Investigating the observed sensitivities of air-quality extremes to meteorological drivers via quantile regression

Porter et al.

Referee #2 Comments

(authors' responses in italics)

The manuscript is an excellent contribution. By and large it is well-written and clear. Examination of the full distribution of pollutant concentrations and the incongruent importance of meteorological factors across that distribution is an important finding. From a societal impacts point of view, the focus on the upper tail is both justified and topical. I recommend publication after the following critiques are addressed.

1. In terms of framing the results, I think the authors need to be careful with regard to their choice of language. In particular, since this is a statistical analysis, the conclusion and presentation of various meteorological factors as 'drivers' seems inaccurate (and the method does not seem up to the task of proving something to be a physical driver). This issue especially stood out to me with the contention that PM events were driven by temperature. I understand the authors' intent, but nuance is required. I recommend that these language considerations be modified throughout the manuscript. The method has found influences, associations, and yes, some well-established drivers (ozone & temperature), but the physical links have not been established for all variables.

   Point well taken – we do not want to imply causation where it has not been established. We have replaced the word "driver" with the more statistically neutral term "covariate" throughout the manuscript wherever direct causation cannot be assumed for a specific meteorological variable.

2. P14078 27: The use of "weather patterns" is general. When I see this I think of circulation patterns, but I'm certain that others have different interpretations. Perhaps the sentiment could be strengthened/clarified by being explicit regarding the meaning of weather patterns? One direction to follow/cite: Currently in review at ACP: Shen et al, 2015, Influence of synoptic patterns on surface ozone variability over the Eastern United States from 1980 to 2012

   This section has been edited for clarity, removing the spatial connotation that "weather pattern" can carry:

   "Previous studies have analyzed the impacts of changes in weather and climate on O3 and PM2.5 levels (e.g. Brasseur et al., 2006; Liao et al., 2006), finding connections between specific meteorological conditions and mean pollutant response."

3. P14079 L7: I highlight this here, but it's something that should be addressed throughout: the word extremes typically refers to both tails, but here it seems to be used to refer to the high tail only, as 'low' is later invoked. I'd suggest clarifying what 'your' extreme is early in the manuscript and sticking with that usage throughout.

   We have updated our usages of "extreme" to clarify our meaning throughout the text.

4. P14080: I am interested to hear more about the biases and their influence on the conclusions. The results place such huge importance on temperature (which reanalyses do moderately well at capturing), but if there is threshold dependence in other variables that are not well-captured (e.g., precipitation & wind), would this not affect your conclusions?

   Our results here are certainly affected by any biases and errors present in the NARR reanalysis product, and this has been clarified in section 2.4:

   "It should be noted that the NARR fields used to provide our input meteorological drivers likely exhibit intrinsic errors and biases which will certainly affect the predictive power of our models, as well as the strength of our variable selection process itself. Variables which are better represented (e.g. temperature) will have an advantage compared to other potentially important variables with greater uncertainties, such as precipitation."

5. P14081: In terms of derived products, if possible, I'd love to see your methods applied to two recent results that deal with the future: (a) Barnes & Fiore, GRL, 2013, Surface ozone variability and the jet position. Does jet position north/south of each EPA region have a controlling influence? (b) Horton et al, Nature Climate Change, 2014, Occurrence and persistence of atmospheric stagnation events. Does the influence of stagnation as defined in this study differ greatly from the stagnation discussed here?

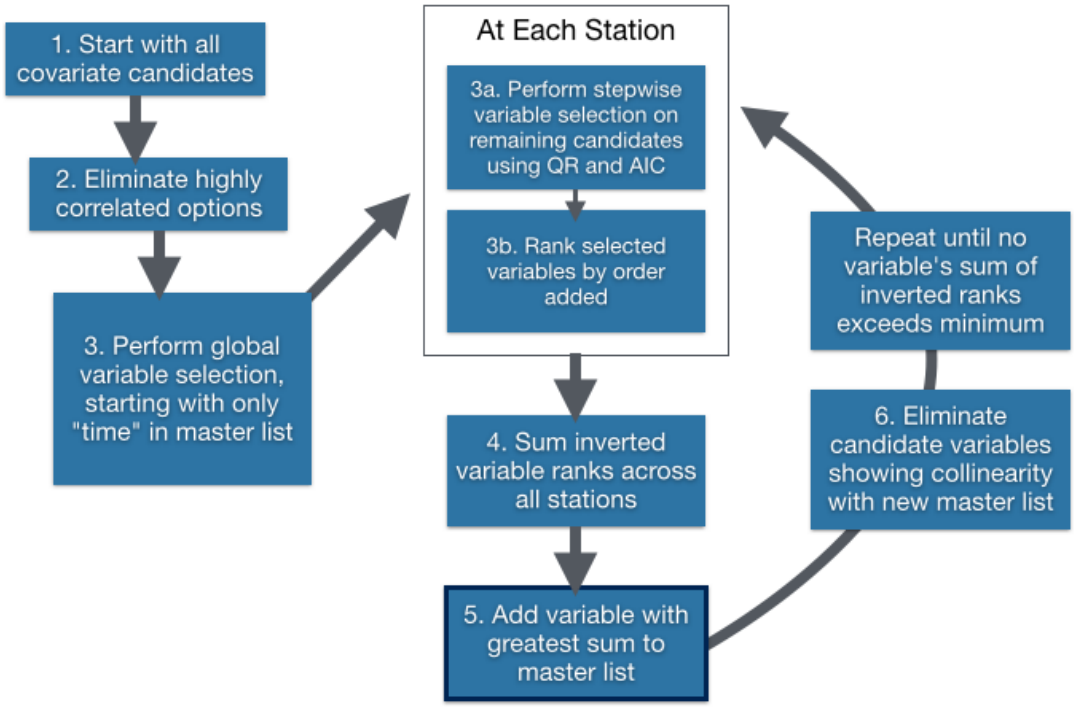
   These are excellent questions, and we hope to address these (and others like them) in future work.

6. P14087 L10: This may be a jargon question, but is Turbulent Kinetic Energy the same as Eddy Kinetic Energy as discussed in Coumou et al, 2015, Science, The weakening summer circulation in the Northern Hemisphere mid-latitudes?

   Yes, these two terms appear to be synonymous.

7. Section 2.4: Could this section be rewritten with a bit more clarity? Is the method sensitive to the order of variable addition?

   We have supplemented this section with additional details, as well as a flowchart describing all steps of the selection process. All candidate variables are tested individually before each selection, so the order of evaluation does not play a role in the final results.



8. What does it mean that ‘rain’ is a top driver of PM? Is this, lack of rain?

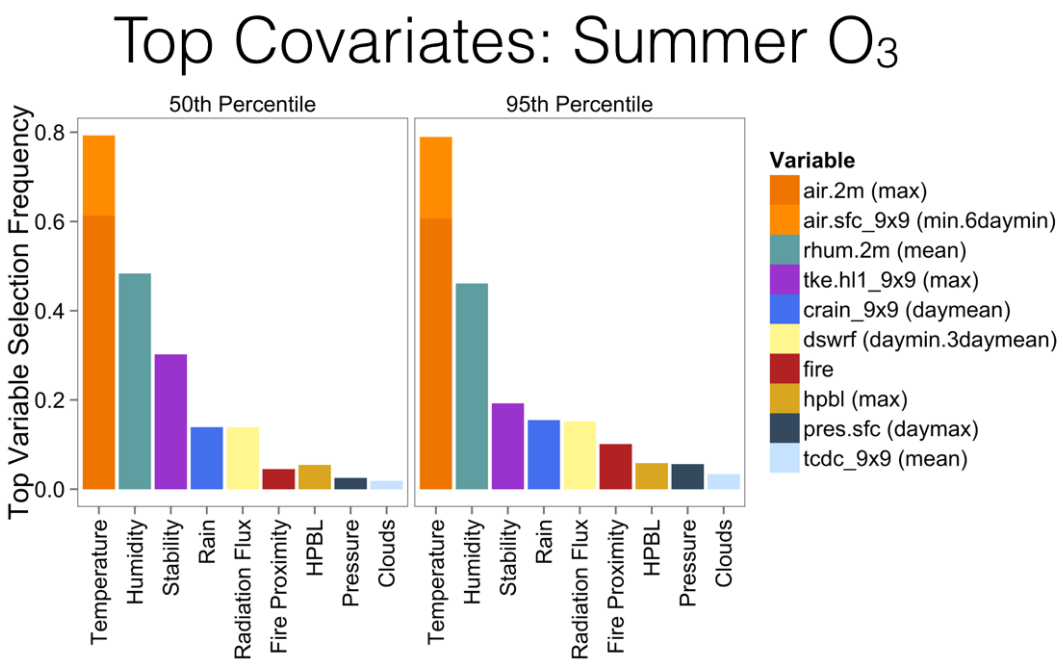
   Correct.

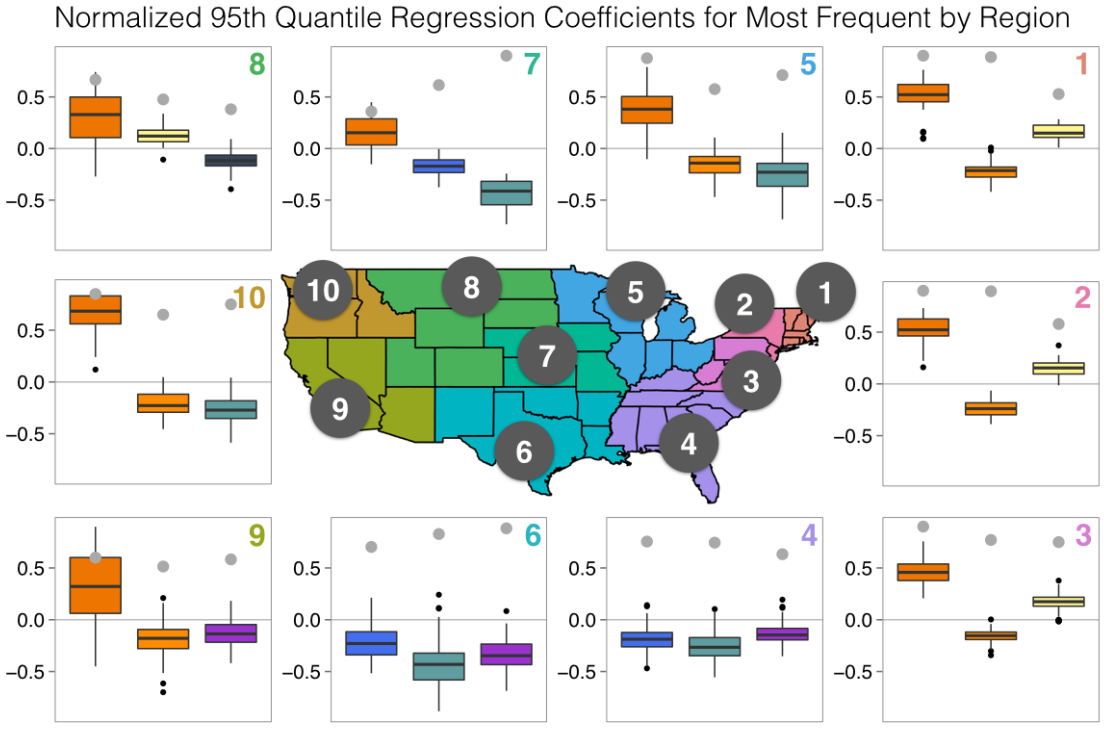
9. I’m a tad confused on all the various variables names, especially in Fig 3 & 5. On the right they are called one thing and on the x-axis they are generalized.

   Correct – we have added a note to the caption of these figures explaining the grouping that was performed.

10. Figure 3 & 5 could perhaps be broken up? Regional plots are miniscule.

The panels in these two figures were relocated and resized to aid legibility. We hope that these changes – along with the move to the larger ACP format – will be sufficient to make them effective, and will continue to monitor the figures as the proofing process continues.



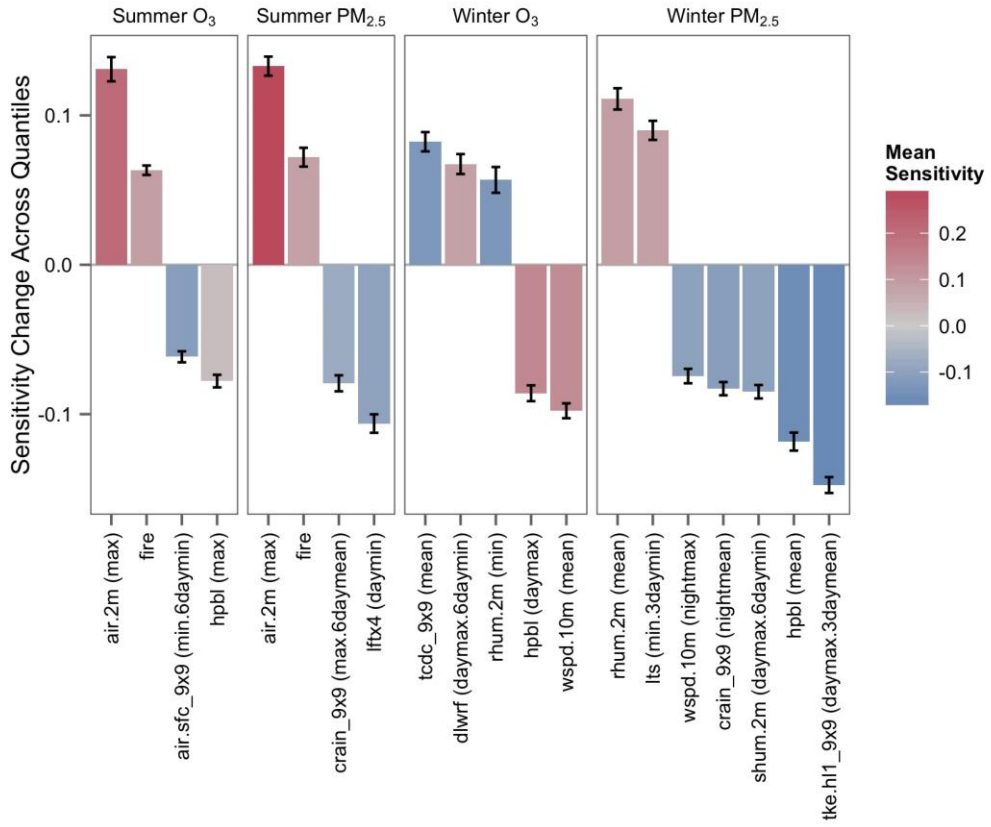


11. Figure 7 is interesting...but I'd imagine averaging things over several stations removes some valuable information...and makes the differences rather insignificant? Perhaps doing this for two particular locales would give a better demonstration of the point?

    (Copied from response to Reviewer 1, question 17.)

    The y-axis of this figure (now Figure 8) was mislabeled as a percentage, rather than a simple decimal value. Under the correct labeling, it should be clear that many of these coefficient ranges across quantiles are in fact on the same order of magnitude as the averages themselves, leading to drastically different sensitivities between the lowest and highest response percentiles. We hope that the relabeled y-axis (along with additional explanation in text) helps to indicate the importance of these differences:

    "Quantifying the extent to which these differences in quantile sensitivities might impact the response distributions themselves is beyond the scope of this work, but the magnitudes of sensitivity differences relative to the mean sensitivities themselves suggest large differences between mean and extreme behavior. For example, the sensitivity change of summer O_3 to maximum air temperature is shown to be roughly equivalent to the mean sensitivity itself. Thus, a location showing a mean increase of 1 ppb O_3 per ºC could be expected to exhibit an increase of only 0.5 ppb O_3 per ºC at the 5th percentile, but a much larger increase of 1.5 ppb O_3 per ºC at the 95th percentile. This could clearly have important consequences for the resulting O_3 distribution, given increasing temperatures."



12. In general, I’d suggest a bit more attention to detail in the figures and figure captions. Axes labels, etc. would be great.

    Thank you for this suggestion, we have added descriptive text and expanded a number of figure captions for clarity.