# MONITORING SUBARCTIC ENVIRONMENTS USING X- AND C-BAND RADAR IMAGERY

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## Context : subarctic vegetation and snow

Subarctic environments are significantly affected by the climate warming observed in recent decades. These perturbations lead to many environmental changes such as permafrost thawing and expansion of shrub vegetation cover. Snow, with its insulating properties, also plays an important role in these processes maintaining relatively warm ground temperatures during the winter while protecting the vegetation from the cold and wind. The presence of shrubs may, in turn, trap wind blown snow and creates a positive feedback favoring the expansion of shrub vegetation at the expense of the tundra. Satellite Synthetic Aperture Radar (SAR) data can provide information on the vertical structure of the observed objects and can be acquired under any meteorological condition.

### Project objective

The objective of this study is to develop methods for the simultaneous monitoring of snow and vegetation in subarctic environments using multipolarized and multifrequency SAR imagery.

## Methods

### SAR Data acquisition :

2010 to 2012 : **fall** (Oct. to Dec.), **winter** (Mar. et Apr.)

| Satellite | Band | Wavelength | Resolution | Polarisations |
|---|---|---|---|---|
| RADARSAT-2 | C | 5.6 cm | 9 m | HH, HV, VH, VV |
| TerraSAR-X | X | 3.1 cm | 6 m | HH, HV |

### Field measurements :

**Snow** measurements: in coordination with acquisitions

- Spatial distribution of: snow **depth**, **density** and snow water equivalent (**SWE**)
- Snow pits: study the vertical structure of the snowpack.

**Vegetation** measurements: summer of 2009

- 245 sample sites: vegetation type, coverage, height and environmental characteristics

### Polarimetric parameters :

**Entropy :** Randomness of the type of scattering mechanisms found within a given pixel. 0 = single dominant mechanism, 1 = multiple mechanisms.

**Anisotropy :** Indicates if one scattering mechanism is dominant

**α angle :** Type of dominant mechanism : **0°** = surface scattering (ground, water); **45°** = volume sattering (vegetation); **90°** = double bounce scattering (ground/tree trunk)

- **Figure 2a** : RADARSAT-2 image (**HH**, **HV**, **VV**)
- **Figure 2b** : 3 polarimetric parameters: **α angle**, **Entropy**, **Anisotropy**
- **Figure 2c** : Wishart unsupervised classification

## Study area

60 km² region located around the Umiujaq community (56.55° N, 76.55° W) in Nunavik (northern Quebec), Canada.

At the northern tree line in a discontinuous permafrost region.

Two distinct environments:

Coastal region: sporadic tundra vegetation

Lac Guillaume-Delisle graben: mainly scrublands with patches of conifers.

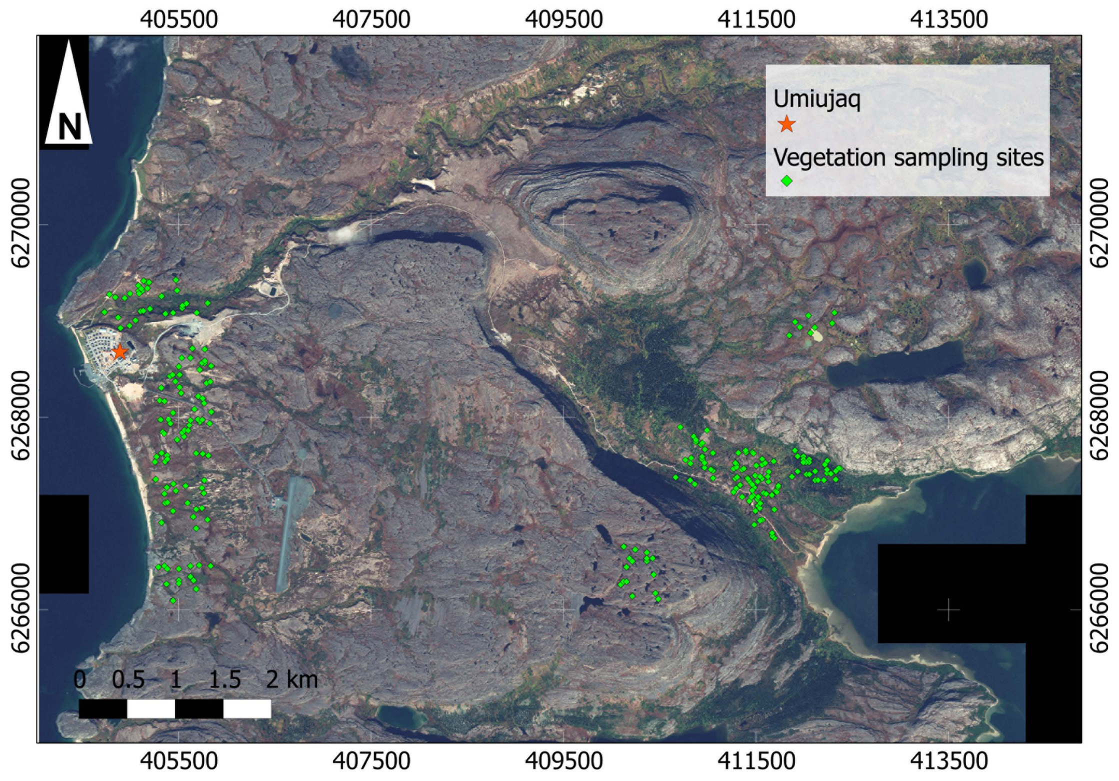
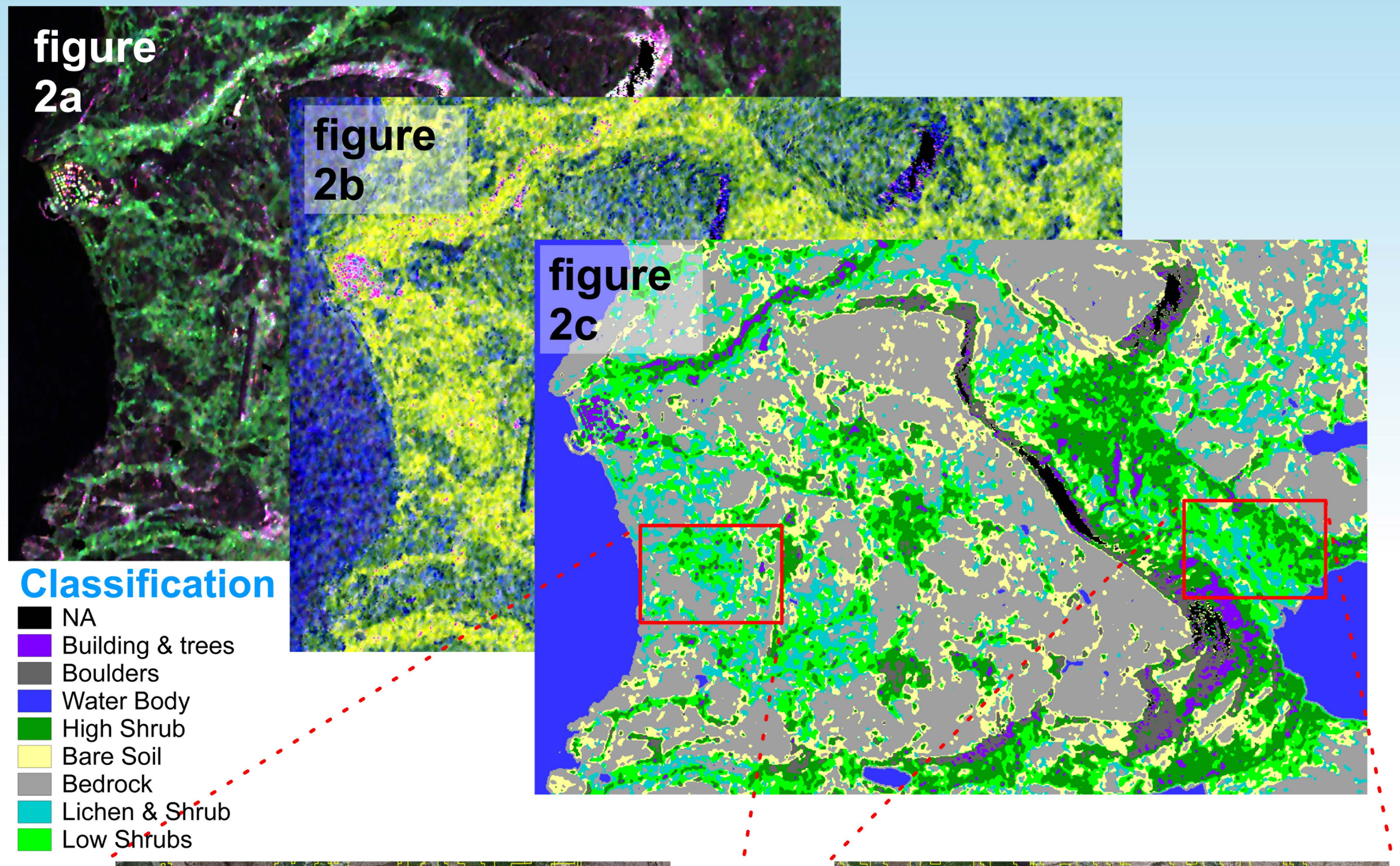



*Figure 1: Study area*

## Radar polarimetry for vegetation classification



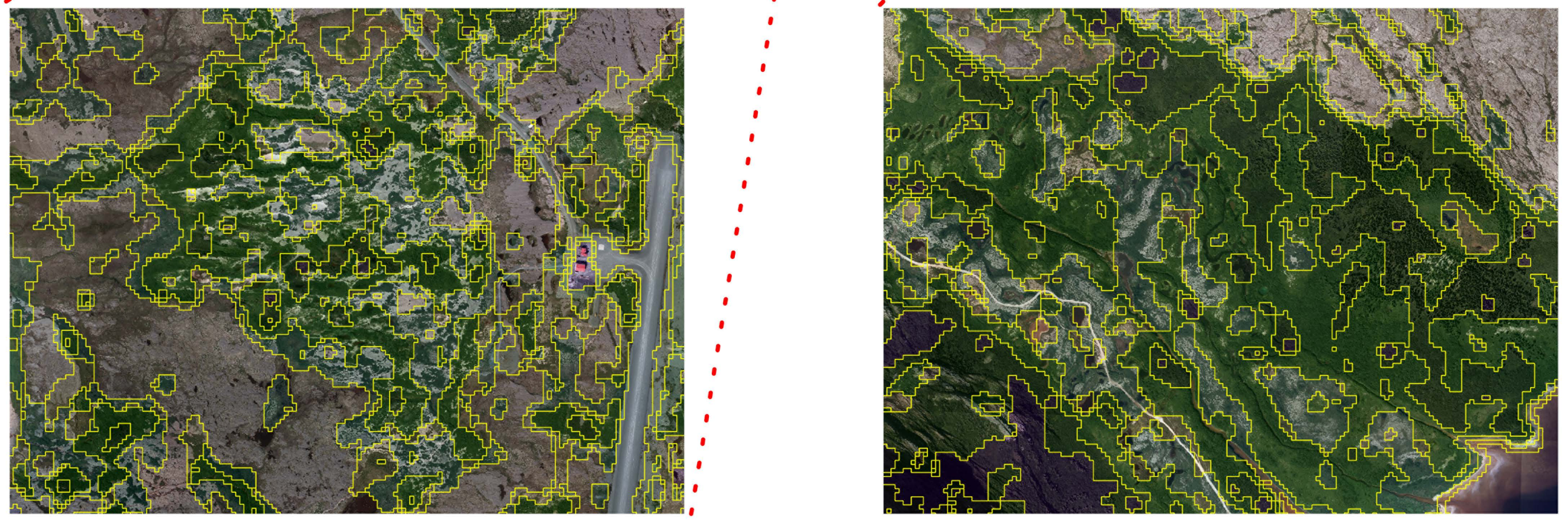



*Figure 3 : Zoom on the classifications of the littoral area (left) and Lac Guillaume-Delisle graben (right) overlayed on aerial photography*

## Effect of vegetation and snow on the radar signal

During the winter, windblown snow is intercepted by shrub vegetation, leading to greater snow accumulations where vegetation is taller (Fig. 4). The effect of snow on backscattering depends on frequency. Backscattering is greater during the winter compared to late fall in X band, probably due to the presence of snow, while it is lower in C band, probably due to ground freeze up. The effect of vegetation height (figs. 5 and 6) on the dynamic range of the backscattering is greater at C band and is still visible during the winter.

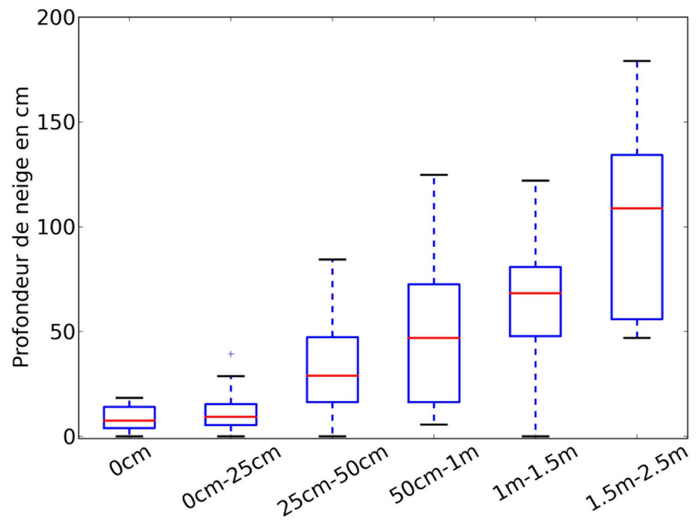



*Figure 4: Snow depth for each vegetation height class (combined data from 2011-2012 winters)*

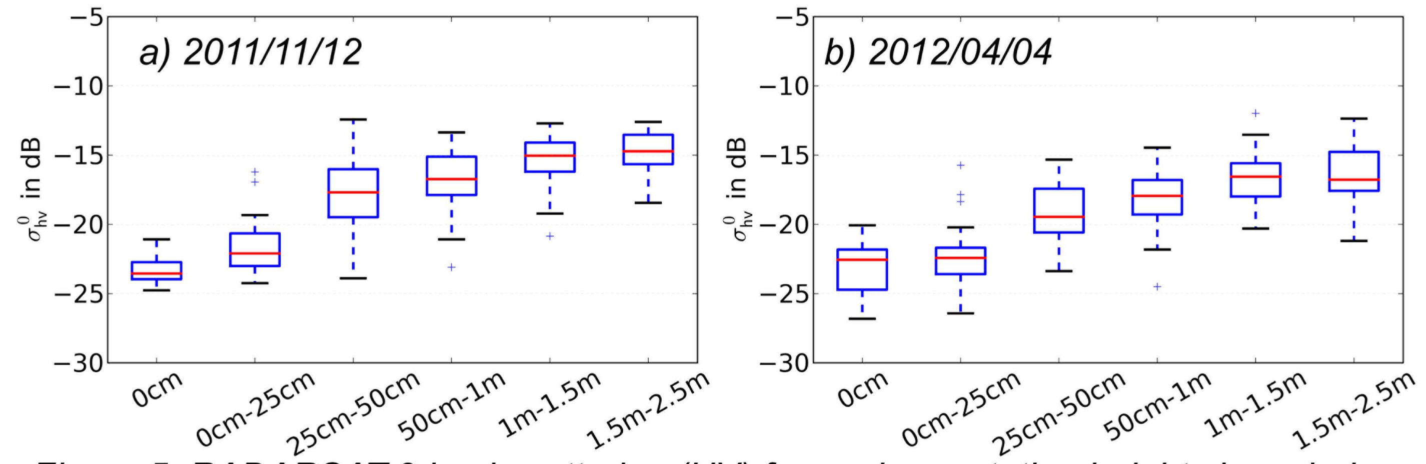



*Figure 5: RADARSAT-2 backscattering (HV) for each vegetation height class during the 2011 fall (a) and 2012 winter (b)*

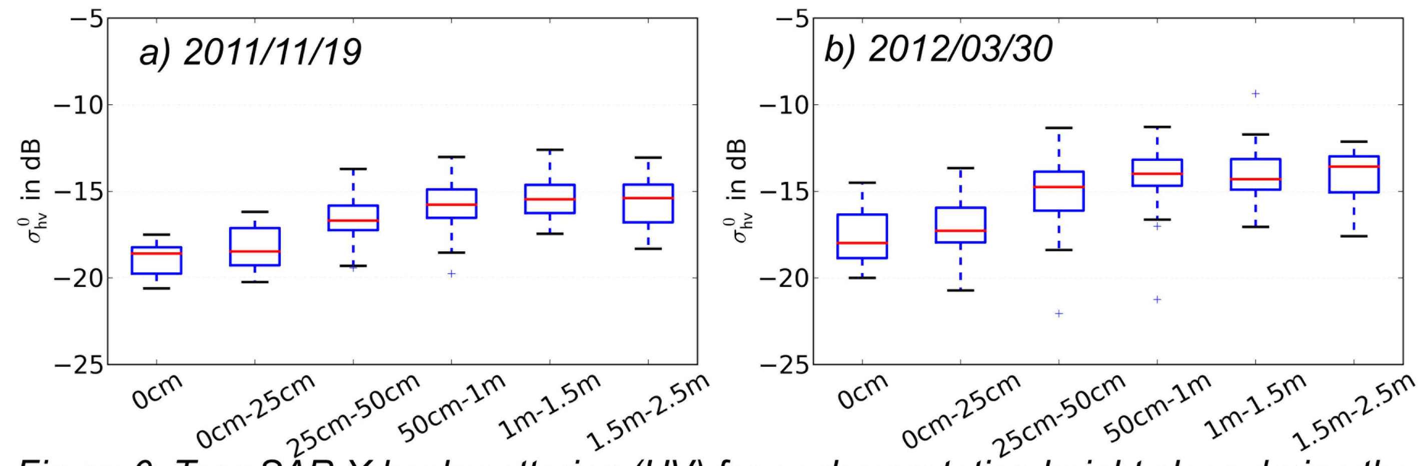



*Figure 6: TerraSAR-X backscattering (HV) for each vegetation height class during the 2011 fall (a) and 2012 winter(b)*

## Conclusions and perspectives

- According to our ground measurements and the litterature, shrub vegetation affects the snowpack's structure.
- SAR backscattering is related to vegetation height.
- The effect of the vegetation characteristics is important during the winter and needs to be considered for snow characterisation using SAR data.

The next steps will be aimed at improving the vegetation classification using supervised classification methods. A semi-empirical model will then be developped to measure snow characteristics within each vegetation class.