URSI GASS 2023, Sapporo, Japan, 19 – 26 August 2023

Characterization of Ionospheric Spatial Decorrelation for GNSS-based Aeronautical Navigation Systems

Susumu Saito*(1), Maho Nakamura(1), Takayuki Yoshihara, Minh Le Huy(2), Thang Nguyen Chien(2), Slamet Supriadi(3), Prayitno Abadi(3), and Dwiko Unggul Prabowo(3)
(1) Electronic Navigation Research Institute, National Institute of Maritime, Port and Aviation Technology, Tokyo, Japan; e-mail: susaito@mpat.go.jp; m-nakamura@mpat.go.jp; yosihara@mpat.go.jp
(2) Institute of Geophysics, Vietnam Academy of Science and Technology, Hanoi, Vietnam
(3) National Research and Innovation Agency, Bandung, Indonesia

The global navigation satellite system (GNSS) is deemed to be a main sensor for air navigation. The ground-based GNSS augmentation system (GBAS) is a GNSS-based air navigation system which is based on the differential GNSS technique and can support approach and landing of aircraft under low visibility conditions. In air navigation, extremely high level of integrity and availability are required at the same time. Because the currently available GBAS systems are based on the single-frequency GNSS signals, the propagation delay of the GNSS signals by the ionosphere is one of the major error sources. Although the differential GNSS technique can eliminate most of the errors induced by the ionosphere, it is still necessary to protect users from remaining errors with high level of integrity.

In the magnetic mid-latitude region, GBAS systems have already been implemented for operational use. In the magnetic low latitude region, however, no GBAS systems has been implemented yet because the ionosphere can be highly irregular in the region especially when the equatorial plasma bubble (EPB) occur.

To estimate remaining errors and protect users from navigation errors exceeding the maximum allowed levels, variability of the ionosphere is characterized as the "ionospheric threat model." It is often described as a front of the ionospheric delay gradient characterized by its slope, depth, width and velocity. The slope of the ionospheric gradient has been modeled for the Asia and Pacific region by consolidating data from the region [1]. However, other three parameters have not been well defined yet in the region. Furthermore, the value may be too conservative for in some part of the region. For example, the slope would be steeper around the equatorial ionization anomaly crest where the background ionospheric density is high. Thus, it is useful to investigate intra-regional variation of the ionospheric threat model parameters to help implementing GBAS systems in the low magnetic latitude region.

We have installed two sets of GNSS receivers in Hanoi, Vietnam and Bandung Indonesia. The receiver set consists of three GNSS receivers with mutual distances of typically 10 km. Observations started from 2019 and 2021 at Hanoi and Bandung, respectively. The data are analyzed by using the method developed in [2]. The results shows that the number of EPB occurrences are increasing with the increasing solar activities. Characteristics of the ionospheric gradients at the two locations will be reported and the similarity/dissimilarity will be discussed.

References

[1] S. Saito, S. Sunda, J. Lee, S. Pullen, S. Supriadi, T. Yoshihara, M. Terkildsen, F. Lecat, and ICAO APANPIRG Ionospheric Studies Task Force, "Ionospheric delay gradient model for GBAS in the Asia-Pacific region," *GPS Solutions*, **21**, 2017, pp. 1937-1947, doi: 10.1007/s10291-017-0662-1.

[2] S. Saito and T. Yoshihara, "Evaluation of extreme ionospheric total electron content gradient associated with plasma bubbles for GNSS Ground-Based Augmentation System," *Radio Science*, 52, 2017, pp. 951-962, doi: 10.1002/2017RS006291.