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Linking Seismicity and (Paleo)Geodetic Observations to Megathrust Earthquake Cycle Processes

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Recent seismological and geodetic observations, as well as sophisticated regional models, indicate that similar physical processes are active during the earthquake cycle at different subduction margins. Part of the observed complexity at these margins is controlled by the fact that they are in different stages of the earthquake cycle. The observations capture critical physical processes like (partial) locking of the plate interface, the detailed co-seismic slip, and mantle relaxation and afterslip (Govers et al., 2018; outreach movie at: https://youtu.be/T1QKPoxMdGg).

We use evolving 3D mechanical models to understand various observations. During the interseismic part of the megathrust earthquake cycle, geodetic velocities show that overriding plates shorten from the trench to a "backstop", where they become close to zero. Co-seismic displacements extend well beyond these backstops. Particularly relevant for understanding kinematic friction on the interface, we also use GPS velocities to unravel the spatial distribution and temporal behavior of asperities on the subduction interface, where most of the seismic energy is released during the largest earthquakes. We dramatically improve previous estimates of asperity locations. (Herman et al., 2018).

An enigmatic observation is that recent great earthquakes were followed by significant normal faulting earthquakes in the overriding plate. Seafloor geodetic observations after the Japan 2011 earthquake hint at rapid re-locking of asperities and we use cyclic 3D geodynamic models to further substantiate these interpretations.