

# Submarine volcanoes and where to find them: Harnessing IMS hydroacoustic data

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Low-frequency underwater sound waves are a key feature of the hydroacoustic waveform component of the International Monitoring System (IMS), a global sensor network maintained by the Comprehensive Nuclear-Test-Ban Treaty Organization in an effort to detect clandestine nuclear explosions in the ocean, in the atmosphere, and underground. However, the potential of IMS data extends beyond test-ban monitoring, for instance, when studying sound phases generated by remote natural sources that otherwise would be difficult to detect, such as submarine earthquakes or volcanic eruptions. Here, we focus on IMS hydrophone recordings of Monowai, a volcanic center in the Kermadec Arc, and Ahyi volcano, located in the Northern Mariana Islands. Tripartite array data are processed using standard cross-correlation and time-difference-of-arrival techniques. Density-based clustering of arrivals at station H03, Juan Fernández Islands, reveals 82 discrete episodes of unrest at Monowai over the course of 3.5-years, making it one of the most active arc volcanoes currently known. IMS data suggests further volcanic activity at both known and unknown sites in the Tonga-Kermadec Arc region. Hydroacoustic recordings of the 2014 eruption at Ahyi show how data analysis can be advanced and streamlined, for example, to determine spectral parameters and acoustic energy release, which has implications for studying volcanic source processes and their respective impact on the ocean soundscape. IMS hydrophone arrays register volcanic seismicity as low as  $\sim 2.5 m_b$  even at megameter distances, thus exceeding the resolution of most regional, land-based networks by more than one order of magnitude. Detectability strongly depends on frequency, source depth, and ray path geometry, which is illustrated by 2D transmission loss modeling for a range of synthetic scenarios. The findings presented here highlight the capabilities of the IMS hydrophone network for remotely detecting and studying volcanic activity in the global ocean.

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