Response to the Editor

Dear Professor Fiedler,

Thank you very much for your kind message and for the continued handling of our manuscript. We sincerely appreciate your careful editorial guidance, as well as your thoughtful holiday wishes. We would also like to take this opportunity to wish you a joyful Christmas and a happy and healthy New Year.

Following your request, we have conducted a comprehensive and systematic technical review of the entire manuscript prior to resubmission. In particular, we carefully checked the manuscript for typographical errors, author and affiliation completeness, terminology consistency, and consistency between the main text, tables, figures, equations, and funding information.

Based on this thorough review, we have corrected several minor but important technical issues, including the following:

1. Standardization of author names, affiliation punctuation, and corresponding author contact information **(manuscript p.1, lines 3–13)**;
2. Corrections to spacing, punctuation, and wording in the Abstract and Keywords, including replacing non-English punctuation and unifying the use of "radiative forcing" **(manuscript p.2, line 34; p.11, line 249)**;
3. Unification of section titles and capitalization, such as "Results and Analysis" **(manuscript p.2, line 36; p.11, line 248)**;
4. Correction of grammatical issues, including singular–plural agreement **(manuscript p.3, line 58)**;
5. Harmonization of technical terminology and notation between figures and the main text, for example, consistent use of SFC to denote surface fluxes **(manuscript pp.20–21; Figures 8 and 9)**.
6. Verification and update of funding information, including funding agency names and grant numbers, to ensure accuracy and completeness **(manuscript p.28, lines 648－651).**

All revisions made in response to this technical check have been highlighted in blue in

the revised manuscript to facilitate review. In addition, a detailed point-by-point response to all reviewer comments has been provided in a separate "Response to Reviewers" document.

We believe that these revisions further improve the clarity, accuracy, and presentation quality of the manuscript. We sincerely thank you and the reviewers for your time and constructive suggestions, and we would be happy to provide any additional clarification if required.

With best regards,
Zhe Zhang
on behalf of all authors

Response to Reviewers

We thank the editor and reviewers for their constructive comments and helpful suggestions on our manuscript. We have carefully considered all comments and revised the manuscript accordingly to improve its clarity and quality.

All revisions have been highlighted in red in the revised manuscript.
A point-by-point response to the reviewers' comments is provided below.

Report #1

1. The author has addressed all my scientific comments in detail. However, I suggest revise the color of the text on graphical abstract, especially "Wet deposition". It's hard to read the black text over a dark figure. I do not need to see the revision after that, and the editor can make the final decision.

We sincerely thank the reviewer for this helpful suggestion and for the positive evaluation of our responses to the scientific comments. As recommended, we have revised the text color in the graphical abstract, particularly for "Wet deposition," to improve readability against the background.

Graphical Abstract **(page 2, line 32)**
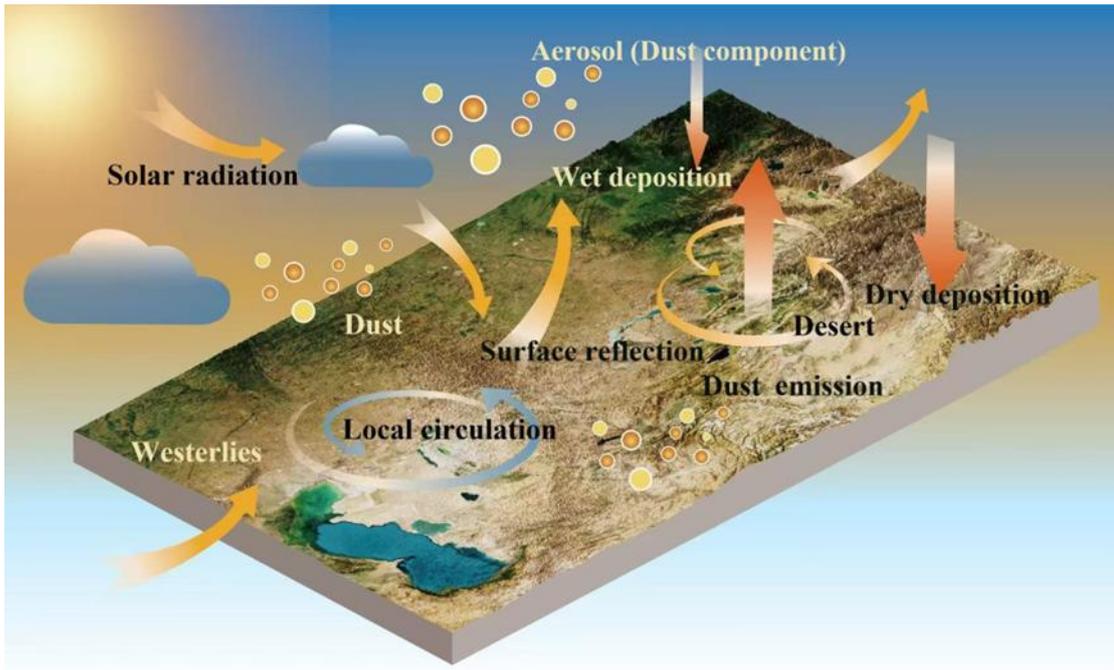
Report #2

1. Figure 2: The text states "The red shading…, and the blue shading…", but these appear to be outlines rather than shadings. Please clarify this.

Thank you for pointing this out. We have clarified the description in the figure caption by explicitly referring to **outlines** rather than shadings. The revised caption now reads:

"The red outline delineates Northern Xinjiang, the blue outline delineates Southern Xinjiang, and the black outlines denote the five Central Asian countries."

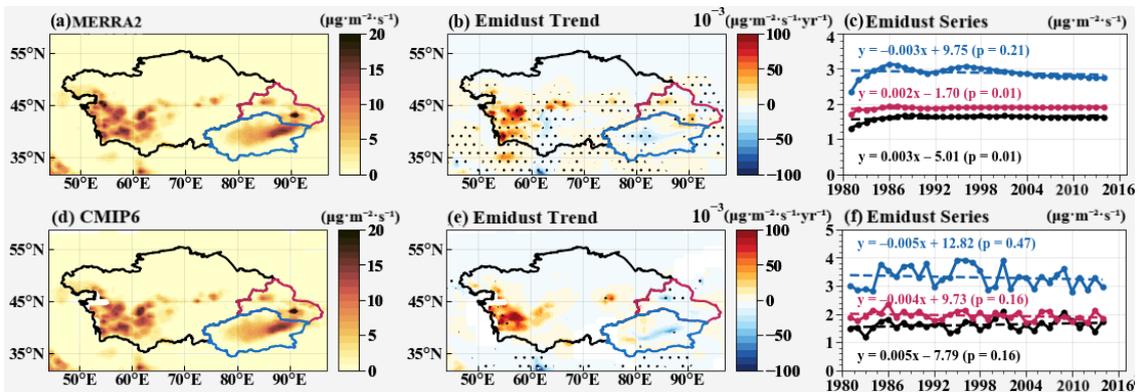This revision can be found on **page 12, lines 272–276** of the revised manuscript.

Figure. 2 Spatial distribution, linear trends, and time series of dust emissions from MERRA-2 and the CMIP6 multi-model ensemble (MME) in Central Asia from 1980 to 2014. The red outline delineates northern Xinjiang, the blue outline delineates southern

Xinjiang, and the black outlines denote the five Central Asian countries. Black dots in panels (b) and (e) mark regions significant at the 95% confidence level.

2. Figure 3: Similar to Figure 2, it would be clearer to indicate the regions using different colors, as the corresponding region for the circular inset includes CA, NX, and SX.

We appreciate this helpful suggestion. Following the reviewer's recommendation, we have revised Figure 3 by using distinct colors to clearly distinguish the three regions (Central Asia, Northern Xinjiang, and Southern Xinjiang) in the circular inset.

For consistency, the same color scheme has also been applied to Figure 5, Supplementary Figure 9, and Supplementary Figure 10, where the circular insets likewise represent CA, NX, and SX.

These revisions are shown on:

- **Figure 3: page 13, lines 302–309**

- **Figure 5: page 15, lines 353–359**

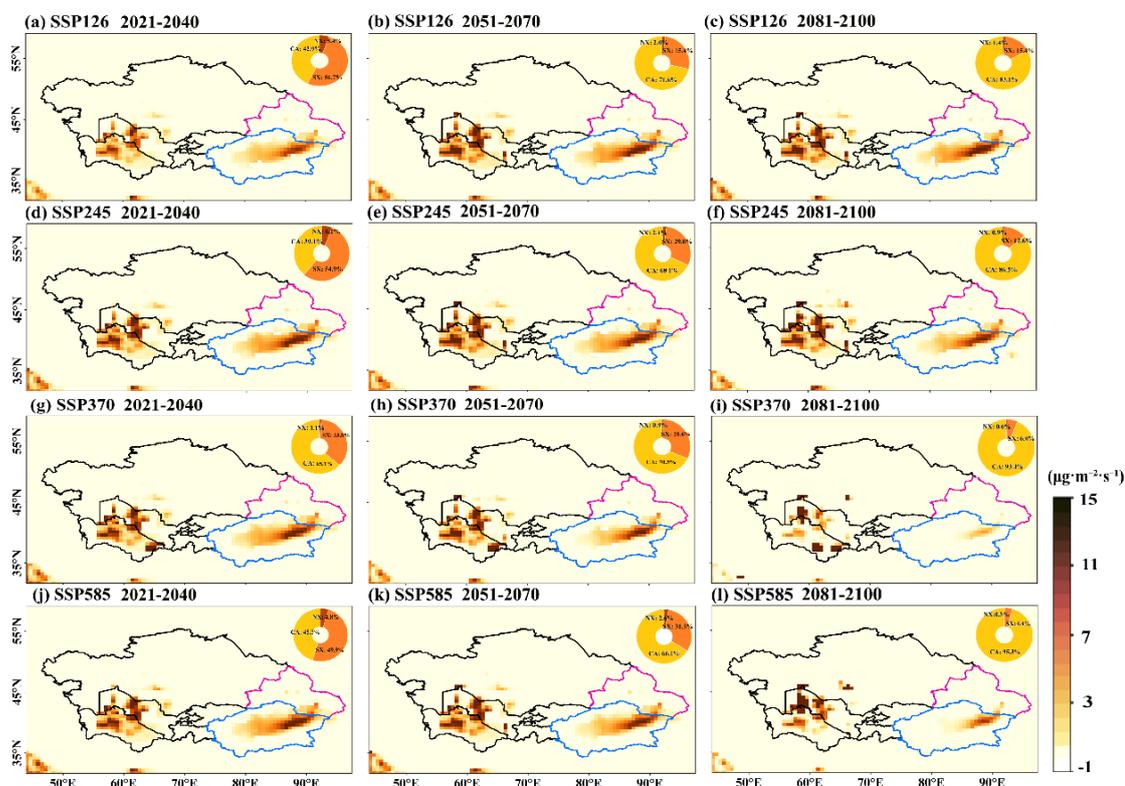- **Supplementary Figures 9–10: Supplementary Information, pages 5–6**

Figure. 3 Future changes in dust emissions across different periods. Spatial distribution of the relative changes in dust emissions over Central Asia under four CMIP6 multi-model ensemble (MME) SSP scenarios: panels (a－d) near term (2021－2040), (e－h)

midterm (2051‑2070), and (i‑l) long term (2081‑2100), relative to the historical period (2000‑2014). The circular inset in the upper-right corner of each panel indicates the mean relative change rate (%) for the corresponding region.
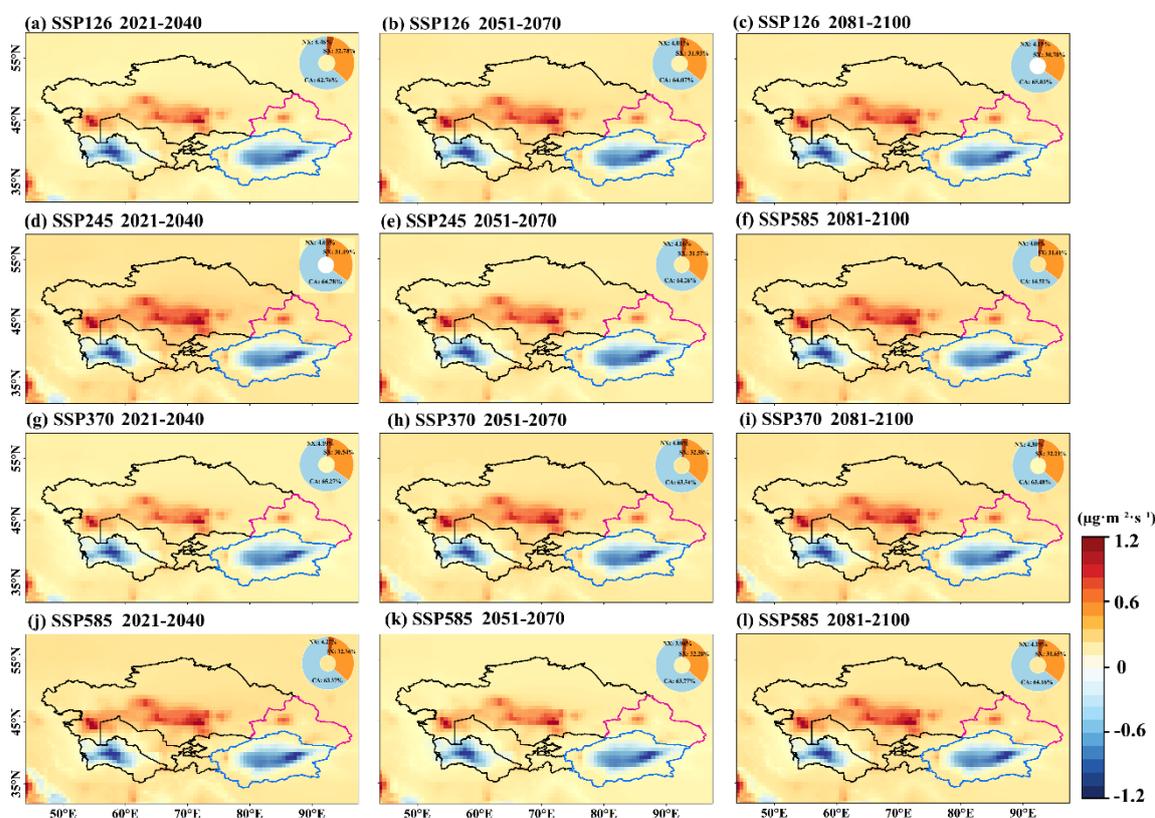

Figure. 5 Spatial distribution of relative changes in total dust deposition over Central Asia under four CMIP6 multi-model ensemble (MME) SSP scenarios for different future periods: panels (a‑d) near term (2021‑2040), (e‑h) midterm (2051‑2070), and (i‑l) long term (2081‑2100), relative to the historical period (2000‑2014). The circular inset in the upper-right corner of each panel indicates the mean relative change rate (%) for the corresponding region.

3. Figure 6: The subpanels are not labeled (a–l). In addition, there is a typo in panel (a): it should be "Northern Xinjiang".

Thank you for identifying these issues. We have revised Figure 6 by:

1. Adding subpanel labels (a–l) to all panels; and

2. Correcting the typo in panel (a) to "Northern Xinjiang".

The revised figure caption now clearly describes all subpanels and regions. The correction can be found on **page 17, lines 382–386**.
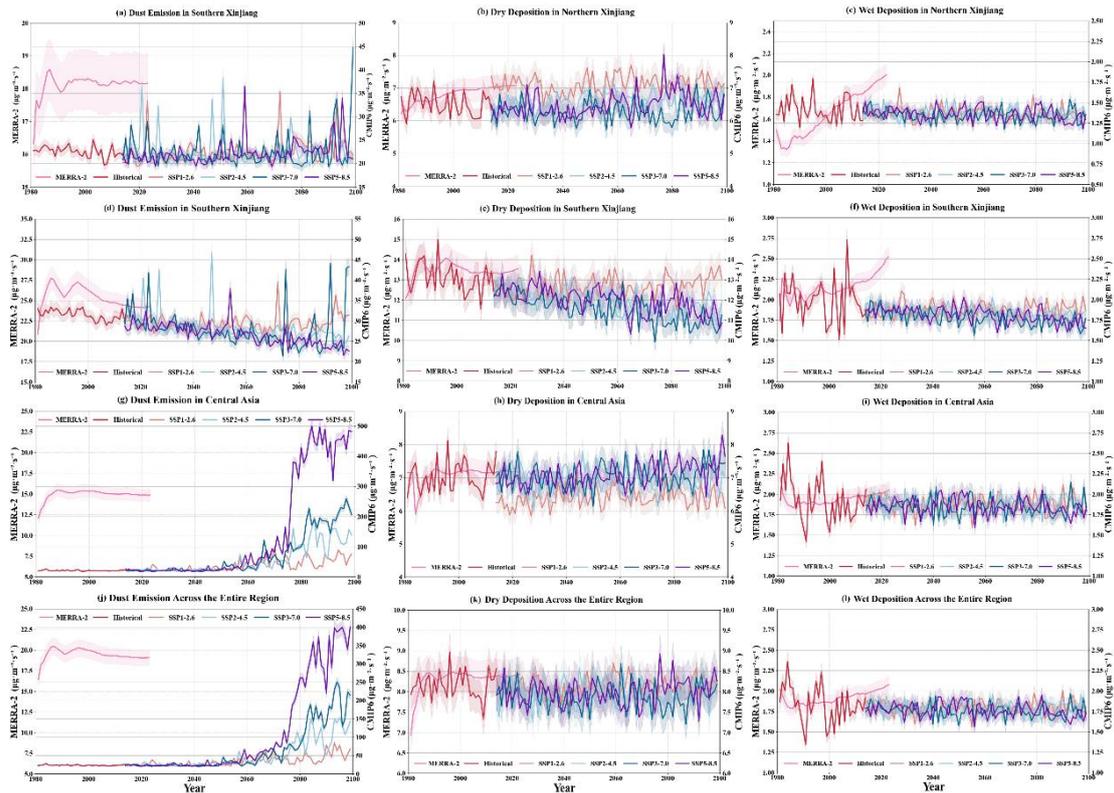
Figure. 6 Time evolution of the dust budget. Dust emissions, dry and wet deposition ($\mu g \cdot m^{-2} \cdot s^{-1}$) for panels (a – c) Northern Xinjiang, (d – f) Southern Xinjiang, (g – i) Central Asia, and (j – l) the entire study region. Results are from the CMIP6 multi-model ensemble (MME; 1980 – 2100) and MERRA-2 (1980 – 2023).

4. Line 469: I don't think Figure 9c shows SFC < –400 W m⁻². Is this a typo?

You are correct—thank you for catching this typo. The text has been corrected to:

"…punctuated by transient episodes of strong negative forcing (SFC < –250 W m⁻²) during extreme dust events."

This correction appears on **page 21, line 472**.

5. Figure 8 and 9: Please ensure consistent naming—should it be "Kashgar" or "Kashi" as shown in the figures?

Thank you for noting this inconsistency. We have now standardized the naming to "Kashgar" throughout both figures and the corresponding captions.

The revisions are located at:
- **Figure 8: page 20, line 461**
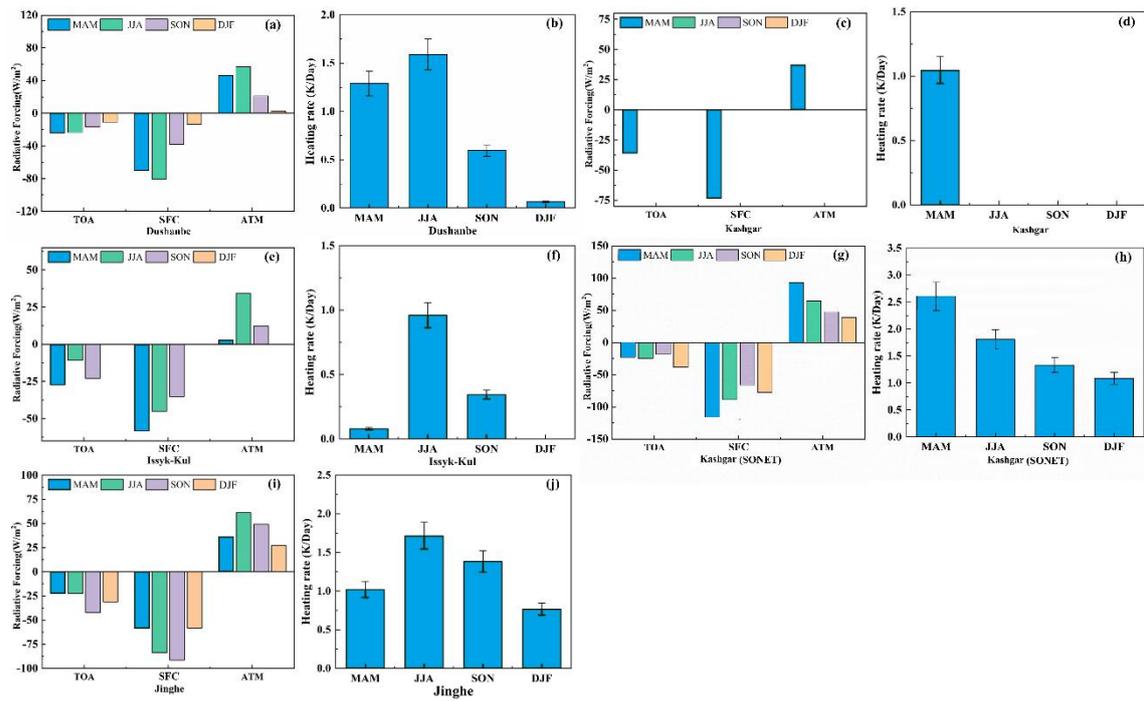- **Figure 9: page 22, line 488**

Figure. 8 Seasonally averaged shortwave radiative forcing and atmospheric heating rate (including direct radiative forcing at the top of the atmosphere (TOA), the surface (SUR), and the atmosphere (ATM)) for dust aerosols at stations in Central Asia.
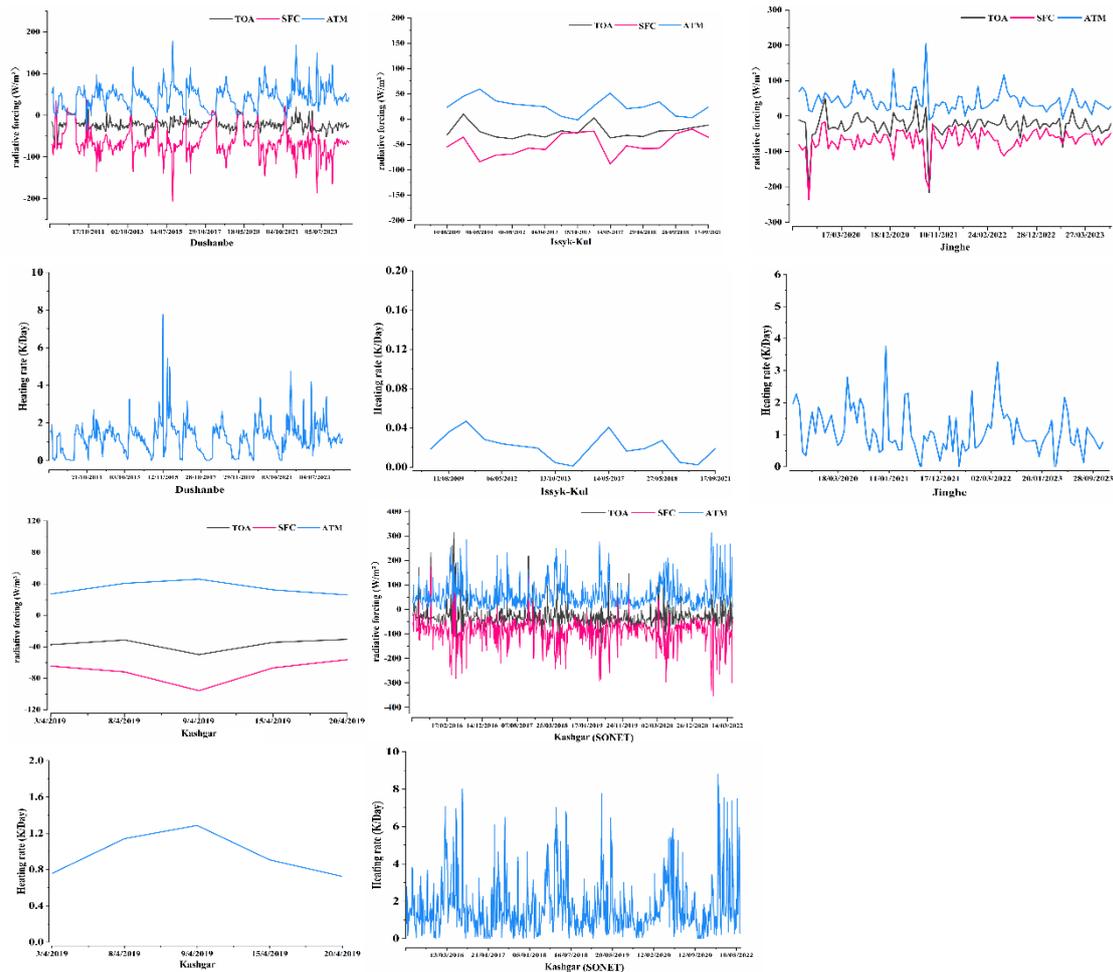
Figure. 9 Shortwave direct radiative forcing and atmospheric heating rates at Central Asian sites (AERONET/SONET data). Upper panels (a, b, c, g, h) show forcing at the top of the atmosphere (TOA), surface (SFC), and in the atmosphere (ATM); lower panels (d, e, f, i, j) show the corresponding atmospheric heating rates for (a, d) Dushanbe, (b, e) Issyk-Kul, (c, f) Jinghe, and (g–j) Kashgar.

6. Line 602: Should this refer to Figure 12b instead of Figure 11b?

Thank you for pointing out this oversight. This was indeed a typographical error. The reference has been corrected to Figure 12b, which illustrates the spatial root-mean-square error (RMSE) between the downscaled CMIP6 outputs and MERRA-2 data.

The correction is now shown on **page 26, line 606.**

7. Line 608: Please check the figure numbering throughout the manuscript. I believe this should refer to Supplementary Figure 13b instead of Supplementary Figure 11b.

We appreciate this careful check. The figure reference has been corrected to

Supplementary Figure 13b, which presents the time-series comparison demonstrating that the downscaled results effectively capture seasonal and interannual variability.

This revision appears on **page 27, line 612**.

We sincerely appreciate the reviewers' time, careful evaluation, and constructive feedback, which have greatly improved the quality and clarity of the manuscript.