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Long Term Slip Deficit Modelling for the Sunda Megathrust beneath the Mentawai Islands, Sumatra

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Shallow earthquakes are a response of crustal faults to stress. Faults are loaded by the slow, heterogeneous accumulation of tectonic stress and the almost instantaneous interaction with neighbouring earthquakes. These effects allow us to model the increase of stress on known active faults. In particular we can calculate changes in stress that can help identify regions of known active faults where secular loading is rapid, elapsed time since the last large event (normalised to the estimated recurrence time for large events) is long and interactions stresses due to recent events suggest that earthquake hazard is particularly high. However, these models implicitly assume a uniform zero stress on the studied fault at the beginning of the study period which is clearly wrong. Even assuming a constant loading rate over a known distribution of fault coupling, earthquakes in the recent past have left stress footprints (both positive and negative) on the fault which must have a first-order effect on the contemporary stress field and therefore on the future activity of the fault. The geographical distribution of these footprints is in principle determinable if the slip distribution on the past earthquakes can be estimated. In general this estimation is unsatisfactory since the resolution of the slip distribution in past earthquakes is in general no better than an unfeasible box-car slip function with a data-consistent moment.
Coral paleo-geodesy on the Mentawai Islands off western Sumatra has produced a multi-seismic-cycle geodetic record which provides physical constraints on the slip distributions of large and great earthquakes. Here we describe a new unifying description of the reconstruction of the evolution of slip deficit (the difference between loading and cumulative seismic and aseismic slip) in which we include 330 years of heterogeneous loading of the Sunda megathrust and slip due to more than 30 historical and instrumentally recorded earthquakes. This complex slip deficit field is heterogeneous not only in the strain energy but also in the resolution and we introduce a new technique to clearly visualise both. We show that these results are consistent with the well published threat of a large tsunamigenic earthquake off western Sumatra and make some comments on constraining the threat.