MANE-VU Mid-Atlantic/Northeast Visibility Union

# Tools and Techniques for Identifying Contributions to Regional Haze in the MANE-VU Region

MANE-VU Board Meeting
May 5, 2005

Gary Kleiman, NESCAUM

# Contribution Assessment and Long-term Strategy

- Long-term strategy requires a "pollution apportionment"

- Long-term strategy also requires an emissions management plan (i.e. control strategies) and BART determinations

# What tools and techniques has MANE-VU developed to improve our understanding of attribution?

- MANE-VU is building a weight of evidence approach looking at monitoring data, emissions inventory data, regional air-quality modeling and key data analysis findings

- All these techniques have been synthesized and interpreted in an interim "contribution assessment" or pollution apportionment report

Lye Brook Falls
Lye Brook
Vermont

# Conceptual Model

- Summertime PM results largely from the regional transport/production of sulfate
- Wintertime PM results from the regional transport/production of sulfate + local sulfate + local organics + local nitrate
- Worst twenty percent days are mostly summer, but include several winter days as well

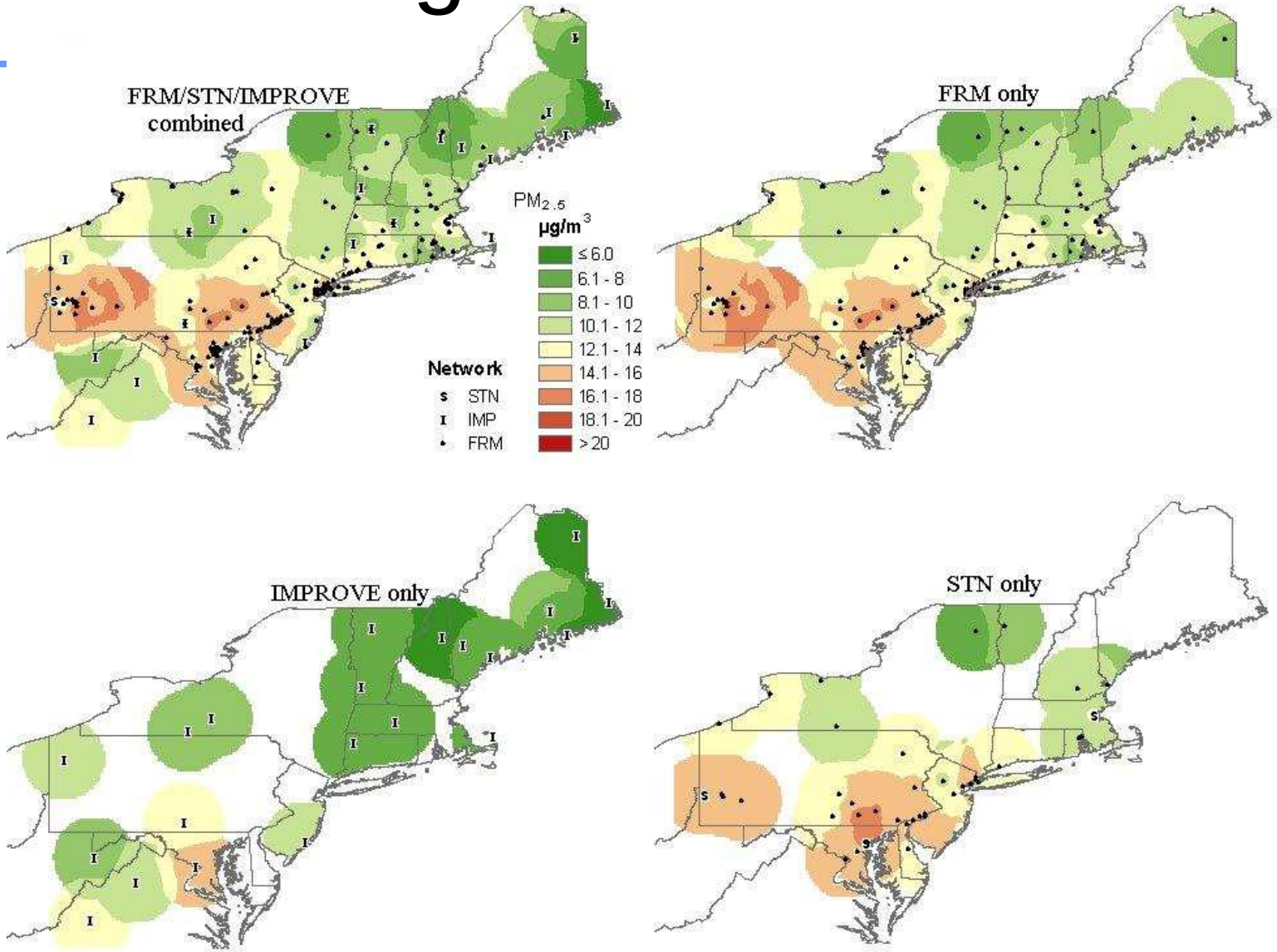
Woodcock
Moosehorn
Maine

# Monitoring

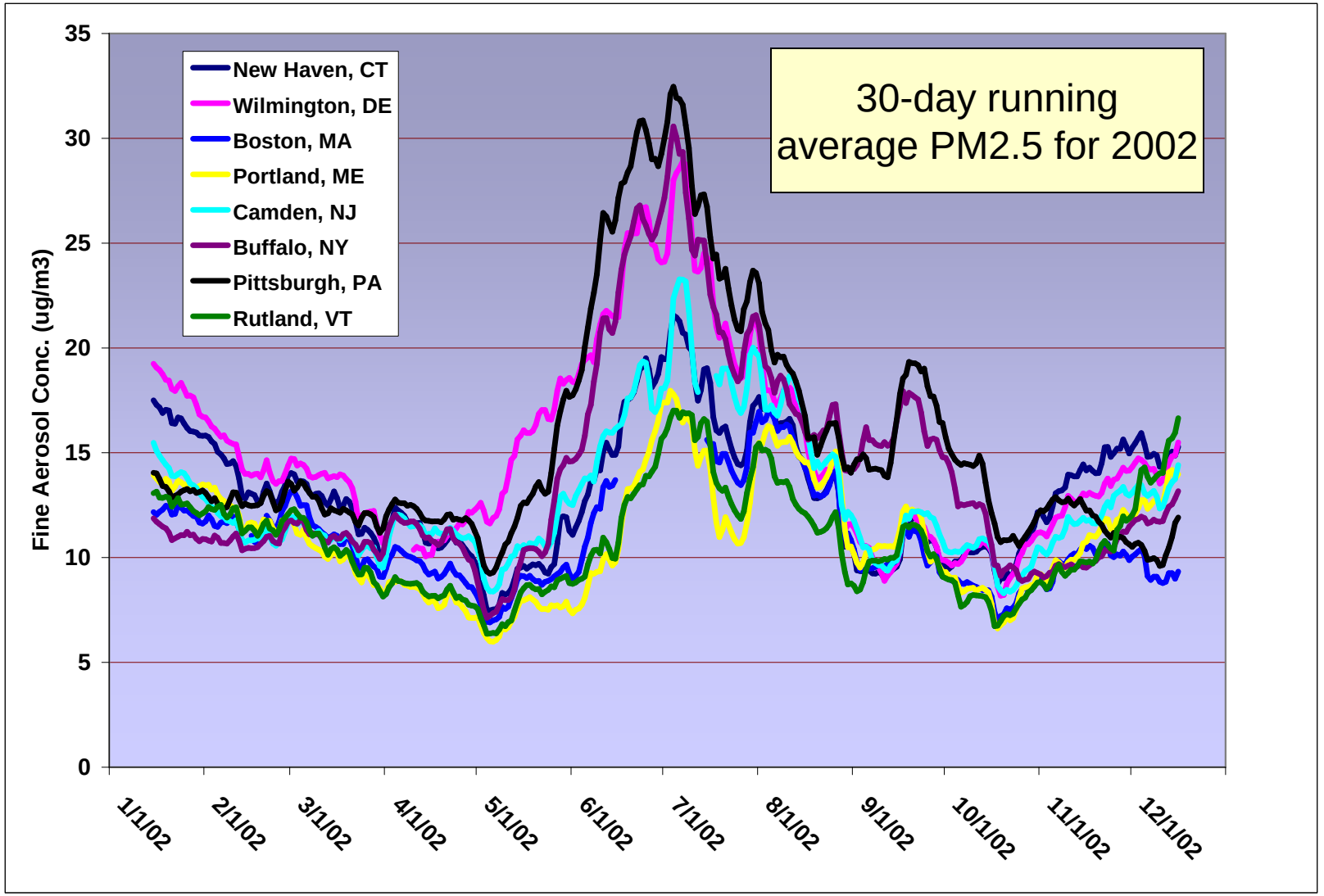
- Review 2002 monitoring data
- Demonstrate how these data support the conceptual model
- Review Baseline Conditions
- Illustrate implications for control strategies
- Review RAIN and how M-V is preparing for long-term demands of monitoring strategy

Mulholland Point Lighthouse
Roosevelt Campobello
Maine

# Monitoring Data: Rural/Urban



# Monitoring Data: Seasonality



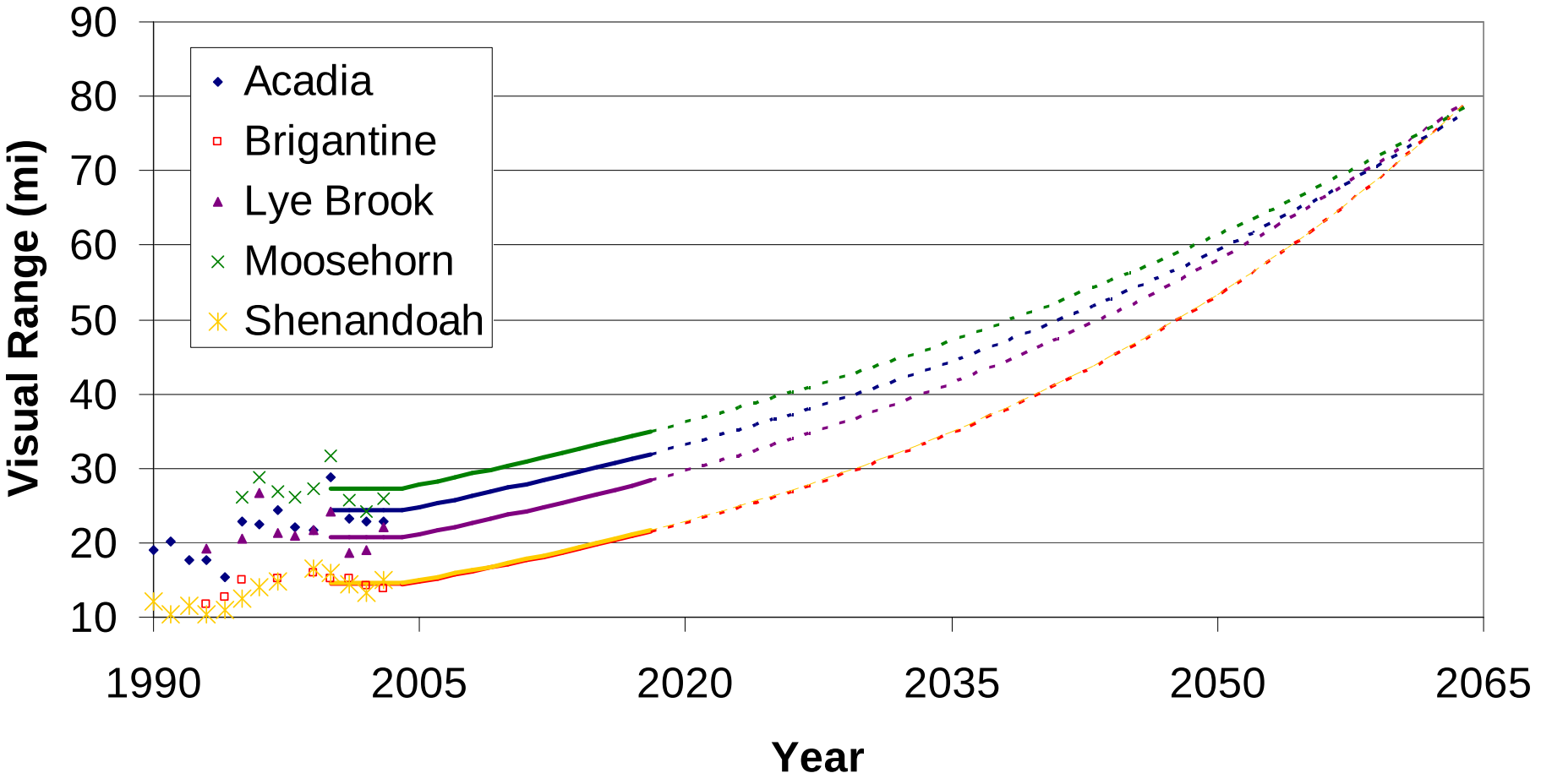
# Monitoring Data: Baseline Conditions/Uniform Progress

**Natural Background and Baseline calculations for Select Class I areas**

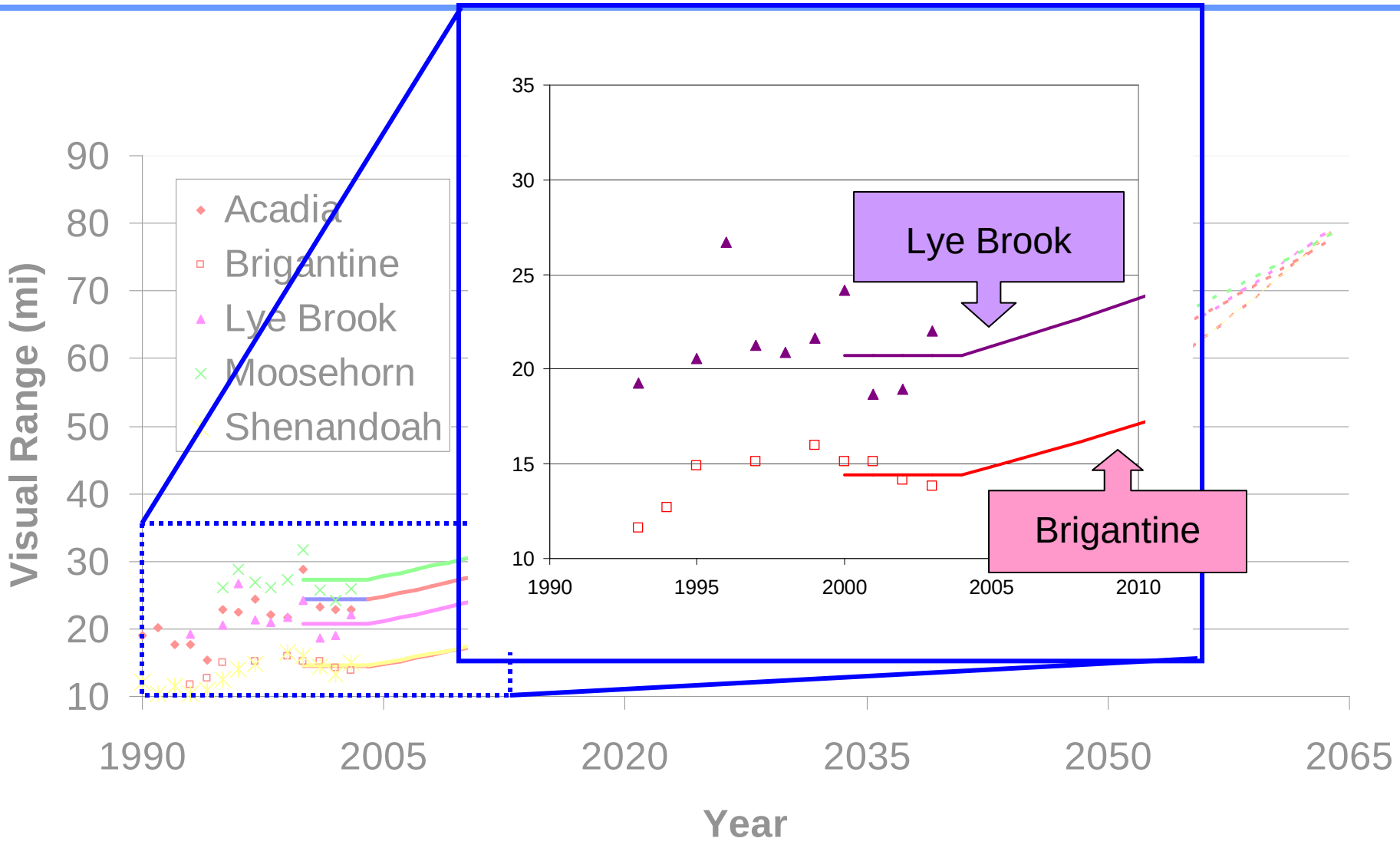
| Site[1] | Natural Background (DV) | Baseline 2000-03 (DV) | Uniform Rate (DV/year) | Interim Progress Goal 2018 (DV) |
|---|---|---|---|---|
| Acadia | 11.45 | 23.06 | 0.19 | 20.35 |
| Brigantine | 11.28 | 28.30 | 0.28 | 24.33 |
| Lye Brook | 11.25 | 24.67 | 0.22 | 21.54 |
| Moosehorn | 11.36 | 21.91 | 0.18 | 19.45 |
| Shenandoah | 11.27 | 28.19 | 0.28 | 24.24 |

[1] The MANE-VU Class I monitoring site, Great Gulf, is not tabulated since only 2001-2003 data are available.

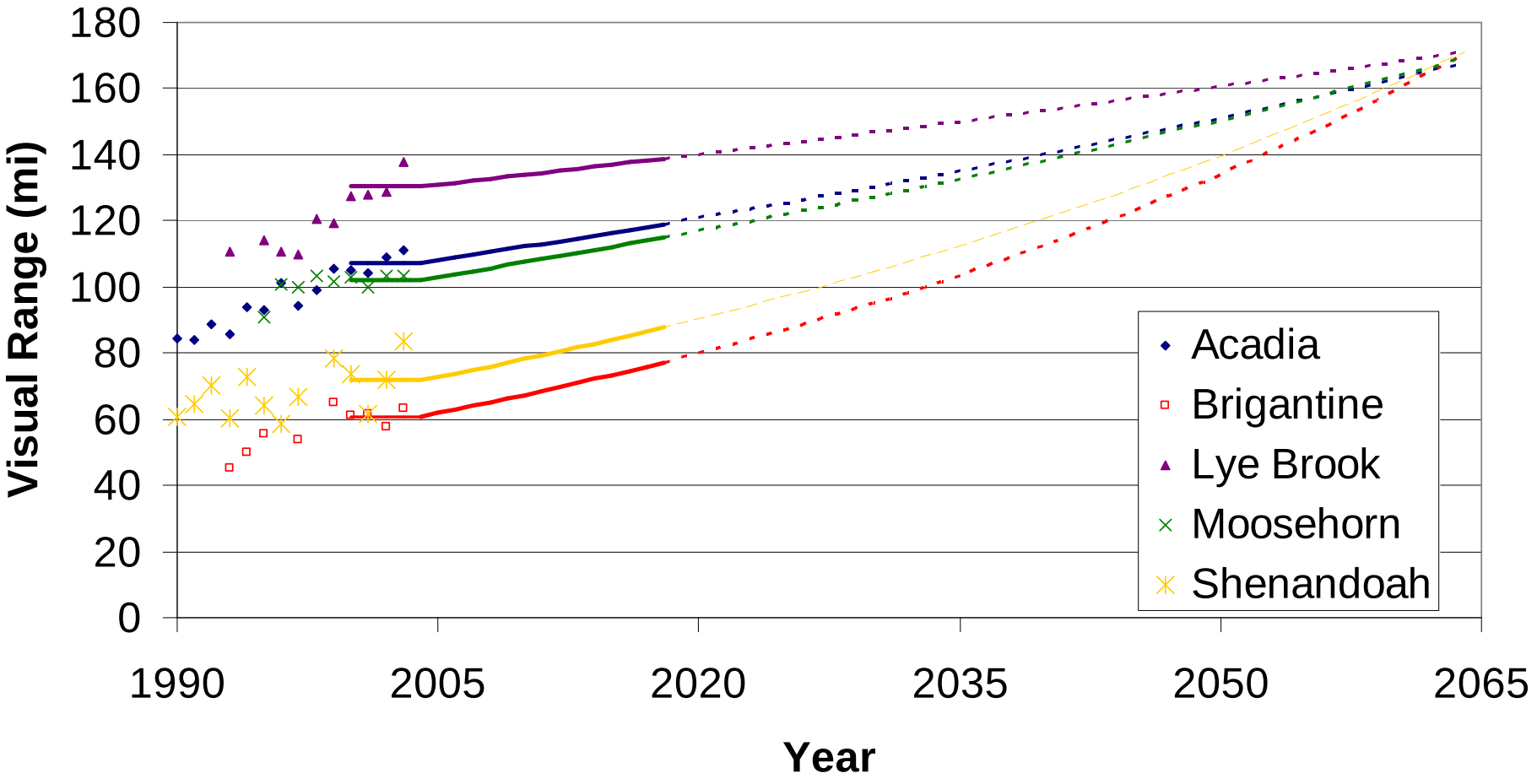
# Preliminary Uniform Progress Goals (20% Worst Visibility Days)



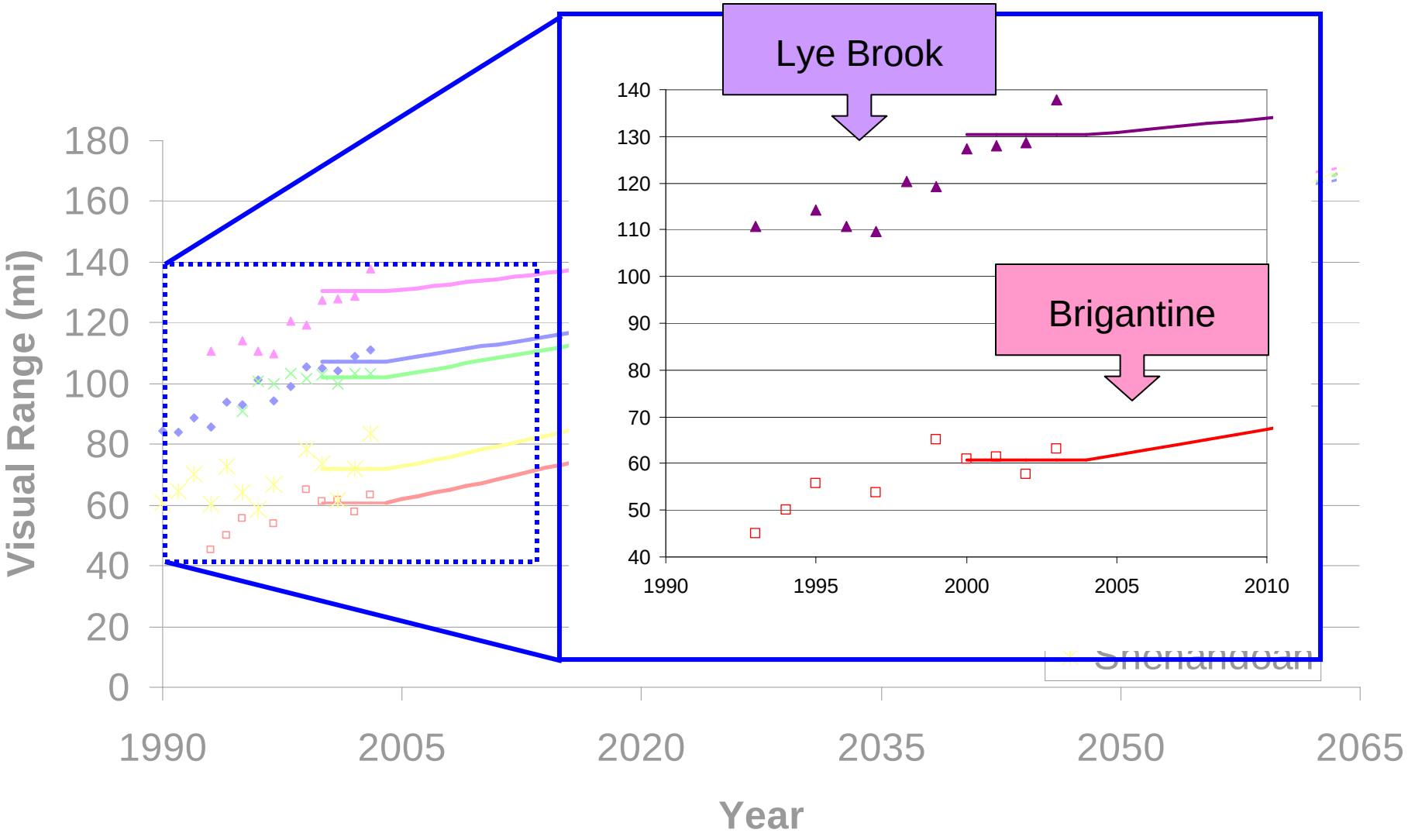
# Preliminary Uniform Progress Goals (20% Worst Visibility Days)



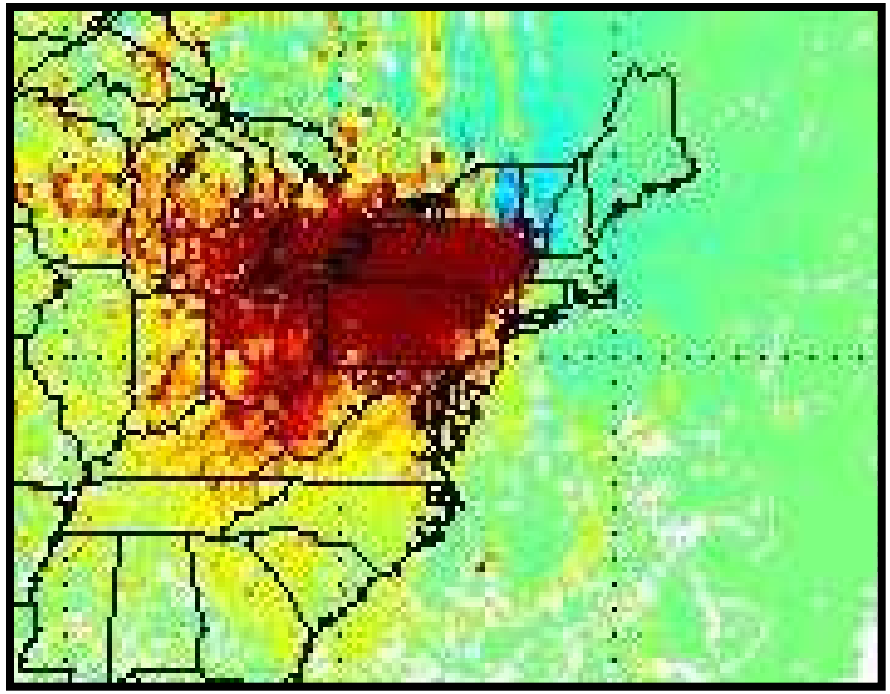
# Preliminary Uniform Progress Goals (20% Best Visibility Days)



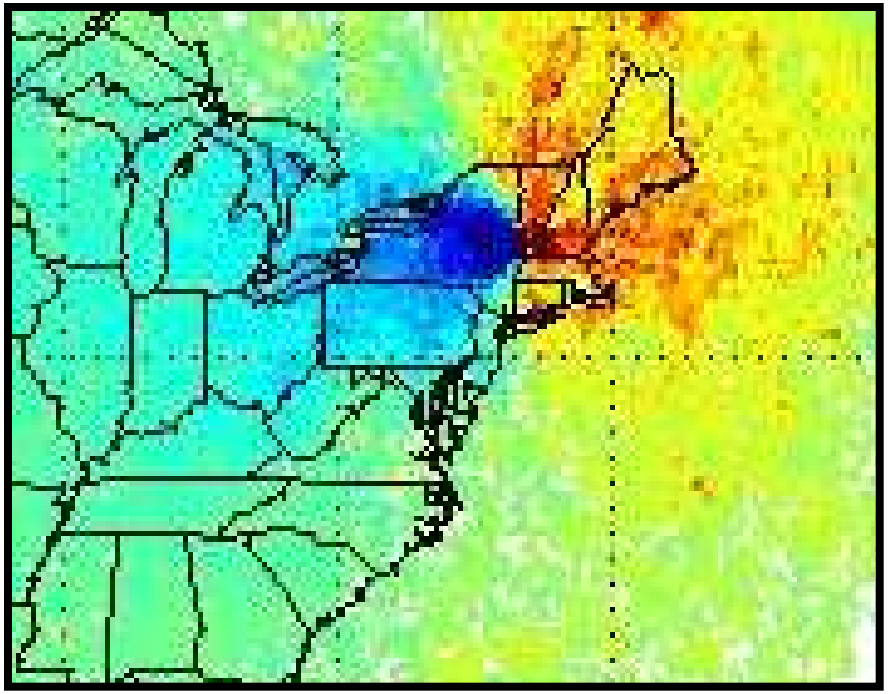
# Preliminary Uniform Progress Goals (20% Best Visibility Days)



# Lye Brook Source Regions



Meteorological source region on 10% highest sulfate days. Red indicates Increased probability of contributing to high days.



Meteorological source region on 10% lowest sulfate days. Red indicates Increased probability of contributing to low days.

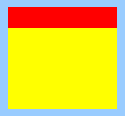
# What to control??
## (Example: Brigantine, NJ)

**Sulfates and Nitrate**

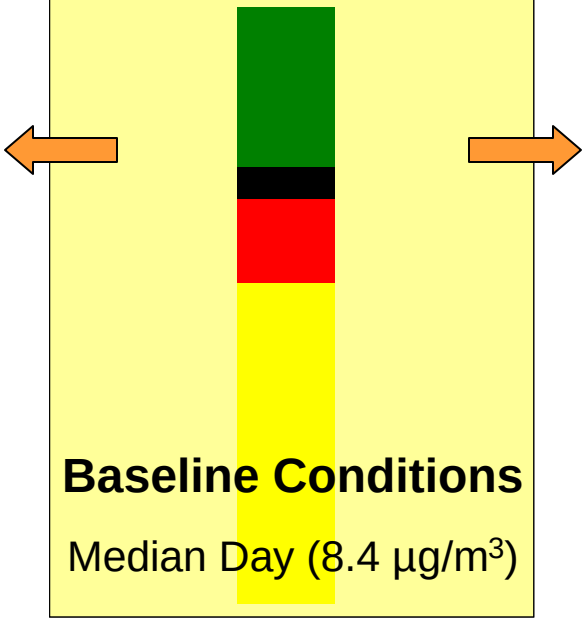
**Based Control Program**

1.26 µg/m3

Mass Reduction



Organic Carbon
Elemental Carbon
Nitrate
Sulfate



**Baseline Conditions**

Median Day (8.4 µg/m$^3$)

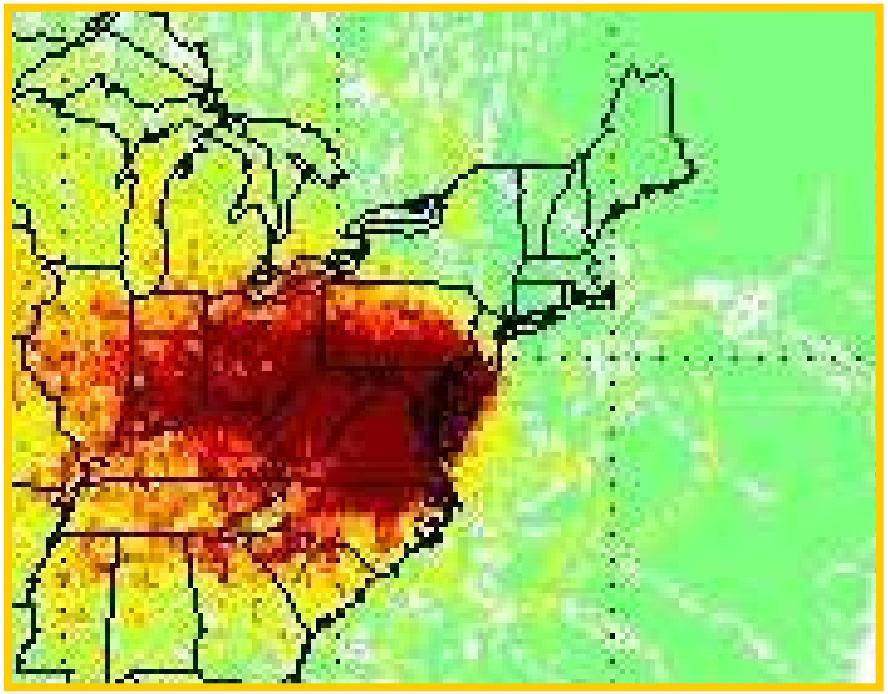
**Control All Components**

**In Proportion**

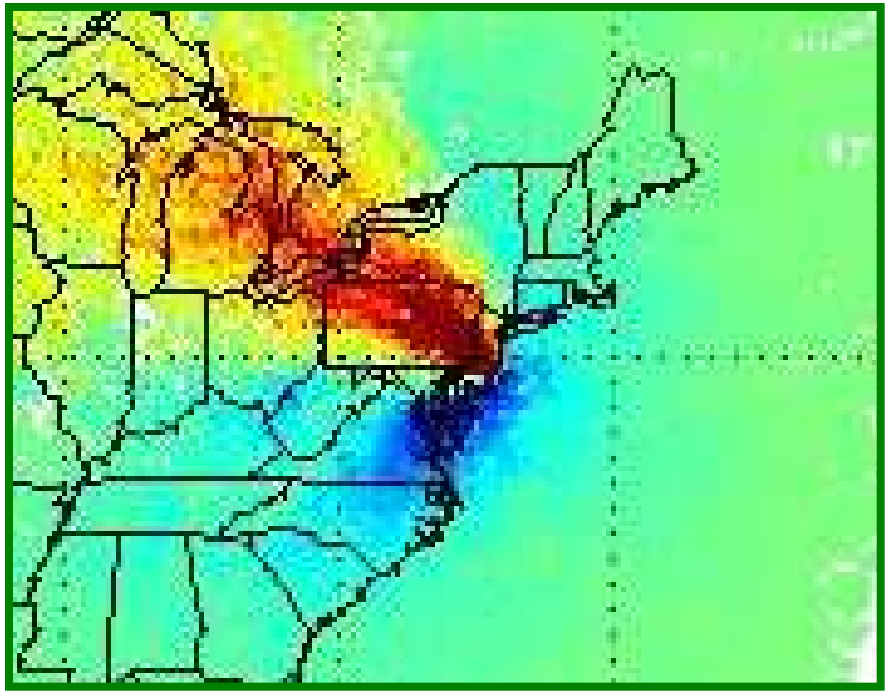
1.46 µg/m3

Mass Reduction

# Same source region??



Meteorological source region on 10% worst sulfate days at Brigantine, NJ



Meteorological source region on 10% worst organic carbon days

# Alternative strategies for achieving uniform progress by 2018

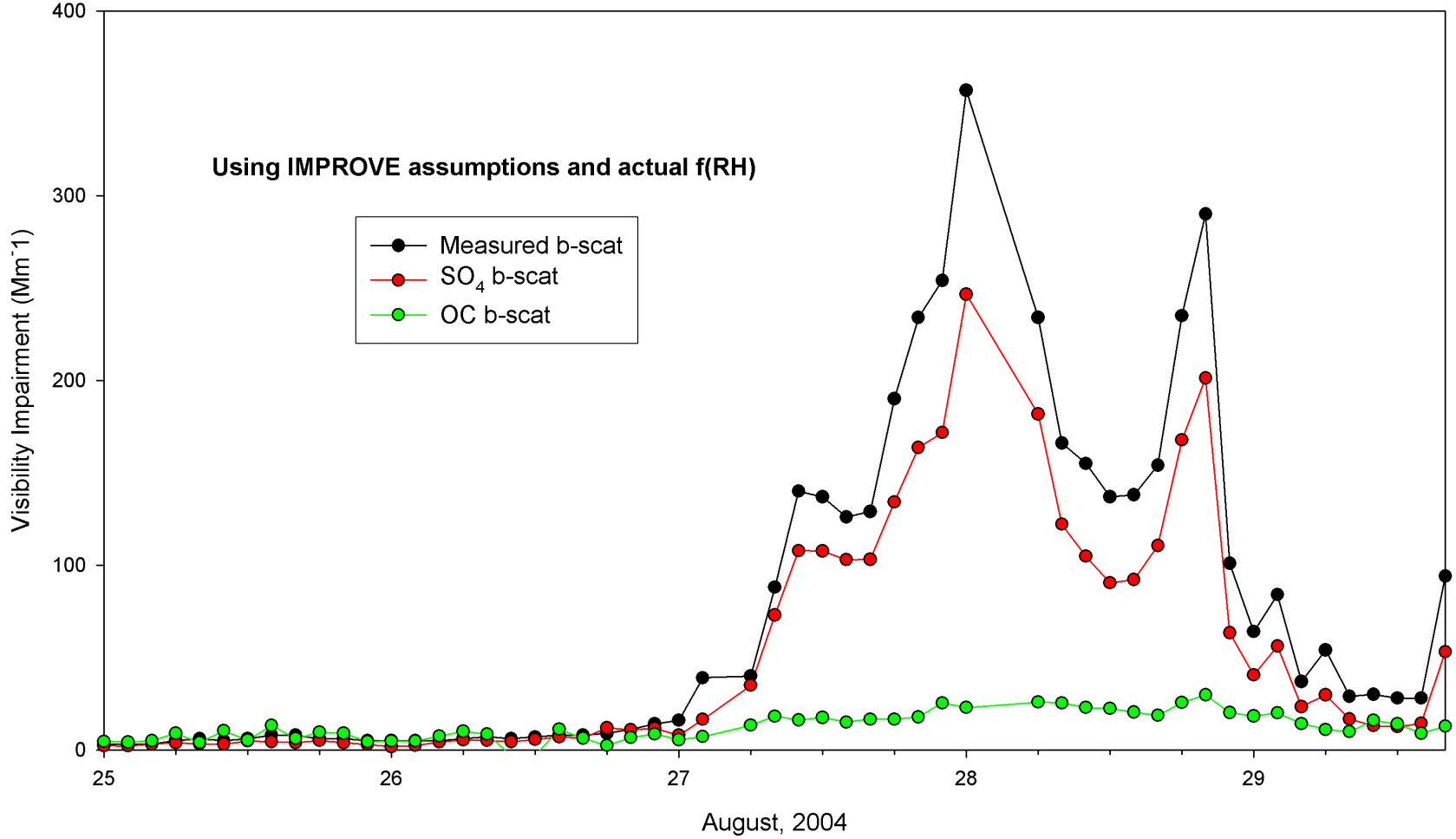
Proportional reductions in sulfate and nitrate only, or …

| .33 | 1.26 | .40 | .33 | 1.16 | (µg/m$^3$) |
|---|---|---|---|---|---|
| Acadia | Brigantine | Lye Brook | Moosehorn | Shenandoah | Median Day |

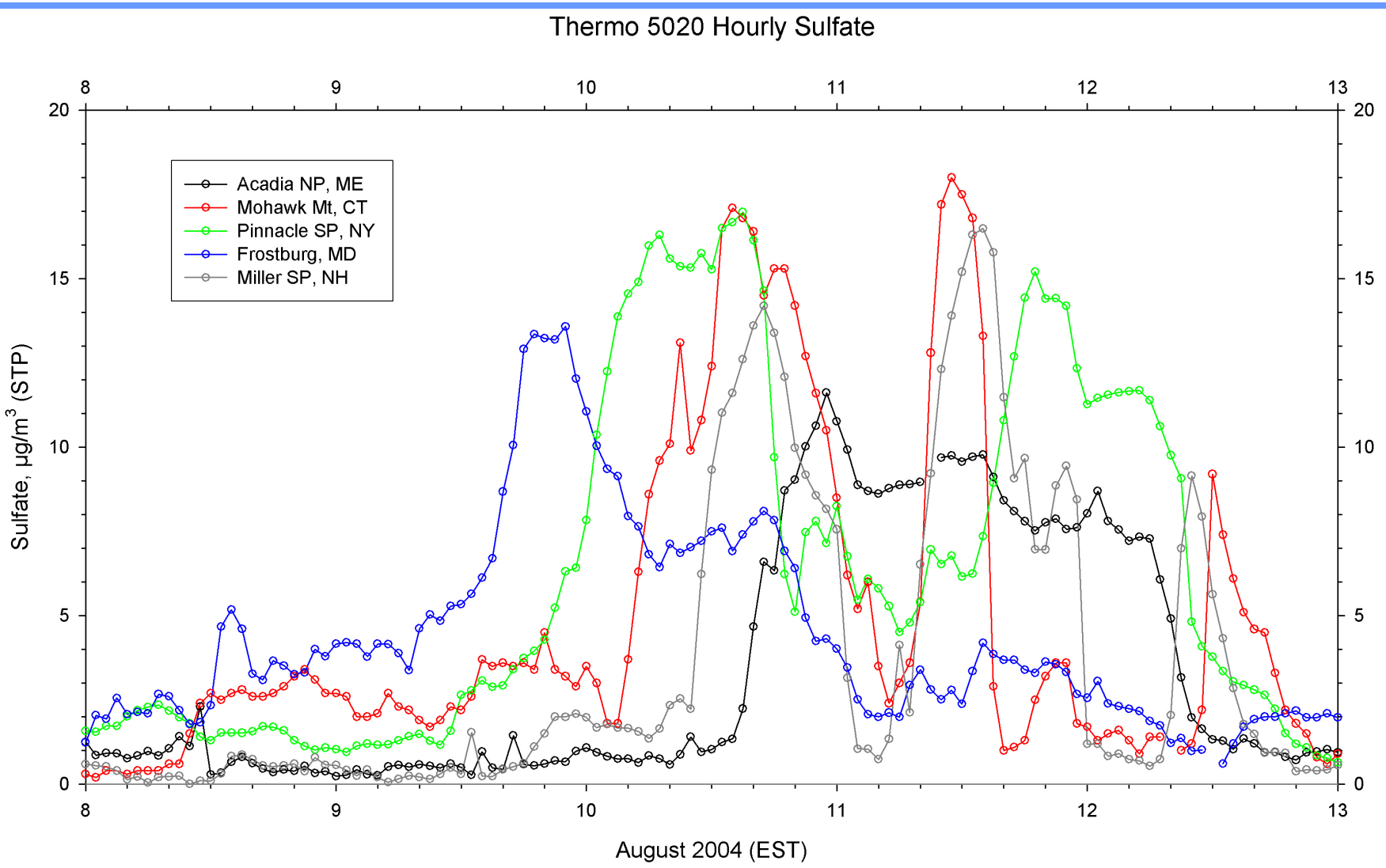
Proportional reductions in sulfate, nitrate, organic carbon and elemental carbon

| .43 | 1.46 | .50 | .45 | 1.33 | (µg/m$^3$) |
|---|---|---|---|---|---|
| Acadia | Brigantine | Lye Brook | Moosehorn | Shenandoah | Median Day |

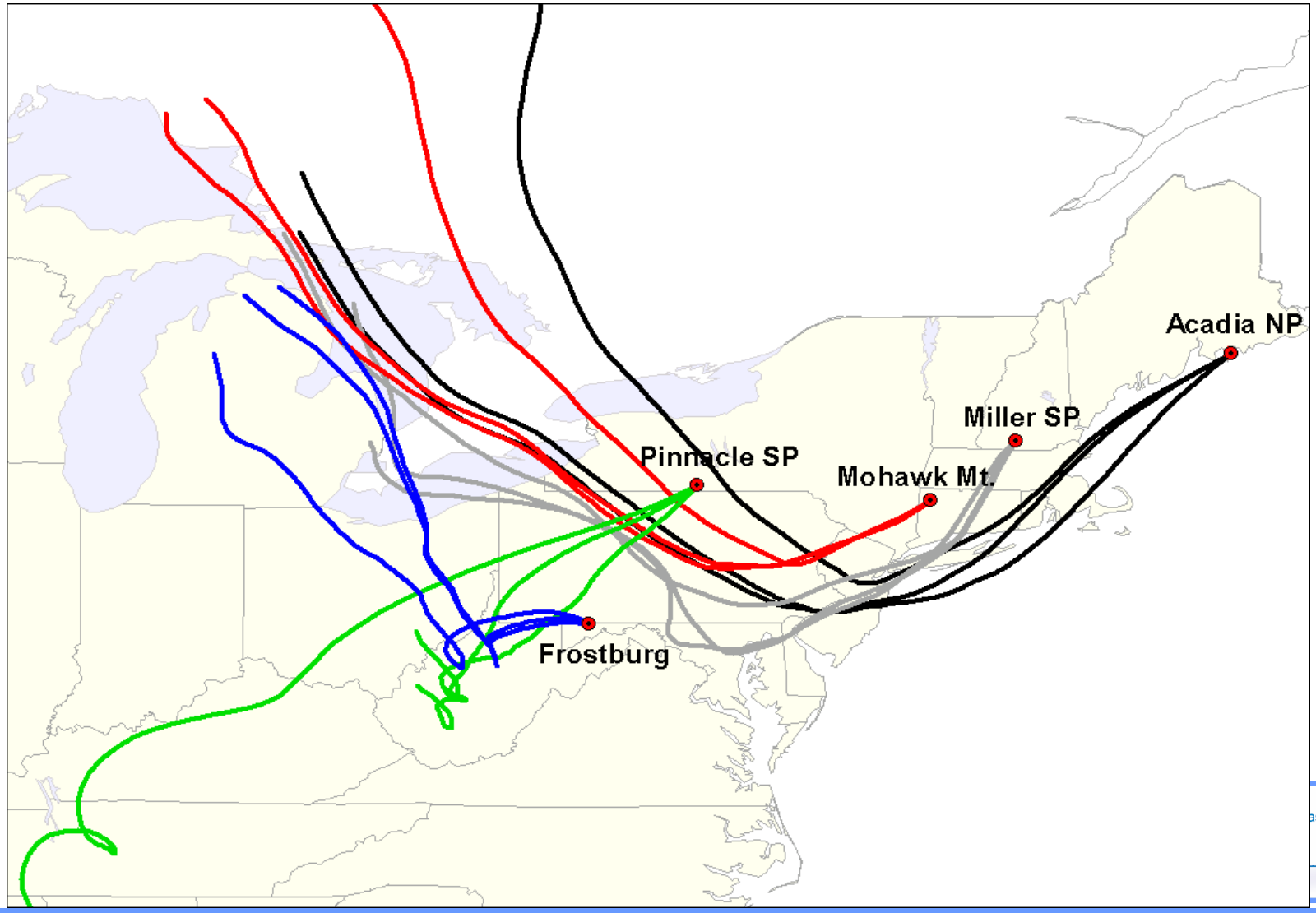
# Monitoring Data: RAIN

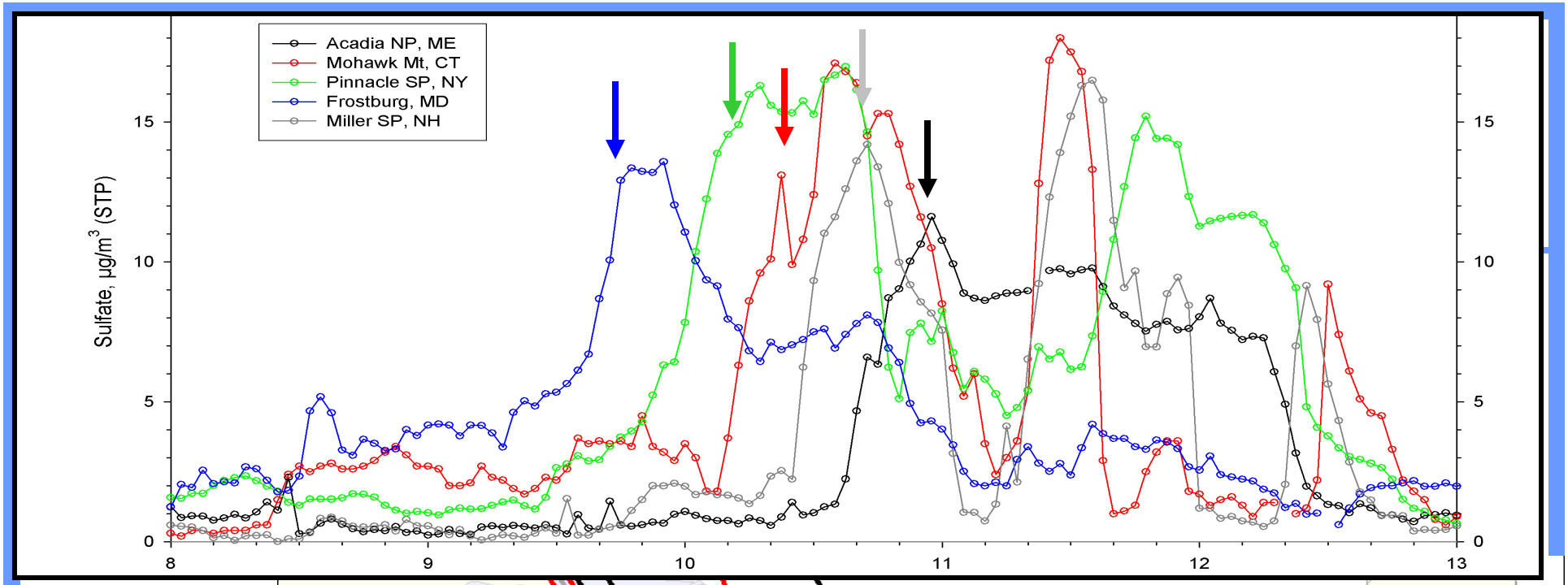


# Monitoring Data: RAIN

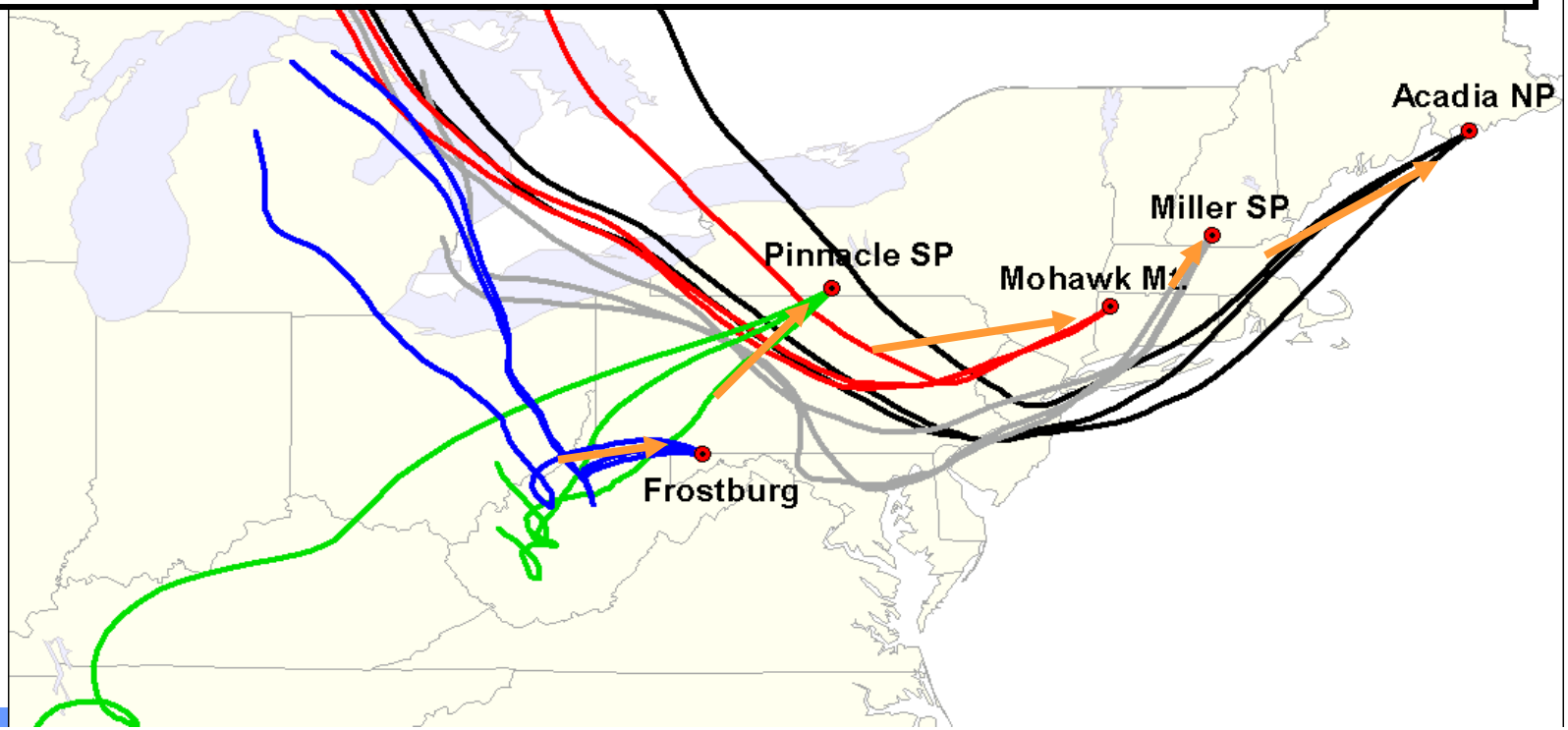


# Where did these peaks come from?





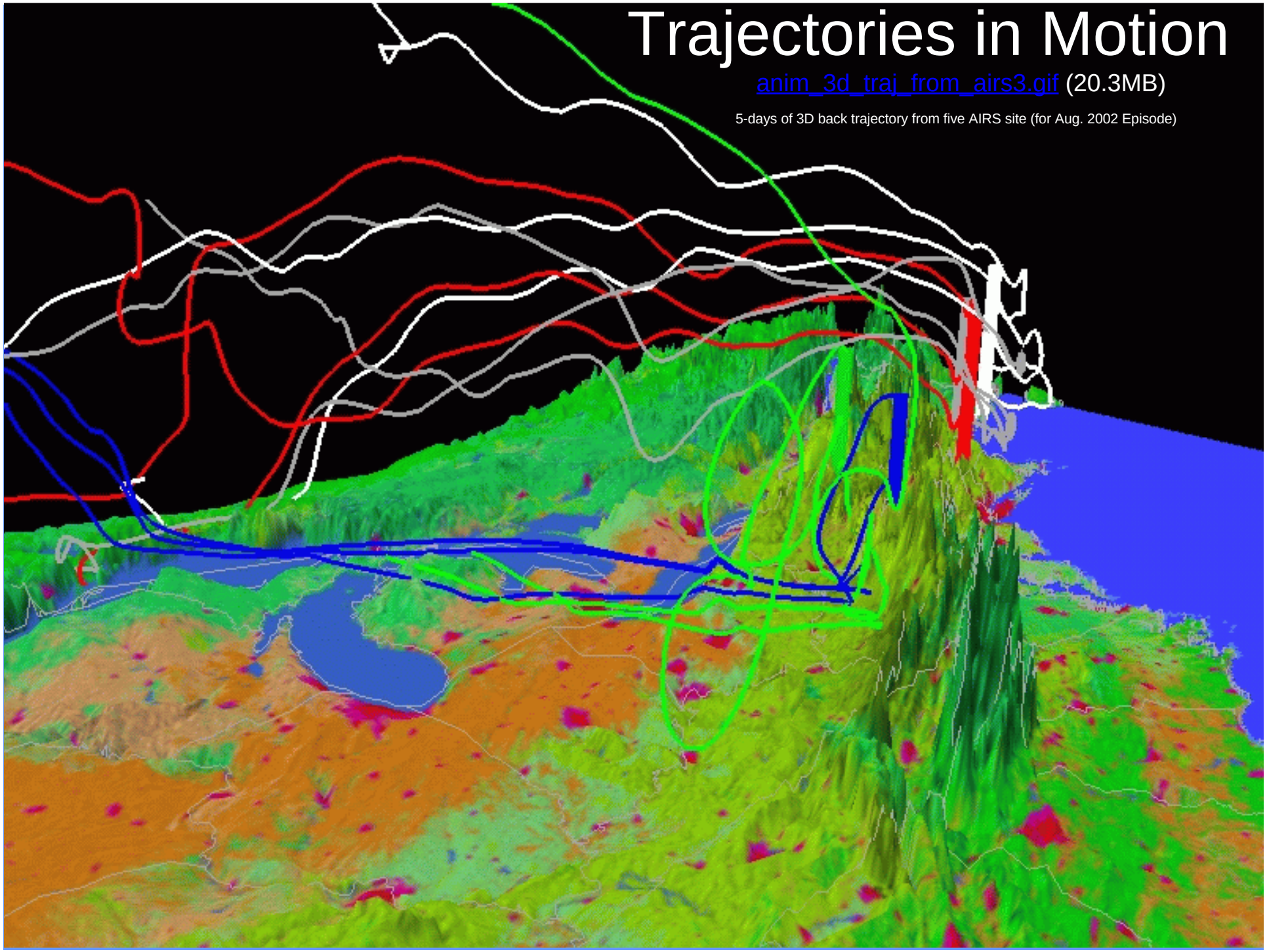

Put them together and…



# Trajectories in Motion

anim_3d_traj_from_airs3.gif (20.3MB)

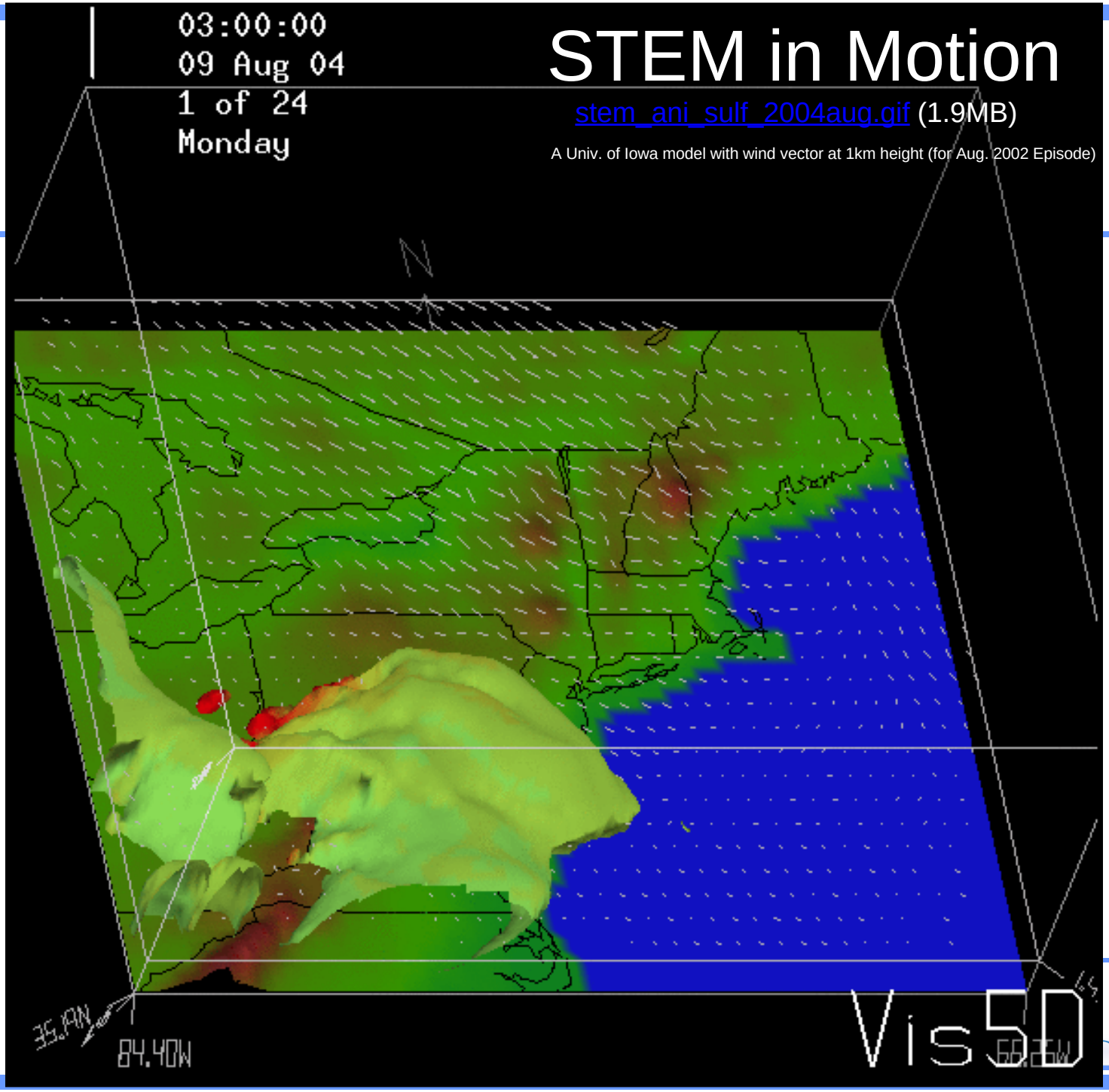
5-days of 3D back trajectory from five AIRS site (for Aug. 2002 Episode)



# STEM in Motion

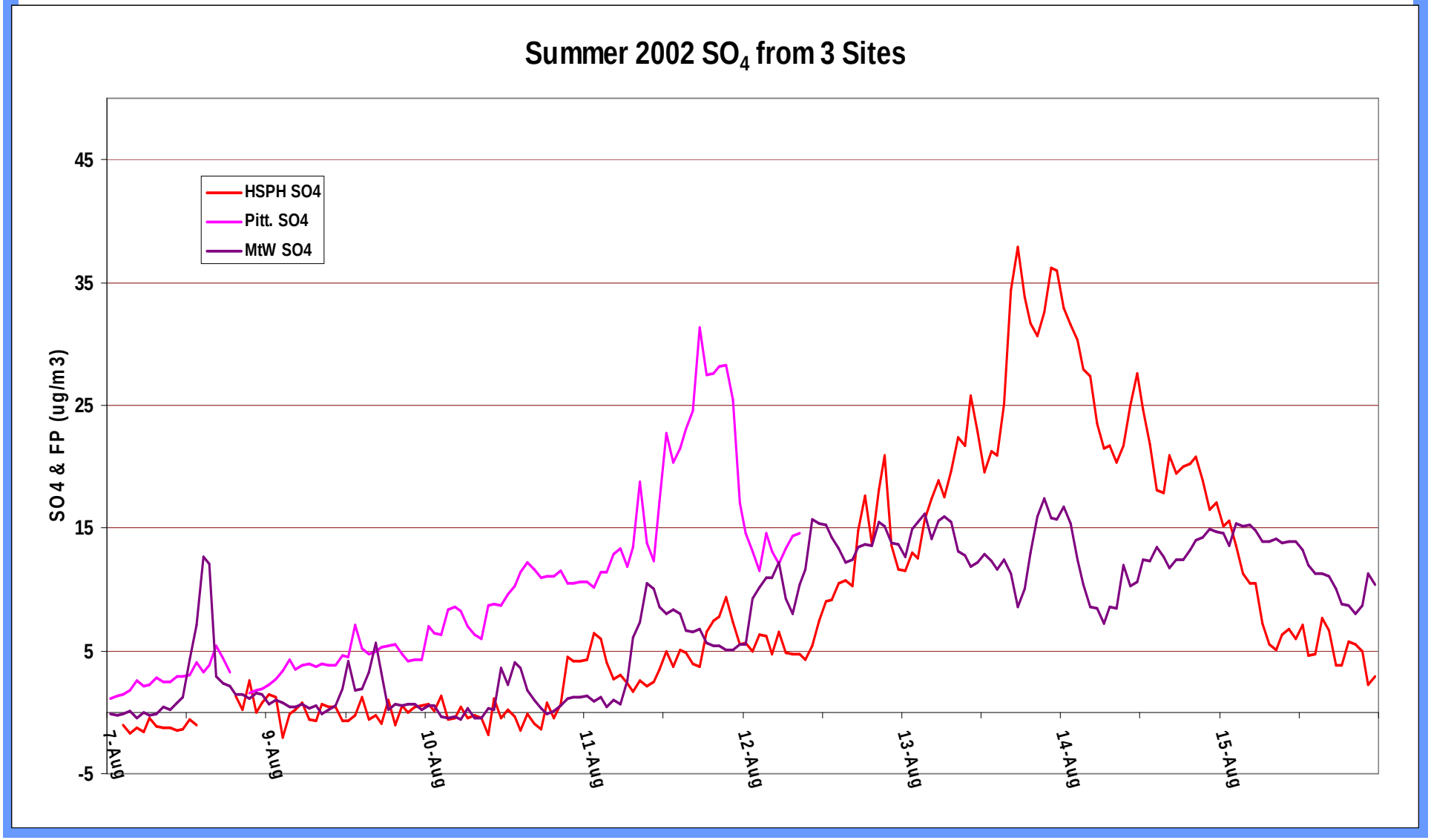
stem_ani_sulf_2004aug.gif (1.9MB)

A Univ. of Iowa model with wind vector at 1km height (for Aug. 2002 Episode)




Mid-Atlantic/Northeast Visibility Union

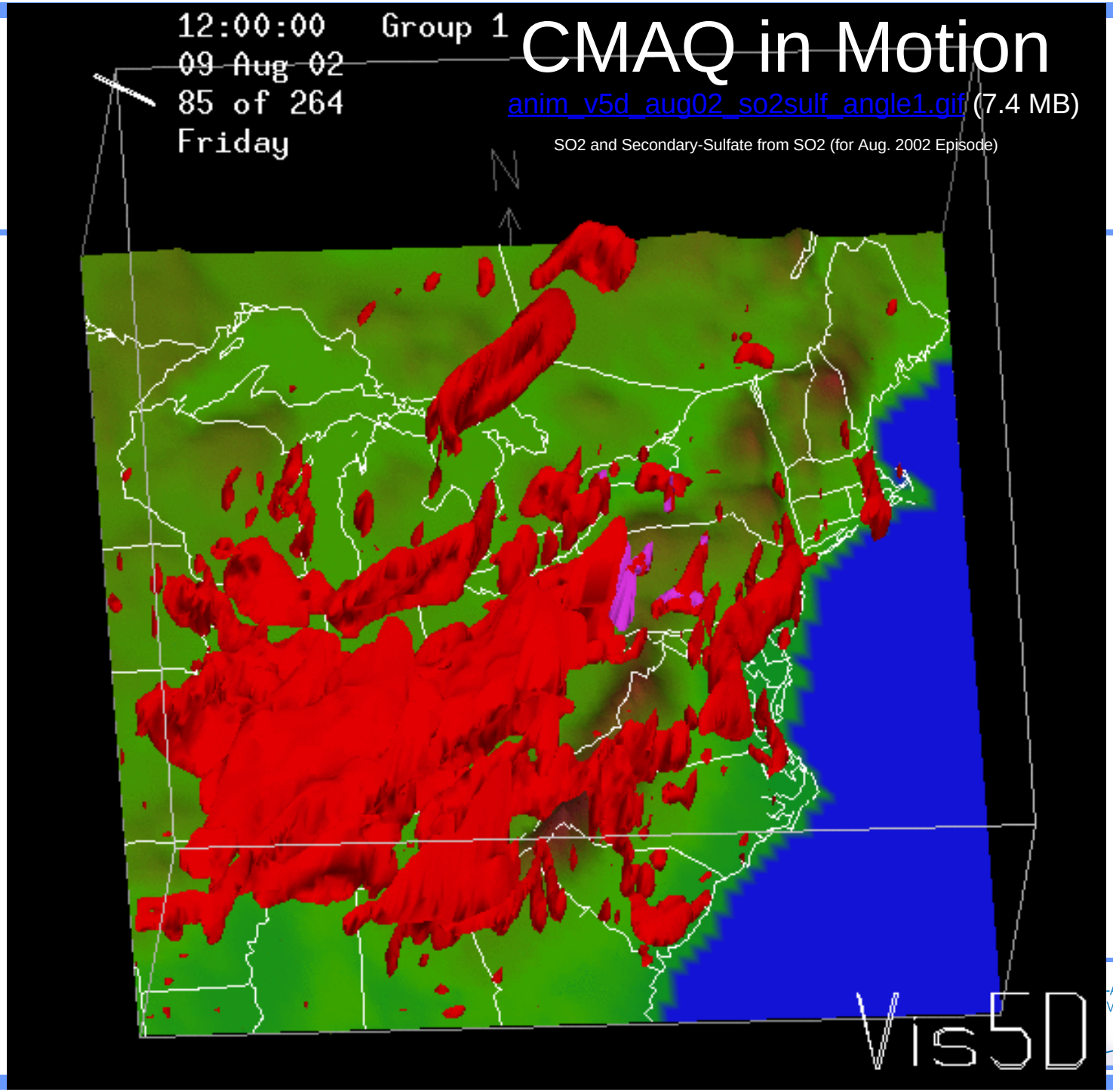
# 2002 Episode w/o RAIN



# CMAQ in Motion

anim_v5d_aug02_so2sulf_angle1.gif (7.4 MB)

SO2 and Secondary-Sulfate from SO2 (for Aug. 2002 Episode)



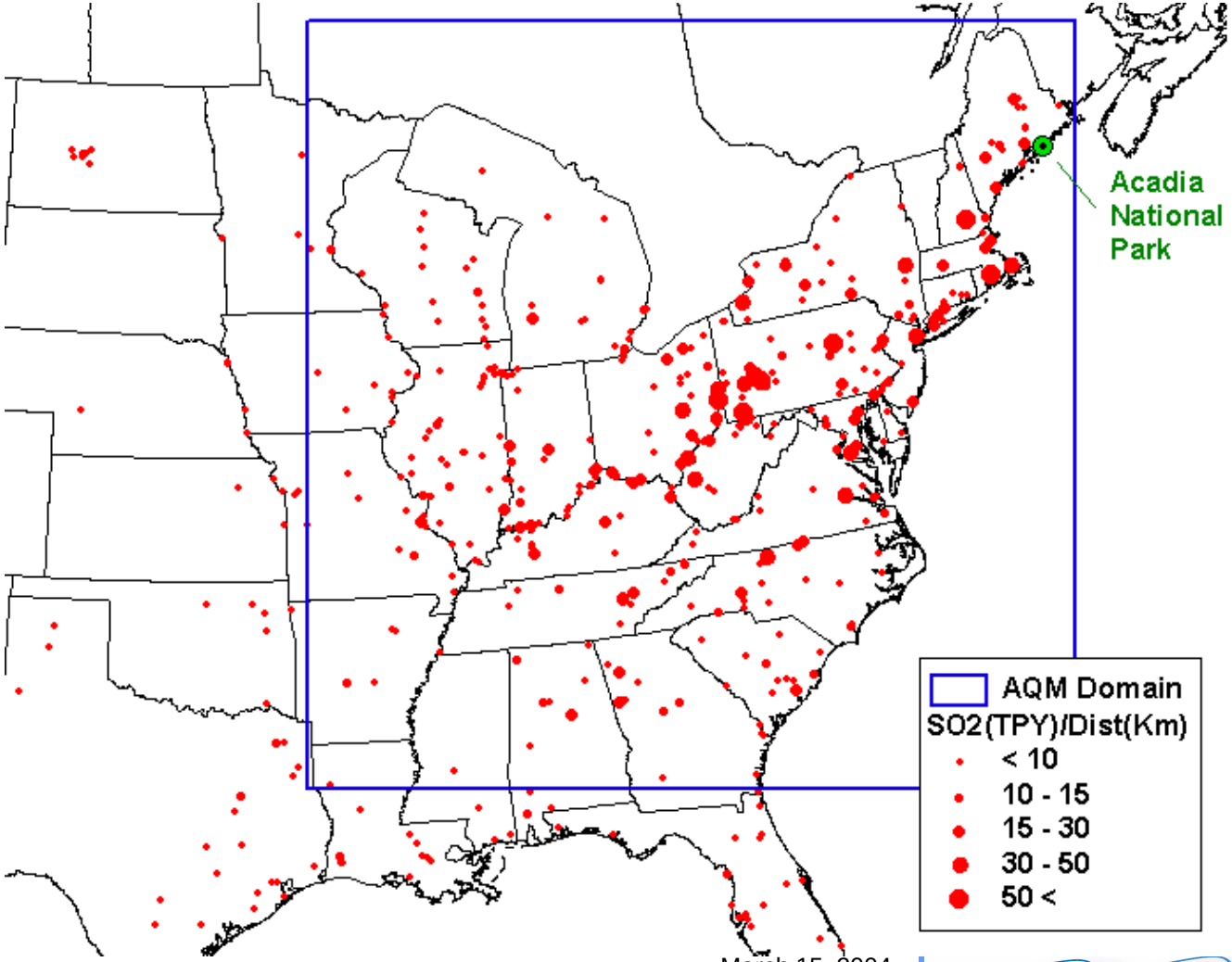

-Atlantic/Northeast
Visibility Union

# Weight of Evidence Approach

| Analytical technique | Approach |
|---|---|
| Emissions/distance | Empirical |
| Incremental Probability | “Receptor”-based trajectory technique |
| Cluster-weighted Probability | “Receptor”-based trajectory technique |
| Emissions x upwind probability | Empirical/trajectory hybrid |
| Source Apportionment Approaches | Receptor model/trajectory hybrid |
| REMSAD tagged species | “Source”-based grid model |
| CALPUFF with MM5-based meteorology | “Source”-based dispersion model |
| CALPUFF with observation based meteorology | “Source”-based dispersion model |

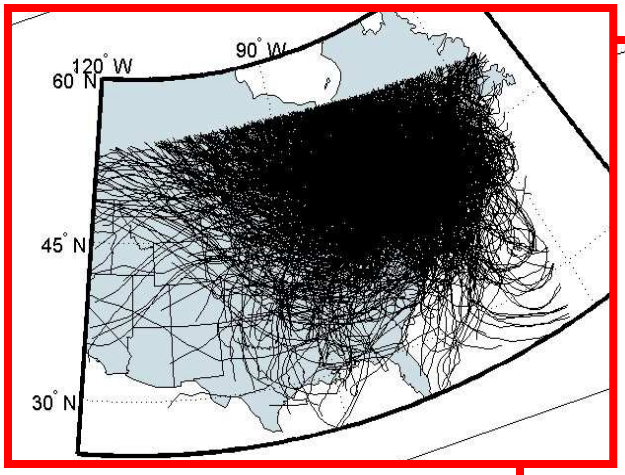
Geese
Brigantine
New Jersey

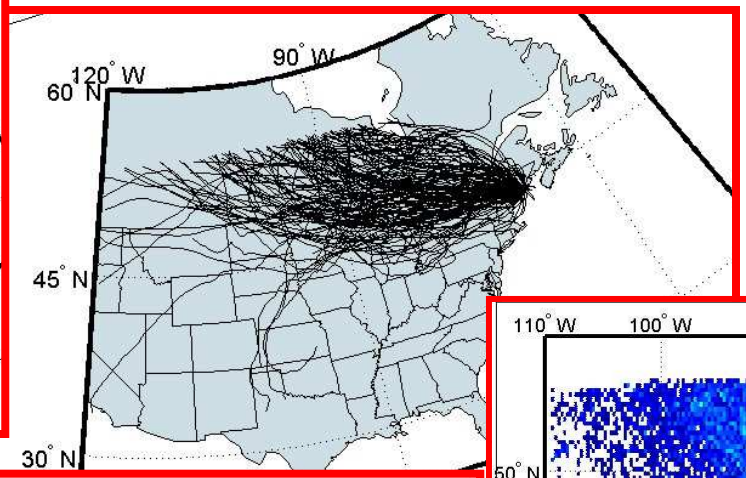
# Emissions/Distance Analysis

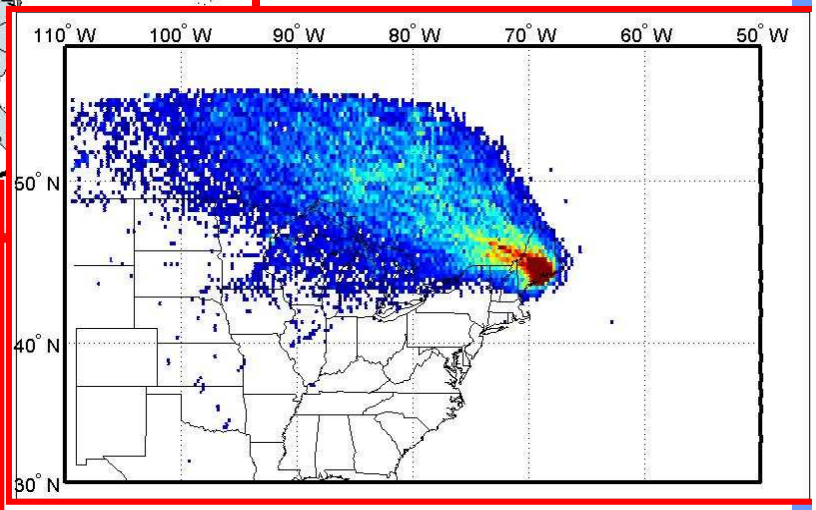


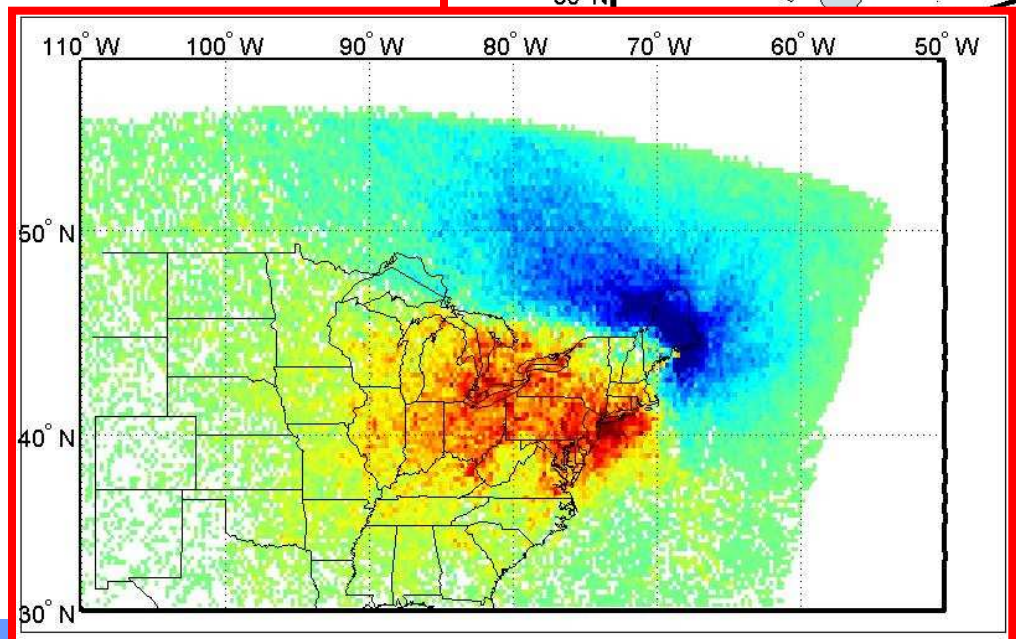

lid-Atlantic/Northeast
Visibility Union

# Trajectory Analysis: Best Day/Worst Day



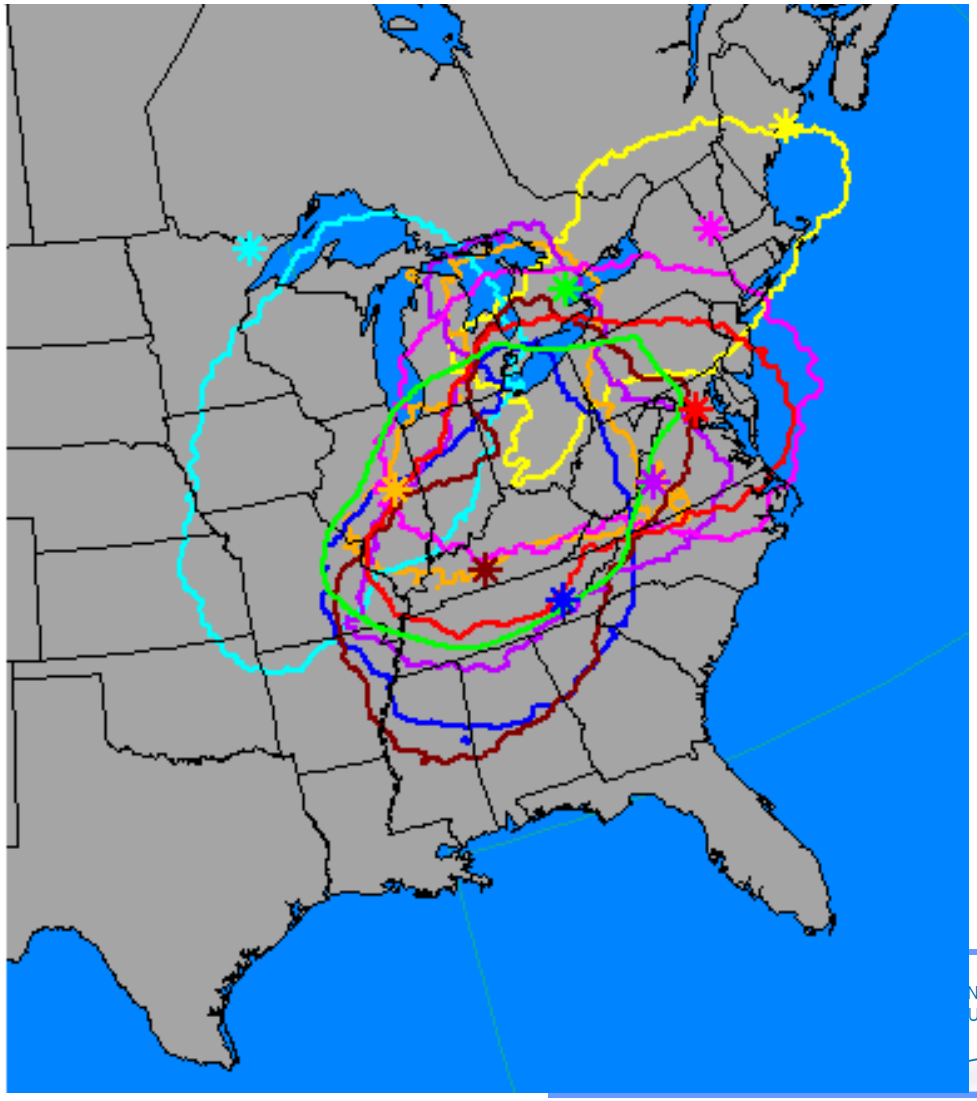



MANE-VU Mid-Atlantic/Northeast Visibility Union

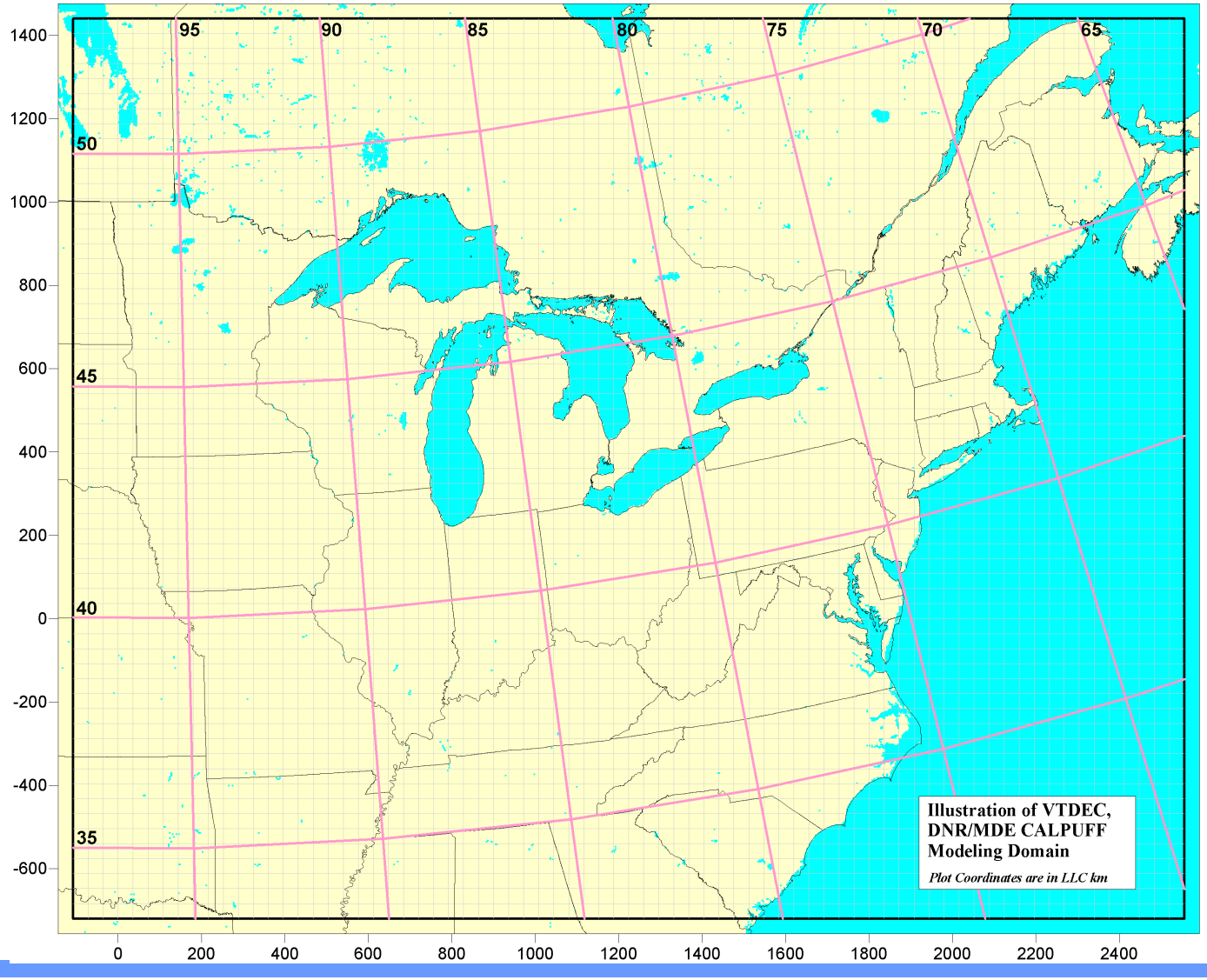
# Source Apportionment Results

Upwind Probability Fields
(P > 0.001) for
"Secondary Sulfate" Source(s)
at 9 Eastern Sites

- Boundary Waters, MN
- Bondville, IL
- Mammoth Cave, KY
- Great Smokey Mtns., TN
- Toronto, Canada
- James River Face, VA
- Washington, DC
- Lye Brook, VT
- Acadia, ME

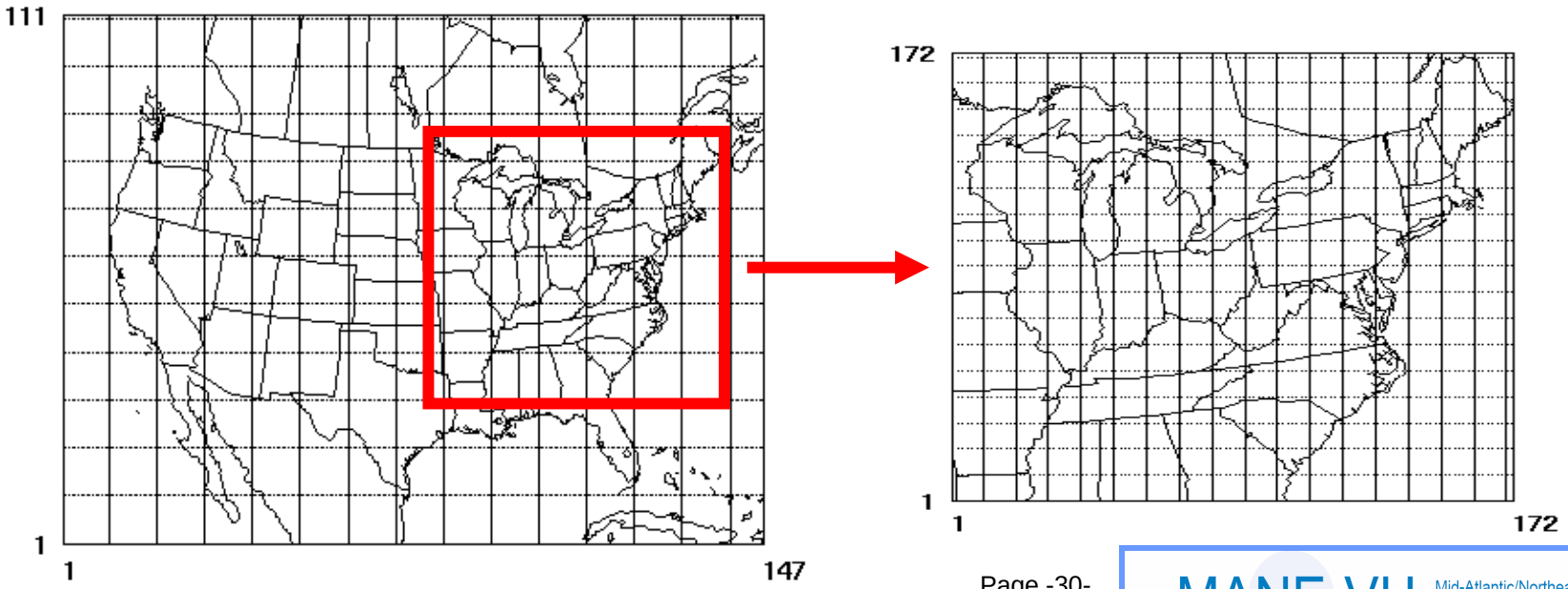


# CALPUFF Domain



# CMAQ & REMSAD

- 36km National Domain/12km Northeast Subdomain
- MM5 Met from UMD
- MANE-VU 2002 Emissions Inventory






MANE-VU Mid-Atlantic/Northeast Visibility Union

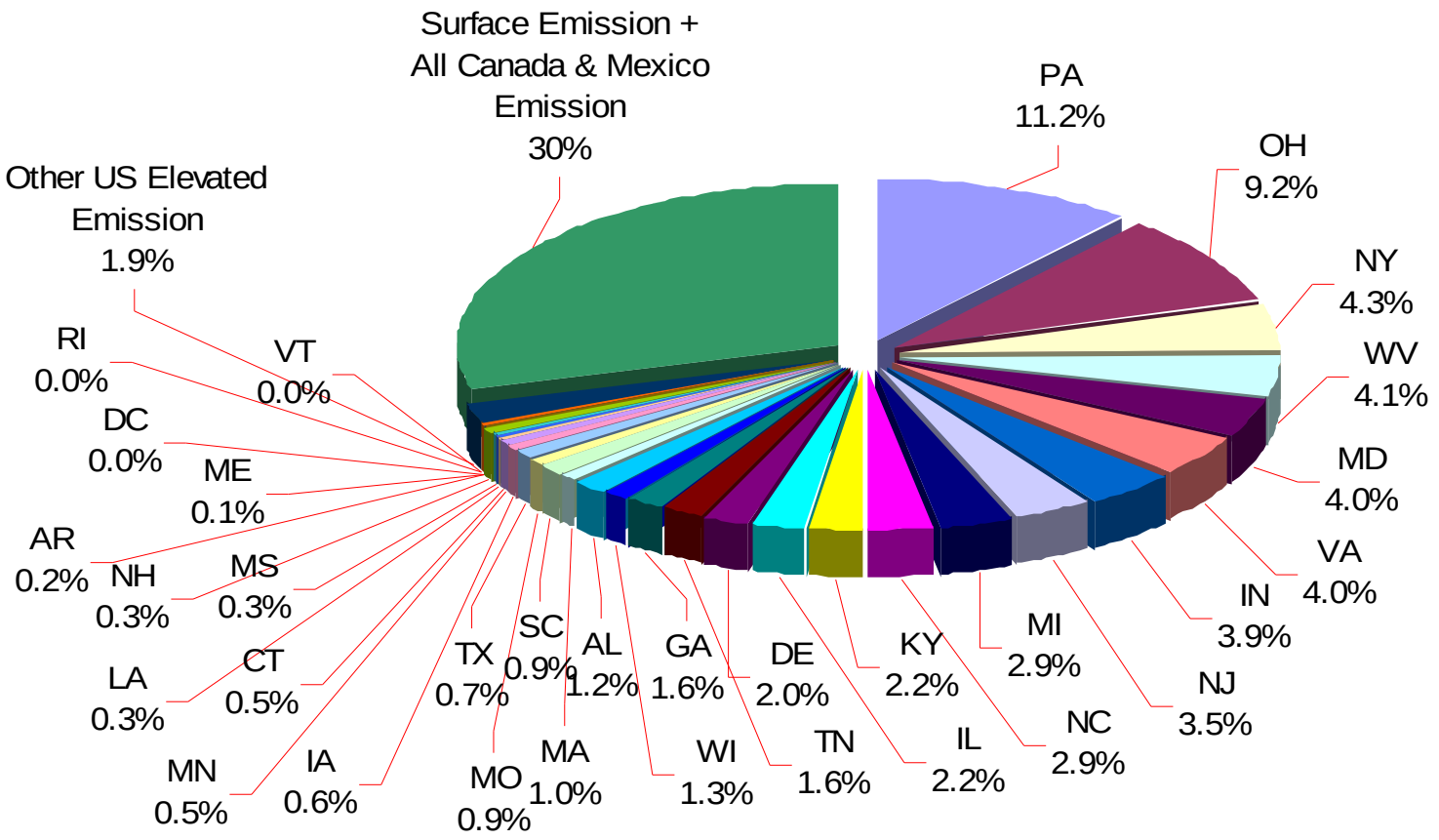
# Preliminary REMSAD results

- SO2 tagging: Elevated point sources from 32 eastern states only
- USEPA Clear Skies [2003] 2001 “proxy” inventory
- USEPA 1996 MM5 meteorology

Bar Harbor, Maine

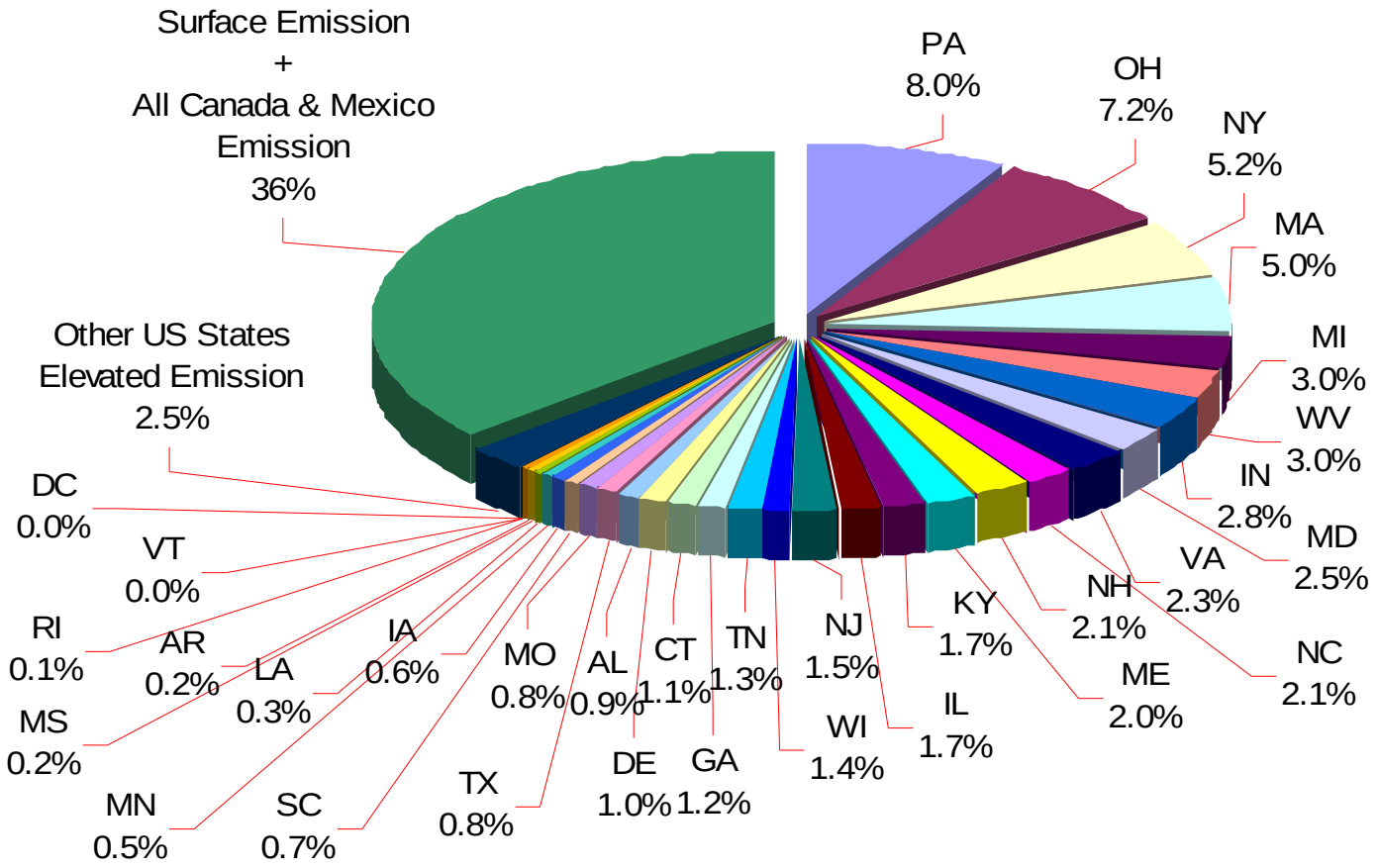
# REMSAD: Tagging Results

## Contribution to PM Sulfate in Brigantine, NJ



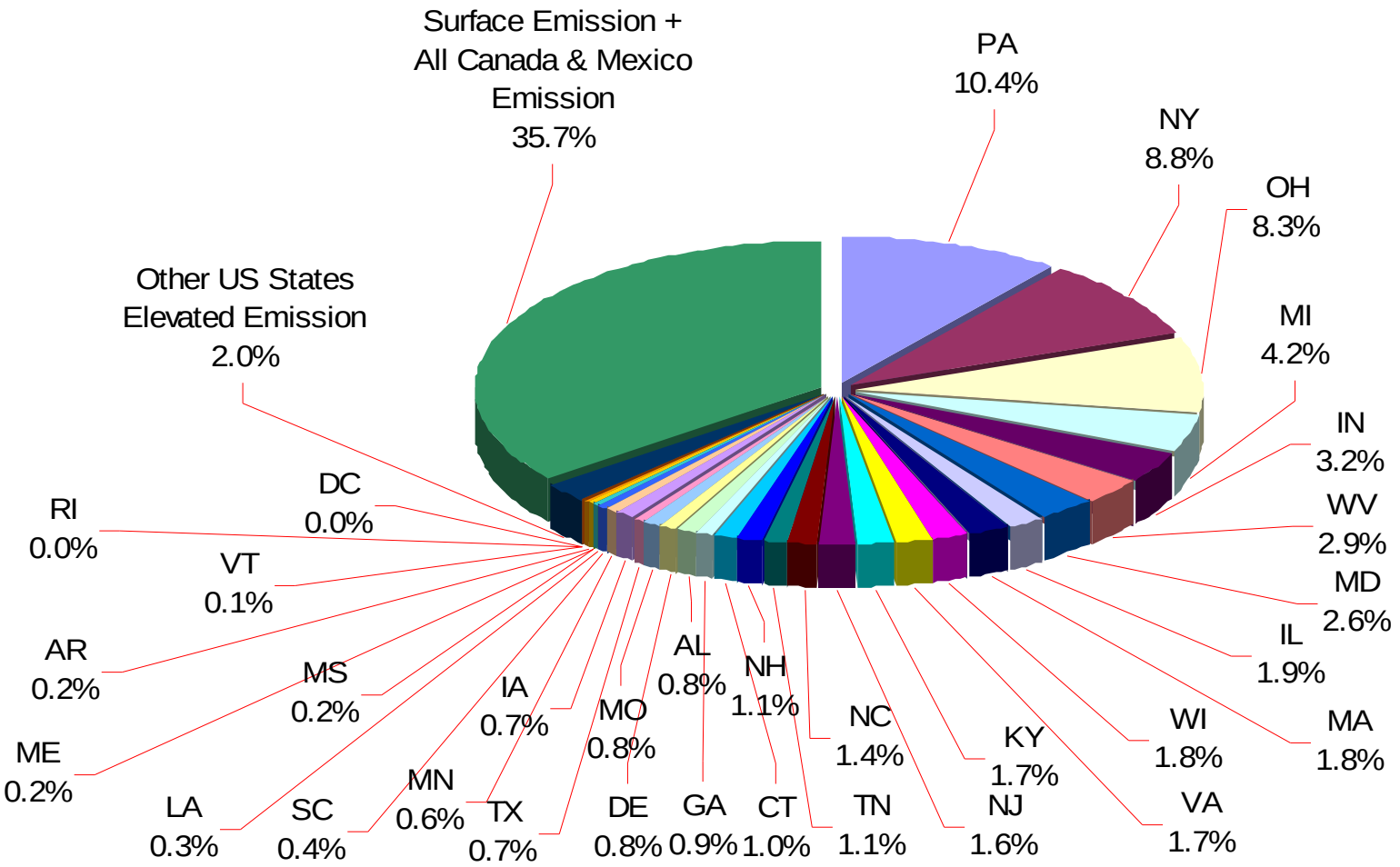
# REMSAD: Tagging Results

## Contribution to PM Sulfate in Acadia, ME



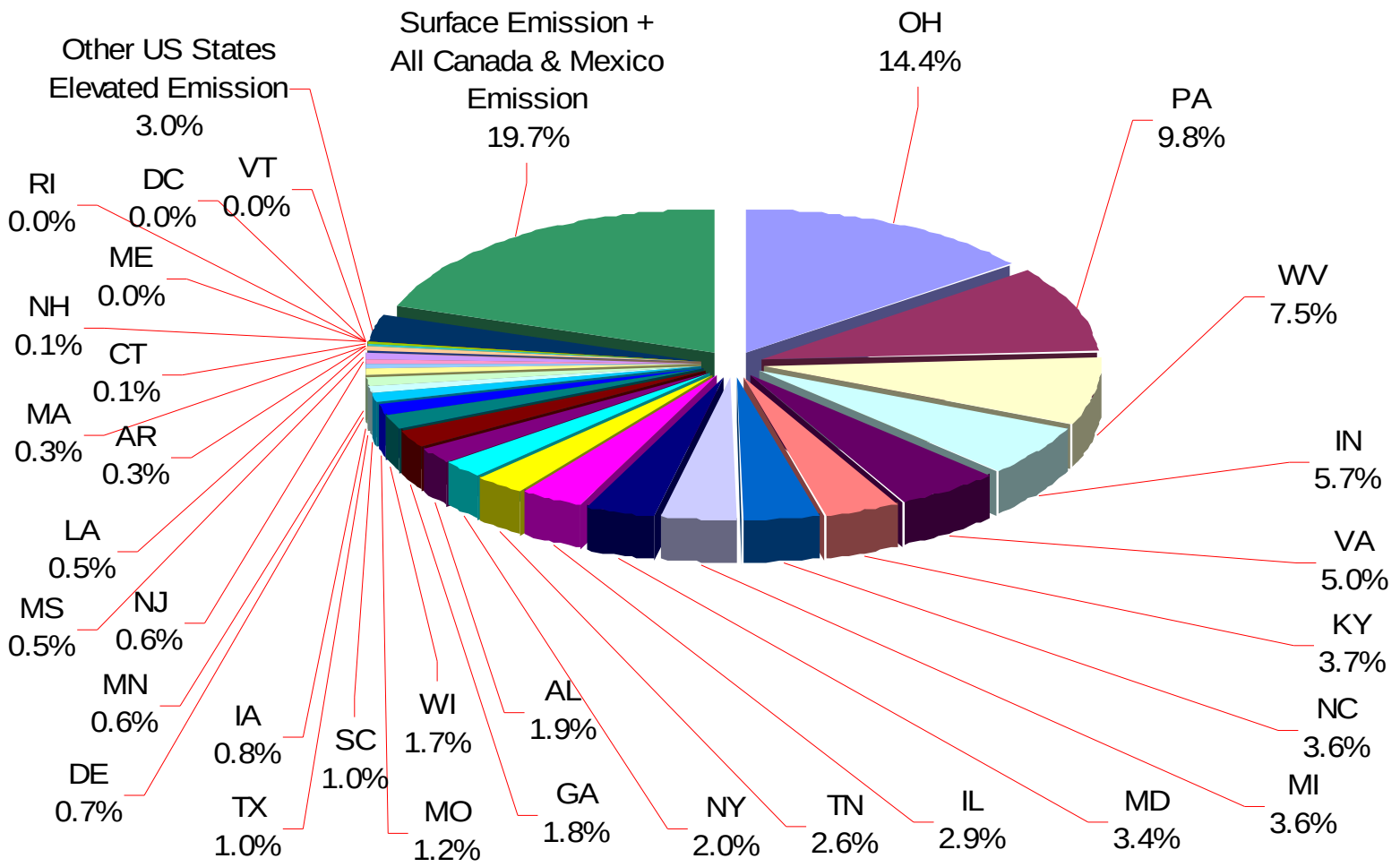
# REMSAD: Tagging Results

## Contribution to PM Sulfate in Lye Brook, VT



# REMSAD: Tagging Results

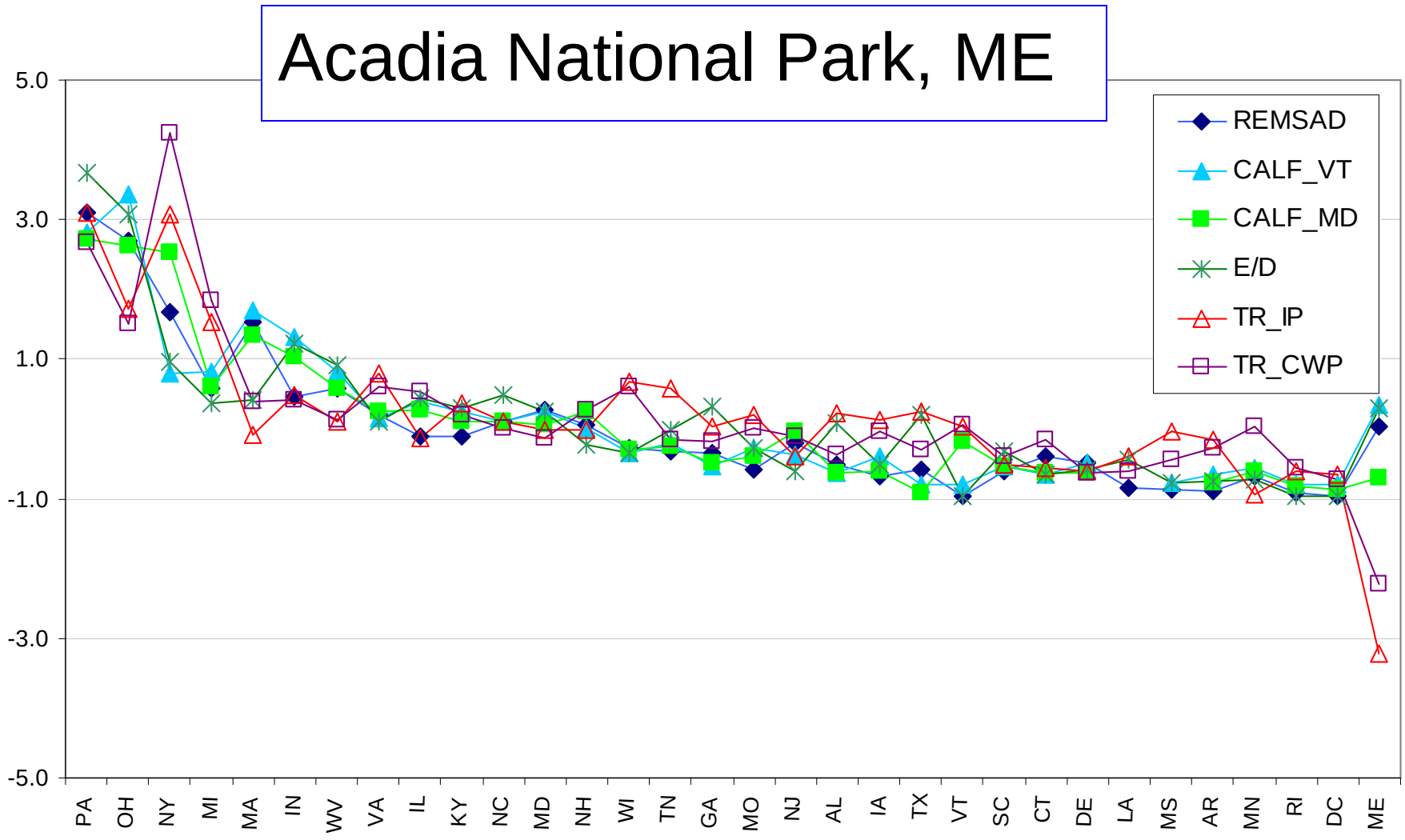
## Contribution to PM Sulfate in Shenandoah, VA



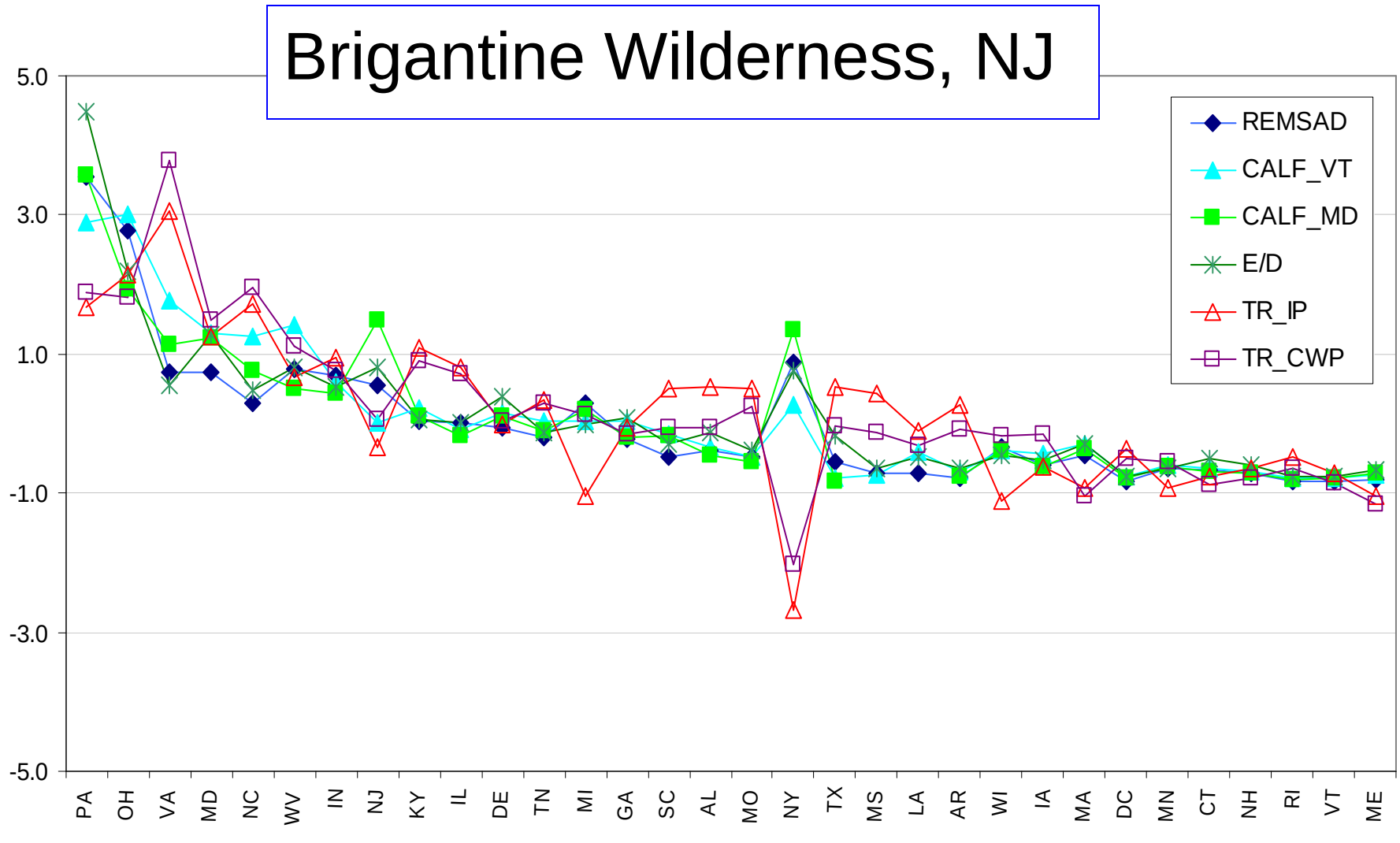
# Synthesis

- Goal is to provide the basis for the pollution apportionment component of state and tribal implementation plans
- Synthesis of monitoring, emissions, modeling and data analysis will provide a framework for developing control strategies focused on the root problems for our region

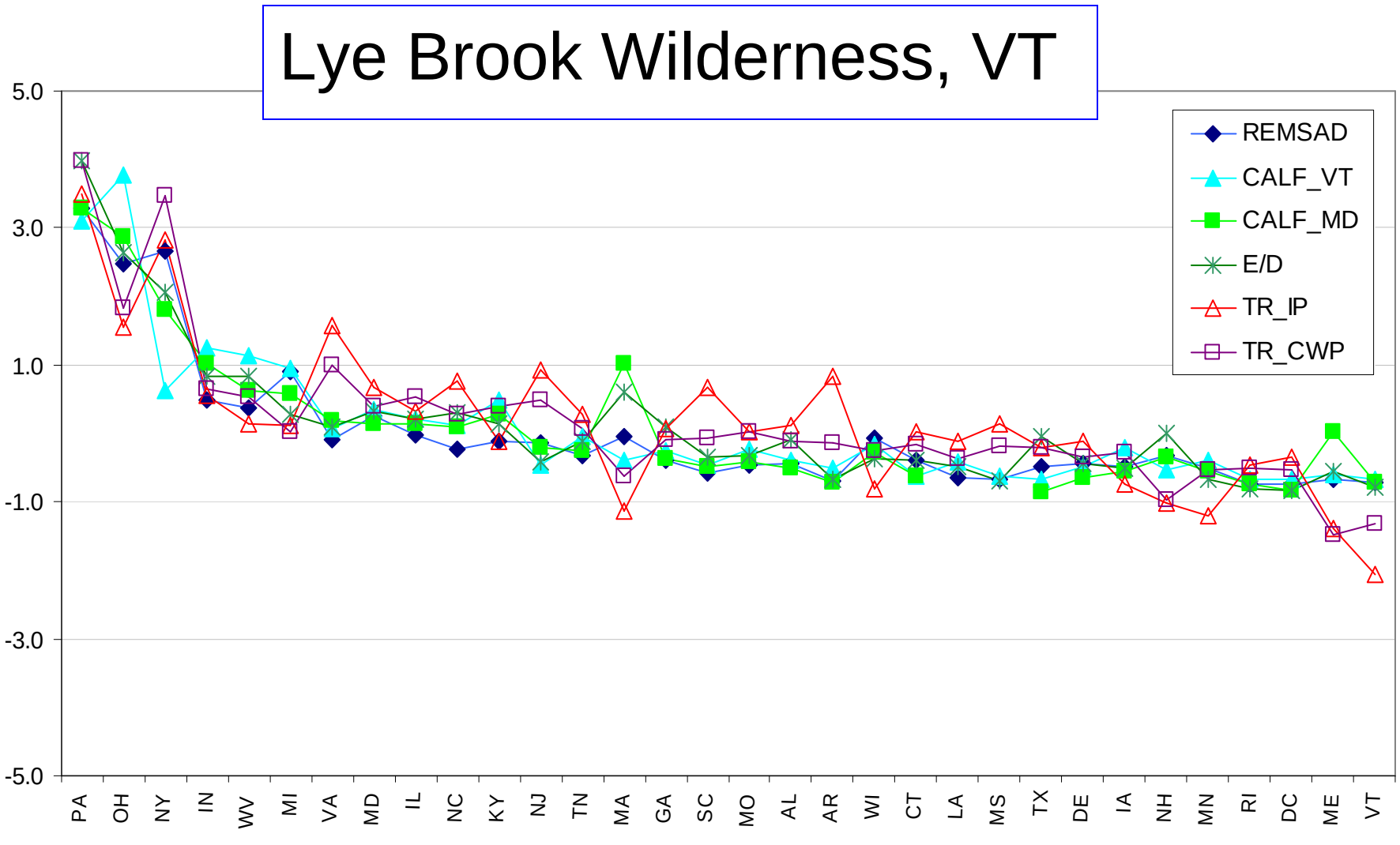
# Multiple Ranking Techniques



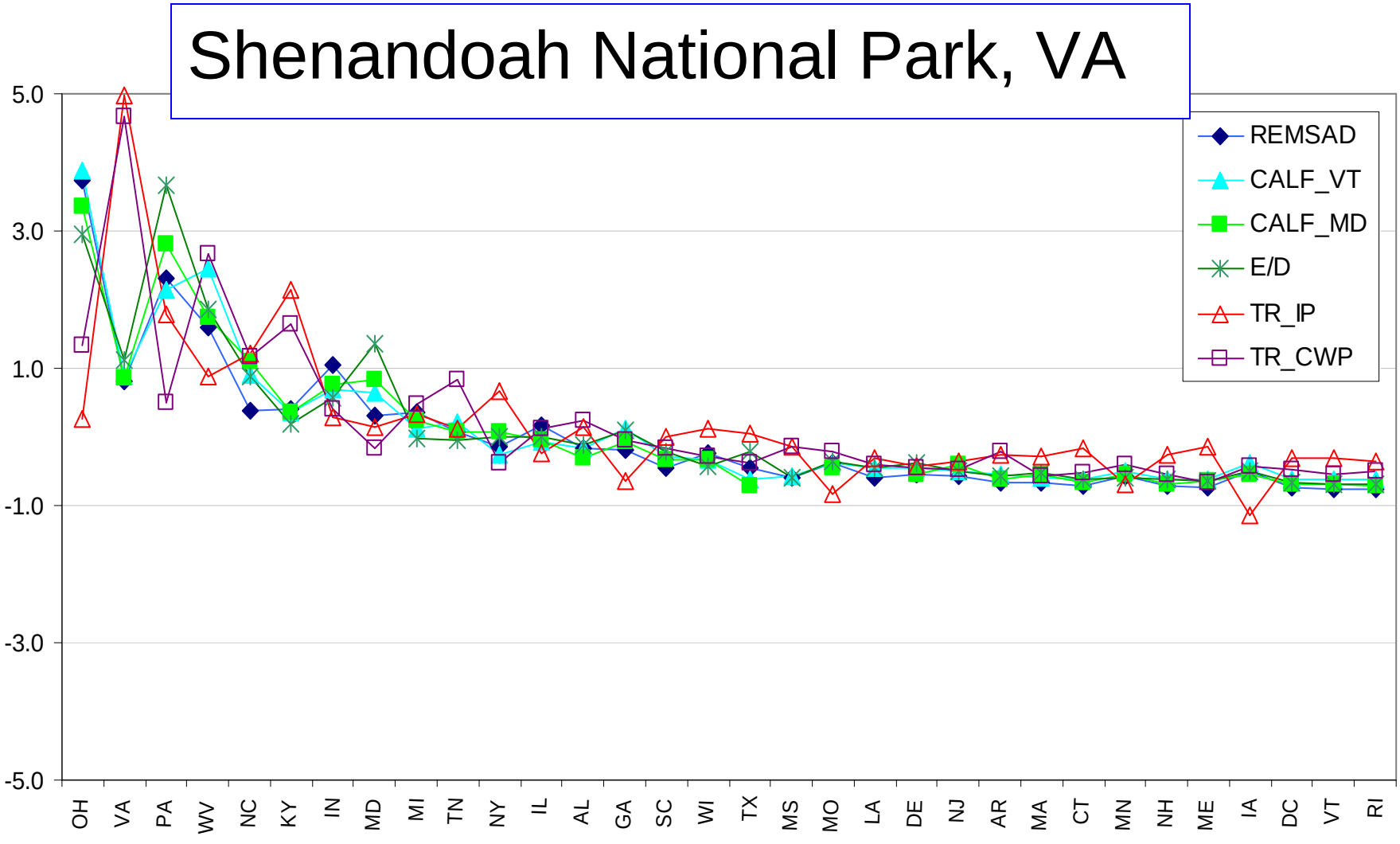
# Multiple Ranking Techniques



# Multiple Ranking Techniques



# Multiple Ranking Techniques



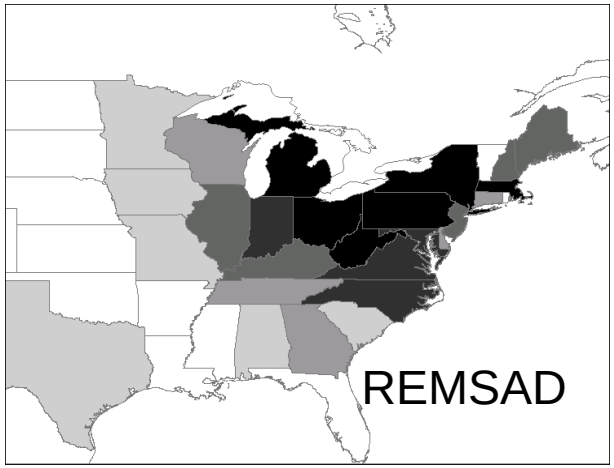
# Alternative ways view results

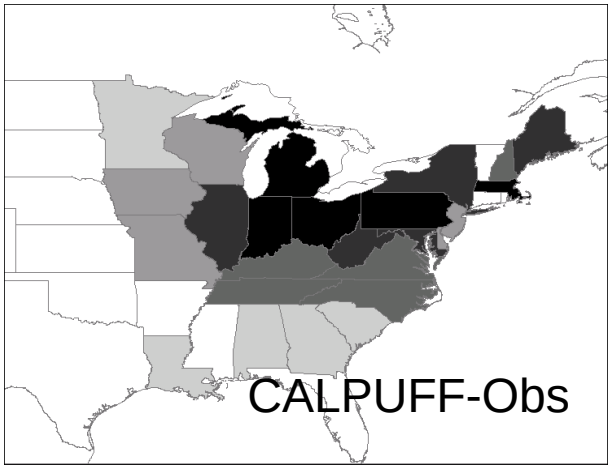
ACADIA:

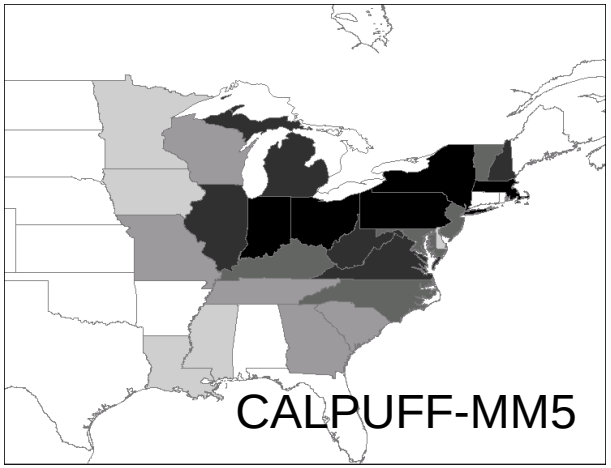
Ranked contributions to annual average sulfate by multiple techniques

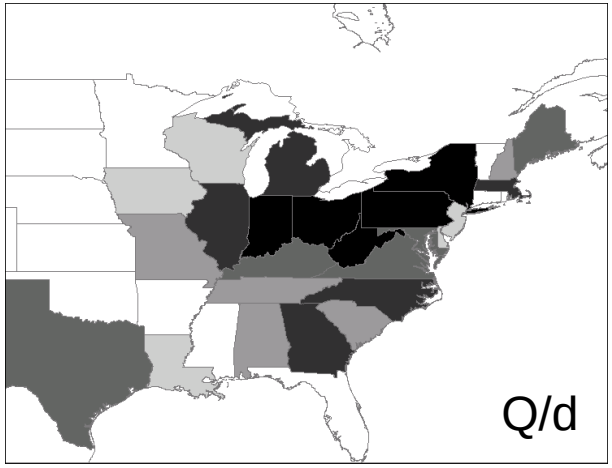
| AVG | REMSAD | CALF_VT | CALF_MD | E/D | TR_IP | TR_CWP |
|---|---|---|---|---|---|---|
| PA | PA | OH | PA | PA | PA | NY |
| OH | OH | PA | OH | OH | NY | PA |
| NY | NY | MA | NY | IN | OH | MI |
| MI | MA | IN | MA | NY | MI | OH |
| MA | MI | MI | IN | WV | VA | VA |
| IN | WV | WV | MI | NC | WI | WI |
| WV | IN | NY | WV | IL | TN | IL |
| VA | MD | IL | IL | MA | IN | IN |
| IL | VA | ME | NH | MI | KY | MA |
| KY | NC | MD | VA | GA | TX | NH |
| NC | NH | KY | KY | ME | AL | KY |
| MD | ME | VA | NC | KY | MO | WV |
| NH | IL | NC | MD | MD | IA | VT |
| WI | KY | NH | NJ | TX | NC | MN |
| TN | NJ | TN | VT | VA | WV | NC |
| GA | WI | MO | TN | AL | VT | MO |
| MO | TN | WI | WI | TN | GA | IA |
| NJ | GA | NJ | MO | NH | NH | NJ |
| AL | CT | IA | GA | MO | MD | MD |
| IA | DE | DE | SC | SC | MS | TN |
| TX | AL | GA | LA | WI | MA | CT |

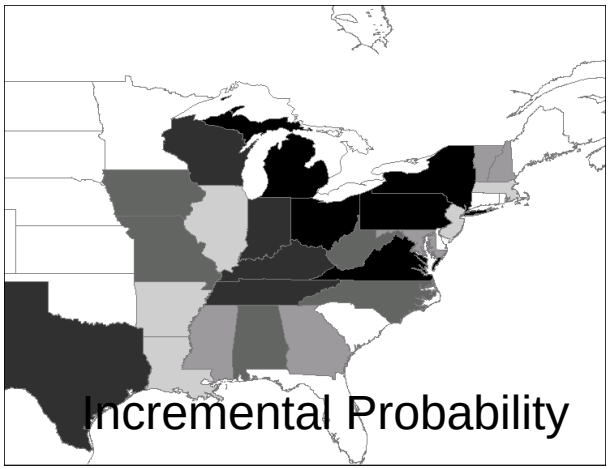
# Alternative ways view results

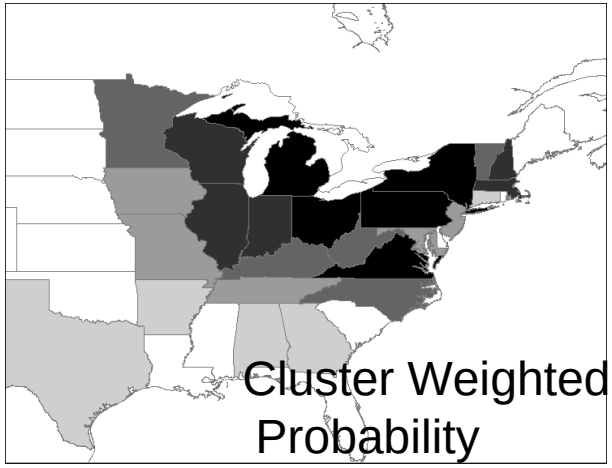


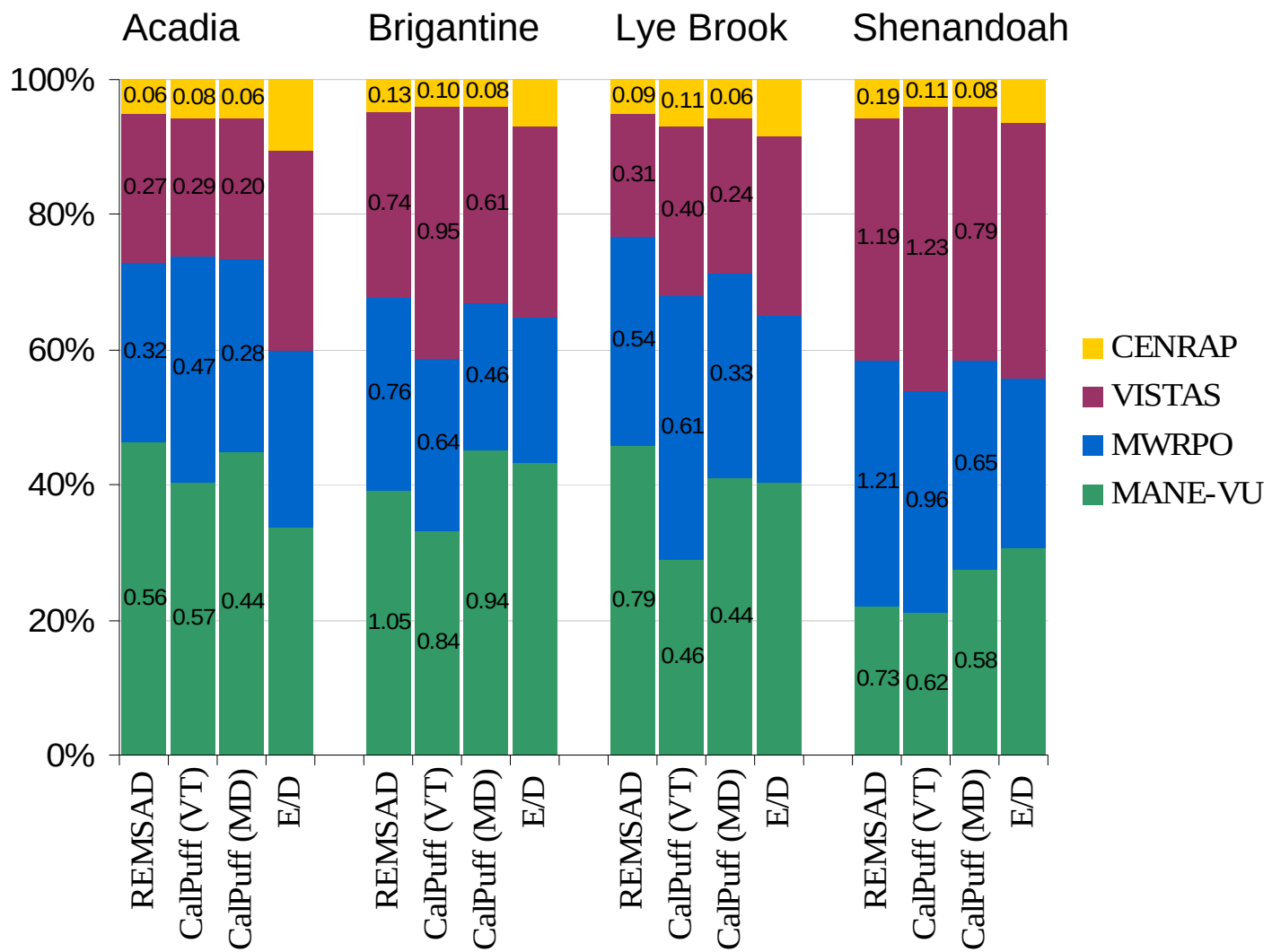




Ranked contributions to annual average sulfate grouped in quintiles for each technique

# Relative contribution of RPOs?

*(to sulfate only; not including Canada yet)*



# Timeline for Control Strategy Modeling

- Base Case Inventory: Complete
- Projection Inventories: Sept. 2005
- Control Strategy Inventories: October/November 2005

Brigantine
New Jersey

- Base Case Modeling: June/July 2005
- OTB/OTW modeling: November/December 2005
- Control Strategy Modeling: January 2006