Toward A Global Real-Time Tsunami Monitoring Network Using GNSS-Derived Ionospheric Disturbances: 2022 Tonga Eruption

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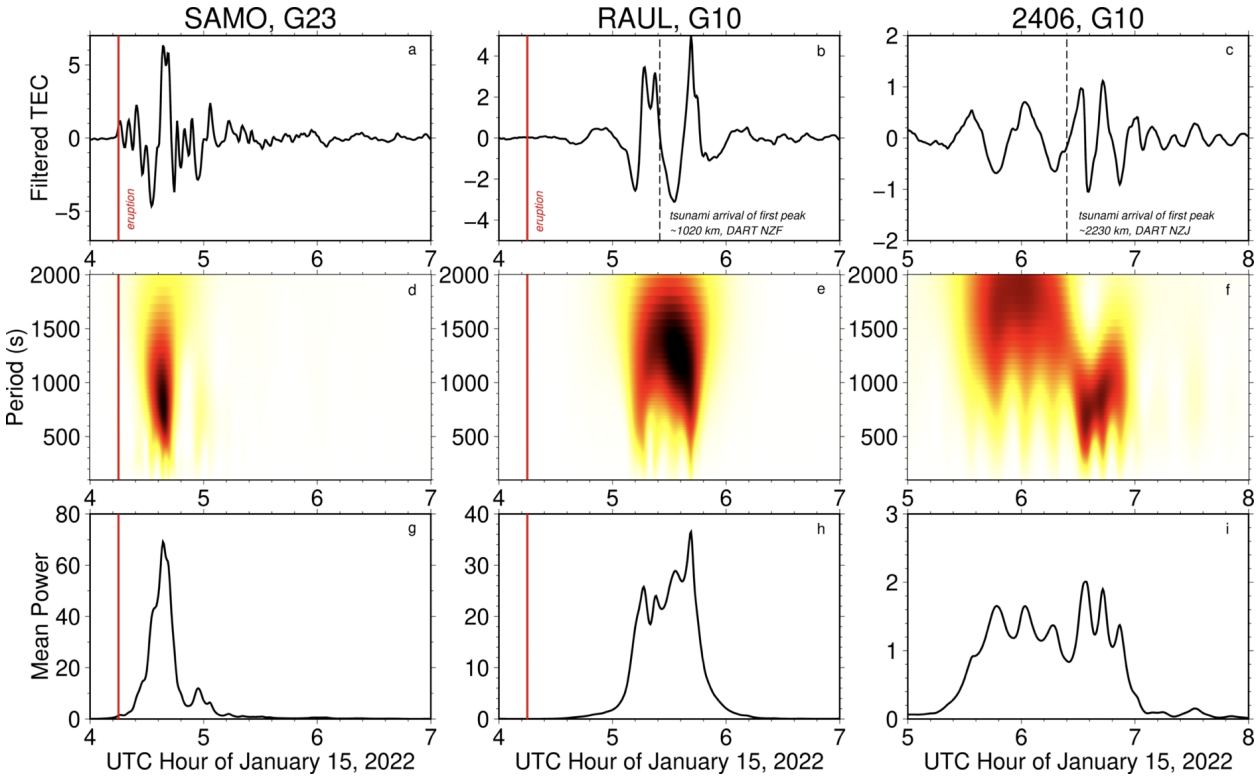
The eruption of Hunga Tonga-Hunga Ha'apai (HTHH) on 15 January 2022 generated a series of tsunamis that crossed the Pacific basin. Given that ocean-spanning tsunami models are largely designed around earthquake source mechanisms, traditional warning systems were ill-equipped to accurately forecast the arrival times, showing the need for a holistic approach to tsunami monitoring. It is well established that the ionosphere, an electrically charged layer of Earth's atmosphere, registers acoustic-gravity waves produced in natural events as perturbations to ions within this layer. These Traveling Ionospheric Disturbances (TIDs) offer valuable information about atmospheric and oceanic behavior during the Tonga eruption and tsunami in areas where conventional monitoring tools are not available. By performing spectral analyses on Global Navigation Satellite Systems (GNSS) data over the southwest Pacific during the event, we show that the eruption's acoustic waves and tsunami's gravity waves can be isolated within the TIDs. Specifically, we highlight that the acoustic and tsunami phases are superpositioned as far away as Samoa, but have separated by the time TIDs are over northern New Zealand. We validate tsunami-generated TIDs against DART buoy data where available. This ionospheric phase separation provides the basis of continued work in which we explore whether observations from Tonga hold true for other tsunami events and whether the isolated tsunami phase can act as a trigger to warn of an incoming tsunami.



Comparison of ionospheric disturbances observed from satellite-receiver pairs G23-SAMO (a, d, and g), G10-RAUL (b, e, and h), and G10-2406 (c, f, and i) following climactic eruption. Image shows separation of two phases at distinct periods, which we have classified as acoustic- and tsunami-generated disturbances. This interpretation is supported by timing of arrival of actual tsunami's first peak (Gusman and Roger, 2022), which separates the TID phases.

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