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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Evaluation of Southern Ocean cloud in the HadGEM3 general circulation model and MERRA-2 reanalysis using ship-based observations" *by* Peter Kuma et al.

Anonymous Referee #2

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Review Kuma et al: ' Evaluation of Southern Ocean cloud in the HadGEM3 general circulation model and MERRA-2 reanalysis using ship-based observations' (MS No.: acp-2019-201) The authors conducted analysis of three model datasets by focusing on the Southern Ocean to understand errors in models in the shortwave (SW) radiative flux at the top-of-the-atmosphere, using ship observational dataset as well as satellite observations to understand the errors. They found that GA7 runs and MERRA-2 runs have the opposite bias in the outgoing SW flux (underestimate in GA7, overestimate in MERRA-2) over the southward latitude of 55S. They compared their cloud amounts with the ship observations and showed that both models underestimate their cloud amounts. They also conducted nudged-runs and showed that there is a big dif-

ference in cloud liquid water amount in these models, concluded that the main source of the difference in their SW bias is from the difference in their cloud properties, which are determined by the sub-grid cloud parameterizations. The shortwave bias over the Southern Ocean tends to be a common problem in climate models. This is a nice piece of work which contributes to improve our understanding of the representations of clouds over the region. However, current manuscript misses some information for their logic to convince readers, hence the key message remains unclear. I suggest this paper to be published after a minor revision. Main comments: Although GA7 runs and MERRA-2 runs have the opposite bias in the outgoing SW flux over the southward latitude of 55S, both HadGEM3 GA7 and MERRA 2 underestimate cloud amount. In Discussion section, the authors mentioned that models may fail to represent fog or low cloud which are generated by convection which are induced from subzero airmass from polar regions over warm water. What our community is keen to know is whether we can improve the representations of such clouds in GCM or we should seriously start thinking of using cloud resolving model or GCM. Whether/how much the underestimate of the cloud amount improves in their nudged runs will provide a clue for it. The authors should add a figure which shows cloud amounts in free run and nudged runs. The authors showed that main difference in SW radiative flux bias over the Southern Ocean between HadGEM3 GA7 runs and MERRA 2 runs is cloud water amount. This shows a big impact of subgrid cloud parameterizations on radiation. Please check subgrid cloud parameterizations in GA7 and MERRA2 then discuss which parameterization could potentially cause the difference in radiative flux. Since the authors showed the opposing sign of the SW CRE south and north of 55S in GA7.1, it would be useful to apply the same analysis (comparison to the ship observations, analysis of the nudged runs) to the region of the north of 55S, confirm whether the smaller error is because of the (less worse) representations of the cloud amount over the region. Minor comments: Discussion: the beginning (L1-10) was difficult to read, because the authors mention the opposing sign of the SW CRE south and north of 55S in GA7.1, but then solely talk about the results over the south of 55S. Figure 6: Clarify what is the weight for the

weighted average. Figure 8: add grid values to the Frequency axis P11-l1: ‘upwelling and downwelling’ Where are regions of upwelling and downwelling radiative flux? If the authors are talking about large scale circulation, these should be ‘ascent and descent’. P11-l4: I cannot see the results described about models. And the contrast between western and eastern sides of the Antarctic Peninsula contradicts to the following description ‘The zonal symmetry. . ..’ P11-l14: Figure 3p? P11-l32: ‘consistently positive’: negative in Sep-Dec in 60S-70S P11-l33: ‘also lower than GA7.0 and GA7.1’: not necessarily in GA7.1 P13-l14: Did you define SLL and LCL? (Super liquid level and lifting condensation level?) How did you define SLL? P13-l22: Give a speculation why min(SLL, LCL) is better correlated with CBH than SLL/LCL individually. P14-l5: Provide a figure or reference about SLL in GA7.0 is higher than observed. P14-l16: Fig 9. It is not clear why the authors create these plots over two different backgrounds. P14-l18: Fig 9. Not clear. Different colors should be used for different levels to show this. P14-l29: cloud cover a reduce ..’: typo? Fig 5: Why did the authors exclude 50S-55S for the plots? Fig 8: The authors did not analyze model results in other latitudes where clouds shows the opposite bias (in 50S-55S). P15-l10-11: I cannot follow the logic here. P16 l23: Is it possible to add the definitions of supercooled liquid in GA7.0 and MERRA-2? P17 l11: Is this a result from the nudged run or from other studies?

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