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

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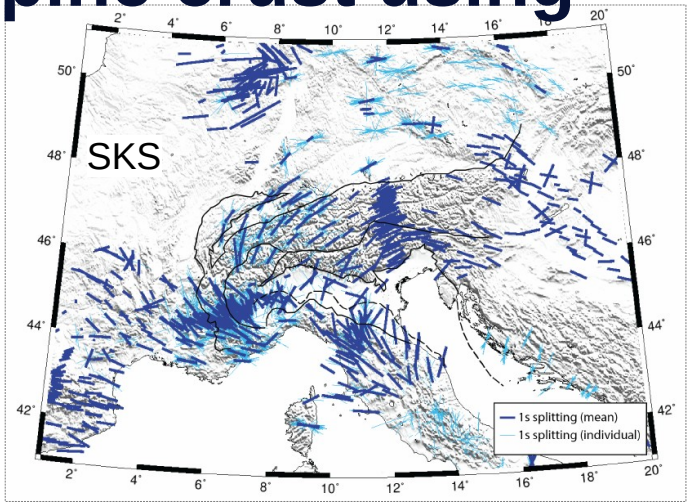
SKS measurements in the greater Alpine area : fast axis ~parallel to the chain. Poor depth resolution implies that key geodynamic questions are not answered → use of surface waves can be critical

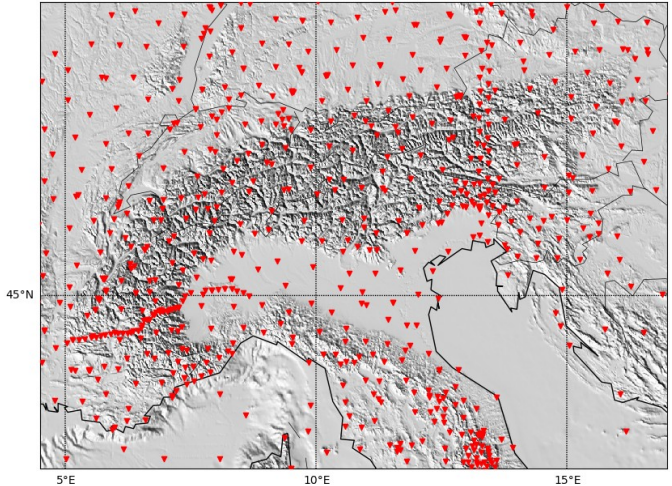
Short to intermediate period anisotropy is difficult to measure with earthquake data due to multipathing and diffraction between source and receivers. This problem is overcome with noise correlations.

This study : uses array analysis on noise correlations, using distant (>2 wavelengths) stations as virtual sources

Data: 2772 stations, 4 million correlations



Barruol *et al.* (2009) ; Wüstefeld *et al.* (2009); Salimbeni *et al.* (2018)



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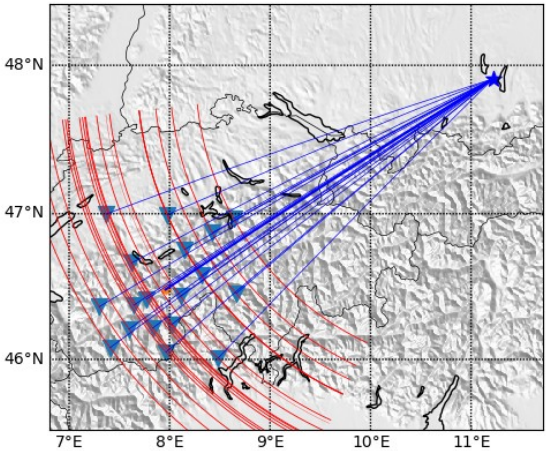
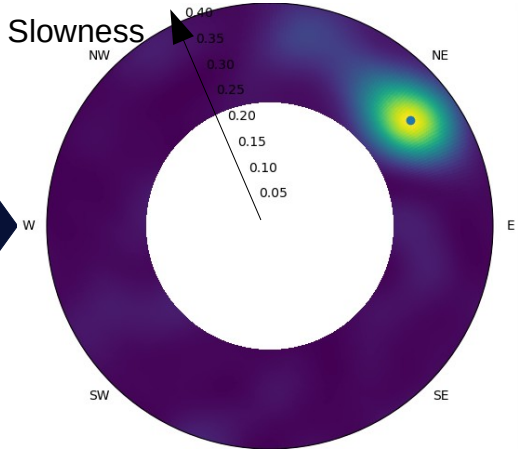
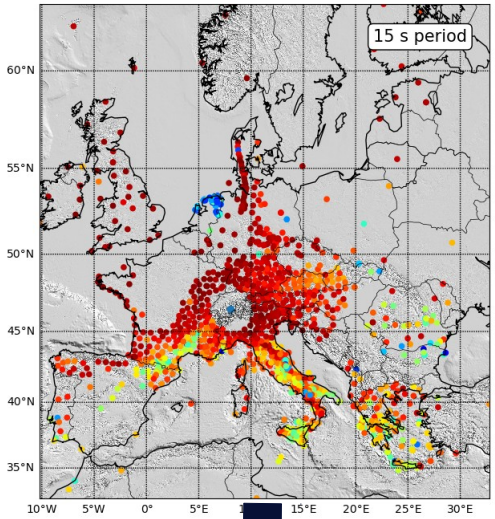
Method

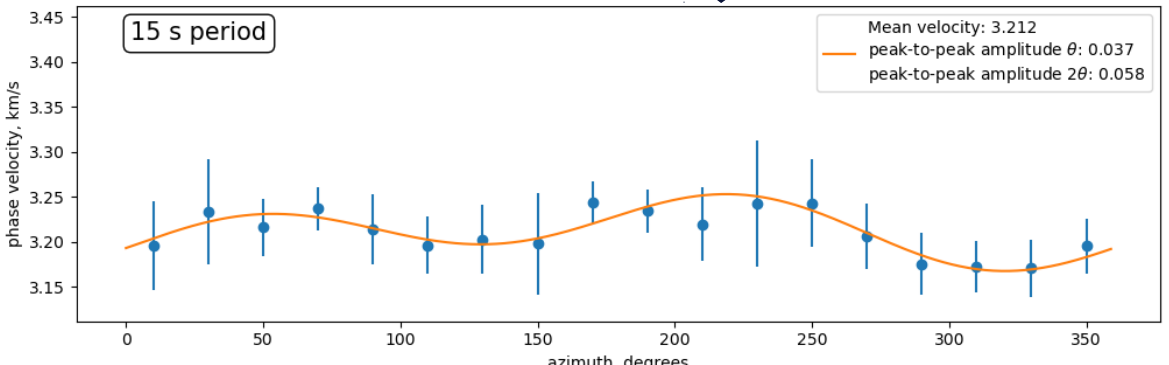
For a given array, and for each virtual source located more than two wavelengths away, carry out time domain beamforming, using circular wavefronts for close sources





Good azimuthal coverage in high-quality data : well-constrained anisotropy measurements





Good azimuthal coverage → retrieve reliable anisotropy estimates (amplitude, fast direction)

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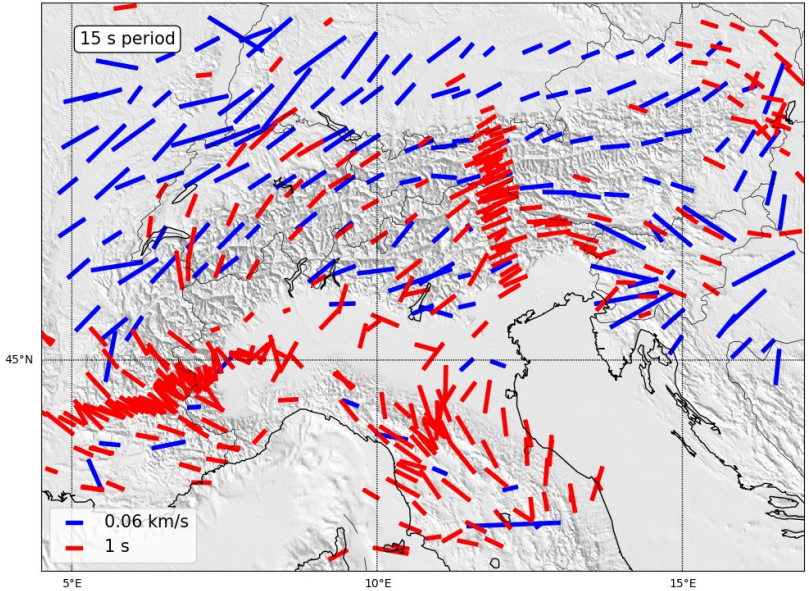
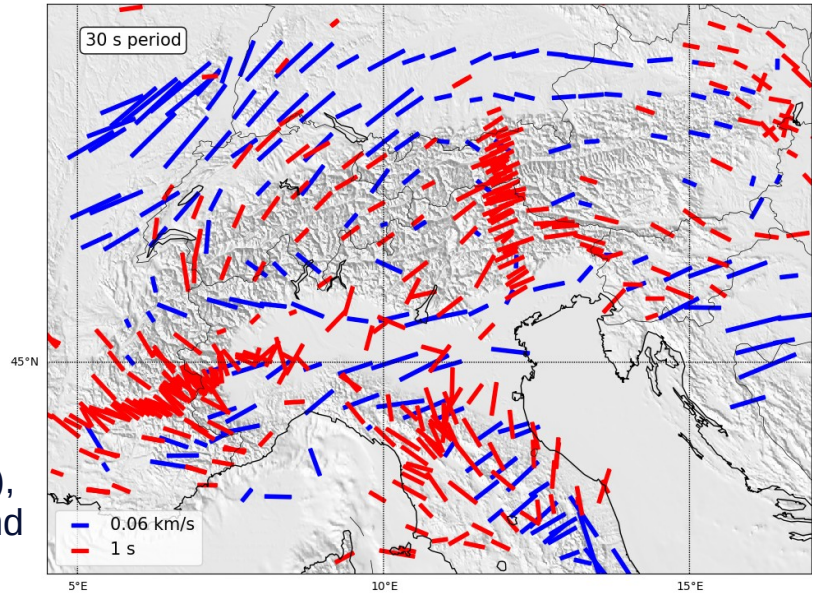
Results and Conclusions

Array analysis on noise correlations :

- Explicit control of station geometry
- Explicit control of quality of measurements
- Explicit identification of 2θ variations versus spurious 1θ variations
- Observed anisotropy at 30 s period : coherent with SKS observations in the greater Alpine area -> SKS pattern does at least partly origin in the upper mantle and/or the crust
- Mismatch with SKS in the Appennines: anisotropy at 30 s period has it origins in strong crustal anisotropy (coherent with strong radial anisotropy as observed by Alder *et al.* (in prep))
- Further work: include longer periods with a main focus on earthquake data





Blue : This work
Red : Barruol et al. (2009), Wüstefeld et al. (2009) and Salimbeni et al. (2018)

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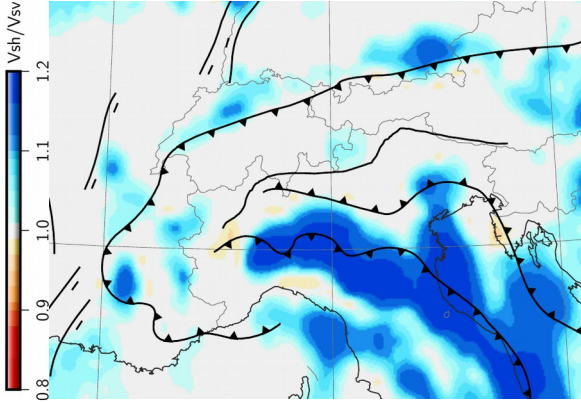
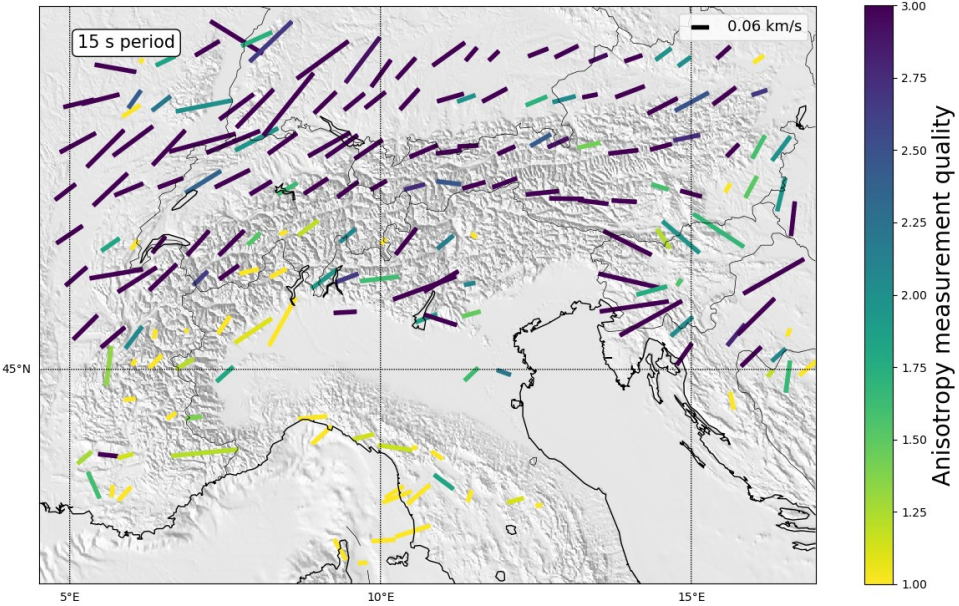
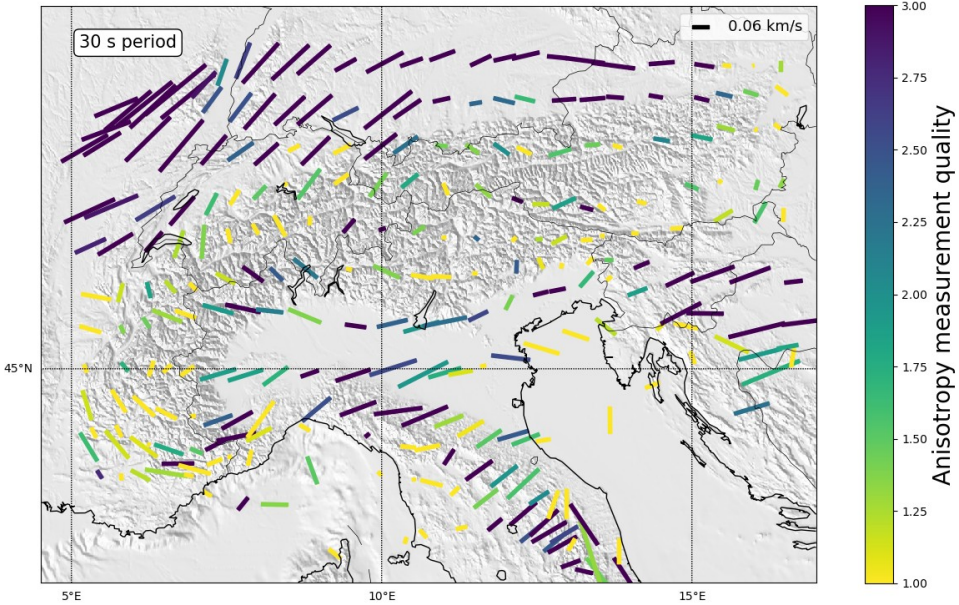
Beamforming quality

Radial anisotropy map from Alder *et al.* (in prep)
East-West anisotropy in the Appenines corresponds to strong radial anisotropy.



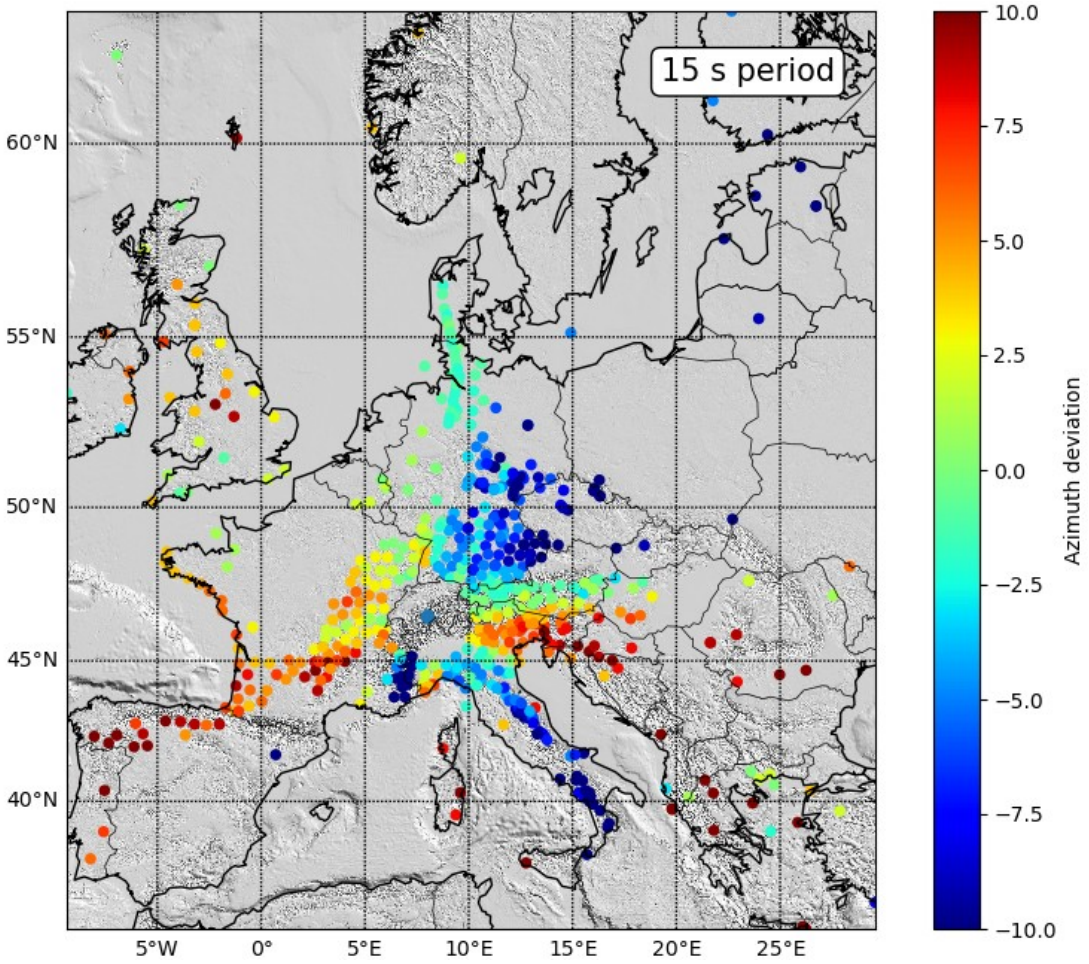
Maps of anisotropy at 15 and 30 s period. The color indicates the amplitude of the 2θ component as compared to the θ component. The best measures are in the northern part of the study area.





Azimuthal Deviations

- Fast and strong variations
- Shows the necessity to account for non-great-circle paths
- Deviation corresponds to rays circumventing mountain belts.



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