URSI - RCRS 2022, IIT (Indore), India, 1 - 4 December, 2022

Atmospheric Origin of Global Long-Period Rayleigh Waves during the 2022 Hunga Tonga-Hunga Ha'apai Volcanic eruptions

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On January 15, 2022, at ~04:14:45 UTC (UTC + 13:00 hrs), the Hunga Tonga-Hunga Ha'apai (~20.55°S ~175.39°W) volcano exploded violently ejecting a large amount of volcanic matter which rose up to stratospheric heights in the atmosphere. A sub-aerial eruption initiated at ~15:20 UTC on January 13, 2022, (but 04:20 Local Time on January 14, 2022) generated an umbrella-shaped eruption plume that reached up to 20 km high in the atmosphere and spread laterally ~260 km. The middle part of the volcanic island was also annihilated by this sub-aerial eruption. The global ionospheric wave perturbations of acoustic and gravity frequencies produced by powerful eruptions that occurred on 15 January are well documented (e.g. Zhang et al. 2022[1]). The Global Positioning System (GPS) - Total Electron Content (TEC) based ionospheric measurements, in the vicinity of the volcanic source region (~1000 km), revealed prolonged ionospheric perturbations centered at ~3.7 mHz and ~4.4 mHz frequencies during the volcanic eruptions of 14-15 January 2022. Besides these, global seismometers marked a strong spectral peak at ~3.7 mHz exhibiting the presence of long-period Rayleigh seismic waves (acoustic normal mode). The prolonged ionospheric perturbations are produced by the trapped atmospheric acoustic modes triggered by the volcanic eruption[2] that subsequently excited the seismic spheroidal modes. Several studies reporting multi-parametric observations of atmospheric-ionospheric response to the powerful eruption of 15 January are available in the literature (e.g. Mantoza et al. 2022[3] and reference therein). However, this is probably the first detailed study revealing the acoustic resonant coupling between the solid earth and the atmosphere and subsequent generation of seismic spheroidal modes during the Hunga Tonga-Hunga Ha'apai volcanic eruptions.

Ref:

1. Zhang S-R, Vierinen J, Aa E, Goncharenko LP, Erickson PJ, Rideout W, Coster AJ and Spicher A (2022) 2022 Tonga Volcanic Eruption Induced Global Propagation of Ionospheric Disturbances via Lamb Waves. Front. Astron. Space Sci. 9:871275. doi: 10.3389/fspas.2022.871275.

2. Watada, S., and H. Kanamori (2010), Acoustic resonant oscillations between the atmosphere and the solid earth during the 1991 Mt. Pinatubo eruption, J. Geophys. Res., 115, B12319, doi:10.1029/2010JB007747.

3. Mantoza et al., Atmospheric waves and global seismoacoustic observations of the January 2022 Hunga eruption, Tonga, Science Vol. 377, pp. 95-100, doi:10.1126/science. abo7063 (2022).