Energy estimation of the 2004/Sep/1 Asama explosion with ionospheric disturbances

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Ionospheric Total Electron Content (TEC) can be easily measured with the phase differences of the L1 and L2 carrier waves from GPS satellites. TEC disturbances have been offering new unique views of various phenomena in earth sciences (Heki and Ping, 2005). They include reports on coseismic ionospheric disturbance of the 2003 Tokachi-oki earthquake, constraint on the source process of the 2004 Sumatra earthquake with ionospheric disturbances, and radio occultation measurement of sudden increase of TEC by solar flares. Here I report a new approach to estimate the energy of a volcanic explosion with ionospheric disturbances for the 2004/Sep/01 11:02 UT eruption of Mt. Asama, Japan. Traveling ionospheric disturbances with amplitude of 0.14 TECU, period of about 2 minutes, and apparent propagation speed of 1.1 km/sec, were found to start to propagate about ten minutes after the first explosion. They were observed in the sky 100-200 km south of the volcano (height about 300 km)in the signals of the satellite 15 received at GPS stations mainly in the Kansai District. From the observed velocity and period, they are considered to be electron density fluctuation associated with the horizontal propagation of acoustic waves through the ionosphere, a phenomenon similar to the case of the 2003 Tokachi-oki earthquake. This is the first detection of ionospheric disturbance by a volcanic eruption since the 1980 explosion of Mount St. Helens (Roberts et al., 1982). Calais et al. (1998) observed ionospheric disturbances of 0.03 TECU after a 1.5 Kt mine blast in a US coal mine. By comparing the (1) incidence angle between the acoustic wavefront and the satellite-receiver line-of-sight, (2) background TEC, (3) difference in the disturbance amplitude, between the two cases, the total explosion energy of the Asama eruption is inferred to be about 33 Kt (=1.2e14 Joule). This is about one third of the 1938 Asama eruption (Minakami, 1942), but different from the value inferred for the same explosion by Yokoo et al. (2005) from the volume deficit by two orders of magnitude. I further assumed that the observed ionospheric disturbance is a part of the spherical wave propagated from the volcano, and estimated the total airwave energy integrated over time and space following the method by Johnson (2003). The estimated energy is about 9 MJ, many orders of magnitude smaller than the total explosion energy, but is quite normal among the values of such energies estimated for various past explosions by Johnson (2003). In addition to conventional methods to estimate the energy of a volcanic eruption, ionospheric disturbance offers a promising brand-new approach for the purpose.

Calais, E. et al., Ionospheric signature of surface mine blasts from GPS measurements, GJI, 132, 191, 1998.

Heki, K. and J. Ping, Directivity and apparent velocity of coseismic ionospheric disturbances observed with a dense GPS array, EPSL, 236, 845, 2005.

Johnson, J.B., Generation and propagation of infrasonic airwaves from volcanic eruptions, JVGR, 121, 1, 2003.

Roberts, D.H. et al., A large amplitude traveling ionospheric disturbance produced by the May 18, 1980, explosion of Mount St. Helens, JGR, 87, 6291, 1982.

Yokoo, A. et al., Asama explosion of September 1st, 2004, On the damage to glass windows and estimation of explosion energy, Kazan, 50, 195, 2005. (in Japanese)