

Micro-Pulse Differential Absorption Lidar (DIAL) for Water Vapor Profiling in the Lower Troposphere

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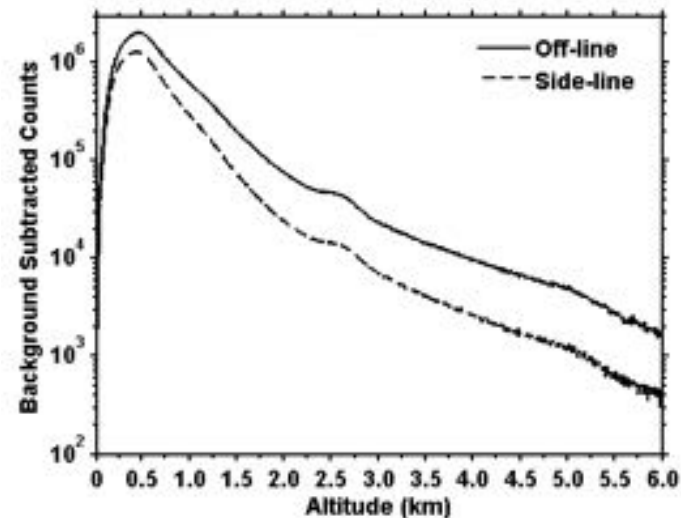
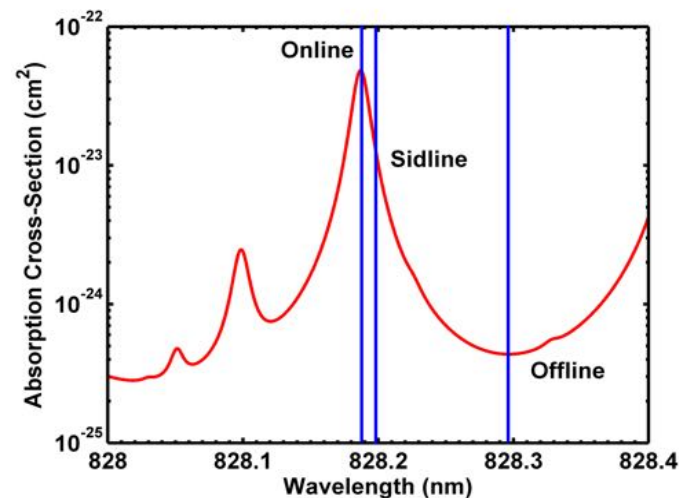


Introduction

- Water vapor distribution is important for understanding the thermodynamic state of the atmosphere and affects both weather and climate.
- Water vapor is highly variable both spatially and temporally.
- A need exists for developing instrumentation for monitoring water vapor in the lower troposphere.
- This talk describes the development of a low cost eye-safe diode laser based differential absorption lidar (DIAL) for water vapor profiling in the lower troposphere.

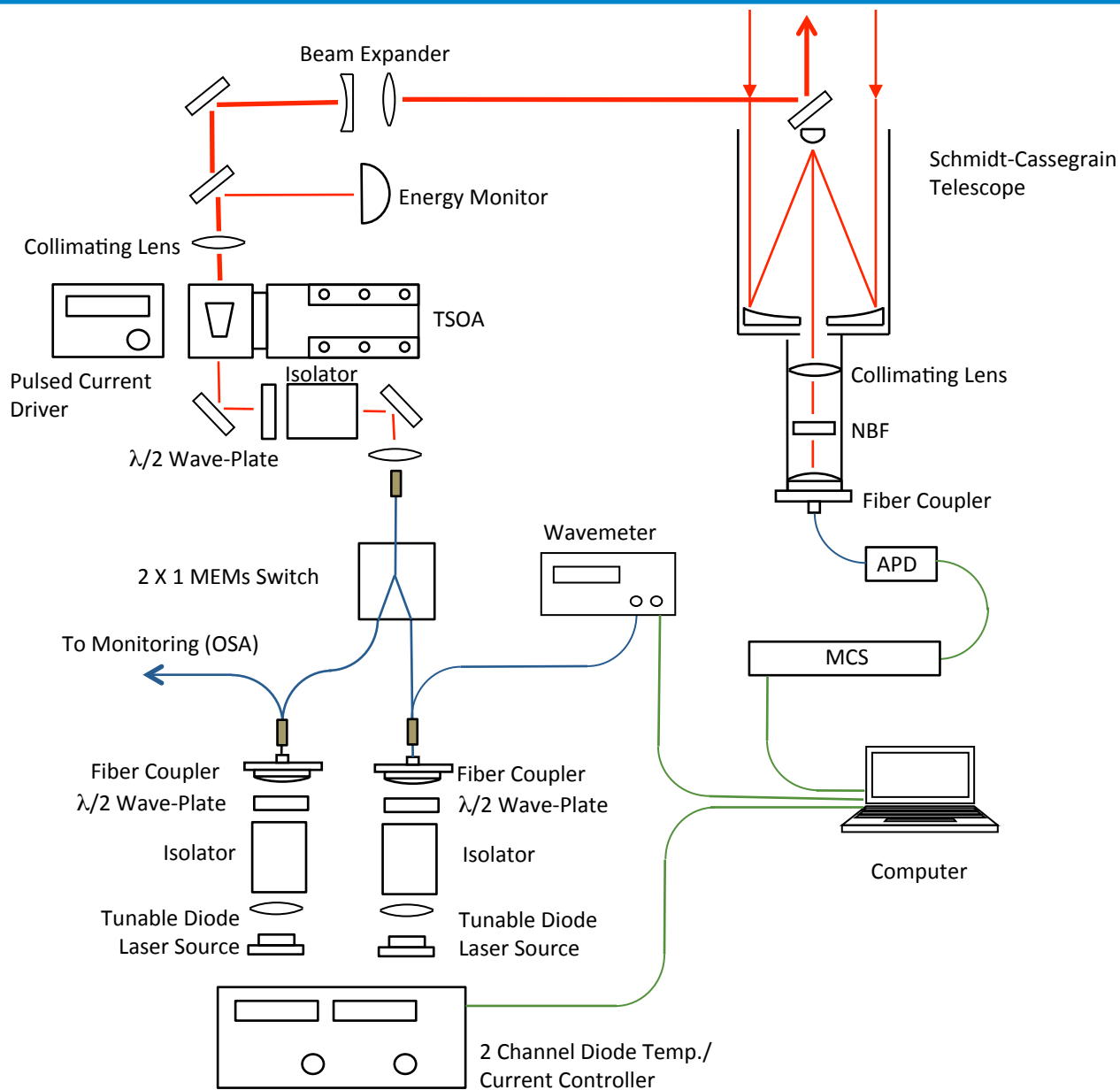
Differential Absorption Lidar (DIAL)

- The DIAL technique uses two closely spaced wavelengths and does not rely on an instrument calibration.
- The difference between the return signal for the two closely spaced wavelengths is related to the molecular number density.
- The number density can be calculated using the DIAL equation.

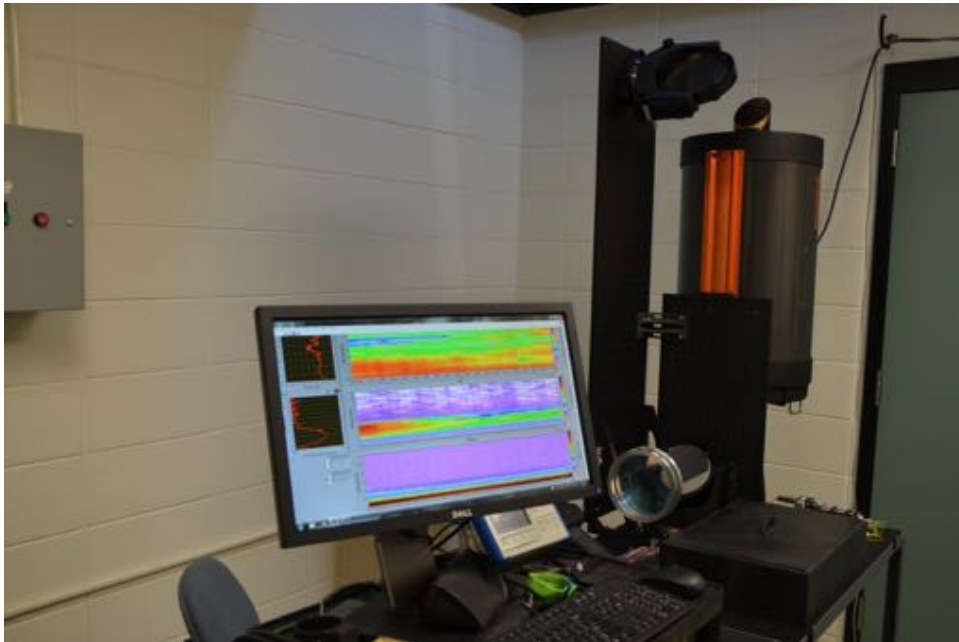


$$N(r) = \frac{1}{2\Delta r(\sigma(\lambda_{on}, r) - \sigma(\lambda_{off}, r))} \left[\ln \left(\frac{P(\lambda_{on}, r)P(\lambda_{off}, r + \Delta r)}{P(\lambda_{on}, r + \Delta r)P(\lambda_{off}, r)} \right) \right]$$

Diode Laser Based DIAL Instrument



Diode Laser Based DIAL Instrument Parameters



The DIAL instrument operating in the Roof-Port Lab at Montana State University.

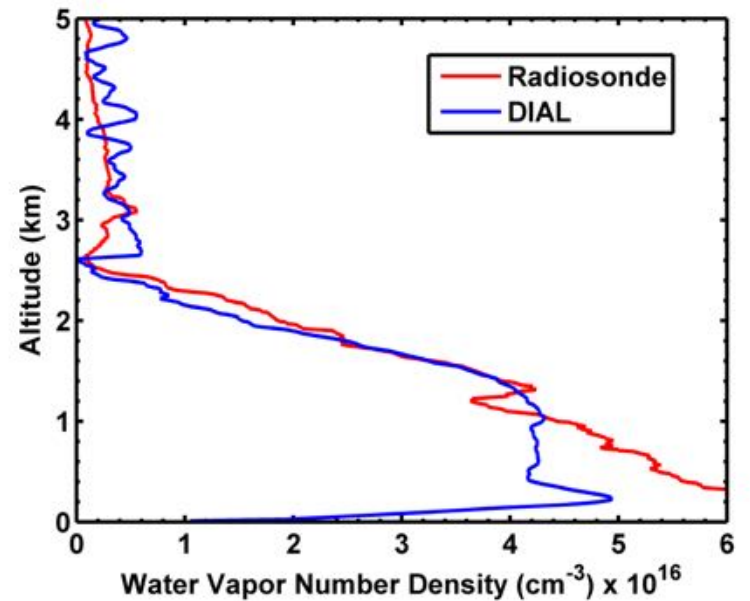
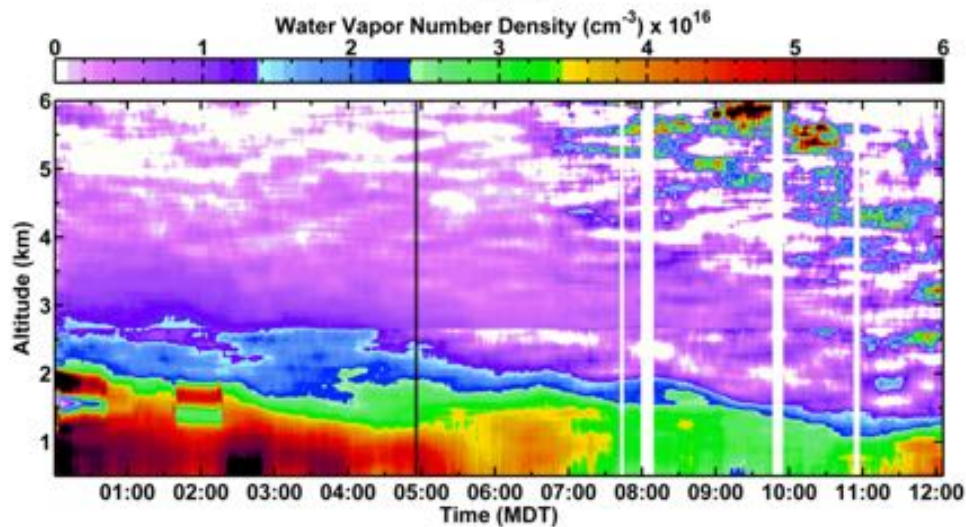
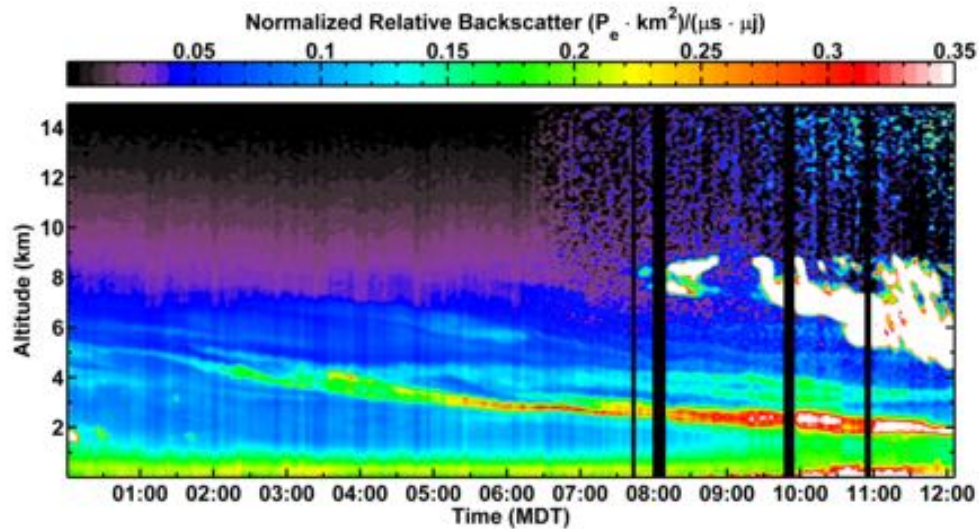
DIAL Transmitter Parameters

Online/Sideline/Offline Wavelength	828.187/828.195/828.287 nm
Pulse Energy	< 14 μ J
Pulse Duration	1 μ s
Pulse Repetition Frequency	10 kHz
Beam Diameter	15 cm
Short Term Stability/Linewidth	< 500 MHz
Long Term Stability	+/- 55 MHz
Switch Time	6 s

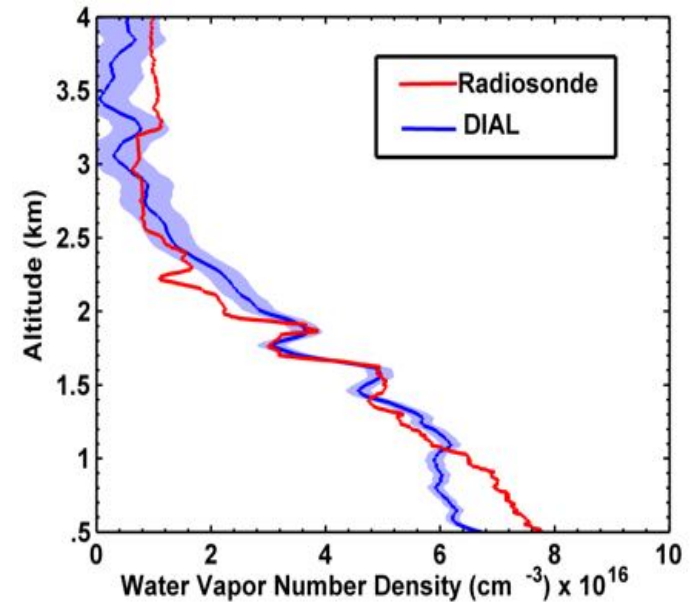
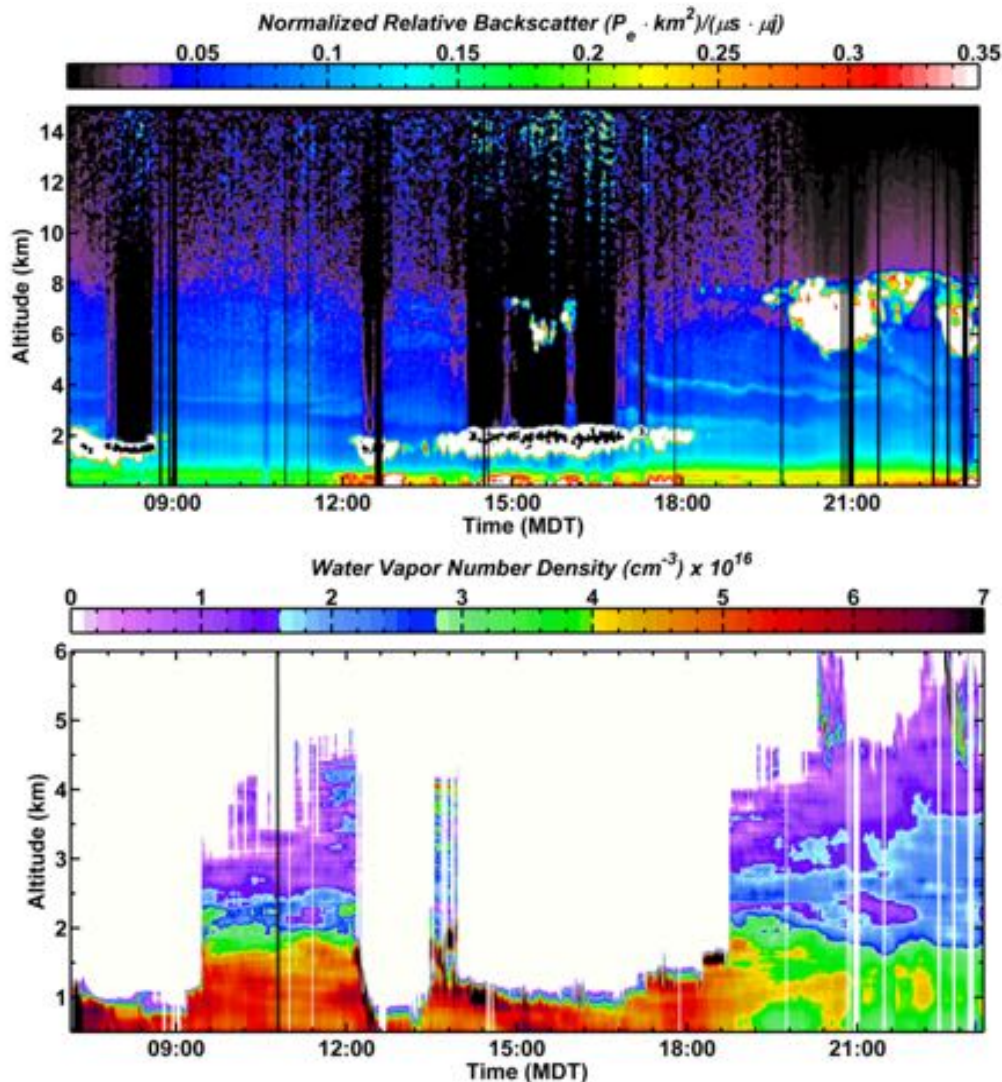
DIAL Receiver Parameters

Telescope	Schmidt Cassegrain
Telescope Diameter	35 cm
Field of View	140 μ rad
Detector	APD (Geiger Mode)
Quantum Efficiency	45%
Optical Filter Bandwidth (FWHM)	0.25 nm
Receiver Efficiency	10%
Range Resolution	150 m – 450 m
Integration Period	10-30 minutes

DIAL Data



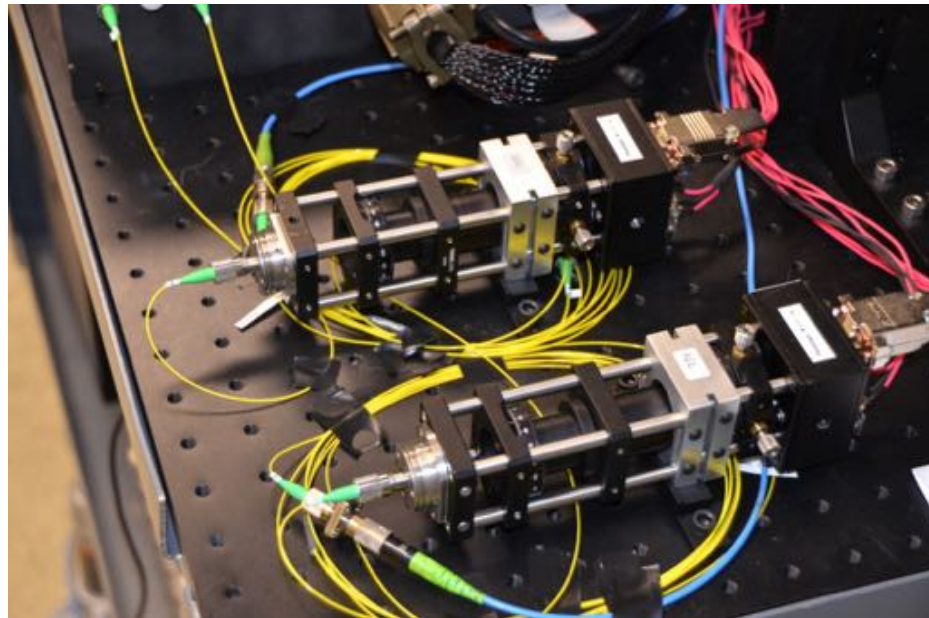
DIAL Data



Data on the last two slides were collected with tunable external cavity diode seed lasers.

These lasers are susceptible to mode hops making long term data collection difficult.

Current Work

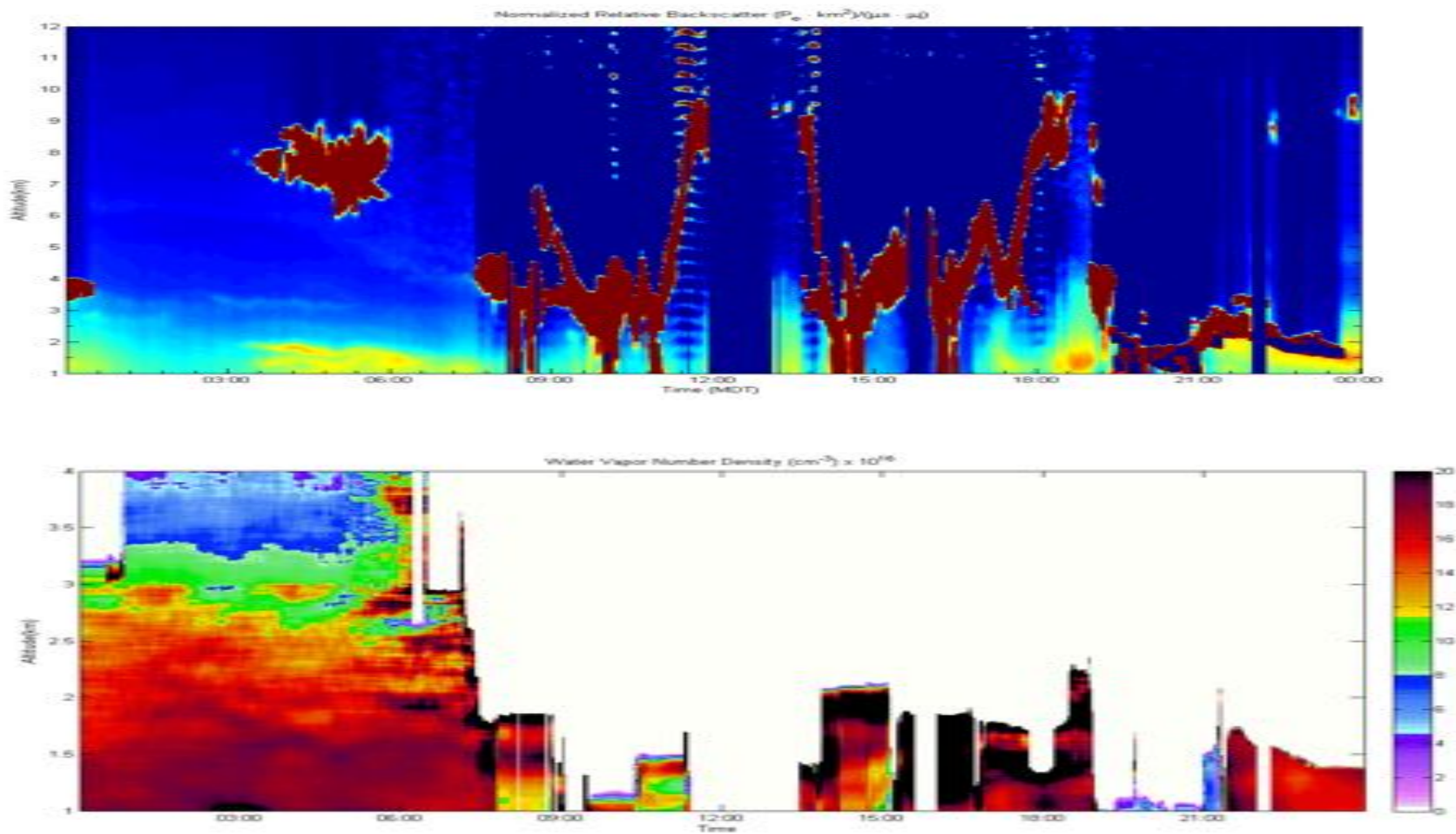


- DBR laser were incorporated into the laser transmitter in May 2012 to replace the external cavity diode lasers.
- The DBR lasers eliminate “mode hops” and are more conducive to long term operations.

- Roof port installed in June 2012 to provide the opportunity for longer term data sets.

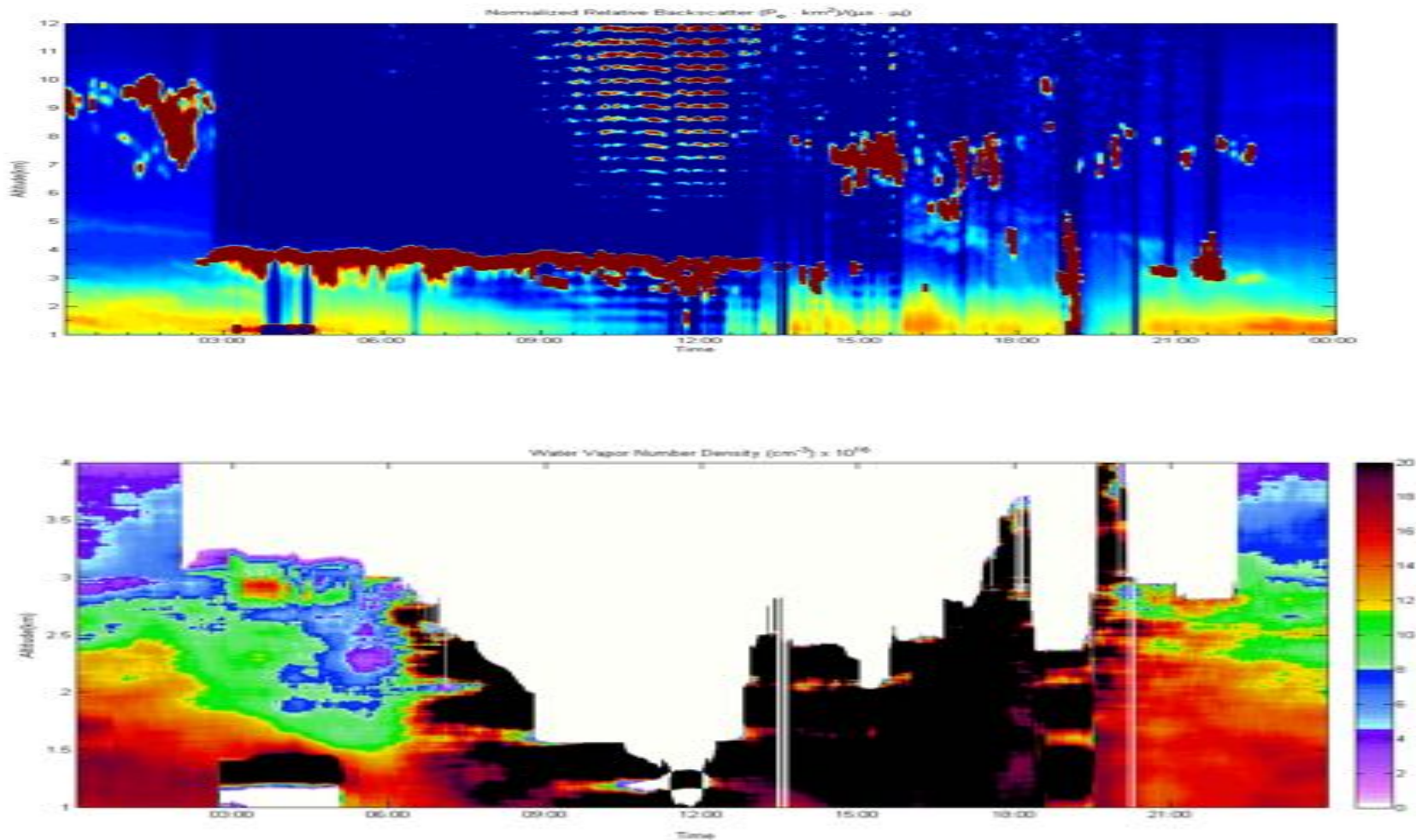


DIAL Data Through the Roof-Port



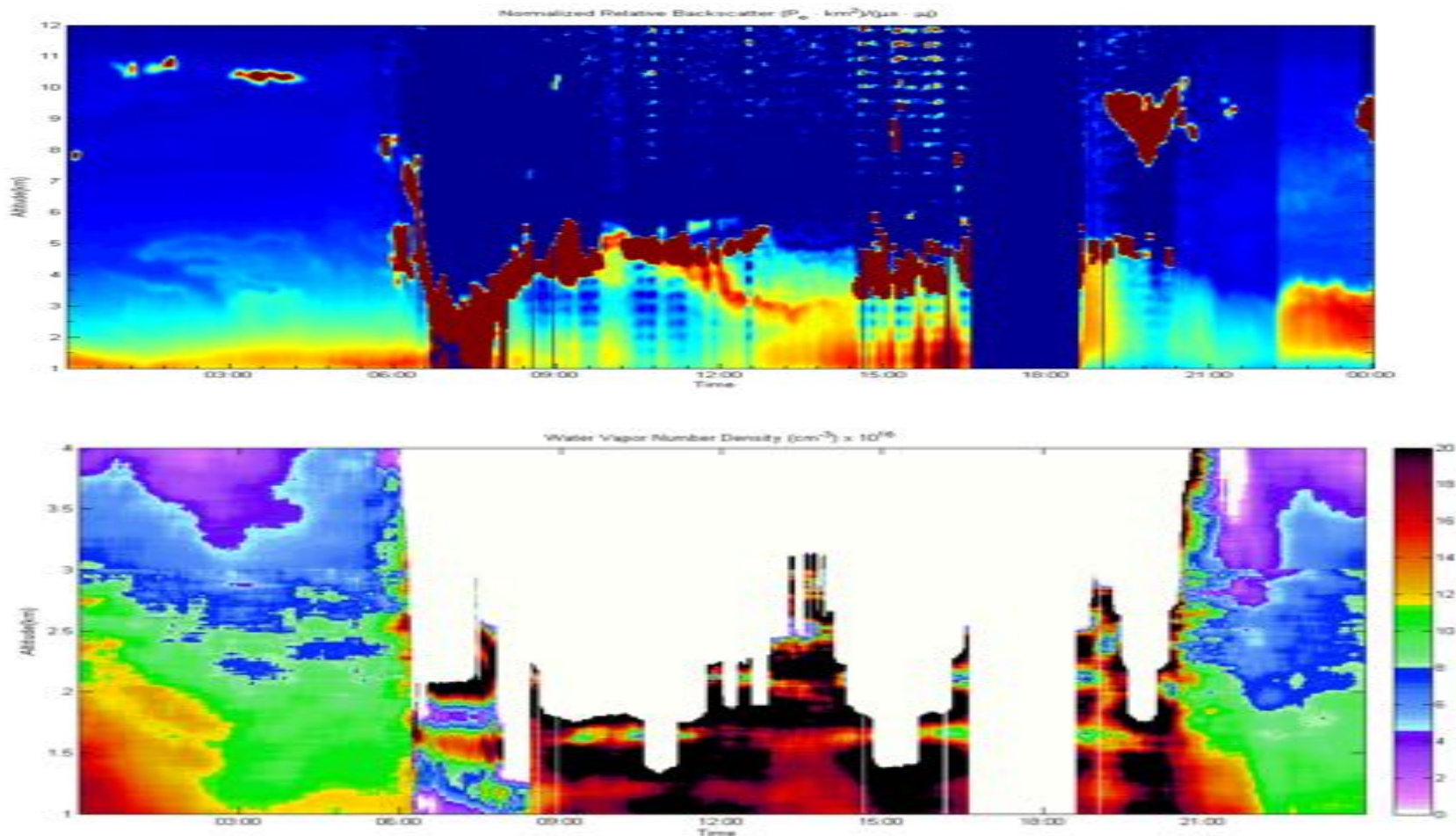
Saturday, June 2, 2012

DIAL Data Through the Roof-Port



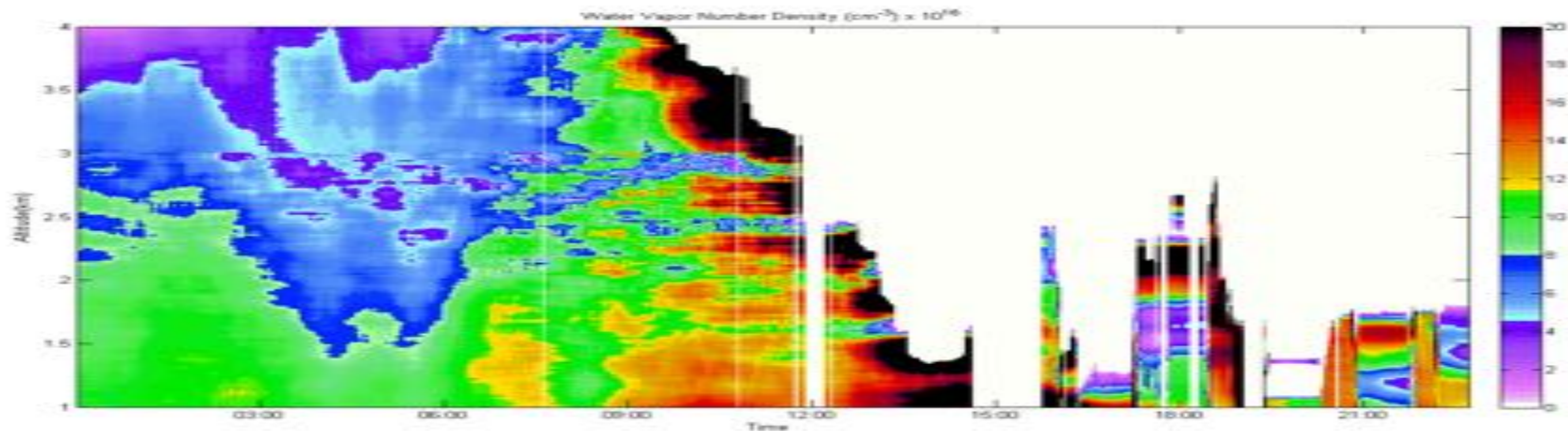
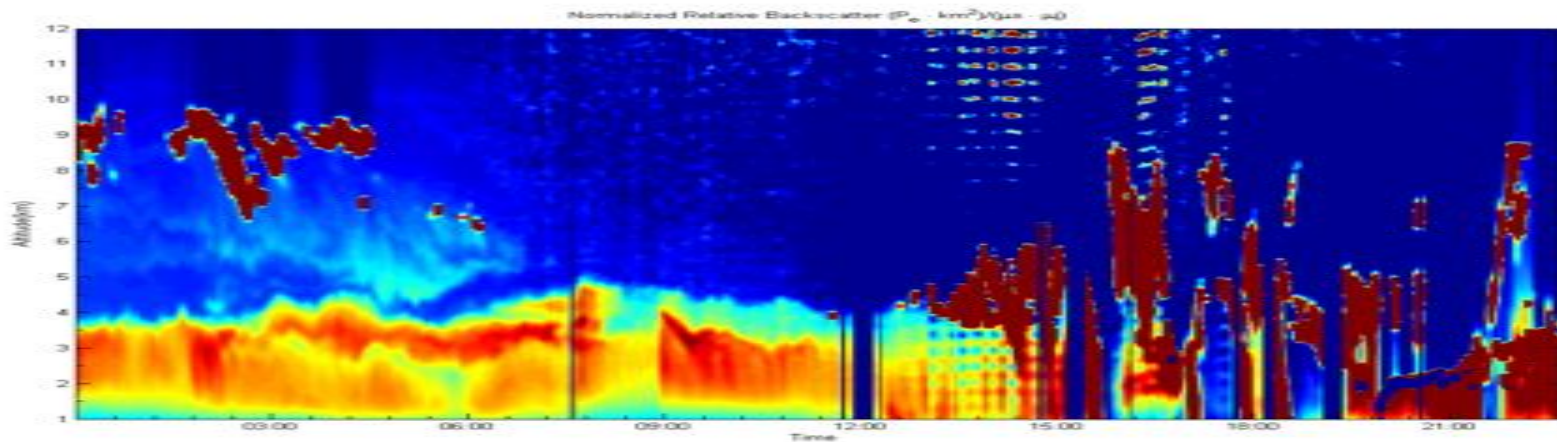
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DIAL Data Through the Roof-Port



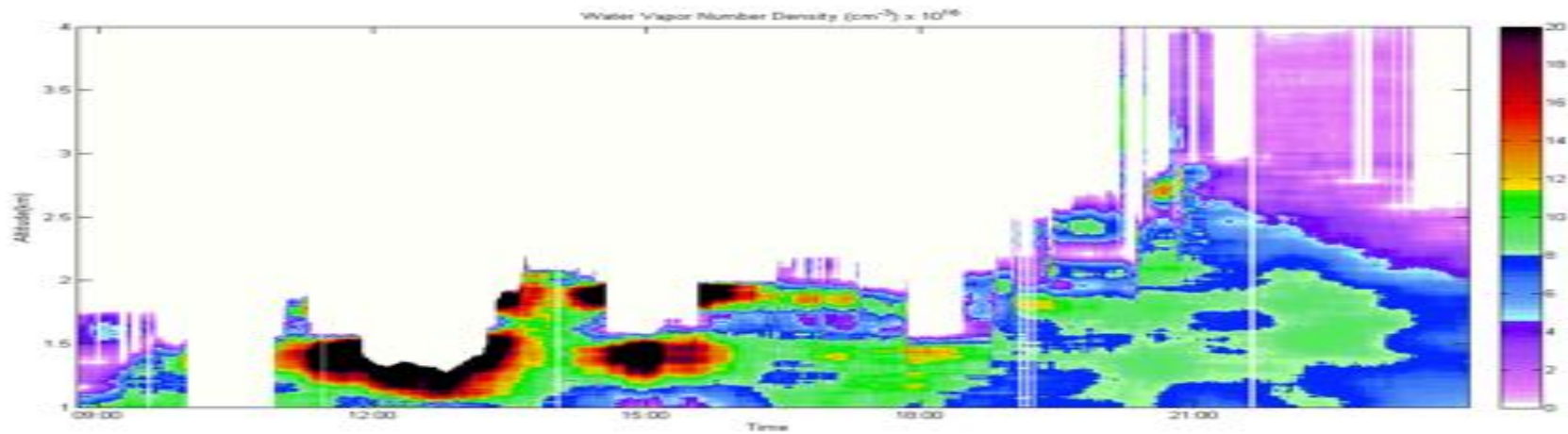
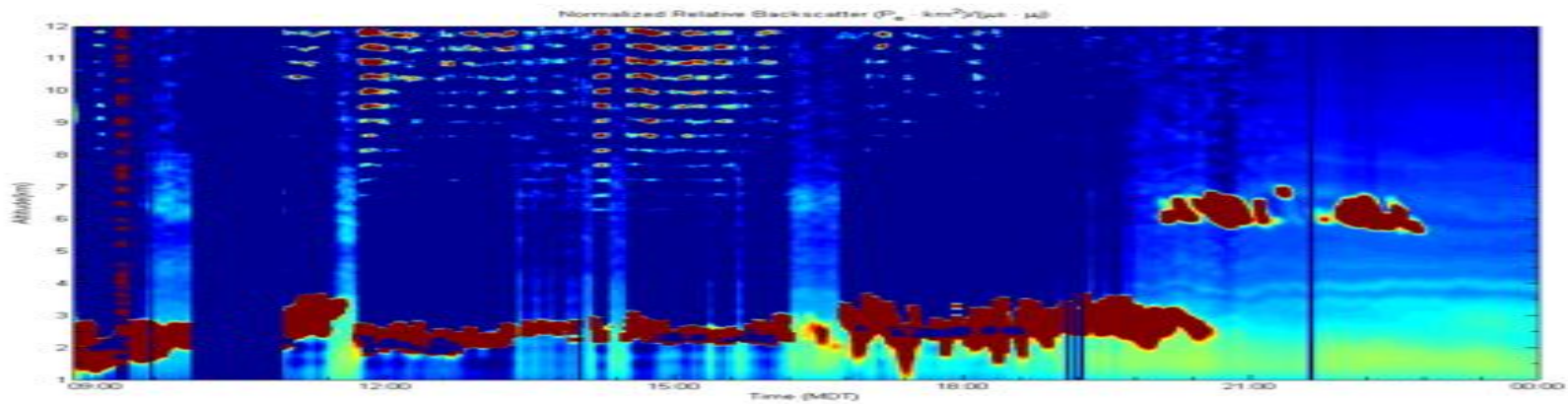
Monday, June 4, 2012

DIAL Data Through the Roof-Port



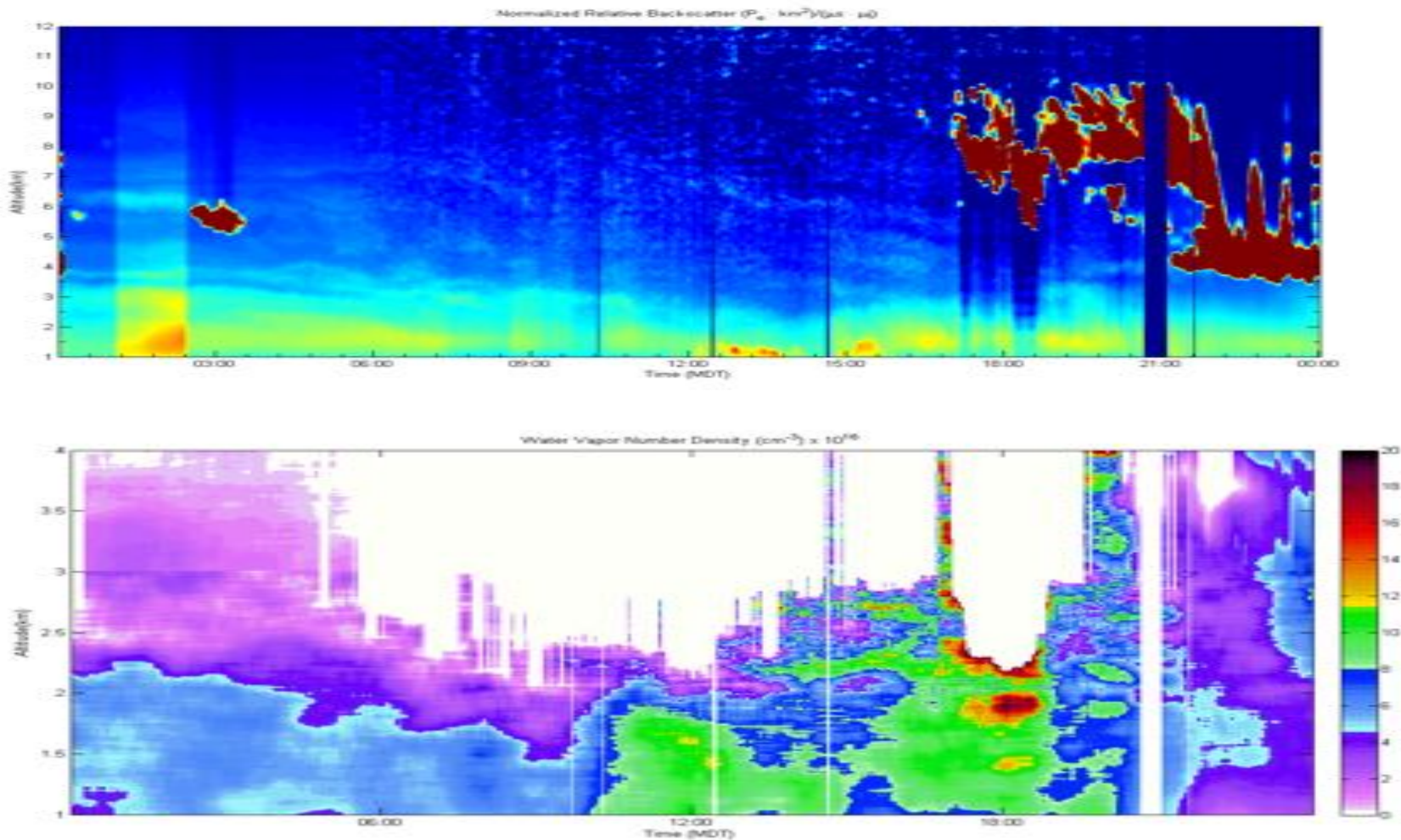
Tuesday, June 5, 2012
Average AOD = 0.102

DIAL Data Through the Roof-Port



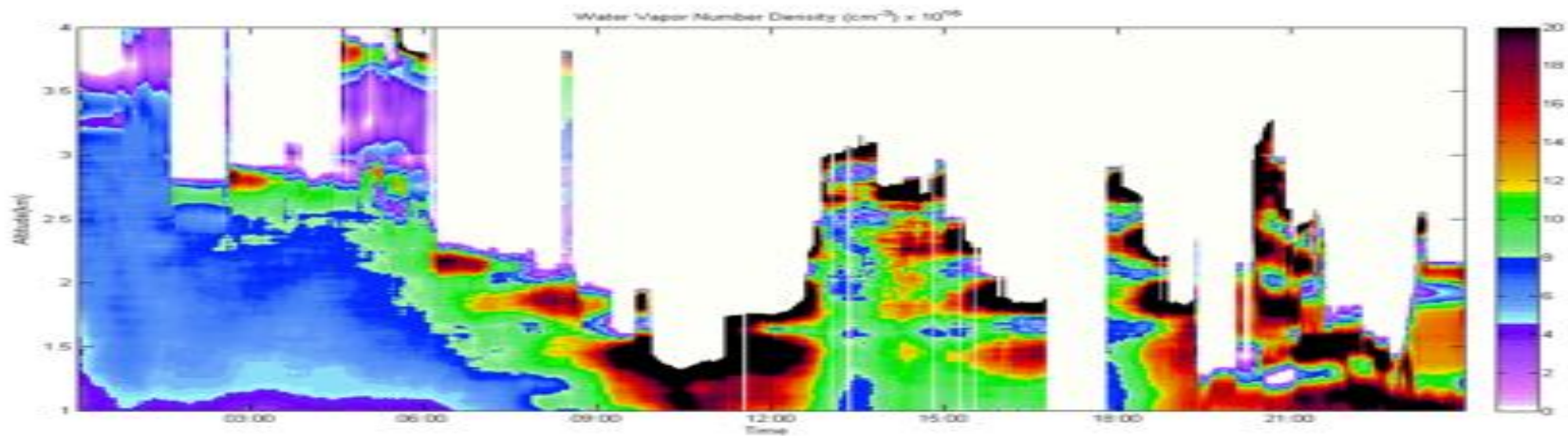
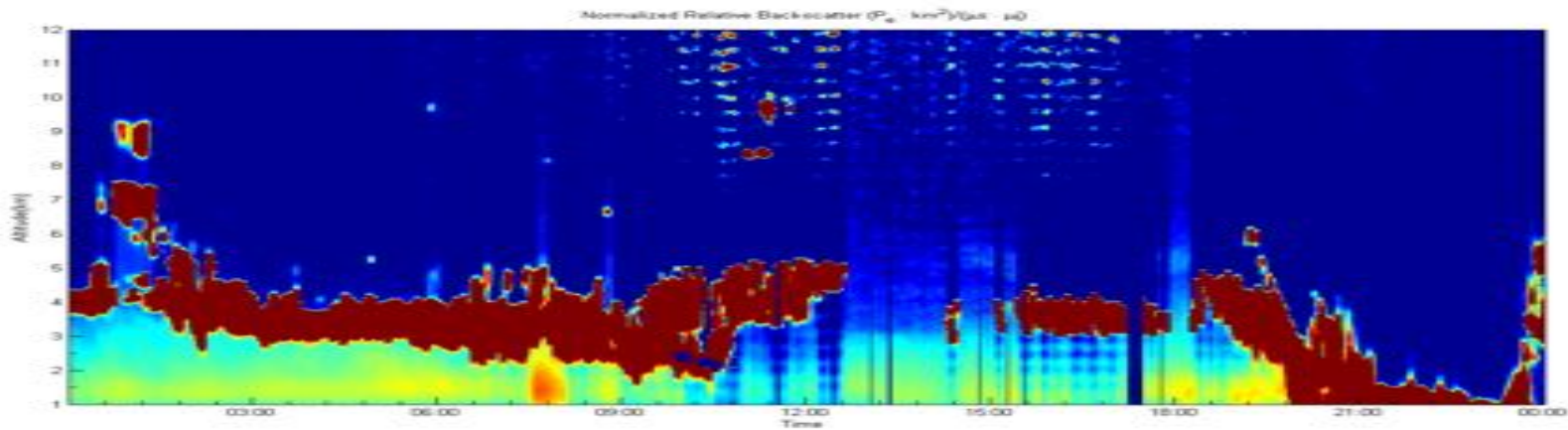
Wednesday, June 6, 2012

DIAL Data Through the Roof-Port



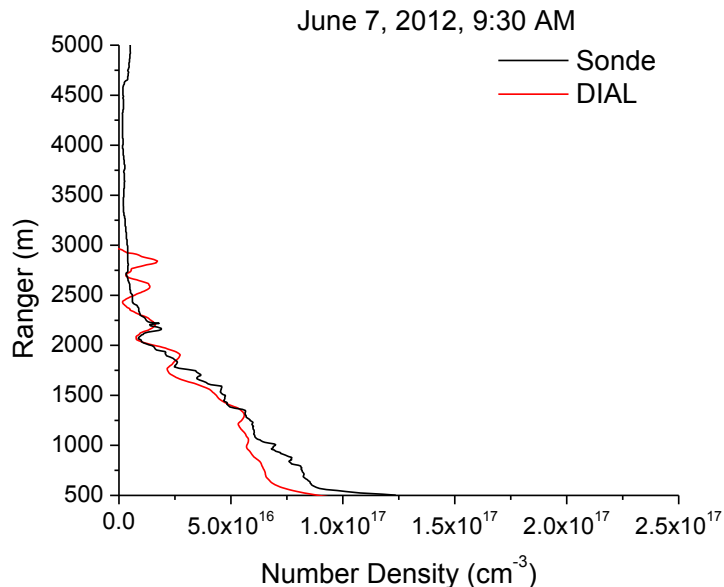
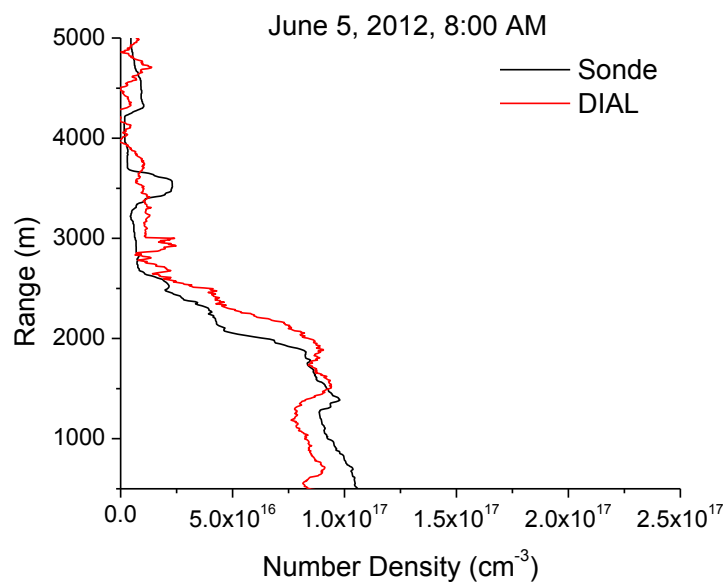
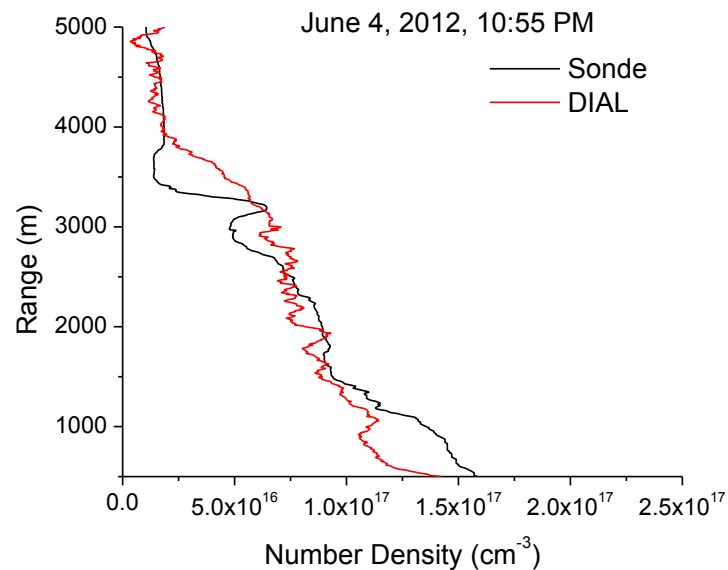
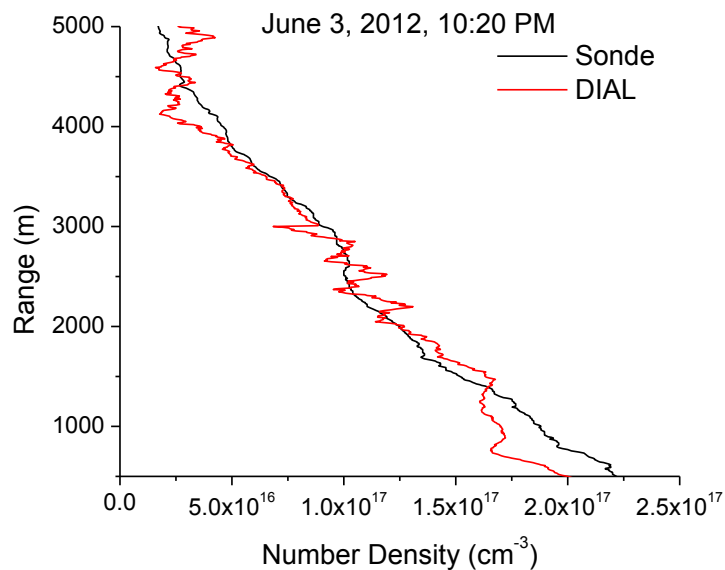
Thursday, June 7, 2012
Average AOD = 0.028

DIAL Data Through the Roof-Port

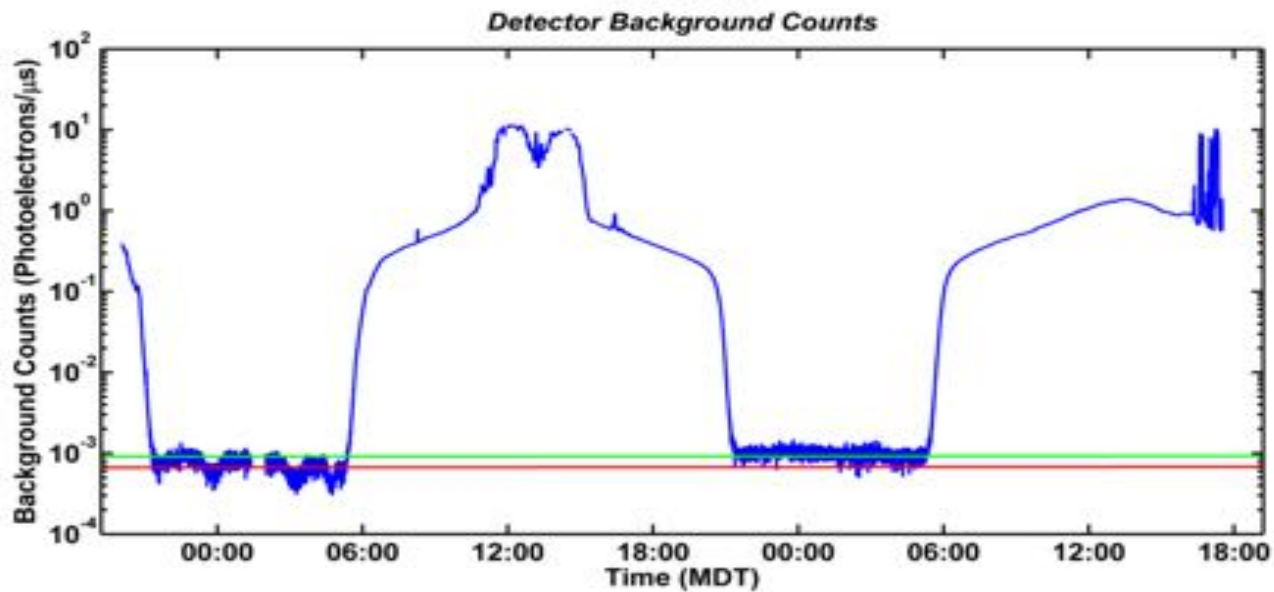
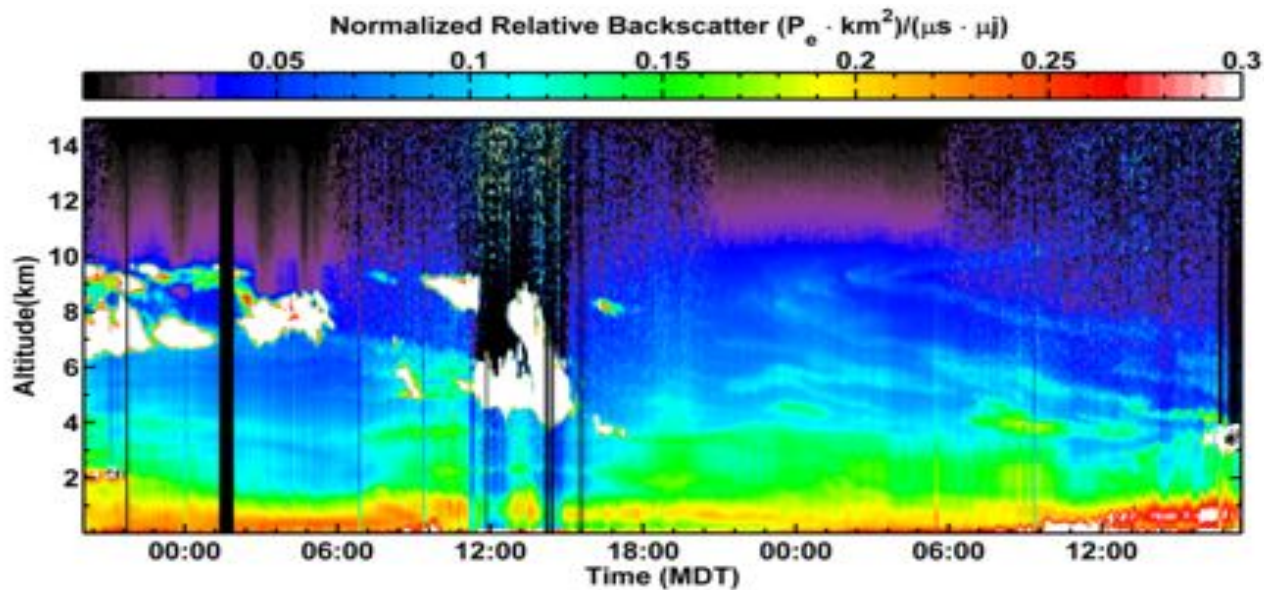


Friday, June 8, 2012
Average AOD = 0.030

DIAL Data Comparisons



MP-DIAL Limitation Detector Saturation



MP-DIAL Needed Improvements

- Develop a second channel (or look at other options) for monitoring lower altitudes.
- Increase power while maintaining eye-safety (Expand beam through telescope).
- Choose an appropriate absorption line for the widest variety of conditions.
- Package instrument.

Conclusions

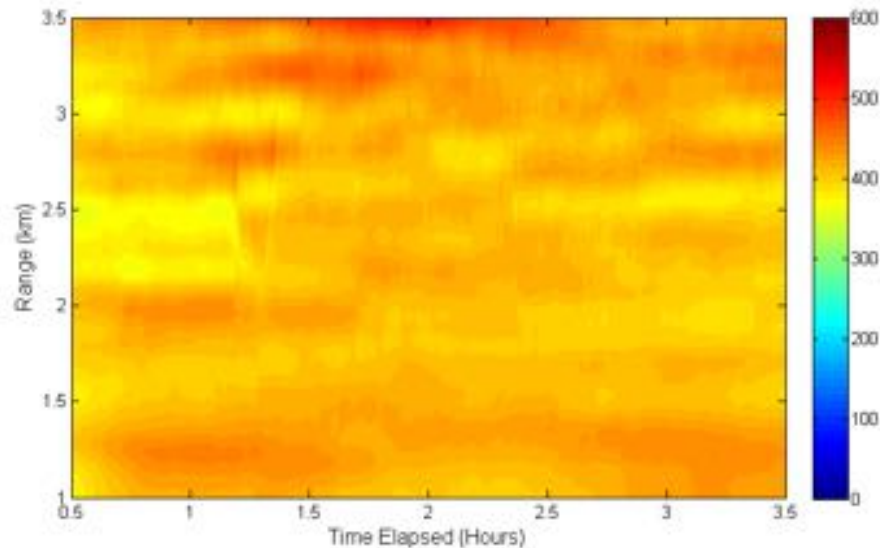
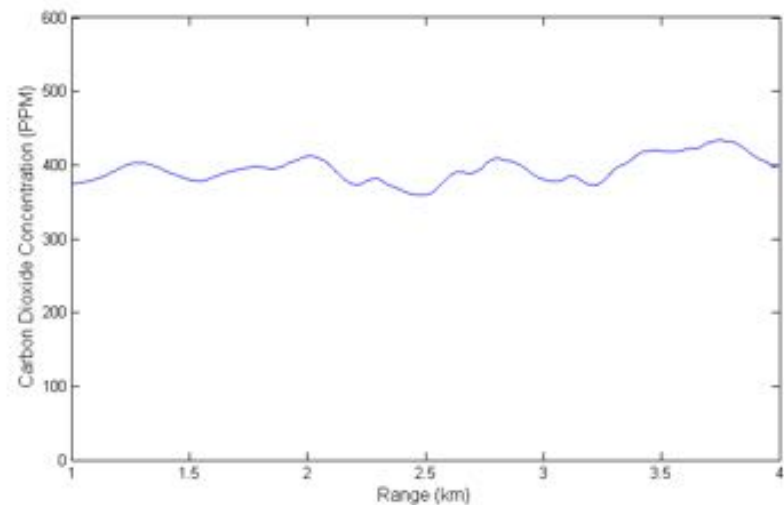
- Eye-safe DIAL for water vapor and aerosol profiling has been demonstrated.
- Current work is focused on longer term data collection demonstration.
- The MP-DIAL technique has limitations due to lower output power (to maintain eye-safety).
- Work is progressing on improving the DIAL performance.

MP-DIAL at 1.571 μm for CO_2



MP-DIAL for CO_2 detection is being developed based on telecommunications components.

This instrument is in its prototype stage and is currently limited to night-time operation.



Thanks kindly for Your Time

