Responses to reviewer 1

We would like to thank the reviewer for the positive and constructive comments about the manuscript (The relationship between $PM_{2.5}$ and anti-cyclone wave activity during summer over the United States). We have studied the comments carefully and made corrections. The corrections are listed in the following responses and all are completed and marked in the manuscript in yellow.

Comments on "The relationship between PM2.5 and anti-cyclone wave activity during summer over the United States" by Wang et al., 2021

Based on regression analysis on anticyclone wave activity (AWA) anomalies and PM2.5 concentrations, the present study attempts to evaluate the possible control of large-scale atmospheric circulation on regional aerosol pollution, which is very important for improving the understanding of air pollution formation and model prediction capability. Since the analysis was conducted on both observations and well-evaluated model simulations under various scenarios, the conclusions drawn from this study are generally reliable and robust. The manuscript is also well organized and prepared. Thus, I recommend it for publication with minor revision. Specific comments are listed as below.

Line 95: How to choose the three sites (i.e., AREN1, SIPS1, and LAVO1) as the representative stations of different part of the country and why? For example, the authors may want to provide more detailed information regarding the representativeness of the three selected stations.

Response: There are two reasons for the representativeness of the three selected stations.

(1) The three sites here correspond to the three sites in Northeast, Southeast and Western region respectively, which has differing impacts of meteorological persistence on the distribution and extremes of ozone in Sun et al. (2017).

(a) AREN1 (39.92°N, 77.31°W) matches with the site PSU106 (40.72°N, 77.93°W, in the Northeast region) which has a well-known association between high ozone and stagnation.

(b) SIPS1 (34.34°N, 87.34°W) matches with the site SND152 (34.29°N, 85.97°W, in the Southeast region) which is least sensitive to the length of a stagnation event for ozone in the Southeast (ozone increases by ~0.06 standard deviation per day on average).

(c) LAVO1 (40.54°N, 121.58°W) matches with the site LAV410 (40.54°N, 121.58°W, in the Western region) which is noted for the fewest number of days between cyclones of 4 days or longer. Furthermore, LAVO1 is considered to be a clean air site in California where anthropogenic influence is at a minimum (Vancure et al., 2002). LAVO1 is a higher elevation (1.76 km) site in Northern California that has also been used to quantify baseline ozone concentrations due to its relatively isolated location (Parrish et al., 2012). In addition, the long range transport from Asia and meteorology are dominant drivers of pollutants at LAVO1 by distinguishing among local, distant North American, and Asian sources of particulate matter ($PM_{2.5}$) and O_3 (Vancure et al., 2015).

The more detailed information regarding the representativeness of the three selected stations are included in lines 97-106 as follows:

We chose three representative stations in different parts of the country to investigate the relation between AWA and $PM_{2.5}$ in detail. The IMPROVE station names are AREN1 (Arendtsville, Pennsylvania; 39.92 °N, 77.31°W; in the Northeast), SIPS1 (Sipsey Wilderness, Alabama; 34.34°N, 87.34°W; in the Southeast) and LAVO1 (Lassen Volcanic NP, California; 40.54°N, 121.58°W; in the West), which are shown with the red dots in Figure 1. They match with the site PSU106 (40.72°N, 77.93°W, in the Northeast), SND152 (34.29°N, 85.97°W, in the Southeast) and LAV410 (40.54°N, 121.58°W, in the West) respectively, which has differing impacts of meteorological persistence on the distribution and extremes of ozone in Sun et al. (2017) to allow comparison between the ozone and $PM_{2.5}$ response to AWA. Long range transport from Asia and meteorology are dominant drivers of pollutants at LAVO1, where anthropogenic influence is at a minimum as a clean air site in California (Vancure et al., 2015).

(2) The three sites of different part of the country differ from each other climatologically (Figure 2). The climatological average for $PM_{2.5}$ is greater in the Eastern than in the Western sites. The highest correlation coefficients between model and observations (0.93) are seen at SIPS1 perhaps due to the large seasonal variation in $PM_{2.5}$ concentrations. Emission changes are more important than climate changes at AREN1, but it is not clear which is more important at SIPS1 or LAVO1.

References

Sun, W., Hess, P., and Liu, C.: The impact of meteorological persistence on the distribution and extremes of ozone, Geophys. Res. Lett., 44, 1545–1553, 2017.

Parrish, D. D., et al.: Long-term changes in lower tropospheric baseline ozone concentrations at northern mid-latitudes, Atmos. Chem. Phys., 12, 11,485–11, 504, 2012.

VanCuren, R. and Gustin, M. S.: Identification of sources contributing to $PM_{2.5}$ and ozone at elevated sites in the western U.S. by receptor analysis: Lassen Volcanic National Park, California, and at Great Basin National Park, Nevada, Sci. Total Environ., 530, 505–518, 2015.

Line 222: It seems that the statement here flipped two simulation terms: it is REFC1SD which is for the reanalysis driven simulations and GCM2000 for the coupled model simulations, right? I also found several other places such as in figure captions show similar typos. Please go through the entire paper and make sure that the case terms are not messed up.

Response:

(1) In order to be consistent with Phalitnonkiat et al. (2018) and Sun et al. (2019), the simulation terms REFC1SD, GCM2000, GCM2100 and REFC2 are used in this study.

REFC1SD is the specified dynamics simulations from the Chemistry-Climate Model Initiative (CCMI) for the period from 1991 to 2010. GCM2000 and GCM2100 simulation are 25-year runs branched from the CCMI reference simulations in the year 2000 and the year 2100, respectively. REFC2 is forced by future climate combined with future emissions following the REFC2 CCMI modeling protocol. In this run greenhouse gas forcing and emissions following the RCP6 scenario.

(2) We have checked the entire paper and make sure the case terms are right.

(a) the description for **REFC1SD, GCM2000, GCM2100 and REFC2** in the text are as follows:

L132: The simulation using specified dynamics (**REFC1SD**) for current levels of $PM_{2.5}$ from 1991 to 2010 is driven by analyzed meteorological data from Modern-Era Retrospective Analysis for Research and Applications (MERRA) (see Tilmes et al., 2016).

L138: The **GCM2000** and **GCM2100** simulations are 25-year runs branched from the CCMI reference simulations in the year 2000 and the year 2100, respectively. Simulations over the first five years are discarded as spin-up, and results from the latter 20 years are discussed here (2006-2025 for **GCM2000** and 2106-2125 for **GCM2100**).

L145: Another future run (**REFC2**) is forced by future climate combined with future emissions following the **REFC2** CCMI modeling protocol. In this run greenhouse gas forcing and emissions following the RCP6 scenario. The relationship between ozone and AWA has been examined in the

GCM2000, **GCM2100** and **REFC2** simulations in Sun et al. (2019). Characteristics of the **REFC1SD** simulation are given in Phalitnonkiat et al. (2018). Note that our **REFC2** set-up covers volcanic eruptions in the past, but possible volcanic eruptions in the future are not included (Eyring et al., 2013).

L212: A statistically significant correlation ($r>0.80$, $p<0.01$; Figure 2) for current $PM_{2.5}$ is found between observations and simulations of monthly mean climatological averages (**REFC1SD** and **GCM2000**) at three representative sites. The highest correlation coefficients between model and observations (0.93) are seen at SIPS1 perhaps due to the large seasonal variation in $PM_{2.5}$ concentrations (Figure 2b). The future PM2.5 concentrations are increased in **GCM2100** under current emissions compared with current climate $PM_{2.5}$ simulations. There is a strong decease in climatological mean for future $PM_{2.5}$ at AREN1 under future emissions and meteorology (**REFC2**), while the climatological average for future $PM_{2.5}$ has no significant change under future emissions at SIPS1 and LAVO1.

L221: Focusing on the spatial distribution, the highest $PM_{2.5}$ concentrations over the 20-year average in summer occur in the south-central US (Figure 3a; green lines; **GCM2000** case). The 20-year averaged AWA on summer days exhibits a maximum over the Southwestern US (Figure 3a; shading). The difference between two current climate simulations (**REFC1SD** minus **GCM2000**) for summertime AWA is shown in Figure 3b.

L228: The difference between two future scenarios (**GCM2100**; **REFC2**) and current climate scenario (**GCM2000**) has a similar pattern (illustrated in Figure 3c and d), which shows a large increase in AWA in the Southwestern US, but there is a difference in the amplitude of these changes (contrast Figure 3c vs. 3d) (Sun et al., 2019). There is an increase in $PM_{2.5}$ concentration for the future scenario with current emissions (**GCM2100**), while there is a decrease in $PM_{2.5}$ concentrations when future emissions are used (**REFC2**), showing the importance of future potential decreases in emissions.

L238: The highest regression coefficient occurs in the observational (Obs) and the reanalysis driven simulated cases (**REFC1SD**), as opposed to the case coupled metereology (**GCM2000**) (Figure 4a, b, c (top row) and Figure 4d, e, and f (middle row) in contrast to Figure 4g, h and I (bottom row)). The highest spatial regression coefficients for site AREN1 and SIPSl are located southward of the sites, while they are located to the northwest at LAVO1. Overall the model simulates similar spatial patterns to the observations for the case of the reanalysis driven simulations (**REFC1SD**), but do less well for the coupled model simulations (**GCM2000**).

L255: The areas with the largest values of the composite AWA are located southward of the AREN1 and SIPSl sites. But at LAV01 the maximum is located to the northwest for the observational and reanalysis driven cases (Obs and **REFC1SD**), and eastward for the coupled model case (**GCM2000**).

L314: Employing daily present-day summertime concentrations of $PM_{2.5}$ and AWA for current climate from the coupled model simulation (**GCM2000**) and equation (5)-(7), we derive that how much of $PM_{2.5}$'s interannual variance can be explained by the projection of JJA AWA anomalies onto the daily $PM_{2.5}$-AWA regression coefficients pattern.

L325: Next we explore how much of the future change in $PM_{2.5}$ concentrations can be predicted just on the basis of changes in AWA. Using $PM_{2.5}$-AWA relationships determined from current coupled model output (**GCM2000**), future $PM_{2.5}$ changes can be estimated by using the linear relationship fitted with the current data and projected change of AWA in the future (as shown in equation (5)-(7)).

L330: Future climate change is simulated to cause an increase in PM2.5 concentrations over most of the US if there are no changes in emissions (**GCM2100**; Figure 9a).

(b) the description for **REFC1SD**, **GCM2000**, **GCM2100** and **REFC2** in figure captions are as follows:

Caption for Figure 2: Climatological monthly mean average with standard deviation for $PM_{2.5}$ used in this study at three sites (AREN1 (a), SIPS1 (b) and LAVO1(c)) for five scenarios used in this study. Red (r) represents the correlation coefficient between observation (Obs) and simulation for current from the **REFC1SD** simulation. Blue r represents the correlation coefficient between observation (Obs) and simulation for current from **GCM2000** simulation. The p-values are included.

Caption for Figure 3: Wave activity (AWA: shading using the legend in 10^8 m^2) and $PM_{2.5}$ concentrations (green contour lines in μ g m^{-3}) for (a) the current climate (**GCM2000**, 2006-2025 summer days' average); (b) reanalysis driven case (**REFC1SD**, 1991-2010 summer days' average) minus the current climate online case (**GCM2000**, 2006-2025 summer days' average); (c) Future climate with current emission (**GCM2100**, 2106-2125 summer days' average) minus the current climate (**GCM2000**, 2006-2025 summer days' average); (d) Future climate with future emission (**REFC2**, 2080-2099 summer days' average) minus current climate (**GCM2000**, 2006-2025 summer days' average). Three black dots are representative stations (AREN1, SIPS1 and LAVO1).

Caption for Figure 4: (Contour) composite 500 hPa geopotential height anomaly (positive values are represented by solid green lines and negative values by dashed magenta lines) and (Shaded) regression coefficients between daily AWA and $PM_{2.5}$ at site (denoted by the black dots) (a, d, g) AREN1, (b, e, h) SIPS1 and (c, f, i) LAVO1 in the study domain for daily JJA time series of current climates. The top row are results using IMPROVE $PM_{2.5}$ and reanalysis AWA, the middle row uses the reanalysis driven simulated $PM_{2.5}$ (**REFC1SD**) and reanalysis AWA, and the bottom row uses current climate simulated $PM_{2.5}$ and AWA (**GCM2000**). Stippling indicates the regions that are statistically significant at the 5% confidence level. Unit: 10^{-8} μ g m^{-3} /m^2 for regression coefficients.

Caption for Figure 5: (Contour) composite 500 hPa geopotential height anomaly (positive values are represented by solid green lines and negative values by dashed magenta lines) and (shading) corresponding AWA for $PM_{2.5}$ larger than 90th quantile at site (denoted by the black dots) (a, d, g) AREN1, (b, e, h) SIPS1 and (c, f, i) LAVO1. The top row are results using IMPROVE $PM_{2.5}$ and reanalysis AWA, the middle row uses the reanalysis driven simulated $PM_{2.5}$ (**REFC1SD**) and reanalysis AWA, and the bottom row uses current climate simulated $PM_{2.5}$ and AWA (**GCM2000**). Stippling indicates the regions that are statistically significant at the 5% confidence level. Unit: m for 500 hPa geopotential height and 10^8 m^2 for AWA. The blue outlined area in a) is the impact region, which is defined as the region of the maximum regression coefficient minus 0.05.

Caption for Figure 6: The maximum of the composite AWA distribution for $PM_{2.5}$ larger than 90th quantile (Shading) (a, c, e, g, i), and the centers of the spatial regression coefficient distribution between $PM_{2.5}$ and AWA (b, d, f, h, j): observations (Obs, first row), current climate from the reanalysis driven simulation (**REFC1SD**, second row), current climate from the coupled model simulation (**GCM2000**, third row), future climate with current emission (**GCM2100**, fouth row) and future climate with future emission (**REFC2**, bottom row). At each grid point, the highest composite AWA anywhere in the domain based on the $PM_{2.5}$ larger than 90th quantile and the highest regression coefficient between AWA and $PM_{2.5}$ are shown. In a) and b), the thee representative sites are denoted by the black dots. In a) and b) the different shapes (circle or triangle) indicate the number of values for every grid that are statistically significant (at the 5% confidence level) is more than

30% or not. The different colors indicate different highest composite AWA and regression coefficients as indicated in the legend. In c) through j) the number of values for every grid that are statistically significant at the 5% confidence level are shown (in black contours).

Caption for Figure 9: (a) Simulated change of JJA $PM_{2.5}$ between simulated future (future climate with current emission, **GCM2100**, 2106-2125 mean) and current (current climate from the coupled model simulation, **GCM2000**, 2006-2025 mean). (b) Predicted JJA PM2.5 change using the linear regression model fitted with simulated current $PM_{2.5}$ (**GCM2000**, 2006-2025 mean). Stippling indicates where R^2 is significant (at the 5% significance level) at model grids. Unit: $\mu g\ m^{-3}$ for $PM_{2.5}$.

Caption for Figure 10: The fraction of predicted JJA $PM_{2.5}$ change using simulated data (current climate from the coupled model simulation, **GCM2000**, 2006-2025 mean; Figure 9b divided by Figure 9a) fitted model accounts for the total JJA $PM_{2.5}$ change from simulations. The fraction that less than zero is regarded as zero.

Lines 295-296: why Wise and Comrie (2005) show much lower coefficient of determinations (i.e., 0.1-0.5) than this study (i.e., 0.75)?

Response:

(1) There are several differences between the approach and time period, as well as location between the Wise and Comrie (2005) study and this one, which we highlight here.

(2) Changes between current and future climates in AWA can explain up to 75% of $PM_{2.5}$ variability using a linear regression model in this study. Wise and Comrie (2005) show that meteorological variability typically accounts for 10–50% of PM variability over the time period 1990–2003 for the Southwest's five major metropolitan areas using stepwise regression (using the 0.01 significance level throughout). The most prominent $PM_{2.5}$ variability (75%) for changes between current and future climates in AWA occurs over Great Plains as shown in this study, while 10%-50% of PM in Wise and Comrie (2005) is for the Southwest's five major metropolitan areas. Less than 50% of $PM_{2.5}$ variability in the southwest in this study is in line with Wise and Comrie (2005), which 10–50% of PM explained by meteorological variability arises from the major metropolitan areas in the Southwest: Albuquerque, NM; El Paso, TX; Las Vegas, NV; Phoenix, AZ; and Tucson, AZ.

(3) Comparison of this study and Wise and Comrie (2005) is as follows:

	This study	Wise and Comrie (2005)
object	$PM_{2.5}$ and AWA	PM and meteorological variables
period	current (2006-2025); future (2106-2125)	1990-2003
data	the IMPROVE data and CESM simulations	Meteorological data were obtained from the National Climatic Data Center and collected by the standard protocols established by the US National Weather Service.
study area	150 IMPROVE sites across US	the Southwest's five major metropolitan areas
method	univariate linear regression	stepwise regression; the KZ filter method
results	Future changes in US $PM_{2.5}$ based only on changes in climate are estimated to increase $PM_{2.5}$	Moisture levels (particularly relative humidity) are the strongest predictors of PM concentrations in all five cities examined.

	concentrations due to increased AWA in summer over areas where PM2.5 variations are dominated by meteorological changes, especially over the western US. Changes between current and future climates in AWA can explain up to 75% of $PM_{2.5}$ variability using a linear regression model.	Meteorological variability typically accounts for 20–50% of PM variability. Long-term trends in PM concentrations were relatively flat in all five cities analyzed but contained coincident extremes unrelated to meteorology.

(4) Because of all the differences in the methodologies, it is unclear what the underlying differences are. We add the following sentence in lines 319-321:

Wise and Comrie (2005) similarly determined R^2 values of 0.1-0.5 for associations of PM with atmospheric variables across sites in the Southwest, and here we see a comparable relationships across the Southwest, although these studies use different methodologies as well as consider different time periods.

Lines 284-286: how about the comparison of PM2.5 results in this study with that in Porter et al. (2015)? Are they consistent with each other as what is shown in ozone?

Response:

Porter et al. (2015) find nationally averaged sensitivities of 95th percentile summer O_3 to changes in maximum daily temperature of approximately 0.9 ppb °C^{-1}, while the sensitivity of 50th percentile summer O_3 (the annual median) is only 0.6 ppb°C^{-1}. They also obtain the greater sensitivities of $PM_{2.5}$ at the highest concentration percentiles to mean daily temperature. While the sensitivities of O_3 to temperature are the greatest along both the northeast coast and Southern California, $PM_{2.5}$ sensitivities to temperature peak entirely in the east due to the regionality of $PM_{2.5}$ speciation. Out of the 150 sites, 145 sites in this study show that 90th percentile $PM_{2.5}$ increases more than the 50th percentile of $PM_{2.5}$ with the enhancement of the AWA. In the Northeast region (north and east of New York state with New York state included), this relationship is the most pronounced. This difference in response between the highest and median $PM_{2.5}$ values indicates the different sensitivities within various percentiles of the $PM_{2.5}$ levels. These results are to some extent consistent with those from Porter et al. (2015), which addressed that averaged sensitivity of 95th percentile summertime ozone to changes in highest daily temperature was larger than the sensitivity of 50th percentile summertime ozone.

The comparison of $PM_{2.5}$ results in this study with that in Porter et al. (2015) is updated to focus on $PM_{2.5}$ in lines 308-310 as follows:

These results are to some extent consistent with those from Porter et al. (2015), which addressed the greater sensitivities to mean daily temperature at the highest concentration percentiles in predicting summertime $PM_{2.5}$, but with $PM_{2.5}$ sensitivities to temperature peak entirely in the east due to the regionality of $PM_{2.5}$ speciation.

Line 150: the full term of AWA should be shown at its first instance (i.e., in Line 59).

Response: As suggested, the full term of AWA (anti-cyclone wave activity) is shown at its first instance in line 2.

Section 2.3: Since the AWA (or LWA) is the key variable in this study, it's better to list the equation(s) used to calculate AWA (or LWA) so that the readers don't need to refer to previous references to understand the detailed calculations related to AWA (or LWA).

Response: As suggested the calculation for the AWA is included in lines 151-160 in section 2.3 as follows:

To calculate AWA, we adopt the procedures in Chen et al. (2015) and Huang and Nakamura (2016). A dynamical quantity, q (here we use Z_{500}, geopotential height at 500 hPa), approximately decreases with latitude in the Northern Hemisphere. For a given value of q = Q, we introduce an equivalent latitude $\emptyset_e$(Q) as

$$\emptyset_e(Q) = \sin^{-1}[1 - \frac{S(Q)}{2\pi a^2}]$$

Here, S(Q) is the area bounded by the Q contour towards the North Pole and a denotes Earth's radius. Defining an eddy term as $\hat{q} \equiv q - Q$ and separating the southward and northward displacements in the Q contour, we calculate the cyclonic (southern), anticyclonic (northern) and total LWA at the longitude λ and latitude $\emptyset_e$ by

$$A_C(\lambda, \emptyset_e) = \frac{a}{\cos \emptyset_e} \int_{\hat{q} \le 0, \emptyset \le \emptyset_e(Q), \lambda = cons}^{\blacksquare} \hat{q} \cos \emptyset d\emptyset$$

$$A_A(\lambda, \emptyset_e) = \frac{a}{\cos \emptyset_e} \int_{\hat{q} \ge 0, \emptyset \ge \emptyset_e(Q), \lambda = const}^{\blacksquare} \hat{q} \cos \emptyset d\emptyset$$

$$A_T(\lambda, \emptyset_e) = A_C - A_A$$

More details on LWA theory and derivation can be found in Chen et al. (2015) and Huang and Nakamura (2016).

Lines 225-226: miss commas after "In addition" and before "suggesting".

Response: Commas are included after "In addition" and before "suggesting" in lines 246-247.

Figures & Table:

Fig. 4: please describe what the contour lines (green and magenta) stand for.

Response: Thank you for pointing this out: the contour lines (green and magenta) is described in caption for Fig4 as follows:

Figure 4. (Contour) composite 500 hPa geopotential height anomaly (positive values are represented by solid green lines and negative values by dashed magenta lines) and (Shaded) regression coefficients between daily AWA and $PM_{2.5}$ at site (denoted by the black dots) (a, d, g) AREN1, (b, e, h) SIPS1 and (c, f, i) LAVO1 in the study domain for daily JJA time series of current climates. The top row are results using IMPROVE $PM_{2.5}$ and reanalysis AWA, the middle row uses the reanalysis driven simulated $PM_{2.5}$ (REFC1SD) and reanalysis AWA, and the bottom row uses current climate simulated $PM_{2.5}$ and AWA (GCM2000). Stippling indicates the regions that are statistically significant at the 95% confidence level. Unit: 10^{-8} μ g m^{-3} /m^2 for regression coefficients.

Fig. 6 caption: GCM2100 should be the case with the future climate with current emission while REFC2 is the future climate with current emission. The original description seems wrong based on methodology section.

Response: Thank you for pointing this out: GCM2100 is the future climate with current emission and REFC2 is the future climate with future emission. The description for REFC2 is wrong here and it is revised as follows:

The maximum of the composite AWA distribution for $PM_{2.5}$ larger than 90th quantile(Shading) (a, c, e, g, i), and the centers of the spatial regression coefficient distribution between $PM_{2.5}$ and AWA (b, d, f, h, j): observations (Obs, first row), current climate from the reanalysis driven simulation (REFC1SD, second row), current climate from the coupled model simulation (GCM2000, third row), **future climate with current emission (GCM2100, fouth row) and future climate with future emission (REFC2, bottom row)**. At each grid point, the highest composite AWA anywhere in the domain based on the $PM_{2.5}$ larger than 90th quantile and the highest regression coefficient between AWA and $PM_{2.5}$ are shown. In a) and b), the thee representative sites are denoted by the black dots. In a) and b) the different shapes (circle or triangle) indicate the number of values for every grid that are statistically significant (at the 5% confidence level) is more than 30% or not. The different colors indicate different highest composite AWA and regression coefficients as indicated in the legend. In c) through j) the number of values for every grid that are statistically significant at the 5% confidence level are shown (in black contours).

Fig. 9: Is the panel (a) for the change between GCM2100 and GCM2000 or between GCM2100 and REFC2 simulation? I note that REFC2 is for future climate as denoted in methodology section, right? Similar issue in Fig. 10 caption.

Response: We agree that the descriptions for Figure 9 and Figure 10 are not clear enough. They are revised as follows:

Figure 9. (a) Simulated change of JJA $PM_{2.5}$ between simulated future (future climate with current emission, GCM2100, 2106-2125 mean) and current (current climate from the coupled model simulation, GCM2000, 2006-2025 mean). (b) Predicted JJA $PM_{2.5}$ change using the linear regression model fitted with simulated current PM2.5 (GCM2000, 2006-2025 mean). Stippling indicates where R^2 is significant (at 5% significance level) at model grids. Unit: $\mu g\ m^{-3}$ for $PM_{2.5}$.

Figure 10. The fraction of predicted JJA $PM_{2.5}$ change using simulated data (current climate from the coupled model simulation, GCM2000, 2006-2025 mean; Figure 9b divided by Figure 9a) fitted model accounts for the total JJA $PM_{2.5}$ change from simulations. The fraction that less than zero is regarded as zero.

Table 1: The time period information for GCM2000 and GCM2100 do not mean anything, as you just simulated a climatology, not specific years. It should be sufficient to just mention the length of the simulations.

Response: Good point: the time period is removed and the table 1 is revised as follows:

Simulation (years)	Model Case Name	GHG^1 forcing	SST^2 and sea ice	Emissions	Meterological driver
REFC1SD (1991-2010)	f.e11.TSREFC1SD.f19. f19.ccmi23.001	$CMIP5^3$	$HadISST2^4$	Anthropogenic and biomass burning emission: $MACCity^5$ Biogenic emissions: $MEGAN2^6$	$MERRA^7$
GCM2000 (2006-2025)	b.e11.TSREFC2.femis 2000.y2000.f19.f19. ccmi23.001	CO_2 = 369 ppm	$Online^8$	Anthropogenic and biomass burning from $AR5^9$ Biogenic emissions: Monthly values from MEGAN2 for 2000	Online
GCM2100 (2106-2125)	b.e11.TSREFC2.femis 2000.y2100.f19.f19. ccmi23.001	CO_2 = 669 ppm	$Online^8$	Same as GCM2000	$Online^8$
REFC2 (2080-2099)	b.e11.TSREFC2.f19.g1 6.ccmi23.001.cam.h7	A1B scenario	Online	A1B scenario	Online