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Postseismic deformation after Maule earthquake and the mechanical properties of the asthenosphere and subduction interface

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The interseismic and postseismic deformations preceding and following the large subduction earthquake of Maule (Chile, Mw8.8, 2010) have been closely monitored with GPS from 70 km up to 2000 km away from the trench. Post-seismic deformations exhibit a behavior generally similar to that already observed after the Aceh and Tohoku-Oki earthquakes: vertical uplift is observed on the oceanward side of the volcanic arc. A moderate large scale subsidence is associated with sizeable horizontal deformation in the far-field (500-2000km from the trench). In addition, near-field data (70-200km from the trench) feature a rather complex deformation pattern.

A 3D FE code (Zebulon Zset) is used to relate these deformations to the mechanical properties of the mantle and of the subduction interface. The mesh features a spherical shell-portion from the core-mantle boundary to the Earth's surface, extending over more than 60 degrees in latitude and longitude. The overridding and subducting plates are elastic, and the asthenosphere is viscoelastic. We test the presence and shape of two low viscosity areas in the mantle : a low viscosity wedge (LVW) above the subducting plate extending beneath the volcanic arc, and a narrow low viscosity channel (LVCh) along the lower part of the subduction interface, and potentially deeper. All the viscoelastic regions feature a Burgers rheology and we invert for their mechanical properties and geometrical characteristics. Our best fitting models present, (i) an asthenosphere extending down to 270km, with a 'long-term' viscosity of the order of 3.10^{18}Pa.s; (ii) a LVCh along the plate interface extending from depths of 50 to 150 km with viscosities slightly below 10^{18} Pa.s; (iii) a LVW restricted to the base of the lithosphere below the volcanic arc, with viscosities of a few 10^{18} Pa.s. Increased horizontal velocities are due to relaxation in both the asthenosphere and the LVCh. A deep channel is necessary to produce enough uplift in the middle-field (200-500km from the trench). Some additional slip on the plate interface, at shallow depth, is also necessary to explain all the characteristics of the near-field displacements.