RESPONSE TO REFEREE 1

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Vertically stratified long-range transport of biomass-burning aerosol over Reunion Island during September 2017

Dear Referee 1,

We thank you for the constructive assessment and for recognizing the value of the multi-instrument dataset. We agreed that the manuscript sometimes assigned more certainty to source, age, and radiative implications than the evidence supports. The revision now separates observations, retrievals, model output, and interpretation; narrows the objective to an observational case study; and integrates the relevant qualifications where each result is introduced. Section 4 then brings the argument together in a continuous sequence from demonstrated findings and model-supported interpretation to limitations and implications.

Line references below refer to the revised manuscript with tracked changes and continuous line numbering.

1. Meaning of 'river of smoke'

Comment: *The term was qualitative and required an objective definition.*

Response: We removed 'aerosol river' from the title (lines 1-2) and no longer use the expression as an analytical classification. The Introduction defines the earlier 'river of smoke' usage descriptively as a spatially coherent, large-scale smoke plume transported from Southern Africa toward the Indian Ocean (lines 57-60). In the regional analysis, we use 'organized smoke-transport corridors' (line 296) and explicitly state that the maps indicate plausible regional connectivity rather than a threshold-based source classification (lines 301-303).

2. Logical integration of datasets

Comment: *The manuscript read as a sequence of independent datasets rather than a combined chain of evidence.*

Response: We revised the opening of Section 3 to state what each evidence type constrains. Ground-based lidars provide the observed layer structure and optical properties; CAMS provides model-based composition information; FLEXPART and FTIR constrain broad CO air-mass transport; and regional satellite observations provide spatial context (lines 250-255). The first two paragraphs of Section 4 then synthesize the observed/retrieved quantities first (lines 486-495) and the model-supported interpretation second (lines 496-504), making the logic explicit without interrupting the discussion with additional subheadings.

3. Source attribution and FLEXPART uncertainty

Comment: *The layer assignments, especially on September 25th , relied heavily on FLEXPART and should be more cautious.*

Response: We agree. FLEXPART is now introduced as a two-source sensitivity experiment rather than an exhaustive source-apportionment calculation. The Methods incorporate uncertainties in GFAS emissions and injection heights, ERA5 transport and convection, unresolved mixing, omitted sources, and the different lifetimes and removal processes of CO and aerosol (lines 243-248). The September results use 'consistent with' and 'supports' rather than definitive attribution (lines 462-482). The percentages are explicitly conditional on the two simulated regions, and Madagascar and other unsimulated sources remain possible.

4. Interpretation of Ångström exponent

Comment: *Ångström exponent alone cannot determine aerosol age.*

Response: We removed definitive age classifications. The observed Ångström exponents are treated as optical descriptors, with size distribution, mixing state, combustion conditions, humidification, processing history, and retrieval assumptions identified as alternative controls (lines 336-342 and 357-360). Section 4 retains the comparison with published biomass-burning ranges but states that Ångström exponent cannot diagnose aerosol age uniquely (lines 506-509).

5. Lidar-ratio uncertainty

Comment: *Using 75 sr for both days and wavelengths requires sensitivity discussion.*

Response: The transferred lidar ratio is now identified within the retrieval description as the principal systematic assumption affecting absolute extinction and layer AOD. The text specifies that 75 ± 9 sr was retrieved at 355 nm for the upper layer on September 25th and then applied to September 19th and 532 nm; it also explains that layer altitude and the one-versus-two-layer structure rely mainly on observed backscatter and are less sensitive to this choice (lines 161-165). The same qualification is incorporated into the synthesis of limitations (lines 518-520). We therefore addressed the requested sensitivity by narrowing the affected claims rather than adding new retrieval profiles.

6. WVMR uncertainty

Comment: *Large WVMR uncertainty weakens quantitative interpretation of moisture differences.*

Response: We now distinguish temporal variability from retrieval uncertainty and interpret the September 19th sub-layer pattern qualitatively (lines 370-372). For September 25th, the approximately 74% uncertainty of the lower-layer mean is retained, while the conclusion is limited to the robust contrast between the very dry upper layer and the moister lower layer (lines 387-391). The Discussion keeps the numerical values and uncertainty while avoiding a quantitative microphysical inference (lines 491-493).

7. CAMS aerosol composition

Comment: *CAMS OM/BC partitioning is model-dependent.*

Response: We agree. The Methods now state that CAMS assimilates total-AOD observations, while its species partition is controlled by inventories, transport, removal, and optical assumptions; nitrate is not represented among the components used here (lines 213-217). The Results explicitly identify the 50-60% OM contribution as model output and state that the AERONET comparison does not validate speciation (lines 275-276). This distinction is retained in Section 4 (lines 496-498).

8. Radiative-forcing claim

Comment: *No radiative-transfer or radiative-forcing calculation was presented.*

Response: We agree and removed radiative-forcing uncertainty reduction from the objective. The objective now concerns vertical structure, optical properties, moisture environment, and whether transport from selected regions is consistent with the observations (lines 101-107). Radiative forcing is retained only as broader motivation and a future application. The final paragraph states explicitly that the study does not calculate radiative forcing (lines 531-535).

9. Additional radiative-forcing literature

Comment: *The Introduction and Discussion could cite broader recent forcing literature.*

Response: We added a concise paragraph to the Introduction connecting source-emission variability, biomass-burning aerosol absorption, and the need to combine observations with models (lines 48-51), citing Wang et al. (2025), Samset et al. (2018), Konovalov et al. (2021), and Kahn et al. (2023). The final paragraph of Section 4 now explains, without implying that a forcing calculation was performed here, how absorption, particle size, mixing state, and column loading affect inferred forcing (lines 531-535), citing Tiwari et al. (2023), Guan et al. (2026a, b), and Tiwari et al. (2026). Thus, all of the studies suggested by the referee are now incorporated at the points where they directly support the text.

10. Terminology

Comment: *Observed aerosol type, model species, and inferred source terminology were mixed*.

Response: Terminology is now tied to the evidence source. 'Elevated smoke' and 'polluted continental/smoke' are presented as CALIOP algorithm labels rather than chemical measurements (lines 139-141 and 315-319); OM, BC, sulfate, dust, and sea salt refer to CAMS model species (lines 279-282); and 'BB aerosol' or 'smoke' denotes an inferred source category supported by the combined evidence. FLEXPART CO is consistently described as an air-mass tracer (lines 246-248 and 453-454).

11. Scientific novelty

Comment: *The manuscript needed a clearer statement of what is new relative to earlier campaigns*.

Response: The knowledge gap and objective are now stated narrowly: vertically resolved observations remain sparse at Reunion in the eastern SWIO, several thousand kilometres downstream of the main source regions (lines 81-87). Section 4 compares the results with DeLiAn, SAFARI-2000, ORACLES, AEROCLO-sA, regional transport-corridor studies, and trans-Atlantic observations before identifying the specific advance as the vertically resolved characterization of aerosol layers reaching Reunion, including two simultaneous elevated layers with contrasting optical and moisture environments (lines 511-515). We do not claim novelty for long-range smoke transport itself.

We believe these changes preserve the observational contribution while aligning each conclusion with the level of evidence available and presenting the limitations as part of the scientific reasoning.