

Minor revisions:

I would like to thank the authors for their detailed and thorough response to the two reviewer comments and the short comment by Dr. Frank Dentener and for revising the manuscript accordingly. Before accepting the manuscript for final publication, I would like to see the following minor issues addressed:

- 1) A discussion of the author's choice to use CBM-Z/MOSAIC which lacks a treatment of SOA should be included in section 2.1 "WRF-Chem Model". The authors do discuss the lack of SOA treatment - which was noted by both reviewers – in section 3.1 and in the summary, but it would be better to include this information up front.
- 2) Response to points (2) and (3) raised by reviewer #2: I have to admit that I was also initially confused by the description of these meteorological perturbation simulations and also thought that the authors were describing counteracting feedback effects. After rereading sections 3.3 – 3.5 a few more times, I realized that this potential misunderstanding is a wording issue that has not been resolved in the revised manuscript and needs to be addressed before final publication.

Take the following sentences from page 16: "..., we decrease temperature by 2C in the initial and boundary conditions to reflect conditions more like 1960. As a result, the monthly domain mean surface temperature increases 2C (CTL – CTL_T2), ...". At first glance, these two sentences seem to suggest that decreasing temperatures in the IC/BC led to increases in simulated temperature, and this is the impression reviewer #2 and I both got. Upon re-reading the section, I realize what is meant here – temperatures were decreased from the 2010 met conditions used in CTL to represent 1960 as a sensitivity case, and consequently there is a temperature increase between CTL_T2 (representing 1960 met conditions) and CTL (representing 2010 met conditions). One way to clarify this might be to change these two sentences as follows "..., in the CTL_T2 simulation we decrease temperature by 2C in the initial and boundary conditions to reflect conditions more like those that occurred in 1960 rather than the 2010 conditions used in CTL. As a result of these changes, the monthly domain mean surface temperature increases 2C between CTL_T2 and CTL, ...".

In a sense, the root cause of the confusion is that the authors treat 1960 as a reference point for their discussion of changes in emissions and meteorology, but the "CTL" experiment does not reflect that reference point but rather relies on 2010 meteorology. This potential for confusion runs throughout sections 3.3 – 3.5 whenever the authors discuss "perturbations" since this term actually seems to refer to the approximated 1960 – 2010 meteorological change rather than the actual perturbation simulation which was a reverse meteorological change meant to "revert" the 2010 meteorological conditions in CTL to 1960 conditions. Examples: page 16, lines 13-16, page 18, lines 8-11, page 19, lines 2-6. I suggest that the author consider using wording like "Due to the approximated change in temperature/Rh/winds between 1960 and 2010" rather than "Due to the perturbation" in these instances.

- 3) I assume that all emission and meteorological perturbations were only implemented in the innermost domain (except the boundary condition sensitivity simulation where emission were

perturbed in the outermost domain). If so, please clarify this in section 2.2. If not, please clarify how the analysis nudging applied in the outermost domain was applied for the meteorological perturbation cases.

- 4) Effect of chemical boundary conditions, page 11, lines 14 – 20. Please clarify that this test investigates changes due to boundary conditions only for the innermost domain, not the outermost domain. In other words, clarify that you are investigating the effects of regional emission changes in the 81 km domain on results in the 27 km domain and that your analysis does not account for the potential effects of changes in global atmospheric composition between 1960 and 2010 since the same 2010 MOZART simulation was used to derive boundary conditions for the outermost domain in all simulations. In addition, the boundary condition sensitivity simulation shown in Figure S2 should be added to Table 1.
- 5) Section 3.2.4. As noted by reviewer #2 and acknowledged by the authors in the new sentence added at the end of this section, a main reason for why the results of the SO₂, NH₃ and NO_x emission sensitivity cases do not add up to the full difference between the CTL and EMI2010 cases is the change of other emissions such as VOC in the latter. Therefore, it is somewhat misleading to label this section “coupled changes in SO₂, NH₃ and NO_x emissions” – a better choice might be “Comparison of individual changes in SO₂, NH₃ and NO_x emissions to simultaneous changes in all emissions” and to state up front that the latter case includes changes in emissions besides SO₂, NH₃ and NO_x.
- 6) As noted by reviewer #1, the PBL decreases associated with the 2C temperature increase are noteworthy. The authors responded that they agree with the reviewer’s suggestion and revised the manuscript to state that changes in vertical temperature profiles are causing the decrease in daytime PBL (“the monthly domain average daytime PBLHs decrease about 2.3% due to changes in temperature vertical profiles”). Please add more information on your analysis of how the vertical temperature profiles changed as a result of the uniform 2C increase in temperature initial and boundary conditions. Or do potential changes in wind speed induced by these temperature changes also play a role?
- 7) The sensitivity simulation with the ECLIPSE_GAINS_4a emissions dataset discussed on pages 21/22 should be added to Table 1.
- 8) Section 3.6. If the authors have any thoughts on whether direct or indirect aerosol radiative effects are more important in driving these changes in PBL heights, it would be good to include this discussion here. This might include comparing changes in clear-sky and all-sky radiation and clouds. However, this is just a suggestion and not required since it is a relatively minor aspect of the overall study and may best be left for future work.
- 9) While the manuscript is generally well written, it would benefit from careful proofreading for language and grammar. A few specific examples are page 7 line 22 “(i.g. SO₂-2010 NH₃-2010 NO_x-2010 cases)” which probably should be “(i.e. SO₂-2010, NH₃-2010, and NO_x-2010)”, page 8, line 1 “pointed out surface air temperature ... increased” which should be “pointed out that

surface air temperature ... increased”, page 8, line 15 “for the January 2010 month” which should be “for the month of January 2010”, and page 8 line 20 “variations of surface temperature, RH” which should be “variations of surface temperature and RH”.