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Observation and interpretation of ocean waveguide impact on long-range, underwater acoustic propagation of recorded hydrophone signals

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The hydrophone stations of the CTBT (Comprehensive Nuclear-Test-Ban Treaty) International Monitoring System (IMS) contribute to a broad range of civil and scientific applications in addition to treaty verification. A notable example of the scientific application of the CTBT hydroacoustic network was the estimation of the location of an unusual impulse-like event detected on 15th November, 2017, in the vicinity of the last known position of the missing Argentine submarine ARA San Juan (EGU General Assembly PICO presentation EGU2018-18559, 2018). The detection and localization capability of the IMS hydroacoustic network was further confirmed by an air-dropped depth charge deployed by the Argentine Navy close to the estimated location of the unusual event in a controlled experiment. The two IMS hydrophone stations used in support of the search of the submarine were HA10 (Ascension Island in the Atlantic Ocean) and HA04 (Crozet Islands in the southern Indian Ocean). The vessel was found resting on the sea-floor at 900 m depth on 17th November, 2018, at a distance of reportedly less than 20 km from the localization estimated and published by CTBTO. The focus of this presentation is on the signals from both the impulse-like event and the depth charge propagating out to a distance of approximately 7700 kilometres along geodesic paths from the event origin through very diverse underwater environments. The impact of the ocean waveguide on the signal propagation over these distances is manifested by strong frequency low-pass filtering and time dispersion of the signal recorded on HA04 compared to the recordings on HA10. Understanding the impact of the waveguide on signal propagation is essential in order to improve signal detection and classification. An interpretation of the signal characteristics recorded on HA10 and HA04 from the impulse-like event and the depth charge is performed by two-dimensional propagation modelling of full time-series including spatially dependent oceanographic database information such as water-column sound-speed structure, bathymetry and sea-ice extent close to Antarctica. The modelling results broadly agree with observed features and point to the importance of adapting detection and classification algorithms to specific propagation paths. In particular, the recordings of the 15th November, 2017, impulse-like event on HA04 exhibit a particular time-frequency behaviour that the modelling results indicate can only appear if the event occurs within a specific depth interval at the source location.