
Space geodetic investigation of the coseismic deformation associated with 12 December 2017 Mw 6.2 Hojdek and 12 November 2017 Mw 7.3 Sarpol-e Zahab Iran earthquakes

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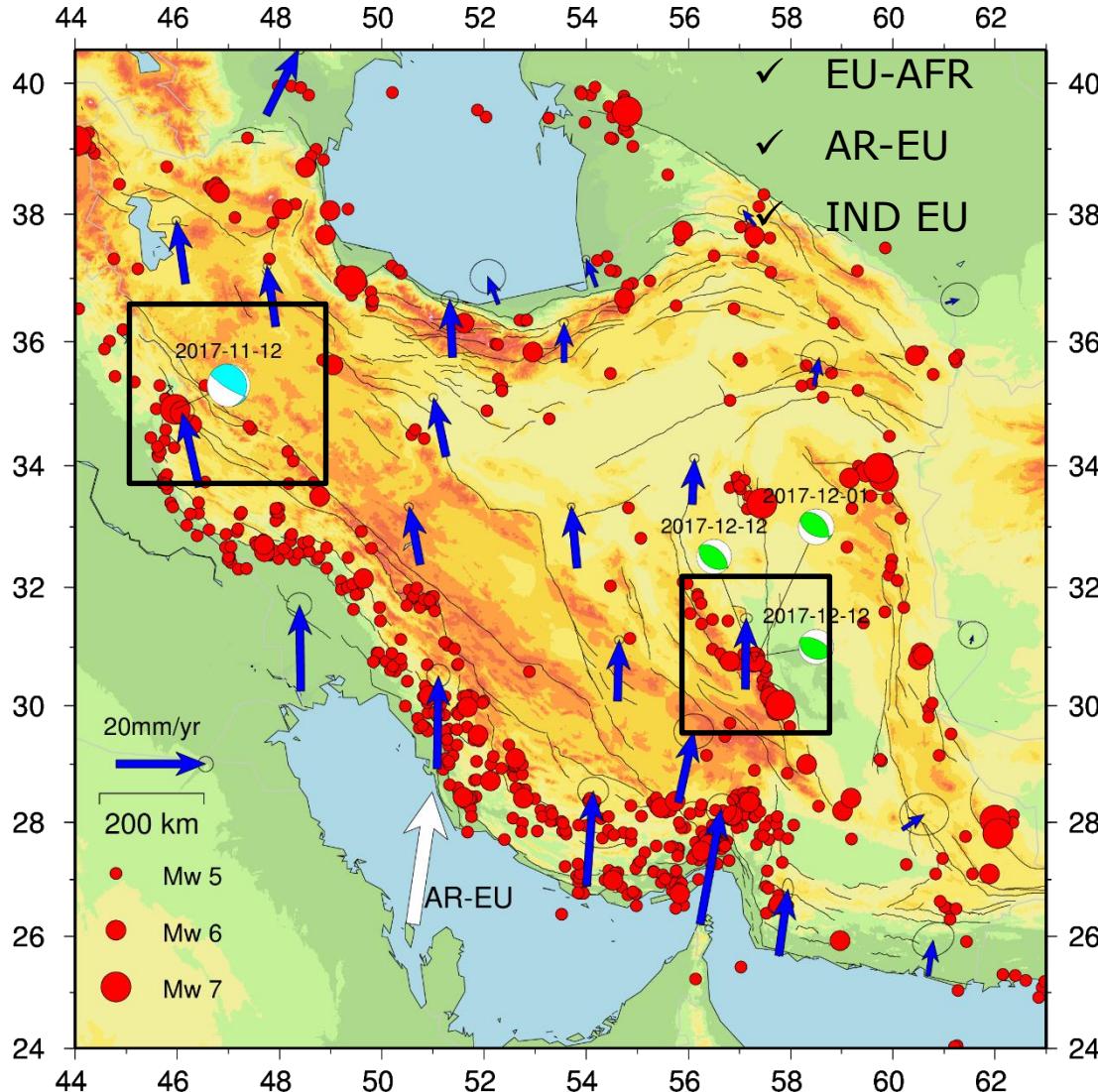
Institut für Photogrammetrie und Geoinformation



Institute for Advanced Studies
in Basic Sciences
Gava Zang, Zanjan, Iran



Objective

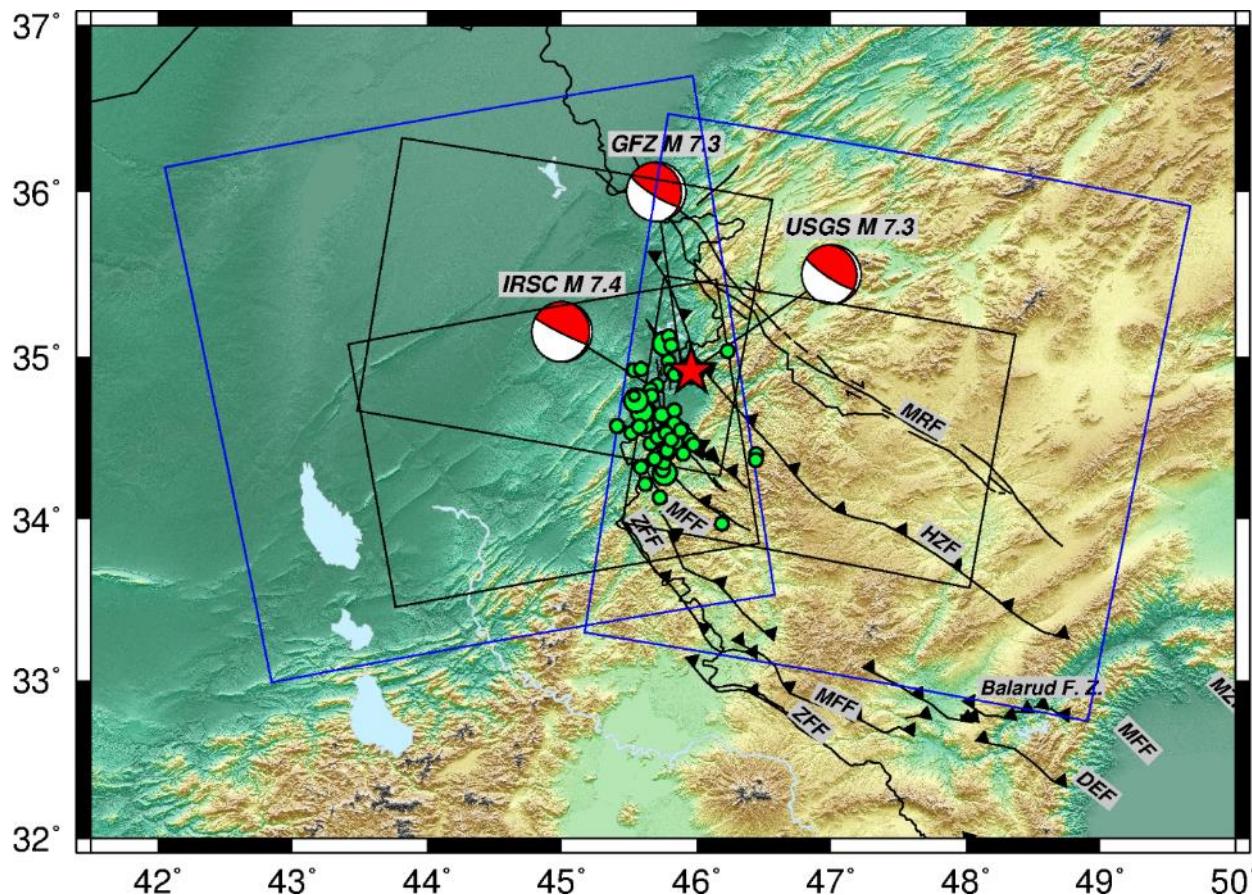


- 12th Nov 2017, Mw 7.3
- Oblique over-thrust earthquake
- NW of Zagros Mountains

- Three thrust earthquakes occurred within 12 days
- 1st Dec 2017, Mw 6.1
- 12th Dec 2017, Mw 6
- 12th Dec 2017, Mw 6
- SW of Kuhbanan fault



Sentinel-1 (S1) and ALOS-2 data



□ S1

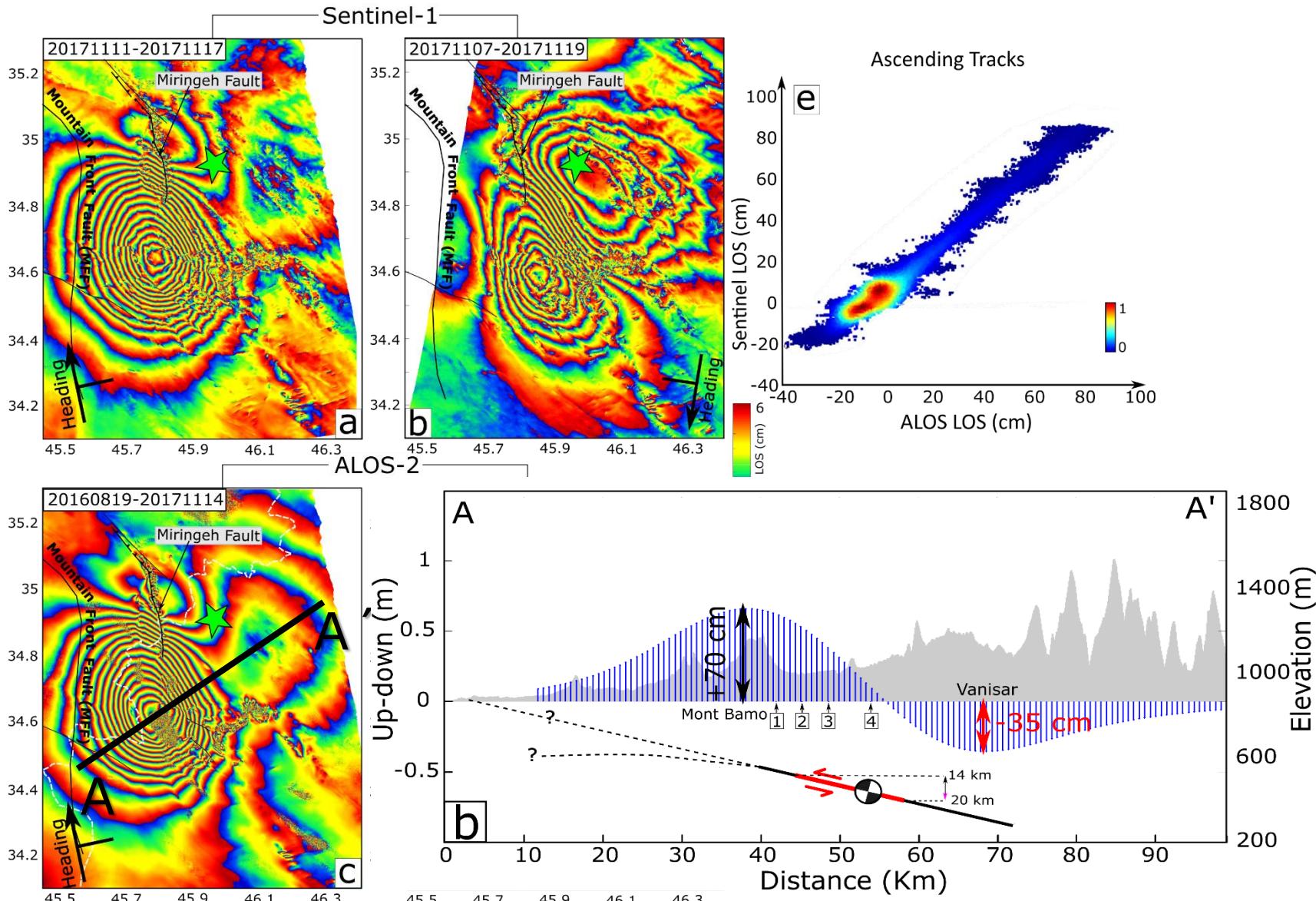
- C-band
- $\lambda = 5.6 \text{ cm}$

□ ALOS-2

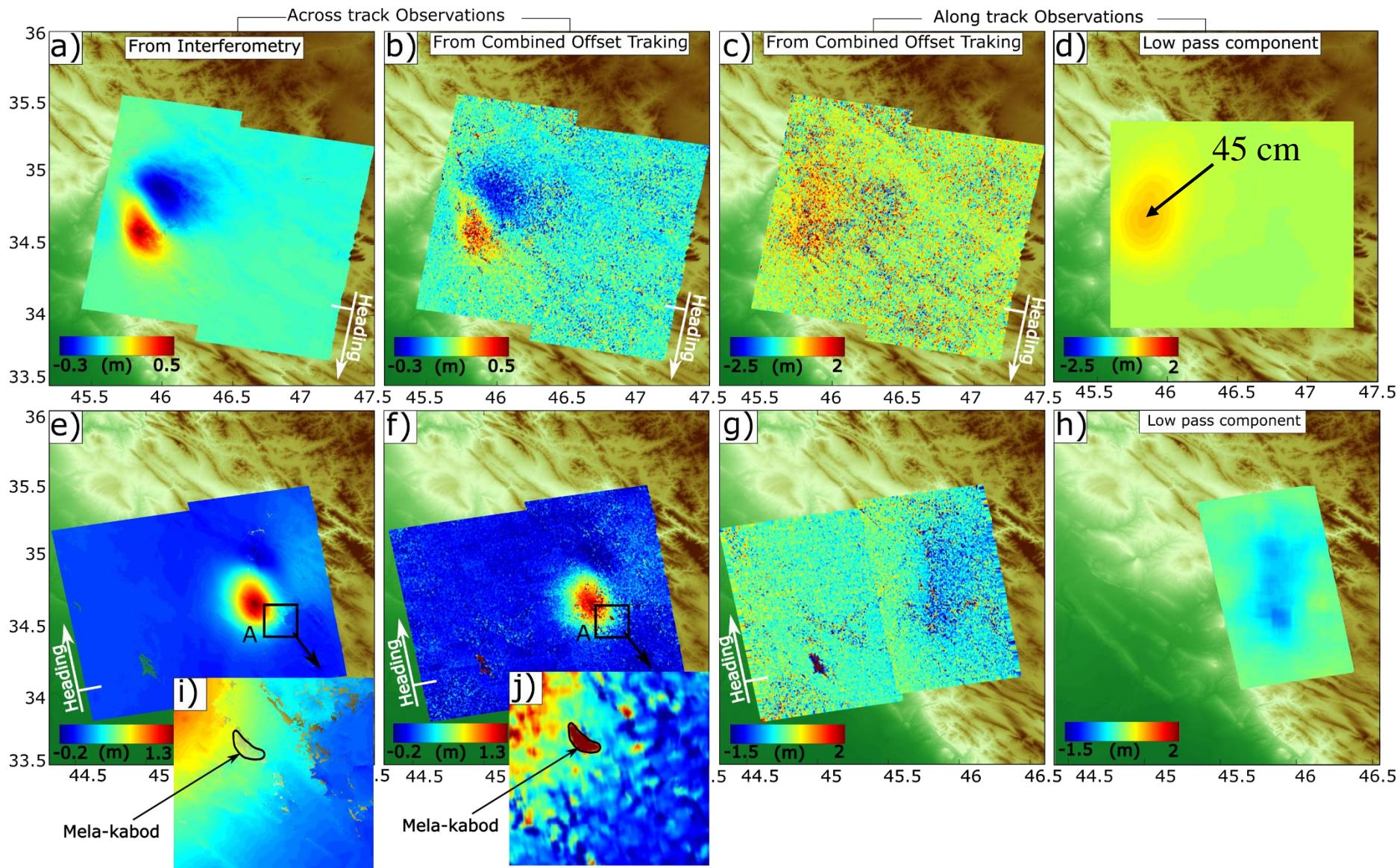
- L-band
- $\lambda = 24 \text{ cm}$



ALOS-2 versus Sentinel-1

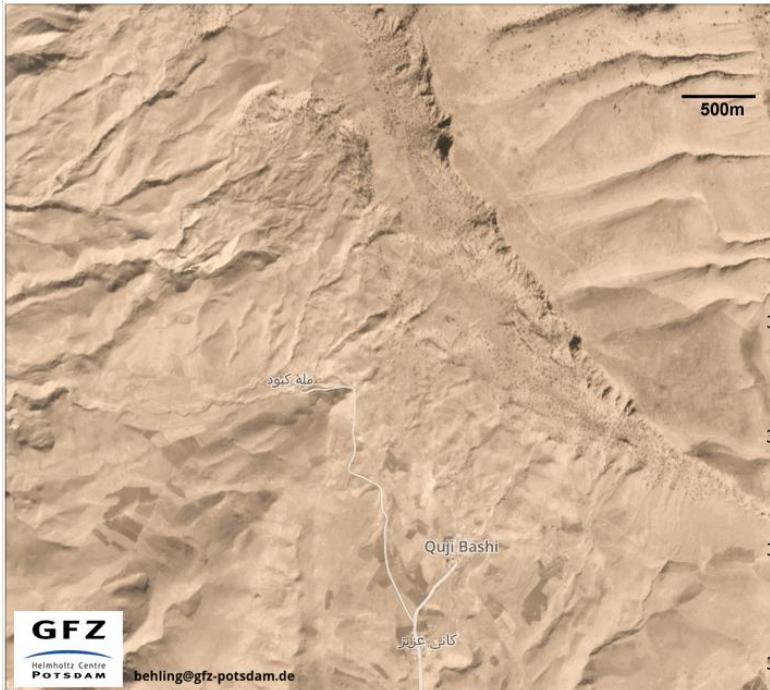


Comparison of InSAR interferometry and Offset tracking ...

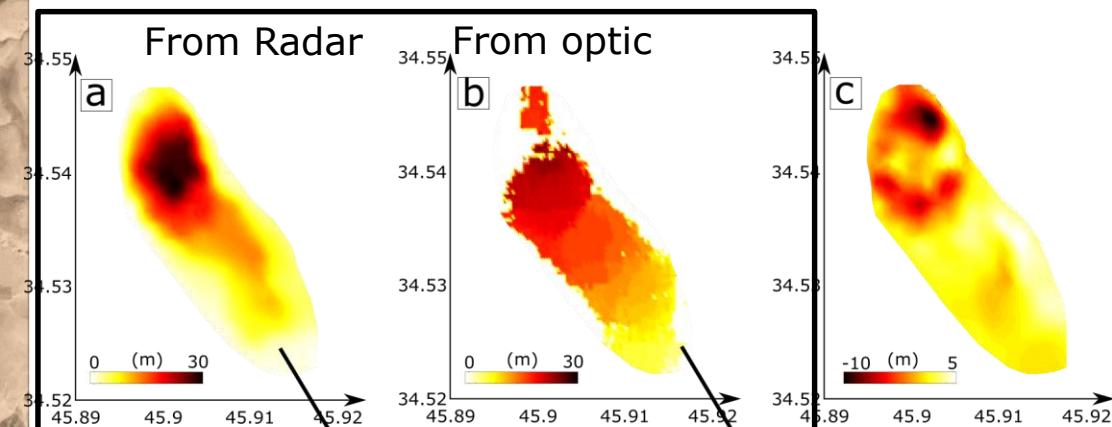


Landslide was triggered after the earthquake

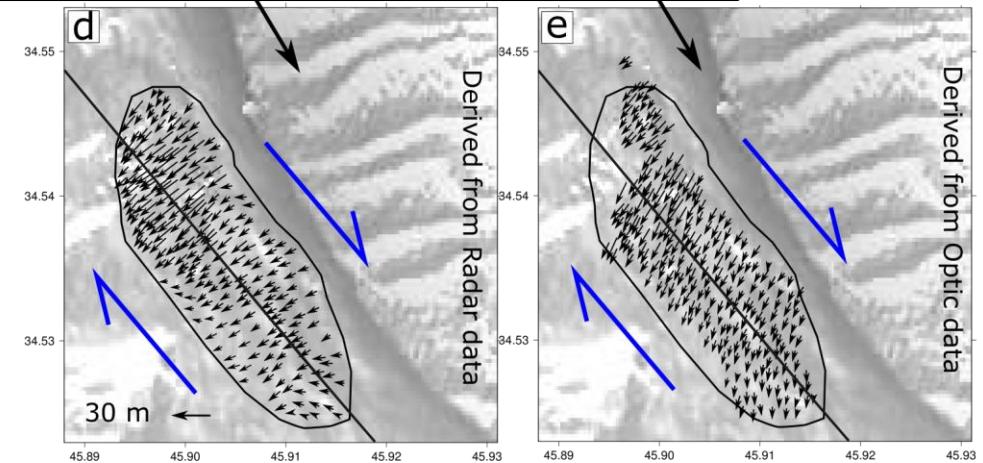
Resulted from the combination of burst overlap interferometry and offset tracking



Horizontal motion Vertical motion



Resulted from optical Data

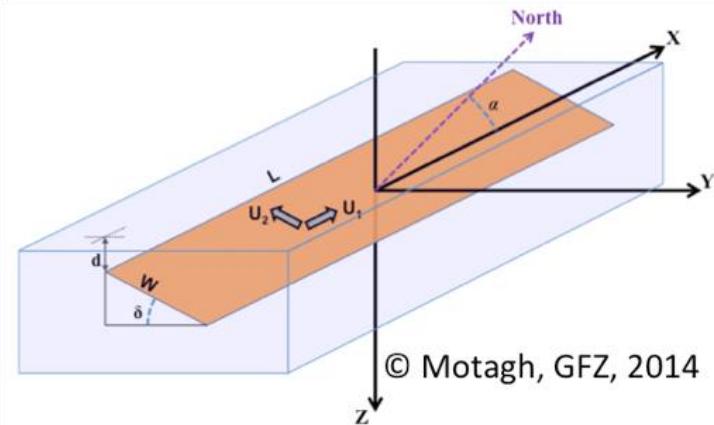


Earthquake source modeling

➤ Uniform Slip Modeling

Bayesian Inversion

$$p(x|d) = \frac{p(x)p(d|x)}{\int p(x)p(d|x)dm}$$



©GBIS software & some modification to add constraints ...

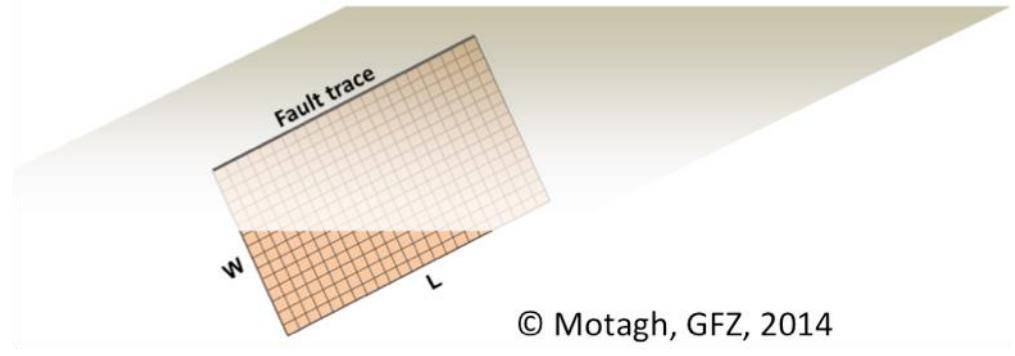


➤ Distributed Slip Modeling

d= vector of surface displacement

G= Green function from Okada (1985)

s= slip vectors



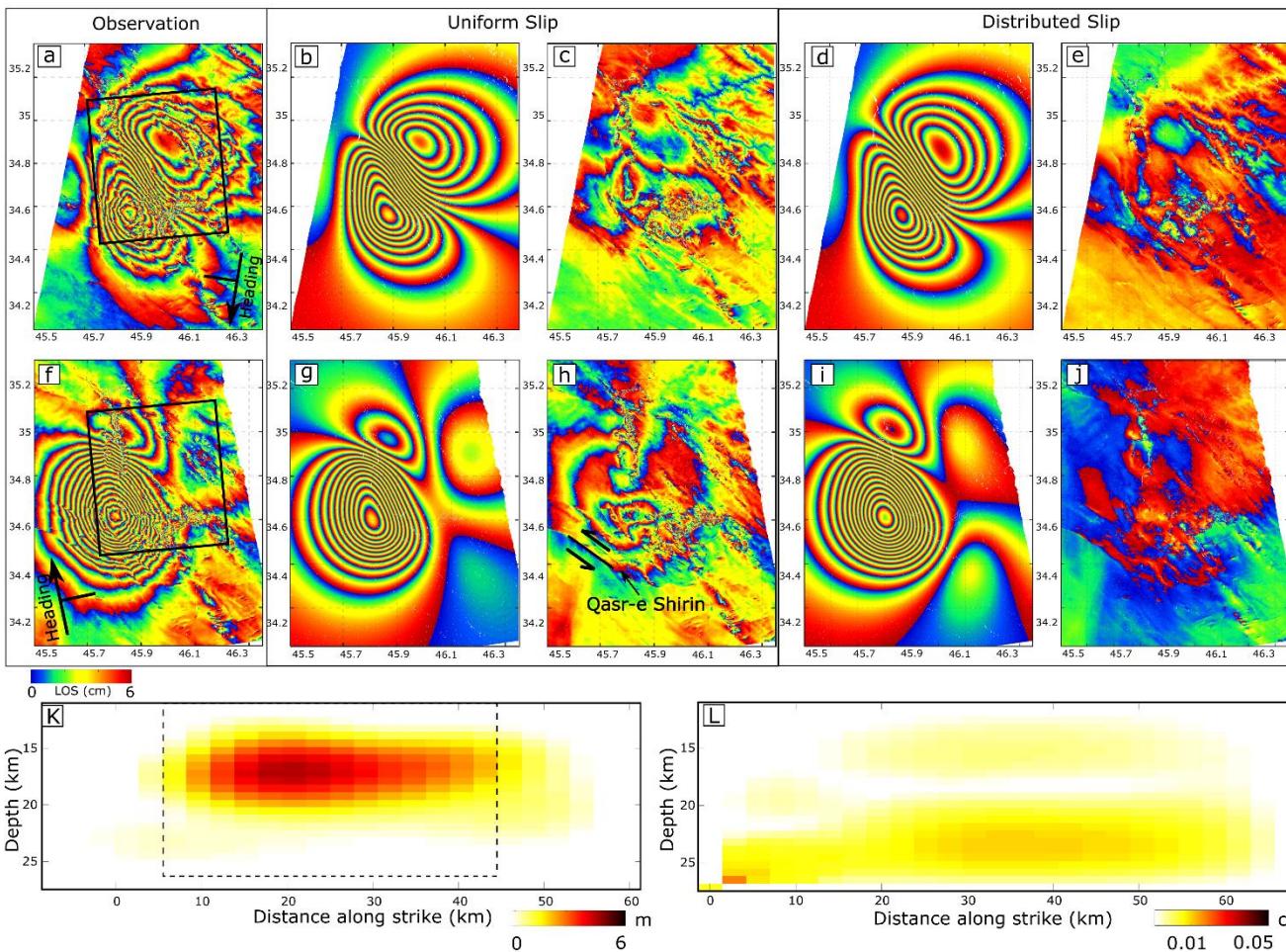
$$f = \|Gs - d\|^2 + a^2 \|s - s_0\| + b^2 \|Hs - d_0\|$$



Modeling results: Sentinel-1 ascending

Oblique overthrust mechanism

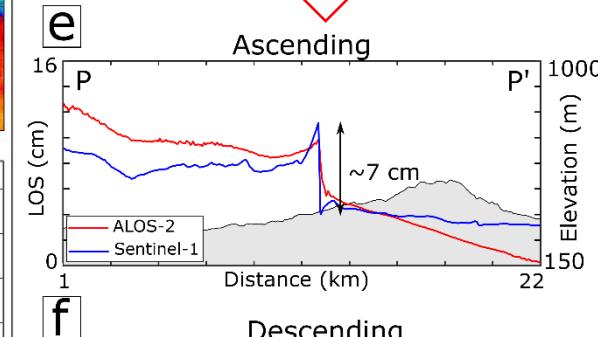
solution	Length (km)	Width (km)	Depth (km)	Dip (deg.)	Strike (deg.)	Rake (deg.)	Scalar Moment	Mw
InSAR	39.5	16	18.7	17.5	354.42	141	9.2895e+19	7.24



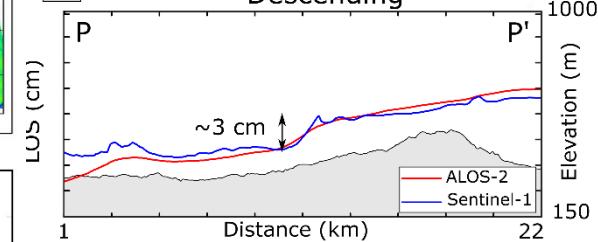
Secondary shallow faulting



Ascending

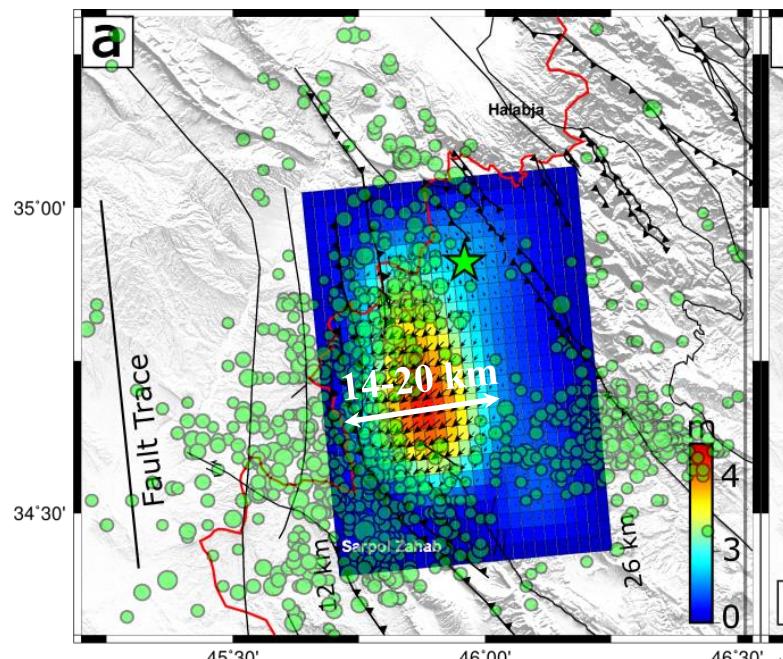


Descending

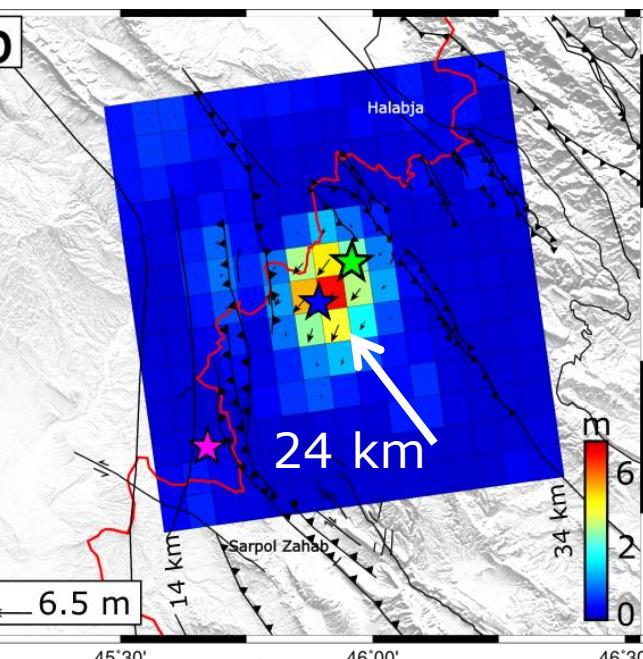


Geodetic model & Seismic model

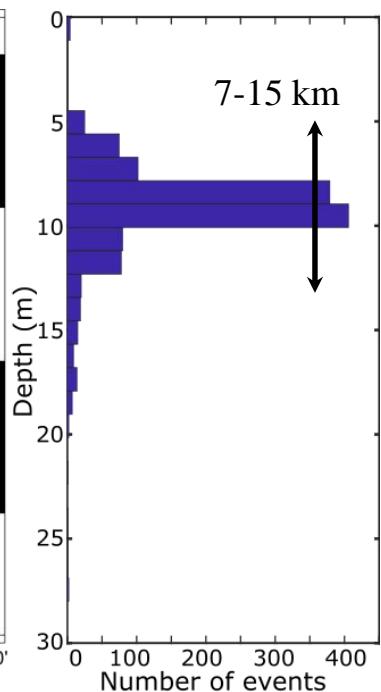
By our geodetic observation



By the USGS GSN network

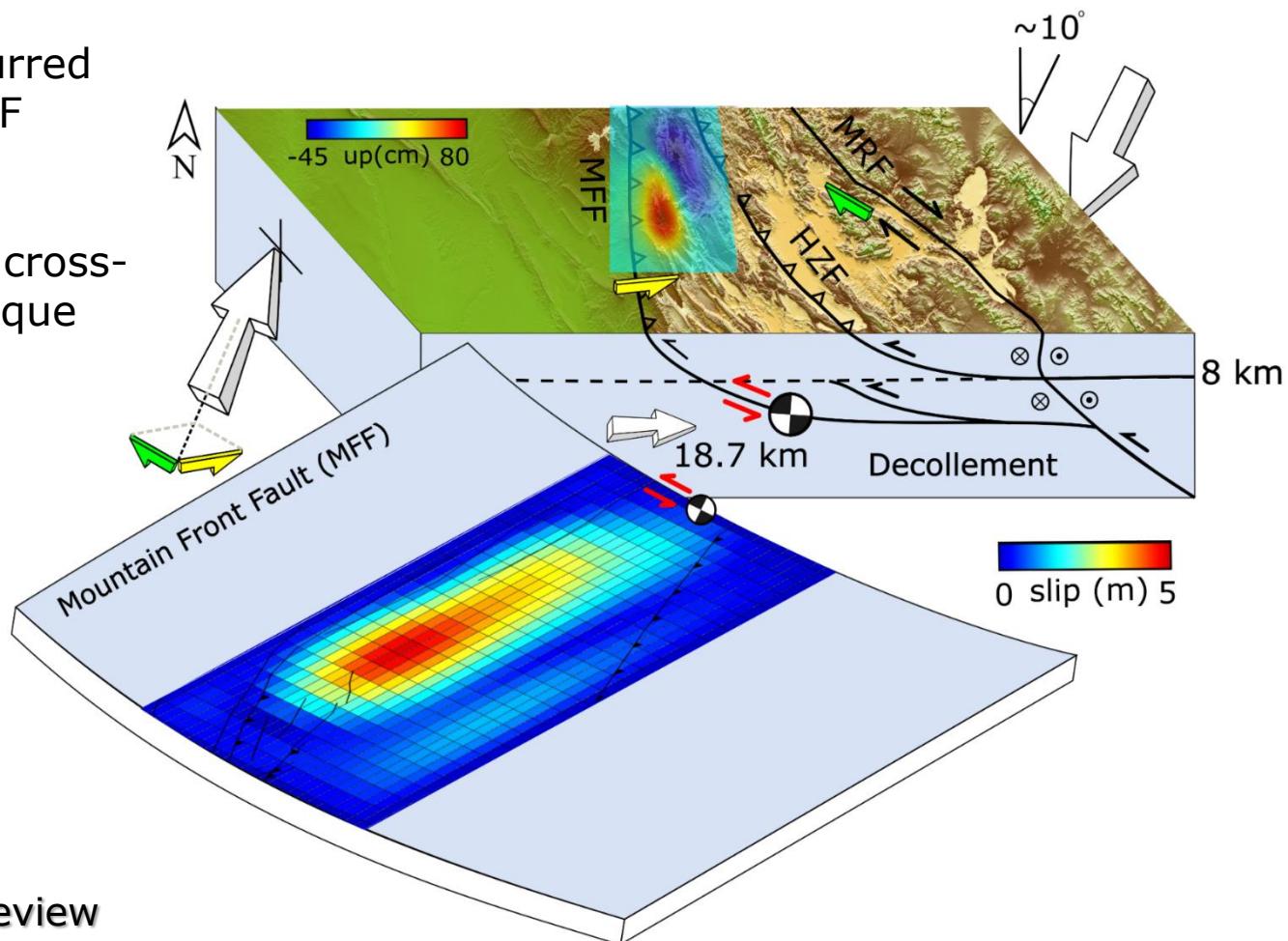


Reported by IRSC



To conclude the first event ..

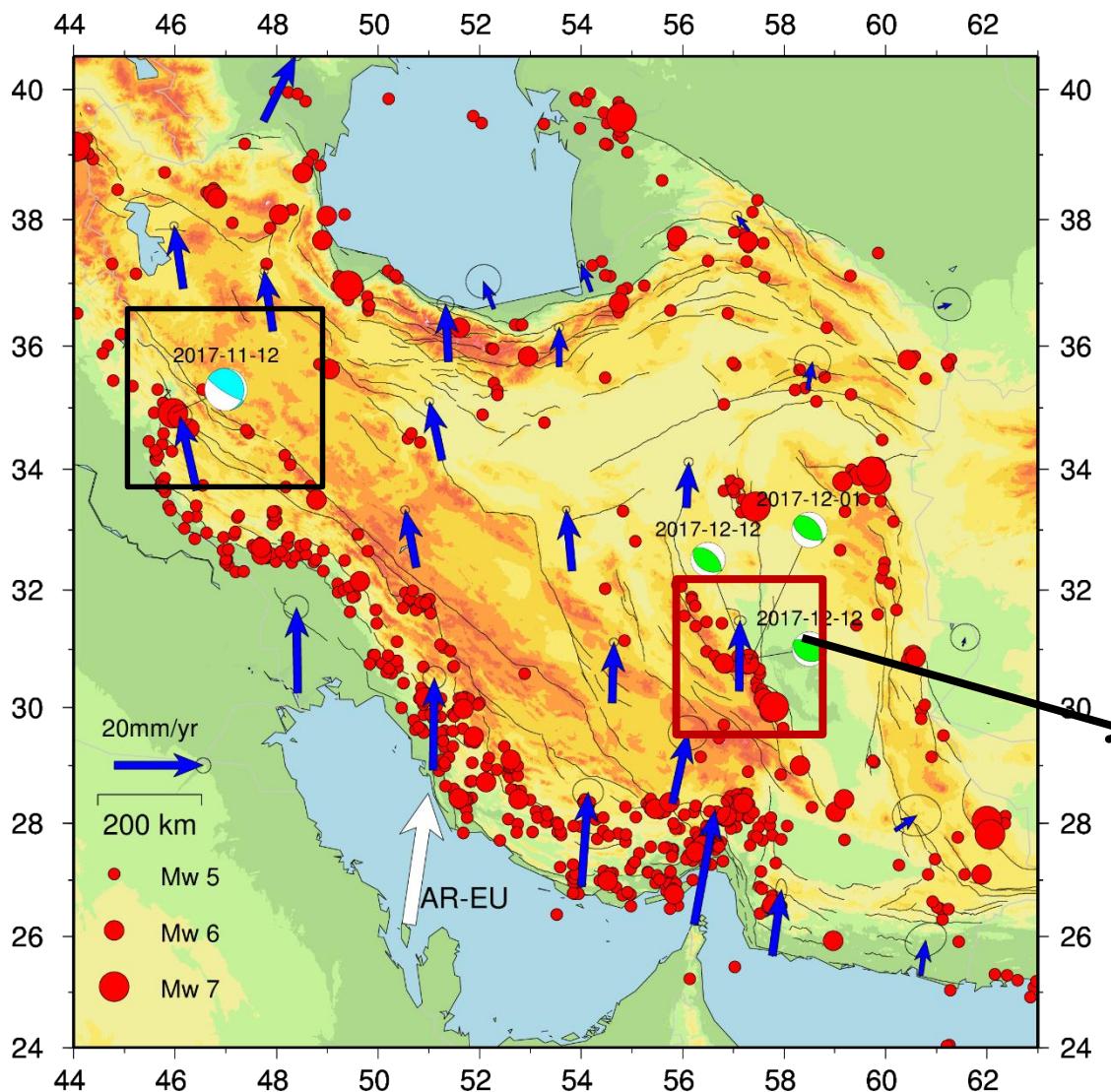
- 2017 Mainshock occurred on the overthrust MFF
- Accommodated the across-strike part of the oblique convergence



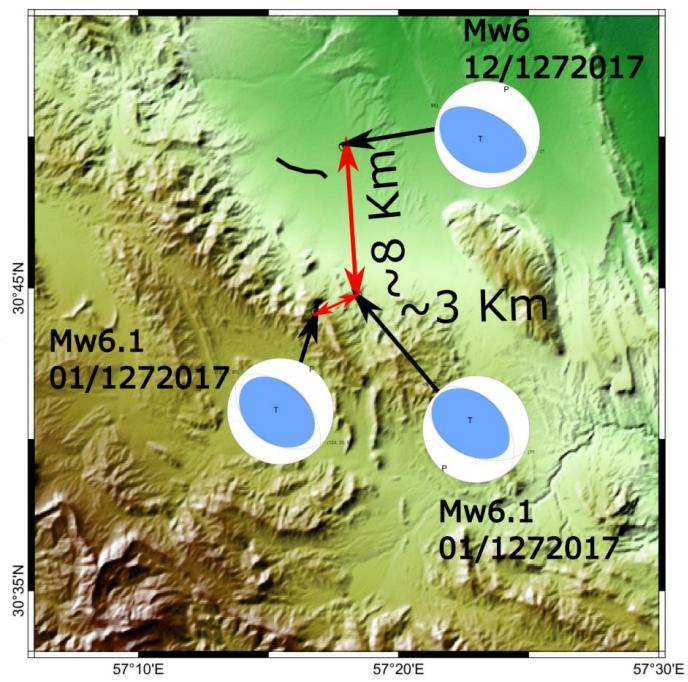
Vajedian, et al 2018, in review



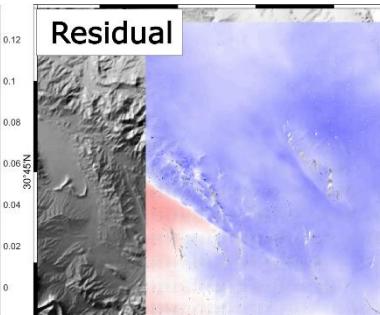
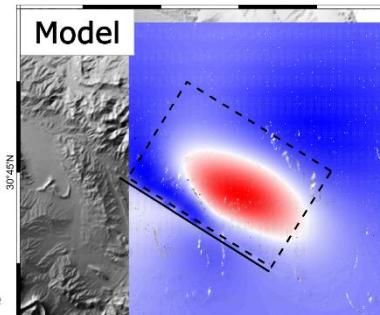
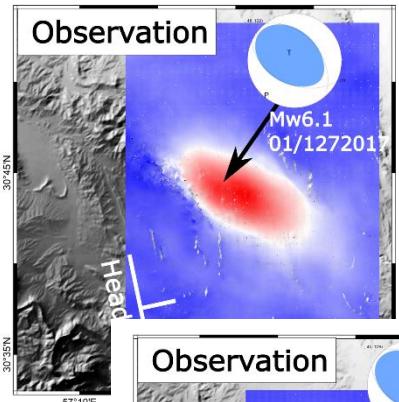
Second event ..



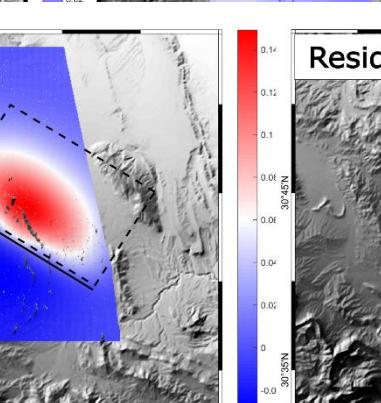
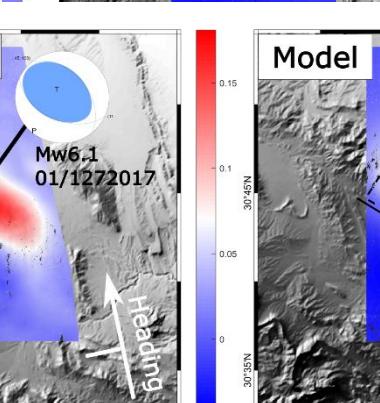
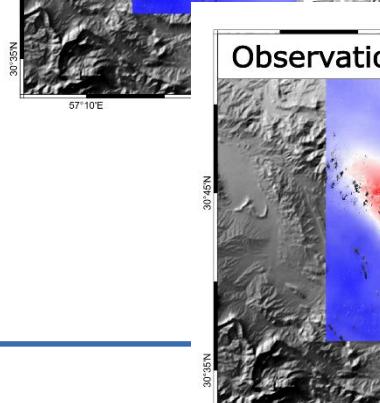
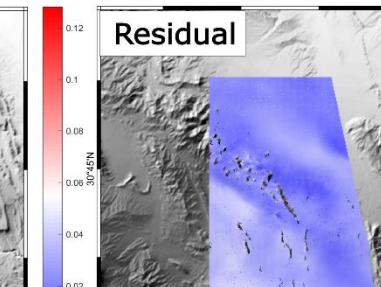
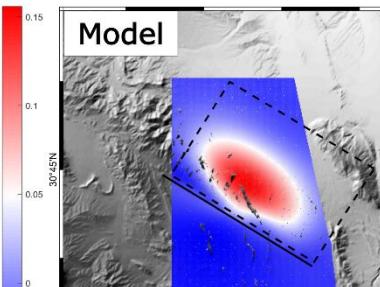
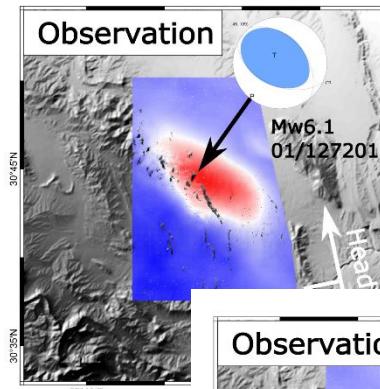
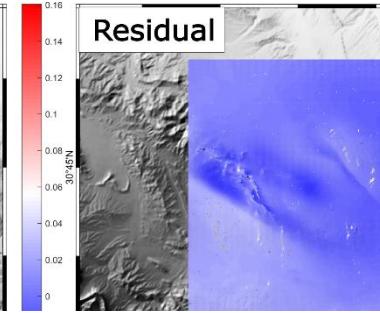
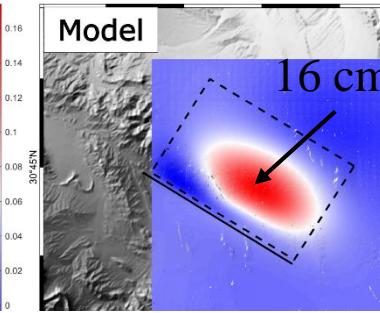
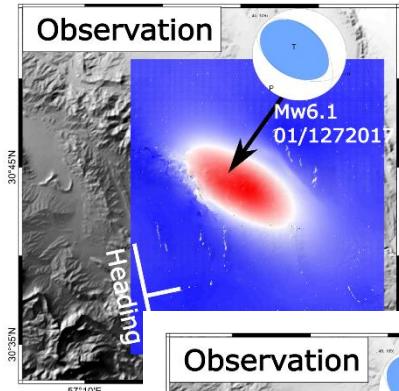
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- SW of Kuhbanan fault



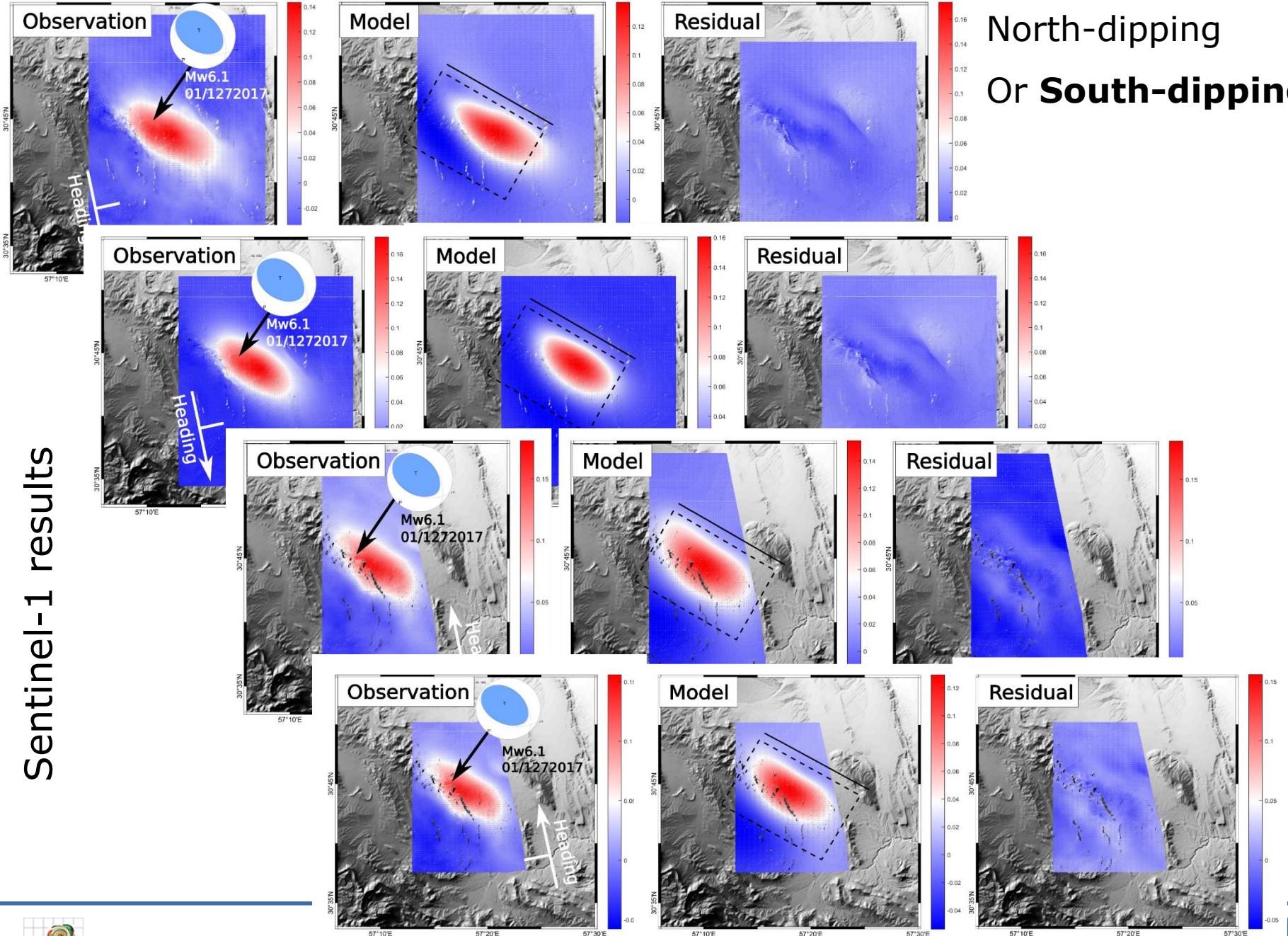
Sentinel-1 results



North-dipping
Or South-dipping ?

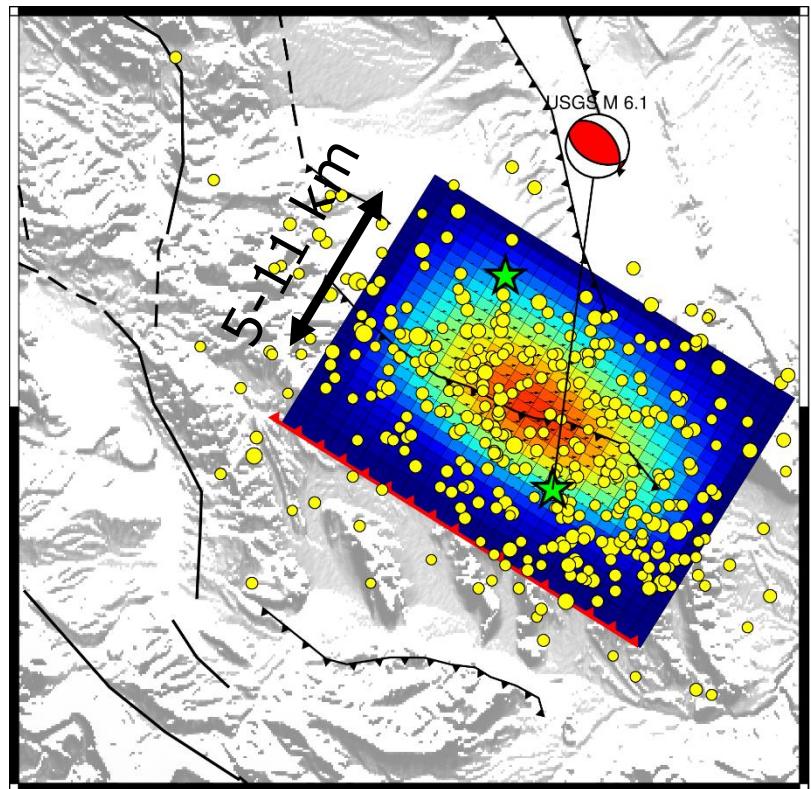


Sentinel-1 results

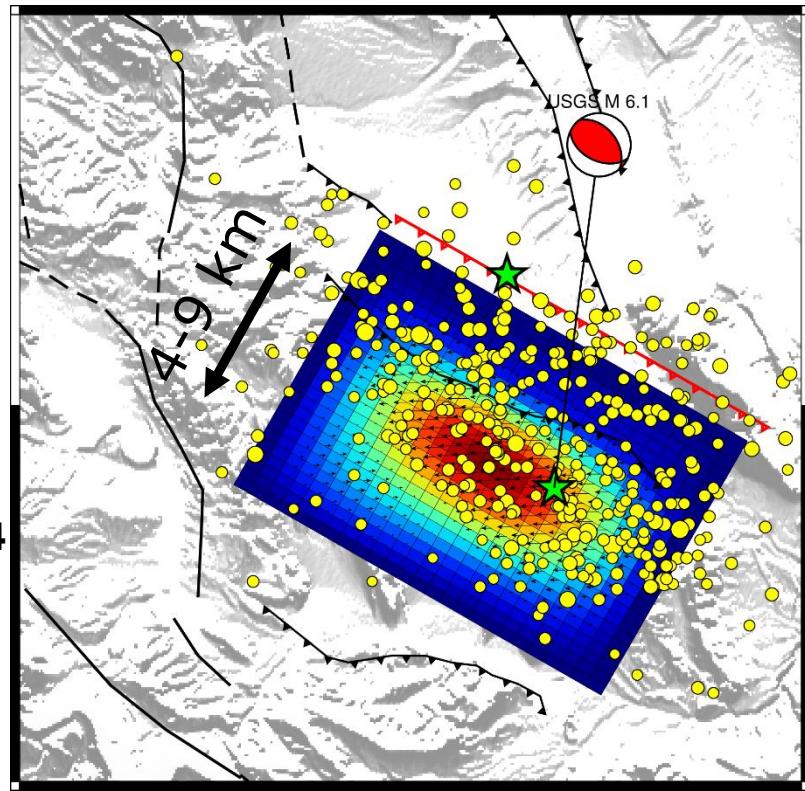


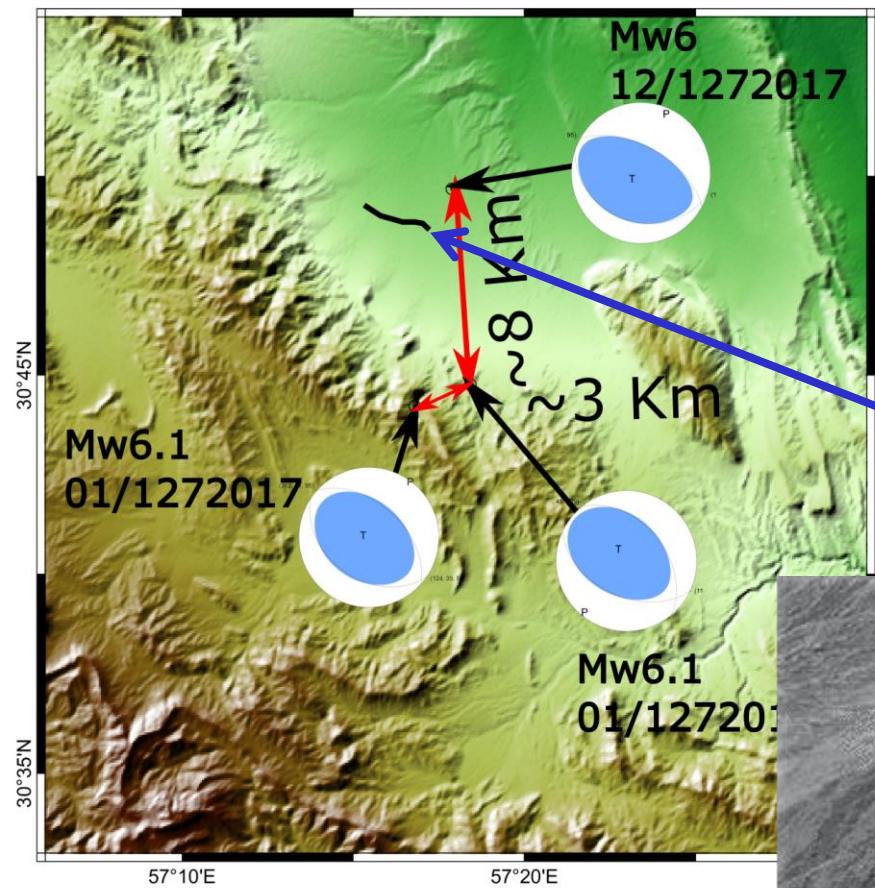
□ 1st Dec 2017, Mw 6.1

North-dipping



South-dipping

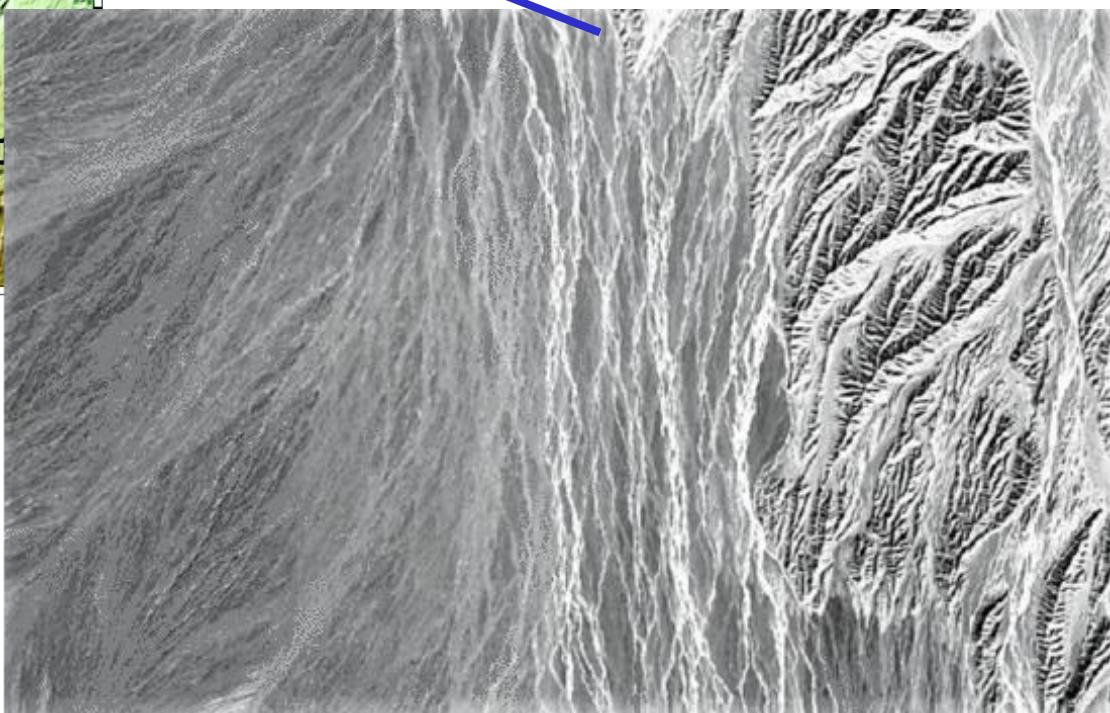




Apply constraint to estimate the
Source parameters ..

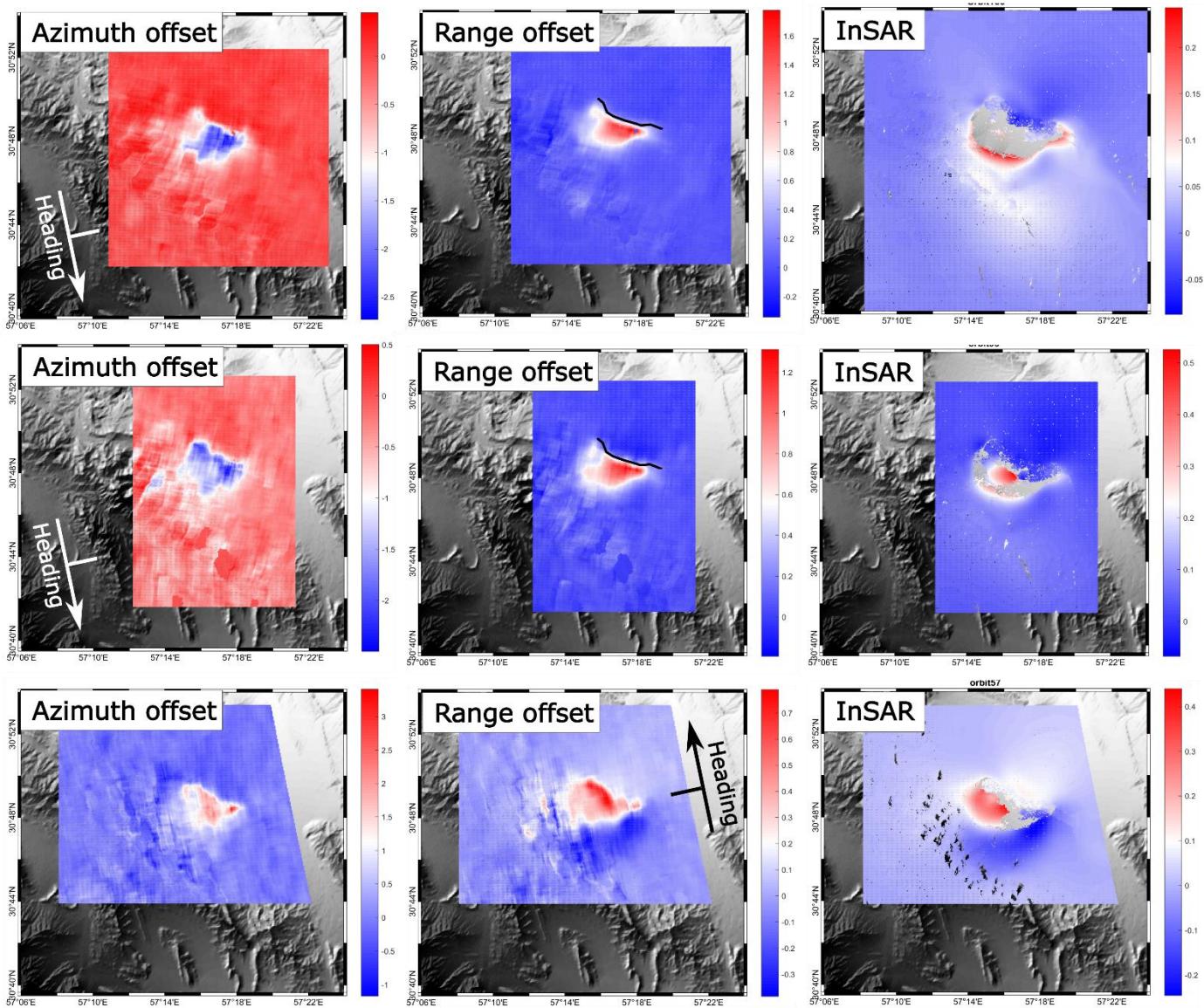
- Fixed length
- Fixed azimuth

Sentinel-2 Optical satellite data

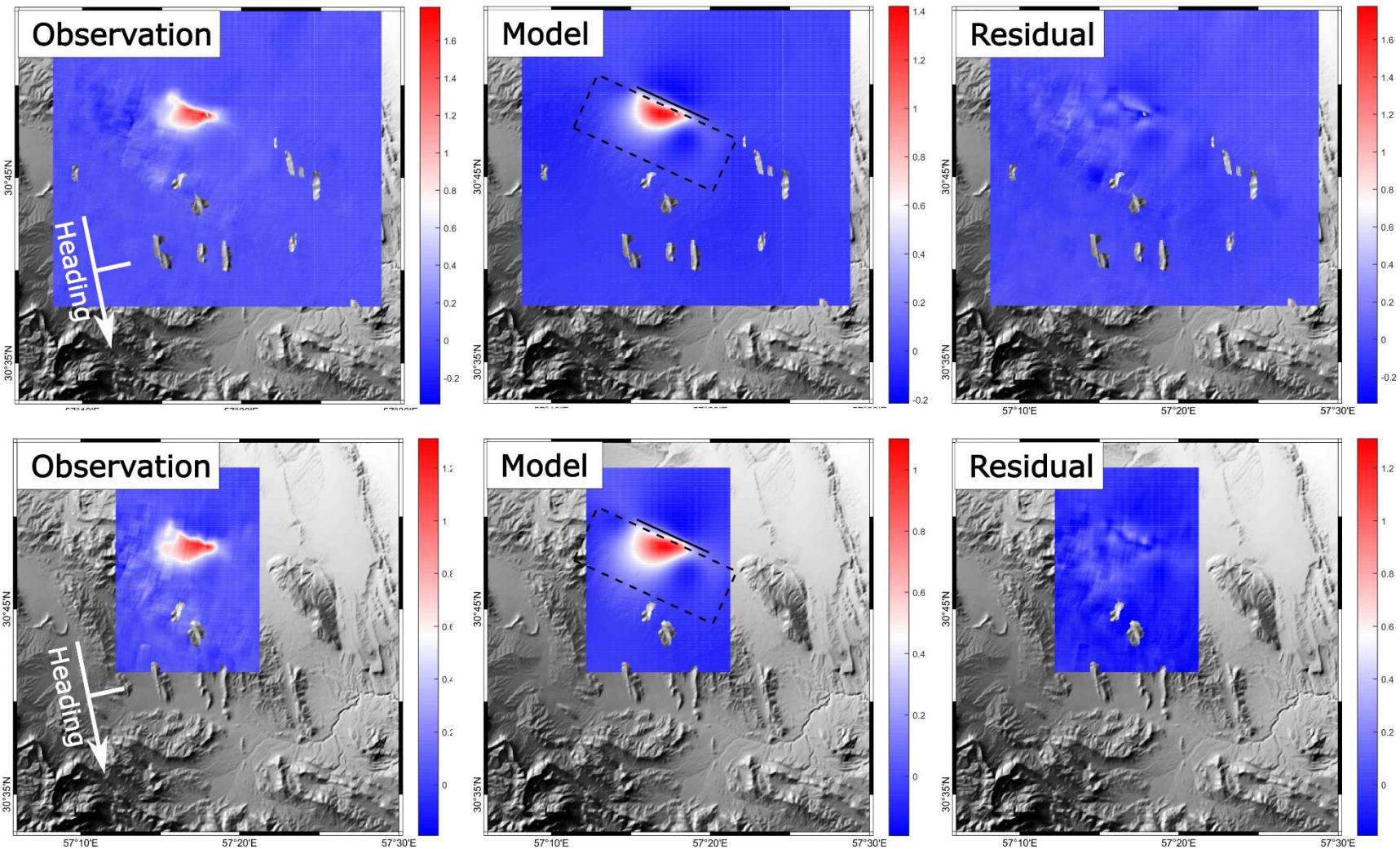


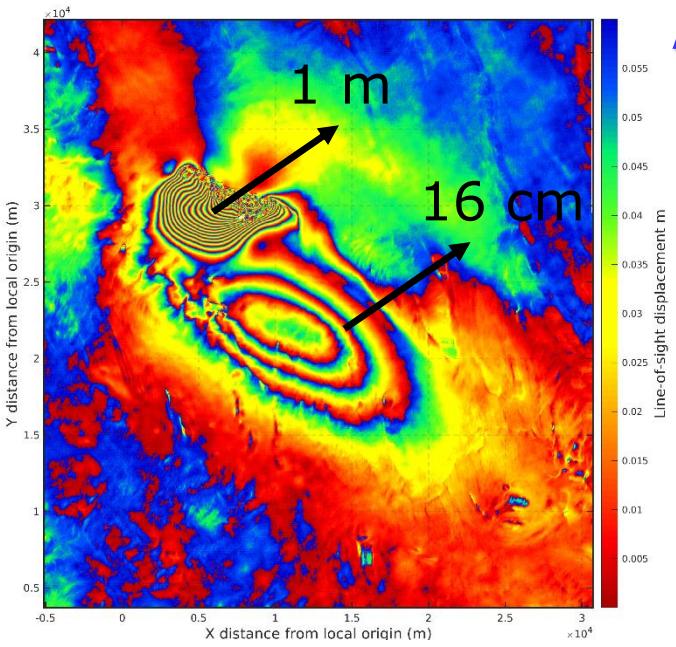
InSAR versus offset tracking ..

□ 12th Dec 2017, Mw 6

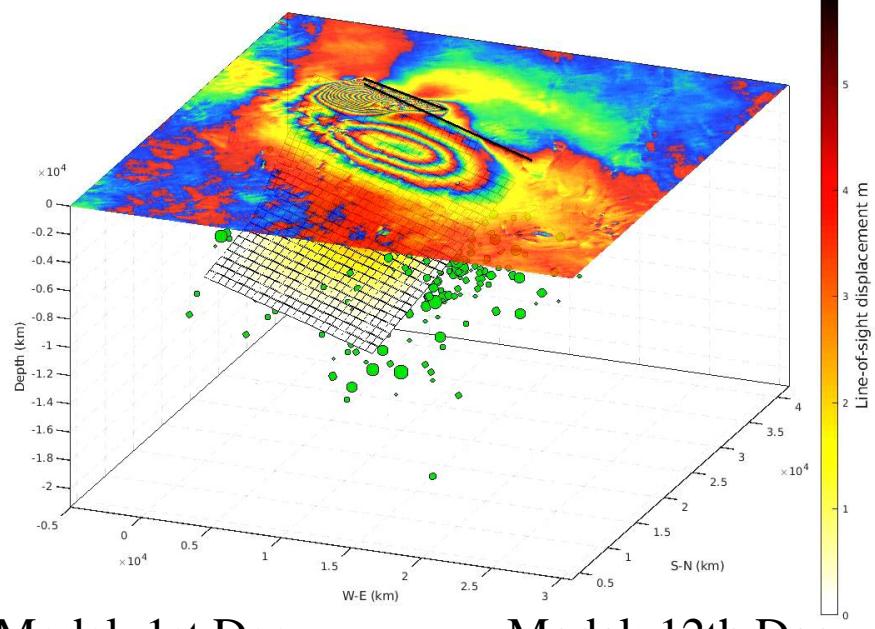


Offset tracking model..



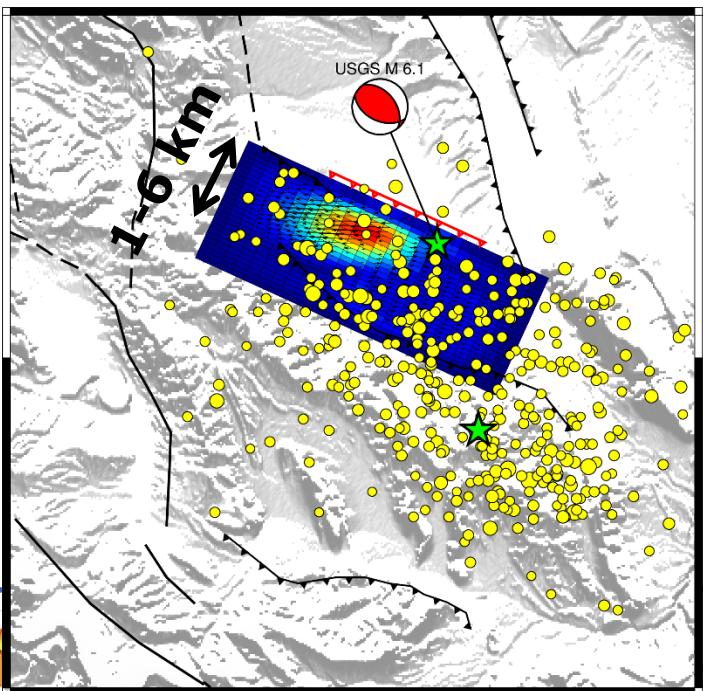


ALOS Processing ..

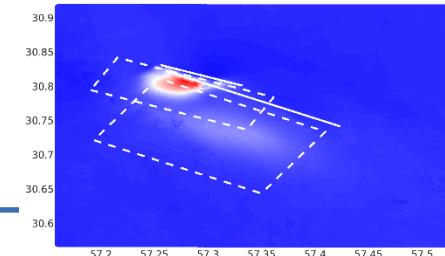


Model: 1st Dec

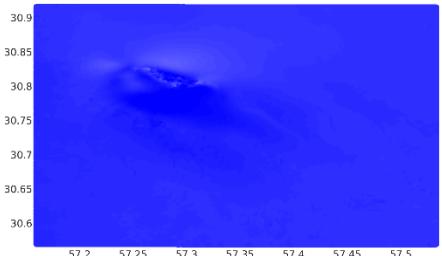
Model: 12th Dec



Observation



Residual

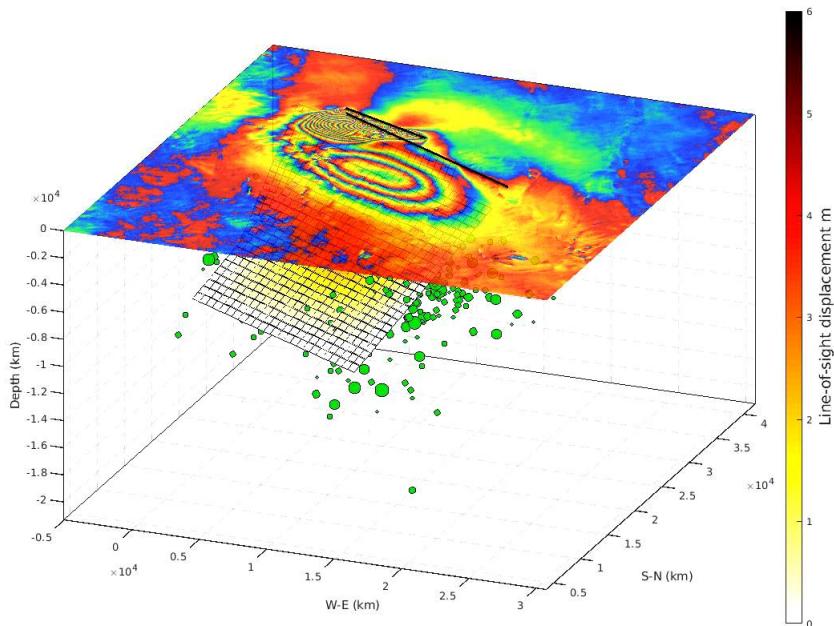


Information

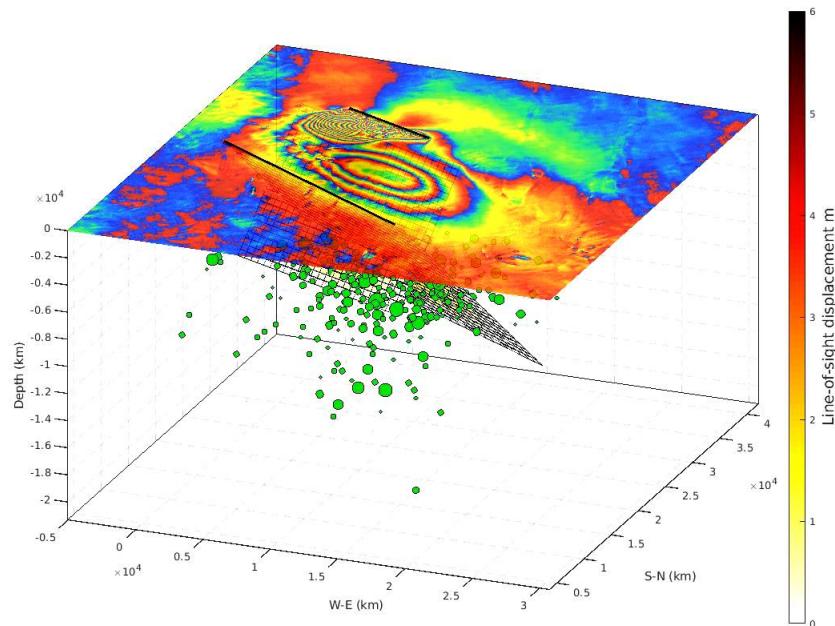
To conclude the second event ..

- Mainshock caused by thrust faults occurred at SW of Kuhbanan fault..
- Which geometry does make sense to accept? North or South?

South-dipping



North-dipping

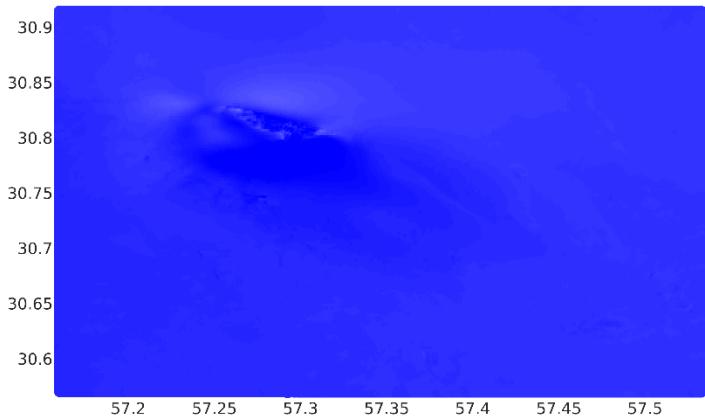
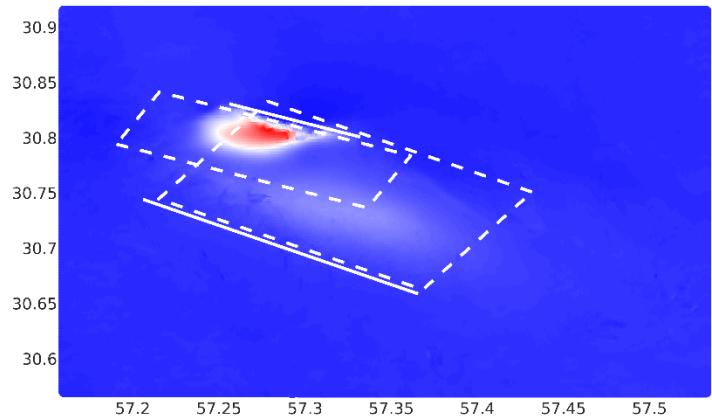
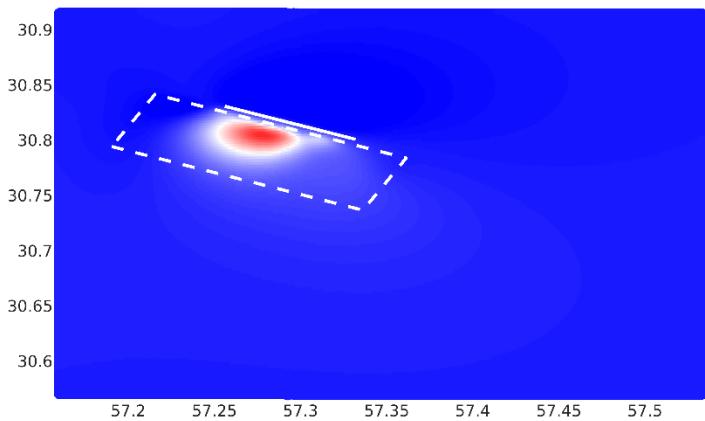
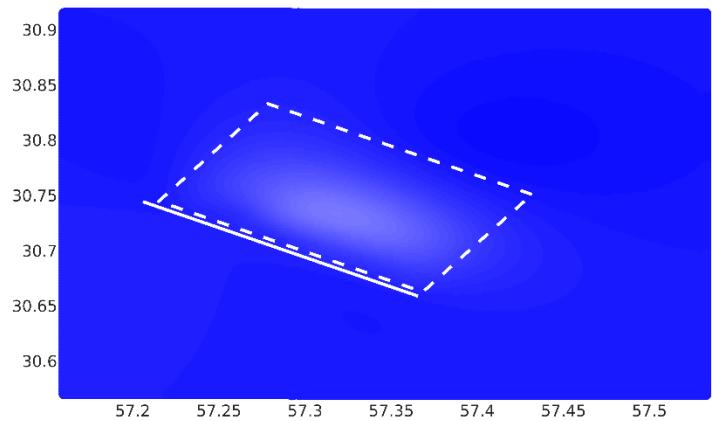


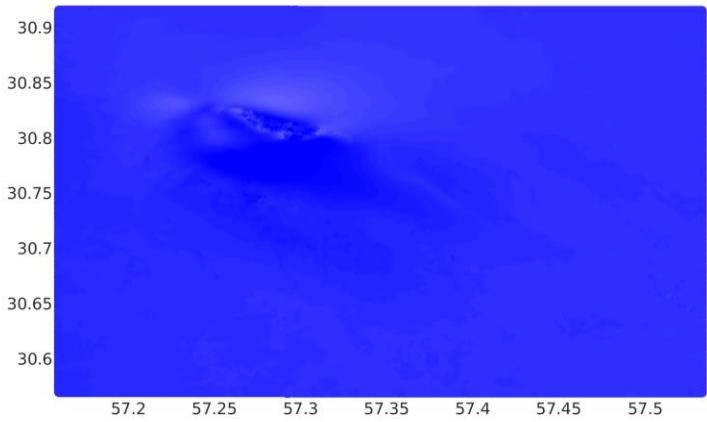
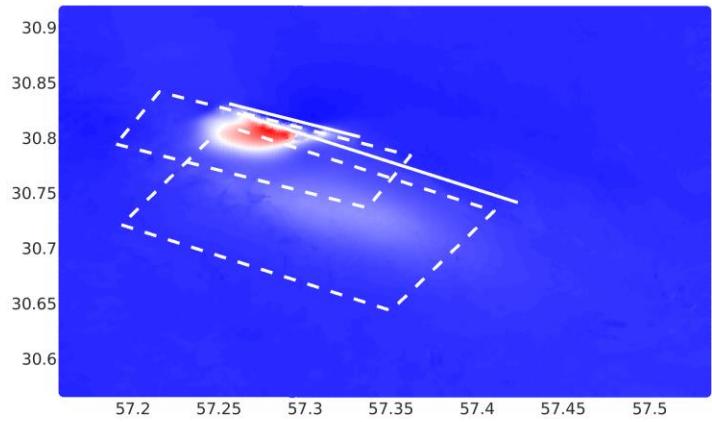
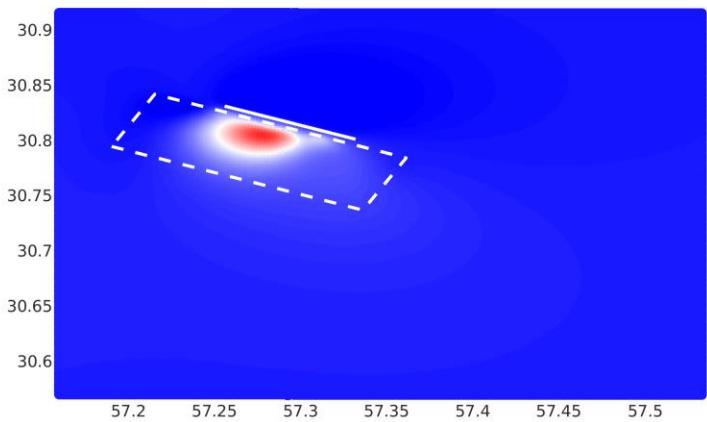
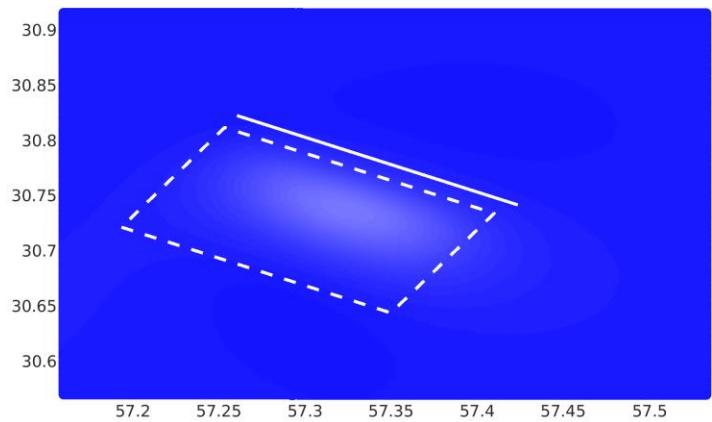
Thanks for your attention ..



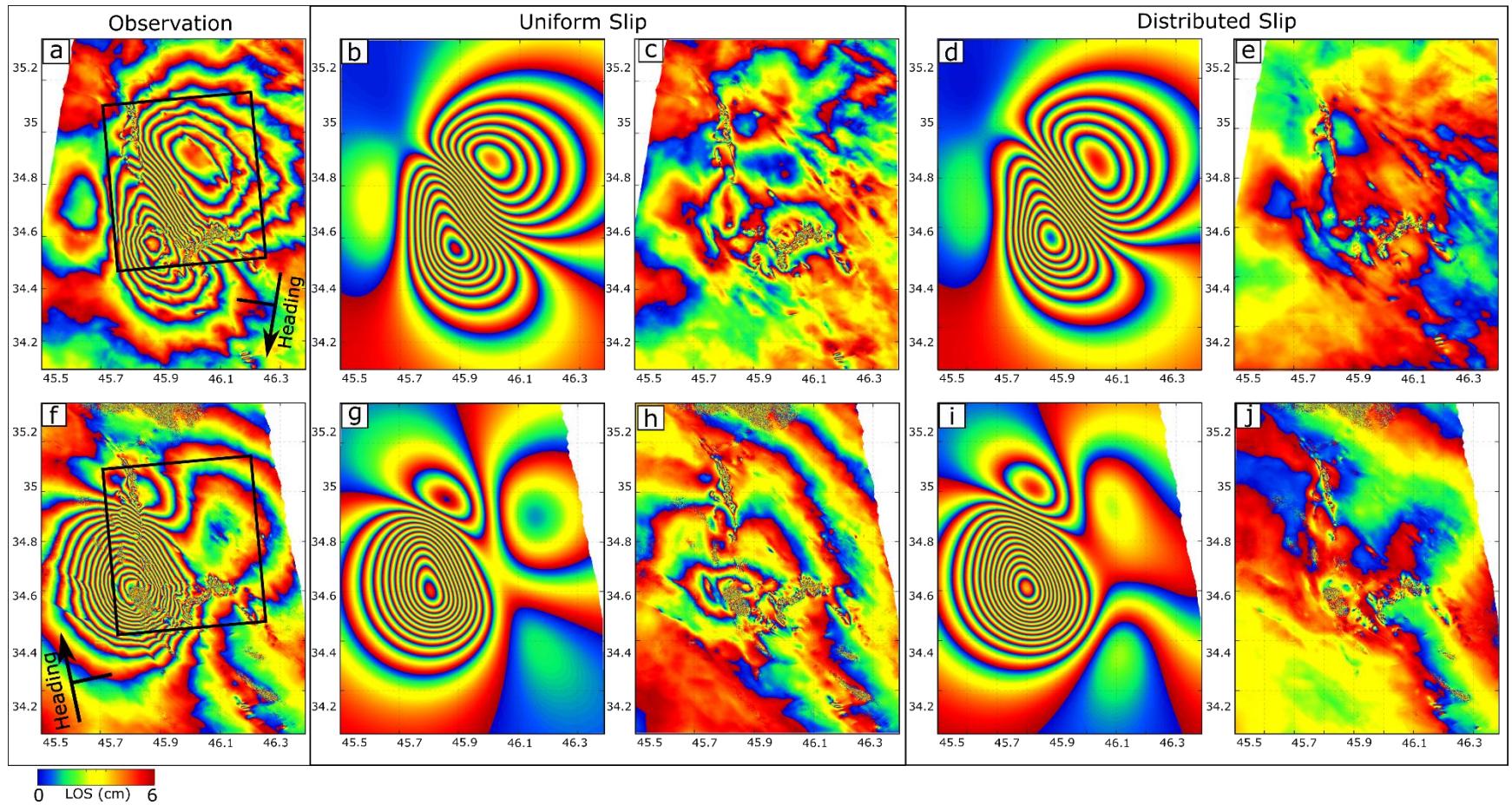
Back up slides

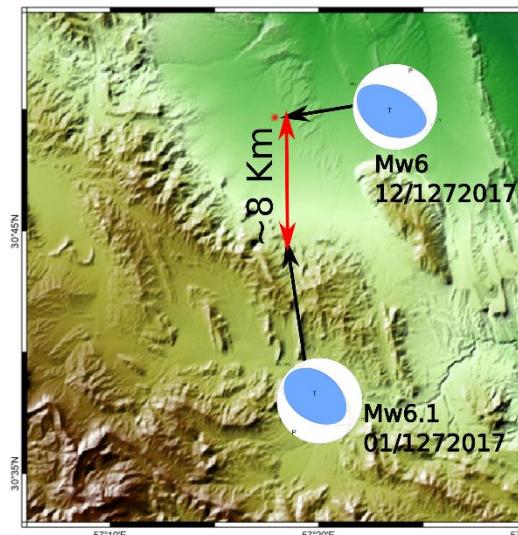
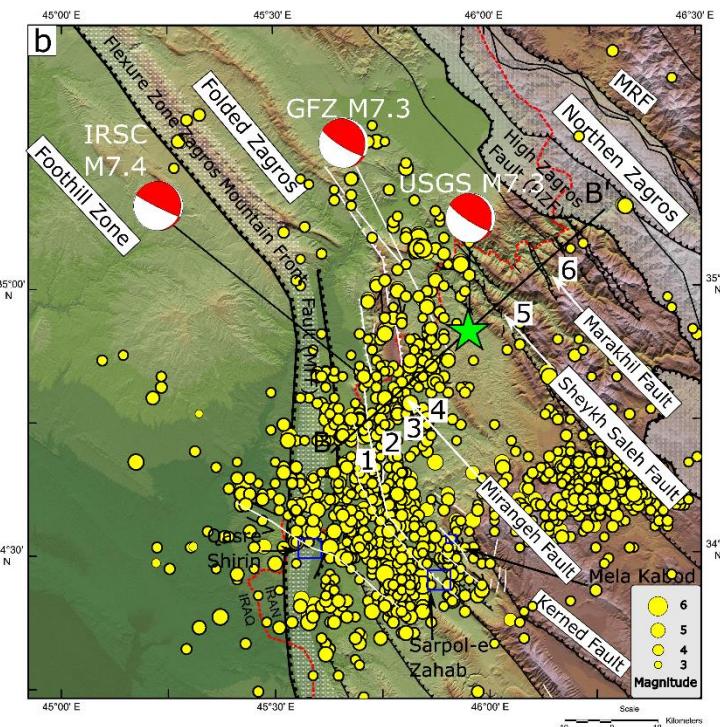
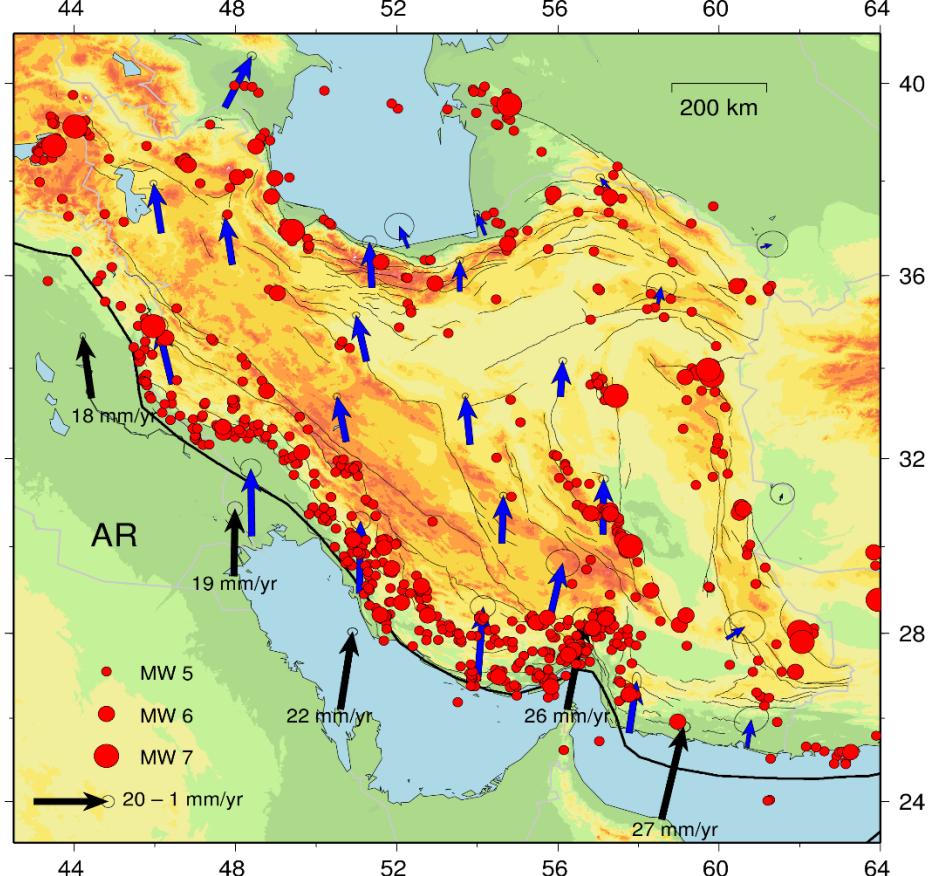


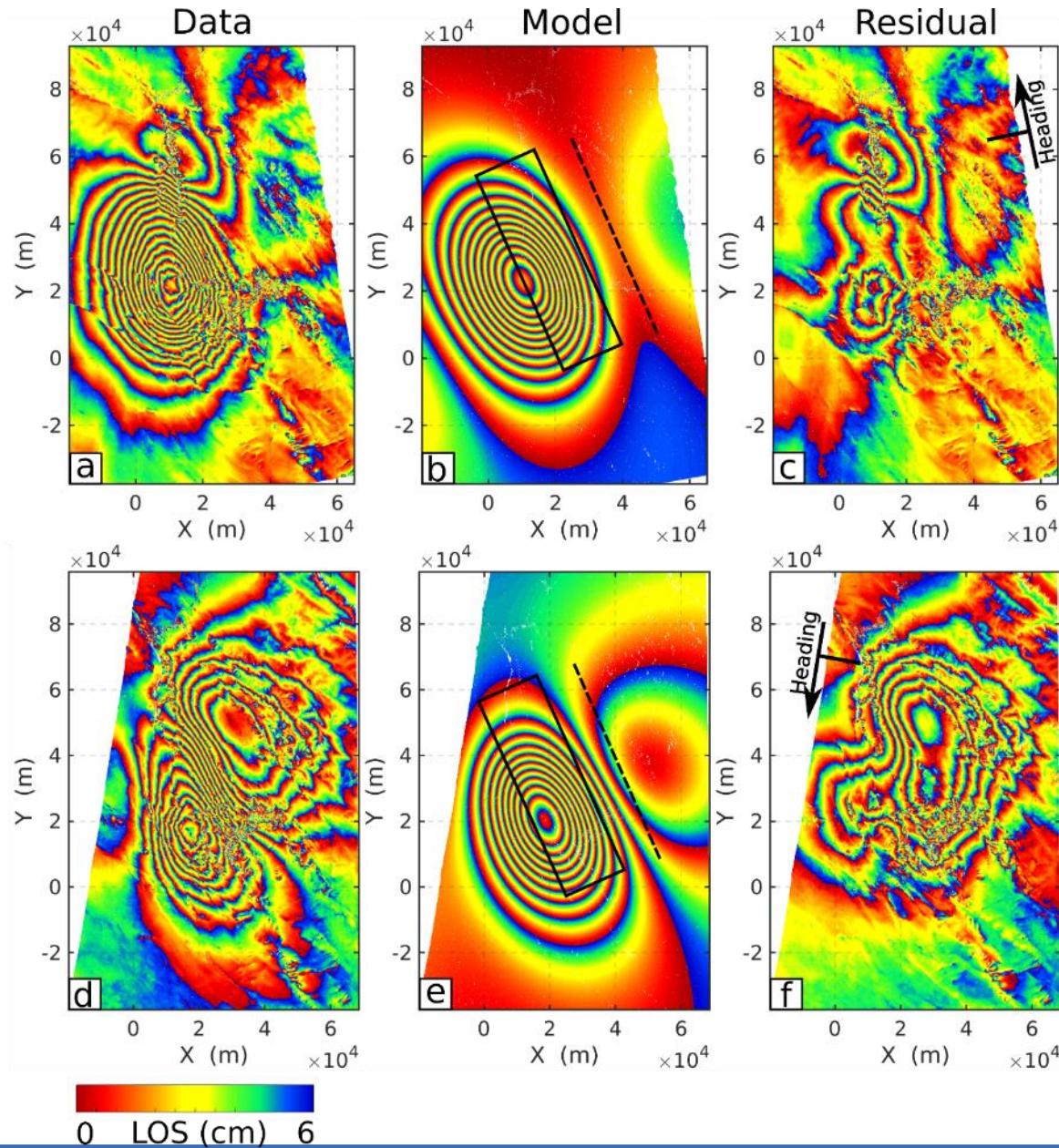










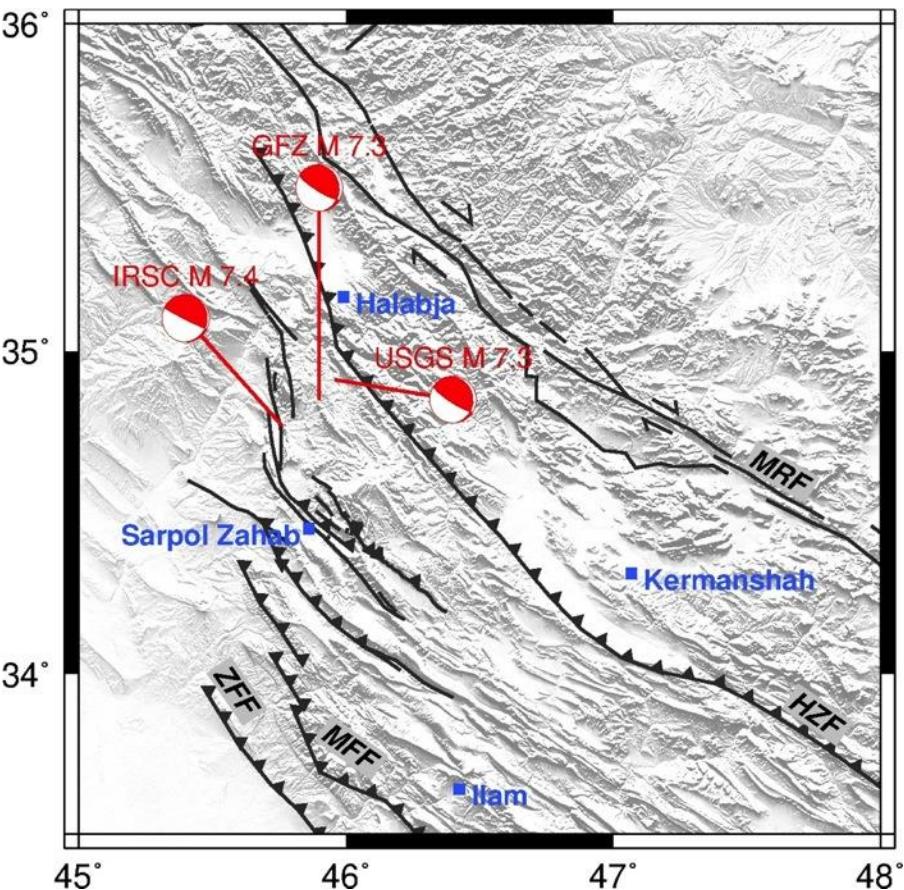


To conclude ..

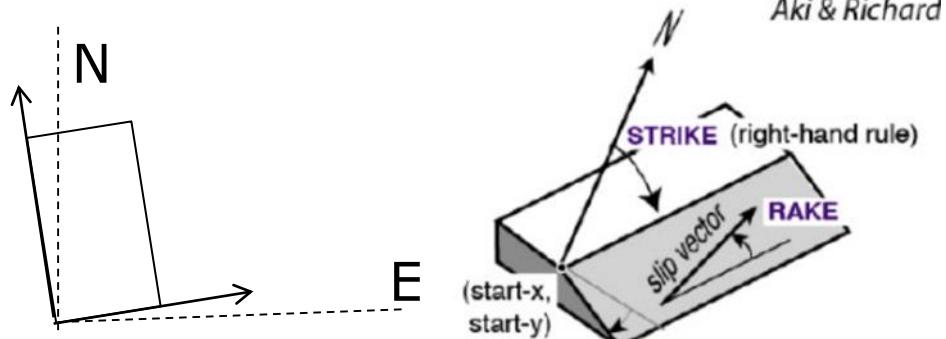
- In this study we presented the applicability of Sentinel-1 and ALOS-2 to resolve coseismic displacement.
- A combination of repeat-pass InSAR, burst overlap interferometry and offset tracking is exploited to retrieve the along-track and across-track deformation fields.
- We then used Bayesian-based inversion to infer source parameters and slip model of the earthquake
- Our results suggest that the earthquake was generated by a blind ENE oblique thrust faulting with maximum slip of approx. 5 m at a depth of 17 km.
- We derived deformation field related to a large landslide motion triggered by this event.
- The Uplift rate of <1 mm/yr are resulted from our procesessing



Controversy in seismic solutions



USGS:	Plane	Strike	Dip	Rake
	NP1	351°	16°	137°
	NP2	122°	79°	78°



ISC:	Plane	Strike	Dip	Rake
	NP1	4°	10°	157°
	NP2	116°	86°	81°

