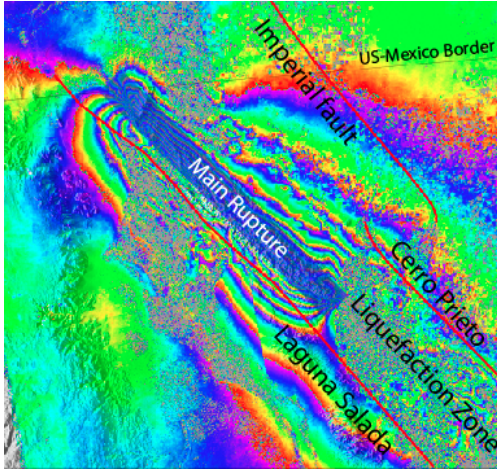
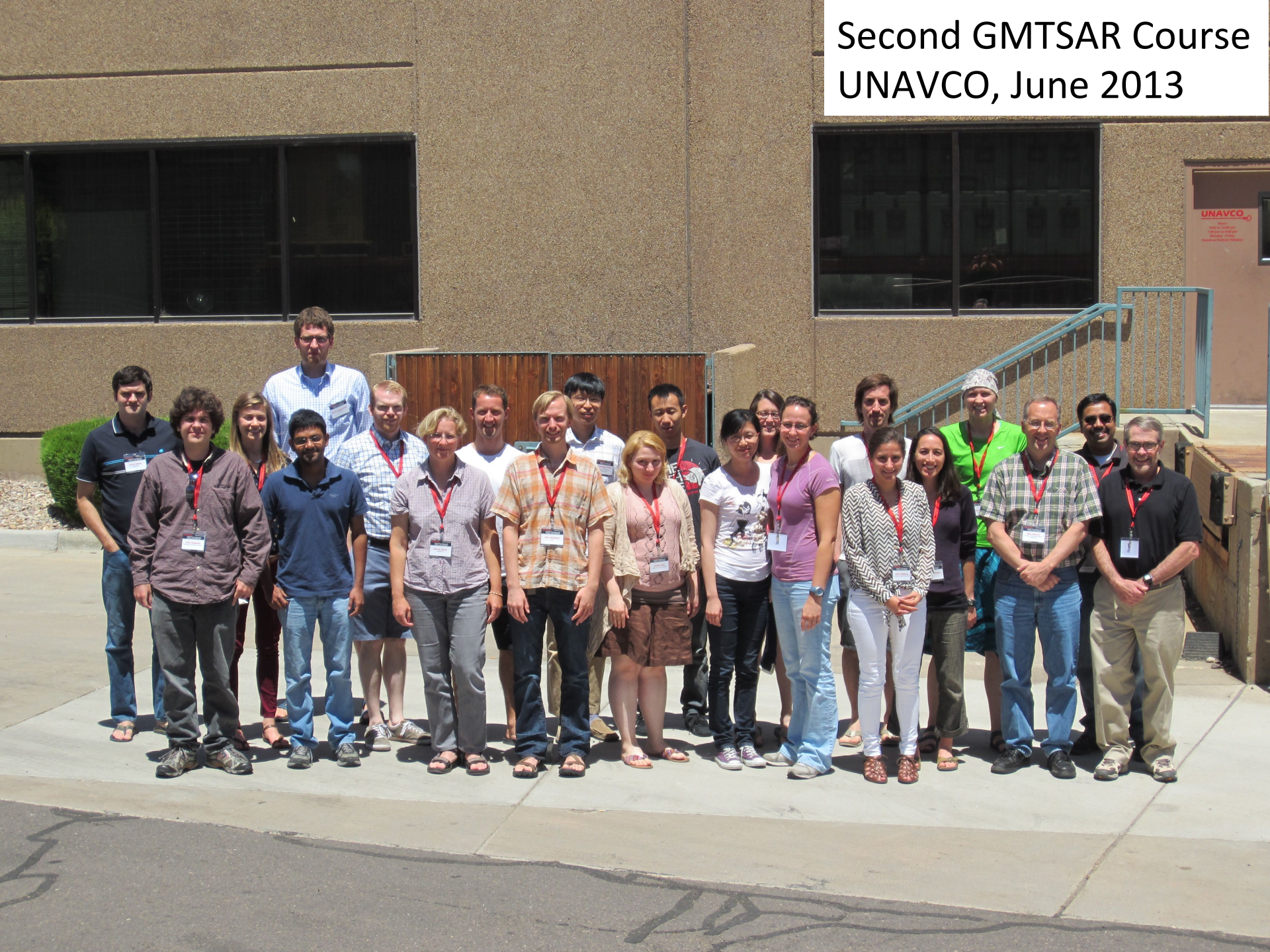
GMTSAR Short Course

Scripps Institution of Oceanography
August 16-18, 2017



- **Objectives:**
  - understand the principles of SAR and InSAR
  - run GMT and GMTSAR on your **own** computer
  - perform 2-pass InSAR processing on your own computer
  - select free and open data from ERS, Envisat, and Sentinel-1
  - process ERS, Envisat, ALOS-1, TSX, CSK, RS2, S1A, ALOS-2
  - prepare large stacks of interferograms for time series


First GMTSAR Course
SIO, June 2011


Second GMTSAR Course
UNAVCO, June 2013

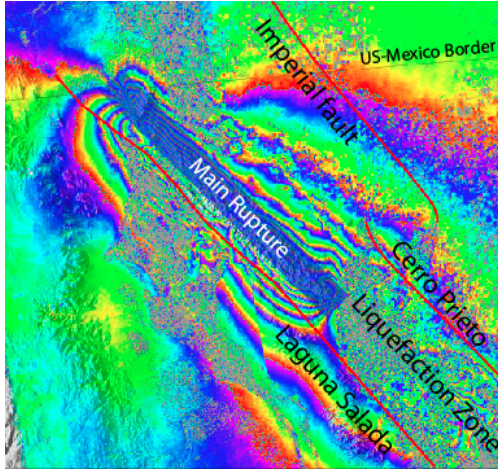
Third GMTSAR Course
UNAVCO, July 2014

Fourth GMTSAR Course
SIO, August, 2015


Fifth GMTSAR Course
SIO, August, 2016

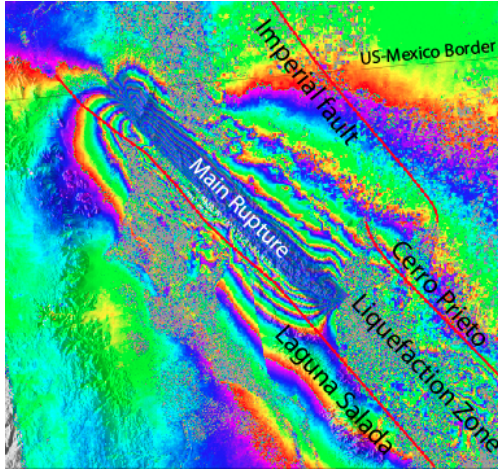

Sixth GMTSAR Course
Chinese Academy of Sciences,
June, 2017

GMTSAR Short Course
OUTLINE



- **Lecture**
  - SAR and InSAR theory
  - overview of SAR, InSAR, processing with GMTSAR
- **Lab**
  - setup UNIX, GMT, and GMTSAR – test cases
  - learn to select SAR scenes
  - GMTSAR overview, standard InSAR processing,
  - batch processing
- **Student presentations**

GMTSAR Short Course
LAB TODAY



- setup:
  - install UNIX and csh
  - make .tcshrc file
  - install GMT5
  - make topography map
  - install GMT5SAR
  - run test cases

HOMEWORK 1P - UNIX and csh/tcsh

We will use UNIX commands for all InSAR processing so one should be able to do the basics. The following web site has a tutorial.
http://www.ee.surrey.ac.uk/Teaching/Unix/

Go through each tutorial unless your are already a UNIX whiz. You will need to have a basic text editor available for this exercise. Common UNIX text editors are vi or emacs. The following web site has an extensive list.

http://en.wikipedia.org/wiki/List_of_text_editors

Note that to do this exercise your computer must have the C-shell (or bash) installed as well as a C-compiler installed. If you have trouble with these installations please send e-mail questions.

Tutorial 8 is especially important. Each type of unix will have slight variations in the .tcshrc or .cshrc file. The default shell on many systems today is bash. GMTSAR is based on the tcsh/csh shell so make sure csh is installed.

After going throughout the tutorial and setting up your .tcshrc or .cshrc (or .bashrc) file, please send me a copy of that file with embedded comments on your custom additions.

HOMEWORK 2P - Generic Mapping Tools (GMT5)

Remove old versions of NETCDF and GMT from your computer unless you are 100% sure you have the latest complete installation including the source code. Many problems related to the installation of GMT5SAR are due to having an old installation of GMT. Installations can be done in a variety of ways. Here is a web page describing the installation options.
http://gmt.soest.hawaii.edu/projects/gmt5sar/wiki

LEARN GMT5

To make sure everything is working properly, you must close all your terminal windows and start new ones. Make sure you are running csh/tcsh in each window by typing the command csh or tcsh. Then type the command 'gmt grdinfo' to make sure the GMT5 programs are in your path.

If you are not familiar with GMT5, then go through the GMT5 Tutorial at the following web site.
http://gmt.soest.hawaii.edu/doc/latest/tutorial.html

The last part of this exercise is to make a map of the area where you live using topography data from the following web site.

http://topex.ucsd.edu/gmtsar/demgen/

HOMEWORK 3 - GMTSAR

The third assignment before the workshop has 3 parts. Part 1 is to install Google Earth. If you have UBUNTU 16.04 then use these instructions.http://www.configserverfirewall.com/ubuntu-linux/install-google-earth-ubuntu-16-04/
Part 2 is to read the review paper by Burgmann et al., 2000. Here is the link.
http://topex.ucsd.edu/insar/burgmann_insar_rev.pdf

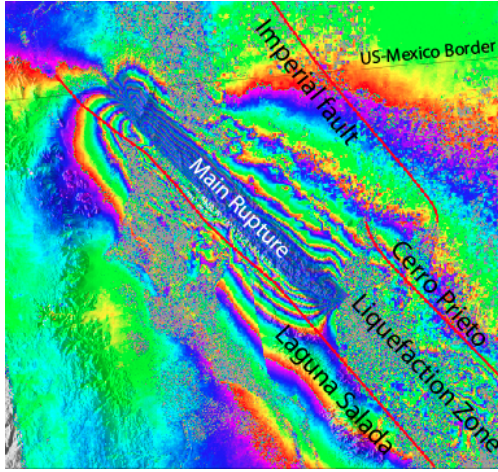
Part 3 is to install GMT5SAR. Go to the following web site and follow the installation instructions.
http://gmt.soest.hawaii.edu/projects/gmt5sar/wiki

Add GMT5SAR to your path
Note: If you are using a Mac OS X and macport, make sure change the following environmental variables in your .cshrc or .tcshrc or .bashrc file before compiling:

for tcsh/csh
setenv GMT5SAR YourPathTo/GMT5SAR
setenv PATH $GMT5SAR/bin:"$PATH"

for bash
export GMT5SAR=YourPathTo/GMT5SAR
export PATH=$GMT5SAR/bin:$PATH

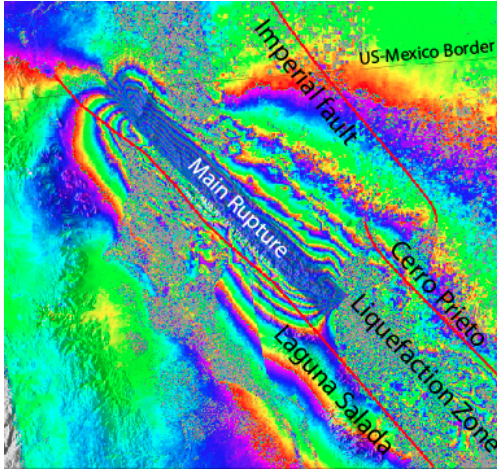
GMTSAR Short Course



Student Presentations (pair or group) – Friday AM

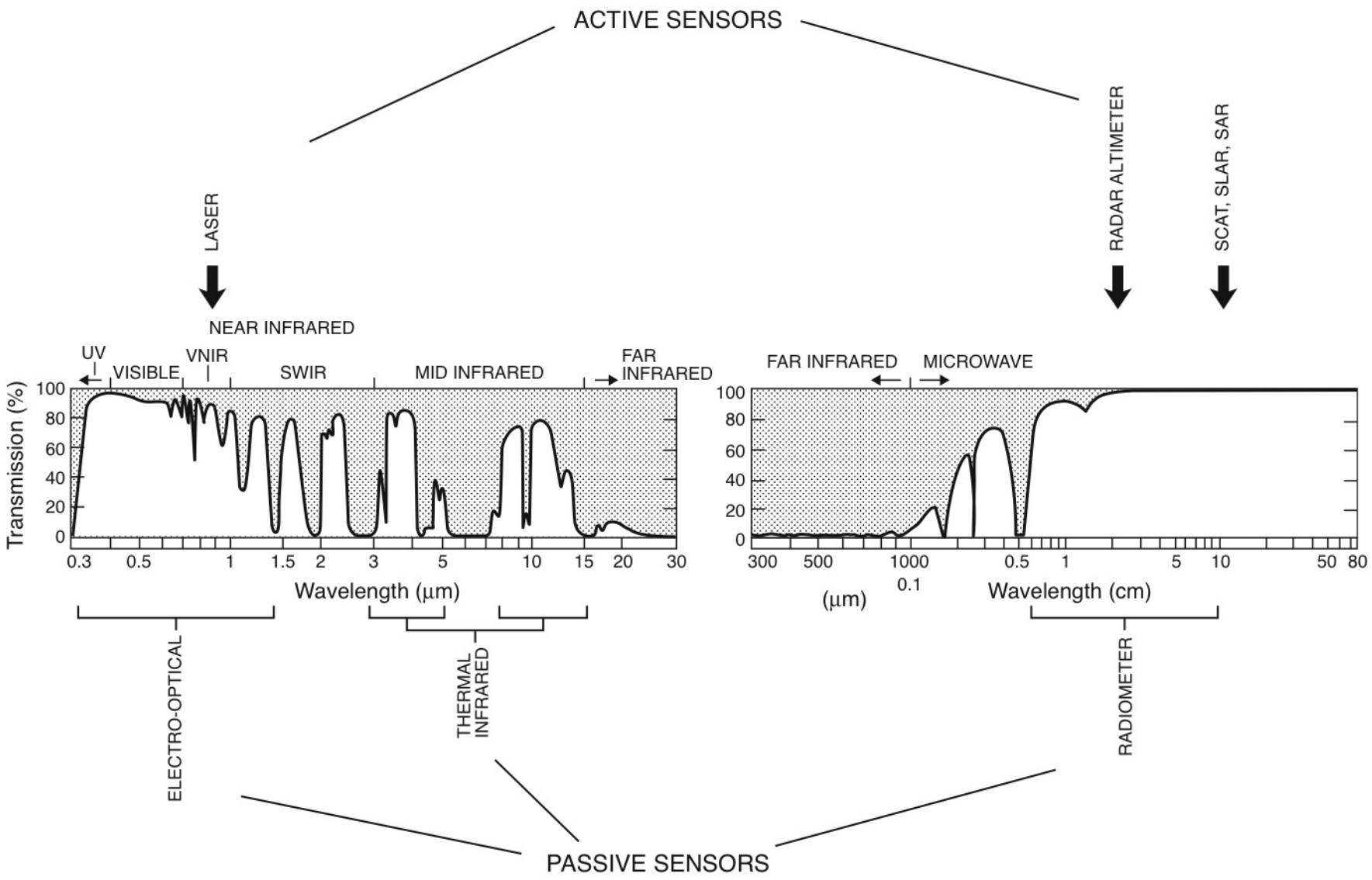
- Group A. – process one of the sample data sets
- Group B. – select new SAR data and process
- Group C. – InSAR batch processing

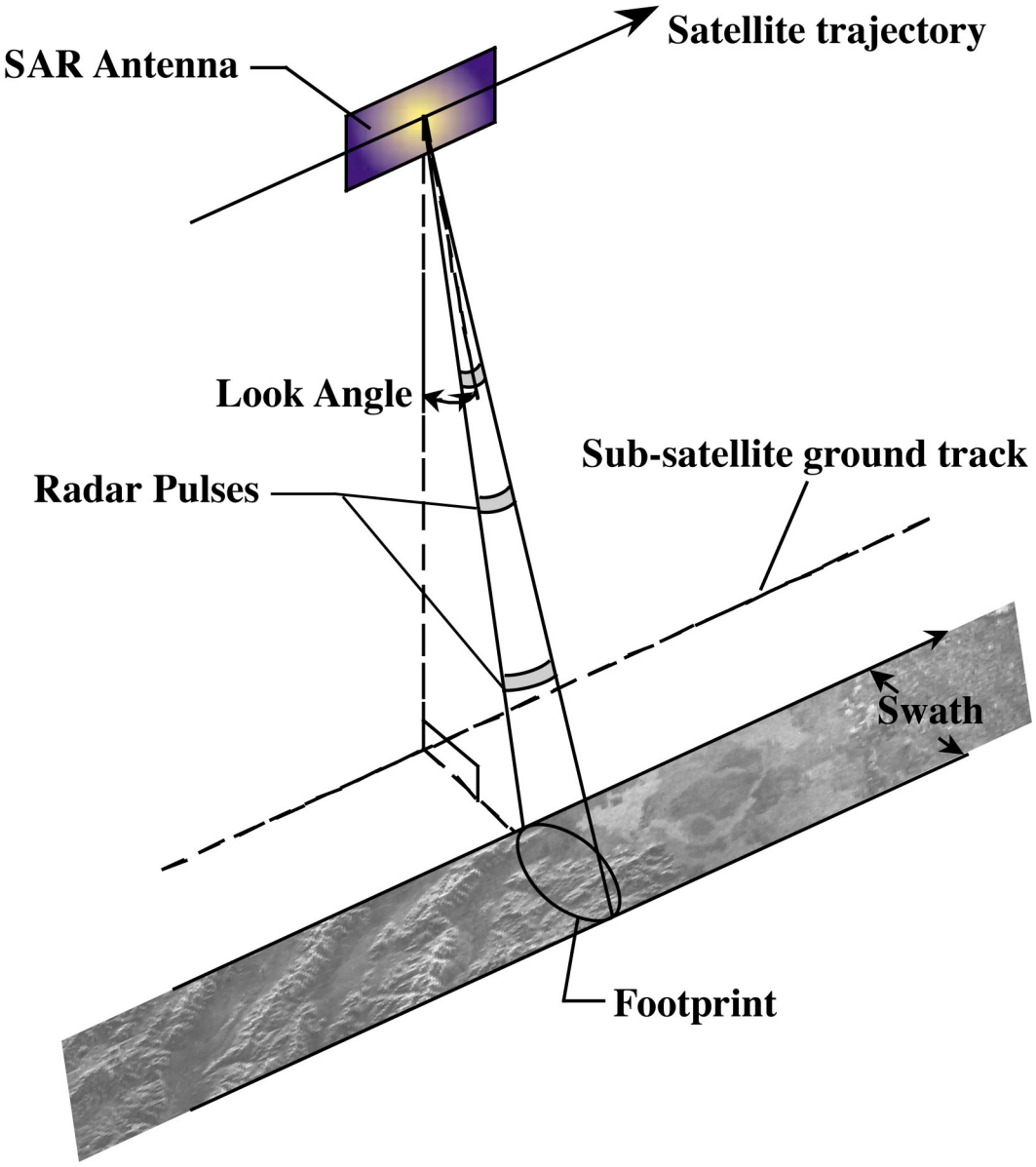
GMTSAR Short Course
Lecture Today



- Brief introduction to SAR and InSAR
- Applications of InSAR
- Appendix A: Principles of Synthetic Aperture Radar

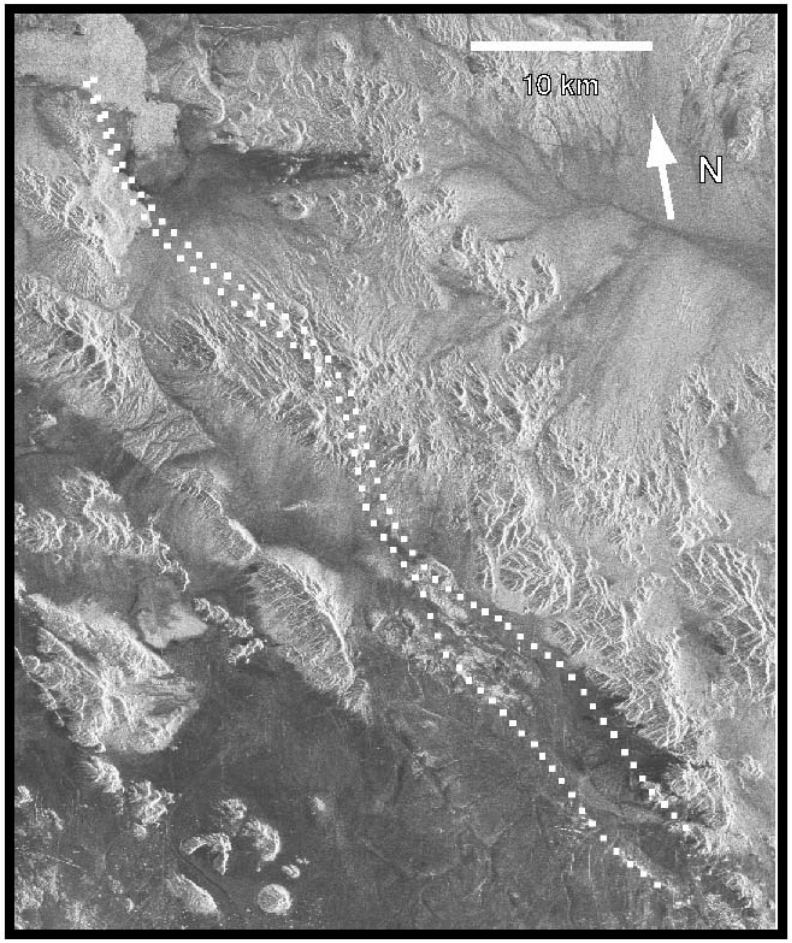
passive and active remote sensing – optical and microwave




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

amplitude and phase

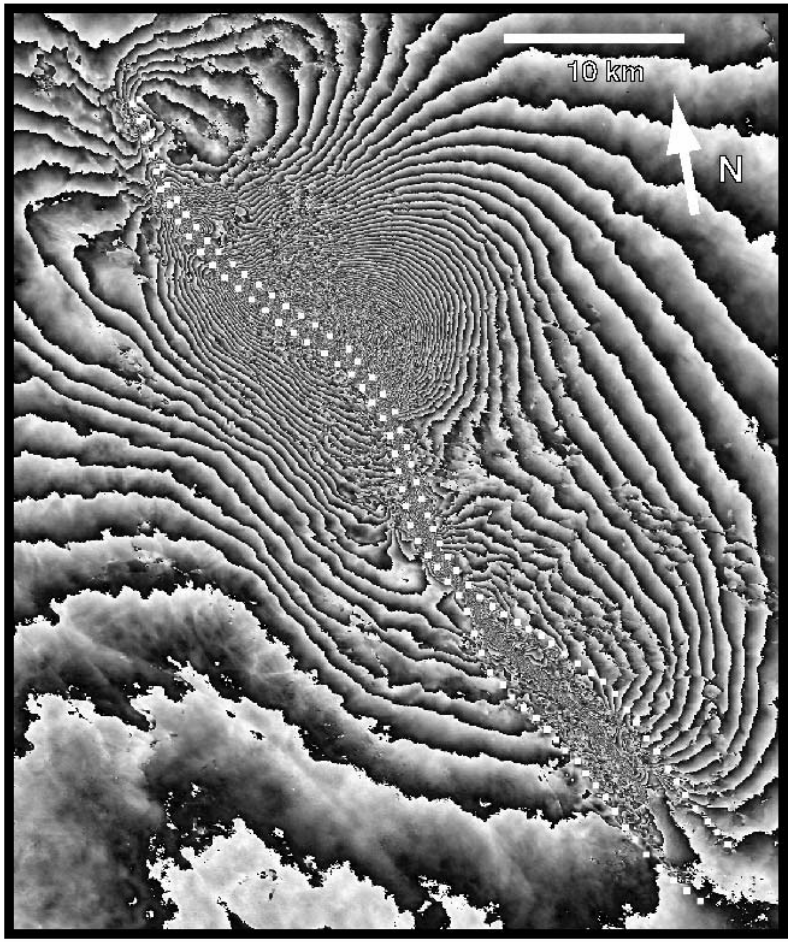
step 1 - SAR (amplitude)



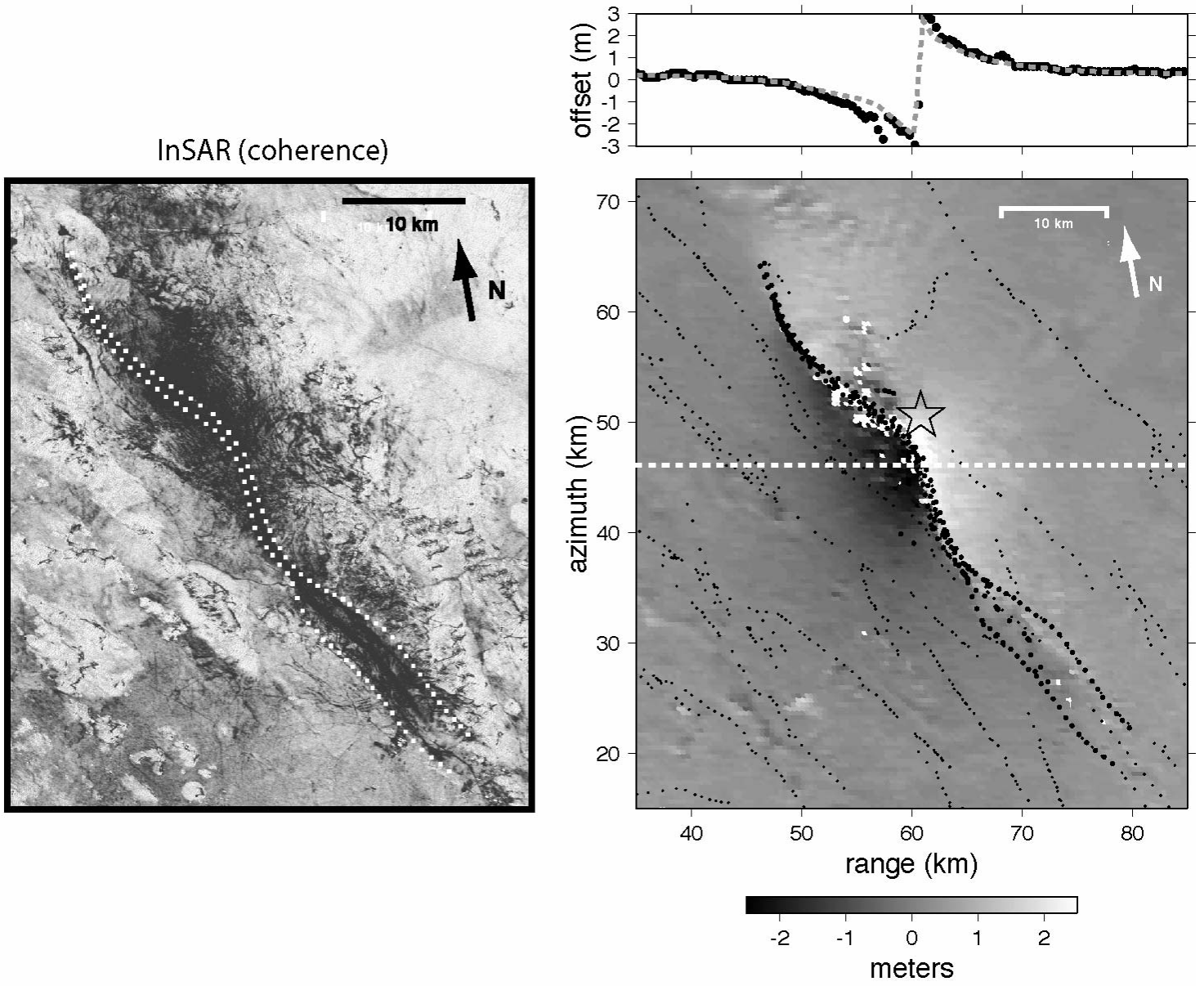
azimuth

range

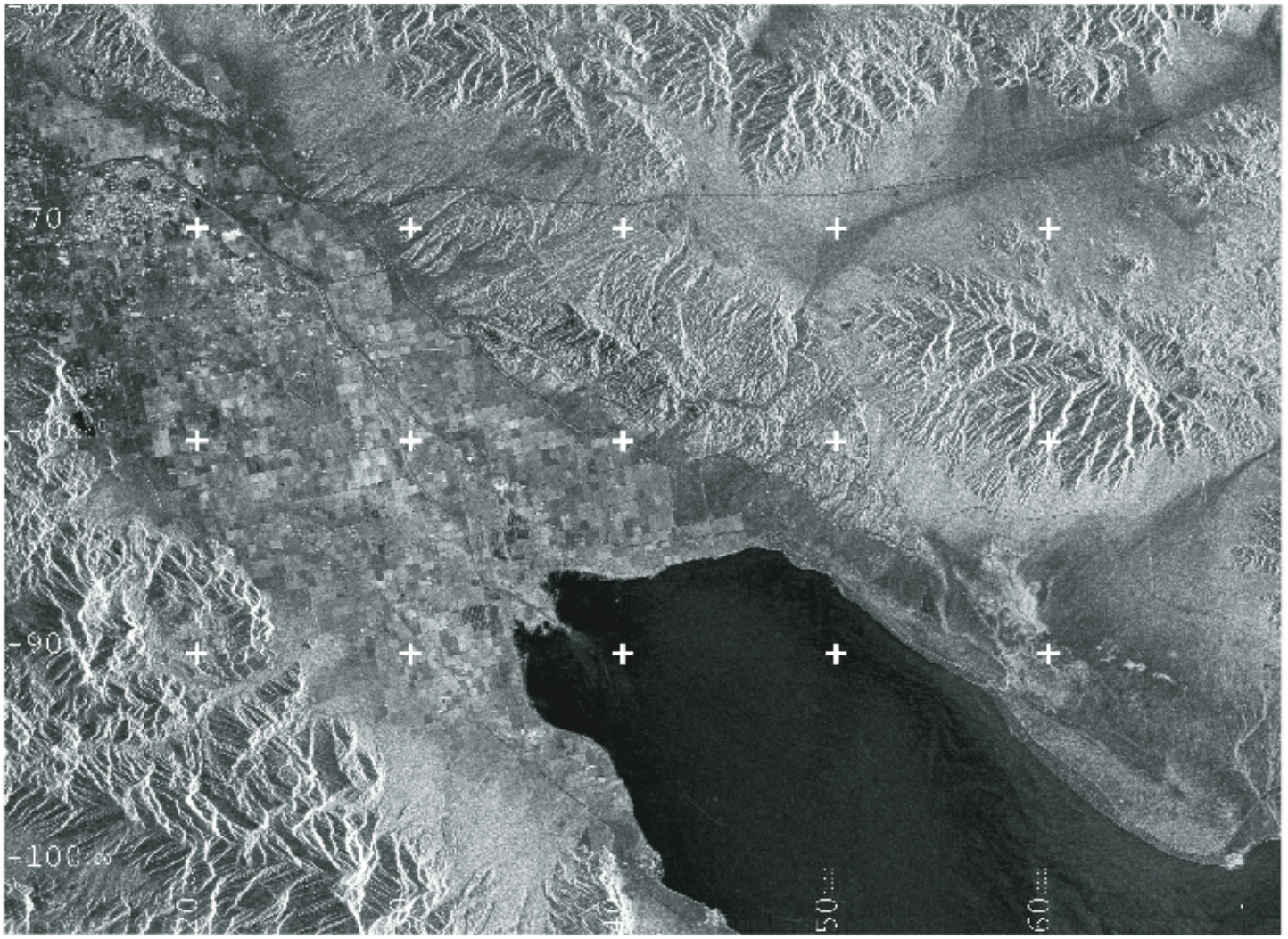
step 2 - InSAR (phase difference)



coherence and pixel matching



ERS amplitude image



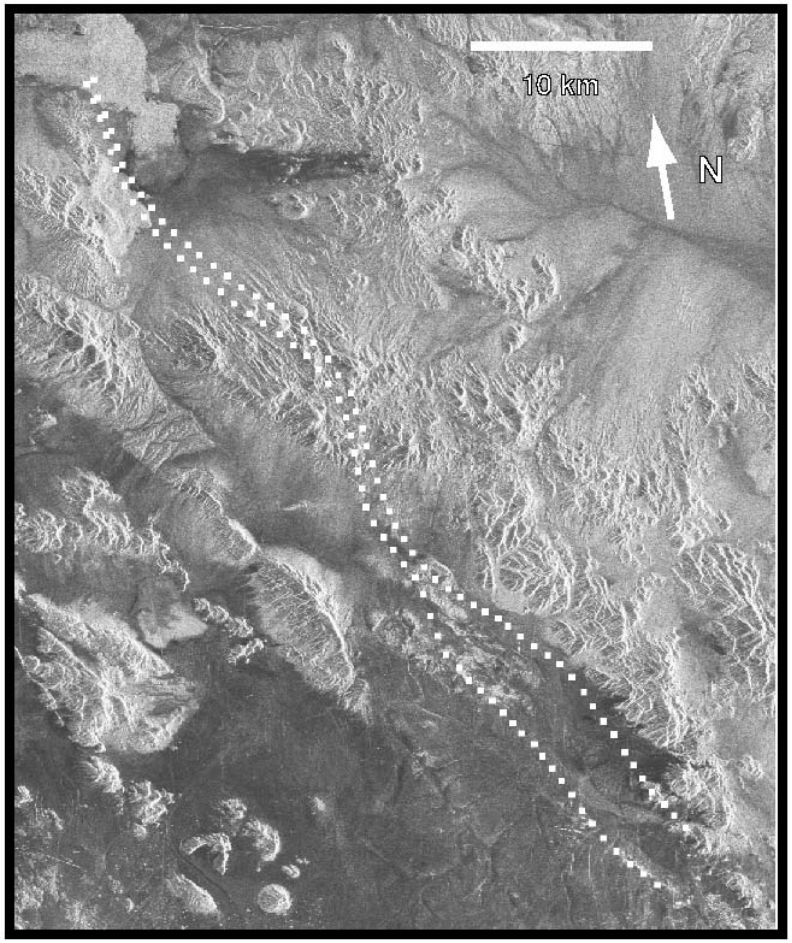
1) This is an image of radar backscatter from a stack of ERS SAR data. The flight path is top to bottom and the radar looks from the right. The area is the Salton Sea and Cochella Valley, and the tic marks are spaced at 10 km. The satellite is 7159717m from the center of the Earth, the local Earth radius 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

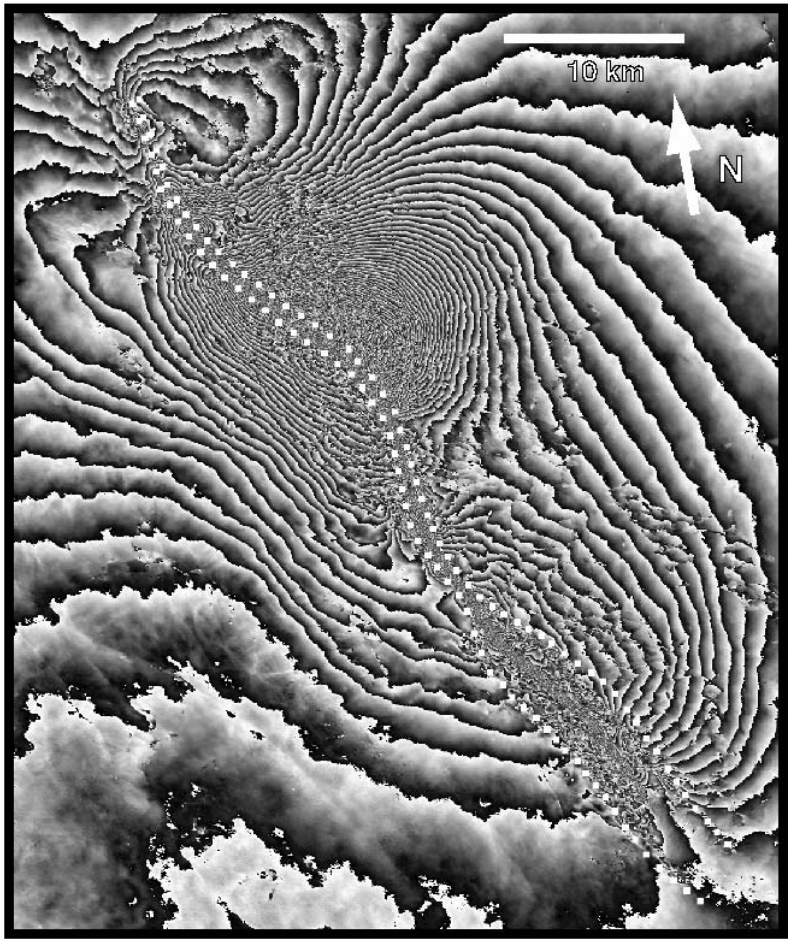
2) This is a zoom of the previous image with 5 km tic marks. Use a map to identify each of the three curved lines running through the images. Why do the fields have different backscatter? Why aren't the fields exactly square? Why do the bright spots have cross patterns?

InSAR uses phase

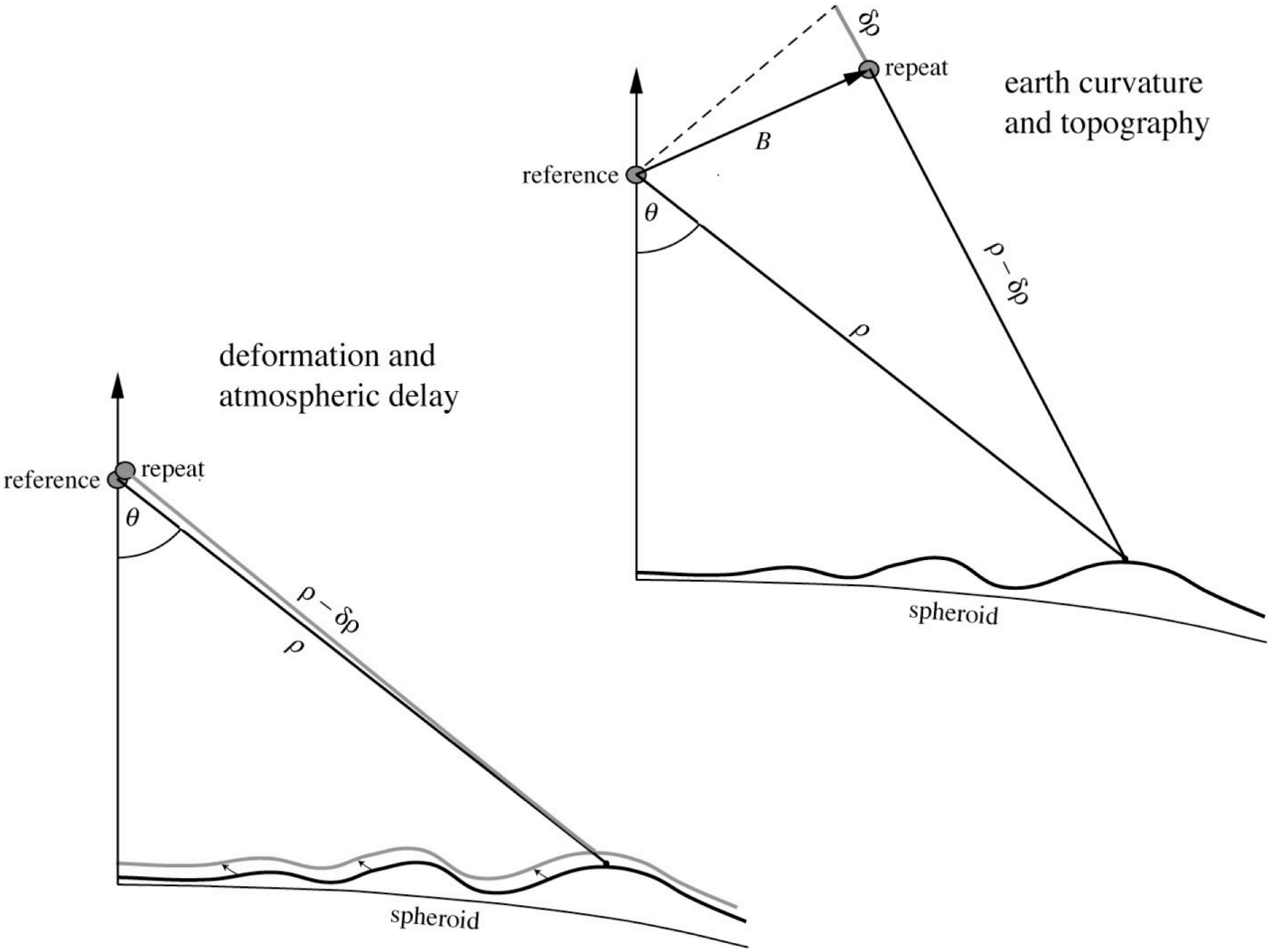
step 1 - SAR (amplitude)



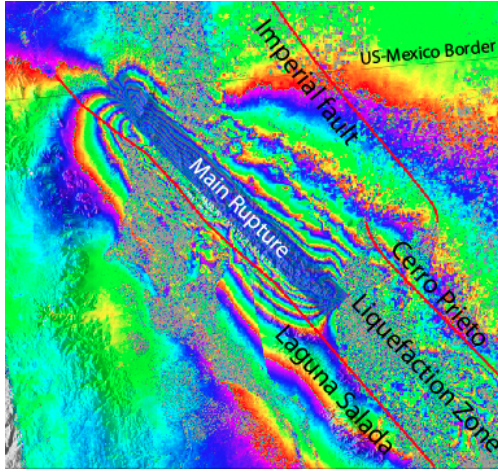
step 2 - InSAR (phase difference)



deformation and topography



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 - next

.cshrc
.tcshrc
.bashrc

what is the . for??

```
#
#  example of .bash_profile
#
alias la='ls -alh'
alias rm='rm -i'
alias lt='ls -lht'
alias ll='ls -l'

export PATH="/Users/elindsey/scripts/:${PATH}”

export GMT5SAR=/usr/local/GMT5SAR
export PATH=$GMT5SAR/bin:"$PATH"

export LD_LIBRARY_PATH=$LD_LIBRARY_PATH:/usr/local/lib
```