Geophysical Research Abstracts
Vol. 16, EGU2014-15796, 2014
EGU General Assembly 2014

A Fusion Model of Seismic and Hydro-Acoustic Propagation for Treaty Monitoring

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We present an extension to NET-VISA (Network Processing Vertically Integrated Seismic Analysis), which is a probabilistic generative model of the propagation of seismic waves and their detection on a global scale, to incorporate hydro-acoustic data from the IMS (International Monitoring System) network. The new model includes the coupling of seismic waves into the ocean's SOFAR channel, as well as the propagation of hydro-acoustic waves from underwater explosions.

The generative model is described in terms of multiple possible hypotheses – seismic-to-hydro-acoustic, under-water explosion, other noise sources such as whales singing or icebergs breaking up – that could lead to signal detections. We decompose each hypothesis into conditional probability distributions that are carefully analyzed and calibrated. These distributions include ones for detection probabilities, blockage in the SOFAR channel (including diffraction, refraction, and reflection around obstacles), energy attenuation, and other features of the resulting waveforms.

We present a study of the various features that are extracted from the hydro-acoustic waveforms, and their correlations with each other as well the source of the energy.

Additionally, an inference algorithm is presented that concurrently infers the seismic and under-water events, and associates all arrivals (aka triggers), both from seismic and hydro-acoustic stations, to the appropriate event, and labels the path taken by the wave.

Finally, our results demonstrate that this fusion of seismic and hydro-acoustic data leads to very good performance. A majority of the under-water events that IDC (International Data Center) analysts built in 2010 are correctly located, and the arrivals that correspond to seismic-to-hydroacoustic coupling, the T phases, are mostly correctly identified. There is no loss in the accuracy of seismic events, in fact, there is a slight overall improvement.