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The Alpine Deep Structure from Surface Wave Tomography

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Collisional tectonics of the Alps is driven by several slab segments. A detailed imaging of the lithosphere-asthenosphere system beneath the Alps is, however, challenging due to the relatively small size of the slab segments and the highly curved geometry of the Alps. Surface waves, due to their high sensitivity to variations in seismic velocities at lower crustal and upper mantle depth, are well suited to study the Alpine deep structure. New azimuthally anisotropic Rayleigh wave phase velocity maps are calculated from automated inter-station phase velocity measurements in a very broad period range (8 – 350 s). The constructed local dispersion curves are then inverted individually for 1-D shear-wave velocity models using a new implementation of the stochastic Particle Swarm Optimization (PSO) inversion algorithm that enables the calculation of a high-resolution 3-D shear-wave velocity model from the crust down to 300 km beneath the Alps. In the Central Alps, a nearly vertical high velocity anomaly down to depth of 250 km is imaged and interpreted as subducting Eurasian mantle lithosphere. In contrast, low velocities in the Western Alps at depth of approximately 100 km and downwards are supporting the shallow slab break-off model. In the Eastern Alps, the presence of a vertically continuous high-velocity anomaly from 75 km to about 200 km depth beneath the northern Eurasian foreland and the almost continuous extension of a high-velocity anomaly from the Dinarides towards the Eastern Alps hint at a bivergent slab geometry beneath the Eastern Alps caused by subducting mantle lithosphere of both Eurasian and Adriatic origin. There is also evidence for subduction of Adriatic lithosphere to the east beneath the Pannonian Basin and the Dinarides down to a depth of about 150 km. Beneath the northern Apennines, the model indicates an attached Adriatic slab, whereas a slab window is found beneath the central Apennines. The results show that surface wave tomography can contribute to the imaging of complex slab geometries and slab segmentation in the Alpine region.