Large earthquakes follow highly unequal ones

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Extended Abstract

Motivation. Earthquakes have been studied for more than a century, and several empirical laws describe their statistical behavior; predicting the exact occurrence of earthquakes is still not possible. One of the main reasons is that earthquake sources are located deep underground and cannot be directly observed. Because of this difficulty, researchers continue to search for statistical patterns that may appear before large earthquakes. In recent years, studies of complex systems have shown that when a system approaches a critical point, the responses become increasingly unequal. Measures such as the Gini index [1] and the Kolkata index [2] can quantify this inequality. In this work [3], we explore whether monitoring such inequality measures in earthquake time series can help identify patterns that occur before large seismic events.

Approach and Methodology. To study this problem, we calculate the inequality of the released seismic energy using the Gini index and the Kolkata index. These indices are computed using a "dynamic reset" approach where we continue to measure g, k with a window size increasing with time. When a large event is encountered by the right end of the window, the left end is reset to that event, and the right end is again moved one step at a time, and so on [3].

Results. In Fig. 1 a clear trend of accumulation of larger events towards higher g k value is observed. In Fig. 2 it is also clear that the top 20 large events occured near or above the intersection point (around $g \approx k \approx 0.865$) of the theoretical line and $g = k$ the equality line.

Conclusions and Outlook. Our results suggest that large earthquakes are often preceded by sequences of highly unequal events [3]. Monitoring inequality measures in earthquake time series may therefore provide useful information for seismic hazard analysis. Now we focus on the ETAS model and catalog data for the Tohoku and Nankai subduction zone and further investigate whether it is possible to estimate the occurrence time of large earthquakes.

References

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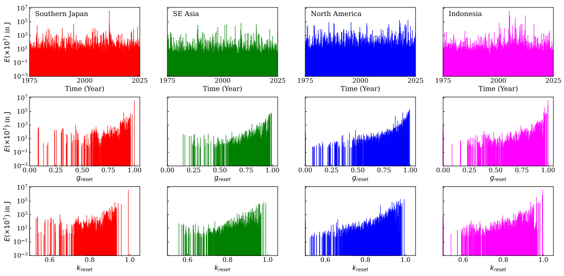

Figure 1: The top row figures show the earthquake events in their original order of occurrence, the middle and bottom row figures show the same events when arranged in terms of their associated g and k values respectively, where the g and k values for any event is calculated from a dynamic time window defined as all events between the previous large ($M \geq 7.5$) event and the current event (excluding both the ends). A clear correlation between higher inequality and larger magnitude is seen for each of the tectonically active region.

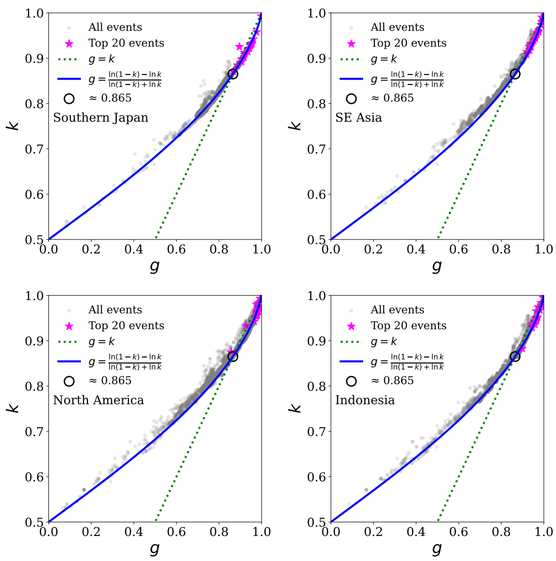

Figure 2: The g vs k values obtained from the “dynamic reset” method are plotted and the largest 20 events are highlighted which are happened around the intersection points ($g \approx k \approx 0.865$).