National Aeronautics and Space Administration

Integrating UAVSAR deformation data with faults and mapping elements through a GIS database server

Jay Parker, Andrea Donnellan, Margaret Glasscoe,

Jet Propulsion Laboratory/California Institute of Technology

Geoffrey Fox, Marlon Pierce, Jun Wang, and Yu Ma

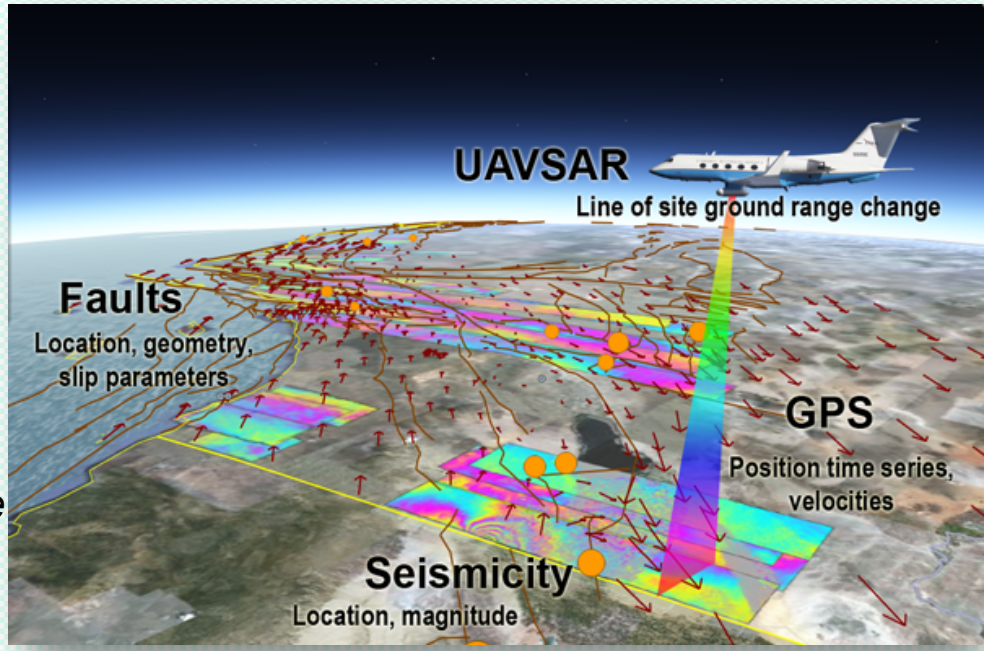
Indiana University

QuakeSim is . . .

QUAKESIM Understanding Earthquake Processes

- . . .developing a solid Earth science framework
  - for modeling earthquake and tectonic processes.

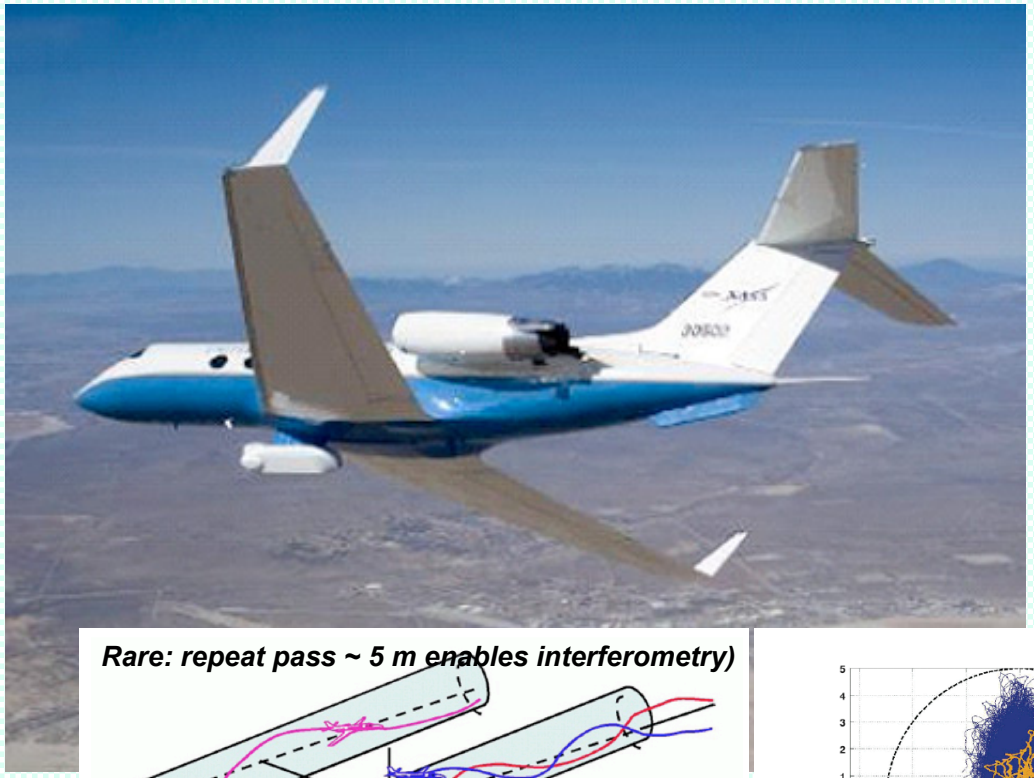
- . . . sponsored by the NASA Earth Science Technology Office (ESTO)
- . . . with core developers at
  - *Brown University*
  - *Indiana University*
  - *NASA Ames Research Center*
  - *NASA Jet Propulsion Laboratory*
  - *University of California Davis*
  - *University of California Irvine*
  - *University of Southern California*
- . . . and the participation of
  - *California State University Northridge*
  - *Harvey Mudd College*
  - *Los Alamos National Laboratory*



UAVSAR Pod On G3

QUAKESIM Understanding Earthquake Processes

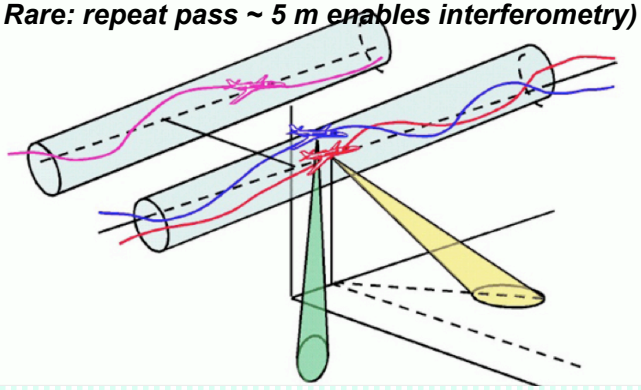
Gulfstream 3 piloted aircraft



- Powerful new instrument for studying earth processes
- Repeat visit→ landscape change image
- High-definition: 7 m pixel size:
- >120 Megapixel images
- Sensitive: sees fault slip at 1 cm

Adapting to Global Hawk unpiloted aerial vehicle (UAV)

Rare: repeat pass ~ 5 m enables interferometry)



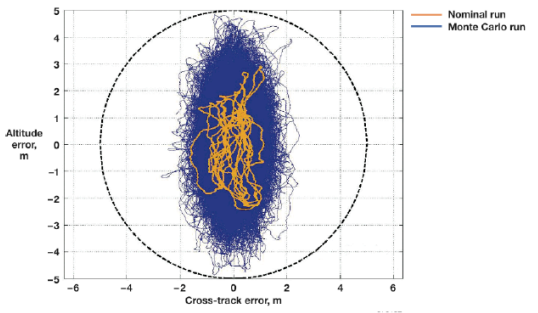
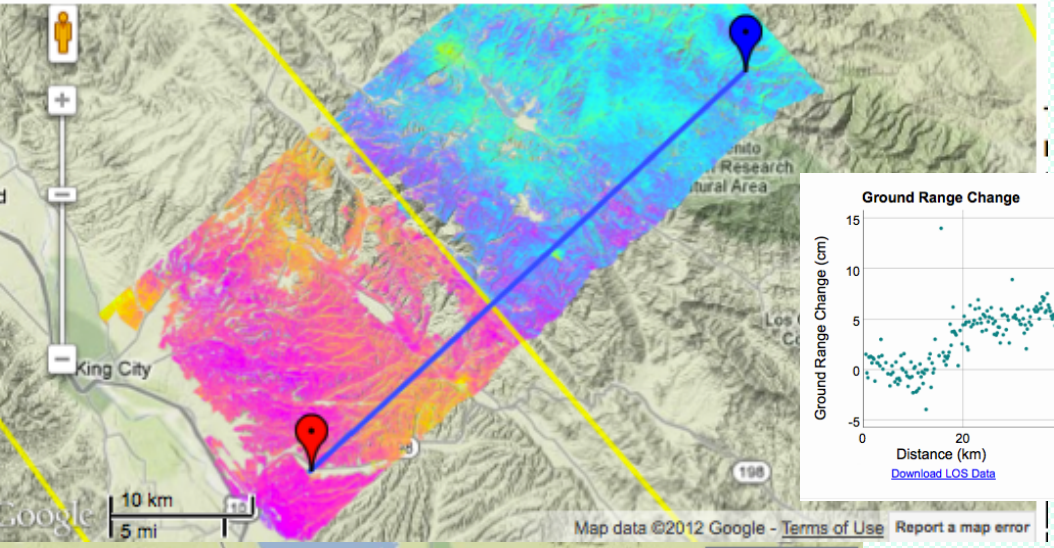


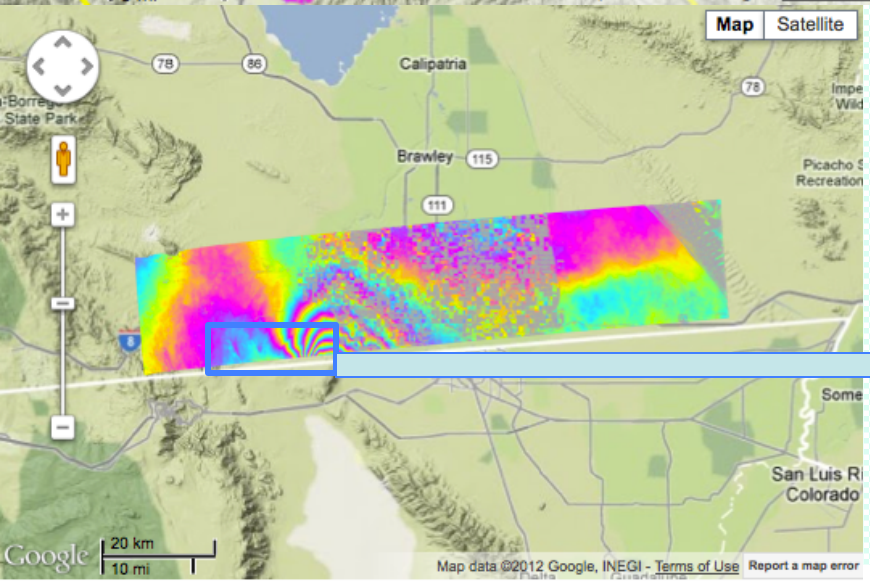
Figure 3. C-20A/G-III Precision Autopilot 10-meter tube tracking performance.

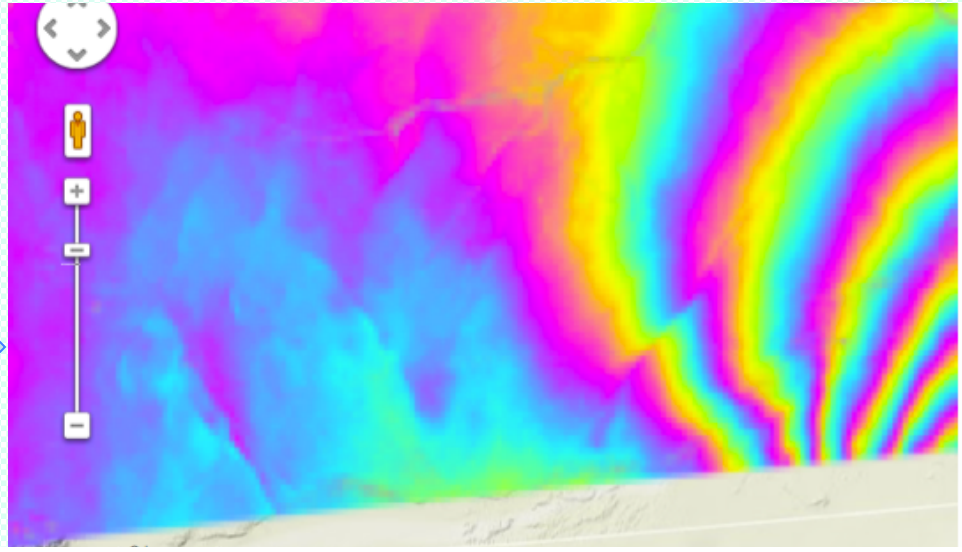
UAVSAR – Geophysical processes

QUAKESIM Understanding Earthquake Processes



- San Andreas Fault (creeping section)
- El Mayor-Cucapah Earthquake (north edge)
- Emerging network of minor faults
- *Goal: allow many users to analyze and model such features in a map tool context*

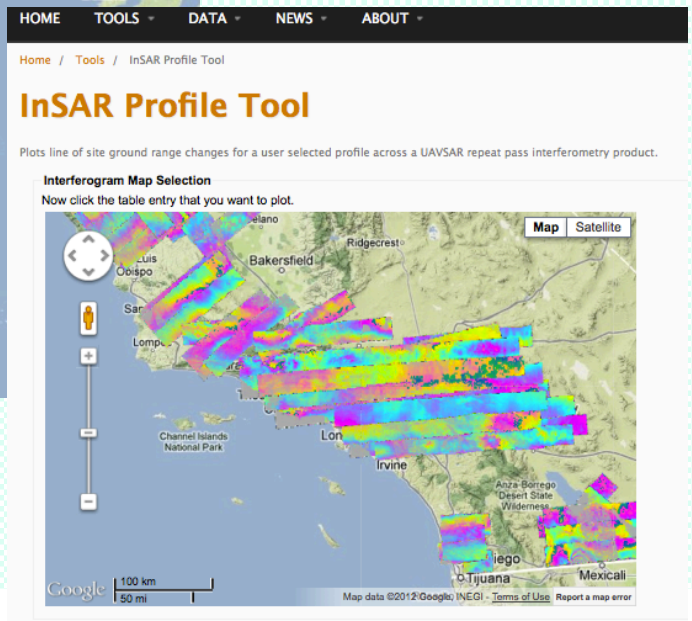




UAVSAR – Data set:

QUAKESIM Understanding Earthquake Processes

- (as of last October): 310 published interferogram strips; 558 flightlines
- Up to 2.2GB images (some over 120 Mpixel)
- Not global, but includes much of hemisphere
- Flights designed to cover California's active faults, 6 month repeat



One way: sar2simplex

QUAKESIM Understanding Earthquake Processes

- Find, download data (up to 7 GB per data image)
- Common speeds:
  - 70 KB/s ~ 1 day
  - 1MB/s: 1.5 hours
- Process on local machine: subset, block average, cross-section
- QuakeSim prototypes:
  - polygon select
  - down-sampling (average value over each box in a grid)
  - cross-section along line
  - graphs, inversion tool input
  - command-line process, requires cooperation to share

But data transfers are slow; not in a map tool environment

GeoServer is . . .

QUAKESIM Understanding Earthquake Processes

. . . **free** from http://geoserver.org

. . . **open**, **standard**-conforming, **community** effort

. . . **manages** geospatial data (subsetting . . .)

. . . **controls** PostgreSQL database (in QuakeSim instance)

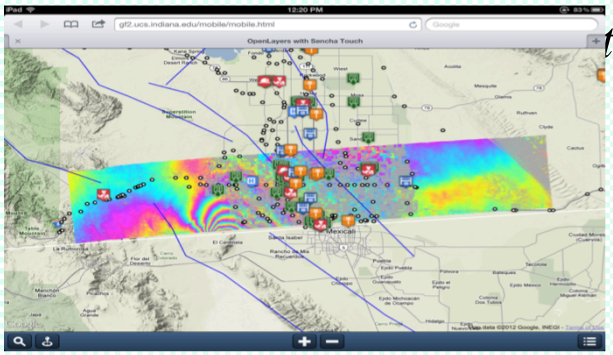
. . . **connects** with web services for display and computing

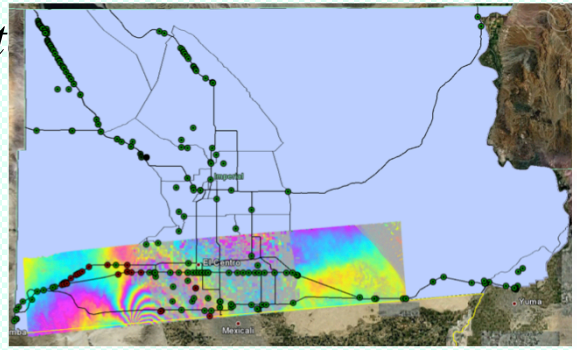
GeoServer: QuakeSim, E-DECIDER solutions

QUAKESIM Understanding Earthquake Processes

- GeoServer: produces KML, images, supplies Web Map Service etc.
- Ready to link in external GIS services:
  - anything affordable/free and useful.
- For QuakeSim manages faults, InSAR deformation images;
- For E-Decider manages HAZUS-MH data
- Can be group or community resource (on web server)

El Mayor-Cucapah 2010 (real deformation, simulated damage):





New: Early Advantages

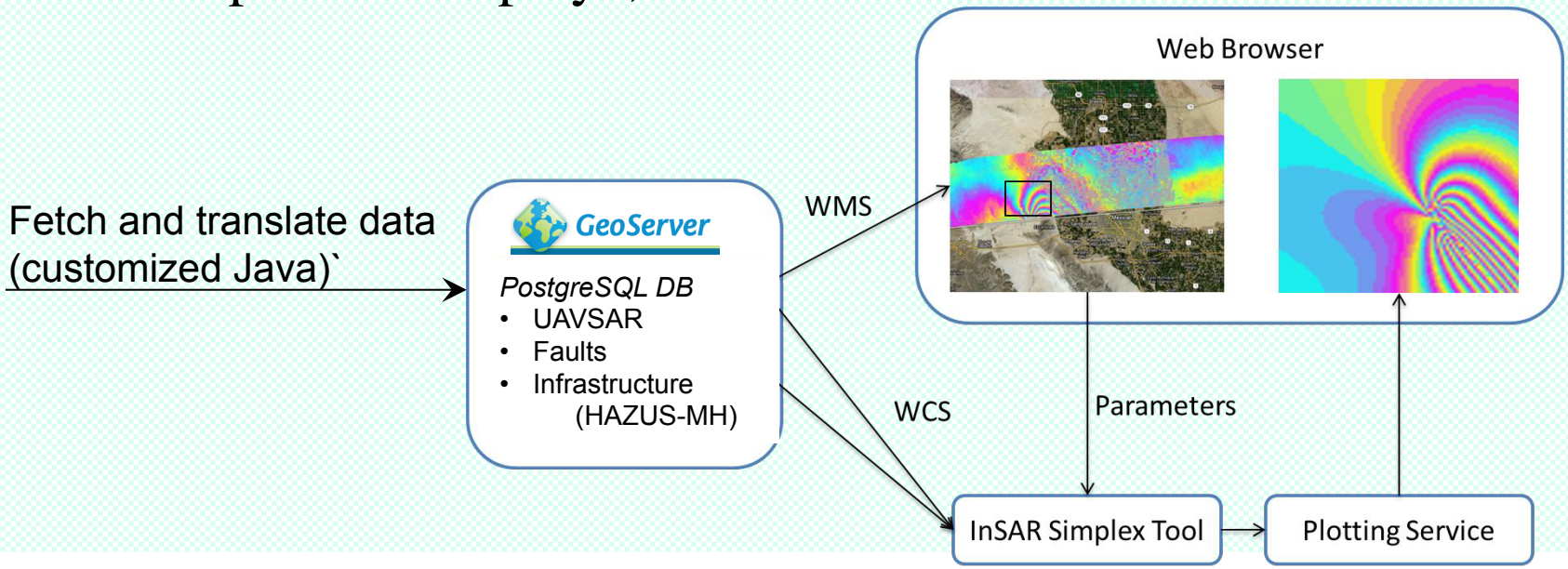
QUAKESIM Understanding Earthquake Processes

- Diverse remote data is integrated in map, browser
- Images, items updated in one place
- Quality is managed centrally
- Multiple data access modes (location, metadata, . . .)
- Version control, provenance info easier to manage
- New images, data equally available for all
- Products immediately in widely used formats (KML, GeoJSON, GeoTIFF)

QuakeSim adapts GeoServer

QUAKESIM Understanding Earthquake Processes

- GeoServer supplies functions for data import (uses GeoTIFF)
- GeoServer produces images, KML
- GeoServer supports browser map services
- QuakeSim supplies management scripts to poll sources for new geospatial data, format, import external data types, interact with web map-based displays, . . .

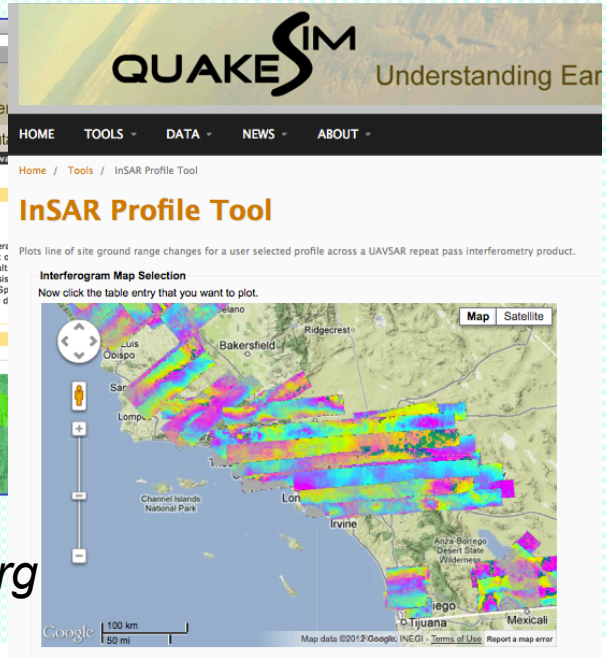


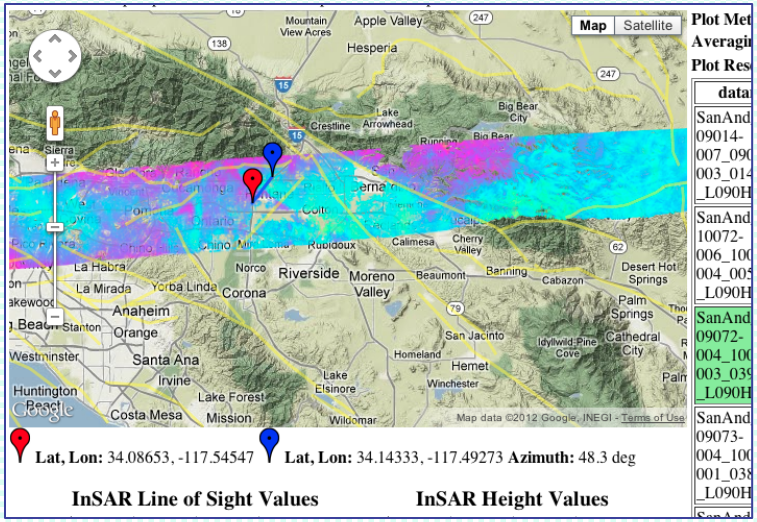
New: browser exploration

QUAKESIM Understanding Earthquake Processes

- Click on map: select all pierced strips
- Right: table of overlapping strips
- No large download required (GeoServer, low-res images)
- From idea to science in three clicks:

1 *2* *3*



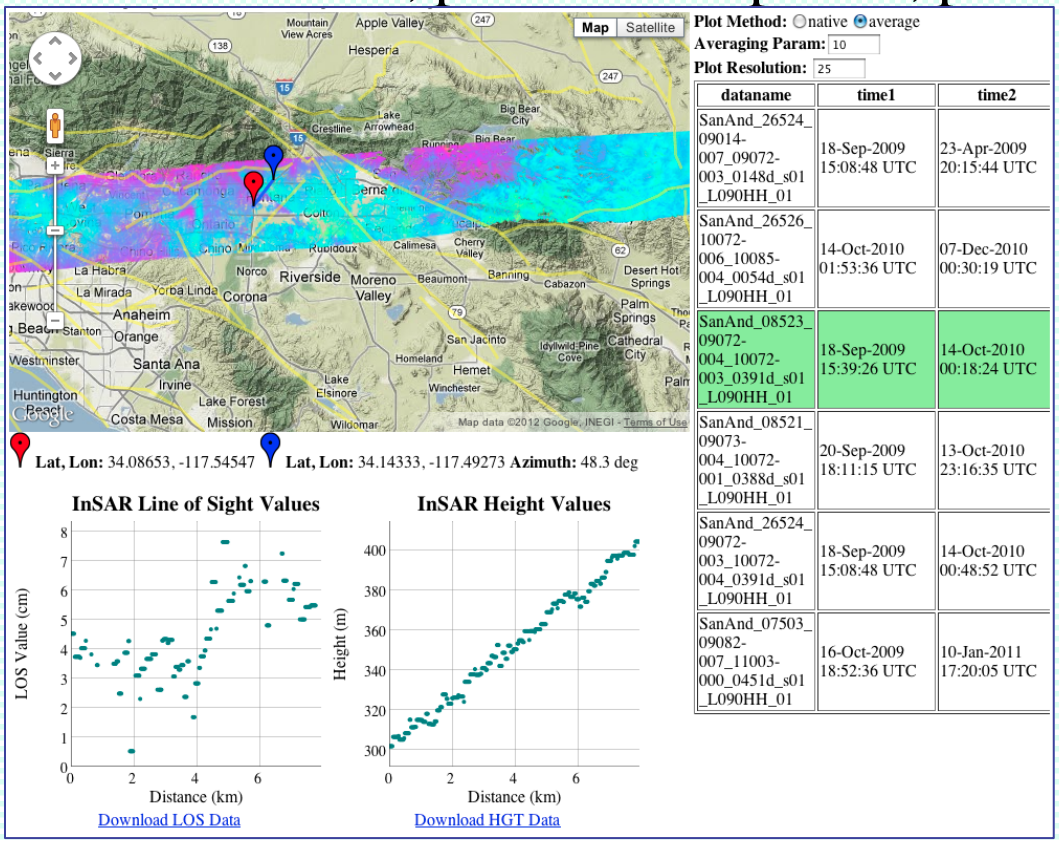


http://quakesim.org

New: quick profiles

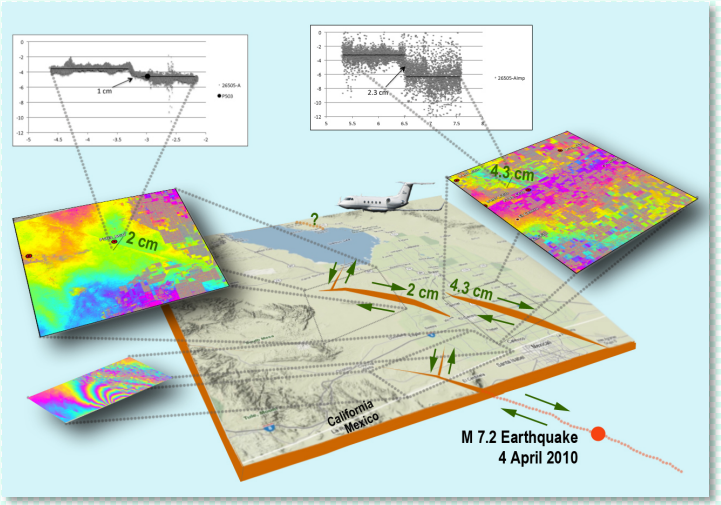
QUAKESIM Understanding Earthquake Processes

- From local list, pick interferogram
- Table includes time span, dates, heading
- In browser, position endpoints, produce cross section.



Plot Method: ○native ◉average
Averaging Param: 10
Plot Resolution: 25

dataname	time1	time2
SanAnd_26524_09014-007_09072-003_0148d_s01_L090HH_01	18-Sep-2009 15:08:48 UTC	23-Apr-2009 20:15:44 UTC
SanAnd_26526_10072-006_10085-004_0054d_s01_L090HH_01	14-Oct-2010 01:53:36 UTC	07-Dec-2010 00:30:19 UTC
SanAnd_08523_09072-004_10072-003_0391d_s01_L090HH_01	18-Sep-2009 15:39:26 UTC	14-Oct-2010 00:18:24 UTC
SanAnd_08521_09073-004_10072-001_0388d_s01_L090HH_01	20-Sep-2009 18:11:15 UTC	13-Oct-2010 23:16:35 UTC
SanAnd_26524_09072-003_10072-004_0391d_s01_L090HH_01	18-Sep-2009 15:08:48 UTC	14-Oct-2010 00:48:52 UTC
SanAnd_07503_09082-007_11003-000_0451d_s01_L090HH_01	16-Oct-2009 18:52:36 UTC	10-Jan-2011 17:20:05 UTC



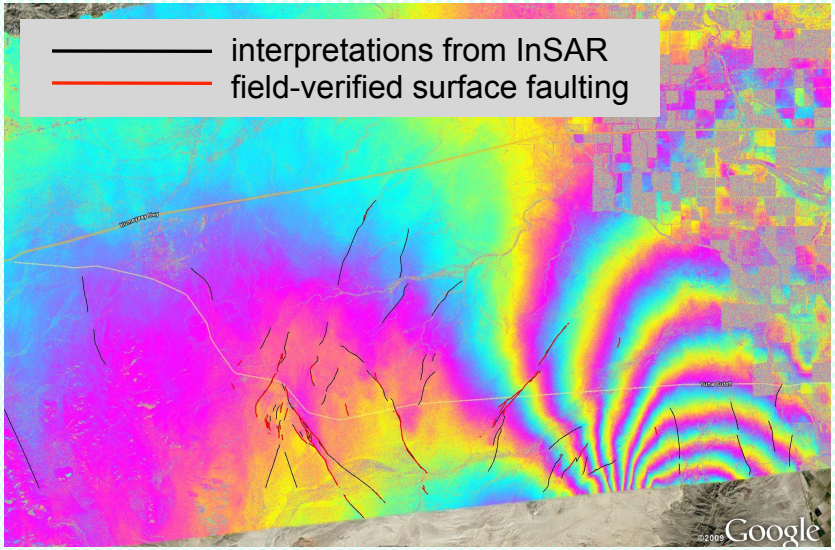
New: Task division

QUAKESIM Understanding Earthquake Processes

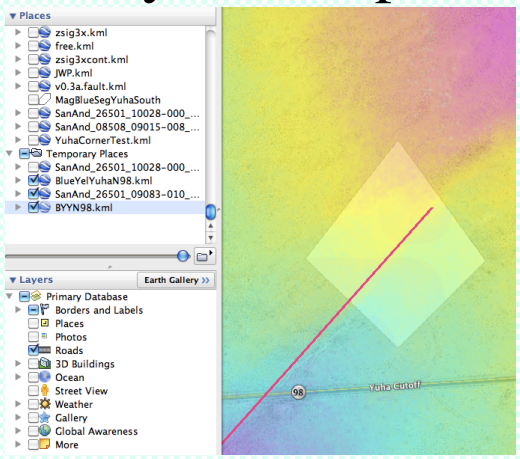
- **GeoServer's** general role:
- 1. Web Map Service/Web Coverage Service /Web Feature Service
- 2. Enable access data in various formats, especially KML and GeoJSON
- 3. Enable access data by both metadata and spatial attributes.

- **QuakeSim:**
- 1. Serve InSAR thumbnails for overview as WMS layer
- 2. Query available InSAR images through location (user click on Google Map)
- 3. Extract LOS profile with WMS getfeatureinfo function
- 4. Export fault table as GeoJSON objects for better integration with
- LOS tool on Google Map.

- **E-DECIDER**
- 1. KMLGenerator: generate on-demand HAZUS layers as KML/KMZ files
- through WCS service with circle filter (centered at epicenter)
- 2. Mobile interface: generate light-weight GeoJSON objects for mobile
- browser (KML is generally too complex in this situation)



- Polygon tool feeds inversion (*prototype*)
- Produces fault and slip estimates
- Yuha, from El Mayor Cucapah
  - x = -26.124935
  - y = -26.486836
  - strike = 41.496913
  - dip = 90.000000
  - depth = 100.000000
  - width = 100.000000
  - length = 2.000000
  - strike-slip = 3.995412
  - dip-slip = 0.000000
  - tensile-slip= 0.000000

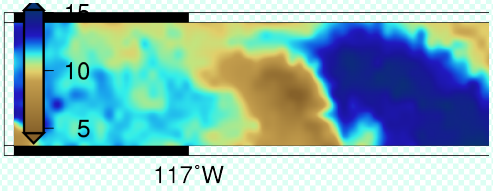


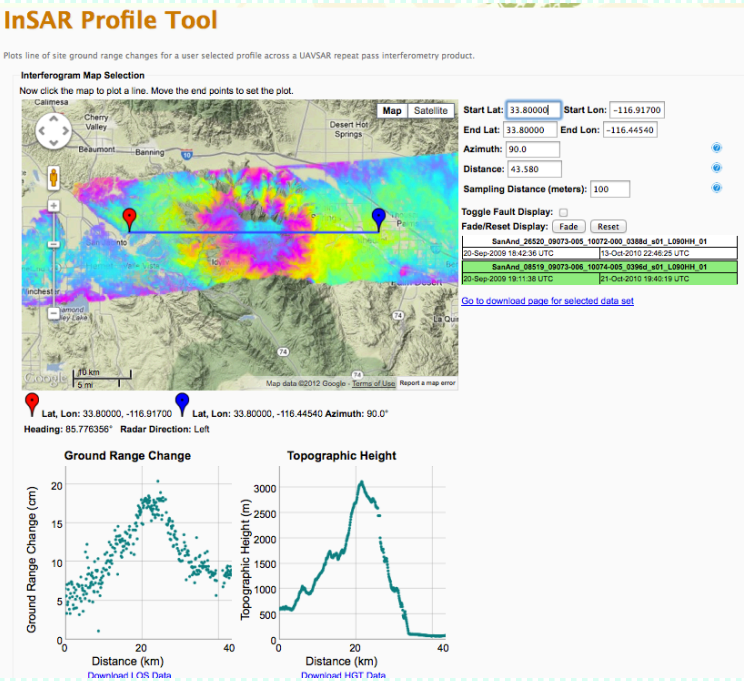
- Coseismic: 3.995 cm
- Postseismic: 2.565 cm
- **Same polygon**

Soon: OSCAR Water Vapor maps

QUAKESIM Understanding Earthquake Processes

- Water vapor maps (*pending*): plan to import as GeoTIFF, coordinate with radar images
- Top is MODIS IR spacecraft map of column water vapor near one flight time of UAVSAR (should be difference of visit times)
- Times, scales not yet integrated
- Middle, bottom show UAVSAR interferogram unwrapped phase
- Information on total path delay difference can explain InSAR nontectonic signal





Conclusions

QUAKESIM Understanding Earthquake Processes

- Repeat-pass *interferometry* sees *volcanic* inflation and *earthquake* processes (and other processes).
- Large data volumes indicate *need for GIS web services.*
- QuakeSim implements *GeoServer dB management*, web services
- Consistent browser *views of maps, raster images,* faults
- Powerfully combines with *infrastructure GIS* (Disaster response)
- Popular: QuakeSim *InSAR Line-Of-Sight profile* tool