

Detection of the air-sea waves from the eruption of Hunga-Tonga Hunga-Ha'apai in 2022 by the tsunami back-projection analysis

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In seismology, the back-projection method has been applied to many earthquakes because it can estimate the fault rupture process without any specific a priori information. In this study, we applied the back-projection method to the tsunami records observed by the ocean-bottom pressure gauge (OBPG) arrays to detect air-sea waves from the eruption of Hunga-Tonga Hunga-Ha'apai in 2022.

Hunga-Tonga Hunga-Ha'apai erupted on January 15, and the OBPGs of DONET and S-net recorded the pressure change from around 20:00 JST. This pressure change is considered to be caused by the air waves because (1) the pressure change started earlier than the expected tsunami arrival time and (2) the atmospheric pressure change was observed on the Japanese Islands at the same time.

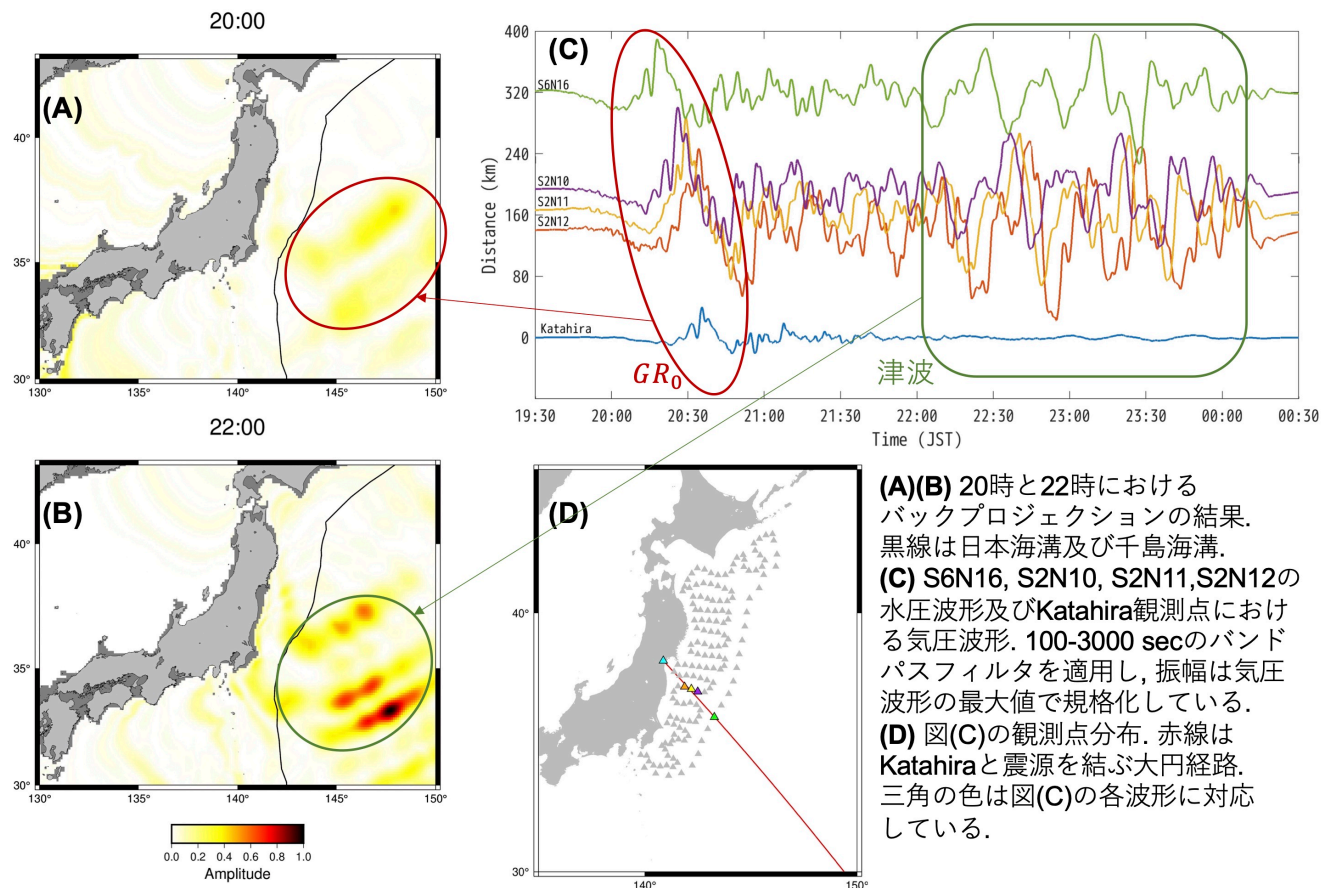
Harkrider and Press (1967) derived the theory of pulse propagation in an atmosphere coupled to an ocean and applied it to air-sea waves excited by the Krakatoa eruption in 1883. They found that the fundamental and 2nd higher modes of atmospheric gravity waves are observed by both barometer and OBPG. On the other hand, the fundamental mode of ocean gravity waves, i.e., tsunami, is observed only by the OBPG.

For the back-projection analysis, we calculated theoretical travel time between each potential source and each station with the linear long-wave approximation. The OBPG records used in the analysis are selected based on the correlation between the raw OBPG records and the theoretical tide model (Matsumoto et al., 2000). The number of stations was 160 with a correlation threshold of 0.9.

Figure 1(A) and (B) shows the result of back-projection analysis at 20:00 and 22:00. At each time, linear wavefronts were propagated from the southwest which is consistent with the location of the volcano.

Figure 1(C) and (D) are the comparison between the records of S-net OBPGs and a barometer. The first arrival wave was observed by both the OBPGs and barometer at around 20:00, but the second wave was only observed by the OBPGs. The propagation speeds of each wave calculated from the great circle path and the arrival time were 294 m/s and 245 m/s, respectively. We can therefore conclude that the waves at 20:00 were caused by the atmospheric gravity waves and the ones at 22:00 were tsunamis or the ocean gravity wave.

Keywords: Back-projection, Hunga-Tonga Hunga-Ha'apai, tsunami



(A)(B) 20時と22時におけるバックプロジェクションの結果。黒線は日本海溝及び千島海溝。
(C) S6N16, S2N10, S2N11, S2N12の水圧波形及びKatahira観測点における気圧波形。100-3000 secのバンドパスフィルタを適用し, 振幅は気圧波形の最大値で規格化している。
(D) 図(C)の観測点分布。赤線はKatahiraと震源を結ぶ大円経路。三角の色は図(C)の各波形に対応している。