Geophysical Research Abstracts
Vol. 16, EGU2014-16760, 2014
EGU General Assembly 2014

Characterizing Plate Re-locking and Mantle Viscoelastic Response Following the 2010 Maule Mw 8.8 Megathrust Earthquake

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Following a subduction zone mega-earthquake we observe afterslip on the plate interface which is predominantly aseismic and can release as much as 20% of the moment release of the coseismic slip. However, as the postseismic period progresses the afterslip rate decays and the seismogenic zone begins to re-lock. Re-locking is manifested in the data by a turnaround of the GPS vectors from trenchwards to a convergence-parallel direction and a decrease in aftershock b-value. Due to the viscoelastic relaxation of the mantle we see a sustained trenchward displacement as we move futher away from the plate interface and into the backarc, concurrent with the turnaround of the stations closer to the plate interface.

The excellent spatial coverage of continuous GPS stations in the region affected by the Maule Mw=8.8 2010 earthquake, combined with the proximity of the coast to the seismogenic zone, allows us to study subduction plate interface kinematics in unprecedented detail. Here we present geodetic evidence for re-locking of the seismogenic plate interface using over 3 years of postseismic data from continuous and campaign GPS stations close to the seismogenic zone. We attempt to characterize the process of re-locking using Finite Element Modelling of the South-Central Chilean subduction margin. Modelling proceeds by introducing a coseismic stress change and varying the parameters of rate-and-state friction along the plate interface to fit the vector turnaround of the near-field GPS stations. The data further towards the back-arc are used to constrain the linear Maxwell viscoelastic response of the mantle in a separate modeling step; the contribution of the viscoelastic relaxation to the surface displacement is then subtracted from the dataset to give a refined estimate of surface displacements due to plate interface kinematics. By analyzing the time dependent linear Maxwell viscoelastic parameters we attempt to deduce the most likely constitutive models of mantle viscoelasticity.