We thank the two anonymous reviewers for their time in reviewing the revised version of the manuscript. In the following, the answers to the reviewers' comments and questions are given in red. Line numbers, if not stated otherwise, refer to the original version of the manuscript and may have changed in the revised version.

Reviewer #1:

General comments

The authors have substantially improved the manuscript by removing the section on the MRR, reorganizing the text, clarifying the focus, and improving the figures. The responses to the reviewer comments are also excellent. I really appreciate the careful work by the authors, and I am pleased with the changes made to the manuscript. The paper now reads very well, and I truly enjoyed reading it. I have only a few minor comments and typos to point out.

Specific comments

L. 153: It is unusual to introduce a figure by referring only to subfigure (b). Consider swapping (a) and (b). Also, it would be helpful to include the all-time average of monthly precipitation frequencies for daily >0 mm and daily >1 mm, in addition to the reported range.

We swapped the sub-figures a) and b) and also added the all-time average values for the monthly precipitation frequencies for daily >0 mm and daily >1 mm in the text.

L. 274: The word "stick" is a bit informal in scientific writing. Suggested revision: "we rely on thecorrected Pluvio data."

changed

Figure 6: The legend does not fully represent the figure. The black and dark gray bars appear with white fill inside. Please update the legend accordingly.

The legend has been updated.

Table 3 caption: "the TS method" should likely be "the TMS method."

changed

Reviewer #2:

The author addressed most of the comments and I really thank them for the effort they put in this work. I think the remaining issue is the lack for a real discussion on your results. For example the separation between solid and liquid precipitation is close to 2°c, which is very high compared to other studies taking frequently 1°c. You need to explain why it is that high and to show the implications for other studies. Is the snow falling between 0 and 2°c really able to stick the ground? (which is the main interest for most studies).

Please see the answer to this comment with respect to the comment on l.314

You also do not really discuss previous studies on linking precipitation and atmospheric circulation. What other studies have shown? How your study improve what was previously shown?

We actually present different studies regarding the impact of atmospheric circulation on precipitation at Svalbard (lines 71-88 in the new version). To better highlight this topic, we separated the paragraph in the introduction from the discussion on extreme precipitation events. We also shifted the findings from Serreze et al. (2015) from the results part to the introduction. Until now, no study has specifically associated atmospheric rivers, cyclones, and fronts with Ny-Ålesund precipitation, to which we could compare our results. A direct comparison with the study by Lauer et al. (2023) is difficult since it focuses on only two shorter time periods and larger Arctic domains. We comment on this in lines (new version ll. 408-411).

However, concerning extreme precipitation in Svalbard, our results are in line with the findings of Serreze et al. (2015): we see enhanced water vapor transport with pressure patterns favoring water vapor transport from the lower latitudes. We comment on this in l. 465-467 (new version). Serreze et al. (2015) did not specifically look into specific weather systems and also did not quantify the relative contribution of these systems to precipitation.

For the method I also have one concern: Why you don't compare your results with the Wolff method used in Champagne et al.? Using the ensemble mean correction introduced a bias between methods, so it is hard to separate the origins of the error here.

Please see the answer to the comment with respect to the comment on l.262

Here are some specific comments:
l.12 : you mean days with highest daily rate ?

Yes. We changed the sentence to:

"Extreme events, defined as days with daily precipitation sums above the 98th percentile, contribute 18% to the total precipitation amount."

l.13 : with fronts and high liquid mass fraction

changed

l.16 : comma between variable and crucial ?

We rephrased the sentence to:
"Precipitation is a key climate variable that is critical to the Arctic climate system."

l.30 : lapse rate of what ?

It is the temperature lapse rate. With regard to Arctic amplification, "lapse rate feedback" is a common name. We thus stick to this wording.

See, for example
Linke, O., Quaas, J., Baumer, F., Becker, S., Chylik, J., Dahlke, S., Ehrlich, A., Handorf, D., Jacobi, C., Kalesse-Los, H., Lelli, L., Mehrdad, S., Neggers, R. A. J., Riebold, J., Saavedra Garfias, P., Schnierstein, N., Shupe, M. D., Smith, C., Spreen, G., Verneuil, B., Vinjamuri, K. S., Vountas, M., and Wendisch, M.: Constraints on simulated past Arctic amplification and lapse rate feedback from observations, Atmos. Chem. Phys., 23, 9963–9992, https://doi.org/10.5194/acp-23-9963-2023, 2023.

l.39 : trend of precipitation

changed

l.59.60 : I don't understand how increase in inter-annual variability suggest that extreme precipitation is becoming more likely. Explain.

Since both, the mean of precipitation and its variability increase, extreme precipitation events are more likely. Bintanja et al. (2020) explicitly state in their abstract: "Because both the means and variability of Arctic precipitation will increase, years/seasons with excessive precipitation will occur more often, as will the associated impacts." Please see also the discussion section in Bintanja et al. (2020): "Increased precipitation variability on top of rising mean precipitation rates can potentially exert severe consequences (10), since both increase the likelihood of wet extremes (21) with large and possibly irreversible hydrological/ecological (e.g., water availability, marine productivity, and permafrost thaw), societal (e.g., local communities), and economic (e.g., infrastructural damage) impacts (10, 22–26). Extremely wet episodes are thus likely to become far more common in the Arctic's (near) future; the unusually wet autumn/winter of 2015/2016 and 2016/2017 in Svalbard (causing a number of climate refugees to abandon their homes) may already have signaled the emergence of extreme Arctic precipitation events along with their long-lasting impacts."

l.58-82 : I think this paragraph would fit better before the previous one to increase the flow of idea.

We thought of about changing the order of the paragraphs. However, since the importance of precipitation phase is highlighted in the lines 33-47, the paragraph on the discrimination phase comes naturally afterwards. We can see that different ways of the logical flow are possible but we would like to stick to the current one.

l.89:94 : maybe it is a bit too detailed here. Some details can be in method section.

We mention these details here because this paragraph also highlights what is new about this data set compared to other studies using classical manual precipitation gauges.

l.145 :10 or 20 %?

The catch efficiency and, thus also the improvement of using a windshield depends on the type of the shield, type of precipitation, and wind speed. This is why the range of 0.1 and 0.2 is reported here.

l.151 : you can remove « made a choice here but want to »

removed “made a choice here”

l.151-153 not sure this is needed. Also in fig.2 why showing minutes and hourly resolution in the same graph ? It is a bit confusing. If parsivel is 1min resolution you can maybe put the pluvio minute resolution in the upper panel.

We assume that you are referring to lines 153-155 (old manucript). We swapped panels a) and b) as suggested by reviewer 1. Panel a) shows Pluvio data and Panel b) shows Parsivel data. For the Pluvio, we also report results in 1 min and daily resolution because often, precipitation data are only daily resolved. We think that this is useful to better understand the data set and the impact of data sampling.

l.183 : you mean from June to September ?

Yes, changed.

l.260-261 : where is the wind measured ? This can greatly impact the correction. It can be also the pluvio that gives better results. If the wind is measured in a open area, it would be stronger and could lead to an overcorrection of MET Norway data.

Champagne et al. (2024) used MET Norway wind speed measurements. The location of these measurements changed over time (see Fig. S1 in the Supplementary Material of Champagne et al (2024); https://doi.org/10.1175/JHM-D-23-0182.s1). For the overlapping time period with the Pluvio data, Champagne et al. (2024) took 10 m wind speed measurements from a Vaisala WAA 151 in the open measurement field (see Fig. S1 in the Supplementary Material by Champagne et al.). This location is about 160 m away from the BSRN station wind sensor that we used to correct the Pluvio data (see Fig. R1).

Figure R1: Location of Pluvio, MET Norway precipitation gauge and wind sensors. Google Maps.

Champagne et al. (2024) calculated the wind speed at gauge height (2 m) from the 10 m height wind speed measurements (Eq. 1 in Champagne et al. (2024)), assuming a roughness length of 0.02 and an average vertical angle of obstacles around the gauge of 12. This wind

speed estimate is very uncertain; on the one hand, due to the logarithmic extrapolation to 2 m, on the other hand, due to the distance to the MET Norway precipitation gauge. Even though they tried to include effects of the surrounding buildings on the wind speed, the wind speed estimate is still quite uncertain. For the Pluvio measurements, we use wind sensor measurements at the same height, which are only about 40 m away from the Pluvio. So these wind speed measurements should be a very good estimate for the actual wind speed at the Pluvio.

Furthermore, Champagne et al. (2024) used wind speed measurements at 0600, 1200, and 1800 UTC to correct the precipitation measurements while we used minute resolved wind speed and precipitation data, resulting in a better temporal matching, i.e. using the actual wind speed at the time when precipitation was observed. All these aspects might result in the observed differences between the corrected precipitation data from Pluvio and the MET Norway gauge.

We expanded the discussion about the differences between der Pluvio and MET Norway data sets in the manuscript (new version ll. 259-303) and also adapted the outlook section (new version ll. 538 ff).

l.262 : I don't know if it's because of the Wolff method. It can be as you said that the wind is larger at the pluvio site than at the MET Norway site.

If we just compare our results to the corrected precipitation data of Champagne et al. (2024) using the Wolff et al. (2015) only method with 2m wind speed, the differences are even slightly larger (see Fig. R2).

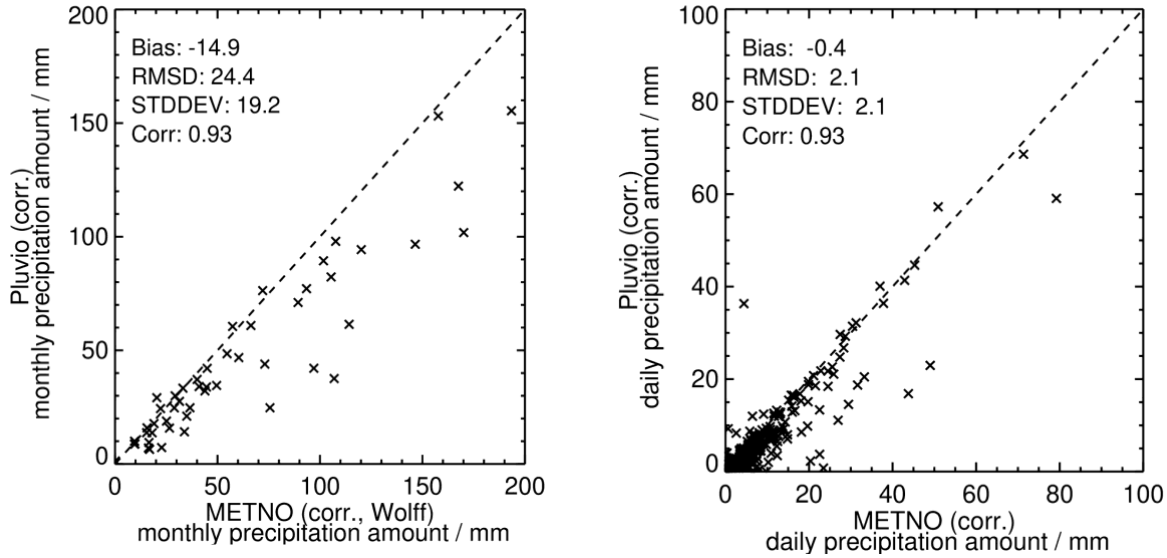

Figure R2: Scatter plots of monthly (left) and daily (right) precipitation sums at Ny-Ålesund for 1 August 2017 – 31 December 2021. Corrected monthly precipitation amount of MET Norway precipitation gauge (Wolff et al. (2015) correction from Champagne et al., 2024) vs. Pluvio (with Wolff et al. (2015) correction).

So the differences in the Pluvio and MET Norway precipitation data sets are not only due to the usage of different corrections functions but likely also related to the different temporal resolutions/data sampling (1 min vs. 12 h resolved data, sampling of T and wind speed data), different T and wind speed data sets, and differences in how the wind affects the

measurements due to the different locations. On the one hand, it might be that the wind effect is overestimated in Champagne et al. (2024), on the other hand, the undercatch correction of Pluvio might be too small. Different data sampling and different temporal resolutions of the data sets also have quite some impact on the corrected precipitation amount. As mentioned in the manuscript, Jacobi et al. (2019) resampled the high-resolution precipitation data by Pluvio and Geonor to 1 h and 24 h intervals, respectively. For the temporally coarser resolved data, the correction was much larger, no matter which correction function was applied (see Table R1).

Table R1: Accumulated precipitation at Ny-Ålesund covering a full hydrological year from Sep 2017 to Sep 2018 based on three different precipitation sensors and different corrections functions(Førland and Hanssen-Bauer (2000); Wolff et al. (2015)) applied to different temporally resolutions (from Jacobi et al, 2019).
Førland, E.J., Hanssen-Bauer, I. Increased Precipitation in the Norwegian Arctic: True or False?. Climatic Change 46, 485–509 (2000). https://doi.org/10.1023/A:1005613304674

Annual accumulation 2017-2018

		Correction according to			
		F & H-B (2000)		***Wolff (2015)***	
Accumulation	***Observed***	*24-hr*	*1-hr*	*24-hr*	*1-hr*
Manual	657	817	·/·	790	·/·
Pluvio	589	770	705	731	673
Geonor	588	781	709	748	670

Yearly precipitation sums increased by about 70–80 mm when the 24 h resolved data were used.
In the present study, we cannot fully explain the differences between the data sets. A more detailed comparison, also between Geonor and Pluvio, which are installed in the same field, is needed to gain a better insight into the uncertaintes.

We expanded the discussion about the differences between der Pluvio and MET Norway data sets in the manuscript (new version ll. 259-303) and also adapted the outlook section (new version ll. 538 ff).

l.264-l265 : the absolute difference is simply because corrected precipitation are higher than uncorrected ?

We removed this sentence from the manuscript and expanded the discussion on the differences (new version ll. 259-303).

l.314 : 1.8°c ? It seems high compared to other studies ! You need to discuss on that.

In Champagne et al. (2024), a 1°C threshold is used to separate snow and rainfall. They do not further comment on why they chose that threshold but in the conference contribution by Jacobi et al. (2019), a similar threshold has been presented (see Fig. R3)

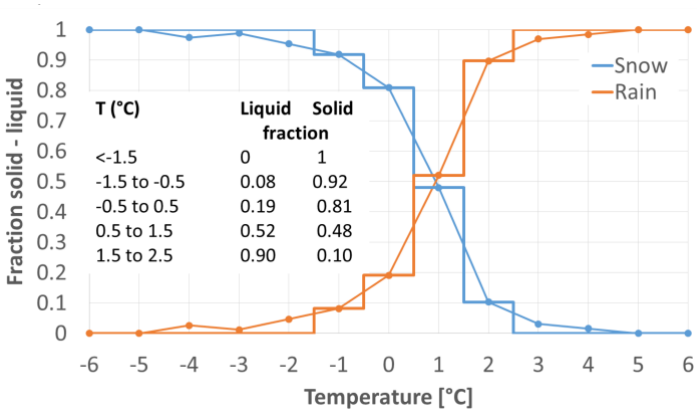

Figure R3: Solid and liquid fraction for the daily precipitation as a function of daily mean temperature. The data was derived using visual observations and recorded temperatures from the period 1975-2007 (from Jacobi et al., 2019).

They show that solid and liquid precipitation equally occur at around 1°C±0.5°C. Their analysis is based on 24h accumulated precipitation measurements, 24h averaged temperatures and weather observers' reports of precipitation type. The latter is of course subjective. Furthermore, the reported 24h mean temperature is not the actual temperature at which precipitation occurred. They also considered a different time period (1975-2007). This is why the solid/liquid fraction as a function of temperature likely differs.

We added a discussion on this in ll. 342-349.

l.316-325 : It is not clear to me what is the temperature based mass separation ? You simply use the % mass fraction per temperature that was derived from parsivel?

Yes. This is exactly how it is written in the manuscript. We explicitly refer also to Fig. 5 b.

Also you used the corrected precipitation data in the calculation of liquid precipitation ? You need to clarify here.

Yes, we use the corrected precipitation data for all analyses in section 3.2 and the following. We mention this at the end of section 3.1: "For the following analyses, we rely on the corrected Pluvio data using the Wolff et al. (2015) method."

We changed the sentence to:
"To split the corrected Pluvio precipitation amount into solid and liquid for the whole period August 2017 to December 2021, …"

We also changed the captions of Tables 3 and 4 and Figs. 8 and 11 to make clear that the results are based on corrected Pluvio data.

Figure 6 : I don't see dark grey bars, I see white bars. What are these white bars representing? Table 4 : wouldn't be better to write 'no system' instead of residual?

We changed the caption to:
"Figure 6. a) Total monthly precipitation (in mm) from corrected Pluvio data (black contour bars). The corresponding liquid precipitation amount (in mm) from the combined Parsivel/temperature-based mass separation (Parsivel/TS; filled red bars) and the monthly liquid fraction (in %, dotted line) are shown as well. b) Differences in monthly liquid

precipitation amount (in mm) if the temperature-based mass separation (TMS; dark gray contour bars) or a simple temperature threshold of 1◦C (T1◦C; filled light gray bars) is used."

In Lauer et al. (2023), precipitation amount that could not be attributed to a weather system was called "residual". We thus use the same term.

337-341 : I don't understand what you did here

The question is if differences in the used temperature thresholds in different studies are due to different data sampling, i.e. 1 min in our case and 1 h (as for example, used in Champagne et al. (2024)). Thus, we wondered if resampling our highly resolved data to hourly data would result in a different liquid/solid fraction-temperature relationship. However, this is not the case.

l.355 : you should talk about the average before talking about the monthly average.

We swapped the order of the sentences:

"On average, fronts occur 14% of the time at Ny-Ålesund. Monthly front occurrence (separated and co-located) shows maxima of more than 20% in summer or late summer."

l.363 : precipitation amount ?

We changed this sentence to:

"….to the total precipitation amount from Aug 2017 to Dec 2021."

l.372 : here you should talk about the long term average before the specific months.

This is unclear to us. In l. 372, we talk about the long-term average:
"Regarding the whole time period, separated fronts contribute only about 4% to the total precipitation. "

We prefer to keep the paragraph as it is.

l.384-385 : AR has a higher occurrence in summer as well

We had a closer look into the data again and a substantial amount of precipitation for both ARs and fronts falls in the warmer months May to September. Specifically, this is 49% of the precipitation associated to ARs and 56% of the precipitation related to fronts.

We thus rephrased the sentence to:
"The high liquid fraction of precipitation related to ARs and fronts is also due to the fact that a substantial amount of precipitation associated with these weather systems, i.e. 49% for ARs and 56% for fronts, falls in the warmer months May to September."

We also added numbers on the frequency of occurrence of fronts and ARs in summer vs. other months when presenting Fig. 7.

"A seasonal dependency is not clearly evident from this short period, although the occurrence of ARs is slightly higher on average in summer (12%) than in the other months of the year (7%)."

and

"On average, front occurrence in June, July and August is 24% compared to 10% during the other months of the year."

l.389-392 : what is the value of these graphs for your analysis? You don't compare hourly with daily here.

To our knowledge, hourly precipitation rates have not been characterized yet for Ny-Ålesund. This is of high interest not only for process studies but also for model comparisons in the future. In addition to total (monthly, yearly) precipitation, hourly (and daily) precipitation rates are relevant for the hydrological cycle. Before discussing the impact of the weather systems on precipitation on hourly and daily scales, we would like to present the general characteristics of precipitation at Ny-Ålesund first. What are typical hourly/daily precipitation sums? Which events would be regarded as extreme events? We do not intend to compare hourly with daily data.

l.395 : « Hourly liquid precipitation amounts are typically between 0.1–1.0 mm (25th and 75th percentiles) ». I am not sure this is needed.

We prefer to keep this sentence.

l.389-402 : I am wondering how much of the higher liquid precipitation with AR and FR is due to higher occurrence of AR and FR in summer.

See answer to previous comment.

l.402 : maybe it needs two digits here. It may be 0.04 and not 0?

It is 0~mm. Since there are many no-liquid precipitation cases in the residual class, the median value is indeed 0. This is why we didn't include a further digit.

l.403-419 : I don't really understand how this part is related to what you talked about right before. I think it needs to be later in the manuscript (in a discussion part?) and needs clarity on what is the purpose of this discussion part.

The high-resolution Pluvio measurements make it possible to assess the amount of precipitation on different temporal scales (instead of just characterizing daily or monthly precipitation data). Section 4 presents the impact of different weather systems on precipitation amount and type at Ny-Ålesund. To get an overall picture, we focus first on the monthly and whole-time characteristics before zooming into smaller time intervals, i.e. hourly and daily.

Looking just at the monthly data does not give us information about the timing of the precipitation. In addition to the monthly precipitation amount, the precipitation rates on shorter time scales are important.
We added a sentence at the beginning of section 4 to clarify this flow of thoughts.

“We first have a look at the monthly and whole-time statistics before zooming into hourly and daily precipitation data. As outlined in section 1, not only the total precipitation amount but also the precipitation intensity is a decisive variable for the Arctic climate system”

l. 421-422 : where do you find that ?

We changed the sentence to:

“When focusing on the right tail of the distribution of the daily precipitation amounts, in particular on the 2% of the days with the highest precipitation amounts (Table 6), we find from inspection of ERA5 reanalysis data (not shown) that all of these events are related to enhanced water vapor transport from the North Atlantic or Eurasia, often in the form of ARs and in combination with fronts.”

l.443 I wouldn’t say they are common. I would say they could occur.

changed

l.459 : « The temperature dependency of the mass separation follows the temperature relation of the phase occurrence ». not very clear, reformulate.

We rewrote the sentence:

“The temperature dependence of liquid/solid mass separation is similar to the temperature dependence of liquid/solid precipitation occurrence.”

l.460 : you could say this suggest that hourly resolution is enough for phase separation.

Applying a temperature-based mass separation method will still result in uncertainties for both minute-resolved and hourly-resolved precipitation data. So when there is Parsivel information in high-temporal resolution, also precipitation data in high temporal resolution is preferred. So, we would not generally say that hourly resolution is enough for phase separation.

l.464 : 6 to 15 % depending on the years ?

Yes, we mentioned “annual liquid precipitation sums”.

Your conclusion is maybe a bit too much detailed. It needs to point out your significant results and the novelty of your work compared to previous studies.

We believe that the main points are presented in a concise way. The summary and conclusions section is divided into 7 paragraphs following the logical order of the manuscript:

1) Outline of the study with instrument setup highlighting the advantage of the new measurements as well as weather system analysis which has not yet been applied to Ny-Ålesund data
2) Main outcomes of phase discrimination analysis using Parsivel and temperature data
3) Discussion on the limitation of Parsivel measurements and outlook for future validation of Parsivel measurements
4) Main outcomes of impact analysis of weather systems on precipitation at Ny-Ålesund (total amount, monthly amount, and hourly intensities)
5) Main outcomes of daily precipitation amount analysis incl. trace precipitation and extreme events
6) Discussion on uncertainties of precipitation estimates and outlook on future comparison studies
7) Discussion on weather system definition and outlook in future usage of auxiliary data sets

Paragraph 3) could have been shifted also to the end, but we found it easier to follow the logical flow if this is discussed directly after the presentation of the corresponding main results.

Overall the manuscript has been greatly improved.

Thank you very much. We really appreciate your detailed comments.