Very Long Term Variability in Interseismic Deformation: A Case Study from the Sumatran Subduction Zone

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Estimates of megathrust coupling are often calculated using geodetic data then used to forecast seismic and tsunami hazard. Given that geodetic time series span relatively short intervals, models of future behaviour dependent solely on them may not accurately reflect cumulative, long-term strain accumulation. Is it possible that, at least for some subduction megathrusts, slip rates estimated from short time series are commonly not representative of rates averaged over the long term? We consider this question for the Sumatran subduction zone using a combination of GPS data and paleogeodetic data from coral microatolls. We conclude that interseismic deformation may be variable over the full course of the cycle.

The coral data cover many earthquake cycles. They indicate significant changes in interseismic deformation rates over time for the Sunda megathrust. Along one section of the megathrust we see evidence for a slow slip event lasting ~15 years.

GPS data from the Sumatran GPS Array (SuGAr) recorded postseismic deformation following recent great earthquakes generated by the megathrust. These observations suggest that Sumatra has a transient rheology with high steady-state viscoelastic relaxation times. Long relaxation times, coupled with recurrence intervals as short as about 200 years, could mean that viscoelastic responses to great earthquakes are above the noise level of the GPS for much (or perhaps all) of the earthquake cycle. Geodetic snapshots at any point in many decades to come might thus not be representative of long-term average rates.

Our results make a strong case for keeping geodetic networks in place for many decades if we are to fully understand the dynamics of interseismic deformation along subduction zones. As we design new initiatives, we should design them with longevity in mind. Our results also highlight the importance of incorporating geological and paleogeodetic information into models that aim to forecast future ruptures.