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.

\[ \lambda_{\text{X-Band}} = 3.1 \text{ cm} \]
\[ \lambda_{\text{C-Band}} = 5.7 \text{ cm} \]
\[ \lambda_{\text{L-Band}} = 23.6 \text{ cm} \]
Radar vs optical imagery
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
A SAR image is a set of pixels characterized by both amplitude and phase values.
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.

![Diagram showing SAR interferometry with phase differences between pre- and post-movement passes.](image-url)
A SAR Interferogram example
InSAR limiting factors

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

$$
\Delta \phi = \phi_{\text{Def}} + \phi_{\text{Orbit}} + \phi_{\text{Topo}} + \phi_{\text{Atm}} + \phi_{\text{Noise}}
$$
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 (5.6 cm): Penetrates further (maybe entire canopy).
- L-Band (24 cm): 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
## Dataset

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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 SAInterferogram

Radar Image Acquisitions
reference SLC: 20160515.slc.par

Perpendicular Baseline (m)

0 50 100 150 200

01-Feb-16 01-Mar-16 01-Apr-16 01-May-16 01-Jun-16 01-Jul-16 01-Aug-16 01-Sep-16 01-Oct-16 01-Nov-16

SAR Image Interferogram
Consecutive coherence maps

24 days

20160421_20160515

20160608_20160726

24 days

20160515_20160608

48 days

20160608_20160726

24 days

20160726_20160819
Interferogram

$B_T = 24 \text{ d}$

$B_P = 82.49 \text{ m}$

20160515_20160608
$B_T = 24 \text{ d}$
$B_P = 194.12 \text{ m}$

Coherence

Interferogram

20160726_20160819
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

- 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

Mobile Big Pond
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.