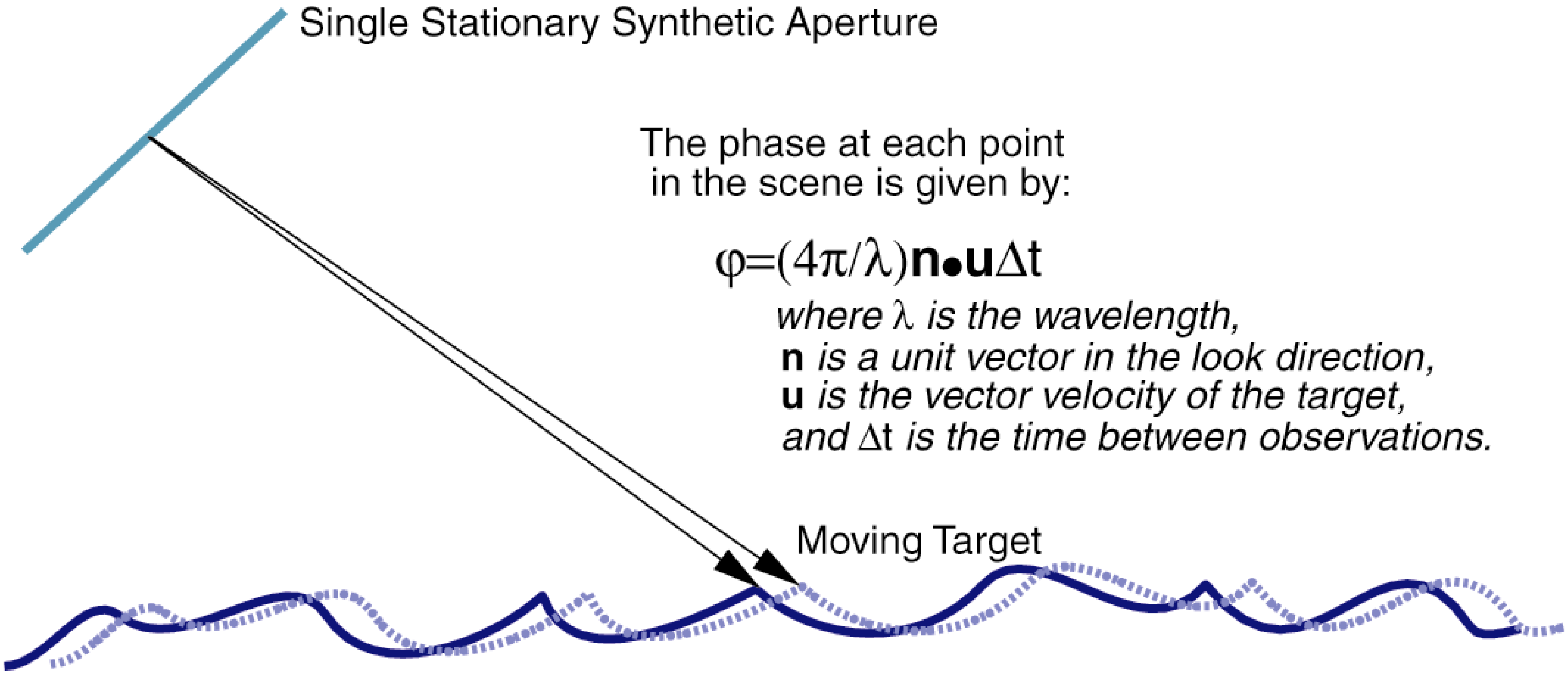
AIRSAR PacRim 2000 Along-Track Interferometry

ATI Concept



The phase at each point in the scene is given by:

$$\varphi=(4\pi/\lambda)\mathbf{n}\bullet\mathbf{u}\Delta t$$

where λ is the wavelength,
n *is a unit vector in the look direction,*
u *is the vector velocity of the target,*
and Δt is the time between observations.

No spatial baseline!
Antenna is formed by synthetic aperture.
Use two antennas on moving platform to achieve time interval.
All motion measured via ATI are components of the velocity along the look vector.
Identical to RepeatPass Interferometry, except...

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Elaine Chapin

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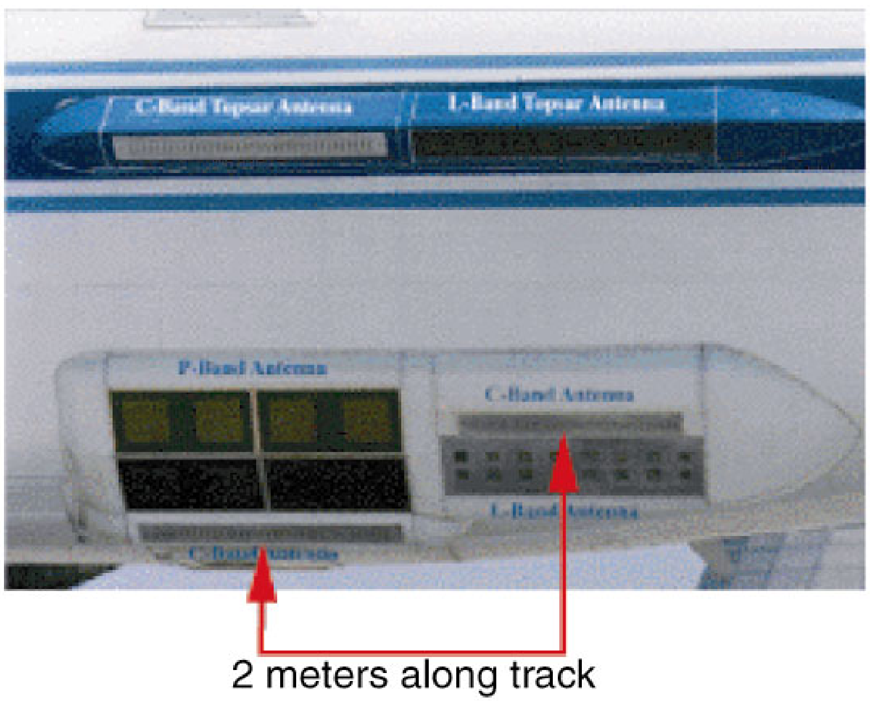
Ernie Paylor
Diane Evans
Charles Werner
Ellen O'Leary

ATI Capability



L-Band

Velocity Wrap

Full Baseline:	1.2 m/s
Half Baseline:	2.4 m/s

C-Band

Velocity Wrap

Full Baseline:	3.0 m/s
Half Baseline:	5.9 m/s

Minimum detectable velocities will depend on surface brightness, system noise and number of looks. Typically the phase resolution is 2-20 degrees, corresponding to a few cm/s.

For PacRim 2000, the half-baseline was used: better SNR (higher PRF), less wrap, reduced minimum detectable velocity.

AIRSAR ATI Processor

Features:

- Motion alignment: algorithm similar to repeat-pass interferometry
- Advanced radar echo resampling: "Presumming"
- Advanced motion compensation
- QA includes registration check, RFI filtering

Caveats:

- No compensation for topography
- Relative phase only
- Interferograms only (phase not unwrapped)
- Radiometry uncalibrated
- C & L-band interferograms have different registration
- Patch boundary and residual motion artifacts

Topography Phase Errors

Motion compensation is performed assuming a constant elevation reference. This is a good assumption for the ocean surface, but introduces phase errors over land:

$$\Delta\varphi \approx \frac{4\pi d_z h}{\lambda r}$$

where d_z is the vertical component of the antenna phase center separation, h is the altitude of the scatterer above the elevation reference, λ is the wavelengeth, and r is the range to the scatterer.

Thus, for PacRim 2000 data, the phase wrap over topographic variations will be:

C-band: 800-1300 m

*L-band: 6600-10000 m

Phase error due to 10 m of topography:

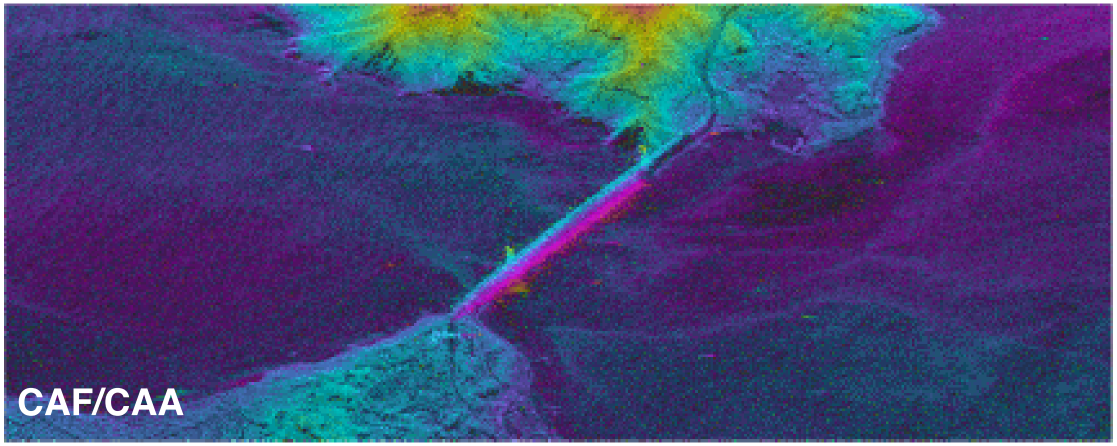
C-band: 5-7 degrees

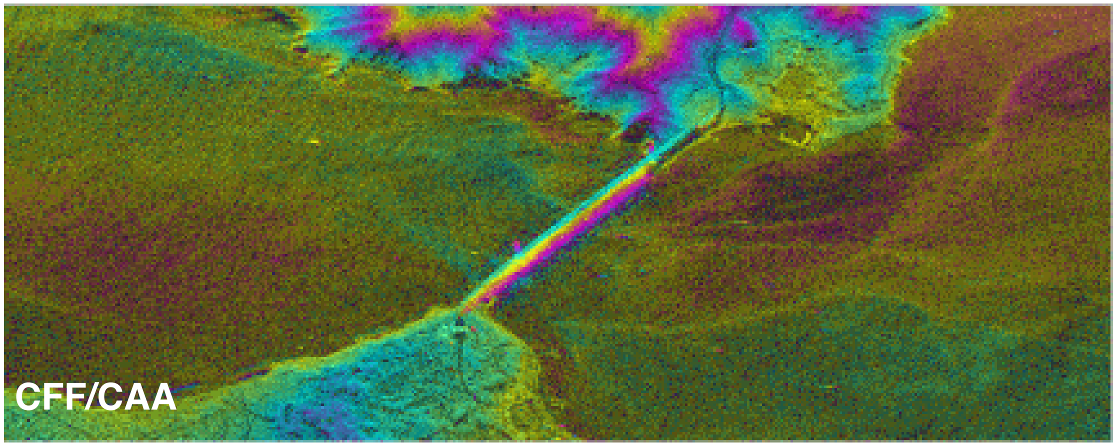
L-band: <0.5 degrees
(for one degree of pitch)

*Divided by degreees of pitch

C-band phase errors are due to a 61 cm vertical baseline, while L-band phase errors are due to pitched 20 m along-track baseline.

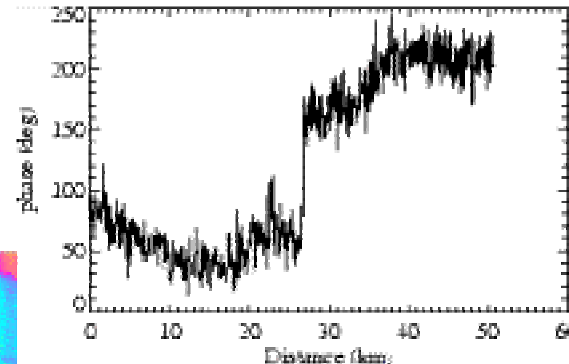
Velocity wrap for upper interferogram is twice that of the lower. Golden Gate Bridge, from EOCAP 1998 data acquisition campaign.

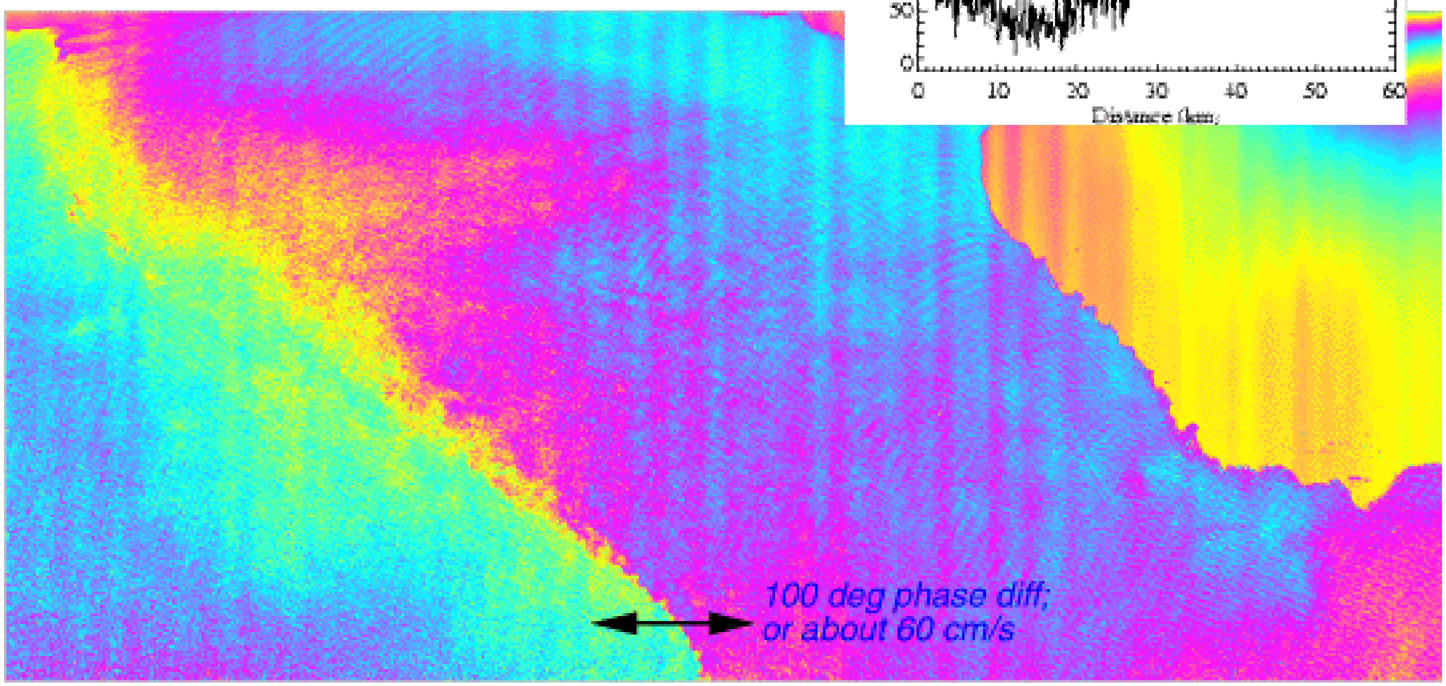




PacRim 1996: Kohala

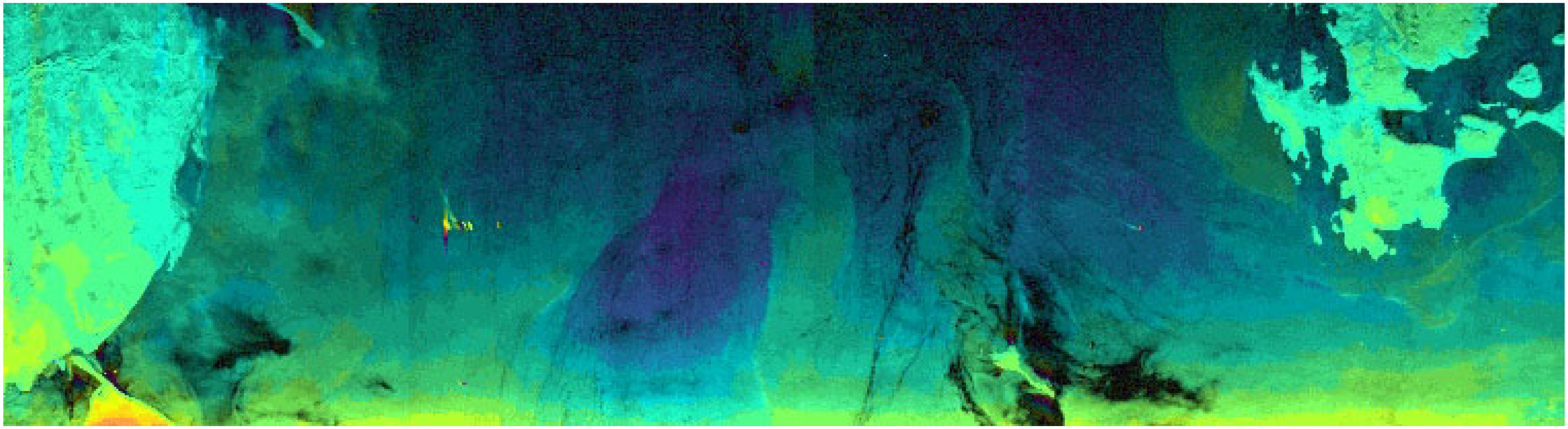
PacRim '96: Kohala Coast
AA/AF Interferometric Phase
(8x120 looks) approx. 60m pixels.



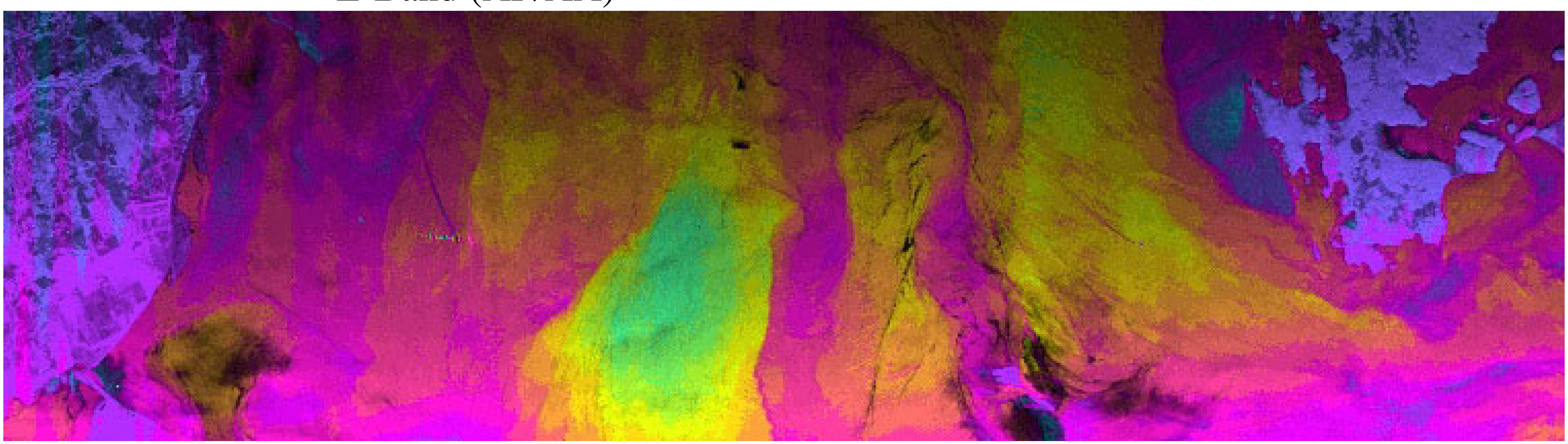


1999: Straits of Juan de Fuca

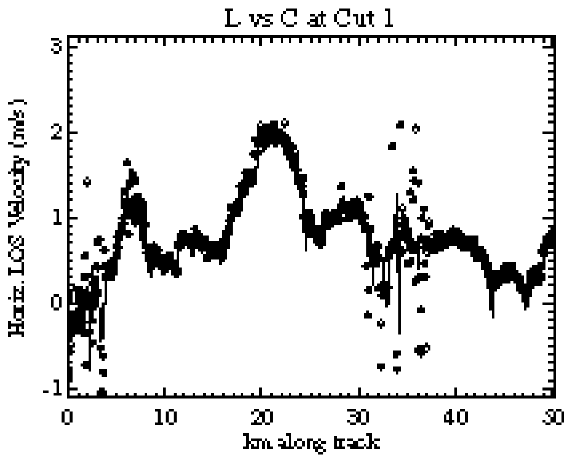
C-Band (AF/AA)

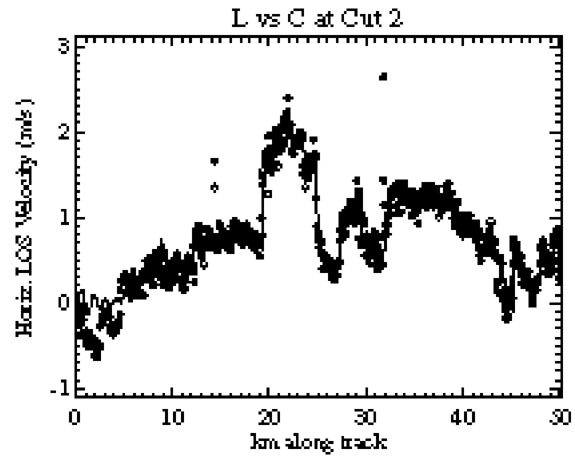


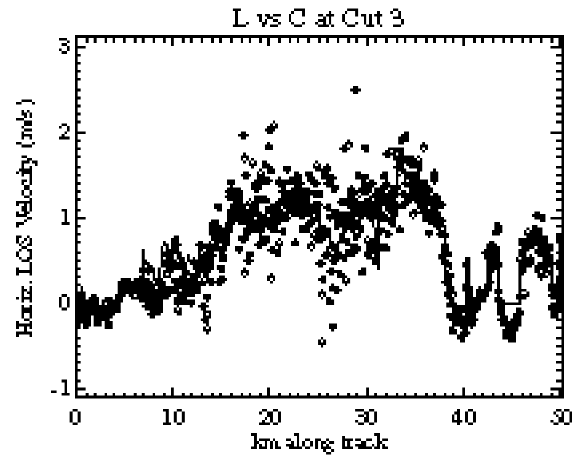
L-Band (AF/AA)

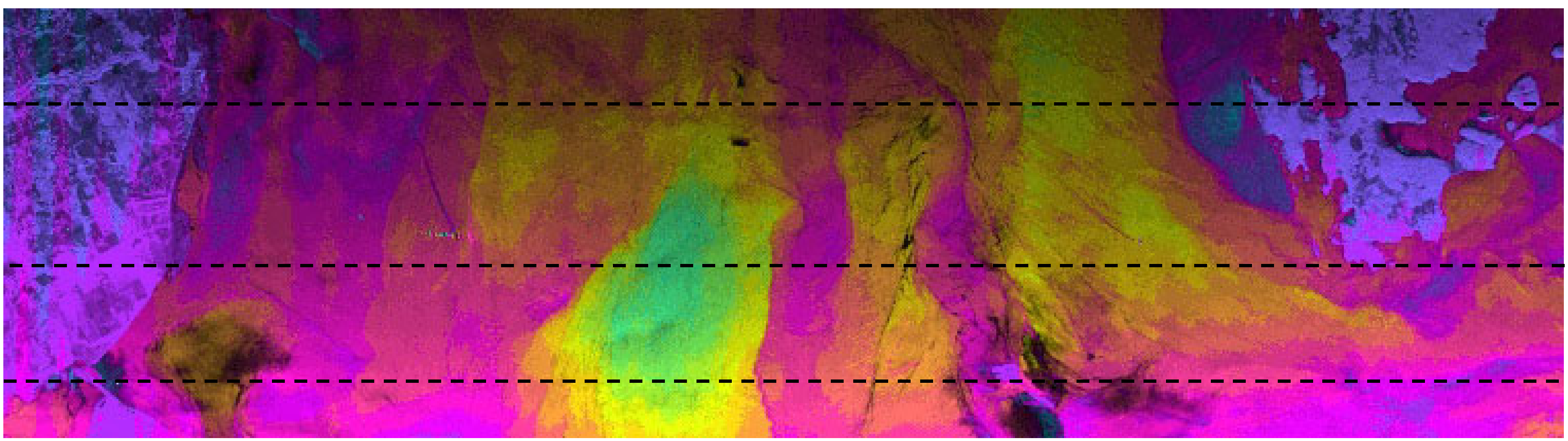


C vs L Current Values

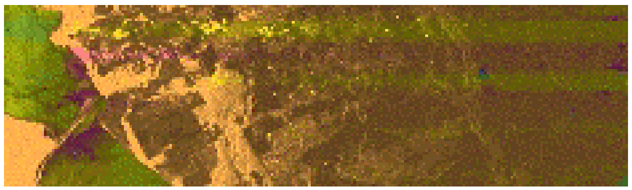


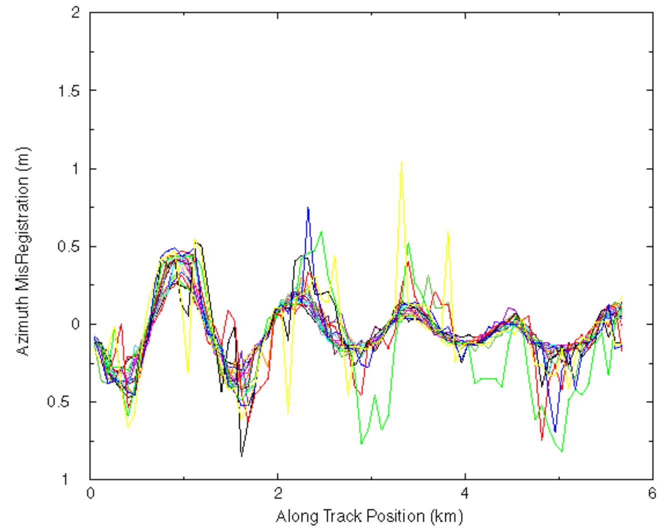


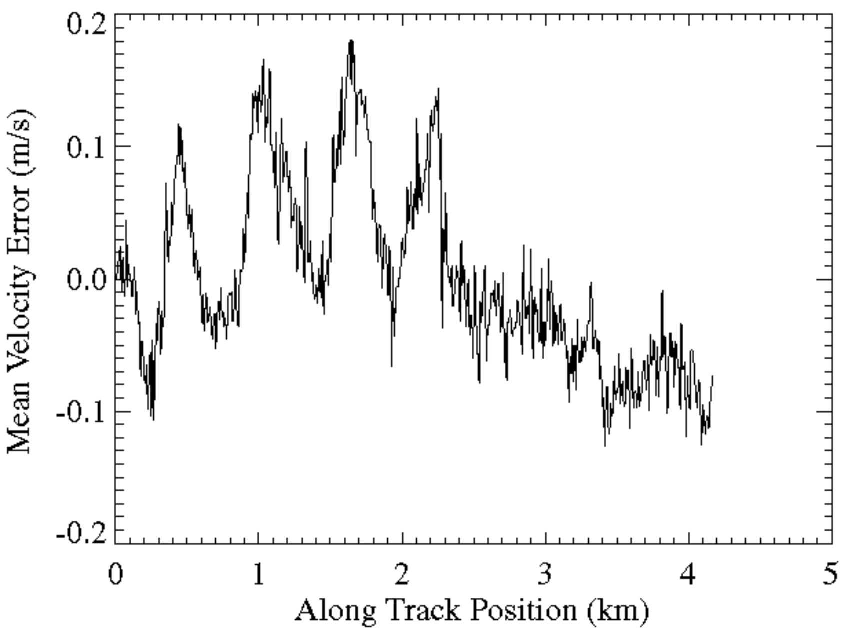


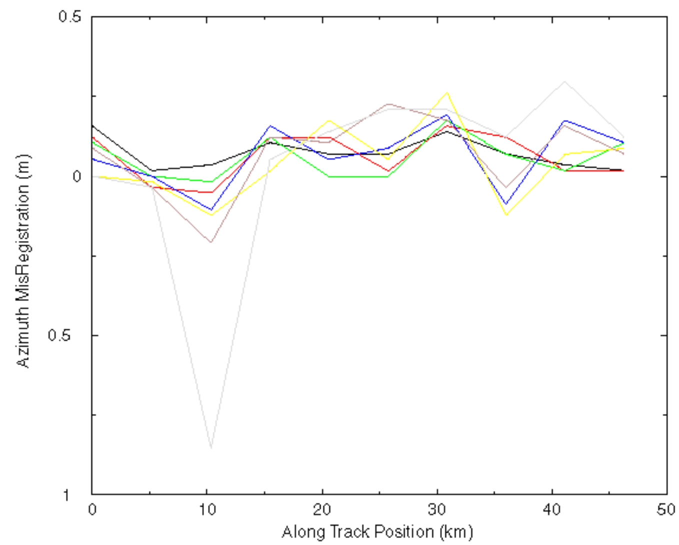


Motion Errors









PacRim 2000 ATI Data

During the Pacific Rim 2000 campaign, AIRSAR collected along-track interferometric data:

- 26 Sites, 48 flight lines
- Countries: United States, Australia, Malaysia, French Polynesia, Taiwan, Japan, New Zealand, South Korea, and the Philippines, as well as the equator.
- Approximately 42000 square km
- 13 investigators

ATI Data Products

*.par file lists contents, file sizes and useful parameters:

```
                              Records   NRecs  Description
--------------------------- -------- ------- ---------------------------------
1231.caf_caa_par             Ascii     N/A   This parameter summary file
1231.cppp                    Ascii     N/A   Complete list of processing parms
1231.caf_caa_intf2x13        882 C*8    3696 Slant-Range Interferogram
1231uwScc2x13                882 R*4    3697 Slant-Range Correlation File
1231.caf-az2x13              882 R*4    3696 Slant-Range Multilook Image caf
1231.caa-az2x13              882 R*4    3696 Slant-Range Multilook Image caa
==============================================================================

 Slant-Range Projection Information:

   8005.165 meters average platform altitude
   8719.293 meters range to first slant-range sample

   0.056698 meters radar wavelength

   6.662055 meters sample spacing
   8.335223 meters record spacing

   0.004372 seconds interferogram repeat time interval
   1.031908 meters/(seconds*radians) phase to velocity component conversion
```

Calibration Procedure

- Data checkout and cleanup
- Set the common range delay: compare range reported by the radar to target - platform known range
- Verify timing alignment between motion data and radar data by comparing predicted along-track coordinates to imagery
- Estimate motion biases, if necessary (must process to near the antenna pattern center)
- Correct timing delays between interferometric channels (range co-registration)
- Estimate along-track baseline component (azimuth co-registration)
- Estimate baseline (look for phase variation across range for non-moving, flat scene)
- Iterate (and iterate some more).
- Verify agreement between before and after deployment calibration

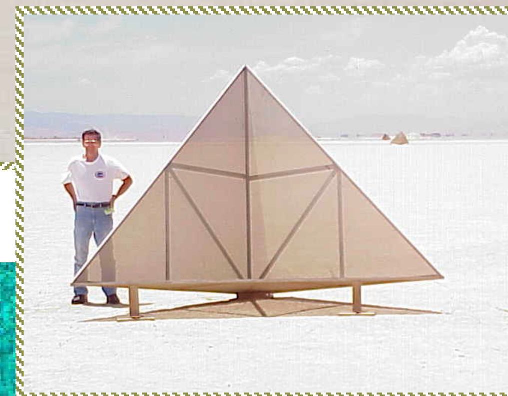
Note: only one set of calibration constants is used for each ATI mode for the entire data acquisition season.

Corner Reflector Array

Rosamond Dry Lake Bed, California

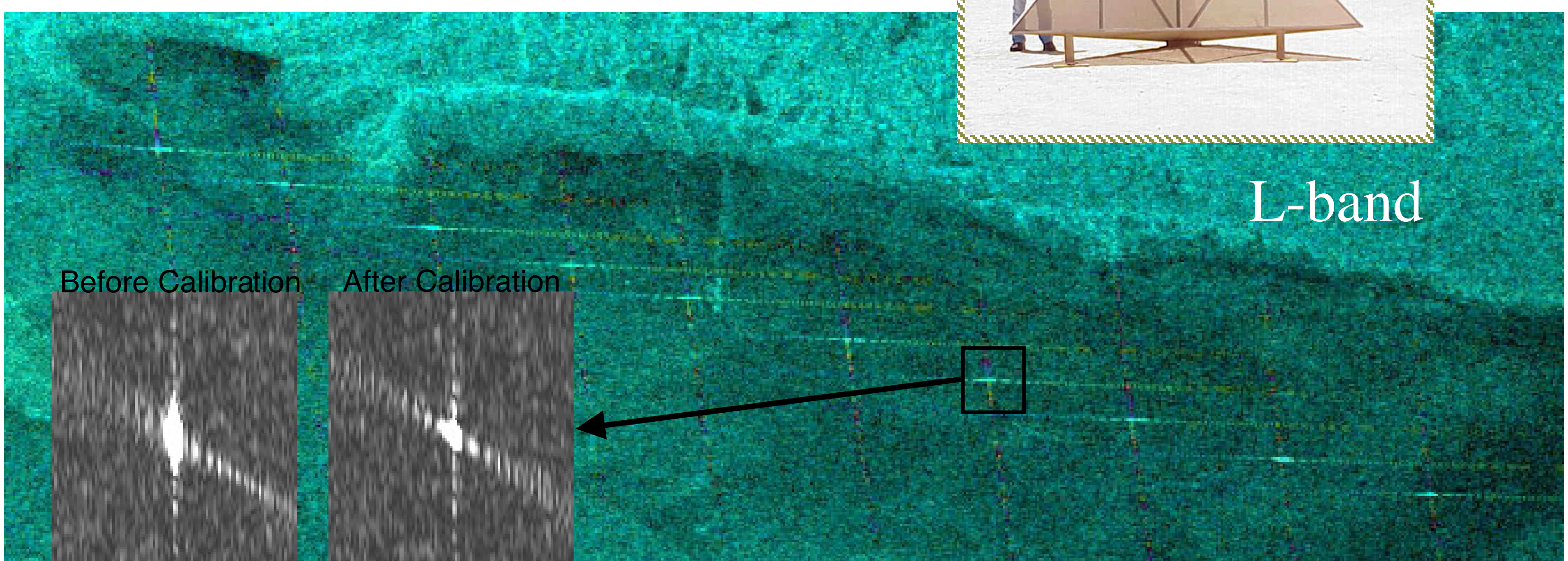
Calibration Scene

Rosamond Dry Lake Bed Corner Reflector Array

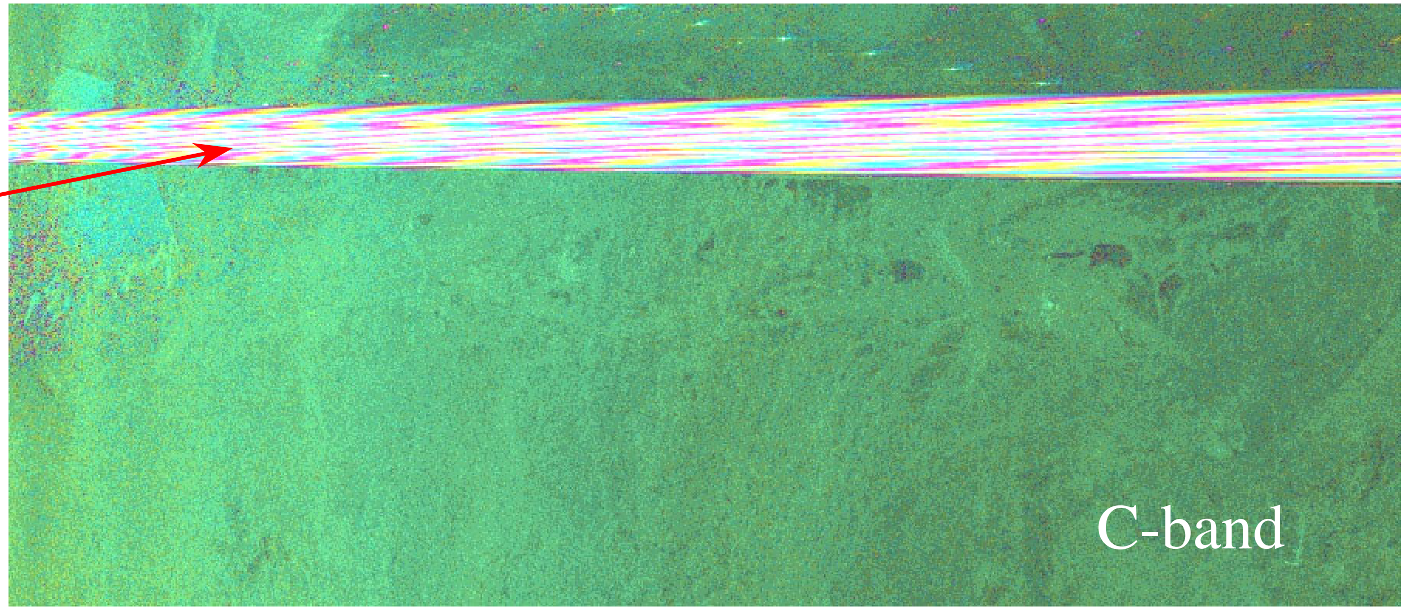


range

platform motion



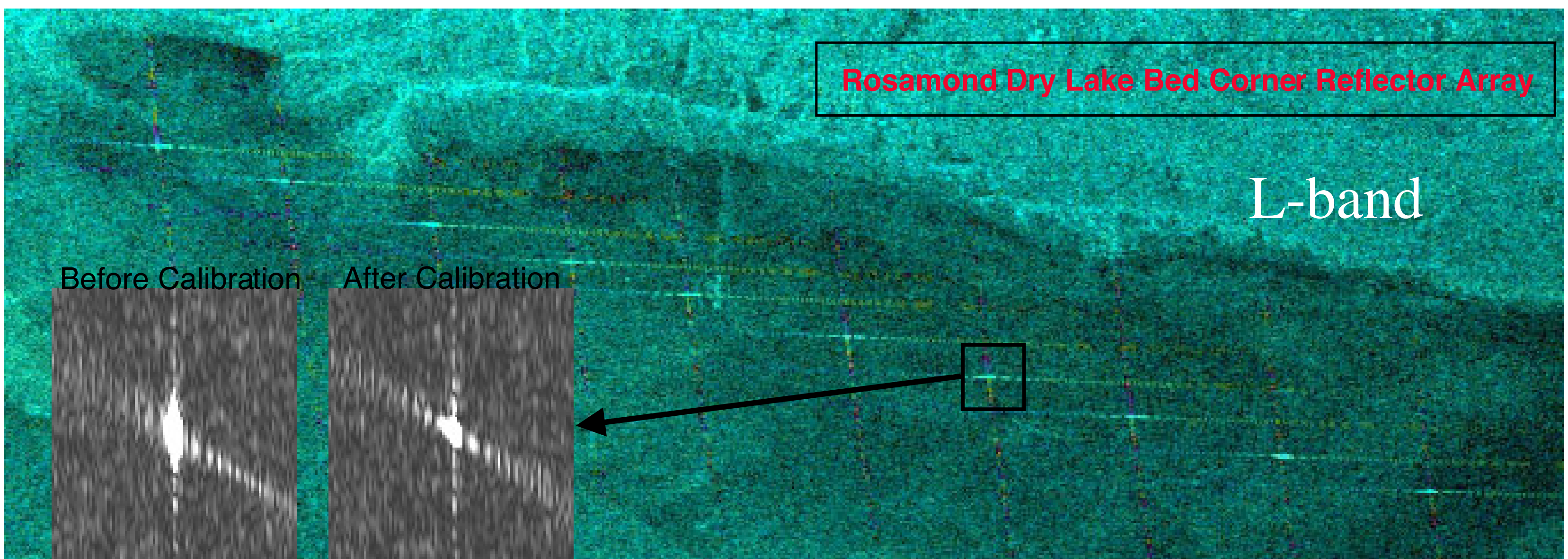
Calibration Scene



Both pre- and post-mission C-band ATI calibration data sets suffer from RFI-like contamination near the corner-reflector array. This artifact is still under investigation.

range

platform motion

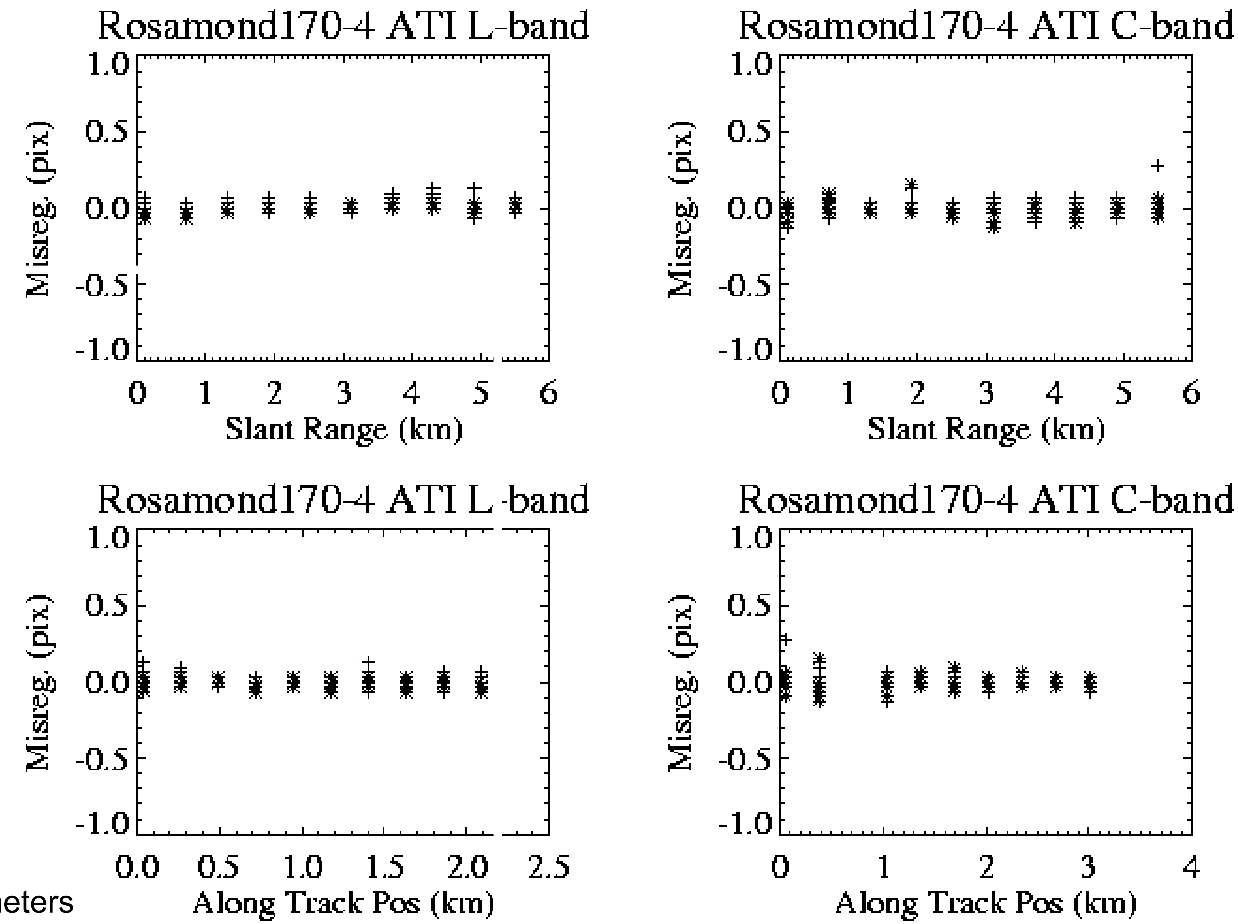


Co-Registration

RMS Registration Accuracy
pre- and post deployment cal

L Band
along track pix: 0.038 0.036
cm: 2.1 2.0
cross track pix: 0.024 0.018
cm: 8.1 6.1

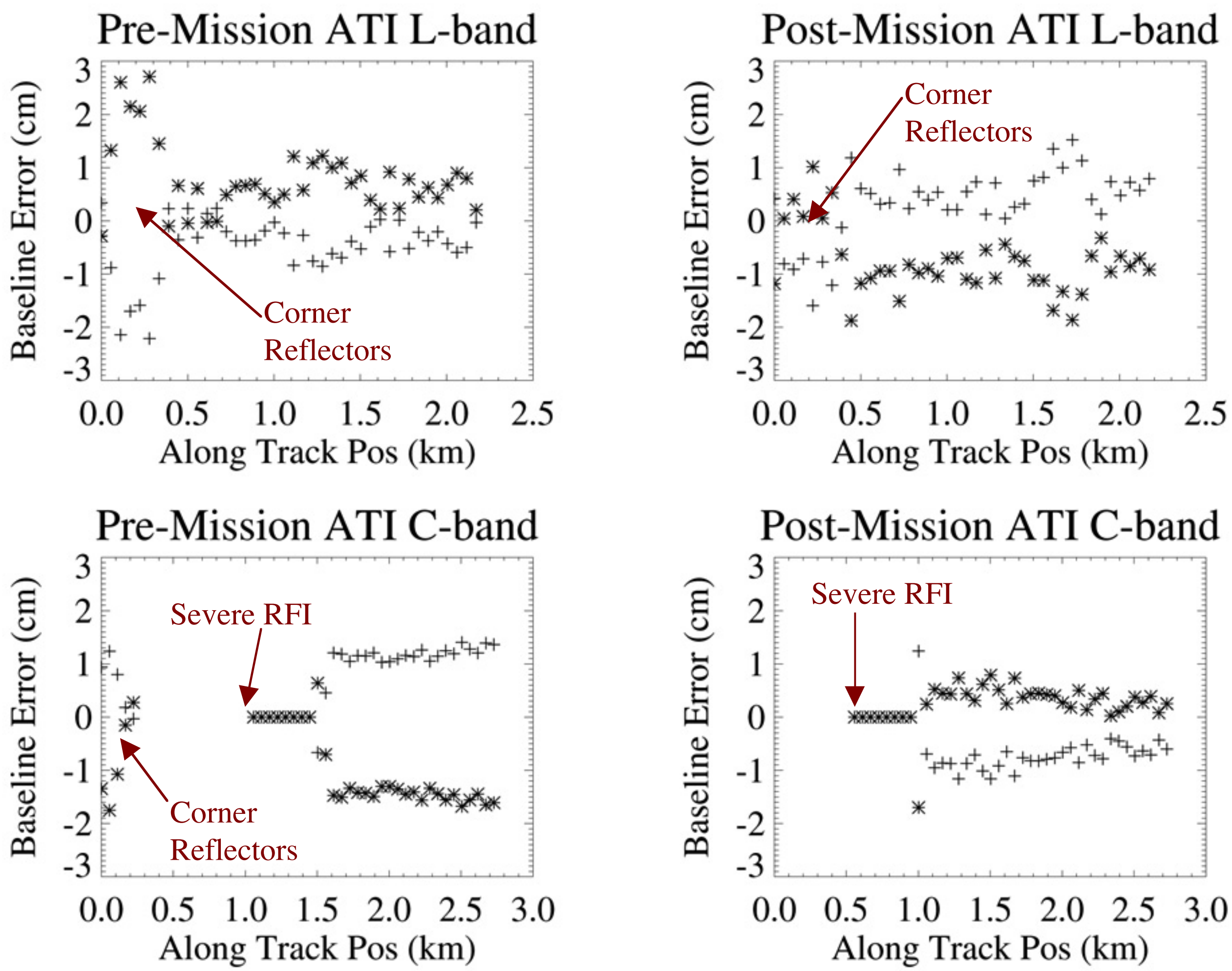
C Band
along track pix: 0.050 0.026
cm: 3.2 1.7
cross track pix: 0.038 0.017
cm: 13 5.8



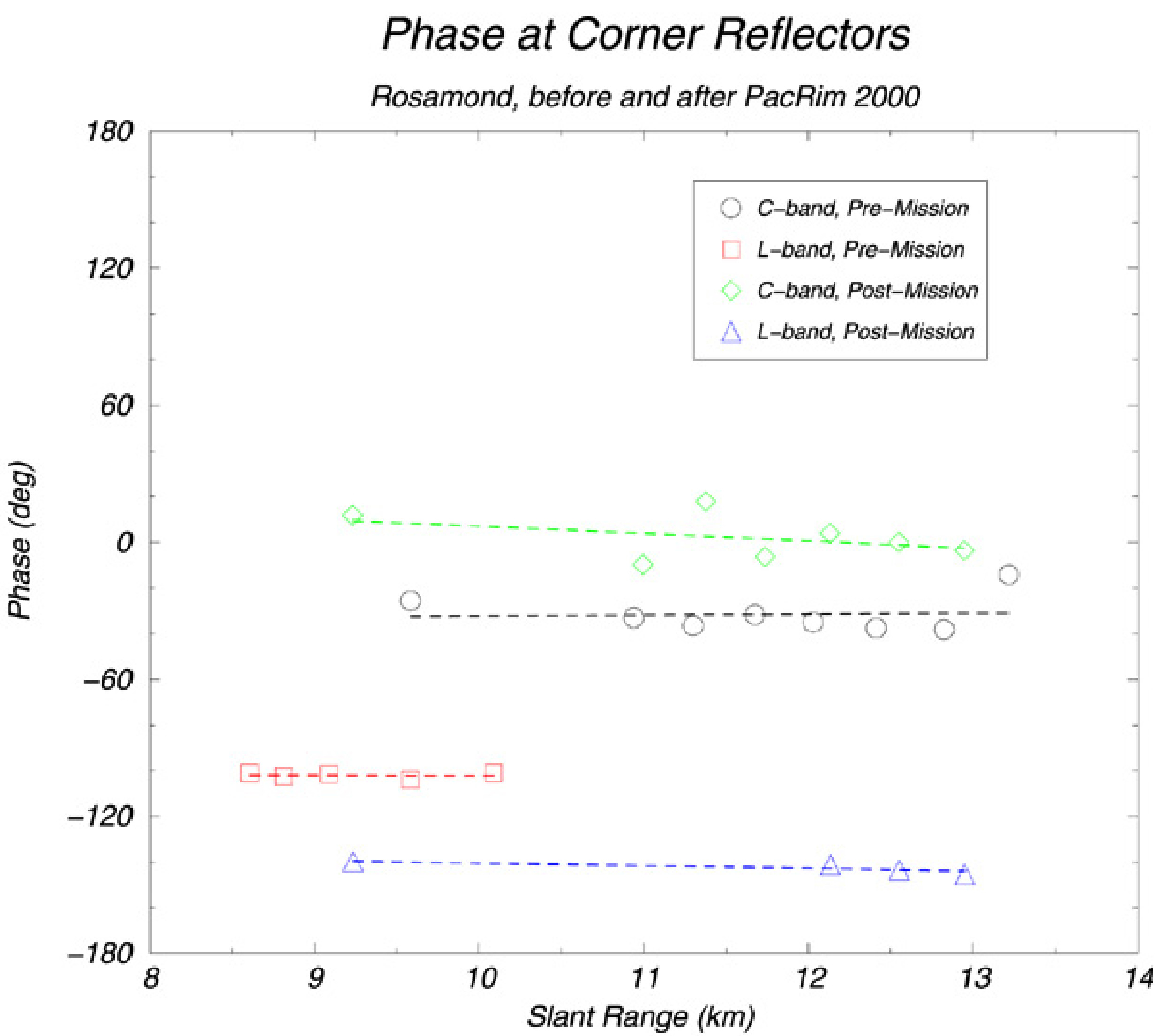
Note that only one set of parameters was used for the entire mission, representing a compromise between the pre- and post-mission calibration runs.

These plots are for the pre-mission calibration

Baseline Determination



Relative Phase Calibration



RMS Phase (deg) at Corner Reflectors:

Radar	Pre	Post
L-band	1.2	2.4
C-band	8.1	9.9

This plot emphasizes that while the phase for a stationary target is constant across the scene, the absolute phase is not calibrated, nor guaranteed to be constant from scene to scene.

Future Work

- Regrid data to ground projection: this will provide geo-location and co-registration of L- and C-band data sets.

- Radiometric correction/calibration. (This is not a high priority for the ATI datasets.)

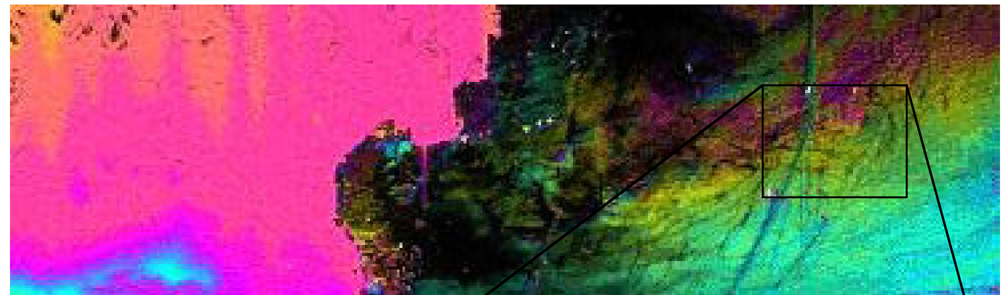
- Absolute phase calibration. May be possible by incorporation of caltone phase estimation and sea-level elevation reference.

- Improve motion artifacts with higher-quality motion data.

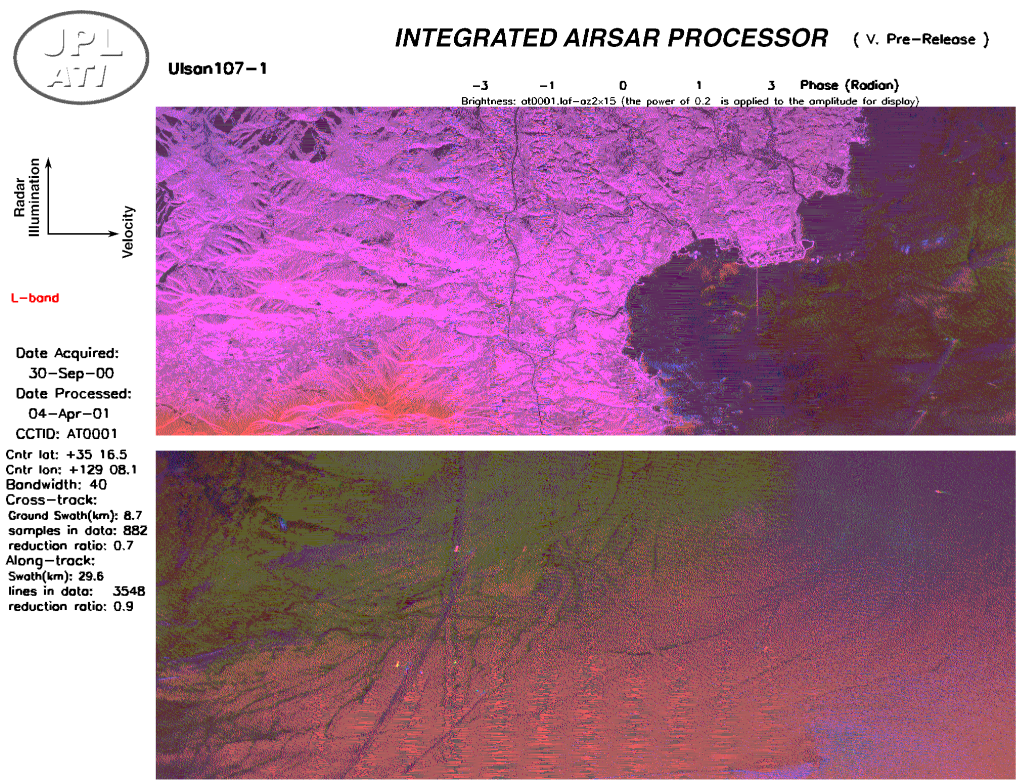
2000: Ulsan ATI Data

16 x 120 looks, 90 degree wrap

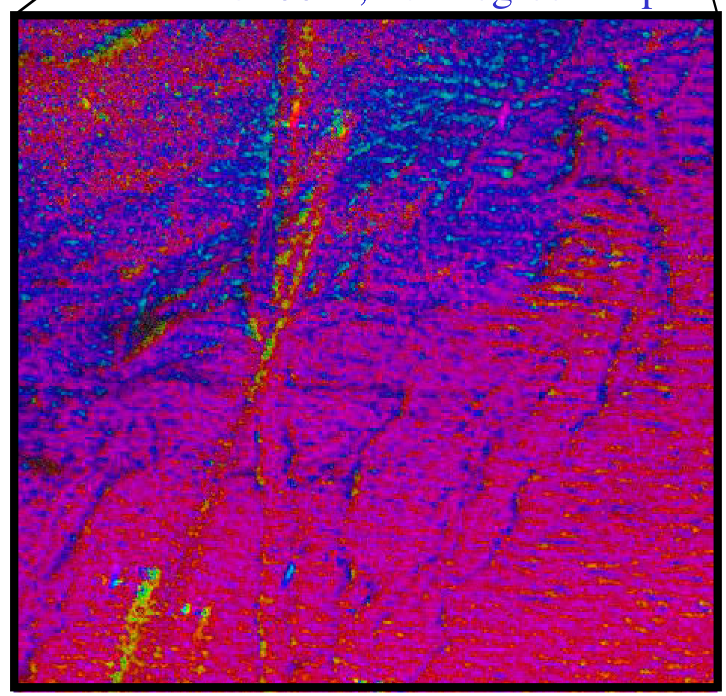
Interferogram:



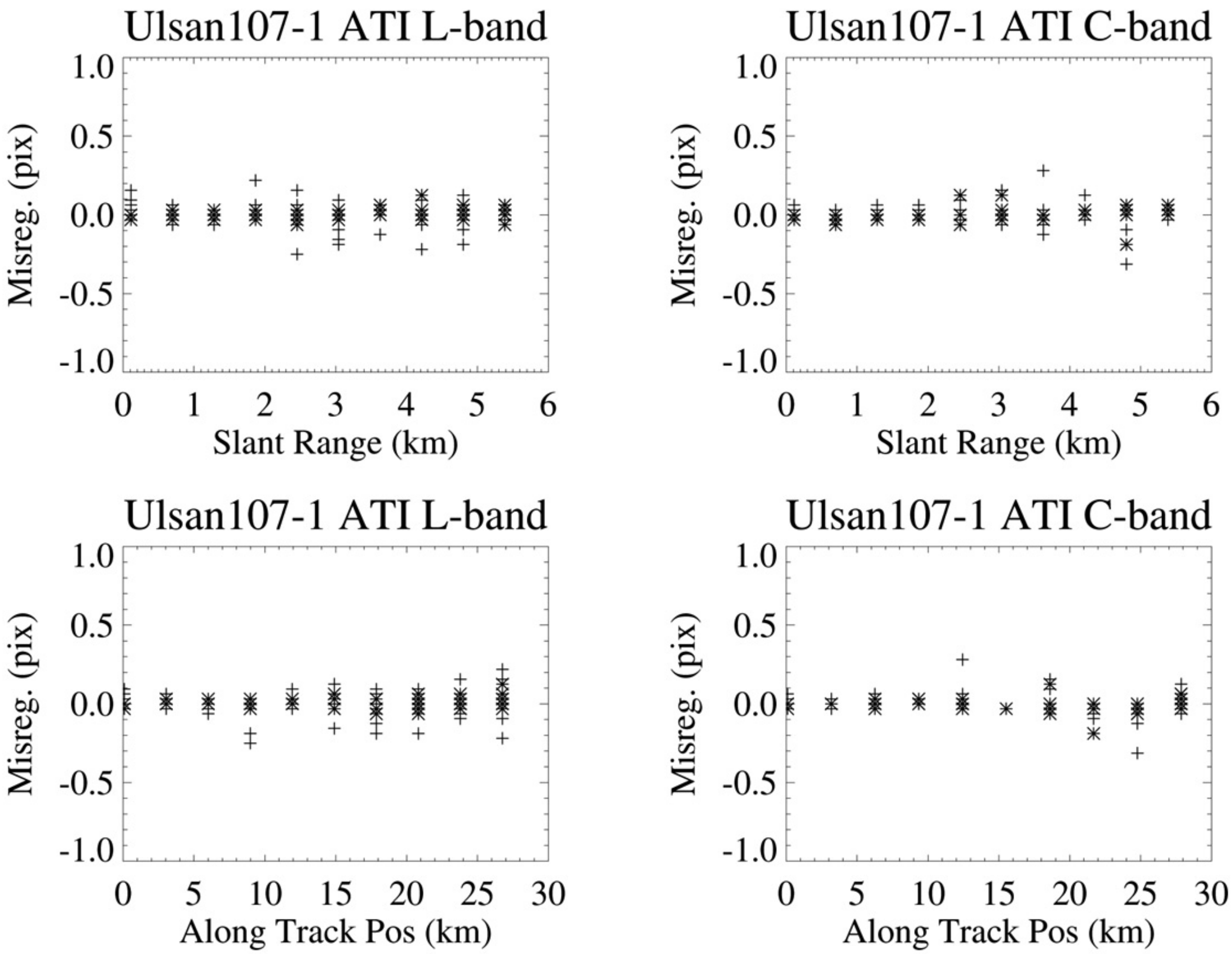
GIF Image from website, 360 degree color wrap, contrast enhanced:



2 x 15 looks, 180 degree wrap



Motion Alignment



x - *along-track*
+ - *slant-range*

Standard deviations (in pixels):

L along-track: 0.09
L slant-range: 0.03

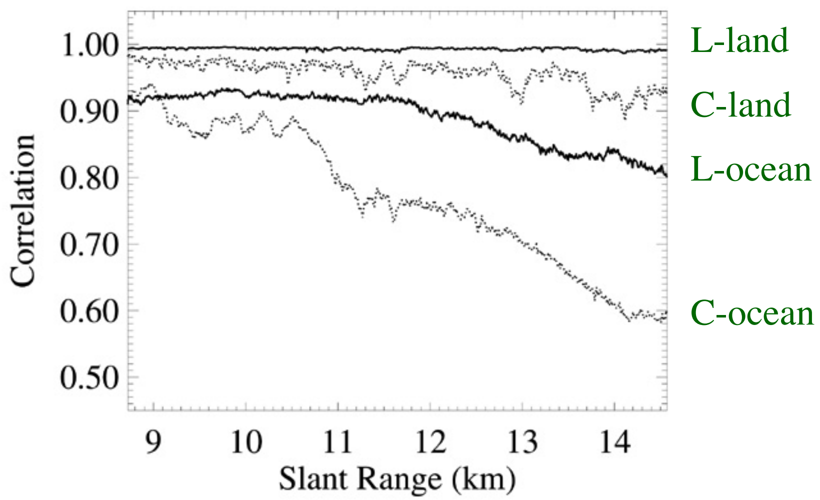
C along-track: 0.07
C slant-range: 0.04

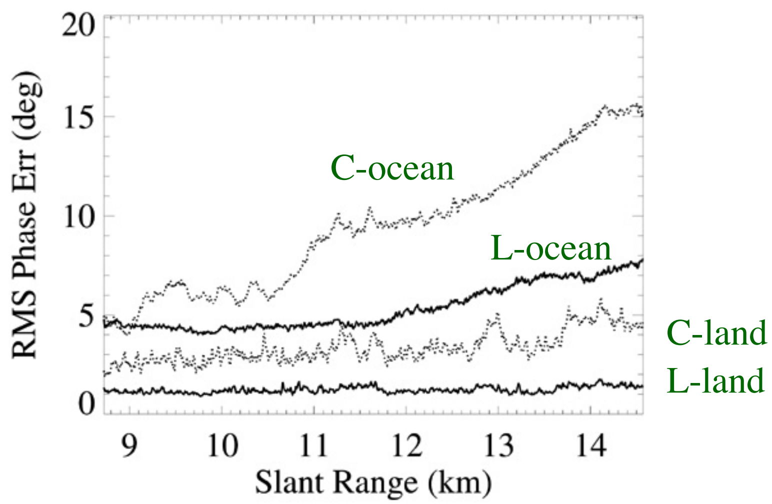
Measurement Precision

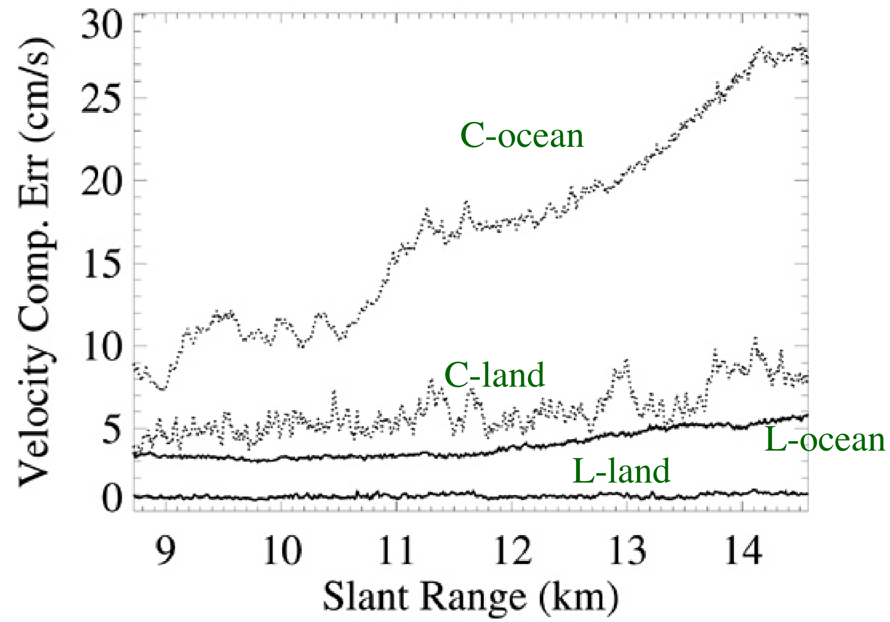
Phase and velocity errors scale as 1/Sqrt(looks) or 1/pixel-size.

These plots correspond to 2 looks in range and 13 (C-band) or 15 (L-band) looks in azimuth.

Pixel size is approximately 6.7 m (range) x 8.3 m (az)



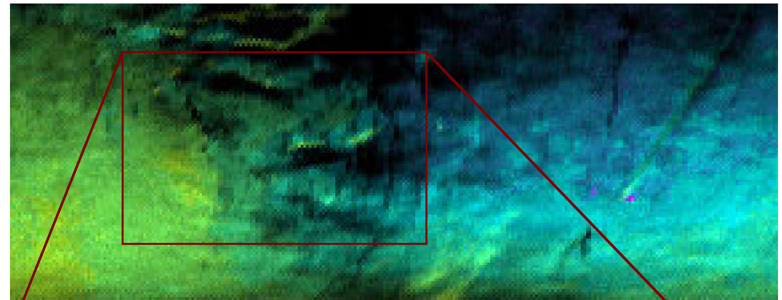




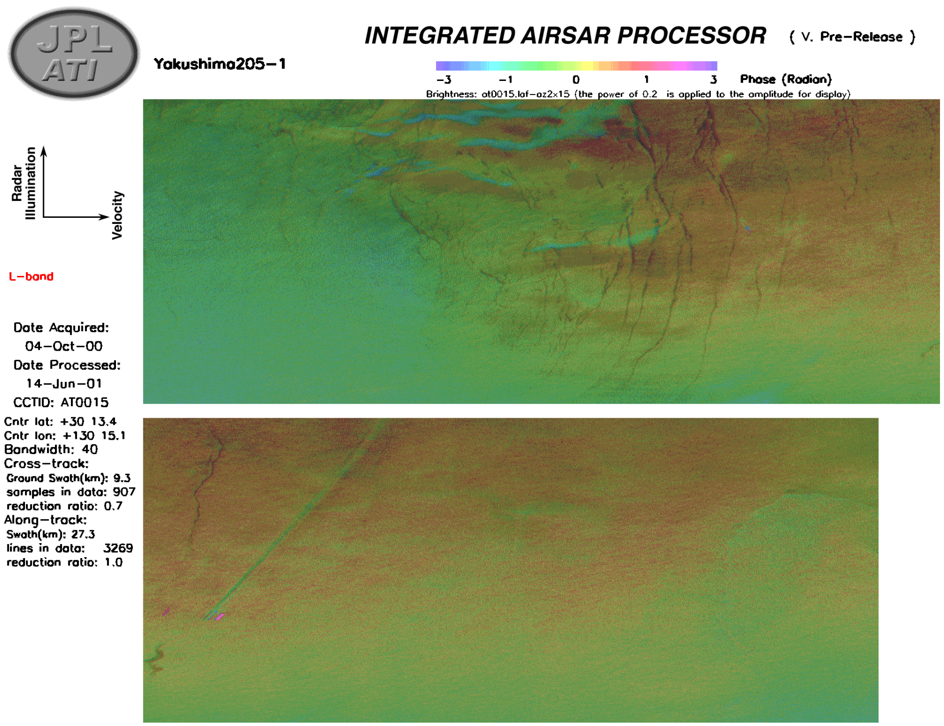
2000: Yakushima ATI Data

Interferogram:

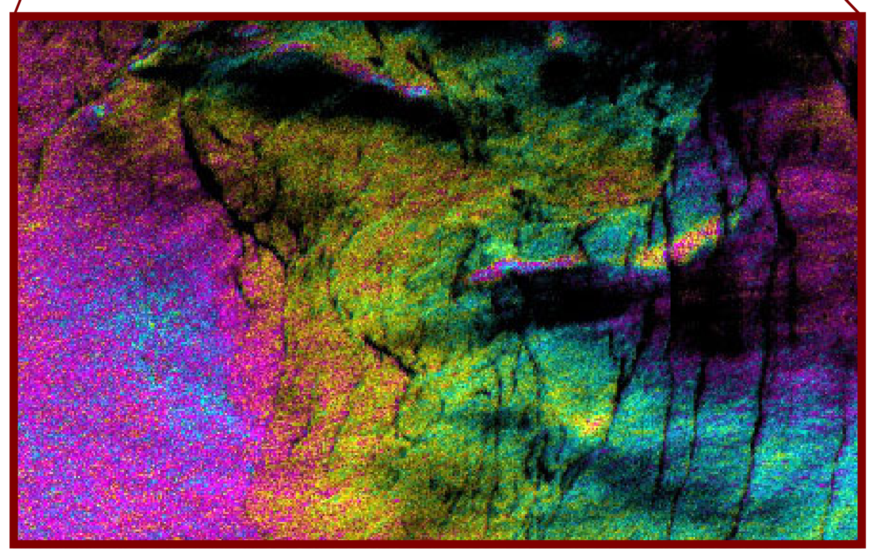
16 x 120 looks, 180 degree wrap



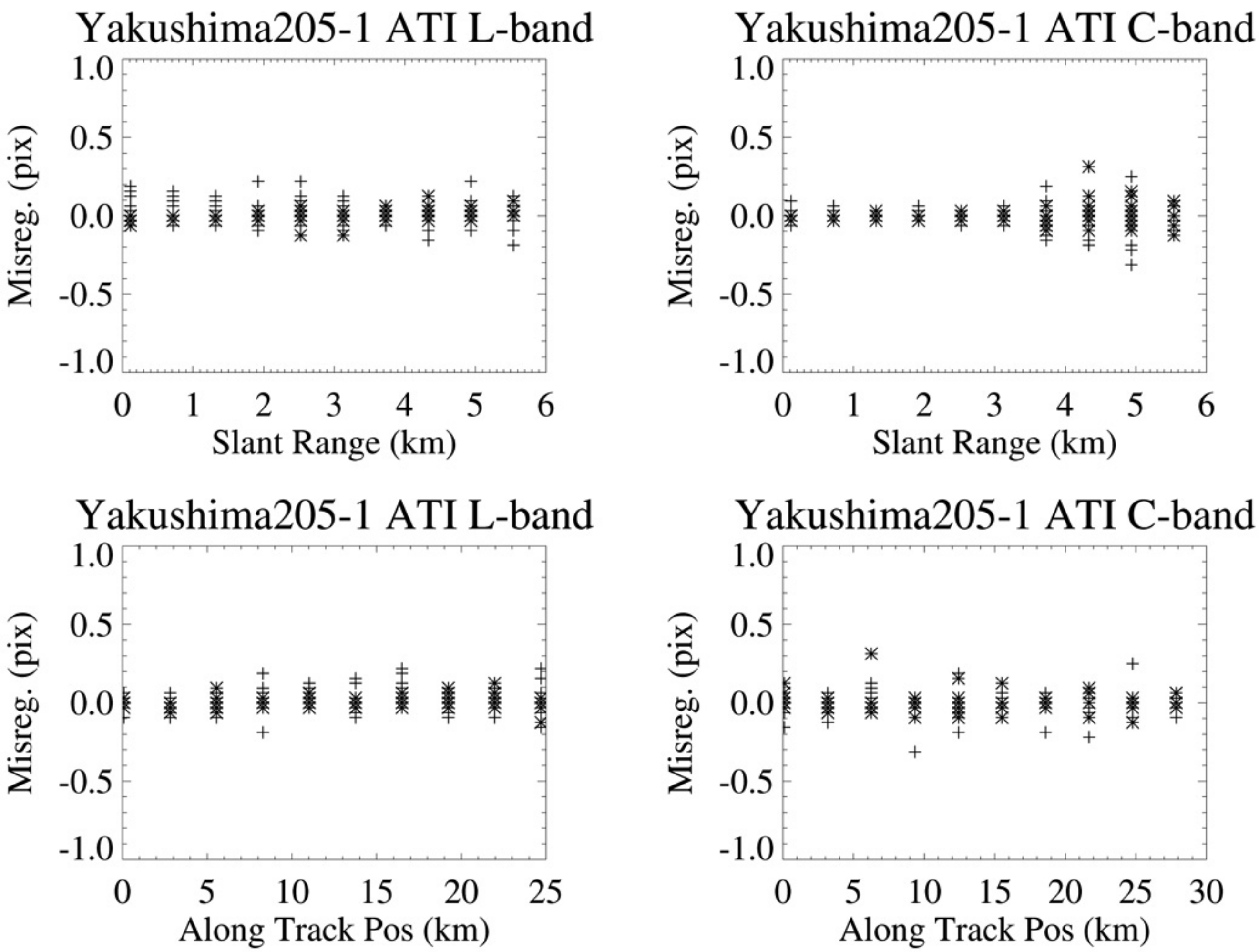
GIF Image from website,
360 degree color wrap:



4 x 30 looks, 90 degree wrap



Motion Alignment



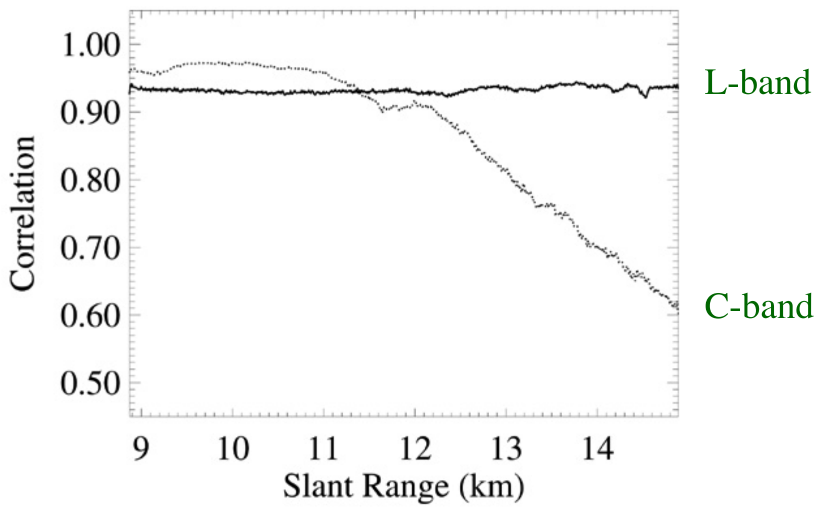
x - *along-track*
\+ - *slant-range*

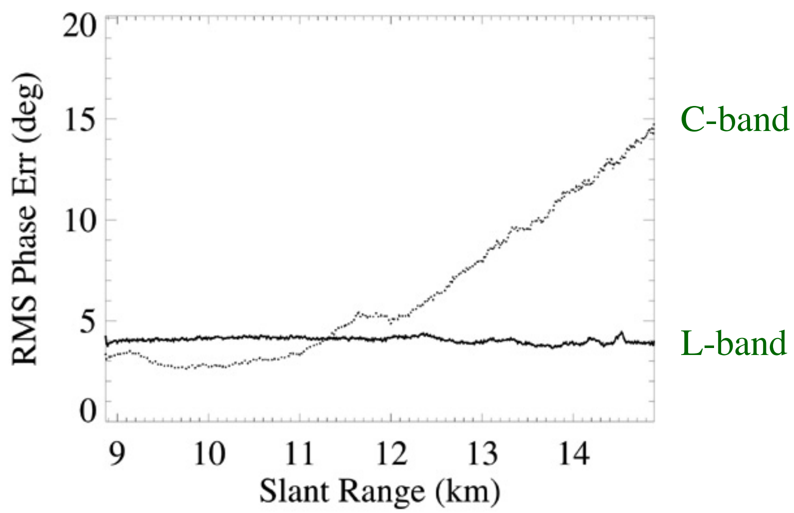
Standard deviations (in pixels):

L along-track: 0.08
L slant-range: 0.04

C along-track: 0.07
C slant-range: 0.05

Measurement Precision





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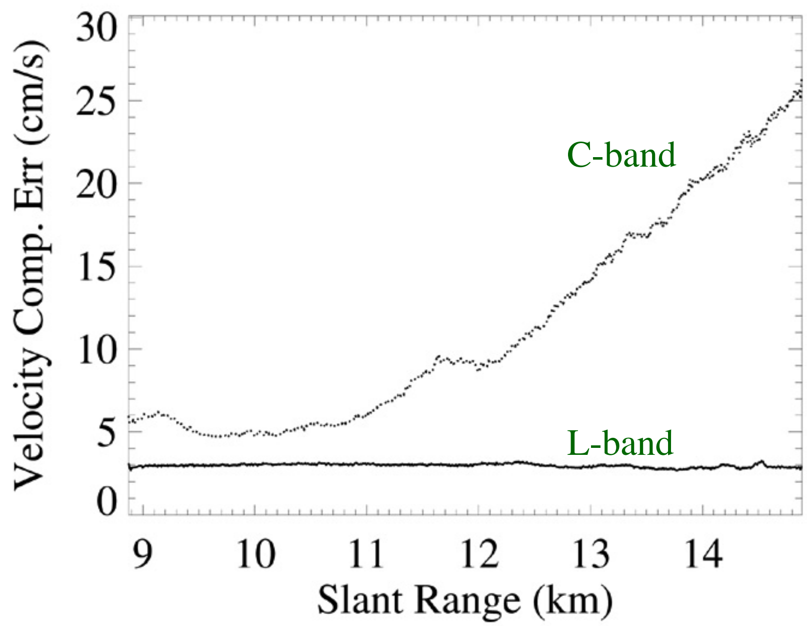

Summary

- **ATI incorporated into AIRSAR operations**
  - all surveys available on website: http://airsar.jpl.nasa.gov
  - data clean-up and RFI-filtering
  - co-registration check
  - database logging
  - data products posted automatically to website

- **Initial ATI calibration completed**
  - good interferogram formation (registration & baseline)
  - absolute phase not yet calibrated
  - no geo-location

- **ATI data processing proceeding**
  - 50% of PacRim 2000 data sets are completed
  - intf. co-registration is typically better than 1/10 pixel