Manuscript Number: egusphere-2025-5729

Journal: ACP

The revised manuscript entitled "Distinct drivers of recent seasonal precipitation increase over Central Asia: roles of anthropogenic aerosols and greenhouse gases" by Jianing Guo, Xiaoning Xie, Gunnar Myhre, Drew Shindell, Alf Kirkevåg, Trond Iversen, Apostolos Voulgarakis, Toshihiko Takemura, Ke Shang, Xinzhou Li, Zhengguo Shi, Yangang Liu, Xiaodong Liu, Hong Yan

We thank the ACP Handling Editor for their hard work and the three anonymous referees for their constructive comments, which have significantly improved our manuscript. We greatly appreciate the positive and helpful comments from all reviewers (Reviewer #1, Reviewer #2, and Reviewer #3) and have addressed the reviewers' concerns in the point-by-point responses provided below (reviewers comments' in black and our responses in blue). We have uploaded the file entitled "Response to reviewers.pdf".

Best wishes,
Xiaoning Xie

Response to Reviewer #2:

General comments:

Review' s comments for the manuscript egusphere-2025-5729, entitled "Distinct drivers of recent seasonal precipitation increase over Central Asia: roles of anthropogenic aerosols and greenhouse gases"

By using single-forcing experiments from the Precipitation Driver and Response Model Intercomparison Project (PDRMIP), this study investigates drivers and physical mechanisms of wetting trend over Central Asia in recent decades. Results show that greenhouse gas (GHG) forcing mainly increases winter precipitation by enhancing atmospheric moisture content through warming. In contrast, in summer, Asian sulfate aerosols enhance precipitation by modulating the westerly jet, which strengthens atmospheric moisture transport into the region. These conclusions are supported by CMIP6 model simulations. Future CMIP6 projections suggest that under moderate- to high-emission scenarios, winter precipitation will continue to rise due to increasing GHG concentrations, while summer precipitation may decline across much of Central Asia as a result of reduced aerosol emissions following Asian clean air policies. Results are interesting and they are well presented in the study. However, the paper needs some clarifications by addressing the following specific comments. Therefore, the paper is acceptable for publication after minor revisions.

Response: We thank the Review's positive and valuable comments on our manuscript. Accordingly, we have revised the figure captions and the associated descriptions in the revised manuscript.

Specific comments:

1. Lines 63. "a meridional shift of the Asian subtropical westerly jet". This is aerosol induced change in summer. Please clarify that it is in summer.

Response: Thanks for the comment about the sentence. We rephrase this sentence as "*Several studies indicate that increased Asian anthropogenic aerosols drive a meridional shift of the Asian subtropical westerly jet in summer, which potentially affects precipitation in Central Asia (Dong et al., 2022; Xie et al., 2022).* "

2. Lines 136-137. Please see my comment on Fig. 1b. It is not clear how authors construct the PDF.

Response: Thanks for your comments. The probability density function (PDF) curves are constructed from the annual or seasonal precipitation trend values at all grid points within the study region. A normal distribution is fitted to these values to obtain the PDFs. We have added corresponding description in Lines 136-138 as "*Based on the annual or seasonal precipitation trend values from all grid points within the study* *region, a normal distribution is fitted to obtain the corresponding probability density function (PDF) curves.*" We have also revised the Figure 1b caption as "*(b) Probability density functions (PDFs) of seasonal precipitation trends, derived from trend values at all grid points within the study area and fitted with a normal distribution.*"

3. Figure 1b caption is clear. Please add more information to understand it.

Response: Thanks for your comments. We have added corresponding description in Lines 136-138 as "*Based on the annual or seasonal precipitation trend values from all grid points within the study region, a normal distribution is fitted to obtain the corresponding probability density function (PDF) curves.*" and revised the Figure 1b caption as "*(b) Probability density functions (PDFs) of seasonal precipitation trends, derived from trend values at all grid points within the study area and fitted with a normal distribution.*"

4. Figure 2 caption. Clarify what bars represent. Are they multimodel means?

Response: Thanks for your comments. We have added corresponding description in the Figure 2 caption as "*Bars represent the multi-model mean across PDRMIP models, and error bars indicate ±1 inter-model standard deviation.*"

5. Figure 3. The reviewer thinks that various panels show the multimodel mean changes. Please state in the figure caption.

Response: Thanks for your comments. We have revised corresponding description in the Figure 3 caption as "*Multi-model mean precipitation changes (mm day−1) in DJF under (a) CO2x2, (b) CH4x3, and (c) Solar+2% forcings, and in JJA under (d) Sulx10Asia and (e) BCx10Asia forcings.*"

6. Figure 5. Please add the zonal wind climatology in panels (b, c, e, and f) for readers to better understand wind changes.

Response: Thanks for your comments. We have added the zonal wind climatology in Figures 5b, 5c, 5e, and 5f, and added corresponding description in Figure 5 caption.

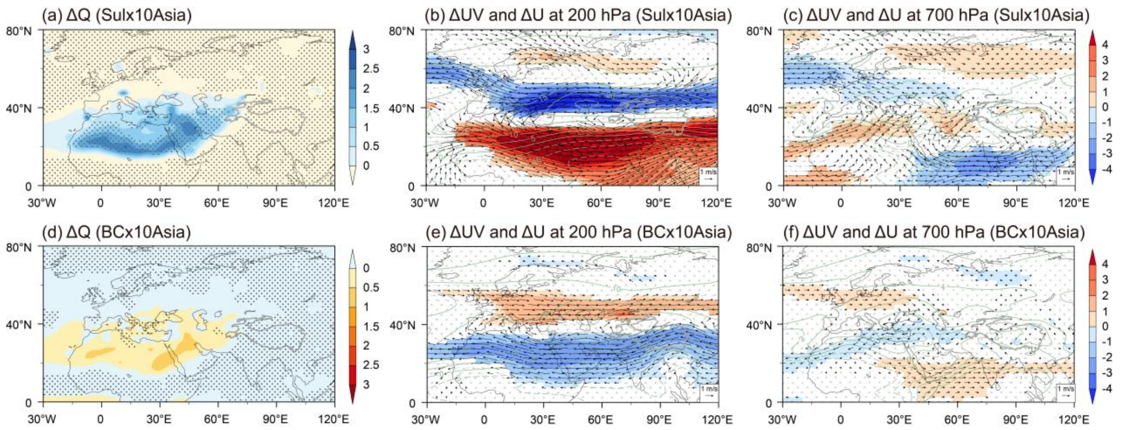

Figure 5. Multi-model mean anomalies during JJA induced by Sulx10Asia and BCx10Asia forcings in PDRMIP. (a) Anomalies of vertically integrated (surface–300 hPa) water vapor (ΔQ, kg m^{-2}), (b) wind field (ΔUV vector, m s^{-1}) and zonal wind (ΔU shading, m s^{-1}) at 200 hPa, and (c) wind field and zonal wind at 700 hPa under Sulx10Asia forcing. (d–f) Same as (a–c) but for BCx10Asia forcing. The gray stippled regions in (a, d), the black arrows in (b, c, e, f), and the colored contours in (b, c, e, f) indicate regions where the PDRMIP multi-model mean anomalies exceed 1 standard deviation from zero. The green curves in (b, c, e, f) represent zonal wind climatology derived from baseline experiments in PDRMIP. The thick gray curves denote Tibetan Plateau terrain height > 2500 m.

7. Figure 6. The reviewer thinks that bars in various simulations show multimodel mean trends. Please add clarification.

Response: Thanks for your comments. We have revised corresponding description in the Figure 6 caption as "*Bars represent the multi-model mean precipitation trend, and error bars represent ±1 inter-model standard deviation. Dots represent the trends in regionally averaged precipitation from individual models, and curves show kernel density estimates of the trend distribution, with the bandwidth selected using Scott's rule.*"

8. Figure 9 caption. Please add more information in figure caption to help reader to understand it (e.g., full lines in panel a-c and e-f, vertical lines in panel d and h).

Response: Thanks for your comments. We have added the corresponding description in Figure 9 caption as "*Solid lines in (a−c) and (e−f) represent the multi-model mean of the regional-mean precipitation over Central Asia. Dashed lines represent the linear trend (mm day^{-1} per 100 years) in precipitation and shadings indicate ±1 inter-model standard deviation. Vertical lines in (d) and (h) indicate ±1 inter-model standard deviation of the 2091–2100 climatological mean precipitation over Central Asia.*"