Co-seismic signatures and precursors of the 26 December 2004 M9.3 Sumatra earthquake

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An Mw 9.3 earthquake originated in the Indian Ocean off the western coast of northern Sumatra at 00:58:53 Universal Time (UT) on 26 December 2004. Both co-seismic signatures triggered by the Rayleigh wave, atmospheric gravity waves, and tsunami, as well as precursors of the earthquake is observed.

Two giant ionospheric disturbances at 01:19 and 04:10 UT are observed by a network of digital Doppler sounders in Taiwan. The first disturbance excited mainly by Rayleigh waves, which consists of a packet of short-period Doppler shift variations, results in vertical ionospheric fluctuations with a maximum velocity of about 70 m/s and displacement of about 200 m. The second disturbance, in a W-shaped pulse propagating at a horizontal speed of 360 ± 70 m/s, is attributable to coupling of the atmospheric gravity waves (AGW) excited by broad crustal uplift together with the following big tsunami waves around the earthquake source zone. The accompanying ionosonde data suggest that the AGW in the atmosphere may have caused the ionosphere to move up and down by about 40 km (Liu et al., 2006a).

Tsunami ionospheric disturbances (TIDs) of the earthquake are detected by the total electron content (TEC) of ground-based receivers of the global positioning system (GPS) in the Indian Ocean area. It is found that the tsunami waves triggered atmospheric disturbances near the sea surface, which then traveled upward with an average velocity of about 730 m/s (2700 km/hr) into the ionosphere and significantly disturbed the electron density within it. Results further show that the TIDs, which have maximum height of about 8.6–17.2 km, periods of 10–20 min, and horizontal wavelengths of 120–240 km, travel away from the epicenter with an average horizontal speed of about 700 km/hr (190 m/s) in the ionosphere (Liu et al., 2006b).

A time series of plots and a sequence of global ionosphere maps (GIMs) derived respectively from regional and worldwide ground-based receivers of the global positioning system (GPS) is used to monitor variations of total electron content (TEC) before the earthquake. The temporal variations of the GIM show that the ionospheric TEC significantly decreases during the afternoon period of 21 December 2004 which is day 5 prior to the earthquake. Moreover, the spatial distributions of the minimum TEC in the GIM reasonably locate the epicenter of the Sumatra earthquake (Liu and Chen, 2007, to be submitted).

Results show that the mechanisms induce the co-seismic signatures and precursors are different. The fore is related to mechanical motions of the earth surface and the later is most likely associated with electromagnetic.

References

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