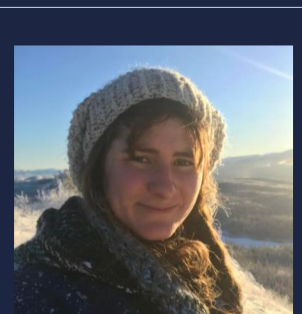
Measuring Surface Displacement using Winter SAR

Inuvik-Tuktoyaktuk Highway



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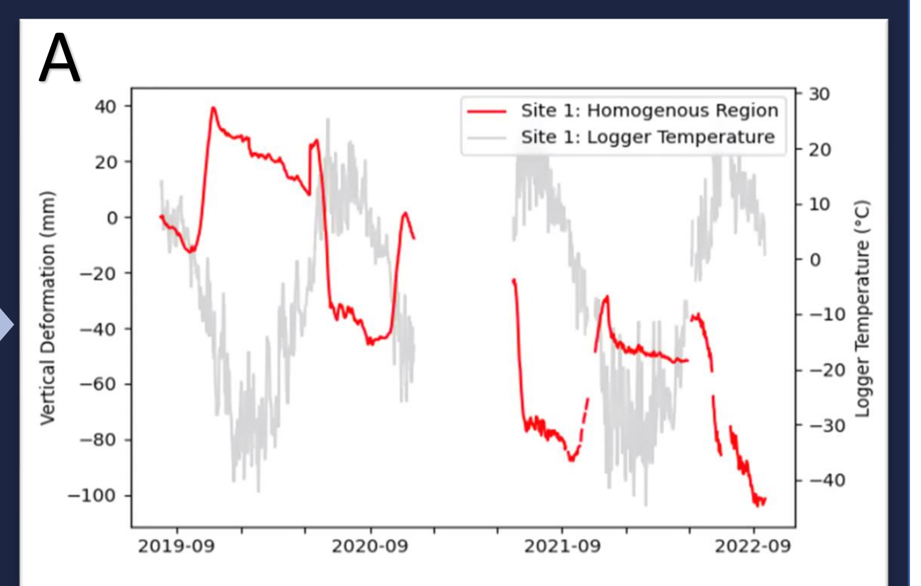
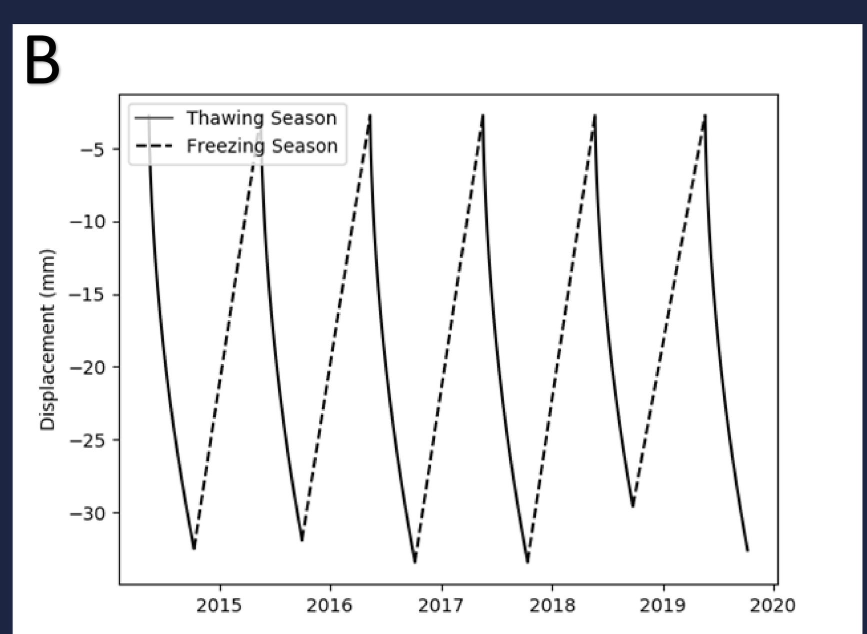
Seasonal Measurements



Long-term Modelling



Permafrost-related surface displacements exhibit both seasonal and long-term trends. (A) The vertical displacement as measured by an in-situ inclinometer shows the periodic seasonal trend of winter-heave and summer-subsidence as well as a long-term trend in subsidence. **(B)** Here, summer InSAR measurements were made over a wider region and combined with ERA-5 reanalysis climate data to create a model of the seasonal and long-term trend. Incorporating winter SAR measurements are expected to improve the results.

Method

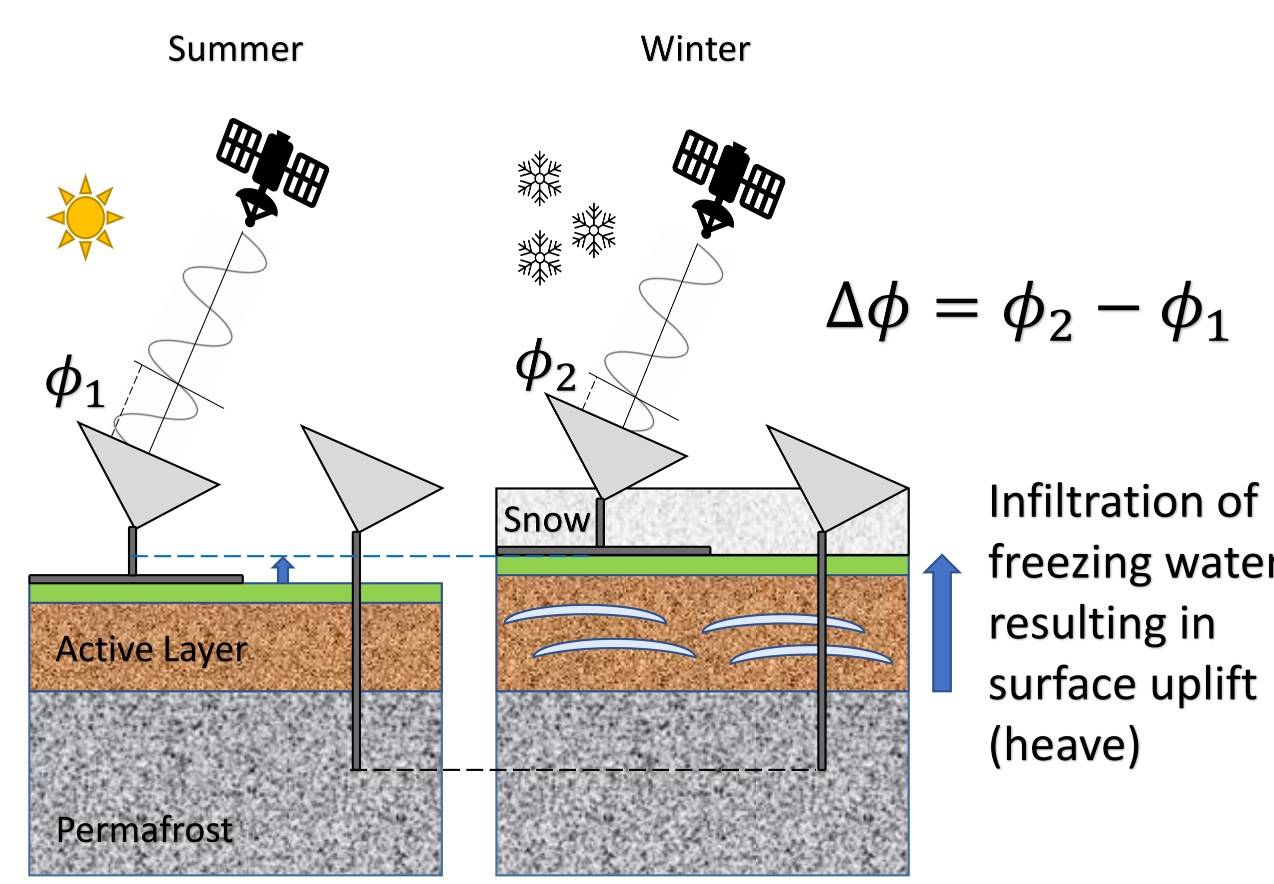
In-Situ — Vertical surface displacement measured by an inclinometer that has one leg mounted into the permafrost and one resting on the surface. Snow depth measured by a sonic ranger.

InSAR — Point measurements from corner reflectors (CRs): one anchored into the permafrost to serve as a stable reference and one resting on the surface. The CRs are fixed with covers that prevent snow accumulation.

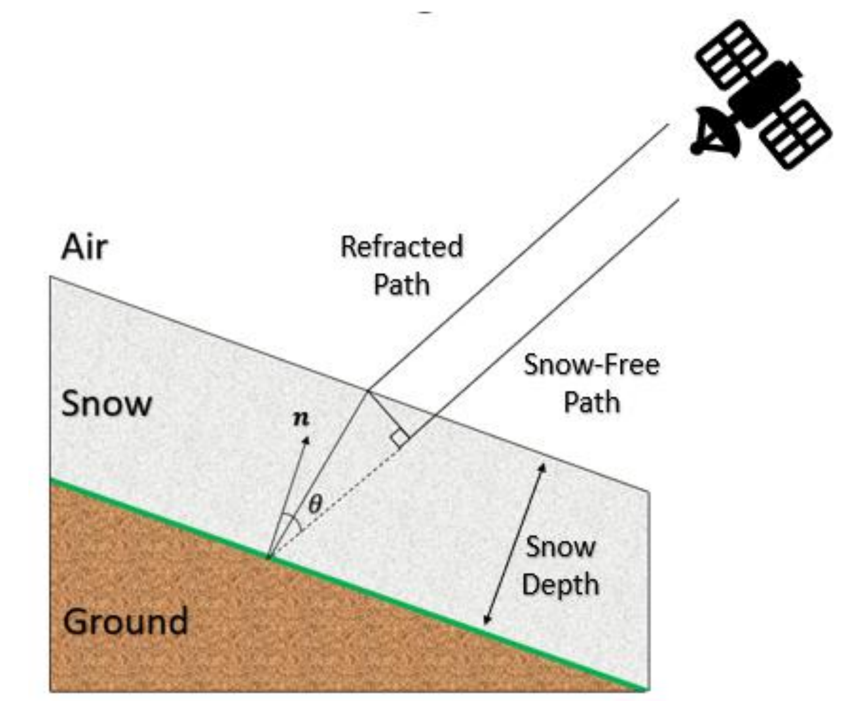
Validate — Infer snow InSAR phase signal by differencing snow-free (corner reflector) and snow signal (site surroundings) and validate against in-situ data and current theoretical models.

Theory

A floating corner reflector (CR) rests atop the vegetation; the anchored CR serves as a stable reference point. **The change in phase, $\Delta\phi$,** between two SAR acquisitions of the floating CR **measures the line-of-site displacement** with respect to the satellite. In the winter, InSAR measurements of the site surroundings will have both a surface-displacement component and snow component.



In dry snow, the signal penetrates the snow layer, undergoing refraction, and is scattered by the ground surface.



The Snow Water Equivalent (SWE) change can be estimated by isolating the phase contribution due to dry snow. **The SAR signal is refracted in dry snow**, causing a change in the path-length (InSAR phase). For a uniformly distributed snow layer**, the dry-snow phase is correlated with the topographic slope of the terrain**. If the topography of the region is known, the dry-snow phase – change in SWE – can be estimated.

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