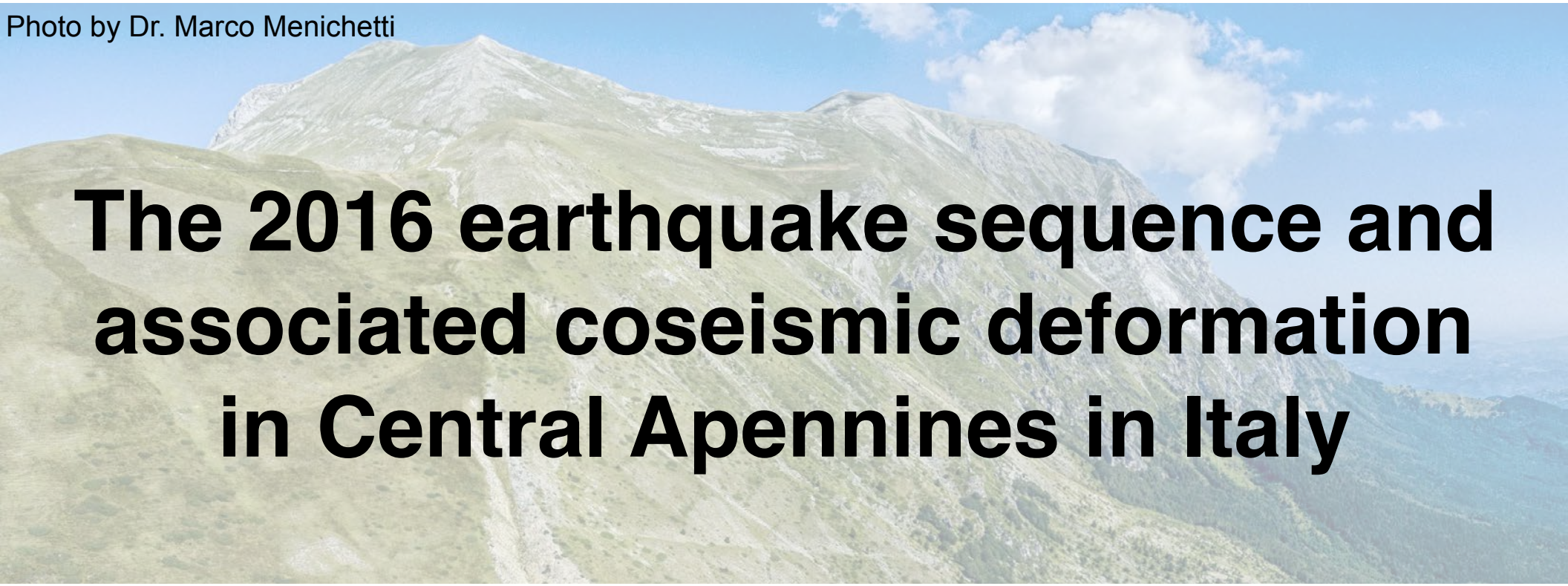

The 2016 earthquake sequence and associated coseismic deformation in Central Apennines in Italy

Mong-Han Huang[1], Eric Fielding[1], Cunren Liang[1], Pietro Milillo[1], David Bekaert[1], Douglas Dreger[2], Jacqueline Salzer[3]

[1]Jet Propulsion Laboratory, Caltech
[2]Berkeley Seismological Laboratory, UC Berkeley
[3]GFZ German Research Centre for Geosciences

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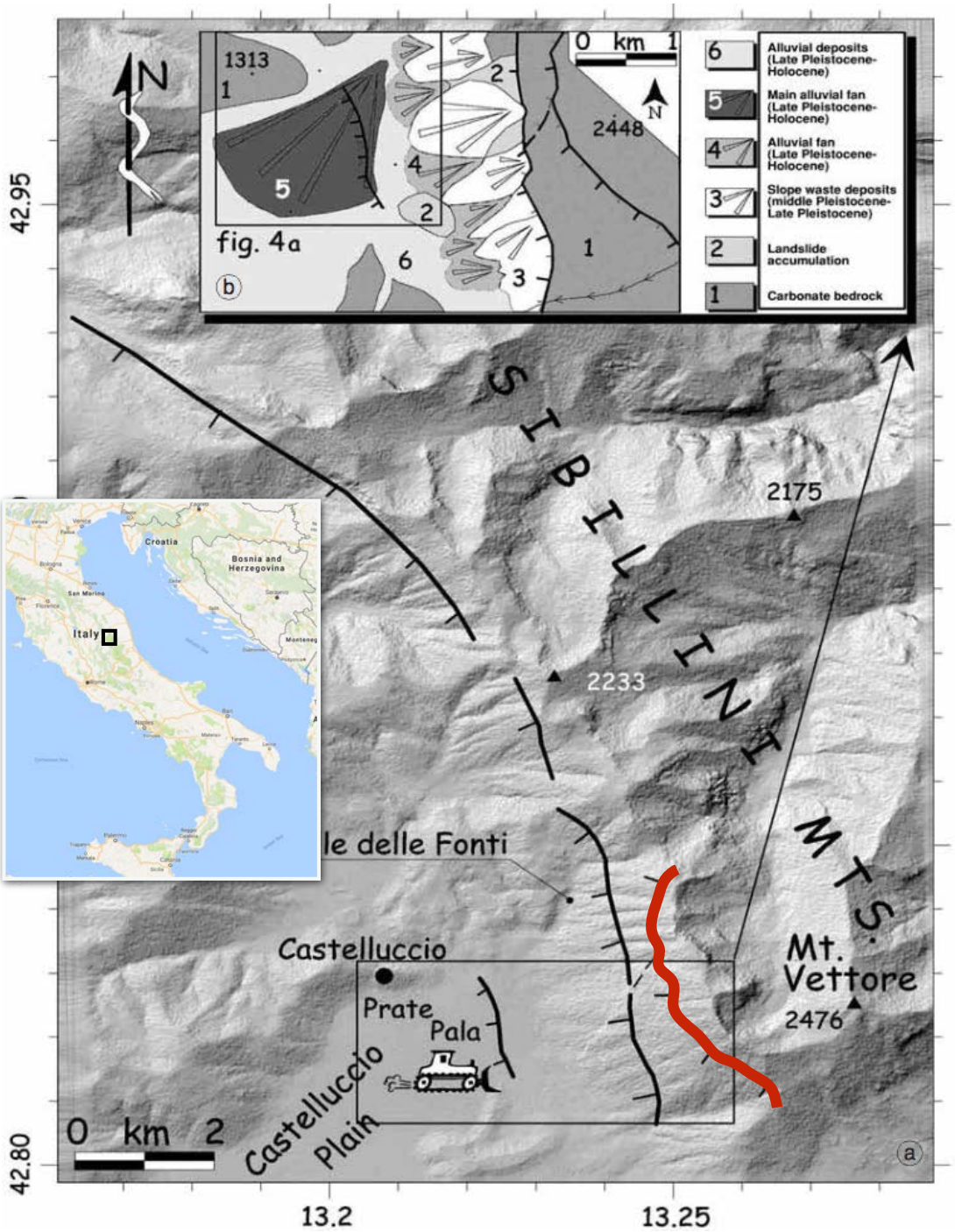
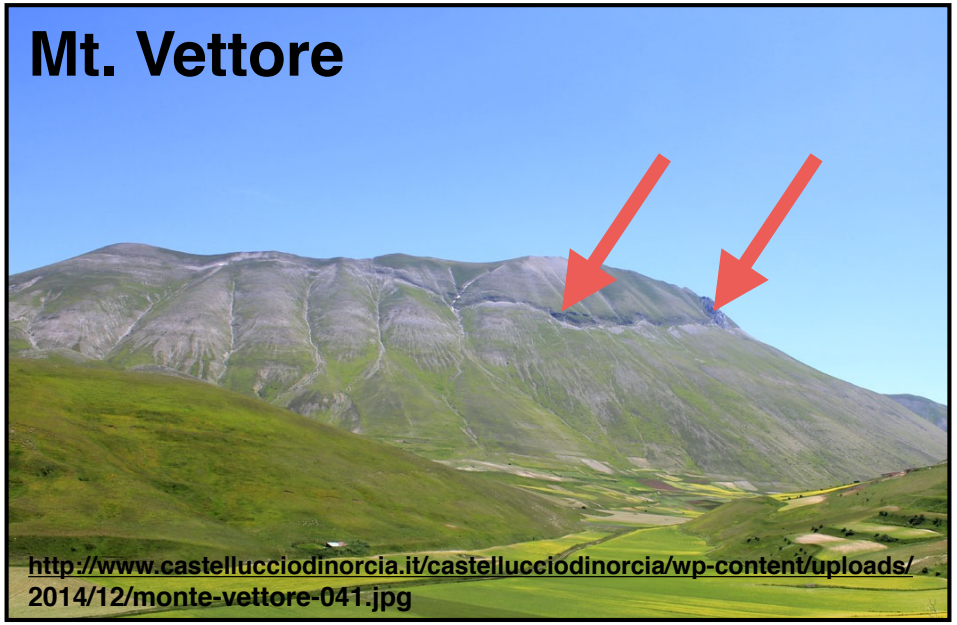
The Mt. Vettore Fault





Limestone scarps

Slip rate: 0.11 - 0.36 mm/yr

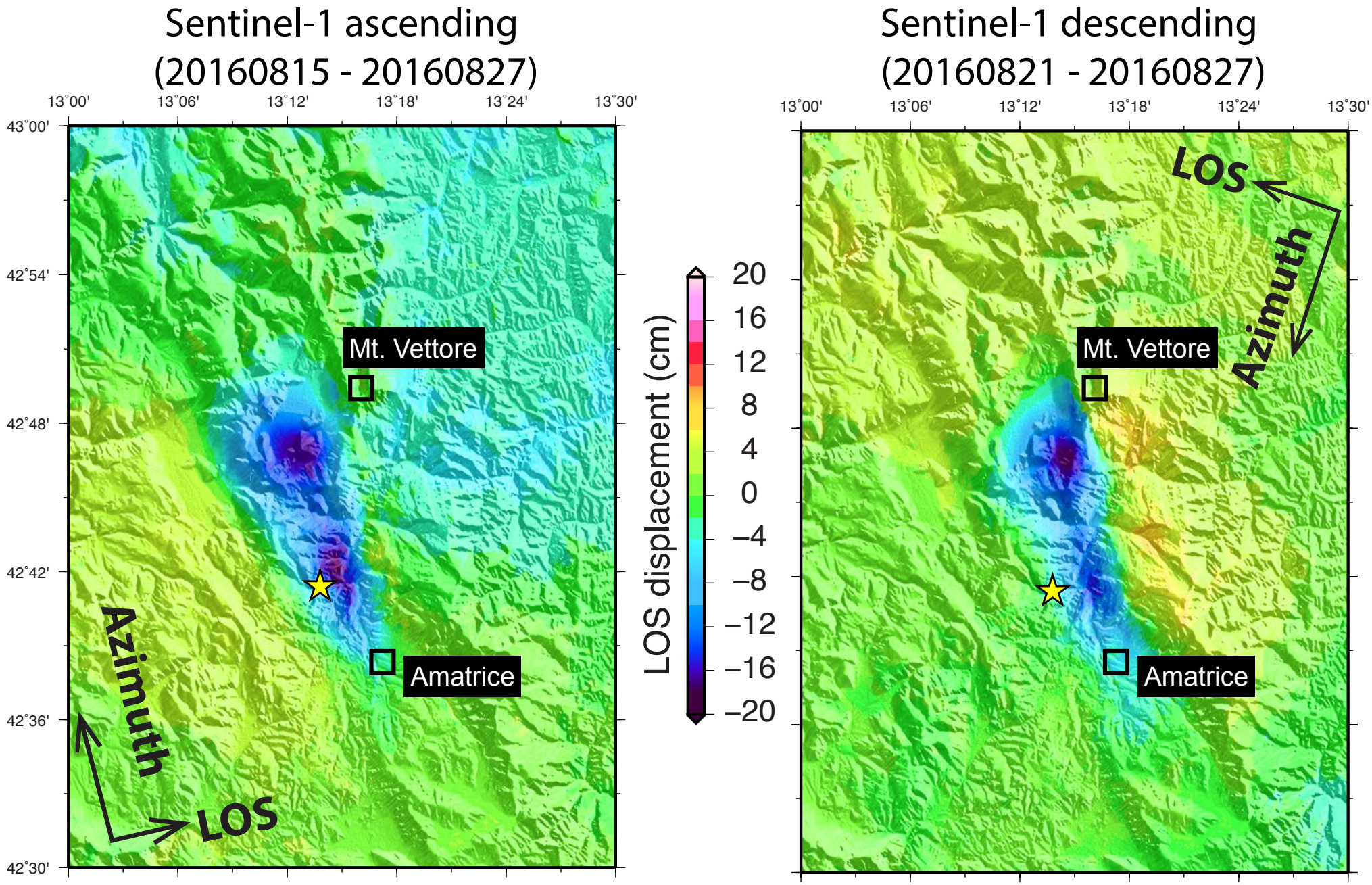
Estimated length: 18 km

M 6.5 - 6.6

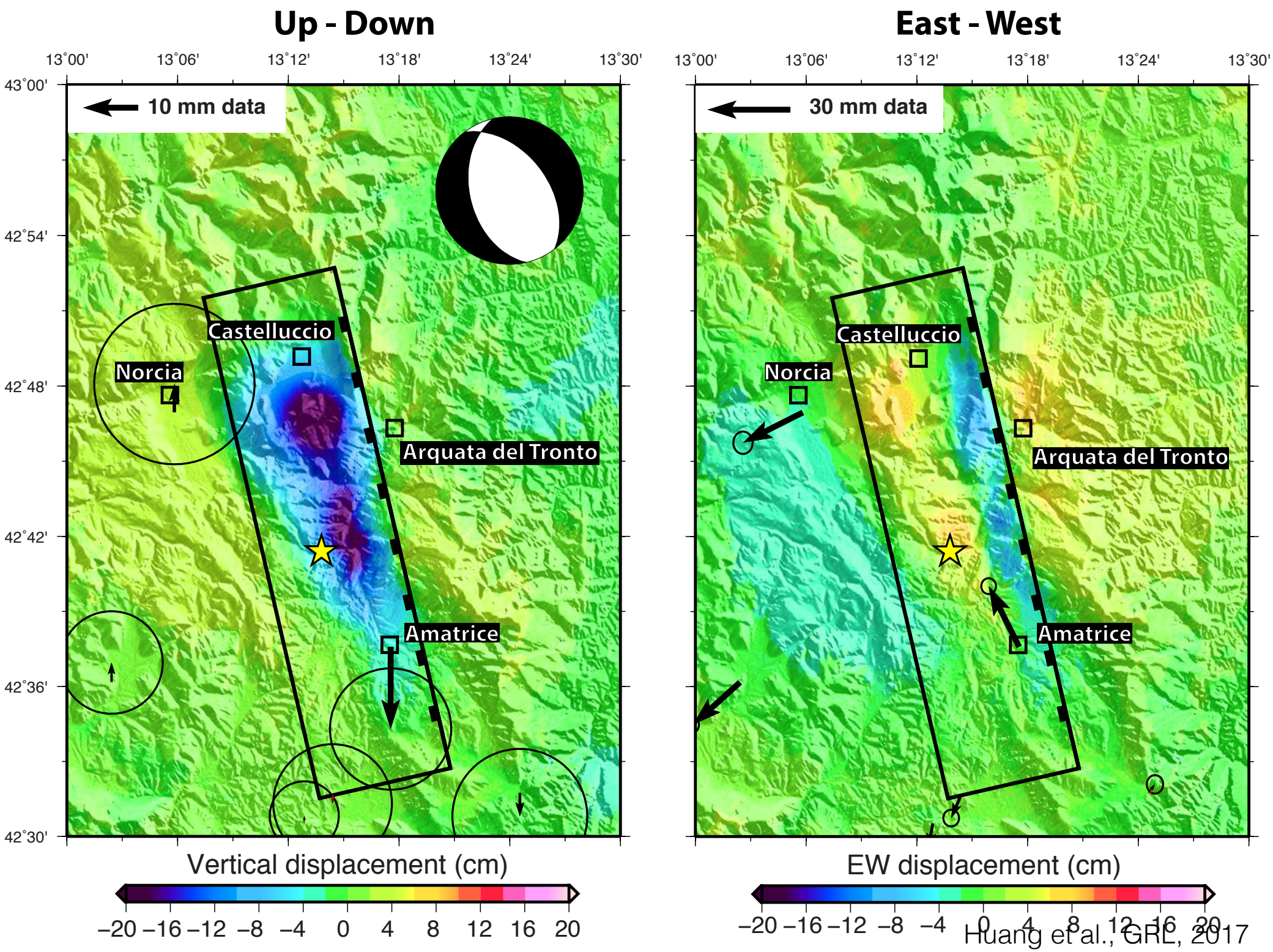
Recurrence interval < ~4700 yr

Galadini and Galli, AG, 2003

The 24 Aug. 2016 M_w 6.2 Amatrice EQ

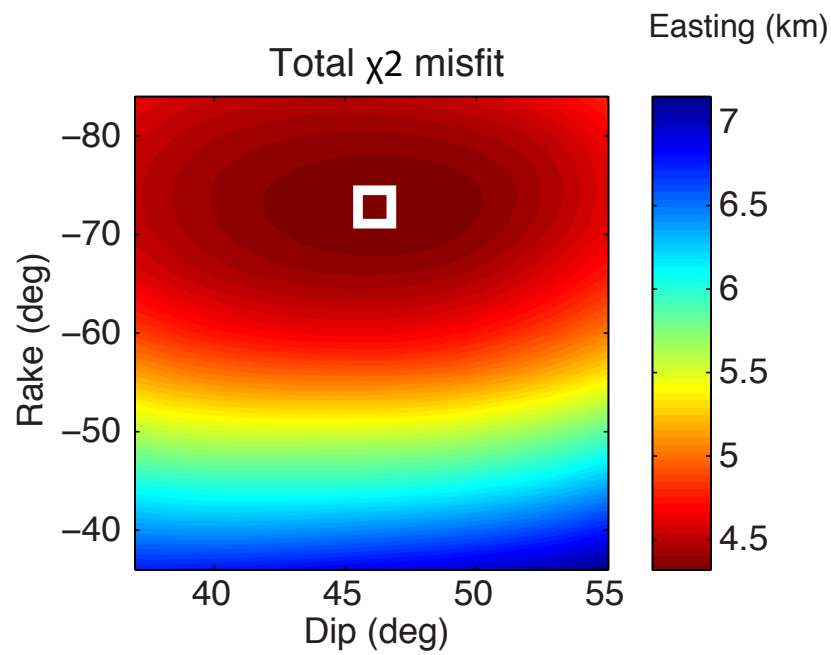


Huang et al., GRL, 2017

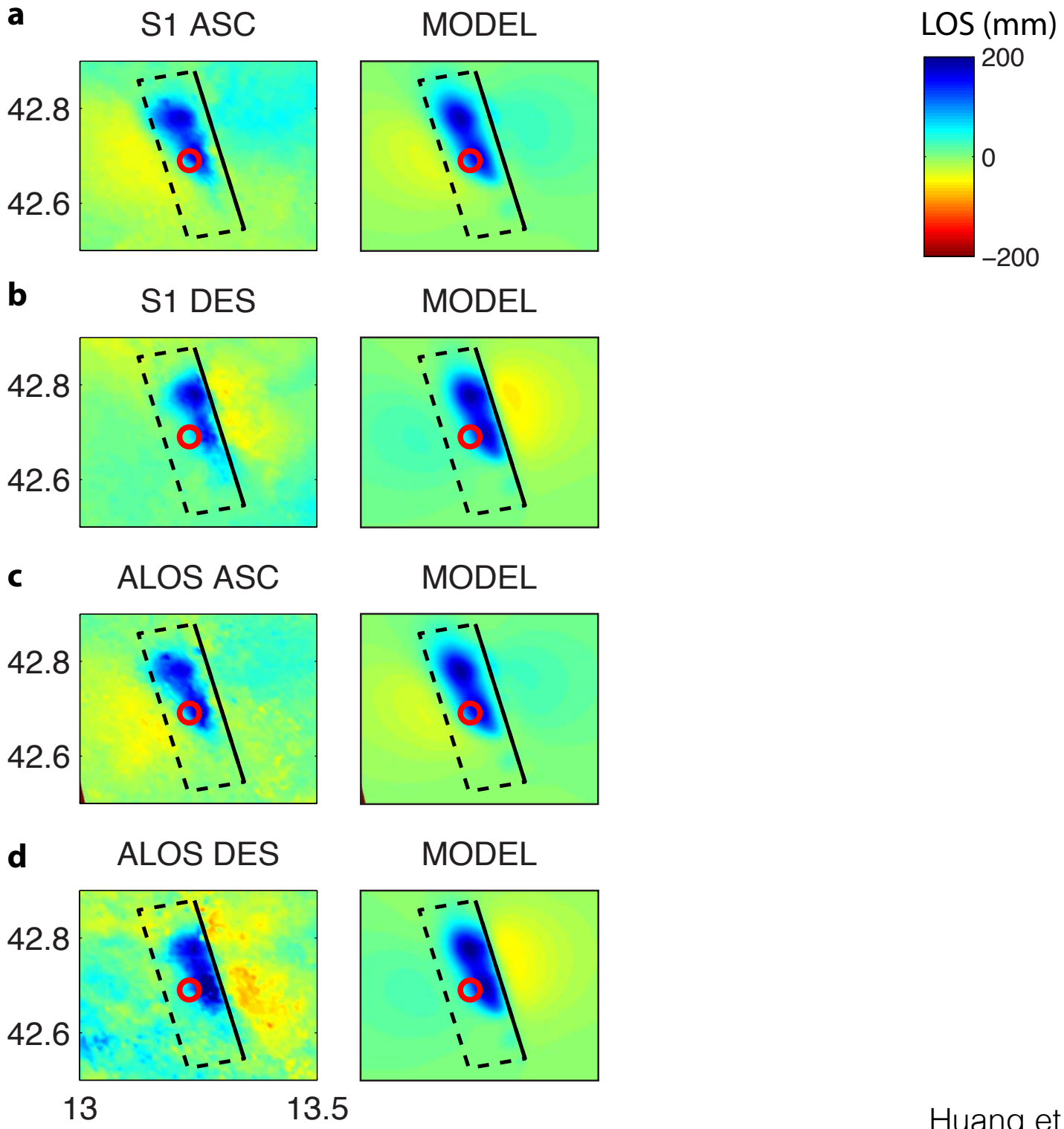


Huang et al., GRL, 2017

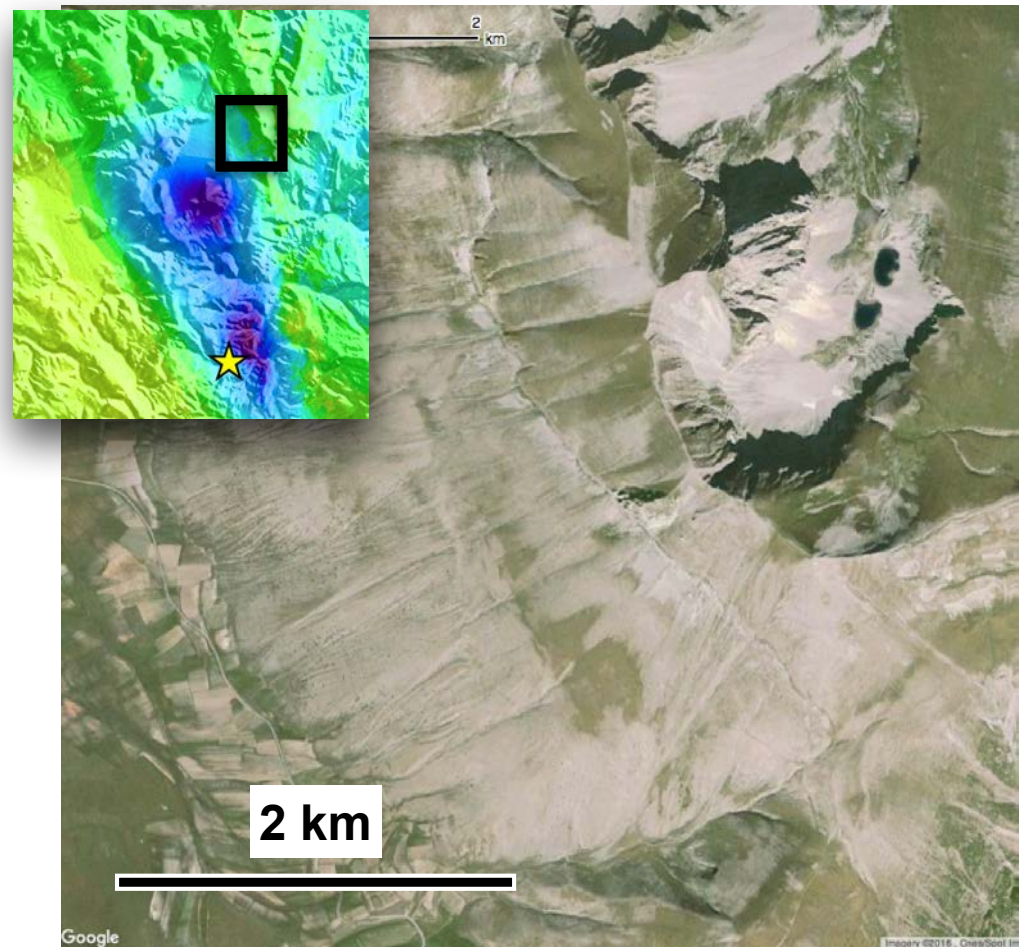
Fault Geometry and Slip based on GPS and InSAR



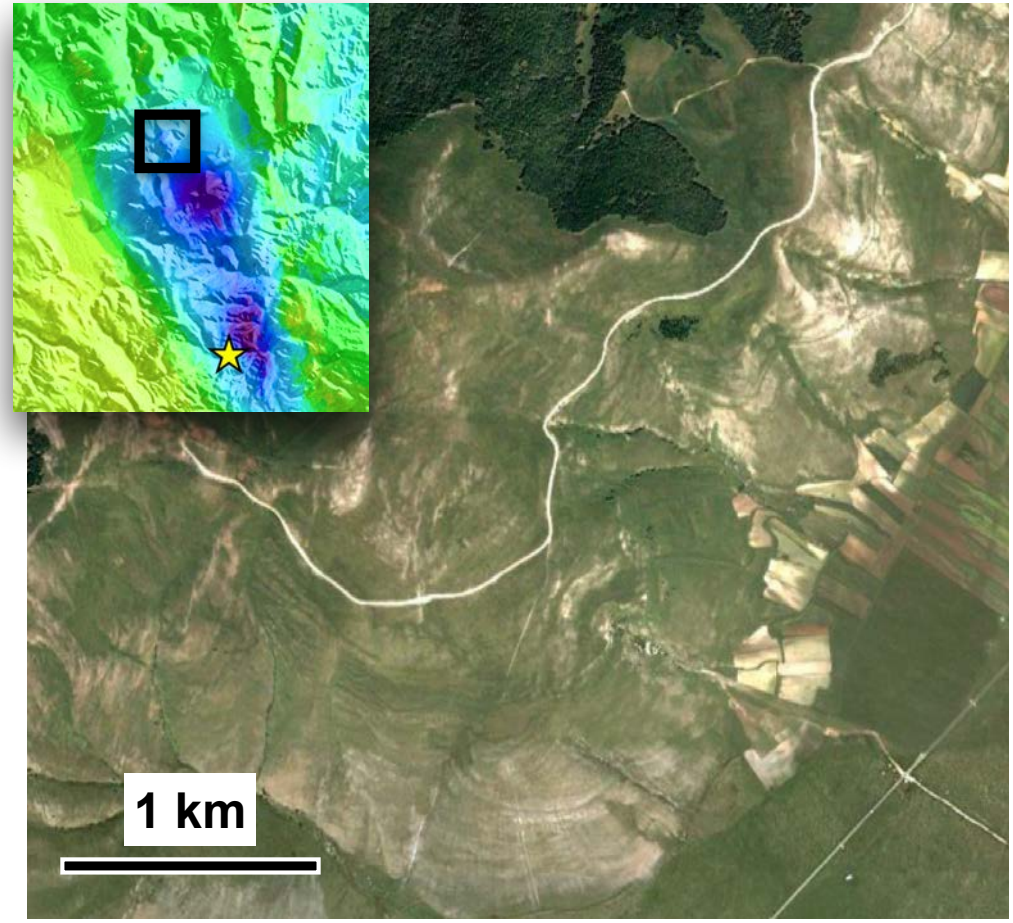
Huang et al., GRL, 2017



Huang et al., GRL, 2017

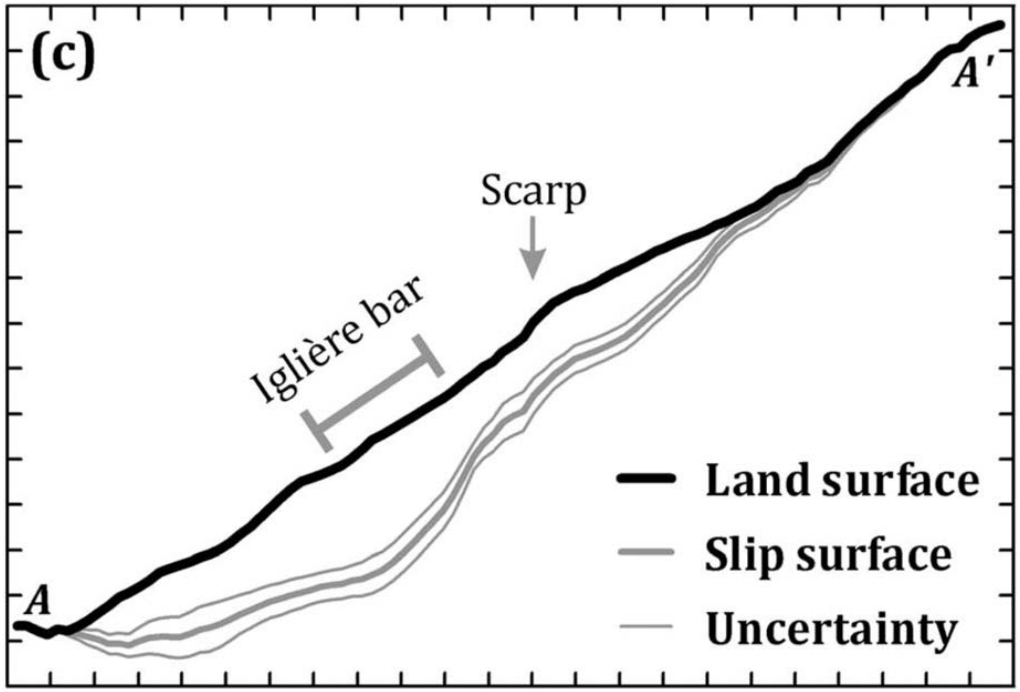


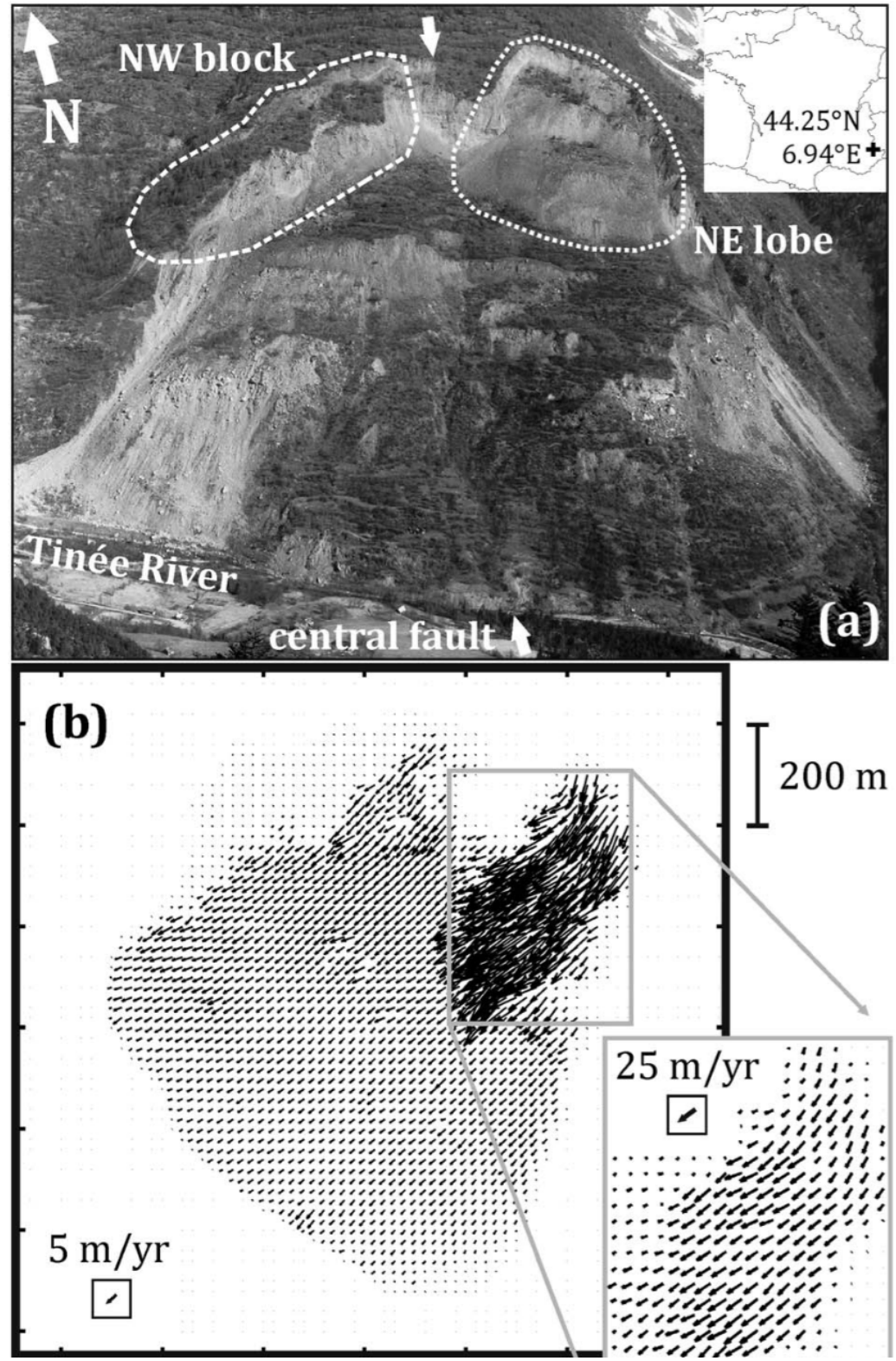
Huang et al., GRL, 2017



Huang et al., GRL, 2017

Landslide modeling

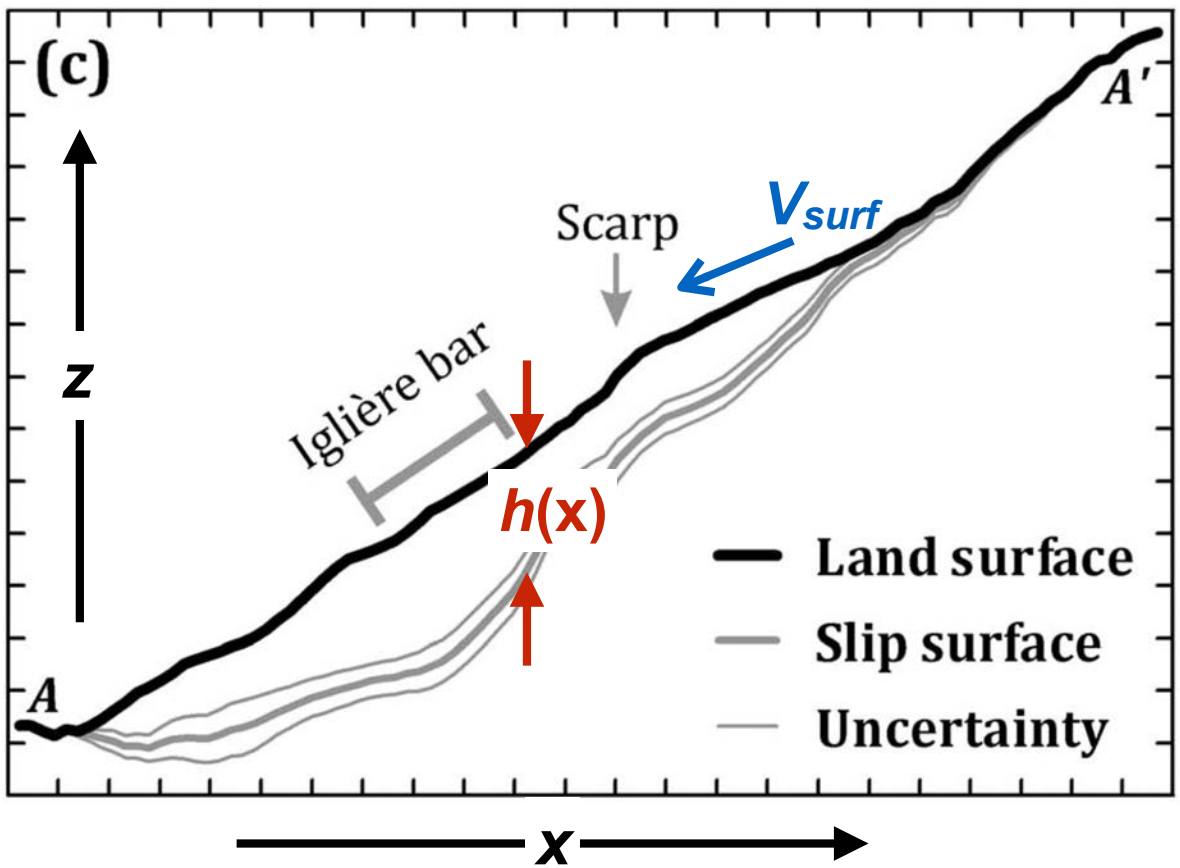




Booth et al., GRL, 2013

$$\frac{\partial z}{\partial t} = -\vec{\nabla} \cdot \left(f \vec{v}_{surf} h \right)$$

$$\Delta z_i = \frac{1}{-2\Delta x} \left[\Delta u_i f \left(h_{i+1} - h_{i-1} \right) + \left(\Delta u_{i+1} - \Delta u_{i-1} \right) f h_i \right],$$



Lowering Thickness

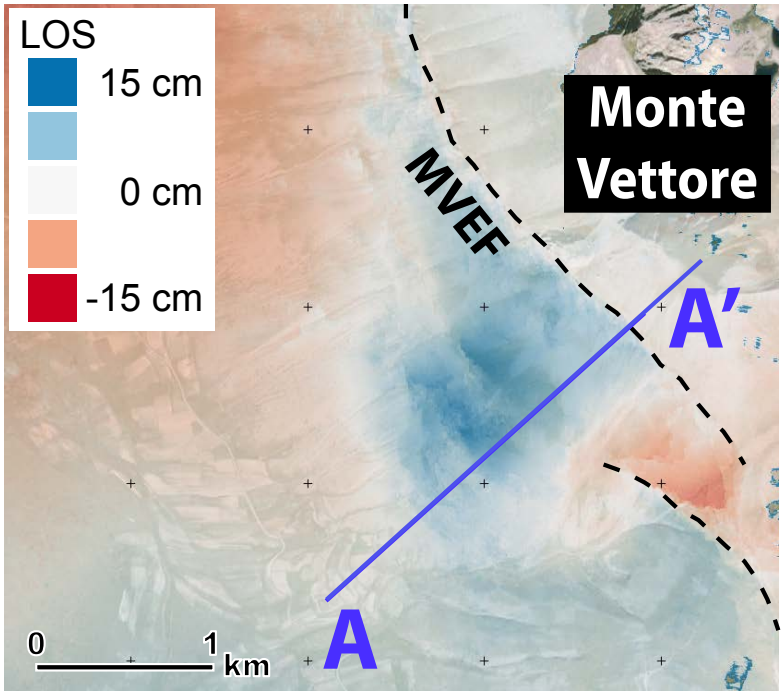
$$\begin{bmatrix} \Delta z_1 \\ \vdots \\ \Delta z_i \\ \vdots \\ \Delta z_N \end{bmatrix} = \boldsymbol{G} \begin{bmatrix} h_1 \\ \vdots \\ h_i \\ \vdots \\ h_N \end{bmatrix},$$

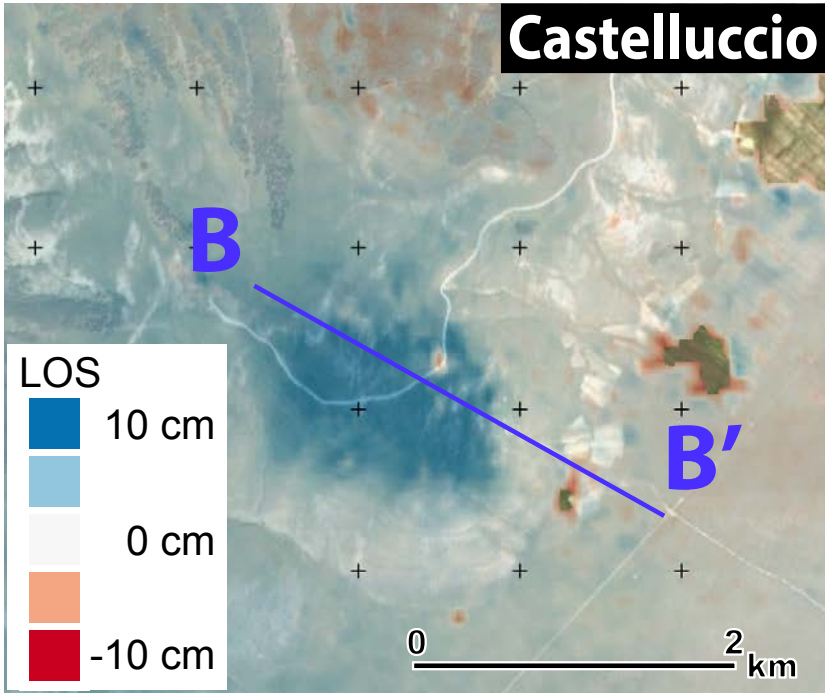
$$\boxed{\boldsymbol{h}^{est} = \left(\boldsymbol{G}^T \boldsymbol{G} + \kappa^2 \boldsymbol{L}^T \boldsymbol{L} \right)^{-1} \boldsymbol{G}^T \Delta \boldsymbol{z}}$$

Estimated thickness

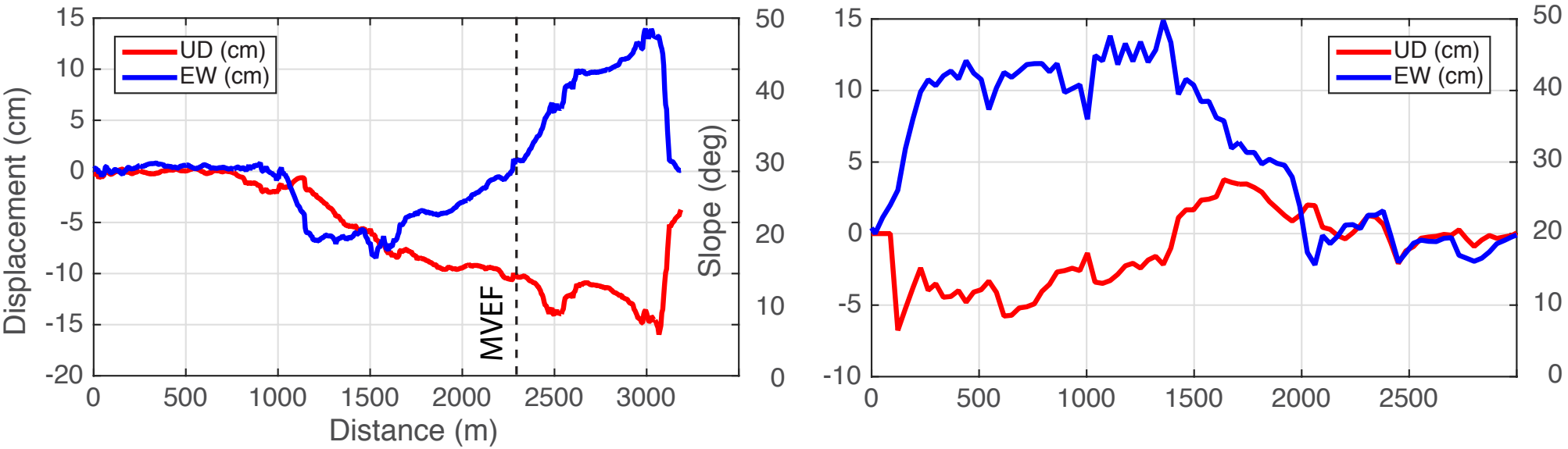
Smoothing

Booth et al., GRL, 2013

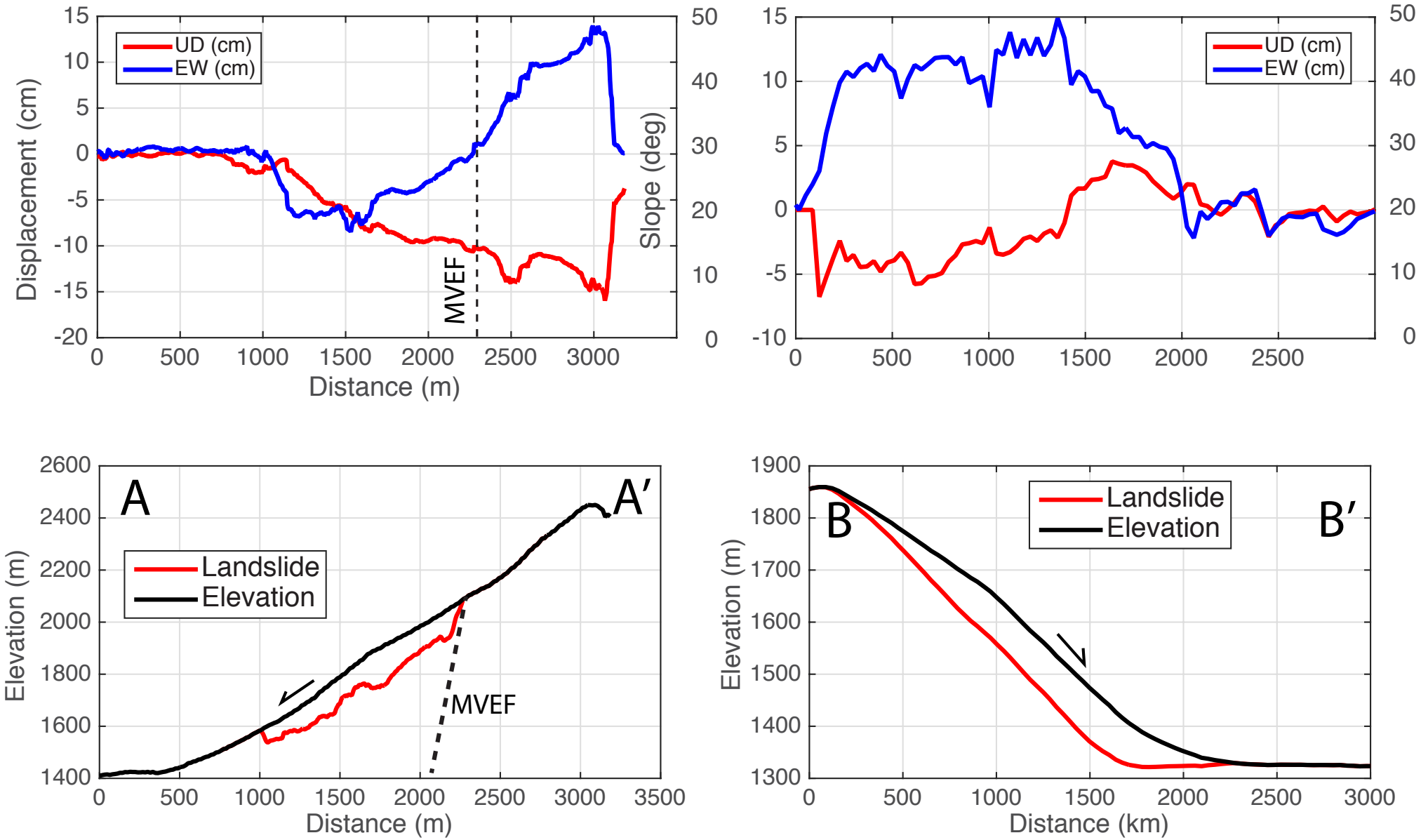




Huang et al., GRL, 2017

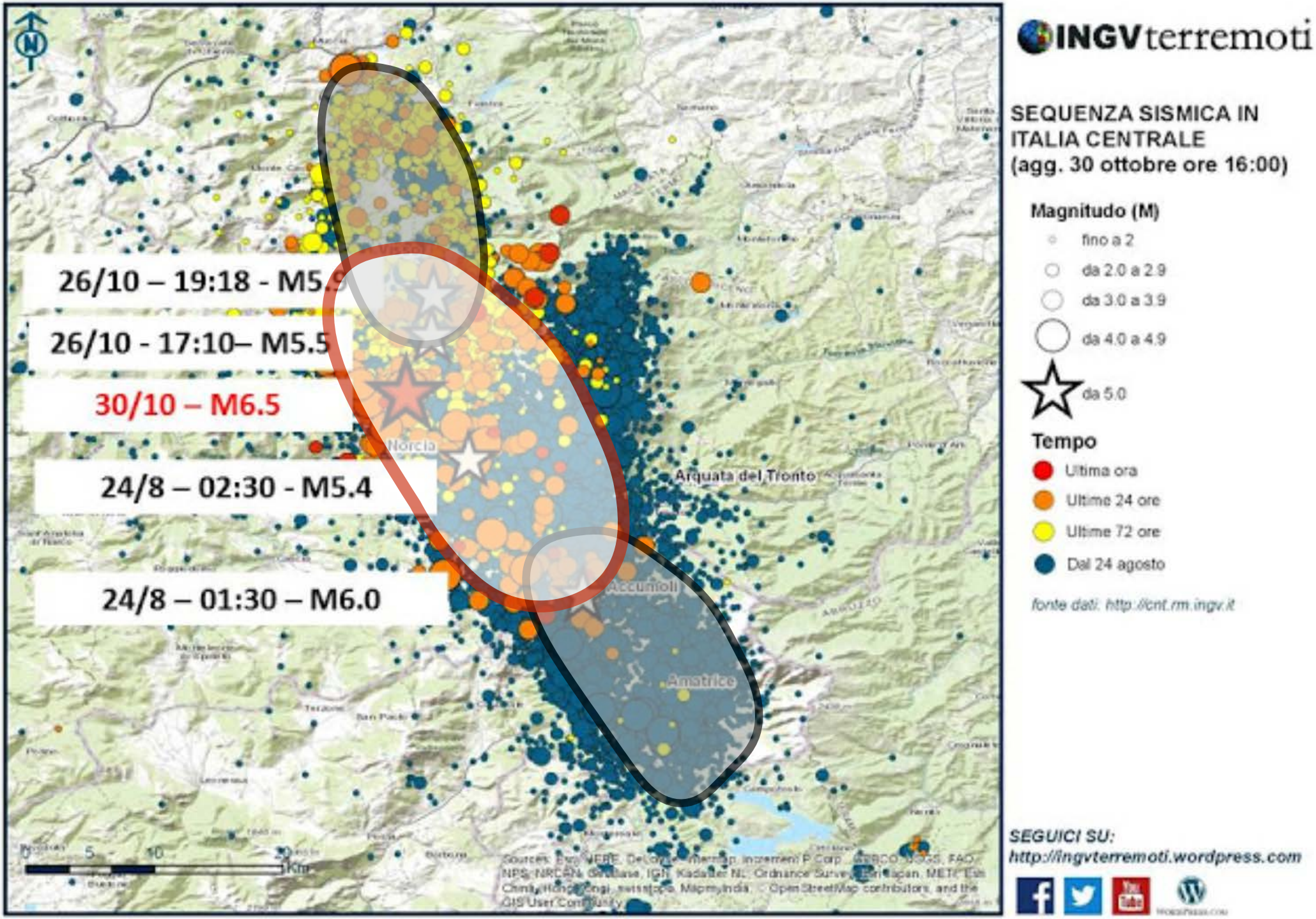


Huang et al., GRL, 2017



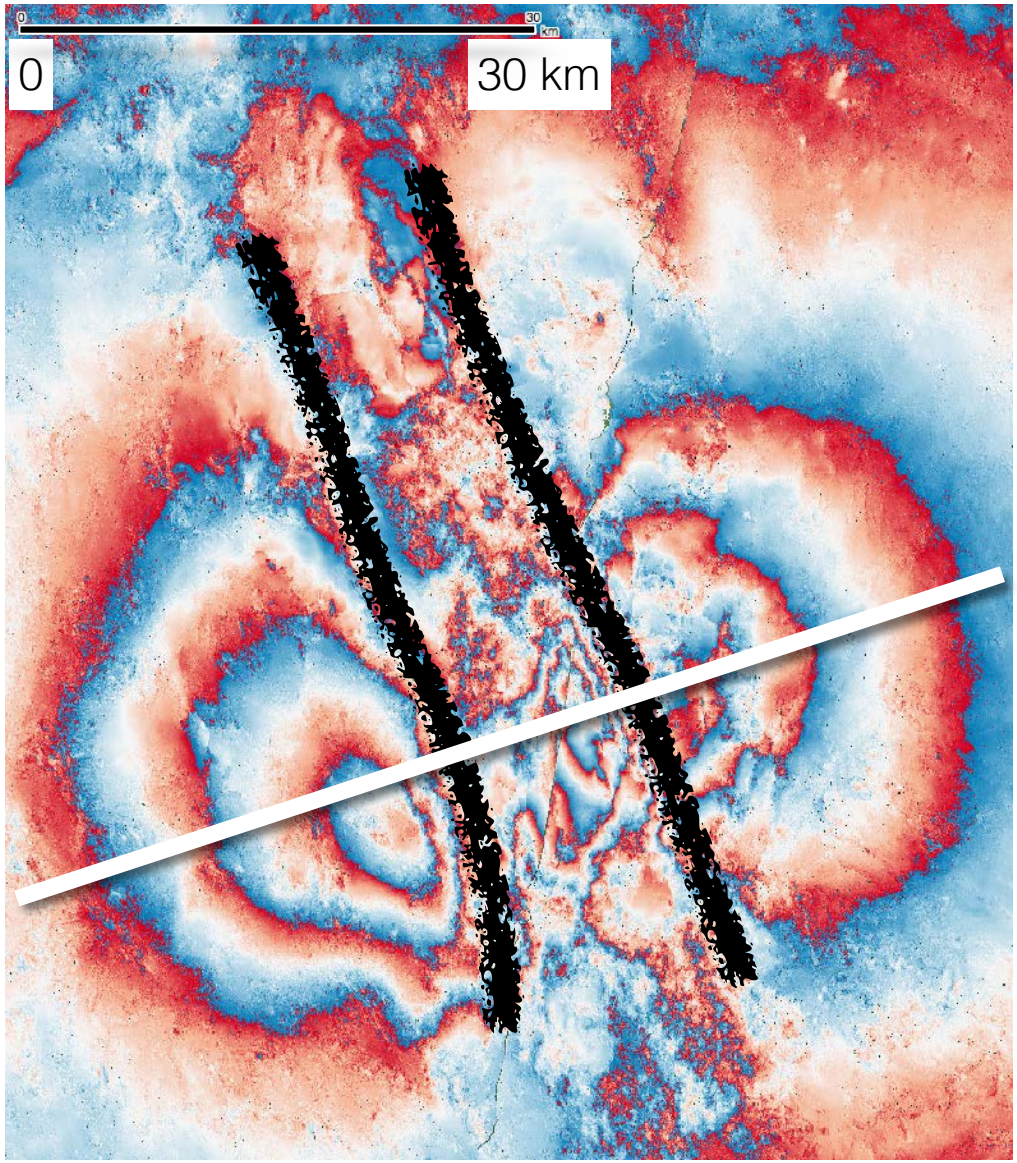
Huang et al., GRL, 2017

The 30 Nov. 2016 M_w 6.4 Norcia EQ

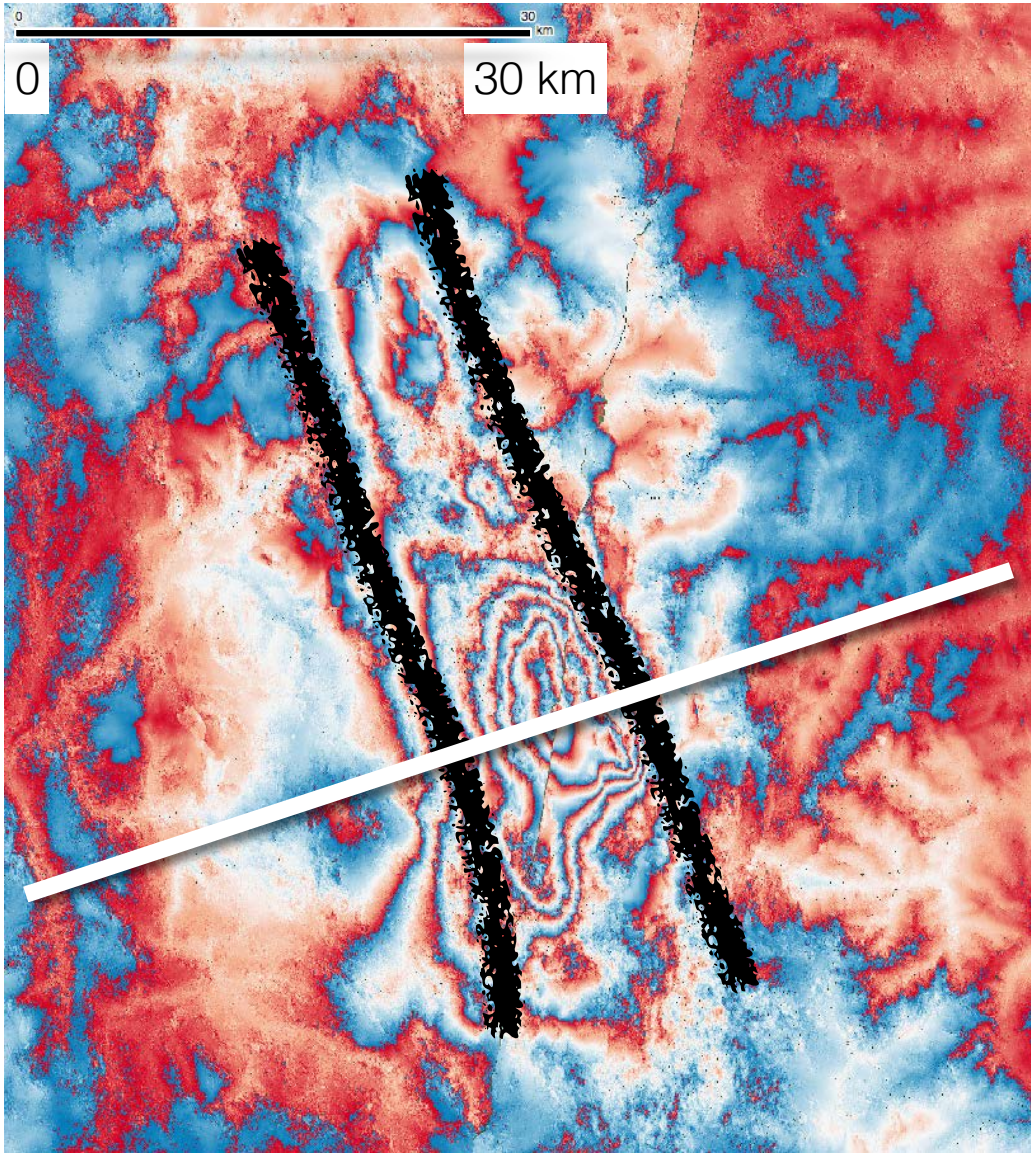


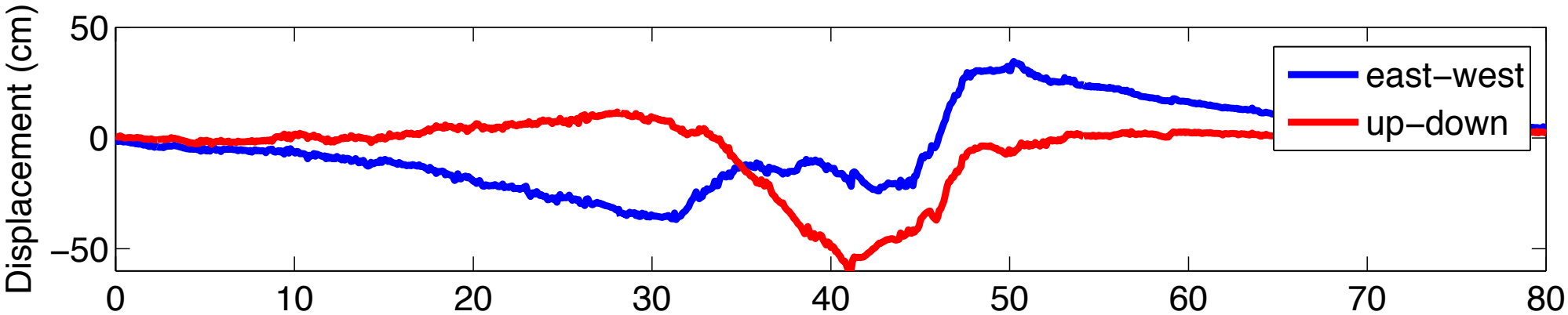
Sentinel-1 InSAR (re-wrapped to 10 cm/fringe)

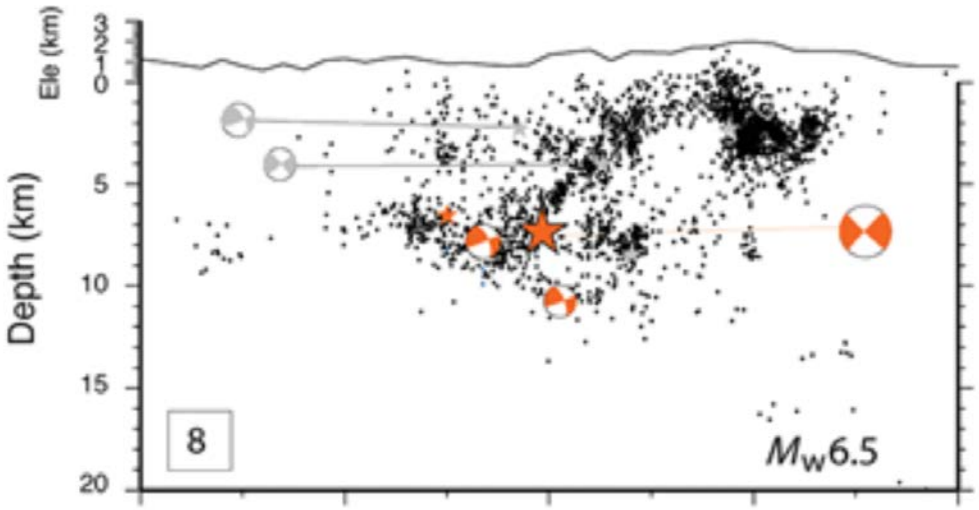
East - West

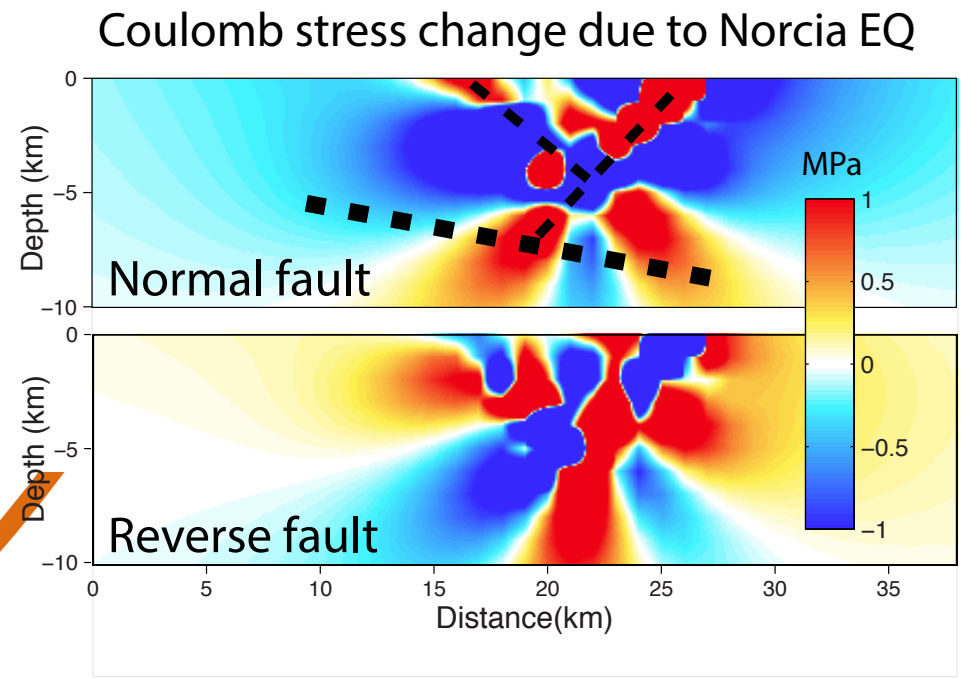


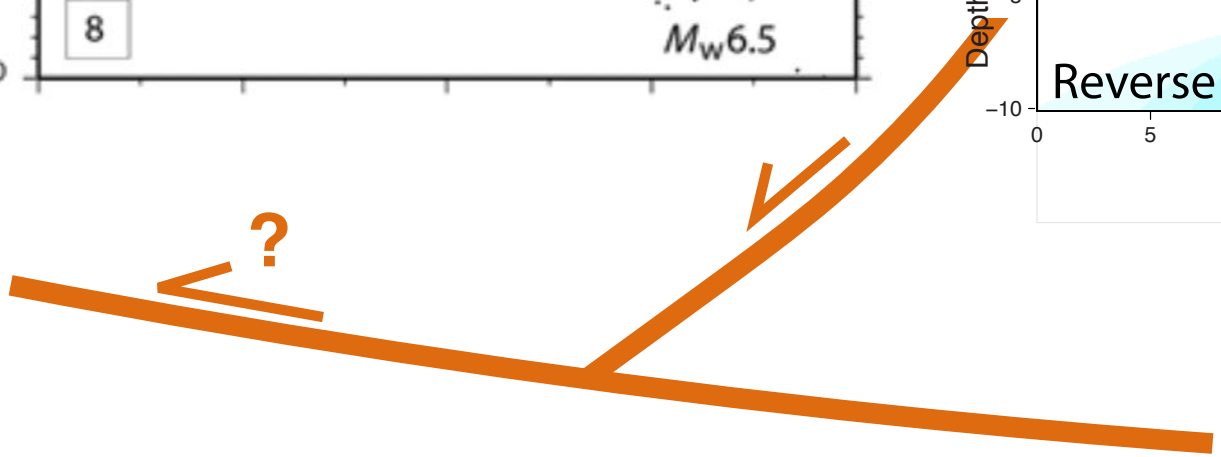
Up - Down

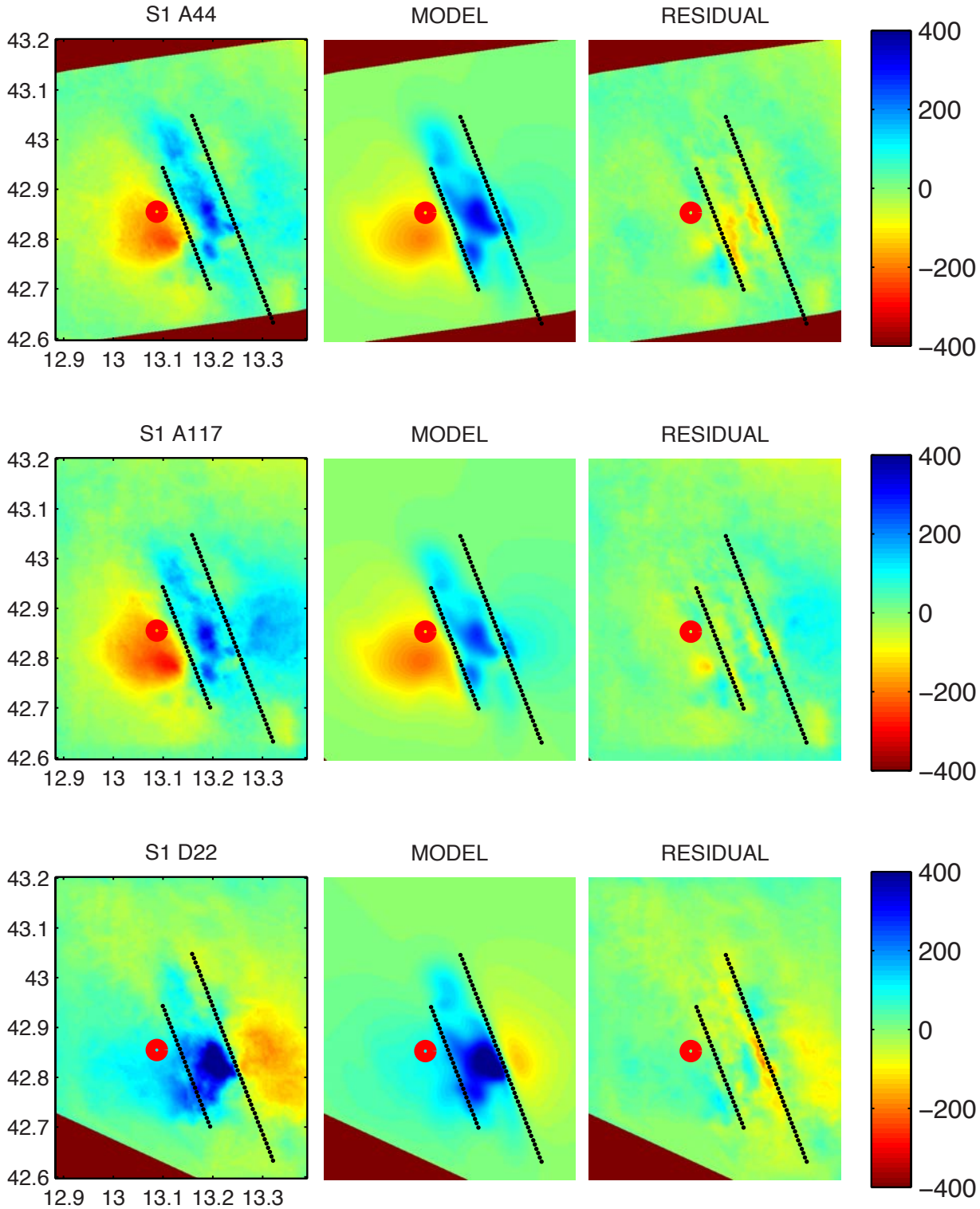



Displacement (cm)
50
0
−50
0
10
20
30
40
50
60
70
80
east−west
up−down


Ele (km)
Depth (km)
5
10
15
20
8
M_w6.5


Coulomb stress change due to Norcia EQ
Depth (km)
Normal fault
Reverse fault
MPa
1
0.5
0
−0.5
−1
0
5
10
15
20
25
30
35
Distance(km)


?


S1 A44
MODEL
RESIDUAL
S1 A117
MODEL
RESIDUAL
S1 D22
MODEL
RESIDUAL
43.2
43.1
43
42.9
42.8
42.7
42.6
12.9
13
13.1
13.2
13.3
400
200
0
−200
−400

Summary-I

1. Nearly all of the slip occurred between 3 and 5 km depth but extends about 20 km along strike with two distinct slip asperities.
2. At least two triggered landslides east and west of a slip asperity.
3. The triggered landslide on the Mt. Vettore fault may contribute additional fault offset and could influence the long-term fault slip rate.

Summary-II

1. The coseismic subsidence is within the low relief region in the Apennines
2. Evidences of a conjugate normal fault system with shallow (~30° - 40°) dip angles
3. May need a detachment below the normal fault system to explain InSAR measurements.

Thank You

Photo by Dr. Marco Menichetti

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