Response to Referee 1 on "A Comprehensive Database of Thawing Permafrost Locations Across Alaska"

We would like to thank referee 1 for their helpful comments. We found all comments to be constructive and have addressed all of them (see detailed responses below). As a result of these revisions, we believe that our manuscript is much improved.
Below please find a point-by-point explanation of our revisions.

The authors present a comprehensive compilation of evidence for abrupt and non-abrupt permafrost thaw in Alaska, integrating 19,540 locations from 44 diverse sources spanning seven decades. In addition, the authors use the database to evaluate existing permafrost maps and to explore the spatial patterns of the two types of thaw using auxiliary data. Given the significance of abrupt permafrost thaw for both local and global effects, combined with the current lack of regional-scale datasets for land managers, the database represents a unique and valuable contribution that will be useful to a broad audience.

Prior to publication, the following issues must be addressed:

1. Figure quality and consistency needs to be increased (see specific comments below)

We thank the reviewer for this helpful feedback and address these issues specifically in our responses below.

2. Some of the discussion material focused on abrupt thaw impacts should be moved to the introduction or removed

We thank the reviewer for this suggestion and have addressed this specifically in comment #18 below.

3. The available inventory of permafrost thaw features is limited not only by where abrupt thaw is taking place, but also possibly by where investigations are being made. You touch on this point in L367-L372. Can you also comment on how the violation of the assumption of 'random sampling' might affect the results of your statistical tests, and which regions, if any, you think might be overrepresented

We thank the reviewer for this helpful feedback. We added the following clarifying sentences to our discussion:

"Because observations in our database are not randomly sampled, the results of our statistical tests should be interpreted with caution. Sampling is biased toward regions that have had more research activity, resulting in overrepresentation of areas including the Brooks Range, Seward Peninsula, and Arctic tundra lowlands." Lines 370-373

Specific manuscript comments

1. L66-68 In the beginning of paragraph 2, the contrast to gradual thaw should also be stated in terms of impacts. The comparison of cm/yr (rate of change) vs (duration and impact) for abrupt thaw could be made more commensurate

We thank the reviewer for this suggestion and have added a clause to clarify:

"Unlike gradual thaw, which occurs when the active layer thickens by a few centimeters a year and causes a gradual shift in vegetation and slower, sustained shift in the carbon balance (Harris et al., 1988), abrupt thaw processes initiate within a few decades and cause severe impacts on the surrounding ecosystem (Turetsky et al., 2019; Webb et al., 2025a)." Lines 68-70

2. L86: "events": but items listed in parentheses are landforms/features. Is the 'event' the initiation of these features?

We thank the reviewer for this comment and have changed the word "events" to "features". Line 88

3. L116: how were lines converted to points?

We thank the reviewer for this comment and agree that there needs to be clarification regarding how polylines were converted to points. We added a clause to the end of the sentence:

"Given that spatial datasets were often in different formats such as points, polylines, and polygons, we standardized the database by converting all locations to point features based on the centroid of the feature (polygons) or the midpoint of the line (polylines)." Lines 118-119

4. L124: consider rephrasing for clarity: "we have not manually verified each individual feature, but rather the features in the database reflect the accuracy of their source datasets" or something

We thank the reviewer for this comment and have reworded the sentence for improved clarity:

"We did not manually verify each individual feature, and the features in the database reflect the accuracy of their source dataset." Lines 126-127

5. L125: "lacking validation data of" -> "lack of validation data for"

We thank the reviewer for this comment and have rephrased the sentence. Lines 128-129

6. L127: what are the ongoing opportunities for community feedback?

We thank the reviewer for this comment and agree that this section needs to be more explicit. We have changed this part to read:

"This level of documentation allows the reliability and limitations of the dataset to be evaluated transparently by users. In addition, the open-access and collaborative nature of the database enables community feedback including the identification and correction of errors, duplicates, omissions, or regional gaps, and provides clear opportunities for continued refinement and expansion as new data become available." Lines 130-133

7. L127: Rather than asserting that it is an effective means, you could state that by providing accuracy, the reliability and limitations of the dataset are provided transparently. Separately, you can comment on community feedback (being specific) and opportunities for continued improvement.

We thank the reviewer for this helpful feedback and agree that we should be more clear and specific in why this database is an effective tool. We changed line 127 to say:

"This level of documentation allows the reliability and limitations of the dataset to be evaluated transparently by users. In addition, the open-access and collaborative nature of the database enables community feedback including the identification and correction of errors, duplicates, omissions, or regional gaps, and provides clear opportunities for continued refinement and expansion as new data become available." Lines 130-133

8. L146: This section could be reworded for clarity: "We chose not to ... case for all areas"

We thank the reviewer for this very helpful comment. We decided to remove that statement because if permafrost is not thawing abruptly, then by definition, it must be thawing gradually.

9. Figure 1: This figure needs to be cleaned up:

- the resolution of this image should be increased.

- There is a problem with the "intermontane boreal" legend item in 1b

- The titles are redundant - information is in caption and legend.

- the grid lines in the viscinity of the legend are not oriented correctly

- while not essential, an outline of the Alaska state border (for consistency with other figures) and/or a map of neighbouring territories would improve the figure

We thank the reviewer for this very helpful feedback regarding Figure 1. We have increased the figure resolution, fixed the issue with the legend text, removed the redundant tiles, fixed the grid lines, and added an outline of Alaska for improved visualization.

10. Figure 2: The resolution of this image should be increased, or converted to a vector format.

We thank the reviewer for this suggestion and have increased the resolution of Figure 2.

11. Sec. 3.3: There appears to be significant spatial structure in Figure 4, suggesting that the mapping 'errors' may represent a systematic bias rather than random mapping resolution mismatch. Can you comment on where these discrepencies tend to occur and how that information could be used to better interpret the maps.

We thank the reviewer for highlighting this discrepancy. We added clarification sentences to results section 3.3:

"The spatial distribution of ice-dependent abrupt thaw events in areas classified as having low ground ice content is not uniform across Alaska, with most of the discrepancies being in the Seward peninsula, northern tundra, and parts of interior Alaska. Because the abrupt thaw processes used in this analysis require substantial ice content to develop, these results highlight the potential limitations of existing ground ice datasets for accurately representing permafrost vulnerability at the local scale." Lines 291-295

To explain why this spatial clustering may exist, we added context to the discussion:

"The spatial clustering of apparent misclassifications suggests that localized ice-rich deposits may not always be resolved in regional maps. These discrepancies may rise from sub-grid heterogeneity, including ice-wedge polygon terrain, or from thermokarst legacy landscapes where thaw features formed when ground ice content was higher in the past." Lines 348-350

12. Figure 3: histogram titles are redundant. Information is in axes and caption. Change axis label from 'elevation' to 'relative elevation'

We thank the reviewer for this comment. We gave both panels a shared legend, removed the titles, and changed axis label "Elevation" to "Relative Elevation".

13. Figure 5 & caption: Rather than call the left hand colour blue/green, please use a colour with a less ambiguous name.

- clarify in figure caption that agreement is based on your aggregated high-mid class

- figure title is unnecessary

We thank the reviewer for these helpful suggestions to improve Figure 5. We condensed the figure into one panel, clarified that agreement is based on our aggregation of moderate and high ground ice classes, increased figure resolution, clarified the color palette, and removed the figure title.

14. Figure 6 caption: typo "independent"

We thank the reviewer for catching the typo and have corrected this error.

15. Figure 6: Text titles are redundant (e.g. "Non-ice-dependent abrupt thaw proecesses"

We thank the reviewer for this comment and agree that the text titles are redundant. We changed the “non-ice-dependent abrupt thaw processes” category to “Other” and specified that this includes other abrupt thaw processes and gradual thaw processes in the figure caption to improve clarity.

16. Figure 6: for greater visual clarity, consider reducing the marker point size in this and other maps.

We thank the reviewer for this helpful suggestion. We collapsed figure 6 into one panel, reduced the point size, and changed the outline of the Yedoma domain to black for improved visibility.

17. L347: "three military training lands in the U.S. Army Fort Wainwright " is this correct?

We thank the reviewer for this helpful comment and agree that the wording is confusing. This was the wording used in the original source (Jorgenson et al. (2025)), but we replaced “the U.S. Army Fort Wainwright” with “interior Alaska” to reduce ambiguity. Line 360

18. L353-364: this could be tightened up. L353-358 in particular is more suitable for the introduction.

We thank the reviewer for this insight. We acknowledge that these talking points are already addressed in the introduction and have removed them entirely for a more succinct discussion section.

Comments on dataset and repository:

1. versioning of dataset: consider including v2.0.0 or v2 in paper title, it is easy to miss in the abstract.

We thank the reviewer for this very helpful comment and have added Version 2.0.0 to the title of the manuscript.

2. I would strongly recommend using tagged commits in git (you could also put version number in a file) instead of separate directories for versioning. Similarly, using a generic name for your files (e.g. Alaska_Permafrost_Thaw_Database.csv) will make it easier to maintain workflows as more contributions are added and the version number changes. Your scripts could then read the version file to embed the version into the geojson, if necessary.

We thank the reviewer for this very helpful suggestion and have updated our GitHub repository to use tagged commits in git instead of separate directories for versioning. We also used a more generic file name (Alaska_Permafrost_Thaw_Database.csv) for easier workflows. Instead of keeping a separate directory for each version, old versions of the database can be found in the release history.

3. In the two csv files, be consistent with column naming (e.g. DataSourceType vs DtSrcTy) and with style (e.g. all in lowercase_with_underscores / snake_case or all with FirstLetterCapitalized / PascalCase). It will make it easier for people to use the dataset.

We thank the reviewer for this comment and, in accordance with comment 5 below, decided to merge both csv files into one, removing any column naming inconsistencies.

4. Add a unique identifier for each feature: FeatureName may not be unique as more data are added.

We thank the reviewer for this suggestion and have added a unique ID number for each feature. These are listed under the UniqueID column.

5. There appear to be duplicated columns between the two csv files (Thaw_Database and Topographic_Variables). Why not just merge these into a single file?

We thank the reviewer for this comment and have merged all the data into one file.

6. The topographic variables file does not seem to be mentioned in the paper. If multiple files are included in the dataset, please ensure the directory tree is well described.

We thank the reviewer for the extremely helpful comments regarding database structure on GitHub. We combined the topographic variables into the main database file to prevent confusion and have incorporated all the repository formatting suggestions above. We believe these edits have greatly improved the usability and organization of our GitHub repository.

Response to Referee 2 on "A Comprehensive Database of Thawing Permafrost Locations Across Alaska"

We would like to thank referee 2 for their helpful comments. We found all comments to be constructive and have addressed all of them (see detailed responses below). As a result of these revisions, we believe that our manuscript is much improved.
Below please find a point-by-point explanation of our revisions.

General comments
The proposed paper presents the Alaska Permafrost Thaw Database, an extended inventory of 19,540 permafrost thawing locations, spanning from 1950 to the present. The inventory distinguishes between abrupt thaw sites and gradual thaw sites.
The sources the inventory is based on are reliable and the methodology used for compiling the inventory are consistent and rigorous. The resulting database is of significant importance for both researchers and the wider community.
The analysis of abrupt thaw and gradual thaw against topographical factors is statistically sound with no clear inconsistencies.

Before publication some minor clarifications and some minor manuscript improvements are needed. Below you can find technical and specific comments.

Technical and specific comments
Technically all the figures are correct but for cartographical reasons and for easier reading, figures need to be improved.
Figure 1
The figure seems clustered and hard to read, especially panel (b). Consider:

- Improving the overall resolution of the image
- removing the title from both panel
- modify the legend, since it's the same for both panels, it can be shared between the panels or can occupy a more marginal space in the figure.
- The points in panel b are dense and make it hard to appreciate their location. Although this is difficult to resolve, consider one of the following: make the points slightly smaller, make the points transparent, make the points color filled but without the black outline.
- If the space allows it consider adding the number of points to the figure, for each panel. Otherwise, you can add this information to the caption.
- The scale bar can be reduced or made simpler and more discrete.

We thank the reviewer for these extremely helpful suggestions. We increased the figure resolution, removed the title, used one shared legend, made the points smaller, added the number of points to the top of each map, and made the scale bar smaller.

Figure 2

- Improve the resolution of the figure

- The individual pie charts will be clearer if the slices will be arranged in ascending/descending order.
- If possible, consider using contrasting colors for consecutive slices.
- If possible, where the slices are very small (e.g. <1%) consider using a panel where you can zoom in to make it visible.
- Make a better alignment of the charts
- Consider removing the title and move it to the caption of the figure.

We thank the reviewer for these helpful suggestions. We increased the resolution of the figure, arranged the pie slices in descending order, added a small pie chart to highlight features that comprise less than 1% of the total ecoregion, improved alignment of the charts, and removed the figure title.

Figure 3

- Improve the resolution of the figure
- Consider removing the title and move it to the caption of the figure.
- For consistency purposes only: In fig.1 the panel labels are in top left corner while here they are on the top right corner. If possible, consider having the label in the same place for all the figures.

We thank the reviewer for these comments. We improved the resolution of the figure, removed the title, and removed the labels altogether. Instead, we refer to the panels as "top" and "bottom" panels. We also created one shared legend and y axis title for improved visibility.

Figure 4

- Improve the resolution of the figure
- Consider removing the title and move it to the caption of the figure.
- The legend is almost as big as the figure itself. Consider one or more of the following: merge the legends for both panels, make the legend smaller or move it more to the side of the figure. Remove the legend altogether from the figure and describe it in the figure caption
- If the space allows it consider adding the number of points to the figure, for each panel. Otherwise, you can add this information to the caption.
- The points are dense and make it hard to appreciate their location. Although this is difficult to resolve, consider one of the following: make the points slightly smaller, make the points transparent, make the points color filled but without the black outline.

We thank the reviewer for these suggestions. We increased the resolution of the figure, created one shared legend and decreased its size, decreased the size of the points, and added the number of points in the caption since it was the same for both panels.

Figure 5

- Consider removing the title and move it to the caption of the figure.
- For esthetic purposes consider removing the legends and just explain the colors in the figure caption
- For consistency purposes consider having the label for the panel in the same place for all the figures (possible if you remove the title from the figure).

We thank the reviewer for these helpful suggestions. We collapsed the panels into one map showing both areas of agreement and disagreement for improved aesthetics, so there was no longer a need for panel labels. We removed the title and kept one shared legend.

Figure 6

- Consider removing the title and move it to the caption of the figure.
- For consistency remove the background color from the legend.
- The points are dense and make it hard to appreciate their location. Although this is difficult to resolve, consider one of the following: make the points slightly smaller, make the points transparent, make the points color filled but without the black outline.
- Consider removing the white outline for the polygons representing yedoma domain.
- Consider using better contrasting colors, especially for panel a.

We thank the reviewer for the feedback. We removed the title, the background color from the legend, and the white outline for polygons representing Yedoma domain. We also decreased the size of the points for better visibility, changed the pink color to green, and collapsed the panels into one figure

Table 2

- The bullet points in the second column are not aligned correctly

We thank the reviewer for noticing the misalignment and have corrected the bullet points in Table 2.

Line 35 missing article “from 1950 through *the* present”

We thank the reviewer for catching this. We changed the phrase to “from 1950 through the present”

Line 54-55 “the Arctic is warming nearly four times faster than the global average”. This depends on a time frame for which the comparison is made

We thank the reviewer for this clarification. We updated the rate of change to three times faster and changed the reference to the 2025 NOAA Arctic report card due to recent pushback about the Rantanen et al. (2022) paper. We have updated the sentence to say:

"However, warming is not uniform across the planet and the Arctic has been warming nearly three times faster than the global average, making it one of the most rapidly changing environments on Earth (Ballinger et al., (2025)." Lines 55-57

Line 89-90 "These sites are broadly representative of gradual thaw processes across Alaska"
Are they representative in a statistically significant way? Otherwise consider rephrasing

We thank the reviewer for this helpful feedback. We rephrased the sentence to say:

"These sites represent gradual thaw processes and are located in areas distinct from abrupt thaw features, allowing them to be treated as independent observations." Lines 91-93

Line 214 -218 "Inconsistent or patchy permafrost distribution is classified as variable, <10 % as low, 10-20 % as moderate, and >20 % as high. In contrast, the *Circum-Arctic Map of Permafrost and Ground-Ice Conditions, Version 2* by (Heginbottom et al., 2002) summarizes permafrost conditions and ground ice distribution across the Northern Hemisphere (20°N to 90°N). Ground ice classification is also based on the upper 20 meters of permafrost, with <10 % defined as low, 10-40 % as moderate, and >40 % as high."
Can you please clarify if the different thresholds used for ground ice classification can affect the comparison of proportions across these classes

We thank the reviewer for highlighting this issue. We added a sentence at the end of this section to clarify how the different thresholds were managed for downstream analyses:

"Because the two datasets use different percentage thresholds to define moderate and high ground ice content, we combined the moderate and high classes into a single category for each map while retaining low ground ice as a distinct class since both maps define it as < 10 %." Lines 223-225

Section 2.4.
There is no mentioning of addressing or considering spatial autocorrelation and clustering of the data (i.e. multiple points from the same study site) which, in my opinion, is likely to have occurred. Can you clarify if it was considered or not and if you think it affects the way the data is interpreted in section 3.3.

We thank the reviewer for this feedback and agree that clarification on spatial clustering is needed. We added the following to the end of section 2.4:

"Although duplicate features were removed (section 2.1), some study sites include multiple thaw features which may result in spatial clustering of observations. Therefore, results in section 3.3 should be interpreted as representing broad regional patterns rather than statistically independent observations." Lines 234-236

Other author changes to manuscript

To better align with our funding agency's priorities, we also reworded some of the framing of the problem in the introduction to be more focused on permafrost degradation impacts and less focused on the cause of thaw.

I noticed a typo in the ground ice section. The ranges of ground ice content for the two ground ice maps were flipped. The Jorgenson et al. map should be: low (0-10%), moderate (10-40%), and high (>40%) and the Heginbottom et al. map should be: low (0-10%), moderate (10-20%), and high (>20%). We corrected these values in the revised manuscript.