Harvard University — Solid Earth Physics Seminar

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4th Floor Faculty Lounge, Hoffman Laboratory, 20 Oxford St.

Temporal Clustering of Tsunami Sources

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Abstract: Branching process models are used to explain the temporal clustering of tsunami sources. Maximum-per-event tsunami sizes and inter-event times used in the analysis are provided by a global tsunami event catalog. Clustering of tsunami sources is demonstrated by the abundance of short inter-event times relative to a stationary Poisson process. Inter-event triggering is likely caused by a variety of mechanisms, including earthquake-to-earthquake static stress transfer and dynamic triggering of submarine mass failures from seismic ground shaking. Examples of likely triggered tsunami events include the 1932 Mexico earthquake/landslide sequence and the 2006 and 2007 Kuril earthquakes. The empirical tsunami inter-event distribution can be modeled by gamma and generalized gamma distributions that have been considered as a model for universal scaling of earthquake inter-event times. These distributions perform better than the exponential distribution associated with a Poisson process according to the Akaike Information Criterion. Two types of branching process models have previously been considered for earthquakes: branching in magnitude and branching in time. In applying branching models to tsunami event data, tsunami sizes are used as an indicator function for tsunamigenesis according to catalog completeness criteria. A result of the branching-in-magnitude model is that tsunami source counts are distributed as a negative binomial distribution. This model fits the >1m tsunami threshold (1890-2010), but does not perform better than the Poisson distribution for the >0.1 m tsunami threshold (1960-2010). The Epidemic Type Aftershock Sequence (ETAS) branching-in-time model is commonly used to understand seismicity patterns, most recently for global, large-magnitude earthquakes (M>5, M>7). It is applied to tsunami catalog data, with corresponding earthquake magnitudes from the Global CMT and Centennial catalogs, providing a better fit to the shortest tsunami inter-event times than the gamma models. The primary result of ETAS parameter estimates from the tsunami event catalog is that the magnitude scaling of triggered events is essentially zero, in contrast to non-zero magnitude scaling for earthquake catalogs of identical magnitude thresholds. If tsunamigenic conditions (i.e., submarine location, shallow focal depth, dip-slip mechanism, in addition to the magnitude threshold) are applied to earthquake catalogs, ETAS parameter estimates are similar to those derived from tsunami event catalogs. It appears that the dip-slip mechanism is the cause of zero magnitude scaling in the triggering function. Branching process models developed for seismicity appear to provide a suitable framework for understanding tsunami source occurrence patterns, and can be used to rigorously identify source clusters and possibly develop short-term tsunami forecasts in the future.