Critical Baseline

The critical baseline is the aperture separation perpendicular to the look direction at which the interferometric correlation becomes zero.

$$B_{\text{crit}} = \rho \Delta\theta_{\Delta\rho_\perp} = \frac{\lambda \rho \tan\theta}{n \Delta\rho} \qquad n=1,2$$

Interferometers with longer wavelengths and finer resolution are less sensitive to baseline decorrelation. When the critical baseline is reached, the interferometric phase varies as

$$\frac{\partial \phi_{\text{crit}}}{\partial \rho} = \frac{\partial \phi_{\text{crit}}}{\partial \theta} \frac{\partial \theta}{\partial \rho}$$

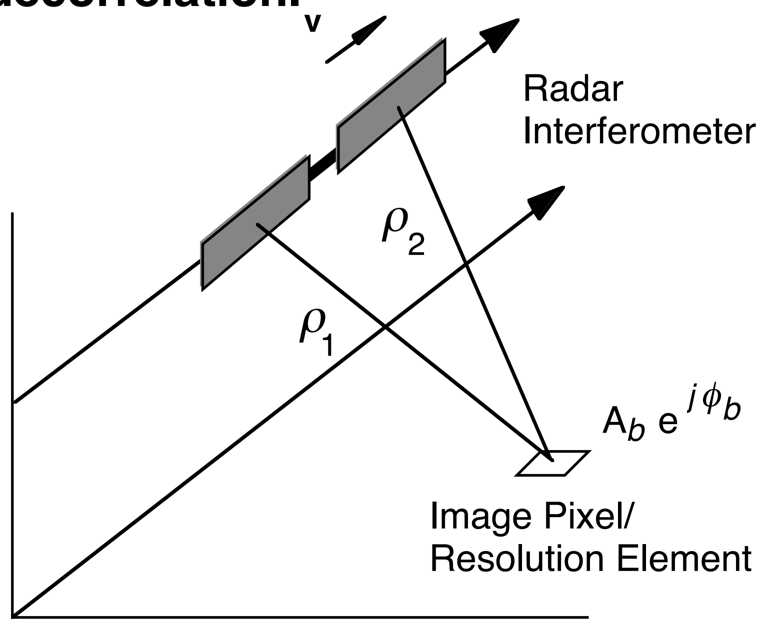
$$= \frac{2n\pi}{\lambda} B_{\text{crit}} \frac{1}{\rho \tan\theta} = \frac{2\pi}{\Delta\rho}$$

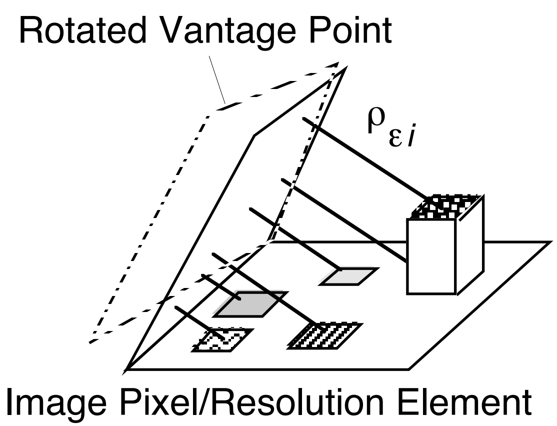
The relative phase of scatterers across a resolution element changes by a full cycle, leading to destructive coherent summation

Rotational Decorrelation

Rotation of scatterers in a resolution element can be thought of as observing from a slightly different azimuthal vantage point. As with baseline decorrelation, the change in differential path delay from individual scatterers to the reference plane produces rotational decorrelation.

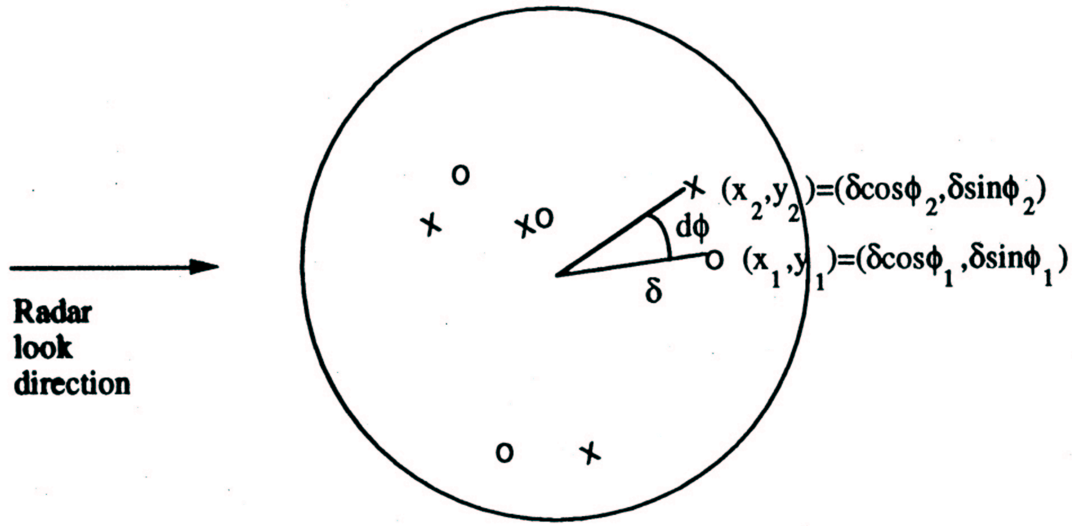
The critical rotational baseline is the extent of the synthetic aperture used to achieve the along track resolution.





$$s_1 = A_{b1} e^{j\phi_{b1}} e^{-j\frac{4\pi}{\lambda}\rho_1} \qquad s_2 = A_{b2} e^{j\phi_{b2}} e^{-j\frac{4\pi}{\lambda}\rho_2}$$

Rotational Correlation Formulation



Cross-correlation for this case is:

$$s_1 s_2^\star = \int dx \int dy \int dx' \int dy' f(x - x_0, y - y_0) f^\star(x' - x_0, y' - y_0)$$

$$e^{-j\frac{4\pi}{\lambda}\delta \sin\theta(\sin\theta_1 - \sin\theta_2)} W(x,y) W^\star(x', y')$$

plus noise cross-products

Form of Rotational Correlation Function

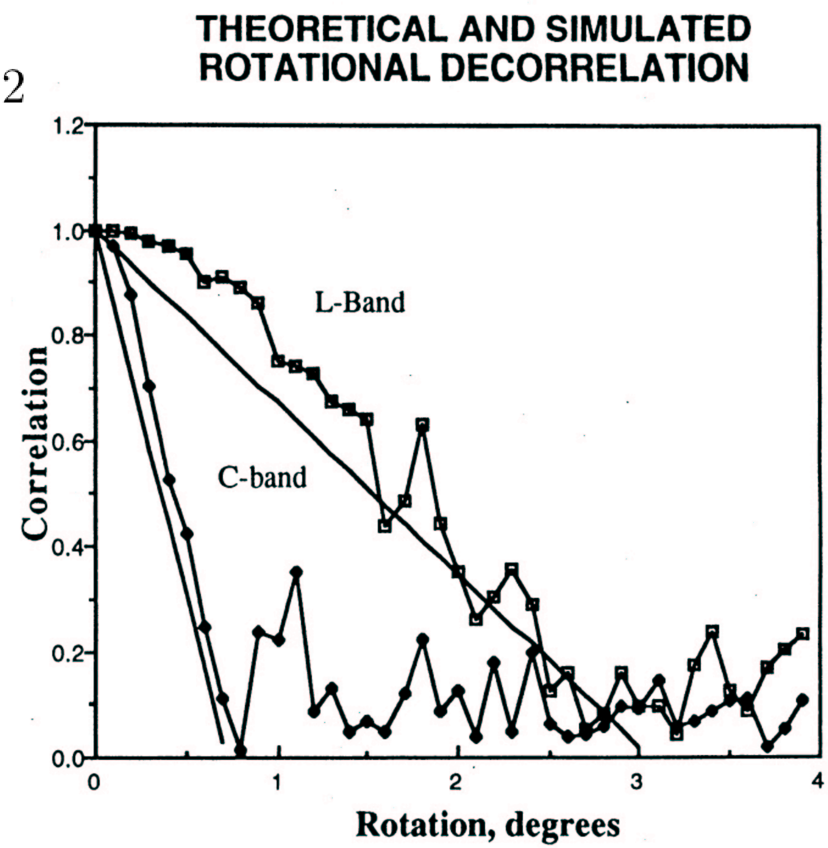
A similar Fourier Transform relation as found in the baseline decorrelation formulation exists

$$\gamma_\phi = 1 - \frac{n \sin\theta B_\phi R_x}{\lambda\rho} \quad n = 1, 2$$

where R_x is the azimuth resolution and B_ϕ is the distance along track corresponding to the rotation angle of the look vector

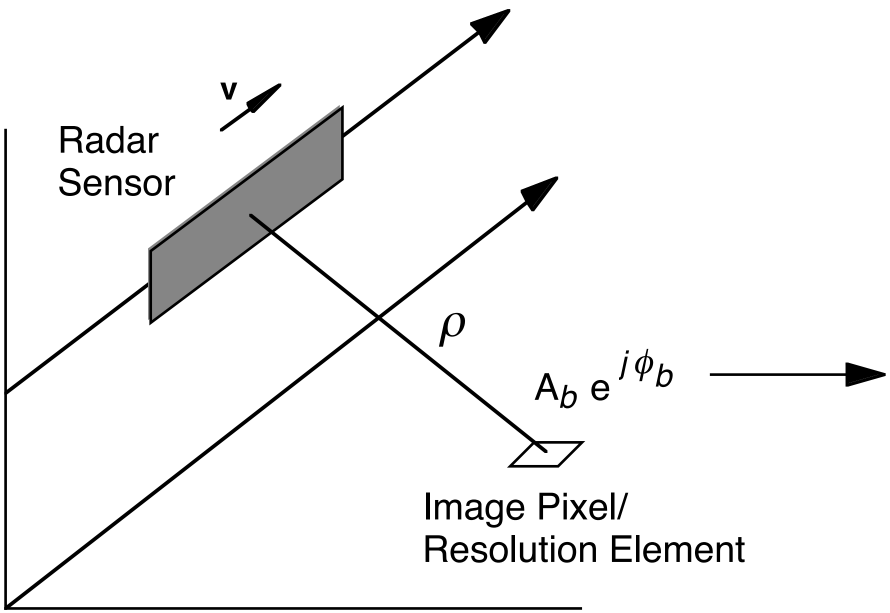
This function goes to zero at the *critical rotational baseline*

$$B_{\phi,\mathrm{crit}} = \frac{\lambda\rho}{n\Delta\rho_\phi}, \Delta\rho_\phi \equiv R_x \sin\theta$$

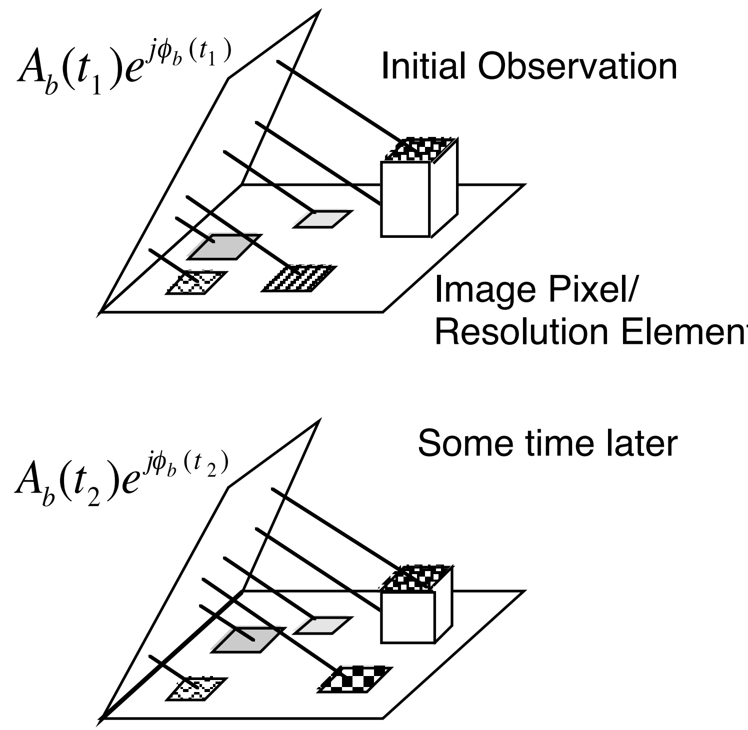


Scatterer Motion

Motion of scatterers within the resolution cell from one observation to the next will lead to randomly different coherent backscatter phase from one image to another, i.e. “temporal” decorrelation.



Propagation Phase Delay $\phi = -j\dfrac{4\pi}{\lambda}\rho$



Motion Correlation Formulation

Assume the scatterers move in the cross-track and vertical directions by random displacements from one observation to the next by δy and δz. The cross-correlation for this case is:

$$s_1 s_2^\star = \int dx \int dy \int dz \int dx' \int dy' \int dz' f(x-x_0, y-y_0, z-z_0) f^\star(x'-x_0, y'-y_0, z-z_0)$$

$$e^{-j\frac{4\pi}{\lambda}(\delta y \sin\theta + \delta z \cos\theta)} W(x,y,z) W^\star(x',y',z')$$

plus noise cross-products

If the motions are independent and unrelated to position

$$\langle s_1 s_2^\star \rangle = \sigma_0 \int d\delta x \int d\delta y \quad e^{-j\frac{4\pi}{\lambda}(\delta y \sin\theta + \delta z \cos\theta)} p_y(\delta y) p_z(\delta z)$$

where p_y and p_z are the probability distributions of the scatterer locations

Form of Motion Correlation Function

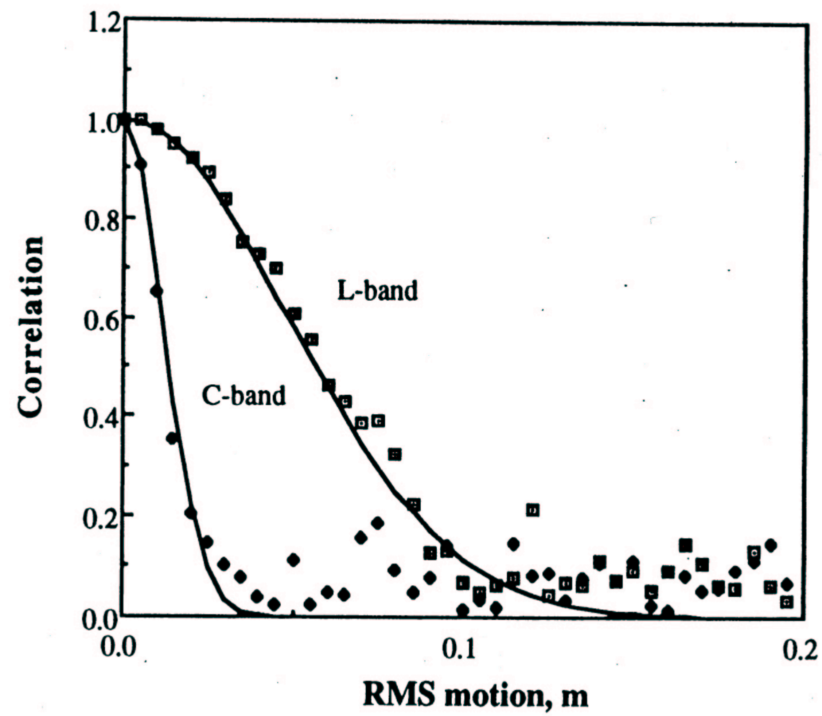
The Fourier Transform relation can be evaluated if Gaussian probability distributions for the motions are assumed

$$\gamma_t = e^{-\frac{1}{2}\left(\frac{4\pi}{\lambda}\right)^2(\sigma_y^2 \sin^2\theta + \sigma_z^2 \cos^2\theta)}$$

where $\sigma_{y,z}$ is the standard deviation of the scatterer displacements cross-track and vertically

Note correlation goes to 50% at about 1/4 wavelength displacements

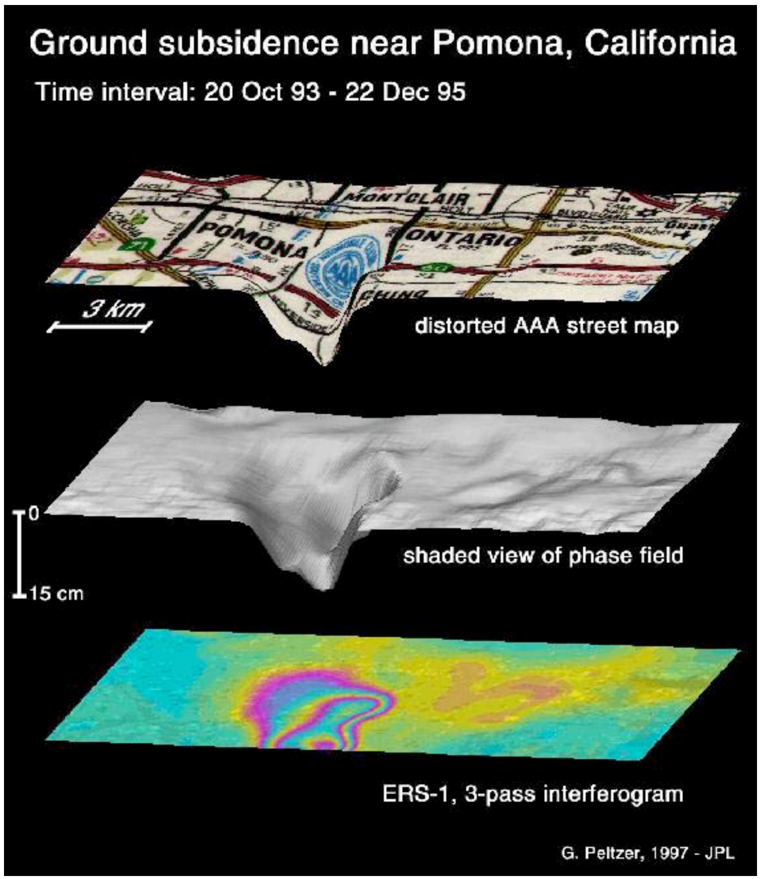
SIMULATED AND THEORETICAL MOTION DECORRELATION



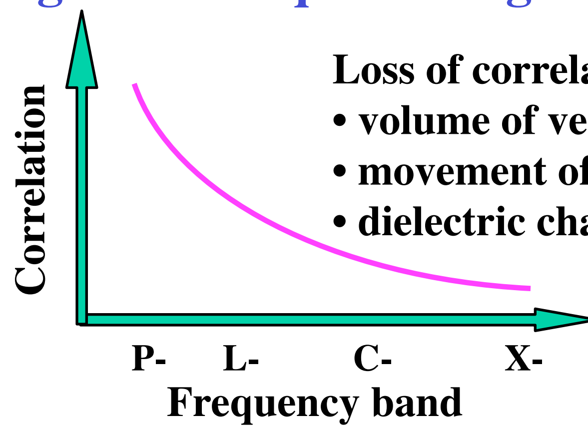
Repeat-pass Interferometry and Coherent Change Detection

L-Band low frequency improves correlation in vegetated areas

Most radars do well in areas of sparse vegetation

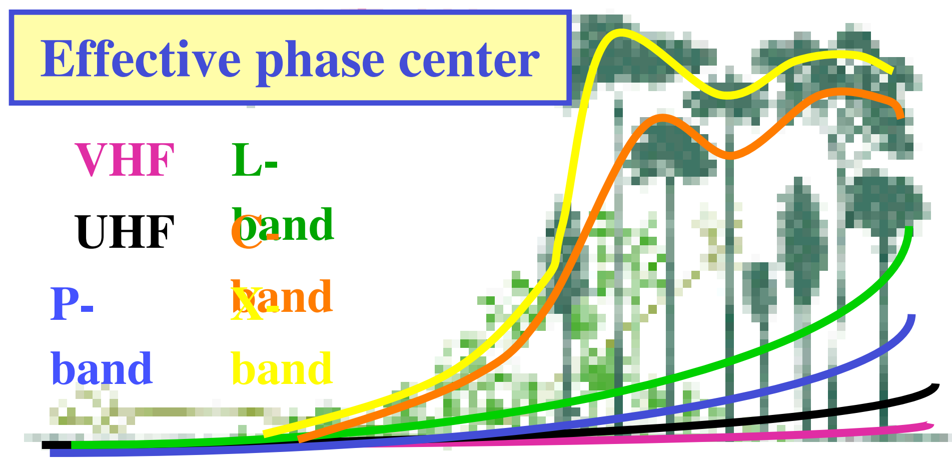


But maintaining correlation in dense vegetation requires longer wavelengths



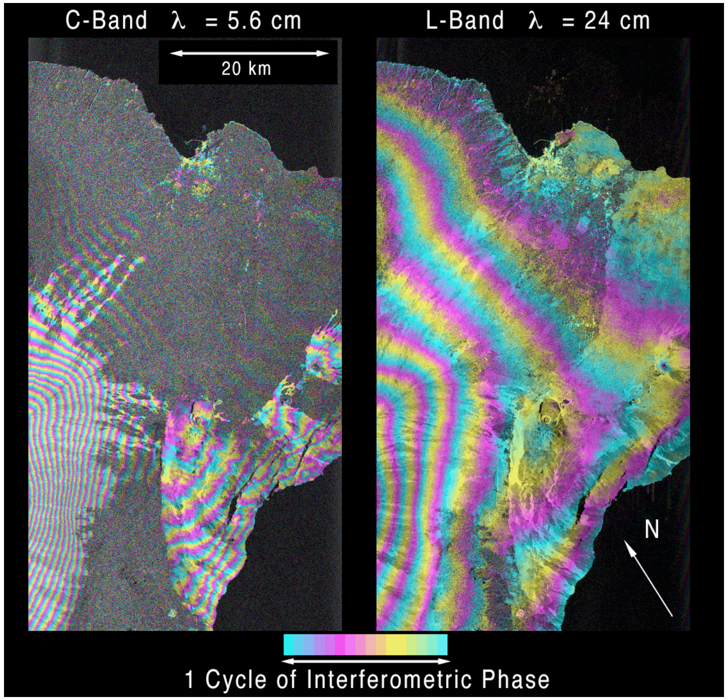
Loss of correlation is due to:

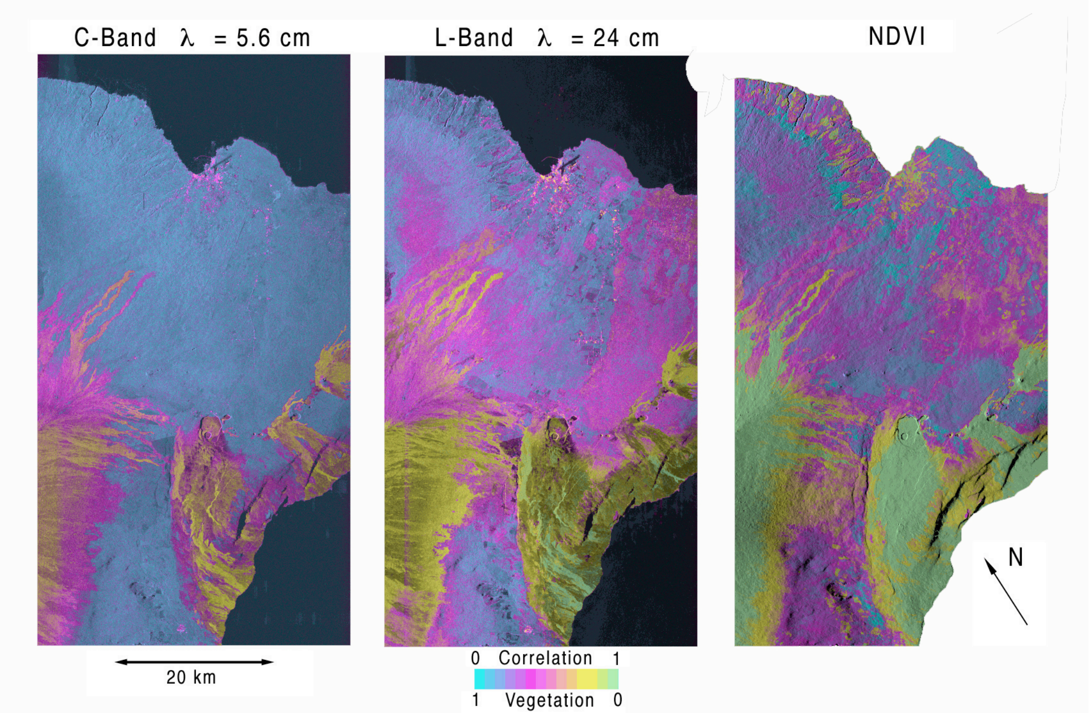
- volume of vegetation
- movement of vegetation
- dielectric change (moisture)



Coherent Change Detection
SIR-C L and C-band Interferometry

6 month time separated observations to form interferograms
Simultaneous C and L band

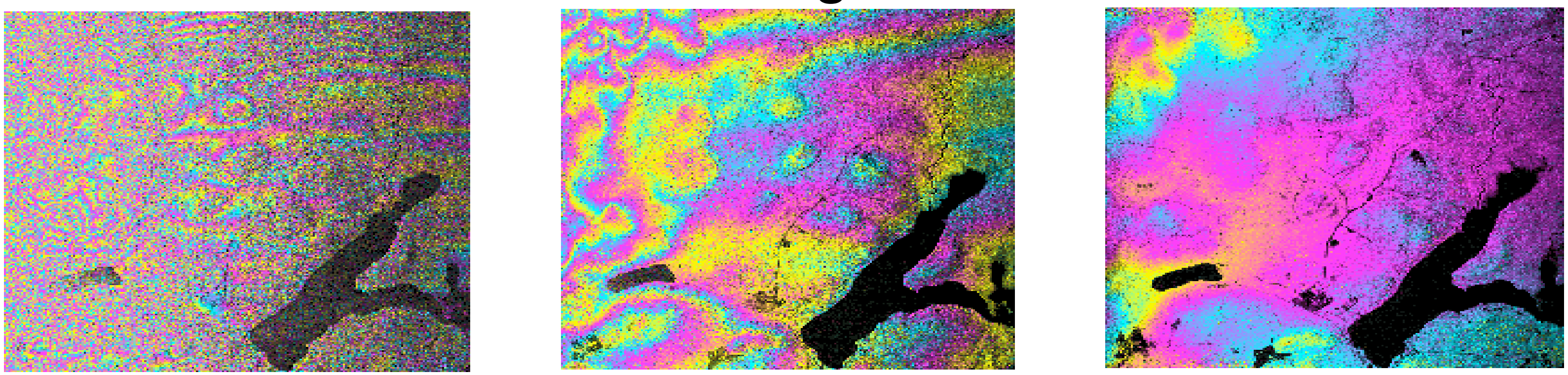




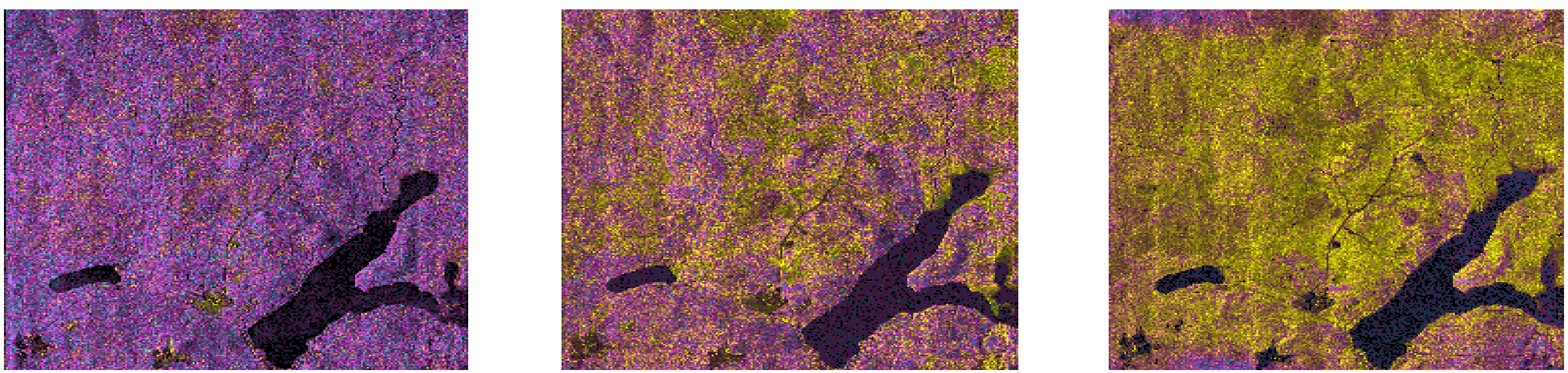
InSAR experiments have shown good correlation at L-band

AIRSAR Coherent Change Detection

Interferograms



C-band **L-band** **P-band**



Correlation

Airborne InSAR experiments have shown good correlation at L-band