Locking degree for the Chilean Subduction Zone inferred through Bayesian inversion of GPS observations: Implications for seismic hazard and earthquake mechanics

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Abstract

The increased spatial density of geodetic instrumentation at subduction zones and the capture of data preceding, during, and following great earthquakes have facilitated the improvement in our understanding of spatial relations between coseismic (slip) and interseismic (locking) plate-interface kinematics. These kinematic models suggest that the lateral extents and magnitudes of earthquake ruptures are fundamentally controlled by the spatial distribution of locking degree, which can be used to infer variations of stress build-up along the seismogenic zone. However, estimates of locking degree rely on the wealth of the geodetic data, modeling assumptions and inversion technique, and therefore maps of locking even for same areas that use similar data are very distinct. Here, we build a spherical Finite-Element model of the Chilean Subduction Zone to generate Green Functions of back slip that takes into account the viscoelastic interseismic response. We use the Bayesian method based on the reversible jump algorithm for the inversion of a compilation of more than 500 interseismic GPS velocities along the Chilean margin. We apply this method to solve for the back slip at the plate interface and for the rotation parameters of a continental-scale forearc sliver block. The method is tested for different areas and compared to standard least square inversion solutions. The implementation of a running mean convergence method allows us to efficiently reduce the computation time of the Bayesian inversion. We further investigate the relation of stress build up, deeper recent and historical earthquakes and interseismic background seismicity at different segments of the Chilean margin aiming to describe the current stage of stress build-up within the seismic cycle. In doing so, we create dynamic models with static friction to characterize the heterogeneous strength distribution and stress loading at the plate interface based on the distribution of locking degree. Together with the seismic observations, the results of our study robustly characterize the locking degree along the Chilean

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seismogenic zone and provide valuable insights for understanding the stress accumulation-and-release processes that lead to great megathrust earthquakes, and allow estimates of the current seismic potential of locked segments.