

We thank both reviewers for taking the time to read the manuscript and for their helpful comments.

### **Responses to reviewer 2 (marked in yellow).**

This paper aims at comparing ground ice abundance modelling output from different scale surficial geology products for a region of the Canadian Shield. It uses an existing modelling method used for creating the GIMC, which was proven to underestimate ground ice abundance. Difference between two surficial geology scales are presented and validated using ancillary data, and implications of accuracy of ground ice abundance modelling are discussed for the Canadian Shield and along a proposed infrastructure route.

#### General comments

This paper presents novel and valuable insights into permafrost ground ice abundance modelling and mapping. It highlights the importance of scale and landscape heterogeneity, which is a very relevant challenge/issue related to products such as the GIMC and IPA map that needed to be addressed. The purpose is clear and is effectively reached using adequate methods. The conclusions are well supported by the results presented.

Overall, this paper is well-written and concise, but I think a few sections could benefit from additional information (discussed below).

#### Specific comments

The introduction is a little bit short in introducing the subject of ground ice and ground ice modelling. First paragraph could contain more information on the influence of surficial geology on ground ice abundance; why are we using surficial geology as an input to ground ice abundance modelling? Could also refer to existing datasets and why it is important to improve them, or even why it is important to quantify ground ice abundance.

The subject of ground ice modelling is described at length in our 2019 paper in the Cryosphere, and elsewhere, so we did not feel the need to repeat this introduction at length here, but rather cite relevant papers. We have added one sentence to establishing the link between surficial geology and frost susceptibility along with references that further deal with controls on ground ice abundance. We feel the first introductory sentences establish why ground ice is important: "Ground ice is a critical component of permafrost terrain and provides geotechnical strength to frozen ground. However, climate change is causing permafrost thaw and ground ice melt (Smith et al., 2022), resulting in widespread terrain subsidence (O'Neill et al., 2023), hillslope failure (Lewkowicz and Way, 2019), changes to hydrologic conditions (Walvoord and Kurylyk, 2016), and damage to infrastructure (Doré et al., 2016)."

Also, at line 35, there is a jump from geology of the study area to modelling methodology. I suggest adding "used for modelling ground ice abundance" after "methodology" and before "was" in sentence "modelling methodology was developed by O'Neill et al. (2019)...".

We have made this change, and added a paragraph break to separate the geology and modelling methodology.

In the Study Area section, some locations are mentioned, but are not presented on Figure 1, which makes it harder to understand the geological and climatic context. Suggest adding locations of the Great Slave Lowlands and Lac de Gras.

Lac de Gras is indicated in Figure 2. We decided to add the locations mentioned in text to Figure 2 instead of Figure 1 so that they could be examined in relation to ground ice conditions. Labeling on Figure 1 is also challenging as the permafrost zones are already indicated, as is Yellowknife, so the Figure would become cluttered. We have added a label of GSL to show Great Slave Lowlands in Figure 2.

In the Methods section, the different products used become obscured. I suggest reviewing and keeping a constant terminology for each product/group to avoid confusion:

Line 84: What are these ten CGMs? Are they the RC surficial geology maps mentioned at line 80?

The first line of Methods section indicates that the 11 maps comprise the regional compilation.

Line 93: What is the meant by “at the national scale”? Is that the product used to generate the GIMC? What product is that?

Earlier on line 83 we indicate “As with the 1:5 000 000 scale national surficial compilation” which introduces the national-scale product. We have clarified the wording to indicate “national-scale surficial compilation”.

Line 90: “surficial material classes” are mentioned, but the term “units” is used at line 92-93. This occurs in other places throughout the text.

We have changed all instances associated with surficial geology to “units” while ground ice abundances are referred to as “classes”.

Line 99: What is meant by the “other model”?

We have clarified the wording here to “other data layers used in the model”

In the Results section, there is mention of “unconsolidated sediments and organic terrain associated with ground ice” (Line 149 and Table 1). Again, I think information on what makes certain types of surficial deposits susceptible to being more ice-rich than others is lacking. This could be addressed in the introduction, as mentioned above.

As indicated above, we have now linked surficial geology to frost susceptibility in the introduction. We believe those requiring further information can consult the references provided.

Technical corrections

I somewhat question the sectioning of the Results and Discussion sections:

Results of the validation (Section 5.1) and infrastructure corridor assessment (Section 5.2.1) belong in the results section.

I suggest keeping the discussion section for the implications of the results only (i.e., impact of homogeneity/heterogeneity of deposits, inclusion of linear features, model exceptions for ice-marginal deposits, limitations of wedge ice modelling based on imagery, etc.)

These implications could also benefit from being further discussed, including within are broader context (E.g., impact of homogeneity/heterogeneity of deposits in other regions/publications, how can linear features be included in such modelling exercises, etc.)

Thanks for this suggestion on formatting. However, we believe it is appropriate to structure the results as summarizing the surficial geology datasets and ground ice model outputs. The validation and infrastructure corridor assessment place these results and discuss them in the context of past work/observations, which is consistent with the typical scope of a discussion section. Since we, the editor, and Reviewer 1 did not believe the structure required adjustment we have kept as is. We have added a sentence in the conclusion about the broader context of the results, also in response to a comment from reviewer 1. We also added a sentence in the section on heterogeneity (I.221) on the broader context of the results for the GIMC: "In contrast, the GIMC may overestimate the distribution of ground ice abundance in areas where frost-susceptible deposits are dominant and where smaller bedrock outcrops or areas of till veneer are not represented on the surficial mapping. "