Dear authors,

Thank you for the revised version of your manuscript "Earth System Model Aerosol-Cloud Diagnostics Package (ESMAC Diags) Version 2: Assessments of Aerosols, Clouds and Aerosol-Cloud Interactions Through Field Campaign and Long-Term Observations". Before accepting the manuscript for publication in Geoscientific Model Development, please consider the following reviewer's comment on the revised version:

"The authors addressed most of my concerns. Nevertheless, I am wondering about the validity of the comparison of the Nd-LWP relationships, which do not agree between the three datasets used (ground-based, satellite model). I am wondering how informative such a comparison is if differences are that large and not that well examined, in particular as this is a rather technical paper. If that part would be left out, I think it would not take away anything from the paper."

Thank you,
Axel Lauer
(handling topical editor)

We thank the reviewer for providing valuable feedback to further improve the paper. We understand your concerns regarding the differences of the Nd-LWP relationships between the three datasets, and agree that the large differences are notable and could be seen as a potential limitation. However, we believe that including this comparison, even with the notable differences, is useful for a few reasons:

1. Bring attention to the uncertainties and limitations of the observational datasets. Many previous studies only use satellite retrievals (e. g., Bellouin et al. 2019, Christensen et al. 2022, Quaas et al. 2009, Gryspeerdt et al. 2019, 2020, Hoffman et al. 2020). Including ground-based retrievals, although with much smaller sample size, offers valuable insights of the observation uncertainty as they measure cloud in different directions (from space and from ground) and use different retrieval algorithms for Nd. Our analysis for different sites (Fig. 12) and different sampling strategies (Fig. S3) also indicate the limitation on clouds other than marine overcasting warm clouds. By including these comparisons, we are being transparent about the discrepancies and uncertainties in the data, which is essential in scientific research for understanding the robustness of any results.

2. Reveal the existing biases of LWP susceptibility in ESMs. In contrast to recent observational and LES studies showing a net decrease in LWP in response to a N_d increase, ESMs most commonly produce a net LWP increase (Quaas et al. 2009, Gryspeerdt et al. 2020). In E3SM, we have shown that the overall LWP susceptibility is negative, consistent with the observations. However, the observed inverted V relation of LWP to Nd is oppositely seen in E3SM, indicating possible different mechanisms of LWP susceptibility than in observations. These diagnostical results provide insights for the current ESM biases to guide future model development. This is exactly the goal of developing this diagnostics package.

Once again, we appreciate your feedback and revise the manuscript to highlight the above points. The revised texts are copied below:

Lines 521-534:

"The slope of the LWP – N_d relation in satellite retrievals at SGP is positive for both N_d ranges. This is opposed to the slope from the ground retrievals and satellite retrievals at ENA. This result reveals a few difficulties on LWP susceptibility studies based on observations. First, limitations of instruments and their platforms (from space or from ground) employed in these observations as well as assumptions and simplifications in their retrieval algorithms, may introduce biases and uncertainties into the retrieved cloud microphysical properties. These biases and uncertainties can be amplified when studying ACI relationships between multiple variables. Second, the robustness of ACI studies is also dependent on geographical locations and cloud types, with environmental dynamic conditions influencing the analytical outcomes. Despite our efforts to constrain meteorology and cloud situations, it is essential to acknowledge the existence of many other factor, such as cloud adiabaticity and solar zenith angle as discussed in Varble et al., 2023), which can impact cloud susceptibility. Given these limitations and uncertainties, researchers should use caution when using observational data to study ACI relationships."

Line 535-549:

"The E3SMv2 simulated LWP – N_d relation is quite different from satellite retrievals at both sites. At SGP, it generates a positive slope for $N_d < 50\ cm^{-3}$, and a negative slope for $N_d > 50\ cm^{-3}$. At ENA, it shows an opposite relation, with LWP decreases for small N_d and increases for large N_d. The overall LWP susceptibility in E3SMv2 is negative, which is consistent with observations and but differs from most ESMs that produce a positive value (Quaas et al., 2009; Gryspeerdt et al., 2020). However, the observed inverted "V" relation of LWP to Nd is oppositely seen in E3SMv2. We examined a few other oceanic regions with frequent stratus or stratocumulus clouds and saw similar behavior (not shown). This indicates possible different mechanisms of LWP susceptibility in E3SM than in observations. Our user-friendly diagnostics package allows these analyses to be routinely performed for the purpose of better understanding critical model behaviors at process- and mechanistic-levels, providing observational constraints to facilitate model development efforts."