Mapping the diffraction patterns of surface waves by AlpArray

Petr Kolínský[1], Gidera Gröschl[1], Götz Bokelmann[1] and the AlpArray Working Group[2]

1 Department of Meteorology and Geophysics, University of Vienna,
petr.kolinsky@univie.ac.at
2 www.alparray.ethz.ch

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. The density of the network allows to track the distortion of travel times and azimuthal deviations of long-period surface waves (30 – 150 s). 30 teleseismic earthquakes from 2016 and 2017 from the first two years of the AlpArray project cover the full range of azimuths. We map the propagation of surface waves by two independent methods. First, we pick group and phase times. Group travel times are much more sensitive to distant heterogeneity then phase times. Using simple Gaussian beam time-delay modeling of the heterogeneity effects on group propagation times, we are able to estimate the distance of the heterogeneity, its position, lateral size and magnitude of the velocity anomaly, which had caused the observed time distortion.

Phase times are, on the other hand, compared with the results of the second method of mapping the deviations: 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. Instead of searching for energy of all possible signals as in traditional 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 (6 – 15) 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. As we have the full vector of phase velocity (true direction as well as the absolute value of the velocity), we can observe deviations of the backazimuths with respect to the great circles for each subarray. These deviations are frequency-dependent throughout the whole region. They follow the same pattern as the phase (and group) times picked at each station separately (see the first method).

The observation serves not only as a detector of upper mantle heterogeneities, but it also allows to determine how phase and group travel time delays and wavefront healing can affect global and regional tomographic studies.