Automatic Picking of Teleseismic P- and S-Phases using an Autoregressive Prediction Approach

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Overview

- Short description of the picking algorithm
- Example waveforms with picks (P & SH)
- Preliminary results for residuals of picked times to theoretical times in a global dataset
- Preliminary results for estimation of picking accuracy by comparison with local average travel times

AR-AIC picker

The picking algorithm presented here is based on an approach using autoregressive prediction[1]. The coefficients are fitted in a sliding window, and the resulting prediction error in a preceding window is used to define the characteristic function. This characteristic function shows high amplitudes in the event of a change in amplitude, frequency or phase in the waveform.
The minimum of the Akaike-Information-Criterion function[2] applied to the characteristic function is understood as the preliminary phase detection time. A second iteration of the algorithm is performed[3], and the phase arrival is picked on a smaller time window around this phase arrival time as the onset of high amplitudes in the characteristic function.

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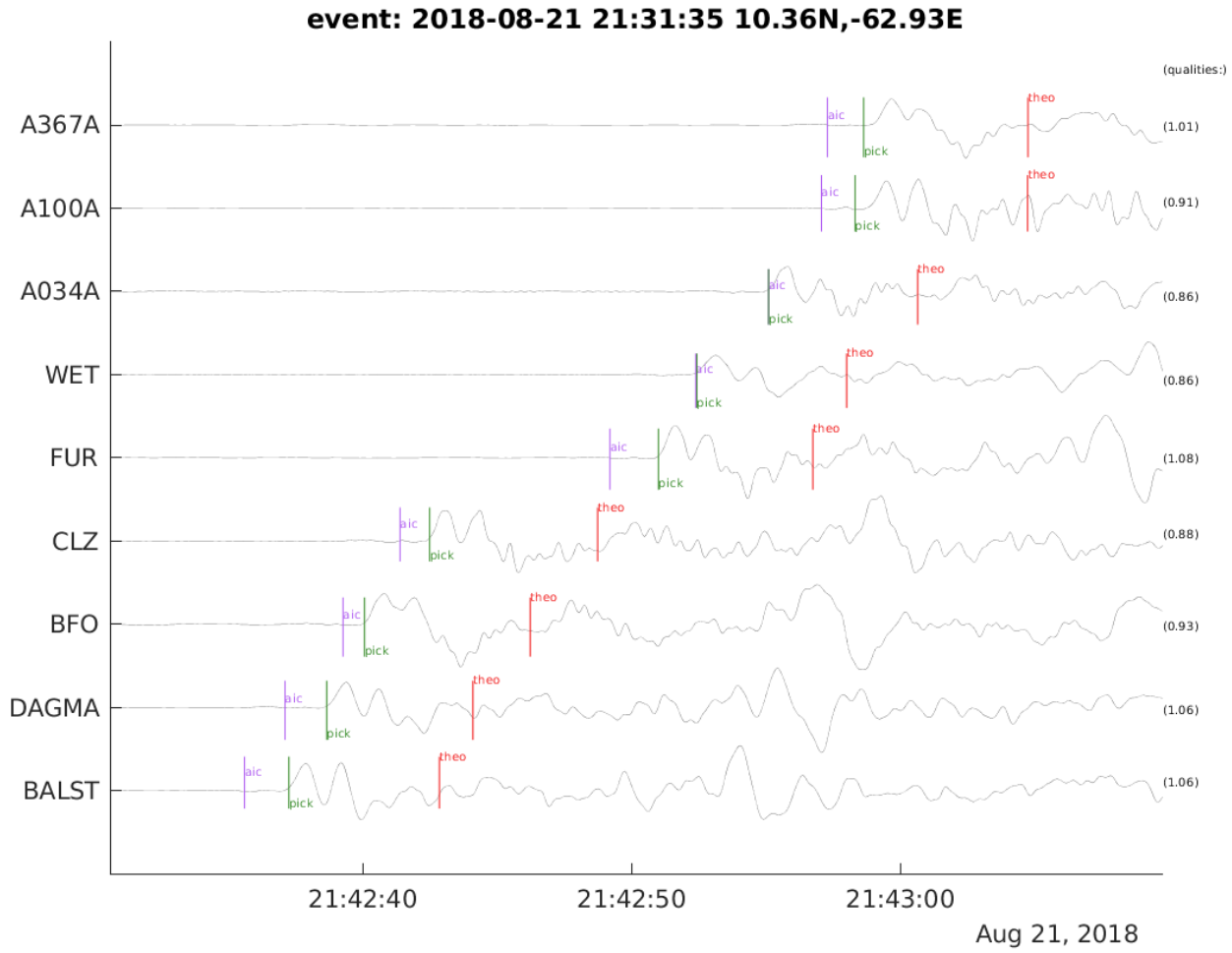
[1] Ludger Küperkoch. "Automated Recognition, Phase Arrival Time Estimation, and Location of Local and Regional Earthquakes". PhD thesis. Ruhr-Universität Bochum, 2010.

[2] Hirotugu Akaike. "On the Likelihood of a Time Series Model". In: *Journal of the Royal Statistical Society. Series D (The Statistician)* 27.3/4 (1978), pp. 217–235. ISSN: 00390526, 14679884. URL: http://www.jstor.org/stable/2988185.

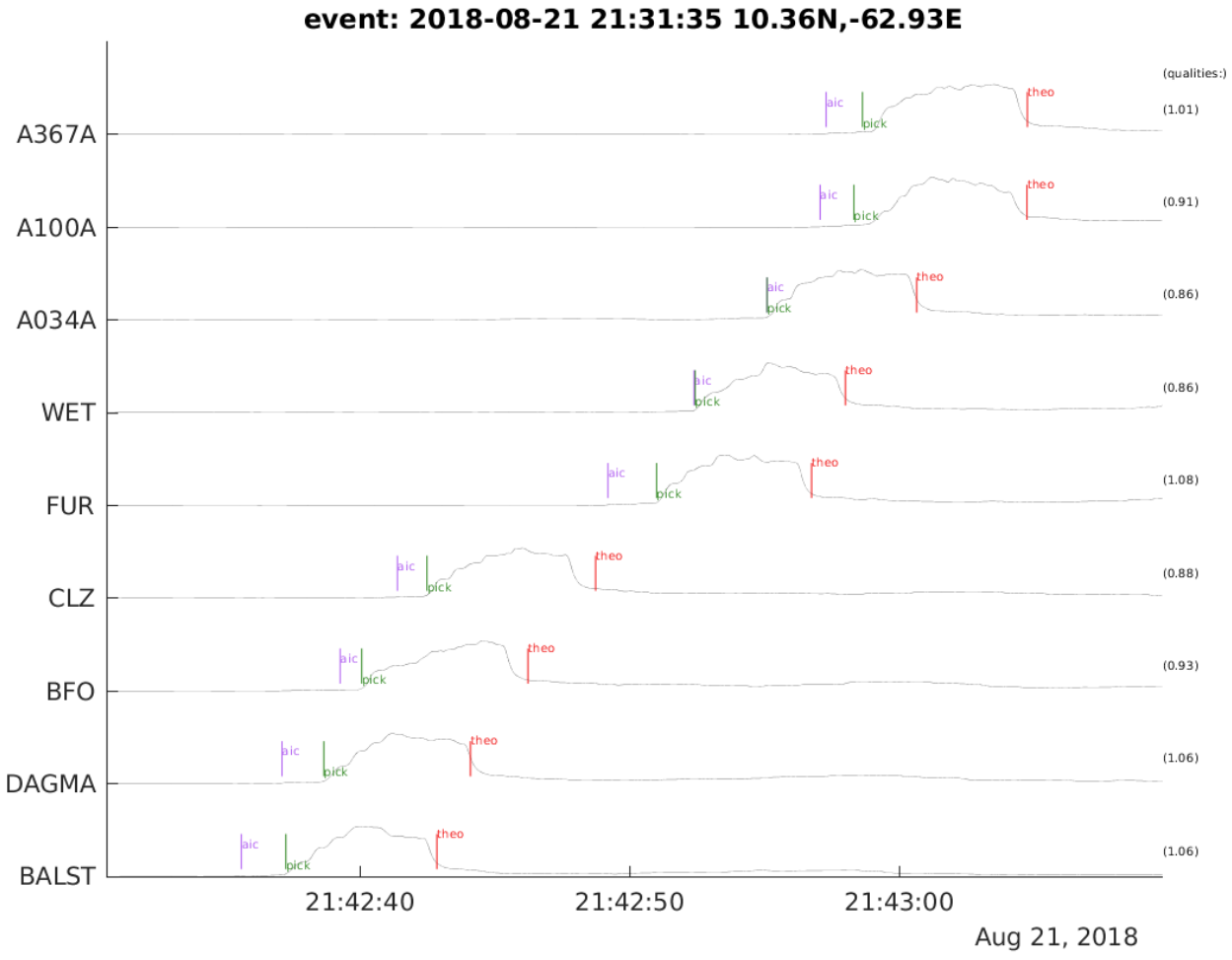
[3] Kai Olbert. "Automatic processing of induced seismicity at the geothermal reservoirs Landau and Insheim". PhD thesis. Christian Albrechts-Universität zu Kiel, 2017.

Waveforms – Processed Z-component data (P-Arrival)



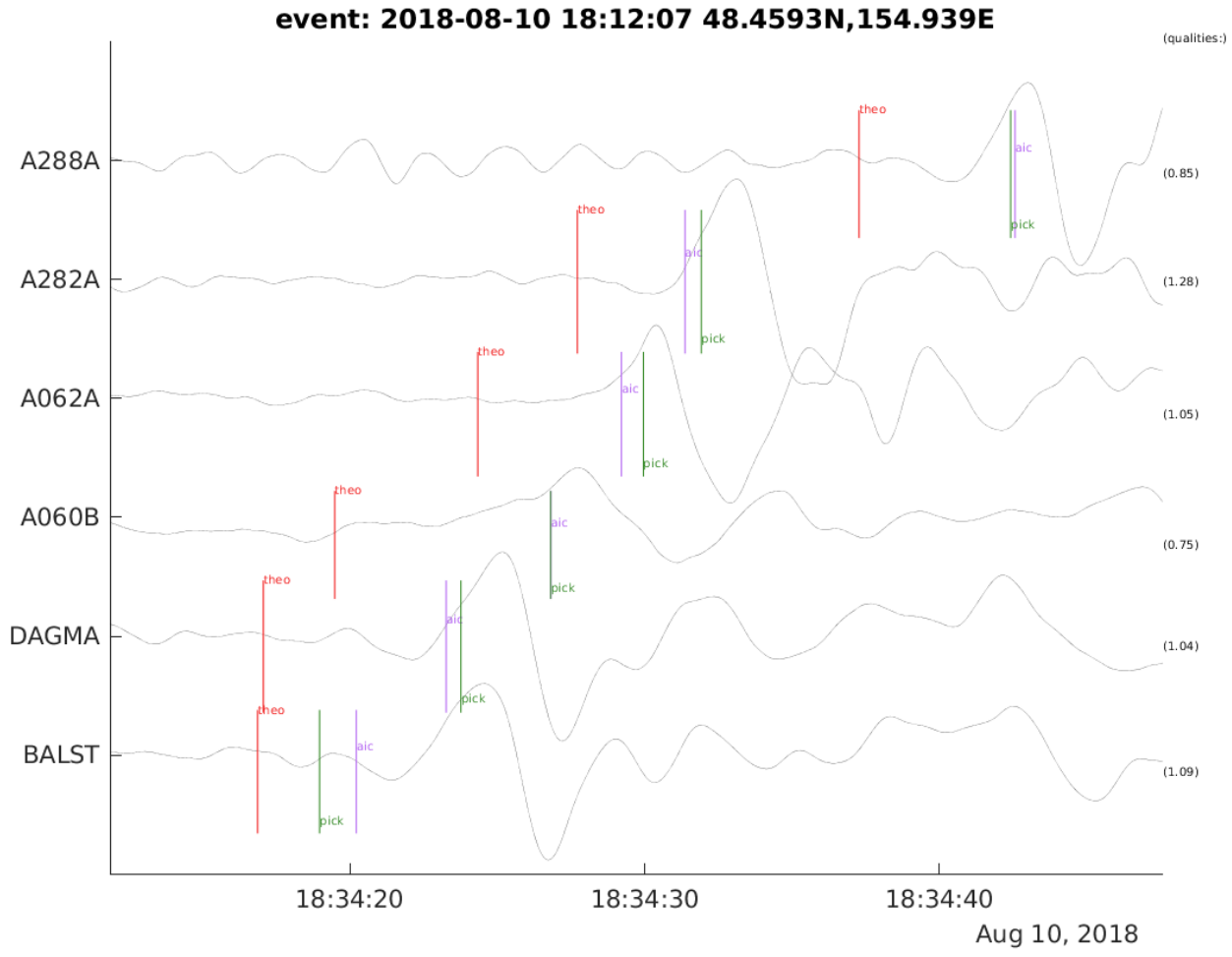
ttheo: theoretical travel times (red),
aic: preliminary phase arrivals (purple),
pick: picks (green)

Waveforms – Characteristic Function (P-Arrival)



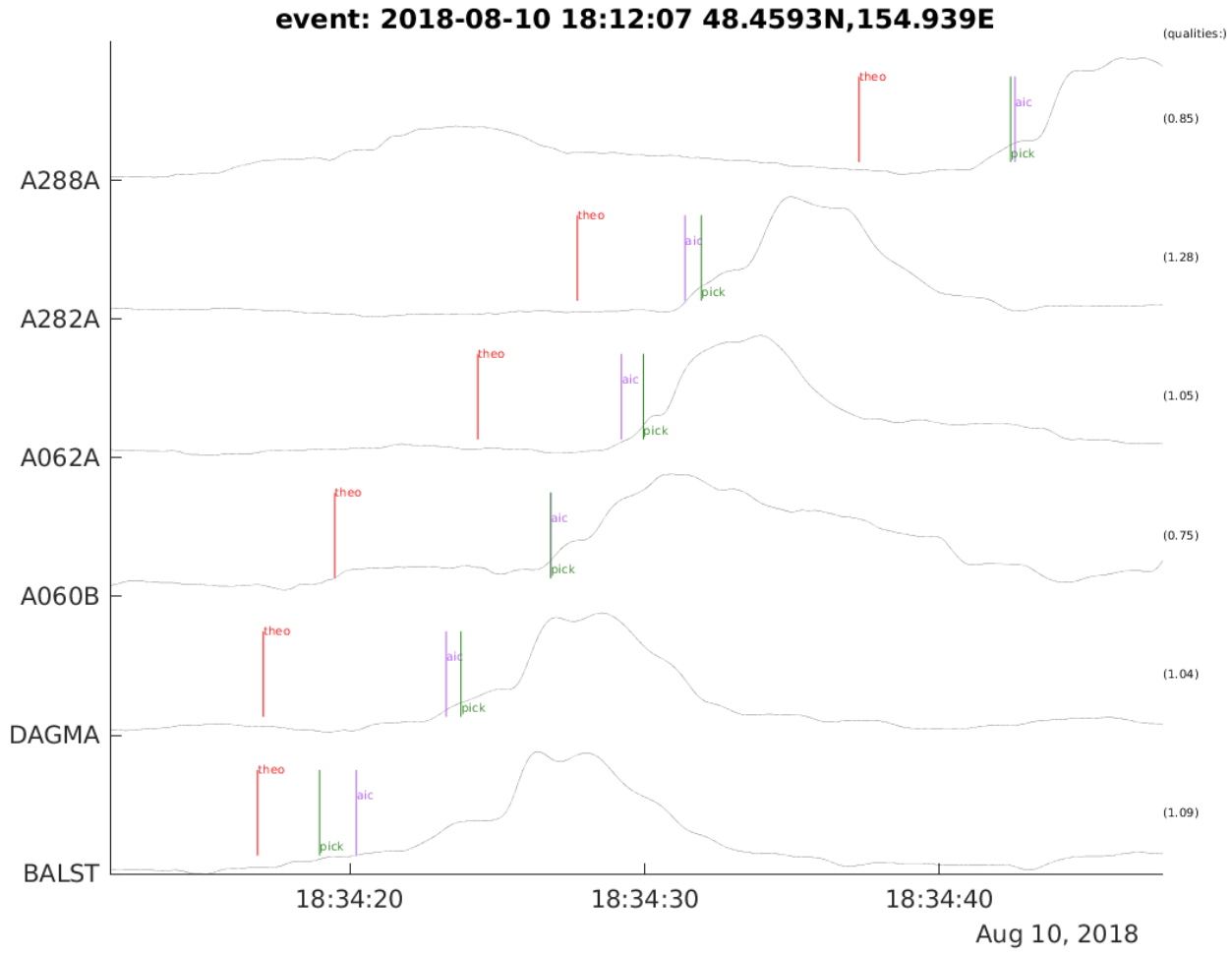
ttheo: theoretical travel times (red),
aic: preliminary phase arrivals (purple),
pick: picks (green)

Waveforms – Processed T-component data (S-Arrival)



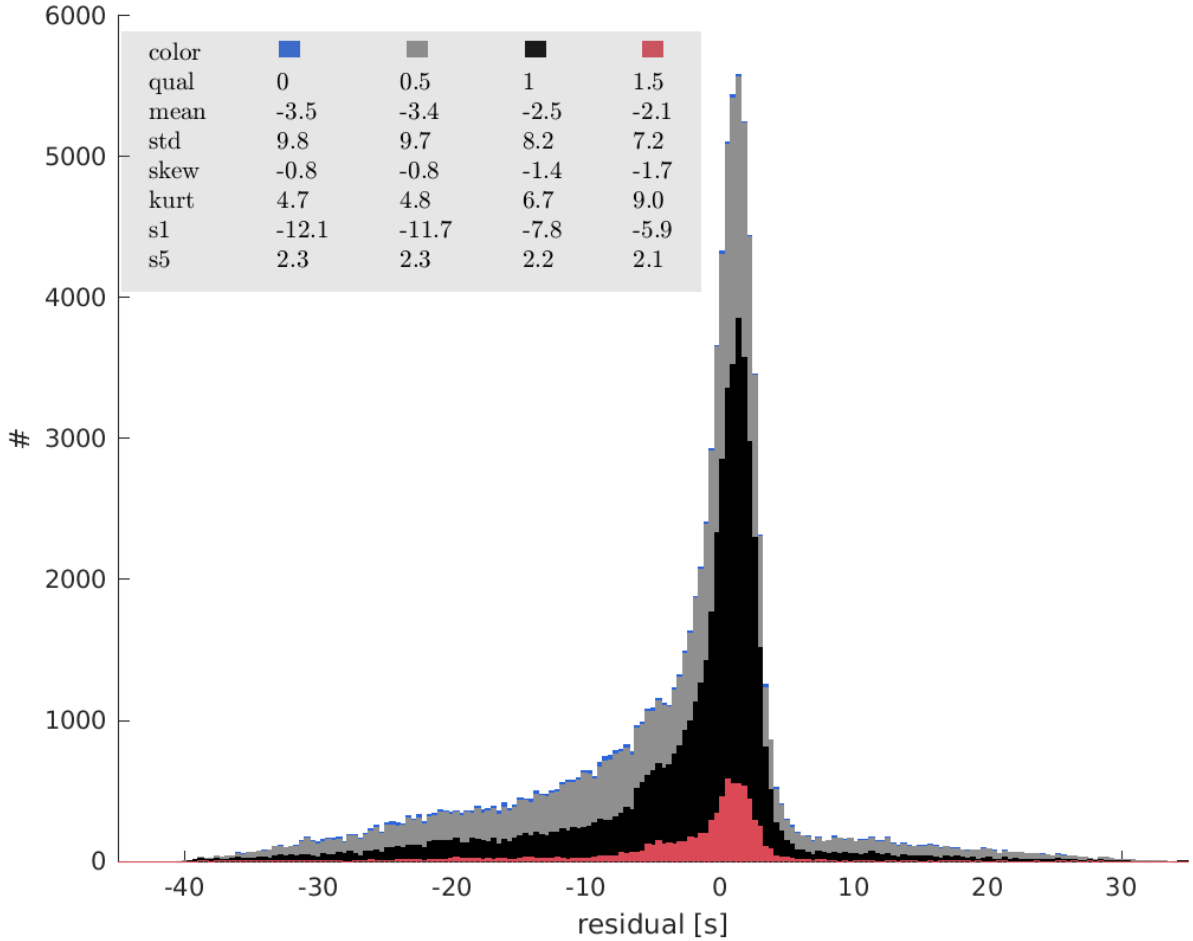
ttheo: theoretical travel times (red),
aic: preliminary phase arrivals (purple),
pick: picks (green)

Waveforms – Characteristic Function (S-Arrival)



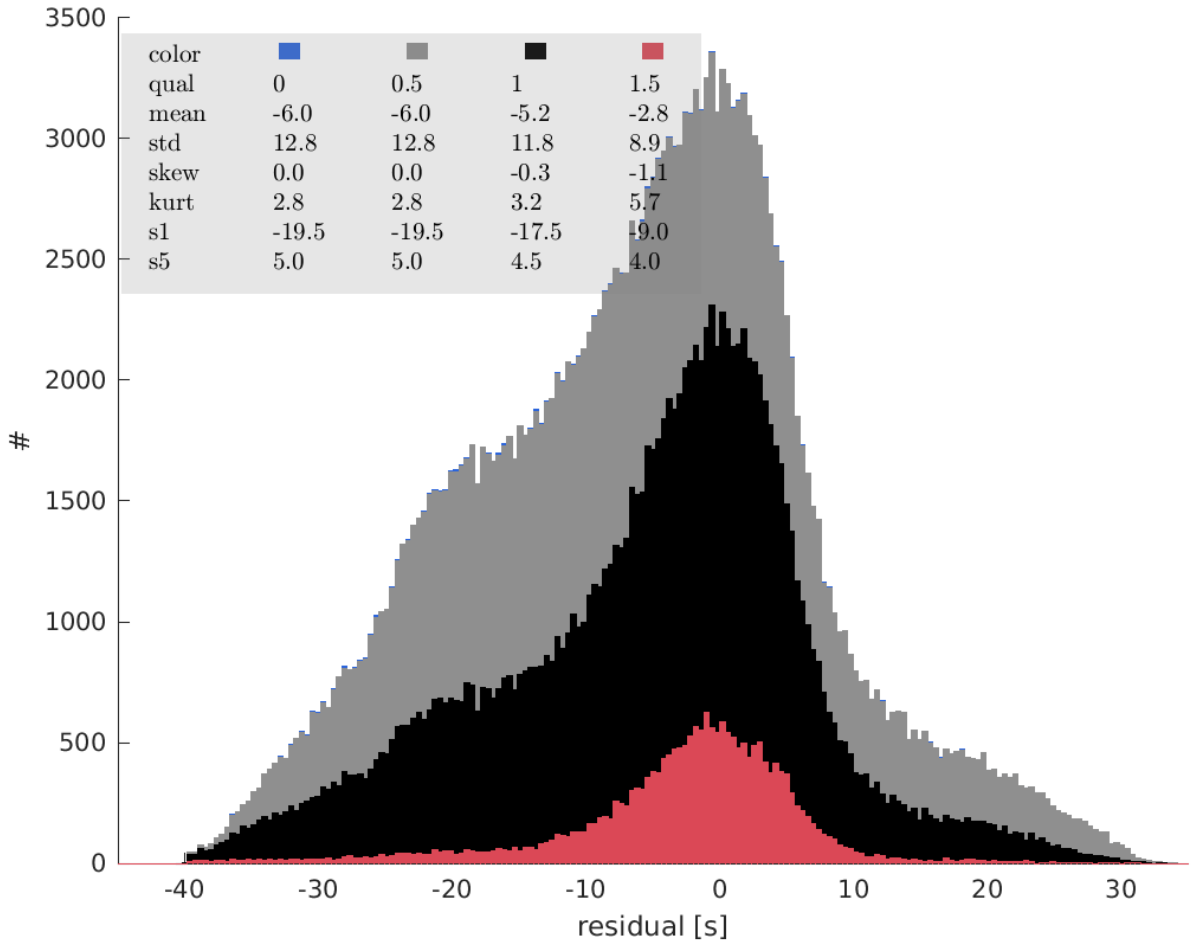
ttheo: theoretical travel times (red),
aic: preliminary phase arrivals (purple),
pick: picks (green)

Residuals of automatically picked P-wave arrival times to 1-D theoretical travel times (97872 picks)



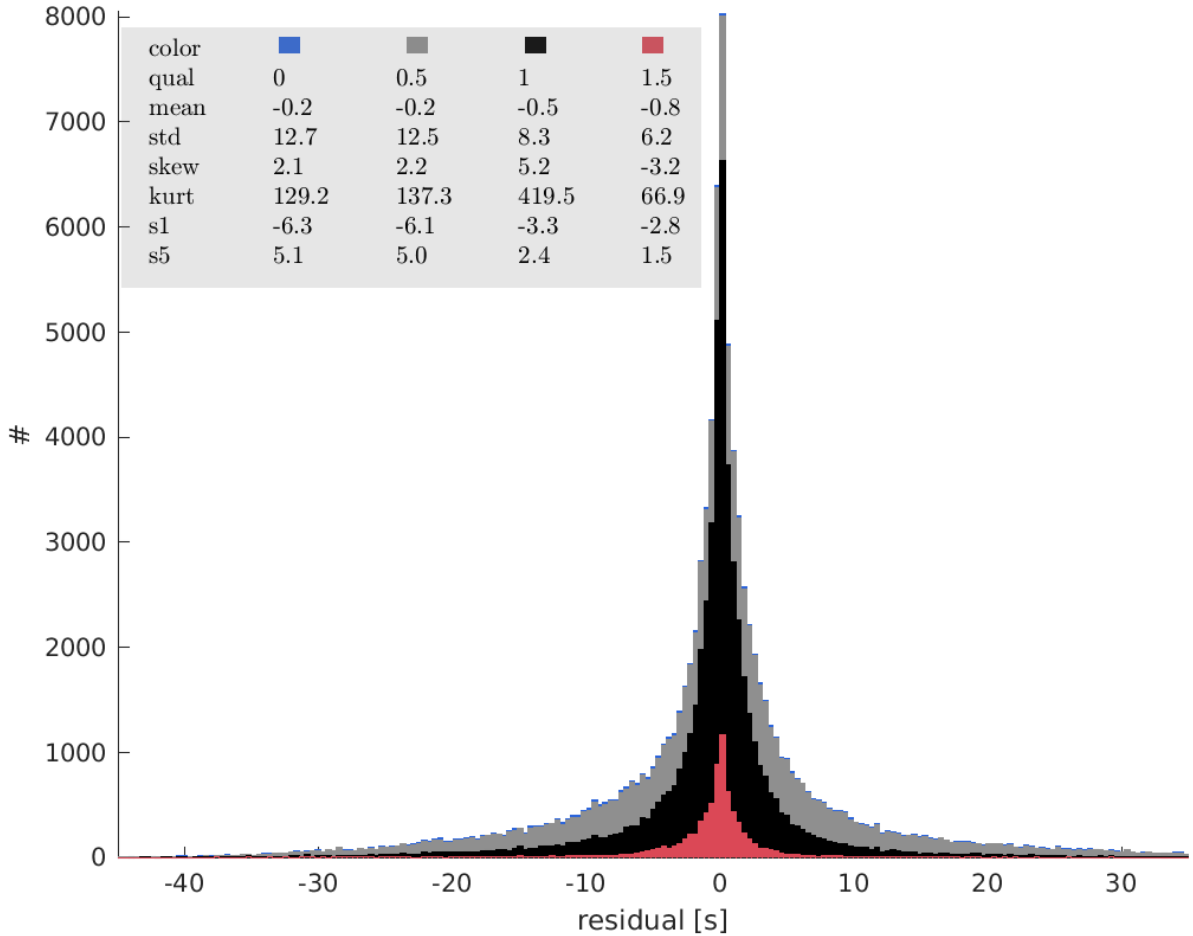
qual: quality metric (high quality means good SNR),
mean: mean value,
skew: skewness,
kurt: kurtosis,
s1,s5: first and last sextile boundaries

Residuals of automatically picked SH-wave arrival times to 1-D theoretical travel times (225610 picks)



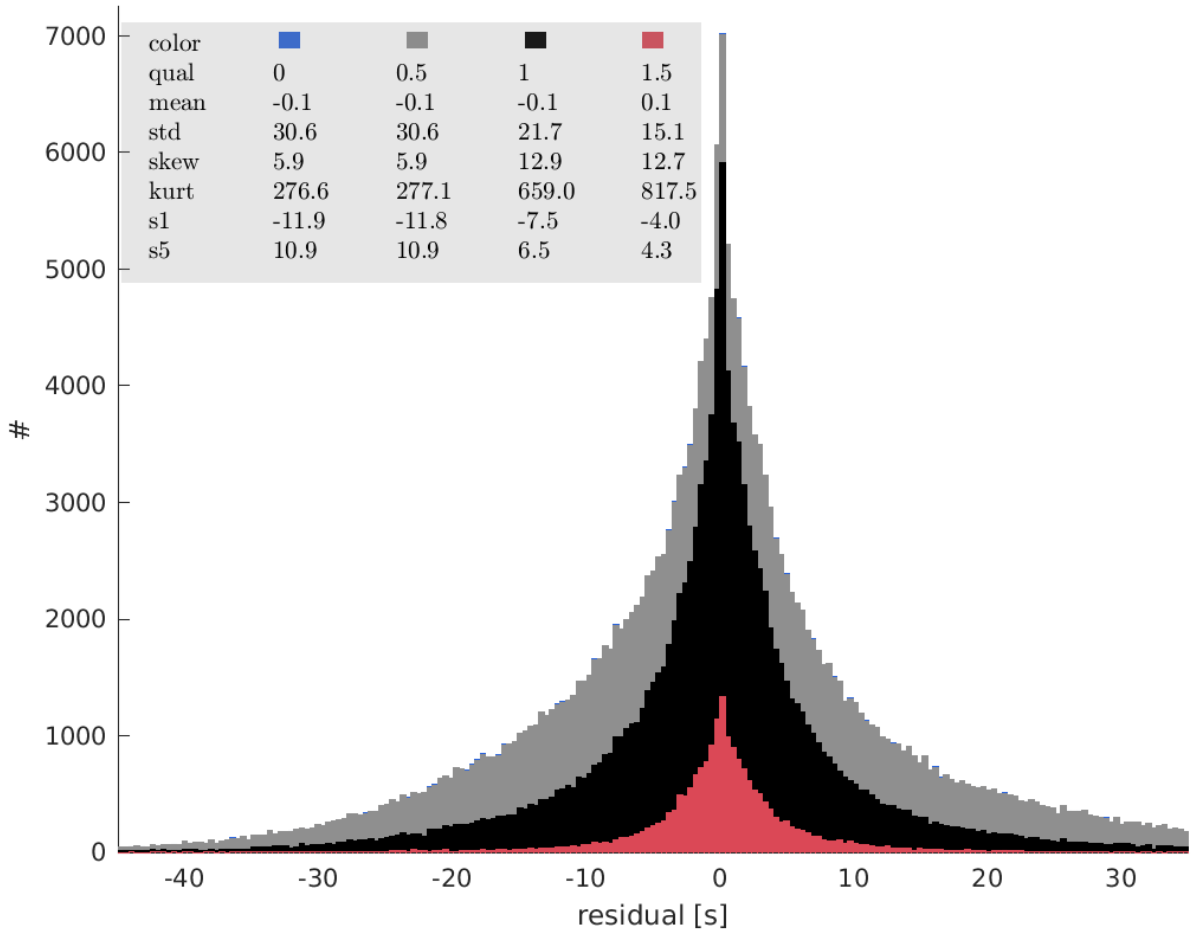
qual: quality metric (high quality means good SNR),
mean: mean value,
skew: skewness,
kurt: kurtosis,
s1,s5: first and last sextile boundaries

Residuals of automatically picked P-wave arrival times to local average (97872 picks)



qual: quality metric (high quality means good SNR),
mean: mean value,
skew: skewness,
kurt: kurtosis,
s1,s5: first and last sextile boundaries

Residuals of automatically picked SH-wave arrival times to local average (225610 picks)



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Conclusions/Outlook

- automated picking needed for real-time processing and processing of large data sets
- automated processing allows for consistent selection of filtering and quality assessment
- large variability of signal and noise waveforms remains a challenge
- multi-component AR-prediction well suited for picking of P- and S-waves
- next steps:
  - optimization of processing parameters
  - determination of relative travel times
  - P- and S-phase travel time tomography