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The Cryosphere Discussions

Interactive comment on "Dry-Air Entrainment and Advection during Alpine Blowing Snow Events" *by* Nikolas Olson Aksamit and John Pomeroy

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I have reviewed the paper "Dry-Air Entrainment and Advection during Alpine Blowing Snow Events" by Aksamit and Pomeroy for publication in The Cryosphere. The study presents results from a field-based experiment at a study site in the Canadian Rockies where ultrasonic temperature and wind data at two measurement heights were collected at 50 Hz during 5 nighttime blowing snow events over one winter period. Turbulent motions during the blowing snow events were identified based on horizontal and vertical wind speed deviations and evaluated based on associated high-resolution air temperature fluctuations. Results highlight that turbulent motions during blowing snow events were responsible for temperature fluctuations by as much as 1°C suggesting that warm air advection during blowing snow processes can be an important energy

balance component and needs to be considered for improved blowing snow sublimation modeling.

I believe this paper addresses an important topic and clearly demonstrates a contribution to the field that is relevant to the readership of The Cryosphere. The paper is clearly organized and well written overall. My comments on the paper are outlined below:

General comment:

1) While this paper is generally well written, it is sometimes missing adequate detail and definition needed for the reader to adequately understand what was done. I would like to encourage the authors to go through the manuscript and provide more relevant background material and methodological details/definitions where needed. This is especially the case in the abstract section. I've outlined some areas that need more detail in my specific comments below. Although the authors have published many papers utilizing this dataset, this paper needs to be stand alone and the reader should not need to have read these previous publications in order to understand the details relevant to the current study. The length of this manuscript is rather short so expanding sections where additional detail is needed should not cause any issue.

Specific comments:

1) Lines 1 - 2: Does it make more sense for the title of the paper to be "Warm-Air Entrainment and Advection during Alpine Blowing Snow Events" based on the study design?

2) Lines 12 - 15: "Atmospheric sweep and ejection motions" should be further defined here.

3) Lines 16 – 17: Define "event magnitude" on line 18.

4) Lines 19 – 20: The "recurrence model" is not well defined. Also, the use of "model modeled described" should be revised.

5) Lines 20 – 22: Again, return frequencies and event durations is not well defined here.

6) Abstract: More details about what the experiment was and where is was completed are generally needed in this section. The abstract needs to provide enough context for it to stand alone.

7) Lines 36 – 37: This sentence needs further explained/rewritten. Are you suggesting that turbulent fluxes are calculated as a snow energy balance residual? This is not the case in most physically based snow models.

8) Lines 55 – 56: Further define VITA thresholds here?

9) Lines 56 – 60: It would be helpful to more specifically call out the "Blowing snow study site" in the text here so the reader isn't confused by the other meteorological stations when first referencing Fig 1. Furthermore, I suggest saying "These data are supplemented by observations of nearby temperature, relative humidity, and wind speeds at three additional meteorological stations within FMSL. . ."

10) Lines 60 – 62: "return frequency" of what and "event magnitude" of what? Need to define these here.

11) Lines 65 - 66: Two ultrasonic sensors at which sites? Clarifying the site descriptions in the introduction will help make this clearer.

12) Lines 101 – 102: VITA and quadrant analysis thresholds are discussed here before they are introduced in the subsequent equations which is confusing upon first read.

13) Lines 114 – 115: How were the ranges in the user identified thresholds in equation 1 and 2 that were tested in this study identified and defined?

14) Lines 116 - 118: Can you comment on the turbulent conditions that are not considered as sweeps or ejections when u' and w' are of the same sign? Are those potentially important turbulent conditions that need to be evaluated and considered in subsequent

studies?

15) Lines 135 – 137; Figure 2: The colors of the y-axis scales on these plots should be revised to match the line color reflected in the figure legend (i.e. temperature y-axis scale should be blue and RH y-axis scale should be red.

16) Lines 139 – 144: Consider moving this information to methods section.

17) Lines 167 – 169; Figure 4: Can you comment further on how the influence of the stabile atmospheric conditions and colder temperature near the surface may have resulted in the greater warmer deviations at the lower anemometer? These near surface temperature gradients over a snowpack are especially pronounced at nighttime as compared to daytime conditions (see Figure 3 from Sexstone et al. 2016; https://onlinelibrary.wiley.com/doi/abs/10.1002/hyp.10864). Therefore, in the absence of this steep air temperature gradient (more characteristic of daytime conditions), would we expect to see such strong temperature deviations associated with sweep and ejection motions?

18) Lines 162 – 163: Based on their frequency, is it likely that the high resolution temperature increases associated with sweep and ejection motions could be resolved in the 15-min time-averaged data?

19) Line 189: I didn't see further discussion of this mixing process in the discussion section according with this statement. It would be good to elaborate on this in the discussion.

20) Lines 243 – 244; Figure 6: Consider swapping the Ejections and Sweeps columns on this figure to be consistent with the presentation in other figures throughout the paper.

21) 260 – 262 – Can you elaborate here on how you expect including these scaling relationships would alter biases in existing blowing snow sublimation models? For example, if a simulation of blowing snow sublimation was completed with existing models

as well as using this scaling relation for warm-air advection, how would the results change?

22) 263 – Please elaborate on the important environmental conditions that should be/need to be represented in future studies to further develop understanding of warm and dry air advection during blowing snow events. Given the study was completed at one study site only, it cannot be generalized that the study results could be applied to all snow covered environments where blowing snow occurs. What are the limiting environmental conditions of the current study (e.g., blowing snow events only observed during nighttime conditions over a limited range of atmospheric stability. . .or only sweep and ejection motions where analyzed?) and how can these be overcome in future experiments.

23) Line 269: Conclusions section should be numbered section 5.

24) Lines 270 – 272: Leading the conclusions section with a sentence about saturation of water vapor during blowing snow events doesn't really fit with the scope of this paper since it was not a measurement directly made at the blowing snow site and only observed at auxiliary meteorological stations.

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