Maryland
Department of the Environment

ENHANCED MONITORING PLANS – A MARYLAND PERSPECTIVE

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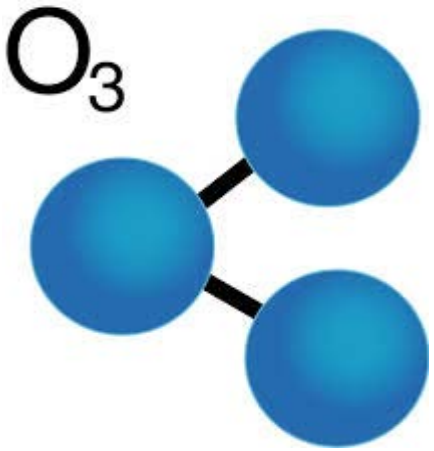
NATIONAL AMBIENT AIR MONITORING CONFERENCE
ST. LOUIS, MO
AUGUST 10, 2016

Topics Covered

- What constitutes enhanced monitoring?
- Why would you want to do it?
- Maryland's ozone challenges.
- Examples of Maryland's enhanced monitoring.
- Costs.
- Enhanced Monitoring Plans (EMP) preparation, submittal and approval process.



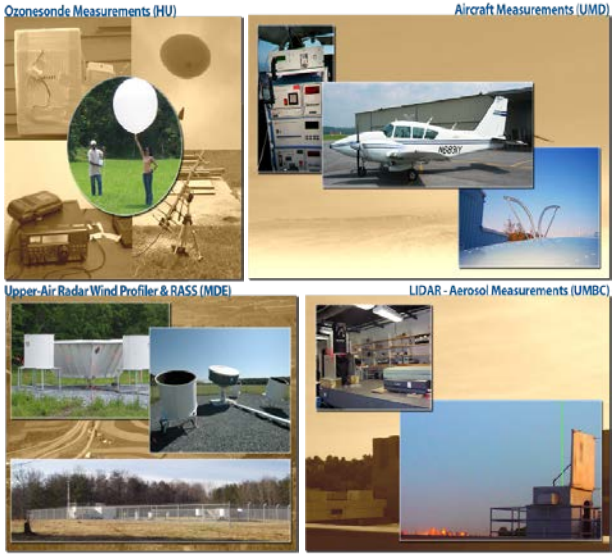
What Is Enhanced Monitoring?

From 40CFR Part 58,

Appendix D, 5.(h)

- Additional ozone monitors beyond the minimum requirements.
- Additional NOx or NOy monitors above minimum requirements.
- Additional VOC measurements beyond minimum requirements.
- Upper air measurements

  of meteorology or air pollution concentrations.

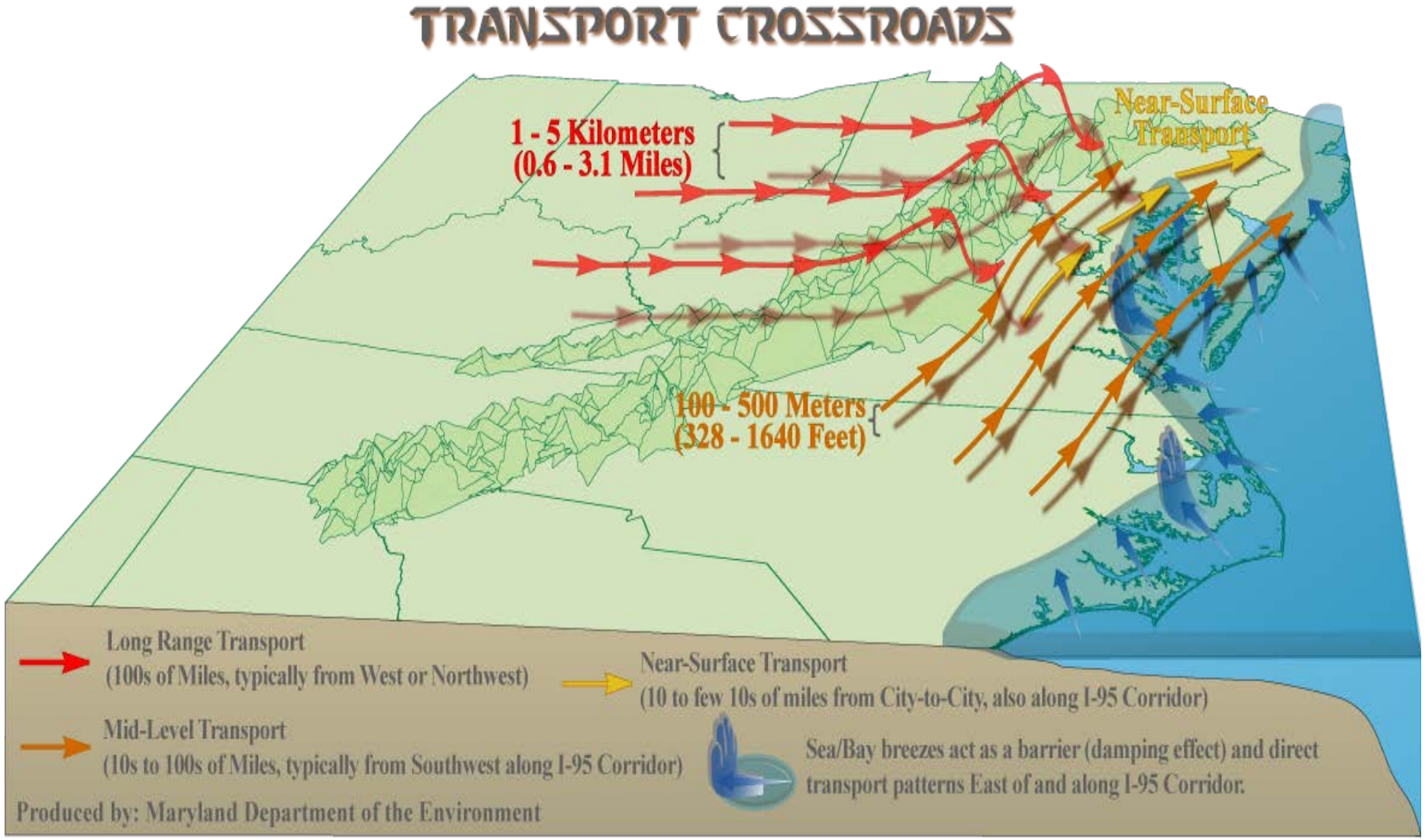


Why Would You Want To Do It?

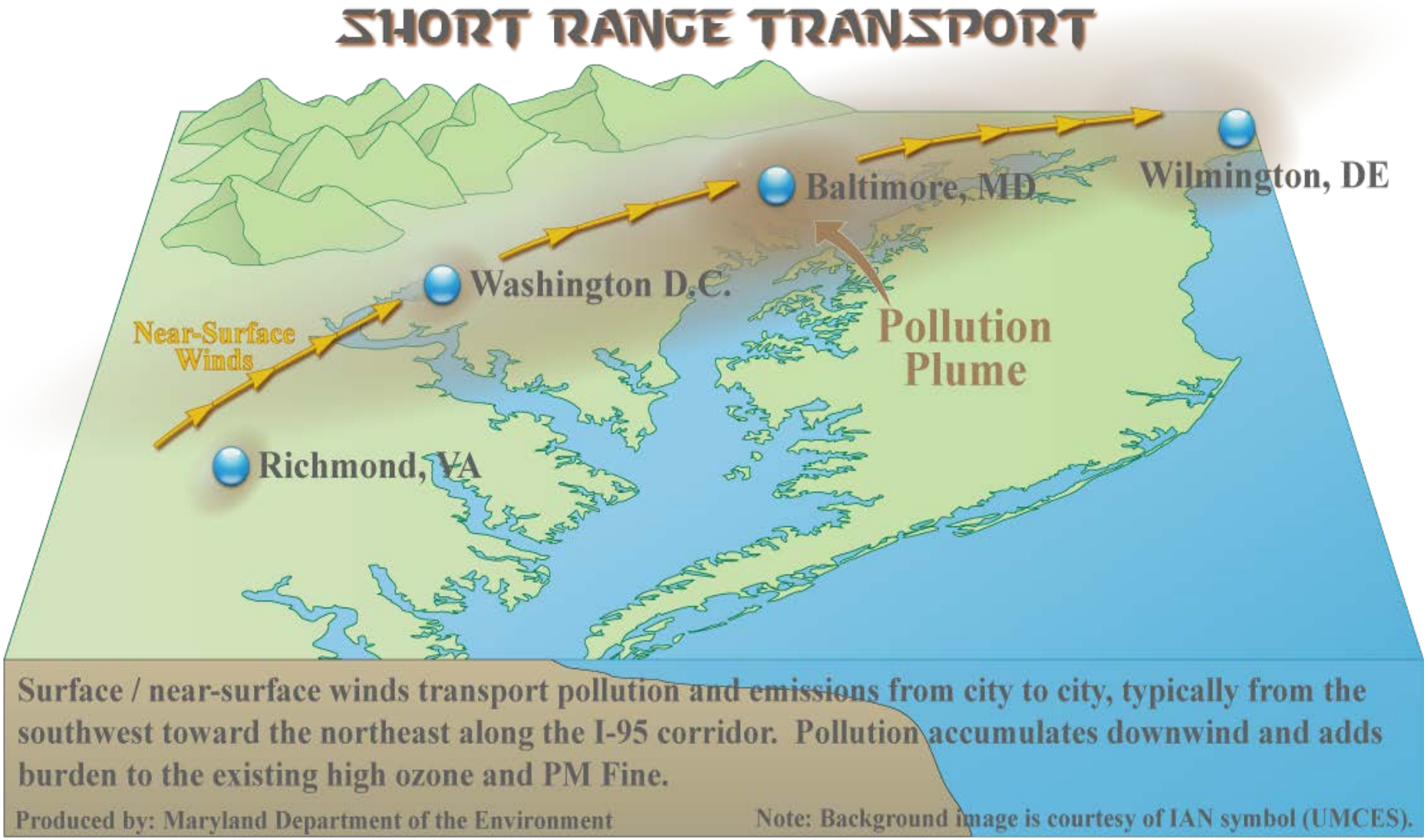
- Surface based monitoring alone cannot determine the nature and origin of your particular ozone problem.
- To produce policy relevant science that will aid in the development and tracking of effective control strategies.
- Evaluate model performance (CMAQ & CAMx), identify weaknesses or areas needing improvements.
- Assist in ozone forecasting.
- EPA requires you to.

MARYLAND'S OZONE CHALLENGES

Maryland's Ozone Challenges

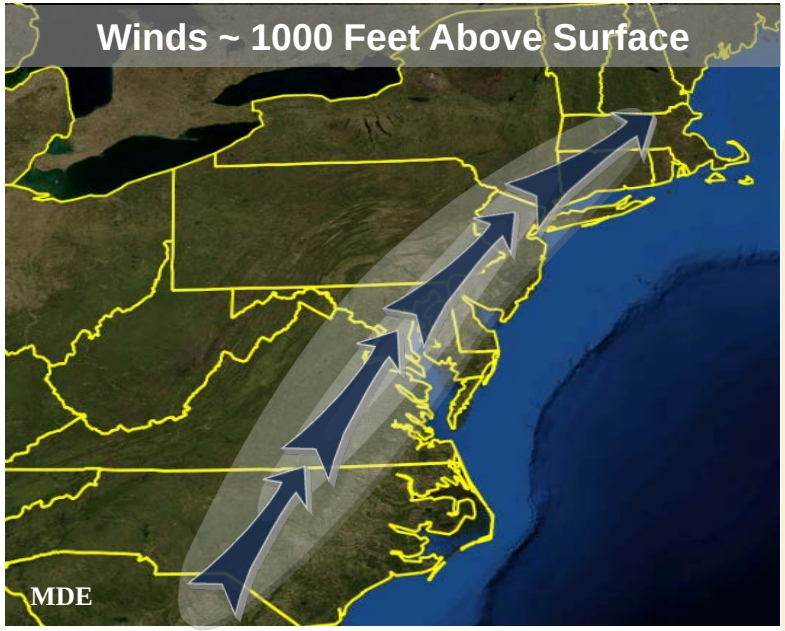


Maryland's Ozone Challenges



Maryland's Ozone Challenges

The Nocturnal Low Level Jet (NLLJ)



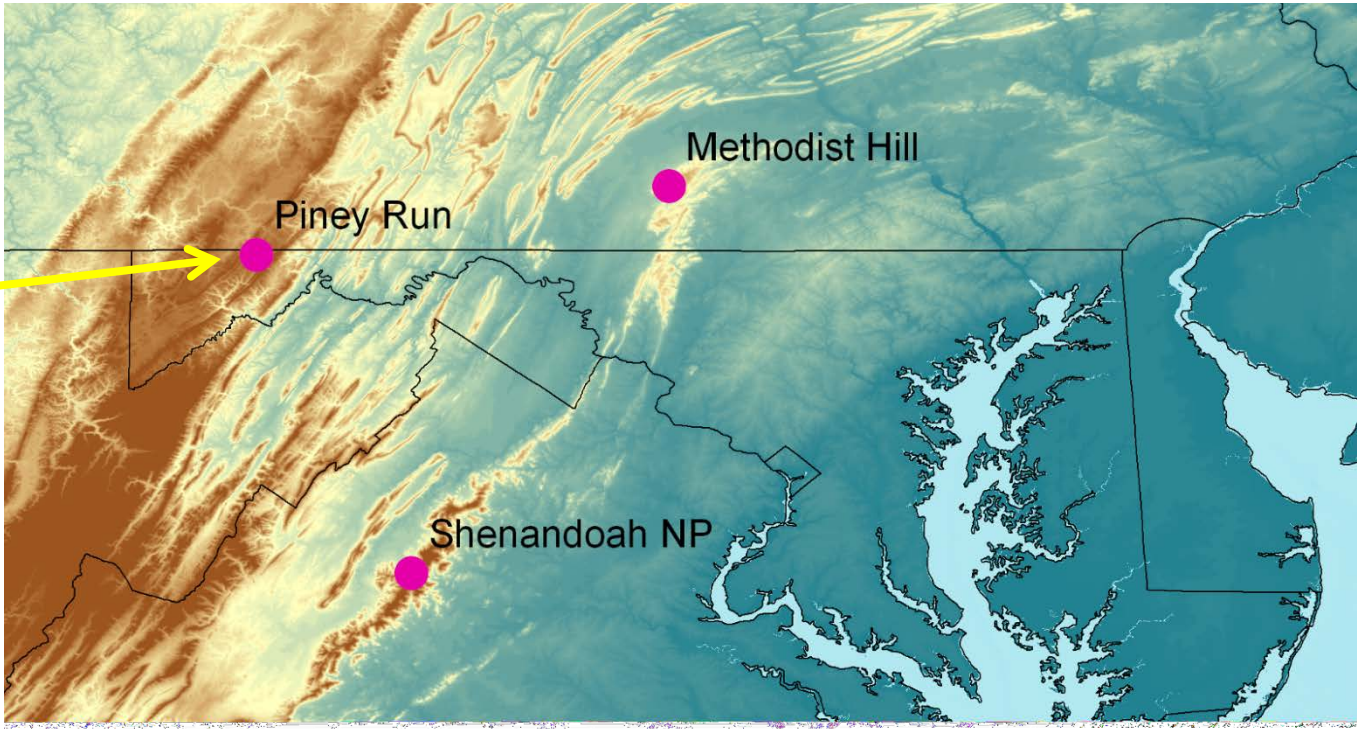
- Fast-moving, narrow "river" of air typically around 1000 feet above the surface
- In the Mid-Atlantic, typically observed during the night between Appalachians and the Atlantic Ocean.
  - Wind speeds can reach 40 mph or more.
  - Stretches from NC to MD to NJ and further up the east coast.
- Seen during most, Mid-Atlantic summer-time air pollution events.
  - Some form of NLLJ on many Code Orange or Red days
- Past findings indicate:
  - Presence of a NLLJ increased Baltimore maximum ozone by 7 ppb.
  - Ozone concentrations of 90 – 100 ppb have been measured in the NLLJ.

Maryland's Enhanced Monitoring Examples

Approaches Utilized

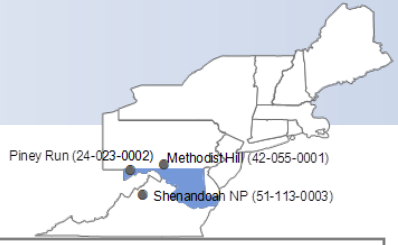
- Continuous
  - Mountaintop monitoring
  - Radar Wind Profilers (RWPs)
- Seasonal/Episodic
  - Ozonesondes
  - LIDAR- Aerosol & Ozone
  - Aircraft
  - Portable Ozone Monitor (POM) for Land/Water Interface
- Short-term Intensive Studies
  - Once in a blue moon

Mountaintop Monitoring



- 3 monitors along Appalachian mountain range can sometimes capture nighttime pollution above the surface.
  - Shenandoah: 1073 m (3,520 ft)
  - Piney Run : 776 m (2,546 ft)
  - Methodist Hill: 676 m (2,218 ft)

Mountaintop Monitoring



Aloft Ozone Reservoir (August 13, 2005)

❶ Elevated Reservoir Before Inversion Break

❷ Inversion Breaks The Regional Signal

❸ Local and Regional Pollution Combined

Piney Run, MD (Elevated)
Methodist Hill, PA (Elevated)
Shenandoah NP, VA (Elevated)
Line: Average Profile of **Maryland** Monitors (Near Sea-Level)
Shaded: Variations of Near Sea-Level Monitors

Hourly Ozone Concentration (ppb)

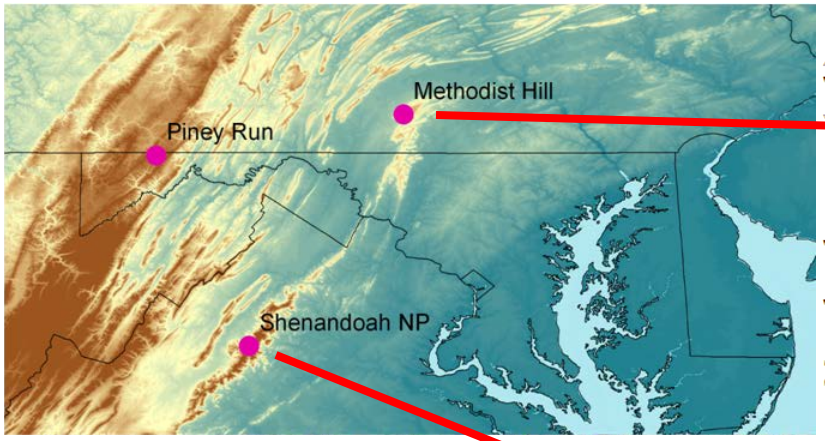
0 20 40 60 80 100 120

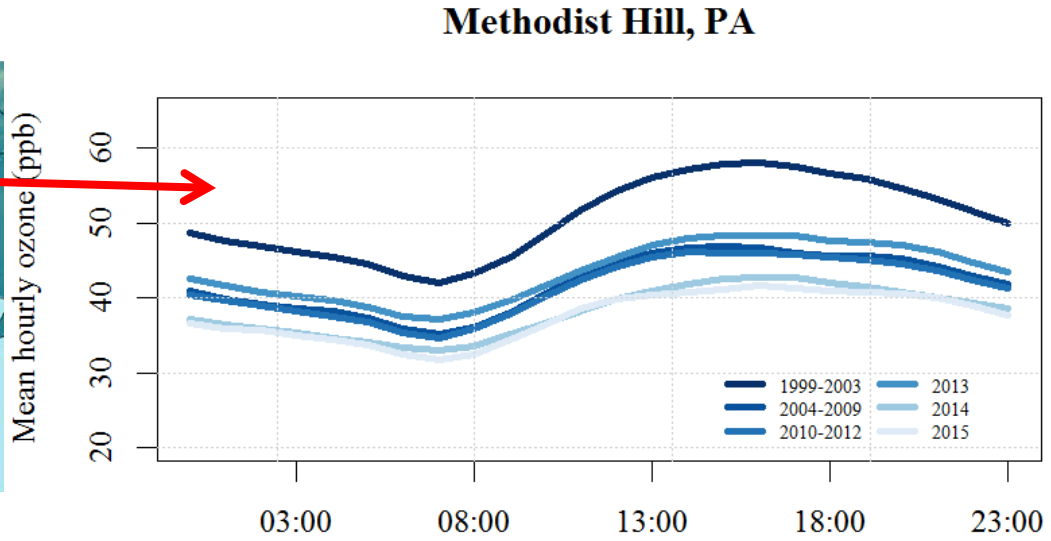
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23

Time (EST)

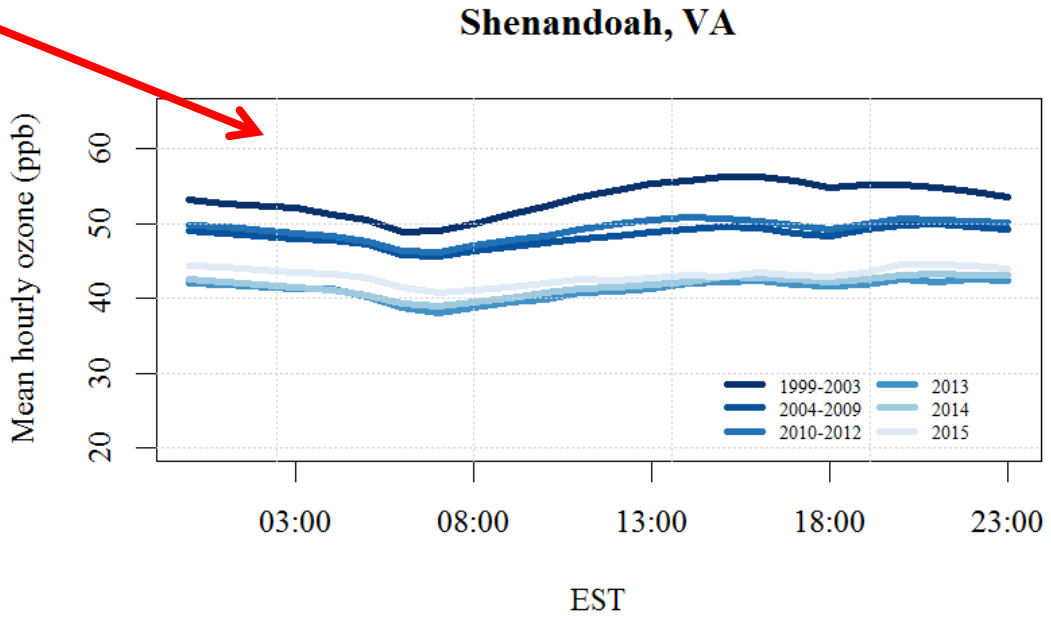
Source: Maryland Department of the Environment

Progress at Mountaintop Monitors

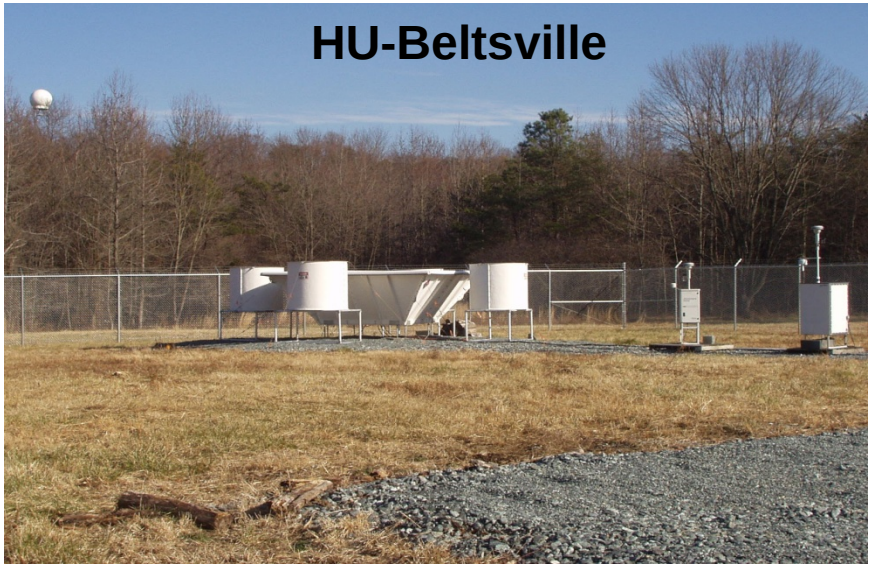


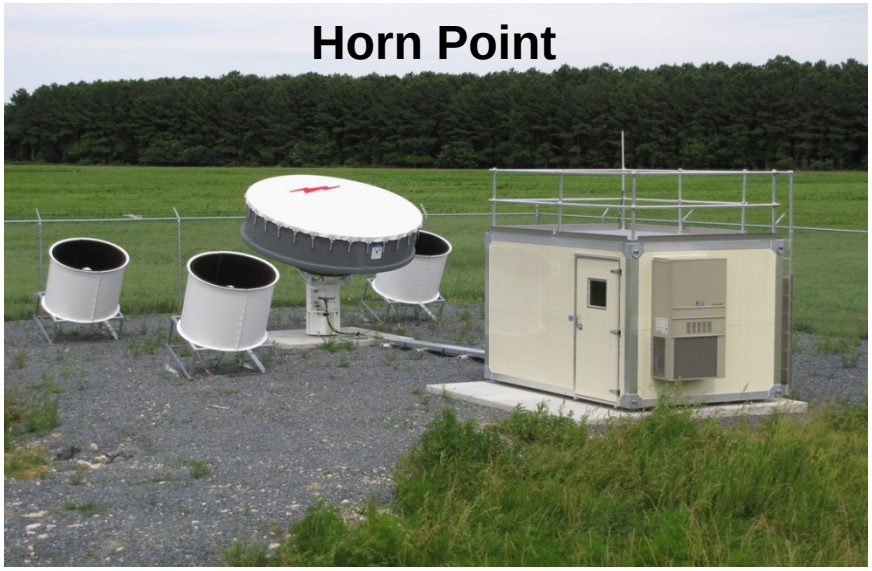


- Pre and post NOx SIP call benefits at Shenandoah and Methodist Hill.
- Diurnal profiles made using May – September hourly ozone data.



Upper-Air Radar Wind Profilers

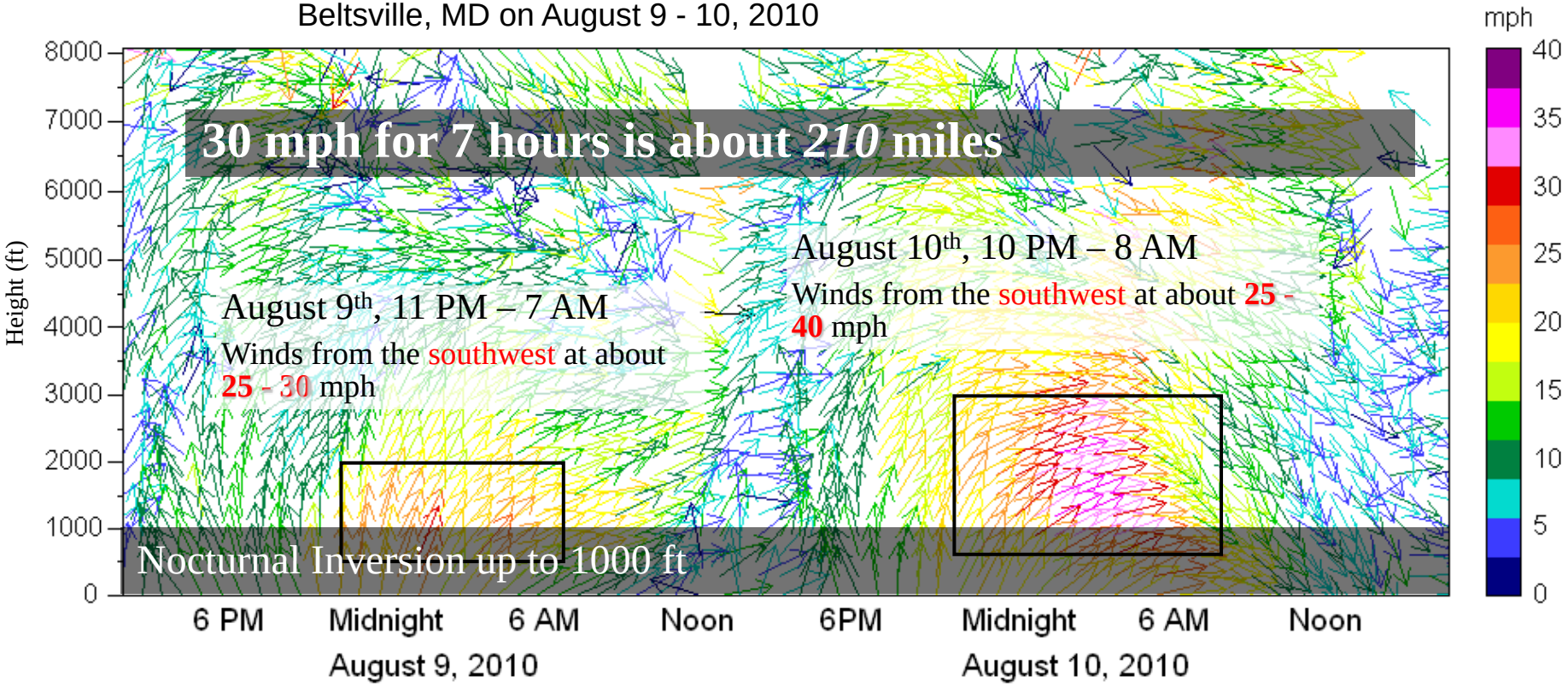




RWP's-Measuring the NLLJ

Wind Speed and Wind Direction

Beltsville, MD on August 9 - 10, 2010

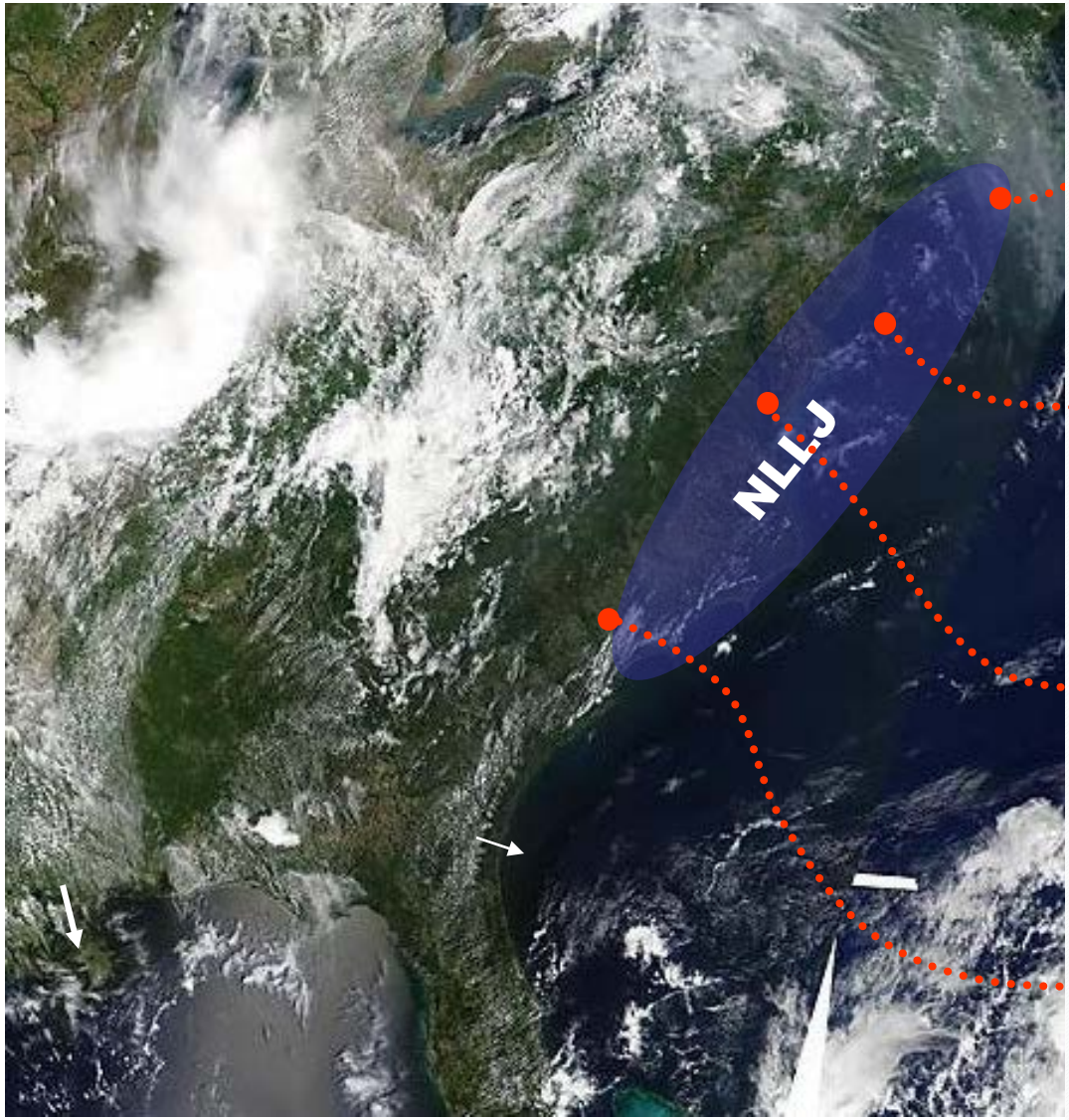


What does this graph tell us?

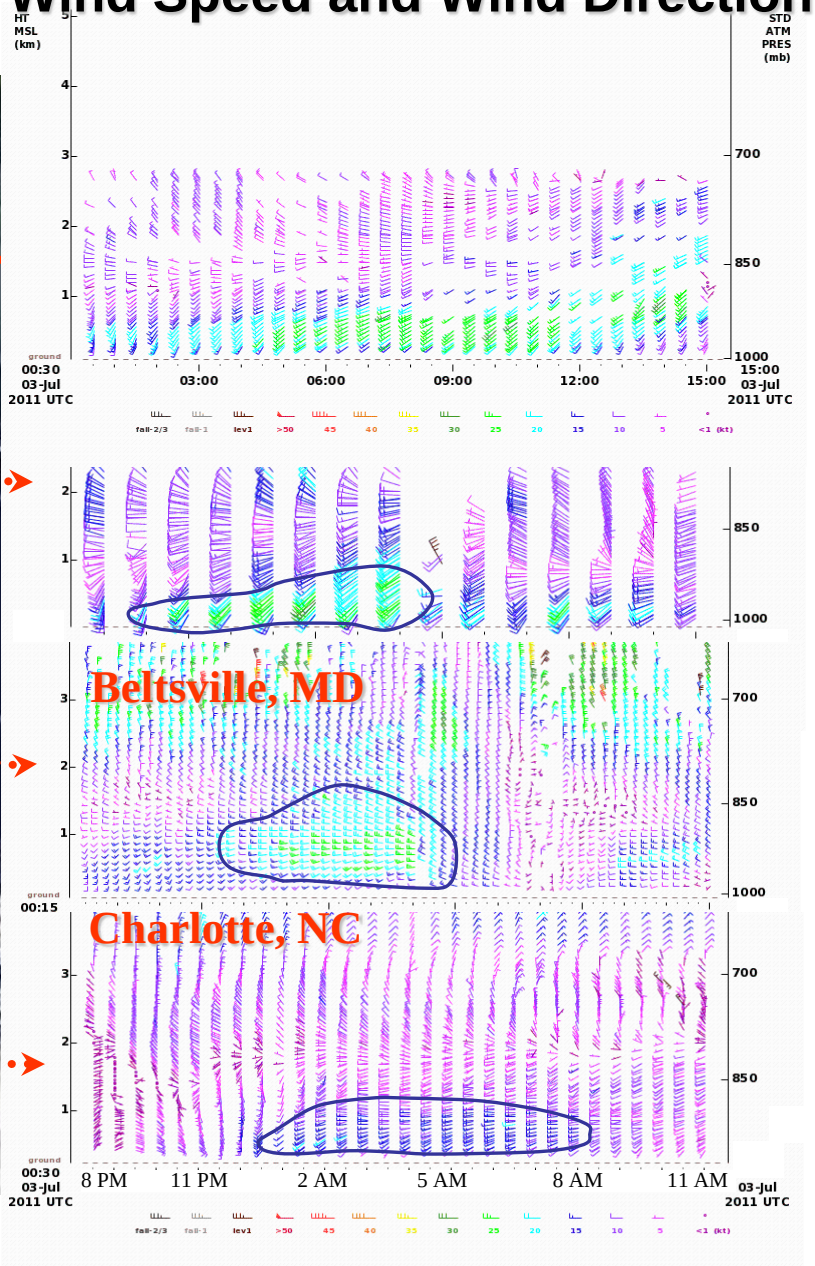
- **Wind direction**
- **Wind speed**
- **From the ground up**

RWP's-How Big is the NLLJ?

May 26 & 27, 2016



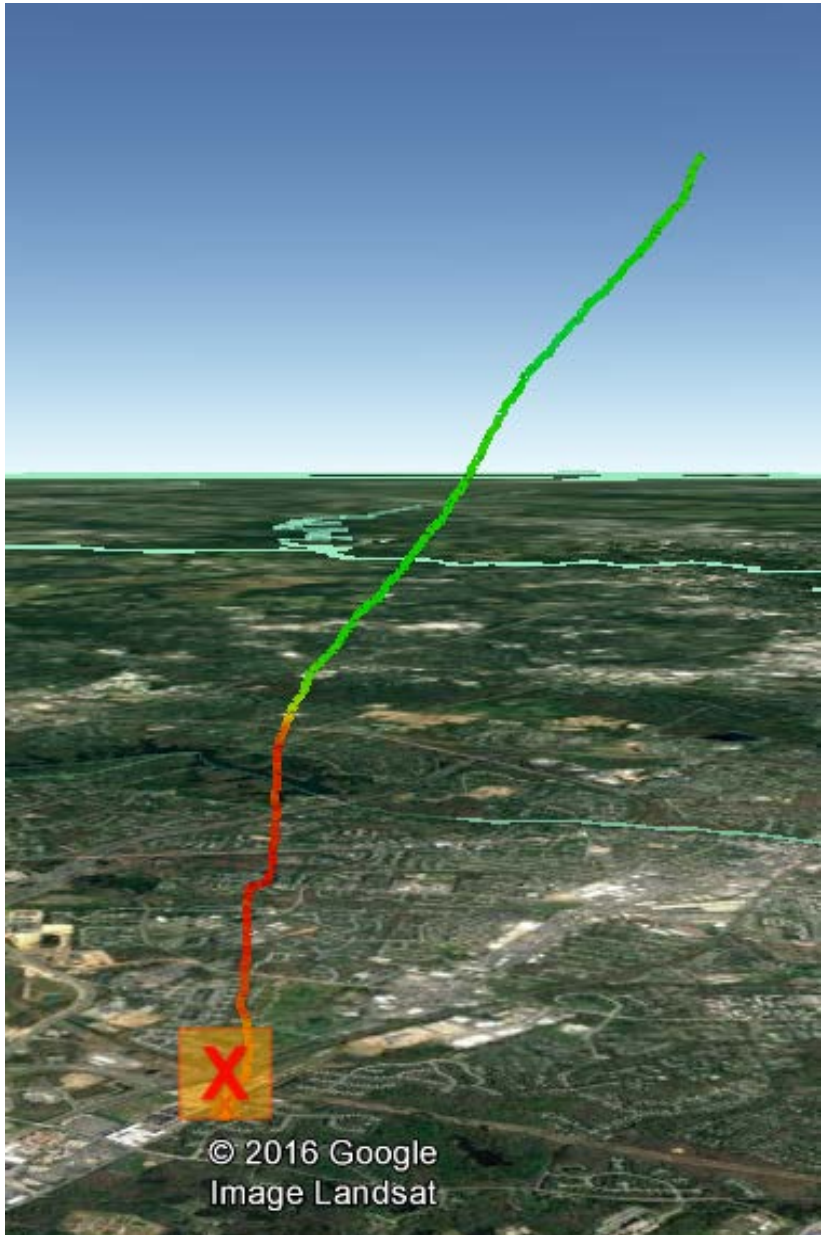
Wind Speed and Wind Direction



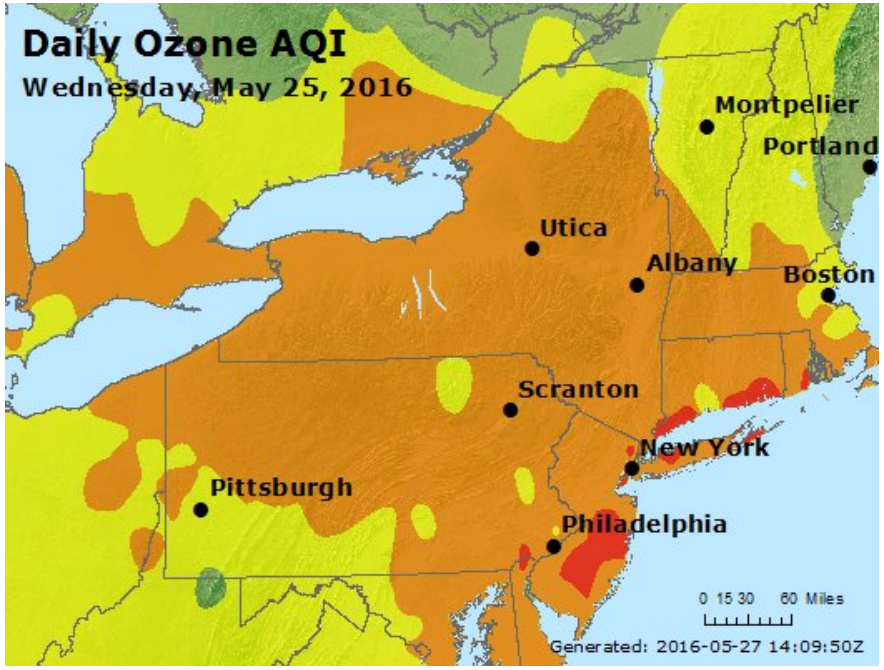
Sources: NASA, NOAA MADIS

OZONESONDES

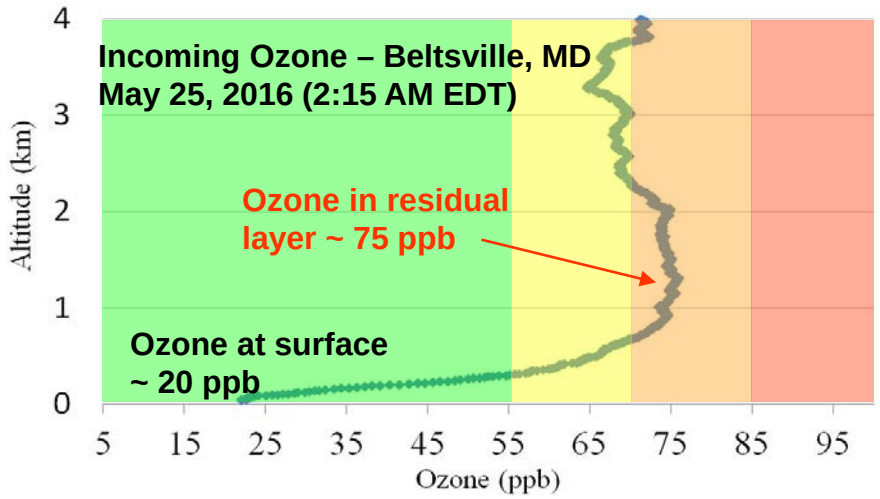
O_3
RH
Temp
WS
WD

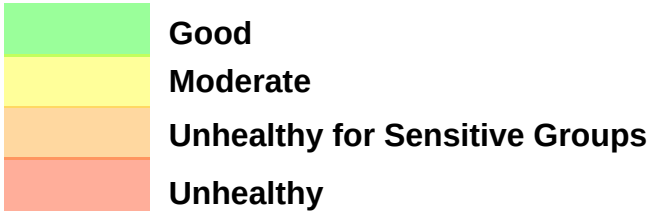


Ozonesondes and the Elevated Reservoir



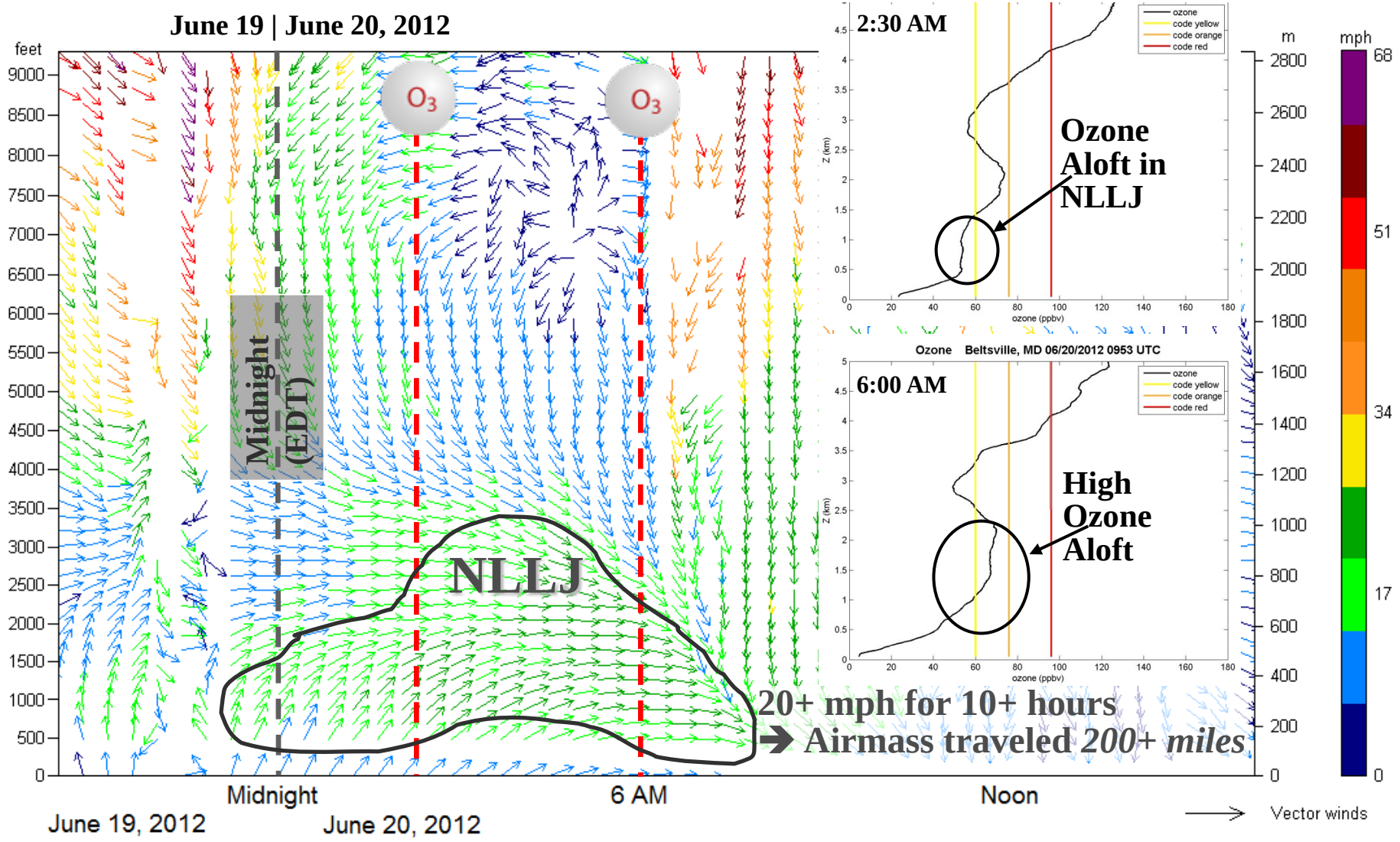
- On many bad ozone days, in the morning hours, a large reservoir of ozone sits above Maryland and the Mid-Atlantic area waiting to mix down.
  - Ozone levels in the reservoir can routinely reach 60 - 100 ppb.
  - In the morning, ozone levels at the surface are very low.
- Around 10 or 11 AM, the ozone in the reservoir mixes down to the surface and degrades air quality.



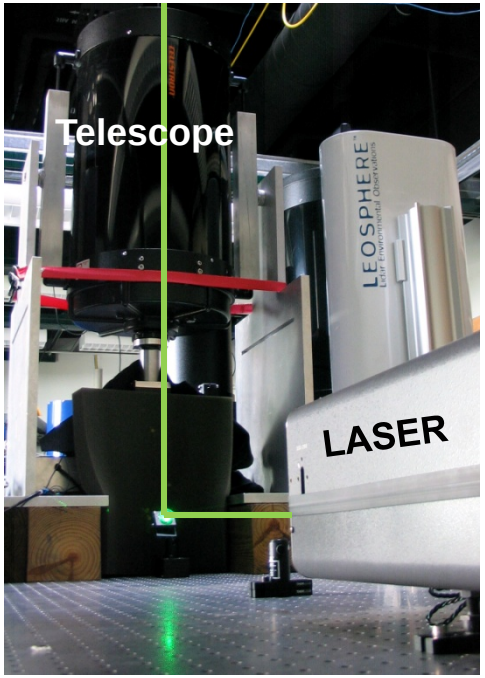


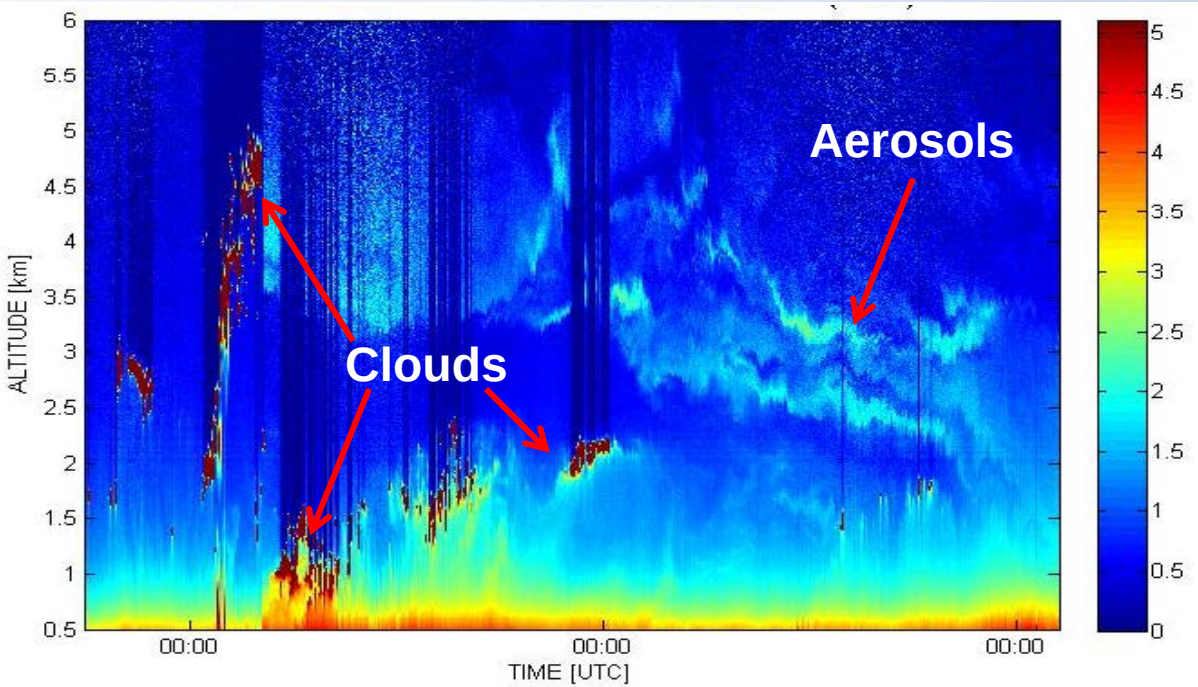
Measuring Ozone Transport in the NLLJ

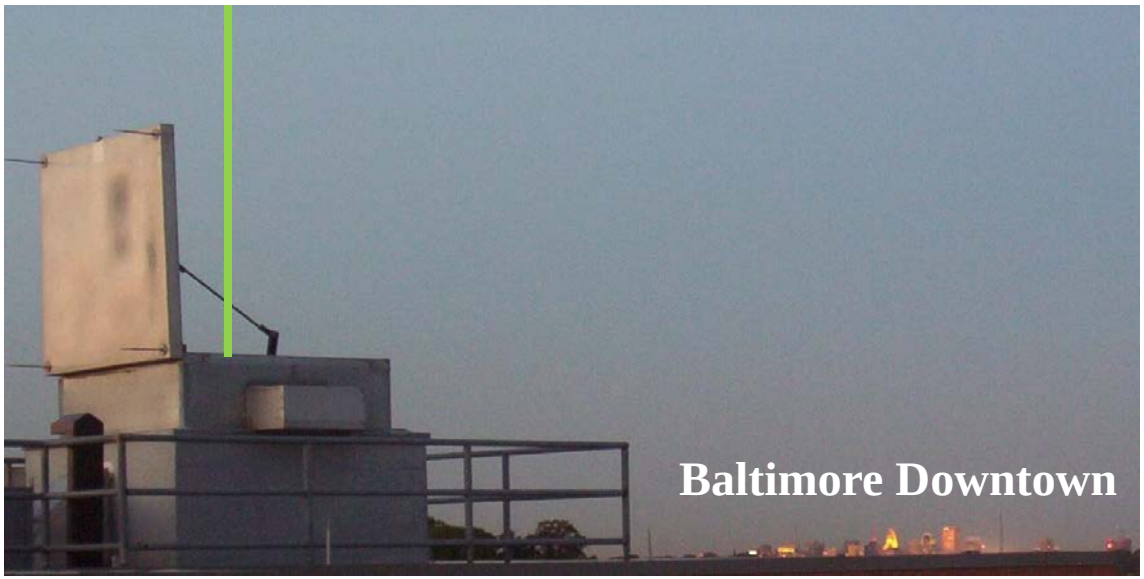
Howard University launched 2 morning ozonesondes on June 19 - 20, 2012 to measure ozone within the **Nocturnal Low Level Jet** (NLLJ), as captured by MDE's upper-air radar wind profiler.

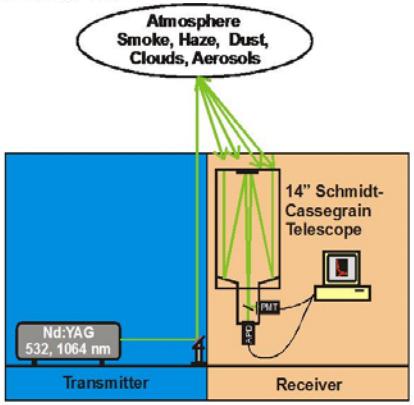


AEROSOL LIDAR









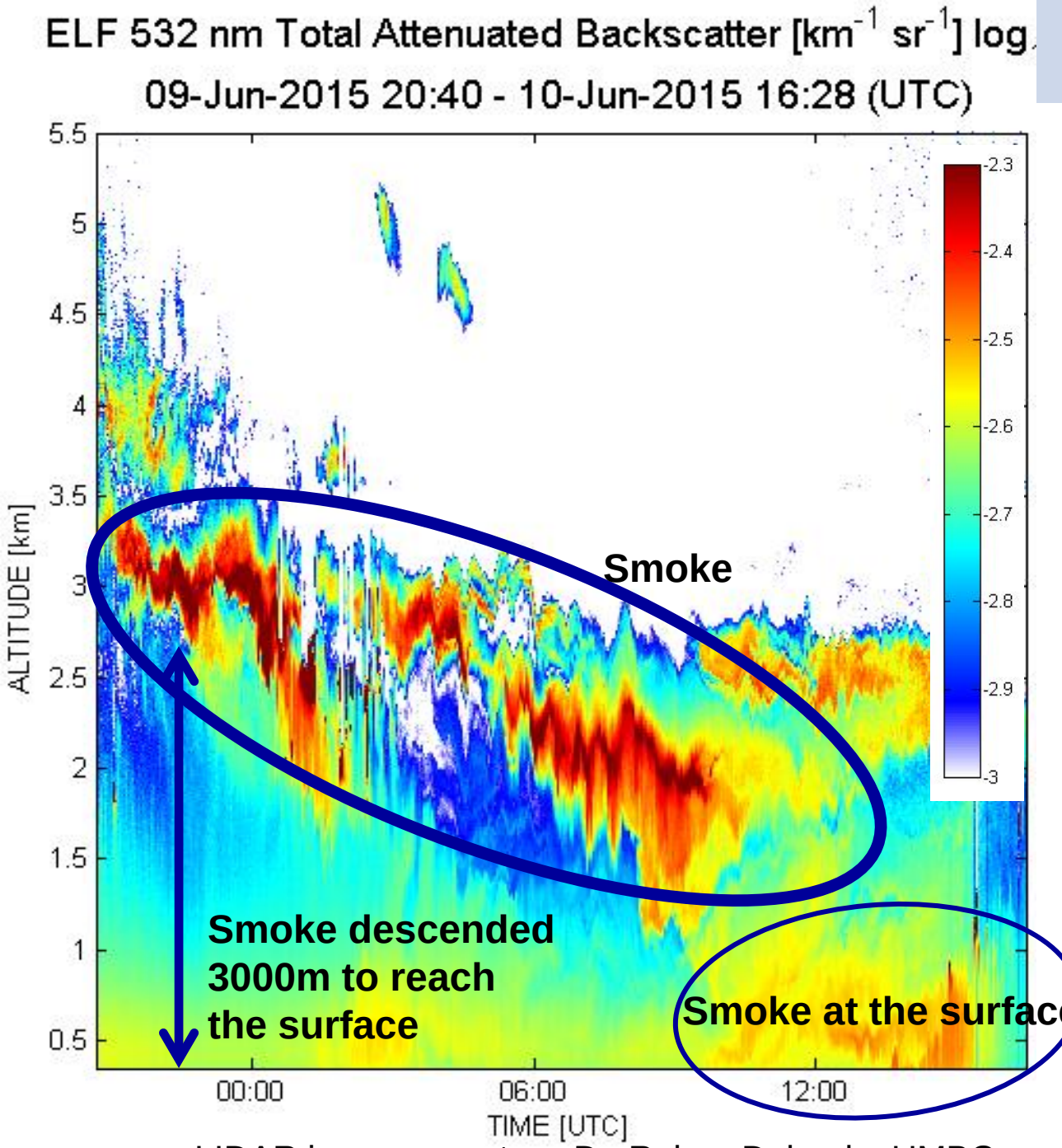
UMBC Elastic Lidar Facility

UMBC LIDAR

•Smoke descended from 3km in height to the surface, as evident by higher fine particle counts and lidar observations, by **<u>June 10, 2015</u>**

•Smoke plume initially heaviest around and south of DC metro (red sunsets publicized)

•Surface winds on Thursday, June 11, 2015, blew DC polluted air back along I-95



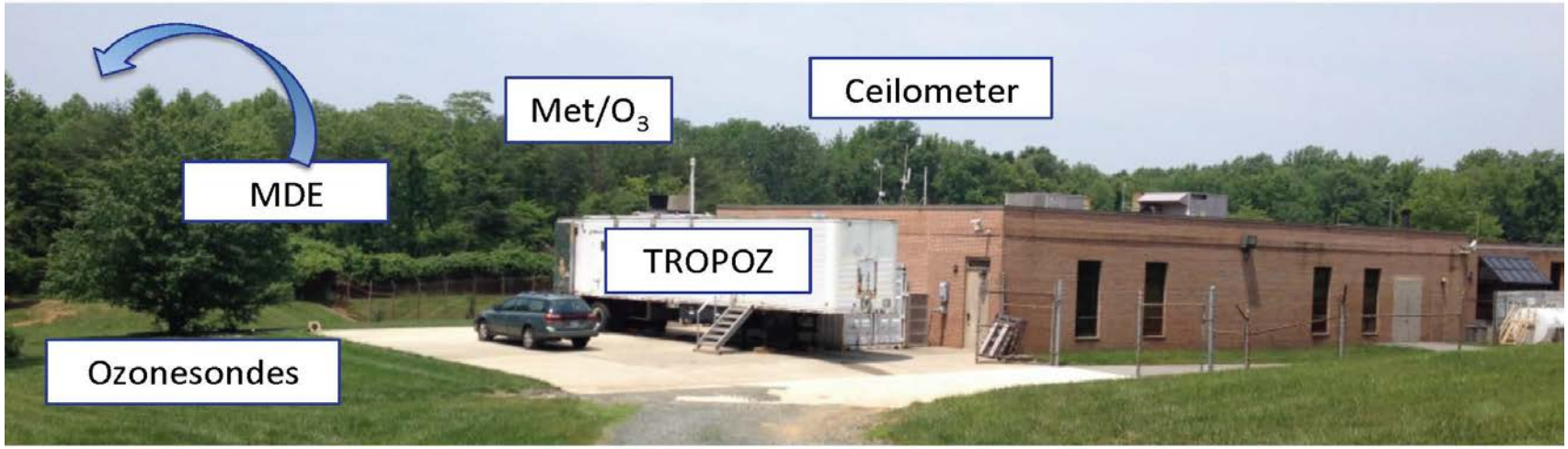
LIDAR images courtesy Dr. Ruben Delgado, UMBC

TROPOSPHERIC OZONE LIDAR

Deployment to Beltsville

NASA POSTDOCTORAL PROGRAM
Administered by Oak Ridge Associated Universities

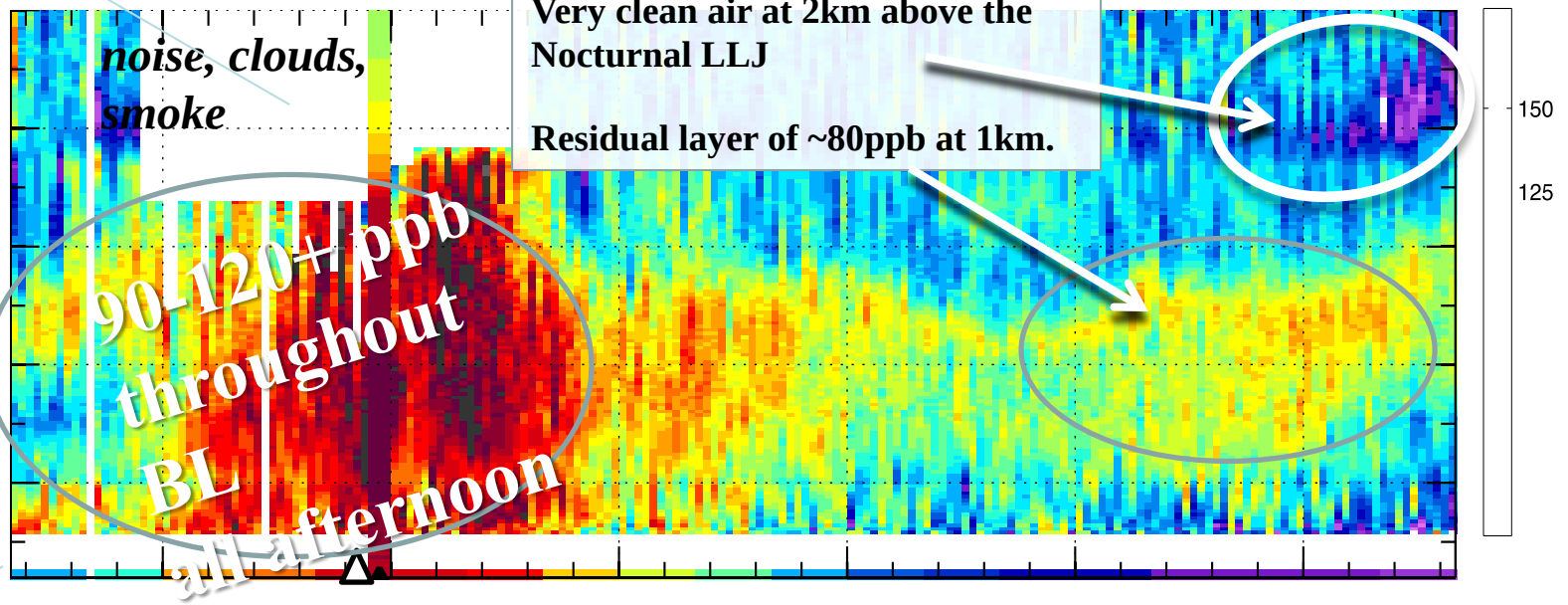
- Deployed to Howard University Beltsville Center for Climate System Observation, a NASA University Research Center



- Deployed from June – October 2015, operated roughly 200 hours in support of MDE AQ forecasts

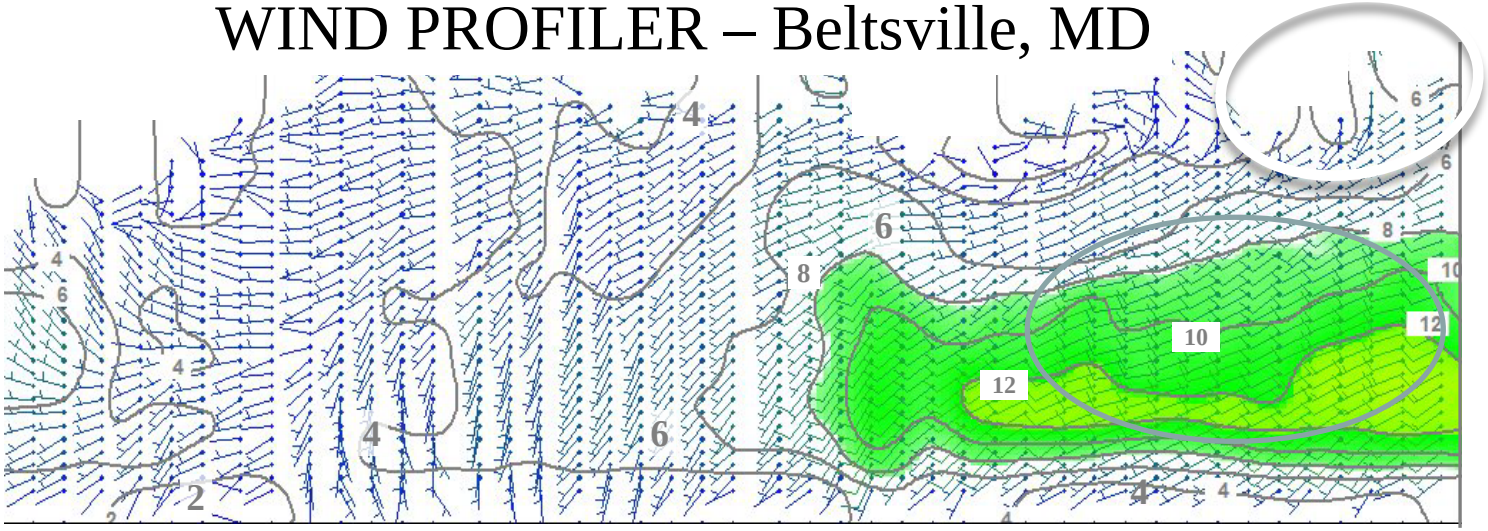
Contact: John Sullivan - NASA GSFC, email: john.t.sullivan@nasa.gov

a



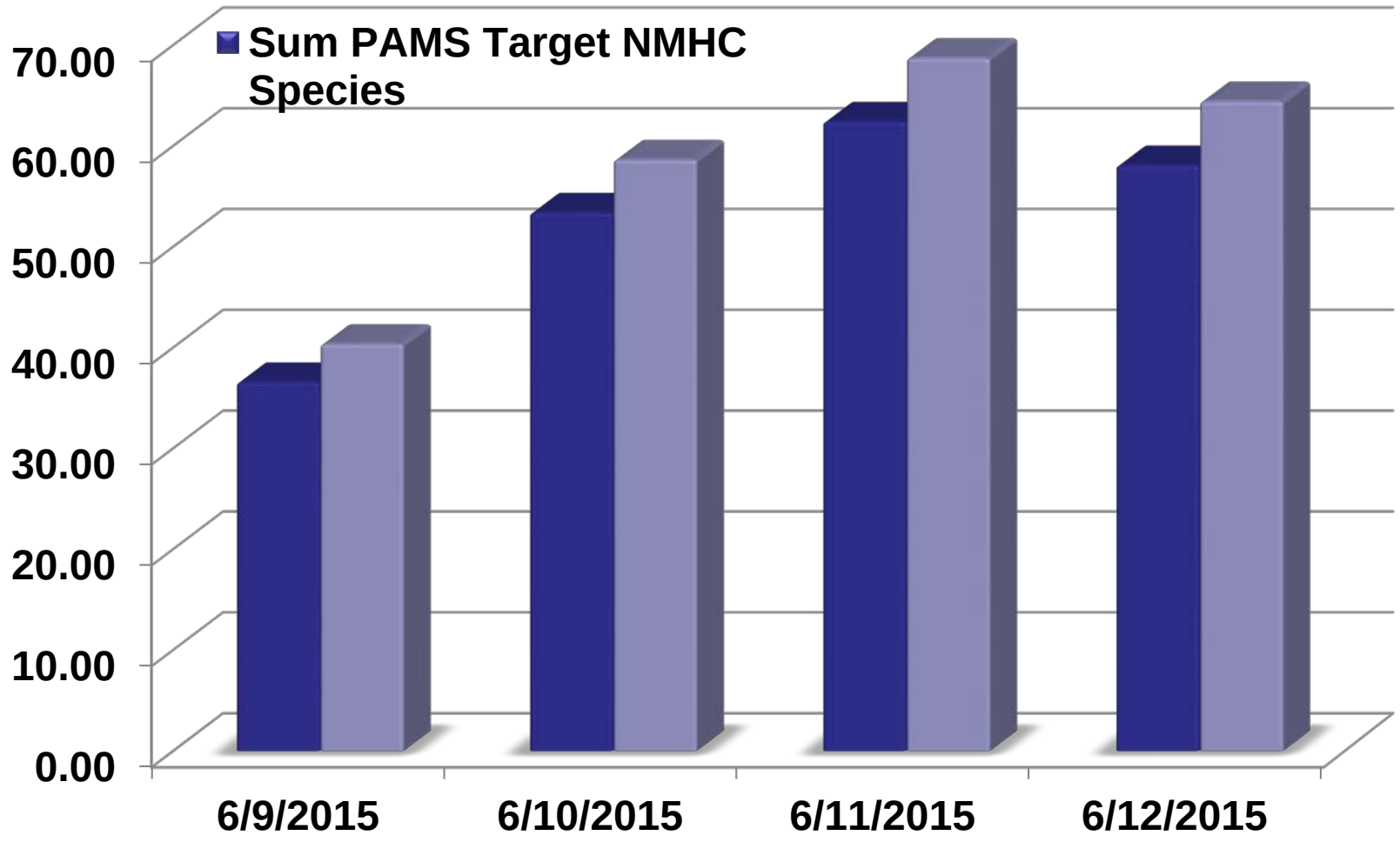
Beltsville surface O3 (bottom)

b

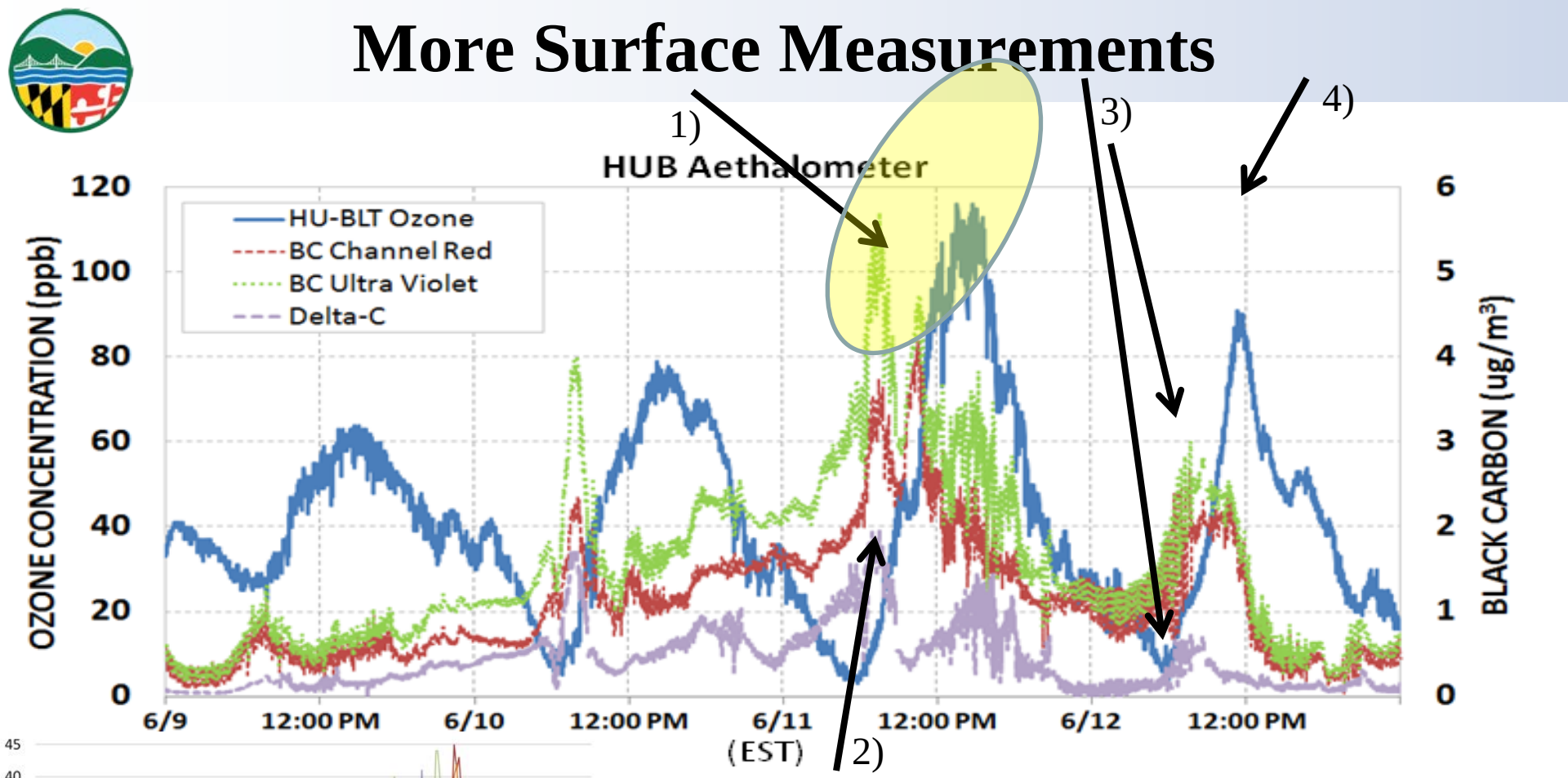


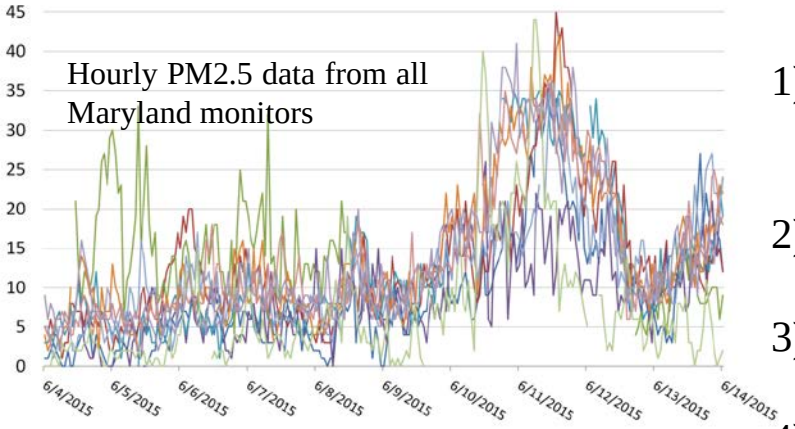
Courtesy of Dr. John Sullivan NASA GFSC

Surface Measurements-VOCs



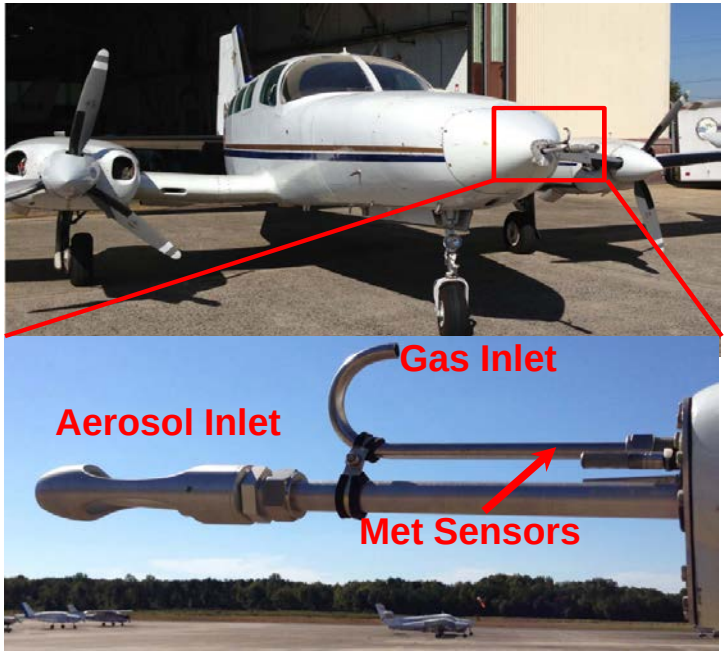
More Surface Measurements





1) Black Carbon reached peak on June 11
   a. Black Carbon is a smoke indicator – highest BC with highest ozone!
2) "Delta-C" is a proxy wood smoke indicator – reached peak on June 11
3) Delta-C goes to zero morning of June 12 but quickly rises after sunrise (same as ozone) – mixing from residual layer??
4) Dramatic drop off in Black Carbon coincident with ozone decrease on June 12, in the middle of a 90°F day!!!

AIRCRAFT



UMD Cessna 402B Research Aircraft

GPS Position (Lat, Long, Altitude, Speed)

Met (T, RH, P, wind speed/direction)

Trace gases:

- O_3: UV Absorption, TECO
- SO_2: Pulsed Fluorescence, modified TECO
- NO_2: Cavity Ring Down, Los Gatos
- $CH_4/CO_2/CO/H_2O$: Cavity Ring Down, Picarro
- K30 CO_2 small sensor
- VOCs: canister samples and GC-FID analysis

Aerosol Optical Properties:

- Scattering: b_{scat} (@450, 550, 700 nm), Nephelometer
- Absorption: b_{ap} (565 nm), PSAP
- Black Carbon: Aethalometer (7-wavelengths)

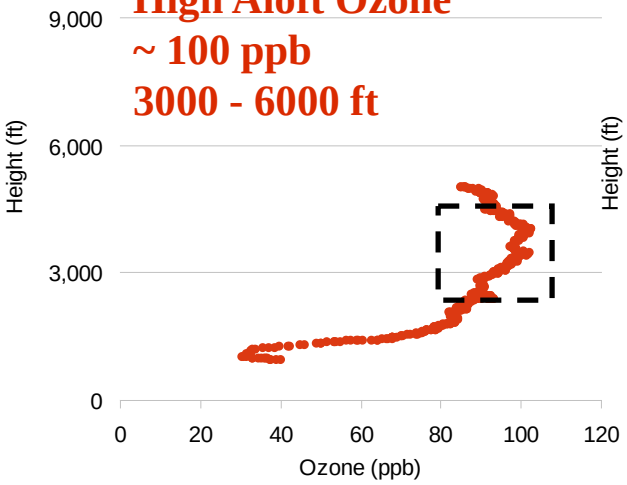
Data Acquisition: 1 sec

Courtesy: Xinrong Ren, UMD

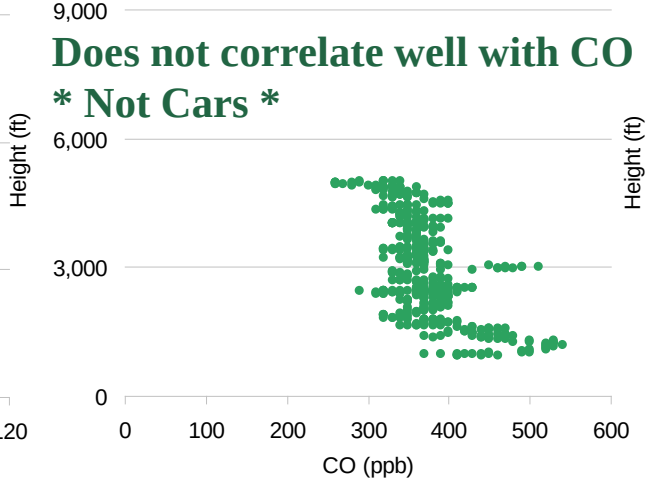
Aircraft Profiles-Westerly Transport Fingerprint

What does the data tell us about its origin?

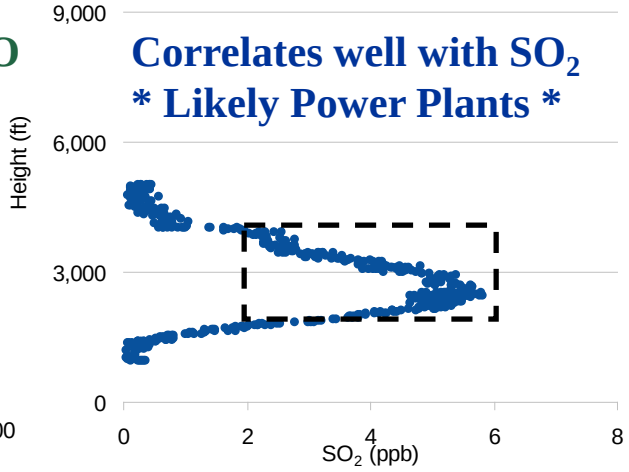
High Aloft Ozone
~ 100 ppb
3000 - 6000 ft



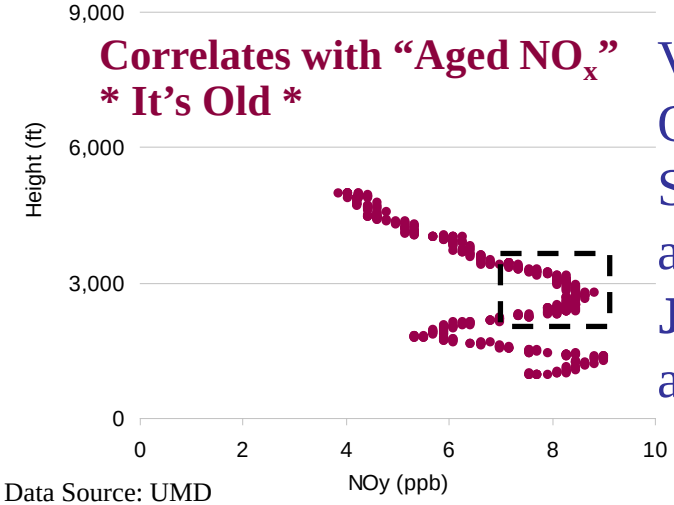
Does not correlate well with CO
*** Not Cars ***



Correlates well with SO_2
*** Likely Power Plants ***



Correlates with "Aged NO_x"
*** It's Old ***

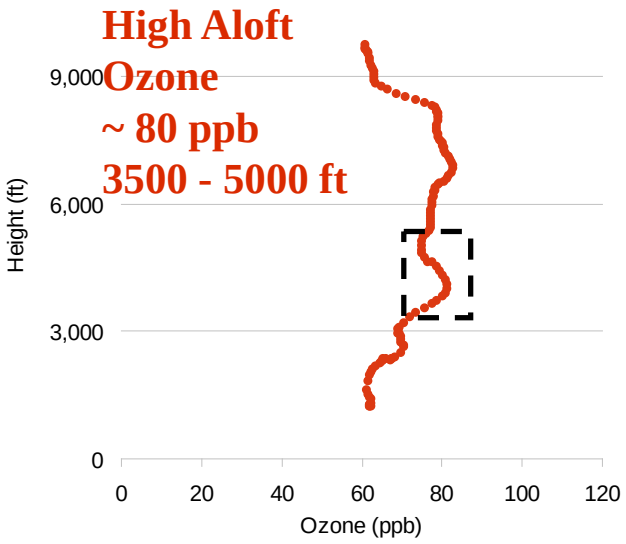


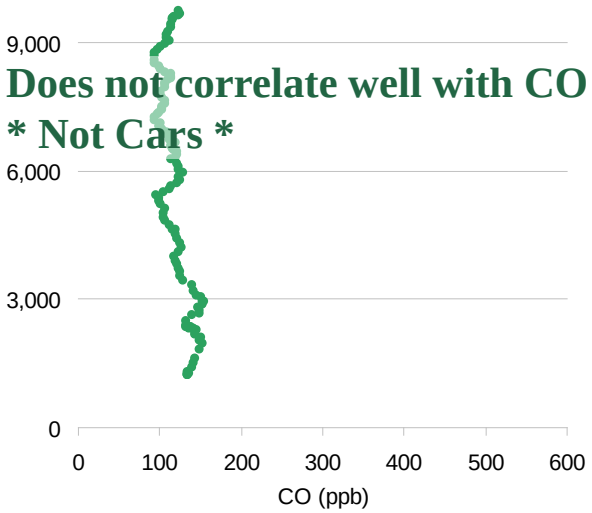
Vertical Profiles of Ozone, CO, SO_2 , and NO_y at Luray, VA **July 15, 1995** at 7 AM

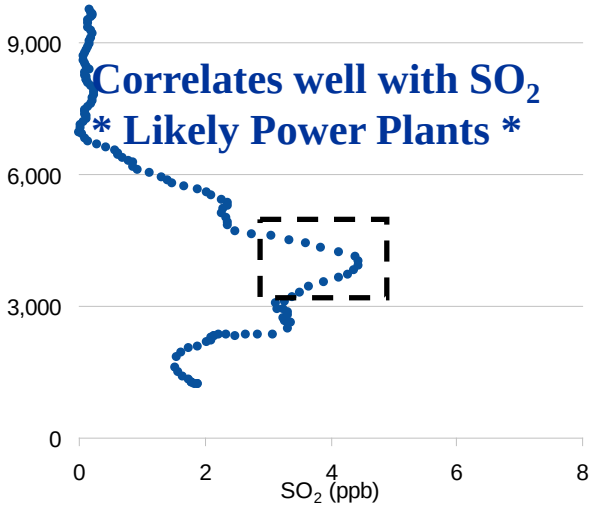
Data Source: UMD

Aircraft Profiles-Westerly Transport Fingerprint

What does the data tell us about its origin?



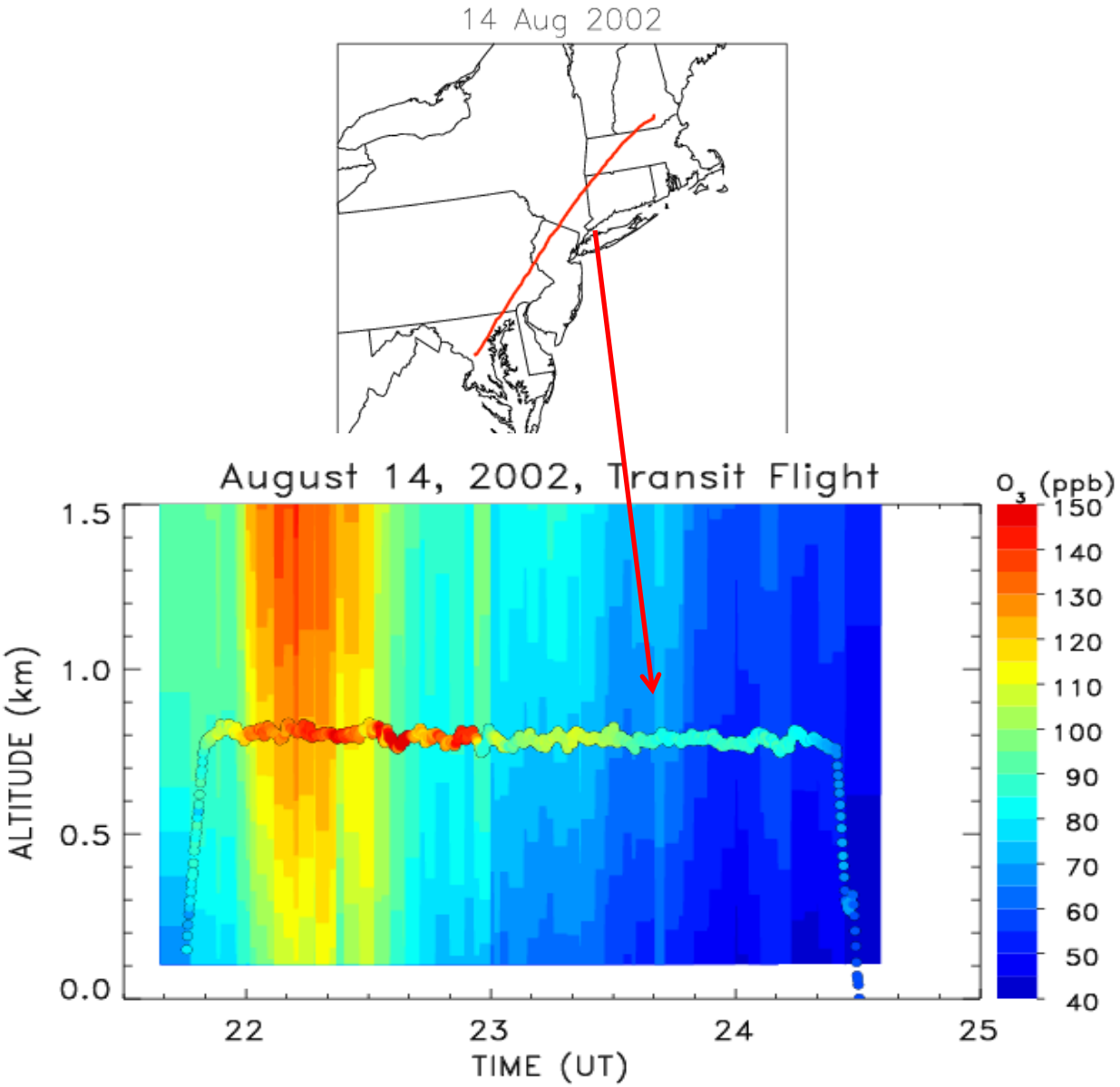




Vertical Profiles of Ozone, CO, and SO_2
at Luray, VA
July 21, 2011 at 11 AM

Data Source: UMD

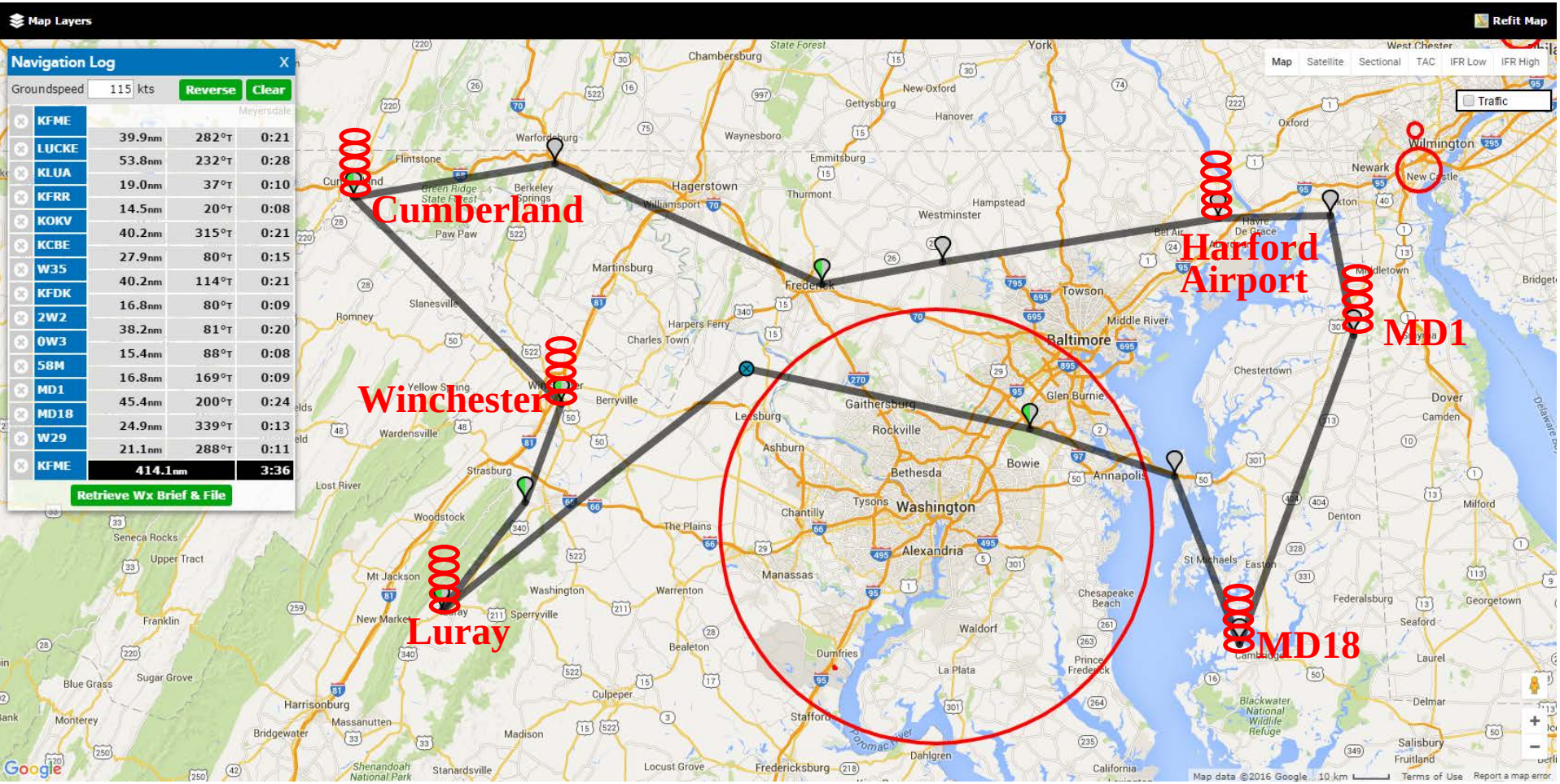
Comparison of Obs & Modeling



Courtesy of University of Maryland College Park – Russ Dickerson

Flight Plan for Summer 2016

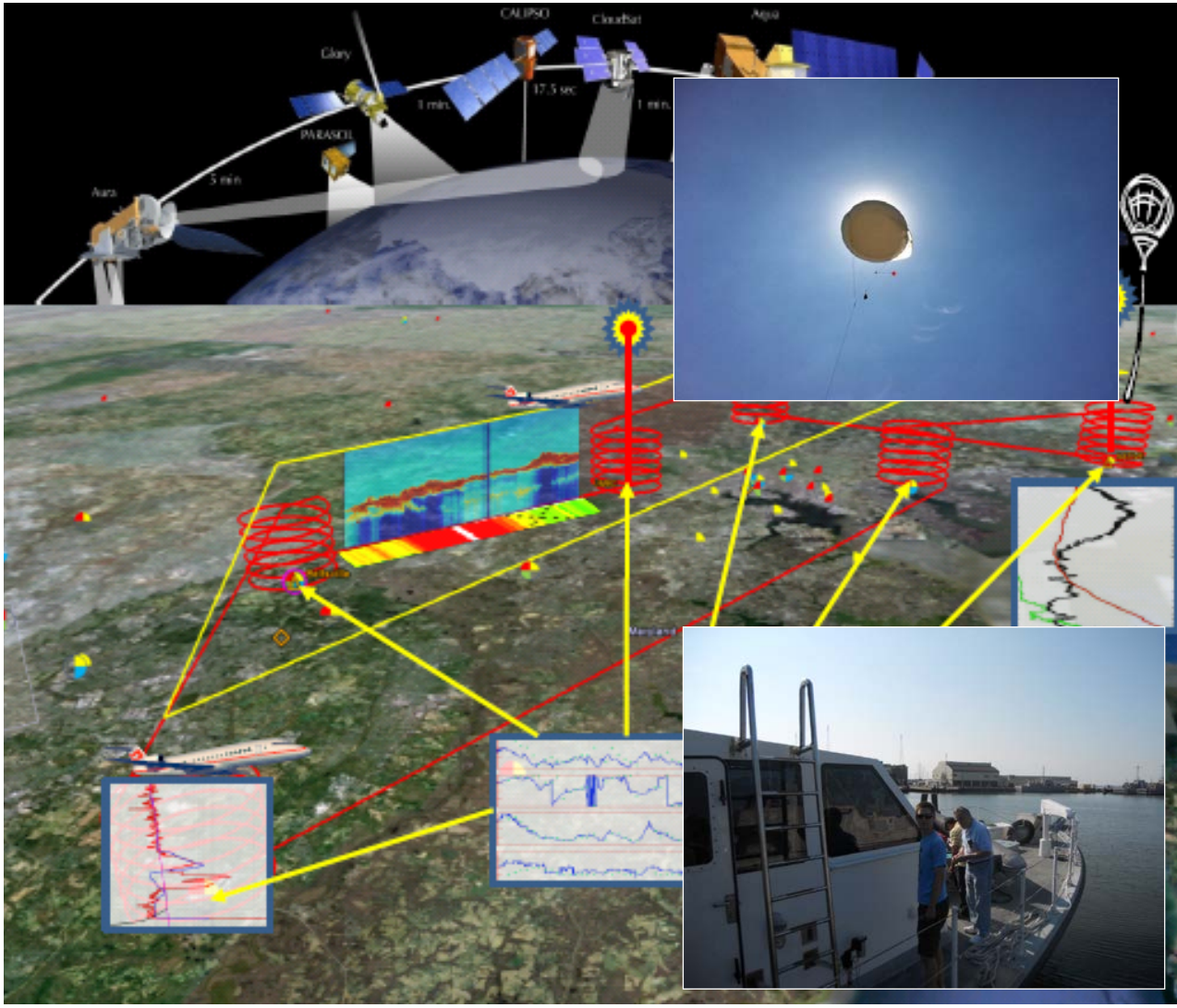
- A morning flight to the west (upwind): spirals at Luray, Winchester, and Cumberland .
- An afternoon flight to the west (downwind): spirals over Harford County, MD1 and MD18.
- En route vertical profiles between spiral locations to capture vertical gradients.
- Missed approaches (low approaches) at regional airports.



Courtesy: Xinrong Ren, UMD

Intensive Studies-DISCOVER AQ

- Sampling was conducted during July 2011 with 16 exceedence days.
- Observations:
  - 3 aircrafts – (254 spirals, this is what UMD RAMMPP has flown in 6 summers).
  - 6 surface sites
  - 4 aerosol lidars
  - 2 O_3 balloon locations
  - 1 tethered balloon
  - 1 ship



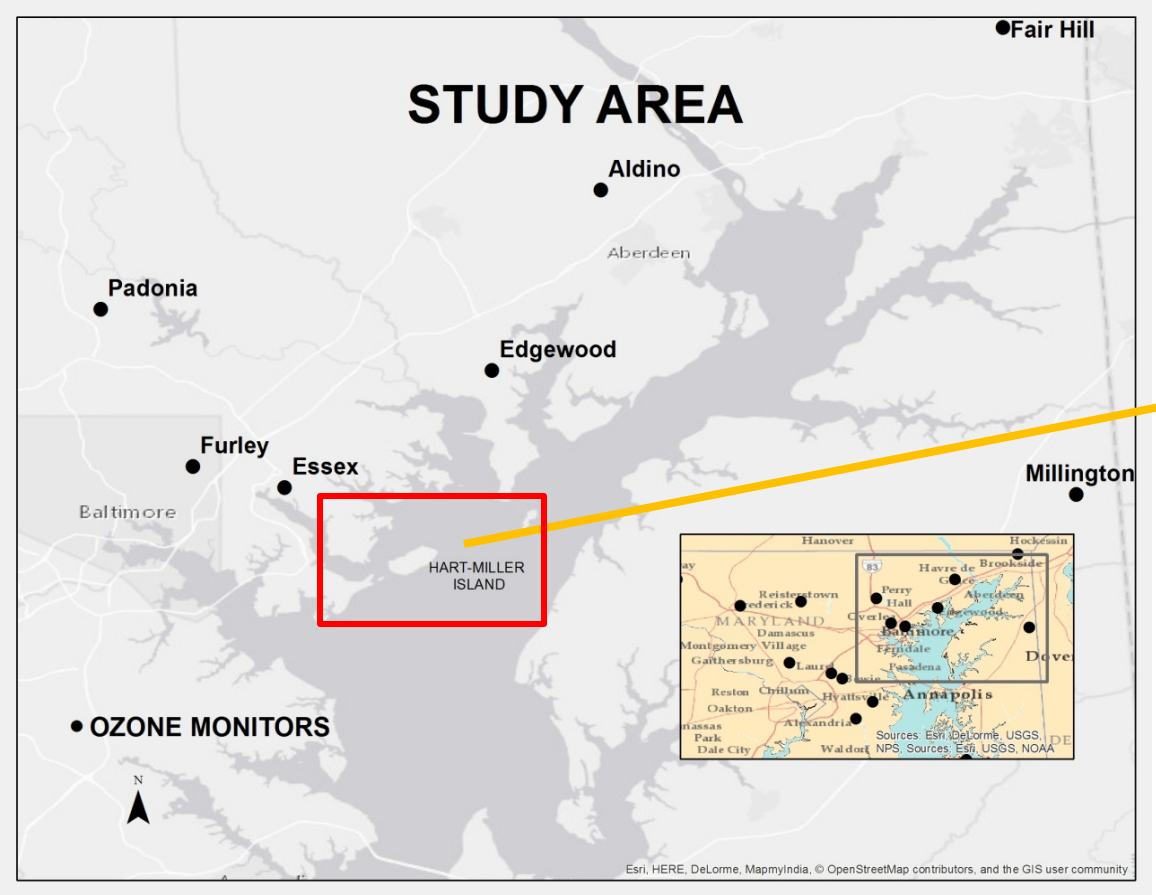
Courtesy: Jim Crawford, NASA

DISCOVER-AQ Significant Findings

- Lifetime of alkyl nitrates is much shorter than assumed in the model chemistry module (CB06). Has major implications for ozone production efficiency
- Measured ratio of NOx/CO indicates that the NOx emissions inventory is overestimated by a factor of 2.

POM-Land Water Interface

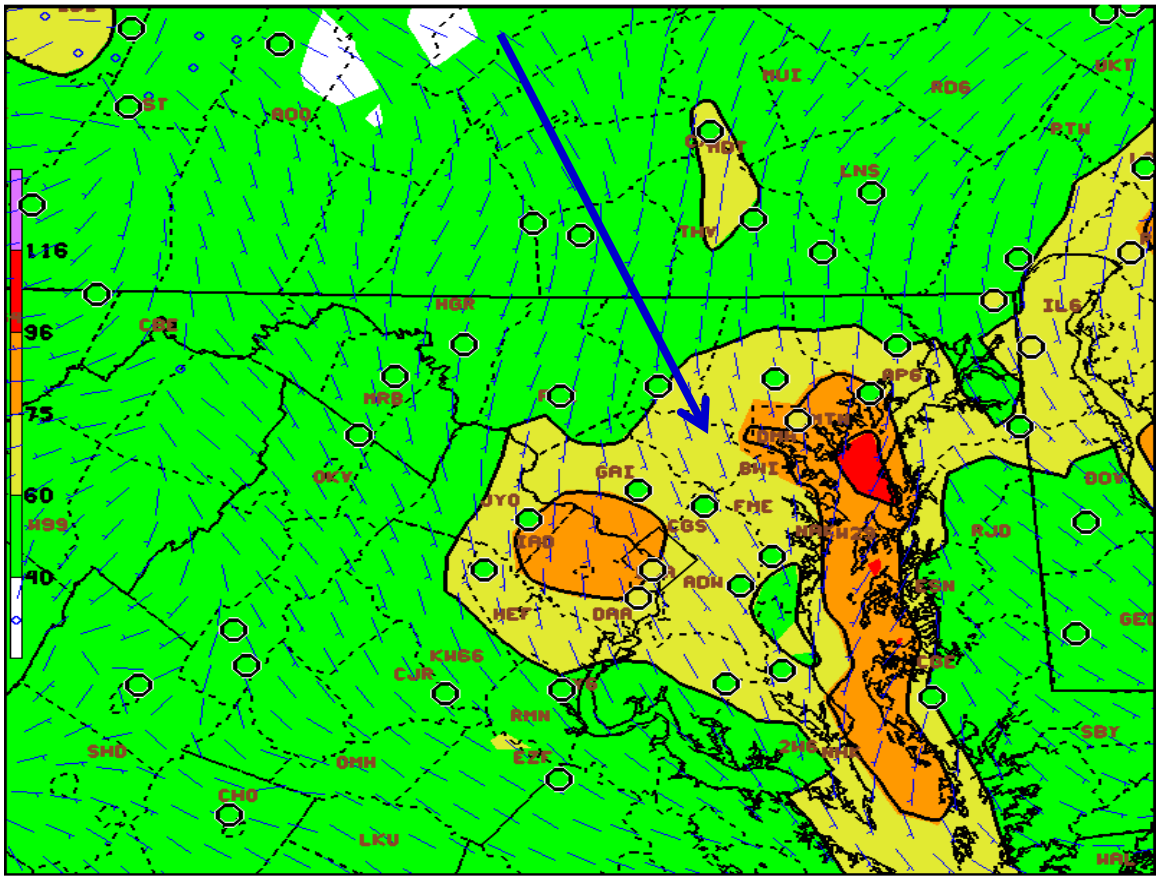
SCOPE OF PROJECT:
Deploy a portable ozone monitor in the Hart Miller Island to investigate the magnitude of ozone concentrations over the Chesapeake Bay.



Hart Miller Island Project

POM-Land Water Interface

MOTIVATION: air quality forecast models have a high bias (that is, forecast too much ozone) over the Bay than what is observed by neighboring shoreline ozone monitors



MAIN QUESTION:
What is the magnitude of ozone over the Chesapeake Bay and the interaction between meteorology and ozone along the land/water interface of the Bay?

Forecast 8-hour ozone (background fill (AQI)) for Maryland on July 11, 2015 overlaid with ozone AQI at ozone monitoring stations across the region (circles).

How much does this stuff cost?

Supported through extramural funding sources

- 3 Radar Wind Profilers
  - ~$45,000 per year for service contract after initial investment
- Ozonesonde launches
  - ~$50,000 per ozone season
- LIDAR - Aerosol
  - ~$30,000 per year
- LIDAR – Ozone
  - ~$75,000 - $100,000 per ozone season
- Aircraft flights
  - ~$50,000 per ozone season
- Intensive Studies like DISCOVER-AQ
  - Multi-million $
- Portable ozone monitor
  - ~ $20,000

EMP Prep/Submittal/Approval Process

- Stay tuned for more detailed guidance from EPA
- Due Oct. 1, 2019, or 2 years after moderate or above designation
- Will be reassessed and approved as part of 5-year network assessments
- Need to get started very soon

Acknowlegements

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