Review of “Biomass Burning Aerosol Radiative Effects in the Southeast Atlantic Depend Strongly on Meteorological Forcing Method”
Giuffrida et al.

In this paper, the authors use the UK Met Office Unified Model to quantify the aerosol and cloud radiative effects by biomass burning aerosol using different meteorological forcing methods and reinitialization frequencies. They first find that the model can adequately represent aerosol absorption changes across two smoky periods of interest (a moderately smoky and a heavily smoky period) by comparing the simulated aerosol properties with ground-based (ARM LASIC) and aircraft (ORACLES, CLARIFY) measurement campaigns and MODIS satellite retrievals. However, they do note that organic aerosol and the overall extinction are biased, which may affect the radiative properties, but they note this limitation. To quantify the different radiative effects, formulations are derived from previous literature looking at differences between “all” and “clean” conditions with and without biomass burning and aerosol absorption. The authors overall find an ~5 W m-2 range in total radiative effect that is largely due to how the semi-direct effect is simulated based on the meteorological forcing/reinitialization. With this support, they argue that free running simulations can lead to chaotic behavior that contribute to widely deviating semi-direct and indirect radiative effects, thus recommending adequate, short-term reinitialization frequencies on the order of 1-2 days to quantify radiative effects. This paper is very well written, and the arguments well supported. After addressing the following minor, and largely technical comments, I feel that this paper is well-suited for ACP and should be published.

<u>Comments:</u>

1. Abstract, Line 1: “BBA” should be defined. “Smoke aerosols” can just be replaced with “Biomass burning aerosols.”

2. Lines 48-49: Can the authors provide a range of SEA REs from the references cited in this sentence?

3. Line 56: Can the authors please explain why they claim that IRE and SDRE cannot be calculated from observations? Specifically, the indirect radiative effect is the response of cloud changes to aerosol and has been quantified using ground-based (Mccomiskey et al., 2009; Varble et al., 2023; Tang et al., 2023) and satellite remote sensing (Christensen et al., 2020; Christensen et al., 2016; Quaas et al., 2020; Gryspeerdt et al., 2017) observations.

4. Line 58: To orient the reader such that the proceeding studies were done in a similar region, the authors should not that these DRE estimates were conducted over the Southeast Atlantic.

5. Can the authors provide a table, either in the main text or supplement, listing their model experiments and set-up conditions that are described in Section 2.1 and 2.3?

6. Line 360-374: Did the authors adjust either of the scattering or absorption coefficients to match wavelengths before summing? This is likely not to be significantly different from just summing the two, but I am interested if this changes the result at all. In Lines 366-367, it appears the authors took the average of the extinction coefficients to approximate at 530 nm. Is there support for why this approach was done rather than calculating an Angstrom exponent (e.g. (De Faria et al., 2021) EQ. 8-9). The similar question is posed for the LASIC extinction (Lines 369-373) as in Dedrick et al. (2022). It is also important to note that the LASIC nephelometer measurements were not conducted in "dry" (<40%) conditions (Dedrick et al., 2022; Zuidema et al., 2018), which may bias results for LASIC comparisons.

7. Line 376-378: please specify that the AMS OA mass is non-refractory.

8. Line 382: Non-refractory OA mass concentrations during LASIC were measured by an ACSM, not an AMS.

References

Christensen, M., Chen, Y., and Stephens, G.: Aerosol indirect effect dictated by liquid clouds, Journal of Geophysical Research-Atmospheres, 121, 14636-14650, 10.1002/2016JD025245, 2016.

Christensen, M., Jones, W., and Stier, P.: Aerosols enhance cloud lifetime and brightness along the stratus-to-cumulus transition, Proceedings of the National Academy of Sciences of the United States of America, 117, 17591-17598, 10.1073/pnas.1921231117, 2020.

de Faria, J., Bundke, U., Freedman, A., Onasch, T., and Petzold, A.: Laboratory validation of a compact single-scattering albedo (SSA) monitor, Atmospheric Measurement Techniques, 14, 1635-1653, 10.5194/amt-14-1635-2021, 2021.

Dedrick, J., Saliba, G., Williams, A., Russell, L., and Lubin, D.: Retrieval of the sea spray aerosol mode from submicron particle size distributions and supermicron scattering during LASIC, Atmospheric Measurement Techniques, 15, 4171-4194, 10.5194/amt-15-4171-2022, 2022.

Gryspeerdt, E., Quaas, J., Ferrachat, S., Gettelman, A., Ghan, S., Lohmann, U., Morrison, H., Neubauer, D., Partridge, D., Stier, P., Takemura, T., Wang, H., Wang, M., and Zhang, K.: Constraining the instantaneous aerosol influence on cloud albedo, Proceedings of the National Academy of Sciences of the United States of America, 114, 4899-4904, 10.1073/pnas.1617765114, 2017.

McComiskey, A., Feingold, G., Frisch, A., Turner, D., Miller, M., Chiu, J., Min, Q., and Ogren, J.: An assessment of aerosol-cloud interactions in marine stratus clouds based on surface remote sensing, Journal of Geophysical Research-Atmospheres, 114, 10.1029/2008JD011006, 2009.

Quaas, J., Arola, A., Cairns, B., Christensen, M., Deneke, H., Ekman, A., Feingold, G., Fridlind, A., Gryspeerdt, E., Hasekamp, O., Li, Z., Lipponen, A., Ma, P., Mülmenstädt, J., Nenes, A., Penner, J., Rosenfeld, D., Schrödner, R., Sinclair, K., Sourdeval, O., Stier, P., Tesche, M., van Diedenhoven, B., and Wendisch, M.: Constraining the Twomey effect from satellite observations: issues and perspectives, Atmospheric Chemistry and Physics, 20, 15079-15099, 10.5194/acp-20-15079-2020, 2020.

Tang, S., Varble, A., Fast, J., Zhang, K., Wu, P., Dong, X., Mei, F., Pekour, M., Hardin, J., and Ma, P.: Earth System Model Aerosol-Cloud Diagnostics (ESMAC Diags) package, version 2: assessing aerosols, clouds, and aerosol-cloud interactions via field campaign and long-term observations, Geoscientific Model Development, 16, 6355-6376, 10.5194/gmd-16-6355-2023, 2023.

Varble, A., Ma, P., Christensen, M., Muelmenstaedt, J., Tang, S., and Fast, J.: Evaluation of liquid cloud albedo susceptibility in E3SM using coupled eastern North Atlantic surface and satellite retrievals, Atmospheric Chemistry and Physics, 23, 13523-13553, 10.5194/acp-23-13523-2023, 2023.

Zuidema, P., Sedlacek, A., Flynn, C., Springston, S., Delgadillo, R., Zhang, J., Aiken, A., Koontz, A., and Muradyan, P.: The Ascension Island Boundary Layer in the Remote Southeast Atlantic is Often Smoky, Geophysical Research Letters, 45, 4456-4465, 10.1002/2017GL076926, 2018.