National Aeronautics and
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Imaging Complex Fault Slip History of 2016 Taiwan and Japan Earthquakes with Geodetic and Seismic Data

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* Work partially performed under contract with the National Aeronautics and Space Administration

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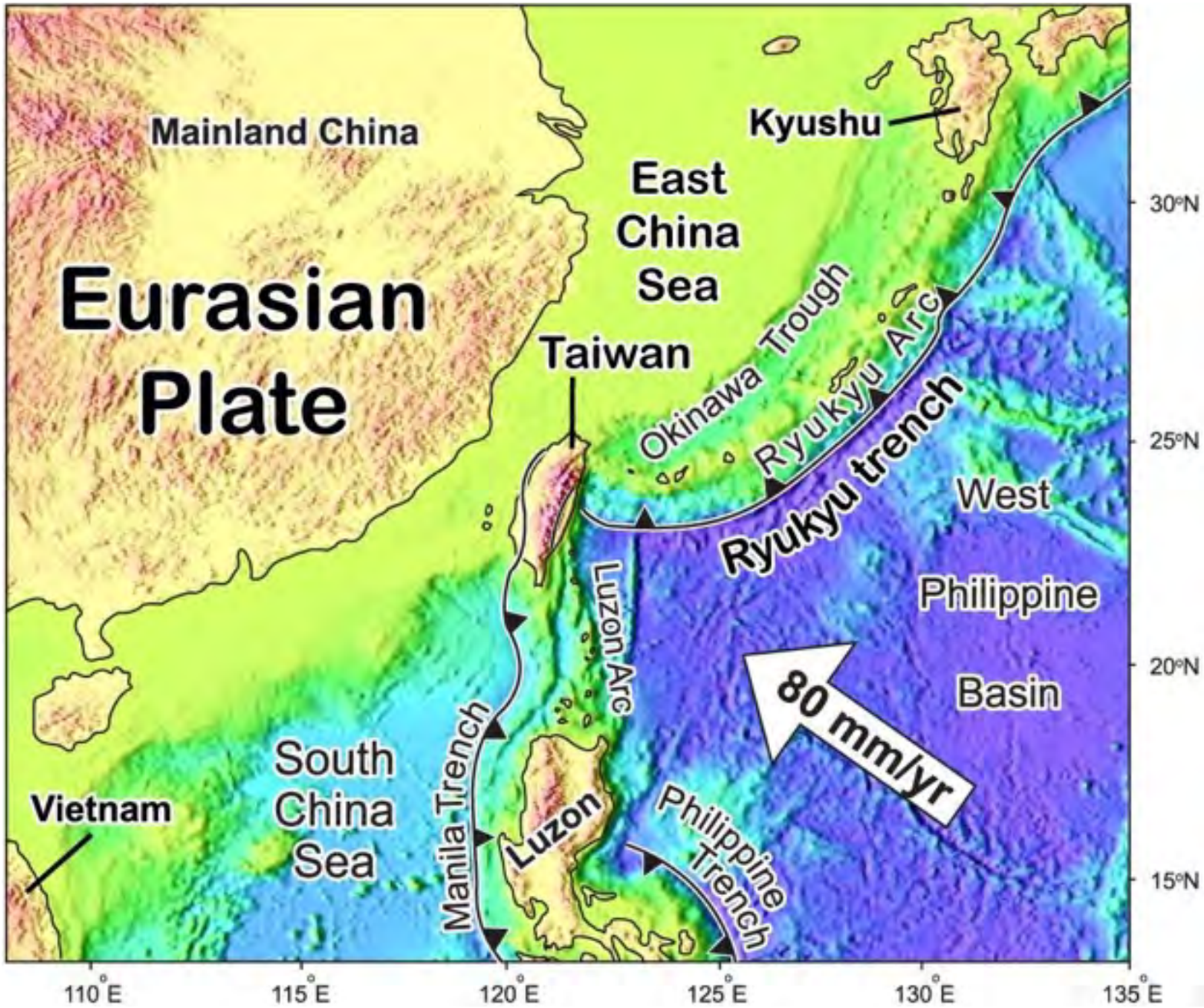
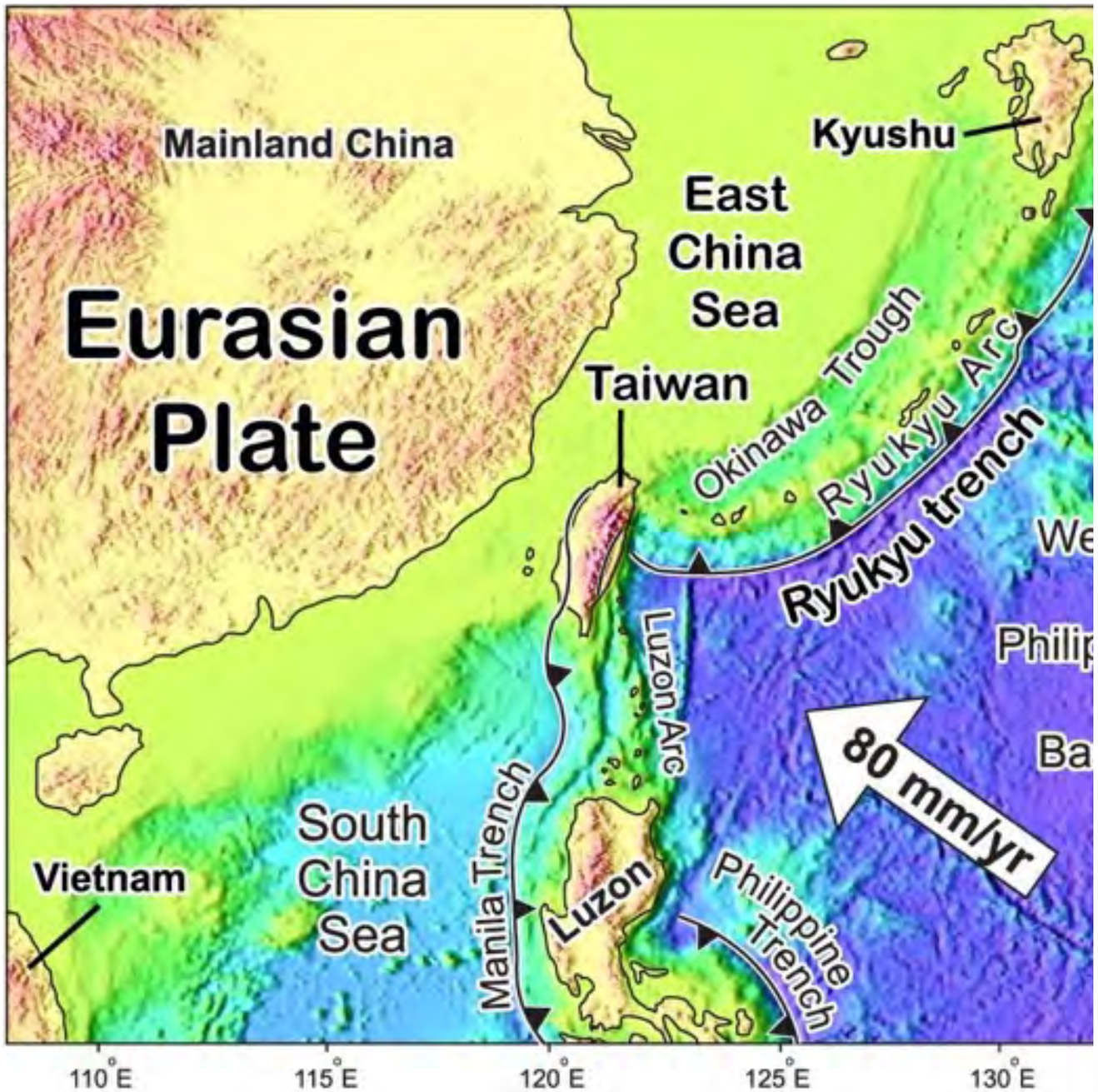


courtesy of K. Ustaszewski



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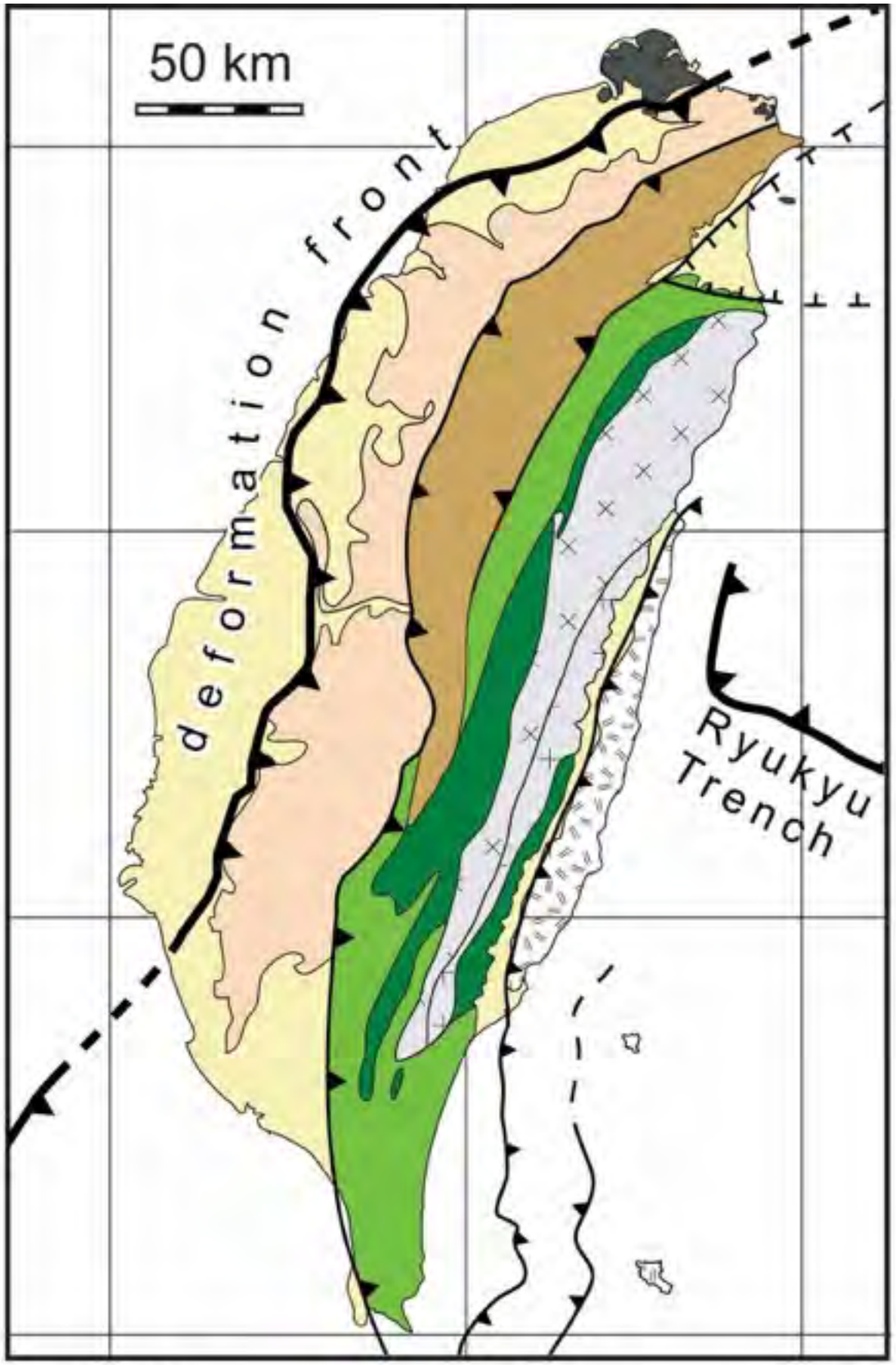
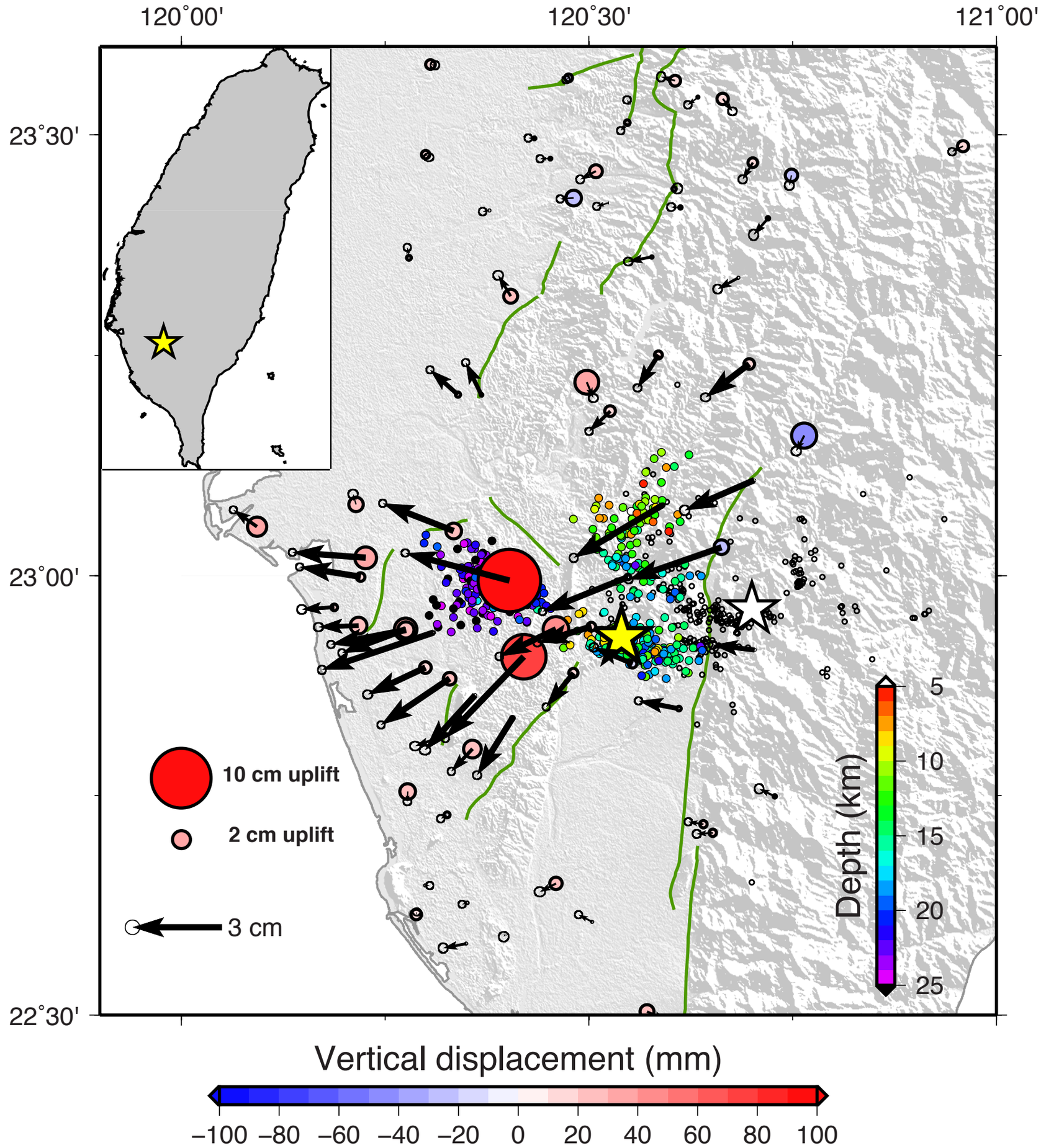
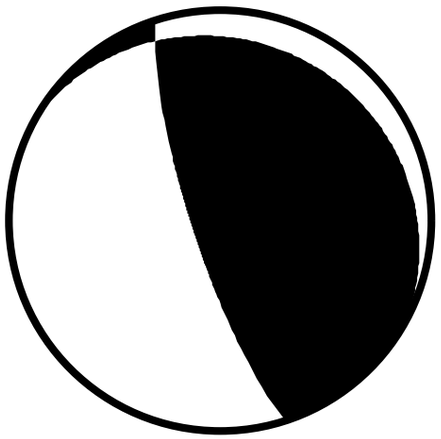


MeiNong EQ

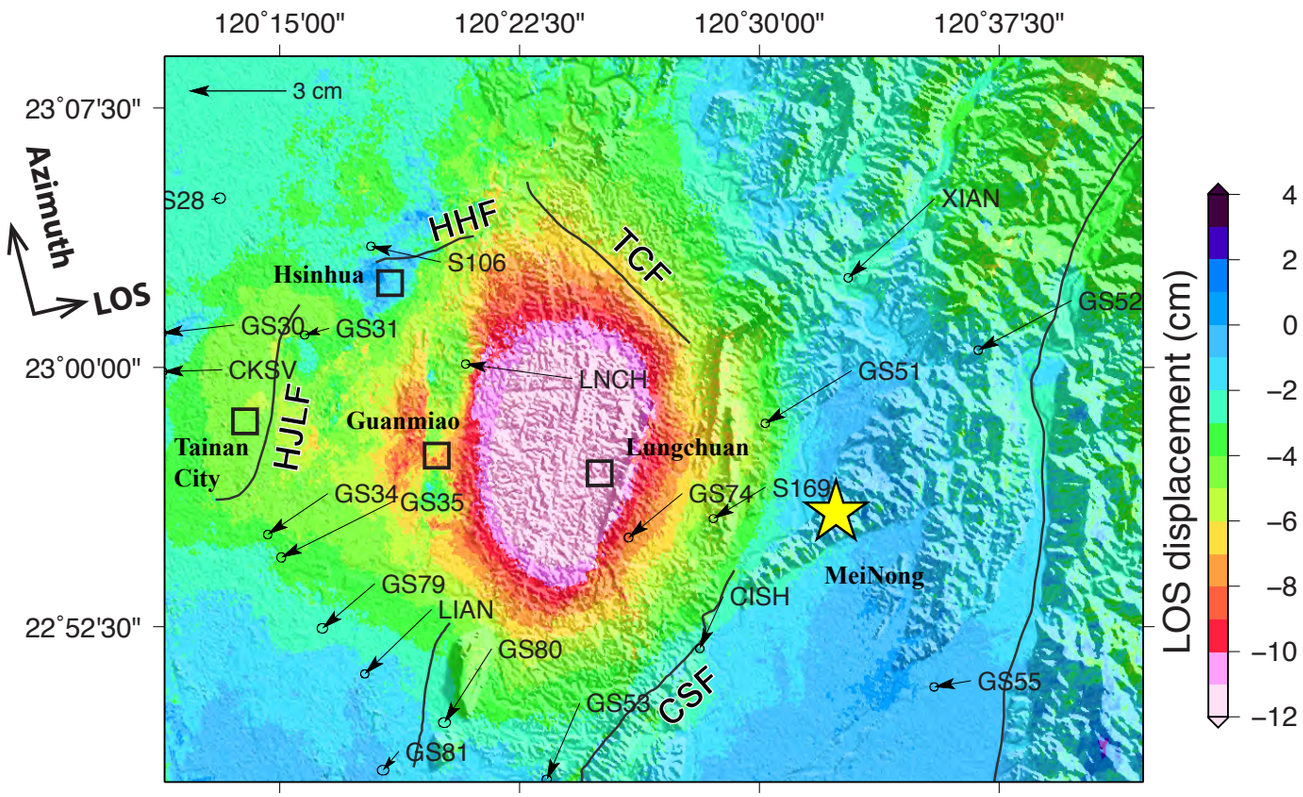
Mw 6.4

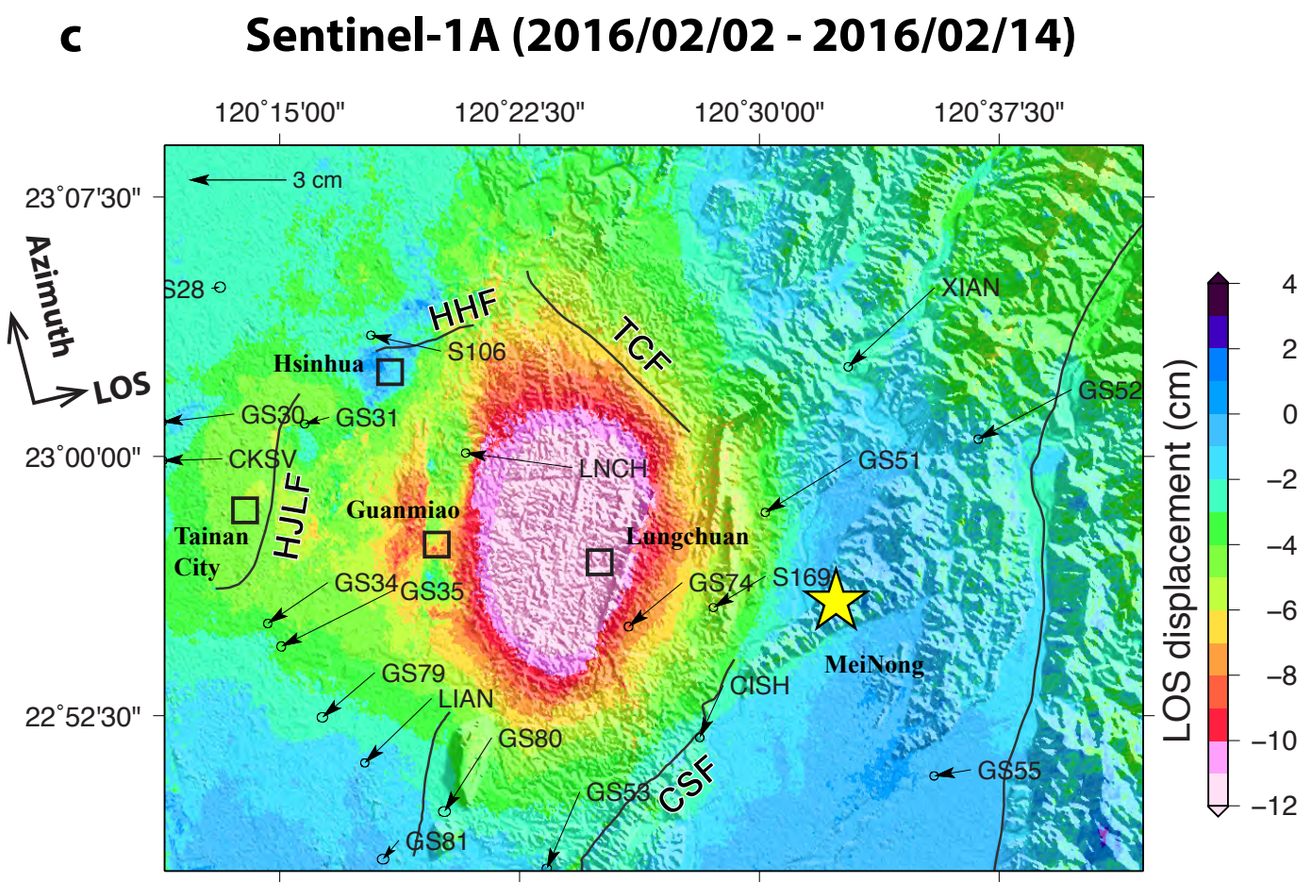
Feb. 5, 2016

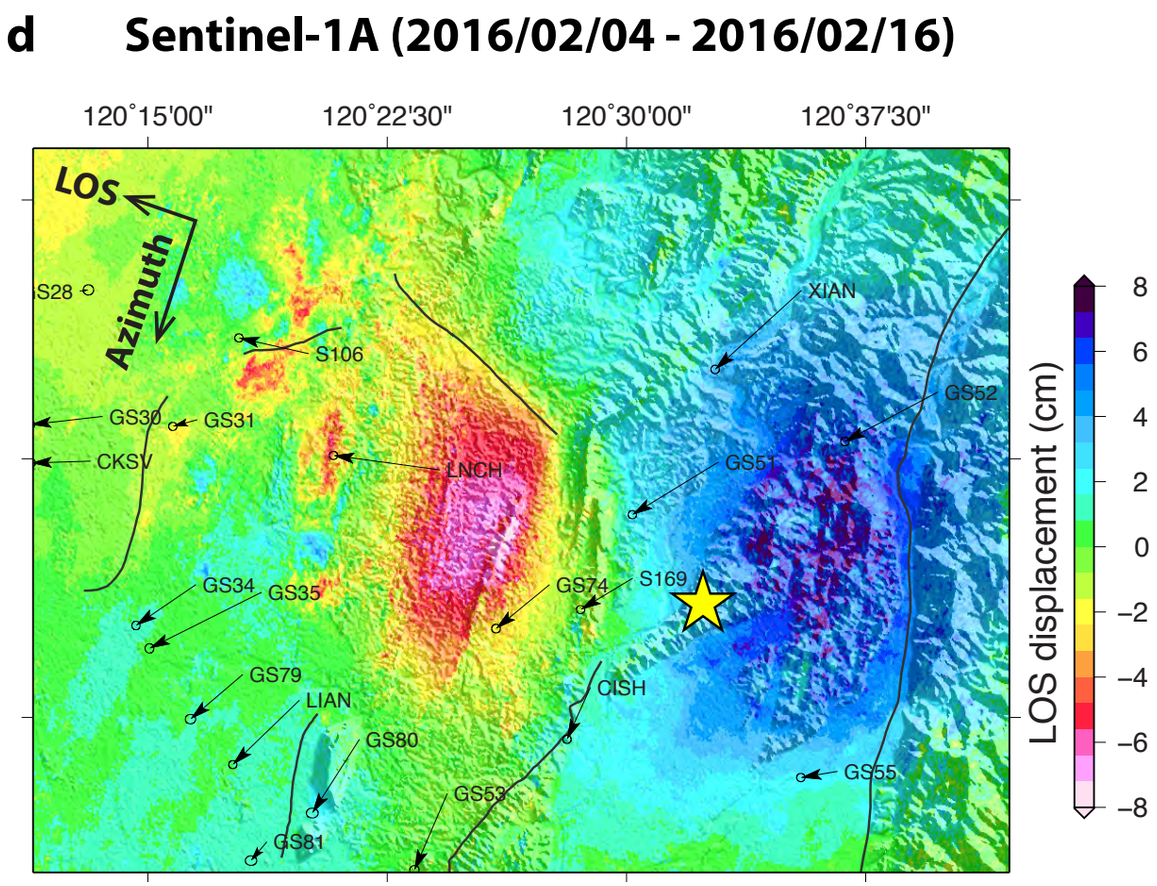


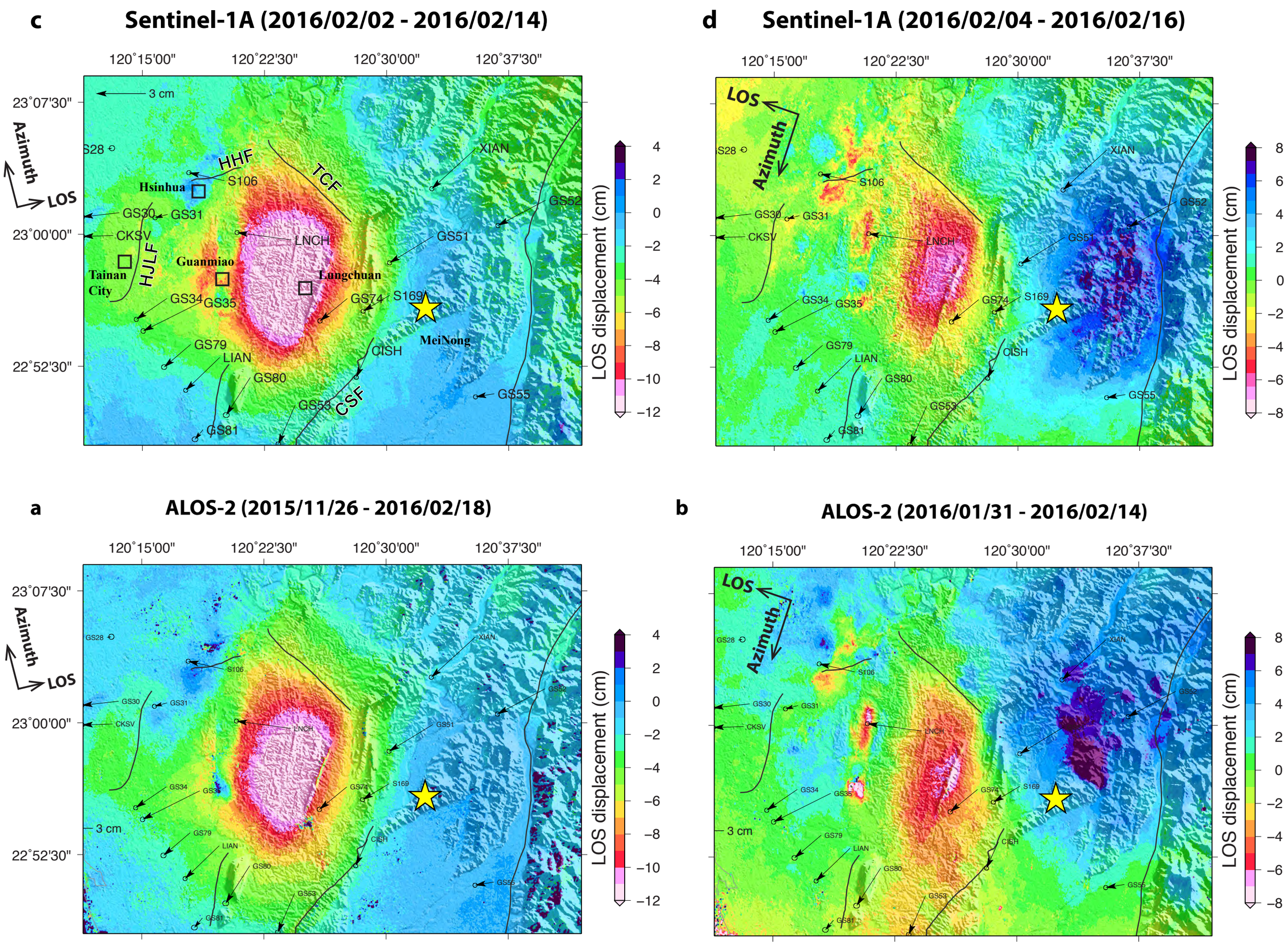


c **Sentinel-1A (2016/02/02 - 2016/02/14)**

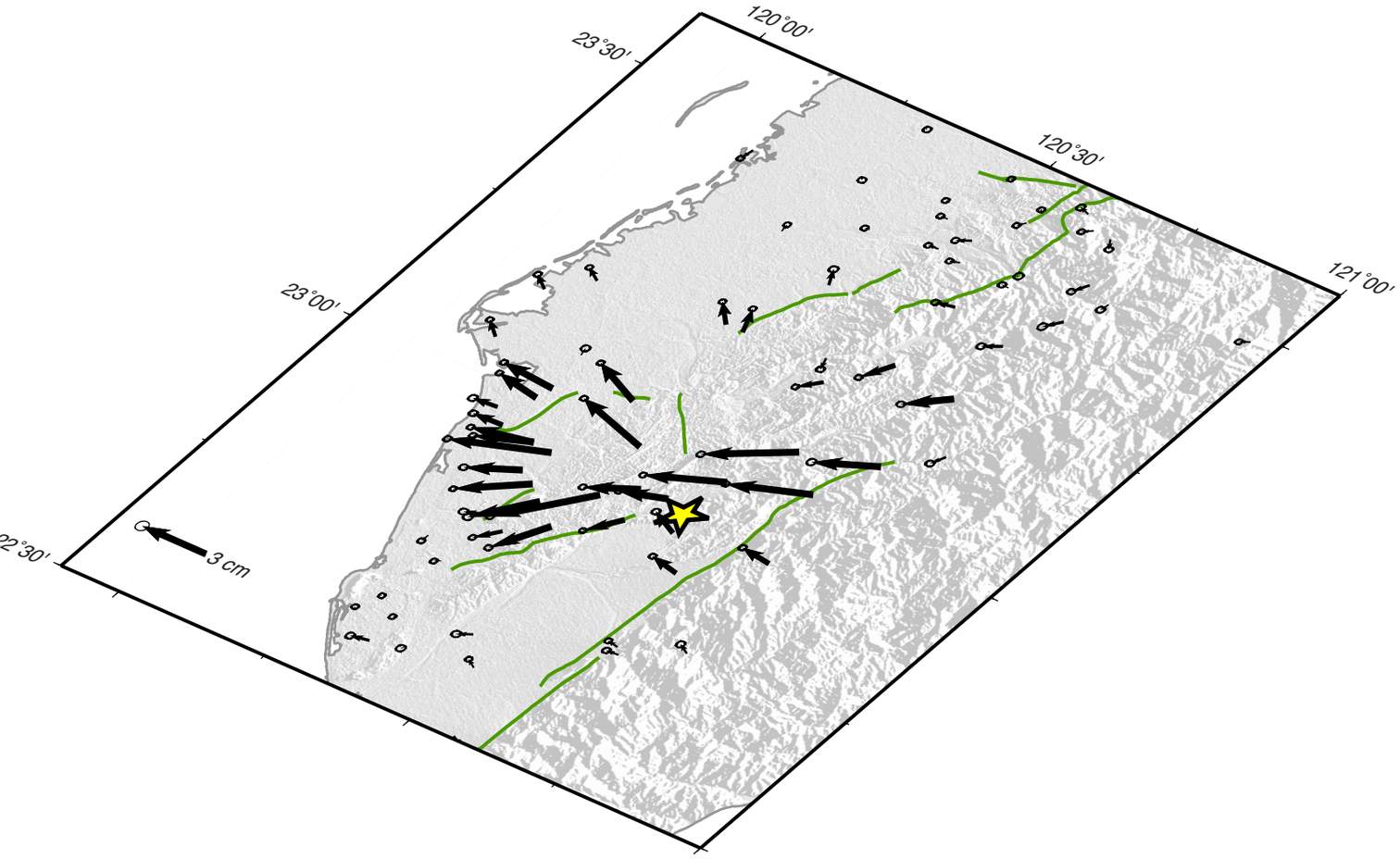



c
Sentinel-1A (2016/02/02 - 2016/02/14)
120°15'00"
120°22'30"
120°30'00"
120°37'30"
23°07'30"
23°00'00"
22°52'30"
3 cm
Azimuth
LOS
S28
HHF
S106
Hsinhua
TCF
XIAN
GS52
GS30
GS31
CKSV
LNCH
GS51
Guanmiao
Tainan City
HJLF
Lungchuan
GS34
GS35
GS74
S169
MeiNong
GS79
LIAN
CISH
GS80
GS53
CSF
GS55
GS81
LOS displacement (cm)
4
2
0
−2
−4
−6
−8
−10
−12

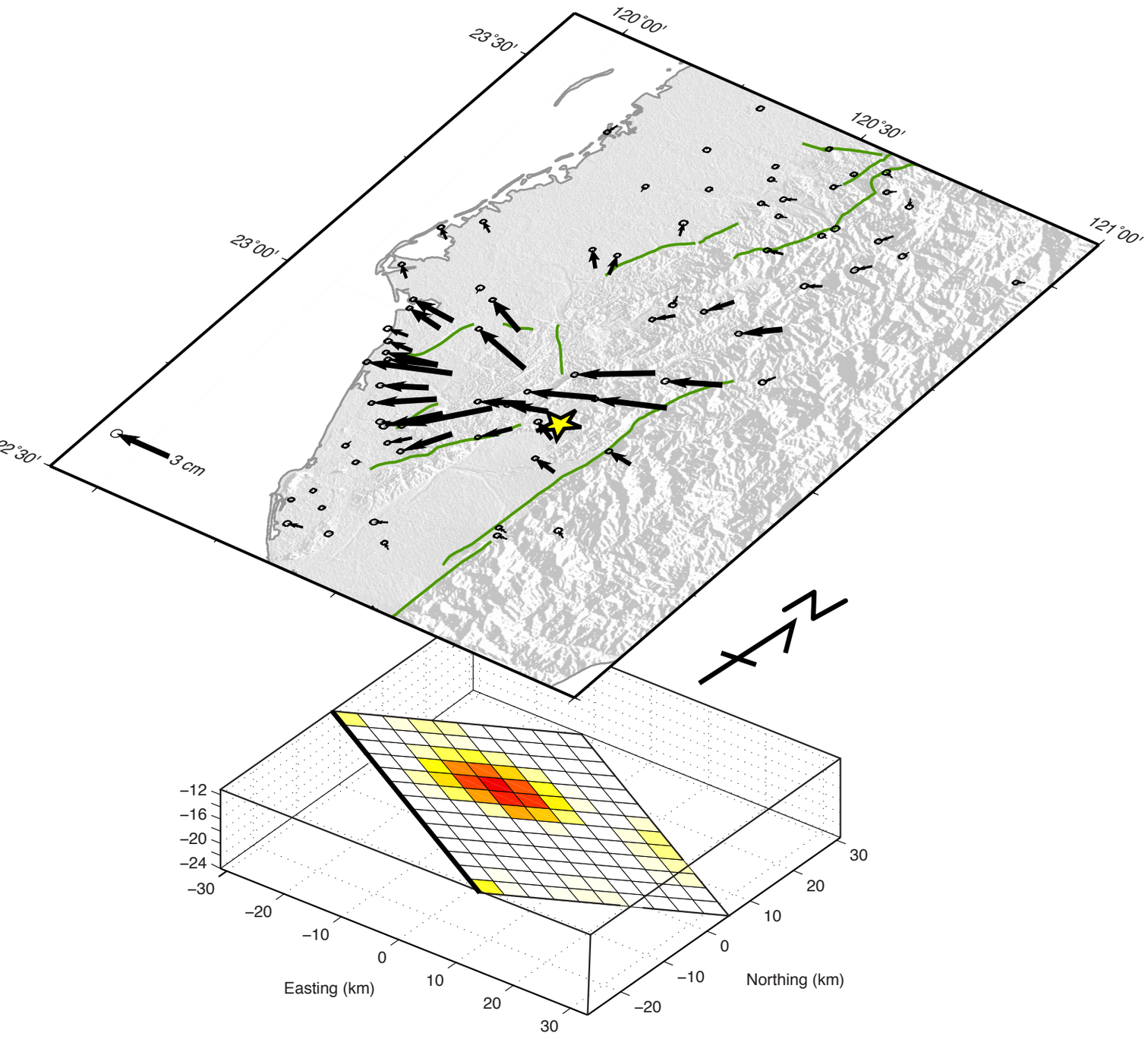

d
Sentinel-1A (2016/02/04 - 2016/02/16)
120°15'00"
120°22'30"
120°30'00"
120°37'30"
LOS
Azimuth
S28
S106
XIAN
GS52
GS30
GS31
CKSV
LNCH
GS51
GS34
GS35
GS74
S169
GS79
LIAN
CISH
GS80
GS53
GS55
GS81
LOS displacement (cm)
8
6
4
2
0
−2
−4
−6
−8


c
Sentinel-1A (2016/02/02 - 2016/02/14)
d
Sentinel-1A (2016/02/04 - 2016/02/16)
a
ALOS-2 (2015/11/26 - 2016/02/18)
b
ALOS-2 (2016/01/31 - 2016/02/14)
120°15'00"
120°22'30"
120°30'00"
120°37'30"
23°07'30"
23°00'00"
22°52'30"
3 cm
Azimuth
LOS
HHF
TCF
HJLF
CSF
Hsinhua
Guanmiao
Tainan City
Lungchuan
MeiNong
GS28
S106
GS30
GS31
CKSV
LNCH
XIAN
GS52
GS51
GS34
GS35
GS74
S169
GS79
LIAN
CISH
GS80
GS53
GS55
GS81
LOS displacement (cm)
4
2
0
−2
−4
−6
−8
−10
−12
8
6
4
2
0
−2
−4
−6
−8

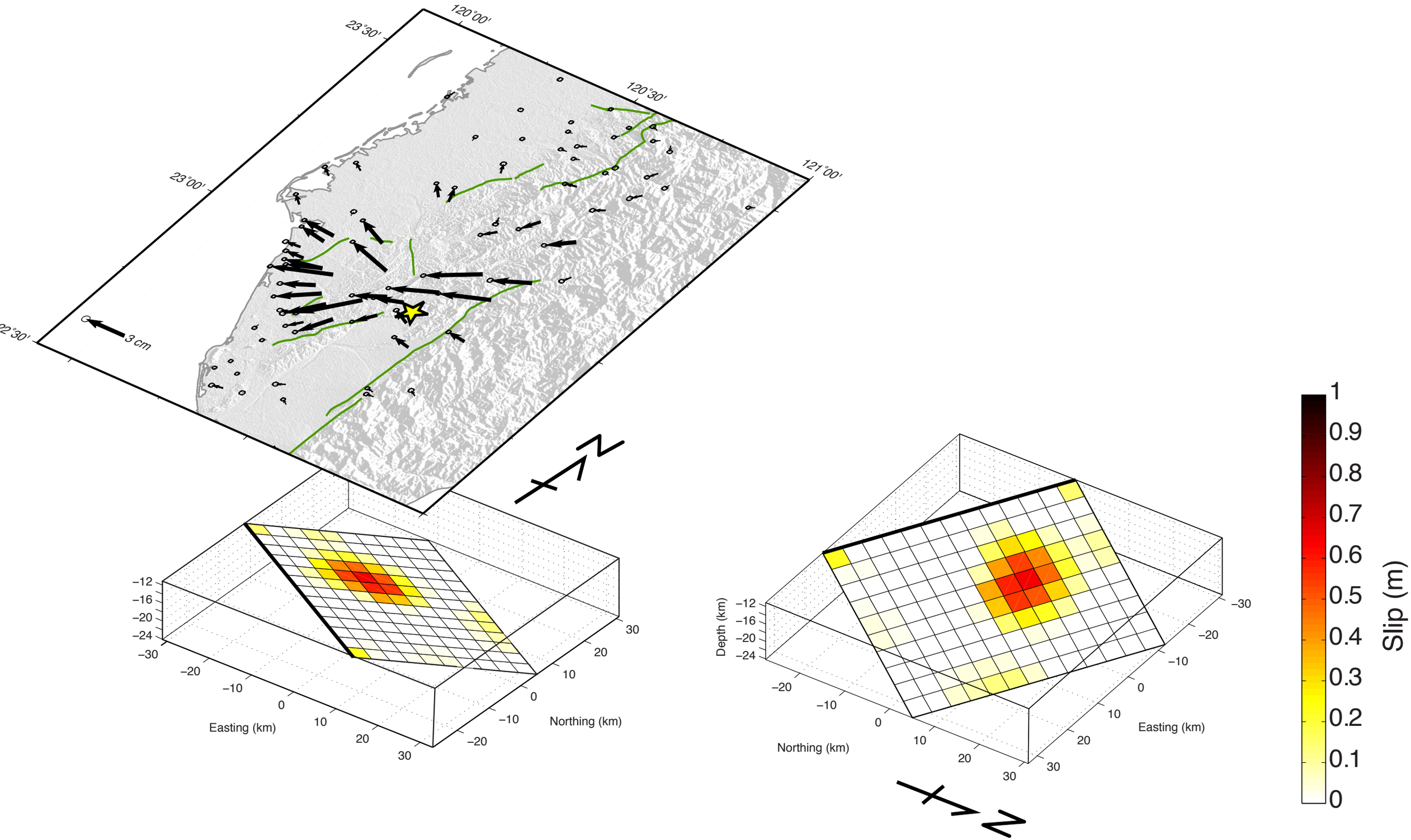
Slip model—main rupture



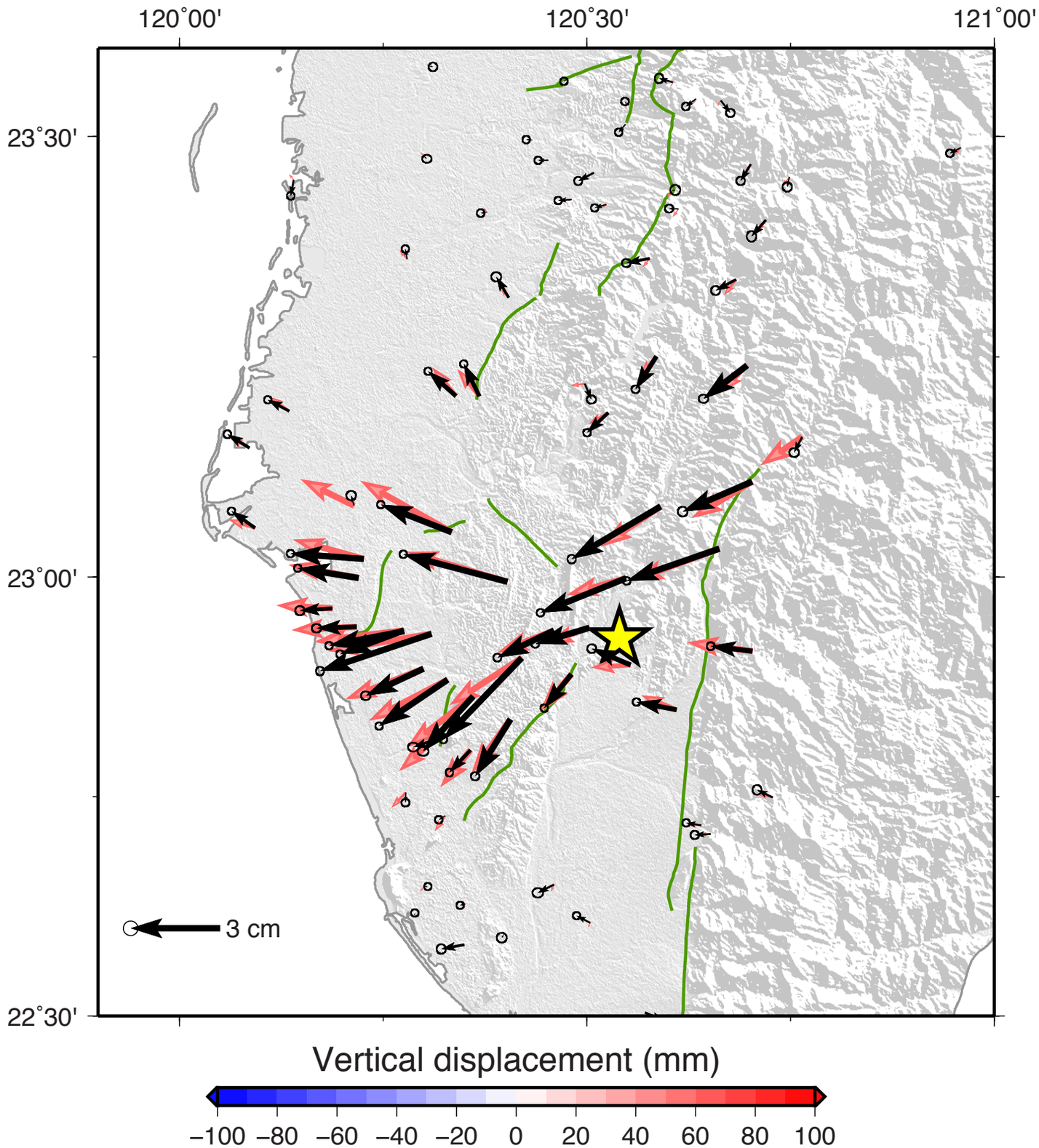
Slip model—main rupture



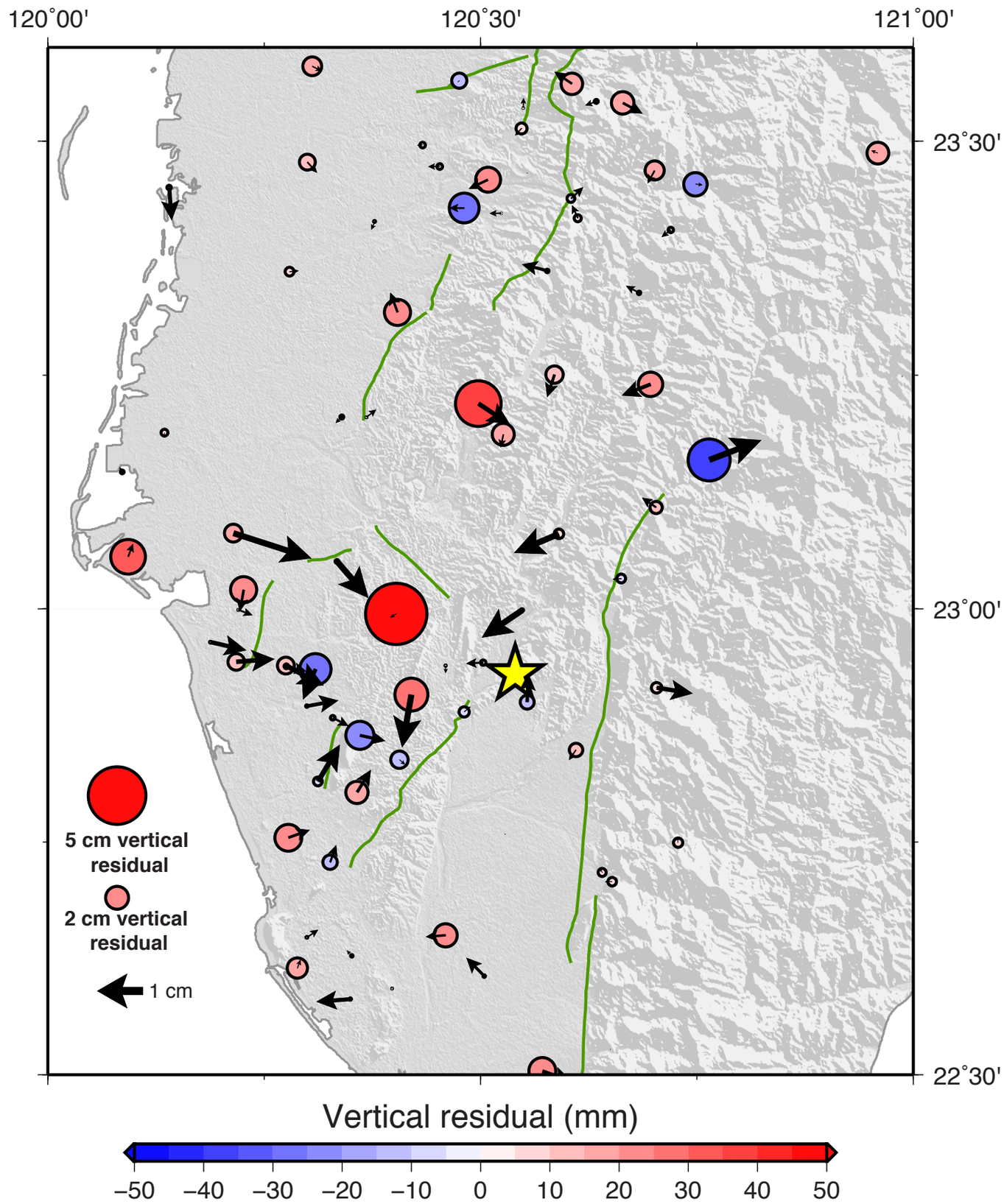
Slip model—main rupture

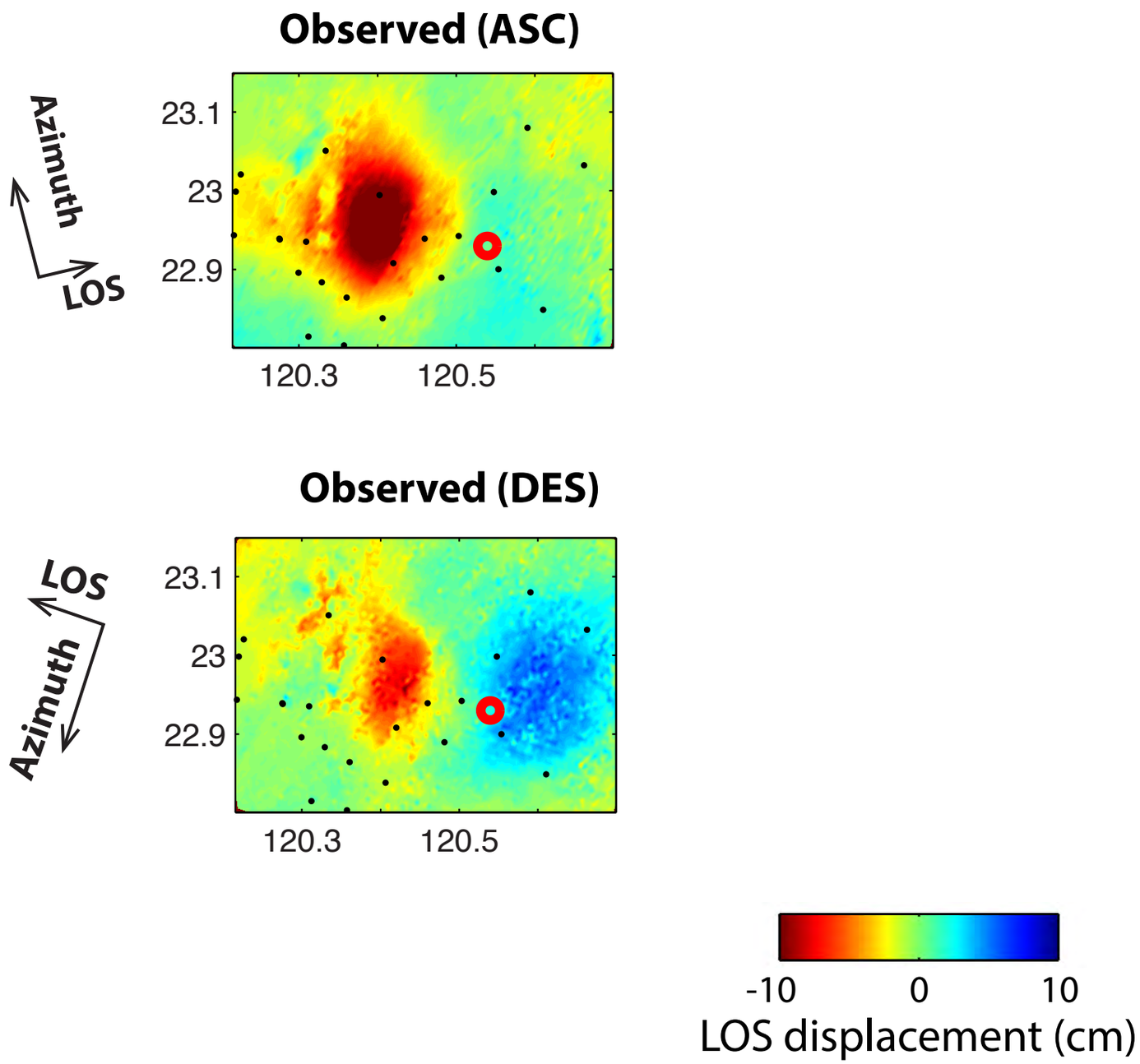


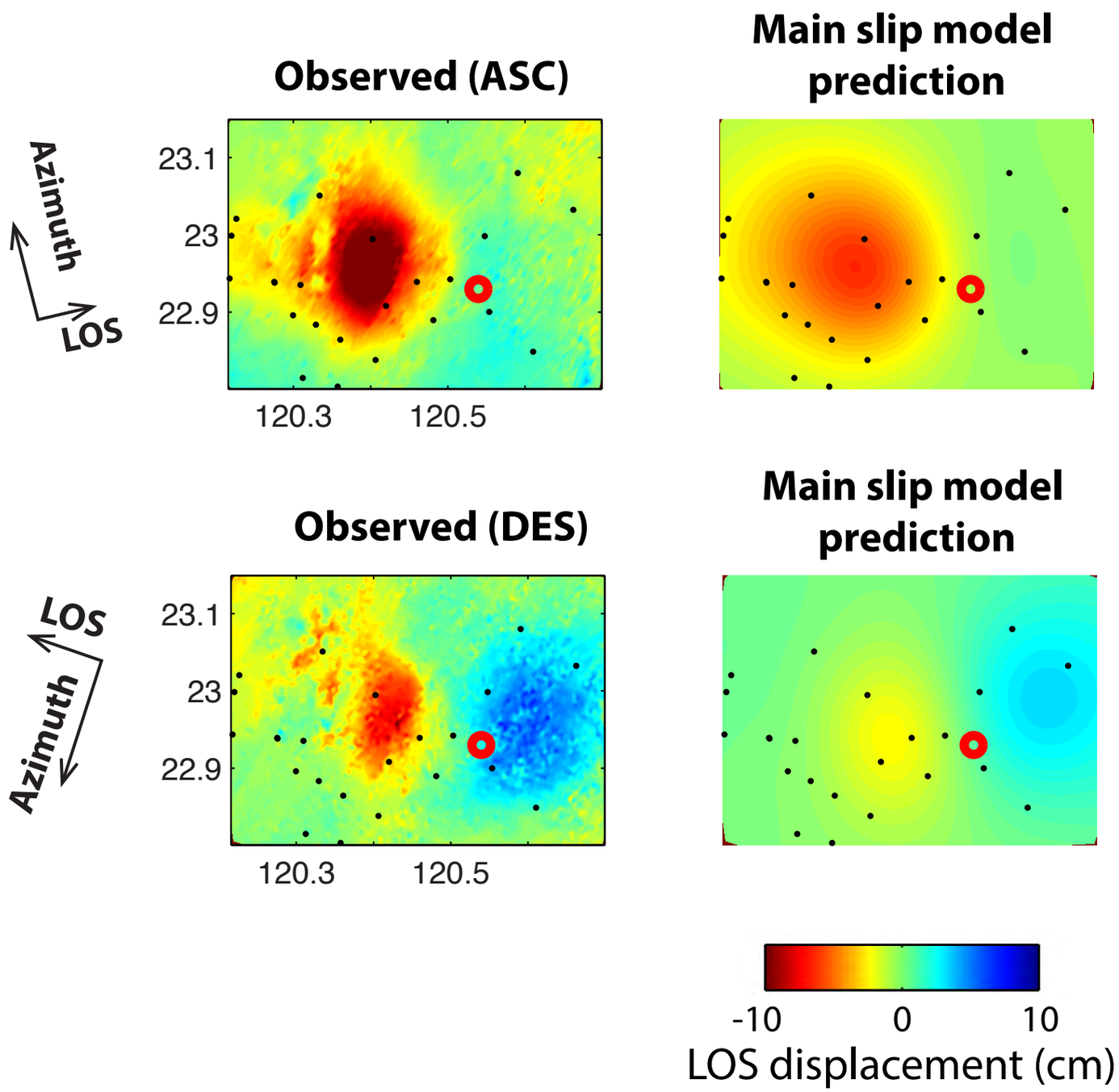
Model fitting

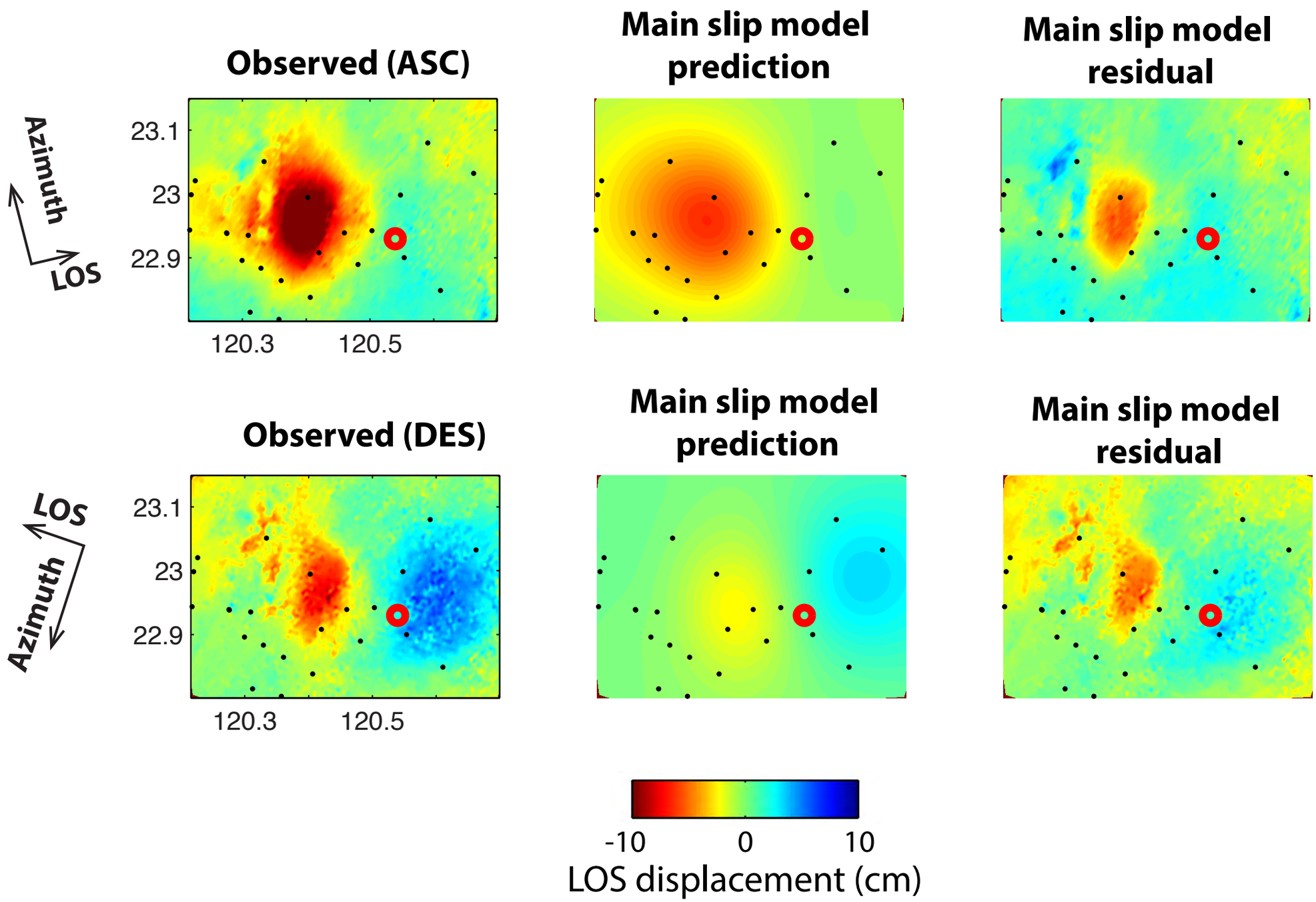


Model fitting residual

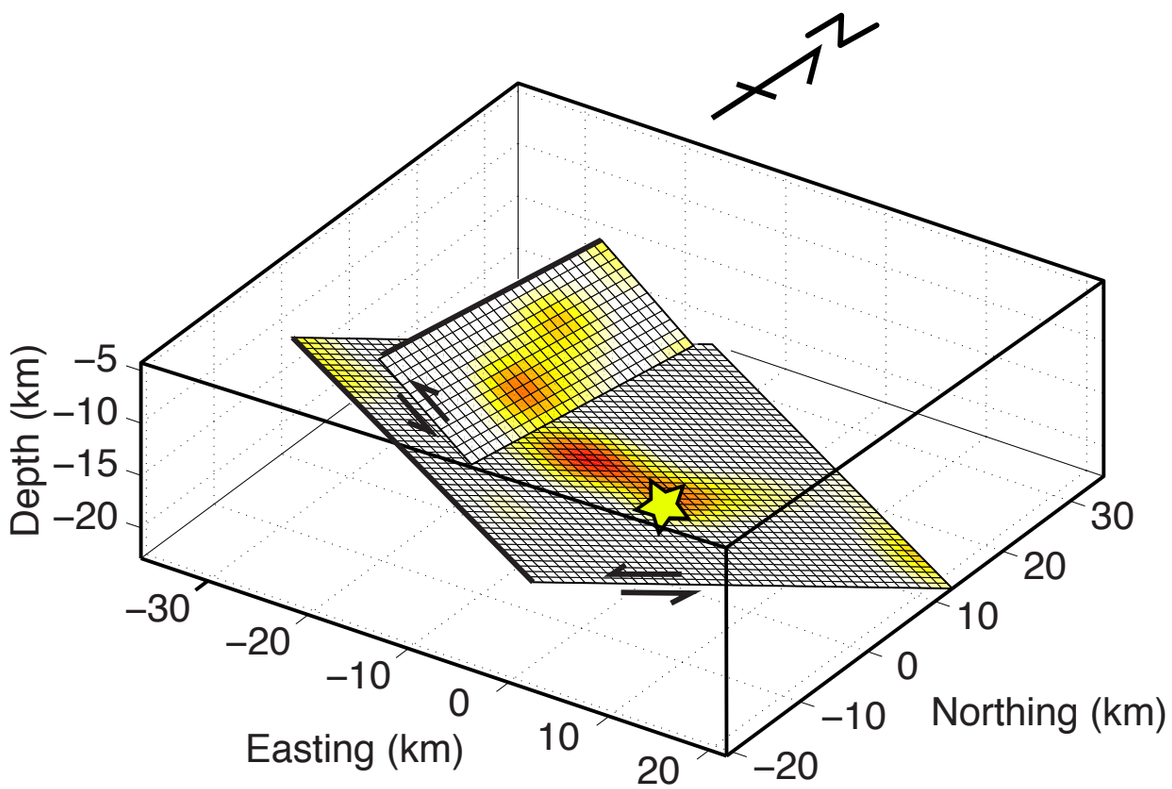


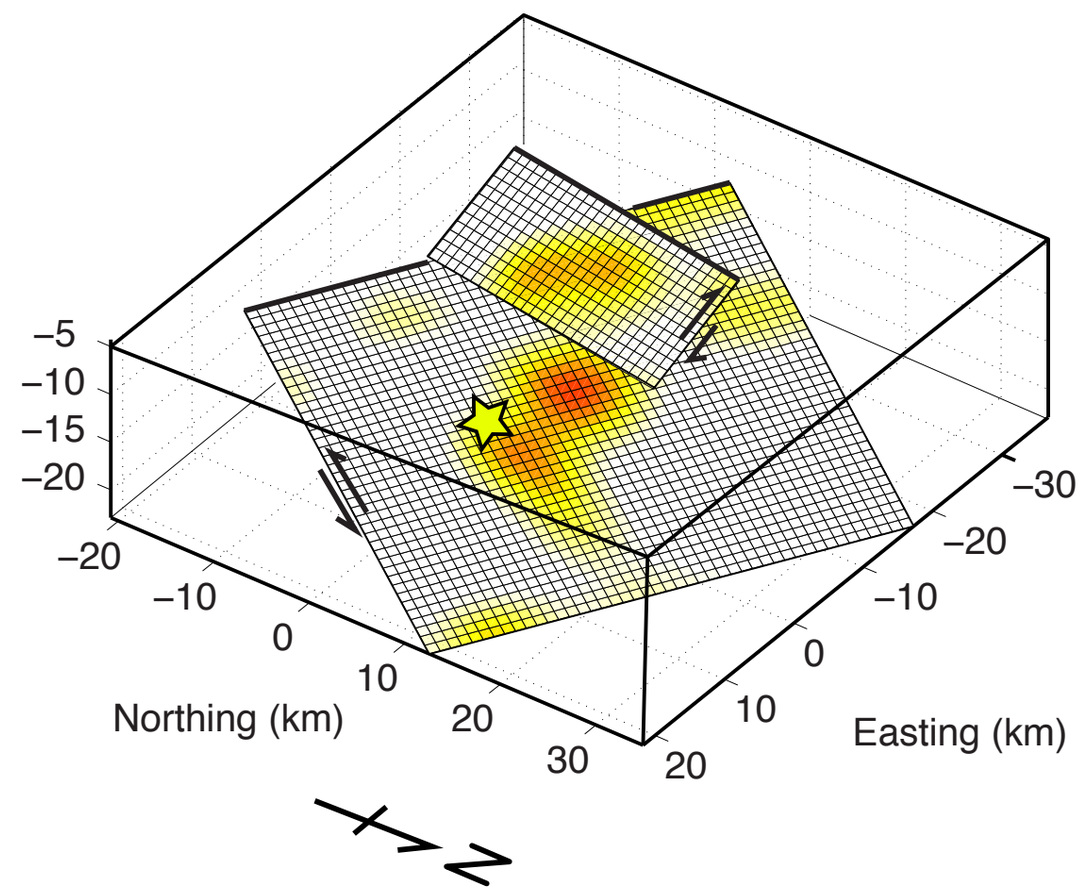

Observed (ASC)
Azimuth
LOS
23.1
23
22.9
120.3
120.5
Observed (DES)
LOS
Azimuth
23.1
23
22.9
120.3
120.5
-10
0
10
LOS displacement (cm)

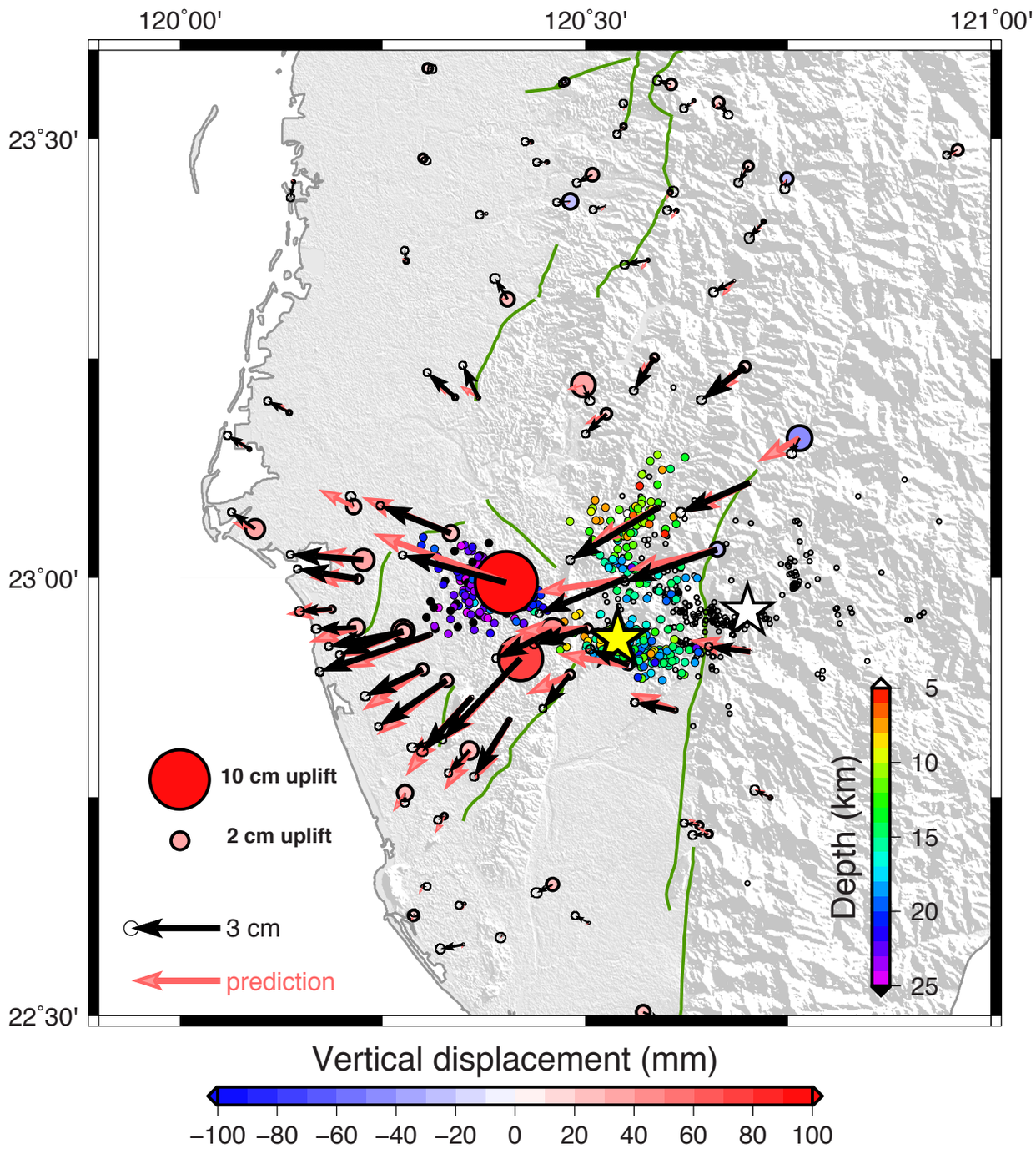

Observed (ASC)
Main slip model prediction
Azimuth
LOS
23.1
23
22.9
120.3
120.5
Observed (DES)
Main slip model prediction
LOS
Azimuth
23.1
23
22.9
120.3
120.5
-10
0
10
LOS displacement (cm)

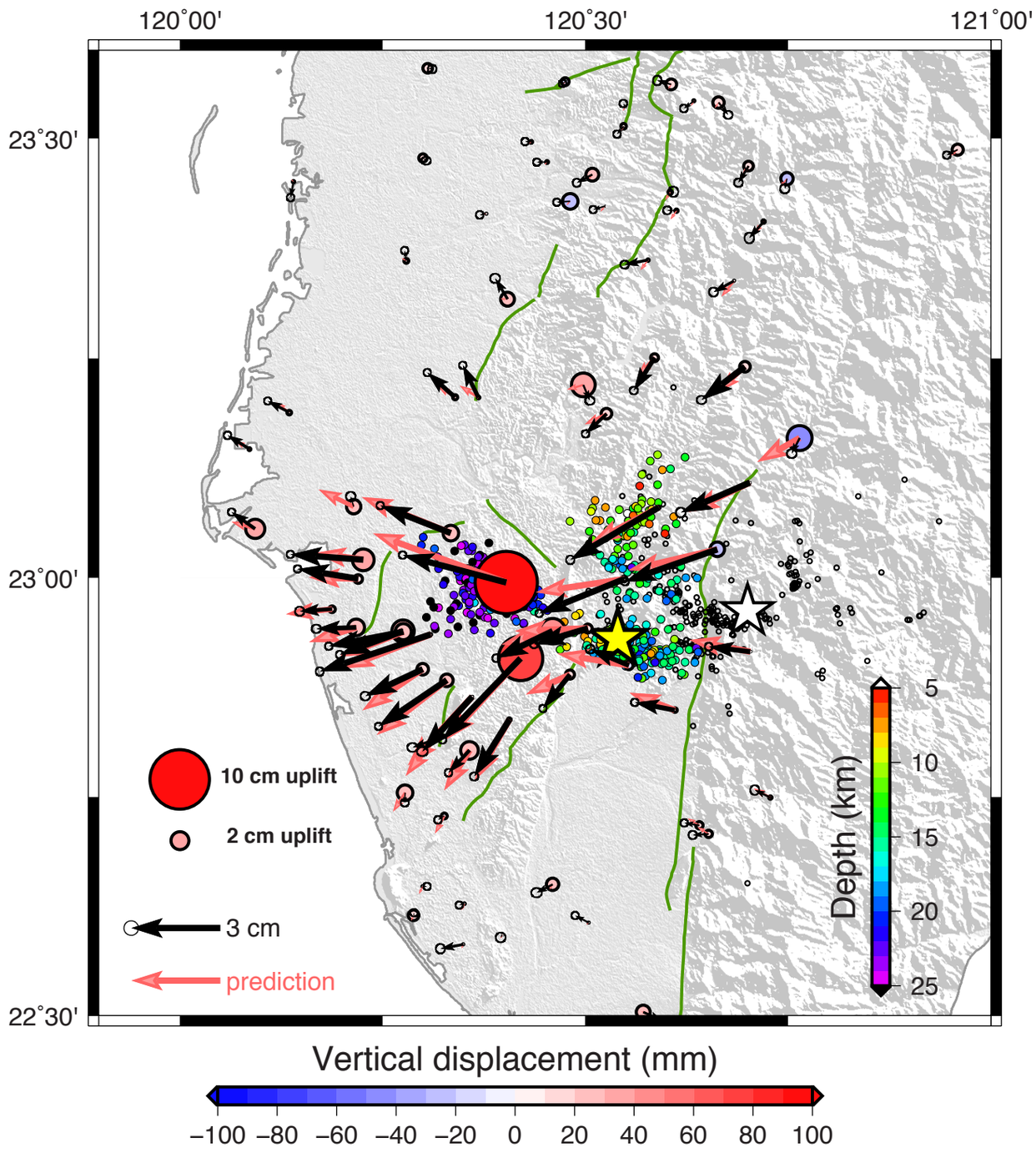

Observed (ASC)
Main slip model prediction
Main slip model residual
Azimuth
LOS
23.1
23
22.9
120.3
120.5
Observed (DES)
Main slip model prediction
Main slip model residual
LOS
Azimuth
23.1
23
22.9
120.3
120.5
-10
0
10
LOS displacement (cm)

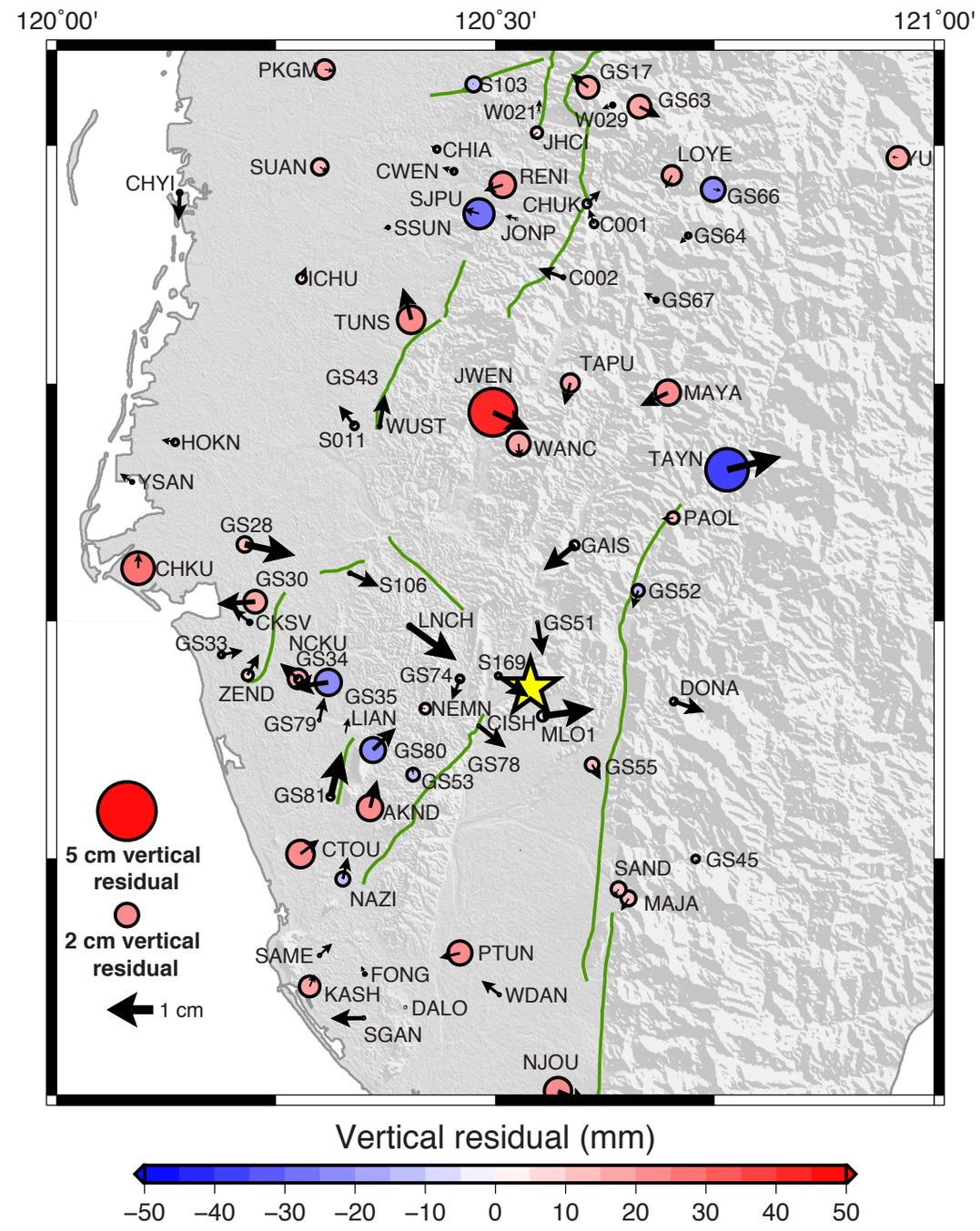
Deep + shallow faults

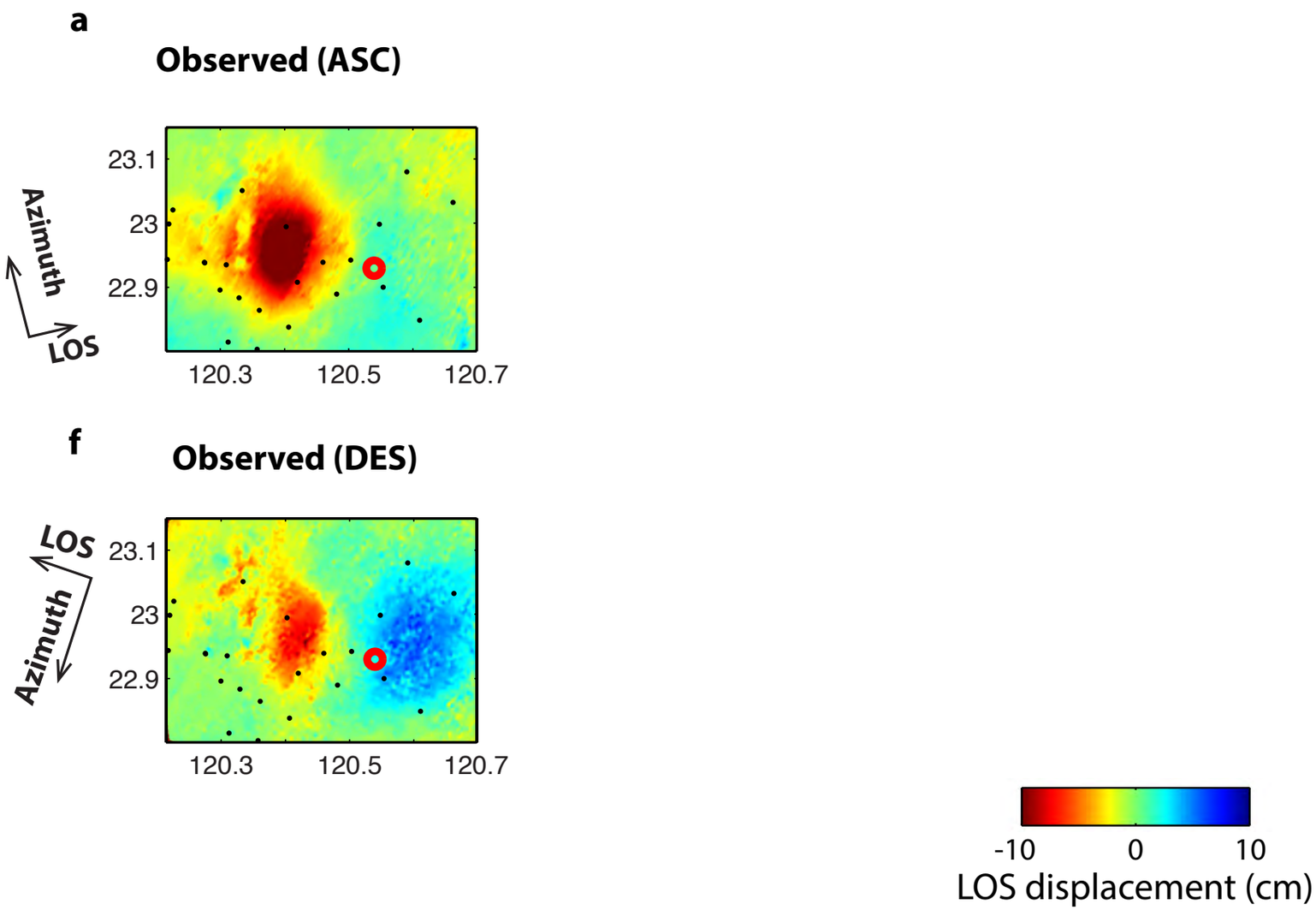




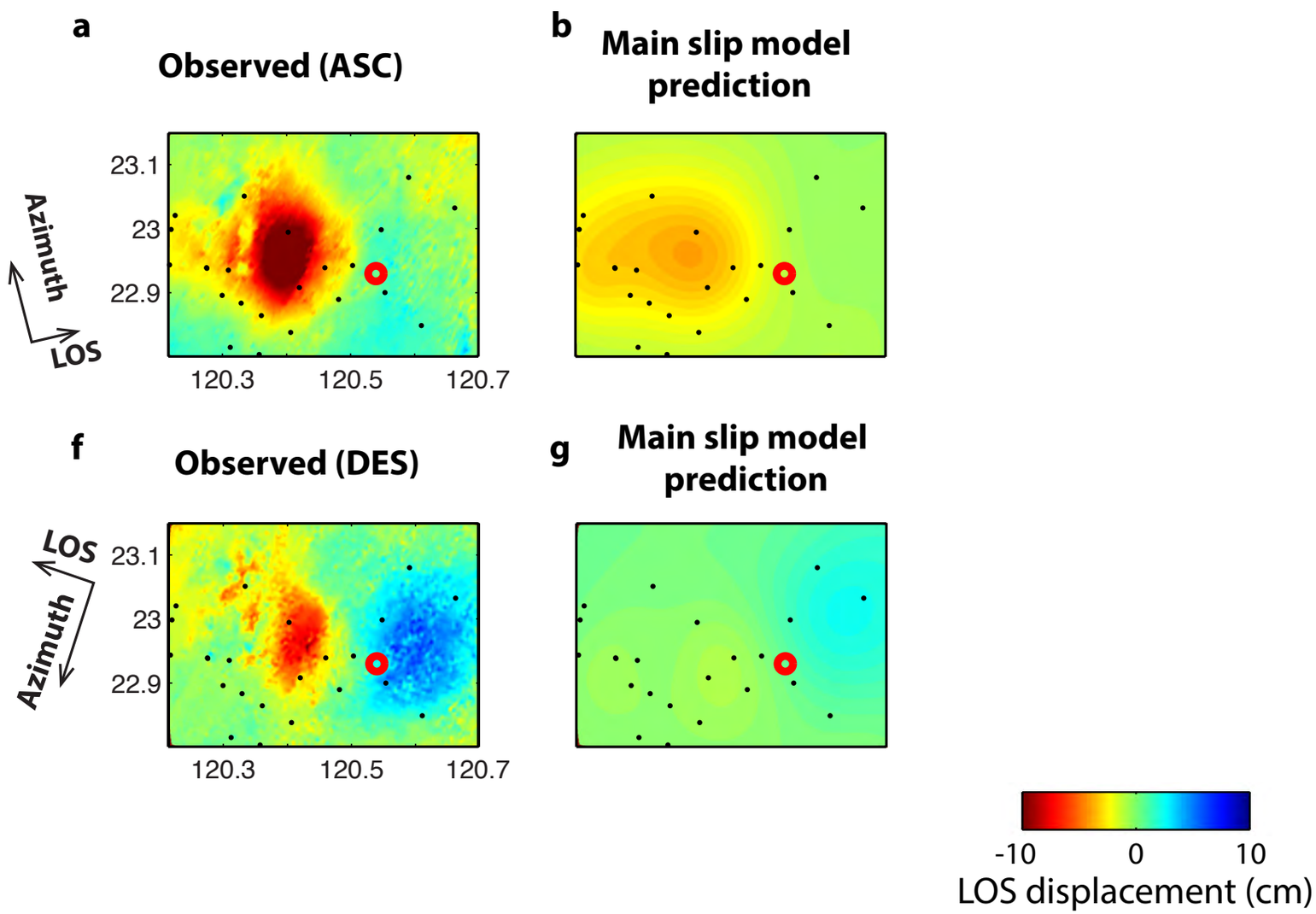

120˚00'
120˚30'
121˚00'
23˚30'
23˚00'
22˚30'
10 cm uplift
2 cm uplift
3 cm
prediction
Depth (km)
5
10
15
20
25
Vertical displacement (mm)
−100 −80 −60 −40 −20 0 20 40 60 80 100


120˚00'
120˚30'
121˚00'
23˚30'
23˚00'
22˚30'
10 cm uplift
2 cm uplift
3 cm
prediction
Depth (km)
5
10
15
20
25
Vertical displacement (mm)
−100 −80 −60 −40 −20 0 20 40 60 80 100

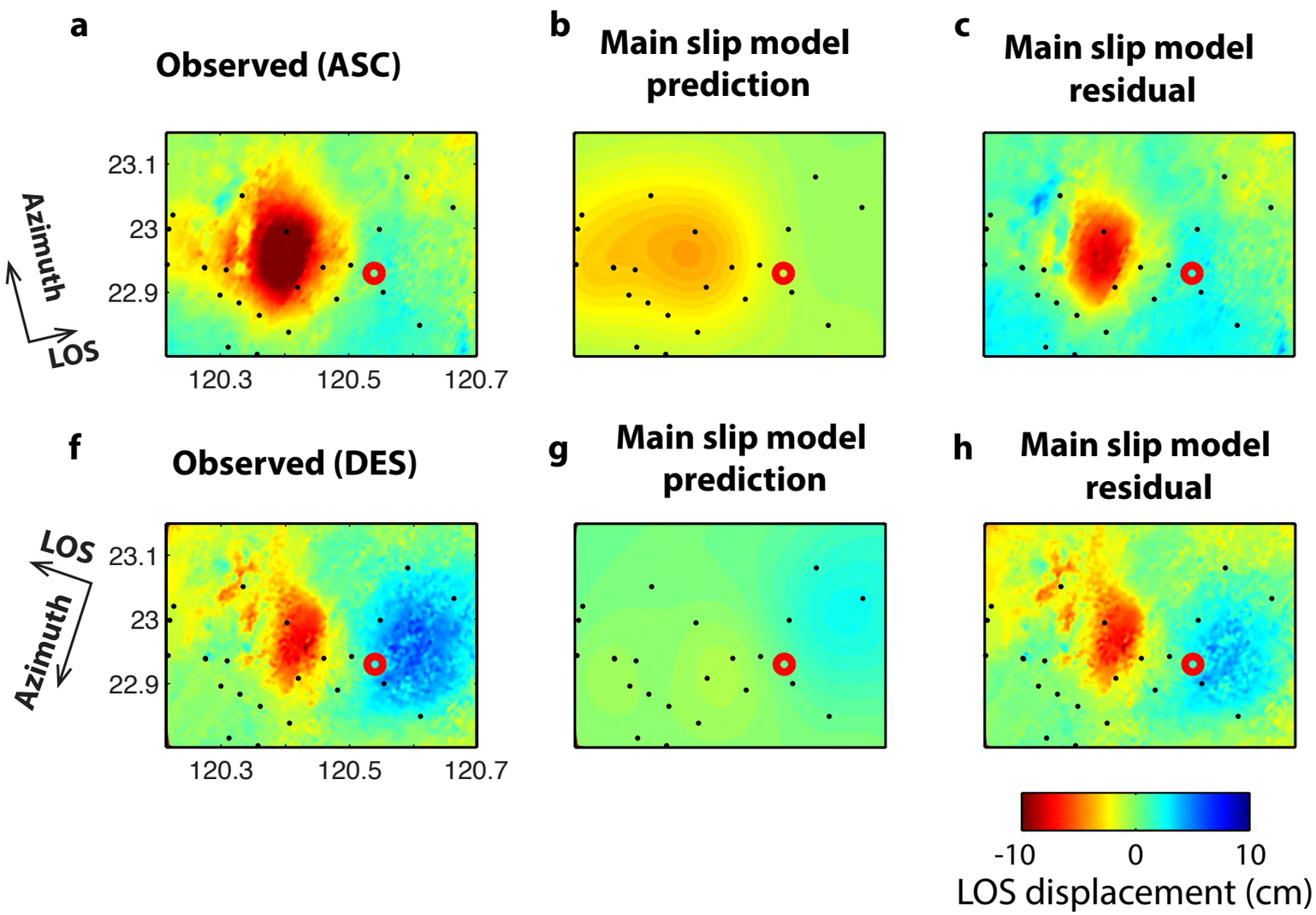

120˚00'
120˚30'
121˚00'
PKGM
S103
GS17
GS63
W021
W029
JHCI
CHIA
SUAN
CWEN
RENI
LOYE
YU
CHYI
SJPU
CHUK
GS66
SSUN
JONP
C001
GS64
ICHU
C002
GS67
TUNS
TAPU
GS43
JWEN
MAYA
S011
WUST
HOKN
WANC
TAYN
YSAN
PAOL
GS28
GAIS
CHKU
GS30
S106
GS52
CKSV
LNCH
GS51
GS33
NCKU
GS34
S169
GS74
ZEND
GS35
NEMN
DONA
GS79
LIAN
CISH
MLO1
GS80
GS78
GS55
GS53
GS81
AKND
CTOU
GS45
SAND
NAZI
MAJA
SAME
PTUN
FONG
KASH
WDAN
DALO
SGAN
NJOU
5 cm vertical residual
2 cm vertical residual
1 cm
Vertical residual (mm)
−50 −40 −30 −20 −10 0 10 20 30 40 50



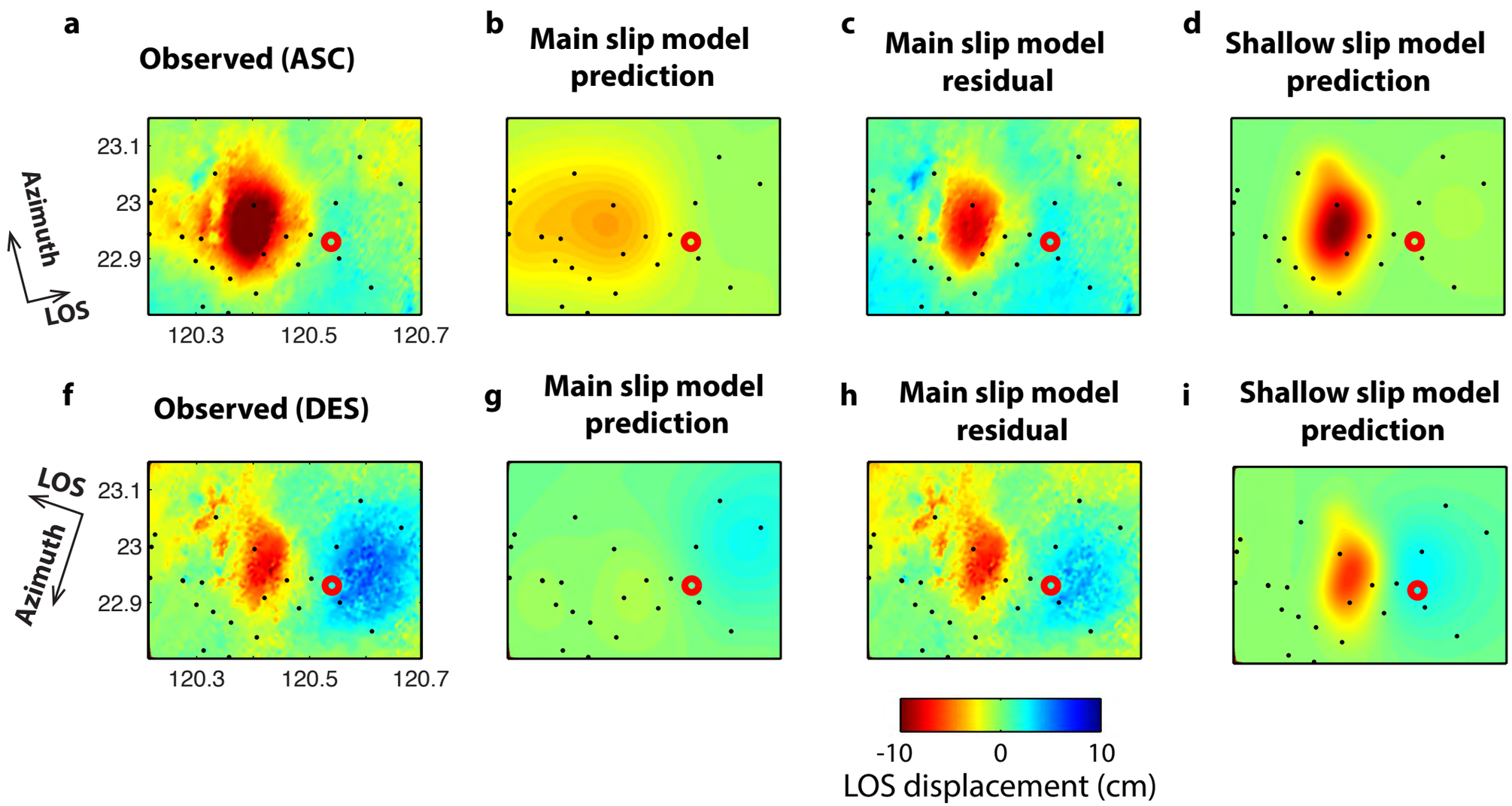
Huang et al., 2016



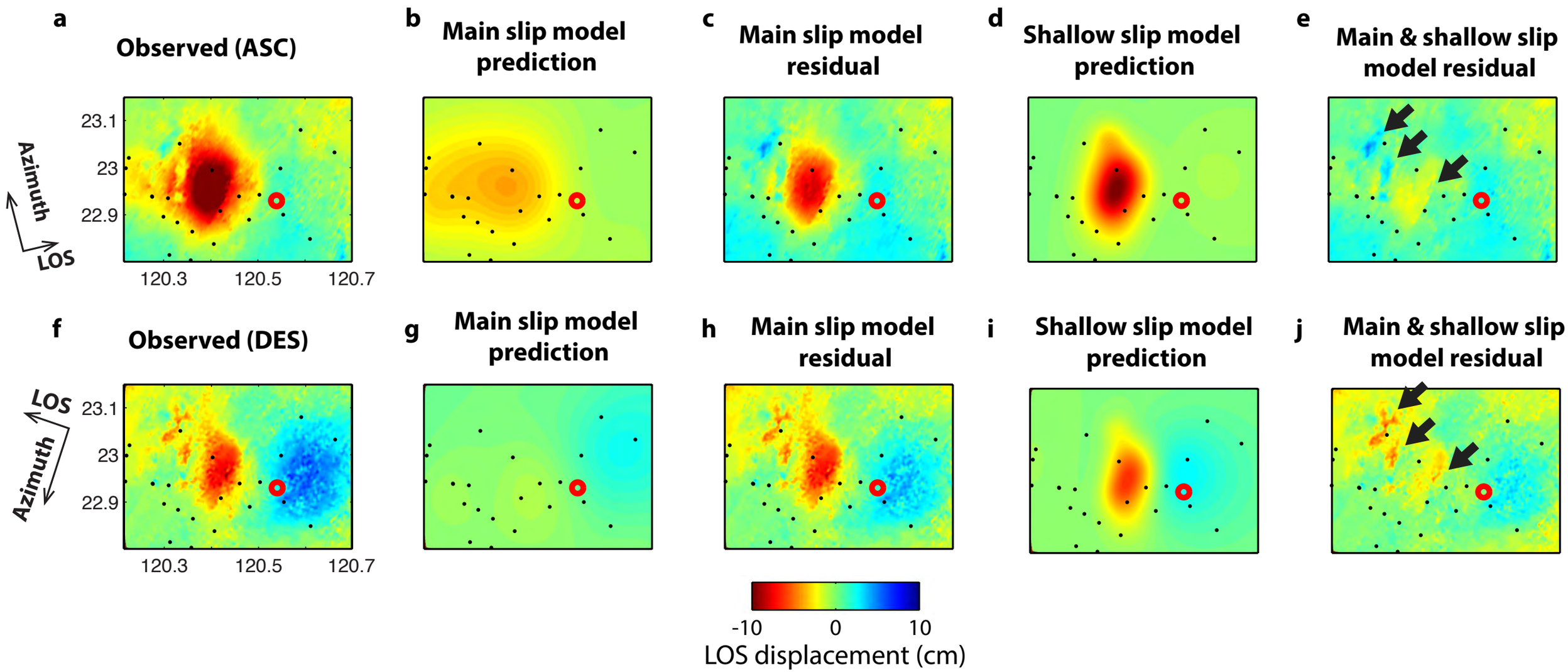
Huang et al., 2016



Huang et al., 2016

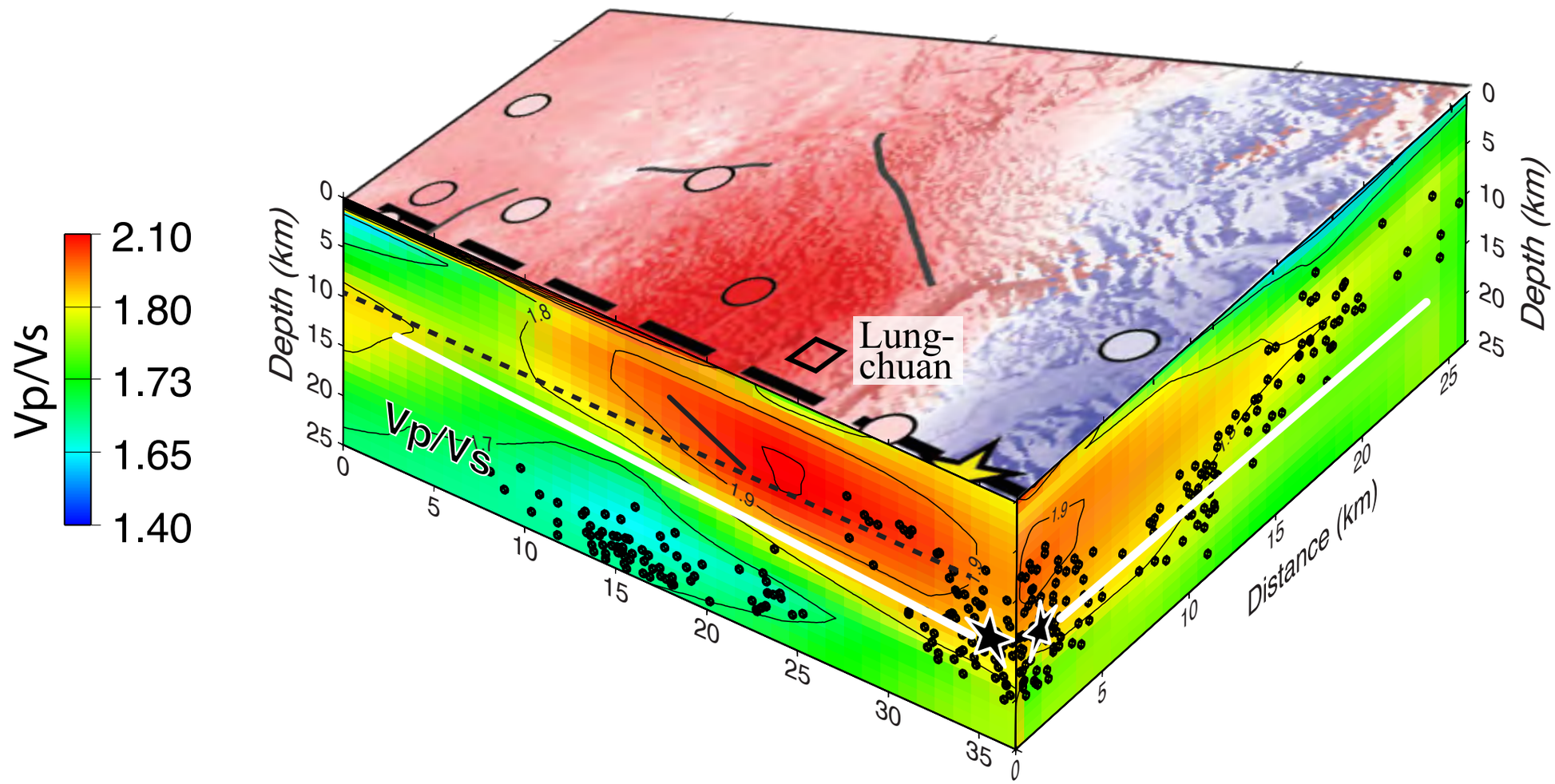


Huang et al., 2016

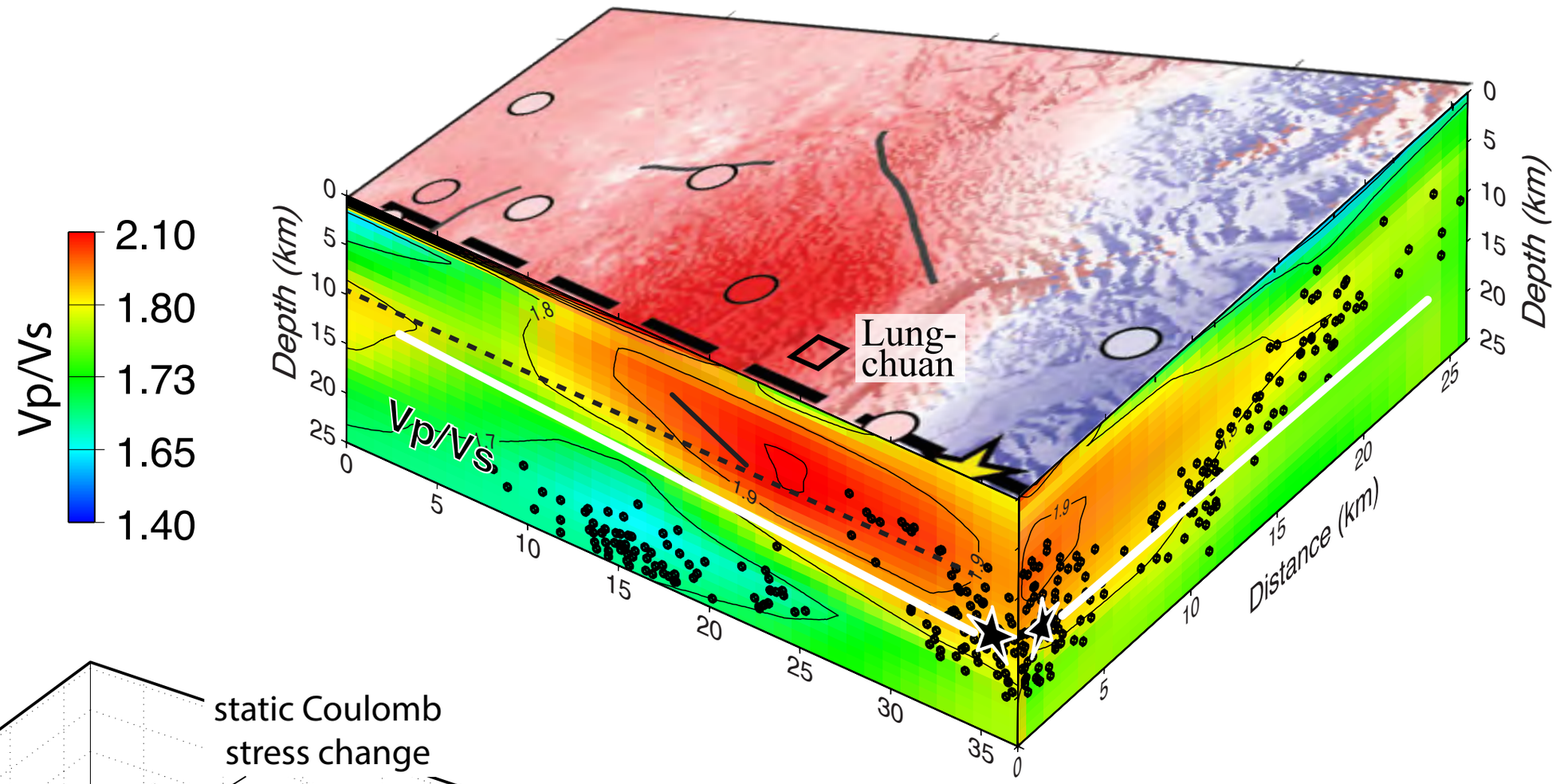


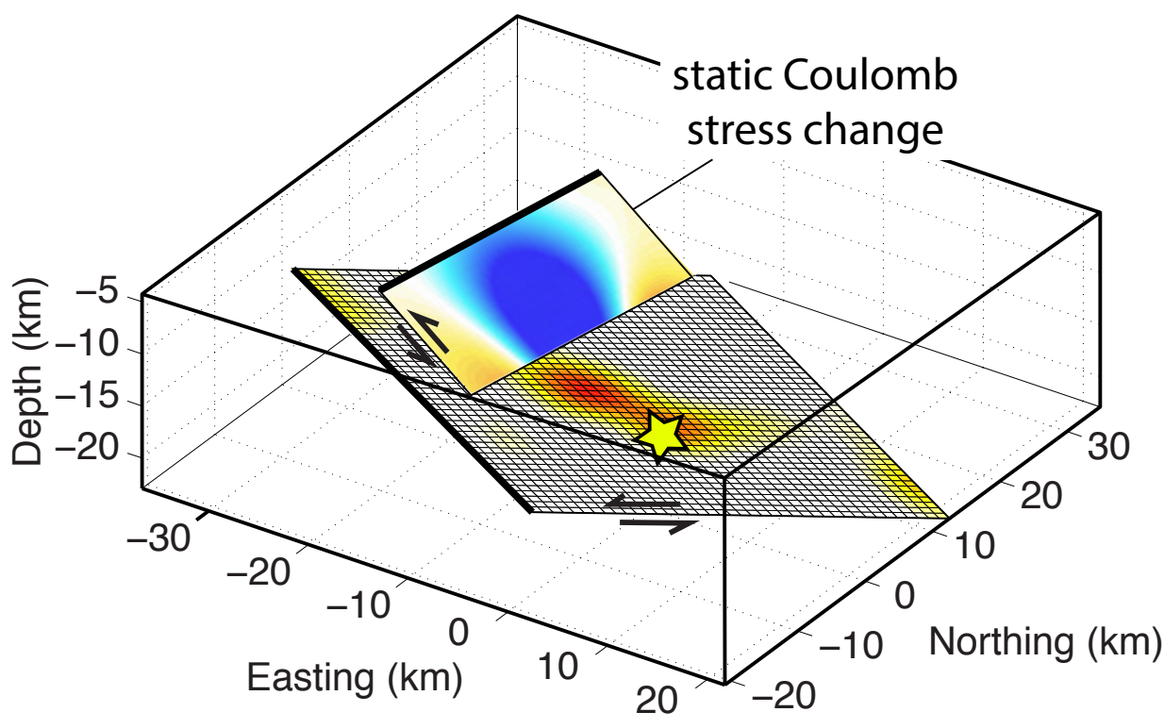
Huang et al., 2016

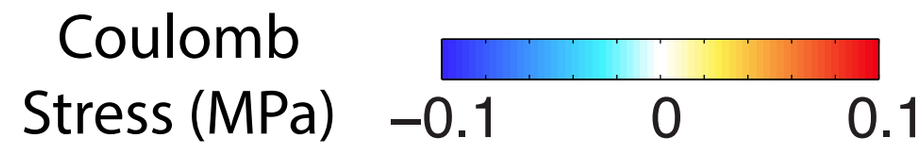
Why fault slip occurred in multiple layers?

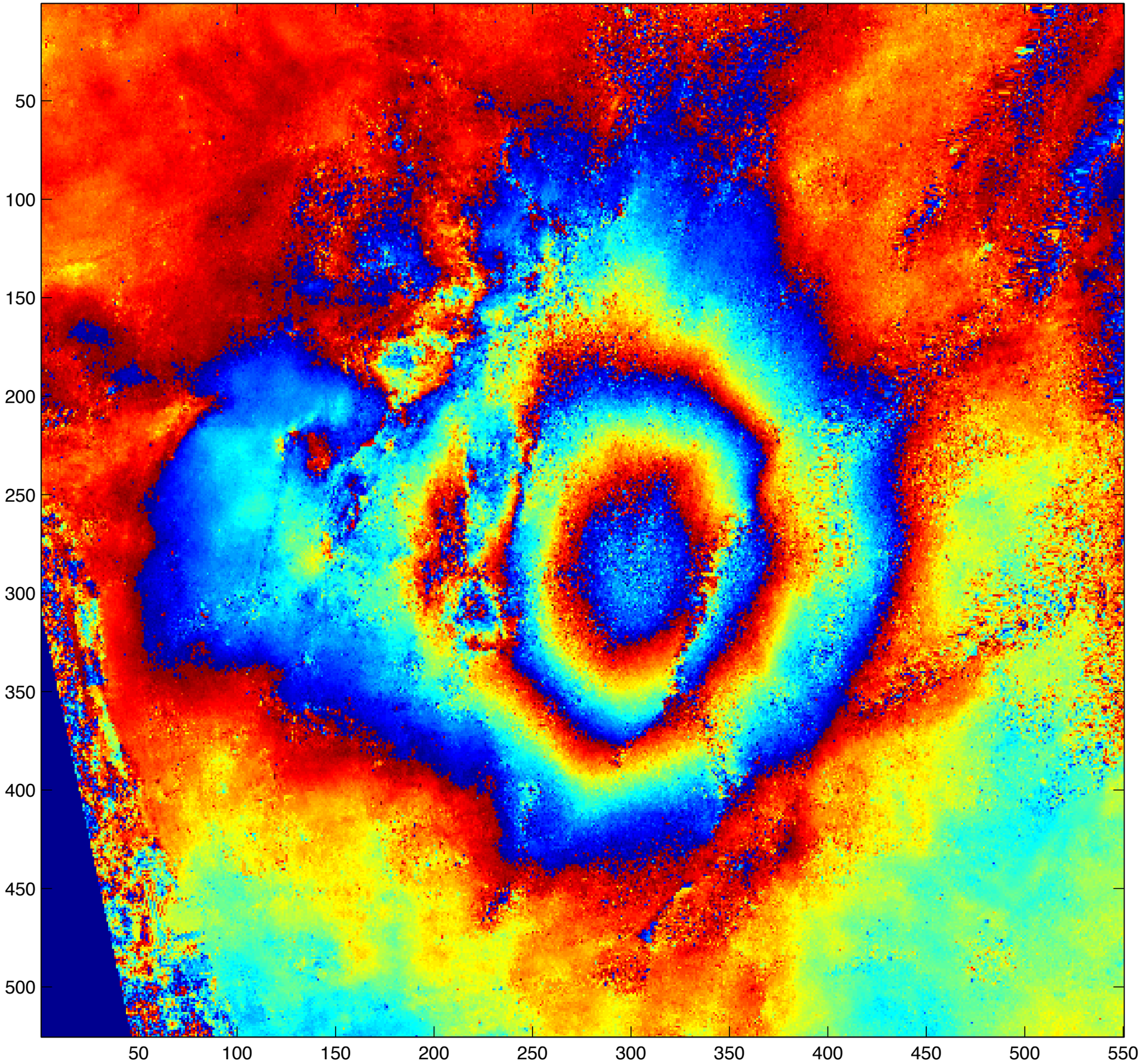


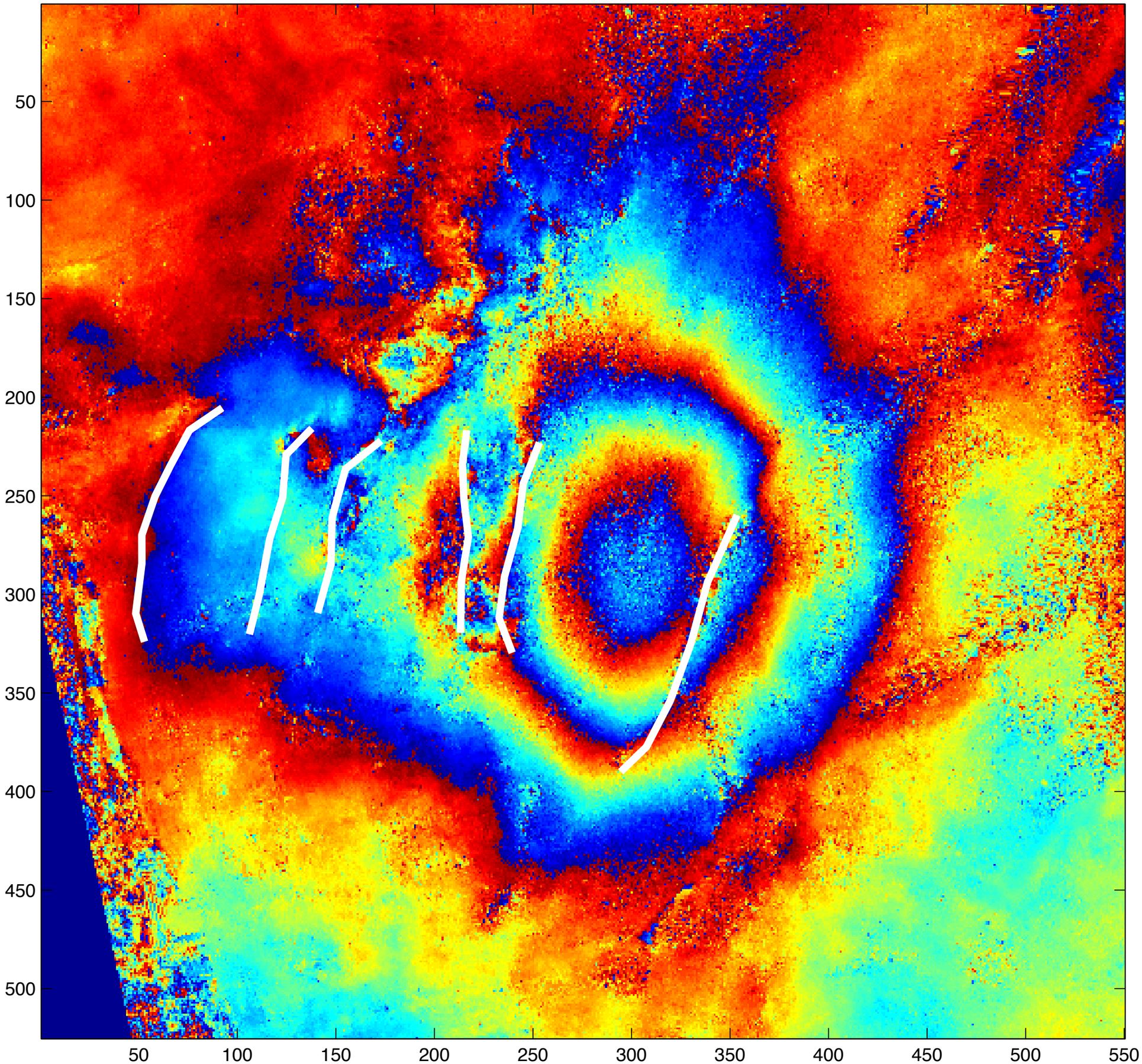
Why fault slip occurred in multiple layers?







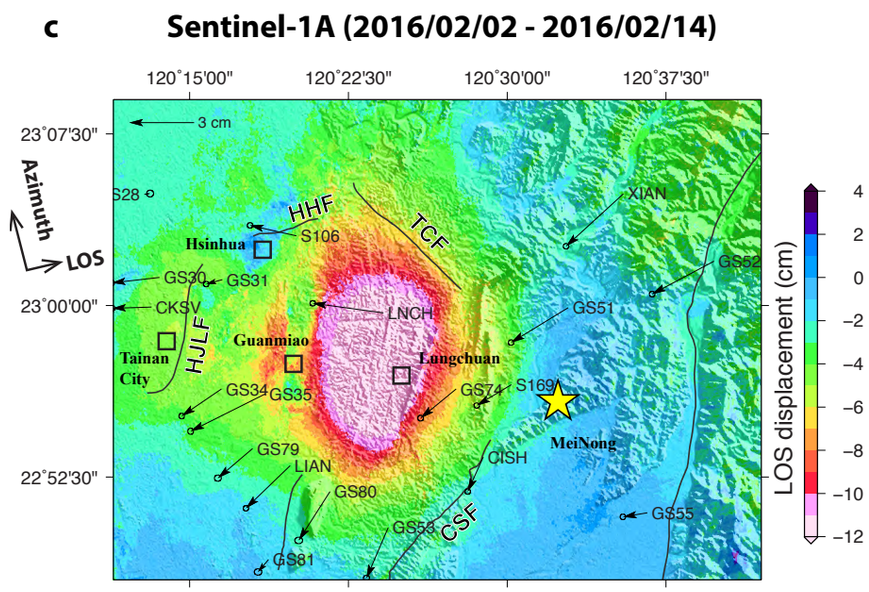

50
100
150
200
250
300
350
400
450
500
50
100
150
200
250
300
350
400
450
500
550


50
100
150
200
250
300
350
400
450
500
50
100
150
200
250
300
350
400
450
500
550

Very shallow ruptures through the Tainan city

MeiNong Summary

Huang, M.-H., Tung, H., Fielding, E. J., Huang, H.-H., Liang, C. R., Hu, J.-C., and Huang, C., 2016, Multiple fault slip triggered above the 2016 Mw 6.4 MeiNong earthquake in Taiwan: Geophysical Research Letters, v. 43, p. 7459–7467.

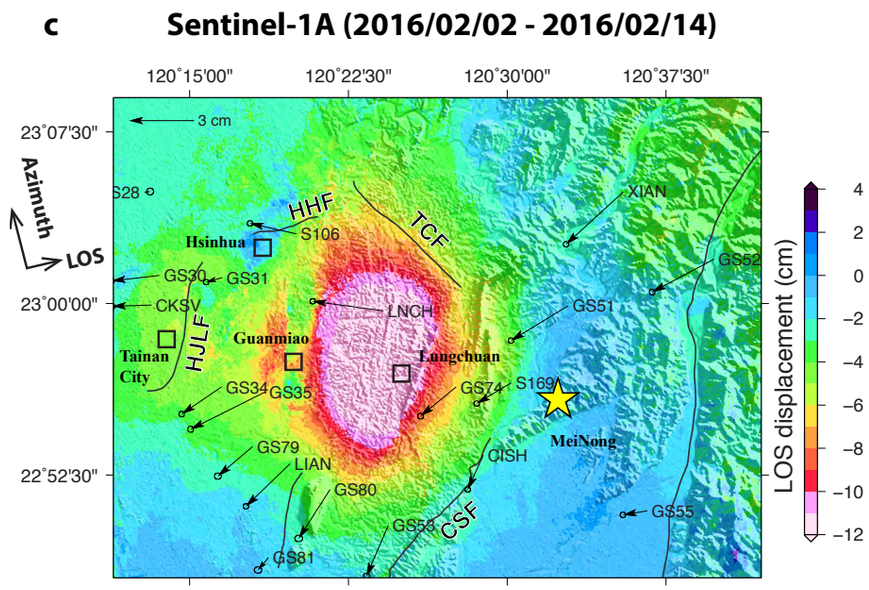


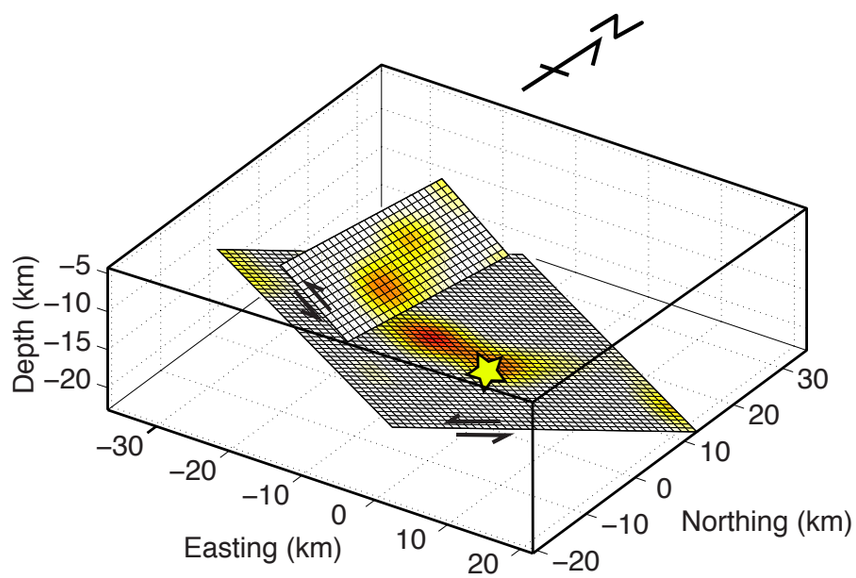
MeiNong Summary

- InSAR can provide high resolution surface displacement

Huang, M.-H., Tung, H., Fielding, E. J., Huang, H.-H., Liang, C. R., Hu, J.-C., and Huang, C., 2016, Multiple fault slip triggered above the 2016 Mw 6.4 MeiNong earthquake in Taiwan: Geophysical Research Letters, v. 43, p. 7459–7467.

MeiNong Summary



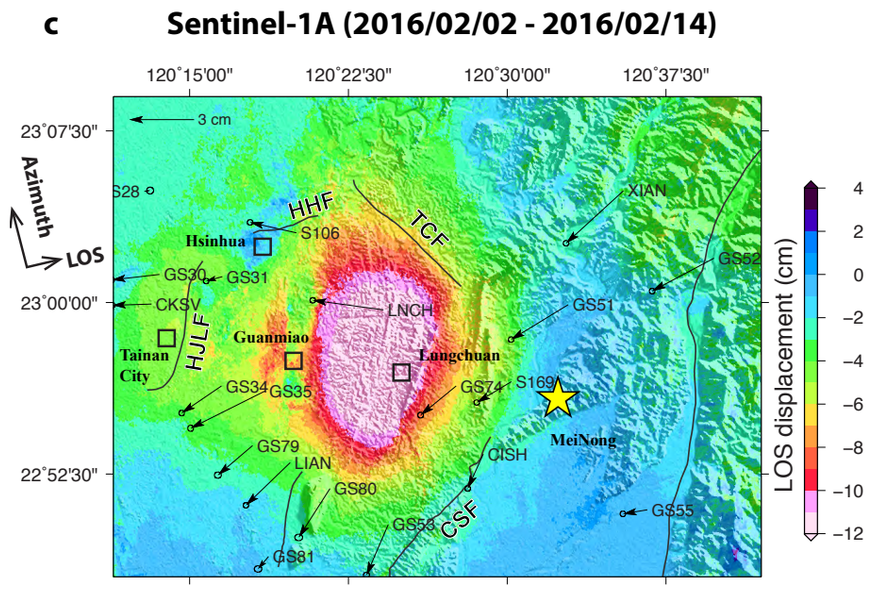


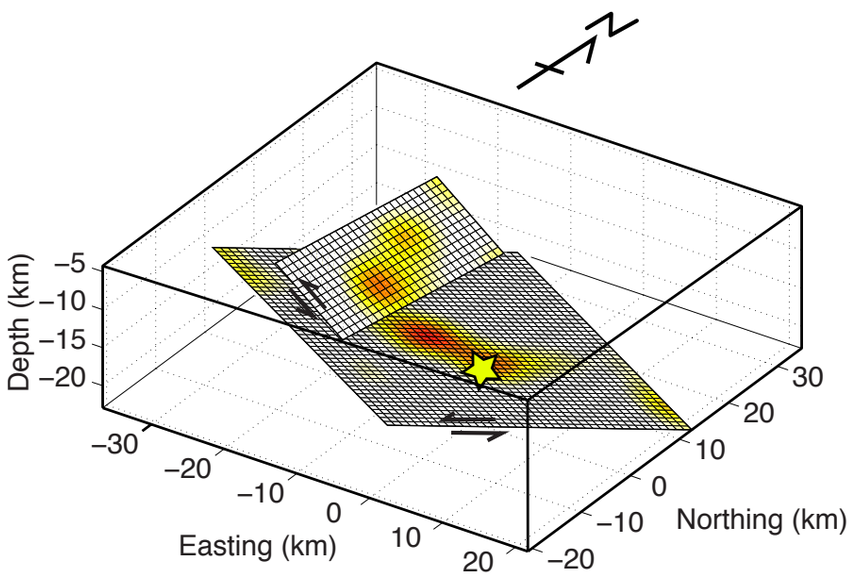
- InSAR can provide high resolution surface displacement

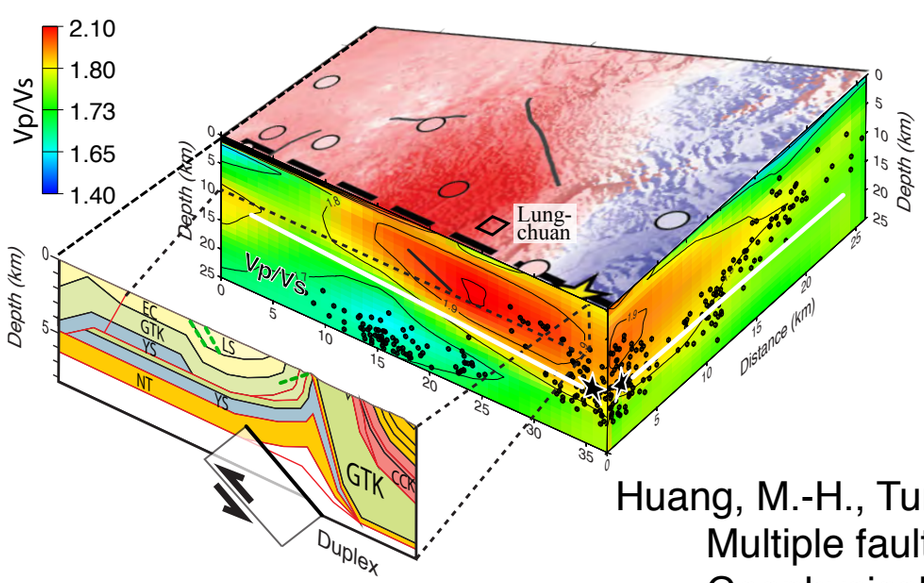
- Shallower fault slip was triggered by deeper EQ

Huang, M.-H., Tung, H., Fielding, E. J., Huang, H.-H., Liang, C. R., Hu, J.-C., and Huang, C., 2016, Multiple fault slip triggered above the 2016 Mw 6.4 MeiNong earthquake in Taiwan: Geophysical Research Letters, v. 43, p. 7459–7467.

MeiNong Summary







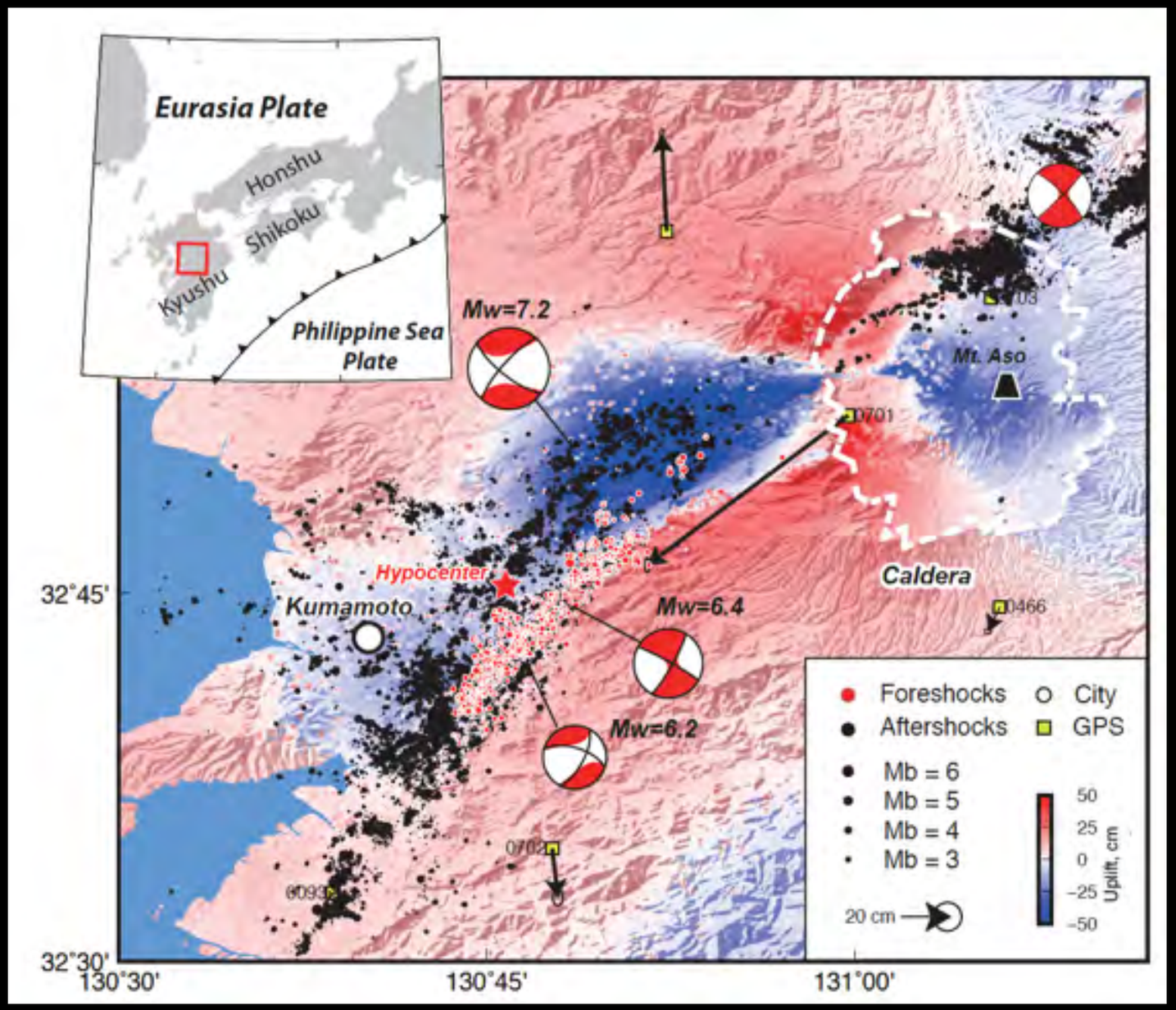
- InSAR can provide high resolution surface displacement

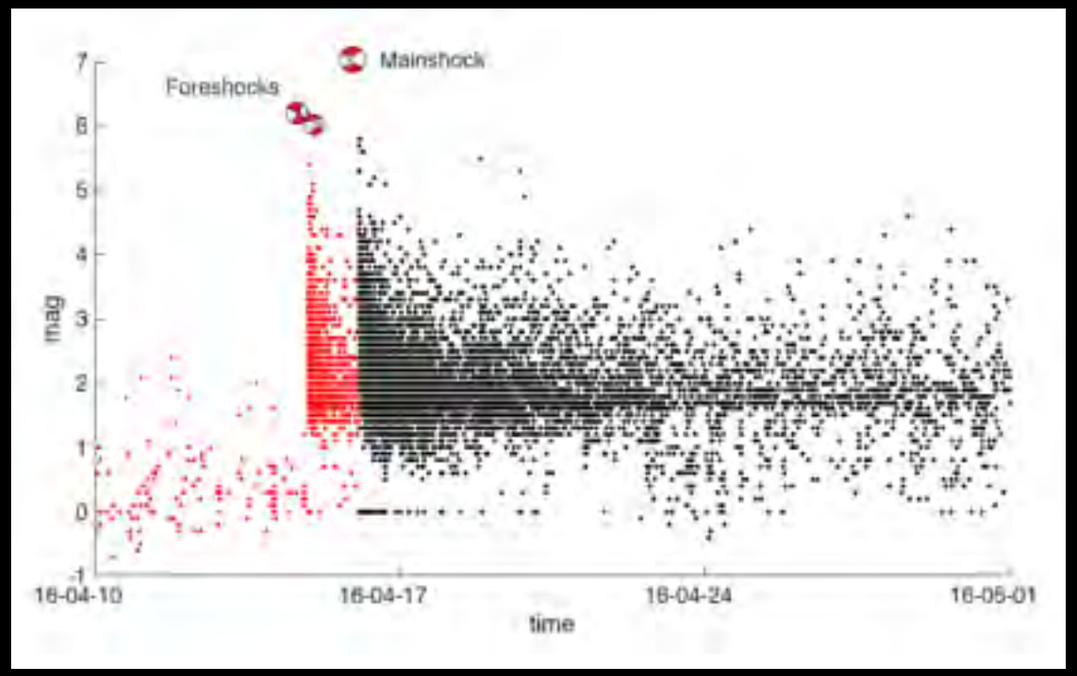
- Shallower fault slip was triggered by deeper EQ

- Triggered slip on a shallower duplex, and is slow or aseismic due to high fluid pressure

Huang, M.-H., Tung, H., Fielding, E. J., Huang, H.-H., Liang, C. R., Hu, J.-C., and Huang, C., 2016, Multiple fault slip triggered above the 2016 Mw 6.4 MeiNong earthquake in Taiwan: Geophysical Research Letters, v. 43, p. 7459–7467.

April 2016 Kumamoto Earthquake sequence



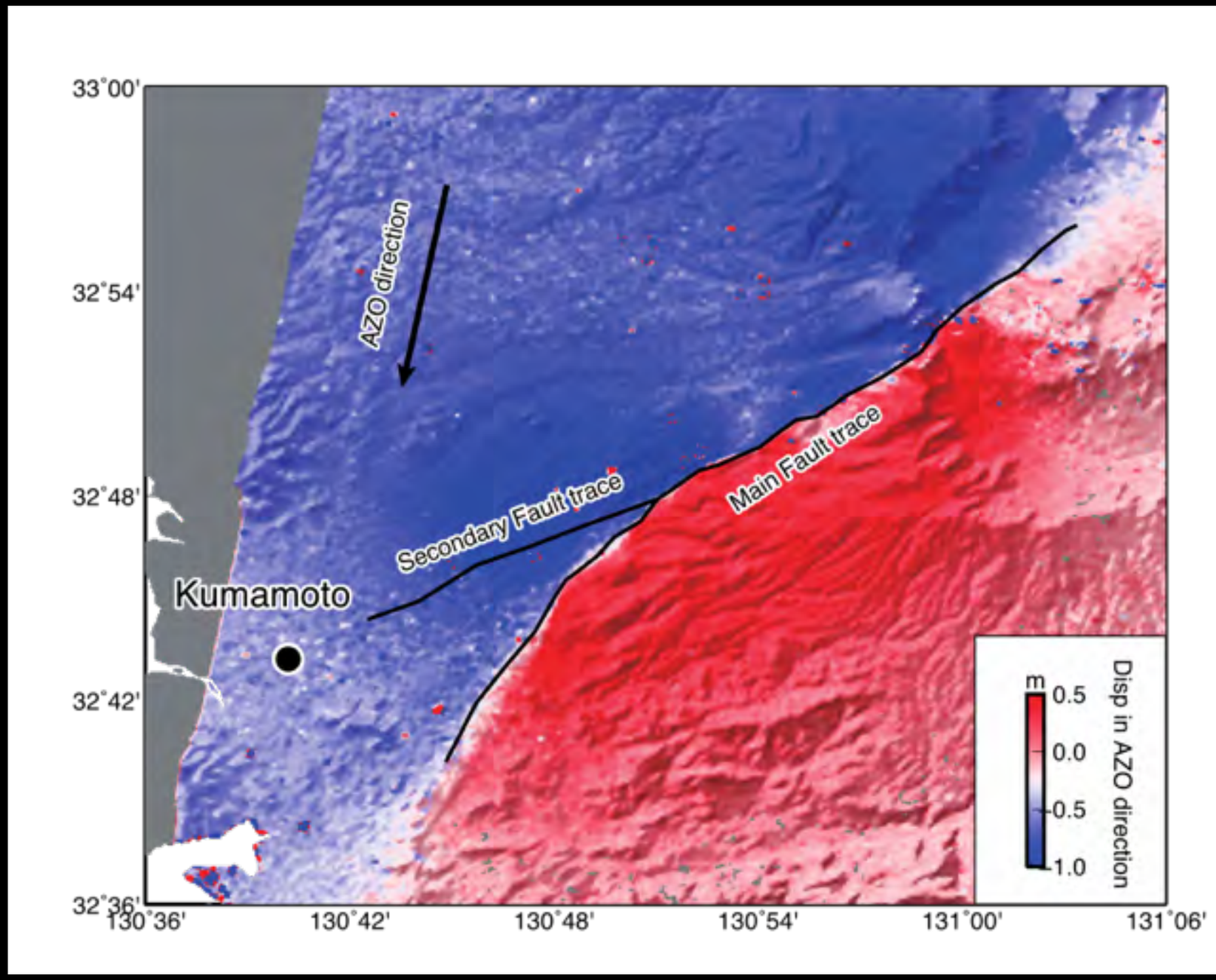


1. Sequence initiated by two Mw > 6 foreshocks

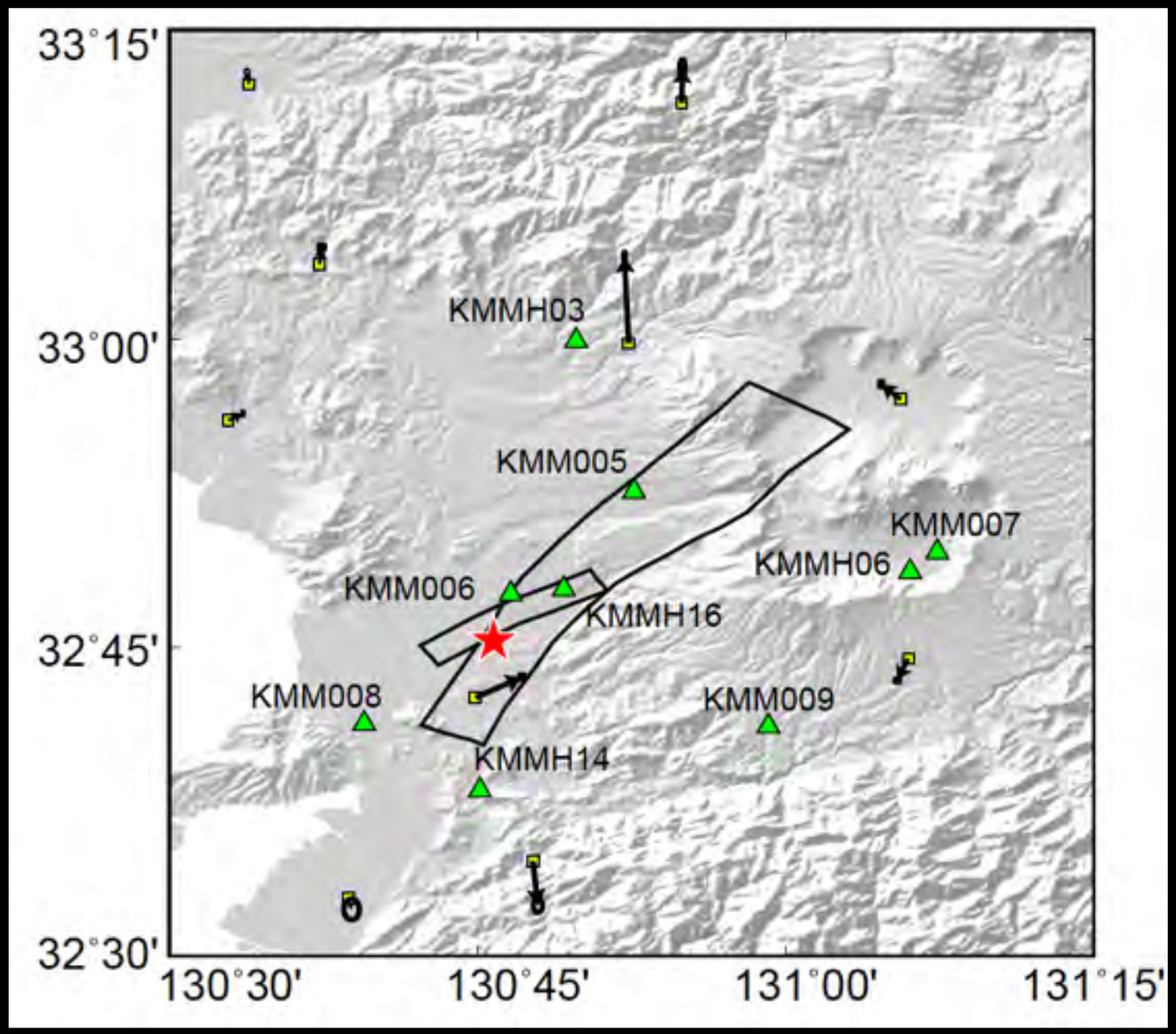
2. Main Mw 7.2 rupture terminates near the caldera

Fault Parameterization

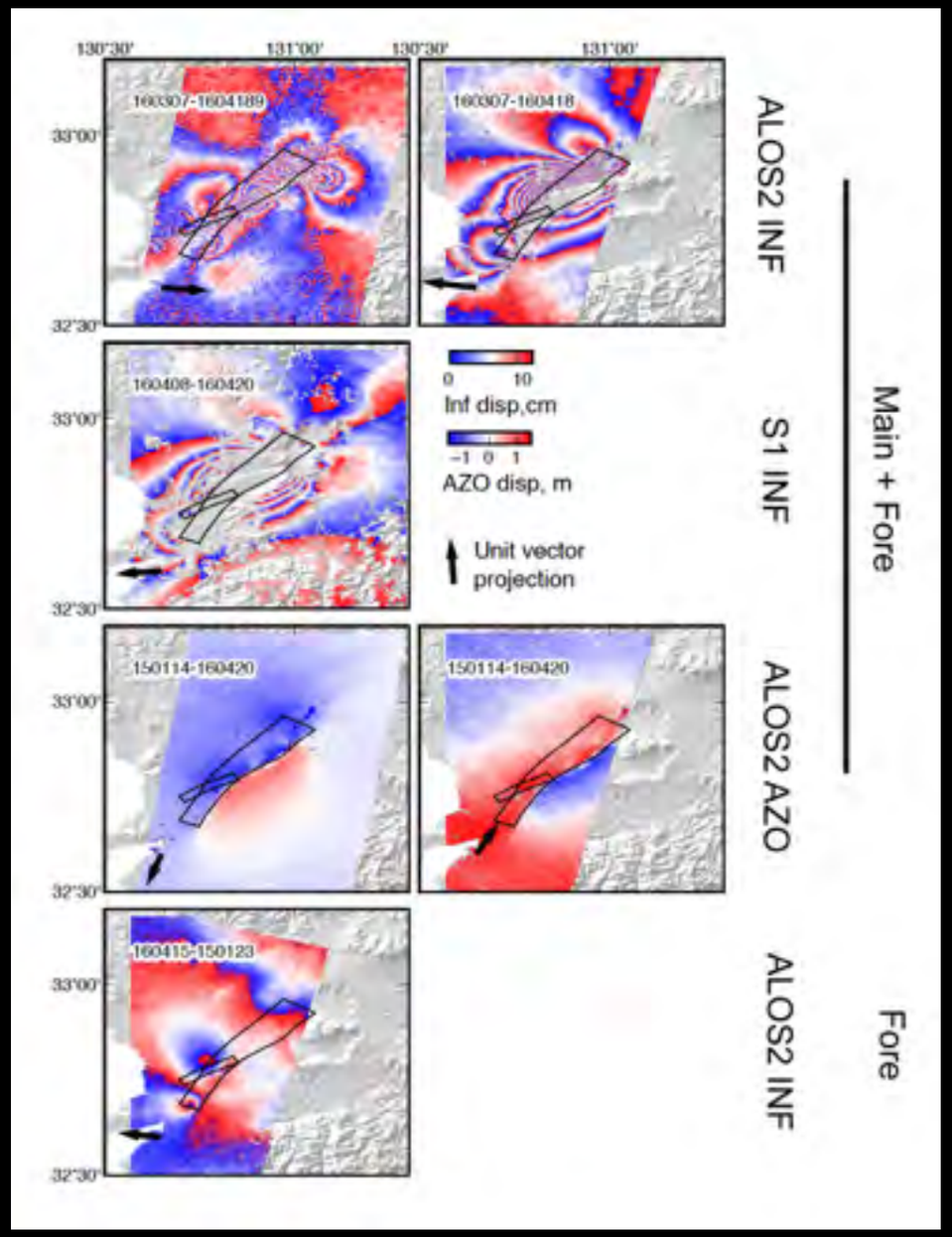
One major fault trace and one secondary fault trace can be identified from the SAR azimuth offset image



GPS + Strong Motion + Surface offset



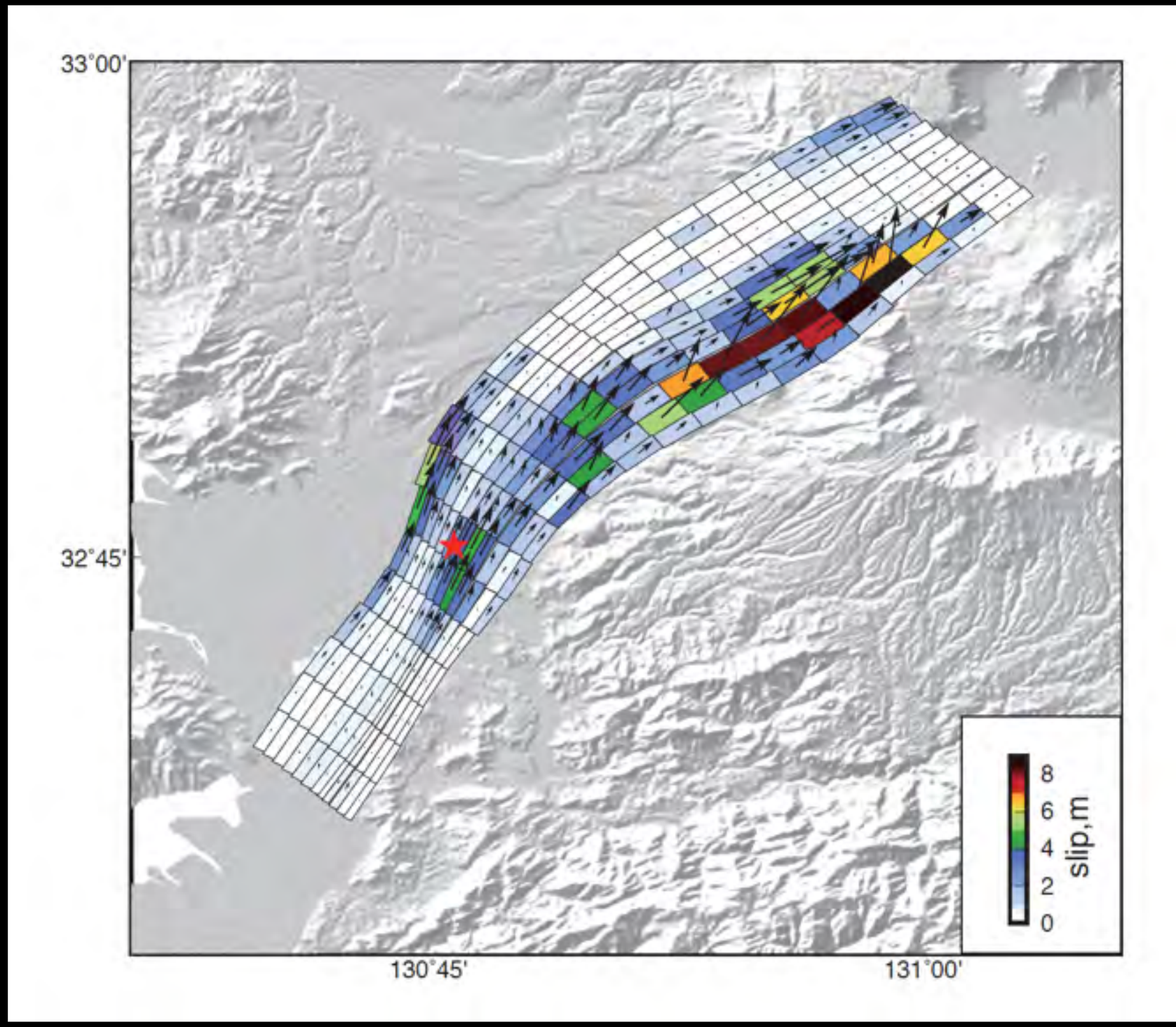
InSAR



Main M7.2 kinematic slip inversion results

1. Uni-lateral rupture

2. Peak slip of ~ 10 m

3. Rupture stopped near the Caldera

4. Significant shallow slip deficit