Slab detachment under the Eastern Alps seen by seismic anisotropy

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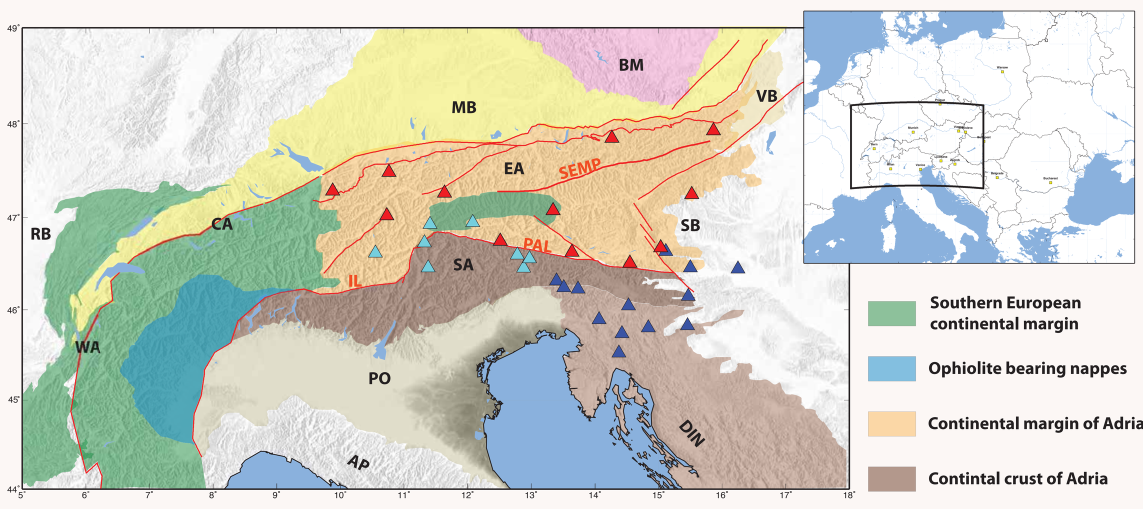
Introduction

- The Alps are an arc-shaped double-verging mountain chain developed at the boundary between the Eurasian plate (to the North) and the Adriatic microplate (to the South).
- While the surface geological structure of the Alps is well-understood, the structure of the deeper parts of the lithosphere and the mantle below still remains an open problem.
- This study focuses on the upper mantle anisotropy under the Eastern Alps by analyzing shear-wave splitting from SK(K)S phases.

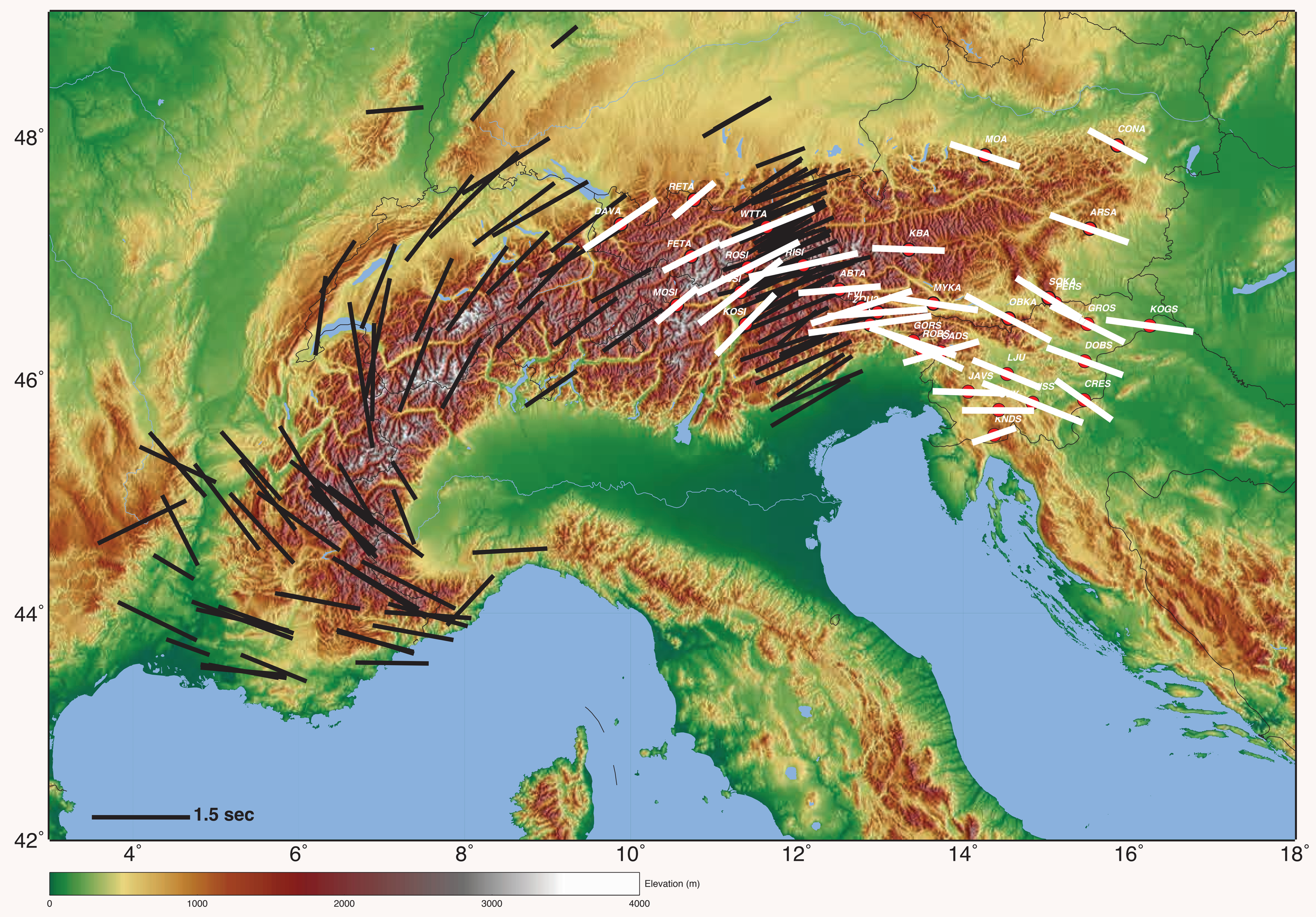


Method and Data

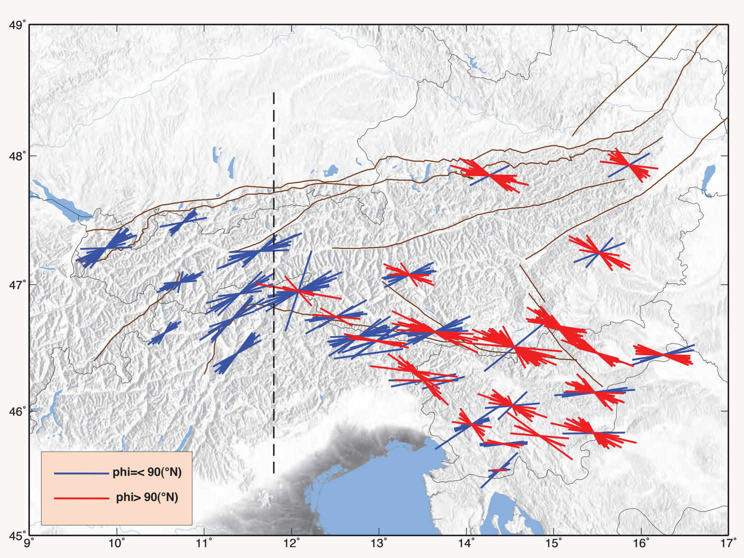
Shear-wave splitting method to measure two splitting parameters (i.e. the fast orientation azimuth, , and the delay time, t). Data from 33 broadband stations consisting of recorded waveforms of teleseismic events with magnitude greater than 6.0 Mw have occurred in the distance range from 90 to 130 between 2002 and 2013.

Belt-Parallel Anisotropy

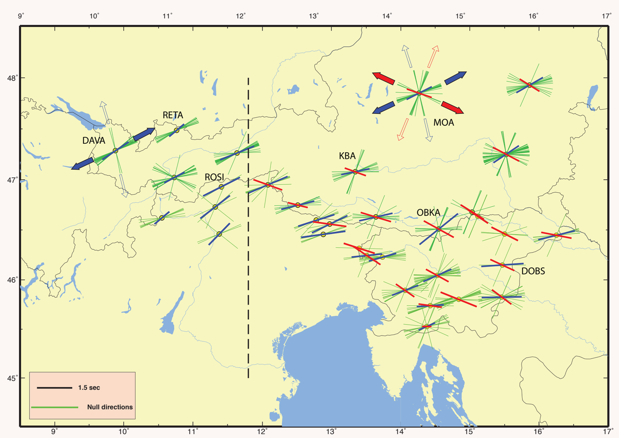
Thick white lines represent average fast orientation at each station. Black lines display measurements from previous studies (Barruol et al., 2011; Kummerow and Kind, 2006; Salimbeni et al., 2013).



Individual Measurements

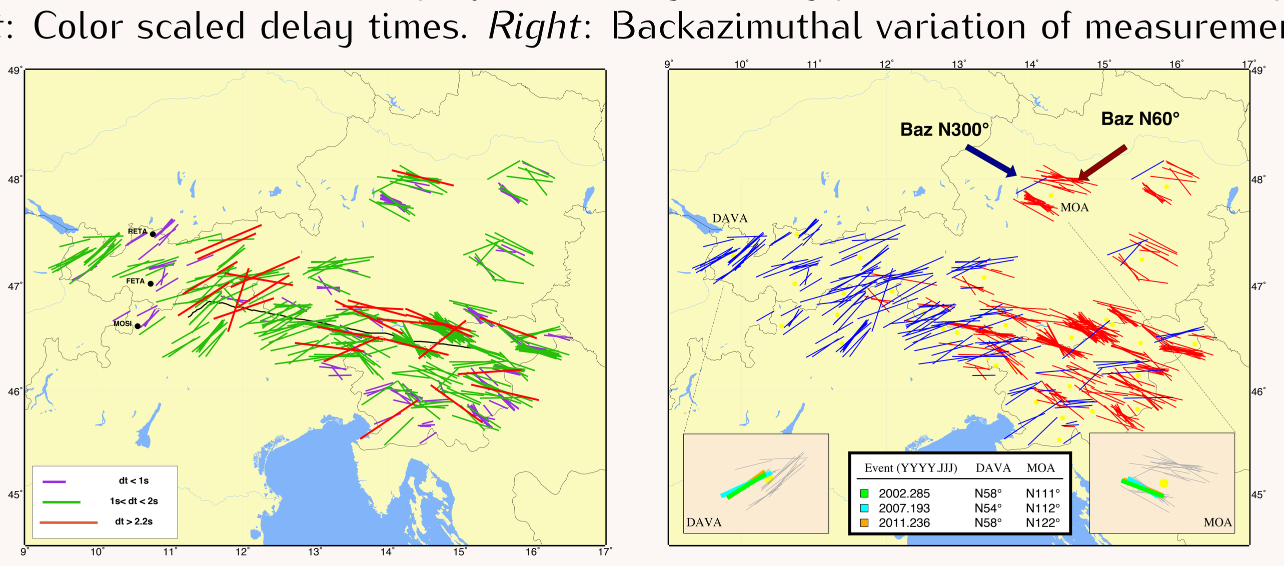


Individual measurements of splitting parameters. The orientation of fast azimuths, , is represented by lines with length corresponding to the delay time value (t). Figure below shows the Null orientations together with the group-averages.



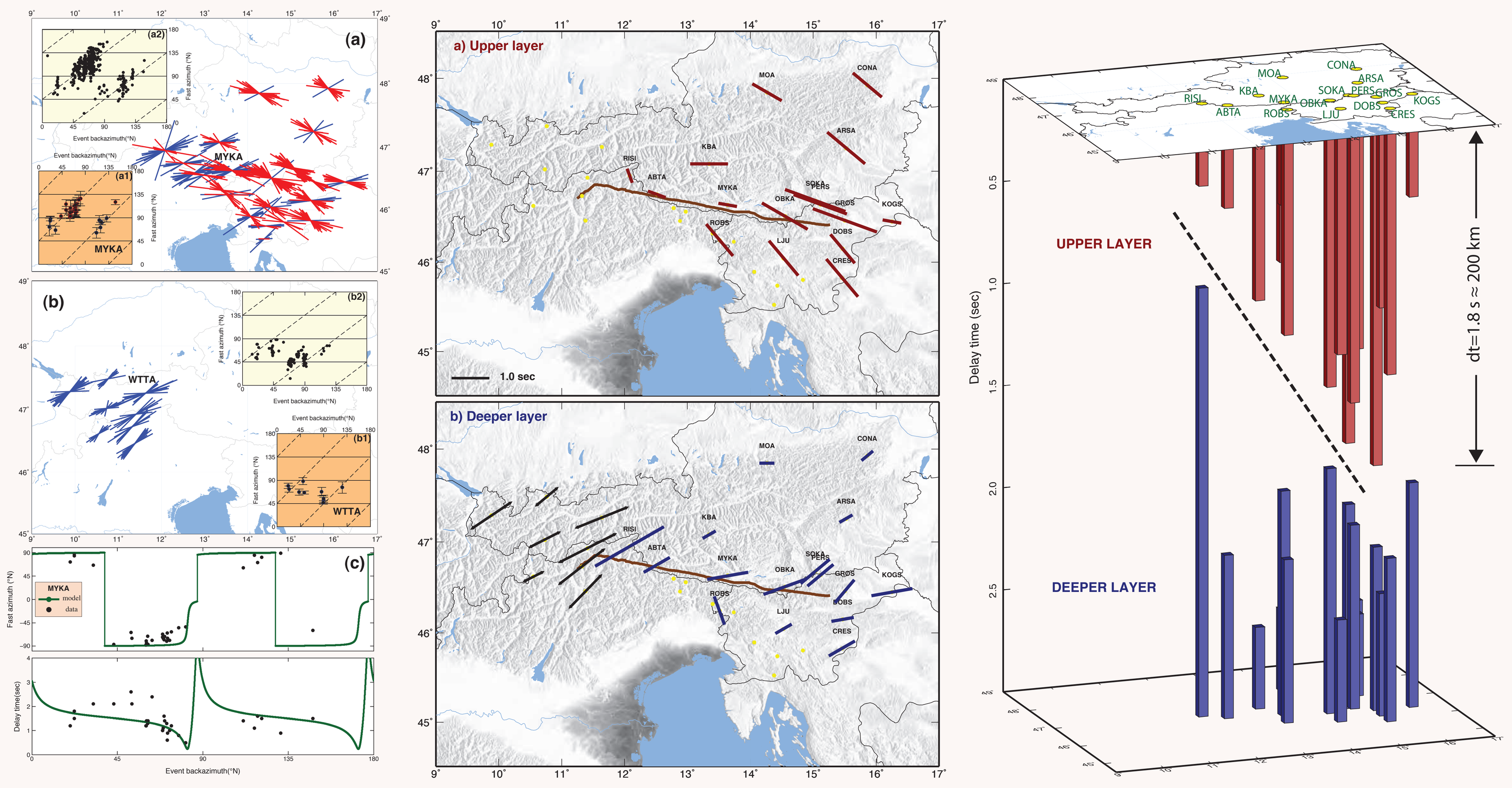
Lateral Change of Anisotropy

Individual fast orientations projected along the ray paths down to 150 km depth.
Left: Color scaled delay times. *Right*: Backazimuthal variation of measurements.



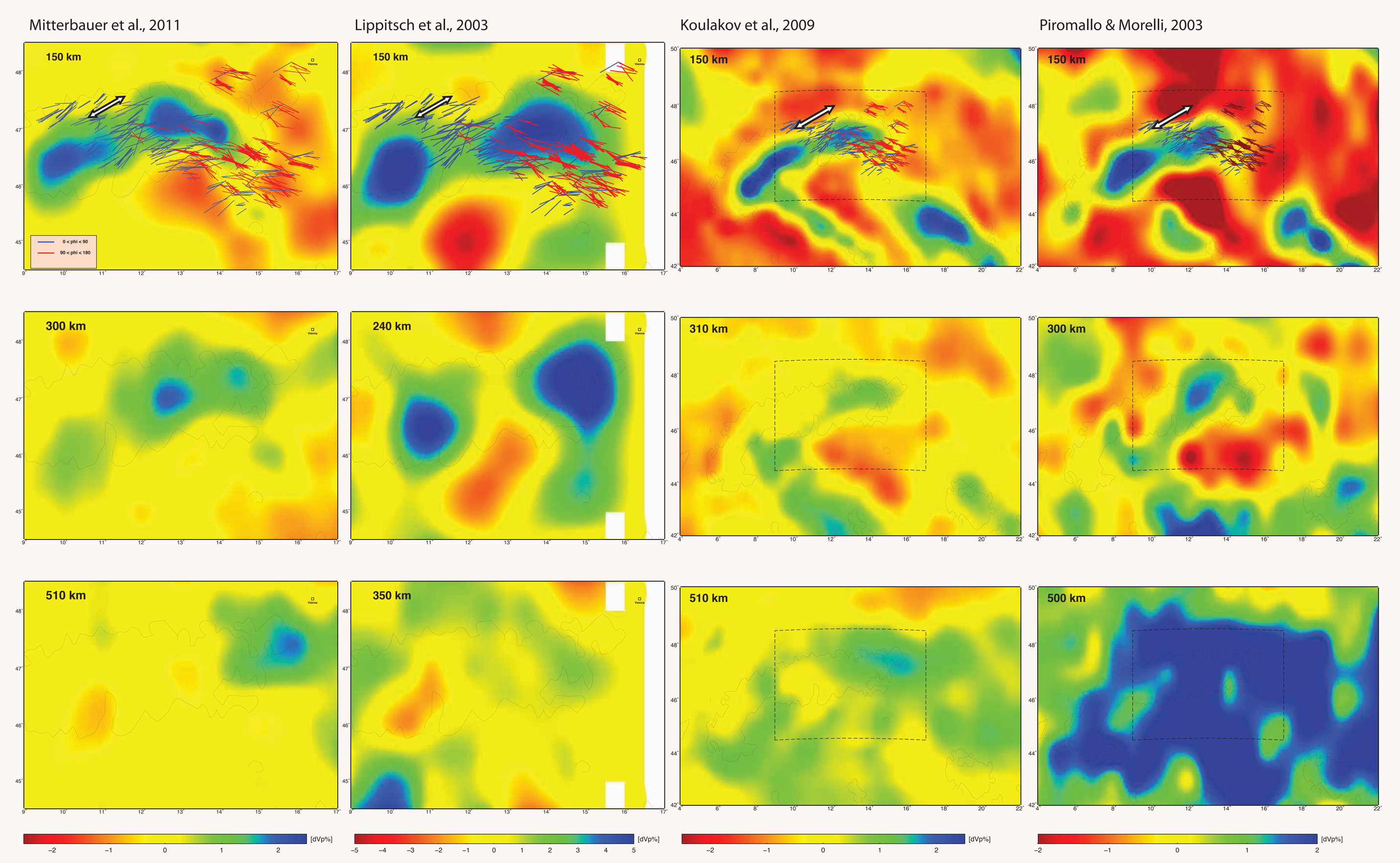
Vertical Change of Anisotropy

Left: Periodicity of fast orientations as function of event backazimuth together with the theoretical distribution of apparent splitting parameters from the best-fit two layers model for station MYKA. *Middle*: Splitting parameters of two anisotropic layers at each station. *Right*: Three-dimensional spatial distribution of splitting delays for the upper layer (red bars) and the deeper layer (blue bars).



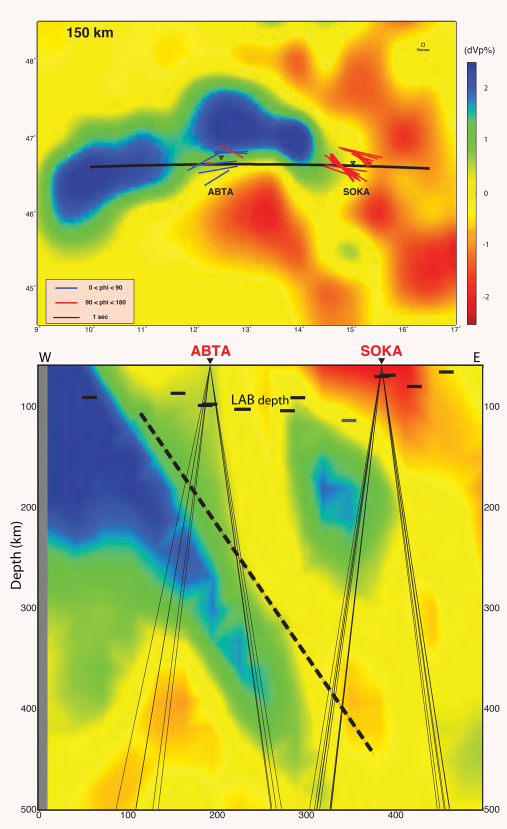
Anisotropy vs Tomographic images

Depth slices of P-wave tomography at 150, 300, and 500 km depth. Projections at 150 km depth of individual splitting measurements are superimposed on the tomographic images.

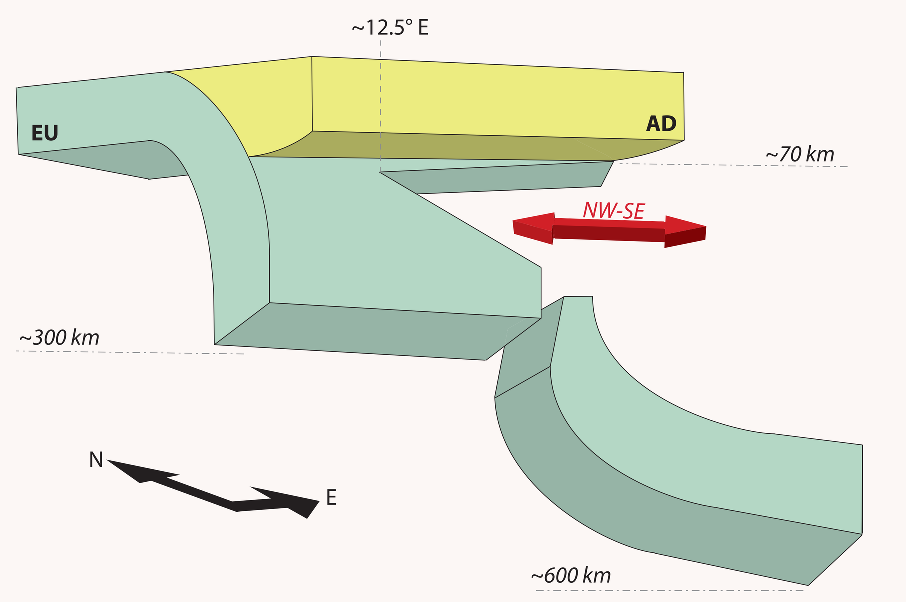


Possible Origin of Anisotropy

- The low-velocity anomaly matches the wedge-shaped distribution of splitting delays of the upper layer.
- Considering anisotropy magnitude of 5% results in a path between 50 km to 200 km.
- LAB depth under the Eastern Alps is mainly less than 100 km.
- NW-SE fast orientations are also observed for the Pannonian basin.



Schematic figure for the upper mantle structures under the Eastern Alps based on the two layers of anisotropy



Conclusion

- The average values of fast orientations show a mountain-parallel anisotropy pattern for the Western and Central Alps. This pattern breaks down at the Eastern Alps showing remarkable lateral change of anisotropy.
- Modeling the vertical change of anisotropy (two anisotropic layers) suggests a possible interpretation for the upper mantle structure beneath the Eastern Alps.

We propose an upper layer characterized by asthenospheric flow with NW-SE orientations.

The deeper anisotropic layer is characterized by a detached slab with NE-SW fast orientation, similar to anisotropy pattern of the Central Alps.

(Qorbani et al., 2015, EPSL, 409, 96-108)