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Strong lateral variations of S-wave velocity in the upper mantle across the western Alps

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Absolute S-wave velocity gives more insight into temperature and mineralogy than relative P-wave velocity variations ($\Delta V_p/V_p$) imaged by teleseismic traveltime tomography. Moreover, teleseismic P-wave tomography has poor vertical but good horizontal resolution. By contrast, the inversion of surface waves dispersion data gives absolute S-wave velocity with a good vertical but relatively poor horizontal resolution. However, the horizontal resolution of surface wave imaging can be improved by using closely spaced stations in mini-arrays. In this work, we use Rayleigh wave phase velocity dispersion data to measure absolute S-wave velocities beneath the CIFALPS profile across the French-Italian western Alps. We apply the array processing technique proposed by Pedersen et al. (2003) to derive Rayleigh wave phase dispersion curves between 20 s and 100 s period in 15 mini-arrays along the CIFALPS line. We estimate a 1-D S-wave velocity model at depth 50-150 km beneath each mini-array by inverting the dispersion curves jointly with receiver functions. The joint inversion helps separating the crustal and mantle contributions in the inversion of dispersion curves. Distinct lithospheric structures and marked lateral variations are revealed beneath the study region, correlating well with regional geological and tectonic features. The average S-wave velocity from 50 to 150 km depth beneath the CIFALPS area is ∼4.48km/s, almost the same as in model AK135, indicating a normal upper mantle structure in average. Lateral variations are dominated by relatively low velocities (∼4.4km/s) in the mantle of the European plate, very low velocities (4.0km/s, i.e. approximately 12% lower than AK135) beneath the Dora Maira internal crystalline massif and high velocities (∼ 5.0km/s, i.e. 12% higher than AK135) beneath the Po plain. The lateral variations of S-wave velocity perturbation show the same features as the P wave tomography (Zhao et al., submitted), but with different amplitudes. In summary, this study reveals a strong S-wave low velocity anomaly in the upper mantle beneath the Dora Maira massif and confirms this unexpected and intriguing result of the P traveltime tomography. To further strengthen our results, we measure P and S wave arrival times for 15 events located approximately in the same azimuth as the CIFALPS profile (2-D cross-section). We expect these complementary observations from P and S waves to be a valuable input to further understand the lithosphere-asthenosphere system beneath the western Alps.