PROJECT OVERVIEW

- Background and Objectives
- Technology Description
- Field Summary
- Learnings and areas of improvement
- Cost implications
- Data product example

EXECUTIVE SUMMARY

Altus Geomatics provided it's ExACT emissions monitoring service to the PTAC Alberta Methane Field Challenge (AMFC) from November 14-24, 2019. Over 10 field days, we conducted 91 ExACT surveys at 50 target facilities near Rocky Mountain House, Alberta. We were able to survey an average of 8 sites per day with the ExACT truck. We calculated the average facility-level emission of the sites to be 150.3 m^3CH_4/day. Data was provided to the research team for analysis and comparison to other alternative monitoring technologies and Optical Gas Imaging cameras (OGI).

BACKGROUND AND OBJECTIVES

Alberta is the highest greenhouse gas emitting province in Canada with the oil and gas sector being responsible for 48% of emissions (National Energy Board, 2019). Methane is a greenhouse gas with a radiative heating potential 28 times that of carbon dioxide over a 100-year timespan. It is estimated that methane emissions from the Alberta oil and gas industry reached nearly 80 megatonnes per year, 3.5 megatonnes of which was attributed to methane leakage from oil and gas wells. In November 2015, the Government of Alberta introduced the Climate Leadership Plan (CLP) with the aim to reduce methane

emissions from upstream oil and gas production by 45 percent from 2014 levels by 2025 (Alberta Climate Leadership Plan, 2018).

Despite recent industry incentives and government policies announced to have emission reduction regulations by 2020, implementing these reductions efficiently remains a challenge. Emission monitoring, leak detection and repair is often time consuming and costly. Alberta Directive 060 will allow alternative technologies to be used in place of OGI cameras or Method 21 for fugitive emissions surveys if they are deemed equivalent to the prescribed technology. To help evaluate alternative methane sensing technologies, the Alberta Methane Field Challenge 2.0 (AMFC) was launched through the Alberta Upstream Petroleum Research Fund (AUPRF). The aim of this challenge is to assess the real-world performance of new methane sensing technologies in comparison with conventional optical gas imaging-based leak detection surveys and controlled release testing. Operators and regulators in Canada are interested in new technologies that can deliver cost-effective methane emission detection and quantification compared to conventional approaches.

TECHNOLOGY DESCRIPTION

At Altus Geomatics, we use vehicle-based technology referred to as ExACT (Emissions Attribution via Computational Techniques) to collect multi-gas measurements to identify and attribute emissions to specific sources algorithmically at the site or facility-level. The ExACT surveys are conducted by driving in triplicate passes around a lease perimeter to intersect an emission plume downwind, as illustrated in Figure 1.

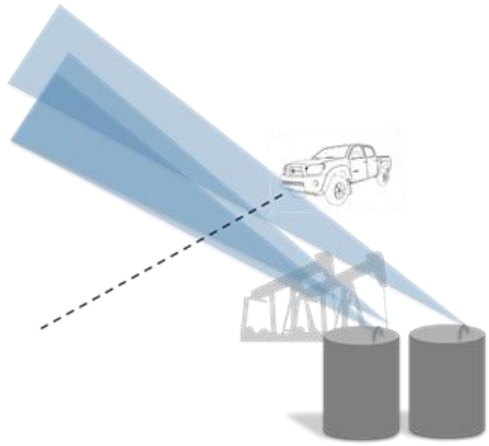

Figure 1. An idealized illustration of the ExACT vehicle intersecting a plume downwind of the source.

The ExACT technology is an innovative solution that offers a competitive advantage over other gas detection technologies as it can cover more area and detect super-emitters quickly. With ExACT technology, industry can easily identify which sites need to undergo repairs to reduce net emissions and meet targets. The technology does not discriminate fugitive emissions from leaks but can highlight sites where the net emissions may be nearing regulatory limits. As 70% of methane in Alberta is generated by the energy industry (Government of Alberta, 2019), the ExACT technology has the potential to assist Alberta and Canada meet greenhouse gas reduction commitments.

The ExACT method, detailed in Baillie et al. (2019), utilizes a truck-based system that collects gas concentration, location, wind and atmospheric stability data once a second while driving. ExACT can measure up to one hundred sites daily, depending on site density and terrain. Emissions monitoring technicians can remain inside of the vehicle during the entire survey, which allows for easy site access and safety protocol compliance. ExACT and the instruments used can be operated autonomously and are powered by onboard continuously charged batteries, allowing the driver and assistant to focus on safety, navigation and efficiency. The method provides real-time feedback, which can prompt the driver or assistant to target high emission sites and areas for same-survey follow up.

Collected data is then processed using patented algorithms and applied to an inverse Gaussian plume dispersion (GPD) model, outputting volumetric emission rate estimates per-facility. As with most inverse GPD applications, there is expected uncertainty that classifies emission rate quantification calculations as estimates. Current uncertainty within a standard three measurement (triplicate drive-by) emission rate estimation is 63%, with a slight bias to underestimate (O'Connell et al., 2019). However, this level of

uncertainty is comparable to similar alternative method, EPA OTM33a, which calculates emission rate within 60% accuracy, using lengthy (15-20 minute) stationary measurements (US EPA Air Quality Assessment Division, 2018).

FIELD SUMMARY

Production Sites and Facilities

As part of the AMFC, Altus targeted 50 site locations of various facility sub-types near Rocky Mountain House, AB from November 14 to 24, 2019. On site, we completed at least 3 loops or downwind transects of the infrastructure. While surveying, the field assistant noted the number and types of equipment such as wellheads, tanks and separators on site, while gas concentration, GPS and ambient weather data were all logged to a central device automatically. Including repeat measurements, we completed 91 surveys of the 50 sites to quantify site-level emissions. Of the 91 surveys, 83 had quantifiable emissions, 5 had no emissions and 3 were inconclusive as we were unable to quantify emissions due to accessibility issues or wind direction.

The ExACT method is extremely efficient, with on-site surveys of sites taking generally 5-10 minutes to complete once on site. The density of the sites was low, with only approximately 1.5 sites per 100 km^2 in the study region. Although travel time between sites was significant, we were able to reach an average of 8 sites per day (not including the controlled release testing site which was visited daily) up to a maximum of 10 in the regions with the highest density. Table 1 breaks down the number of sites visited on each survey day and the counts of emitting, non-emitting and sites unable to be surveyed.

*Table 1. A breakdown of the number of sites visited, emitting, not emitting and sites unable to be surveyed on each survey day. *Other sites were sites which we're visited but not surveyed due to maintenance activities on site, etc.*

Survey Date	No. sites visited	No. sites emitting	No. sites not emitting	No. sites unable to get downwind	No. sites other*
Nov-14-2019	9	9	0	0	0
Nov-15-2019	7	5	1	0	1
Nov-16-2019	6	6	0	0	0
Nov-17-2019	9	9	0	0	0
Nov-18-2019	8	7	0	0	1
Nov-19-2019	9	8	1	0	0
Nov-20-2019	8	6	1	1	0
Nov-21-2019	9	8	1	0	0
Nov-22-2019	7	7	0	0	0
Nov-23-2019	10	9	1	0	0
Nov-24-2019	9	9	0	0	0
Total	**91**	**83**	**5**	**1**	**2**

We calculated the average facility level emission of the emitting sites to be 150.3 m^3CH_4/day with a range of 0.1 to 9244.2 m^3CH_4/day. Most sites had extremely small emissions, with only 13 measurements estimated over 100.0 m^3CH_4/day. The distribution of median emission rate estimates is shown in Figure 2.

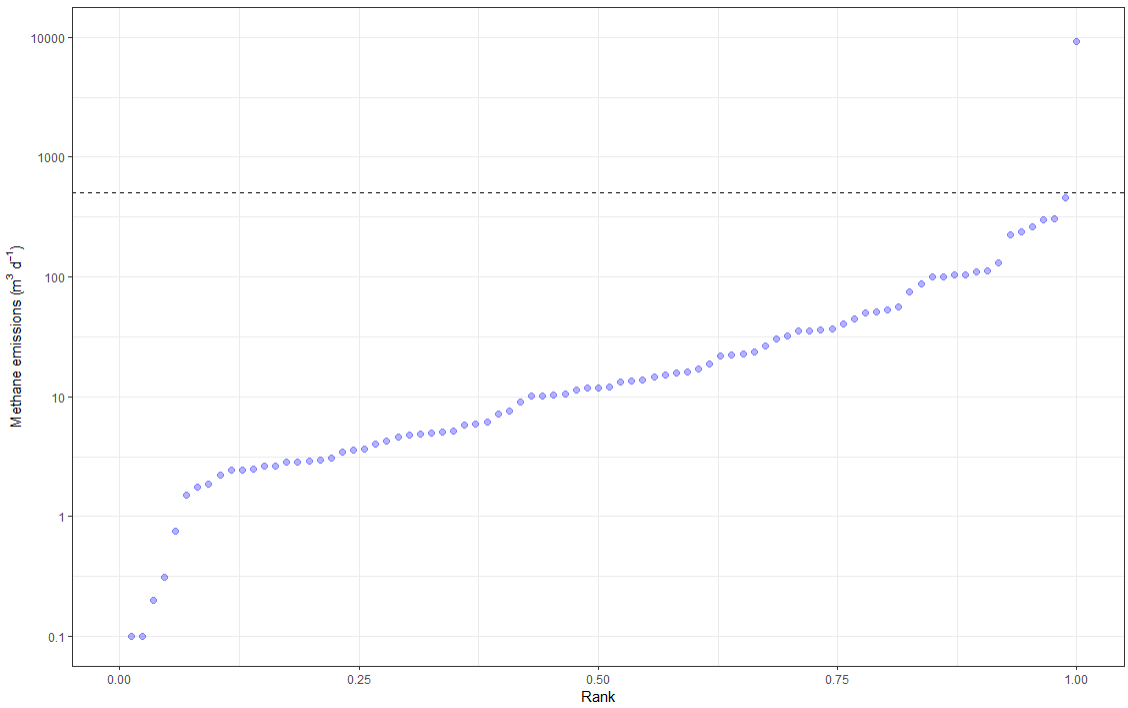

Figure 2. Median emission rate calculation for each emission survey completed. Emissions sorted by normalized rank. (Please note the logarithmic scale on the y-axis.)

The weather conditions during the study were fair, with daytime temperatures generally around the freezing mark. We were not negatively impacted by the weather during our participation and were able to monitor continuously. Although, due to snowy conditions some of the access road conditions were poor, but we were able to safely access and obtain measurements of most sites.

Controlled Release Test Site

Controlled release testing was incorporated into the daily schedule of the AMFC. Controlled release testing involved the project team releasing methane from vent stacks on site, where the emission rate was unknown to participants. Controlled releases were scheduled in the morning, noon-time, and afternoon by the project team. During the scheduled controlled release time slots the project team performed five, fifteen-minute releases at differing release rates. During the releases, we conducted our ExACT emissions surveys as we would on a production site or facility by driving around the perimeter of the lease area to ensure we transected the methane plume downwind of the source. We completed approximately 8-10 perimeter surveys during each 15-minute release. We provided an emission rate estimate to the project team for each of the 55 releases that were conducted over the 11-day AMFC field campaign. Altus plans to release a separate document outlining the performance results of the controlled release testing as the data becomes available.

LEARNINGS AND AREAS OF IMPROVEMENT

Infrastructure Geolocations:

Complete and accurate infrastructure location files are vital to the ExACT process. The attribution and quantification calculations are highly sensitive to missing or incorrect infrastructure location data. Infrastructure location errors as small as 1-5 meters can impact emission rate quantification results by 3-4 orders of magnitude (i.e. 1,000,000 m^3CH_4/day instead of 100 m^3CH_4/day). By using updated and accurate

geolocation data, provided by regulators or operators, rather than estimated locations, we can improve the accuracy of ExACT's emission attribution and quantification.

Additionally, the capabilities of vehicle-based technologies that use continuous-monitoring sensors, like ExACT, can be maximized by providing additional geolocations of proximal sites or all sites within a target development. Currently, any gas data collected from sites without geolocation data is not considered, as the plume dispersion model requires an input for the source location. However, the gas concentration data is retained in the raw files, giving us the ability to reprocess pre-existing survey data if it becomes available in the future and can attribute these plumes to sources that were not initially available.

Emission Source Height:

On-pad and close-proximity measurements of sites with infrastructure of significantly varying heights can create potentially over-inflated emission rate estimates. This is due to close-proximity measurements being outside of the typical assumed geometry of the Inverse GPD model used by many vehicle-based measurement techniques. Some sources are too tall to be picked up by close-proximity measurements and will be better measured using ExACT at distance. To date, manual analysis is done on a case by case bases to include only infrastructure pieces that are within the appropriate measurement area when quantifying a sites emission rate. Such analysis prevents improper quantification and may be combined with measurements at greater distances for whole site measurements. Altus is actively building analysis tools into ExACT's automated scripts as a form of quality assurance.

Controlled Release Testing:

The controlled methane release testing data will be utilized as a true field-representative experiment for ExACT. The measurement, interpretation, and calculations involved will encompass all potential sources of uncertainty within the ExACT process, where-as prior inhouse controlled gas releases could not account for on-site source location and height variability. This is largely due to the AMFC blind releases being protected by a third party; and will allow for an all-encompassing emission rate calculation uncertainty value to be derived for the measurement scenarios represented at the AMFC. These defendable and all-encompassing uncertainty values will allow for bootstrapping statistical analysis that will provide insight on the relationship between measurement repetition (or stacking) and measurement accuracy and precision. This data-driven insight is invaluable when designing surveys to fit a client or equivalency model's needs.

The outcomes of the AMFC controlled release experiment will be:

1. A clearly defined ExACT emission rate calculation uncertainty value that encompasses all potential sources of uncertainty, for multiple field-representative measurement scenarios.

2. A quantified relationship between measurement repetition and calculation accuracy/precision. This will show the positive or negative impacts of increasing or decreasing the number of measurements required for a single emission rate estimation.

COST IMPLICATIONS

When evaluating our costs, we looked at the pre-planning, field and post-processing costs of the project. Our pre-planning costs were low, as expected, as site access and schedules were pre-arranged. This project highlighted that we have a high level of confidence in our field pricing and the time it takes to execute field work. From this project, we foresee the possibility of additional costs in data processing and reporting.

The amount and quality of infrastructure data available is an important factor impacting post-processing cost. Where we have comprehensive information about the facilities, equipment and their geolocations,

Altus can provide not only more comprehensive, accurate data product, but it can be prepared more rapidly. Where data is lacking, the quality infrastructure source files may be compromised, necessitating additional data collection and manual adjustments, which is time consuming and costly. Obtaining current, complete and accurate infrastructure databases is a challenge faced by operators, regulators and emissions monitoring service providers alike. We will consider the additional time and cost to deal with infrastructure files in future projects.

Flexibility is an important factor in the implementation of any new approach or procedure. Based on our participation in the initial phase of the AMFC we were able to proactively update our data outputs were to include parameters such as distance to source, weather conditions, etc. In the first phase, more time was required for post-processing and data entry than initially expected. However, those additional data products are now integrated into our processing and reporting procedure, these additions did not add any extra costs to reporting.

DATA PRODUCT EXAMPLE

ExACT is offered as a technology-as-service product. We provide products which are tailored to client needs and may vary from client-to-client. ExACT survey products include volumetric methane emission rates (m^3CH_4/day) on a per-facility basis, accompanied by key information such as monitoring time, UWI, Facility ID code, latitude, longitude and operator information tied to each measurement.

Figure 3 is an example of the data interactive report produced by ExACT. Producers can view survey routes driven by the ExACT truck, methane heat maps to visualize hot spots and graphs of emissions. All tables can be downloaded for record keeping and reporting. Using the emission rate estimates we can highlight sites which may be exceeding regulatory limits, need follow up, or are compliant. We can also include information on sites that are not emitting, maximum above-ambient concentration enhancement of CH_4, distance to emission source and weather conditions at the time of monitoring.

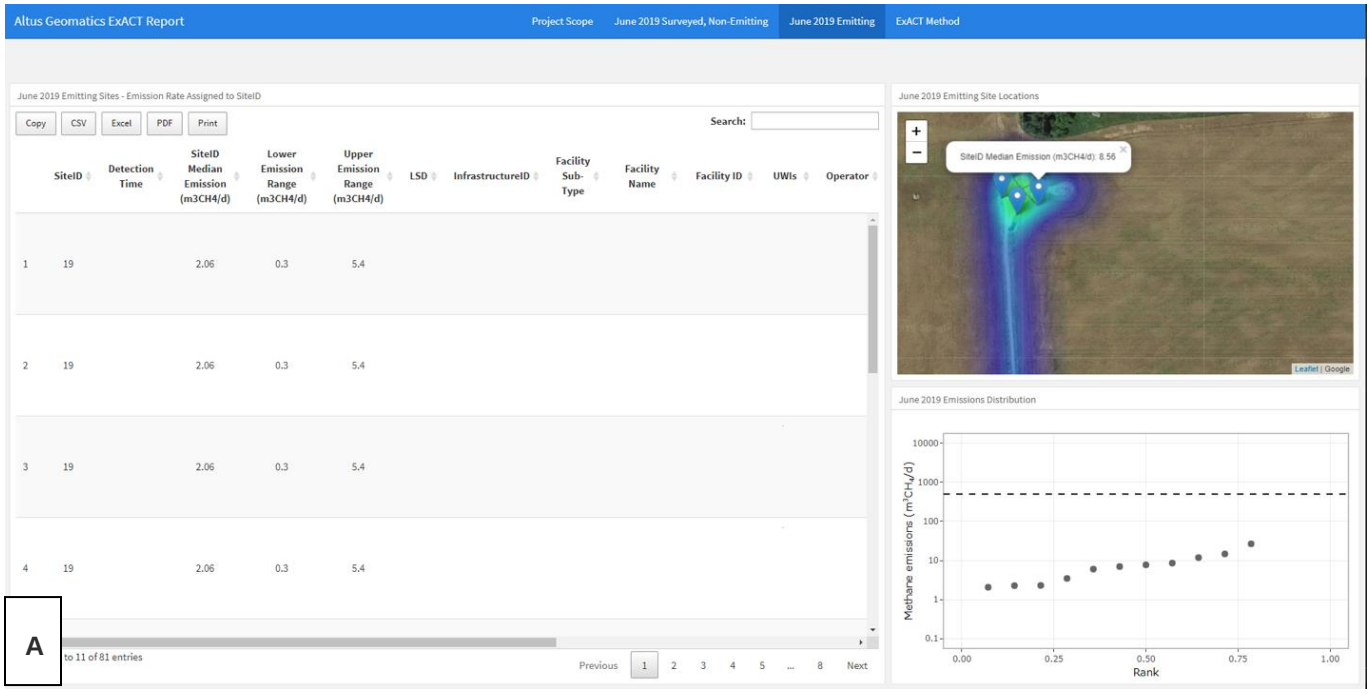

Figure 3. ExACT interactive report example. (A) Displays the table on the emitting sites, heat map and emissions distribution graph. (B) Is a zoomed in image of a heat map displaying methane relative methane concentrations on site.

REFERENCES

Baillie, J., Risk, D., Atherton E., O'Connell, E., Fougere, C., Bourlon, E., Mackay, K. 2019. Methane emissions from conventional and unconventional oil and gas production sites in southeastern Saskatchewan, Canada. Environ. Res. Commun. 1 011003

Climate Leadership Plan. (2018). Implementation Plan 2018-2019. Retrieved from https://open.alberta.ca/dataset/da6433da-69b7-4d15-9123-01f76004f574/resource/b42b1f43-7b9d-483d-aa2a-6f9b4290d81e/download/clp_implementation_plan-jun07.pdf

Government of Alberta (2019). Reducing Methane Emissions. Retrieved from https://www.alberta.ca/climate-methane-emissions.aspx

McGlade C. (2019). Methane Emissions from Oil and Gas: Tracking Clean Energy Process. International Energy Agency. Retrieved from https://www.iea.org/tcep/fuelsupply/methane/

National Energy Board. (2019). Provincial and Territorial Energy Profiles-Alberta. Retrieved from https://www.neb-one.gc.ca/nrg/ntgrtd/mrkt/nrgsstmprfls/ab-eng.html?=undefined&wbdisable=true

Natural Resources Canada. (2019). Energy and Greenhouse Gas Emissions (GHGs). Retrieved from https://www.nrcan.gc.ca/science-and-data/data-and-analysis/energy-data-and-analysis/energy-facts/energy-and-greenhouse-gas-emissions-ghgs/20063

O'Connell, E., Risk, D., Atherton, E., Bourlon, E., Fougere, C., Baillie, J., Lowry, D., Johnson, J., 2019. Methane emissions from contrasting production regions within Alberta, Canada: Implications under incoming federal methane regulations. Elem Sci Anth, 7(1), p.3.

US EPA Air Quality Assessment Division, 2018. EPA handbook: optical and remote sensing for measurement and monitoring of emissions flux of gasses and particulate matter, publication no. EPA-454/B-18-008. (https://www.epa.gov/sites/production/files/2018-08/documents/gd-52.v.2.pdf)