A dense geodetic block model of western continental United States deformation

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Abstract

Seismic hazard assessment, such as the United States Geological Survey (USGS) National Seismic Hazard Model (NSHM), relies on estimates of long-term fault slip rate based on geology and/or geodetic observations such as the Global Navigation Satellite System (GNSS), including the Global Position System (GPS). Geodetic fault slip rates may be estimated within a three-dimensional spherical block model, in which the crust is divided into microplates bounded by mapped faults; fault slip rates are determined by the relative rotations of adjacent microplates. Uncertainty in selecting appropriate block-bounding faults and in forming closed microplates has limited the interpretability of block models for seismic hazard modeling. By introducing an automated block closure algorithm and regularizing the resulting densely spaced block model with total variation regularization (TVR), I develop the densest and most complete block model of the western continental United States (WCUS) to date. The model includes 853 blocks bounded by 1017 geologically identified fault sections from the USGS NSHM Fault Sections database. Microplate rotations and long-term fault slip rates are constrained by 4979 GNSS velocities and 1243 geologic slip rates. I identify a regularized solution that fits the GNSS velocity field with a root-mean-square misfit of 1.9 mm/yr and reproduces 57% of geologic slip rates within reported geologic uncertainty and model sensitivity, consistent with other geodetic-based models in this Focus Section. This block model includes slip on faults that are not included in the USGS NSHM Fault Sections database (but are required to form closed blocks) for an estimate of "off-fault" deformation of 3.62e19 Nm/year, 56% of the total calculated moment accumulation rate in the model.

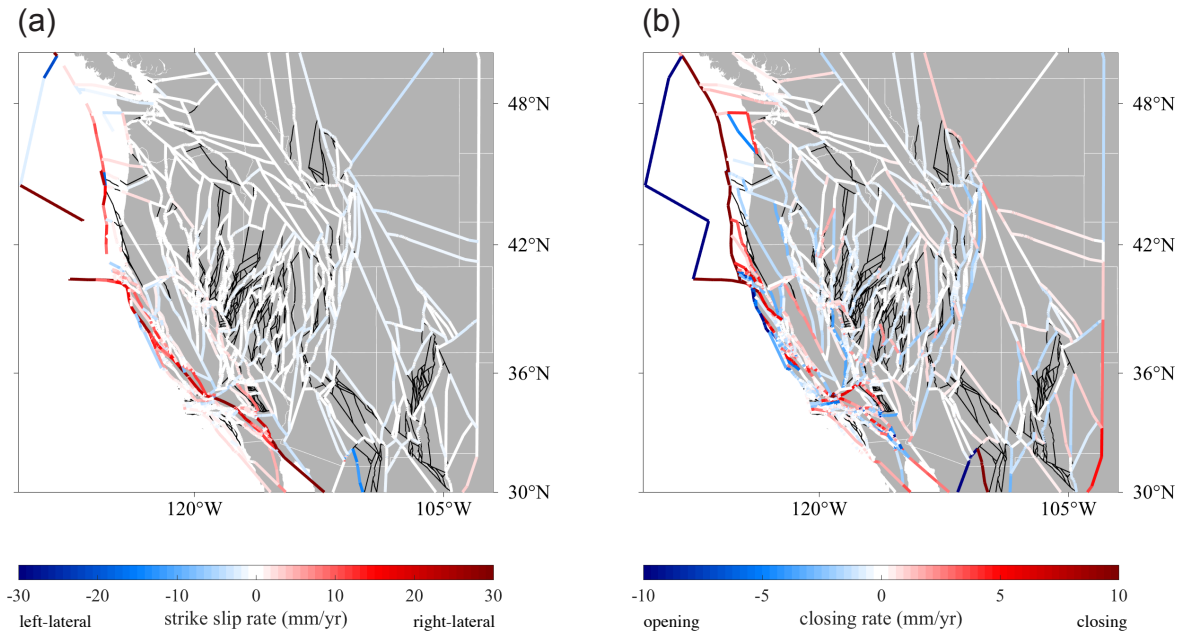

Figure: Strike slip rates (a) and dip-slip rates (b) of reference model $\lambda = 320$. Note different color scale between (a) and (b). Faults with slip rates of exactly zero shown as black lines.