Reply to Referee#2 on Manuscript # acp-2021-1064 in ACPD: "Evaluating seasonal and regional distribution of snowfall in regional climate model simulations in the Arctic" by Lerber et al.

We are extremely grateful and naturally very happy for the reviewer#2 to make such an encouraging review. We appreciate for the comments to improve the overall readability of the paper and to indicate us the parts that needed further explanation.

We have included the reviewer comments below in bold and italic, and responded to them individually following the numbering. The individual comments and responses are followed by the revised text, with changes highlighted with colours: deletions in red and additions in blue.

1. Line 239-240: "Multiple scattering …. not considered in these computations", does this mean that the model-to-observation process does not include multiple scattering? If so, how does this affect the comparison?

Yes, correct. The scattering computations in PAMTRA are not considering the multiple scattering effect, but the single scattering approximation is assumed to be valid. As stated in the lines 239-240, the effect of multiple scattering "…can be approximately 1 dB in snowfall with reflectivity values greater 10-15 dBZ". These numbers are from the study of Matrosov and Battaglia, 2009. There it is also stated that the reflectivity enhancement due to multiple scattering can be as high as 5 dB in heavy stratiform snowfalls in W-Band and that multiple scattering effects counteracts with signal attenuation. Thus, in the two comparisons we have in model-to-observation space, i.e. the CFTDs (Figure 7.) and reflectivity profiles (Figure 8.), the multiple scattering would influence particularly at the warmer temperatures and lower altitudes, respectively, where assumably the snowfall intensity is heavier.

In case of the CFTDs, we study the temperature region up to -10°C. It can be assumed that most likely the multiple scattering should not play a major role as the reflectivity region is mostly below 0 dBZ, and according to the results, even considering the attenuation, the model sees higher reflectivities in these -15 - -10 °C temperatures. However, with the study of mean reflectivity profiles at low altitudes the multiple scattering may be the explanation, why it seems that observed reflectivities at the surface are higher than the model estimates when the attenuation is considered. And reasoning for this is not that the model overestimates the attenuation as assumed in the manuscript, but that multiple scattering counteracts the attenuation in the observations. With this in mind, we have changed the sentences in lines 506-508:

"Generally, it seems that the modeled attenuation is higher than actually seen in the observations, especially during summer months. This difference could also (at least partly) be explained with multiple scattering effects which would counteract attenuation (Matrosov and Battaglia, 2009). However, without considering attenuation in the simulations, the model overestimation increased by more than 10 - 20%."

Commented [SC1]: I am still unhappy with this sentence – how can you know? Or maybe I forgot an explanation

Commented [vLA(2R1]: In the mean modeled profiles with the attenuation, the observed CloudSat reflectivites were increasingly higher than modeled ones when closer to the surface. If attenuation was not considered HIRHAM5 modeled higher reflectivites closer to the surface.

2. Section 3.2: suggest to add more details on the procedure of using the Jenkinson-Collison method for circulation weather type classification.

The revised chapter is now:

~~In order~~ To better identify reasons for potential deviations between observations and HIRHAM5, we also composite snowfall maps for different distinguishable weather regimes and evaluate the model output to observations in each regime separately as performed in Akkermans et al. 2012. Separating the daily modeled and observed snowfall rates according to an external parameter allows us to identify possible systematic model biases related to synoptic processes. In this study, we chose to investigate regimes of large-scale atmospheric circulation classified by strength, direction, and vorticity of the geostrophic wind.

~~Here, w~~We selected two sub-regions of the northern North Atlantic around Svalbard (Fig. 3d) covering the latitude band of 70° N - 81° N. The regions East (40° E - 10° E) and West (20° W - 10° E) are considered such that the East region is directly north of Scandinavia and includes Svalbard while the West region avoids land regions and is placed between Greenland and Svalbard. Both areas are characterized by high synoptic variability with frequent cyclone passages. The regime classification was performed with ERA-Interim 6-hourly 850 hPa geopotential height and shear vorticity for the studied period with the methodology of Jenkinson-Collison (Jenkinson and Collison, 1977, Philipp et al. 2016). The geopotential at 850 hPa is used to avoid topographic and boundary layer effects. The Jenkinson – Collision method is an automatic classification scheme (Philipp et al. 2016), where the geostrophic wind speed and vorticity at high/low central pressure are assessed in horizontally and isotropically arranged grid points and based on threshold values are set to eight exclusionary directional classes according to compass points (N, NE, E, SE, S, SW, W, and NW) and two vorticity circulation regimes (cyclonic (C) and anticyclonic (AC) (Akkermans et al. 2012)).

The daily regime classification of the two sub-regions (West/East) is specified with the software package *cost733class* of the COST Action framework (Philipp et al. 2016) and the occurrence of each regime for both sub-regions are determined. Clearly, the northerly, southerly, and both vorticity classes are by far most frequent with an occurrence of 16% (25%), 12% (10%), 31% (38%), and 34% (32%), respectively for the East (West) sub-region. To simplify the analysis, the less frequent NE (6 % (7%)) and NW (9% (6 %)) were added to the northern regime typically representing situations when cold Arctic air masses move southward. Similarly, SW (7% (10%)) and SE (8% (3%)) were added to the southern cluster which is a typical situation for warm air intrusions into the Arctic. Finally, we divided the modeled and observed daily mean snowfall rates to these four regimes and calculated the contribution to the yearly mean snowfall rate to each regime separately.

3. Caption of Figure 7: The number at the end didn't show up correctly in the pdf text.

Corrected.

4. Figure 9: Panel c was not labeled.

Corrected.