We sincerely appreciate your invaluable feedback and thorough review of our research. Your insights are crucial for enhancing the quality and reliability of our study. We are highly grateful for the time and effort you've devoted to this process. Your comprehensive comments have provided us with valuable guidance, and we are committed to addressing all the issues you've raised to ensure that our research meets the highest standards. Thank you for your dedication to advancing science and your commitment to assisting us in refining our research. We look forward to resubmitting the revised manuscript and responding to your suggestions.

Main comments

1.What is the rationale behind choosing March 2019 as the study timeframe? How does the fire season (March 2019) compare to other fire seasons in the region, was it representative of the average conditions (or anomalously high/low)?

Response:

1. We have accepted the reviewer's suggestions and added the spatial distribution characteristics of the MODIS inversion fire points in March 2019 to Figure 1(b), as well as a histogram showing the total number of fire points for each month in 2019 in Figure 1(c). This will help to further emphasize the importance of the period used in the simulation.
2. Regarding the reviewer's inquiry about the rationale for selecting March 2019 as the study period, we have incorporated pertinent information in the manuscript.

1)Lines 83-86. " Wiedinmyer et al. (2023) have shown that the seasonal cycle (averaged over 2012-2019) of CO emissions from BB in various regions of the world and the latest version of FINN v2.5 (MODIS+ VIIRS) has an emission peak in March, primarily driven by emissions from the PSEA. However, this peak is absent in GFED and is less pronounced in other emission inventories (FINN1.5, FEER, GFAS, QFED). " Therefore, it is imperative to determine the causes of emissions from different fire sources in mainland Southeast Asia in March.

2)Lines 95-102. "The World Meteorological Organization's report highlights that the early part of 2019 corresponds to the El Niño cycle (from April to May, the temperature of waters beneath the surface of the tropical Pacific has notably declined) (Organization, 2019), during which meteorological conditions are more favourable for the occurrence and propagation of BB (Cochrane, 2009). Additionally, Yin (2020) discovered that over the past 18 years (2001-2018), the PSEA region predominantly experienced the peak of BB activity in March each year. Fan et al. (2023) and Duc et al. (2021) confirmed that the PSEA suffered severe air quality impacts during the BB in March 2019. Therefore, centered on the period of March 2019, this study aims to analyze how emission uncertainties or differences from different BB inventories affect the spatial and temporal distribution of aerosols and their radiative effects in the PSEA region."

3)Lines 111-114."Figure 1 depicts the simulation domain, outlined in blue (Figure 1(a)). It shows that the MODIS active fire instances during March 2019 were primarily consolidated in Laos, Cambodia, and Northern Thailand, as well as in Eastern and Western Myanmar (Figure 1(b)). Importantly, with a total of 69,771 fire counts, March 2019 saw the highest monthly peak of fires for that year (Figure 1(c))."

2.The influence of external dust aerosol on AEC is mentioned in section 3.5, 4.2, and in the

summary and conclusions. Can you provide more details on how external dust (or other inorganic aerosols e.g., sea salt aerosol) impacts the AEC profiles?

Response:
We accepted the reviewer's suggestion to add Figure S4 to illustrate the effect of dust and sea salt aerosols on AEC
1. Lines 486-493
"Figure S4 illustrates the frequency distribution of six aerosol types at an altitude of 8 km over the PSEA region in March 2019. Within the higher altitudes of 5-7 km the presence of dust, polluted dust, and smoke aerosols is evident, with the dust aerosols originating from the upper-level westerlies in the Indian region. Within this altitude range, the simulated AEC gradually approaches zero with increasing altitude. However, the AEC retrieved by CALIPSO exhibits three peaks, which may be attributed to uncertainties in the calculation model for BB injection heights and the influence of external dust transport."
2. Lines 580-583
"Despite the influence of sea salt aerosols in the near-surface region of PSEA (Figure S4), the contribution of sea salt aerosol to AOD is notably small, approximately 2% (Zeng et al., 2023). Additionally, Dong and Fu (2015a) observed that the model, during the period from 2006 to 2010, accurately simulated BB AOD without incorporating sea-salt emissions over the PSEA region. Consequently, our model does not consider sea-salt emission inventories."

3.Lines 553 – 556, Jin et al. mention that when direct and indirect radiation feedbacks are included in WRF-Chem they improve the representation of AOPs, but indirect radiation feedbacks are not included in their simulations. Jin et al., mention that this, "may also lead to biases in the AOPs" (Line 556), but what specifically are those biases? Please expand on this point.

Response:
We have made corresponding changes to lines 587-592 based on the reviewers' suggestions, which mainly involve two parts defining ACI and modeling how the absence of ACI affects aerosol optical properties.
1."Additionally, the inclusion of ARI and aerosol–cloud interactions (ACI) in the WRF-Chem model has been found to effectively improve the simulation of AOPs in European wildfire simulations, whereas this study only incorporates ARI"
2."ACI is concerned with aerosols altering albedo and lifetime of clouds (Baró et al., 2016). "
3."Failure to account for ACI may result in models that do not accurately simulate cloud droplet numbers and sizes, lifetimes, and radiative balances, with implications for climate and atmospheric AOPs (Gao et al., 2022)."

4.The semi-direct effect from absorbing aerosols (AAs) is another important process that impacts DRF. AAs are effective at absorbing shortwave radiation in the atmosphere and can burn-off clouds (impacting DRF). Is this process included in this modelling framework? A useful study for this may be Mallet et al., 2020.

Response:
The ARI in the WRF-Chem model includes traditional aerosol direct and semi-direct effects. We

have revised this section in the model introduction section to show that the model includes semi-direct radiative effects.

Lines 129-131

"The aerosol-radiation interactions (ARI) scheme of WRF-Chem includes the traditional aerosol direct and semi-direct effects (Baró et al., 2016). Mallet et al. (2020) and Palacios-Peña et al. (2018) found that model incorporation of ARI can effectively replicate smoke aerosol simulations, so the ARI scheme was selected for this paper."

5. Understanding more details of the aerosol composition in the BB inventories will be useful. How are aerosol mixing processes (external and internal mixed aerosol) included in your modelling framework? These mixing processes will impact the hygroscopicity of aerosols, impacting AOPs depending on the aerosol composition of each inventory.

Response:

We thank the reviewers for their valuable comments. All eight BB emissions use the WRF-Chem model with the MOSAIC 4 bin scheme to simulate atmospheric aerosols. In the model, we considered that the aerosol compositions were externally mixed between the size bins and internally mixed in each size bin. The internal mixing refractive index was the volume-weighted mean refractive index of each composition. This means that the different aerosol components are homogeneously mixed within the same size range, which helps to model the chemical and optical properties of the aerosol more accurately. However, the aerosol components are mixed externally between different size bins. This means that there can be different chemical compositions between aerosol particles of different size ranges, which reflects the complexity of aerosols in the actual atmosphere. This external mixing process has an important effect on the water hygroscopicity of aerosols and thus on AOPs. This study aims to analyze how the uncertainties or differences in emissions in different emission inventories in the PSEA region affect the spatial and temporal distribution characteristics of aerosols and aerosol radiative effects in the WRF-Chem model. In addition, Reddington et al. (2019) found that the modeled AOD of BB aerosols is relatively insensitive to the assumption of aerosol mixing state. Therefore, the interrelationships between different inventory emission aerosols and their modeled mixing state-absorption-optical properties are relatively less explored in this paper.

Minor points are below.

1. Figures 3, 4, and 13 should have the inventories labelled on the top of the panel. This will make it easier to interpret the results.

Response:

We have accepted the reviewer's comments and have carefully rechecked the figures throughout the paper, in particular adding the names of the emission inventories to Figures 3, 4, and 13 to facilitate the reader's understanding.

2. Line 152 – is "gas" referring to SO2 and NH3 (as it is on line 310)? If so, I might suggest just stating SO2 and NH3 explicitly as "gas" is somewhat ambiguous.

Response:

We have adjusted Line 166, where "gas" has now been changed to "gases (CO, NO_X, SO_2, NH_3)"

and the Table 1 header "Gas" has been modified to "Gases", to differentiate it from "Gas" in Line 324.

3.Lines 321 – 322, Jin et al., mention that QFED exhibits a lower BC to OC ratio compared to the other inventories. Do you have any comments as to why this inventory leads to a lower BC/OC compared to the other inventories?

Response:

We accept the reviewer's suggestion to make changes in lines 339-340. "In addition, differences in emission EF in Southeast Asia may result in a BC/OC equal to approximately 0.08."

4.Line 493 – 494, "(with FINN2.5 MOSVIS reaching a maximum of 70 W m-2)" Please make it clearer what maximum you are referring to.

Response:

It refers to the DRF of the FINN25 MOSVIS scheme in Figure 10 that simulates SFCs in the PESA region with a maximum of about 70 W m^{-2}. We accept the reviewer's suggestion to make changes at lines 516-517."The eight schemes simulate the DRF of -32.60±24.50 W m^{-2} at SFC in the daytime with FINN2.5 MOSVIS reaching a maximum of approximately70 W m^{-2} (Figure 10)"

5.In table 1, I suggest changing the "Main EF" label to "EF reference (s)". Make it clear that these are references.

Response:

We accepted the reviewers' comments and revised Table 1

6.(As an example) Line 45 uses "W/m2", please change all instances of this to "W m-2".

Response:

We thank the reviewers for their comments, and we have revised the manuscript in its entirety in accordance with the journal's requirements.

7.On figure S1, please remove the "figure" label at the top left.

Response:

The "figure" has been removed.

8.Figure S2, make it clearer which letter labels refer to which of the 23 cities.

Response:

Thank you for the reviewer's suggestions. In order to better illustrate the comparison between simulated and observed data for various city sites, we have added city titles to Figure S2.

Reference

Reddington, C. L., Morgan, W. T., Darbyshire, E., Brito, J., Coe, H., Artaxo, P., Scott, C. E., Marsham, J., and Spracklen, D. V.: Biomass burning aerosol over the Amazon: analysis of aircraft, surface and satellite observations using a global aerosol model, Atmos. Chem. Phys., 19, 9125-9152, 10.5194/acp-19-9125-2019, 2019.