TOLNet Annual Meeting 2018
Langley Mobile Ozone Lidar (LMOL) Station Report

Tim Berkoff - PI

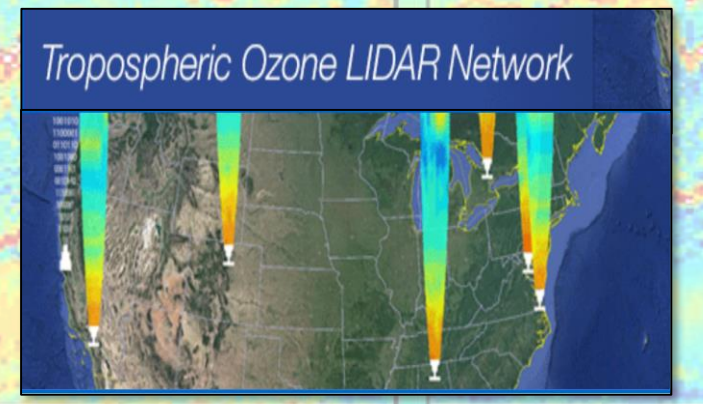
Guillaume Gronoff, Co-PI, Data & Analysis Lead

Bill Carrion, Co-PI, Technology lead

Joey Sparrow, Engineer support

Betsy Farris, Summer TEMPO intern (now at Ball Aerospace)

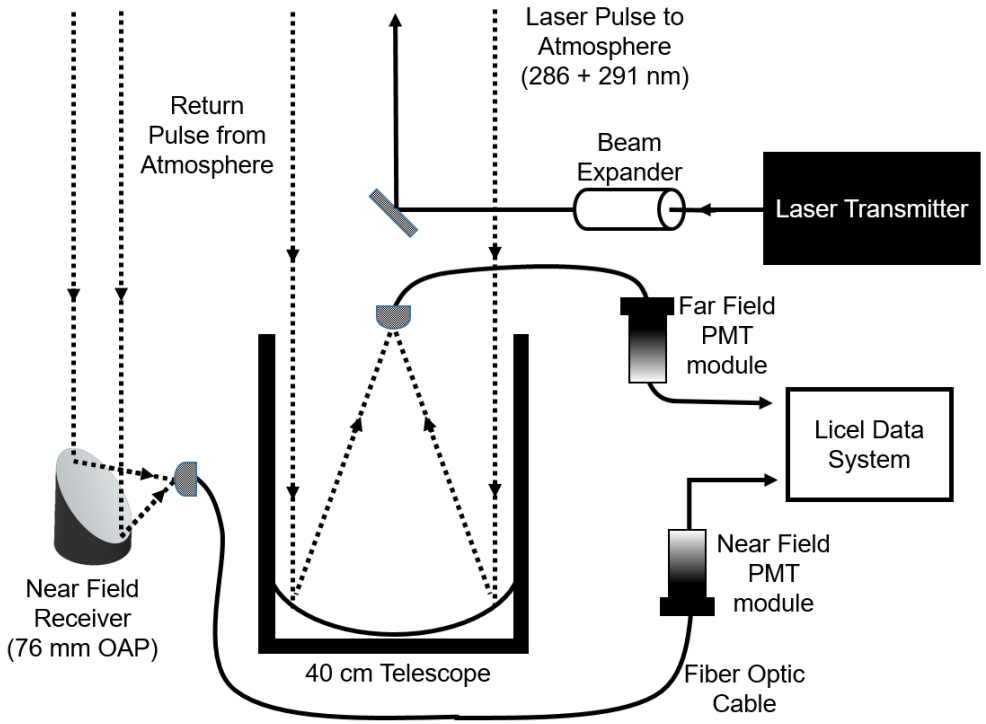
Travis Knepp (Sondes & OWLETS-1)



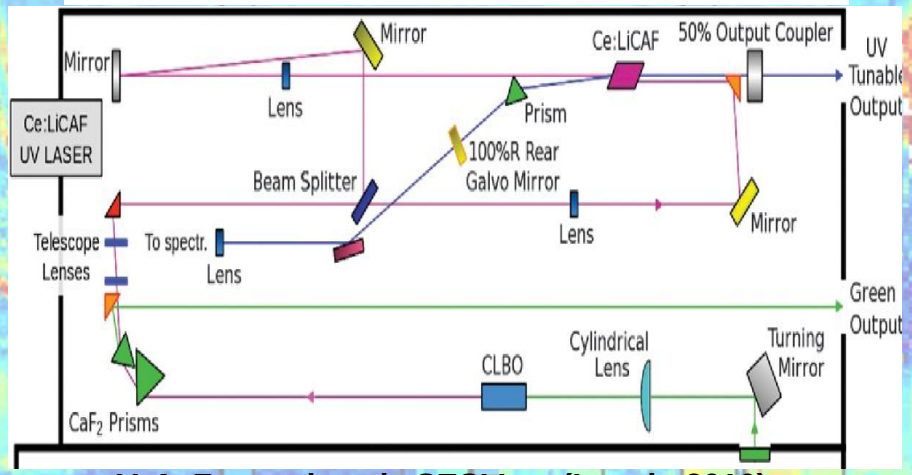
Langley Mobile Ozone Lidar (LMOL)

- **DIAL UV lidar using Ce:LiCAF laser oscillator time multiplexed at two wavelengths**
- **Licel analog and photon counting data system**
- **Ozone profiles up to 8+ km**
- **Capable of transmitting green 527 nm light for aerosol and cloud retrievals**

Instrument description: De Young et al., Appl. Opt. ***56****, 721-730 (2017)*



Tunable UV Ce:LiCAF laser transmitter



Smallest TOLNet lidar system, highly mobile trailer – can be moved with a pick-up truck

V. A. Fromzel et al., SESI Inc. (Intech, 2010).

LMOL Hardware Enhancements

Significant changes to LMOL in the past year!

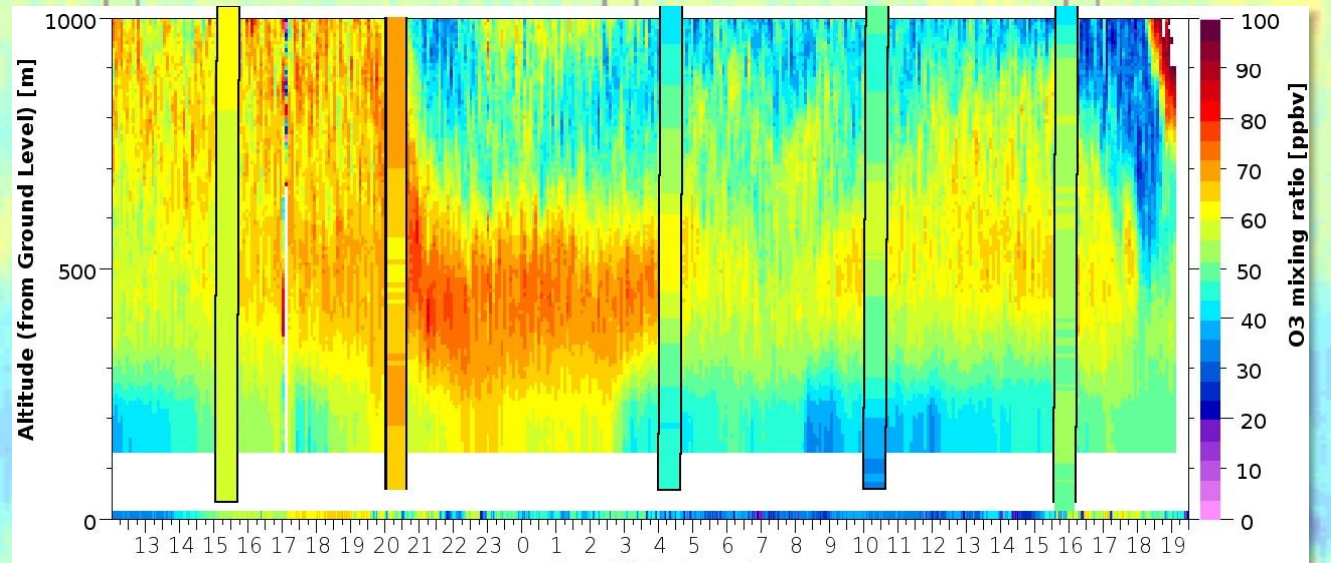
- **New wide-field receiver (last summer) for 0.12 to 1.5 km altitude**
- **Rebuilt far-field PMT module using R9980U-113 PMT, no more PMT gating**
- **Unattended/automated operation improvements:**
  - **New multi-window roof enclosure (instead of prior hatch)**
  - **Bi-axial configuration, fully enclosed beam path to window**
  - **Expanded UV beam for "eye-safe" operation NOHD=0 feet for 0.25 sec**
  - **Remote beam alignment capability**
  - **Dry-air system to eliminate need for compressed gas cylinders**
- **New 2B POM sensor in trailer for surface O_3**

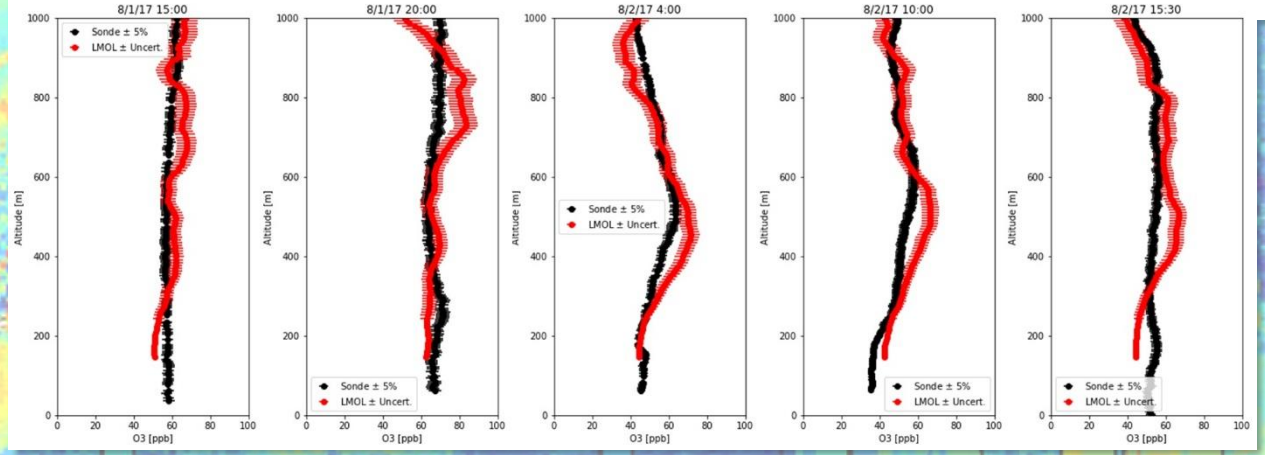
Validation of a new near-field receiver (0.12 to 1.5 km)

Farris et al., to be submitted to AMT

Small diameter Fiber coupled 90-deg off axis parabola

LMOL comparisons with multiple sonde launches





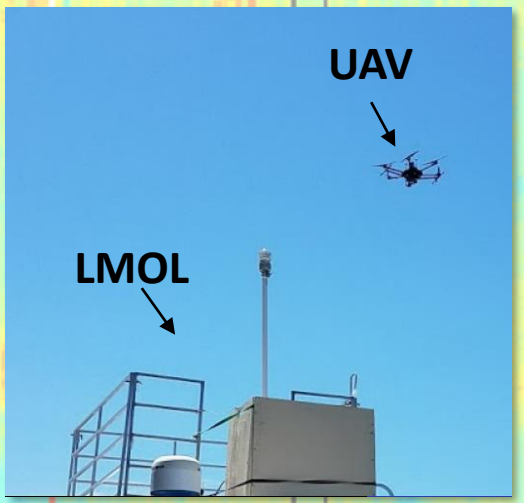
Quantitative statistics

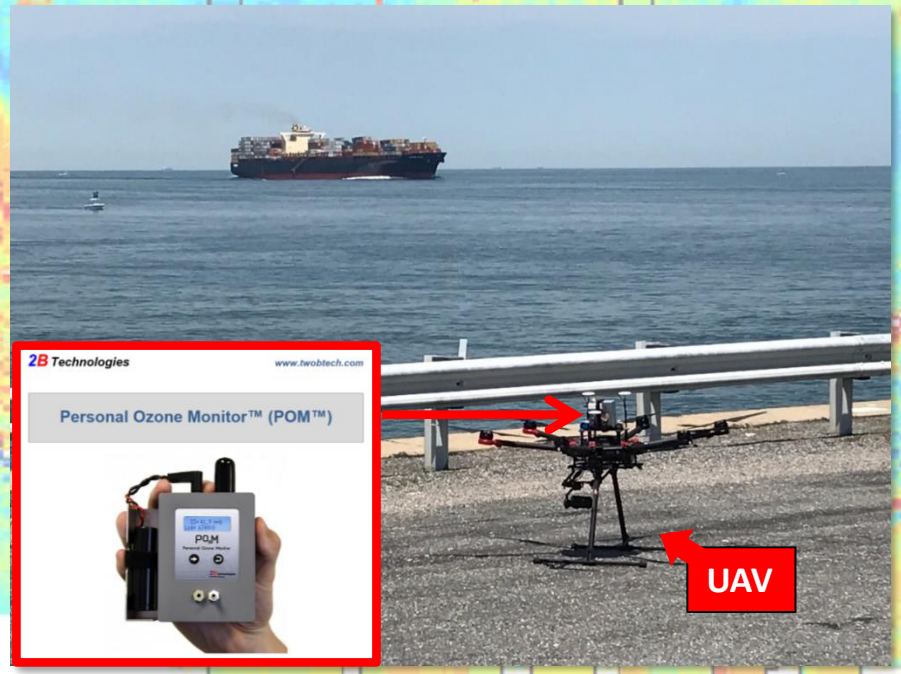
	Sonde Mean +/- St. Dev.	LMOL Mean +/- St. Dev.	% Difference
Flight 1 15:00 UTC	58.5 ± 1.97	60.8 ± 4.92	3.86
Flight 2 20:00 UTC	67.3 ± 2.35	69.5 ± 6.85	3.22
Flight 3 04:00 UTC	52.7 ± 6.26	54.0 ± 10.8	2.44
Flight 4 10:00 UTC	49.0 ± 6.13	53.4 ± 7.28	8.59
Flight 5 15:45 UTC	53.1 ± 2.63	55.3 ± 7.72	4.06

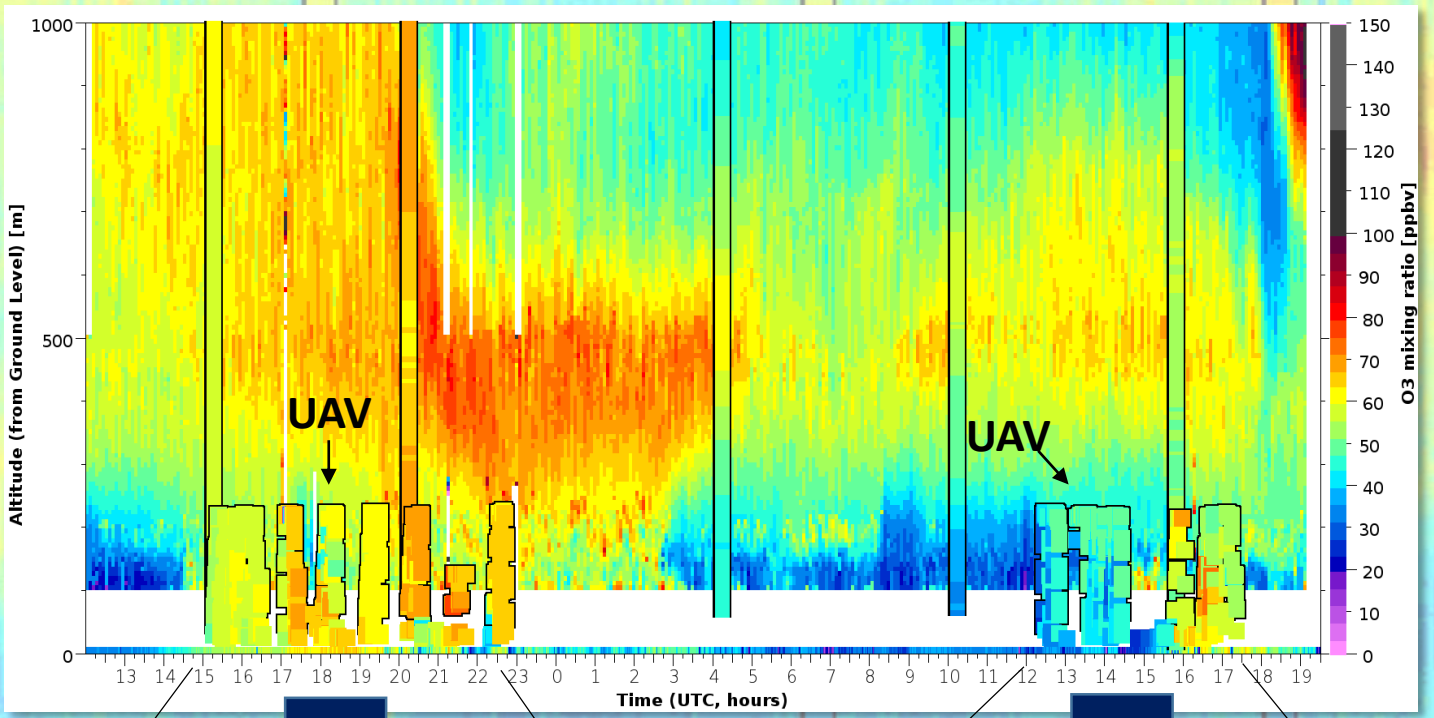
Validation of a new near-field receiver (0.12 to 1.5 km)

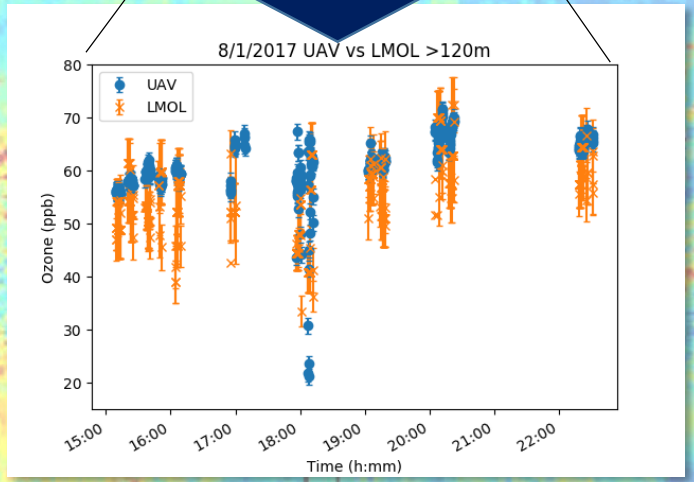
Farris et al., to be submitted to AMT

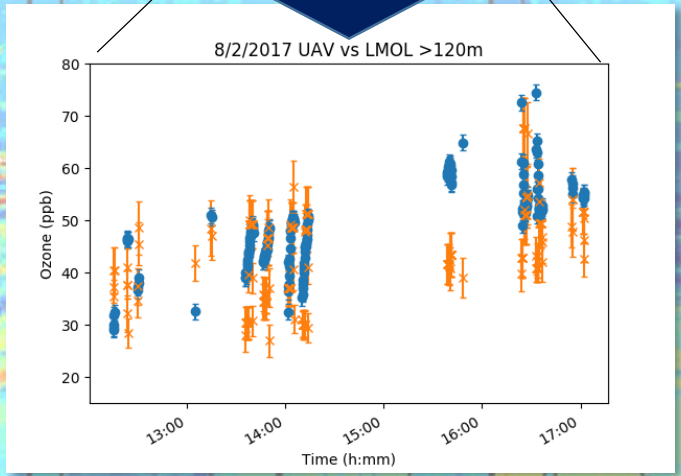
UAV in-situ comparisons to LMOL









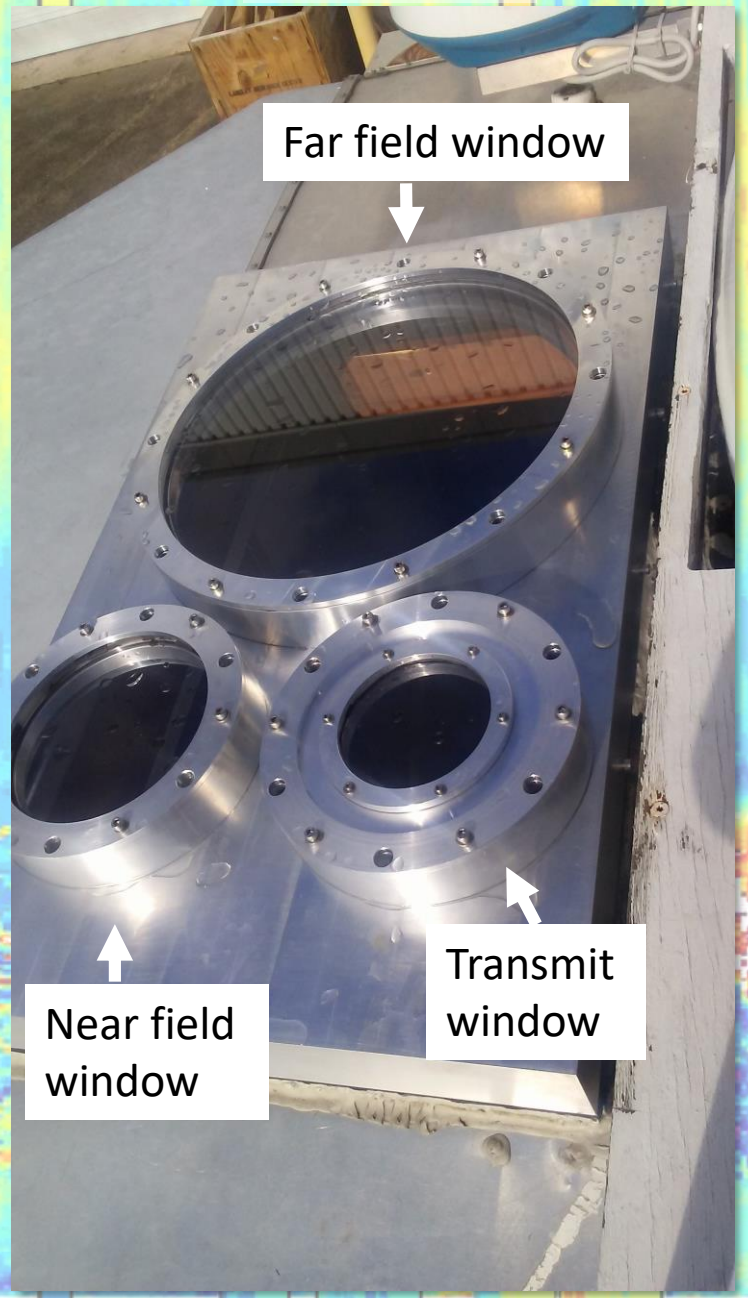


New LMOL transmit path installation and trailer roof window

Inside view

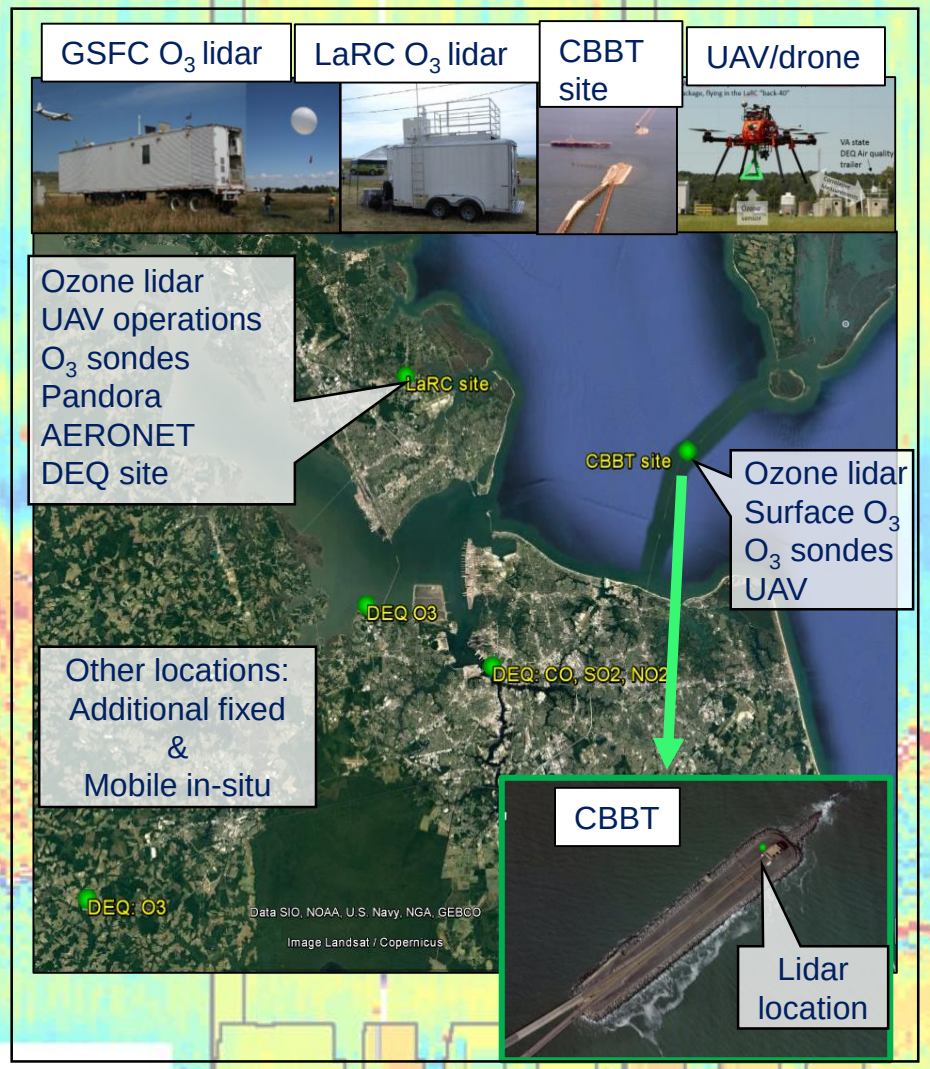
- Separate windows for transmit and receive to reduce initial laser flash effects (afterpulse and ringing)
- Expanded more “eye-safe” UV beam
- NOHD=0 for 0.25 sec exposure
- Reduces the need for aircraft radar interlock
- Key improvements for unattended operations!

Outside view

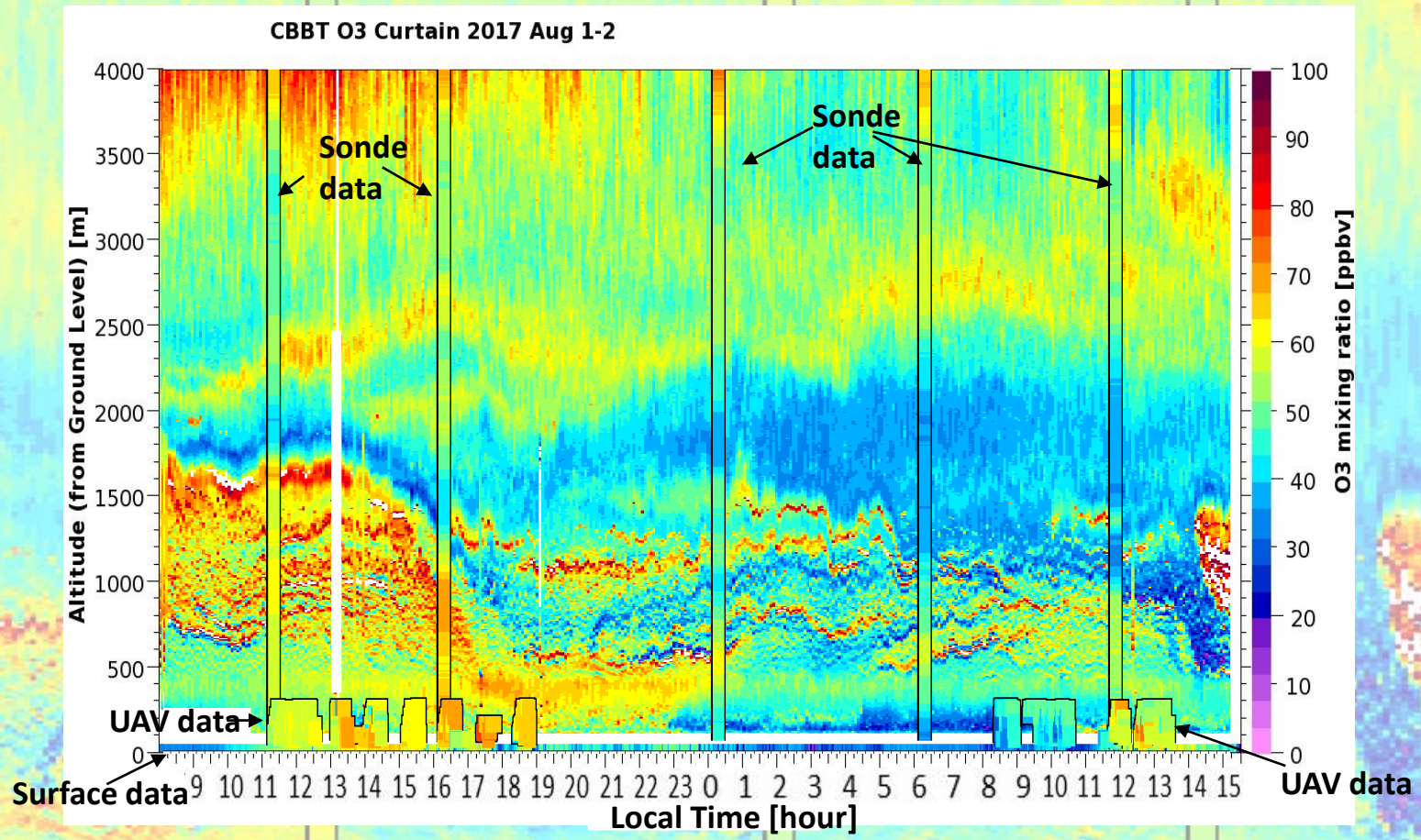


Ozone Water Land Environmental Transition Study

Overview paper by Sullivan et al submitted to BAMS



Example data from LMOL during the OWLETS campaign



Funded in part by the NASA Science Innovation Fund

OWLETS-1 analyses topics

OWLETS-1 archive is now open to the public!

Measurement Techniques

- Demonstration of new near-range receiver for LMOL, Betsy Farris et al, AMT pub underway
- Lidar-Pandora ship titration paper, Guillaume Gronoff, Joe Robinson, Pandora and LMOL Teams, submitted to AMT
- Cross-calibration between sensors, Tim Berkoff et al. (Cross-calibration between O3 sensors (Sherpa, UAV, surface, mobile, sonde, lidar)
- Sonde, Pandora, Lidar synergies and for O3 validation –Joe Robinson, Elena Lind, Bob Swap, et al

Model analyses

- NAQFC archive data, comparisons between lidar and model(NAQFC with Barry Baker, Berkoff, Sullivan et al)
- Possible EPA/CMAQ model EPA improvements, Heather Simon
- High resolution trajectory analyses for data archive, Lindsey Rodio (multiple vertical and spatial runs)

Coastal transition

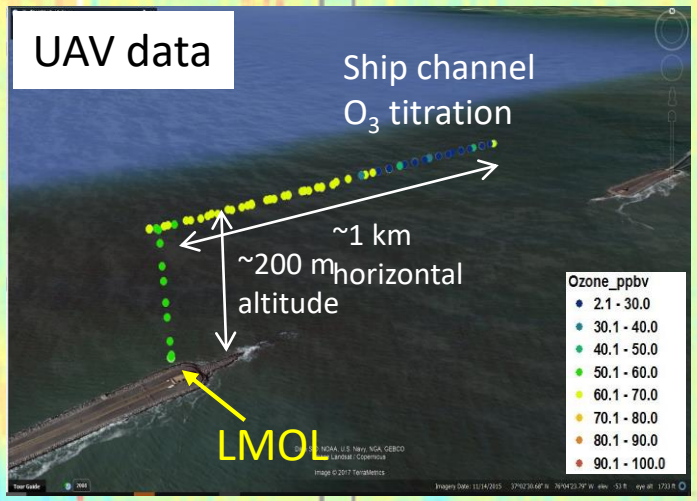
- Lidar water-land differences, Sullivan et al.
- Sonde water-land comparison – Travis Knepp
- Aerosol: Aeronet, HU-MPL, and ceilometers, OWLETS aerosols
- Mobile/ground water-land transition, 4-D visualization, Jeremy Schroeder, Masters thesis

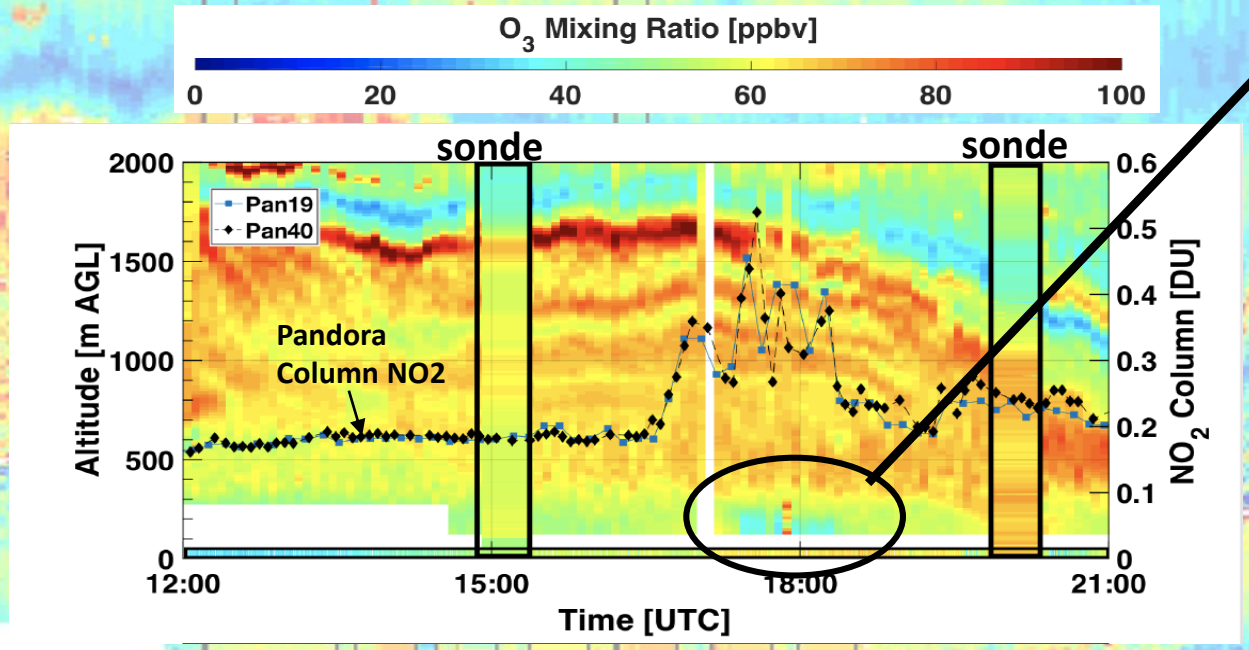
Variability over water

- Sherpa spiral variability analysis identifying and understanding gradients , Megan Buzanowicz, Hampton University
- Overview of SERC cruise in support of OWLETS (surface v. column, water-land,) Maria Tzortziou
- Spatial/vertical variability with the eye towards TEMPO, TROPOMI, and model spatial limits

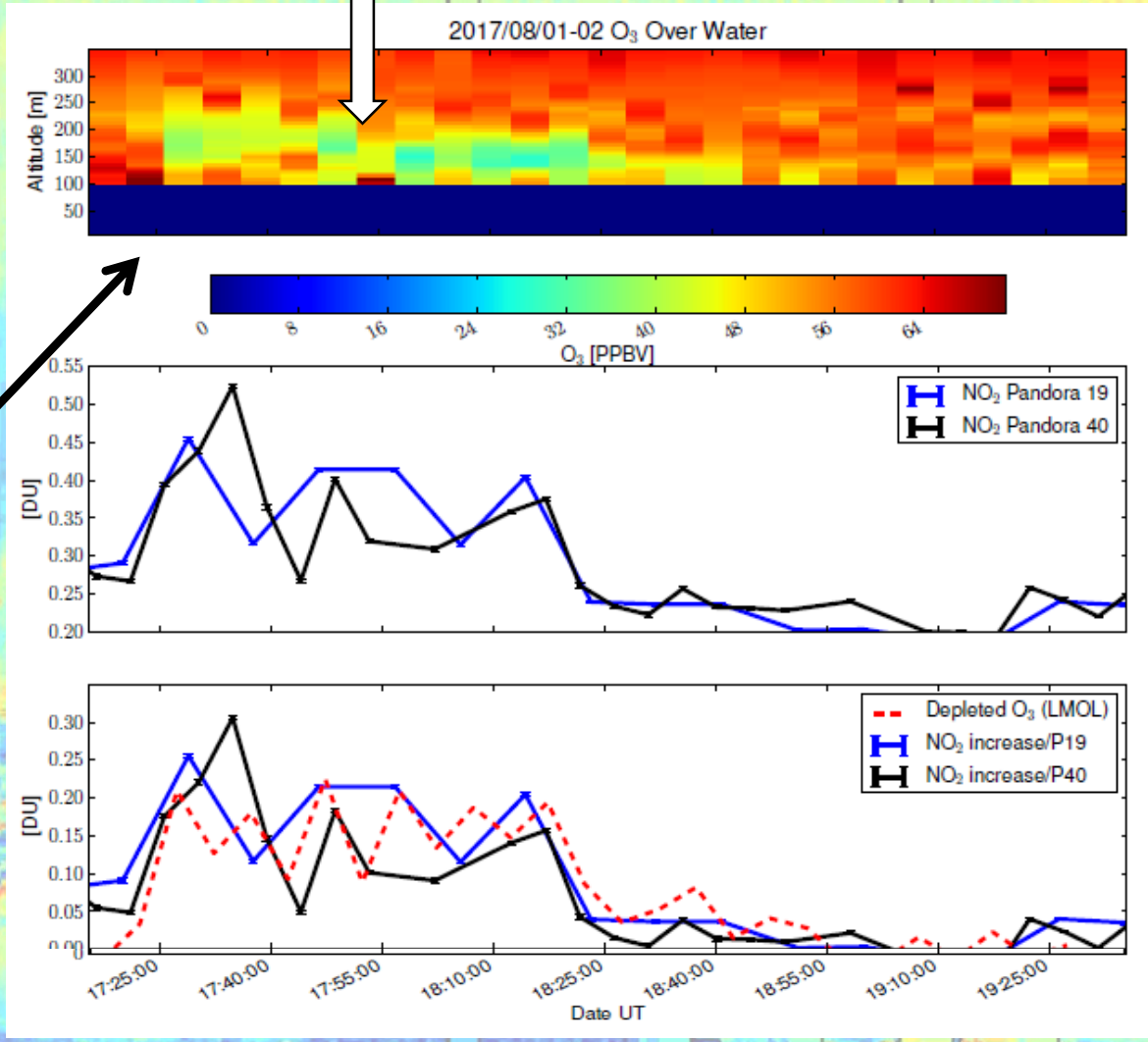
Lidar-Pandora retrieval method – ship titration event

Gronoff et al, submitted to AMT





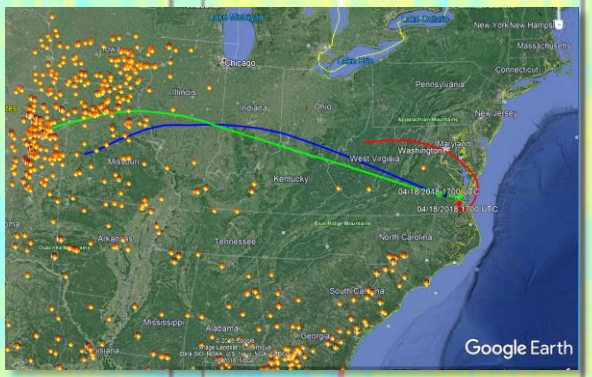
$$O_3 + NO \rightarrow NO_2 + O_2$$

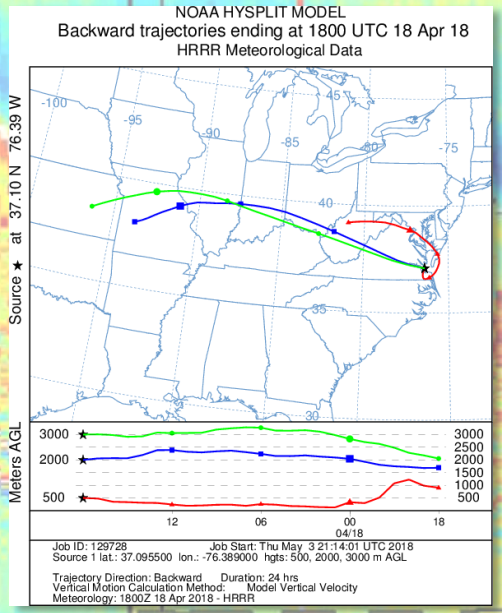


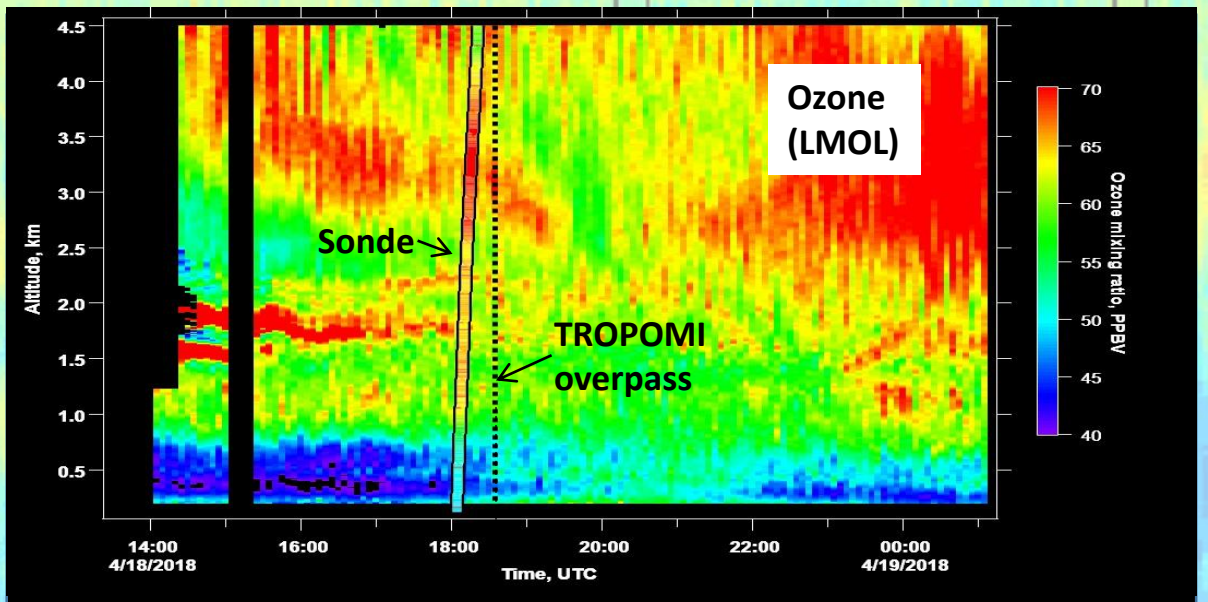
LMOL coincidence measurements with TROPOMI

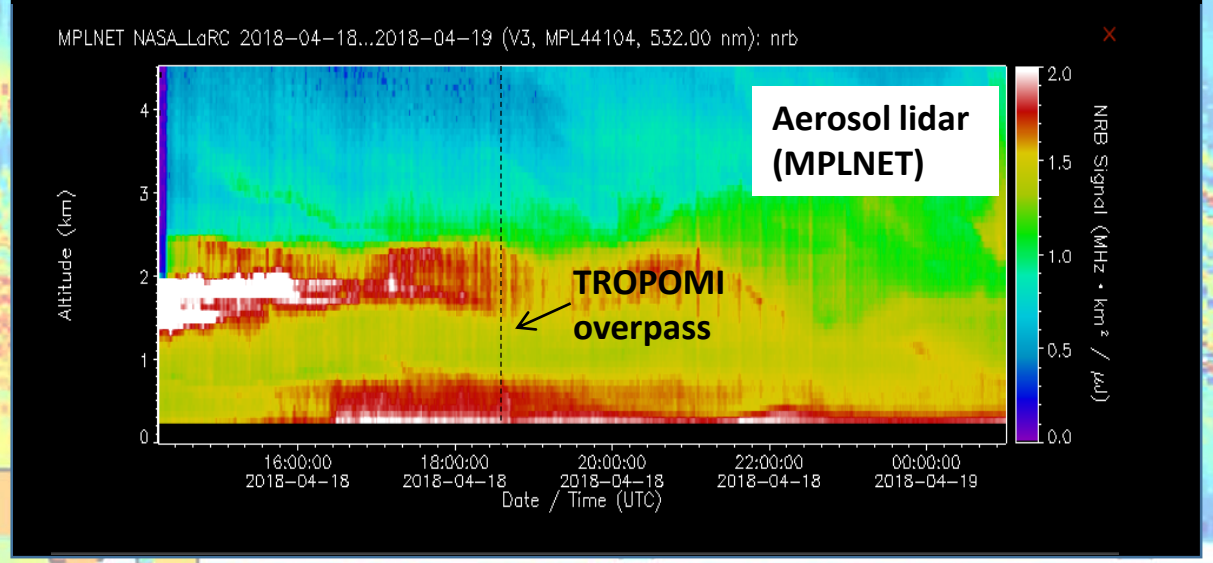
Measurements obtained so far: Jan 24, 25, 26, 31; Feb 1, 2, 5, 27; March 2, 5, 9, 13; Apr 18, 30; May 1, 2

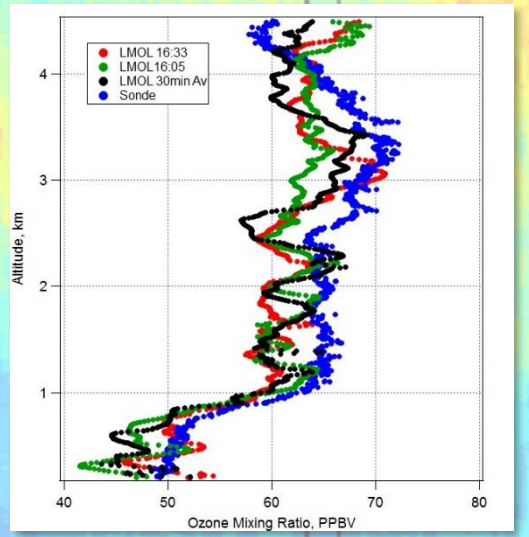
Example TROPOMI April 18, 2018 Case Study

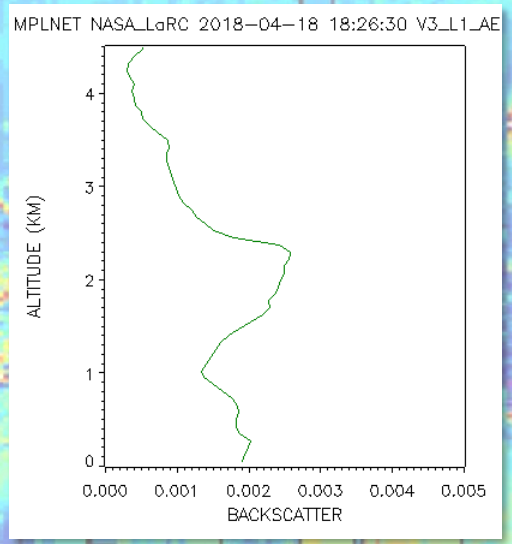






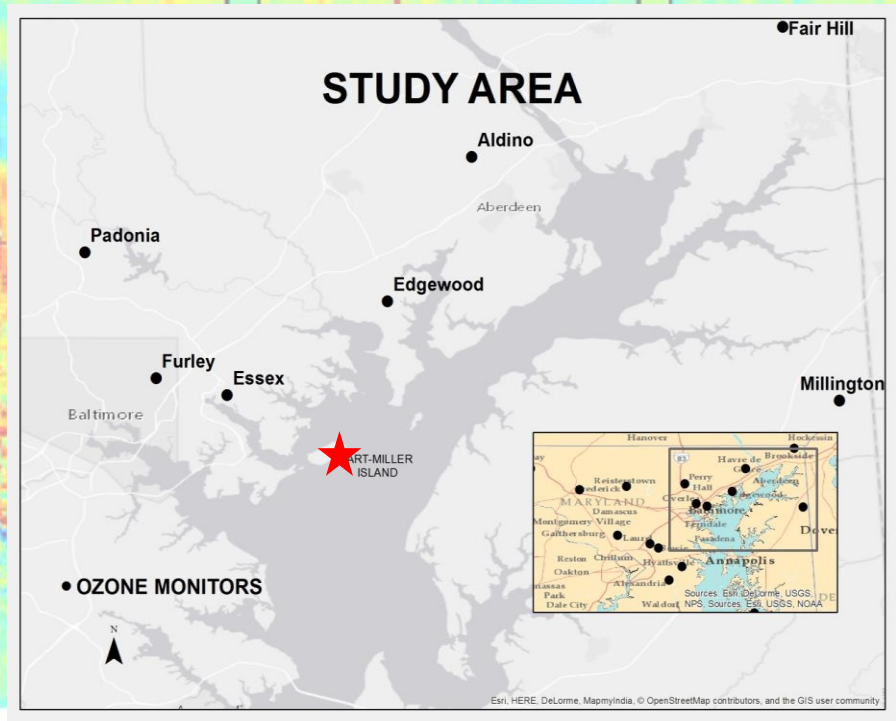


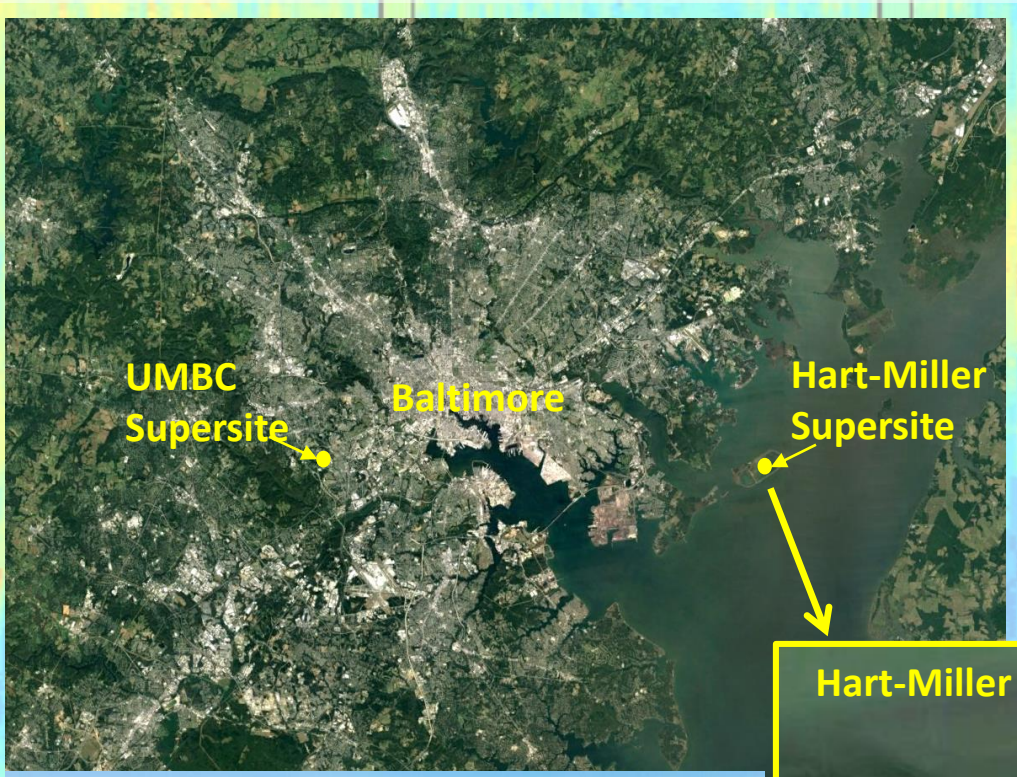




LMOL Participation in OWLETS-2 (June 6 to July 6)

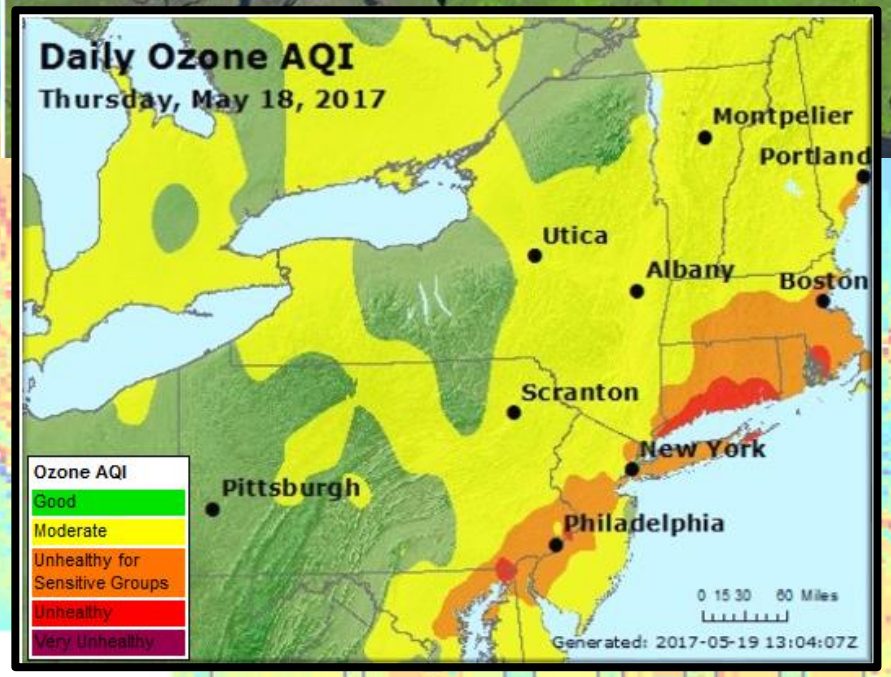
- **OWLETS-2 in upper Chesapeake/Baltimore region summer 2018**
- **Science measurements June 6 to July 6**
- **Two "super-sites" identified: UMBC, Hart-Miller island**





Possible LMOL participation in the LISTOS study

Dr. Paul Miller, NESCAUM Chief Scientist



NESCAUM study with variety of groups contributing

LMOL 30-day deployment July 15 to Aug 15+

Connecticut 2017 Annual Air Monitoring Network Plan 36

Town – Site:	**Westport – Sherwood Island State Park**		
County:	**Fairfield**	Latitude:	**41.11822°**
Address:	**Sherwood Island SP**	Longitude:	**-73.33681°**
AQS Site ID:	**09-001-9003**	Elevation:	**4 m (13 ft)**
Spatial Scale:	**Regional**	Year Established:	**1996**
Statistical Area:	**CSA (New York-Newark-Bridgeport)**		

LMOL lead publications and presentations

- Berkoff et al: “Summary of the Ozone Water Land Environmental Transition Study” TOLNet annual meeting, Egbert, ON, Sept 21, 2017
- Gronoff et al., “OWLETS Ship Titration Event” TOLNet annual meeting, Egbert, ON, Sept 21, 2017
- Berkoff et al., “Overview of the Ozone Water-Land Environmental Transition Study: Summary of Observations and Initial Results”, AGU Fall Meeting.
- Gronoff et al., “Comparison of tropospheric ozone profiles measured by lidars simultaneously over land and water during the 2017 NASA OWLETS campaign” AGU Fall Meeting
- Berkoff et al. “OWLETS: Example measurements in an attempt to provide a 4-D view of ozone in a coastal region”, Mid-Atlantic Regional Air Management Association Monitoring Workshop
- Berkoff et al., “Overview of OWLETS 2017“, OWLETS Science Team meeting, Baltimore, MD
- Gronoff et al., “ LMOL Data Observations at CBBT” OWLETS Science Team Meeting, Baltimore, MD
- Farris et al, “Near Field Improvements for LMOL” OWLETS Science Team Meeting, Baltimore, MD
- Gronoff et al, “A Method for Observing Near Range Point Source Induced O 3 Titration Events Using Co-located Lidar and Pandora measurements
- Berkoff et al, SIF final report, “Ozone Water Land Environmental Transition Study”, NASA internal report
- Gronoff et al., “A Method for Observing Near Range Point Source Induced O3 Titration Events Using Co-located Lidar and Pandora measurements” AMT submitted
- Farris et al, “Demonstration of an off-axis parabolic receiver for near-range retrieval of lidar ozone profiles” to be submitted to AMT
- Gronoff et al, “Monitoring tropospheric Ozone and Aerosols with LMOL, the NASA Langley Mobile Ozone Lidar, at the Chesapeake Bay Bridge Tunnel”, BIRA/IASB, 2018

LMOL: Future plans for the upcoming year

- Continue OWLETS-1 analyses
- Continue TROPOMI data collection
- OWLETS-2 campaign June 6 to July 6
- LISTOS campaign July 16 to August 16 (if funded)
- Practice autonomous operations, migrate towards 24-7 operational capability
- Explore extreme near-field retrievals (15 to 150 m)
- Explore next generation Ce:LiCAF (no chiller, BBO instead of CLBO, no moving parts)
- Explore possible 355 nm channel for aerosols

Many thanks!!!

Acknowledgements: Funding provided by the NASA HQ Tropospheric Composition Program through the TOLNet project. Data credits: Micro-Pulse Lidar Network (MPLNET) and NOAA's HYSPLIT Ready site.