Afterslip in the ETS zone at Nankai trough, SW Japan, and implications for rheology

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Postseismic and interseismic deformation at the Nankai subduction zone in southwestern Japan following 1944 M8.1 Tonankai and 1946 M8.4 Nankai earthquakes was recorded with GPS, leveling and tide gauge data. Using this data, we have estimated the vertical velocity field of southwestern Japan from immediately after the 1944/46 events until near present day. Analysis of these data with 2D and 3D postseismic and interseismic deformation models show that observed inland postseismic subsidence pattern is diagnostic of about 50 years of viscoelastic mantle flow uplift along the southern coastline is diagnostic of afterslip on the subduction interface. Furthermore, both kinematic inversions and forward models with rate-strengthening afterslip show that afterslip overlaps the zone of Episodic Tremor and Slip (ETS) on the subduction interface. This gives us the opportunity to probe physical conditions within the ETS zone that will permit creep manifesting as both afterslip and spontaneous episodic slow slip events. Nearly all models for ETS require very low effective normal stress of order 1-10 MPa and rate-weakening friction conditions, however our rate-strengthening afterslip simulations as well as kinematic afterslip inversions suggest much higher effective normal stresses of order 100-300 MPa at Nankai. In this study, we examine several hypotheses for reconciling this apparent discrepancy in physical conditions using 2D earthquake cycle models with rate-state friction, fault zone dilatancy, and pore pressure evolution. We find that afterslip can be generated in the ETS zone on if there is a rate-strengthening gap between the bottom edge of the locked zone and the top of the ETS zone.

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