We thank both reviewers and the editor for their time and thought in reviewing our paper. Reviewer comments are in black and our responses are in red. We are using the latexdiff to track changes and provide screenshots of changed text for the reviewers' convenience as well as a track changes version of the manuscript.

Reviewer #2

The authors present an updated version of their paper in which they addressed most of comments. I have few minor comments that should be addressed before publication. Line numbers refer to the manuscript version with tracked changes.

Minor comments

In my previous review, I inquired about the limitation of the analysis to model output associated with the stratiform scheme (i.e., excluding contributions from the convective scheme). The authors confirmed this limitation in their response. I strongly recommend that this important caveat be explicitly stated in the manuscript.
Additionally, it would be helpful to quantify the extent to which CAM6 low-level clouds over the SOCRATES domain are handled by the convective scheme. I suspect that the convective scheme may be frequently triggered during postfrontal cloud conditions, possibly due to elevated surface fluxes.

Response:

Thank you for this important follow-up. We have now explicitly stated in the manuscript that our analysis is limited to CAM6 cloud output from the stratiform cloud microphysics scheme (MG2), as the convective cloud scheme in CAM6 does not include prognostic microphysical variables such as cloud droplet number concentration (Nd).

To further address your comment, we examined the vertical profiles of in-cloud water content and Nd over the SOCRATES domain for both CAM6 and the observations (see Figures 14 and 15 in Zhou et al., (2021)). In CAM6, the majority of simulated Nd is concentrated below 2 km (Zhou et al., 2021) and is entirely controlled by the stratiform cloud microphysics scheme. Consistently, observations shows that high Reflectivity factor (associated with fronts or convection) is not typical of the shallow (cloud tops <2 km) and largely overcast stratocumulus sampled during SOCRATES (Kang et al., 2024) .

The convective scheme, while it may be triggered during postfrontal cloud conditions, does not contribute to Nd, as it lacks explicit microphysical calculations. Although the convective scheme can contribute to precipitation, this is beyond the scope of analysis in the present study.

We have clarified this point explicitly in the revised manuscript.

In this study, we focus exclusively on low-level, liquid clouds simulated by the stratiform (large-scale) cloud microphysics scheme (MG2) in CAM6, as CAM6's convective scheme does not include prognostic microphysical variables such as N_d, which is a key quantity in our analysis. As such, all N_d values analyzed in this study originate from the stratiform cloud scheme. Furthermore, we limit our comparison with aircraft observations to altitudes below 2 km, corresponding to the marine boundary layer and excluding a large potion of clouds formed by deep convection (Kang et al., 2024). The majority of simulated N_d in CAM6 is also concentrated below 2 km (Zhou et al., 2021). The convective scheme, while it may be triggered during postfrontal cloud conditions, does not contribute to N_d in CAM6. The convective scheme can contribute to precipitation, while this is beyond the scope of analysis in the present study.

Fig. 3 Please label the y axis.

Response: labeled.

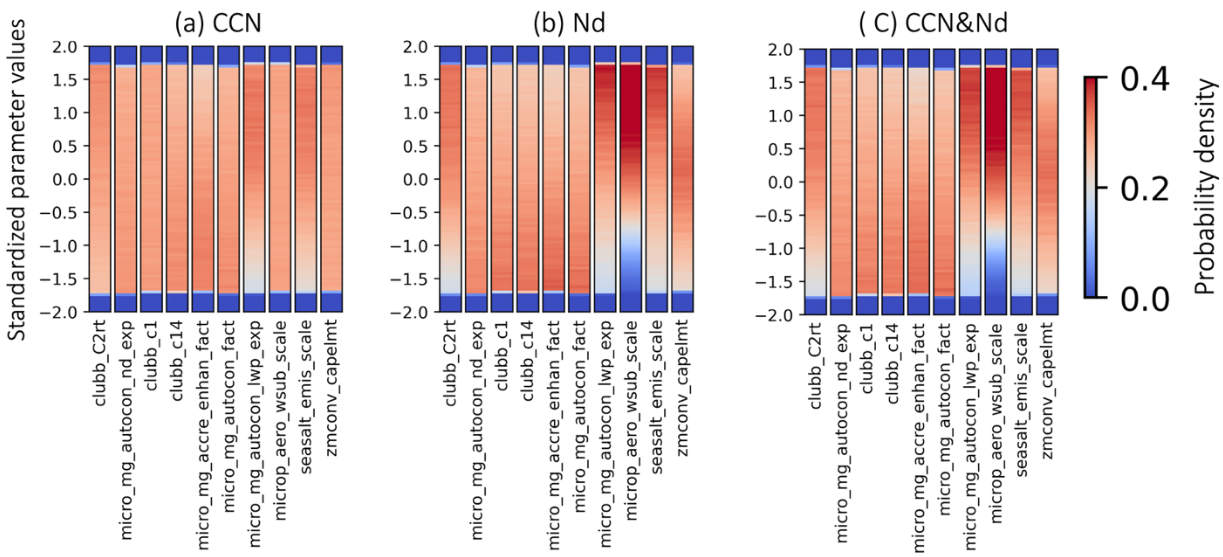
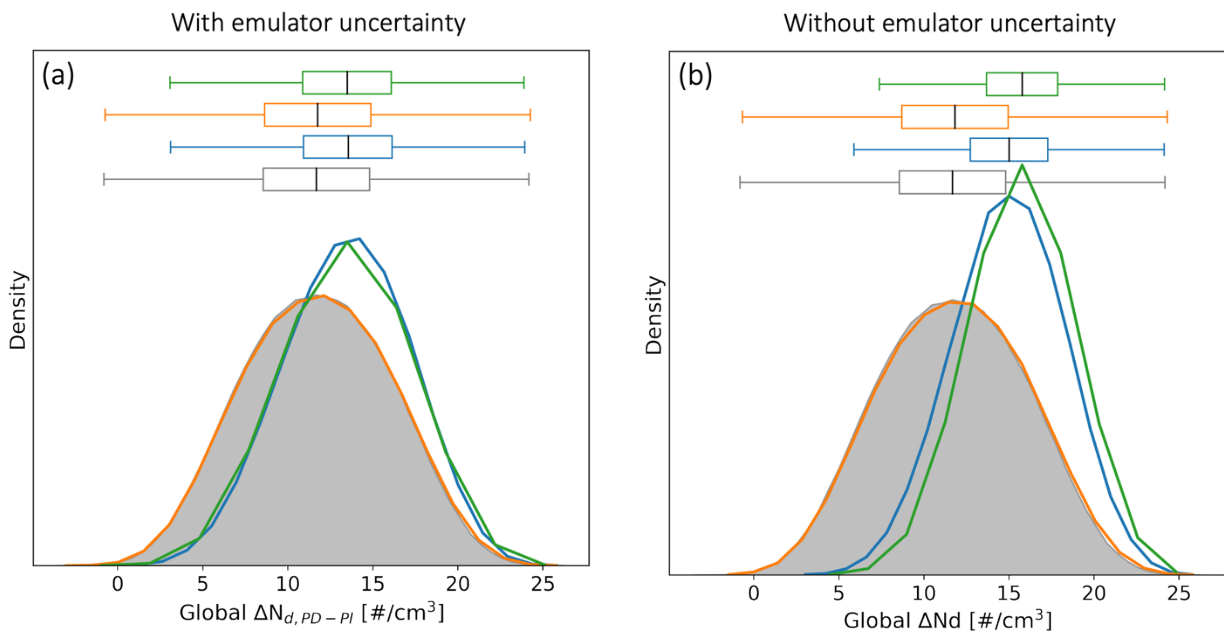


Fig. 8 Please use the same font size for x-axes across panels (a) and (b).

Response: corrected!



Typos

l. 134 (and also l. 136) Please change to either g/m^3 or g m^-3.

Response: corrected.

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(LWC) from the CDP exceeds 0.001 ~~g/m^{-3}~~ g/m^3, along with the subsequent 10 seconds after cloud detection. This is to avoid measurement contamination from cloud (McCoy et al., 2021). In-cloud N_d measurements are restricted to regions where the LWC from the CDP is greater than a threshold (0.1 ~~g/m^{-3}~~ g/m^3) following McCoy et al. (2021). Because the observations of

l. 240 Please change from "lower" to "greater", assuming the authors mean poor illumination conditions.

Response: corrected.

degree resolution as in Grosvenor and Wood (2014). During winter, high-latitude regions (e.g., Arctic, Antarctic) have ~~lower~~ greater solar zenith angle (SZA), resulting in lower reflected solar radiation, making retrievals of cloud properties (e.g., r_e and

Reviewer #2

I appreciate the authors taking the time to address the comments from my review so thoroughly. In Figure 7, the range of the vertical shaded area is the campaign mean +/- 20% 20%. The range of the shaded area in Figure S9 now represents the campaign mean CCN + 8% (lower) and CCN + 40% (upper), which is a different representation of uncertainty. I don’t think this is a problem. Furthermore, the authors did another sensitivity test where they increased the range of the campaign CCN to be +30% and +70% of the original campaign mean. Because the distribution of simulated PD-PI global Nd is similar over this range of CCN, these sensitivity tests do not change the conclusions about the constraint provided using CCN only. Interestingly, using both the adjusted CCN and Nd together to constrain the PD - PI global Nd slightly broadens the distribution of plausible values (Figure S9b) compared to the original analysis (Figure 8C), bringing it closer to the constraint provided by using Nd alone. These differences are very subtle and, if anything, further highlight the importance of Nd measurements. This additional work reiterates the importance of accurate measurements highlighted by the authors in their current discussion.

Technical comments:

Line 193 (tracked changes doc) : “representing the lower and upper bounds of the CCN02:N100 ratio uncertainty”. Assuming the aggregate and error bars in CCN/UHSAS100 in McCoy et al., (2021) Figure S2 represent the mean and standard deviation, should this be changed to “representing the mean and upper standard deviation of the CCN02:N100 ratio”? If yes it might be good to check this is expressed wherever it is mentioned in the revised manuscript and supplementary material.

Response: Thanks for pointing this out! We reached out to the corresponding author of McCoy et al. (2021), who confirmed that the dots and lines in Figure S2 represent the **median** and **25–75% interquartile range**, not the mean and standard deviation. We have clarified this point in the revised manuscript and supplementary material.

Another potential source of systematic uncertainty may arise from the use of UHSAS100 as a proxy to CCN02 over SOCRATES. While a near one-to-one relationship between UHSAS100 and CCN02 has been reported for the SOCRATES campaign ~~(e.g., (McCoy et al., 2021))~~(McCoy et al., 2021), the campaign-mean ratio of CCN02 to UHSAS100 is approximately 1.08 ($\pm$0.3)~~according to~~, based on the median and interquartile range of the CCN02:UHSAS100 ratio uncertainty shown in their Figure S2. This suggests that UHSAS100 may underestimate CCN02 by 8% on average. Moreover, the acti-

Figure S9: Sensitivity tests on the constraints on $\Delta N_{d,PD-PI}$. (a) Same as Figure 7b, but with CCN increased by 8% and 40% (red shaded bar) relative to the original campaign-mean CCN (gray shaded bar). The 8% and 40% increases represent the lower and upper bounds of CCN uncertainty in our sensitivity tests, respectively. The lower bound is based on the median of the CCN0.2:UHSAS100 ratio, and the upper bound corresponds to the 75th percentile of the CCN0.2:UHSAS100 ratio uncertainty, as reported in McCoy et al. (2021). (b) Similar to Figure 8a but showing the distribution of $\Delta N_{d,PD-PI}$ constrained by observations of CCN and N_d, with CCN increased as described, and emulator uncertainty excluded. (c) Same as (b), but including emulator uncertainty.

Figure S9: it was CCN rather than CCN uncertainty increased by 8% and 40%? The caption indicates the latter.

Response: corrected!

Figure S9: Sensitivity tests on the constraints on $\Delta N_{d,PD-PI}$. (a) Same as Figure 7b, but with CCN increased by 8% and 40% (red shaded bar) relative to the original campaign-mean CCN (gray shaded bar).

Figure 2 caption: “Flight composite are “ to “Flight composites are”

Response: corrected!

Figure 2. Relationships between SOCRATES CCN and in-cloud cloud droplet number concentration (N_d) from in-situ measurements (red) and CAM6 members (black), based on flight composites along individual flight tracks (scatters). Flight ~~composite~~ composites are constructed