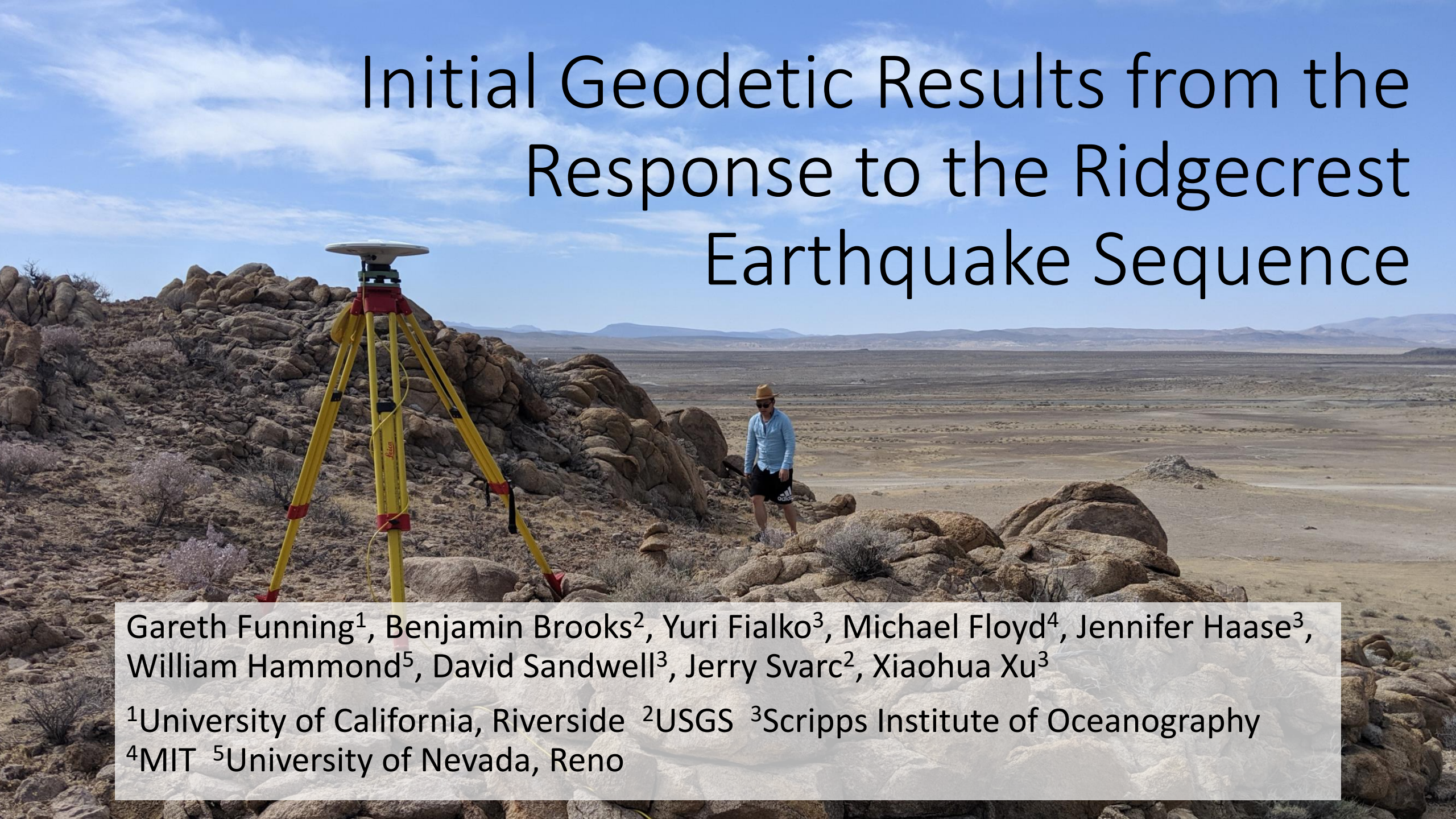
Initial Geodetic Results from the Response to the Ridgecrest Earthquake Sequence



Gareth Funning[1], Benjamin Brooks[2], Yuri Fialko[3], Michael Floyd[4], Jennifer Haase[3], William Hammond[5], David Sandwell[3], Jerry Svarc[2], Xiaohua Xu[3]

[1]University of California, Riverside [2]USGS [3]Scripps Institute of Oceanography
[4]MIT [5]University of Nevada, Reno

Gareth Funning
@gfun

Just felt an earthquake through my bottom

10:35 AM · Jul 4, 2019 from Riverside, CA · Twitter for Android

View Tweet activity

10 Likes

Gareth Funning
@gfun

We were in Ridgecrest a few months ago doing GPS. Probably ought to go back, huh?

> **Earthquake Robot** @earthquakeBot · Jul 4
> A 6.6 magnitude earthquake occurred 7.46mi SW of Searles Valley, CA. Details: eqbot.com/HYU Map: eqbot.com/HY5

10:42 AM · Jul 4, 2019 from Riverside, CA · Twitter for Android

View Tweet activity

3 Retweets **24** Likes


PASO
Rachel Terry


J701


H701


ATOL
February 2019

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@gfun

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10 Likes

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View Tweet activity

3 Retweets **24** Likes

Gareth Funning @gfun · Jul 4
Replying to @gfun
A little wrinkle is that being July 4th and also the middle of field camp, we have no access to university vehicles. M'colleague @ChrisGeophysics is currently working his connections to borrow a vehicle from Plant Pathology at UCR... I daresay we could get there this afternoon.

1 4

Gareth Funning @gfun · Jul 4
Progress! A vehicle full of equipment!

C. Kyriakopoulos

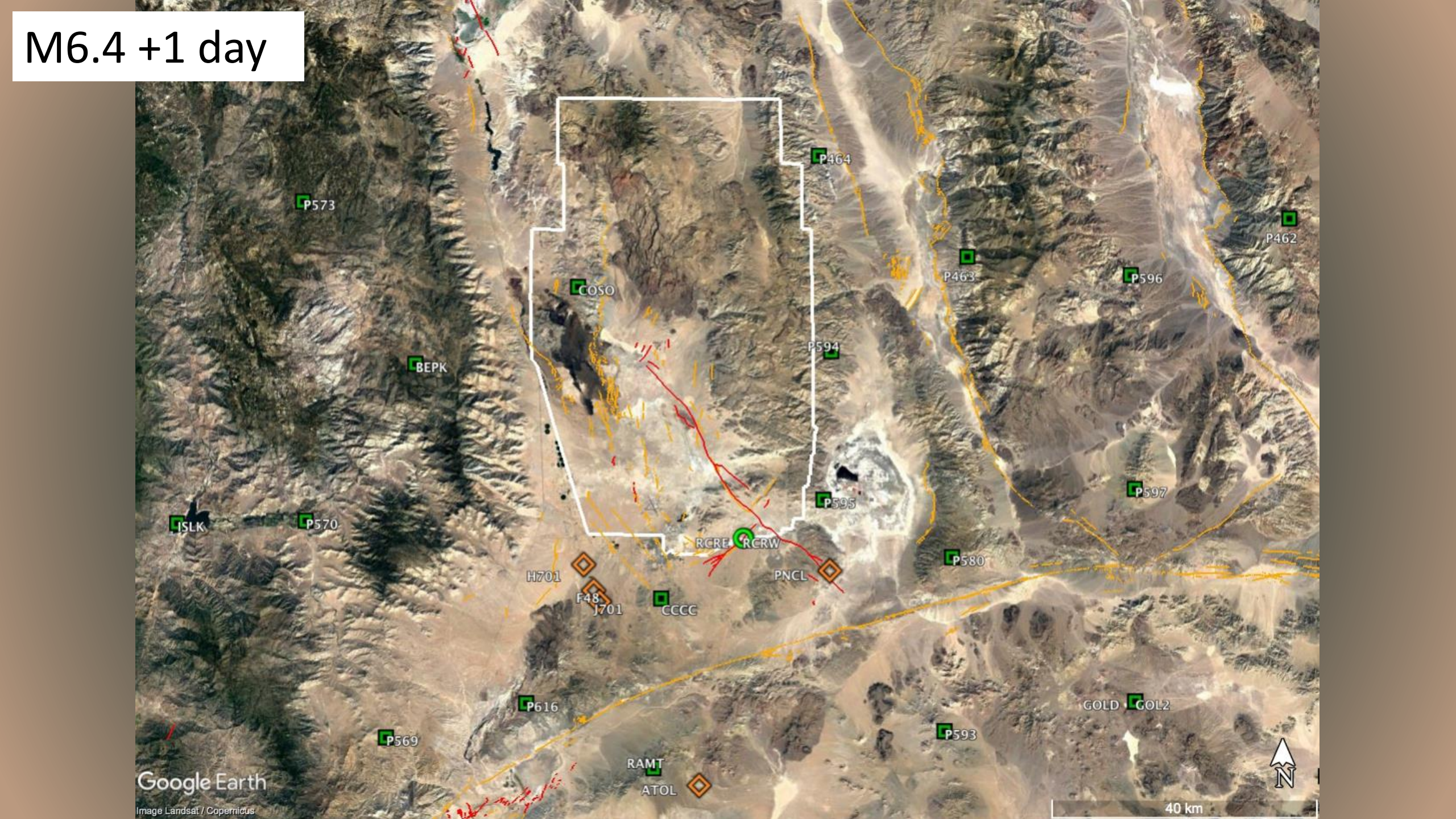
2 1 21


F048
Baoning Wu
Christos Kyriakopoulos

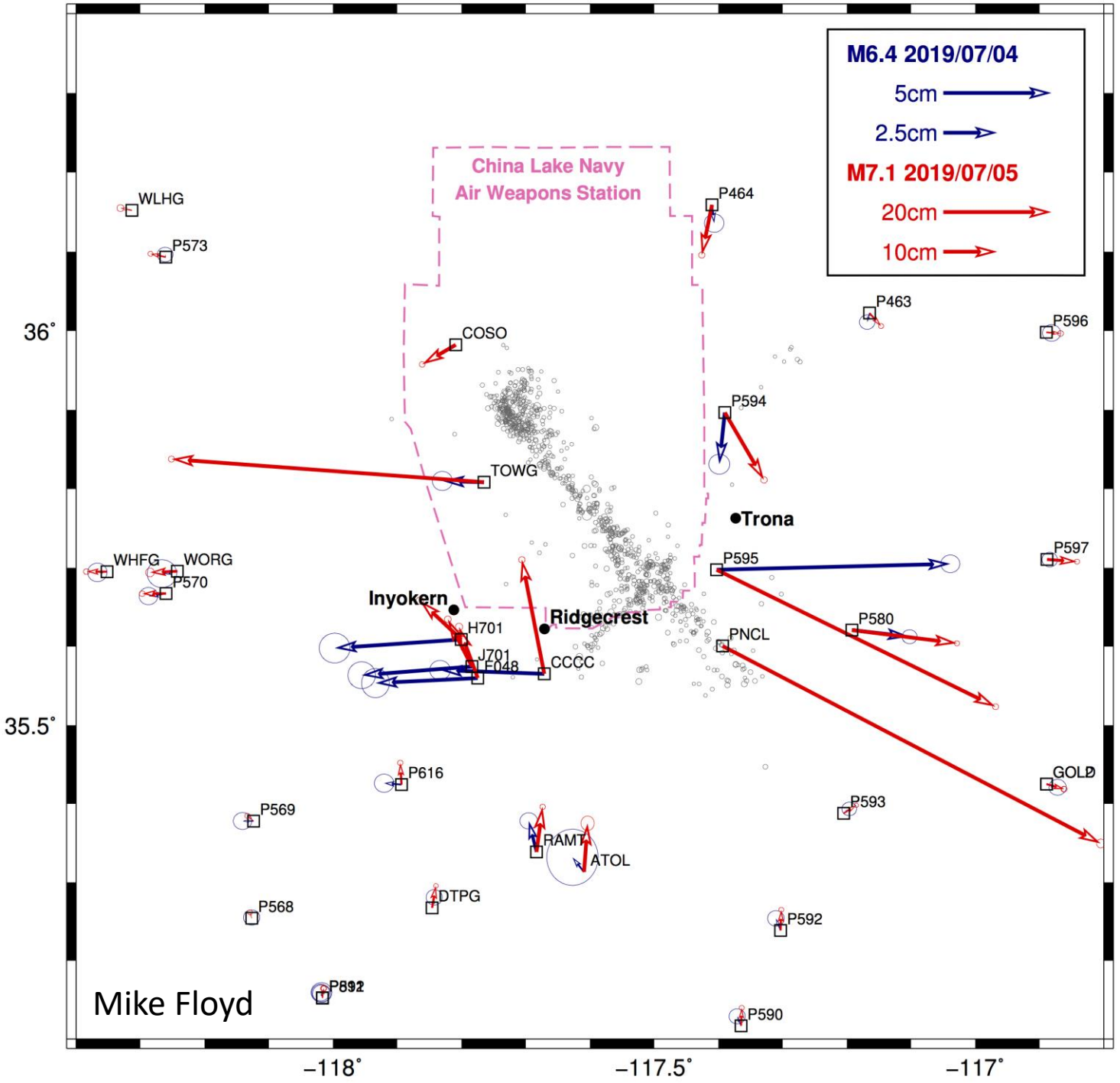

PNCL


H701


ATOL
July 2019


M6.4 +1 day
P464
P573
P462
P463
P596
COSO
P594
BEPK
P595
P597
ISLK
P570
RCRE
RCRW
P580
H701
PNCL
F48
J701
CCCC
P616
GOLD
GOL2
P569
P593
RAMT
ATOL
Google Earth
Image Landsat / Copernicus
N
40 km

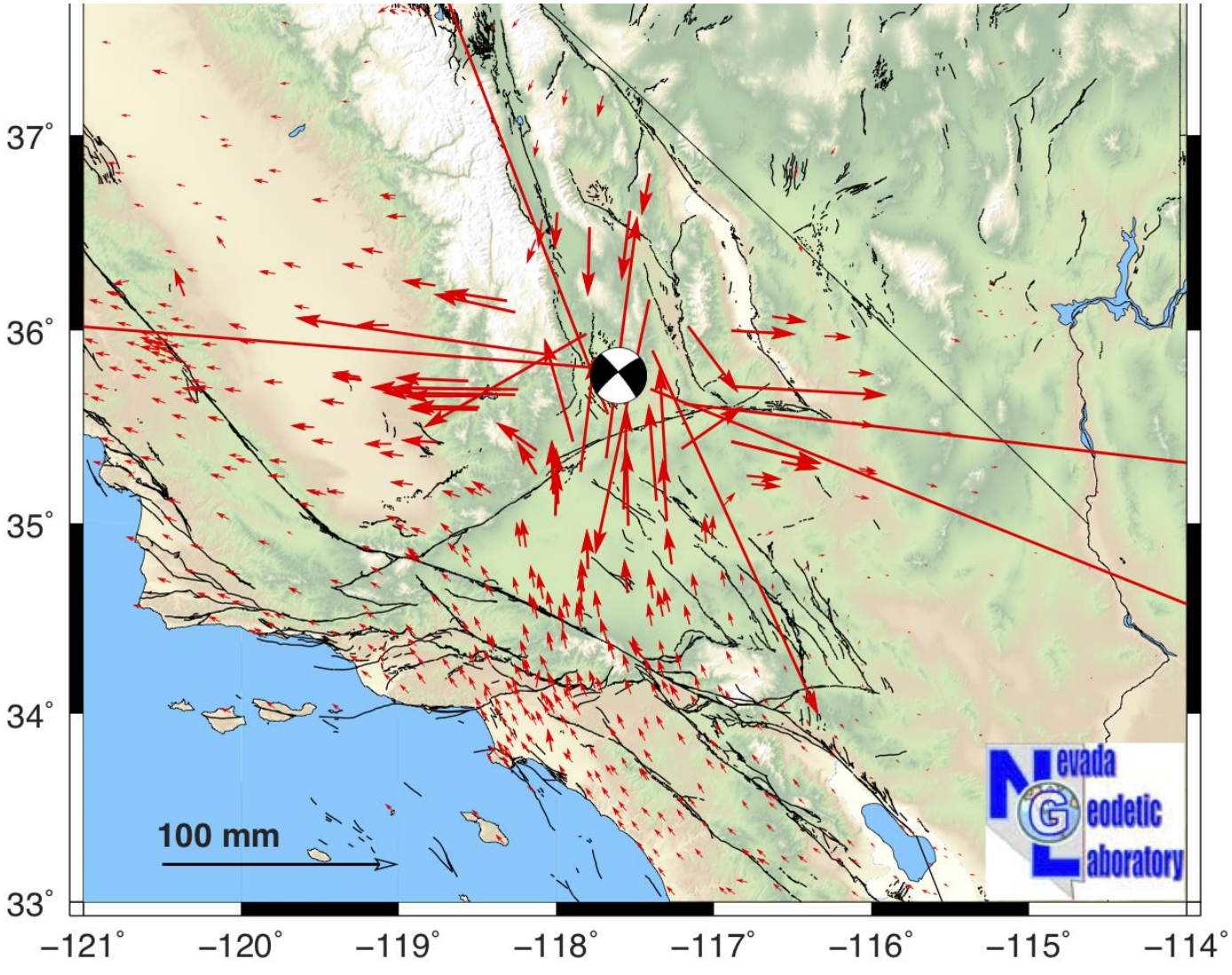
Coseismic displacements from campaign and continuous GPS



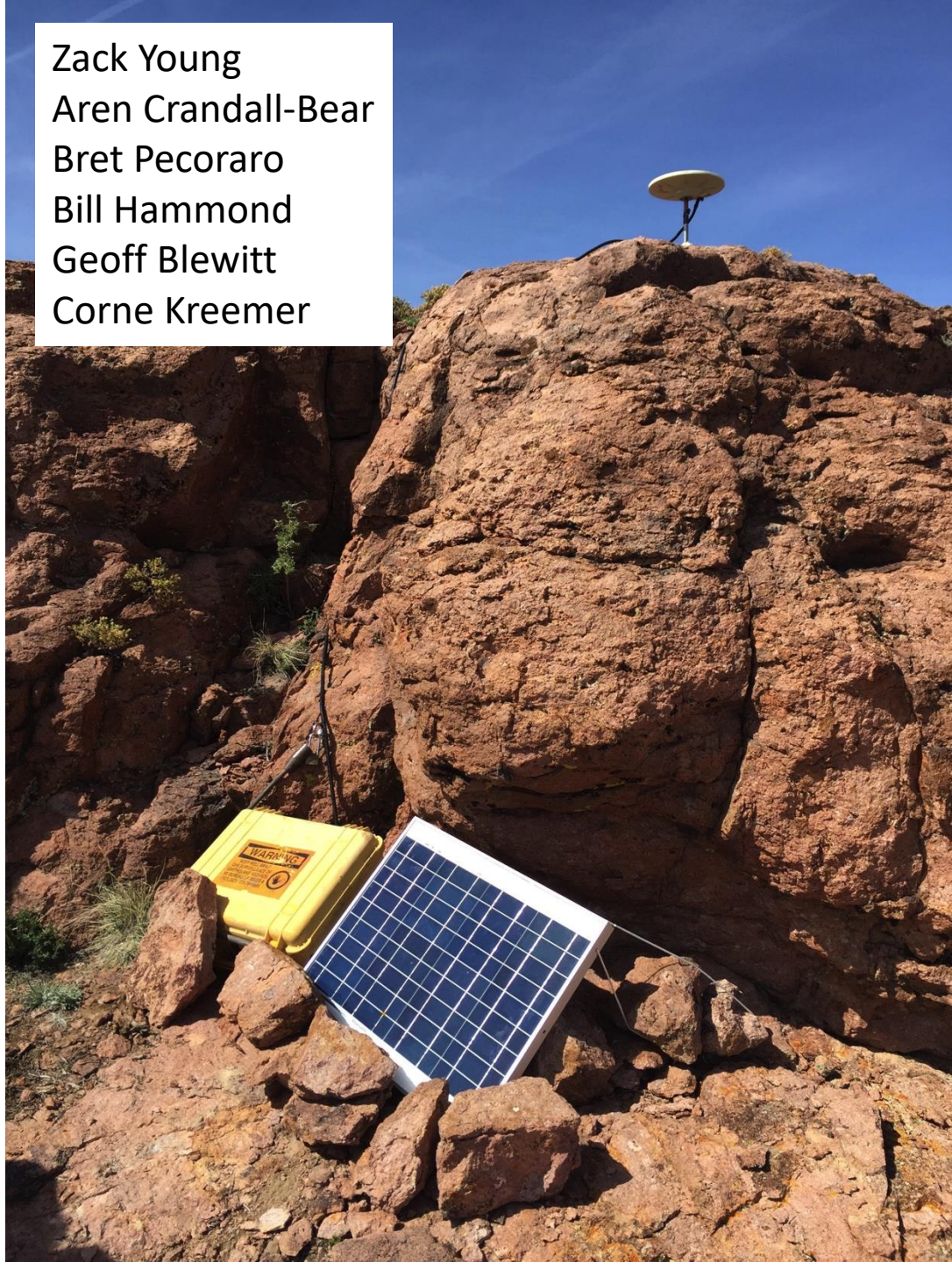
Yuri Fialko
Jennifer Haase
David Sandwell
Ignacio Sepulveda
Zeyu Jin
Katia Tymofyeyeva
Xiaohua Xu

Scripps Institute of Oceanography
8 stations deployed
(7 semi-continuously)

University of Nevada, Reno
7 stations deployed near Ridgecrest
55 moved to the SW of their network



Zack Young
Aren Crandall-Bear
Bret Pecoraro
Bill Hammond
Geoff Blewitt
Corne Kreemer

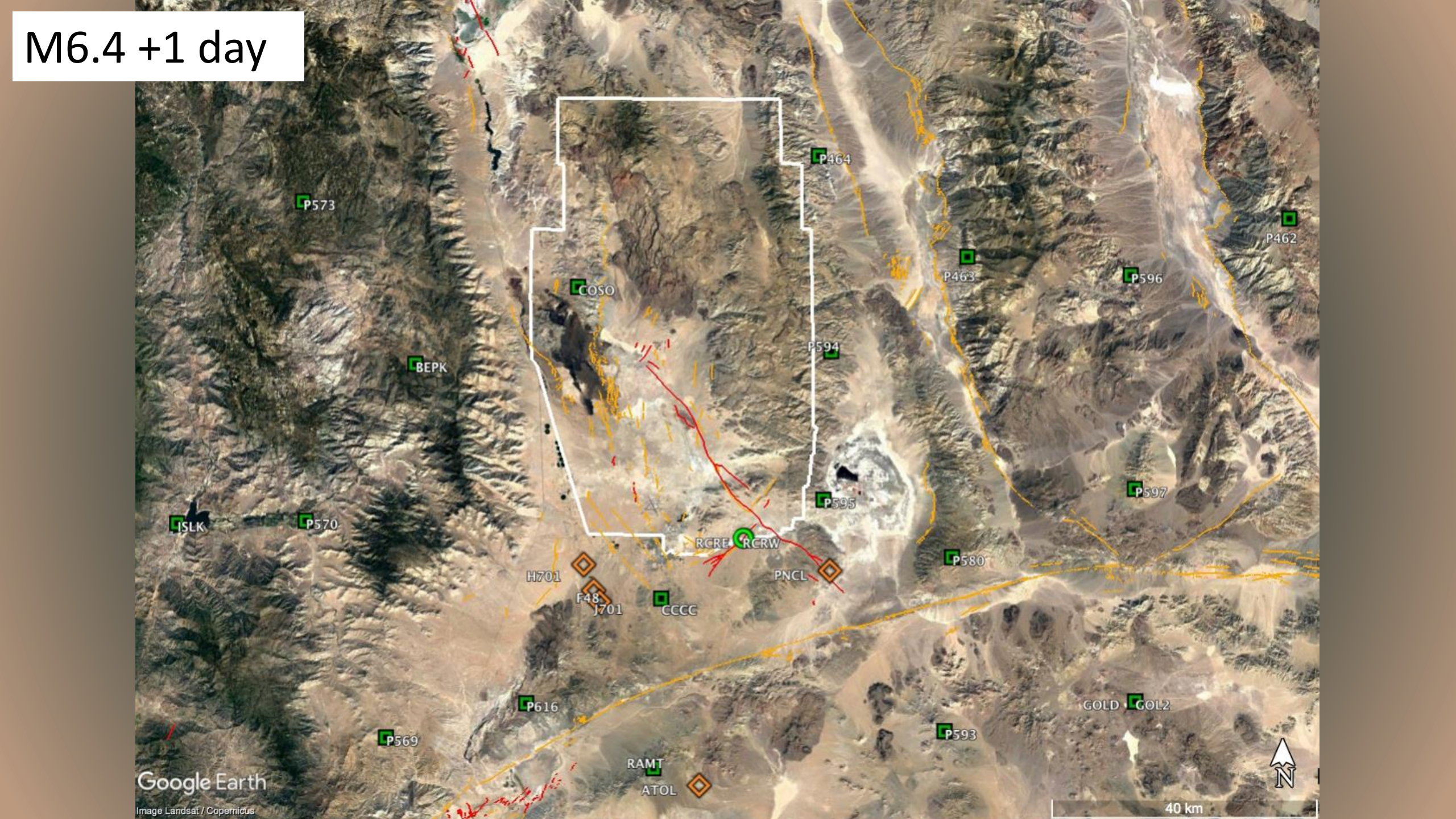


USGS

4 short baseline cross-fault arrays

9 sites surveyed (5 on base)

Ben Brooks
Jerry Svarc
Eleyne Phillips
Mark Murray


M6.4 +1 day
P464
P573
P462
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COSO
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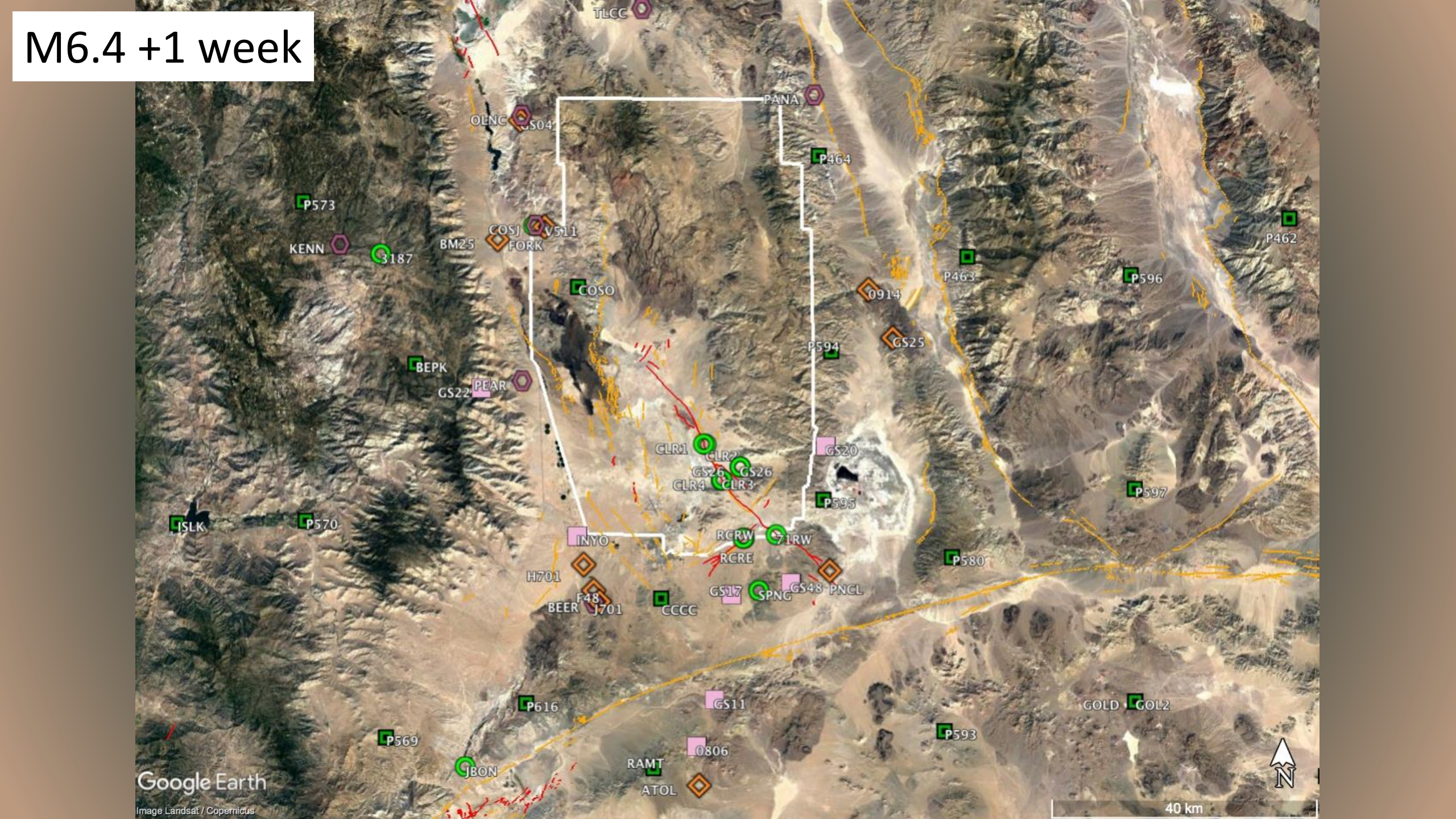
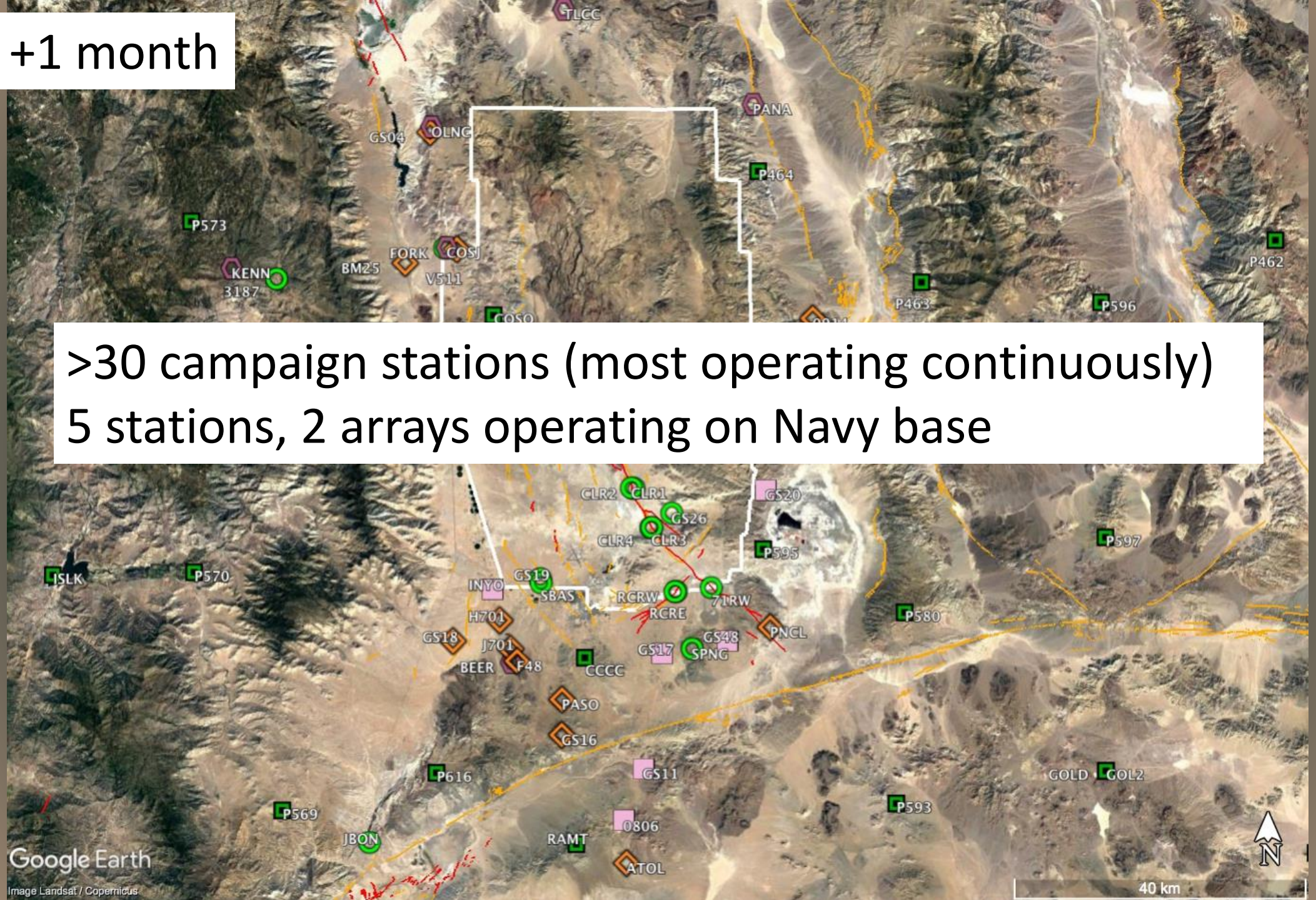
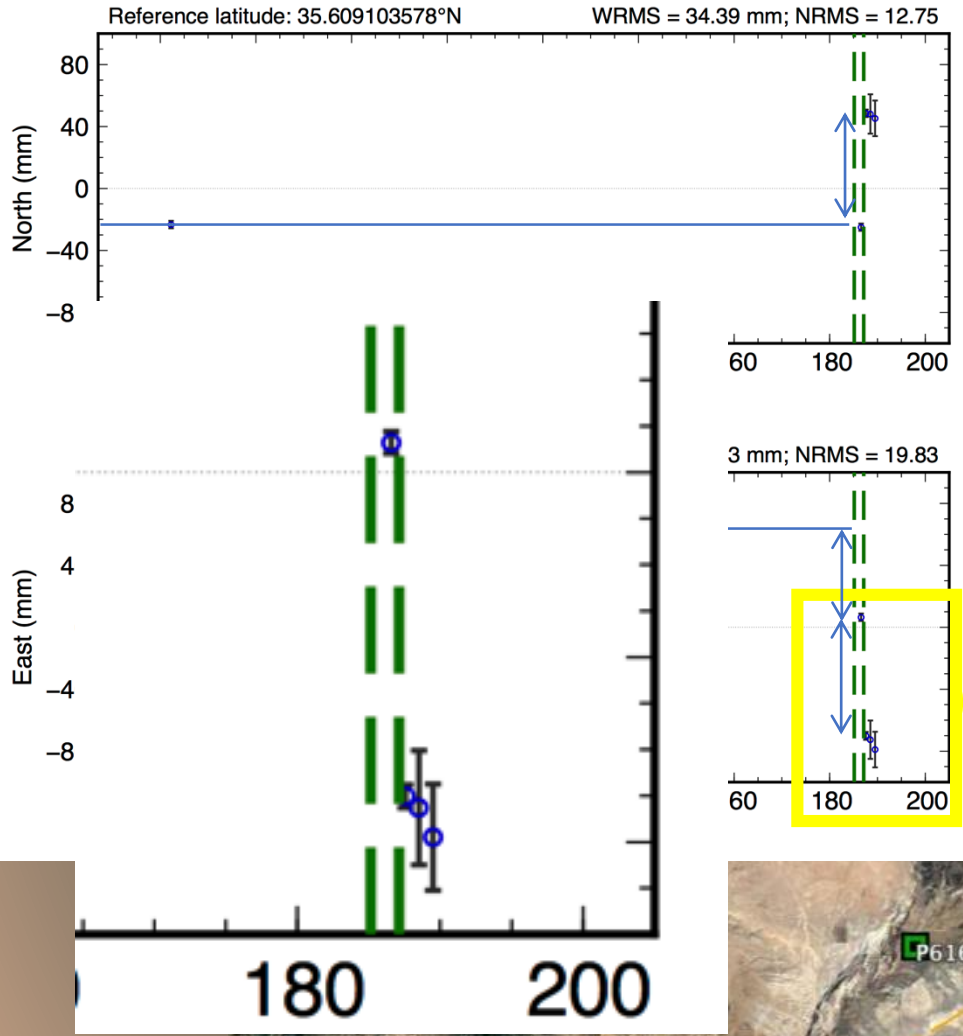
P593
RAMT
ATOL
Google Earth
Image Landsat / Copernicus
N
40 km


M6.4 +1 week
TLCC
PANA
OLNC
S04
P464
P573
KENN
3187
BM25
COSJ
FORK
V511
COSO
P463
P596
P462
0914
GS25
P594
BEPK
PEAR
GS22
GLR1
GLR2
GS20
GS26
GS26
CLR4
CLR3
P595
P597
ISLK
P570
INYO
RCRW
71RW
RCRE
P580
H701
F48
BEER
J701
CCCC
GS17
SPNG
GS48
PNCL
P616
GS11
GOLD
GOL2
P569
0806
P593
JBON
RAMT
ATOL
Google Earth
Image Landsat / Copernicus
N
40 km

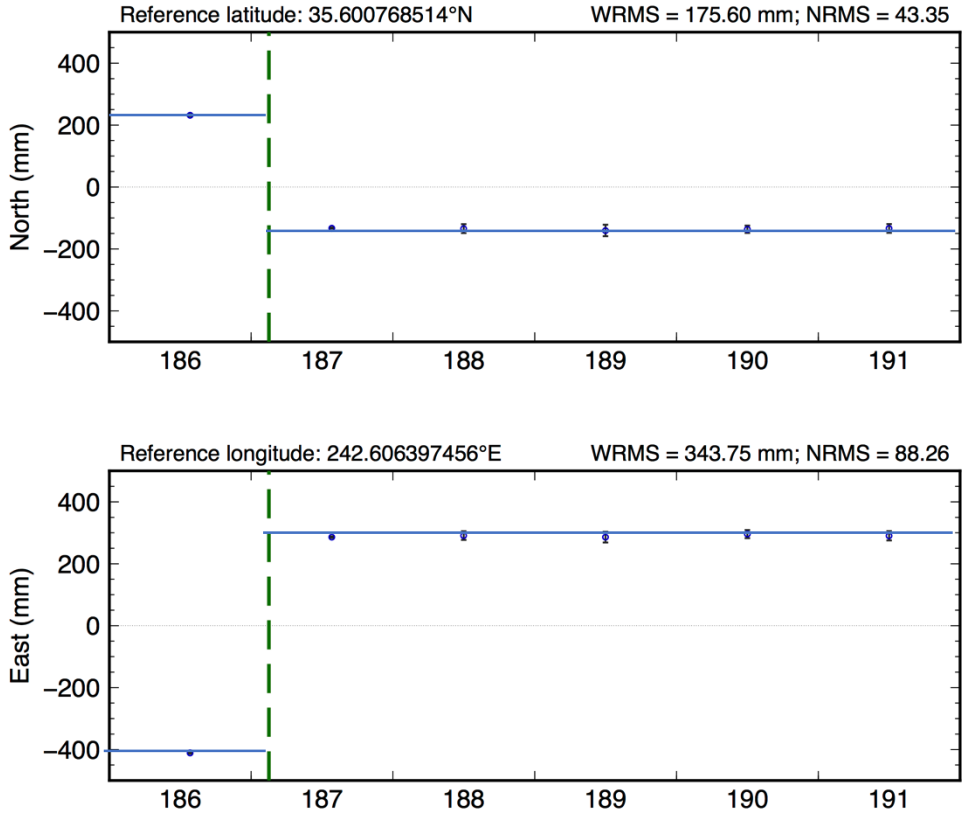

M6.4 +1 month
>30 campaign stations (most operating continuously)
5 stations, 2 arrays operating on Navy base
TLCC
PANA
GS04
OLNG
P464
P573
FORK
COSJ
KENN
3187
BM25
V511
COSO
P463
P596
P462
CLR2
CLR1
GS20
GS26
CLR4
CLR3
P595
P597
ISLK
P570
GS19
INYO
SBAS
RCRW
71RW
RCRE
H701
P580
PNCL
GS18
J701
GS17
GS48
SPNG
BEER
F48
CCCC
PASO
GS16
P616
GS11
GOLD
GOL2
P569
P593
JBON
0806
RAMT
ATOL
Google Earth
Image Landsat / Copernicus
N
40 km

(very) preliminary postseismic results

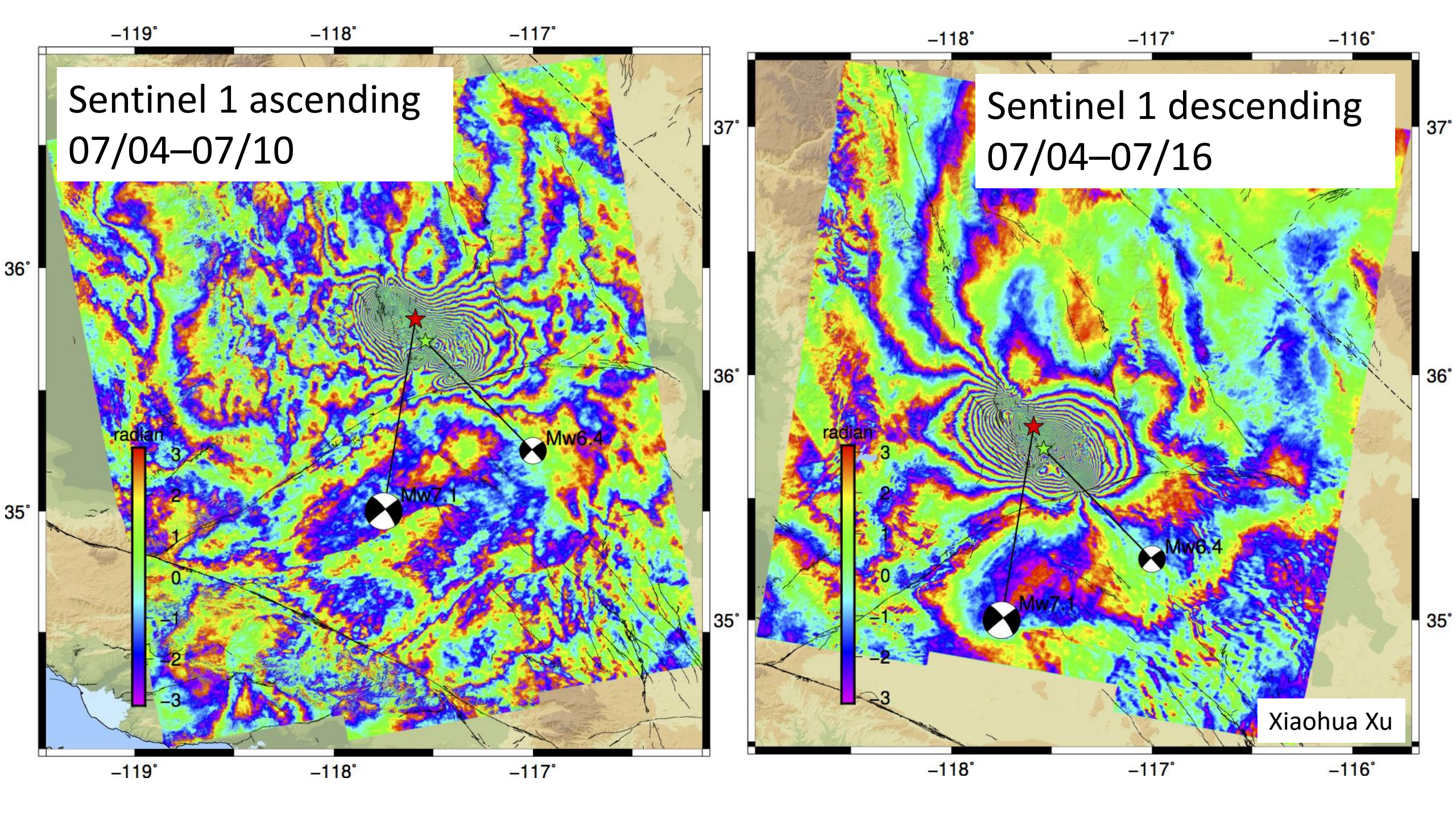
H701: 18 km from M6.4 fault, 24 km from M7.1

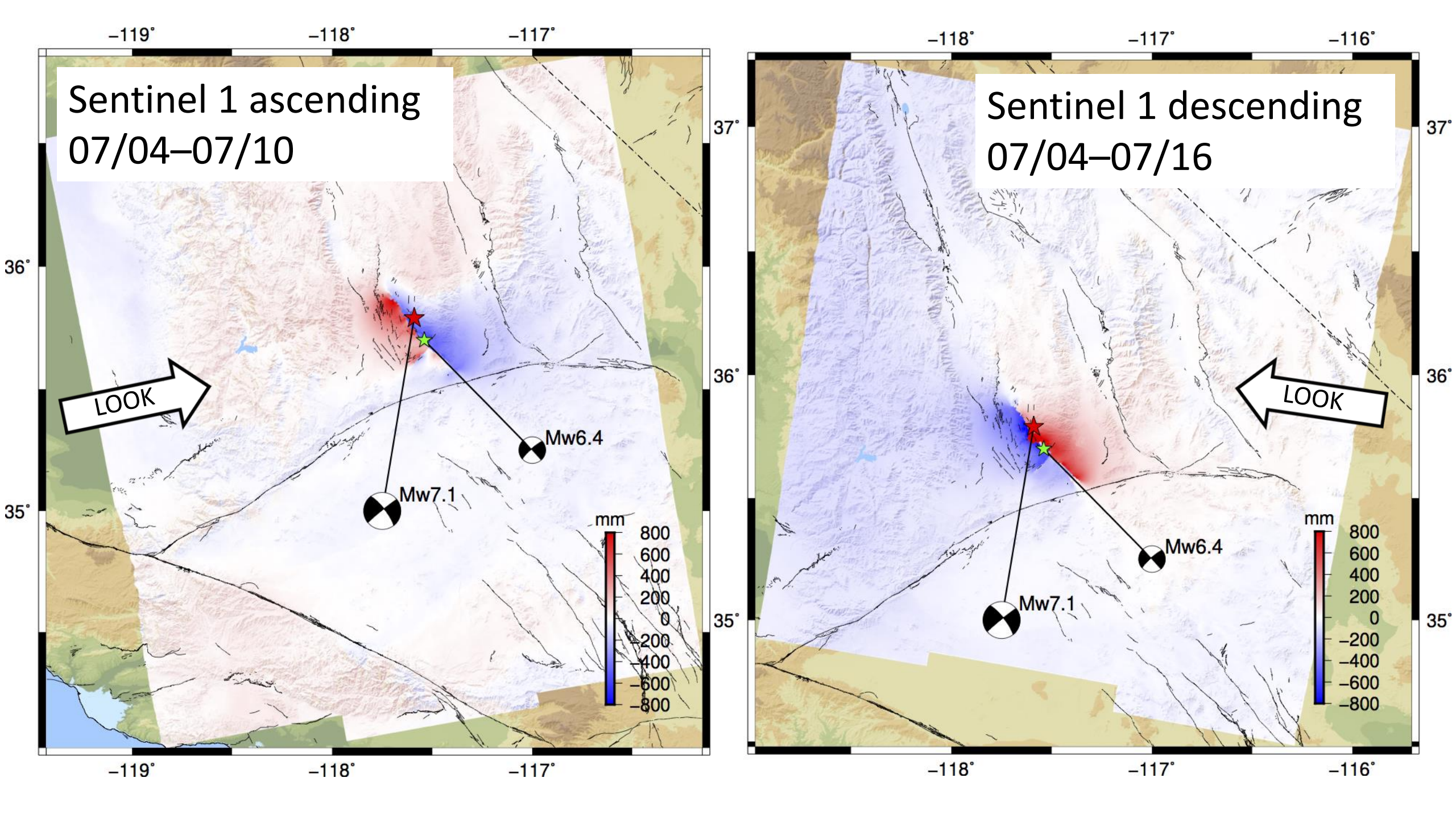


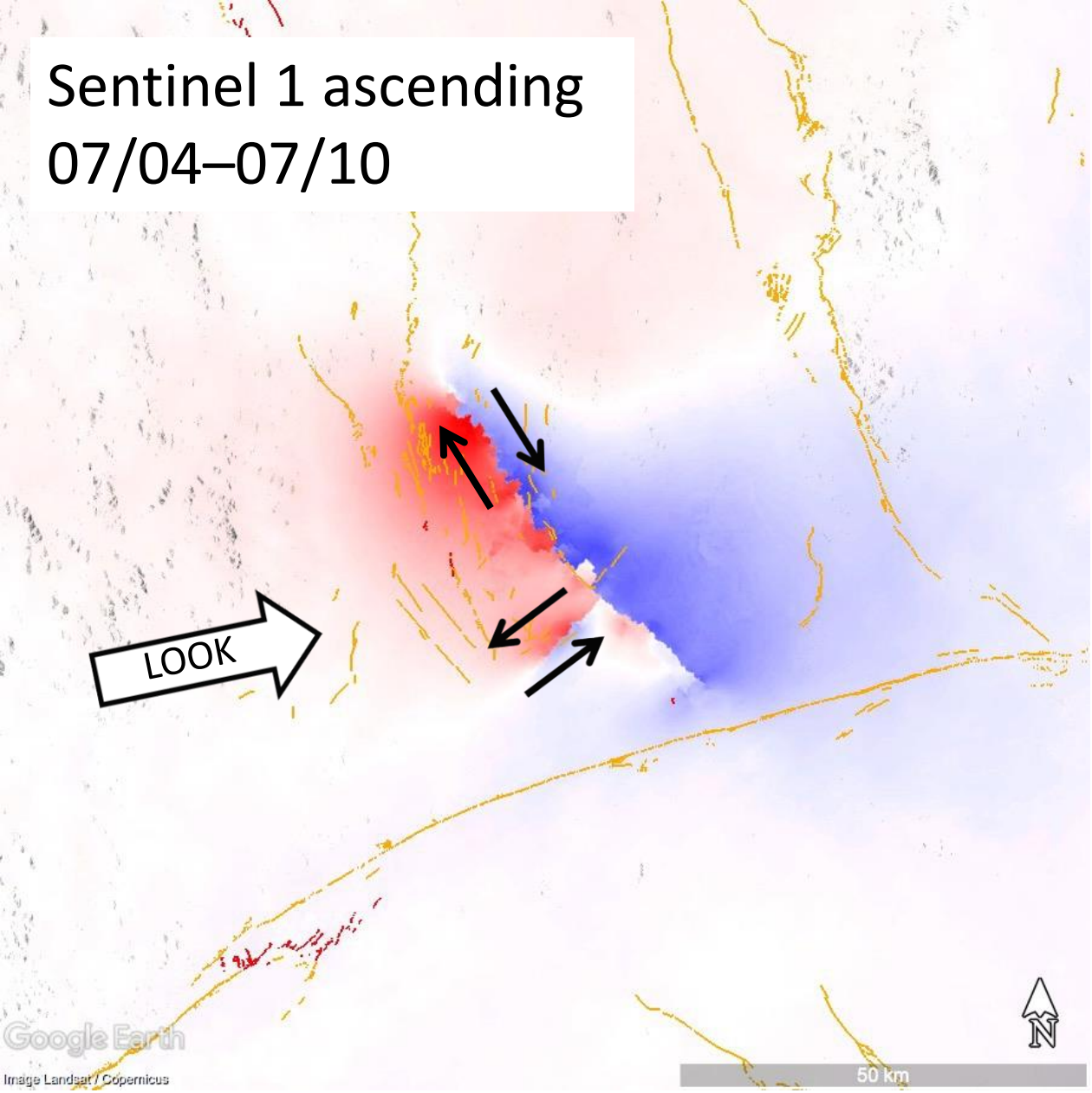
PNCL: 0.6 km from M7.1 fault

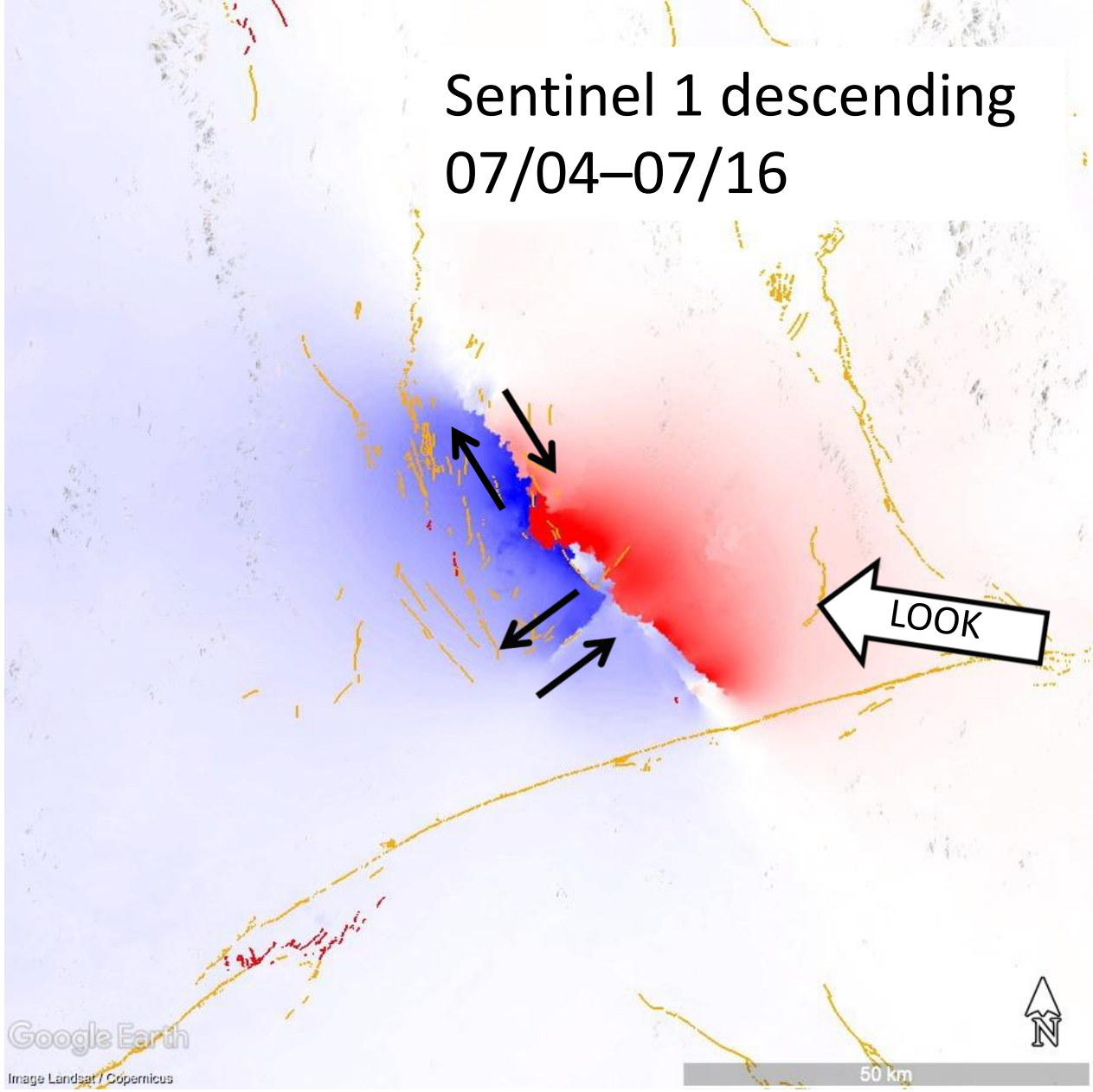


- Very little shallow afterslip
- Tentative evidence for deeper afterslip

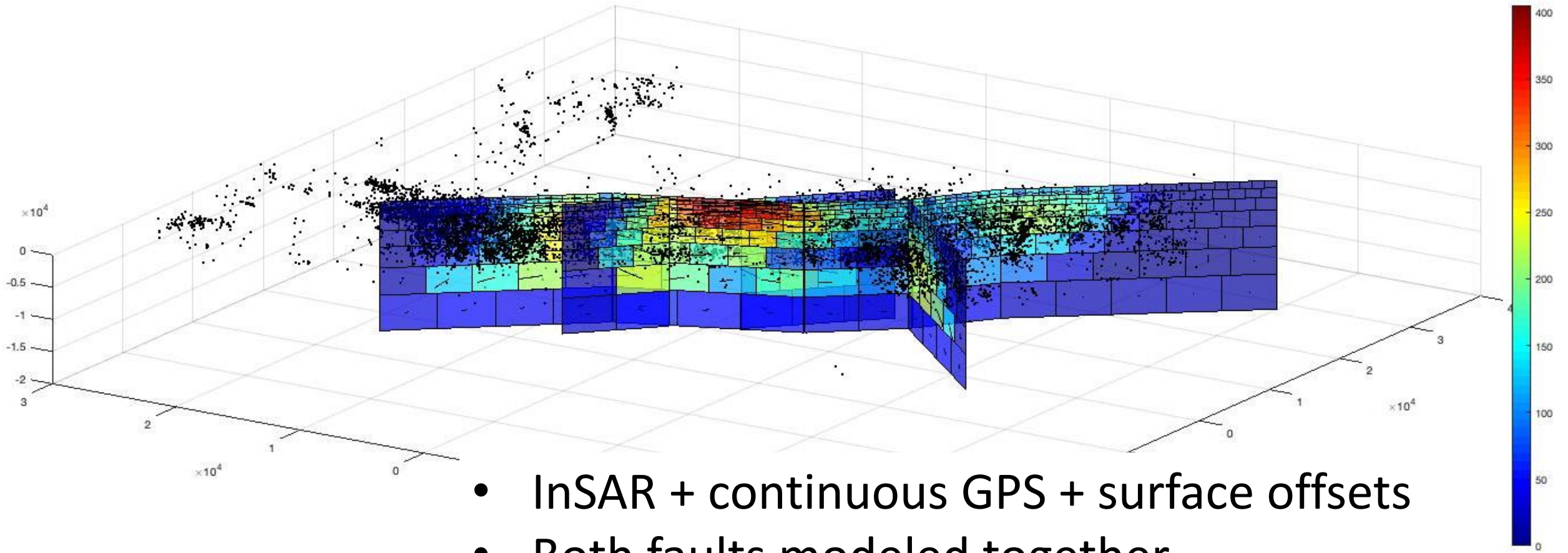

Sentinel 1 ascending
07/04–07/10
Sentinel 1 descending
07/04–07/16
radian
3
2
1
0
−1
−2
−3
Mw6.4
Mw7.1
−119°
−118°
−117°
−116°
37°
36°
35°
Xiaohua Xu


Sentinel 1 ascending
07/04–07/10
LOOK
Mw6.4
Mw7.1
mm
800
600
400
200
0
−200
−400
−600
−800
−119°
−118°
−117°
36°
35°
Sentinel 1 descending
07/04–07/16
LOOK
Mw6.4
Mw7.1
mm
800
600
400
200
0
−200
−400
−600
−800
−118°
−117°
−116°
37°
36°
35°





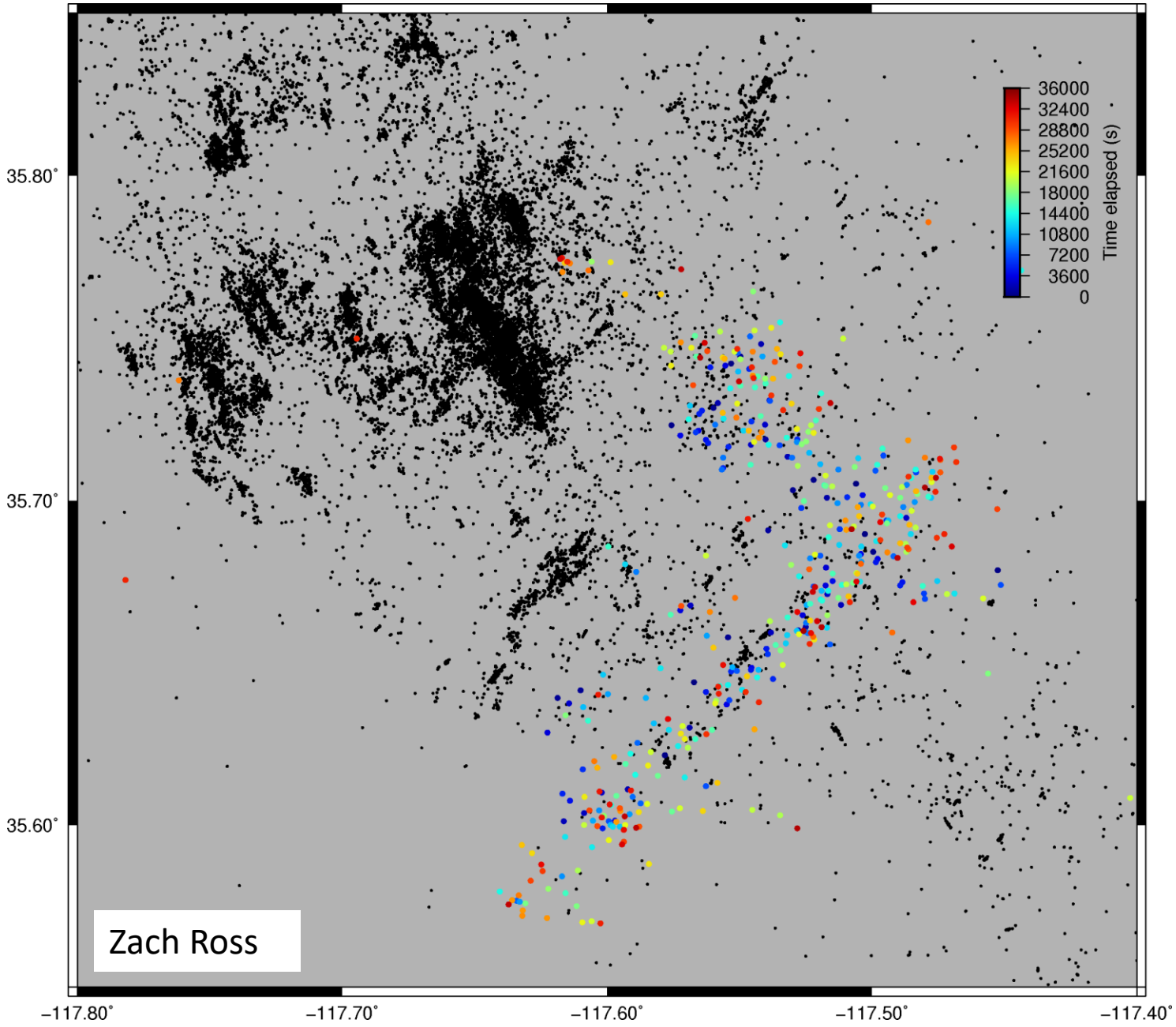
Red = towards satellite, blue = away from satellite



- InSAR + continuous GPS + surface offsets
- Both faults modeled together
- Peak slip >4 m, upper ~6 km of fault
- More dip-slip at ends of rupture

Bridget Smith-Konter
Xiaohua Xu
David Sandwell

Aftershocks of the M6.4 earthquake showed a conjugate pattern from the beginning. Was there conjugate slip?



$$\mathbf{Am = d}$$

$$\begin{pmatrix} A_{GPS6} & 0 \\ 0 & A_{GPS7} \\ A_{InSAR6} & A_{InSAR7} \end{pmatrix} \begin{pmatrix} m_6 \\ m_7 \end{pmatrix} = \begin{pmatrix} d_{GPS6} \\ d_{GPS7} \\ d_{InSAR} \end{pmatrix}$$

Green's functions for M6.4

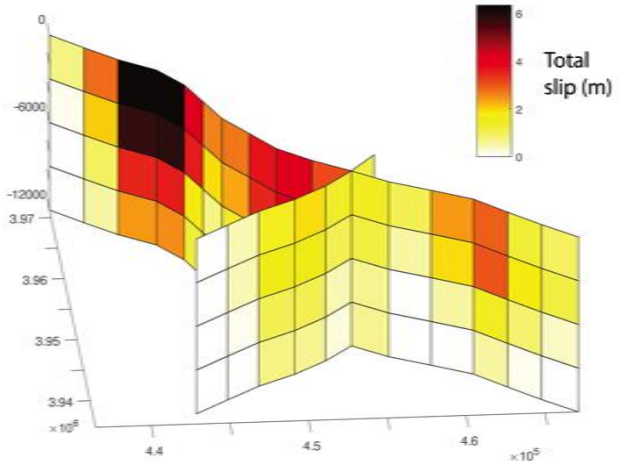
Green's functions for M7.1

$$\mathbf{m = (A^T E^{-1} A)^{-1} (A^T E^{-1} d)}$$

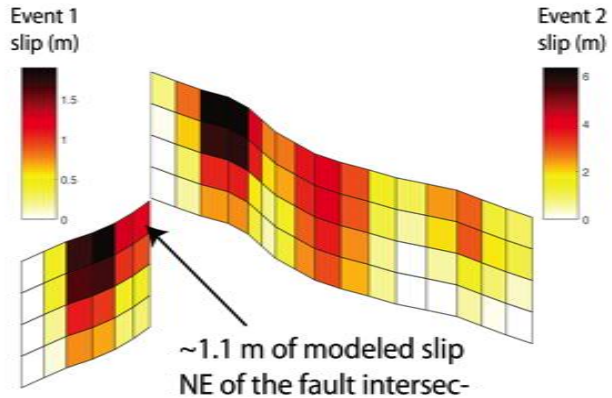
Inverse data covariance matrix

- GPS data for M6.4 (d_{GPS6}) constrain slip of M6.4 (m_6) only
- GPS data for M7.1 (d_{GPS7}) constrain slip of M7.1 (m_7) only
- InSAR data (d_{InSAR}) constrain sum of slip for both events

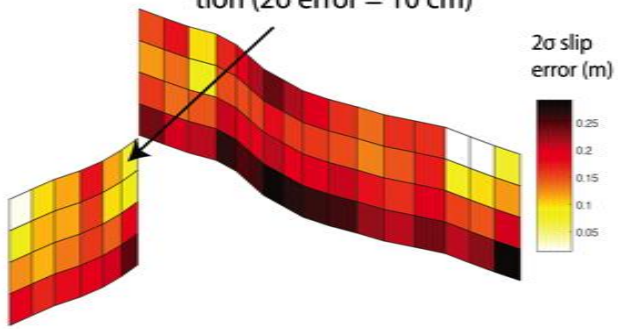
Model 1:
Each event only slips on one fault



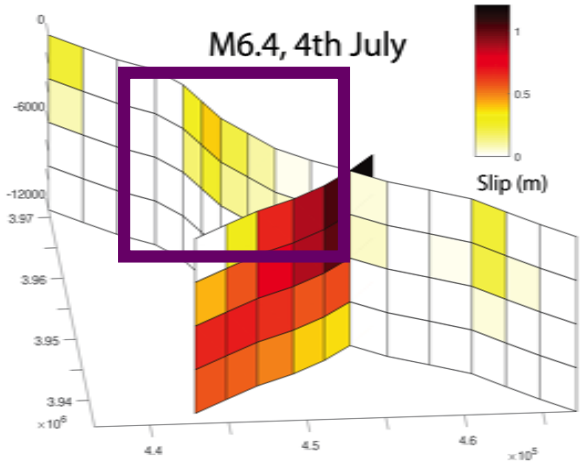
Slip per fault

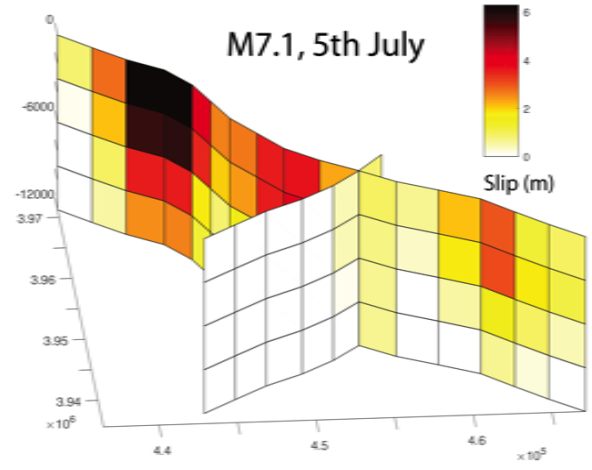


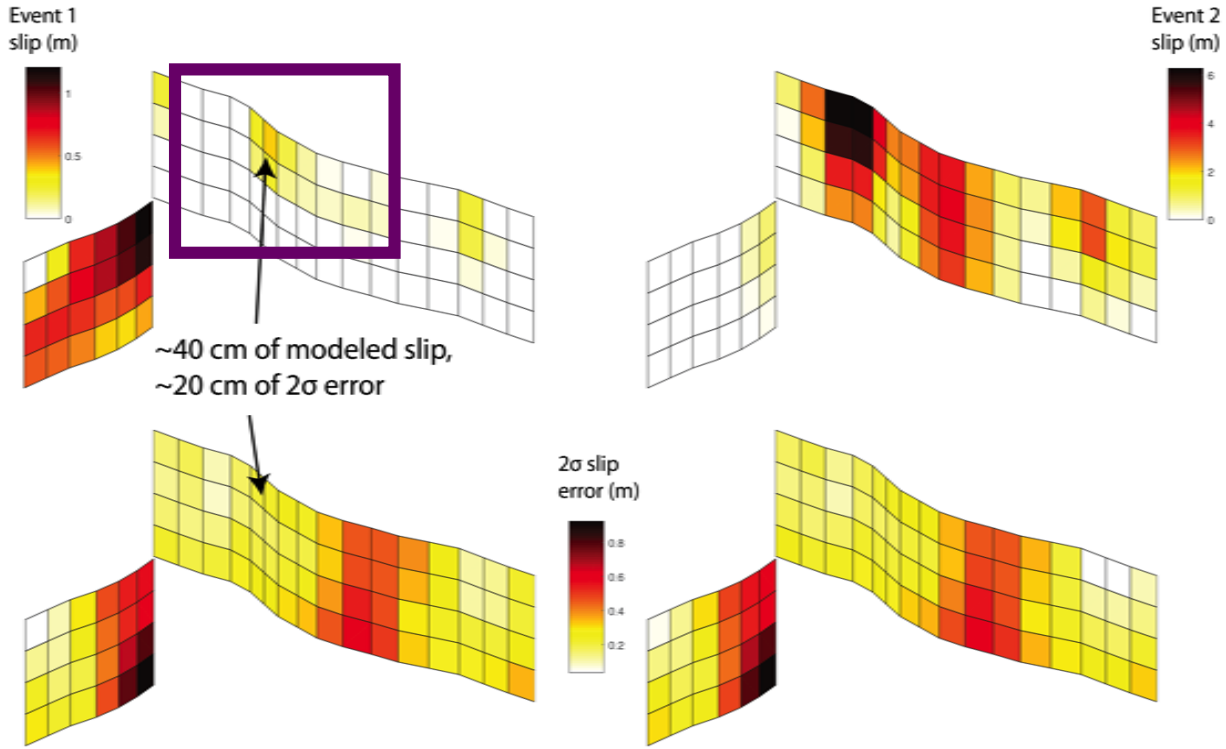
2σ slip error



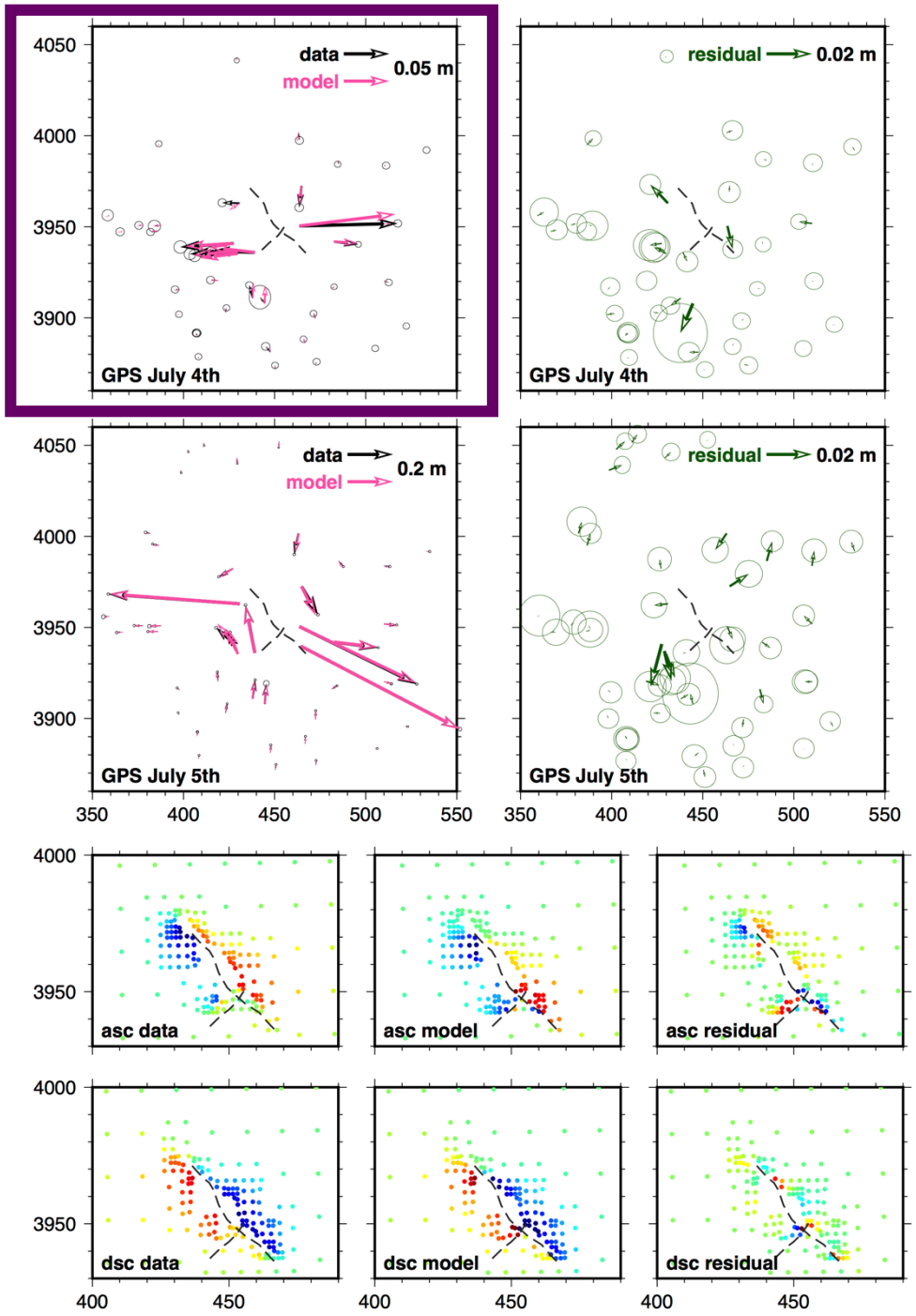
Model 2:
Each event can slip on both faults



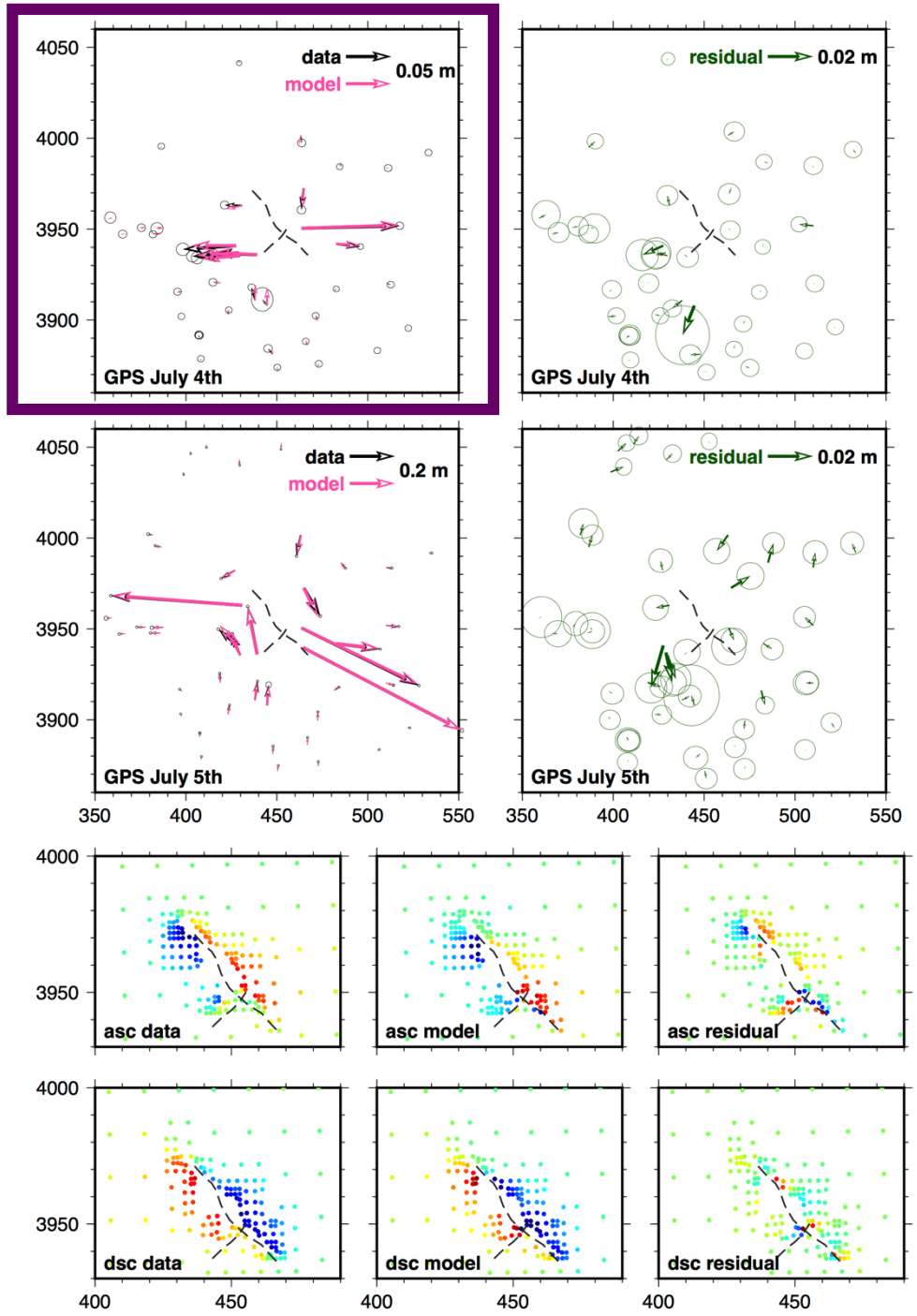




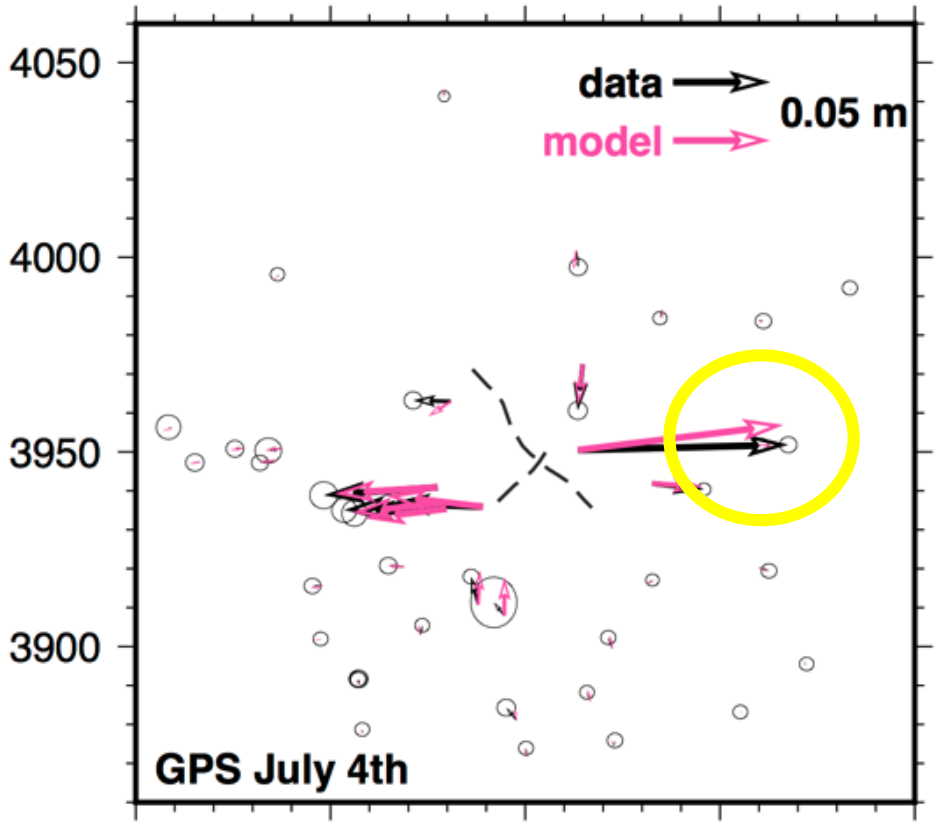
earthquakes on separate faults



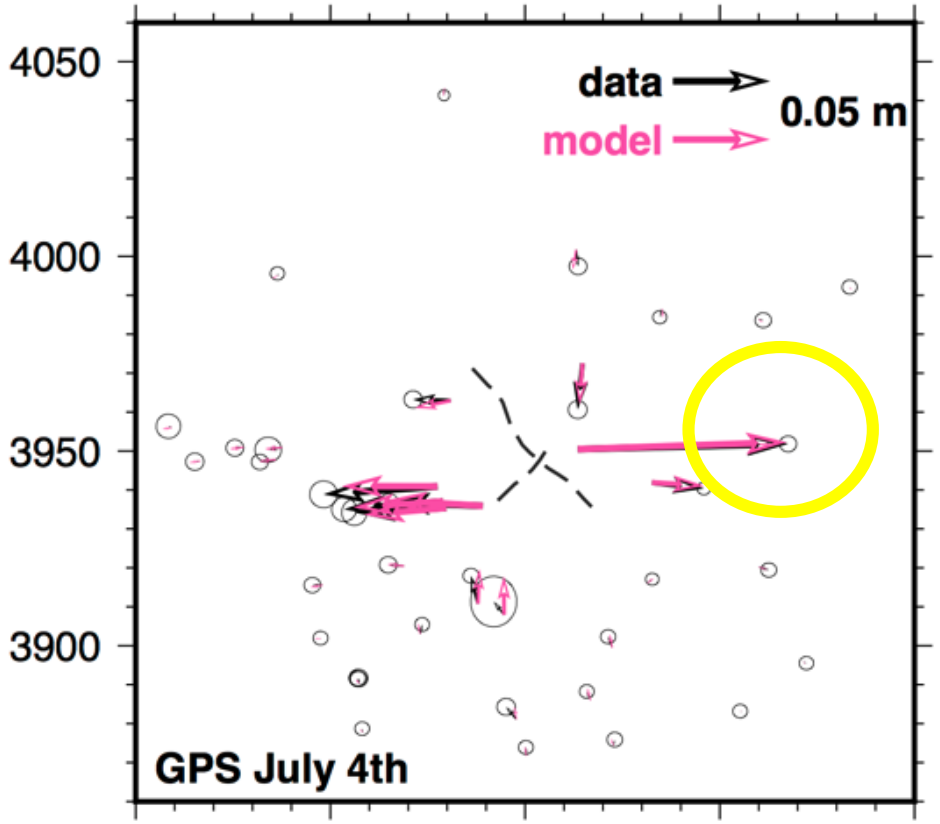
earthquakes allowed on both faults



earthquakes on separate faults



earthquakes allowed on both faults



- Model with slip on conjugate fault fits ~13% better (WRSS)…
  …but has double the number of model parameters (significance?)
- Currently testing other conjugate fault geometries (splay?)

Take home points

- We collected campaign GPS data between the two earthquakes
- InSAR data cannot separate the earthquakes; coherence is excellent
- Slip in the earthquake was mostly shallow (upper 6 km)
- We do not see shallow afterslip in the GPS (maybe some deeper)
- GPS data may support conjugate slip in the M6.4 event (but need to evaluate statistical significance)

Data collection supported by NSF SCEC AN NSF+USGS CENTER – thank you!