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Along strike changes in the crustal structure of the Alps documented by a new ambient-noise tomography

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Unlike large mountain belts such as the Himalayas or the Andes, the lithospheric structure of the Alps displays strong and quick changes both across and along strike. Probing this very heterogeneous belt in 3-D at sufficiently high resolution is a challenge for geophysicists as it requires dense, 2-D arrays of sensors. Before the Alparray seismic experiments, the crustal structure of the alpine belt has mainly been probed along seismic transects using either controlled sources (EGT, ECORS-CROP, NFP-20, Transalp) or earthquake data (Transalp, Cifalps, EASI). The gaps between these transects were filled using potential field data such as Bouguer anomaly modeling in 3-D, albeit at a much lower vertical resolution. The AlpArray temporary seismic network and the high quality permanent broadband seismic networks now make it possible to image the lithospheric structure of the Alps in 3-D and with resolutions of a few tens of km.

Using 4 years of ambient noise data at ∼1300 european seismic stations, we computed a new, 3-D, high-resolution probabilistic model of the crust in the greater Alpine region that helps filling the gaps between transects. Thanks to the big dataset, our 3-D crustal shear-wave velocity model has a higher resolution than previous published models. Moreover, our Bayesian inversion algorithm provides a probabilistic 3-D shear-wave velocity model, including probability densities for the depth of layer boundaries such as the Moho discontinuity.

We firstly compare our crustal model (Vs structure and probability of layer boundary depth) with published cross-sections along 3 reference transects in the south-western Alps (Cifalps: receiver functions and local earthquake tomography), north-western Alps (ECORS-CROP: vertical-incidence and wide-angle seismic reflection), and eastern Alps (Transalp: vertical-incidence reflection and receiver functions). In the western Alps, our model displays striking similarities with the reference sections. Besides, it provides new structural information such as a 8 km Moho jump along the ECORS-CROP profile that was not imaged by reflection data due to poor penetration across a heterogeneous upper crust. In the eastern Alps, our image along the Transalp section is similar to the controlled-source section but rather different from the receiver function section. Our model documents a progressive change in the vergence of the lithospheric scale thrust between Transalp cross-section (longitude 12°) where Adria is the upper plate, and the cross-section at longitude 14.5 ° where Adriatic Moho is deeper than European Moho.