Ozone Lidar Observations During the Long Island Sound Tropospheric Ozone Study

Timothy Berkoff¹, Guillaume Gronoff¹,³, John Sullivan², Lance Nino², William Carrion¹,³, Larry Twigg²,³, Joseph Sparrow¹, Travis Knepp¹,³, Dean Tully⁴, Michele Chaffee⁴, Pete Babich⁴, Lukas Valin⁵, James Szykman¹,⁵

1. NASA Langley Research Center (LaRC)
2. NASA Goddard Spaceflight Center (GSFC)
4. Connecticut Department of Energy & Environmental Protection (CDEEP)
5. United States Environmental Protection Agency (EPA)

Acknowledgements: In addition to NASA TOLNet funding, additional support was graciously provided by NASA HQ Tropospheric Composition Program to enable ozone lidars to participate in the LISTOS NESCAUM study. And a special thank you to the Rutgers team (Luis Lim, Mark Miller, and Matthew Drews) and CT DEEP for being great site hosts at the O₃ lidar locations!!
Long Island Sound Tropospheric Ozone Study (LISTOS)

Miller et al., “Overview of the Long Island Sound Tropospheric Ozone Study (LISTOS)”, AGU Fall Meeting, 2018

Summer 2018:
- Multiple aircraft
- Marine vessels
- Automobiles
- Ground lidars
- Sounding systems
- In-situ sensors
- Pandora sun-spectrometers
- Aeronet sun-photometers
- Radiosonde/Ozonesondes

Campaign description website:
http://www.nescaum.org/documents/listos
Using Two TOLNet $O_3$ lidars to measure regional spatial differences in atmospheric ozone profiles

**OWLETS-1**: Land/Water Chesapeake Bay South (summer 2017, see Sullivan et. al BAMS 2018)

**OWLETS-2**: Land/Water Chesapeake Bay North (summer 2018)

**LISTOS**: Urban inflow/outflow (summer 2018)

**NYC “inflow”**

**NASA Goddard Tropospheric Ozone Lidar (TROPOZ)**
Rutgers site, ~ 50 km SW of NYC
PI: John Sullivan, NASA GSFC
john.t.sullivan@nasa.gov  301-614-5549

**NYC “outflow”**

**NASA Langley Mobile Ozone Lidar (LMOL)**
Westport site, ~ 60 km NE of NYC
PI: Tim Berkoff, NASA LaRC
timothy.a.berkoff@nasa.gov  757-864-3684
Tropospheric Ozone Lidar Network (TOLNet): Developing the maturity of O$_3$ lidar measurements

Southern California Ozone Observation Project (SCOOP campaign, 2016) See Leblanc et al. AMT 2018

Example LMOL O$_3$ curtain data overlapped with JPL ozonesondes (black arrows)

Five TOLNet O$_3$ lidars in one location!

TOLNet O$_3$ lidars utilize common approach for processing and error propagation, enabling lidar intercomparisons

SCOOP 2016 campaign: TOLNet O$_3$ lidars typically fall within +/-5% when compared to each other and ozonesondes
Ozone lidar measurements obtained during LISTOS

LaRC Lidar (Westport, CT):
Data taken on 30 different days between July 12 to Aug 29, 2018:
>300 hours of data

GSFC Lidar (Rutgers, NJ):
Data taken on 20 different days between July 19 to Aug 17, 2018

Data collected on 11 Days > NAAQS 8-hour O₃ standard in CT

All data (LaRC & GSFC) are available on the NASA LISTOS archive, along with quicklook lidar curtain images

3 cases highlighted in these slides:
Jul 20: Simultaneous O₃ lidar
Aug 8: Urban Outflow
Aug 24/25: Wildfire transport
**Case 1: July 20 Simultaneous O₃ Lidar Measurement Example**

**Rutgers site GSFC ozone lidar July 20**

- Cloud cover

**Westport site LaRC ozone lidar Jul 20 2018**

- Fine mode increase!
Case 2: Aug 8 Urban outflow exceedance event

Westport site LaRC ozone lidar Aug 8 2018

Westport CCNY wind data

Aug 8 CT surface O₃ (AirNow-Tech)
Case 3: Aug 24, 25: Aloft ozone layers from wildfire emissions

HMS & HYSPLIT (1.0, 2.5, 4.3 km)

MODIS

Airborne HALO DIAL/HSRL Aug 24, 18.5 to 21 UTC

Ozone lidar

HALO flight

Westport site LaRC ozone Lidar Aug 24 to Aug 25

Aerosol backscatter

Airborne HALO overpass

Aerosol type

Westport LMOL, HALO Profile Coincidence
Summary

- Vertical profiles of O$_3$ are needed to understand air quality events at the surface; TOLNet O$_3$ lidar systems provide a unique observation capability in this regard.
- During LISTOS, LaRC and GSFC O$_3$ lidars captured data in a wide range of conditions, including “classic” urban outflow events & wildfire transport cases.
- Anticipate further analyses and model comparisons (e.g. Brian McDonald’s and Michael Geigert’s presentations).
- Potential measurement synergies with ceilometers, surface-in-situ, wind profilers, aircraft and other mobile platforms (e.g. CCNY Westport wind profiler).
- Python free & open source example code can be provided upon request to read and display LaRC and GSFC lidar data.

O$_3$ lidar data collected is ripe for further analysis, anyone interested is encouraged to contact:

Tim Berkoff (LaRC) 757-864-3684 timothy.a.berkoff@nasa.gov
or John Sullivan (GSFC) 301-614-5549 john.t.Sullivan@nasa.gov

Data acknowledgements: AirNow, AirNow-Tech, NRL NAAPS Model, NOAA HYSPLIT, CT Dept of Energy and Environmental Protection, TROPOMI, MODIS, NOAA RTMA, NOAA HMS, CCNY wind lidar data, LaRC HALO-HSRL lidar data.