UAVSAR Observation of Multi-Temporal Multi-Fault Behavior Associated with the 2010 M7.2 El Mayor – Cucapah Earthquake

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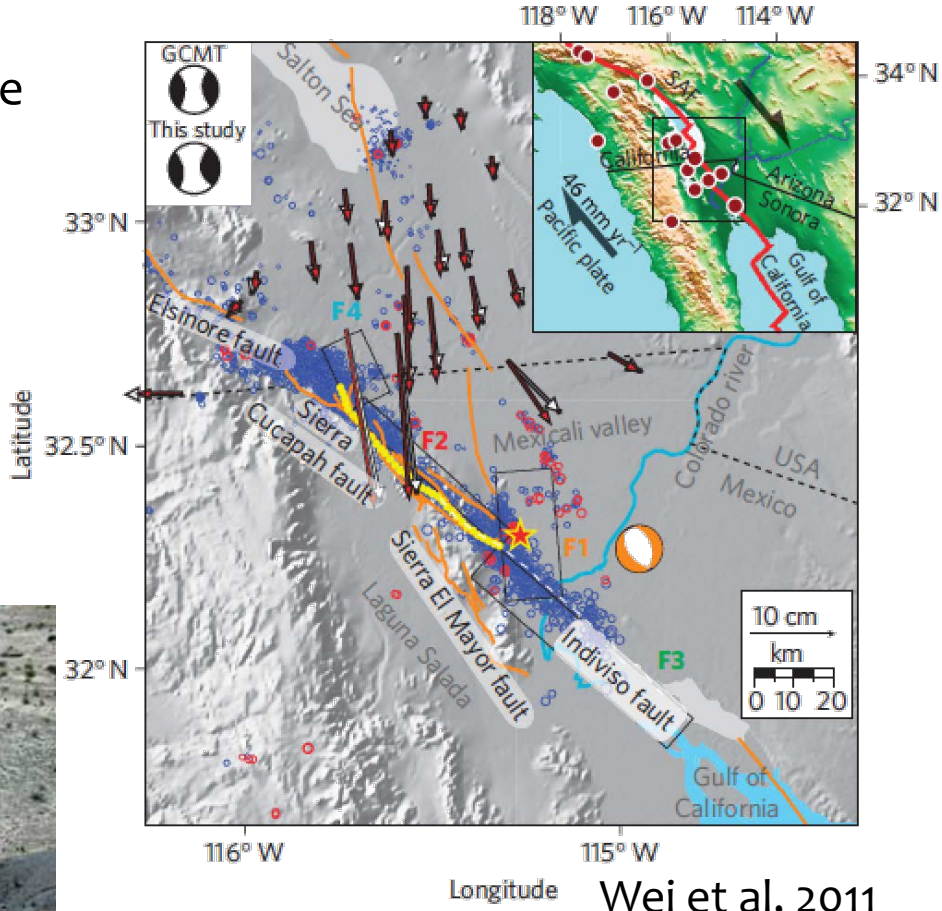
2010 M7.2 El Mayor-Cucapah Earthquake

- M 7.2 earthquake
  - About 3 m of fault slip on the rupture
  - Large 60 cm level overprint of deformation across the Salton Trough
- Coseismic triggered slip on other faults
  - mm to cm level
  - Mostly NE of mainshock rupture
- Postseismic activity NW of rupture



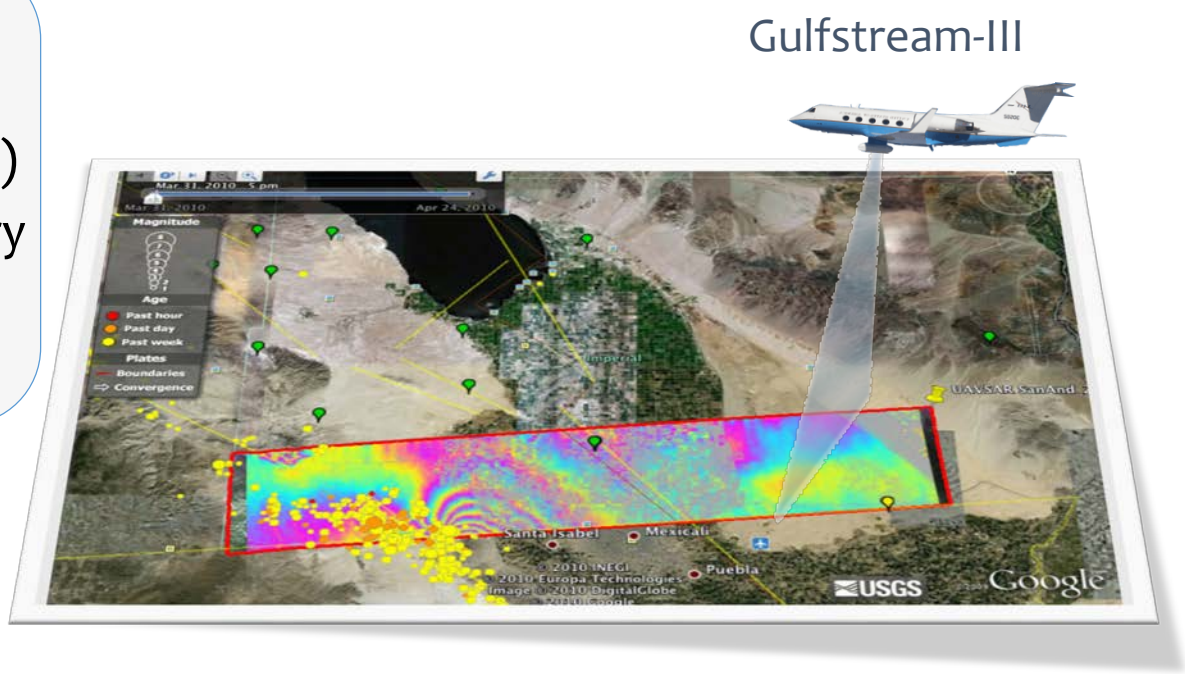
Wei et al, 2011

UAVSAR/InSAR

- Airborne Interferometric synthetic aperture radar (InSAR)
- Products provide ground changes in a line of sight direction to/from the instrument

UAVSAR

- Airborne InSAR
- L-band (24 cm wavelength)
- Repeat pass interferometry
- Flown on a Gulfstream III
- Color cycle is 12 cm



UAVSAR

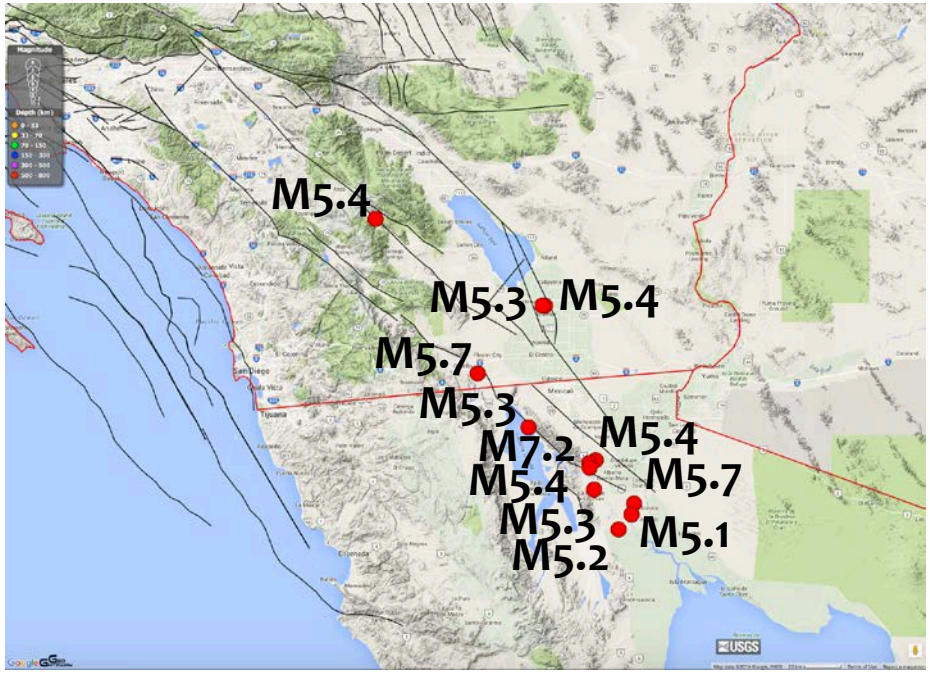
- Applications
  - Identifying fault slip
    - Main Rupture and triggered slip
  - Observing damage to buildings and infrastructure
- Types of damage
  - Damaged roads and tilled farm lands during the El Mayor - Cucapah earthquake in 2010

Timeline: UAVSAR and Events

Key events in California

- Yuha Desert M5.7 6/15/10
- Borrego Springs M5.4 7/7/10
- Brawley Swarm 8/26/2012

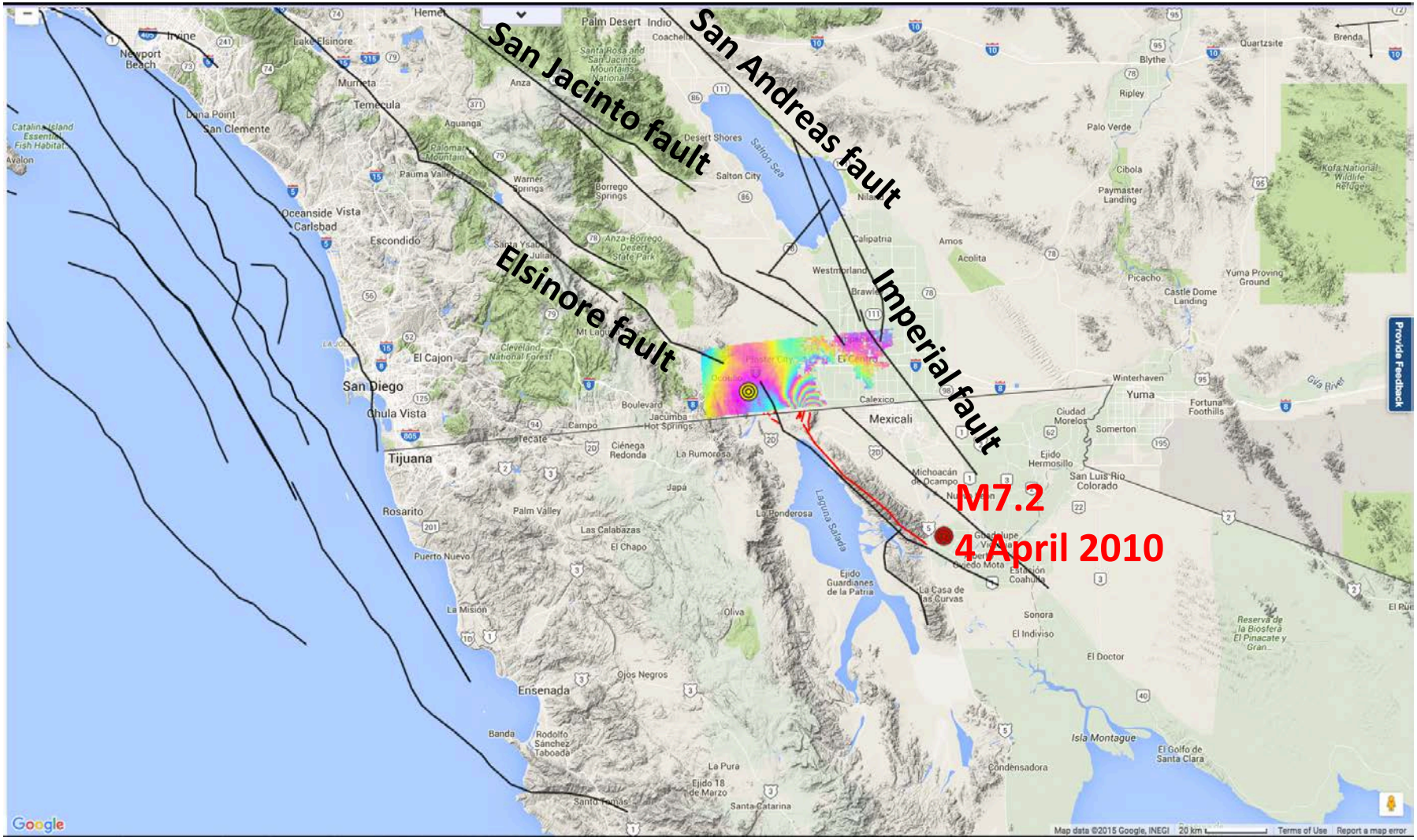
Wei et al, 2015



M7.2
M5.3
M5.7
M5.4
M5.4
M5.2 4/5/16
M5.3 4/8/16
M5.7 M5.4

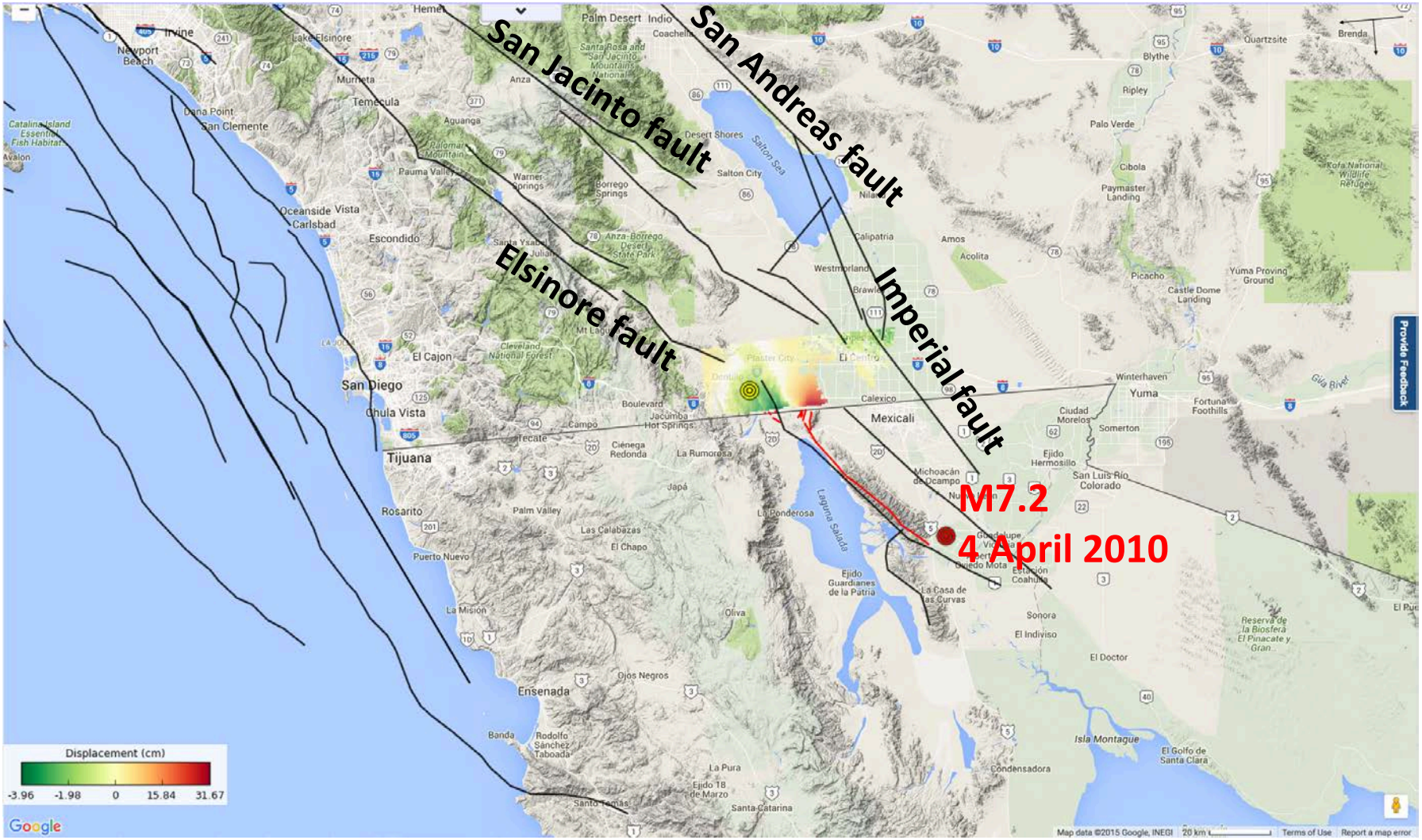
October 21, 2009
April 4, 2010
April 12, 2010
April 13, 2010
June 15, 2010
July 1, 2010
July 7, 2010
September 25, 2010
December 1, 2010
February 18, 2011
May 18, 2011
August 26, 2012
May 23, 2013
February 11, 2014

Setting



UAVSAR Interferogram 21 October 2009 – 13 April 2010

Setting

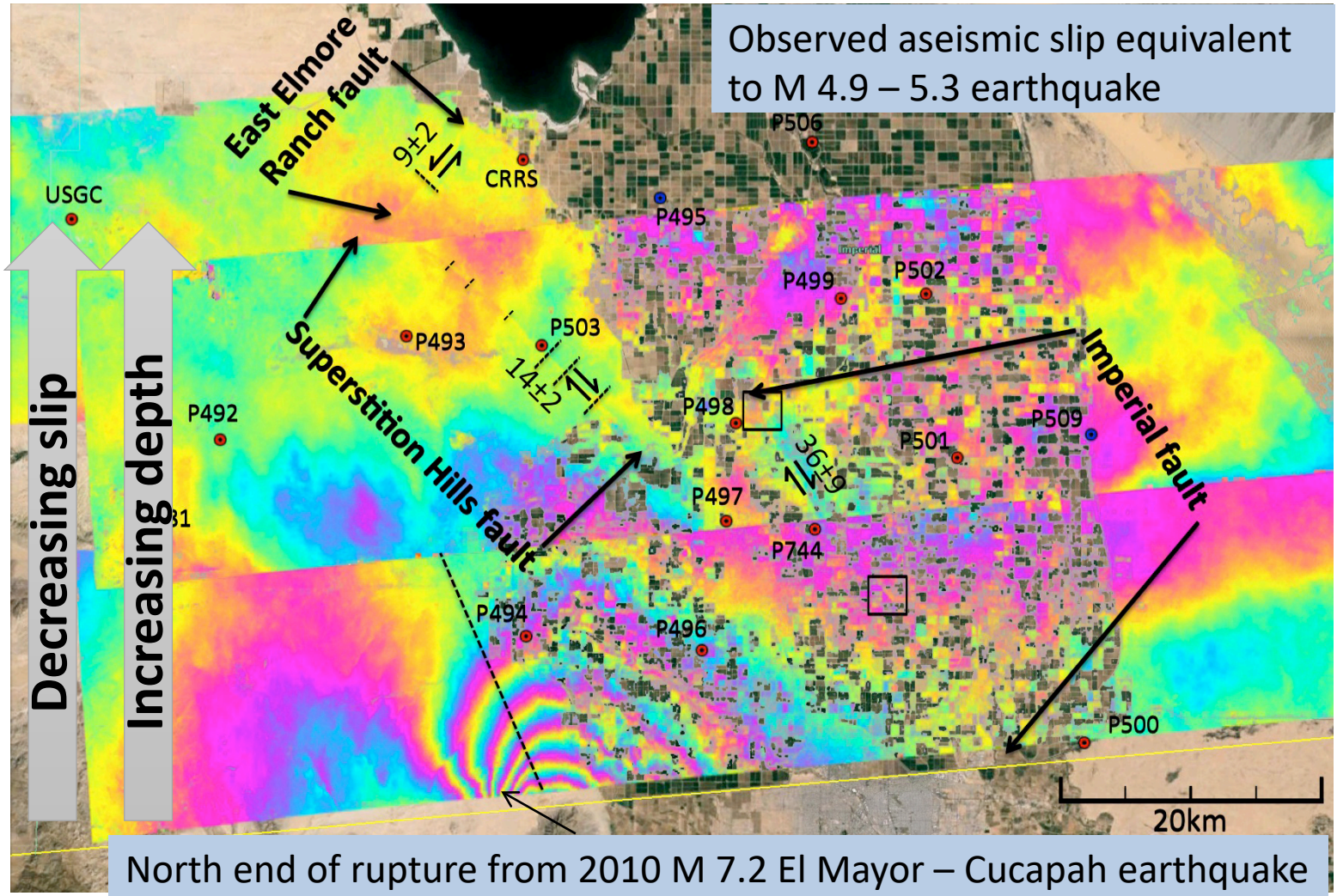


UAVSAR Interferogram 21 October 2009 – 13 April 2010

Coseismic Results

- Coseismic interferogram
  - Pair of images 6 months before and one week following the earthquake
- Overprint of broad deformation in the Salton Trough, just north of the US-Mexico border
  - Consistent with the mainshock rupture
- Additional slip
  - Network of right- and left-lateral conjugate faults branching toward the Elsinore, Superstition Hills, and San Andreas faults
- Major faults showing shallow triggered slip
  - Yuha, Imperial, Superstition Hills, and East Elmore Ranch faults

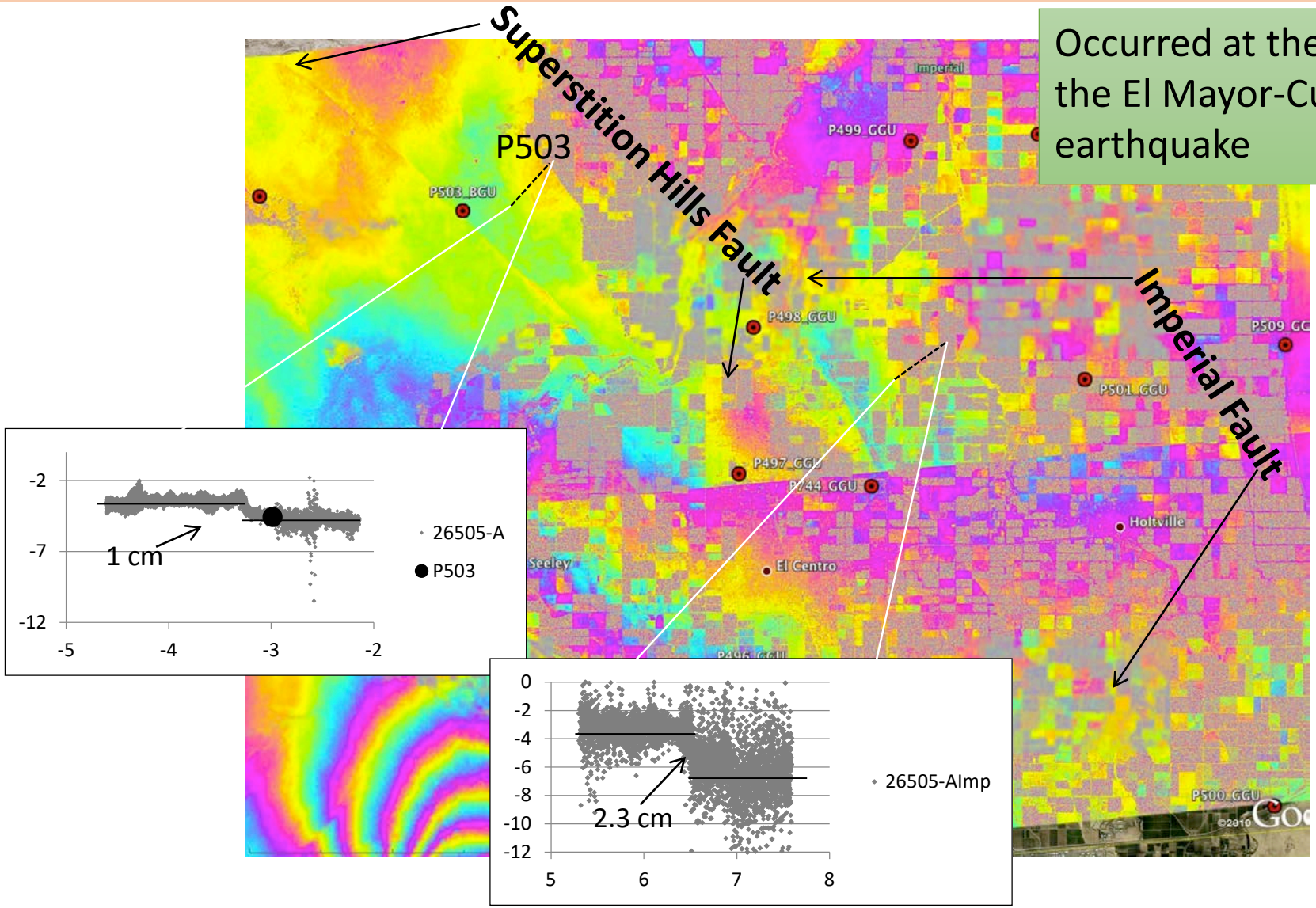
Triggered Fault Slip in the Salton Trough Observed with UAVSAR



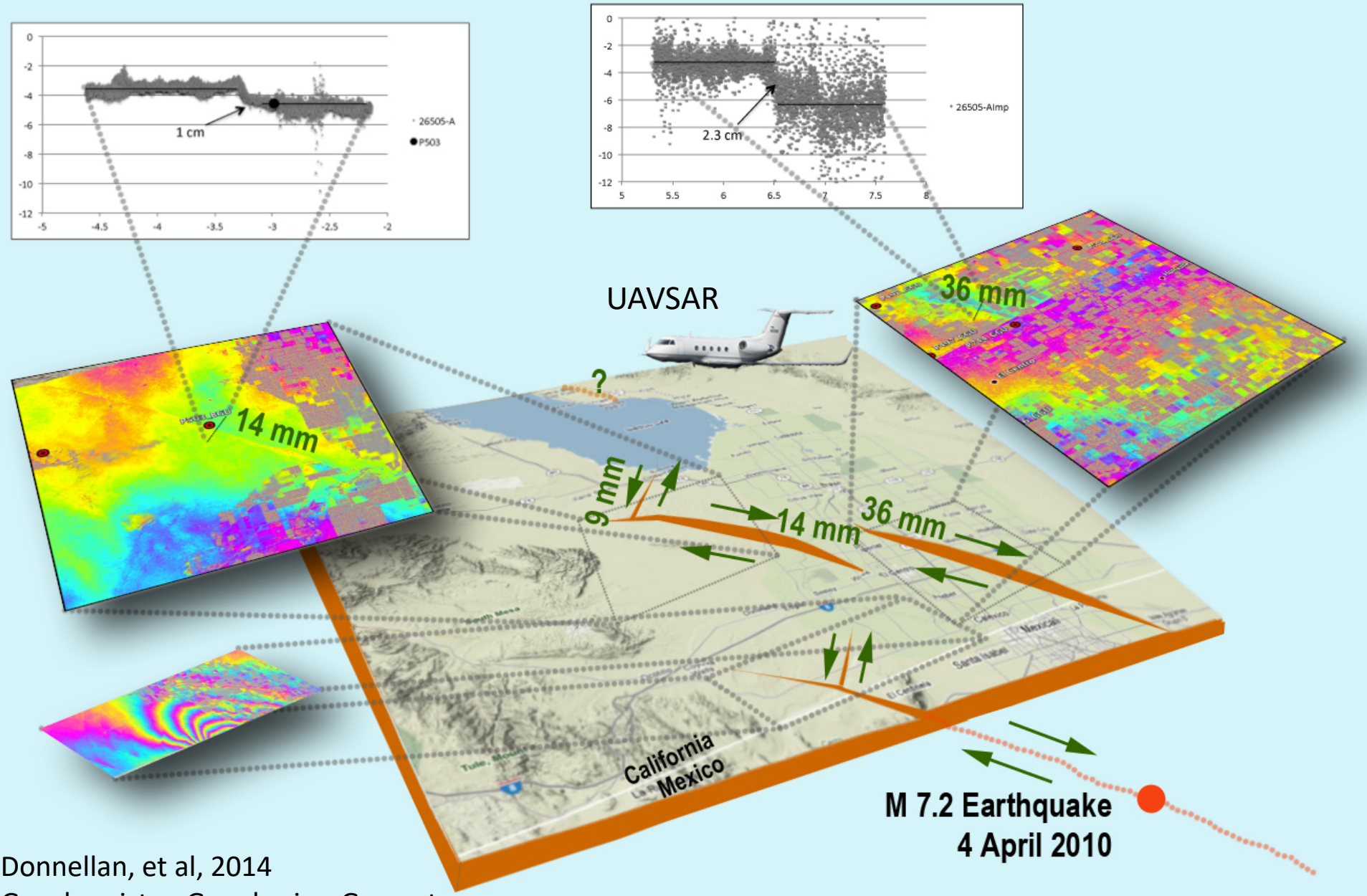
Donnellan et al 2014

Triggered Slip on Faults to the North

Occurred at the time of the El Mayor-Cucapah earthquake



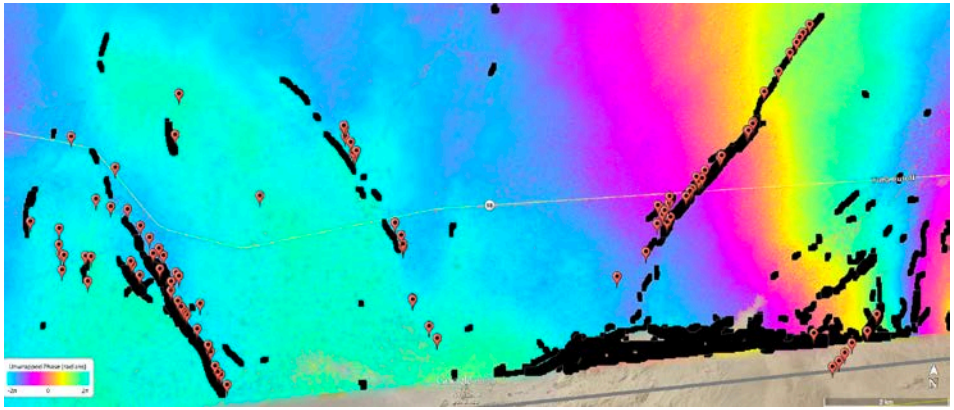
Salton Trough Slip from 2010 M7.2 Earthquake

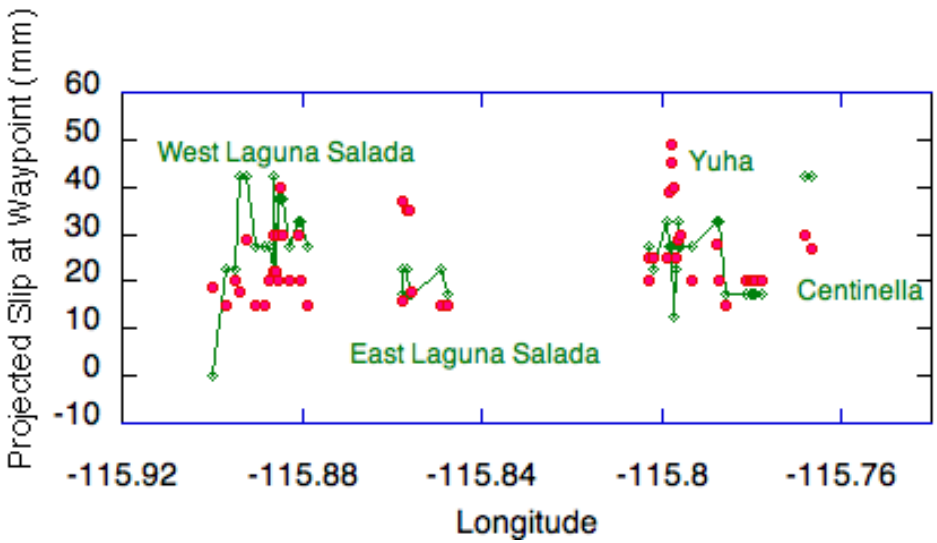


Donnellan, et al, 2014
Geochemistry, Geophysics, Geosystems

Automated Slip Detection

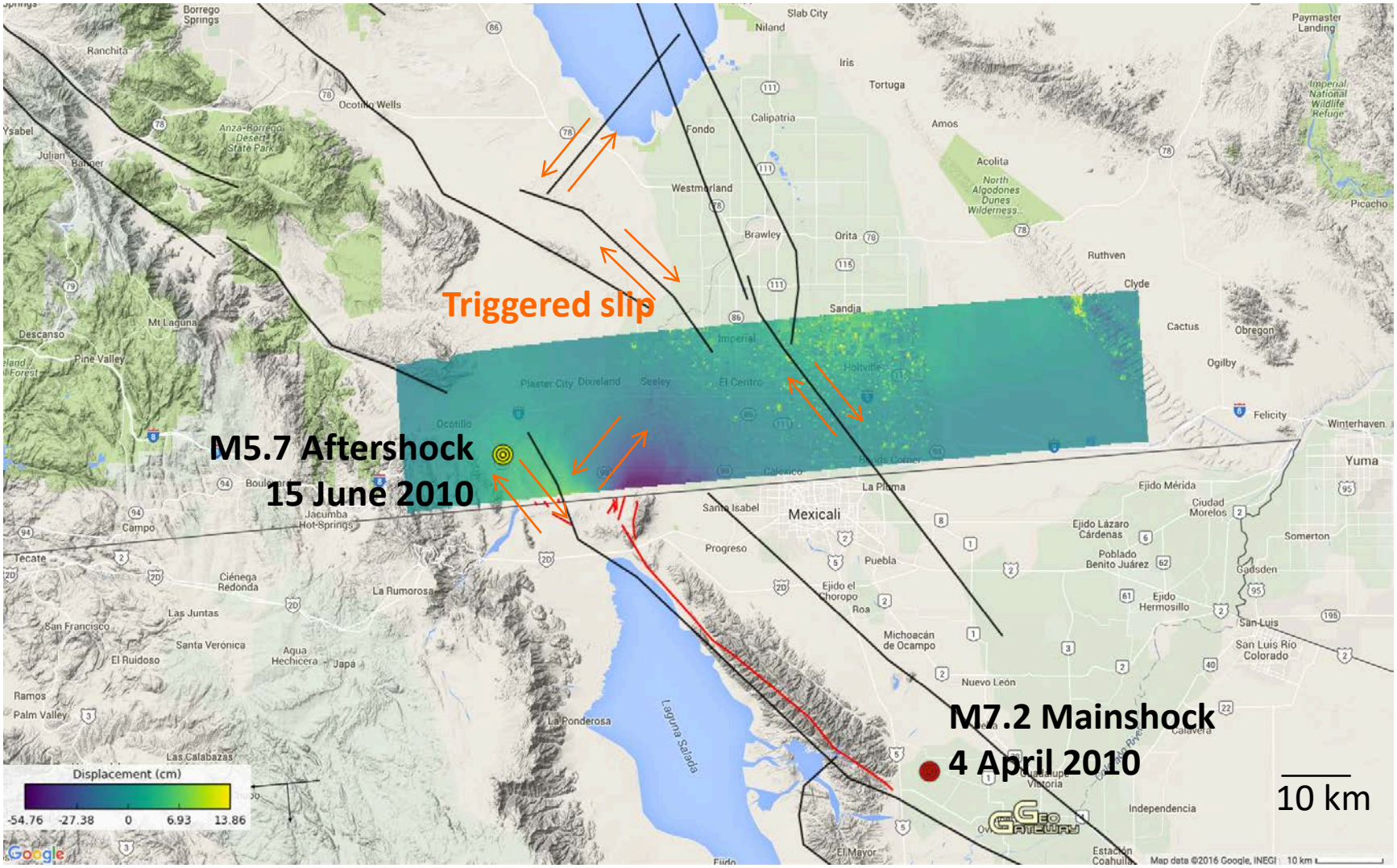
- El Mayor-Cucapah, Rymer et al waypoints displayed with phase edges (surface ruptures)
- EMC, Rymer waypoints with projected slip vs longitude



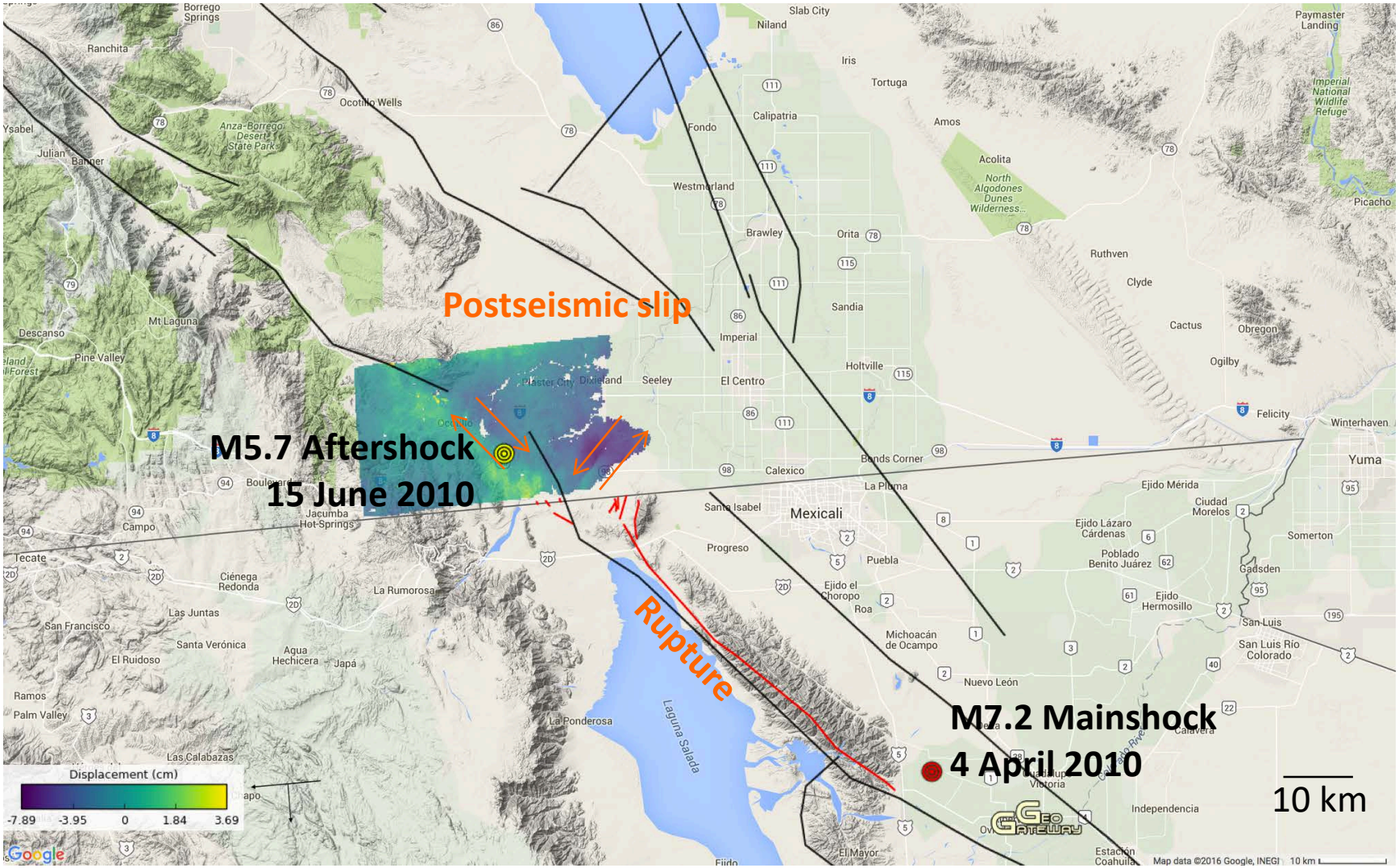


Parker, Glasscoe, Donnellan, Stough, Pierce, Wang, Radar Determination of Fault Slip and Location in Partially Decorrelated Images, *Submitted*

2010 M7.2 El Mayor – Cucapah Earthquake



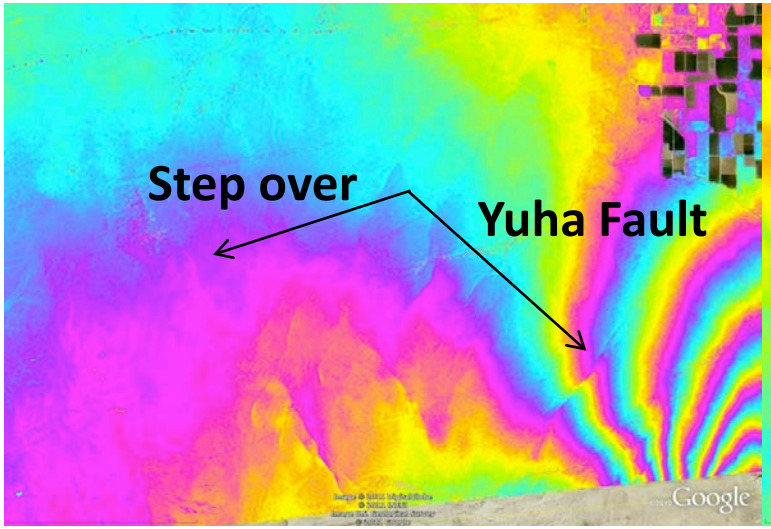
Postseismic



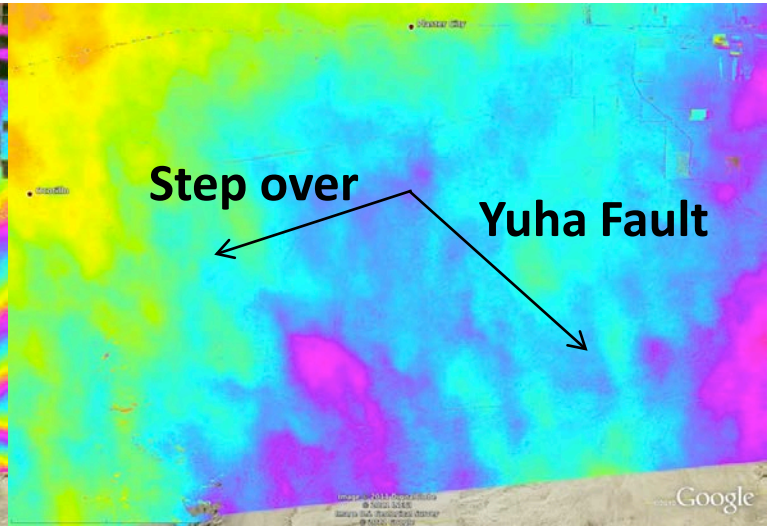
Postseismic Results

- A M5.7 aftershock occurred on 15 June 2010
  - In the gap connecting the El Mayor – Cucapah rupture and the Elsinore fault
- The aftershock produced discernable deformation
  - UAVSAR pair spans the event
  - Images collected 13 April 2010 and 1 July 2010
- Inversions of the data are consistent with coseismic slip from the aftershock

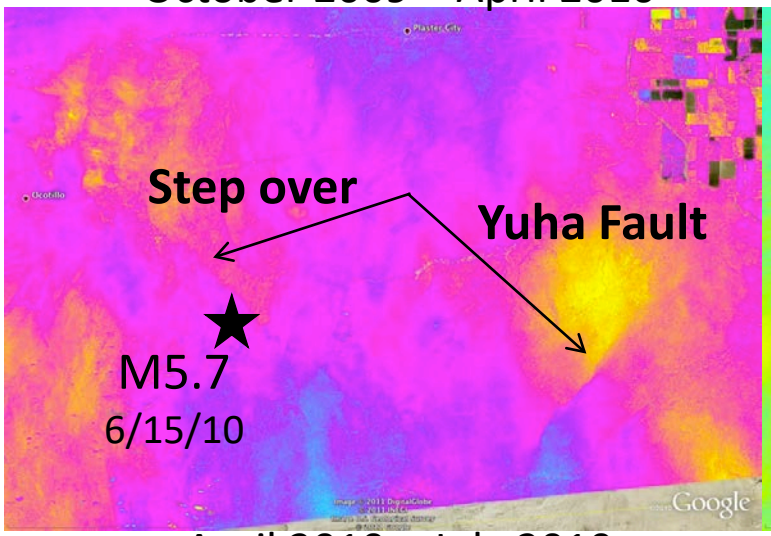
Stepover Develops northwest of the Rupture



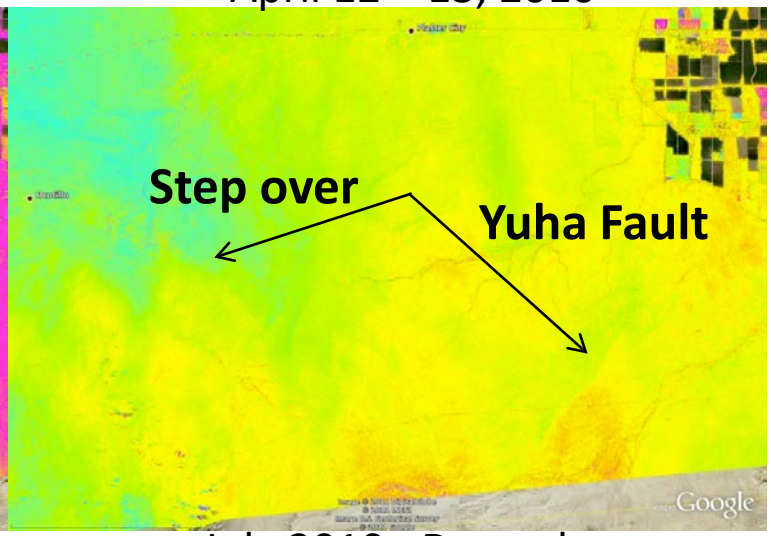
October 2009 – April 2010



April 12 – 13, 2010

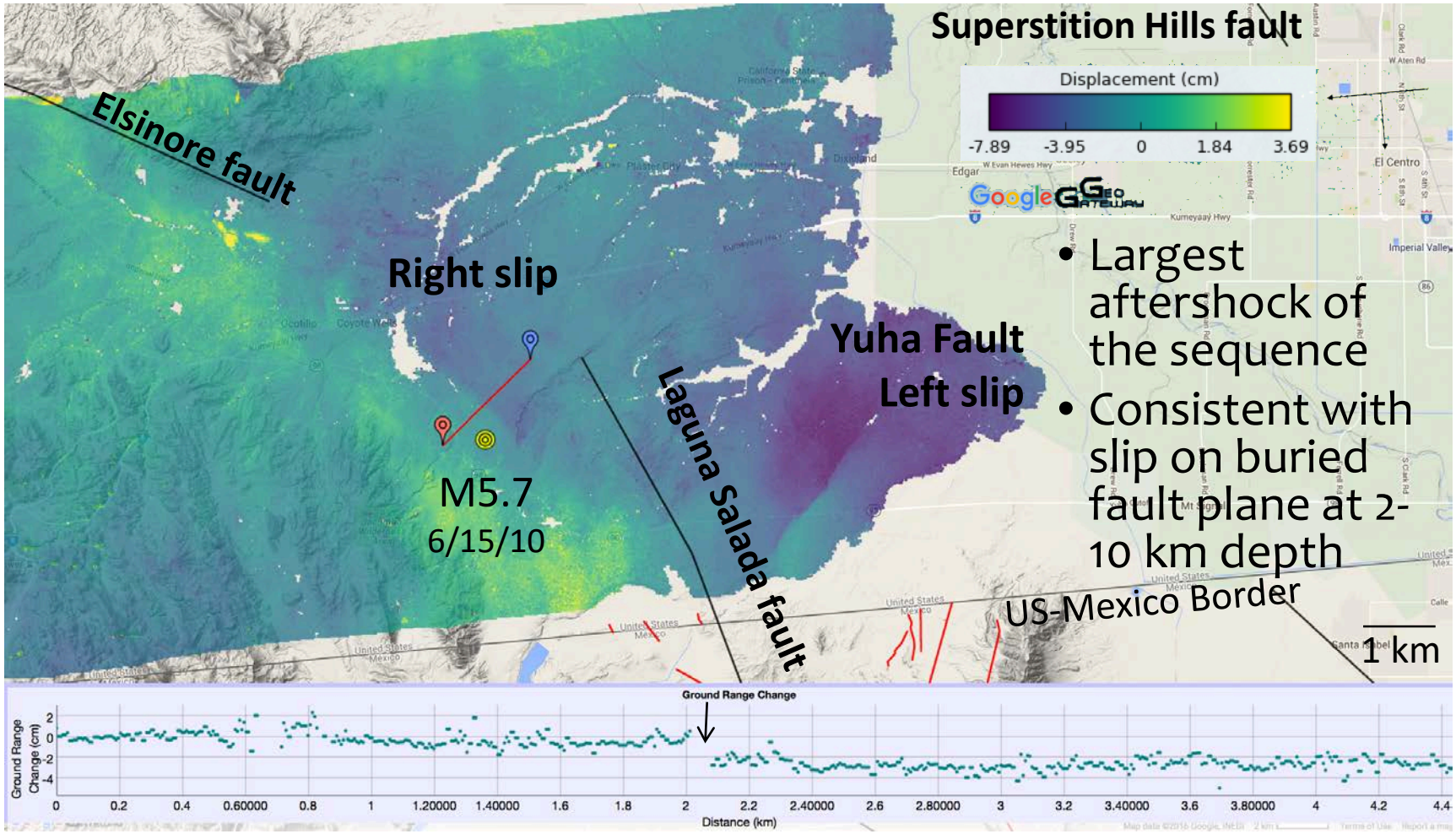


April 2010 – July 2010



July 2010 - December

Additional Slip from M5.7 Aftershock

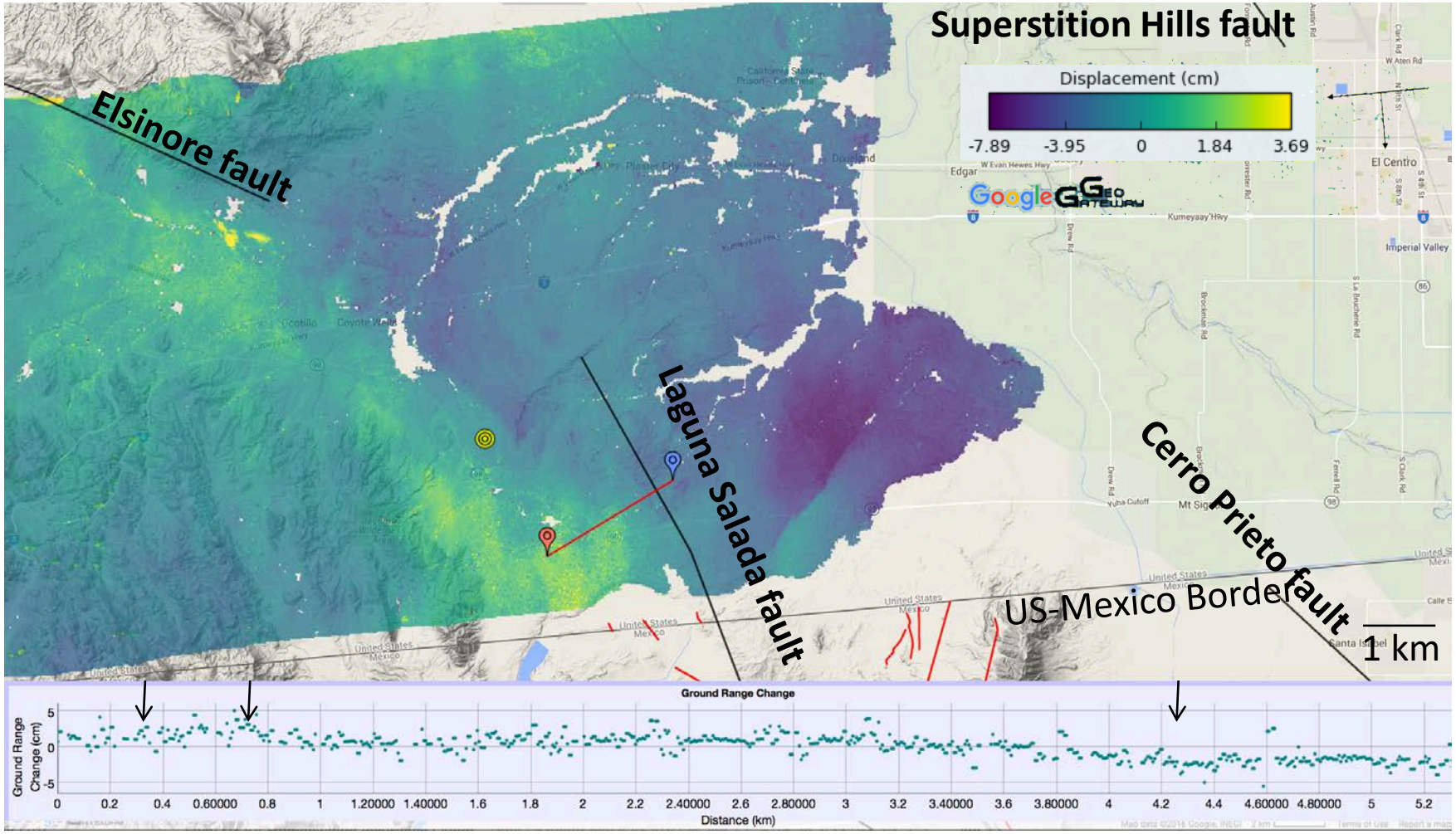


- Largest aftershock of the sequence
- Consistent with slip on buried fault plane at 2-10 km depth

13 April 2010 – 11 February 2014

Structure connects El Mayor – Cucapah rupture and Elsinore Fault

Continued Postseismic Slip



13 April 2010 – 11 February 2014

Aftershock and Postseismic

- Left-lateral conjugate slip is observed on two structures
  - About 2 km long and about 900 m apart
  - Southern end of the aftershock rupture zone
- UAVSAR observations
  - Consistent with afterslip on the main El Mayor – Cucapah rupture plane that continues for at least several months after the earthquake
- Continued slip occurs on a conjugate set of faults located between the mainshock rupture and the Elsinore fault
- The Imperial, Superstition, and East Elmore Ranch faults do not show continuing slip following the main rupture on 4 April 2010

Implications

- Earthquakes such as this can trigger slip on a far reaching networks of faults
  - Shallow slip due to dynamic shaking?
  - Postseismic slip is not observed on most of those faults
- Gap between Laguna Salada fault and El Mayor – Cucapah rupture is filled in to some extent by M5.7 aftershock and continued postseismic deformation
- Is northwesterly deformation from mainshock rupture loading the Elsinore fault or are the two decoupled?