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PRELIMINARY MODELLING OF GROUND ICE ABUNDANCE IN THE SLAVE GEOLOGICAL PROVINCE, NORTHWEST TERRITORIES AND NUNAVUT

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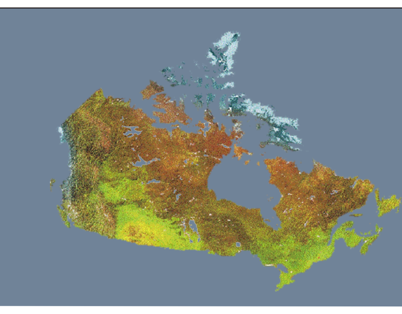


Abstract

New infrastructure corridors within the Slave Geological Province could provide transportation, electric, and communications links to mineral-rich areas of northern Canada, and connect southern highway systems and Arctic shipping routes. Relatively little information on permafrost and ground ice is available compared to other regions, particularly in the north of the corridor. Improved knowledge of permafrost and ground ice conditions is required to inform planning and management of infrastructure. Work within the Geological Survey of Canada's (GSC) GEM-GeoNorth program includes mapping periglacial terrain features, synthesizing existing permafrost and surficial data, and modelling ground ice conditions along the Yellowknife-Grays Bay corridor. Here we present initial modelling of ground ice abundance in the region using a methodology developed for the national scale Ground ice map of Canada (GIMC), and higher resolution surficial geology mapping. The results highlight the increased estimated abundance of potentially ice-rich deposits compared to the GIMC when using more detailed surficial geology as model inputs.

Methods

The ground ice modelling routines for the GIMC[1] are described in ref[2]. For this regional application, a new surficial materials raster layer was assembled from 11 larger-scale (1:125,000) GSC maps. These Canada Geoscience Maps (CGMs) conform to the GSC Surficial Data Model, ensuring a standardized legend and mapping conventions. Fine- and coarse-grained tills were differentiated as on the GIMC[2]. Preliminary model parameters for surficial material units that did not appear on the GIMC were assigned based on a review of surficial unit descriptions on all map sheets, surficial geology-ground ice associations identified in previous literature[3,4], and expert knowledge.

Surficial materials compilation

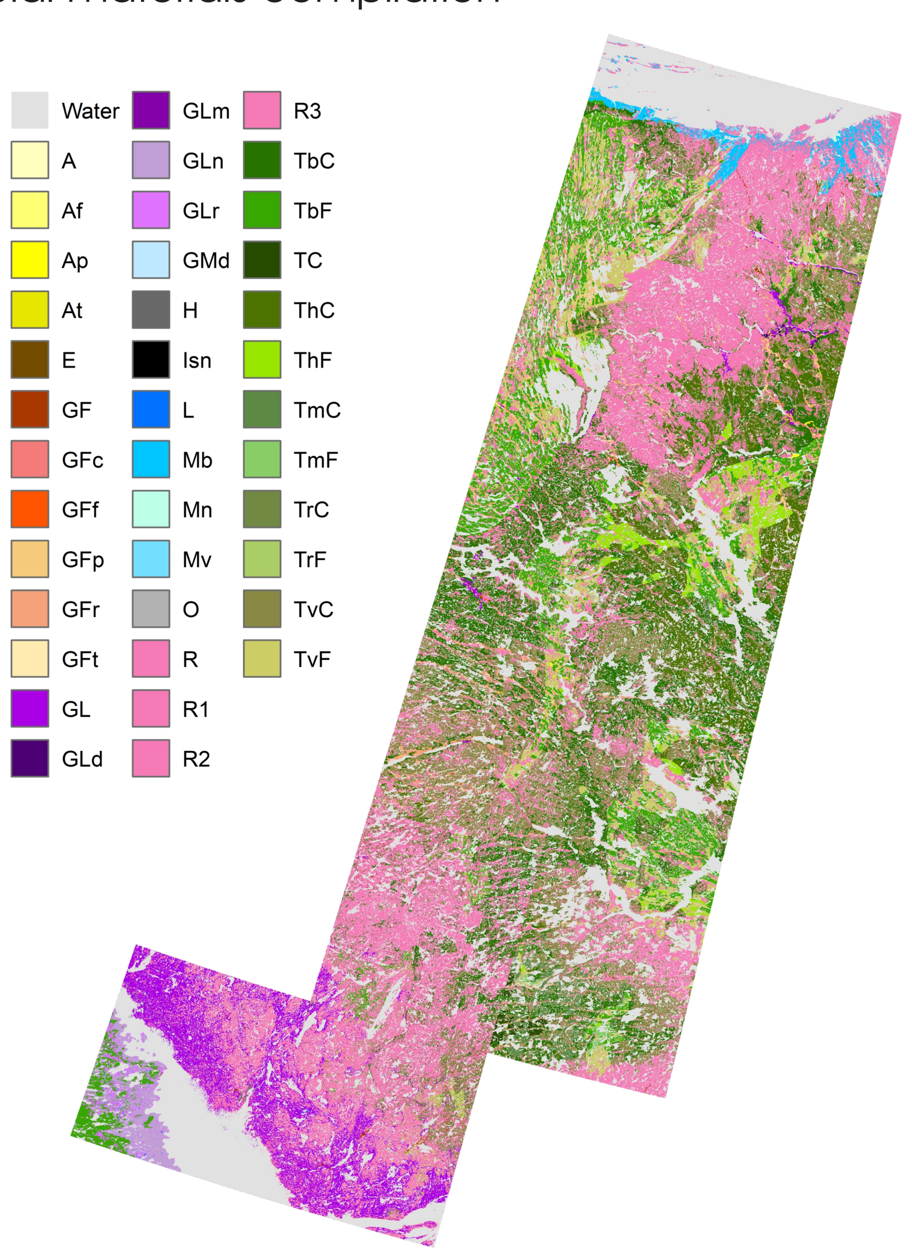
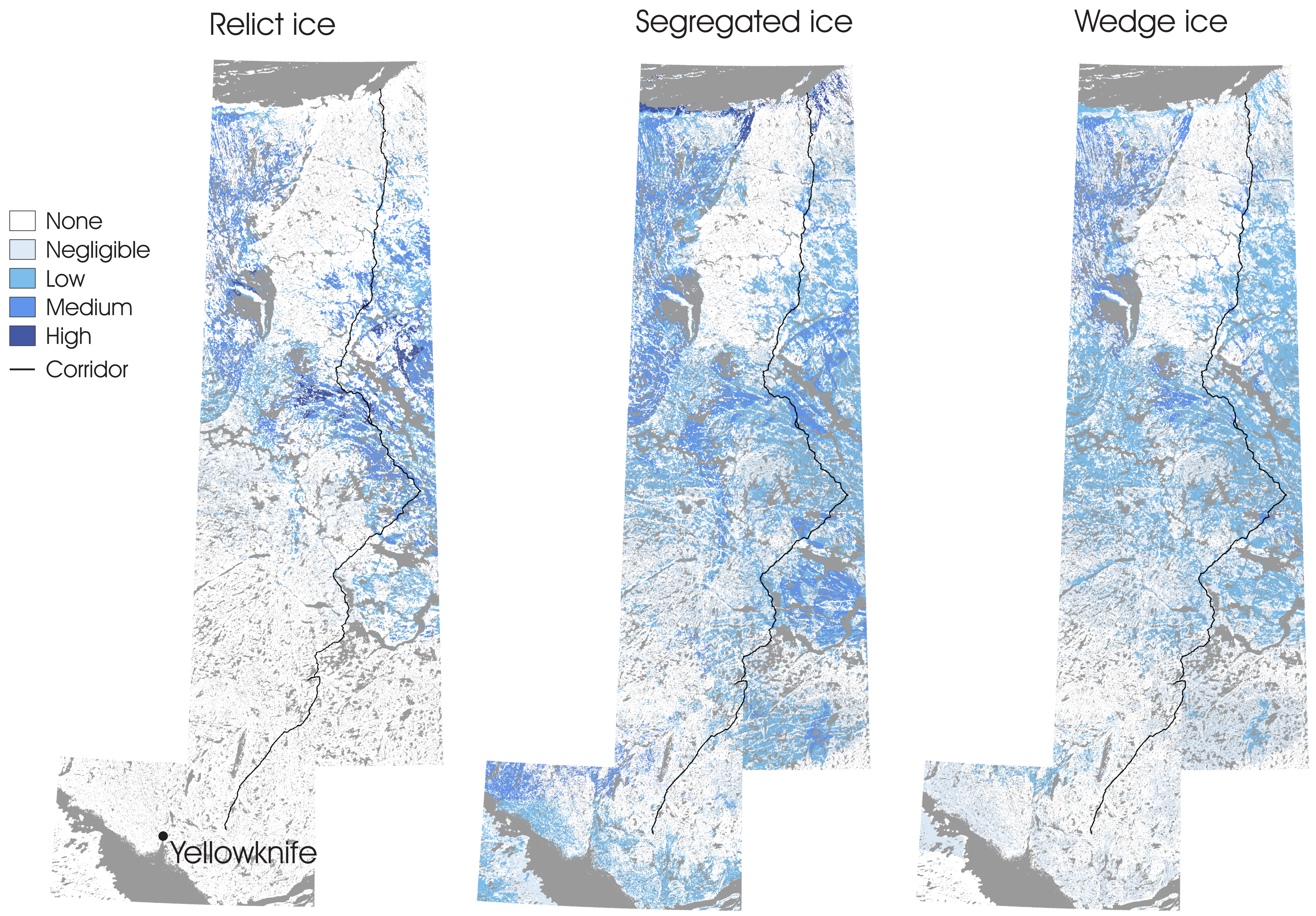


Figure 1. Surficial materials compilation from 11 Geological Survey of Canada maps. Yellows = alluvial, oranges = glaciofluvial, purple = glaciolacustrine, blues = lacustrine and marine, pinks = bedrock; greens = tills.

Preliminary results



Ground ice map of Canada

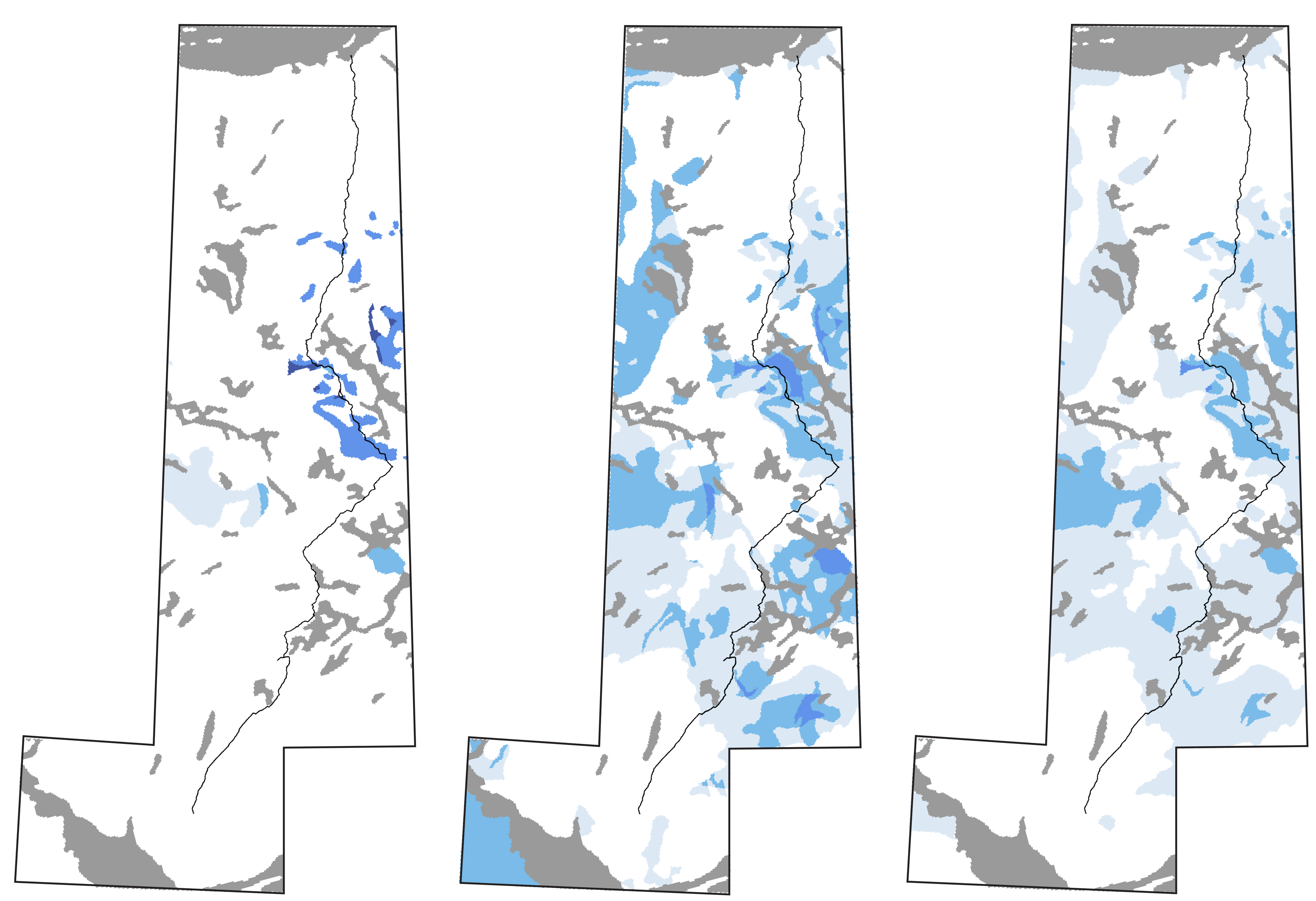


Figure 2. Preliminary modelling results using the surficial materials compilation from Figure 1 (top), and subset of outputs from national-scale modelling (bottom) from the Ground ice map of Canada for relict, segregated, and wedge ice.

Effect of surficial geology scale on modelled ground ice abundance

For all ice types, the area modelled as having no excess ground ice is significantly less (38-58%) than on the GIMC (Fig. 3), mainly due to the over-representation of bedrock on the national-scale surficial geology layer. This is the result of less detailed mapping and of photographic reduction during the original conversion of maps to the 1:5M national scale representation. For relict ice, the new model output has significantly more area with low, medium, and high abundance, due to more widespread abundance of glacial deposits that could preserve buried glacier ice. For segregated and wedge ice, the new model outputs had less area of negligible ice content, but significantly more of low and medium abundance, a result largely attributable to greater coverage of thicker till units on the Canada Geoscience Maps. Overall, the model outputs indicate greater areal fractions with ground ice than the GIMC, and an increase in areas simulated with low, medium, and high (for relict) ice abundance. This is despite the considerably greater % area coverage of water on the CGMs compared to the national-scale basemap of the GIMC (Fig. 3). In this region of the Canadian Shield, it can be concluded that the abundance of relict, segregated, and wedge ice is considerably underestimated on the GIMC, as bedrock is more widely represented in the surficial geology dataset at the expense of unconsolidated sediments that could host ground ice.

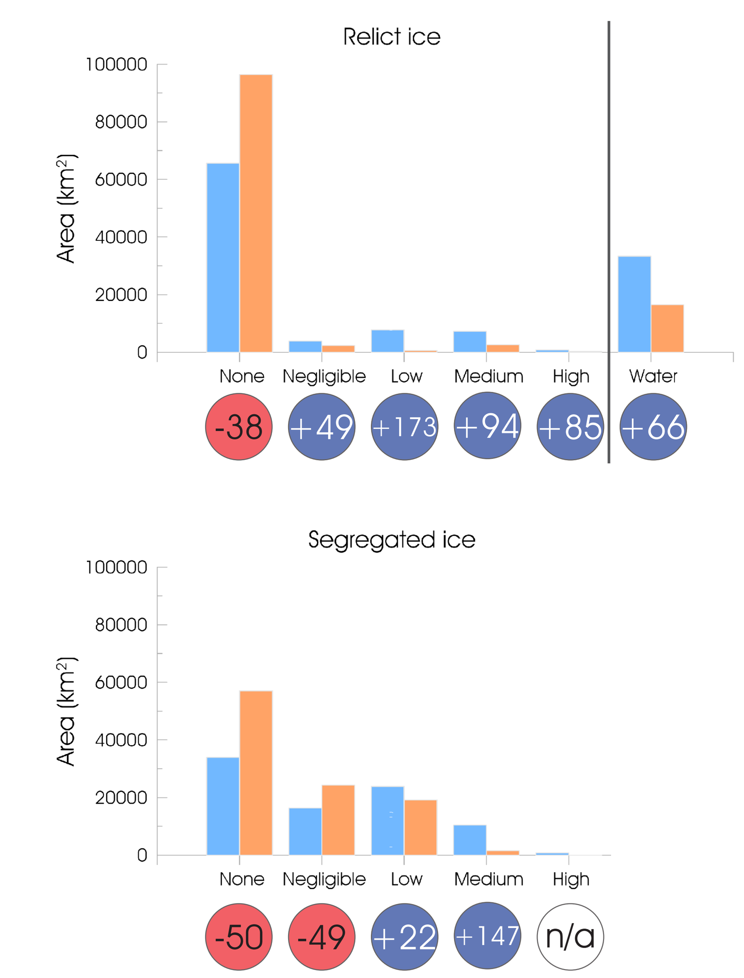
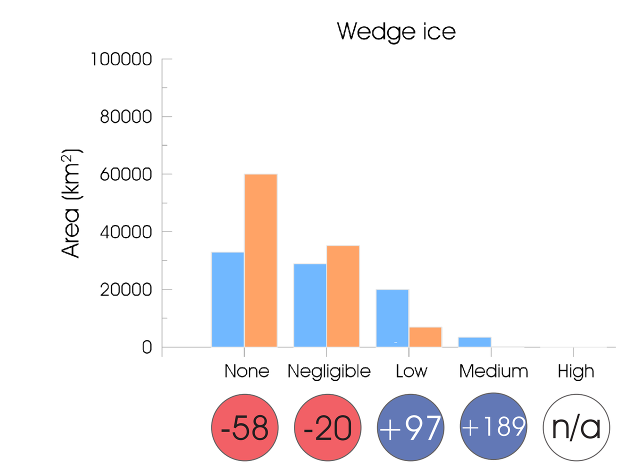


Figure 3. Bar charts showing area of the study region occupied by each ice abundance class, and water, for the regional-scale mapping (blue) and the Ground ice map of Canada (orange). The numbers within the circles indicate the % difference in the areas depicted by the new model outputs vs. the Ground ice map of Canada. Percent difference (%) of areas is calculated as:

$$\frac{(\text{New model - GIMC})}{((\text{New model} + \text{GIMC}) \div 2)}$$



Next steps

Available, location-specific data on ground ice conditions will be synthesized for this region, and used to help validate the modelling. Terrain mapping[5] and aerial surveys of thermokarst features in partnership with the Government of Northwest Territories will also serve to validate outputs. Particularly, we hope to assess the accuracy of the modelled transition from terrain with relict and wedge ice to areas lacking these ice types moving southward. Once satisfied with the parameterization of new surficial units in this regional-scale modelling, we can derive estimated volumes of excess ice content using the legend presented on the GIMC[1] and produce an updated cartographic output and comparison. We also plan to extend mapping at this scale into adjacent regions of development interest, including the Kivalliq and Mackenzie corridor regions, and Nunavik.

References:
[1]O'Neill, HB, Wolfe, SA, Duchesne, C. 2020. Ground ice map of Canada. Geological Survey of Canada, Open File 8713, https://doi.org/10.4095/326885
[2]O'Neill, HB, Wolfe, SA, and Duchesne, C, 2019. New ground ice maps for Canada using a paleogeographic modelling approach. The Cryosphere, 13(3), pp.753-773. https://doi.org/10.5194/tc-13-753-2019
[3]Wolfe, SA, Kerr, DE, and Morse, PD. 2017. Slave Geological Province: An Archetype of Glaciated Shield Terrain, in: Landscapes and Landforms of Western Canada, edited by: Slaymaker, O., Springer, Switzerland, 77–86, 2017
[4]Dredge, LA, Kerr, DE, and Wolfe, SA. 1999. Surficial materials and related ground ice conditions, Slave Province, NWT, Canada. Canadian Journal of Earth Sciences, 36(7), pp.1227-1238.
[5]Morse, PD, Smith, SL, Parker, RJ. 2021. Periglacial landforms of the Grays Bay Road corridor region, Nunavut, and implications for climate-resilient infrastructure. Geological Survey of Canada, Scientific Presentation 123, https://doi.org/10.4095/328247

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