EGU Sharing Geoscience Online 2020

Robust splitting measurements for the AlpArray from the splitting intensity method

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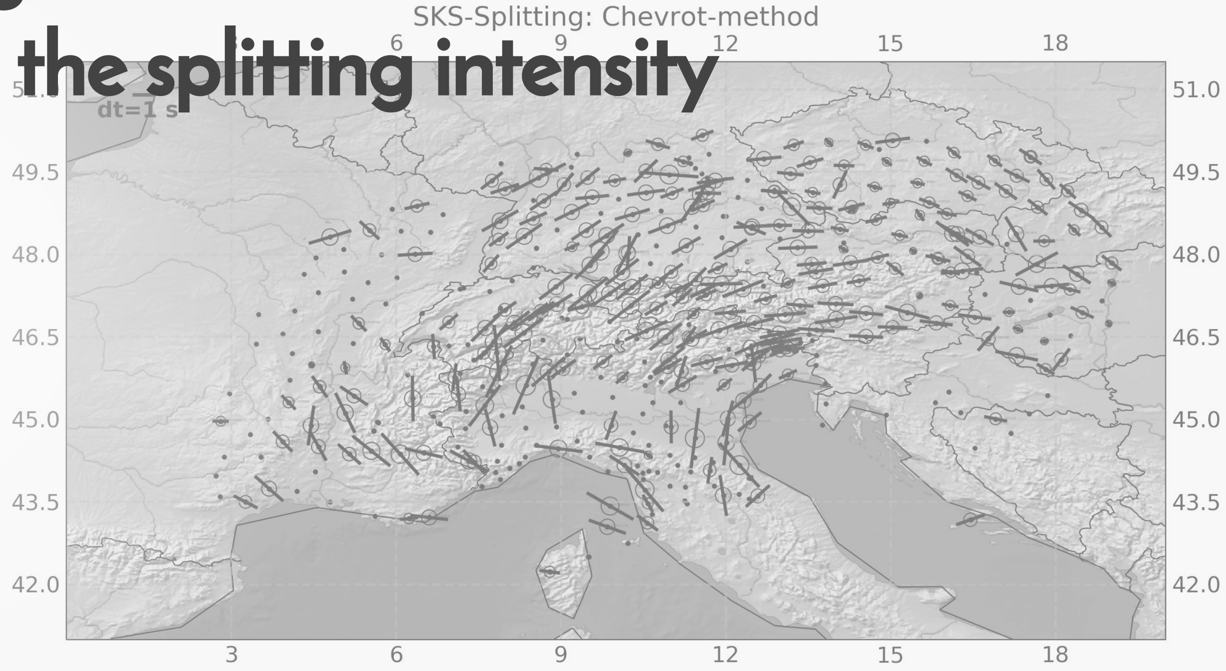

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01. Geodynamic setting

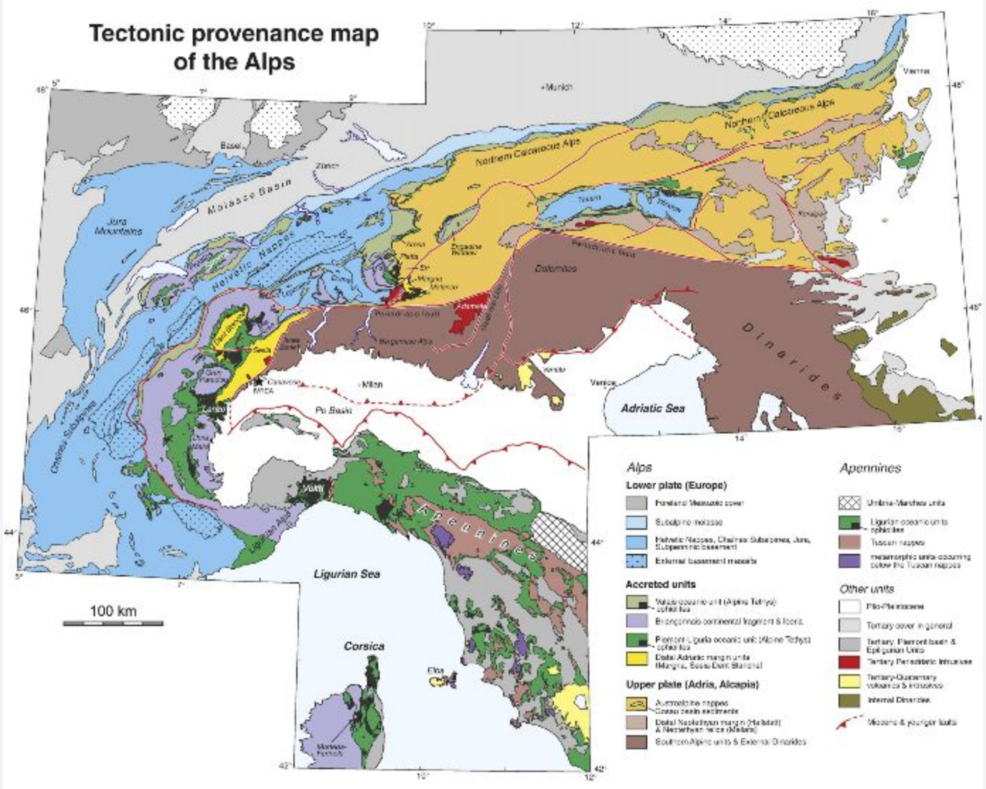
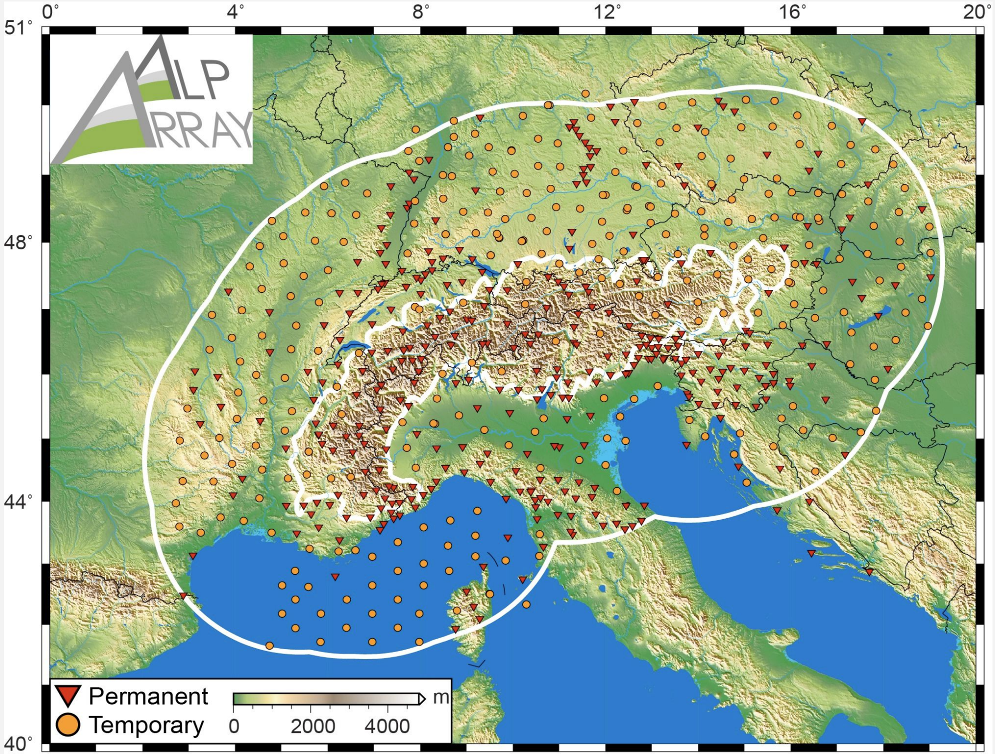


Fig. 1: Tectonic setting of the Alps (Handy et al 2010)

01. AlpArray

Fig. 2.: The AlpArray seismic network (Hetenyi et al., 2018)



02. Measuring seismic anisotropy

splitting parameters
phi - dt

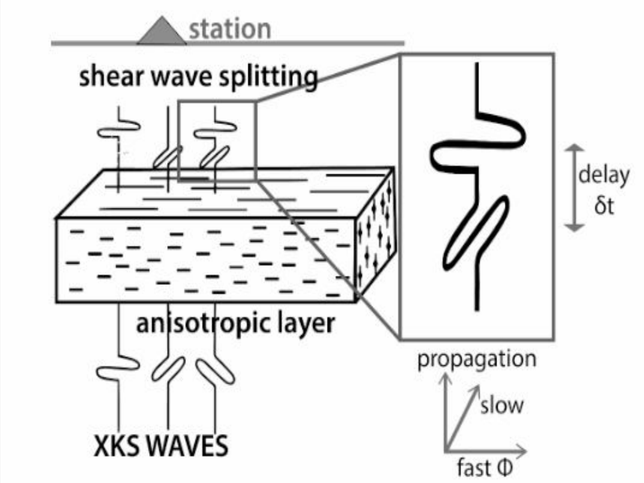


Fig.3: Principle of shear wave splitting, (de Melo 2018)

Transverse minimization technique (Silver and Chan 1991)

Is widely used, (often in a manual and therefore subjective fashion)

Cross correlation technique (Ando et al 1980)

Very sensitive to noise in the measurements.

Splitting intensity method (Chevrot 2000)

Makes simple assumptions and seems to be very robust, given enough data

The splitting intensity method

The Splitting Intensity Method capitalizes on the common assumption that an SKS-waveform obeys

$$R(t) \approx \mathrm{w}(t)$$

$$T(t) \approx -\frac{1}{2}\left(\delta t \sin 2\beta\right) \mathrm{w}'(t)$$

For each SKS measurement R(t) and T(t), a splitting intensity (SI) is calculated. SI relates with the splitting parameters (dt, beta), and the latter are determined from the backazimuthal variation of SI, a sinosoidal variation for a single layer.

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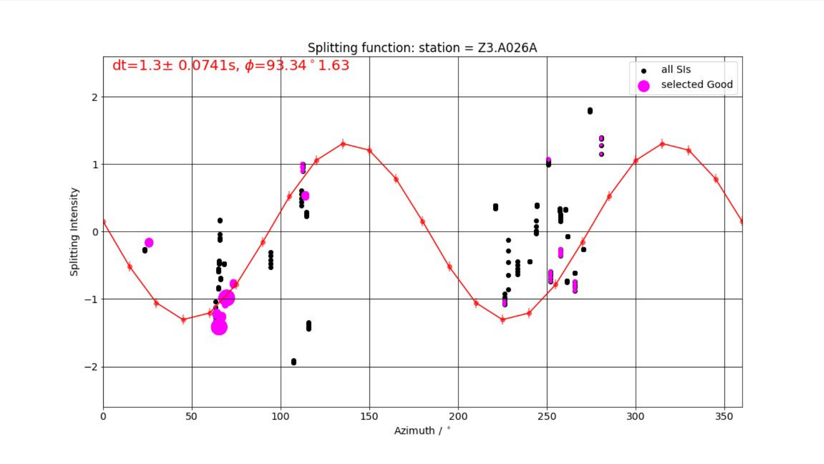


Fig. 4: Example of the Splitting Intensity measurement and fitted splitting function. The magenta colours shows only “good SKS measurements”, that satisfy our quality criteria.

02. Automatic extraction of good SKS phases

Recipe:

- slice around theoretical arrival
- z-detect trigger
- bandpass between 10-50 s
- rotate to RTZ-system
- Wiener filter
- cosine similarity criteria > 0.6
- calculate SI
- repeat for next event

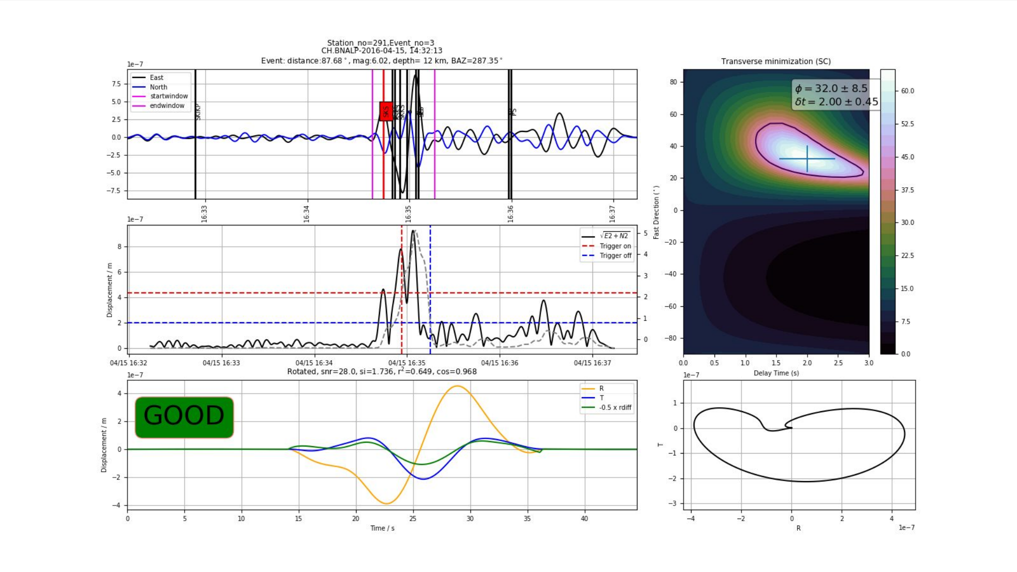


Fig. 5: Exemplary work flow for a good SKS phase. Top right figure shows the result, which can be achieved with the transverse minimization technique.

03. Results

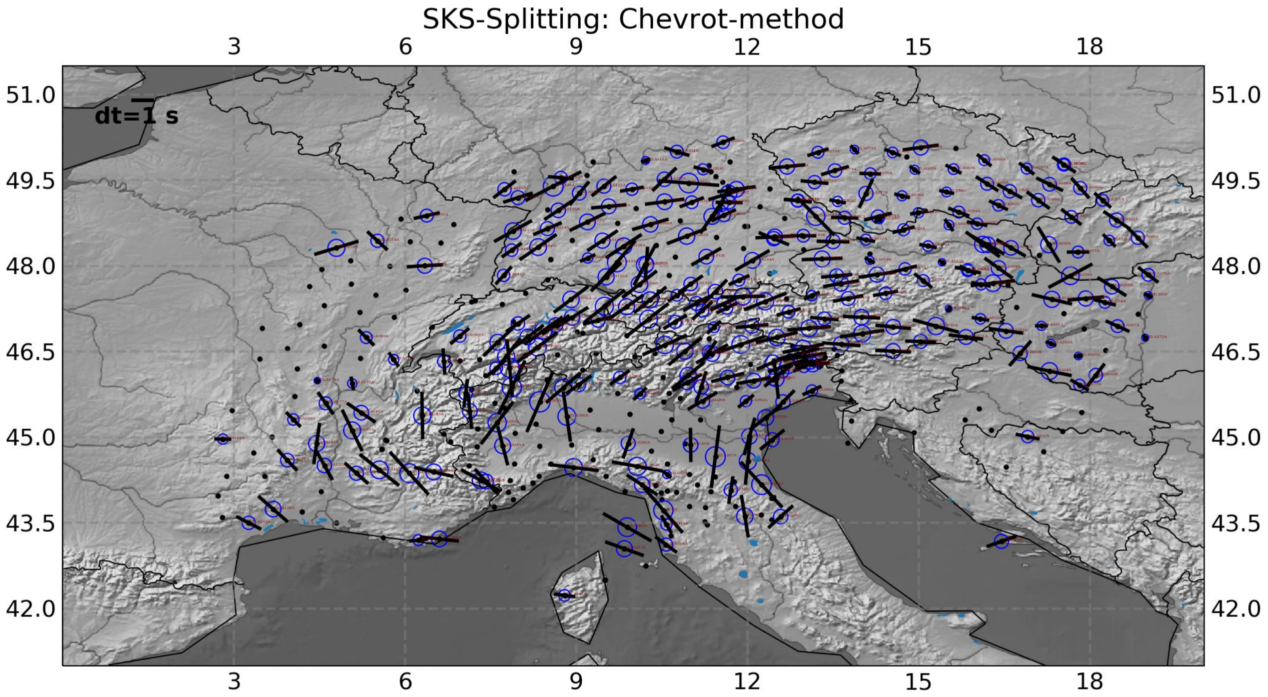
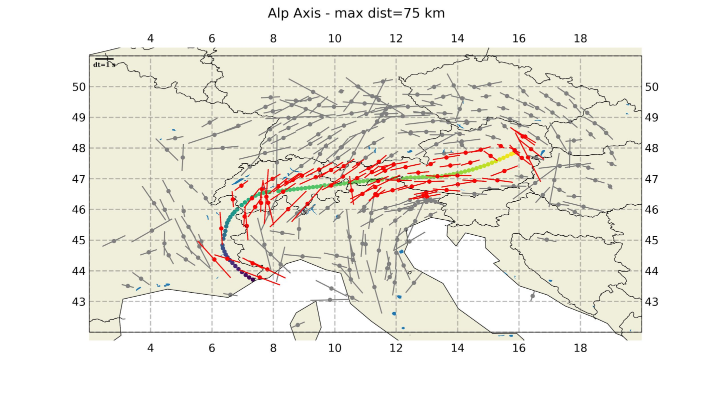


Fig.6: Map of the found splitting parameters for the AlpArray, shon in the usual fashion (line orientation and length). Dots show the stations that did not satisfy the quality criteria.

There is a more-or-less mountain-chain-parallel pattern of fast orientations - in and outside the mountain chain, as already described in earlier studies.

03. Results



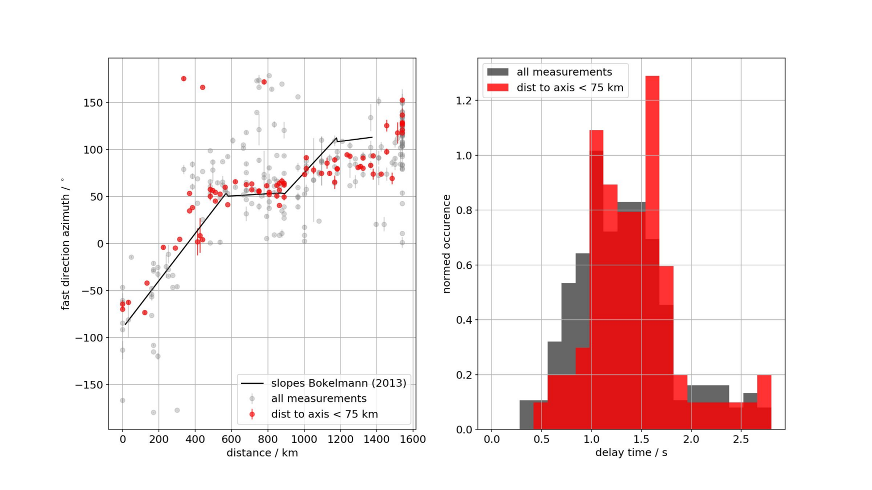


Fig. 7: The splitting parameters projected onto the Alpine Axis. Red values correspond to the innermost stations (distance < 75 km).

There is a systematic variation of fast orientations with distance along the Alpine axis, similar to that in the studies of Bokelmann et al. (2013) and Qorbani et al. (2015).

03. Results

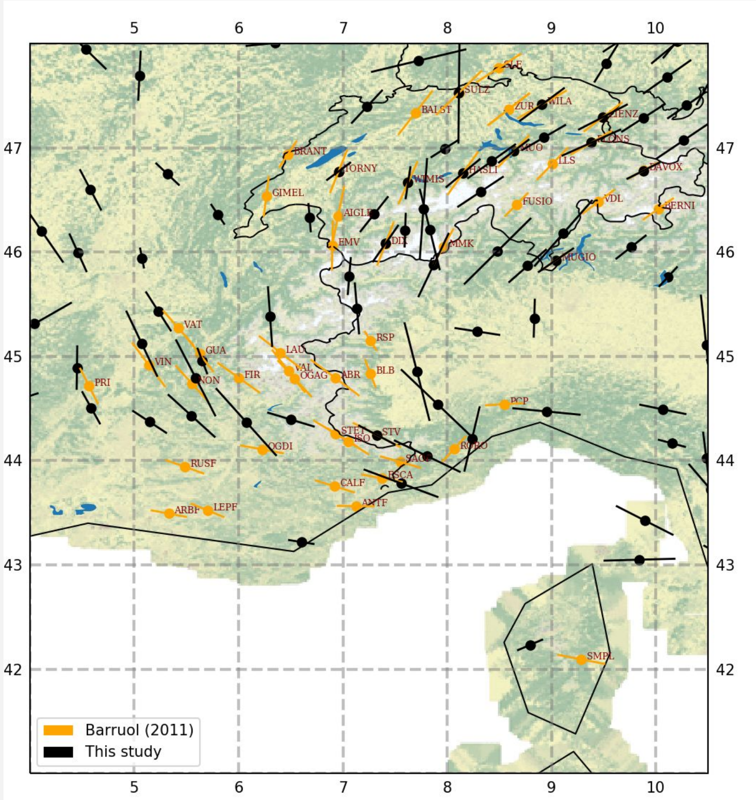


Fig. 8: The variation of anisotropy in the western Alps compared with results from Barruol 2011 shows a similar pattern.

04. Interpolated delay times

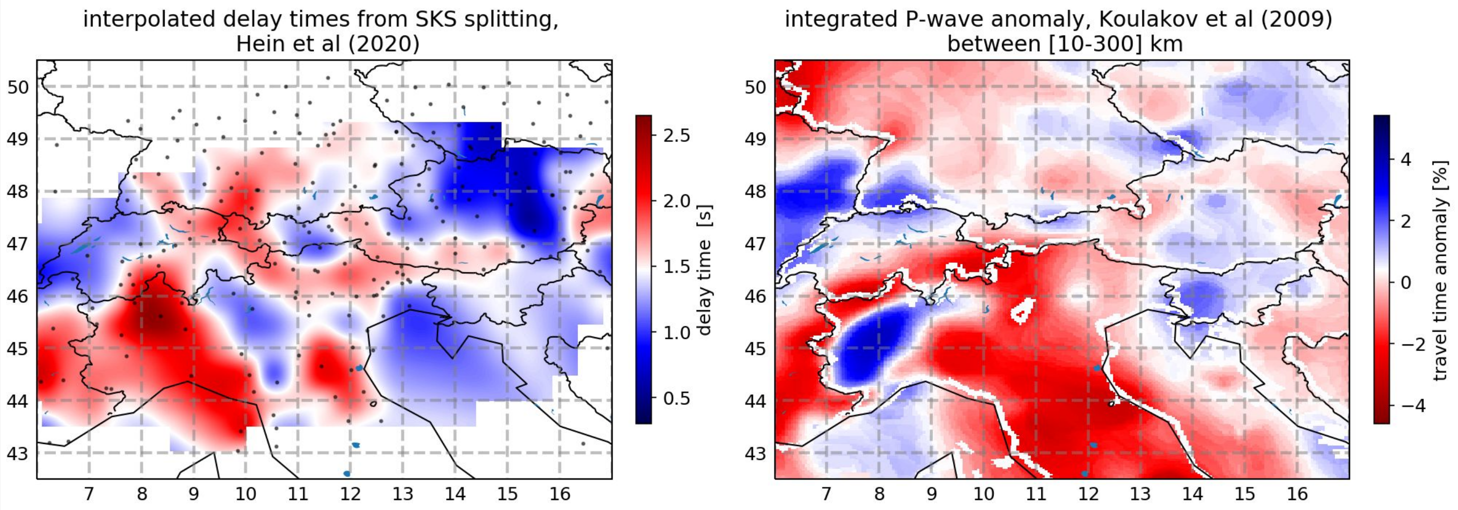


Fig.9:
left) Preliminary (!) map of interpolated splitting delay times. Note the generally stronger splitting delay times in and around the Western Alps, compared to in/around the Eastern Alps.
Right) Vertically-integrated travel-time through the tomographic model of Koulakov et al. (2009), which shows a somewhat similar general pattern (although different in detail). Part of this is probably due to the crude interpolation technique used on the left.

04. Error analysis

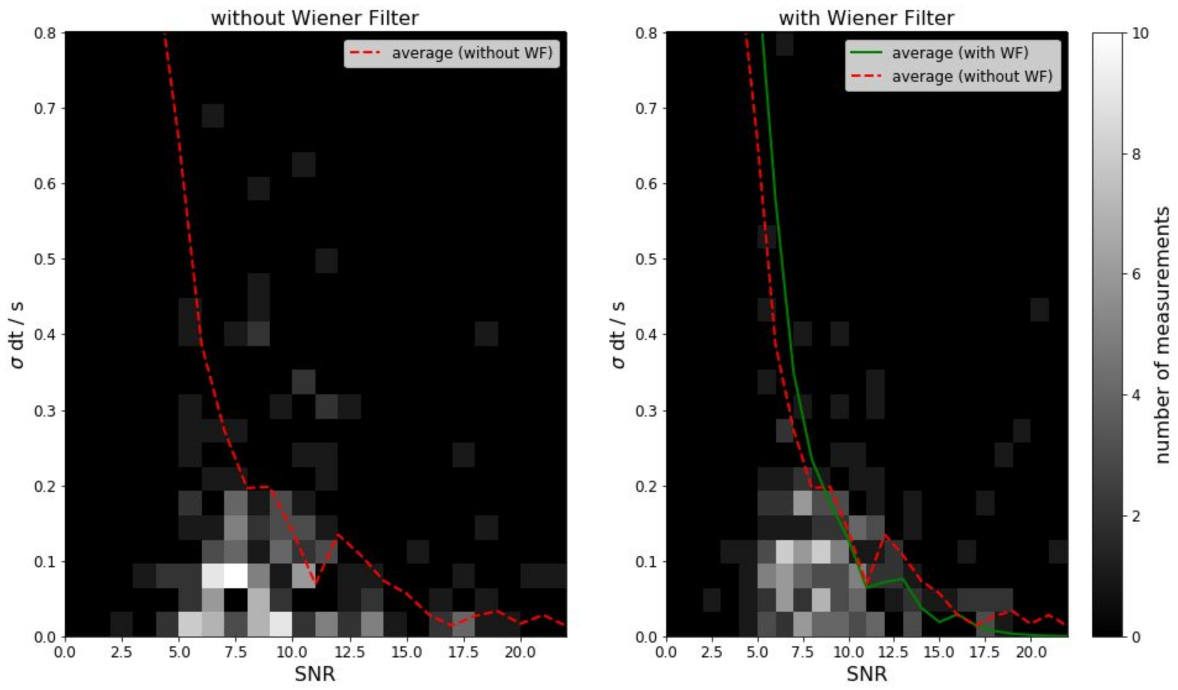


Fig.10: The estimated errors in the delay times plotted against the respective SNR ratios. The application of a Wiener Filter seems to marginally reduce the error for SNR ratios above 10.

SNR for each station is calculated as the

$$\mathrm{SNR} = \frac{1}{n}\sum_{n}\frac{max(R_n)}{2\sigma(\mathrm{Noise}_n)}$$

Restivo and Helffrich (1999)

Summary

- Automatically-determined map of splitting parameters (based on splitting intensity) is objective, and comparatively stable
- We confirm several earlier findings (e.g., trend along most of the Alps).
- New is the better spatial coverage, and especially the stable splitting delay, which may allow additional insight into Alpine geodynamics.
- The splitting delay shows clear and interesting spatial variations in the Alpine region.

thanks