Sub-ionospheric effects of volcano eruptions using VLF/LF standard radio waves

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Several studies for the F-region ionosphere associated with volcano eruptions based on GPS-TEC data have been reported so far (e.g., Heki, 2006; Dautermann et al., 2009; Heki et al., 2010). These studies reported that acoustic waves excited by volcano eruptions reach up to the F-region ionosphere and caused F-region perturbations. After eruption of the Kelud Volcano, Indonesia, in February 2014, acoustic resonance between the Earth's surface and lower thermosphere was reported based on TEC data and the seismic wave data (Nakashima et al., 2015). However, little studies on the D-region ionosphere associated with volcano eruptions have been reported. In this study, we investigate the D-region effects of eruptions of Sakurajima volcano (31.59N, 130.66E), Japan, and Eyjafjallajokull (63.63N, 19.63W), Iceland, using intensity and phase of VLF/LF transmitter signals. The VLF/LF propagation paths used in this study were JJY60 kHz - TWN (Taiwan), JJI (22.2 kHz) - TWN, and NRK (37.5 kHz) - NYA (Norway). As for eruptions of Sakurajima volcano at 04:11 UT on June 6, 2014, based on wavelet spectra, the variations of both intensities (JJY60kHz - TWN and JJI - TWN) had a frequency of 2-6 mHz during 04:12-04:30 UT after the eruptions. We compared the VLF/LF variations with atmospheric pressure data obtained by an infrasonic meter observed by Sakurajima Volcano Research Center, Kyoto University, and seismic waves in the NIED F-net data (FUK, STM, and SBR) located close to the JJY-TNN path. The atmospheric pressure and vertical velocity of the seismic waves had the similar frequencies of 2-10 mHz during 04:12-04:47 UT. As for eruptions of Eyjafjallajokull at 05:55 UT on April 14, 2010, the intensity of transmitter signals (NRK- NYA) increased by about 2 dB after the eruption. Frequencies of 0.8-1.5 mHz and 2-10 mHz appeared during 06:12-06:18 UT. The variations in the VLF/LF intensity with the common frequencies of the 2-10 mHz for two eruption events could be caused by acoustic resonance between the Earth's surface and lower thermosphere, or by acoustic or atmospheric gravity waves generated by volcanic eruptions. However, variations in the VLF/LF intensity with the frequencies of 0.8-1.5 mHz have not been reported so far. In the presentation, we will show the results of these eruption events and discuss the cause of the VLF/LF variations in more detail.