Estimating shrub height as indicator for snow depth and permafrost modelling

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Abstract

Shrub height is of relevance for snow redistribution and impacts ground temperatures. Certain land cover classes derived from satellite observations can to some extent be associated with vegetation heights but available maps are often too coarse and lack thematic content. We have tested an approach, which directly provides height information. It is based on Sentinel-2 data and has been calibrated and validated over Yamal. Results indicate the potential for large scale application.

Keywords: tundra vegetation, remote sensing, Sentinel-2

Introduction

Land cover has strong implications for the small-scale distribution of snow cover. Specifically, shrub height is required in order to identify areas with trapping of snow and subsequent impact on ground thermal conditions. Current global and circumpolar maps lack thematic detail and/or spatial resolution to appropriately represent shrubs, their types and height (Bartsch et al. 2016). In this study, we specifically investigate the capability of Sentinel-2 to estimate shrub height across large areas. It is part of the ESA DUE GlobPermafrost initiative (www.globpermafrost.info).

Data and methods

The recently launched Sentinel-2 satellite acquires optical data suitable for land cover monitoring with 10 m spatial resolution. We have selected a transect spanning from the northern tip of the Yamal peninsula (continuous permafrost) to the south into the tundra-taiga transition zone (with discontinuous permafrost) in order to test these data for shrub height retrieval. The region represents not only a gradient in vegetation zones but also sites with high heterogeneity of shrubs. Especially central Yamal is characterized by willow shrubs of up to 1.5 m height and continuous permafrost, while Southern Yamal is characterized by smaller dwarf-birch (Ukraintseva, 1997). Several studies over a CALM site and additional transects have exemplified the role of the shrubs for active layer thickness in relation to snow using in situ measurements (Leibman et al. 2015, Dvornikov et al. 2015) as well as Synthetic Aperture Radar data (Widhalm et al. 2017) from satellites in this region.

Shrub height measurements have been collected between 2014 and 2017. All available cloud-free images of summer 2016 and 2017 have been combined and seven indices derived.

Results

Figure 1 shows the mosaic over the chosen transect. The two summers have not been sufficient to obtain a complete coverage due to frequent cloudiness.

An R^2 of up to 0.72 could be obtained for the comparison to shrub heights from in situ measurements. The approach can be potentially applied over the entire Arctic to derive maps of shrub height.

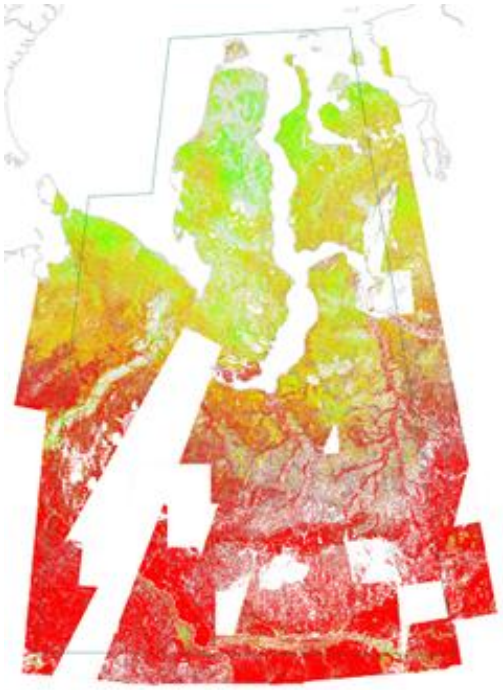

Figure 1. Shrub height derived from Sentinel-2 (2016 and 2017 acquisitions) over a transect covering the Yamal peninsula and the West Siberian Lowlands. Grey – masked, white – no data, other colors represent 0 (green) to 160cm (red – 160 cm or higher).

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