MONITORING OF WETLAND WATER LEVELS IN NEWFOUNDLAND AND LABRADOR USING INTERFEROMETRIC SYNTHETIC APERTURE RADAR (INSAR) TECHNIQUE

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Presented By: Bahram Salehi

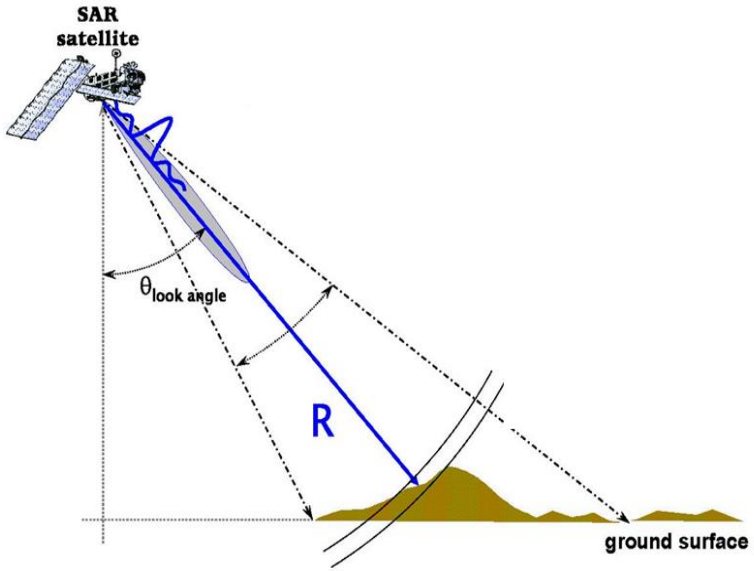
Outline

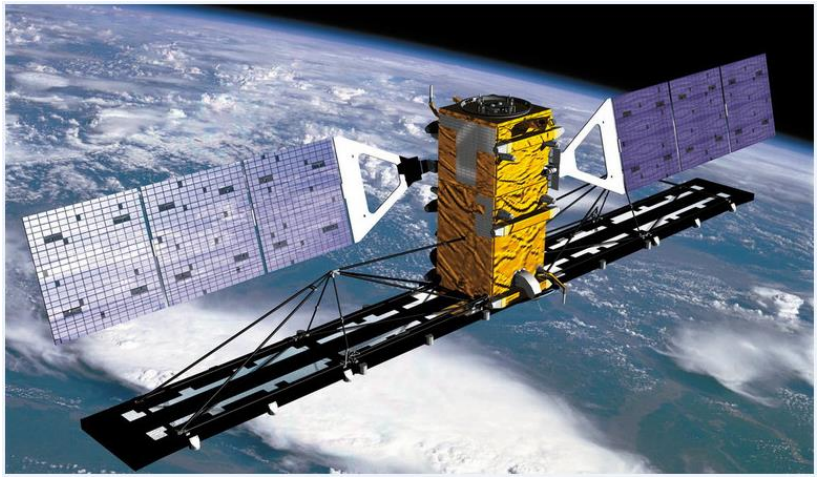
- **Introduction**
  - Satellite radar sensors
- **How to measure deformation phenomena from space**
  - Interferometric Synthetic Aperture Radar (InSAR) and its advancements
- **InSAR Wetland**
  - Important parameters
  - Study area and dataset
  - Results

Satellite Radar Sensors

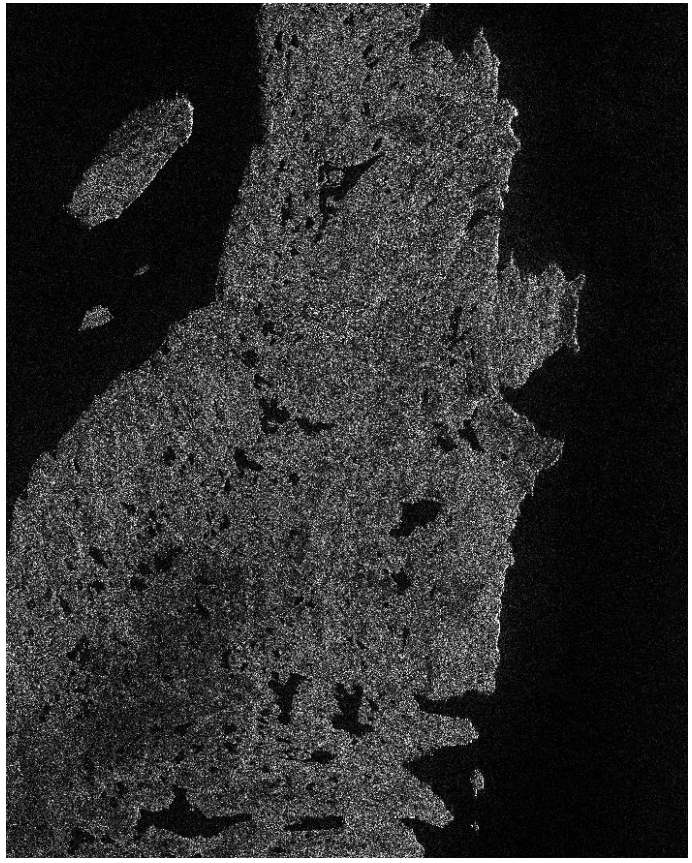
A Synthetic Aperture Radar (SAR) sensors illuminates the Earth surface using a coherent microwave beam radiation such as laser.

X-Band ⟶ λ =3.1 cm
C-Band ⟶ λ =5.7 cm
L-Band ⟶ λ =23.6 cm





Radar vs optical imagery

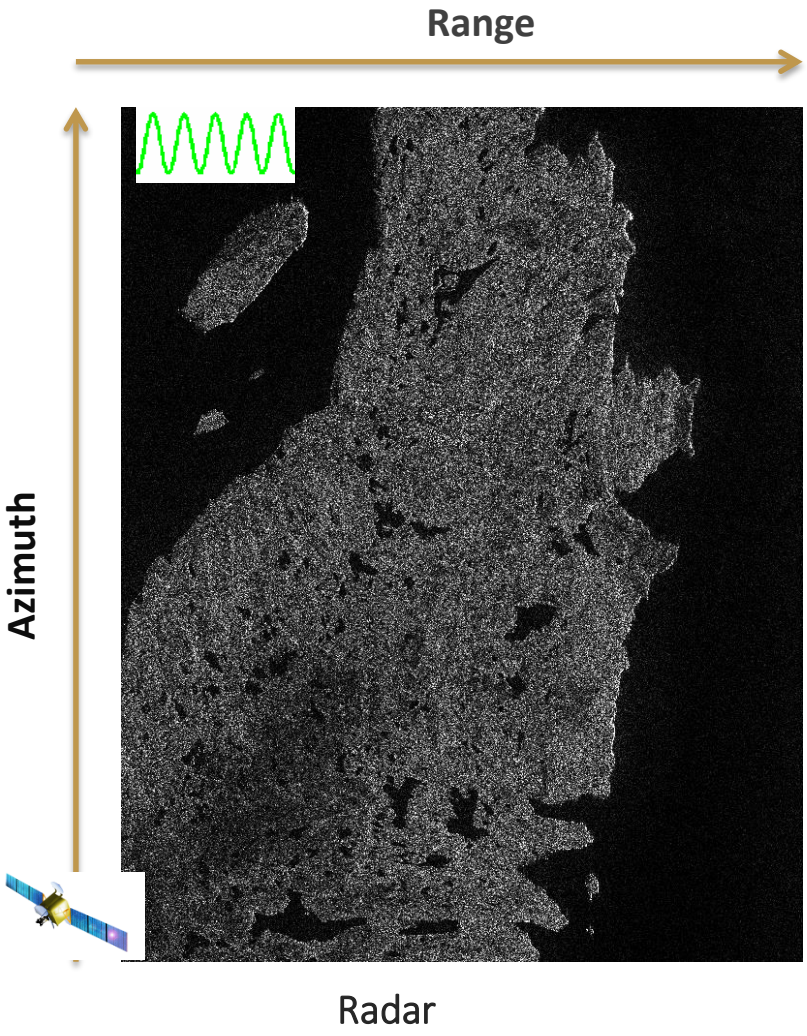


Azimuth

Radar

Optical

Radar vs optical imagery

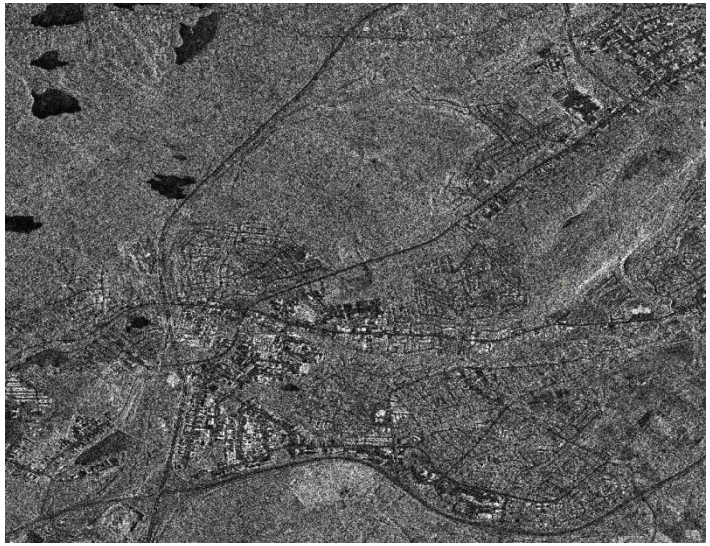


1. Day/night monitoring, Active system, no need for external illumination

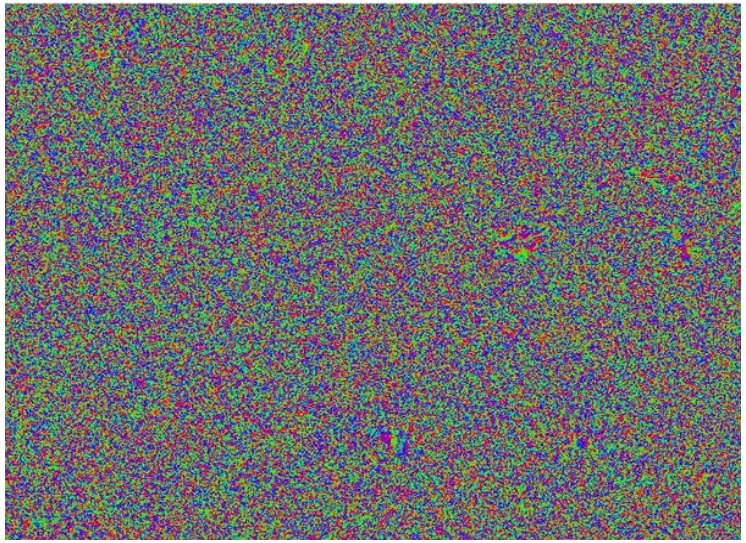
2. All-weather Penetration through clouds, rain, dry soil, and partial vegetation

SAR image

A SAR image is a set of pixels characterized by both amplitude and phase values.



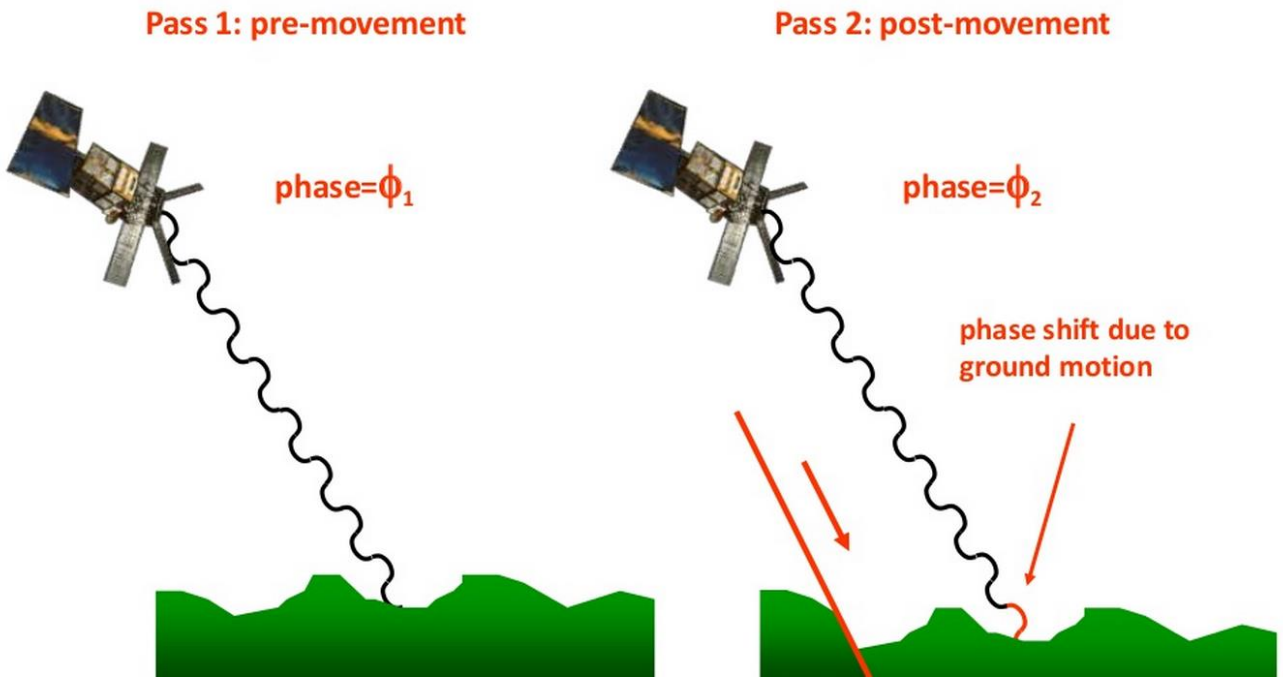
Amplitude



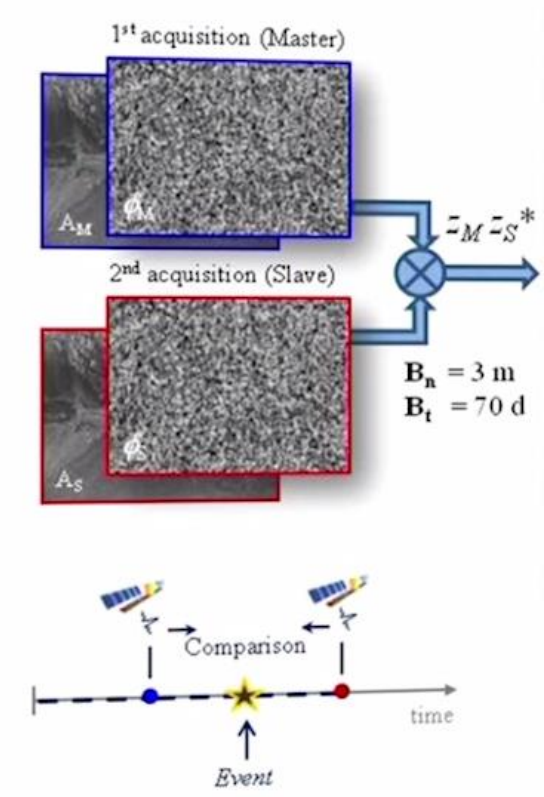
Phase

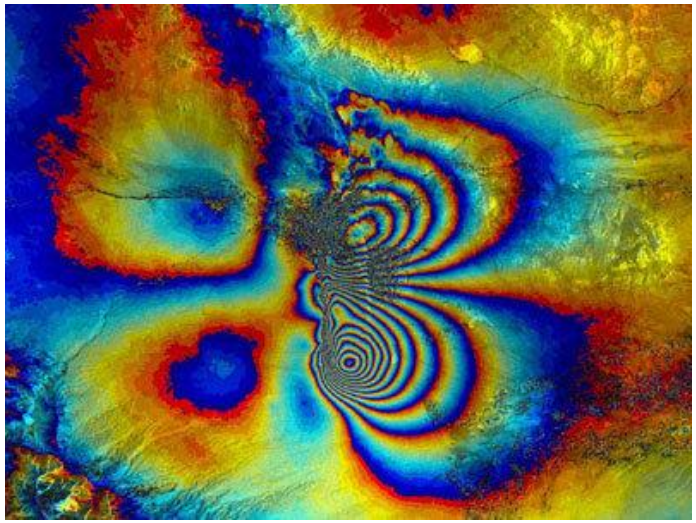
SAR Interferometry

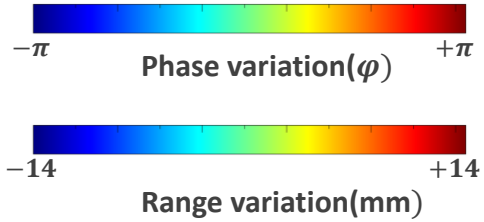
- In SAR interferometry, phase component is used, and it is related to **Sensor-Target distance**.
- The two SAR images are generally acquired from slightly different imaging geometries.
- The second SLC must be precisely co-registered and resampled to the geometry of the first SLC.



A SAR Interferogram example



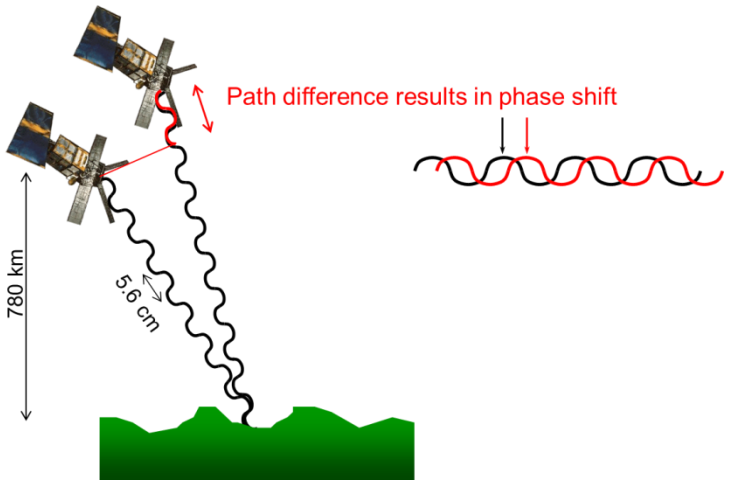


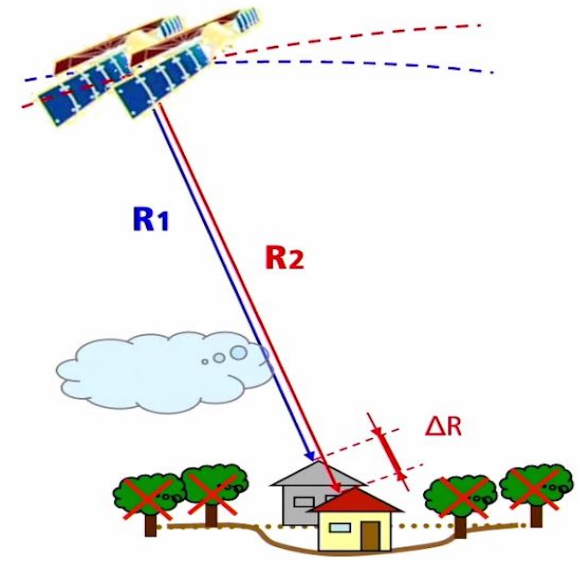


InSAR limiting factors

- Phase change between images depends on several factors that must be removed before measuring deformation:

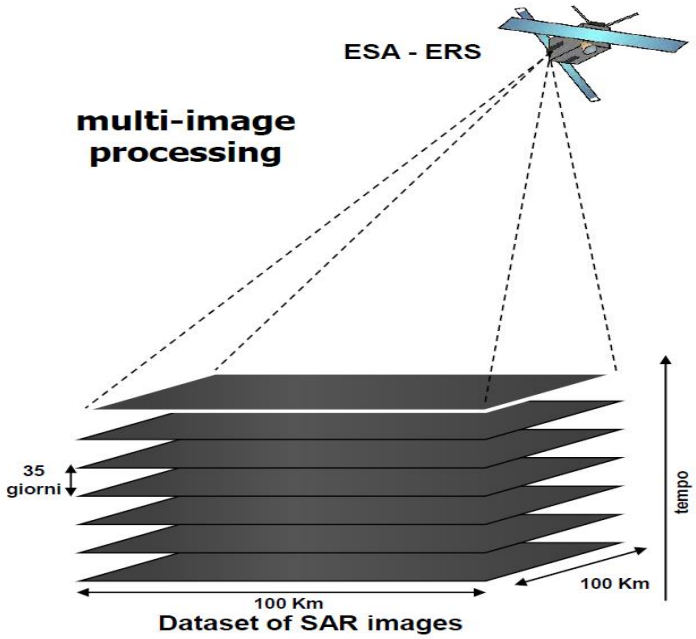
$$\Delta\emptyset = \emptyset_{Def} + \emptyset_{Orbit} + \emptyset_{Topo} + \emptyset_{Atm} + \emptyset_{Noise}$$



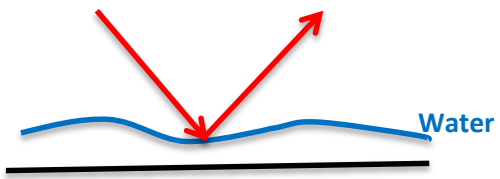


Advanced InSAR techniques

- Using a long series of SAR data
- Identifying coherent radar targets (Permanent Scatters) , where atmospheric effects can be estimated and removed.
- After removing all undesirable terms, just phase changes related to deformation will be remained.

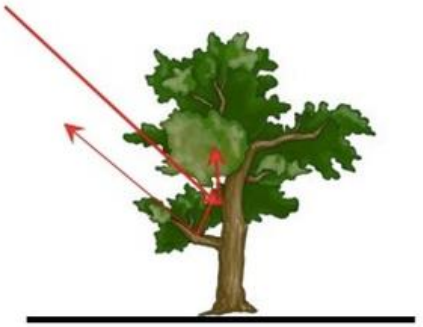


Wetland InSAR

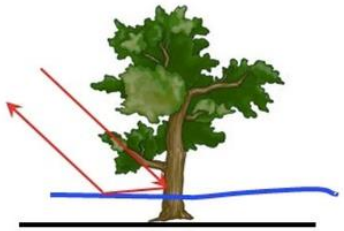


Specular Backscattering

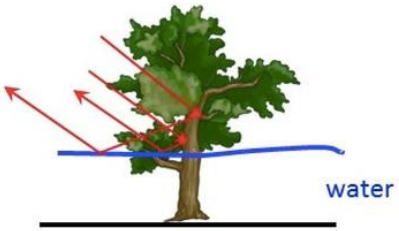
Volume Backscattering



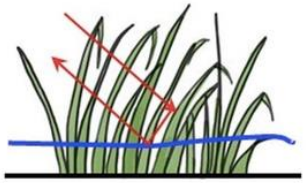
Volume Backscattering



Double-bounce
Backscattering



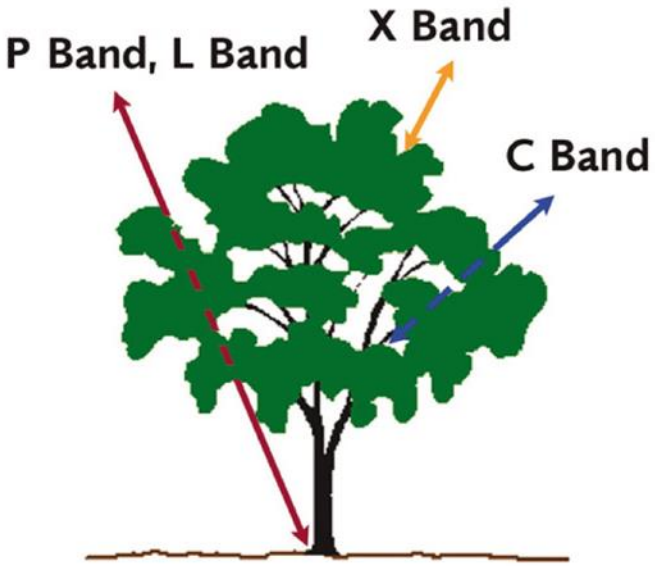
Enhanced Double-bounce
Backscattering

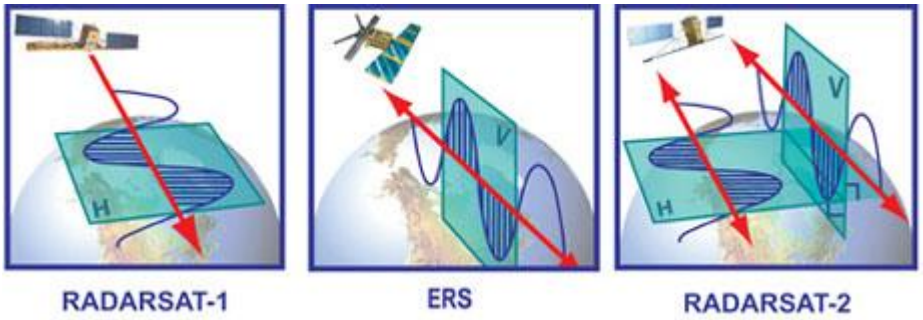


Double-bounce
Backscattering

Important factors in using InSAR for wetland monitoring

- Wetland type.
- Wavelength.
- Polarization.
- Other factors.

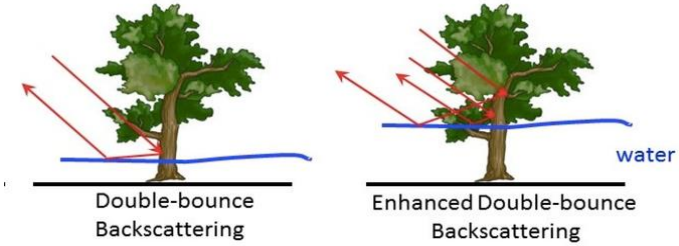




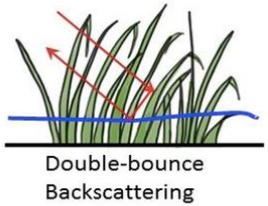
Wetland types

- Freshwater Swamp
- Marsh
- Shallow water
- Bog
- Fens

Swamp forest



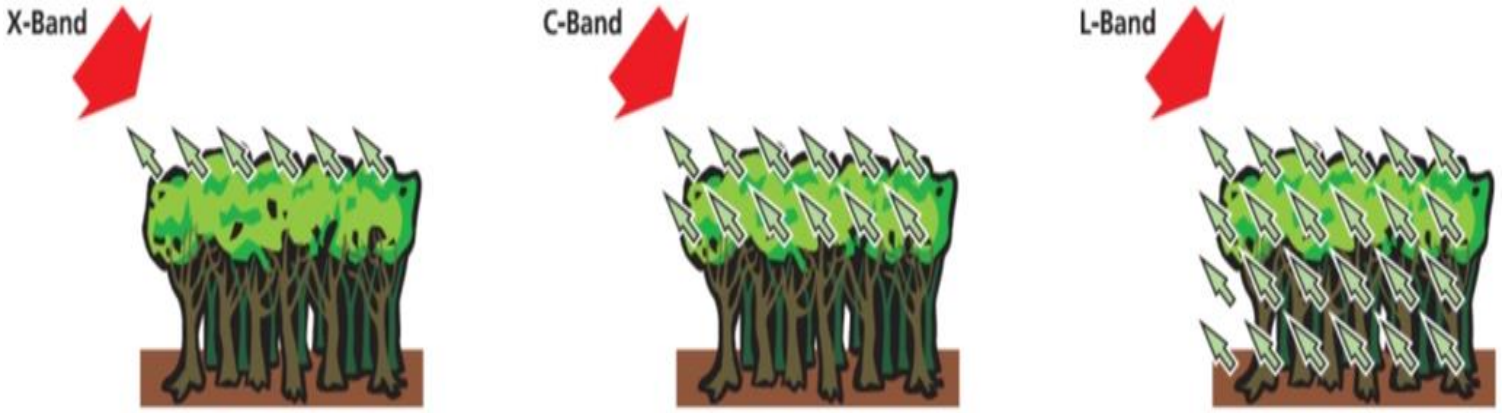
Marsh



Wavelength

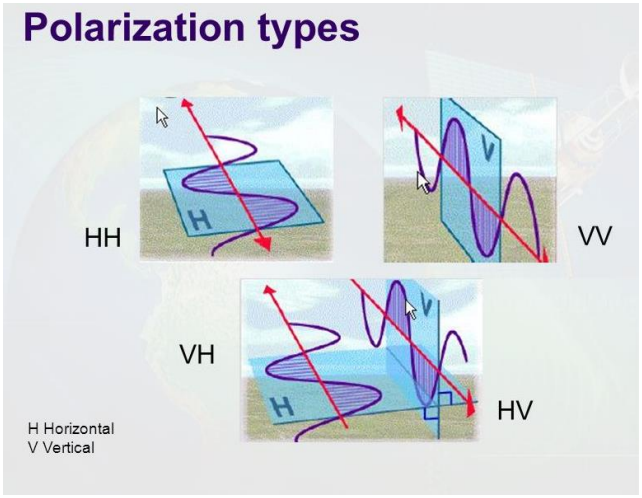
Longer wavelengths, better penetration

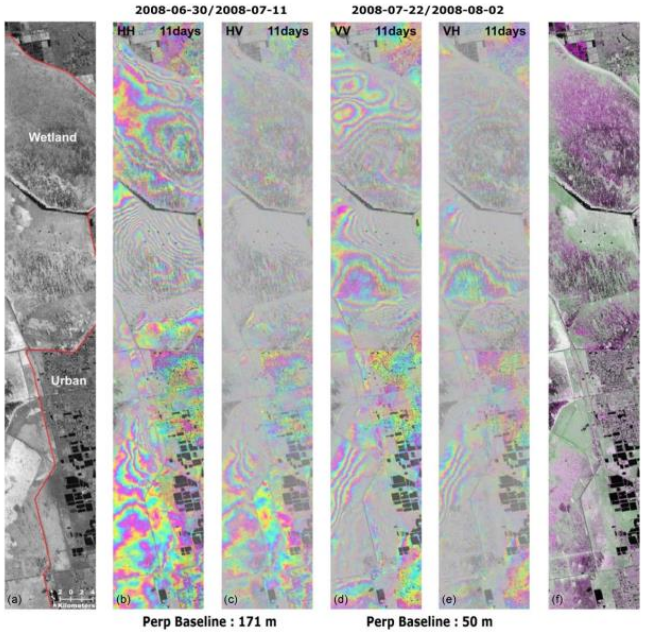
- X-Band(3.1 cm):Upper section of vegetation canopy.
- C-Band(5.6cm):Penetrates further (maybe entire canopy).
- L-Band(24cm): Throughout vegetation and interacts with the surface beneath the vegetation.



Polarization

- The phenomenon ,wherein wave radiations are restricted to direction of vibration.
- Water level changes can be detected by all polarization.
- ✓ HH polarization can maintain better coherent than other polarizations for flooded vegetation.
- ✓ VV is the second best.



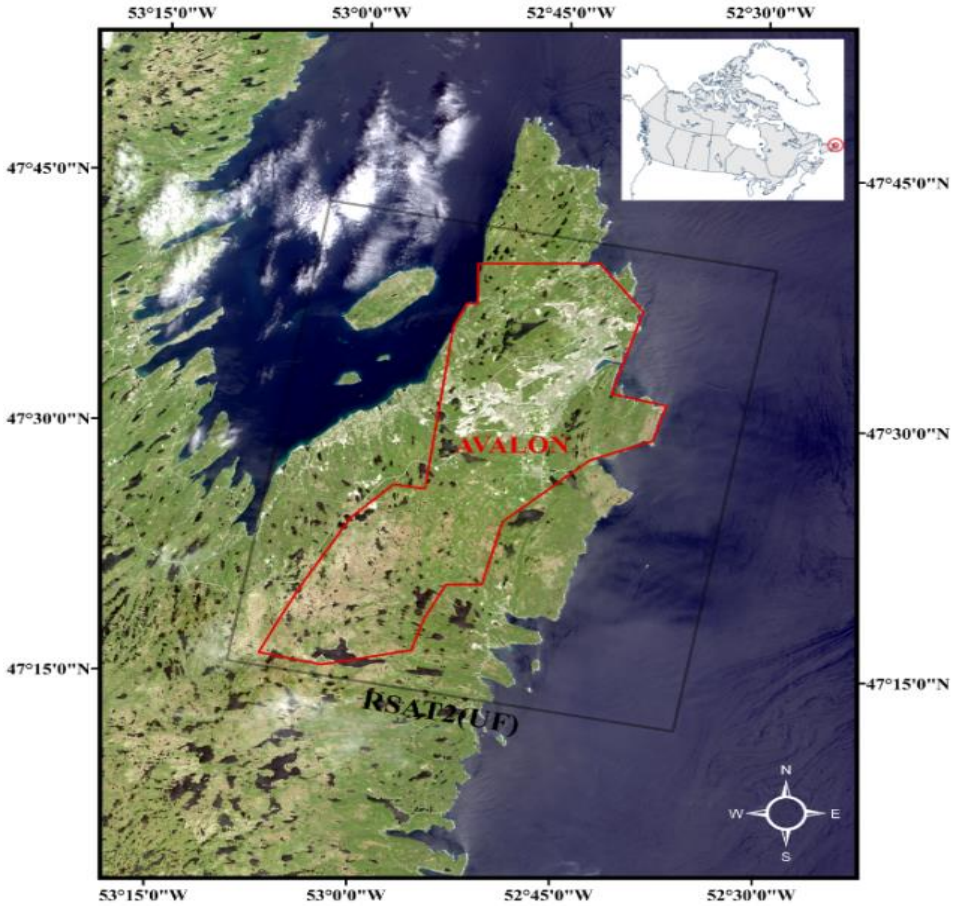


(Sang-Hoon Hong et al., 2010)

Other factors

- Temporal baseline
- Perpendicular baseline

Study area


53°15'0"W
53°0'0"W
52°45'0"W
52°30'0"W
47°45'0"N
47°30'0"N
47°15'0"N
AVALON
RSAT2(UF)
N
W
E
S

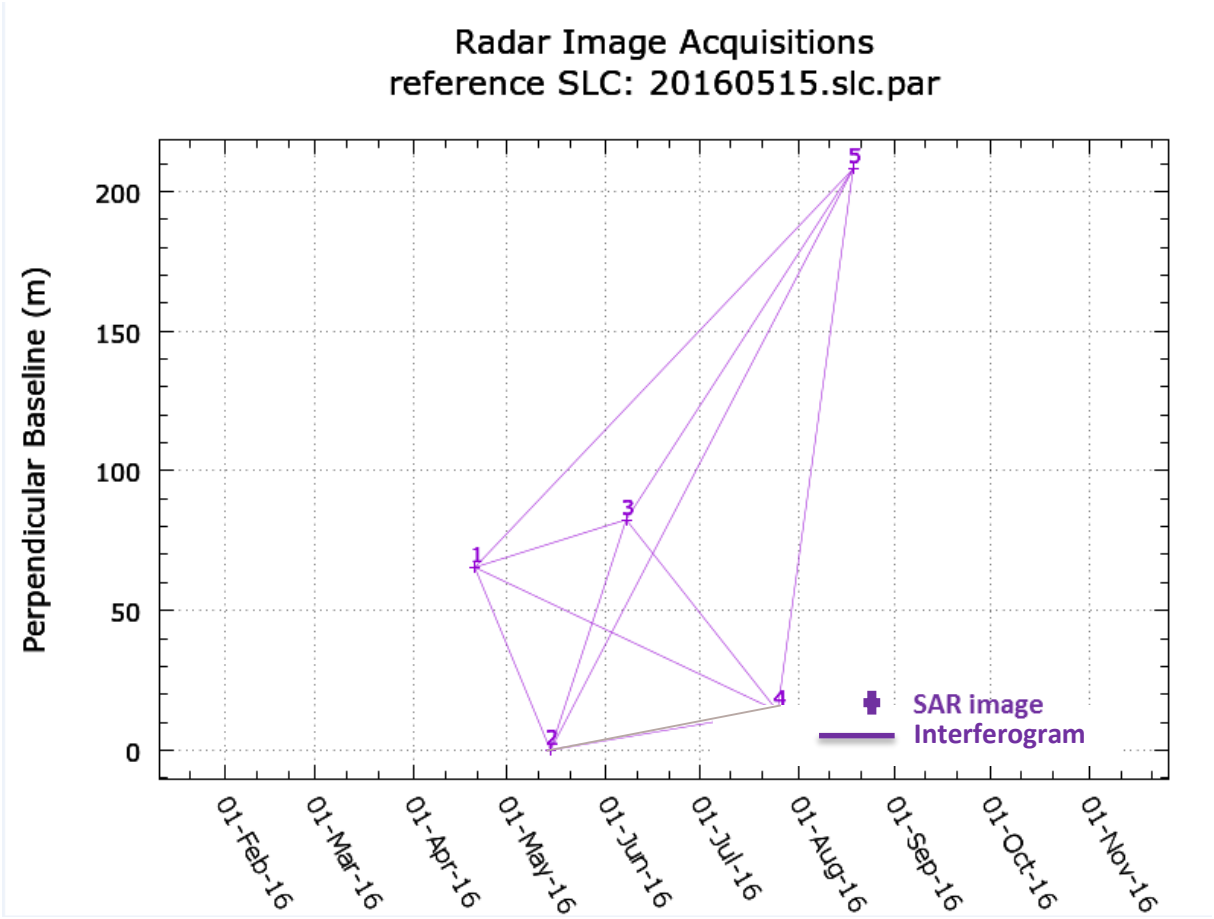
Dataset

Name	
Number of images	5
Acquisition type	Ultrafine
Beam mode	U16W2
Polarization	HH
Resolution	2.4m
Pass direction	Descending

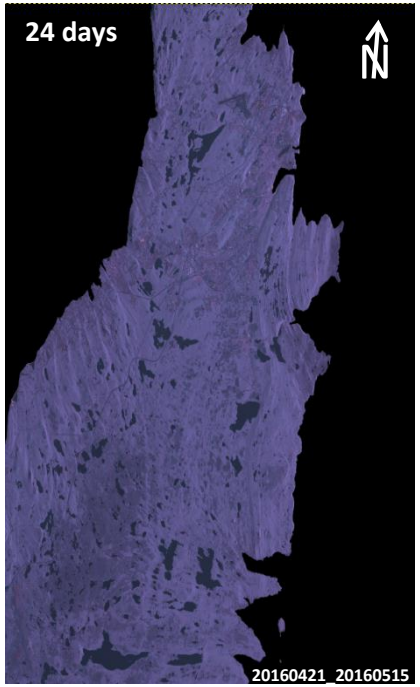
Methodology

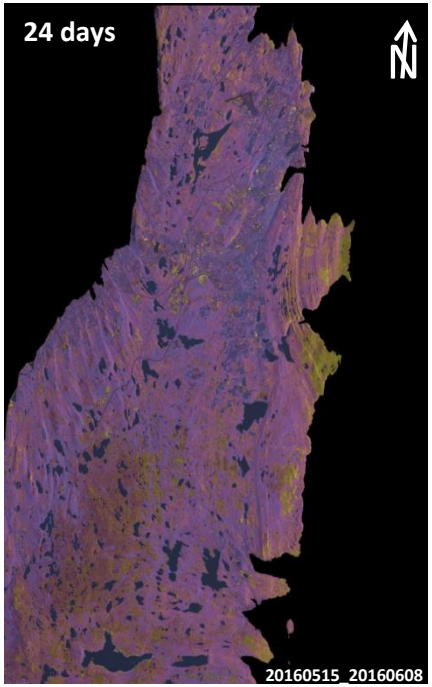
- Standard repeat-pass interferometry technique
- 5 Radarsat-2 images in Ultrafine mode
- 10 interferograms were produced
- Topographic phase was removed using an external Digital elevation Model(DEM)
- Some patterns were detected
- From 10 produced interferograms, just two interferograms with temporal baseline of 24 days illustrated an adequate coherence.

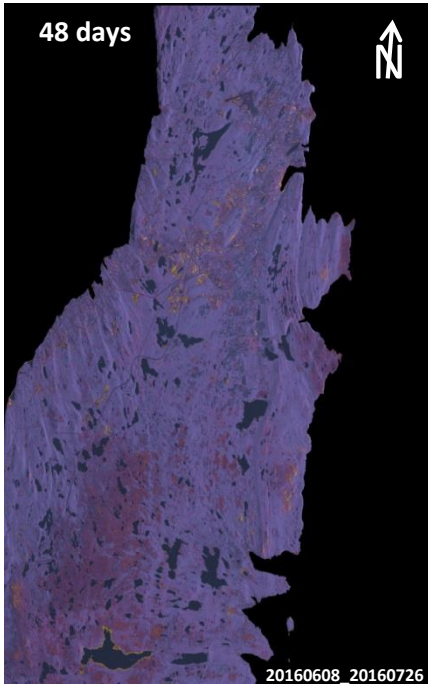
Small Baseline SAbset

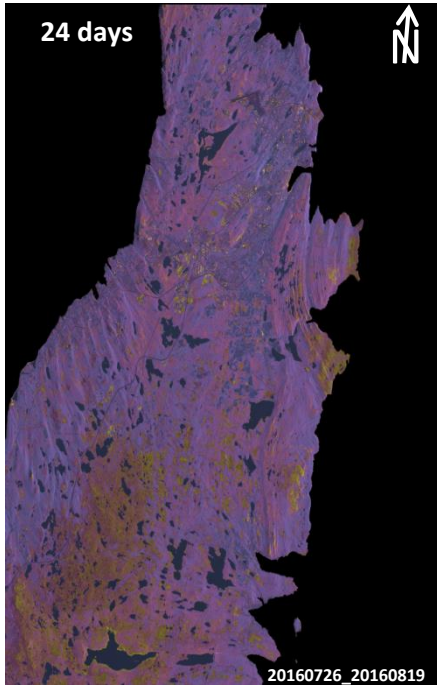


Consecutive coherence maps

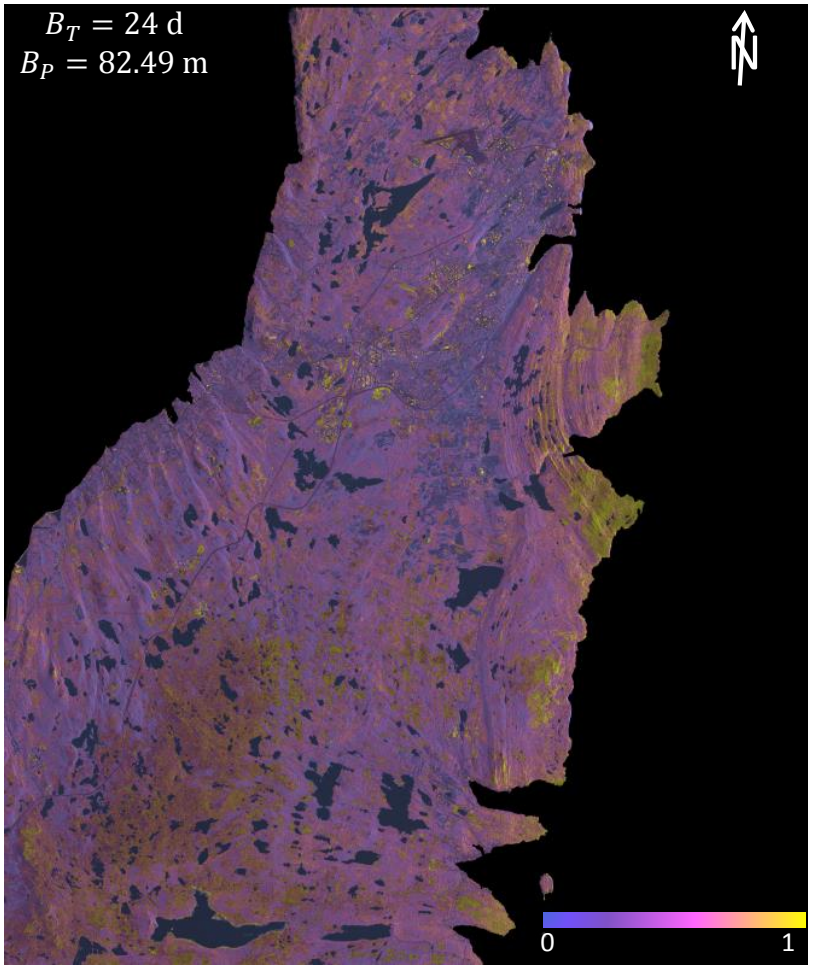




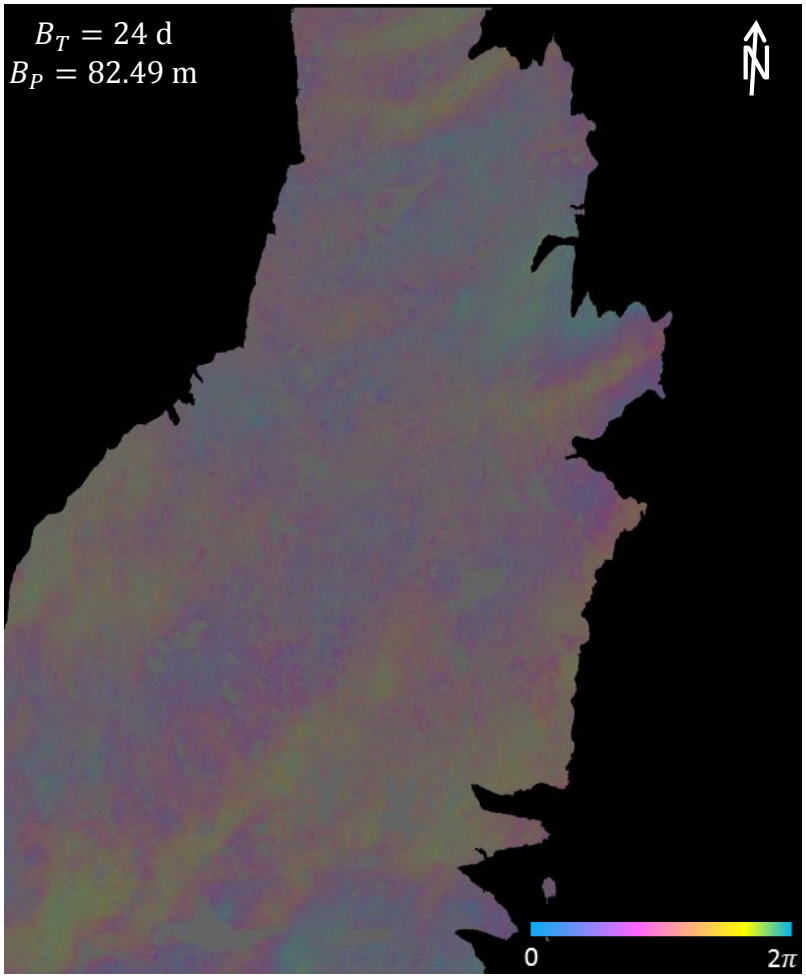




Interfergram



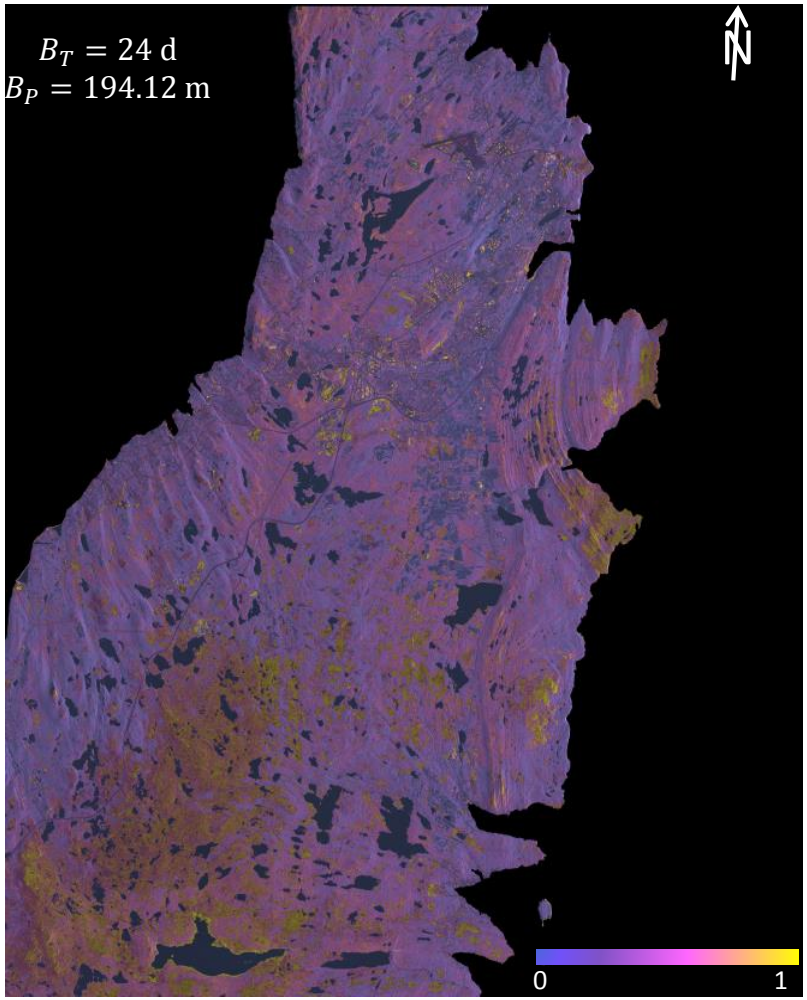
Coherence



Interferogram

20160515_20160608

Interfergram



Coherence

20160726_20160819

Interferogram

First field trip(May 2016)

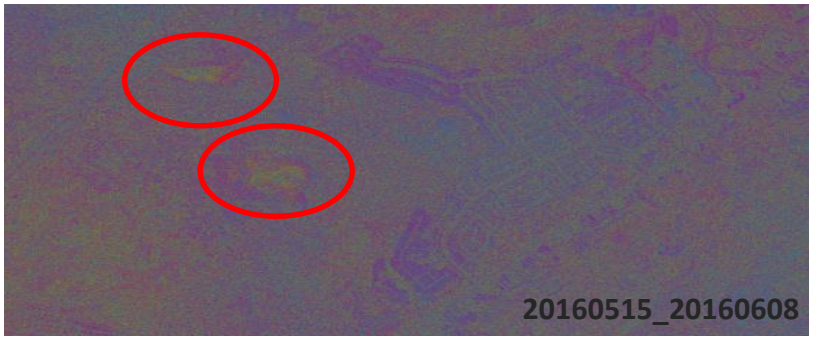

White hill industrial park

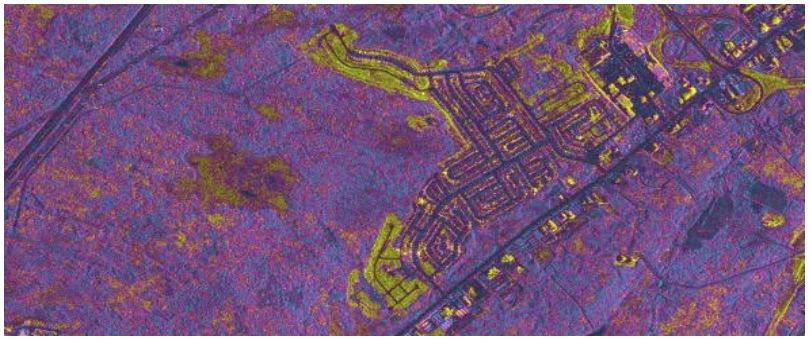

Torbay wetland

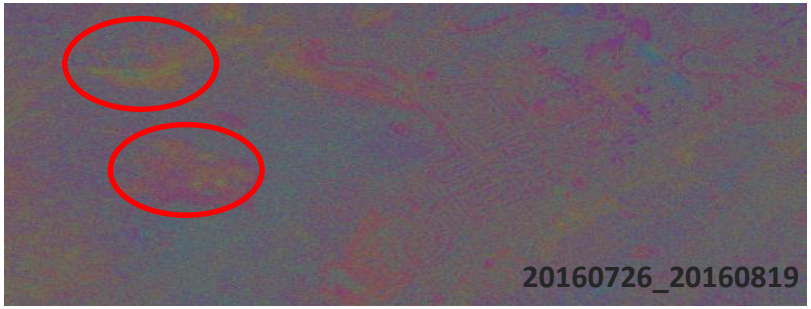

Pippy park

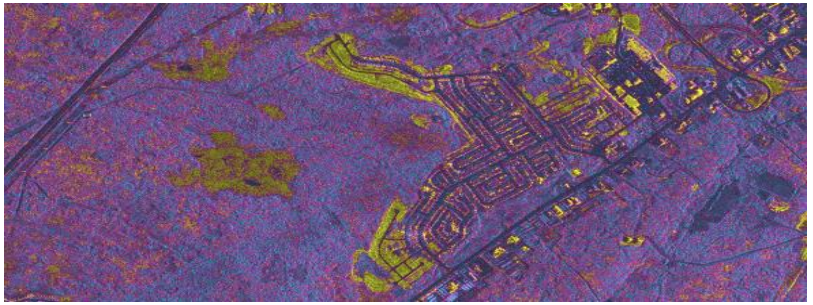

Mount pearl

Detected patterns





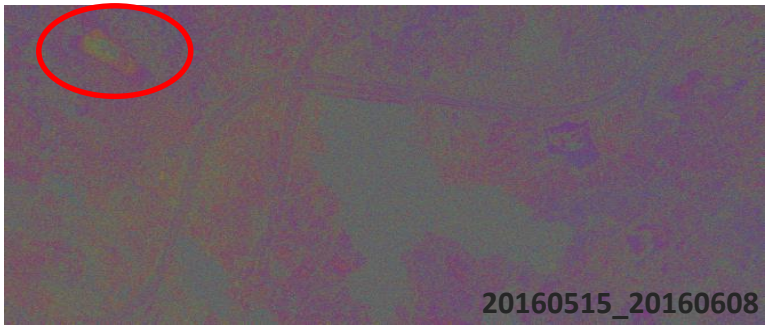


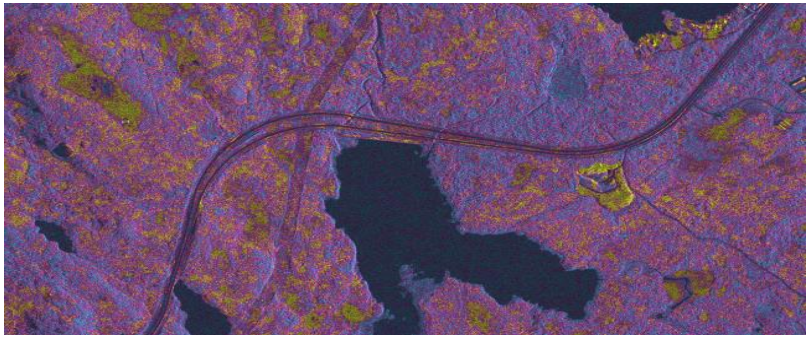


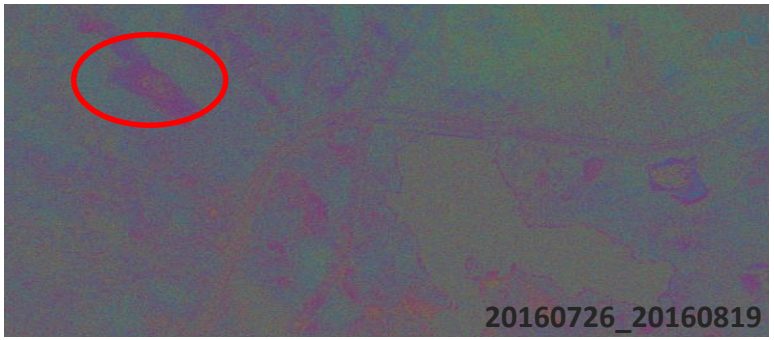
Interferogram

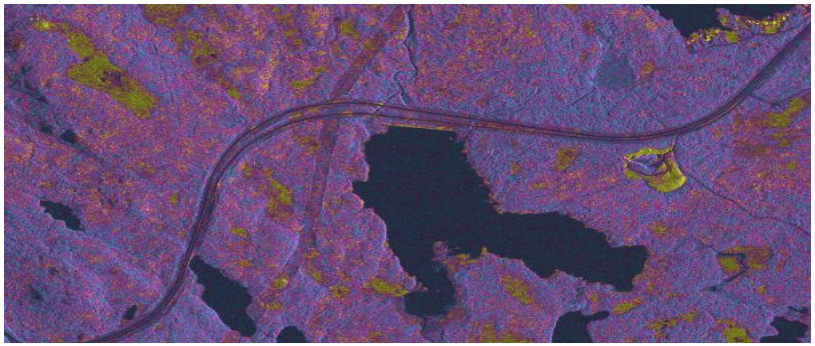
Coherence

Detected patterns





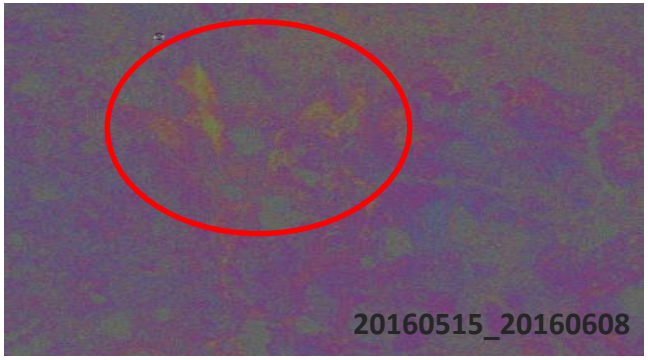




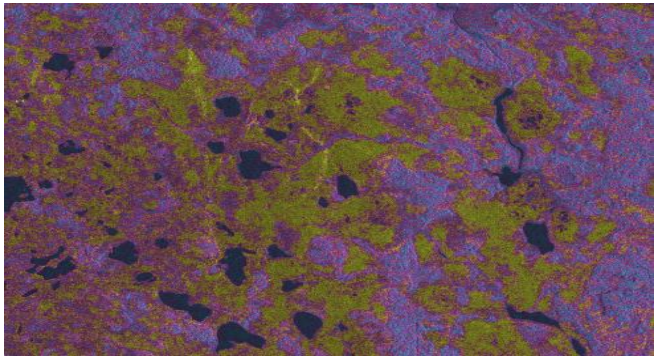
Interferogram

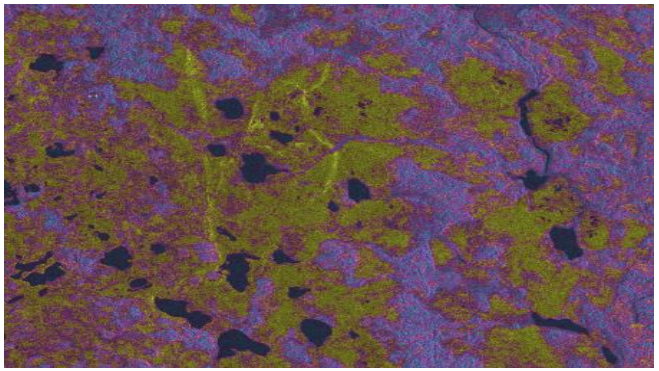
Coherence

Detected patterns



Interferogram

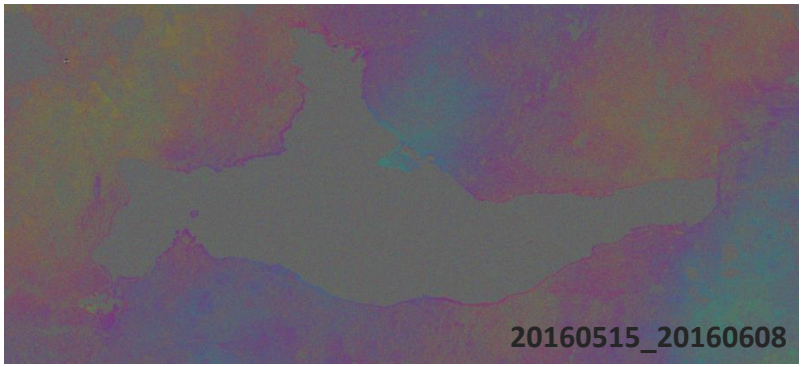


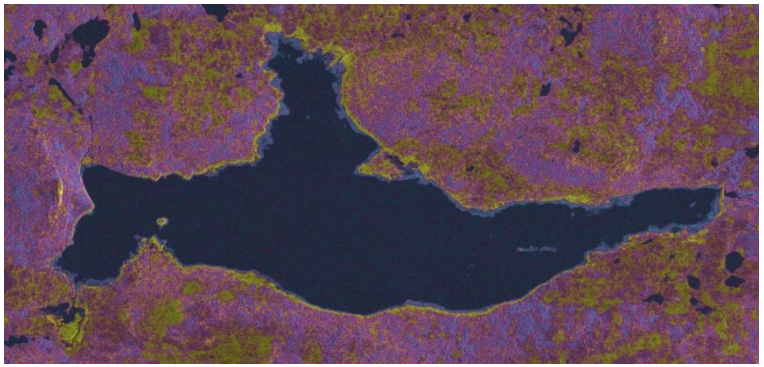


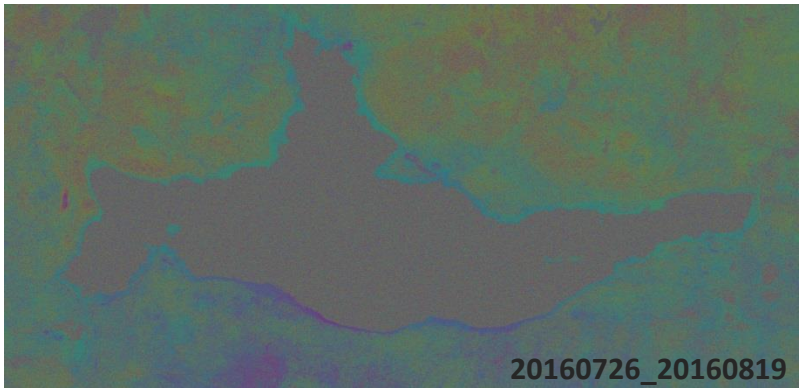
Coherence

- Marsh is very difficult to be find by Google Earth image.
- Not much open-water
- Mostly highly water saturated soils, like as peatland, and bogs.

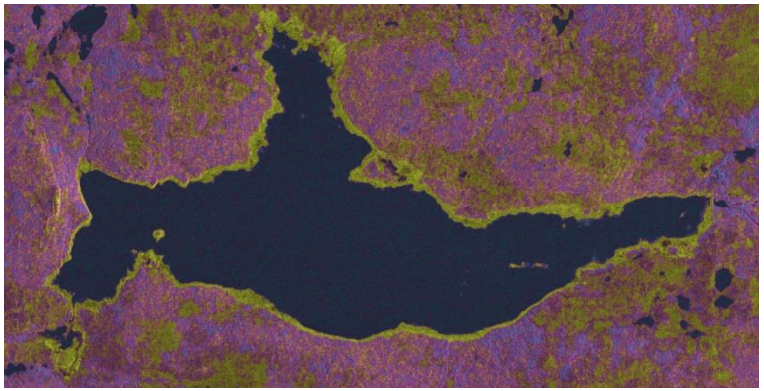
Detected patterns







Interferogram



Coherence

Conclusion

- 5 Radarsat-2 SAR data were processed and 10 interferograms in time interval between April to August 2016 were produced.
- No patterns were detected in the marsh areas that have been detected in the first field trip (May 2016).
- Some patterns were detected in other areas and the next field trip showed (September 2016) that they were related to wetland bodies.
- The results were the preliminary results of this study, more analysis should be done to extract water level height from the phase data.

Acknowledgments

Natural Resources Canada
Ressources naturelles Canada
Canada

MEMORIAL UNIVERSITY

RDC
RESEARCH & DEVELOPMENT CORPORATION
NEWFOUNDLAND AND LABRADOR

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