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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Estimates of Exceedances of Critical Loads for Acidifying Deposition in Alberta and Saskatchewan" *by* Paul A. Makar et al.

Anonymous Referee #1

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General Comments:

This manuscript by Makar et al. entitled "Estimates of Exceedances of Critical Loads for Acidifying Deposition in Alberta and Saskatchewan," is a comprehensive assessment of atmospheric deposition of nitrogen (Ndep), sulfur (Sdep), and base cations (BCdep) for Alberta and Saskatchewan, and how that relates to critical loads of acidification for terrestrial and aquatic systems. They explore many different improvements to base datalayers using climatic adjustment, and improved source emissions from aircraft estimates. These improvements move the field forward in our understanding of this environmental stressor, specifically in Canada, but potentially for any temperate

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industrialized country with active mining operations.

I only had two substantial comments, neither of which negate the quality of the manuscript (though #2 may), and addressing each I think would improve an already strong submission. First, little attempt is made to extrapolate and infer whether the improvements to deposition (i.e. climatic adjustment for Ndep and Sdep and emissions adjustments for BCdep), which appear very important for Alberta and Saskatchewan, may or may not be advised in other industrialized parts of the world. My suspicion is that in vast areas of the US, Europe, and China, similar adjustments may be warranted. Second, the use of the 5th percentile for lakes (or the minimum) may be flawed. This is elaborated more below in the specific comments, but the accuracy of the 5th percentile as truly representing the 5th depends on the nderlying sample. If there are many lakes in the grid cell (e.g. >20), it will be accurate, if there are not, (e.g. <10), it will not. This is exacerbated when the authors decided to select the minimum when the sample is very small. In these cases, the minimum of the small sample is unlikely to be anywhere near the true minimum, and is probably closer to the mean. Some discussion of this is needed or edits to the methods for the aquatic. This is the same problem that Clark et al. (2018) fell into, and needs to be mentioned (https://doi.org/10.1002/eap.1703). These two issues raised are important, but neither is a “deal breaker” in terms of acceptance for publication, as there are many important strengths and insights in the manuscript. Other, specific comments below.

Specific Comments:

Abstract:

“Aircraft-observation-based estimates of fugitive dust” is awkward, how about “Aircraft-based estimates of fugitive dust” or “Aircraft observations of fugitive dust”

“Aircraft-observation-based estimates of fugitive dust emissions, shown to be a factor of ten higher than reported values”. Clarify “reported”, is this from ground observations, reported in some governmental permit, modeled?

Introduction:

Pg 4 lines 13-17: Hard to follow multiple embedded proportions, just proportionalize everything to Canada.

Pg 4 line 17-18: If NOx and NHx emissions from the oil sands are only 3.8 and 1%, respectively, of the total emissions of NOx and NHx in Alberta, how are they the main anthropogenic sources? Everything else is natural?

Methods:

18 pages of methods is ridiculous, but if this is ok with the journal, it's ok with me. I'd prefer to see this in an Appendix and have a brief methods section in the main text.

Pg 9 line 19-23: The subsampling is likely flawed. Using the 5th percentile is only appropriate if there are many lakes in a grid cell (i.e. > 20). If there are very few lakes in a grid cell, assuming a normal distribution, the lakes will more approximate the mean than anything else. Thus, selecting the "minimum" when there are only a few lakes is the minimum in name only, as these lakes more likely represent the mean. We ran into the same problem in Clark et al. (2018) Ecological Applications and discussed its implications (https://doi.org/10.1002/eap.1703). Please consider revising the methodology (i.e. only use grid cells with > 20 lakes) or discuss this issue in the paper.

Parse out in the figures and captions of Figs 2-4 the "No Data" category. There are many possible reasons for no data, and knowing and communicating that is helpful. What that "No Data" because it was not the right land cover type (e.g. non-forested) or because there was no estimate of data (e.g. BC dep), or some other reason. These are very different. Please separate the reason for no data into at least two categories (i.e. "No appropriate cover" and "No data").

Results:

Figure 5: Interesting that most of the N dep is from NH4+ wet, which did not seem to

be mentioned much in the introduction. Maybe introduce this a bit more so it's not a surprise.

Pg. 24-25: Please add a bit more discussion on the sources of error that could be attributable to the model and could be attributable to the observed estimates. Both are potential sources of error and I found this a bit too brief.

Pg. 25: Very nice that you used uncorrected and corrected deposition estimates in calculations of exceedance.

As mentioned earlier "Aircraft-observation-based" is a mouthful and not necessary. Use "aircraft-based." It would be silly to take a computer up in the aircraft to make this an "aircraft-simulation-based" estimate.

Pg 27, line 12-13. I don't follow the logic of why this following from the preceding sentences: "This in turn suggests that the primary particles may rapidly deposit with increasing distance from the emissions sources." If the emission inventories are too low, why does that mean they deposit faster? Couldn't this explain the bias in the BCdep (i.e. that the actual emissions are higher, and thus the model estimates BCdep as too low)?

Pg 27 line 18-19. It shouldn't be "aircraft emissions estimates" (i.e. the emissions of the aircraft) it should be "aircraft-based emissions estimates"

Pg. 27-28. Would be nice to have a "take home message" in terms of how far from a large point source do you need to be before one needs to worry. Seems like from Figure 8 you need to be >100 km, which would be a useful rule of thumb to include. Are these underestimates for Canada likely occurring elsewhere in the world as well?...Later I see that the 142 km threshold (pg. 33) is presented, which is slightly different but related and useful.

Pg 29 line 1-2. Unclear why the improvement in the BC emissions using the aircraft observations also improves the Sdep and Ndep, please clarify.

Section 3.4. It's not really clear to me what value the comparison with snowpack adds except to say that the snowpack isn't a very useful comparison. If that is the case, I'd move all this to the supplement, and just have a short statement to that effect. This would shorten an already very long paper.

Figure 12 a, what is the red hotspot to the NE of the Athabasca oil sands where BCdep again dominates? Is that another source or evidence of long range transport?

Figure 14 b-c: Unclear whether the S and N dep are precipitation adjusted, which I think they should be in one of either b or c? The description in Figure 13 is more clear and complete (i.e. "GEM-MACH S+N deposition scaled according to precipitation observations, base cations scaled using precipitation and aircraft data".

Not really clear what Figures 15 and 19 on the Regions adds, please clarify.

Discussion:

This is fantastic work for Canada, but some discussion of whether the results and lessons would hold for other parts of the world would be nice if briefly discussed (e.g. Europe and the US?).

Pg 46 line 29-30: In addition to exceedances not helping with the timeline or recovery, they also don't really comment on the magnitude of effect, also an important note.

Pg 47 and Figure 20: This is a really nice addition, but it seems to me that comparing exceedances with actual impact is a much bigger effort than this would suggest. If it's just included as a preview, it's fine, otherwise, maybe caveat that much more comparison with observed effects is needed (e.g. forest tree growth??).

Please add a non-spatial plot to simplify the information in Figure 20. The take home point appears to be that exceedance does not translate to effect.

Pg 49 line 15: I would not characterize a radius of 142 km as "rapid". I'd say 10 km would be rapid, but that circle in the figures is pretty large!

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