Response from the authors for review of 'Proposed improvement of the detection and measurements of light precipitation in the Canadian Arctic'.

We thank the reviewer for reviewing our manuscript and for the helpful comments and suggestions. We have carefully considered each point and provide our responses below. Where appropriate, we have undertaken additional analyses and revised the manuscript to address the reviewer's comments. We believe these revisions have improved both the clarity and scientific content of the manuscript.

Reviewer 1

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General comments

RC1.1: This paper studies light precipitation events in the Artic, critical to estimate total snow depth but poorly measured by traditional weighing precipitation gauges. The authors use precipitation radar (MRR) data to complement the measurements of a collocated snow gauge in Northern Territories, Canada, during the winter season 2023-2024.

The MRR is considered as the reference, as unlike the snow gauge it is able to capture light precipitation events. This result is assessed by manual observations during an intensive observation period (IOP) near the end of the winter. Raw precipitation from the snow gauge are beforehand corrected using a wind-dependent function from Colli et al, 2020 that heavily affects precipitation rate. After this adjustment, the method proposed by the authors consists in gap-filling the light precipitation events missed by the snow gauge with the MRR data.

While the paper is clear, concise, well referenced, and uses very valuable data in a harsh environment, I find that its conclusions are somewhat limited as the adjusted precipitation accumulation over the whole season without the "MRR-filling" method proposed by the authors is closer to the reference. This point is not discussed in the paper. Also, the snow gauge accumulated snowfall with the gap-filling method is greater than the MRR's, which is not realistic.

Moreover, I do not understand why data from another collocated snow gauge (Wilfried Laurier University (WLU) instruments) are not used to complement the study, maybe with different acquisition parameters or sample rate. Higher-frequency data for the snow gauge (for instance every minute) seem to me important to assess more precisely consistency with the radar.

I would also have appreciated a better assessment of the role of wind conditions at the site. Indeed, under strong wind and blowing snow conditions the snow gauge could be expected to overestimate snowfall as precipitated snow may be remobilized in the atmosphere.

Response: Thank you for reviewing our manuscript and for these thoughtful general comments. We are pleased that the reviewer found the manuscript to be clearly written and recognized the value of the observations collected in this challenging Arctic environment.

We agree that the original manuscript did not sufficiently emphasize the complementary roles of the Geonor precipitation gauge and the MRR. Our intention was not to present the MRR as a reference instrument, but rather as a complementary observing system capable of detecting periods of low-intensity snowfall that are not well represented in the operational hourly Geonor precipitation record. Likewise, the Geonor was not treated as a definitive reference measurement, as it is itself subject to uncertainties associated with wind undercatch and the operational reporting threshold. We have revised the manuscript to better emphasize that the study combines two independent observing systems with different strengths and limitations, and that no single instrument can be considered a complete reference for snowfall measurements in this remote Arctic environment.

Several of the points raised in these general comments prompted additional investigation during the revision process. We undertook a sensitivity analysis using the Haukeliseter wind-undercatch transfer function in addition to the Marshall coefficients used in the original manuscript. This analysis demonstrated that changing the wind-undercatch correction also changes the optimized MRR Z-S relationship, illustrating that the calibration chain is coupled rather than independent. Although the Haukeliseter transfer function increased the corrected Geonor seasonal snowfall, recalibration of the Z-S relationship resulted in a higher RMSE and slightly lower correlation than obtained using the Marshall coefficients. We have therefore retained the Marshall transfer function and expanded the discussion to describe this sensitivity.

The reviewer also raises several important points regarding the WLU precipitation gauge, the availability of higher-frequency Geonor data, and the influence of wind and blowing snow. These topics are addressed individually in the responses below, and the manuscript has been revised to clarify these aspects of the methodology and discussion.

Specific comments

RC1.2 Fig. 2: if I understand correctly, the instruments in the front of the picture are not those used in the study. If so, I find it quite confusing and suggest using another picture.

Response: Thank you for this comment. We agree that the original photograph could be confusing, as several of the instruments visible in the foreground were not used in this study. We are currently searching our image archives for a more suitable photograph that better represents the instrumentation used during the study period. If a more appropriate image is available, Figure 2 will be replaced in the revised manuscript. Otherwise, the figure caption and accompanying text will be revised to clearly identify the instruments used in this study and distinguish them from those shown in the photograph.

RC1.3 l122: I do not understand why the fact that the WLU snow gauge is used for "research purposes" prevents from using the data. It would be very interesting to compare snowfall rates between the 2 collocated snow gauges to get an estimation of the ECCC Geonor uncertainty. Moreover, are higher frequency "raw" data available for the snow gauges? This would allow to see if light precipitation events are detected in the raw instantaneous data and maybe smoothed out afterwards.

Response: Thank you for this comment. We agree that an independent collocated precipitation gauge would have provided a valuable comparison. However, the Wilfrid Laurier University (WLU) Geonor dataset contains substantial gaps during the study period, including no data prior to January 2024 and several extended outages thereafter. In addition, many of these gaps were subsequently filled using observations from the collocated ECCC Geonor gauge. Consequently, the WLU dataset does not provide an independent reference for evaluating the ECCC measurements and was therefore not included in the analysis.

With respect to the availability of higher-frequency Geonor data, no such dataset was available for this study. We intentionally used the publicly available hourly ECCC Geonor observations because these are the data products available to the majority of hydrologists, ecologists, and other environmental scientists who may wish to apply the methodology presented in this paper. As such, the temporal resolution and 0.2 mm reporting thresholds were not under our control but are representative of the operational ECCC precipitation products available across Canada. We also note that the hourly wind-bias-adjusted precipitation dataset from the ECCC automated surface observation network (*CanAdjAutoP hly*) is not available for the Trail Valley Creek station.

The manuscript has been revised to clarify why the WLU observations were not used and to explain the rationale for using the publicly available ECCC hourly precipitation data.

RC1.4 The Geonor datasheet specifies sensitivities finer than 0.2 mm for all models. I also suggest you specify the model / capacity in the description of the instrument.

Response: Thank you for this comment. We agree that our original description could be interpreted as referring to the intrinsic sensitivity of the Geonor instrument, whereas the 0.2 mm value relates to the publicly available hourly ECCC precipitation product used in this study. We have revised the manuscript to clearly distinguish between the instrument characteristics and the reporting threshold of the operational dataset.

We have also expanded the instrument description to identify the precipitation gauge as the Geonor T-200B weighing precipitation gauge with, to the best of our knowledge, a 600 mm capacity, which is the standard configuration used by Environment and Climate Change Canada at this site.

RC1.5 l135: why do you use the parameters from Marshall and not Haukelister? Are the Marshall conditions more similar to TVC? If so, I think it should be specified.

Response: Thank you for this comment. Following the reviewer's suggestion, we performed a complete sensitivity analysis using both the Marshall and Haukeliseter wind-undercatch transfer functions. This required recalculating the wind-adjusted Geonor precipitation, re-deriving the site-specific MRR Z-S relationship, and reprocessing the MRR-derived snowfall estimates.

Using the Haukeliseter transfer function increased the corrected Geonor seasonal snowfall from 172 mm to 209 mm. However, recalibration of the MRR *Z-S* relationship produced a higher *RMSE* (4.37 mm compared with 2.37 mm) and a slightly lower correlation ($R = 0.70$ compared with 0.72) than obtained using the Marshall transfer function. Although the final combined Geonor + MRR seasonal snowfall also increased (230 mm compared with 215 mm), the agreement between the MRR-derived and Geonor-derived daily snowfall amounts was poorer.

This analysis highlighted that the wind-undercatch correction and the site-specific Z-S relationship are not independent. Changing the wind correction alters the snowfall amounts used to calibrate the MRR, resulting in a different optimized *Z-S* relationship. Consequently, the entire retrieval chain must be considered when evaluating alternative wind-undercatch transfer functions.

Although the Marshall site was initially selected because its gauge configuration and exposure were considered more representative of Trail Valley Creek than Haukeliseter, we believe the additional sensitivity analysis provides quantitative support for this choice. The manuscript has been revised to explain the rationale for selecting the Marshall transfer function and to discuss the sensitivity of the final snowfall estimates to this choice.

RC1.6 l137 : I do not understand why you use the same extrapolation as Colli et al 2020 to compute the 2-m wind from the 10-m measurements at TVC. If I am correct, it has been derived over grass (see their Fig. 1d) and therefore roughness length will be very different. They used z0 = 1 cm; for bare snow a more typical value is z0 = 1 mm.

Response: Thank you for this comment. We revisited the derivation of the wind-speed adjustment used by Colli et al. (2020) and Kochendorfer et al. (2017). We confirmed that the conversion factor U2 = 0.71 U10 was derived using a logarithmic wind profile with z0 = 1 mm, not z0 = 1 cm. This roughness length is representative of snow-covered terrain and is consistent with the value suggested by the reviewer for bare snow.

Although the Marshall site may appear grass-covered in the figure referred to by the reviewer, according to the text Kochendorfer et al. (2017) derived the adjustment using snowfall periods, when the surface was treated as snow covered. We have revised the manuscript to clarify the origin of the 0.71 conversion factor and to state explicitly that it is based on z0 = 1 mm.

RC1.7 l141: how was this threshold defined? During the post-processing? Is it internal to the snow gauge? As light precipitation events undetected by the Geonor are crucial in this study I think this point should be developed.

Response: Thank you for this comment. We agree that this point was not sufficiently clear in the original manuscript. The 0.2 mm threshold is not an intrinsic characteristic of the Geonor instrument, nor was it introduced during our post-processing. Rather, it reflects the reporting threshold of the publicly available hourly ECCC precipitation dataset used in this study.

We have revised the manuscript to clarify this distinction and to explain that the Geonor itself is capable of resolving much smaller changes in bucket weight. However, because the objective of this study was to evaluate a methodology that can be applied using operational ECCC precipitation products available to the wider hydrological and environmental science communities, we elected to use the publicly available hourly dataset. Consequently, the reporting threshold is an inherent characteristic of the dataset used for the analysis rather than the measurement capability of the instrument itself.

This clarification has been incorporated into the revised manuscript.

RC1.8 l156: the MRR "agrees well" with the Geonor. I think it is important to quantify the consistency between the 2 instruments at this point to grasp the percentage of events the snow gauge misses. If the MRR is considered as the reference, you could be inspired from Sect. 2.4.3 of Roussel et al, 2023 (https://doi.org/10.1002/qj.4463) that statistically evaluates the detection of daily snowfall occurrence in coastal Antarctica.

Response: Thank you for this comment. We agree that a quantitative assessment of the consistency between the Geonor and MRR observations is valuable. However, our intention was not to treat the MRR as a reference instrument against which the Geonor was evaluated. Rather, the objective of this study was to investigate how two complementary observing systems, each with different strengths and limitations, can be combined to improve the characterization of low-intensity snowfall.

Unlike the study by Roussel et al. (2023), which we understand evaluates the detection capability of one observing system relative to another, our methodology uses the wind-adjusted Geonor observations to derive a site-specific Z-S relationship for the MRR. The calibrated MRR is then used to identify and quantify periods of light snowfall that are not well represented in the operational hourly Geonor dataset.

Consequently, a conventional event-detection analysis would not be appropriate, as the two datasets are not independent.

To clarify this point, we have revised the manuscript to better describe the complementary roles of the Geonor and MRR observations and to avoid implying that either instrument is treated as a definitive reference. We have also clarified the methodology used to derive and apply the site-specific Z-S relationship.

RC1.8 l164: why observations are not possible during winter? Is it due to harsh weather, or polar night?

Response: Thank you for this comment. Routine manual observations are not possible during the Arctic winter because the Trail Valley Creek research station is not occupied from late autumn until early spring (typically November to April) owing to its remote location and the logistical challenges associated with maintaining personnel on site. For this study, we brought forward the seasonal opening of the research station to conduct the Intensive Observation Period (IOP), allowing manual observations to be collected during late March and early April 2024.

One of the long-term objectives at Trail Valley Creek is to improve unattended winter observations through the deployment of advanced instrumentation, including the MRR, optical disdrometers, and ceilometers. However, maintaining reliable autonomous observations in the Arctic remains challenging, and considerable logistical effort is required simply to sustain continuous meteorological measurements throughout the winter. We have revised the manuscript to clarify why routine manual observations are not available during the winter months.

RC1.9 l172 : using the detection threshold of the camera to separate between snow and light precipitation is an ingenuous idea! Maybe you should provide a bit more details about this instrument, such as its reference.

Response: Thank you for this comment. We agree that the methodology could be described more clearly. The macrophotography system consisted of a Nikon DSLR camera fitted with a macro lens (shown in Fig. 4d), following the methodology described in Thériault et al (2019) and Thompson et al. (2023).

We have revised the manuscript to clarify that the classification between snowfall and light precipitation was not based on a detection threshold of the camera itself. Rather, it was based on the particle collection methodology. If sufficient hydrometeors accumulated on the black velvet collection pad to permit a series of macrophotographs to be acquired, the observation was classified as snowfall. If precipitation particles were present but insufficient particles accumulated for routine photography, the observation was classified as light precipitation. This adaptation proved to be more reliable than using a snow board to identify trace snowfall under the windy conditions encountered at Trail Valley Creek.

RC1.10 l190: were the MRR switching vertical resolution described in l150 used? Why didn't you use the 70 m level?

Response: Thank you for pointing this out. The reviewer is correct that our description of the MRR processing was not sufficiently clear. The lowest range gates (35 m and 70 m) were not used in the analysis. Instead, reflectivity from the 105 m, 140 m, and 175 m range gates was averaged to derive the near-surface reflectivity used in this study.

The 35 m and 70 m range gates are commonly discarded in MRR studies because they are more susceptible to near-field effects and other measurement uncertainties. We have revised the manuscript to correctly describe the range gates used in the analysis.

RC1.11 l192 : Wiener et al 2023 (https://doi.org/10.5194/essd-16-821-2024) used higher-frequency snow gauge data to test the sensitivity of the Z-S relation to time averaging at Dumont d'Urville, Antarctica. They found that "the parameters a and b are approximately independent of the integration time".

Response: Thank you for bringing this study to our attention. We have now reviewed Wiener et al. (2023) and appreciate the comparison. Their finding that the optimized *Z-S* relationship is relatively insensitive to the temporal averaging interval provides additional confidence that the use of hourly Geonor observations in our study is unlikely to have substantially influenced the derived *Z-S* relationship.

Unfortunately, higher-frequency Geonor observations were not available for the Trail Valley Creek site, and therefore we were unable to perform an equivalent sensitivity analysis. As discussed in our response to the previous comment, we intentionally based our methodology on the publicly available hourly ECCC precipitation dataset, as this represents the operational data product available to the wider hydrological and environmental science communities.

We have cited Wiener et al. (2024) in the revised manuscript and briefly discuss the implications of their findings in the context of our methodology.

RC1.12 l197: I did not understand the argument…

Response: Thank you for this comment. We agree that our wording was unclear. Our intention was not to imply that a mismatch in temporal resolution inherently requires the use of a fixed *Z-S* relationship. Rather, because independent snowfall measurements were only available from the hourly Geonor observations, there was insufficient information to derive a time-varying site-specific *Z-S* relationship. Consequently, a single optimized *Z-S* relationship was calibrated for the study period and then applied to the higher-temporal-resolution MRR observations. We have revised the manuscript to clarify this explanation.

RC1.13 l208: to my knowledge, b can also be < 1 (e.g., Grazioli et al, 2017, Wiener et al 2023). Did you check lower values of b as well?

Response: Thank you for this suggestion. Following the reviewer's recommendation, we expanded the parameter search to include values of bzs less than 1.0, as reported by Grazioli et al. (2017) and Wiener et al. (2024). However, no improvement in the optimized *Z-S* relationship was obtained. The resulting relationships produced poorer agreement between the MRR-derived and Geonor-derived daily snowfall amounts and did not improve the overall performance metrics. We have revised the manuscript to note that values of bzs < 1 were evaluated but did not improve the site-specific calibration for Trail Valley Creek.

RC1.14 l210: the method to derive the Z-S relation seems very robust, but I would have liked to see the cloud point with the best fit to get an idea of the data dispersion. Besides, this relation is established on snow events only (i.e., precipitation strong enough to exceed the snow gauge threshold). Would you know if / how the results would be impacted when you fill the light precipitation events in the snow gauge data, using the MRR light precipitation computed from heavier precipitation?

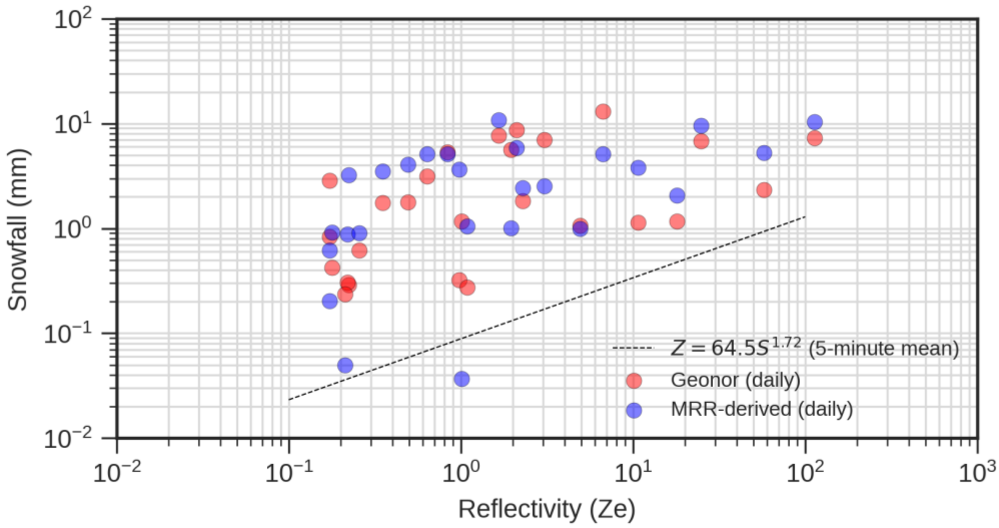
Response:
Thank you for this suggestion. We produced the requested figure (shown below), however, in doing so we realized that our original description of the methodology was not sufficiently clear. The figure appears different from a conventional Z–S relationship because the coefficients a_{ZS} and b_{ZS} were **not** derived by fitting a regression to concurrent reflectivity and snowfall observations.

Instead, the coefficients were obtained through an optimization procedure designed to reproduce accumulated snowfall. Following Schoger et al. (2021), MRR effective reflectivity from the 105, 140, and 175 m range gates was first averaged over five-minute intervals. We then performed an exhaustive parameter search by evaluating 10,000 candidate Z–S relationships, using 100 uniformly spaced values of a_{ZS}between 10 and 100 and 100 uniformly spaced values of b_{ZS}between 1.0 and 2.0. For each candidate relationship, every five-minute reflectivity observation was converted to snowfall using Eq. (3), and the resulting five-minute snowfall estimates were summed to daily accumulations. These daily MRR-derived accumulations were then compared with the corresponding daily accumulations measured by the adjusted Geonor gauge. The optimal coefficient pair was selected by maximizing the coefficient of determination (R^2) while simultaneously minimizing the RMSE and the difference in total seasonal snowfall.

The attached figure illustrates why this optimization differs from the conventional derivation of a Z–S relationship. The dashed line represents the optimized relationship ($a_{ZS} = 64.55$, $b_{ZS} = 1.72$), while the red and blue points represent the observed Geonor daily snowfall totals and the corresponding MRR-derived daily snowfall totals, respectively, plotted against the mean five-minute MRR reflectivity for each day. Because the optimization was performed on the **daily accumulated snowfall obtained by integrating all five-minute estimates throughout each day**, rather than by fitting a regression to the daily mean reflectivity, the optimized coefficients are **not expected to pass through the centre of this scatter**. Consequently, this figure should not be interpreted as a conventional reflectivity–snowfall regression.

For this reason, we believe that including this figure without the accompanying explanation could inadvertently suggest that the coefficients were derived using a conventional regression-based approach, which was not the case. Instead, we have substantially revised the Methods section to clarify the optimization procedure used to derive the coefficients and to explicitly distinguish it from the conventional regression-based derivation of a Z–S relationship.

With respect to the reviewer's second question, the light snowfall events were intentionally excluded from the Z–S calibration because they represent the unknown quantity that the MRR is intended to estimate. Including MRR-derived snowfall for these events in the calibration dataset would introduce circular reasoning, as the Z–S relationship would effectively be calibrated using snowfall estimates produced by the same relationship. We therefore restricted the calibration to events for which independent snowfall measurements from the wind-adjusted Geonor were available.



RC1.15 l220 : is the snow gauge housing heated? If so I guess snow cannot accumulate into capping. With higher-frequency data it would have been possible to set a threshold discarding unrealistically large instantaneous values corresponding to capping events; but those may be smoothed out with an hourly average.

Response: Thank you for this comment. The Geonor gauge used at Trail Valley Creek is not heated. To the best of our knowledge, operational federally operated weighing precipitation gauges in Canada are not equipped with heated collectors. Consequently, snow accumulation and capping can occur under appropriate conditions.

We agree that higher-frequency observations would provide an opportunity to identify and remove isolated, unrealistically large precipitation increments that may be associated with capping events. However, only the publicly available hourly ECCC precipitation dataset was available for this study, and therefore such an analysis was not possible. We have added a brief discussion of this limitation to the revised manuscript.

RC1.16 l229: given the huge impact of the adjustment on the Geonor values, did you test the sensitivity of the function? For instance, by taking the Haukelister parameters?

Response: Thank you for this suggestion. Following the reviewer's recommendation, we performed a complete sensitivity analysis using both the Marshall and Haukeliseter wind-undercatch transfer functions. This required recalculating the wind-adjusted Geonor precipitation, re-deriving the site-specific MRR *Z-S* relationship using the adjusted Geonor observations, and reprocessing the MRR-derived snowfall estimates.

Using the Haukeliseter transfer function increased the corrected Geonor seasonal snowfall from 172 mm to 209 mm. However, the recalibrated *Z-S* relationship produced poorer agreement between the MRR-derived and Geonor-derived daily snowfall totals, with the *RMSE* increasing from 2.37 mm to 4.37 mm and the correlation decreasing slightly (R = 0.72 to 0.70). Although the combined Geonor + MRR seasonal snowfall also increased (215 mm to 230 mm), the overall agreement between the two observing systems was reduced.

This exercise demonstrated that the wind-undercatch correction and the site-specific *Z-S* relationship are not independent. Altering the wind correction changes the snowfall amounts used to calibrate the MRR, resulting in a different optimized *Z-S* relationship and, consequently, different MRR-derived snowfall estimates. We have revised the manuscript to discuss this sensitivity and to explain why the Marshall transfer function was retained for the final analysis.

RC1.17 l242: Are you sure these values are given in dBz and not in mm6/m3? 400 dBz seems a lot.

Response: Thank you for identifying this error. The reviewer is correct that the values reported in the manuscript were reflectivity (mm^6 m^{-3}) rather than reflectivity expressed in dBZ. We have corrected the manuscript accordingly and now report reflectivity in dBZ, consistent with standard practice in the radar meteorology literature.

RC1.18 l246: I do not understand this sentence. You did explicitly define a Z-S relation for TVC in Sect. 2.5, didn't you?

Response: Thank you for pointing this out. We agree that the original wording was unclear. Our intention was not to suggest that a Z-S relationship was not defined in this study. Rather, we meant that this study presents the first site-specific MRR Z-S relationship developed for Trail Valley Creek. As this is the only Micro Rain Radar operating in the region, no site-specific MRR Z-S relationship had previously been derived. The manuscript has been revised to clarify this point.

RC1.19 l269: if the snow gauge is not heated sublimation inside the housing would be negligible, wouldn't it?

Response: Thank you for this comment. We agree that sublimation of snow already collected within the unheated Geonor bucket is likely to be negligible. Our intention was instead to refer to the potential sublimation of snow adhering to the inside of the gauge housing or inlet before reaching the collector. We expect this effect to be small and unlikely to have a measurable influence on the seasonal snowfall total. To avoid ambiguity, we have revised the manuscript to clarify this point.

RC1.20 l297: I wonder if comparing the new amount to the unadjusted value here is relevant, as most of the increase is due to the adjustment and not to the MRR correction. The important value seems to me the +24%.

Response: Thank you for this comment. We agree that comparing the final total with the unadjusted Geonor measurement in this context is misleading, as most of the increase results from the wind-undercatch correction rather than the addition of MRR-derived light snowfall. The purpose of this section is to quantify the contribution of the MRR, and therefore we have revised the manuscript to emphasize that incorporating the MRR observations increased the adjusted Geonor accumulation by 24%. The comparison with the unadjusted Geonor total has been removed from this section.

RC1.21 Fig.7: I wonder if this Figure is necessary, as it shows an example of a particular event. I would have been more interested to see a mean/median MRR snowfall profile. Plus, the data is smoothed by the colorbar, especially for subpanels (a) and (c). If you want to keep the figure, I suggest to refine the colorbar ranges.

Response: Thank you for this comment. We agree that the original figure could be improved. Since our intention was illustrate a specific light snowfall event that was detected by the MRR but not by the operational weighing precipitation gauge, and this being the central motivations of the study, we believe that retaining a case-study figure provides a useful demonstration of the methodology and its application.

In the revised manuscript, we have redesigned the figure to better illustrate this event. The reflectivity panel has been retained, while the Doppler velocity and spectral width panels have been replaced with MRR-derived precipitation rate and supporting near-surface meteorological observations. These additional panels provide greater context for the event and more clearly demonstrate the atmospheric conditions associated with the light snowfall. We have also revised the colour scales to improve the visibility of the radar observations.

RC1.22 l348: did you try to discard data when wind speed exceeds a given threshold, such as done in Wiener et al, 2023?

Response: Thank you for this suggestion. We did not investigate the effect of excluding periods with wind speeds exceeding a prescribed threshold, as was undertaken by Wiener et al. (2024). Our objective was to evaluate the methodology using the complete observational record available at Trail Valley Creek, rather than restricting the analysis to a subset of lower-wind conditions. We agree that investigating the sensitivity of the derived Z-S relationship to wind-speed thresholds would be an interesting avenue for future work, particularly as longer datasets become available from the site.

RC1.23 l351 : if you want to measure blowing snow in the future, you could install 2 FlowCapts (Chritin et al, 1999, https://doi.org/10.1016/S0165-232X(99)00012-9) on top of each other between 0 and 2 m. Although not very precise quantitatively, they are fairly reliable to detect blowing snow events and operate on low energy.

Response: Thank you for this helpful suggestion. We were not previously aware of the use of paired FlowCapt sensors for detecting blowing snow events and appreciate the recommendation. We agree that this approach could provide a practical, low-power means of identifying periods of blowing snow at remote Arctic sites. Other instrumentation to detect blowing snow is installed at TVC; however, it has been affected by technical issues and data were not available for the period of this study.

RC1.24 l360: however, to complement the discussion, climate models are able to simulate very light snowfall and conversely struggle to simulate the heavier snowfall events (Roussel et al 2023, Wiener et al 2023).

Response: Thank you for this suggestion. We agree that this provides useful context and have expanded the discussion accordingly. We have incorporated these references into the discussion section in the revised manuscript to provide a broader perspective on the importance of accurately characterizing snowfall across a range of intensities.

Technical corrections

RC1.25 l65 : about atmospheric rivers in Antarctica, I suggest a more recent and general paper : Wille et al 2025, Nature (https://doi.org/10.1038/s43017-024-00638-7)

Response: Thank you for this recommendation. We have updated the manuscript accordingly and now cite Wille et al. (2025) in place of the previous reference.

RC1.26 l77-79: I do not understand the sentence; I suggest a reformulation.

Response: Thank you for this comment. We agree that the original sentence was not clearly worded. We have revised the manuscript to better convey that uncertainties in catchment water balance estimates increase because winter snowfall is frequently underestimated at observation sites owing to measurement biases, while snowfall remains unmeasured in areas where observations are sparse or unavailable.

The sentence now reads: *"Closing catchment water balances remains particularly challenging because winter snowfall is frequently underestimated at observation sites due to measurement biases, while snowfall in many remote regions remains poorly observed or entirely unmeasured."*

RC1.27 l86: a reference was not found

Response: Thank you for noticing this. The error has been fixed.

RC1.28 l157: benefit instead of benifit

Response: Thank you. This has been corrected

RC1.29 l233: Arctic (with an upper case)

Response: Thank you. This has been corrected

RC1.30 l256: I suggest: of no precipitation nor blowing snow.

Response: Thank you, the wording has been revised as suggested

RC1.31 l259: upper cases for Intensive Observation Period?

Response: Thank you. This has been corrected.

RC1.32 l256: the -1 is not exponent

Response: Thank you. This has been corrected.

RC1.33 l297: I think you forgot a "by" 24%

Response: Thank you. This has been corrected.

We again thank the reviewer for their thoughtful comments, which have helped improve both the clarity and scientific rigour of the manuscript.