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Interactive comment on "Sources of Particulate Matter in the Athabasca Oil Sands Region: Investigation through a Comparison of Trace Element Measurement Methodologies" *by* Catherine Phillips-Smith et al.

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In this manuscript the authors investigated sources of ambient concentrations of elements in fine particulate matter (PM2.5) at three industrial locations in the Athabasca Oil Sands Region (AOSR) using 24-h (Dec. 2010 – Nov. 2012) and 1-h (August 2013) data. The receptor model EPA PMF3.0 was applied and seven emission sources were identified. In general, the results appear to be impressive and interesting for the international scientific community. However, I would like to raise some points that would be needed to address to better understand and reveal the sources of PM2.5 in the AOSR.

Some assumptions and interpretations have been made particularly in the methodology and result sections, which make the findings more uncertain. I would therefore suggest that the authors should consider major revisions as outlined in the specific comments.

Specific comments: 1. The authors investigated sources of PM2.5 using trace element concentrations that accounted for only a small fraction of PM2.5 mass. The authors should consider using all available chemical components e.g., cations (K+, Ca2+), anions (SO42–, NO3–). It is reported that additional chemical composition data would be available in the follow-up analysis (page 20). To the best of my knowledge, carbonaceous aerosol (EC/OC) measurements were not performed at oil sands region. Therefore, checking PM2.5 mass closure is helpful to identify the proportion of unaccounted mass, which can be included as an input variable (missing mass) in the model as suggested by Larson et al (2006) and have been applied in several other studies (e.g., Wu et al., 2007; Bari and Kindzierski, 2017). This helps to better explain some source factors.

2. It is not clear how the authors come up with the 5-factor solution using EPA PMF3.0. The authors provided justification for choosing the optimum number of factors screening basic criteria e.g., Q-values, G-space plots, Fpeak values. However, they didn't report any error estimation techniques such as bootstrapping (BS) analysis. The authors should apply the current version of the PMF model (EPA PMF5.0) that allows to better assess the uncertainty of PMF solutions, using three error estimation methods i.e., BS, displacement (DISP) and bootstrapping with displacement (BS-DISP) analysis.

3. The selection of chemical elements for PMF analysis was based on the frequency of detection and species only >10% of the measurements above the detection limit were chosen. This may increase more uncertainty in PMF-resolved sources. It is suggested to exclude the elements with more than 70% of samples below the detection limit. The authors should include data quality information (including percentage of detection,

below detected and missing values) in the supplemental. It is also suggested to provide QA/QC for laboratory analysis.

4. The authors identified seven sources including two types of upgrader emissions, soil, haul road dust, biomass burning and two sources of mixed origin. It is suggested to improve the interpretation for describing some specific sources that are related to oil sands development. For example, adding secondary ions (SO42–, NO3–) in PMF analysis will help to better characterize the input of oil sands emissions.

5. Recent studies in the AOSR indicated fugitive dust (e.g., from oil sands tailings, unpaved roads and hauling fleet emissions) as a dominant source contributing ∼20%–40% to PM2.5 (Landis et al., 2017, 2012; Bari and Kindzierski, 2017). The authors should check 'soil' and 'haul road dust' factors to better interpret the influence of fugitive dust.

6. The authors tried to compare the observed levels of PM2.5 elements in the industrial locations in the AOSR with other Canadian cities. Elemental levels at oil sands communities (e.g., Fort McKay and Fort McMurray) were not investigated here. Due to the unique nature of emission sources (not available in other Canadian region), the comparison analysis may not be informative and therefore suggested to exclude from the manuscript.

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