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Time-frequency and wavelet methods to detect and classify earthquake signals in noisy environments

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In the not too distant future, the oceans will be populated by autonomous instruments equipped with a hydrophone, which, passively drifting at mid-depth in the water column, will detect water pressure variations due to conversions from incoming seismic phases. Global data bases of seismic arrival times collected over the oceans will supplement and dramatically extend existing catalogs made from many years of land-based observations. The quality of the coverage resulting from a more uniform sampling of the wave field of teleseismic earthquakes will result in global tomographic earth models whose resolution will be improved due to the addition of new data.

For this vision to become a reality, intelligent algorithms need to be developed and implemented on board such instruments. We must recognize teleseismic arrivals in the presence of local and regional P, S, and T phases, ship and whale noise, and other contaminating factors such as airgun surveying work. The teleseismic phases must be automatically identified and discriminated. Here, we present approaches in the time domain, by means of spectrogram analysis, and with wavelet methods.

We discuss issues related to recording and triggering mechanisms, noise characterization, and methods for the analysis as well as representation of hydroacoustic data by the discrete wavelet transform. We pay special attention to the efficiency of our algorithms and their numerical implementation, and emphasize their impact on power consumption and hence the lifespan of the instrument.

The most promising wavelet algorithm is the lifting scheme due to Sweldens, which allows an in-place implementation of the fast wavelet transform, using a minimum in battery power and memory. Lifting allows in-place calculation without allocating more memory and can be implemented as an integer-to-integer transform. This will be shown using examples of data collected in situ.