A study of equatorial plasma bubble structure using VHF radar and GNSS scintillations over the low-latitude region

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The ionospheric irregularity can cause the deleterious effects on the signal in space, such as global navigation satellite system (GNSS) signals. In low-latitude region, the irregularity of the electron density in the ionosphere frequently occurs, which is called the equatorial plasma bubble (EPB). The amplitude GNSS scintillations are caused by the Fresnel diffraction with the irregularities 300 to 500 meters scale sizes depending on the wavelengths corresponding to the signal frequency, which are L1 (1575.4 MHz), L2 (1227.6 MHz), and L5 (1176.45 MHz). The ionospheric irregularity with spatial scale sizes of a few meters associated with EPBs have been detected by VHF band. Multi-beam observations by a VHF radar can show precise spatial structures of EPBs. In this work, we aim to achieve a better understanding of the EPB effects on the multi-frequency GNSS signals by analyzing the amplitude scintillation index (S4) and relate it with the EPB structures. The multi-constellation and multi-frequency (MC/MF) GNSS scintillation receiver which is installed at Kototabang (geographic; 0.20S, 100.32E) is utilized to observe the signals from GPS and Galileo constellations at the frequencies of L1 and L5. The Equatorial Atmosphere Radar (EAR) which is located at the same site and operated at 47.0 MHz is used to detect the EPB structures. We compare the EPB structures shown by the EAR with the S4 indices at each ionospheric pierce points (IPPs) of GNSS signals. Figure 1 shows the spatial distribution of EAR echoes which are mapped at a certain altitude of 350 kilometers and the GNSS IPPs with S4 indices which are mapped from the altitudes of 250 (the black dots) and 350 (the red dots) kilometers to the same altitude of the EAR echoes. With this result, the three-dimensional relationship between the EPB structure and GNSS signal paths can be found. We consider inside the echo area, the S4 value of GPS satellite (G26) is equal to 0.07 and Galileo (E30) is 0.13. In this case, the signal of the G26 passes through only the lower portion of the EPB, which would be considered as the reason why the S4 enhancement is not significant but just noticeable. Further detailed analysis of the S4 enhancements of MC/MF GNSS signals with EPB structures will be presented at the meeting.

Keywords: Equatorial plasma bubble, Scintillation, VHF radar