

Improvements on the BRAMS wildfire-atmosphere modelling system

Isilda Cunha Menezes, Luiz Flávio Rodrigues, Karla M. Longo, Mateus Ferreira e Freitas, Saulo R. Freitas, Rodrigo Braz, Valter Ferreira de Oliveira, Sílvia Coelho, Ana Isabel Miranda

egusphere-2025-2495

Answers to Editor and Referees

We would like to thank the editor and the anonymous reviewers for their availability, dedicated time, and thoughtful analysis of our manuscript. We greatly appreciate their constructive comments and insightful suggestions, which have been invaluable in guiding the improvement of this work.

The revised manuscript has undergone a comprehensive restructuring and theoretical update in direct response to the reviewers' observations. The analytical framework, methodology, and interpretation of the optical results were entirely reformulated, ensuring stronger physical consistency, improved coherence between figures, tables, and discussion, and full alignment with the state of the art. These revisions substantially enhance the scientific rigor and clarity of the manuscript.

For transparency, we provide both a tracked-changes version, highlighting all modifications relative to the original submission, and a clean revised version for final evaluation.

We sincerely hope that this revised version meets the expectations of the editor and reviewers and reflects the depth of revision undertaken in response to their valuable feedback.

Yours Sincerely,
Isilda Cunha Menezes
(Corresponding author on behalf of all authors)
Universidade de Aveiro
Campus Universitário de Santiago, edifício 7
Aveiro, Portugal
E-mail address: isildacm@ua.pt

Response to Reviewer 1 Comments

Comments 1: First of all, some of the results are compared with MERRA-2 reanalysis products. It is mentioned (lines 298 and 299) that monthly mean results of MERRA-2 products were compared with AERONET retrievals. Considering SSA in particular, was the MERRA-2 result also compared with AERONET retrievals? As detailed below, some inconsistencies were observed. Finally, please, consider increasing the font size of Figures 9 and 10 and verify if the isolines of CAPE in the vertical profiles of the Figure 9 are correct. I had difficulty in interpreting the results just looking at the figures.

Response 1: We thank the reviewer for this valuable observation. In our work, the comparison between MERRA-2 and AERONET included not only AOD but also SSA retrieved from AERONET data. This has been clarified in the revised text. The font size of Figures 9 and 10 was increased to improve readability, and the CAPE isolines in Figure 9 were verified and corrected to ensure consistent interpretation with the legend.

Comments 2: line 42 - GFED, CAMS-GFAS - What do the acronyms mean?

Response 2: The acronyms GFED (Global Fire Emissions Database) and CAMS-GFAS (Copernicus Atmosphere Monitoring Service – Global Fire Assimilation System) have been defined in the manuscript.

Comments 3: line 58 - replace “originates” by “originated”.

Response 3: Corrected: “originates” was replaced by “originated.”

Comments 4: line 68 - include “the” in “increases the heat release...”

Response 4: Corrected: “increases heat release” now reads “increases the heat release.”

Comments 5: line 84 - replace smoke-related aerosols by smoke-related aerosol optical properties.

Response 5: Corrected as suggested. The text now reads “smoke-related aerosol optical properties.”

Comments 6: line 106 - Give the meaning of the acronyms CPTEC and USP.

Response 6: We added the definitions of the acronyms: CPTEC/INPE (Centre for Weather Forecasting and Climate Studies – National Institute for Space Research) and USP (University of São Paulo).

Comments 7: lines 166, 167, 171 (Eq. 1). Please, verify the subscripts of I and R (initialization x inicialization, respectively). The correct answer should be initialization, unless the authors have a reason to differentiate them. If so, a brief explanation is necessary.

Response 7: We thank the reviewer for noticing this issue. The incorrect Portuguese term “inicialization” was replaced with “initialization” throughout the manuscript.

Comments 8: line 400 - please add references discussing the spectral region where OC and BC present higher absorption efficiency.

Response 8: We have expanded the description of the optical properties of black carbon (BC) and organic carbon (OC), specifying their distinct spectral absorption behaviours across the visible range (400, 550, 700 nm). References were added and integrated within the discussion (Bond et al., 2004; Kirchstetter and Novakov, 2004; Bond and Bergstrom, 2006; Andreae and Gelencsér, 2006; Lack and Cappa, 2010).

Comments 9: lines 408 and 411 - Use of AOD x AOT. I recommend using only AOD - aerosol optical depth. Please, check the manuscript thoroughly. Also, in lines 411-412, the authors mention that MERRA-2 estimates AOD at 500 nm, while BRAMS calculates SOD at 550 nm. Given that smoke optical depth varies spectrally, please, clarify if the comparison between these variables was made at different wavelengths (500 nm x 550 nm).

Response 9: We have standardized the nomenclature by using AOD (Aerosol Optical Depth) consistently throughout the manuscript. Although MERRA-2 labels these variables as “Aerosol Optical Thickness,” we adopted “AOD” for consistency. We also corrected the typographical error regarding the comparison wavelength: both MERRA-2 and model results correspond to 550 nm, not 500 nm.

Comments 10: lines 452, 720 and 751 - is there any reason to include all the authors of Menezes et al. (2024) paper? Please, just refer to Menezes et al. (2024).

Response 10: Corrected as requested. The references to the full author list of Menezes et al. (2024) now appear only as “Menezes et al. (2024).”

Comments 11: line 485 - the correct acronym is AOD, instead of TOA. Please, refer to the previous comment.

Response 11: The incorrect acronym TOA was replaced with AOD, consistent with Response 9.

Comments 12: line 486 - what do you mean by biomass fuel models?

Response 12: Revised to clarify that “biomass fuel models” refers to the NFFL fire-behaviour fuel models (Anderson, 1982) that characterize vegetation and fuel types used by SFIRE to determine combustion intensity and emissions.

“Forest fires, during their propagation, consume the available biomass as characterized by the different NFFL fire behaviour fuel models (Anderson, 1982), which represent the landscape, and release high concentrations of particles and trace gases into the atmosphere.”

Comments 13: line 487 - it is not only during the flaming phase that aerosol particles are emitted, but during the combustion process. Please, rephrase.

Response 13: Corrected for accuracy. The text now reads:

“Primary aerosols are emitted throughout combustion, during both the flaming and smouldering phases.”

Comments 14: line 520 - add a dot signal after wavelength.

Response 14: A period was added after the word “wavelength.”

Comments 15: line 521 - rephrase “Understanding the spectral behaviour of smoke aerosols is essential for interpreting optical depth measurements” to “Understanding the spectral behaviour of smoke aerosol optical properties is essential for interpreting optical depth measurements”.

Response 15: Revised as suggested:

“Understanding the spectral behaviour of smoke aerosol optical properties is essential for interpreting optical-depth measurements.”

Comments 16: line 522 - what do the authors mean by spectrally integrated SOD?

Response 16: We clarified the meaning of SOD as representing the column-integrated attenuation of solar radiation due to aerosols at 550 nm, consistent with AOD at the same wavelength. The sentence was rewritten accordingly.

Comments 17: Figure 3 - Please verify the top numbers in the vertical colorbar (2502.00 and 5000.00) representing SOD values. From the maps, MERRA-2 AOD higher values were observed in the northern part of the region, while SOD highest values were observed between 39.8° and 40° N at 15:00, moving to the north later, reaching 40.3° N at 21:00, when both AOD and SOD presented similar patterns (six hours later only). From the discussion presented in lines 542 to 552, how do the authors explain the high AOD values, above 1.3, further north at 15:00? As discussed, if MERRA-2 did not fully capture the peak of the fresh fire emission, shouldn't we expect low AOD values at 15:00 everywhere in the map? Or does that mean that MERRA-2 fire source is located further north? From

the color gradient, it seems that the peak of AOD from MERRA-2 is further north outside the presented map. Maps at 15:00 in Figure 4 seems to confirm this.

Response 17: We thank the reviewer for this detailed observation. The explanation in the revised text now reads: the MERRA-2 AOD maxima further north at 15:00 UTC arise from the coarse spatial resolution and assimilation smoothing of the reanalysis system, which tends to shift aerosol peaks relative to high-resolution model output. The BRAMS-SFIRE SOD captures the fresh fire emissions over the actual burning area, while MERRA-2 represents the broader regional aerosol load. The agreement improves later in the day (21:00 UTC), when both datasets reflect the same mature plume position, confirming that the differences are primarily due to spatial averaging and temporal lag rather than physical inconsistency.

Comments 18: lines 579-580 - Even though OC/BC ratio is higher during the smoldering combustion phase compared to the flaming, OC concentration is always higher than BC for most of the vegetation types, independently of the combustion phase. According to the review by Reid et al. (2005), the exceptions are forest debris and herbaceous fuel.

Response 18: The discussion of Figure 4 was revised. We clarified that OC concentrations are substantially higher than BC across most vegetation types, independent of combustion phase, consistent with Reid et al. (2005). The high OC/BC ratios observed indicate strong smouldering combustion contributions, which dominate under the studied conditions.

Comments 19: Figure 6 - The numerical scale of the vertical colorbar must be verified (Simulated single scattering albedo). SSA can vary only between 0 and 1. The top left map (from 15:00) shows lower SSA values from MERRA-2 in the southeastern portion of the map, increasing towards the northern region. Maps generated for later times also show lower SSA values in the southeastern region. Does it mean that MERRA-2 is not reproducing the smoke event accordingly? If not, maybe it is not a good reference for comparison.

Response 19: We verified the SSA colour scale and corrected the numerical range in Figure 6 to 0–1. The pattern differences between MERRA-2 and BRAMS-SFIRE are discussed as resulting from resolution and averaging effects: MERRA-2 underrepresents near-source SSA variability because of its coarse grid and data-assimilation smoothing. Despite this, the regional distribution trends remain consistent, indicating that the satellite-derived reanalysis captures the smoke event qualitatively, even if with reduced contrast.

Comments 20: lines 687-688 - Please add the references of the mentioned studies.

Response 20: The missing references cited in lines 687–688 have been added. These correspond to studies already present in the reference list and discuss aerosol–radiation interactions and surface cooling effects associated with smoke.

Comments 21: Figure 8 - It is not clear what the authors mean by "Fire-weighted smoke absorption", whose value can reach 60000 W/m², according to the presented scale. Sertã time zone is UTC + 1, thus, the absorbed solar irradiance should be close to zero at 17:00 UTC and zero at 21:00 UTC (i. e., no absorbed irradiance, since no solar radiation is available), as shown in the map of No Fire - Fire change in downwelling flux. In the longwave spectrum, by contrast, please confirm if the correct variable is "Fire-weighted smoke absorption" or "Fire-weighted smoke emission", i. e. the irradiance emitted by the smoke plume due to its higher temperature compared to the surrounding environment.

Response 21: We appreciate this important comment. The variable originally labelled "Fire-weighted smoke absorption" has been corrected to "Fire-weighted smoke emission" in the long-wave context. The analysis now clarifies that this quantity represents radiative emission from the smoke plume, not solar absorption, consistent with the timing (17:00–21:00 UTC) when shortwave irradiance is negligible. The wording and figure legend were updated accordingly to prevent confusion between absorbed shortwave and emitted longwave fluxes.

Comments 22: line 735 - replace "shown" by "shows".

Response 22: Corrected: "shown" was replaced by "shows."

Comments 23: lines 737-738- Discussing Figure 9, it is mentioned "while CAPE and CIN isolines are superimposed: dashed yellow lines indicate the fire simulation and solid orange lines represent the no-fire scenario". But in the legend, it says: "Dashed black lines indicate the fire simulation, while dashed orange lines represent the no-fire scenario". What do the authors mean by "superimposed" in the context? Looking at Figure 9, I couldn't identify the superposition of CAPE and CIN, since it seems they were plotted separately. How can one distinguish the differences of Fire x No-Fire for CAPE in the profiles? Moreover, it is very difficult to read the information in Figure 9, as the font size is too small (the same for Figure 10). Please, consider increasing the font size.

Response 23: We have rewritten the description of Figure 9. The term "superimposed" was removed and replaced with a clear explanation: CAPE and CIN are displayed as separate contour lines, with dashed black indicating the fire simulation and solid red the no-fire case. The caption and legend now match, and the font size of Figures 9 and 10 was increased to improve legibility.

Comments 24: line 764 - the mentioned wavelength is 400 nm, but in the legend, it says 700 nm.

Response 24: Corrected: the mentioned wavelength now matches the legend, 700 nm.

Comments 25: lines 766 to 768 - The spectral dependency is also a result of the smoke particle size distribution, concentrated in the fine mode.

Response 25: We thank the reviewer for this useful remark. A sentence was added noting that the spectral dependency of optical properties also reflects the dominance of fine-mode smoke particles in the size distribution, which enhance scattering in the shorter wavelengths and drive the observed wavelength dependence.