Sporadic E Signatures in Radio Signals and their Application for the Study of Medium-Scale Traveling Ionospheric Disturbances

Woo Kyoung Lee[1], Hyosub Kil[2] and Young-Sil Kwak[1]

[1]Korea Astronomy and Space Science Institute, Daejeon, South Korea
[2]Johns Hopkins University Applied Physics Laboratory, Laurel, Maryland, USA

We investigate the occurrence climatology of sporadic E by analyzing the GPS radio occultation (RO) data provided by CHAMP satellite in 2002-2008 and by COSMIC satellite in 2006-2014 and discuss the role of sporadic E in the creation of medium-scale traveling ionospheric disturbances (MSTIDs). Es is a thin transient ionospheric layer with high electron density occurring at 80-130km altitude. MSTIDs are wave-like ionospheric disturbances in the middle latitude F region that have the wavelength of a few hundred kilometers and propagate to a specific direction with the phase velocity of ~100 m/s. Sporadic E has been suggested as an important source of MSTIDs, but their relationship has not yet been rigorously investigated by comparing their global behavior. We first validate the signatures of sporadic E in RO data by comparing the observations of CHAMP and COSMIC RO data. The observations of the E region by a radar and an ionosonde in Korea are also used for the validation. Using the electron density irregularities as the detection proxies, we derive the global distribution of MSTIDs from CHAMP and Swarm satellite observations. The validity of the proxies is validated by comparing with the MSTID signatures in the total electron content (TEC) perturbation maps over Japan. The characteristics of sporadic E obtained from our preliminary analysis of CHAMP data can be summarized as follows: (1) the occurrence of sporadic is pronounced during summer in both hemispheres, (2) the occurrence rate does not show a notable local time dependence, (3) the longitudinal variation of the occurrence rate is pronounced with the peak occurrence rate in the Asian sector in the northern hemisphere during the June solstices and in the American-Western Pacific sector in the southern hemisphere during the December solstices, and (4) the solar cycle dependence of the occurrence rate is not obvious. We assess these characteristics by comparing with the results obtained from COSMIC RO data and ground-based observations. Some of these characteristics agree with the characteristics of MSTIDs derived from the CHAMP and Swarm satellite observations. The high occurrence rate of MSTIDs during the solstices can be explained by the effect of sporadic E in the conjugate hemisphere. The high occurrence rate of MSTIDs in the Asian sector during the June solstices is also consistent with the behavior of sporadic E. However, the longitudinal distribution of MSTIDs during the December solstices is not explained satisfactorily in association with sporadic E. The discrepancy between the behavior of sporadic E and MSTIDs is on the solar cycle dependence; the occurrence rate of sporadic E does not show any notable solar cycle dependence while that of MSTIDs shows a clearly decreasing trend with a decrease of the solar activity. This discrepancy may be related to the solar cycle dependence of the growth rate of the Perkins instability, but the effect of seed perturbations such as gravity waves may not be ignorable. By conducting numerical calculations, we investigate to what extent the solar cycle dependence of the MSTID activity can be explained in terms of the variation of the growth rate with the solar cycle.