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Infrasound in the ionosphere and disturbances triggered by earthquakes

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We report an overview of observation of infrasound waves in the ionosphere over the Czech Republic by multi-point Continuous Doppler sounding system. We conclude that these observations are rare. The infrasound waves of periods about 3 minutes (∼2.5 to ∼4.5 minutes) were observed in the case of passages of extreme convective systems or cold fronts.
Unusually strong infrasound waves (large Doppler shift frequencies) with mean periods about 50 s were observed about 9 minutes after the arrival of seismic waves excited by the 11 March 2011 Tohoku earthquake (M∼9). This time delay is consistent with vertical propagation of infrasound from the ground below (not from epicenter) to the height of observation (210-220 km). For several wave packets, the fluctuations of Doppler shift frequencies showed very good (0.98) cross-correlation with the vertical velocity of the ground surface motion. The individual wave packets recorded on the ground had different observed horizontal velocities and corresponded to different types of seismic waves. A comparison of the vertical velocities of ground motion with oscillation velocities of air particles in the ionosphere (derived from Doppler shift measurements) indicates that about 1/10 of the infrasound energy flux excited at the ground reached the altitudes of ∼210-220 km for wave periods longer than ∼30 s. A similar phenomenon was also observed for the 17 February 2010 earthquake near Chile coast.
It is also shown that to get reasonable oscillation velocities of air particles from the observed Doppler shift frequencies a simple mirror-like approximation of reflection of sounding radio waves (radar formula) cannot be used. It is necessary to consider the value of electron density gradient at the reflection height, and air (plasma) compression owing to the infrasound wave.