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Modeling Fault Slip for China and Vicinity Using GPS Data

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Fault slip rates are critical information for estimating seismic hazard. Many geological faults have been mapped in China. However, slip rates are determined only for a fraction of the faults. During the past two decades, precise GPS positioning has become an effective tool to measure tectonic and earthquake-related crustal deformation on the surface of the Earth. Extensive research has been done to link the surface deformation to physical processes of the crust and fault systems, and to assessments of associated earthquake hazards.

We collected GPS velocities in and around China, rotated them to a common reference frame, and screened them to eliminate the data that were possibly contaminated by post-seismic deformation of large earthquakes and those that appear anomalous with respect to their neighbors. To invert fault slip rates using the GPS data, we first developed a regional geological fault model, comprising about 280 linked fault segments. Each of the fault segment uses a simplified geometry. In the inversion model, crustal deformation is assumed to be the result of slip of a network of buried faults, computed using a model of dislocation in an elastic medium. The fault slip across neighboring segments is connected, and the degree of slip continuity across fault junctions is optimally determined through evaluation of the trade-off between the data fitting and model resolution. The block motion model and the separate fault segment model (with no constraints on slip of neighboring segments) can be considered as two end members of our model: when slip continuity is strictly enforced at fault junctions, our model works as the block motion model; and when the slip continuity constraint is completely loose, it becomes the separate fault segment model. Because of its flexibility, our model fits the GPS displacement data better than the end member block motion model and requires a smaller number of free parameters to fit the data than a separate fault segment model. Our model is more suitable than the block motion model to describe continental deformation such as that associated with the fault systems in Tibet, where fault slip sometimes dies out or varies along strike, and the deformation field gets more distributed in some areas that cannot be easily captured with a block model.

Overall, our model fits the GPS data well, except in the Himalaya region where it shows relatively large post-fit residuals. This can probably be ascribed to the limitation of our model, which approximates deformation across a thrust fault (the low angle Main Himalayan Thrust) as contraction across a vertical fault. We compared the inverted slip rates with available geological slip rates. For the faults in western China, the rates are consistent. For the faults in eastern China, the inverted slip rates are larger than the geological ones, probably because each fault segment in the linked fault model represents multiple geological faults. The resultant fault slip rates, which are expressed in fault parallel and fault normal components, are used to supplement the active fault data for seismic hazard analysis.