EMSO TIME SERIES CONFERENCE
OBSERVING OCEAN SOUND
20-22 OCTOBER 2021
CANARY ISLANDS SPAIN

Propagation from the Pacific to the Atlantic of T-phases by a Kermadec Trench earthquake

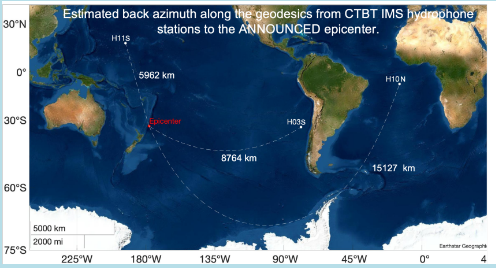
Tiago C.A. Oliveira[1], Ying-Tsong Lin[2], Noriyuki Kushida[3], Sergio Jesus[4], Peter Nielsen[3]

[1] Physics Department & Centre of Environmental and Marine Studies, University of Aveiro, 3810-193 Aveiro, Portugal. toliveira@ua.pt, [2] Applied Ocean Physics and Engineering Department, Woods Hole Oceanographic Institution, Woods Hole, Massachusetts 02543, USA. ytlin@whoi.edu, [3] Comprehensive Nuclear-Test-Ban Treaty Organization, Vienna International Center, 1400 Vienna, Austria. noriyuki.kushida@ctbto.org, peter.nielsen@ctbto.org, [4] Laboratory of Robotics and Engineering Systems, University of Algarve, 8005-135 Faro, Portugal. sjesus@ualg.pt

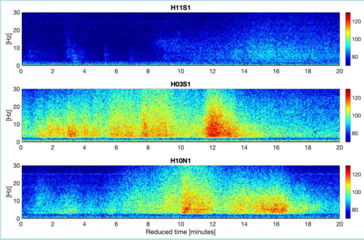
Abstract

On 18 June 2020, energetic underwater acoustic T-phase signals were recorded at the Comprehensive Nuclear-Test-Ban Treaty (CTBT) International Monitoring System (IMS) hydrophone stations in the Pacific (HA11 and HA03) and South Atlantic (HA10) Ocean. In this work, the long-range propagation of these T-phases is investigated. They were associated with an M_w7.4 submarine earthquake with an epicenter in the Kermadec Trench located at approximately 6000, 8800, and 15100 km from HA11, HA03, and HA10, respectively. The recorded T-phases were analyzed using the Progressive Multi-Channel Correlation algorithm (DTKGPMCC) installed on the CTBT Organization (CTBTO) virtual Data Exploitation Centre (vDEC). Different arrivals within the duration of the earthquake were identified, and estimated back azimuth showed variability over time. These results suggest that the T-phases could be triggered at different locations along the Trench and far from the declared earthquake epicenter. Furthermore, the analysis revealed much higher Transmission Loss (TL) in the propagation path to HA11 than to HA03 and to HA10. Moreover, for HA10 and HA11, discrepancies between expected and measured arrival angles were observed. A 3D parabolic equation (3DPE) model is utilized to identify the cause of these differences in TL and arrival angles. Numerical results confirm the importance of 3D effects induced by the, Kermadec Ridge, Fiji archipelago and Marshall Islands on sound propagation to HA11 and Antarctica peninsula to HA10.

The 18 June 2020 M_w7.4 south of the Kermadec Islands earthquake

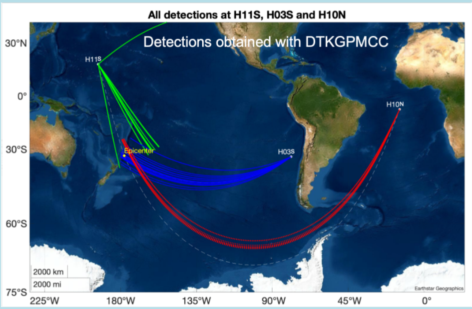


- According to the United States Geological Survey (USGS) earthquake database, a moment magnitude (M_w) 7.4 submarine earthquake occurred on June 18, 2020, at 12:49:53.70 (UTC) in the Kermadec Trench (in the south Pacific Ocean) with epicenter at 33.29°S 177.86°W (uncertainty ± 10km) and depth 10.0 km (uncertainty ± 1.7km).

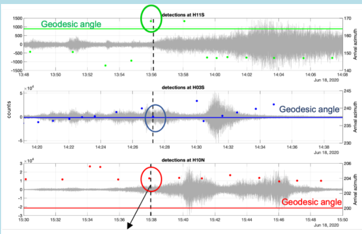


- T-phases from the earthquake were recorded at CTBT IMS hydrophone stations HA11 (Wake Island), HA03 (Juan Fernandez Island), and HA10 (Ascension Island).
- Spectrogram of the T-phase signals indicate higher TL between epicenter and H11S (5962 km) than between epicenter and H03S (8764 km).

Detections at CTBT-IMS hydrophones



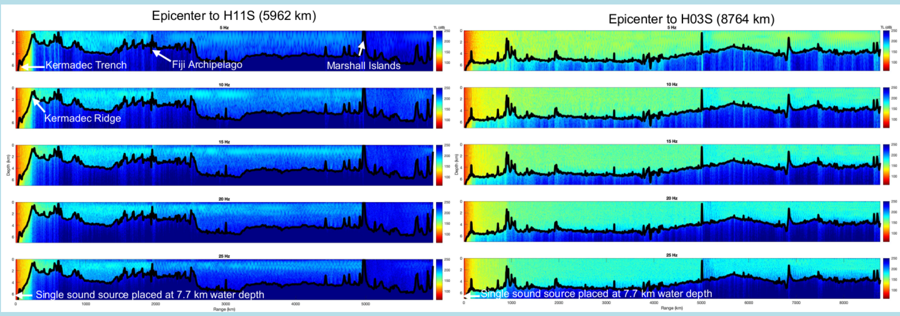
- Several arrivals (detections) were identified at the three hydrophone stations (H11S, H03S and H10N) related with the earthquake. Detections suggest that the source of T-phases was moving during the observation, and the event location could not necessarily correspond to the sound generation point.



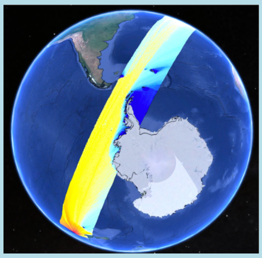
Detection close to the theoretical arrival time (considering c_w=1500m/s)

- Discrepancies between expected and measured arrival angles were observed. For the detection near the theoretical arrival time, the arrival azimuth is higher than the geodesic for H11S (4.4 deg) and H10N (4 deg), and close to the geodesic for H03S (0.3 deg).

Numerical simulations



- TL for 5 to 25 Hz obtained with 3DPE modeling indicates i) high TL when T-phases have to cross the Kermadec Ridge and ii) higher TL between epicenter-H11S (5962 km) than epicenter-H03S (8764 km).



- Depth integrated TL between epicenter and H10N (15127 km) for 5 Hz shows the 3D effects induced by Antarctica peninsula.

CONCLUSIONS

- Data and 3D model results indicate much higher TL between epicenter and H11S (5962 km) than between epicenter and H03S (8764 km);
- High TL is observed when T-phases have to cross the Kermadec Ridge, which is the case of the sound path between epicenter and HA11;
- 3D model indicates significant horizontal reflection between epicenter and H11S (up to ~3 deg) and between epicenter and H10N (up to ~3 deg), and small for H03S (up to ~ 0.4 deg). As expected, horizontal reflection is frequency dependent;
- Numerical results revealed the importance of 3D effects induced by the, Kermadec Ridge, Fiji archipelago and Marshall Islands on sound propagation to HA11 and Antarctica peninsula to HA10.

Disclaimer: The views expressed in this study are those of the authors and do not necessarily reflect those of the Preparatory Commission for the CTBTO.