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Discussions

Interactive comment on "Snow-induced buffering in aerosol–cloud interactions" *by* Takuro Michibata et al.

Johannes Mülmenstädt (Referee)

johannes.muelmenstaedt@pnnl.gov

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I have reviewed "Snow-induced buffering in aerosol–cloud interactions" by Takuro Michibata et al. The authors present an interesting set of sensitivity studies that show that prognostic snowfall in their GCM strongly reduces ERFaci compared to diagnostic snowfall, in large part because the longer residence time of snow leads to greater collection of cloud water by snow, which reduces the relative importance of warm phase ACI. Based on my own work, I think this is a plausible mechanism. There are a few potential weak links in the argument, which I will point out below. I don't think those should hold up publication of this potentially very useful result; after all, no paper is ever the final word on any topic. I recommend minor revisions to clarify the points I list below.

Major points

l. 110: The tuning strategy needs to be described in more detail. The worry with retuning is that the ERFaci difference may not be due to the change that was intentionally made, but due to the retuning.

l. 170 ff.: This is a question rather than a comment. From the conclusion of the paper, I would have expected the relationship between ΔLWP and ΔSWP to be the opposite – that when there is more snow, it would lead to more efficient removal of liquid cloud water. Would you mind making these plots separately for supercooled and non-supercooled water?

Minor points

l. 39 ff.: I don't think this argument is logically consistent. First, the authors say ERFaci in GCMs is "too negative" compared to satellite studies (I would prefer "more negative", since satellite studies have their own problems). But then they cite a (problematic) satellite study with a very negative SW ERFaci to argue that the problem is with the models' LW ERFaci. The rest of the paragraph is fine, but I would suggest removing the first two sentences.

l. 111: Didn't Ghan (2013) show that the change in cloud radiative effect is not a good estimate of ERFaci because it contains pieces of ERFaci and ERFari?

l. 130: It might be worth pointing out that the Heyn et al. (2017) behavior *is* present in the zonal mean distribution (wherever SW ERFaci becomes stronger [weaker], LW ERFaci also becomes stronger [weaker]), but not in the global mean.

Fig. 3: The legend should say what the aggregation is, i.e., are the box and whiskers calculated based on monthly mean grid boxes? Also, in my mind, "susceptibility" implies susceptibility to a measure of aerosol; I would call the LWP, RWP, and SWP changes ΔLWP etc.

l. 190: See my comment about retuning above. For example, in Mülmenstädt et al. (2020), https://doi.org/10.1126/sciadv.aaz6433, we found that ERFaci is fairly insensitive to the cloud droplet number exponent but very sensitive to the liquid water mixing ratio exponent and the overall normalization in the Khairoutdinov and Kogan (2000) autoconversion scheme. If the retuning strategy for the change in N_c exponent involves changing other parts of the autoconversion, that may result in an overly strong apparent ERFaci change. Of course, which parameters ERFaci is sensitive will vary between models.

l. 210: Is this list complete? E3SM has prognostic snow (Rasch et al., 2019), and I believe GISS Model E3 does too. HadGEM3 may do so as well.

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