 400 km, 500 km, and 600 km. The results of this study are presented in Figs. 4 and 5.

6. Conclusions

The height of the ionospheric layer is a key parameter of the ionospheric layer model. The error made by a given solar activity and magnetic is selected to reduce to zero the average of the TEC bias for a given solar activity, but not the ionospheric variation error.