Characterizing spatio-temporal ozone gradients along coastal boundaries: Sondes and mobile measurements from OWLETS-2

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Ozone Water-Land Environmental Transition Study (OWLETS-2) Abstract

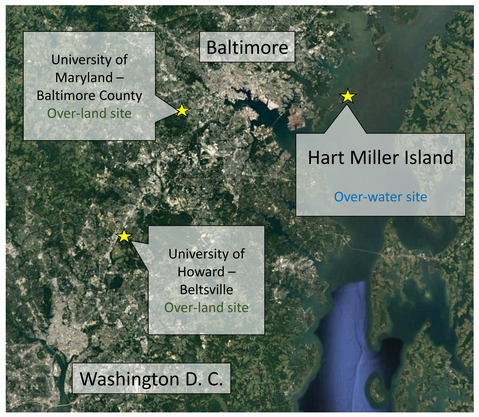
One of the major difficulties for the modeling and satellite communities is the validation of O_3 levels in sharp coastal transition regions within metropolitan areas. Land-water gradients of ozone as well as its precursors can be significant due to differences in emissions, land use, surface deposition, boundary layer height, and mesoscale wind patterns. The Ozone Water-Land Environmental Transition Study (OWLETS-2) was a follow-on field campaign spearheaded by NASA GSFC and LaRC's Tropospheric Ozone Lidar Network (TOLnet) conducted in the summer of 2018 within the Upper Chesapeake region to better characterize spatial and vertical distribution of various pollutants across the coastal boundary. Supporting this campaign, 40 ozonesondes were simultaneously launched directly in the marine environment on Hart Miller Island (HMI) and on two land sites: both the University of Maryland, Baltimore County (UMBC) and Howard University – Beltsville (HUBV). In addition, Personal Ozone Monitors (POMs) — small sensors — were deployed in a variety of environments — car, boat, and drone, to name a few —to quantify ozone across fine spatial and temporal thresholds. The purpose of these measurements is multifaceted: to provide both ozone pollution information to coastal metropolitan communities and validation to satellite, modeling, and forecasting communities, especially in current and future satellite endeavors such as TROPOMI and TEMPO.

Motivation and Objectives

- The Chesapeake has seen many recent air pollution studies, but they have not focused heavily on the land-water boundary:
  - Martins et al., 2012 (Hampton Roads region)
  - Goldberg et al., 2014
  - Loughner et al. 2014
  - Stauffer et al., 2015 (Baltimore-DC region)
- Land-water ozone gradients in coastal regions can occur due to many different meteorological factors, such as the timing of the bay breeze, boundary layer height, and frontal boundaries. The vast majority of air quality models predict a significant land-water ozone gradient, and government agencies such as the Virginia DEQ and the Maryland Department of the Environment rely on these models for daily air quality forecasting.
- Our key goal is to provide the user community high resolution vertical ozone profiles simultaneously over the land and water during various air quality events:
  - Daytime, nighttime, sunset and sunrise, high AQI as well as low, etc.
- NASA Looking Forward: Measurements from micro-scale pollution events are needed to describe the complexity of the Chesapeake airshed and others like it. These measurements will be used for validation of current and future ozone models as well as the upcoming TEMPO satellite.

Methods and Instrumentation

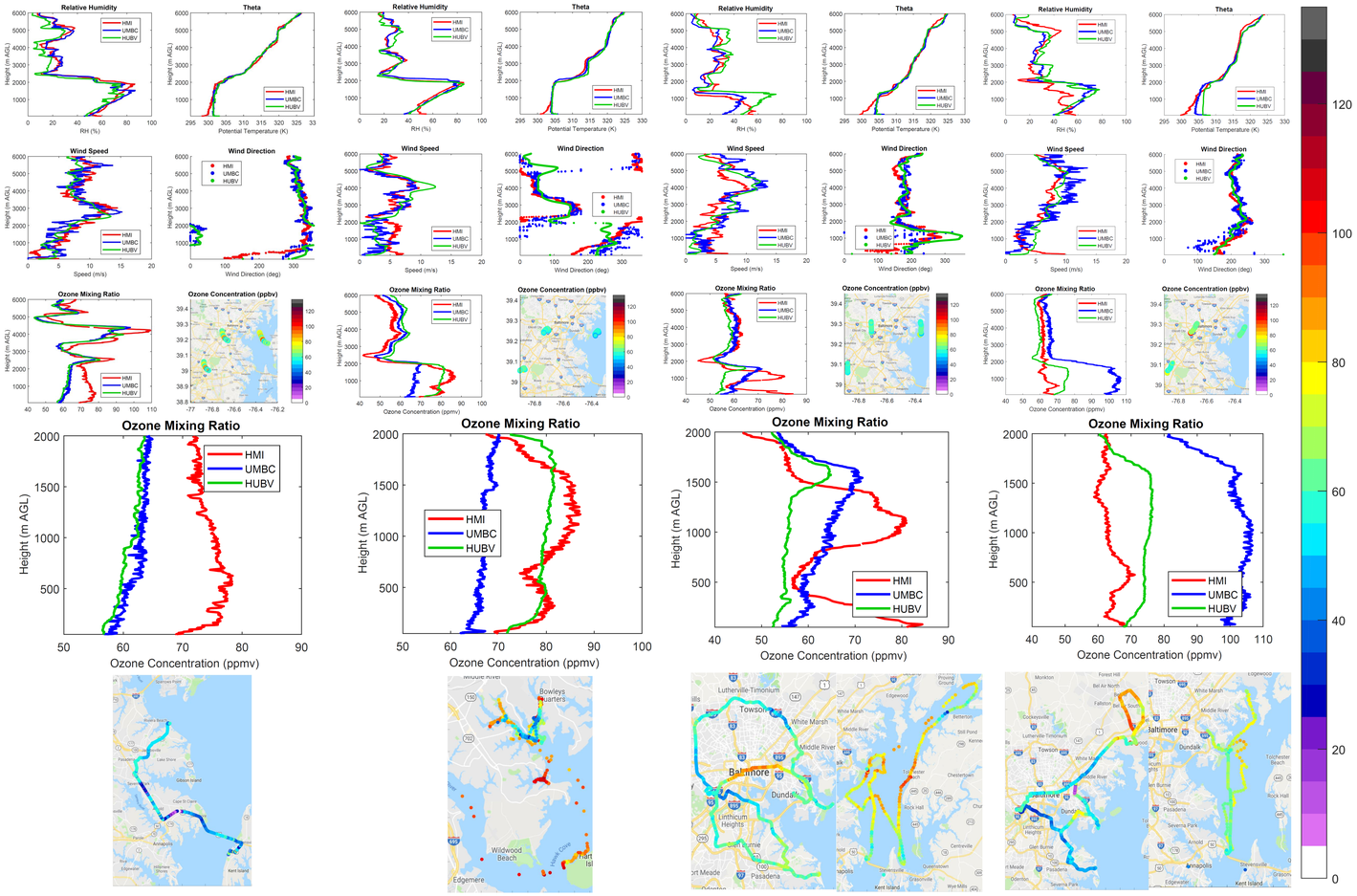
Ozonesonde Locations



The EN-SCI 2Z34 ECC (electro-chemical cell) ozonesonde was used at the UMBC and HMI sites. Vaisala sondes were used at Beltsville. These instruments were attached to a radiosonde in coordinated launches and flew up to 35 km.

2B Technologies' Personal Ozone Monitors (POM) were used in mobile car, boat, and UAV measurements because of its portability and high (1 second) interval data acquisition. These operated throughout the Chesapeake and Baltimore metro area.

Results



Top panels: Relative humidity, potential temperature, wind speed and direction, ozone, and geolocation from 0-6 km for the three coordinated sites' ozonesondes during the heat wave of June 29th – July 2nd, 2018.

Middle panels: Close-up of ozone mixing ratio from 0-2 km for the three coordinated sites' ozonesondes during the heat wave of June 29th – July 2nd, 2018.

Bottom panels: Mobile measurements during the June 29th – July 2nd, 2018 heatwave. Both measurements by automobile and boat are shown. The color scale for the mobile measurements is to the far right of the figures.

Green: Howard University – Beltsville, (HUBV) over-land site
Red: Hart Miller Island (HMI), over-water site
Blue: University of Maryland – Baltimore County (UMBC), over-land site

Conclusion

The ozonesondes and mobile measurements during the Ozone Water-Land Environmental Transition Study (OWLETS-2) were able to gather proof of horizontal and vertical ozone gradients across the water-land boundary. Ozonesonde and POM retrievals showed significant gradients between June 29th-July 2nd. By taking more measurements from the other instruments on this campaign, including lidar, UAV, airborne, and satellite, we can elucidate a multi-dimensional view of pollution transport in coastal regions that can be examined with limited resources. Data analyses will ultimately contribute to improvements in forecast models and related satellite-derived air quality data products. With more stringent regulatory policy for pollution, it is becoming increasingly imperative that we fully characterize ozone pollution events, verify models, and evaluate satellite products – OWLETS-2 has proven a novel dataset for these purposes.

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