Effects of the plasma bubble on the ground-based augmentation system

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To meet the increasing air traffic, navigation systems with the global navigation satellite systems (GNSS) are required. Since the accuracy with GNSS only is not enough for precision approach, the ground-based augmentation system (GBAS) has been developed with international standards. In GBAS, reference stations on the ground measure errors and augmentation messages are broadcast to aircraft.

Ionospheric delay is the most serious error source in single-frequency GBAS. Local ionospheric total electron content (TEC) gradient results in different ionospheric delays between the reference stations and aircraft, which lead to increased positioning errors. Since extremely high safety is required for aviation, ionospheric inhomogeneity prevents advanced use of GNSS for aviation.

The storm enhanced density (SED) or plasma bubble are ionospheric phenomena which associate sharp gradient of TEC. In magnetic low latitudes including Japan, the plasma bubble must be taken into account carefully.

Electronic Navigation Research Institute (ENRI) has been conducting radio and optical observations of the ionosphere. However, the amount of data is not enough to evaluate the effects of the plasma bubble on the GBAS. To conduct safety analysis for various cases with different ionospheric, system, and aircraft conditions, we have developed an ionospheric model which take into account the plasma bubble based on the knowledge acquired in the long history of the plasma bubble study.

In this paper, we report the effects of the plasma bubble on the GBAS based on analysis with our model as well as what is required to the space weather from the point of view of the aviation application of GNSS.