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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Subgrid Variations of the Cloud Water and Droplet Number Concentration Over Tropical Ocean: Satellite Observations and Implications for Warm Rain Simulation in Climate Models" *by* Zhibo Zhang et al.

Anonymous Referee #3

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This paper discusses the GCM sub-grid scale variability of cloud water content and droplet number observed by MODIS, and the consequences this variability has for autoconversion parametrization in GCMs. This has become a popular topic in recent years with many papers discussing the cloud water content variability, although the attempts to discuss droplet number variability are particularly novel and welcome in this study. The paper is well written and interesting. I have compiled a list of relatively minor comments or suggestions that the authors may wish to consider.

General comment - the paper is very long, I'd encourage the authors to look for oppor-

tunities to be more concise in their descriptions and refrain from repetition of points.

L57 - the reference here should be Boutle et al. (2014, QJ) not Boutle & Abel (2012)

L60-62 - would be good to clarify a couple of things in these lines. Firstly, I think it would be better to refer to autoconversion and accretion "parametrizations" rather than "processes" - we shouldn't confuse the way we parametrize these things with physical reality, as there is not much overlap! Secondly, you should also clarify that you are ignoring variability in rain water content (qr) or Nc, as the nonlinearity of these (and correlations with qc) could strongly influence the result.

L92-95, 99-106 - this reads a little harshly on Boutle et al. (2014), who also used CloudSat data in their analysis to give a global perspective (and discussed the increase in variability from Sc to Cu and importance of co-variability on accretion). It might be worth mentioning the study of Hill et al. (2015, QJ) here as well, who extended this work to explicitly build in the regime dependence to the parametrizations. Also there is a typo on L104/5, which should say "cloud water variance is larger over the Cu region than over the Sc region".

L117-118 - again, might be good to clarify here - Boutle et al. (2014) and Lebsock et al. (2013) discuss the variation in rain water (which is distinct from cloud water). But you are correct that I'm also unaware of any studies looking at CDNC variability.

L194 - would be good to clarify here - it's not the LES that was important in KK2000, but the fact that they used a bin-resolved microphysics scheme, which accurately represented the physical processes of collision-coalescence, to derive the simple parametrizations

Figure 1d - I cannot see this referred to at all in the text, yet it shows something interesting/puzzling to me, namely a significantly different CDF of rain rate for the gamma and lognormal distributions of CDNC - can you explain why this is?

L256-260 - I'd always thought part of the argument for ignoring Nc is that its value

is typically linked to the underlying aerosol distribution, which varies on much larger spatial scales than qc, therefore the amount of Nc variability that would be 'sub-grid' is expected to be small/negligible.

L274 - please define CER as this has not been previously defined

L278 - brackets should be around the years only of Platnick et al. (2013,2017)

L344 - I'd say the current generation of GCMs are those being used for CMIP6, so perhaps update this and the reference (although 1x1degree still doesn't seem unreasonable for what many models are running)

L372 - should say "dominant" cloud types

L450 - I think there is something missing from this sentence - "this approach is more although it may be..."

Figure 6d - does not appear to be referred to in the text. It should either be discussed why it is relevant, or not shown.

L487-501 - given there is already a parametrization of v(f_liq) in existence, namely that of Boutle et al. (2014), it would be interesting and very easy to see how well their parametrization compares to the independent MODIS dataset generated in this study. It's probably too much work to investigate the Hill et al (2015) parametrization as that would require a way of determining from MODIS whether cloud is convective or not, but that would also be interesting.

L506-516 - it would also be worth noting that these fits are only applicable to a single model resolution, and so not as useful as existing parametrizations with inbuilt scale-adaptiveness.

L559 - there is reference to supplementary materials, yet I cannot find any?

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