Simulation of the tsunamis associated with the Tonga volcanic eruption on January 15, 2022

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We simulated tsunamis generated from the Hunga Tonga-Hunga Ha'pai volcano eruption on January 15, 2022. The atmospheric waves from the eruption were recorded globally with propagation velocities of ~0.31 km/s (Lamb wave) and 0.20 - 0.24 km/s (atmospheric gravity wave). In the far-field, the tsunamis were recorded earlier than the expected arrival time calculated by long-wave velocity, suggesting that at least the initial part of the observed tsunami was caused by propagating atmospheric waves. We numerically solved the linear long-wave equations in the spherical coordinate system with a grid interval of 24 arc-sec for 20-hour tsunami propagation.
We simulated the tsunami from the moving ring-shape sea surface elevation. The ring is parameterized by its propagation speed and peak amplitude. The amplitude decays with a distance as 1/sqrt(R*sin(delta)), where R is Earth radius, delta is epicentral angle distance. From the comparison at three US DARTs and 10 New Zealand DARTs, we assumed a circular source starting at the eruption time (at 04:15). The observed first phase can be reproduced by a ring with an amplitude of 4 m and a rise time of 10 min, propagating at Lamb wave speed of 0.31 km/s. The corresponding ring width is ~370 km. The later phase can be better reproduced by adding another propagating ring with a negative amplitude and a gravity wave speed of 0.20 - 0.24 km/s. The DART stations around the Pacific indicate that the gravity wave speed is higher toward Japan and South America, while it is slightly slower toward North America. The simulated waveforms roughly reproduced the far-field tsunami waveforms recorded on tide gauge stations, including the later phase, suggesting that the large amplitude wave in the later phase may be due to resonance around tide gauge stations.

Keywords: Hunga Tonga-Hunga Ha'apai volcano eruption, Tsunami simulation, Atmospheric wave

