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Observation of ionospheric disturbance using GPS, and evaluation of their impact on air navigation augmentation system

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In recent years, GPS has been utilized for navigation system for airplanes. Propagation delays in the ionosphere due to total electron content (TEC) between GPS satellite and receiver cause large positioning errors. In precision measurement using GPS, the ionospheric delay correction is generally conducted using both GPS L1 and L2 frequencies. However, L2 frequency is not internationally accepted as air navigation band, so it is not available for positioning directly in air navigation. In air navigation, not only positioning accuracy but safety is important, so augmentation systems are required to ensure the safety. Augmentation systems such as the satellite-based augmentation system (SBAS) or the ground-based augmentation system (GBAS) are being developed and some of them are already in operation.

GBAS is available in a relatively narrow area around airports. In general, it corrects for the combined effects of multiple sources of positioning errors simultaneously, including satellite clock and orbital information errors, ionospheric delay errors, and tropospheric delay errors, using the differential corrections broadcast by GBAS ground station. However, if the spatial ionospheric delay gradient exists in the area, correction errors remain even after correction by GBAS. It must be a threat to GBAS.

In this study, we use the GPS data provided by the Geographical Survey Institute in Japan. From the GPS data, TEC is obtained every 30 seconds. We select 6 observation points from 26.4 to 35.6 degrees north latitude in Japan, and analyze TEC data of these points from 2001 to 2011. Then we reveal dependences of Rate of TEC change Index (ROTI) on latitude, season, and solar activity statistically. ROTI is the root-mean-square deviation of time subtraction of TEC within 5 minutes. In the result, it is the midnight of the spring and the summer of the solar maximum in the point of 26.4 degrees north latitude that the value of ROTI becomes the largest. We think it is caused by plasma bubbles, and the maximum value of ROTI is about 6 TECU/min. Since it is thought that ROTI is an index representing the spatial ionospheric delay gradient, we can evaluate the effect of spatial ionospheric delay gradient to GBAS. More detailed results will be reported in this presentation.

Keywords: ionosphere, GPS, satellite navigation, GBAS, ROTI