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Rupture Propagation of the 2008/05/12 Ms8.0 Wenchuan Earthquake

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Abstract

We study the rupture propagation of the 2008/05/12 Ms8.0 Wenchuan Earthquake. We apply array techniques such as semblance vespagram analysis to P waves recorded at seismic broadband station within 30-100° epicentral distance. By combination of multiple large aperture station groups spatial and temporal resolution is enhanced and problems due source directivity and source mechanism are avoided. We find that seismic energy was released for at least 110 s. Propagating unilaterally at sub-shear rupture velocity of about 2.5 km/s in NE direction, the earthquake reaches a lateral extent of more than 300 km. Whereas high semblance during within 70 s from rupture start indicates simple propagation more complex source processes are indicated thereafter by decreases coherency in seismograms. At this stage of the event coherency is low but significantly above noise level.

We emphasize that first result of our computations where obtain within 30 minutes after source time by using an atomized algorithm. This procedure has been routinely and globally applied to major earthquakes. Results are made public through internet.

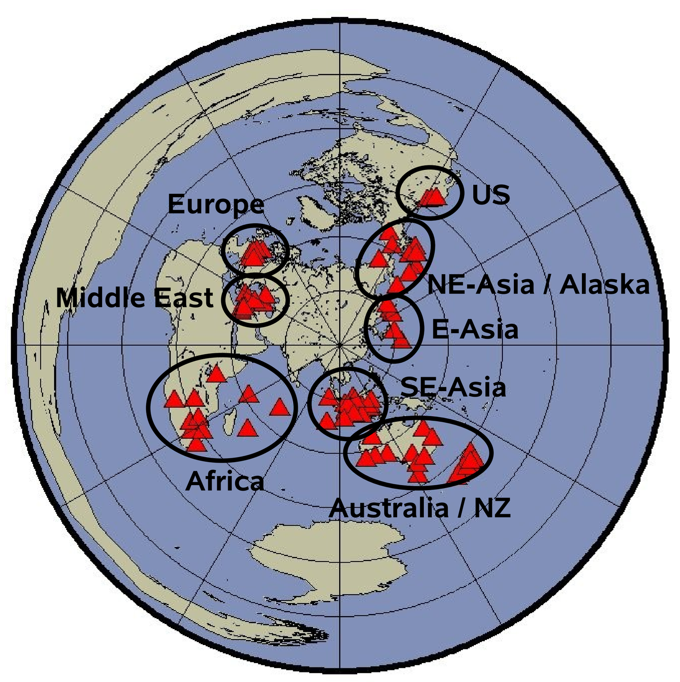
Method

By standard array methods [1], [2] we study the propagation and the extent of the rupture front of the Wenchuan earthquake. We determine waveform similarity at global seismic broadband stations that are combined to 8 separate arrays. For one specific source time and one assumed hypocentre, waveform similarity is expressed by means of the semblance within time windows of 30 s:

$$semblance = \frac{1}{M} \frac{\sum_{k=1}^{N} \left(\sum_{i=1}^{M} a_{ik} \right)^2}{\sum_{k=1}^{N} \left(\sum_{i=1}^{M} a_{ik}^2 \right)},$$

where a_{ik} is the *k-th* seismogram sample at the *i-th* station. High semblance indicates increased probability that an earthquake occurred. We back-propagate the semblance for first-arrival phases recorded at broad-band stations within teleseismic distances (30°-95°, **Fig. 1**). To gain semblance maps and temporal event information, time windows are shifted in time assuming many hypocentres **(Figs. 2, 3)**. Results from single arrays are biased by their transfer function and inappropriate Earth models. Therefore, semblance maps of the 8 arrays multiplied resulting in increased spatial and temporal resolution (compare **Fig. 4**).

Fig. 1: Seismic broadband stations used in this study. Arrays are indicated (see also Fig. 4).



Acknowledgements: Data provision by SZGRF/BGR, IRIS, and FNET are acknowledged.

References:
[1] Krüger, F., Ohrnberger, M., 2005, Tracking the rupture of the *M*w=9.3 Sumatra earthquake over 1,150 km at teleseismic distance, Nature, 435
[2] Krüger, F., Ohrnberger, M., 2006, Spatio-temporal source characteristic of the 26 December 2004, Sumatra earthquake as imaged by teleseismic broadband arrays, Geophys. Res. Lett., 32
[3] http://neic.usgs.gov
[4] Global Centroid Moment Tensor Project, online at *http://www.globalcmt.org/*

Event Summary

- **event onset**: near the GEOFON location and source time.
- **source duration**: 115 s
- **rupture length**: approx. 300 km
- **rupture propagation**: SW-NE at about 2.5 km/s with 2 phases (0-70 s, 70-115 s)

Fig. 2: Spatio-temporal event evolution from combined solution. Contours show areas of seismic energy release at times indicated by their colours. Our analysis shows similarities of event onset with epicentre (**star**). Rupture length and area are comparable to aftershock locations (**circles**). Note some systematic shift to the SE imposed by the simplified Earth model used during analysis.

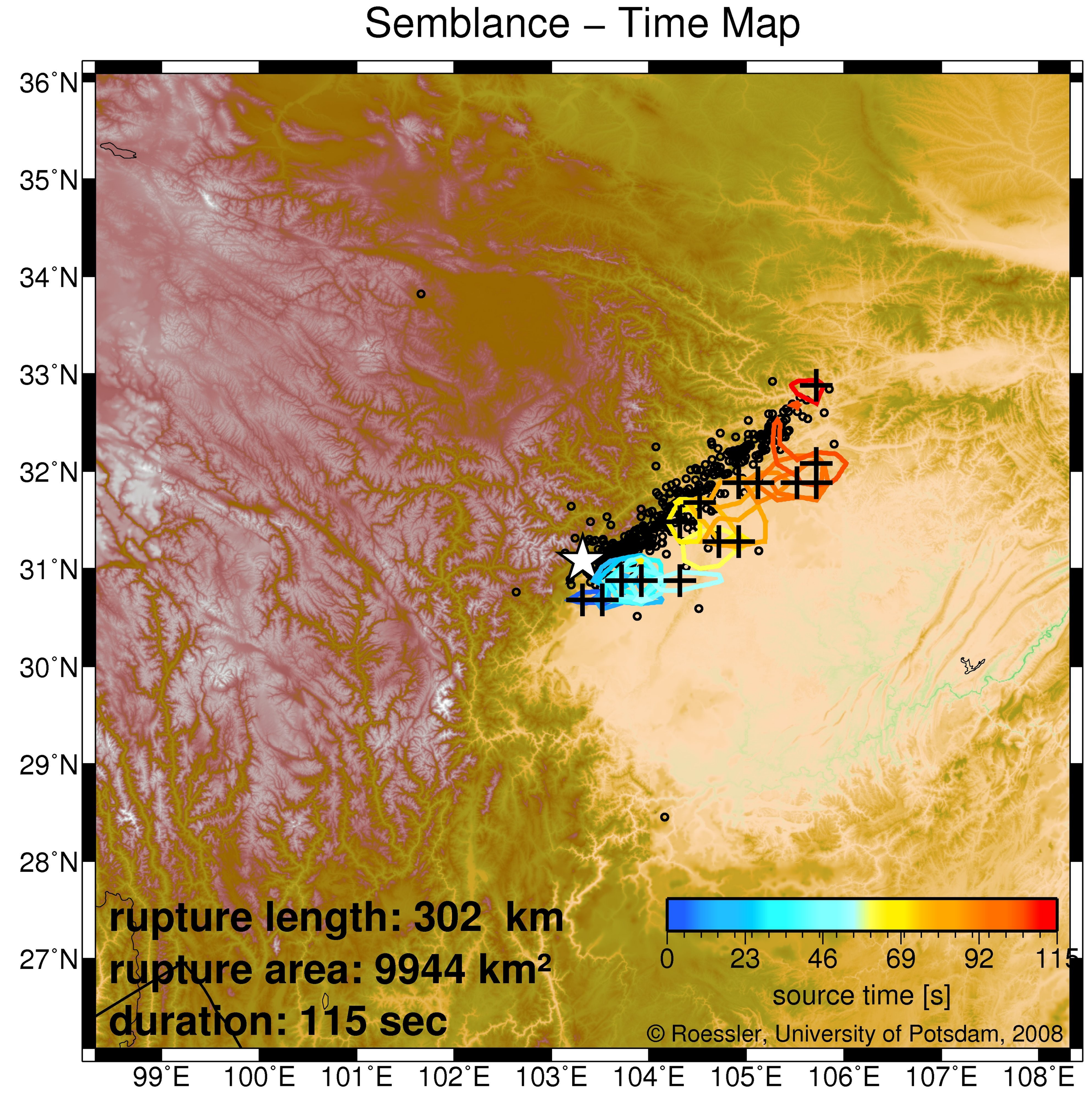
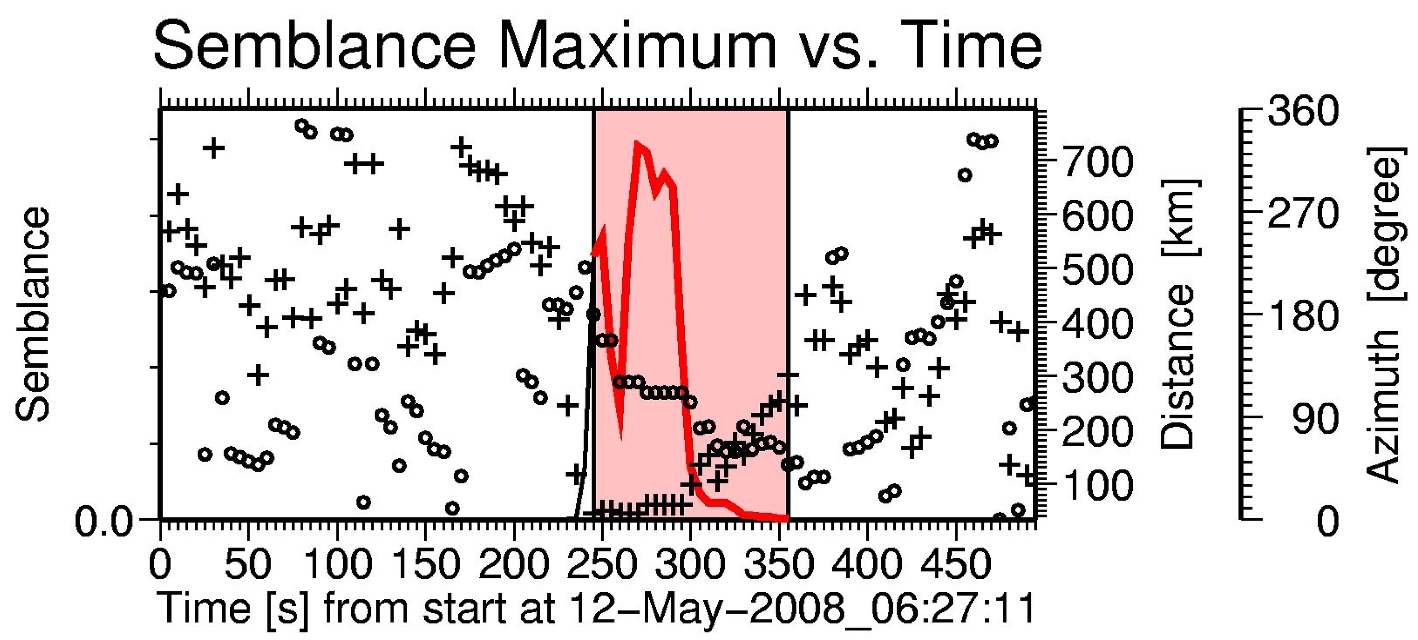
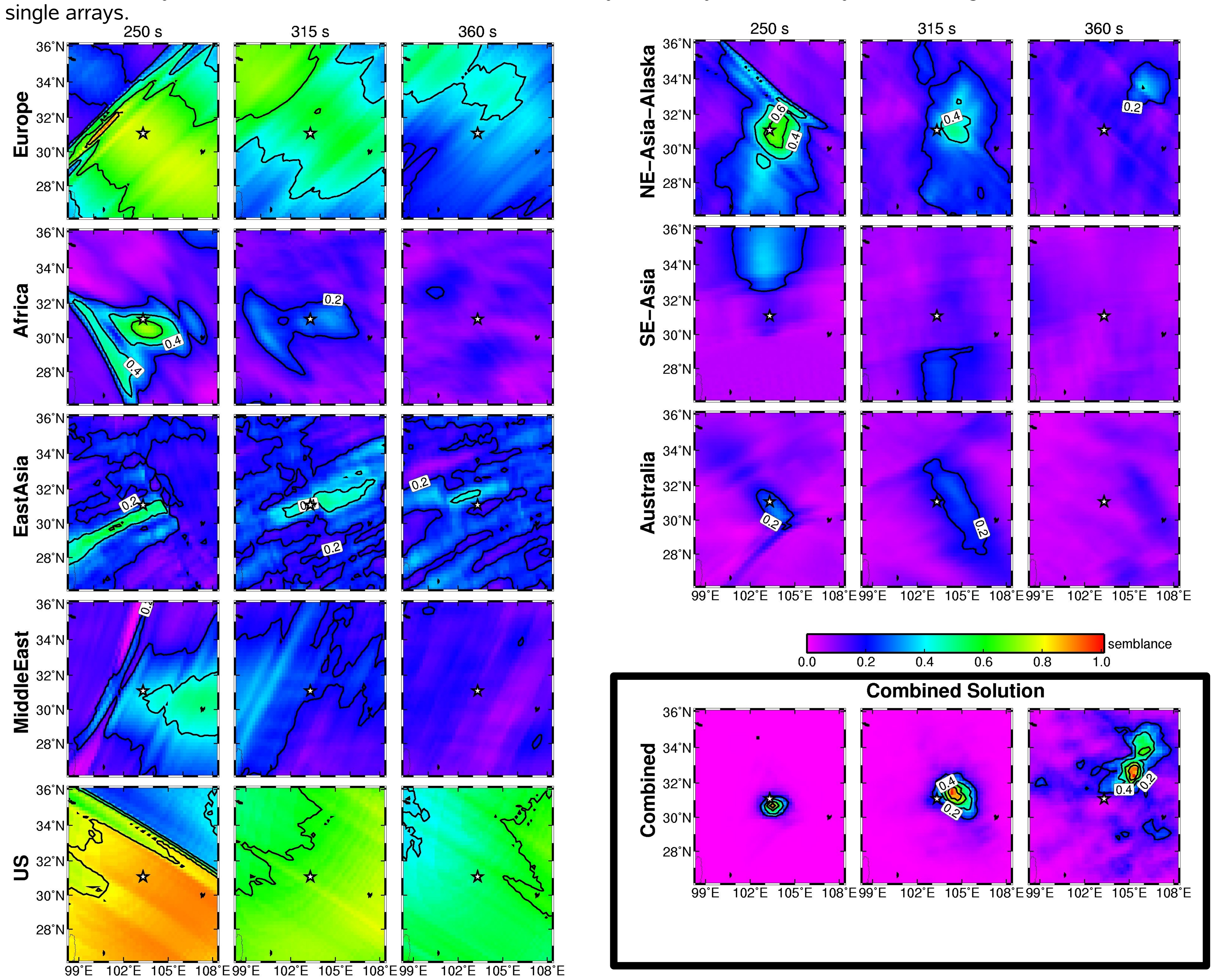


Fig. 3: Time evolution of the event. The **solid line** indicated the maximum of semblance in combined solutions as function of time. Event onset is a 275 s after the start of the calculations. **Red line / highlighted area** indicates source duration. **Crosses** indicate epicentral distance of energy release to GEOFON epicentre. Onset of the event as implied by our analysis is located near the GEOFON epicentre (compare Fig. 2). Rupturing departs smoothly from epicentre at 2.5 km/s. For increasing source duration, **circles** show smooth azimuthal changes in energy release with respect epicentre.



Array Combination

Fig. 4: Uncombined semblance maps for different arrays (compare Fig. 1) and combined solution (compare Fig. 2) at different times of the analysis. Start is at 250s before source time. Clearly, our array combination yield much higher resolution that the single arrays.



Focal Mechanism

Fig. 5 shows results for a test if the mechanism can be determined from P and S wave polarities. For this purpose the global network is grouped into subarrays in a way that covers the focal sphere as good as possible. All P and S waves arriving within the first 20 minutes after the origin time are used to form a common semblance coefficient for all grid points around the hypocentre, where the polarity of the waveforms is taken into account. A grid search in 5 degrees steps over strike, dip and rake then results into the mechanism as shown on top left, where the maximum semblance is found for relative time t = 106 s.

Fig. 5: