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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Impacts of transported background ozone on California air quality during the ARCTAS-CARB period – a multi-scale modeling study" *by* M. Huang et al.

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First of all we thank the reviewer for the constructive comments. We have addressed all of the comments in the revised paper.

This paper describes a model analysis of the influence of ozone-rich air from over the Pacific on surface ozone in California during the period of a measurement campaign in June 2008. It focuses on the transport of ozone from coastal to inland areas and quantifies the sensitivity of this transport to the choice of boundary conditions, comparing with ozonesonde profiles and surface observations at four locations. The focus on summertime conditions is particularly welcome, as the most intense ozone episodes

from local emissions occur during this season, and previous studies have generally focused on periods of rapid transport during spring. The performance of the model is quantified, and the use of above-surface measurements to constrain the vertical profile of ozone over the Pacific and its variability is shown to improve representation of the inflow to ozone over the west coast.

Although the paper is interesting and the concluding recommendations are useful, it provides only limited new insight into the problem. The study confirms the earlier observation-based analysis of Parrish et al., 2009, but misses an opportunity to extend this to wider temporal or spatial scales. The model applied here should be able to provide a monthly or seasonal picture of ozone contributions beyond the very short measurement period considered here, quantifying the variability in these influences, and relating them to meteorological conditions in summer. While the focus on the measurement period will be of great interest to those involved in the campaign, the study would be of value to a much larger audience if it provided a wider seasonal context, allowing a more robust estimate of surface contributions and their variability. This would make the results relevant to larger-scale issues, such as how surface ozone over the West Coast might be expected to change in future. I would recommend that the authors consider making an additional model run that would allow them to extend the results of their study to monthly or seasonal scales.

» We agree that it is important to place our analysis in a larger context. We have addressed this in several ways in the revision. We emphasize that Parrish's paper shows multi-year results based on observations and has already proved that the summertime transport events are not occasional and the correlations during summer are stronger than springtime. We also extended our analysis of model sensitivity and correlations over a longer period from June 18-June 28.

A major focus of our paper is to see if these correlations are found in air quality models, and then use the model to provide a better understanding of the transport using modeling as a complement of the measurement study.

The measurements are shown to provide better boundary conditions than the RAQMS model, a not unexpected result. Can a suitable method be derived (based on meteorological variables or some assessment of other RAQMS variables) that would allow improvement of model performance when measurements were not available? This would also add significant value to the study.

» This is a very important point. In this paper we demonstrate that the additional observations can improve predictions. Not surprising, but it is necessary to show it. We added discussion regarding this and offered ideas on what is needed to be able to achieve better LBC. Clearly aircraft observations are not available routinely so they cannot by themselves be used. Ultimately, future measurement should be more frequent temporally and represent spatial (3-D) variability.

We show that the constant value over the Pacific is not recommended in section 3.3. To prepare better LBC:

1. Downscaling from global models: 1) Applying data assimilation to global model using appropriate satellite data 2) Using multi-year/seasonal/monthly averaged global model LBCs can possibly reduce the errors, because the episodic errors can be removed for both O3 and its precursors.

2. Nesting is also recommended to reduce the uncertainties over the inner domain. For example, in this case, the LBC in 12 km base case was downscaled from 60 km base case and has lower discrepancies than RAQMS.

In addition as you suggested, we must continue to develop our global and regional to reduce errors and biases.

Specific comments p.12085, l.12: Please explain "highest O3 design value"

» In Parrish's most recent paper that has been cited, it is defined as "3-year average of the fourth highest daily maximum 8-h average O3 mixing ratio".

p.12086, l.10: Some details of the tagged tracer scheme are needed here. Are the

tracers used real or artificial? How are they removed, and what decay rates are applied? CO has a large secondary source, is this accounted for? How appropriate is this scheme for estimating Asian impacts, given that the contributions identified here are large?

» Further details have been added to the paper, including additional references. The CO tracers are primary/inert tracers. The more detailed description of tracer for gas-phase species can be found in Tang et al (2004)'s paper: Tang, Y., et al. (2004), Multiscale simulations of tropospheric chemistry in the eastern Pacific and on the U.S. West Coast during spring 2002, J. Geophys. Res., 109, D23S11, doi: 10.1029/2004JD004513

p.12088, top: Why were different emission datasets used at the different model resolutions? How much do they differ?

» The emission section has been revised to more clearly describe the emissions used. Basically the 60 km case used the ARCTAS - specific inventory which covered the northern hemisphere. For the US it was based on the NEI 2001 inventory. All the ARCTAS modeling teams used this same inventory. These inventories were used in forecast and post analysis. For the 12 km post-mission simulations that we present in the paper, we used an update inventory prepared by CARB.

p.12088, l.26. State the time resolution of the LBC data applied here (6 hours?)

» Done. Also shown in Table 1.

p.12089, l.5. Please explain "Step and Stare".

» Special observations can only be scheduled during the 9 or 10 orbit gaps in the Global Surveys, and are conducted in any of three basic modes: Step--Stare is one of them, meaning: Point at nadir for 4 seconds (5.2 seconds with necessary reset). During that time, Aura moves 39 km in its orbit, and its nadir point on Earth's surface moves 35 km. Point at nadir again. Repeat indefinitely. Source:

http://tes.jpl.nasa.gov/instrument/specialobservations/

p.12090, l.8. The use of "complicated" is not informative here - more variable? In space or time?

» We changed the words with “better captured aspects of the wind fields (spatially and temporally) over California”. The spatial and temporal variations can be also reflected in Figure 3.

p.12090, l.15. How typical are the meteorological conditions described here? Providing a longer-term context here would make the results much more useful.

» The high pressure system is typical over the eastern Pacific. The high pressure off the coast California intensifies and extends northward during summertime relative to winter time and spring time, due to the position of the sun- the sun is over the Tropic of Cancer around June 22. (according to the NCEP/NCAR reanalysis project based on 1959-1997 climatology)

These result in hot and dry conditions in California during summertime.

In contrast to the eastern Pacific, the Siberian high pressure over Asia during winter disappears during summer and the pressure stays low over Asia.

Summer cyclones are usually weaker.

p.12091, l.27: These fire events are not introduced earlier. Where did they occur and how large were they?

» Summertime fire events are normal over both northern and southern California. The hundred of fires starting on June 21, 2008 over northern California were ignited by lightening, and lasted for several days under the warm and dry conditions influenced by the Pacific high system. (Northern California fire behavior assessment, 2008). The locations included Sacramento valley, northwestern mountains, as shown in figures 1. The impacts of fire on predicted O3 are further discussed in section 3.3.

p.12093, l.25: The equation here is the standard definition of a mean, and is not needed.

» We have removed it.

p.12097, Section 3.3 How do the results here compare with the (numerous) other studies that have evaluated the impact of boundary conditions?

» We have revised this section to better point out our motivation. There have been many studies looking at boundary conditions, and we have published one of the first that point out the value of using global models. Most previous studies did not address the issue of how the biases in the global model influence the regional model results, or how reductions in that bias lead to better predictions.

p.12101, The use of "SI" in equations 3 and 4 is confusing - it is described in Eqn.2 as a percentage. Eqn. 3 and 4 should be reformulated to clarify them.

» We have clarified this in the text.

p.12107, l.6: reference should cite NASA as a source here

» Done.

p.12107, l.7: Parrish references not adequately differentiated.

» Done. We re-cited Parrish’s most recent paper in ACPD published on June 30, as a replacement of his presentation in summer, 2009.

p.12107, l.20: NCEP (or NOAA) should be cited for authorship here.

» Done.

Figures This paper has a lot of figures, and I would encourage the authors to reduce the number for clarity. In some cases it would be clearer to show changes at selected locations rather than all of them (Figs 6-8). Specific recommendations follow.

» We have eliminated one figure and modified several others. Figure 6-8 and 17 are the only figures showing four selected sites together in this paper. These figures show the similarities and differences of the situations between these sites. The sensitivity studies (section 3.3) focus on one of these sites TB.

Several figures show both observations and model results (Figs 9, 13-15, 18) but the color schemes for these figures are different. The figures would be easier to interpret if consistent colors were used, e.g., observations blue (or black?) and model results red.

» Good suggestion. Now we keep the observations blue, the 60 km base prediction in purple, and the 12 km base case in red. Sensitivity case results are in other colors and line styles.

Fig 1: It is not clear if the regions marked represent the model domains, if so, please state this in the caption. The flight track in panel 3 would be clearer in white.

»Panel (a) and (c) show the entire tracer and 12 km domains, respectively. The panel (b) only shows the North America part (and the higher latitudes areas were chopped out). We modified the caption.

Fig 2: panel (b) should be reoriented (centered on the date-line?) or a more suitable projection used. It would be helpful to include the flight track in panel c and/or d.

» The panel (b) has been rotated into a lat-lon projection and more colors have been used. We added flight path in panel (c) and (d).

Fig 3: This is not easy to interpret without additional meteorological information (e.g., mean sea level pressure?).

» We feel the flow fields do add value and can help in the discussions of the O3 spatial distributions as well as the trajectories.

Fig 5: Note in the caption that these are observations.

» Done.

Fig 6: Elevation labels would be clearer if moved into the figure caption.

» Done.

Figs 16, 17: These figures would be easier to interpret if they used a two-color scale (e.g., red-blue) with values around zero in white. The rainbow color scheme masks regions of agreement (close to zero) and is used differently for O3 and CO. The captions for these figures would be clearer if they stated what the figures show, e.g., the difference in O3 and CO if using observation-based boundary conditions rather than the default RAQMS LBC (i.e., Base case - Obs case)

» Done. The figures are re-plotted using red-blue color scale with values around zero in white. Titles for individual figures have been removed and the figure captions have been modified.

Minor issues There are minor grammatical inconsistencies in a number of places, e.g., in point 2 of the conclusions.

The abbreviation “a.g.l.” needs to be spelled out somewhere.

» It is now spelled out when we introduce Figure 3.

p.12081, l.9 "Oceanic O3 profiles" → “O3 profiles over the ocean”

» Done.

p.12104, l.5: remove “are needed”

» Done.

Interactive comment on Atmos. Chem. Phys. Discuss., 10, 12079, 2010.

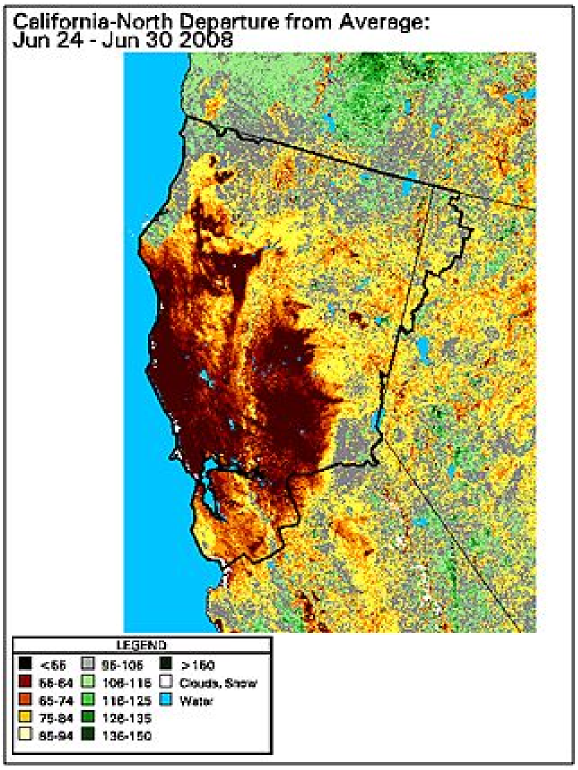
California-North Departure from Average:
Jun 24 - Jun 30 2008
LEGEND
<55
55-64
65-74
75-84
85-94
95-105
106-115
116-125
126-135
136-150
>150
Clouds, Snow
Water

Fig. 1.