Remote Sensing of CH$_4$ under Controlled Release by Differential Absorption Light Detection and Ranging (DiAL)

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Presentation Layout

- The Alberta DiAL
- DiAL principle
- System arrangement
- Set-up for CH\textsubscript{4} measurement
- The real time data
- Data Processing
- Results
- Summary
The First DiAL unit in North America

- Differential Absorption LiDAR (DiAL) mobile system was the product of collaboration between Government of Alberta and the Space Dynamic Lab (SDL) of the Utah State University.
- It was delivered in March 2013
DiAL features

- Can travel across Alberta.
- Can map pollutants in 2D and 3D.
- Sensing of CO\textsubscript{2} and CH\textsubscript{4} in the ppm range for 2 km.
- Sensing of PM for 10 km.
- Spatial resolution of 10 m.
- Eye Safe

Particularly suited for measuring sources in oil sands region: mining site, tailings pond, industrial complex, SAGD and cold flow operations.
How does DiAL work?

- Two laser beams are sent out with slightly different wavelengths: one corresponds to the absorption peak of the pollutant gas of interest and the other one corresponds to the non-absorbing background.

- The difference between the two signals corresponds to the gas concentration.
Gases of Present Interest

Carbon Dioxide ($\text{CO}_2$)

Methane ($\text{CH}_4$)
AEMERA’s DiAL unit

Cut-away view

- Floor and ceiling mounts
- Scanner overlap plate
- Optical Bench
- HVAC unit
- Laser chiller
- Laser power supply
- Laser dye pumps
- 12u computer racks
- Solvent cabinet
- Storage
- Access door*
- Office space
- Nitrogen K-cylinder*
Optical system in DiAL
Optical system in DiAL — Laser system

Pro-230 YAG Laser

532 nm

Cobra-Stretch Dye Laser

1064 nm

OPANIR

Wavelength Meter

Grating
Optical system in DiAL
— Beam TX & RX system

Power meter
Beam Expander
Receiver Telescope
Filter
APD
Setup for Gas Sensing
The 40 feet Sea-Can
Laser Beam Alignment
Laser Beam Profiling

Beam on Target

Beam partially on Target

Beam off the Target

Laser hitting the edge of a hard target
Estimation of Beam Divergence

Target Distance = 400 m
On line Divergence = 0.035°; Beam size = 24.4 cm
Off line Divergence = 0.062°; Beam size = 43.3 cm
Spatial misalignment = 0.006°; Spatial separation = 4.2 cm
Real Time PM Waterfall Plot
Data Extraction and Processing

- Absorbing ‘On’ data
- Non-absorbing ‘Off’ data

Path-integrated concentration
Laser power profile
Non-absorbing ‘Off’ data
Absorbing ‘On’ data
Laser Beam Through Sea-Can

Non-absorbing ‘Off’ data

Absorbing ‘On’ data

Less scattering inside the Sea-Can
Laser Beam Through Sea-Can on Gas Release

- Non-absorbing ‘Off’ data
- Absorbing ‘On’ data
- Stronger reduction of the ‘On’ laser power
Concentration Profile of CH$_4$ inside the Sea Can

Concentration (ppm)

Path Integrated Concentration
Path-Integrated \( \text{CH}_4 \) Concentration

\[ \text{CH}_4 \text{ Release} \]

\[ \text{No gas release} \]
Waterfall Plot of CH$_4$ Concentration under Controlled Release

Distance from DiAL unit (m)

CH$_4$ concentration inside the Sea Can (ppm)

Laser Pulses

CH$_4$ start

CH$_4$ stop
Summary

• DiAL can be used as a powerful remote sensing tool for selected gas elements.
• Detection is achieved without a hard reflector.
• Detection of controlled release of CH$_4$ at a distance of 400m is demonstrated.
• Gas concentration is profiled along a length of 12 meter with a spatial resolution of 1.5 meter.
• Temporal variation of gas concentration is monitored and profiled.
Participants

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Thanks!
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