Fugitive and vented emissions from energy developments in Alberta, Canada
Lessons from extensive measurement campaigns

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Dave Risk, Ph.D.
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‘FluxLab’ research group

At St. Francis Xavier University in Nova Scotia

30-strong group

Research on gases and emissions measurement technology, tracers

Multi-scale work from satellite to soil gas

Industry focus
Our work in oil and gas – mostly mobile

Moved into mobile (truck-based) air measurement approaches in 2012 at the request of an operator. These techniques are the focus of this talk.

Extensive campaigns for operators. Various analytes – H₂S, CH₄, CO₂, SO₂
Methane ‘wave’ hits in 2015

Trudeau-Obama 2015 + Alberta 2015 + Three Amigos 2016 = 45% reduction targets

Need for information from operators, NGO, regulators, etc. In response, we took a break from soil science to build datasets that could drive big GHG change.

Our Questions:
• What’s our baseline in Canada?
• Are the inventories accurate?
• Do we have super-emitters? What emits?
• Particular developments with issues?

We have launched projects across Canada, including Alberta
Emissions detection techniques

**Traditional methods**

- ‘Bottom up’
- Emission factors estimate emissions using a small population of infrastructure in good condition
- Not representative, tends to under estimate (Brandt, 2017)
- Super-emitters?

**New methods**

- ‘Top down’ (well by well)
- Mobile methods measure a representative sample of infrastructure in representative condition
- Super emitters sampled

Predictably, top down techniques always measure more emissions than bottom up
Super emitters?

80% of total emissions are from the top 22% of the sources.

The bottom 50% of the sources contribute less than 2% of the total emissions.

Because they’re rare, the only way to find them is to search.

(Rella et al. 2015, Barnett Shale)
Data acquisition trucks

Targeting Vented and Fugitive Emissions

Anemometer, GPS, thermal gradient (stability) T sensors, logger, etc
Typical field instrumentation – in bed

Site-specific mix of:

- Picarro G-2210 (CH$_4$, $\delta^{13}$CH$_4$, CO$_2$, C$_2$H$_6$) CRDS
- Picarro G-2201 (CH$_4$, $\delta^{13}$CH$_4$, CO$_2$) CRDS
- Picarro G-2204 (H$_2$S, CH$_4$)
- Teledyne T101 UV (H$_2$S)
- LGR UGGA (CH$_4$, CO$_2$)
- Horiba SO$_2$

-Airportable, cooled and cell/wifi-enabled cases

- Gases log at 1-2 Hz
1. Vehicle-based data acquisition: multiple gases
2. Signal Processing Algorithms:
   a) Variable ambient background
   b) ID Plumes via gas ratio fingerprints
   c) Back-trajectory to geospatial “priors”
   d) Estimate minimum inventories or volumes
3. Interpret, visualize
Detect faster, from farther away

Methane leaks in light 5 km/h wind

- FLIR Camera – >10,000 ppm
- EPA Method 21 using FID and 8 ppm threshold
- ExACT (100-400 pads/d)
Typical sensitivity

On-Pad at 15 m, ~0.002 g/s CH₄ or \(<1 \text{m}^3/\text{d}\) (100 wells/d)

On-road at 60m, ~0.065g/s CH₄ or \(~10 \text{m}^3/\text{d}\) (400 wells/d)

On-road at 300-400m, ~0.59g/s CH₄ or \(86 \text{m}^3/\text{d}\) (400 wells/d)

Sensitivity is 10-100X higher than handheld tools (FID or FLIR)

Wind direction must be favorable

Typical Confidence of Detection

95-99% even for anomalies as small as 10 ppb CH₄.

Multi-gas approach reduces false positives.

Every route done at minimum in triplicate.
Table: Frequency of fugitive emission detected (%)

<table>
<thead>
<tr>
<th>Operator</th>
<th>Number of Wells Surveyed</th>
<th>Frequency of fugitive emission detected (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>All (average across all operators)</td>
<td>1015</td>
<td>20.1</td>
</tr>
<tr>
<td>Operator 1</td>
<td>534</td>
<td>27.9</td>
</tr>
<tr>
<td>Operator 2</td>
<td>90</td>
<td>18.9</td>
</tr>
<tr>
<td>Operator 3</td>
<td>71</td>
<td>4.2</td>
</tr>
<tr>
<td>Operator 4</td>
<td>69</td>
<td>0.0</td>
</tr>
<tr>
<td>Operator 5</td>
<td>60</td>
<td>13.3</td>
</tr>
<tr>
<td>Operator 6</td>
<td>30</td>
<td>10.0</td>
</tr>
<tr>
<td>Operator 7</td>
<td>22</td>
<td>4.5</td>
</tr>
<tr>
<td>Operator 8</td>
<td>21</td>
<td>19.0</td>
</tr>
<tr>
<td>Operator 9</td>
<td>18</td>
<td>44.4</td>
</tr>
</tbody>
</table>

- What class of infrastructure emits the most frequently and severely?
- Where are the super emitters?
- Are CH$_4$ emissions persistent or episodic?
- What volume?
Example detail project: 700 well pads (on-pad)
Regional Alberta project thus far (3/5)
Regional Alberta project (2016-2018)

Funded by the Petroleum Technology Alliance of Canada and Natural Sciences and Engineering Research Council of Canada

“Mapping fugitive gas emission sources and severity across Alberta”

Multi-week survey campaigns in 3 developments with ongoing air / GHG issues in Alberta.

Study will quantify the baseline on a development-wide basis (independent of industry reported figures), and allow Alberta-based producers to better understand occurrence and persistency of emissions. Volume, emission rates, and inventory estimates will benefit industry and government.
Medicine Hat, AB – shallow conventional gas

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max CH&lt;sub&gt;4&lt;/sub&gt;</td>
<td>5.54 ppm</td>
</tr>
<tr>
<td>Min CH&lt;sub&gt;4&lt;/sub&gt;</td>
<td>1.92 ppm</td>
</tr>
<tr>
<td>Mean and Standard Deviation CH&lt;sub&gt;4&lt;/sub&gt;</td>
<td>2.03 ± 0.15 ppm</td>
</tr>
<tr>
<td>Number of Data Points</td>
<td>2,051,518</td>
</tr>
<tr>
<td>Infrastructure Surveyed</td>
<td>1,137</td>
</tr>
</tbody>
</table>

Routes driven in triplicate

Infrastructure: Yellow
Routes: Black
Active gas wells a prominent source of emissions

Emitting and surveyed well totals, broken down via status.
Preliminary results in Alberta (2016-2018)

Initial focus on **FREQUENCIES. VOLUME** estimates by well to come in autumn 2017
Simple severity indices

Simple analysis:
Running average maxima
= frequency & severity of plumes across different geographies
General absence of super-emitters, unless far away. Max plumes are 2.5x global norm

Horizontal line represents global CH$_4$ background concentration (1.88 ppm)

Typical profile for Canada

US developments 4-13 ppm regionally (60 min). Lloydminster is 6 ppm (atypical for Canada).

The largest “regional anomalies” hit ~2.5 ppm

Medicine Hat

Not significantly enriched on regional scale
Broad learnings

- Sometimes, vents and fugitives occur with high incidence
- Infrastructure of all classes have shown to emit to some degree, including abandoned wells and facilities
- Tank batteries are a common emission source
- Some developments are more emission-prone than others
- Volumes reflected in bottom-up inventories seem underestimated when measured from top (makes sense)

Positives:
- Sites with historic odour or H₂S issues are tighter, indicating that regulators + industry *can* solve problems
Other projects 2015-2017

- Natural Resources Canada
- SUNCOR Energy
- Carbon Management Canada
- CMN-CCE
- Apache
- Altus Geomatics
- SESAA
- Southeast Saskatchewan Airshed Association
- MEG Energy
- cenovus Energy
- PTAC
- David Suzuki Foundation
- BC Oil & Gas Commission
- NOAA
- INSTAAR
- West Virginia University
- West Virginia University, Institute for Policy and Economic Research
- The University of North Carolina at Chapel Hill
Mobile surveying for upstream now offered via Altus Geomatics (Licensed Jan 2017)
More information at:
Website: [http://www.fluxlab.ca](http://www.fluxlab.ca)
Twitter: @FluxlabX
Dave Risk - [drisk@stfx.ca](mailto:drisk@stfx.ca)
Survey Film: [https://goo.gl/R3oSp5](https://goo.gl/R3oSp5)