Modeling and Air Quality

Richard A. “Chet” Wayland
U.S. EPA OAR/OAQPS/AQAD
LADCO Regional Air Quality Meeting
April 15, 2019

Air Quality Modeling Topics

- Modeling Guidance
- Regional Haze Modeling
- Interstate Transport Modeling
- Hemispheric/Global Modeling
- National/Regional Model Evaluation
- Upcoming Modeling Efforts

Updated Ozone, $PM_{2.5}$, and Regional Haze Modeling Guidance

- EPA finalized updated SIP modeling guidance in November, 2018
  - https://www3.epa.gov/ttn/scram/guidance/guide/O3-PM-RH-Modeling_Guidance-2018.pdf
- The modeling guidance describes:
  - How to setup and apply a photochemical modeling platform, including meteorological, emissions, and air quality modeling
  - How to use air quality modeling to show future attainment of the ozone and/or $PM_{2.5}$ NAAQS and evaluate reasonable progress goals for regional haze

Updates to the Modeling Guidance

- Guidance updates include:
  - Document reorganization, removal of outdated language, and updated references
  - Updates to reflect the 2015 ozone and 2012 $PM_{2.5}$ NAAQS implementation rules, and the 2017 regional haze rule.
    - Finalized use of the top 10 modeled days to calculate relative reduction factors for the ozone attainment test
    - Updated regional haze section to refer/apply to the 20% most anthropogenically impaired days
  - Extensive updates to the emissions modeling section consistent with the SIP emissions inventory guidance.

Regional Haze: Technical Guidance on Tracking Visibility Progress

- "Technical Guidance on Tracking Visibility Progress for the Second Implementation Period of the Regional Haze Rule"
  - The guidance was released on December 20, 2018 and fulfills a commitment in EPA's Regional Haze Reform Roadmap
- EPA held a public webinar on February 20, 2019 to explain the guidance contents and answer questions.
- The guidance document and the webinar presentation can be found here:
  - https://www.epa.gov/visibility/technical-guidance-tracking-visibility-progress-second-implementation-period-regional

Visibility Tracking Metric

- The 2017 Regional Haze Rule revisions require a revised approach to tracking visibility improvements over time.
  - The guidance finalizes a recommended methodology to develop baseline and current visibility conditions, and natural conditions on the 20% *most impaired* and clearest days at Class I areas.
    - The recommended visibility tracking metric focuses on anthropogenic visibility impairment
- Compared to the metric used in the first implementation period:
  - In the eastern U.S.: little difference between metrics
  - In the western U.S.: many sites that were above the URP in 2012-2016 are now at or below the URP with the recommended metric
    - Days selected as the 20% most impaired tend to have:
      - Lower extinction
      - Wider distribution across seasons
      - Higher fractions of sulfate and nitrate, much lower organic carbon
- States can easily download data using the recommended EPA methodology by going to the following website: http://views.cira.colostate.edu/fed/QueryWizard/Default.aspx and choosing the "IMPROVE aerosol, RHR III" dataset

Glidepath International Adjustment

- The 2017 Regional Haze Rule also includes a provision that allows states to propose an adjustment to the uniform rate of progress (URP) glidepath to account for anthropogenic international sources (and prescribed fires).
- The guidance describes recommended tools and methods to develop optional URP adjustments
  - Year selection for quantifying international visibility impacts
    - Base year or 2028
  - Modeling to estimate anthropogenic international visibility impacts
    - Recommended types of models
      - Regional and global/hemispheric photochemical grid models
    - Modeling techniques
      - Zero-out and/or source apportionment of international anthropogenic emissions

Updated EPA Regional Haze Modeling Summer 2019

- New 2016 based modeling platform with emissions projections to 2028, including sector-based PM source apportionment
  - 2028 projected deciviews and glidepath estimates at Class I areas
  - Estimate of international anthropogenic contributions
  - Model Improvements
    - New 2016 and 2028 emissions from the State/EPA platform collaborative
    - Regional model improvements
      - Updates to CAMx
      - Larger regional domain (including 36km outer domain)
    - Updated boundary conditions
      - Hemispheric CMAQ
  - Modeling will be completed by the end of the summer 2019

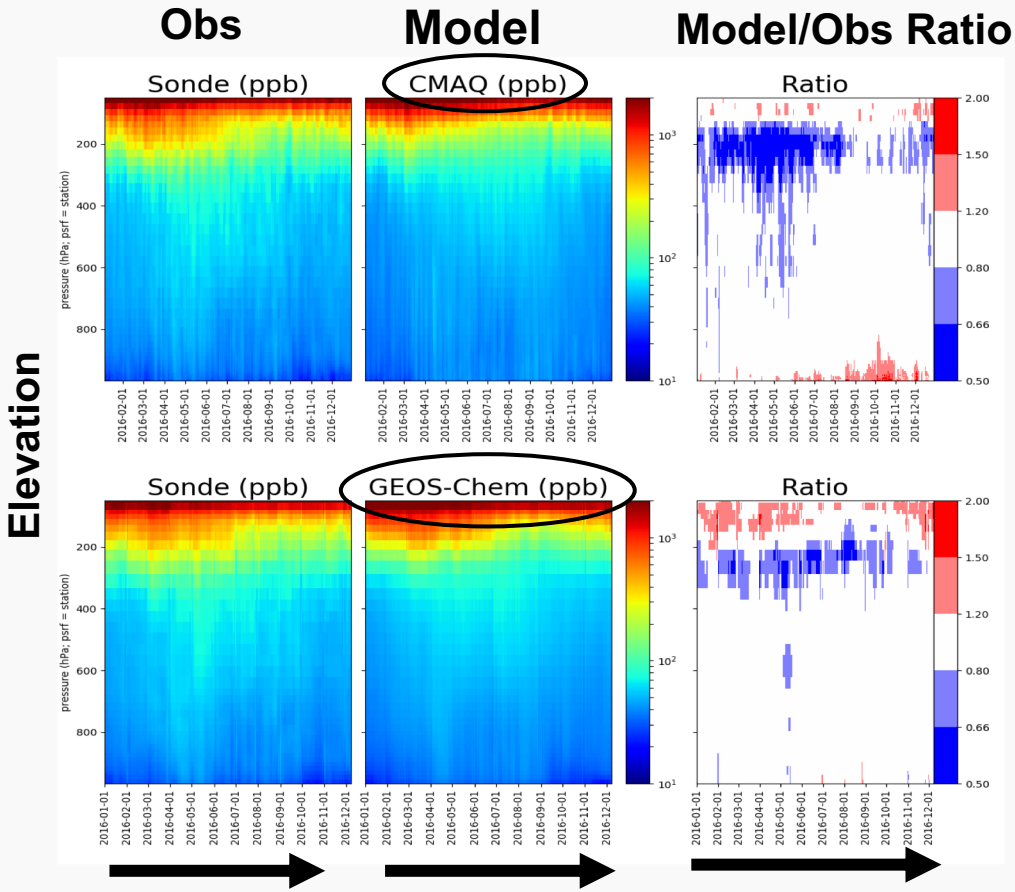
Modeling Insights on Interstate Transport

- In March 2018 EPA provided transport-related air quality modeling data to the states for potential use in developing 2015 NAAQS 110 SIPs.
  - These data include 2023 projected ozone design values at individual monitoring sites nationwide along with the contribution to these design values from NOx and VOC emissions in upwind states
  - Some states are using EPA's modeling in their SIPs
  - Other states are using their own modeling or modeling performed by other organizations
- At this time EPA does not plan to perform additional transport modeling.
- EPA has encouraged states to work together regionally on developing foundational technical data for their SIPs.
  - Since many states have yet to formally submit SIPs to EPA, it may be premature to identify technical lessons learned.
  - However, early indications suggest that this type of collaboration has not happened.

Modeling for Boundary Conditions

- EPA has applied both GEOS-Chem and Hemispheric CMAQ to model international transport and to develop boundary conditions for national modeling of the US.
  - GEOS-Chem v11-01
    - out-of-box emissions (EDGAR v4.2, NEI daily)
    - Plus 2016 FINN fires + 2016 lightning
    - Using these boundary conditions produced ozone predictions in the US were high-biased
  - Hemispheric CMAQ with updated inventories
    - Easy to use latest EPA derived domestic inventories for consistency
    - Global inventories based on international partnerships
      - EDGAR-HTAP Emissions
      - Updated China inventory from Tsinghua University
  - Continued to improve GEOS-Chem simulations; using CMAQ in 2015 and 2016 platform simulations

Evaluation using Hemispheric O_3 Sonde Vertical Profile Data



Both have a near tropopause low bias.

Both perform reasonably in the free troposphere (800-400 hPa).

H-CMAQ predicts concentrations lower than GEOS-Chem v11-01 in the free troposphere.

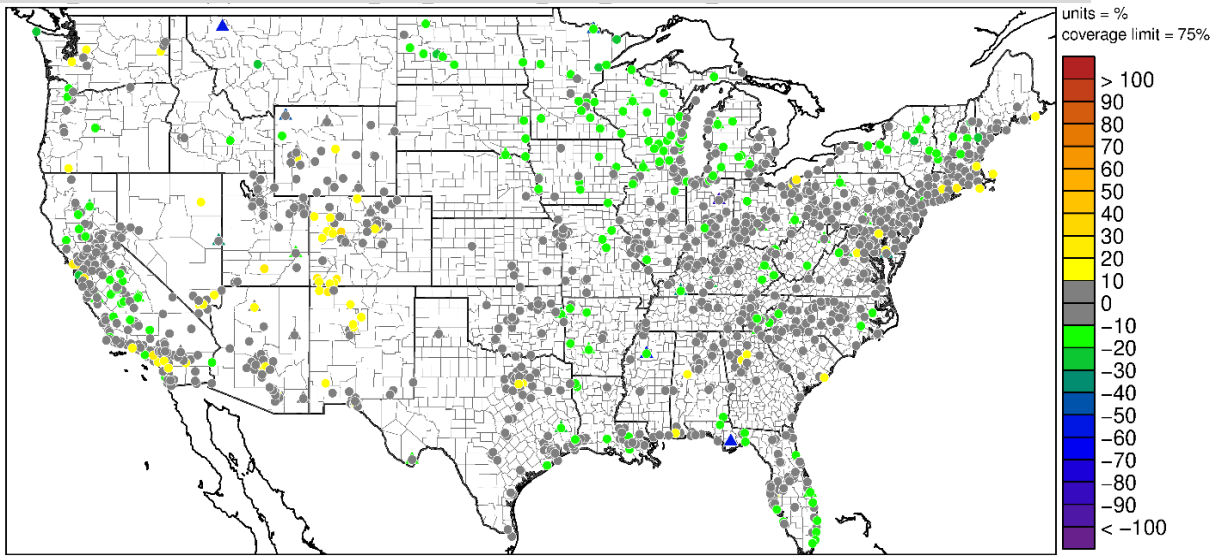
Recent Updates to CMAQ and CAMx have improved credibility of ozone modeling

- Updated chemical mechanisms (CB6) have been implemented into both CMAQ and CAMx. The updated mechanism
  - better represents organic nitrogen species
  - leads to more accurate lifetime and cycling of NOx and NOy compounds
  - more accurately represent interstate transport of ozone precursors
- Updated treatment of marine chemistry captures ozone depletion over the ocean due to iodine-mediated deposition and gas-phase halogen reactions. The marine halogen updates
  - reduce ozone estimates in coastal areas and to a lesser degree over continental locations
  - impact the amount of long-range transport over marine environments

Recent Ozone Model Evaluation

- Example of ozone model performance from recent 2014 CMAQ run conducted for collaboration with CDC
  - Incorporates updated CB6 chemical mechanism
  - Incorporates marine halogen chemistry
- Many sites show Normalized mean bias within ± 10% (gray dots)
- Provides credible basis for modeling ozone for regulatory applications

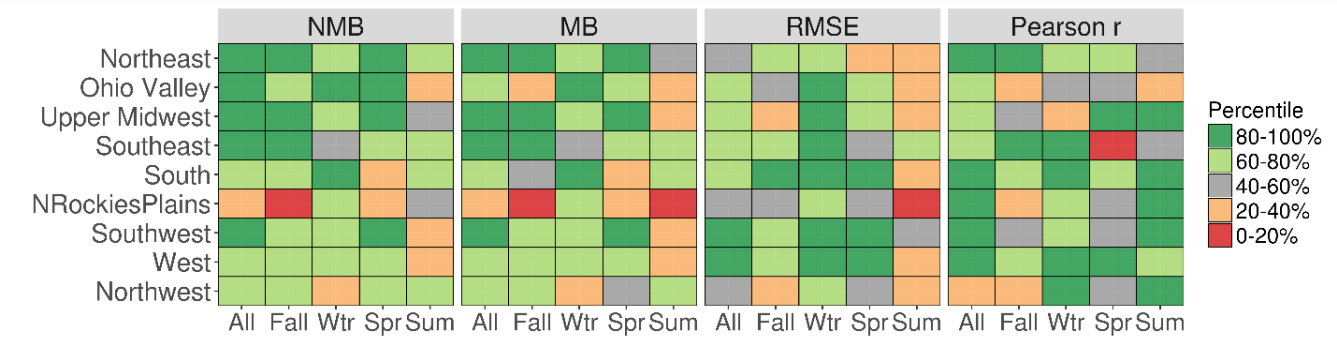
CMAQ MDA8 ozone Normalized Mean Bias (%)
May-Sep, 2014 on days > 60 ppb



Source: https://www.epa.gov/hesc/rsig-related-downloadable-data-files

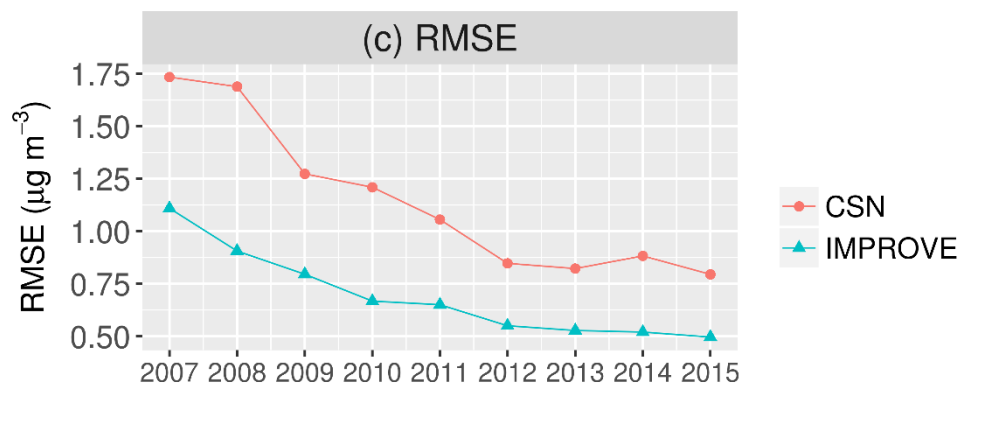
Improved Performance for $PM_{2.5}$ OC in Recent Modeling

Ranking of 2015 model performance with earlier modeling



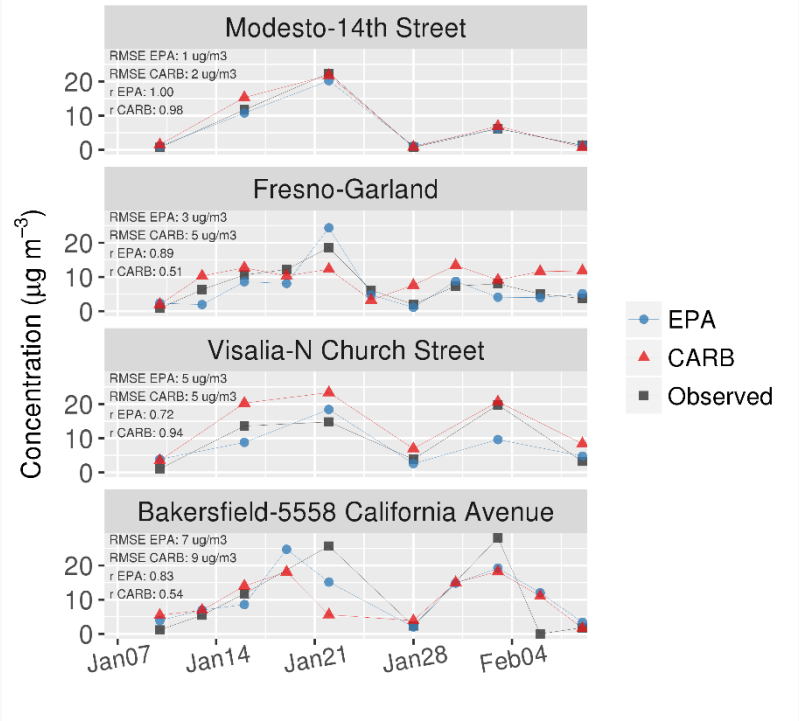
- The figure shows the ranking of model performance for our recent 2015 CMAQ modeling of OC compared with model performance for simulations done largely with previous modeling platforms
  - Green: recent modeling performs relatively well
  - Red: recent modeling performs relatively poorly
- The prevalence of green colors in the figures indicates that performance of our most recent modeling is generally better than our previous modeling
- Improved performance appears to be due to better representations of atmospheric mixing, emissions, and biogenic secondary organic aerosol

Improved Error Statistics for $PM_{2.5}$ Sulfate in Recent Modeling



- The figure shows the root mean-square error (RMSE) for sulfate model predictions compared with observations for CMAQ modeling of 2007-2015
- The RMSE generally is decreasing over time suggesting better performance in our recent modeling
- We are currently investigating whether the lower RMSE values in recent years are due to model improvements or the large decreases in ambient sulfate concentrations in the eastern US during 2007-2015

Improved Ability to Simulate Nitrate Episodes in the West



- Simulating PM nitrate episodes in complex terrain the west has been a long-standing challenge
- However, we recently demonstrated good nitrate predictions during major winter episodes (e.g., nitrate > 20 µg m^{-3}) in the San Joaquin Valley using 4-km CMAQ modeling
- The figure shows good agreement between observations and modeling done by CARB and EPA, particularly in northern SJV (e.g., Modesto)
- Convergence of the mountain ranges south of Bakersfield makes that site relatively hard to simulate

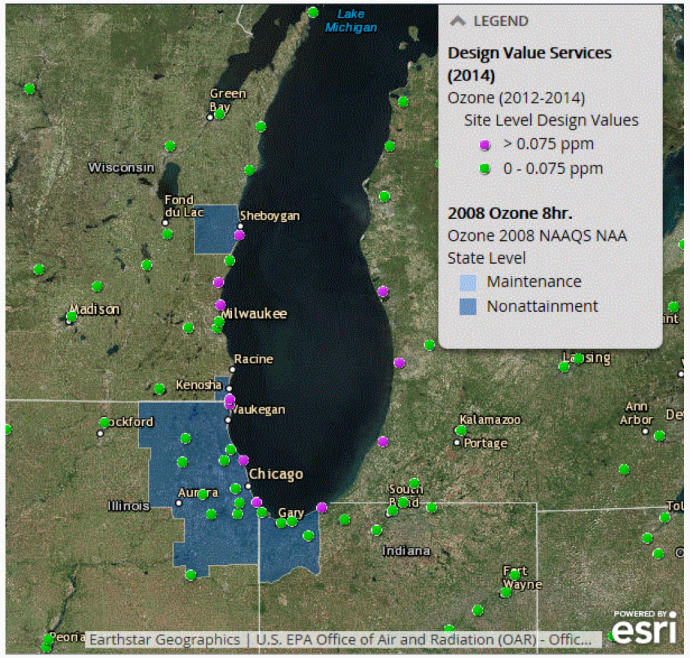
Source: https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2018JD028290

Planned State-EPA 2016 Model Evaluation Forum

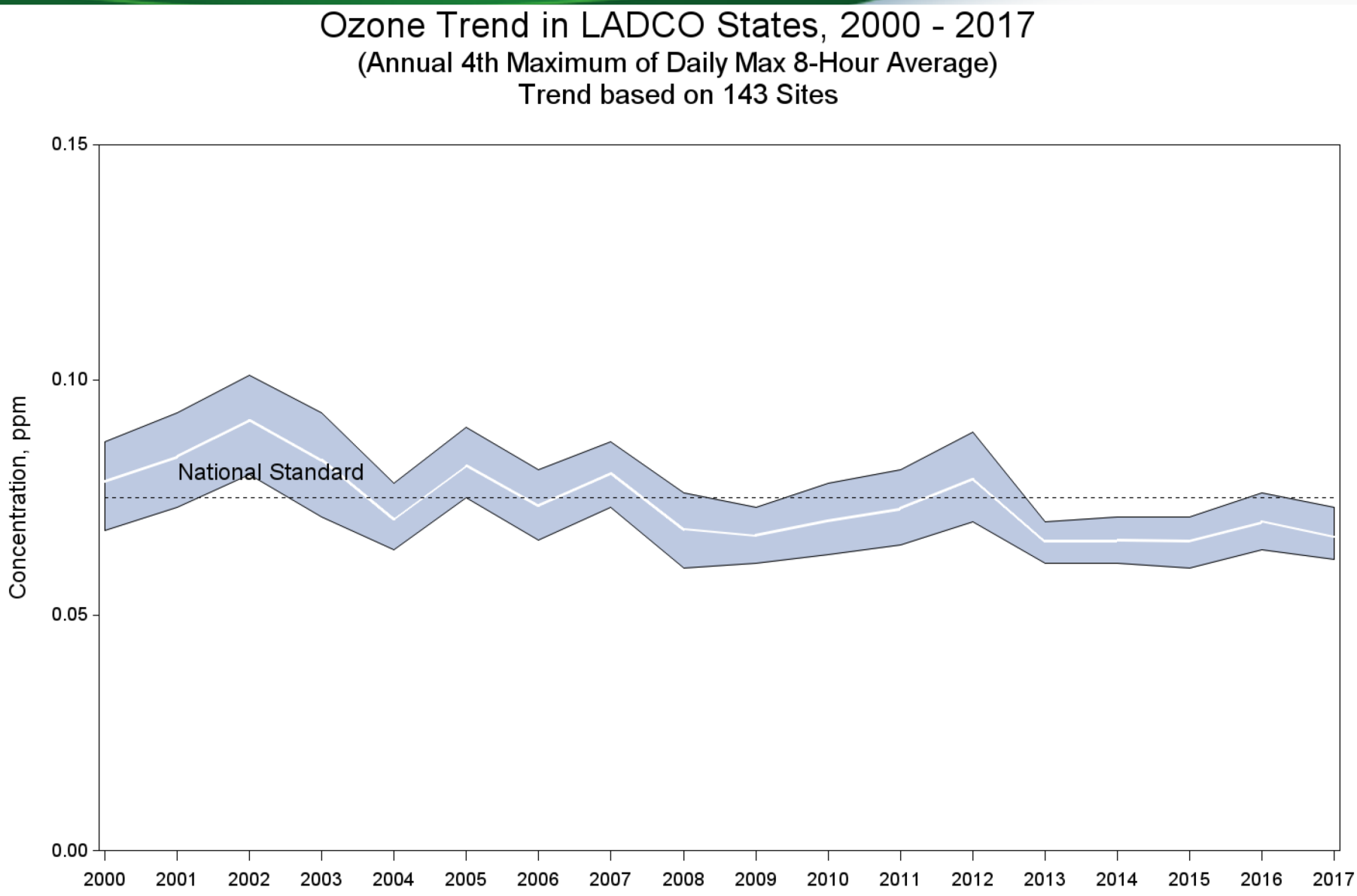
- EPA OAQPS and Regional staff are reaching out to states and MJOs to collaborate on model evaluation for the 2016 platform
- EPA presented this idea to MJOs on March 15
- The forum will
  - Promote collaboration with state partners on characterizing and understanding model performance and identifying performance issues for possible further research by EPA and/or the modeling community.
  - Serve as a venue for forming working teams which will independently meet and investigate model performance issues of mutual interest
  - Provide an opportunity for sharing data and evaluation results
  - Serve as a resource for modelers who intend to use the 2016 modeling platform

Planned Finescale Modeling for the Lake Michigan Region

- Multiple sites in the Lake Michigan region still exceeding the level of the NAAQS
- AQAD plans to take advantage of special field study measurements made in the region during 2017 as part of the Lake Michigan Ozone Study (LMOS) to evaluate and improve model representation of land-lake interfaces and important sources
- Intend to continue collaboration with the LMOS study group which includes academic institutions, state agencies, and federal partners (NOAA and NASA)



Air Quality Data

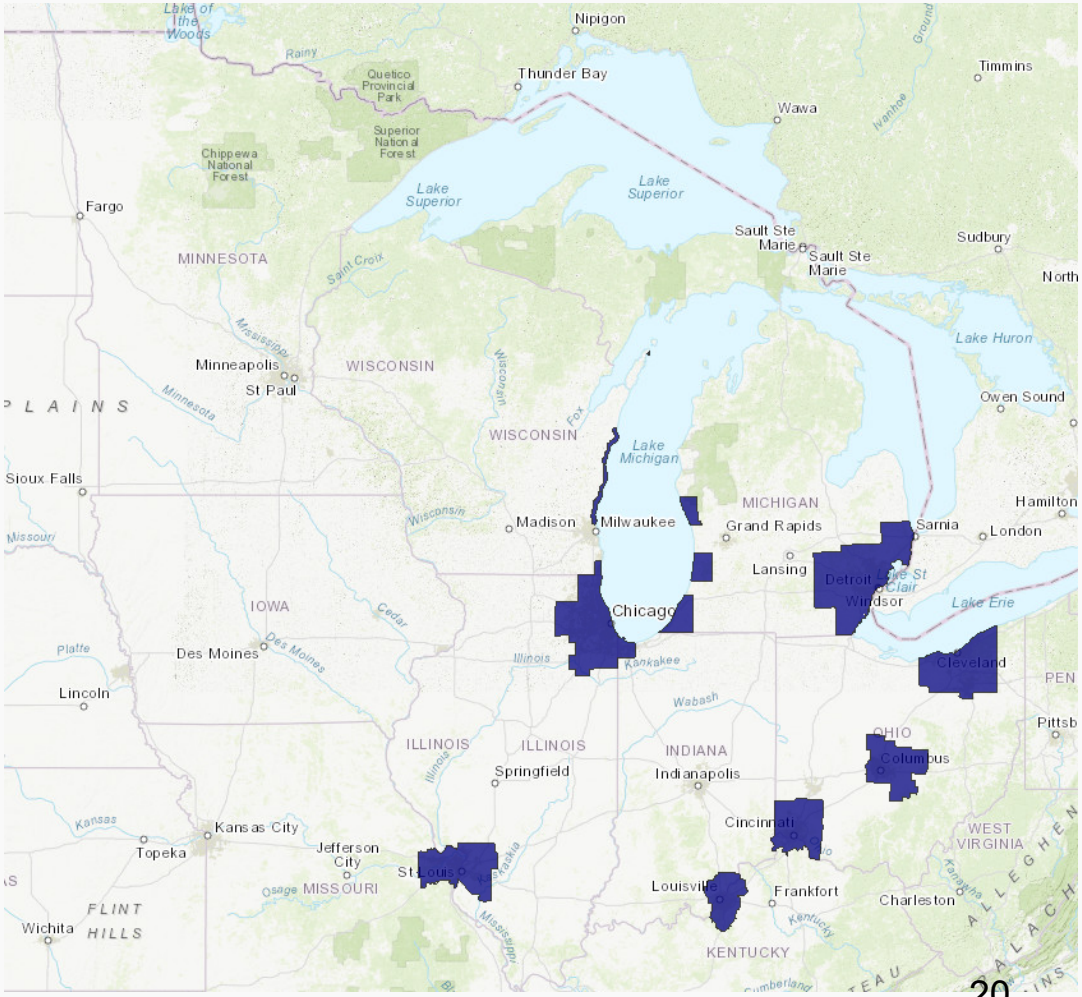


2000 to 2017 : 15% decrease in LADCO states

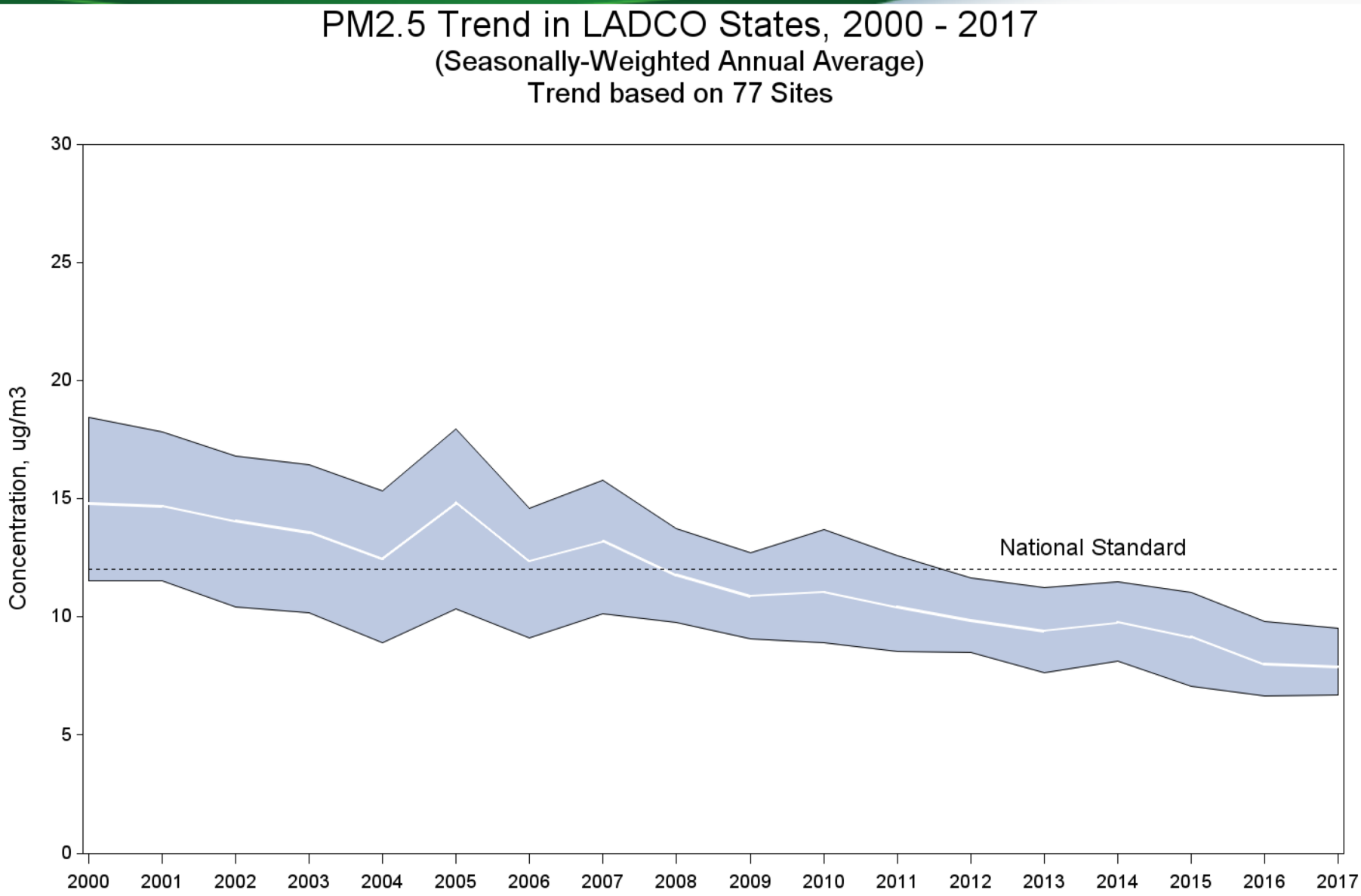
Air Quality Data

LADCO Ozone NAA Update

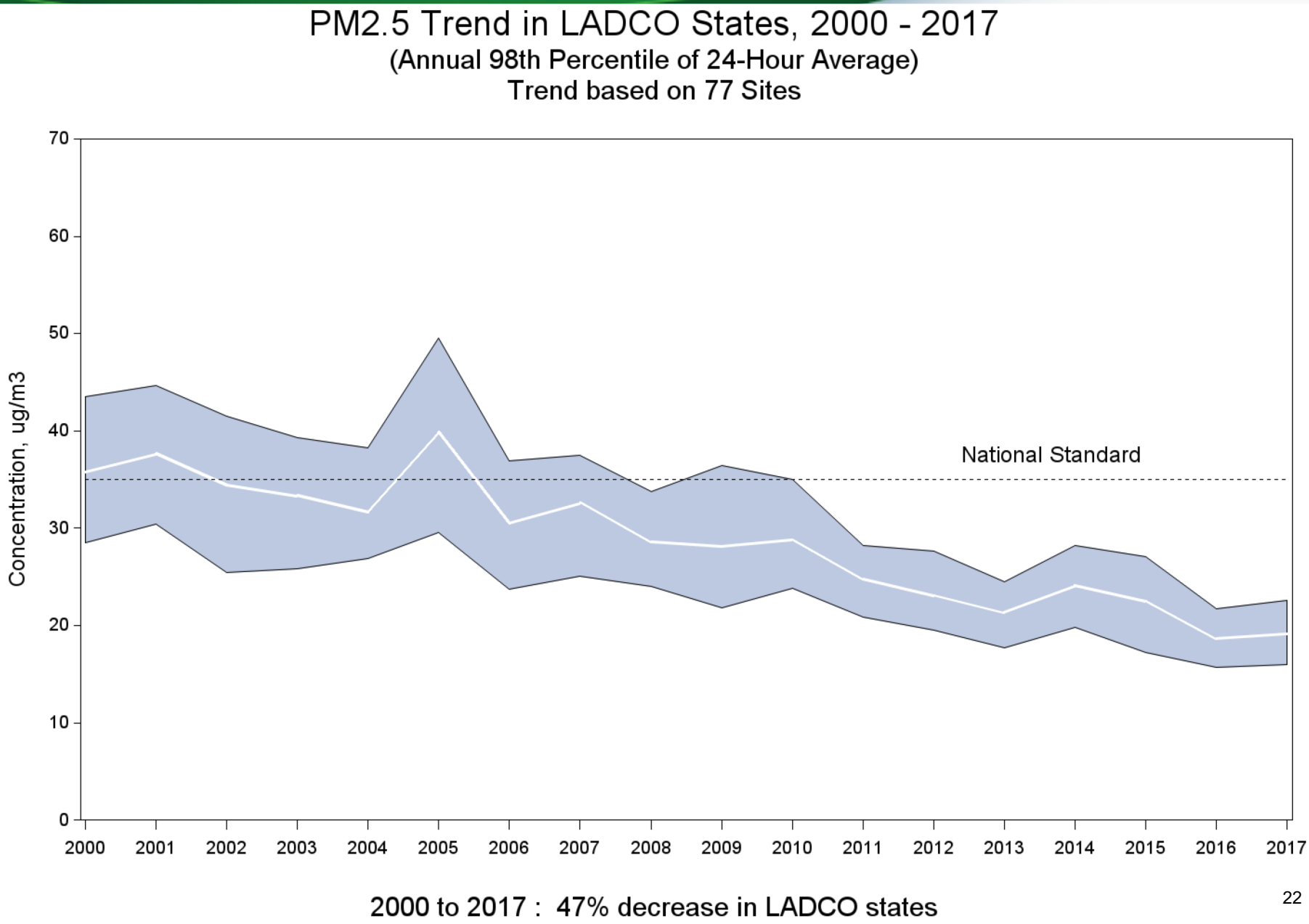
- EPA completed designations for the 2015 Ozone NAAQS in April 2018
- 14 areas wholly or partially in LADCO States designated as nonattainment
- Based on latest published Design Values (2015-2017), all 14 areas still exceed the NAAQS
- Based on latest published Design Values (2015-2017), two LADCO State monitors outside existing NAAs exceeded the NAAQS (Cass County, MI – DV: 0.072 and Racine County, WI – DV: 0.074)



Air Quality Data



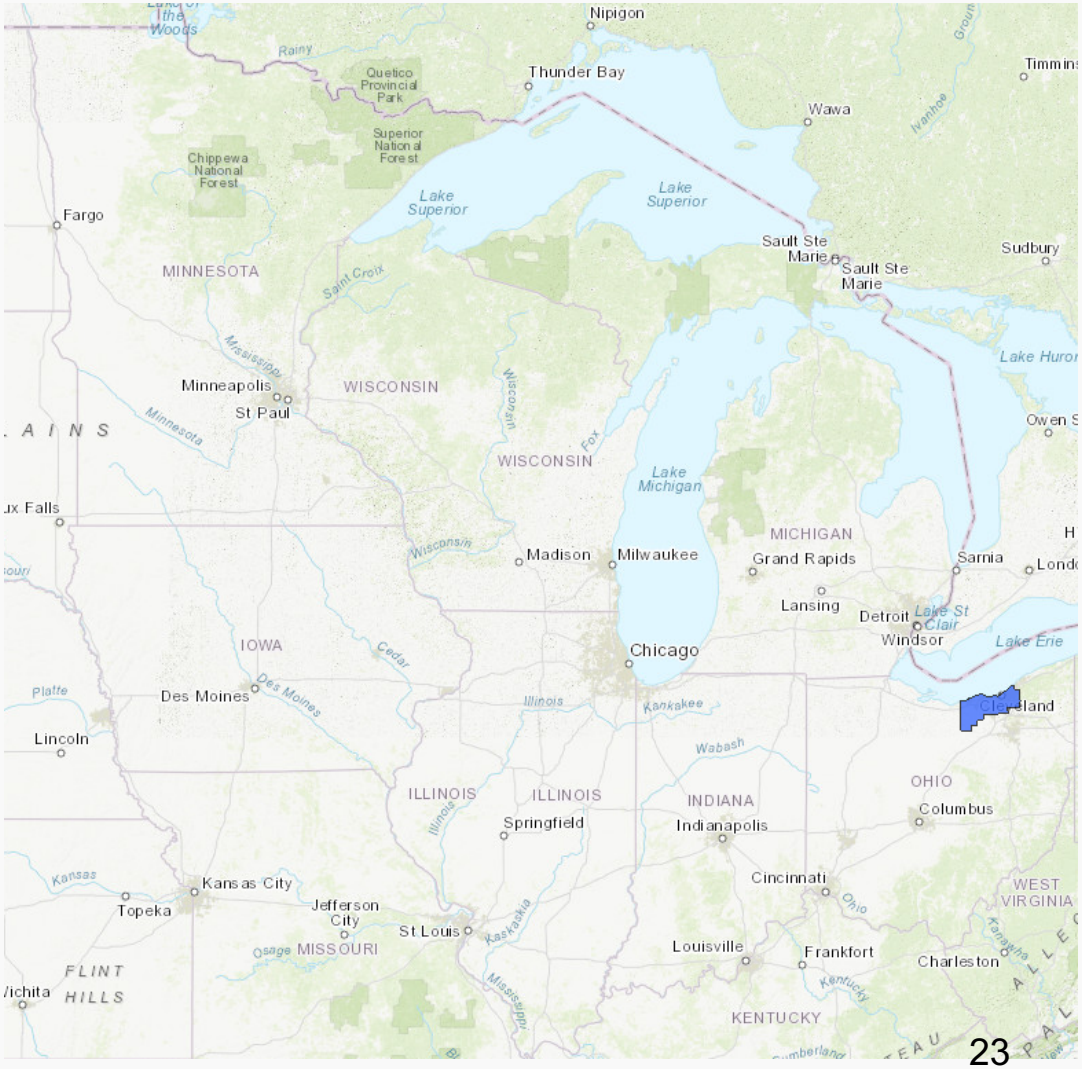
Air Quality Data



Air Quality Data

LADCO
$PM_{2.5}$ Annual
NAA Update

- EPA completed designations for the 2012 $PM_{2.5}$ Annual NAAQS in April 2015
- 1 area (Cleveland, OH) in LADCO States designated as nonattainment
- Based on latest published Design Values (2015-2017), Cleveland, OH NAA now below the NAAQS
- Based on latest published Design Values (2015-2017), no LADCO State monitors outside a NAA exceeded the NAAQS



Air Quality Data

LADCO
$PM_{2.5}$ 24-hour
NAA Update

- EPA completed designations for the 2012 $PM_{2.5}$ 24-hour NAAQS in November 2009
- 5 areas wholly or partially in LADCO States designated as nonattainment
- All 5 areas have been redesignated to Maintenance
- Based on latest published Design Values (2015-2017), all 5 areas now below the NAAQS
- Based on latest published Design Values (2015-2017), no LADCO State monitors outside a NAA exceeded the NAAQS