Reply #2

Dear Reviewer,

We thank you for the comments on the revised version of the manuscript. Choosing case studies is probably always a way of cherry picking. However, we fully agree that we want to show the comprehensive benefit of the proposed method, despite the challenges we faced while applying it to the whole PS106 campaign data. Hence, we ran the radiative transfer simulation with the improved input for the whole campaign period. We have extended the manuscript with an analysis of how often it was possible to apply the proposed method and on the frequency of the challenges. We show how the proposed method has increased the quality of the radiative transfer simulations during the periods where the correction could be applied.

In the course of applying the requested revisions we have noticed an inconsistency in the calculation of the radiative effect of the LLS during the presented case study. In the first versions of the manuscript, we have reported the deviation between the simulation and the observation for the whole day of the case study, not, as it was supposed to be, for the presented period only. Based on these numbers, we have then calculated the radiative effect of the LLS as difference of the two simulation runs. In the updated manuscript we now report the deviation between the simulation and the observation for the period of the case study only. Finally, to derive the effect of the LLS on the radiative budget, we have averaged the differences between the two simulations only for those moments where the criteria as proposed in the manuscript in Section 2.3 (LLS present in addition with different LWP from Cloudnet and HATPRO) were fulfilled. The text in the manuscript was revised accordingly (lines 261-267 in the diff version of the manuscript).

Here our detailed answers to your comments (comments from the Report #2 are given in black, our replies in blue). We have updated the manuscript accordingly and provide line numbers to the diff version of the revised manuscript.

Comment 1
Can you provide some statistics in the manuscript about how often low-level stratus cloud situations occur, for how many cases the cloud properties retrieval method can be applied, for how many cases not and for which reasons (% values)

The frequency of LLS occurrence was presented in Griesche et al. (2020) and was determined as 25% of the observation time. The criteria for the LLS correction presented in this manuscript (LLS occurrence + LWP disagreement) were fulfilled during 15% of the time.

The frequency of occurrence of the following challenges was determined:

- Ship superstructure caused shadowing of the radiometers: 10% of the time
- No reliable LWP: 18% of the time

(Note that both challenges may have been occurred during the same time.)

After removing these periods, the criteria for the LLS correction (LLS occurrence + LWP disagreement) were fulfilled during 11% of the observational time. For these periods we have applied the proposed correction of the LLS and did run the radiative transfer simulations.

Based on these data, we have calculated the relative error for both the standard and the scaled T-CARS input for the solar (SD) and terrestrial (TD) downward radiative fluxes after removing periods where shadow effects and unreliable LWP were detected. The frequency of occurrence of the respective errors for those periods where the correction was applied is shown in Figure 1. The occurrence of a relative error below 50% for the SD fluxes increased from 15.6% to 71.4% of the time, when applying the proposed correction method. For the TD fluxes, the occurrence of a relative error below 5% increased from 15.8% to 86.7% of the time.

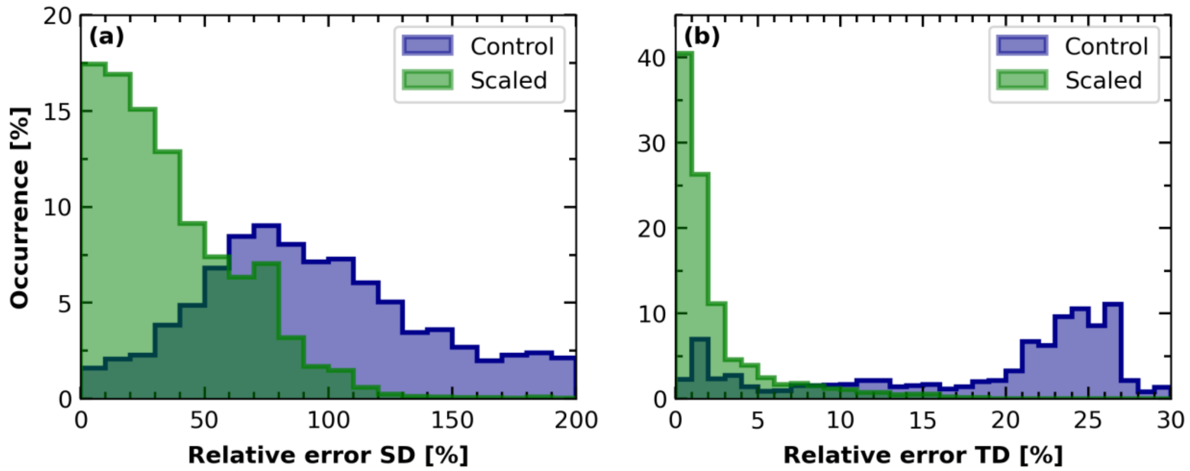

Figure 1: Frequency of occurrence of the relative error between the Control and the Scaled simulation and the observed broadband downward radiative fluxes for the data points where the correction was applied during PS106.

The manuscript was updated accordingly. We added a new Subsection 3.2 (lines 268 - 283) and revised the Abstract (lines 13 - 15) and the Discussion and conclusion (lines 335 - 342) accordingly.

Comment 2

Why are you sure that this method will better work for the MOSAiC measurements? In many situations (very low sun angle, broken clouds,…) you will probably have the same issues. Can you already provide corresponding numbers as mentioned in comment 1 but for the MOSAiC data set to give more confidence in the applicability for upcoming studies as mentioned in the outlook?

During the year-long MOSAiC expedition, we were able to collect a sufficient amount of good-quality data to cover different meteorological scenarios during a complete annual cycle. Low-sun elevation angles may only play a role during the summer half of the expedition period. Additionally, there were installed several broadband radiometers on board Polarstern and in the vicinity of the icebreaker on the ice floe, which will allow a complete comparison without the interference of the ship's superstructure. We revised the paragraph on the MOSAiC plans in the Discussion and conclusion accordingly (lines 360 - 369).

Comment 3

You should consider the application of the improved cloud retrieval method independently of the fact that the 1D radiative transfer simulations can be applied or not. You can still apply the cloud retrieval to all PS106 cases where possible and provide some overall statistics of Arctic LLS properties. The radiative closure study/analysis of cloud radiative effect might not be possible for all these cases due to for example 3D effects but this is another issue and might be solved in future by using a 3D radiative transfer code. Having an improved cloud microphysical data set of LLS is already quite an achievement. But here you need to clearly demonstrate the applicability. What are the limitations and how could you improve this in future (related to comment 1)?

The LLS retrieval was already applied to the whole PS106 campaign, and the results were presented by Griesche et al. (2020). We apologize that this was not made clear before. The manuscript has been updated accordingly (lines 114 and 271). Related to this comment, please see also the answer to Comment 1 for more details. In the future, we aim to automatize the method and embed it into the coding routines of the Cloudnet algorithm for the MOSAiC expedition. In this way, the Cloudnet microphysical products tailored for the Arctic region would already be corrected for the LLS occurrence in the Arctic and could, for example, be applied in comparable radiative closure studies or other cloud related studies. We extended the discussion on the MOSAiC data to inform the reader about these plans (lines 360 - 369).