Ozone Water-Land Environmental Transition Study

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ACKNOWLEDGEMENTS:

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Additional affiliations/contributors

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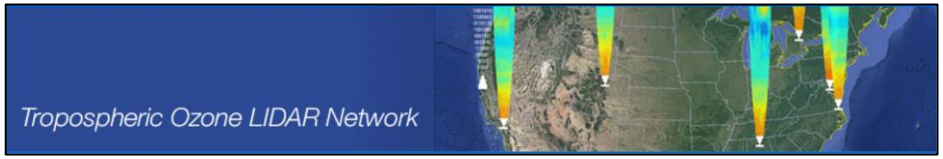
Ozone Water-Land Environmental Transition Study



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
Chespeake 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

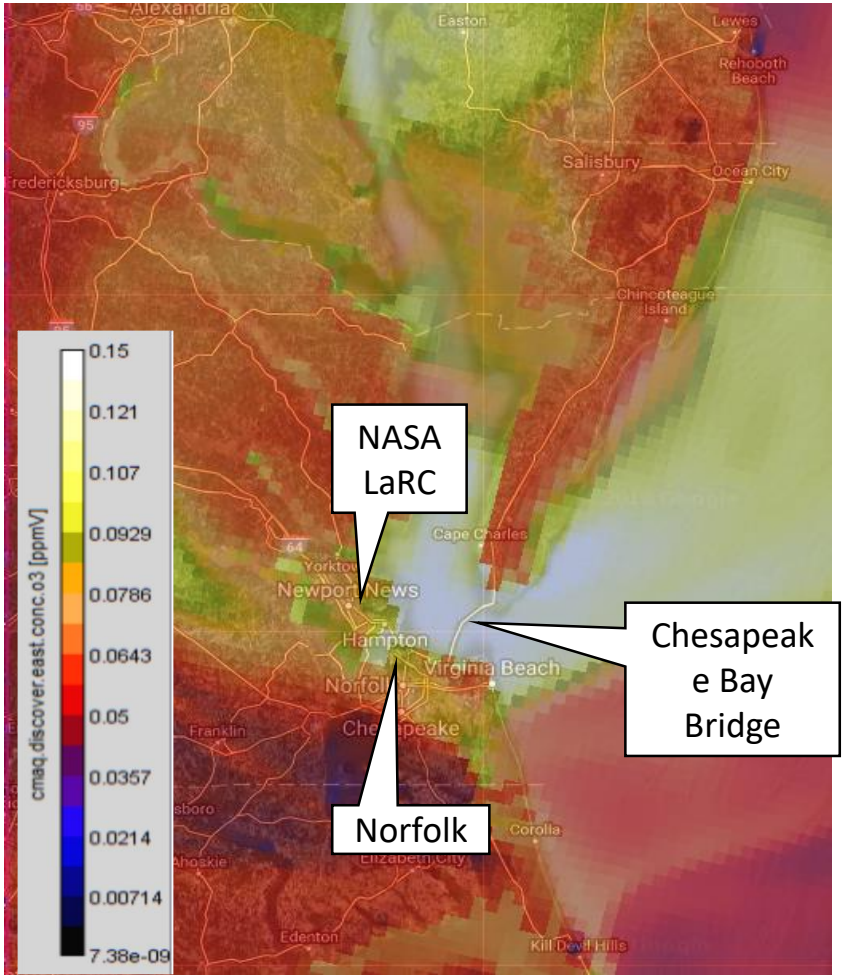
Motivation/background

- 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

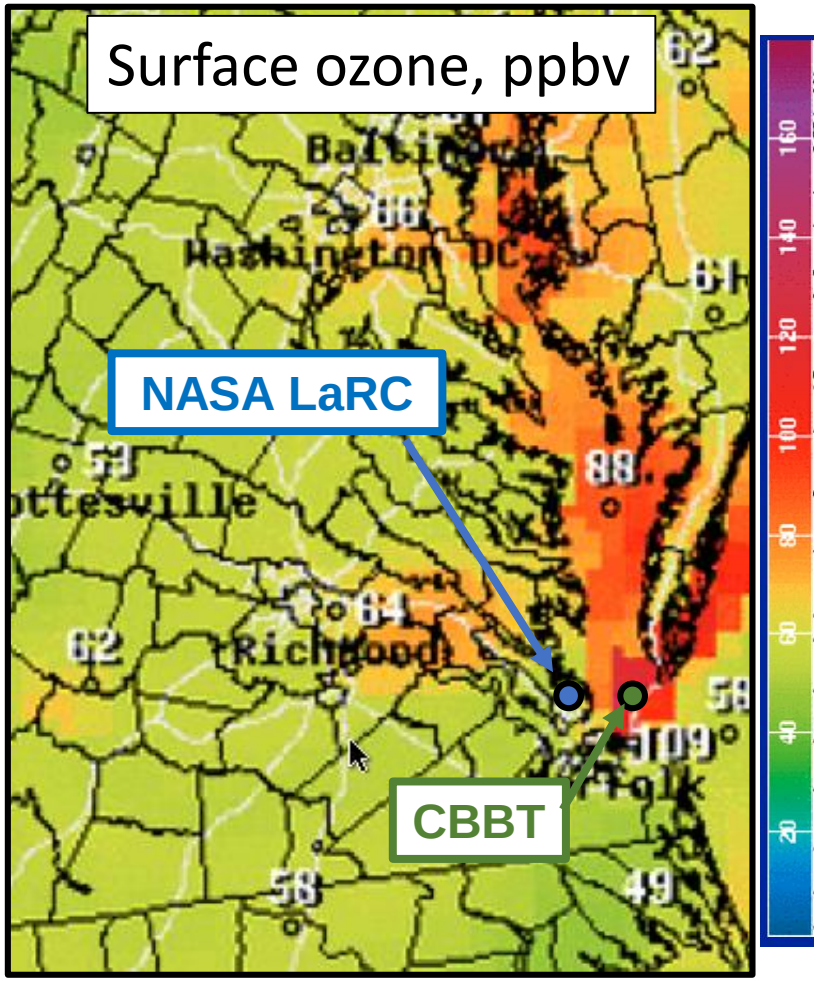
- Studies have examined the Chesapeake air-shed with respect to ozone including: Martins et al. 2012 (Hampton Roads region), Goldberg et al. 2014, Loughner et al. 2014, Stauffer et al. 2015 (Baltimore-DC region)
  - O_3 measurments over water are scarce

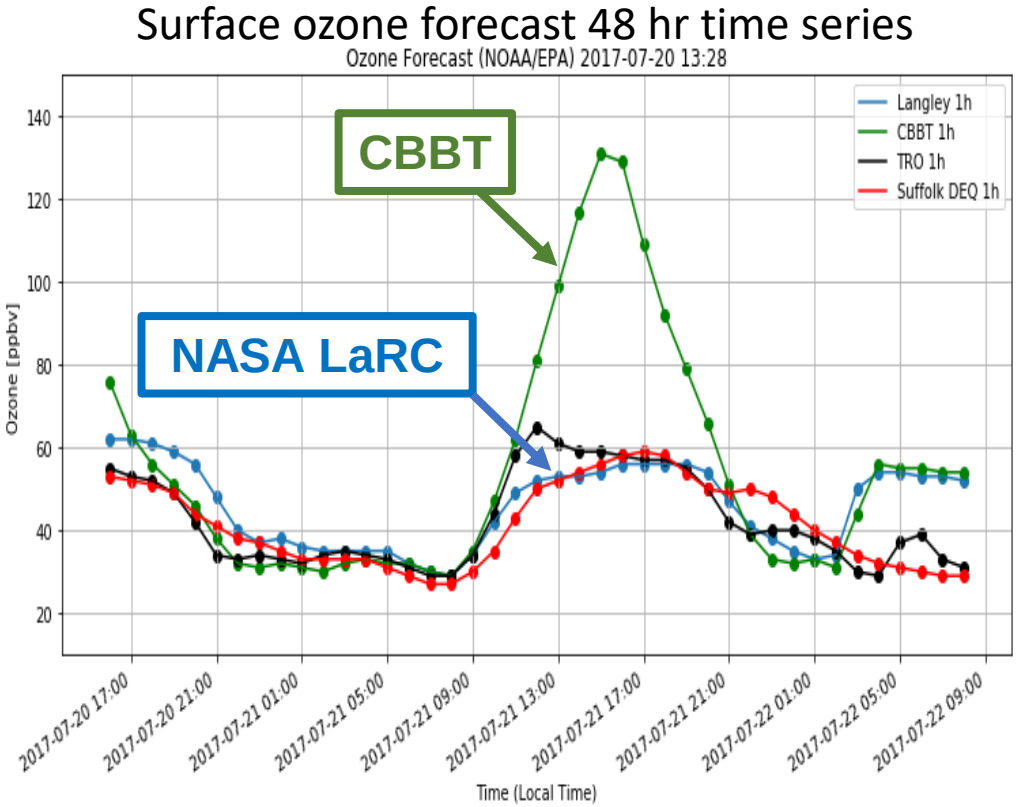
- Vertical, horizontal, and temporal (4-D) measurements are needed to describe complex scenes to improve forecast models and air quality satellite retrievals
  - TEMPO/GEOCAPE

Chesapeake Bay Region
EPA/RSIG3D – July 29 2011 20:00 GMT (16:00 EDT)
CMAQ-DISCOVER-AQ, O_3 surface concentration

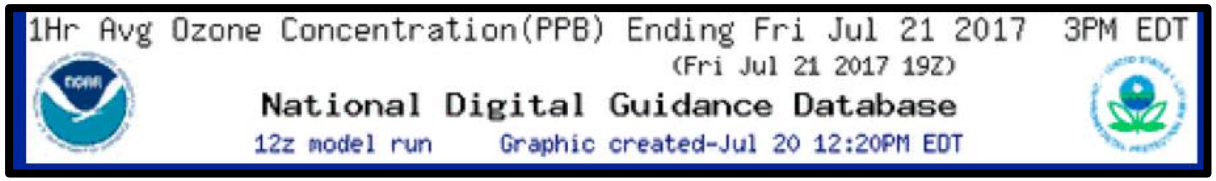


Forecast example July 20-21





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



Map of measurements

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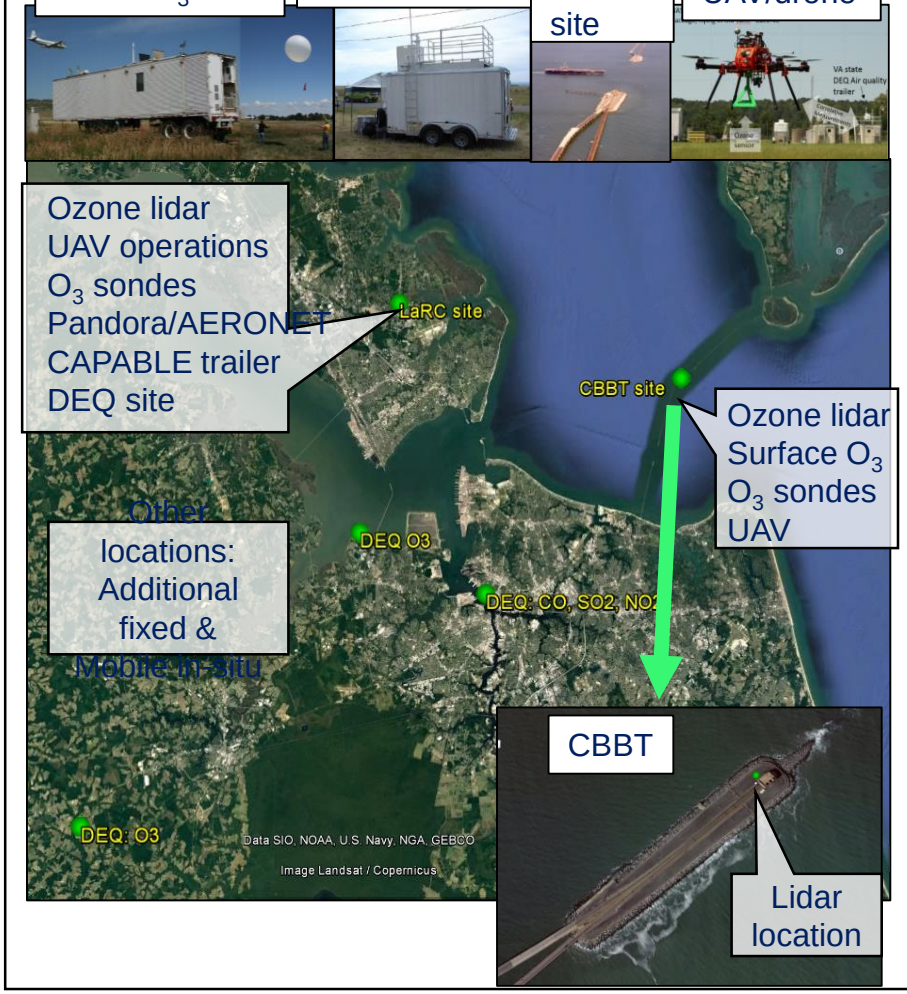
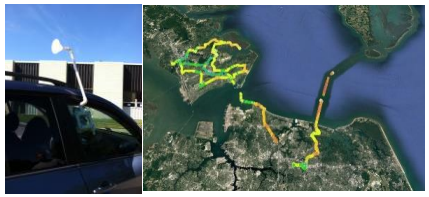
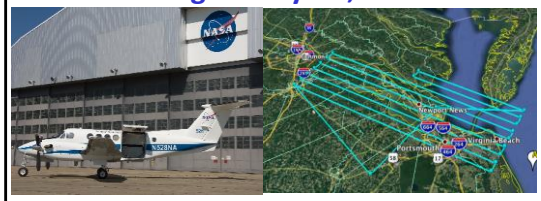
- 2 ozone lidars (CBBT & LaRC)
- UAV/drone (CBBT or LaRC)
- Simultaneous ozonesonde launches (LaRC & CBBT)
- DEQ sites
- CAPABLE (LaRC)
- PANDORA (CBBT & LaRC)
- AERONET (CBBT, Hampton U., LaRC)
- Mobile Cars (2)
- MPL at Hampton U
- Two Ceilometers (CBBT, LaRC)
- Surface NO2 at some sites (CBBT, LaRC)
- Supplemental O3 sites (TRO, VLM)
- Two Sherpa flights
- Three GeoTASO flights
- Two days SERC research vessel



Car In-situ: 2 cars, ~12 days

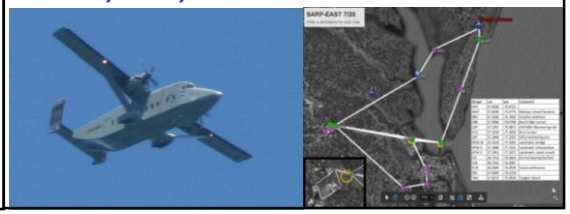


UC12: 3 flights July7-8, GeoTASO



SERC research vessel July 17-18
O3, NO2, Pandora, Ceilometer

Sherpa aircraft: 2 flights July 19-20
O3, NOx, VOCs



Measurement schedule

July 7 to Aug 2: 12 days of measurements

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	Location	7-Jul	8-Jul	12-Jul	13-Jul	17-Jul	18-Jul	19-Jul	20-Jul	21-Jul	26-Jul	1-Aug	2-Aug
Boat													
SERC Research Vessel	Misc					🟢	🟢						
Aircraft													
Sherpa aircraft (in-situ)	Misc							🟢	🟢				
King Air (GeoTASO remote)	Misc	🟢	🟢										
UAV/drone	LaRC or CBBT					🟡		🟡		🔴	🟢	🟢	🟢
Remote sensors													
LaRC ozone lidar (CBBT over-water site)	CBBT	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢
GSFC ozone lidar (at LaRC over-land site)	LaRC	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢
Pandora	LaRC, CBBT, VCU				🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢
MPL	Hampton U.	🟢	🟢		🟢	🟢	🟢	🟢	🟢	🟢			
Ceilometers	LaRC, CBBT, VCU			🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢
Aeronet sunphotometers	LaRC, CBBT, Hampton U.				🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢
In-situ sensors													
Ozonesondes	LaRC, CBBT	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢
Mobile car O3 sensors	Misc	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢
Supplemtnal O3 sensors, TRO, VLM, CBBT	TRO, VLM, CBBT	🟢	🟢	🟡	🟡	🟡	🟡	🟡	🟢	🟢	🟢	🟢	🟢
Supplmental NO2 sensors	LaRC, CBBT		🟢	🟢			🟡	🟡	🟡	🟡	🟡	🟢	🟢
CAPABLE trailer	LaRC			🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢
VA DEQ sites	LaRC (O3, SO2, NO2)Norfolk(CO, SO2, NO2), Tidewater CC(O3), Suffolk	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢

In-situ O_3 sensor for UAV flights & Mobile cars

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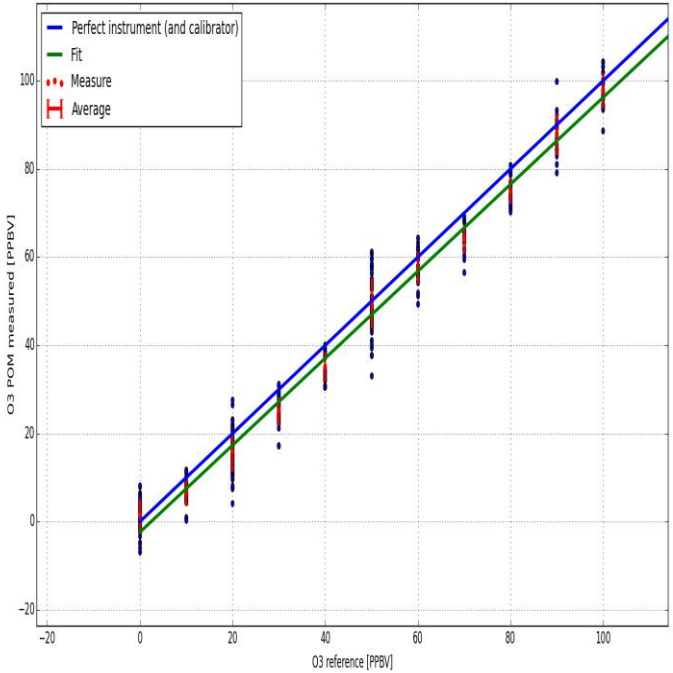
2B POM sensor

- 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

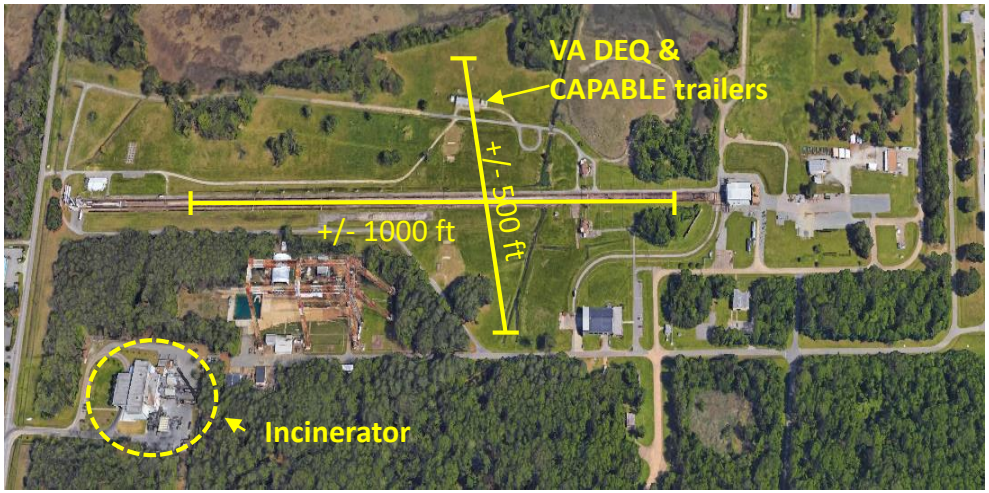
UAV/drone flights

- 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

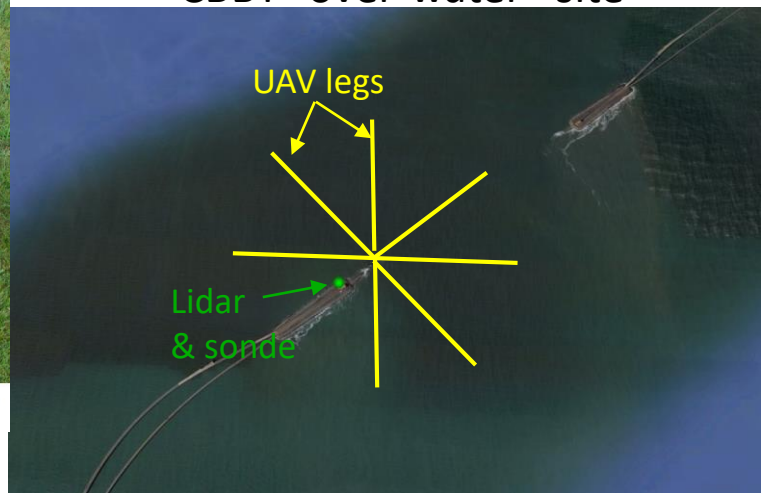
- At LaRC line-of-site flight paths would be in close proximity to VA DEQ & CAPABLE trailers

LaRC "Back-40"



Mark Motter, left, and Eddie Adcock of Langley's Autonomy Incubator prepare to fly a UAV that will take ozone measurements near the ground at Langley. Credit: NASA/David C. Bowman

CBBT "over-water" site



UAV Investigation of near-range variability in ozone

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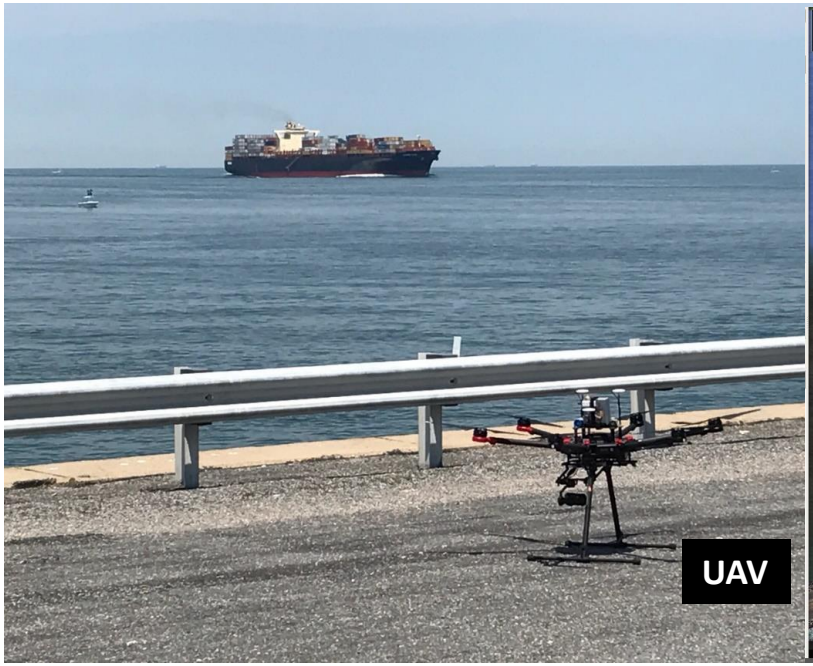
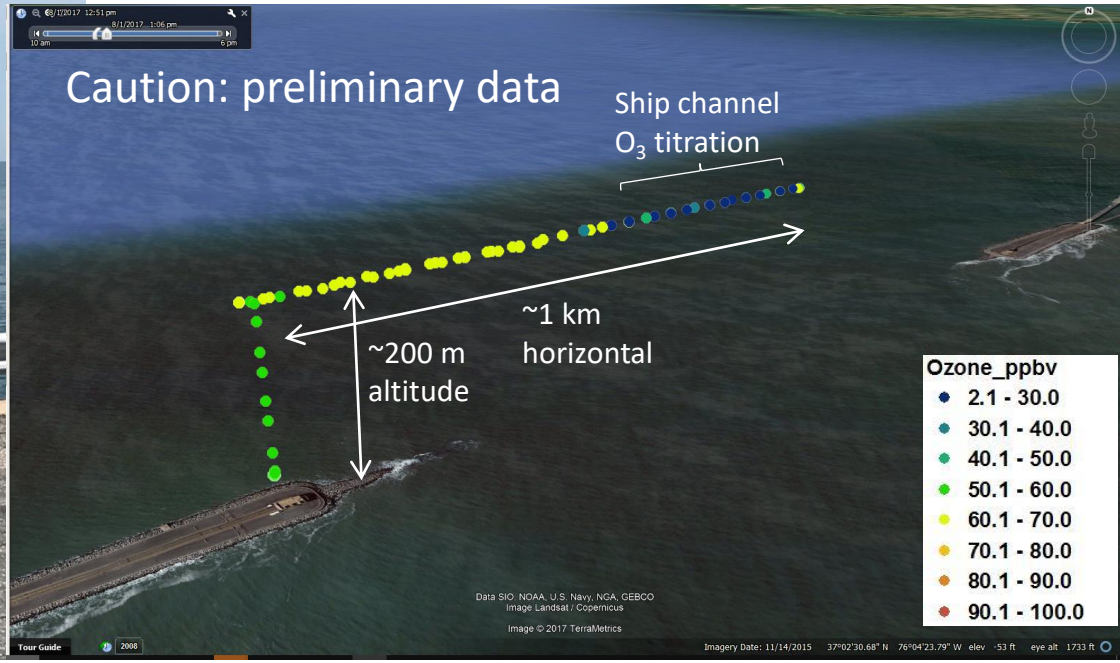
CBBT site with UAV in foreground with a ship about to pass through channel



UAV August 1 flight from the CBBT third island



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

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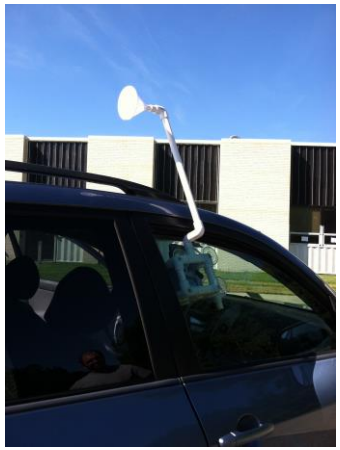
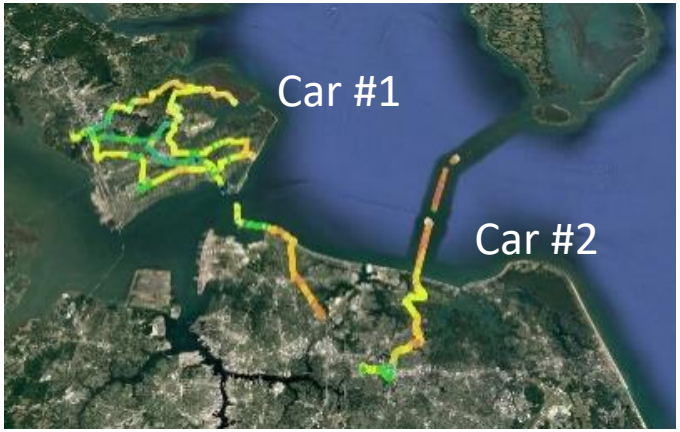
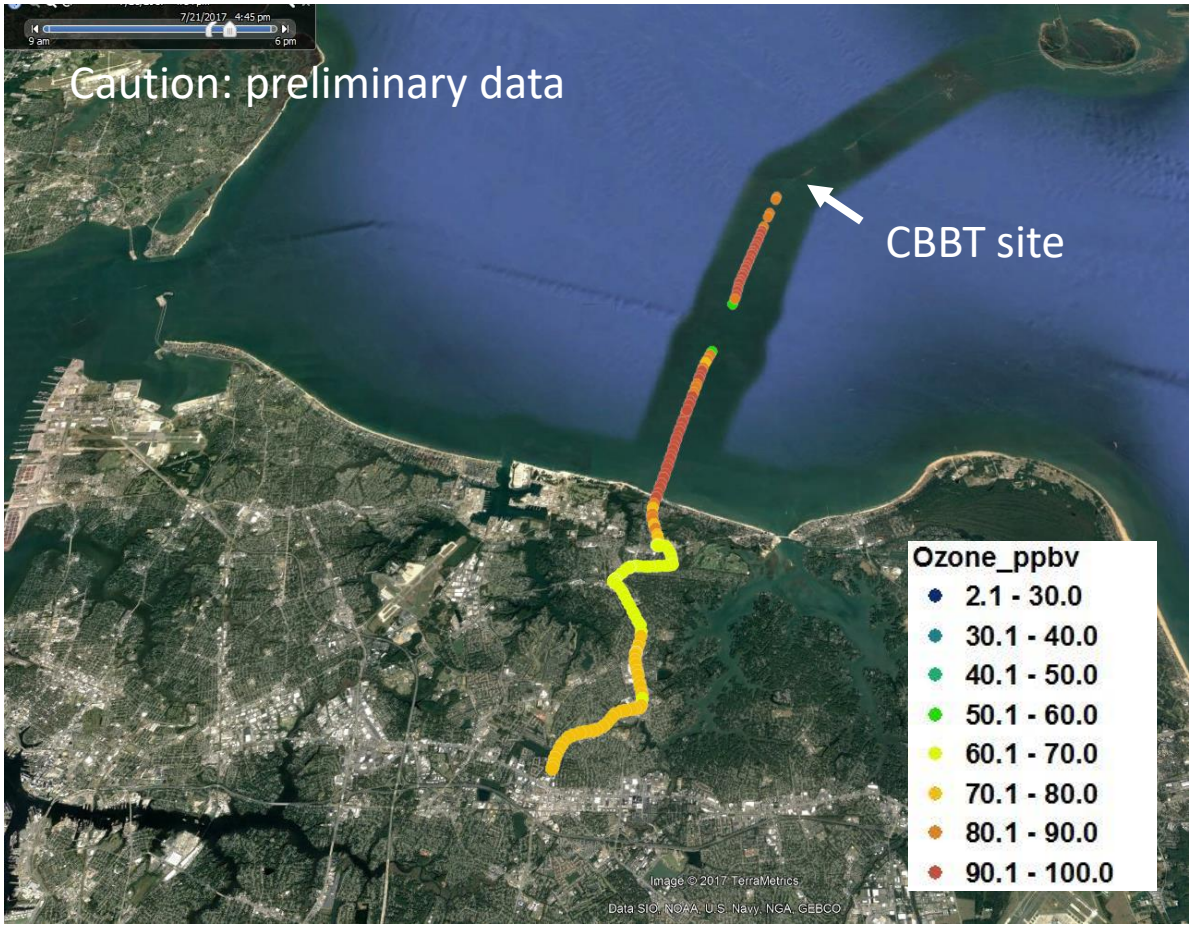
Car in-situ ozone sensor configuration



July 21



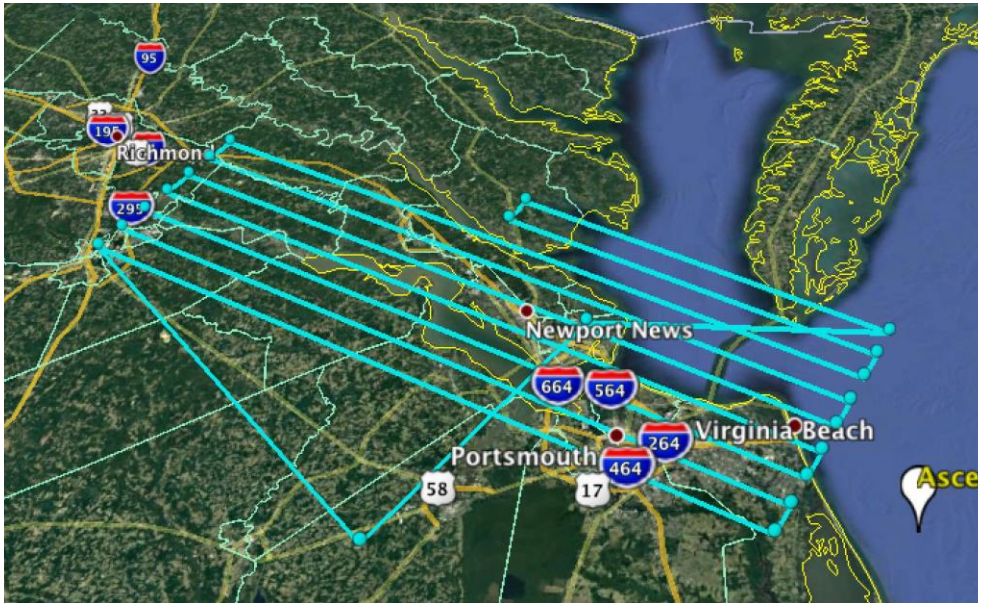
Example car in-situ ozone sensor data segment from July 21



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 prelimary file prep in progress

Micro-pulse Lidar (MPL) at Hampton University

Ozone Water-Land Environmental Transition Study

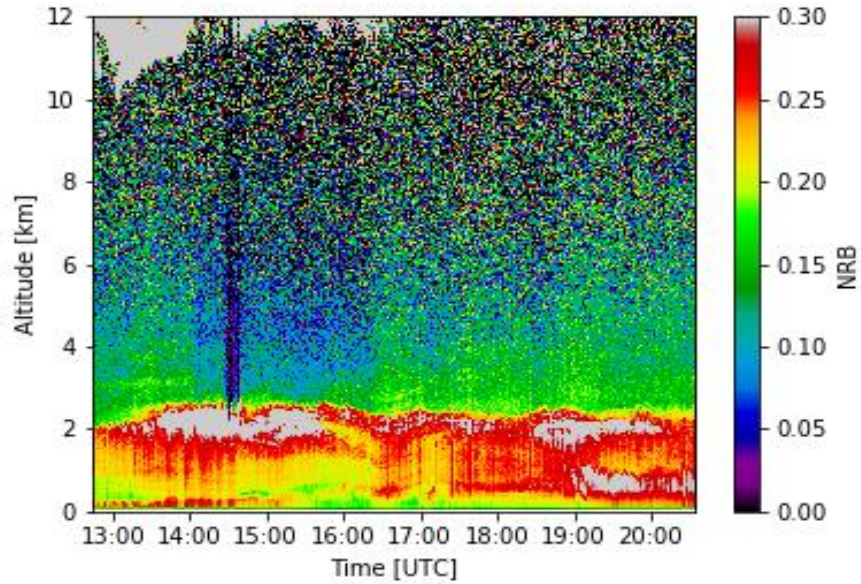
<u>Data Products:</u> Attenuated backscatter profiles at 527 nm, Cloud and Mixed layer heights, Cloud fraction

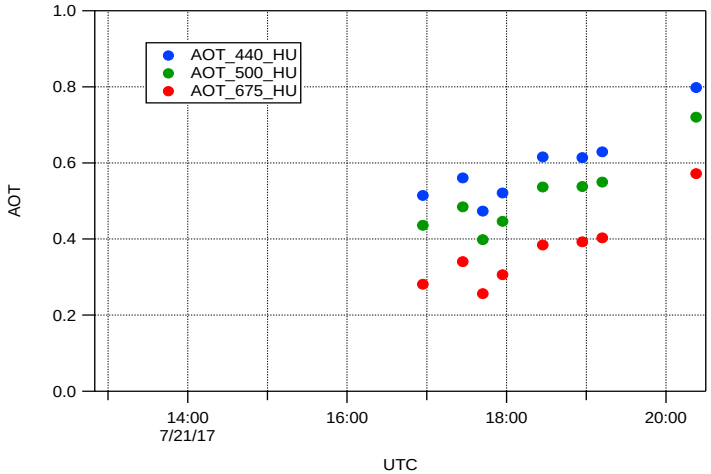
<u>Data collected:</u> 8 days

<u>Data status:</u> Waiting on final data quick-looks, preliminary archive file prep in progress

MPL

July 21





Ozonesonde launches

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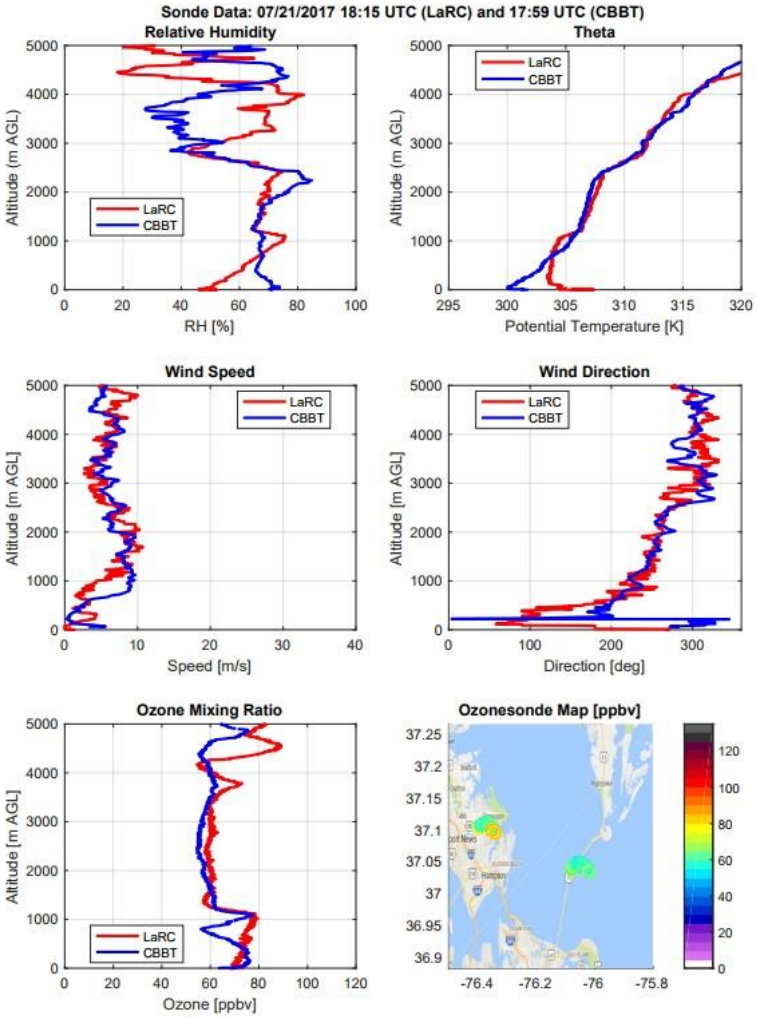
~35 launches
LaRC-CBBT launches were simultaneous

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

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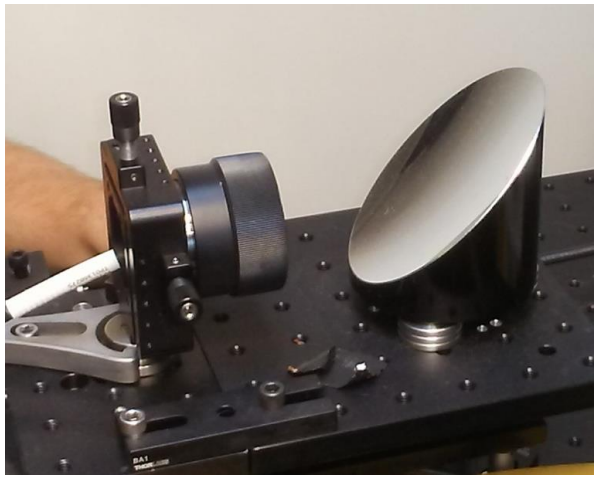
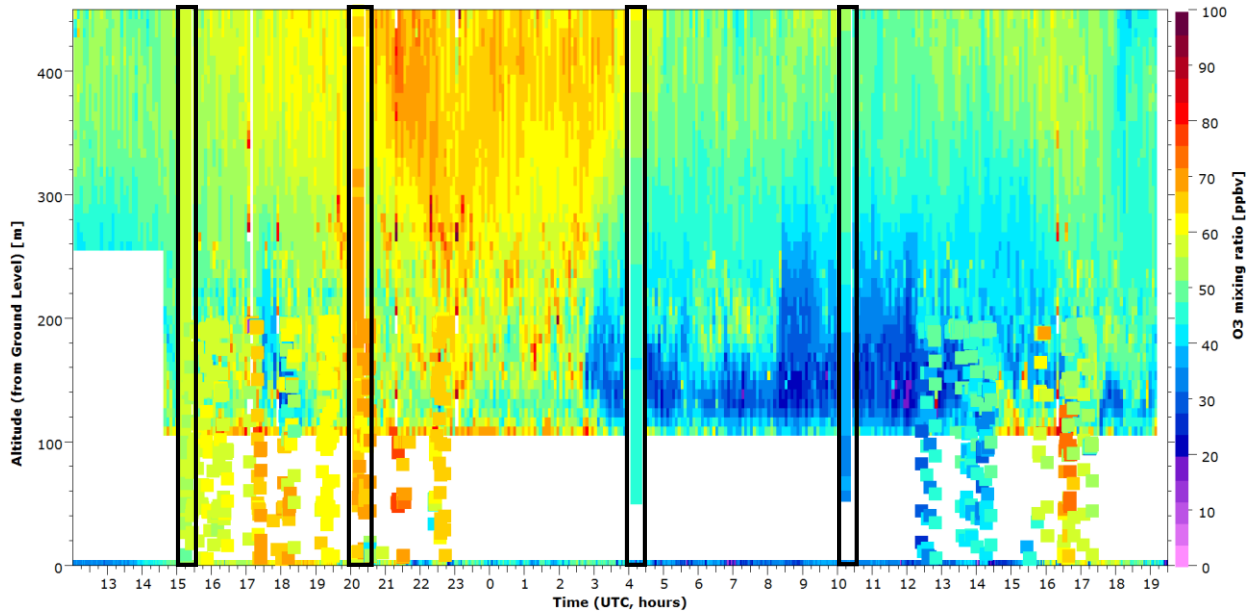
Farris et. al (tech. note to be submitted)

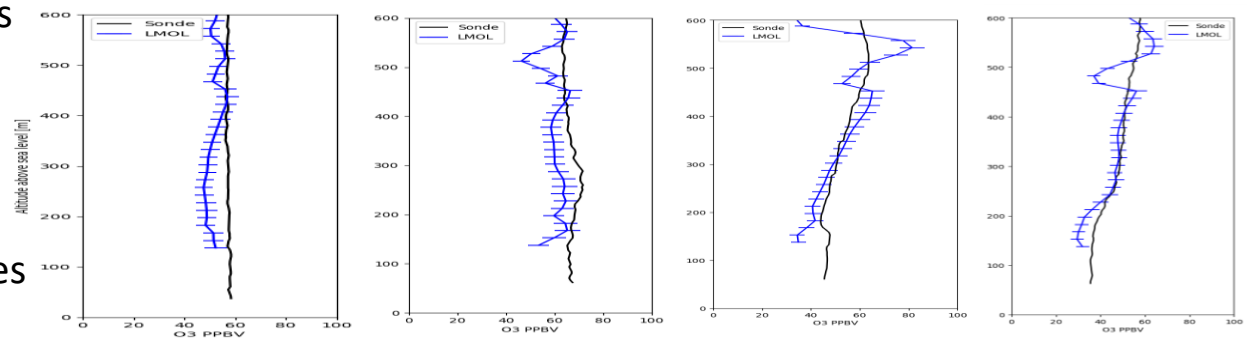
90 deg. OAP test setup



Case Study: Preliminary Intercomparison at CBBT (8/1-8/2), Near Field

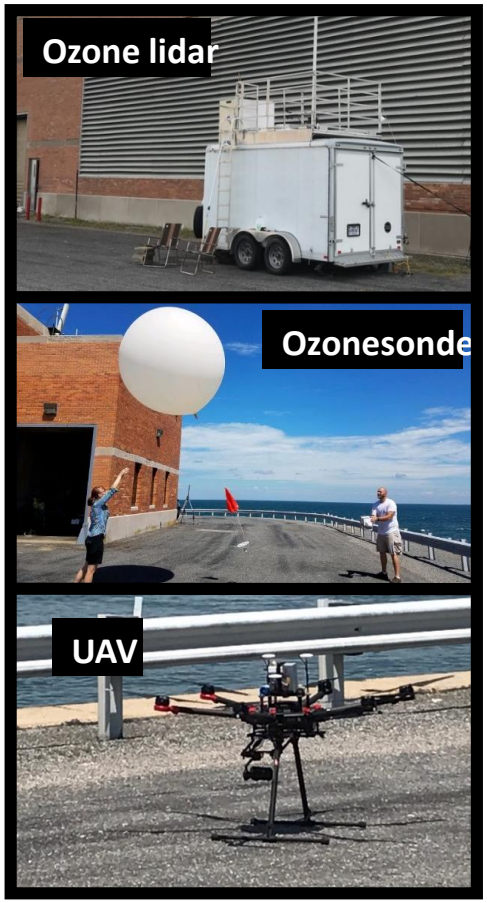


- Testing two different 90-deg OAPs
- Using Licel channel #2 (12 bit analog & PC)
- Refinement of alignment procedures
- Comparisons with UAV and sondes
- Initial assessment ~ 150m and higher appear to be usable



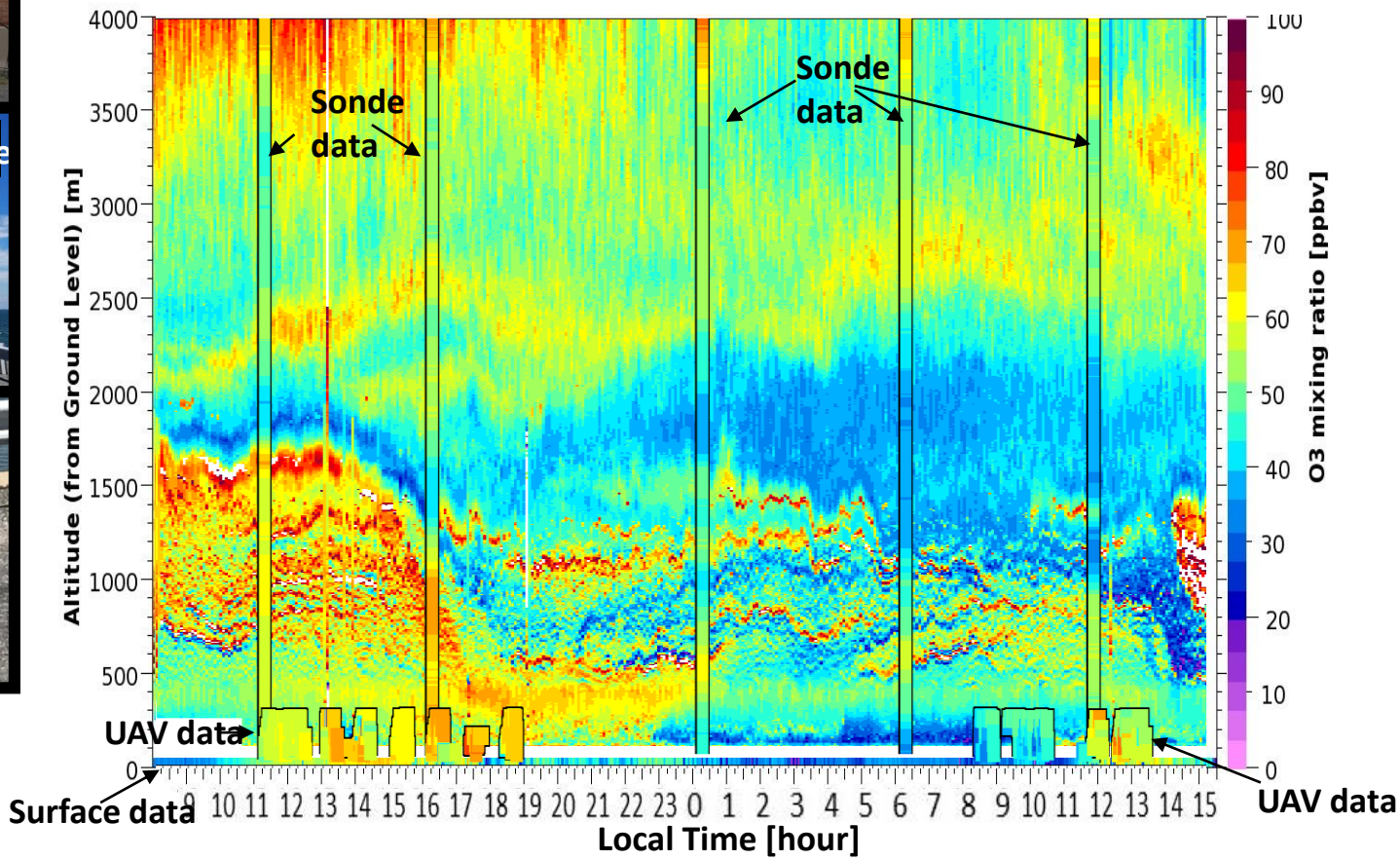
15:00 **20:00** **4:00** **10:00**

Data Integration Example
Lidar, Sonde, & UAV



Gronoff et al. (to be submitted)

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



Ozone cross-validation

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- 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

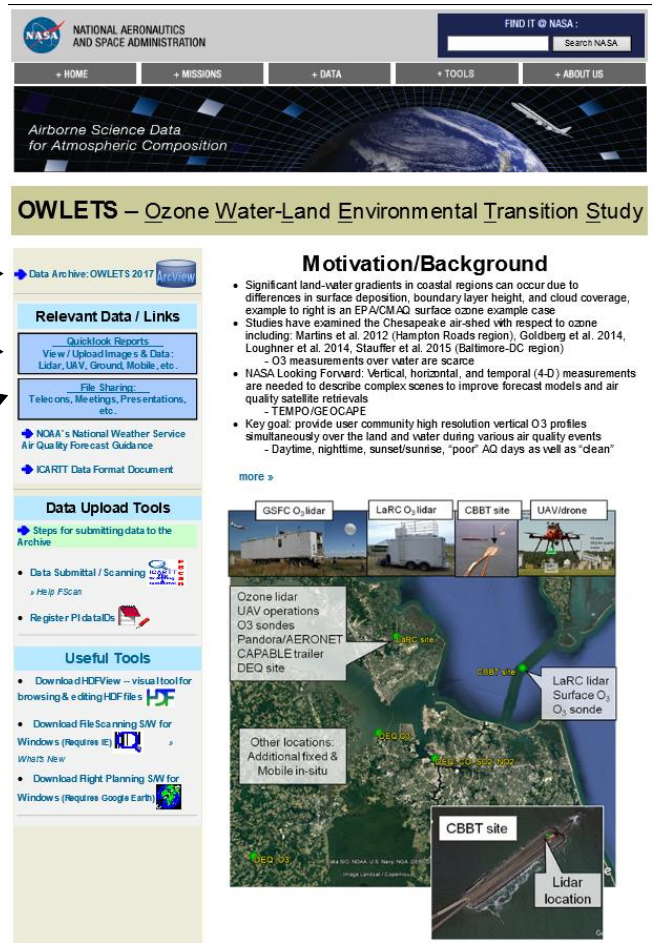
OWLETS Website

Ozone Water-Land Environmental Transition Study

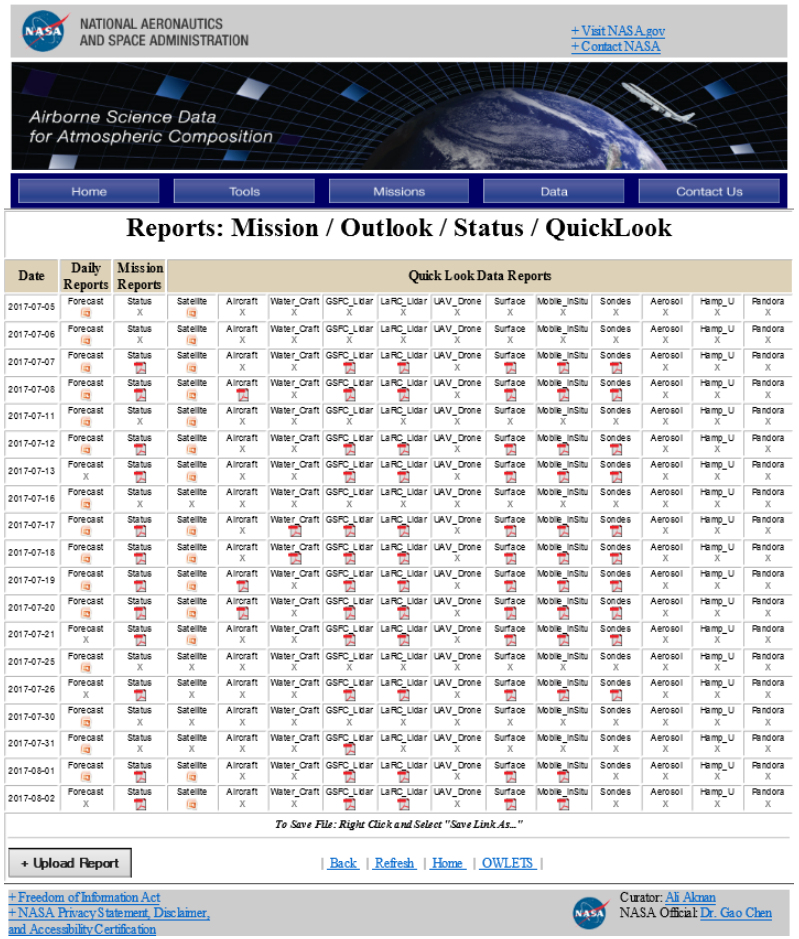
Data Archive →

Quick looks →

Presentations, Etc.



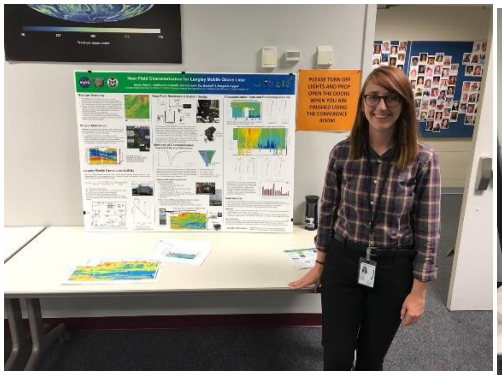
Quicklook page



Student Interns: LaRC TEMPO student collaborators (Mentor: Margaret Pippin)
GSFC NIFS Program (Mentor: John Sullivan)
Hampton University NIFS Program (Mentor: Bill Moore)

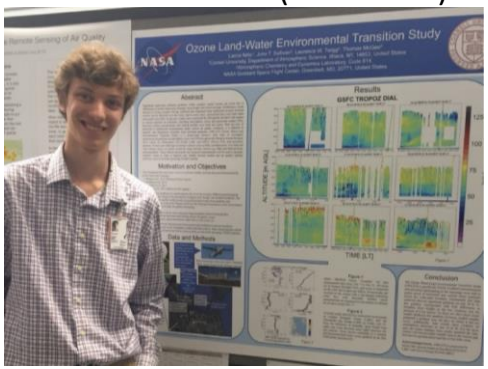
OWLETS
Ozone Water-Land Environmental Transition Study

Betsy Farris (Lidar)

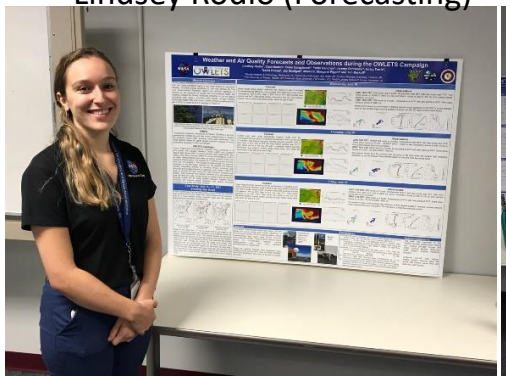


Jeremy Schroeder (UAV & Mobile Car)

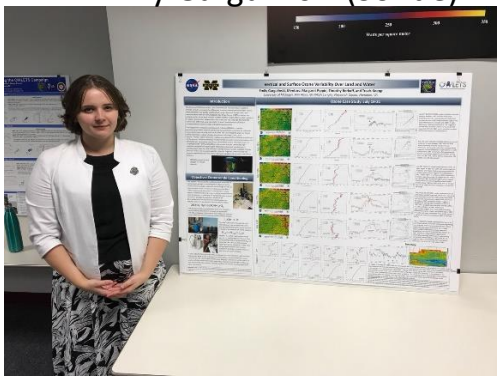
Lance Nino (GSFC lidar)



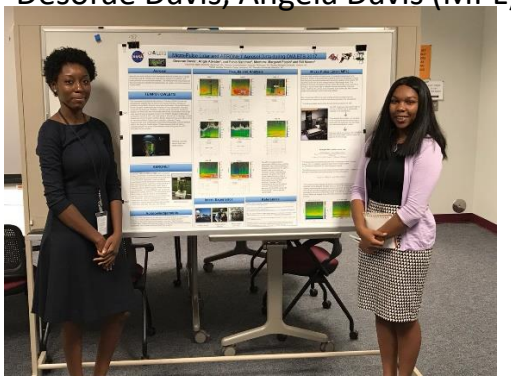
Lindsey Rodio (Forecasting)



Emily Gargulinski (Sonde)



Desorae Davis, Angela Davis (MPL)



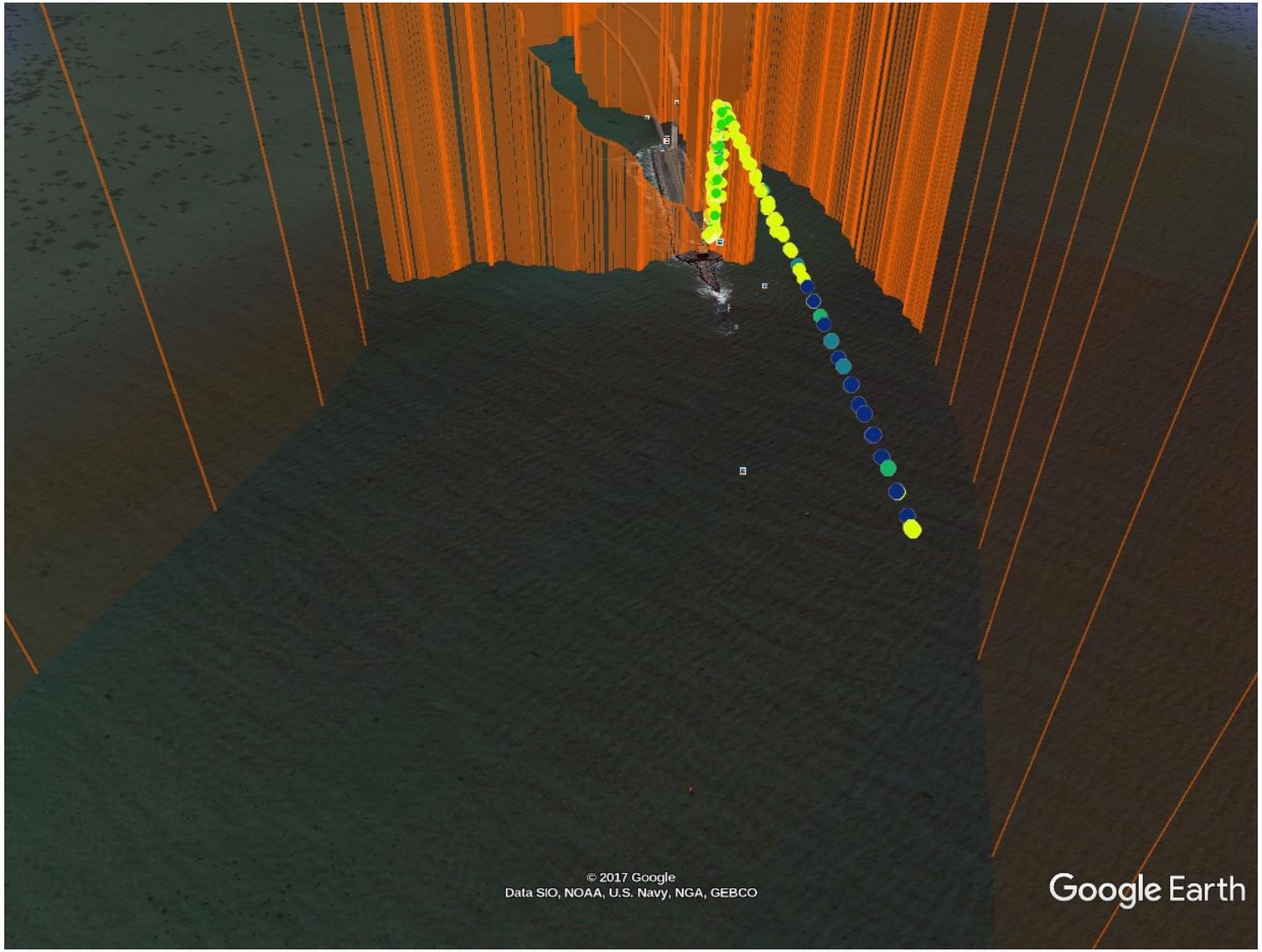
Pablo Sanchez to be added, other students contributed from SARP aircraft & SERC vessel!

OWLETS Ship Titration Event

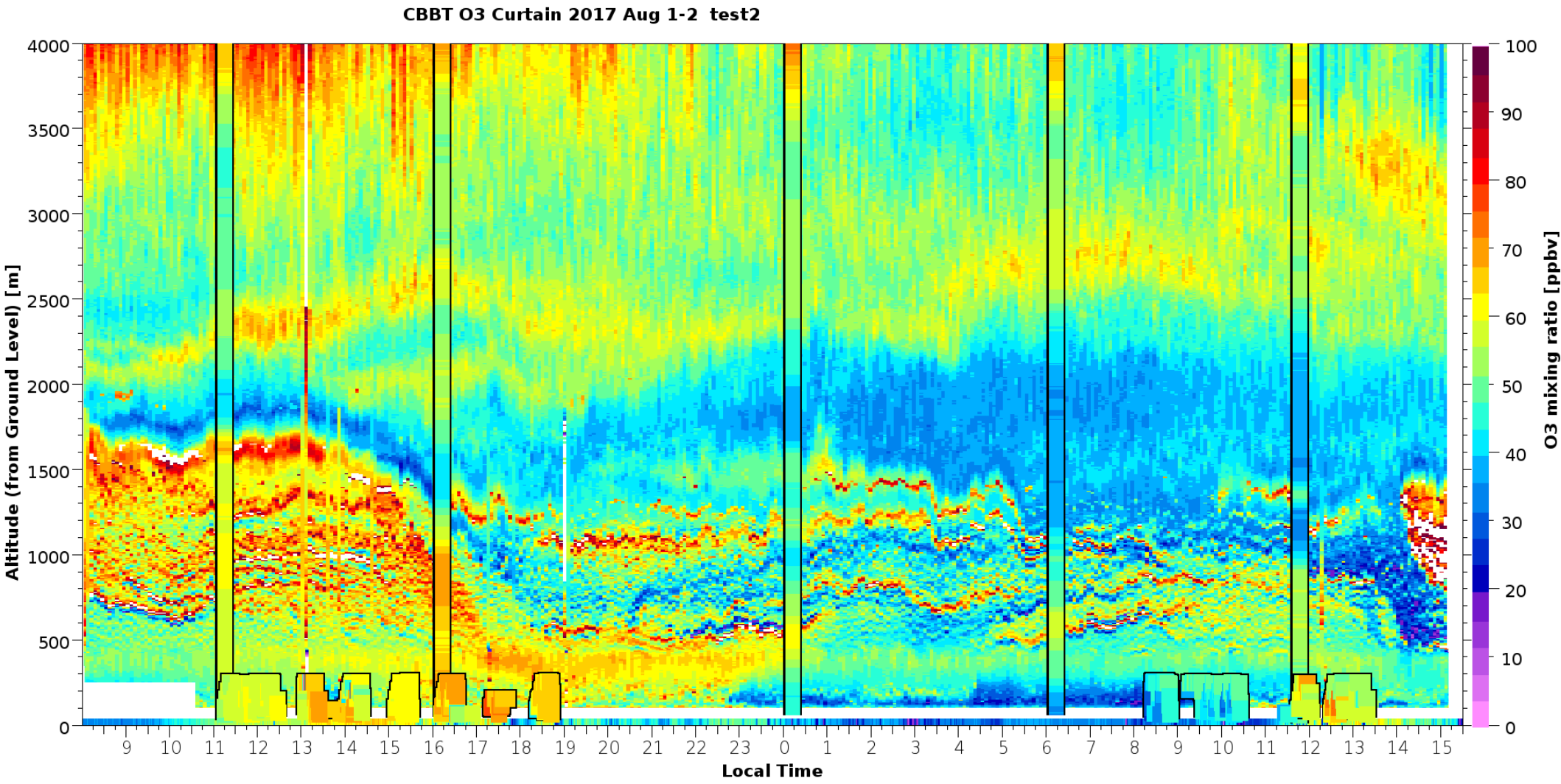
- Location: CBBT 3rd island
- Observation with UAV/POM sensor
- Observation with LMOL lidar (Very Near Field, newly developed, with minimum altitude ~100m)

Google Earth/POM UAV

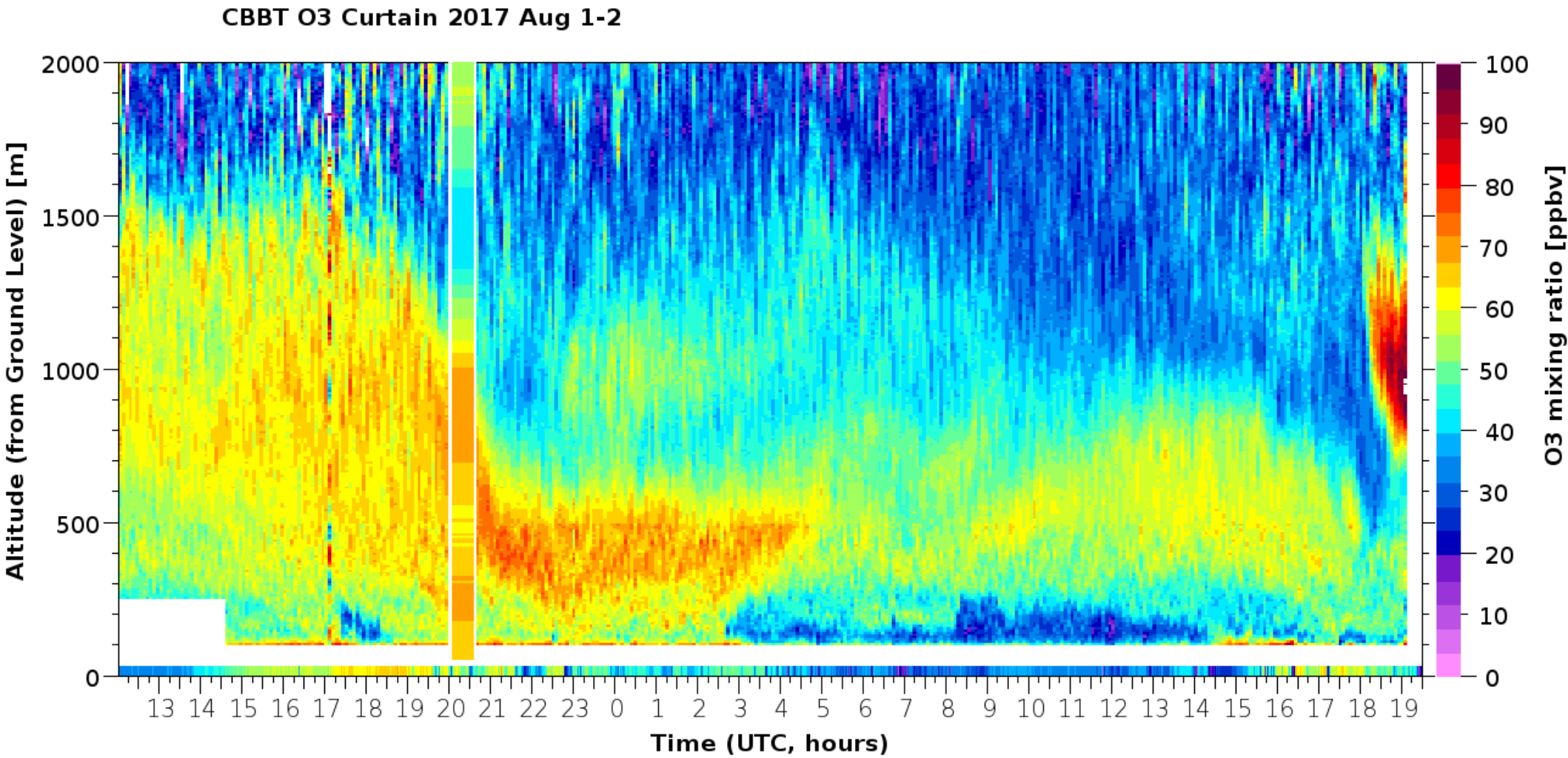
- The titration is observed above the channel



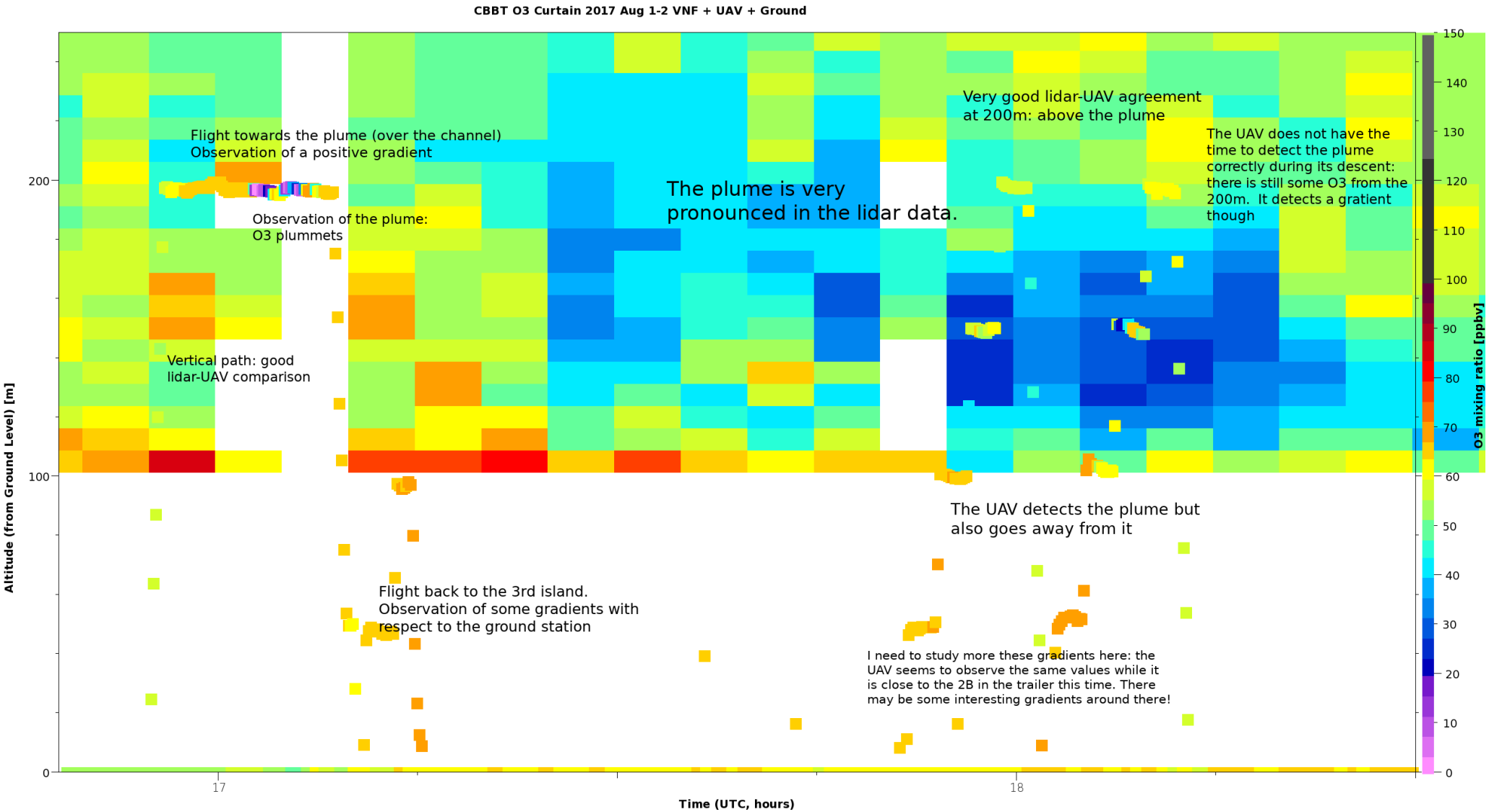
LMOL data


CBBT O3 Curtain 2017 Aug 1-2 test2
Altitude (from Ground Level) [m]
4000
3500
3000
2500
2000
1500
1000
500
0
9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
Local Time
O3 mixing ratio [ppbv]
100
90
80
70
60
50
40
30
20
10
0

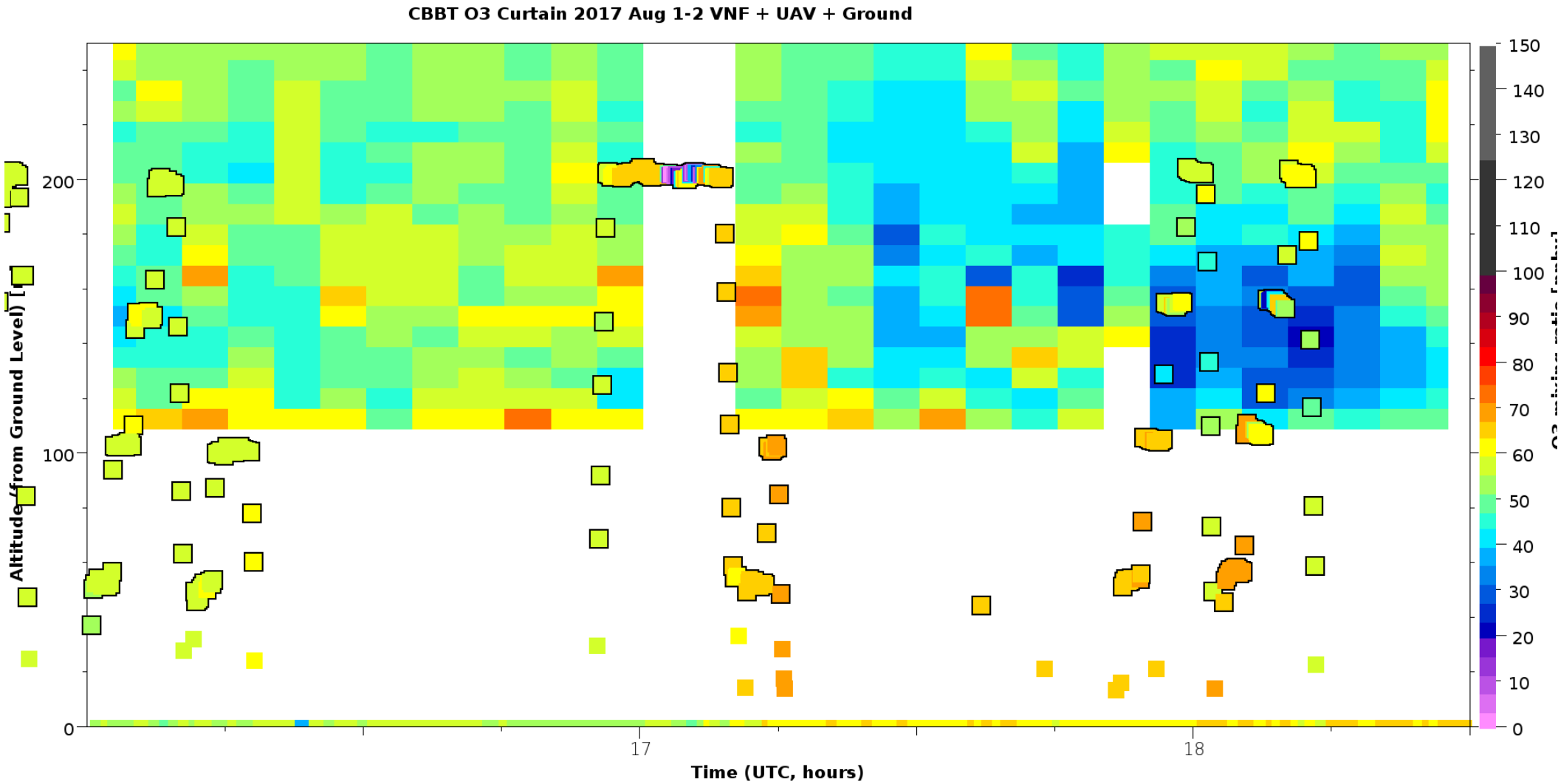
Very Near field only: titration at 17h UT on Aug 1



LMOL/POM comparison



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)

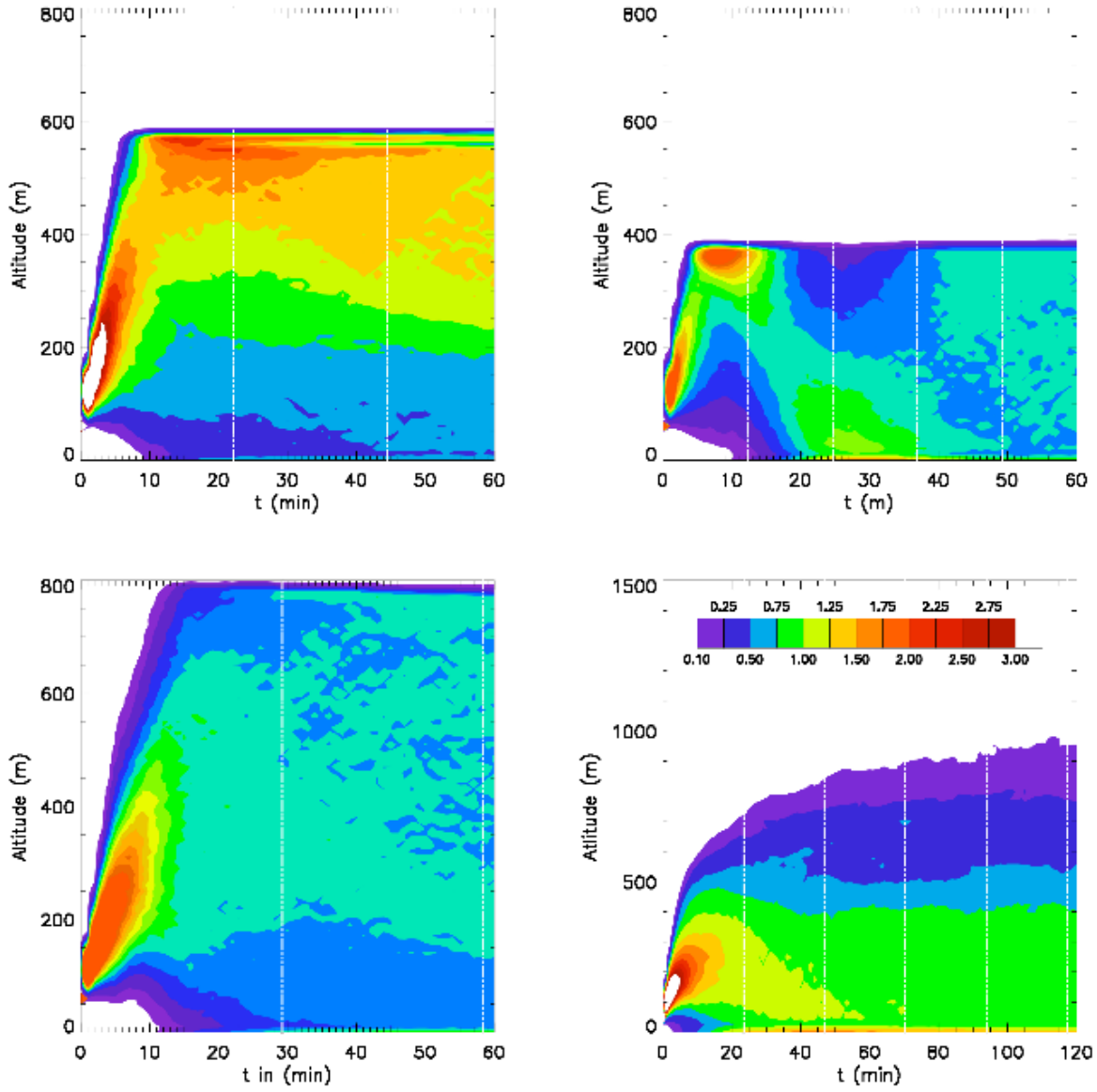


Fig. 5. Time evolution of normalized mean vertical concentration for FIRE1 (top left), FIRE2 (top right), FIRE3 (bottom left) and BOMEX (bottom right) with initial mean buoyancy flux $\overline{F}$=120 $m^4\,s^{-3}$. The vertical dashed-dotted lines represent the characteristic turnover time scale of 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

Refs

- Chosson, F., Paoli, R., and Cuenot, B.: Ship plume dispersion rates in convective boundary layers for chemistry models, Atmos. Chem. Phys., 8, 4841-4853, https://doi.org/10.5194/acp-8-4841-2008, 2008.
- Huszar, P., Cariolle, D., Paoli, R., Halenka, T., Belda, M., Schlager, H., Miksovsky, J., and Pisoft, P.: Modeling the regional impact of ship emissions on NOx and ozone levels over the Eastern Atlantic and Western Europe using ship plume parameterization, Atmos. Chem. Phys., 10, 6645-6660, https://doi.org/10.5194/acp-10-6645-2010, 2010.
- Knepp T, Pippin M, Crawford J, et al. Estimating surface NO2 and SO2 mixing ratios from fast-response total column observations and potential application to geostationary missions. Journal of Atmospheric Chemistry. 2015;72(3-4):261-286. doi:10.1007/s10874-013-9257-6.
- Song, C. H., G. Chen, S. R. Hanna, J. Crawford, and D. D. Davis (2003), Dispersion and chemical evolution of ship plumes in the marine boundary layer: Investigation of O3/NOy/HOx chemistry, J. Geophys. Res., 108, 4143, doi:10.1029/2002JD002216, D4.