

Dear editor and anonymous referee #2,

We appreciate the careful review and comments by referee #2. Overall referee #2 gave positive comments and he/she thinks that this paper answers several important policy-relevant science questions and presents interesting results through comprehensive analysis. The main suggestion is to clarify “how the breadth of data, models, simulations, and analysis methods unite to create a single study”, and “how do the results from different sections relate to each other?” This is an insightful comment and in the revision we will carefully work to clarify and unify the connections between the different parts of the paper. Below we discuss in more detail our thinking related to the importance and organization of this paper.

The focus of this paper is to demonstrate the impact of transported background pollutants on surface air quality over the western United States during the studied summertime period. Transported background pollutants reflect the strength of impacts from long-range transport of pollution. Hemispheric transport of pollution has been an active area of study for some time, but not until recently has the summertime period been paid more attention, and most of the existing modeling-based studies that discuss summertime periods have used global models. As the US air quality standards are expected to be tightened and as the international pollution levels may increase, accurately monitoring the plume transport and quantifying extra-regional contribution, understanding the processes of airmasses descending and entraining into the boundary layer, as well as improving the model predictability become more important. These issues have been brought up by the HTAP (Hemispheric Transport of Air Pollution) science community as topics of focus in the 2011-2015 working plan.

Our paper addresses several of these points through the analysis of a specific period where several types of observations were available. The paper starts with the results from the coarse resolution model simulations (60 km/18 layer). These results are used to answer questions such as: 1) identify the US regions that are most strongly impacted by extra-regional pollution; 2) identify the most important species in the trans-boundary plumes; 3) assess the overall non-linear surface O_3 response function to perturbations in trans-boundary plumes over different land types/geographical regions; and 4) estimate the impacts of US anthropogenic emissions on the surface O_3 sensitivity to trans-boundary pollutants. It is found that O_3 is the most important transported background species to impact the western US, therefore we choose to focus on this species in the following sections. Then, by comparing the surface O_3 sensitivity to boundary conditions in different model resolutions, at the end of Section 3.1, we demonstrate that to accurately estimate the extra-regional contributions a higher-resolution model grid is recommended.

The higher resolution analysis is discussed in detail in Section 3.2 where the “Impacting Probability” metric and adjoint sensitivity were calculated. In this section we also compare the adjoint sensitivities calculated on two grid resolutions, and show that the finer resolution model grid better represents the processes that link the imported airmasses to the surface, which further supports the findings in Section 3.1.

The final section (3.3) introduces a case study of a long-range transport event. The analysis in this section builds upon the techniques and findings in the previous two sections, and it provides a concrete example of how eastern Pacific airmasses move inland. We introduce various observations available to document this event and then explore the extent to which these observations can reduce the uncertainty in the model predictions. Assimilation of surface observations not only improved predicted surface O_3 , but also changed O_3 distribution vertically—this further demonstrates that O_3 vertical information is important to better understand the downwind surface O_3 distributions. However, we pointed out that the current observing system provides limited vertical information and this is a point to consider in future observing system designs.

We feel that this study shows that transported background/extraregional pollution impacts surface O_3 concentrations in summertime and that higher resolution analysis is needed to quantify the impacts in future. It also provides suggestions for future modeling studies and observation needs to better quantify extraregional contribution and improve model predictability.

We will make sure to emphasize the main focus of this paper and the relationship between the three result sections in the revised version, especially in the abstract, introduction and conclusions. We feel that the findings in each section supports each other, and breaking the current form into 2-3 separate papers would weaken each part. Therefore, we would prefer them to stay in a single paper.

We look forward to receiving the comments from reviewer #1 and revising the paper.

Min Huang

On behalf of authors