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Multi-Year Mobile Surface Measurements of CH_4 in the Athabasca Oil Sands Region of Alberta

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The Athabasca Oil Sands Region (AOSR) of Alberta, Canada is estimated to be responsible for $\sim$10% of total methane (CH_4) emissions in the province, with the majority of released CH_4 due to fugitive emissions that are an unintended byproduct of operations. A previous aircraft campaign led by Environment and Climate Change Canada (ECCC) in Summer 2013 showed that the fugitive emissions of 19.6 $\pm$ 1.1 tonnes hr^{-1} are from surface mining activities (50%), tailings ponds (45%), and other facility-controlled releases of natural gas (5%). However it is uncertain how these emissions vary according to season and on an inter-annual basis. In this work we use data from two mobile surface campaigns (Fall 2014 and Spring 2017) during snow covered conditions and continuous ground-site data (2013-2017) from the Wood Buffalo Environmental Association (WBEA) surface station network and the ECCC monitoring station in Fort McKay to provide insights into the uncertainties regarding the variability of emissions in time. Previous results from the Summer 2013 aircraft campaign are used to build an a priori map of emissions in space and their respective uncertainties. Maximum enhancements from large fugitive plumes ($\sim$1 km wide) up to 3.7 ppm were observed in 2014 and 4.3 ppm observed in 2017. Occasional narrow enhancements of $>$15 ppm were observed in 2014 and as high as 90 ppm in 2017 from surface venting at one facility. Emissions estimates are determined for select plumes using a mobile-surface mass-balance approach (MSMB). Plume sources are identified using wind back-trajectories onto the constructed map of known emissions sources. MSMB requires vertically extrapolating measurements of mixing ratios made at the surface, with the top of the planetary boundary layer (PBL) determined using continuous LIDAR backscatter measurements. Our results provide insight into the variability and evolution of AOSR emissions in time, which are valuable for the accurate seasonal and inter-annual quantification of emissions needed to develop mitigation strategies. The observations can further be assimilated within a complementary high-resolution modeling approach to provide constraints on emissions.