THE 1999 M_w 7.6 CHI-CHI EARTHQUAKE: CO-SEISMIC STUDY BASED ON INSAR AND GPS DATA

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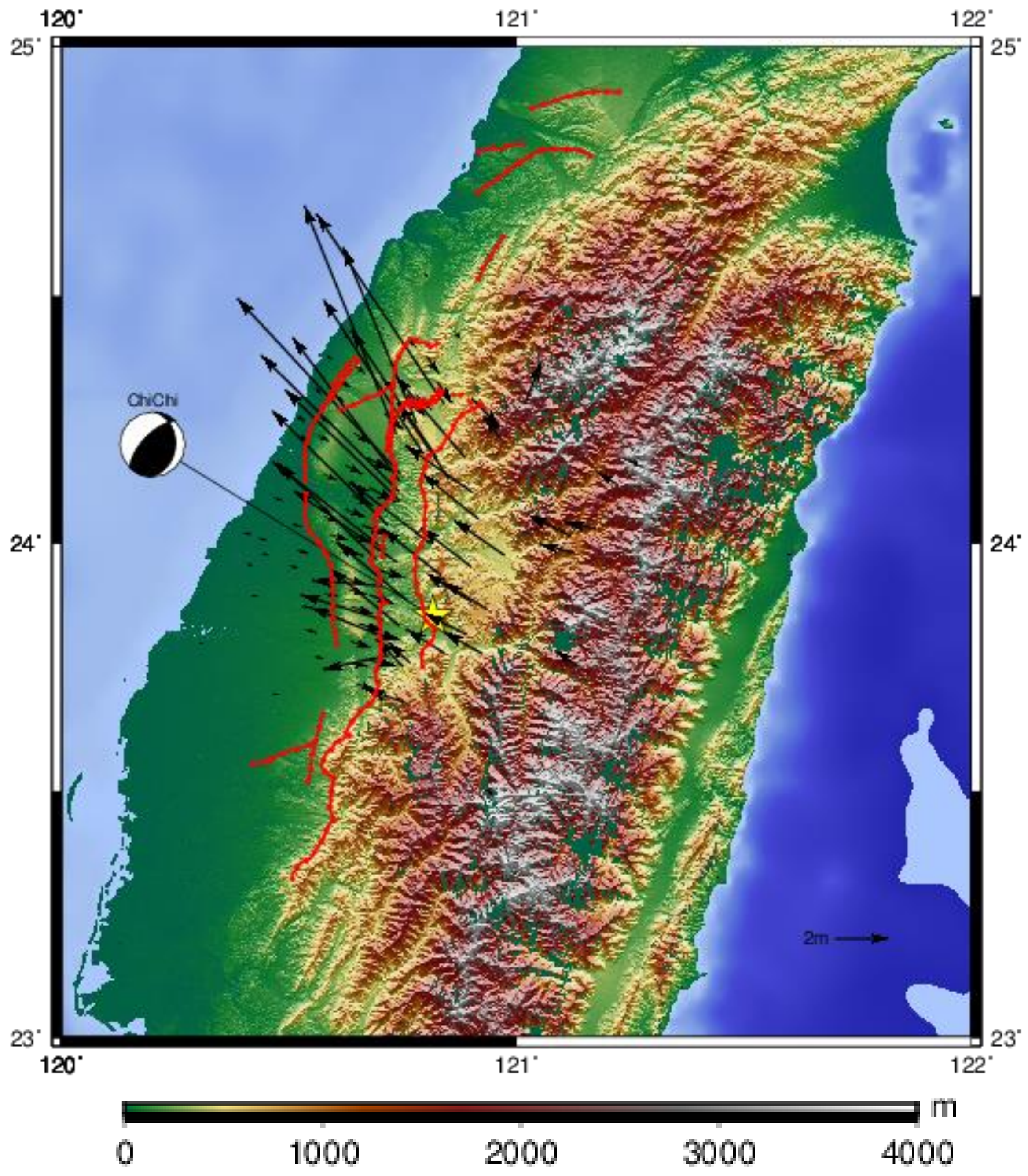
Taiwan is a high risk seismic area located at the collision boundary between the Eurasian and Philippine Sea plates entering in convergence at a rate of 82 $mm.yr^{-1}$. One of the largest inland earthquake in Taiwan happened on 21 September 1999, the M_w 7.6 Chi-Chi event. It struck the Taipei Basin, in the Central western part of the island, killing more than 2400 people and damaging 100 000 structures. Thousands of aftershocks followed, including six with a magnitude superior to 6.5, during the three months after the event, starting at the north and migrating downward of the main event. This earthquake was due to the reactivation of the Chelungpu fault: thrust faulting on a north-south striking fault plane dipping to the east. The rupture was complex with several dislocations, reached the surface and created a 90 km-long scarp between the hanging-wall to the east and the footwall to the west. A clear change of direction is present at the north end of the fault turning toward east.



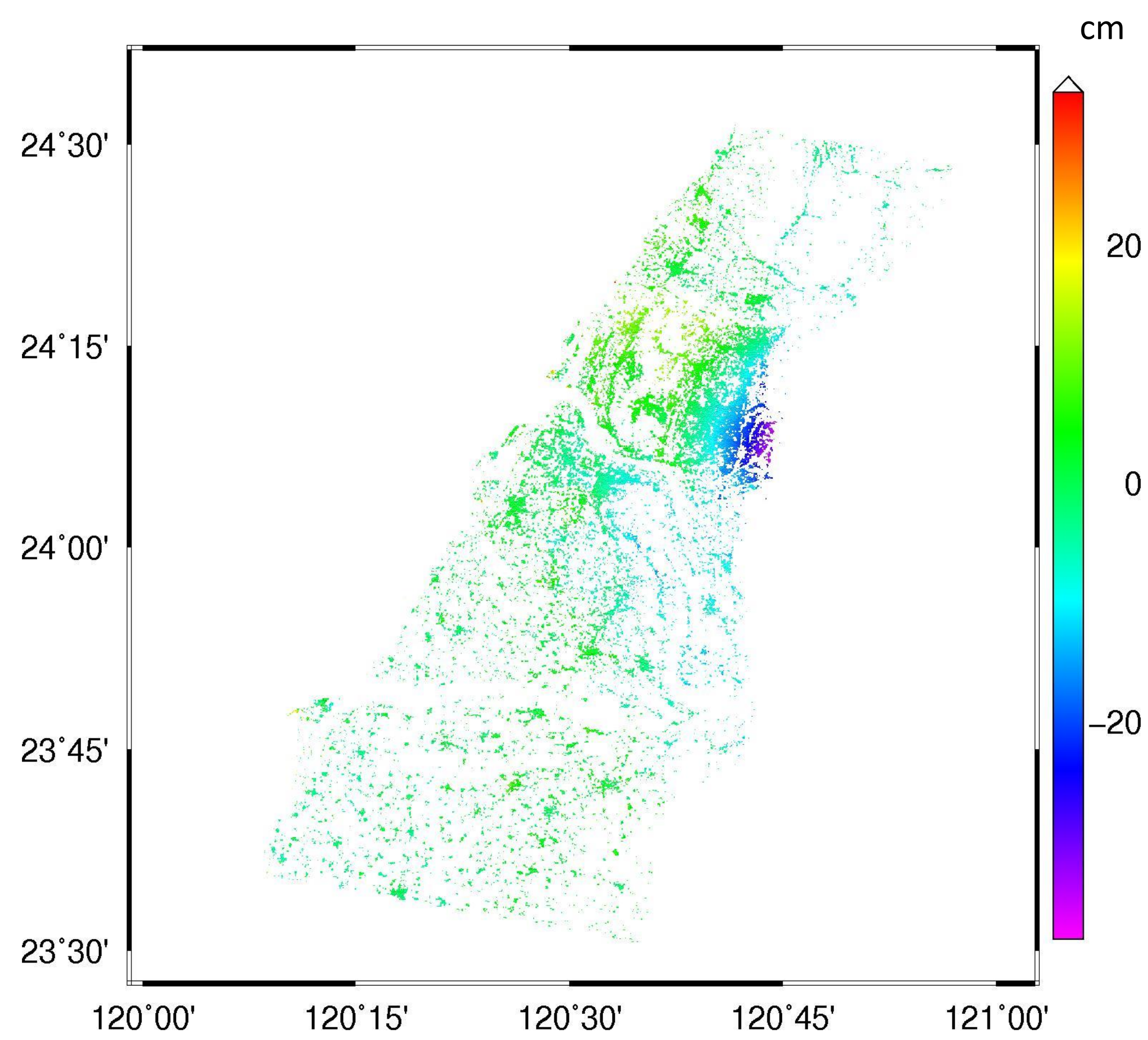
Geodynamic map of Taiwan showing the location and focal mechanism (CWB) of the Chi-Chi earthquake, position of faults and GPS data from *Yu et al. 2001.*

CO-SEISMIC DISPLACEMENTS

GPS and InSAR are complementary data to study surface deformation. Thanks to the GPS network present in Taiwan, we can study both side of the Chelungpu fault even the hanging-wall (east side) where no InSAR data are available (no coherence due to dense vegetation). We can see the thrust fault movement of the fault: subsidence of the footwall of the Chelungpu fault and larger movements of the hanging wall.

According to **GPS data**, the maximum uplift is of 4.4m and **0.26m** of subsidence. 9m of horizontal movement on the hanging-wall and **1.5m** on the footwall.

Four ERS-2 SAR images were selected and processed using SNAP (ESA open source software) and unwrapped thanks to SNAPHU. About **12 fringes** are present on the footwall of the fault (1 fringe = 2.8 cm), about **33cm** of deformation.

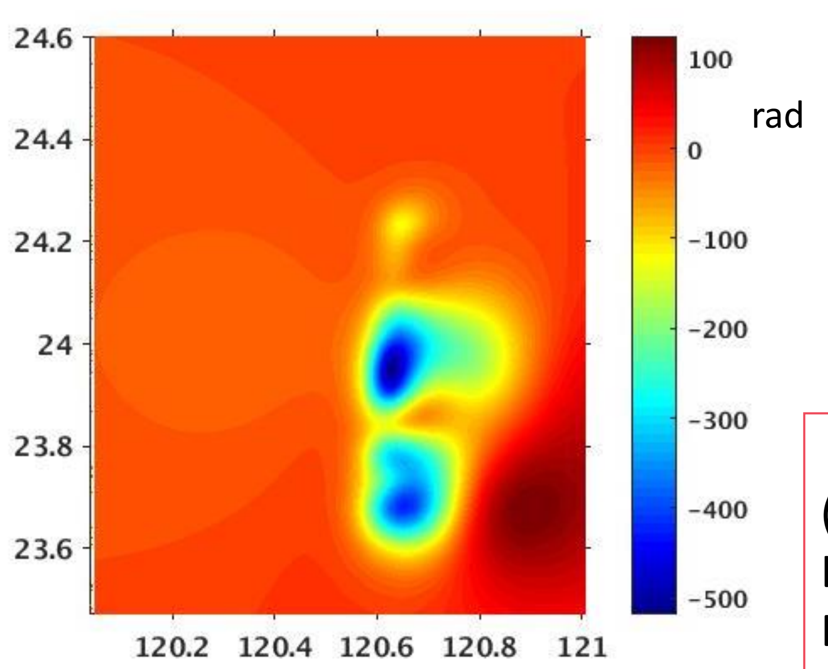


Unwrapped interferogram (21/01-28/10/1999) processed with SNAP/SNAPHU and corrected from the tropospheric effect thanks to GACOS (*Yu et al. [2017a]* & *Yu et al. [2017b]*). The DEM used for this study is SRTM 30m.

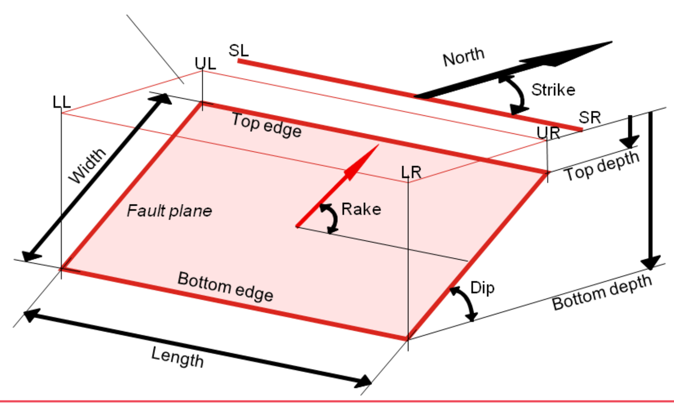
GEODETIC INVERSION

The modelling is done thanks to PSOKINV (Particle Swarm Optimization and OKada Inversion), a program written by Wanpeng Feng (*Feng et al. 2013*). The steps are described in the following graph:

- Unwrapped interferograms — INPUT DATA — GPS data
- Linear trend removal
- Downsampling of InSAR observations by Quadtree algorithm
- Fault parameters determination using improved particle swarm optimization under an assumption of an uniform slip on a rectangular fault
- Slip distribution over the fault plane: iterative technic for estimating optimal dip angle and smoothing factors
- Simulation of the observations and computation of residuals

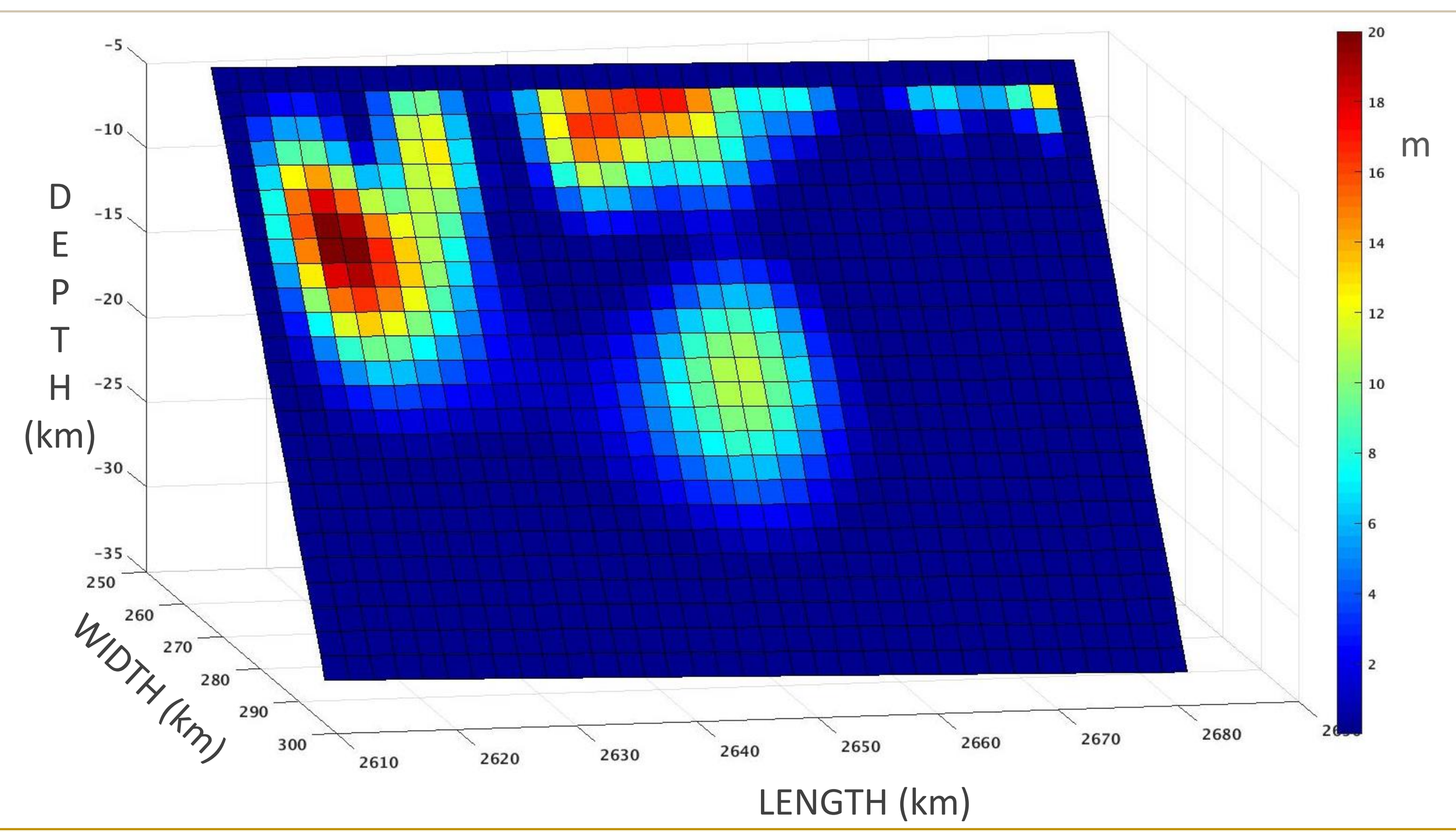


Simulated co-seismic deformation field



Fault geometry
(image from http://diss.rm.ingv.it)
Length = 55km | Width = 25km
Dip = 34.5° | Rake = 65° | Strike = 5°
Top depth = 5km
Slip opening = 1.67m

Slip distribution obtained by PSOKINV using three InSAR products and GPS data



PRELIMINARY CONCLUSION

The modelling of the Chelungpu fault due to Chi-Chi earthquake has been done based on interferograms of the footwall and about 100 GPS stations covering both side of the fault. The model we obtained still need some refinements but is in agreement with previous studies using different data: mainly GPS but also strong ground motion, teleseismic... The main issue comes from the low coherence of the SAR products on the footwall, no data on the hanging-wall and sparse GPS data.
In order to improve our work, levelling as well as optical data (SPOT images) will be processed and added to PSOKINV. Pixel offset determination from radar and optical data are also in process. Furthermore, to get a consistent model, the fault should be divided in several segments as shown by previous studies (*Zhang et al. 2007*) and the GPS data (an east turn is visible at the north of the fault and a west one at the south).
This work is the first part of my PhD studying the earthquake cycle of this event.

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