Point-by-point replies to the question and comments by Reviewer 2

Dear Reviewer 2,

we are pleased to submit the replies to your questions and are thankful for the insightful comments and many good suggestions, as well as we are grateful for your time and effort in providing valuable feedback. We believe that addressing the issues raised by you, have now substantially improved our manuscript.

We hope our answers meet your approval. Your comments and our point-by-point responses are presented below. Please note that the updated figures are presented in the appendix.

Reviewer #2 comments	**Action**	**Response**
Summary:		
1. "Comparing High-Resolution Snow Mapping Approaches in Palsa Mires: UAS LiDAR vs. Modeling" by Störmer et al. evaluates snow distribution retrieval methods in palsa mires using UAS lidar and random forest (RF) modeling across three study sites in northwestern Finland. The study highlights the role of palsas as indicators of climate change and reviews remote sensing and machine learning approaches for estimating snow depth. Both methods produced comparable results, although RF modeling showed higher accuracies over thermokarst ponds and open areas. Overall, the paper offers valuable insights into snow cover dynamics over palsas, though minor revisions could enhance its clarity and impact.	Answered	Thank you very much for your constructive comments and the positive overall assessment of our manuscript. We appreciate the suggestions, which have helped to improve the clarity and quality of the paper. Please note that the line numbers referenced in the review do not correspond to the final version of the manuscript as submitted. We have made every effort to match each comment to the relevant section and have indicated the correct line numbers where possible.
Recommendations:		
2. Line 6: Change "Digital Surface Model" to "Digital Terrain Model"	Changed	Thank you for pointing this out. We have corrected the term to "Digital Terrain Model" in lines 6 - 7.
3. Lines 15-18: It may be preferable to present the UAS lidar results first and then note the enhancements made by using RF modeling. Differentiating the two could be misleading given that the RF model relies on input parameters derived from UAS lidar data.	Changed	Thank you for this valuable feedback. We have revised the abstract to present the LiDAR results first, followed by the RF modeling results. This reordering better reflects the fact that the RF model relies on input parameters derived from the LiDAR data.
4. Figure 3: Perhaps this figure could have the first row represent the UAS lidar process and the second row represent the RF process? Or maybe specify the input parameters to make it clearer?	Answered/Changed	Thank you for this suggestion. While we appreciate the idea, we believe that emphasizing the data acquisition process rather than the modeling workflow is more appropriate at this point in the manuscript. The UAS LiDAR and RF procedures are

		described in detail in Section 3. However, to improve clarity, we have added the list of input parameters to the figure to show at which stage they are derived.
5. Figure 5: The negative snow depth from UAS-Lidar is mentioned in the Discussion, but I would suggest briefly making note of it in the Results as well. Also, changing the color of the snow depth points to indicate snow depth measurements could also be useful to directly compare to RF and lidar data.	Changed	Thank you for the helpful suggestion. The requested changes have been implemented in the figure, and a corresponding note on the negative values has been added to the Results section (lines 290–292): "*The UAS LiDAR dataset includes negative snow depth values, which result from elevation mismatches between the summer and winter DTMs. These are visualized in red to distinguish them clearly in Figure 5.*"
6. Table 3: Can you clarify why MAE and SD are missing for each of the 3 study sites?	Answered/Changed	Thank you for your comment. We originally considered MAE and SD to be less informative for the external validation and therefore excluded them. However, to ensure consistency and avoid confusion, we have now added these values to Table 3.
7. Line 464: It could be helpful to quantify this tighter spread, since the numbers in the previous tables seem to indicate that RF would have lower variance.	Changed	Thank you for pointing this out. We acknowledge that we had mistakenly reversed the interpretation of the LiDAR and RF results in the original sentence. This has been corrected in lines 341 - 343: "*The SD_{RF} results exhibit a tighter spread around the regression line, indicating lower variance compared to SD_{LiDAR}. This is consistent with the standard deviation values reported in Table 4, where SD_{RF} shows a 13 - 65% lower spread across validation point groups*."
8. Line 555: Clarify "open water" considering it's still snow covered in the winter dataset. Noting that the lidar is scanning open water in the summer dataset could be helpful to the reader.	Changed	Thank you for the helpful comment. We have replaced "open water" with "thermokarst pond" for greater clarity, and we added the following sentence in lines 387 - 389: *Although these areas are snow-covered during winter LiDAR acquisition, they are characterized by open water surfaces in the summer dataset used to derive snow depth by DTM subtraction.*
9. Line 558: Volumetric scattering does occur when lidar scans a snow surface, but the error is on the scale of <4 cm at this wavelength. I would suggest the difference	Changed	Thank you for this insightful comment. We have addressed this point in lines 393 - 395 with the following sentence: *Even though*

in snow depth (~30 cm) is most likely from scanning the open water during the summer as more absorption is occurring over this surface.		*volumetric scattering in snow can affect LiDAR results, the associated error at wavelengths commonly used for snow depth measurements, such as the 905 nm wavelength applied in this study, is typically in the low centimeter range (Deems et al., 2013), and thus does not account for the larger discrepancies observed in this study.*
10. Lines 672-673: Perhaps it could be helpful to note the snow conditions at the time of winter data collection, which would also impact scattering and lidar returns (i.e., general age of snow/grain size, presence of light-absorbing impurities, etc.).	Answered/Changed	Thank you for the suggestion. As snowpack properties were not recorded during the field campaign, we cannot provide detailed information on snow conditions. However, we agree that such data could be useful to assess uncertainty in LiDAR-derived snow depth. Therefore, we added the following sentence in lines 473 - 476: *While the wavelength-related interaction with the snow surface is a key factor, detailed information on snow conditions, such as grain size, snow age, or impurity content, was not collected during the field campaign. Such data could, however, help to better assess potential sources of uncertainty in the LiDAR-derived snow depth, particularly those related to scattering and absorption effects.*
11. Lines 678-682: Could you specify which wavelengths would be used to improve snow depth mapping? Visible wavelengths would penetrate deeper into the snowpack, and shortwave infrared has a higher likelihood of absorption (Deems et al., 2013).	Changed	Thank you for the helpful comment. We agree that a clearer specification of relevant wavelengths can improve the understanding of LiDAR snow interactions. We have therefore expanded this section in lines 468 - 473 to recommend the use of shortwave infrared wavelengths, such as 1550 nm, due to their stronger absorption in ice and the resulting surface-confined return signal. This can help reduce uncertainty, particularly over complex or low-reflectivity surfaces. The updated text now reads: *Another source of uncertainty is the choice of LiDAR wavelength. The 905 nm wavelength used in this study is typical for many airborne systems and generally produces only minor depth errors in snow due to limited penetration, with most of the signal returned from the upper centimeters of the snowpack (Deems et al., 2013). In comparison, shortwave infrared wavelengths such as 1550 nm are more*

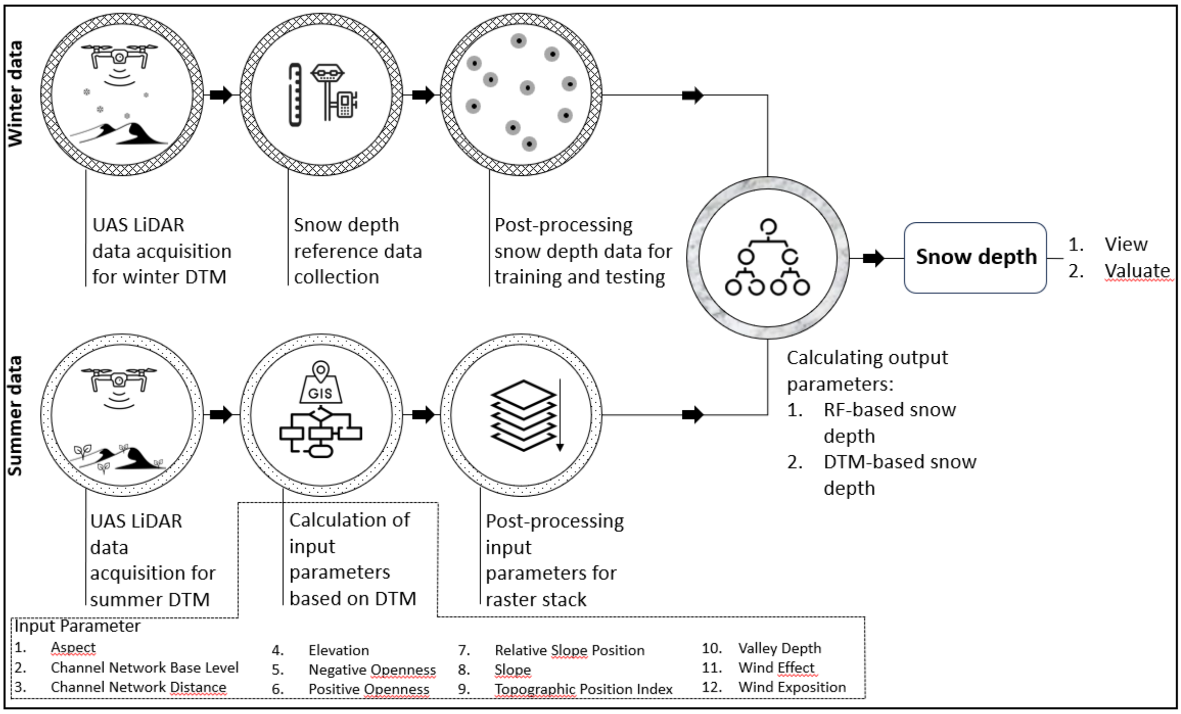
		strongly absorbed by ice, resulting in a return signal that is more confined to the snow surface. This characteristic can help reduce uncertainty, particularly in areas with complex surface conditions or low reflectivity.
Minor Suggestions:		
12. Line 14: "…0.77 and 0.691, respectively."	Changed	Corrected in lines 8 - 12.
13. Lines 130-148: Looks like there's use of both past and present tense, maybe double check for consistency.	Changed	Past tense adjusted for consistency. The sentence "In-situ measured snow depth data was used..." was changed to present tense in line 101.
14. Line 147: "…approach provides the most reliable results, and (2) how do the snow depth patterns…"	Changed	Corrected in line 108.
15. Figure 1: The font in 1b could be larger. The "Road" label could also be replaced with "Route E8" instead.	Changed	Thank you very much for the suggestions. We increased the font size, replaced "Road" with "Route E8", and lake names were removed to improve readability.
16. Line 160: Instead of "in the west" perhaps "extends to the west"?	Changed	We changed it in line 118.
17. Line 249: May want to double-check the grammar on this line ("-,").	Changed	We changed the sentence in lines 195 – 197: "*Based on the summer and winter DTM of the palsa sites, snow distribution datasets were calculated by substracting the winter by the summer DTM in Geographic Information Systems (GIS) using ArcGIS Pro by Esri, allowing the comparison of UAS LiDAR conducted snow depth* SD_{LiDAR} *and RF modeled* SD_{RF}*.".*
18. Line 375: I'd recommend using either "Especially" or "directly".	Answered	Unfortunately, the line number indicated does not match the corresponding section in the manuscript, and despite careful review, we were unable to identify the specific sentence referred to in this comment.
19. Figure 6: Perhaps it could be useful to clip the results to the palsa boundaries (or at least a palsa buffer) rather than the raster extent.	Answered	We acknowledge the suggestion to clip the results to the palsa boundaries or a surrounding buffer. However, we decided to retain the full raster extent in Figure 6, as it provides a more comprehensive visual comparison between the RF and LiDAR approaches. Clipping the results would exclude relevant areas at the palsa edges, which are important for interpreting snow accumulation patterns and include several

		measurement points. Additionally, the figure illustrates that the LiDAR data covers areas not included in the RF training data, thereby highlighting differences in spatial coverage and model performance. For these reasons, we decided to keep the original extent.
20. Line 490: “indicate” rather than “indicating”; RF may improve the lidar results, but I would be hesitant to present the results as distinct.	Changed	The verb was changed from “indicating” to “indicate” in lines 341–345.
21. Figure 9: Maybe “demonstration” rather than “explanation”?	Changed	We changed it to demonstration.
22. Line 732: Similar to the previous comments, perhaps “alternative” could be rephrased as this suggests that it’s an independent method.	Changed	“Alternative” was replaced with “approach” in line 505 to avoid implying that the method is fully independent.
23. Figure A2: I would suggest differentiating the colors more, especially the white and yellow points.	Changed	The color of the “Thermokarst” class was changed from yellow to orange in Figure A2 to improve visual differentiation.

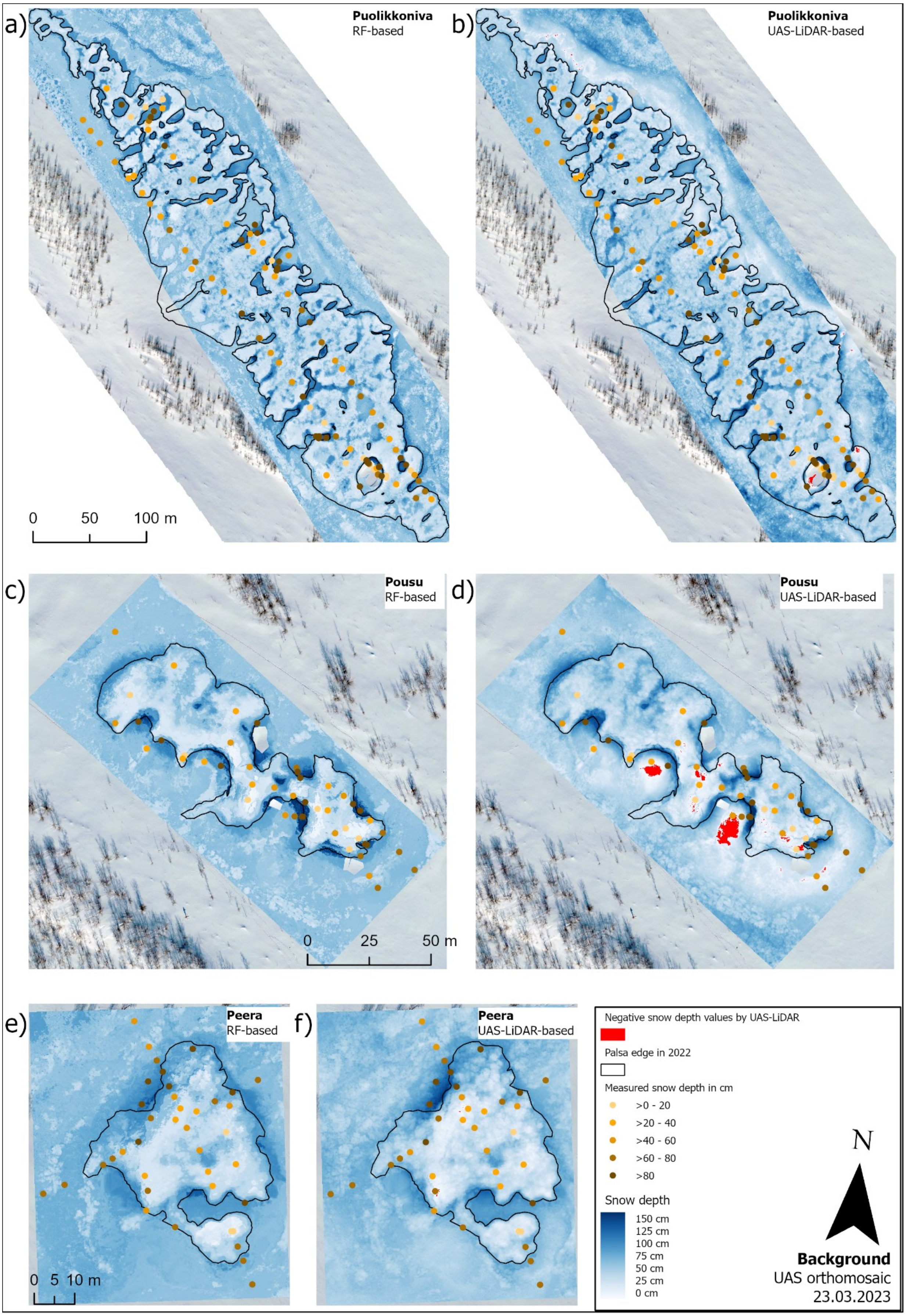
Appendix

This section provides revised figures in response to comments #4, #5, #15, and #23.

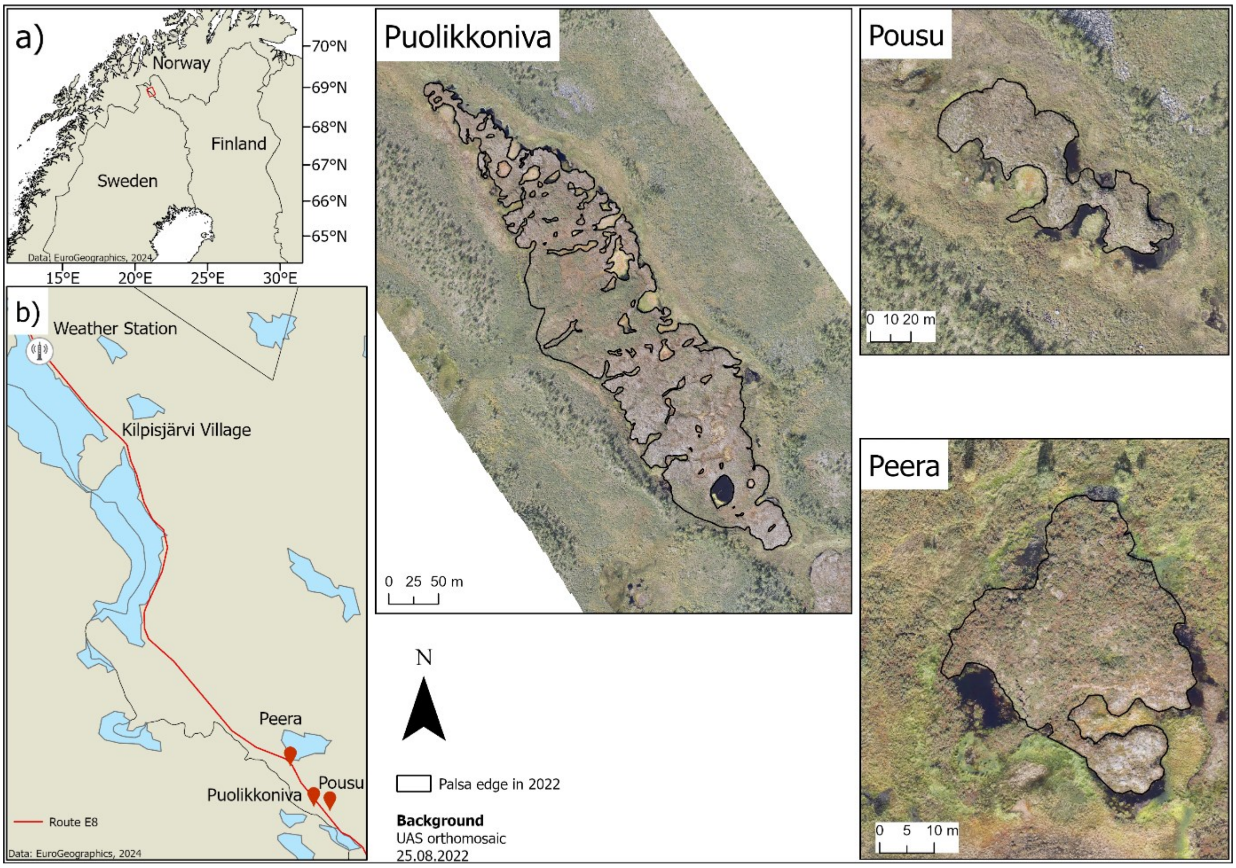
Appendix A



Appendix B

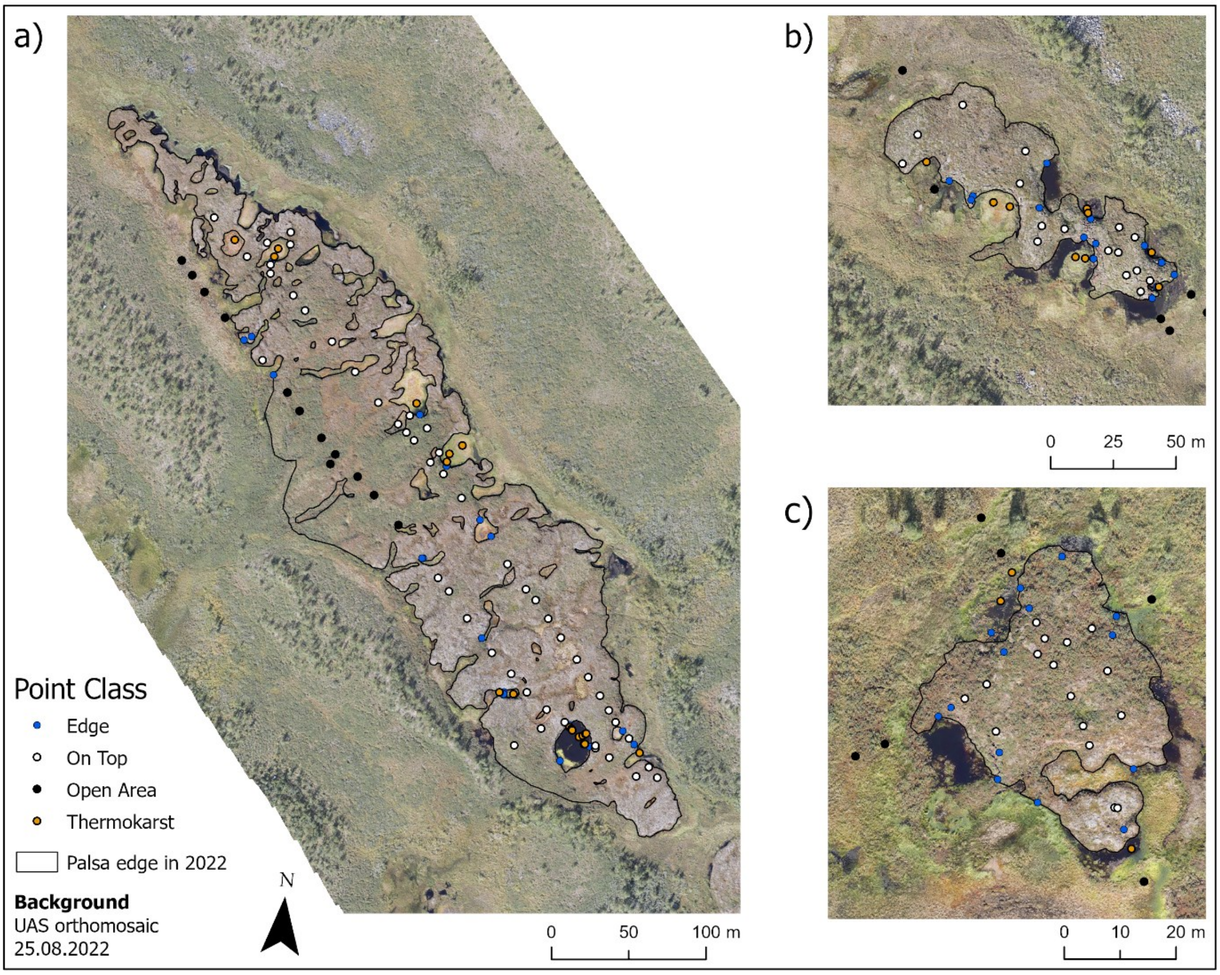

a)
Puolikkoniva
RF-based
b)
Puolikkoniva
UAS-LiDAR-based
0 50 100 m
c)
Pousu
RF-based
d)
Pousu
UAS-LiDAR-based
0 25 50 m
e)
Peera
RF-based
f)
Peera
UAS-LiDAR-based
0 5 10 m
Negative snow depth values by UAS-LiDAR
Palsa edge in 2022
Measured snow depth in cm
>0 - 20
>20 - 40
>40 - 60
>60 - 80
>80
Snow depth
150 cm
125 cm
100 cm
75 cm
50 cm
25 cm
0 cm
N
Background
UAS orthomosaic
23.03.2023

Appendix C



a)
Norway
Finland
Sweden
70°N
69°N
68°N
67°N
66°N
65°N
15°E
20°E
25°E
30°E
Data: EuroGeographics, 2024
b)
Weather Station
Kilpisjärvi Village
Peera
Pousu
Puolikkoniva
Route E8
Data: EuroGeographics, 2024
Puolikkoniva
0 25 50 m
Pousu
0 10 20 m
Peera
0 5 10 m
N
Palsa edge in 2022
Background
UAS orthomosaic
25.08.2022

Appendix D



a)
b)
c)
Point Class
Edge
On Top
Open Area
Thermokarst
Palsa edge in 2022
Background
UAS orthomosaic
25.08.2022
N
0 50 100 m
0 25 50 m
0 10 20 m