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Autonomous hydrophone array for long-term acoustic monitoring in the open ocean

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We are developing an array of new autonomous hydrophones, benefiting from a long-lasting collaboration with the Pacific Marine Environmental Laboratory (NOAA and Oregon state University). The hydrophones are deployed on a mooring line anchored to the seafloor by an expendable anchor weight. The length of the line is adjusted so that the sensor (and buoy) lies in the middle of the SOFAR channel at about 1000m depth for mid-latitudes (depending on the speed-of-sound profile). The buoy at depth keeps the line under tension and prevents wave-motion noise from the sensor. The instrument continuously samples and records the acoustic signals at 240Hz for seismic studies, or 480Hz (or more) for marine mammal studies. The SOFAR channel acts as an acoustic wave-guide in the ocean so that acoustic waves can propagate with little attenuation over long distances. Autonomous hydrophones allow the detection and localization of the low-magnitude (Mw>2.5) seismic activity along oceanic ridges and in deformed intraplate areas, which remains generally undetected or poorly localized by land-based seismic networks. An array of hydrophones can monitor a much wider area (more than 1000 km across) than ocean-bottom seismometers, which suffer from the rapid attenuation of seismic waves in the crust and upper mantle. Arrays of autonomous hydrophones thus succeed in detecting and locating 30 to 50 times more earthquakes than those listed in the catalogs from land-based seismograph stations.

Data are buffered on flash cards and then regularly stored on hard disks or on solid-state drives (e.g. 20Gb of data per year at 240Hz sampling rate). We use 24-bit sigma-delta converters with programmable gain amplifiers. As timing is a key issue for an accurate localisation of the seismic events, instruments are synchronized with GPS time and have a low-power, highly stable calibrated clock (10-8 drift). All electronics and batteries (Li or alcaline) are placed in titanium pressure cases for long-term corrosion resistance.

As neither the occurrence of seismic events, nor the recurrence period between events can be predicted, long-lasting deployments (one to several years) are required. The autonomy of the instruments now allows a turn-over period of up to 2 years. However to retrieve the data at shorter time intervals and to limit the turn-over ship-time costs, we are working on a new generation of disposable instruments with a 5-year autonomy and recoverable messengers containing the data, that could take advantage of ship's opportunities. In open seas and remote areas (e.g. Southern Ocean), this approach may provide a more accessible and cheaper alternative than observatories cabled to shore. Solutions based on real-time acoustic links between the hydrophones and an autonomous buoy remotely linked to shore also suffer from limited data-transfer rate, high consumption of power and vulnerability to sea conditions.