Rupture propagation of the TsE (Mw7.7) on 17 July 2006 off-coast Java

Dirk Rößler, Frank Krüger, Matthias Ohrnberger, Universität Potsdam, contact: diroess@uni-potsdam.de
online at: *http://www.geo.uni-potsdam.de/forschung/geophysik/gitews/tsunami.htm*

Summary

The Mw=7.7 **tsunamogenic earthquake (TsE)** on 17 July 2006, 08:19:28 shock the Indian Ocean at about 15 km depth off-coast Java, Indonesia (**Section 1**). It caused a local tsunami with wave heights exceeding 2 m. The death toll reached several hundred. Thousands of people were displaced.

By means of standard array methods [1], [2] we have investigated the propagation and the extent of the rupture front of the causative earthquake. Waveform similarity is expressed by means of the semblance:

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

where a_{ik} is the *k-th* seismogram sample at the *i-th* station. We back-propagate the semblance for first-arrival phases recorded at broad-band stations within teleseismic distances (30°-95°, **Fig.3**). Image enhancement is realised by stacking the semblance of 8 arrays within different epicentral and azimuthal directions.

From teleseismic observations (**Sec. 2, 3**) we find rupturing of a **200 x 100 km wide area** in **at least 2 phases** with propagation from **NW to SE** and source duration **>125 s**. The event has some characteristics of a circular rupture followed by unilateral faulting with change in slip rate. Unusually **slow rupturing (≈1.5 km/s)** is indicated. Fault area and aftershock distribution coincide. Spatial and temporal resolution are frequency dependent. Studies of a Mw6.0 earthquake on 2006/09/21 and one synthetic source **(Sec. 4)** show a ≈1° limit in resolution. Retrieved source area, source duration as well as peak values for semblance and beam power increase with the size of the earthquake making possible an automatic detection and classification of large and small earthquakes.

1 Recent TsE earthquakes

Since 2004 three large earthquakes have caused significant tsunamis in the Sunda arc subduction zone: (1) the Mw9.3 megathrust event on 2004/12/26, (2) the Mw8.6 event on 2005/03/28, and (3) the Mw7.7 event on 2006/07/17 (**Fig. 1**). Although event (2), Mw8.6, was much larger than event (3), Mw7.7, the duration of (3) exceeds that of (2). This indicates low rupture velocities for event (3).

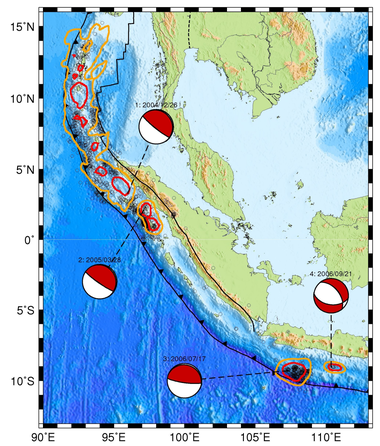


Fig. 1: Epicentres, fault-plane solutions [3], and aftershocks (within 3 days) of events (1)-(3) and, (4), one event (Mw6.0) on 2006/09/21. **Orange** and **red** lines contour semblance values **0.5** and **0.75**, respectively and approximate the ruptured areas.

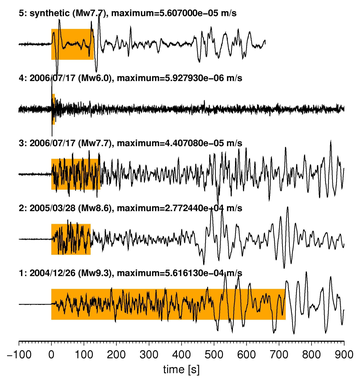


Fig. 2: Seismograms at station ABU (FNET, Japan) for events (1)-(4) in **Fig. 1** and one synthetic event (see **Sec. 4**). The wavetrains of direct P waves are highlighted.

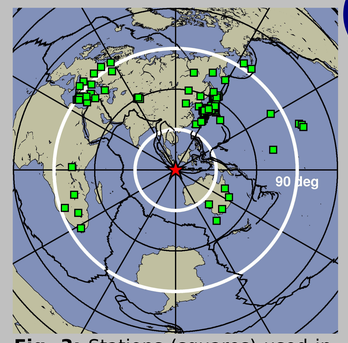


Fig. 3: Stations (squares) used in this study and event (star).

2 Frequency-wavenumber analysis at GRSN stations

Long source duration (>120s) for event (3) on 2006/07/17, Mw7.7, TsE, is indicated by long P wavetrains seen at the German Regional Seismic Network (GRSN), see **Figs. 1, 4a-c**.

Fig. 4a: F-K-diagram for a time window including 100s before to 20s after the first arrival on station MOX (Pdiff).

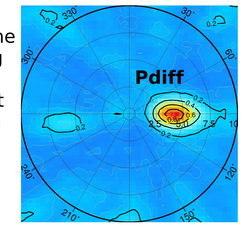


Fig. 4b: F-K-diagram including 100-200s after first arrival on MOX.

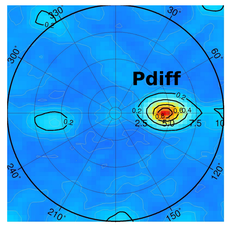
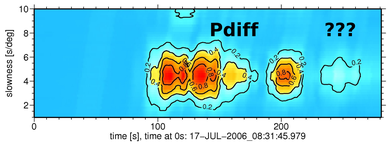
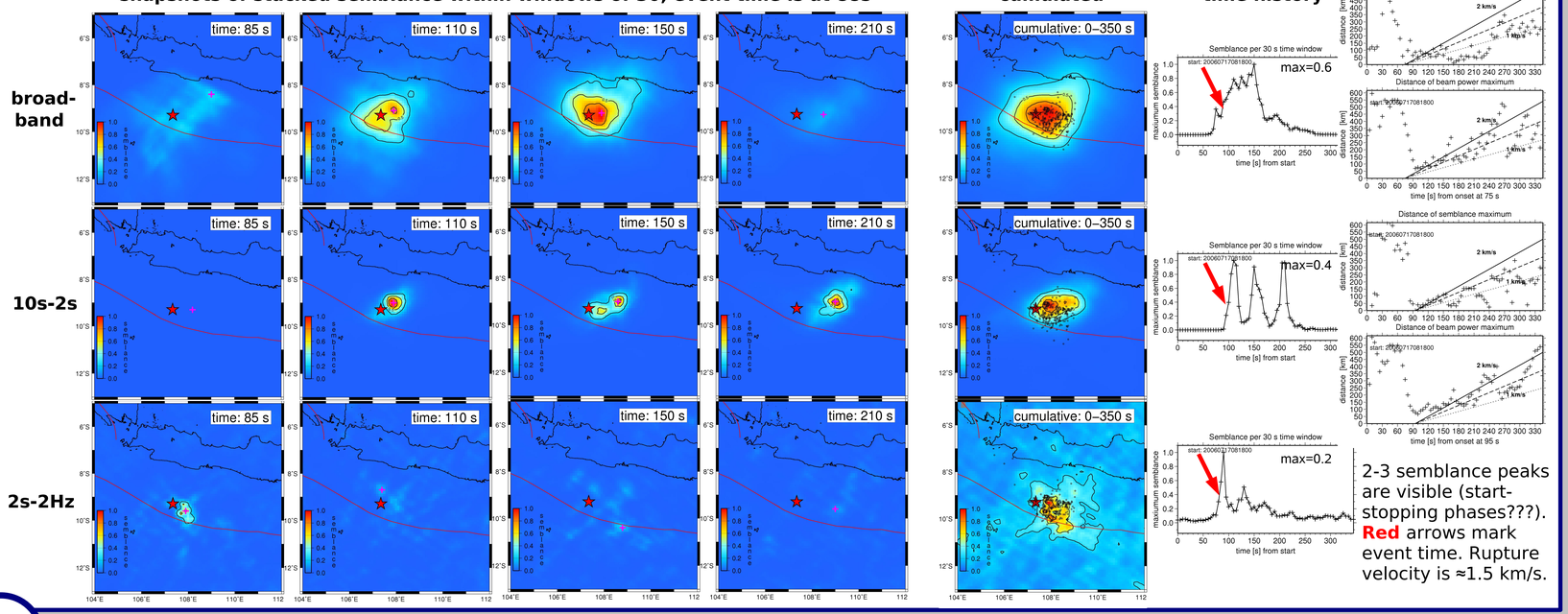


Fig. 4c: Vespagram (normalised beam power) for 100s before to 200s after first arrival on station MOX.



3 Rupture propagation of the TsE on 2006/07/17 seen at different frequencies

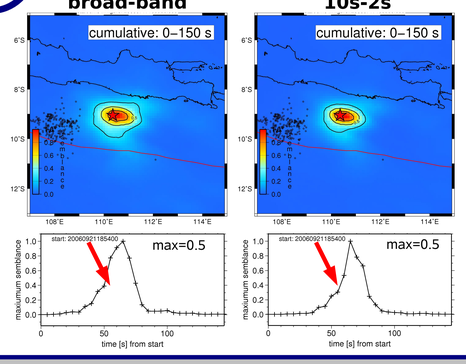
Fig. series 5:



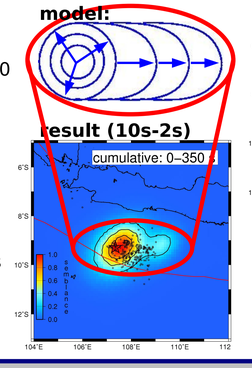
2-3 semblance peaks are visible (start-stopping phases???). **Red** arrows mark event time. Rupture velocity is ≈1.5 km/s.

4

Event (4),Mw6.0, on 2004/09/21

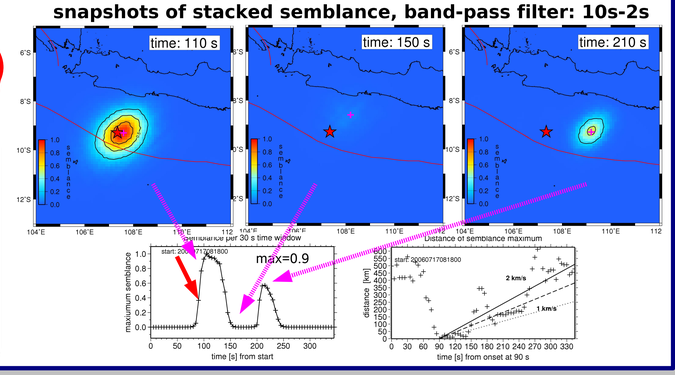


Resolution tests



Size, duration, and beam power (not shown) differ clearly between the Mw6.0 event (4),left, and the Mw7.7 event (3), above. Right: Assuming a synthetic source (circular rupture + unilateral Haskell source, area: 200x100km, duration: 130s) shows that only start and stopping phases or fault segments where changes in slip occur can be imaged.

Synthetic event



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

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