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Seismological investigations of the subduction zone plate interface: New advances and challenges

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In the last decade, huge advances have been made in analysing the slip distribution of large megathrust earthquakes and how slip relates to geodetic locking, shedding light on the character of the seismic cycle in subduction zones. Recently, a number of studies have suggested that at convergent plate boundaries, geodetic locking may be closely related to slip distribution of subsequent large earthquakes, as found recently for the Maule 2010 and Tohoku 2011 earthquakes. However, the physical (e.g. seismic) properties along the subduction zone interface are still poorly constrained, posing a major limitation to our physical understanding of both geodetic locking and earthquake rupture process.

Here, we present high-resolution seismic tomography results (P- and S-wave velocity), as well as earthquake locations to make a detailed investigation of seismic properties along the portion of the plate interface that ruptured during the 2010 Maule earthquake. Additionally, to test the robustness of our models, we performed numerous numerical tests including changes to the parameterization, synthetic recovery tests and bootstrap analysis.

We find P-wave velocities of about 5.7 km/s at 10 km depth and linearly increasing to 7.5 km/s at a depth of 30 km. Between 30 km and 43 km, P-wave velocities are relatively constant at around 7.5 km/s before a subsequent increase to 8.3 km/s at larger depths (>60 km) is observed. The Poisson's ratio is significantly elevated, at values of up to 0.35 at shallow depths of 10km to 15km, before reaching less elevated values of 0.28-0.29 in the depth range between 20km and 43km. Comparison of these velocities to petrological models shows good agreement below 30 - 50 km depth. At shallower depths though P-wave velocities are significantly lower, which together with the elevated poisons ratio indicates that this portion of the mega thrust is highly hydrated, suggesting that material properties may in part control the seismogenic character of subduction megathrusts Comparison of our findings to other regional tomographic models from other subduction zones worldwide (Japan, Sumatra) shows excellent agreements with our results.