Response to RC2 comment on "Sublimation Measurements of Tundra and Taiga Snowpack in Alaska" by Kelsey Spehlmann, Eugénie Euskirchen, and Svetlana Stuefer.

RC2: 'Comment on tc-2023-153', Anonymous Referee #2, submitted on 19 Jun 2024

Dear Reviewer,

Thank you for your thoughtful review, comments, and suggestions. We are happy to answer your questions and provide more information.

The following pages contain comments that appear exactly as they were received. Our responses are inserted next to each comment in blue text. Thank you again for taking time to review our manuscript.

Sincerely,
Svetlana Stuefer on behalf of the coauthors

General comments:
The manuscript shows significant improvements compared to the previous version. While the authors have addressed most of the comments, the following must be considered. The authors were invited to consider additional investigations to assess whether the snow sublimation variability among sites within the same snow class or among years could be related to specific meteorological conditions and site characteristics. This point still needs to be addressed. Table 1 is perfect for characterizing, on average, the meteorological conditions in the tundra and lowland boreal regions over the entire study period. Still, it does not support explanations for the snow sublimation variability mentioned above.

Response 1: We appreciate Reviewer's suggestion to perform additional investigation to access if there is a statistically significant relationship between sublimation rates and specific meteorological conditions that can explain variability in sublimation rates. We address Reviewer's point by stating the following:

1) *"Single linear regressions with daily sublimation rates as the response variable show moderate relationships ($r^2 > 0.1$) between air temperature, wind speed, net radiation, vapor pressure deficit, and temperature gradient." (Line 310–311, Table 5)*
2) *"Cumulative annual sublimation rates are proportional to the length of the snow cover season at all lowland boreal sites …, but there were no significant relationships between the sublimation rates and amount of solid precipitation or SWE. Sublimation rates at the tundra sites did not show significant relationship with the length of the snow cover season, solid precipitation, and SWE". (Line 331–334)*
3) *See Response 3 for details on MLR analysis and Table 6.*

We would like to use this response as an opportunity to emphasize that the main goal of our paper is to calculate and quantify sublimation rates in the Arctic tundra and subarctic environments. The quantification of snow sublimation rate provides novel contribution that has not been done before. While statistical analysis presents an interesting exploration into the potential relationships with weather variables, the main value of this paper is in accurately quantifying the snow sublimation rates in remote and harsh environments.

Although asked, figures showing the correlations between sublimation rates and meteorological variables for the lowland boreal and tundra are not displayed. How the dataset is used in the different analyses needs to be added in the section on methods since some analyses are performed with the cumulative annual snow sublimation rates and others with hourly and daily sublimation rates over the entire study periods, some considering the six sites and others with the data aggregated in lowland boreal and tundra regions.

Response 2: We disagree with Reviewer's statement. Information on correlations between sublimation rates and meteorological variables for lowland and tundra is clearly presented in the manuscript in Table 5 "Hourly and daily sublimation mean correlation coefficients (r) with standard deviations at the lowland boreal forest and tundra sites". The data used (hourly or daily) are also clearly stated in the table.

The response clarified that the highest coefficient of determination of the multiple linear regression resulted from a stepwise approach, although the different steps are not shown. Showing these steps would highlight how the explanatory power of the relation increases or degrades with the addition of the meteorological variables and demonstrate whether or not the increase is significant between the regions and among the sites of the same region. The description of how the multiple linear regression approach is applied needs to be improved in the section on the methods.

Response 3: Additional details on regression models were added to the method section. We clarified how the meteorological variables were introduced in the stepwise regressions and the effect it had on the regression models. The revised text in methods section now reads (Line 209–213): "The meteorological variables were added in the stepwise regression in the following order: 1) air temperature and wind speed, 2) vapor pressure deficit (VPD) and wind speed, 3) air temperature, wind speed, and relative humidity, 4) air temperature, VPD, net radiation, temperature gradient, and wind speed. Regression models were evaluated based on their p-values, r2, and adjusted r2." A sentence on a MLR analysis with two meteorological variables was added in the result section (Line 324–325): "An MLR with air temperature and wind speed explains 33–42% of the variance in the daily sublimation rates."

In addition to the sole SOS Project, 2023, other studies on the impact of snow sublimation on water balance should be cited. This reference needs to be double-checked, as the link in the Bibliography leads to a page not found.

Response 4: The link to SOS project 2023 was removed. A recently published article by Lindquist and colleagues was added to the reference list: Lundquist, J. D., Vano, J., Gutmann, E., Hogan, D., Schwat, E., Haugeneder, M., Mateo, E., Oncley, S., Roden, C., Osenga, E., and Carver, L: Sublimation of Snow, Bull. Am. Meteorol. Soc., 105(6), doi: 10.1175/BAMS-D-23-0191.1, 2024.

Detailed Comments:

Line numbers refer to the marked version.

Line 159: It is clear from the response, but not reading the section. Please rephrase to make it understandable that it is an integral part of the study characteristics.

Response 5: Line 159 in marked manuscript is the sub-section title 2.2 Types of Sublimation. The print screen of the manuscript shows text in Line 159.

2.2 Types of Sublimation

160 Total sublimation equals st

Lines 220-224: Please provide more information on the analysis of variance, the type of test, what it tests for, and why it was chosen compared to other statistical tests.

Response 6: We specified that a one-way Welch's t-test was applied to investigate whether there are significant differences in sublimation rates across the six sites, between regions/snow classes, and between sites with and without a canopy (Line 193). The t-test is particularly useful for small sample sizes and remains a robust option for central tendency comparisons.

Line 316-317: Please add "lowland boreal forest" and "tundra" so it is clear what you mean by "grouped by region/snow class".

Response 7: The suggested wording was added. The revised sentence now reads (Line 289–290): "Sites grouped by snow class measure insignificantly different cumulative annual sublimation rates between lowland boreal forest and tundra sites (p value = 0.24)."

Line 330: "Temperature gradient measures highest in the coldest months (November–March)…" please add a reference to a table or figure.

Response 8: The statement in question is removed.

Lines 362: Please clarify what does it mean "Sublimation rates at the tundra sites are not measurably affected by the same variables".

Response 9: The sentence in question is revised to state (Line 334): "Sublimation rates at the tundra sites did not show significant relationship with the length of the snow cover season, solid precipitation and SWE."

Lines 420-422: Please add the reference to a table or figure where "US-BZS shows significantly higher annual sublimation rates than the tundra sites".

Response 10: We added "(Table 2, Table 3, and Figure 5)" to the end of the sentence to refer to the summary statistics of each site (Table 2), the snow cover duration in each region (Table 3), and the boxplot comparison (Figure 5). The revised sentence now reads (Line 386): "It is worth highlighting that US-BZS measures higher annual sublimation rates than the tundra sites, even though tundra sites have, on average, 69 additional days of snow cover per year (Table 2, Table 3, and Figure 5)."

Figure 2: Please add "Imnavait Creek Station" and "Fairbanks Station" to show where the precipitation in Table1 is measured.

Response 11: Revised Figure 2 includes reference to the Imnavait Creek stations. Fairbanks station is outside of the map on Figure 2b. The exact location of Fairbanks Station is added in the data section: "Solid precipitation is not measured at boreal forest sites; therefore, we used precipitation measurements from the NOAA, NWS (National Oceanic and Atmospheric Administration, National Weather Service) weather station USW0002641 at Fairbanks International Airport at 64°48'N, 147°52'W (https://www.ncdc.noaa.gov/cdo-web/datasets/GHCND/stations/GHCND:USW00026411/detail)." (Line 185)

Figures 3 and 4: Please adopt consistent units of mm/year

Response 12: Revised Figures 3 and 4 now have units of mm/month and mm/year.

Figure 5, 6, 7: Please adopt consistent units of mm/year

Response 13: Revised Figures 5–7 now have units of mm/month and mm/year.

Figure 6: This figure shows that the two groups have different sample size. What is the effect on the test results? The results of the post-hoc Tukey tests in section 4.3 and Figure 5 show that the cumulative annual sublimation at sites with trees (US-BZS) is not significantly different from those at the tundra sites without trees. This finding suggests that the effect of the canopy sublimation term makes a difference within the lowland boreal region but not beyond. Can you really draw strong conclusions?

Response 14: We agree two groups have different sample size. Methods were adjusted (Section 3.3 updated) to run a Welch's t-test to accommodate the unequal group sizes, which ensures valid comparisons between group means. The Welch's t-test confirms that sublimation rates at sites with a canopy are significantly different than sites without a canopy. To address the Reviewer's note on contradiction between findings in Figure 5 and Figure 6, we revised Line 281–284 to clarify the meaning of pooling data in different ways: "The Welch's t-test demonstrates that sublimation rates are significantly different between sites with trees and without trees (p value = 0.02), a finding that is masked by the small site-to-site variation evaluated in Figure 5."

Table 1: Please specify in the caption if air temperature, mean, and max wind speed values are averages at the three sites within each region.

Response 15: We added "Mean air temperature, mean wind speed, and max wind speed are averages of the three sites in each region." to the caption (Line 90).

Table 2: Please add over which period the daily and annual sublimation rates are calculated.

Response 16: We included "The daily and annual sublimation rates are calculated for water years with complete records." to the caption (Line 226).

Table 4: Please specify Pearson's correlation coefficients in the caption.

Response 17: We added "Pearson's" correlation coefficients to the caption (Line 268).