Response to review #1 on acp-2018-498

Long-term trends in the PM$_{2.5}$- and O$_3$-related mortality burdens in the United States under emission reductions from 1990 to 2010

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General comments: This is an interesting and useful contribution which evaluates the contribution of underlying factors to long-term air pollution-related mortality trends in the continental US, with the aim of highlighting the importance of concentration reductions. This appears to be the first application of a multi-decadal air quality modeling exercise to analyse such a question.
The manuscript is clearly written, with balanced arguments and inclusion of recent, relevant literature. The methods employed are appropriate, clearly described, and well supported.

We thank referee #1 for the very positive comments on our manuscript. We also appreciate the reviewer for the constructive suggestions, which have helped us improve the manuscript. All referee comments (in blue below) have been carefully addressed, and changes incorporated in the revised manuscript are shown using the track-changes option.

It would be helpful to have additional information on the accuracy of the linear interpolation method for population across Census years. Can they discuss the accuracy of this, perhaps with reference to sources that estimate inter-Census population? There are a variety of sources for this, with more sophisticated methods than linear interpolation that rely, e.g., on the American Community Survey. Geolytics Inc. has annual products for population, or perhaps LandScan Global population.
Response: The interannaul population between two censuses (1990 and 2000; 2000 and 2010) was not directly linear interpolated by us, instead they were derived from the Population Estimates project by US Census Bureau. The intercensal population estimates are estimates made for the years between two completed censuses which take into account the census at both the beginning and end of the decade.
(https://www.cdc.gov/nchs/data/nvss/bridged_race/Documentation_bridge_postcenv2017.pdf, accessed 5 September 2018).

From their documentation, the population products from the American Community Survey of Geolytics Inc. and the LandScan Global population both adopted the annual mid-year national population estimates from the US Bureau of Census (https://landscan.ornl.gov/documentation, accessed 5 September 2018)
(http://www.geolytics.com/USCensus,AmericanCommunitySurvey(ACS),Data,Features,Products.asp, accessed 5 September 2018).

To avoid confusion, we rewrote the sentence in line 17-19 in page 5 (page and line numbers are in the revised manuscript):
"Annual population in the US at county level was taken from the US Bureau of Census, which reported populations associated with the 1990, 2000, and 2010 censuses and estimated population for each year in between (CDC 2017;

accessed 5 September 2018)"

Specific comments: Page 10, Lines 1-3: The authors are careful to talk about "reduced mortality burden", but here they mention 'avoided deaths'. Perhaps add "premature" in front of deaths.

Response: We thank the reviewer for the suggestion. In the revised manuscript, we add the word "premature" as the referee suggested.

"The air quality improvements have significantly decreased the mortality burden, avoiding roughly 35,800 (38%) $PM_{2.5}$-related premature deaths in 2010, compared to the case if air quality had stayed at 1990 levels."

Page 7, line 1: recommend introducing Table 1 here, since this seems to be the first time its results are mentioned.

Response: We add the introduction to Table 1 in the beginning of this paragraph, and also rewrite the first sentence:

"Table 1 shows the mortality burdens for $PM_{2.5}$ and O_3 in 2010, and also the burden changes since 1990 from different contributing factors. From the table, we see that the $PM_{2.5}$-related mortality burden in 2010 would have decreased by only 24% (94,400 deaths yr^{-1} in 2010, 95%CI, 50,300-139,800) compared with that in 1990, if the $PM_{2.5}$ concentrations had stayed constant over the period 1990-2010,"

Figure 5(a) color bars took a moment to interpret, since for (b) using symmetric saturation with cool = reduction and warm increase, but for (a) these are all reductions. Despite the note, it still took a moment. Perhaps consider only using cool colors for 5(a)?

Response: This figure is now Figure 6, after we added a new figure 5 to the paper. We have changed panel a of this figure to use only cool colors in different shades, as suggested by the reviewer. Thank you for this very good suggestion.

Figure S1 – can you add a legend, perhaps, and/or indicate color of population increase line in caption?

Response: We now add a legend in Figure S1, and also in the caption, we wrote:

"The red line is the US total adult population > 25 yrs old from 1990 to 2010 with the y-axis on the right."

Technical corrections: Page 6 Line 18 - refers to the split decadal trend, which is in Table S5 not Table 1.

Response: We thank the reviewer for noticing this. We now changed "Table 1" to "supporting Table S5".

Page 6 Line 28: Table 1 says 54% not 53%

Response: The reviewer is correct. We have updated the number in the revised manuscript.

Page 5 Line 29: "Zhang" instead of Zhaneg.

Response: We thank the reviewer for pointing this out. We now made the changes in the revised manuscript.