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The mechanical properties of the deep portion of the subduction interface and of the mantle wedge revealed by postseismic motions after Tohoku and Maule earthquakes

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The interseismic and postseismic deformations preceding and following the two large subduction earthquakes of Maule (Chile, Mw8.8, 2010) and Tohoku (Japan, Mw9.1, 2011) have been closely monitored with modern geodetic techniques. We dispose of large datasets, (GEONET cGPS network in Japan and international collaboration networks in Chile, including survey mode GPS).
In both cases, post-seismic deformations show similar behavior, with a vertical uplift on the oceanward side of the volcanic arcs, so called mid-field (between 300 and 500 km from the trench), and a large scale subsidence associated with non negligible horizontal deformations in the far-field (from 500 to 2000km from the trench). In addition, near-field data with complex patterns are available in Chile (thanks to the proximity between the trench and the coastline) and in Japan (thanks to sea bottom geodesy).
We use a 3D finite element code (Zebulon Zset) to relate these deformations to the mechanical properties of the mantle in the subduction zone area. The meshes feature 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) a low viscosity wedge (LVW) above the subducting plate, extending potentially beneath the volcanic arc, b) a low viscosity channel (LVC) extending along the lower part of the subducting interface and just above it, potentially deeper. Burger rheologies have been adopted for all the viscoelastic regions. We invert for the mechanical properties and geometrical characteristics of the asthenosphere of the LVW and of the LVC. Our best fitting models feature, (i) an asthenosphere with a 'long-term' viscosity of the order of 2.10^{18} Pas, extending down to 300km; (ii) a LVC along the plate interface but not extending deeper in the mantle with viscosities of a few 10^{17} Pas, and (iii) a LVW restricted to the base of the lithosphere below the volcanic arc, with viscosities of a few 10^{17} Pas. Mid-field uplift is due to relaxation in both the LVW and the LVC.
The viscoelastic mechanical properties deduced from the postseismic motions can also be used to model deformations through the whole seismic cycle. Predicted interseismic deformations seem to differ strongly from those predicted by purely elastic backslip models.