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Geoscientific Model Development Discussions

Interactive comment on "The Importance of Considering Sub-grid Cloud Variability When Using Satellite Observations to Evaluate the Cloud and Precipitation Simulations in Climate Models" *by* Hua Song et al.

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The authors explore the sub-grid variability assumed in COSP, which many studies use to compare observations to models. Use of SPCAM at 4km resolution allows the authors to examine the impact of resolving sub-grid variability on COSP.

I really like this paper and think it is very important to get it out there to allow people to better understand the abilities of COSP and that it shouldn't be applied fecklessly to any given model. Frequently COSP is used in studies as some sort of magical talisman that

bridges models and observations. This is rarely questioned as far as I can tell. As the authors point out in line 91 page 4, there are some basic resolution issues in coupling a GCM to COSP and trying to pull out something like a satellite pixel. I would almost suggest that the authors move their comments on line 91-98 into the abstract somehow so that people who just skim it will have this brought to their attention as it is critically important. However, this change is not required scientifically and may be disregarded by the authors. This paper will be a very useful reference in the COSP documentation for people trying to set their model up to run with COSP.

Thank you very much for the encouraging remarks. In our revision, we have revised our manuscript based on your helpful advices.

Line 126- convectional=convective **Ans**: This correction is done.

Line 129- it is worth noting that this is still in the so-called convective grey zone, for example: Field et al. (2017). Do you think your results would change much if you doubled your grid size?

Ans: Yes, 4-km resolution is still in the so-called convective grey zone. As mentioned in Field et al. (2017), it is common practice for models operating in the convective Grey Zone to simply switch off the convection parameterization somewhere in the resolution ranging between 500 and 5km. No, we don't think our results would change much if we doubled the grid size.

Line 186 'sub-columns are' **Ans**: This correction is done.

Line 262- Although not required, the authors might consider how this might contextualize results such as Nam et al. (2012).

Ans: We have added a sentence to contextualize the results from previous studies such as Nam and Quaas (2012) in our revised manuscript.

Line 374- The authors have focused on the warm rain process representation. This may be a very ignorant comment on my part, but I would be interested in how the evaluation of the first indirect effect in GCMs might be affected by the assumptions in homogeneous COSP. For example, most empirical studies of the first indirect effect utilize level 3 gridded data (McCoy et al., 2017a;Gryspeerdt et al., 2017;Bellouin et al., 2013;Quaas et al., 2008;Quaas et al., 2009), either using observed AOD/AI (Gryspeerdt et al., 2017) or reanalysis aerosol mass (McCoy et al., 2017a;McCoy et al., 2017b). These studies compare to level 3 aggregated cloud and aerosol from models and make statements regarding the ability of models to represent the first indirect effect. If the authors could comment on whether this is a valid approach that would be highly informative.

Ans: We have compared the simulated total cloud fraction by the MODIS, CALIPSO and CloudSat simulators, and the in-cloud properties by the MODIS simulator for the SPCAM5 and SPCAM5-Homogeneous simulations. As shown in the below figure (Figure S1), all the simulated cloud properties are influenced by the sub-grid cloud variability but to different extents. The CloudSat simulation is affected most notably since the calculation of radar reflectivity is strongly sensitive to the inhomogeneous distribution of cloud droplet size. To what extent these differences will influence the aerosol-indirect effect evaluation is beyond the scope of our study, but it'd be wise to keep in mind this potential uncertainty.

Figures 2 c-d are somewhat hard to parse.

Ans: Figure 2c shows the distribution of large-scale (red plus signs for frac$_{o}ut = 1)andconvective(blueplussignsforfrac_{o}ut = 2)cloudamongthesub - columnsgeneratedbytheSCOPSscheme, thevariablefrac_{o}utisproducedinthescops.froutine.$ $columnatcertainverticallevelisstratiformcloudyiffrac_{o}ut = 1, orconnectivecloudyiffrac_{o}ut = 2atthatverticallevel.Figure2dshowsthedistributionoflarg$ $scale(redplussignsforprec_{f}rac = 1), convective(blueplussignsforprec_{f}rac = 2), andmixed(greenplussignsforprec_{f}rac = 3)precipitationamongthesub - columnsgeneratedbytheSCOPS-PRECscheme(i.e., prec_{f}racfromprec_{s}cops.f).Wehavead$

$Pleasealsonotethesupplementtothiscomment:$
$https://www.geosci-model-dev-discuss.net/gmd-2018-13/gmd-2018-13-AC1-supplement.pdf$

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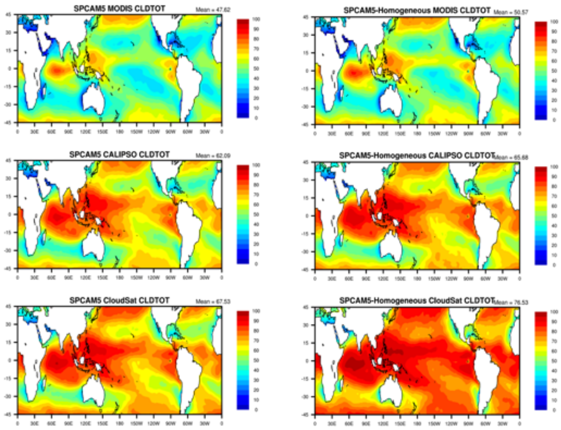
Total Cloud Fraction [%]



In-Cloud Properties of Liquid Cloud