Response to the Reviewer #3: Analysis of the cloud fraction adjustment to aerosols and its dependence on meteorological controls using explainable machine learning # EGUSPHERE-2023-1667

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We thank the Referee #3 for the review of the revised manuscript. Below, the reviewer's comments and suggestions are incorporated in italics and addressed hereafter, and the authors' responses are coloured in blue. Unless otherwise stated, line numbers in this document refer to the manuscript after the third-round review (before the updates following in this response letter).

Referee 2

Specific comments

1. *I thank the authors for their changes to the manuscript and I look forward to the final version of the paper.*

   Thank you for your positive feedback on our revised version.

2. *I would note that although the authors state that they can't use the G19 Nd dataset from the Gryspeerdt et al (2022) output, if they are currently performing their filtering on a 1x1 degree grid - they could apply their filtering to the Q06 Nd dataset instead to achieve the 'non-CLF filtered' Nd dataset they require. This is a minor point (and I appreciate that this bias is likely small and would require significant additional work to fix). I might instead recommend that the authors note (perhaps where they discuss the potential impact of Nd biases) that small-scale sampling issues can have large impacts on estimates of aerosol-cloud relationships (e.g. Arola et al, 2022 - 10.1038/s41467-022-34948-5)*

   Thank you for your insightful feedback. We appreciate your recognition that this point is minor, and we thank you for acknowledging that the potential bias is likely small and that implementing the change would require significant additional effort. We also value your suggestion on the possible use of the Q06 N_d data set. We recognize that applying additional filtering for solar zenith and satellite zenith to the Q06 data set could provide a viable alternative, allowing us to retain the full CLF value range. As we already noted in the revised manuscript (Line 275), we plan to implement the Gryspeerdt et al. (2022) data set in our companion study, where we aim to compare observational results with those from the ICON-HAM climate model using the same machine learning framework.

   We agree that it is a good idea and a more practical approach to incorporate the impact of small-scale sampling issues on estimating aerosol-cloud relationships. In response to the reviewer's suggestion, we have included the following

discussion in Sect. 2.1, Line 114: “Furthermore, the interpretation of the causal effect of N_d on CLF can also be obscured by small-scale sampling issues. In particular, apart from the retrieval errors in r_e and τ_c, the natural spatial variability in cloud fields can also propagate into N_d estimates and distort the N_d–CLF relationship (Arola et al., 2022; Liu et al., 2024).”

3. *The only other technical point I would make is that the text on Fig. 1 is quite small. This might be corrected in typesetting, but I wanted to note it just incase.*

Thank you for pointing this out. We have already adjusted Fig. 1 as well as the corresponding non-standardized plots (Fig. S2).

Minor modifications independent of the reviewer comments

Line 106: “This retrieval approach relies...” has been modified to “This derivation approach relies...”

References

Arola, A., Lipponen, A., Kolmonen, P., Virtanen, T. H., Bellouin, N., Grosvenor, D. P., Gryspeerdt, E., Quaas, J., and Kokkola, H.: Aerosol effects on clouds are concealed by natural cloud heterogeneity and satellite retrieval errors, Nature Communications, 13, 7357, https://doi.org/10.1038/s41467-022-34948-5, 2022.

Gryspeerdt, E., Mccoy, D. T., Crosbie, E., Moore, R. H., Nott, G. J., Painemal, D., Small-griswold, J., Sorooshian, A., and Ziemba, L.: The impact of sampling strategy on the cloud droplet number concentration estimated from satellite data, pp. 3875–3892, 2022.

Liu, Y., Lin, T., Zhang, J., Wang, F., Huang, Y., Wu, X., Ye, H., Zhang, G., Cao, X., and de Leeuw, G.: Opposite effects of aerosols and meteorological parameters on warm clouds in two contrasting regions over eastern China, Atmospheric Chemistry and Physics, 24, 4651–4673, https://doi.org/10.5194/acp-24-4651-2024, 2024.