Origin of the ahead of tsunami traveling ionospheric disturbances during Sumatra tsunami and offshore forecasting

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The 26 December 2004 Sumatra megathrust (~15 m maximum slip) earthquake (Mw 9.1–9.3) [Lay et al., 2005; Banerjee et al., 2007] was the first great magnitude seismic event to occur since the advent of modern space geodesy. Moreover, the earthquake generated the most devastating tsunami (maximum intensity of ~6.5 m) in history and the largest ever recorded in the offshore region of northwestern Sumatra so far. The presence of ionospheric disturbances associated with Sumatra 2004 tsunami that propagated ahead of tsunami itself has previously been identified. Dasgupta et al. [2006] reported the tsunami-induced ionospheric disturbances in GPS TEC observations at the Indian coast about 90 min prior to the actual Sumatra tsunami arrival. However, their origin was unresolved. Focusing on their origin mechanism, we documented these ionospheric disturbances referred as Ahead of tsunami Traveling Ionospheric Disturbances (ATIDs). Using total electron content (TEC) data from GPS Aided GEO Augmented Navigation GPS receivers located near the Indian east coast, we had first confirmed the ATIDs presence in TEC at the Indian east coast.

We proposed a simulation study based on tsunami-atmospheric-ionospheric (TAI) coupling that considers tsunamigenic acoustic gravity waves (AGWs) to excite these disturbances. Sumatra tsunami simulated parameters [Sladen and Hébert, 2008] served as input to the TAI simulation model. The simulated dynamics involve the excitations of primary AGWs from the tsunami forcing, their dissipation in the thermosphere, and subsequent generation of secondary AGWs in the thermosphere [Kherani et al., 2016]. Although both primary and secondary waves contribute to ATIDs, the dissipation of transverse mode of the primary waves is fundamentally responsible for their generation. In this process, the horizontal momentum associated with the transverse mode provides essential thrust (i.e., secondary forcing) for the generation of secondary waves and so for the ATIDs which then propagates dominantly horizontally due to the horizontal thrust. Moreover, the associated longitudinal secondary mode acquires longer (as compared to the primary) horizontal wavelength, leading to the faster speed (as compared to the tsunami) of ATIDs, equals to the acoustic speed in the thermosphere.

The simulation corroborated the excitation of ATIDs with characteristics similar to the observations. Therefore, we assume that the present study offer an alternative theoretical tool to monitor the offshore ATIDs where observations are either rare or not available and could be potentially important for the tsunami early warning [Bagiya et al., 2017]. The present talk will discuss the above briefed observations and simulation results in detail.

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