Development of an Innovative UAV-Mounted System for the Detection of Fugitive Methane Emissions

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Introduction

• Federal and provincial plans for carbon pricing of upstream producers means that there is currently considerable impetus for finding methods of detecting and quantifying emissions of methane and other GHGs associated with oil and gas production and transmission infrastructure.

• The aim of this project was to localize fugitive emissions and determine flux rates for methane leaks from conventional oil and gas production facilities, using a UAV-based methane sniffer.

• For phase one of this project, the study was carried out at a facility which had known sources of fugitive emissions.
Open Path Laser Spectrometer (OPLS)

• Dr. Lance Christensen from NASA’s Jet Propulsion Laboratory was part of the development team for the Tunable Laser Spectrometer (TLS) carried by the Curiosity Mars Rover. He developed the OPLS from this for terrestrial applications.

• Sniffer type detector, which comprises an open-path multi-pass Herriott cell optical head, custom electronics boards, and room temperature semiconductor laser and detector. Total laser path length is 4.3 m.

• The instrument’s sensitivity towards methane is 10 ppb/s, and it has a signal-to-noise of 200 at background atmospheric pressure.

• The operating range is from 0 – 1% methane concentration, for measurements made at 1 Hz.
Study Site

• Active oil and gas facility, located in the Drayton Valley area of western Alberta.

• The facility was selected from a shortlist of sites provided by the Alberta Energy Regulator (AER), and was specifically chosen because it had a number of known methane leaks present.

• Site is approximately four hectares in extent and comprises five storage tanks, approximately eight outbuildings including a mobile office, as well as a flare stack and three pump jacks.
Field Campaigns

• Three field campaigns were carried out. Flights took place on August 30\textsuperscript{th}, 2017, October 19\textsuperscript{th}, 2017, and March 20\textsuperscript{th}, 2018.

• For the second (October) campaign, the OPLS instrument was carried by a DJI M200 platform.

• The M200 has been designed to operate in cold conditions, and is able to operate in temperatures as low as \(-20\, ^\circ \text{C}\).

• A customized mount for the M200 was fabricated. This assembly was considerably smaller and lighter than the frame originally developed for the M600, which was used for the August field campaign.

• A mobile weather station was used to record ambient conditions and wind information.
Field Campaign 2 - Flights

• Six flights were carried out during the second field campaign.

• Conditions on site were generally calm, with temperatures ranging between 6°C and 13°C.

• Winds were light through the day, and at one point the wind speed remained < 0.8 m/s for an extended period of time (> 15 min).

• This necessitated a gap between flights 3 and 4 in the middle of the day, since the OPLS requires > 0.8 m/s winds in order to accurately estimate back trajectories and flux rates.
Field Campaign 2
Flight 2

Methane Concentration (Red) and Altitude (Blue) for Flight 2

Methane Concentration (Red) and Relative N (Green) for Flight 2
Field Campaign 2
Flight 4

Methane Concentration (Red) and Altitude (Blue) for Flight 4

Methane Concentration (Red) and Relative N (Green) for Flight 4
Field Campaign 2 - Leak localization from Flight 5
The effect of low wind conditions: Field Campaign 2 - Flight 3
Field Campaign 2 - Results

• From Flight 4, the two major leaks from the westernmost storage tanks were identified and quantified. Flight 5 localized three more smaller leaks north of the storage tanks.

• Flight 6 focused on measuring overall flux from the site. OPLS was flown back-and-forth downwind of the infrastructure at several different heights up to 27 m.

• Surveying the flux plane once gives an accuracy of ~50%. Greater accuracy can be obtained by repeating the survey multiple times. For Flight 6, the plane was repeated twice giving a 35% uncertainty.

• The majority of emissions projected back to the storage tanks, but there was a sizeable contribution north of the storage tanks. Overall, the estimated methane flux was 465 ± 172 SCFH or 13.2 ± 4.9 CMH.
Field Campaign 2 - Overall emissions projected onto a mass-balance plane
Overall results from all three field campaigns

• The OPLS proved to be highly successful at detecting methane leaks.
• Flux estimation was possible during both August and October campaigns.
• Using back trajectories, it was possible to identify leak sources to within 1 m.
• Detection of methane downwind of leak sources was found to be possible at a range of more than 250 m.
• The OPLS proved to be very accurate, and was able to detect small leaks of less than 1 SCFH.
• The sensor showed increased noise and a decrease in performance during the winter campaign. It is unclear whether this was a response to lower temperatures, or whether this was a result of other factors.
Next Steps

• Use of complementary technologies for rapid assessment of production facilities.

• Where a problem is detected the OPLS to be used for detailed inspections.

• Distinguishing methane associated with oil and gas production is also a problem. A version of the OPLS capable of detecting Ethane will allow much of the ambiguity associated with the detection of fugitive emissions to be eliminated.

• The proposed Phase 2 of the project will seek to develop an operational system, which will allow the assessment of multiple production and transmission facilities in a single day.
Thank You

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