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The revised manuscript entitled "Distinct responses of Asian summer monsoon to black carbon aerosols and greenhouse gases" by Xiaoning Xie, Gunnar Myhre, Xiaodong Liu, Xinzhou Li, Zhengguo Shi, Hongli Wang, Alf Kirkevåg, Jean-Francois Lamarque, Drew Shindell, Toshihiko Takemura, and Yangang Liu.

We thank the ACP Handing Editor (Professor Jianzhong Ma) for his hard work and the two anonymous referees for their constructive suggestions to improve our manuscript significantly. We greatly appreciate the generally positive comments from both the two Reviewers (Reviewer #1 and Reviewer #2), and have addressed all the concerns, with point-by-point responses detailed below (reviewers comments in red color and our responses in blue color). If you have any questions, please do not hesitate to contact me via email at xnxie@ieecas.cn. Thank you very much for your kindness and hard work.

Best wishes,

Xiaoning Xie, Gunnar Myhre, Xiaodong Liu, Xinzhou Li, Zhengguo Shi, Hongli Wang, Alf Kirkevåg, Jean-Francois Lamarque, Drew Shindell, Toshihiko Takemura, and Yangang Liu.

Response to Reviewer #1:

General comments:

By using PDRMIP simulations under double greenhouse gases (GHGs) forcing and 10 times of present-day Black carbon (BC) forcing this paper investigates the changes of Asian summer monsoon (ASM). Results show that both GHGs changes and BC changes lead to enhanced precipitation minus evaporation over the Asian monsoon regions, but physical processes involved show some distinct characteristics. GHG changes lead to enhanced monsoon precipitation mainly through the thermodynamic effect through increased water vapor in the atmosphere while changes by BC are through dynamical effect by enhanced large scale monsoon circulation due to enhanced upper tropospheric warming over Asia. The topic is an interesting one. Results are interesting and they are well described. The paper is worth of publication. However, there are some specific comments listed below that need to be addressed to improve the quality of the paper. The paper, therefore, needs a minor revision before it can be acceptable for publication.

Response: Thank the Reviewer #1 very much for the positive comments. According to the comments, we have addressed all the specific comments with point-by-point responses detailed below.

Specific comments

1. Section 2.1 on pages 3-4. It is better to summarize experiments in a Table and to give some extra information about model horizontal and vertical resolutions.

Thank the Reviewer for his suggestions. According to the Reviewer's comments, additional table (Table S1) has been added in the Supporting Information about the model horizontal and vertical resolutions, as well as aerosol information for the nine PDRMIP GCMs.

Table S1: Models used for the present study as summarized in Myhre e t al., (2017).

Model	Version	Horizontal resolutions	Vertical resolutions	Ocean setup	Aerosol emissons
CanESM2	2010	2.8x2.8	35 levels	Coupled	Emissions
GISS-E2R	E2-R	2x2.5	40 levels	Coupled	Fixed concentration
HadGEM2	6.6.3	1.875x1.25	38 levels	Coupled	Emissions
HadGEM3	GA 4.0	1.875x1.25	85 levels	Coupled	Fixed concentration
IPSL-CM5A	5A	3.75 x1.875	19 levels	Coupled	Fixed concentration
MIROC-SPRINTARS	5.9.0	T85	40 levels	Coupled	Emissions
NCAR-CESM1-CAM4	1.0.3	2.5x1.9	26 levels	Slab ocean	Fixed concentration
NCAR-CESM1-CAM5	1.1.2	2.5x1.9	30 levels	Coupled	Emissions
NorESM1	1-M	2.5x1.9	26 levels	Coupled	Emissions

2. Section 2.2 on page 4. Highlight the three monsoon regions in figure 1.

Taken. According to the Reviewer's comment, the three monsoon regions are shown including East Asian, South Asian, and western North Pacific monsoon regions in Figure 1.

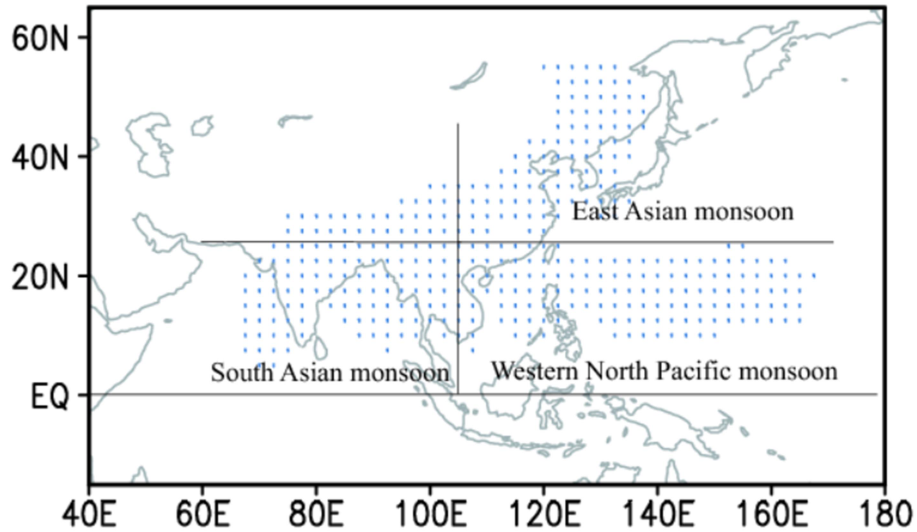

Figure 1. Spatial distribution of the Asian monsoon region (stippled, blue) including East Asian, South Asian, and western North Pacific monsoon regions based on the CMAP data from 1979-2011.

3. Line 26 on page 4 Please confirm that the EASM region is over region (105-160E). It includes large part of ocean.

Yes, the EASM region is defined as the region (105-160E) with dotted regions in Figure 1. However, there is not large dotted region over large part of ocean. Hence, the EASM does not include large part of ocean.

4. Line 6 on page 5. Change “the surface precipitation” to “precipitation”.

Taken.

5. Line 9 on page 5. Change “thermal gradients” to “pressure gradients” since this statement is on changes in SLP.

Taken.

6. Lines 12-13. The statement of excessive precipitation over the southern slope of Tibetan Plateau in model simulations is due to model horizontal resolution lacks evidence to support this. Please add some refs to support it or whether you have analyzed individual model simulations to get this conclusion.

Yes, we have added the corresponding reference in the revised manuscript. Some researches show that low-resolution GCMs are inadequate to reproduce the precipitation closely associated with fine-scale orographic forcing, such as the narrow large-rainfall belt along the southern edge of the Tibetan Plateau. Spatial distribution of precipitation over and around the elevation of the Tibetan Plateau and high-altitude mountains becomes more realistic at higher resolutions (Li et al., 2015). Hence, we have added in the manuscript “Note that MMM of these simulations produces excessive rainfall over the southern slope of Tibetan Plateau compared to the CMAP precipitation, mainly due to a relatively coarse horizontal resolution of the models in Figure 2f, as noted by Li et al., (2015). They also show that spatial distribution of precipitation over and around the Tibetan Plateau and high-altitude mountains becomes more realistic for the higher resolutions (Li et al., 2015).”

7. Line 15 on page 5. Change "the surface precipitation" to "precipitation".

Taken.

8. Line 6 on page 6. The moisture budget decomposition is vertically integrated quantities. It is better to have word "vertically integrated" when authors describe each terms.

Yes, the Reviewer's point is correct. It indicates that the moisture budget decomposition is vertically integrated quantities. We have added the "vertically integrated" in the manuscript.

9. Line 20 on page 7. BC absorbs solar radiation and therefore leads to decreased solar radiation at the surface. Why it leads to warming of surface air temperature? Some clarifications on this would improve the paper and helpful for readers.

As noted by the Reviewer's comment, the BC aerosols can absorb solar radiation and therefore leads to decreased solar radiation at the surface. The rapid temperature response is a significant cooling as shown in fixed SST experiments over India, China, and Central Africa in Stjern et al., (2017), caused by the strong reduction in shortwave radiation reaching the surface. However, the increases in surface temperature in Figure 9 and Figure S1 are derived from the coupled experiments. Previous studies show that the change in surface temperature in the coupled experiments is dependent on the effective radiative forcing (ERF) at the TOA (Gregory et al., 2004; Myhre, 2013). Hence, the increase in surface temperature in Figure 9 and Figure S1 is resulted from positive ERF at the TOA in Figure 8a. The corresponding descriptions have been added in the manuscript.

10. Line 33 on page 7. There are a rich of literatures on enhanced land warming over continents in response to GHG changes and these studies suggest that warming contrast is not due to different heat capacity of land and ocean. Suggest authors rephrase this and add a few of refs.

Taken. We agree with the Reviewer's point and have added the corresponding references (Lambert and Chiang 2007; Lambert et al., 2011) in the revised manuscript.

11. Line 14 on page 8. Rephrase this statement.

Taken. This sentence has been revised as "This spatial pattern of changes in atmospheric temperature and geopotential height at 200 hPa induced by GHGs decreases the upper-level MLOTG, leading to insignificant changes in the low-level ASM circulation and the upper-level westerlies (Figures 6b, 6d, and 6f)."

12. Line 3 on page 9. Remove word "enhancement".

Taken.

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