Response to Reviewer 1:

Reviewer: Exhaustive examination of regional aerosol variability during the 2010 CalNex and CARES campaigns using WRF-Chem.

Response: We thank the reviewer for taking the time to read our long paper and giving us valuable comments, including many typos we missed in the original submission. We have revised the paper by taking into account the reviewer's suggestions and provide responses to the individual comments below.

Reviewer: Suggest shortening abstract by at least 33%. I would also mention the overarching goals of CalNex/CARES within the abstract.

Response: The overall goals of the campaign are now included and the abstract has been shortened.

Reviewer: End sections 4.1, 4.2, 4.3, 4.4, and 4.5 with summaries of how well the model simulated the respective quantities: meteorological quantities (4.1), trace gases (4.2), etc.

Response: We have added short summaries to sections 4.2 - 4.4. Section 4.5 is shorter and therefore we thought that a summary was not needed. Section 4.1 has been moved to the supplemental information to shorten the paper, but a short summary is still included in the main paper.

Reviewer: How much of the high-bias in emissions is due to emission reductions between 2008 and 2010 and how much is due to a high-bias in the CARB2008 emission inventory?

Response: The reported trends in emissions during the decade would suggest a relatively modest reduction in emissions between those two years, which is smaller than the 50% reduction used in the 50%_ANT simulation. That suggests there are likely biases in the emission inventory itself, but we cannot quantify that without performing simulations for 2008. There would only be surface air quality data available for that period which not as comprehensive as the CARES/CalNex measurements.

Reviewer: Specific Comments: P7199L27: Needs a more specific web site

Response: There is a more direct link now available that will still be valid by the time of the publication, but it could be moved in the future so it is better to contact the first author directly for the datasets. Therefore, the link has been replaced and moved to the appendix along with some additional contact information.

Reviewer: P7200L12: Why did Shrivastava et al. adjust primary organic aerosol emissions by a factor of two?

Response: This was done to obtain a better agreement between simulated POA and HOA (a surrogate for POA) obtained from PMF analysis of AMS measurements. The text has been modified to clarify this point.

Reviewer: p7202L19: With respect to the "considerable differences" found by Knote et al., is there anything readers of this paper should know?

Response: As shown in Figure 2 of Knote et al. (2014), the differences vary from specie to specie. The results are presented as a histogram and the exact VOC scaling factors were not given in a table or in the text. For propene and ethane, emissions were increased by a factor of ~3. For lumped alkenes, emissions were adjusted downward by a factor of ~8. Other species are somewhere in-between. We have modified the text to better clarify the range of values used in that study.

Reviewer: p7205L30: What do you mean by smaller "wind speed statistics"? Please re-write.

Response: This was a poorly worded sentence and has been changed.

Reviewer: p7209L25: How much of models low bias for MVK+MACR is explained by these interferences?

Response: It is not possible to speculate. Liu et al. (2013) did not provide a quantitative estimate on the magnitude of the interference.

Reviewer: p7224L16: impact of the marine intrusions –> After reading the following paragraph it wasn't clear to me what you meant by this statement. You focus on a refinery source as opposed to a marine source.

Response: The marine intrusions are responsible for transporting the emissions from the refinery source inland to Sacramento. The text has been revised to clarify.

Reviewer: p7240L9: Reducing anthropogenic emissions by 50% decreased isoprene and terpene concentrations by what percent?

Response: Not sure what the author is referring to in this line. In line 7 we state that changing anthropogenic emissions also affected isoprene and terpene concentrations, even though the biogenic emissions remained the same. The text has been altered somewhat to be more specific.

Reviewer: p7241L8: You state the MOZART boundary conditions are likely too high. Any thoughts as to why?

Response: There could be a number of reasons, including emissions in Asia that are too high, the lifetime of aerosols that are too long (either from how chemical aging is handled/or and rate of aerosol wet removal processes), or how MOZART treats dust. Dust in this version of MOZART is based on climatological values, which may or may not be applicable to the meteorological conditions during May and June of 2011. While it is beyond this study to evaluate MOZART, a sentence has been added at the end of Section 5 regarding the potential uncertainties associated with global model predictions.

Technical Corrections

Reviewer: p7189L10: evaluate the one configuration –> evaluate one configuration

Response: Done.

Reviewer: p7189L12: sensitivity of regional variations in aerosol –> sensitivity of aerosol

Response: Done.

Reviewer: p7189L18: contribute to errors (in what?)

Response: Added "to simulated trace gases and aerosol."

Reviewer: p7189L26: some aerosol species (which?)

Response: The species were sulfate and nitrate mentioned in the second half of the sentence. To avoid confusion, the first phrase of the sentence has been deleted.

Reviewer: p7199L19: are also been included –> are also included

Response: Done.

Reviewer: p7200L18: model domain that encompasses –> model domain encompasses

Response: Done.

Reviewer: p7200L19: grid spacing of 4 km is identical –> grid space of 4 km. It is identical

Response: Divided the sentence into 2 sentences, but somewhat different than suggested.

Reviewer: p7202L9: consistent with trend –> consistent with the observed decrease

Response: Done.

Reviewer: p7202L10: that has decreased the –> over the

Response: Done.

Reviewer: p7203L14: optical properties variables from –> optical properties from

Response: Done.

Reviewer: p7205L10: observed, but the largest biases are for–> observed with the largest biases for

Response: Done.

Reviewer: p7209L24: PTR-MS as the –> PTR-MS at the

Response: Done.

Reviewer: P7209L25: may be expected to be larger that simulated –> are likely to be biased high

Response: Done.

Reviewer: p7211L2: Statistics that describing –> Statistics describing

Response: Done.

Reviewer: p7214L18: detection range 80 –> detection range of 80

Response: Done.

Reviewer: p7215L11: are higher than the observations at times –> are occasionally higher than the observations at SPECIFY LOCATION(S)

Response: Done.

Reviewer: p7226: likely to low –> likely too low

Response: Done.

Reviewer: p7232L25: contribute to a significant –> contribute a significant

Response: Done.

Reviewer: p7237L8: may be due missing important –> may be due to missing important

Response: Done.

Comments on Tables and Figures

Reviewer: Table 4: How is index of agreement defined?

Response: Added a sentence at the beginning of Section 4 citing the Index of Agreement.

Reviewer: Table 6: What are range gates?

Response: The radar wind profiler measurements are not made at a point, but are average values over a vertical layer in the atmosphere. Ranges gate is the term used to describe the vertical layer

in the atmosphere that the measurements occur, analogous to vertical grid spacing in a model. The Table caption has been modified to clarify this point.

Reviewer: Table 4 etc. The RMSE contains a contribution from the bias. Consider replacing the RMSE with the centered root mean square error (i.e., the RMSE after removing the mean)

Response: This is a good suggestion, but we have decided to leave RMSE since it has been used in past studies in case readers want to compare these statistics with other studies.

Reviewer: Figure 1a: R/v Atlantis line does not show up well -

Response: A darker blue is now used.

Reviewer: Figure 1c: Acronym key would be useful

Response: Added to the figure caption.

Reviewer: Figure 3 caption should mention LA basin

Response: Done.

Response to Reviewer 2:

Reviewer: The manuscript examines the spatial and temporal variability in aerosol concentrations, composition, and size distribution simulated with a version of the WRF-Chem model. The model predictions are evaluated in great detail with measurements from the two field experiments (CalNex and CARES) during May and June of 2010. It presents an extensive review of meteorology, trace gases and aerosol distributions in the California region using both observations and regional model. The manuscript is suitable for publishing in the ACP but could be improved by largely reducing its length and being more focused on its center objectives. Currently, it is titled as modeling regional aerosol variability, although not until half way through the main text, there are discussions on aerosol properties. Analyses of meteorological conditions and gaseous precursors are important, however, it is more appropriate to include them for explaining the biases in aerosol simulations, than giving a full and detail evaluation upfront. The second- half discussions on aerosol extinction profile and AOD seem to be detached from the extensive comparison of surface meteorology and trace gases in the first half; because as pointed by the authors, the latter in this region/time is dominated by the uncertainty in the long-range transport (boundary conditions) of aerosols.

Response: We thank the reviewer for taking the time to read our long paper and giving us valuable comments regarding the organization and objectives. We have revised the paper by taking into account the reviewer's suggestions and provide responses to the individual comments below. The other reviewer suggested we add summaries at the end of each results sub-section and that has added to the length of the paper. To shorten the paper, we moved Section 2.2 and Figure 2 to the supplemental information. We also moved Figures 3 and 4 and much of the discussion in Section 4.1 on the meteorological evaluation to the supplemental information. In this way, the aerosol evaluation appears earlier in the text, but the trace gas evaluation is also needed to explain some of the biases in the aerosol predictions. The title of the paper has been changed somewhat to reflect precursors of aerosols that affect the simulated aerosol distributions.

The text on the aerosol extinction and AOD is presented last because those quantities are affected by the distributions of aerosol mass, composition, and size. The vertical profiles of extinction from the lidar provide the key piece of information needed to understand why simulated AOD was too high, when many aerosol species (e.g. OA, sulfate in southern CA) were too low compared with aircraft and surface measurements. In the revised text we have added some additional discussion to tie Section 5 back to Section 4.

Several specific comments are suggested below:

Reviewer: 1. Introduction (Page 7194, lines 24-): the first objective of this study is said to describe how the multi-platform observational data sets have been integrated into the Aerosol Model Testbed (AMT). This may be more appropriately included as part of the methodology rather than a science objective: except for 2.2, most of the discussions are about the evaluation of the WRF-Chem simulations and uncertainties. Also, will this AMT testbed case and toolkit mentioned become available at the time of publication? If so, the link to the ARM front page needs to be replaced with the correct webpage.

Response: The paragraph objectives have been changed as suggested. There is a more direct link now available that will still be valid by the time of the publication, but it could be moved in the future so it is better to contact the first author directly for the datasets. Therefore, the link has been replaced and moved to the supplemental information along with some additional contact information.

Reviewer: 2. Section 3: Model description: Consider to move the discussions in the first two paragraphs about the WRF-Chem set-ups and emissions (i.e., second paragraph on page 7202) to the Appendix.

Response: While we understand that moving the text to the Appendix would shorten the paper, we prefer to leave this material where it is. Based on past studies, we find that many readers want to have some details on how the model was configured. This is an issue of reproducibility of the model results. The paragraph associated with the emission uncertainties provides motivation for the simulations chosen in this study. Readers may not see these important points in an appendix.

Reviewer: 3. Section 4: please refer to the main comment above.

Response: See response to the main comments.

Reviewer: 4. Section 5: what's the difference between AOT and AOD here? Usually they are inter-exchangeable in the modeling world. How important is the relative humidity bias in the model and aerosol water take contributing to the AOD differences in the column? What is the main aerosol type being reduced in the 50%_LBC case? If initial conditions are reduced by half too, does it mean this sensitivity study also include adjustment of local aerosol contributions?

Response: These are not interchangeable terms. AOD is the aerosol optical depth computed through the entire atmosphere column, whereas AOT is the aerosol optical thickness computed over a portion of the atmospheric column. The lidar only sees a portion of the troposphere (in this case within 9 km of the ground), so it is more appropriate to label the vertically integrated extinction as AOT. The lidar's AOT is not the same as a satellite or AERONET measurement of AOD. To avoid confusion, text at the beginning of Section 5 is included to clarify the differences.

Relative humidity (RH) is very important; however, RH over the inland aircraft flight paths was usually very low (< 55%) so that uptake of aerosol water would be much lower than other locations of the world. Still, it is likely to be one source of uncertainty contributing to the low bias in simulated extinction. This is an important point and we have added a few sentences to this section.

Dust and sulfate are the two primary aerosol species coming from the boundaries. Other species are much smaller. 50%_LBC simulation also includes the reduction in local anthropogenic emissions. As seen in Figs. 27 and 28, extinction is reduced in both the free troposphere and boundary layer. Most of this is due to dust and sulfate (to a lesser extent), so the changes in local BC and POA emissions contribute the most to changes in those concentrations (as shown in Fig. 12).

minor comments:

Reviewer: 1. Page 7237, line 8: should be "due to missing"

Response: Done.

Reviewer: 2. Figures 27 and 28: title of panel (a) is missing from the graph

Response: The captions for (a) were included in the files uploaded, but we failed to notice that in the galley-proofs they were cut off for some reason. We will check them in the final revision.