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Atmospheric Chemistry and Physics Discussions

Interactive comment on "The role of climate and emission changes in future air quality over southern Canada and northern Mexico" *by* E. Tagaris et al.

E. Tagaris et al.

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Reply to Referee 2 comments

Comment: In general, I believe this paper is well written and covers important work. There was clearly a substantial amount of work that went into this paper, and it could potentially be an important contribution. There are, however, some major issues that would have to be addressed before this work is published.

Response: We would like to thank the reviewer for his/her positive opinion for our work and the detailed review that he/she provided giving us the opportunity to improve the quality of our manuscript.

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General comments: Comment 1. The authors have not established that this model predicts meteorology, ozone, or PM accurately over Canada or Mexico. While Tagaris et al. (2007) evaluated the model over the US, there has been no evaluation over the areas that are discussed in this paper. It is difficult to put any stock in the conclusions of this study when we have no idea of the quality of predictions in the regions being studied. Data should be available for comparison (for example, http://www.statcan.ca/english/freepub/16-251-XIE/2007000/maps/map2-en.htm). I believe the lack of model evaluation is a major flaw of the work in its present form.

Response: The reviewer's concern is understandable. In the revised version of the manuscript a new paragraph and a table have been added evaluating air quality model's performance for both Canadian sub-regions using observational data from the National Air Pollution Surveillance (NAPS) Network (about 150 monitoring stations for ozone and 50 for PM2.5 belongs to the domain of our interest). Moreover, in the revised manuscript we compare concentrations derived from our analysis with concentrations from other works. Comparison is done for average summer ozone concentrations from GCMs (Wu et al., JGR 2007, 2008; Zeng et al., ACP 2008); the spatial patterns are similar. Due to the lack of data from monitoring stations over northern Mexico, model performance could not be evaluated in as much details. We believe that the evaluation we perform in our previous work and here is sufficient for model's performance.

Comment 2. This work uses the IPCC A1B scenario to represent future climate and emissions. This is simply one of a set of many (infinitely many, actually) futures that are within the realm of possibility. The authors frequently use the future tense (i.e. from the abstract "Global climate change combined with the projected emissions will decrease M8hO3..."); this implies that the A1B scenario is THE future, not just one possible future scenario. The authors should stress that this is one of many possible scenarios and that predictions are for the 2050s under the A1B scenario, not just for the 2050s.

Response: We have complied with the reviewer's suggestion. The phrase "for the projections used in this study" has been added in the abstract, results and discussion,

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and conclusions.

Comment 3. It is uncertain whether three present years and three future years are representative of “the present” and “the future”. For example, one unusually hot year, such as 2002, could have a large influence when only three years are simulated. Interannual variability is a very important issue when trying to predict these long-term effects, but they are barely discussed in this paper.

Response: Good suggestion. Standard deviations (1σ) of the summer average values for meteorological variables and pollutant concentrations have been added to the tables and a relative discussion in the text. Moreover a table presenting the number of days per year and per region where M8hO3 concentration exceed the 75ppb and the daily PM2.5 concentration is higher than 15 μg/m^3 as well as the peak estimated concentrations for the historic and future summers using emissions projection (Future) and no emissions projection (Future_np) has been added.

Specific comments: Comment: Introduction 1. The authors assert that the cited studies lead to the conclusion that “climate change alone seems to play a minor role” in determining future ozone concentrations. Some of the studies, especially Hogrefe et al. (2004), show climate changes to have an important effect on ozone. The authors imply that there is a consensus that climate effects on ozone are expected to be small, when this is not the case.

Response: The conclusion that climate change alone seems to play a minor role in ozone concentrations was in reference to the Dentener et al. work. We have modified the text to make it more clear and we have added that Hogrefe et al. estimate that climate change will significantly modify ozone concentrations.

Comment: Methods 2. Another importance difference between Tagaris et al. (2007) and the present work is the model evaluation in the 2007 paper that is not in this paper.

Response: We trust that the reviewer will find sufficient the modifications discussed in

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response to the general comment 1.

Comment: 3. Given that there is no data assimilation, are your present-day summers actually representative of 2000-2002, or are they really theoretical generic present-day summers? The impression the paper gives is that the work is actually reproducing the meteorology and air quality from 2000-2002, though without any meteorological assimilation, which seems quite difficult. Was there any assimilation done at the global (GCM) scale? If the "historical" years are actually generic present-day years, it may be clearer to label them as such.

Response: No data assimilation has been used for any simulation mentioned in the text so the work could not actually reproduce the meteorology and air quality for the period 2000-2002. Our evaluations, as well as the analysis by Leung and Gustafson, show that historic meteorology is being simulated without data assimilation.

Comment: Results and discussion Meteorology 4. It is difficult to have faith in the predicted meteorological changes when no comparison to measurements has been made for the present day.

Response: The meteorological fields used here have been published by Leung and Gustafson (2005, GRL), and that work (and, presumably the peer-review as well) included extensive analysis. In this work we focus on future air quality under climate and emissions changes. However, in order to have a better understanding for the variables used in air quality modeling the changes in meteorology and emissions for the projections used in this study are briefly presented. For that reason although we have extended the air quality evaluation we believe that extending the evaluation for meteorological fields is out of the scope of this work.

Comment: 5. Table 1 - Four significant digits seems like overkill for temperature, mixing height, and insolation. These should probably just be rounded to the nearest integer.

Response: Done

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Comment: 6. Figure 2b - Is this (total number of rainy days in three future summers) - (total number of rainy days in three present summers), or is this the difference in the average number of rainy days per summer? Either way, it should be clarified. It is probably more meaningful to the reader when expressed as a per summer average. If this already is shown as a per summer average, the change in the number of rainy days is enormous, especially around Vancouver - up to 60 out of a total of 90 days in the entire summer. This would be a very important, noteworthy result. Also, it may be more meaningful to show the number of days with rain over a certain threshold amount rather than just any amount of rain greater than 0.

Response: The reviewer is right. We have replaced the figure with a new one presenting the difference in the average number of rainy days per summer. Moreover, we have added how we define the rainy days. Rainy day is a day where the precipitation is more than 1/4 mm.

Comment: Emissions 7. Are the changes in emissions in Table 2 the average per grid cell? Whether this is the average per grid cell or the total for the entire region, it should be stated explicitly. The impression given in Figure S1 is that these are per grid cell.

Response: The reviewer is right. Emissions are per grid cell and it is stated now in the table caption.

Comment: 8. For the case where only climatic changes are considered, is there a dependence of NOx emissions on lightning? If so, climate could increase NOx if more convective systems are expected.

Response: NOx emissions on lightning are not considered in our simulations. We agree that climate change could alter lightning NOx. However, this modification would have minor impacts as lightning NOx emissions lead to local impacts and will have a relatively small impact on typical maximum levels (Kaynak et al., ACPD, 2008).

Comment: 9. Does industrial growth explain the increase in ammonia emissions?

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Wouldn't most of this be due to livestock and agriculture?

Response: The increase in ammonia emissions comes predominantly from livestock and agriculture.

Comment: Air quality Ozone 10. p. 3412, line 25 - "while it is expected an increase" should probably be "while it is expected to increase".

Response: Done

Comment: Particulate matter 11. Figure 3b - These average concentrations seem rather low, but there is a lot of remote area in the domain, so it is possible that they are correct. It is difficult to know when there has been no model evaluation.

Response: The reviewer is right. Average concentrations are low similar to our previous study over US. To make it more clear a table presenting the number of days per region where M8hO3 concentrations exceed the 75ppb and the daily PM2.5 average concentration is higher than 15 μg/m3 as well as the peak estimated concentrations for the historic and future summers using emissions projection (Future) and no emissions projection (Future_np) has been added. The 75ppb is the new NAAQS for M8hO3 while 15 μg/m3 is the NAAQS for annual PM2.5 average concentrations (the 35 μg/m3 for the daily average gives low numbers). Further, we now have the requested evaluation.

Comment: 12. The main meteorological effects are asserted to be due to temperature and precipitation. Do the authors think that PBL changes are also important?

Response: We have added this in the manuscript.

Comment: 13. Table 4 - Given that the relative compositions of PM under historic and future_np scenarios are nearly identical, it seems that processes that affect all PM species equally may have the largest effects. This could mean things like precipitation, PBL height, and wind speed may be the most important.

Response: Very good comment. We have added that in the manuscript. Actually this is

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in agreement with Dawson et al., 2007 ACP paper (we mention that in the manuscript) where they found that "...while in July, absolute humidity, wind speed, mixing height, precipitation intensity, and precipitating area all had potentially major effects on PM2.5"

Comment: 14. Figure 8 - The color scale chosen shows changes in the US quite well, but obscures the (smaller) changes in Canada and Mexico - the actual regions of study in this paper. Perhaps the color scale should have finer resolution so the changes in Canada and Mexico are more apparent.

Response: Following reviewer's suggestion we have changed the scale in Figures 5 and 8 (ozone and PM) to have a finer resolution in Canada and Mexico

Comment: 15. p. 3414, line 24 - "lower compared to" should probably be changed to "smaller than" for clarity.

Response: Done

Comment: Conclusions 16. The second-to-last sentence is not worded clearly.

Response: It has been changed to say "Global climate change impacts on air quality over western and eastern Canada and northern Mexico are simulated to change future summer average PM2.5 concentrations but have little impact on average O3 levels for the projections used in this study, although changes in the higher concentrations are more pronounced. Global climate change combined with projected emission changes is simulated to reduce pollutants concentrations in all examined sub-regions. One of the most important findings of this study is that although future emissions over northern Mexico are projected to be higher, future pollutant concentrations are not as reductions in the US provide benefits to the south. Climate change alone is found to slightly modify PM2.5 composition while the combined effect of climate and emissions changes is forecast to significantly change aerosol composition over Canadian sub-regions as OC becomes more dominant followed by sulfate. Over northern Mexico, sulfate is simulated to continue to be the dominant PM2.5 component."

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Interactive comment on Atmos. Chem. Phys. Discuss., 8, 3405, 2008.

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