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Review of Che et al.

Anonymous Referee #2

Referee comment on "Source attribution of cloud condensation nuclei and their impact on stratocumulus clouds and radiation in the south-eastern Atlantic" by Haochi Che et al., Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2022-43-RC2, 2022

In this short study, the authors use the United Kingdom Earth System Model to attribute cloud condensation nuclei, supersaturation, cloud droplet number and liquid water path of stratocumulus clouds in the southeastern Atlantic to specific primary and secondary aerosols, and in particular biomass-burning aerosols (BBA). They find that BBA impact cloud droplet number and liquid water content through adjustments to aerosol-radiation interactions (absorption) rather than through aerosol-cloud interactions.

The paper is well written, with good figures. The main finding is not surprising, given that the BBA layer is rarely in contact with the cloud, but the story is worth telling.

I found two important aspects that would need clarifying:

- The discussion does not distinguish between attribution of the baseline CDNC and LWP and the attribution of changes in those quantities. There is probably a Sc deck in the preindustrial simulation without BB. So BB/anthro cannot be the main drivers of LWP/CDNC, but they drive their temporal changes. Is that an accurate way of describing the findings?
- How do the findings depend on the way aerosol activation and cloud formation are represented in the model? It is important to insert a summary on Page 5 lines 4-5 of the representation of aerosol activation in the model and the calculation of cloud droplet number. Does that account for vertical transport in the boundary layer, or does it only consider those aerosols that happen to be in the same model level as liquid cloud water? And is cloud formation dependent on aerosols, or is liquid water content determined by thermodynamics, with droplet number being assigned in a second step? In other words, how close to the real world are the model and the attribution?

The importance of nucleation in driving CDNC may also be a feature of Hadley Centre models. For example, Bellouin et al. 2013 https://doi.org/10.5194/acp-13-3027-2013 found a positive RFaci over pristine ocean regions, a feature that other AeroCom models (especially the ECHAM family, if I remember well) do not share. It could be worth giving a note of caution to that effect in the conclusion.

Other comments:

Page 5, line 10: Could clarify that the word anthropogenic is used here is the emission/CMIP sense. In a more general sense, most biomass burning emissions are anthropogenic too.

Page 5, line 20. Are there units for the rate of 0.26?

Page 7, figure 2: Is that total aerosol number or BBA only? I was expecting to see a secondary maximum near the surface, as stated on page 7 lines 14-16.

Page 11, 22-23: Isn't the free tropospheric transport more due to convection over land?

Page 12, 14-15: BBA probably also has a decreasing effect on supersaturation via cloud droplet formation, which would offset some of the absorption-driven increase?

Page 15, line 3: So stratocumulus evolution is driven by precipitation in the model? Are there non-precipitating Sc?

Page 15, line 18: “times to that” --> “times that”