Responses to Referee #1:

This research article investigates the impact of anthropogenic aerosol reductions in China on Australia's climate. The study found that the decline in Chine's aerosols since 2013 contributed to drier and warmer conditions in Australia by altering temperature and pressure gradients, which intensified the Southern Trade Winds and caused moisture divergence over Australia. The study also links these climate changes to an increase in wildfire risks in Australia. This research highlights the significant influence of distant aerosols on regional climate and offers insights for drought and wildfire risk mitigation.

The manuscript is interesting, well written and tackles an important topic of research (i.e., impact of Chinese aerosols on Australian climate). However, some technical details between the comparison of modelling results and observations need to be corrected and the selection of figures should be adjusted. I recommend acceptance of the manuscript if the major comment below can be addressed.

We thank the reviewer for the constructive suggestions, which are very helpful for improving the clarity and reliability of the manuscript. Please see our point-by-point responses (in blue) to your comments below.

Major comments

One of my main comments is related to the comparison of observation/reanalysis data and simulated results: There seems to be some inconsistency between the timeperiods used. In the method section it is mentioned that the period 2013-2019 is used for the observation/reanalysis data as well as the simulated data. However, in the captions of the supplementary figures as well as in the description of these figures in the text (e.g. L274, 278) it is mentioned that the observations are for 2010-2019. Please clarify if the same timeperiod is used for observation/reanalysis data and modelling data and if that is not the case, the plots have to be redone for the correct timeperiod to ensure an accurate comparison. Besides, is this warming and drying trend over Australia still continuing or why did the authors look at the time period 2013-2019?

The warming and drying trends in Australia due to the reduction of aerosols in China were simulated based on the two simulations with anthropogenic emissions of aerosols and precursors at years 2013 and 2019. It is because China implemented the "Air Pollution Prevention and Control Plan" in 2013 and established nationwide $PM_{2.5}$ observation sites in 2013. Whether the simulated climate responses can be detected in the real world requires the observational evidence. However, the seven years of period 2013–2019 are too short to fully capture the trends in climate variables, as various natural variabilities could influence temperature and rainfall in Australia. For example, climate variabilities, such as ENSO, can have significant impacts on the Australian monsoon and rainfall patterns and influence the long-term trends of temperature and precipitation in Australia. Therefore, we included more years to calculate the trends of the climate variables in observations. It will not affect the results since that the aerosol reductions in China only account a small amount of the changing climate in Australia. We have now added the explanation in the manuscript as "Note that, the trends in observations are calculated during 2010–2019 to minimize the internal variability.". Regarding whether the trend is continuing, CSIRO and BOM (2022) reported that the warming is still ongoing in Australia and the drying trend is still ongoing in Northern Australia, which could be contributed by the further reductions in Asian aerosols.

While it is great that the author's tried to reduce the figures in the main text to only 4 to explain the whole story, in particular the mechanistic analysis (Section 3.2) is difficult to follow for the reader with the limited number of figures. For instance, a combination of Figure S16 and S17 (i.e. the filled contours showing the SST pattern overlaid by the climatological wind field) would be a relevant figure to show. Additionally, Figure S21 is heavily referenced in the manuscript but the figure is only shown in the supplementary. Besides, maybe a small schematic of the described mechanism similarly as in Fahrenbach et al. 2024 would be helpful to guide the reader through the description.

As requested, we have moved several figures in the main text and added the schematic diagram as shown below.

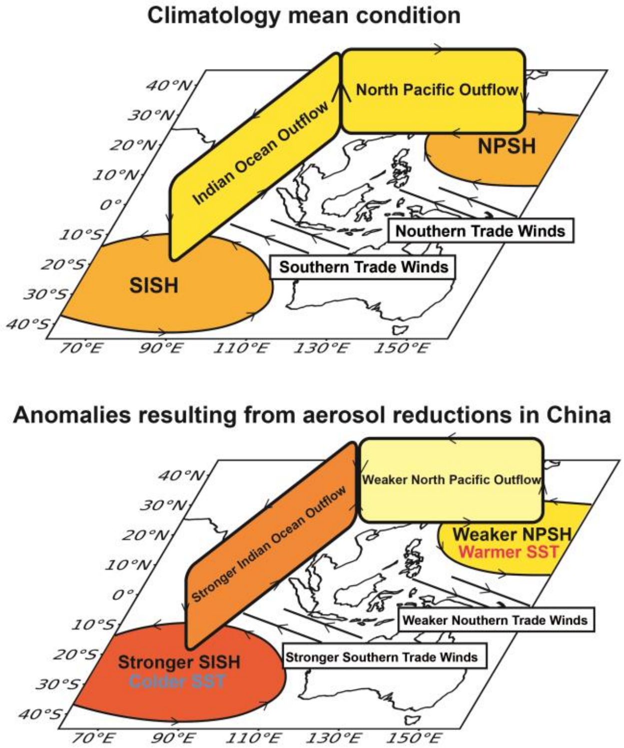

Figure 6. Schematic of the response in large-scale 3D circulations in the Asian-Pacific region to aerosol reductions in China. The top panel shows climatology mean condition, and the bottom panel shows anomalies resulting from aerosol reductions in China.

On the topic of figures, it would be important to show a comparison of the simulated changes with the observed precipitation pattern (Figure S8) as well as the observed wind changes (Figure S18). This is particularly relevant since the authors are trying to do an "attribution" study and it has to be quantified that the observed and modelled changes agree. Additionally, the authors claim that the modelled and observed wind changes are similar (L319-321). While I do acknowledge that 3D wind changes are not the most reliable fields in reanalysis data, this is a bit of an overstatement. Figure S18b and c show very few significant changes making it difficult to understand the simulated flow and Figure S18d shows the largest significant trends in the winds east of Borneo and around stronger southern Trade winds based on the simulated data.

Maybe the authors could think about showing all wind vectors and colouring the significant ones in, so that the reader can at least see if the observations show the same trend even if they might not be significant based on this test?

Thank you for your suggestion. We have revised the figure displaying the 3D wind fields, with significant and insignificant circulations clearly distinguished. Additionally, the statement has been revised to: "Although only a few significant changes persist in Northern Australia, the large-scale circulations around Australia show noticeable similarities to the simulated results." to avoid the overstatement.

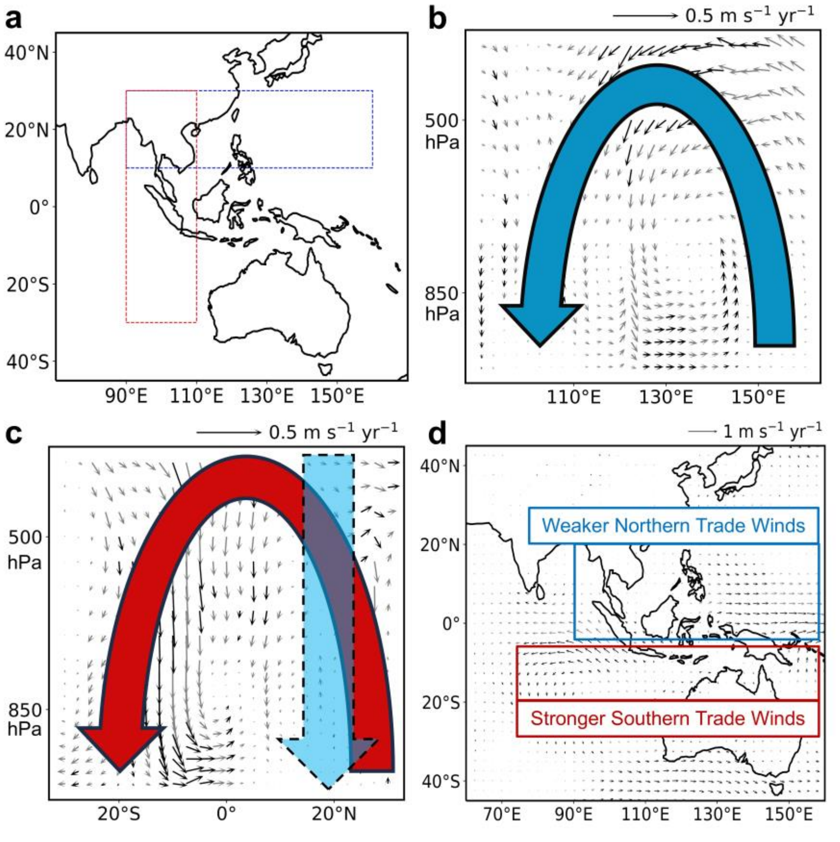

Figure S17. Linear trends in observed vertical circulations and 850 hPa wind fields in Asia-Pacific regions. Panel **b** and **c** shows pressure–longitude and latitude cross-section of linear trends in annual mean atmospheric circulations (unit: m s^{-1}, vectors) over areas marked with the blue and red box in panel **a** during 2010–2019 from ERA5. Panel **d** shows linear trends of wind fields (unit: m s^{-1}, vectors) at 850 hPa in Asia-Pacific regions. Trends of atmospheric circulations and winds which are statistically significant at the 90% confidence level are shown in black, while the insignificant ones are shown in grey.

My last comment regarding the figures is that the figure S15 should also be included in the main text. It seems biased to try to find a link / attribution but only show the plots for China which the authors have identified as the relevant one. Maybe a figure showing the annual precipitation trends for CHN, OTH, NA+EU and then a seasonal plot for the CHN plots would be best?

As requested, we have moved the figure in the main text and showed the CHN, OTH, NA+EU (Figure 1 below) and then a seasonal plot for the CHN (Figure 2 below).

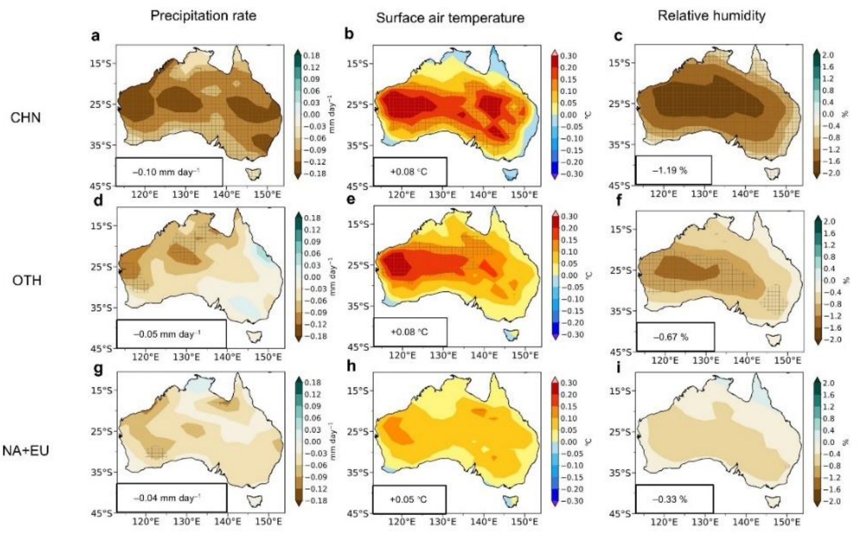

Figure 1. Simulated changes in precipitation rate, surface air temperature and relative humidity in Australia due to aerosol changes between 2013 and 2019. Spatial distributions of simulated differences in annual mean precipitation rate (Pr, **a**, **d,** and **g**, unit: mm day^{-1}), surface air temperature (TS, **b**, **e**, and **h**, unit: °C) and relative humidity (RH, **c**, **f**, and **i**, unit: %) in Australia between BASE and CHN (CHN minus BASE, **a**–**c**), between BASE and OTH (OTH minus BASE, **d**–**f**), and between BASE and NAEU (NAEU minus BASE, **g**–**i**). The shaded areas indicate results are statistically significant at the 90% confidence level. Regional averages over Australia are noted at the bottom-left corner of each panel.

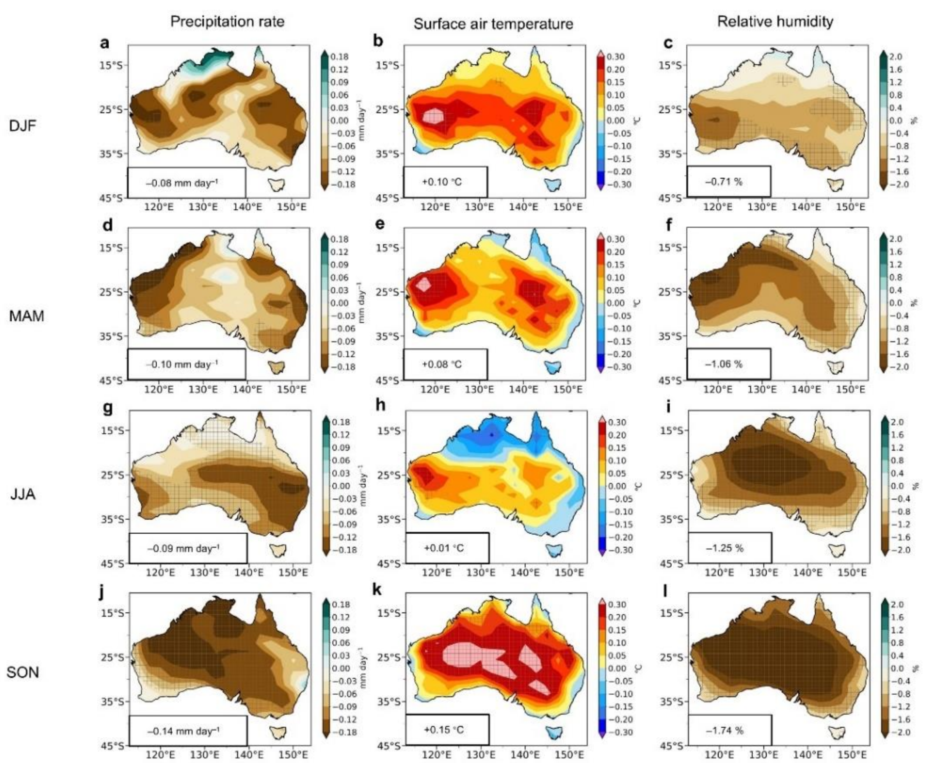

Figure 2. Simulated changes in precipitation rate, surface air temperature and relative humidity in Australia due to aerosol changes in China between 2013 and 2019. Spatial distributions of simulated differences in DJF (December, January and

February, **a**–**c**), MAM (March, April and May, **d**–**f**), JJA (June, July and August, **g**–**i**) and SON (September, October and November, **j**–**l**) mean precipitation rate (Pr, **a**, **d**, **g**, and **j**, unit: mm day^{-1}), surface air temperature (TS, **b**, **e**, **h**, and **k**, unit: °C) and relative humidity (RH, **c**, **f**, **i**, and **l**, unit: %) in Australia between BASE and CHN (CHN minus BASE).The shaded areas indicate results are statistically significant at the 90% confidence level. Regional averages over Australia are noted at the bottom-left corner of each panel.

The authors discuss the influence of the (very strong) low bias in PM2.5 in CESM1 compared to the observations in L385-388, which is good and relevant. However, this should also be mentioned throughout the manuscript, for instance when the authors try to estimate very precise values for the influence of the Chinese aerosol reductions on precipitation and temperature (L270-271).

To address this, we have now included notes regarding this low bias and its potential impact on the accuracy of these estimates in the relevant sections throughout the manuscript, such as: "However, considering that aerosols are underestimated in the model, the impact of aerosol reductions in China on Australia's climate/wildfire risks may also be underestimated."

Minor comments

L29-31: The times mentioned in this sentence seem confusing since when first reading it seems that a trend from 2013 is caused by something happening around the 2010s. Maybe using "conditions since the 2010s" would help to settle this confusing sentence.

Revised.

L68-70: Please change "increasing GHGs" to increasing GHG emissions.

Changed.

L72-75: This sentence is very long and confusing, please split it up into two or shorten it

This sentence has been shortened as: "Atmospheric aerosols are the second-largest anthropogenic climate forcer, exerting an overall cooling effect that partially masks the warming induced by GHGs."

L73: "Earth's" instead of "earth's"

OK.

L104: "especially in northern Australia/especially in the North of Australia" instead of "especially the northern Australia"

Revised.

L104: "affected by the Australian monsoon" instead of "affected by Australian monsoon"

Revised.

L153-159: Is there a reason for the choice of the GPM dataset rather than for instance GPCP data?

"GPM provides higher temporal and spatial resolution data compared to GPCP, making it more suitable for studies focused on short-term precipitation variability and regional climate dynamics." The statement has been added to the manuscript.

L224: "Earth's surface" instead of "earth's surface"

Revised.

L244: The setting of DF to 10 according to Sharples et al 2009 needs some more explanation. At least one sentence why Sharples et al choose this value and why it is also applicable here.

Thank you for your suggestion. Sharples et al. (2009) mentioned that "Such a factor will have no real bearing on the methods of comparison employed in the later sections of the paper and so for convenience we assume that DF = 10 in what follows." We acknowledge that this assumption is idealized. To address this, we have calculated gridded DFs (Figure S7 below) and found that the DFs in Australia are close to 10, with spatial distributions being nearly homogeneous. Therefore, setting DF = 10 for Australia is reasonable in this context.

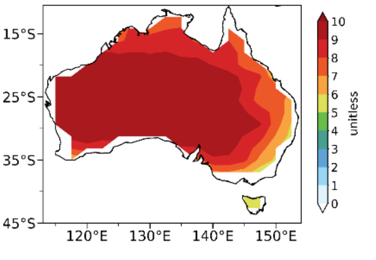

Figure S7. Spatial distributions of annual mean dry factor (unit: unitless) in Australia during 2010–2019. The data is from fire danger indices historical data from the Copernicus Emergency Management Service (CEMS, 2019; Vitolo et al., 2020).

Additionally, we compare FFDI with DF = 10 and FFDI with the gridded DF (Figure S8 below). The patterns and regional averages of both are similar.

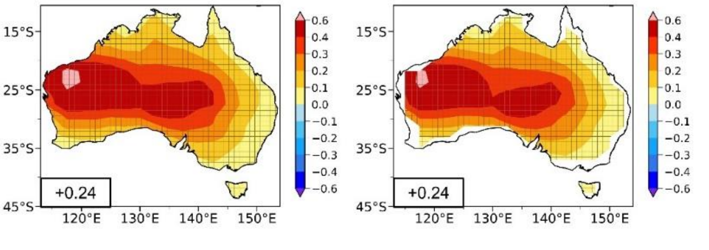

Figure S8. Spatial distribution of simulated changes in FFDI (unit: unitless) during fire seasons in Australia between BASE and CHN (CHN minus BASE). Shaded areas indicate results that are statistically significant at the 90% confidence level. Regional averages for Australia are noted at the bottom-left corner of each panel. The left panel shows FFDI (DF = 10), and the right panel shows FFDI (gridded DF).

L277: Please change “evidence“ to “indication“.

Changed.

L389: Please use “Earth System Model” or “fully-coupled climate model” instead of “aerosol-climate model” which would imply to me that this model is not fully coupled (which is the case according to the method section)

Thanks for your reminder. The term “aerosol-climate model” has been replaced with “fully-coupled climate model” throughout the manuscript, as suggested.

Figure S3: The colourbar of these two plots should be the same as the reader might be tricked into thinking that the magnitude changes between the observed and modelled data are similar.

Thank you for your suggestion. If we use the same color scale for both plots, the color range of the modeled results becomes overly uniform. However, we have now added a note in the figure caption to remind the reader that the magnitudes of the observed and modeled data are not directly comparable, and that the color scales represent different ranges.

References:

CSIRO and BOM: State of the Climate 2022, 2022

CEMS: Fire danger indices historical data from the Copernicus Emergency Management Service, https://doi.org/10.24381/cds.0e89c522, 2019.

Vitolo, C., Di Giuseppe, F., Barnard, C., Coughlan, R., San-Miguel-Ayanz, J., Libertá, G., and Krzeminski, B.: ERA5-based global meteorological wildfire danger maps, Sci. Data, 7, 216, https://doi.org/10.1038/s41597-020-0554-z, 2020.