Geophysical Research Abstracts
Vol. 20, EGU2018-14039, 2018
EGU General Assembly 2018

Megathrust Earthquake Cycle: Observations of Backstops in the Overriding Plate and Their Link With Tectonic Setting

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Emerging from both recent seismological and geodetic observations, and from sophisticated regional models, is that similar physical processes are active during the earthquake cycle at different subduction margins. Part of the observed complexity is controlled by the fact that different margins 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, poro-elastic and mantle relaxation and afterslip (Govers et al., Reviews of Geophysics, 2018).

We review interseismic strain accumulation worldwide. Geodetic observations demonstrate that overriding plates shorten from the trench to a backstop during the interseismic part of the megathrust earthquake cycle. We estimate the distance of the (interseismic) backstop to the trench along major subduction margins and find significant variability. An important question is what controls the backstop location. We correlate backstop location with boundaries of tectonic terranes, continental geotherms, and slab dip angles.

Next, we use geodynamic models to isolate the geodetic and geological signature of the relevant physical processes over many mega-thrust cycles. Co-seismic and subsequent slip on the subduction interface are dynamically (and consistently) driven. This setup allows us to incorporate earthquake history, to access the sensitivity of the (short-term) seismological and geodetic signals to mechanical properties of the overriding plate/slab system, and to predict (longer-term) geological imprints. The results are used to evaluate the implications of backstop location for the duration of the earthquake cycle, and to compare cycle length estimates for the Chile, Sumatra-Andaman, and the Japan Trench margin.