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Reply on RC2

Ashu Dastoor et al.

Author comment on "Impact of Athabasca oil sands operations on mercury levels in air and deposition" by Ashu Dastoor et al., Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2021-296-AC2, 2021

We thank the reviewer for the positive and constructive comments on our paper. Our responses to the reviewer's comments in italic.

Specific comments:

Figure 1: "…The Athabasca Oil Sands Region is indicated with an approximate rectangular shape within northeastern Alberta, bordering Saskatchewan."

The "approximate rectangular" is very poorly seen in the figure as well as in all other figures of the manuscript.

We have revised the concerned figures to make the oil sands region more visible by making the window blue with a thicker line.

Lines 615-619: "… spatial distributions of simulated annual average surface air concentrations of GEM … and TOM … along with their contributions (as % increases) from oils sands emissions (OSE, middle panels) and biomass burning emissions (BBE, right panels)…"

The concentration/deposition increase (in %) due to OSE and BBE is among the key characteristics analyzed in the manuscript and mentioned in the conclusions. However, it is not clearly defined in the text. More certain definition is needed to understand particular numbers and figures given in the text.

Both oil sands and biomass burning Hg emissions (in the context of total global and regional emissions) and the design of model simulations conducted to study their impacts are clearly defined in detail in preceding sections including introduction, objectives, "the model and emissions inputs", and "model simulations". We think that this is sufficient and additional definition is not needed in this section.

Lines 789-790, Figure 17: "… the upper panels show process contributions of changes in meteorology (blue), oil sands (red) and biomass burning (purple) emissions to interannual changes in total Hg deposition."

Similarly, it is not clear how the relative contributions of particular processes to deposition changes were calculated. More detailed description is needed.

The model simulations for estimating process contributions are already described in the section "model simulations" and in the first paragraph of the section mentioned by the reviewer (please see lines 776-785).

To improve the clarity, we have revised the lines 776-785 as follows: "Since meteorological changes are expected to occur regardless of changes in emissions, a controlled model simulation was first conducted by applying only meteorological changes from 2012 to 2015. Subsequently, two additional model simulations were performed by successively adding BBE and OSE changes from 2013-2015. The differences in these simulations provided the relative process contributions. It should be noted that, in addition to the changes in emissions, the BBE and OSE impacts on Hg deposition also depend on changes in meteorological conditions (synoptic as well as local scale), thus the results presented here are cumulative contributions of changes in meteorology and emissions."

Lines 903-907: "… Model-measurement agreement of Hg surface air concentrations and snow loadings in AOSR … implies that NPRI reported emissions of Hg from oil sands operations … are consistent with Hg burden in the region."

It seems to be too strong conclusion repeated in the Abstract taking into account that contribution of the AOSR region emissions to GEM air concentration is negligible and it does not exceed 55% for mercury accumulation in snow.

This conclusion is based on 4 years of model simulations during which oil sands emissions were changing. In the vicinity of oil sands activities, oxidized Hg concentrations in air and snow Hg loadings are highly sensitive to oil sands Hg emissions. For example, within 10 km of oil sands sources, average enhancement in wintertime deposition to snow due to oil sands emissions were 250 – 350% in 2012-2013, but only 50-100% in 2014-2015, because of declining oil sands Hg emissions (see Figure 16). Since year to year variations in modeled oxidized Hg and snow Hg levels in the vicinity of oil sands facilities follow the changes in oil sands emissions quite consistently, also seen in observations, this conclusion is accurate.

Conclusions, Abstract: Overall, the conclusions and abstract seem to be too extensive and are overloaded with plenty of numerical details. In my view, their shortening would improve readability of the manuscript.

We have shortened the abstract as suggested by the reviewer. We have retained the numerical details in the conclusion for easy accessibility of results to the readers.