Estimating Earthquake Rupture Processes through Analysis of Hydroacoustic Signals

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Abstract

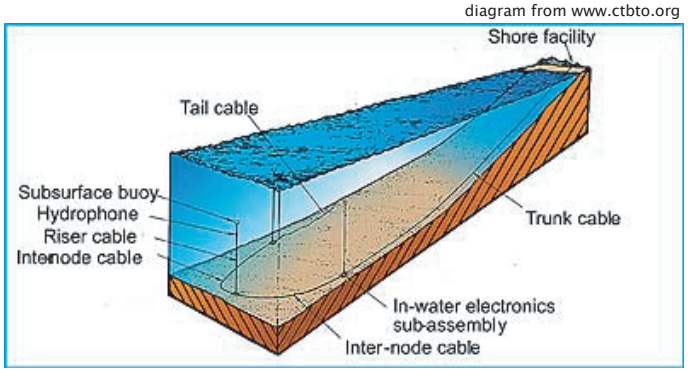
A network of 5 small hydroacoustic arrays in the Indian Ocean allows for estimation of earthquake repture processes. This network is unique in that each array is configured to allow for accurate determination of the receiver to source azimuth for low-frequency hydroacoustic arrivals, called T-waves.

Hydroacoustic observations of the megathrust earthquake of 26 Dec, 2004 allowed for an estimation of the event's rupture extent and velocity. For this event, analysis of a series of short time windows within the T-wave coda shows that the receiver to source azimuth varies smoothly as a function of time. Under the hypothesis that the T-wave source tracks the fault rupture, data from 3 arrays were used to track the motion of the T wave source. The T-wave source is observed to propagate northward along the Sunda trench at an average velocity of 2km/s for a distance of over 900km. Data at one array indicate that the rupture progressed further to the north. For the first 600km, the rupture propagated at about 2.4km/sec, then slowed to about 1.5km/sec.

□ □ □ Another hypothesis is that seismic energy from the hypocenter are propagating to bathymetric contours more favorable to T-wave excitation; that is, that the azimuth vs. time characteristics of the arrivals represent acoustic excitation over a broad expanse of the seafloor. This hypothesis is examined in this poster and found to be inconsistent with the observations.

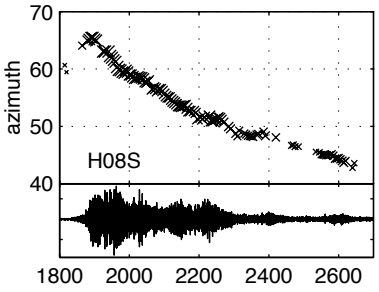
Detection of hydroacoustic energy in the Indian Ocean

diagram from www.ctbto.org

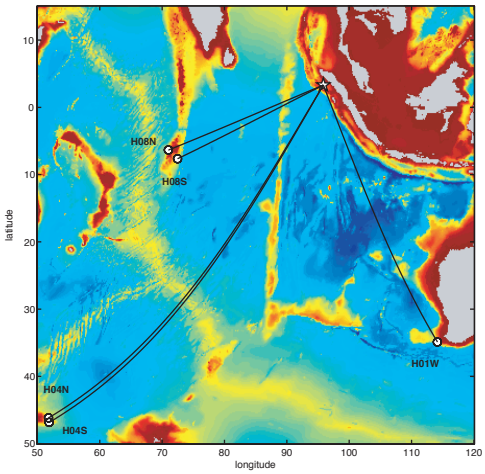


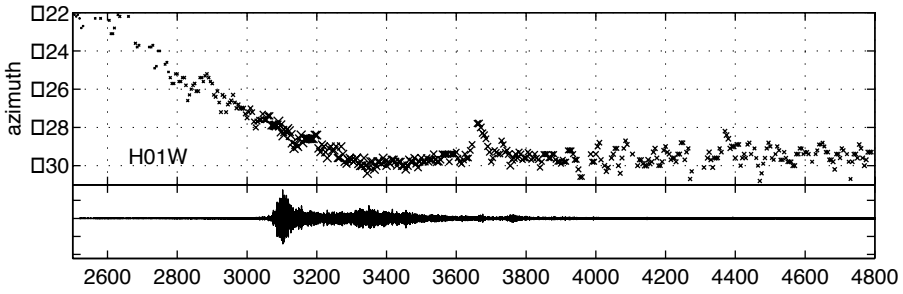
The diagram above shows a typical setup for the hydroacoustic stations in the Indian Ocean operated by the Comprehensive Nuclear-Test Ban Treaty (CTBT) Organization. Each array consists of three hydrophones, configured as a triangle with sides of approximately 2 km length, moored near the depth of the ocean sound speed minimum. The sampling rate is 250 samples/s.

Azimuth vs. time observations



The 3-element hydroacoustic arrays in the Indian Ocean are shown in the map at right, superimposed on the bathymetry.





The receiver to source azimuths were computed for 4-6Hz bandpassed waveforms for a series of 10 second time segments within the T wave coda. Azimuths from each array to the T wave source region are shown as a function of time, for H08S (top), H01W (center), and H04S (bottom). The size of the x'es is proportional to the log(amplitude) of the bandpassed data. The bandpassed waveforms are shown for one sensor in each array. Two hypotheses to explain these observations are that the azimuthvariations indicate either

1) a northward progression of the T wave source, or
2) that the T-waves are excited over a broad expanse of the seafloor.