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CRITICAL REVIEW DISCUSSION REBUTTAL

Advances in science and applications of air pollution monitoring: A case study On oil sands monitoring targeting ecosystem protection

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ABSTRACT

The 2019 Critical Review authors respond to the Discussant comments in Altshuler et al. (2019).

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Introduction

The Air & Waste Management Association's Critical Review (CR) represents an excellent opportunity to discuss current scientific knowledge on an important topic via a well-recognized, open forum. In this context, Brook et al. (2019) accepted the challenge of examining recent aspects of research focusing on the ecological impacts Alberta's Oil Sands Region (OSR) development. Producing oil in an economically and environmentally responsible manner is an ongoing challenge complicated by long time scales over which OSR activities change and cumulative effects might manifest themselves.

Much research has been undertaken in the past 10-20 years; findings and implications, including peer-reviewed publications, continue to be assessed. Part of this growing body of work has come from the Joint Oil Sands Monitoring program (JOSM), which was initiated less than 10 years ago by Environment and Climate Change Canada (ECCC) and Alberta Environment and Parks, to help improve scientific knowledge and environmental monitoring.

To keep the 2019 CR practical, and anticipating that the Discussion would supplement the CR with input from other experts, the CR authors proposed a focus on ECCC published research related to air, water and wildlife, with emphasis on potential effects from atmospheric emissions. a broader integration of ecosystem impacts. How to minimize or eliminate these impacts remains an important, long-term objective. The authors appreciate that the Discussion recognizes the CR as "…a useful starting point for future review efforts", and encourages efforts to break new ground in integrated analysis and adaptive management.

The CR exercise has led to new insights into key gaps and future priorities. Much relevant and up-to-date information is now openly available for consideration as a result of the CR and its Discussion (Watson et al., 2019). The task of further interpreting and ultimately responding to all of these recent findings and those to come is indeed a journey. However, the destination is critical, meaning that there is a need to continue, if not accelerate, assessment of new knowledge, involving all stakeholders, to quickly adapt environmental management practices and/or address the impacts as their implications become more fully understood.

Responses to the CR Discussion

While the Discussion identifies complementary work and knowledge, there are some points that require responses. Dr. Legge states that, "ECCC modeling found that acidification was widespread in eastern Alberta and Saskatchewan. However, field measurements…do not show such acidification." Models are a necessary and accepted tool to expand the spatial and temporal scope of assessments. ECCC's approach to examining the potential for acidification in the region, including outside of Alberta, was to build upon a globally-recognized model by improving inputs, process representations, quantitative evaluation, assimilation of observations such as base cation deposition and measured wet deposition,

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and a range of measures/methods for assessing critical loads. Makar et al. (2018) found that critical loads are being exceeded, but not that acidification is widespread. Critical load calculations suggest that base cation inputs are insufficient to prevent eventual acidification of aquatic ecosystems in the region. Specifically, there is predicted neutralization close to the sources (within tens of km), but there are critical load exceedances further downwind. Base cation deposition was identified as having a neutralizing impact, but this impact dropped off with increasing distance from the source region. The cause for this drop-off was identified as the deposition of base cations at a faster rate than anions and their precursors. The modelling does not disagree with the relatively near-source findings highlighted by the Discussion. As noted in the CR,, the critical load methodology does not provide a time-to-effect, but given the depositional inputs and best available data to quantify critical loads, there is potential for effects in the future. This potential requires ongoing research, further testing and improvement of models, and targeted monitoring of both aquatic and terrestrial ecosystems over a large region.

The base cation deposition ('dust') may include petcoke in some areas, which presents a separate set of concerns. The CR authors agree with the Discussion in highlighting the issue of petcoke and its contribution to toxic deposition and potential impacts.

Dr. Dubé disagrees with the CR statement that "…there is growing evidence of the impact of current levels of PACs on some species", contending that although polycyclic aromatic compound (PAC) deposition is occurring and has been found in animal tissues, the linkage between exposure and effects has not yet been established. The CR authors contend that there is evidence of biological effects associated with PAC exposure in tree swallows, which were proposed as a sentinel species (Fernie et al., 2018, 2019) Mundy et al. (2019) exposed chicken and double-crested cormorant embryonic hepatocytes to graded concentrations of passive semipermeable membrane device (SPMD) extracts obtained in the OSR. They found that 7-ethoxyresorufin-O-deethylase (EROD) activity and Cypla4 mRNA induction adverse health indicators were highest at a near-site wetland (which corresponded with measurements of PACs in the wetlands using the SPMDs; total PACs were highest in SPMDs deployed within 10 km of mining activities). Extracts from sites with the highest PAC concentrations resulted in the most genes altered on the chicken ToxChip. The CR raised the question of how to interpret the significance of such biomolecular responses. This remains an important issue for environmental management. Evidence of biological effects is emerging and growing. Follow-up research is necessary to better understand these exposure/effects relationships to determine their significance and how, if necessary, they can be mitigated. This may implicate petcoke dust as a contributor to PACs that adversely affect ecosystems/species in the region.

Dr. Ahad notes that, "Hall et al. (2012) found no evidence for significant atmospheric transport of mining-related PACs to the Peace-Athabasca Delta (PAD), and no measurable increase in river-transported bitumen-associated PACs in sediments deposited in a flood-prone lake since the onset of OSR development." The PAD should continue to be an area of focus to ensure that OSR development is not having adverse impacts. The CR notes that PACs, metals and mercury in water, sediment and biota are being studied in the PAD and upstream along the Athabasca River. Detecting these contaminants and identifying their sources is a major challenge and progress is being made. The CR cites Hebert (2019) as demonstrating the influence of Athabasca River flow, bird food sources, and bird species on egg mercury levels in downstream PAD environments. Quantifying contributions from natural (i.e., erosion) and manmade discharges, as well as land, water, and atmospheric pathways for these contaminants requires further research.

The Discussion rightly notes that there are important non JOSM or non ECCC studies relevant to OSR. It is agreed that cooperation among all stakeholders is needed to ensure the PAD is protected, especially considering the traditional uses of the region (i.e., Indigenous) and its global stature (i.e., UNESCO World Heritage site).

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