On-site analysis of environmental air and water samples at a SAGD oil production facility (Statoil) in Northern Alberta using MIMS.

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Introduction

- Statoil ASA operates a steam-assisted gravity drainage (SAGD) (Figure 1) demonstration facility in Leismer, AB – about 120 km south of Fort McMurray, Alberta, Canada.
- Statoil ASA and the Applied Environmental Research Laboratory (AERL) group at Vancouver Island University are working together to develop a membrane introduction mass spectrometer (MIMS) system that is capable of temporally and spatially resolved determinations of both atmospheric and aqueous analytes using MSMS.
- The ruggedized MIMS system is capable of collecting continuous multi-day datasets while producing calibrated results from experimentally derived calibration factors.
- Data was post-processed using Matlab (Natick, MA) to produce geographically referenced files for analysis using Google Earth.

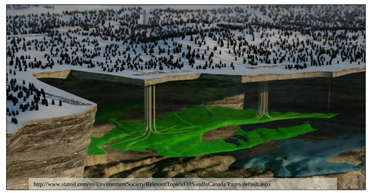

Figure 1. During SAGD operations bitumen is mobilized in situ by steam injection and is recovered via a lower well bore.

Instrumentation

- **Mass Spectrometer System:** Griffin 400, EI mode, with $5x10^{-5}$ Torr base pressure, with ~1.0mL/min He flow.
- **Membrane**: Dow Corning Silastic polydimethylsiloxane capillary tubing (10.0 cm x 0.94 mm OD x 0.51mm ID). Regulated to 50°C during air analysis, unregulated during aqueous analysis.
- **Sampling System**:
  Water – Cole Parmer Portable sampler peristaltic pump was operated at 300 ml/min
  Atmospheric – Diaphragm pump as operated at 4.0 L/min determined by rotameter. Glass fibre filters (5 µm) were used for particulate removal.
- **Calibration**: Dynacalibrator (VICI, model 340) was used with Kintek Trace Source certified permeation tubes to produce gaseous standards of target analytes. Water samples were calibrated by spiking known sample volumes with analyte combined with internal standard additions.
- **Power**: Four 6 V deep cycle batteries were used in series to produce 24 VDC during mobilised studies.
- **GPS**: A Qstarz BT-Q1000XT Data Logger was used to produce positional data.
- **Weather**: A Kestrel 2000 Wind meter was used to produce meteorological data including wind speed (when stationary), wind direction, temperature, and barometric pressure.

Figure 2. The MIMS system continuously analyzing aqueous sample from an on-site creek.

Instrumentation

The MIMS system (Figure 2) was equipped with a thermally regulated diffusion chamber wherein deuterated toluene (D8) is infused into atmospheric sample streams. Quantification is improved through the use of the D8 as an internal standard; further, the D8 greatly improves usability as the data quality can be observed real-time.

MSMS was performed on those analytes that are easily fractionated.

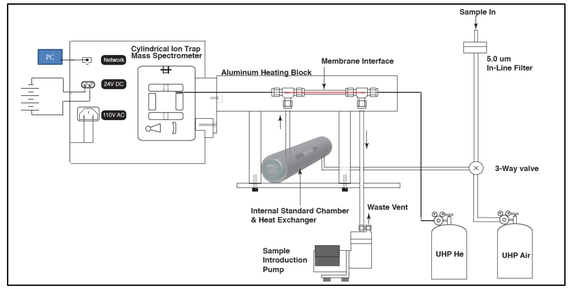

Figure 3. The MIMS system schematic. This setup is designed for portable air analysis using a D8 internal standard.

Analyte	Parent Ion	Progeny Ion	Response Factor Air	Response Factor Water	Interference Factor	Detection limit (s/n=3) Air (ppbv)	Detection limit (s/n=3) Water(ppb)
Toluene	91	85	1.5	1.0	2.6	36	23
Benzene	78	51	0.3	0.2	0.4	33	26
Etbz/Xyl	106	91	1.0	-	0	16	-
Chlorobenzene	112	77	0.8	7.6	0	11	27
Chloroform	SIM	83	2.8	2.5	0	14	5
Naphthalene	128	102	3.9	-	0	3	-
Dimethylsulfide	82	46	0.03	0.01	0	72	170
Dimethyl Disulfide	94	79	0.4	-	0	39	-
Methyl Iodide	SIM	142	0.2	1.0	0	25	22

Table 1. Analytes were analyzed in lab prior to deployment. Response factors (relative to D8), interference factors (relative to EtBz/Xyl), and instrumental detection limits were determined.

Data

- Atmospheric data were successfully collected at the Leismer facility and at the adjacent, unassociated, open pit mines north of Fort McMurray in June 2010 and June 2011. Meteorological and positional data were also collected.
- Aqueous data were collected in timeseries at several sampling site, though aqueous data are not yet worked up. Grab samples from facility processes were also collected.

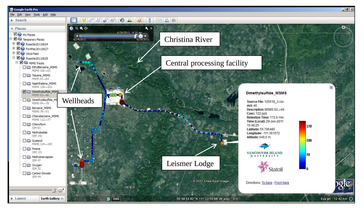

Figure 4. Google Earth screenshot of atmospheric dimethylsulfide data collected at the Leismer facility. The data were collected over an 8 hour period and includes stationary monitoring.

Results

- Using Matlab, time referenced MSMS data were programmatically correlated with positional data to produce a .kml document for analysis in Google Earth (or other GIS software).
- Calibrations were also performed automatically.

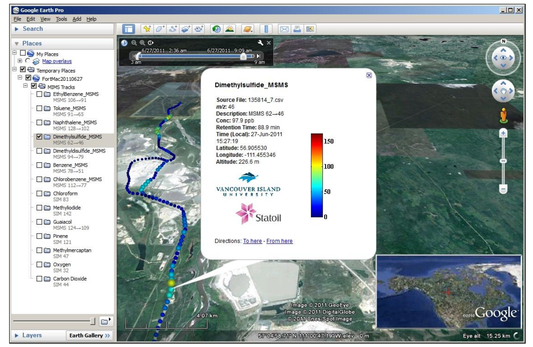

Figure 5. Google Earth screenshot of atmospheric dimethylsulfide data collected while travelling along the highway north of Fort McMurray, AB. All data are available for analysis in a single .klm file and each point contains a description balloon which including of relevant metadata.

- Using Google Earth, data can be easily shared across the internet using the built-in networking capabilities.
- Besides convenient navigation of very large data sets, video capabilities also enable the production of excellent presentation material.

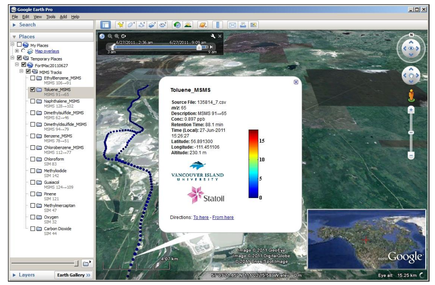

Figure 6. Google Earth screenshot of atmospheric toluene data collected north of Fort McMurray.

Conclusions

- High temporal and spatial data densities were obtained at remote locations in Northern Alberta, Canada.
- Calibrated geospatial data were programmatically produced and used for environmental assessments.
- Future work will include presenting data in real-time, enabling adaptive sampling strategies.

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- Note: The views and conclusions contained in this presentation are those of the authors and should not be interpreted as necessarily representing the official policies, either expressed or implied, of the funding organizations.