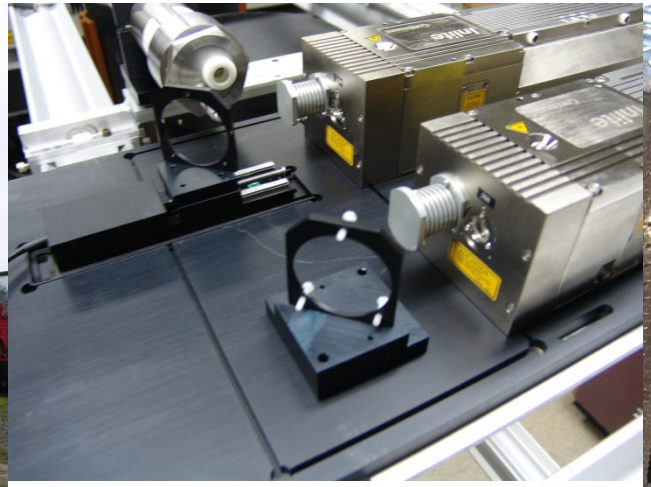
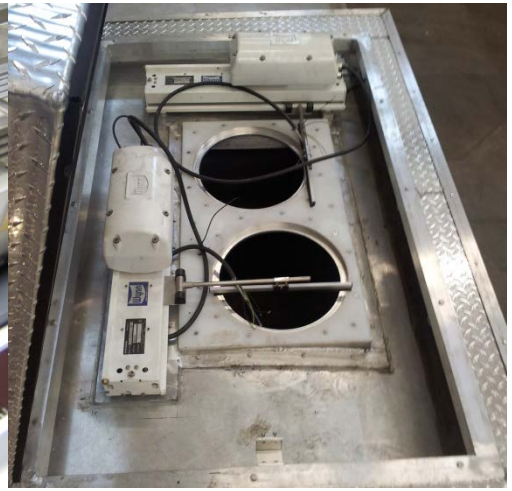
Environment Canada Environnement Canada

Canada

Autonomous ozone and aerosol lidar measurements: a synergistic approach to air quality





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Overview

- Motivation – Why build it??
- Operating an Autonomous LIDAR – What we have learned!
- Mobile Platform
- Instrument Description
  - Aerosol Backscatter LIDAR
  - Tropospheric Ozone DIAL
- Testing and Deployment
- Collaboration (eg. TOLNET)
- Summary and Future Work

Motivation – Why build it??

Ozone and Aerosols

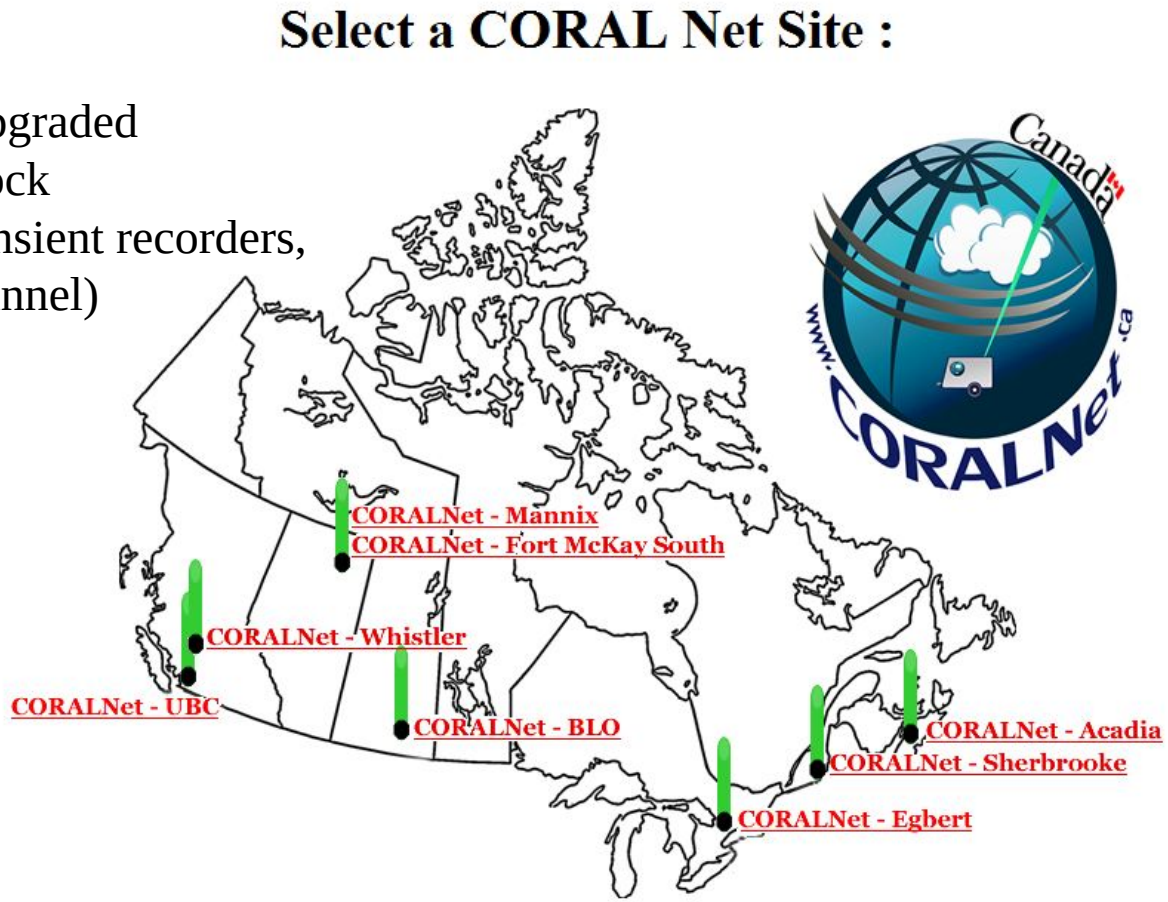
- Tropospheric ozone and aerosols (PM10 and PM2.5) are important atmospheric constituents in low altitude pollution affecting human health and vegetation
- Ozone is photo-chemically active with nitrogen oxides – diurnal variations of photochemical smog
- Aerosols contribute to the radiative budget, tracer for pollution transport, complex mixing, visibility and cloud formation
- Improve AQ forecast and diagnostic models

Operating an Autonomous LIDAR
What we have learned!

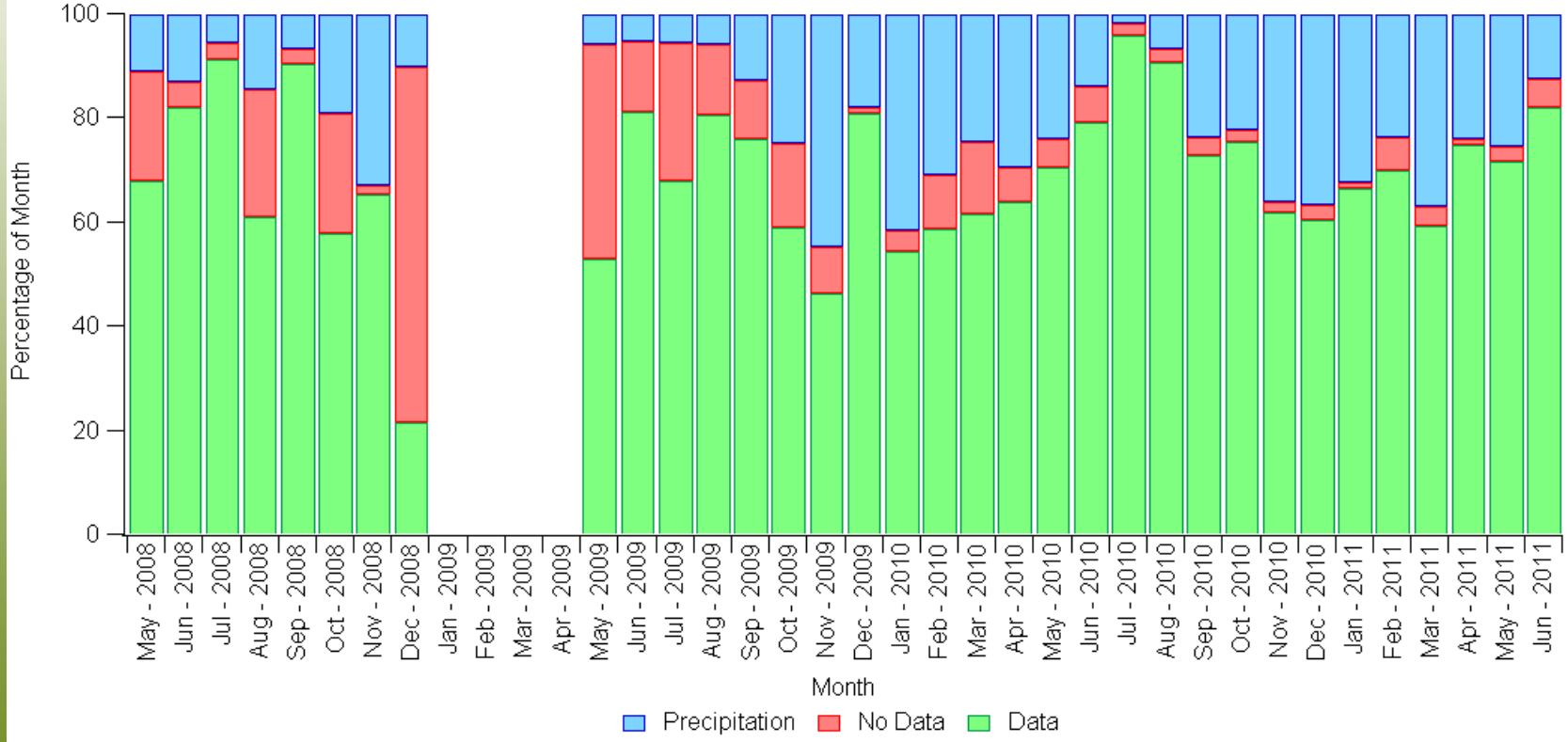
CORALNet

- The Canadian Operational Research Lidar Network

Recently upgraded detector block (LICEL transient recorders, 607 nm channel)



UPTIME!!


100
80
60
40
20
0
Percentage of Month
May - 2008
Jun - 2008
Jul - 2008
Aug - 2008
Sep - 2008
Oct - 2008
Nov - 2008
Dec - 2008
Jan - 2009
Feb - 2009
Mar - 2009
Apr - 2009
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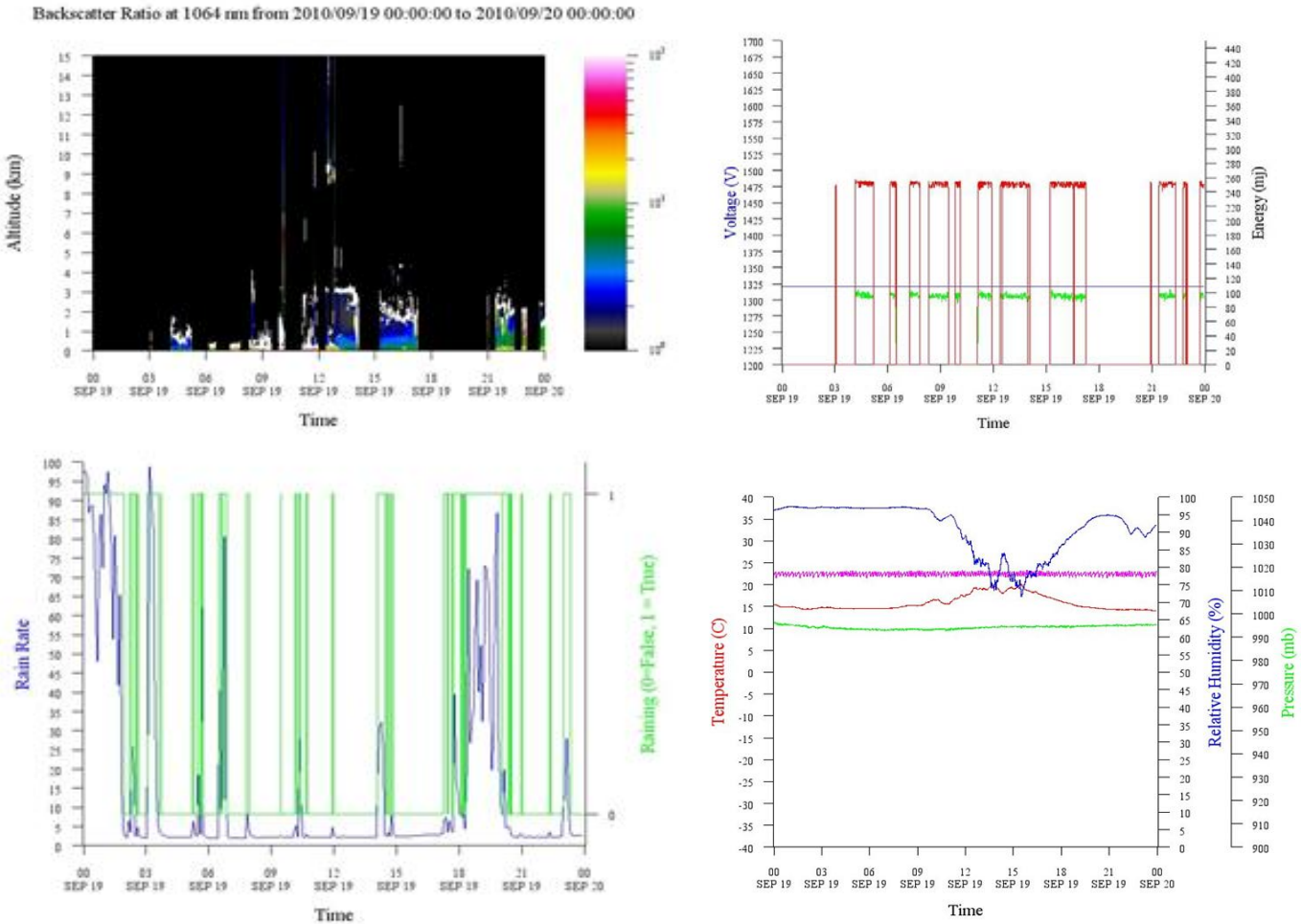
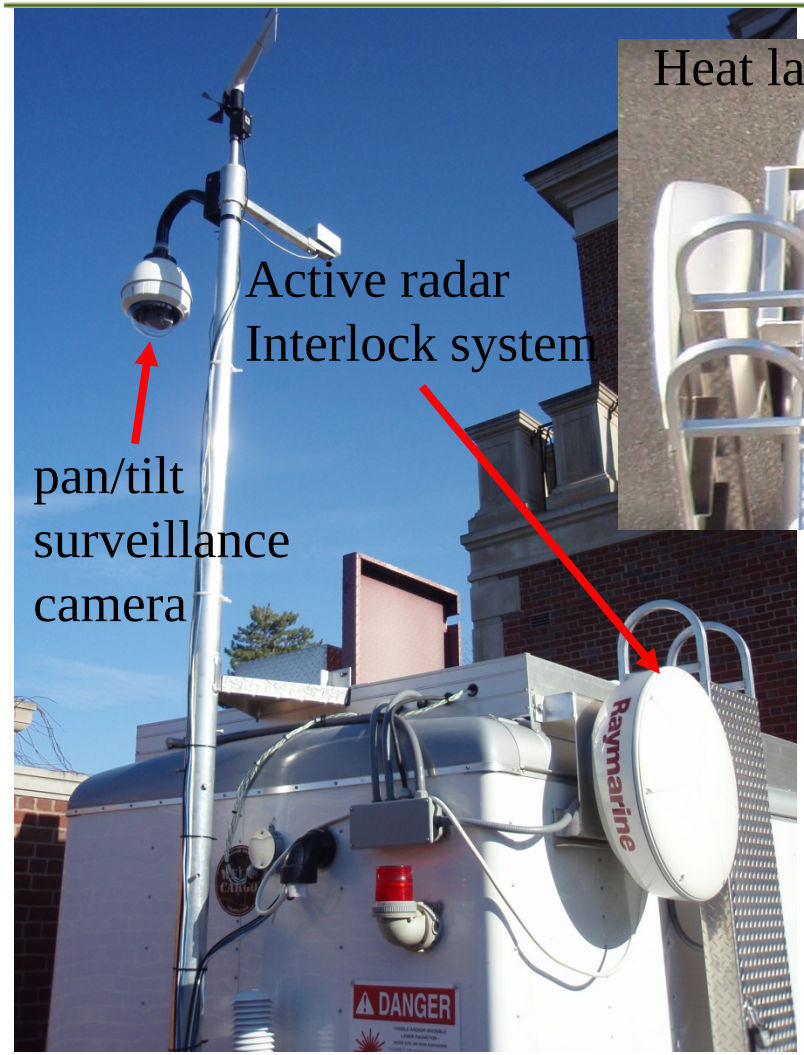
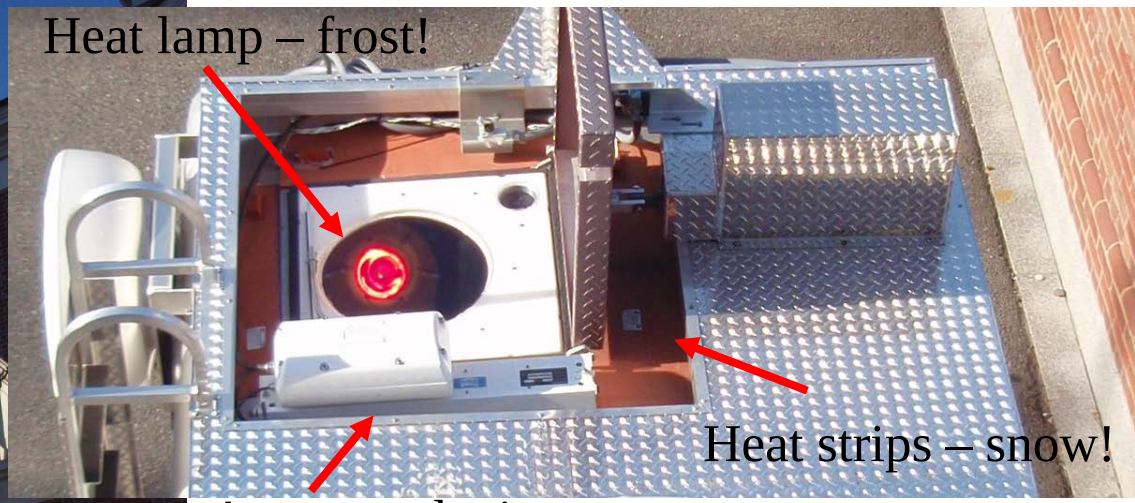
Apr - 2011
May - 2011
Jun - 2011
Month
Precipitation
No Data
Data

Monitor Health of Instrument

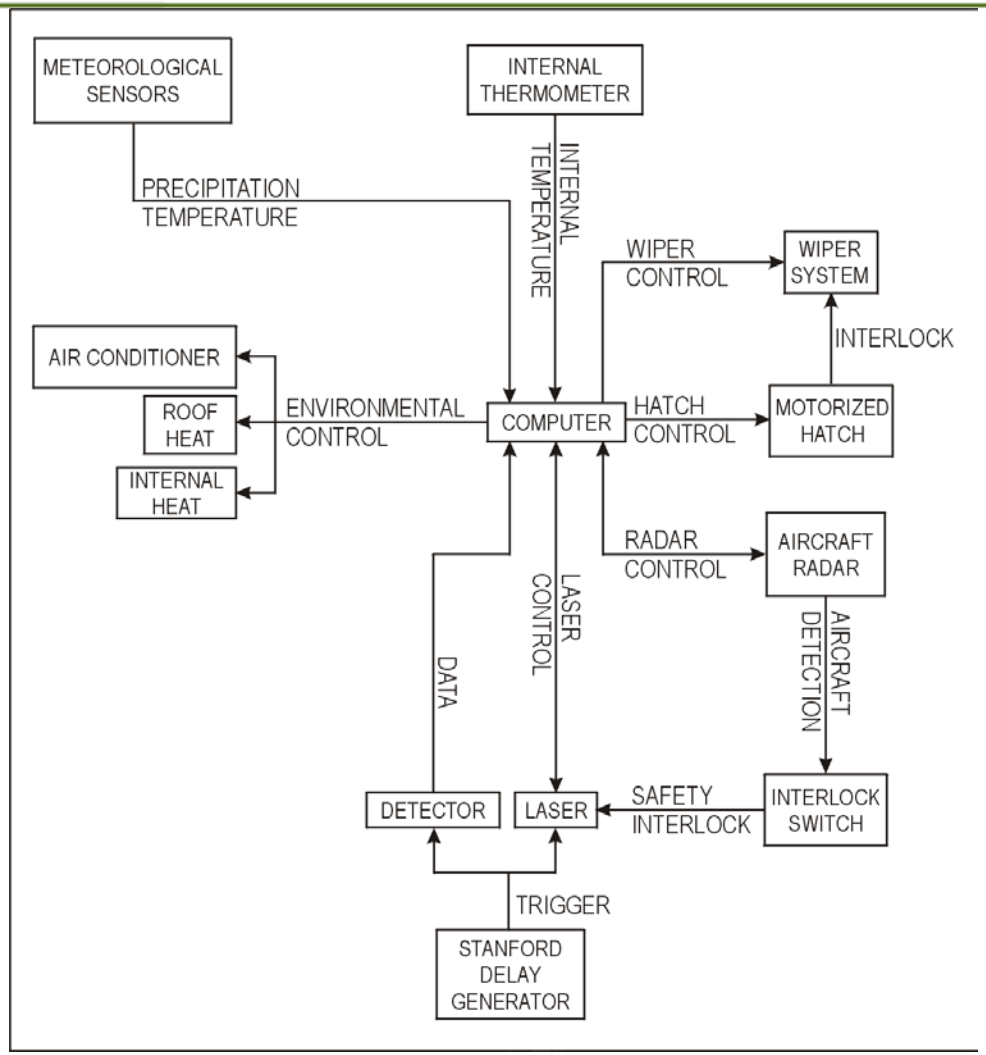


Autonomous LIDAR challenges





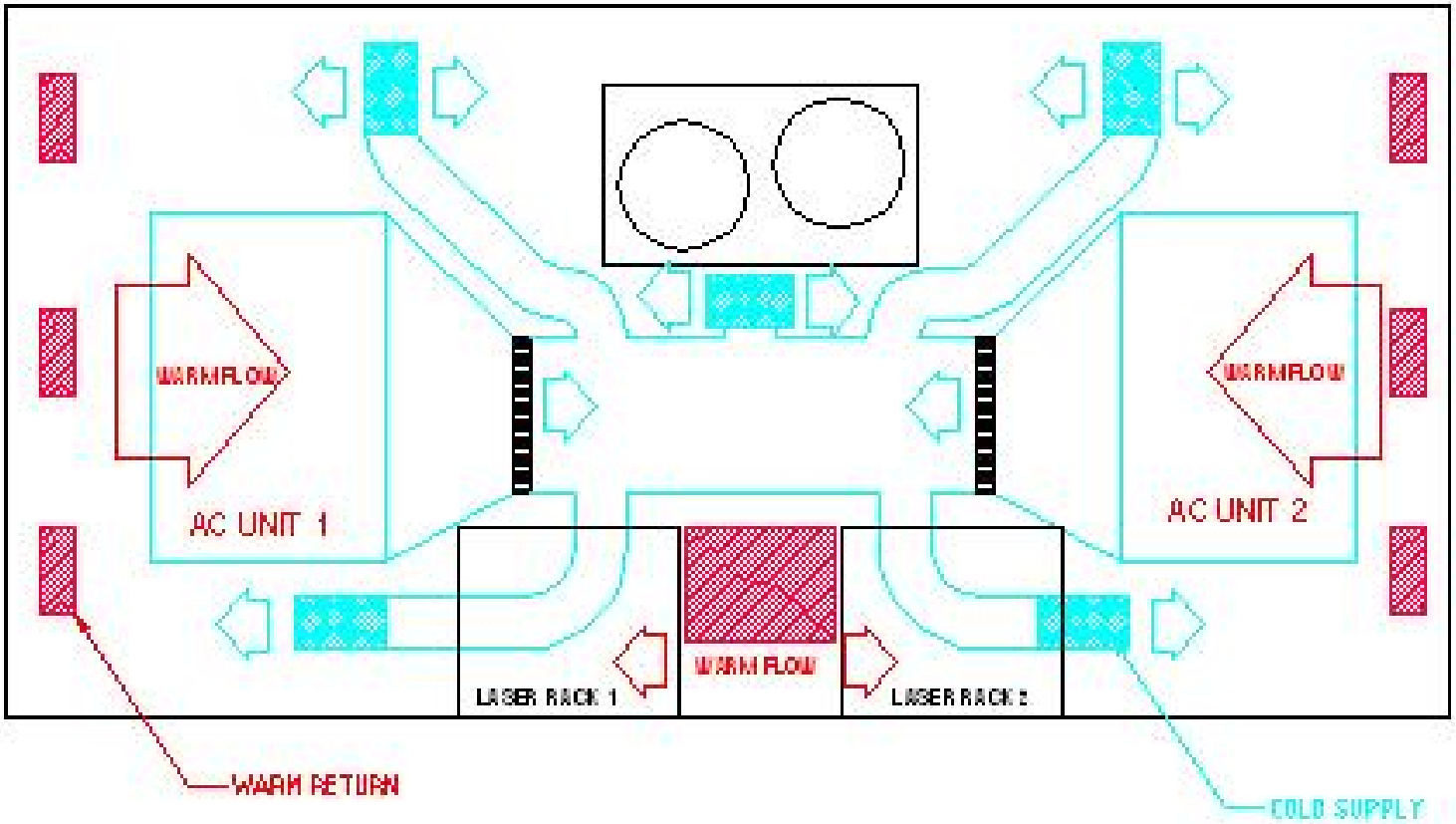
AI Control Systems



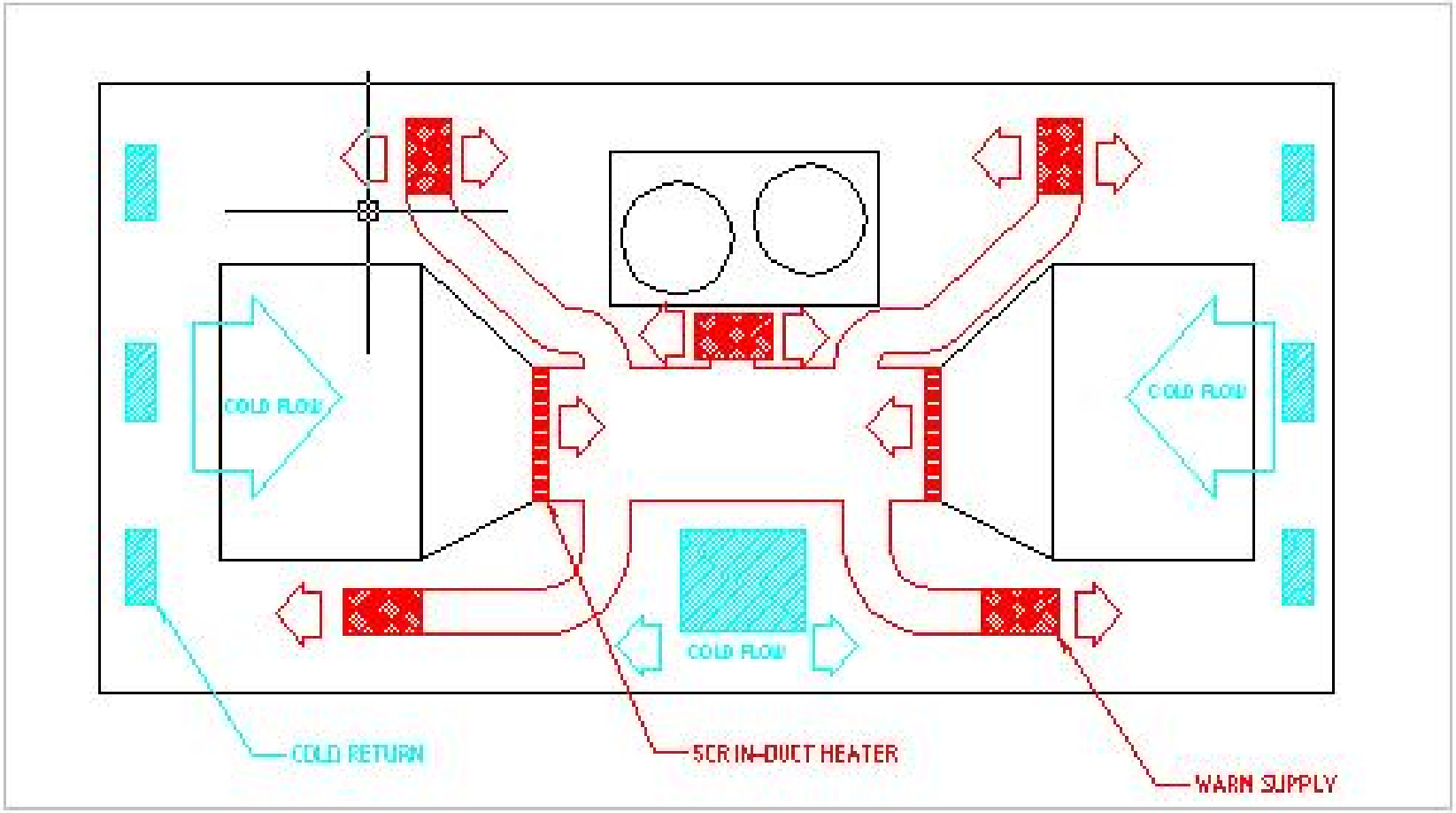
Mobile Platform

Trailer Design

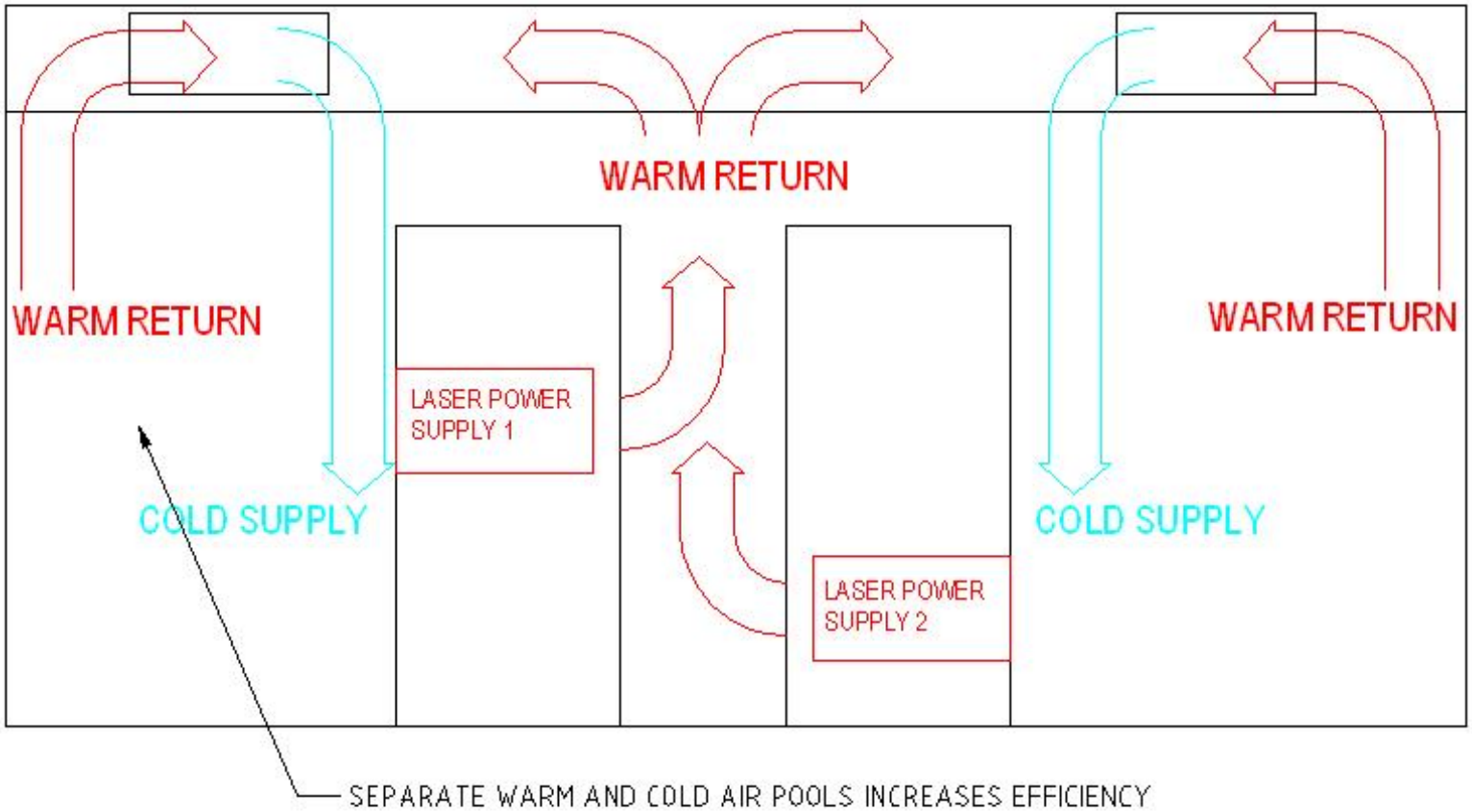
Cooling Cycle



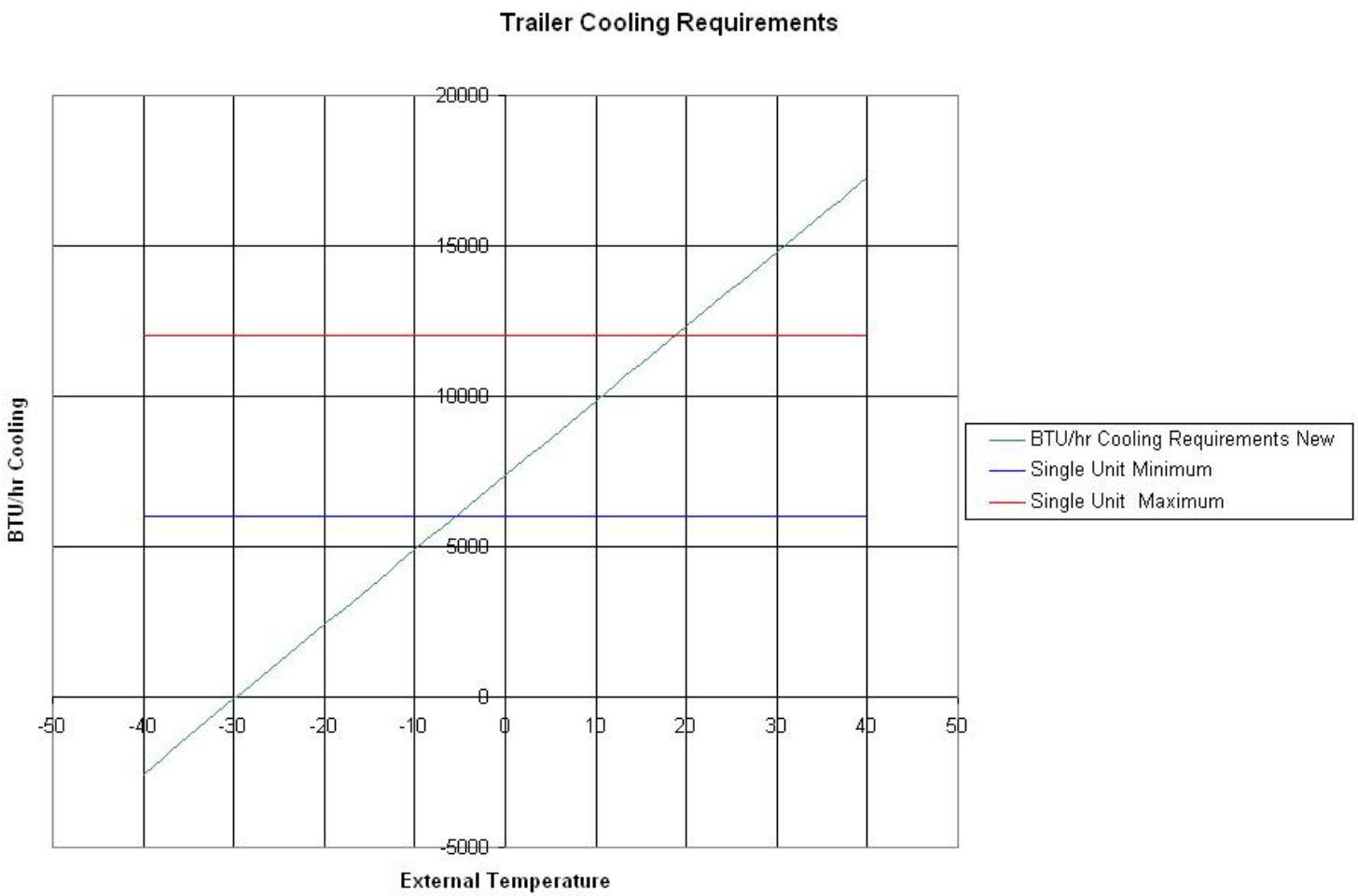
Heating Cycle



Airflow Pattern



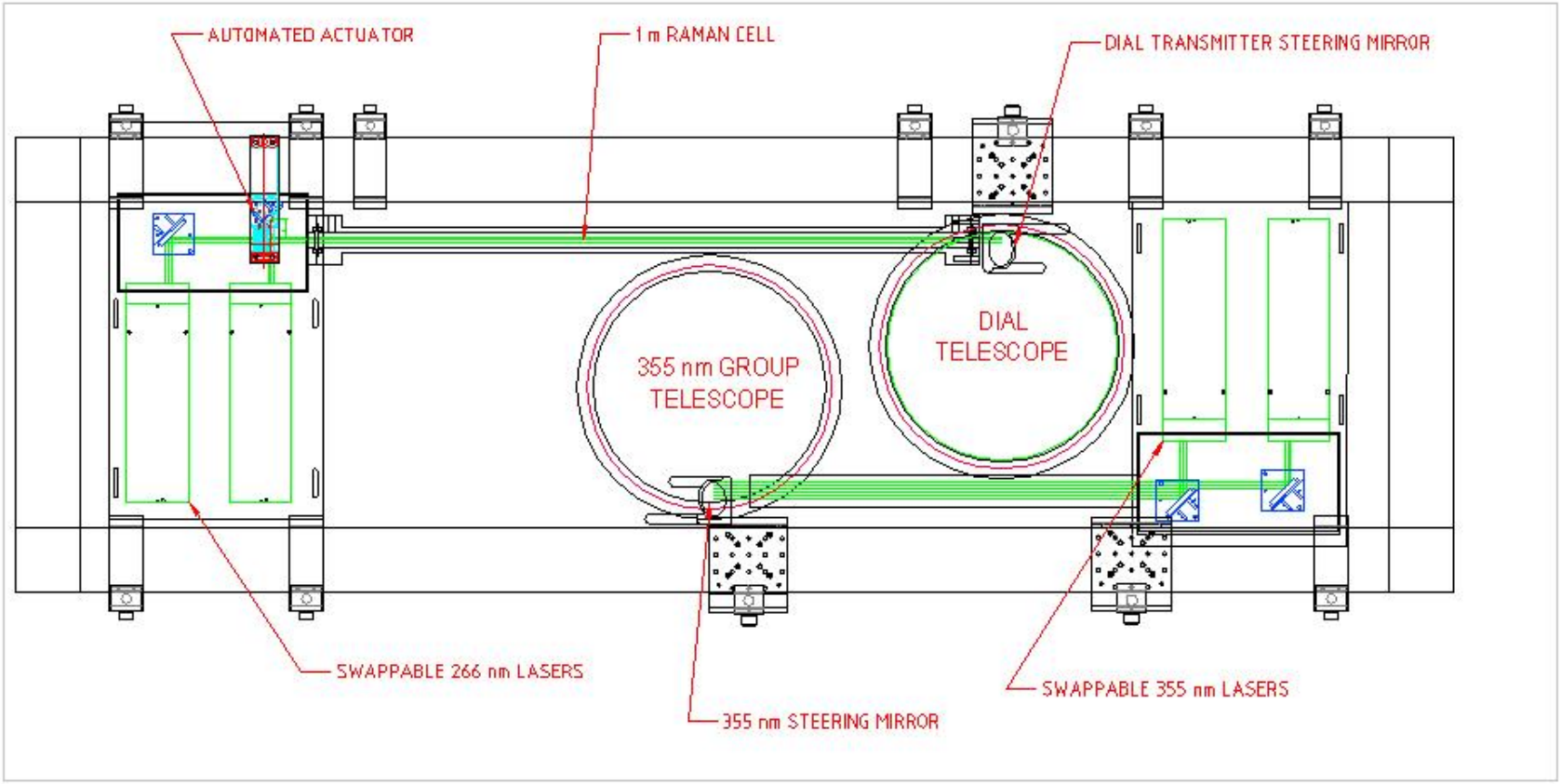
Cooling Budget



HVAC Hardware

Aerosol Backscatter LIDAR

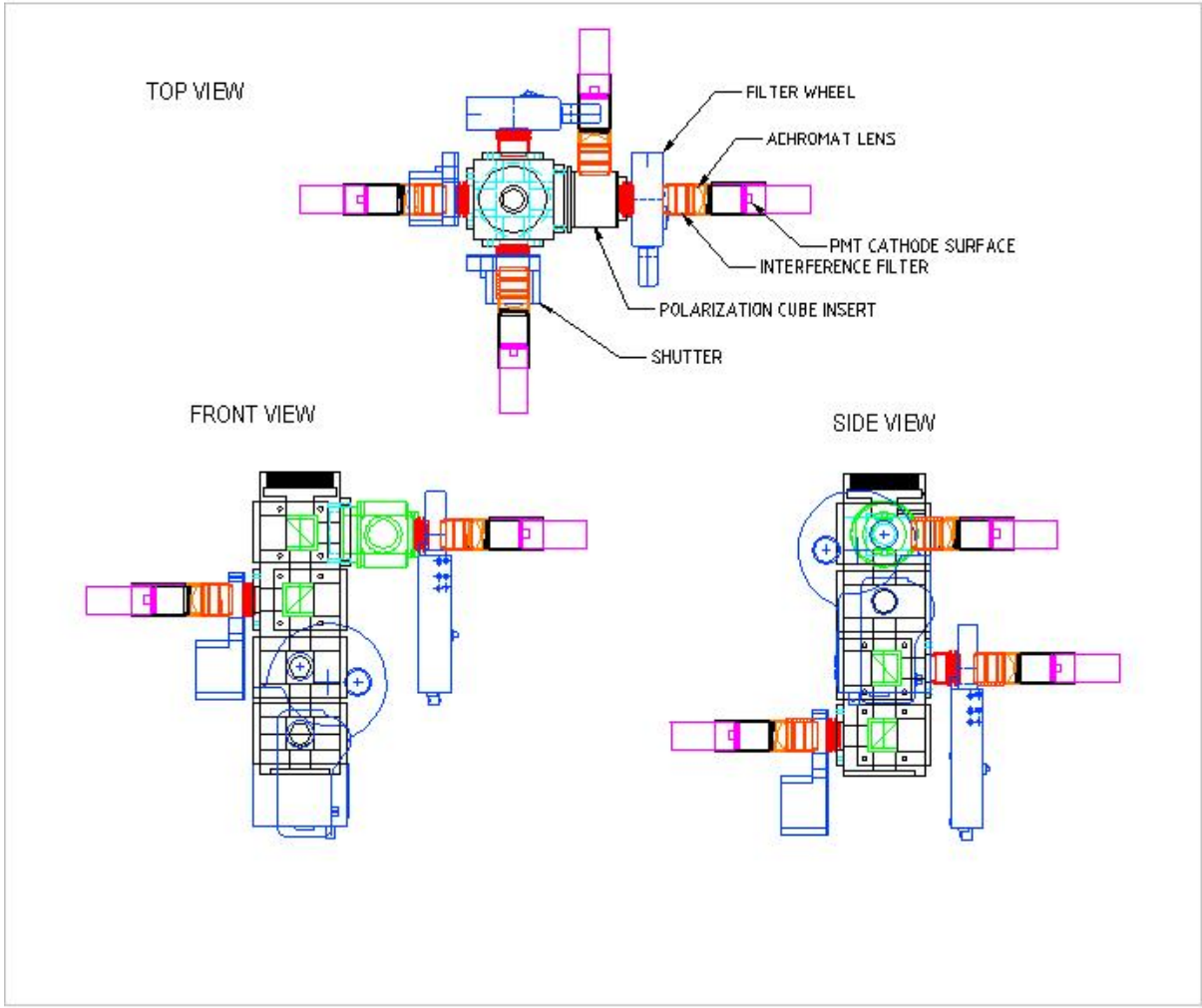
Trailer Layout



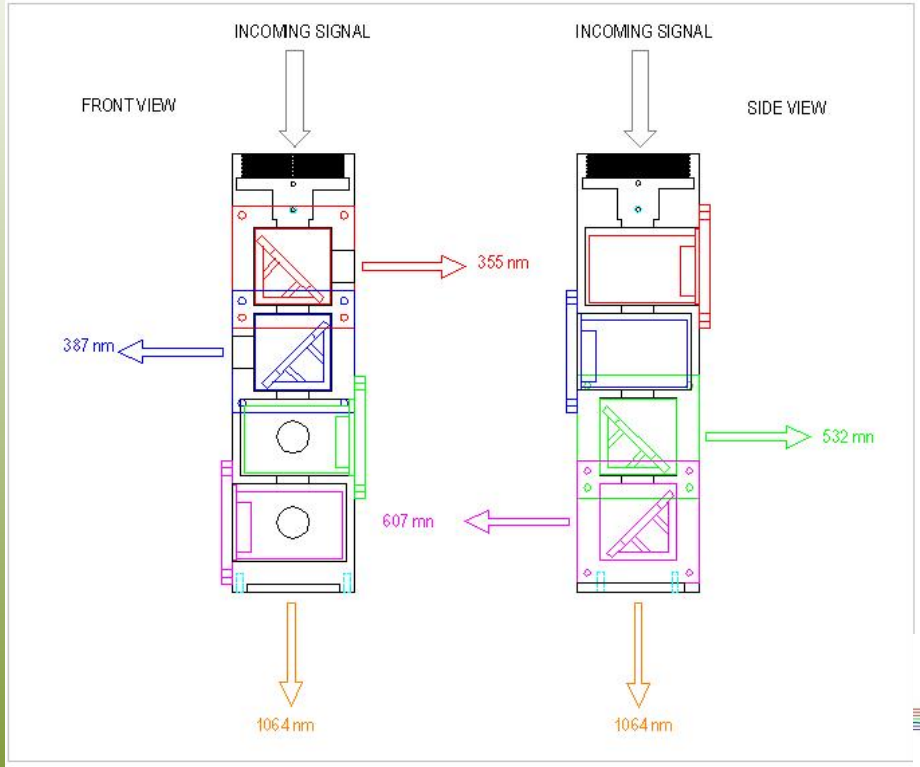
System Parameters

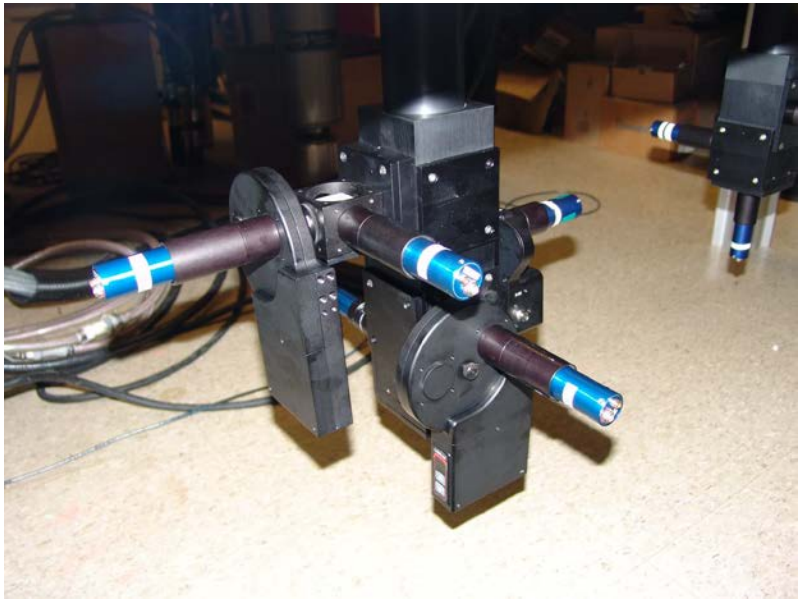
- range/resolution
  - near ground to 15 km
  - 3 – 7.5 m vertical resolution
  - 10 s – 1 min temporal resolution
- three wavelength transmitter / 6 channel receiver
  - 355 nm/532 nm/1064 nm (355 nm is 65mJ @ 20Hz) – Continuum Inlite III-20
  - cross polarization channel at 355 nm
  - 35 cm Schmidt Cassegrain telescope
  - two Raman channels
  - 355/387/532/607 nm - LICEL electronics/PMT's
  - 1064 nm – APD with log amp

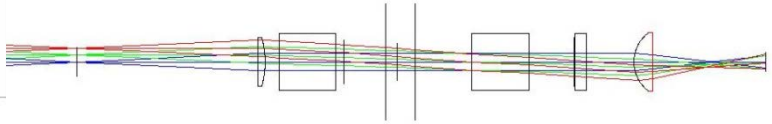
Detector Layout



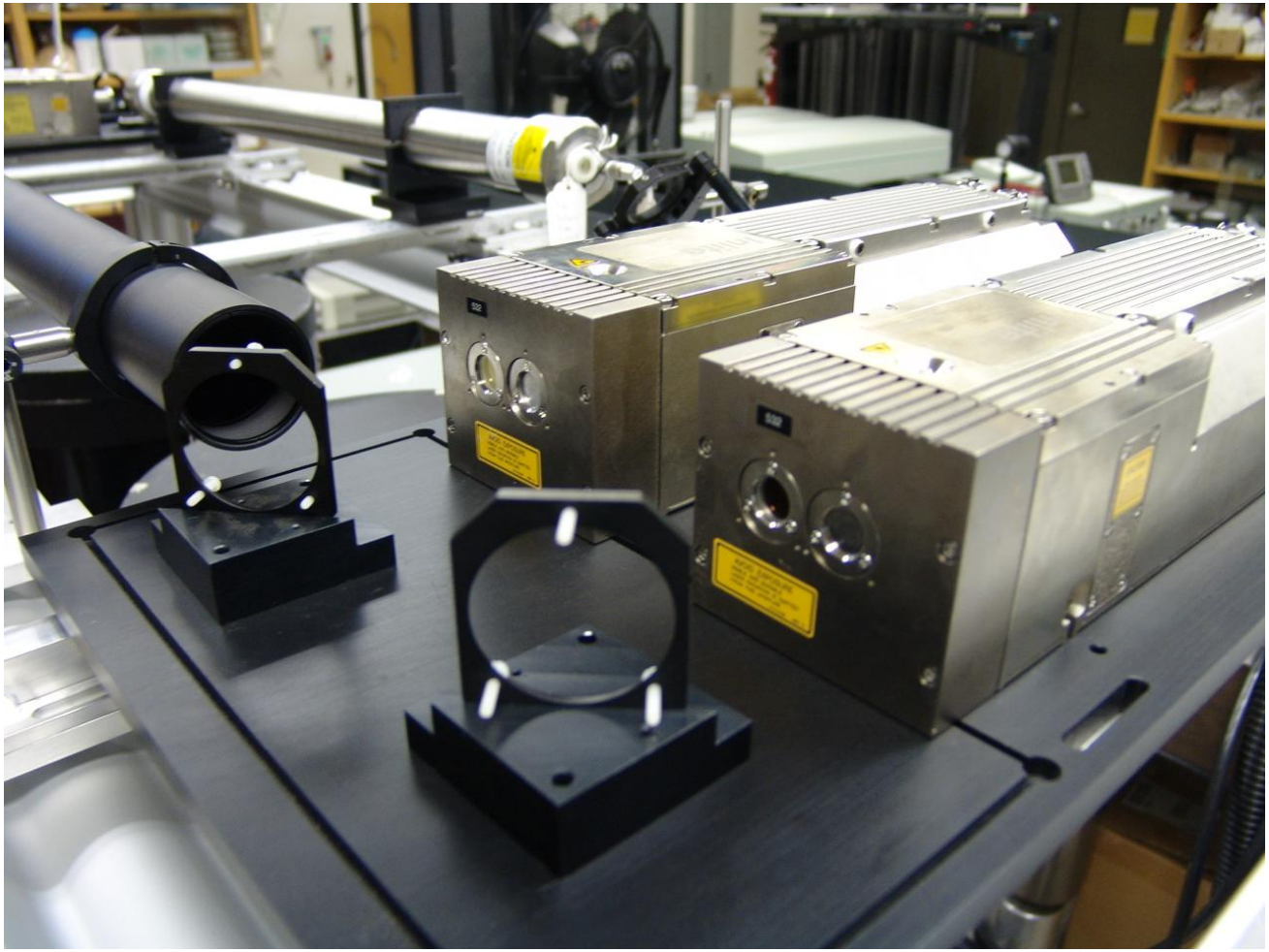
Detector Layout







Dual Laser Design



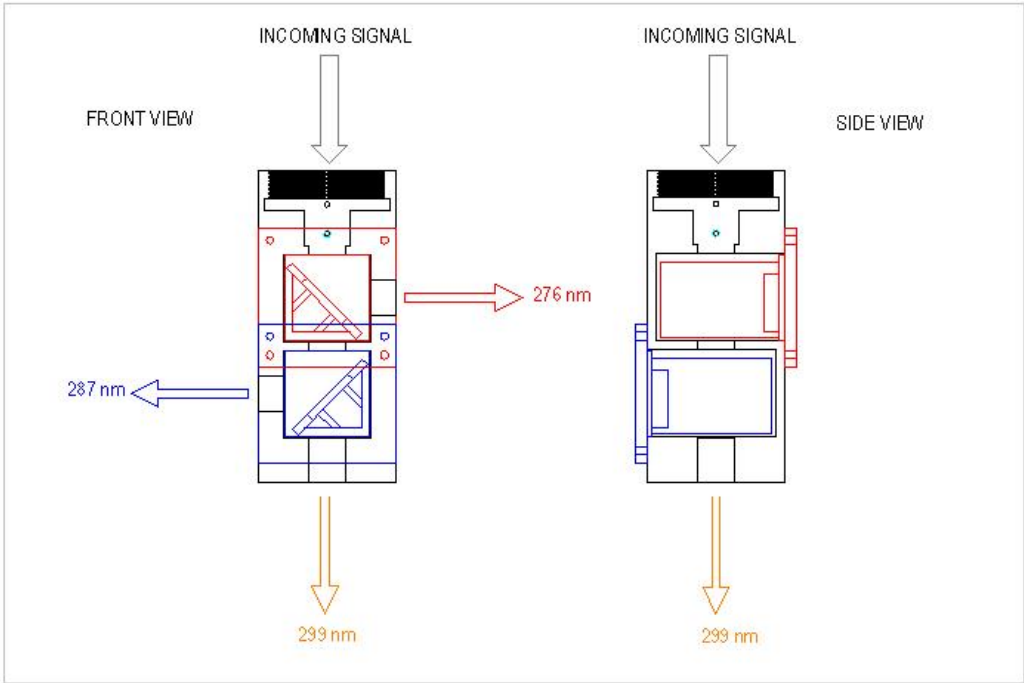
Tropospheric Ozone DIAL

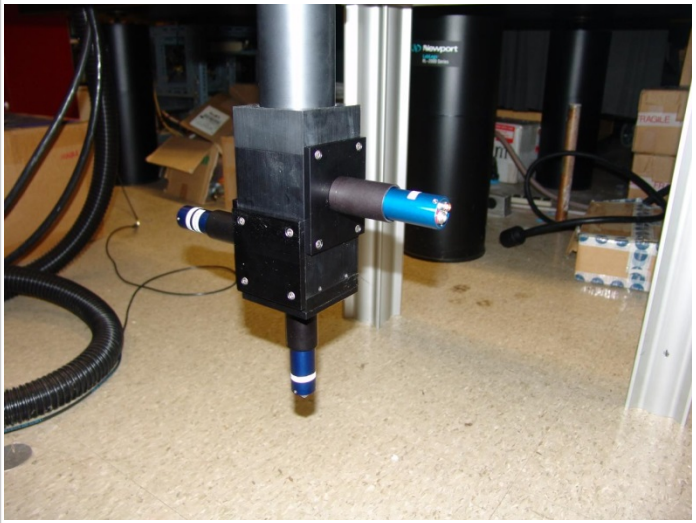
System Parameters

- range/resolution
  - near ground to 10 km
  - 7.5 m vertical resolution minimum
  - 1-10 min temporal resolution
- transmitter / receiver
  - Continuum Inlite III-20 laser
  - output energy/power @ 266 nm

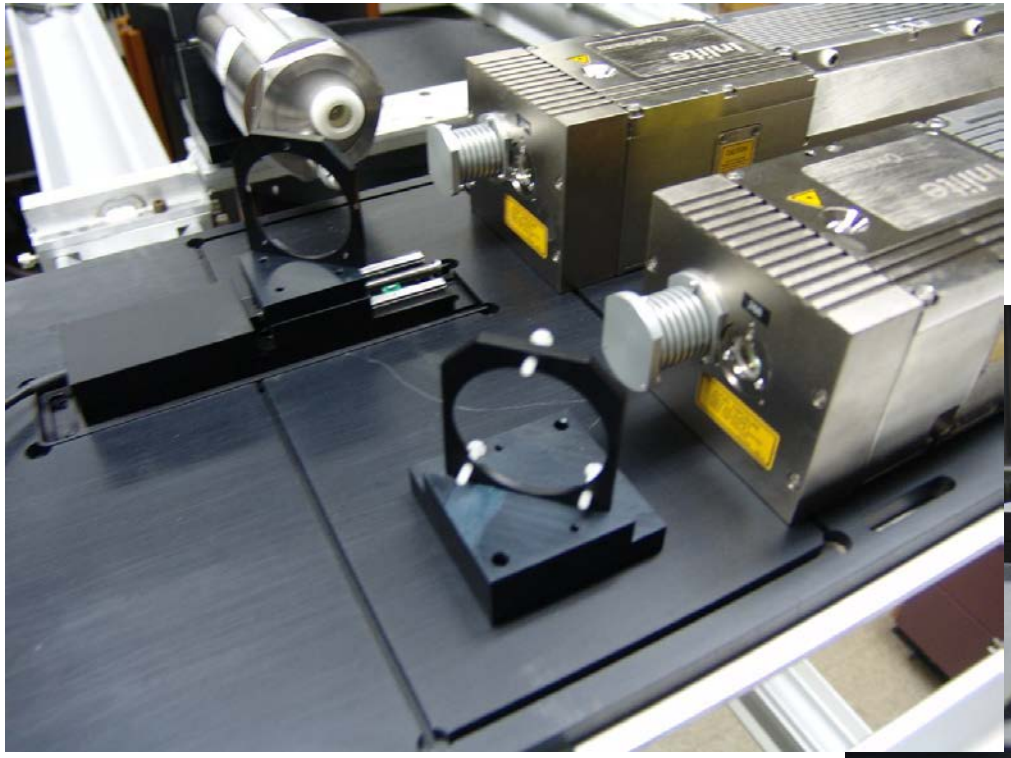
    45mJ @ 20Hz = .9 W
  - 35 cm Schmidt Cassegrain telescope
  - 276/287/299 nm - LICEL electronics/PMT's

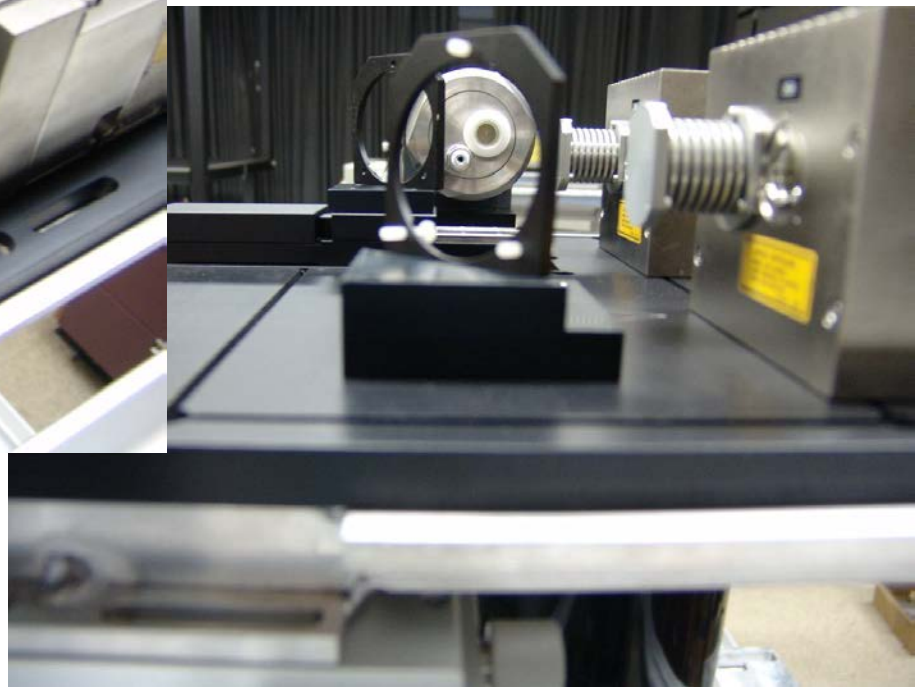
DIAL Detector Block





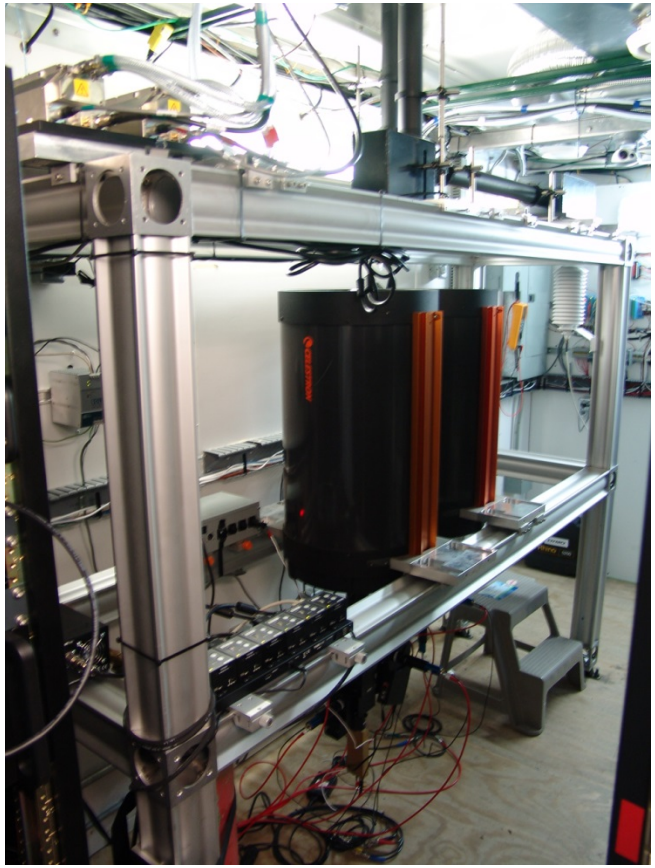
DIAL Lasers



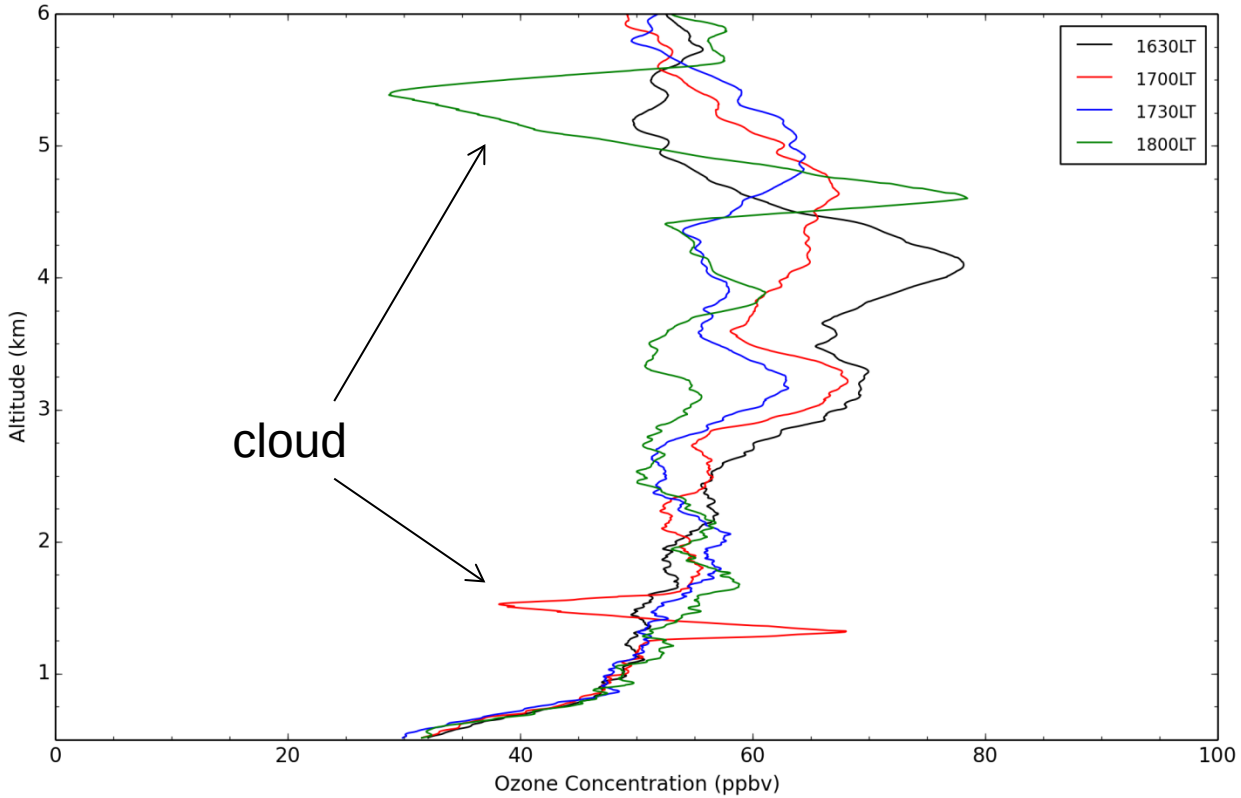


Testing and Deployment

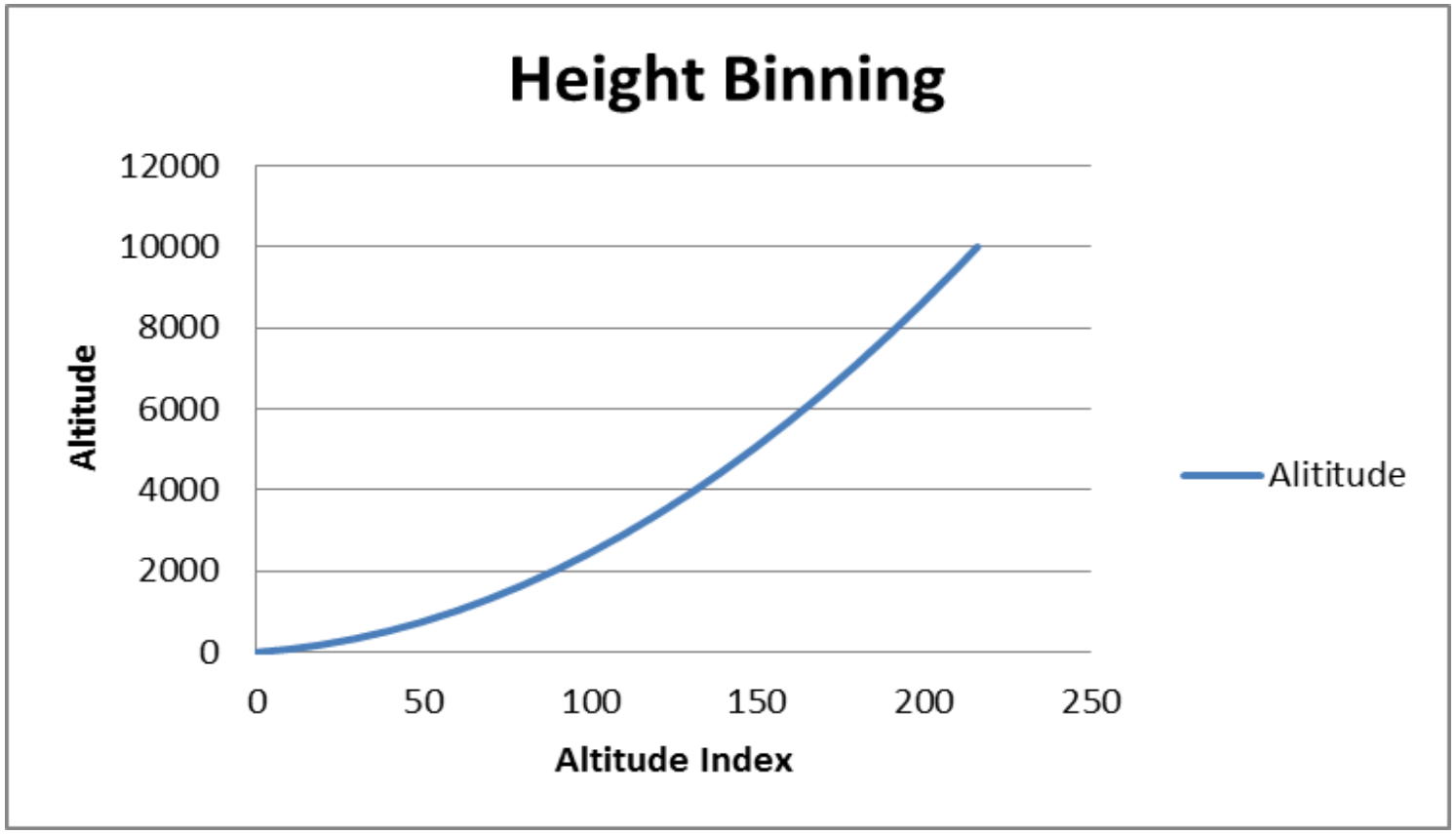
Transmitter Layout



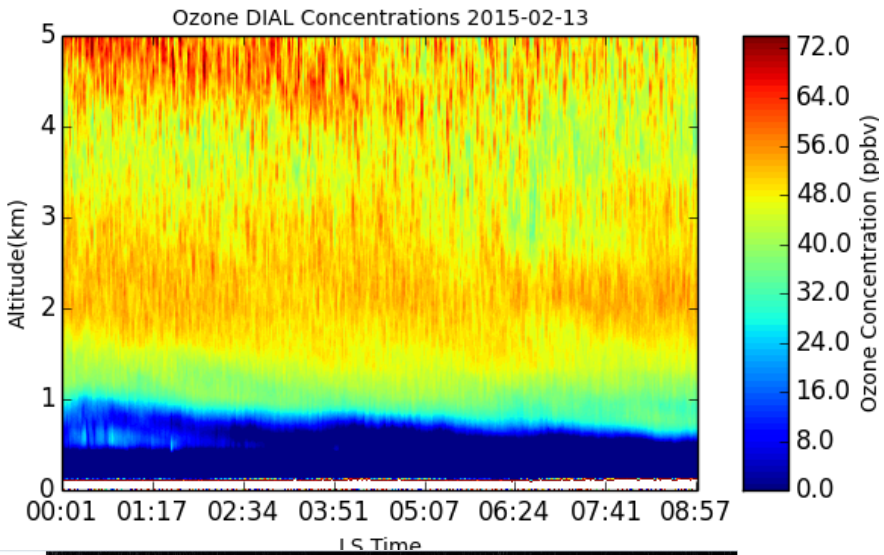
Lidar First Light – 30 min avg O_3

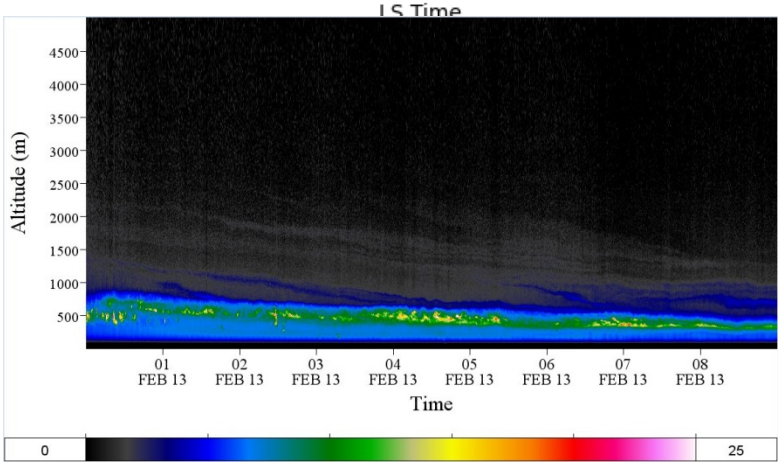


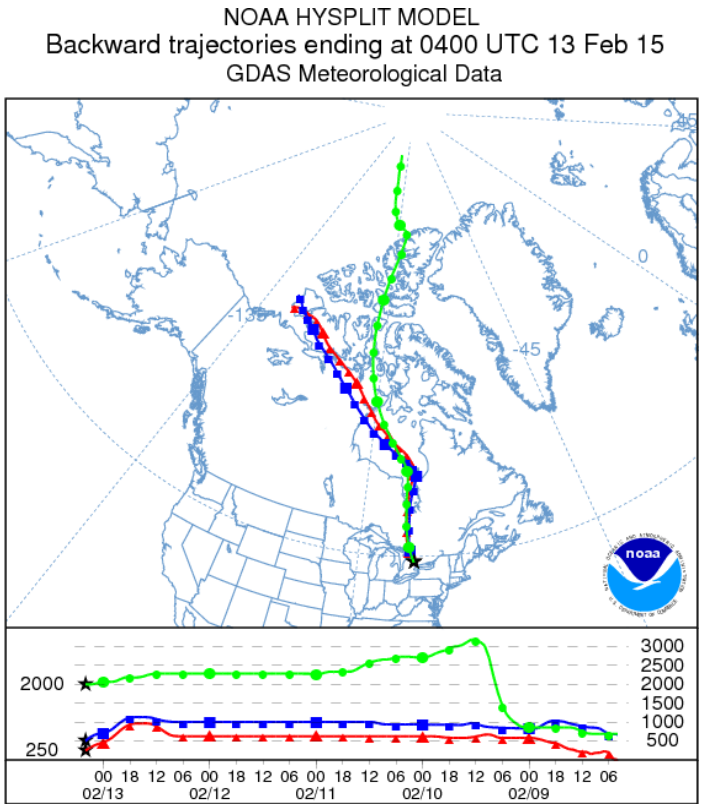
Non Linear Height Binning



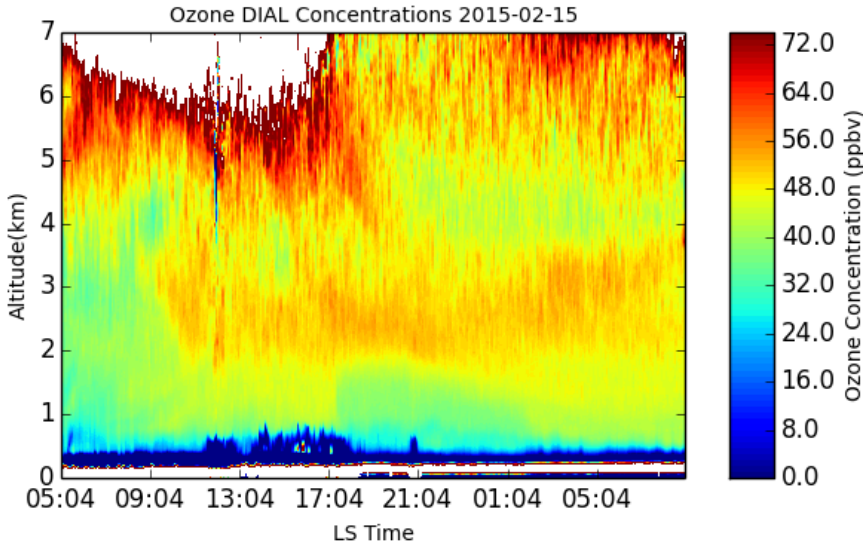
Ozone Depleted Air from Arctic

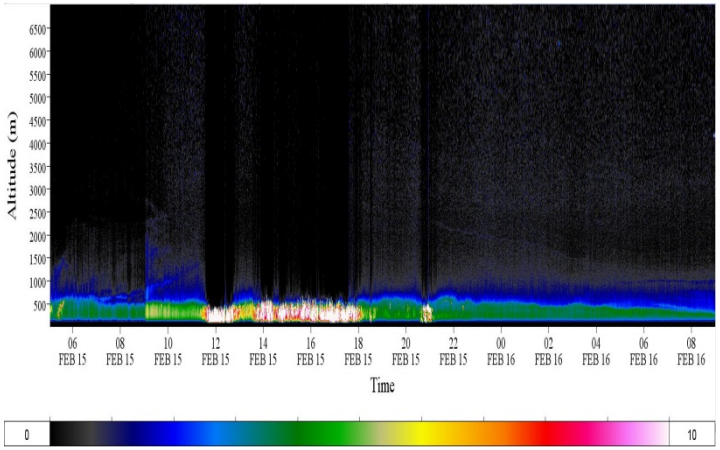


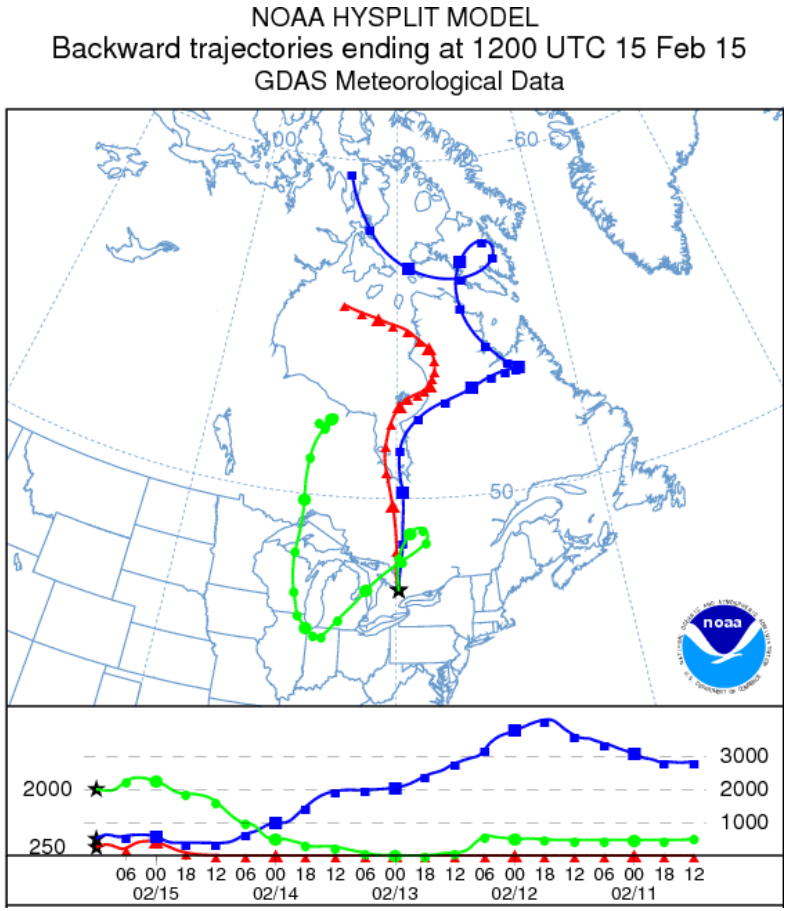




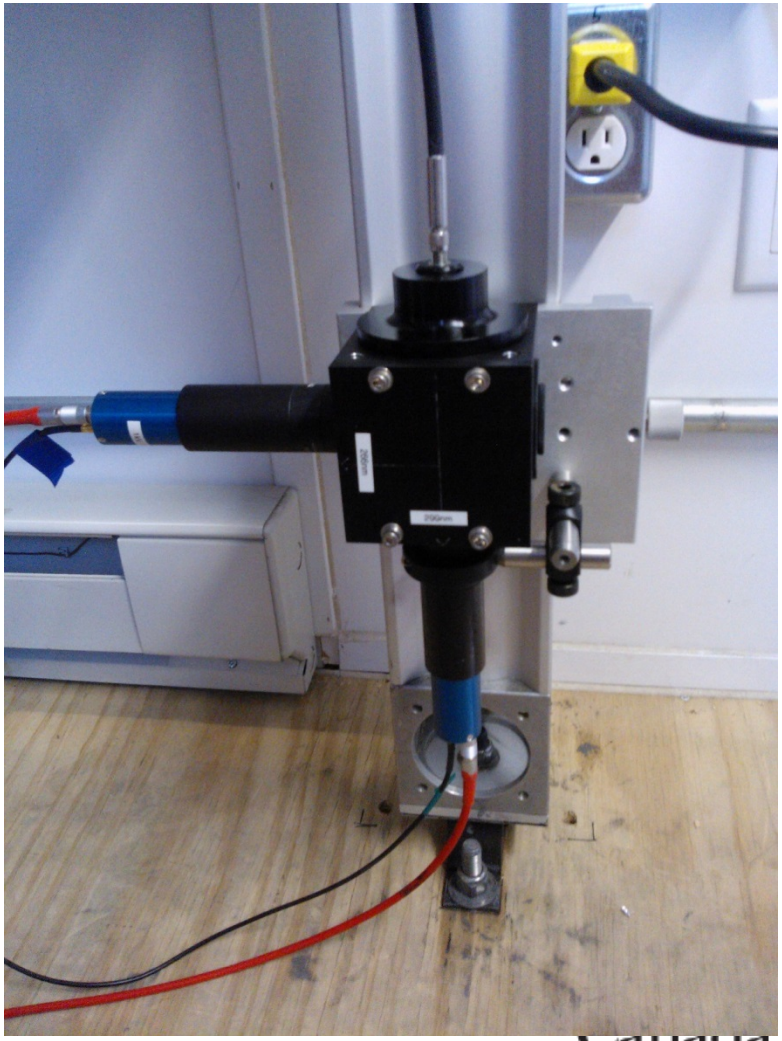
Ozone Depleted Air from Arctic







Small Telescope/Optical Fibre



Calibration/Upgrades

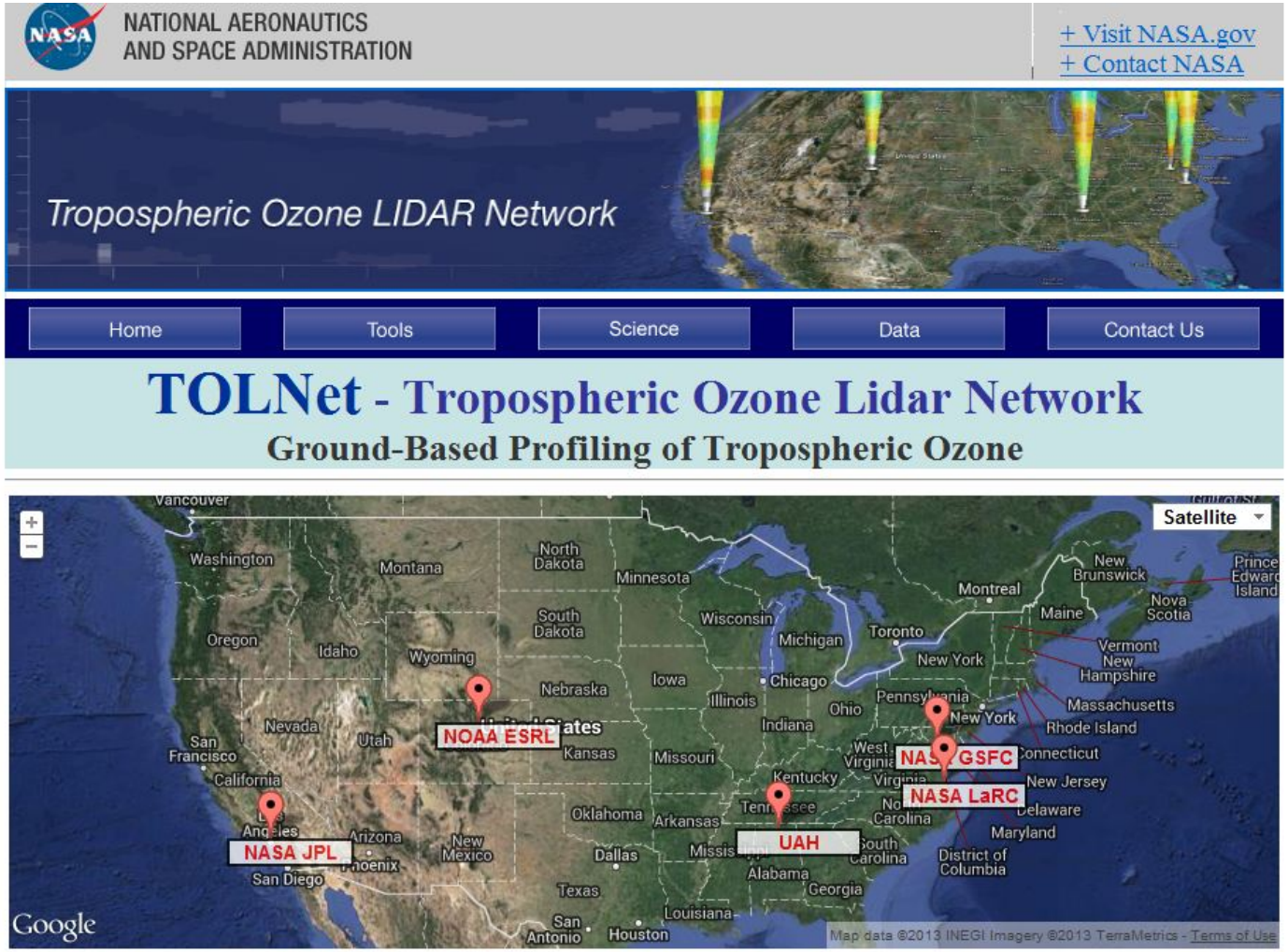
- Ozone sonde campaign will be carried out at Centre For Atmospheric Research
- Awaiting laser modifications
- 355 nm laser undergoing optical re-design for stability, cooling group modifications and pyro re-design
- 266 nm laser has same upgrades as well as crystal tuning and testing with in-line UV lamp to kill algae

Collaboration

Deployment to the Oil Sands Region

- Coincident and long-term record for aircraft measurements
  - In-situ chemistry package
  - Airborne ozone lidar (J. Whiteway – York University)
- Coincident and long-term record for ground measurements
  - Ground-level ozone, NO_x etc
  - CIMEL sunphotometer
- Satellite comparison/validation (eg. TEMPO, TOLNet)
- Environment Canada GEM-MACH Model verification/validation

TOLNET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Summary and Future Work

- the newly developed autonomous tropospheric ozone/3+2 aerosol lidar will add a unique capability for Environment Canada to explore the presence, vertical distribution and seasonal variability in the lower atmosphere
- the synergistic approach to simultaneous measure tropospheric ozone lidar and aerosol lidar will provide an improved understanding of boundary layer and free tropospheric processes which impact visibility and air quality
- If the instrument is successful, funding should be available to build another unit for deployment