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Lithospheric and Sub-lithospheric Upper Mantle Structure of Africa from Full Wave Long-Period Ambient Noise Tomography

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The relationship between lithospheric structure, upper mantle flow, and topographic anomalies in Africa is a subject of ongoing interest. Despite a pronounced increase in temporary and permanent broadband seismic stations, seismic arrays are distributed unevenly throughout the continent. As a result, models of the upper mantle beneath Africa are well-resolved in many regions along the East African Rift directly beneath seismic deployments, but other key regions throughout the continent remain poorly resolved. In order to better image the upper mantle structure between existing broadband arrays, we use a long-period ambient noise tomography approach that has been utilized to study other sparsely covered regions [1].

We use overlapping records from temporary and permanent broadband seismic arrays (1980-2015) throughout Africa, southern Europe, and the Middle East in order to image the upper mantle beneath poorly-resolved regions of North Africa, the East African Rift, and the Congo Craton. We extract empirical Green's functions (EGFs) by cross-correlating ambient seismic noise using a frequency-time normalization method [2]. The normalized, cross-correlated records are stacked, and coherent signal is retrieved at 10-340 seconds. We then simulate wave propagation through the spherical Earth using a finite-difference method [3], measure the phase delay between data and synthetic signals, calculate sensitivity kernels using the scattering integral approach [4], and iteratively invert for structure using least-squares. Due to computational demands of the waveform simulations, initial results include signal at periods of 80-340 sec for 186 broadband seismic stations, resulting in the best resolution at depths of ~100-350 km. Current iterations will allow signals at 40-340 seconds to be included, and will significantly improve resolution in the shallow upper mantle. The full dataset (400+ sensors) will be incorporated in future iterations.

Initial results show a number of interesting features: 1) Low-velocity anomalies were imaged in the upper mantle beneath the volcanic Hoggar and Tibesti Plateaus in Northern Africa. 2) The Congo Craton exhibits a distinct separation in the west-east direction down to 200-250 km depths – a feature that has been previously imaged only at shallow lithospheric depths and supports the idea that the Congo Craton is two distinct Archean cratons [5]. 3) A prominent fast-velocity feature exists beneath the Atlantic Ocean off the coast of Namibia and the Congo. 4) A possible separation beneath the Ethiopian and East African hotspots at shallow upper mantle depths beneath the Turkana Depression will be better resolved during subsequent iterations.

References:
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