A Path Forward For Reducing Ozone in Maryland and the Mid-Atlantic States

Driving Policy With Science

What Has Worked
What Has Not Worked
What We Now Know
Where To Go From Here





OZONE TRANSPORT COMMISSION

Tad Aburn, Air Director, MDE
AQCAC - December 11, 2017

Making Progress on Cleaner Air

What We've Achieved Under the Clean Air Act Amendments of 1990, and Where We Need to Go

Getting to the New Ozone Standards
A Pathway Forward

November 10th, 2010
Sheraton Hotel Boston, MA

November 10, 2010 "Path Forward" Presentation – Boston Massachusetts

Are We Winning the War on Transport?

Appear to be Winning Quite a Few Battles. Still A Lot More to Do.

2010 and 2013 – Same Conclusion

We Have a Clear Path Forward

We understand the science of ozone better than ever

We've implemented programs that have worked in the real world

We need a two-part strategy

1. Local … inside the Ozone Transport Region (OTR) controls are still important
   - Can help reduce about 1/3 of the ozone problem in most cities in the OTR
2. National or super-regional controls of nitrogen oxide (NOx) to reduce ozone transport are critical
   - Incoming ozone is already measured at levels approaching the 70 ppb standard
   - Regional contribution represents approximately 2/3 of the ozone problem in cities in the OTR

November 2017

The solution to the ozone problem in the East has not changed

- We know that widespread regional NOx reductions reduce ozone
- Local controls also are important

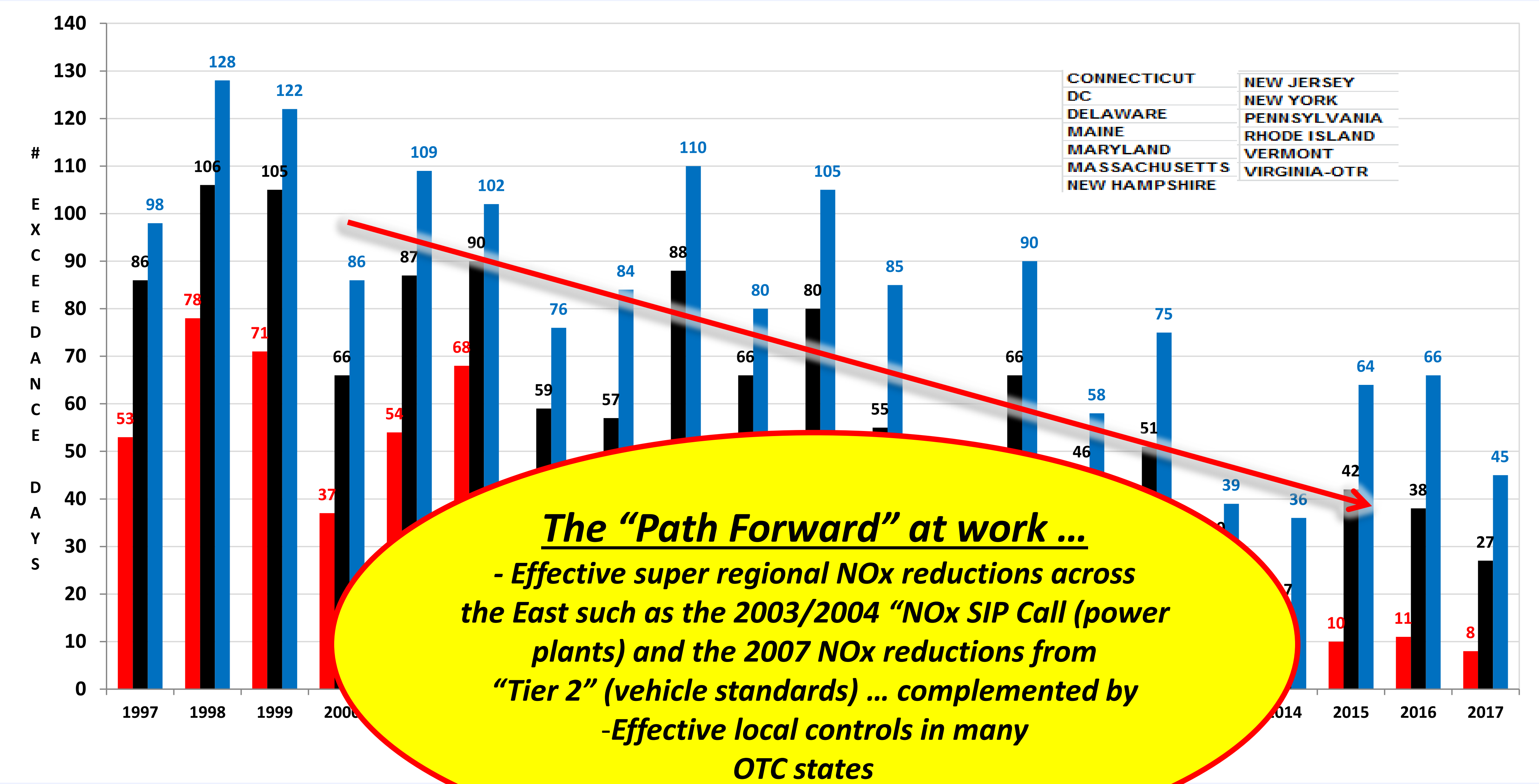
We now have even better science proving that the solution will work

- In most areas … NO_X reductions are now “supercharged” … smaller reductions get greater benefits
- CT/NY/NJ area is close to the tipping point for supercharged NO_X reduction

We’re poised to make even greater progress … more regional and local NO_X reductions are on the way

We also have some very significant challenges with the new standard

Ozone Trended Downward from 1997-2017

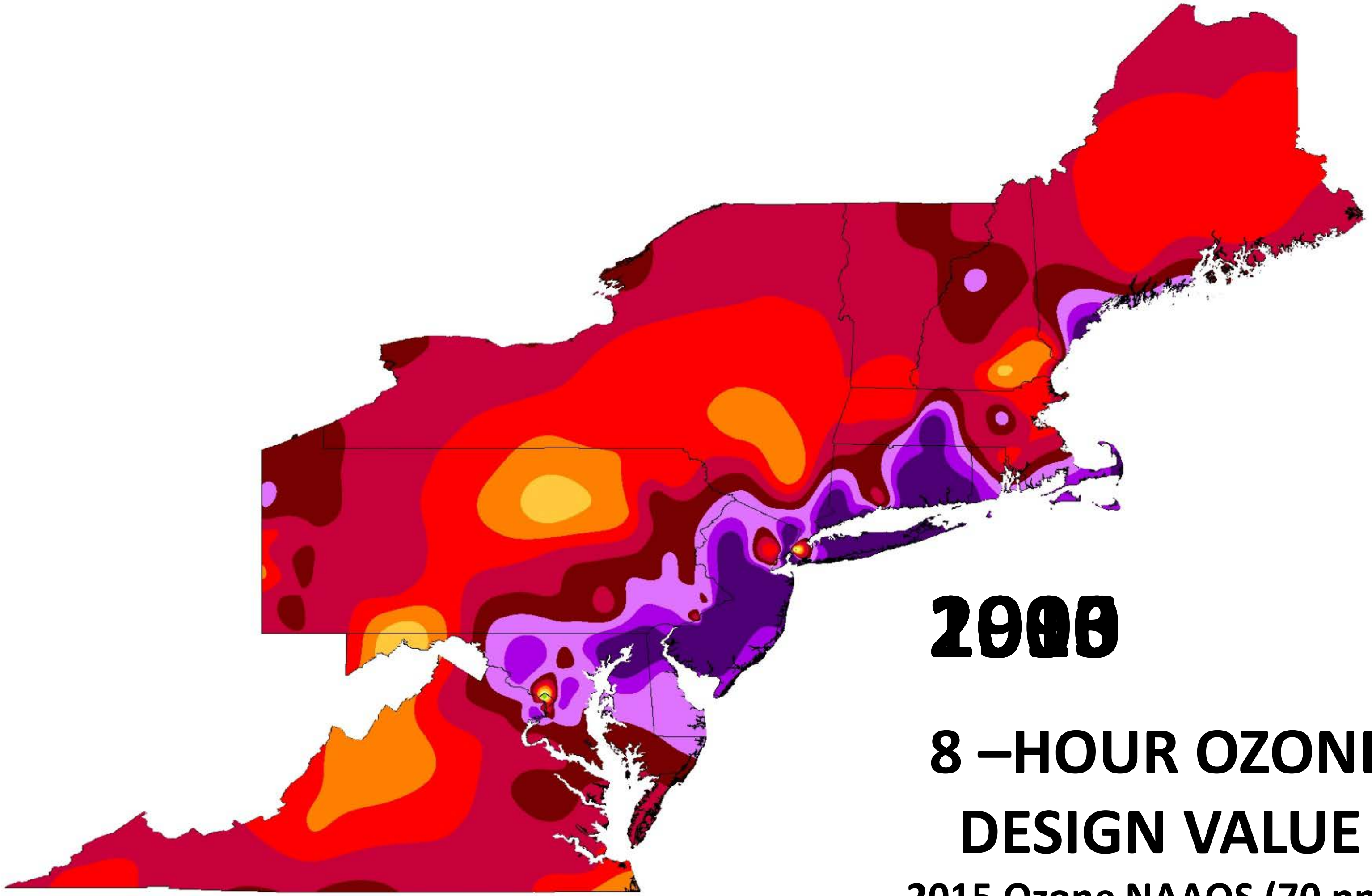


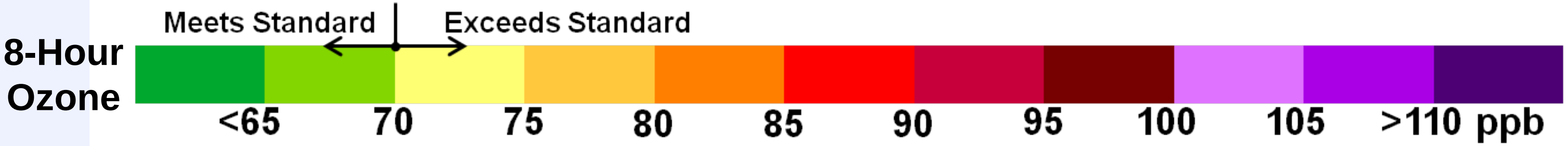
<u>The "Path Forward" at work …</u>

- Effective super regional NOx reductions across the East such as the 2003/2004 "NOx SIP Call (power plants) and the 2007 NOx reductions from "Tier 2" (vehicle standards) … complemented by

-Effective local controls in many OTC states

The Shrinking Ozone Problem



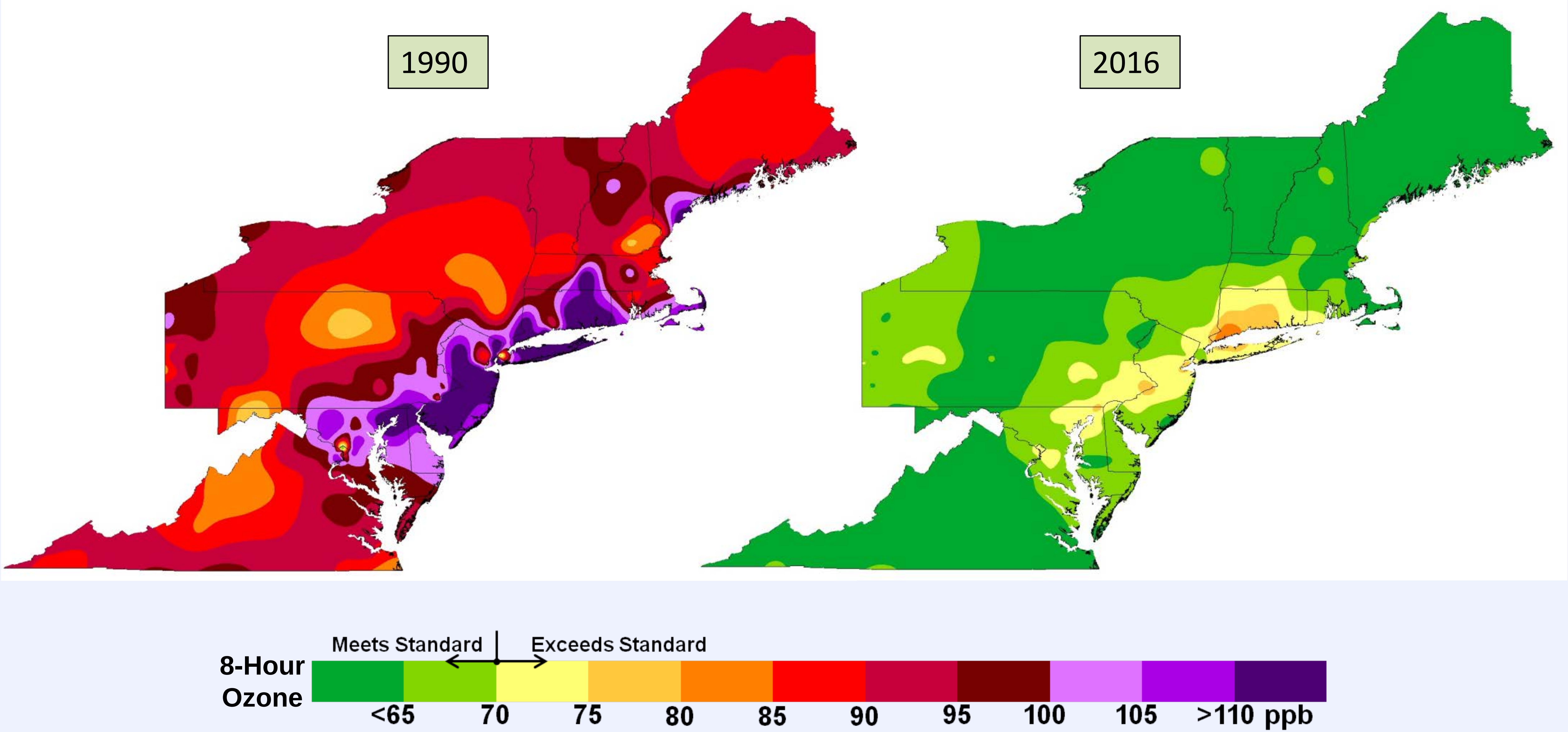


8 –HOUR OZONE DESIGN VALUE

2015 Ozone NAAQS (70 ppb)

* 2016 Data is considered Preliminary

The Shrinking Ozone Problem



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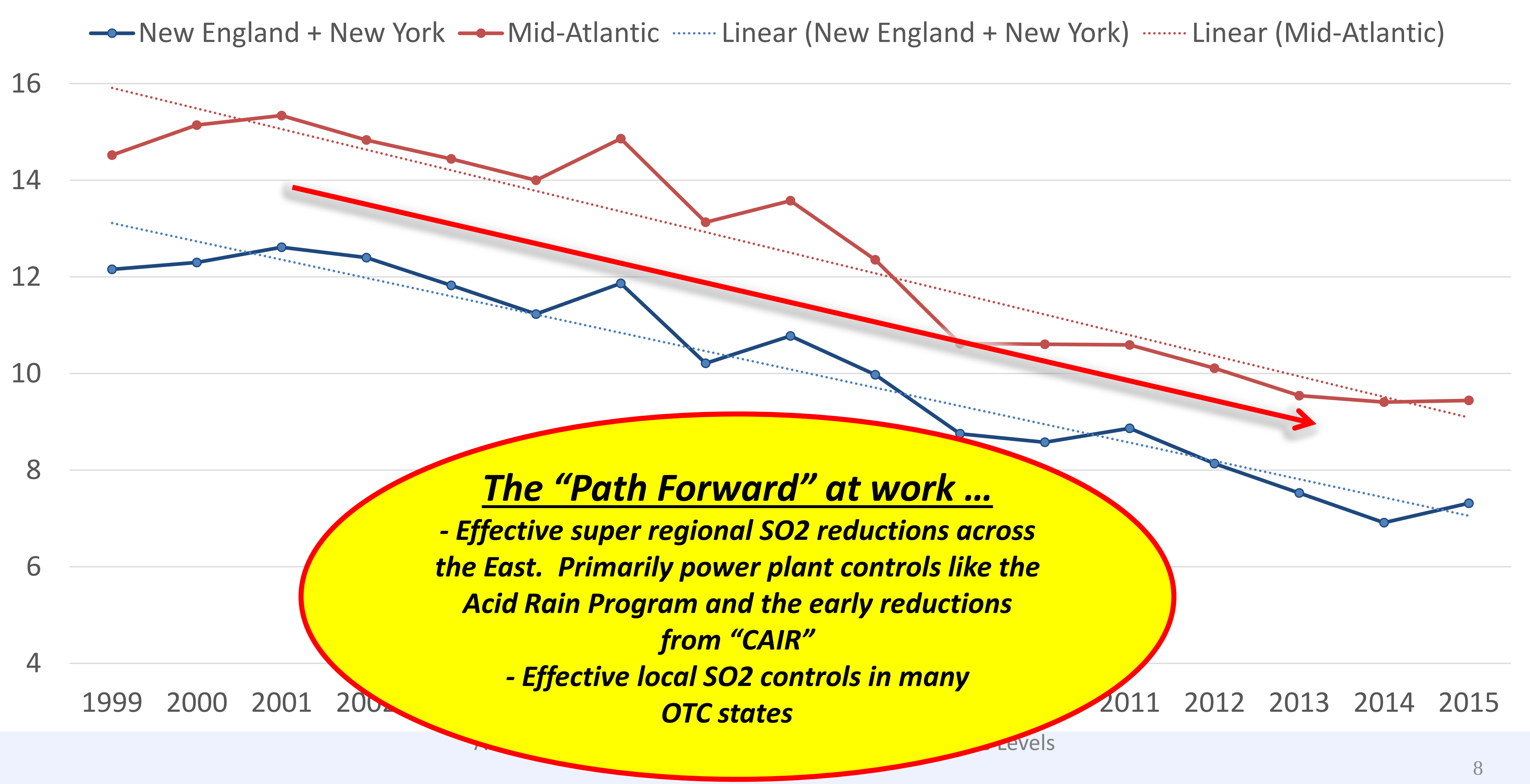
Fine Particulate … Dramatic Downward Trend

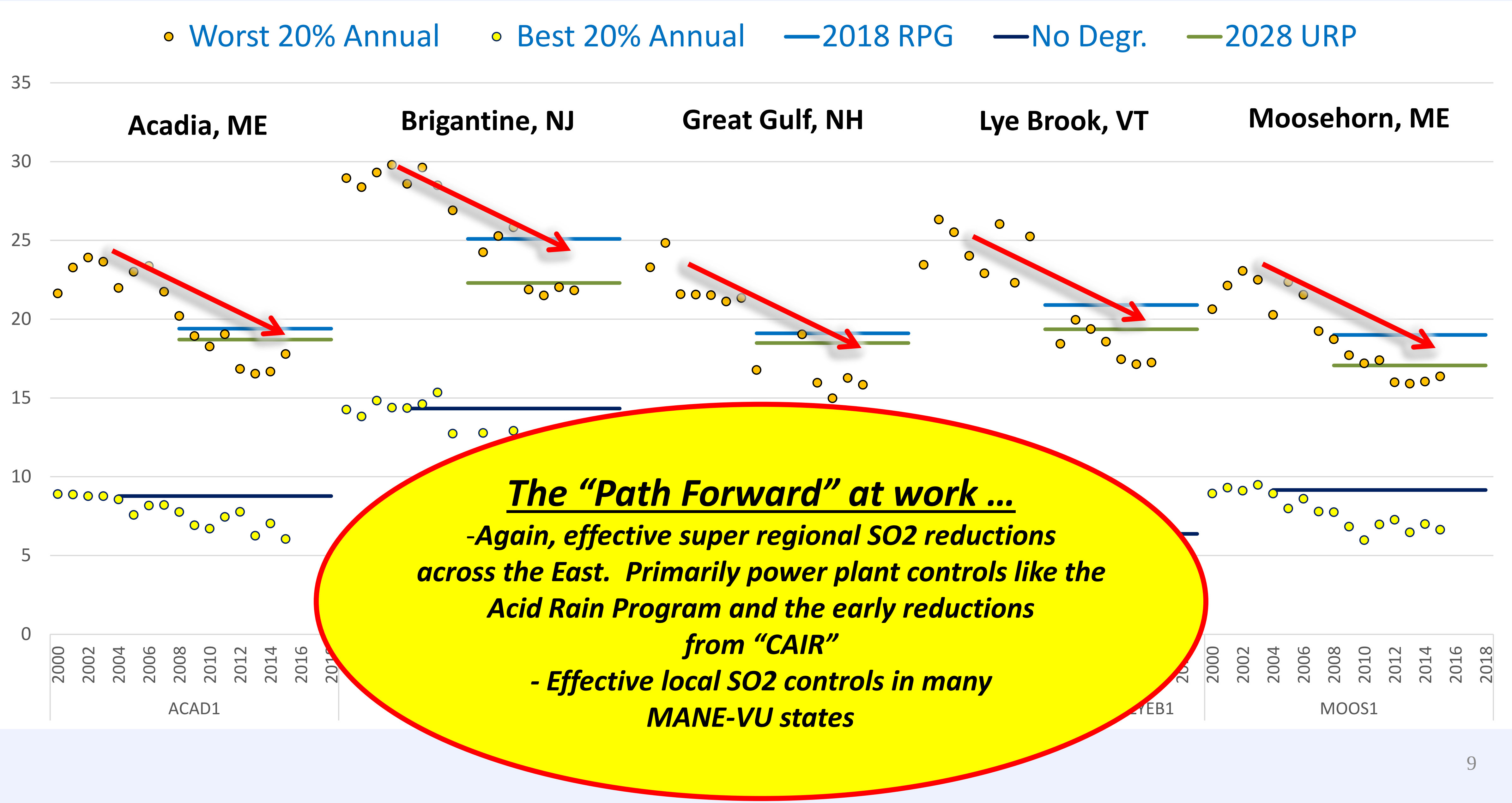


The "Path Forward" at work …

- Effective super regional SO2 reductions across the East. Primarily power plant controls like the Acid Rain Program and the early reductions from "CAIR"

- Effective local SO2 controls in many OTC states

Visibility Has Also Improved Significantly



So Why is it Working?

In simple terms, we are making significant progress by addressing the 2 key parts to our ozone problem

1. Local emissions
2. Regional emissions or transport

They bring us ozone in different ways and vary by day in terms of importance

Continuing the progress will be more challenging

Understanding the "How" piece of the ozone transport problem is critical to our current and future policy development and progress

Understanding Ozone Transport

It's complicated … but not that complicated … some key concepts

An "elevated reservoir" of ozone

- A transport cloud
- An elevated ocean of ozone
- The residual layer
- Where transport collects

Three different types of transport

1. Westerly Transport – Power plants are a major contributor
2. Night-time, Southerly Transport – Vehicles, power plants, more
3. "Local" or "City-to-City" Transport – An urban soup … Washington to Baltimore … Baltimore to Philly … NJ & NY to CT … to MA … to ME … etc. etc. etc.

THE EVOLUTION OF A BAD OZONE DAY

DAYTIME … NIGHT TIME … LONG DISTANCE TRANSPORT … LOCAL EMISSIONS

The Four Phases of A Bad Ozone Day

1. The night before the bad ozone day
   - Ground Level ozone is mostly very low
   - Transported ozone builds up and is trapped aloft in an "elevated reservoir"
2. The morning of the bad ozone day
   - The elevated reservoir mixes down to ground level
   - As a result, the day starts with a "transport penalty" of 60% to 70% of the standard
3. The day of a bad ozone day
   - Local emissions cook and add ozone
   - Emissions from nearby areas (DC → Baltimore, NYC → CT) cook and add ozone
   - Daytime transport continues to add ozone

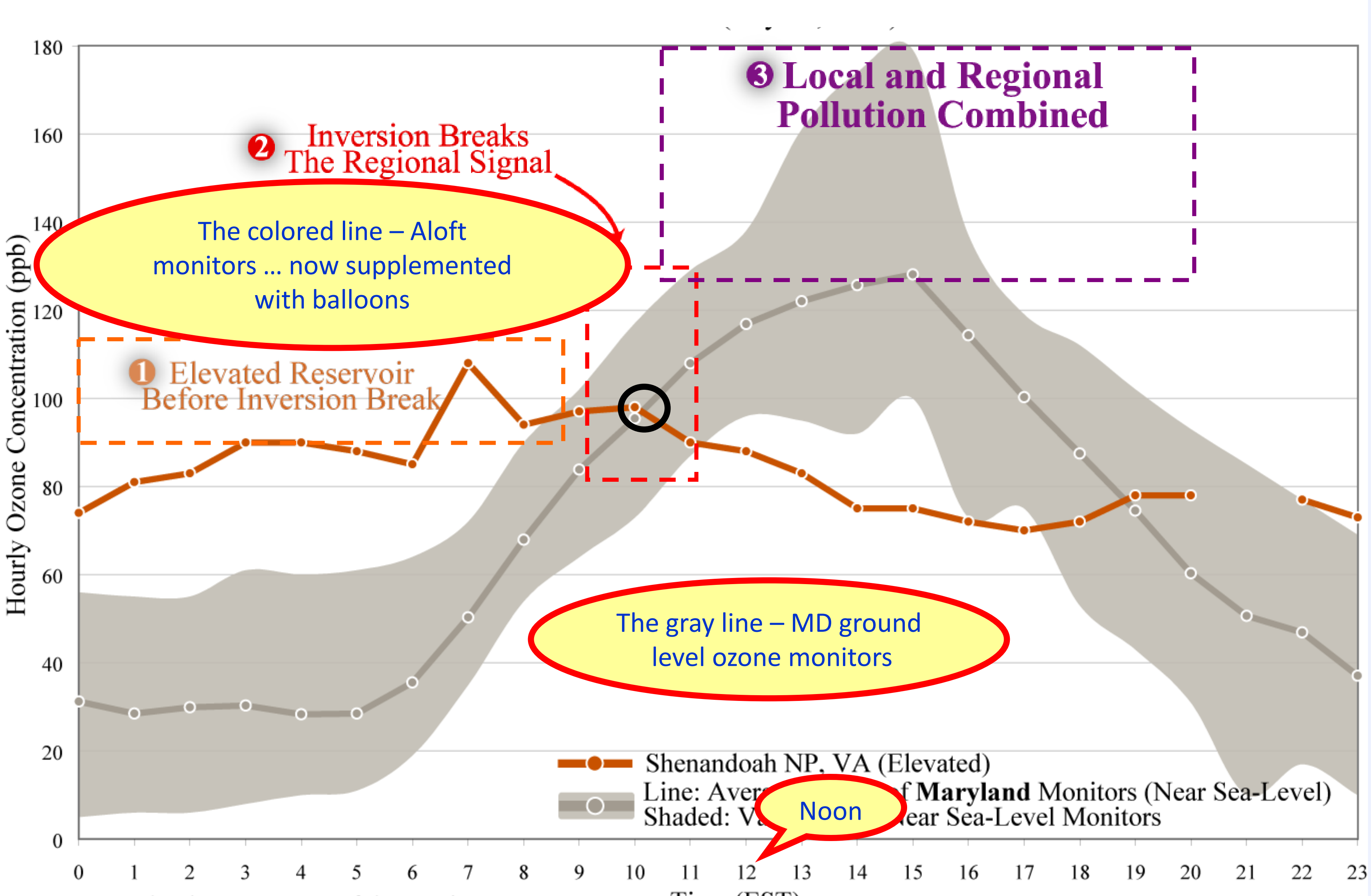
Add it all up on a bad day - 80 ppb ozone

4. The night after the bad ozone day
   - Everything starts again … NJ/NY/CT plume gets transported up the NE coast to MA/RI/NH/ME

Ground Level Ozone	Edgewood, MD	Fairfield, CT
The morning of the bad ozone day	50 ppb	50 ppb
Local emissions cook and add ozone	10 ppb	5 ppb
Emissions from nearby areas cook and add ozone	10 ppb	15 ppb
Daytime transport continues to add ozone	10 ppb	10 ppb
Total	80 ppb Exceedance Day	

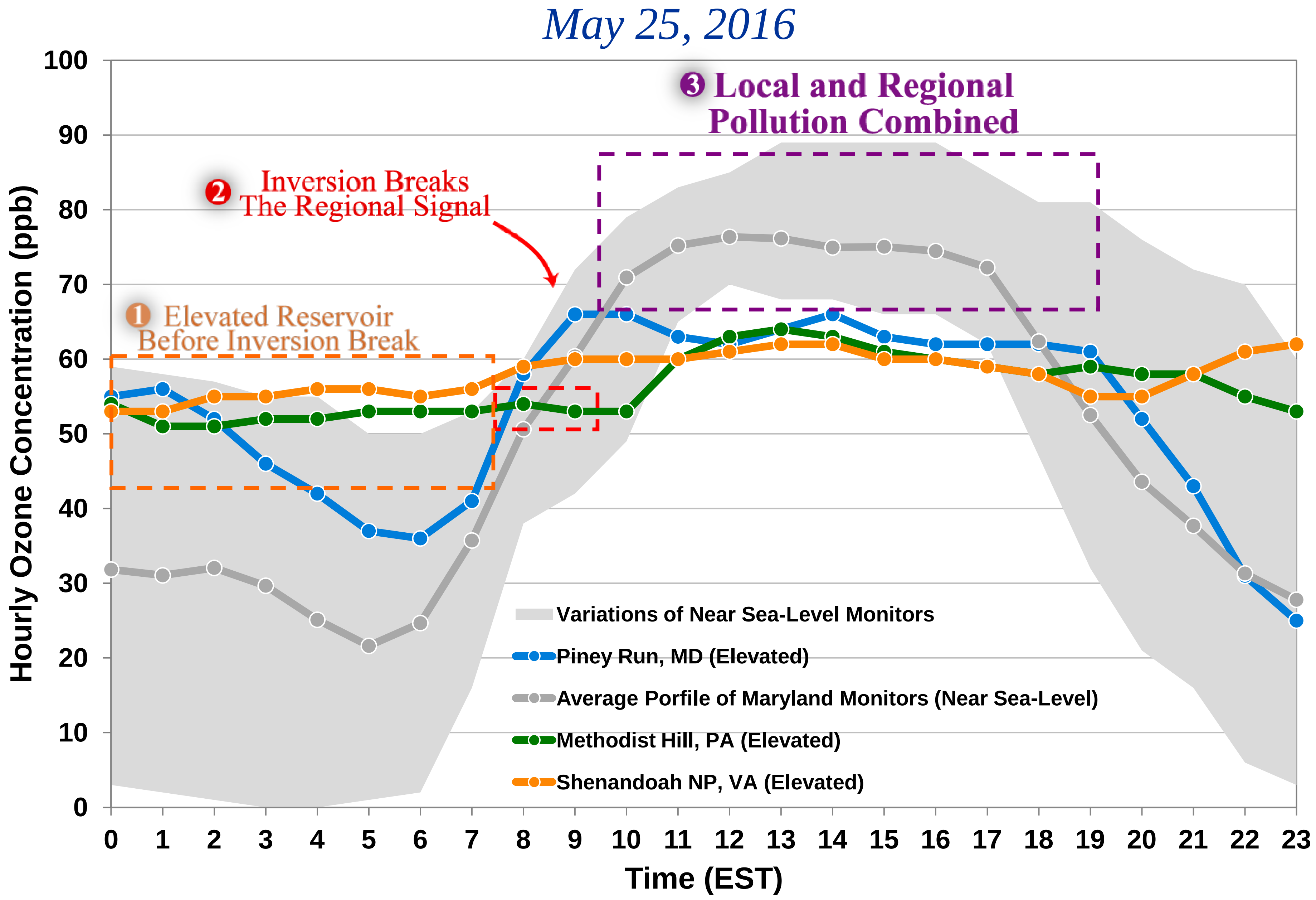
The Daily Ozone Creation Pattern

A classic, worst-case event on July 15. 1995

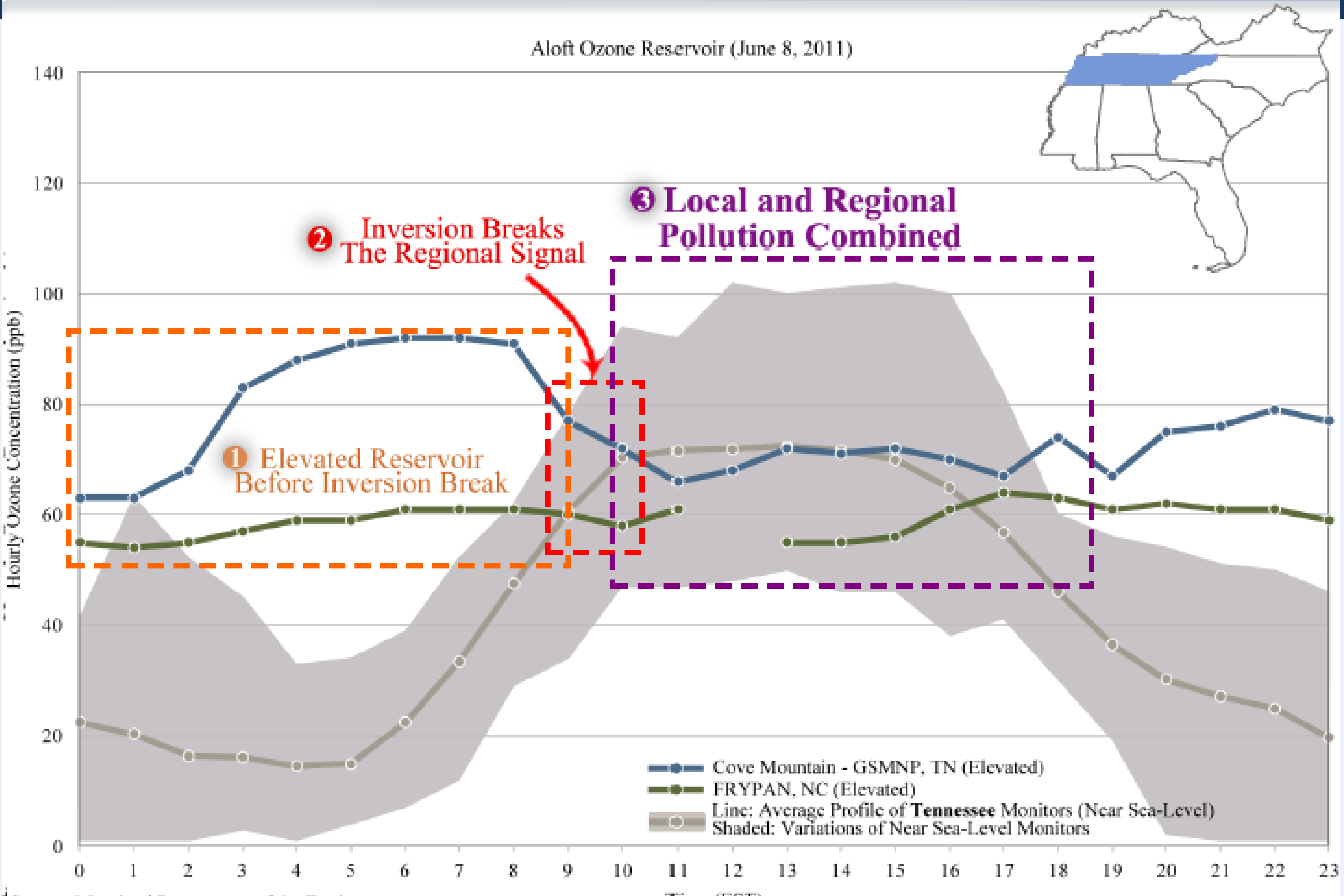


Source: Maryland Department of the Environment

Daily Ozone Pattern - Very Recent - Maryland



Same Signal – Tennessee 2011

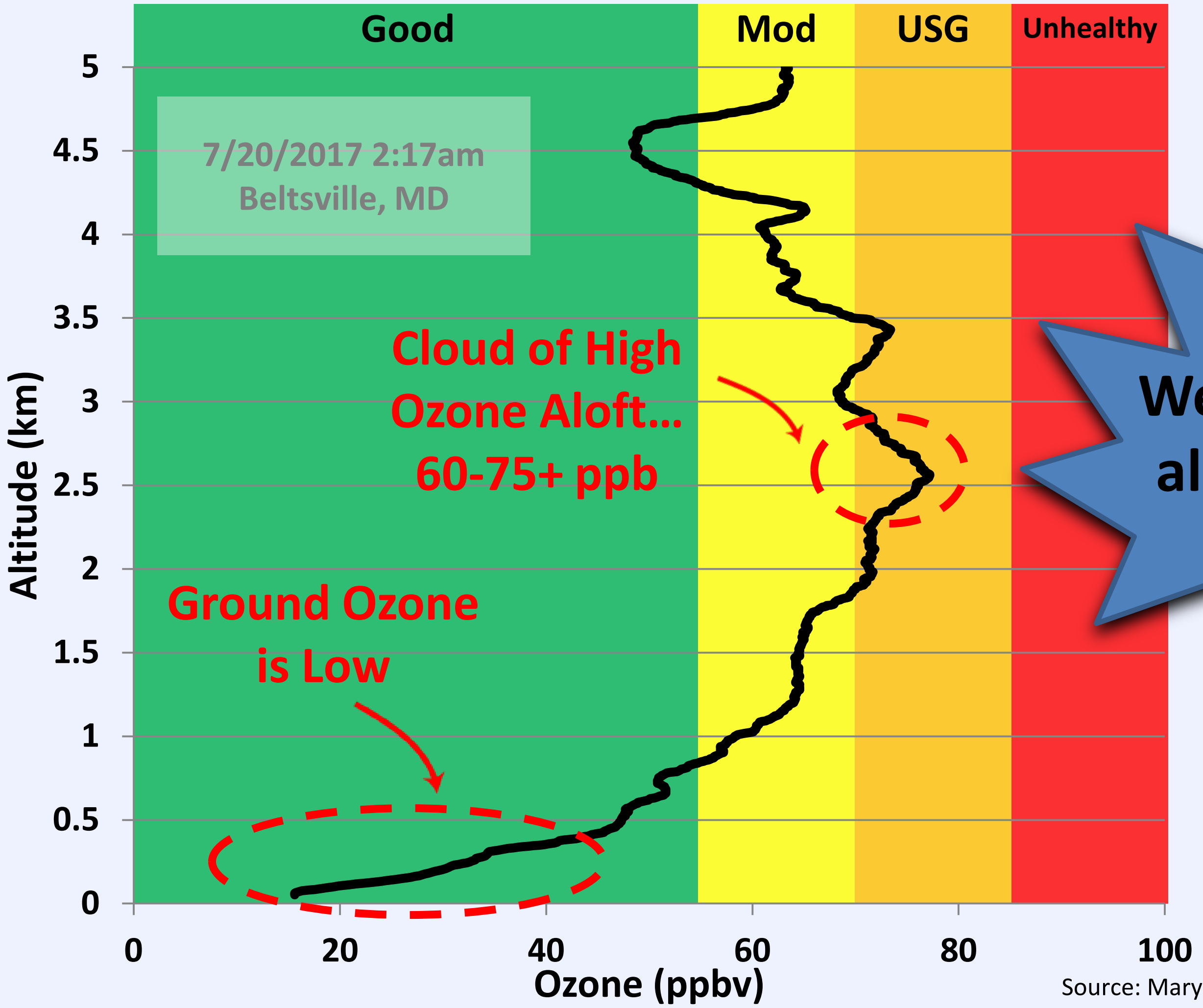


Source: Maryland Department of the Environment

The Night Before - July 2017

A Reservoir - Maybe More Like an Ocean - of Ozone
Sitting 2000 feet Above Us - While We Sleep

A balloon launch at 2:20 am south of Baltimore … north of Washington

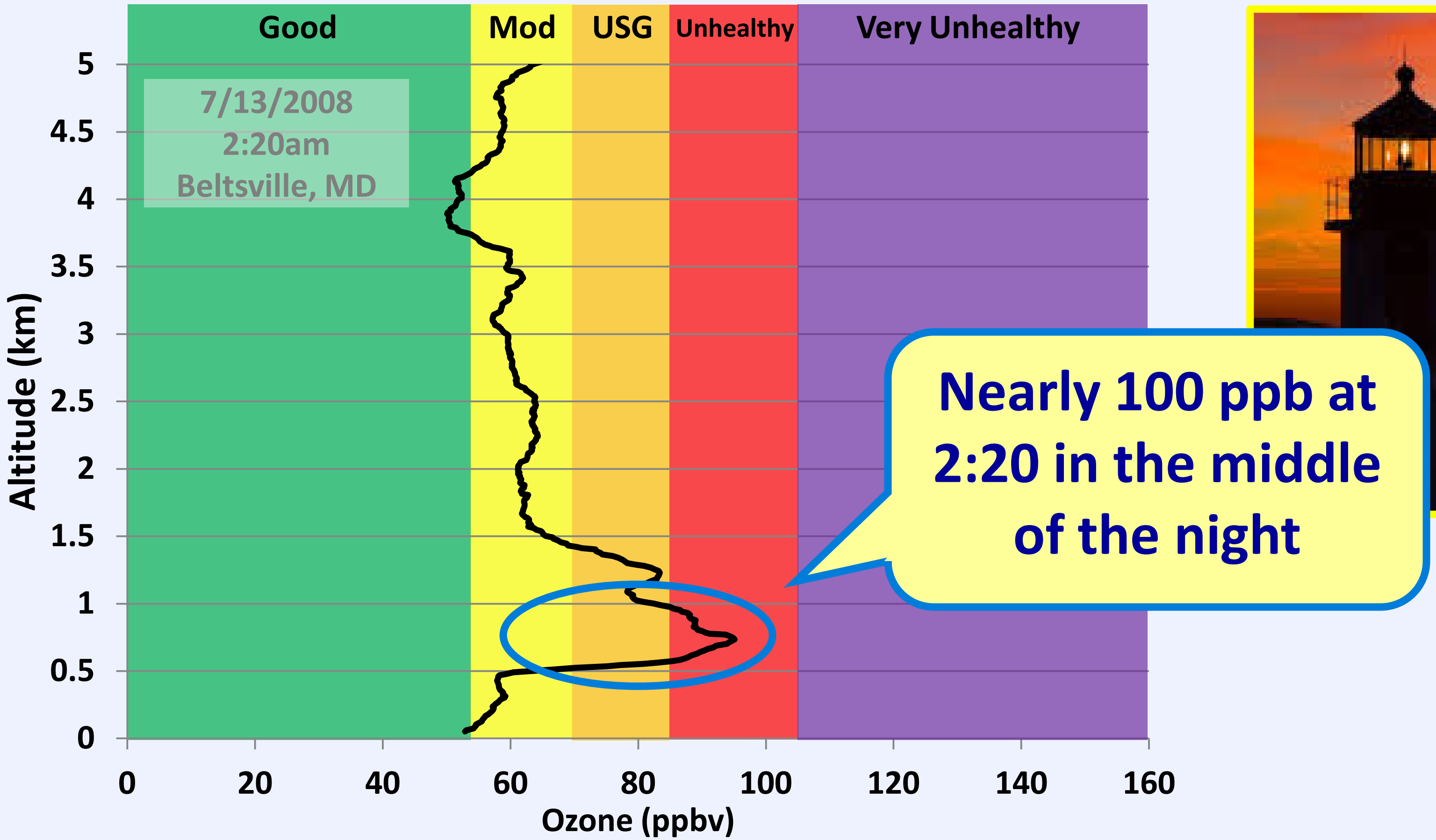


Source: Maryland Department of the Environment and Howard University

The Night Before - 2008

At least we are not seeing 100 ppb in the night time reservoir anymore

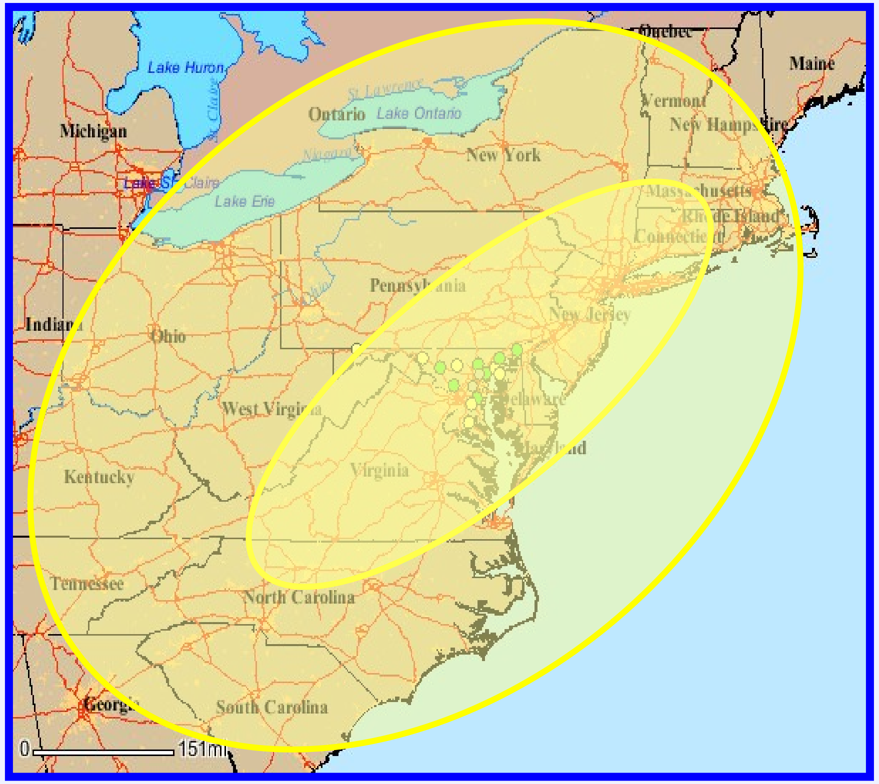
A balloon launch at 2:20 am south of Baltimore … north of Washington



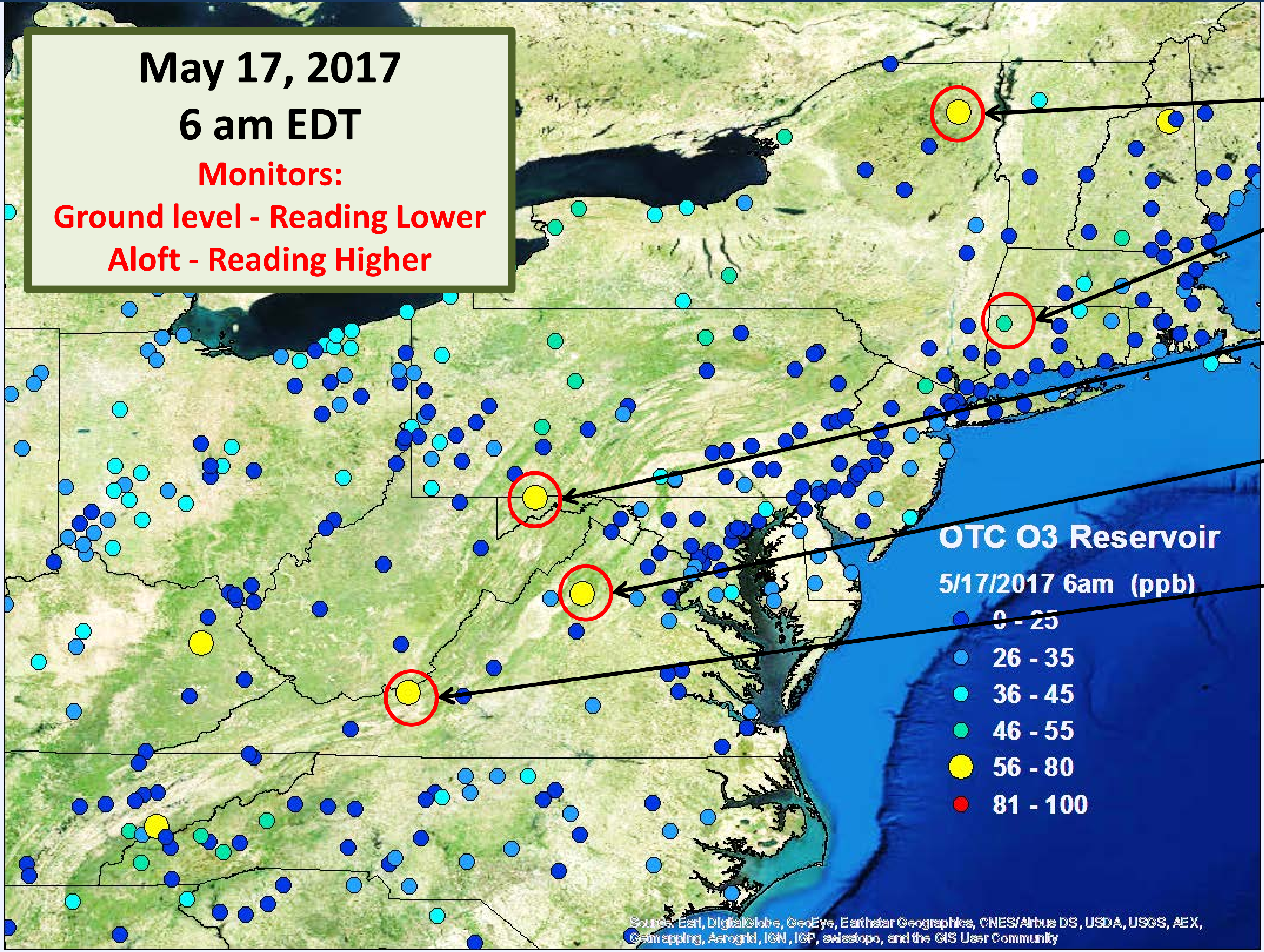
The Night-Time Elevated Ozone Reservoir

What creates the reservoir and how big is it?

- The night before every bad ozone day, a large reservoir of ozone sits above the OTC
- What's over MD on Tuesday night started off in Ohio and North Carolina on Monday
  - MD's pollution soup floats to New Jersey and New York
  - New York's pollution floats to CT and New England
- Power plants, cars, trucks and other sources are all contributors to the elevated pollutant reservoir.
- Filled with ozone and ozone precursors.



An Ozone Transport Reservoir Example



Whiteface Mt., NY
59 ppb

Mohawk Mt., CT
55 ppb

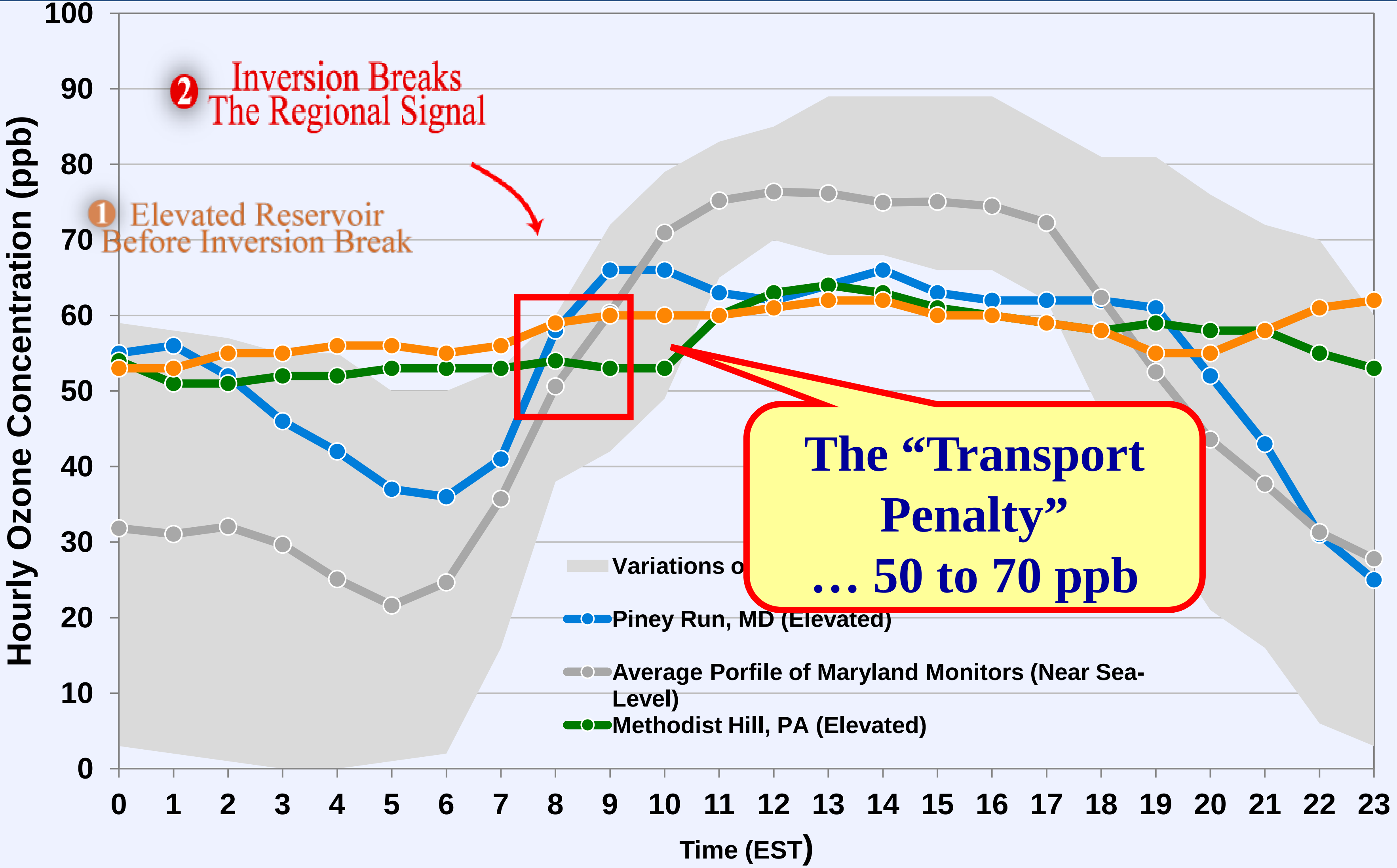
Piney Run, MD
57 ppb

Shenandoah NP, VA
65 ppb

Horton Station, VA
62 ppb

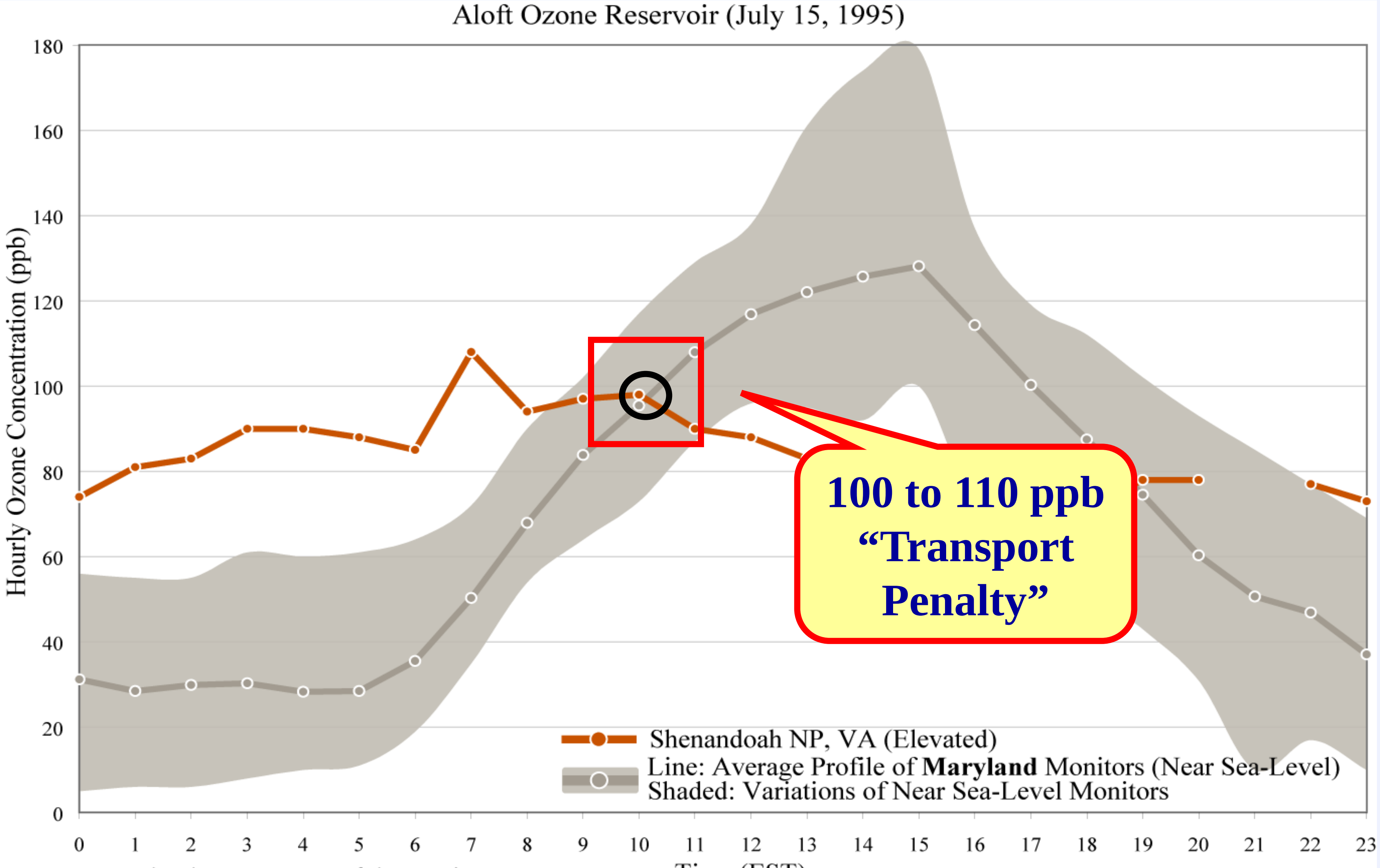
The" Morning Of" a Bad Ozone Day

What was trapped aloft … mixes down around 9 am as the earth heats up and the nocturnal inversion collapses



The Morning Of - 1995

At least we are not seeing 100 ppb as a transport penalty anymore



Source: Maryland Department of the Environment

Day of the Event

A lot happens the day of the bad ozone event …

- But remember, you're already starting with a 50-60 ppb penalty from "day before" transport

Four key factors add pollution during the afternoon

1. Your low-level local emissions - which actually start at around morning rush hour - float and cook and begin to add to ozone levels around 10:00 and eventually to peak ozone levels in the late afternoon
2. The low-level emissions from areas just upwind of you also start at rush hour - float, cook and also gradually contribute to the afternoon peak
3. Continued "aloft" transport can continue to "mix down" all day long
4. Local meteorology, geography and chemistry can push … and pull … and redirect … and trap … and compress ozone to make late afternoon ozone even higher

More on these issues later

“Local” Emissions

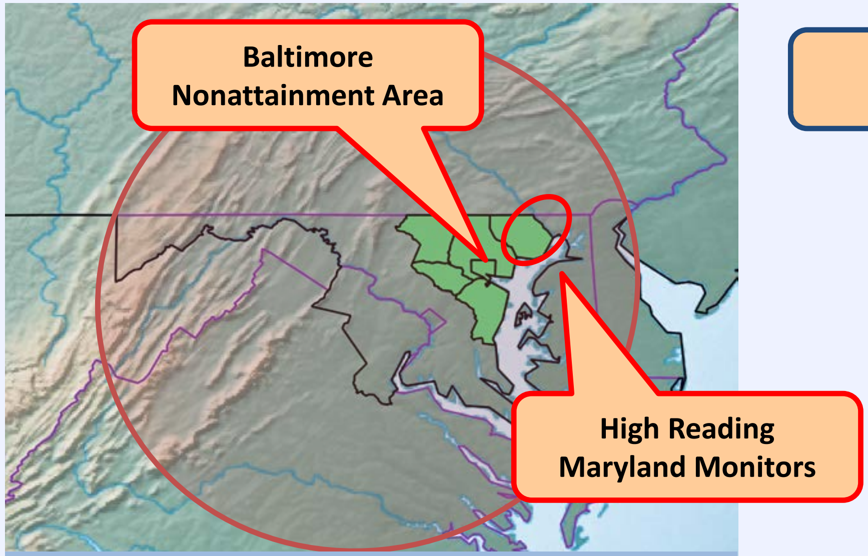
In the real world, all emissions that can react at ground level to create ozone on the same day of an exceedance event are considered “local”

- Scientists call this the “local airshed”

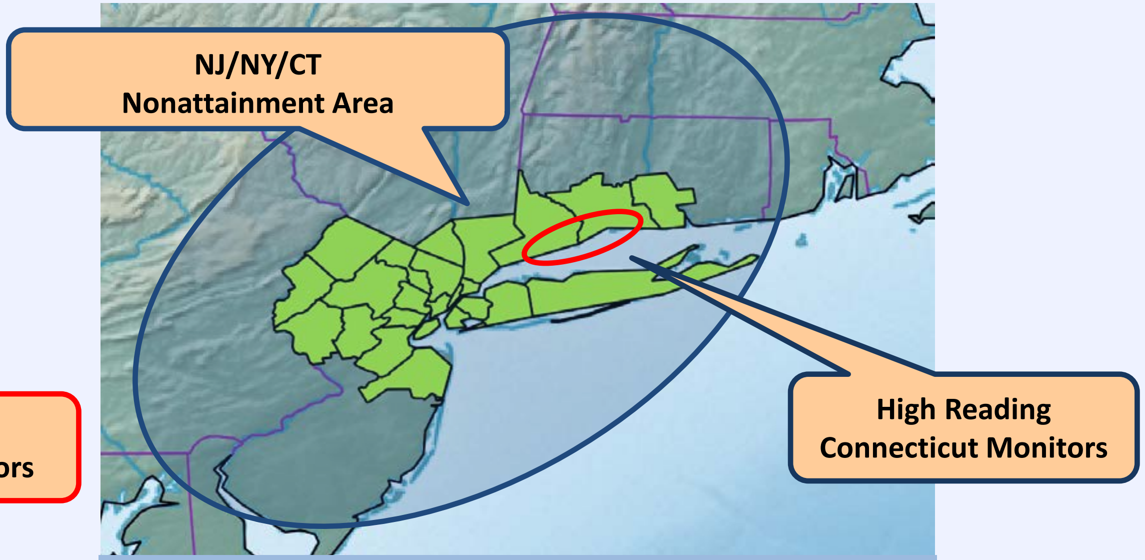
Unfortunately the CAA works differently

- Nonattainment areas are almost always smaller than the local airshed
- Washington is part of the local airshed for the Baltimore Nonattainment Area (NAA)
- Much of Eastern PA, NJ and NY are part of the NJ/NY/CT airshed

Under the CAA this kind of local emission transport is handled by Transport (Good Neighbor) SIPs not Attainment SIPs



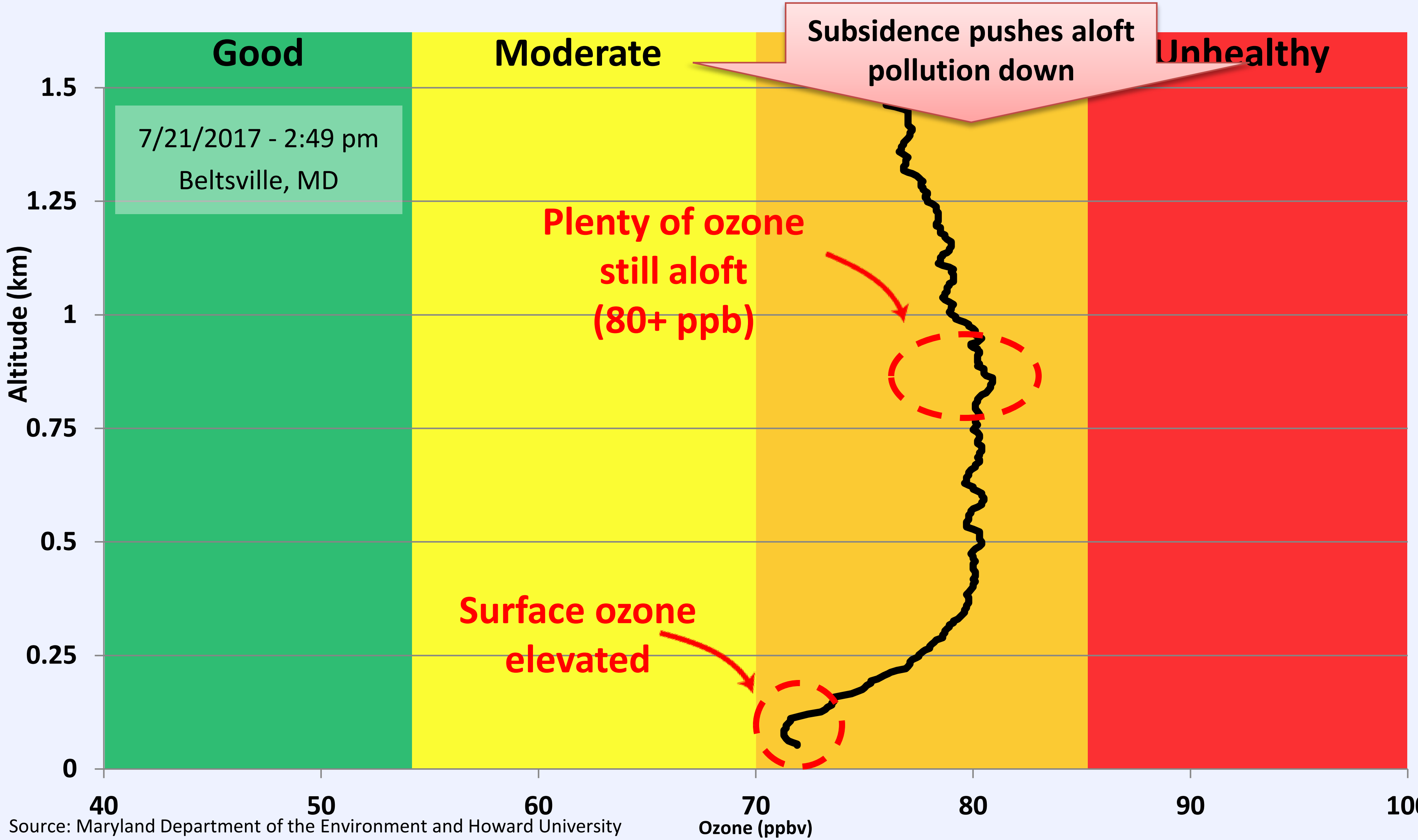
Rough Approximation
Baltimore Local Airshed



Rough Approximation
Connecticut Local Airshed

Daytime Transport - Baltimore

High aloft … daytime … ozone … between Baltimore and Washington



Source: Maryland Department of the Environment and Howard University

The Night After the Bad Ozone Day

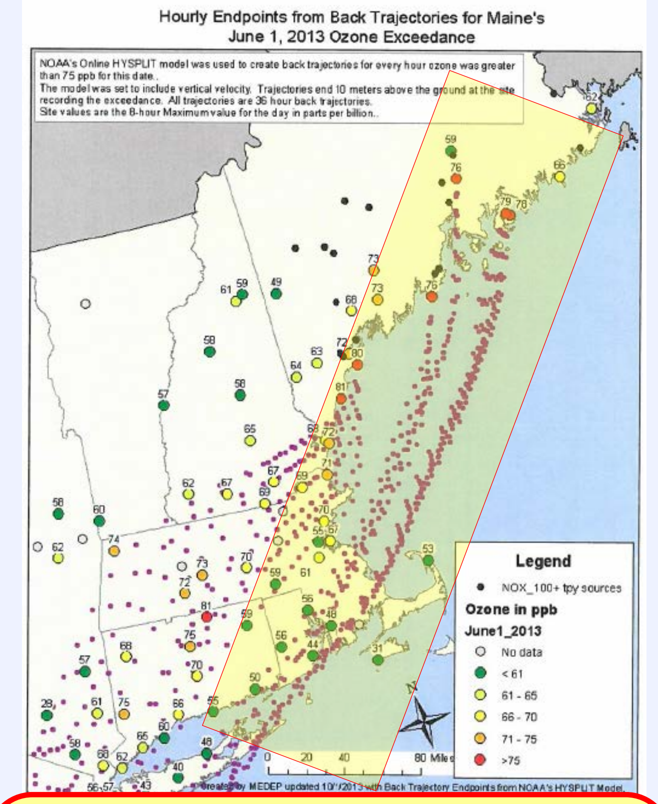
The same cycle begins to repeat itself

- Elevated ozone reservoir builds overnight as the night time inversions traps ozone aloft
- Reservoir mixes down the next morning - the 50 to 60 ppb ozone transport penalty
- Local emissions and emissions from close by areas are added in to create afternoon peak ozone levels

For Northern New England - The New York City plume floats north - towards areas like Maine and Massachusetts

- New York City plume moves out over the Atlantic
- Moves up the New England Coast over night
- Winds push the plume back on to land and can sometimes be high enough to create exceedances in Maine and Massachusetts

Following the New York Plume Up the NE Coast



NJ/NY/CT Ozone Plume
- Long Island Sound to Atlantic then through RI and MA
- Back out over the Atlantic and then back to NH and ME

THE THREE DIFFERENT TYPES OF TRANSPORT

Ozone Research in the OTR

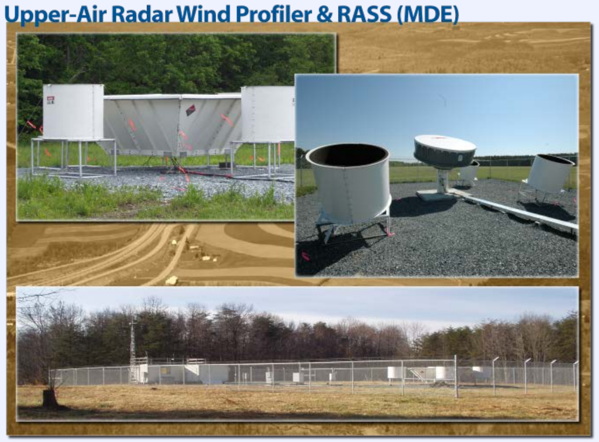
OTC and the states work in partnership with local universities (UMD at College Park, UMBC, SUNY, Rutgers, Penn State and Howard University) to study ozone and fine particulate air pollution problems

- MD has the luxury of a dedicated research fund

Major focus … Transport

- Airplanes … Balloons … Lidar (laser based measurements)
- Profilers … Satellites … Special monitors … Modeling
- Much, much more

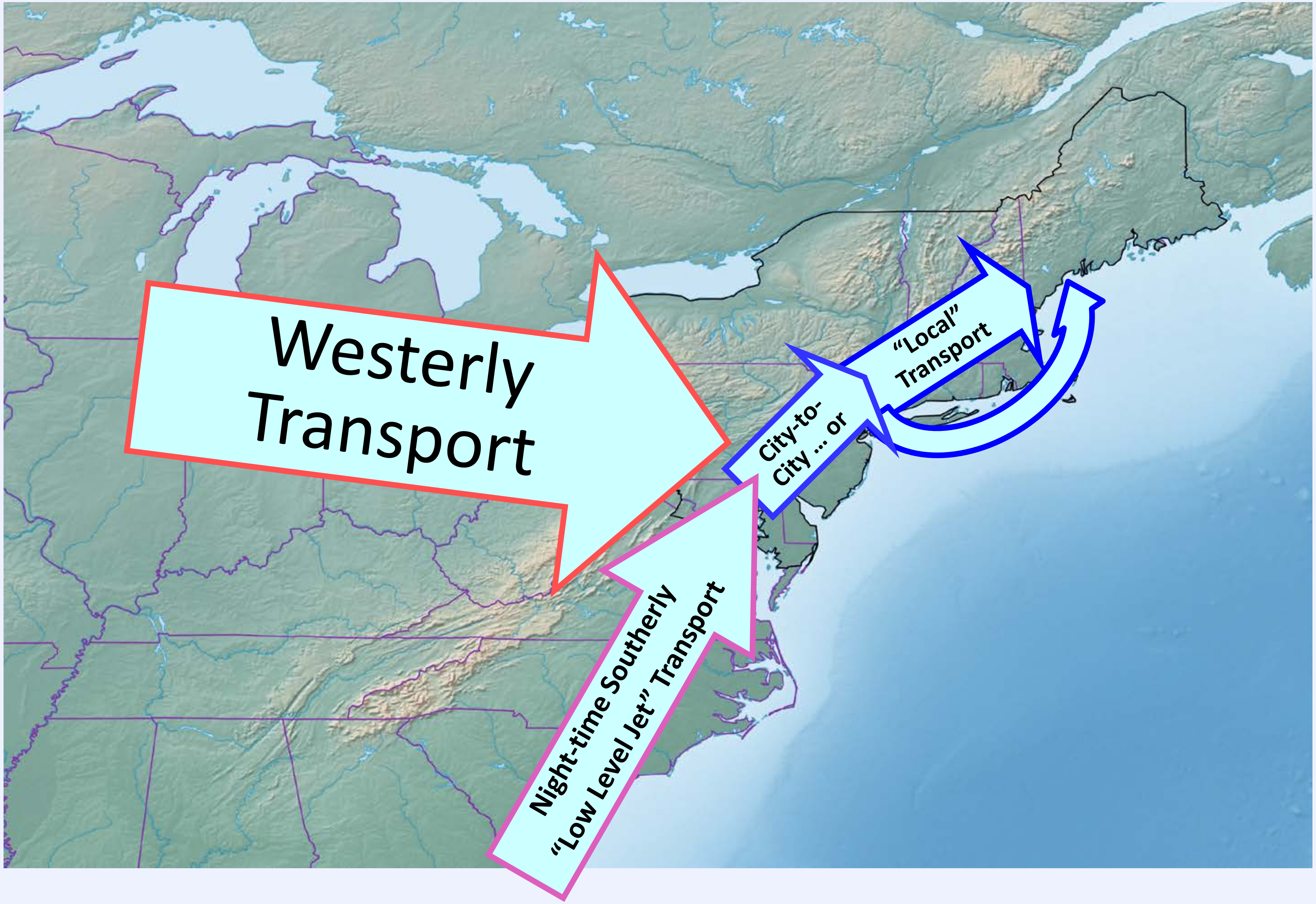
Early focus was Maryland and the Mid-Atlantic



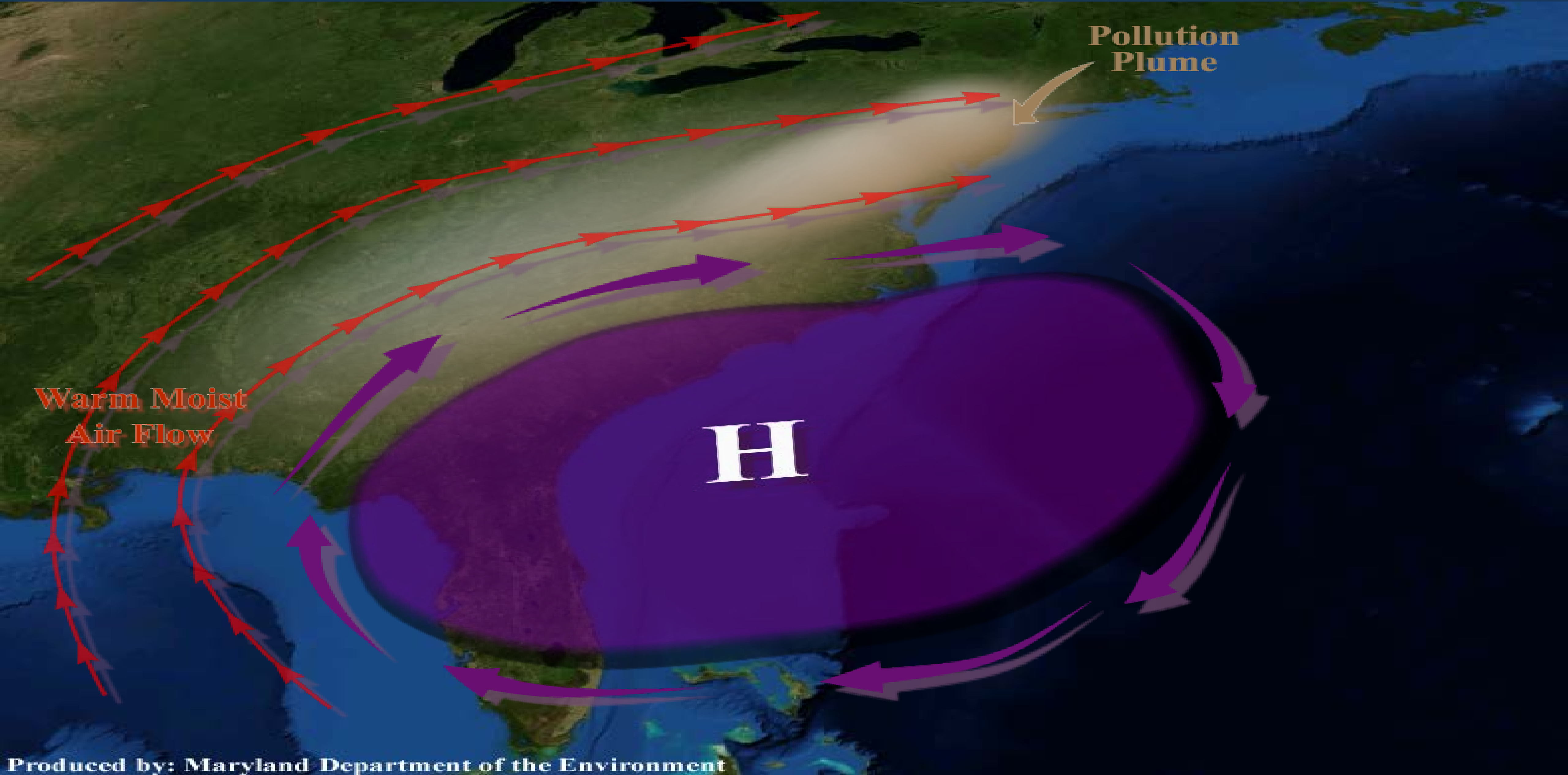
Some earlier research in Northern New England also looked at transport

More recently, 2017 research shifted to the north to study the NJ/NY/CT area

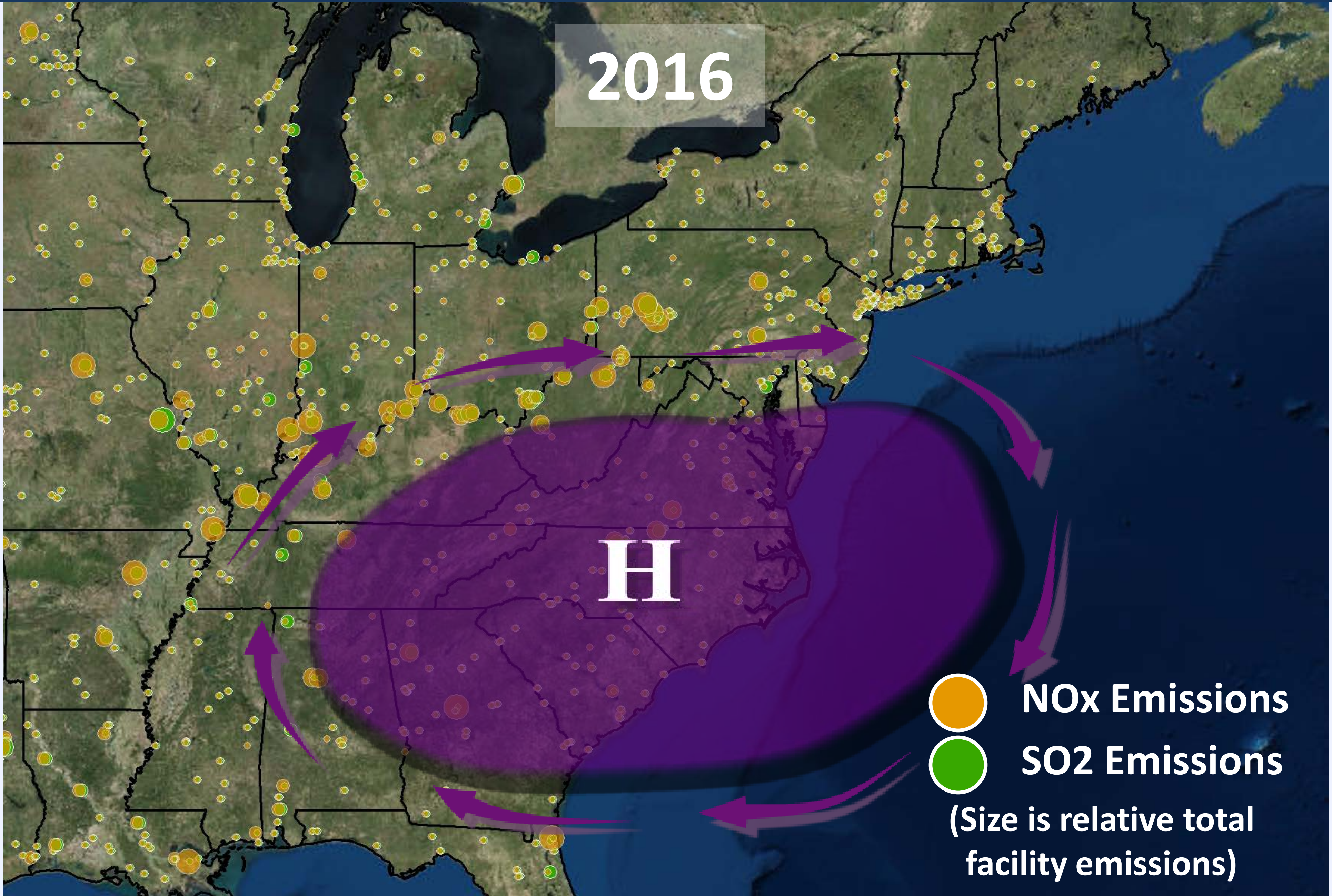
The Three Different Types of Transport



Classic Ozone Weather for the OTR

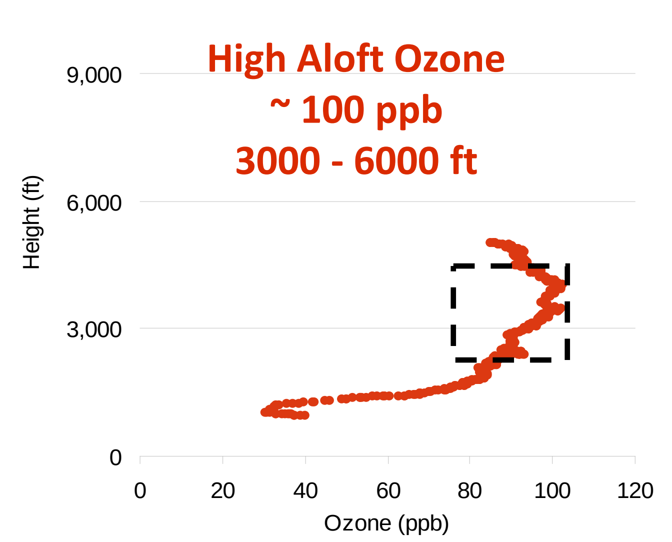


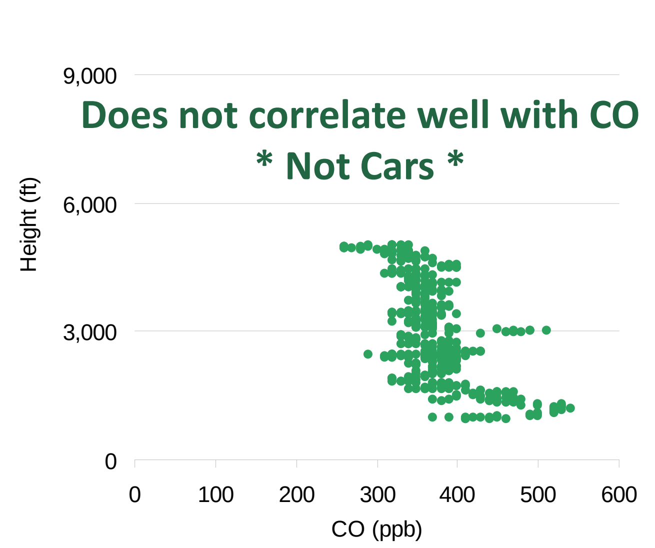
Westerly Transport

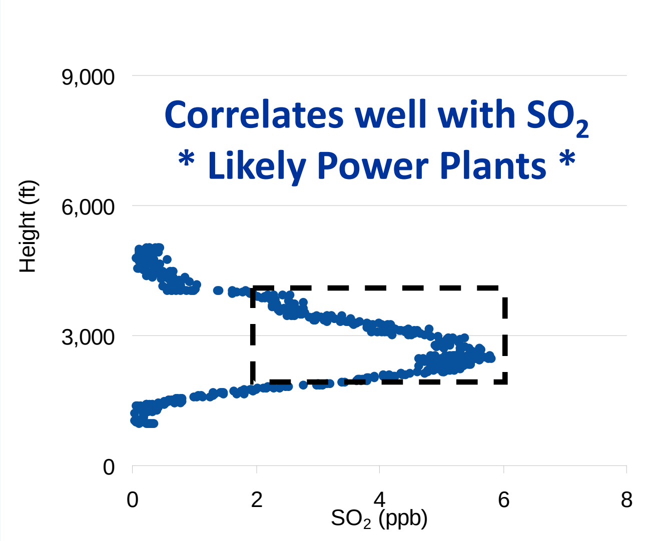


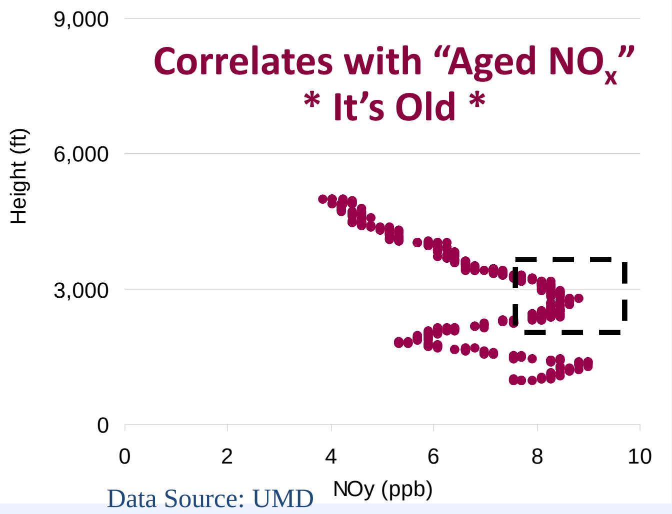
Fingerprinting Westerly Transport - Then

Classic work from 1995 - What can data tell us about its origin?





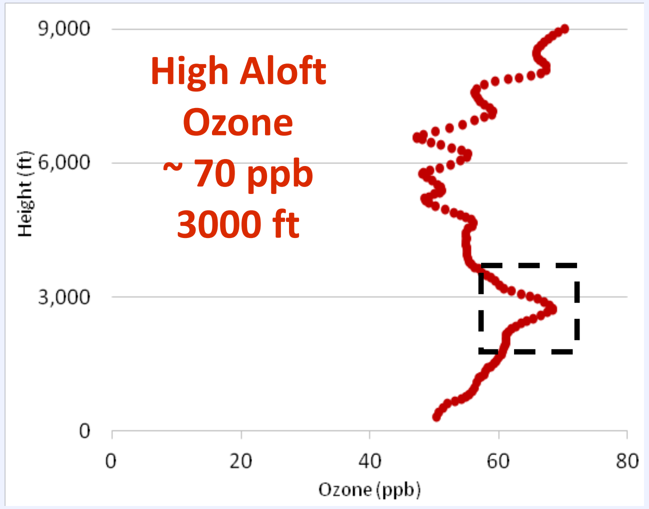


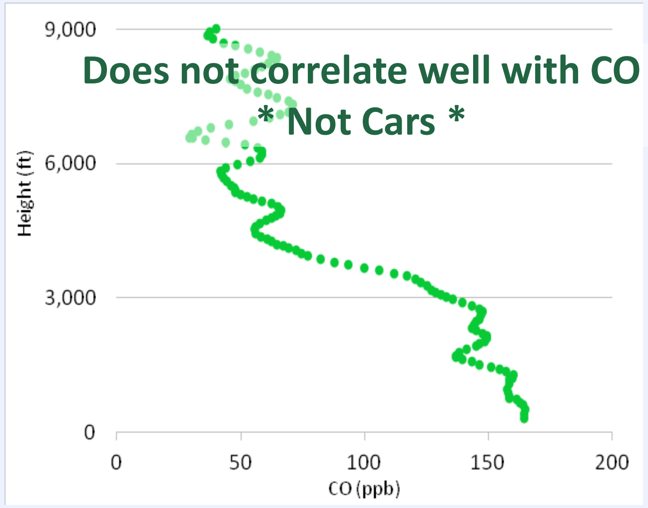


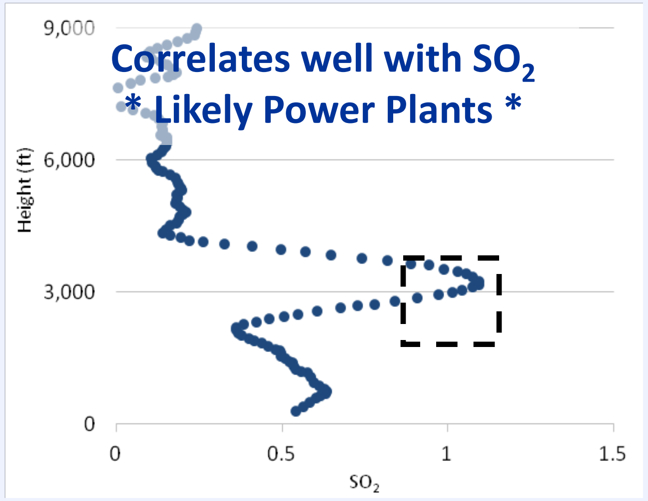
Vertical Profiles of Ozone, CO, SO_2 , and NO_y at Luray, VA **July 15, 1995** at 7 AM

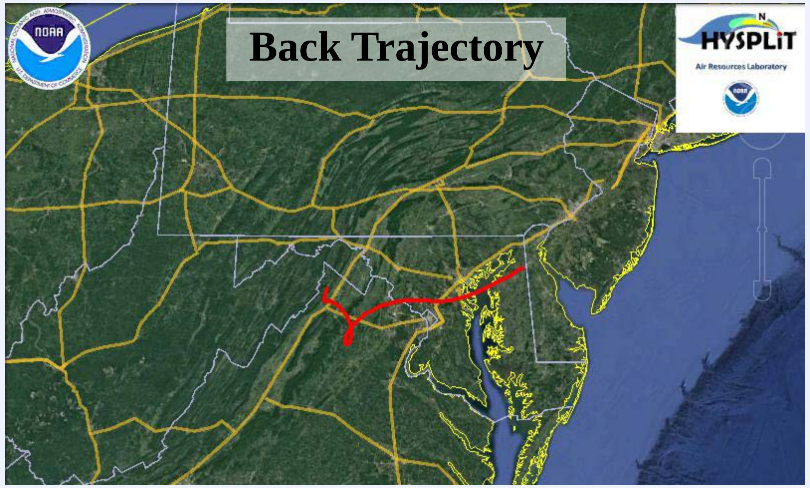
Fingerprinting Westerly Transport - Now

Same basic story - Just less ozone







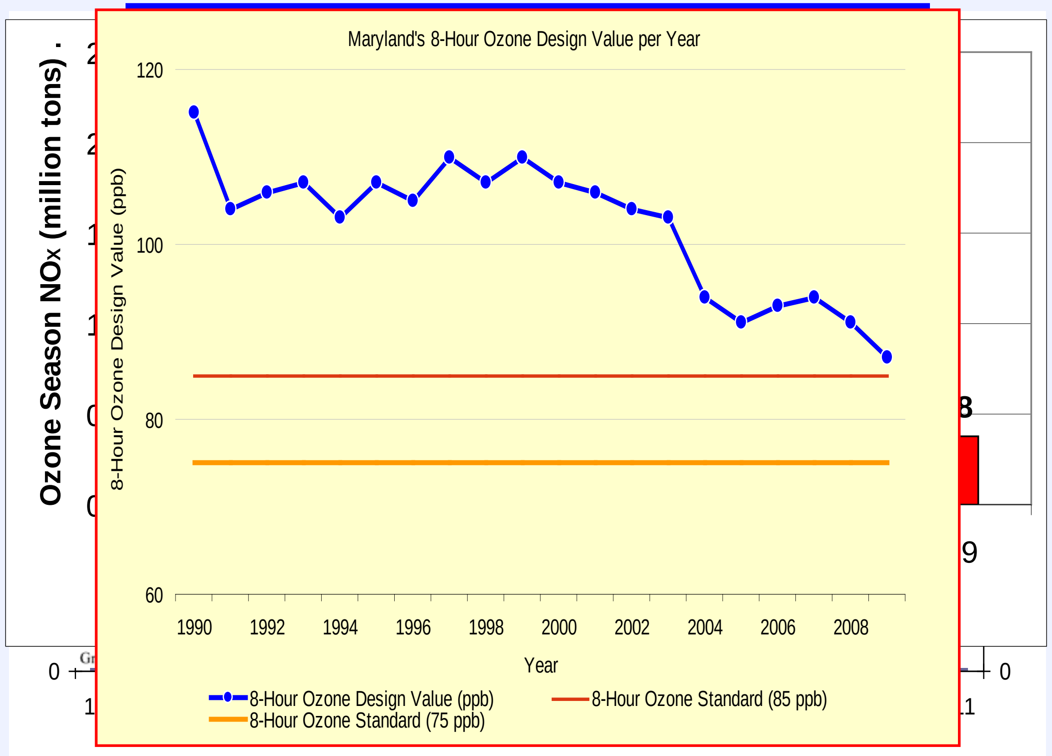


Vertical Profiles of Ozone, CO, and SO_2 at Millington, MD **July 19, 2013** at 12 PM

Data Source: UMD

Reducing Westerly Transport – A Classic Case Study

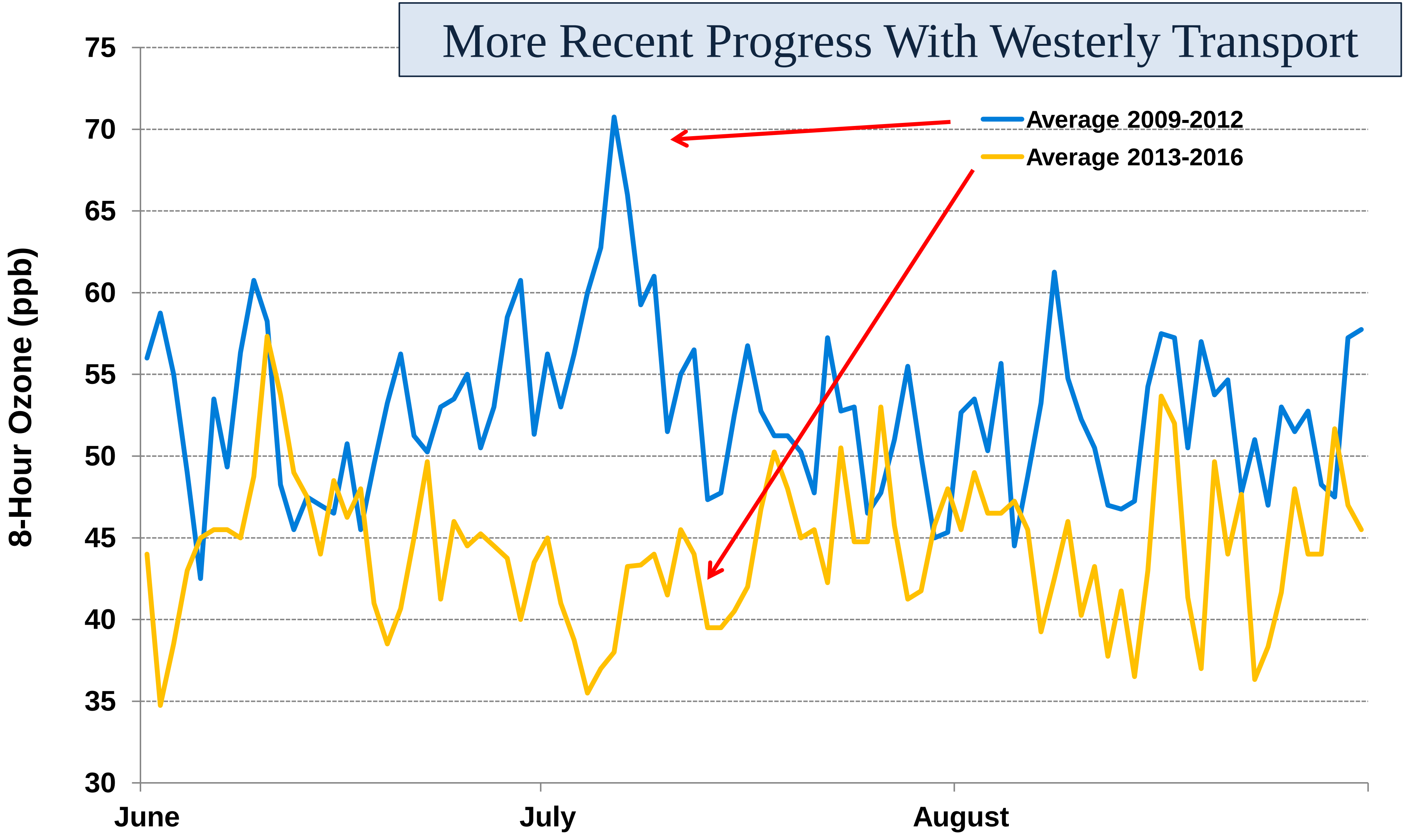
Ground Level Ozone Drops Dramatically in the Same Time Frame



The 2003/2004 "NO_X SIP Call" as a case study. Significant NO_X reductions from Federal Tier 2 Vehicle Standards occurring in the same time frame

- A classic ozone transport success story
- Incoming ozone levels collect in the elevated reservoir over night
- Real world programs like the NO_X SIP Call (power plants) and the Tier 2 Vehicle Standards show that:
  - Adding regional controls …
  - Results in regional NO_X emission reductions …
  - Which leads to reduced ozone in the elevated reservoir …
  - Which lead to lower ozone at ground level and public health protection!

Maryland's Westerly Transport "Spy" Site



Period	Avg. all days June – August
2009-2012	52.7 ppb
2013-2016	44.2 ppb

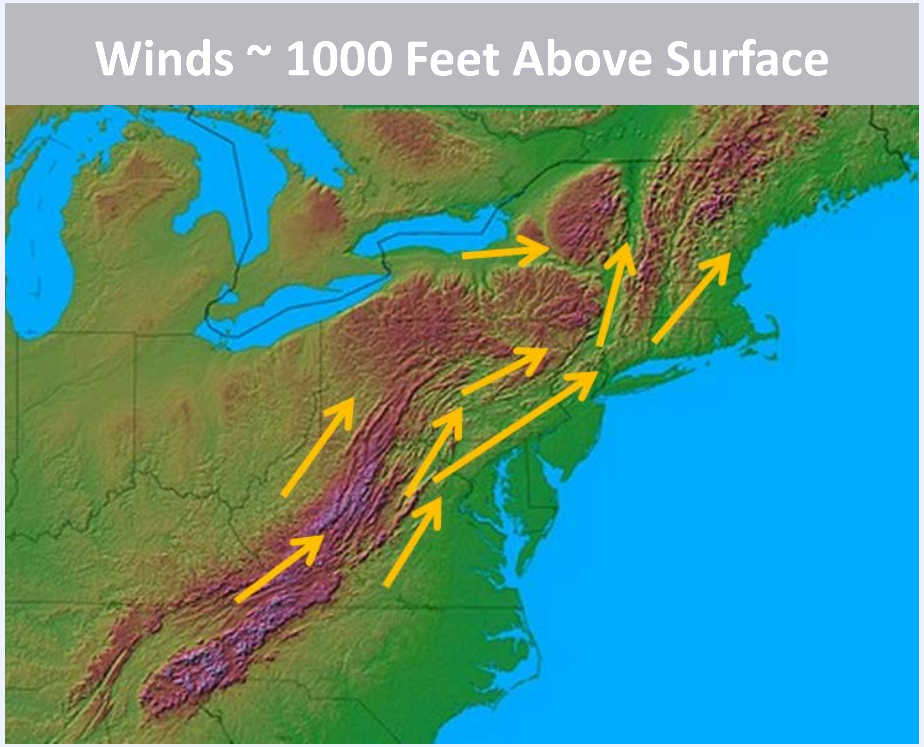
Difference 8.5ppb

4-year daily maximum 8-hour ozone average: 2009-12 & 2013-16

Piney Run is a mountain-top monitor and measures the amount of ozone being transported into Maryland's western border.

Southerly Transport at Night

The Nocturnal Low Level Jet (NLLJ)



Fast-moving, narrow "river" of air typically around 1000 feet above the surface

In the Mid-Atlantic and New England, 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.

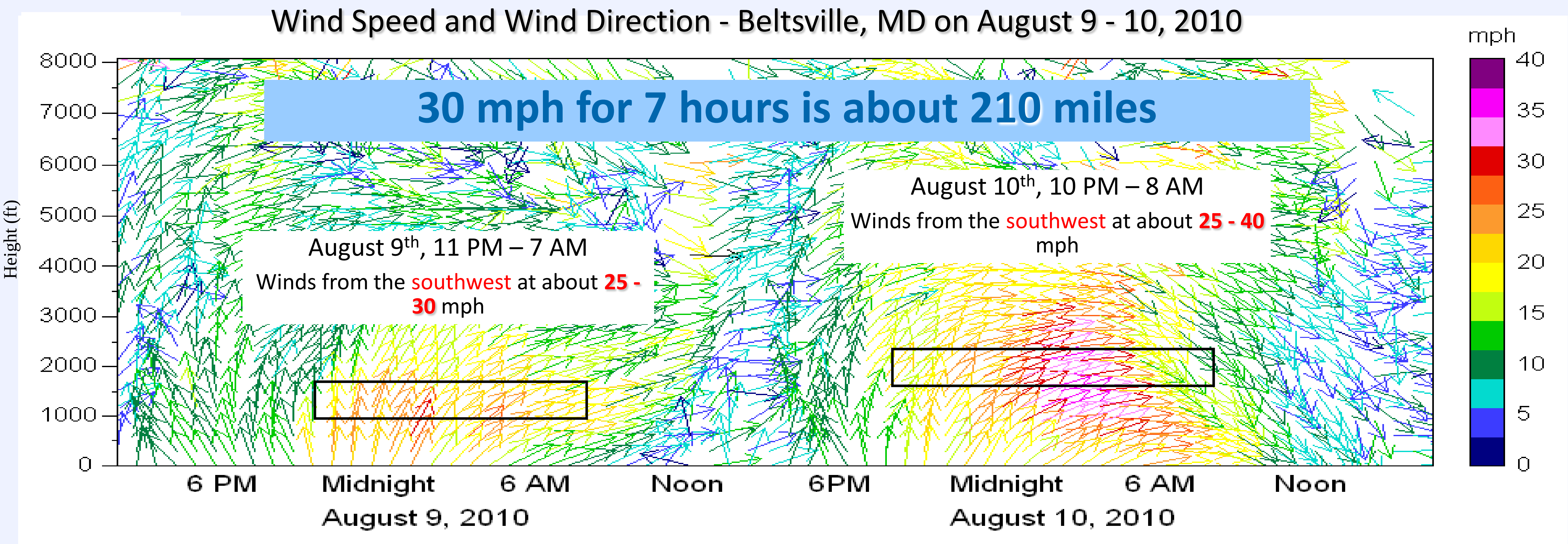
Seen during most, Mid-Atlantic summer-time air pollution events.

- Some form of NLLJ on virtually all code orange or red days

Old and new findings:

- 10 years ago … the presence of a NLLJ increased Baltimore ozone by 7 ppb.
- Past few years … Ozone being transported by the NLLJ is still important, but it has decreased remarkably

Measuring the Nocturnal Low Level Jet

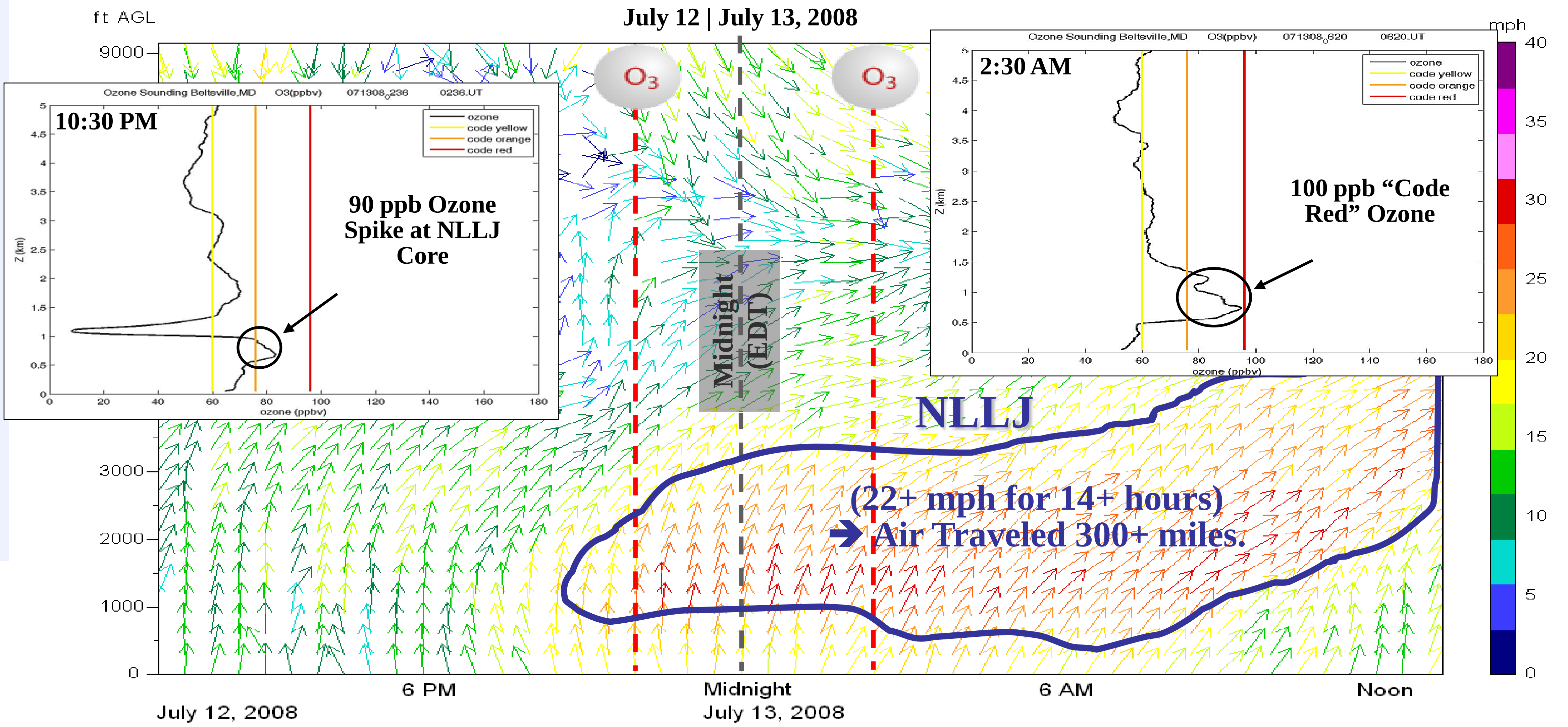


What does this graph tell us?
- Wind direction
- Wind speed
- From the ground up

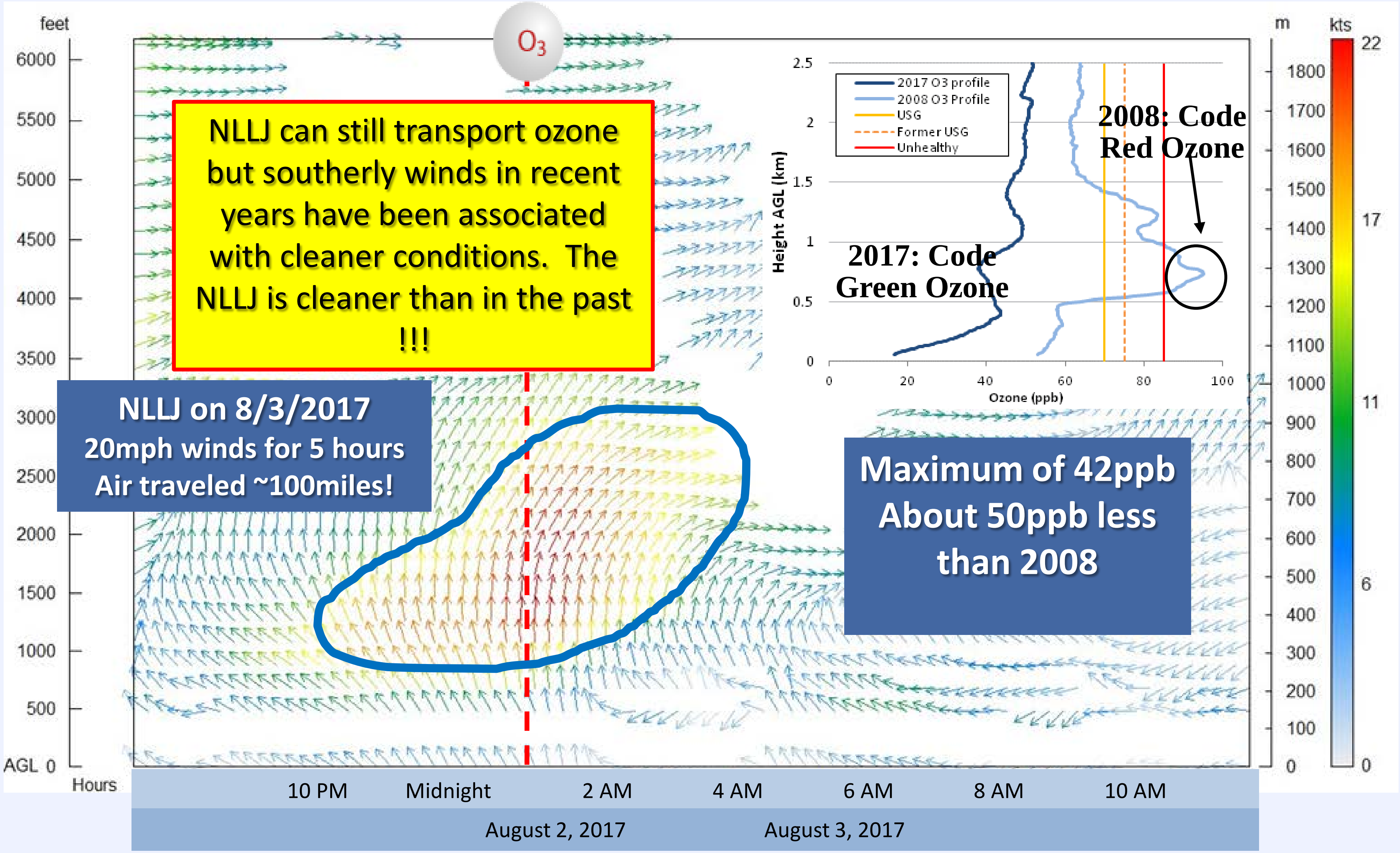
Upper-Air Radar Wind Profiler & RASS (MDE)

Measuring Ozone Transport in the NLLJ - 2008

Howard University launched 4 ozonesondes on July 12-13, 2008. The 10:30 PM (Saturday, July 12th) and 2:30 AM (Sunday, July 13th) occurred during a NLLJ event, as captured by MDE's Wind Profiler.



Progress - Lower Transport in the NLLJ - 2017



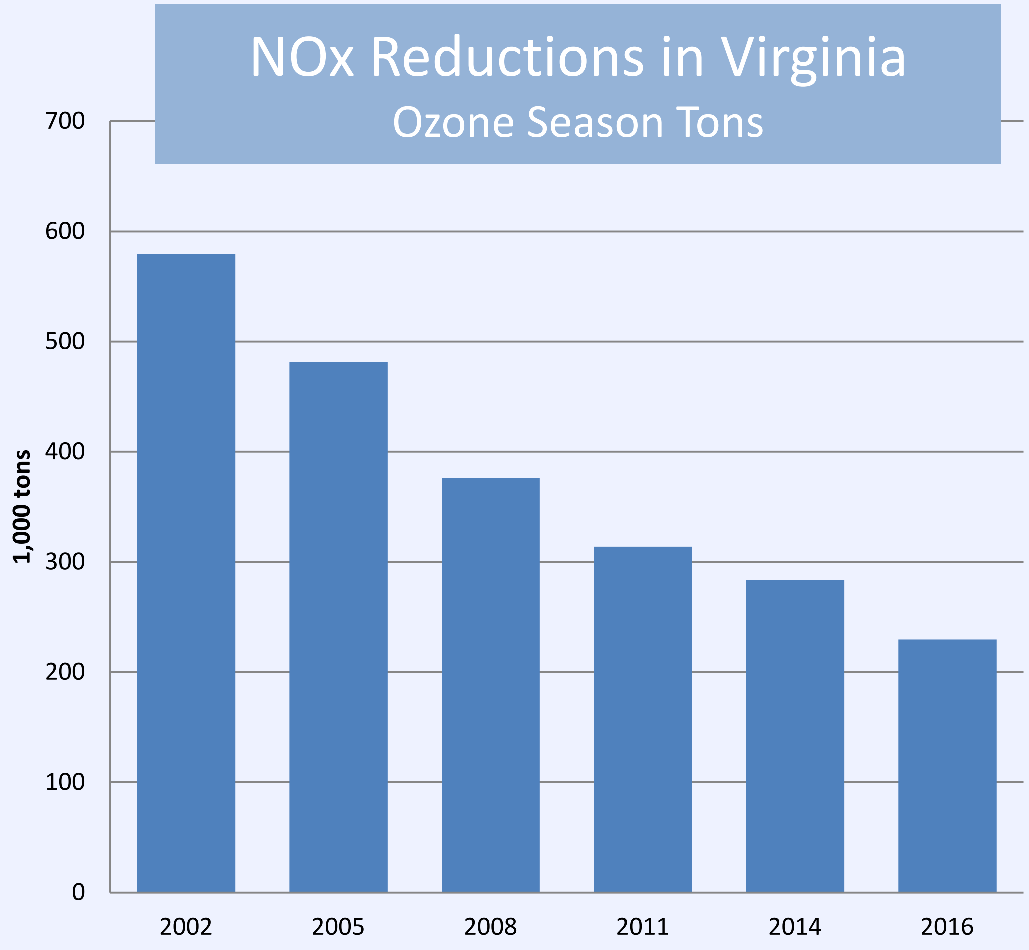
Lower Ozone in the NLLJ - Why?

10 years ago, we saw the NLLJ pushing high ozone levels from south to north all the time.

That has changed !!!

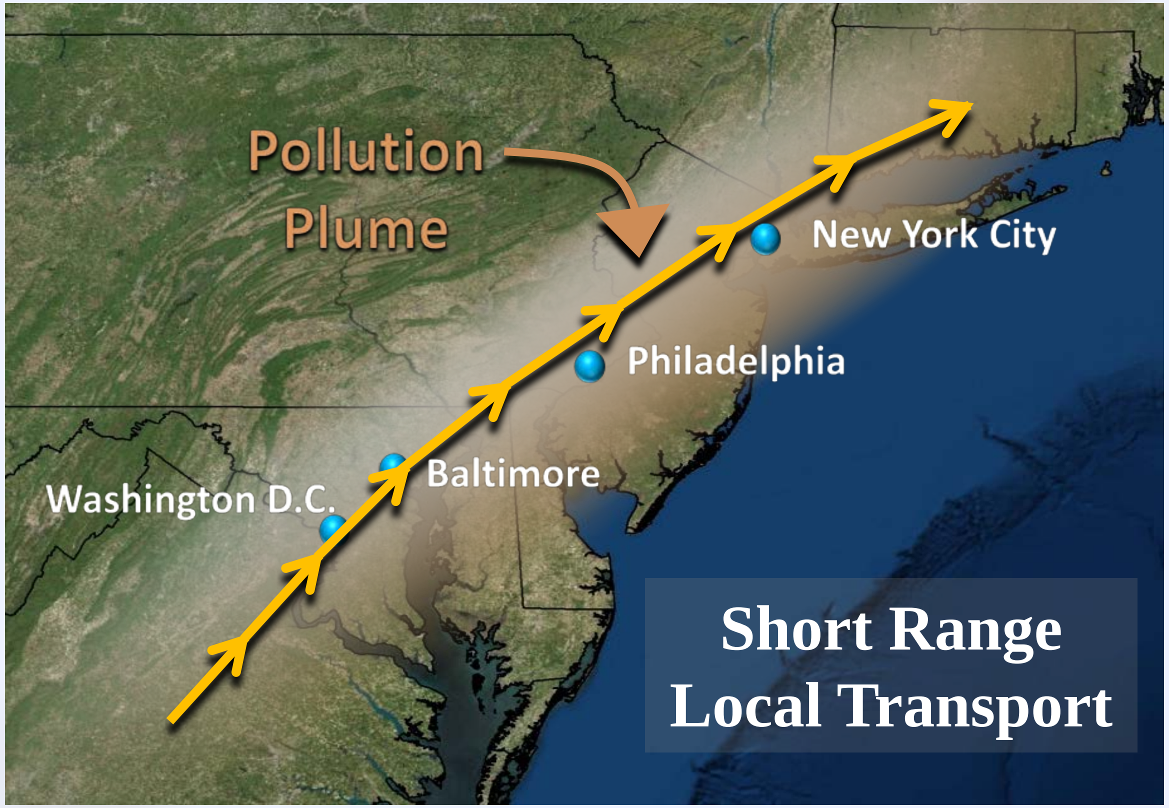
Large NO_x reductions in VA are clearly linked to this progress

Should continue to improve as mobile source NO_x is reduced by the Tier 3 Vehicle and Fuel Requirement and EGU emissions are further reduced by federal rules and continuing market pressures



City-to-City or "Local" Transport

- This type of transport is all at ground level … Westerly and NLLJ transport is aloft transport that mixes down
- Surface winds in the OTR are typically from the southwest to the northeast.
- The morning pollution in Washington stays at ground level and floats downwind to become a major part of the afternoon pollution in Baltimore
- The morning pollution in NJ, NY and New York City becomes part of the afternoon ozone pollution measured in CT
- MD to PA … PA to NJ … NJ to NY … NY to CT … CT to MA … MA to NH & ME … and so on



What Drives "Local" Transport?

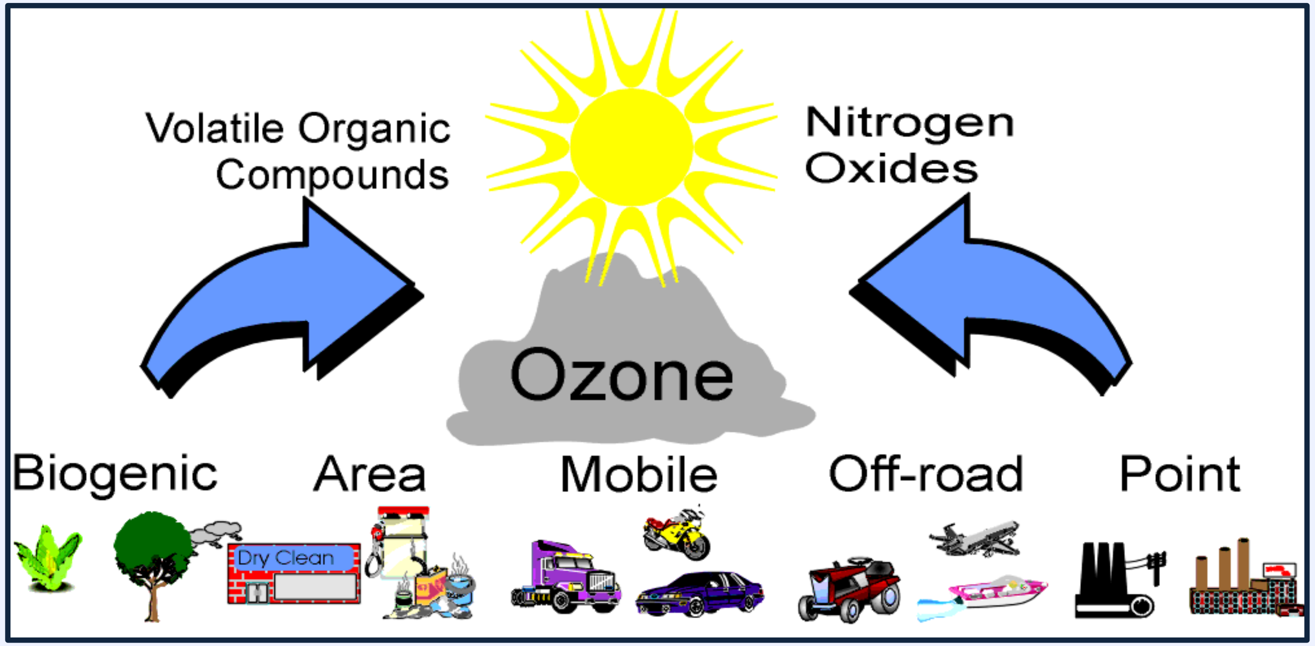
Includes emissions in the nonattainment area, emissions from close by upwind cities and emissions from other emission sources in the "local airshed"

- In OTR low level winds generally push pollution from the southwest to the northeast - but not always

Sources include everything …

- Cars, trucks and other mobile sources along the I-95 corridor
- Power plants including "peakers" that don't run every day, but often run on the hottest (worst for ozone) days
- Collectively, the hundreds to millions of "mini" or area sources linked to people doing things (painting, consumer products, small businesses like dry cleaning and so on and so on…)

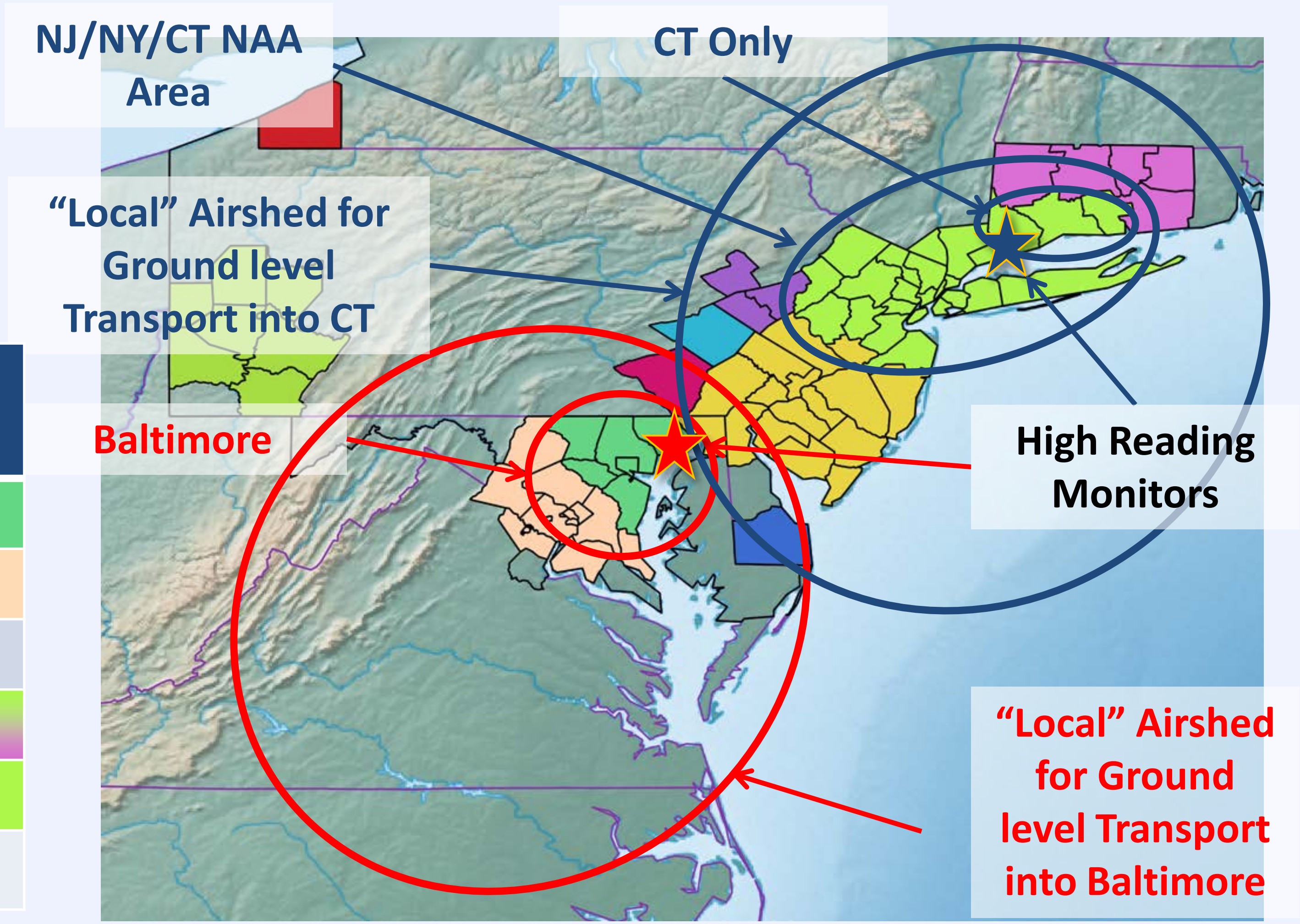
We know that reducing local NOx emissions works. In areas like New York City, reducing local volatile organic compounds (VOCs) also appears to be important



Two Examples of "Local Airsheds"

Approximations of the local airsheds for the Baltimore and the NJ/NY CT Nonattainment Areas

Approximate 2011 NO_X Emissions Tons per Year	
Baltimore NAA	~ 70,000
Washington NAA	~ 96,000
Baltimore Local Airshed	~ 500,000
Just CT	~ 65,000
NJ/NY/CT NAA	~ 330,000
CT Local Airshed	~ 900,000



Continued Daytime Contribution from Long Distance, Aloft Transport

While local and city-to-city transport continue through the daytime … on the worst ozone days … daytime ozone transport from aloft is added to the mix.

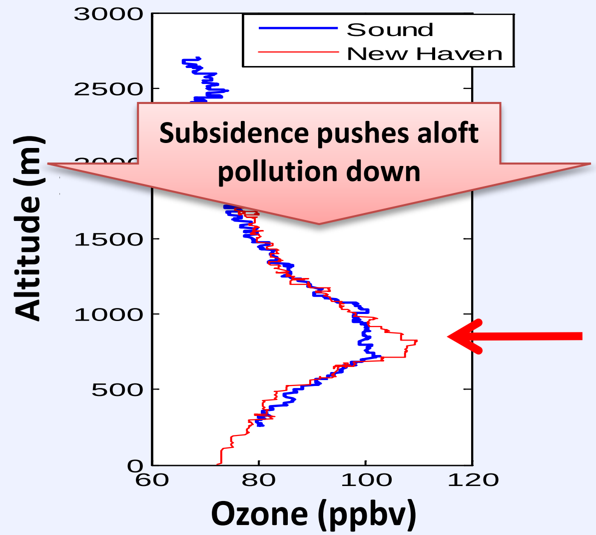
- Wind and sunshine act like a boat propeller and "mix" air higher up with air near the surface.
- High atmospheric pressure causes a weather phenomenon called subsidence. Literally the atmosphere pushes the aloft air towards the surface

Vertical mixing is a two-edged sword

- On days with **dirty** daytime aloft transport - dirtier air aloft is mixed down making ground-level ozone **worse**
- On days with less continuing transport **cleaner** air aloft is mixed down making ground-level ozone **better**

Afternoon Aircraft Spiral

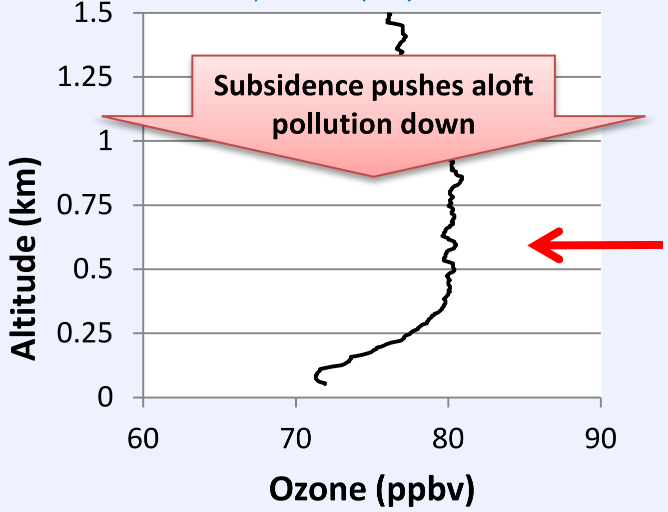
Fairfield, CT – 5/17/2017



100+ ppb aloft in the afternoon

Afternoon Balloon Launch

Beltsville, MD – 5/17/2017

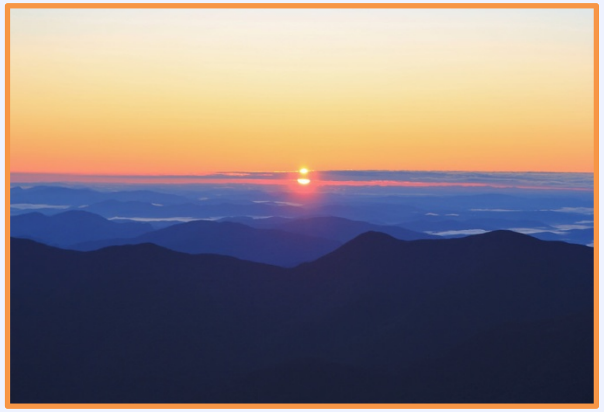


80+ ppb aloft in the afternoon

Three Other Critical Issues that Make Ozone in the OTR Challenging

Fine-scale but policy critical phenomena driven by local chemistry, meteorology, and geography make afternoon ozone extremely interesting but troublesome

- Changing chemistry - less ozone being formed - in most areas of the OTR
  - But not as much in NJ/NY/CT !!!
- The build up of very high ozone over water bodies like the Chesapeake Bay, Long Island Sound and off the Northern New England Coast
  - Higher ozone levels over water than over land
- Local wind patterns like Bay and sea breezes often push the high ozone over the water onto the land
- Other routine summertime wind patterns like something called the “Lee-Side Trough” can change flow of ozone from “west to east” … to … “south to north” … sort of a hard left in MD/PA … up to CT



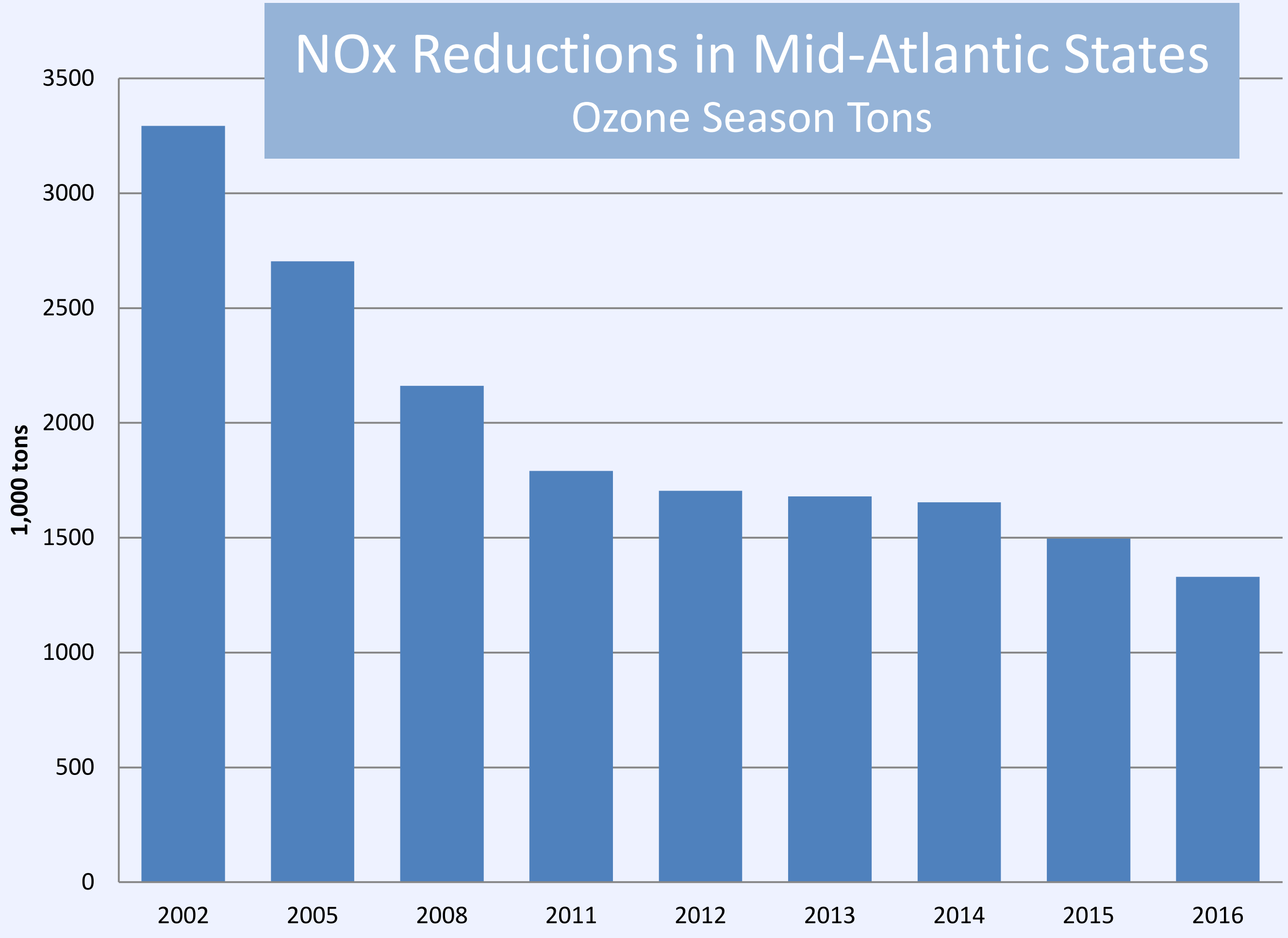
Changing Chemistry … Some Good News

In the Mid-Atlantic, NO_x reduction efforts seem to be returning unexpected dividends

We know that regional NO_x reductions will clearly reduce ozone levels

It appears that in 2017, enough NO_x has been taken out of the system that the chemistry has changed

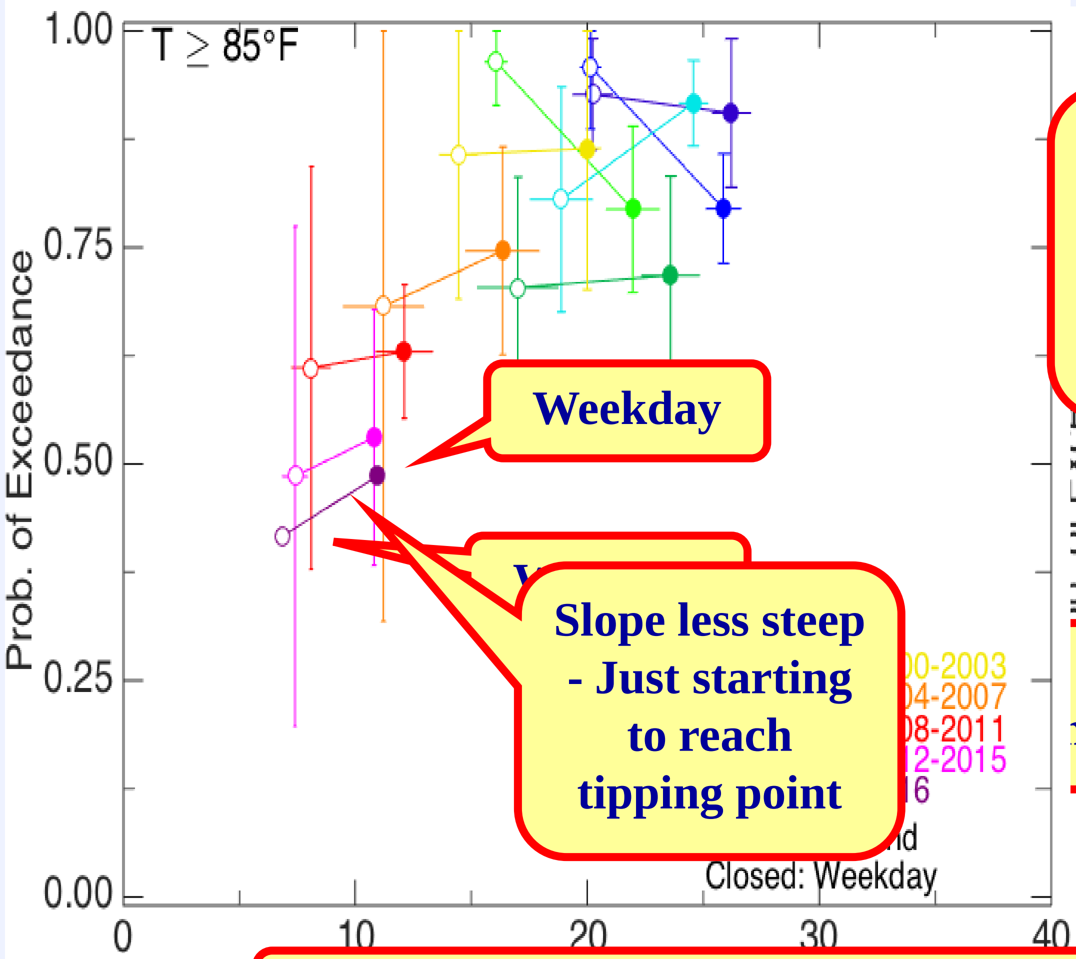
- We now get more ozone reduction per every ton of NO_x we reduce compared to 2000



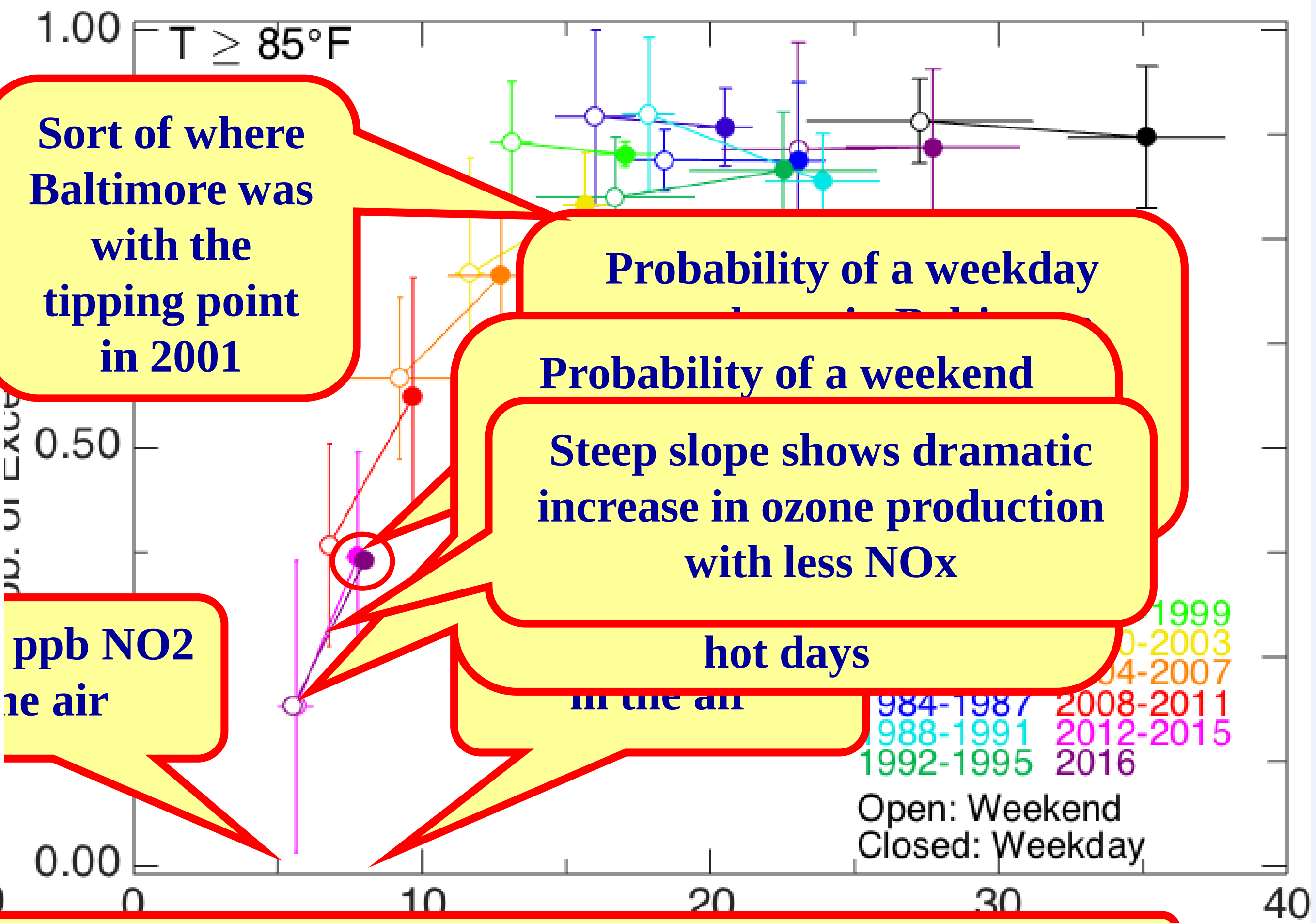
Why a Ton of NOx Reductions Works Better in Baltimore

- We can calculate the ozone production efficiency in an area and how it relates to measured

Likelihood of an Exceedance in NJ/NY/CT
1996 to 2016



Likelihood of an Exceedance in Baltimore - 1996 to 2016



The key to pushing the tipping point in NJ/NY/CT … Keep reducing NOx emissions

7. What do we learn

Ozone and Bodies of Water

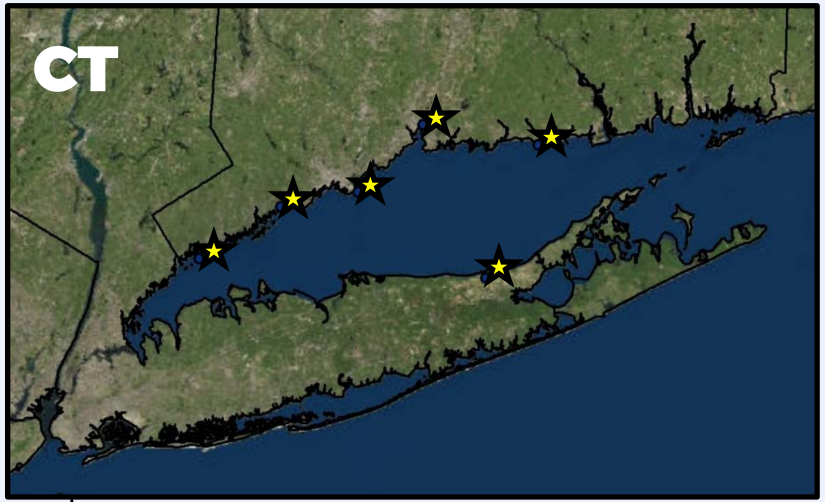
The dreaded "Land/Water Interface" issue

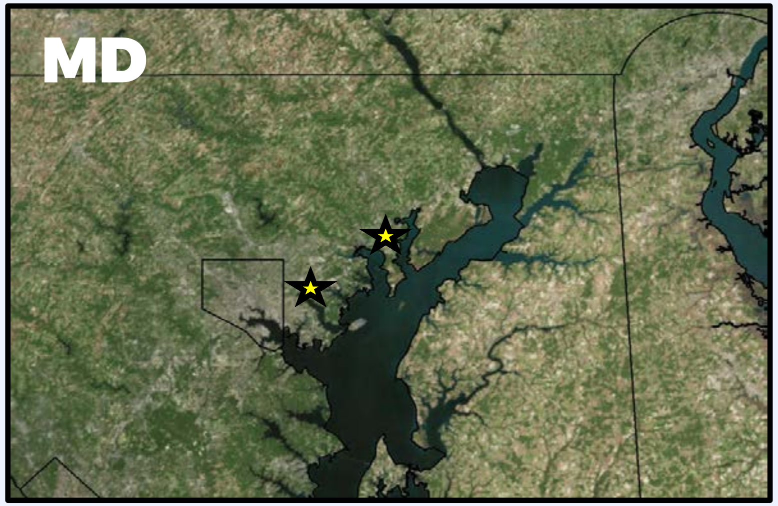
Why are the toughest monitors to solve (Harford, MD - Fairfield, CT - Suffolk, NY, Coastal NE) located right next to bodies of water?

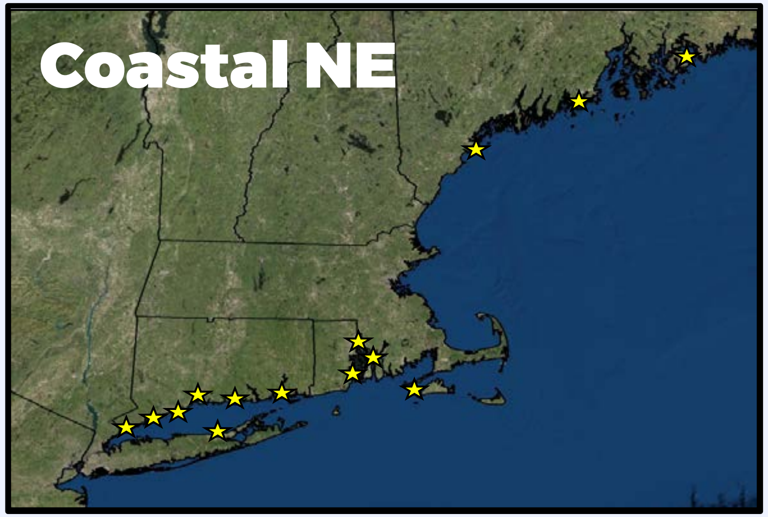
- The Chesapeake Bay, the Long Island Sound, the Atlantic Ocean off of the northern New England coast, etc.
- Not unique to the OTC - Sheboygan WI another great example

The meteorology, geography and chemistry are slightly complicated

- … but the reality is ozone is almost always higher over water than land







★ - Land/Water "Problem" Monitors

How do We Know Ozone is Higher Over Water?

Lot's of studies, lots of theory say it is so

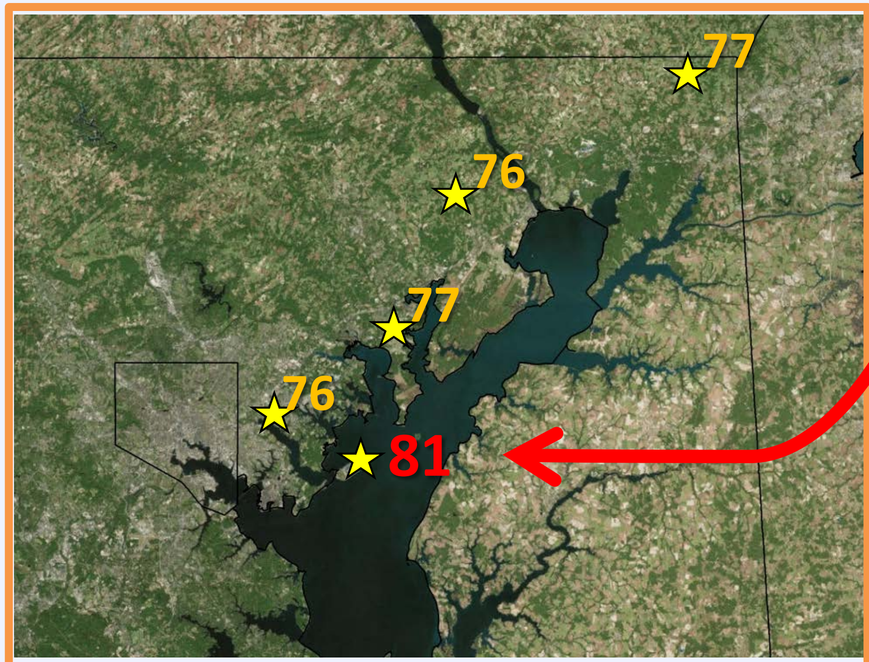
But, for the last three years, Maryland has run a research monitor at Hart-Miller Island - right in the middle of the Chesapeake Bay.

- It consistently reads higher for ozone on bad ozone days

Although a treasured resource, the Bay can be a "dirty air collector" and an "ozone factory"

- At night the water is warmer than adjacent land pulling polluted air from the land over the water. With sunlight the already polluted air over a body of water forms even more ozone.
- Water is often cooler than land. The mixing height over the water is always lower than on land. Less room to spread out - higher concentrations of ozone.
- Light reflectivity also increases over bodies of water and leads to increased ozone formation
- 2011 Discover AQ ozone study also showed that chemistry over the Chesapeake Bay can enhance ozone formation

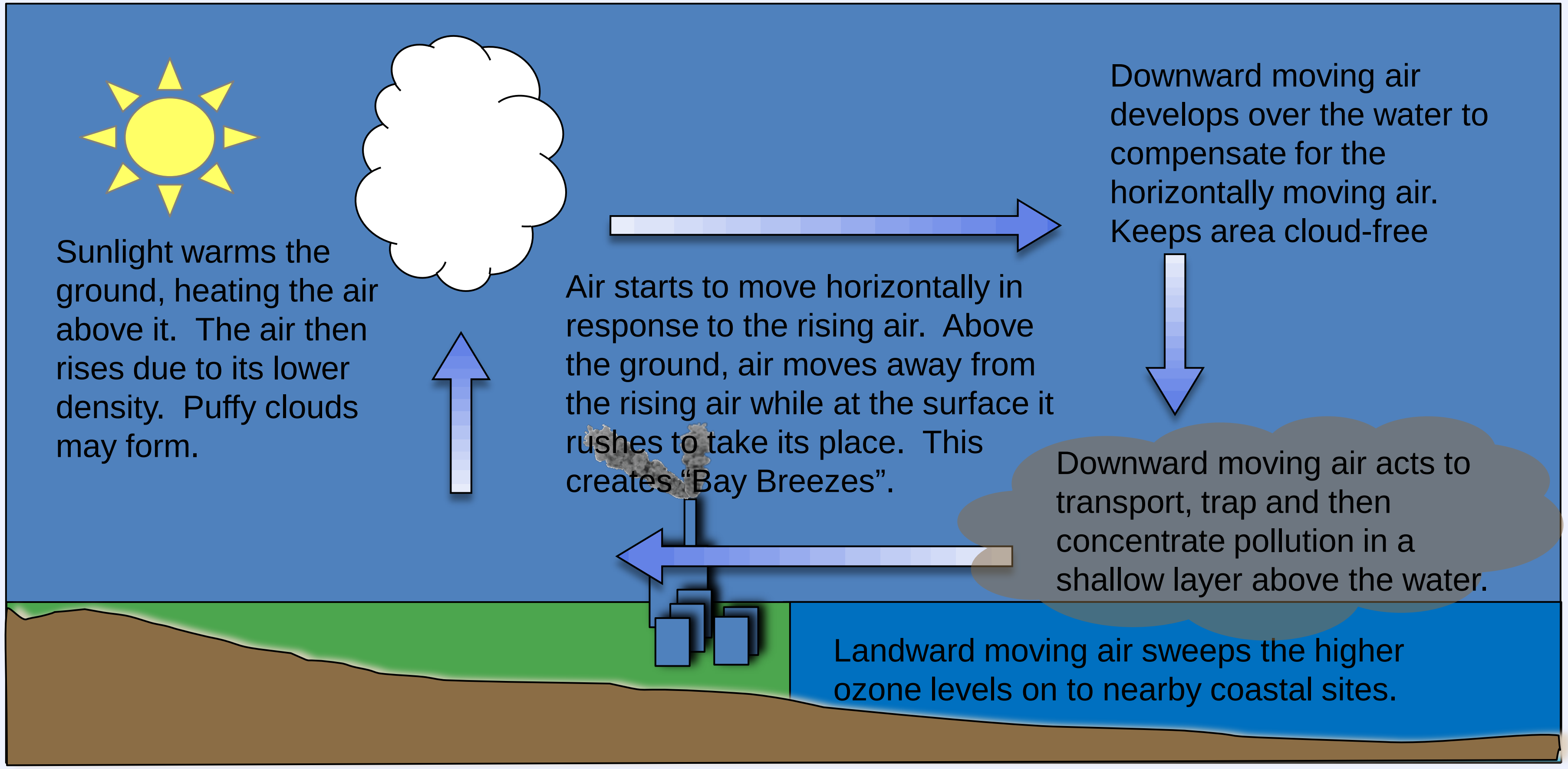
Highest Ozone on Bad Days in MD … Right in the middle of the Bay



Average Ozone Concentration (ppb) on Exceedance Days 2016

Bay and Sea Breezes

To make matters worse, meteorology and geography conspire to create Bay and sea breezes that push and pull the dirtier air over the water - back onto land where people live



SO … WHAT HAVE WE LEARNED

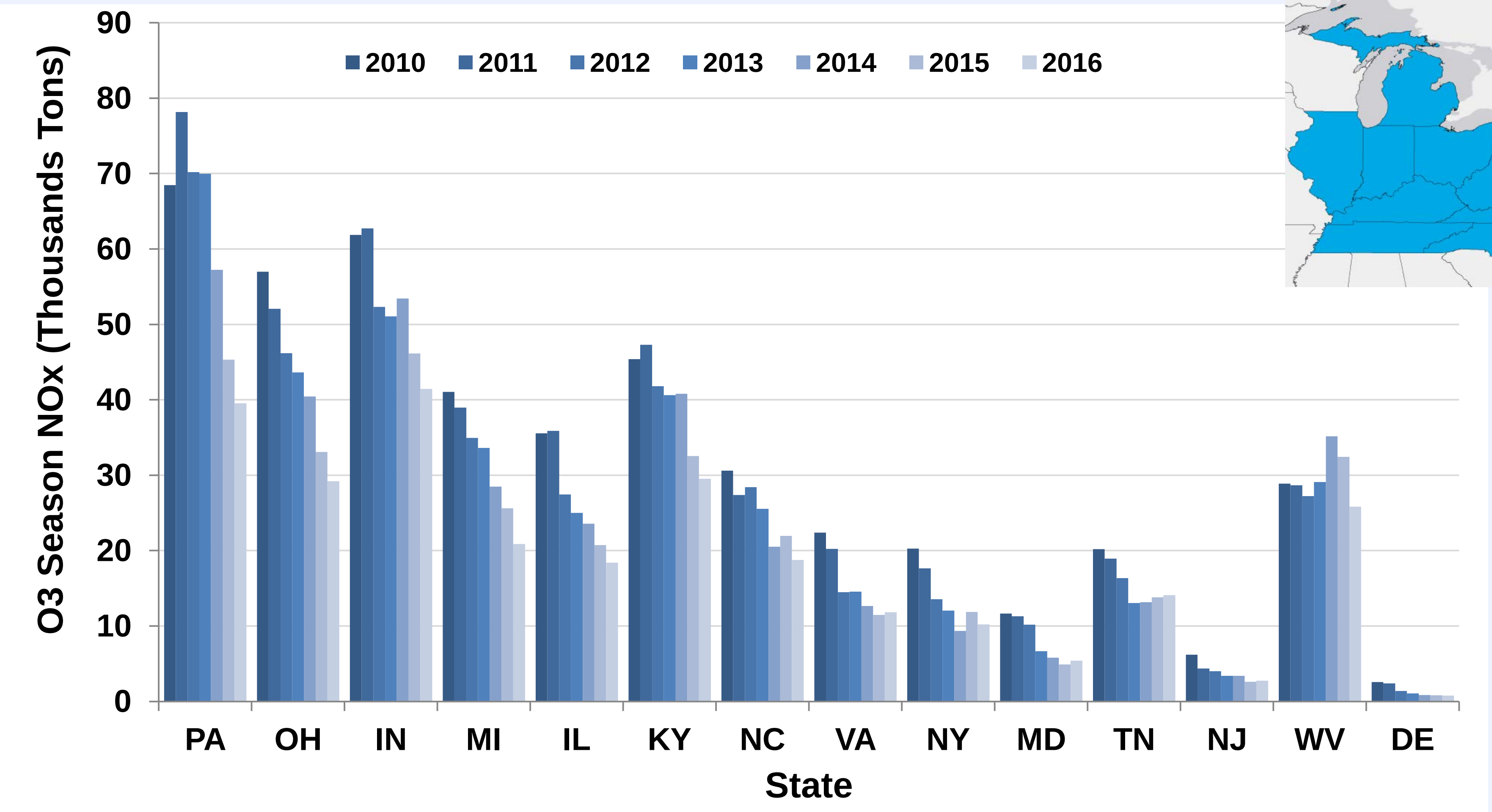
AND

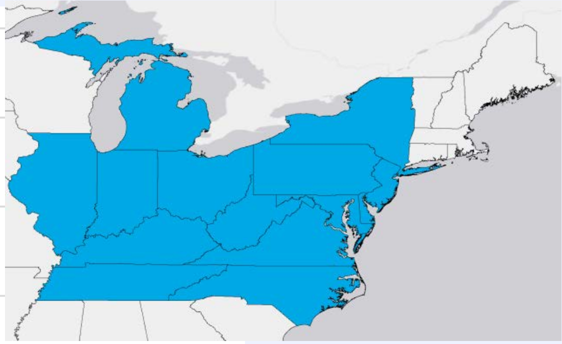
WHERE DO WE GO NEXT

EGU Emissions - Are We Winning the War?

Sort of … Ozone season EGU NO_x emissions continue to decrease across the East

- That said, still more work to do
- Most states had lowest ozone season NO_x emissions on record in 2016

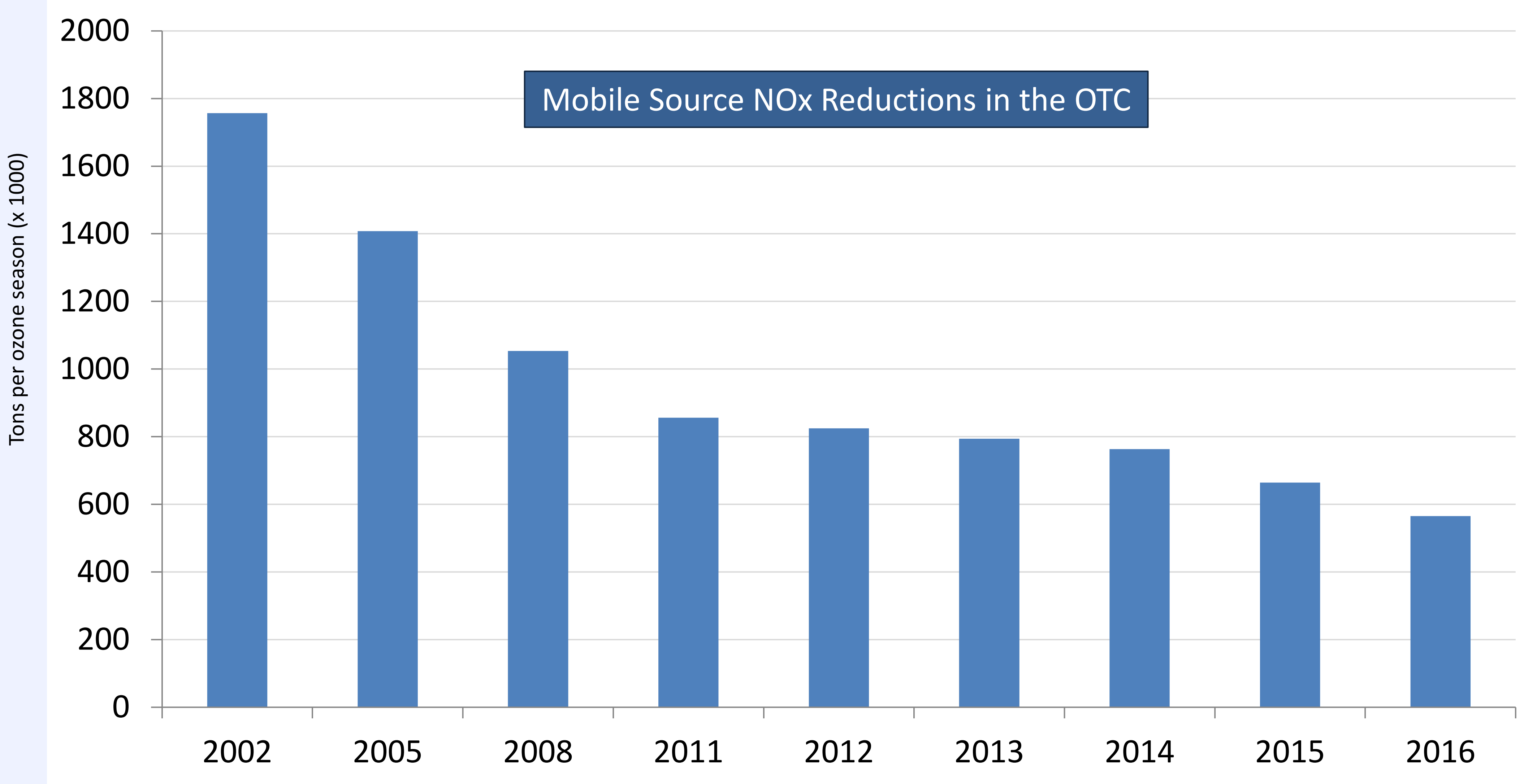




Shown are states from which emissions may influence ozone concentrations in OTC states.

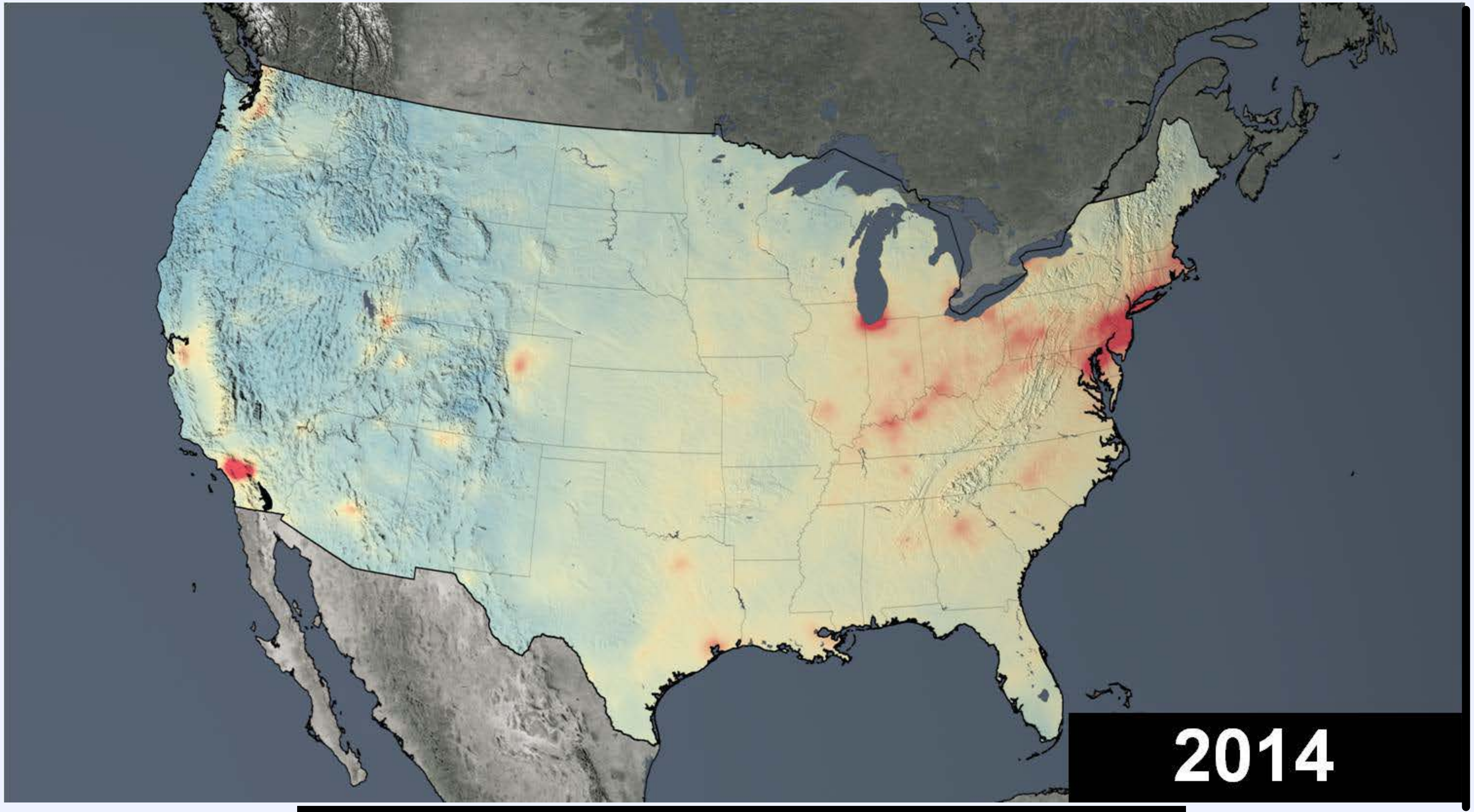
How About Mobile Source NOx Reductions?

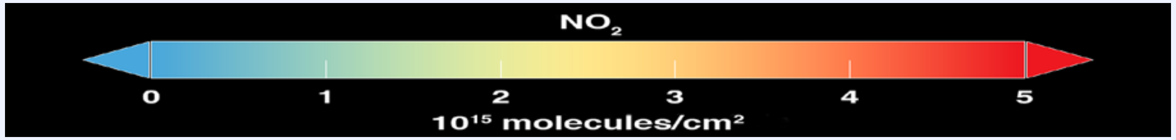
Significant reductions in this sector as well … more on the way



NOx Reductions As Seen From Satellites

NO_2 Reductions from Space - 2005 to 2014

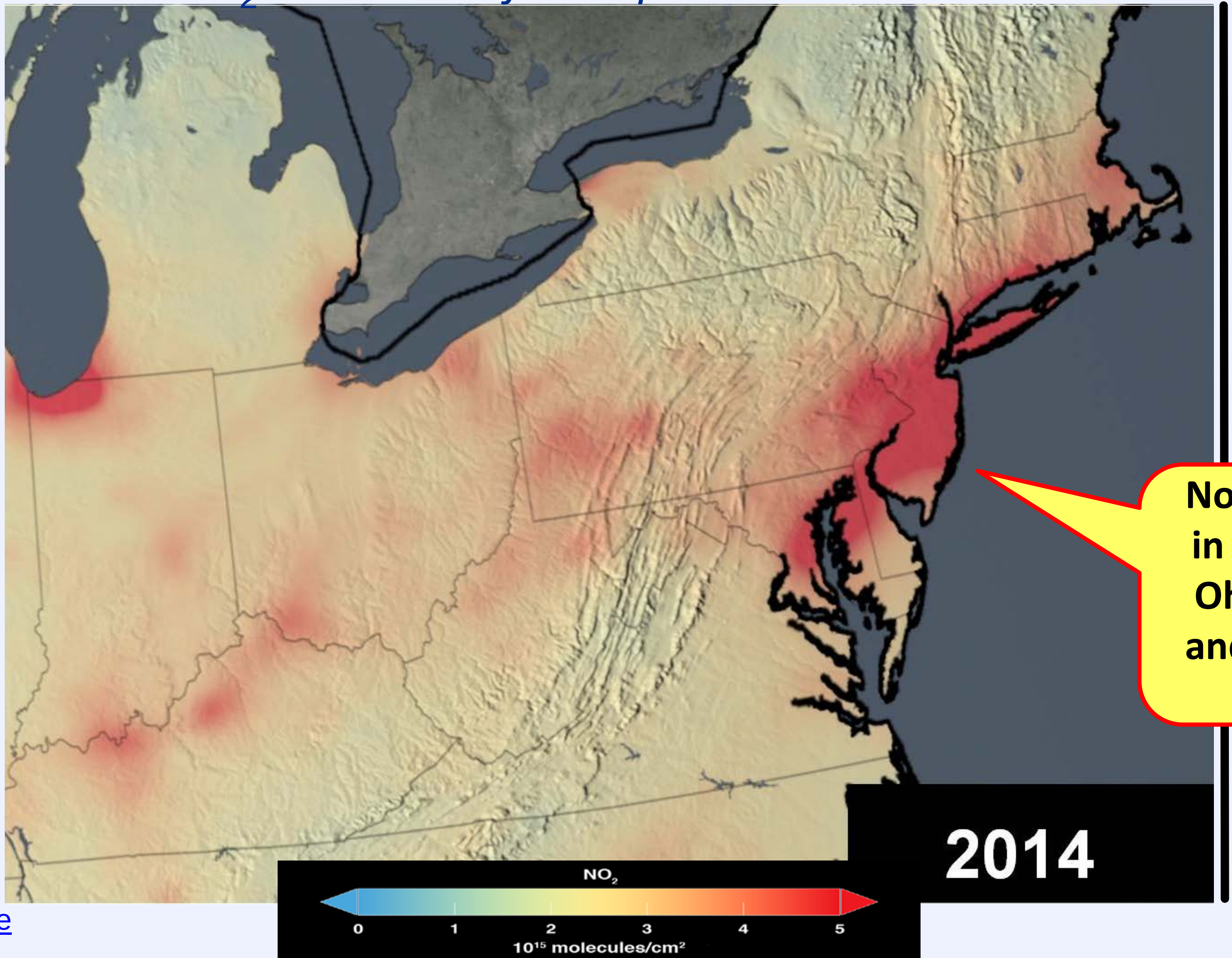




Source: [NASA's Aura Satellite]

Focusing on the East

NO_2 Reductions from Space - 2005 to 2014

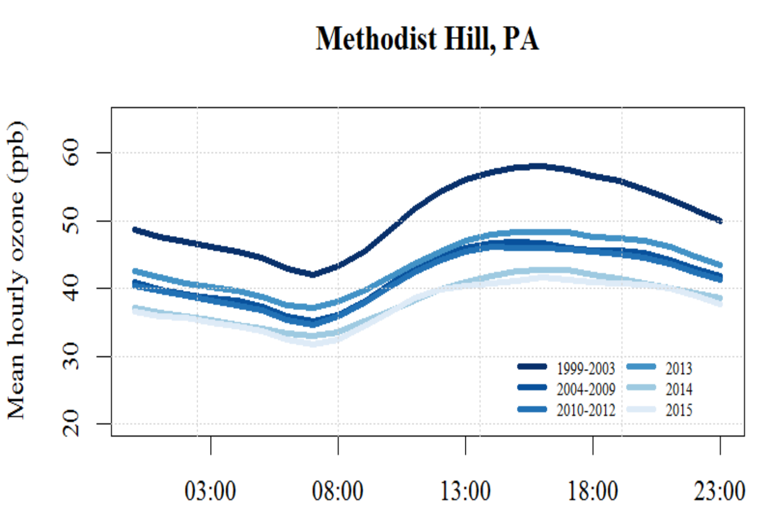


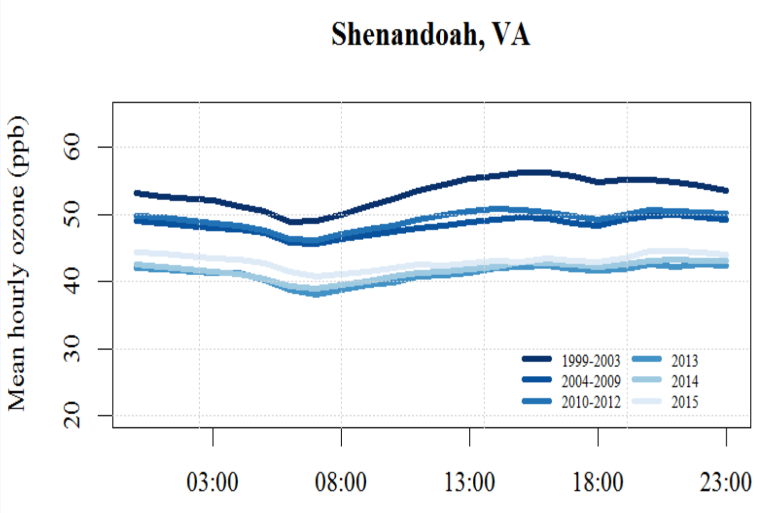
Notice the change in NO2 along the Ohio River Valley and along the I-95 Corridor

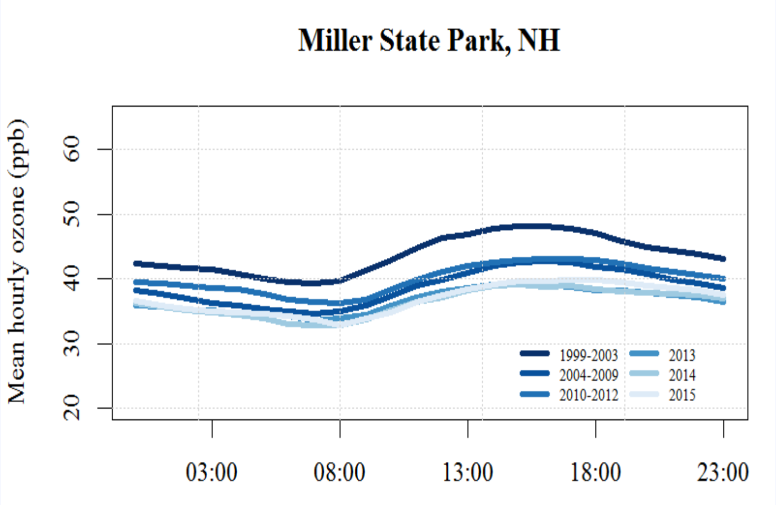
Source: [NASA's Aura Satellite]()

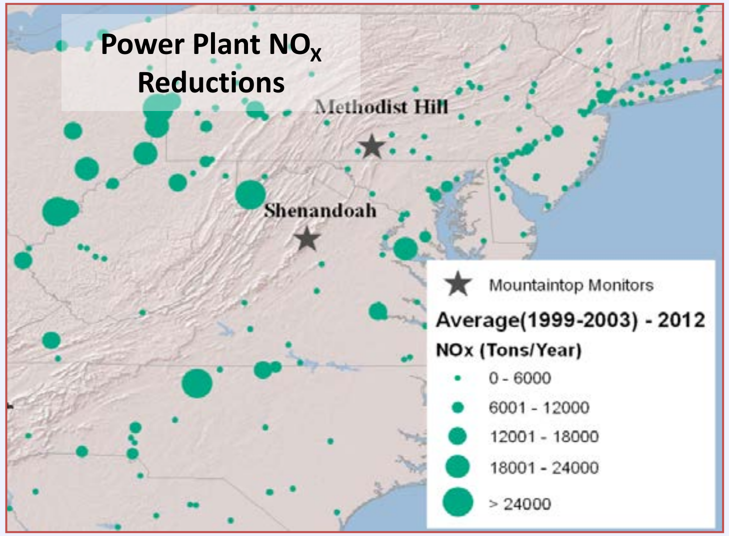
Aloft Ozone Reservoir - Lower Each Year … i.e. Less Transport

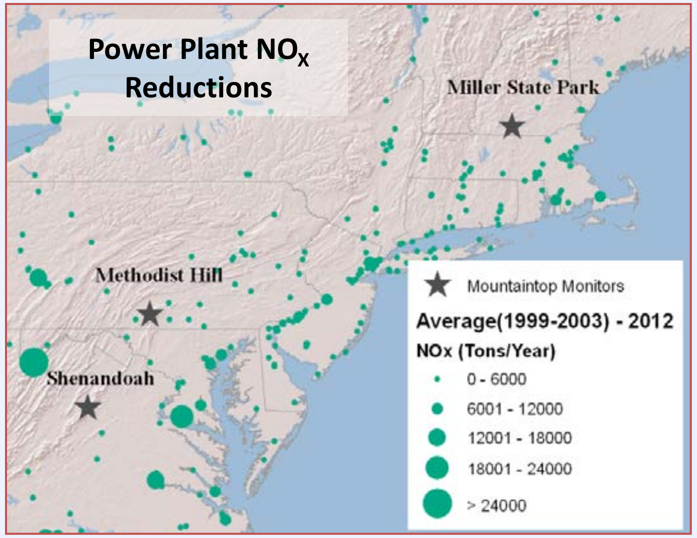
Dramatic Progress in Reducing Long Distance, Aloft Transport





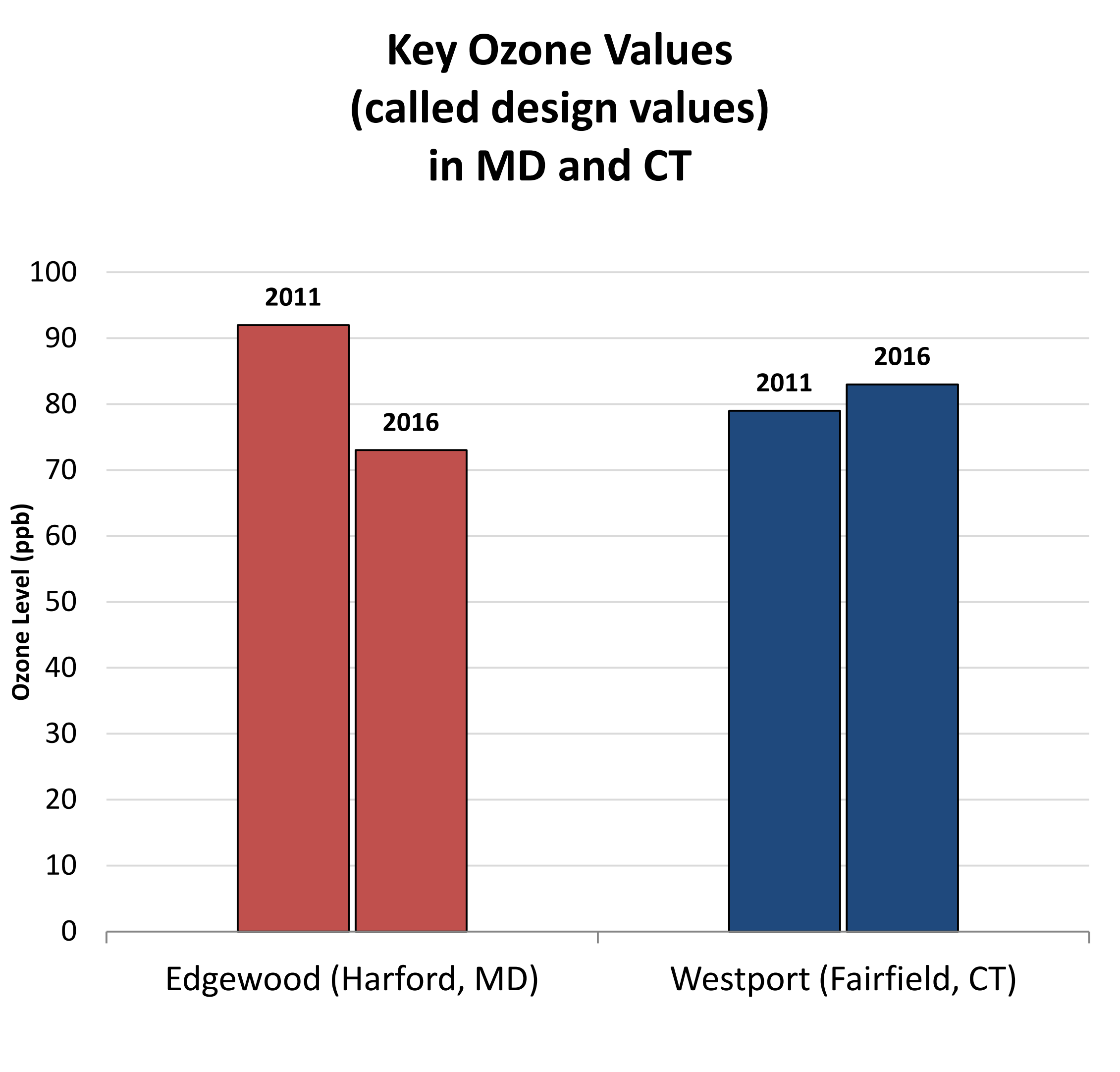




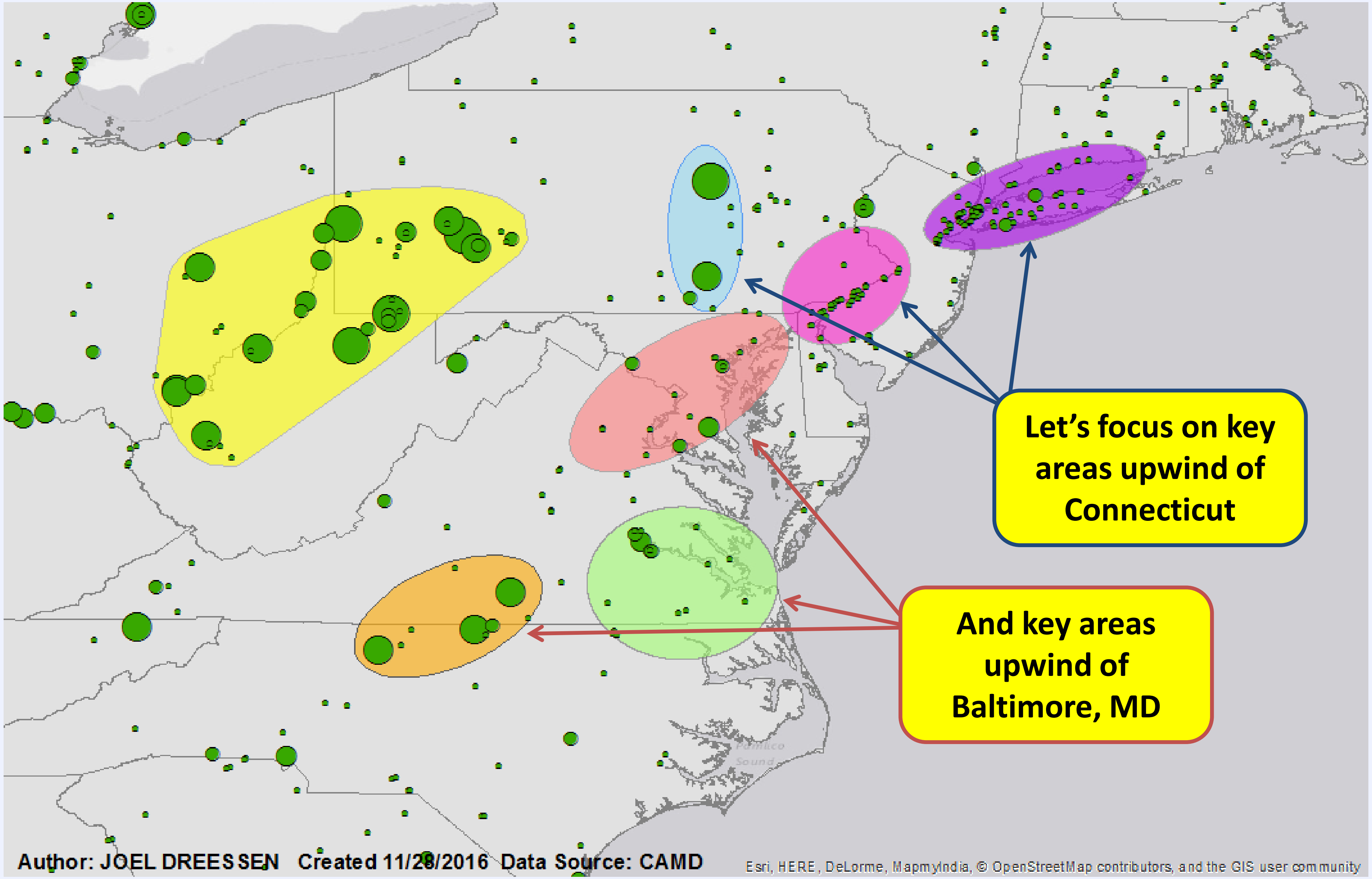


That's All Great, But What Going on in Connecticut?

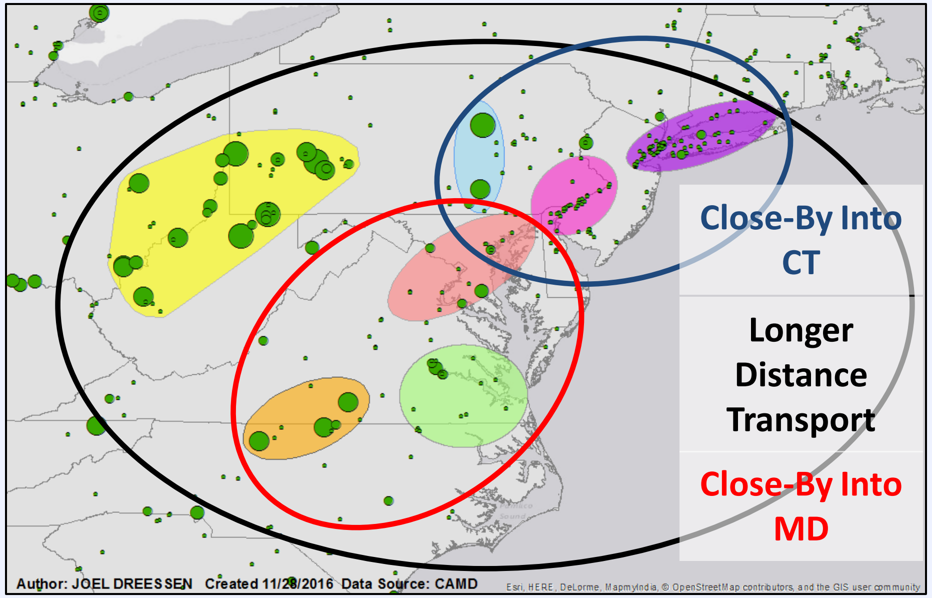
- Ozone has been going down in almost all of the East … Except in Connecticut
- Why?
- Research shows that the NJ/NY/CT area has just started to reach the tipping point in the atmosphere that allows new NOx reductions to generate even greater ozone benefit
- It also appears that NOx emissions from EGUs that are directly upwind of NJ/NY/CT are not going down like they are elsewhere

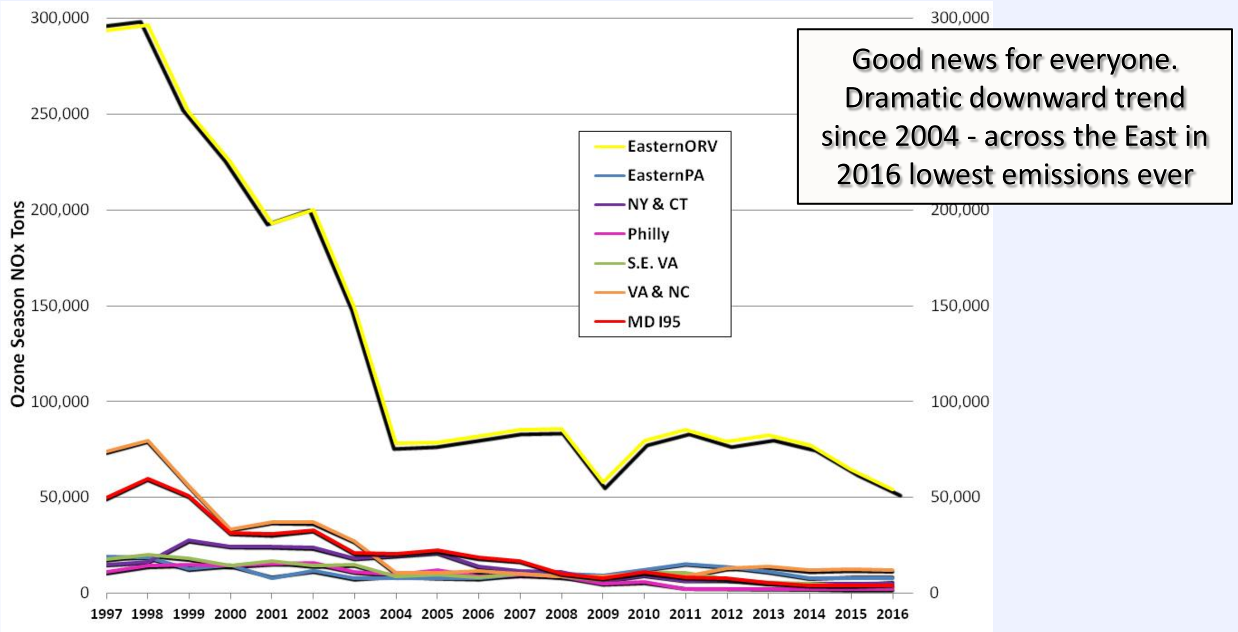


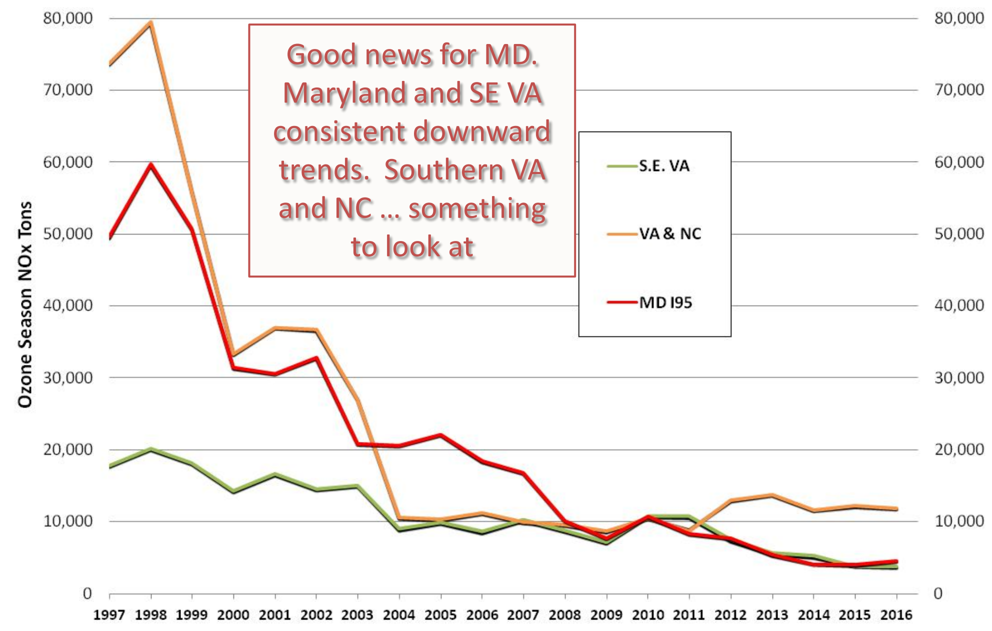
Key Upwind Areas of Contribution … EGUs - MD and CT

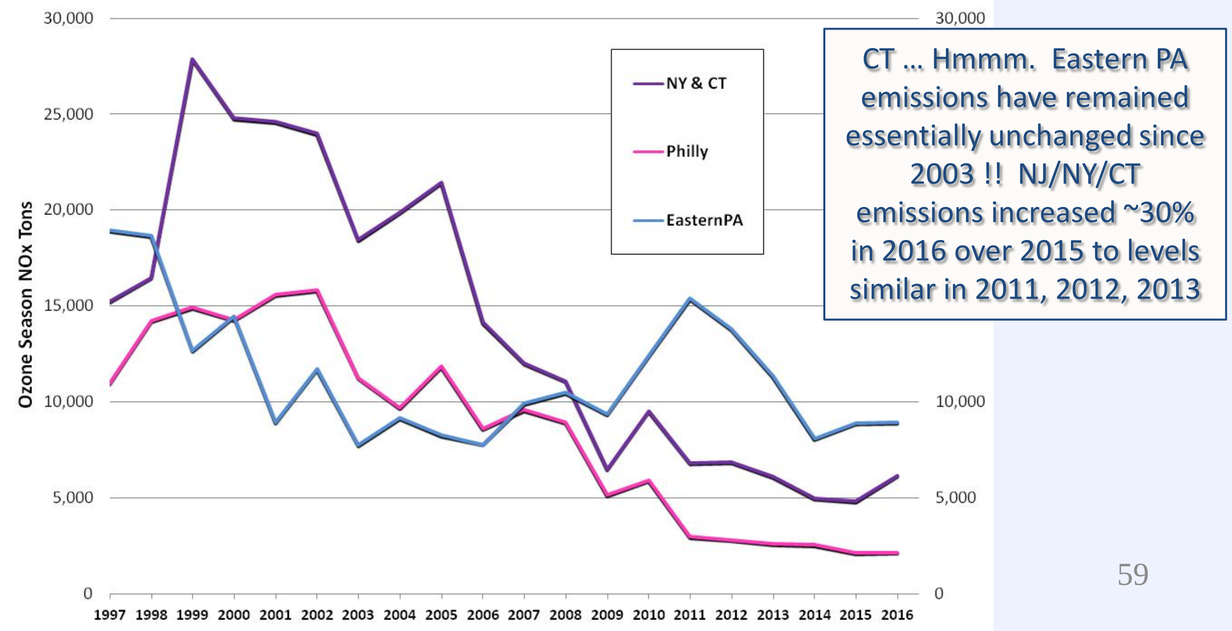


NOx Emission Trends and Ozone Levels Comparing Upwind CT to Upwind MD









So … Where Do We Go From Here …

Again … We Have a Clear Path Forward

- **We** understand the science of ozone better than ever
- **We've** implemented programs that have worked in the real world
- **We** need to continue to push two basic emission reduction policies
  1. We know that widespread regional NOx reductions work
     - We must continue to push this issue - We know it works - Our #1 priority
       - New federal programs will help
       - OTC EGU optimization effort and Section 126 Petitions will help
       - Good Neighbor SIPs should help
       - Market changes and … yes … climate change efforts will help
  2. We need to continue to push for even deeper NOx and VOC reductions in areas just upwind of OTC problem areas
     - Mostly upwind of Connecticut right now - A little Maryland
       - New NY rules on small generators should help
       - New OTC initiatives … like idle reduction .. . will help
       - Anything that we can do to reduce mobile source NOx will be critical
         - Aftermarket catalysts
         - Electric and other zero emission vehicles

More NOx Reductions - What's on the Plate?

- Key Federal Programs to Watch
  - Tier 3 Vehicle and Fuel Standards - Large NOx reductions from fuels in 2020/2022
  - The Cross State Air Pollution Rule (CSAPR) Update - Significant NOx reductions 2017/2020 - Watch litigation
- Actions that are In the Works
  - Maryland MWC RACT rule (today's meeting)
  - OTC aftermarket catalyst initiative (Spring OTC Meeting - 2017) - Meaningful NOx reductions
  - Idle Free Maryland Initiative (regional action at OTC Fall Meeting - 2017) - More NOx
  - Good Neighbor SIPs - Due in 2018- Inside and outside of OTR
    - OTC states pushing 5 NOx reduction strategies - coal fired power plants run controls, uncontrolled power plants add controls, implement aftermarket catalyst initiative, enhance idle reduction programs, compressor stations
  - EPA actions on 126 Petitions - CT, DE & MD - Large potential NOx reductions
    - Pushing upwind power plants to simply run existing controls optimally (MD 2015 NOx Regulations) continues to be the most significant control option we have for the near term

Maryland's 126 Petition

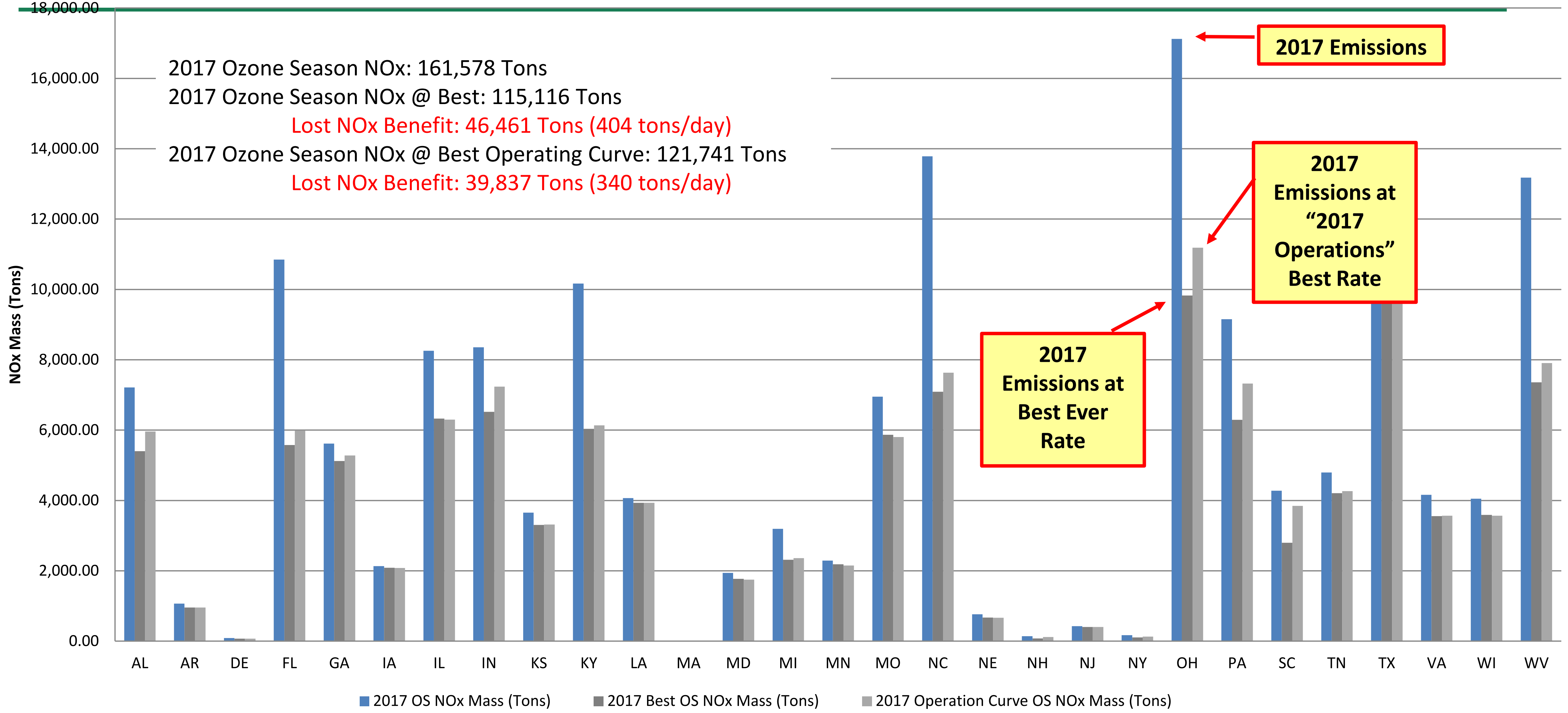
- 36 Units at 19 plants in 5 states
  - PA, WV, OH, KY and IN
- Petitions EPA to require these units to optimize the use of existing control technologies every day of the summer
  - Maryland's 2015 NOx regulation established this requirement in MD
- Benefits are potentially very large
  - Up to a 300 tons per day of NOx reductions
  - 2 to 5 ppb ozone benefit according to modeling
- Maryland filed a law suit in August of 2017 because of EPA's failure to respond to the Petition

Maryland's 126 Petition and the 2017 CSAPR Update

- Did the CSAPR Update achieve the "Ask" in Maryland's 126 Petition?
  - Sort of … sometimes
- First year of implementation of the CSAPR Update (and the PA RACT 2 rule) did result in significant new NOx reductions
- That said, the CSAPR Update is still a "cap-and-trade" program where optimization of controls each day of the ozone season is not required
- Maryland has just completed sophisticated analyses of the 2017 emissions data (CAMD data) submitted by about 400 power plants across the East.
  - Available if folks are interested
- Bottom Line
  - Lots of Progress … but … still a lot of NOx reductions to be achieved … if folks just simply run their NOx controls the way they were designed to be run

Lost NOx Reductions - By State

2017 Ozone Season Total NOx Emissions - Actual, Best Rates from Past & Best OS Operating Curve



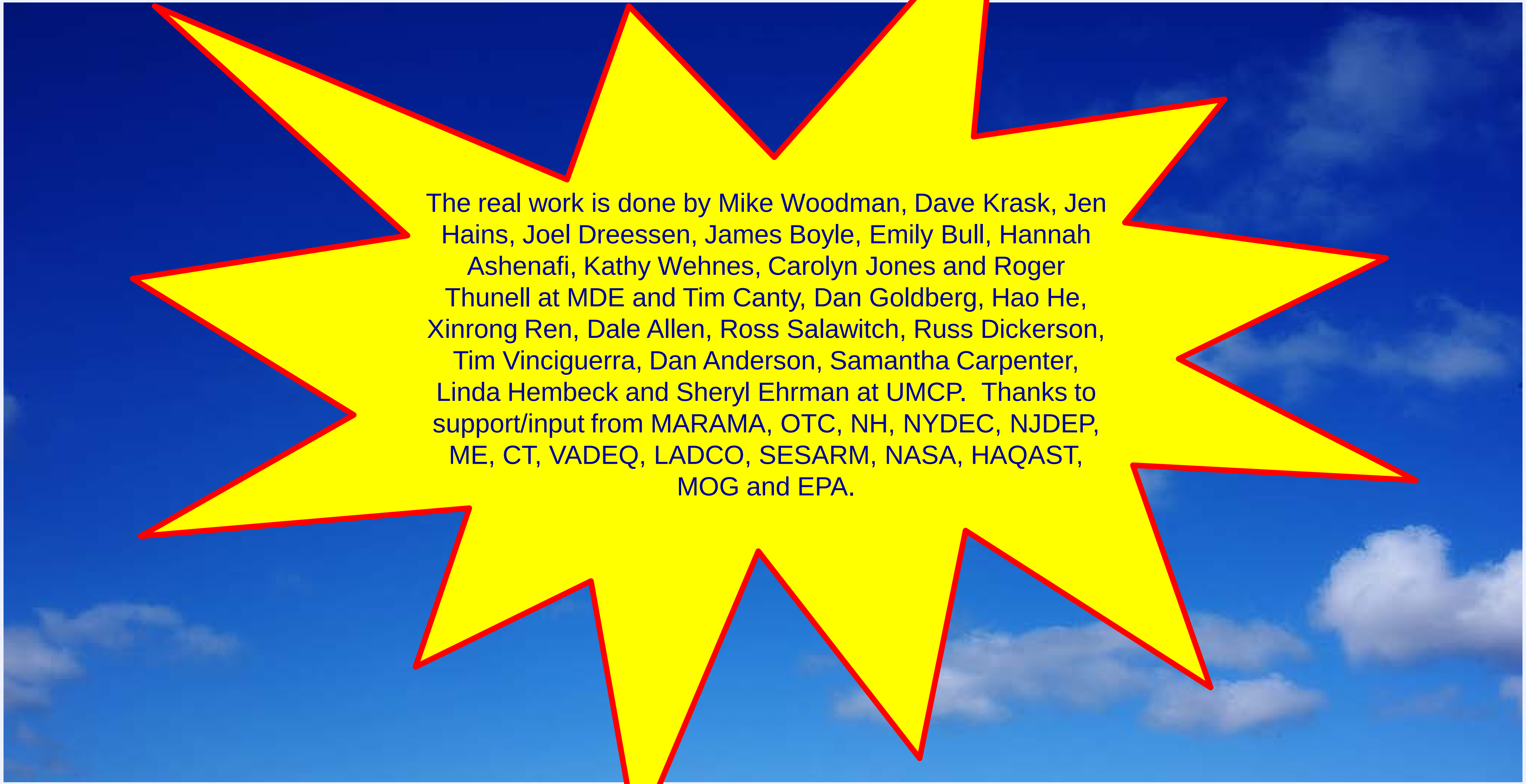
Some Additional Observations from the 2017 Ozone Season CAMD Data Analysis

- Good News - There are more states with units that appear to be optimizing controls than states with units that are not
  - Many of the states that have been identified by EPA as contributing to Maryland appear to have many units not optimizing controls.
  - With reasonable efforts to optimize controls, up to 400 tons of additional daily NOx reductions could have been achieved in 2017.

- More Good News - Many states have a majority of their units close to meeting best historical rates.
  - AR, GA, IA, KS, LA, MD, MN, MO, NE, NJ, TN, TX, VA and WI all have a majority of reported units close to best historical rates
    - Accounting for low capacity operation, AL, IN, NH, PA and SC could also be considered as having a majority of the units close to best historical rates
  - Generally the same states that had a majority of reported units close to best historical rates in 2016.

- Other News - Many states have a significant number of units emitting at rates that are noticeably higher than best historical rates … at least 6 contribute significantly to ozone in MD
  - AL, DE, FL, IL, IN, KY, MI, NC, NH, NY, OH, PA, SC and WV all have units exceeding best historical rates
  - Generally same states that had a majority of reported units exceeding best historical rates in 2016.

Thanks … Questions? … Discussion?



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