The response to Reviewer #2:

Observational Constraints Suggest a Smaller Effective Radiative Forcing from Aerosol-Cloud Interactions

Park, C., et al

General Comments:

The paper uses models and observations to evaluate assumptions made in the determining aerosol-cloud interactions. Specifically, the authors argue that assuming a one-to-one relationship between activation rate of cloud droplet number concentration in response to sulfate aerosol variations and effective radiative forcing by aerosol-cloud interactions (ERFaci) leads to an underestimation of ERFaci. The corroborate this by performing a “perfect-model” validation comparison between climate model “true” ERFaci and that obtained via the aforementioned assumption. They compare observationally constrained ERFaci with previous estimates and conclude that ERFaci may be smaller than previously estimated.

The paper is acceptable with minor revisions (see below). It would be helpful if the authors provided readers with a sense of how widespread the above one-to-one assumption is used in prior studies (e.g., by providing references).

We deeply appreciate the reviewer’s thoughtful comments and valuable suggestions. Due to the strict word limits of *ACP Letters*, we have focused on presenting the main findings concisely. Where appropriate, additional details have been added to the Appendix to support for our findings. We kindly ask for your understanding in this regard. Below, we provide specific responses to each comment, highlighted in blue.

Specific Comments:

Lines 48-51:”The conventional assumption is that the activation rate has a one-to-one relationship when aerosols convert into cloud droplets and is typically not explicitly incorporated into the estimation process of ERFaci.”

Awkward sentence. Please reword. Also, please provide some references where the “conventional assumption” is used.

Thank you for your comment. We agree that the original phrasing was awkward. We revise the sentence to: “In some studies, the activation rate is not explicitly incorporated into the estimation process of ERFaci as it is implicitly assumed to have a one-to-one relationship (e.g. Chen et al., 2014; Christensen et al., 2016; Douglas and L’Ecuyer 2020; Wall et al., 2022, 2023).” This revision provides clarity and includes relevant references.

Line 73: “This ratio, commonly referred to as the activation rate, quantifies the efficiency with which aerosol particles convert into cloud droplets.”

Is a constant ratio assumed everywhere? If so, please state this and provide the assumed value.

Thank you for your comment. The activation rate is not assumed to be constant across all conditions. In this sentence, we aimed to define what the activation rate represents rather than imply a fixed value. The activation rate varies based on environmental and aerosol properties, and we address this variability further in the manuscript. To avoid any confusion, we revise the text to: "This relationship…".

Line 78: "Figure 1".

Please consider using a different color scale. It's not easy to decipher the values when only red is used.

Thank you for your comment. We update the color scheme in Figure 1 to improve clarity and make it easier to distinguish between different values.

Line 87: "The relatively low correlation coefficients observed for…"

Do you mean regression coefficient?

Thank you for pointing this out. We correct "correlation coefficients" to "regression coefficients".

Lines 279-280: "Specifically for sulfate aerosols, it employs bias-corrected observations of total aerosol optical depth in conjunction with…"

Please state where the total aerosol optical depth observations are from.

Thank you for your comment. We specify that the total aerosol optical depth observations are sourced from MODIS satellite data, stating: "it employs bias-corrected observations of total aerosol optical depth from the Moderate Resolution Imaging Spectroradiometer (MODIS; Platnick et al., 2015) satellite data…".

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References

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Christensen, M. W., Chen, Y.-C., and Stephens, G. L.: Aerosol indirect effect dictated by liquid clouds, Journal of Geophysical Research: Atmospheres, 121, 14,636-14,650, https://doi.org/10.1002/2016JD025245, 2016.

Douglas, A. and L'Ecuyer, T.: Quantifying cloud adjustments and the radiative forcing due to aerosol–cloud interactions in satellite observations of warm marine clouds, Atmospheric Chemistry and Physics, 20, 6225–6241, https://doi.org/10.5194/acp-20-6225-2020, 2020.

Wall, C. J., Norris, J. R., Possner, A., McCoy, D. T., McCoy, I. L., and Lutsko, N. J.: Assessing effective radiative forcing from aerosol–cloud interactions over the global ocean, Proceedings of the National Academy of Sciences, 119, e2210481119, https://doi.org/10.1073/pnas.2210481119, 2022.

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