Geophysical Research Abstracts
Vol. 16, EGU2014-16137-1, 2014
EGU General Assembly 2014

Long-term slip deficit and the forecasting of slip in future earthquakes

John McCloskey, Mairead NicBhloscaidh, and Nuno Simao
University of Ulster, Environmental Sciences, Coleraine, Ireland (j.mccloskey@ulster.ac.uk)

In the last decade a series of devastating earthquakes have between them killed more than three-quarters of a million people. None of the events were formally forecast and have been repeatedly referred to a seismological ‘surprises’. Here we argue that while earthquakes within the wide swath of diffuse deformation comprising the Alpine-Himalayan belt pose a set of particularly difficult set of challenges, earthquakes which are driven by high strain-rates at plate boundaries and which have relatively short nominal recurrence times might be forecast if the data exists to perform long-term slip deficit modelling and stress reconstruction. We show that two instrumentally recorded event on the Sumatran margin in 2007 and 2010 occurred in regions of high slip deficit identified by reconstruction of slip in historical earthquakes in 1797 and 1833 under the Mentawai Islands using more than 200 years of geodetic data recorded in the stratigraphy of coral micro-atolls growing there.

In the presentation we will describe the data and a new Bayesian-Monte Carlo slip reconstruction technique. The technique is based on the stochastic forward modelling of many slip distributions each using the same set of elastic Green’s functions to estimate, by superposition of contributions from each fault cell, the vertical displacement at the coral locations resulting from each simulated event. Every solution, weighted by its goodness of fit to the data, is added to a stack whose final values contain an estimate of the most likely distribution of slip in the historical earthquakes. Further, we estimate the Kullback-Liebler divergence over the fault area providing a non-arbitrary assessment of the spatial distribution of information gain, identifying regions of low- and high-model confidence.

We then model the long-term slip deficit on the megathrust assuming a zero of stress immediately after the 1652 Mentawai Islands earthquake. We use the resulting slip deficit field to compute the entire stress field including both secular loading and earthquake interaction stresses. We show that the spatial distribution of energy release in the 2007 and 2010 earthquakes correlates strongly with regions of high slip deficit accumulated over the previous 350 years and that in principle both could have been identified as areas of particularly high seismic hazard.

The following more general seismological lessons emerge from our work:
1 At least for this region of this margin, the characteristic earthquake concept entirely fails to explain the data
2 Earthquake slip tessellates the fault plane under the Mentawai Islands rather than repeatedly breaking the same patch.
3 The tessellation by high slip is largely constrained by the interface coupling distribution (which, of course, played no part in the slip reconstruction).
4 Homogeneous loading of a heterogeneous fault in a linear-elastic medium explains all the observations, no rheological time dependence is necessary.
5 Even small amounts of nonlinearity in the rupture process would ensure that this sequence will not be repeated, calling into question many long-standing, fundamental concepts in earthquake science.