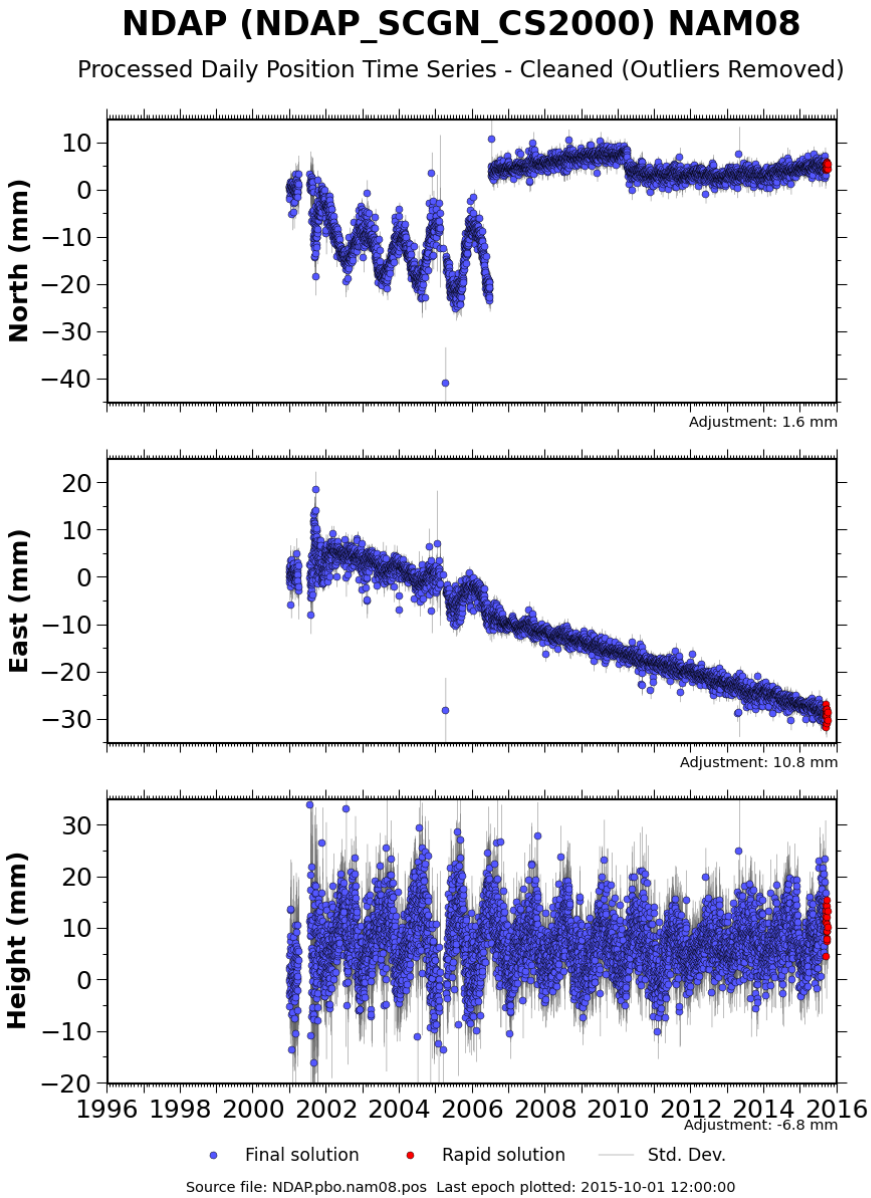
ERTH 455 / GEOP 555
Geodetic Methods

– Lecture 13: InSAR - Making the Interferogram –

Ronni Grapenthin
rg@nmt.edu
MSEC 356
x5924

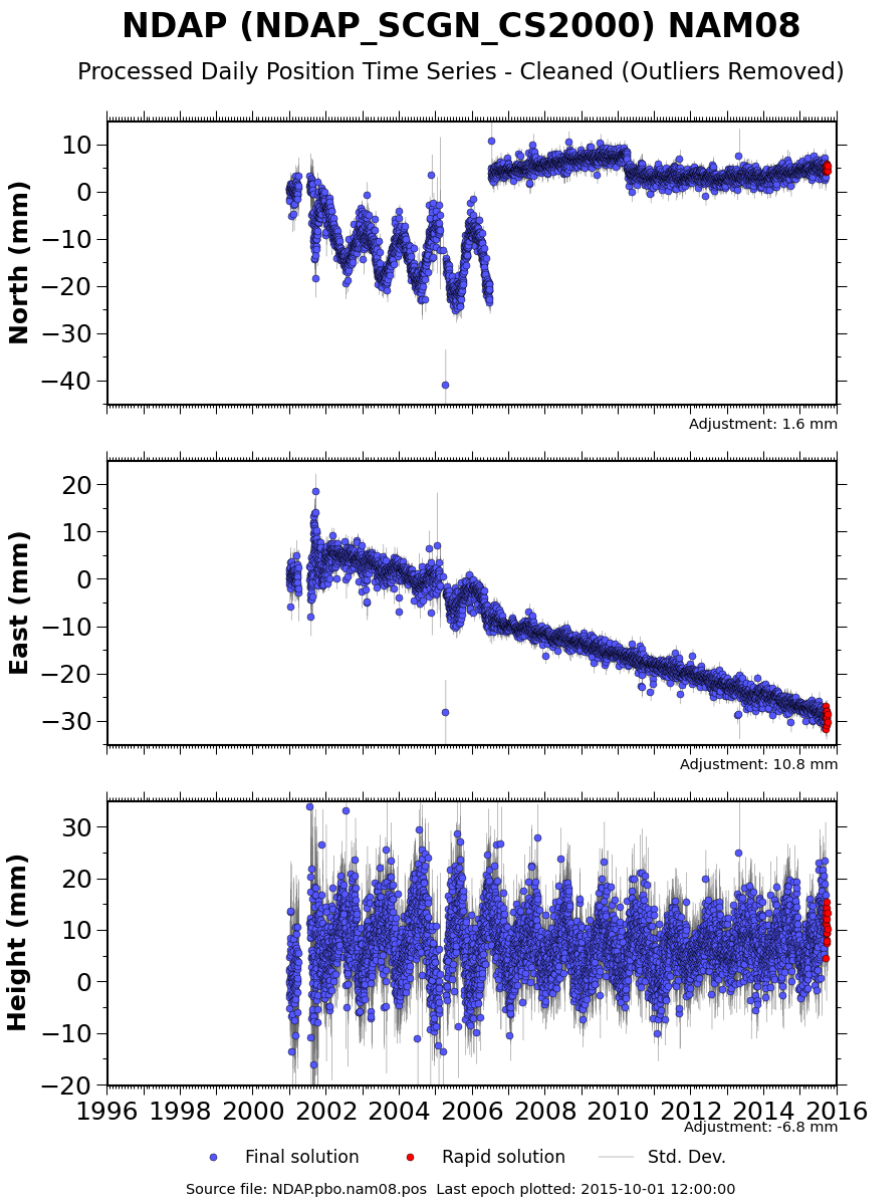
October 04, 2017

New Segment: “Guess the Process”



source: *UNAVCO*

New Segment: “Guess the Process”



source: *UNAVCO*

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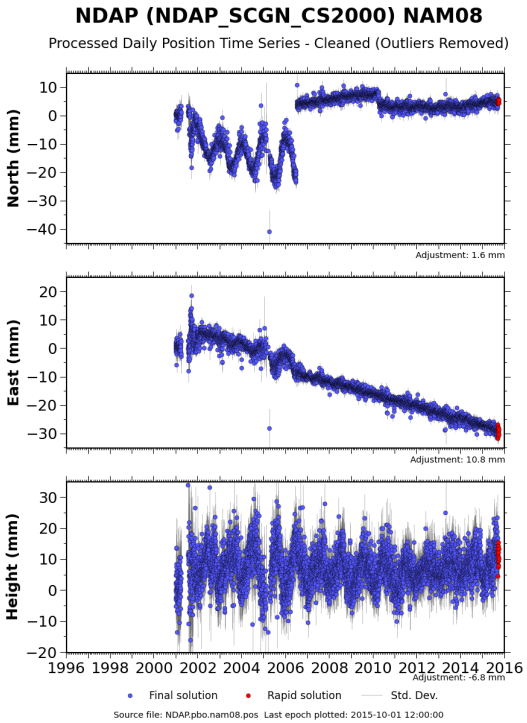
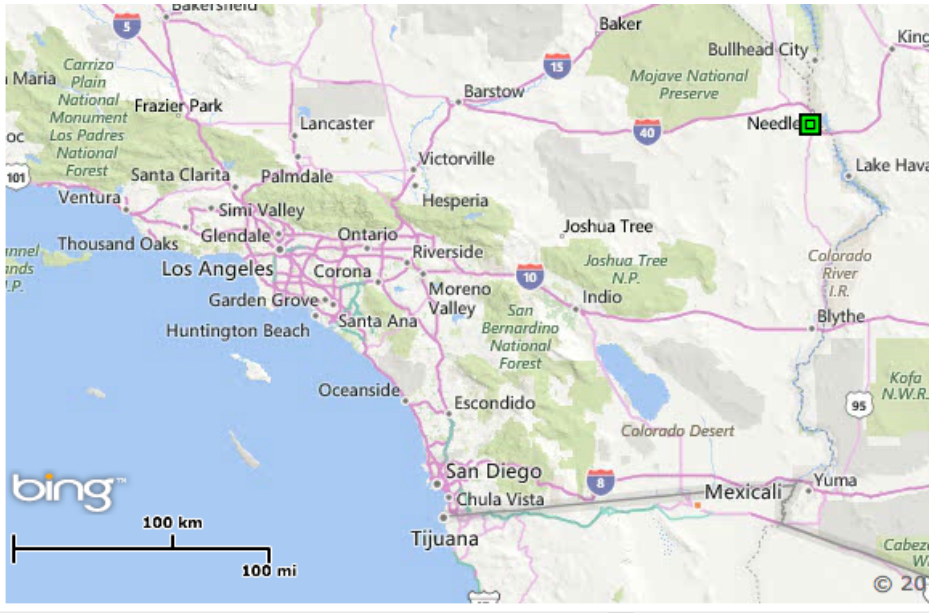




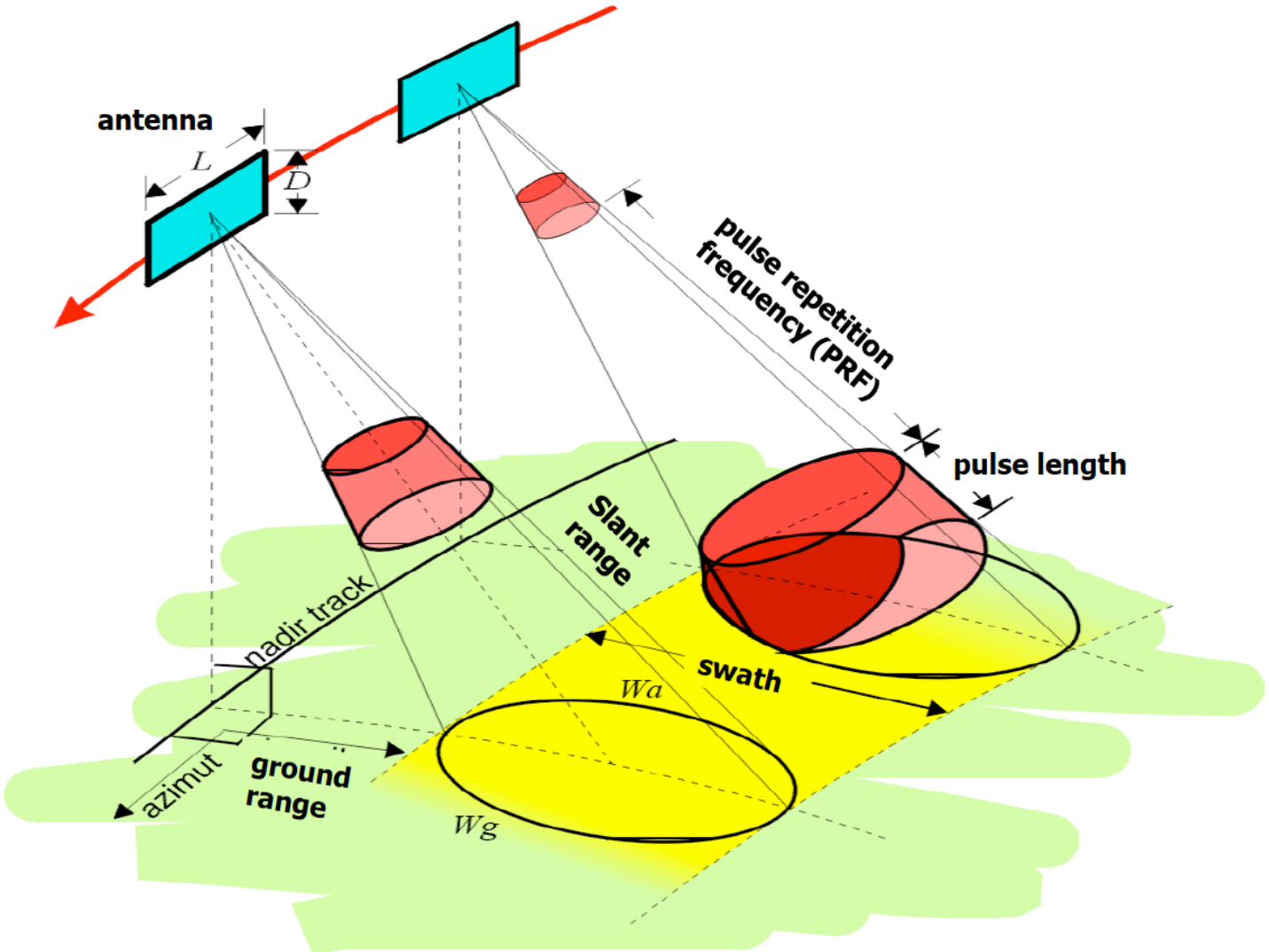
source: *UNAVCO*

Equipment and Configuration History

Double-click on a row to see the configuration synopsis for that occupation.

Start Time ▼	End Time	Receiver	Receiver Serial	Receiver UNAVCO ID	Firmware	Antenna	Antenna Serial
2010 Jul 03 00:00	2015 Oct 03 23:59	TRIMBLE NETRS	4611206670	20811	1.3-0	ASH701945B_M	CR620012201
2006 Jul 14 16:35	2010 Jul 02 23:59	TRIMBLE NETRS	4611206670	20811	1.1-2 19 Apr 2005	ASH701945B_M	CR620012201
2006 Mar 27 18:53	2006 Jun 30 23:59	TRIMBLE NETRS	4549261314	20069	1.1-2 19 Apr 2005	ASH701945B_M	CR519991876
2005 Apr 20 01:29	2006 Mar 27 17:32	TRIMBLE NETRS	4427235673	15582	0.3-9	ASH701945B_M	CR519991876
2000 Dec 30 00:01	2005 Feb 08 23:59	ASHTECH Z-XII3	LP03246	not provided	CD00	ASH701945B_M	CR519991876

InSAR - General Concept



loaned from *J. Freymueller*

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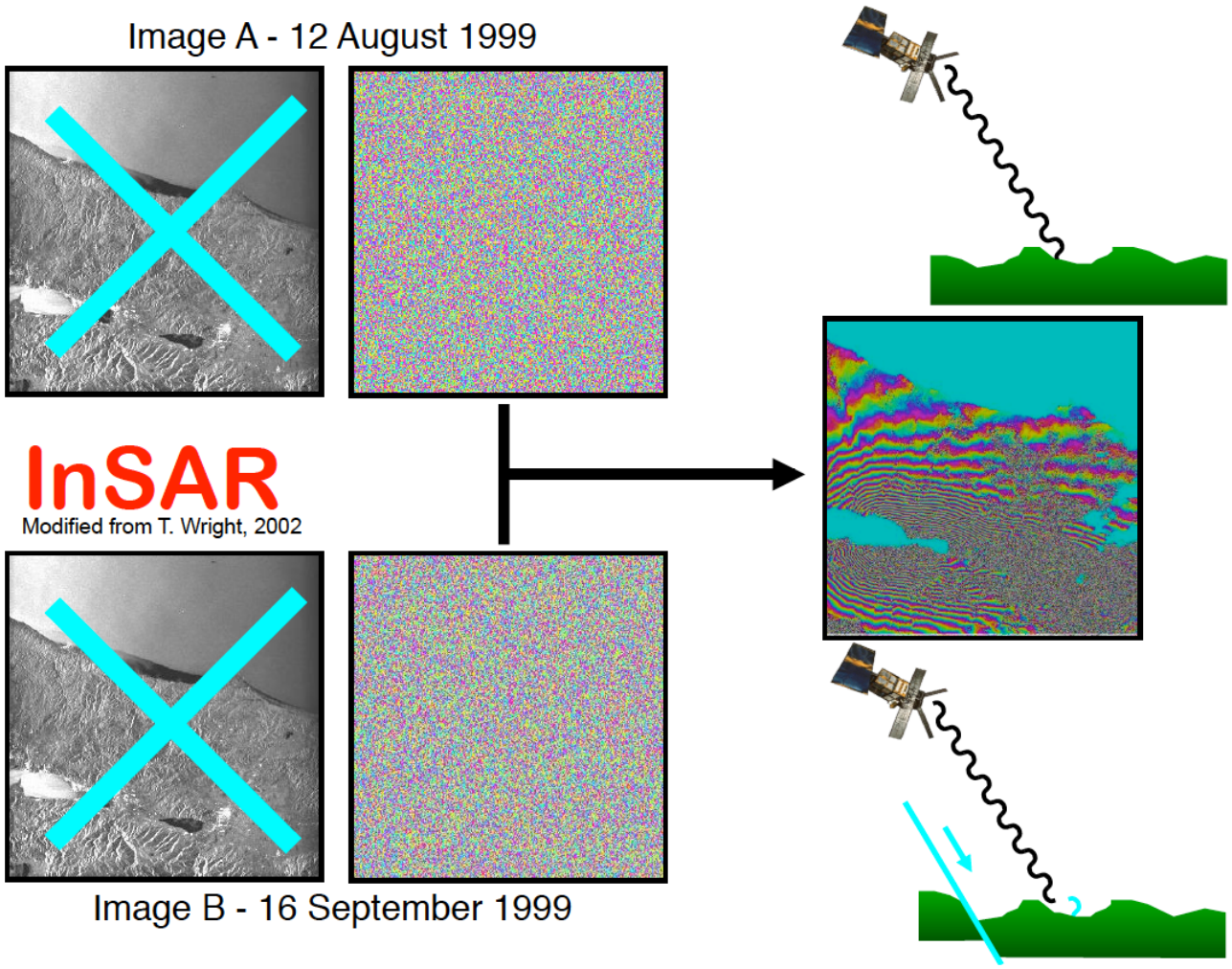
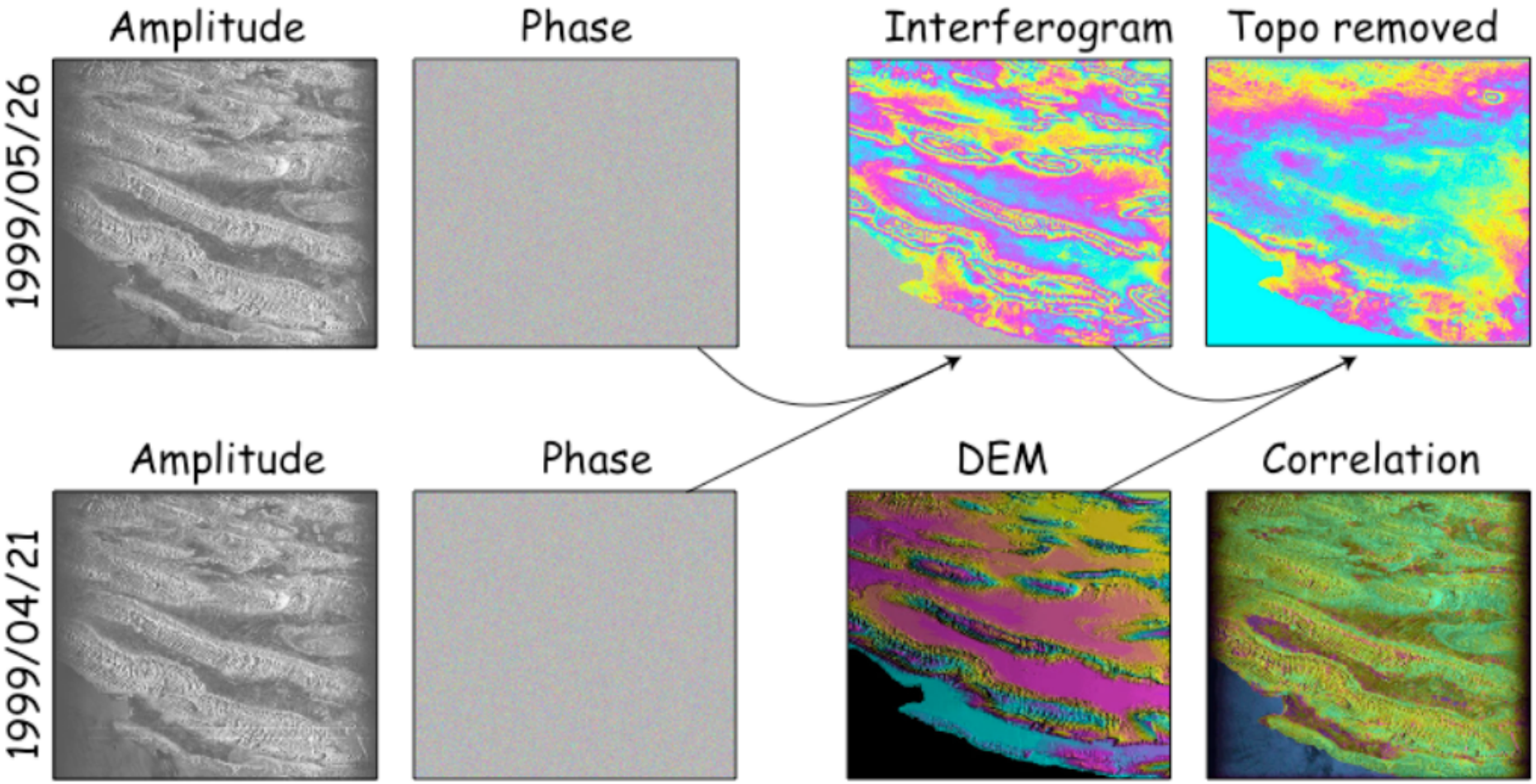


loaned from *R. Bürgmann*

complex values radar signal contains information on amplitude $a = \sqrt{Im^2 + Re^2}$, and phase $\phi = arctan\frac{Im}{Re}$

InSAR - General Concept



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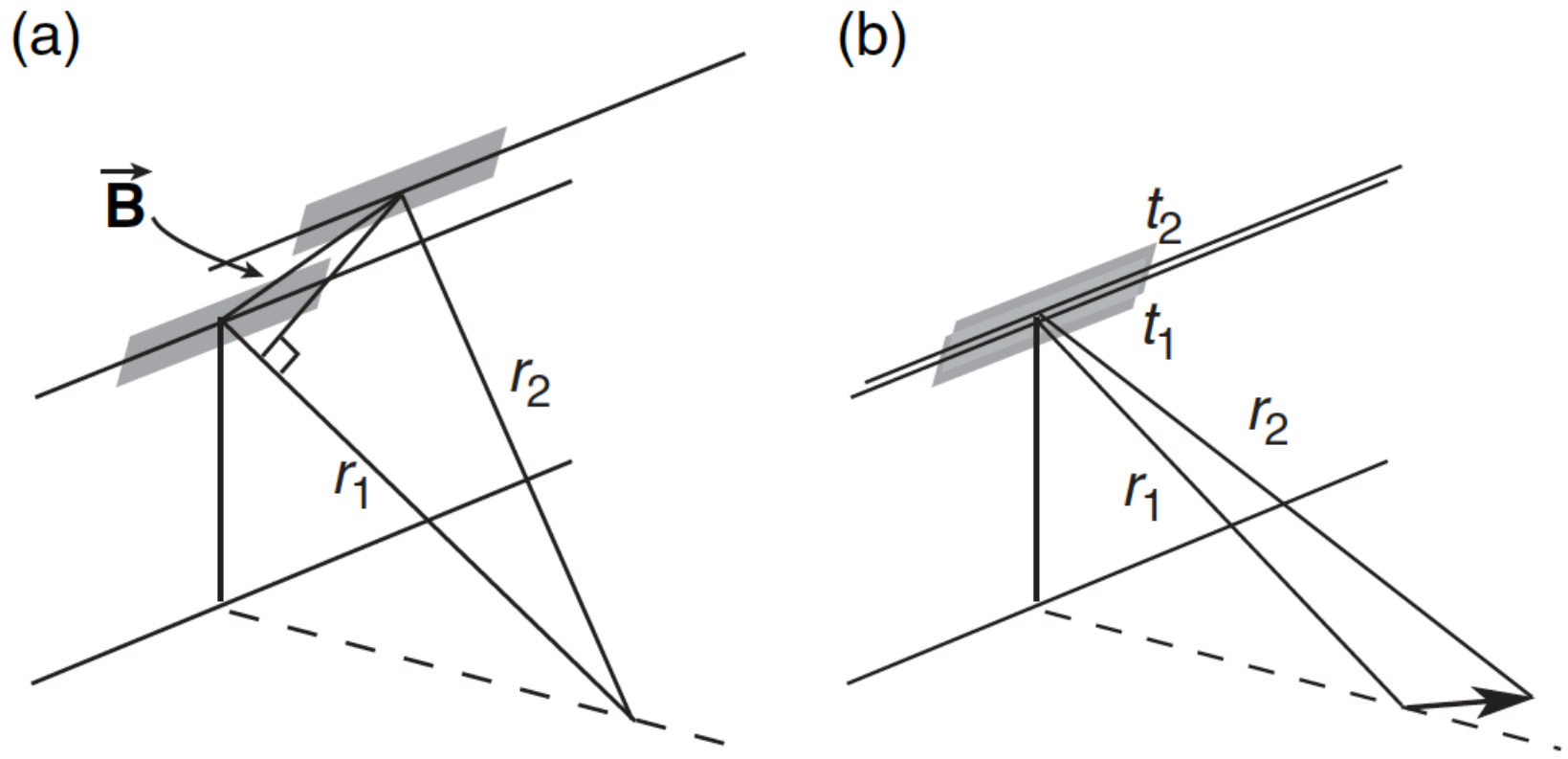
Difference between InSARs

Topography: look at same thing from 2 views (SRTM)
Deformation: look at same thing from same point and see whether it moved



Simons and Rosen, 2007

Making an Interferogram

Make interferogram from 2 Single Look Complex images (images are in radar coordinates: range ρ, azimuth a):

1. align reference and repeat images to sub-pixel accuracy
2. multiply complex images (SLC) to form complex interferogram
3. extract phase: $\phi_2 - \phi_1 = arctan\frac{Im}{Re}$

Making an Interferogram: Step 1 - Alignment

- take 100s of small sub-patches (e.g. 64 $\times$ 64) from master and slave
- 2D cross correlation of patch pairs
- determine 6-parameter affine transformation to align slave to master image
- affine: parallel remains, straight remains, points preserved

Making an Interferogram: Step 2 - Multiply

Complex number of each pixel, $C(x)$, in terms of amplitude, $A(x)$, and phase, $\phi(x)$:

$$C(x) \quad = \quad A(x)e^{i\,\phi(x)}$$

with position vector $\mathbf{x} = (\rho, a)$ defined by range and azimuth

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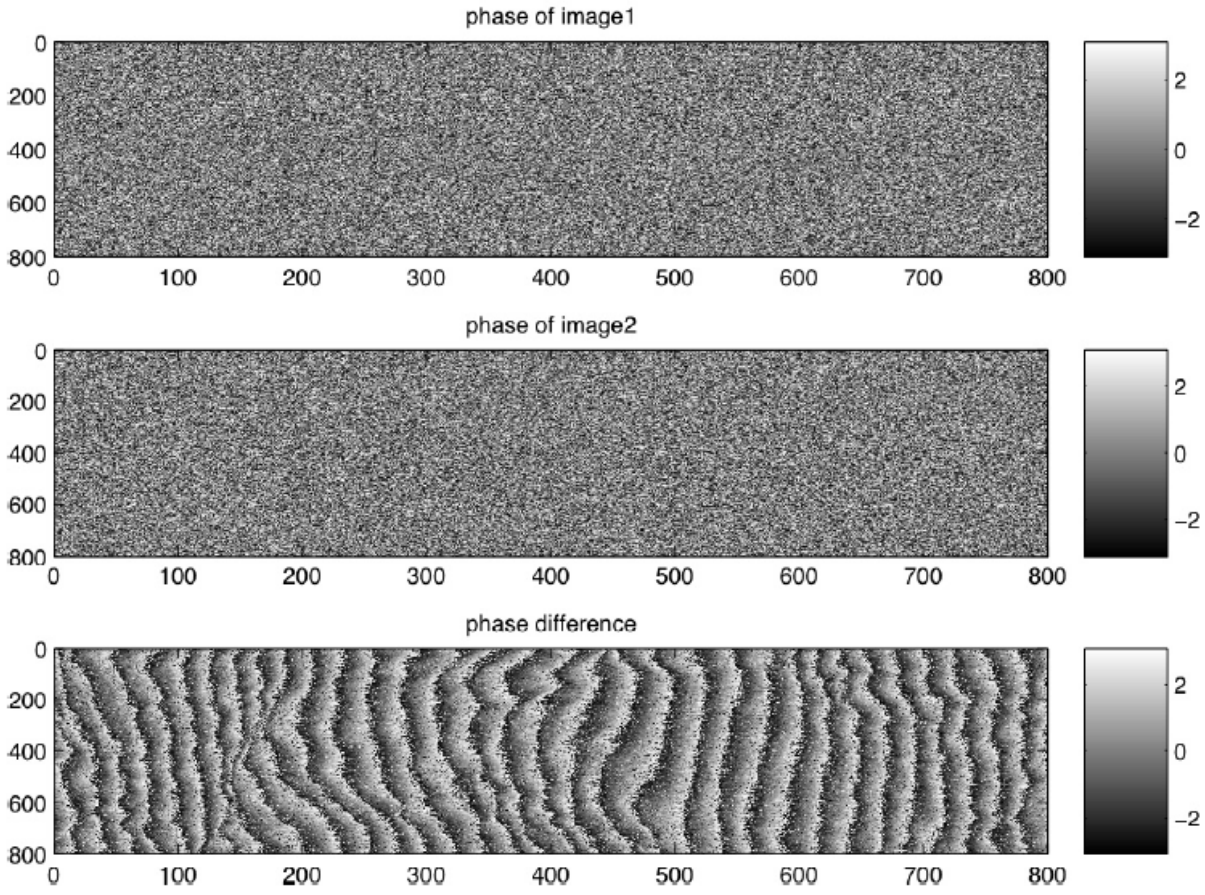
Multiply (pixel by pixel, note complex conjugate!):

$$\begin{aligned} C_2\, C_1^* &= A_2\, A_1\, e^{i(\phi_2 - \phi_1)} \\ &= Re(x) + i\, Im(x) \end{aligned}$$

Making an Interferogram: Step 3 - Get Phase

$$\phi_2 - \phi_1 = arctan \frac{Im(C_2\, C_1^*)}{Re(C_2\, C_1^*)}$$



Sandwell et al., 2011, GMTSAR documentation

Phase Contributors

What's in the phase?

Phase Contributors

$$\phi = E + \phi_{topo} + D + \epsilon_{orbit} + I + T + \epsilon$$

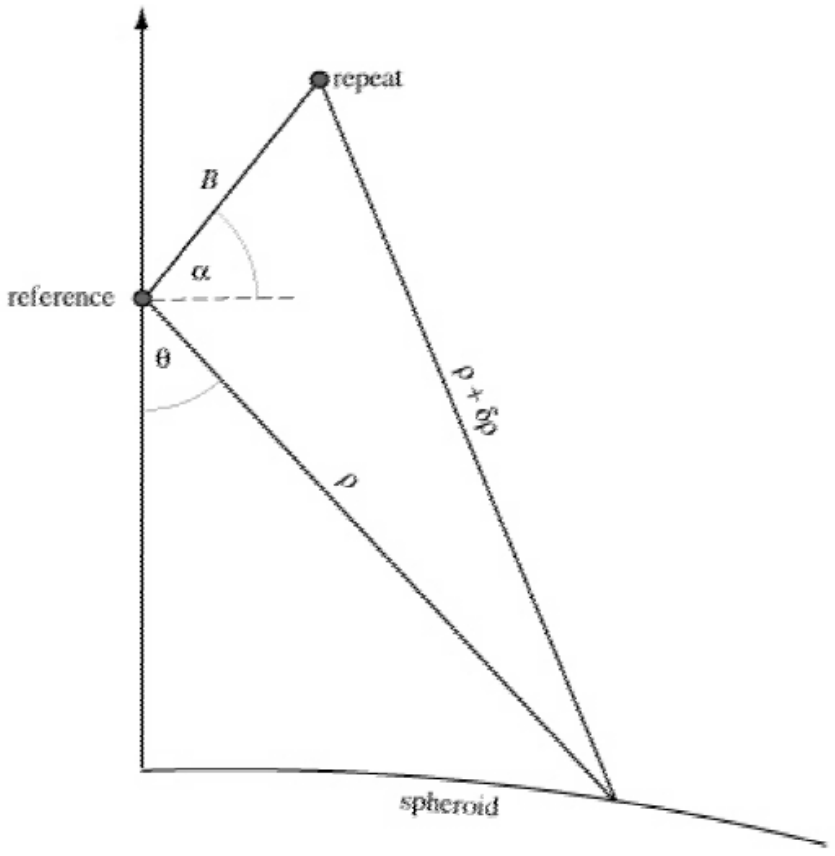
where:

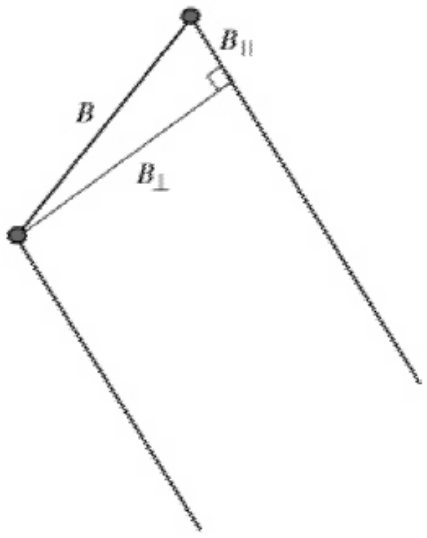
- E: earth curvature (almost planar, known)
- ϕ_{topo}: topographic phase (broad spectrum)
- **D: surface deformation (unknown, we want to know!)**
- ϵ_{orbit}: orbit error (almost a plane, mostly known)
- I: Ionospheric Delay (plane or 40 km wavelength waves!)
- T: Tropospheric Delay (power law, unknown)
- ϵ: phase noise (white, unknown)

Correct for Earth's Shape

EarthShape = curvature + topography

Repeat-pass interferometry geometry:





Topography Correction Algorithm

- map topography from lat, lon, height to radar coordinates and topography over range, azimuth $t(\rho, a)$

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- interpolate topography to each range pixel get look angle from:

$$\theta_{\rho,a} = cos^{-1}\left[\frac{(b^2 + \rho^2 - (r_e + t(\rho, a)))^2}{2\rho\, b}\right]$$

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- with look angle for each range pixel, calculate phase correction for repeat image:

$$\phi_{\rho,a} = -\frac{4\,\pi\, B}{\lambda} sin(\theta_{\rho,a} - \alpha) + \frac{2\,\pi\, B^2}{\lambda\rho} cos^2(\theta_{\rho,a} - \alpha)$$

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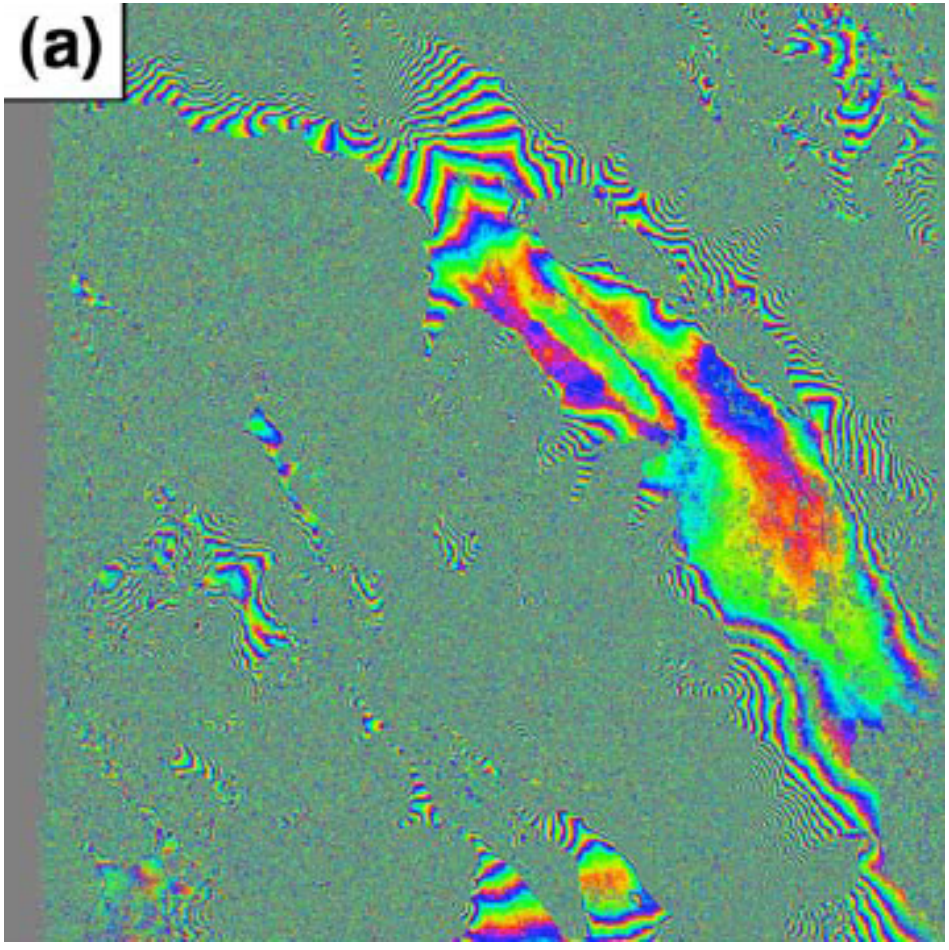
- multiply $C_2\, C_1^*$
- extract phase difference $\phi_2 - \phi_1 = arctan(\frac{Im}{Re})$

Phase due to Topography

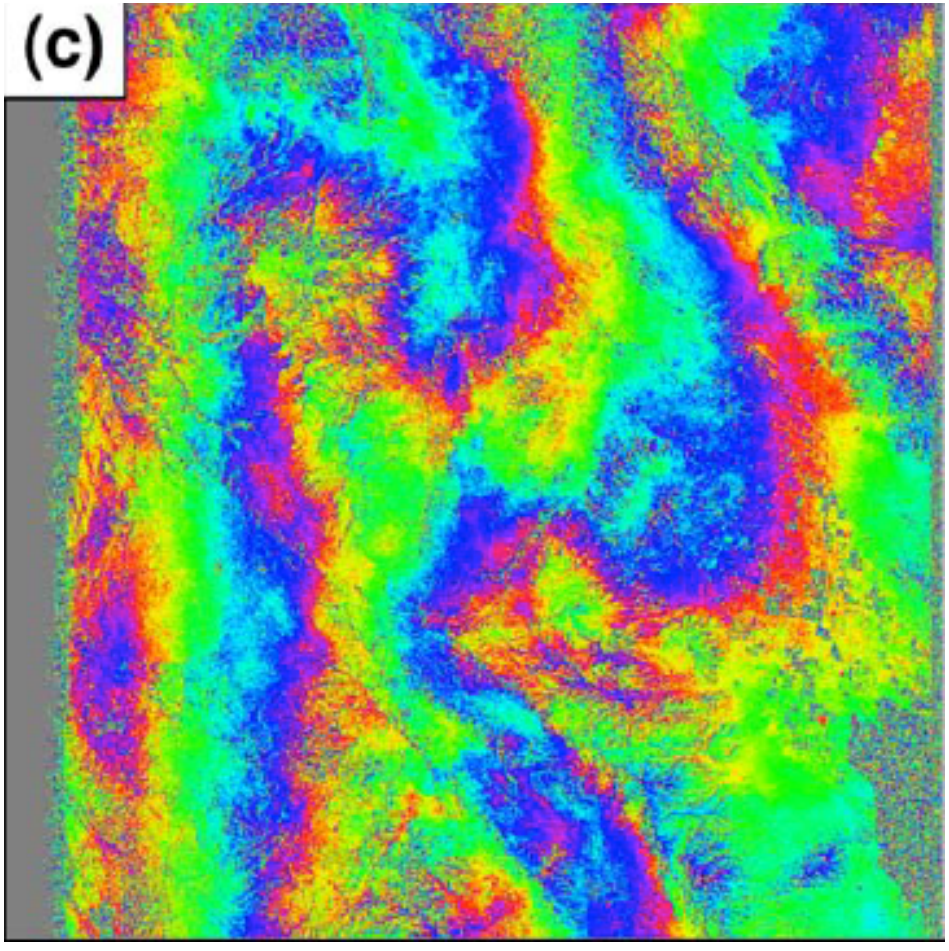
1.95 km baseline Interferogram,
no topo removed (120 fringes need removal):



Sandwell et al., 2011, GMTSAR documentation

Phase due to Topography

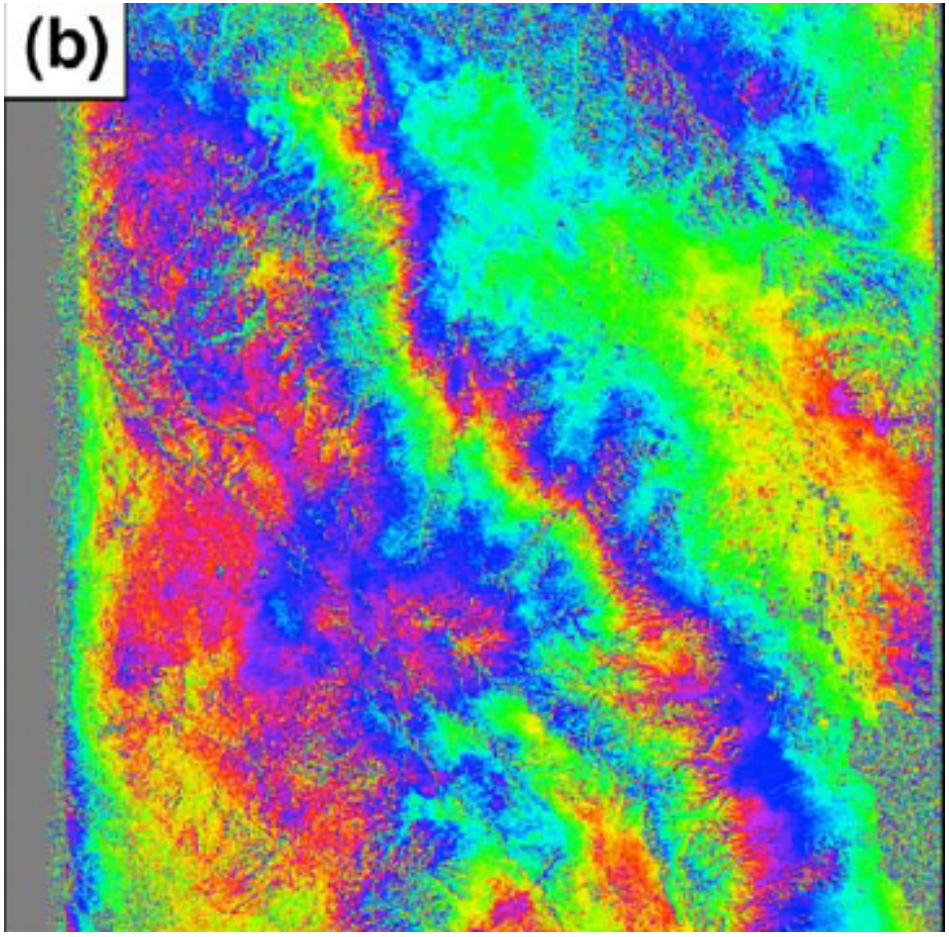
1.95 km baseline Interferogram,
topography correction using **approximate** formulas:



Sandwell et al., 2011, GMTSAR documentation

Phase due to Topography

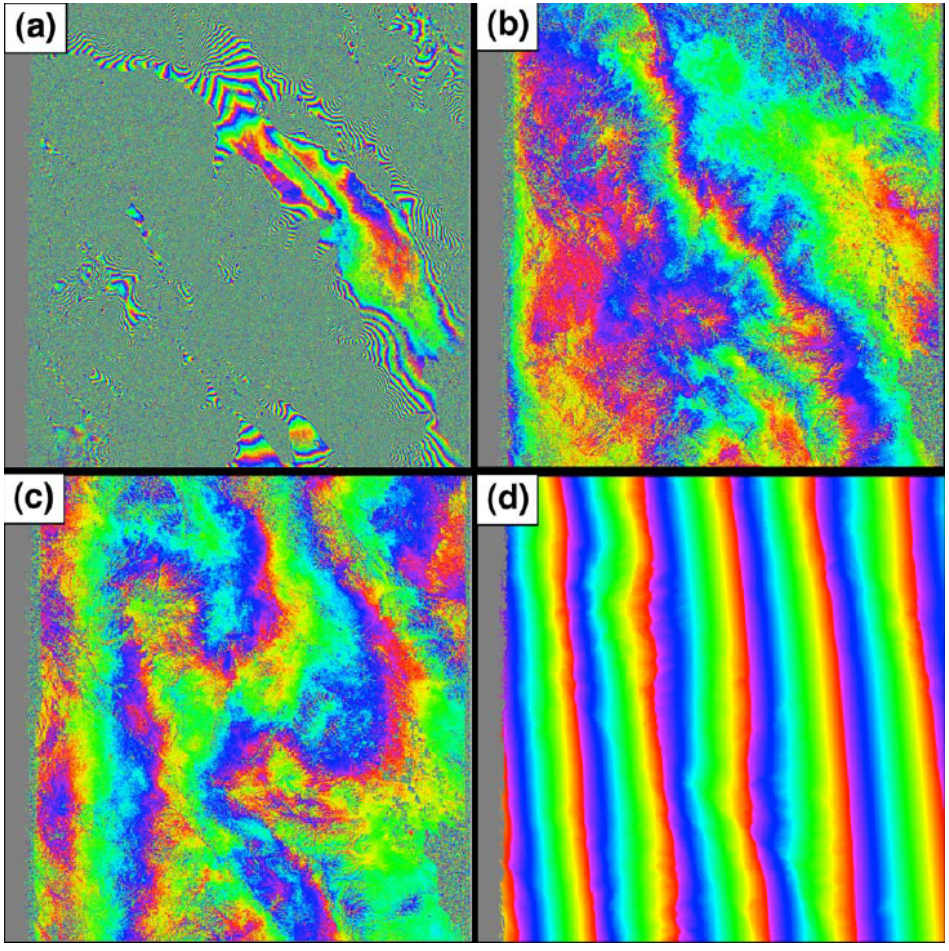
1.95 km baseline Interferogram,
topography correction using **exact(er)** formulas:



Sandwell et al., 2011, GMTSAR documentation

Phase due to Topography

1.95 km baseline Interferogram,
Difference between exact and approx. formulas = 0.6 m ramp



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Phase due to Topography

In one image