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Ionospheric co-seismic signatures at far and near distances from the earthquake epicenters

Jaroslav Chum (1), Jann-Yenq Liu (2), Miguel Cabrera (), Jan Zednik (), Jan Lastovicka (), Jiri Fiser (), and Zbysek Mosna ()

(1) Institute of Atmospheric Physics CAS, Bocni II/1401, 14131 Prague 4, Czech Republic, (2) Institute of Space Science, National Central University, Chung-Li 320, Taiwan, (3) Laboratorio de Telecomunicaciones. Facultad de Ciencias Exactas y Tecnología, (4) Institute of Geophysics CAS, Bocni II/1401, 14131 Prague 4, Czech Republic

Ionospheric signatures of three recent large earthquakes observed by continuous Doppler sounding are presented. The co-seismic signatures of 11 March 2011 Tohoku M9.0 earthquake were observed ∼9000 km away from the epicenter in the Czech Republic. The ionospheric responses to 25 April 2015 Nepal M7.8 earthquake were recorded in Taiwan (∼3700 km from the epicenter) and in the Czech Republic (∼ 6300 km from the epicenter). The ionospheric disturbances caused by the 16 September 2015 Chile M8.3 earthquake were measured over Tucumán, Argentina, about 800 km from the epicenter.

It is shown that the ionospheric disturbances can be in all these cases associated with long period infrasound waves that were excited locally by vertical component of the ground surface motion and propagated nearly vertically to the ionosphere. The infrasound waves are heavily damped at the heights of F2 layer, so their amplitudes strongly depend on the altitudes of observations, which can be obtained from nearby ionosondes and/or simulations. Consequently, under specific conditions, the observed ionospheric response at larger distances from the epicenter can be comparable with the observed ionospheric response at shorter distances, although the amplitudes of causative seismic motions differ significantly.

The wave packets observed in the ionosphere far outside the epicenter resemble the wave packets of vertical component of the local ground surface motion. The observed co-seismic wave packet near the epicenter (∼800 km) however has different shape. It is shown that this shape cannot be explained by linear theory of infrasound propagation, including attenuation. It is documented that non-linear effects owing to large infrasound amplitudes in the upper atmosphere play an important role.