Aerometrix Inc.

Alberta Methane Field Challenge (AMFC)

Final Report

June, 2019

Prepared by: Dr. Michael J. Whiticar
President, Geochemical Analytic Services Corp
(Aerometrix Inc. CEO and GHGMap PI)
2355 Lincoln Rd., Victoria, BC, Canada, V8R 6A3
Tel: 250 744 0007, email: whiticar@gas-co.ca

Prepared for: Lorie Mayes
Environmental Research Coordinator
PTAC Petroleum Technology Alliance Canada
Suite 400 Chevron Plaza, 500 - 5 Ave. SW, Calgary, Alberta, Canada, T2P 3L5
Tel: 403-218-7707, email: lmayes@ptac.org

Date: July 30, 2019

1. Participants

The GHGMap and Aerometrix Inc participants in AMFC study were:

Dr. Michael J. Whiticar – GHGMap project PI and Aerometrix Inc. CEO, Canada
phone: 250 744 0007, email: whiticar@uvic.ca
Derek Hollenbeck – U. California, Merced, Mechanical Engineering, USA
phone: 209 898 5633, email: dhollenbeck@ucmerced.edu (member field team)
Philip Reece –InDro Robotics Inc. CEO and Aerometrix Inc. COO, Canada
phone: 250 931 3933, email: philip@indrorobotics.com
Brad Billwiller – InDro Robotics Inc. Canada
phone: 250 931 3933, email: brad@indrorobotics.com (member field team)
Carlos Salas – Exec VP and CSO Geoscience BC, Canada
phone: 604.662.4147 ext. 28, email: salas@geosciencebc.com
Dr. Lance Christensen – NASA/JPL, Pasadena, USA
phone: 818-237-7510, email: lance.e.christensen@jpl.nasa.gov

2. Objective

There is a strong and identified need to provide cost and logistically effective solutions that can rapidly and reliably measure natural and fugitive gas emissions associated with upstream oil and gas operations, such as wellheads, compressor stations and pipelines. Our participation in the Alberta Methane Field Challenge (AMFC) in June 2019 was designed to comprehensively demonstrate our GHGMapper™ system as a substantial improvement to the standard, conventional Leak Detection and Repair (LDAR) and Optical Gas Imaging (OGI) methodologies. The goal was to deploy our GHGMapper™ system over two weeks at a wide range of O&G facilities in the Rocky Mountain House region of Alberta. We successfully accomplished this at 50 sites with a range in leak types and intensities at each.

Our GHGMapper™ system quantitatively measures the gas mass fluxes. We can pinpoint locations and intensities. Distinguishing the location and magnitude sources of any gas anomalies is more of a definition of the emission parameters than a measurement limitation. Obviously, if a leak is intermittent, then our GHGMapper™ must be operating during such an emission to detect it.

Since 2017, through the GHGMap project, we have previously conducted 13 field trials using our GHGMapper™ system. We have measured multiple natural gas processing plants and wells, pipelines, landfills, sewage treatment plants and gas distribution facilities, cattle and dairy farms. Some of our 2017 and 2018 activities are described in our 2 publications (Whiticar et al., 2018 and 2019).

Whiticar, M.J., Christensen, L.E., Salas, C.J. and Reece, P. (2018): GHGMap: novel approach for aerial measurements of greenhouse gas emissions, British Columbia; in Geoscience BC Summary of Activities 2017: Energy, Geoscience BC, Report 2018-4, p. 1–10

Whiticar, M.J., Christensen, L.E., Salas, C.J. and Reece, P. (2019): GHGMap: detection of fugitive methane leaks from natural gas pipe-lines, British Columbia and Alberta; in Geoscience BC Summary of Activities 2018: Energy and Water, Geoscience BC, Report 2019-2, p. 67–76.

3. Technology Description

Our GHGMapper™ system uses our high sensitivity laser spectrometer sensor on a small UAV drone to make mapping surveys and flux determination of specific gases (Whiticar et al., 2018 and 2019). In addition, we have pioneered the use of sonic anemometry to create two-dimensional flux-planes "Gas Flux Curtains™" to provide quantitative cross-sectional mass transport measurements of gases on well and facility dimensions.

Our GHGMapper™ system only needs manual intervention at the start and end of the flights. The data is streamed in real-time to our base station. Our system does not need line-of-sight for the detection. However, for the AMFC we exclusively used VLOS operation of the sUAV.

The GHGMapper™ system provides instantaneous measurement and data streaming. The software is designed to provide immediate feedback and back-trajectories to target leaks. This approach has already been successfully employed by several natural gas companies we have worked with in NE BC.

For the AMFC, our GHGMapper™ system was configured only to measure methane. However, our technology can also be configured to measure other smaller gas species, e.g., ethane, carbon dioxide, hydrogen sulphide, and ammonia, etc.

Most importantly, our GHGMapper™ system is a quantitative method. We measure calibrated, true mass fluxes. Furthermore, the mobility of our method allowed us during the AMFC to easily and safely access facility infrastructures that may otherwise present challenging HSE constraints. In addition, our aerial methodology demonstrated during the AMFC quick, efficient and therefore cost-reducing operations.

4. AMFC Participation

The GHGMap and Aerometrix Inc team participated in the complete AMFC study. Including on-site mobilization, demobilization, training, travel, surveying and daily reporting, we were active on the AMFC project for 15 days from June 08, 2019 to June 22, 2019. In addition, we spent 3 days pre-survey preparing and packaging the equipment, and 6 days post-survey with data processing and reporting.

During the actual AMFC surveying we visited 50 sites over 10 days.

5. Learning from Participation

Although in our GHGMap program we had already conducted and gained experience from several similar surveys in BC, Alberta and in the USA, the AMFC provided us with

the opportunity to showcase the capabilities of our GHGMapper™ system.

Our primary lessons learned are:

1. logistics required to conduct multi-week operations,
2. logistics required to conduct multiple surveys on different sites during a daily operation,
3. develop a more streamlined data processing and reporting workflow.
4. requirement to adapt operations and requirements to different clients and facilities

6. Areas of Technology Improvement

Although several minor changes were identified for our GHGMapper™ system, the two primary areas of improvement that we are currently addressing are:

1. ability to make real-time, on-board sUAV wind field measurements by sonic anemometry
2. Real-time gas flux calculations and reporting workflow simplification.

7. Cost Implications

Our forward calculations for the cost of operations for similar surveys has not changed. However, we are examining options to enhance the workflow and operations that could lead to some time and therefore cost savings.

8. Example of Data Product

GHGMap/*Aerometrix Inc.*
Data Report: Site 23

Pilot: **Brad Billwiller** **Date: 06/20/2019**
Observer: **Derek Hollenbeck**

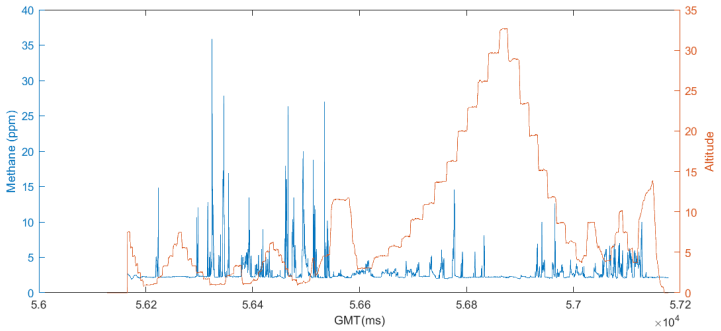
Weather

Wind Speed (m/s)	Wind Dir. (deg)	Temperature (C)	Pressure (kPa)	Rel. Hum. (%)
5.4 ± 1.8 m/s	$-48° \pm 14°$	6.8	89.77	90

Flight Overview

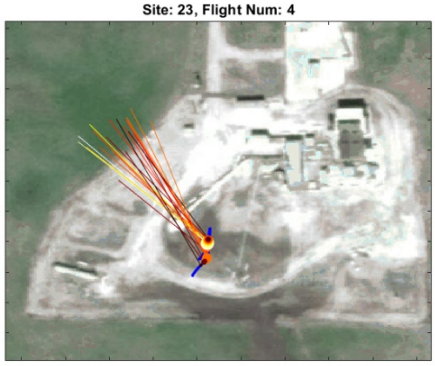
The survey started on west side by the propane tank and worked towards the east. There were five curtains conducted on the site.

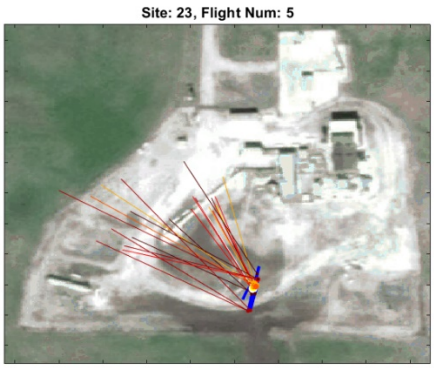
Elevated Methane

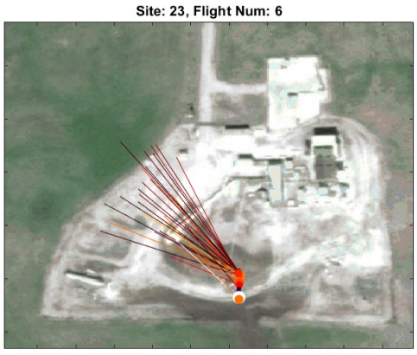


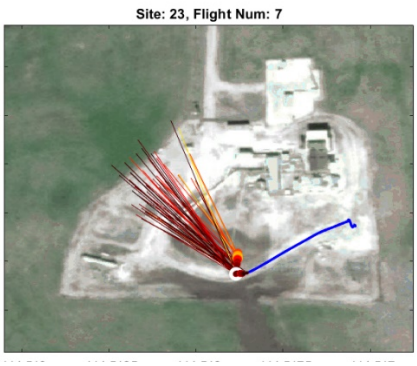
Heat Maps

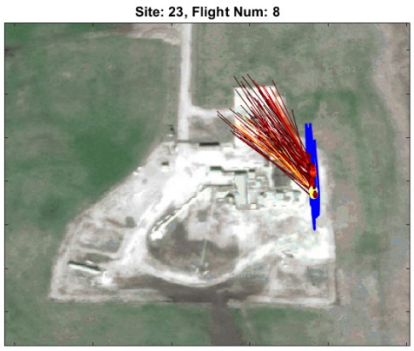
Hits indicated on map as overlaid colored circle (larger and hotter color indicate larger hit) and wind vector pointing in direction of the wind.





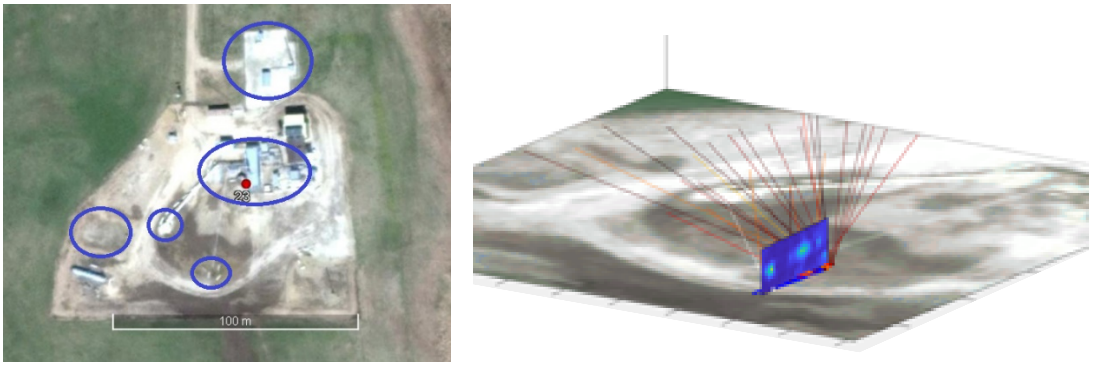






Methane Anomalies Localization

The curtain points toward several pieces of equipment on this site. Starting the survey on the west and moving east. The first curtain showed a very low-lying weak emissions leak coming from the underground tanks to the west. The next curtain showed the tank to the south west. When inspecting the well head to the south the wind was in line with the south west tank. The emission seemed to go around the south well head building and appear on either side. The next curtain captured emissions coming from the northern pipeline and surrounding buildings. The last curtain captured emissions from various sources in the center/east side of the site.

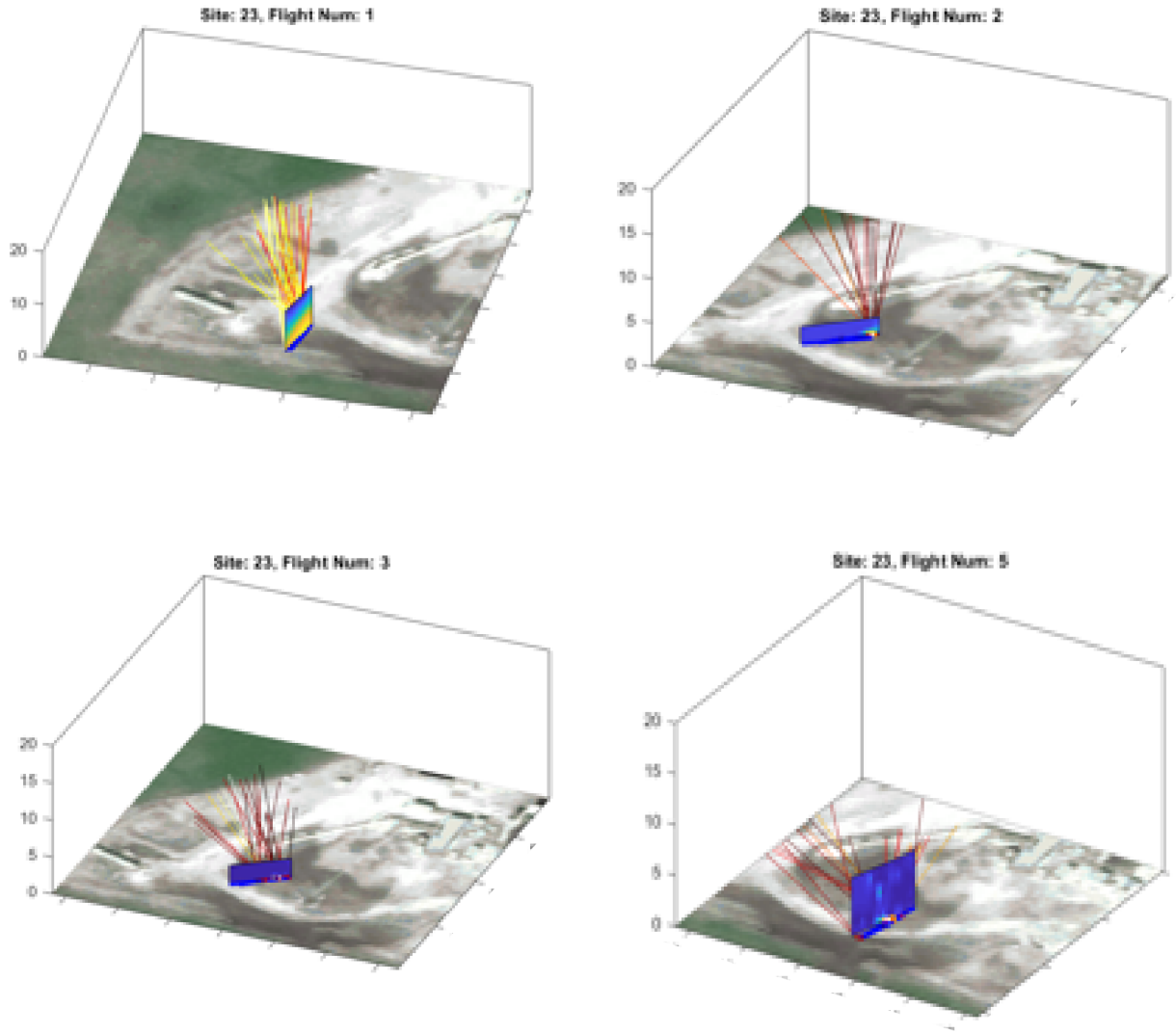


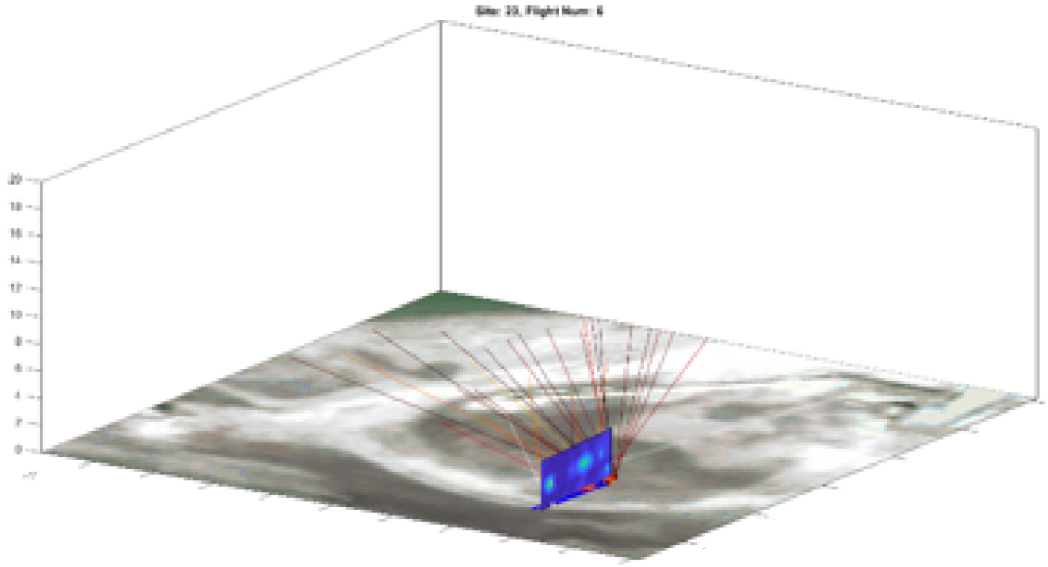
Note: as requested for this report, to anomalize the locations, the geographic positions have been removed and the image resolutions have been reduced

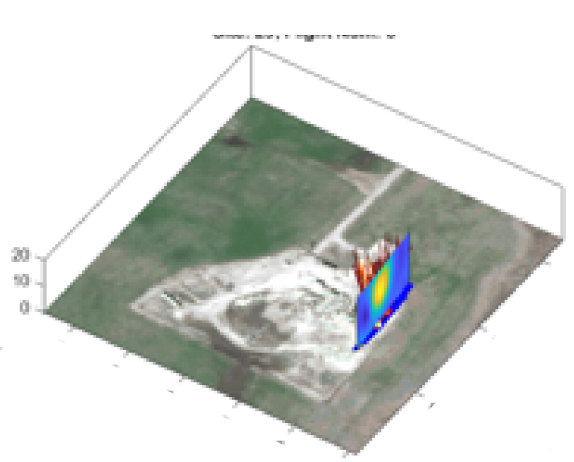
Methane Emissions

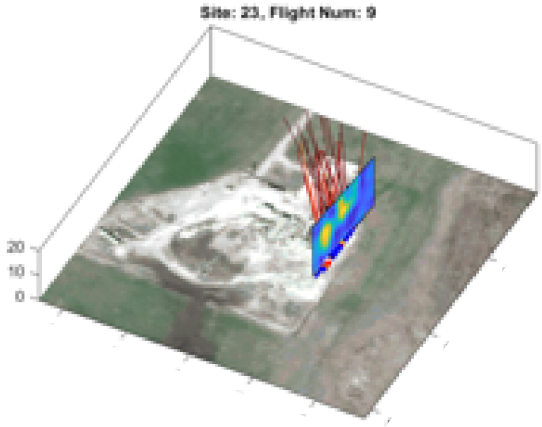
Flight 1: 2.9 ± 0.9 SCFH W underground tank
Flight 2: 10.3 ± 2.9 SCFH SW Tank
Flight 3: 23.6 ± 8.4 SCFH SW Tank
Flight 5: 30.6 ± 9.8 SCFH S Well head (maybe SW Tank)
Flight 6: 40.4 ± 10.8 SCFH S Well head (maybe SW Tank)
Flight 8: 203.3 ± 74 SCFH NE pipeline/buildings
Flight 9: 206 ± 67.8 SCFH NE pipeline/buildings
Flight 3: 61.8 ± 12.2 SCFH E tanks/buildings

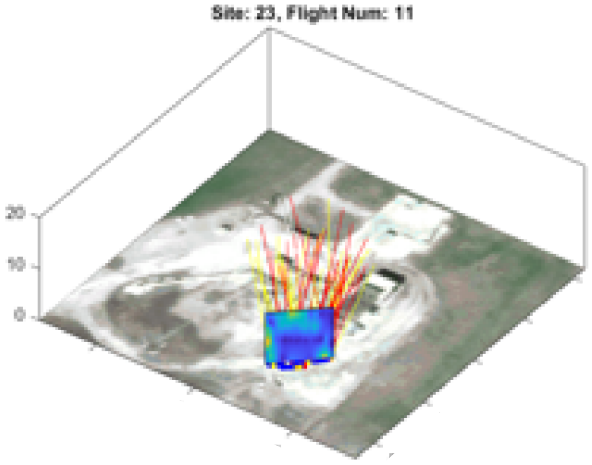
Methane Flux Curtains








Site: 23, Flight Num: 9


Site: 23, Flight Num: 11