Referee #3

The authors investigate the response of Asian monsoon regions to South and East Asian BC perturbations using a simplified climate model. They analyze the seasonal response to BC forcing, with a focus on summertime for the energy budget analysis. This study compares the relative effects of local versus remote forcing, as well as their combined impact. The work underscores the importance of the spatial location of aerosol forcing in determining regional climate responses. I have several concerns that I would like the authors to address.

We sincerely appreciate your constructive feedback, which has greatly improved our manuscript. We have carefully addressed all comments through comprehensive revisions. We hope these meet with your approval. The main changes in the manuscript and the responses to the comments are as follows:

1. The Introduction could be better structured to more clearly articulate the motivation for using a simplified climate model to investigate the impacts of regional aerosol emissions. Given the extensive body of literature on aerosol-driven responses in the Asian monsoon region, the referenced studies cloud be organized to highlight the value of using a simplified model and specifically using observed AOD over the past two decades as forcing. However, the aerosol forcing used requires further clarification (see point 2 below).

Response: Thank you for your valuable comments. We have revised the Introduction accordingly. Please refer to lines 61-130.

2. The description of experimental design is confusing. Some information needs clarification.

- The method of "adding" a single aerosol species is not well explained. Is the prescribed AOD distribution from reanalysis data considered the "added" aerosol forcing? Is monthly mean AOD from reanalysis repeated each year in the experiment? Is there a seasonal cycle of AOD in the experiments that could influence the seasonal

response to BC? A clearer description of the regional AOD used, along with a figure showing its spatial distribution and trends, would be helpful.

Response: We appreciate this valuable comment. The relevant descriptions have been clarified in the revised manuscript (Lines 163-167): "The CAMSRA incorporates anthropogenic BC emissions from the MACCity inventory (Granier et al., 2011) for 2003-2010, transitioning to Representative Concentration Pathway 8.5 emissions (Riahi et al., 2011) post-2010. The simulations were idealized with monthly AOD climatologies prescribed as repeating annual cycles."

The spatial pattern of the BC AOD has been included in the Supplementary Fig. S1.

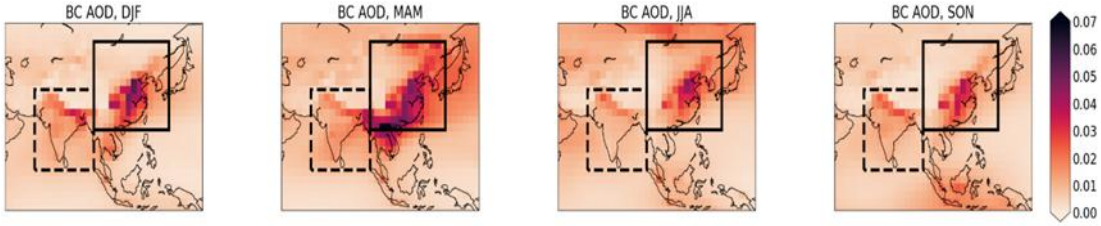

Figure S1. Spatial patterns of seasonal AOD of BC within the China (CHI, solid) and the India (IND, dashed).

- Lines 180–187 mention aerosol-radiation interactions (ARI) versus aerosol-cloud interactions (ACI), while line 171 refers to the inclusion of the semi-direct radiative effect. Which of these radiative effects are actually included in the experiments in this work? Moreover, described experiments aren't directly analyzed or discussed in this work.

Response: Apologize for any confusion caused. This section (L180-187) has been relocated to the introduction with a brief discussion. Please refer to lines 127-130: "The SyRAP-FORTE2 framework enables comprehensive analysis of climate effects of different regional aerosol perturbations and aerosol species, as well as ARI versus ACI, and allows comparison of their relative importance and interactions (Stjern et al., 2024)."

The original statement regarding "The semi-direct effect of BC is included" has been

removed. We have rephrased the relevant statements. Please refer to lines 186-189: "Given that BC primarily influences climate through direct scattering and absorption of radiation (Bond et al., 2013), only climate impacts due to ARI (including the semi-direct effect of BC) were considered here."

- The parameterization discussed in lines 173–178 and does not appear to be applied in the current study. If this is the case, why is it included?

Response: This section has been removed.

3. There are substantial differences between the response and patterns in the energy analysis based on SyRAP-FORTE2 BC_CHI+IND simulations and those in PDRMIP models. In PDRMIP, aerosol emissions are artificially amplified, however, responses in SyRAP-FORTE2 have a similar magnitude to those from PDRMIP experiments, for example, δQ in GISS-E2-R. Additionally, the radiative effects included across PDRMIP models vary. Given these discrepancies in forcing magnitude, model configuration, and included radiative effects, I question the robustness of the conclusion that "the results of these models are overall consistent qualitatively".

Response: We fully agree with you that substantial differences exist between FORTE2 and PDRMIP simulations including model configurations, aerosol forcing magnitudes, and responses in intensity and spatial patterns. However, the "qualitative consistency" conclusion specifically indicates that: thermodynamic processes (δQ) dominantly decrease precipitation, while dynamic processes (δH) increase precipitation and partially offset the effects of δQ. We have clarified this in the revised manuscript. Please refer to lines 511-516.

In addition, we have addressed a brief discussion regarding the response magnitude in the Conclusion and Discussion section, please refer to lines 591-594: "Additionally, despite the much weaker BC forcing in FORTE2, it produces larger thermodynamic (δQ) and dynamic (δH) responses than most PDRMIP models (except for GISS-E2-R).

This may arise from the absence of wet deposition feedbacks in FORTE2 (Stjern et al., 2024).”