Estimating objective locking distributions of the Kamchatka subduction zone from GNSS data using a modified Metropolis-Hastings approach

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Knowledge of the spatial distribution of frictional locking on subduction interfaces is a critical input to models of potential seismic hazard. Locking distributions can be estimated from geodetic data – for instance, by modeling the backslip necessary to produce the deformation of the upper plate, which can be achieved by a regularized linear inversion (*left*). One issue with such an approach is that geodetic data for most subduction zones are land-based, meaning that they provide very limited resolution for locking on the shallow, offshore portions of the plate interface; such models can be highly uncertain in those areas.

An alternative approach with greater sensitivity to shallow locking is to use a boundary element model in which fault elements may either be 'locked' (backslipped at the plate motion rate) or 'unlocked' (allowed to slide freely to accommodate stresses imposed by the backslipping elements). These models include more physical constraints on the locking distribution, as the presence of locked elements can influence slip on elements tens to hundreds of km away. Such an approach was used by Bürgmann et al. (2005) for the Kamchatka subduction zone, using campaign GNSS velocities from the upper plate and locked areas based on estimated rupture areas of historic earthquakes, which were reduced in area until an approximate fit to the data was obtained. While this approach was successful as a proof of concept, it required manual intervention and relied on the initial choice of approximate historic rupture areas.

Here, I present an alternative approach to selecting the locked fault elements, where elements are selected by a modified Metropolis-Hastings algorithm with no intervention from the user. Using the same GNSS data as Burgmann et al., and a plate interface model based on Slab2.0, I run the algorithm for 1 million iterations. After a short 'burn-in' period, each iteration produces an alternative model of subduction zone locking (e.g. *center*). The statistics of this ensemble of models (*right*) reveal details of fault behavior. 34% of fault elements are locked in fewer than 5% of models; 16% of the elements are not locked in *any* of the models – including elements that have significant backslip in our inverted 'kinematic' model. Conversely, a handful (2%) of elements show locking in a majority of the models – these define three potential asperities. We also find a broader zone where elements are locked in 20–30% of the models. These indicate areas of potential locking where additional data are needed to further narrow down the possible fault elements involved.