

## Ionospheric disturbances by volcanic explosions: Observations with GNSS

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There have been numbers of reports that atmospheric waves, e.g. internal gravity waves and acoustic waves, excited by various natural or artificial phenomena on the ground, shake up the ionospheric F layer as high as 300 km [Calais et al., 1998 GJI; Heki and Ping, 2005 EPSL]. Acoustic waves from volcanic eruptions are observed as infrasound in near fields, but they also propagate upward and cause ionospheric disturbances [Heki, 2007 GRL]. We try to reveal the characteristics of ionospheric disturbances caused by volcanic explosions using Total Electron Content (TEC) data derived at the dense array of ~1240 Global Navigation Satellite System (GNSS) stations in the Japanese GEONET.

Heki [2006] detected TEC changes of ~0.1 TECU in the region to the south - southeast of the volcano ~10 minutes after the explosion of the Asama Volcano, central Japan, on Sep. 1, 2004, at 11:02 UT. He estimated the atmospheric wave energy from the amplitude of TEC disturbances, and inferred the explosion energy by comparing the TEC change amplitudes with those caused by an artificial explosion with known energy [Calais et al., 1998]. Later, Dautermann et al. [2009 JGR] performed a similar study for the 2003 explosion of the volcano in the Montserrat Island, West Indies.

Here we report on the TEC disturbances caused by the explosion of the Kirishima-Shinmoe volcano, southern Kyushu, Jan. 31 2011, 22:54 UT. According to the JMA documents issued in 2011 January, this explosion induced the infrasound of ~458 Pa, which blasted some window glasses in Kirishima-city, Kagoshima. We also detected 0.2-0.3 TECU peak-to-peak amplitude disturbances after the 2009 October explosion of the Sakurajima volcano, southern Kyushu. They appeared 10 minutes after the explosion and propagated southward with a sound speed at the F layer height. In contrast to the period of ~4 minutes of typical coseismic ionospheric disturbances, TEC changes by volcanic explosions were found to have periods of ~2 minutes or shorter.

In the presentation, we will compare new examples of ionospheric disturbances by volcanic explosions, such as the 2011 Shinmoe and 2009 Sakurajima cases, with older cases such as the 2004 Asama case.

Keywords: GPS, GNSS, infrasound, acoustic wave, volcanic explosion, ionosphere