Geophysical implications

of the

December 26th Earthquake

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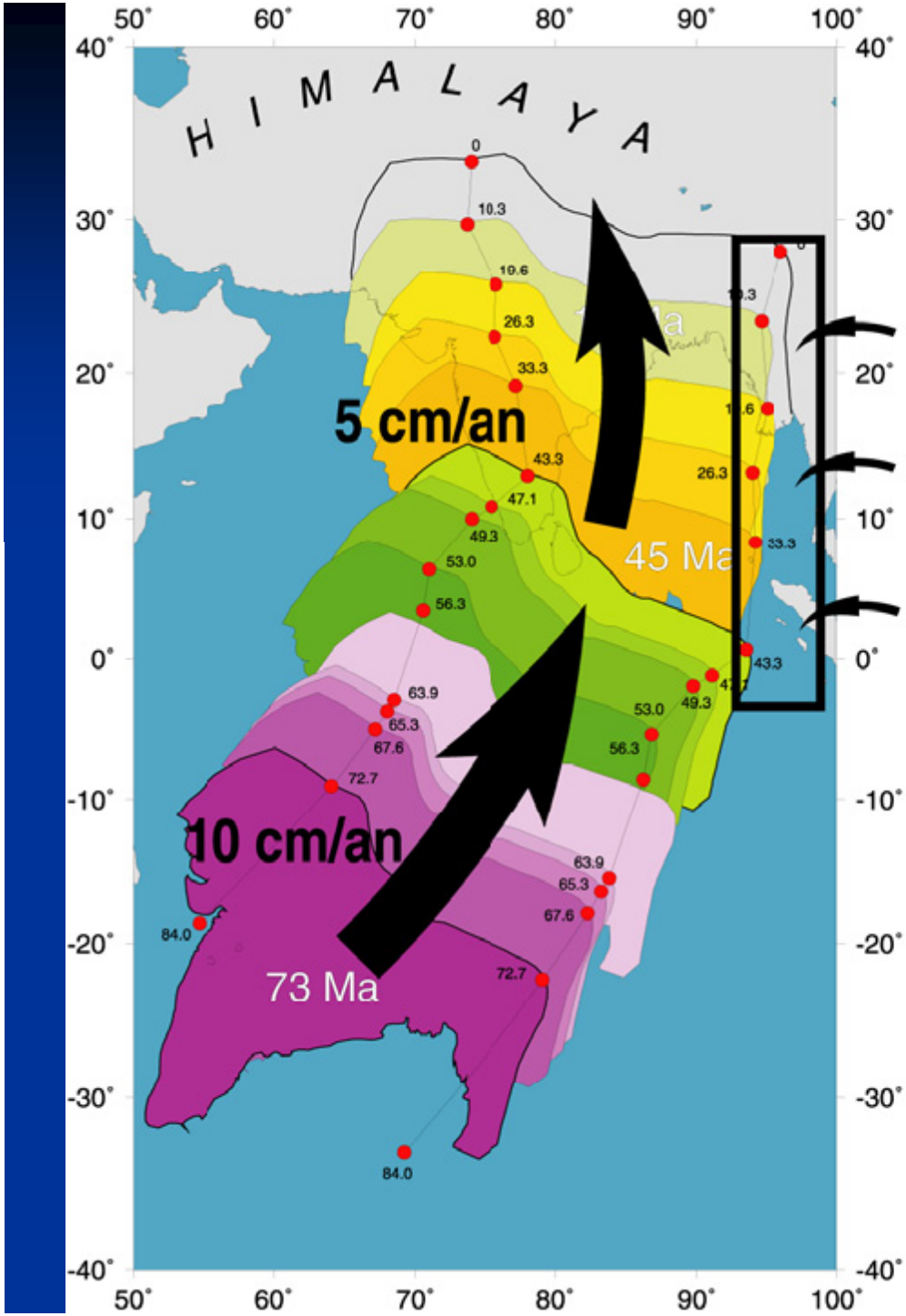
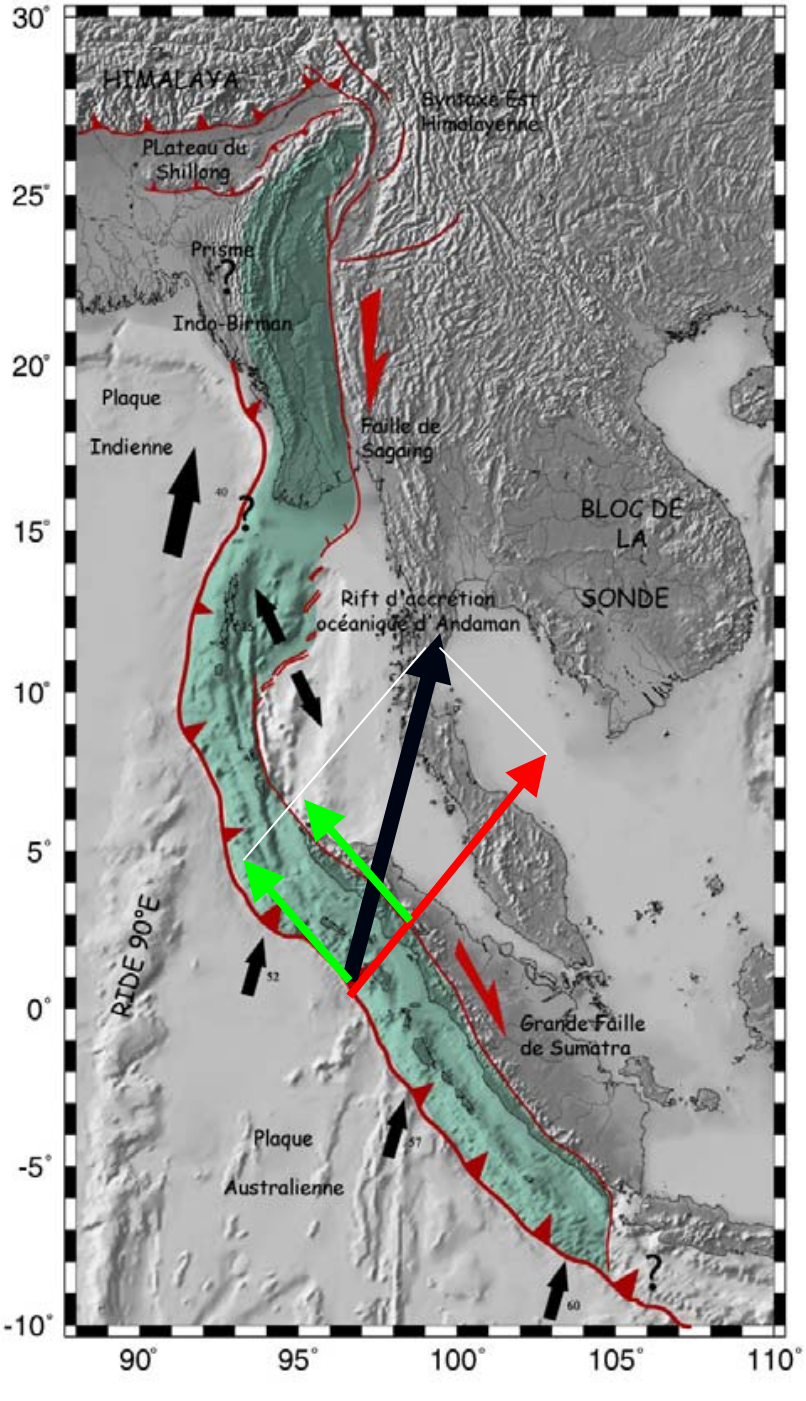
SEAMERGES : http://www.deos.tudelft.nl/seamerges

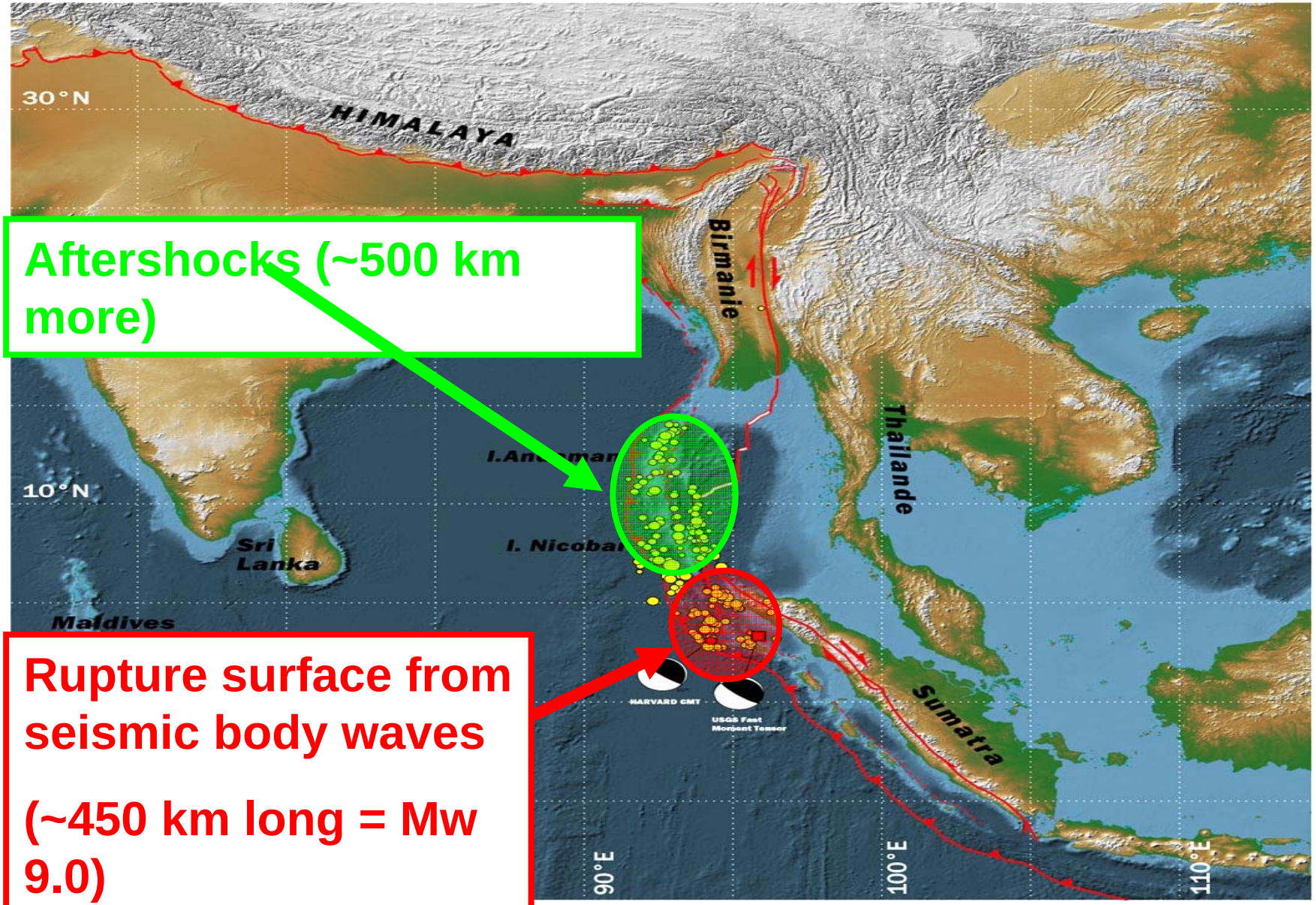
EUROPEAID CO-OPERATION OFFICE

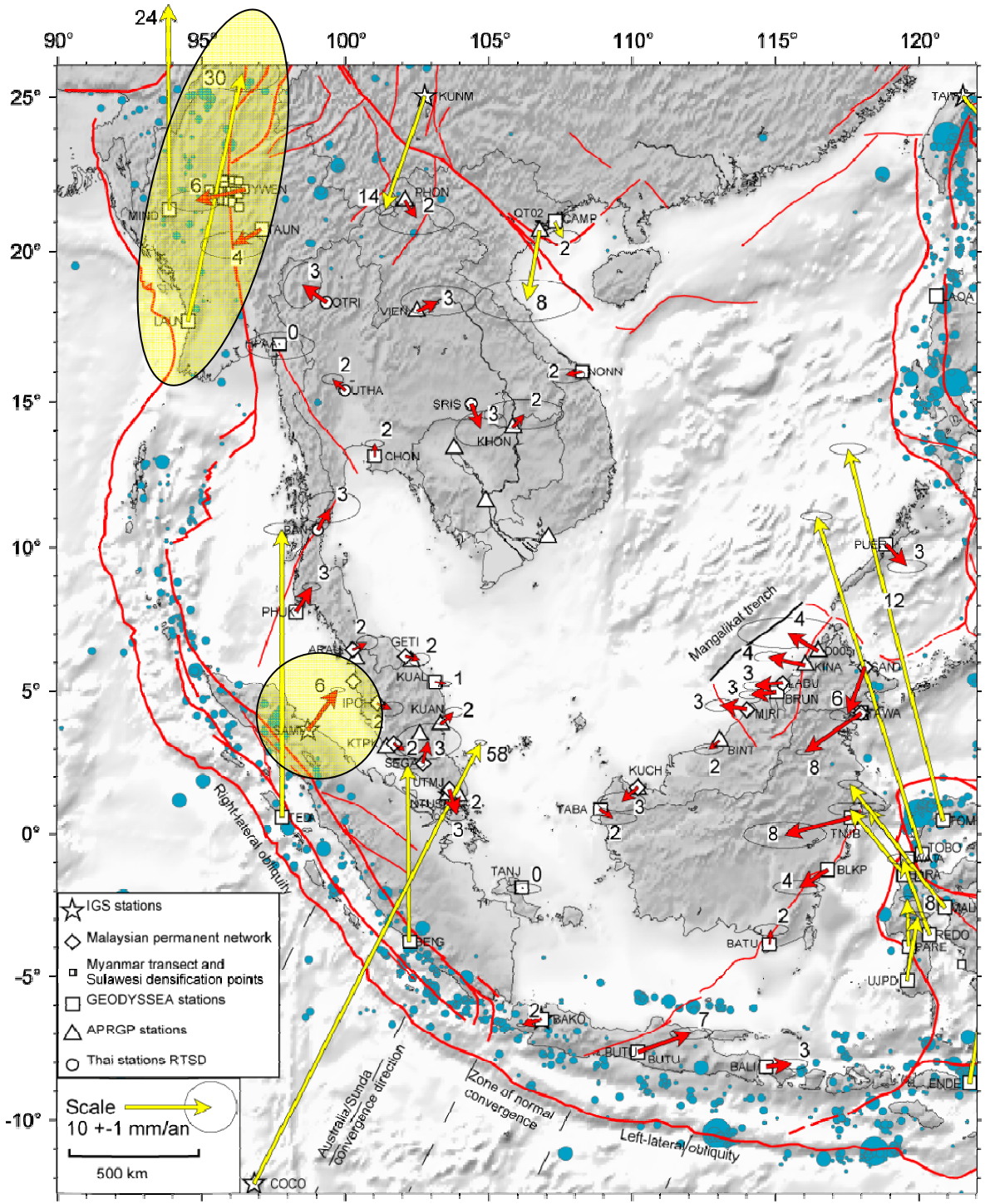
AUNP ASEAN-EU UNIVERSITY NETWORK PROGRAMME

asean


HIMALAYA
5 cm/an
45 Ma
10 cm/an
73 Ma
0
10.3
19.6
26.3
33.3
43.3
47.1
49.3
53.0
56.3
63.9
65.3
67.6
72.7
84.0


HIMALAYA
Syntaxe Est Himalayenne
PLateau du Shillong
Prisme
Indo-Birman
Plaque Indienne
Faille de Sagaing
BLOC DE LA SONDE
Rift d'accrétion océanique d'Andaman
RIDE 90°E
Grande Faille de Sumatra
Plaque Australienne


Aftershocks (~500 km more)
Rupture surface from seismic body waves
(~450 km long = Mw 9.0)
30°N
10°N
90°E
100°E
110°E
HIMALAYA
Birmanie
Thailande
Sumatra
Sri Lanka
Maldives
I. Nicobar
HARVARD CMT
USGS Fast Moment Tensor

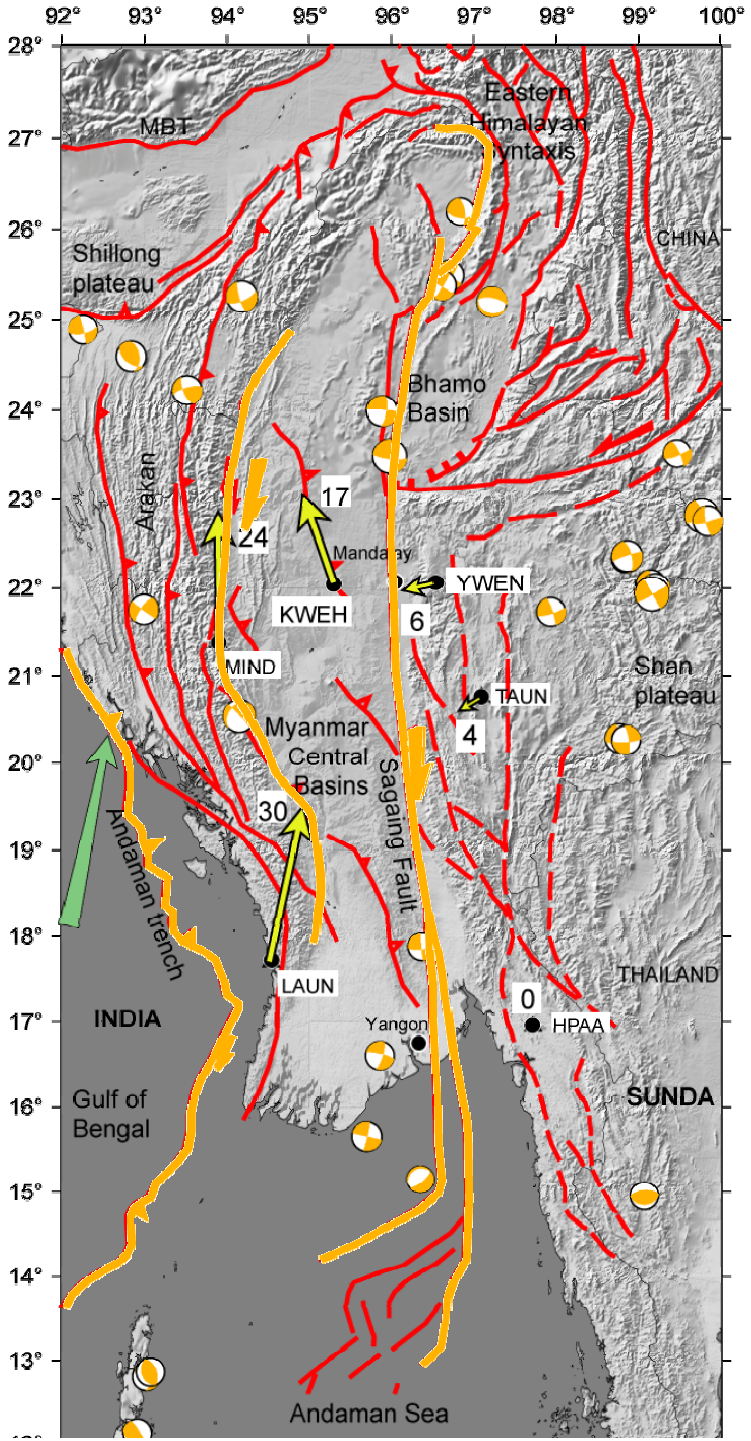


An Earthquake there was not unexpected

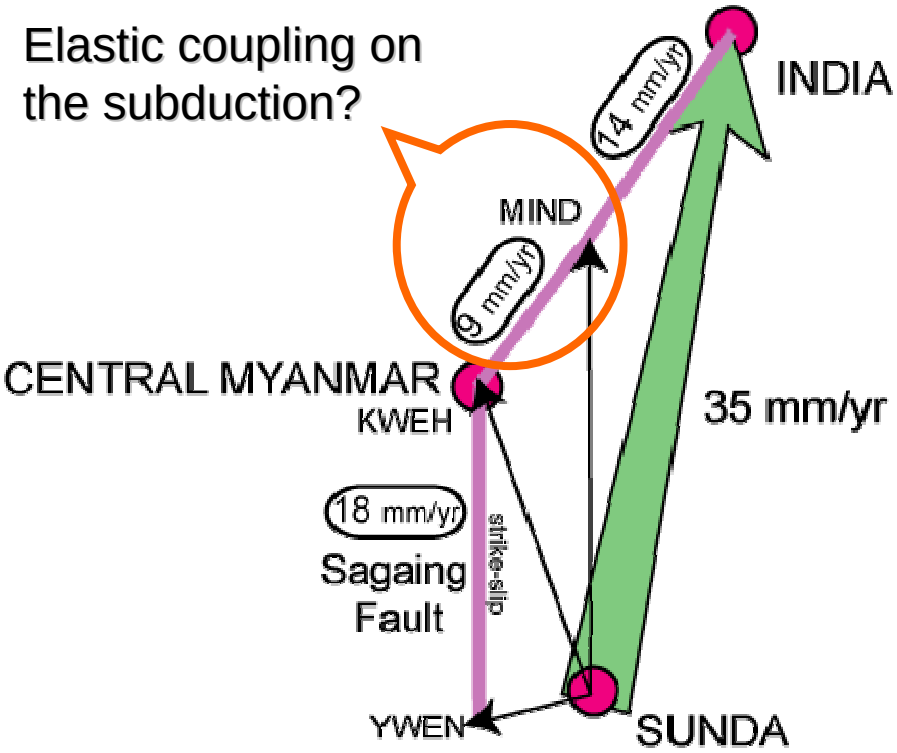
GEODYSSEA / SEAMERGES

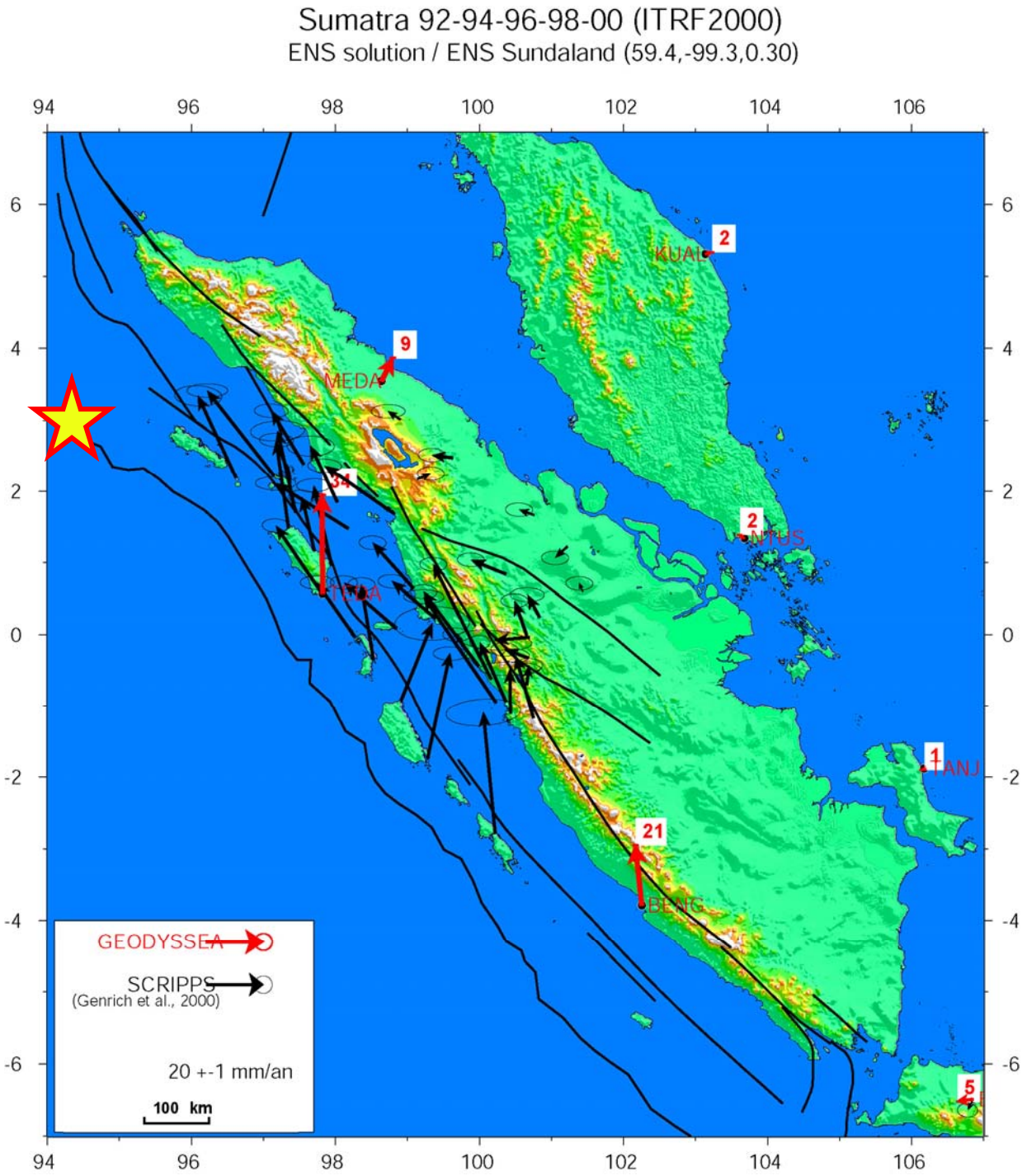
GPS on Sundaland (~80 sites)

Accommodation in Myanmar of India-Sunda motion



Elastic coupling on the subduction?





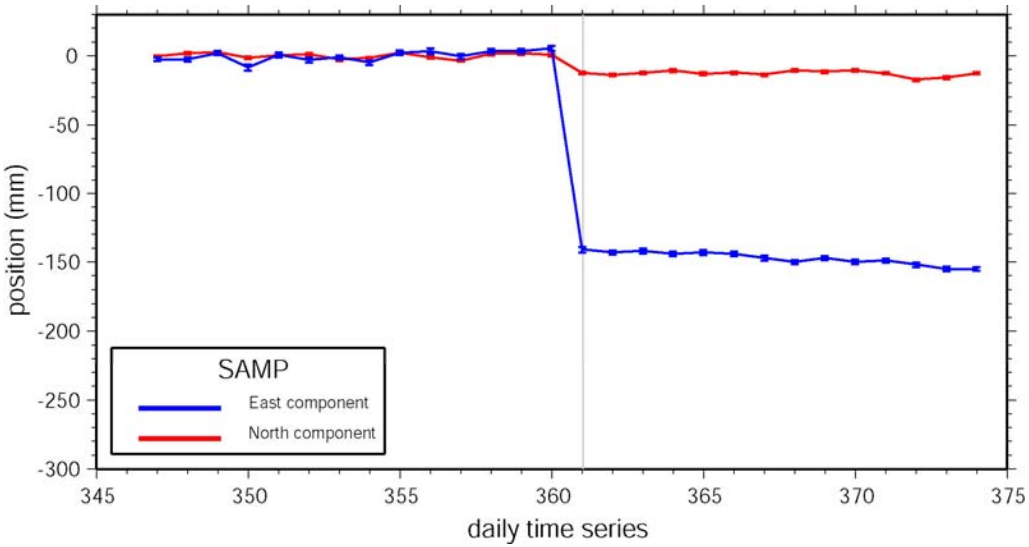
SCRIPPS / RPI

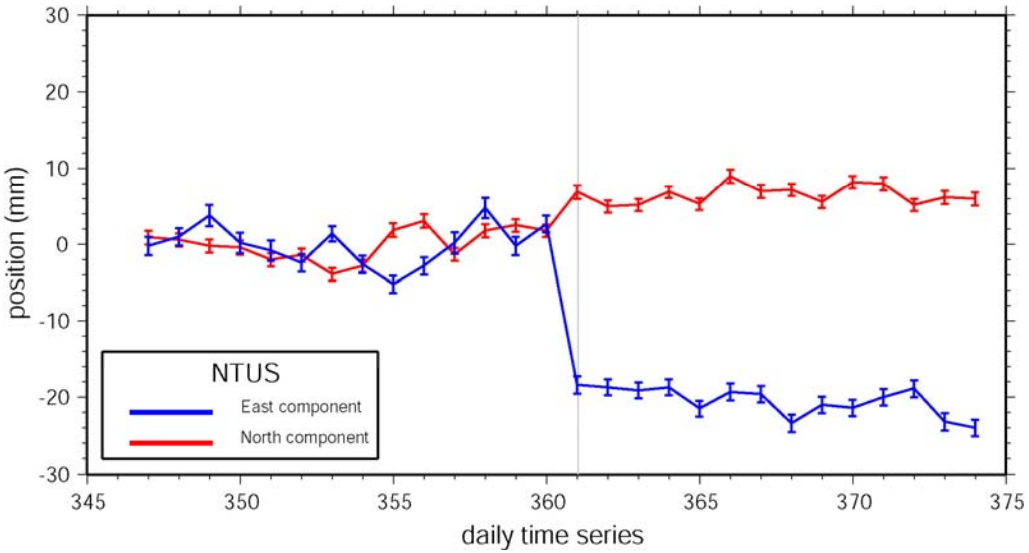
GPS on Sumatra
(~50 sites)

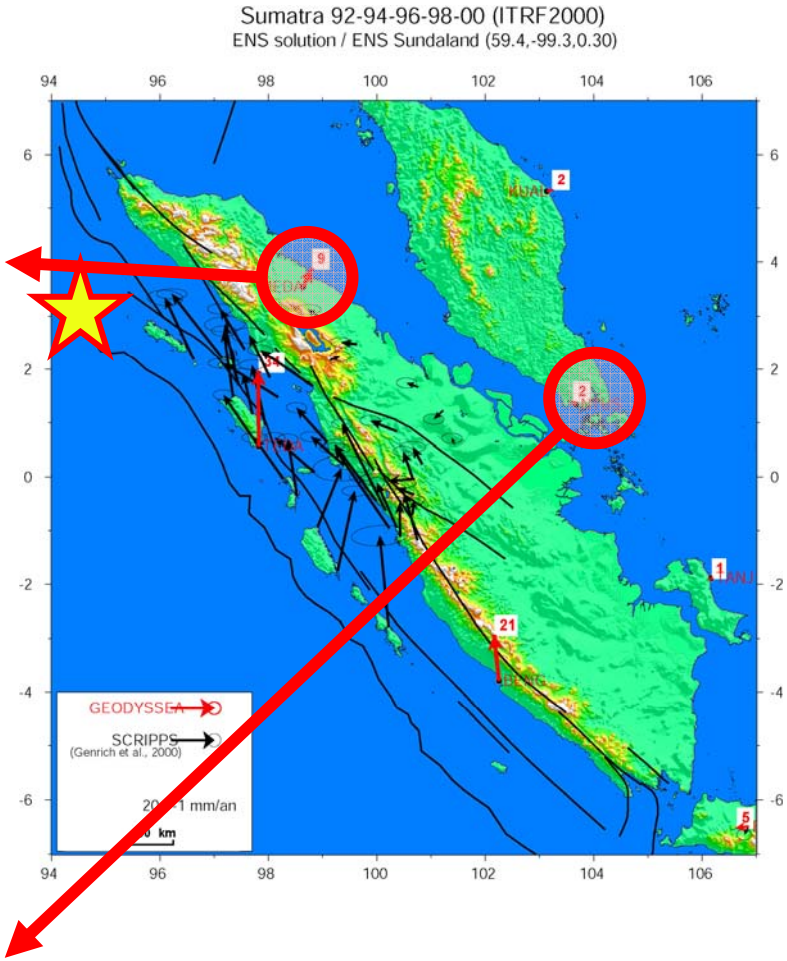
Comparison with US measurements:

-Y. Bock, SCRIPPS

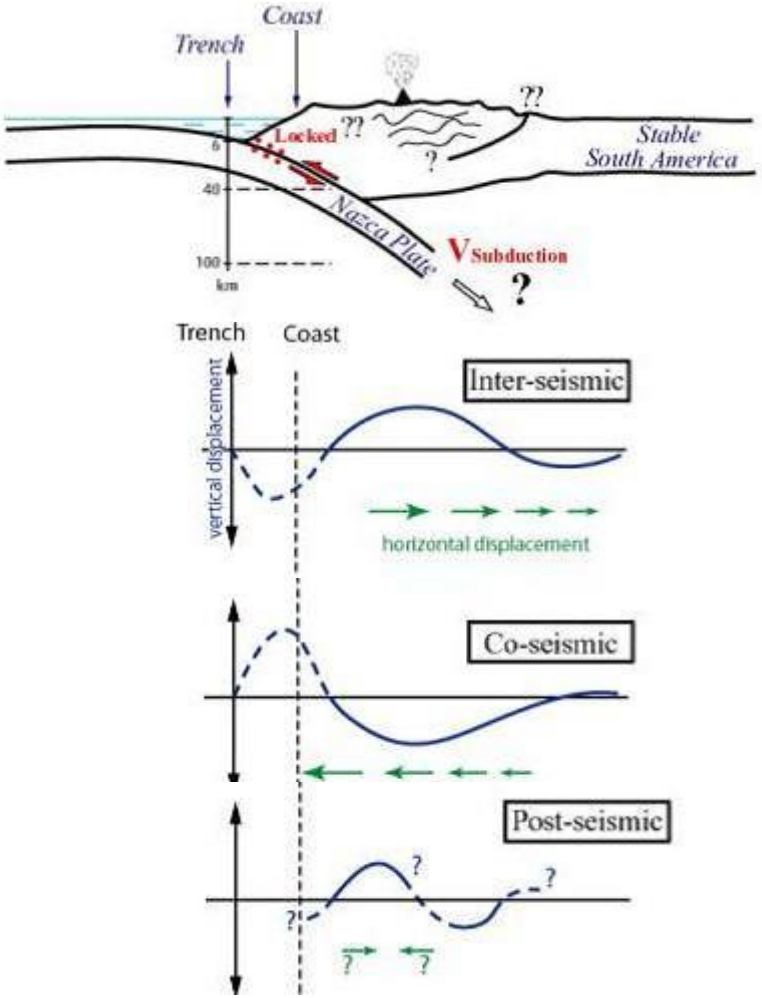
- R. McCaffrey, RPI

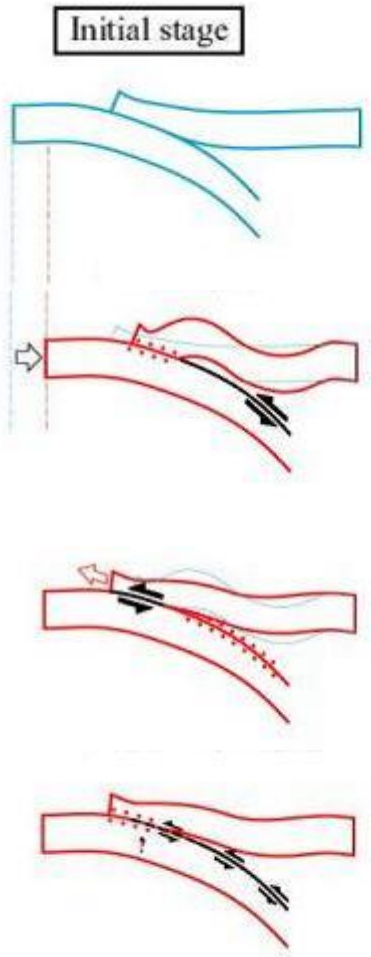

position (mm)
daily time series
SAMP
East component
North component


position (mm)
daily time series
NTUS
East component
North component


Sumatra 92-94-96-98-00 (ITRF2000)
ENS solution / ENS Sundaland (59.4,-99.3,0.30)
GEODYSSEA
SCRIPPS
(Genrich et al., 2000)

Accumulation of elastic deformation

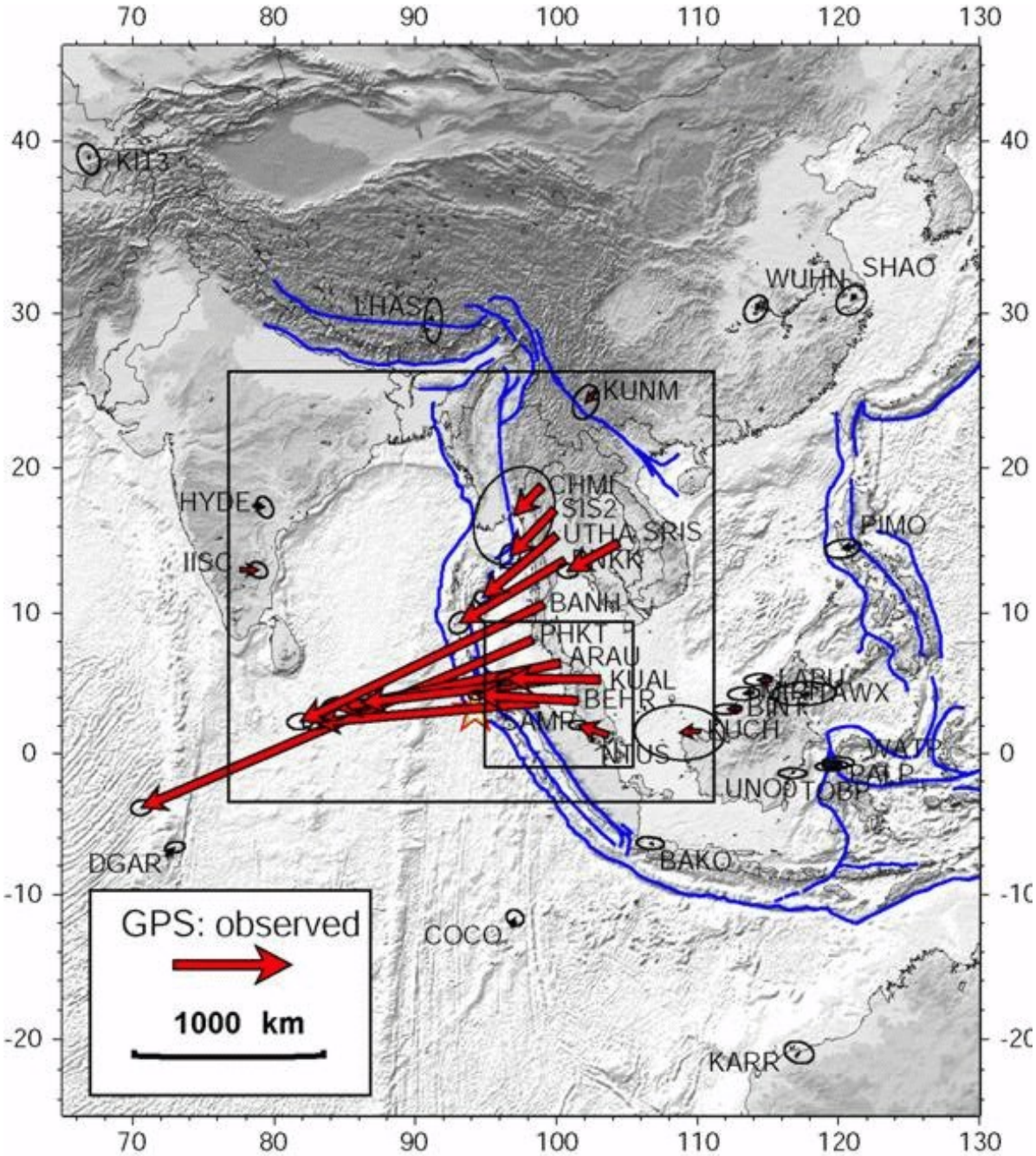




100s of years

Seconds or minutes

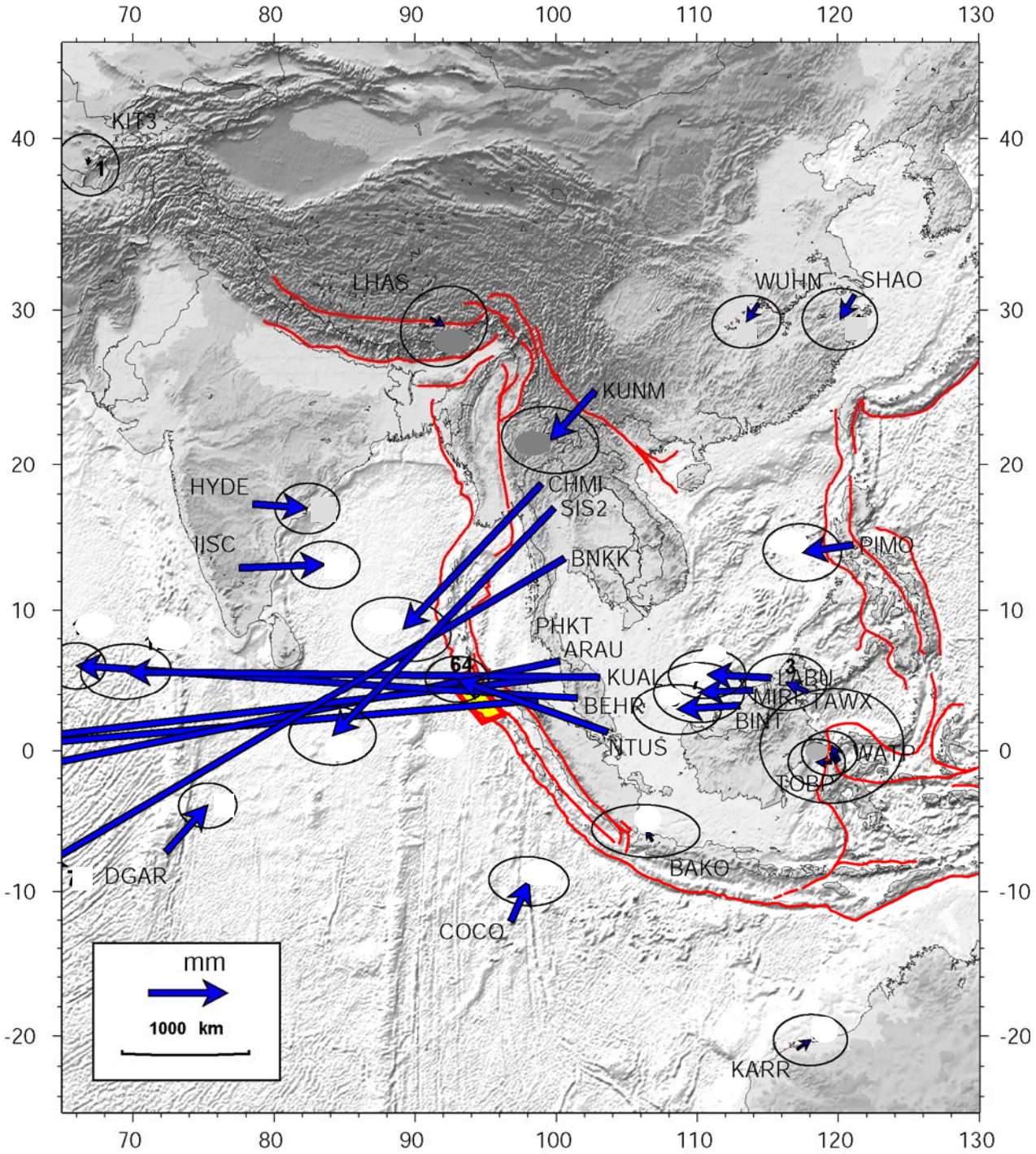
Months or years



Co-seismic displacements measured by GPS

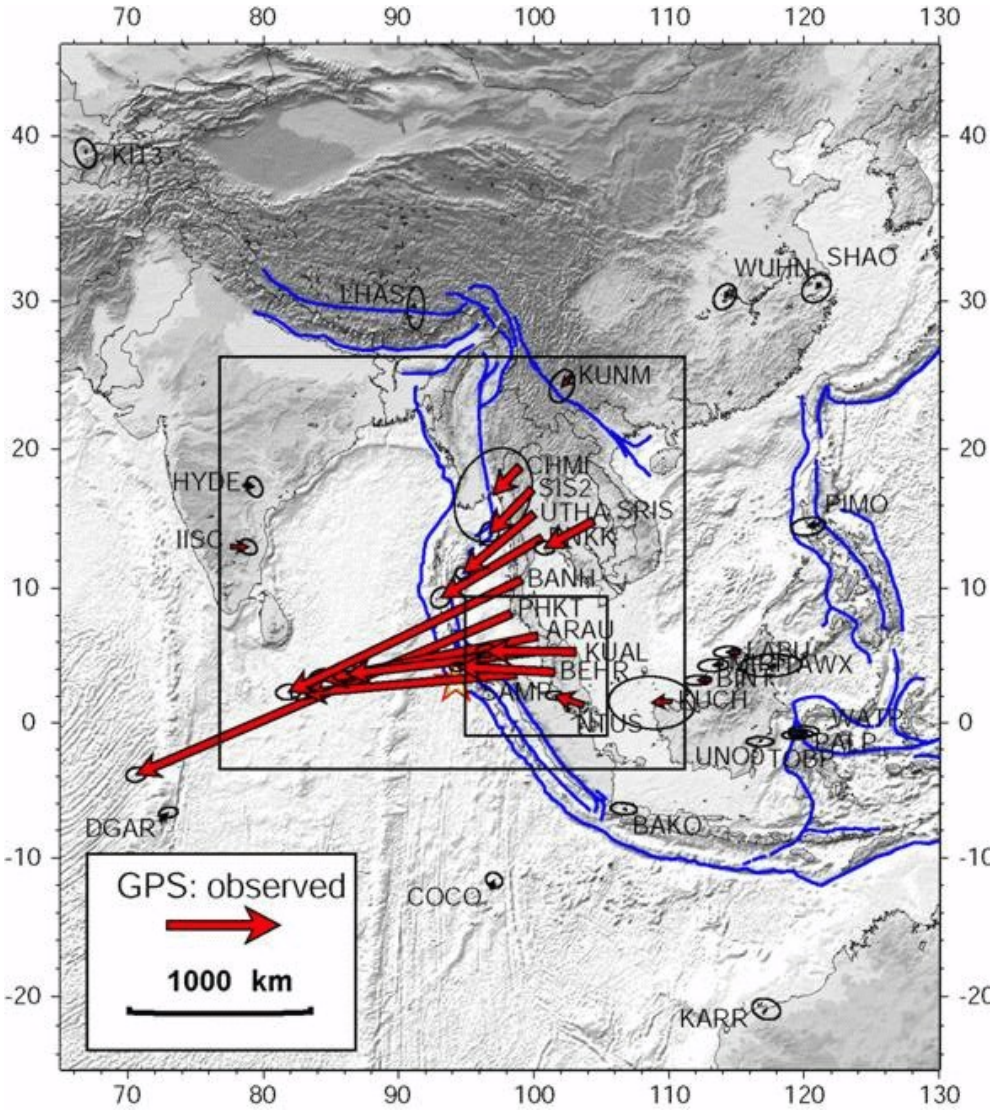
(continuous stations in Malaysia, Thailand, Indonesia and India which were operational on December 26th)

Motions up to 30cm - 500 km away from epicenter

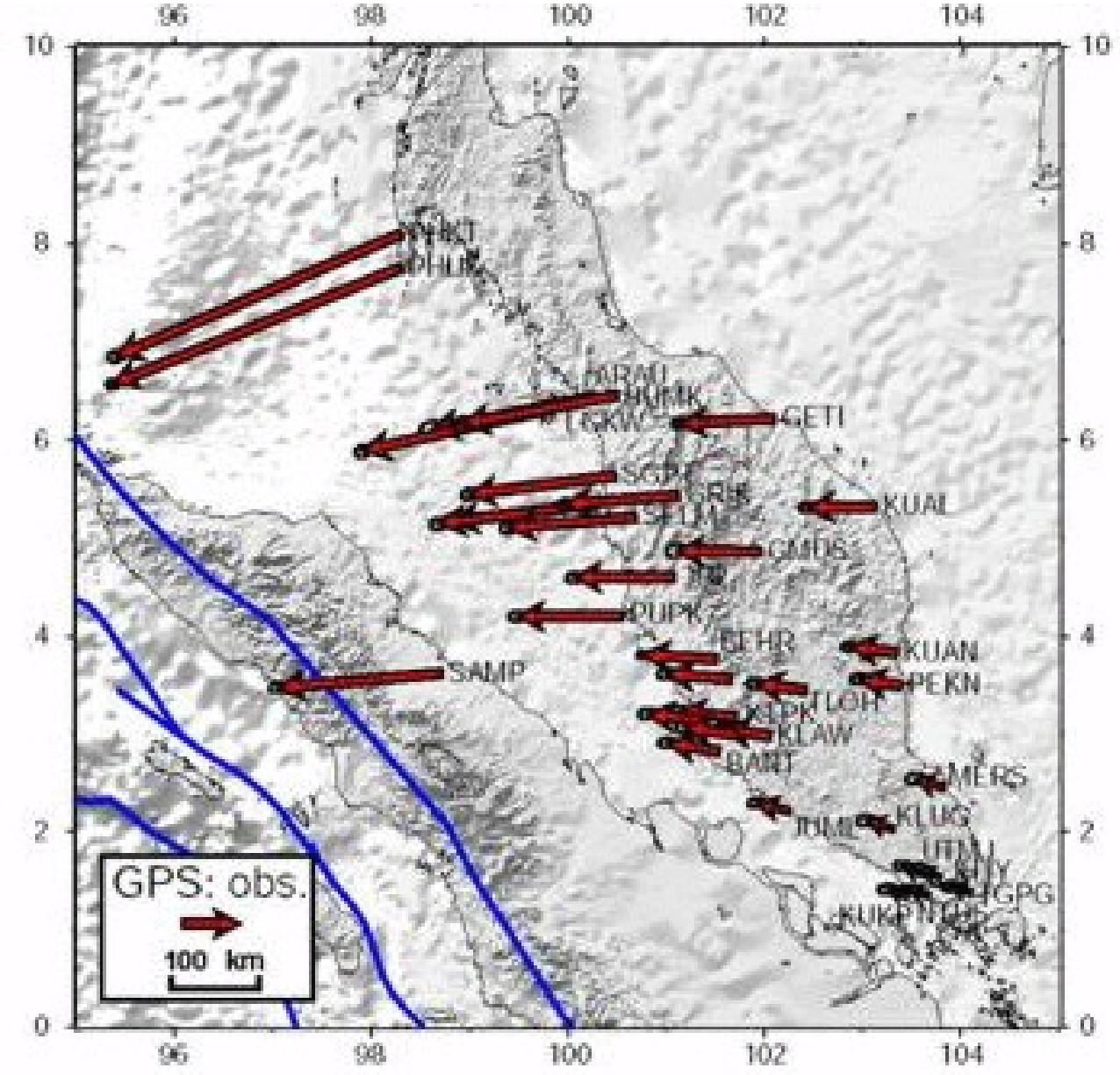


And detectable motions (~1-3 mm) 3000 km away from epicenter !

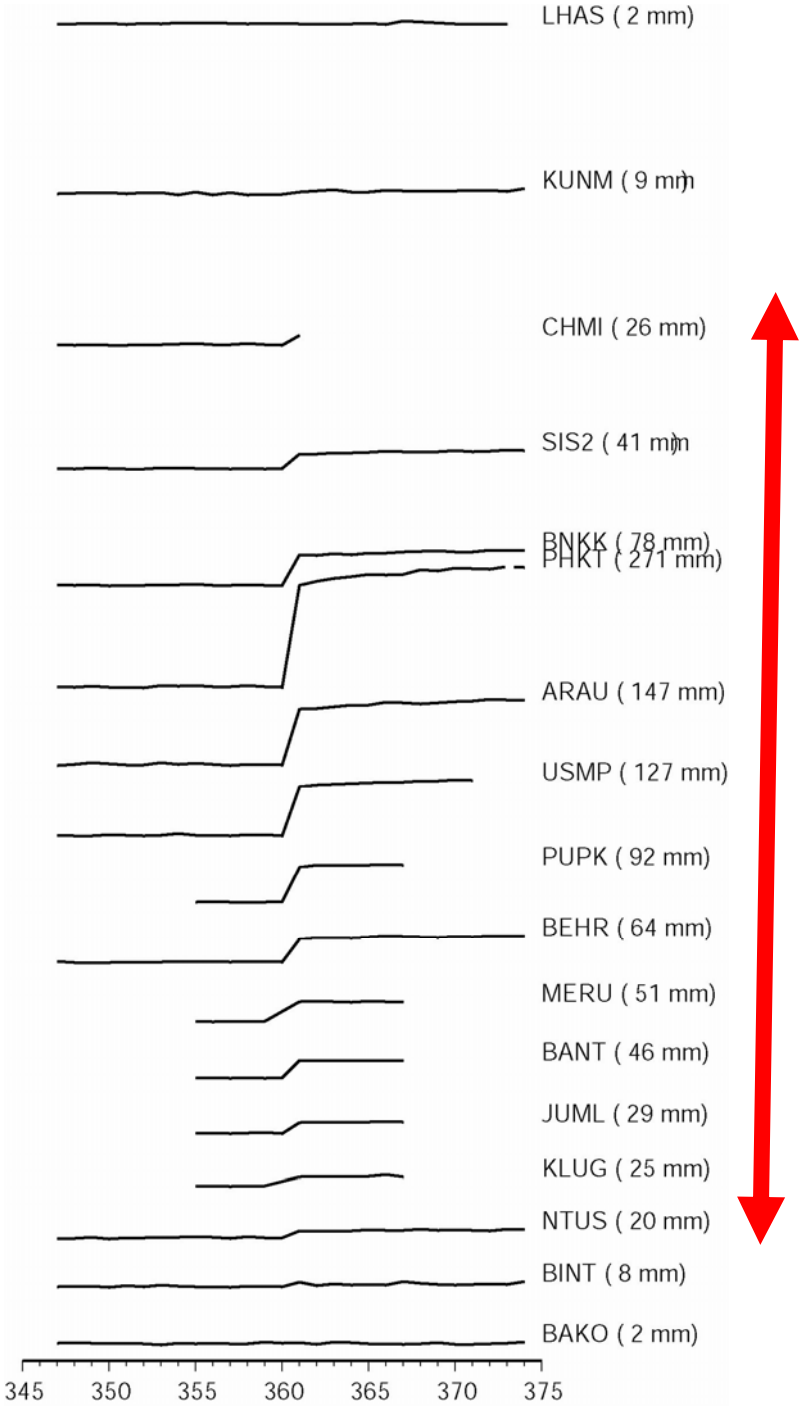
In India, China, Philippines, …



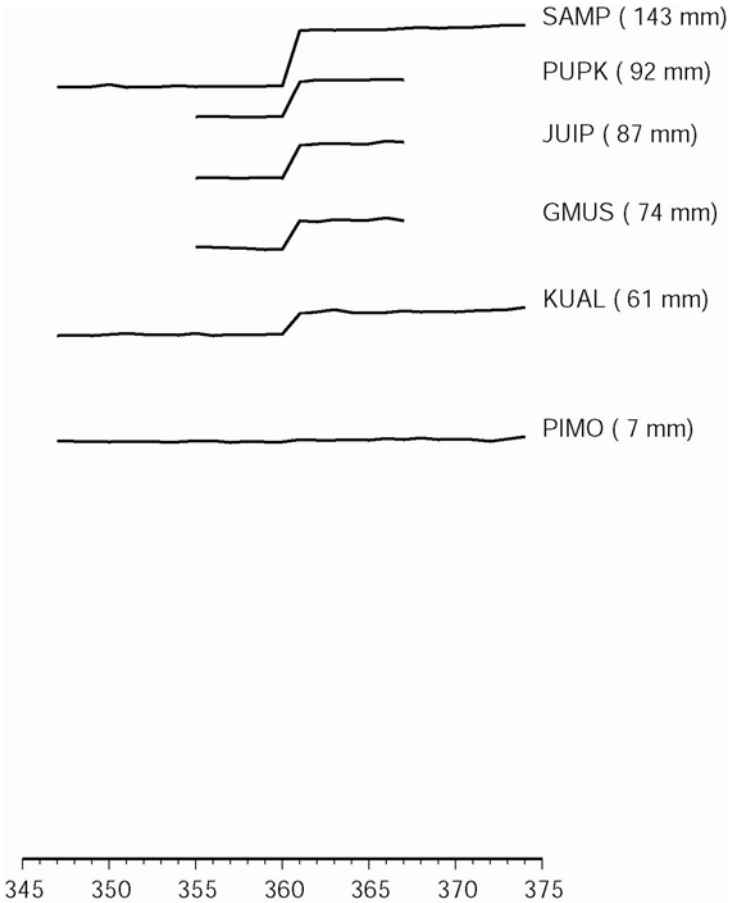
The largest motions are not in front of the epicenter (located from seismic body waves) but at least 200 km North

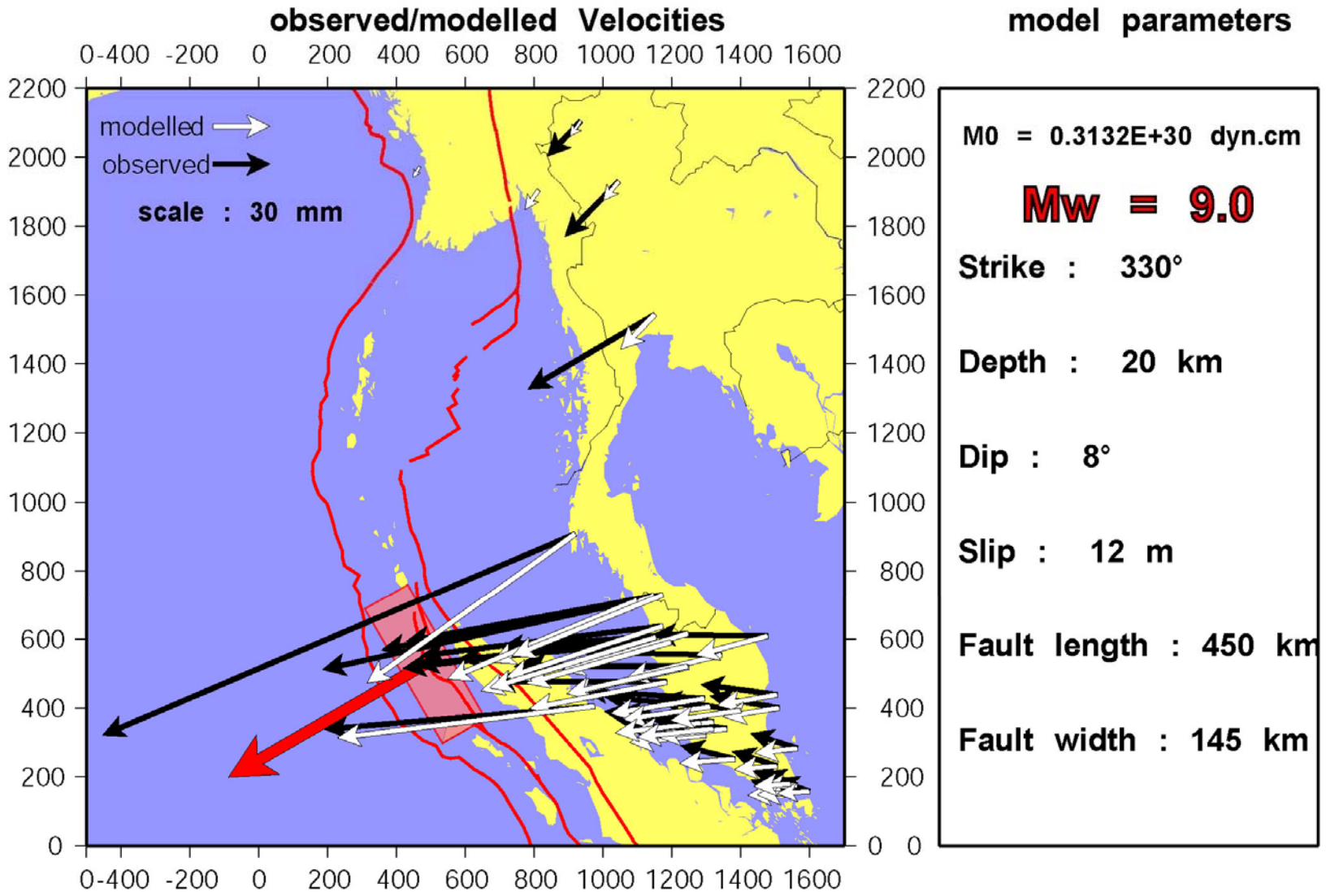


Densification in Malaysia show rapid increase of displacements magnitude and rotation of directions from South to North

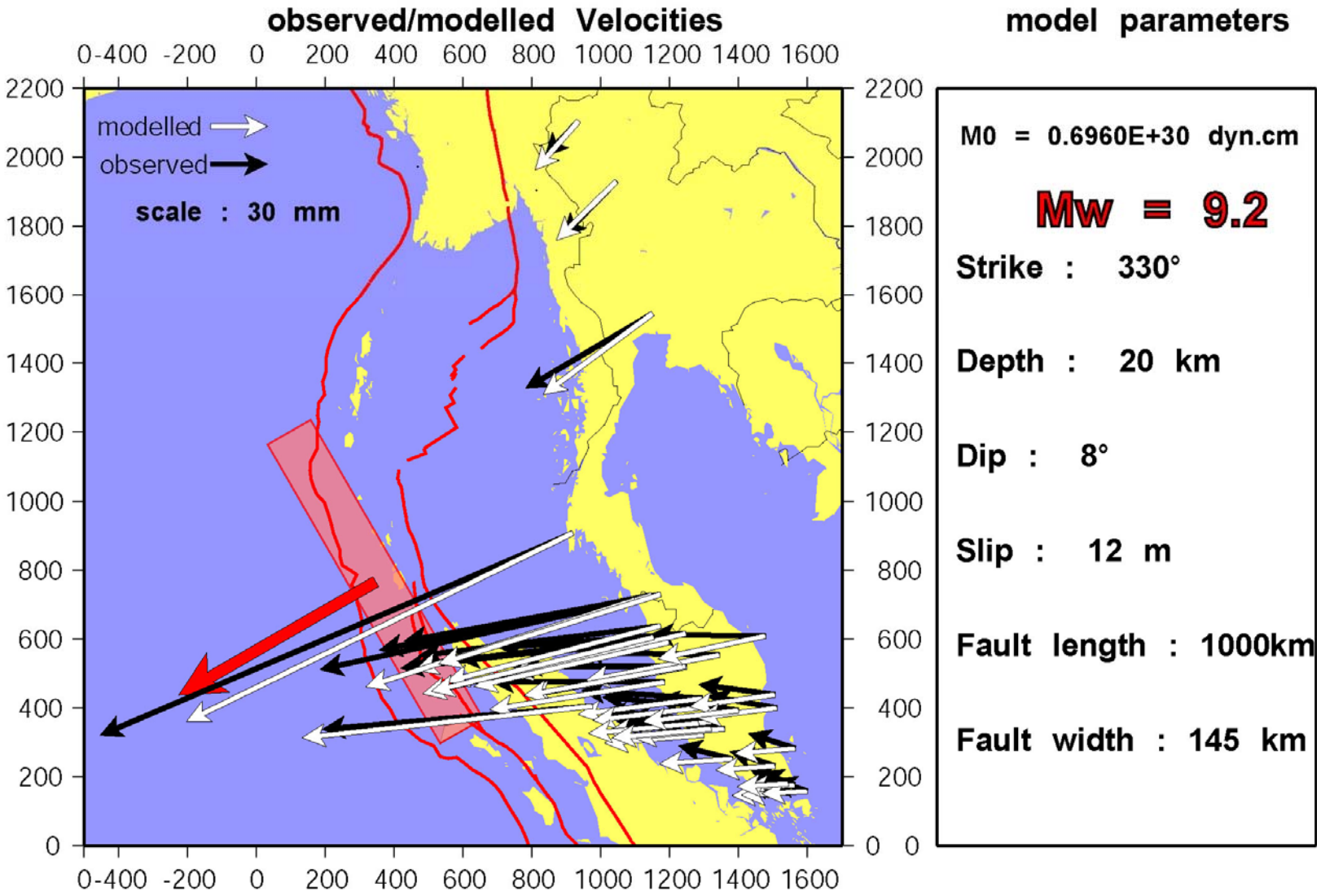


Co-seismic steps are visible in daily time-series and define a very long rupture from South to North

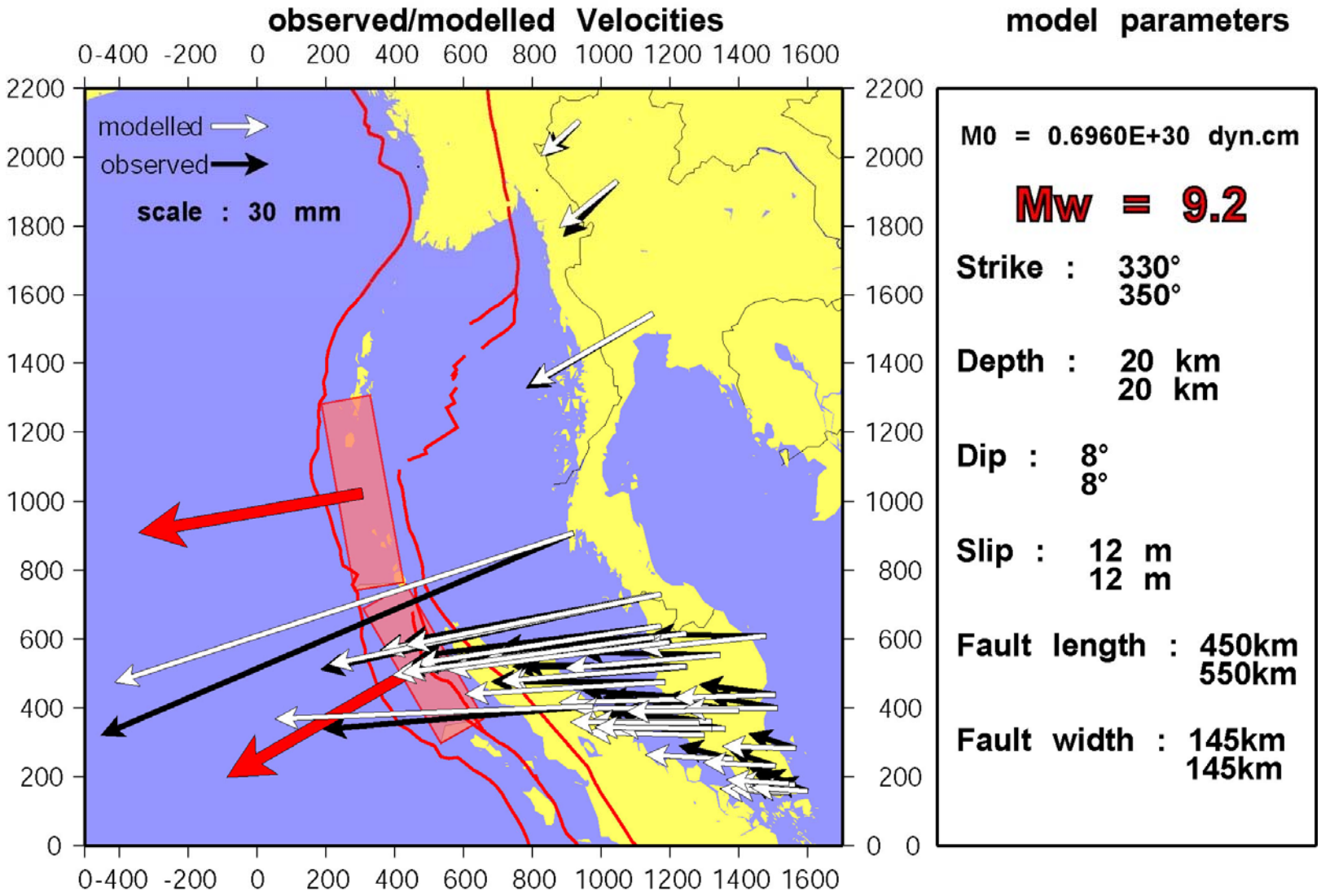




A rupture of 450 km length gives the reported magnitude (Mw=9.0) but it does not fit the observed deformation



A rupture of 1000 km length is required to fit far field deformation it corresponds to a larger magnitude Mw=9.2

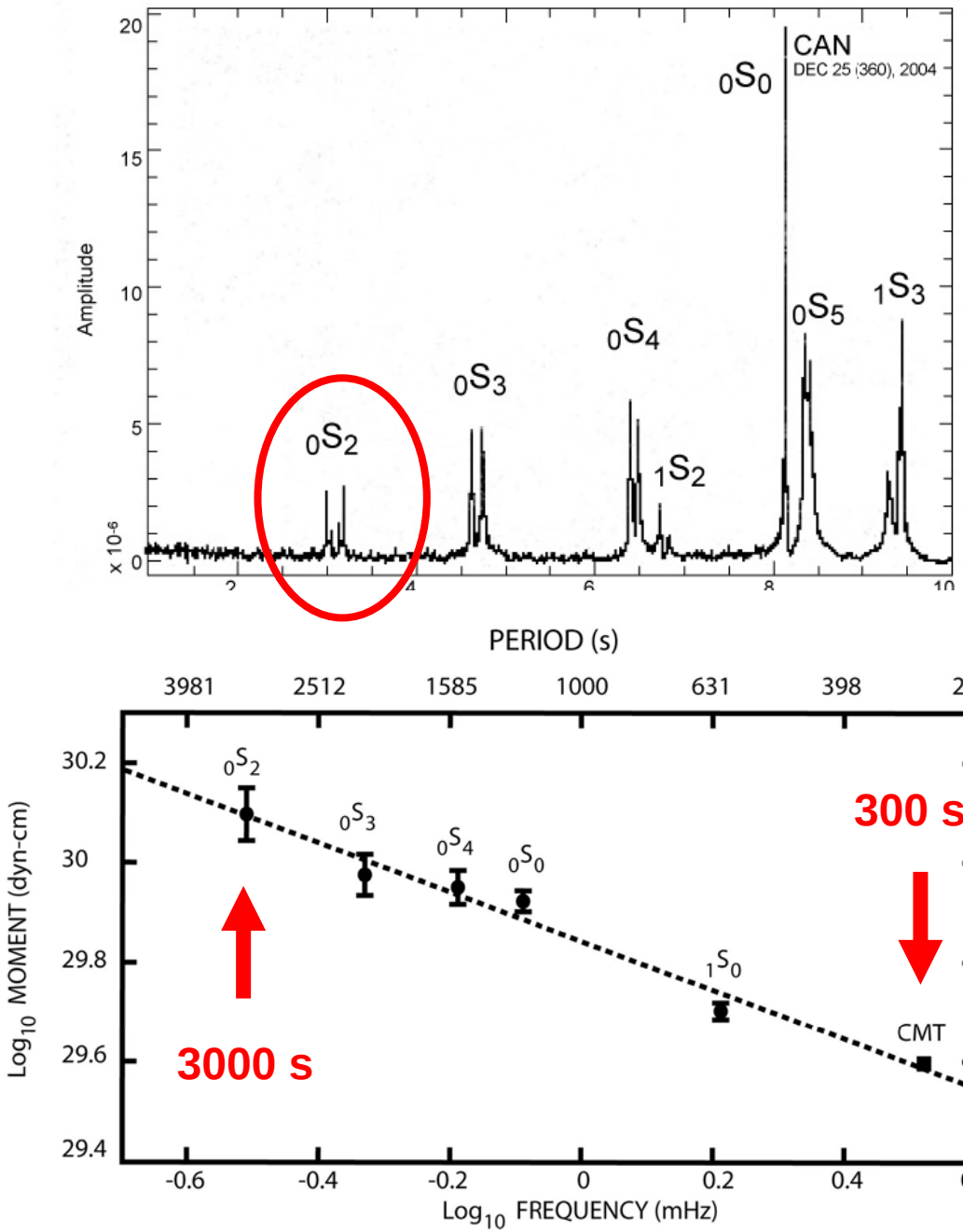


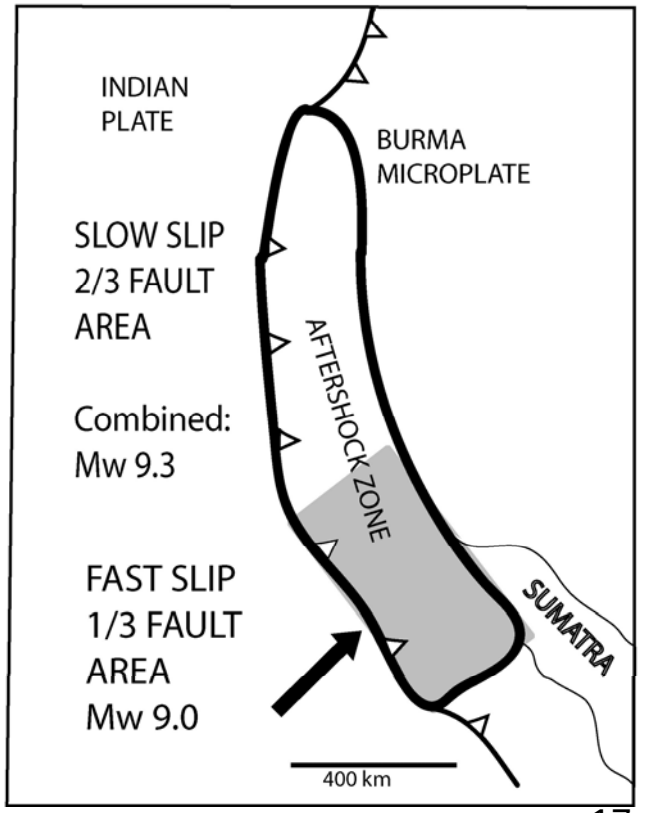
Curvature of the trench must be taken into account to fit observed directions in Northern Malaysia

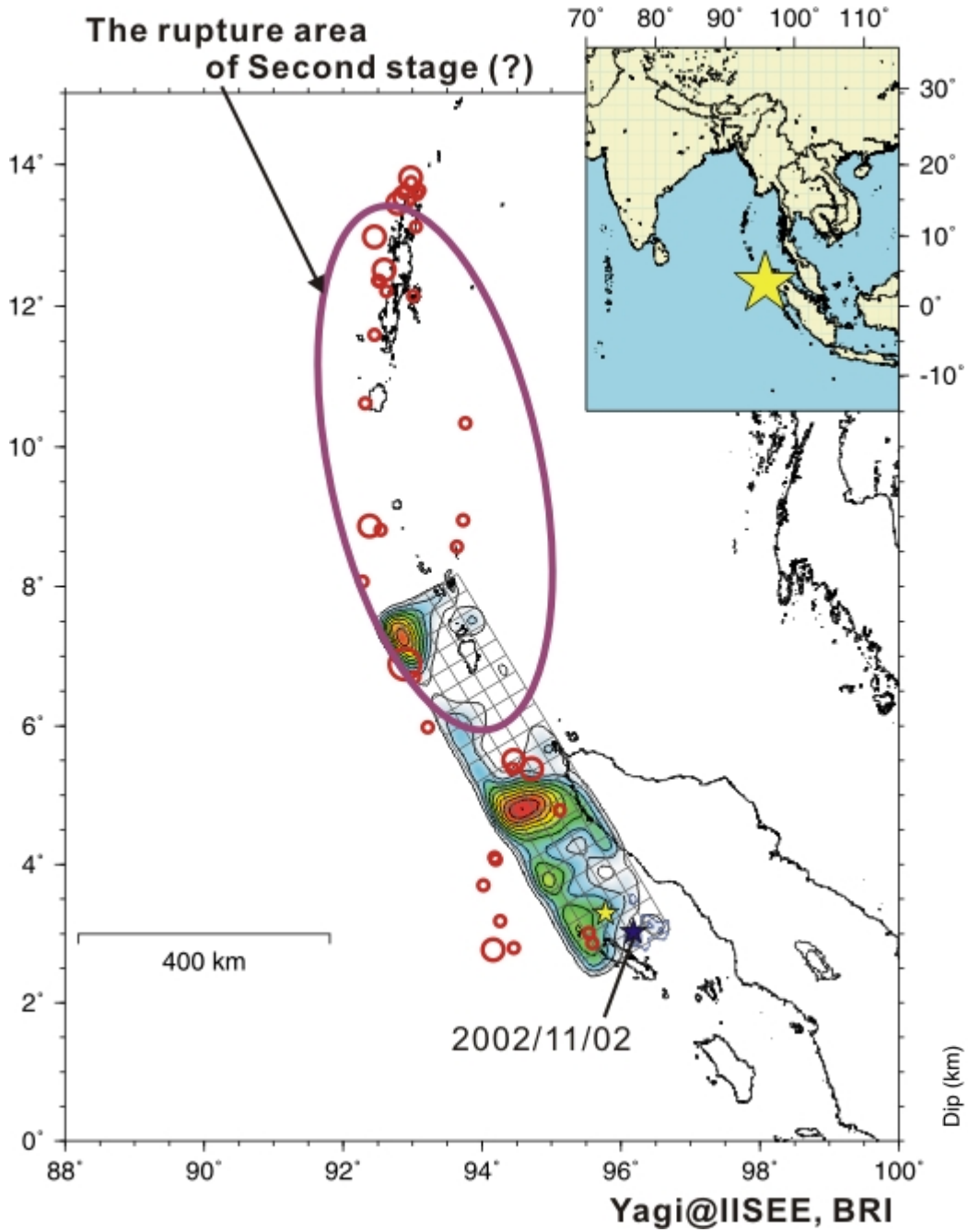
Study of the very low frequencies Earth free oscillations leads to a revised Magnitude

Mw=9.3

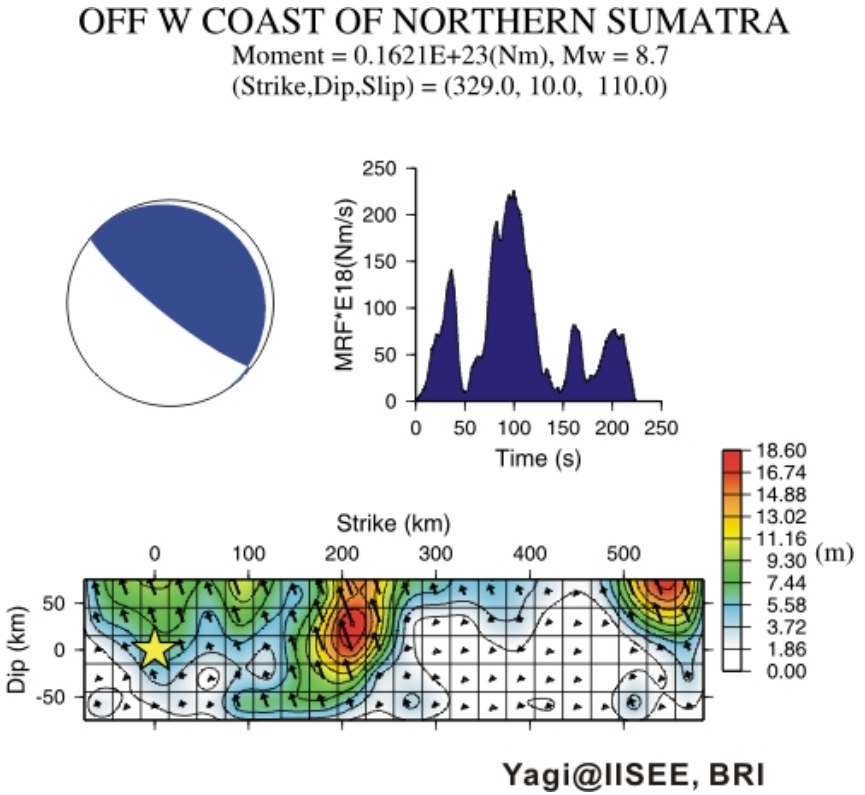
E. Okal, NW Univ. USA

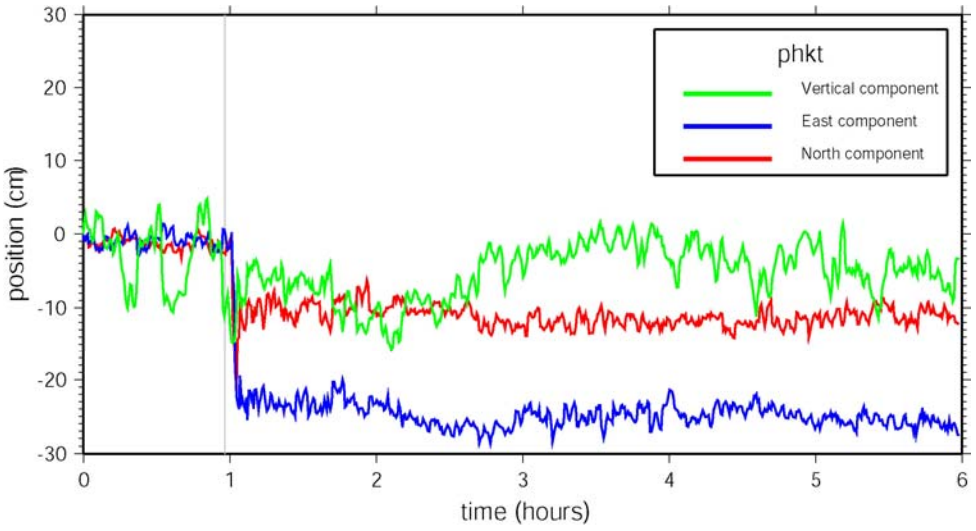






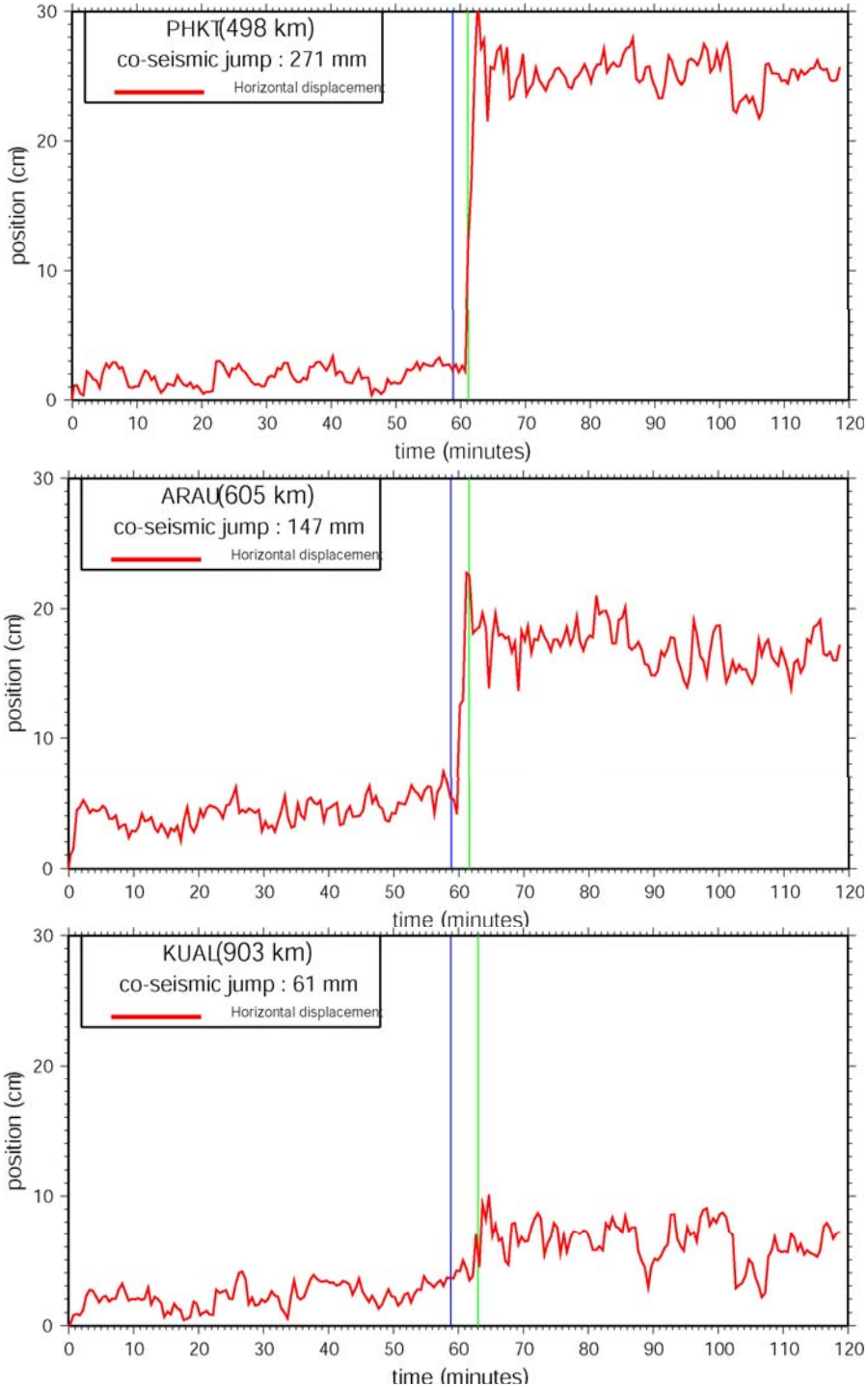
Inversion of body waves cannot "see" the long rupture but also detect a very non-uniform slip, with a patch of very high slip (>20 m) 200 km North of the epicenter

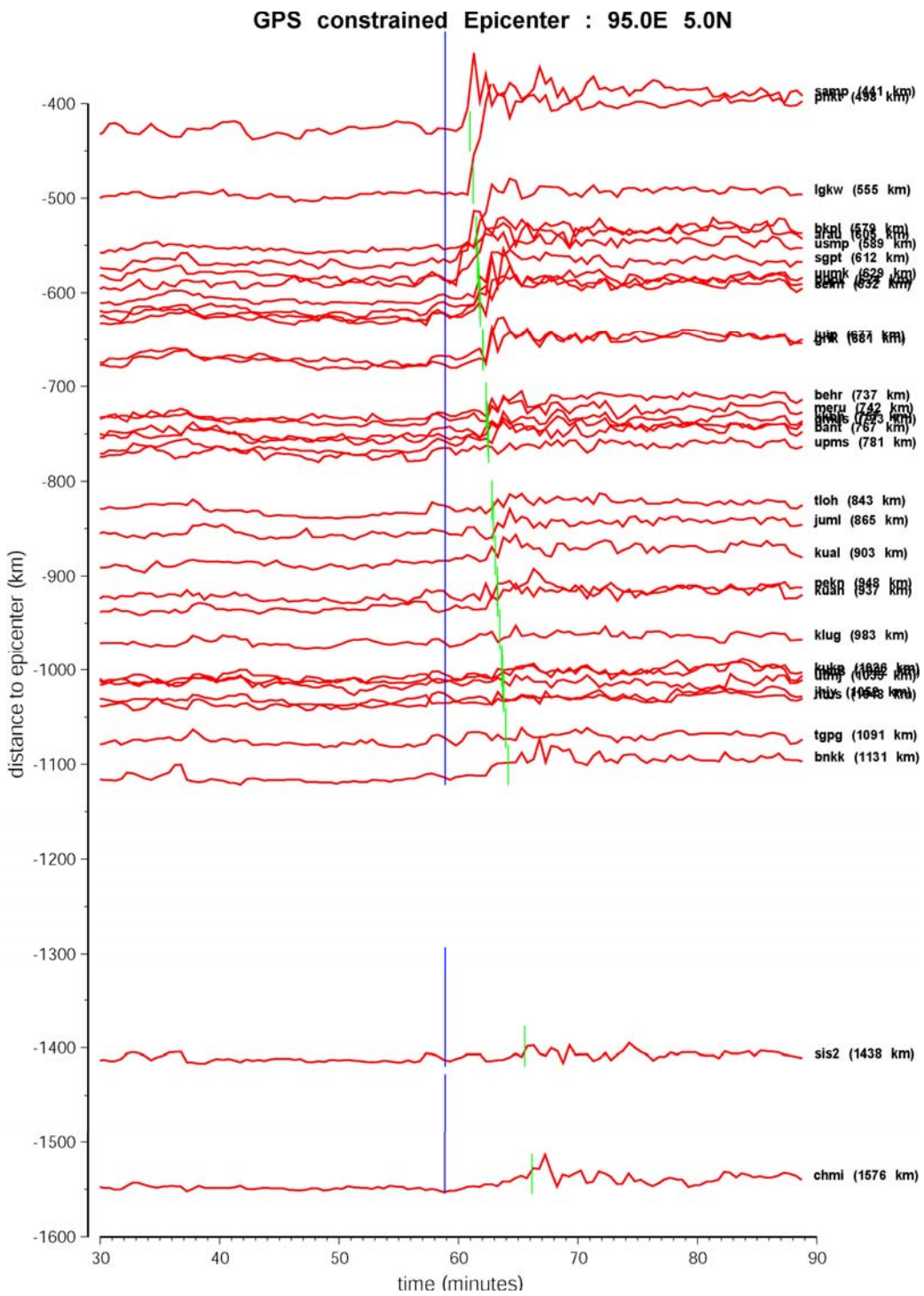




“Kinematic” (epoch-per-epoch) positioning of the GPS station show the co-seismic step…

…and allow to determine the seismic wave arrival time

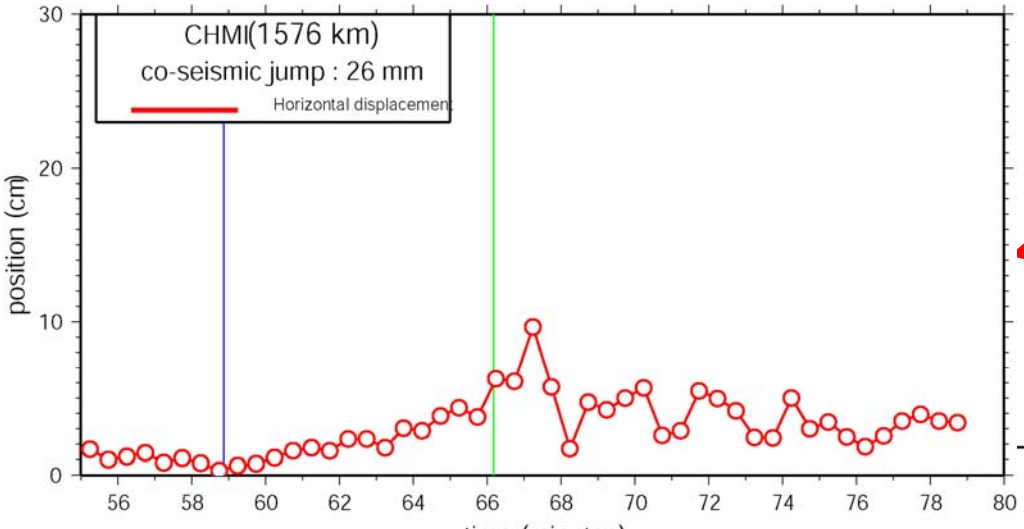


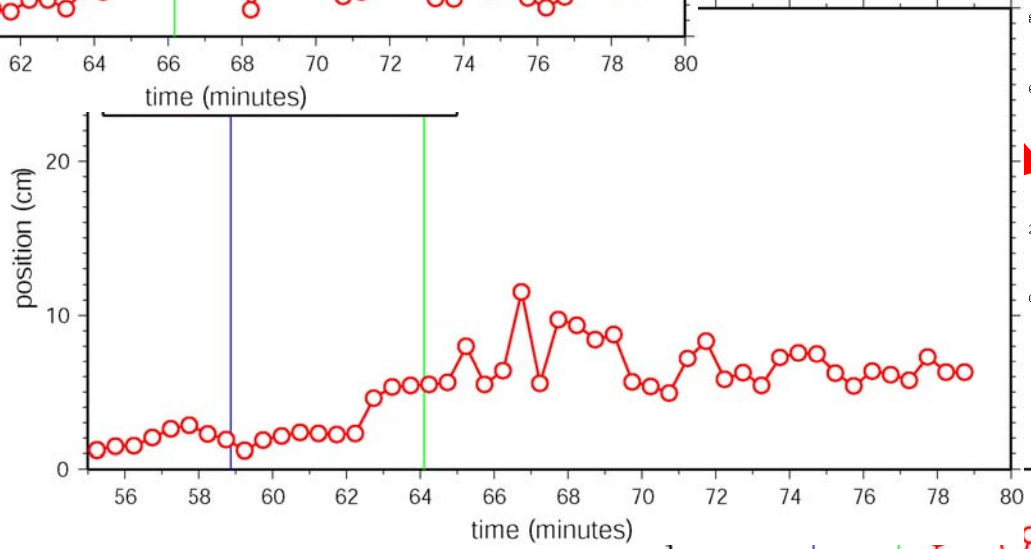


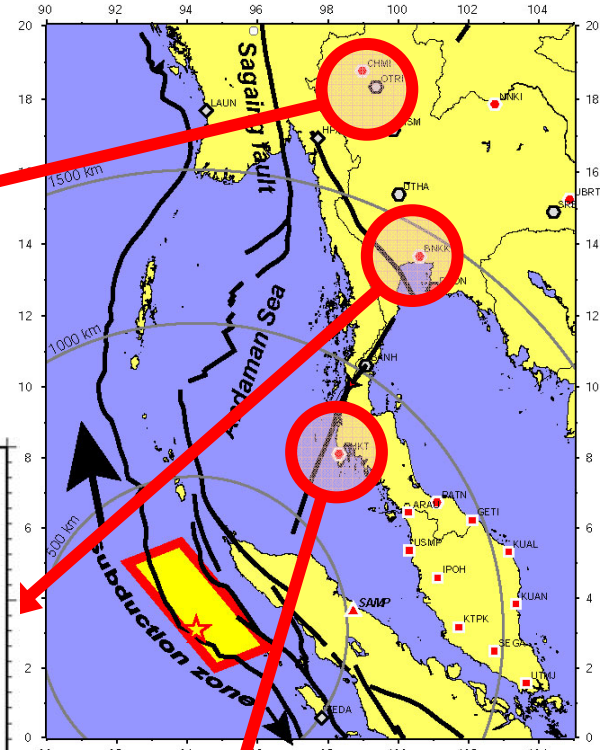
Assuming a velocity of 3.6 km/s for seismic waves

relocation of the source of the seismic energy is needed to match and sort arrival times at stations

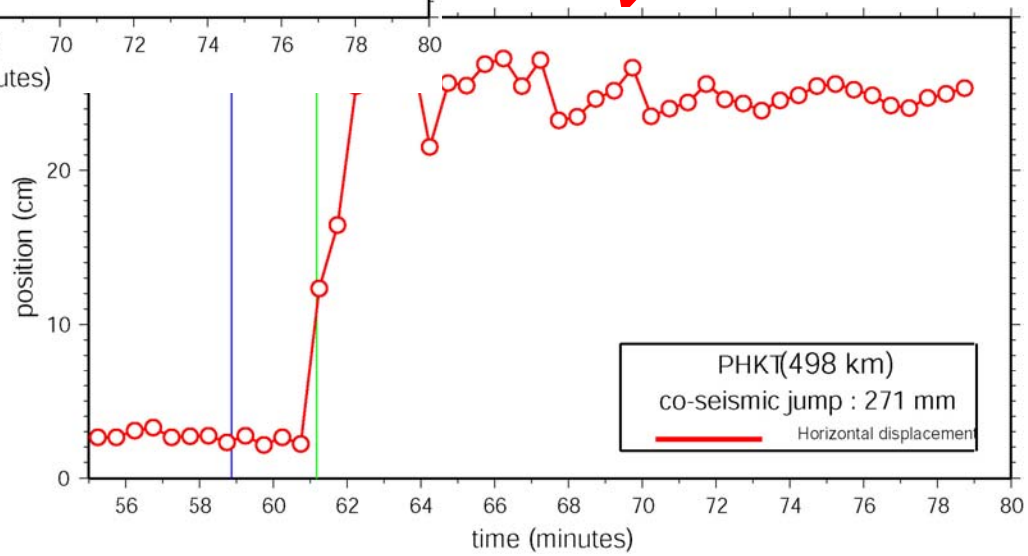
Again, a relocation of 200 km to the north is requested

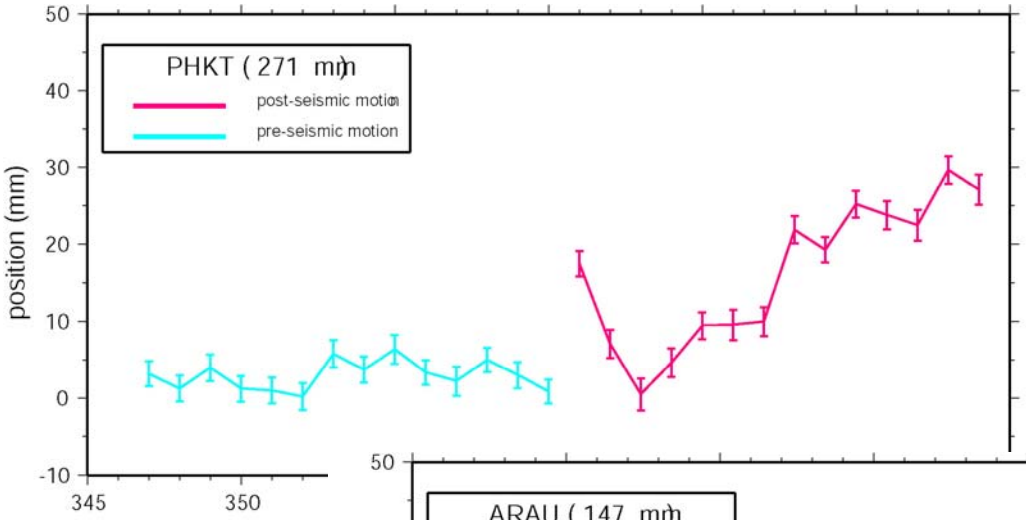


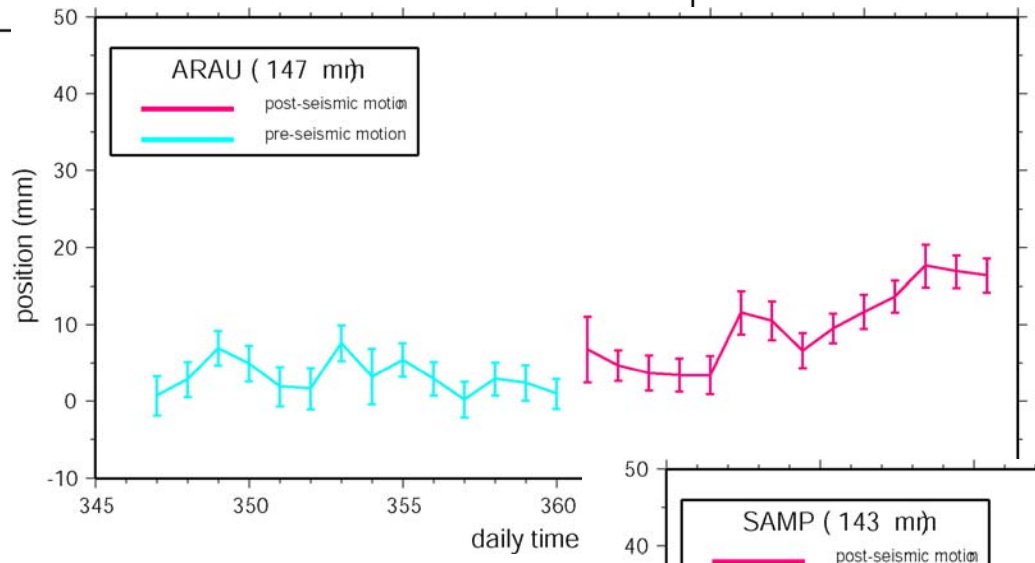


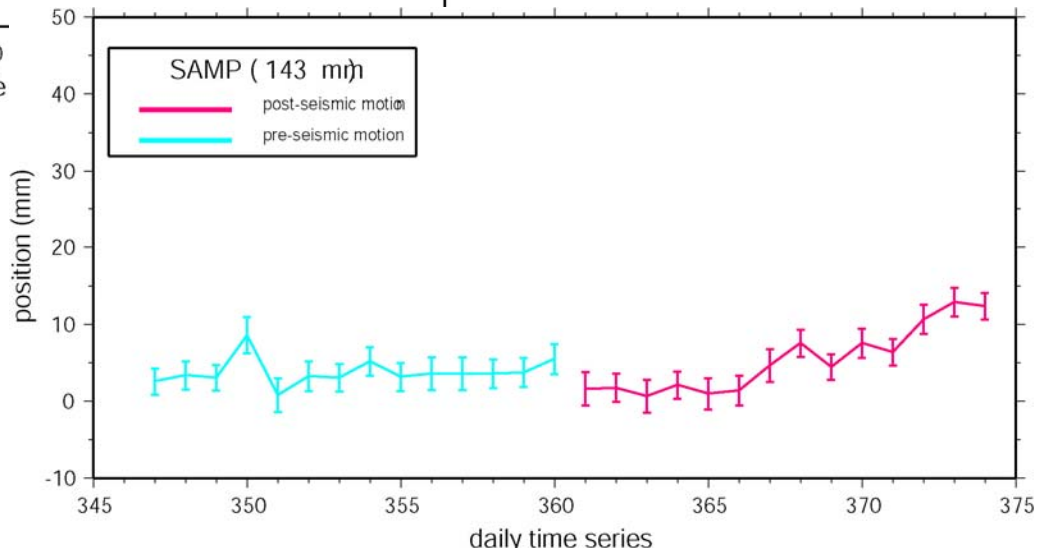


Indication of source directivity is pointed by the fact that the further away from the epicenter the longer it takes for the station to reach its final co-seismic position….This indicates a very slow rupture propagation

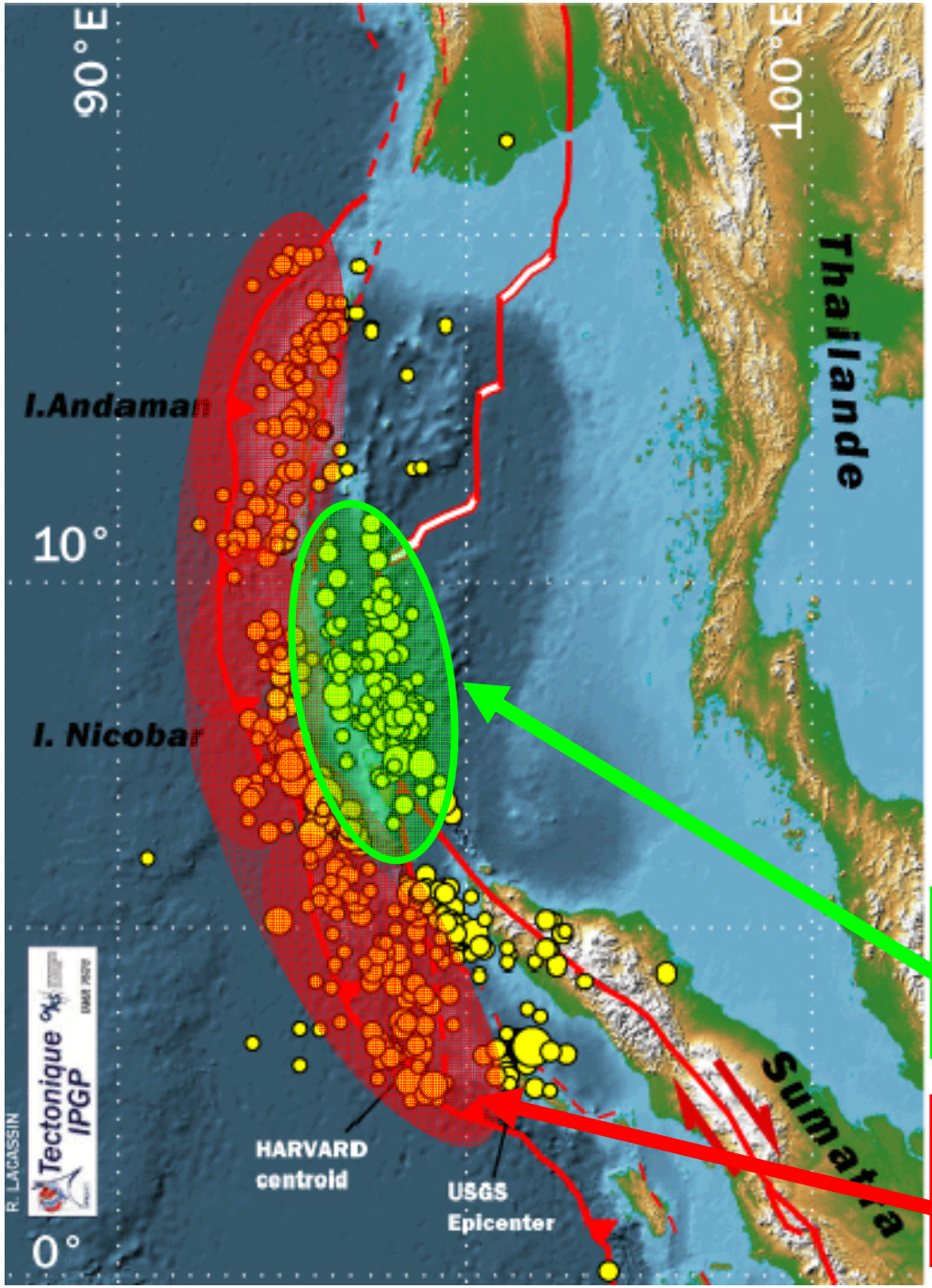








No pre-seismic motion was detected.
Post Seismic deformation will go on for years …
and may be for decades



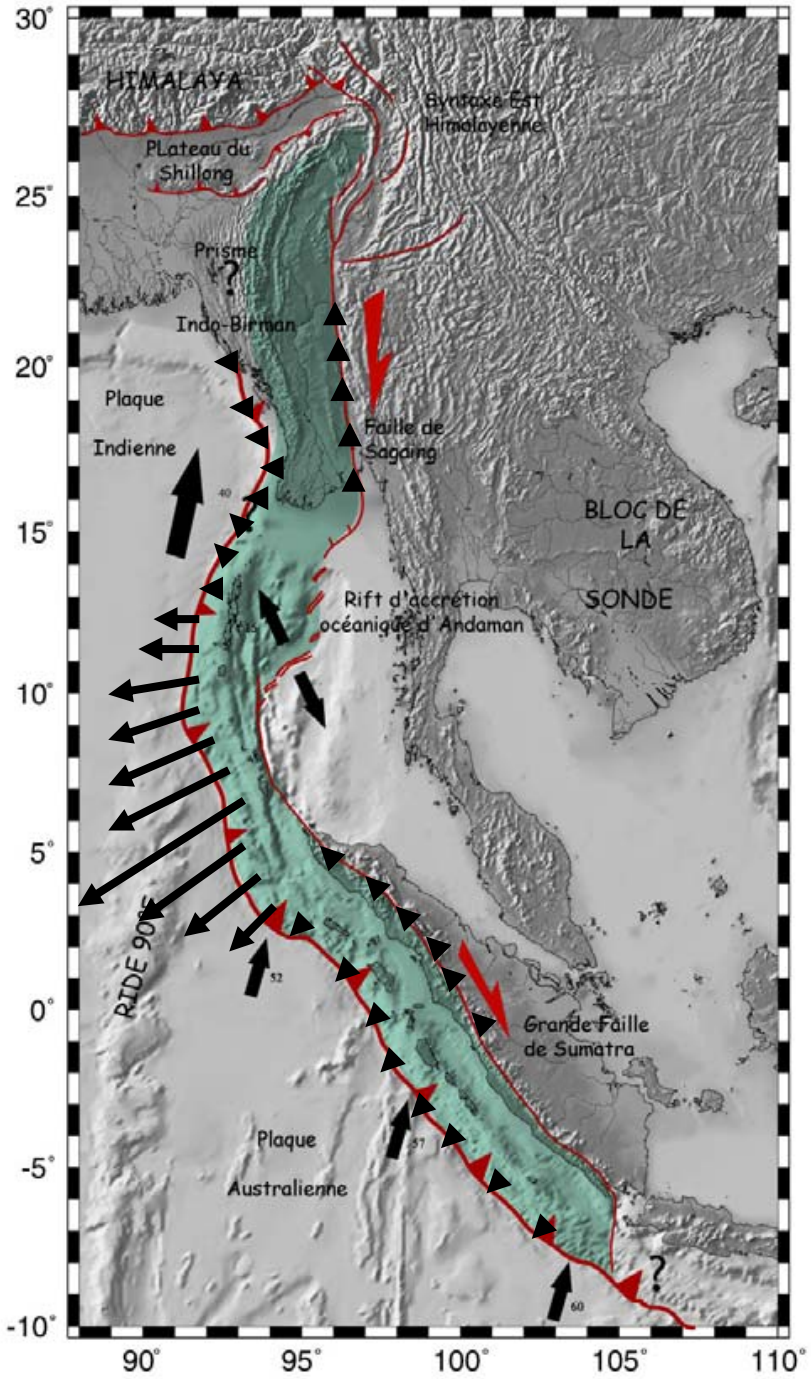
The aftershocks distribution shows :

-The rupture stopped at the northern tip of the Andaman basin

-The strike slip faults "behind" the subduction were activated in the Andaman basin

Strike-Slip aftershocks

Thrust aftershocks



Modification of seismic hazard in the area

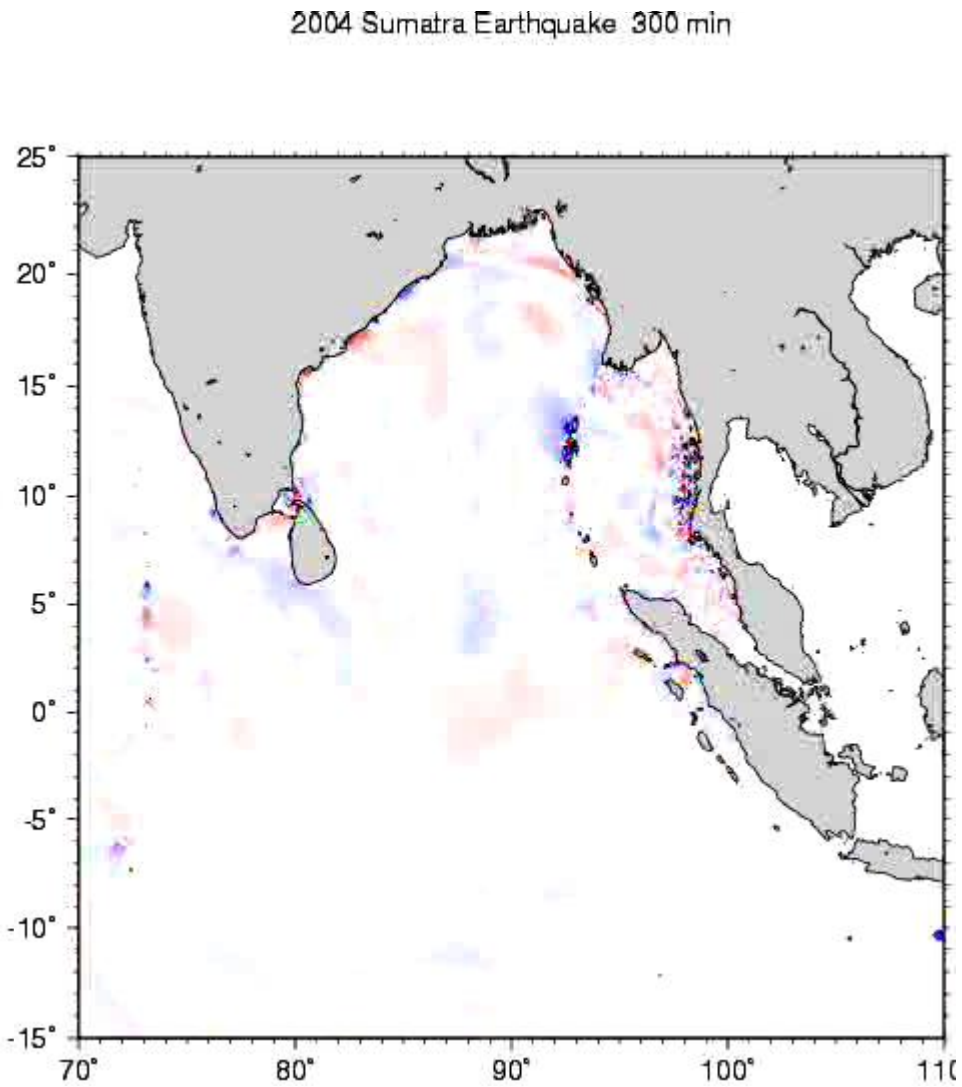
There is a higher risk of a near future event

1/ further South on the subduction

2/ further North on the subduction

3/ on the Great Sumatran Fault

4/ on the Sagaing fault


2004 Sumatra Earthquake 300 min
25°
20°
15°
10°
5°
0°
-5°
-10°
-15°
70°
80°
90°
100°