Methane emissions from oil and gas industries in three western provinces of Canada using GOSAT observations in mass balance method and comparison with GEOS-Chem

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1. Background

- In Canada's three western provinces the oil and gas production rate has changed since 2010 with the large-scale practice of horizontal drilling and hydraulic fracturing (Fig. 1).

- Government estimated oil and gas methane emissions do not reflect large emissions increase with production growth and are likely too low (Atherton et al., 2017; Johnson et al., 2017)

- Accurate independent estimates of oil and gas methane emissions are required to assess compliance with government emission reduction requirements

2. Methods

2.1. Background

- NOAA's ESRL sites

Fig. 1: Industry reported methane emissions for the year of 2015. ESP and ETL are two NOAA's ESRL sites.

2.2. GC simulations

- We performed MERRA-2 met field based 0.5°×0.25° NA CH\(_4\) simulation (2009-2012) using boundary conditions from 2°-2.5° global CH\(_4\) simulation in GeoChem (GC) v12.3.0

- To evaluate our GC simulations, we compared simulated products of several days in 2009 with collocated aircraft profiles, finding them similar (Fig. 2).

- We evaluated GOSAT OCPR v7.0 satellite profiles with aircraft (Fig. 2).

- We estimated methane emissions using satellite data products (2009-2016) and simulated GC products in a simple mass balance technique (Buchweitz et al., 2017)

- Four source regions were identified where XCH\(_4\) are elevated relative to their surroundings and elevated concentrations coincide with oil and gas locations (Fig. 3)

- We considered several GOSAT XCH\(_4\) data products, such as OCPR, SRPR, and SRFP, and emissions estimated from each product is taken for averaging in a given year with total errors coincident with oil and gas locations (Fig. 3)

- Four source regions were identified where XCH\(_4\) are elevated relative to their surroundings and elevated concentrations coincide with oil and gas locations (Fig. 3)

- We also evaluated GOSAT OCPR v7.0 satellite profiles with aircraft profiles (Fig. 2).

- We estimated methane emissions using satellite data products (2009-2016) and simulated GC products in a simple mass balance technique (Buchweitz et al., 2017)

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3. Results

- In general GC outputs capture overall spatial patterns of CH\(_4\) for NA, but do not fully detect the pattern that is consistently observed by the satellite products particularly where major Canadian oil/gas industries are located (Fig. 3 and 4)

- Instead of detecting comparatively high concentrations over densely located oil/gas industries particularly at the southeastern corner of AB and SK, GC simulated outputs detected elevated concentrations at the middle of SK and SK-MB border which are more likely associated with wetland (Fig. 1 and Fig. 3)

4. Conclusions:

- Satellite methane data products can detect methane emissions from oil and gas industries in western Canada quickly and with reasonable accuracy

- We identified that GC CH\(_4\) simulation needs updated Canadian oil and gas emissions information

- Although we did not estimate emissions with the 1-month of available TROPOMI data products, it promises even better performance than its predecessor (GOSAT) (Fig. 5)

- Our further investigation will emphasize inverse analysis for optimizing the emissions, and perhaps simulation with the new optimized emissions could resolve the existing discrepancies

- We also recommend further studies, particularly in NE-BC and SK, using aircraft-based measurement to detect emissions more accurately

5. References


- Bloom et al. 2017. Geosci. Model Dev., 10, 2141-2156 [as BL in the text]


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Table 1: Summary of the estimated methane emissions in four source regions

<table>
<thead>
<tr>
<th>Sectors</th>
<th>Mean (2009-2016)</th>
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<tbody>
<tr>
<td>NE-BC</td>
<td>0.58±0.60</td>
</tr>
<tr>
<td>AB-1</td>
<td>0.86±0.78</td>
</tr>
<tr>
<td>AB-2</td>
<td>2.44±2.01</td>
</tr>
<tr>
<td>SK-ND</td>
<td>2.89±1.80</td>
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</tbody>
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Fig. 5: XCH\(_4\) spatial distributions in western Canada using TROPOMI data. Only valid data (mixing ratio bias corrected and qa value 0.5) have been considered to prepare monthly mean TROPOMI 0.24°×0.24° map

Fig. 2: Comparison of GC and NOAA ESRL aircraft profiles of several days in 2009 (top: GC vs ESP, middle: GC vs ETL). Bottom: Validation of GOSAT OCPR retrievals with collocated ETL aircraft profiles. We obtained only 12 collocated ETL profiles between 2009 and 2015 for OCPR data validation.

Fig. 3: XCH\(_4\) spatial distributions in western Canada using GOSAT (left) and GC data (right). Four source regions (black rectangles) and geographical distribution of NPRI reporting facilities for the year 2016 (n=4818) (purple dots) are shown in left panel. Right: GC NA nested simulated outputs have been used to prepare 0.5°×0.5° map for western Canada.