From: Chris Alemany <chris_alemany@portalberni.ca>
Date: October 10, 2017 at 3:05:19 PM PDT
To: Keith Wyton <wyton@shaw.ca>, Kelly Gilday <kelly_gilday@portalberni.ca>, "Earle N ENV:EX Plain" <Earle.Plain@gov.bc.ca>, Chris Alemany <chris_alemany@portalberni.ca>, Patty Edwards <pledwards@shaw.ca>, Larry Cross <Larry.Cross@catalystpaper.com>, H & J Carlson <judyharoldc@shaw.ca>, Gary Swann <gwswann@shaw.ca>, jarretts <jarretts@shaw.ca>, "ashley.popovich@catalystpaper.com" <ashley.popovich@catalystpaper.com>, Andrew McGifford <andrew.mcgifford@acrd.bc.ca>, "Jade.Yehia@viha.ca" <Jade.Yehia@viha.ca>, "stephanie.bruvall@viha.ca" <stephanie.bruvall@viha.ca>, "kazuhiro.takeuchi@viha.ca" <kazuhiro.takeuchi@viha.ca>, "jolleen@hupacasath.ca" <jolleen@hupacasath.ca>, "Steve@hupacasath.ca" <Steve@hupacasath.ca>, Keith Hunter <firstnationswildcrafters@shaw.ca>
Cc: John Jack <john.j@huuayaht.org>, Josie Osborne <Osborne@tofino.ca>
Subject: Re: Letter of Support: Neighbourhood Air Quality Research

Note: The letter of support is to a "Dr. Vaugeois", but the actual request is from the VIU Applied Environmental Research Laboratories group at VIU lead by Erik Krogh.

On Oct 10, 2017, at 2:56 PM, Chris Alemany <chris_alemany@portalberni.ca> wrote:

Dear AQC members, and ACRD Board

I have had a rather last minute request for support come from a group at VIU called the Applied Environmental Research Laboratories. They are trying to do a year long PhD research campaign on airborne pollutant mapping at the neighbourhood level and they are looking for matching funding from regional districts or cities to do that research on Vancouver Island. It is quite an exciting initiative involving local researchers wanting to do their work in local communities with state-of-the-art technology.

The ask is only for a letter of support (attached) that indicates a commitment to consider $7000 in funding to the research. They are asking other regional district as well to create a pool that would be matched by VIU and the Federal Government. The actual decision on funding can be made in due course after fully consulting with the people involved. In our case, since the AQC would be the likely body that would work with the group, I suggested it would make the most sense to have that monetary ask go to the ACRD.

Unfortunately, they need a letter of support very quickly, before Monday the 16th of October. I have attached some background documents as well as a draft letter of support.

I am going to bring this to City Council tonight (Oct 10) to ask that the City advocate for that ask at the ACRD meeting tomorrow (Oct 11).

If any of the AQC members see this email before 7PM tonight and are able to respond supportively, that would of course be beneficial.

Apologies for the last minute nature of the request,

Sincerely,
Chris

Chris Alemany
Councillor - City of Port Alberni
250-731-7930

<340-226shm503@viu.ca_20171010_132413 copy.pdf><ACRD Draft Letter of Support for Air Quality Mapping Project RIF October 2017.docx>

DRAFT Letter of Support

October 15, 2017

Re: Support for the Vancouver Island University Regional Initiatives Fund - *Regional Air Quality Mapping Pilot Project*

Dear Dr. Vaugeois;

The Alberni Clayoquot Regional District strongly supports community-based applied research that relates to the conservation and management of the natural environment, particularly as it pertains to air quality.

We are excited to work with Drs. Krogh and Gill in the Applied Environmental Research Laboratories at Vancouver Island University on a *Regional Air Quality Mapping Pilot Project*. We support their application for funding through the Regional Initiative Fund and look forward to collaborating on this project to generate neighborhood scale maps that show the geospatial distribution of atmospheric constituents that have an immediate impact on regional air quality, including particulate matter, nitrogen oxides, ground level ozone and volatile organic compounds.

Our involvement in the project will include working with the principle investigators to set strategic priorities on specific air quality parameters, plan sampling times and locations, and to assist in the public dissemination of results. We understand that this project is enabled by the recent completion of a nationally funded state-of-the-art mobile research lab that is capable of making real-time air quality measurements in a moving vehicle. The result is the ability to collect data that depicts chemical concentration and composition as it varies over time and space. In addition to supporting applied science and student training, this work supports strategic policy objectives that inform sustainability initiatives and land-use planning, and protect human and environmental health.

The ACRD will commit to consider $7,000 to this project in the upcoming budget. This will support the application for the principle investigators to the Regional Initiatives Fund, which provides matching funds from the Vancouver Island University and the Province of British Columbia. We understand that if the funds from the Regional District are not approved, the project will necessarily be scaled back in accordingly.

We believe that this project builds meaningful scholarly connections to VIU and directly responds to community needs.

Sincerely,

VANCOUVER ISLAND UNIVERSITY

AERL
Applied Environmental Research Laboratories

Real-time Chemical Analysis in the Real World

To effectively measure the long and short term effects of changes in our environment, it's essential to have good quality information in a timely manner. At Vancouver Island University's Applied Environmental Research Laboratories (AERL), Directors Dr. Chris Gill and Dr. Erik Krogh collaborate widely with researchers from around the world to use their leading edge instrumental innovations for direct, real time chemical analyses in complex environmental samples. This includes air and water quality monitoring, environmental forensics, and emergency response applications. Their technologies are also well suited for rapid bioanalytical screening and point-of-care applications.

The coupling of analytical mass spectrometry with direct, on-line sampling strategies is addressing an important shift in environmental chemistry, enabling researchers to quickly identify and quantify chemicals of concern directly in air and water. This approach provides information *when* and *where* it is needed and allows for a better understanding of the effects humans are having on the environment. The focus of this work is to enable real-time analysis in real-world samples that are both regionally relevant and globally significant.

By bringing high precision, portable equipment to the sample rather than bringing grab samples back to the lab, the AERL can understand the extent and degree of contamination at a study site immediately instead of waiting weeks or months to get results back. By approaching the science this way, it gives researchers the ability to immediately determine the degree, extent and movement of contamination. It also enables real-time decision support, emergency response and continuous monitoring.

Innovations, Collaborations and Knowledge Mobilization

Work at the AERL is supported by the Natural Science and Engineering Research Council of Canada Discovery Grants program, and involves collaborations with regional, national and international partners in academia, government agencies and the private sector. The principle researchers currently have three patents involving innovations related to technologies that enable real-time measurement of chemical contaminants. Key innovations by the team include the development and use of mobile chemical sensors, in-field calibration/data management techniques and real-time geospatial visualizations of chemical information. Applications include in-field environmental assessments, biomedical screening, exposure studies and industrial process monitoring. The emergence of portable sensor technology and crowd sourced environmental data has applications including community level assessments, First Nations empowerment and national transportation and energy policy.

Some recent projects receiving international attention include:

- development of new membrane sampling interfaces for the rapid screening of contaminants and their metabolites in natural and produced waters
- in-situ reaction monitoring of chemical kinetics in the treatment of drinking and waste waters;
- photochemical degradation of contaminants in natural waters; and
- on-site field measurements of air and water pollutants using mobile mass spectrometry for real-time, continuous monitoring applications.

chris.gill@viu.ca erik.krogh@viu.ca aerl.viu.ca

Sample Research Project Areas

1. Geospatial mapping of fugitive and aquatic industrial emissions

The rapid expansion of natural gas extraction has led to considerable interest in understanding the extent of fugitive emissions of methane (a powerful greenhouse gas) and toxic volatile organic compounds (e.g., benzene) over the lifecycle of the production process. We are developing and using state-of-the-art mobile chemical sensors to map volatile and semi-volatile organic compounds in air and water.

2. Development of marine underwater mass spectrometry

We are developing a prototype mass spectrometer to measure dissolved gases, light hydrocarbons and biomarkers of marine organisms (e.g., sea lice and algal blooms). The instrument is based on a patented thermally assisted semi-permeable membrane technology, which provides continuous measurement capability for a range of chemical compounds.

3. Development of direct, high precision quantitation approaches for trace level molecular measurements

The contamination of ground and surface water resources by anthropogenic activities can compromise its suitability for human consumption and use. Conventional analyses can be time-consuming and are not well suited for real-time decision support, emergency response or continuous monitoring applications. We are developing direct, online analysis and in-field calibration methods for contaminants. Our methodologies also show great potential for the direct, rapid bioanalytical screening of trace levels of important molecules in complex bio-fluid samples such as urine and blood, and we are actively exploring this potential new area.

Personnel

The AERL supports the training of a wide spectrum of highly qualified personnel spanning the range from undergraduate students to post-doctoral research fellows. In addition to the two principle investigators, the AERL team currently includes undergraduate students, graduate students, research associates, and post-doctoral researchers. The AERL research group has collaborated with a number of government and private sector researchers to train highly qualified personnel and mobilize emerging knowledge, leading to lasting economic growth and prosperity in Canada.

What Others Are Saying

Taken from external expert reviewers comments of an application for a mobile mass spectrometry laboratory

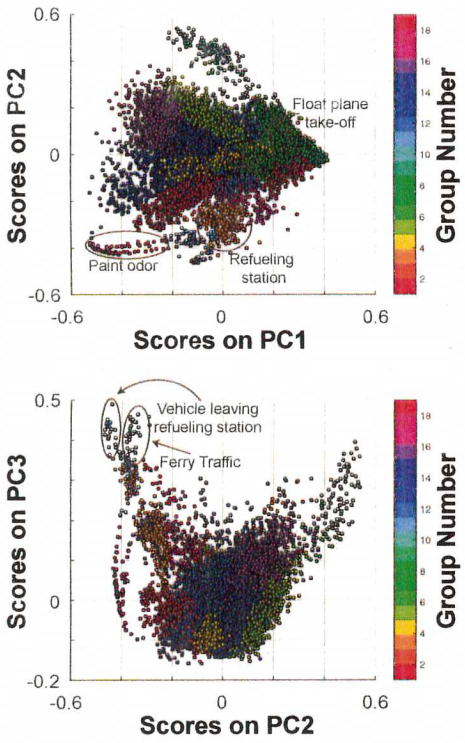
1. **The researchers:**
   highly capable in this field
   have pioneered the technique of membrane introduction mass spectrometry are uniquely capable of implementing this in their mobile laboratory
2. **The equipment:**
   mobile labs are a rarity worldwide
   there are very few mobile labs operated by universities and none have these capabilities… will be unique in Canada
   will enable studies of critical importance to the field of environmental chemistry
3. **The research:**
   innovative and at the leading edge internationally
   needed and timely in Canada
   highly innovative
4. **The benefits to students:**
   unique training opportunity for undergraduate and graduate students

chris.gill@viu.ca erik.krogh@viu.ca aerl.viu.ca

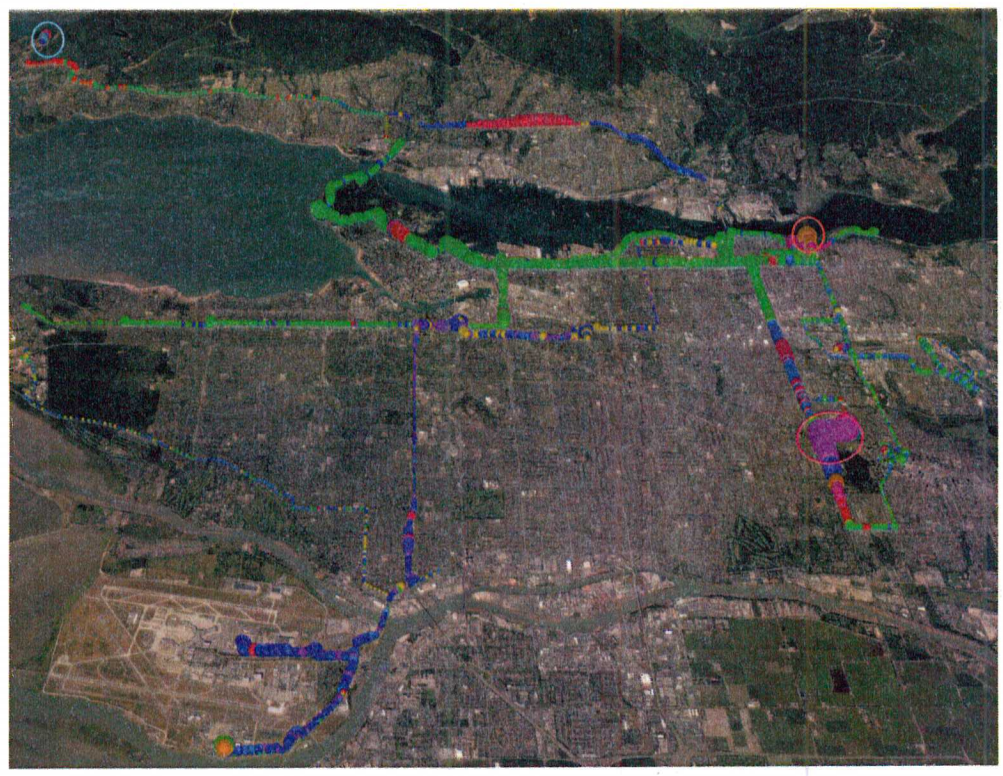
Untargeted Chemometric Analysis of MIMS Field Data

Metro Vancouver Field Campaign September 2016 (3 days)

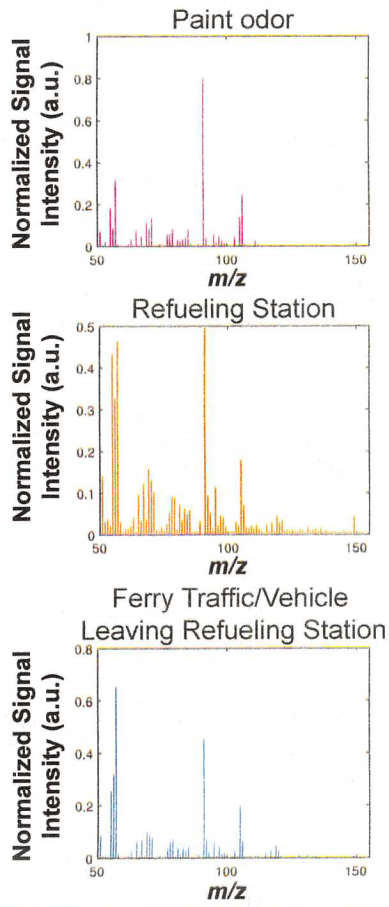
PCA Scores Plots of Metro Vancouver Mobile MIMS Data



Sample clusters identified using a Gaussian Mixture Distribution algorithm.

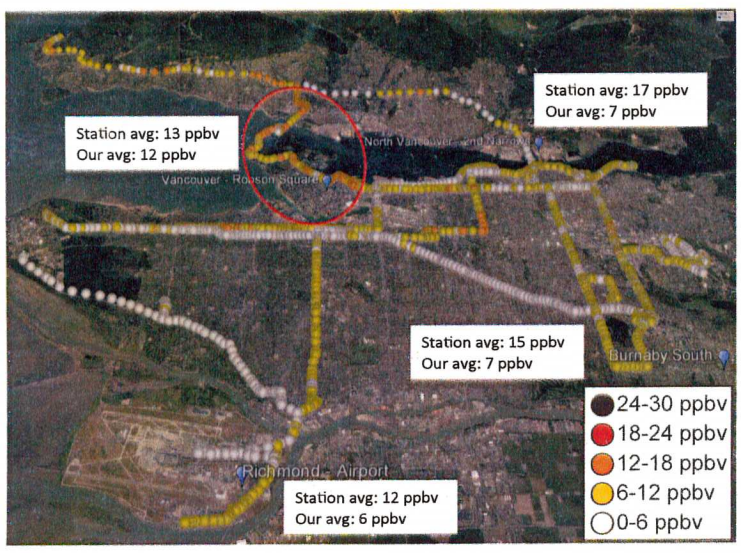


Data points colour based on group assignment, and sized based on total ion current.



Ozone Concentrations

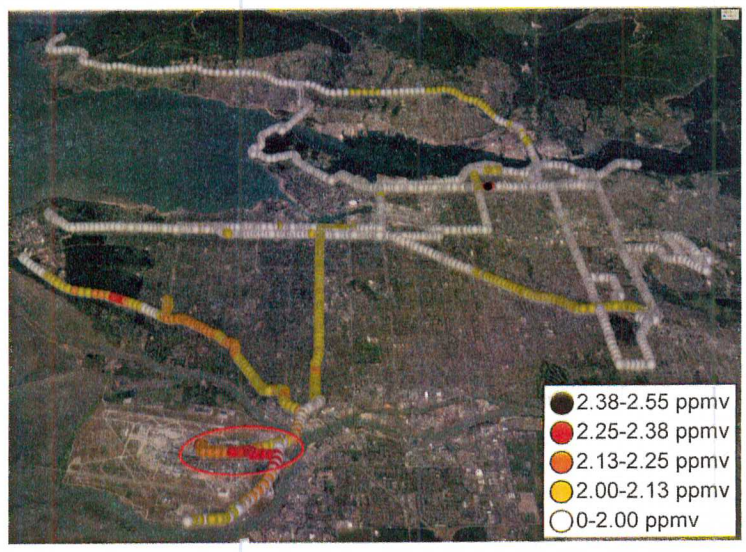
Metro Vancouver



High ozone concentrations measured in downtown Vancouver in the afternoon.

Methane Concentrations

Metro Vancouver



High methane concentrations measured near YVR.

Chemometric analysis of mobile membrane introduction mass spectrometry data for source discrimination

Larissa C. Richards, Nicholas G. Davey, Chris G. Gill, Erik T. Krogh

Applied Environmental Research Laboratories - Vancouver Island University, Nanaimo, British Columbia, Canada
Department of Chemistry - University of Victoria, Victoria, British Columbia, Canada

AERL
Applied Environmental Research Laboratories

VANCOUVER ISLAND UNIVERSITY

University of Victoria

Introduction

Atmospheric volatile organic compounds (VOCs) have both natural and anthropogenic sources.

VOCs can be detrimental to human health both directly (benzene is a carcinogen) and indirectly (precursors to secondary organic aerosols and ground-level ozone).

Atmospheric VOCs vary widely with time and space.

Membrane introduction mass spectrometry (MIMS) allows for the direct, continuous, online measurement of VOCs without chromatographic separation.

Mobile MIMS systems produce time and location stamped mass spectral data for VOC source identification and apportionment.

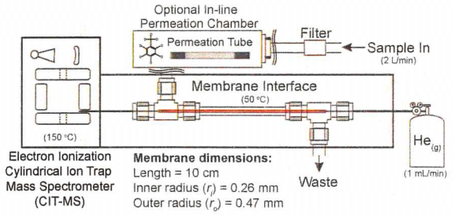
Mobile Air Quality Monitoring

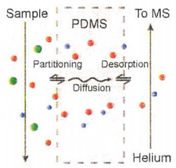
Advantages:
- Direct sampling
- Reduced contamination and loss
- Real-time, adaptive sampling
- Information when/where needed

Instrumentation:
Mass Spectrometers
- Ruggedized Griffin 400 MS (FLIR)
  - PDMS membrane interface
  - Mu-metal shield
- Proton-transfer reaction time-of-flight MS (Ionicon Analytik)

Other sensors
- ThermoFischer 49i Ozone Analyzer
- Las Gatos Greenhouse Gas Analyzer
- Qstarz BT-Q1000XT GPS

Membrane Introduction Mass Spectrometry (MIMS)





Electron Ionization Cylindrical Ion Trap Mass Spectrometer (CIT-MS)

Membrane dimensions:
Length = 10 cm
Inner radius (r_i) = 0.26 mm
Outer radius (r_o) = 0.47 mm

Samples continuously flow over a semi-permeable membrane.
VOCs permeate through membrane as a mixture.
Analytes measured as a suite.
Full scan MS data used for VOC fingerprinting.

Bell, R. J., et al. *J. Am. Soc. Mass Spectrom.* **2015,** 26, 212-223.
Krogh, E.T.; Gill, C. G. *J. Mass Spectrom.* **2014,** *49*, 1205-1213.

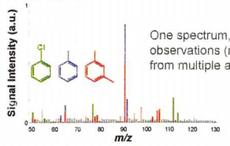
Principal Component Analysis (PCA) and Data Analysis

Full scan MIMS data is multivariate; many variables (*m/z*) per spectrum (sample).

Principal Components (PCs) represent the directions of most variance in a data set.

Plotting samples on PCs reduces data dimensionality.

Underlying patterns in the data structure may be revealed.

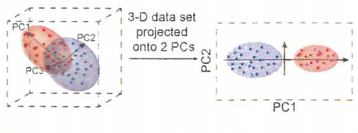


One spectrum, 80 observations (*m/z*) from multiple analytes.

Data analysis done using MATLAB (Mathworks) and PLS_Toolbox (Eigenvector Research).

Full scan MIMS data (*m/z* 50-160) unit vector normalized to remove concentration effects.

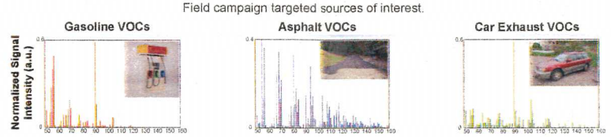
PCA applied to full scan MIMS data for sample discrimination.
- Nanaimo data: PCA of selected samples
- Metro Vancouver data: PCA of entire data set



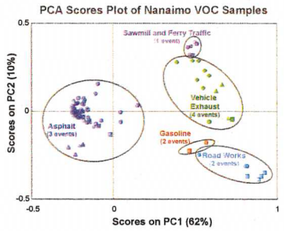
Targeted Chemometric Analysis of MIMS Field Data

Nanaimo Field Campaign August 2016 (4 days)

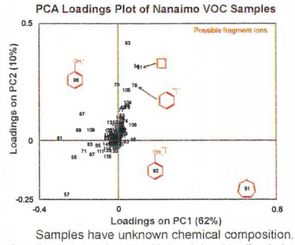
Field campaign targeted sources of interest.



Full scan data for user-identified samples averaged over 30-60 s. Background subtracted 'clean' outdoor air.



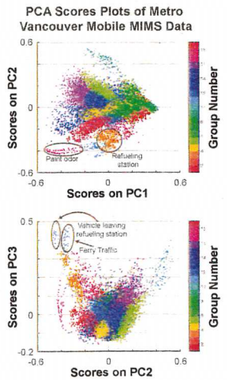
Samples clustered based on source.



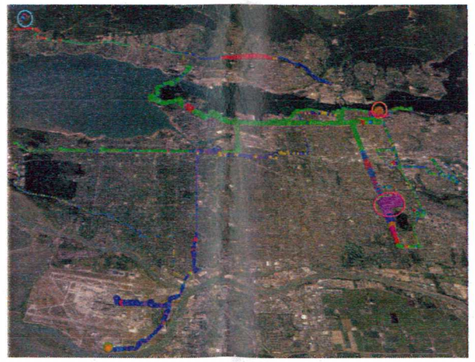
Samples have unknown chemical composition.
Loadings plot indicates which *m/z* lead to discrimination.

Untargeted Chemometric Analysis of MIMS Field Data

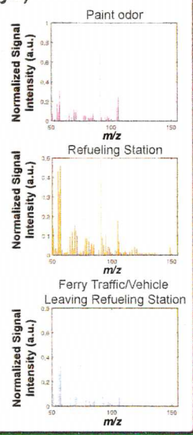
Metro Vancouver Field Campaign September 2016 (3 days)



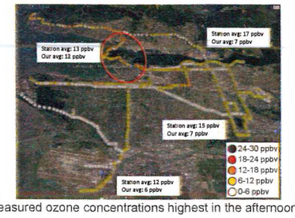
Sample clusters identified using a Guassian Mixture Distribution algorithm.



Data points colour based on group assignment, and sized based on total ion current.



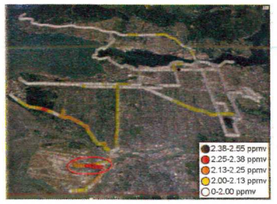
Ozone Concentrations
Metro Vancouver



Measured ozone concentrations highest in the afternoons.

Ozone measurements near Metro Vancouver stationary monitoring stations used for comparison purposes.

Methane Concentrations
Metro Vancouver



High methane concentrations measured near YVR.

Conclusions

Targetted Chemometric Analysis

PCA successfully used to discriminate VOC samples from real-world sources:
- Asphalt
- Other road works
- Gasoline
- Vehicle Exhaust
- Ferry traffic/sawmill emissions

The loadings plot *m/z* allow visualiation of possible compounds leading to sample discimination.

Untargetted Chemometric Analysis

PCA of entire MIMS data set allowed samples of interest to be identified mathematically.

Some user-identified sources with high total ion current (*e.g.*, float plane take-off, asphalt) are not differentiated in the PCA plot.

Geospatial mapping allows for the visualization of data based on group assignment and total ion current.

Ozone and Methane Concentrations

Continuous ozone and methane measurements allow for the geospatial mapping of analyte concentrations.

Ozone concentrations were higher in the afternoon than the morning.

Our ozone measurements agree with stationary measurements at the Vancouver-Robson Square station, and were lower than the other three comparison stations.

Future Research and Acknowledgements

Interlace data streams from additional air quality and meterological sensors (e.g. proton-transfer reaction time-of-flight mass spectrometer, ozone detector, sonic anemometer).

Analyze incoming data streams as they are collected for real-time output to Google Earth™.

Real-time chemometric analysis of comprehensive, mobile chemical data for geo-spatially resolved source apportionment of atmospheric samples.

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Fraser Basin Council
Mitacs