Observations of Backstops in the Overriding Plate During the Megathrust Earthquake Cycle

*Rob Govers[1], Taco Broerse[1], Matthew Herman[1]

1. Utrecht University, Netherlands

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.

We analyze geodetic observations along sections of the South America, Japan, and Sunda trenches during the interseismic part of the megathrust earthquake cycle. The results show that overriding plates shorten from the trench to a "backstop", where interseismic velocities become close to zero. Stress accumulation in the overriding plate is controlled by the distance to the backstop. In most, but not all, regions, the backstop location from trench-perpendicular GPS velocities agrees with that from trench-parallel velocities. The distance of this interseismic backstop to the trench varies along major subduction margins. We explore what controls this distance by correlating backstop location with locking area on the plate contact, with boundaries of tectonic blocks in the overriding plate (mechanical contrasts), and with estimates of the recurrence time of the largest events.

An enigmatic observation is that co-seismic geodetic displacements of great earthquakes, including the 2004 Sumatra earthquake, the 2010 Maule earthquake, and the 2011 Tohoku earthquake extended into the overriding plates well beyond what we infer to be the backstops. We use cyclic 3D geodynamic models to further understand and quantify these correlations. Co-seismic and subsequent slip on the subduction interface are dynamically (and consistently) driven. This setup allows us to access the sensitivity of the geodetic signals to mechanical components of the overriding plate and the slab system. We conclude that gradients in the effective elastic thickness of the overriding plate explain the observations.

Keywords: interseismic, geodetic velocities, earthquake cycle