Supplement A: Comparison of semi-automatic and automatic analysis

We compare the results of the joint splitting of all measurements assigned to be good, average or null to invert for a single anisotropic layer. For the automatic analysis, the accelerated inversion based on the stack of the energy grids from the single splitting analysis and the following bootstrap statistics with 1000 random sample sets is used, while for the semi-automatic analysis, the joint splitting is calculated independently from the single splitting analysis and the error is calculated from the 50 randomly selected time windows. For completeness we show here also the comparison for stations MDND and TIGA.

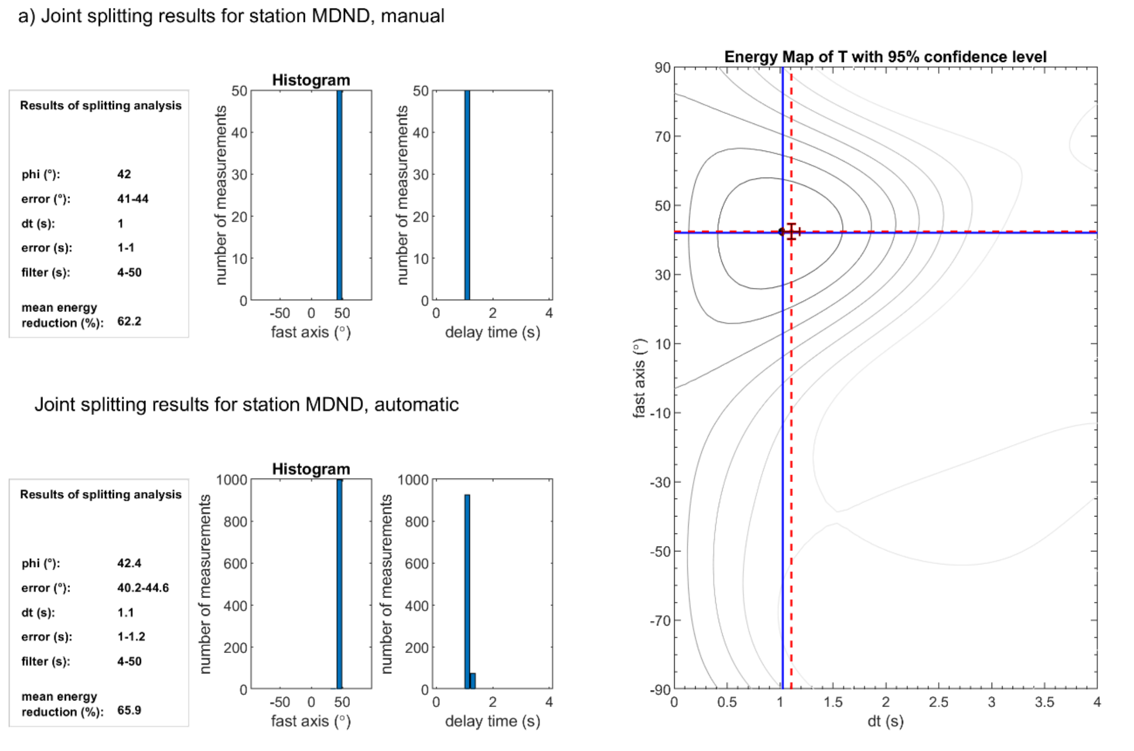
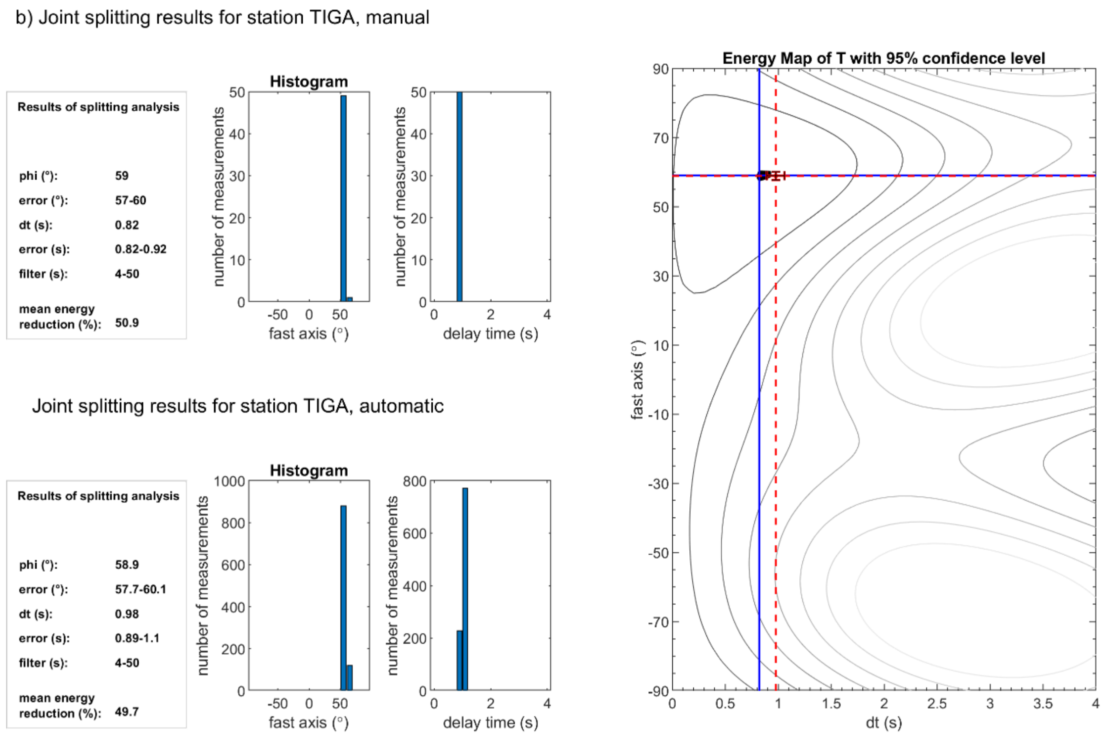


Figure SUP1: Results from the joint splitting inversion for one anisotropic layer based on the semi-automatic (denoted "manual" in figure legend) and automatic analysis procedure for stations MDND (a) and TIGA (b). The bar graphs for the automatic analysis are based on a bootstrap analysis for the stack of 1000 subsets of the individual energy grids from the single splitting analysis. In the semi-automatic procedure, the bar plots show the distribution of the results from the analysis of 50 random time windows. The blue crosslines in the energy map mark the results from the semi-automatic approach with the black area representing the error surface. The red crosslines and corresponding error bars show the results from the automatic analysis.



continued Fig. SUP1

Supplement B: Comparison with previous studies of the USArray data set

We compare the splitting results for the USArray data set using the SplitRacer toolbox with results available from data archives by Liu et al. (2014, based on measurements from Liu 2009, Refayee et al. 2014, Yang et al. 2014, Liu et al. 2014) and Yang et al. (2017). While they also include results of preliminary projects and permanent stations of the regional networks, we focus in our comparison on data collected in the USArray project only.

We calculate a normalized RMS, where we combine the deviation of the results for the fast axes direction and the splitting time.

$$RMS = \sqrt{\sum_{i=1}^{N} \frac{1}{2 \cdot N}\left(\frac{\left(\delta t_{i,1} - \delta t_{i,2}\right)^2}{4s} + \frac{\left(\phi_{i,1} - \phi_{i,2}\right)^2}{90°}\right)}, \quad (1)$$

with δt_i the splitting time and ϕ_i the fast axis direction of phase i at a certain station with N phases in total. The indices 1 and 2 represent the results from our automatic and the previous analyses, respectively. The RMS values (mainly below 0.15) also reflect the good agreement of our results with the splitting parameters in the data base (see Fig. SUP1). Isolated larger deviations above an RMS-value of 0.2 up to 0.45 can be identified at 21 stations, which can be traced back to an insufficient data coverage in the comparison (on average less than 5 events) in combination with a generally low data quality at the stations.

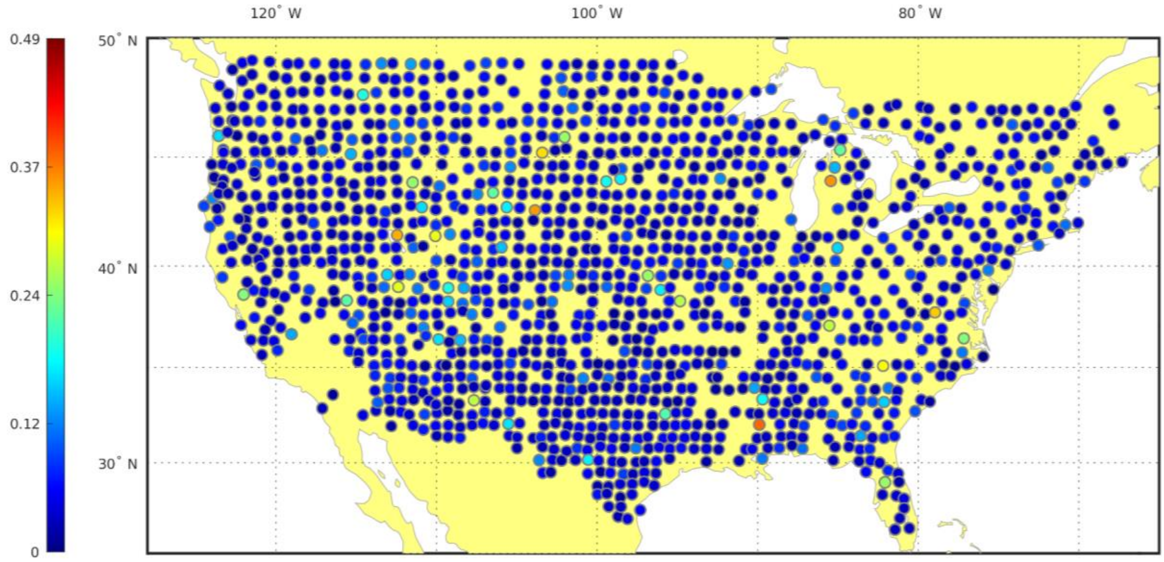


Figure SUP2: Deviation of the results derived from SplitRacer from the splitting parameters of previous studies represented as normalized rms at each station location (see eq. 1). Large rms are characterized by yellow to red colors while low rms is characterized by green to blue colors. Only few locations show rms-values above 0.2. See text for discussion.

For a large number of stations, we can produce a better coherency with the anisotropic pattern of the neighboring stations (see Fig. SUP2 a-c). However, we also find examples with the contrary effect (see Fig. SUP2 d-f). Here, the joint splitting is based on no good and/or very few average measurements with a large number of null-measurements at the same time. This is symptomatic of poor data quality at the station. Naturally, in such a case, a carefully selected waveform by hand can produce better results than a data set selected automatically, which is possibly dominated by noise. To assure a high-quality result, stations with few good and average measurements should be revised manually for categorization. Station Q36A (see Fig. SUP2 d) is an example for a station with a sufficient number of measurements but showing a less coherent fast axis direction with the neighboring stations compared to the result from the data base. As the individual measurements also show a large scatter of fast axis direction, this indicates a structural cause (e.g. layered anisotropy) for the differences between the result from the joint splitting and the averaging of the data base.

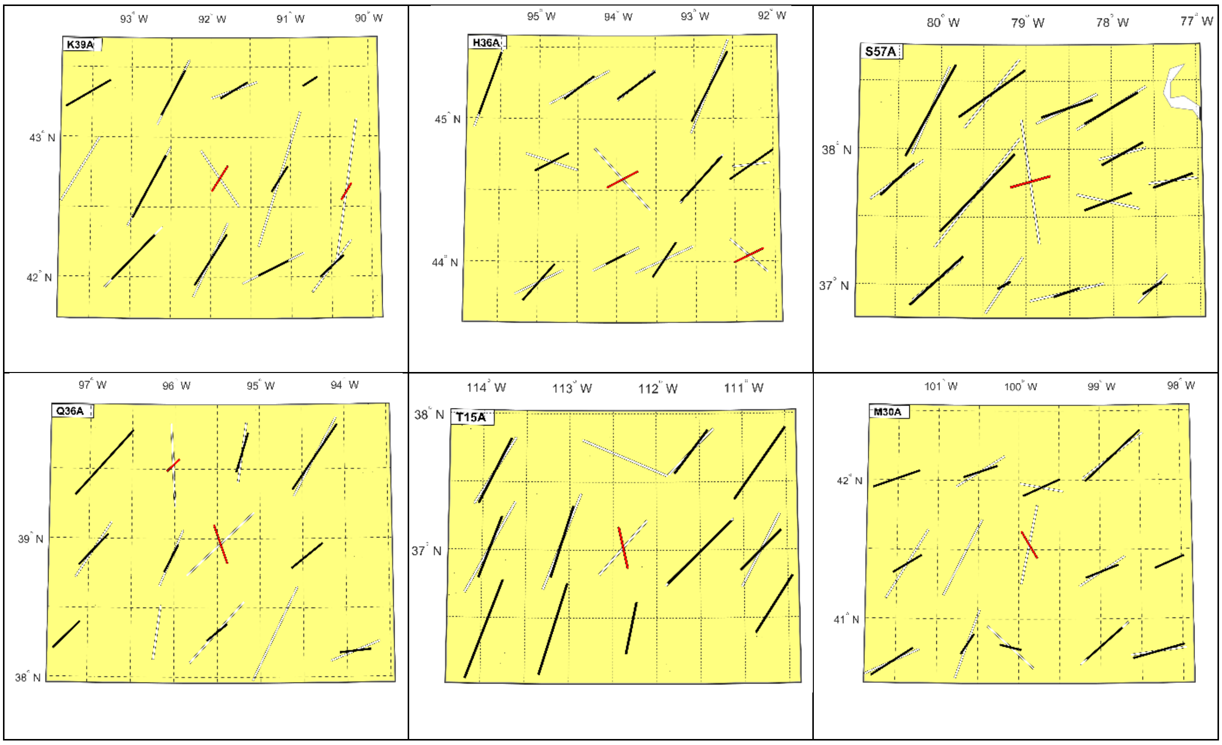


Figure SUP3: Comparison of a one-layer anisotropy approximation based on station averages (white bares) calculated from SKS-data bases (Liu et al. 2014; Yang et al. 2017) and the joint-splitting approach (black/red bars) of this study. The bars are aligned with the fast axis direction and their lengths scale with the splitting time. The red bars show the splitting results for stations with an RMS > 0.2. Each map is centered around one station with large RMS, which is indicated by name in the upper left corner. (a-c) The joint-splitting shows a better coherency with the fast axis direction of the neighboring stations. (d-f) The result of the previous study shows a better coherency with the fast axis direction of the neighboring stations compared to the joint-splitting result.

Supplement C: Single splitting measurements for USArray data set

In the file *USArray_Catalogue_SingleSplittingMeasurements_FL_MCR_GR.txt*, we present a catalogue of single splitting measurements for the full data set of the USArray Transportable Array including the expansion to Alaska. The format is:

Station | Network | lat | lon | Origin | Event_lat | Event_lon | Phase | Backazimuth | Dt [s] | Dt_err [s] | phi [deg] | phi_err [deg] | Category

Where lat and lon present the latitude and longitude position of the station, origin shows the origin time of the earthquake of the corresponding analyzed phase. Event_lat and Event_lon are the epicentral latitude and longitude position of the earthquake. Phase provides the name of the analyzed phase (e.g., SKS, SKIKS). Dt and phi show the results for the splitting time and fast axis direction and Dt_err, phi_err their corresponding error. In Category the assigned quality class is listed (e.g., good, average or null-measurement).

Supplement D: Joint splitting measurements for USArray data set

In the file *USArray_StationList_EffectiveSplitting_FL_MCR_GR.txt,* we present the effective splitting parameters for the stations of the USArray Transportable Array assuming one anisotropic layer as origin for the measured splitting. The format is:

Station | Network | lat | lon | Dt [s] | Dt_err [s] | phi [deg] | phi_err [deg] | NoEvents

Station, Network, lat and lon correspond to the station information also found in the single splitting catalogue. Dt and phi show here the effective splitting parameters from a joint splitting analysis. Dt_err and phi_err are the corresponding errors and NoEvents shows the number of events considered in the analysis.