RESPONSE TO REFEREE 2

Manuscript egusphere-2026-3070

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

Dear Referee 2,

We thank you for the careful distinction between measurement quality and strength of inference. We adopted that distinction throughout the revision. Observations and retrieved quantities are presented before model-supported interpretation, the objective is limited to an observational case study, and the relevant qualifications are integrated where the results are discussed. Section 4 follows a continuous progression from demonstrated findings to model-supported interpretation, literature comparison, limitations, and implications.

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

Major comment 1 - Objective not achieved

Comment: *The study claimed to reduce radiative-forcing uncertainty but presented no forcing calculation.*

Response: We agree and removed that claim from the objective. The revised objective is to characterize vertical structure, optical properties, moisture environment, and whether transport from selected source regions is consistent with the observations (lines 101-107). Radiative forcing is mentioned only as motivation and a possible application of future work; the final paragraph explicitly states that no radiative-forcing calculation is performed (lines 531-535).

Major comment 2 - Circular CAMS reasoning

Comment: *Agreement in total AOD cannot validate species-resolved CAMS AOD.*

Response: We agree. The Methods now distinguish assimilated total AOD from model-determined species partition and list the relevant model assumptions (lines 239-259). In the Results, the AERONET-CAMS comparison is used only as qualitative temporal context; the OM contribution is explicitly model-derived and is not validated by the total-AOD comparison (lines 213-217). The same evidence hierarchy is retained in the Discussion (lines 496-498).

Major comment 3 - Observation versus inference

Comment: *Direct observations, retrieved quantities, simulations, and interpretation were interwoven.*

Response: The opening of Section 3 now defines the contribution of the observations/retrievals, CAMS, FLEXPART, and the combined interpretation (lines 250-255). In Section 4, the first paragraph reports the observed and retrieved quantities, including the numerical values and uncertainties (lines 486-495); the second paragraph then presents the CAMS- and FLEXPART-supported interpretation (lines 496-504). We implemented the requested distinction in this explicit paragraph order rather than adding visible subsections, which keeps the discussion readable while preserving the evidential boundary.

Major comment 4 - Model-dependent source attribution

Comment: *Individual-layer source statements should be consistently qualified.*

Response: Source language is now conditional throughout. The Methods define FLEXPART as a two-source experiment and explain that Madagascar and other sources were not simulated separately (lines 243-248). The Results use model-supported language and define the reported percentages relative to the two

selected simulations (lines 462-483). Section 4 states that these percentages describe represented CO air-mass transport, not aerosol-mass fractions or unique source assignments (lines 502-504 and 522-524).

Major comment 5 - Representativeness

Comment: *Two routine lidar nights cannot establish representativeness of the September episode.*

Response: We agree. The two lidar nights are described as illustrative cases selected from the available routine measurements. Section 4 states that they do not establish how frequently these configurations occur during September or over the biomass-burning season (lines 524-525). The implications paragraph identifies longer lidar records, systematic case selection, and aerosol-specific simulations as the work required to quantify representativeness (lines 530-531).

Major comment 6 - Alternative hypotheses

Comment: *Transport timing, hygroscopicity, mixing state, and injection-height uncertainty should be considered.*

Response: Alternative explanations are now incorporated where each inference is made. Ångström-exponent contrasts may reflect size, mixing, combustion conditions, humidification, or processing (lines 336-342 and 357-360); WVMR is used only to describe the moisture environment and not hygroscopicity (lines 370-372); and the lower-layer interpretation includes mixed transport pathways, humidification, combustion, and processing as alternatives (lines 387-391). Section 4 then synthesizes injection-height, meteorological, mixing, retrieval, and omitted-source limitations (lines 517-525).

For the referee's information, during the preparation of this manuscript, the hygroscopic growth factor was estimated using the so-called Hänel parameterization. The only layer that showed simultaneous variations of extinction and relative humidity is the bottom layer of September 25th. A hygroscopic growth factor of 5.2 was found, far beyond literature values that fall in the range 0.10 – 1.84 (Sicard et al., 2022). We concluded that hygroscopic growth was not the driving phenomenon here.

Sicard, M., Fortunato Dos Santos Oliveira, D. C., Muñoz-Porcar, C., Gil-Díaz, C., Comerón, A., Rodríguez-Gómez, A., and Dios Otín, F.: Measurement report: Spectral and statistical analysis of aerosol hygroscopic growth from multi-wavelength lidar measurements in Barcelona, Spain, Atmos. Chem. Phys., 22, 7681–7697, https://doi.org/10.5194/acp-22-7681-2022, 2022.

Abstract and novelty wording

Comment: *The phrase 'for the first time' should be qualified.*

Response: The broad phrase has been removed. The revised Introduction and Section 4 limit the contribution to vertically resolved characterization at Reunion in the eastern SWIO, far downstream of the principal source regions, including one case with two simultaneous elevated layers with contrasting optical and moisture environments (lines 81-87 and 511-515).

Knowledge gap after previous campaigns

Comment: *The residual observational gap was unclear.*

Response: The Introduction now explains that most intensive measurements focused on source-proximal regions, the southeast Atlantic, or the western SWIO, whereas vertically resolved observations remain sparse at Reunion in the eastern SWIO after several thousand kilometers of transport (lines 81-87).

AOD_{500}-to-AOD_{550} conversion

Comment: *The conversion introduces uncertainty.*

Response: The conversion paragraph now identifies the Ångström-law assumption, explains how uncertainty in the measured Ångström exponent propagates to the converted AOD, and treats the converted values as comparison quantities rather than independent measurements at 532 or 550 nm (lines 118-123).

Klett inversion and lidar-ratio sensitivity

Comment: *Dominant assumptions and sensitivity should be discussed.*

Response: The Methods now identify transfer of the 75 ± 9 sr lidar ratio as the main systematic assumption for absolute extinction and layer AOD, while noting that observed backscatter controls the layer boundaries and one-versus-two-layer structure (lines 161-165). The same qualification is incorporated into the synthesis of limitations (lines 518-520). We therefore addressed the referee's 'assess or discuss' alternative through explicit sensitivity discussion and qualified conclusions rather than new retrieval profiles.

FTIR averaging-kernel smoothing

Comment: *The effect of smoothing on comparison with FLEXPART should be explained.*

Response: The revised Methods explain that averaging-kernel smoothing makes FLEXPART and FTIR comparable at the limited FTIR vertical resolution but removes fine model structure; the comparison therefore cannot validate individual aerosol-layer boundaries (lines 240-242). The event comparison repeats this limit when interpreting the broad vertical distribution (lines 444-446).

FLEXPART inputs and uncertainties

Comment: *GFAS, injection height, and ERA5 uncertainties affect attribution.*

Response: These uncertainties are now integrated into the FLEXPART description: GFAS emissions and injection heights, ERA5 transport and convection, unresolved mixing, incomplete source coverage, and the different lifetimes/removal of CO and aerosol are all identified (lines 243-248). Their implications are synthesized in Section 4 (lines 521-524).

CAMS-AERONET metrics

Comment: *RMSE, bias, and sample size were requested in addition to Spearman correlation.*

Response: We removed the model-validation claim on which this request depended and, after re-examining the point, also removed the Spearman statistic. The AERONET-CAMS comparison is now explicitly qualitative and is used only to place the observed episode in the temporal context of the reanalysis; it neither evaluates model performance nor validates CAMS composition (lines 215-217 and 275-276). Because no quantitative performance assessment is retained, adding RMSE, bias, or sample-size metrics would no longer support a manuscript claim.

CAMS OM dominance

Comment: *OM dominance is model-derived.*

Response: This is now stated in the Methods (lines 213-215), Results (lines 285-286), and Discussion (lines 496-498).

Qualitative 'river of smoke'

Comment: *Either define the criteria or identify the term as descriptive.*

Response: We followed the second option. The earlier literature term is defined as descriptive in the Introduction (lines 57-60), removed from the title, and replaced in the Results by 'organized smoke-transport corridors'. The text states that the maps support plausible regional connectivity rather than a threshold-based source classification (lines 301-303).

CALIOP typing

Comment: *Classification uncertainty should be acknowledged.*

Response: CALIOP subtyping is now described as an algorithmic classification based on measured optical properties, location, and assumed aerosol models; mixed or weakly scattering layers may be misclassified (lines 139-141). The Results accordingly treat the CALIOP labels as regional context rather than direct chemical identification (lines 318-319).

Ångström exponent

Comment: *Humidity, mixing state, and combustion conditions also affect Ångström exponent.*

Response: We agree and now list these influences explicitly. The observed values are used as optical descriptors, not unique age diagnostics (lines 336-342 and 357-360).

WVMR uncertainty

Comment: *The moisture interpretation was too strong for the reported uncertainty.*

Response: The revised text distinguishes retrieval uncertainty from temporal scatter and treats the September 19th pattern qualitatively (lines 370-372). For September 25th, it retains the approximately 74% lower-layer uncertainty and restricts the interpretation to the clear dry-upper-layer/moister-lower-layer contrast (lines 387-391).

Discussion and conclusions

Comment: *Demonstrated findings should be distinguished from model-supported interpretations.*

Response: Section 4 now does this through a continuous sequence: observed and retrieved quantitative findings (lines 486-495), CAMS- and FLEXPART-supported interpretation (lines 496-504), comparison with current literature (lines 506-515), limitations (lines 517-525), and implications/future work (lines 527-535). This preserves the requested distinction without introducing short, disconnected subsections.