

Near Field Improvements for Langley Mobile Ozone Lidar

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OWLETS Science Team and Planning Meeting

Oct. 17-20th, 2017



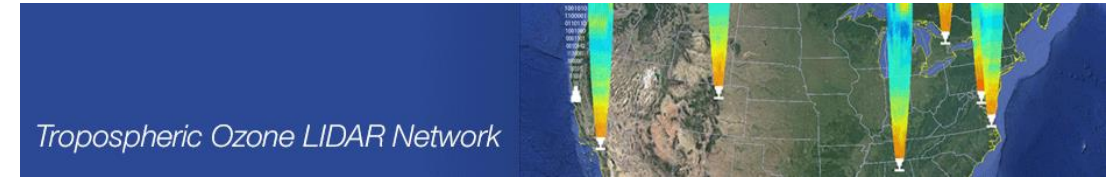
OUTLINE

- **Langley Mobile Ozone Lidar (LMOL):** *System Design and Capabilities*
- **Motivation for Improved Receiver Design**
 - *Previous Instrument Validation During Campaigns*
 - *Significance & Challenges of Near-field Measurements*
- **Near-Field Receiver Design:** *Fiber-Coupled Off-Axis Parabolic Mirror*
- **OWLETS Data and Receiver Testing**
 - *Multi-instrument Intercomparison at CBBT (8/1-8/2)*
 - *Ozonesonde Intercomparison for Near Field*
- **Summary:** *Future Analysis and Potential Designs*

Langley Mobile Ozone Lidar (LMOL)

System Design and Capabilities

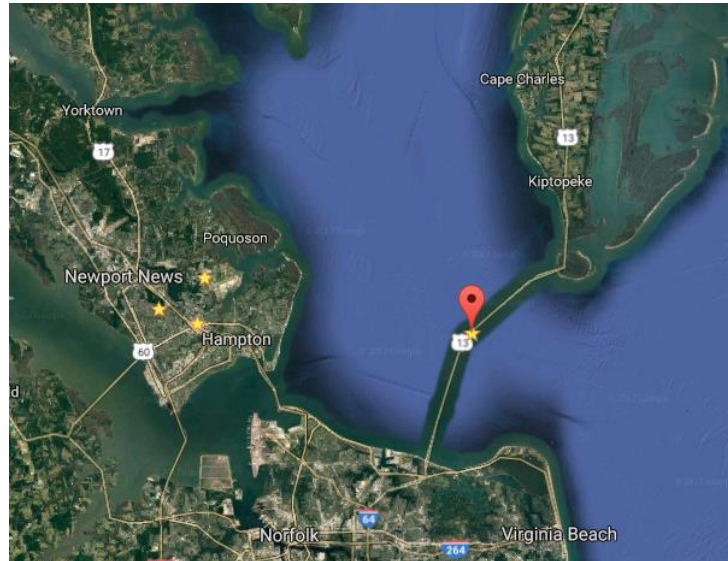
- Differential absorption lidar (DIAL) instrument
- Small, highly mobile trailer
- Ozone and aerosol profiles up to 8 km



LMOL trailer located at the CBBT site



Chesapeake Bay Bridge Tunnel (CBBT)



Team LMOL: Tim Berkoff, Bill Carrion, Betsy Farris, Guillaume Gronoff



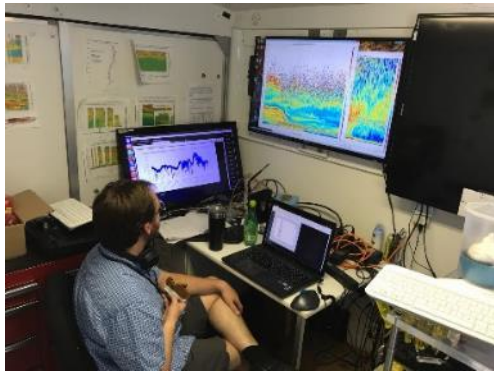
Russell De Young et al. "Langley mobile ozone lidar: ozone and aerosol atmospheric profiling for air quality research," Appl. Opt. 56, 721-730 (2017)

Langley Mobile Ozone Lidar (LMOL)

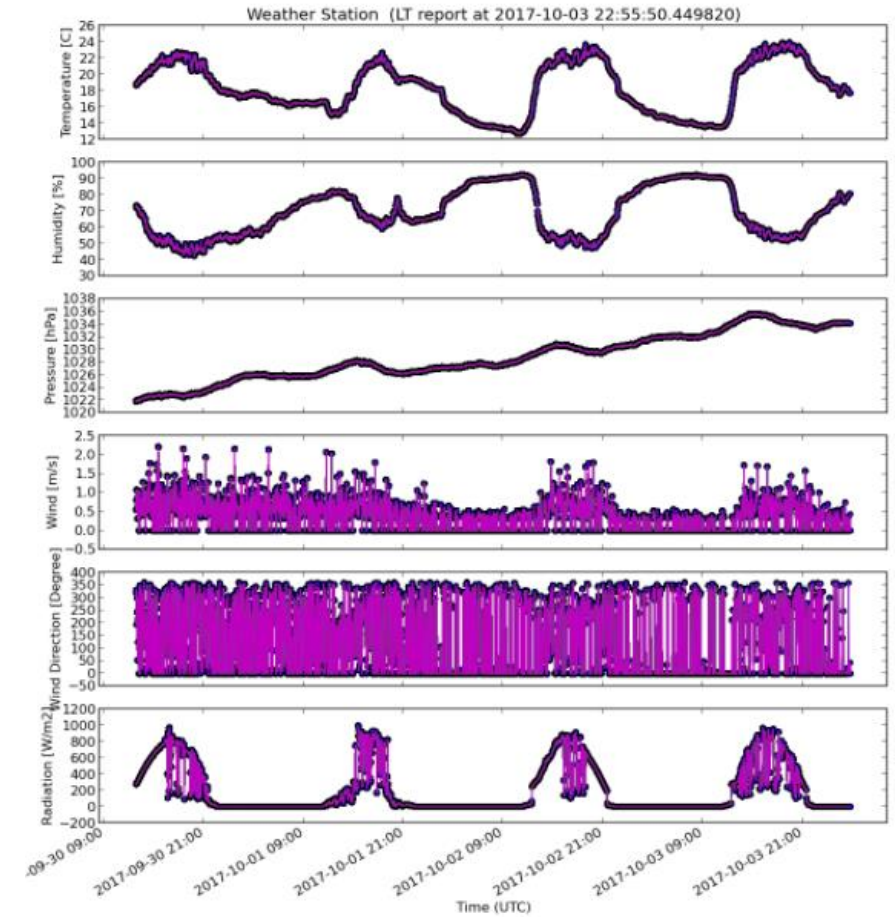
System Design and Capabilities

- Site Capabilities
 - Surface in-situ ozone (2B Technologies)
 - Meteorology station (temperature, wind speed & direction, Relative Humidity)
 - Surface radiance
- Real-time ozone and aerosol processing and display
 - Website reporting lidar data and ground ozone
 - <https://lmoldata.is-very-good.org/>

Real-time processing display



202 Surface Ozone Monitor



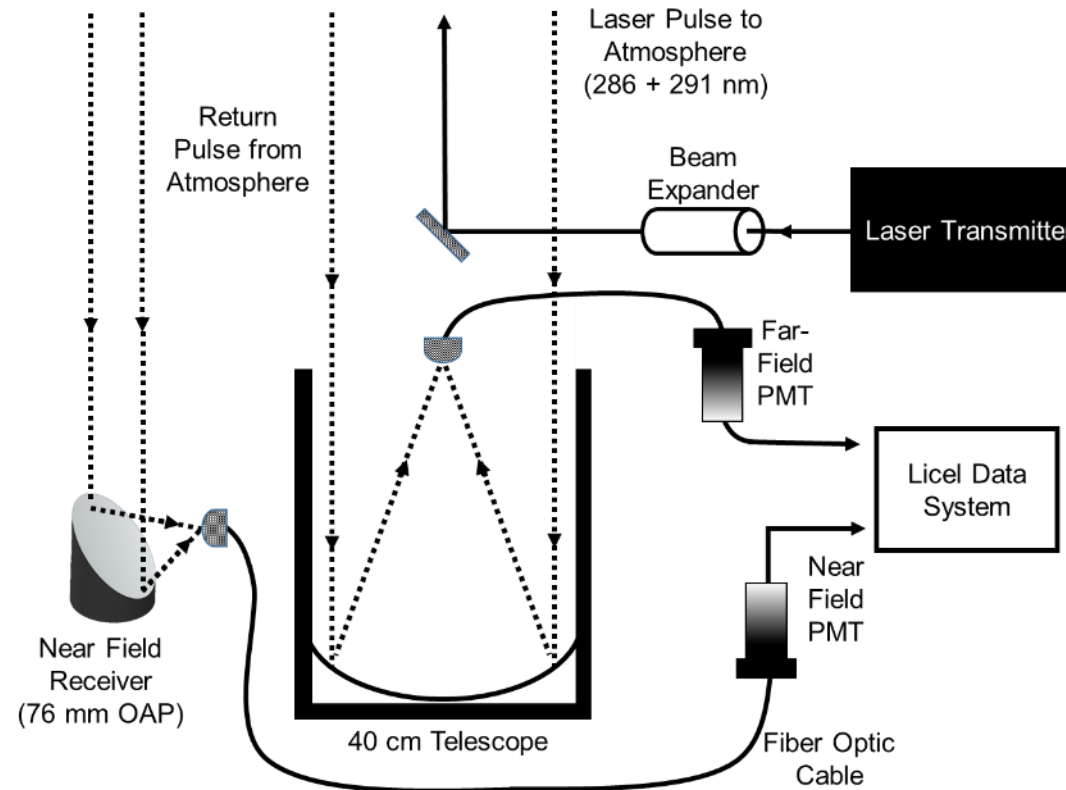
Example Meteorology Data from LMOL

Langley Mobile Ozone Lidar (LMOL)

System Design and Capabilities

- Pulsed UV laser transmission into atmosphere
- Far-Field Receiver: fiber-coupled Newtonian receiver (1.5 mrad field of view)
- Near Field Receiver: Off-axis parabolic mirror, fiber-coupled
- Photonmultiplier Tube (PMT) Detector: analog and photon counting channels (Licel data system)

Far Field: 8,000-600 m
Near Field: 0-600 m



System Diagram



Laser System in Trailer

Motivation for Improved Receiver Design

Previous Instrument Validation During Campaigns

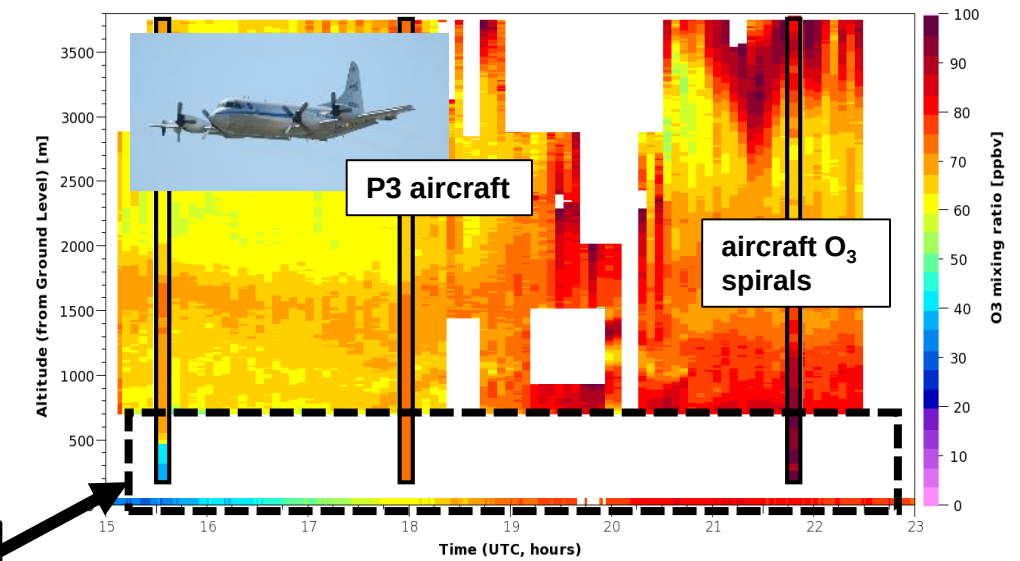
DISCOVER-AQ 2014

- Multiple TOLNet lidars participated in the DISCOVER-AQ field campaign in 2014
- P3 measurements included ozone, enabling comparisons with LMOL profiles
- Aircraft P3 data provided by NCAR (Ridley et al., 1992 & Weinheimer et al. 1993)

SCOOP 2016

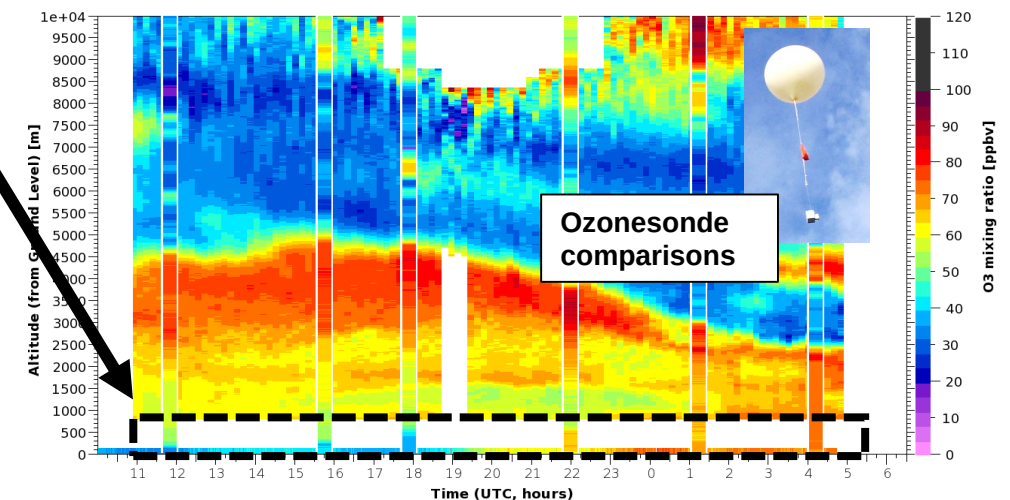
- LMOL participated in the TOLNET/SCOOP at the JPL/TMF facility
- Lidar observations were compared with several ozonesondes
- Monitoring O₃ and Aerosols with the NASA LaRC Mobile Ozone Lidar System (Ganoe, Gronof, Berkoff, DeYoung, Carrion; 2016)

DISCOVER-AQ: LMOL example data (July 28, 2014)



**Near Field:
0-600m
missing!**

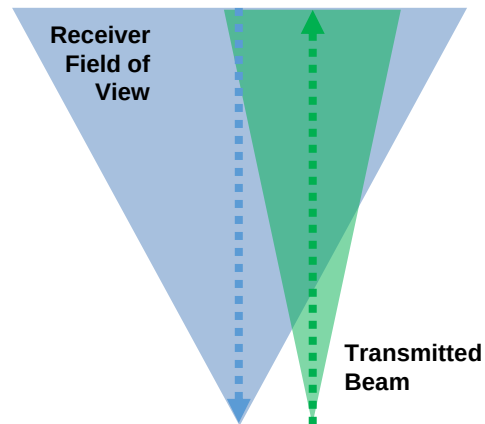
SCOOP Campaign: LMOL Data (Aug. 15, 2016)



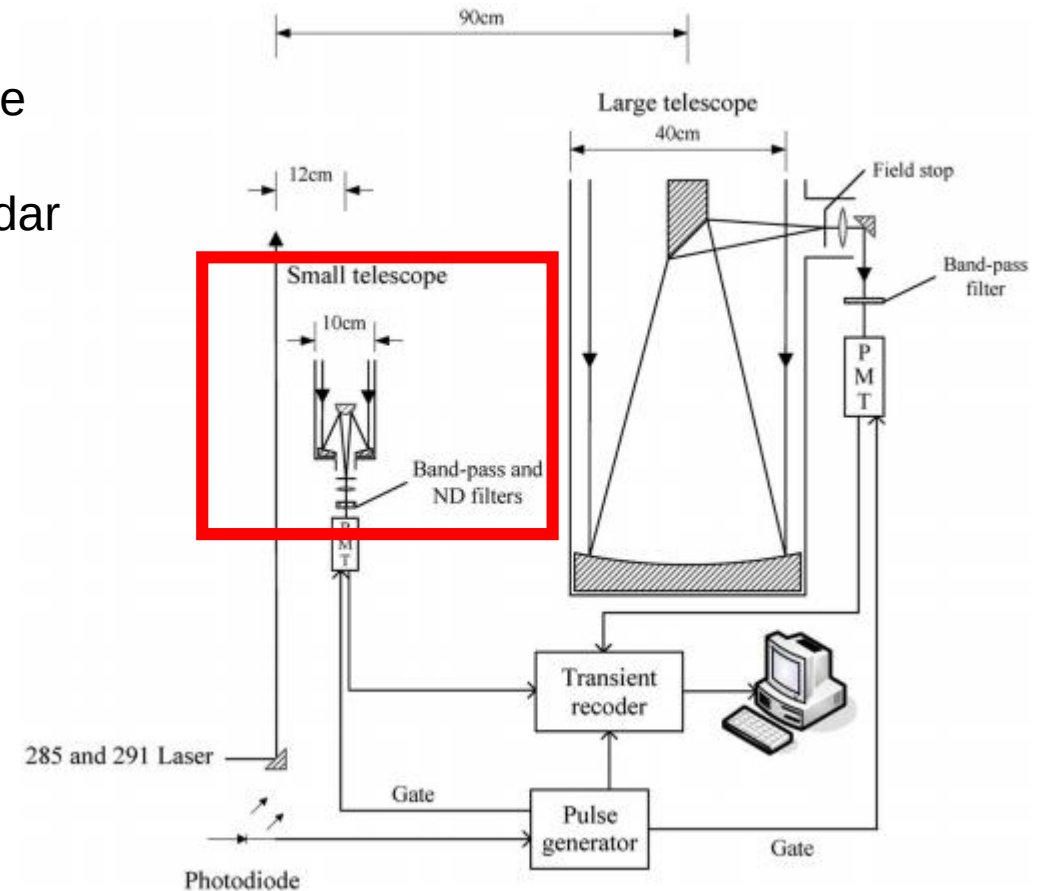
Motivation for Improved Receiver Design

Significance & Challenges of *Near-field Measurements*

- Importance of near field (0-600m)
 - significant changes can occur in this lower atmosphere
 - most critical for human health
- Previous LMOL data screened due to non-linear effects (lidar overlap function, detector saturation effects, etc)



- Many lidars use a second smaller diameter telescope to obtain near-range signals with a wide field-of-view
 - Newtonian & Cassegrain Telescopes: two mirror design
 - Refractor: difficulties with multiple wavelengths

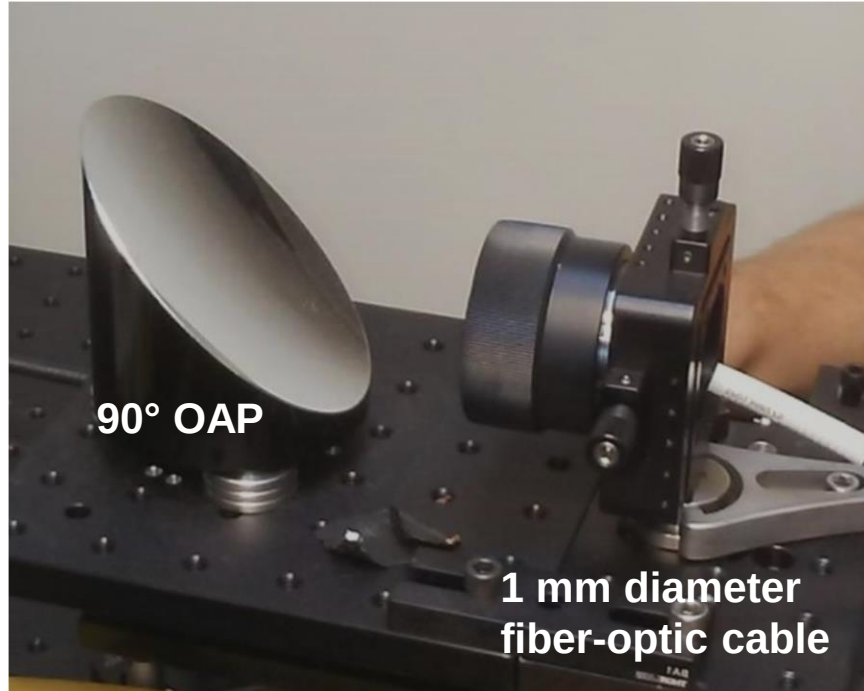


Cassegrain Telescope Receiver: retrieves ozone between 1-5 km

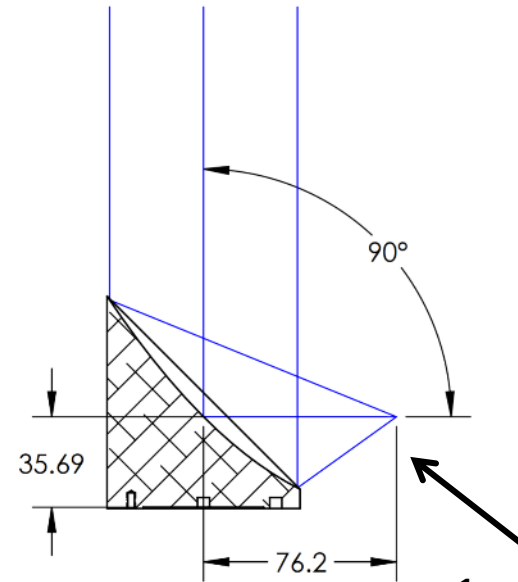
Differential Absorption Lidar to measure subhourly variation of tropospheric ozone profiles, *IEEE Trans. Geosci. Remote Sens.* (Kuang et al., 2011)

Near-Field Receiver Design

Fiber-Coupled, Off-Axis Parabolic Mirror



Atmospheric
Backscatter



1 mm diameter fiber-optic cable

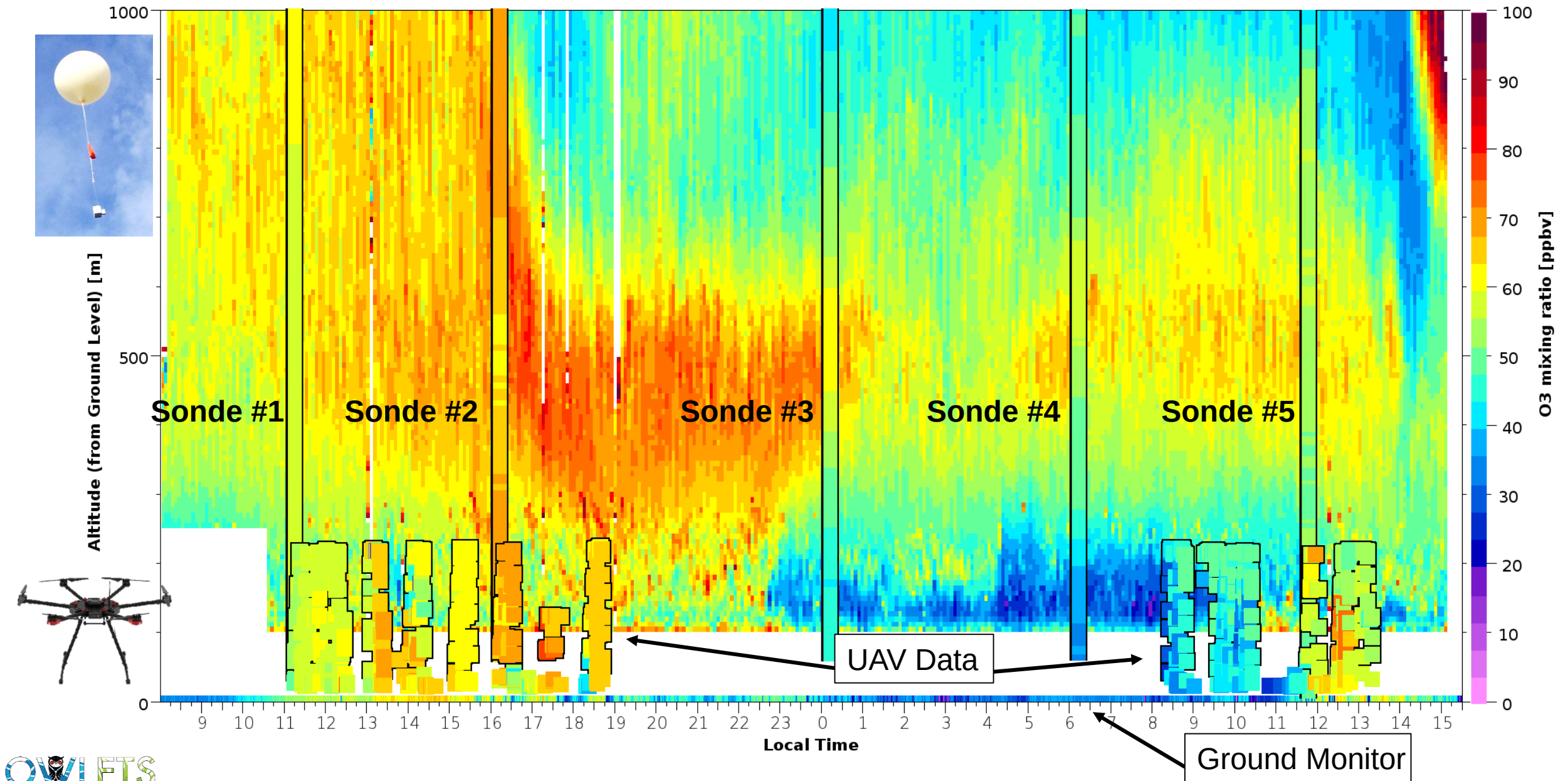
- 90-deg OAP enables a small compact form and low center of gravity for easy of alignment
- Multiple wavelengths to be collected with a single receiver
- Fiber-coupling enables “modular” approach ease of use for testing and evaluation

- UV protected aluminum coating
- High NA (0.5) 1mm diameter core fiber to accept input from mirror
- Alignment checked with a shear-plate and an autocollimator
- Fiber output connected to an optical assembly that includes a BP filters and PMT (simultaneous analog and photon counting)

OWLETS Data and Receiver Testing

UAV ozone data (Pippin et al.)
Sonde data (Knepp et al.)

Multi-instrument Intercomparison at CBBT (8/1-8/2), Near Field

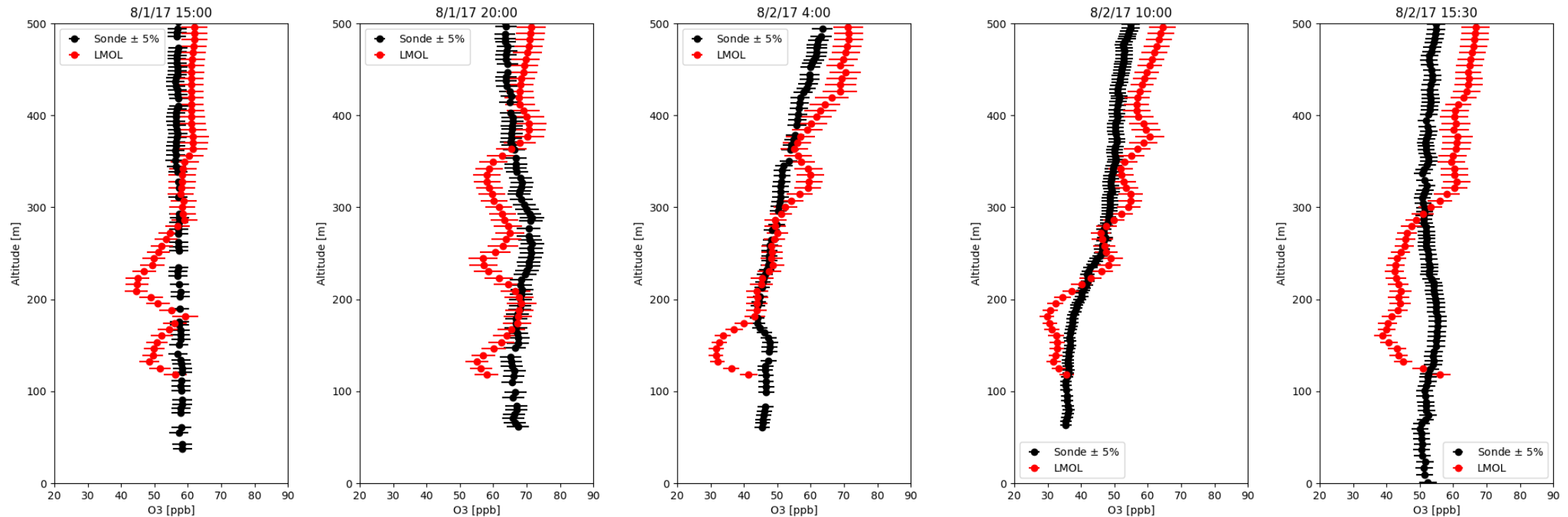


OWLETS Data and Receiver Testing

Ozonesonde Intercomparison for Near Field

Retrievals of Ozone ~120 m and higher deemed reliable

- Ozonesonde vertical resolution: 300 m
- LMOL vertical resolution: 7 m
- LMOL data may have detected structure missed by sondes
- 30 min averaging for LMOL data, no vertical smoothing

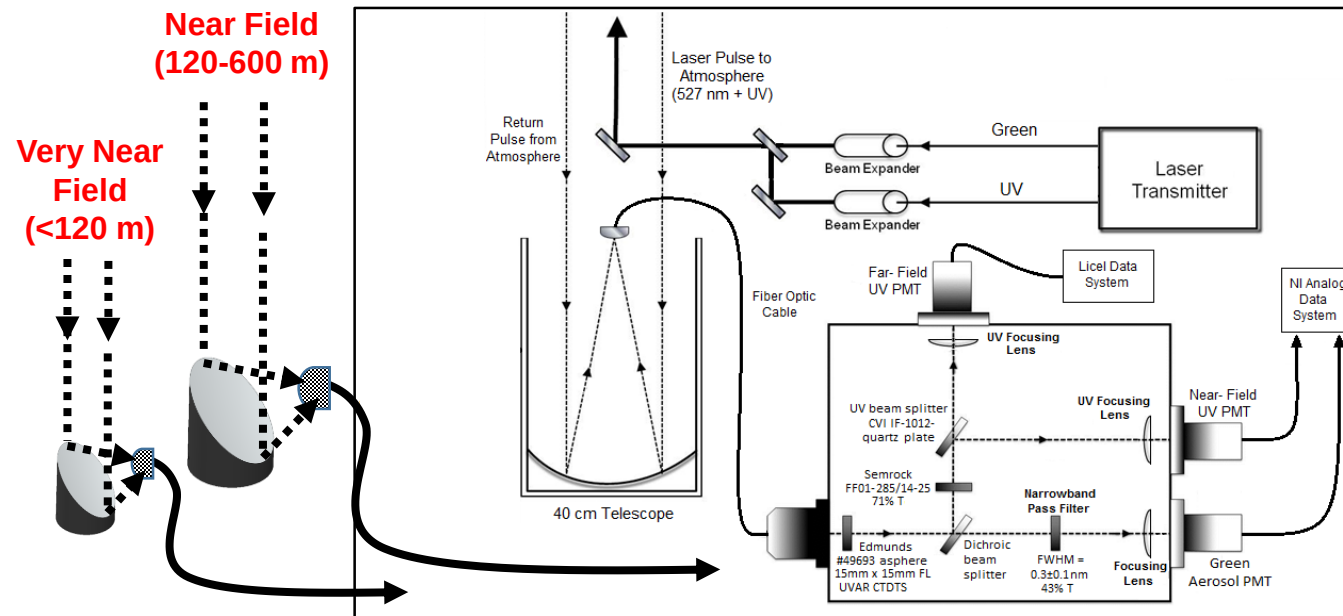


Preliminary Ozonesonde Intercomparison at CBBT (8/1-8/2), Near Field

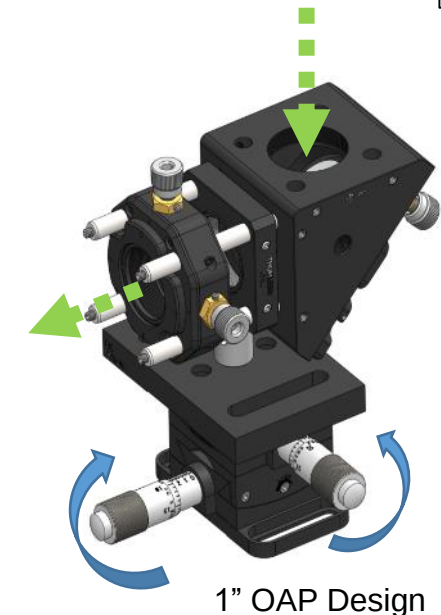
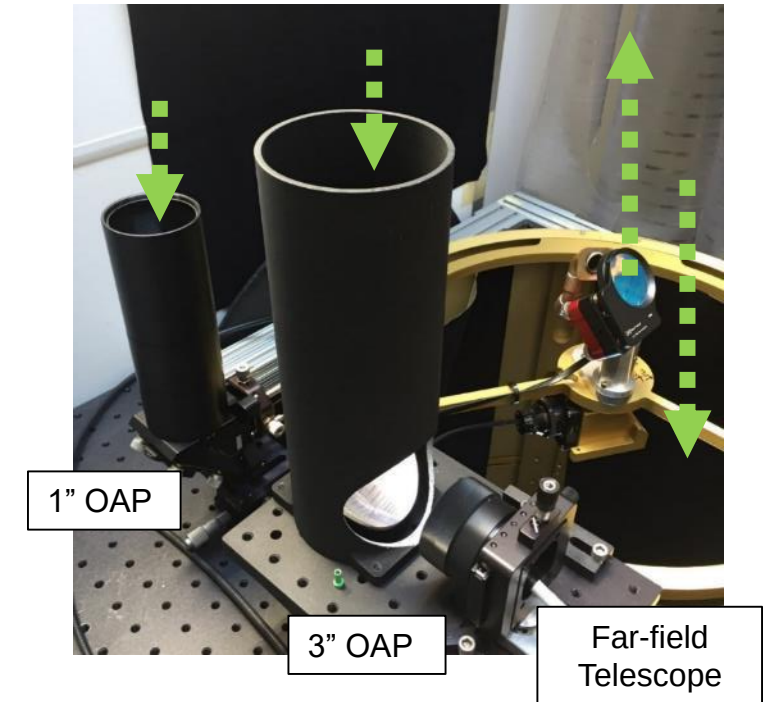
Summary

Future Analysis and Potential Designs

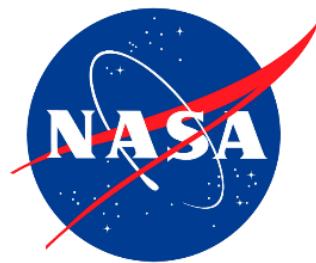
- OAP receiver testing was a success
- LMOL now capable of obtaining reliable O₃ measurements as low as ~120 m
- More detailed analysis planned and publication of results
- Alternate 1" diameter OAP being considered for possible further improvements in performance



Russell De Young et al. (2017)



Acknowledgements



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