J03-2-03 Reconciling short and long term observations of megathrust cycles at subduction zones

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Regional models of the earthquake cycle have become increasingly sophisticated tools to understand the seismological and geodetic observations. They capture critical physical processes like (partial) locking of the plate interface, the detailed co-seismic slip, poro-elastic and mantle relaxation and afterslip. Emerging from both the observations and the models is that similar physical processes are active at different margins, and that part of the observed complexity is controlled by them being in different stages of the earthquake cycle. We use geodynamic models to isolate the geodetic and geological signature of these physical processes over many mega-thrust cycles. Co-seismic and subsequent slip on the subduction interface are dynamically (and consistently) driven. Our 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. We find that the mega-thrusts induce significant tensile stresses in the overriding plate near the down-dip end of the co-seismic fault. Down-dip afterslip reduces these tensile stresses, and observed aftershocks agree with fast slip during a short period here. Transient tectonic uplift and subsidence of the overriding plate results from flexure/buckling. Permanent deformation of the overriding plate accumulates slowly inboard of the locked plate contact in response to long-term compression. We discuss the potential of thrust faults in the overriding plate for producing transient uplift/terraces. We review pre-, co- and post-seismic observations and conclude that our models capture the principal aspects of megathrust cycles that are shared by many margins, including that in Chile, in Alaska-Aleutians, Sumatra-Andaman, and in the Japan Trench margin.