T-phases Recorded by the IMS Hydrophone Network from Tsunamigenic Earthquakes in Indonesia

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OUTLINE

- Introduction and Motivation
- Methodology
- T-phase Mechanism
- Result and Discussion
- Conclusions

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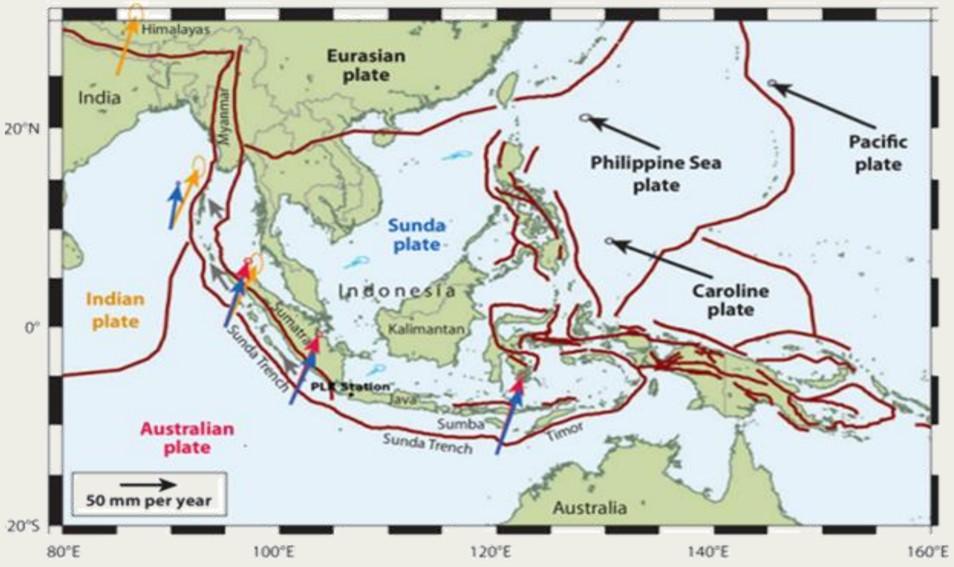
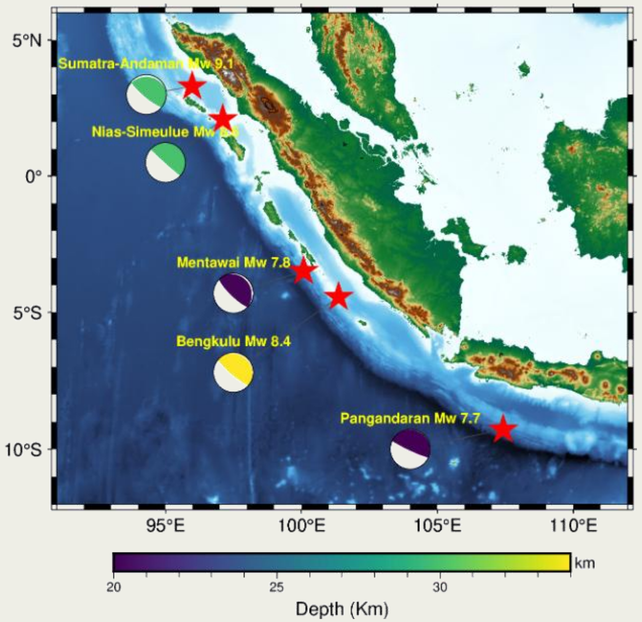
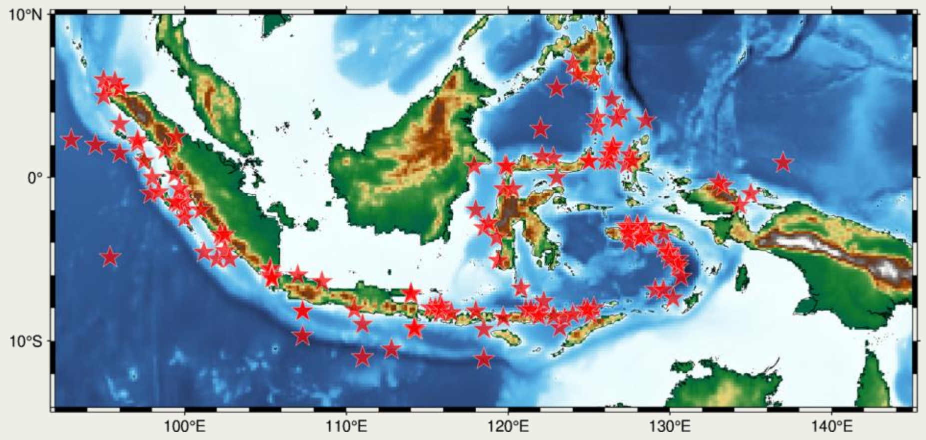
INTRODUCTION AND MOTIVATION



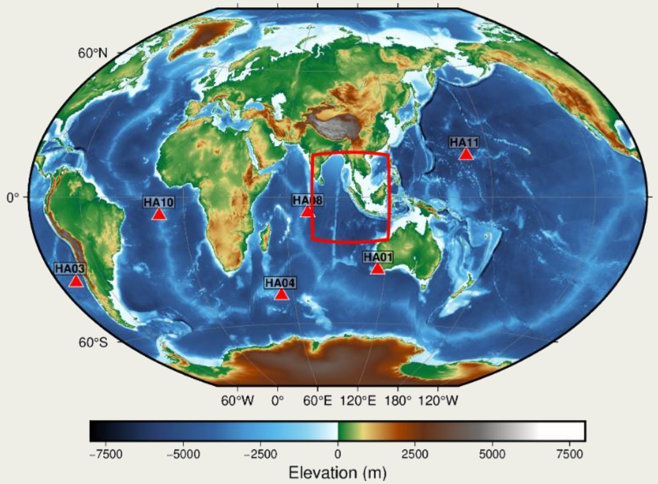
Tectonic Setting of Indonesia (McCaffrey, 2009)



Five Massive earthquakes from 2004 to 2010



Indonesia Tsunami Catalogue from 416 to 2023 (BMKG)



Hydroacoustic Station used in this research

- Indonesia is prone to tsunamis caused by seismic and non-seismic events.
- Five massive earthquakes between 2004 and 2010 generated tsunamis.
- Motivation: Investigate T-phases recorded by the IMS hydrophone stations **HA01**, and **HA08** triggered by these five earthquakes, using the NDC-in-a-box provided by CTBTO to the Indonesian NDC (BMKG).

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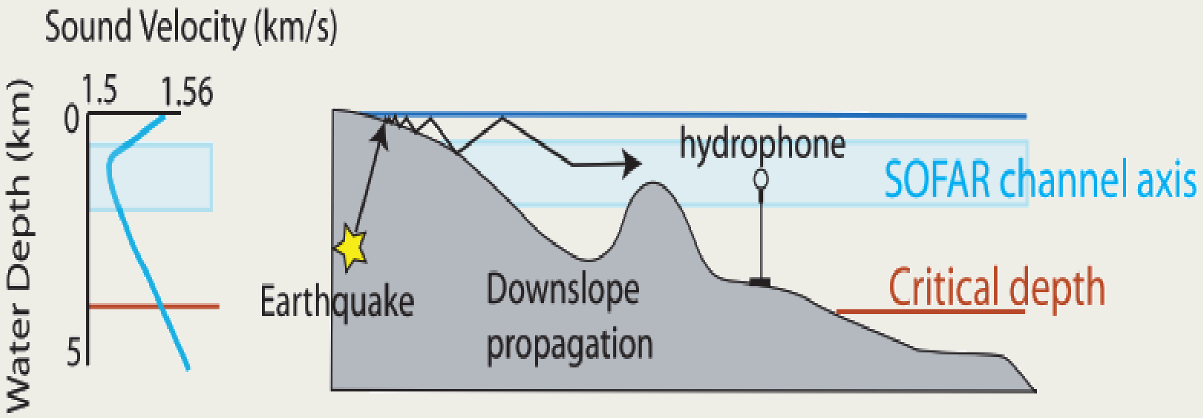
T-PHASE MECHANISM



T-phase Mechanism (Williams et al. 2006)

- Earthquake generates elastic waves
- Seismoacoustic Conversion
- SOFAR (Sound Fixing And Ranging) Channel
- Hydroacoustic (T-phase) by Hydrophone

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METHODOLOGY

1 – Data

Earthquake information (USGS and Global CMT)

Hydroacoustic waveform (IMS)

2 - PMCC Processing

- T-phase estimation:

a) Provide direct information: Back-Azimuth and Back Projection

b) Kind of T-phases (Early – Main – Later); Earlier arrivals of T-phase due to seismic to hydroacoustic coupling far from the epicenter

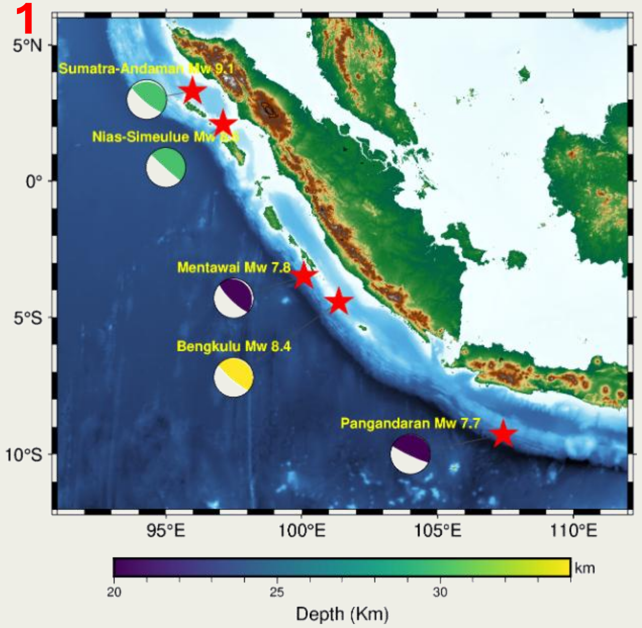
c) later arrivals due to reflections from islands and seamounts

3 – Rupture length estimation

from the main T-phases

4 - Compare to previous research

1



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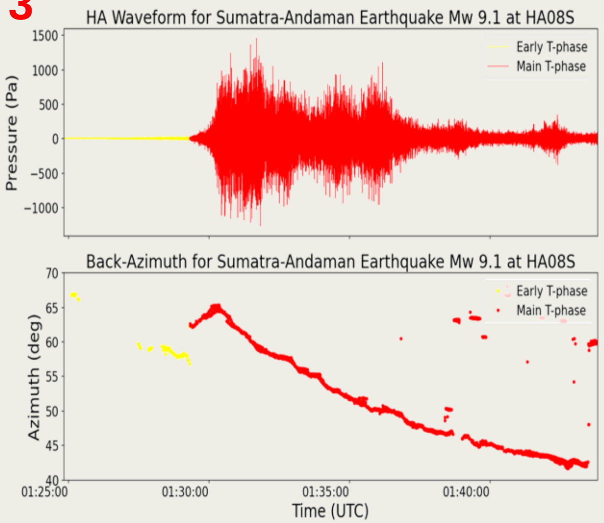
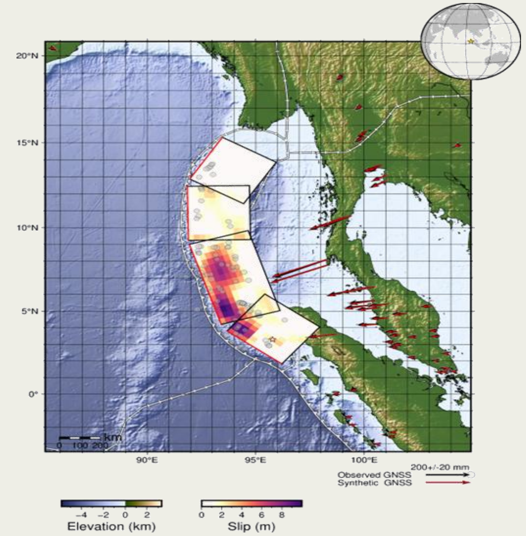


2

4



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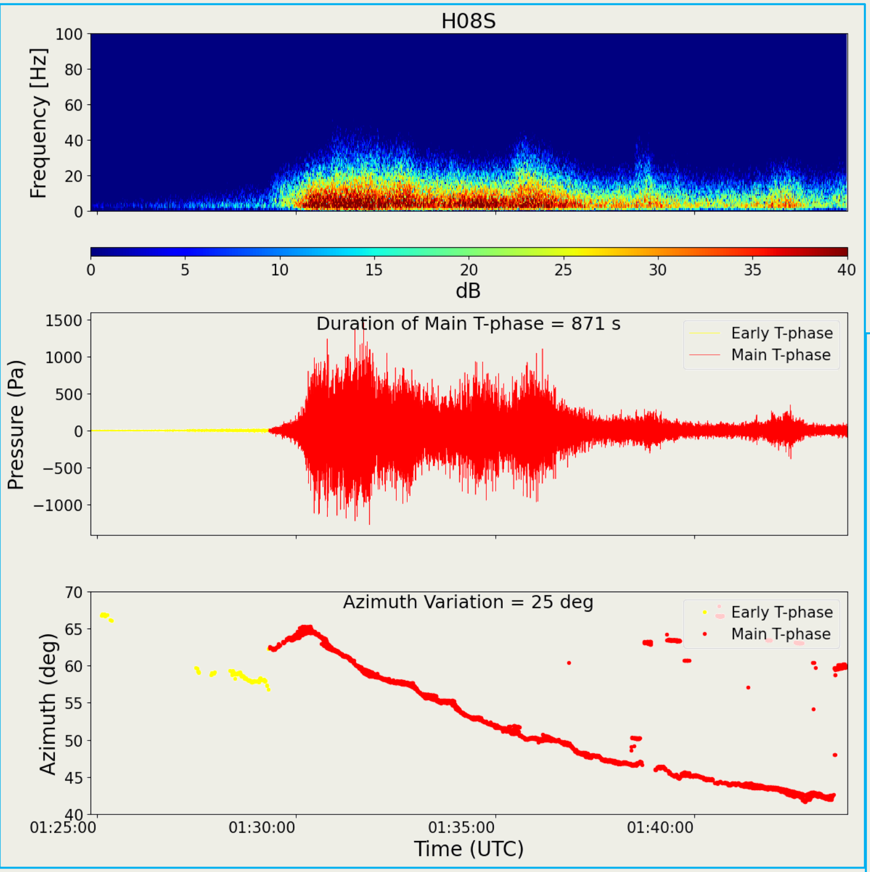
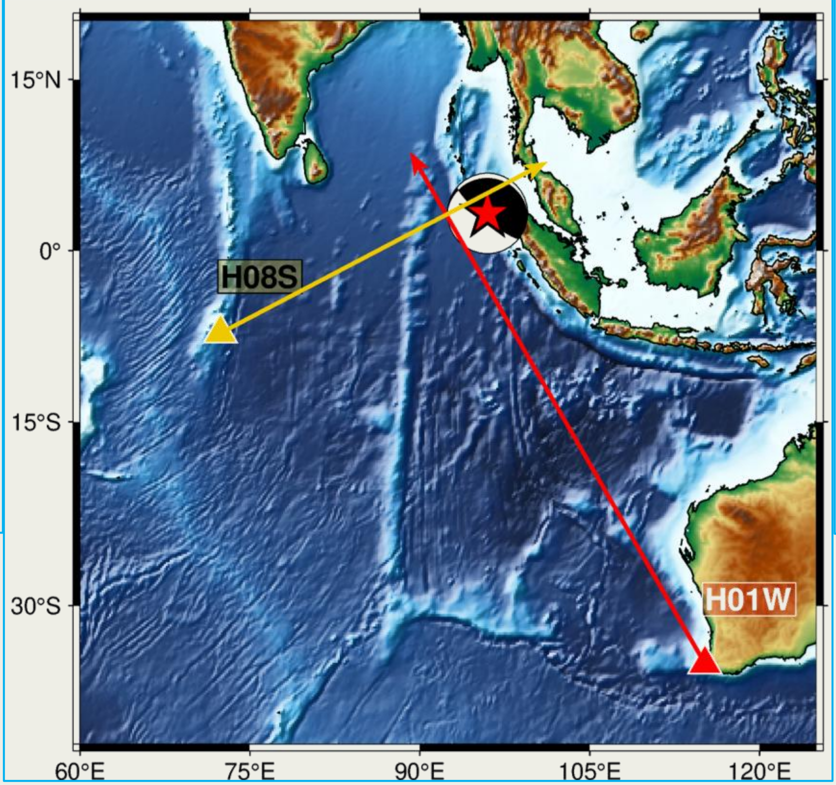
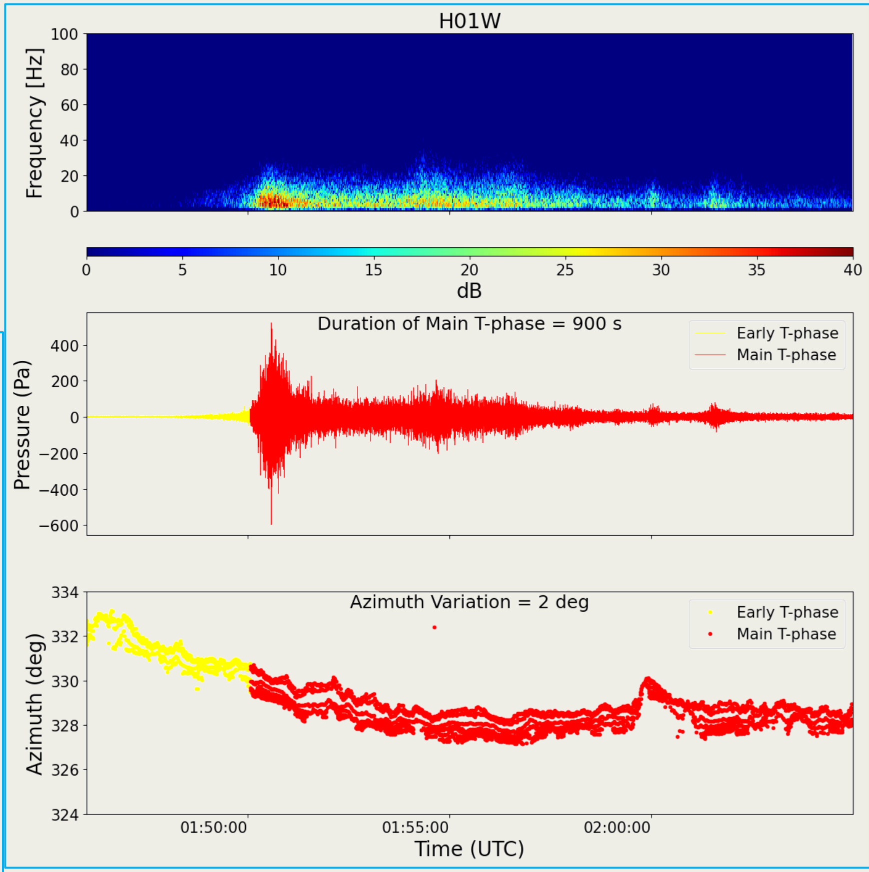
CASE 1 : SUMATERA – ANDAMAN EARTHQUAKE Mw 9.1 (Dec 26, 2004. 00:58:53 UTC)



Back-Azimuths of H01W and H08S are the back-azimuths with the highest frequency on a waveform.





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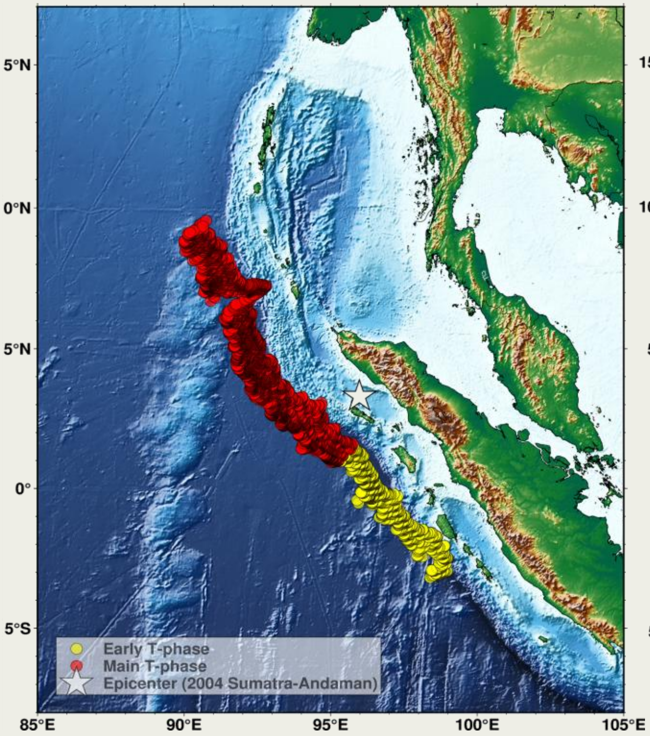
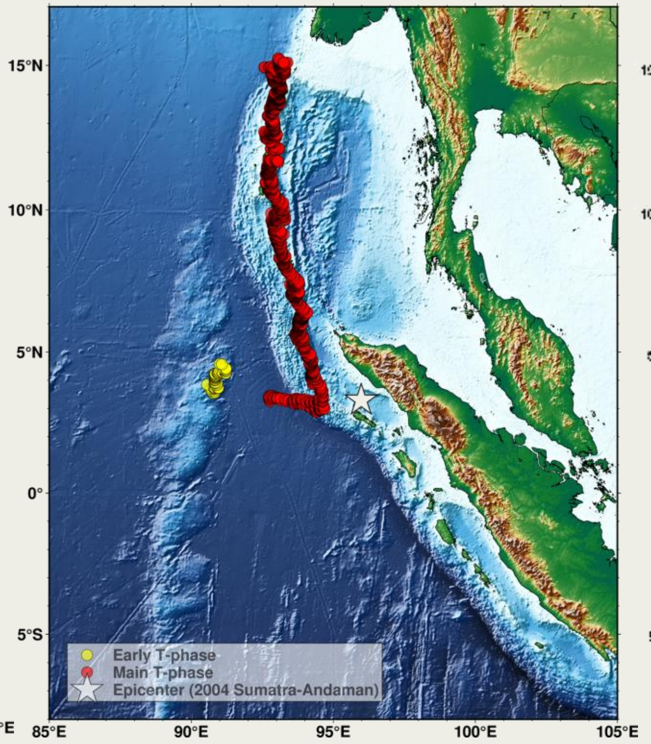
CASE 1 : SUMATERA – ANDAMAN EARTHQUAKE Mw 9.1 (Dec 26, 2004. 00:58:53 UTC)

Back Projection from

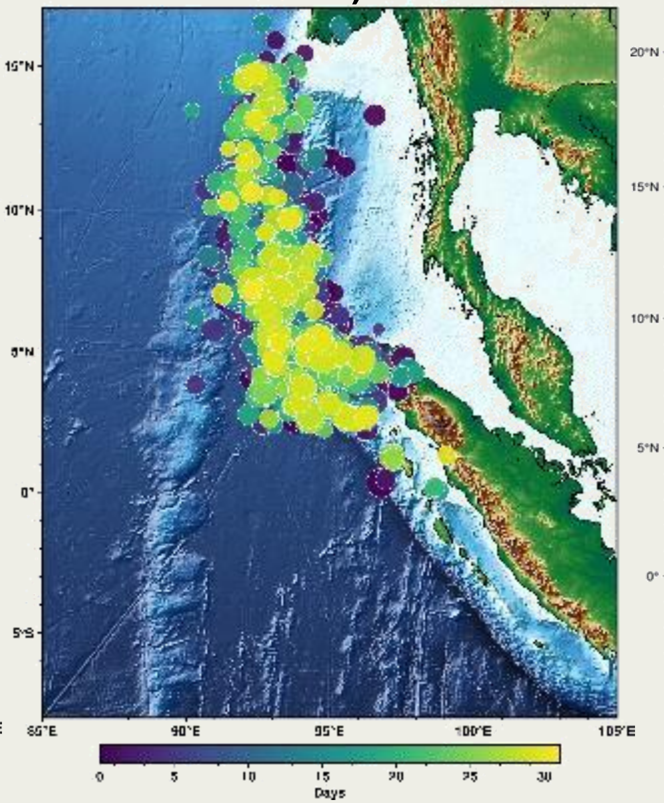
H01W



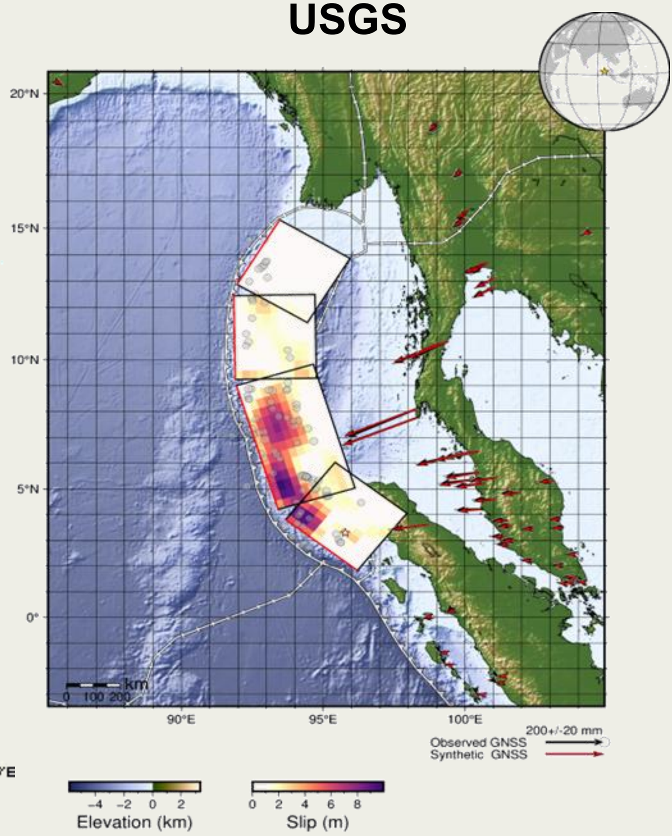
H08S



Aftershock Distribution (from ISC)



Rupture model : USGS



H01W – Earlier T phases detected along the Sunda Trench (~800 km)

H08S – Provides a good estimation of the rupture length (± 1289 km)

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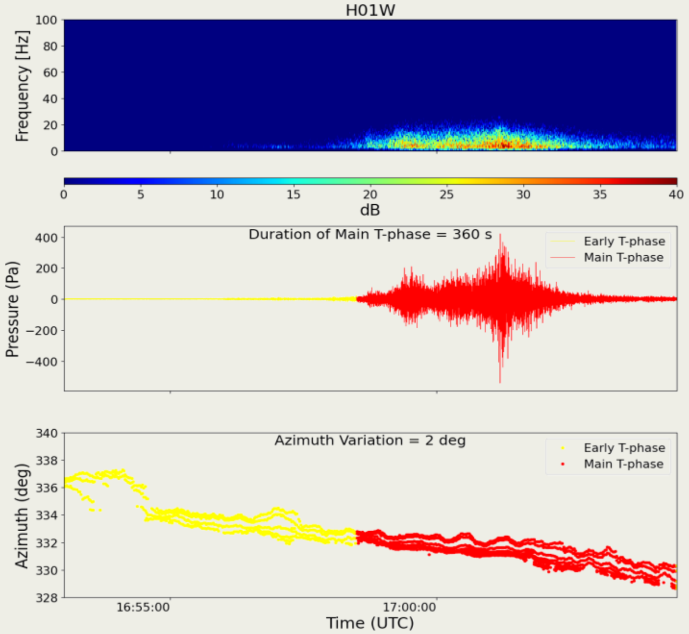
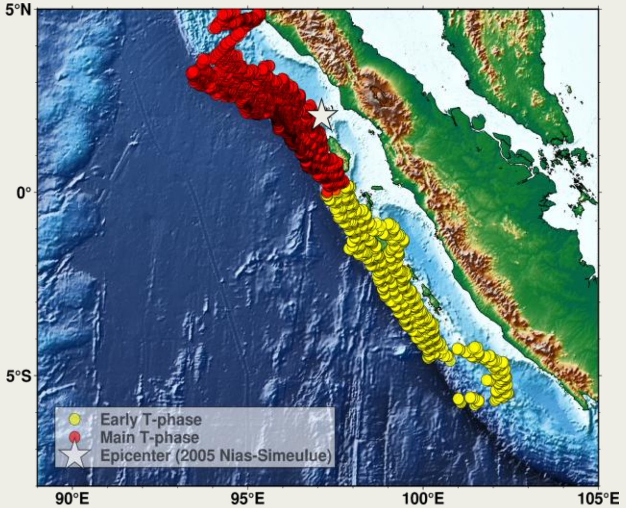
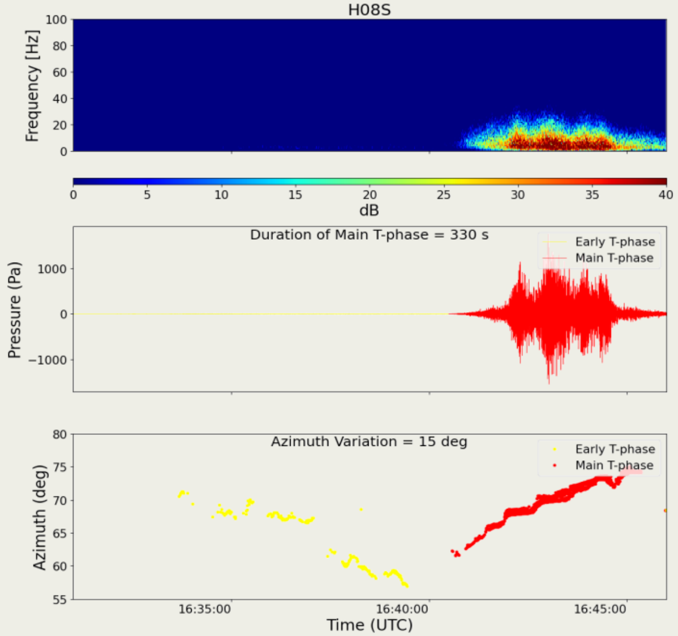
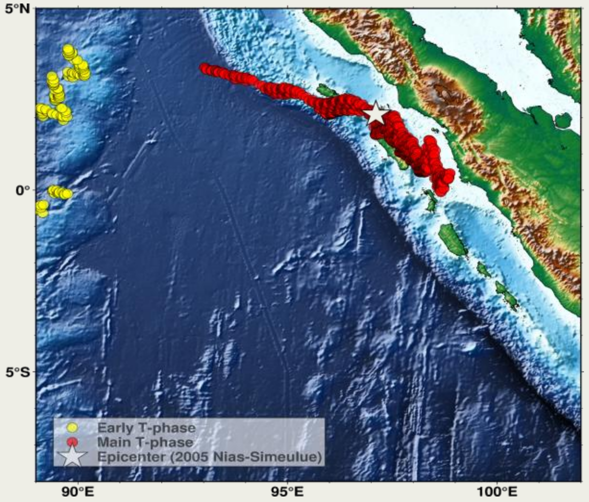
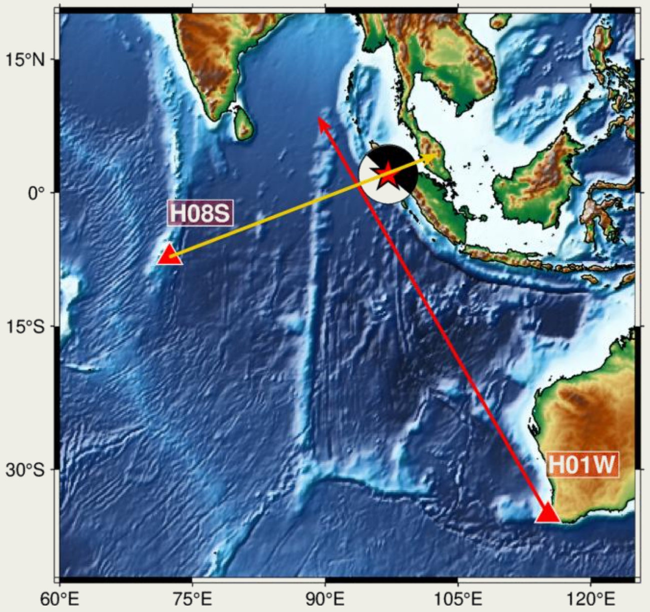
CASE 2 : NIAS – SIMEULUE EARTHQUAKE Mw 8.6 (March 28, 2005. 16:09:36 UTC)

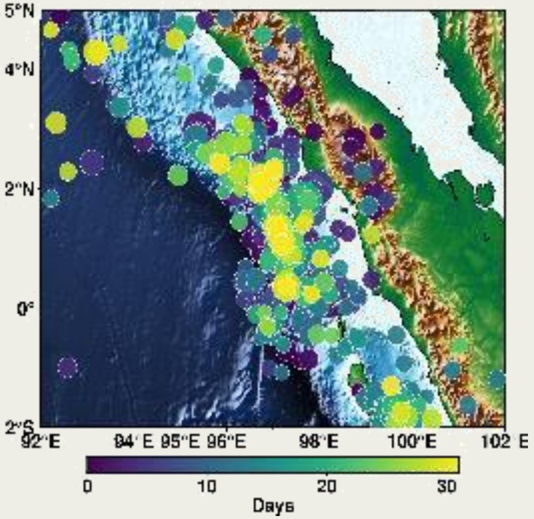




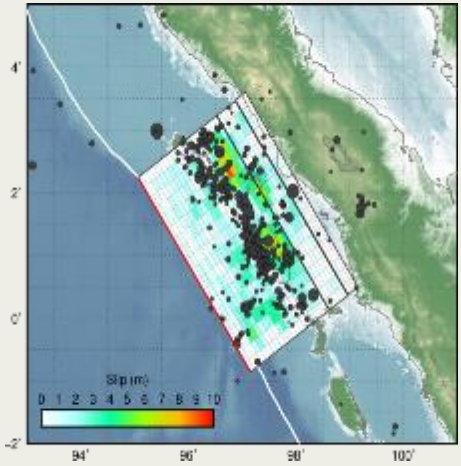








Aftershock Distribution



Source : USGS

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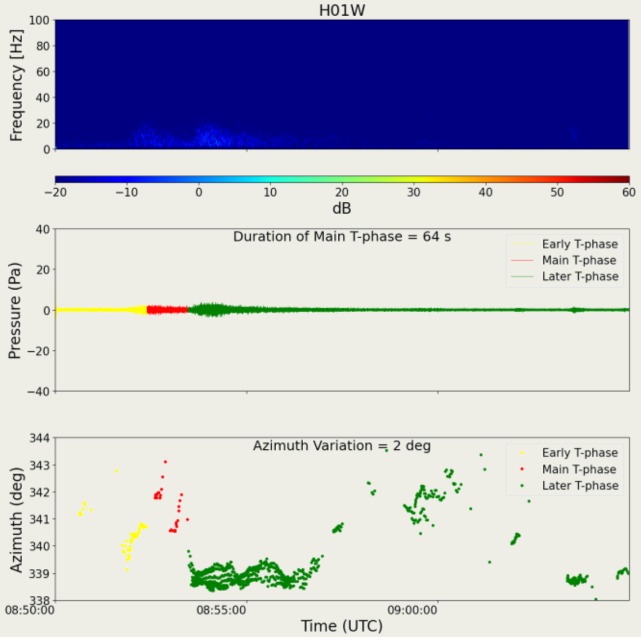
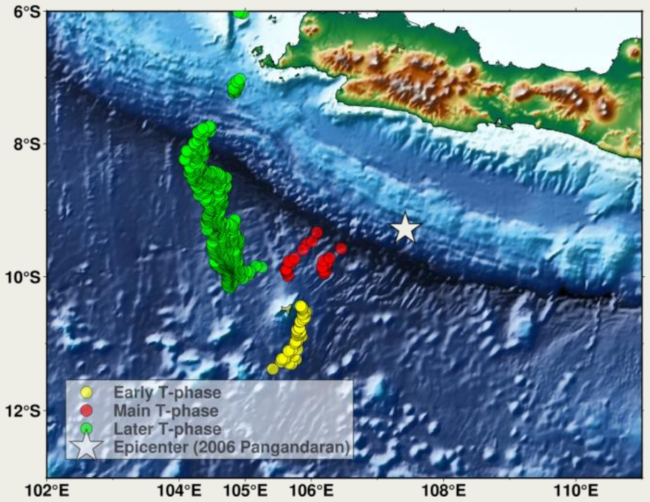
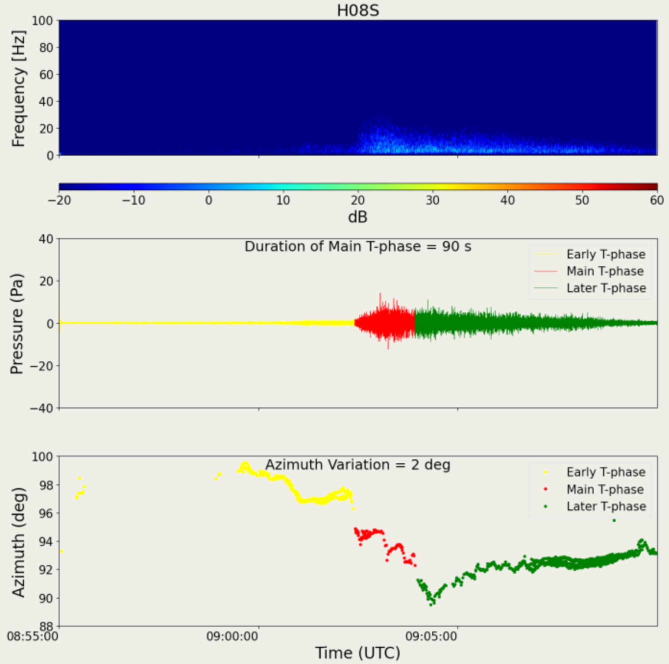
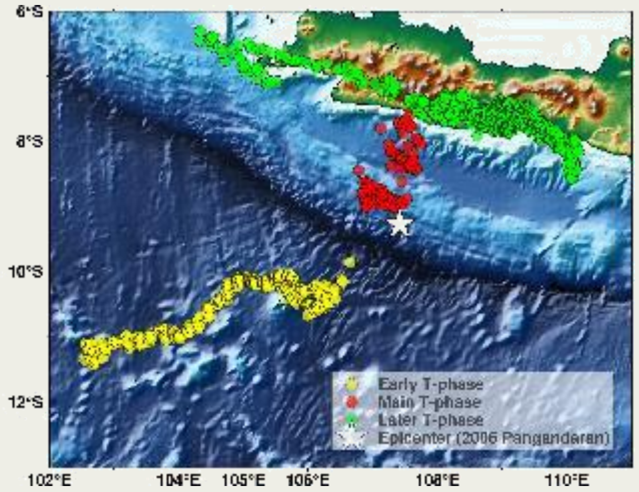
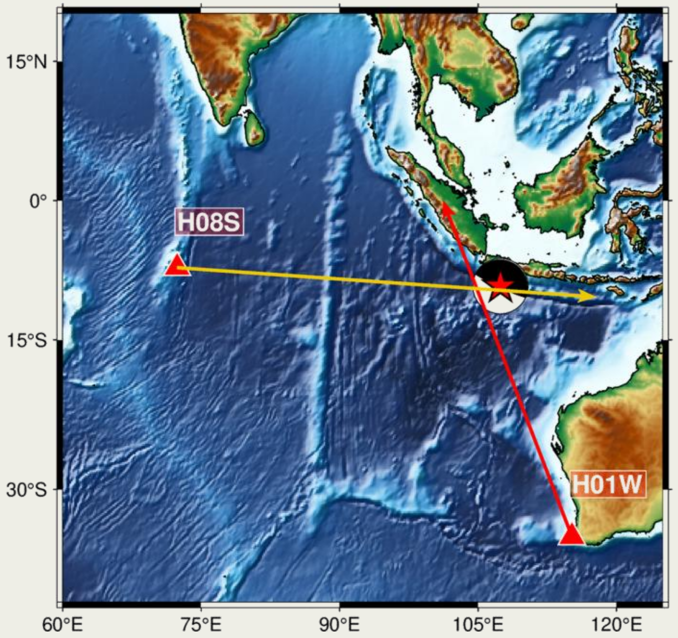
CASE 3 : PANGANDARAN EARTHQUAKE Mw 7.7 (July 17, 2006. 08:19:26 UTC)

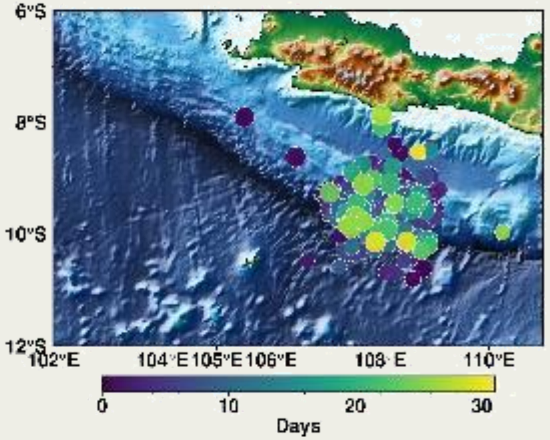




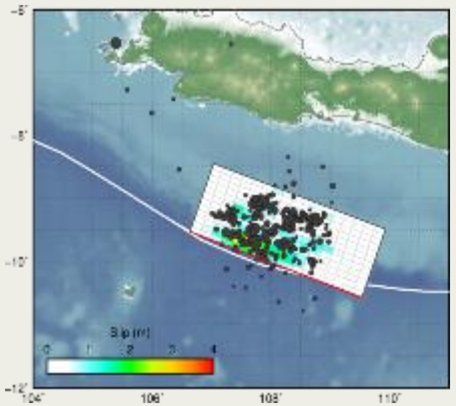








Aftershock Distribution



Source : USGS

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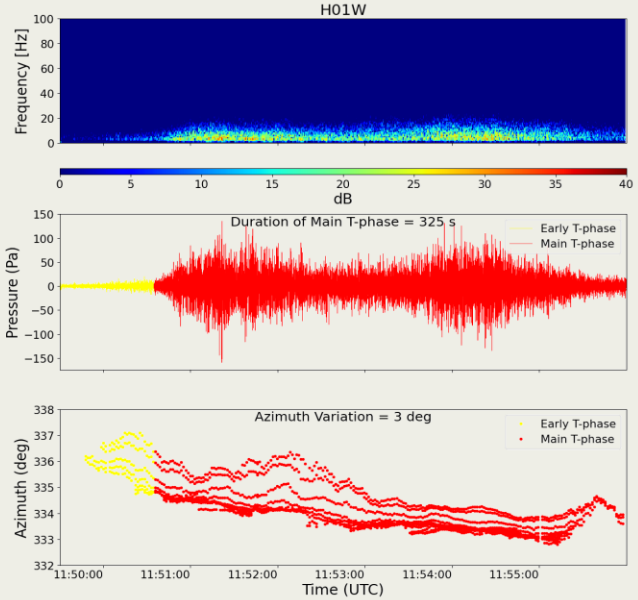
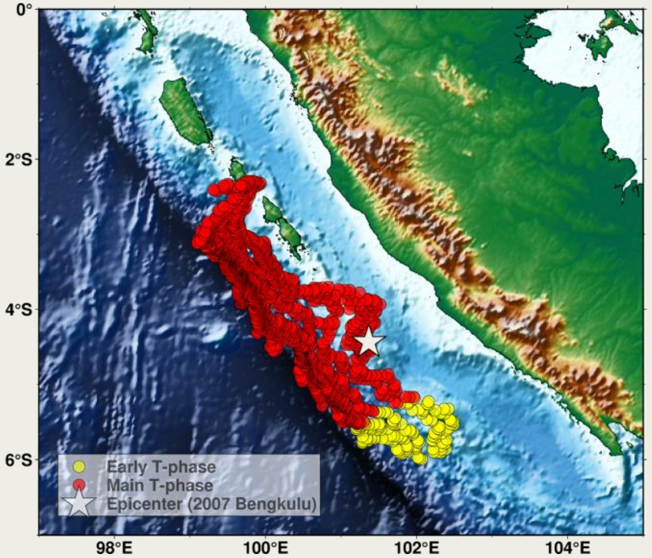
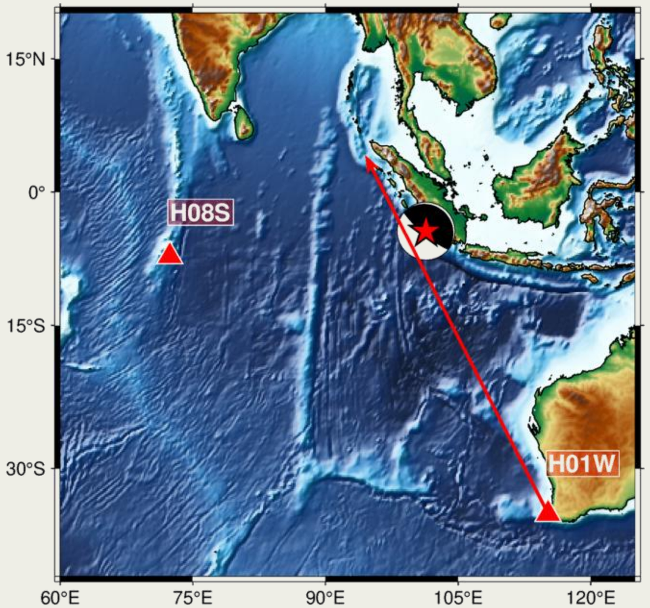
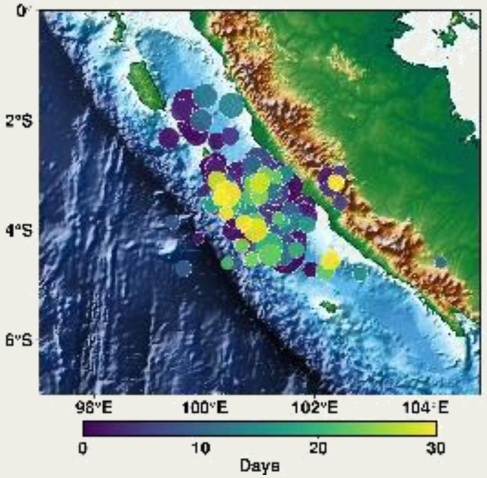
CASE 4 : BENGKULU EARTHQUAKE Mw 8.4 (Sep 12, 2007. 11:10:26 UTC))



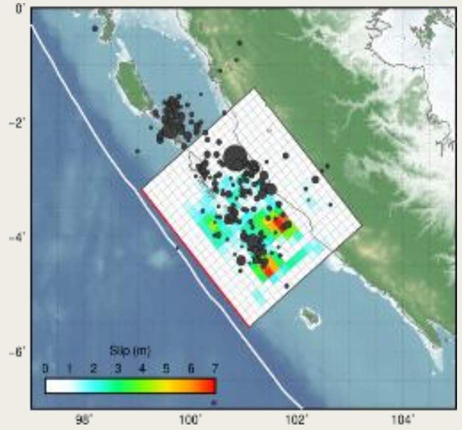


NO DATA AT HA08S FOR BENGKULU EQ





Aftershock Distribution



Source : USGS

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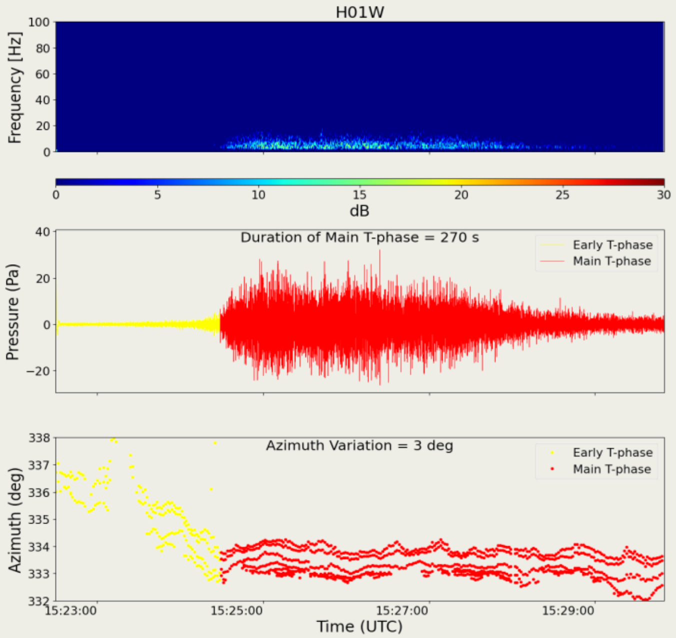
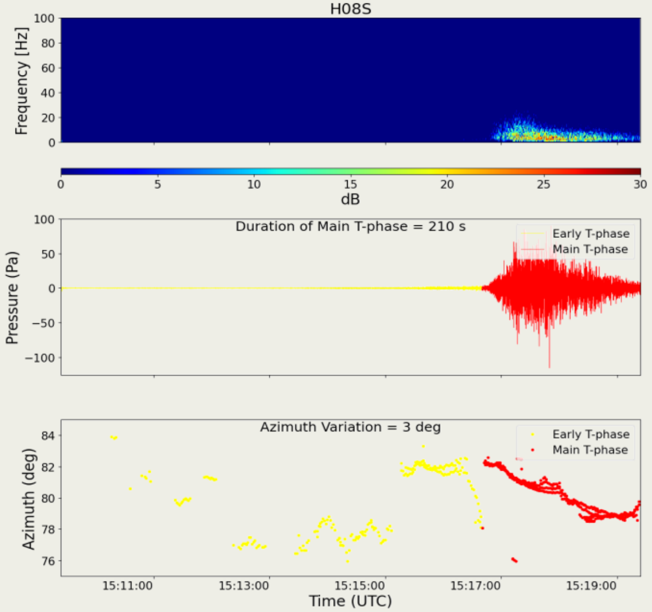
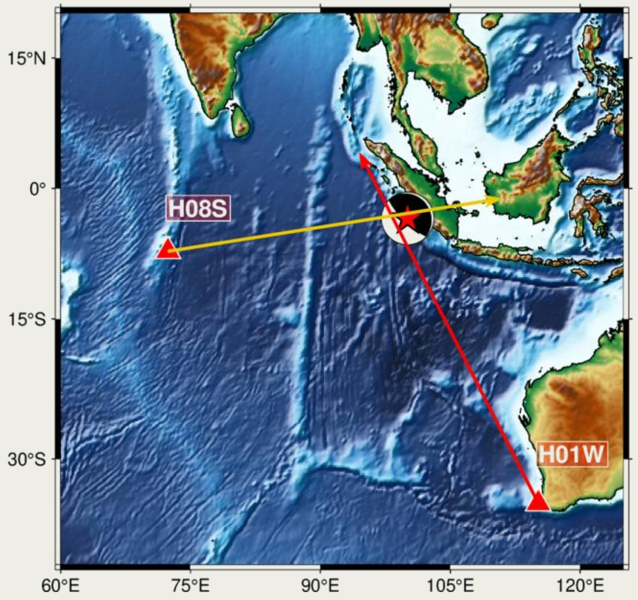
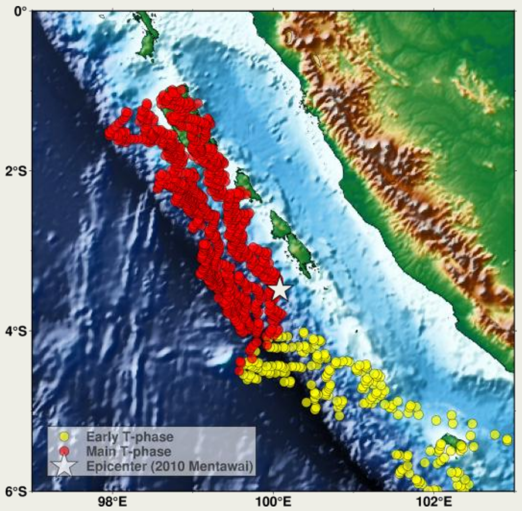
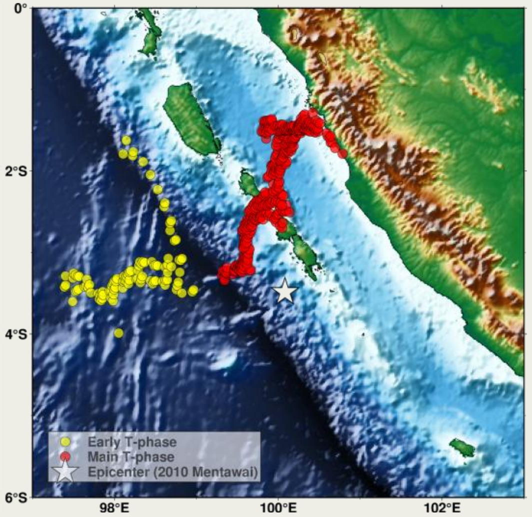
CASE 5 : MENTAWAI EARTHQUAKE Mw 7.8 (Oct 25, 2010. 14:42:22 UTC)

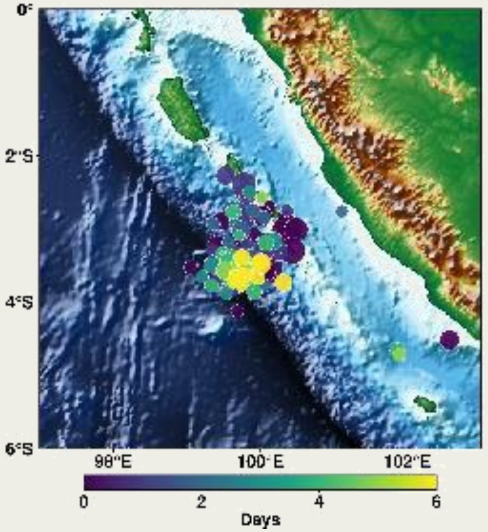




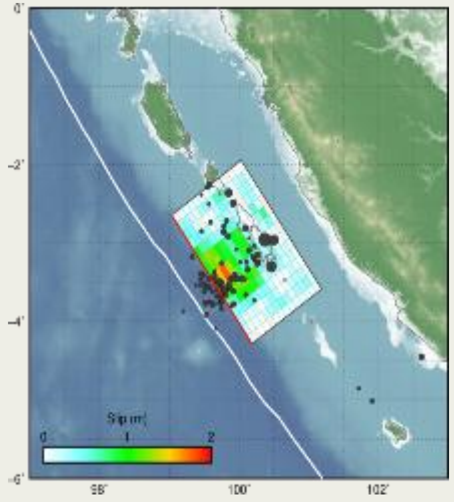








Aftershock Distribution



Source : USGS

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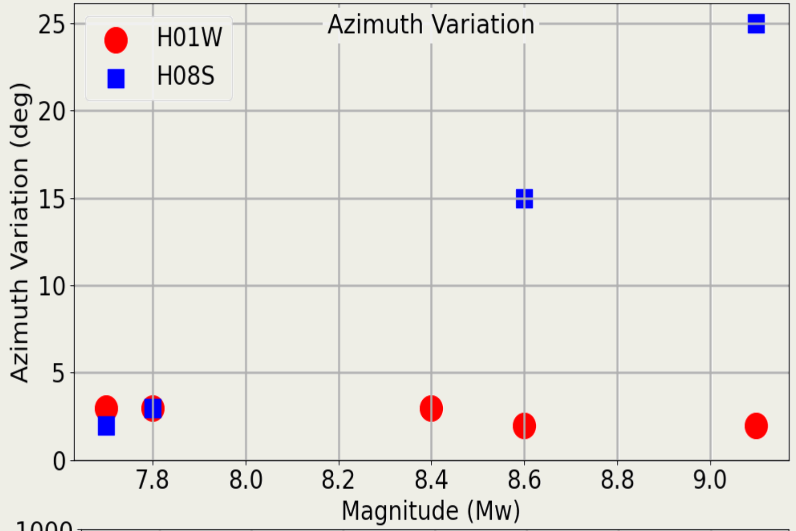
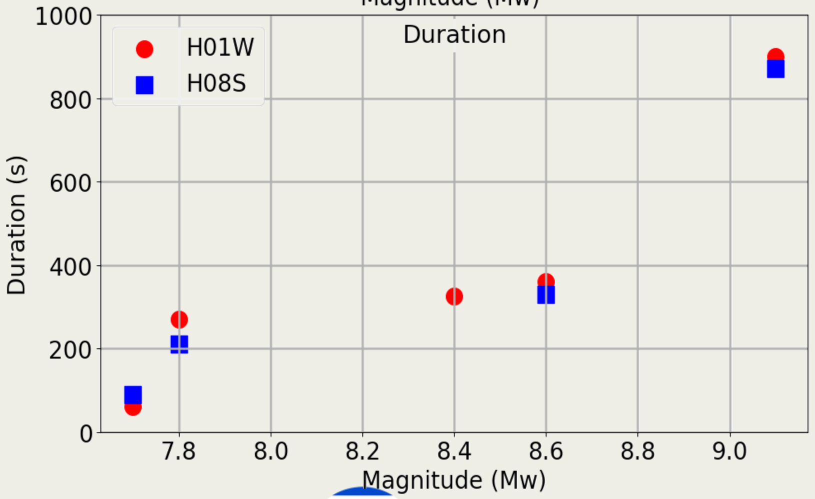
MAIN T-Phase: AZIMUTH VARIATION (°) AND SIGNAL DURATION (s)

No	Tsunamigenic Earthquake	Magnitude (Mw)	Azimuth Variation (°) and Signal Duration (s)	
			H01W	H08S
1	Sumatra-Andaman	9.1	± 2° 900s	± 25° 871s
2	Nias-Simeulue	8.6	± 2° 360s	± 15° 330s
3	Pangandaran	7.7	± 3° 64s	± 2° 90s
4	Bengkulu	8.4	± 3° 325s	-
5	Mentawai	7.8	± 3° 270s	± 3° 210s





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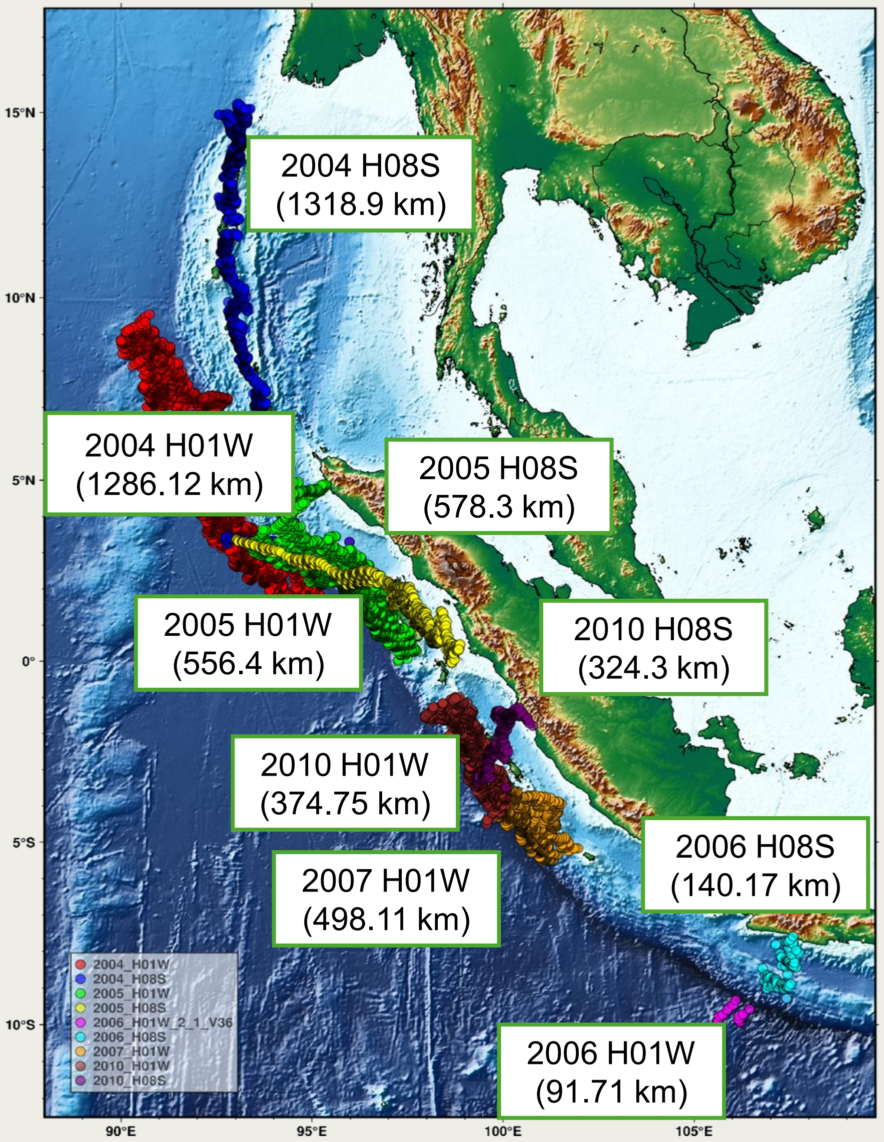
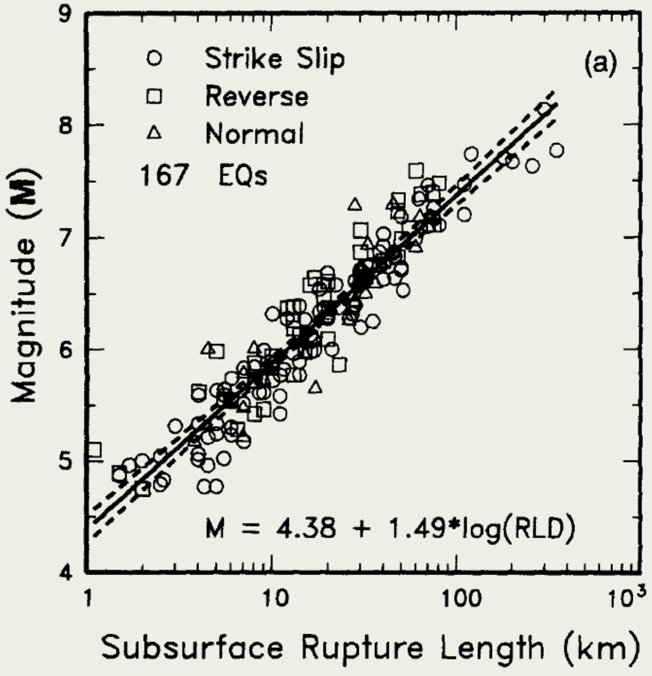
Rupture Length Estimation





Wells & Coppersmith (1994)

No	Tsunamigenic Earthquake	Rupture Length Evaluation (Km)		
		H01W	H08S	Wells & Coppersmith (1994)
1	Sumatra-Andaman (Mw 9.1)	1286.1	1318.9	1258.9
2	Nias-Simeulue (Mw 8.6)	556.4	578.3	630.9
3	Pangandaran (Mw 7.7)	91.7	140.2	158
4	Bengkulu (Mw 8.4)	498.1	-	501
5	Mentawai (Mw 7.8)	374.8	324.3	199

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RUPTURE LENGTH EVALUATION

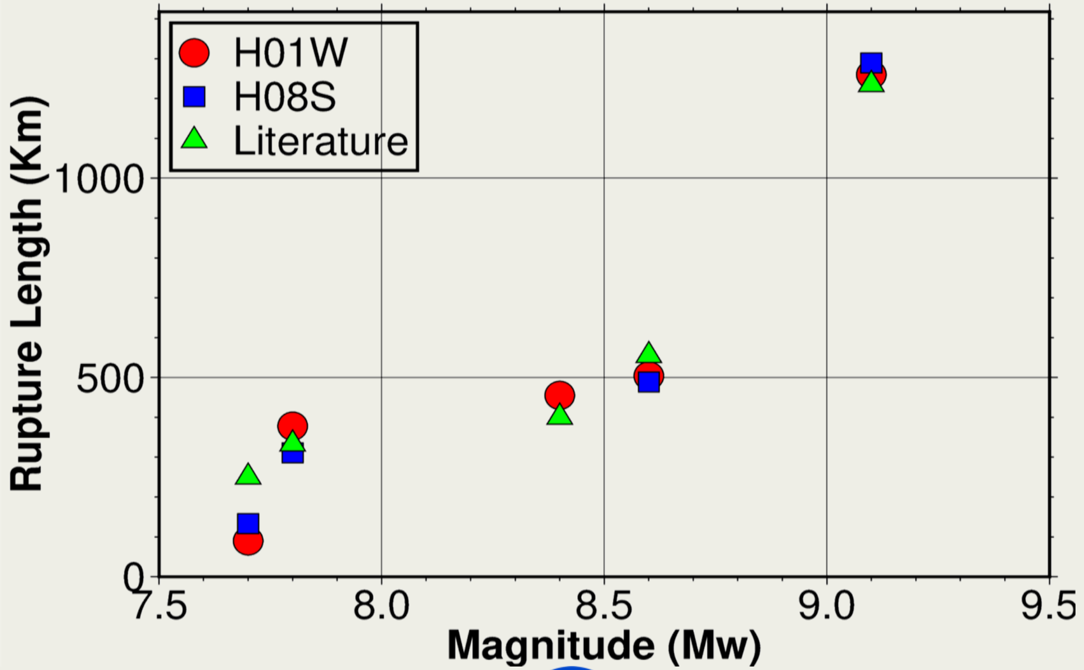
No	Tsunamigenic Earthquake	Magnitude (Mw)	Rupture Length Evaluation (Km)				
			Google Earth Estimation		Calculation (RL= DT x Alfa)		Literature
			H01W	H08S	H01W	H08S	
1	Sumatra-Andaman	9.1	1286.1	1318.9	1260	1289.1	1235 (Guilbert et al., 2005)
2	Nias-Simeulue	8.6	556.4	578.3	504	488.4	555 (USGS)
3	Pangandaran	7.7	91.7	140.2	89.6	133.2	250 (Fujii dan Satake, 2006)
4	Bengkulu	8.4	498.1	-	455	-	400 (Gusman et al., 2010)
5	Mentawai	7.8	374.8	324.3	378	310.8	333 (USGS)

1. Guilbert et al., 2005. Use of hydroacoustic and seismic arrays to observe rupture propagation and source extent of the Mw 9.0 Sumatra earthquake. Geophysical Research Letters
2. USGS
3. Fujii dan Satake., 2006. Source of the July 2006 West Java Tsunami estimated from tide gauge records. Geophysical Research Letters, Vol. 33.L 24317
4. Gusman et al., 2010. Slip distribution of the 2007 Bengkulu earthquake inferred from tsunami waveforms and InSAR data. Journal of Geophysical Research
5. USGS

Proposed rule of thumb for Rupture Length (RL) estimation:

RL=DT x Alpha

Where: DT is the Duration of Main T-phase (s) and ALPHA is a fitted coefficient – 1.40 for H01W and 1.48 for H08S



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CONCLUSIONS

- IMS data from hydrophones in the Indian Ocean can provide precise and reliable back-azimuths for a fast estimation of epicentres and rupture length for earthquakes in Indonesia (Sunda-Java Trench).

- Earlier and later T-phases can be observed. Rupture length can be estimated from the duration of the main T-phases. Rule of thumb is proposed.

- For the main T-phase signals, back azimuths variations from 1 to 25 deg and duration from 60 to 900 s for the 5 earthquakes studied.

- The length of the rupture increases with the earthquake magnitude leading to an increase in the duration of the main T-phases recorded.

Thank you

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