Study of ionosphere over Japan by using three-dimensional GPS-TEC tomography

Mamoru Yamamoto* (1), Ryo Mizuno (1), Susumu Saito (2), and Akinori Saito(3)
(1) Research Institute for Sustainable Humanosphere, Kyoto University, Uji, Kyoto, Japan
(2) Electronic Navigation Research Institute, Chofu, Tokyo, JAPAN
(3) Department of Geophysics, Kyoto University, Sakyo, Kyoto, JAPAN

1. Introduction

Measurement of ionospheric total electron content (TEC) by using ground-based GPS receivers is now widely used, which we refer to as GPS-TEC. This technique is suitable for constant monitoring of the ionosphere as there are always several GPS satellites available at any location at any timing. One of the most dense and well-known network of the GPS receivers is GEONET (GNSS Earth observation network system) operated by Geospatial Information Authority of Japan (GSI). This is the network of more than 1300 stations over Japan. We have been developing three-dimensional (3D) tomography analysis based on the GEONET data to know the ionospheric plasma density distribution over Japan [1, 2]. The tomography technique is the constrained least-squares fitting method that is to reduce both the least-squares error of the analysis and keep fluctuation of the density distribution to some extent. In this technique, we do not need to start the analysis from pre-defined initial distribution using a density model like IRI. There is a report that this tomography technique can resolve ionospheric perturbations of 200 km wavelength [3].

2. Realtime analysis and further studies

Recently we developed the software system to conduct the tomography analysis in the real-time basis. The realtime GONET data are provided by Electronic Navigation Research Institute (ENRI) where data at 200 stations are selected from total 1300 sites. The software determines the bias of both GPS satellite and receivers at every hour, and use them to estimate the absolute TEC. Analysis products from the software are two-dimensional (horizontal) mapping of the absolute GPS-TEC, and 3D GPS-TEC tomography results, both obtained at every 15 minutes. Calculation speed of the tomography analysis is less than 10 minutes by the LINUX PC. The whole software system is written in Python. We started this online analysis from April 2016, and open the results on the web page of http://www.enri.go.jp/cnspub/tomo3/.

We are now in the process of further development. There are thee directions; 1) Comparison of our analysis with other observations. Limited comparison with COSMIC occultation and ionosonde measurements were good, but more studies are necessary. 2) Analysis of past GEONET data. GONET archives the GPS data since 1996. It would be possible to obtain at least 20 years of tomography analysis. We now try to conduct every-15-minute and 200-receiver analysis for years by using the supercomputer at Kyoto University. 3) Web development. Brush-up of the web data service is now underway. In the presentation, we will report status of the 3D GPS-TEC analysis at that time.

Key words: GPS-TEC. 3D tomography, GEONET, Real-time monitor of ionosphere

3. References

