Tsunamis converted from meteotsunamis of the 2022 Tonga eruption

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A large eruption occurred at the Hunga Tonga-Hunga Ha' apai volcano in Tonga on 15 January 2022. Wavefield excited by the eruption in the atmosphere and ocean has been investigated using records observed by worldwide multivariant sensors (e.g., Kubota et al. 2022): atmospheric disturbances, called Lamb wave, were observed over the world as a first arrival, and meteotsunamis were observed at the timing of the Lamb wave arrivals in the ocean, but at slight delays at the shore surrounding the Pacific Ocean. A numerical simulation study (Sekizawa and Kohyama, 2022) reported that the meteotsunamis (forced wave) propagate as tsunamis (free wave) when they propagate at the bathymetric slope to the shore (decreasing water depth). In order to observe the transformation from meteotsunamis to tsunamis, dense arrays of sensors were needed at the slope region in the ocean.
A dense offshore observation network, the Seafloor Observation Network for Earthquakes and Tsunamis (S-net: Kanazawa et al. 2013; Aoi et al. 2020), has been recently constructed with 150 stations off the eastern coast of Japan. Each station contains absolute pressure gauges (APGs), and these APGs observed the meteotsunamis due to the eruption. In this study, we investigate the wavefield of the meteotsunami and its conversion to tsunamis using the APG records.
To measure the propagation velocity and incoming direction of meteotsunamis, we set 282 triangular subarrays (triads, Okuwaki et al. 2021) which consist of adjacent three stations of S-net. Assuming a plane wave incident to each triad, we estimate the propagation velocity and incoming direction of meteotsunamis that explain the differential travel times of three stations.
Our results show that the estimated propagation velocities near the Japan Trench are 0.3 km/s (Fig. 1(a)), but those tend to be linked to the dispersion relation of tsunamis, , at water depth < 2000 m, where g and H are the gravitational constant and water depth, respectively (Figs. 1(a) and (b)). This indicates that meteotsunamis are transformed to tsunamis within the observation region of S-net. Moreover, the maximum amplitude distribution shows that the amplitudes at the southern part of S-net are larger than those at the northern part (Fig. 1(c)). It is considered that this difference is caused by the shoaling effects of tsunamis, and this also indicates the transformation from the meteotsunamis to tsunamis. Our results indicate that (1) the sea level changes observed right after the Lamb wave arrivals at the coast of Japan are caused by tsunamis converted from the meteotsunamis, and (2) the amplitudes of the converted tsunamis are controlled by the incoming direction of the Lamb wave because the shoaling effects are affected by the slope gradient of the bathymetry.

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Keywords: The 2022 Tonga eruption, Meteotsunamis, Tsunamis

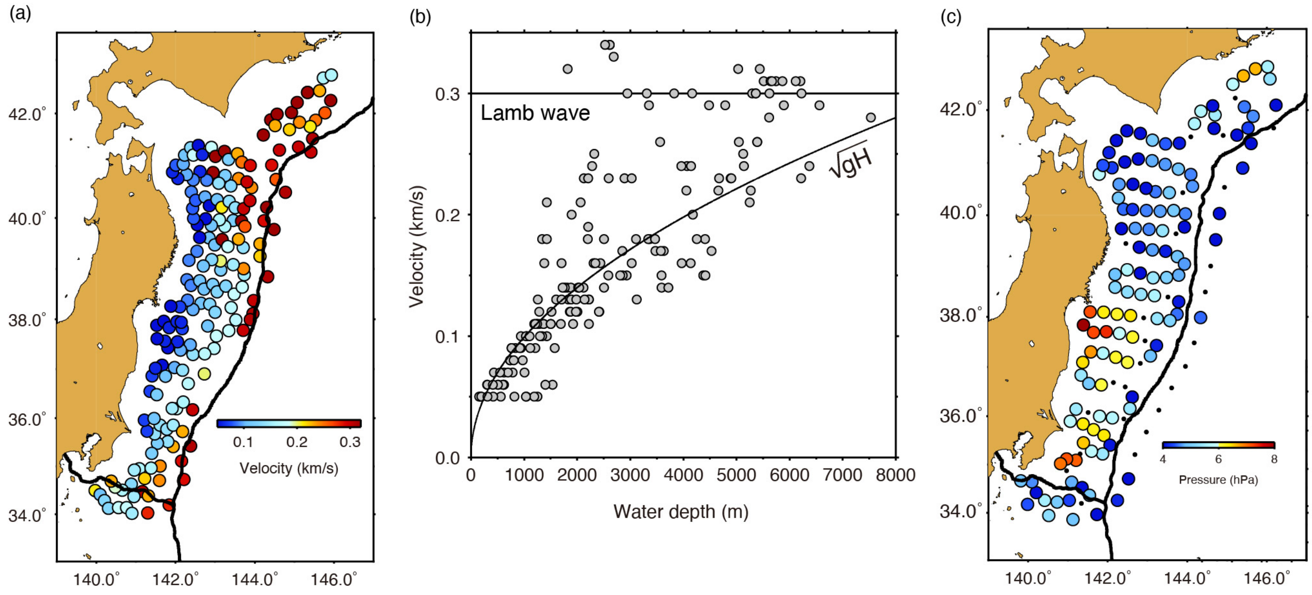

Fig. 1 (a) Propagation velocity of meteotsunamis. (b) Plots for propagation velocity versus water depth. (c) Maximum amplitude distribution of meteotsunamis.