Solar flare effects of the D-region ionosphere using daytime tweek atmospherics and VLF/LF standard radio waves

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It has been known that intensity and phase of very low frequency (VLF, 3-30 kHz)/low frequency (LF, 30-300 kHz) transmitter signals significantly change due to intense ionization by solar flares [e.g., Mitra, 1974; Thomson et al., 2005]. The duration of the D-region enhancements due to X-ray is easier to be estimated using the VLF/LF waves, because the relaxation time for recombination in the D-region ionosphere is short to be within ~100 s [e.g., Ohya et al., 2015]. Santolik and Kolmasova [2017] showed daytime tweek atmospherics (1.5-10.0 kHz) did not become observable for two hours at least just after a solar flare of M2.2 class, which suggests large absorption due to the solar flare. In this study, we investigate solar flare effects on the D-region ionosphere using tweek atmospherics and VLF/LF transmitter signals. We analyzed the daytime tweek atmospherics observed at Moshiri (44.37N, 142.27E), Japan, during several M-class flares occurred in 2015. The sampling frequency was 20 kHz, and the wideband VLF data were recorded for each two minute at 20-22 and 50-52 minutes every hour. The transmitters used in this study were NWC (21.817S, 114.167E, 19.8 kHz), JJI (32.05N, 130.82E, 22.2 kHz), JJY40kHz (37.37N, 140.85E), JJY60kHz (33.47N, 130.18E), and BPC (34.63N, 115.83E, 68.5 kHz).The receivers were PTK (Pontianak, Indonesia, 0.003N, 109.367E), and SGR (Sasaguri, Japan, 33.632N, 130.505E). The occurrence rate of the tweeks after the M-class solar flares was smaller than that before the flares except for a M2.0-class flare. When the distance between the sub-solar point and the middle point of the VLF/LF paths decreased, amplitude of the variations in the VLF/LF phase and time difference between onsets of variations in X-ray flux and the VLF/LF intensity increased for a few M-class solar flares. It suggests that the D-region ionization near the sub-solar point was more intense than that located away from the sub-solar point. In the session, we will show the results in detail and discuss the solar flare effects on the D-region ionosphere.

