Detecting and Characterizing Submarine Volcanic Eruptions from Land and Sea

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Submarine volcanism accounts for an estimated 75% of the worldwide volume of magmatism, yet it is difficult to detect and characterize, often only being discovered after eruptions have ended. Since 1939, geophysical observations have been reported for at least 129 known or inferred submarine eruptions. About half of these occurred at only 3 seamounts. Thus, the opportunity for scientific discovery and improved monitoring of submarine volcanoes is great, especially with the advances in and growth of geophysical networks. Submarine eruptions are most often detected by water-based hydrophones and OBSs along with land-based seismometers and occasionally infrasound detectors located on sparse islands. While direct seismic phases from volcanic activity can only be detected when seismometers are nearby (typically within ~100 km), hydroacoustic phases can propagate efficiently through the water column and be detected at distances of over 15,000 km. Since information is lost during the conversions between seismic and hydroacoustic phases, both land- and sea-based instruments may be needed to fully understand submarine eruptions.

We characterize the eruptions of Ahyi Seamount, Mariana Islands in 2014 and Bogoslof volcano, Alaska in 2016-2017 using hydrophone and seismic data. The Ahyi eruption comprised thousands of explosions over a 2-week period along with occasional tremor-like activity. While island-based seismometers recorded converted hydroacoustic phases from the eruption, they were too distant (>250 km) to detect direct seismic phases. However, comparisons of the seismically-recorded hydroacoustic phases with those detected by distant hydrophones (~2250 km away) show what information can be obtained with the different types of instruments. In contrast, the Bogoslof eruption lasted much longer, ~8.5 months, and comprised a variety of activity in all three spheres: ground, sea, and atmosphere. It was also much better recorded. Seismometers on nearby islands (~50-80 km away) recorded both seismic and converted hydroacoustic phases. A hydrophone deployed ~7 km from the active vents during the last 3 months of the eruption recorded weaker activity which adds detail and more information to the activity detected by seismometers and infrasound arrays.

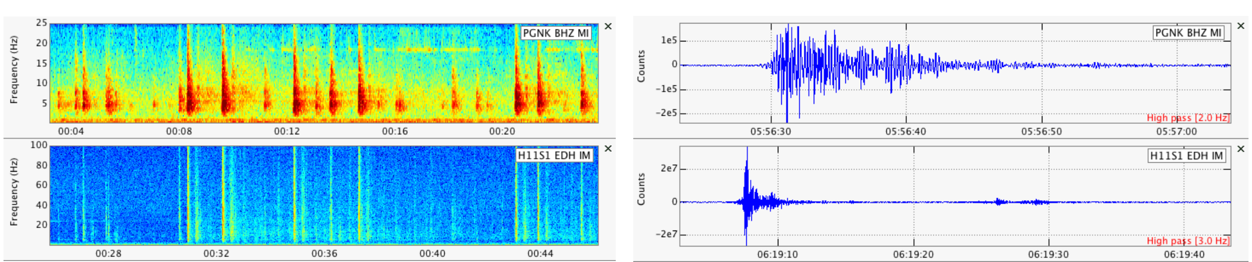

Figure: Seismic (top) and hydroacoustic (bottom) recordings of activity from the 2014 Ahyi eruption. Left: Spectrograms of seismic and hydroacoustic detections after the onset of single events on April 24, adjusted for arrival time delay between receivers. Right: Hydroacoustic phases from a single explosive event on April 24. Note the difference in waveform character between the data types.