

Atmos. Chem. Phys. Discuss., referee comment RC2
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Comment on acp-2022-259

Alex Schuddeboom (Referee)

Referee comment on "Southern Ocean cloud and shortwave radiation biases in a nudged climate model simulation: does the model ever get it right?" by Sonya L. Fiddes et al., Atmos. Chem. Phys. Discuss., <https://doi.org/10.5194/acp-2022-259-RC2>, 2022

This study successfully extends an increasingly popular tool for model analysis (cloud cluster analysis) in several innovative ways. The most important development is the introduction of an approach for comparing the performance of a model when cloud type is correctly simulated to when it is not. This is made possible through the usage of nudged model input and provides previously undiscovered information on the quality of model simulation of these cloud types. While limited to one model, this study provides a pathway to determining the answer to a fundamental research question in this field ("If models can accurately simulate cloud types, what will the impact on the biases in other cloud variables be?"). There are some places within the manuscript where the text could be updated to be more clear or concise and a few methodological queries that I feel need to be addressed. Otherwise, I believe this is an outstanding paper.

Major Comments:

In the current manuscript the normalisation of the cloud top pressure - cloud optical thickness joint histograms is ambiguous. For the majority of prior papers using these histograms, they are normalised by the cloud fraction value so that the sum of the cells of the histograms add to the cloud fraction value. If I had to guess based on figure 2, each of the histograms in this study are normalised to a value of 1 (I could be wrong about this). If this is the case it will have some implications on the interpretation of the results with respect to prior studies. This alternative normalisation could be justified by arguing the paper's focus is on phase and vertical structure which may be better captured with this approach, however currently I cannot find any discussion of this in the paper and it should definitely be discussed. While not expected in this paper, it could be interesting to compare results of these different normalisations.

I am surprised by the lack of discussion of supercooled liquid water throughout the manuscript. There are several places, particularly in your results, where I think some

discussion is warranted. Many of your results show too much ice fraction and not enough liquid in key cloud types which is indicative to me of issues with the model representation of supercooled liquid water. Some good places to add this would be the paragraph starting on line 273, the discussion of figure 7-9 and the conclusions.

There are some figures that are passingly discussed in the text but not currently in the paper which would make great additions to an appendix. In particular, I am thinking about the phase property versions of Figure 5 and the individual sub-region versions of Figure 6. I know I would be interested in seeing those figures and the most appropriate place via ACP guidelines appears to be in an appendix.

Minor Comments/Typos/Suggested Text Changes:

Line 7: Sentence starting on this line should be simplified due to its complex clausal structure.

Line 20: Consider changing "simulation by models of cloud properties" to "simulation of cloud properties within models"

Line 46: Consider changing "compensate the" to "compensate for the"

Line 84: I think something has gone wrong with the citation formatting here

Line 153: Can you please be more specific about the identification of clear sky cases and their removal from the dataset

Line 190: I think you have cited the wrong paper by mistake here. From what I can see Pendregosa 2011 does not have that information.

Line 201: Sentence starting on this line is a little clunky. Perhaps change to something along the lines of them being defined globally and only examined in detail over the Southern Ocean

Section 3 could possibly do with some references to past paper which have identified similar seasonal (Bodas-Salcedo et al. 2012) or spatial (eg. Kuma et al. 2020) biases

Line 225: Consider changing "less zonal" to "less zonally coherent"

Figure 1 appears to have an issue where some rows are more magnified than others leading to some straight edges

Line 261: I think "indicating that this is a complex system to understand" should be changed to something that stresses the behaviour in the system is complicated in place of how understandable it is.

Line 282: Simplify the wording of "using 12 clusters for five years of daily-mean joint histograms"

Line 288: Consider deleting "while this is important to note,"

Figure 3 and 4: The last sentence in the caption is a little unclear and awkwardly worded. Consider simplifying.

Line 327: Consider deleting "region of interest"

Line 328: Consider rewording "are spatially consistent in sign and for some, magnitude" as it is a little confusing.

Line 333: The sentence stating on this line may need some rewording as it could imply you do not look at subregions instead of the intended meaning that non-SO data is excluded.

Line 371: I found the wording of the first three sentences of this paragraph quite hard to follow. I would suggest rewriting them with an emphasis on clarity.

Section 5.2.1 even though it is incredibly rare, a sentence discussing the extreme phase based biases shown in the TC class could be a valuable addition here.

Line 401: The transition to a new sentence discussing mid-level clouds feels off, because I assume the previous sentences were already discussing them. I think this could probably

just be resolve with some more clear wording

For figures 7-9 I think the exact definition of the total column is unclear. I can't determine if it shows the overall biases associated with accurately simulated clouds or with all clouds. If it is showing for both "incorrectly" and "correctly" represented cloud types combined, it could be interesting if there was a way to decompose this information and show each independently. Regardless of if this is possible or not, some text needs to be added clarifying what this column represents.

Line 446: The sentence starting on this line is confusing due to its clausal structure. Can you simplify the sentence or split it into two.

Line 449: Consider deleting the "For" at the start of the sentence.

Line 454: Please simplify "Considering now what may be contributing to"

Line 531: I think the sentence starting on this line is a little confusing and would benefit from being rewritten.

Line 533: Consider deleting "biases, again whether the cloud regime is correctly simulated or assigned as something else,"