

RECENT RESEARCH ACTIVITIES

Three-dimensional tomography of the ionosphere over Japan based on GPS-TEC observations

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Real-time information of the ionospheric electron distribution is important for the correction of the measurement errors in satellite navigation. We developed three-dimensional ionosphere tomographic analysis system under collaboration with Dr. Susumu Saito at Electronic Navigation Research Institute, Dr. C.-H. Chen at National Cheng Kung University (Taiwan), and Dr. Akinori Saito at Graduate School of Science, Kyoto University. The tomography is based on the GPS-TEC data from selected 200 stations of GOENET, and the analysis technique reported by Gopi et al. [1]. The developed system consists of four parallel processes; parallel decoding of BINEX binary data, estimation of instrument bias, two-dimensional fluctuated and absolute TEC distribution analyses and the three-dimensional tomographic analysis. The real-time tomography started in April 2016. The 3D ionospheric plasma distribution is obtained at every 15 minutes with about 6 minutes latency, and the results are open to public from <http://www.enri.go.jp/cnspub/tomo3/> [2]. An example results on June 27, 2016 is shown in Figure 1.

We now try to improve this real-time system. The first point is to analyze past data. We keep the same way as to the real-time analysis. As the real-time system use 200 selected stations, we selected the same number of stations on January 1st of each year. Also, in order to improve computation speed of this analysis, we ported our analysis system to the super computer system A (Camphor 2) of Kyoto University. This super computer consists of 1800 nodes, and each node comprises 68 cores and 112GB of memory. We assigned 10-day data analysis to each node, and used 37 nodes to analysis one-year data. This whole one-year analysis takes about 10 hours, which corresponds to about 230 times improvement of the computation time. Also, in the future, we will enhance our analysis area by including data from Korea and/or Taiwan.

References

- [1] Seemala, G. K., Yamamoto, M., Saito, A. and Chen, C.-H.: Three-dimensional GPS ionospheric tomography over Japan using constrained least squares, *J. Geophys. Res. Space Phys.*, **119**, 3044-3052, 2014.
- [2] Saito, S., S. Suzuki, M. Yamamoto, C.-H. Chen, and A. Saito, Real-time ionosphere monitoring by three-dimensional tomography over Japan, *J. Inst. Navig.*, in press, 2017.

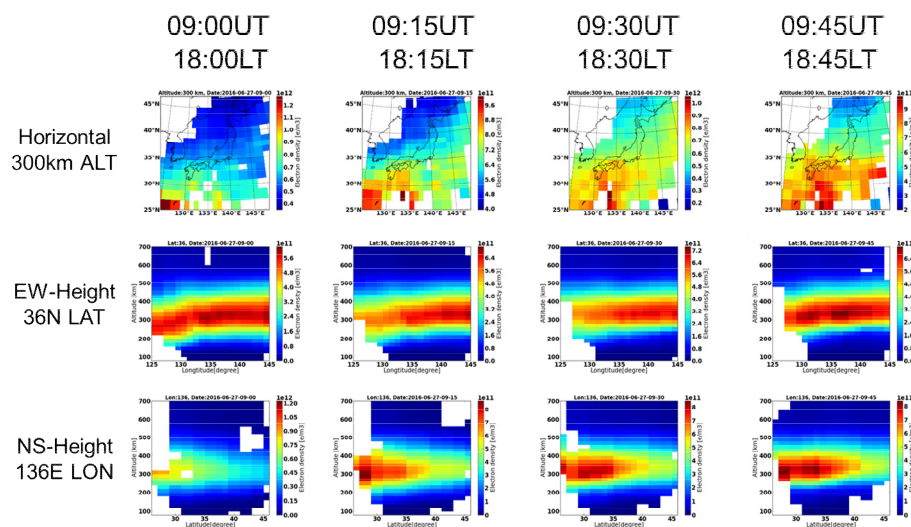


Figure 1: Example of real-time 3D tomography of the ionospheric plasma density over Japan. The real-time analyses are conducted at every 15 minutes with about 6 minutes latency [2].