Hydromagnetic simulation of the ionospheric anomalies generated by the 2011 Tohoku-oki tsunami and associated acoustic-gravity waves

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Recent Japan tsunami that occurred on 11 March 2011 over Tohoku-Oki caused enormous damage in terms of human life and infrastructures. Moreover, it triggered nuclear catastrophe that makes it a global disaster and much more alarming. The growing concern is towards failure of short-term forecasting of this event in spite that the Japan is densely populated with the various ground based seismic instrument as well with the GPS receivers that may detect the activities in the space related to the tsunami. However, owing to these dense networks, this event is examined much more deeply than other big events in the past, leading to the knowledge of various interesting aspects that may be helpful in the future for the short-term forecasting of such event. One such aspect is that the effects of the seismic activities occurring deep into the ocean, are detected much more efficiently and in varieties in space (in the overlying atmosphere and ionosphere) than in the ocean or Earths surface. In the present work, hydrodynamic and hydromagnetic simulations of the atmospheric and ionospheric anomalies are performed for the Tohoku-Oki tsunami (11 March 2011). The Tsunami-Atmosphere-Ionosphere (TAI) coupling mechanism via acoustic gravity waves (AGWs) is explored theoretically using the TAI coupled model. In this mechanism, tsunami in the ocean excites the AGWs in the atmosphere owing to the vertical uplift which subsequently interact with the ionosphere to gives rise density, electric and magnetic field disturbances or anomalies. For the modeled tsunami wave as an input, the coupled model simulates the wind, density and temperature disturbances or anomalies in the atmosphere and electron density/magnetic anomalies in the F region of the ionosphere. Also presented are the GPS-TEC and ground-based magnetometer measurements during first hour of tsunami and good agreements are found between modeled and observed anomalies. The high frequency component $\sim$ 10 minutes of the simulated wind, TEC and magnetic anomalies in the F region develops within 6-7 minutes after the initiation of the tsunami, suggesting the importance of monitoring the high-frequency atmospheric/ionospheric anomalies for the early warning. These anomalies are found to maximize across the epicenter in the direction opposite to the tsunami propagation suggesting that the large atmospheric/ionospheric disturbances are excited in the region where tsunami does not travel.