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
amplitude and phase

step 1 - SAR (amplitude)

step 2 - InSAR (phase difference)
coherence and pixel matching
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?
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

step 1 - SAR (amplitude)  

step 2 - InSAR (phase difference)
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)

Welcome to the WinSAR Data Archive at UNAVCO.

WinSAR is a consortium of universities and research laboratories established by a group of practicing scientists and engineers to facilitate collaboration in, and advancement of, Earth science research using radar remote sensing. WinSAR helps coordinate requests for data acquisition and for data purchase, aiding individual investigators by simplifying interactions with data providers and with government agencies funding science, including NASA, NSF, and the USGS.

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!

<table>
<thead>
<tr>
<th></th>
<th>ERS</th>
<th>Envisat</th>
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<tr>
<td># of scenes</td>
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<td>7185</td>
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<tr>
<td>size</td>
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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
Kilauea - East Rift Zone, Dike Event

June 17 - June 21, 2007

data from: http://www.soest.hawaii.edu/pgf/SEQ/
Dike event - LOS ascending

Kilauea deflation

Rifting and flank uplift

Decorrelation from surface change

Look direction

LOS disp: May 5 – June 20, 2007
(ascending, 34 deg. look angle)
ALOS PALSAR: FBD – HH; Bperp = 326 m
Data from JAXA and processed at SIO.

Sandwell et al., 2008
Earthquake Hazards
Coseismic deformation of the Maule, Chile earthquake, ALOS-1

a) ascending

Valparaiso

40 km

Santiago

Concepcion

Constitución

Temuco

look direction

ScanSAR provides second look direction

look direction

6.5 cm/yr

b) descending

Valparaiso

40 km

Santiago

Concepcion

Constitución

Temuco

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 sub swath boundaries with NO adjustments!

Note adequate phase coherence even in snow-capped mountains.

[Lindsey et al., 2015]
Interseismic Deformation
Line of sight velocities from stacked InSAR data

35 interferograms


Fialko, Nature 2006
Line of sight velocities from stacked InSAR data
35 interferograms
Fialko, Nature 2006
GPS data

[Tong et al., JGR 2013]
Hydrological Applications
Annual groundwater recharge in LA Basin

(Watson et al., JGR 2001)
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
• 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