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Upper mantle imaging with AlpArray surface wave diffraction: The Cameroon Volcanic Line

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The AlpArray seismic network stretches hundreds of kilometers in width and more than thousand kilometers in length. It is distributed over the greater Alpine region (Europe) and consists of around 250 temporary and around 400 permanent broadband stations with interstation distances around 40 km. We report here on novel possibilities allowed by the high spatial density of such a network. In particular, it allows to track travel times and azimuthal deviations of long-period surface waves (30 – 150 s) across the AlpArray.
We utilize an array-beamforming technique for surface waves. The signal is well-recognized and the fundamental mode for Rayleigh waves is separated before the beamforming. We identify the frequency-dependence of surface-wave phase velocity and the true directions of propagation. We consider each AlpArray station as a centre of a subarray of neighboring ($\sim$ 13) stations with a diameter of 80 km. This allows us to calculate the local phase velocity for more than 500 stations included in the AlpArray project. The full phase-velocity vector (true direction as well as the absolute value of the velocity) allows us to observe deviations of the backazimuths with respect to the great circles for each subarray. These deviations are frequency-dependent throughout the whole region and form intriguing stripe-like patterns.
We test a hypothesis that these stripe-like arrival-angle deviation patterns are caused by interference of diffracted wavefield after passing a single low-velocity anomaly. We use Rayleigh waves from two earthquakes under the Southern Atlantic Ocean. Around 500 subarrays of 160 km aperture covering the broader Alpine region are used for beamforming at 15 discrete periods between 50 and 120 s. A grid-search inversion scheme is set up for determining characteristics of the anomaly: The exit point of the anomaly is found to be at 10.5°N/15.0°E, which falls onto the Cameroon Volcanic Line. The fit of the space and frequency patterns is remarkable. The width of the anomaly is between 320 – 420 km, and its length matches the 2500 km long upper-mantle low-velocity region under the volcano-capped swells of the Cameroon Volcanic Line. We will discuss the new inferences about the Cameroon line, especially its eastern end, and the importance of that observation in light of models for small-scale convection in the upper mantle.
This observation serves not only as a detector of low-velocity features in the upper mantle, but it also allows to determine how phase and group travel time delays and wavefront healing can affect global and regional tomographic studies. It has important consequences for the local phase-velocity measurements as well.