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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 the transport of ozone from Asia to California during the ARCTAS-CARB experiment in June 2008. The authors compared in situ measurements from surface stations in California and NASA-DC8 with the STEM model output at different resolutions. They confirmed that Asian inflow can increase surface ozone in California. They also showed that using different model lateral boundary condition of ozone tends to modify ozone concentration in the boundary layer of STEM. Those results are

interesting and make this paper useful. I recommend this paper for publication after addressing the following comments.

Specific comments:

The ozone concentration and trajectory studies (section 3.1, 3.2 and 3.3) are based on the 12km run because transport processes and ozone concentration are better represented in the 12km run than the 60km run (first paragraph section 3.1). Surprisingly, section 3.3 that treats the lateral boundary conditions (LBC) sensitivity uses exclusively the 60km run to show differences in ozone over California using different LBC. The authors introduce this section by saying page 12097 line 8 "To demonstrate the impact of the western LBC on surface ozone predictions over California, a series of LBC sensitivity simulations were performed in the 60km model grid". In my opinion, you cannot say that. You demonstrate that the 60km run has a strong sensitivity to LBC conditions, but to demonstrate the sensitivity of ozone prediction at the surface by the STEM model, I think the results should be based on the 12km run as the 12km run is the one that you would use in case of ozone prediction with STEM.

»The paper's presentation and discussion of the LBC sensitivity studies have been revised to better state the purpose of the analysis. The modeling system used in air quality studies is typically based on nested grids. The outer grid is the grid that takes the boundary conditions from the global model and the inner grid (say the 12 km grid) get it's info from the outer grid. We wanted to focus on how information in the LBC in the outer grid influences the performance of the outer grid (which of course then influences the performance of the inner grids. These tests were done using the 60 km grid as this resolution is representative of that used in higher resolution global CTMs and that used in the outer grid in nested air quality models.

In section 3.4, the model performance is analyzed using a base case and an observation case for LBC. Figures 16 and 17 show that the model at 60km and 12km doesn't have the same response at the surface due to a change in LBC. If you are right by saying that it's because of the mesoscale flows in central valley, does that mean the results in the 60km and 12km run are similar at say 3km in altitude? If this is the case, it doesn't explain why the ozone background at TB is so well represented by the 12km run (Fig9b). I think that the reduction of ozone at the surface of the 60km run due to changes in LBC improves the surface ozone prediction but for the wrong reasons.

»Figure 15 and 16 show the changes of O3 predictions in Obs cases relative to the base cases, therefore, the changes are dependent on how the base cases performance, as well as the met fields.

Ideally (given accurate meteorological fields), we should be able to see changes in both southern and northern California. The winds carried pollutants from coastal to inland northern California, and the instate transport and processes brought them to the south. However, the winds in 60 km are too coarse so the changes in southern California were not shown.

The 12 km generates better results than the 60 km in the base cases due to various reasons, such as the impacts of resolution and better LBC. Therefore, the changes over northern California are less significant relative to 60 km. The changes over southern California in 12 km is larger due to the better meteorological fields, which captured the instate processes from northern to southern California.

Speaking about "surface ozone prediction", it would be interesting to know by how much is the ozone prediction improved (or different) by changing the resolution from 60km to 12km. Figures 18 and tables 3a 3b only "quantify" the significant improvements at different surface stations (3 stations for the 60km run, 1 station for the 12km run). It can potentially confuse the reader. You should show the results of the base case and observation case of the 12km and 60km run for the 4 stations on figure 18. At least we will see how different are the 60km and 12km runs.

»The context here is not inter-comparison between 12 km and 60 km cases, but the inner-comparisons between base case and obs cases for both 12 km and 60 km res-

olutions. Therefore, we did not show the 12 km and 60 km results together to make the figures busy. However, we modified the figures as suggested. These results show clearly that the 12 km simulations are better in terms of capturing peaks.

Furthermore, the improvement of ozone at the JOT station in the 12km run is so small that it's hard to say it's significant. The surface ozone prediction improvement in the 12km run is not very convincing. I would think that more work is needed on other parameters (surface emission inventories, vertical transport, sea breeze, etc...) to improve surface ozone prediction in the model before modifying the LBC. Results along the DC8 flight (figure 19 and section 3.4.3) are more convincing though. Maybe the reason is that the ozone prediction along the DC8 flight is less dependent on the accuracy of surface ozone precursor emission inventories and mesoscale transport at the surface. It would be interesting to add some comments in the text about that.

»Certainly there are many aspects of O3 models that need improvement in addition to the LBC. The direct use of observational based LBC did show positive results, but at the observation site the changes were small. However from Fig 16 changes at some locations were as high as 10 ppb. Furthermore, the changes at JOT (Figure 17) are absolute and the changes along flight path (Figure 18) are relative, with the latter comparison including two days (but in afternoons only) and having a wider spatial coverage.

My second point is that it is hard to speculate on any future improvement of the model from a 2-day Asian inflow event using your methodology. I agree that the ozone predictions in the boundary layer are improved by using the observation of the DC8 rather than the LBC from RAQMS. Is that always the case anyway? I assume that there are cases when the latitudinal variability of ozone is larger due to differences in long range transport from Asia (passage of a cold front for instance). What would have been the consequence of using in situ measurements made in a region of 5 degrees in latitude as a LBC in such a case? You should be more cautious in your comments and conclusions about improving the surface ozone prediction with localized in-situ observations instead of RAQMS LBC. With an analysis based on a 2-day event, you cannot say page 12104 line 2 "Accurate real-time LBC for long-live species together with high quality meteorology fields improve model predictions at areas where the background pollutants are transported aloft as well as their downwind regions". This conclusion is definitively overstated.

»We have revised the paper to more clearly state our findings and how they can be used moving forward. Right now the most robust way to improve model prediction is to take BCs from global models. We also show that further improvements will require reducing the uncertainty in the global models. One way to do that is to assimilate additional observation data. We show that such information obtained in this experiment can be valuable.

Technical comments: figure 14a: You should plot red dots and not lines between the data points from the DC8.

»Done.

page 12084 line 11: "high resolution meteorology fields". High resolution is somewhat arbitrary. Better say "12km resolution" instead of "high".

»We have revised the text as suggested.

WCB: put in the text that WCB stands for western clean boundary.

»WBC stands for western boundary conditions. Table 2 provides details for all BC sensitivity cases. We also introduced in the text that “Clean WBC” is short for “clean western boundary conditions”.
