We sincerely thank the editor and reviewers once again for their great efforts and constructive comments. In this document, we outline our responses to the second-round comments. Reviewer comments are shown in black italics, and our responses are provided in blue regular text. A manuscript with tracking changes is attached at the end.

Reviewer #1:

1) Please discuss the long-term trends in fire-$PM_{2.5}$ in the context of long-term trends in the used emission inventory (GFED and QFED).

- In the revised version, we added discussion about the long-term trends in fire-$PM_{2.5}$ with GFED and QFED inventories: "These differences in fire-sourced [$PM_{2.5}$] are mainly due to the discrepancies in fire inventories. In global fire-prone regions, organic carbon (OC) emissions from fires are 51.08-65.18% lower in the GFED inventory compared to the QFED inventory (Fig. 6a). Consequently, the global average fire-sourced [$PM_{2.5}$] is estimated at 2.04 μg m^{-3} with GFED, nearly half of the 3.96 μg m^{-3} estimated with QFED (Table 2). Moreover, fire emission trends in QFED tend to be more negative or less positive than in GFED (Fig. 6b), leading to stronger negative trends in fire-sourced [$PM_{2.5}$] derived from QFED (Fig. 6d). For both inventories, simulated fire [$PM_{2.5}$] trends are more negative than the corresponding emission trends, likely due to climatic or chemical conditions that enhance pollutant removal. For example, in North America, increased atmospheric oxidant levels (e.g., increased OH and O_3) and changes in boundary layer height over the past two decades may have offset rising fire emissions by accelerating aerosol aging and modifying vertical mixing (Heilman et al., 2014;Zhou et al., 2019). In Siberia, the positive trend in GFED emissions is not fully reflected in fire-sourced [$PM_{2.5}$], likely due to concurrent increases in rainfall and deposition efficiency that enhance particulate scavenging (Konovalov et al., 2024)." (Lines 269-282)

2) Figure 4 is interesting to show higher uncertainty of the estimates at low concentrations. Could you bin the pairs based on the Child et al. (2019) data in different concentration levels and provide evaluation statistics for different bins? I anticipate this to be a more valuable quantitative constraints of the uncertainty of the estimates at *different levels of fire-$PM_{2.5}$.*

- In the revised version, we added Figure S9 to quantify the discrepancy between our estimates and Childs et al. at different bins: "Consequently, validations in the U.S. reveal substantial low values with GFED relative to previous estimates (Fig. 4), a bias that is alleviated in QFED for small to moderate fires (Fig. S9). Although both inventories perform comparably during high-emission events (Figs. 3 and S7), their estimates remain much lower than those of Childs et al. (2022) at the highest levels of fire-sourced [$PM_{2.5}$] (Fig. S9). " (Lines 251-255)

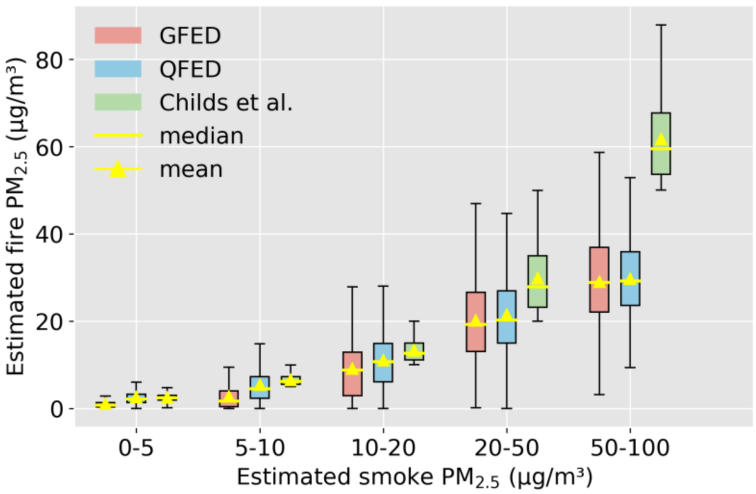

Figure S9. Boxplot of estimated GFED and QFED fire $PM_{2.5}$ v.s. Childs et al. (2022) estimated smoke $PM_{2.5}$ under various levels.

3) Figure 5b,d,f. My original doubt was: why are these slashes spaced so distant and regularly? Could you plot the map of p values to check if you are actually labeling the correct locations with significant trends?

- In the revised version, we replotted Figure 5 with denser slashes. We also added Figure S10 to indicate the *p* values of trends.

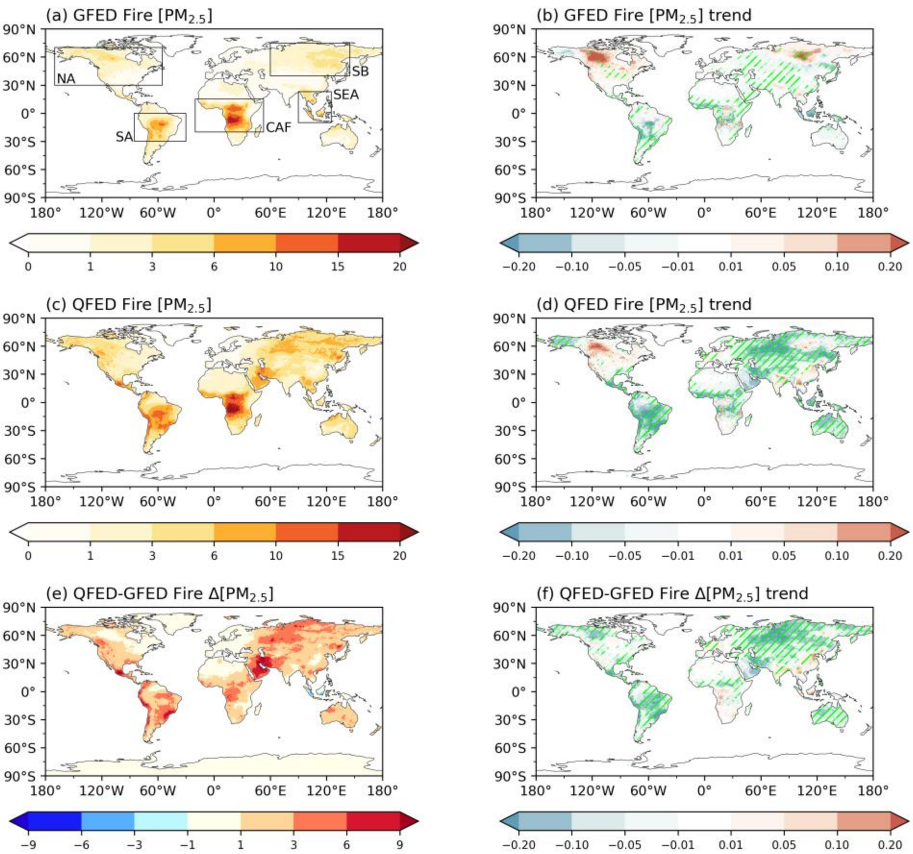

Figure 5. Long-term (a) mean and (b) trend of fire [$PM_{2.5}$] ($\mu g\ m^{-3}$) derived using the GFED inventory for 2000-2023. The box regions in (a) indicate areas used for comparing differences between two inventories. Panels (c) and (d) display the same information as (a) and (b), but for fire [$PM_{2.5}$] from QFED inventory. The differences in fire [$PM_{2.5}$] ($\Delta[PM_{2.5}]$) between the two inventories are presented for the long-term (e) mean and (f) trend during 2000-2023. Green slashes indicate areas with significant ($p < 0.05$) changes. The *p* values of these trend are shown in Fig. S10.

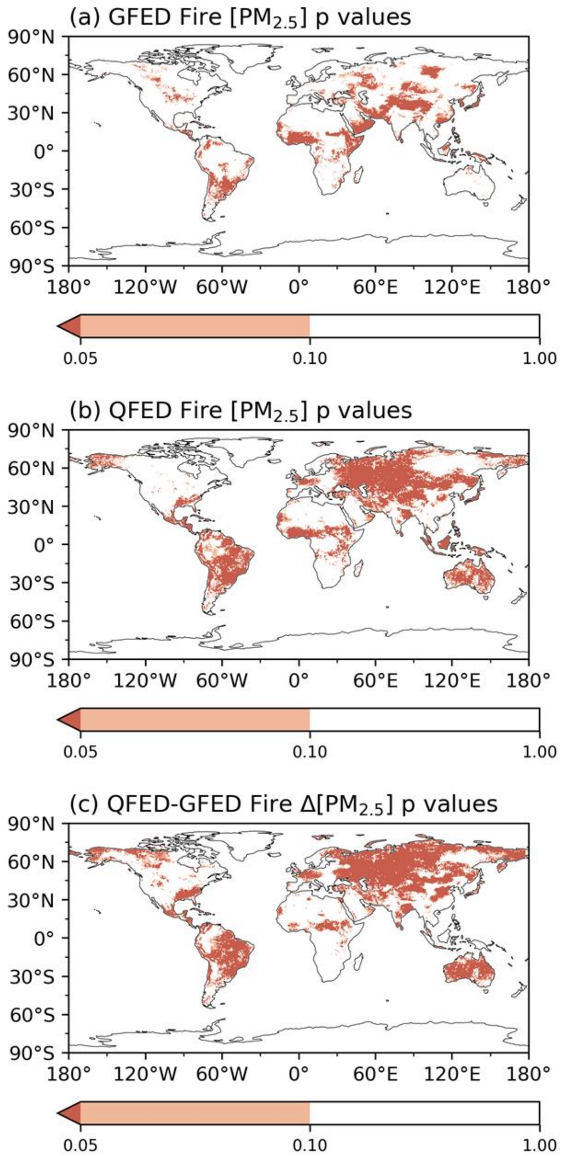

Figure S10. The *p* values of long-term (a) trends in fire [$PM_{2.5}$] derived using the GFED inventory for 2000-2023. Panels (b) and (c) display the same information as (a), but for fire [$PM_{2.5}$] from QFED inventory and differences between QFED and GFED inventories.

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