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Dear authors and editors,

thank you for the opportunity to review this interesting study. The work presents a laboratory experiment exploring snow processes during aeolian transport using a ring-shaped wind tunnel. The experiment leverages two technologies, microCT scanning to determine the change in physical properties of the snow grain during transport, and stable water isotope analysis of both the transported snow and the air water vapor to study the physical processes in phase change, i.e. sublimation and deposition during transport. They find that grain snow SSA decreases and grain size increases, and snow particles experience longer time of wind transport. The isotope data suggest both net sublimation in the early stage of the experiment, and vapor deposition on the transported snow particles.

The work is an innovative way to study the changes in snow during wind transport, which is difficult to do in-situ in field conditions. The work used a unique combination of microCT scanning and stable water isotope measurements, allowing novel insights to micro scale processes. I think the experiment is carefully planned and executed, and the findings have implications for both snow physics research, and research using stable water isotopes as tracers of paleoclimate or hydrology in snow-influenced regions. I recommend the work to be published, after addressing my comments below.

We thank the reviewer for the time that was spent on this review which helped to improve this manuscript. We detailed our changes in reply to the comments below (answers in green). In addition to edits based on the reviewers' comments, we updated a few inconsistencies in the text and figures, such as the color code in Fig. 3 to be consistent throughout the manuscript. In summary the major changes made are related to:
1) New Fig. 5 to describe the co-evolution of d18O and dD during and after snow introduction in more detail and an adjustment of the vapour isotope change results section 3.2.2
2) the statistics of observed isotope changes in vapour and snow. We included a table (Table 2) to group the information and declutter section 3.2
3) A short paragraph in the introduction to define temperature-gradient and isothermal snow metamorphism

L32: Cite some large and small scale wind drift modeling studies.
L. 31: We added the following citations: (Agosta et al., 2019; Groot Zwaaftink et al., 2011; Lenaerts et al., 2012).

L55: start new paragraph
We followed the reviewer's suggestion.

L85: also melt and freeze
We added melt and freeze fractionation, the sentence now reads: L. 98: "*Due to their predictable partitioning, i.e. fractionation into the vapour, liquid and ice phase during phase changes (i.e. water vapour deposition and sublimation or freeze and melt), stable*

water isotopes are powerful tracers (Ala-aho et al., 2021; Beria et al., 2018; Galewsky et al., 2016), which allow to identify and quantify the impact of metamorphic processes on the PPP (Ebner et al., 2017; Harris Stuart et al., 2023). Ideally, stable water isotope measurements comprise all involved phases (in dry snow regions this means solid and gas) to fully constrain the isotopic fractionation during phase change processes."

L89: suggest to cite papers that use water isotopes as tracers in snow studies.
We followed the reviewer's suggestion and added these citations instead of the Mook-fundamentals citation: (Ala-aho et al., 2021; Beria et al., 2018; Ebner, 2012; Galewsky et al., 2016; Harris Stuart et al., 2023) to the sentence.

L104: in my understanding the d18O_ice < d18O_vapor in any deposition process, not only supersaturated, fractionation factor in Eq (2) take values >1.
The reviewer is wrong in this regard. Generally, d18O_ice > d18O_vap (remember that delta values are negative numbers given in ‰) which is the case when alpha_net > 1 with alpha_net=R_{snow}/R_{vapour}. The equilibrium fractionation factor will always be alpha_eq > 1 due to vapour pressure differences for the different isotope species. However, the kinetic fractionation factor is <1 (the higher the supersaturation, the smaller alpha_k). Given that the relative importance of equilibrium and non-equilibrium fractionation is determined by the supersaturation, there is a critical supersaturation value above which, alpha_net in eq. (2) can become <1 which then leads to d18O_ice < d18O_vap. See Mook, (2000) Sec. 3.3. p. 27 or (Jouzel and Merlivat, 1984) Fig 9.

L135: changes in what?
We changed the sentence structure to avoid confusion. It now reads L. 147: *"The experiments aimed to simulate wind-blown snow transport in the ring wind tunnel for long transport times while monitoring changes in snow properties and environmental variables to identify the corresponding governing mechanisms."*

L140: tab -> tap?
That was a typo, yes. We corrected it.

L140-141: Don't get this – how it was not in operation, but was producing new snow minimum four days before the experiment (L144)?
We added more information to this sentence in the hope that it is clear now. L. 153: *"The snowmaker was situated in the same cold-laboratory but the snowmaker and the wind tunnel were not operated simultaneously to limit heat and moisture sources during the experiment hours."*

L143: did you analyze the influence of storage time? And how to determine mixing success? If not, suggest to remove the start of this sentence.
We think the reviewer refers to L 148 and we removed that first half of the sentence as the standard deviation measurements are indeed the relevant information to define mixing success.

L170: out of interest: what was the mass balance of your 600g of added snow? x g sampled, y g deposited, the residual z g sublimated? Maybe not very important for your results and findings, but this would give an idea where did the snow in the air column end up, and allow better imagining the experimental setup?
The reviewer proposes a very important metric which is essential for modeling efforts.

We tried to monitor the mass balance components as closely as possible but it became apparent that the uncertainties in the accumulated snow mass was too high to establish a reliable mass balance. These uncertainties were due to snow getting stuck in cracks and screw boreholes etc which we had to clean with vacuum cleaners and brushes. In future experimental set-ups our goal will be to find a way to minimize the uncertainties in the accumulated snow mass with the hope that we will be able to perform mass balance calculations and sublimation modeling.

Table 1: please specify the variables, not only units for the DeltaH2O column. Also, what does DeltaT mean?
We included the humidity variables in the table header and added an explanation of DeltaT to the table caption.

section 2.2.1: a carefully though of experimental equipment and setup: trying hard to think of points of criticism but cannot find any😊
Thank you!

L228: what is the difference specifically between drifting and blowing snow in your experiment?
Essentially in our experiment, we can not differentiate between drifting and blowing snow as we take one integrating sample from the whole air column. In general, as we argue in L. 627ff, the wind tunnel might be more representative of saltation layer conditions.

L371-375: cannot locate this data in your plots
As this is not an essential part of the experiment but rather a way to check our assumptions we decided that we don't show these data. We clarified this in the sentence L. 385: *"The snow samples taken from the accumulated snow (not shown) show a clear difference between the samples from the inner part and the surface layer of the accumulated snow."*

L395-406: this difficult to follow. First you stare that most experiments follow example in Fig. 4. On L402 you talk about subsequent evolution, subsequent to snow addition? to which of the categories does the example in Fig.4 belong to, for example? Not sure what is the best way to summarize this data, perhaps in a table, but the current way is difficult for me to digest.
This point was also raised by reviewer 1 (specific comment 5). Thus, we included a new figure (Fig 5) that shows the net vapour isotope change as a way to visualize the co-evolution between snow and vapour isotopic composition. The upper row demonstrates the change in vapour isotopic composition during snow introduction, and the lower row the change in vapour isotopes between end of snow introduction until the end of the experiment. We also simplified the whole section, and included Table 2 with the relevant statistics of the isotope changes and we are confident that the updated version together with the new figure will be better understandable to the reader.

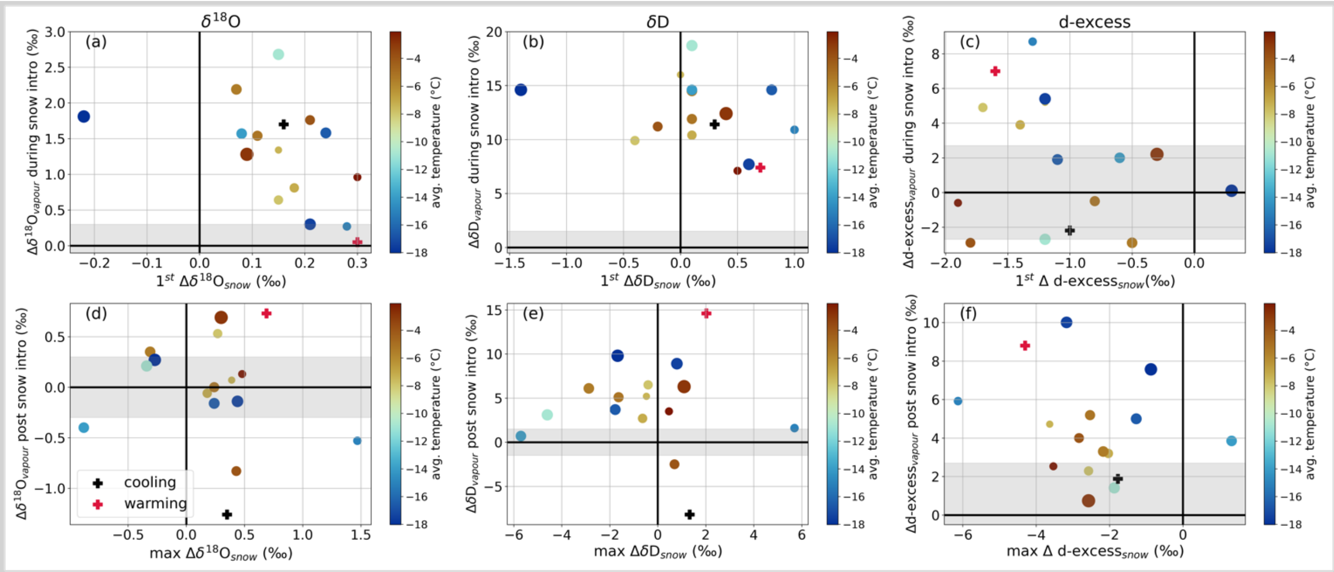

Figure 1 The co-evolution of changes in vapour and snow isotopes in all experiments with vapour isotope observations The change in the snow isotopes (x-axes) is plotted against the changes in the vapour isotopes (y-axes). The changes in vapour isotopes are calculated from the 3-min averaged data. The upper row (a, b, c) shows changes in vapour isotopes during the snow introduction plotted against the observed change in snow isotopes of the first airborne sample (see Fig. 3). The lower row (d, e, f) shows the subsequent change in vapour isotopes post snow introduction until the end of the experiment plotted against the maximum observed change in the snow isotopic composition. Shaded areas represent low variability in vapour isotopic composition (|Δδ18O| <0.3 ‰, |ΔδD| <1.5 ‰, |Δd-excess| <2.7 ‰). Note that the colour code represents the average air temperature during the experiments and allows the comparison between upper and lower row and the results shown in Fig. 3. The cooling (black cross) and warming (red cross) experiments are exempt.

L404: does the reversed evolution pertain only to 18O?

From the new Fig. 5 it becomes clear that the reversed evolution is more often visible in d18O vs it only happened once for dD. This has to do with the disequilibrium between vapour and snow isotopic composition and we elaborate on this in L. 686: “*As we produced snow from tap water this disequilibrium was at times more pronounced than generally assumed in nature. As the disequilibrium defines the isotopic evolution, it is not possible to unambiguously predict the expected changes in the snow isotope signal under wind influence without considering water vapour isotope variability which is driven by synoptic-scale atmospheric variability (Aemisegger et al., 2022; Bagheri Dastgerdi et al., 2021).*”

Chapter 3.2: I was expecting also the snow samples and their temporal evolution in Fig.4 to be described in the this paragraph.

As suggested, we added two short sentences describing the change in snow isotopes that can be seen in Fig. 4: L. 407: *“The snow sampling events every 15–30 min can be identified as short-lived dips of 1–2 min in the wind speed (Fig. 4d). In this experiment, the first airborne snow sample (1st $\Delta\delta^*_{snow}$) shows a 0.18 ‰ enrichment in $\delta^{18}O$ (Fig. 4f) and a -1.4 ‰ decrease in d-excess (Fig. 4j) whereas the δD value (Fig. 4h) does not change significantly (+0.1 ‰). The maximum observed change (max $\Delta\delta^*_{snow}$) for this experiment is a 0.18 ‰ enrichment in $\delta^{18}O$, a -0.6 ‰ depletion in δD and a -2.0 ‰ decrease in d-excess.”*

L459: start a new paragraph to give rhythm to the section?

We started a new paragraph

L476: What's your view: would the full sublimation of small particles conceptually lead to isotope fractionation in the suspended snow?
This is indeed an interesting question to think about. It would certainly not lead to isotopic *fractionation* in the snow as fractionation requires that there is a leftover compound that collects the remaining isotopes. However, one could discuss whether removing the smallest particles would lead to a change in the bulk isotopic composition if we assumed that the smallest particles have an initially, fundamentally different isotopic composition than the bigger ones. The snowmaker snow is fairly homogenous and we would assume that the smallest particles probably stem from abrasion or breaking of larger particles. Thus, I would not assume that the bulk snow isotopic composition changes much if only the smallest grains would get sublimated and the larger ones stayed inert. In nature, however, I would expect that snow particles of different sizes (formed at different altitude and/or different temperature) probably have a different isotopic composition and a selective removal of only the smallest sizes might change the bulk isotopic composition. But this is only speculation and a question that is difficult to test, because it would require analysing the snow's isotopic composition in bins of different particle sizes. We are not aware of a method to efficiently separate snow of different particle sizes and the usefulness (beyond curiosity satisfaction) is questionable since snow in nature is always a mix of different particle sizes. But a fun thought experiment!

L564: replace "in other words" by this is demonstrated by … or similar. Because you haven't really show the evidence for the statement.
We agree. We replaced "in other words" with "specifically". The sentence now reads:
L. 595: *"Specifically, the initial disequilibrium prior to snow introduction (i.e. vapour produced by fractionating sublimation) is a better predictor for the changes…"*

L582?: can you propose a way to conceptualize the processes you have found into a modeling context, where isotope values in the snowpack are important, such as isotope-enabled climate of hydrological models?
The reviewer is asking the follow up question to this manuscript and we can share that we are continuing to work along this idea to find a way to incorporate our findings in a numerical isotope-enabled model. However, an adequate answer to this question would go beyond this work's scope, but we hope to answer the reviewer's comment in a subsequent manuscript.

L613: start new paragraph
We have started a new paragraph

L659: can you find any field studies that would have observed similar (or any) change in the isotope values of wind-transported snow? Or can you propose an experiment that could study this in the field conditions?
To our knowledge there is no published water isotope dataset that was targeted towards wind-blown snow yet. On the contrary, many studies excluded intense wind periods for their sampling campaigns to limit possible drivers of post-depositional isotope change (Harris Stuart et al., 2023; Wahl et al., 2022). However, a recent study of surface snow at Concordia station in Antarctica (Ollivier et al., 2024) discusses wind as potential driver for post-depositional changes in snow isotopic composition during polar night conditions. Reviewer 3 (comment 1) was skeptical about the possibility to differentiate between fresh and wind-blown snow based on the d-excess values since the d-excess variability

in fresh, precipitated snow is very high in itself. In an effort to combine both comments we changed the paragraph to L. 690: *"However, the results suggest that a strong d-excess decrease can be linked to airborne metamorphism. This should be kept in mind when observations of snow d-excess values are used as hydrological tracers. Further field studies in windy and dry locations such as the katabatic wind zones on the Antarctic Ice Sheet could support this idea."*

L684: You do not have data for this? the conclusions are indirect from processes.
This is correct which is why we used the vague term "indicated" rather than "demonstrated" or "showed". We think that this is an important interpretation of the experimental data and will therefore keep this sentence in the conclusions.

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