# Examination of Inter-relationships among Atmospheric Transport Patterns, Ozone Concentrations, and Human Health Endpoints in New York State

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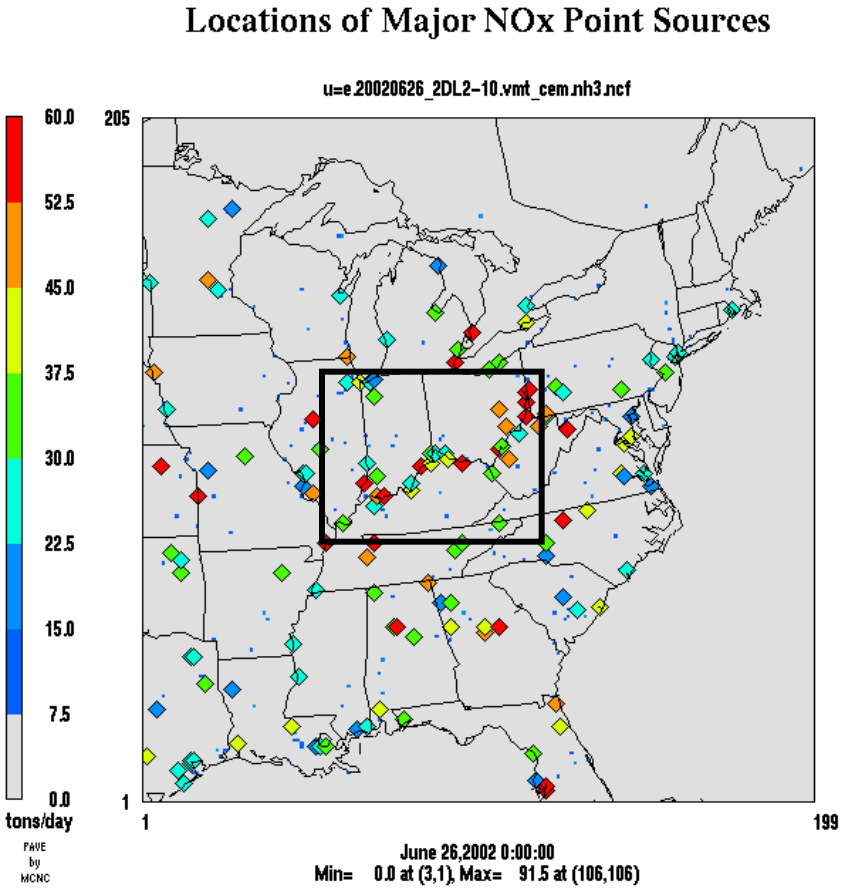
# NOx Emissions and the Formation and Transport of Ozone

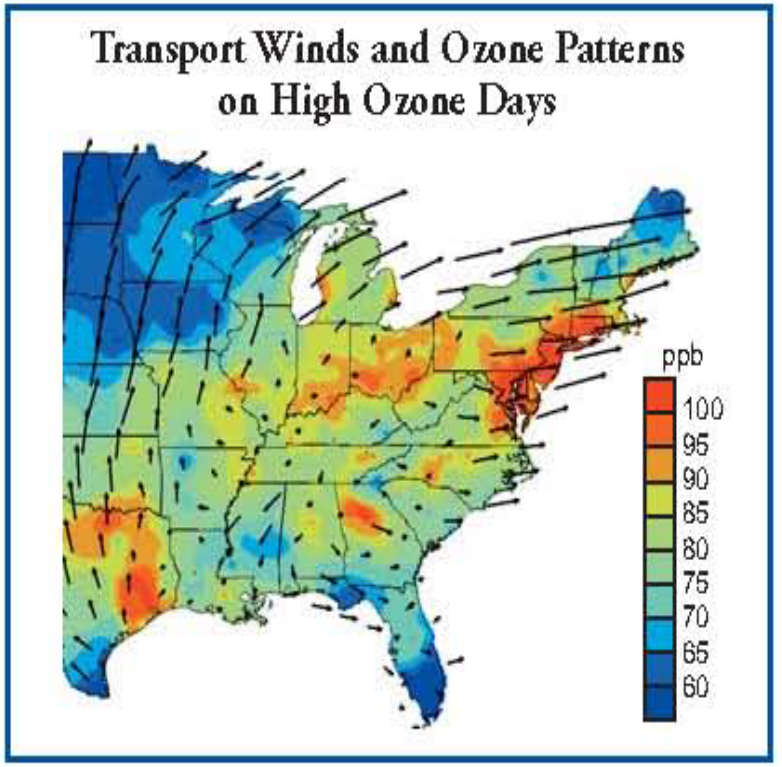
- Ozone is not directly emitted but is secondarily formed from NOx and other organic compounds in the presence of sunlight.
- NOx emitting power plants clustered in the Ohio River and Tennessee Valleys release pollutants well into the free troposphere.
- Pollutants released aloft can travel hundreds of kilometers downwind “aging” the pollutant mixture.




Total daily NOx emission rates for a summer day (June 26, 2002)

# NOx Budget Trading Program (NBP)

- First EPA regulation specifically focused on regional-scale transport.
- Reduce regional transport of ozone in the Eastern U.S. by reducing summertime NOx emissions from major sources (EGUs).
- Compliance began for some states in 2001; most states complied by 2004.

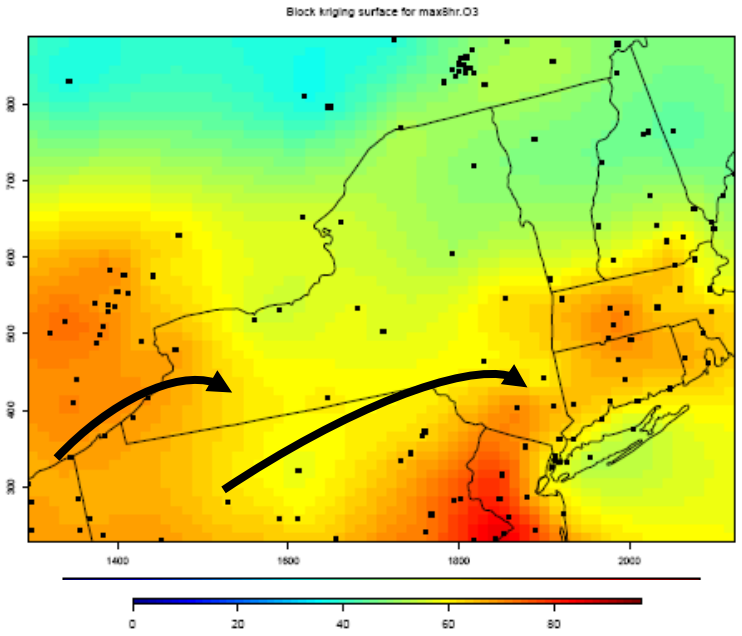



1-hr. maximum ozone concentrations averaged for June, July and August, 1991-1995. Source: OTAG 1997.

# Study Overview

- This research investigated associations between respiratory-related hospital admissions in New York State (NYS) and polluted air parcels transported from the Midwest.

- Three major steps:
  1. Identify days when air pollution from the Midwest is transported to NYS.
  2. Classify population as “exposed” or “unexposed” based on trajectory source.
  3. Use classifications in epidemiology odds ratio analysis to assess the health risk over a 10-summer time period (1997-2006).



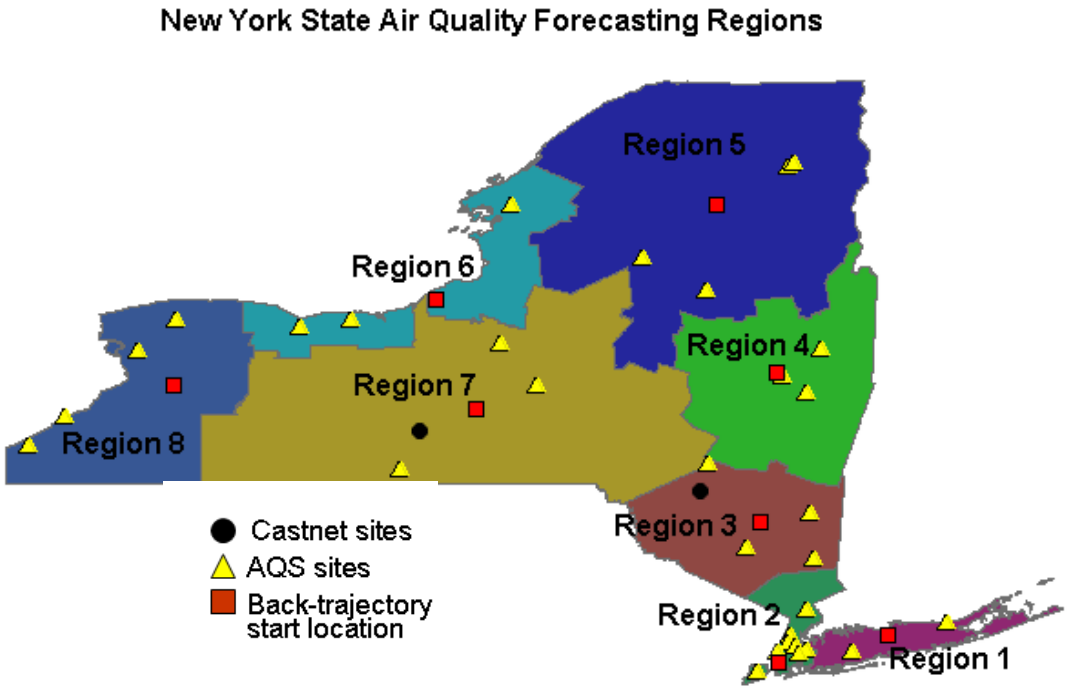

Surface concentrations of daily maximum 8-hr. ozone concentrations from bias-corrected CMAQ model
(June 12, 2001 as example)

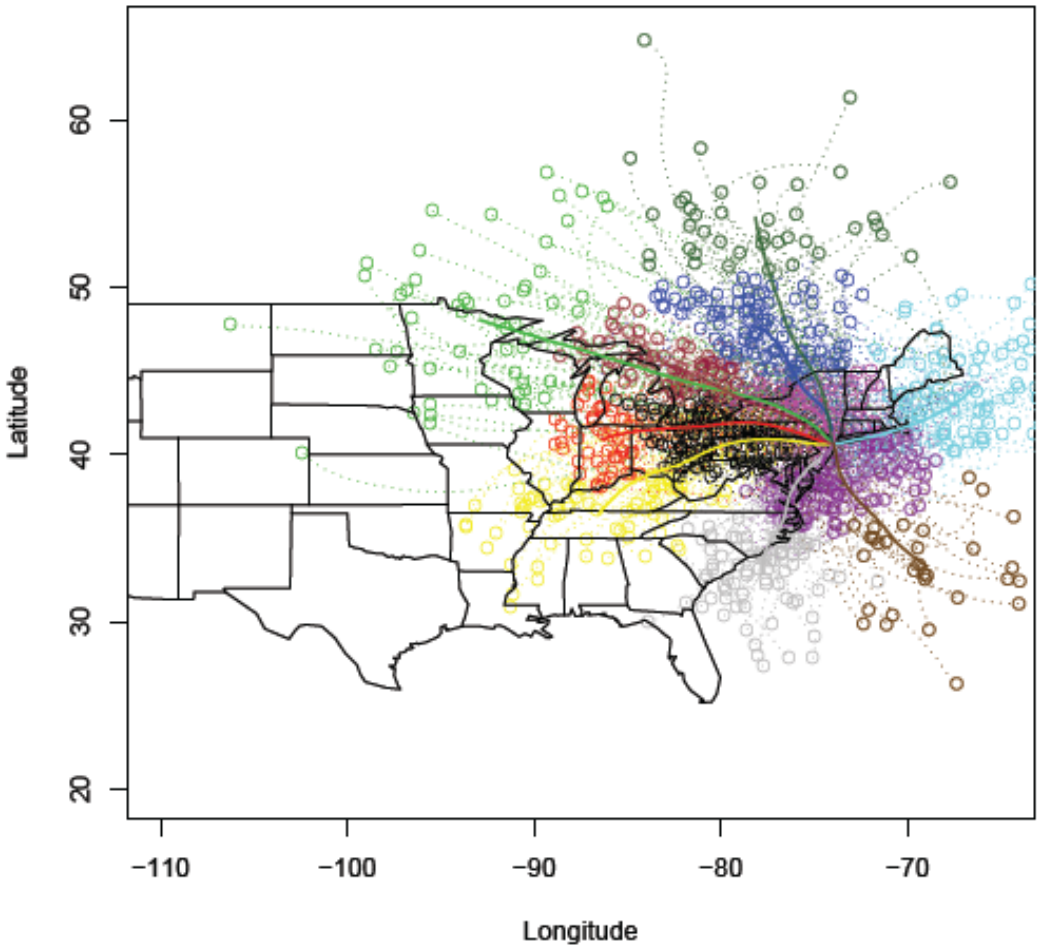
# Transported Pollution Approach

- Back-trajectories were performed from centrally located sites in eight NYS regions for all 10 summers (920 days) to identify the transport of “clean” v.s.

  “polluted” air parcels

- Observed daily maximum 8-hr ozone concentrations were used to validate the classifications.
- Daily weather patterns were matched to respiratory-related hospital admissions to examine associations.

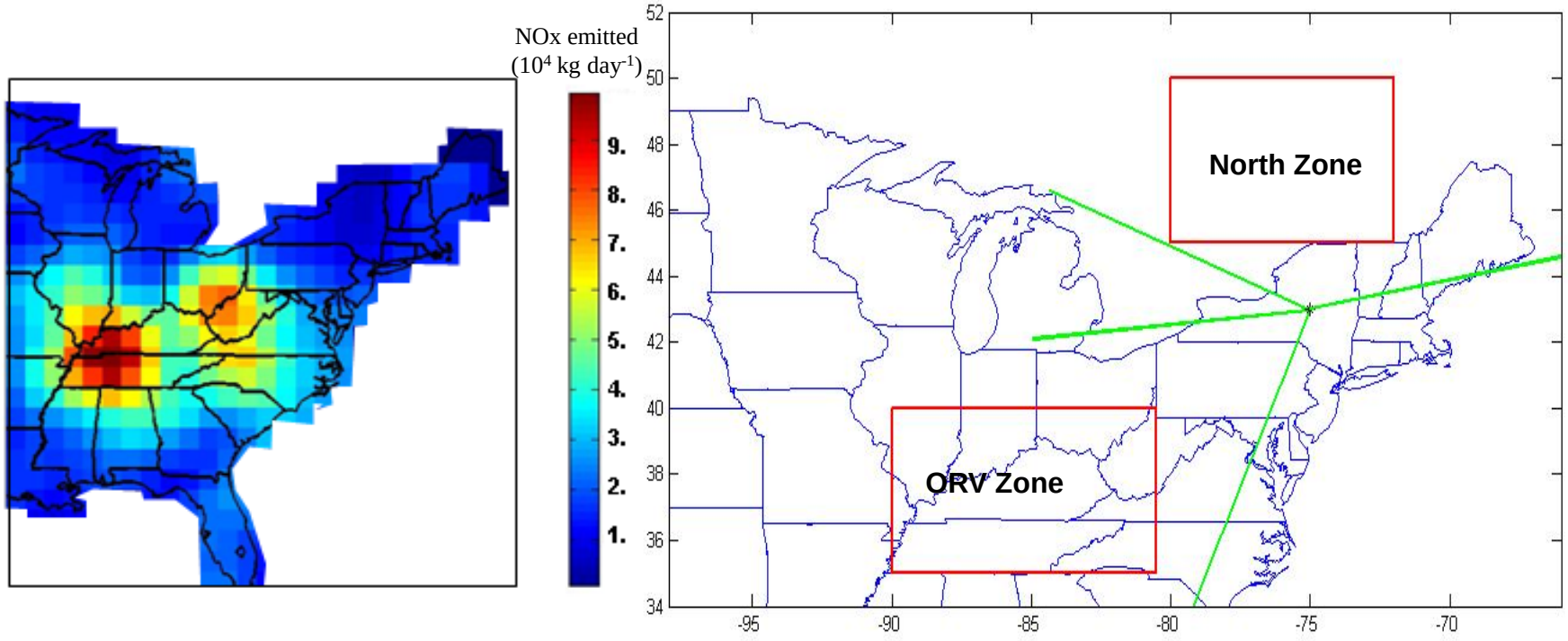





**ıstering**

- Example of back trajectories run for NYC Metropolitan Regions.
- 7,360 back trajectories run using HYSPLIT model (92 days x 10 years x 8 regions)

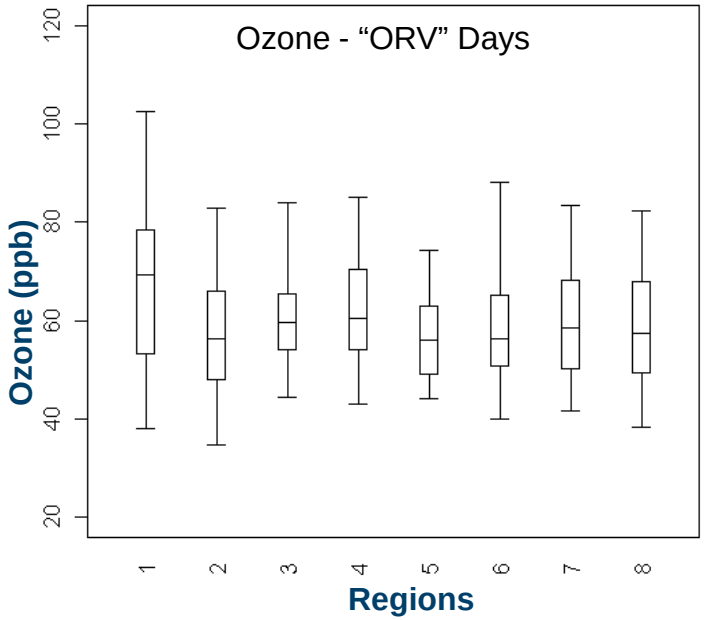
# 3. Bounded Zone Approach



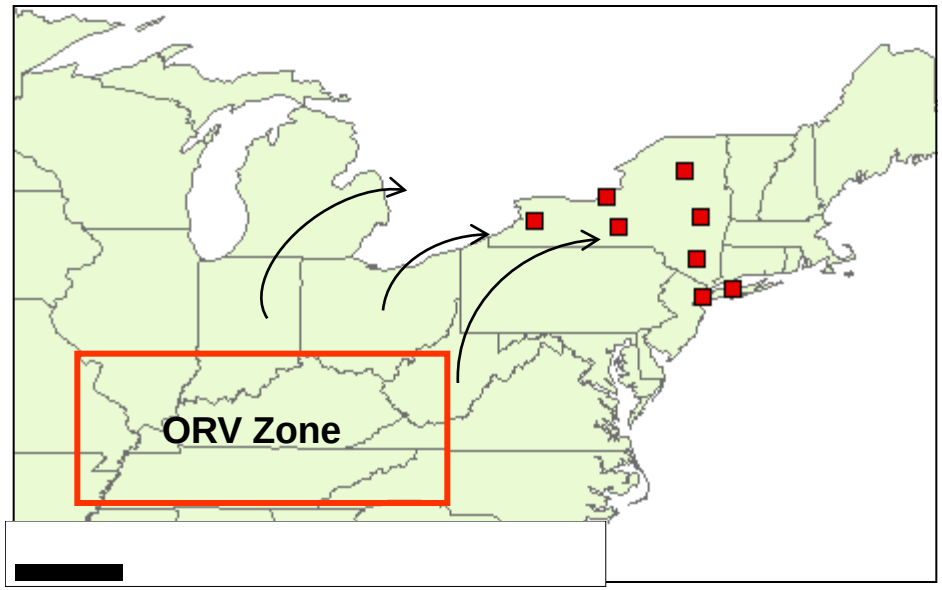

- The zone approach applied boundaries to target major NOx emissions in the Ohio River Valley (ORV).
- The North zone was used to represent relatively clean air for calculating an unadjusted odds ratio.

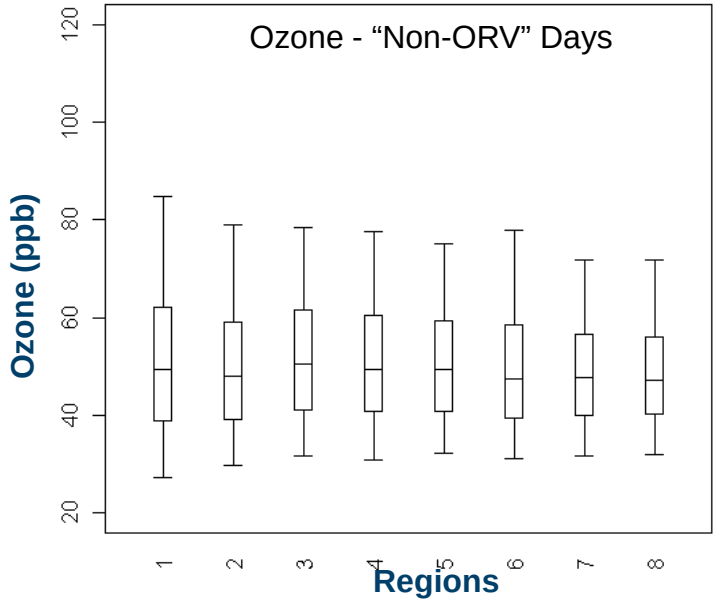
# ORV Indicator

- The seasonal mean 8-hr ozone concentrations for “Non-ORV” Days is 51 ppb and 63 ppb for “ORV” Days.
- Air parcels traveling through the ORV zone have relatively higher ozone concentration levels.
- The difference is statistically significant for all regions.

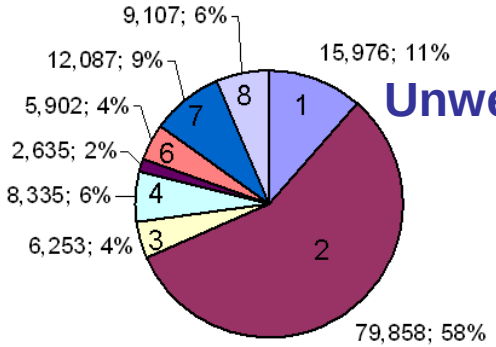



**Defining Transport with the ORV Zone**



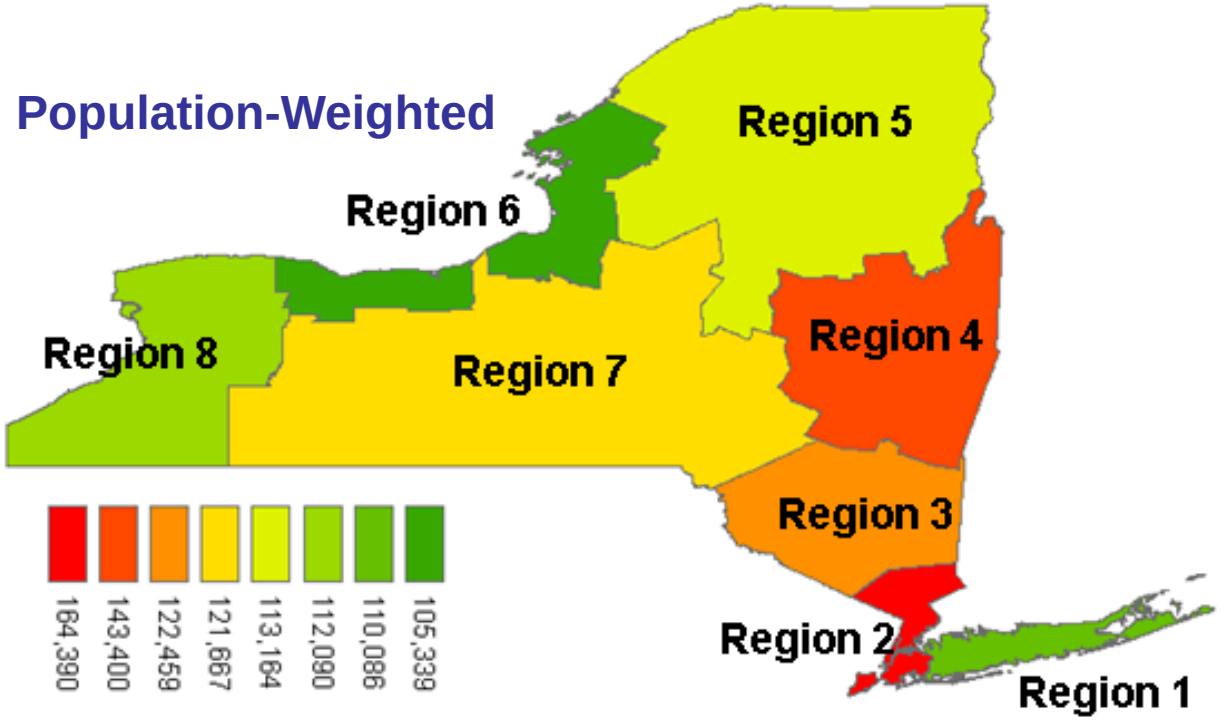



# Calculating Health Risk between Ozone and Respiratory-Related Hospital Admissions

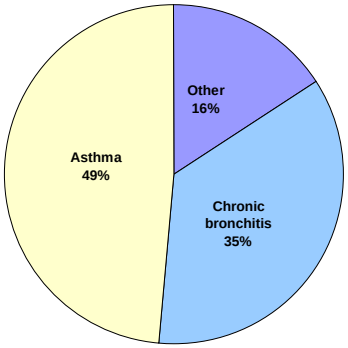



## Unweighted

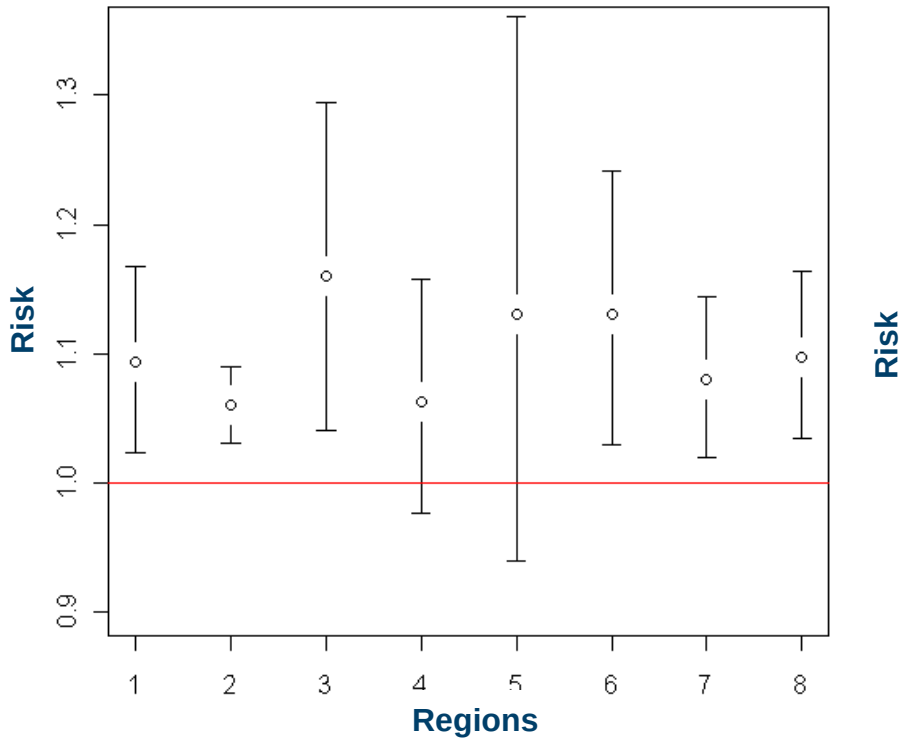
## Population-Weighted




## Hospital Admissions



# Results




- Based on the unadjusted odds ratio calculation, NYS Regions 1, 2, 3, 6, 7 and 8 experienced excess risk of respiratory-related hospital admissions as a result of exposure to air parcels transported through the ORV as compared to the North for all 10 summers.

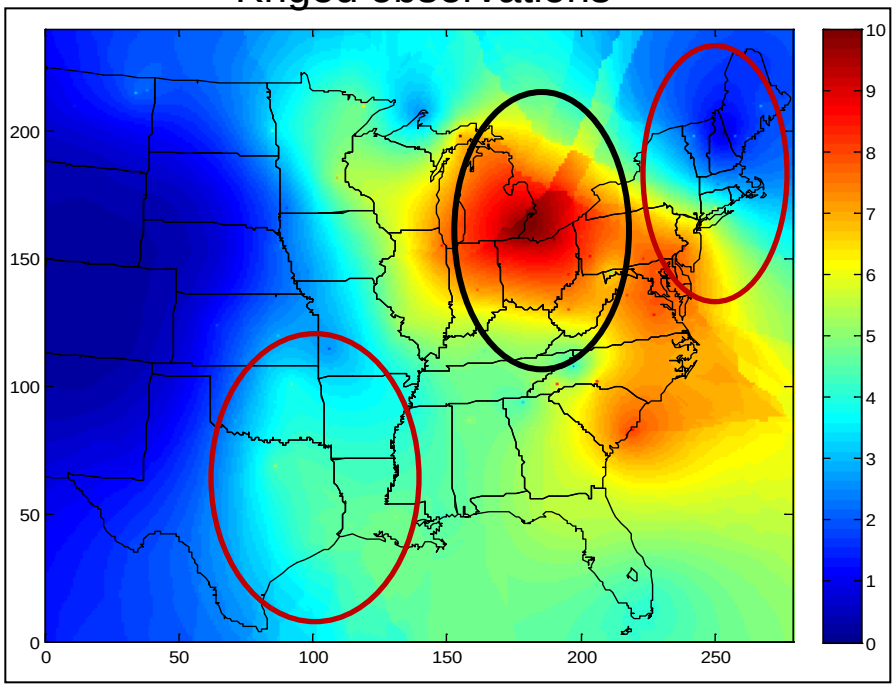
# Future Research

- Apply approach in other States affected by transported pollution (i.e., Pennsylvania, Maine) to determine if results are consistent.
- Use bias-adjusted 3-D air quality model estimates in other health studies; do we see similar results of using these “enhanced” surfaces?
- Continue accountability assessments (to be discussed by Dr. Lin) that explicitly consider transported pollution vs. mobile sources and the new interstate rule.
- Assess future impacts of climate change by developing and applying indices that consider joint effects of meteorology and pollution.

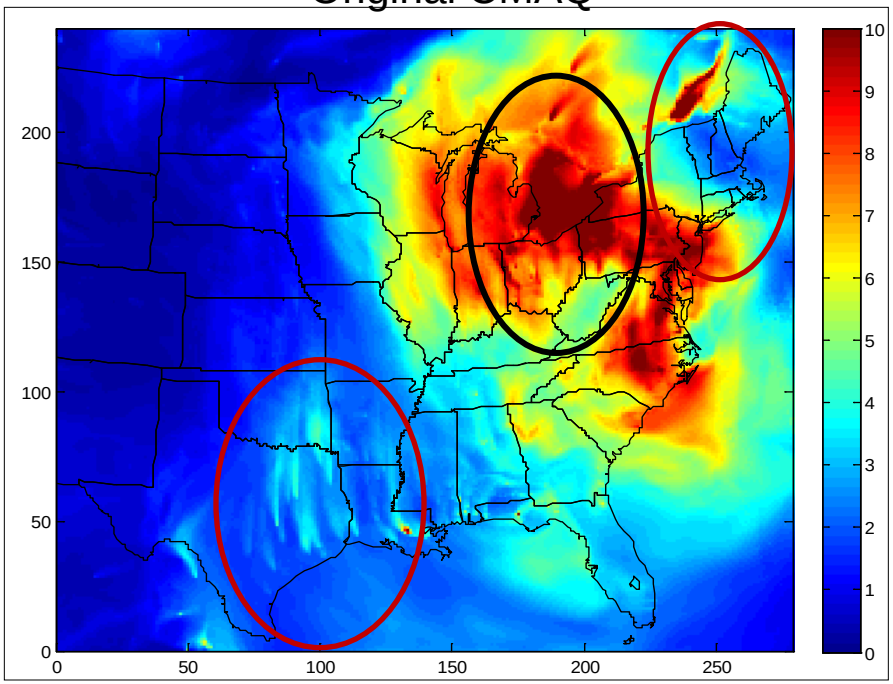
Although this presentation has been reviewed and approved for publication, it does not necessarily reflect the views and policies of the U.S. Environmental Protection Agency.

# Back-up Slides

Kriged observations

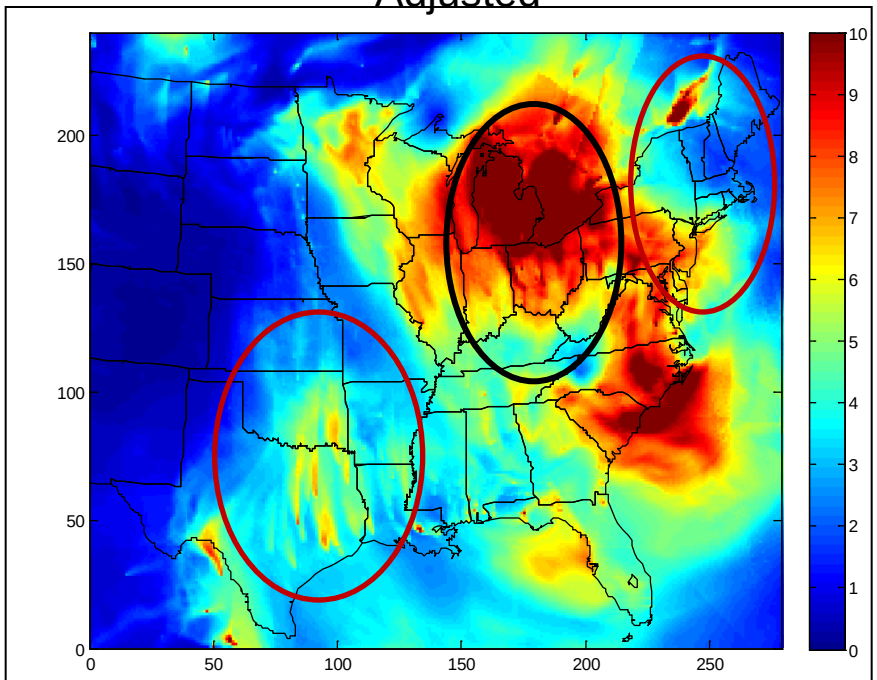



Original CMAQ




- CMAQ and observations combined using adjusted bias approach (obs:CMAQ ratio kriged across domain and the multiplied by CMAQ value).
- Difference in ‘texture’ between smoothed kriged surface and bias-adjusted surface indicates that CMAQ adds spatial information (red circles are areas where bias was high; black circles are areas where bias is low)

Adjusted



# Unadjusted Odds Ratio

- Used “polluted” and “clean” air parcel designations to define exposed and unexposed groups for calculating odds ratio.
- Used unadjusted odds ratio calculation to examine associations between respiratory-related hospital admissions and transported air parcels from the ORV zone.
- “Unadjusted” indicates that the calculation does not adjust for other variables that may impact the results.
    - Does account for population-based variables, such as smoking, but not variables such as temperature.

# Calculation of Crude Odds Ratio

**1. Prevalence:**

$$\Pr ev_{\exp} = {\#\, RHAs_{sw}} \Big/ {Total\ Pop}$$

$$\Pr ev_{un\exp} = {\#\, RHAs_{ne}} \Big/ {Total\ Pop}$$

**2. Prevalence Odds:**

$$\Pr evOdds_{\exp} = {\Pr ev_{\exp}} \Big/ {1 - \Pr ev_{\exp}}$$

$$\Pr evOdds_{un\exp} = {\Pr ev_{un\exp}} \Big/ {1 - \Pr ev_{un\exp}}$$

**3. Prevalence Odds Ratio:**

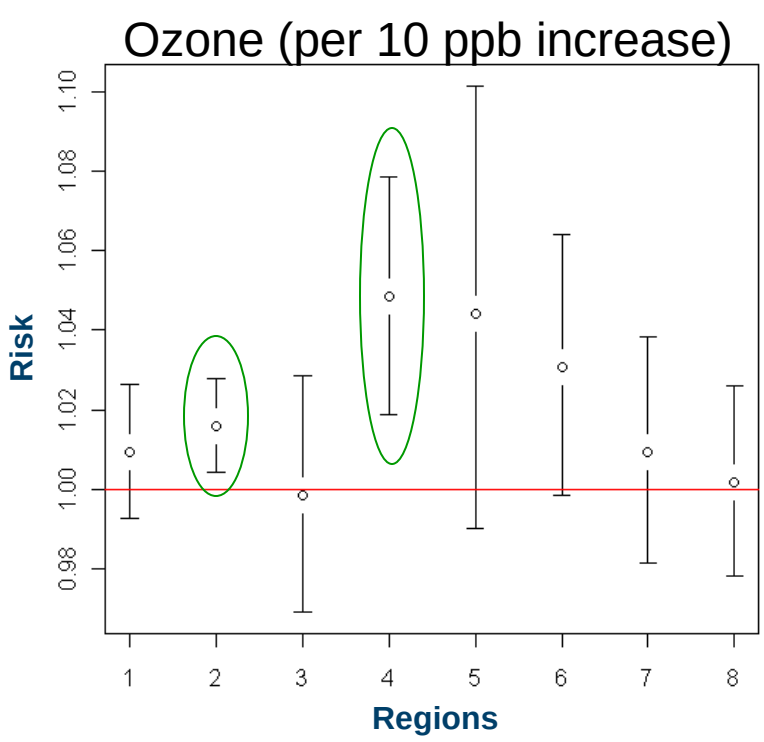
$$\Pr evOdds_{\exp} \Big/ \Pr evOdds_{un\exp}$$

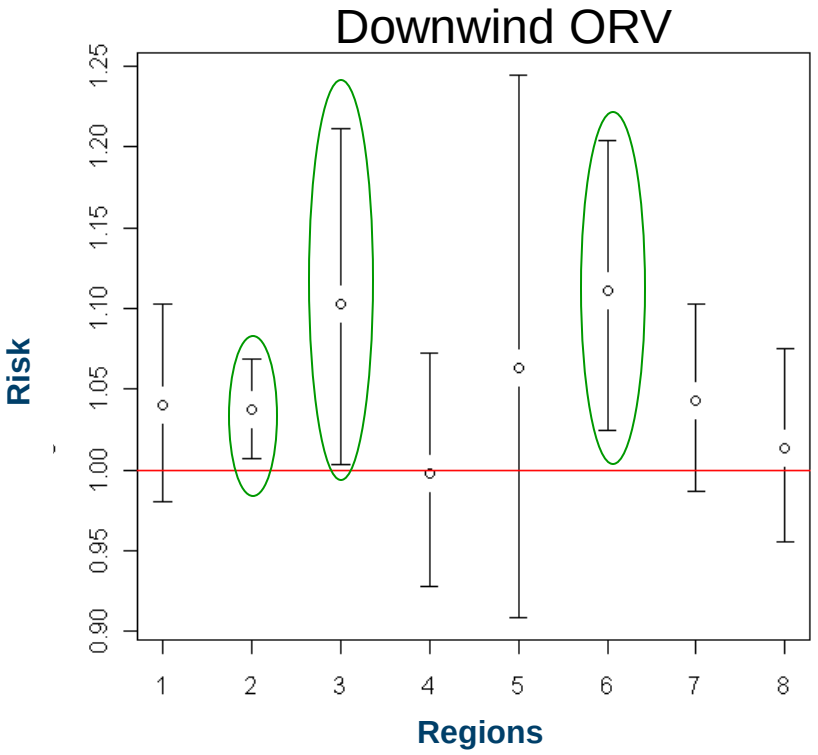
RHAs: Respiratory-Related Hospital Admissions with number of days normalized.

Exp.: Exposed group=hospital admissions on days with sw wind flow.

Unexp.:Unexposed group=hospital admissions on days with ne wind flow.

# Ozone vs. ORV Variable (GAM) (10 Summers of Data)

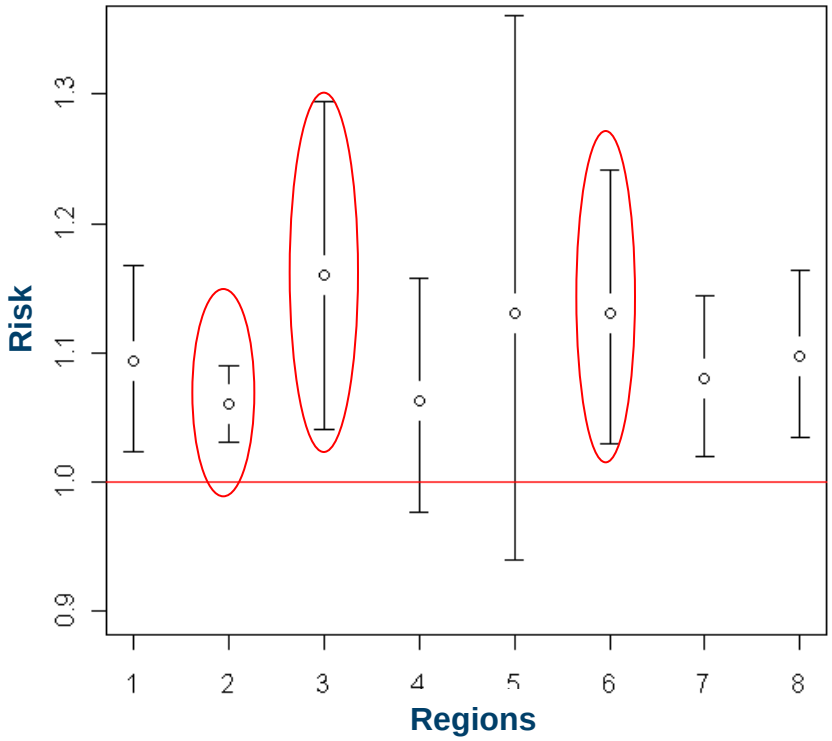


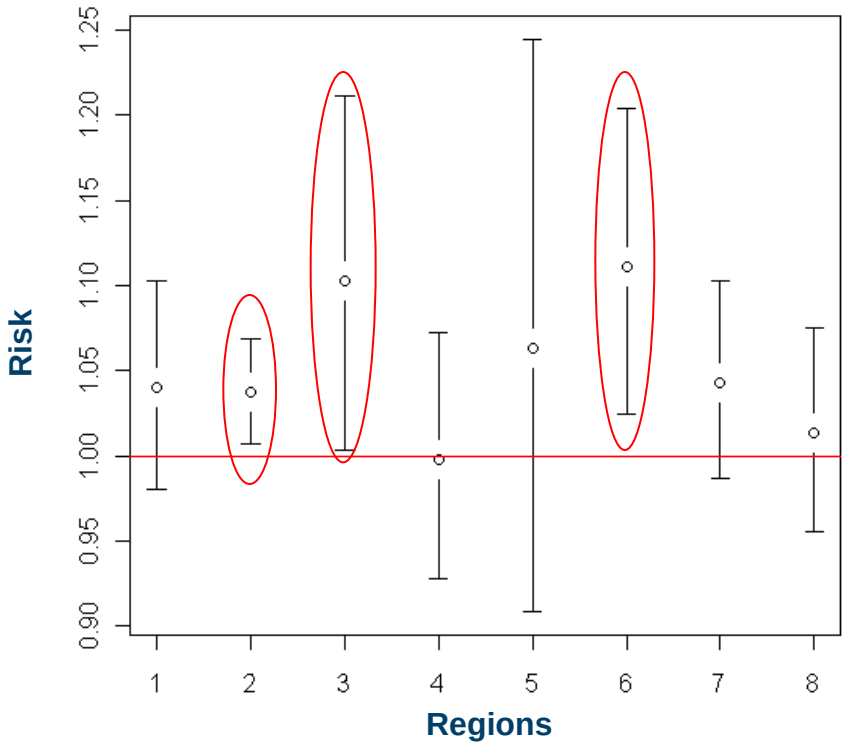

- NYS Regions 2 and 4 indicate excess risk associated with exposure from ozone (after accounting for variability from met and ORV variables);
- NYS Regions 2, 3 and 6 indicate excessive risk associated with air parcels transported from the ORV (after accounting for variability from met and ozone).

# Results for “ORV” Variable

Unadjusted Odds Ratio




GAM




Results are consistent with previous findings, but with lower risk estimates and fewer regions showing significant associations.