A new method produces improved surface strain rate maps

July 20 2021, by Jack Lee

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Earthquakes occur when tectonic strain that has gradually accumulated along a fault is suddenly released. Measurements of how much Earth's surface deforms over time, or the strain rate, can be used in seismic hazard models to predict where earthquakes might occur. One way that scientists estimate strain rate is via orbiting satellites and detailed measurements of how much GPS stations on Earth's surface move.

There are challenges, however, to using such geodetic data. The stations provide measurements only at specific locations and aren't evenly distributed—constructing a continuous strain rate map requires that scientists make estimates to fill in data gaps. These interpolated data add uncertainty to resulting mathematical models.

To tackle these issues, Pagani et al. developed a transdimensional Bayesian method to estimate surface strain rates in the southwestern United States, with a focus on the San Andreas Fault. Their method essentially divided the study area into nonoverlapping triangles and calculated velocities within each triangle by incorporating measurements from the GPS stations located inside.

The team didn't rely on just one such model. They used a reversible-jump Markov chain Monte Carlo algorithm to produce up to hundreds of thousands of such models, with slightly tweaked coordinates for those 2D triangles. In fact, across these models, even the number of triangles could change—because the method is transdimensional, the authors didn't predetermine any parameters. Finally, they stacked all these models together to generate a final continuous strain rate map.

Using test data, the authors found that their approach handled data errors and uneven data distribution better than a standard B spline interpolation scheme. In addition, because the approach included information from many models, it produced a range of strain rate estimates at each point and probabilities for those values.

When the team used the new approach to calculate strain rates around the San Andreas Fault system, they found that their map agreed with past studies. It even successfully identified creeping sections of the fault system from locked segments. The newly described technique could potentially be used by researchers to develop other strain rate maps and may generally have application to other interpolation problems in the geosciences.

More information: C. Pagani et al, Bayesian Estimation of Surface Strain Rates From Global Navigation Satellite System Measurements: Application to the Southwestern United States, *Journal of Geophysical Research: Solid Earth* (2021). DOI: 10.1029/2021JB021905

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