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Near Field Ionospheric Disturbance by the 2014 Kelud Volcano Observed by GNSS-TEC

NAKASHIMA, Yuki[1*] ; HEKI, Kosuke[1] ; TAKEO, Akiko[1] ; CAHYADI, Mokhamad nur[2] ; ADITIYA, Arif[3]

[1]Department of Earth Sciences, Hokkaido University, [2]Sepuluh Nopember Institute of Technology, [3]Geospatial Information Agency (BIG)

The Kelud volcano, eastern part of the Java Island, Indonesia, erupted on 13 February 2014. This Plinian eruption recorded the strength 4 in the Volcanic Explosivity Index (VEI). Ionospheric wave from the eruption was detected by the Global Navigation Satellite Systems - Total Electron Contents (GNSS-TEC) method around the volcano. The ionospheric results were compared with seismic records, and the whole excitation scenario has been studied.

The raw GNSS data files in the Receiver Independent Exchange Format (RINEX) were obtained from 37 GNSS stations, and the TEC information has been extracted from them. These stations were located in the Java, the Sumatra and other small islands around the volcano, and are operated by Badan Informasi Geospatial (BIG), International GNSS Service (IGS) and Sumatra GPS Array (SuGAr).

The ionospheric oscillations were detected from slant TEC time series. They continued from 16:25 UT to 19:00 UT, and propagated as fast as ˜1.0 km/s. The oscillation had frequency peaks at 3.7 mHz, 4.6 mHz, and 6.7 mHz. The former two components coincide with the two lowest atmospheric eigenfrequencies. The 6.7 mHz may correspond to one of the higher modes.

GEOFON (15 broadband seismometers; STS-1) also detected seismic waves excited by the eruption. The time series showed one Rayleigh pulse at 16:15 UT, and following continuous acoustic waves. One of the GEOFON stations, UGM, is located about 200 km away from the volcano. The seismic wave of the eruption was clear and the components with periods 200-300 sec continued from 16:25 to 19:00. It lasted ˜1 hour longer than shorter period components. GSN (78 broadband seismometers; STS-2) recorded the Rayleigh wave from the erupting volcano. Their spectrogram had several clear peaks at frequencies, 3.7 mHz, 4.8 mHz, 6.7 mHz, and so on. Some of the components have been excited by atmospheric free oscillation.

These observations indicate the GNSS-TEC results detected free oscillation of the atmosphere excited by continuous Plinian eruption. This oscillation continued over an hour.

More realistic eigenfrequencies must be inferred in the future considering the atmospheric structure in the region surrounding the Kelud volcano. It must be compared with other observations, for example infrasound data or airglow, and be considered the mechanism of the excitation in detail.

Keywords: GNSS, GPS, Volcano, Ionosphere, Infrasound, Atmospheric resonance