Innovative approach for investigating subduction slip budgets

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Shikoku Island (bottom center) in Japan is seen in this photo taken from the International Space Station in 2015. Credit: NASA

The Nankai subduction zone hugs the southeastern curve of Japan and is one of the most seismologically active regions on the planet. The combination of the region's short seismic cycle—great earthquakes (magnitude 8 or greater) occurring roughly every 100–150 years—and its superb history of geophysical observations makes it an attractive natural observatory for scientists looking to study the evolution of subduction zones during and between great earthquakes. The last major quakes in the region occurred in the mid-1940s, and the decades since have offered opportunities for researchers to pursue innovative geodetic monitoring and modeling.

In a new study, Sherrill and Johnson provide the most complete 3-D coseismic and postseismic model of the Nankai subduction zone yet, using a new approach that relies on iteratively inverting vertical surface displacement data to characterize movement, or slip, along the fault. Slip at subduction zones displays a range of complex behaviors, such as slip during earthquakes, afterslip following major earthquakes, and episodic tremor and slow slip (ETS) events. Understanding the distribution of these slip behaviors in space and time relative to the area of a fault where earthquakes occur is crucial for assessing seismic hazards at subduction zones.

For Nankai, the researchers teased apart the types of slip that have contributed most to the total slip budget (the amount of slip that must be accommodated in a subduction zone because of tectonic plate convergence). The model also offers new insights into the last large earthquakes at Nankai, allowing the researchers to estimate that the maximum slip during the 1940s events was 7.5 meters. Since then, afterslip has reached a maximum of 2.6 meters, they report.

The slip budget at Nankai comprises coseismic slip, afterslip, short-term and long-term slow slip, and interseismic creep. Below eastern Shikoku Island, the researchers report that the slip budget is nearly met. However,

below western Shikoku, there is a considerable deficit—about half the total budget—implying the potential for significant future earthquakes in that area. The study also revealed that long-duration afterslip occurred in the same area of the fault as ETS, an observation that provides new constraints on the frictional properties of this part of the subduction zone.

Beyond what the research reveals about Nankai specifically, the work also offers a state-of-the-art approach for modeling geodetic data across a complete seismic cycle—a feat necessary for improving risk assessments and related policy decisions—that should be applicable to subduction zones around the world.

More information: E. M. Sherrill et al. New Insights Into the Slip Budget at Nankai: An Iterative Approach to Estimate Coseismic Slip and Afterslip, *Journal of Geophysical Research: Solid Earth* (2020). DOI: 10.1029/2020JB020833

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