We thank Nora Krebs and Dr. Paul Schattan for their comments on this manuscript. Our response to each comment is highlighted in blue.

Minor comments

- The title should indicate that the analysis covers a case-study in a prairie environment.
- We agree our title is very broad and should be more definitive. Along with the previous comment from Prof. Köhli, we will change the title to highlight that this is a case study in a prairie environment. Our proposed revised title is "Influence of Snow Spatial Variability on Cosmic Ray Neutron SWE in Northern Prairies".

- The major outcome that is outlined in the abstract from line 17 to 20 should not be indicated as a logical consequence. It rather seems that study 4.1 shows that CRNS is influenced by snow drifts and study 4.2 shows that an area average can be obtained by placing a sensor in the proximity of a snow drift. However, figure 8 c) and d) shows that an area average may also be obtained in a location afar from snow drifts, meaning that both findings are true, but don´t condition each other.
- We agree that lines 17 to 20 is not an exact logical consequence from our results in this study. We will revise these lines to better reflect the results of our analysis.

- Line 186-188: It is acceptable to use a constant footprint size, but the footprint dependency on the amount of present moisture (i.e. snow) should be briefly discussed.
- Thank you for this comment. We agree that the amount of moisture around a CRNS alters the effective footprint. We will add a brief discussion to the manuscript about the importance of footprint size and its dependency on moisture.

- Analysis 4.1 distinguishes between uniform snow thickness scenarios, computed from the SWE average of the CRNS footprint and the SWE average of the study domain. In the substudies, outlined from line 240 to 283, it becomes not clear, which of the two scenarios have been used.
- We apologize that parts of the manuscript were not clear about which SWE scenario we used. For lines 240 to 276, the analysis around Figures 4 and 5 used the model results from the heterogeneous (i.e., "natural") snow distribution and the SWE average from the given CRNS footprint. We will revise these sections to increase clarity.

- The results and discussions around Figure 4 and 5 seem straight forward. However, it is questionable if the "snow-free" day is a good choice for an analysis of the effect of snow cover. If the SWE average is based on the CRNS footprint in this analysis, almost all virtual detector locations are compared under completely snow-free conditions, except for the sensors close to the remaining snow patch ("snow drift"). Choosing a day with a more prominent snow cover (e.g. 17 February) would be more relevant.
- Results and discussions around Figure 6 and 7 would benefit from additional information on how much each virtual detector was affected by fractional snow cover throughout the study. This would strengthen the discussion, which seems to evaluate the complexity of snow cover within the footprint area from visual inspection.
- We are responding jointly to the two comments above, since they seem related. Our intent in Figures 4 and 5 was to illustrate the influence of spatially limited, high SWE snow drifts on our CRNS results. We felt that January 15th was ideal for this because of its lack of snow cover outside of the snow drift. The snow distribution from other dates would include this effect, but it would be overprinted by the influence of snowpack elsewhere in the CRNS footprint. We accept the criticism that this example doesn't necessarily show all of the considerations that influence the CRNS model results.

  We also accept the feedback on Figures 6 and 7. We agree that the analysis can further benefit from how the virtual detector was affected by fractional snow cover throughout the study. We will add qualitative comparisons to our discussion. To that end, we also propose changing the order of the results presented in Section 4.1. We will present the complete results first (current Figures 6 and 7), which are all affected by the heterogeneous snow distribution, and add a color scale to the points to reflect the fractional snow cover. Then, we will discuss how the snow drift also affects our results (current Figures 4 and 5).

- The analysis of section 4.2 and 4.3 give a great added value to the study. While results of 4.2 are partially mentioned in the abstract (l. 20-22) and a hint on 4.3 is provided in the introduction (l. 94-95) they appear hidden and should be more clearly visible, in both abstract and introduction.
- Thank you for this comment. We agree sections 4.2 and 4.3 are important to this study and should be highlighted in our abstract and introduction. We will edit our abstract and introduction to include these results.

- The analysis in 4.1 shows that CRNS measurements on the "snow-off" day (January 15) were affected by the snow drift, presumably lowering the $N\theta$ that was chosen for the SWE conversion. The effect on the converted SWE signal should be briefly discussed in 4.3.
- We agree and we will include a brief discussion of the converted SWE signal into 4.3. We will also revise Fig. 9 to include the SWE calculated from the bare ground conditions.

- Consider rephrasing line 480 to 482 for better logical reasoning and more clarity.
- Thank you for pointing out this lack of clarity. We will rephrase lines 480 to 482.

Illustration remarks

- Figure 1:
    - For clarity, the position and viewing direction of these images could be marked in Figure 2.
    - Thank you for this comment. We will add markers to Figure 2 that will clarify the position and viewing direction of our images on Figure 1.

- Figure 3:
    - A different color should be applied to snow-free areas to allow for a differentiation into areas of heterogeneous snow cover and areas of partial snow cover.
    - We agree that marking the snow-free areas and areas of partial snow cover may be beneficial and clearer to readers. We will change Figure 3 to include these no-snow masks (see example figures below, with no snow areas shown in gray). However, we must note that the snow was very shallow for many of our observation dates, and orthophotos were only available for one of the dates, so we cannot be completely certain about the fractional snow cover percentage across all dates. The uncertainty that exists with our lidar measurements were outlined in Woodley et al. (2024), with RMSE values between 4 and 7 cm. The high RMSE values were likely from the wheat stubble giving a false return. There is potential that an incorrect threshold snow depth for delineating snow-covered vs. snow free areas could drastically change the fraction of snow cover within the study area. However, we compared our masks (using 0 cm snow depth as "no snow") with a snow cover class analysis of the CARC conducted by Palomaki and Sproles (2023). We are including Figure 1d and 1e into this discussion from Palomaki and Sproles (2023) which

shows that creating a snow cover mask using a threshold snow depth of 0 cm matches the snow cover class analysis from an orthomosaic photo on 21 Jan. We will include discussions of this uncertainty in our manuscript as well.

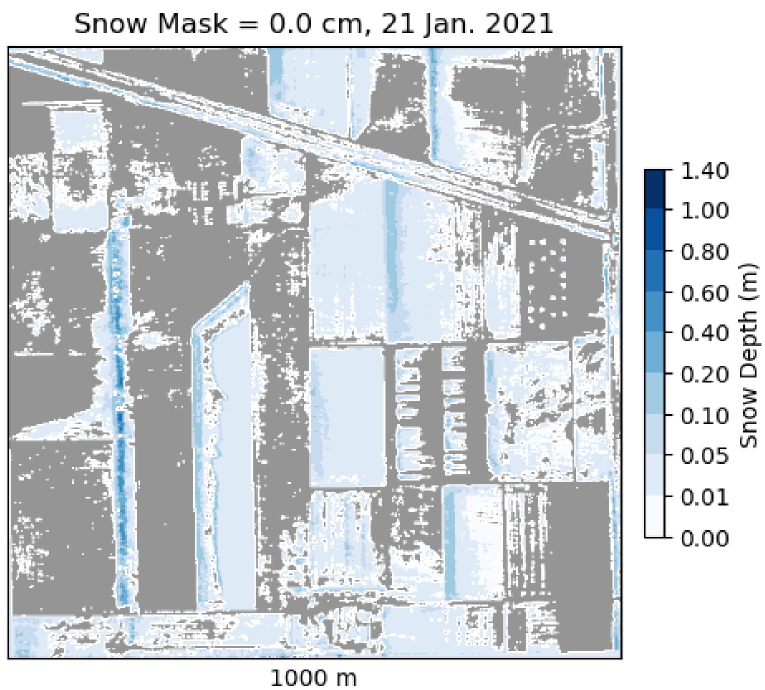

Figure R1. Lidar snow depths (SD) in m for 21 January 2021. Snow free pixels are shown as grey. Snow free pixels are any pixels with a SD equal to 0 m.

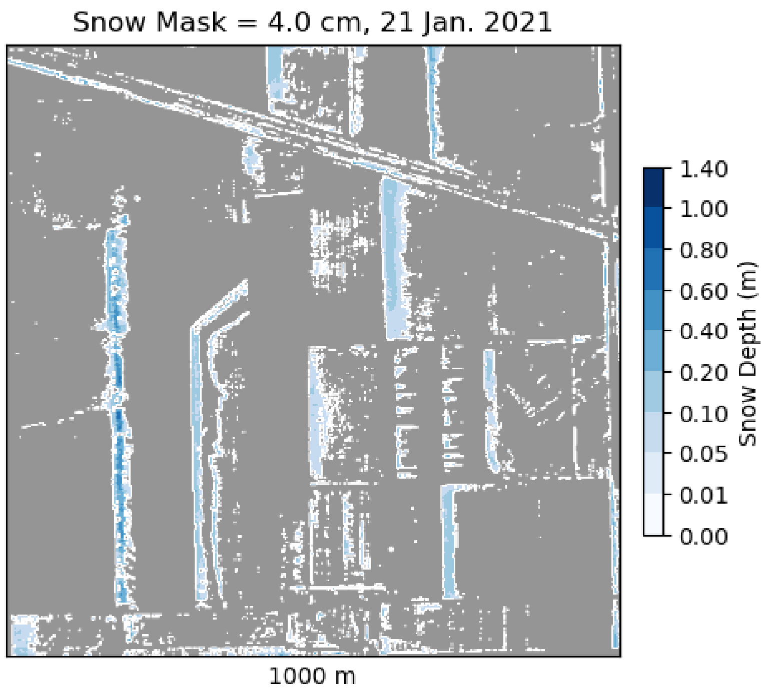

Figure R2. Lidar snow depths (SD) in m for 21 January 2021. Snow free pixels are shown as grey. Snow free pixels are any pixels with a SD less than 4 cm (0.04 m). This threshold was chosen due to the uncertainty in the lidar flights.

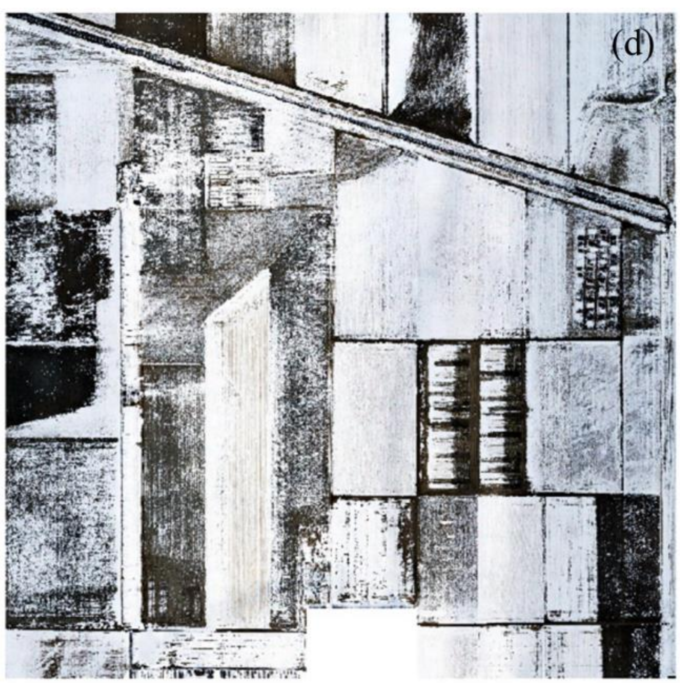

Figure R3. Figure 1(d) from Palomaki and Sproles (2023). An orthomosaic image of the CARC on 21 January 2021 with a spatial resolution of 10 m.

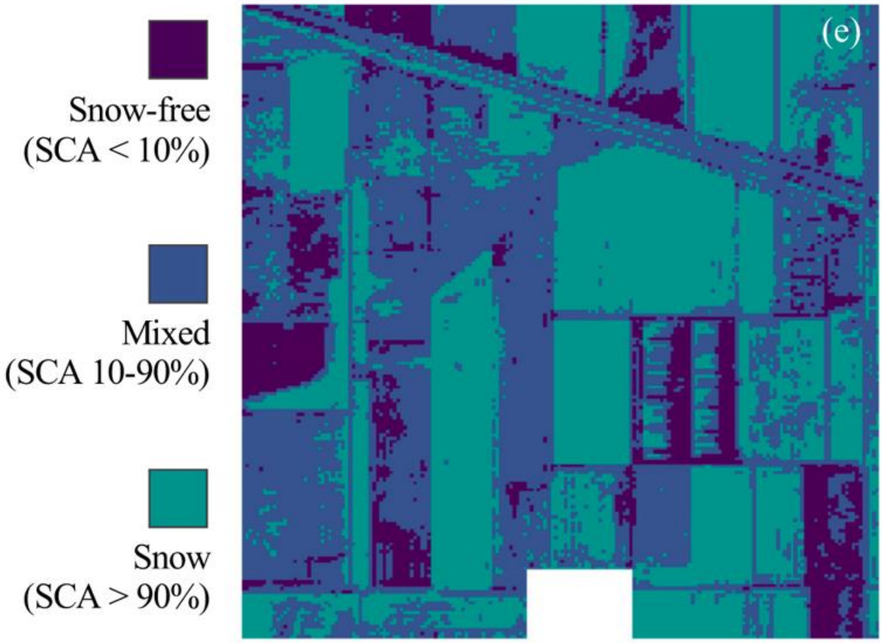

Figure R4. Figure 1(e) from Palomaki and Sproles (2023). The snow cover classes at the CARC at a spatial resolution of approximately 5 m.

- The choice of an exponential color scale is reasonable, but should be better indicated in the legend (e.g. color bar with exponential color distribution, instead of even increments)
- We understand the reviewers point that showing the colorbar on an exponential scale would be a clear signal to the reader that the colorbar is not linear. However, we found that the exponential scale makes the tick mark values harder to read, as it is harder to differentiate the colors when the ticks are compressed into the upper portion of the colorbar. While the scale is nonlinear, we think that showing a set number of categories makes the snow depth more interpretable to the reader. We have attached an example of the figures below. We found that the differences between the colormaps are very minor. However, we note that it is not possible to show a value of 0 with a log distribution, so we do lose any values between 0 and 1 cm (0.01 m). For these reasons, we have retained the current color scale on our figures. However, we will make sure to note the irregular color scale in the figure captions so that readers are aware.

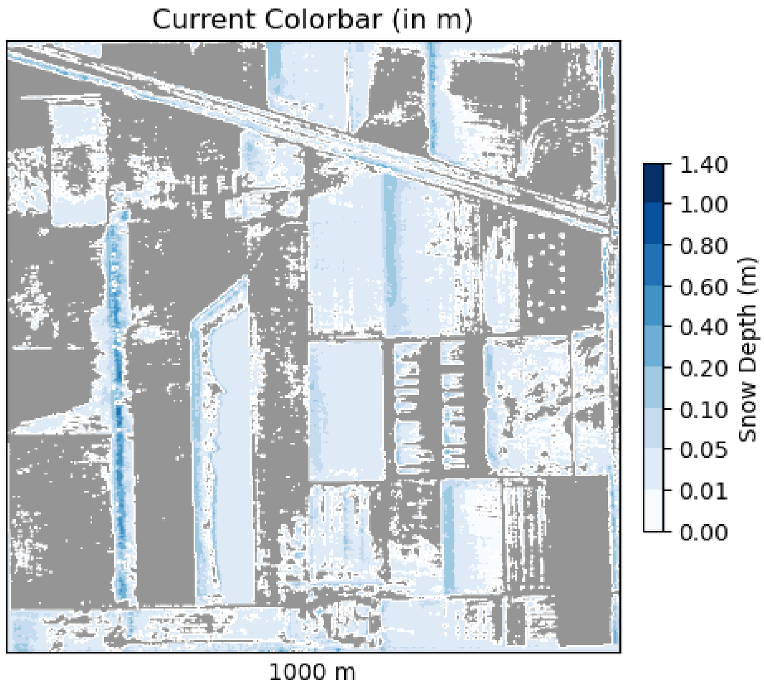

Figure R5. Lidar DSM of snow depths at the CARC for 21 January 2021. The colorbar is the same colorbar as the manuscript.

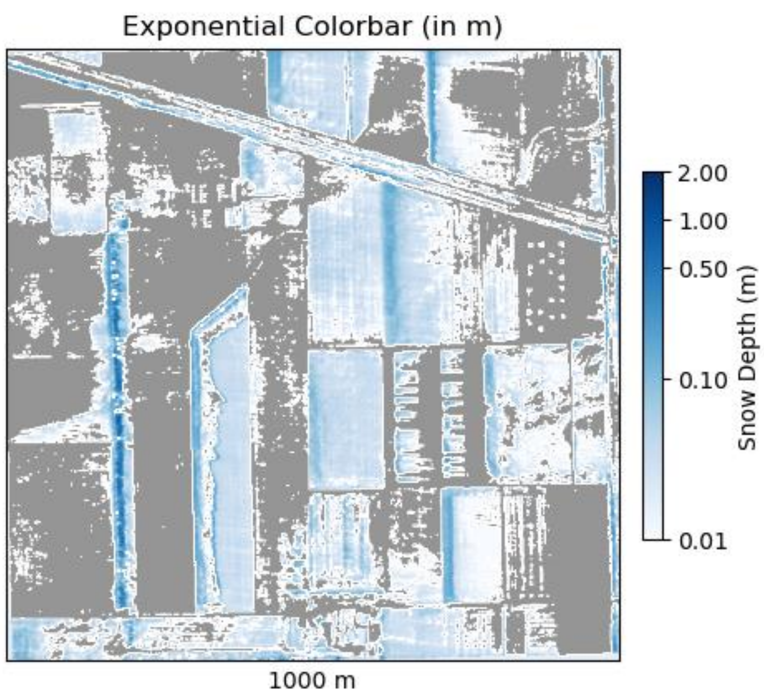

Figure R6. Lidar DSM of snow depths at the CARC for 21 January 2021. The colorbar distribution is now exponential.

- The images miss a scale bar. A dashed line that indicates the domain outline as in Figure 2 would be additionally interesting, as well as the distance of the outer virtual detector locations to the domain boundary.
- We thank the reviewers for their comment. We will add a scale bar to the maps. To address the second part of the comment, all of these maps are within the dashed domain outline in Figure 2, which is why we did not plot it in Figure 3. The footprint for p04 was added to illustrate what the comment suggested. We understand that this was not clear. We will add a label to the x-axis on Fig. 3b like the ones in Figures R5 and R6 to show it was a 1000m and will clarify in the caption of Figure 3 that our study area was 1000 m by 1000 m.

- Figure 5:
  - For consistency, the color scale in e) to f) should be the same as in the previous figures (white indicating low snow and blue indicating high snow accumulation). Further, the SD maps miss a scale bar.
  - In the original Figure 5, we reversed the colormap because the SD maps would blend into white background of the figure but kept the colors consistent. We will alter the figure so that the colors are consistent. Also, we will add scale bars to our SD maps.

  - Since the findings at P00 and P19 are contrary (larger changes on the snow side) to the findings at P07 and P05 (larger changes on the no-snow side) besides the similarity in snow distribution, P19 should also be presented in this figure.
  - We originally left off P10 from figure 5 because we felt the individual panels would have been too small to make out any details. We will include P19 in Figure 5 to highlight the contrary findings.

- <u>Figure 6 & 7:</u>
  - The figure should indicate which scenarios were included in the analysis (all except 15 January).
  - We apologize for the lack of clarity. All scenarios were used in this figure. We will clarify this in the text, caption, or figure.

  - Coloring the scatter plot after the snow cover fraction within the corresponding virtual detector footprint may add valuable insights.

- We agree that coloring the scatter plot by the snow cover fraction may yield valuable insights. We will revise the figure accordingly.

- Figure 8:
  - The choice of red as a color for agreement seems counter intuitive. Green may be a better choice (the significance of that color needs to be indicated in the legend).
  - We understand the reviewer's comment about our choice of color, however, selecting a decent color to contrast with the blue is a challenge. Green may not be the best choice if we want to have a figure that is colorblind friendly. We can potentially change it to orange, but feel the red color serves the purpose of being visible and distinguishable from the background colormap.

  - All maps miss a scale bar.
  - We will add a scale bar to all figures that show maps.

  - The exponential character of the SWE color bar should be displayed with exponential color increments.
  - This comment is similar to a previous comment about exponential color increments. Please refer to our response above that includes Figures R5 and R6.

References:

Palomaki, R. T. and Sproles, E. A.: Assessment of L-band InSAR snow estimation techniques over a shallow, heterogeneous prairie snowpack, Remote Sensing of Environment, 296, 113744, https://doi.org/10.1016/j.rse.2023.113744, 2023.