Estimation of the seismic moment from tsunami heights : application to historical events.

Dominique Reymond (1), Emile A. Okal (2), and Hélène Hébert (3)

(1) CEA/DASE/LDG, Papeete, Tahiti, 98713 French Polynesia, (2) Department of Earth & Planetary Sciences, Northwestern University, Evanston, IL 60208, USA, (3) CEA DAM/DIF/DASE/LDG 91297 Arpajon Cedex FRANCE

Okal et al. (2014) developed an algorithm, named TS formula, to estimate teleseismic tsunami amplitudes from the seismic moment of the parent earthquake, the azimuth between its fault strike and the receiver, and the epicentral distance; this method was based on least-square regressions over a large data set of numerical simulations (4650), using 10 source regions located in the main subduction zones of the Pacific Basin, and a range of four orders of magnitudes of seismic moment.

We apply the inverse methodology to recover the seismic moment of historical earthquakes from their tsunami amplitudes.

Inversion of the TS formula to recover the seismic moment was first tested on a set of real tsunami amplitudes, recorded in deep ocean basins by the DART buoy network (see http://www.ndbc.noaa.gov/dart.shtml). The tests were conducted on more than 250 measurements from 20 sources, and reproduced estimates of the seismic moment with an average precision of 0.22 logarithmic units. We point out that this method, which is independent of direct seismic measurements, provides the possibility to highlight non regular earthquakes like 'snappy' or 'slow' ones, and large unusual 'compact' sources like the 2011 Tohoku event.

This methodology was then applied to historical events using a data set of 52 earthquakes and tsunamis, between 1854 and 2010, at 164 tide-gauge stations. For this study, the concept of deep sea measurement of tsunami amplitudes has been extended to amplitudes recorded by coastal sea-level stations (tide gauges), using a transfer function based on Green's law, which gives an estimation of the tsunami amplitude near the shore as a function of the deep sea measurements (see Reymond et al. (2011) and Jamelot & Reymond (2015)) and conversely.

In this framework, we were able to reassess the seismic moment of some remarkable historical events including Peru-Chile 1868 and 1877, Ecuador 1906, Samoa 1917, Kermadec 1917, Tonga 1919, Chile 1922 and 1960, Alaska 1964 ..etc. The case of the tsunami earthquakes (Aleutian 1946, Nicaragua 1992, Java 1994 and 2006, Sumatra 2004, etc.) has been also considered.

References:

Okal, E.A., D. Reymond, and H. Hébert, From earthquake size to far-field tsunami amplitude: Development of a simple formula and application to DART buoy data, Geophys. J. Intl.,196, 340-356, 2014.

Reymond, D., E.A. Okal, H. Hébert, and M. Bourdet, Rapid forecast of tsunami wave heights from a database of pre-computed simulations, and application during the 2011 Tohoku tsunami in French Polynesia, Geophys. Res. Letts., 39, (11), L11603, 6 pp., 2012.

Jamelot, A., & Reymond, D.. New tsunami forecast tools for the French Polynesia tsunami warning system Part II: numerical modelling and tsunami height estimation. Pure and Applied Geophysics, 172(3-4), 805-819, 2015.