Bay Breeze Impact on Surface Ozone at Edgewood, Maryland

R. M. Stauffer[1]; A. M. Thompson[1]; D. K. Martins[1]; R. Clark[2]; J. R. Herman[3]; T. Berkoff[3]; B. Baker[3]; R. Delgado[3]

[1]Department of Meteorology, The Pennsylvania State University, PA; [2]Department of Earth Sciences, Millersville University, PA
[3]Department of Physics, University of Maryland Baltimore County, Baltimore, MD (author email: rms5539@psu.edu)

Introduction

- Ozone (O_3) in the troposphere is an EPA criteria pollutant due to its ability to irritate and damage the human respiratory system as well as detrimentally affect plant photosynthesis rates
- The meteorological conditions necessary to produce widespread ozone pollution also favor formation of a bay or sea breeze depending on proximity to a large body of water. These include:
  Light or calm synoptic scale winds
  Intense Solar Radiation (leading to land/water temperature gradients)

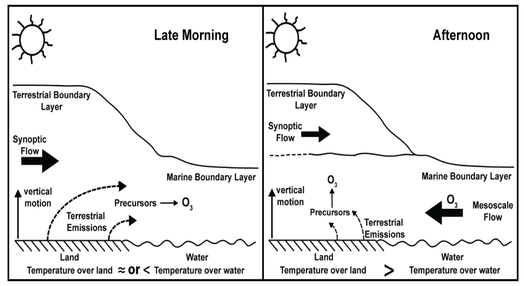

Fig. 1: Diagram of bay breeze from Martins et al. (2012), accepted JGR.

- Ozone surface deposition slower over water than land
- Ozone precursors emitted into shallow, stable over-water boundary layer
- Bay breeze creates a convergence zone for pollutants

NATIVE (Penn State)

Fig. 2: 2011 Penn State NATIVE members from left to right: Hannah Halliday, Ryan Stauffer, Anne Thompson, and Douglas Martins. NATIVE trailer (left) and MDE trailer (right) are in background.

Nittany **A**tmospheric **T**railer and **I**ntegrated **V**alidation **E**xperiment:

Mobile platform with in-situ measurements of trace gases and ground station for balloon launches

Meteorological measurements of temperature, RH, wind speed and direction and SW radiation from UVMFR-7 Shadowband Radiometer

Measurements taken at Aberdeen Proving Ground, Edgewood, MD (39.411°N, 76.298°W) as part of NASA's DISCOVER-AQ Campaign

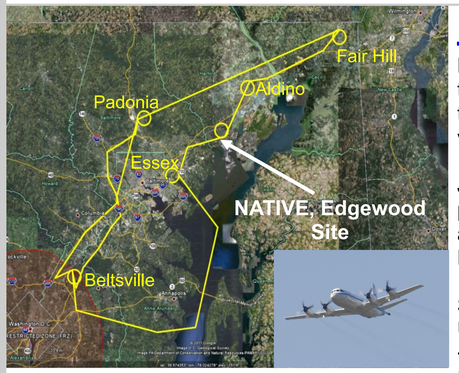

Fig. 3: Planned NASA P3-B (picture insert) flight path. Circles are spiral profiles, co-located with DISCOVER-AQ ground sites.

DISCOVER-AQ:

Multi-year project designed to relate column amounts of trace gases to surface variability

July 2011: NASA P3-B profiles of trace gases and aerosols over Maryland Dept. Environment sites

Supplementary Millersville University measurements ~1km from NATIVE (sodar, tethered balloon trace gases)

Methodology

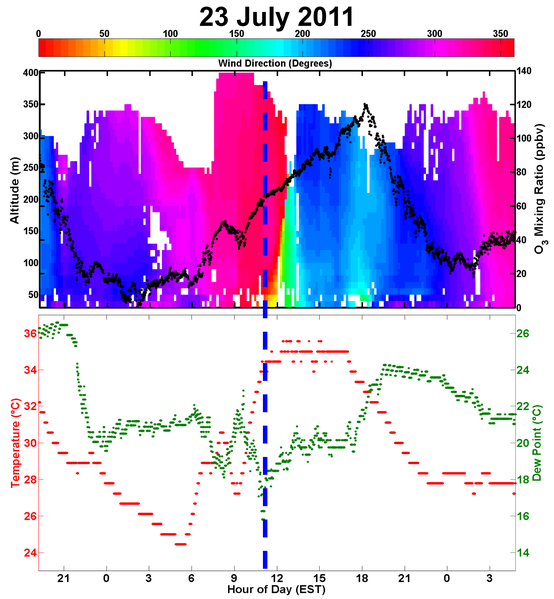

Fig. 4: Example of bay breeze impact on ozone (black), wind direction, temperature (red), and dew point (green) on 23 July, 2011. Bay breeze front passage occurred at approximately 11:30 EST as marked by the dotted line.

Bay Breeze Criteria:

1) Wind direction change from calm or offshore (~300°-30°) to onshore (~150°-240°) during daylight hours

2) Increase in dew point temperature

3) No synoptic or mesoscale frontal passage as analyzed by Hydrometeorological Prediction Center

Days that exhibited a bay breeze front, but were then interrupted by rain, outflow boundary etc., are included in neither bay breeze nor non-bay breeze days, and termed "interrupted days"

Results

- 5 of 31 days (top) met all bay breeze criteria. 4 of those days exceeded the EPA 8 hour average ozone standard of 75 ppbv
- 4 of 31 days (omitted from figures) exhibited bay breeze front passage, but were then inhibited by rain or gust fronts
- Only 2 of 10 July 2011 exceedances at Edgewood, MD occurred on days without bay breeze frontal passage
- Late day advection of high surface ozone mixing ratios leads to exceedances. Bay breeze ozone maximum occurs an average of 3 hours later than non-breeze days
- Aerosol Lidar (bottom) shows quick boundary layer growth during morning of bay breeze days, slow gradual growth during non-bay breeze days

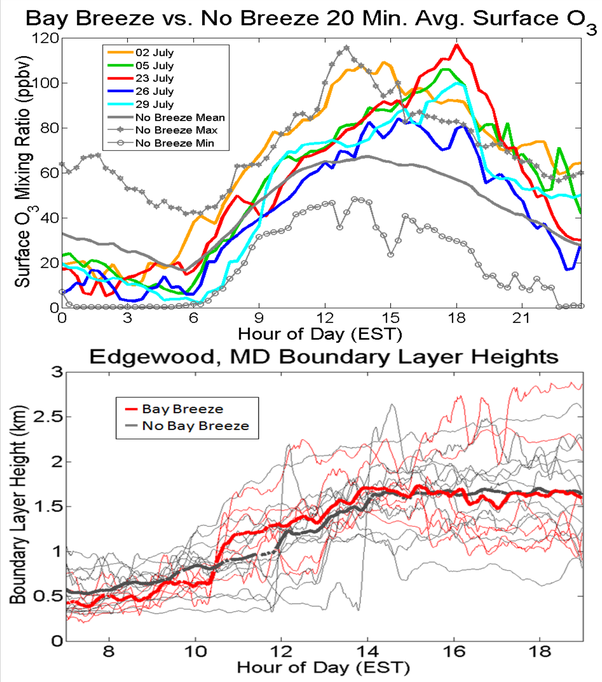

Fig. 5: (Top) Bay breeze (colors) vs. min, average and max ozone for non bay breeze days (grey lines) and (Bottom) boundary layer height for bay breeze (red) and non bay breeze (grey) days with averages in bold colors.

Future Work

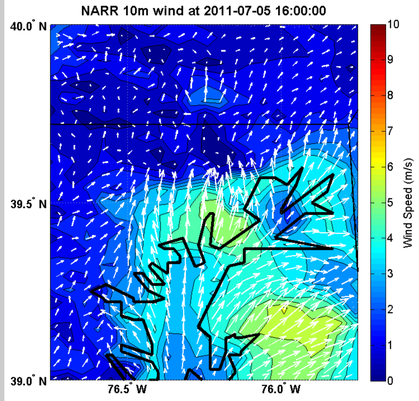

Fig. 6: 4km resolution WRF initialized with NARR data 10m wind vectors (arrows) and speed (color contours) for 11 EST on 05 July, a bay breeze day.

- (Top) Use hi-res WRF runs to visualize bay breeze and transport of pollutants
- Consistent morning transport to over bay waters, followed by bay breeze initiation?
- (Bottom) Does total column ozone behave differently on bay breeze days?

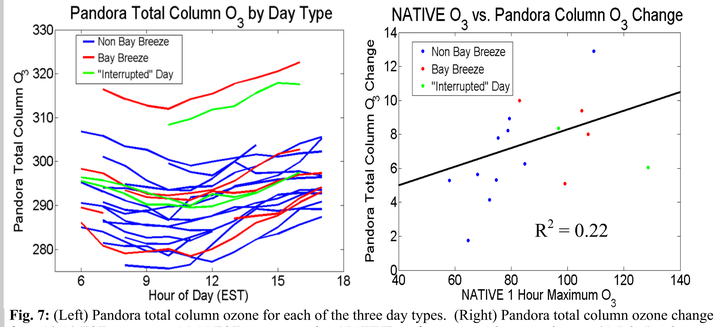

Fig. 7: (Left) Pandora total column ozone for each of the three day types. (Right) Pandora total column ozone change from 10-12 EST average to 15-17 EST average against NATIVE surface ozone 1 hour maximum. 01 July Pandora data are excluded from both plots.

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