Response to Referee #1

General Comments:

This study diagnoses uncertainties in global biomass burning emission inventories and discusses the causes of large biases. In this study, the authors compared gas- and particulate-phase emissions from four biomass burning emission inventories established by bottom-up and top-down approaches. The authors quantified the contribution of different factors to the uncertainty in biomass burning emissions and proposed that dry matter was the main cause of regional bias in CO emission estimates. Vegetation classification methods and fire detection products led to the uncertainties in bottom fuel consumption and burned area calculations, resulted in biases in dry matter. They reported that the variability of particulate-phase emission was even higher than that of gas-phase emission. In addition, they compared the simulated results with satellite measurements, and given certain inventory recommendations based on different study areas and spatiotemporal scales. This study is well written and well organized, and could support improvements in biomass burning emission inventories in further studies. I recommend accepting it after minor revisions.

Response:

We thank the reviewer for the positive comments. We have revised the manuscript carefully according to the reviewer's suggestions.

Specific Comments:

1. The second paragraph beginning with "Recent studies" can be combined with the third paragraph beginning with "Previous studies".

Response:

Thank you for your suggestion. We have revised the sentence as follows: "Previous studies often found that there is a significant deviation between the gaseous or particulate pollutants simulated by the model and the satellite retrieval value (Bian et al., 2007; Chen et al., 2009; Carter et al., 2020), one of the most important reasons comes from the uncertainties in emission inventories." Please find in lines 62-65.

2. Section 2. The description of Biomass Burning emission inventories and Quantitative statistical methods can be shortening. Some details can be moved to supplementary information.

Response:

Thank you for your helpful suggestion. We have shortened section 2.1, which introduces the biomass burning emission inventories. Details have been relocated to the supplementary information. For specific changes, please refer to the tracked changes in section 2 of the manuscript.

3. Line 545-561. There is a little bit of confusion about this paragraph. The authors said, "The total QFED FRP is 1.5 times higher than VFEI0, but DM in QFED2.5 inventory is 30% lower than VFEI0", and also said: "Therefore, although the two top-down emission inventories use similar algorithms, significant bias occurs under high cloud fraction conditions, with QFED2.5 estimating DM much higher than VFEI0". So, does the low DM in the QFED2.5 mainly occur under low or medium cloud fraction? Could the authors give some specific values?

Response:

Apologies for the confusion. Upon reevaluation of the data, we observed that the DM in QFED2.5 inventory is consistently lower than that in VFEI0, with a significant bias occurring under high cloud fraction conditions. We have revised the paragraph for clarity as follows:

"The estimations of FRP and DM are strongly influenced by the horizontal resolution of satellite products. For example, in the BONA region during July (the month with the most intense burning at the position of 50°-70°N, 100°-130°W), the total QFED FRP (average FRP measured by MOD and MYD) is 1.5 times higher than VFEI0 (Fig. S7). Additionally, the differing α values between QFED2.5 and VFEI0 in BONA can potentially result in higher DM in QFED2.5 compared to VFEI0 by a factor of 1.3-3.8. However, the actual DM in the QFED2.5 inventory is 30% lower than in VFEI0. The relatively high FRP density used in VFEI0 (Fig. S8) results in a higher DM than in QFED2.5 due to its superior horizontal resolution, enabling the precise delineation of fire areas. It is important to note that while the empirical factor also influences the amount of DM, its impact should not be as significant as the difference caused by the horizontal resolution of satellite products (Kaiser et al., 2012; Darmenov et al., 2015; Ferrada et al. 2022)."

Please refer to lines 492-502 for the specific details.

4. Figure 2 showed that FINN1.5 estimated much larger CO emissions than other emission inventories in EQAS. The authors also selected the EQAS as one of the important biomass burning regions based on the fact that "(1) regional BB CO emissions above 20Tg/yr, (2) BB CO emissions account for more than 70% of the total". However, table 3 shows similar CO column averages across the four BB emission inventories. Could the authors also explain why? Additionally, it is important to show simulated near-surface/different vertical layer CO concentrations.

Response:

Thank you for the comment. Various vertical layers of CO concentrations have been added to Table R1. While a substantial bias exists among BB emissions (~30%), influencing surface-layer CO concentrations, these differences decrease with altitude. For example, the ratio of maximum to minimum CO values at the 900 hPa level is 1.18, decreasing to 1.07 at the 200 hPa level. Our results are consistent with Bian et al (2007).

Table R1. Comparison of CESM-CAM6 simulated CO column averages and satellite retrieved CO mixing ratio averages (units:ppbv) in EQAS during the fire season

Layer	Satellite	CESM2-CAM6			
	MOPITT	FINN1.5	GFED4s	QFED2.5	VFEI0
100hPa	49.19	47.53	48.96	46.58	46.83
200hPa	66.20	68.22	72.09	67.07	67.58
300hPa	64.29	69.62	74.27	68.51	69.06
400hPa	65.65	70.76	76.58	69.56	70.18
500hPa	68.58	70.24	77.25	68.98	69.67
600hPa	74.14	67.54	75.00	66.56	67.23
700hPa	75.10	67.21	77.89	66.24	66.91
800hPa	75.44	70.91	85.49	69.62	70.51
900hPa	86.42	75.37	89.32	74.83	75.79

5. Line 660-665. Is there any reference to support the conclusion that the overestimation of SOA in South Hemispheric South America is due to biogenic sources?

Response:

Thank you for your important comment. He et al. (2015) used CESM/CAM5 and reported that 75% of secondary organic aerosol in South Asia originates from biogenic sources. Tilmes et al. (2019), using CESM2, further reported that biogenic emissions contribute to at least two-thirds of the total SOA burden. Additionally, Jo et al. (2023) suggest a higher SOA concentration than other aerosols in South America across all vertical levels. Thus, the overestimation of SOA in the South Hemisphere is attributed to biogenic sources.

We have included the related references in Line 614.

References:

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