Introduction

Government monitoring of gaseous organic emissions has traditionally relied upon measurements of lighter volatile organic compounds (VOCs). In reality, carbon emissions from most anthropogenic sources span a wide range of molecular sizes and functionalities. This is particularly relevant for the oil and gas sector, where emitted hydrocarbons from extraction and processing include heavier intermediate- and semi-volatile organic compounds (IVOCs and SVOCs, C_{12+}) that form secondary air pollution. Specifically, the Athabasca oil sands (OS) region in Canada, which currently produces ~3 million barrels of crude oil and gas sector

Problem

• The global transition to unconventional petroleum resources and the associated shift in the volatility of emissions present challenges for traditional organic carbon monitoring and reporting.
• Limited reported emissions of individual carbon species from Canadian oil sands regions cannot be reconciled with incomplete existing emissions measurements.

Purpose & Objectives

We use airborne real-time measurements of total gaseous organic carbon (TC) to compare top-down emissions from oil sands mining operations to industry-reported bottom-up estimates.
• Chemically speciate organic carbon emissions to highlight reporting discrepancies.
• Compare the magnitude of emissions from oil sands operations to other Canadian sources.
• Capture the full range of organic air pollutants and demonstrate the need to improve routine emissions reporting and monitoring beyond VOCs.

Methods

• First application of sampling on a plane with offline high resolution mass spectrometry.
• Research aircraft flew in box patterns and straight-line tracks to sample airborne measurements above oil sands facilities in summer 2018.

• Online instruments: real-time measurements for total gaseous organic carbon & NOy.
• Offline instruments: adsorbent tube sample collection of I/SVOCs, analyzed via GC-MS.

Results

1. Total observed emissions greatly exceed reported emissions

2. Abundant complex I/SVOC mixtures near OS operations

3. Carbon enhancements downstream of OS

4. An important role for non-combustion emissions

5. Potential non-combustion emission pathways

Conclusions

• The magnitude of emissions from OS facilities far exceeds industry reports.
• Underlying pathways are OS-derived.
• Adequate reporting requires complete coverage of a wider volatility range of emissions (I/SVOCs).
• The total carbon approach here is a valuable tool to capture combustion emissions.
• The importance of accounting for lifecycle combustion emissions that form unknown organic carbon.

Acknowledgement:
Environment and Climate Change Canada, Yale University, Washington University St. Louis, University of St. Paul, Scherrer Institute, Massachusetts Institute of Technology, Ramboll.

Figure: Volatility distribution of hydrocarbons.