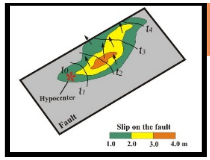
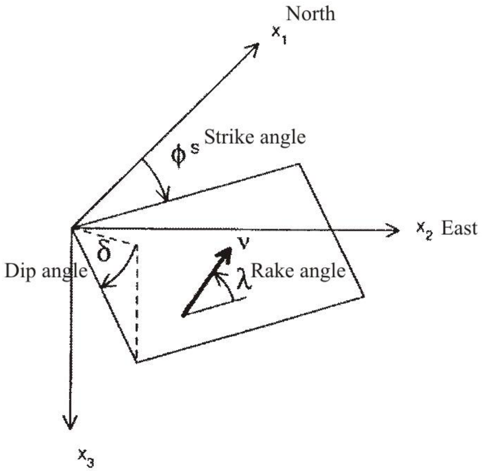
Introduction to the Kinematic source inversion

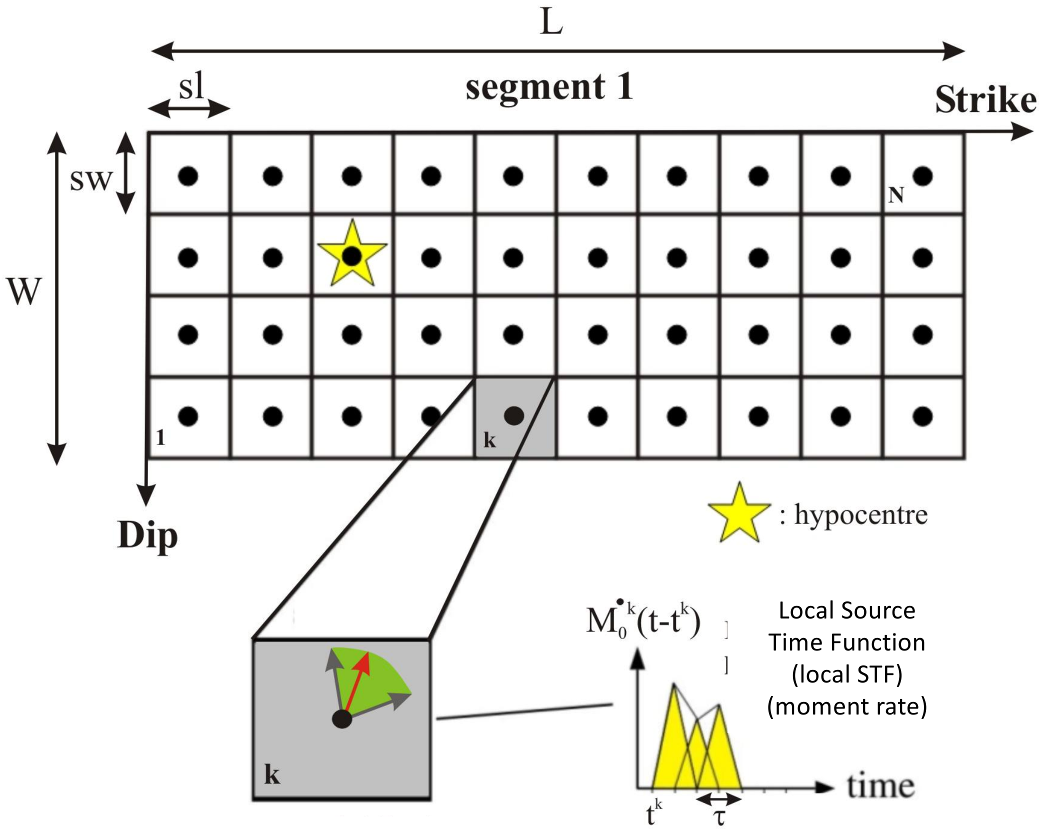
(Example from Delouis et al., 2002)



Kinematic source model

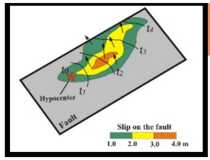


● : point source



Sub-fault k

$M_0 = \mu.S.Slip$ with $S = sw.sl$



Kinematic model

Unknown per sub-fault:

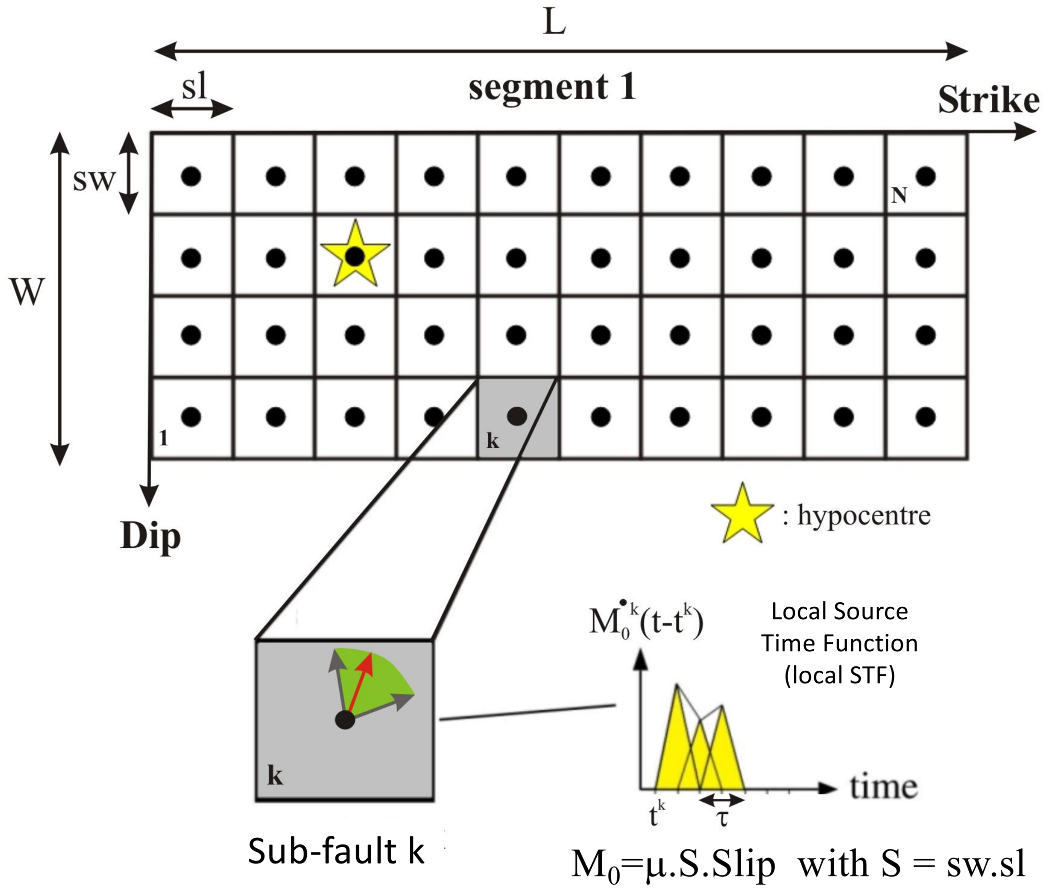
- t^k : onset time of rupture
- rake : slip angle
- amplitudes of the local source time function (local STF)
  (the local STF can be integrated to obtain the local seismic moment, hence the local slip knowing μ and the sub-fault area)

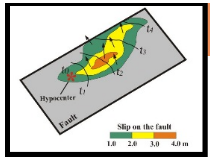
Computation of the elastic response of the Earth:

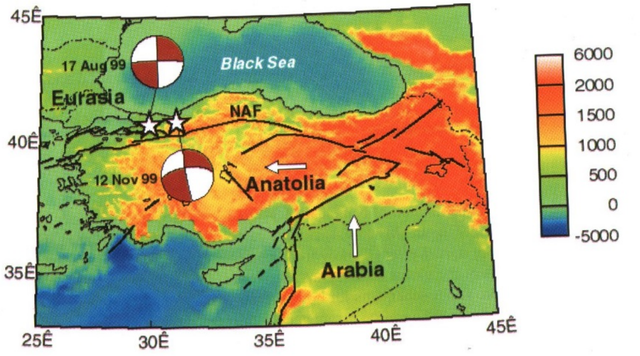
- Discrete wavenumber integration method (Bouchon 1981) for local to regional seismological data
- Dislocation model (Savage 1980) for geodetic data

Inversion method:

- Non linear, simultated annealing

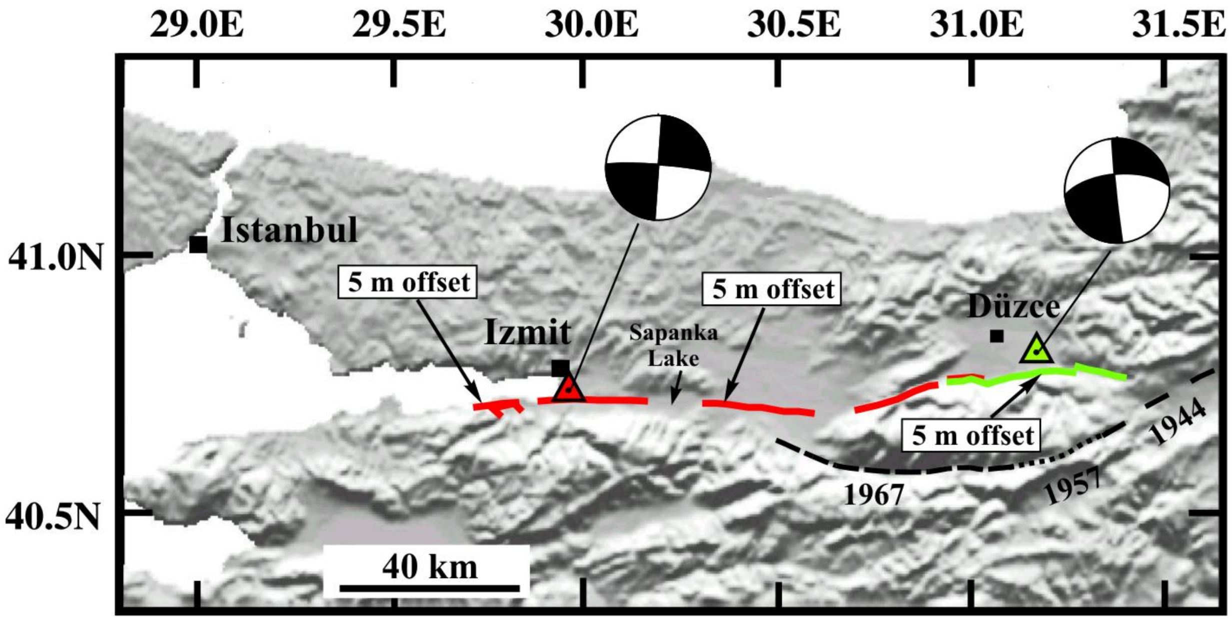




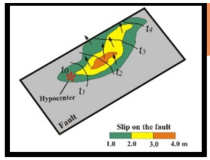


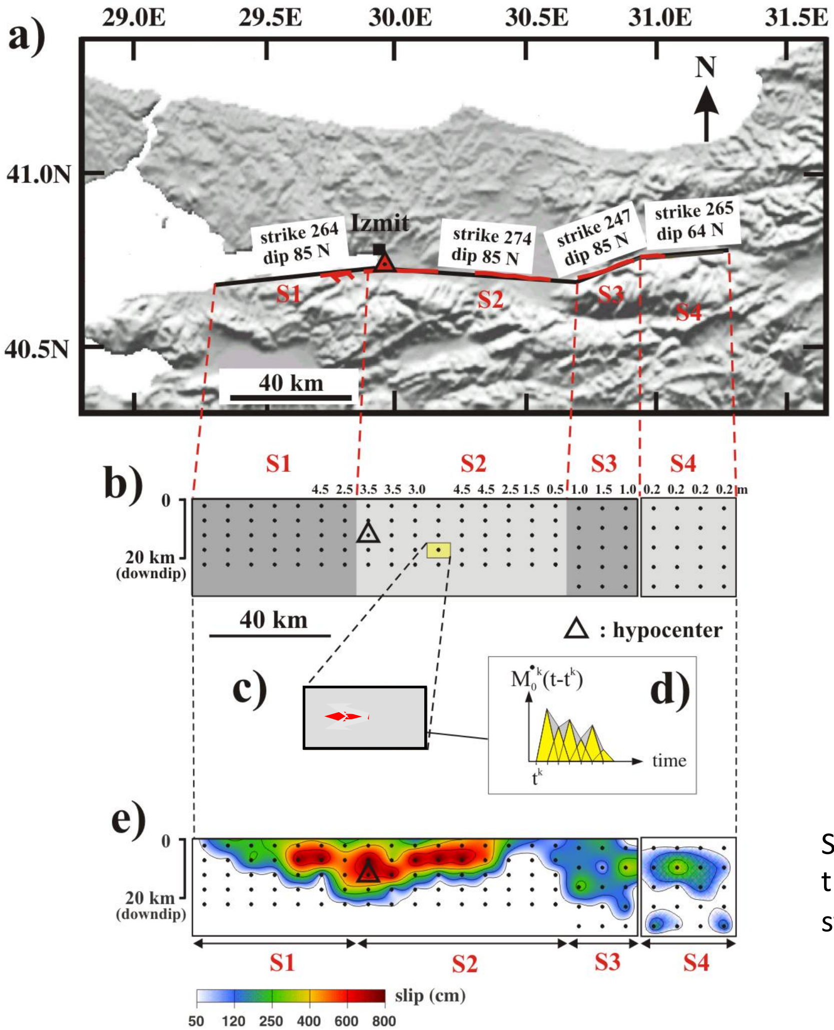
Izmit earthquake
(Mw 7.6 1999)

Red lines: surface breaks of Izmit earthquake

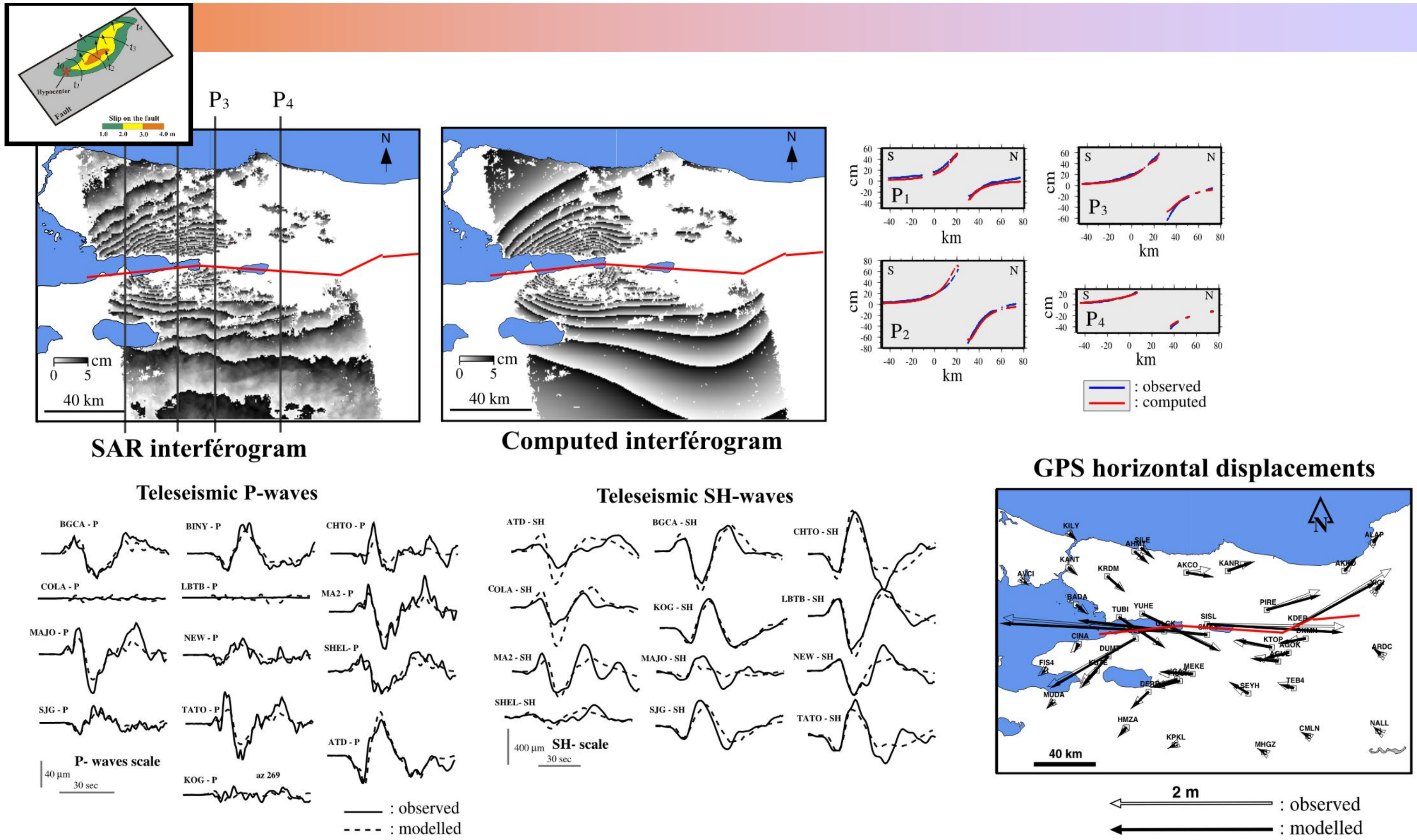


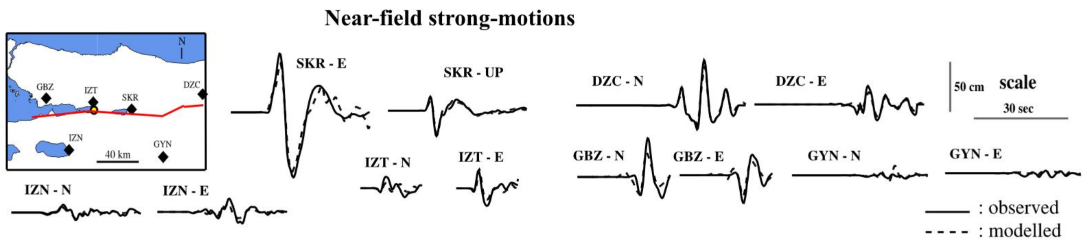
Kinematic model



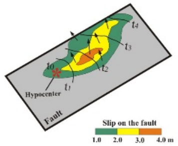


Slip distribution resulting from the joint inversion of teleseismic, strong-motion, GPS, and InSAR data

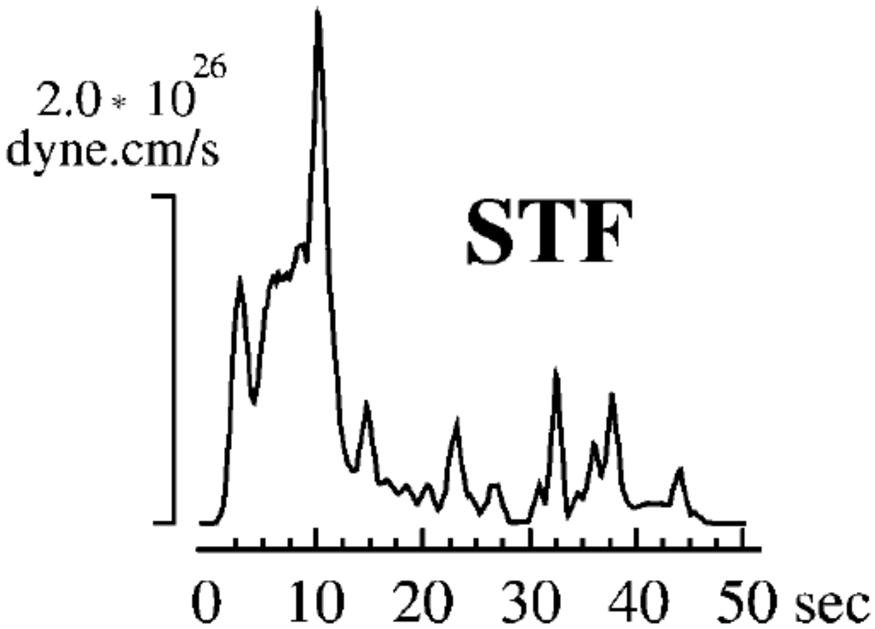




Data modeling from joint inversion

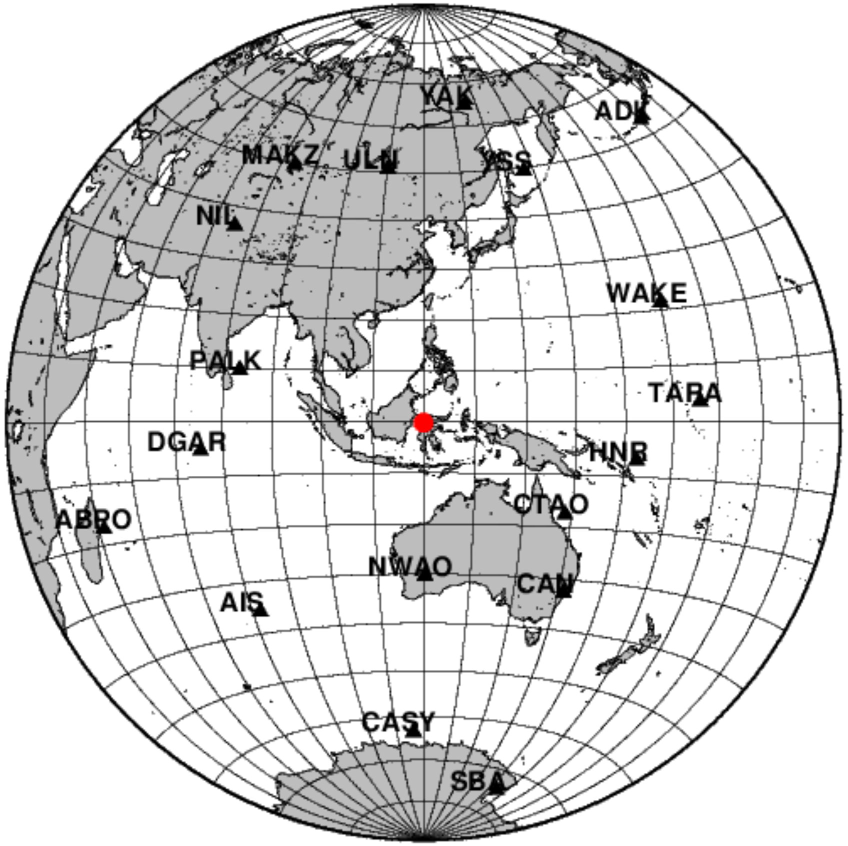


Global STF, sum of the contributions of all the local STFs shifted by their onset times



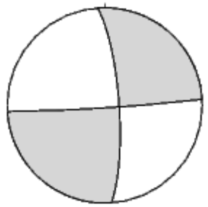
Application (exercice): the 2018 Mw 7.5 PALU (Indonesia) earthquake

Teleseismic stations (P and SH broadband waveforms)

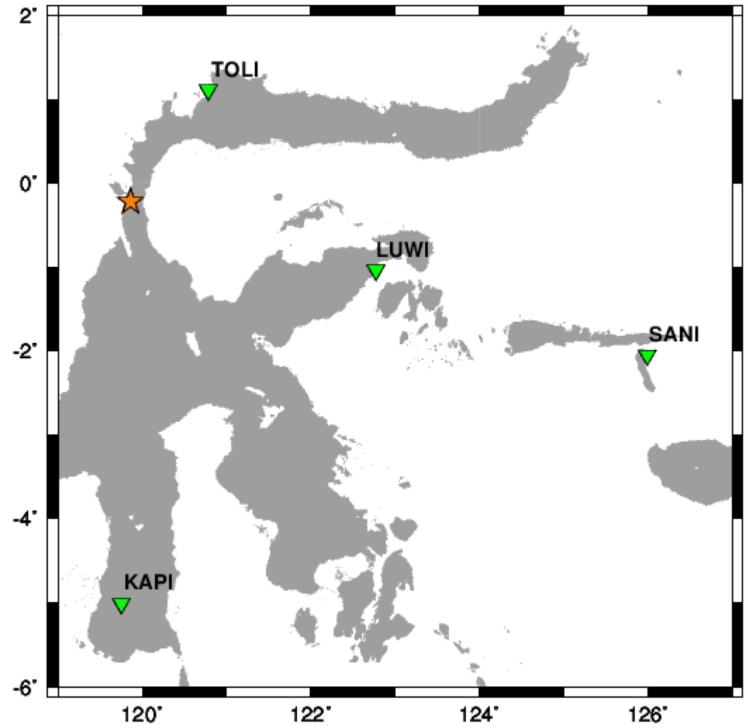


Focal mechanism used

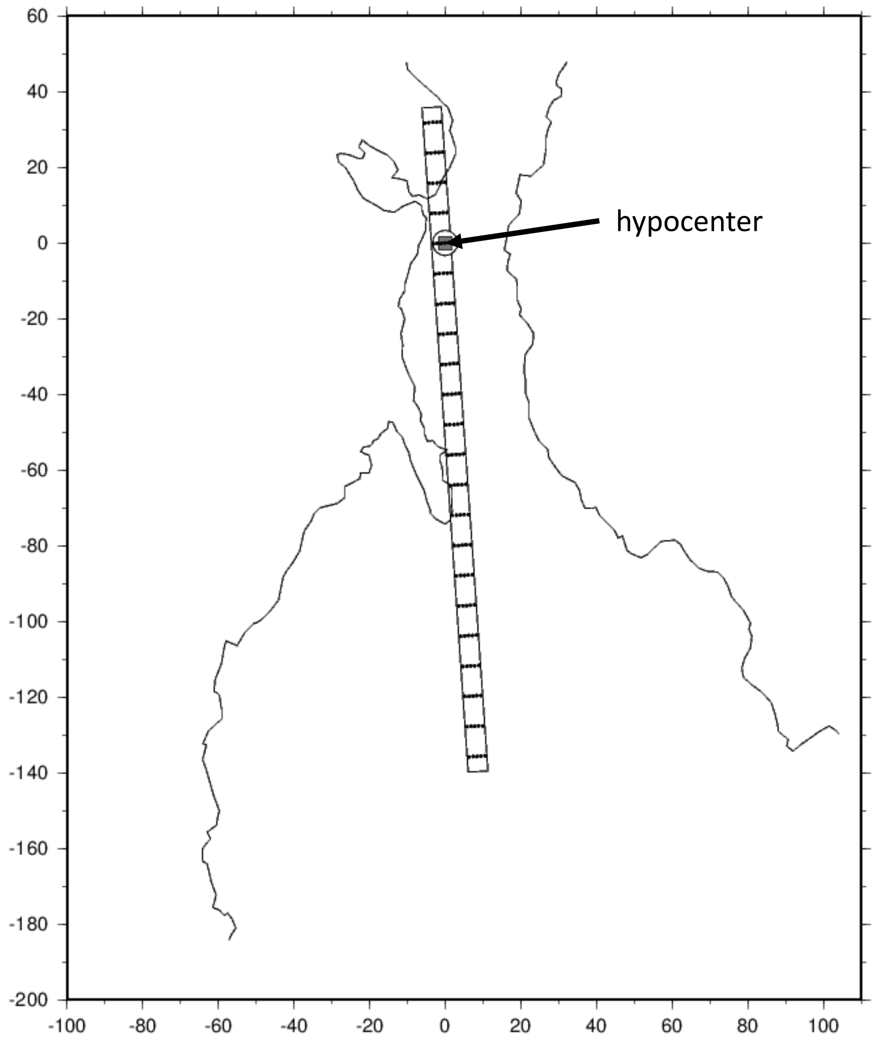
strike dip rake
356. 78. -2.



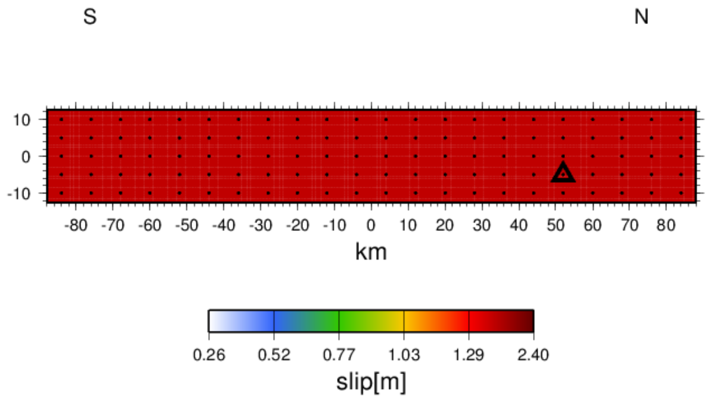
Regional seismic stations (broadband and strong-motion full waveforms)



Faut model
(coords in km)

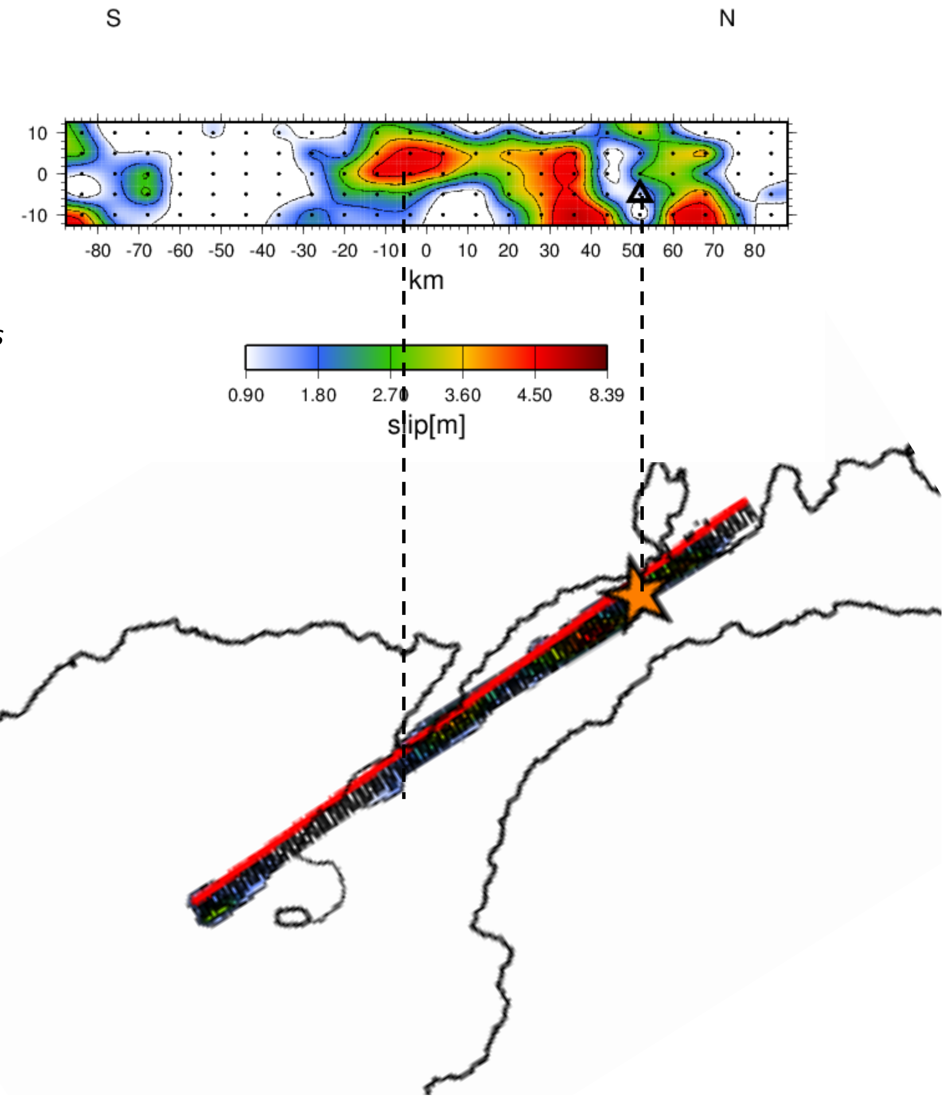


Slip distribution at zero iteration (initial parameter values)

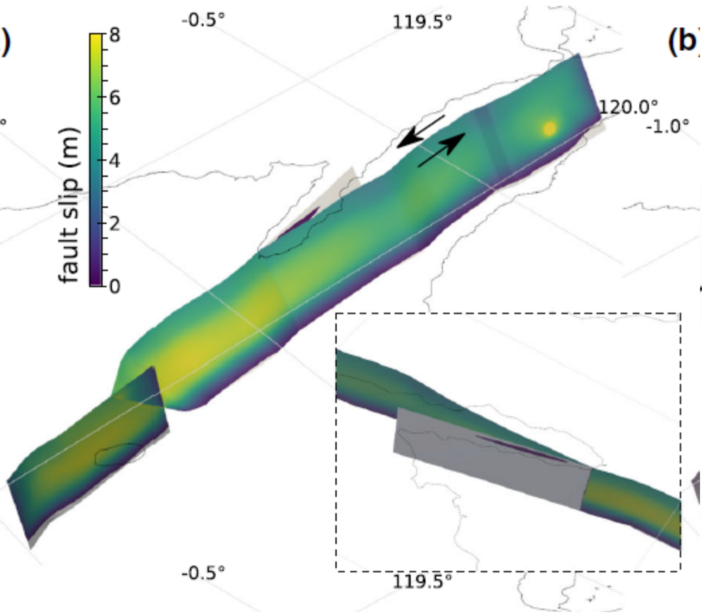


Slip distribution at end of iterations

Beware: not same color scales

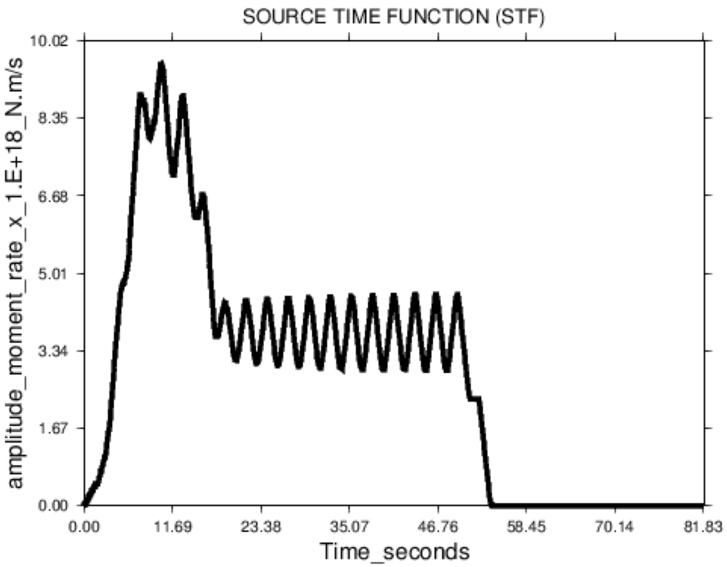


Dynamic model reproducing teleseismic, tsunami, InSAR and optical correlation displacements



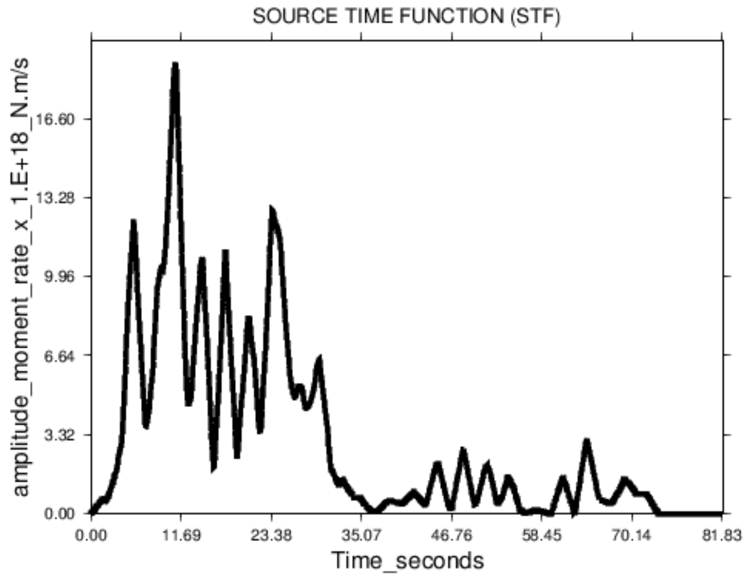
Ulrich et al., 2019

Global STF at zero iteration (initial parameter values)



Note: the spiky overall shape ff the STF suggests elementary triangular functions are slightly too narrow

Global STF at end of iterations



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Pure and Applied Geophysics

Coupled, Physics-Based Modeling Reveals Earthquake Displacements are Critical to the 2018 Palu, Sulawesi Tsunami

T. Ulrich,[1] S. Vater,[2] E. H. Madden,[1,3] J. Behrens,[4] Y. van Dinther,[5] I. van Zelst,[6] E. J. Fielding,[7] C. Liang,[8] and A.-A. Gabriel[1]

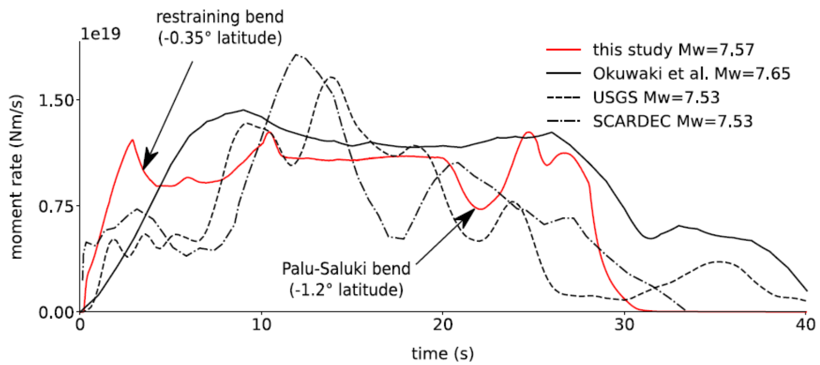
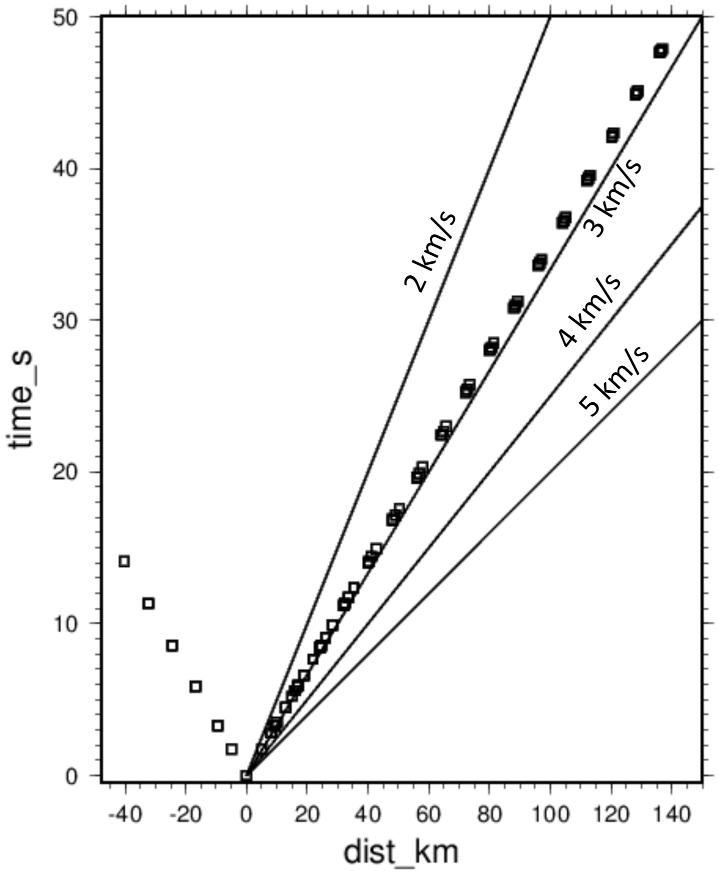
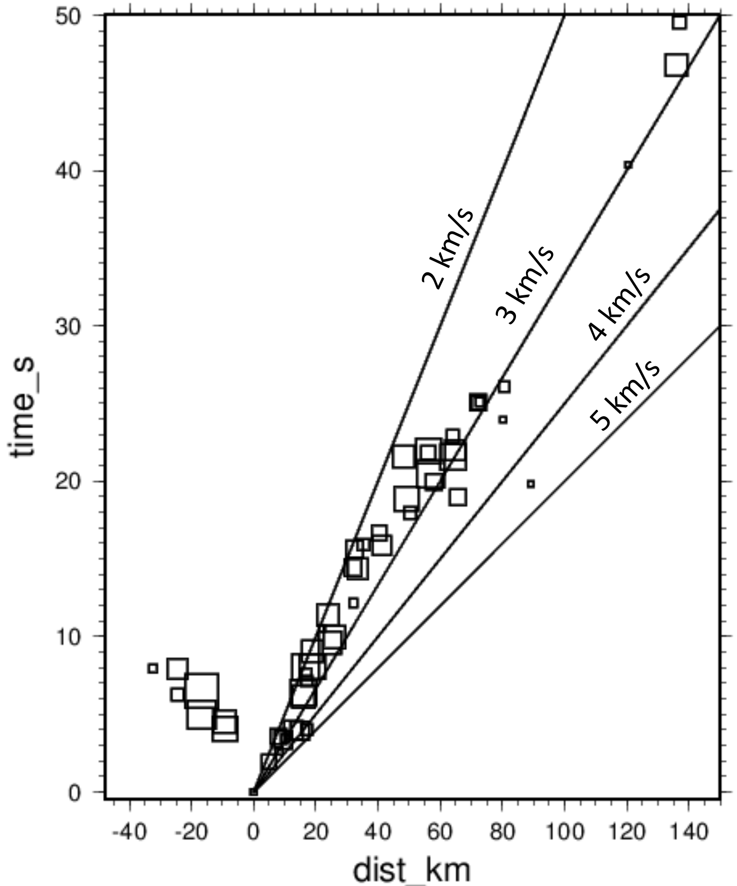


Figure 6
Synthetic moment rate release function compared with those inferred from teleseismic data by Okuwaki et al. (2018), the USGS and the SCARDEC method (optimal solution, Vallée et al. 2011)

Rupture timing at zero iteration (initial parameter values)



Rupture timing at end of iterations



Note 1: the single rupture plane used in this exercise is a strong simplification of reality…

A preliminary report on the M7.5 Palu earthquake co-seismic ruptures and landslides using image correlation techniques on optical satellite data[1]

Sotiris Valkaniotis[1], Athanassios Ganas[2], Varvara Tsironi[2], Aggeliki Barberopoulou[3]

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[3]*Stevens Str., Stoneham MA 02180 United States* aggeliki.barberopoulou@gmail.com

Note 2: convergence of the slip inversion has been made fast for the purpose of the exercise. The result is hence not fully optimized.

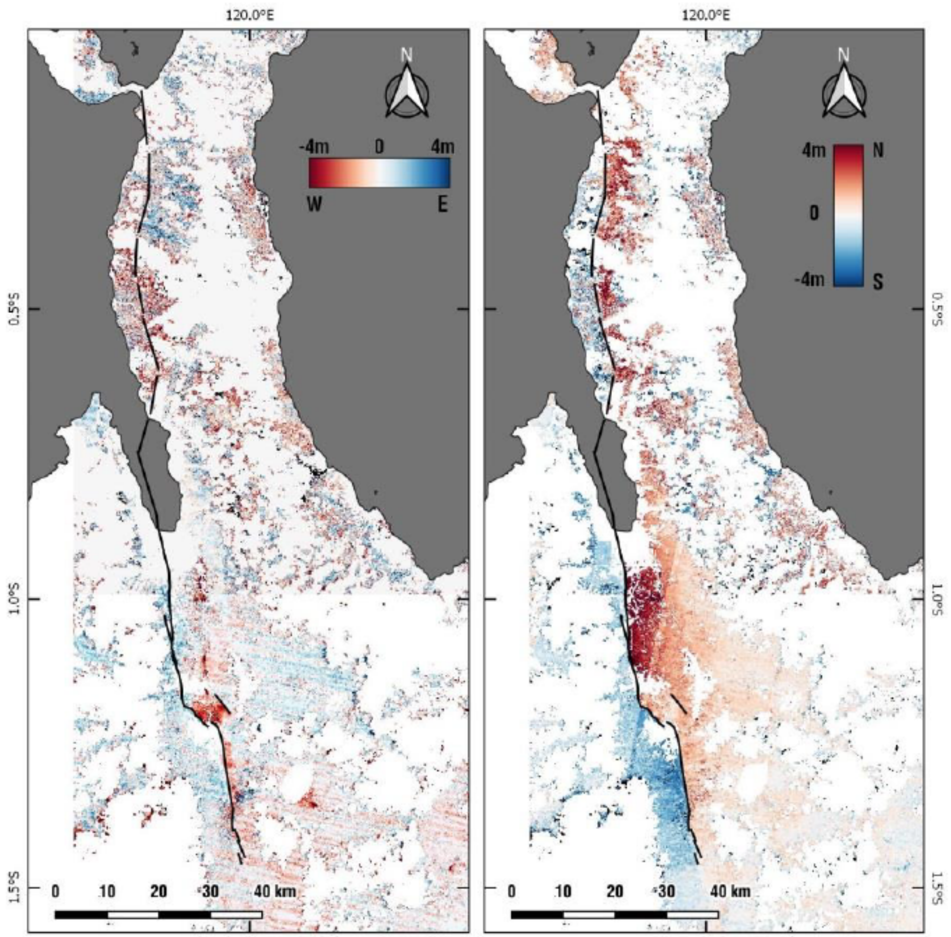
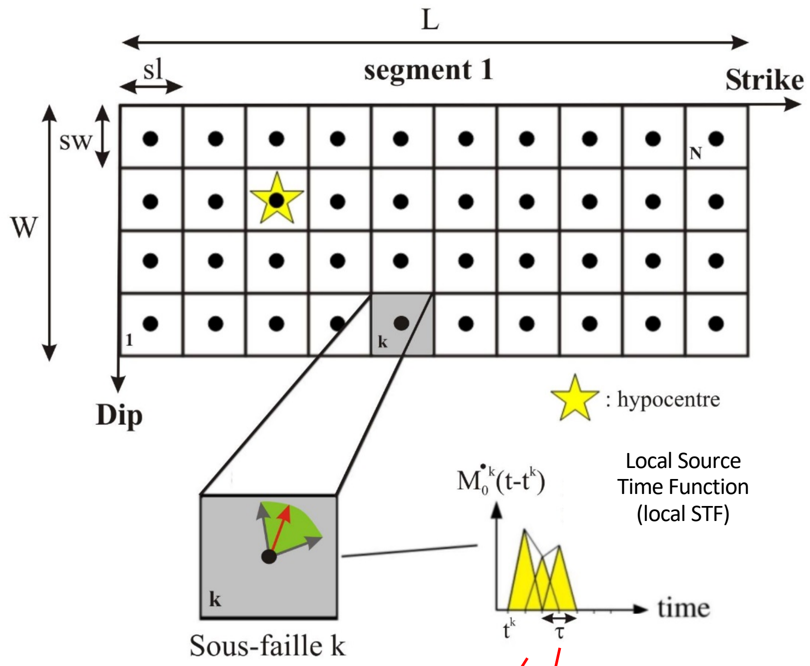


Figure 3. Horizontal displacement of several metres along the M7.5 Palu, Sulawesi earthquake rupture produced from Sentinel-2 optical imagery using the MPIC-OPT service. Left-lateral movement of the fault is apparent from the N-S component (right panel: red is towards north, blue towards south). E-W component (left panel) is more indicative of large gravitational coseismic features. Total fault rupture exceeded 140 km in length.

File « param_rupt » defining the kinematic model and some inversion parameters



It would be possible to « play » with parameters in green, which do not require a re-generation of the Green's functions

strength of smoothing on slip

strength of smoothing on rupture velocity

strength of the seismic moment minimization

number of elementary triangular functions used for local STFs

shear modulus used (dyn.cm) to convert moment in slip

duration (s) of elementary triangular functions used for local STFs

```
PALU_EQ_M7.5_v4 #title for file names for Nabelek teleseismic programs
2.35e27 3  1.5  3.0e11 1e24  140. 1.0 1.0 0.0 0.0 0.0 # M0ref ntau halftau mu m0synth dtmax ptele psm psar pgps pco
0.1  2.0  5.0 400  1.0 0.2 1   # coefminM0 vrmin vrmax dutrmax coefsmooth_du coefsmooth_vr
356 78 -2 45                     # SEGMENT 1 : strike dip rake of the focal mechanism (conv. Aki) and max rake deviation
176. 25.                                 # total fault length and width (l w) (km)
 2.590306       -51.94585 12.3          # segment center cartesian coord. (xc yc zc)  (km)
8.0 5.0 40                              # length and width of subfaults (sl sw) (km), and number of the subfault corresponding to the hypocenter
```

upper bound for rupture velocity (km/s)

lower bound for rupture velocity (km/s)

weight of reginal data in the inversion

weight of teleseismic data in the inversion