Estimation of Earthquake Rupture Processes through Analysis of T-waves

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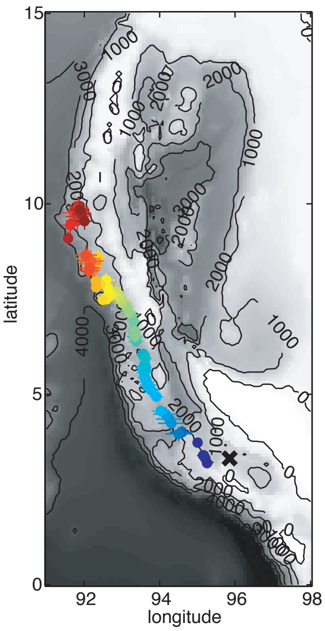
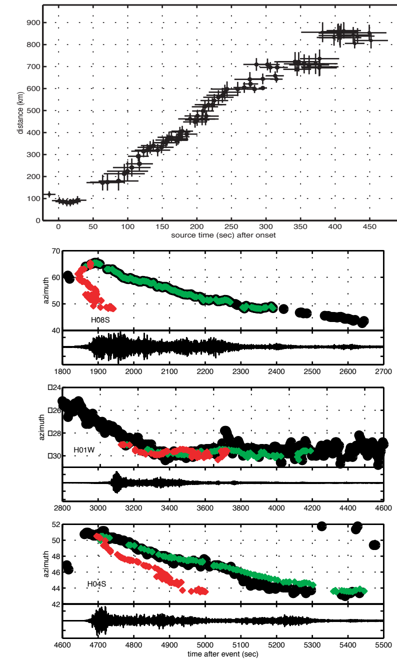
hypothesis 1: T-wave source tracks rupture



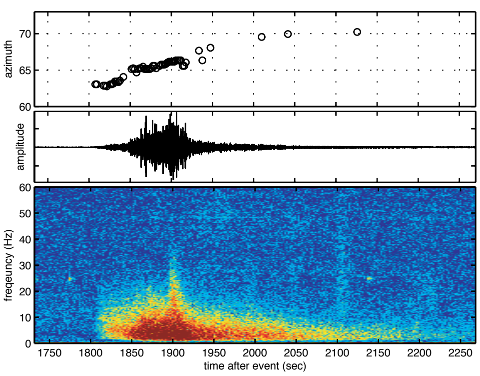
Only azimuths derived for times after the maximum amplitude arrival were used to estimate T-wave source location. Results at a single array give the direction only. The locus and source times of each arrival can be tracked as a function of time by combining results from two or more arrays. Results are shown at left. Color coding indicates **earlier (blue)** to later (red)

In the plot above right, the distance between the derived locus of T wave excitation and rupture onset is plotted against the apparent T wave source time. These data suggest that the Dec 26 rupture phase initially progressed northwest with a velocity of 2.4 +/- 0.3km/sec to a distance of 600km from the epicenter. The rupture then slowed to 1.5 +/- 0.4 km/s as it propagated to a distance of over 800km from the epicenter. This has also been observed in seismic data analysis.

The locations and source times can be used to predict azimuths for a given rupture velocity. In the plot below right, green x's show the predicted azimuths from the estimated rupture locations and source times (see below), and red x's show the azimuths that would result from an instantaneous rupture over the entire source regions. These are compared to the observations (black circles).

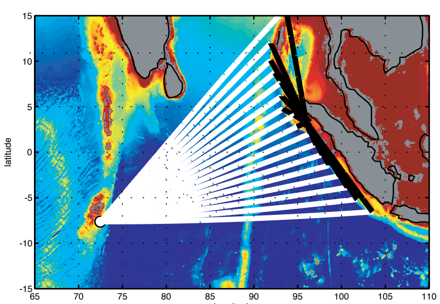


hypothesis 2: azimuth vs. time characteristics represent excitation over a broad expanse of seafloor

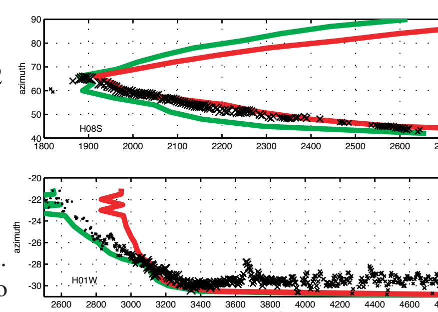


Estimation of the rupture solely from T-waves is complicated by the physics of seismic to acoutic coupling, since coupling does not occur at a point source immediately above the hypocenter. As shown in the figure to the left for a Mb=5.3 event with hypocenter at 3.35N, 95.57E, 45km depth, excitation occurs over a range of azimuths, even though the rupture extent cannot be large for an event this size. In this case the azimuth vs. time characteristics indicate a broad area of T-wave excitation; seismic energy propagates through the crust and couples to acoustic energy over shallow regions of the seafloor.

However, note that the azimuth **increases** as a function of time for this event, which has a hypocentral location very near to the 26 Dec tsunamigenic event, while the azimuth **decreases** vs. time for the tsunamigenic event.



Hypothesis 2 is illustrated in the figure to the left for the Diego Garcia station (H08S). Seismic energy (black lines) propagate to a point on the continental slope, couple to acoustic energy and propagate as T-waves to the receivers (white lines). Under this hypothesis one can predict travel times and azimuths to the receivers, as shown at right for 2 crustal velocities. The red lines show the predicted arrival times and azimuths for a crustal velocity of 2km/s; green corresponds to a crustal velocity of 4.5km/s. The lower right plot indicates that this hypothesis does indeed fit the low amplitude arrivals observed before the main onset at the Cape Leeuwin station, for a crustal velocity of 4.5km/s. The upper right plot indicates that T-waves are predicted to arrive simultaneously from 2 azimuths at H08S under this hypothesis; this is **not** observed therefore **this hypothesis may be rejected.**



Conclusions

The estimation of rupture location, velocity, and duration using T-wave analysis is complicated by the physics of T-wave coupling. Nevertheless, it is generally possible to distinguish between acoustic coupling effects and fault rupture size and duration.

Therefore hydroacoustic sensors can be used as an integral part of any tsunami detection system.