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Monte Carlo estimation of slip on historical subduction earthquakes and interplate coupling distributions.

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The Sumatran coast and offshore islands are colonised with coral microatolls whose growth habit records the vertical component of deformation extending back up to 700 years. It has been possible to invert these unique data for the slip distribution on historical earthquakes though, due to the scarcity of coral paleogeodetic sites and their limited spatial distribution, the resolution of these inversions is poor. Some of these segments have ruptured again recently in well-instrumented, great subduction earthquakes.

Here we approach the problem from a different perspective, rather than asking: what was the slip distribution on an historical earthquake? we instead ask: what are the set of slip distributions which could have produced the observed vertical coral displacements? We generate many ([U+F07E]108) stochastic slip models and compute the coral displacements for each storing those which satisfy some goodness-of-fit criterion. Stacking the successful models yields a map of the probability of slip; it is probable that areas of high slip in the map experienced high slip in the earthquake. The resolution of the map is assessed quantitatively providing an assessment of the quality of the slip likelihood estimate.

The method is applied to the 1797 (M8.7) and 1833 (M9.0) Sumatran earthquakes. Examination of the successful coral displacement sets exposes some internal inconsistencies in the coral data and indicates that some secondary mechanism, such as failure on a splay fault, may be required to reconcile the entire data sets. We show that the most likely distribution of slip on these events correlates well with areas of strong coupling exposed by inversion of recent geodetic data indicating that the spatial distribution of coupling under the Mentawai Islands has persisted for more than one seismic cycle. Estimates of Coulomb stress interaction based on the most likely distributions of slip show that the 1833 event was encouraged by 1797 quake but that knowledge of the distribution of coupling, plate convergence rate and interaction stress could not have produced an accurate, deterministic forecast of the slip on either event. This suggests that Monte Carlo simulations of rupture and tsunami generation which have been constrained by the measured distributions of plate coupling and convergence, possibly augmented by stress interaction studies, will provide the best, probabilistic estimates of the impact of future earthquakes in this region.