Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

SSS02-09 Room:201B Time:May 21 11:20-11:40

Testability of maximum magnitude estimates

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Disasters caused by unexpectedly large earthquakes illustrate the need for reliable estimates of the maximum possible magnitude M (also known as M_{max}) at a given fault or in a particular zone. Such estimates are essential parameters in seismic hazard assessment, but their accuracy remains untested. In fact, whether M can be tested or not is still uncertain. In this study, we discuss the testability of M and the limitations that arise from testing such rare events. We use a simple extreme value theory approach to derive the sampling distribution for the maximum magnitude, i.e. the probability distribution for the maximum of a sample of earthquake magnitudes, and propose a straightforward hypothesis test for M. The test is based on the largest magnitude observed in the sample. If it is larger than the estimate of M, or it is too unlikely, given the assumed magnitude probability density function, the estimate of M is rejected. We then perform a sensitivity analysis to identify which parameters have the most influence on this sampling distribution and conduct a power analysis for the test. Our results suggest that the sampling distribution is relatively insensitive to the overall M, except when the b-value of the Gutenberg-Richter distribution is low and the size of the sample is high. Consequently, the power of the test is high only under optimal conditions, such as when the hypothesized value of M is grossly different than the true M, or when the seismicity rate is very high. Finally, we discuss that these limitations, in practice, may imply that a wrong maximum magnitude estimate can rarely be falsified, and express our concern about the use of these unfalsifiable estimates in seismic hazard assessment.

Keywords: Maximum Magnitude, Seismic Hazard, Seismic Risk, Statistical Seismology, Earthquake Forecasting