Response to Comments by Reviewer 2

General Comments

Comment: The manuscript is a very detailed investigation of dry deposition within the CMAQ model, which places the runs for the AQMEII4 exercise in context with other configurations and inputs that have been used recently or are more typically used for CMAQ. The sensitivity studies provide a great deal of new or updated information about the impact on air quality concentrations and fluxes of land use definitions and treatment, the underlying details of the resistance parametrization, and inputs such as meteorology and boundary conditions. The results will be primarily of interest to atmospheric modelers, but also are a significant contribution to the larger project that is of broad interest to the air quality and deposition impacts communities. Given the length and level of granularity, the paper needs to be carefully organized, and the authors have done a good job of this. I recommend publication with very minor revisions.

Response: We would like to thank the reviewer for the overall positive assessment of our manuscript and the careful review and helpful suggestions which have led to an improvement in some of the figures. Our responses to reviewer comments are shown below in italics while changes incorporated into the revised manuscript are shown in bold font.

Specific comments:

Comment: Section 2.2: the description of the set of model runs is missing the M3DRY_APPEL_EMIS_2016 one

Response: Thank you for catching this omission. The relevant sentence has been updated in the revised manuscript as follows:

"M3DRY_HCMAQ_2016 can be used to assess the impact of using chemical boundary conditions from CAMS compared to using boundary conditions from H-CMAQ as in Appel et al. (2021) **while M3DRY_APPEL_EMIS_2016 can be used to quantify the impacts of the different anthropogenic and wildland fire emissions used in this study vs. Appel et al. (2021).**"

Comment: Section 2.4: There's significant discussion in the paper about results in southern Canada; what was the reason for not using data from Canadian sites (or Mexican, if available)?

Response: Thank you for raising this point. In the revised manuscript, we have added observations of O_3, SO_2, NO_x, and $PM_{2.5}$ from the Canadian National Air Pollution Surveillance (NAPS) program to the tables in Section 3.1 and the model bias maps in the supplemental material. Evaluation results at NAPS monitors are generally comparable to those at the AQS monitors with the exception of SO_2 for which the simulations are biased low at AQS sites and high at NAPS sites. We do not have access to air quality observations at sites in Mexico.

Comment: Fig. 1: it's a bit difficult to see the observations distinctly. Can you make them dashed, or points, to bring that line out a bit better?

Response: Thank you for this suggestion. We have changed the line depicting observations from a solid to a dash pattern which indeed makes the observations easier to distinguish from the model results.

Furthermore, we have also removed the lines depicting the Appel et al. (2021) simulations from the figures shown in the main manuscript, and the new figures S2 and S3 in the supplement that include the Appel et al. (2021) simulations are for 2016 only. Both of these changes also helped to better distinguish observations from model simulations in these figures.

Comment: Fig. 6: maybe choose a more contrasting color for the WRF lines

Response: Thank you for this suggestion, we have changed the color of the WRF lines to orange in the revised manuscript.

Comment: Fig. 8: are these plots linear scale? I can't tell with only 2 values.

Response: Yes, the y-axis scale is linear. In the revised manuscript, we have updated this figure with additional y-axis tick labels to make this clear.

Comment: Fig. 9: I suggest you swap the M3DRY and STAGE order on the plots to better correspond with Fig. 7

Response: The M3Dry and STAGE order was actually specified consistently in the plotting code for both figures, but for horizontal bar plots such as the one in Figure 9, the plotting software arranges bars from bottom to top rather than using a top to bottom order that for many readers might be more consistent with the left-to-right ordering in Figure 7. For the revised manuscript, we have modified the plotting code to now use top to bottom ordering for Figure 9, and have also made the hatching angle and density consistent between both plots. In addition, we have also revised Figure 13 comparing the fractional land use coverage for M3DRY_2016 and M3DRY_NLCD40_2016 to use the same top-to-bottom ordering, now showing the M3DRY_2016 base case at the top of each pair of bars.

Comment: L. 695-6: I would include deciduous broadleaf in the list of LUCs where NLCD > MODIS flux, it's a significant difference (here and in the summary/abstract)

Response: Thank you for this good suggestion, deciduous broadleaf forest has been added to the list of landuse categories for which using NLCD40 results in a higher flux compared to using MODIS, both here and in the summary.

Comment: L. 732: pretty sure you mean NO2, not SO2, here

Response: No, we believe the statement is correct as written. Figure 7b shows that the M3Dry cuticular effective flux is larger than the STAGE cuticular effective for SO_2 while they are very similar for NO2. This statement in the summary is the same as on line 468 in Section 3.2.1 where Figure 7b is discussed.

Comment: Section 4: It would be helpful to provide some context as to how significant are these deposition velocity (or flux) differences between configurations compared to differences that are seen between CMAQ and other models with different schemes entirely. Presumably this will be discussed in the larger AQMEII4 exercise, but there are studies in the literature that could be cited to give the reader a sense of the relative magnitude.

Response: Thank you for this suggestion. We have added the following text passage to Section 4:

"Absolute differences in seasonal mean O3 Vd are on the order of 0.05 – 0.1 cm/s for many locations, While these differences tend to be smaller than the range of model differences reported in intercomparison studies performed at flux measurement sites (e.g. Wu et al., 2018 and Clifton et al., 2023) and for global models (Hardacre et al., 2015), their magnitude nevertheless represents a variation of about 10-30% of CMAQ simulated seasonal mean Vd with the highest relative differences generally occurring during winter."

"Initial analysis of results from all AQMEII4 grid model simulations show that the differences in simulated O3 Vd, deposition pathways, and deposition fluxes between the CMAQ M3Dry and STAGE simulations analyzed in this study tend to be smaller than the differences relative to other AQMEII4 grid models."

In addition, we also added the following discussion at the end of revised Section 3.1 to provide additional context:

"The results presented in the supplemental material show that the choice of the CMAQ dry deposition scheme (M3Dry vs. STAGE) has a smaller impact on aggregated model performance metrics than the sensitivity of CMAQ results to model input data sets and boundary conditions that represent the large-scale chemical environment. However, it is important to note that M3Dry and STAGE share many structural similarities (see Figures B2 and B3 in Galmarini et al., 2021) and that the similarity in model evaluation results therefore does not imply that uncertainties and potential errors in representing dry deposition are not a potentially important source of overall model error. An analysis of point model simulations at eight ozone flux measurement sites performed with all dry deposition schemes participating in AQMEII4 shows that differences in seasonal cycles of Vd and deposition pathways between M3Dry and STAGE are generally smaller than differences relative to other schemes. In addition, the following sections demonstrate that the choice of M3Dry vs. STAGE in CMAQ can have more pronounced impacts for specific seasons, regions, and deposition pathways than its impact on these domain-wide model performance results."

Comment: References: I expect you are aware that the Clifton "in prep" paper is now citable on ACPD

Response: Yes, this reference has been updated to refer to the ACPD manuscript.