Capabilities & example data from the Langley Mobile Ozone Lidar (LMOL)

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Outline

• Brief description of Langley Mobile Ozone Lidar (LMOL) & capabilities
• Hardware/software upgrades & calibration/validation
• Recent Air Quality Case studies:
  • April 19, 2016 Exceedance
  • May 24 & 26, 2016 Transport
• Possible future studies
• Summary & conclusions
**NASA Langley Mobile Ozone Lidar (LMOL)**

Deposed for the first time in the NASA DISCOVER-AQ campaign (2014).

### Science investigations addressed:
- Provide high spatio-temporal profiles of Planetary Boundary Layer (PBL) and Free Troposphere (FT) ozone and aerosols.
- Help improve air-quality forecast models.
- Improve understanding of ozone and aerosols aloft and its influence on surface ozone and PM values.

### Capabilities:
- Small, highly mobile trailer, can be towed with a pick-up truck to relocate.
- Ozone profiles up to 6-7 km AGL for a 5 minute time average.
- New software upgrade provides real-time curtain display for ozone and aerosol profiles.
- Possible to run 24 hours, but currently limited by staff support, looking into unattended options in 2017.
LMOL example data comparison with P3B spirals during DISCOVER-AQ

O3 for 2014/07/28, Golden

- Aircraft O3 spirals
- Surface monitor

Altitude (from Ground Level) [m]

Time (UTC, hours)

O3 mixing ratio [ppby]
Recent LMOL hardware upgrades

- Recent LMOL laser pump replacement funded by NASA HQ/TOLNet: 3x increased transmitted laser power starting in 2016, dramatic increase in stability
- Receiver box re-alignment in May 2016, stray light & BP filter improvements
- Data system & detector upgrades expected in 2017
- Near-range (0-600m AGL) absolute stability to be improved in 2017
- Unattended operation in 2017?

LMOL increase in transmitted power

Operational for 6 months at higher power, no sign of difficulties
LaRC related laser development efforts for TOLNet

- John Hair NASA LaRC technical point of contact
- SBIR Phase II recently awarded to Bridger Photonics, Bozeman MT
- Addresses the need for a commercial source for TOLNet ozone DIAL lidar systems
- Estimated transmitter commercial cost: ~$200K
- 2-year maintenance-free interval
LMOL Algorithm improvements & calibration/validation

- Working closely with TOLNet team members for routine cross-comparison with measurements & algorithm improvements
  - August 2016 field deployment planned in California, multiple TOLNet lidar systems
- Routine ozonesonde launches from LaRC (Travis Knepp)
- Cross-comparisons with LaRC HSRL-2 lidar (John Hair) measurements (June 2016) and other opportunities when they occur
- Overpasses from other aircraft (ie. C130 ACT-America mission overflight in May 2016)
- Working with Danette Allen/Intelligent Flight Systems at NASA LaRC for possible use of LaRC UAV platform in 2017 for more effective near range (low altitude) calibration/validation tests
First test-case applied to LMOL data for “PBL” height retrieval

- Feasibility test of processing LMOL backscatter signal through Scarino’s MLH algorithm (Scarino et al, 2014 ACP)

- Uses a Haar wavelet covariance transform with multiple dilations to identify sharp gradients in aerosol backscatter (Brooks, 2003, Davis et al., 1997 & 2000)

- Daytime lidar MLH can be used as a proxy for PBL under certain conditions (ie. well-mixed, daytime boundary layer)

- Test on one day from DAQ Colorado and did a good job on aerosol, possible further development and validation in 2017

PBL height critical to constrain atmospheric models to better represent boundary layer concentrations of ozone
April 19: First Hampton Roads Exceedance for 2016

Map of VA DEQ monitors near LaRC

Ozone exceeds 70 ppbv in the afternoon

Increase in winds in the afternoon from the NW
LMOL measurement on April 19, 2016

LMOL reveals a strong aloft ozone from 0.6 to 2 km in altitude, that extends down towards the surface around mid-day.

Back-trajectories indicate surface air recirculating in region, upper levels in the O3 layer formed from a NW airmass subsiding in the boundary layer.
April 2016 Rocky Mount Fire

250 km NW of NASA LaRC
Second largest fire in history of Shenandoah National Park
NRL-NAAPS Aerosol Model for April 19, 2016

Columnar AOD (Blue= smoke)

NAAPS Total Optical Depth for 12:00Z 19 Apr 2016
Sulfate: Orange/Red, Dust: Green/Yellow, Smoke: Blue

Surface Smoke Concentration

Smoke Surface Concentration (ug/m**3) for 2016041912
May 24 & 26, 2016 Hampton Roads

NOAA HMS smoke product

VA DEQ surface Ozone
Hampton, VA

70 ppbv
May 24 & 26: Aloft ozone layers appear to be from different sources. May 26 mixed into the boundary layer, but May 24 did not.
Future studies?

- LMOL can be paired with other TOLNet systems to help characterize ozone transition zones in a variety of situations
- Rural v. Urban, Water v. Land
  
  “The observation of land/water horizontal and vertical gradients of O3 over the Chesapeake Bay on four separate days during DISCOVER-AQ 2011 point to a need for more consistent monitoring of air quality over the Chesapeake Bay waters, allowing more statistically stringent analyses to determine if the existence of higher O3 mixing ratios over the Chesapeake is commonplace during the summer months.”

- LMOL is small enough to go onto a small ship/barge
- Chesapeake Bay Bridge/Tunnel is close to LaRC, and could be a possible site for over-water measurements
Summary

- Case studies presented illustrate the complex nature of ozone vertical structure & temporal dynamics
- LMOL/TOLNet lidars are able to more fully characterize these complex events, i.e. when aloft ozone may be mixing down into the boundary layer and compromising surface air quality
- Assessment of local v. transport generated ozone
- Combined with back-trajectory and model information to help identify contributing sources (ie. wildfires, urban, etc.) and improve
- With multiple TOLNet lidars, possible to study ozone transition profiles (ie. water v. land, urban v. rural, etc.)

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- Travis Knepp (NASA LaRC) for ozonesonde support
Call for Papers

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Eighth Symposium on Lidar Atmospheric Applications
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Observations Lead the Way

Please consider submitting your work! Go to the link annual.ametsoc.org, select call for papers and scroll to “Eighth Symposium on Lidar Atmospheric Applications” for more information. Abstracts are due by 1 August 2016.

Questions? Please contact the program chairperson(s), Sara Tucker (email: sara.tucker4ea@gmail.com) and Tim Berkoff (email: timothy.a.berkoff@nasa.gov)

Papers for this conference are solicited on:
- Lidar observations as model assimilation inputs and verification data-sets
- Lidar applications to air quality and climate studies
- Lidar networks
- Making lidar data accessible to decision makers and the public
- New lidar technologies for atmospheric applications: from instrumentation to data distribution
- Lidar applications to the energy sector
- Space-based lidar observations
- The CALIPSO Mission and its impact on AMS community interests.
- Polar lidar observations
Example “PBL” height determination from lidar data
From Compton et al., *J. Atmos. Oceanic Technol.*, 30, 1566–1575
Recovery of near-surface signal with wide field-of-view (WFOV) receiver

- San Joaquin Valley has extremely low PBL, so low that standard MPL channel would not ordinarily capture aerosol dynamic.
- WFOV implemented at some DAQ sites in California, Houston, & Denver to enable on-site cals and better retrievals of near-field (< 1 km) aerosols.