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Phase velocities and azimuthal deviations of teleseismic surface waves across AlpArray

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Distributed across the greater Alpine region in Europe, the AlpArray seismic network stretches hundreds of kilometers in width and more than thousand kilometers in length, with interstation distances of around 40 km. AlpArray can thus be used to study heterogeneities in crust and mantle by their influence on long-period surface waves propagating from distant earthquakes to the array. We present a mapping of true propagation paths of 20 – 150 s surface waves of nearly 30 earthquakes from 2016 and 2017 (first two years of the AlpArray project duration).

We utilize array beamforming techniques to investigate (deterministic) surface waves from regional and teleseismic earthquakes. The signal is well-recognized and the fundamental mode for Rayleigh waves is separated before the beamforming. Instead of searching for energy of all possible signals as used in traditional beamforming, we identify the frequency-dependence of surface wave phase velocity and the true backazimuths of propagation. We consider each AlpArray station as a centre of a subarray of neighboring (6 – 15) stations. This allows us to calculate the local phase velocity dispersion curves for individual subarrays with a diameter of approximately 80 – 100 km. We repeat the procedure for more than 500 stations included in the AlpArray project. By the beamforming, phase velocities are corrected for the true propagation backazimuth, which is slightly frequency-dependent for each event.

As a result, we provide phase velocity maps for specific periods of surface waves for individual events. In addition, the true backazimuths determined for each subarray and plotted in the map show the frequency-dependent deviations from the great-circles through the whole Alpine region.

To benchmark the backazimuths determined by the array measurement of phase velocities, we also determine the teleseismic surface wavefronts by measuring the phases at each station separately. We see a good match of the two results.

Merging the phase velocity maps for individual earthquakes – weighted by the residuals of each sub-array plane wave fit – allows us to obtain frequency-dependent phase velocity map of the region.