Sincere thanks to all our 2018 project partners and collaborators. As you are aware, our FluxLab research group at St. Francis Xavier University specializes in gas measurement, geochemistry, tracers, sensor techniques and computation. Our expertise is applied in ecological research and in the oil and gas sector. Please enjoy this collection of FluxLab Research Highlights from 2018.

Dave Risk PhD
Methane in the Mackenzie Beaufort Delta

With support from the Northwest Territories Environmental Studies Research Fund and a partnership with Ronald Layden at the Aurora College, we participated in a pilot study to measure natural methane emissions in the Arctic. Research began in the spring with truck-based and snowmobile-based surveys of the Mackenzie River Delta. We discovered permafrost melt-related anomalies, in addition to natural geological seepage. The methods and hardware developed during this project will help expand the reach and application of mobile surveying. **Lead: Daniel Wesley**

Gas Emissions Projects

**Aquistore: Carbon Capture and Storage**

We renewed our contract with the Petroleum Technology Research Center to carry out the surface soil gas Measurement, Monitoring, and Verification (MMV) program at Aquistore, a Carbon Capture and Storage site. We published a manuscript in *International Journal of Greenhouse Gas Control* and another is in progress that should benefit MMV programs at all CCS sites. **Lead: Nadia Tarakki**

**Autonomous Arctic soil gas sampler**

We worked with UNI Research Climate to refine and improve an automated methane and carbon dioxide soil gas sampling system that we built and deployed last year. The system measures soil gases at depth from a permafrost thaw site in northern Norway. **Lead: Renee McDonald, Sara Murrin**
We published several papers this year that were authored by outstanding FluxLab alumni and extended team: Liz O’Connell’s Methane emissions from contrasting production regions within Alberta, Canada: Implications under incoming federal methane regulations in Elementa; Chris MacIntyre’s Processes driving the soil CO$_2$ temporal variability in Antarctic Dry Valleys in Geoderma; Laura Graham’s Explaining CO$_2$ fluctuations observed in snowpacks in Biogeosciences; Lyndsay Spafford’s Spatiotemporal Variability in Lake-Atmosphere Net CO$_2$ Exchange in the Littoral Zone of an Oligotrophic Lake in Journal of Geophysical Research: Biogeosciences; and James William’s Atmospheric impacts of a natural gas development within the urban context of Morgantown, West Virginia in Science of the Total Environment.

**Gases in Natural Waters**

**Diving further into ground water methane.**

Elevated groundwater methane concentrations are often found in coal-bearing areas. In this Natural Resources Canada project, led by Dalhousie University, we sampled 95 water wells in Nova Scotia to examine methane occurrence in groundwater, and its origin. We also used mobile and atmospheric methane surveys to determine if any methane from groundwaters was seeping to the surface through gas migration pathways. **Lead: Kim Taylor, Owen Sherwood, Grant Wach**

**Spatially and temporally resolved marine surface water measurements**

Methane concentration in seawater is an indicator of natural gas seepage from the sea floor, which may be of biologic (natural) or thermogenic (deep reservoir) origin. Memorial University and StFX are in early stages of designing a surface water measurement system that we will use to continuously map methane, carbon dioxide, and isotope signatures in surface waters offshore Atlantic Canada. This work will be the first of its kind in the area, and it will help understand regional patterns, identify hotspots, and it will provide a means of monitoring offshore oil and gas infrastructure. **Lead: Katlyn MacKay, Lesley James**
Methane sensing from vessels of opportunity

For a change of pace this year, we deployed a gas measurement suite on someone else’s truck. In this case, it was a wellsite operator who moves continually during his work day. Without being onsite, we had a window into service-related emissions, unexpected fugitive emissions from infrastructure, and plumes coming across fenceline. As the system continues to measure through the winter of 2018/19, we will refine the setup, and in particular its computational processing infrastructure. **Lead: Issac Ketchum, Evelise Bourlon**

Refining truck-based detection

With support from NSERC and Altus Geomatics, we’ve advanced our truck-based methane measurement approach called ExACT. Recent achievements include: 1) in-truck software to detect and size plumes in real time; 2) developing uncertainty factors for on-road plume detection and quantification; and 3) a better understanding of how truck-based surveying compares to conventional well-pad monitoring techniques. Altus Geomatics is actively using the technique in its work for clients. **Lead: Jennifer Baillie**

Real-time methane leak detection and visualization

With Atlantic Innovation Fund support, we developed software that analyzes our ExACT mobile methane survey data in real-time, detects leaks, attributes them to probable sources, and estimates emission rate. The software includes an interactive web map that helps our technicians quickly sniff out plume sources and the software helps us collect field data that is more definitive and meaningful. **Lead: Billy Garrison**

Reducing uncertainties in dispersion measurement

As Canadian O&G emissions regulations on methane come into effect, we need to reduce measurement uncertainties. Emission rate measurements made from trucks are more accurate when source height is known, which is rare. Leveraging our understanding of plume geometry, we are creating algorithms that help us solve for this missing variable. We conducted controlled gas release experiments at the Carbon Management Canada Research Institute field site to help us fine tune our computational model. **Lead: Jack Johnson**

Conventional well pad methane measurement vs truck-based

ExACT is a vehicle-based survey method used to detect methane and other gases that is used in conjunction with close-range OGI or Method 21. To determine the pass-off scale between them, we completed controlled release experiments. We will use the results of controlled releases to validate and refine our method, and to understand how various methane measurement methods can work together in smart triage-based monitoring programs. **Lead: Jennifer Baillie, Evelise Bourlon**
Methane emissions from legacy oil wells & mitigation potential in Atlantic Canada

In Atlantic Canada, historic fossil fuel extraction has left behind thousands of abandoned (and in some cases) reclaimed sites. The aim of the multi-university Gas Seepage Project was to determine whether these legacy sites emit methane to the atmosphere, as they likely did at the time of abandonment. Using multiple measurement approaches, we conducted surveys to look for methane emissions across a large population of legacy oil and gas wells in New Brunswick, and legacy coal mine adits in Nova Scotia. We apparently benefit from time, and geology, since we found only a few impacted sites - luckily none with significant emissions. Dalhousie University, Natural Resources Canada, Lead: James Williams, Grant Wach

Top-down and bottom-up emission inventories

In July our team conducted mobile methane surveys within Lloydminster and Peace River CHOPS developments to supplement fly-over surveys conducted in the same area by Environment and Climate Change Canada to ground truth and build top-down and bottom-up inventories. A ‘screening’ truck captured regional methane, while a ‘detail’ truck used a secondary analyzer suite plus an optical gas imaging camera to determine emission source locations. This data is useful for the development of emissions mitigation policies and improved inventories that are more reflective of true emissions. Lead: Jennifer Baillie, Liz O’Connell

Fugitive and vented emissions surveying on the Weyburn CO₂-EOR field

For many years we have been measuring soil gases and atmospheric emissions on the Weyburn Enhanced Oil Recovery field, formerly owned by Cenovus and now by Whitecap Resources. Fugitive and vented emissions are low here in comparison to other O&G developments, due to a combination of design factors and best practices. Plus, the operation stores >1M tons of carbon dioxide annually. We’re pleased to be wrapping up measurement projects onsite with sponsors including Cenovus Energy, Natural Resources Canada, the Natural Sciences and Engineering Research Council, and the Nova Scotia Government. And, we’re excited to be starting new projects with the great team at Whitecap, who recently called attention to our work in their 2018 Sustainability Report. Lead: Katlyn MacKay
A history of measurement innovation

In the summer we continued our long-term work at the Whitecap Resources Weyburn oilfield. We used our sniffer truck to screen for produced and injected gases, as we have been doing since 2013. Our 'ExACT' truck-based measurement technique was developed, tested, and awarded on this field. We love working here in part because emissions are so low, challenging us to detect better. This year at Weyburn we once again worked with innovative measurement approaches. We used an Eosense eosAC computer-controlled gas flux chamber tethered to our instrumentation to screen sites for, and confirm absence of, gas migration (GM). Lead: Katlyn MacKay

Denver-Julesburg Basin Methane sourcing & attribution

A manuscript is currently in the works with research results from a partnership with National Oceanic and Atmospheric Administration and Institute of Arctic and Alpine Research. The study used mobile surveying to compare different methane emission source types in a complex multi-use landscape, and our computational techniques helped to derive meaning from the complicated dataset. Stay tuned for the publication!

Fugitive and vented emissions in Alberta energy developments

In a follow-up project to last year’s Petroleum Technology Alliance of Canada Alberta Upstream Petroleum Research Fund project, we conducted new methane screening surveys in Lloydminster and followed the same routes as in 2016, enabling us to observe changes in emissions over time. Dave Lowry of Royal Holloway University in London took bag samples downwind of plumes to support our analysis. A paper from this project was recently published in the journal Elementa. The Natural Science Engineering Research Council has also supported this work. Lead: Liz O’Connell, Dave Lowry

Distinguishing biogas emissions

As founding members of the Biogas Collaborative Working Group (BCWG) at the University of Vermont we’re helping develop sensors and geochemical approaches that detect and prove leaks from renewable natural gas (RNG) facilities where biodigesters convert livestock manure into RNG. This form of natural gas is harder to detect definitively, so leaks are more likely to go unnoticed. This work will help contribute to safe and economical production and distribution of RNG, and decrease reliance on fossil fuels. Lead: Dave Risk

Shale gas risk assessments in the UK

We’re excited to be part of a new British Geological Survey project called EQUIPT4RISK. Awarded as part of the £8 million Natural Environment Research Council research program on unconventional hydrocarbons in the UK, this project will investigate surface and near-surface processes that affect pollutant behaviour in water and air, and earthquake hazard associated with shale gas development in the UK, with an eye towards cumulative, long-term, and regional effects. Lead: Dave Risk
Methane leak detection using multispectral and hyperspectral imagery

Working with Cenovus Energy, with support from Petroleum Technology Alliance of Canada and Natural Resources Canada, we validated airborne methane detection techniques. We built approaches to mimic those of commercial providers and tested those in experiments, using real aircraft and satellite data. We investigated seasonal performance and limits of resolution. Under optimal conditions, satellite measurements can detect only the largest of oilfield emissions. Newer and better satellite and airborne systems are coming, and to realize their full technical and business potential, we also need to build novel retrieval and processing algorithms. We are now working with Bluefield on experimental design and third party testing of their new air- and space-borne sensors. Lead: Billy Garrison, Evelise Bourlon

Improving vehicle-based anemometer measurements

Using our inventory of truck-based anemometer measurements and new field tests, we explored new ways of improving wind measurement quality from mobile systems. We developed a systematic method to compensate for anemometer placement on the vehicle, and several quality control and spatial filters. We have one manuscript currently in peer review, and another ready to go. Thanks to ANSYS, Compute Canada, and the Garmin Canada Aero Team for software, infrastructure, and insights. Lead: Tara Hanlon

Truck-based anemometers for fuel efficiency

As an extension of previous wind measurement work, we’ve begun to explore opportunities in the transport sector. About half of a vehicle’s fuel is spent pushing air. This year we worked with Classic Freight to measure winds experienced by a truck in highway environments. These data, along with computational fluid dynamics modelling helped us develop a cruise control algorithm that could reduce fuel consumption in the transportation sector. This work goes hand in hand with our goal of reducing greenhouse gas emissions in Canada. This work was supported by StFX University Council for Research and the Wallace Family Internship. Lead: Connor McCabe, Jenny Bowie, Meghan Flood
Coordinated industry effort on methane emissions

The **Fugitive Emission Management Program Effectiveness Assessment Study** (FEMP-EA) is a new methane initiative from the *Petroleum Technology Alliance of Canada* and *Canadian Association of Petroleum Producers*. We’re supporting this large project by building context. There is a degree of uncertainty on actual methane emission levels in developments across Alberta so we’re bringing together measurements we’ve made, combining those with other available data, ultimately to be combined with FEMP-EA measurements. This will help us better understand FEMP-EA scalability, so we can understand how the results apply to other sites across Alberta. **Lead: Dave Risk**

Statistical Analysis of Oil and Gas Field Measurement Data

We’re working with *Environment and Climate Change Canada* to perform a statistical analysis of methane measurements from oil and gas developments across Canada. This work will help understand the uncertainty on Emission Factors (representative emission rates associated with various infrastructure types). By compiling measurements from numerous developments, we’re gaining a better understanding of how methane emissions vary across the Canadian oil and gas landscape. **Lead: Emmaline Atherton, Martin Lavoie**
**Arolytics launches in 2018**

This Halifax- and Calgary-based spin-off was co-founded this year by Liz O’Connell, Emmaline Atherton, and Dave Risk. Building on extensive experience with alternative measurement technologies, the Arolytics team is helping industry plan, secure approvals for, and implement **more efficient methane leak detection and repair programs**. Arolytics is also building cloud software that uses GHG data to **dynamically predict the impact of air toxic pollutants**, for stakeholder management. In late 2018, Emmy and Liz moved full-time to Arolytics.

**Eosense moves on sensors, gas migration tools**

Eosense is a leading manufacturer of gas sensor equipment, launched from this lab nearly a decade ago. From its base in Dartmouth, it is one of the main providers worldwide for scientific soil gas measurement hardware. With help from the **Natural Sciences and Engineering Research Council**, we are working with Eosense to develop new low-cost in-situ gas detection analyzers for applications in oil and gas. We are also working extensively on projects to improve measurement of Gas Migration. In another project sponsored by the **National Research Council**, we’re using our gas transport modeling expertise to help with instrument design. Long-time FluxLab tech-spert Alex Marshall moved to Eosense this year.

**Supporting Altus Geomatics**

**Altus Group** and StFX have a technology collaboration agreement to improve vehicle-based methane detection, for example, through improved wind measurement or new real-time software. This year Altus started commercial truck-based emission survey projects for O&G clients who are preparing for upcoming federal regulation. To embed know-how and experience within the company, Jennifer Baillie recently moved from the FluxLab to become the GHG Emissions Monitoring Coordinator at **Altus Geomatics**. In her new role, Jennifer integrates the technology with their diverse service offerings, and supports the needs of current and future clients. It’s been a pleasure working with the Altus team in 2018.
In closing

We are appreciative of our many valuable project partners and funders in 2018, including those unnamed in this newsletter. These partnerships are important, particularly for methane reduction in the oil and gas sector. We’re happy to announce that in 2018, Altus Geomatics began exclusively providing our truck-based surveying in commercial projects. Now that our people spend less time behind the wheel, we’ve been able to re-focus on computational emissions research, reducing uncertainty, and improving and streamlining measurement methodologies. We’ve been able to push a myriad of other projects in 2018 - including major gas migration measurement initiatives with Eosense, two satellite projects, and data analytics projects with PTAC, ECCC, and others. This year we also reached beyond the lab, and three members of the group launched Aryolytics Inc. This new company commercializes our expertise in emissions data, to help companies better measure, track, and interpret their emissions. We value your continued support. Our team of researchers at St. Francis Xavier University looks forward to working with you in 2019!

Dave Risk PhD (Team Lead)
Chelsie Hall BA BEd PMP (Projects Manager)