Response to 'Comment on acp-2022-233' by Referee #1

We thank the Referee for his/her time and his/her constructive comments. We have complied with most of the proposed changes. In the following, the comments made by the Referee appear in black, while our replies are in blue.

In this manuscript, the authors use two convection-permitting simulations one taking into account the BBA radiative effect and the other not to address the direct and semi-direct effects of BBA over southern Africa and the southeast Atlantic during the AEROCLO-sA field campaign in September 2017.

Both simulations are examined against satellite, airborne and ground-based observations and ECMWF analyses. Efforts are made to understand the acceleration of the southern components of the African Easterly Jet.

There is no doubt that such a comparison adds value to understanding the overall dynamic of AEJ-S and heat low, which are linked to the direct radiative effect over Angola and Namibia. However, there are numerous (sometimes major) concerns with the analysis and approach. Therefore, I encourage the authors to significantly revise the paper.

Abstract:

The readability of the Abstract may be improved by using scientifically relevant terms such as "baroclinicity" and highlighting key mechanisms in general terms rather than discussing specific simulations issues.
We revised the abstract and highlighted the radiative effect as the key mechanism of the study by rewording the two sentences as follows "The occurrence of stratocumulus over the southeast Atlantic, deep convective clouds over equatorial Africa and the large-scale circulation are all reproduced by the model. If the radiative effects of BBA are omitted in the model, we show that (i) the smoke plume is too low in altitude, (ii) the low-cloud cover is too weak, (iii) the deep convective activity is too frequent but not intense enough, (iv) the Benguela low-level jet is too strong, and (v) the southern African easterly jet is too weak. "

Introduction :

The introduction is quite good and correctly motivates the study. But there are less relevant sentences and less citations. I strongly recommend looking at the introduction in a direct and succinct way to properly motivate the questions you hope to answer.
The first sentence of the second paragraph was changed to read "BBA have also a semi-direct effect by affecting air temperature, atmospheric stability, low-level clouds and the regional atmospheric circulation." Following the suggestion of Referee #2, we added two citations: "Tummon et al. (2010) found a shallower boundary layer over the continent resulting from surface cooling combined with BBA-induced warming of the lower troposphere. [...] Das et al. (2020) found that elevating the BBA layer to higher levels, in agreement with lidar observations, increases oceanic cloudiness near the coast south of 10 S and decreases it far from the coast. [...] These changes in regional atmospheric circulation are crucial for the path of rivers of smoke, from the BBA sources in the tropics to their transport to the temperate mid latitudes and the southwestern Indian Ocean (Flamant et al. 2022)."
To better explain our methodology, we added in the presentation of the outline of the paper: "It also evaluates the simulations against observations and shows the superiority of the simulation with radiatively-active BBA."

Data:

It is not clear why only September 2017 was used in the study. Please explain why.
We chose to focus our study on September 2017 because during this period we have the data from the AEROCLO-sA field campaign. This is explained in the penultimate paragraph of the introduction: "To achieve this objective, we investigate their effects using the airborne assets deployed during the AErosol, RadiatiOn, and CLOuds in southern Africa (AEROCLO-sA) field campaign (Formenti et al. 2019). From 5 to 12 September 2017, airborne lidar and dropsonde observations provided dedicated measurements of atmospheric dynamics, thermodynamics and aerosol composition."

Results section:

The dynamic and corresponding mathematical framework (e.g., Radiative heating, temperature gradient etc.) used in this study is unclear and makes it very difficult to understand the attributions/mechanisms for the differences in the AEJ-S intensity. Improvements are necessary here.
To quantify the effect of BBA on dynamics and physics, we added two new figures (Figs. 4 and 10 with the new numbering) that clearly show the changes in atmospheric dynamics, thermodynamics, and BBA loading due to the radiative effects of BBA. In addition, the significance of these changes is evaluated using two newly completed ensemble runs.

The authors need to clarify the method used to define the AEJ-S core to produce Figure 3. Also, clarification should be provided on why 8 m/s was used to identify AEJ-S.
Line 143 and following, introducing Fig. 3, we wrote "The fields are averaged between 8 and 16 September 2017 [...] The dynamics is represented by the wind field averaged at 12:00 UTC and taken at different altitudes: [...] 4 km is the altitude where the AEJ-S is maximum [...]". Line 165, we added: "The value of $-8\,\mathrm{m\,s^{-1}}$ is chosen because this threshold provides a good identification of the S-AEJ."

Refine the colour bar in Figure 1 so that all colours are used.
Figure 1 has been revised so that all colors are used to represent the carbon flux from biomass burning.

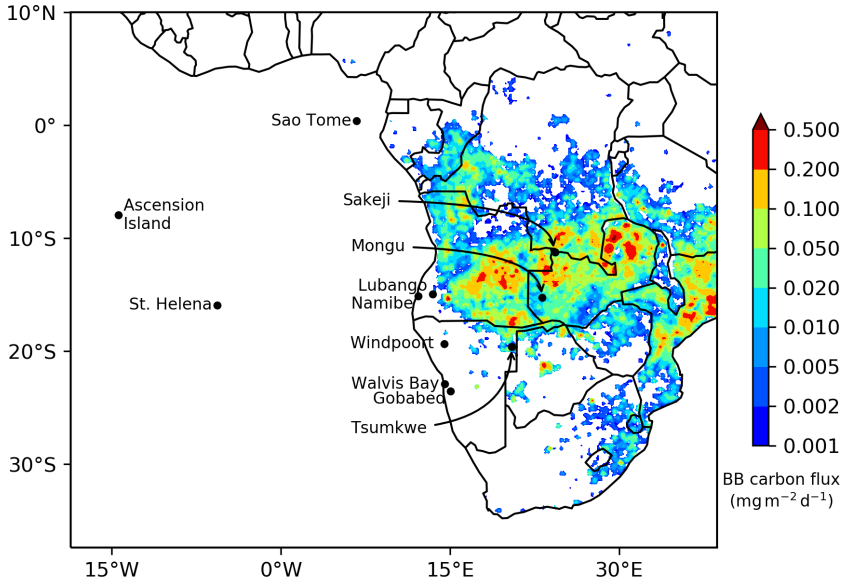

Figure 1 (revised): Meso-NH domain. The color shading shows the GFED emission of biomass burning carbon averaged between 1 and 16 September 2017.

Clarify by explicitly writing the equation/formula used to create Figure 5.
The left column of Fig. 5 shows the vertical cross-section of the extinction as explained in its legend. When we present Fig. 5, we now refer explicitly to the extinction. We describe the LNG extinction retrievals in Sec. 3.2 and refer to the Chazette et al. (2019) paper for the method. For the model, we write in Sec. 3.1 that we consider a mass extinction efficiency of $5.05\,\mathrm{m^2\,g^{-1}}$ for BBRAD, which multiplied by the BBA mass results in extinction.

Section 3 was essentially descriptive and was correct. Section 4 deals with the direct effects of the BBA on the atmosphere - radiation distribution and circulation and have a better-developed process approach. I like your analyses. The main concern I have is about the perspective of coupling within the atmosphere (radiation, transport, rain and convection), in that the acceleration of the AEJ-S is associated with radiative heating and increases the temperature through the intensity of the thermal heat low and gradient in temperature. So there must be some relationship and consistency among the sections 3 and 4 analyses.
To clearly distinguish the content of Secs. 3 and 4, we added in the last paragraph of the introduction: "Section 3 gives an overview of aerosols, clouds and dynamics during the 16 d period. It also evaluates the simulations against observations and shows the superiority of the simulation with radiatively-active BBA." More references to Sec. 4 were added in Sec. 3 to better link the two sections.