

Ionospheric effects caused by June 11-16, 2009 Sarychev Peak volcano eruption

*Nikolai Shestakov^{1,2}, Alexander Orlykovskii², Natalia Perevalova³, Nikolai Titkov⁴, Danila Chebrov⁴, Mako Ohzono^{5,6}, Hiroaki Takahashi⁵, Evgenii Lialushko²

1. Institute for Applied Mathematics FEB RAS, Vladivostok, Russia, 2. Far Eastern Federal University, Vladivostok, Russia, 3. Institute of Solar-Terrestrial Physics SB RAS, Irkutsk, Russia, 4. Kamchatka Branch of Geophysical Survey of RAS, Petropavlovsk-Kamchatsky, Russia, 5. Institute of Seismology and Volcanology, Hokkaido University, Sapporo, Japan, 6. Earthquake Research Institute, University of Tokyo, Tokyo, Japan

According to numerous studies ionosphere is sensitive to different man-made and natural phenomena such as rocket launches, explosions (mining explosions, nuclear tests and asteroid atmospheric blasts), earthquakes, tsunami, tropical storms, volcano eruptions, etc. Ionospheric reaction to volcano eruptions is still insufficiently studied and understood. In this work we analyzed the ionospheric response to June 11-16, 2009 Sarychev Peak volcano eruption (VEI class 4) by using surrounding Russian and Japanese GPS networks.

Sarychev Peak stratovolcano (elevation 1446 m above the sea level) is situated on Matua Island. It belongs to the Kuril Islands Arc and is located as far as 400 km to the southwest from the Kamchatka Peninsula tip (Russian Federation) and 750 km to the northeast from Hokkaido Island (Japan). Strong explosive eruption of Sarychev Peak volcano occurred after 33 years of inactivity. The active phase of the eruption consisted of two series of explosions separated by 13 hours pause. More than twenty explosions of different strength and duration resulted in eruptive columns of 3-21 km height. Ash plumes propagated within a few hundred up to 800 km from the volcano. The eruption chronology was reconstructed primarily based on satellite data including observations from the International Space Station and infrasonic measurements provided by the International Monitoring System infrasound network. No seismic records of the eruption were obtained by the nearest seismic arrays due to remote location of Matua Island.

Prominent covolcanic TEC disturbances (CVIDs) with amplitudes and periods ranged between 0.03-0.15 TECU and 2.5-4.5 min were discovered for the three eruptive events occurred at 18:51 UT, June 14; at 01:15 and 09:18 UT, June 15. The estimates of apparent CVIDs velocities vary within 700-1000 m/s in the far-field zone (300-900 km to the southwest from the volcano) and 1300-1800 m/s in close proximity to Sarychev Peak. The obtained characteristics of the observed TEC variations allow us to attribute them to acoustic mode. The south-southwestward direction is preferred for CVIDs propagation. We concluded that the ionospheric response to a volcano eruption is mainly determined by a ratio between explosion strength and background ionization level. A few evidences of secondary (F2-layer) CVIDs source eccentric location were obtained. The limited observation data amount remains this question opened for the future investigations.

This work was supported by RFBR grant 20-05-00509a and grants of JSPS KAKENHI numbers 19H01984, 20KK0073, 25257204

Keywords: volcanic eruption, explosion, covolcanic ionospheric disturbances, GNSS, acoustic mode