Research with ALOS PALSAR data within the WinSAR consortium

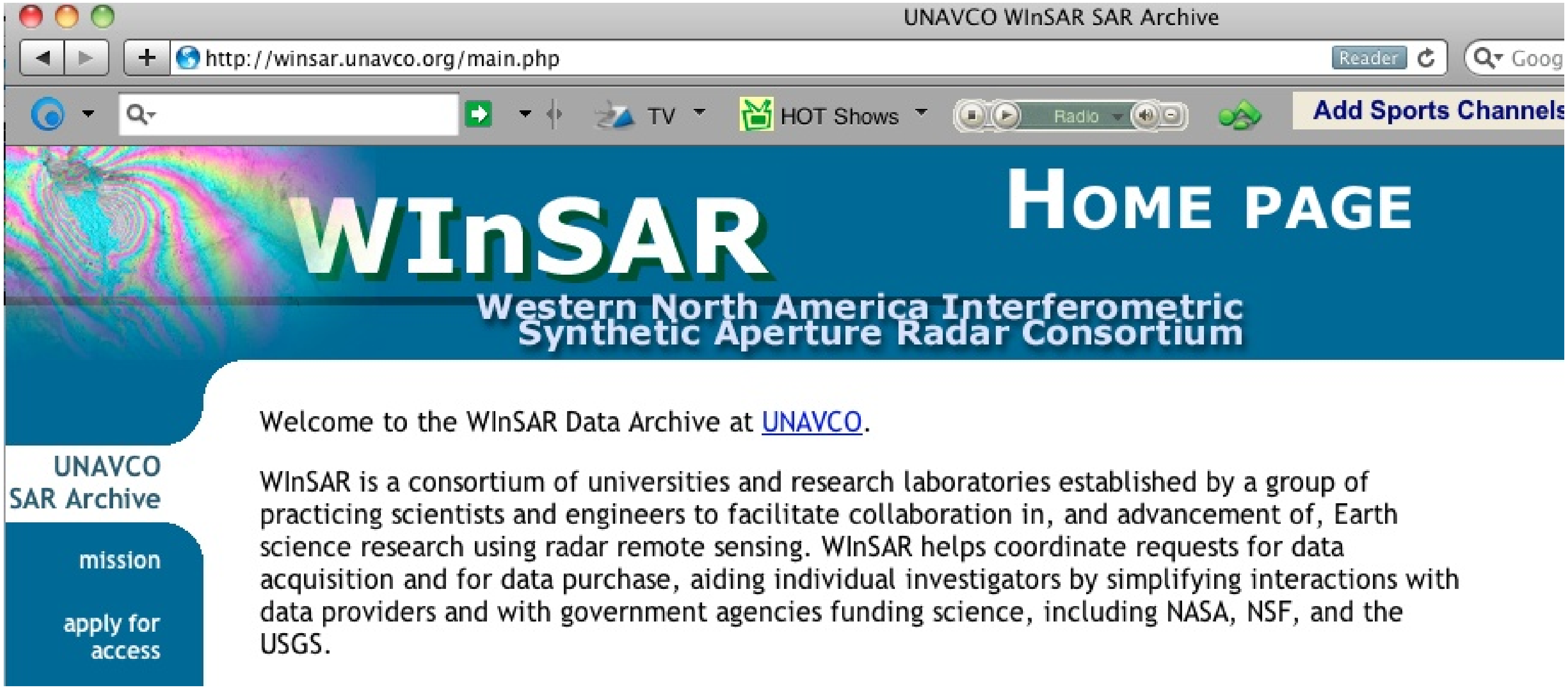
Falk Amelung, University of Miami (Chair)
and the WinSAR Executive Committee

Roland Burgmann, Yuri Fialko, Eric Fielding and David Schmidt

Outline of talk: What is WinSAR ?
Research examples:
- Earthquakes
- Inter-seismic
- Volcanoes
- Subsidence
- Others

Recommendations

What is WinSAR ?



- Consortium of 83 Universities/ Research Institutions (~20 non U.S.)
- Executive Committee (elected, 2-year terms)
- ALOS-PALSAR access through L1 data pool at ASF (U.S. Government Research Consortium, USGRC)

Funding:

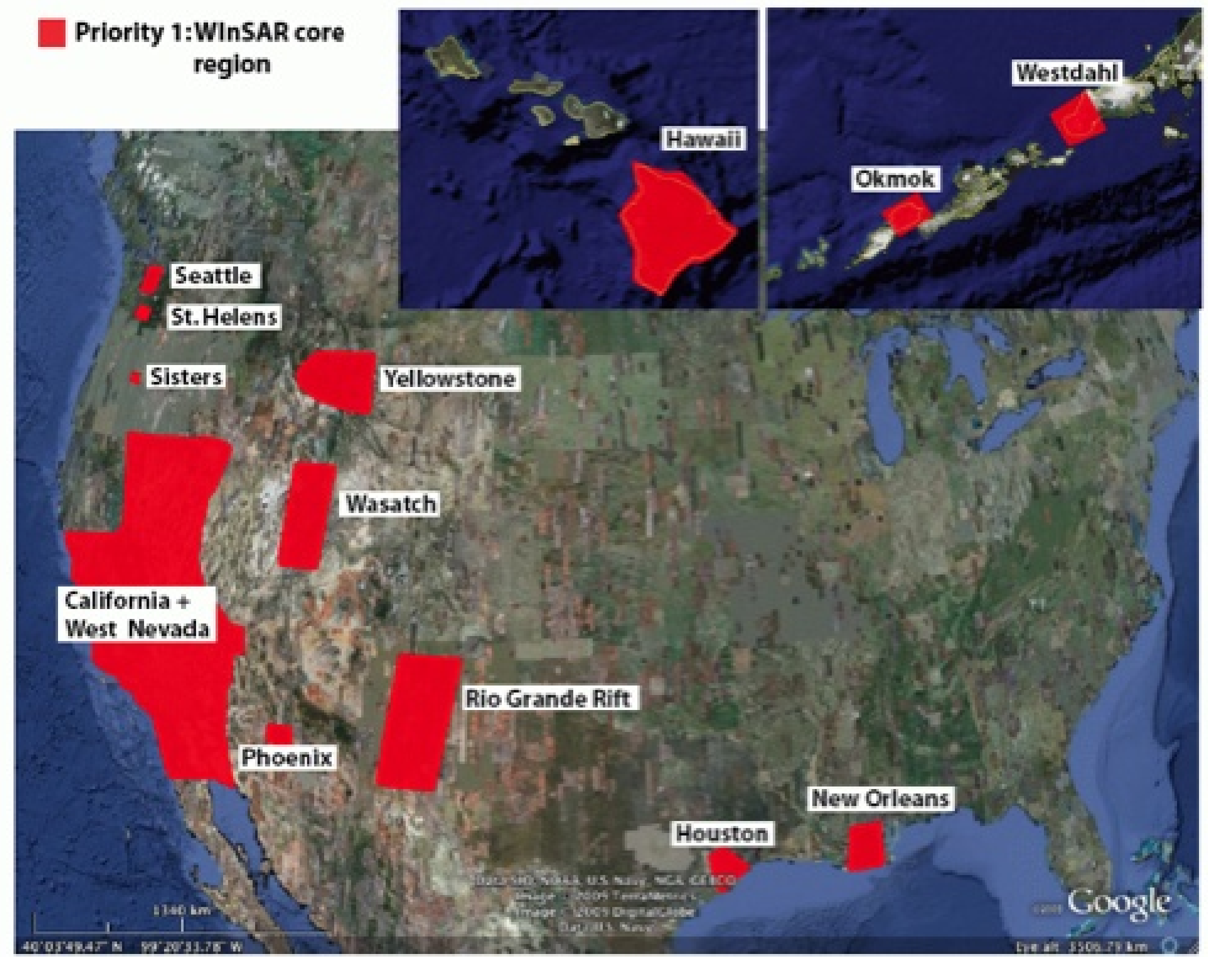
WinSAR objectives

- Promote the use and development of InSAR technology for scientific investigations.
- Promote free and open access to SAR data as allowed by data providers.
- Acquire, archive and catalog SAR data of the U.S. active areas

Complete ERS,Envisat data sets for core area!

	# of scenes	
ERS	22826	8.9 TB
Envisat	7185	1.7 TB

Download: 40MB/s
(4 sec/1 Envisat scene)



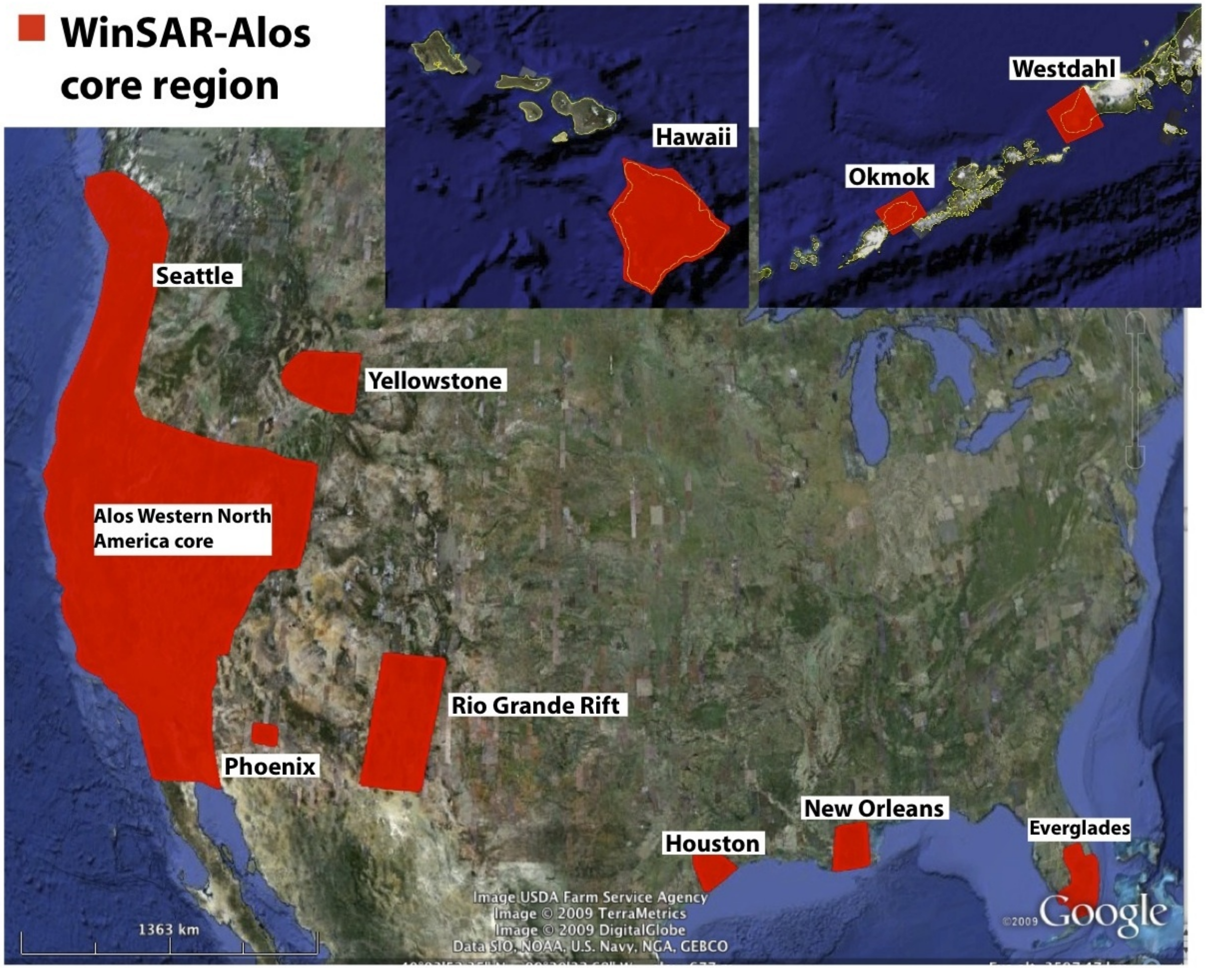
WinSAR objectives

- Promote the use and development of InSAR technology for scientific investigations.
- Promote free and open access to SAR data as allowed by data providers.
- Acquire, archive and catalog SAR data of the U.S. active areas

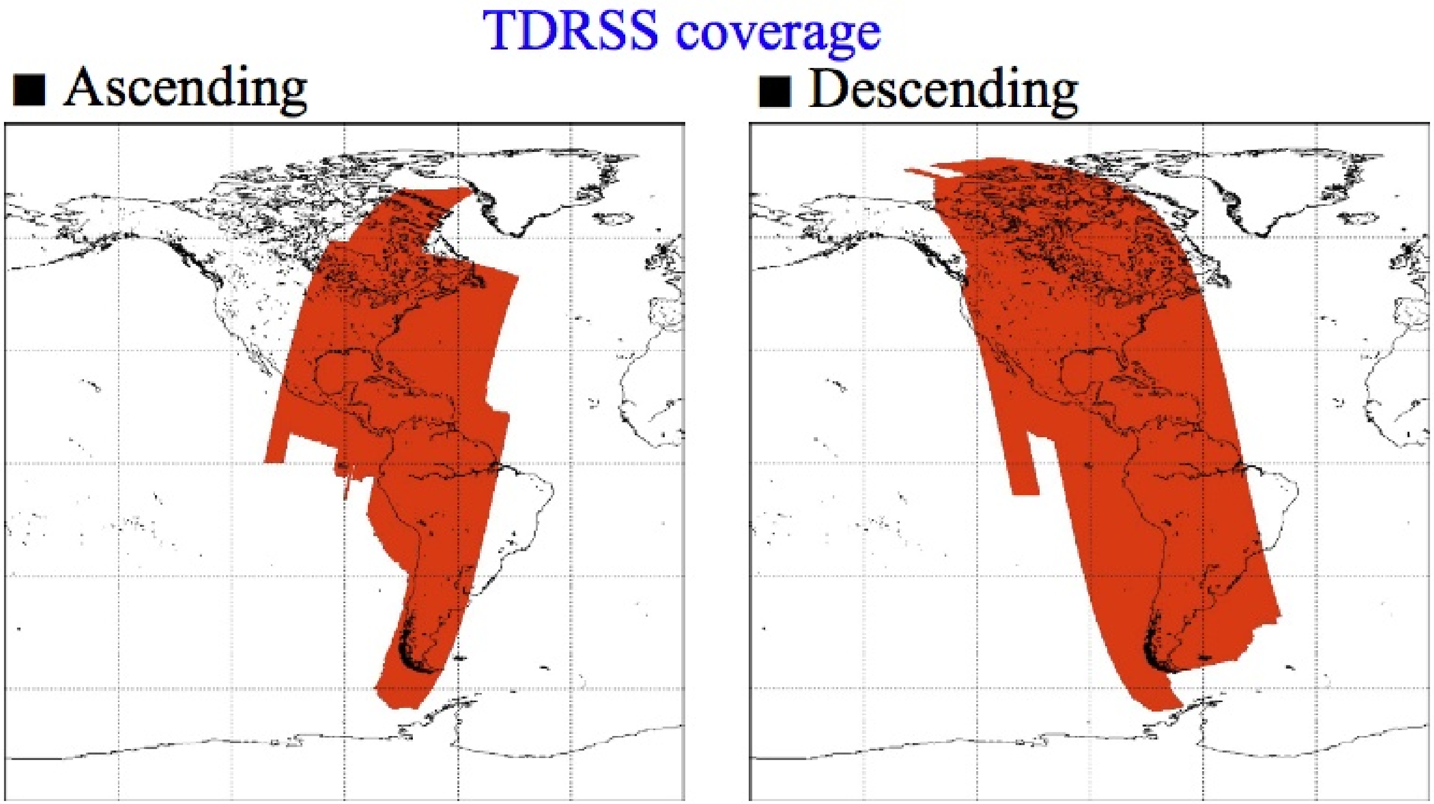
“Data Subscriptions”

Download: 2MB/s
(300 sec/1 ALOS scene)
Soon: 40MB/s, 15s/scene)

WinSAR successful
when it is not needed
anymore!



NASA Tracking and Data Relay Satellite System TDRSS



JAXA/NASA collaboration

TDRSS operations started: 13 Apr. 2010

Downlink to White Sands, New Mexico (USA)

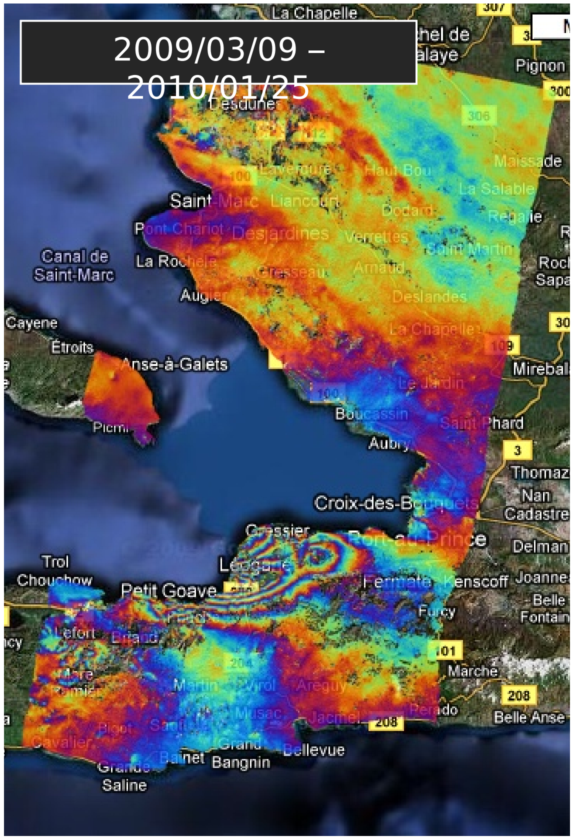
Data Subscriptions for tectonic and volcanic areas

1. Earthquakes

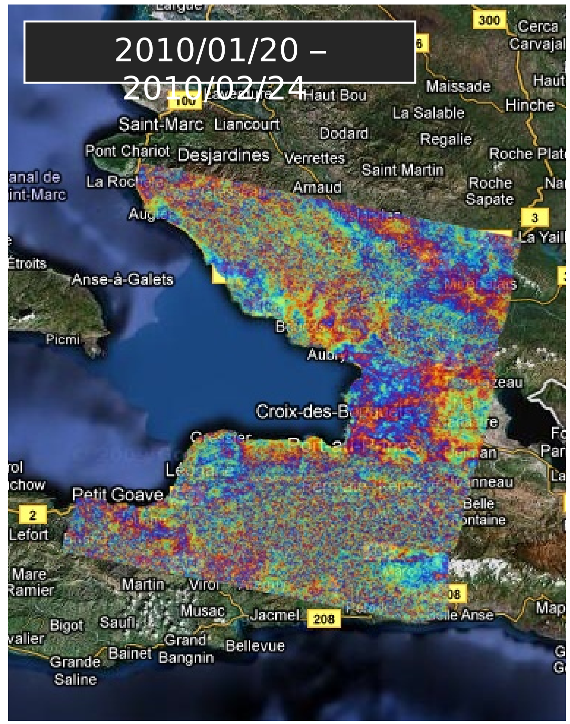
Tolerance to Temporal Degradation

2010 Mw 7.0 Haiti Earthquake

ALOS PALSAR (L-band)
Time span = 322 days
Bperp = 805 m



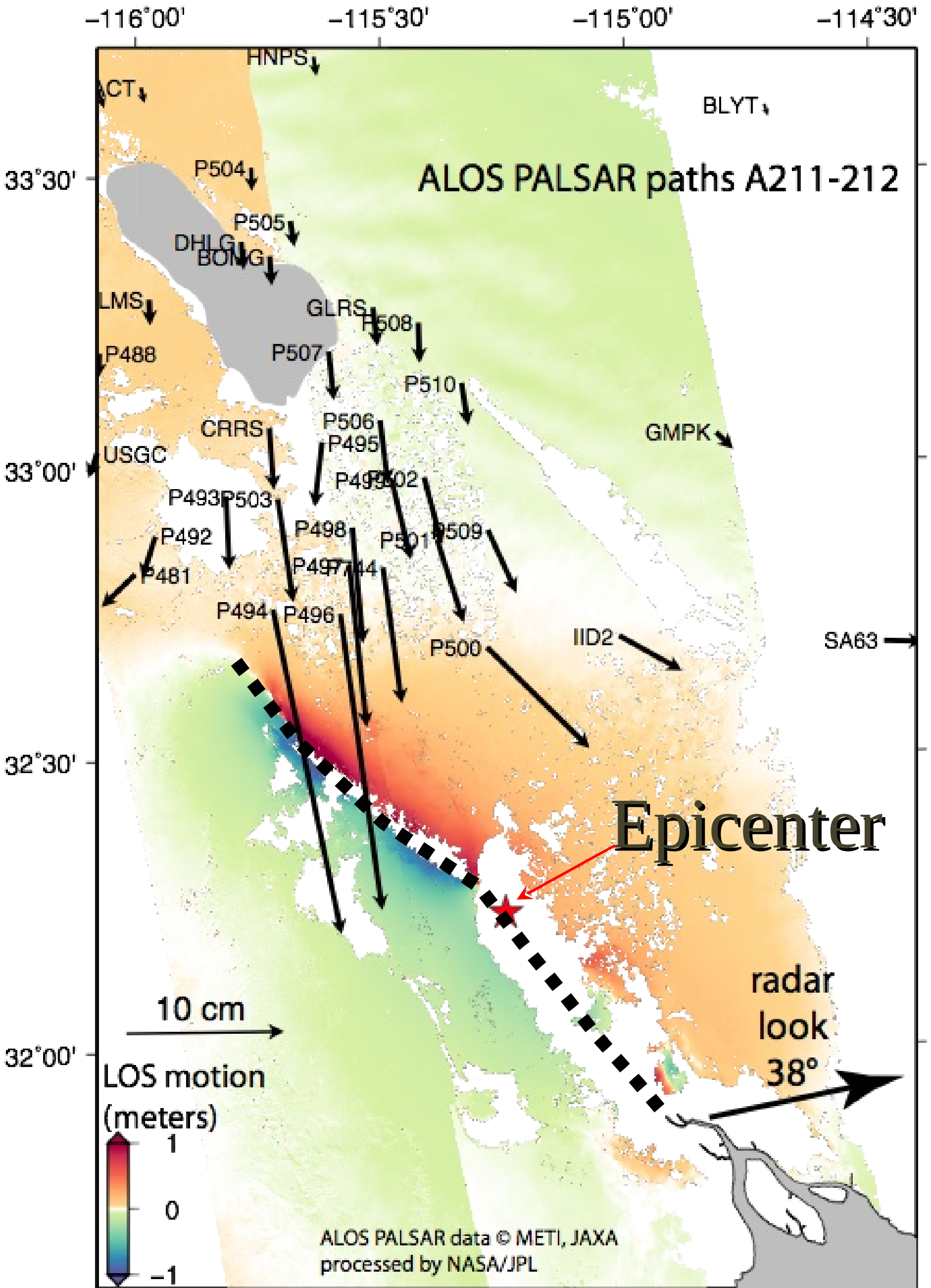
Envisat ASAR (C-band)
Time span = 35 days
Bperp = 394 m



Yun et al., 2010 UNAVCO Workshop

Interferogram by Eric Fielding

- Temporal baseline of ALOS is 9 times larger.
- Perpendicular baseline of ALOS is 2 times larger.
- The C-band interferogram is post-seismic, and the L-band is coseismic → C-band decorrelation is not by earthquake (high fringe rate) but by temporal change + volume decorrelation.
- Same color scale applied.

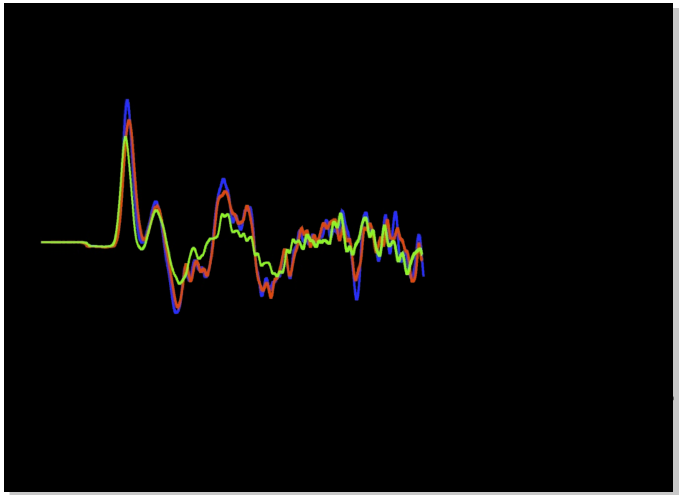


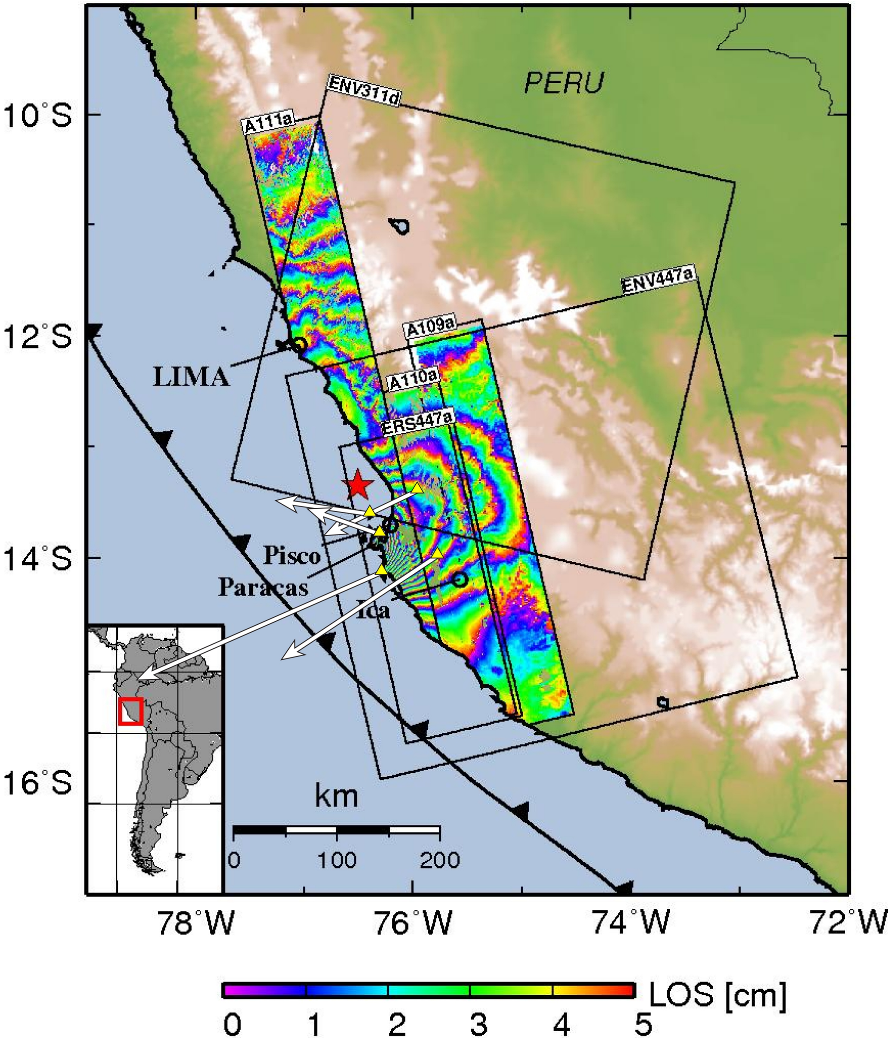
2010 Baja California Mw 7.2

- El Mayor-Cucapah earthquake
  4 April 2010
- PALSAR shows full 110 km length of rupture (dashed line)
- widespread liquefaction in Mexicali Valley and Colorado River Delta causes decorrelation

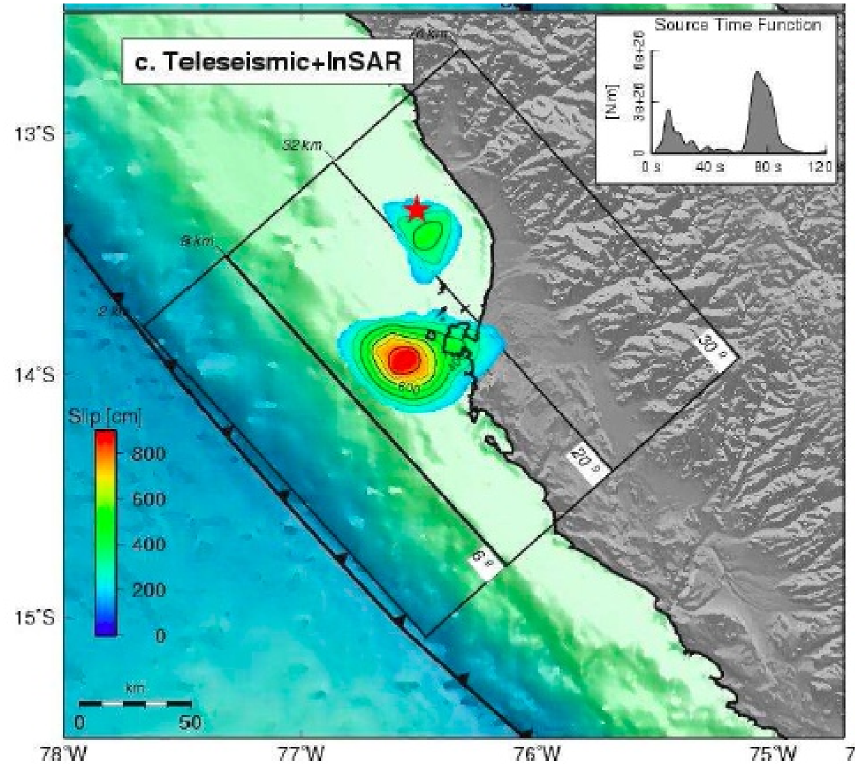
Wei, Fielding, JPL

August 15, 2007 Mw 8.0 Pisco (Peru)



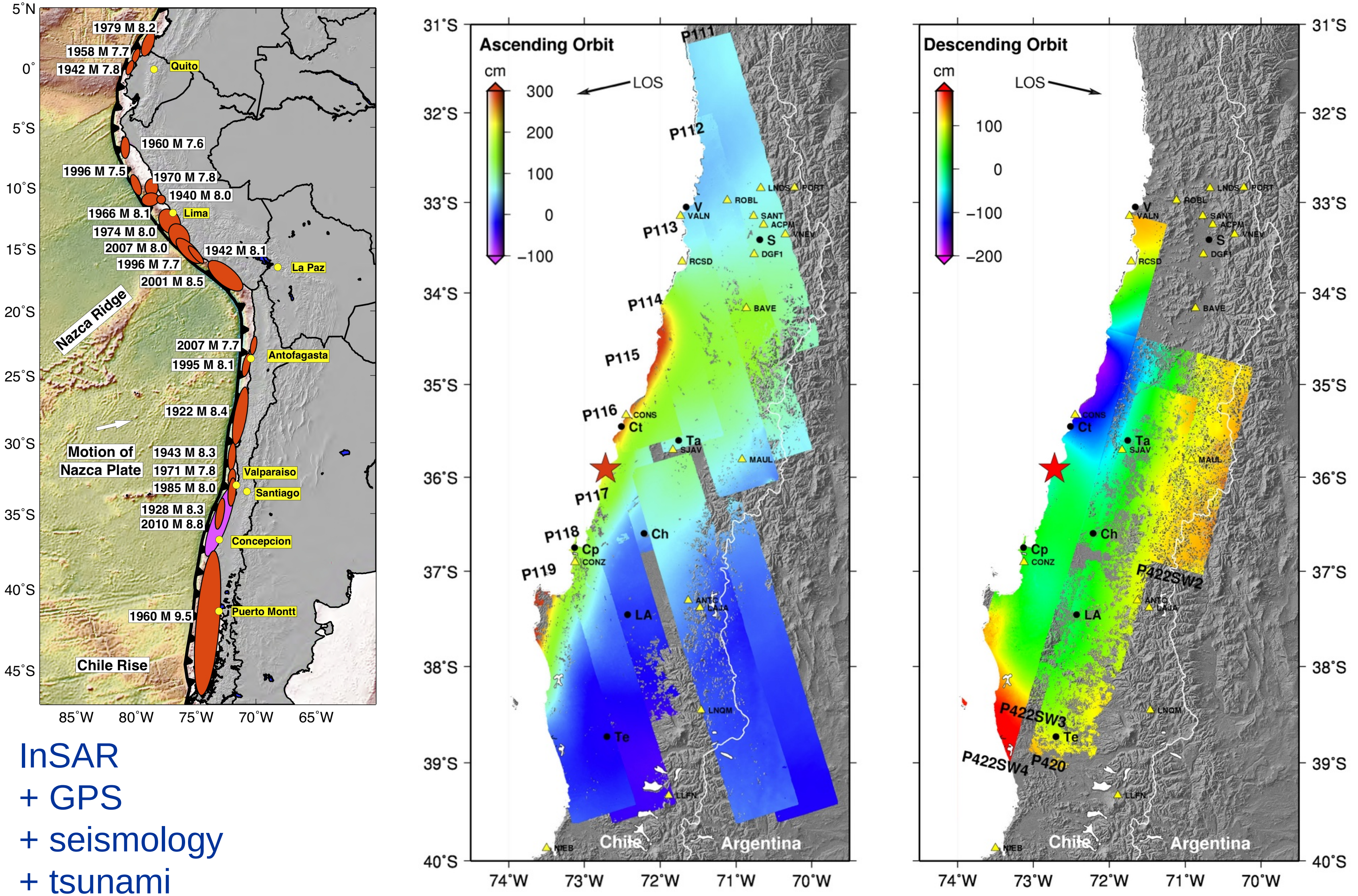


ALOS/Envisat/Tsunami waveforms



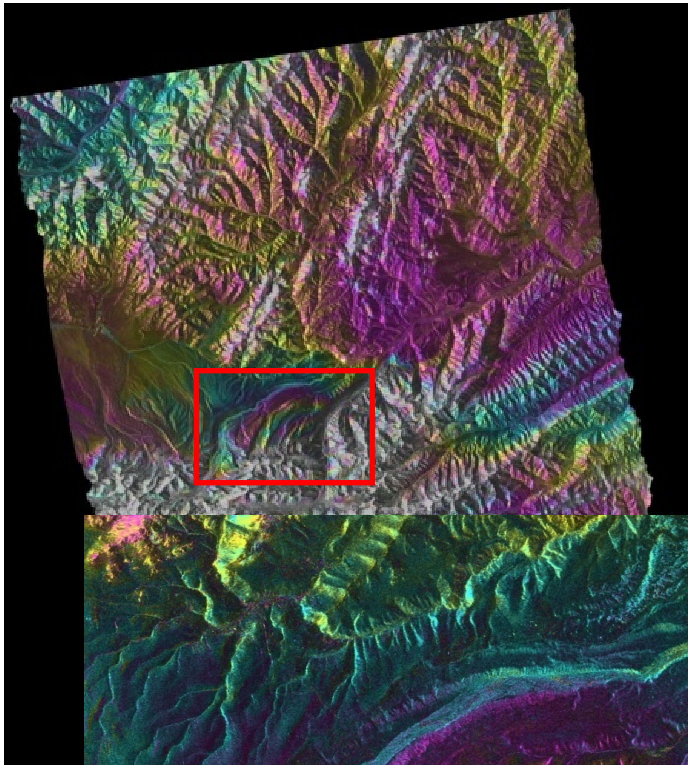
Sladen et al., 2009

2010 Mw 8.8 Chile



- InSAR
- + GPS
- + seismology
- + tsunami

Simons, Caltech



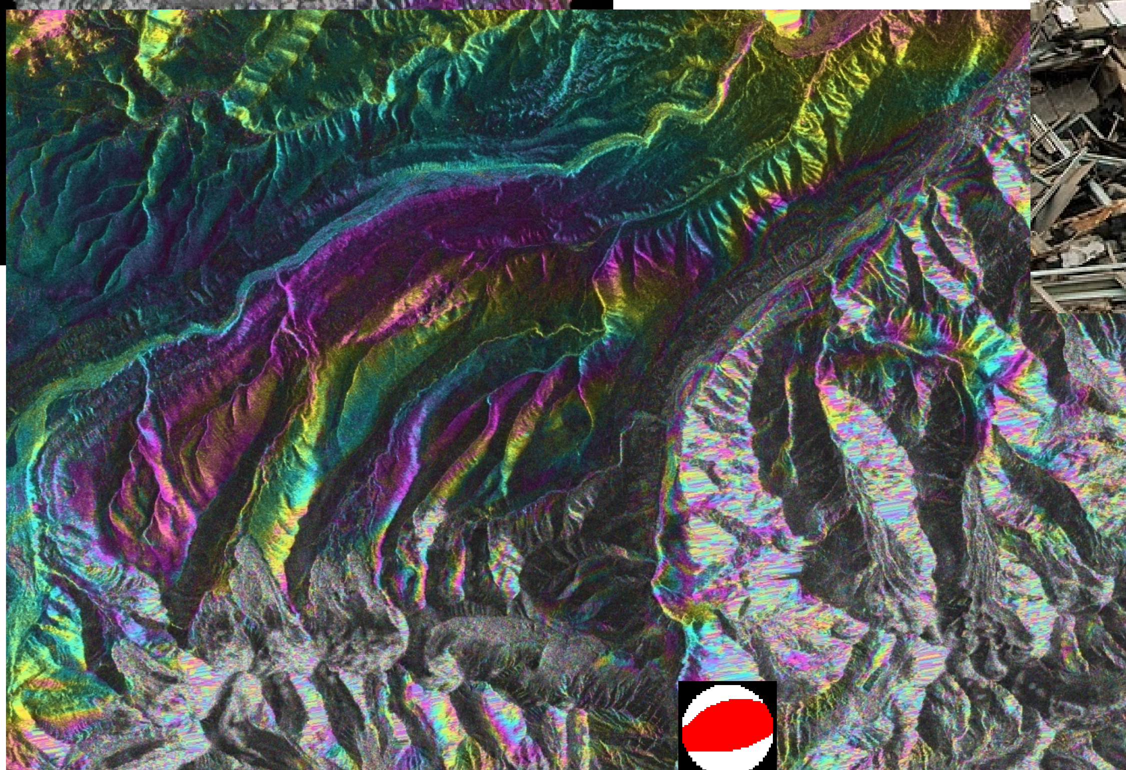
M 6.6 earthquake

5 October 2008, Nura, Kyrgzystan

70 deaths

N 39.51, 73.81 E, 27 km (USGS NEIC location)

www.asiannews.it



10 km

U.S. G. S. epicenter and Harvard CMT

ALOS PALSAR, FBS

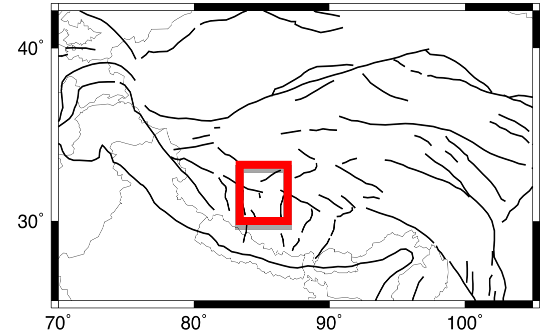
10/2/2008-11/17/2008

- *area has very poor coherence at C band but L band is possible.*
- *improved depth estimate of earthquake*
- *possibly identification of fault*
- *useful for hazard studies*

R. Mellors, SDSU

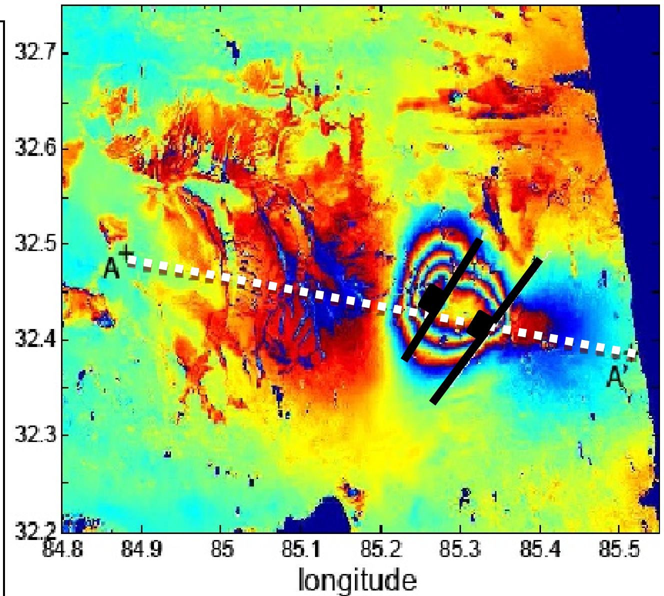
PI 168

Nima-Gaize

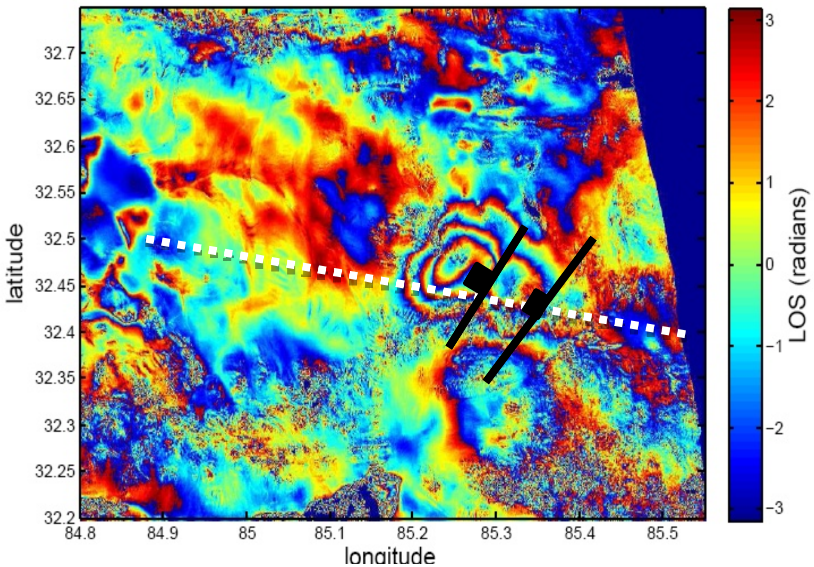


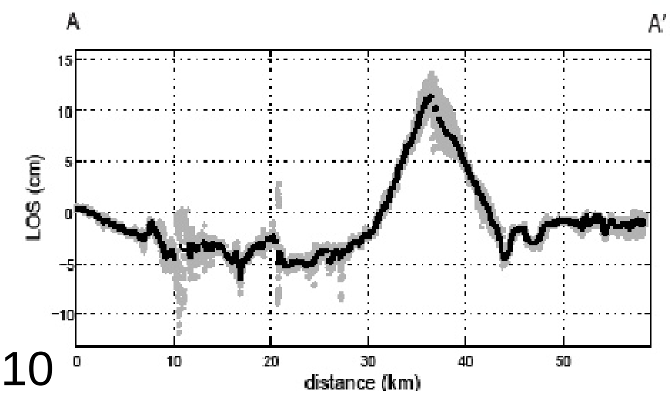
- 9 January 2008
- M 6.4 mainshock
- M 5.9 aftershock 1 week later
- Normal fault source mechanisms
- Afterslip occurred on both fault planes and have very similar spatial deformation as co-seismic period

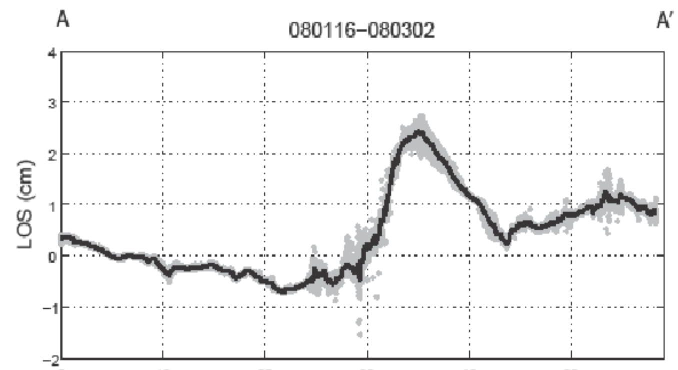
Coseismic: 071016 - 080116



Postseismic: 080116 - 080302





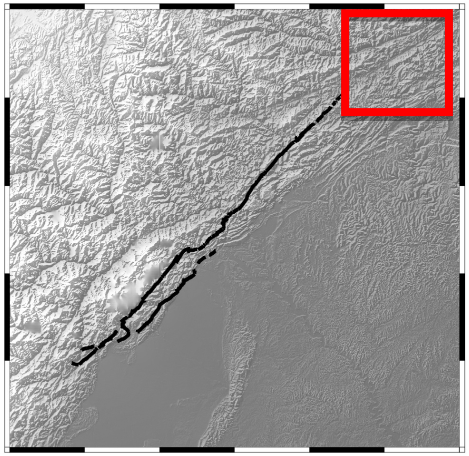


Ryder et al. *JGR*, 2010

Huang, Burgmann, Berkeley

PI 168

Post Wenchuan EQ

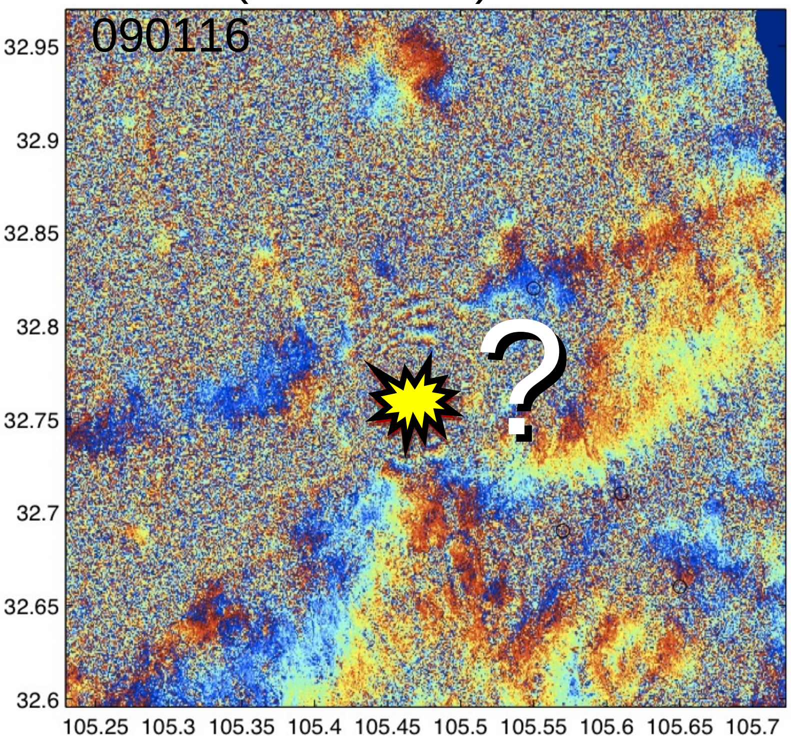


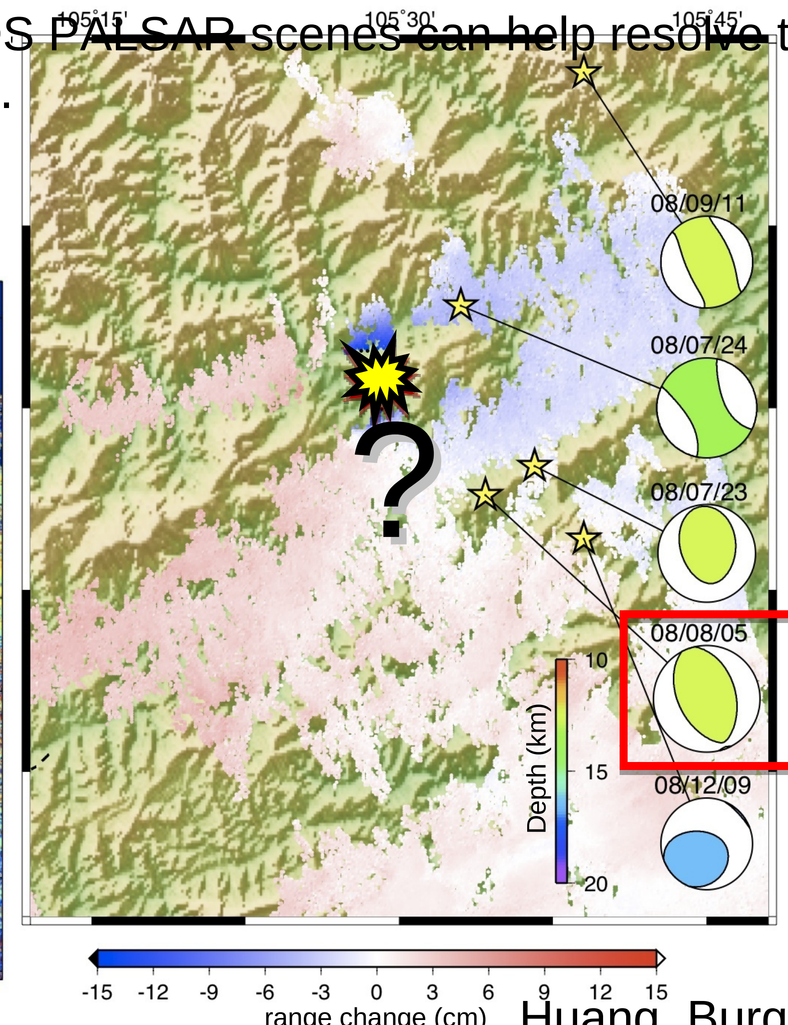
- Earthquakes during 080716 and 090116 (Harvard CMT solutions)

- InSAR can also indicate the epicenter of earthquake events.

- More ALOS PALSAR scenes can help resolve the aftershocks.

ALOS (Track: 471) 080716 - 090116



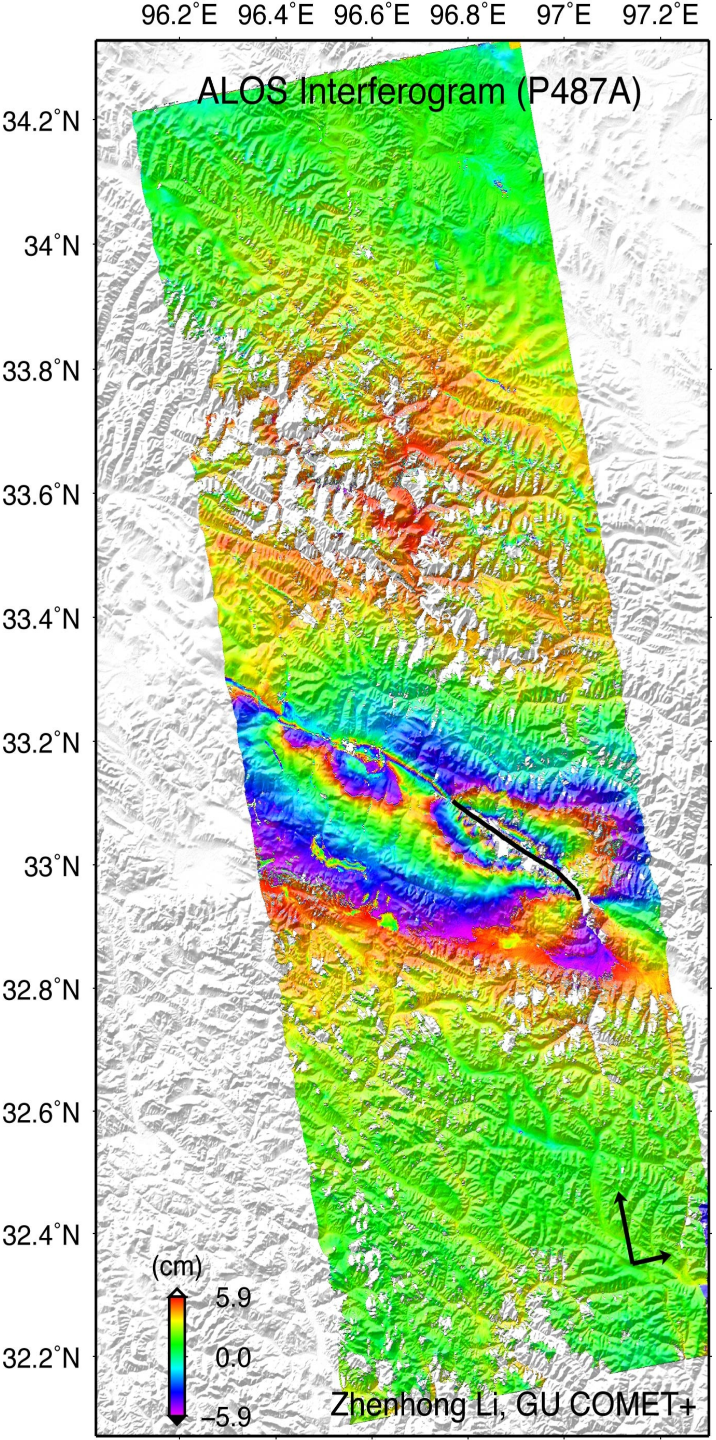


	080531
080716	-2435.45,
080831	-4499.94,
081201	-3407.80,
090116	-2969.71,
090303	-2905.92,
090719	-2506.77,
091019	-1611.49,
100119	-1299.18,
100306	-910.88,
100722	-587.83,

B

(km)

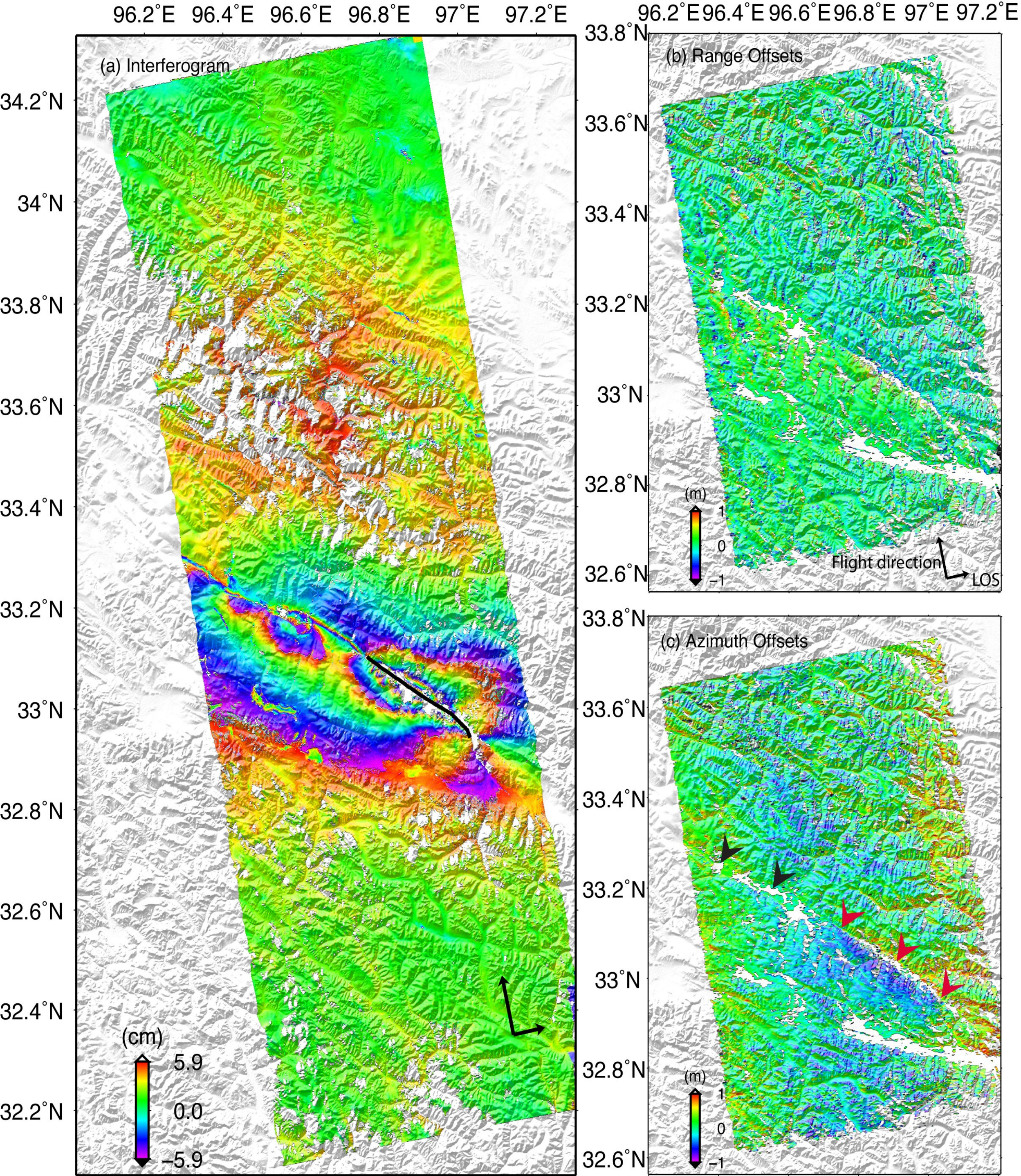
Huang, Burgmann, Berkeley



The 2010 Mw 6.9 Yushu earthquake

- 13 April 2010 (UTC 23:49:37): Earthquake occurred
- 14 April 2010: COMET+ scientists started to coordinate GEO's event website – Yushu
- 17 April(Sat): JAXA collected first post-seismic image
- 19 April(Mon): Glasgow COMET+ received ALOS images
- 20 April: First interferogram and fault trace released to the public via web sites and to Chinese colleagues via emails (http://yushu.ges.gla.ac.uk)
- 20 April: First source model released
- 21 April: Surface rupture determined and released
- 25 April: Source model refined
- 29 April: COMET+ Yushu web article published (http://comet.nerc.ac.uk/current_research_yushu.html)
- 30 April: C-band data processed and released

ALOS observations



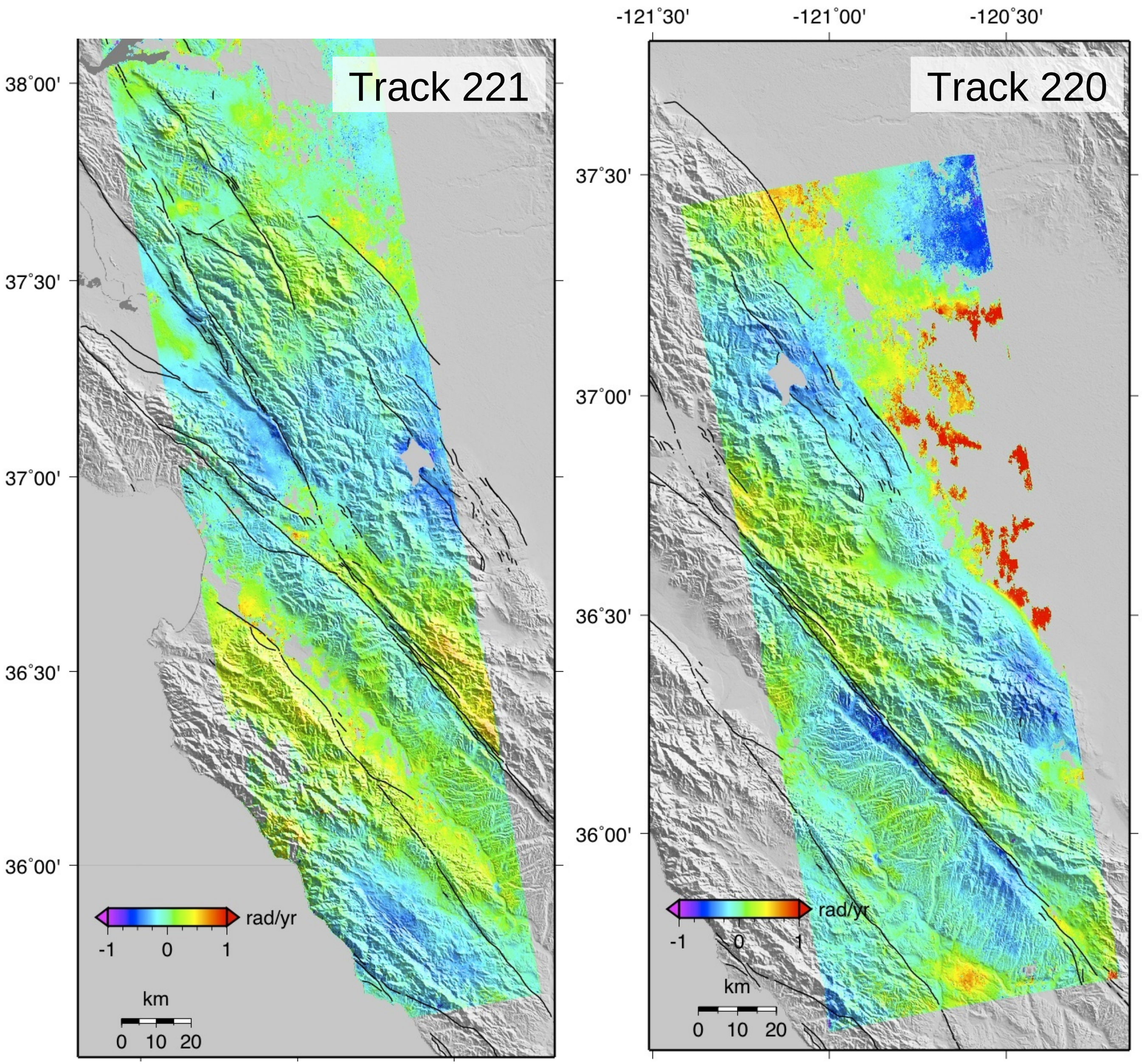
- Red arrowheads: surface rupture
- Black arrowheads: fault trace, possible surface rupture?
- Max azimuth offset: 1.7 m (consistent with field data of 1.8m)

(Dr Zhenhong Li, Glasgow COMET+)

2. Interseismic

Central California – San Andreas fault creep

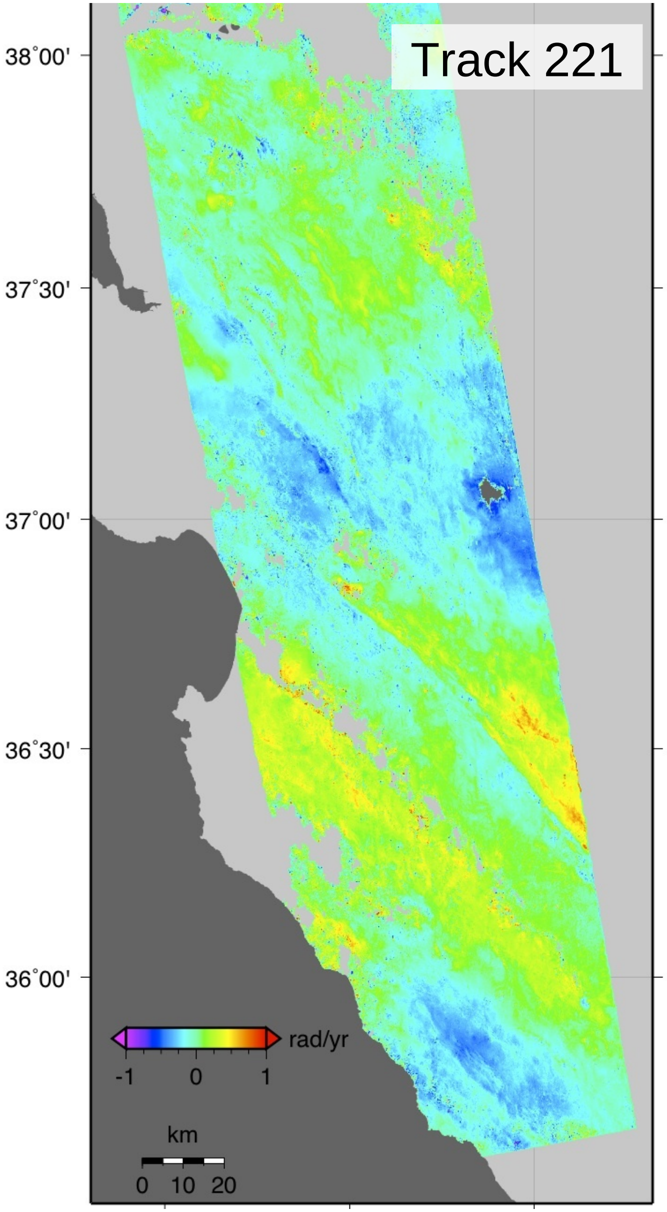
UC Berkeley Active Tectonics Group

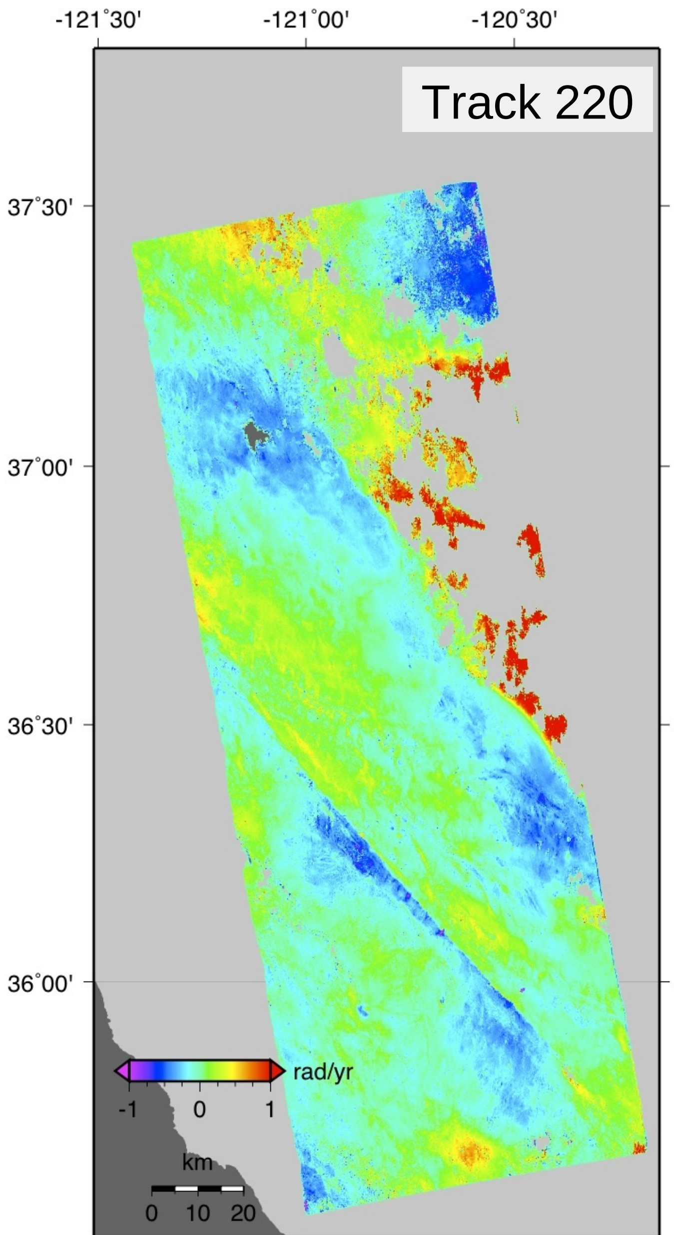


- At left are two stacks of 3 x 2.5 year interfs, scaled to yearly rate
- L-Band provides excellent coherence, even for 2.5 years, over the creeping section.
- Can just begin to make out ~0.3 rad/yr creep signal in ascending interfs.
- More pairs will allow better separation from atmosphere.
- Descending data would show SAF creep very clearly and completely.

Central California – San Andreas fault creep

UC Berkeley Active Tectonics Group

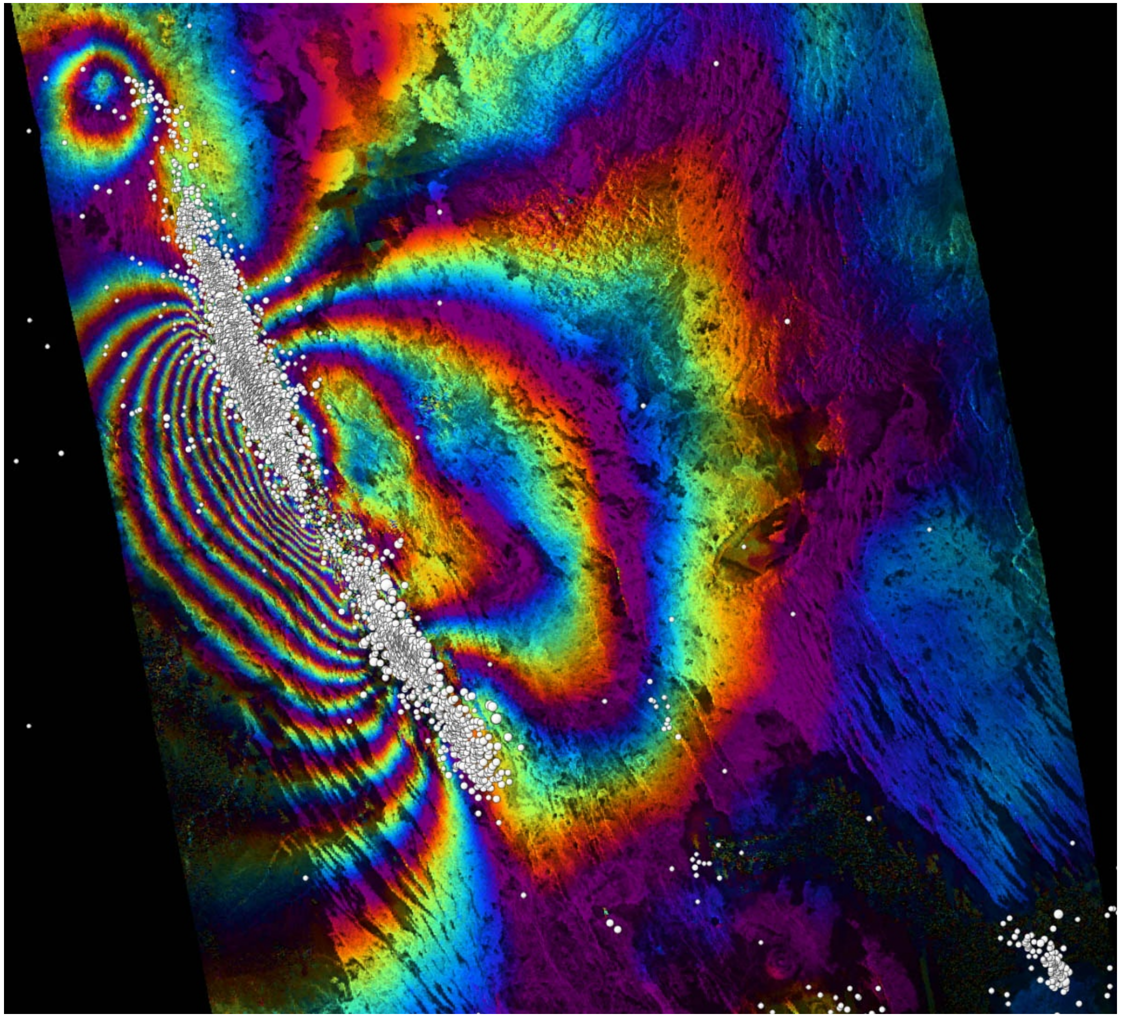




- At left are two stacks of 3 x 2.5 year interfs, scaled to yearly rate
- L-Band provides excellent coherence, even for 2.5 years, over the creeping section.
- Can just begin to make out ~0.3 rad/yr creep signal in ascending interfs.
- More pairs will allow better separation from atmosphere.
- Descending data would show SAF creep very clearly and completely.

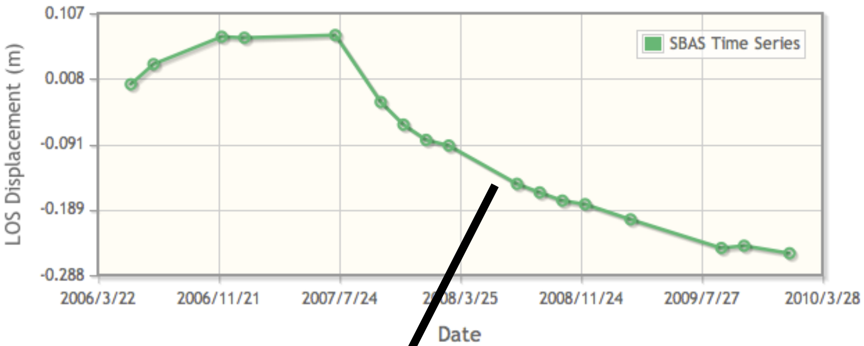
3. Magmatic

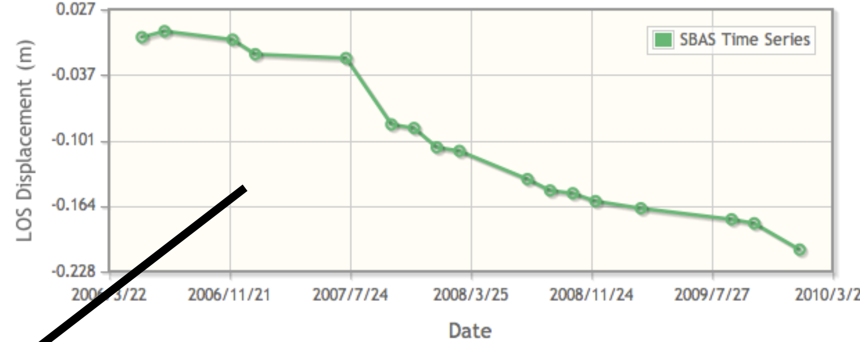
Afar Dike Intrusion (2007/06/12 – 2009/08/02)

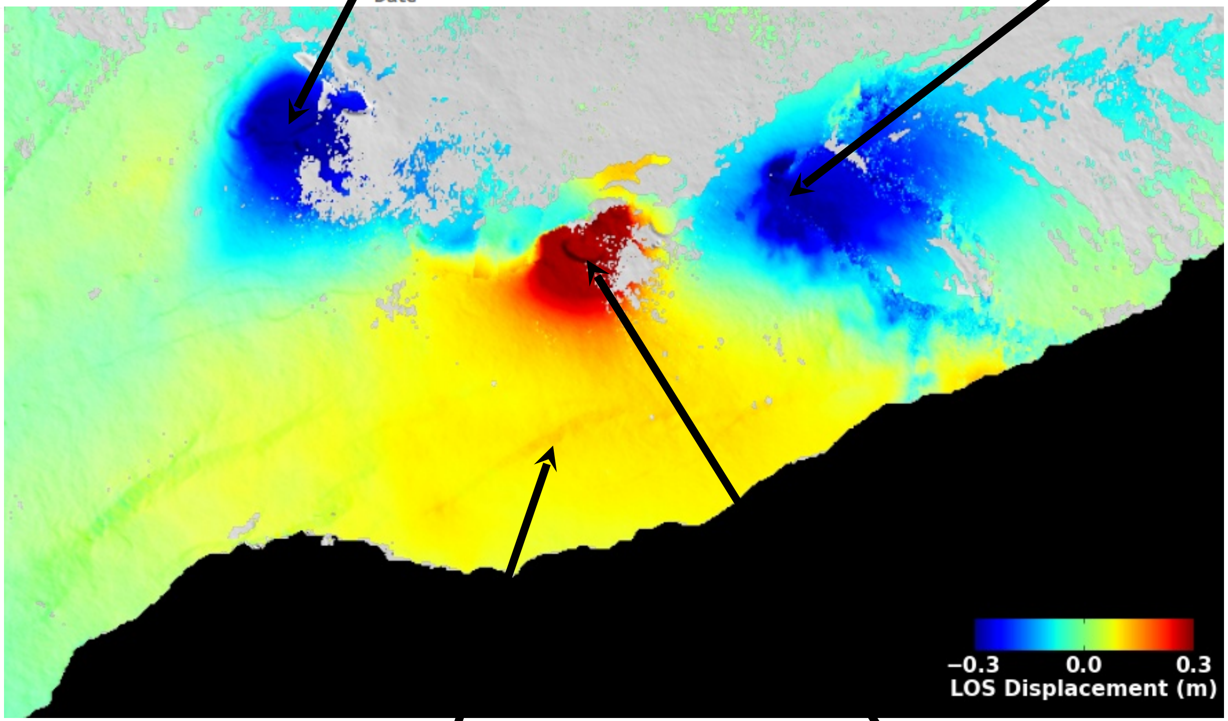


- ALOS PALSAR Interferometry
- Bperp = 500 m
- Swath width = 70 km
- 1 color cycle = 11.8 cm line-of-sight displacement
- Accumulated displacement from 7 major dike intrusion events
- Data critical for dike imaging with joint inversion of seismicity and InSAR (Segall and Yun, 2005)

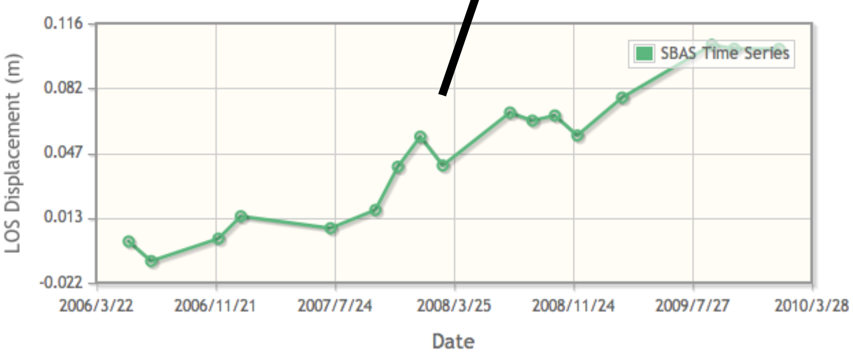
Interferogram by Sang-Ho Yun
Seismicity by Manahloh Belachew

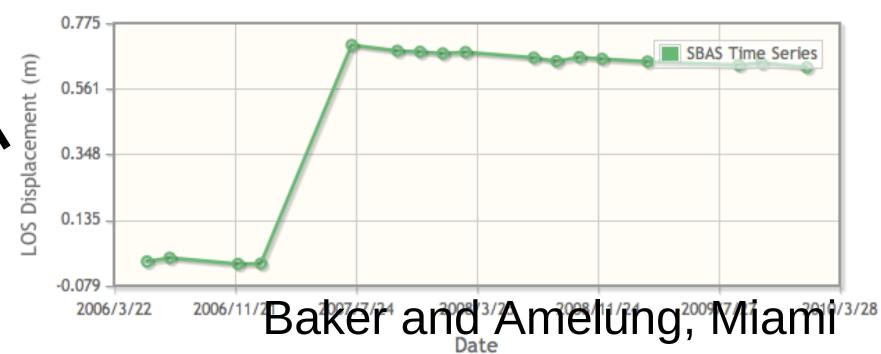




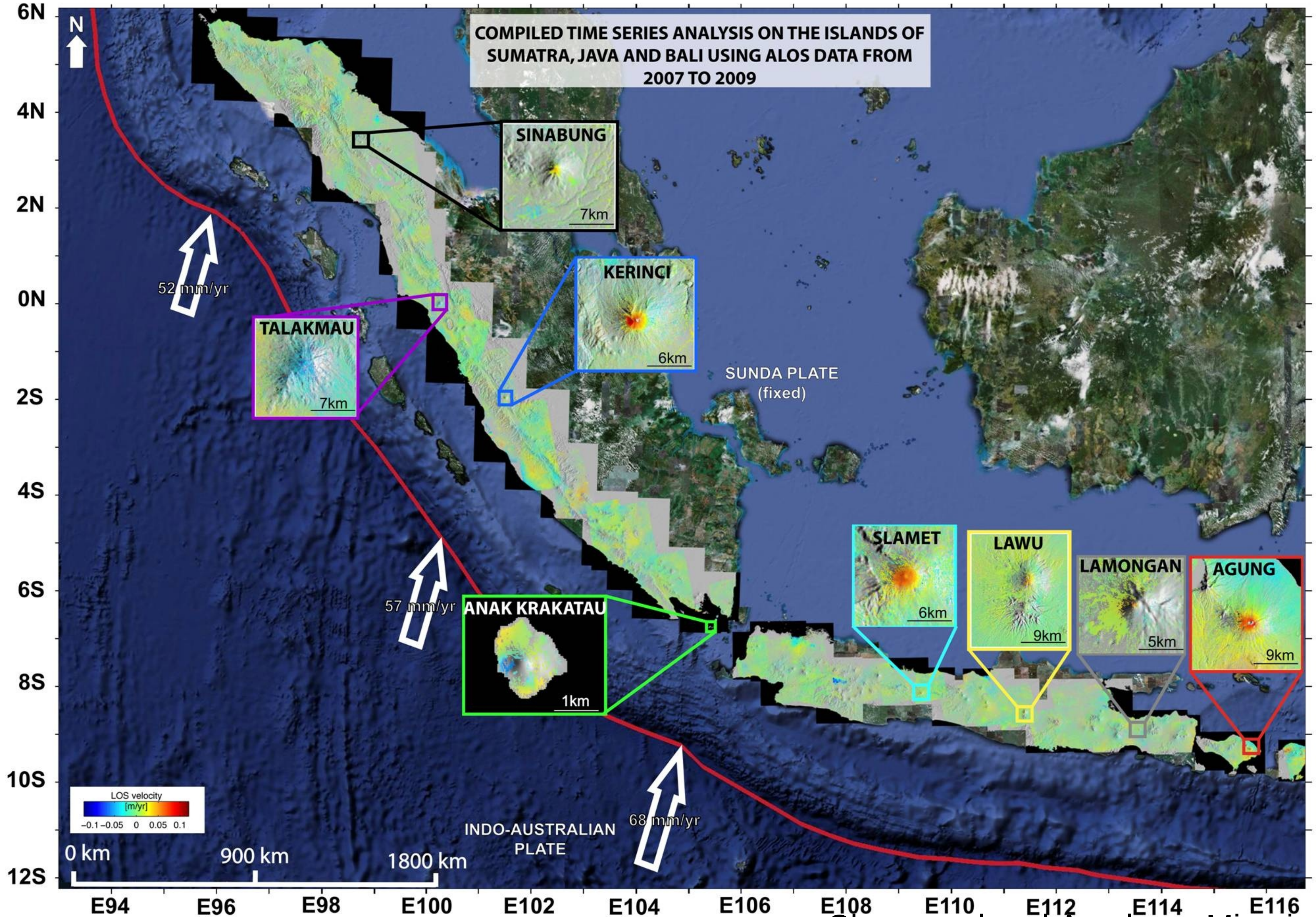


ALOS SBAS Time Series
Ascending Path 291
17 Acquisitions
May 2006 to Jan 2010

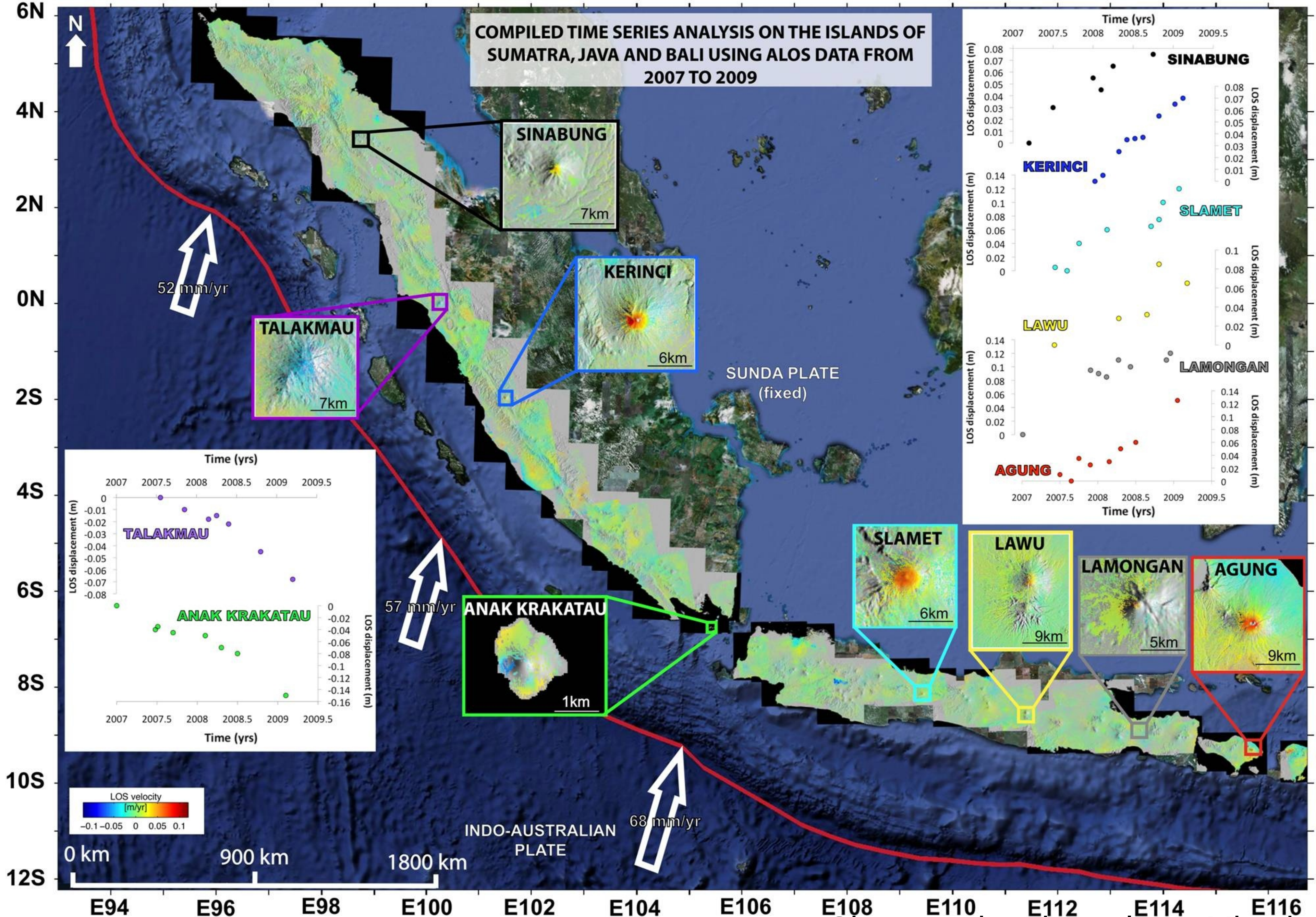




Baker and Amelung, Miami



Chaussard and Amelung, Miami

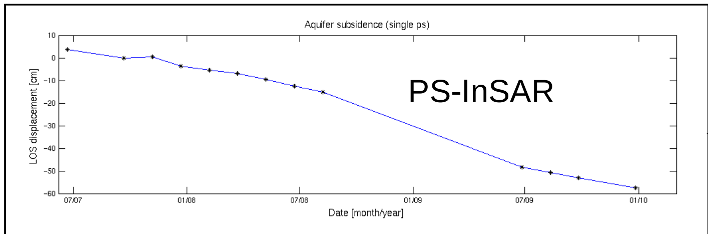


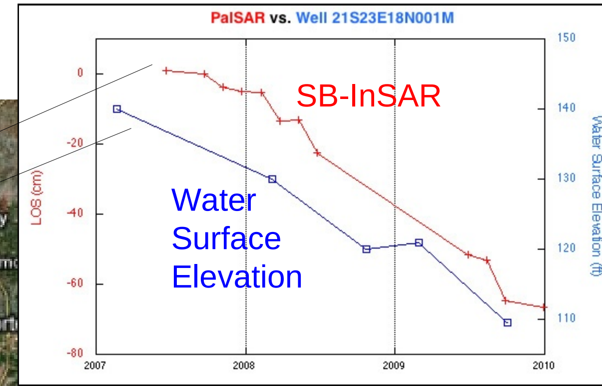
Chaussard and Amelung, Miami

4. Subsidence, Landslides

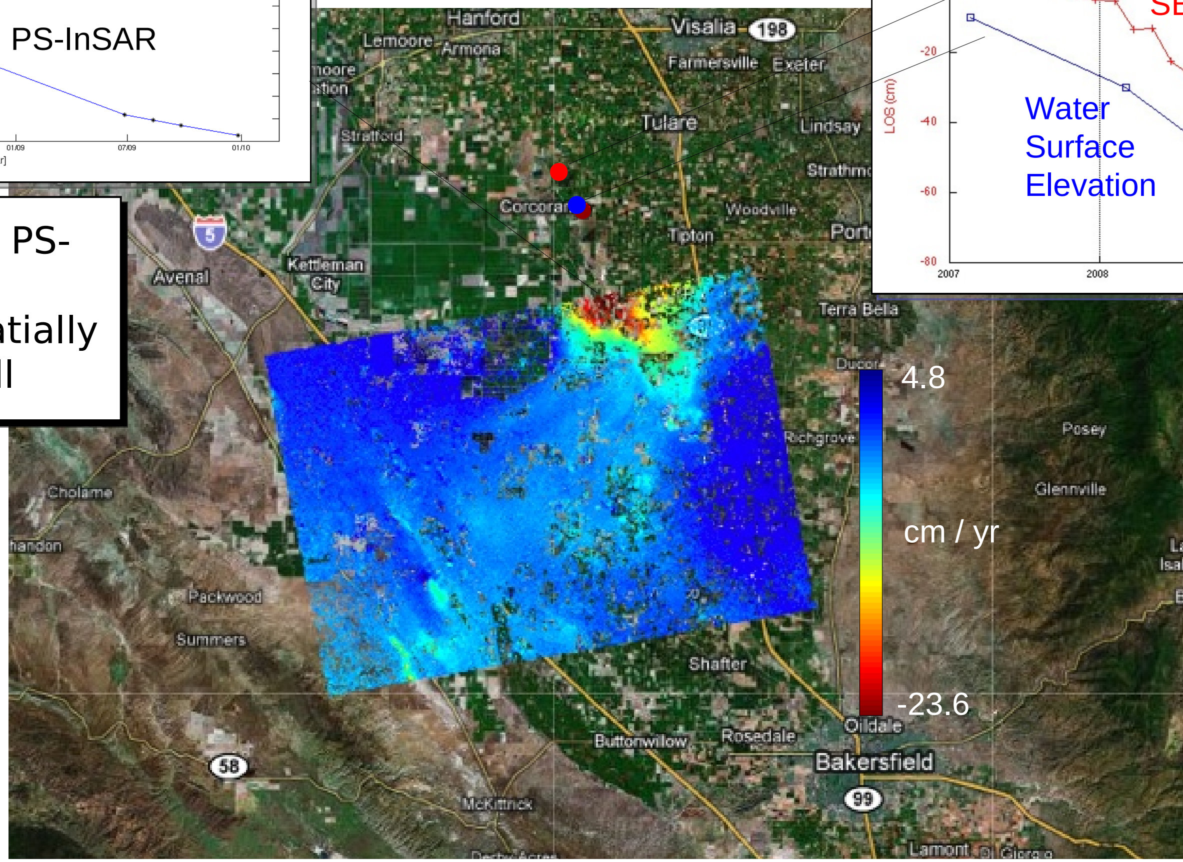
ALOS PS-InSAR Time Series Analysis

Central California (June 2007 – December 2009)





Both SB-InSAR and PS-InSAR data are temporally and spatially correlated with well data

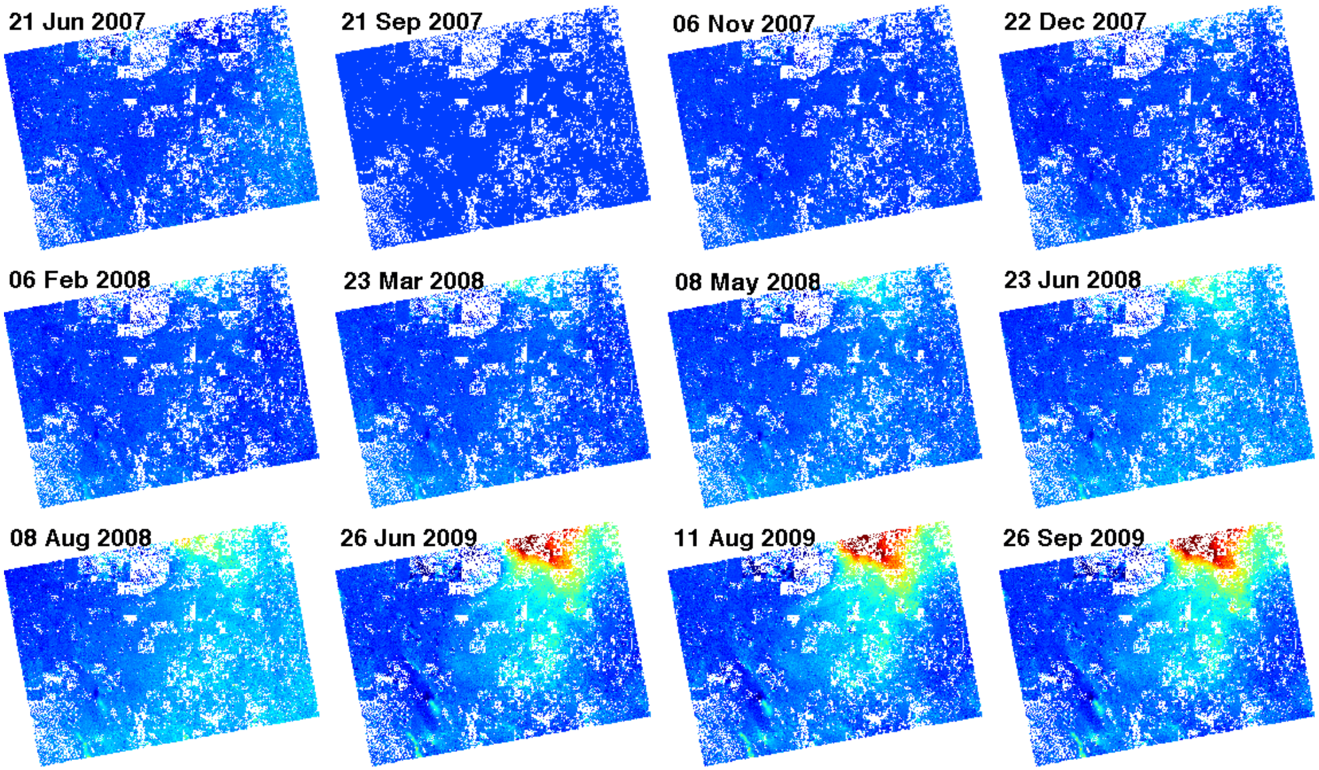


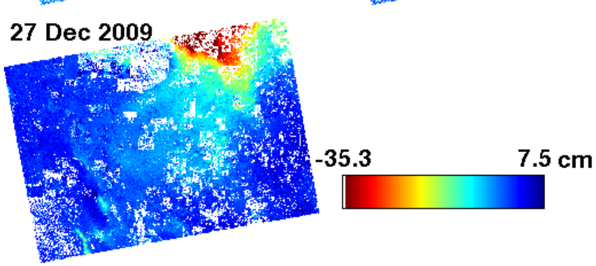
PS-InSAR by Bekaert, Yun, Hooper

SB-InSAR by Lundgren

ALOS PS-InSAR Time Series Analysis

Central California (June 2007 – December 2009)

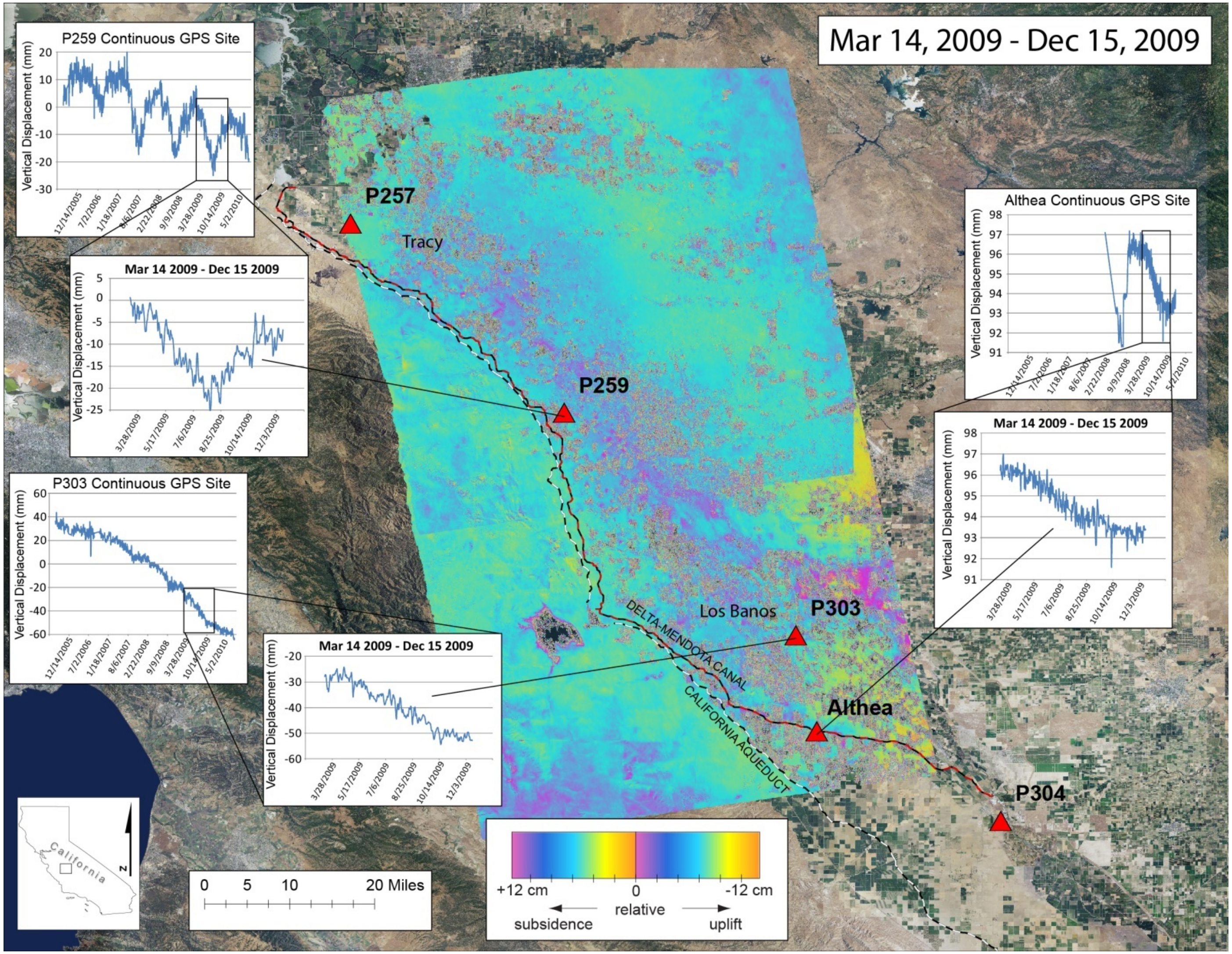




All interferograms show accumulated line-of-sight displacement (34.3 degrees off from vertical) relative to the one on 21 Sep 2007.

Land subsidence in Central California

276 Day L-band (ALOS)

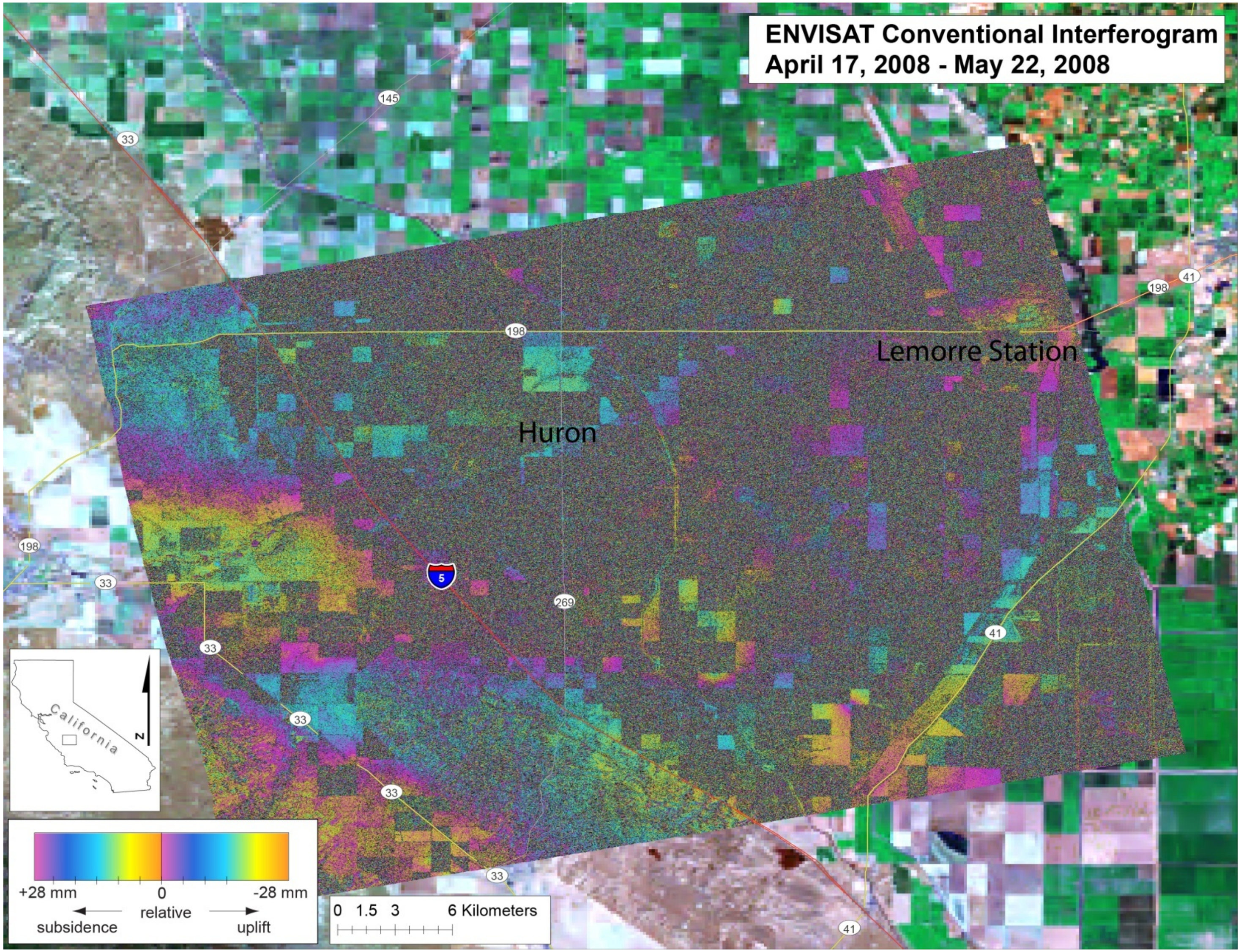


*Preliminary: Subject to revision

Brandt and Bawden, USGS

Land subsidence in Central California

35 Day C-Band (ENVISAT)



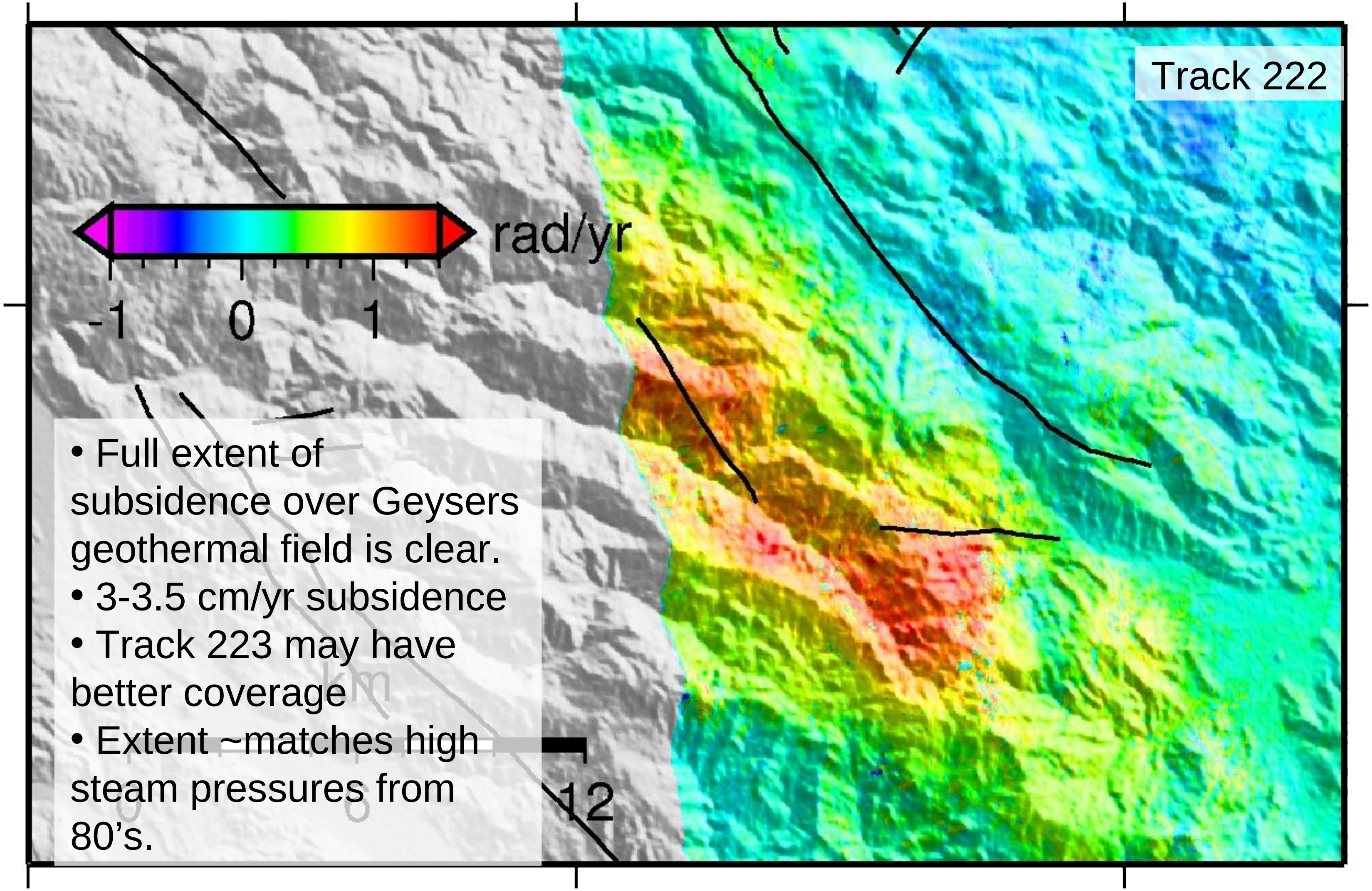
Subsidence studies would not be possible without L-Band imagery due to significantly lower coherence of C-Band imagery

*Preliminary: Subject to revision

Brandt and Bawden, USGS

Geysers Geothermal Field Subsidence

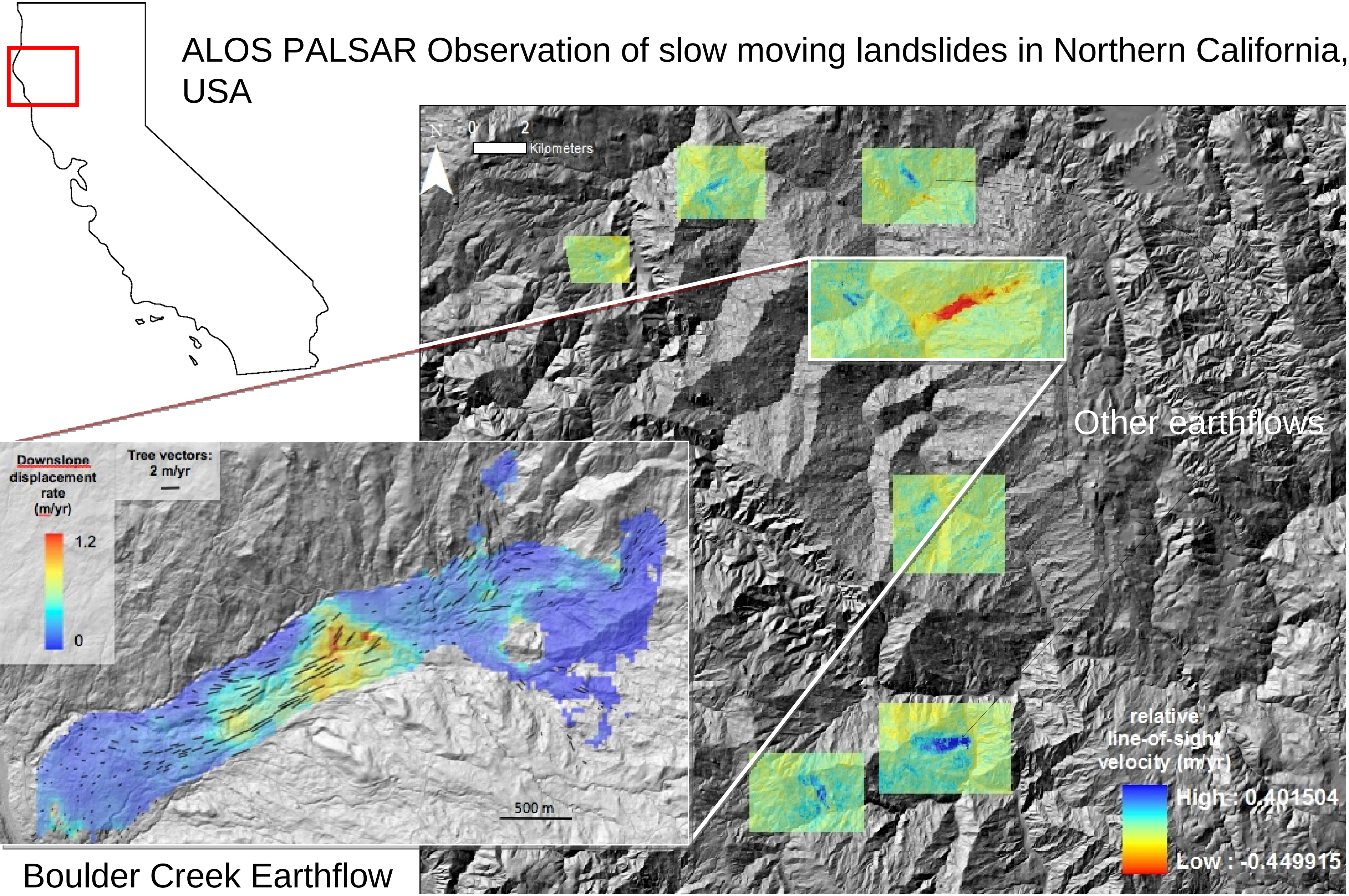
UC Berkeley Active Tectonics Group



• Full extent of subsidence over Geysers geothermal field is clear.
• 3-3.5 cm/yr subsidence
• Track 223 may have better coverage
• Extent ~matches high steam pressures from 80's.

Johannson Burgmann, Berkeley

ALOS PALSAR Observation of slow moving landslides in Northern California, USA



Boulder Creek Earthflow

Figure prepared by Al Handwerger

[Roering et al., GRL, 2009]   From the crustal deformation group at the University of Oregon

4. Other activities

- wetlands
- ice
- forrests

Louisiana Wetland Monitoring Using ALOS PALSAR

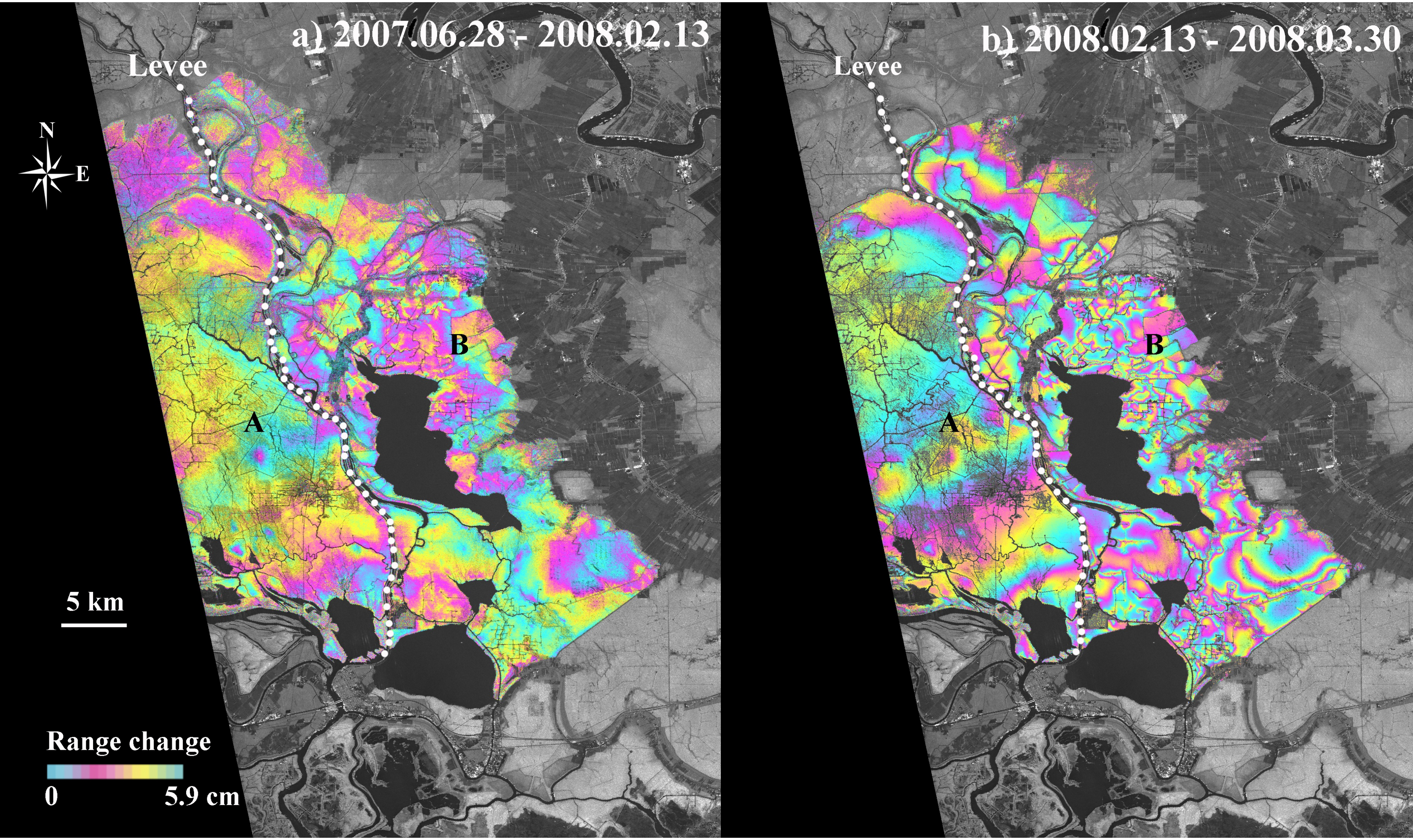
- **Habitat for a variety of wild life**
- **Flood control**
- **Water purification**
- **Shoreline stabilization**
- **Storage of Carbon Dioxide**

Destructed by severe storms and sea level rise

__Kim, J__., Z. Lu, H. Lee, C. Shum, C. Swarzenski, T. Doyle, S. Baek, Integrated Analysis of PALSAR/Radarsat-1 InSAR and ENVISAT altimeter for mapping of absolute water level changes in Louisiana wetland, Remote Sens. & Environment, doi:10.1016/j.rse.2009.06.014., 2009.

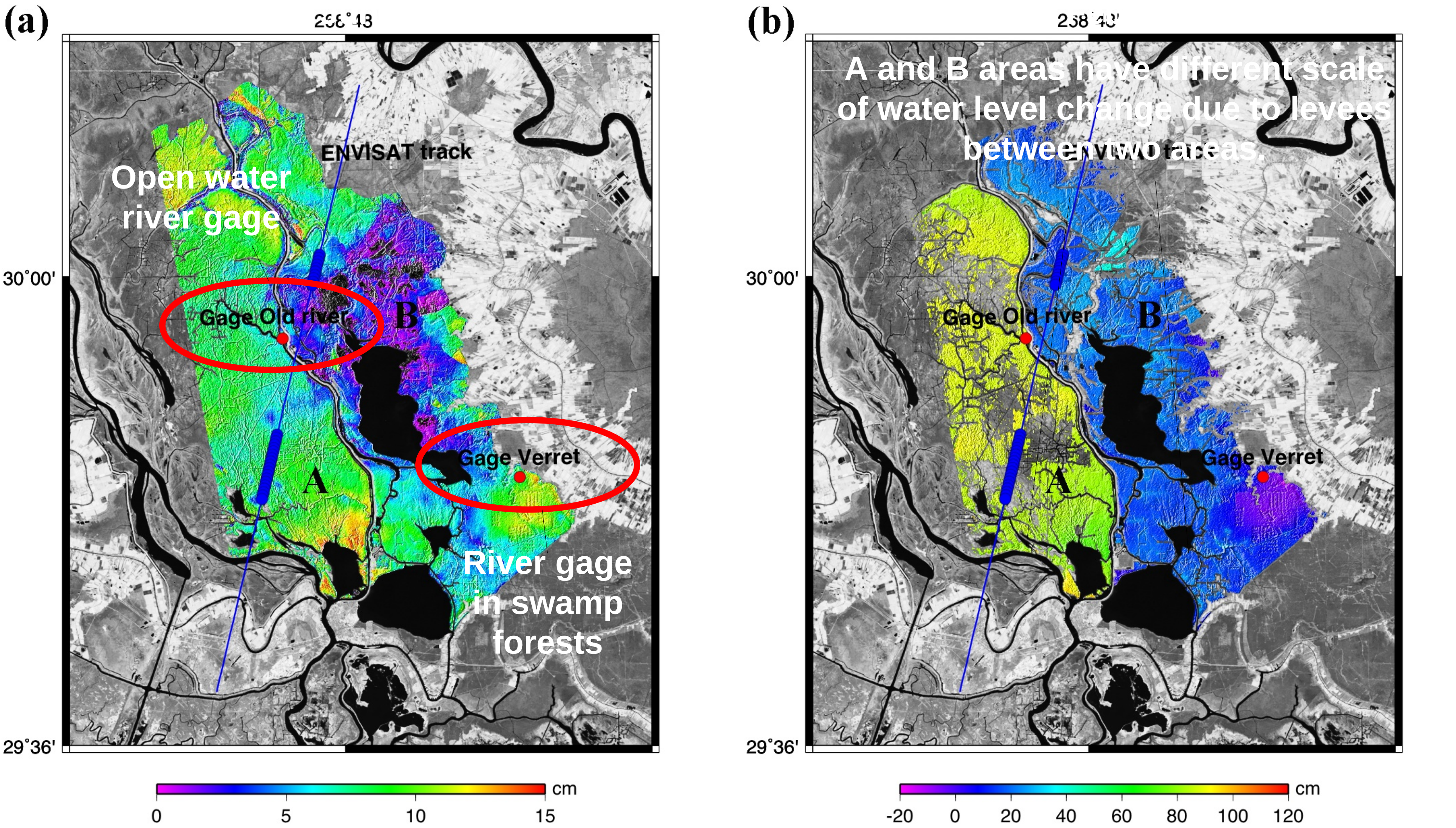
Shum et al, Ohio

Louisiana Wetland water level change from ALOS PALSAR



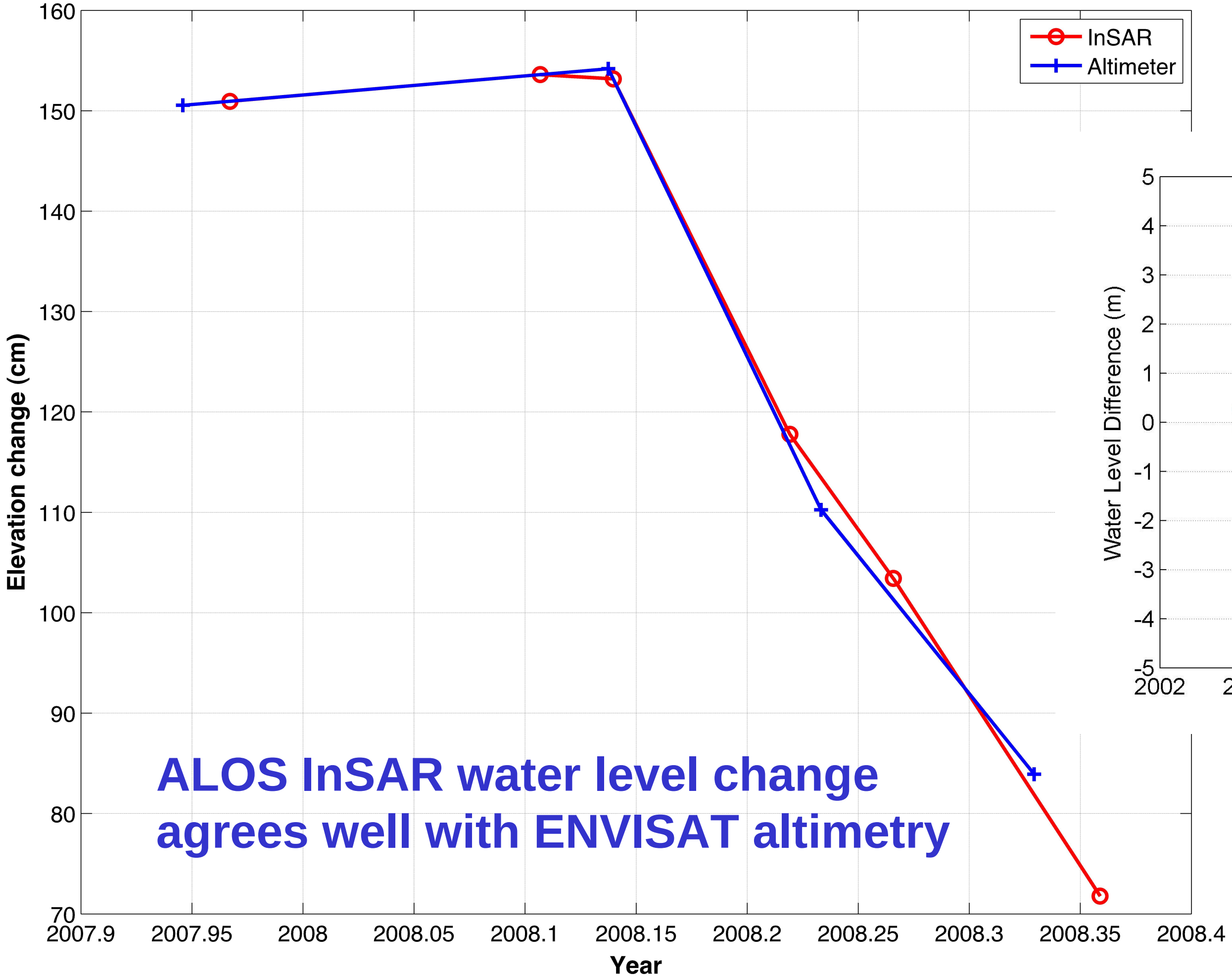
Shum et al, Ohio

Absolute water level change map from ALOS InSAR/Altimeter

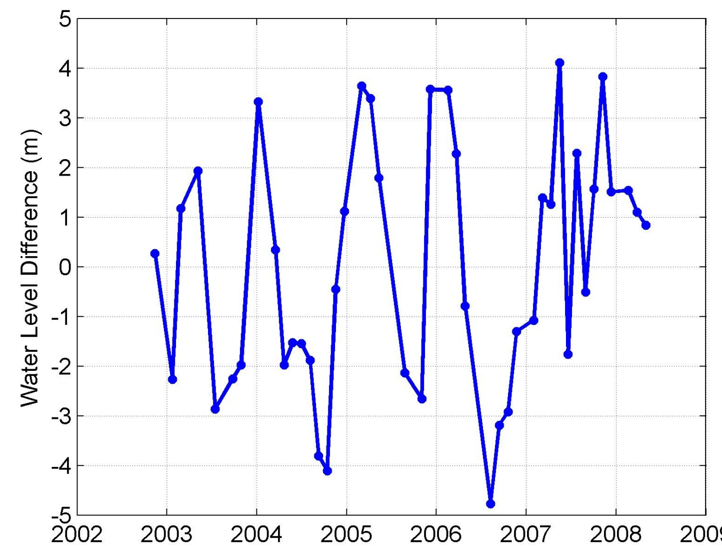


Shum et al, Ohio

Helmand River Water Level: ALOS InSAR vs ENVISAT Altimetry



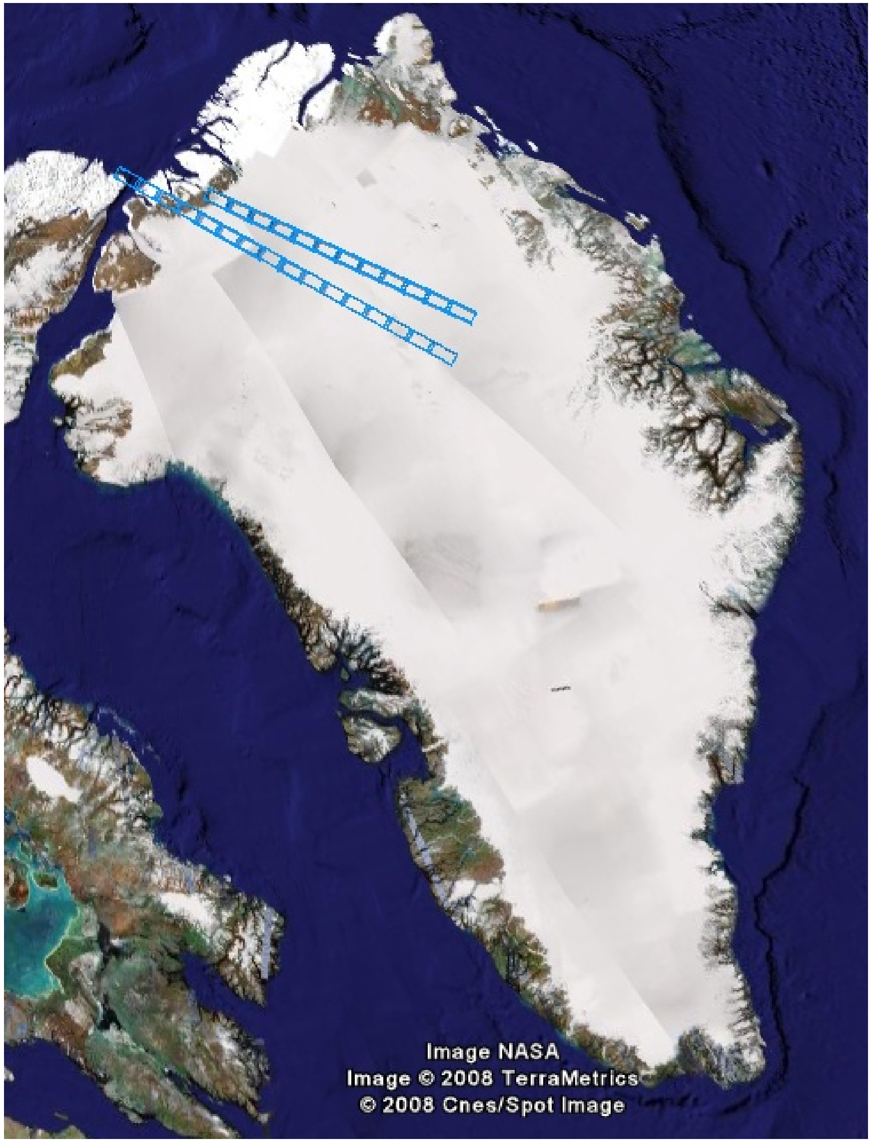
ENVISAT Water Level (2002–2008)



ALOS InSAR water level change agrees well with ENVISAT altimetry

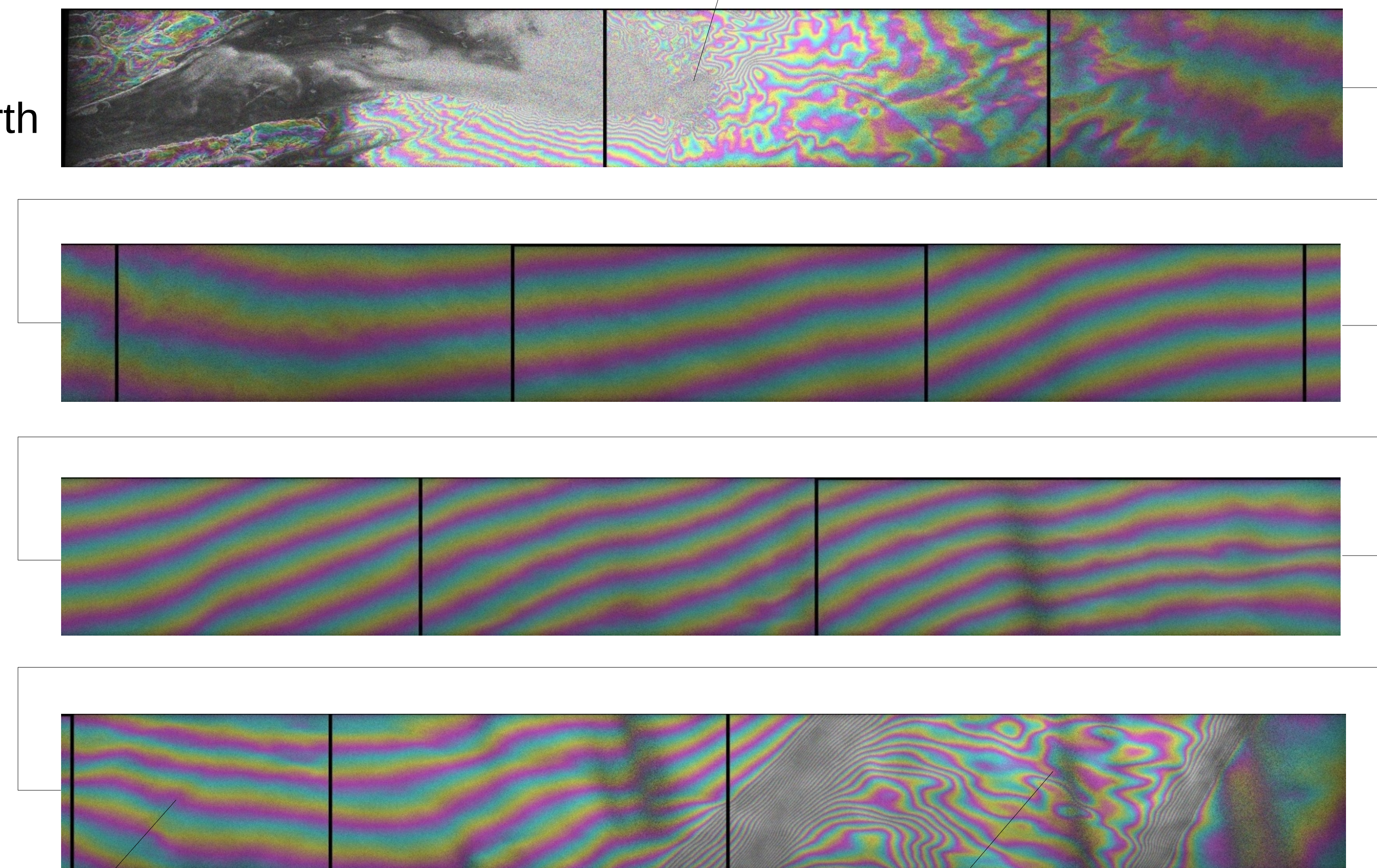
Shum et al, Ohio

Greenland Locations



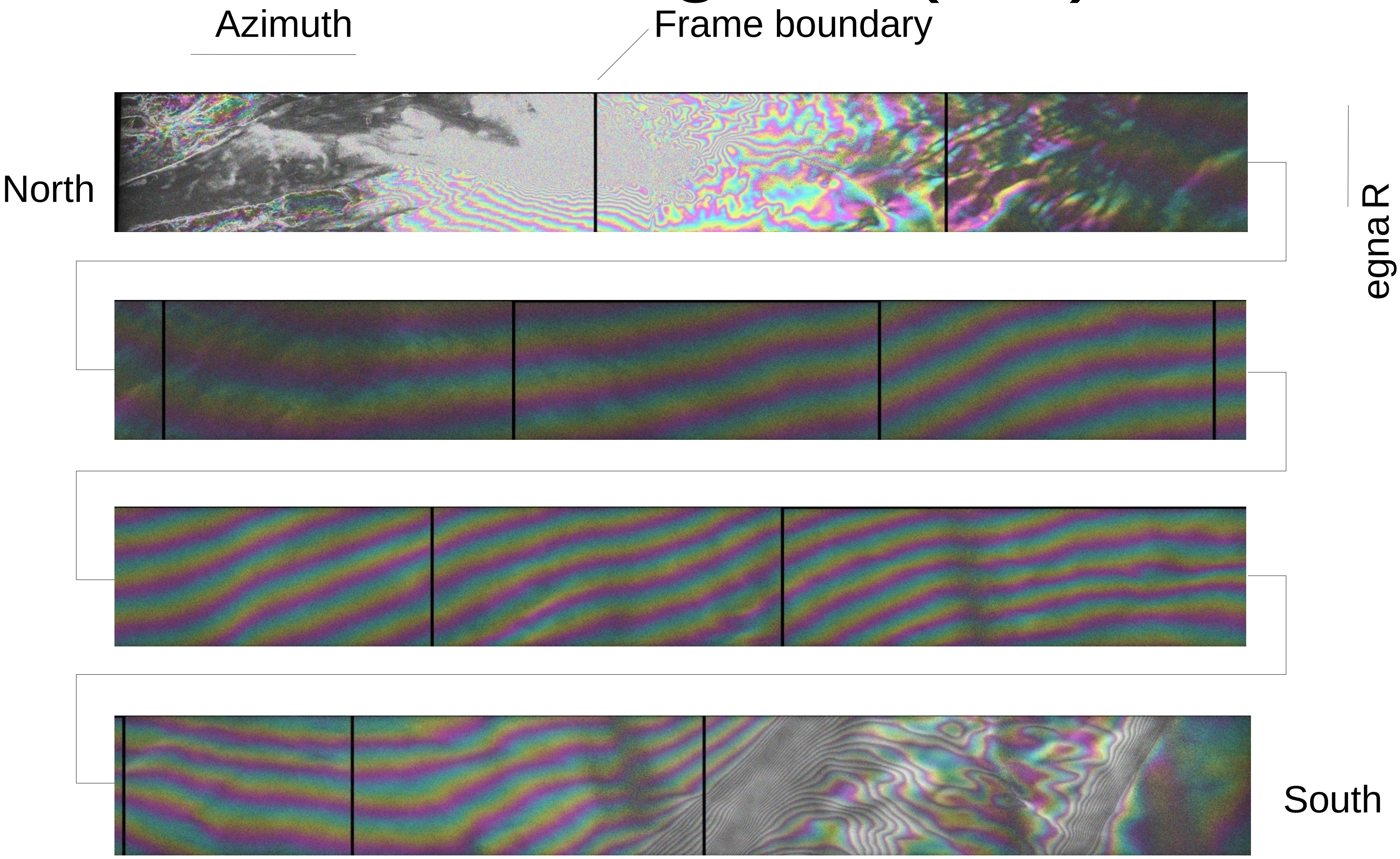
Zebker, Chen, Stanford

Interferogram (HH)



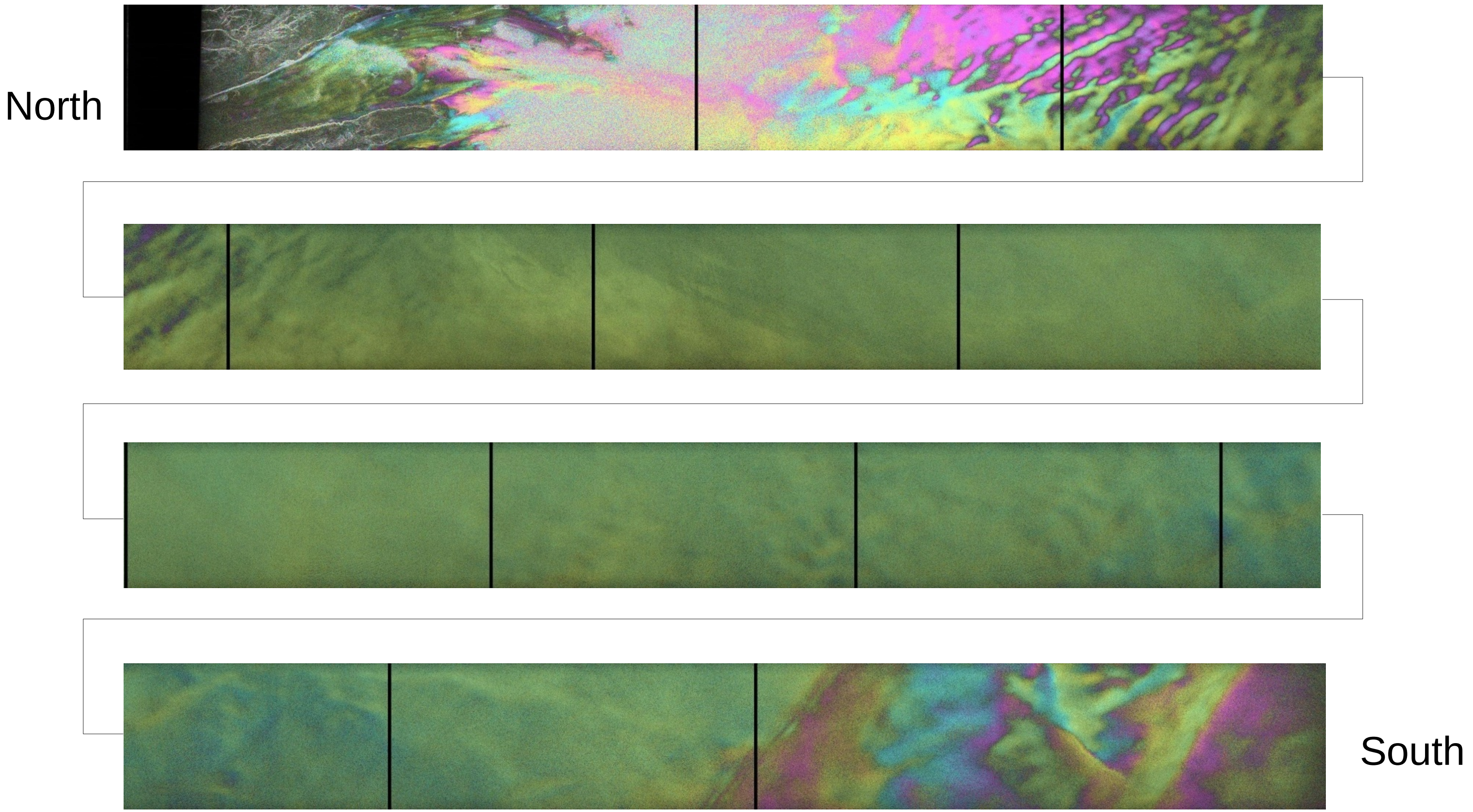
Zebker, Chen, Stanford

Interferogram (HV)



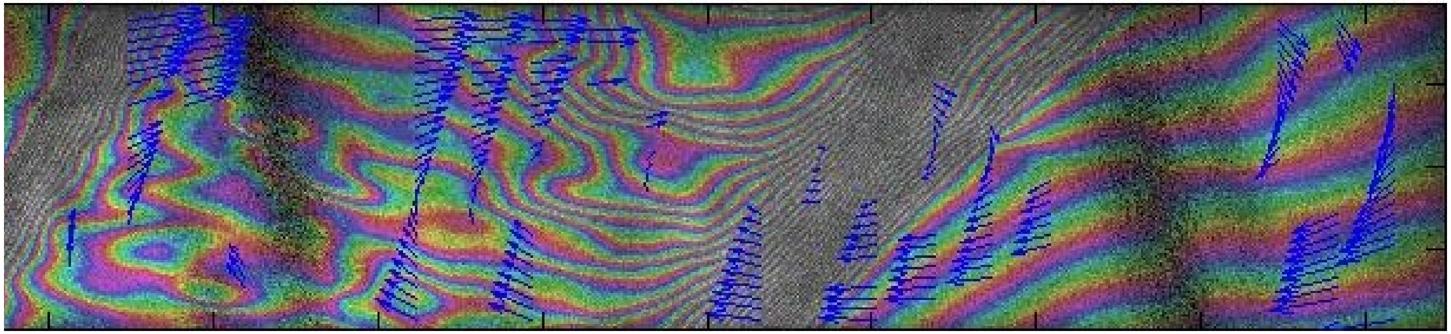
Zebker, Chen, Stanford

Frame 5979 HH-HV phase



Zebker, Chen, Stanford

Image Coregistration Offsets

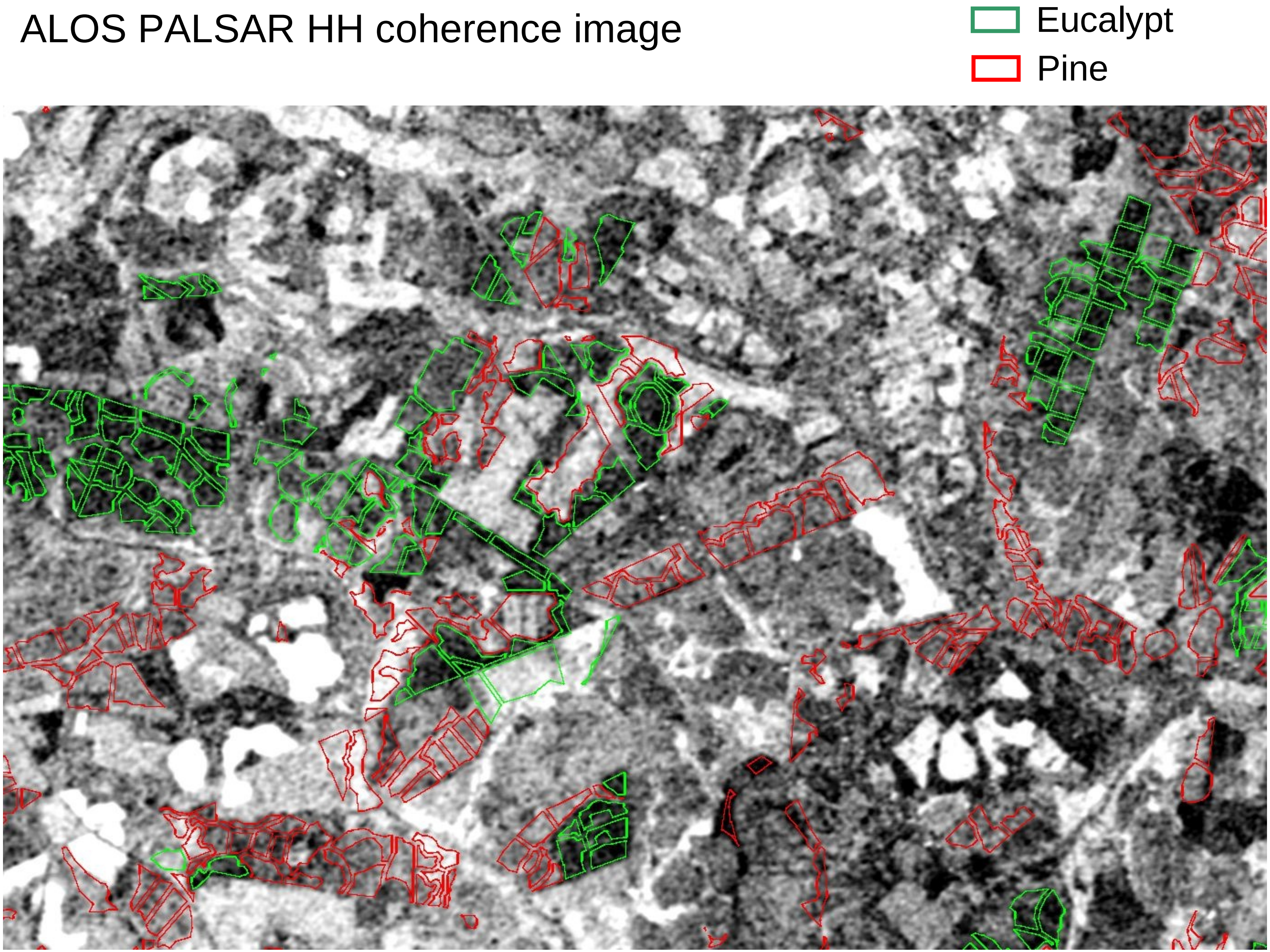


Frame 1550

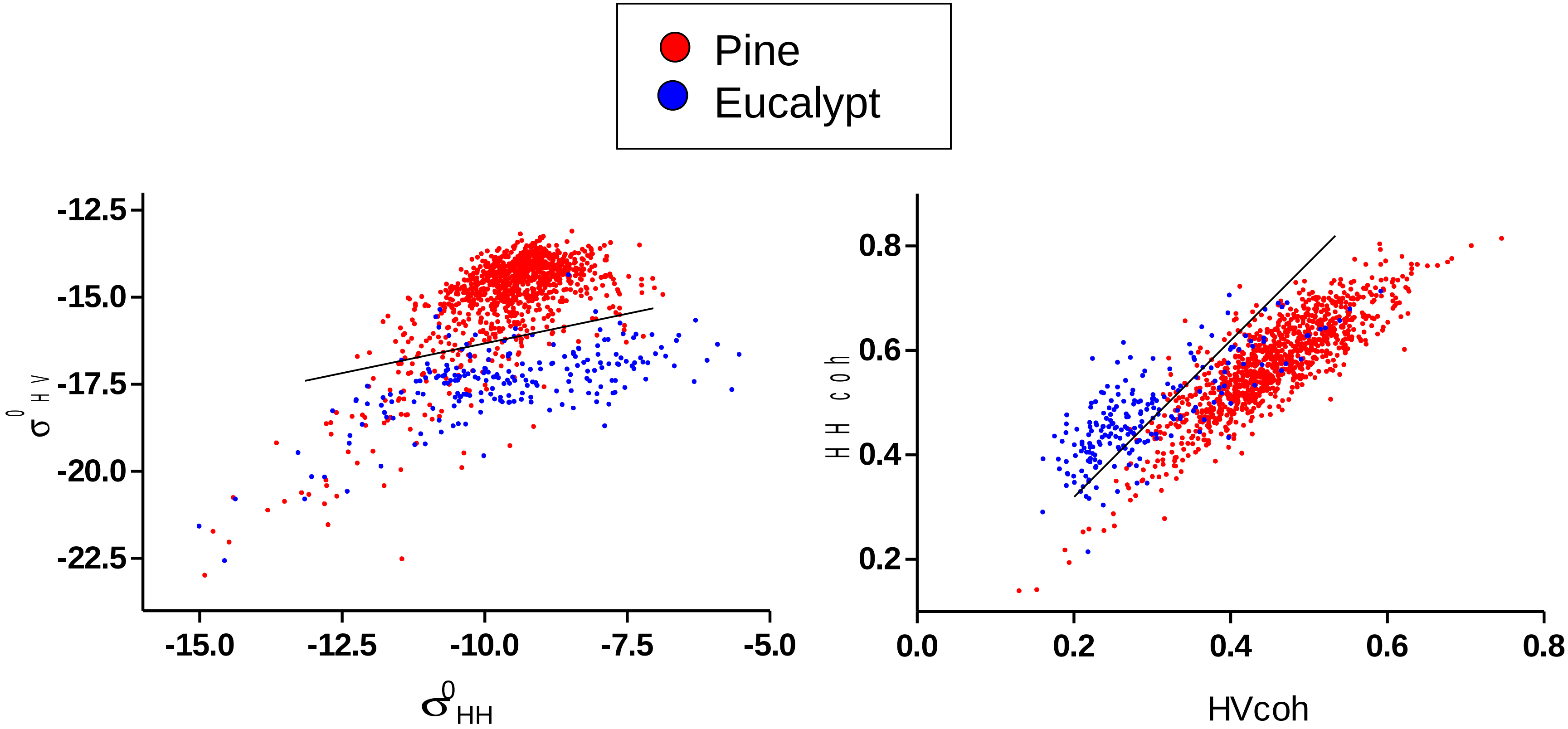
Decorrelation Artifact

- Arrows show offset estimates used to compute best-fit polynomial for offset between master and slave
- mean abs(range_shift) = 0.42
- mean abs(az_shift) = 1.01
- Note decorrelated regions are ignored

ALOS PALSAR HH coherence image



Diego de Abelleyra



RADAR bands

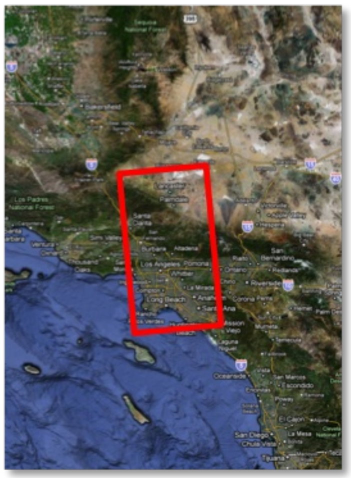
Diego de Abelleyra

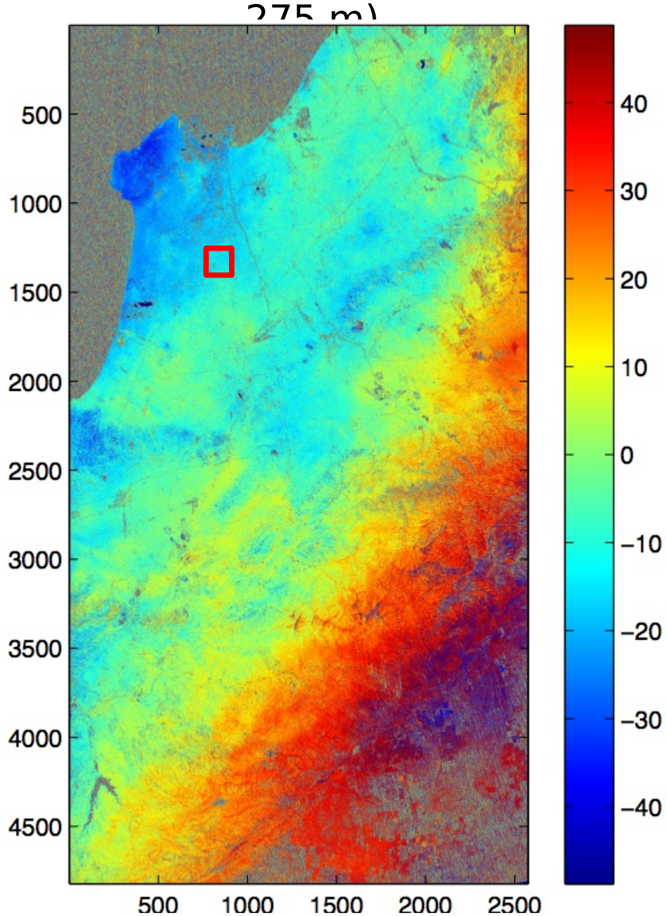
4. Technique development

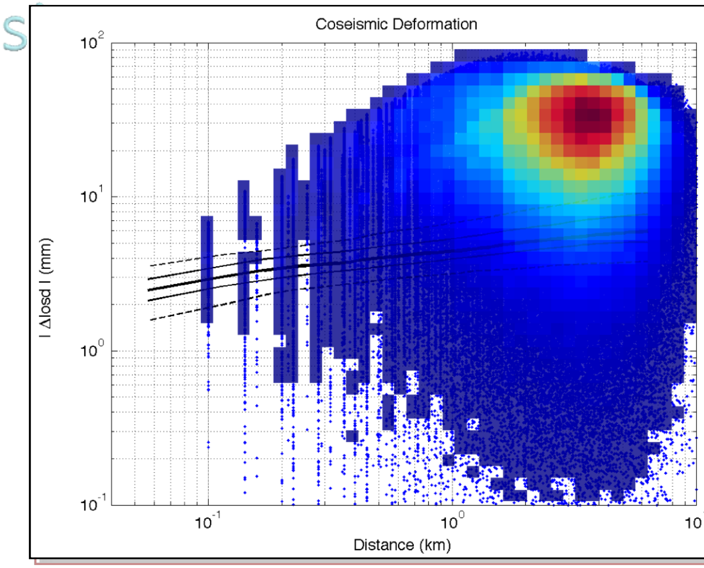
Atmospheric Noise Study

for DESDynI Miss

Zenith delay from ALOS InSAR (2008/11/20 – 2009/01/05, Bp = 275 m)





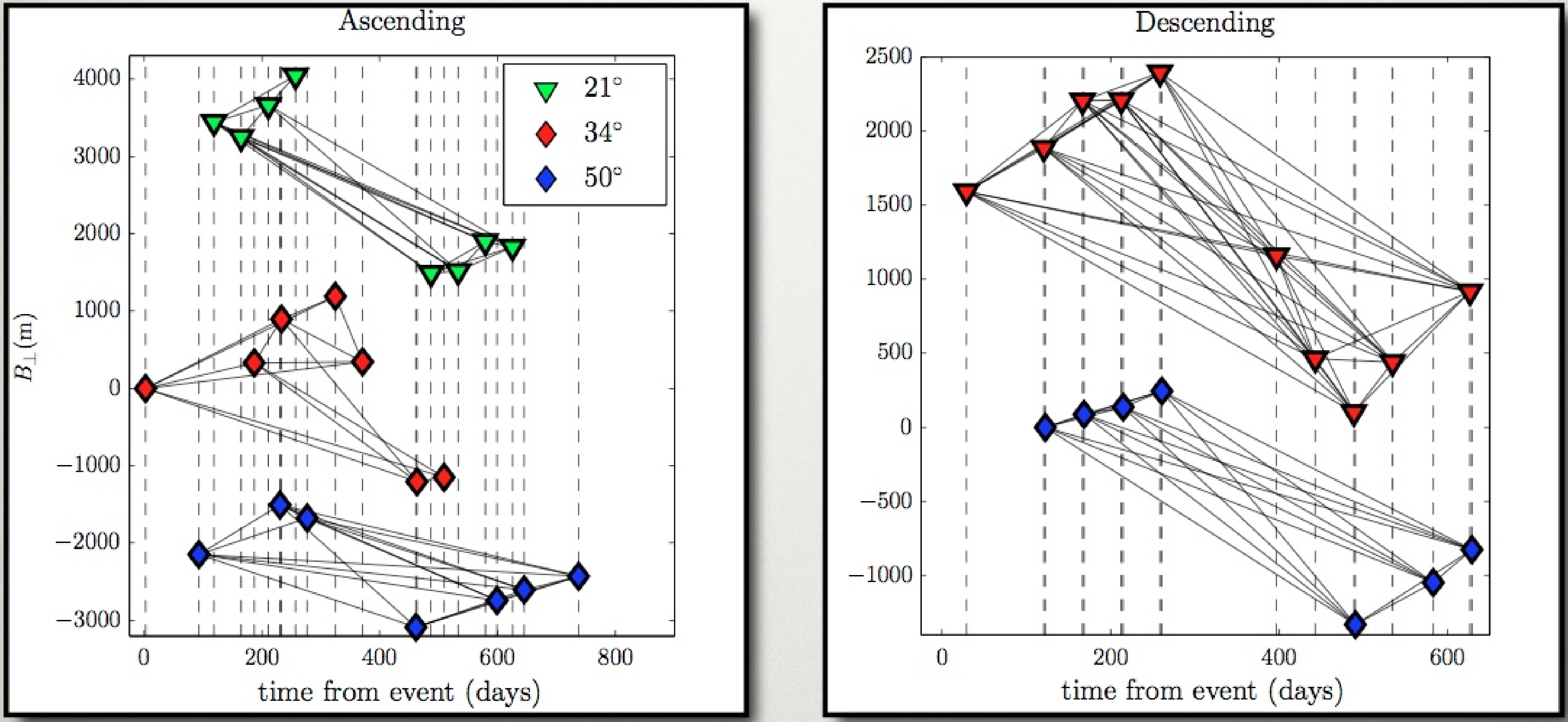


Yun et al., IGARSS 2010

- Tropospheric delay variation is a major source of error.
- Useful for characterizing atmospheric noise
- Error budget analysis for future missions (e.g. DESDynI)

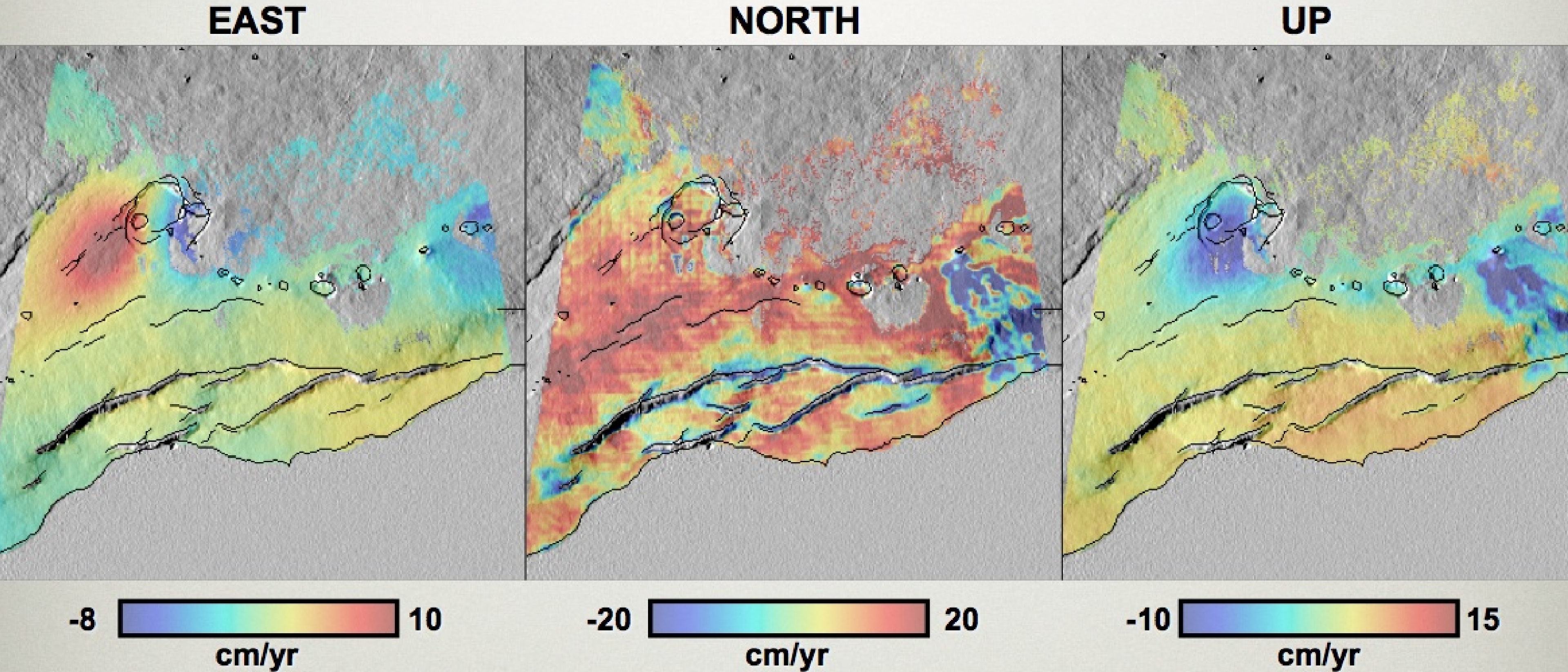
3-D SBAS

ALOS Data



Zebker, Stanford

Interpolated Inversion Results



Zebker, Stanford

Summary

- ALOS-PALSAR ***fantastic*** for earthquake studies (without ALOS we'd know nothing about the Haiti earthquake).
- ALOS-PALSAR ***fantastic*** for volcanoes in tropical areas (could not be studied with C-band) (Hawaii interferometric coherence dissapointing)
- Creep and interseismic deformation studies starting (need longer time series)
- Land subsidence studies in agricultural areas possible (in contrast to C-band)
- Consistent data format is a pleasure!
- Very convenient data access through L-1 data pool at ASF

Recommendation to Audience

Spell out in Recommendations to JAXA:

- Access needed to ASF’s L1 data pool.

Recommendation to JAXA

- Make use of ALOS-1 archive to develop volcano observation plan for Alos-2 (revisit times)
- Provide on-line access to global volcano and tectonic data sets
- Talk about granule download speed instead data policies.

Tomorrows’s breakout session on Supersites:
13:00-15:00, room 312

Thank you, JAXA,
for these wonderful data sets !

… and by the way, please think of us when you launch Alos-2…