

# **UAVSAR Observations of Slip on Faults in the Salton Trough Associated with the 2010 M 7.2 El Mayor-Cuicapah Earthquake**

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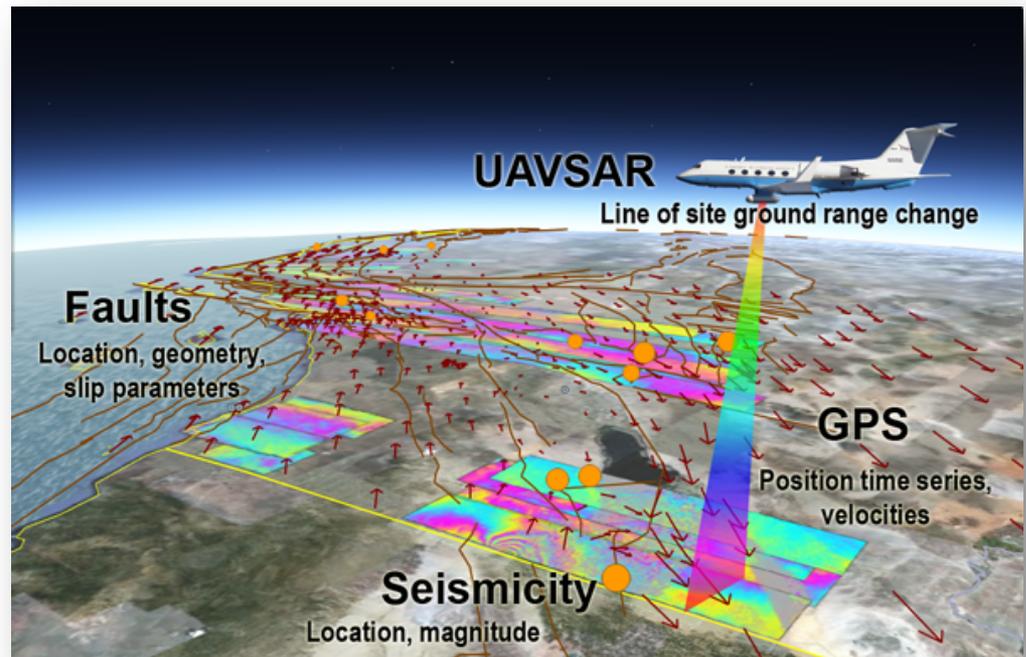
Jet Propulsion Laboratory, California Institute of Technology & University of Southern California

Jay Parker

Jet Propulsion Laboratory, California Institute of Technology

# Context

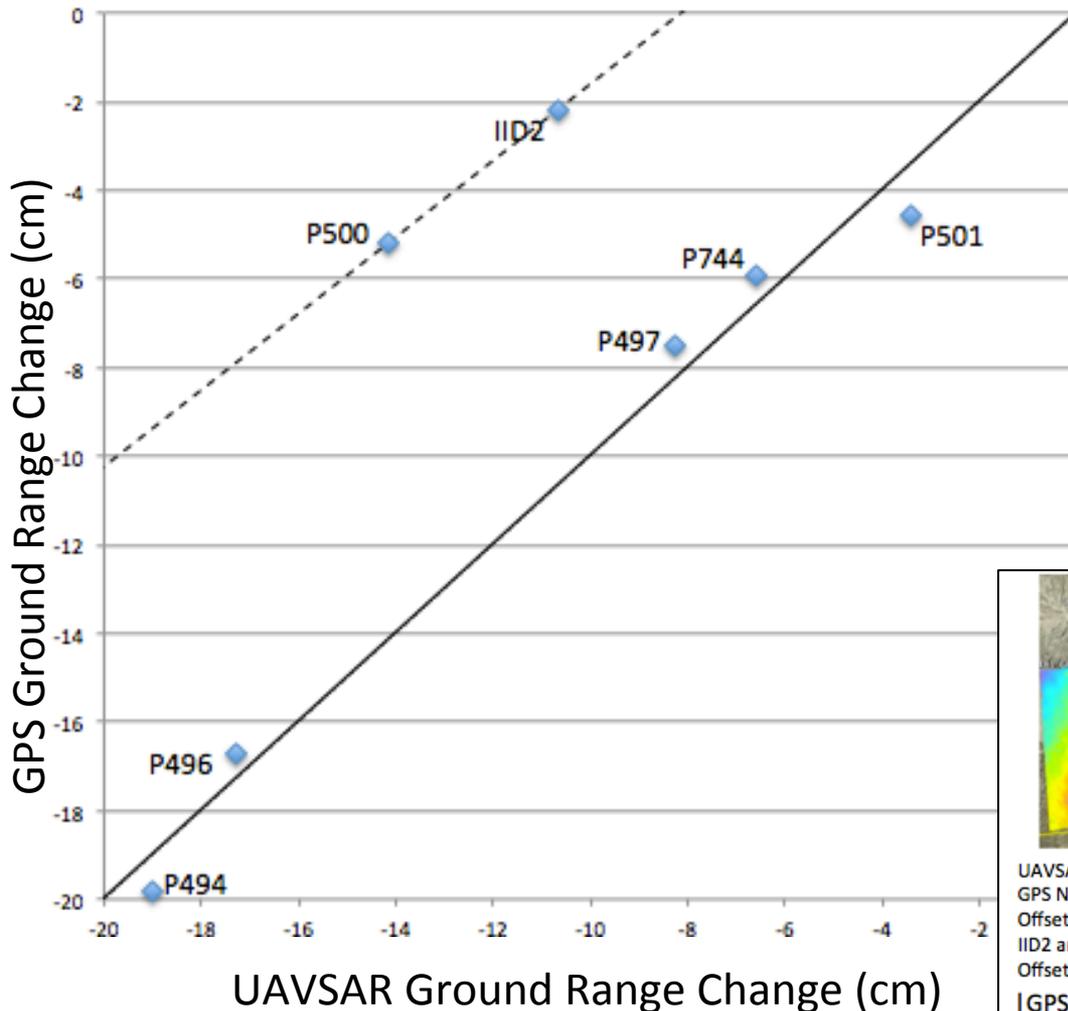
- UAVSAR Repeat Pass Interferometry indicates that the 4 April 2010 M 7.2 El Mayor-Cucapah earthquake triggered slip on several faults north of the mainshock rupture
- UAVSAR is an L-band (24 cm wavelength) airborne synthetic aperture radar platform
  - Repeat pass interferometry products provide ground changes in a line of site direction to/from the instrument on the aircraft
  - Flown on a Gulfstream III
  - Color cycle is 12 cm
- Observations of the Salton Trough were collected
  - October 20-21, 2009
  - April 12-13, 2010
  - July 2010
  - September 2010
  - December 2010
- Repeat Pass Interferometry (RPI) products indicate slip events on several faults north of the main rupture
- GPS and seismicity confirm the magnitude and timing of the slip events



# UAVSAR Repeat Pass Interferometry Quality

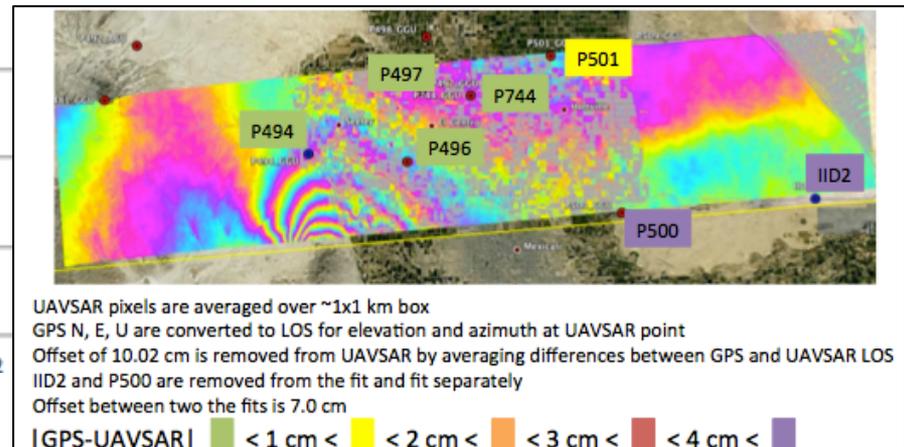
## UAVSAR Correlations with GPS

26501 Coseismic: 10/21/09 - 4/13/10



- UAVSAR is locally good
  - < 1 cm ground range change scatter
- Suffers regionally from large error sources
  - Troposphere
  - Aircraft flight path estimation
  - Up to 10 cm errors

- ◆ Stations
- ..... Corr = 1
- Corr=0.998
- - - Corr=0.861

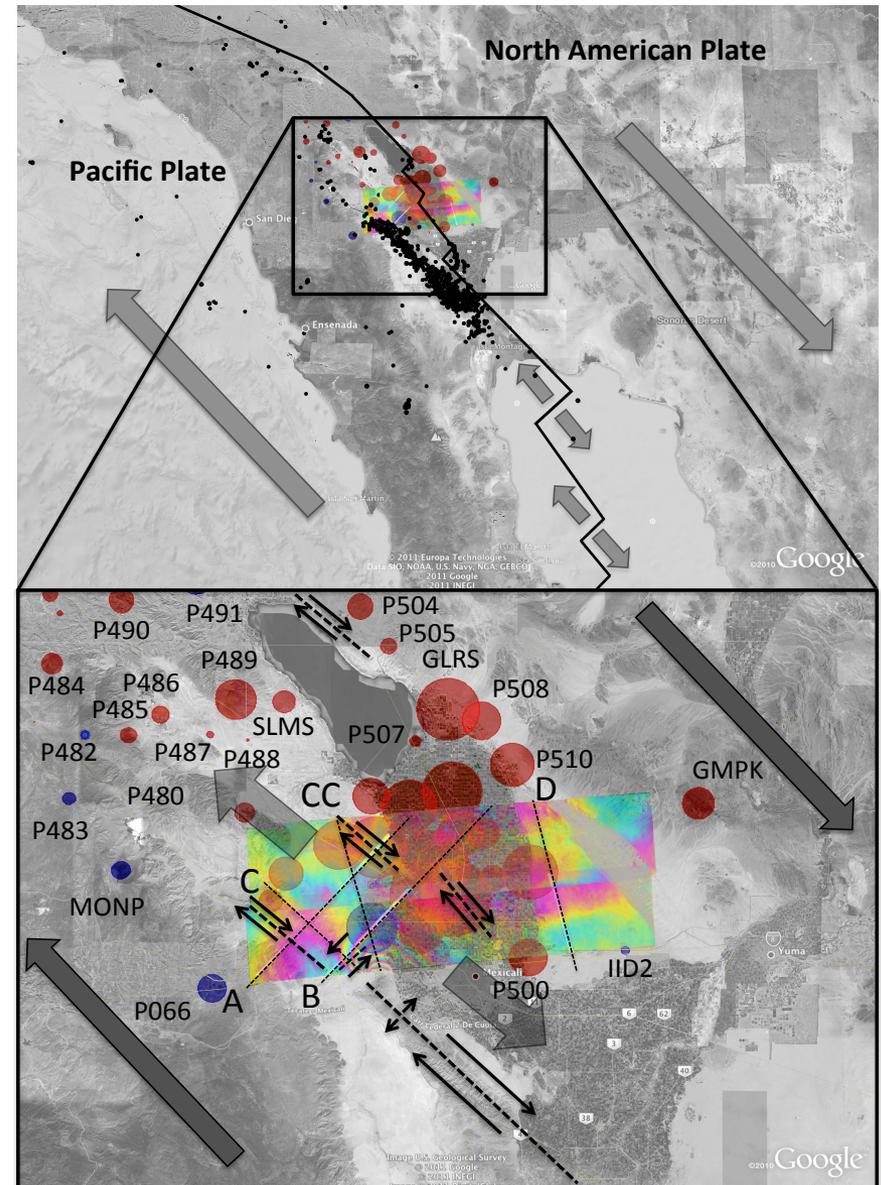


# M 7.2 El Mayor Cucapah Earthquake

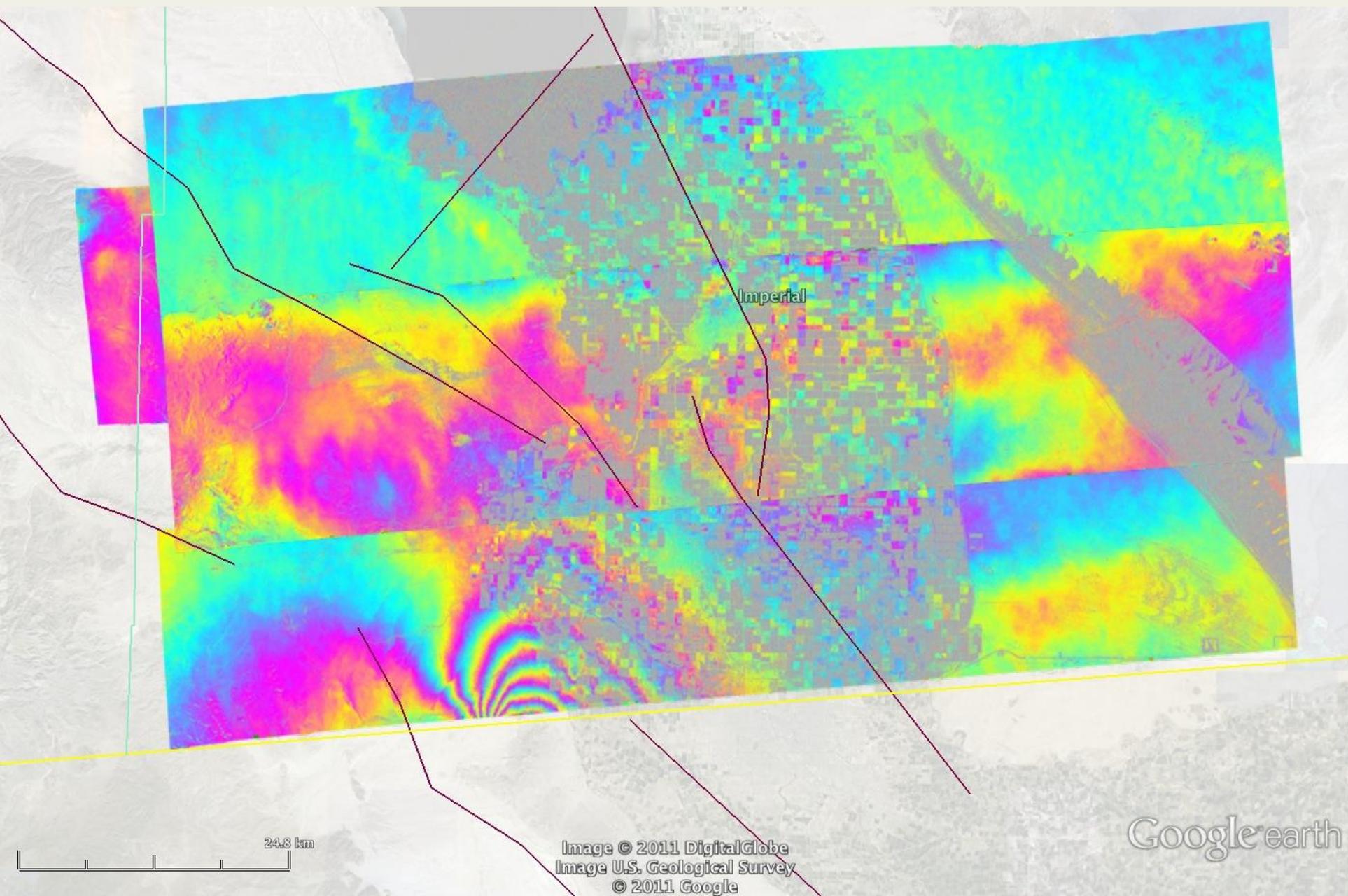
## First UAVSAR Image of an Earthquake

April 5, 2010

- Creep was observed on several faults north of the rupture
  - Yuha fault
  - Imperial fault
  - Superstition Hills fault
- Right lateral deformation develops between the rupture and the Elsinore fault
- Postseismic data reveal fault buried at 2 km responsible for the M 5.8 aftershock on 15 June, 2010



# Regional View



# Regional View

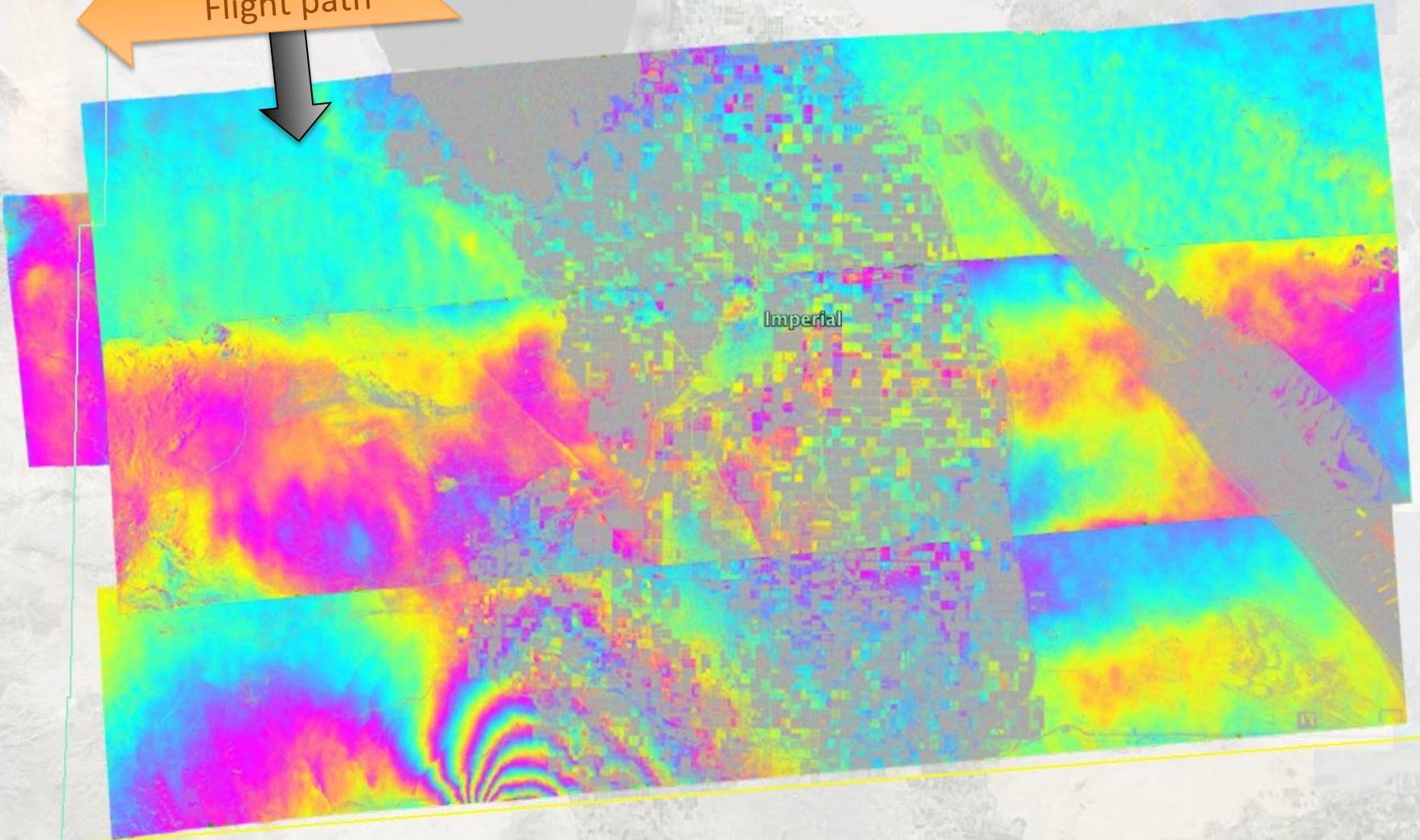
Flight path

Imperial

24.8 km

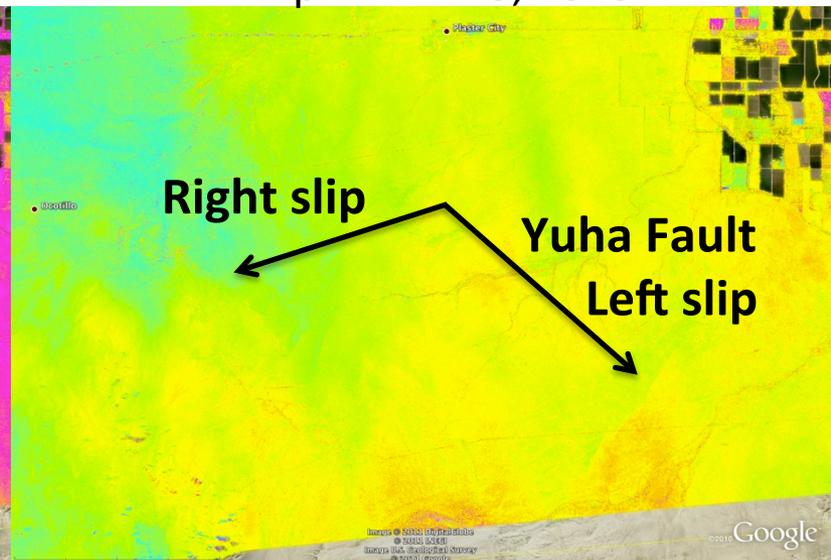
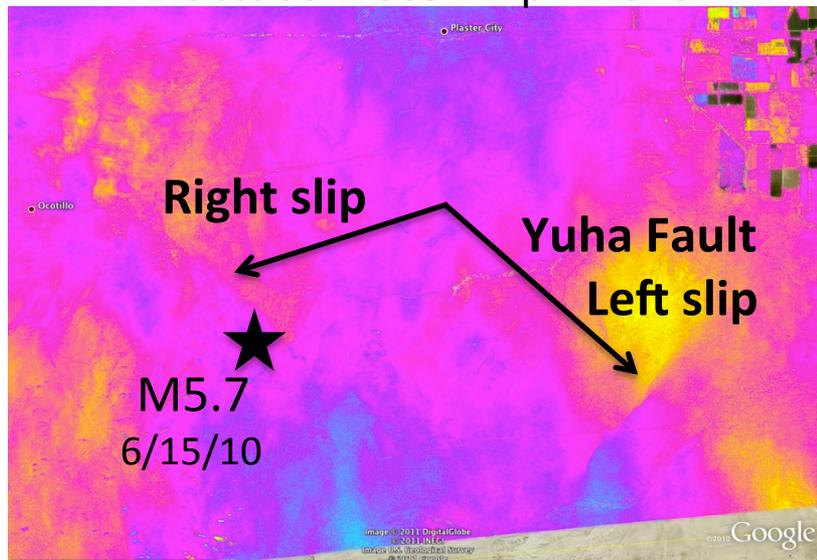
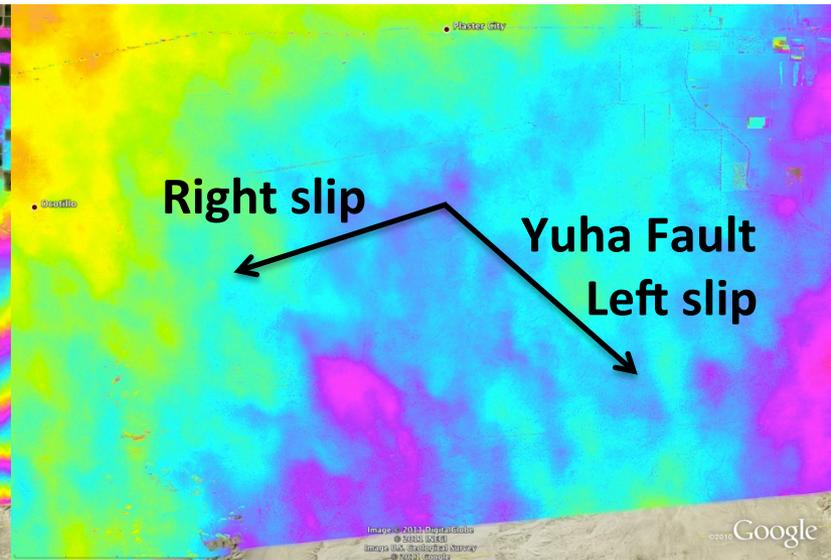
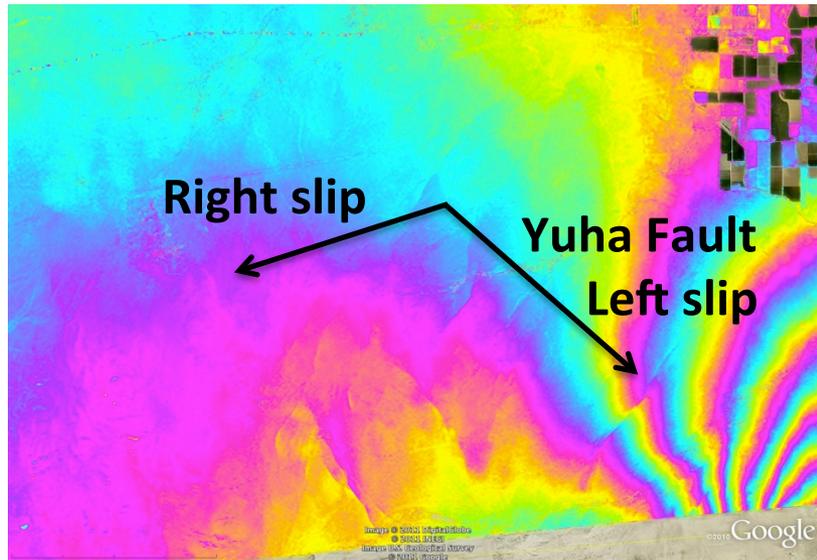
Image © 2011 DigitalGlobe  
Image U.S. Geological Survey  
© 2011 Google

Google earth

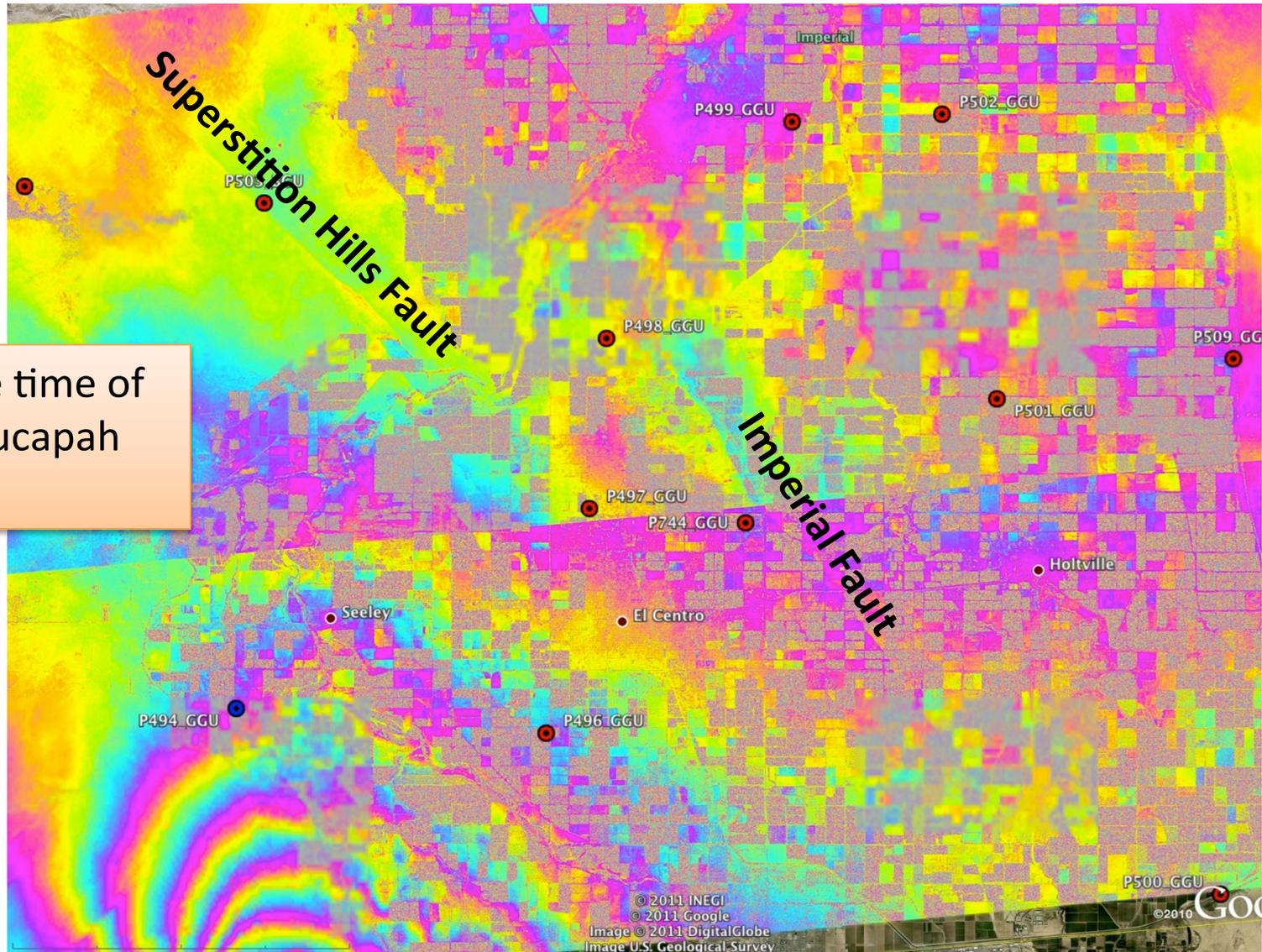


- The left-lateral conjugate Yuha fault slipped at the north of the rupture during the event, but continued to slip for several months following the earthquake
- The UAVSAR observations show a lineation indicating that the M 5.7 aftershock that occurred on 15 June 2010 produced right slip on a fault patch buried from 2-10 km

# Right Slip Develops North of the Rupture

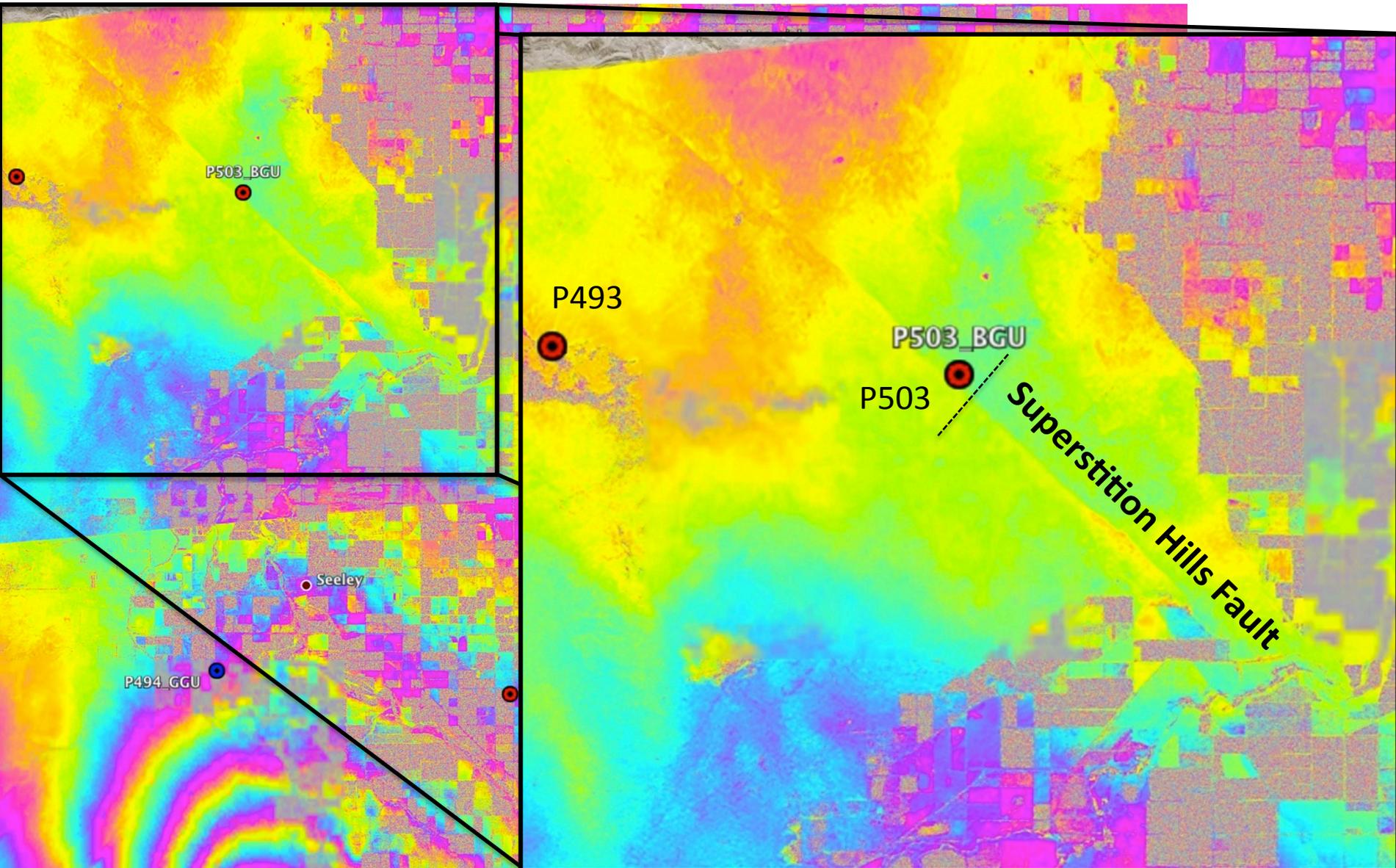


# Creep on the Imperial and Superstition Hills Faults



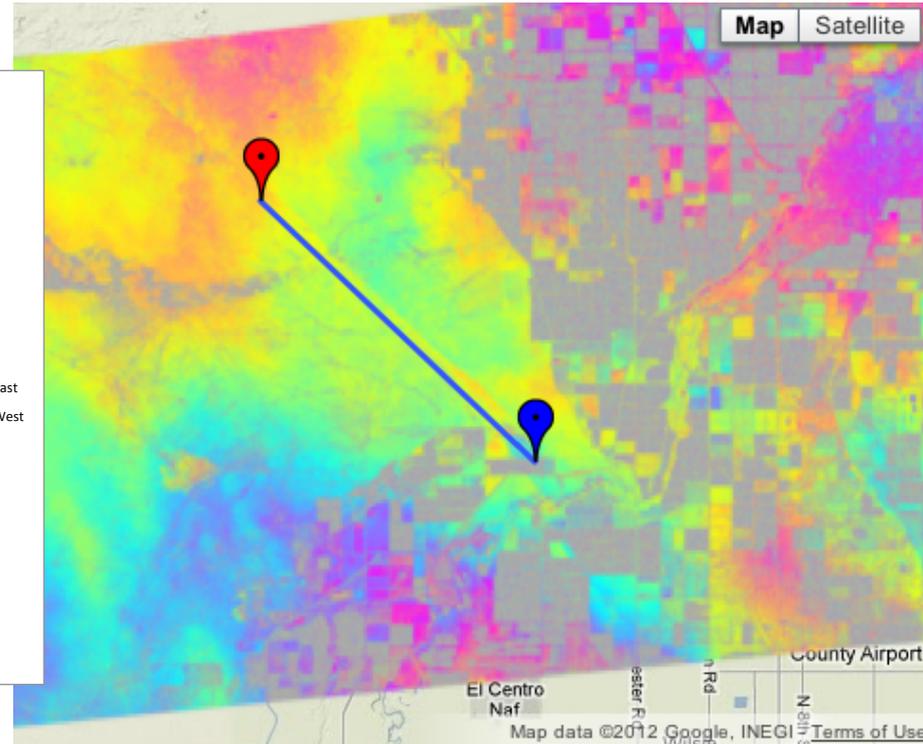
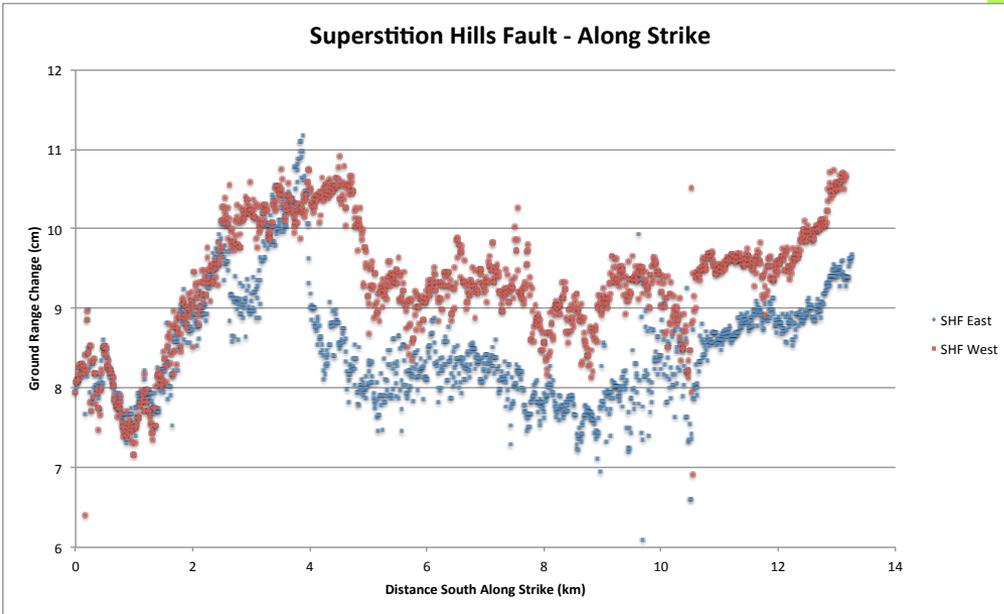
Occurred at the time of the El Mayor-Cucapah earthquake

# Superstition Hills fault



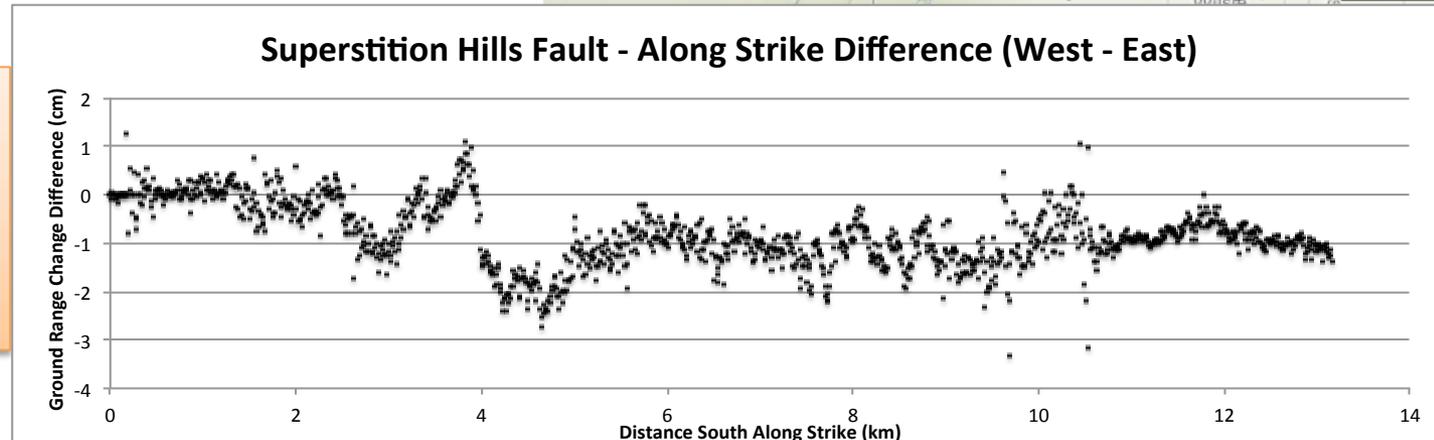
# Superstition Hills Fault Along Strike Difference

Superstition Hills Fault - Along Strike



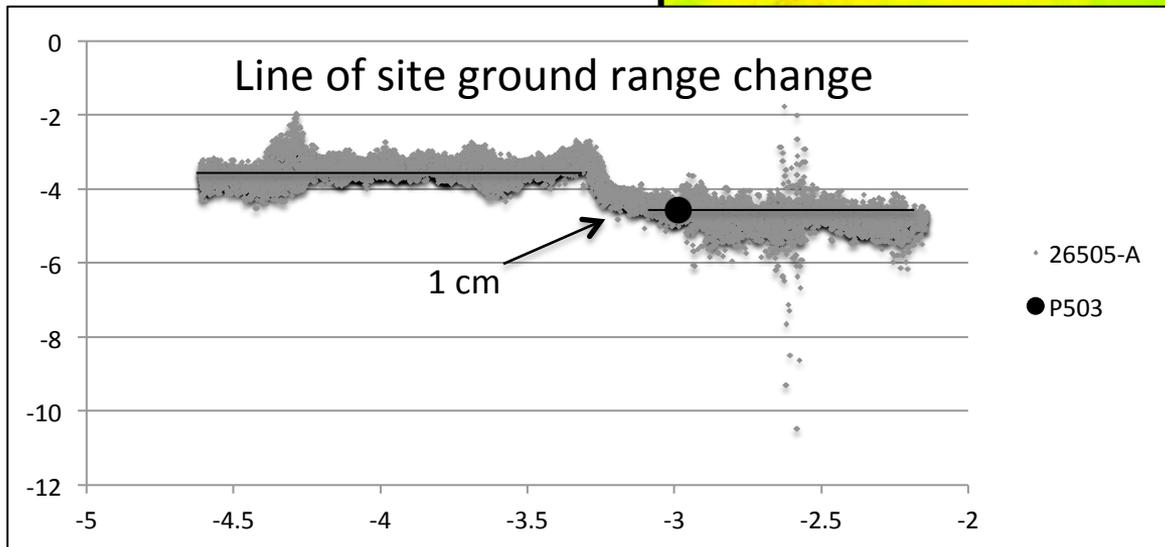
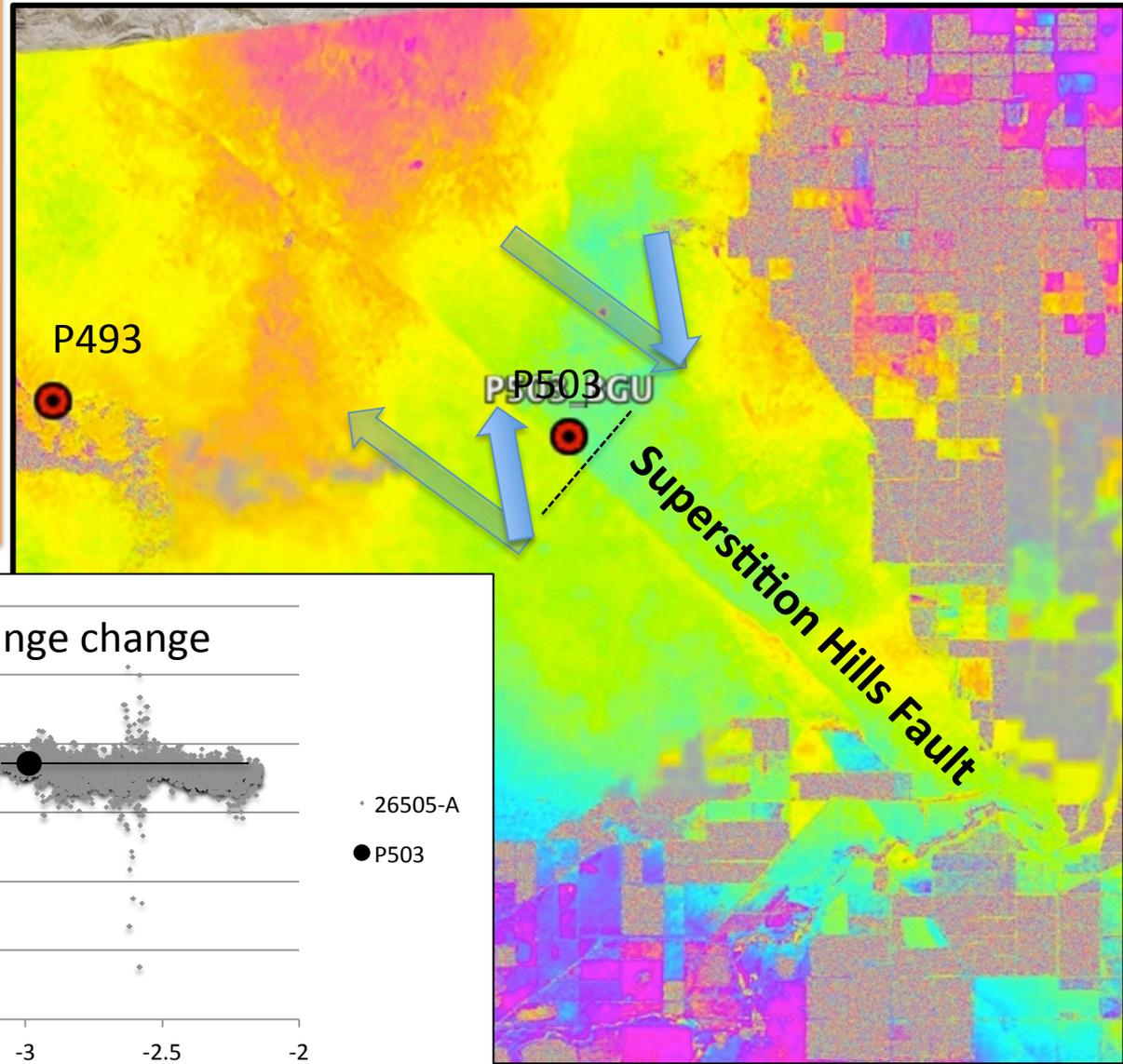
1 cm of creep occurred along a ~10 km segment of the fault

Superstition Hills Fault - Along Strike Difference (West - East)

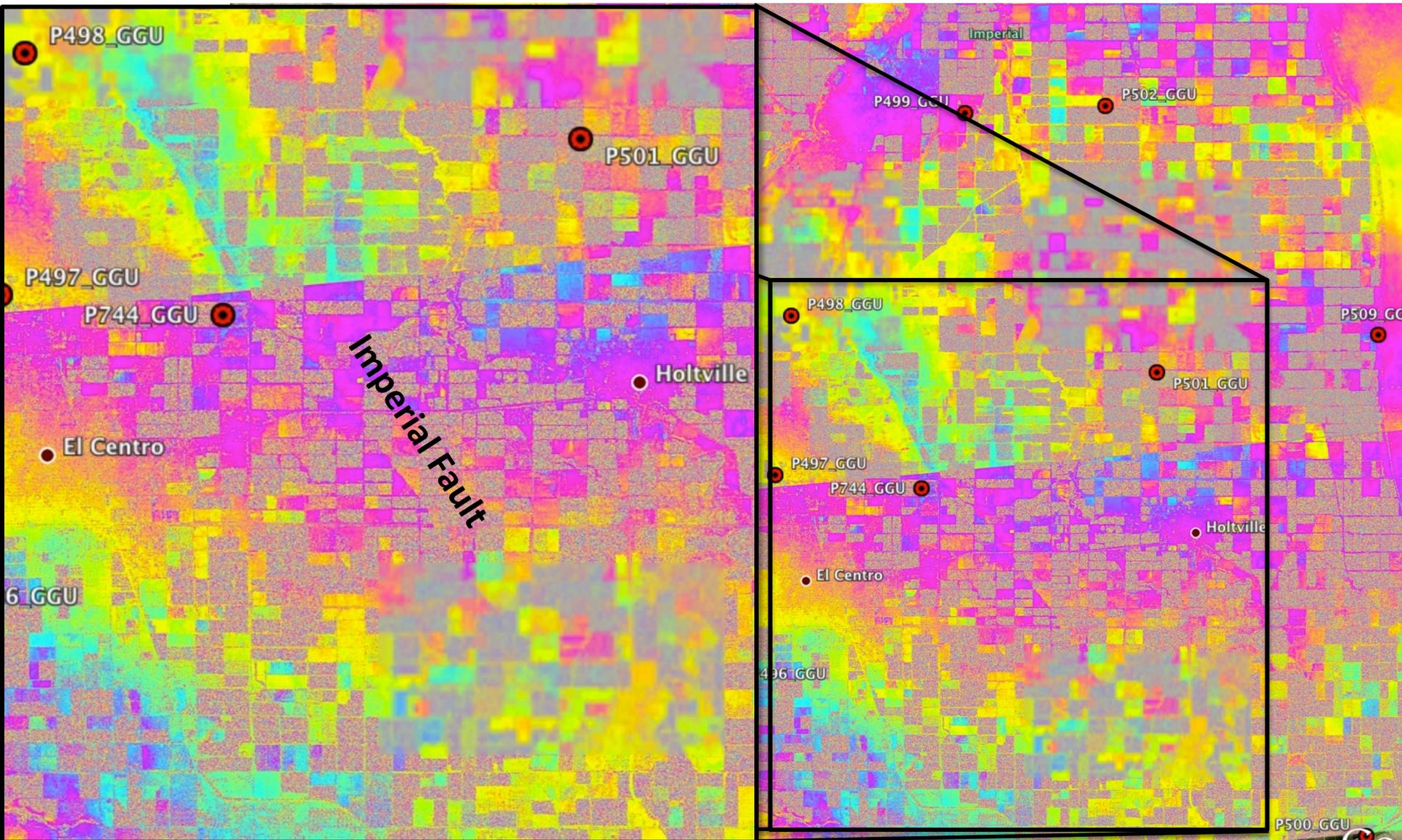


# Line of Site Range Changes

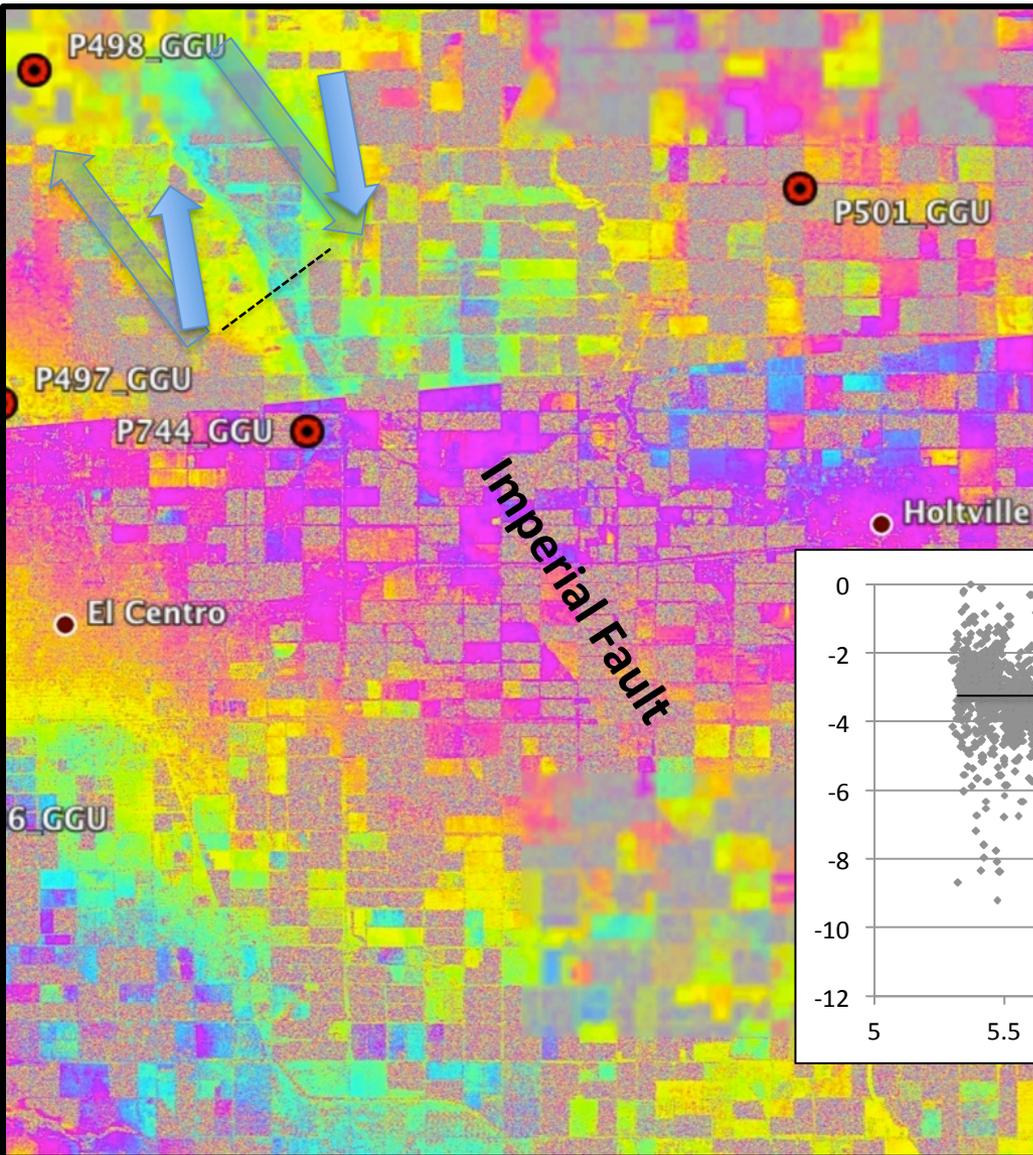
- 1 cm relative displacement of ground to instrument (which is airborne)
  - Consistent with GPS difference between stations
  - Assume slip is
    - Horizontal
    - Fault parallel
- ⇒ 2 cm creep on the Superstition Hills fault



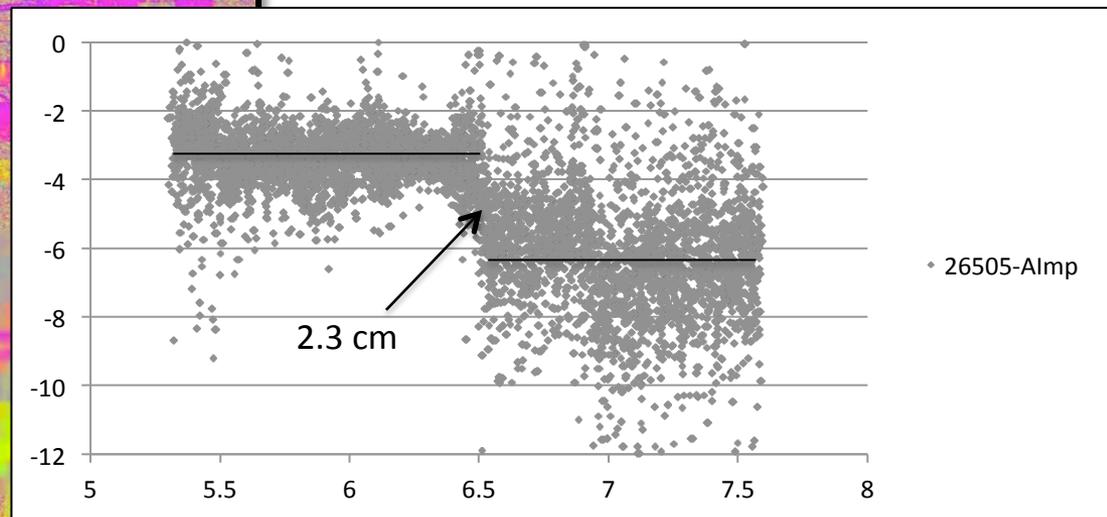
# Imperial fault



# Imperial fault

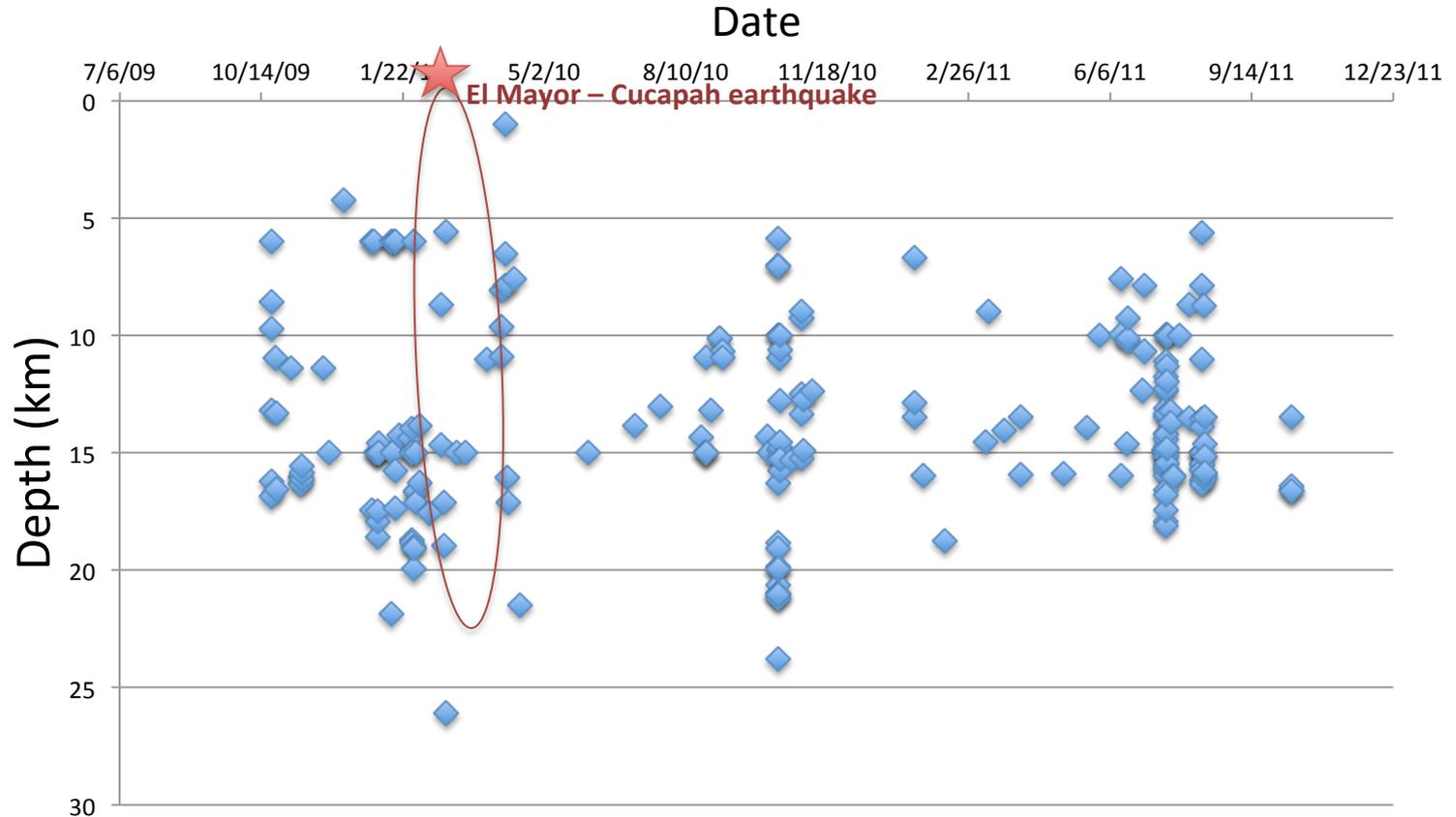


- 2.3 cm relative displacement of ground to instrument (which is airborne)
  - Assume slip is
    - Horizontal
    - Fault parallel
- ⇒ 4.3 cm creep on the Imperial fault along a 25 km segment



# Imperial Fault Seismicity

Cluster on specific days with one such cluster of earthquakes occurring on 4 April 2010, the day of the mainshock



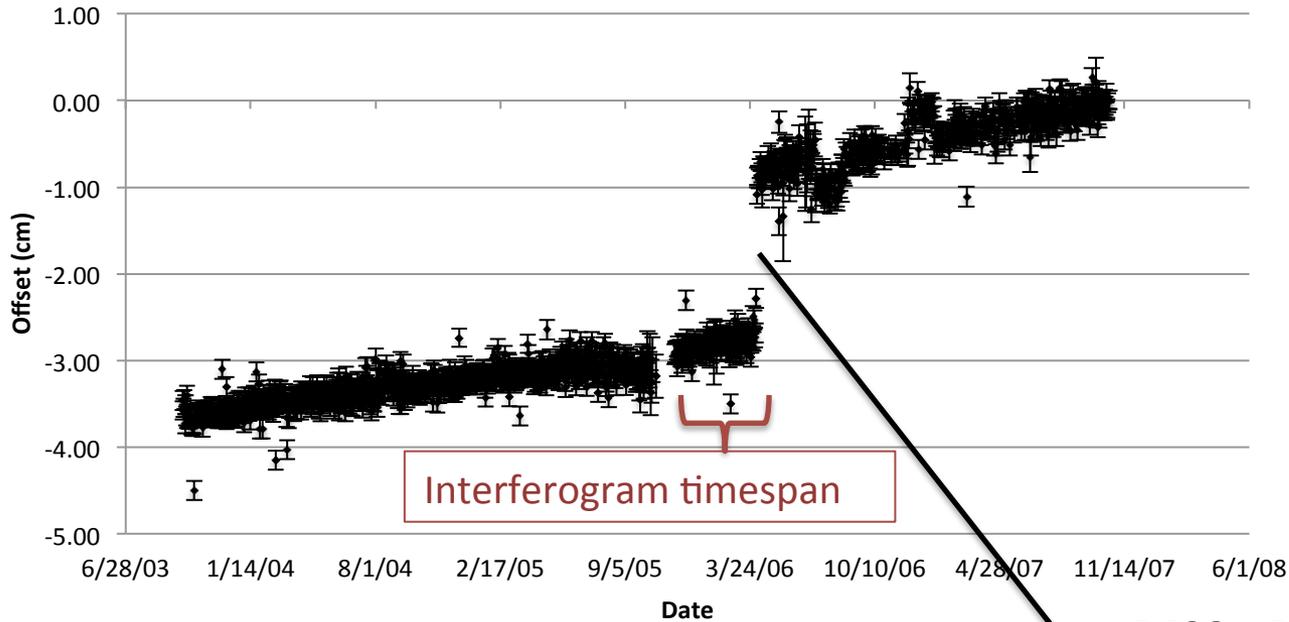
Events range from M 1.4 – 2.5 at depths of 0–25 km

Average M 1.9

Equivalent to moment release from 4.3 cm slip on 25x25 m asperities

# Creep Event Occurred at Time of Earthquake

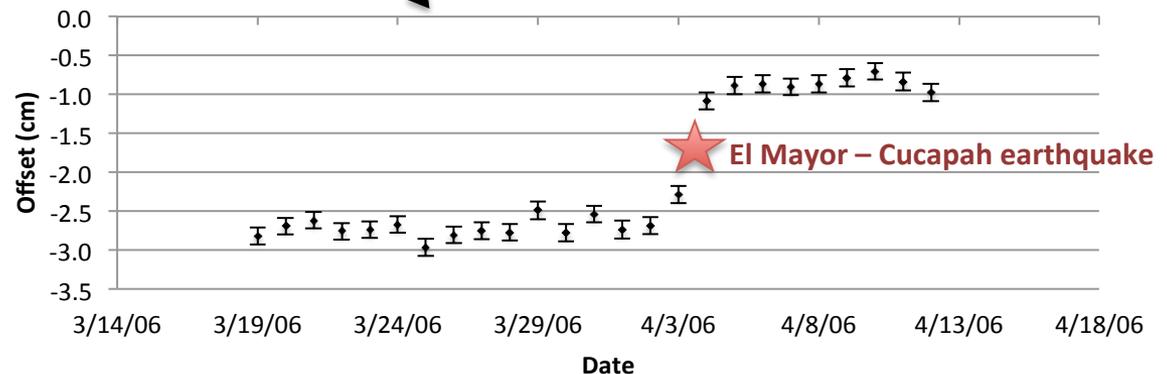
## P493 - P503 Fault Parallel Component



GPS time series  
Difference between stations  
near Superstition Hills fault  
are differenced and  
projected onto the fault

⇒  $1.8 \pm 0.3$  cm offset  
⇒ Comparable to UAVSAR

## P493 - P503



# UAVSAR Analysis Tool

- QuakeSim UAVSAR line of site tool
- Integrates science and end-user workflow
- Goal is to make NASA remotely sensed crustal deformation observations available and interpretable to a wide range of scientists and end users

Interferogram Map Selection  
Now click the map to plot a line. Move the end points to set the plot.

Sampling Distance (meters): 10  
Plot Method:  native  Average  
Averaging Radius: 10  
Toggle Fault Display:

|  |                          |                          |
|--|--------------------------|--------------------------|
| SanAnd_26501_09083-010_10028-000_0174d_s01_L090HH_01 | 13-Apr-2010 17:39:51 UTC | 21-Oct-2009 00:21:20 UTC |
| SanAnd_08504_10028-001_10057-101_0079d_s01_L090HH_01 | 13-Apr-2010 17:56:56 UTC | 01-Jul-2010 17:14:01 UTC |
| SanAnd_26501_10028-000_10057-100_0079d_s01_L090HH_01 | 13-Apr-2010 17:39:51 UTC | 01-Jul-2010 16:42:33 UTC |
| SanAnd_26501_10027-001_10028-000_0001d_s01_L090HH_01 | 12-Apr-2010 21:23:06 UTC | 13-Apr-2010 17:39:51 UTC |
| SanAnd_26501_10057-100_10084-000_0153d_s01_L090HH_01 | 01-Jul-2010 16:42:33 UTC | 01-Dec-2010 18:31:52 UTC |
| SanAnd_26501_09083-010_10028-000_0174d_s01_L090HH_02 | 21-Oct-2009 00:21:20 UTC | 13-Apr-2010 17:39:51 UTC |
| SanAnd_26501_09083-010_10028-000_0174d_s01_L090HH_C2 | 21-Oct-2009 00:21:20 UTC | 13-Apr-2010 17:39:51 UTC |

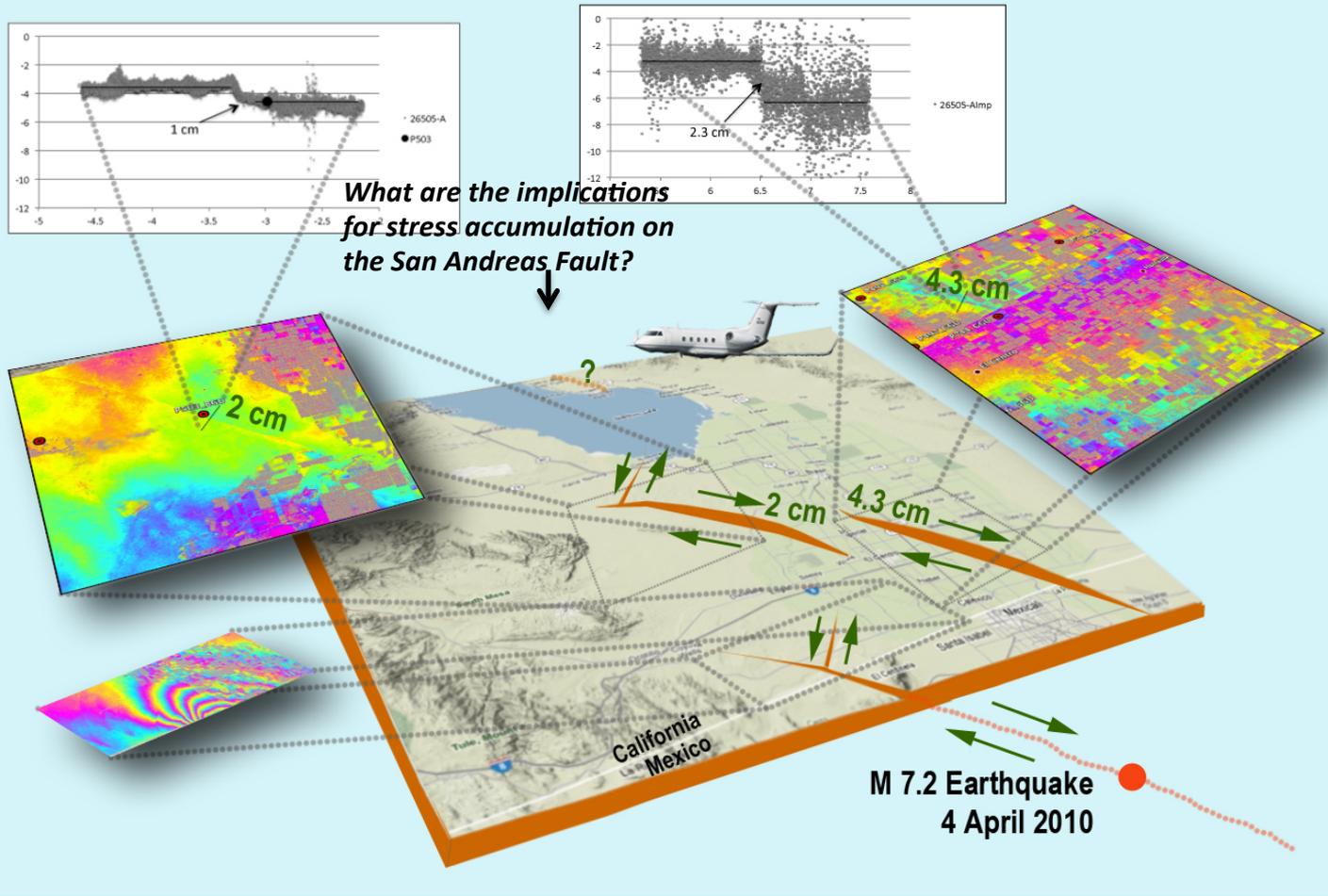
Go to download page for selected data set

Lat, Lon: 32.76884, -115.76101    Lat, Lon: 32.65940, -115.69727    Azimuth: 145.3°

InSAR Line of Sight Values  
InSAR Height Values

Download LOS Data    Download HGT Data

# Summary



- UAVSAR identified creep on several faults north of the main rupture
  - Yuha fault
  - Superstition Hills fault
  - Imperial fault
- GPS observations confirm the results, but stations were too sparse to capture details of the events
- UAVSAR, GPS, seismicity, and fault knowledge were needed for this analysis