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Volcanic meteo-tsunamis in Southeast Asia: A first-time assessment

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Volcanic meteo-tsunamis are rare and potentially devastating natural phenomena. In physical terms, they are comparable to meteorological tsunamis, where a relatively high atmospheric pressure disturbance leads to the formation of tsunami-like waves. A significant recorded example of volcanic meteo-tsunami is the one produced by the Hunga Tonga – Hunga Ha'apai (HT-HH) eruption in January 2022. Volcanic meteo-tsunamis have the peculiarity to generate waves that propagate beyond landmasses, due to the interaction between the air pressure wave and water, such as those observed in the Gulf of Mexico following the HT-HH eruption; they also move much faster than tsunamis generated by other mechanisms. These features increase the hazard potential of a given volcano, and expose countries that are generally protected by landmasses to tsunami waves. The South China Sea (SCS), for example, is relatively protected to the west and south from Indonesia, to the north from Taiwan, and to the east from the Philippines. However, volcanic meteo-tsunamis may be generated from a volcanic eruption from regions such as southern Japan, and affect the SCS and its surrounding coastlines. Southeast Asia (SEA) presents several records in the literature of volcano-induced tsunami events, including as source mechanisms landslides, Pyroclastic Density Currents, lava dome collapse, and underwater explosions. There are also two instances from Taal, Philippines, and Krakatau, Indonesia, where airwaves have been inferred as a possible tsunami source mechanism, with waves reported also across the Indian and Pacific Oceans, in the latter case. Here, we selected four potential candidates for a submarine or near-surface volcanic eruption, both outside (Kikai and Fukutoku-Oka-no-Ba, Japan) and inside the SCS (Banua Wuhu, Indonesia, and KW-23612, Vietnam), capable of generating volcanic meteo-tsunamis, with the aim to have a first-time assessment from such natural phenomena on SEA countries surrounding the SCS. At this stage, we focused on the general wave propagation in the region, based on the different source locations, and offshore wave maximum height (observed at 16 synthetic tide gauges placed around the SCS, at the 50-m water depth contour, to avoid shallow water complexities near coastlines that cannot be resolved through public bathymetry datasets). We modelled three potential scenarios for each selected seamount, with 100%, 66% and 33% of the HT-HH eruption intensity, respectively. This choice allows us to investigate a broad range of explosion intensities expressed through a perturbance of the atmospheric pressure field, following previous works. Initial results from this first assessment show that bathymetry has a strong control on tsunami wave propagation, being rather fast in deep waters (e.g. northern South China Sea) and much slower in shallow waters (e.g. Sunda Shelf).

The higher waves are recorded at offshore stations 11 (Hong Kong) and 16 (West Philippines), with ~10 and 20 cm respectively, in both cases generated from within the SCS from seamount KW-23612. Work is ongoing to integrate higher resolution grids near these locations closer to coastlines, and also to assess the hazard at other areas on the Sunda Shelf where water depth is larger in proximity of coastlines (e.g. Singapore Strait).