Spatial Fluctuation of TEC Index: A new index of ionospheric irregularities

Guanyi Ma[1, 2], Qi Li[1, 2], Takashi Maruyama[1, 3], Jinghua Li[1], Qingtao Wan[1], Xiaolan Wang[1]

[1]National Astronomical Observatories, Chinese Academy of Sciences, Beijing, China.

[2]University of Chinese Academy of Sciences, Beijing, China.

[3]National Institute of Information and Communications Technology, Koganei, Tokyo, Japan.

Corresponding author: Guanyi Ma (guanyima@nao.cas.cn)

Abstract:

This study presents a new spatial fluctuation of total electron content (TEC) index (SFTI) to identify and analyze ionospheric irregularities. Defined as the dispersion of vertical TEC (VTEC) in a small area at a given time, $SFTI = \sqrt{<VTEC^2> - <VTEC>^2}$, SFTI is a measure of the spatial variation of the ionospheric irregularities, which have scale lengths from a few meters to several tens of kilometers. The data used in this study are carrier phase of the dual frequency GNSS signals from GNSS Earth Observation Network (GEONET) consisting of more than 1200 GNSS receivers. A relative slant TEC was first obtained from the differential phase at 30-s intervals, which contains carrier phase bias that combines ambiguity and hardware delays. Assuming the ionosphere is a single layer at an altitude of 400 km, vertical TEC was converted from slant TEC by applying a mapping function that is secant of the zenith at ionospheric piercing point (IPP). The cutoff angle of satellite elevation is set to be 10° to use as much data as possible. With a convolution algorithm applied, the carrier phase bias can be estimated with a very high accuracy, which consequently ensures the calculating ionospheric TEC with the uncertainty lower than 1.0 TECU.

The criterion for SFTI calculation demands more than 10 measurements of VTEC. To distinguish the ionospheric irregularities, we set a threshold to SFTI>2 TECU. The size of the specific area can be chosen as 0.8°× 0.8° in longitude and latitude, is computed for an area of about 77km x 95km in longitude and latitude at 400 km height for a location at 35°N. The location of SFTI is defined by the center of the area. Two dimensional SFTI is obtained by a sliding window method with 0.1° as the sliding step. An SFTI map was made by projecting the SFTI values on the Earth from the ionospheric pierce point at 400 km altitude. It can be used to obtain the size, shape, orientation and intensity distribution of the irregularity structures.

With a series of SFTI maps, we analyzed three strong irregularity events on 12 February 2000, 20 March 2001 and 10 November 2004. While different from one another in appearing time and spatial scale, the irregularities in the three events are found to consist of branching structures, which are anisotropic and elongate along

longitudinal direction when first seen at low latitudes. The structures can drift and eventually move perpendicular to their orientations. It is concluded that SFTI will provide a detailed view of irregularity development and help to understand the process of irregularity generation.