Anisotropy and deformation beneath the Eastern Alps

E. Qorbani, G. Bokelmann, I. Bianchi

Department of Meteorology and Geophysics (IMGW), University of Vienna

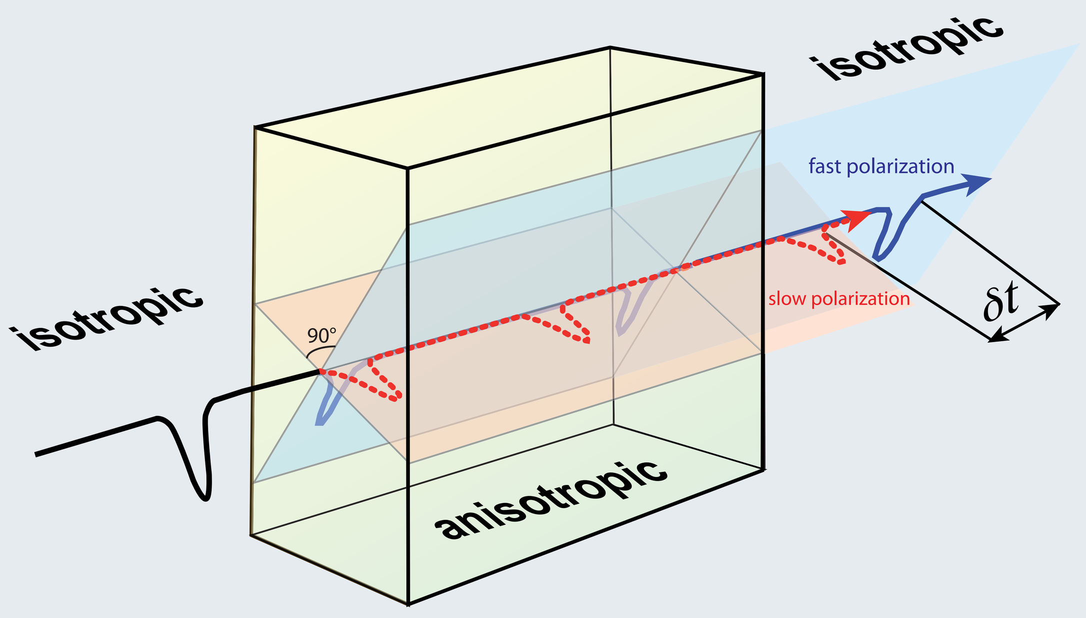
ehsan.qorbani@univie.ac.at, goetz.bokelmann@univie.ac.at, irene.bianchi@univie.ac.at

10TH ANNIVERSARY 15-20|SEPT SALZBURG PANGEO AUSTRIA 2012

Overview

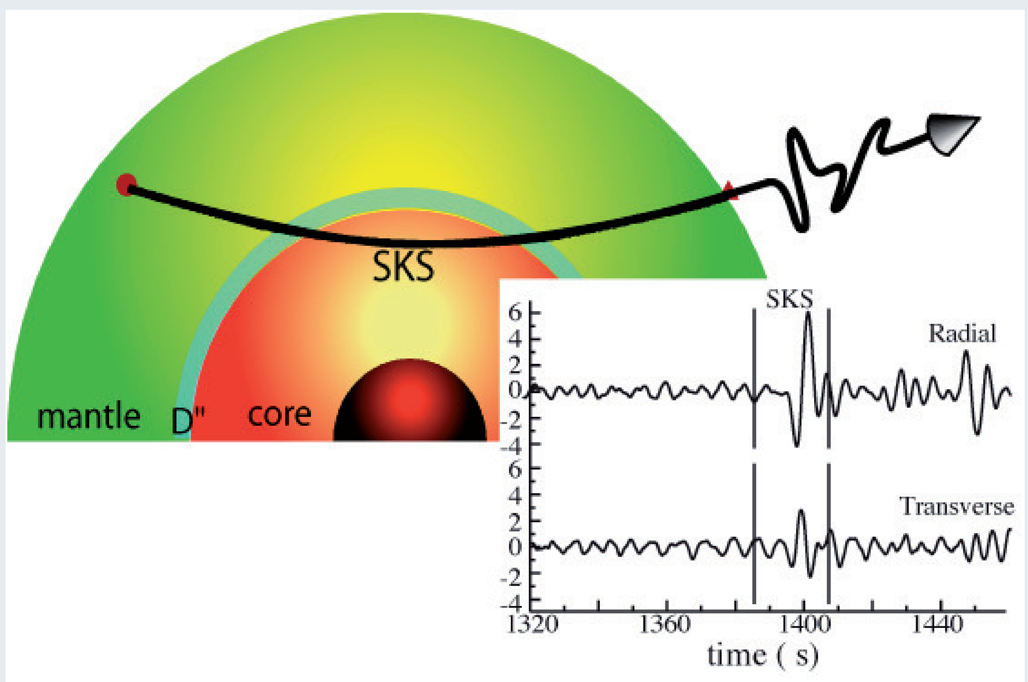
One of the most interesting features of the Earth's interior is its deformation state, which we may in principle constrain using seismic anisotropy. Here we are interested in the upper mantle under the Eastern Alps, and the main goal is to study seismic anisotropy at lithospheric/asthenospheric depths. This may help to constrain past-present deformation and mantle flow.

Anisotropy is defined as the dependence of seismic velocity on the direction of wave propagation. In anisotropic media a shear wave can be split into two pulses with orthogonal polarization at different speeds, called fast and slow polarization.



Shear wave splitting in anisotropic media

Good examples of shear-wave splitting are observed in teleseismic SKS core phases. Because of the fluid nature of the outer core, the initial polarization of SKS is known to be radial. Nevertheless we often observe significant energy also on the transverse component.



Method and Data

The most useful method for constraining upper mantle anisotropy is shear-wave splitting that uses the splitting of teleseismic shear waves like SKS/SKKS core phases [2].

To characterize the nature of anisotropic structures, we measure two splitting parameters, the fast direction azimuth ϕ (angle between fast axis and radial direction), and arrival delay time between the fast and slow polarizations (δt) using the SplitLab package [3].

We used teleseismic events occurring between epicentral distances of 90° to 130° from 12 broadband stations of the Austrian seismological network (**OE**).

References

[1] S.M. Schmid et al (2004): *Tectonic map and overall architecture of the Alpine orogen*, Eclogae geol. Helv. 97, 93-117, doi:10.1007/s00015-004-1113-x.

[2] P.G. Silver and W.W. Chan (1991): *Shear wave splitting and subcontinental mantle deformation*, J Geophys Res. 96, 16429-16454.

[3] Wüstefeld et al (2008): *SplitLab: A shear-wave splitting environment in Matlab*. Computers and Geosciences. 34, 515-528.

[4] TRANSALP working group (2002): *First deep seismic reflection images of the Eastern Alps reveal gaint crustal wedges and transcrustal ramps*, Geophys. Res. Lett. 29, 92-1-92-4.

[5] R. Lippitsch et al (2003): *Upper mantle structure beneath the Alpine orogen from high-resolution tomography*, J. Geophys Res. 108, doi:10.1029/2002JB002016.

[6] E. Brückl et al (2010): *Crustal structure and active tectonics in the Eastern Alps*, Tectonics. 29, doi:10.1029/2009TC002491.

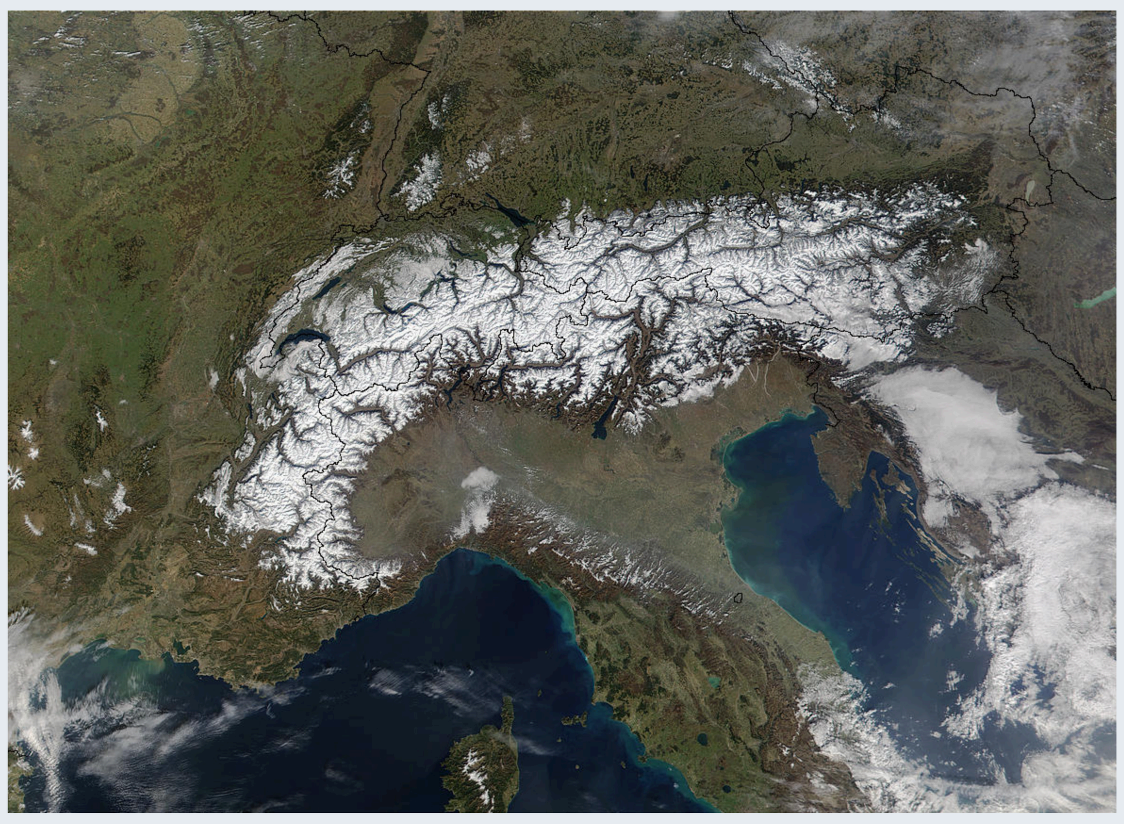
[7] U. Mitterbauer et al (2011): *Shape and origin of the East-Alpine slab constrained by the ALPASS teleseismic model*, Tectonophysics. 510, 195-206.

[8] J. Kummerow and R. Kind (2006): *Shear wave splitting in the Eastern Alps observed at the TRANSALP network*, Tectonophysics. 414, 117-125.

[9] G. Barruol et al (2011): *Belt-parallel mantle flow beneath a halted continental collision: The Western Alps*, Earth and Planetary Science Letters. 302, 429-438.

Study region

The selected region in this study mainly comprises the Eastern Alps. The Alpine belt is divided into E-trending Eastern Alps and the arc of the Western Alps [1].



Surface structures and deep tectonics

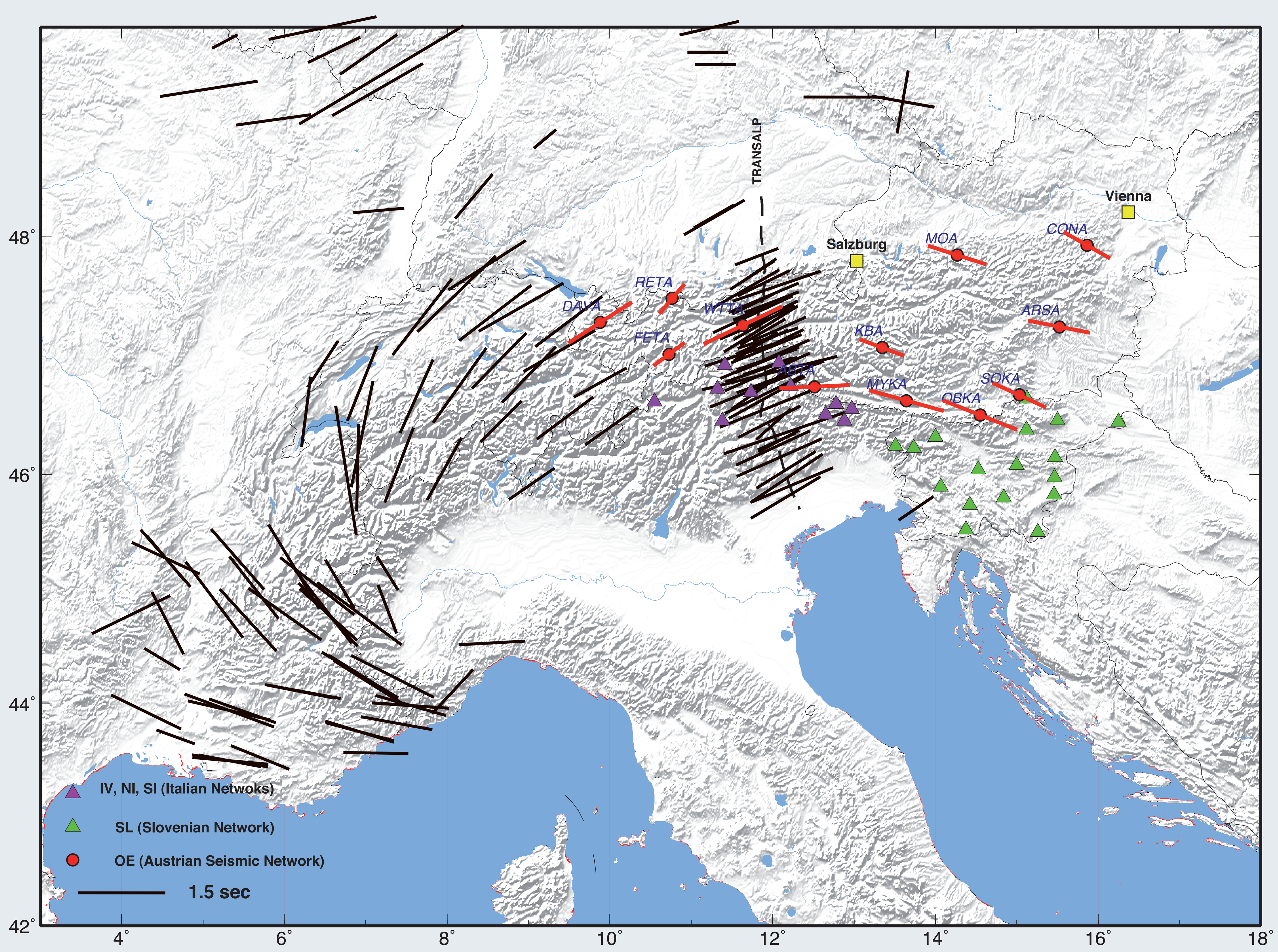
While surface geology of the Alps is relatively well-known, the interior structure is less clear, and there are only a few geophysical studies and 3D tomographic models for the area [4, 5, 1, 6, 7].

Tectonic history of the Alps is complex, and this complexity is probably reflected by subsurface structure. This includes besides the two major plates, namely the European and the Adriatic plate also some small microplates (i.e. Meliata plate and Pannonian fragment).

Deformation associated with the long-term convergence generally leads to alignment of minerals, and to seismic anisotropy. Is there, despite the complex structure, a coherent pattern of seismic anisotropy under the Alps? As a new constraint, seismic anisotropy may perhaps allow shedding light on the geodynamical hypotheses proposed for the Alps, and which have been so far difficult to distinguish based on seismic tomography alone.

Results

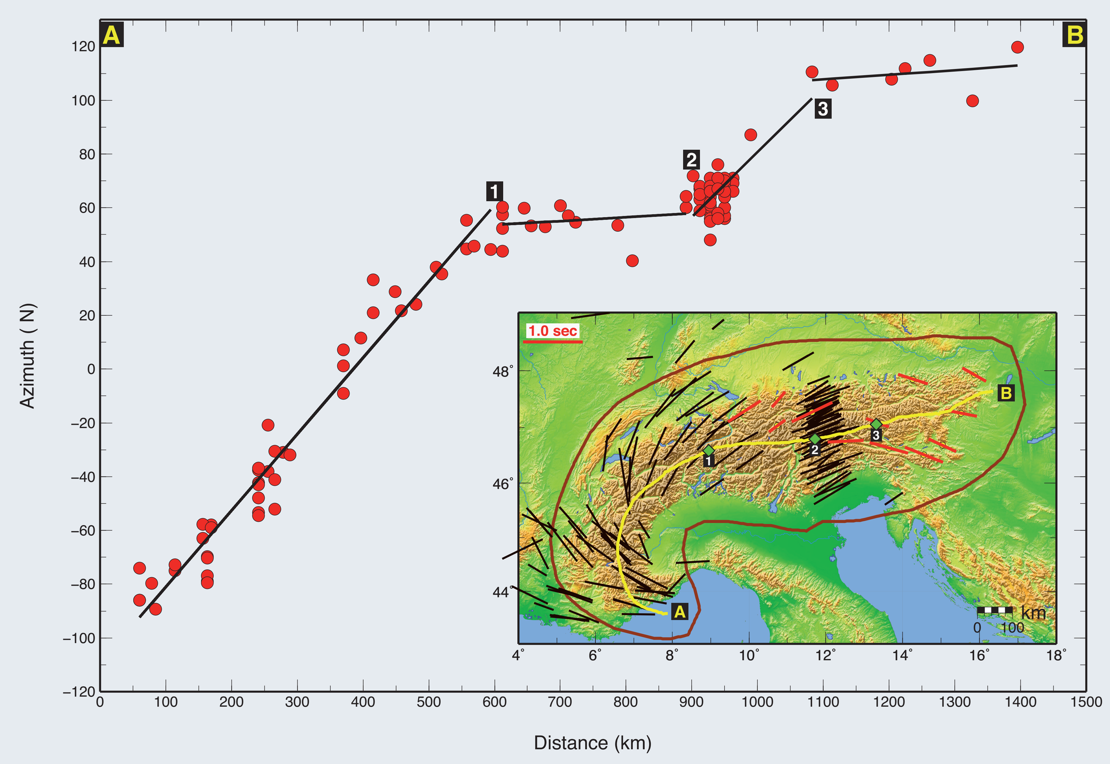
Results of fast direction measurements in this study including the distribution of fast axis directions from the former studies [8, 9, among others]; The fast directions are consistent with former studies in the Western and Central Alps but they show a different pattern in the Eastern Alps.



Preliminary Interpretation

There is a clear pattern of seismic anisotropy under the Alps, with a remarkable rotation of fast orientations along the Alpine chain.

The figure shows that the rotation rate is particularly prominent in all of the Western Alps as well as the Tauern Window region, and that there are two regions in the Central and Eastern Alps where fast axes orientations are constant.



Questions and Future work

1. What is the major anisotropic structure in upper mantle beneath the Eastern Alps? Which depth does correspond to the anisotropy?
2. What causes the different rotation rates in the Alps, e.g., what is the role of the Tauern Window? Can the Adriatic indenter explain the rotation across the Tauern Window?
3. How do fast orientation azimuths relate to upper mantle flow in the Eastern Alps?
4. Does that constrain (or distinguish) the two suggested subduction mechanisms in the Alps?

Next steps: to measure the SKS splitting parameters for the stations belonging to the following seismic networks; Slovenia (SL), Italian seismic networks (IV), (NI), and (SI); assessing the presence of two anisotropic layers with different nature and thicknesses, and/or the presence of dipping anisotropic structures.