Response to Referee #2:

We are grateful to the referees for their time and energy in providing helpful comments and guidance that have improved the manuscript. In this document, we describe how we have addressed the reviewer's comments. Referee comments are shown in black and author responses are shown in blue text.

Review of "Impacts of reductions in non-methane short-lived climate forcers on future climate extremes and the resulting population exposure risks in Asia" by Li et al.

This study uses AerChemMIP simulations to examine the effects of improved air quality through pollutant emissions reductions on projected climate extremes and associated population exposure in south and east Asia. A significant accelerated warming effect is found highlighting the importance of these short-lived forcings in policy-making and planning for future extremes.

The study will make a useful contribution to the literature and this is a very important area for analysis. I do have some significant concerns that I would ask the authors to consider.

- Thank you for your positive evaluations. All the questions and concerns have been carefully answered and the paper has been revised accordingly.

1. My first major concern is a technical one. The data are regridded using bilinear interpolation onto a 1-degree grid (L128). This is a much higher resolution than all but one of the models' native resolutions (Table 1). By interpolating to a higher resolution (in effect extrapolating) additional synthetic information is being added unintentionally and this could have a substantial effect on the extremes analysis in particular. My suggestion is to interpolate onto a common grid that is coarser (perhaps 2-degrees) and to use a different interpolation method for precipitation. I would recommend having a look at this webpage for useful discussion: https://climatedataguide.ucar.edu/climate-data-tools-and-analysis/regridding-overview.

Response: Thanks for your constructive suggestion!

(i) As suggested, we applied new interpolation method (first-order conservative) to interpolate precipitation data and updated the results for precipitation extremes (Figures 2, 7, 8, 9 and 12). The following information were added in the revised paper:

"All model outputs as well as observations were interpolated into a common grid (1° × 1°) through bilinear interpolation except for precipitation data, which used first-order conservative interpolation." Lines 153-154

(ii) We selected hottest days (TXx) and heavy precipitation days (R10) as examples to compare the results between low (2° × 2°) and high (1° × 1°) resolutions. It is seen that there are limited differences of both spatial pattern and magnitude for temperature (Figure R1) and precipitation (Figure R2) extremes between low- and high-resolution results. Because our study focused on regional assessment, we choose to use the original results at high resolution (1° × 1°) in the revised paper.

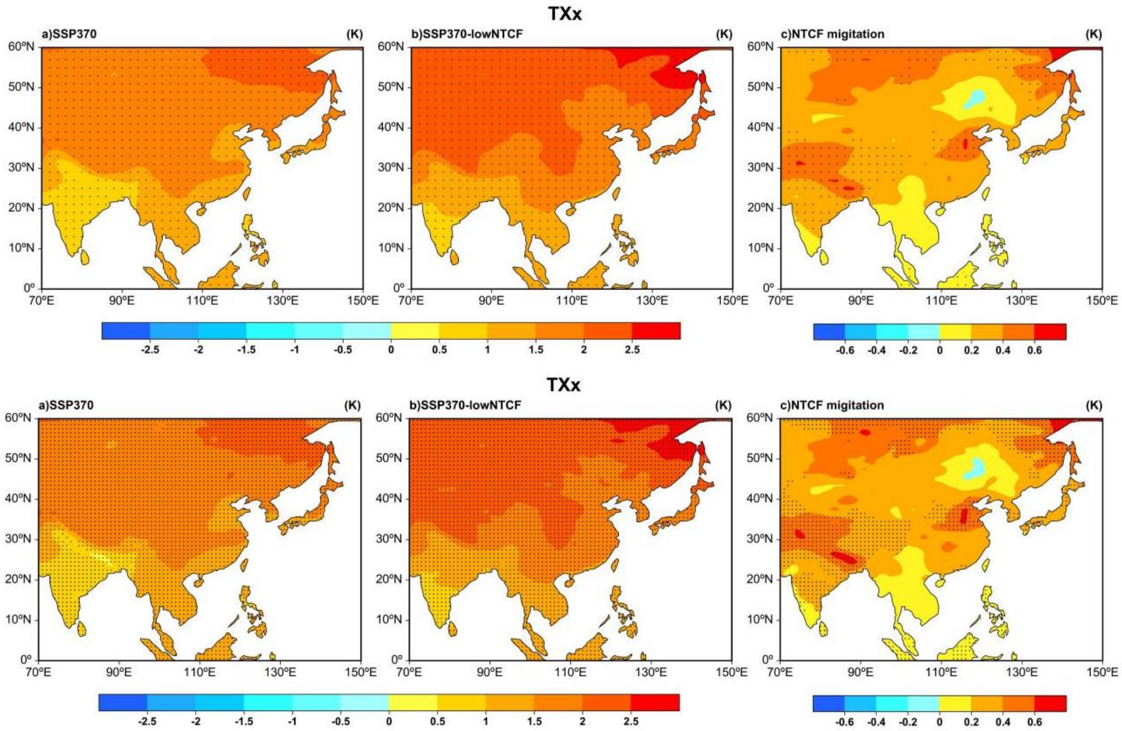

Figure R1 Spatial distribution of TXx at different resolutions. (top: 2°× 2° grid, bottom: 1°× 1° grid).

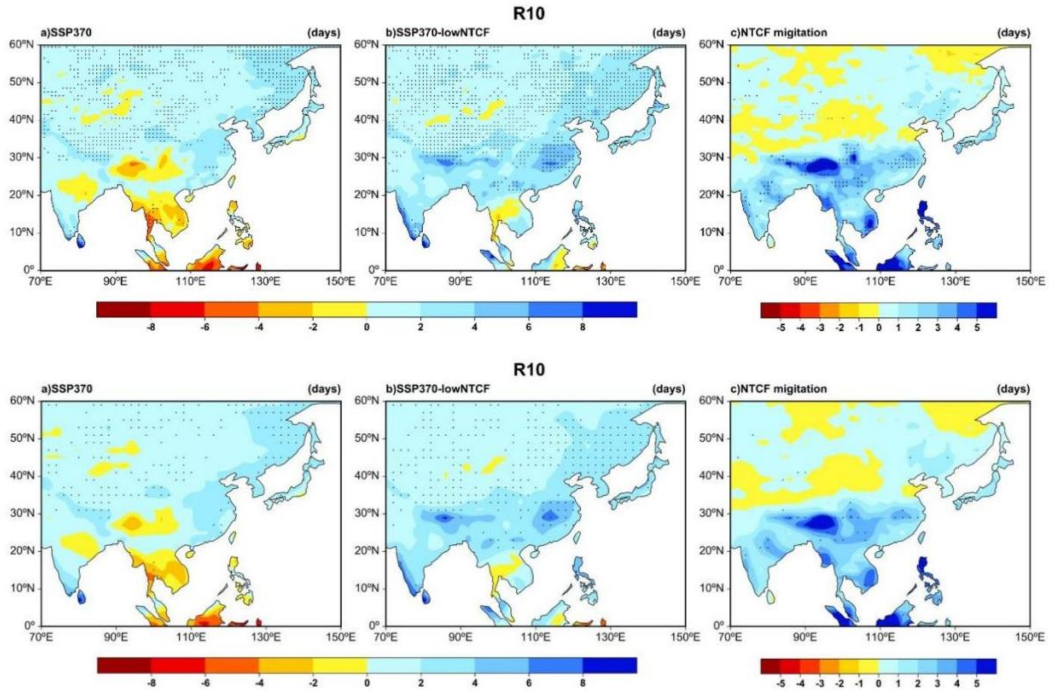

Figure R2 Spatial distribution of R10 at different resolutions. (top: 2 °× 2 °grid, bottom: 1 °× 1 °grid).

2. My other main concern is that there is no attempt at model evaluation apparent. I understand this may be challenging but given the analysis I would suggest some evaluation of extremes against an observational dataset over the recent period would be useful to benchmark whether the models are performing well enough.

Response: As suggested, we added new Figure 2 to evaluate the performance of the CMIP6 MME in simulating temperature and precipitation extremes in the historical period (1995-2014). The following information are added in the revised paper:

"To evaluate the performance of the models, a gridded daily maximum and minimum temperature and daily precipitation dataset obtained from the National Oceanic and Atmospheric Administration (NOAA) Climate Prediction Center (CPC) is used here. This dataset was constructed using optimal interpolation methods based on approximately 16,000 station and satellite observations (Chen et al., 2020b). It spans the period from 1979 to the present and has a high level of resolution of 0.5 °×0.5 °. All model outputs as well as observations were interpolated into a common grid (1 ° × 1 °) through bilinear interpolation except precipitation data, which used first-order conservative interpolation."

Lines 148-153

“We compared the simulated results with the observational climate extremes during 1995–2014 (Fig2). In general, the CMIP6 MME can reasonably reproduce the observed spatial distribution of extreme temperature and precipitation indices. For the extreme temperature indices, the maximums obtained from both the CMIP6 MME and observations are found in eastern China and southern Asia, especially for the simulated absolute extreme indices (TXx, TR) (Fig. 2a and b, Fig. 2e and f), which are generally consistent with the observations in spatial distribution with limited difference in magnitude. Relative to the absolute extreme indices, the percentile and duration indices show large differences between the CMIP6 MME and observation (Fig. 2c and d, Fig. 2g and h). Previous studies also shown that both CMIP5 and CMIP6 perform relatively unsatisfactorily in simulating spatial patterns of the duration and percentile indices (Fan et al., 2020; Guo et al., 2021). For R10, RX5day and R95p, the climatological mean is well captured by CMIP6 MME, although it tends to produce overestimates especially over southeastern Qinghai-Tibet Plateau and the Indo-China Peninsula (Fig. 2i-n). In addition, the CMIP6 MME underestimates the CDD in northwest China and along Mongolia (Fig. 2o and p), which is consistent with previous studies (Zhu et al., 2021; Kim et al., 2020). Although the CMIP6 MME produce some regional biases with respect to observation, such biases will be significantly reduced when considering the difference between the two segments of time (Sillmann et al., 2013b; Chen et al., 2020a). In this study, we focused on the changes in the future (2031–2050) relative to the reference period (1995–2014), so the results of the CMIP6 MME can be considered representative.” Lines 155-169

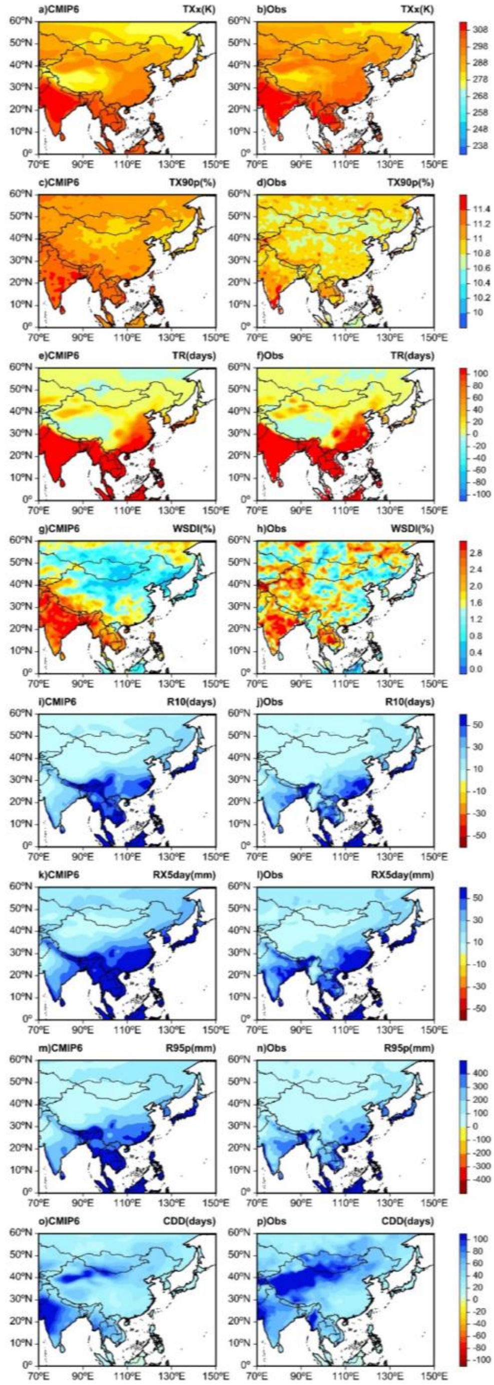

Figure 2: The annual mean of the hottest day (TXx), warm days (TX90p), tropical nights (TR), warm spell duration (WSDI), heavy precipitation (R10), maximum consecutive 5-day precipitation (RX5day), total wet-day precipitation (R95p), and consecutive dry days (CDD) over study area during 1995-2014 for CMIP6 multi-model mean (left column) and gridded observations (right column).

3. There is other relevant literature on the role of aerosols in influencing the climate of this region (Freychet et al. 2019), including on accelerated warming and associated extremes (King et al. 2018; You et al. 2020).

Response: As suggested, the above three papers were discussed and cited in the revised paper.

"North-East of India witnessed cooler maximum temperatures due to increased aerosols (Freychet et al. 2019)." Lines 45-46.

"In eastern Asia, under global warming 1.5 ℃ and 2 ℃, China is expected to grow at a faster rate than the global mean, and there is a strong warming in the Tibetan Plateau and when studying changes in local climate between 1.5 ℃ and 2 ℃ of global warming, non-GHGs influences need to be considered (King et al. 2018; You et al. 2020). The effect of projected reductions in anthropogenic aerosol emissions over eastern Asia caused an increase in summer temperatures and raised the likelihood of extreme hot summers (King et al. 2018)." Lines 69-73.

4. Section 3.2. Some comparison of the changes in temperature extremes over Asia relative to other parts of the world would also be useful in reinforcing your point about the role of short-lived forcers in affecting local climate extremes.

Response: In the revised paper, we clarified as follows:

"In the SSP3-7.0 and SSP3-7.0-lowNTCF scenarios, the warming in most regions exceeds 1.5 K, and the warming is greater at higher latitudes under both scenarios, but the magnitude of the increase is larger under the SSP3-7.0-lowNTCF scenario than the SSP3-7.0 scenario. Such strong local effects of short-lived forcers to temperature extremes were also revealed in other high emission and population density regions (Sillmann et al., 2013a; Samset et al., 2018; Luo et al., 2020). The greatest changes in TXx, exceeding 5K, were simulated in RCP8.5 in such regions as South and North America, Eastern Europe, north-central Eurasia as well as Australia by the end of the 21st century (Sillmann et al., 2013a)." Lines 236-242

“For populated regions such as Europe, the United States and East Aisa, the TXx change in response to remove short-lived aerosol reductions is on average 25% stronger than global land-area mean (Samset et al., 2018). ” Lines 246-248

5. Table 1: “America” should be the “United States” and “England” should be “United Kingdom”.

Response: Corrected as suggested.

6. All map figures: Stippling where 60% of models agree (I’m assuming you mean five out of seven?) is quite a weak threshold for agreement that could be met by chance quite often. It might be more useful to just say the fraction of models and use a higher threshold (e.g. six out of seven).

Response: As suggested, we used a higher threshold (six out of seven models for SAT, four out of five models for the extreme temperature indices and five out of six models for the extreme precipitation indices) to estimate whether the changes of climate extremes are robust. Meanwhile, the inappropriate description “e.g., 60% of models” has been modified as “e.g., six out of seven models” in all figure captions. For example:

Figure 5: Spatial patterns of changes in the hottest day (TXx), warm days (TX90p), tropical nights (TR), and warm spell duration (WSDI)during 2031-2050 in Asia under the SSP3-7.0 (left column) and SSP3-7.0-lowNTCF (middle column) scenarios relative to 1995-2014. The right column represents changes caused by the non-methane SLCFs mitigation. The dotted regions indicate that at least four out of five models agree on the sign. Lines 796-799

Reference:

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