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Using a hybrid Monte Carlo/ Slip Estimator-Genetic Algorithm (MCSE-GA) to produce high resolution estimates of paleoearthquakes from geodetic data

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Identifying fault sections where slip deficits have accumulated may provide a means for understanding sequences of large megathrust earthquakes. Stress accumulated during the interseismic period on an active megathrust is stored as potential slip, referred to as slip deficit, along locked sections of the fault. Analysis of the spatial distribution of slip during antecedent events along the fault will show where the locked plate has spent its stored slip. Areas of unreleased slip indicate where the potential for large events remain. The location of recent earthquakes and their distribution of slip can be estimated from instrumentally recorded seismic and geodetic data. However, long-term slip-deficit modelling requires detailed information on the size and distribution of slip for pre-instrumental events over hundreds of years covering more than one 'seismic cycle'. This requires the exploitation of proxy sources of data.

Coral microatolls, growing in the intertidal zone of the outer island arc of the Sunda trench, present the possibility of reconstructing slip for a number of pre-instrumental earthquakes. Their growth is influenced by tectonic flexing of the continental plate beneath them; they act as long term recorders of the vertical component of deformation. However, the sparse distribution of data available using coral geodesy results in a under determined problem with non-unique solutions.

Rather than accepting any one realisation as the definite model satisfying the coral displacement data, a Monte Carlo approach identifies a suite of models consistent with the observations. Using a Genetic Algorithm to accelerate the identification of desirable models, we have developed a Monte Carlo Slip Estimator- Genetic Algorithm (MCSE-GA) which exploits the full range of uncertainty associated with the displacements. Each iteration of the MCSE-GA samples different values from within the spread of uncertainties associated with each coral displacement. The Genetic Algorithm element of the MCSE-GA allows it to recombine the information stored in a population of randomly generated models to rapidly converge on a possible solution. These solutions are evaluated and those satisfying a threshold number of observations join an ensemble of models contributing to a final Weighted Average Model (WAM). The WAM represents a high resolution estimate of the slip distribution responsible for any given set of displacements. Analysis of the slip values of the ensemble models allows areas of high confidence to be identified where the standard deviation is low. Similarly, areas of low confidence will be found where standard deviations are high.

This presentation will demonstrate the ability of the MCSE-GA to produce both accurate models of slip for a number of recent instrumentally recorded earthquakes along the Sunda Trench and estimates of slip during 1797 and 1833 paleoearthquakes that are consistent with those produced from other techniques.