Traveltime residuals at regional and teleseismic distances for SE-Asia

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Summary

Traveltime residuals for worldwide seismic stations are calculated. We use P and S waves from earthquakes in SE-Asia at teleseismic and regional distances. The obtained station residuals help to enhance earthquake localisation.
Furthermore we calculated regional source dependent station residuals. They show a systematic dependence of the locality of the source. These source dependent residuals reflect heterogenities along the path and can be used for a refinement of earthquake localisation.

Data Base

We read first arrivals for earthquakes in SE-Asia and stations within regional or teleseismic distances. The number of picks per station depends on s/n-ratios.

Range	Picks	Phases	Events	Stations
regional	1036	Pn, P	63	69
regional	461	Sn, S	51	40
teleseismic	6547	P, Pdiff, PKP	87	901

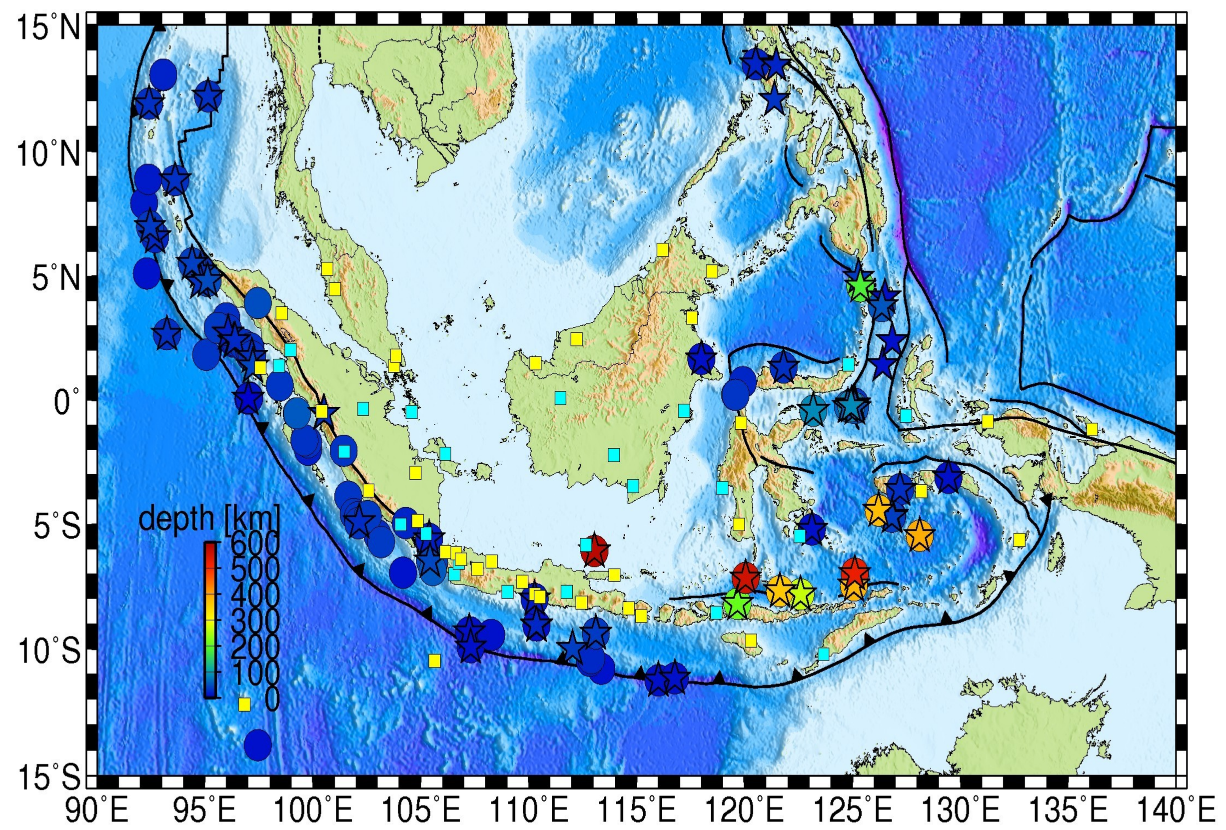


Fig. 1: Epicenters of earthquakes used for the regional (stars) and teleseismic (circles) study (colour indicates focal depth) and stations for analysis of regional phases (squares). Stations in cyan have been in operation since 2007. The irregular distribution of stations and events causes biased ray coverage.

Traveltimes and Pn/Sn-velocity

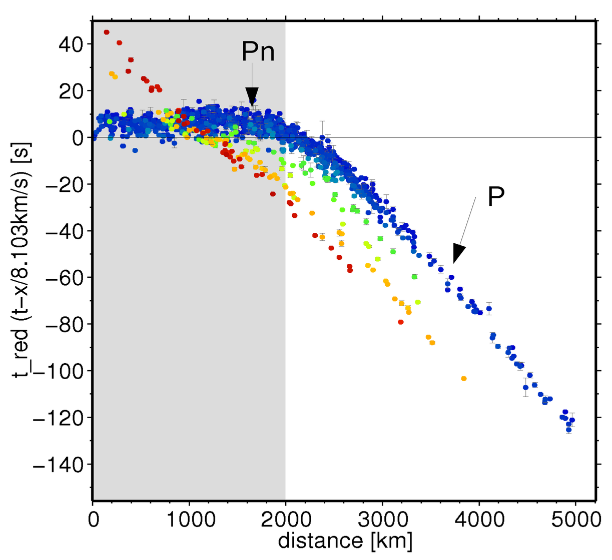


Fig. 2: Reduced traveltimes of first arrivals for stations and events in Fig. 1 (reduction velocity = 8.103 km/s). The change in slope for the blue curve indicates the transition from Pn to P as first arrival. As Pn occurs only for earthquakes with epicentres above the Moho, this change in slope is not observable for the deep earthquakes. Grey shaded area belongs to the distance zone shown in Fig. 4.

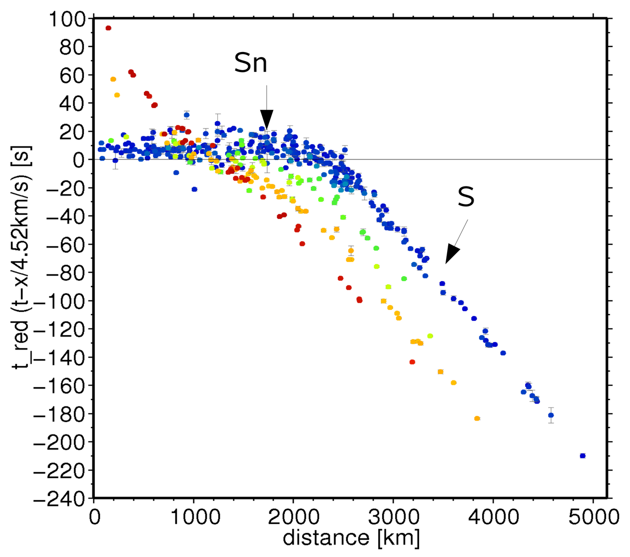


Fig. 3: Reduced Traveltimes for S-first-arrivals (reduction velocity = 4.52 km/s). Otherwise see Fig. 2.

Observations at regional distances

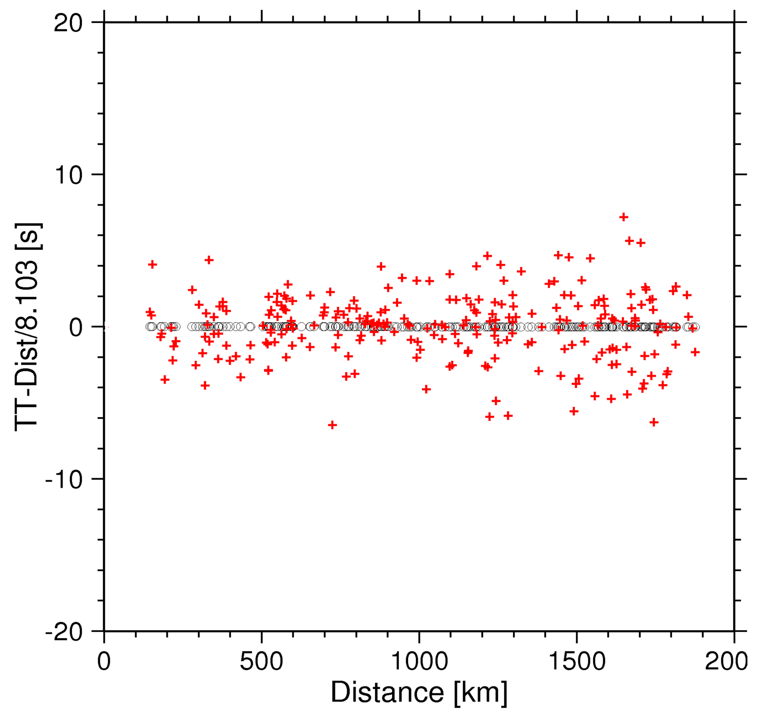


Fig. 4: Reduced traveltimes for Pn first arrivals after off-set removal. Reduction velocity is 8.103 km/s indicating normal upper mantle velocities. The resulting residuals can be used for a further structural analysis.

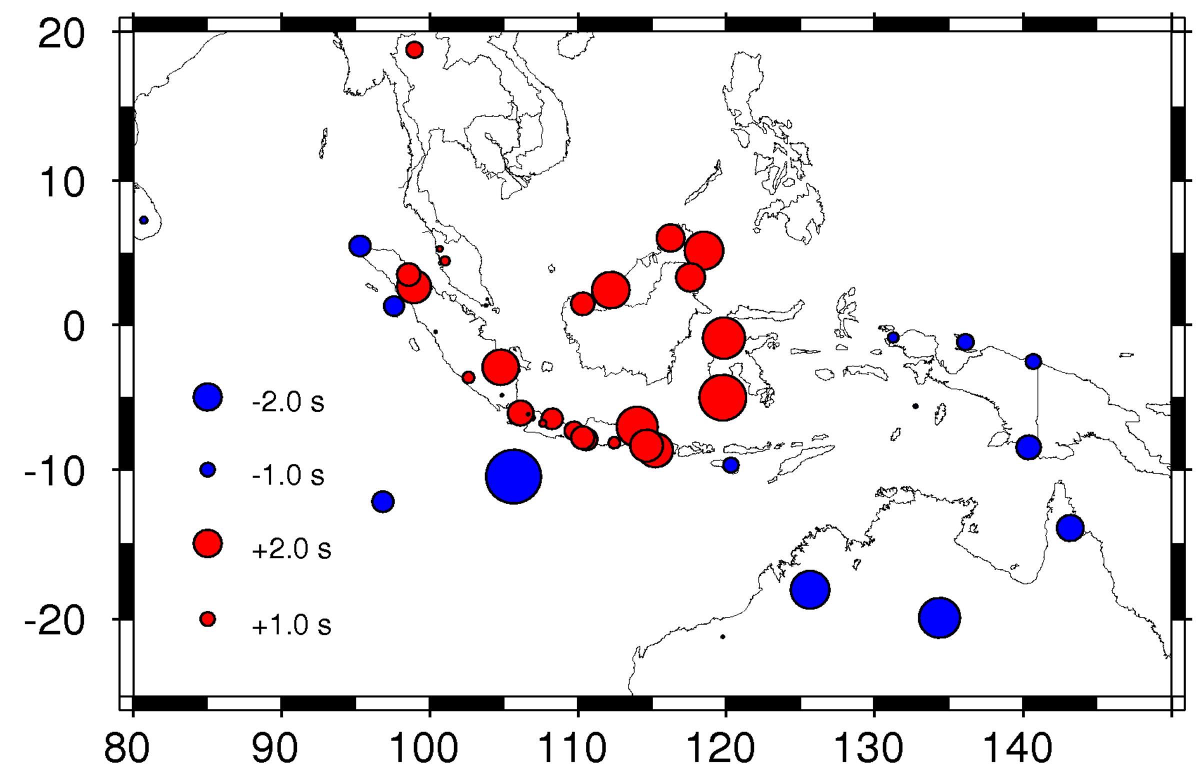
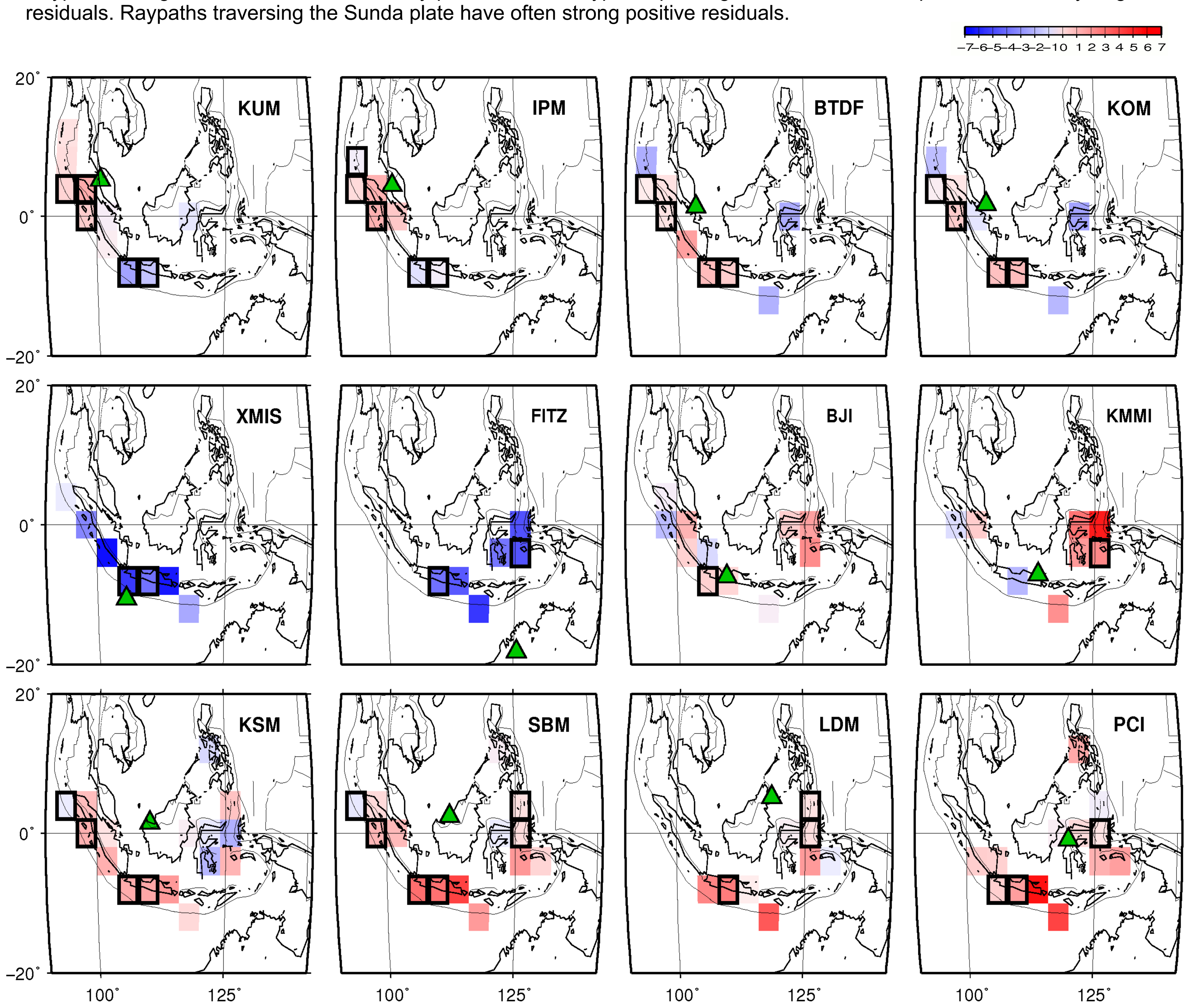


Fig. 5: Station residuals showing clear dependency on location (separation by Sunda arc). Positive: stations on Sunda plate, negative: stations on Indo-Australian plate. Stations south of the Sunda arc travel within the oceanic lithosphere with a higher velocity. Consequently they are faster than expected by the model (AK135).

Fig. 6: Traveltime residuals for selected stations (green triangles) and events in different focal areas show systematic dependency on their locations indicating complex structures. They are obtained after correcting for event residuals (mean of at least 5 traveltime residuals for one event). If more than one event lies in a bin (4°x4° area), their mean residual is plotted. Bins with at least 3 events are framed in black.
Raypaths along the Sunda arc show mostly positive, while raypaths passing the Indo-Australian plate show mostly negative residuals. Raypaths traversing the Sunda plate have often strong positive residuals.



Observations at teleseismic distances

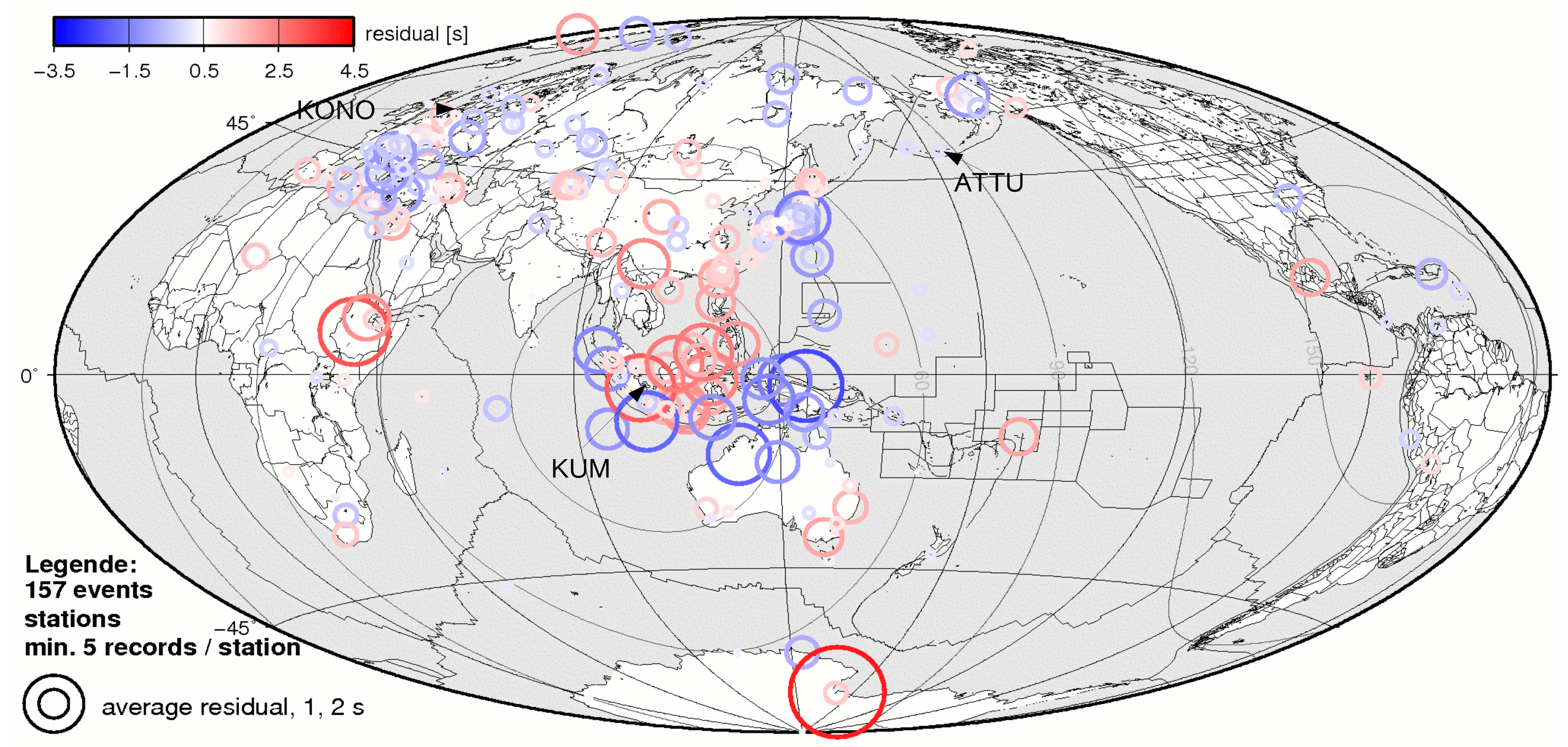


Fig. 7: Station residuals for teleseismic distances are mostly negative in Europe, positive in SE-Asia with a gradual transition to negative values for Japan.

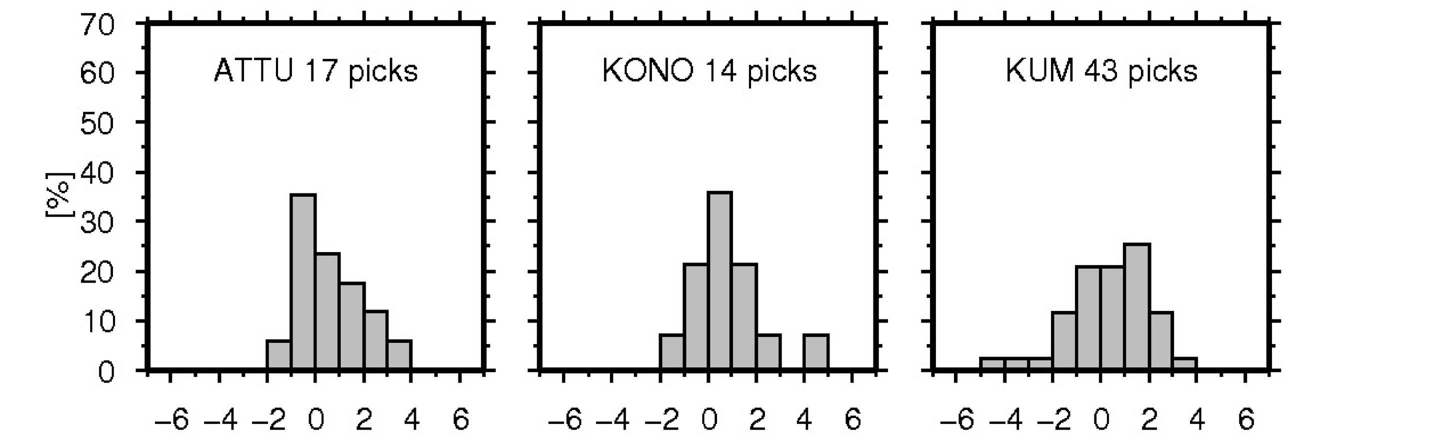
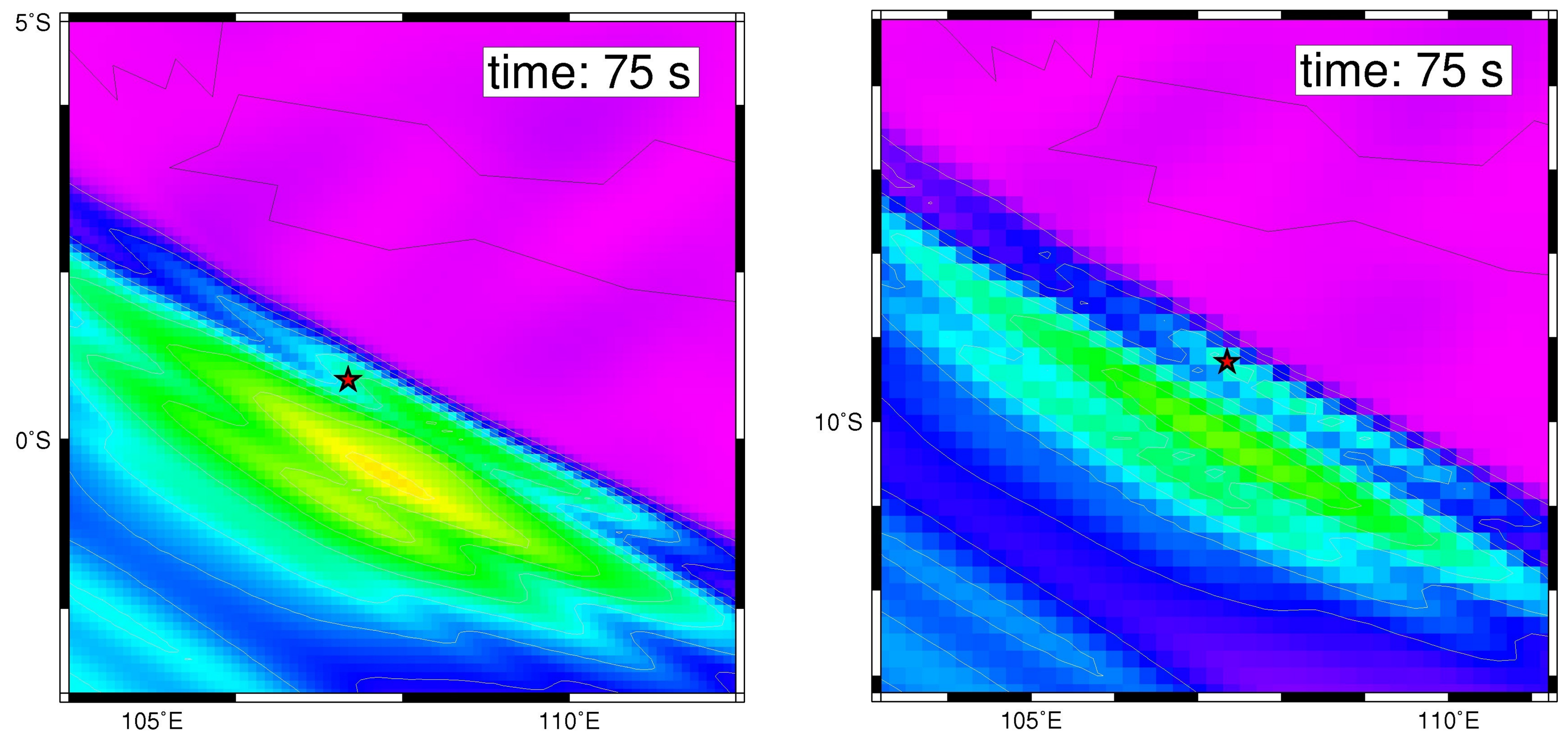


Fig. 8: Distributions of station residuals are either one-sided with a trend to negative values (left), normal (or Gaussian, centre) or one-sided with shifts to positive values (right).

Application of traveltime residuals to array methods



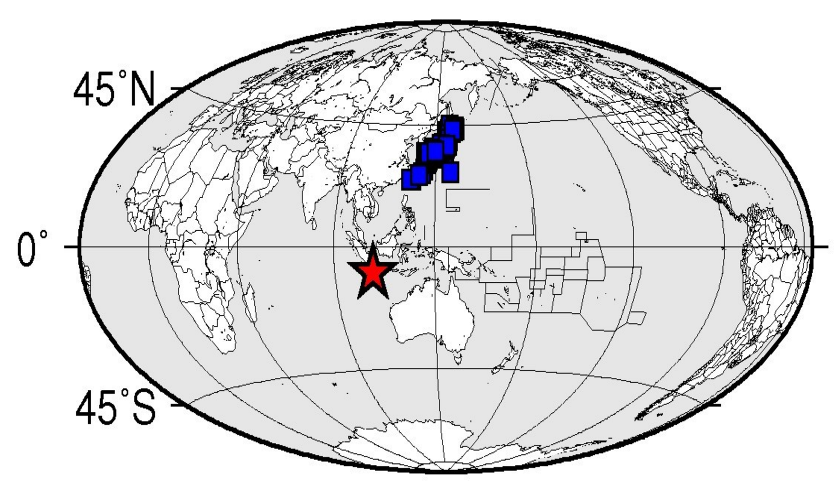


Fig. 9: Applying station residuals results in enhanced earthquake localisation and higher resolution. The example shows the epicentre of the tsunamogenic earthquake on 17th July 2006- (star, from GEOFON) and its localisation as seen from FNET using array methods.
Top-left: no corrections are applied. Toprght: corrections are applied. Warm colours represent high coherency.
Bottom-left: FNET Stations (squares) and the event (star) considered in this example.

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