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A 3-D shear-wave velocity model across the Alpine-Mediterranean mobile belt from high-resolution Rayleigh wave tomography

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The Alpine-Mediterranean mobile belt is, tectonically, a highly complicated and active region. Since the early Tertiary, a series of collisions between Gondwana-derived continental microcontinents and Eurasia have shaped the Mediterranean geology due to the closure of the intervening ocean basins. Plenty of studies have attempted to characterize its lithosphere-asthenosphere structure, however there are still many controversial issues such as the presence and geometry of slabs and slab fragments e.g. in the Alps, the Dinarides, the Apennines, in the western Mediterranean and Anatolia. In this study, a high-resolution 3-D shear-wave velocity structure of the lithosphere-asthenosphere system beneath the Mediterranean including the Alps and the adjacent regions from surface wave tomography is presented. An automated algorithm for inter-station phase velocity measurements is applied to obtain Rayleigh and Love fundamental mode phase velocities. We utilize a database consisting of ∼3800 teleseismic earthquakes recorded by ∼4500 broadband seismic stations provided by IRIS and EIDA in a combination, for the first time, with waveform data from the Egyptian National Seismological Network (ENSN) in order to ensure a good path coverage especially for the eastern Mediterranean. Path average dispersion curves are obtained by averaging the smooth parts of single-event measurements. We calculate Rayleigh- and Love-phase velocity maps for periods between 8 s and 350 s that, in turn, provide the local phase-velocities for each geographical grid node of the map at lateral inter-knot spacing of 30 km. Each local dispersion curve is inverted individually for 1-D velocity model using a newly implemented Particle Swarm Optimization (PSO) algorithm. The resulting 1-D velocity models are then combined to construct the 3-D velocity model. The obtained model shows significant variations in shear velocities both horizontally and vertically. It reveals slow velocities indicative of shallow asthenosphere beneath Anatolia, the Aegean, the Pannonian Basin, and the Western Mediterranean including Iberia and the Atlas. The eastern Mediterranean from the Herodotus basin in the East reaching the Ionian Sea in the west is dominated by rather thick oceanic lithosphere that is subducting beneath Calabria and in the southern Aegean. Both the Hellenic and Cyprus arcs are clearly imaged with a complicated transition from the Hellenic arc towards the Hellenides and the Dinarides where slab is observed only down to about 150 km depth. The Alpine mantle shows a nearly vertical subducting Eurasian slab in the central Alps, a pronounced change towards the eastern Alps in the region of the Judicaria fault, and a nearly vertically dipping slab in the northern Apennines, whereas a slab window is present in the central Apennines and below about 150 km depth in the northern Dinarides. In the western Mediterranean, the Alboran detached slab is imaged below about 180 km depth along the SE Iberian striking almost parallel the south-west Iberian coastline. The Kabylides slab has been imaged beneath northwestern Africa with an almost NS-striking detached continuation towards the Tyrrhenian Sea. Based on our results, surface wave tomography can contribute significantly to the imaging of the complex slab geometries and slab segmentations in the Mediterranean.