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Crustal scale imaging of the Arabia-Eurasia collision zone from transdimensional trees inversion of seismic noise

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The Arabia-Eurasia collision zone accommodates a major structural segment of the Alpine-Himalayan chain and one of the most seismically active fold-and-thrust-belts in the world, the Zagros mountains. Seismic activity substantially decreases east of a series of nearly north-south dextral transpressive faults in Iran, known as Oman Line. This delineates the transition from continent-continent to ocean-continent collision, occurring along the Makran active margin. Another prominent tectonic feature of the region is the obducted Semail ophiolite, which represents the largest exposure of Tethyan oceanic lithosphere in the world. The interplay of the above tectonic features has not been fully investigated, partially due to a lack of detailed information about crustal structure.

Our effort is focused on ambient seismic noise for imaging 3D crustal shear velocity structure using surface waves. The data used in this study is sourced from 77 broadband sensors, which have an average recording time of one year. Phase dispersion measurements derived from the cross-correlations of the vertical component have been inverted using a novel hierarchical, transdimensional, Bayesian algorithm to obtain Rayleigh-wave velocity maps at different periods from 2 to 50 s. The new algorithm applied here involves a tree-structured wavelet parametrization of the velocity field within a parallel interacting chain framework (Parallel Tempering). Transdimensional trees are multiscale and allow to contract models from coarse to fine, in the same fashion as image compression techniques. Trees are also dynamic, in the sense that they have the characteristic of altering the model space by locally adapting to the data coverage. After obtaining 2-D maps for different periods, phase dispersion curves extracted from a uniform grid of nodes are inverted for 1-D shear wave velocity structure using the rj-McMC algorithm (reversible-jump Markov chain Monte Carlo). Here we assume that the number, position and velocity of the layers are all unknown during the inversion. This allows us to achieve the first 3-D shear velocity model of the whole crust beneath the Arabia-Eurasia collisional system.

Results show the 3-D structure of the deformed Cambrian to Quaternary cover of the Arabian plate, which exhibits a thickness ranging between 8 and 11 km, where most of the seismicity seems to nucleate. Our shear velocity model also shows a marked transition in seismic wavespeed along the Oman Line from continent-continent to continent-ocean collision. We also provide direct evidence of low-angle thrusting of Arabian basement beneath central Iran as associated by relatively high velocities of the Arabian basement.