GMTSAR Short Course
SIO, August 2015

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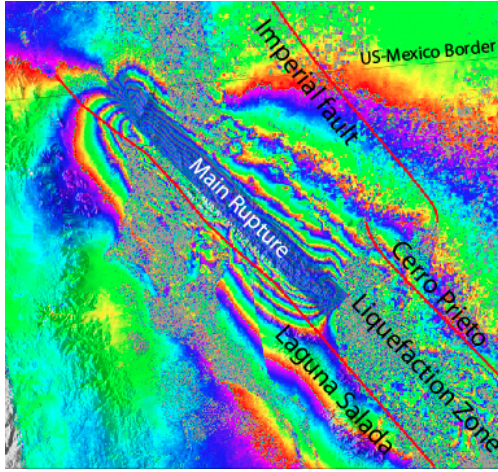
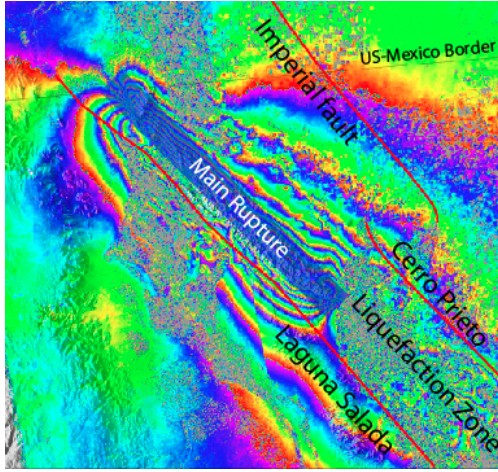


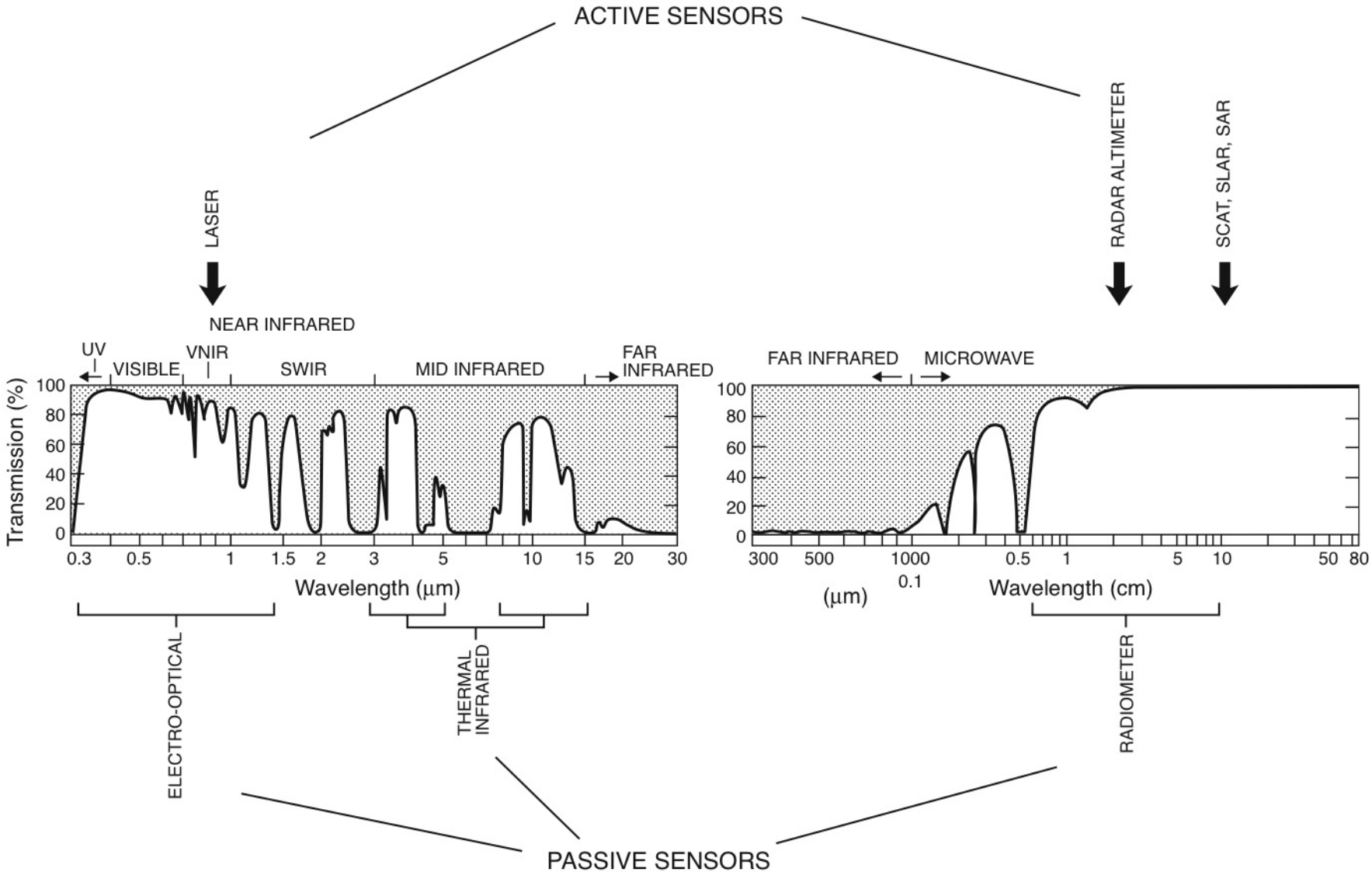
- **Objectives:**
  - run GMT5 and GMT5SAR on your **own** computer
  - understand the principles of SAR and InSAR
  - perform 2-pass InSAR processing on your own computer
  - get data ERS, Envisat, ALOS-1 from UNAVCO and ASF
  - process ERS, Envisat, ALOS-1, TSX, CSK, RS2, S1A, ALOS-2
  - prepare large stacks of interferograms
  - time series

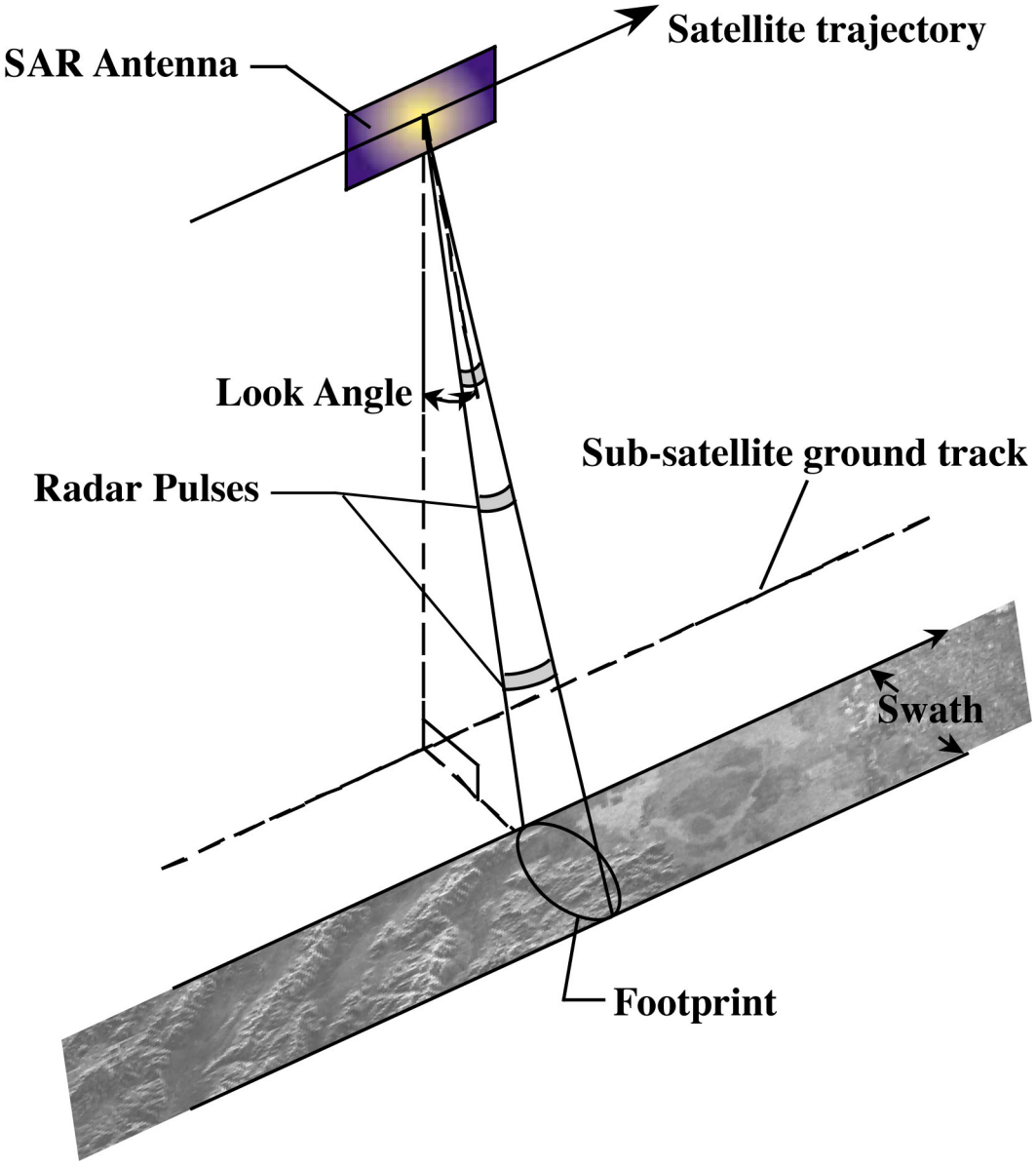
GMTSAR Short Course
OUTLINE



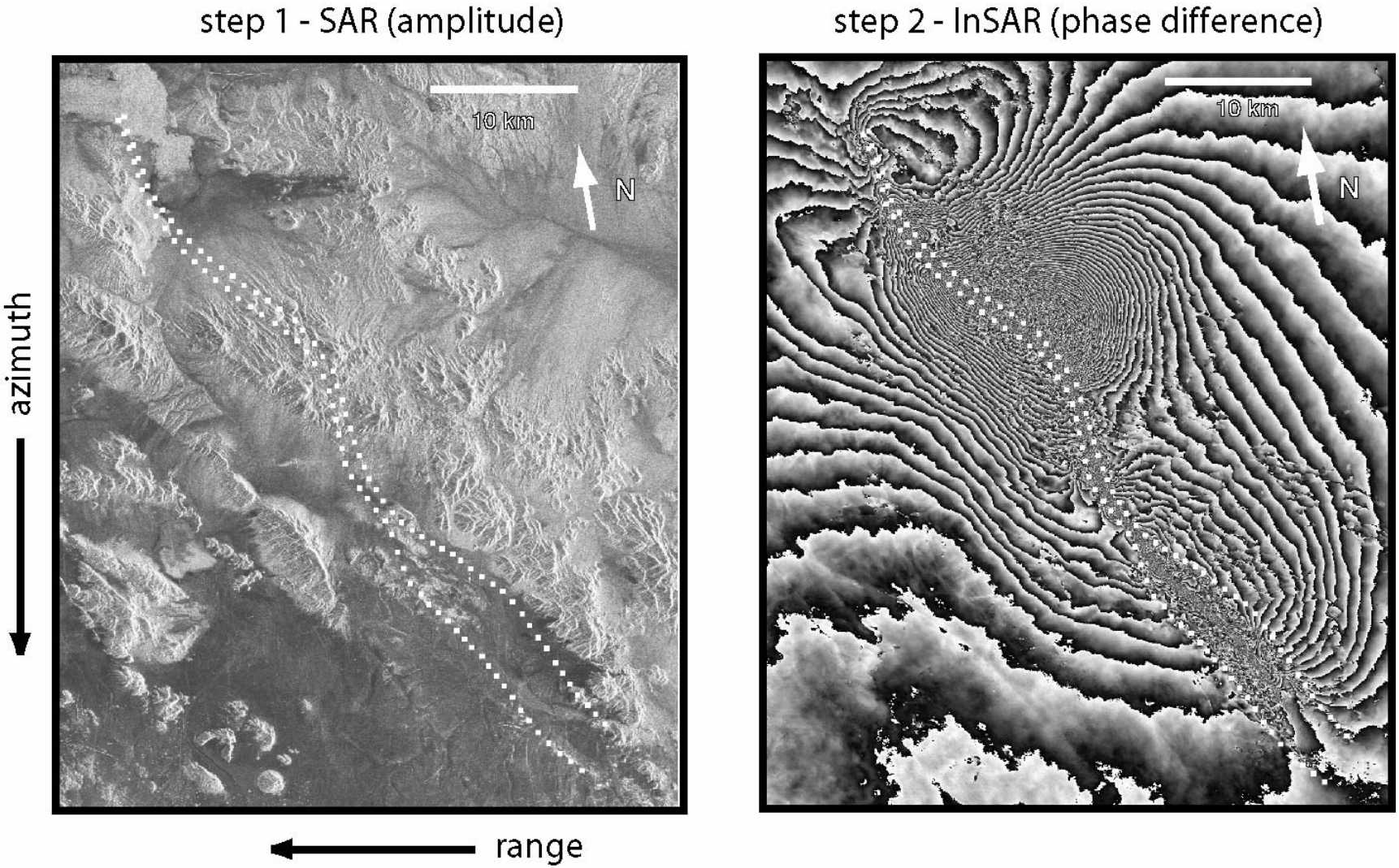
- setup UNIX, GMT, and GMTSAR – test cases
- **overview of SAR, InSAR, and GMTSAR**
- learn to select SAR scenes at UNAVCO and ASF
- SAR and InSAR theory
- GMTSAR overview, modules, standard InSAR processing
- 2-D phase unwrapping
- batch processing
- student presentations of interferograms

passive and active remote sensing – optical and microwave

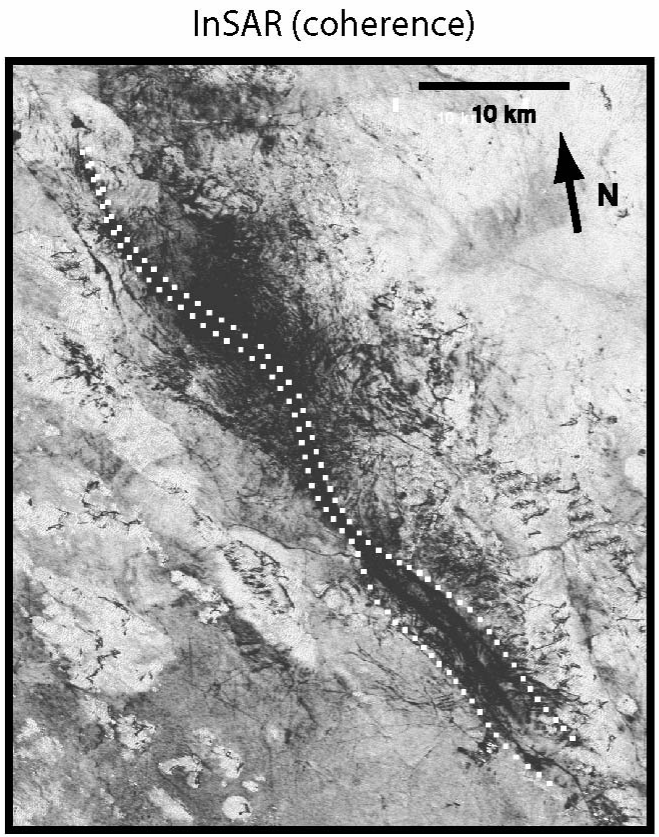


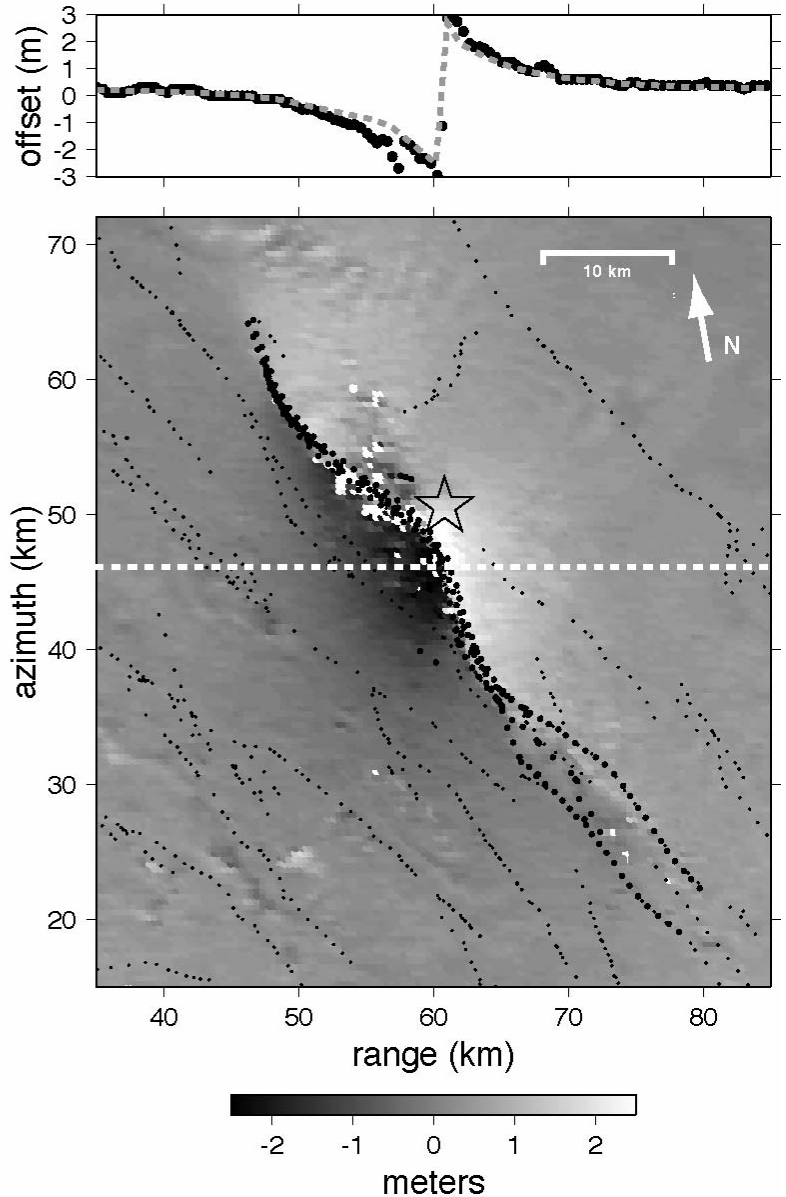

Satellite trajectory
SAR Antenna
Look Angle
Sub-satellite ground track
Radar Pulses
Swath
Footprint

amplitude and phase

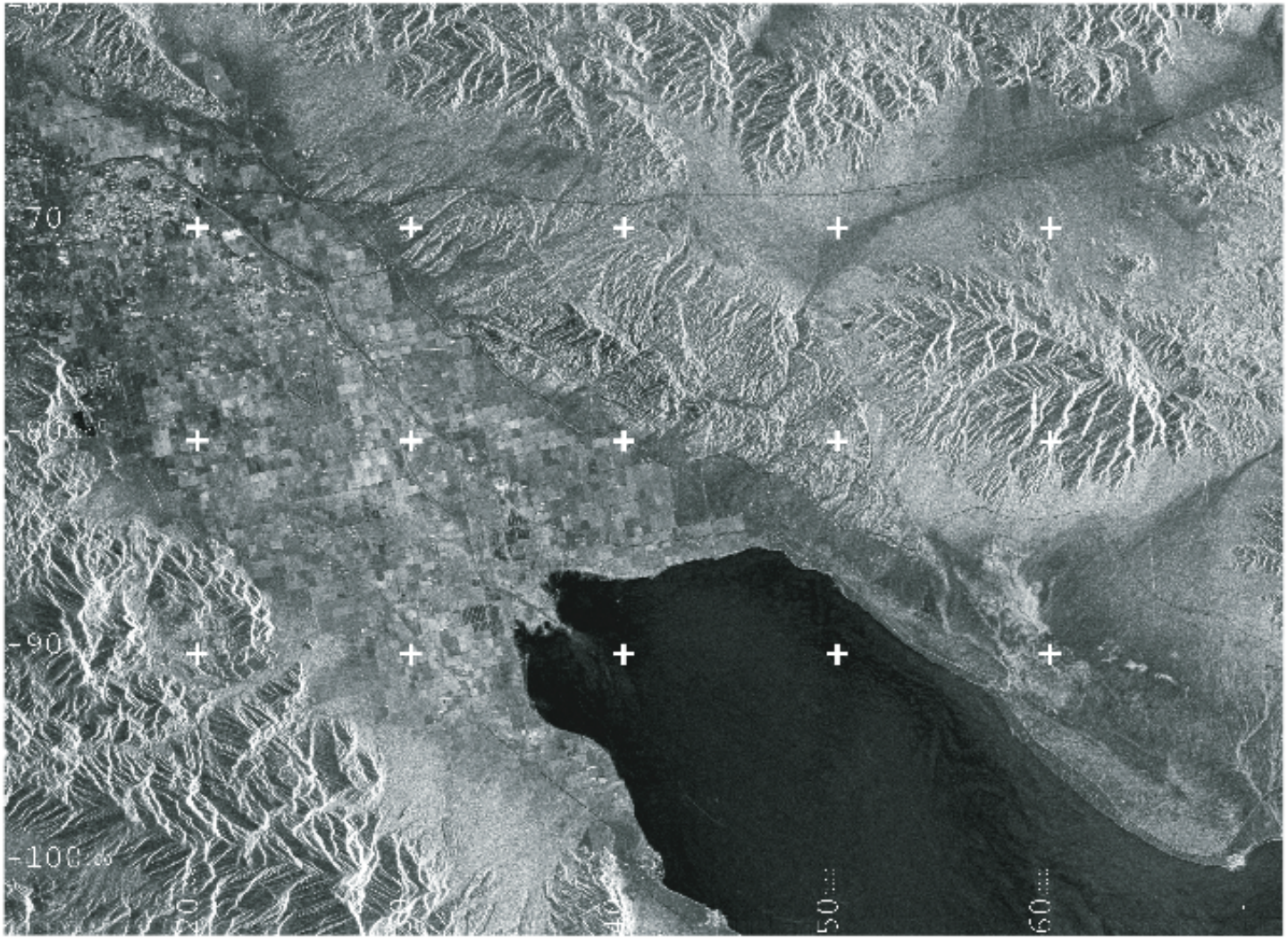


coherence and pixel matching





ERS amplitude image

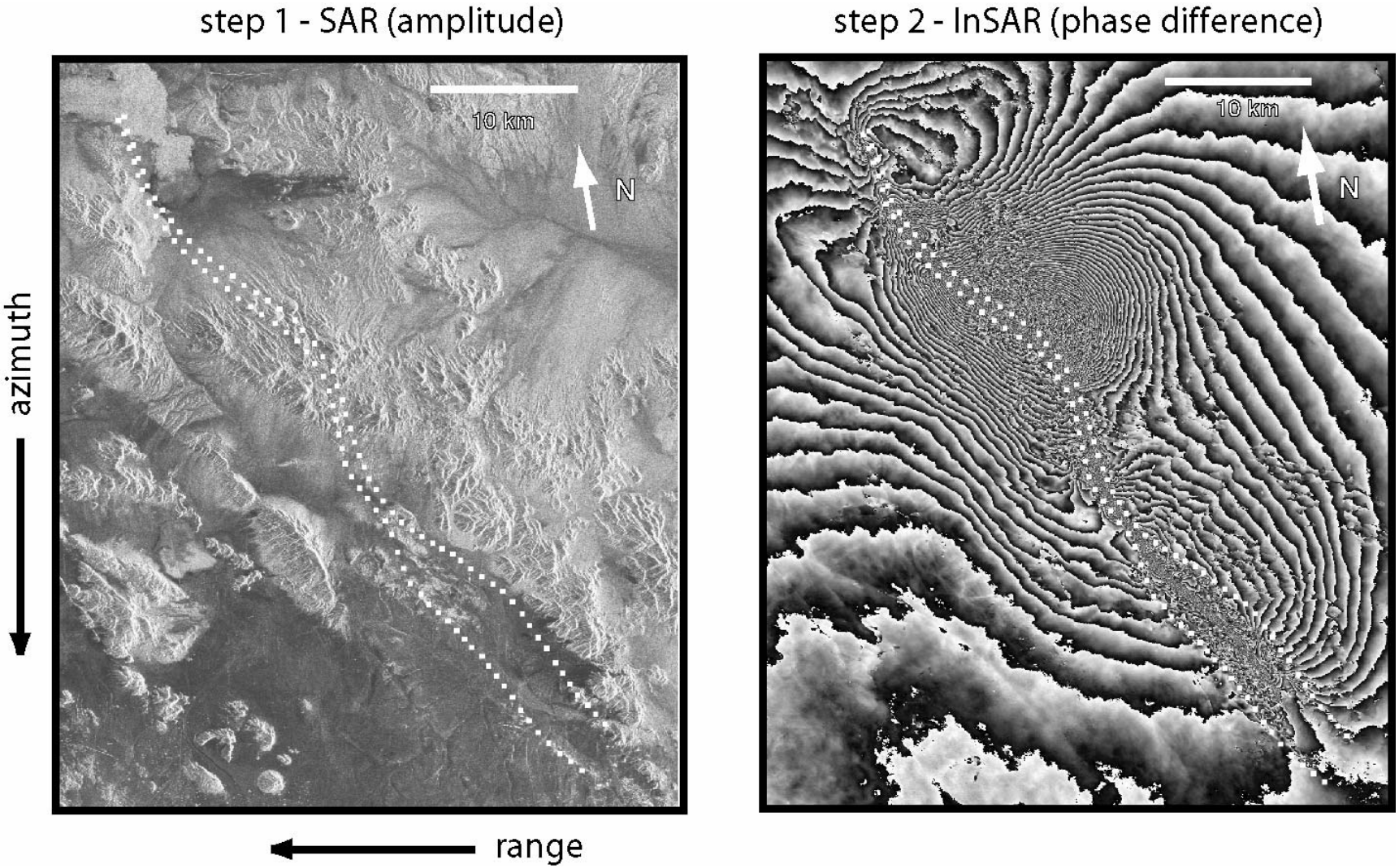


1) This is an image of radar backscatter from a stack of ERS SAR data. The flight path is top to bottom and the radar looks from the right. The area is the Salton Sea and Cochella Valley, and the tic marks are spaced at 10 km. The satellite is 7159717m from the center of the Earth, the local Earth radius is 6371593 m, and the range to the center of the image is 850148 m. Calculate the look angle to the center of the image. Identify areas of layover. What is the minimum mountain slope in the areas of layover? Why is the Salton Sea dark?

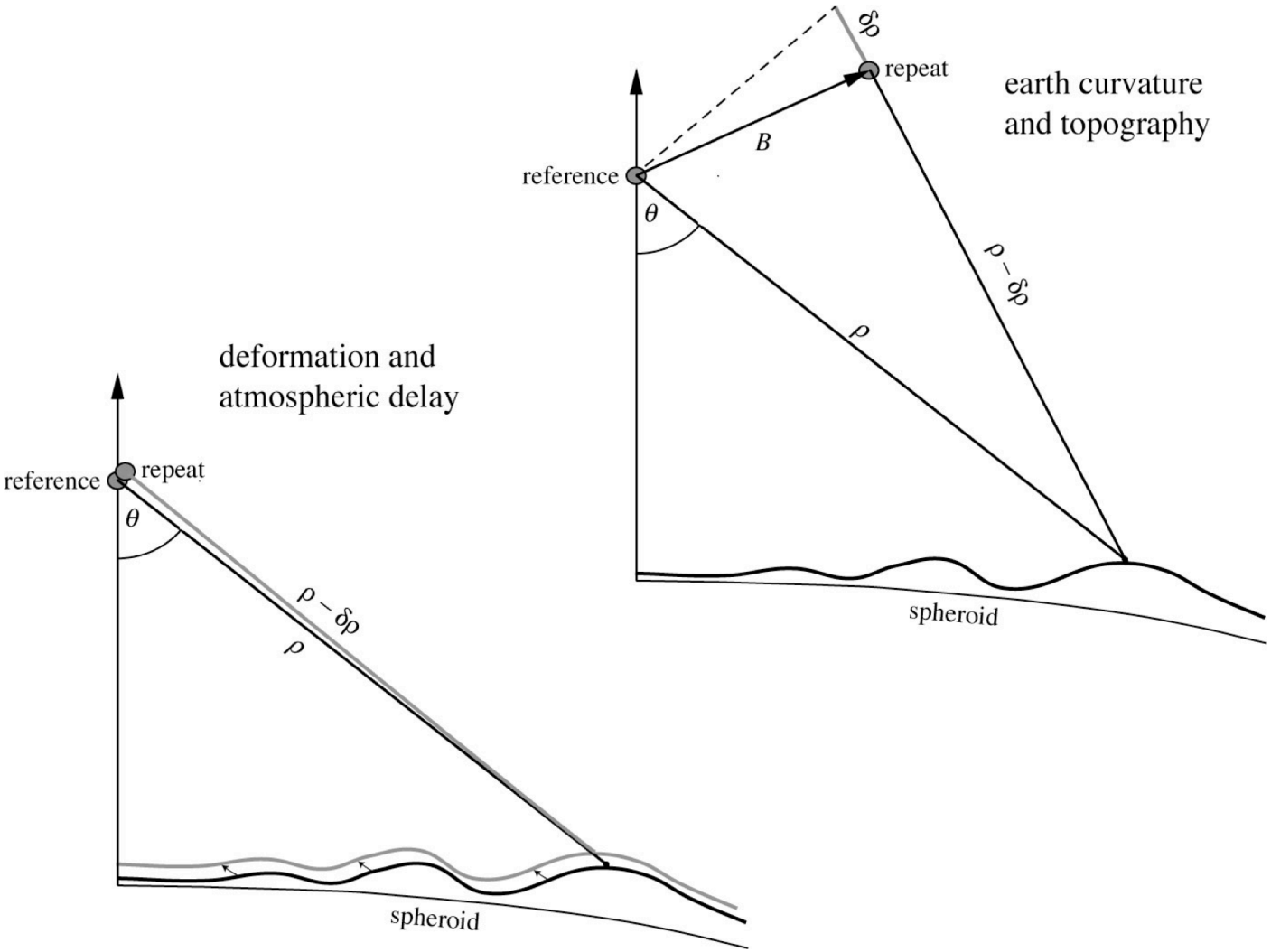
zoom of amplitude image

2) This is a zoom of the previous image with 5 km tic marks. Use a map to identify each of the three curved lines running through the images. Why do the fields have different backscatter? Why aren't the fields exactly square? Why do the bright spots have cross patterns?

InSAR uses phase



deformation and topography



Research with ALOS PALSAR data within the WinSAR consortium

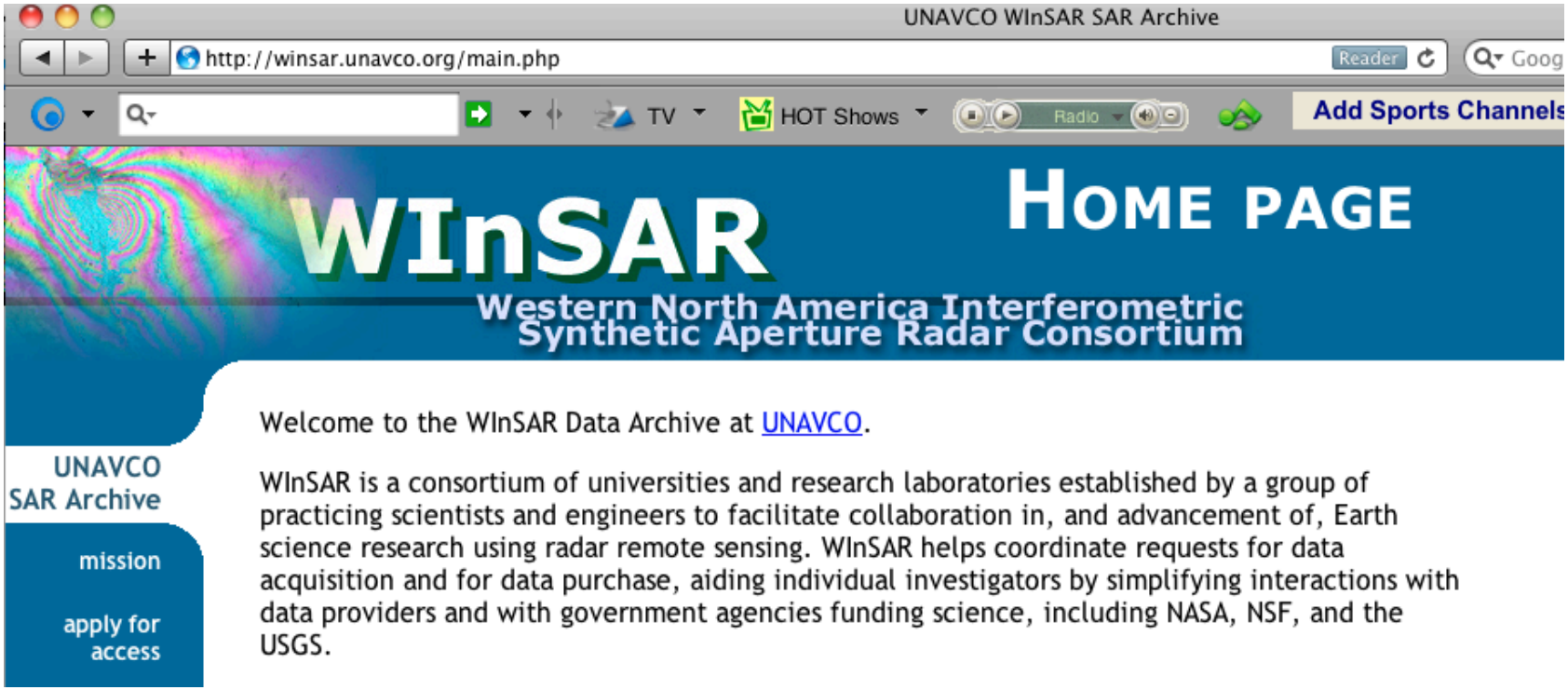
Matt Pritchard, Cornell (Chair)
and the WinSAR Executive Committee

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:

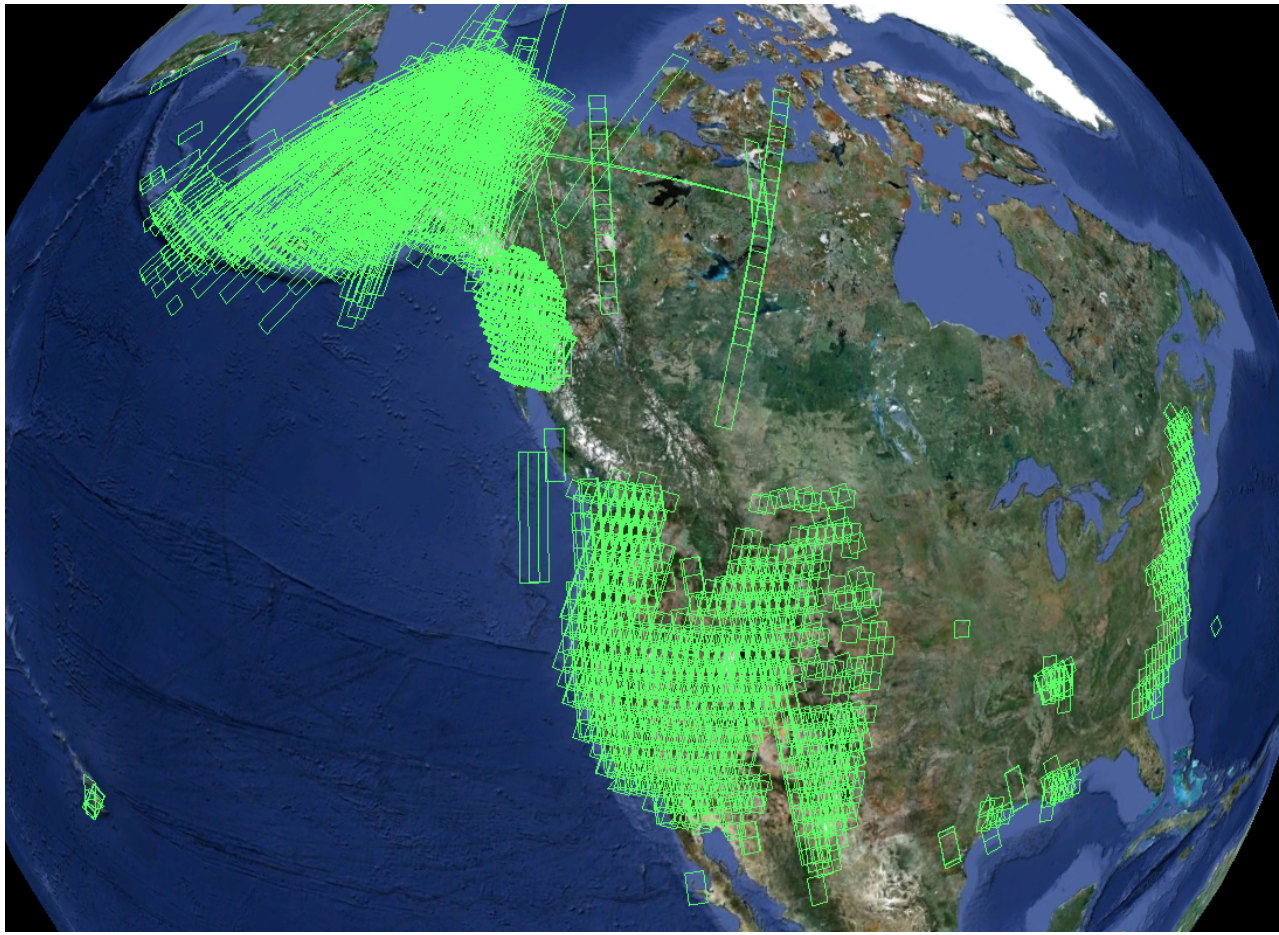
WinSAR objectives

- 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

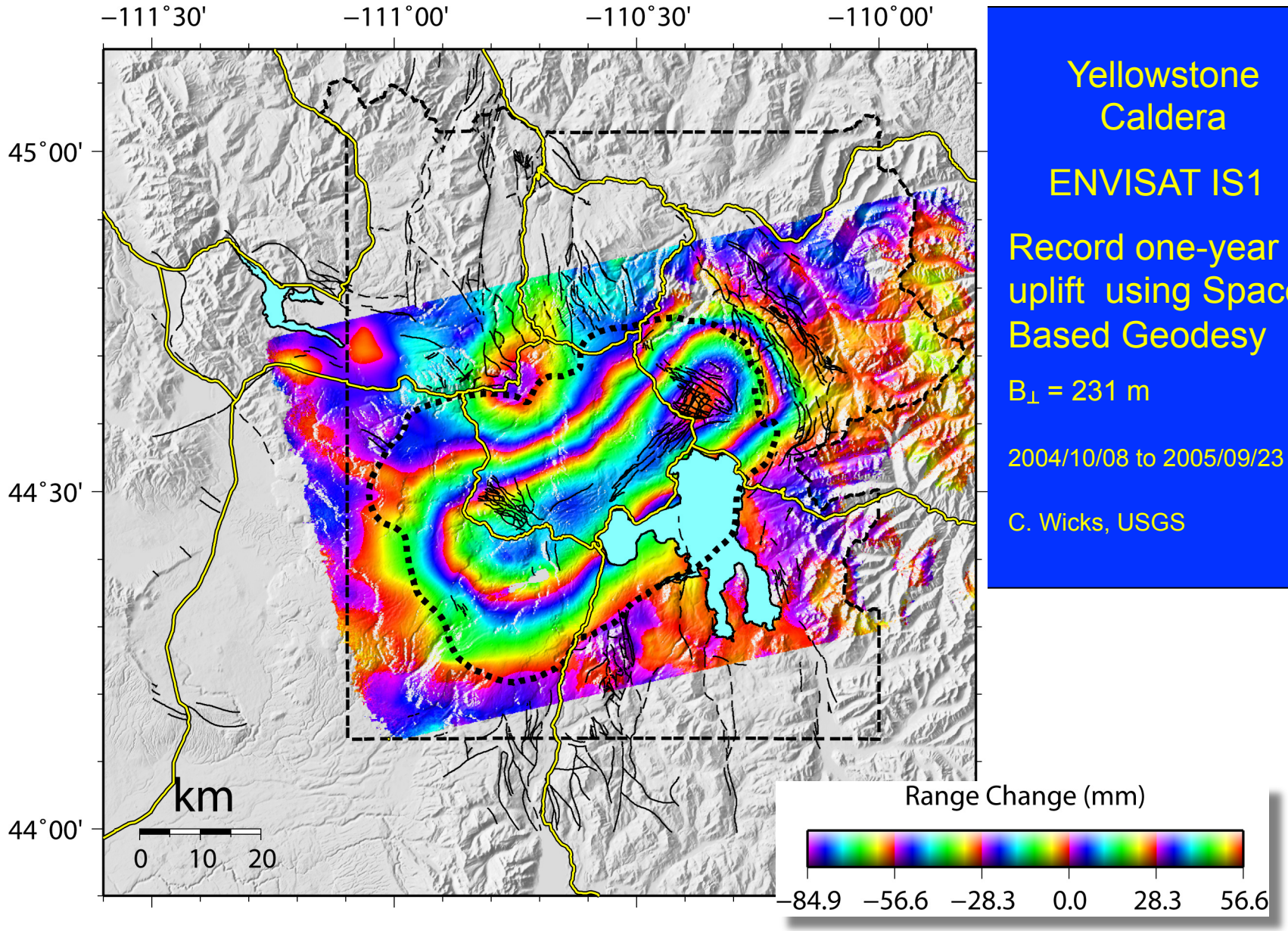
Complete ERS,Envisat data sets for core area!

	# of scenes	
ERS	22826	8.9 Tb
Envisat	7185	1.7 Tb

Nearly complete ALOS-1 data set for North and South America available at ASF L1 Data Pool.



Volcanic Hazards



Yellowstone Caldera

ENVISAT IS1

Record one-year uplift using Space Based Geodesy

$B_{\perp}$ = 231 m

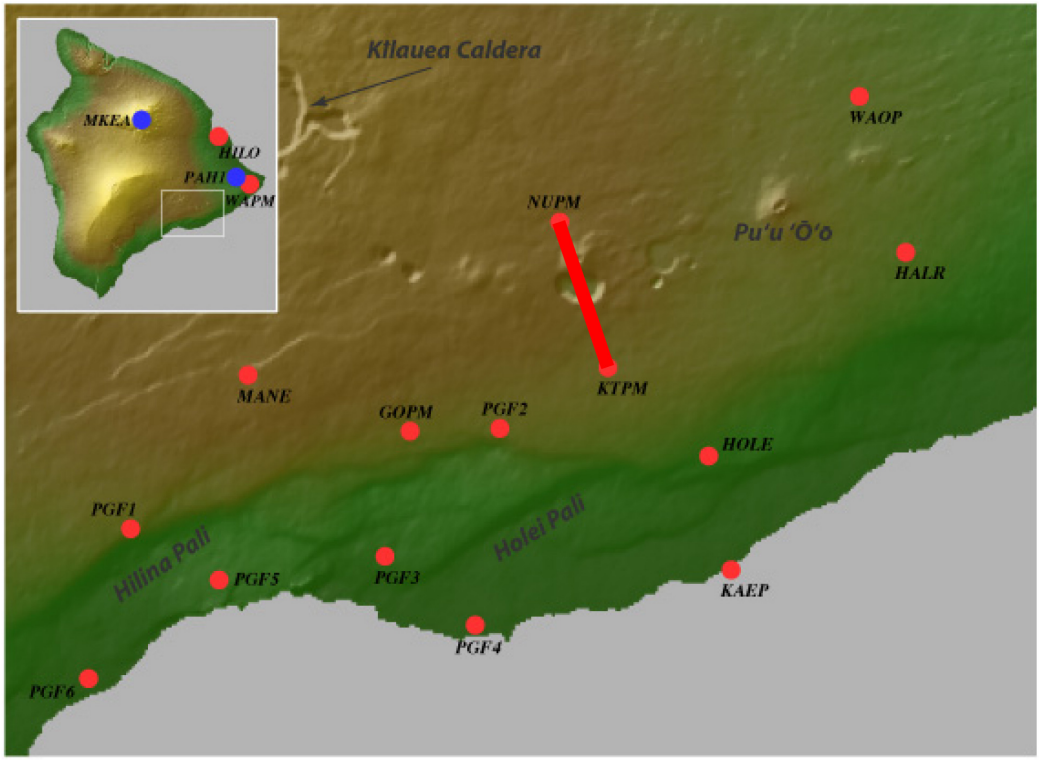
2004/10/08 to 2005/09/23

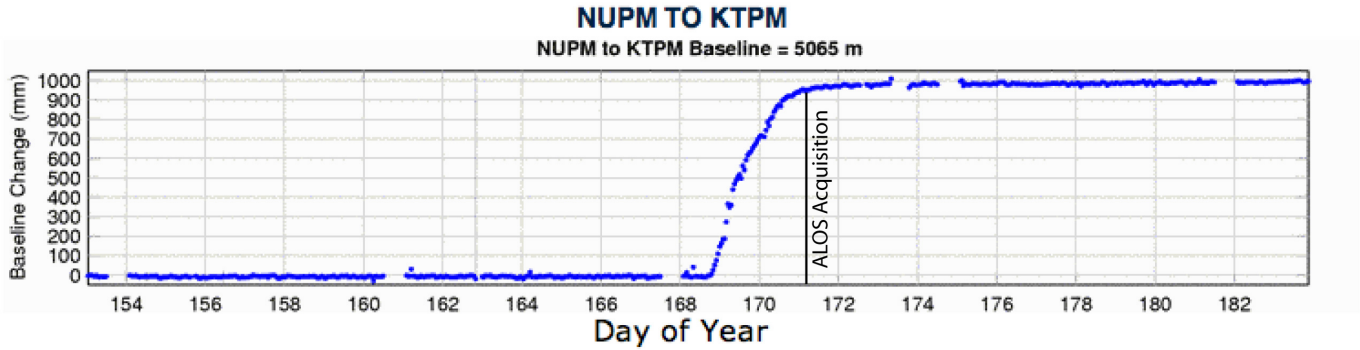
C. Wicks, USGS

USGS

Kilauea - East Rift Zone, Dike Event

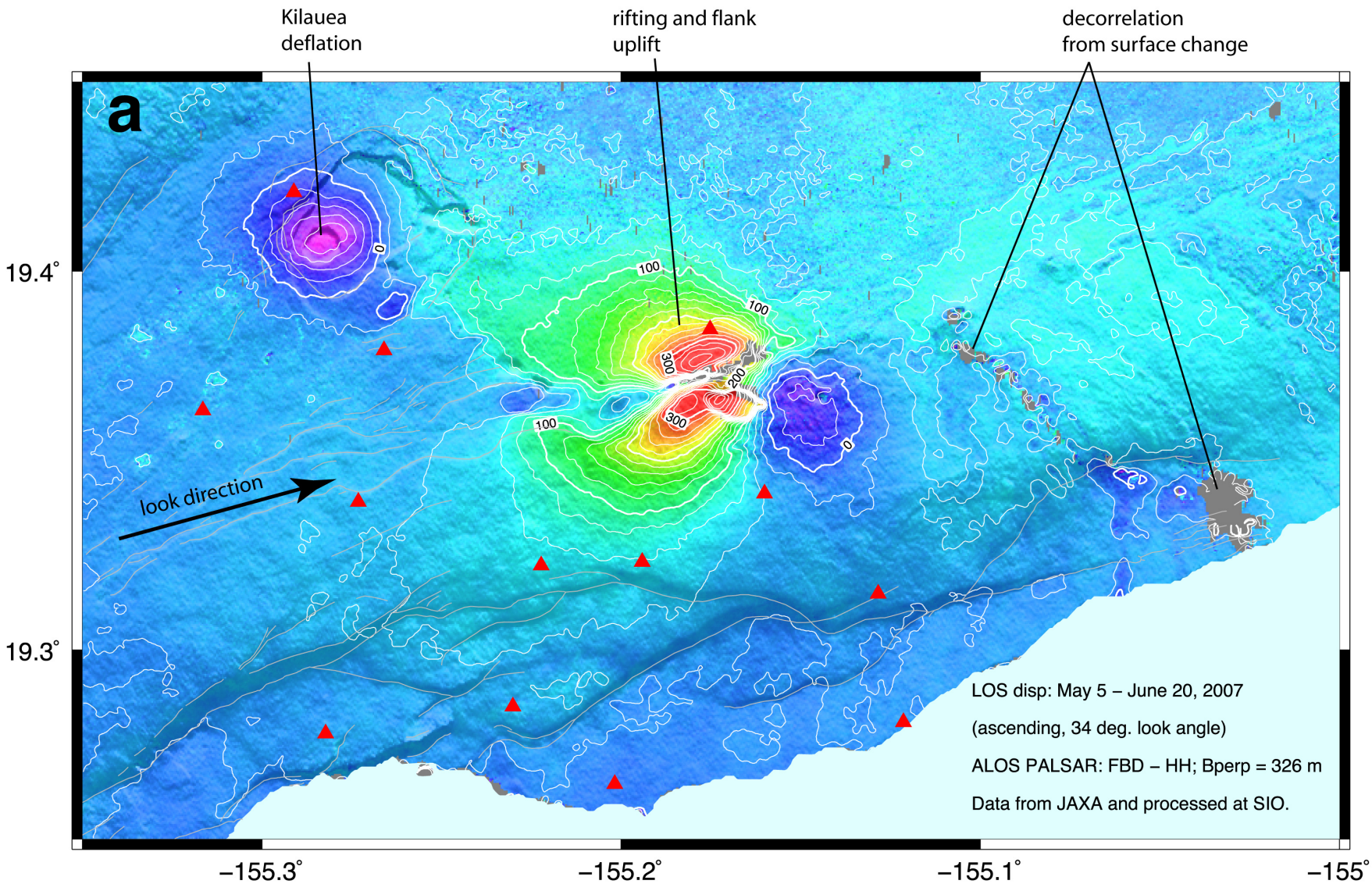
June 17 - June 21, 2007





data from: http://www.soest.hawaii.edu/pgf/SEQ/

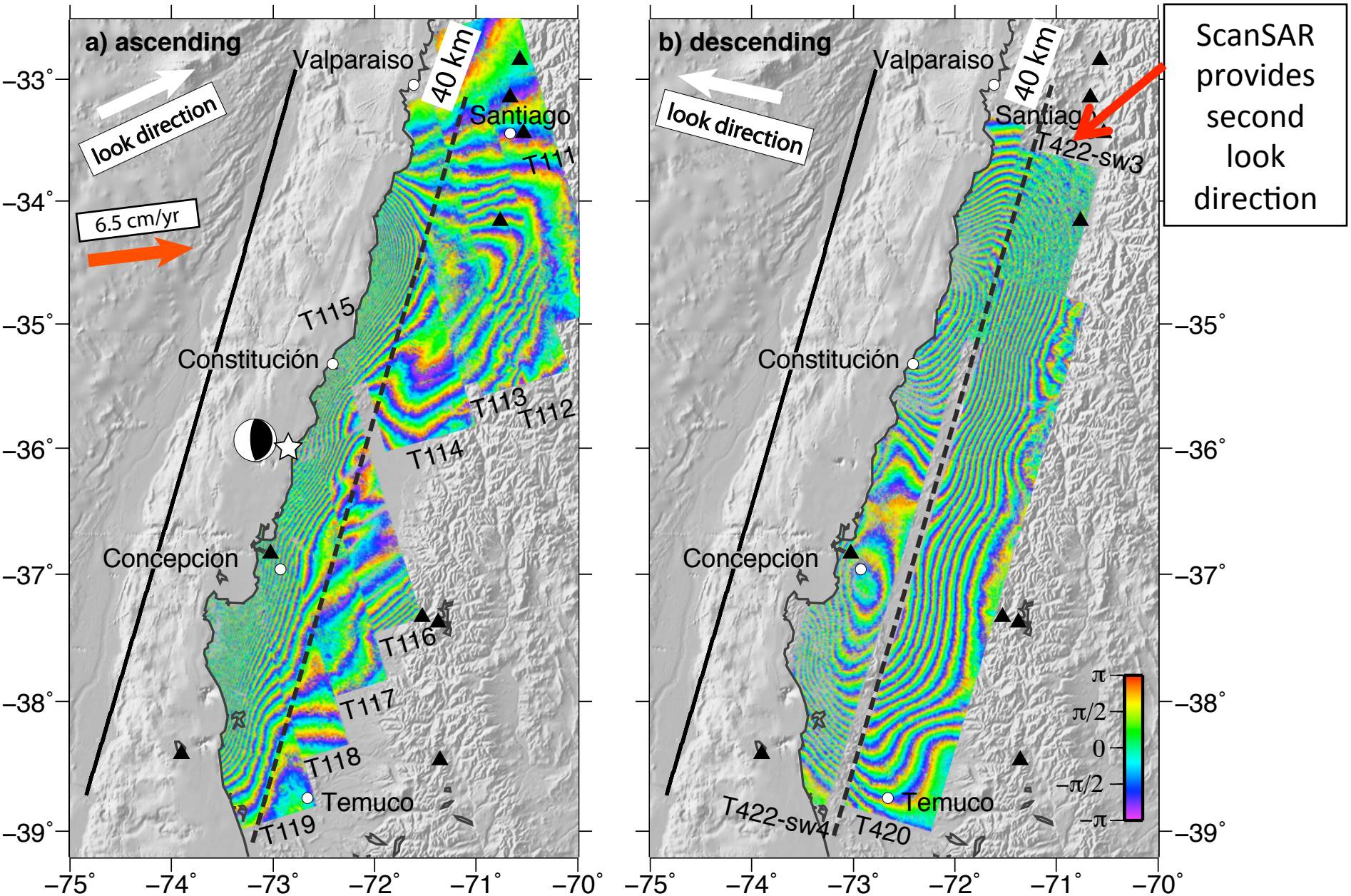
Dike event - LOS ascending



Sandwell et al., 2008

Earthquake Hazards

Coseismic deformation of the Maule, Chile earthquake, ALOS-1



[Tong et al., 2010]

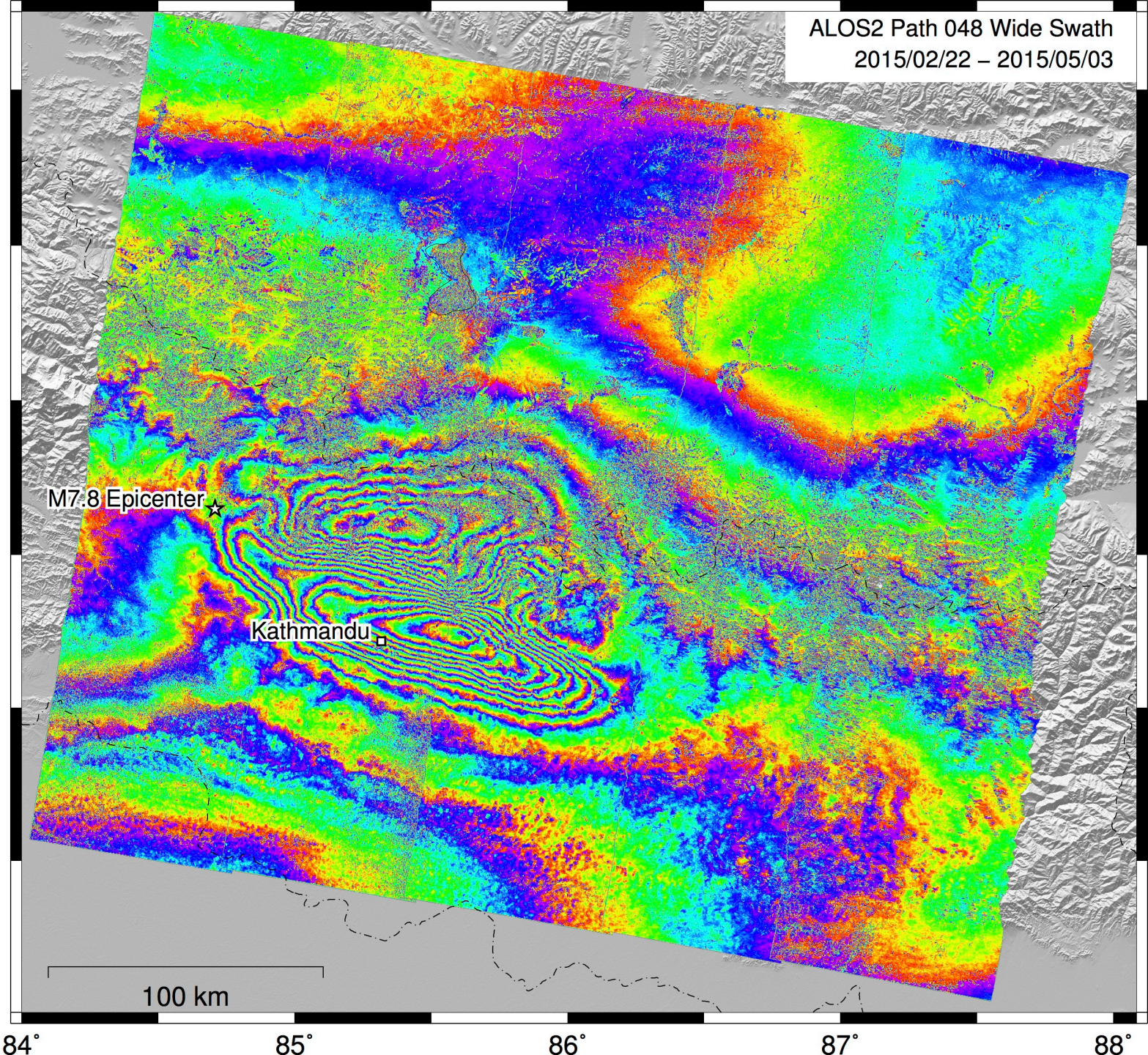
Nepal Earthquakes April 28, 2015

Single 350km by 350 km interferogram.

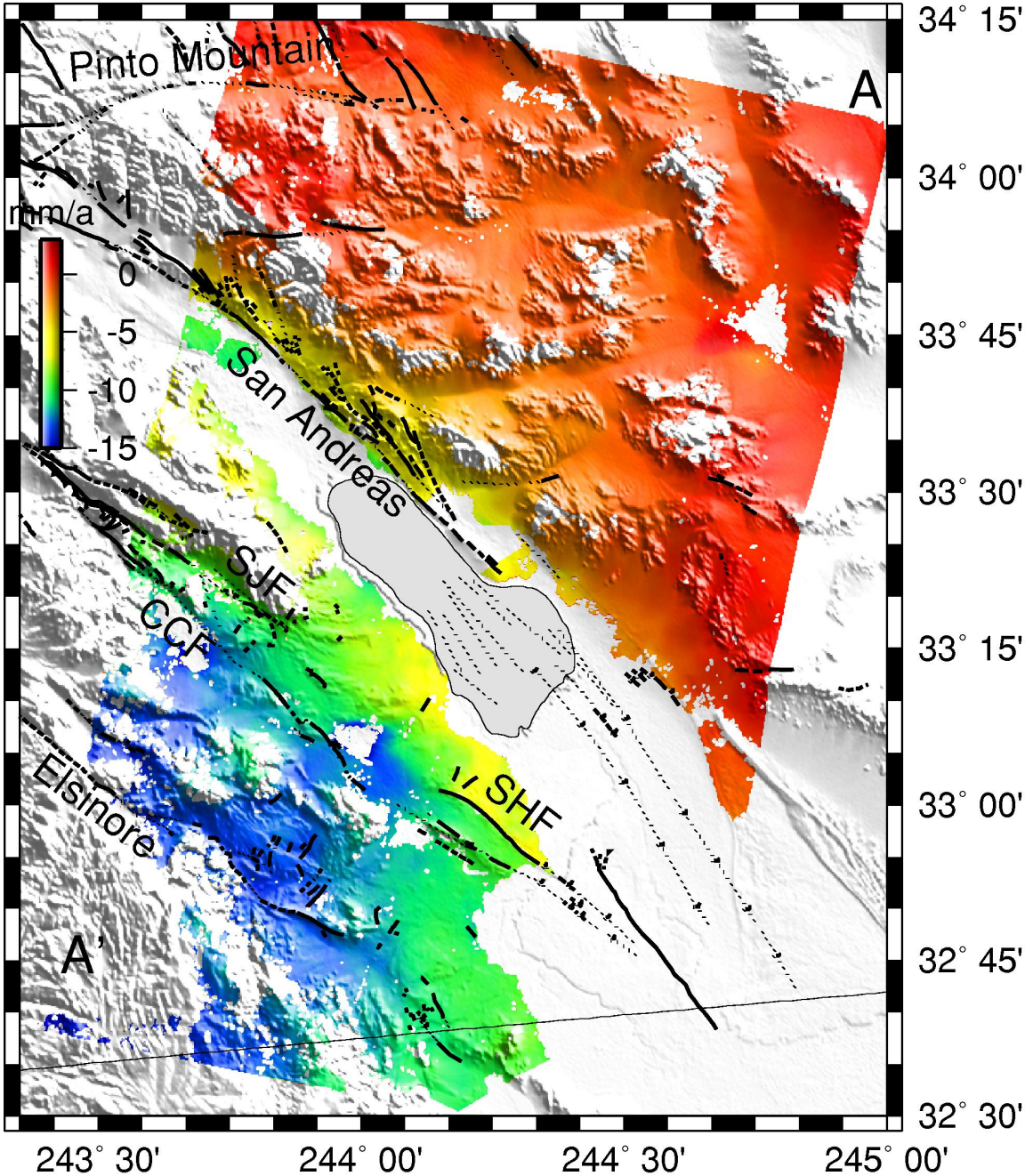
Note phase is continuous across the subswath boundaries with **NO adjustments!**

Note adequate phase coherence even in snow-capped mountains.

[Lindsey et al., 2015]



Interseismic Deformation



Fialko, Nature 2006

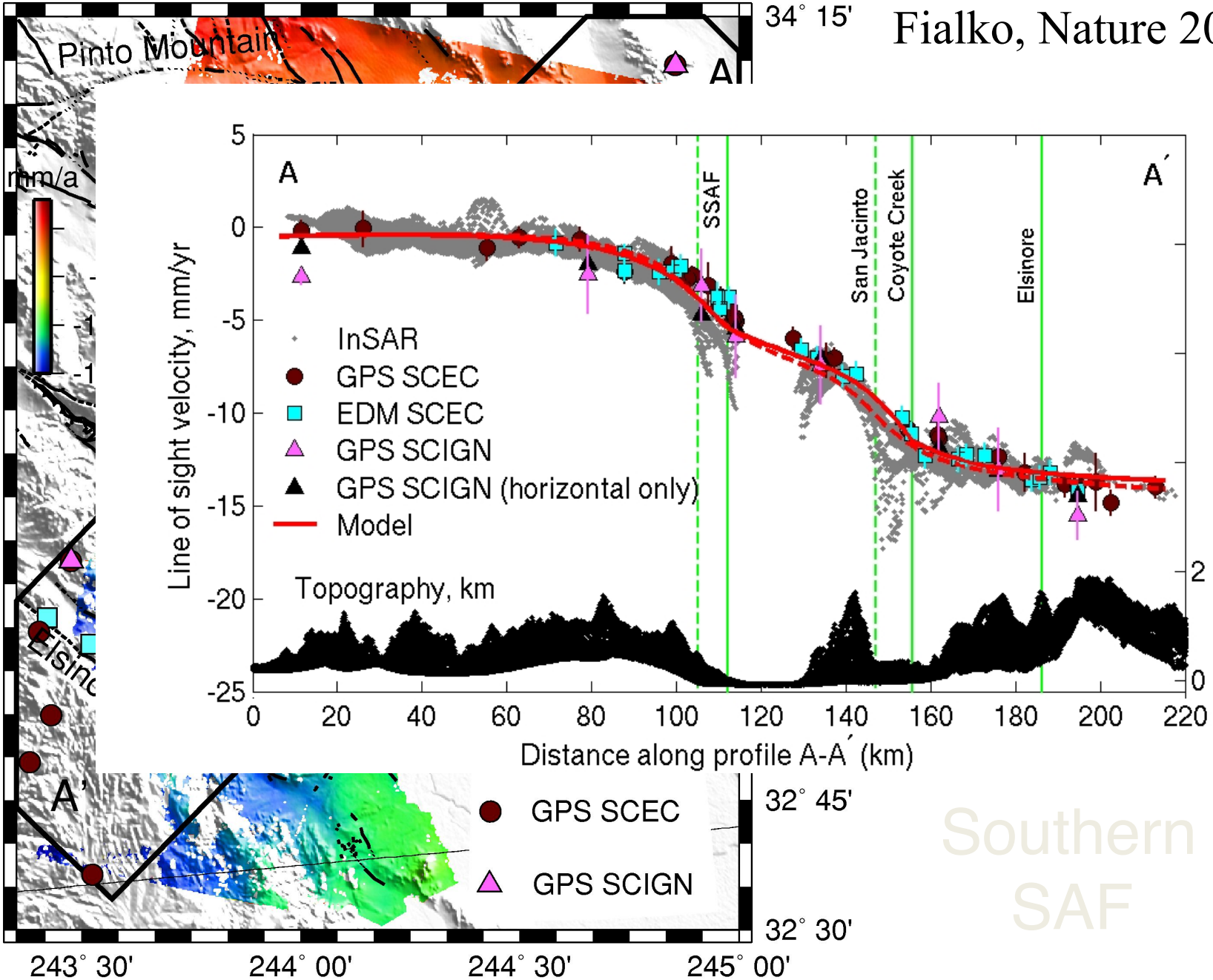
Line of sight velocities from stacked InSAR data

35 interferograms

Epoch: 1992-2000

Southern SAF

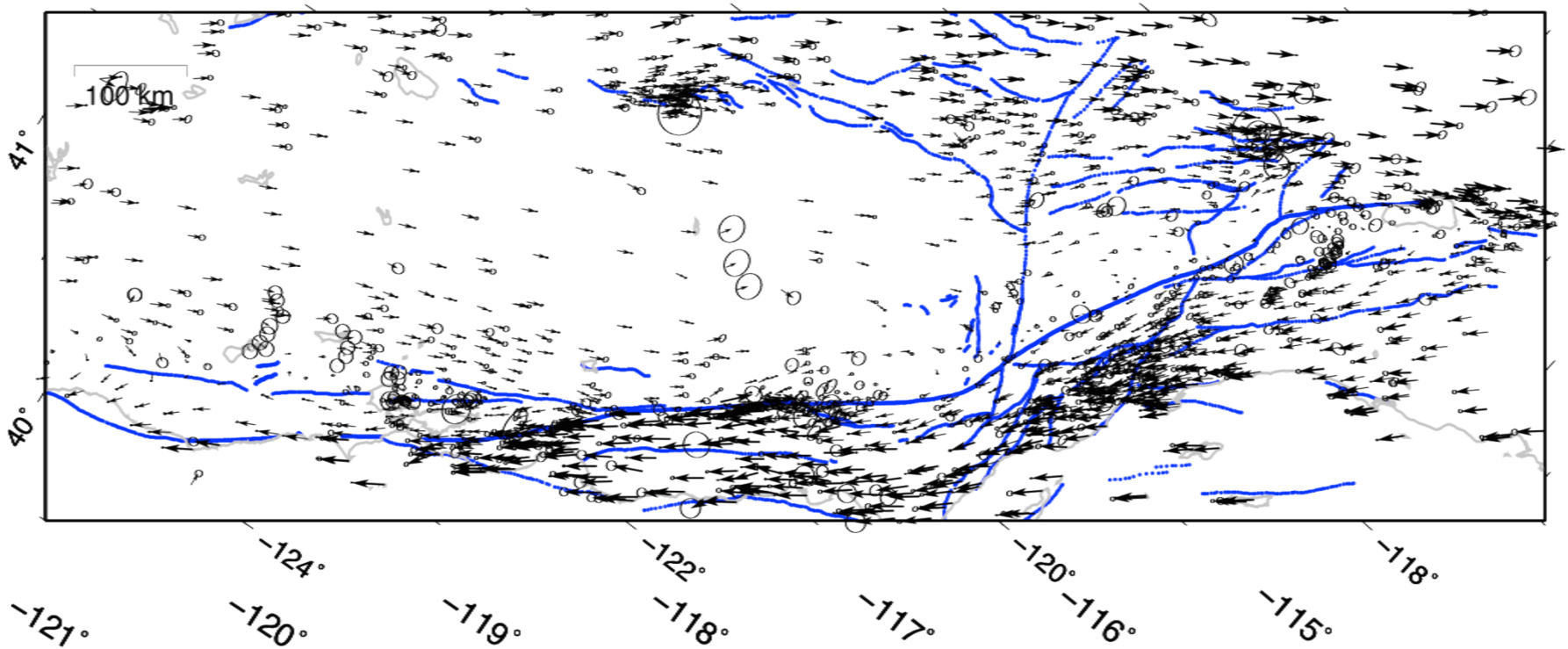
Fialko, Nature 2006

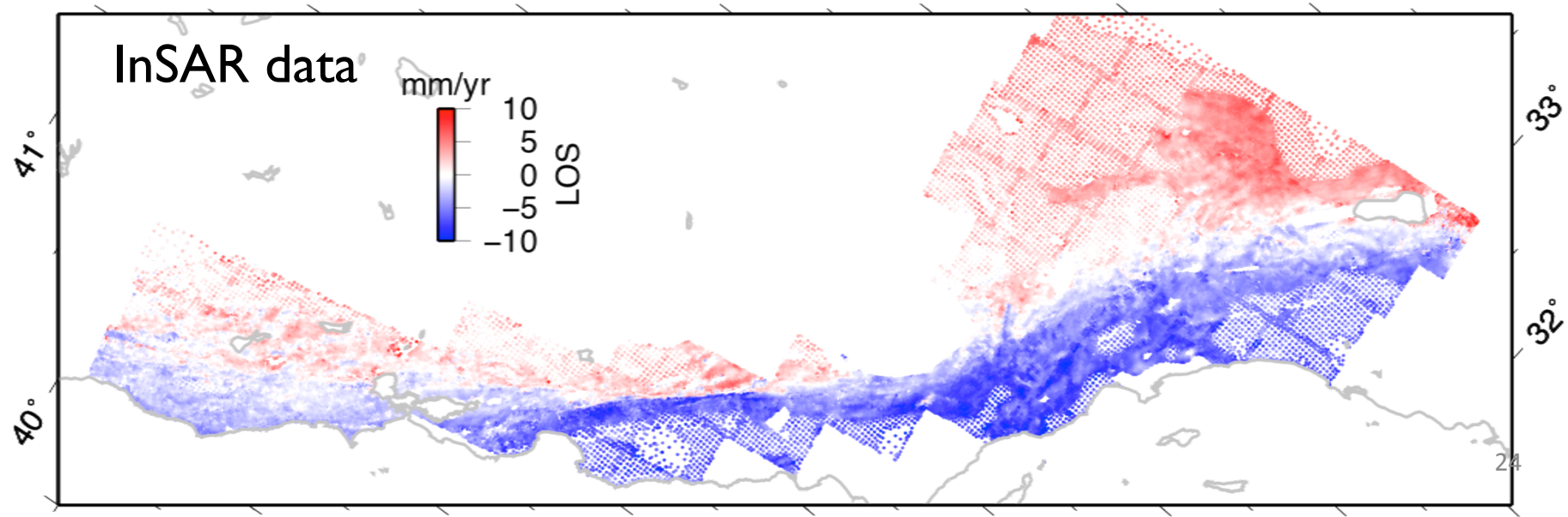


Southern SAF

GPS data

[*Tong et al., JGR* 2013]





Hydrological Applications

Annual groundwater recharge in LA Basin

(Watson et al., JGR 2001)

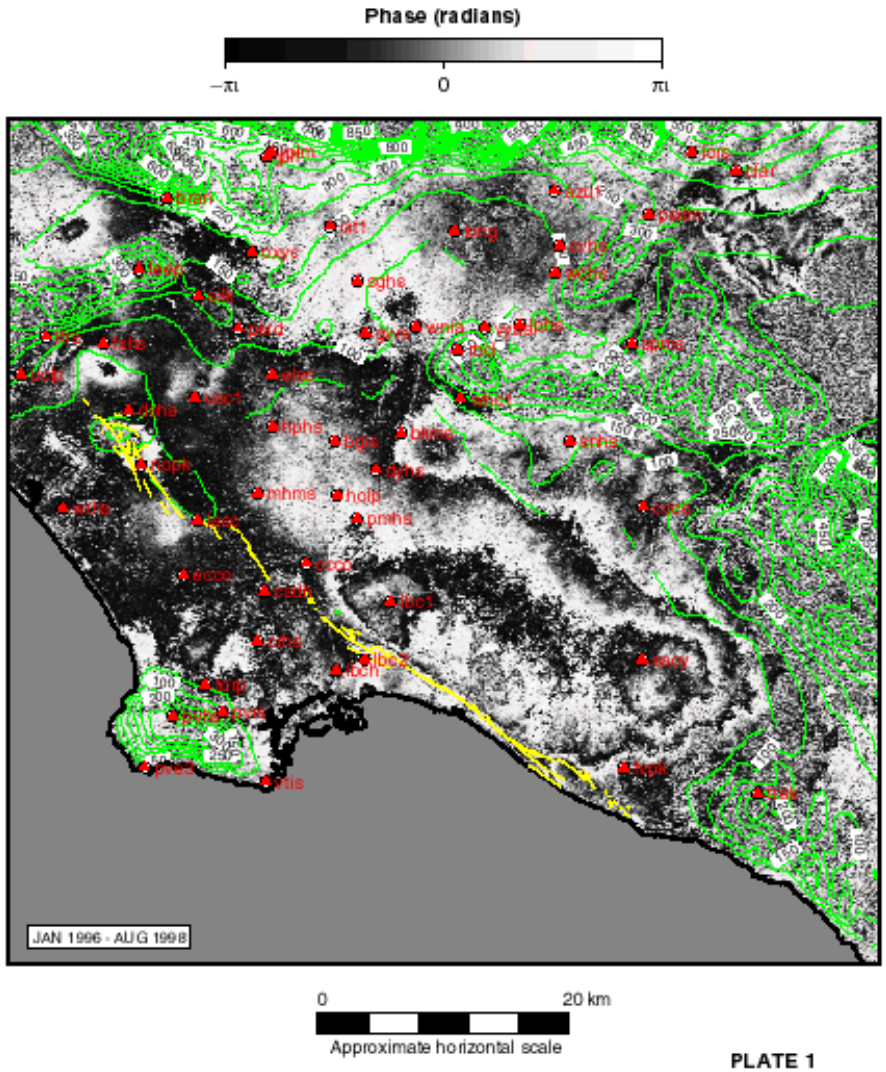


PLATE 1

GPS Data

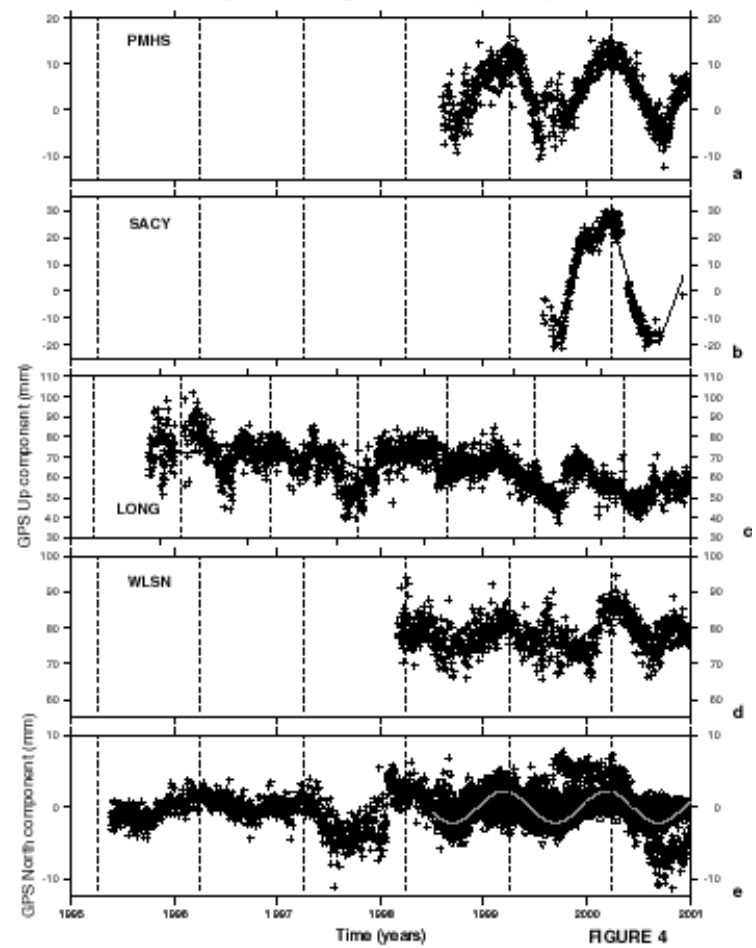
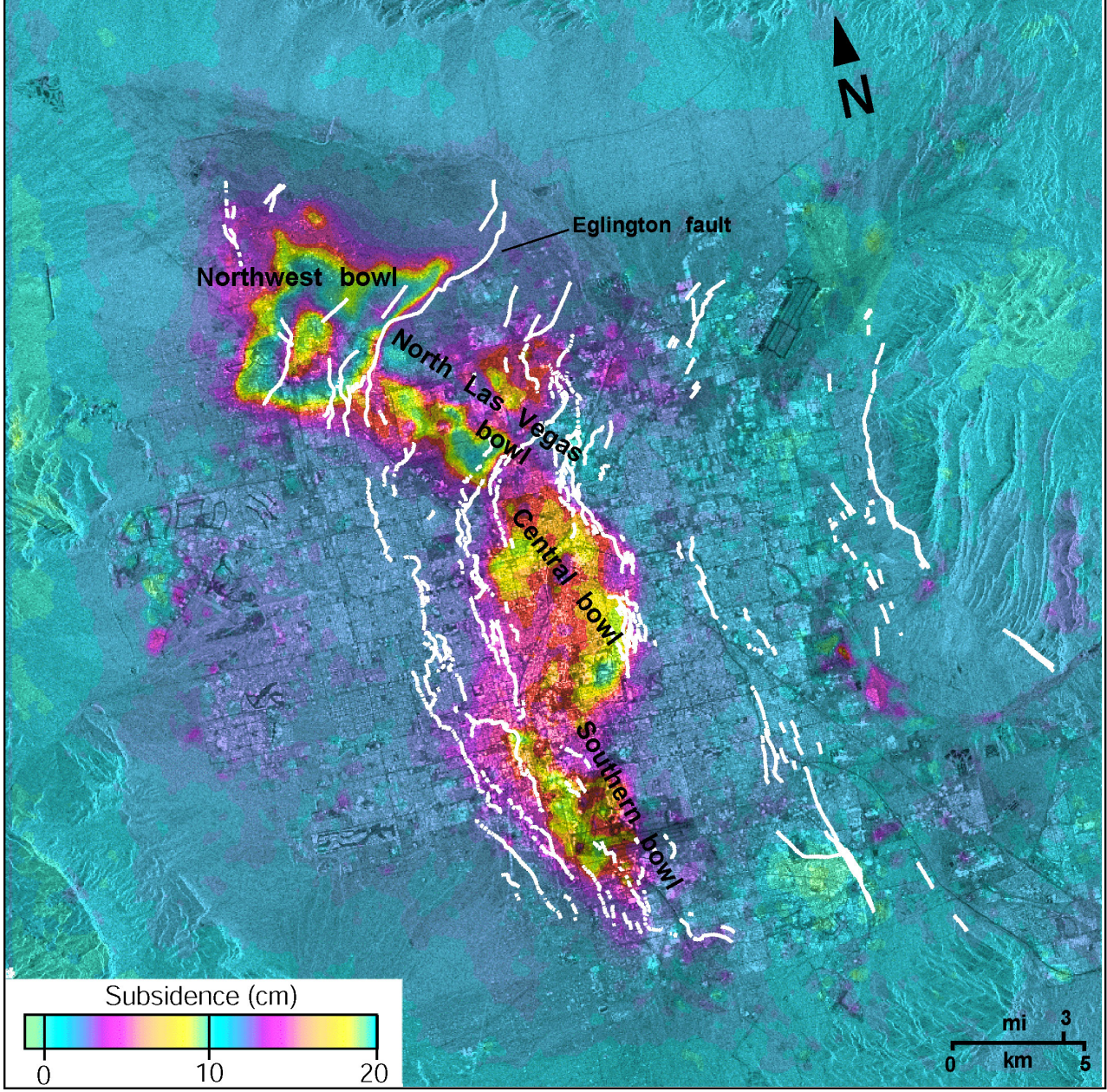


FIGURE 4

Groundwater Pumping, Las Vegas

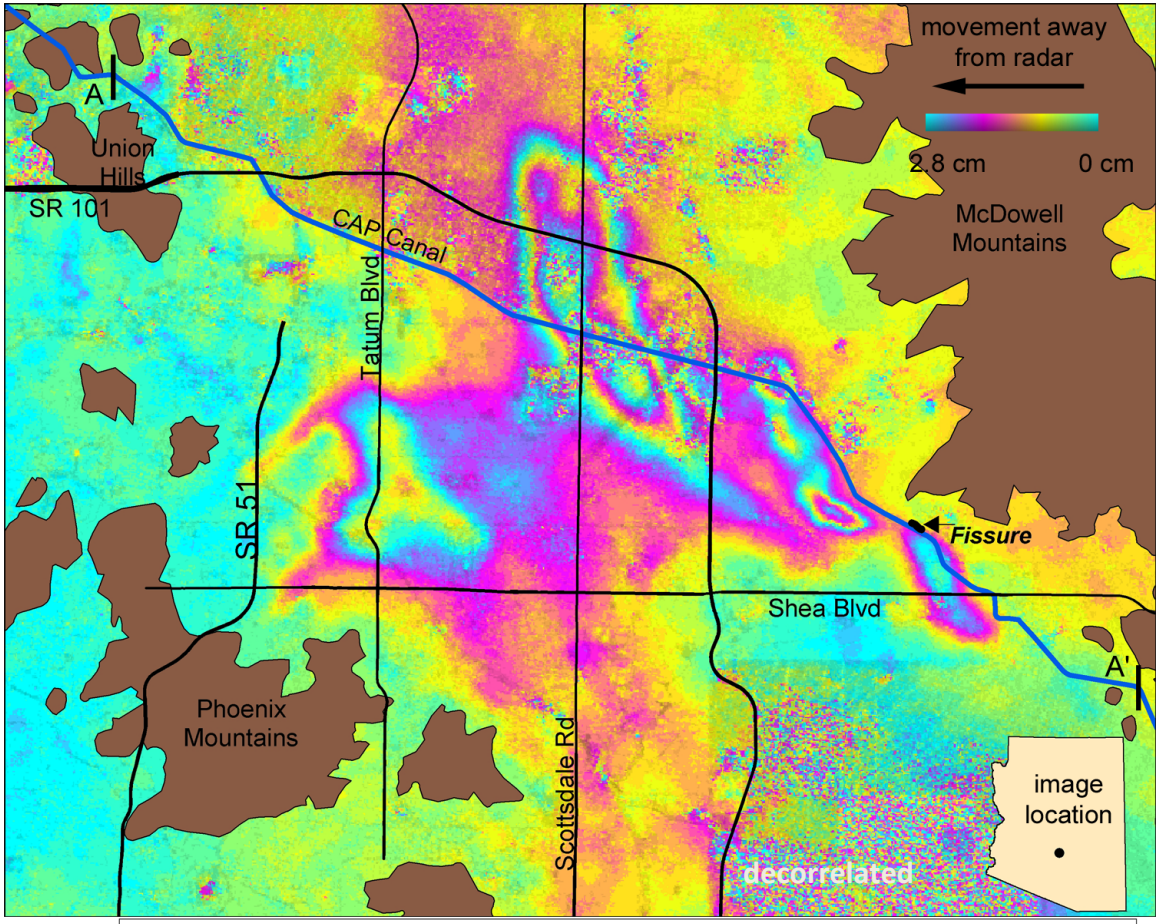
(Amelung et al., Geology, 1999)

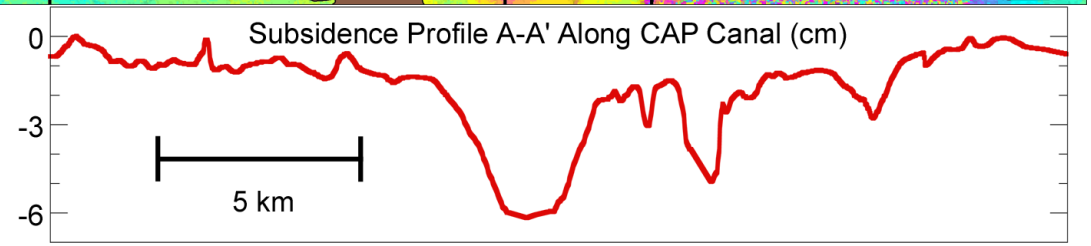


Composite InSAR map showing subsidence between 1992-1997
(from Amelung et al., 1999)

Subsidence Measuring – Northeast Phoenix / North Scottsdale

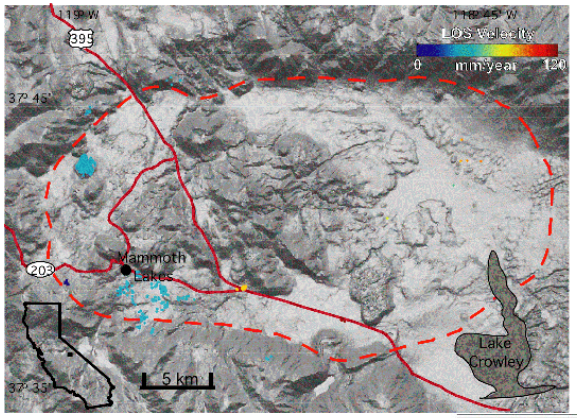
(Buckley et al., 2003)

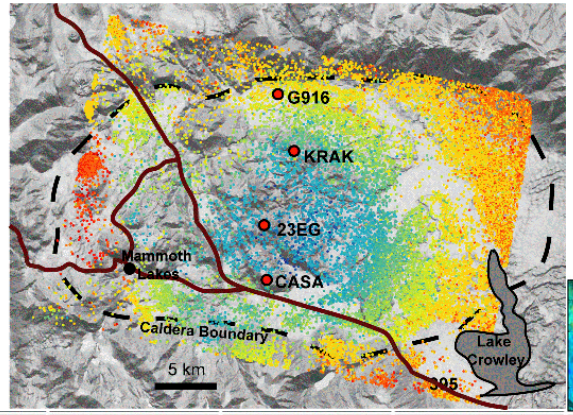




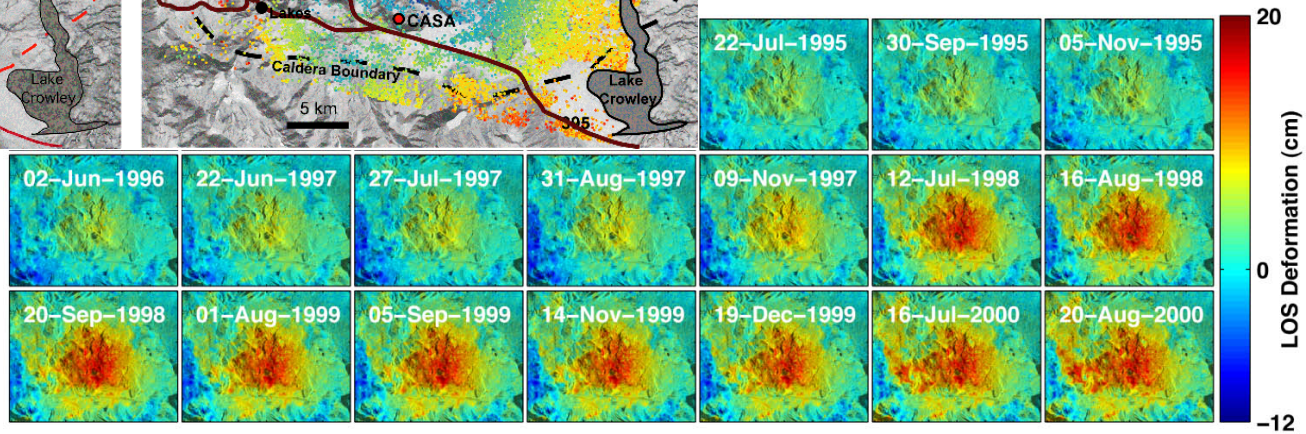
InSAR Technology and Method

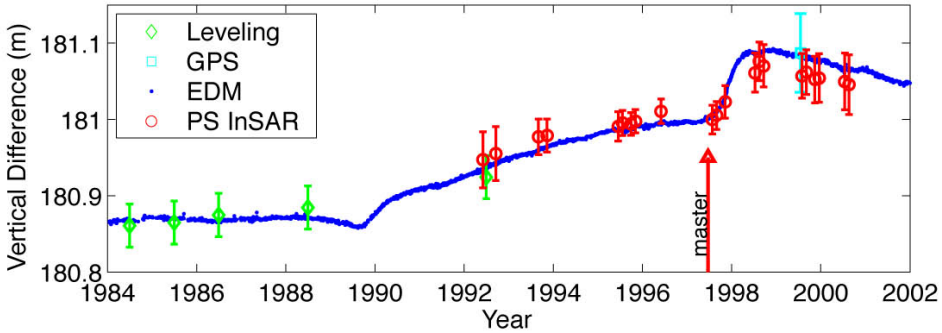
Persistent scatterers



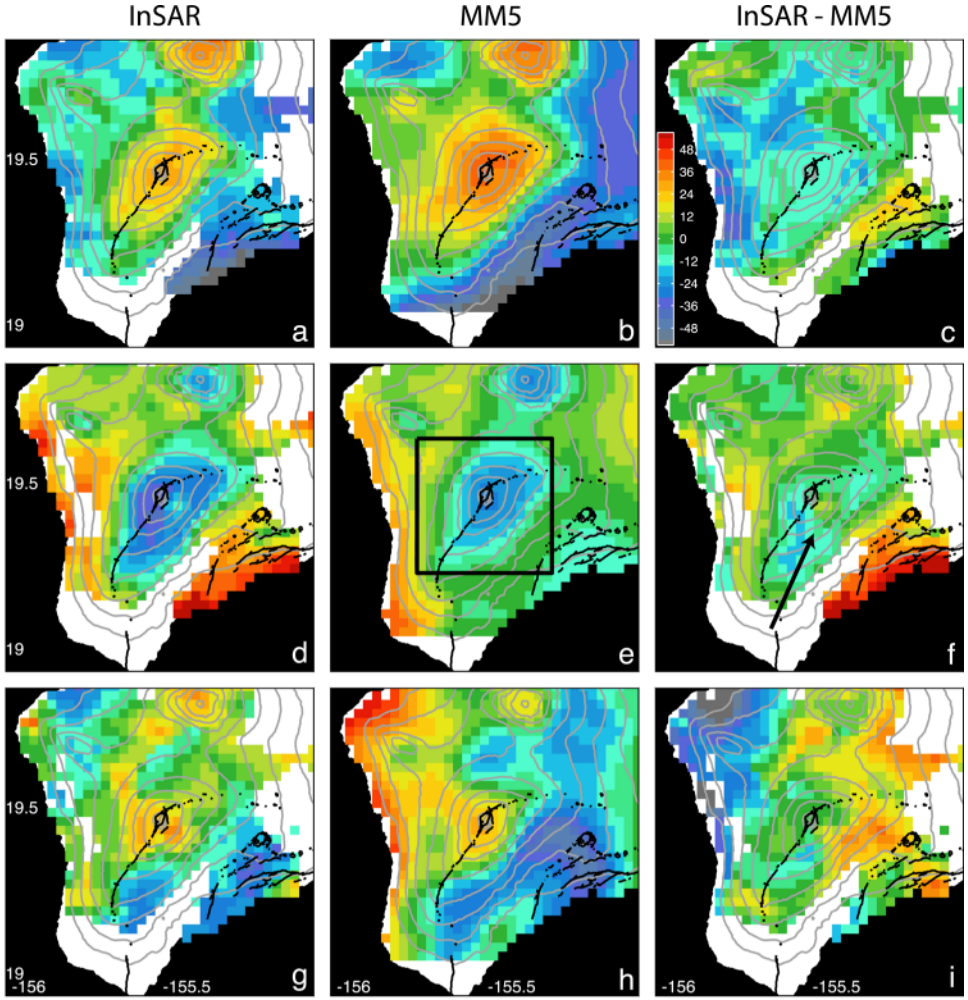


Long Valley Caldera,
Hooper et al. 2004





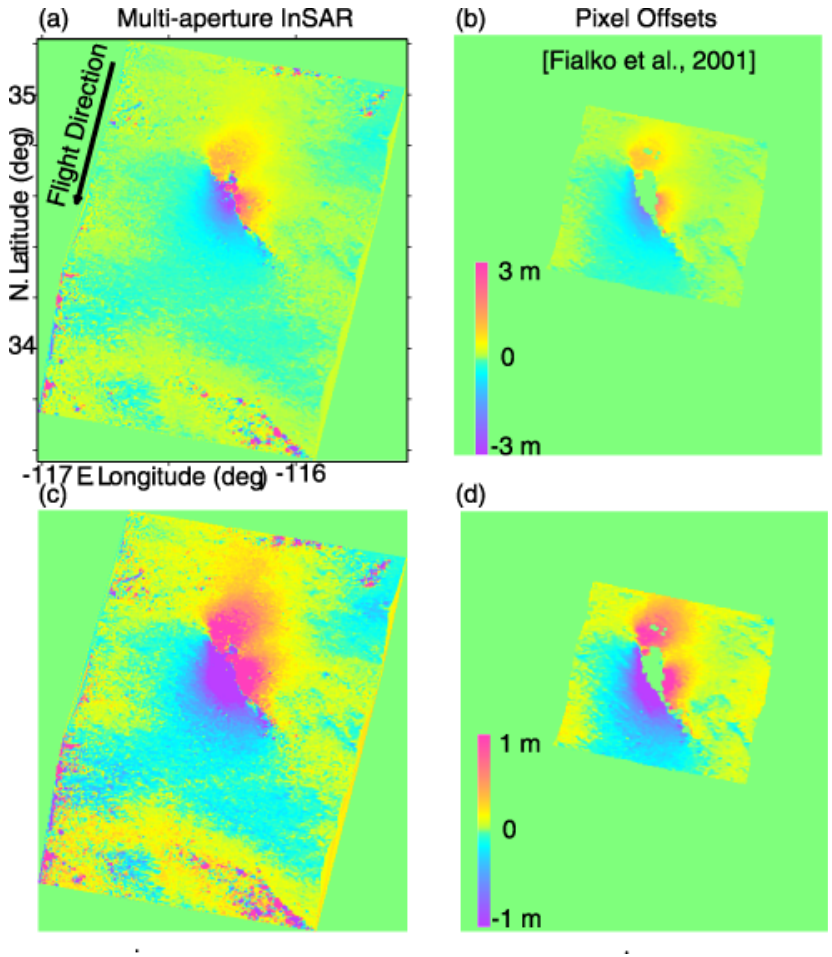
Atmospheric Corrections



- From Foster et al., correction of Hawaii interferograms

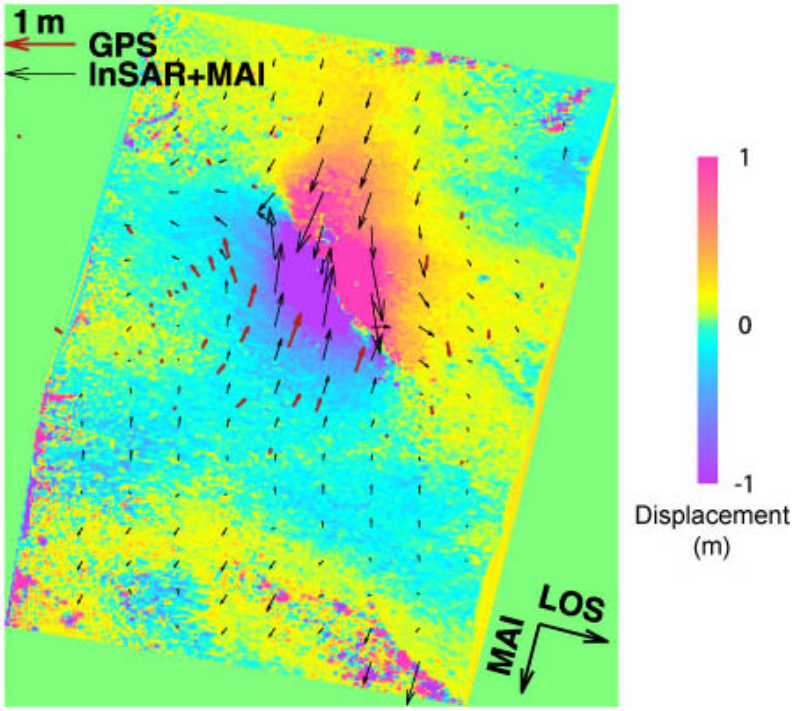
- Weather models can predict large-scale atmospheric signal

Split-Beam Processing for 2-D

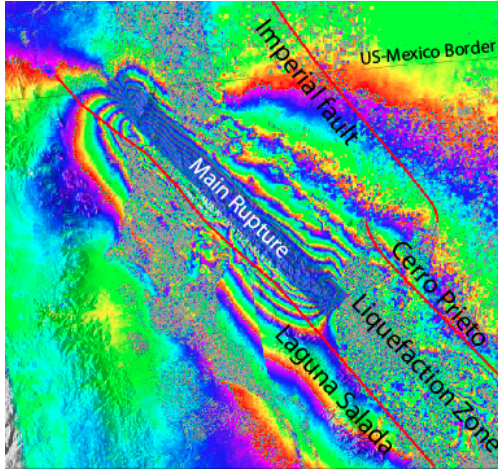


Split-beam processing yields 2-D vectors

Bechor, 2006



SAR and InSAR Overview
Conclusions



- atmosphere is very transparent to microwaves
- radars measure range and azimuth
- radar image has amplitude and phase
- amplitude depends on roughness, slope, and dielectric constant.
- phase differences reveal topography
- phase differences reveal deformation
- deformation from: volcanoes, earthquakes, groundwater
- WInSAR has large archive of ERS, Envisat and ALOS data