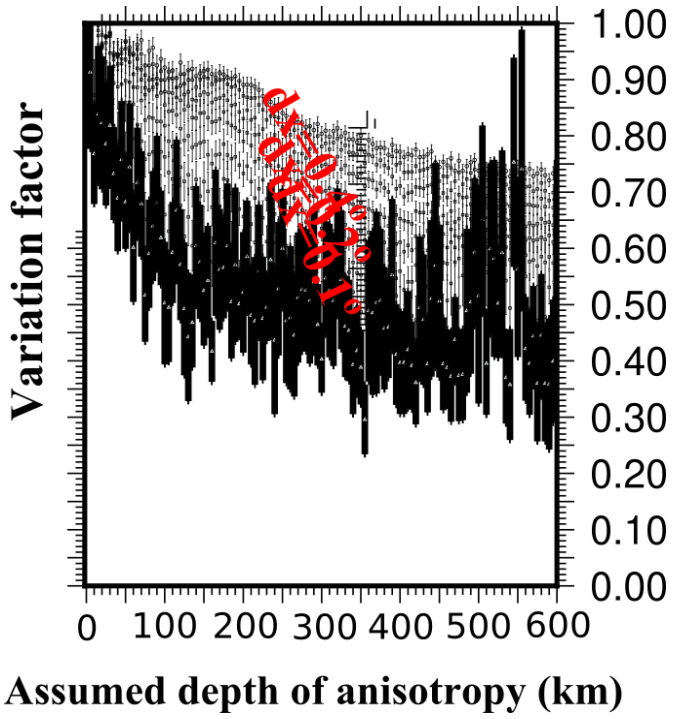
RC2: 'Comment on egusphere-2024-468', Anonymous Referee #2, 31 Mar 2024 reply

In this paper, the authors use seismic data from the CIFALPS2 network to measure shear-wave splitting, thus shedding light on mantle dynamics in the Western Alps. This paper as a whole is well written, shows interesting results and provides reasonable explanations, and the figures are intuitive, thus meeting the interest of ***SE***. However, I still have some major considerations for the analysis of shear-wave splitting measurements.

1. the authors assume that the anisotropic source of the measurements is at 150 km and present all the measurements at the pierce points at this depth. Given that subsequent interpretations are based on this, I might suggest that the authors first perform an estimation of the depth of the anisotropic source, e.g., based on the general use of the method proposed by Liu & Gao (2011). https://doi.org/10.1785/0120100258

Since the scarce depth resolution using the SKS phases, and considering that most of the anisotropy is thought to be in the upper mantle, the depth of 150 km is the one that best approximates its location. To have better details about the depth we followed the suggestion of the reviewer trying to apply the mentioned code. We used it for different cases, testing several dimensions of the region and/or the selection of the measurements, but we didn't find a satisfactory result. As an example, in the following, we show the results of the inversion considering measurements included in what we defined zone A (Figure 5 of the manuscript). No clear visible "valley" is present in the plot and there are no unambiguous depths that could be identified considering different spacing grids. The reason for that unsatisfactory result could be the great variability of fast directions in such a narrow area, that limited the applicability of the code. Liu & Gao, in their paper, apply the code in an area with a very homogeneous fast axes distribution, a condition that is not present here.



2. Similarly, the authors assumed single-layered anisotropy. Although the actual measured FPDs more or less deviate from surface faults or block boundaries, it is still uncertain whether crustal/lithospheric anisotropy contributes to this, so I would suggest that the authors make a comparison with related studies of crustal anisotropy. SI measurements should be another way in which this can be differentiated, according to Silver & Long (2011). From Fig. S2, monolayer anisotropy is the preferred interpretation and the authors should emphasize it further. https://doi.org/10.1111/j.1365-246X.2010.04927.x

We did not exclude the presence of a variation of the anisotropy with depth. We consider a valid hypothesis the single-layered anisotropy because of the agreement between mean SWS and SI FPD directions. As shown in Figure 4, most of the averaged directions calculated with the two techniques are in agreement along the chain, some deviations are for stations in the Po Plain, where we know the peculiar difficulty of having high-quality data. As for comparisons with shallower anisotropy measures, we find a good agreement with Pn anisotropic directions (representative of the Moho depth) by Diaz et al. (2013). All this information can confirm our assumption. Moreover, taking into account that the scarce back-azimuthal coverage of our measurements per station hamper the evaluation of the presence of a multilayer structure, even using codes for modelling anisotropic structures like Menke and Levin (2003) or Raysum (Frederiksen, A. W., and M. G. Bostock, 2000), we consider the average values as a main, prevailing signal, that should be related to a principal mantle source. We would better emphasise the concept in the manuscript.

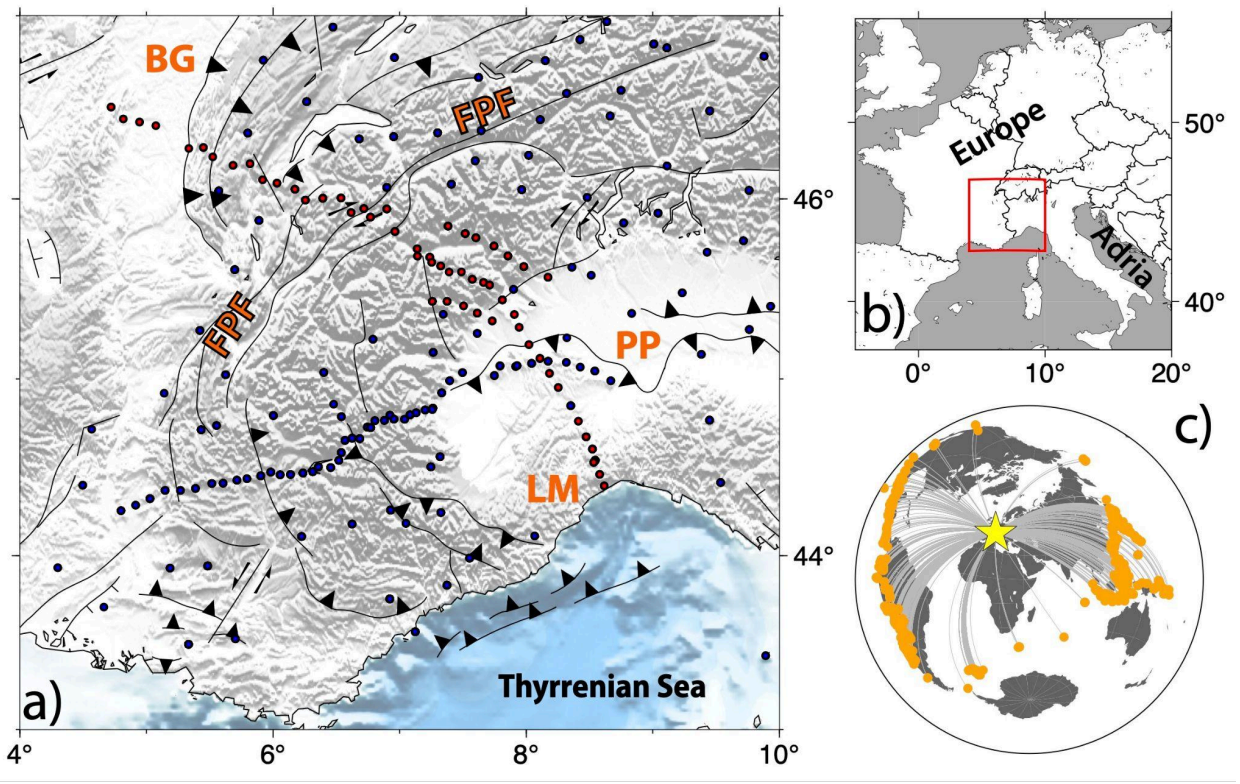
Some other comments:

Lines 17-19: Please rephrase this sentence.

Yes, done.

Fig. 1: Please mark the key block names here. Also please add the scale of the latitude axis, this will help the reader to determine the position (same for the other diagrams).

Done. Here you are the new Figure 1:



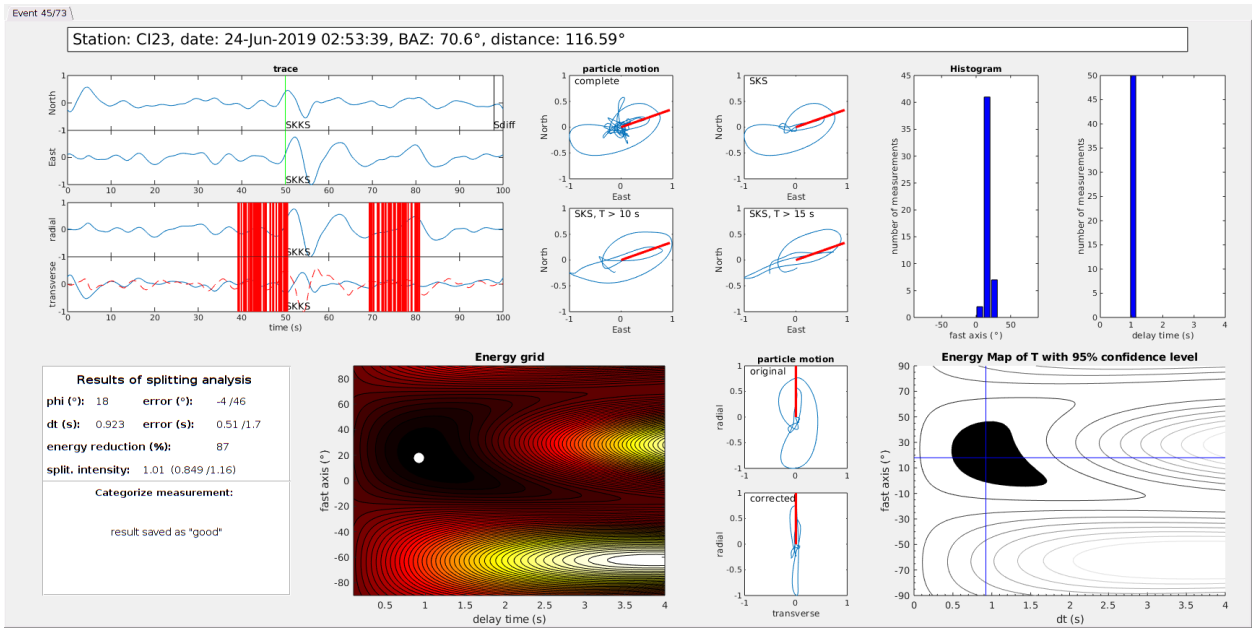
Lines 45-57: The authors provide an overview of previous studies of lithospheric structure in the region, but for readers unfamiliar with the region, an introduction to the tectonic settings may be missing. In addition, pending scientific issues need further elaboration.

Thanks for the suggestion. We added a small description of the geodynamic history of the Alps to introduce the following overview of previous studies of lithospheric structure, that helps the understanding of still pending scientific issues.

Data and Methods: I suggest that the authors show shear-wave splitting measurements with different data quality under different regions in the supplementary material.

As a working rule, we applied the same criterion of quality assignment to all analysed measurements. This means that a 'good' measurement in Alpine chain and a 'good' measurement in the Po-Plain should have the same properties, that are the same listed at lines 103-105: "The quality assignment is given following the SplitRacer criteria (Reiss and Rümpker, 2017), considering the visibility of the phase, the ellipticity of the initial particle motion and its linearity in the final stage, and the errors associated with phi and dt values."

We will include some examples in the Supplementary Material. In the following an example of a "good" measurement:



The same consideration is used also for 'null-measurements', i.e. the case in which the energy on the transverse component is absent (see the image in the following) or when a phase did not split because the back azimuth direction of the event is parallel or perpendicular to the anisotropy fast axis direction.

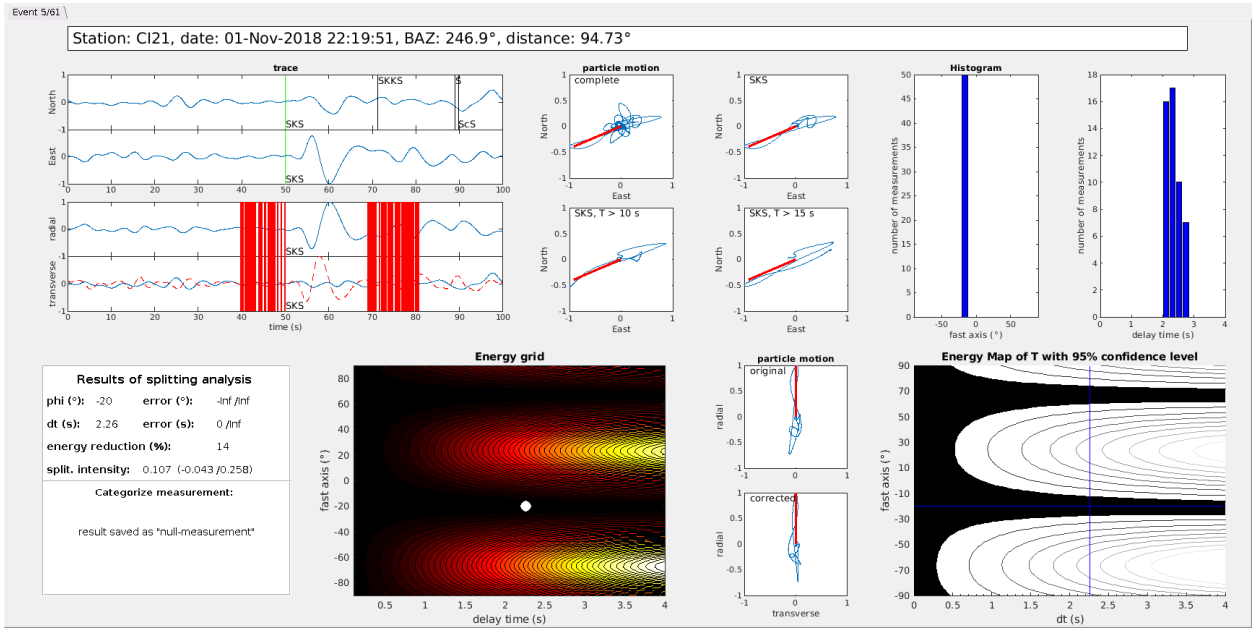


Fig. 3: R-values are difficult to discern from the graphs. Or maybe use a transparent background colour instead?

To improve the readability of R values we changed colors (and added also some labels, requested by REV1). Here you are the new Figure 3:

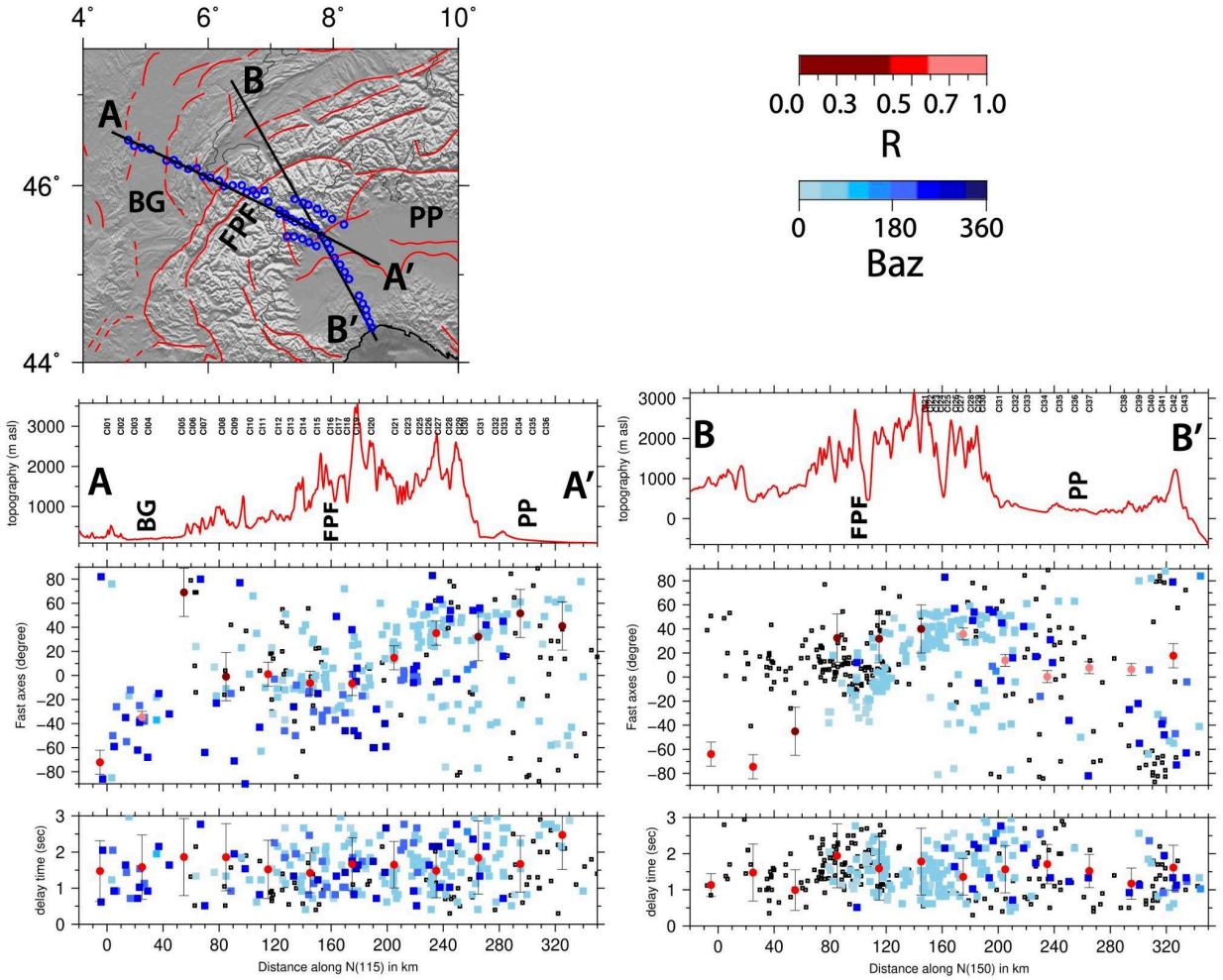


Fig. 4: Lack of explanation for the dots.

Dots are the stations. Now we added the explanation in the caption.

Lines 191-193: Please rephrase this sentence.

Done

References:

Díaz, J., Gil, A., & Gallart, J. (2013). Uppermost mantle seismic velocity and anisotropy in the Euro-Mediterranean region from Pn and Sn tomography. *Geophysical Journal International*, *192*(1), 310-325.

Frederiksen, A. W., & Bostock, M. G. (2000). Modelling teleseismic waves in dipping anisotropic structures. Geophysical Journal International, 141(2), 401-412.

Menke, W., & Levin, V. (2003). The cross-convolution method for interpreting SKS splitting observations, with application to one and two-layer anisotropic earth models. *Geophysical Journal International*, *154*(2), 379-392.

Reiss, M. C., & Rümpker, G. (2017). SplitRacer: MATLAB code and GUI for semiautomated analysis and interpretation of teleseismic shear‐wave splitting. *Seismological Research Letters*, *88*(2A), 392-409.