Ozone Water-Land Environmental Transition Study

PI-Tim Berkoff (NASA LaRC), John Sullivan (NASA GSFC/UMBC), Guillaume Gronoff (NASA LaRC/SSAI), Margaret Pippin (NASA LaRC), Travis Knepp (NASA LaRC/SSAI/EPA), Danette Allen (NASA LaRC), Jim Neilan (NASA LaRC), Tom McGee (NASA GSFC)

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LaRC Lidar team:  Bill Carrion, Betsy Farris
GSFC Lidar team:  Larry Twigg, Lance Nino
UAV/drone team:  Eddie Adcock, Mark Motter, Ryan Hammit, Zak Johns, Ian Fenn
LaRC TEMPO student collaborators:  Lindsey Rodio, Jeremy Schroeder, Betsy Farris, Pablo Sanchez, Emily Gargulinski

Chesapeake Bay-Bridge Tunnel Authority:  Ed Spencer, Tim Holloway
Hampton University:  Bill Moore, student interns:  Desorae Davis, Angela Atwater
GeoTASO team:  Scott Janz, Jay Al-Saddi, Matt Kowalewski, Laura Judd
GSFC/SERC marine research vessel:  Ryan Stauffer, Owen Parker, Julio Roman, Lena Shalaby, Cpt.  Mike Goodison
Belay Demoz
SARP/Sherpa team:  Sally Pusede, Glen Wolfe, Jame Flynn, Jessica Munyan, Thomas F Hanisco, Don Blake
PANDORA team:  Bob Swap, Maria Tzortiou, Nader Abuhassan, Alexander Cede, Si-Chee Tsay, et al.
GSFC AERONET team:  Brent Holben et al.
LaRC Website and archive:  Gao Chen, Ali Aknan
VA DEQ:  Dan Salkovitz, Kristen Stumpf, Brian King, John Brandt, Chuck Turner
MDE:  Joel Dreessen
Virginia Living Museum:  
EPA:  James Szykman
Misc:  Marlia Harnden, James Szykman
Motivation/background

- Significant land-water gradients in coastal regions can occur due to differences in surface deposition, boundary layer height, and cloud coverage, to the right is an EPA/CMAQ surface ozone example case.

- Studies have examined the Chesapeake airshed with respect to ozone including: Martins et al. 2012 (Hampton Roads region), Goldberg et al. 2014, Loughner et al. 2014, Stauffer et al. 2015 (Baltimore-DC region).
  - $O_3$ measurements over water are scarce.

- Vertical, horizontal, and temporal (4-D) measurements are needed to describe complex scenes to improve forecast models and air quality satellite retrievals.
  - TEMPO/GEOCAPE.
NAQFC 12Z forecast for hourly ozone on 07/20/17 for 07/21/17 [9am to 9pm] (airquality.weather.gov), updated 2x daily, 12 km resolution, 48 hrs
2 ozone lidars (CBBT & LaRC)

UAV/drone (CBBT or LaRC)

Simultaneous ozonesonde launches (LaRC & CBBT)

DEQ sites

CAPABLE (LaRC)

PANDORA (CBBT & LaRC)

AERONET (CBBT, Hampton U., LaRC)

Mobile Cars (2)

MPL at Hampton U

Two Ceilometers (CBBT, LaRC)

Surface NO2 at some sites (CBBT, LaRC)

Supplemental O3 sites (TRO, VLM)

Two Sherpa flights

Three GeoTASO flights

Two days SERC research vessel

GSFC O3 lidar

LaRC O3 lidar

CBBT

UAV/drone

Ozone lidar

UAV operations

O3 sondes

Pandora/AERONET

CAPABLE trailer

DEQ site

Ozone lidar

Surface O3

O3 sondes

UAV

Car In-situ: 2 cars, ~12 days

UC12: 3 flights July 7-8, GeoTASO

SERC research vessel July 17-18

O3, NO2, Pandora, Ceilometer

Sherpa aircraft: 2 flights July 19-20

O3, NOx, VOCs

Map of measurements
# Measurement schedule

**July 7 to Aug 2: 12 days of measurements**

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In-situ O₃ sensor for UAV flights & Mobile cars

2B POM sensor

- NIST traceable
- EPA approved equivalent method
- Small, lightweight (~ 1 lb.)
- Internal pump
- GPS
- On-board memory
- Rechargeable battery

Preliminary Calibration Example

- Initial test and calibration
- Calibration close matches standard 2B sensor & ozone calibration source
UAV/drone flights

- At LaRC: 500 ft vertical, 1200 ft horizontal
- At CBBT: 700 ft vertical, 1200 ft horizontal
- Although UAV primary focus provided vertical closure between lidar and surface data, horizontal patterns were also flown to allow investigation of near-range variability, point source influences
- At LaRC line-of-site flight paths would be in close proximity to VA DEQ & CAPABLE trailers
UAV Investigation of near-range variability in ozone

Data product: In-situ ozone
Data collected: 20? Flights, last three measurement days were the most significant
Data status: Quicklooks and KMZ format available, preliminary archive file prep in progress
Mobile car in-situ measurements

Data collected: In-situ Ozone, 2 mobile cars on 12 days
Data status: Quicklooks and KMZ format available, preliminary archive file prep in progress
GeoTASO flights July 7,8 (3 flights)

Data product: NO2 column
Data collected: 3 flights on two days (July 7-8)
Data status: Have prelim quicklooks, waiting on final data quick-looks.
Archive preliminary file prep in progress
Data Products:
Attenuated backscatter profiles at 527 nm, Cloud and Mixed layer heights, Cloud fraction

Data collected: 8 days

Data status: Waiting on final data quicklooks, preliminary archive file prep in progress
Ozonesonde launches

~35 launches
LaRC-CBBT launches were simultaneous

Data: RH, T, Wind, Ozone

Data status: Quicklooks on-line, archive files for CBBT uploaded, LaRC to be uploaded soon.
New fiber-coupled 90-deg. OAP near-range receiver for LMOL

Farris et. al (tech. note to be submitted)

90 deg. OAP test setup

- Testing two different 90-deg OAPs
- Using Licel channel #2 (12 bit analog & PC)
- Refinement of alignment procedures
- Comparisons with UAV and sondes
- Initial assessment ~ 150m and higher appear to be usable
Data Integration Example
Lidar, Sonde, & UAV

Example Quick-look Data From The Langley Mobile Ozone Lidar: Ozone Data Obtained at the “over-water” CBBT site Aug 1-2, 2017

Gronoff et al. (to be submitted)
Ozone cross-validation

- 2B technologies sensors (POMs and 202s) all cross-calibrated with same ozone calibration source
- Mobile car co-located measurements with DEQ, static sites (Misc, including LaRC & CBBT)
- Lidar-lidar: Daily sonde launches, post-campaign cross-comparison at LaRC, GSFC processing for both lidars (merged data product) expected in the future
- Lidar-UAV (lidar near field, LaRC & CBBT)
- Lidar-aircraft (LaRC & CBBT)
- UAV-surface (LaRC & CBBT)
- Marine SERC vessel – surface (at CBBT)
- Pandora – lidar?

CAUTION: All current OWLETS analyses are preliminary, absolute ozone cross-validation closure work still in progress for cross-platform comparisons
OWLETS Website

Quicklook page

Reports: Mission / Outlook / Status / QuickLook

Data Archive
Quick looks
Presentations, Etc.
Student Interns: LaRC TEMPO student collaborators
(Mentor: Margaret Pippin)
GSFC NIFS Program (Mentor: John Sullivan)
Hampton University NIFS Program (Mentor: Bill Moore)

Betsy Farris (Lidar)
Jeremy Schroeder (UAV & Mobile Car)
Lance Nino (GSFC lidar)

Lindsey Rodio (Forecasting)
Emily Gargulinski (Sonde)
Desorae Davis, Angela Davis (MPL)

Pablo Sanchez to be added, other students contributed from SARP aircraft & SERC vessel!
OWLETS Ship Titration Event

- Location: CBBT 3rd island
- Observation with UAV/POM sensor
- Observation with LMOL lidar (Very Near Field, newly developed, with minimum altitude ~100m)
Google Earth/POM UAV

- The titration is observed above the channel
LMOL data

CBBT O3 Curtain 2017 Aug 1-2 test2

Altitude (from Ground Level) [m]

Local Time

O3 mixing ratio [ppbv]

0 10 20 30 40 50 60 70 80 90 100
Very Near field only: titration at 17h UT on Aug 1

CBBT O3 Curtain 2017 Aug 1-2
The plume is very pronounced in the lidar data.

Very good lidar-UAV agreement at 200m: above the plume.

The UAV does not have the time to detect the plume correctly during its descent; there is still some O3 from the 200m. It detects a gradient though.

The UAV detects the plume but also goes away from it.

I need to study more these gradients here: the UAV seems to observe the same values while it is close to the 2B in the trailer this time. There may be some interesting gradients around there!

Flight towards the plume (over the channel)

Observation of a positive gradient

Observation of the plume: O3 plummets

Vertical path: good lidar-UAV comparison

Flight back to the 3rd island. Observation of some gradients with respect to the ground station.
The UAV data is highlighted
Video of ship coming

- The specific event has a very yellow plume, and is way stronger than the following ones.
Plume and chemistry

- Paper have been published on impact of maritime traffic on O3 and NOx, but on a global scale
- Other papers are more specific (Huszar et al 2010. www.atmos-chem-phys.net/10/6645/2010/ ) but require a characteristic time parameter
- Chosson et al. 2008 has some plume dispersion simulations for that characteristic time (next slide)
Fig. 5. Time evolution of normalized mean vertical concentration for FIRE1 (top left), FIRE2 (top right), FIRE3 (bottom left) and BOMEX (bottom right) with initial mean buoyancy flux $F=120 \text{ m}^3 \text{s}^{-3}$. The vertical dashed-dotted lines represent the characteristic turnover time scale of each boundary layer.
Questions

- What is the relevant chemistry? (Song et al 2003)
- Are sulfur oxides relevant? Could we observe the plume with PANDORA data (Knepp et al 2015)
- How can we retrieve the informations about the boats/traffic (I saw https://www.marinetraffic.com/)
- What is the importance of these effects on the OWLETS measurements.
- → We are working on a paper to address these problems

