Pan-arctic coastal settlements exposition to coastal erosion and warming permafrost

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Introduction

As the Arctic region is warming, the vulnerability of arctic coastal settlements is increasing in relation with coastal erosion and warming permafrost, threatening livelihood and infrastructures stability. Automated remote sensing technics allowed the detection of infrastructures, recent coastal dynamics and permafrost ground-temperatures. Coupled, these observations spatially highlight recent and future exposure of arctic coastal settlements to potential coastal erosion, marine submersion and subsidence hazards.

Infrastructure detection

The updated **Sentinel-1/2 derived Arctic Coastal Human Impact** dataset (SACHI, Bartsch et al. 2021) includes additional classes and distinguishes between 3 road types. Buildings (and other constructions such as bridges) and airstrip were detected, and artificial water reservoir have been added to the dataset. The dataset was compared to very-high resolution validation data acquired over 16 arctic settlements for accuracy assessment.

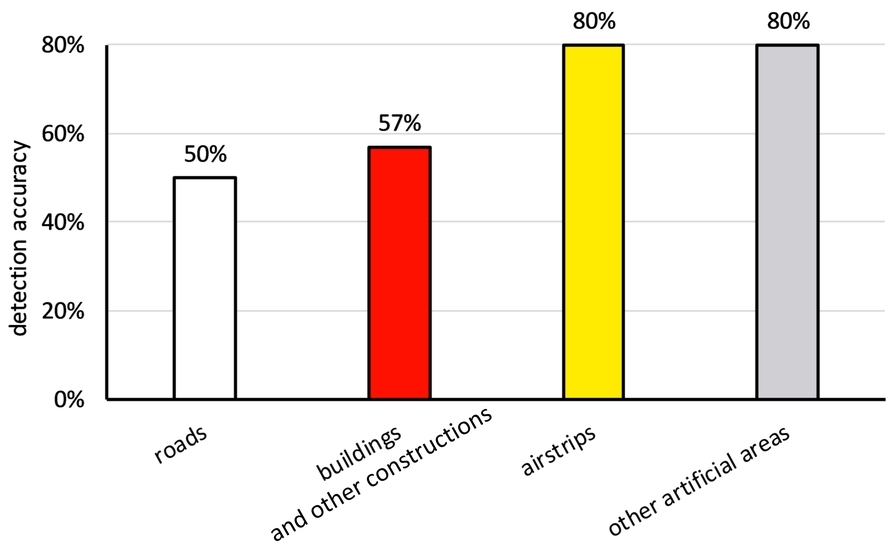

Figure 2: Validation results of the updated SACHI dataset.

Dataset accuracy

The results reveal an overall accuracy of **55%** with **50 %** accuracy for the detection of roads and up to **80 %** for the detection of airstrips and other artificial areas. The 10 m resolution of the sentinel imagery is limiting the detection of small and irregular features. Buildings are the least accurately detected class and are sometimes confused with trash, construction debris and or with wood log beaches.

Settlement exposition to coastal erosion

The combination of the infrastructure dataset with the erosion rates and projected coastline position allowed to identify settlements and infrastructures threaten to coastal erosion for short and long-term periods.

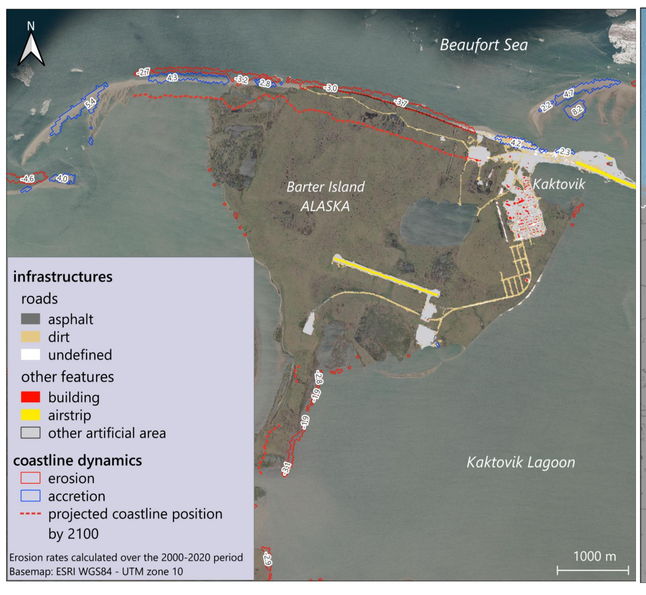

Figure 5: Example for updated SACHI and coastline dynamics showing the potential loss of the front road and a part of the radar station of Kaktovik.

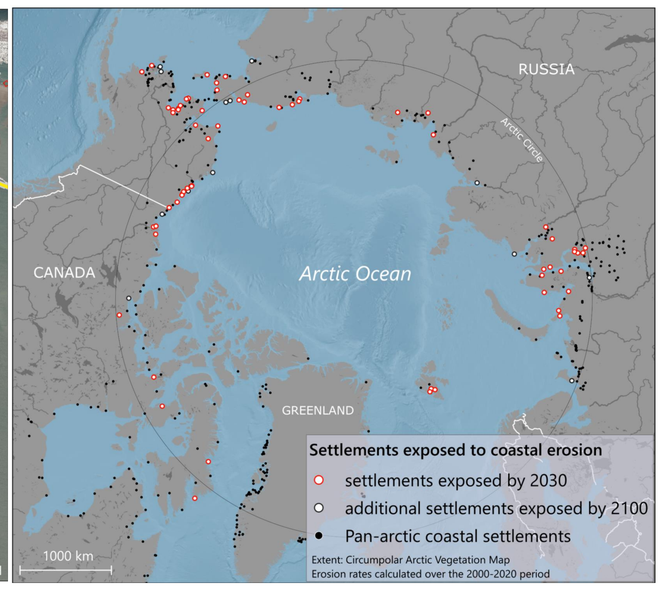

Figure 6: Settlements exposed to coastal erosion.

Workflow

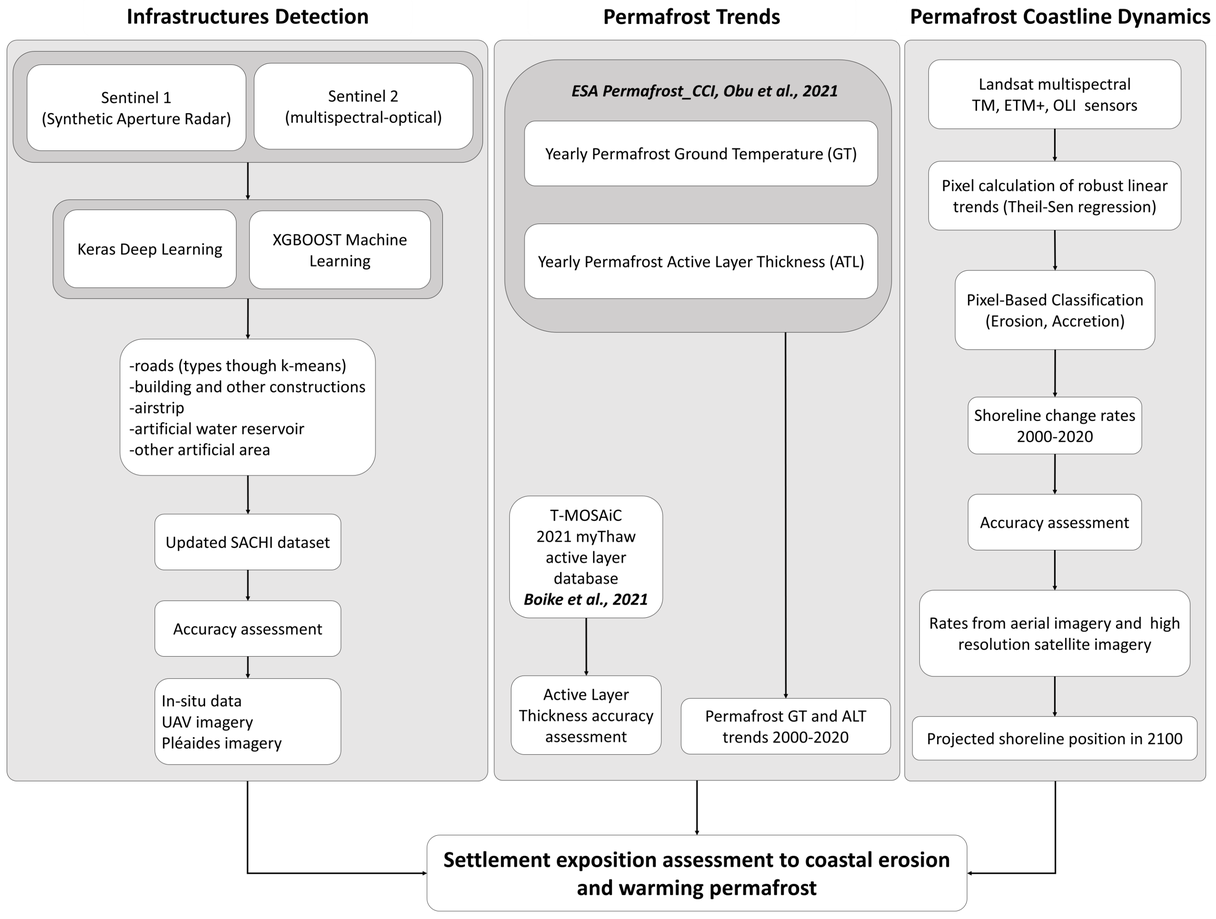

Figure 1: Data and detailed workflow for the analysis.

Arctic coastal settlements and warming permafrost

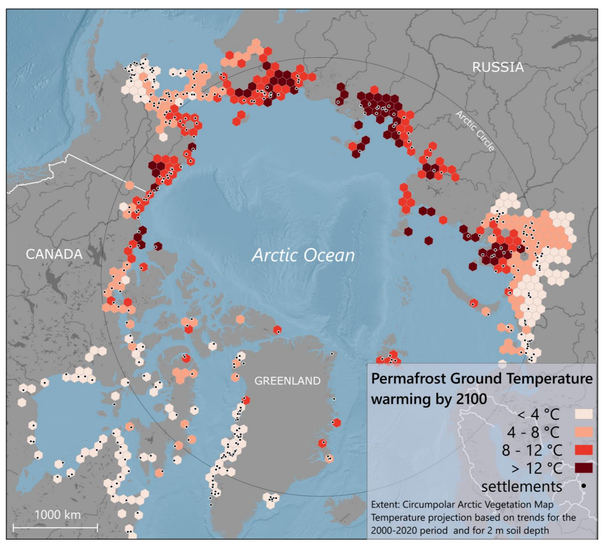

Figure 3: In the realm of Arctic coasts the average permafrost ground temperature is expected to increase by **6.3** °C by 2100. **40%** of all detected 453 coastal settlements will be affected by permafrost warming in the range of **2 to 5 °C**.

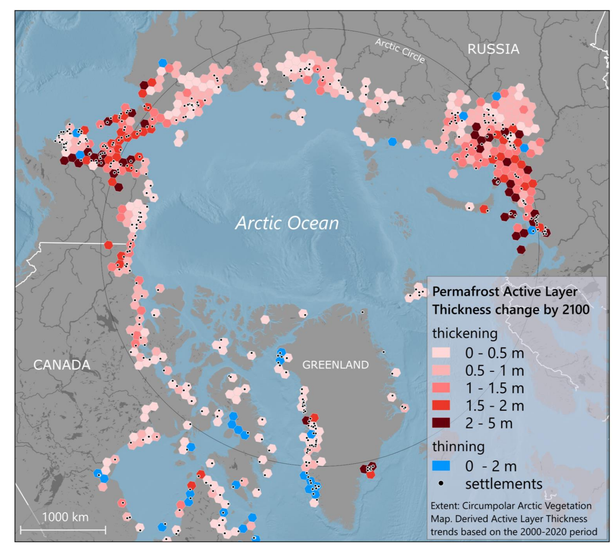

Figure 4 The average Active Layer Thickness (ALT) is expected to increase by 0.8m by 2100. 33% of all detected 453 coastal settlements will be affected by an increase of ALT of more than 1 m.

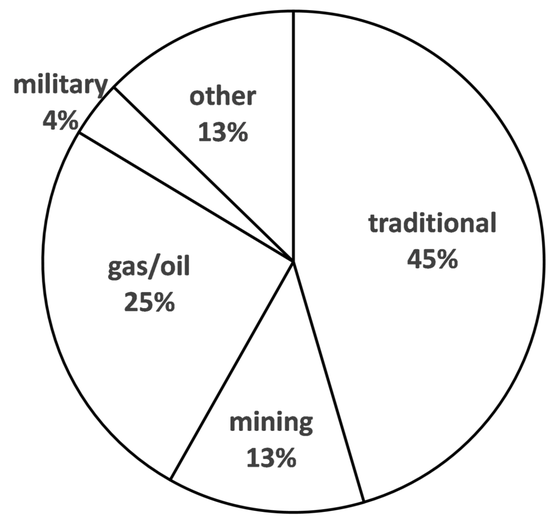

Figure 7: Considering linear coastline erosion rates, **10 %** of the total settlements in the study area will be affected by coastal erosion by 2030, mainly from traditional and industrial use.

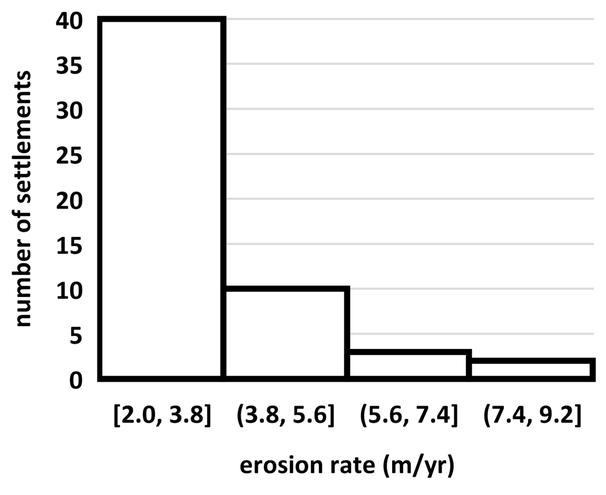

Figure 8: Regarding the exposed settlements (Figure 6), **78 %** are exposed to coastline erosion rates between 2 to 4 m/yr. With the uncertainty inherent to the Landsat spatial resolution, coastal changes below **2 m/yr** are not significant and were excluded from the analysis.

Acknowledgements

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