Bistatic coherence from CoSSC TanDEM-X data for tree height estimation in the Canadian Subarctic

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In the frame of PermaSAR project (BMWi and DLR)

Introduction

The heterogeneous subarctic **forest-tundra transition zone** is a vulnerable ecosystem. Its response to current climate change trends is not well understood. Accurate mapping of the **tree cover and tree height** would provide the baseline for future studies aiming at monitoring vegetation changes in the Arctic.

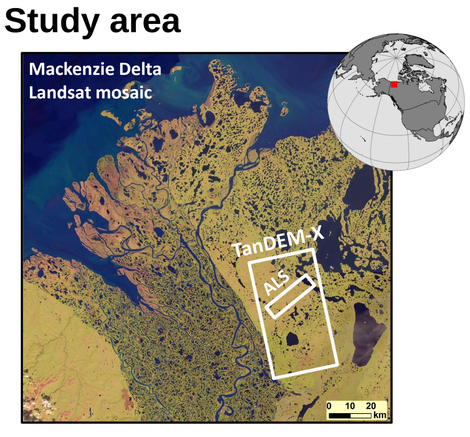
Interferometric SAR **coherence** is sensitive to the vertical structure of vegetation and thus can be used in the estimation of tree height. Coherence from bistatic TanDEM-X data is highly valuable due to the lack of a temporal decorrelation factor.

We use seven **TanDEM-X bistatic pairs** to evaluate their potential to distinguish pockets of sparse forest in the Canadian Subarctic to Arctic transition region. Moreover, we relate the coherence values with tree height obtained from **Airborne Laser Scanning (ALS)**.

Data

- TanDEM-X CoSSC pairs June-August 2015 → coherence images
  incidence angle: ~46°; polarization: VV (single-pol); baseline: ~583 m; HoA: -14 m; cell size: 8 m
- ALS from Polar 5 AIRMETH campaign 2016 → vegetation height (preliminary results) cell size: 1 m
- Orthophotographs: 2004-2008 from Northwest Territories Centre for Geomatics (open access) cell size: 50 cm

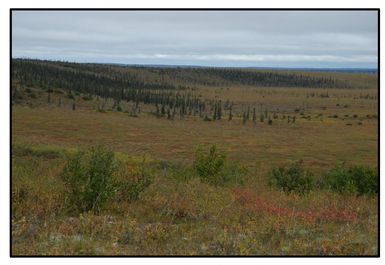
Study area



Trail Valley Creek,
Northwest Territories, Canada
68°45'N, 133°30'W

- zone of continuous permafrost
- transition from forest to tundra
- pockets of spruce forest

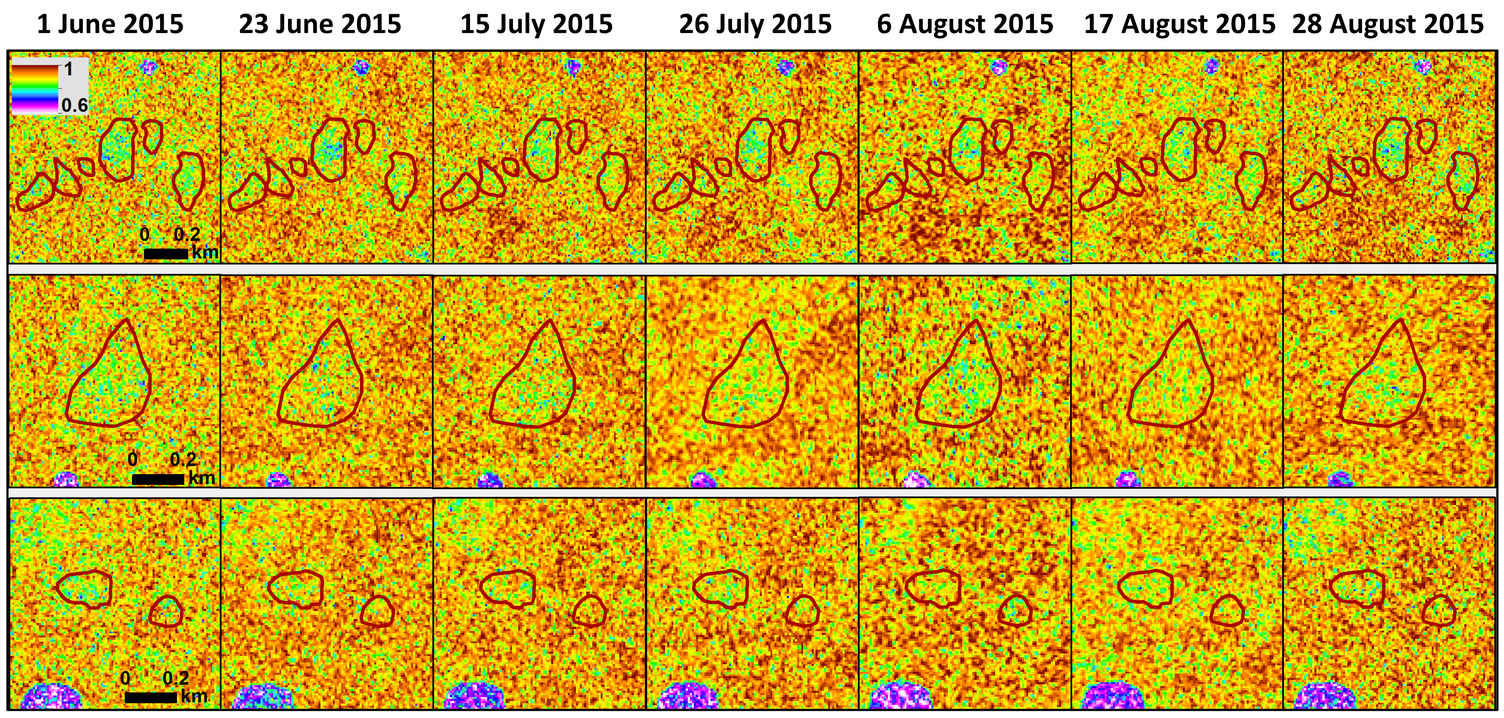
Oblique aerial photograph showing high landscape heterogeneity



Forest area on the background

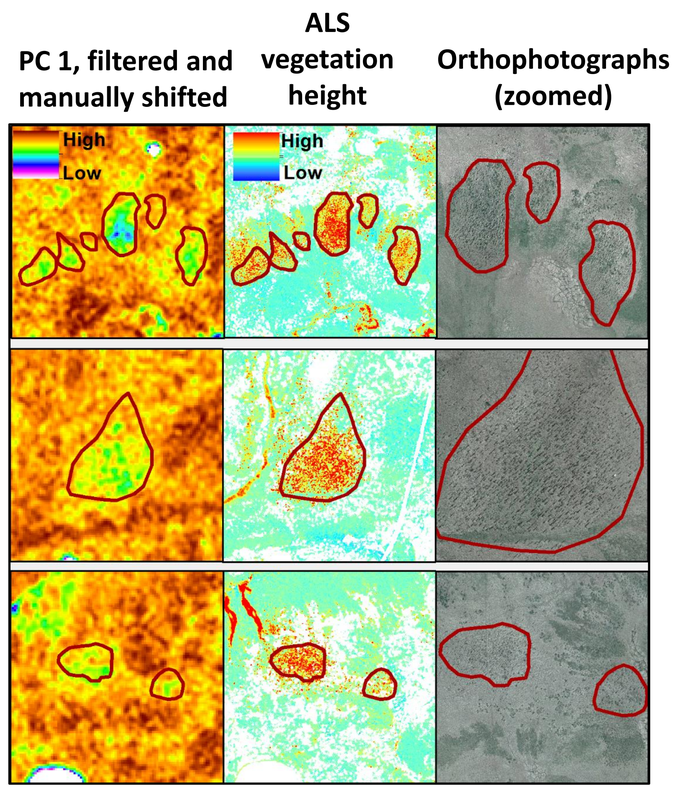
In the forest area

Results



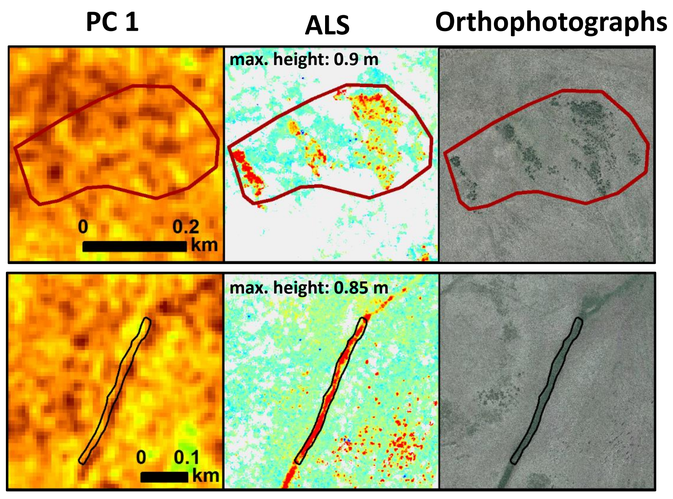
Coherence for all individual CoSSC pairs for selected tree areas

All individual coherence images are highly affected by noise. Tree areas are visually distinguishable with different levels of confidence. Principal Component Analysis (PCA) enhances the signal and reduces the noise, which provides a clearer identification of the tree areas.



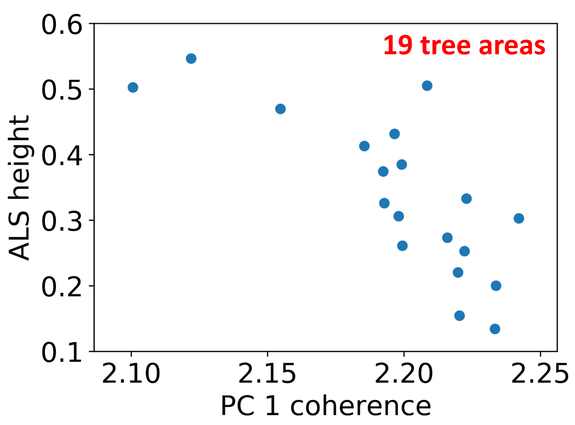
Left: *PC 1 of all coherence images;* ***Middle:*** *ALS vegetation height;* ***Right:*** *fragments of orthophotographs where single trees can be identified.*

No sensitivity to shrubs



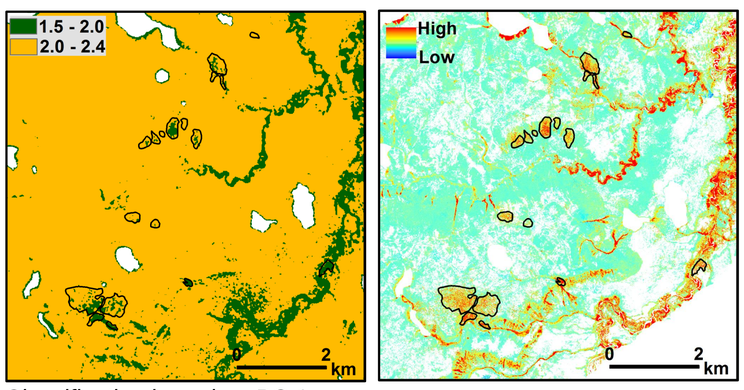
- coherence does **not** show a **sensitivity** to shrubs
- **shrubs** within these two areas are **lower in height** compared to trees within studied tree areas
- this can be useful in case forests need to be mapped

Coherence and vegetation height



- for single coherence images, **correlations** between mean **coherence** and mean **vegetation height** are between **-0.41 to -0.71**
- for the **PC 1**, the correlation is -0.64 and improves to **-0.76** after manual shifting (to correct inaccurate georeferencing) and filtering

Classification trees/non-trees



Classification based on PC 1 of all coherence images

ALS vegetation height

- for the **classification**, individual coherence images are not suitable due to **noise**
- **PC 1** is used instead of individual images and classification is performed using simple thresholding
- **most** of the studied tree areas are **classified correctly**