Evolution of earthquake rupture potential along the Pacific Plate off Japan, inferred from seismicity

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One of the major unresolved questions in Seismology is the evolution in time and space of the earthquake rupture potential and thus time-dependent hazard along active faults. What happens after a major event: is the potential for further large events reduced as predicted from elastic rebound, or increased as proposed by current-state short-term clustering models? How does the rupture potential distribute in space, i.e. does it reveal imprints of stress transfer?

Based on the rich earthquake record along the Pacific Plate off Japan we investigate what information on spatial distributions and temporal changes of normalized rupture potential (*NRP*) for different magnitudes can be derived from time-varying, local statistical characteristics of well and frequently observed small-to-moderate seismicity. The *NRP* is obtained from the frequency-magnitude distribution of sampled earthquakes, specifically from the slope (*b*-value) and y-intercept (*a*-value) of this distribution, in a log-linear plot. The *b*-values describe the relative frequency of large versus small earthquakes, while *a*-values express the seismic activity during the observation period (in this study, the *a*-values are annualized and distance-weighted, i.e. we consider the relative earthquake-grid-point distances, with close-by events gaining higher weights than more distant events). We analyze the seismicity from 1998 ~ 2015, including the massive 2011 M9 Tohoku-oki earthquake and its aftermath.

Seismicity records show strong spatio-temporal variability in both activity rates and size distribution. We show first (Tormann et al., 2015) that the size distribution of earthquakes has significantly changed before (increased fraction of larger magnitudes –relatively small *b*-values) and after that mainshock (increased fraction of smaller magnitudes –relatively large *b*-values); these changes are particularly stronger in areas of highest Tohoku-oki coseismic slip. Remarkably, a rapid recovery of this effect is observed within only few years.

We then combine this significant temporal variability in earthquake size distributions (*b*-values) with local activity rates (*a*-values) and infer the evolution of *NRP* distributions. We study complex spatial patterns and how they evolve with time, focusing on the detailed temporal characteristics in a simplified spatial selection, i.e. inside and outside the high slip zone of the M9 earthquake. We resolve an immediate and strong *NRP* increase for large events prior to the Tohoku-oki event in the subsequent high slip patch and a very rapid decrease inside this high-stress-release area, coupled with a lasting increase of *NRP* in the immediate surroundings. Even in the center of the Tohoku rupture, the *NRP* for large magnitudes has not dropped below long-term average values and is now not significantly different from conditions a decade before the M9 event.

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