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Imaging azimuthal anisotropy in the alpine crust using noise cross-correlations

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Imaging azimuthal anisotropy from seismic noise cross-correlations is challenging, especially in very complex tectonic settings such as the Alps. In this region, the focus has been mainly on retrieving anisotropy using SKS-splitting data, but this data does not provide strong depth constraints. In this work, we map the azimuthal anisotropy of Rayleigh-wave velocity in the Alps using seismic noise cross-correlations. This initial study focusses on waves at ~15 s period. The study area is divided into small zones for which all the stations outside are used as virtual sources and all the stations inside are used as receivers. For each virtual source and each zone, we perform time domain beam forming to retrieve the local phase velocity and propagation direction. As the distances between sources and receivers are relatively small, we use an algorithm that takes into account circular wavefronts. The beam forming shows that the waveforms are very coherent for different stations within each small array, and that deviations from great-circle propagation can be significant. The resulting phase velocities in each zone show a variation with azimuth which is in some locations very small (indicating that anisotropy is insignificant) and which in all other locations has a 2θ dependency on azimuth, indicative of well resolved azimuthal anisotropy. Bootstrapping uncertainty estimates show that the results are very stable if a sufficient number of source stations is used. The combination of permanent stations with the temporary AlpArray stations provides us with a very high station density that allows us to carry out this measurement across a large area. The resulting anisotropy maps show a good resolution, with higher uncertainties in the Po plain and the areas of low station density. The clear 2θ azimuth dependency is a sign that our method overcomes both effects related to source directivity (which has an approximate 1θ dependency) and measurement instability which can be significant for Eikonal tomography in the case of irregular networks.