Relation between the spatial variation of creep rate and the 2017 Mw 6.5 Ormoc earthquake along the Philippine fault on Leyte Island

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Acknowledgements

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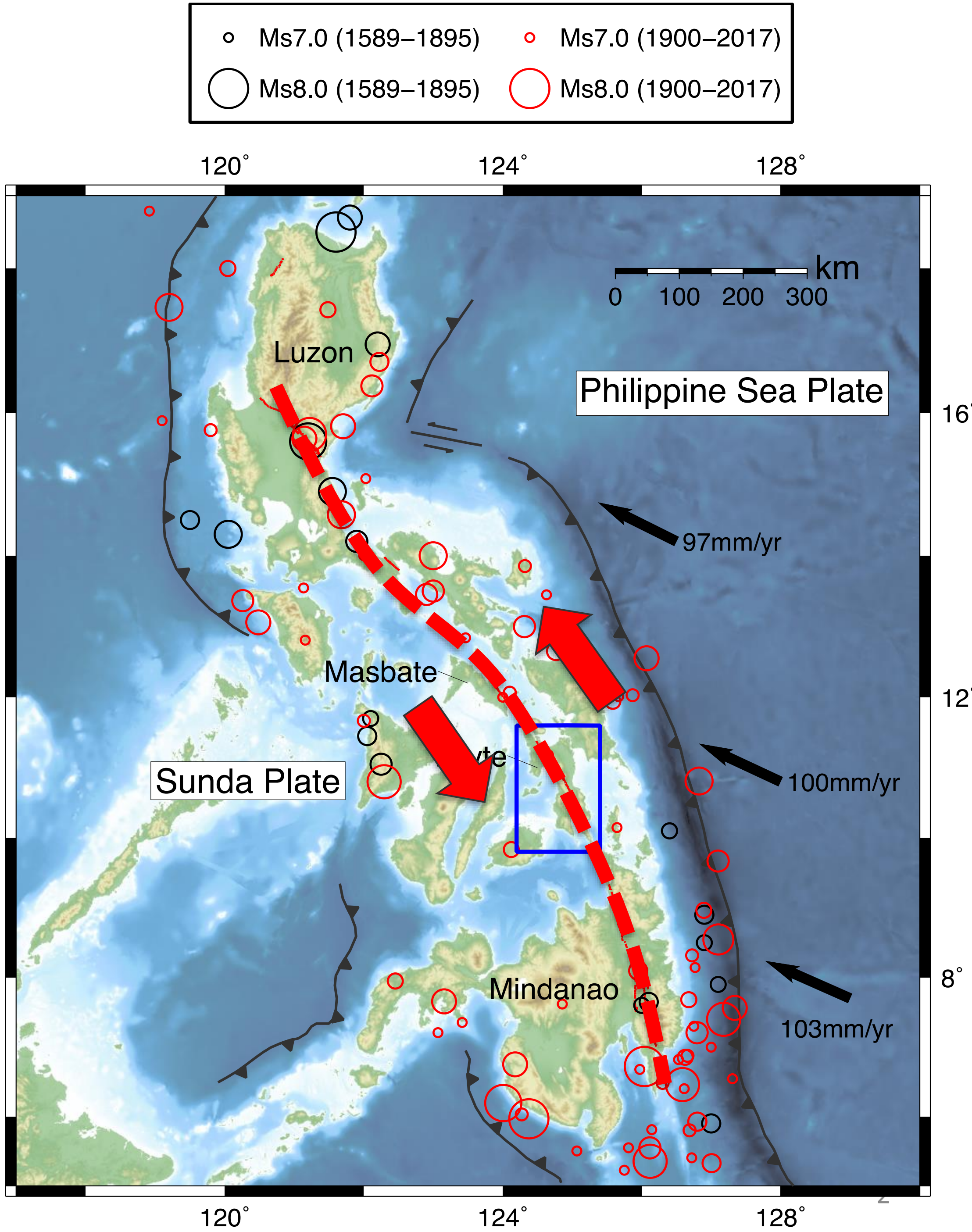
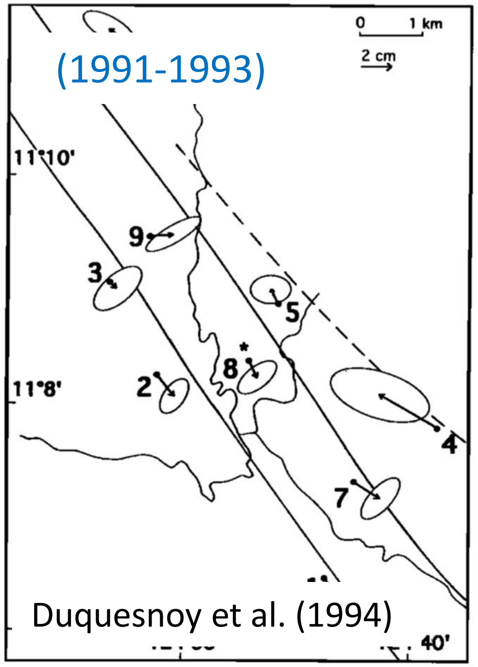
Philippine Fault accommodates the left-lateral component of the oblique subduction

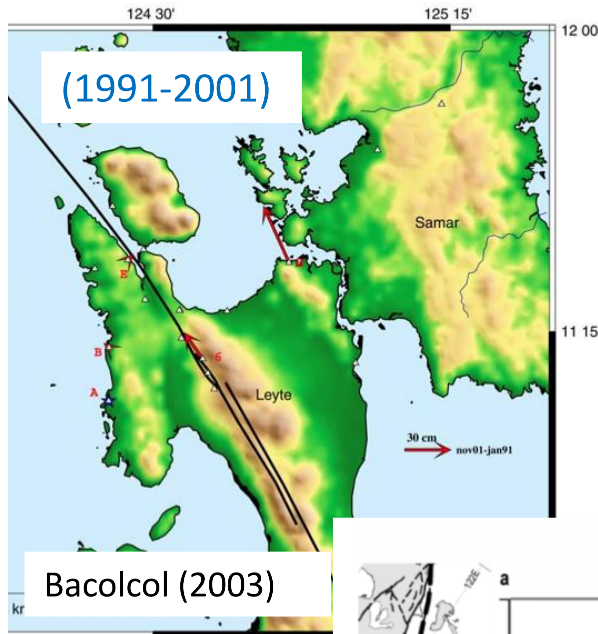


Indication of creep at Philippine Fault on Leyte

from GPS



Duquesnoy et al. (1994)



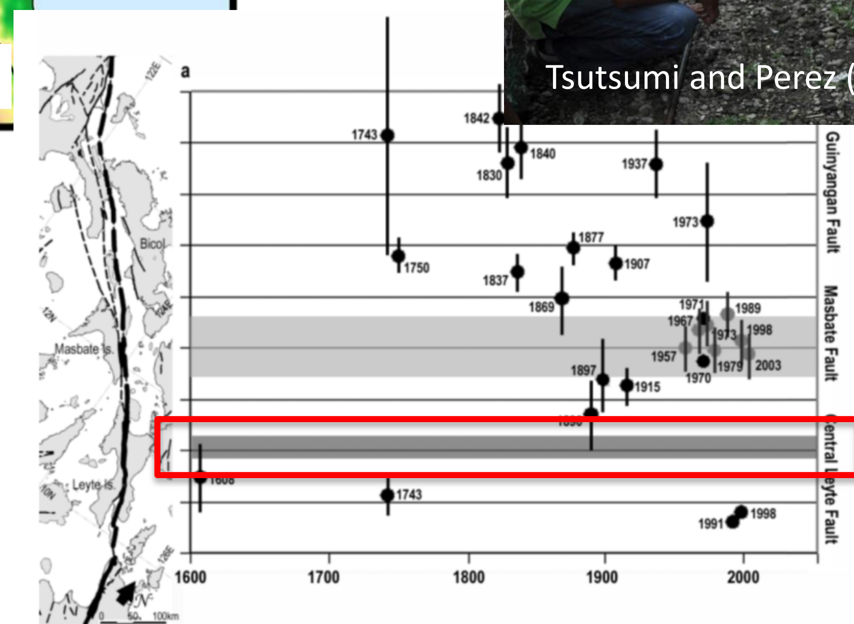
Bacolcol (2003)

from field surveys

Tsutsumi and Perez (2011)

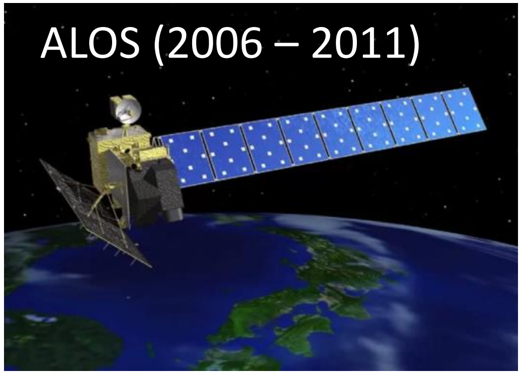
from historical seismicity

"No large EQs = Indication of creep" (Besana and Ando, 2005)

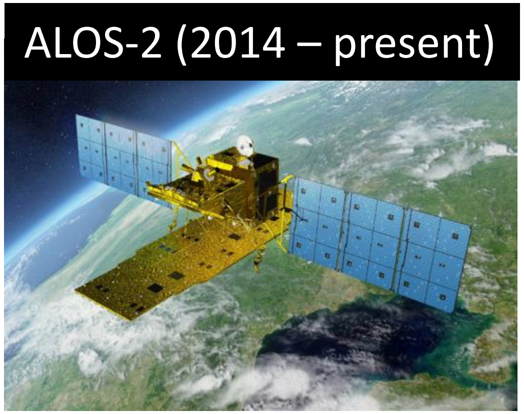


Purpose of the Study

1. Obtain the detailed spatial variation of the creep of the Philippine Fault on Leyte by InSAR time-series analysis



2. Obtain the fault slip distribution of the July 2017 earthquake from InSAR analysis

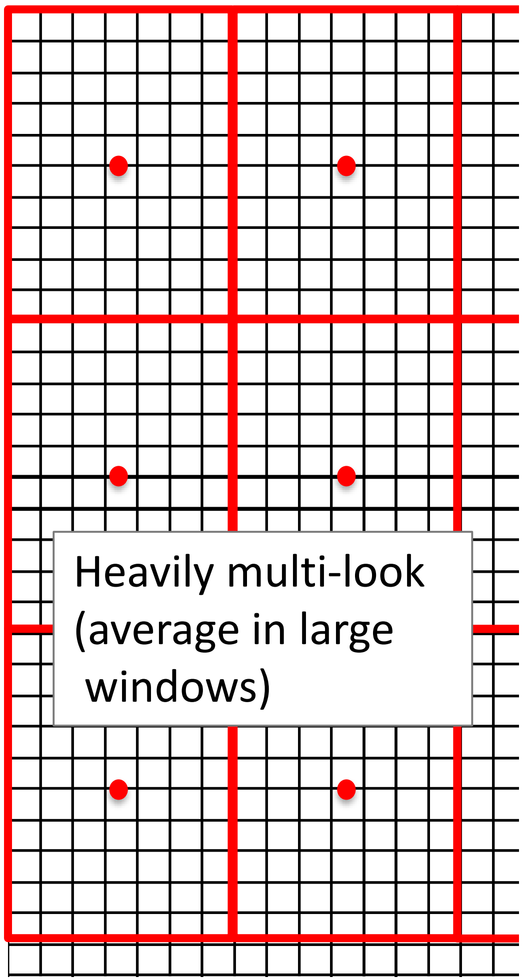


3. Discuss the relation between the creep and earthquake slip distributions

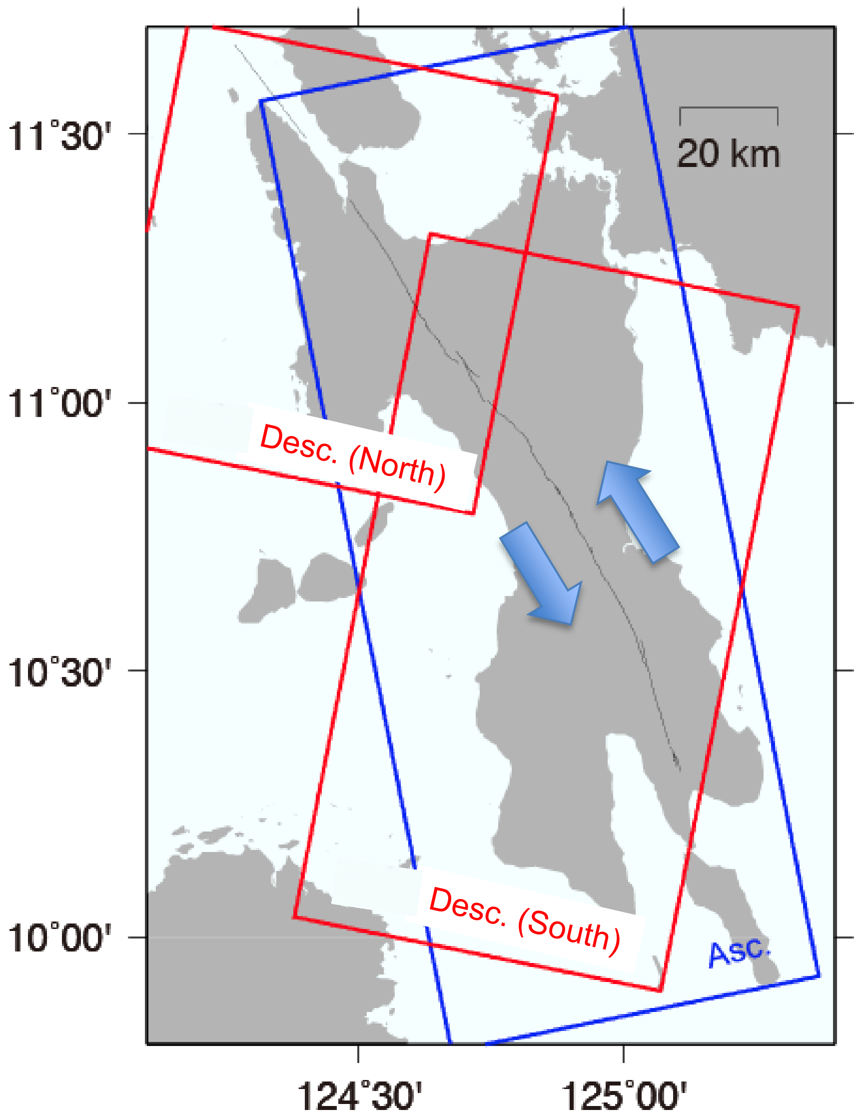
Analysis 1: Creep rate estimation

Method of InSAR Time-Series Analysis

- Small-baseline approach
- Heavily multi-look the interferograms before solving for the displacement time-series
  (-> pixel interval ~500 m)
- Offsets and bi-linear trends in the interferograms were estimated simultaneously

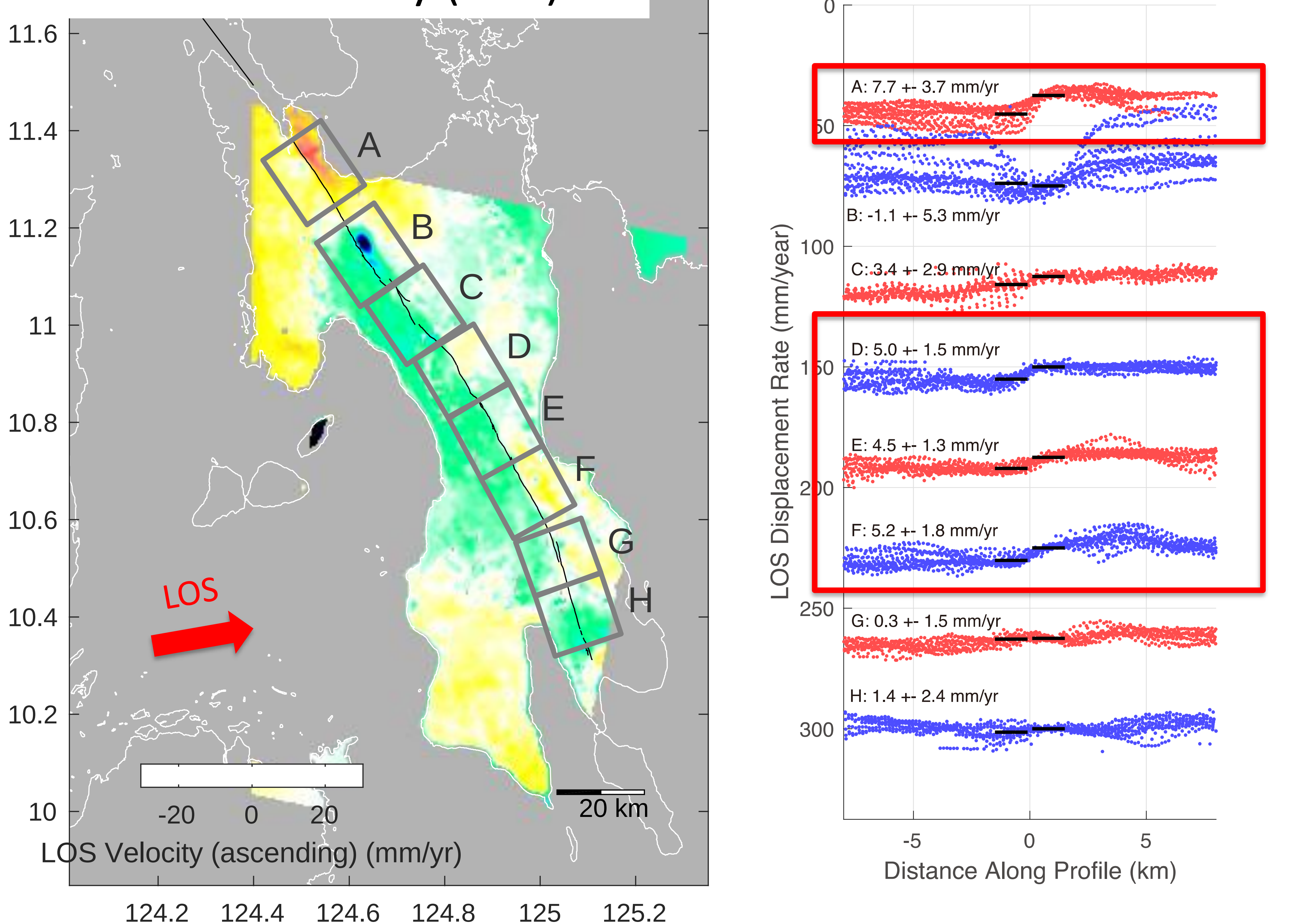


Used ALOS Dataset for Creep Rate Estimation

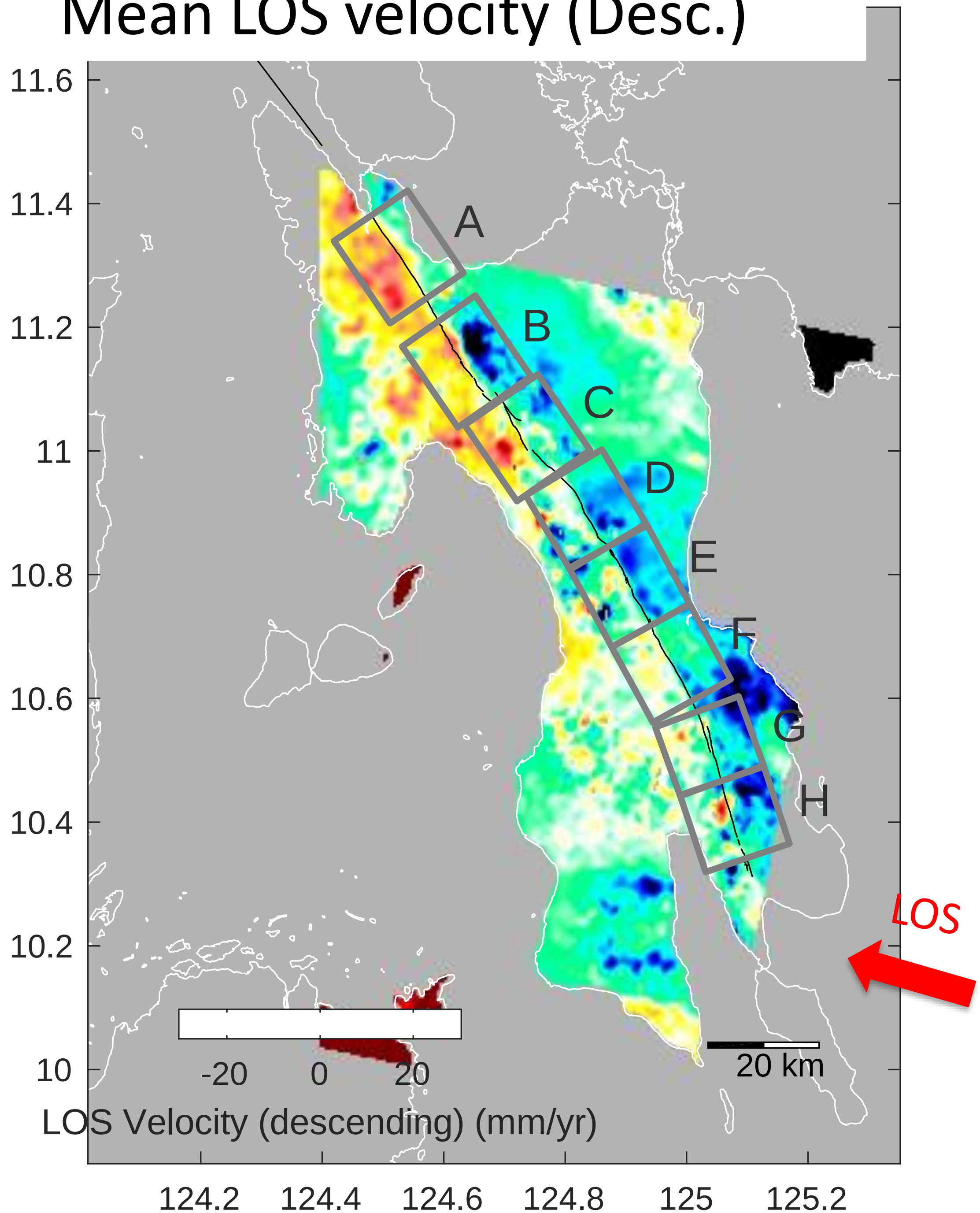


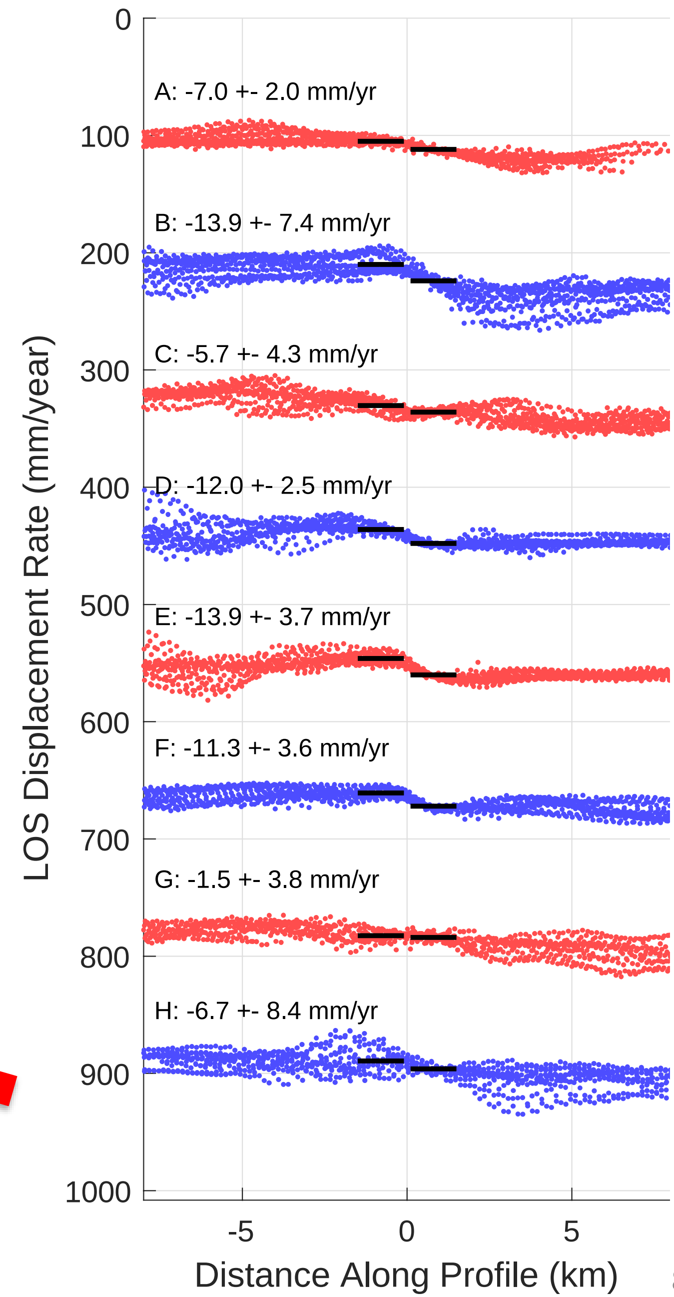
- Oct. 2006 to Jan. 2011 (4.3 years)
- 20 ascending images, covering the whole island
- Descending images,
  3 for the northern path
  5 for the southern path
  more sensitive to the creep

Mean LOS velocity (Asc.)



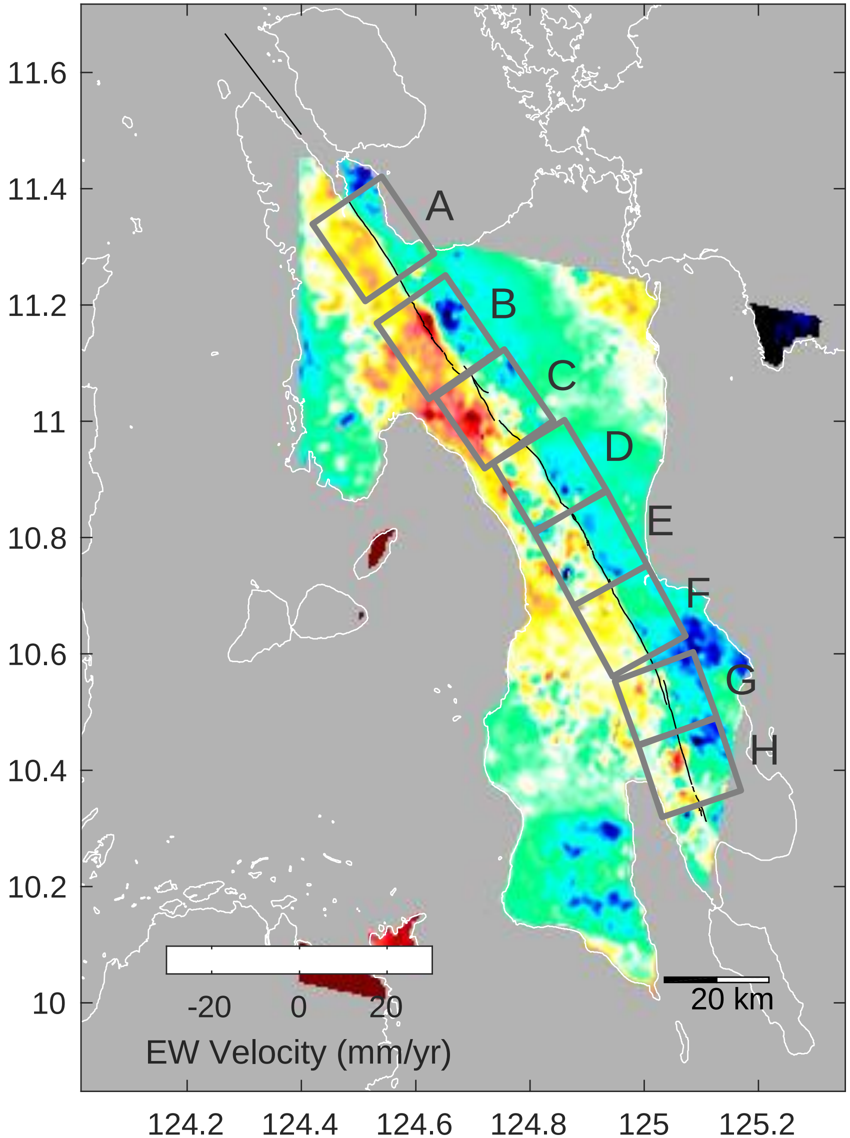
Mean LOS velocity (Desc.)



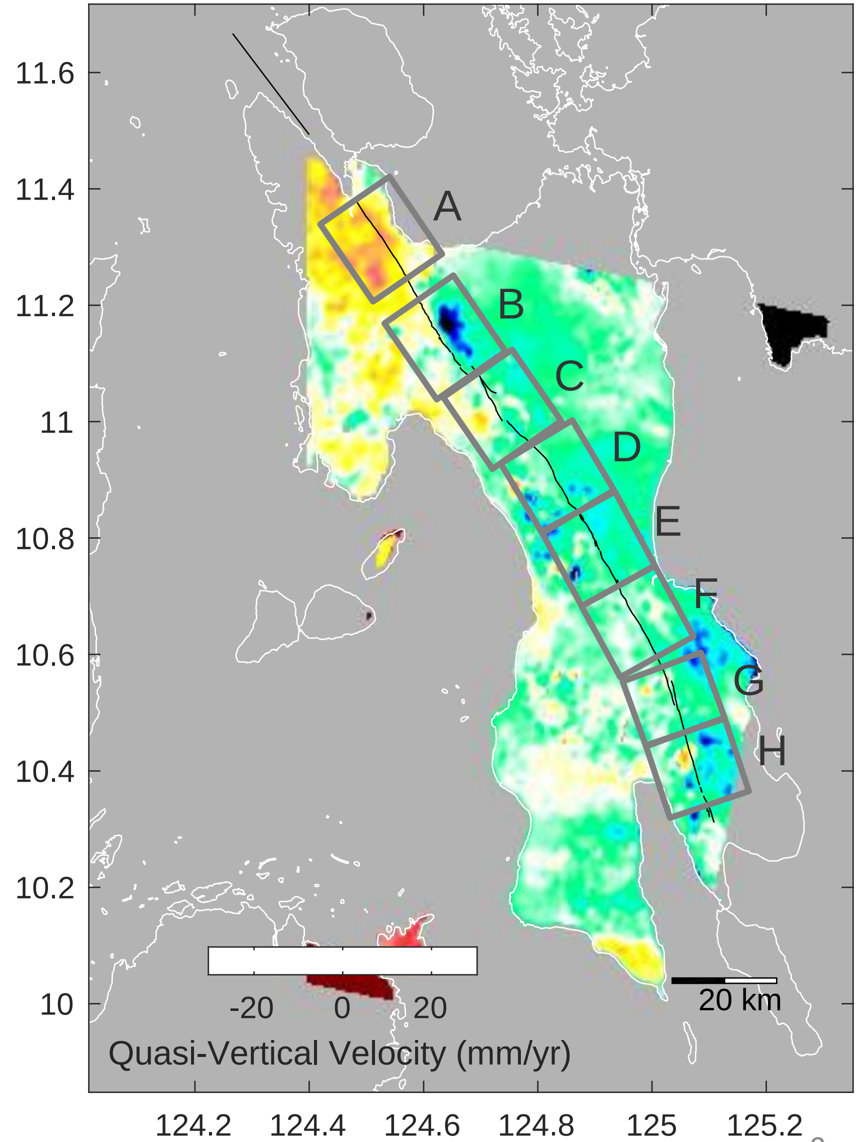


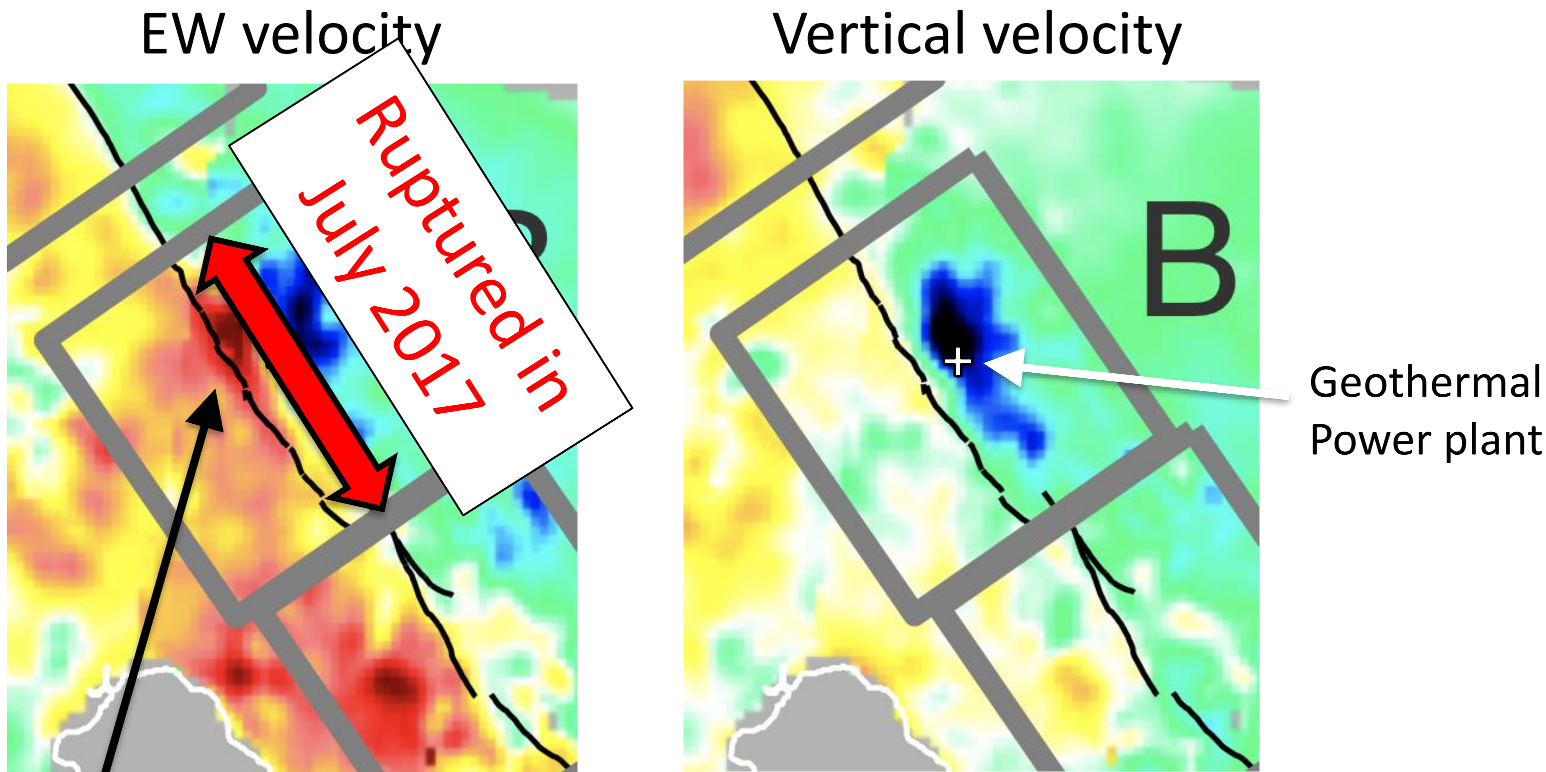
2D Decomposition

EW Velocity (mm/yr)

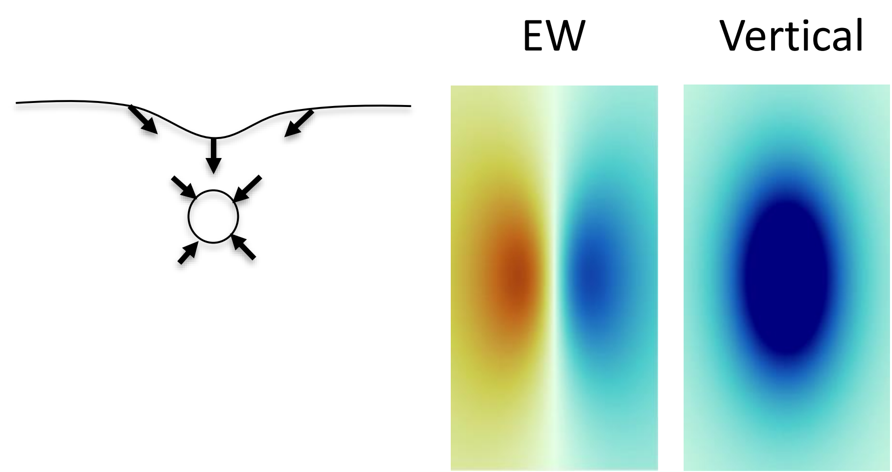


Quasi-vertical Velocity (mm/yr)



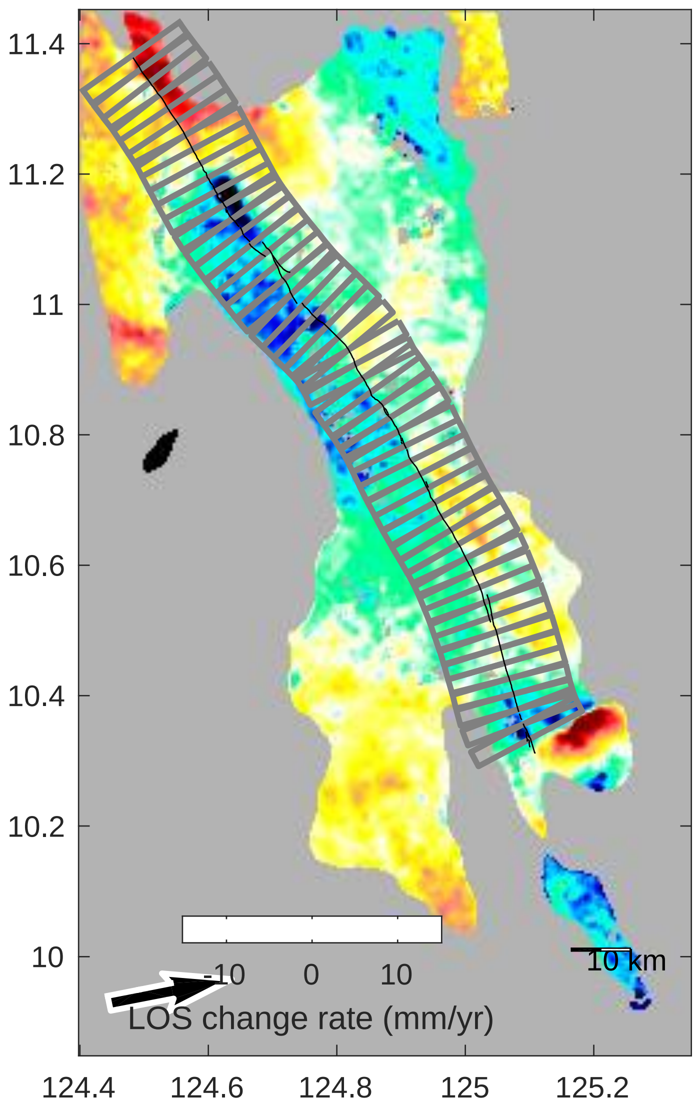


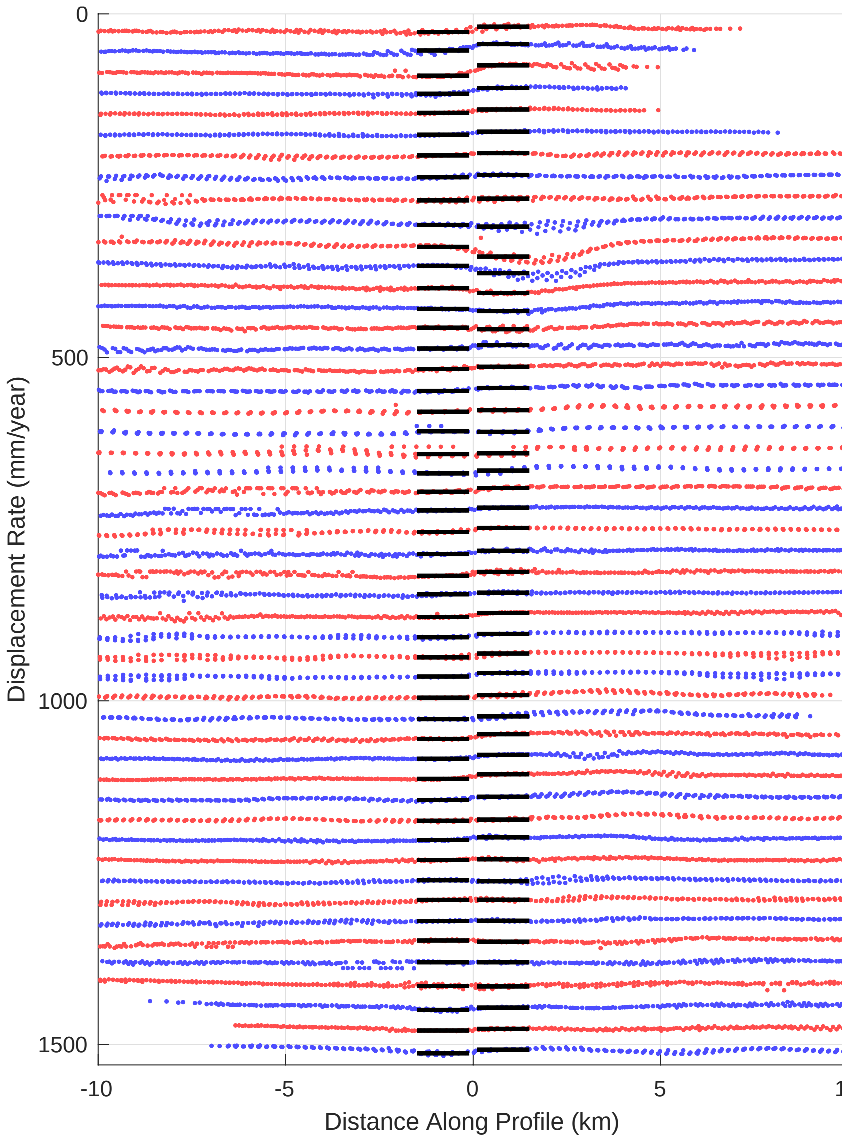
NOT creeping, rather similar to the pattern of subsidence due to subsurface depressurization



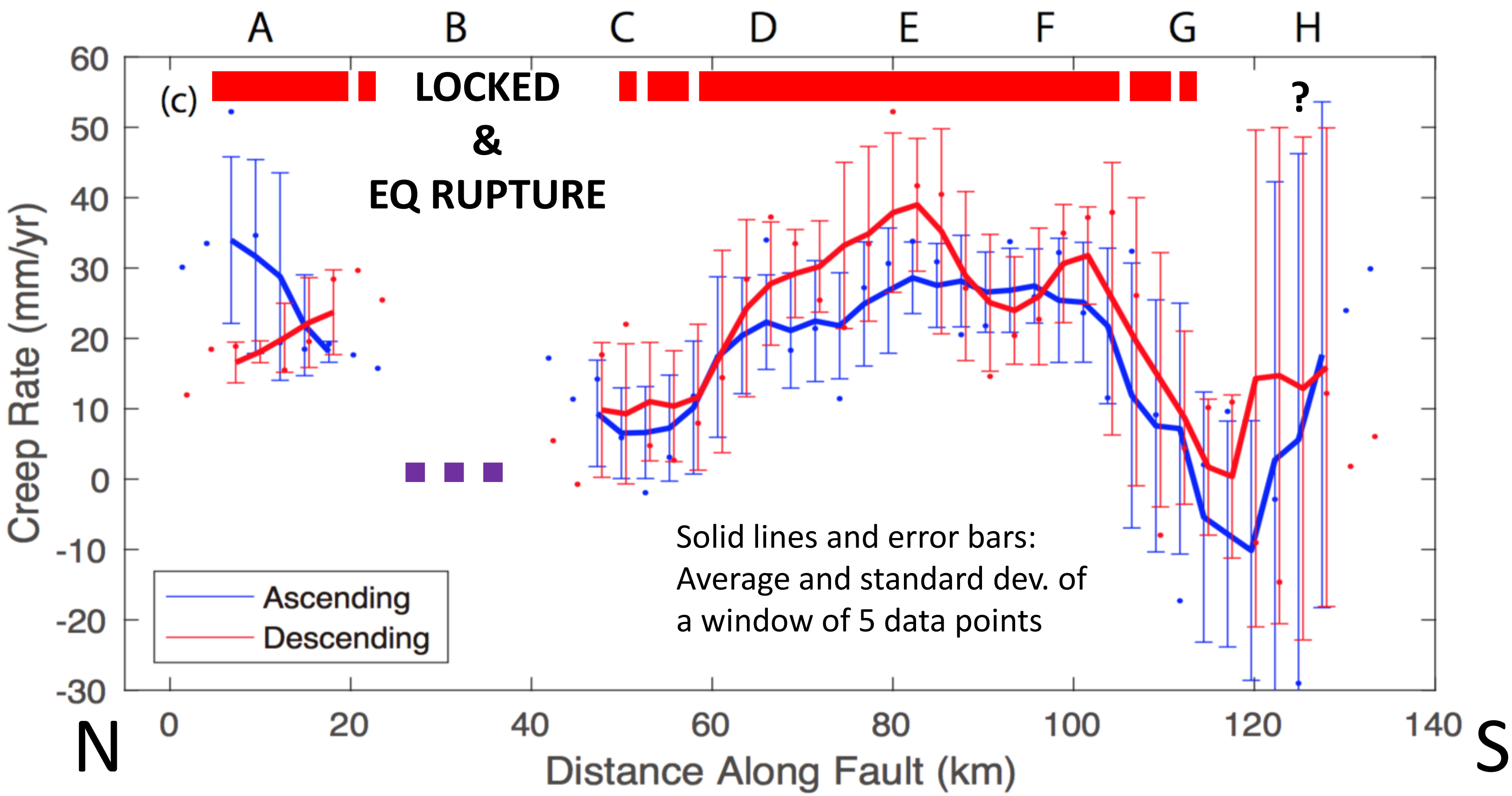
Estimation of Creep Rates:

1) Measure the offsets in each of the 50 boxes
2) Convert LOS displacement rates into creep rates (fault strike is known)





Estimated Creep Rates



Consistent results obtained from independent asc. and desc. datasets

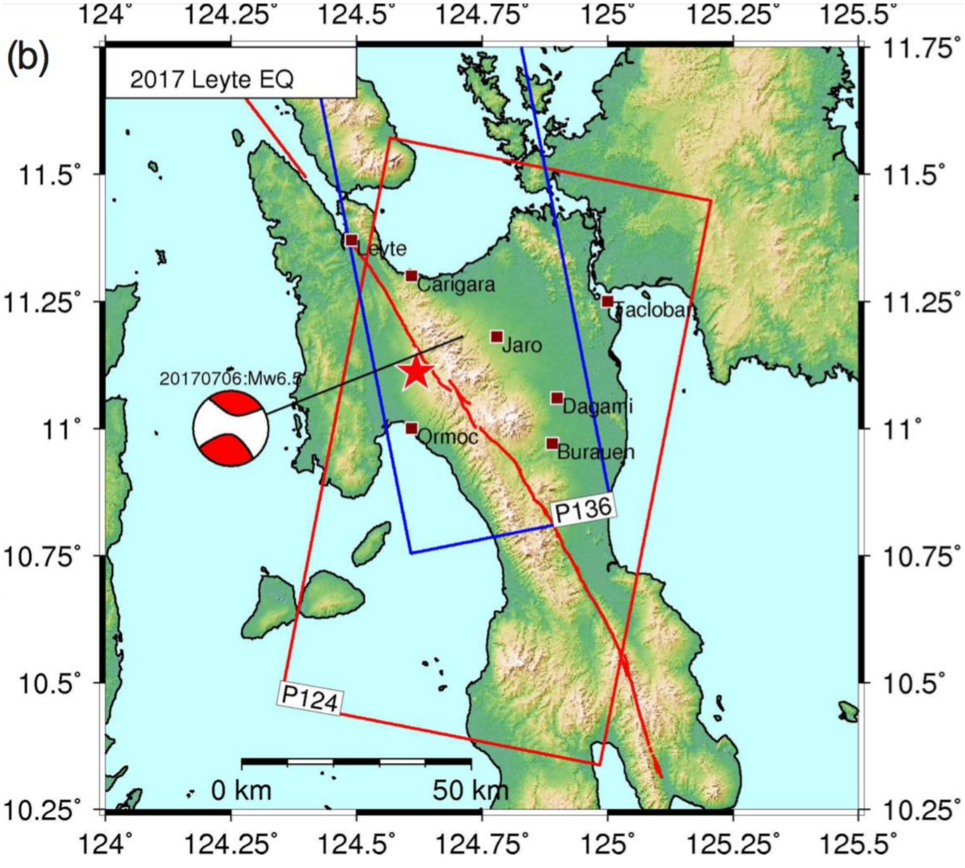
A and D to F: creeping with 20 – 30 mm/yr

B: locked (and ruptured in 2017)   C: transition zone

G: transition zone?   H: cannot be known from this study

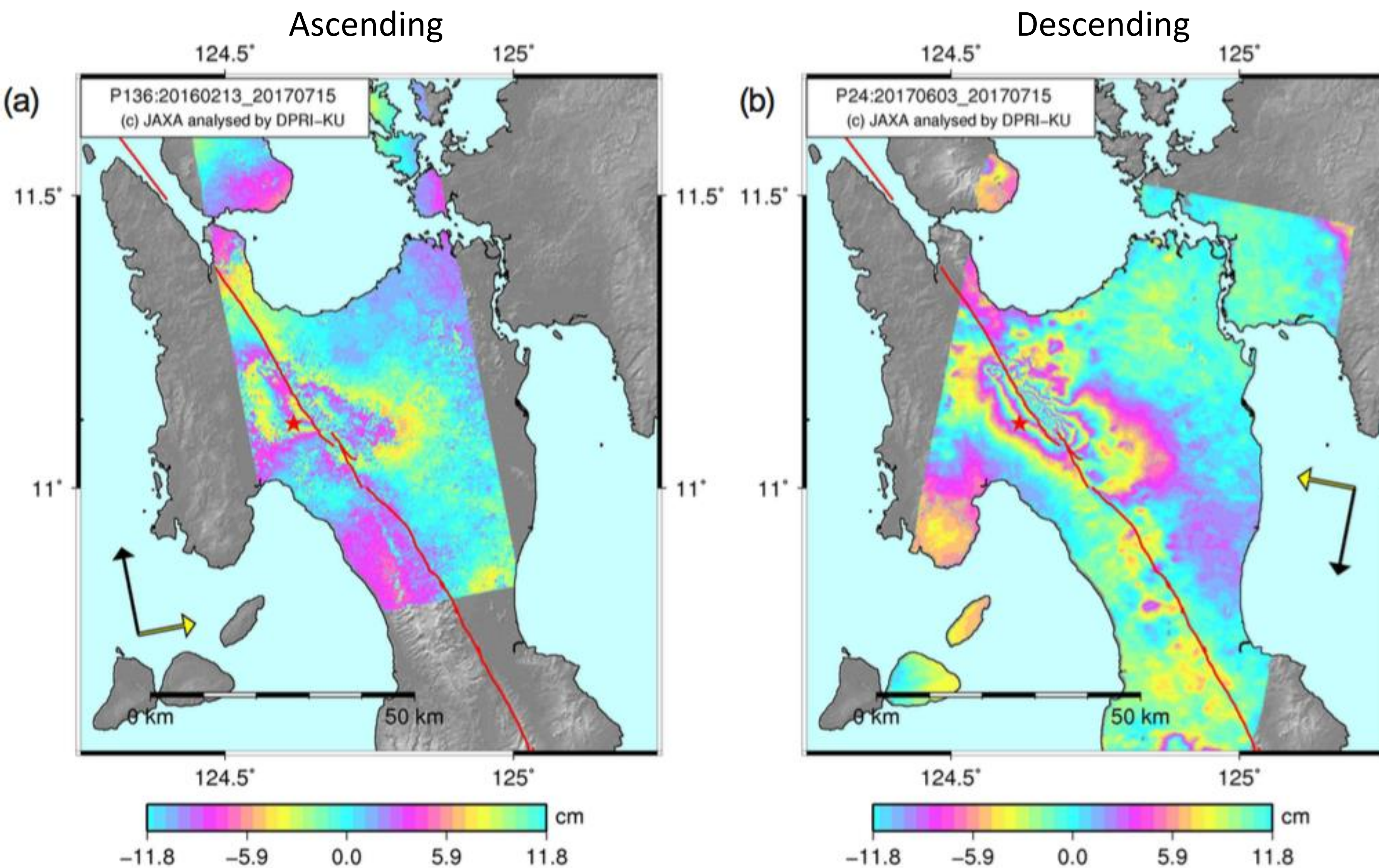
Analysis 2: Earthquake of July 2017

http://www.interaksyon.com/look-phivolcs-shows-pics-of-ground-rupture-after-leyte-quake/

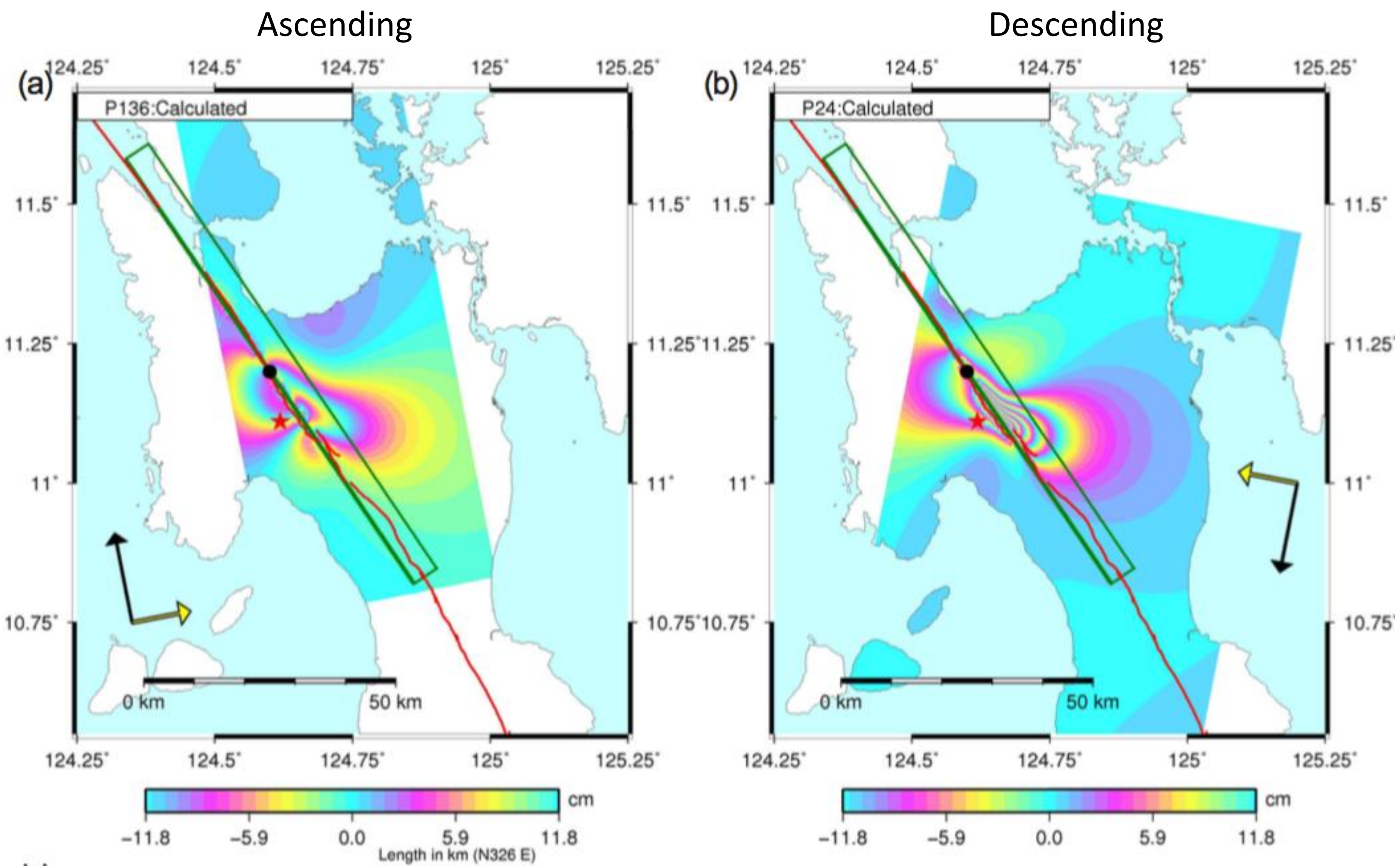


- Along the mapped fault
- Left-lateral (consistent w/creep)
- One of the largest EQ in the historical seismicity

ALOS-2 coseis. interferograms

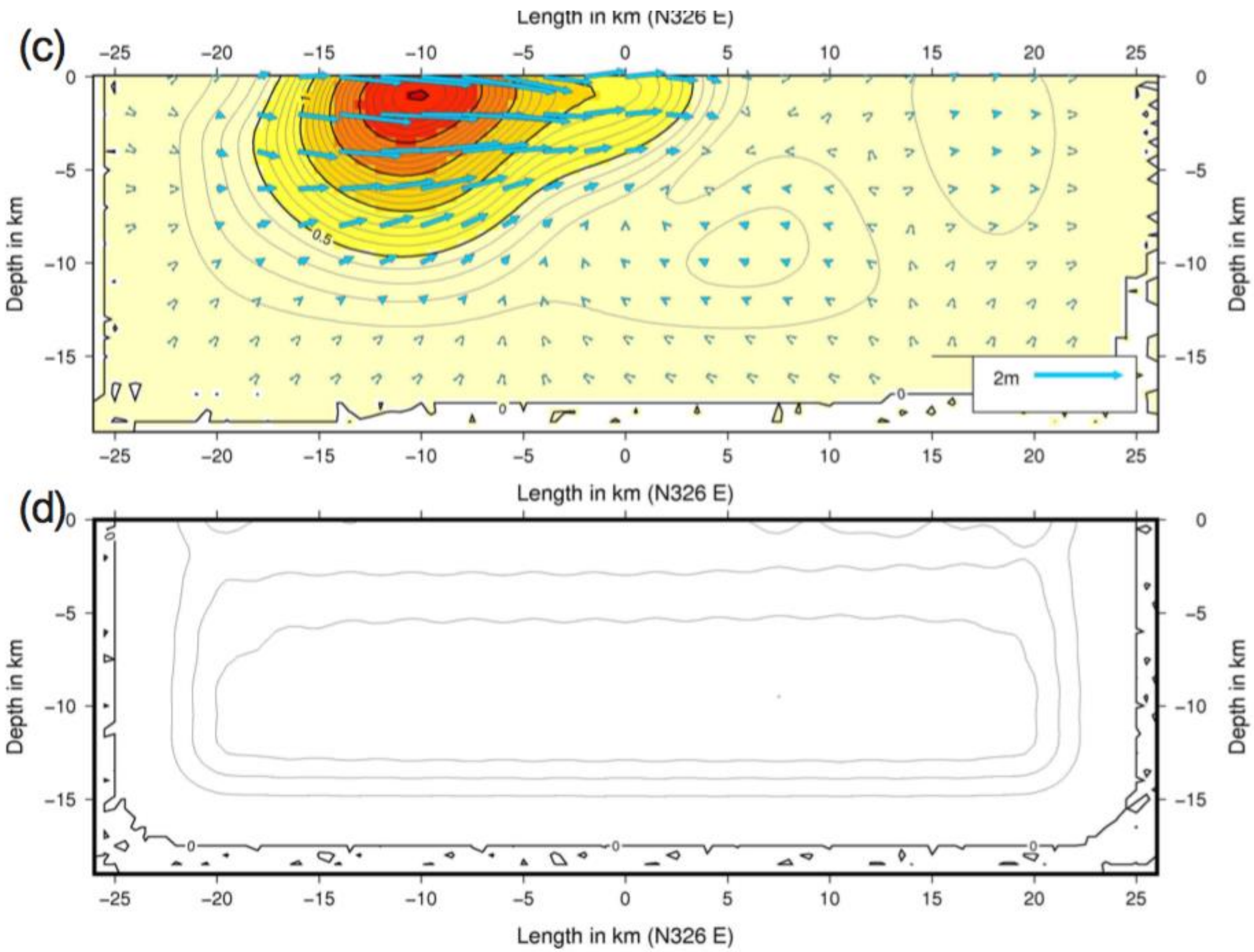


ALOS-2 modeled interferograms



Good fit except for the region west and very close to the fault

(c) Slip distribution and (d) error distribution



Solved with the method of Fukahata and Wright (2008)

Estimated Mw 6.5

Estimated dip angle was 74 deg. Toward NE

Max. slip ~ 2.5m

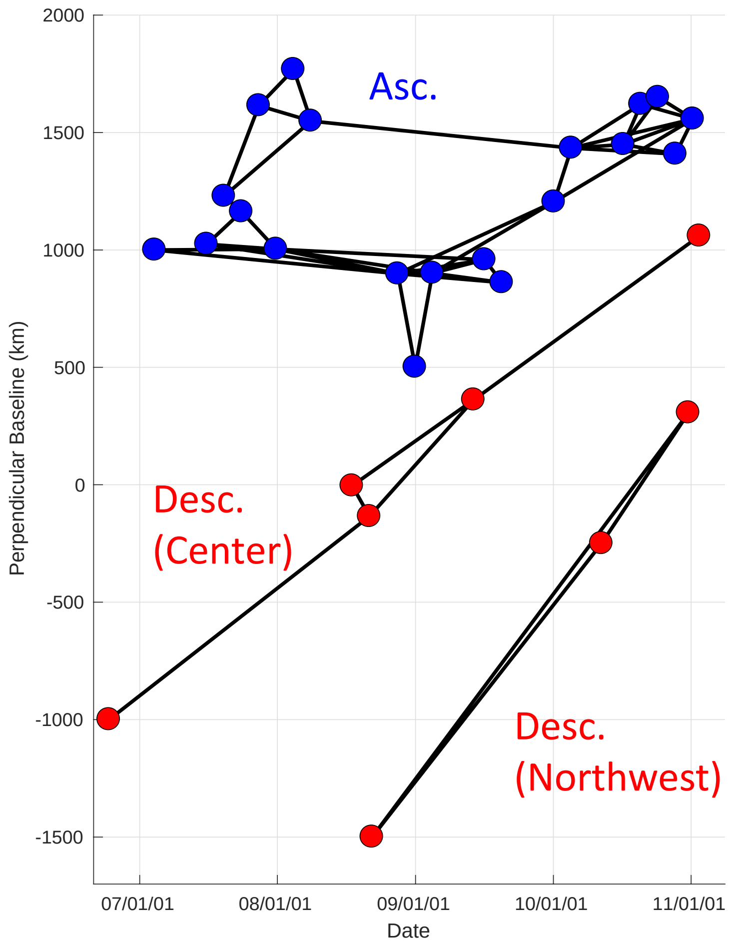
Shallow (< 10km) (due to large thermal gradient?)

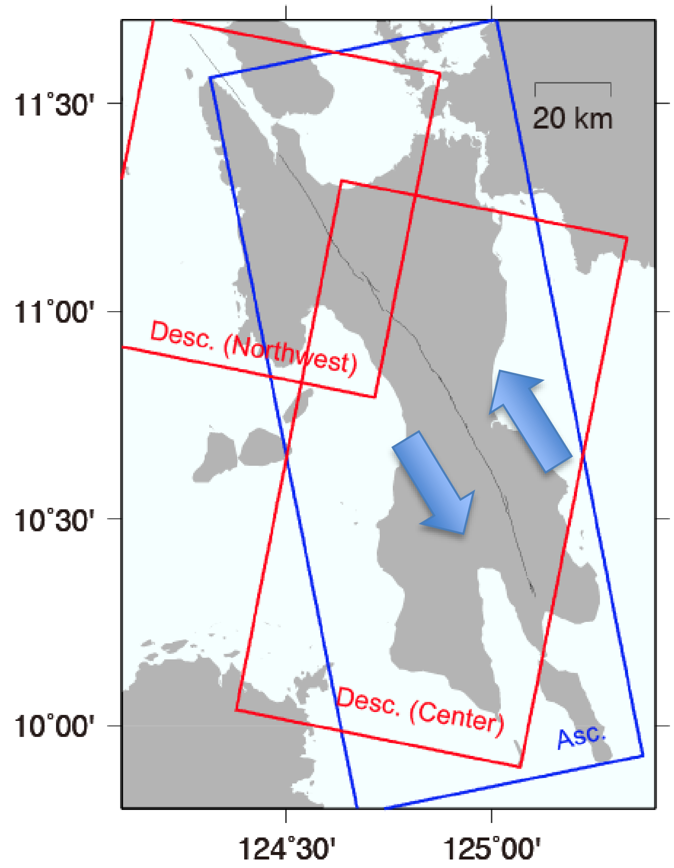
Discussion, Conclusions and Additional Remarks

- Creeping part had 20 – 30 mm/yr of creep rate.
- 2017 rupture (max. 2.5m) coincides with the locked portion of the fault. 2.5 meters of slip deficit would accumulate in 100 years.
- The largest historical EQ (1589 - before 2017) was a Ms 7.0 event in 1947 (70 years apart), located close (21km from the 2017 epicenter, PHIVOLCS catalogue comparison). The seismic waveforms are also similar. 1947 and 2017 events may be “repeating earthquakes” that ruptured the same and isolated asperity.

Dataset

- ALOS/PALSAR (Oct 2006-Jan 2011), asc. & desc.

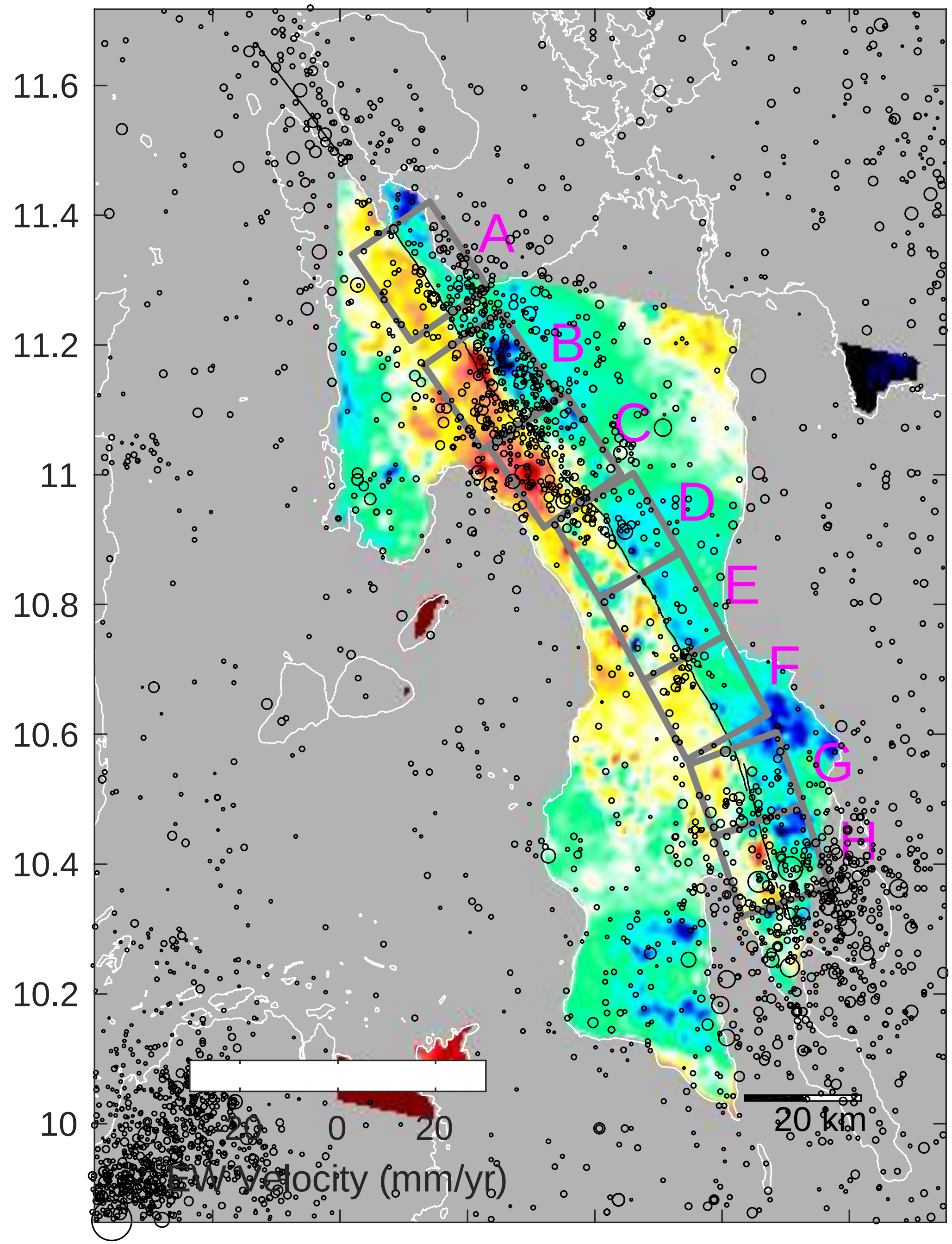




Comparison with Seismicity 1980-2016

PHIVOLCS catalogue
All magnitude, depth < 50km

Anti-correlation of creep rate and seismic activity



Observation Equation for InSAR T-S analysis

Unwrapped phase at the *k*-th pixel of the *i*-th ifg:

$$\phi_{i,k} = \frac{4\pi}{\lambda}\mathbf{g}_i\mathbf{v}_k + a_i + b_i x_k + c_i y_k + f_i h_k + \frac{4\pi}{\lambda}\frac{B_{\perp i,k}}{R_{i,k}\sin\theta_{i,k}}\delta h_k$$

Phase (Obs.)	LOS displ.	Offset	Ramp（bilinear）	Correlated w/altitude	DEM error contribution

We solve for:

- ***v***：Velocity time-series at every px
- *a, b, c, f*：coefficients for every ifg
- δ*h*：DEM error for every px

Technically, two-step approach is taken such that *a, b, c,* and *f* are determined using data at selected pixels, then solve for the displ. and DEM errors.