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Spatial anti-aliasing for T-phase directivity estimation using data from the International Monitoring System (IMS) hydroacoustic network of the Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO)

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IMS hydrophone stations are used to estimate the T-phase back-azimuth from a mega-thrust earthquake. Each IMS hydrophone station consists of two triplets (except for HA01 Cape Leeuwin, Australia, which has only one triplet). The hydrophones of each triplet are suspended in the water, at a depth near the SOFAR channel axis, and form an approximately equilateral triangle with each side 2 kilometers long. With such an arrangement, it is possible to process incoming waves by a technique similar to seismic array analysis. The frequency range applied in the array analysis is chosen to be 0.4 Hz, by assuming the target phase velocity to be 1.5 km/s for T phases. In the present study, data from the recent Chile earthquake on 16 September 2015 is analyzed. The waveforms were received at HA03 and HA11, which are located off Juan Fernández Island (Southeastern Pacific) and off Wake Island (Western Pacific), respectively. The signals from the T-phase originated at the seismic source show peaks in the frequency band up to a few Hz. However, spatial aliasing is observed in the frequency-wavenumber analysis (F-K analysis) if the entire 100 Hz bandwidth of the hydrophones is used, because the distance between hydrophones in the triplet becomes large in comparison to the ratio between phase velocity of T-phase and the frequency. To circumvent the spatial aliasing problem, a three-step processing is applied: (1) high-pass filtering above 1 Hz to retrieve the T-phase, followed by (2) extraction of the envelope to highlight the T-phase contribution, and finally (3) low-pass filtering below 0.4 Hz. The recordings processed in this manner show a good cross-correlation across the triplet. The F-K analysis provides useful back-azimuth and slowness estimations with spatial anti-aliasing. The resulting seismic beamforming both from the HA03 and HA11 sites points towards the earthquake epicenter.