Comment on egusphere-2022-919
Anonymous Referee #1

Referee comment on "Local and remote climate impacts of future African aerosol emissions" by Christopher D. Wells et al., EGUsphere, https://doi.org/10.5194/egusphere-2022-919-RC1, 2022

General comments

The authors of this manuscript have conducted a study of the impacts of different future African aerosol and CO$_2$ emission pathways on global and local climate. This is done through simulations with one Earth system model (ESM), UKESM1, using several ensemble members for each experiment. They find that increased future non-biomass burning carbonaceous aerosols in Africa lead to warming on the northern hemisphere, northwards shift of the Inter-Tropical Convergence Zone and precipitation changes in the vicinity of the emission changes, compared to their control experiment. The authors present a detailed analysis of the mechanism behind the local precipitation response in the emission region.

Climate impacts of future aerosol emissions over Africa, the topic presented in this study, is relevant for the climate research community and readers of Atmospheric Chemistry and Physics, and, as the authors claim, not yet well studied. The method the authors use is well described and appropriate for the study.

The manuscript is in general well structured but the writing and presentation need a major revision. The whole manuscript needs to be reworked for clarity and preciseness (including abstract, figure captions and supplement material) but in particular the result section, and the discussion and conclusion section for clarity and conciseness, please also see specific comments below.

The authors have presented an interesting and well conducted study, but are asked to address the following questions/comments:
I miss a motivation for why the authors choose to focus on the results from the scenario simulations. At least one sentence describing the motivation behind this choice should be added.

Figure 1 where the authors present the aerosol emission in the different experiments is very confusing, and the authors need to rethink how the emissions are presented. Please also see specific comment below.

There is no description of the radiative forcing or effects on radiation generated by the different aerosol (or CO₂) emissions in the manuscript, apart from the short-wave radiation absorption profile in two limited regions. The authors describe competing effects of reflecting (cooling) organic carbon and absorbing (warming) black carbon, but never present a quantification of these effects. Moreover, the authors describe an ESM with a climate sensitivity larger than that of other ESMs participating in CMIP6. Therefore, it is relevant to present the radiative forcing or changes in atmospheric radiation in the simulations, and perhaps the multi model mean sensitivity of the CMIP6 models when discussing the high climate sensitivity of the model used in this study.

The authors cite literature that describe the influence of aerosols on global atmospheric circulation and in particular the Asian monsoon, but, despite being a study of African aerosol emissions and associated local and global effects on the climate, there is no discussion or citations of studies regarding the African monsoon and previous studies of climate impacts of African aerosols on regional or global scale. The authors need to present more background regarding African aerosols and climate impacts and African monsoon and cite relevant previous studies on this topic.

The high sensitivity of the particular ESM used in this study warrants a more elaborate discussion of the impact on the results in relation to the choice of using future scenarios (SSPs) and not idealised emission perturbations, and the simulated aerosol burden and forcing (which is not shown in the manuscript). The authors should present more numbers (e.g. radiative forcing, sensitivity) to illustrate how this model responds to changed emissions compared to other models participating in CMIP6.

The authors need to work on making the language more precise and at times more concise. The disposition of the Discussion and Conclusions section is not optimal, where discussion and conclusions are mixed and presented in an order that is not always logical.

Specific comments
Given the particular high sensitivity of the single model used in this study, it might be appropriate to change the title to “Local and remote climate impacts of future African aerosol emissions in UKESM1”, to highlight the fact that this study portrays the result of this particular model, which is not necessarily representative for what a similar study using a different model might show.

The figure/table captions are inconsistent throughout the manuscript. In some of the figures the indication of whether a result is statistically significant or not is described in the figure caption, sometimes it is described in the text. Sometimes a capital letter is used at the start of the figure captions sometimes it is not. The authors should go thorough all the captions to make sure they describe the figures/table in a consistent manner.

Line 12: Please change “investigating” to “to investigate”.

Line 14: “sees” should be rephrased

Line 14: What is meant by “direct anthropogenic”? And are not biomass-burning emissions anthropogenic?

Line 15: The reduced short wave surface radiation is never shown in the manuscript.

Line 16: What do the authors mean here? That absorption from black carbon takes place away from the emission region?

Line 16: Can the authors provide a quantification of the global warming here?

Line 18: The authors should be more specific regarding how the ITCZ changes, i.e. northward shift due to a warmer northern hemisphere compared to the control experiment.

Line 27-28: Please provide a context for the scenarios. For example that they are used for simulating future climate impacts with general circulation models or similar.

Line 29-31: This sentence is very difficult to read, please rephrase.
Line 51-52: I am not sure what the authors mean by this, they need to specify what emission trajectory differs in contrast to what. There are definitely published studies where specific regions follow an aerosol emission trajectory different from the one specified for the CMIP5.

Line 58: This sounds more like the hypothesis you are set out to investigate, please change to something like “These emissions could therefore have a substantial effect on local and remote climates.”

Line 58-60: This sentence is not very clear and could be rephrased to be easier to read.

Line 79: Please be more specific when describing the model’s performance that stating the it represents the climate “well” (and “reasonable”). A quantification of differences, e.g. sensitivity, forcing etc.

Line 80-84: Repetition of “its”. Please rephrase.

Line 103-104: What is meant in this sentence, please clarify. Is there no biomass emissions of SO$_2$? What impact does this have on the result regarding absorption/scattering dominating the radiative effect of in the different experiments?

Line 105: Should it not be “‘AerAll’ refers to the experiment where all aerosols and reactive gases follow the SSP370 scenario over Africa” or similar? Please go through this paragraph to make sure that the experiments are described properly, and that the references to the different experiments are consistent with the result sections, i.e. are you referring to the aerosols or the experiment? As the text reads now, there is no consistency regarding this.

Line 116: I doubt that climate equilibrium was reached, rather that the ocean mixed layer has adjusted to the imposed forcing.

Line 132: What is meant by “larger three experiments”? Should it be the experiments with large emission increases?

Line 132-136: Do the authors have an estimate of how much this might influence the results?
This paragraph and Figure 1 need some reworking/clarifications, and better connection between the emission descriptions in the text and what is shown in the figure. Figure 1 would benefit from labeling of each panel and more specific references in the text. It is difficult to understand which panel describes which experiment and how to interpret the figure.

The black solid lines in the line plots describe the emissions in the control/SSP119 of different aerosols and CO$_2$. Likewise, black dashed lines describes African emissions in control/SSP119. My interpretation is that the emissions in “AerAll” are described by “OC+BC total” and “SO2”, but this is not obvious. Moreover, when it comes to the “AerBB” and “AerNonBB” experiments, it is no longer clear to me how I should read the total aerosol emissions in these experiments from the figure. I understand that “OC+BC BB” shows the change in biomass burning aerosols, but how do the total aerosol emissions change, including SO$_2$? I also do not see what the map plot “All 2xBB” should represent in this context.

The authors should rethink how the emissions are presented in Figure 1. What does “perturbation” represent in the legend in each panel?

Is Figure 1 showing actual SO$_2$ emissions or perturbation/control ratio?

This sentence seems out of place here. What is the point of the table? What does the table add to the story? It would be better to first focus on Figure 2 and then discuss the table. Where does the pi-control data come from?

What is cooling in comparison to what? The whole result section suffers from this lack of clarity and needs to be carefully reworked so that is clear in everywhere what is being compared. The authors also have a tendency to describe the figures rather than letting the figure support the result they are describing.

Higher warming in comparison to what? Is the difference of 0.16K between the CO$_2$ experiment and the control/SSP119 scenario? Why is Table 1 referenced here which shows the temperature differences between the experiments and a pre-industrial state?

Warming compared to what?

Please change “plot” to “panel”, and check the other figure captions as well.
Line 197: I think it would be more appropriate to explain the red/blue numbers here than in the text.

Line 200: It has not been shown here where the aerosol-burden change is largest or radiative effect of the changed aerosol emissions.

Line 210: To me it looks like the warming is more prominent in south western Africa. I can’t see a statistical significant warming in South eastern Africa neither in DJF nor in JJA. Could the authors clarify what is meant here?

Line 214-219: This paragraph seems to belong together with the discussion about the global mean temperature response before line 198.

Line 216-219: This sentence is confusing. The temperature change over Africa is compared to that of the global mean relative to the pre-industrial(?) simulation, and the contrasted to temperature changes relative to the control. Please rephrase.

Line 220-221: Cooling compared to what?

Line 228: Which season?

Line 230: What is meant by “north of this”?

Line 239: What is referred to by “this”? Please be more specific. Please remove “850hPa map” and specify which figure/panel is being discussed.

Line 240: Please rephrase “hints of northward shifts”. Which figure is discussed here?

Line 254: "In the AerAll and AerNonBB experiments"

Line 256-257: What do the authors mean here? Please clarify. How does the position of the ITCZ influence the strength of the forcing asymmetry?
Line 258: Discussed presently?

Line 258-260: This is also true for AerAll experiment.

Line 260-261: This sentence does not make sense to me. “ITCZ impacts can produce substantial changes in locations remote from their emissions”? Please rephrase.

Line 273: How can this be three pairs?

Line 276-278: This sentence seems redundant.

Line 280: Please add labels for each panel in Figure 7 and specify which panel is discussed.

Line 284: What role does the seasonality of precipitation have in the aerosol burden in these areas?

Line 286: What is meant by “since the amount of aerosol present to block radiation decreases with altitude”? The near-surface cooling is most likely a consequence of changed surface energy fluxes.

Line 289: Which panel if Figure 7?

Line 298: Please add a reference to Figure 7 and which panel specifically.

Line 298-299: Where is this result shown, and what do the authors mean? That aerosols transported over the Atlantic lead to enhanced precipitation locally?

Line 233: To my it sound strange to write that “This study analyses”. Likewise, that “scenarios sees changes”.

Line 334: Please remove “bulk” and rephrase.
Line 237: Should it be “two-moment scheme” here?

Line 360: Perhaps “locally in the emission regions”? But the pattern did not match the emission strength? Please be more specific, where is the cooling and in what sense does it not match the emissions?

Line 272: ERF has not been introduced previously in the text.

Line 376: What is meant by accurate in this context? Detailed or sophisticated perhaps?

Figure 3: The global maps are very small and it is difficult to see which temperature changes are statistically significant. The panel showing the temperature change due to changed CO$_2$ emissions from Africa is never discussed in the text and should perhaps be removed.

Figure 4: These map plot are even smaller then those in Figure 3 and are even harder to read. Perhaps the authors should split the map plots and pressure/latitude plots into two different figures.

Figure 5: Please see comment regarding Figures 3 and 4.

Figure 6: The description of how the profiles of stability and vertical velocity change relative to the control experiment and whether they are significant or not is difficult to follow. Is there not a better way of presenting this, perhaps by showing the profiles from the control experiment? Omega ($\omega$) is usually used to denote pressure velocity, and is never introduced in the text, neither is $\theta$.

**Technical corrections**

Line 43: Remove parentheses around reference at the beginning of this sentence.
Line 53: The acronym CMIP6 has not been introduced.

Line 64/66: Repetition of “inform/ed”

Line 65: Please change “bulk” to something more elegant.

Line 85: Insert space before reference.

Line 100-102: and throughout the text: SO2 to SO₂, NH3 to NH₃, C2H6 to C₂H₆, C3H8 to C₃H₈, C3H6O to C₃H₆O, C2H4O to C₂H₄O

Line 168: Are these temperature differences from the scenario experiments?

Line 171: “Run” is jargon.

Line 177: Space between forcing (O’Connor

Line 227: remove “upwards”

Line 228: Change circulation to vertical velocity

Line 274: bottom right panel of Figure 7