RESPONSE TO COMMENT COMMUNITY

First of all, the authors acknowledge this referee and the editor for the time spent to review this manuscript and also for their constructive comments. Note that the reviewer's comments are highlighted in blue-light font and our answer can be read in normal font. The modifications are indicated by blue font, and the removed text is shown in red and crossed out in the revised manuscript.

Referee: General Assessment: This manuscript presents an analysis of aerosol optical properties and transport during two events in September-October 2022 at Skukuza, South Africa, as part of the Biomass Burning Aerosols Campaign (BiBAC). While the study provides valuable data on aerosol characteristics during these events, there are several areas that require improvement to meet the standards of an EGU publication. The authors, however, need to improve their analysis, clarify their novel contributions, and improve the overall presentation of this paper. Reasons for this are as follows:

Detailed Comments:

Referee: Abstract. (Lines 1-14) The abstract lacks quantitative results and clear statements of the study's novelty. Suggest revising to include key numerical findings and explicitly state how this work advances our understanding beyond previous studies.

Authors: We agree with this referee. As a consequence, the abstract was rewritten in the revised manuscript. As it is explained here after, the manuscript was re-organized in its revised version.

Introduction

RefereeLines 15-88:: The literature review is comprehensive, but the gap this study aims to fill is not clearly articulated. Suggest adding a paragraph (around line 85) that explicitly states the research questions and how they build on previous work.

Authors: The purpose of the present study is to highlight the transport modes which explain the transport of biomass burning plumes over the Southwest Indian Ocean (SWIO) basin during the BiBAC campaign. The motivations come from the fact that few studies treating on the transport of the biomass burning plume in the SWIO basin (Flamant et al., 2022; Swap et al., 2003; Chang et al., 2021). These previous works pointed out a main transport mode over the SWIO basin which shaping like a river of smoke. In the present study, the structure of smoke river is also found but under different synoptic conditions than those reported by these previous works. We focused our effort to describe properly these news synoptic conditions leading to river of smoke over the SWIO basin. The motivations and the aims of our work was clarified in the revised manuscript.

Referee: Line 70-72. The statement about few studies on the east coast needs supporting evidence. Consider citing specific gaps in the literature.

Authors: An overview of the main campaign which held in South Africa from 1990 has been reported by Formenti et al. (2019). They pointed out that the common point with these previous campaign is interest for the characterization and transport of aerosol plume over the western part of Southern Africa. As suggested by the referee, this point was more emphasis and discussed in the revised manuscript.

Methodology (Lines 89-199):

Referee: Lines 94-99. The description of the study site is good, but a map showing the regional context would be helpful.

Authors: We understand the point of view of the referee. The figure 1 was re-plotted in order to provide information about the regional context as suggested by the referee.

Referee: Lines 101-116. The use of Level 1.5 AERONET data instead of Level 2 needs more justification. What are the potential implications for the results?

Authors: The sun-photometer AERONET observations are processes by two algorithm which leading to obtain data at level 1.5 and 2.0. In the case of AERONET data at level 1.5, a cloud mask is applied automatically without final calibration of the dataset. In the case of the AERONET data at level 2.0, a cloud mask is also applied with a final calibration of the data set. As a consequence, the quality check of the data is reinforced with the process applied to obtain data at level 2.0. The use of these latter improve the robustness of the results (no bias due to cloud or calibration). The data at level 2.0 was not available when the previous version of the manuscript was submitted. The data at level 2.0 have been upgraded only for the Skukuza site. Thus, these data were used in the revised manuscript.

Referee: Lines 150-155 More details on the CAMS reanalysis product are needed, including its known biases or limitations in Southern Africa.

Authors: Khaykin et al. (2020) revealed an underestimation of AOD values from CAMS reanalysis products over some regions of Southern Africa, Southern America and Southern Asia. The Modified Normalized Mean Bias (MNMB) is estimated between 0 and -25 % in Southern Africa (Langerock et al., 2024). The work of Plangerock et al. (2024) also revealed a negative bias up to 30 % in the estimation of CO over Southern Africa and Southern America during the biomass burning season. These information were added in the revised manuscript.

Results and Discussion:

Referee: Section 3 (Lines 200-250) The criteria for selecting the two events need more explanation. How do these events compare to typical conditions during the biomass burning season?

Authors: The criteria for selecting the two events is based on statistical approach. The anomalies is through the calculation of the quantiles Q1, Q2, Q3 of the relative difference. This latter is calculated by comparison with typical conditions defined from observations recorded between 1998 and 2021. The anomalies were defined as the period for which the relative difference values exceeding the Q3 line. The period which occurs these anomalies define the events of our study.

Referee: Section 4 (Lines 251-355) The analysis of aerosol transport is informative, but could benefit from more quantitative assessment. Consider adding statistical measures of the spatial and temporal variability of AOD and CO.

Authors: As suggested by the referee, this kind of assessment was considered in the revised manuscript.

Referee: Section 5 (Lines 356-530) The discussion of synoptic conditions is detailed but could be more tightly linked to the aerosol observations. ***The comparison with previous "river of smoke" events (Lines 419-430) is interesting but needs more rigorous analysis.*** **The discussion of intercontinental transport (Lines 460-499) is speculative and needs stronger evidence or should be significantly shortened.**

Authors: We agree with the referee. Thus, Section 4 which treats on the synoptic and meteorological conditions driving the transport of the biomass burning plume during the BiBAC campaign was significantly re-organized in the revised manuscript. Furthermore, new meteorological CAMS products were added in the revised manuscript to better characterize the synoptic system which driven the transport of the biomass burning plume.

Figures and Tables:

Referee: Figure 3: This figure is dense and hard to read. Consider splitting into two separate figures.

Authors: It was corrected in the revised manuscript

Referee: Figure 4: The aerosol classification results are important but difficult to interpret. Consider using a different visualization method or adding a summary table.

Authors: The figure was re-plotted in order to allow easy read of the results as suggested by the referee. In the previous version a summary table was included and was maintained in the revised manuscript.

Referee: Figures 7 and 10: These synoptic maps are informative but could benefit from annotations highlighting key features discussed in the text.
Authors: It was corrected in the revised manuscript.

Referee: Scientific Approach: The multi-instrument approach is a strength, but the integration of different data sources could be improved. For example, a more quantitative comparison between AERONET, MODIS, and CALIOP data would strengthen the results. The analysis of vertical aerosol distribution (Lines 314-329) could be expanded, perhaps incorporating additional data sources or modeling approaches to better characterize the 3D structure of the aerosol plumes.
Authors: We understand the point the point of view of the referee. Nevertheless, the present study focuses on one scientific question : Meteorological and synoptic conditions driving the transport of biomass burning plume over SWIO basin. In order to maintain clear the purpose of the article and not to extend the overall text length, we did not consider comparative analysis between the different instruments. Furthermore, a comparative study between these instruments (AERONET, MODIS and CALIOP) over Southern Africa has been already carried out by the authors in a previous article (Ranaivombola et al., 2023). In the present study, the analysis of the vertical is helpful to characterize the altitude associated to the transport of the plume and to determine the synoptic scheme driving its transport at this altitude. The use of numerical model (in particular, FLEXPART by coupling with emissions inventories) is planed in a further-coming study. This next of our work is mentioned in the revised manuscript (in the conclusion, section 5).

Referee: Presentation and Language: The manuscript would benefit from careful editing for grammar and clarity. There are several instances of awkward phrasing or run-on sentences (e.g., Lines 380-385, 460-465).
Authors: The referee is right. The quality of the english was checked in the revised manuscript

Referee: The conclusion section is missing. Add a concise conclusion that summarizes the key findings and their implications.
Authors: This comment is quite confusing. Indeed, the previous version of the manuscript

included a conclusion section (Summary and concluding remarks). Nevertheless, we can understand that this section in its initial version did not contain the points which characterize a conclusion section as defined by the referee. As a consequence, the conclusion section was rewritten in the revised manuscript.

Referee: Data Availability: A data availability statement is needed, detailing how readers can access the data used in this study.
Authors: These information were included in the previous version of the manuscript. As a consequence, these information were maintained in the revised version.

Referee: Compared to typical ACP papers I have seen in this line of research, this manuscript:

- **Provides a good multi-instrument dataset but falls short in the depth of analysis.**
- **Lacks a clear articulation of its novel contribution to the field.**
- **Needs improvement in the presentation of results, particularly in the figures.**
- **Requires a more rigorous discussion that places the findings in the context of existing literature.**

For clarity, major revisions are needed to:

- **Clearly state the research questions and novelty of the work.**
- **Improve the quantitative analysis of aerosol properties and transport.**
- **Strengthen the discussion, particularly in relating the findings to previous studies and broader implications.**
- **Enhance the quality of figures and tables.**
- **Add a robust conclusion section.**
- **Improve overall clarity and organization of the manuscript.**

Authors: In order to clarify the objective of the paper, this latter was re-organized in the revised manuscript. In particular, Section 4 which treats on the synoptic and meteorological conditions driving the transport of the biomass burning plume during the BiBAC campaign was significantly re-organized in the revised manuscript. Indeed, this section was rewritten by corrected the inappropriate meteorological diction. To better characterize the synoptic conditions occurred during BiBAC, cloud cover products from CAMS reanalysis was added

in the dataset used in this study. The motivations come from the fact that few studies treating on the transport of the biomass burning plume in the SWIO basin (Flamant et al., 2022; Swap et al., 2003; Schmid et al., 2003). These previous works pointed out a main transport mode over the SWIO basin which shaping like a river of smoke. In the present study, the structure of smoke river is also found but under different synoptic conditions than those reported by these previous works. We focused our effort to describe properly (with the appropriate language) these news synoptic conditions leading to river of smoke over the SWIO basin. In the previous works, the synoptic conditions responsible for the formation of the smoke river involved the propagation of a westerly wave and the development of a cut-off low (Swap et al., 2003; Stein et al., 2003; Flamant et al., 2022). However, we observed during the event 1 a river of smoke structure involved by westerly wave without a cut-off-low. The river of smoke developed in a synoptic context characterized by three successive cold fronts associated with saddle points during the event 2. In order to allow an easy read and understanding of these results, the quality of the english and figures were improved in the revised manuscript.

References

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