GLOBAL ATMOSPHERIC AND IONOSPHERIC DISTURBANCES CAUSED BY THE SUMATRA TSUNAMI

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Lee et al. [2008] reported observations of unusual global atmospheric and ionospheric disturbances that they attributed to the Sumatra earthquake and subsequent tsunami. The primary measurements were of ionospheric plasma dynamics acquired by the 430 MHz incoherent scatter radar (ISR) and two ionosondes near the Arecibo Observatory between 20:00 and 24:00 local time (LT) on December 25 and 26, 2004. These data were supplemented by observations from an extensive network of Global Positioning System (GPS) satellite monitors. The ISR detected very different ionospheric behaviors during the vertical-transmission periods on the consecutive, magnetically quiet nights. On the night of December 25 the ionosphere descended smoothly and spread F signatures faded (cf. Figure 1). For about two hours on the evening of December 26 the bottomside of the ionospheric F layer rose by ~50 km, inducing plasma irregularities and intense spread F. Alternating cycles of bottom-side plasma rising and falling persisted through the remainder of the experiments (cf. Figure 2).

December 26 experiments were conducted about a day after an $M_W = 9.2$ earthquake launched tsunami waves first into the Indian, and subsequently into the Atlantic and Pacific Oceans. The different radar responses were verified in GPS-based measurements of regional TEC, indicating that during the observation period of December 26 gravity waves passed Puerto Rico causing plasma in the ISR field-of-view to rise and fall.

Figure 3 schematically represents two interpretive scenarios that are consistent with the timing of the Arecibo and GPS observations. In Scenario 1 large-scale "solitary type" gravity waves propagated along a great circle toward Arecibo. Based on simulations by *Titov et al.* [2008], Scenario 2 suggests that causative gravity waves were launched by the part of the tsunami wave train that propagated into the Atlantic Ocean. GPS data recorded in Asia, Europe, and the Caribbean indicate that global travelling ionospheric disturbances (TIDs) were induced when tsunami-launched gravity waves reached ionospheric altitudes, supporting Scenarios 1 & 2 illustrated in Figure 3. Both scenarios postulate that energy leaks into the ionosphere from imperfectly ducted gravity waves, in this case over Puerto Rico. Wind-velocity fields of the gravity waves caused local ionospheric plasma to rise, thereby exciting irregularities in the bottomside of the F layer via the generalized Rayleigh-Taylor instability.

The possibility of seismic events can affect space weather halfway around the world on the following day was surprising and motivated us to conduct further investigations of gravity-wave induced ionospheric plasma turbulence over Arecibo, Puerto Rico. Over the past several years we have focused on effects of anomalous heating as remote sources for generating gravity waves. Radio and optical instruments have been used, including Arecibo ISR, ionosondes, Fabry-Perot Interferometer, GPS receivers, All Sky Imaging System (ASIS) for multi-diagnostics of gravity wave-induced ionospheric plasma effects. Simulation experiments were recently conducted at Gakona, Alaska, using the HF ionospheric heating facility to produce gravity waves. Preliminary experimental results and their theoretical interpretation will be presented.

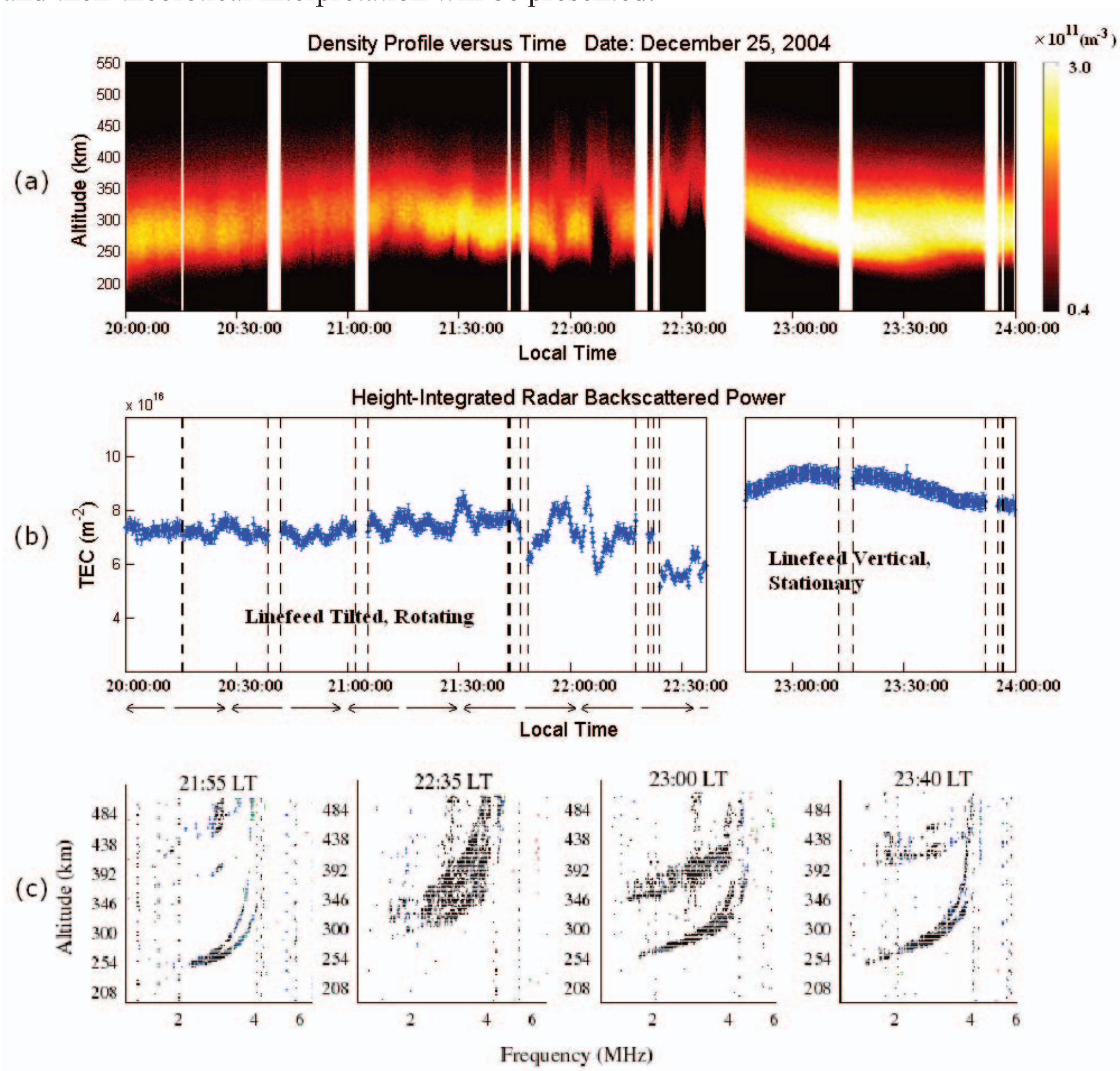

Figure 1. (a) The range-time-intensity (RTI) plot of radar backscatter power recorded on December 25, 2004 from 20:00:00 to 24:00:00 local time (LT). (b) The computed TEC is based on the height-integrated radar backscatter power and plotted as a function of local time. (c) Four representative ionograms recorded during the experiments, to monitor the local ionospheric plasma conditions.

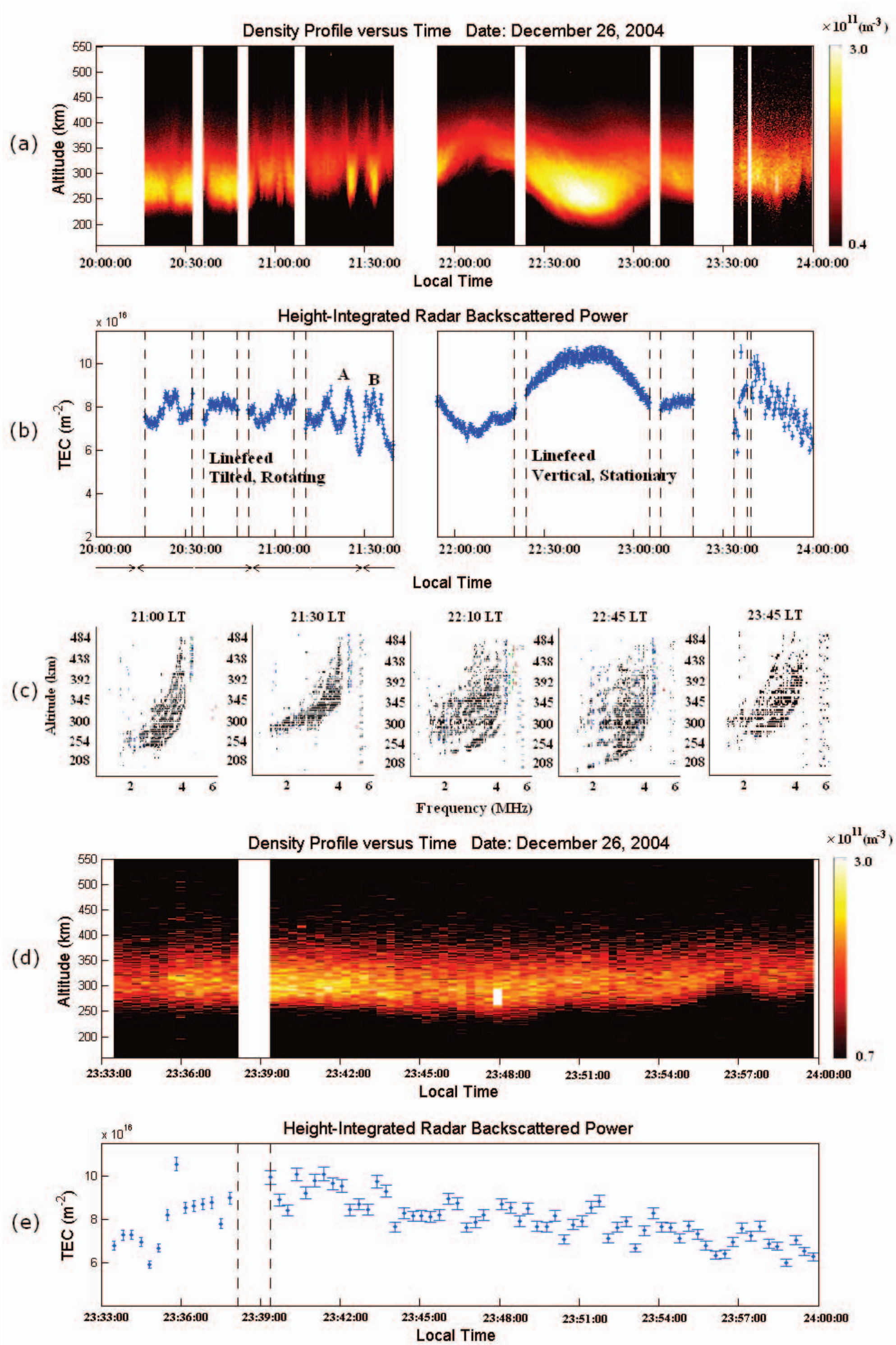

Figure 2. (a) The range-time-intensity (RTI) plot of radar backscatter power recorded on December 26, 2004 from 20:16:21 to 24:00:00 local time (LT). (b) The computed TEC is based on the height-integrated radar backscatter power and plotted as a function of local time. (c) Five representative ionograms recorded during the experiments that demonstrate the excitation of spread F and naturally occurring ionospheric plasma turbulence. (d) Enlarged RTI plot recorded from 23:33 to 24:00 LT. (e) The corresponding computed TEC from 23:33 to 24:00 LT.

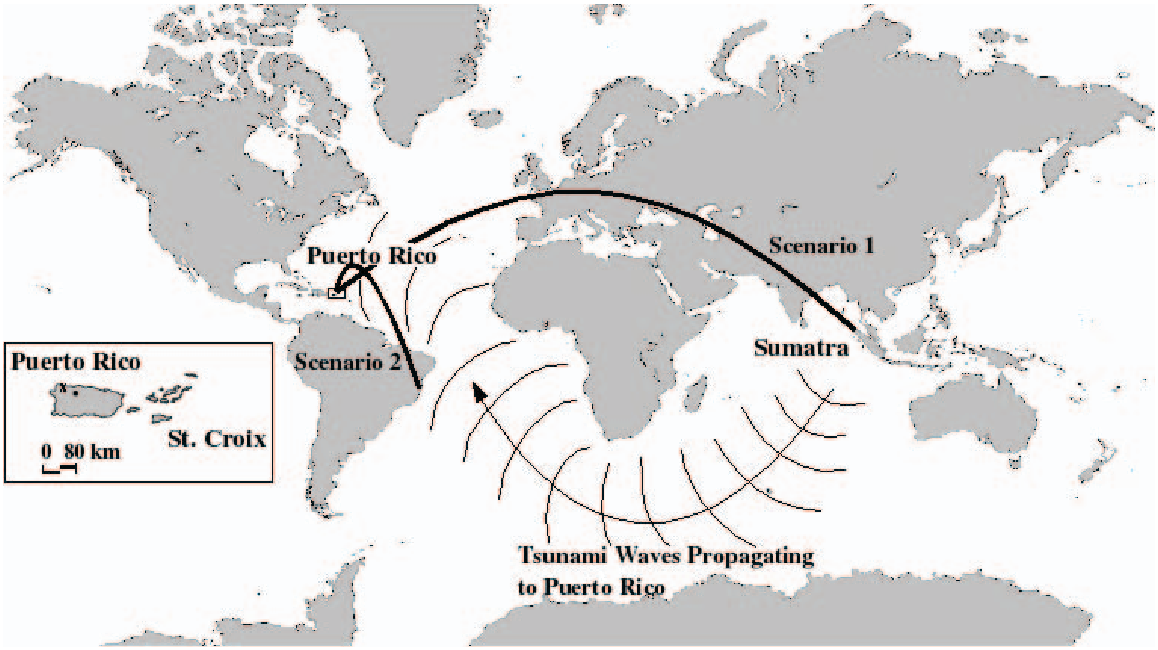

Figure 3. Mercator projection of gravity-wave propagation paths illustrating Scenario 1: along a great circle between northern Sumatra and Puerto Rico and Scenario 2: from moving tsunami waves propagating toward Puerto Rico in the South Atlantic Ocean.

References

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