

Mid-Atlantic/Northeast Visibility Union

MANE-VU



Contributions to Visibility Impairment in the Northeast and Mid-Atlantic U.S.

Gary Kleiman

NESCAUM Directors Meeting

June 29, 2006

The Drivers: CAA §169A

“...prevention of any future, and the remedying of any existing, impairment of visibility in... which impairment results from manmade air pollution”

40CFR §51: The Regional Haze Rule

“...calls for States to establish goals and emission reduction strategies for improving visibility in all 156 mandatory Class I national parks and wilderness areas.”

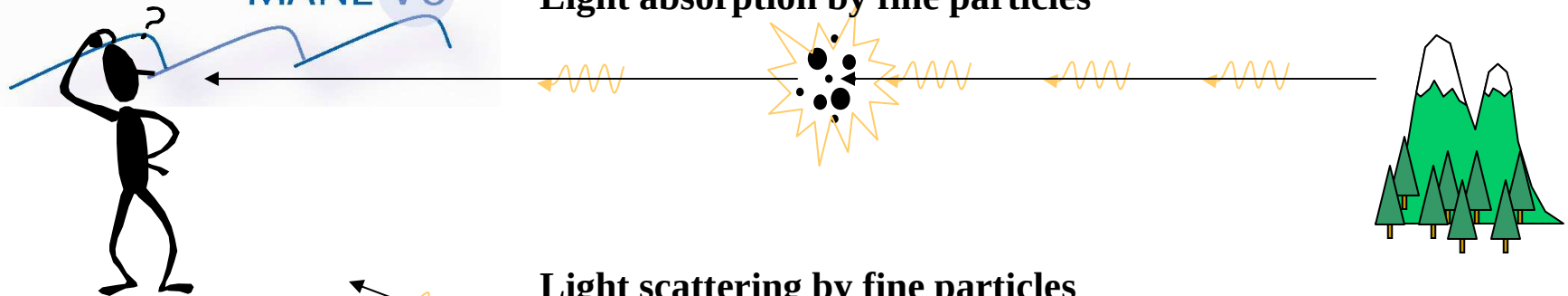
Great Gulf Wilderness 35.8 Mm-1
8 $\mu\text{g}/\text{m}^3$
13 dv



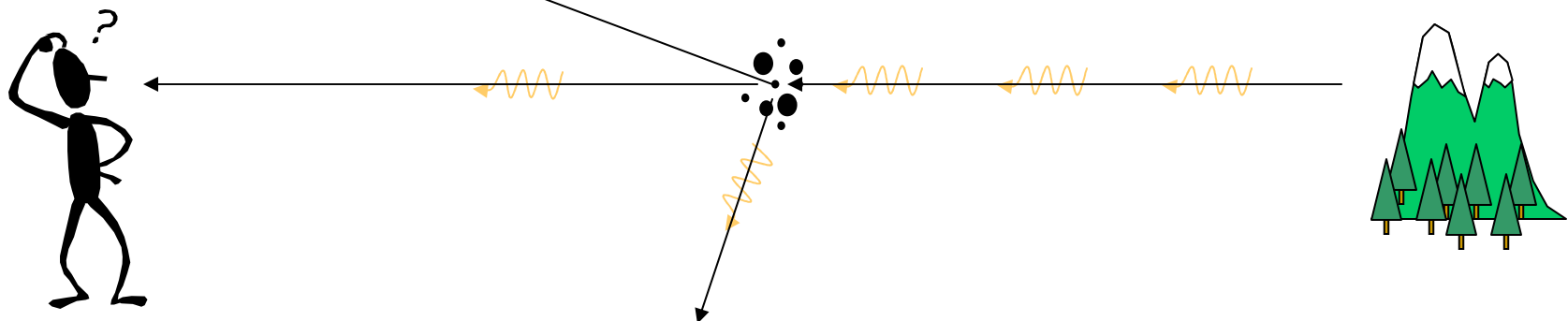
Great Gulf Wilderness 125 Mm-1
21 $\mu\text{g}/\text{m}^3$
25 dv



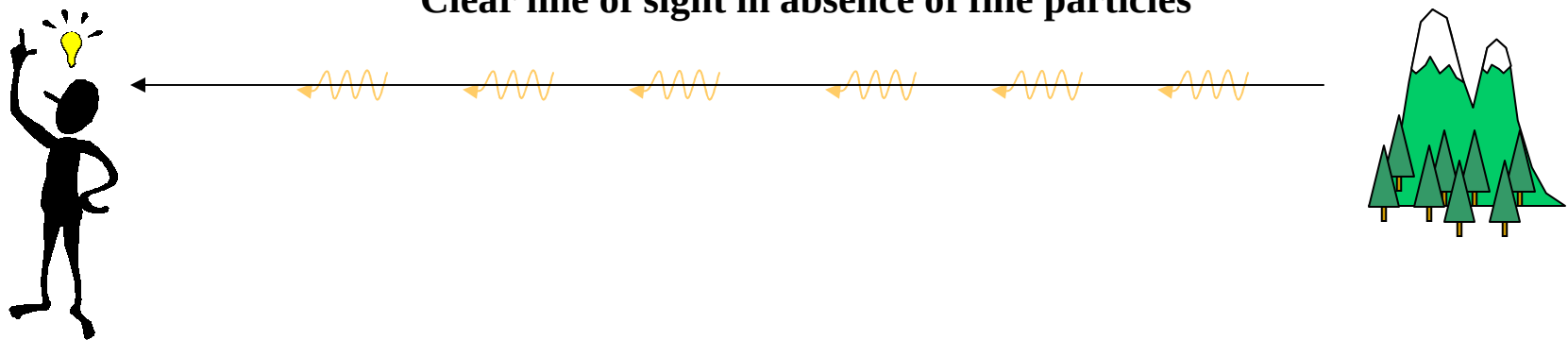
Light absorption by fine particles



Light scattering by fine particles



Clear line of sight in absence of fine particles

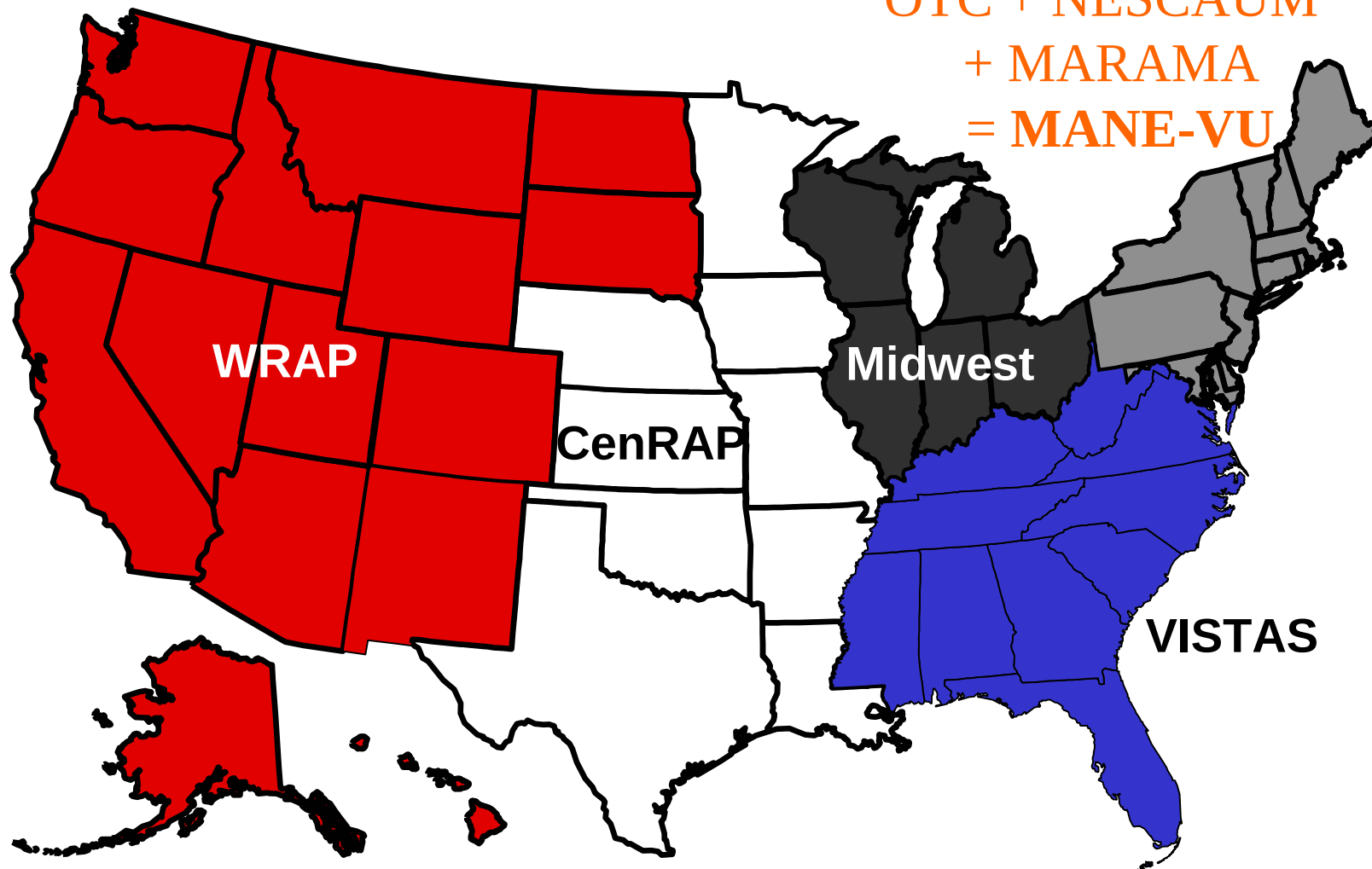


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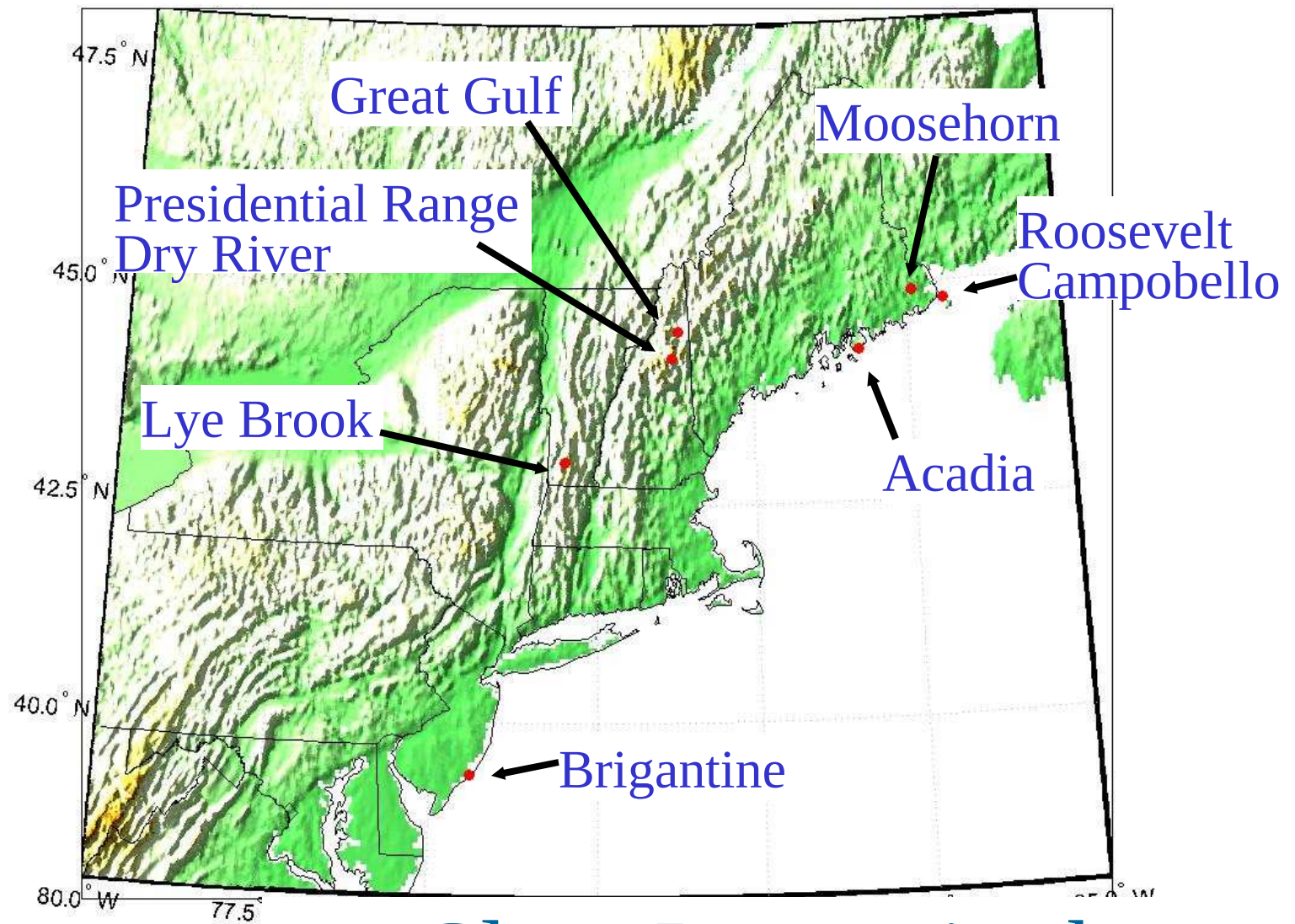
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Regional Planning Organizations

OTC + NESCAUM
+ MARAMA
= MANE-VU

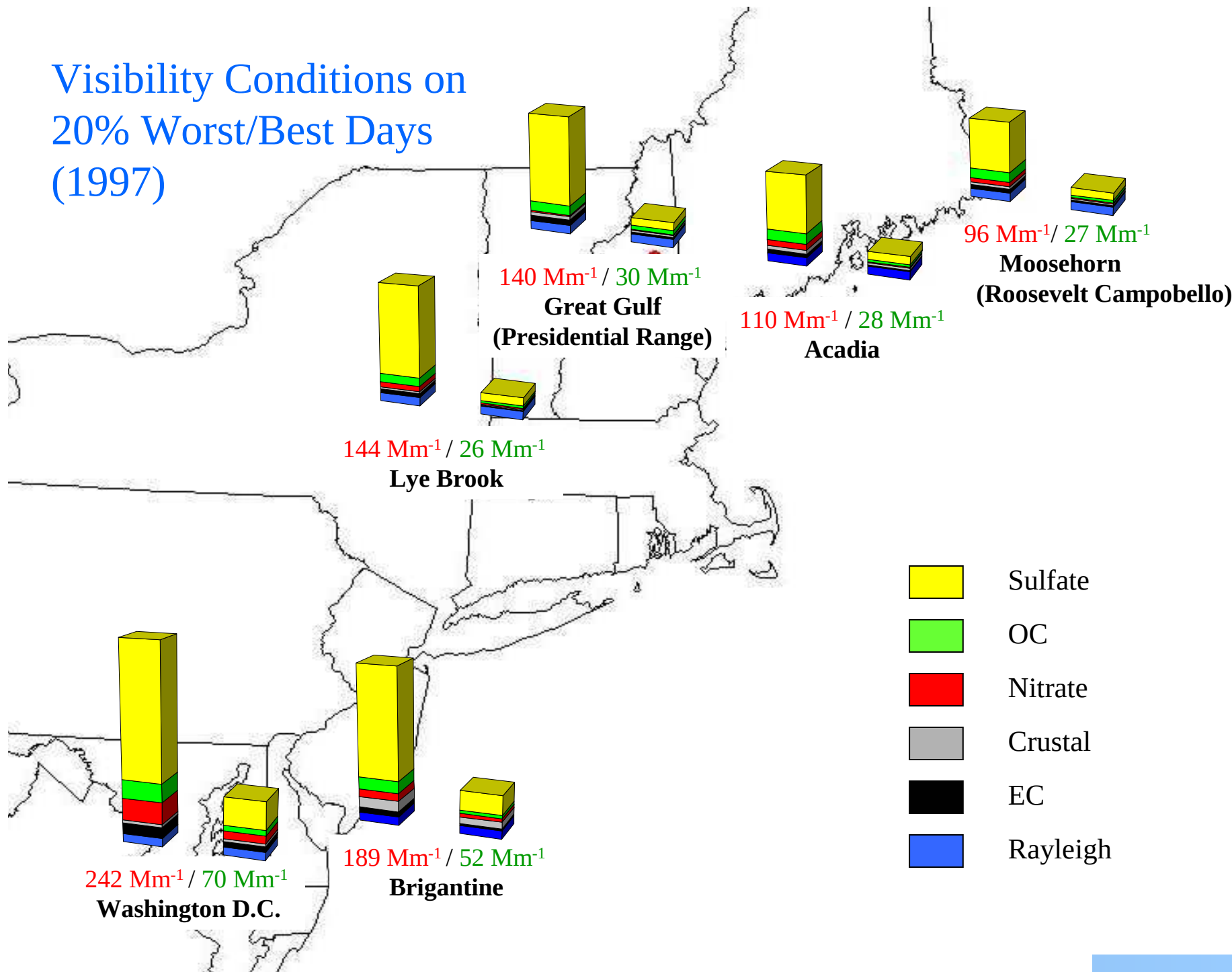


Mid-A



Class I areas in the
MANE-VU Region

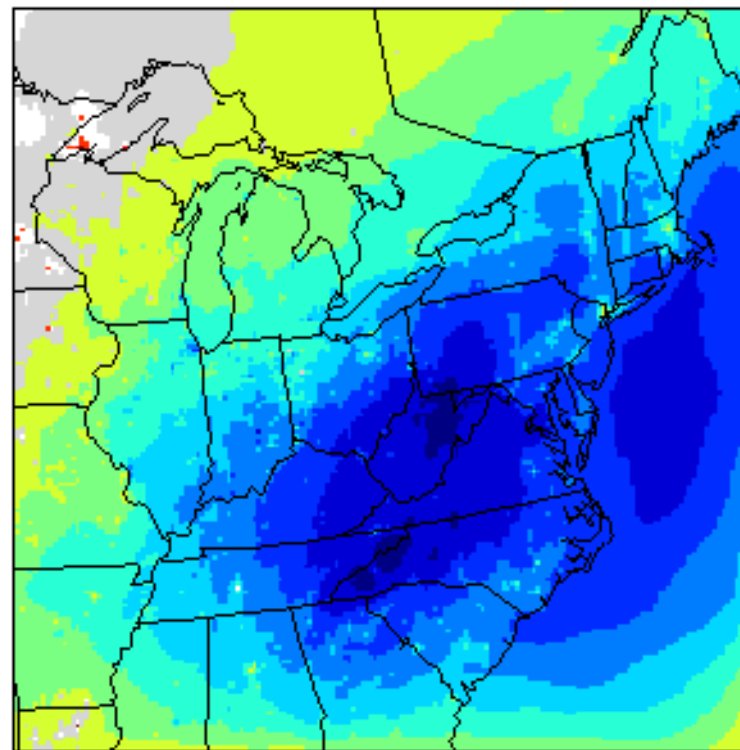
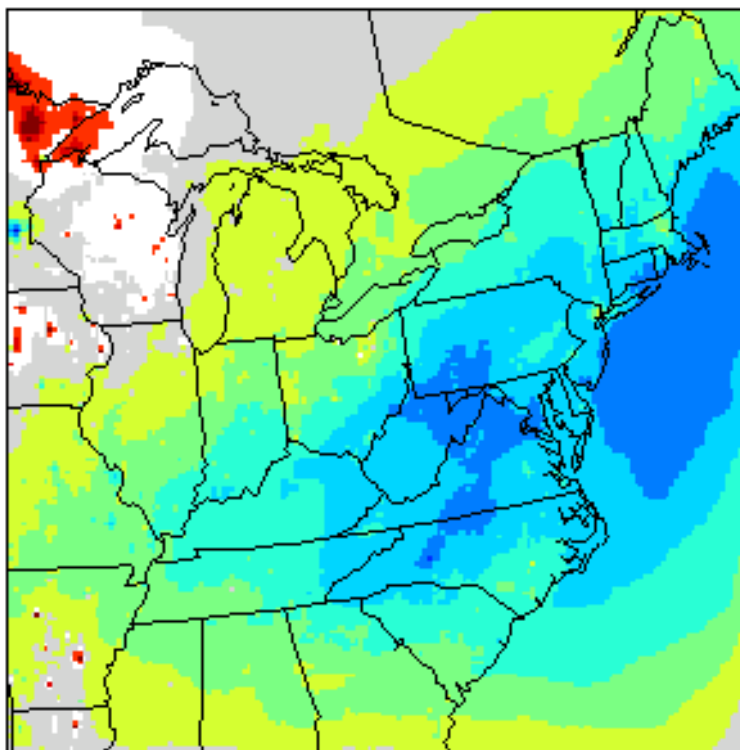
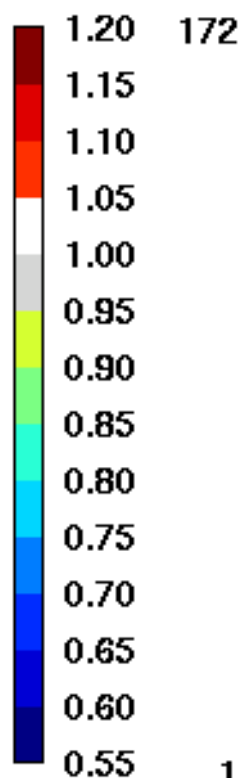
Visibility Conditions on 20% Worst/Best Days (1997)



Sulfate Relative Reductions

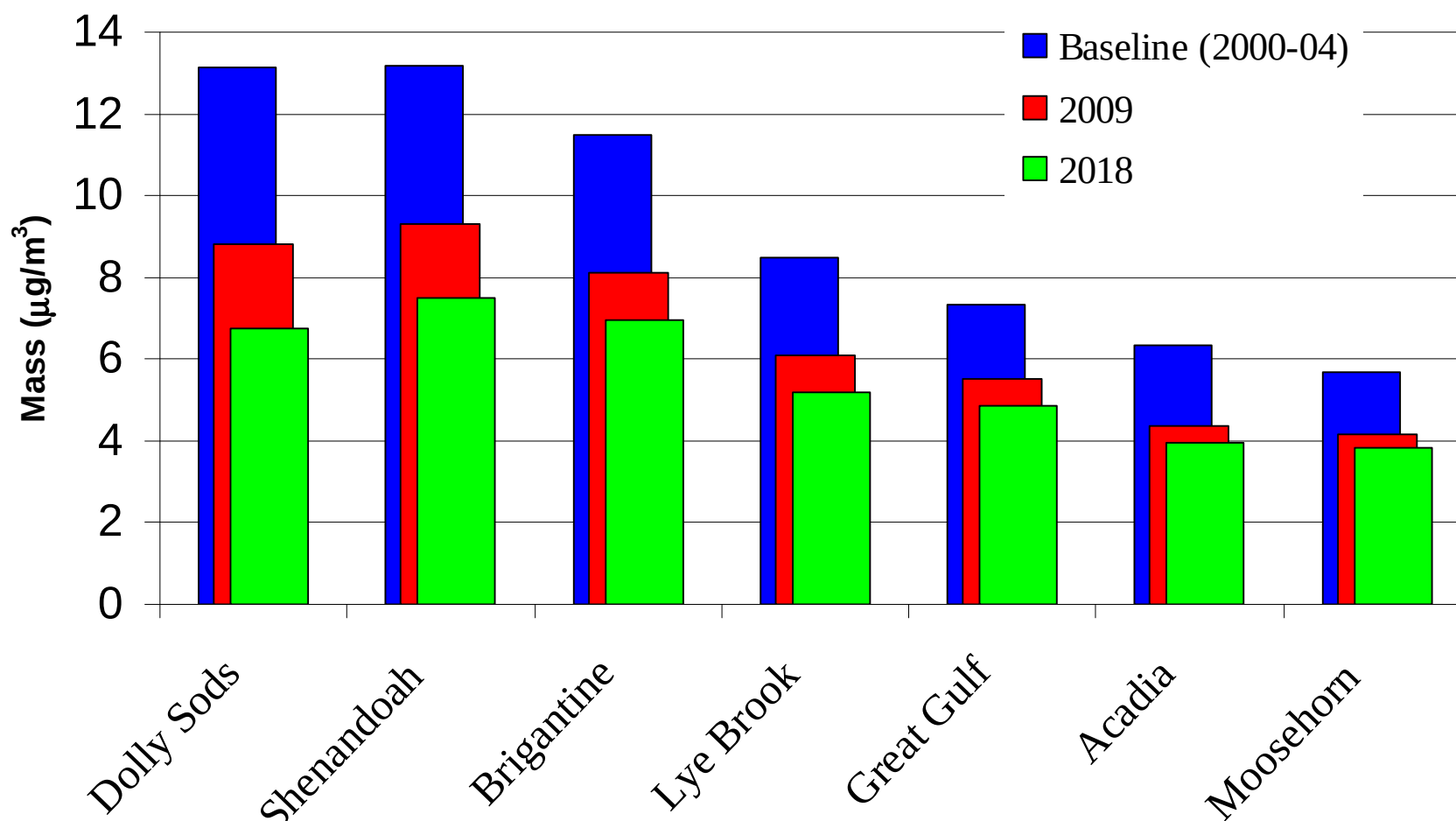
2009 Relative Mass Reduction

2018 Relative Mass Reduction

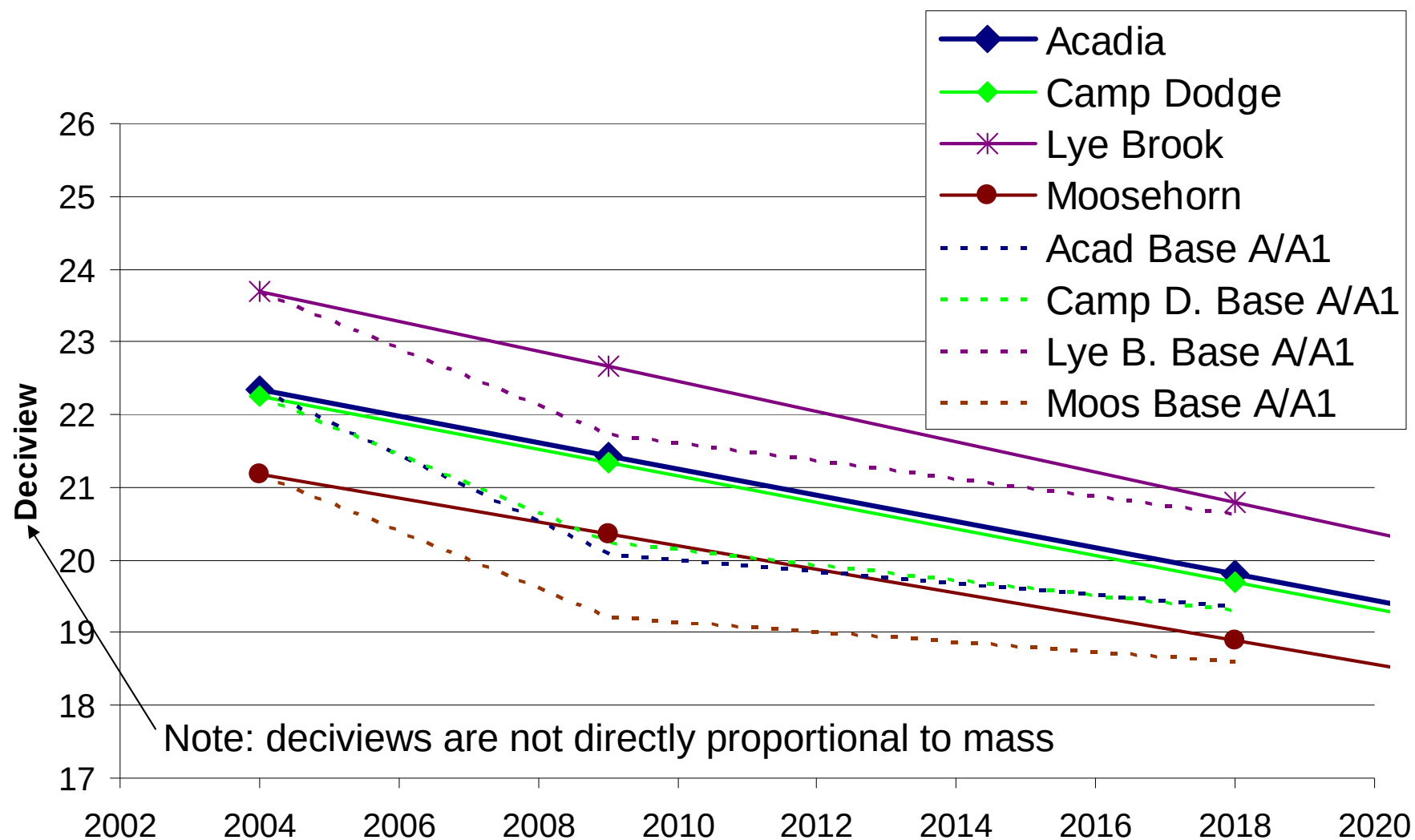


Projected Mass Reductions

Annual Average Sulfate Values



Relative mass reductions applied to visibility metric for New England sites



M-V Contribution Assessment

- **Empirical data analysis** methods exploit observed relationships between emissions, meteorology and observations
- **Trajectory models/dispersion models** use minimal chemistry but link source and receptor locations via meteorology
- **Factor Analysis/Source Apportionment** techniques determine optimal combinations of various sources which match observed pollution
- **Chemical Transport Models** attempt to fully integrate knowledge about emissions, meteorology, atmospheric physics and chemistry to simulate ambient concentrations



Contributions to Regional Haze in the Northeast and Mid-Atlantic United States

- Available in draft form – comments through Friday
 - REMSAD with SO₂ tagging
 - CALPUFF with 2 types of Meteorology
 - Trajectory methods (Incremental Probability and Cluster Weighted Probability)

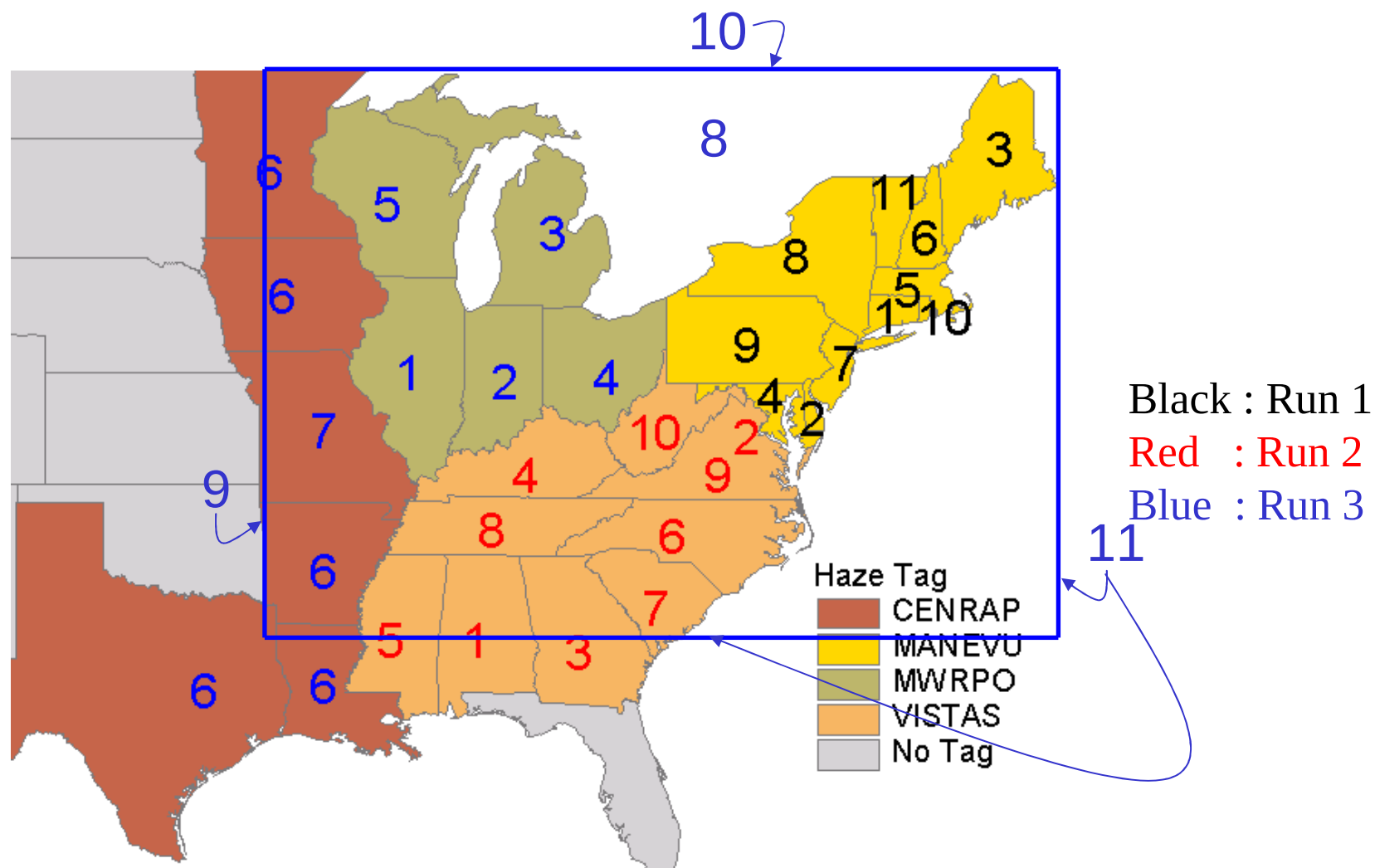
Residence time probability x emissions

Plus conceptual model, monitoring strategy,
baseline conditions, emission inventory, and more...

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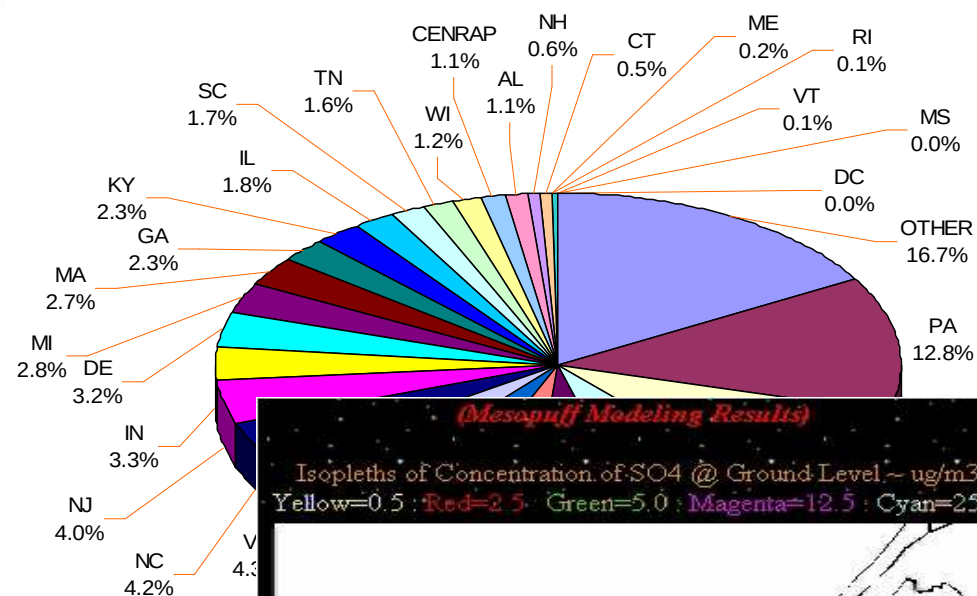
Contribution Assessment Analysis Domain



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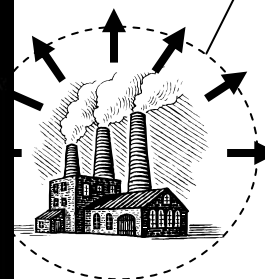
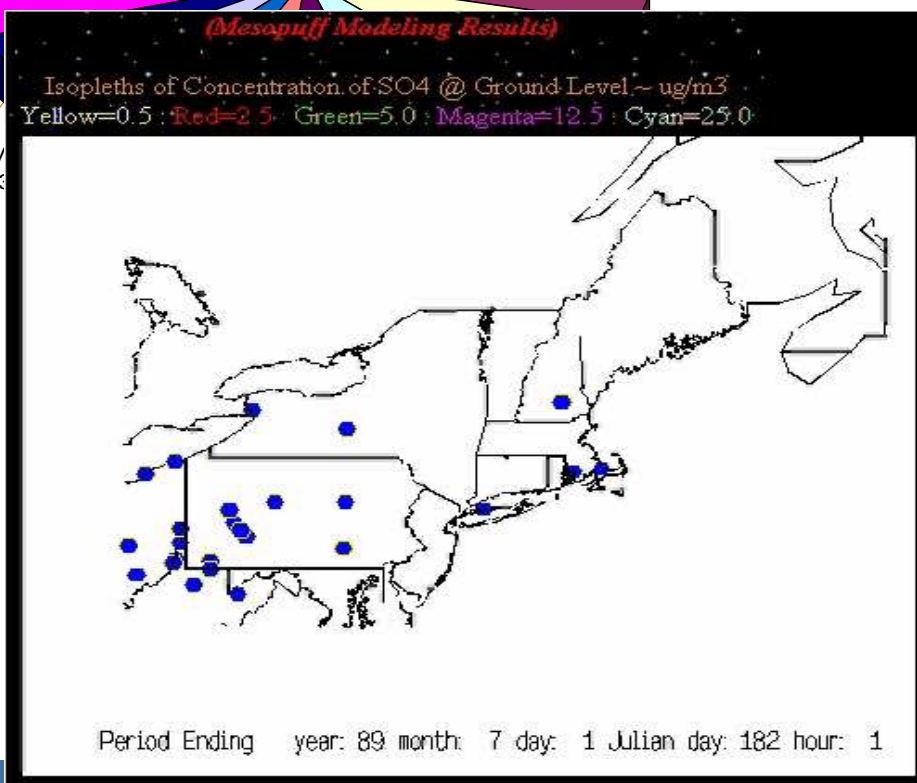
Weight of Evidence



$$\text{Impact} = C \times \frac{Q}{d}$$



d



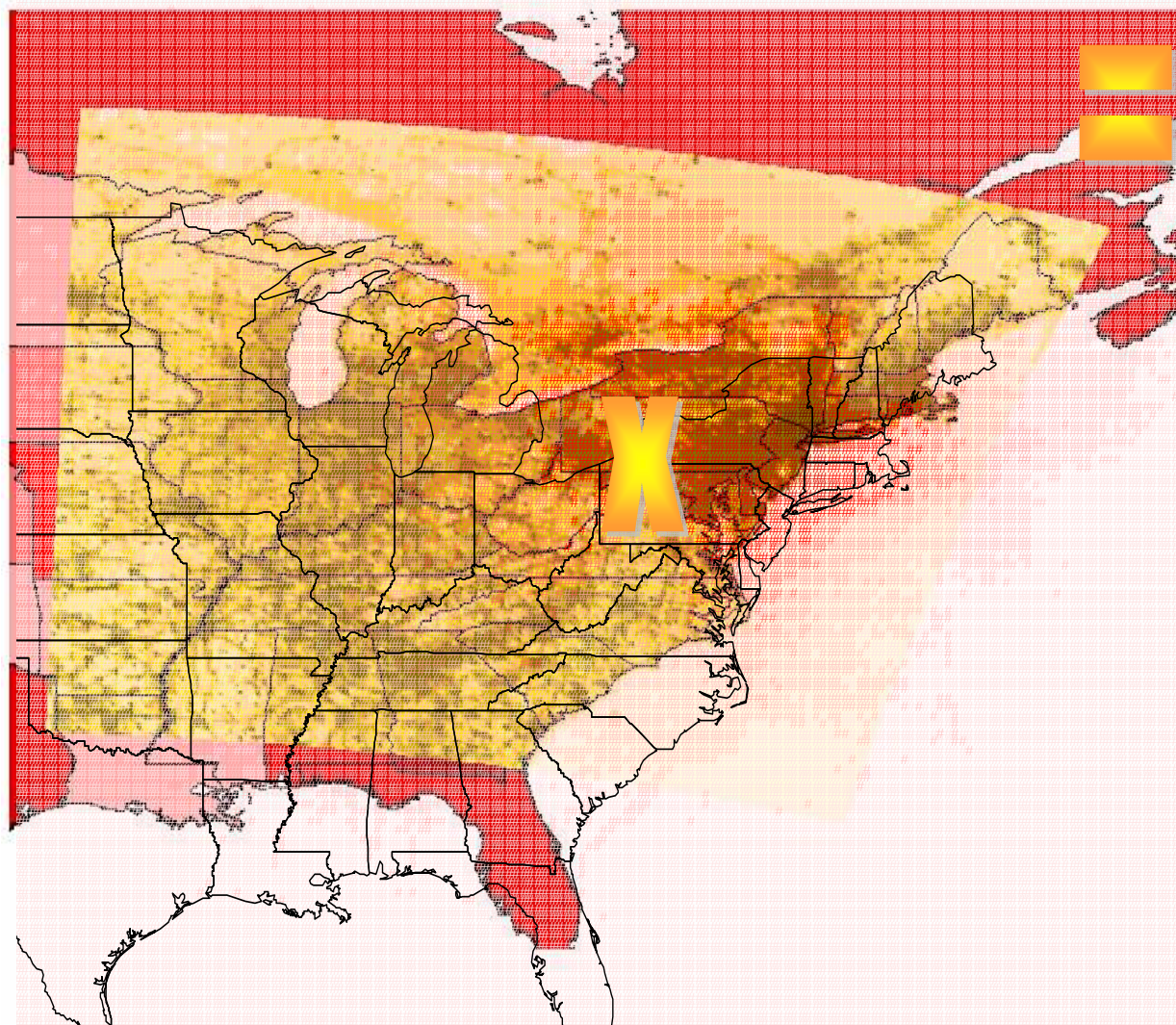
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Residence Emissions

State

Σ

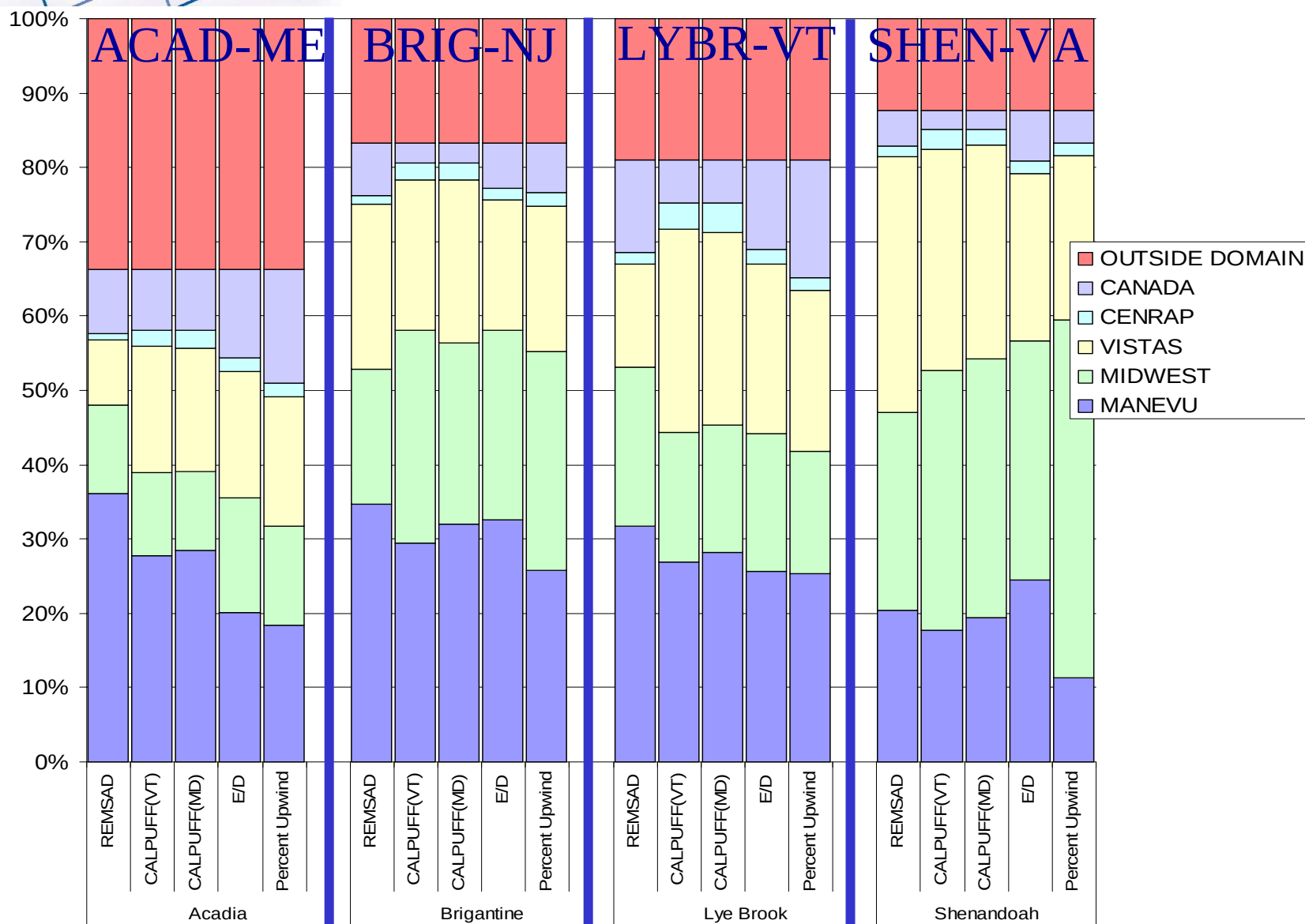


Source



Contribution

Sulfate Contribution by Region



Attribution/Consultation

Moosehorn/
Roosevelt-
Campobello

Average	REMSAD	Q/d	CALPUFF (VT)	E x RTP
CANADA	ME	CANADA	CANADA	CANADA
PA	CANADA	OH	PA	OH
OH	MA	PA	OH	PA
NY	PA	IN	MA	NY
MA	OH	NY	NY	IL
ME	NY	MI	IN	IN
IN	IN	IL	MI	WV
MI	WV	WV	WV	MI
WV	NH	GA	ME	KY
IL	MI	KY	IL	ME
KY	MD	NC	CENRAP	CENRAP
CENRAP	IL	CENRAP	KY	VA
MD	NC	MA	MD	NC
NC	VA	MD	WI	WI
VA	NJ	ME	NC	MD
NH	KY	VA	NH	MA
WI	CENRAP	TN	VA	TN
GA	WI	AL	TN	NJ
TN	DE	WI	NJ	NH
NJ	GA	SC	VT	GA
SC	CT	NH	GA	SC
AL	TN	NJ	SC	CT

Attribution/Consultation

Acadia

Average	REMSAD	Q/d	CALPUFF (VT)	CALPUFF (MD)	E x RTP
CANADA	MA	CANADA	CANADA	MA	CANADA
PA	CANADA	PA	PA	CANADA	PA
OH	PA	OH	OH	OH	OH
MA	ME	NY	MA	PA	NY
NY	OH	IN	NY	NY	IL
IN	NY	MA	IN	IN	WV
WV	WV	MI	MI	WV	IN
ME	NH	WV	WV	CENRAP	MI
MI	MD	IL	ME	MI	KY
IL	IN	GA	IL	NH	CENRAP
KY	MI	NC	CENRAP	KY	VA
CENRAP	VA	KY	KY	IL	ME
MD	NC	VA	NH	NC	GA
NH	NJ	MD	MD	MD	WI
NC	IL	CENRAP	NC	ME	MD
VA	KY	ME	VA	VA	NC
WI	DE	TN	WI	TN	NH
GA	CENRAP	SC	TN	WI	MA
TN	WI	AL	NJ	NJ	TN
NJ	CT	WI	VT	GA	NJ
SC	GA	NH	GA	DE	AL



Attribution/Consultation

Great Gulf

Average	REMSAD	Q/d	CALPUFF (VT)	E x RTP
CANADA	CANADA	OH	OH	CANADA
OH	OH	CANADA	PA	OH
PA	PA	PA	CANADA	PA
NY	NY	IN	IN	NY
IN	NH	MA	MI	WV
MI	IN	MI	NY	IN
WV	MI	NY	WV	KY
IL	MA	IL	CENRAP	IL
KY	WV	WV	KY	MI
MA	IL	KY	IL	CENRAP
CENRAP	ME	NJ	WI	NH
NC	KY	GA	NC	VA
WI	MD	NC	MD	MD
VA	NC	CENRAP	VA	WI
NH	CENRAP	VA	TN	GA
GA	VA	TN	MA	TN
MD	WI	WI	GA	NJ
TN	GA	AL	VT	NC
NJ	TN	SC	SC	MA
ME	NJ	CT	NH	ME
AL	AL	ME	AL	AL
SC	SC	VT	NJ	CT

Attribution/Consultation

Lye Brook

Average	REMSAD	Q/d	CALPUFF (VT)	CALPUFF (MD)	E x RTP
PA	CANADA	PA	PA	OH	CANADA
CANADA	PA	CANADA	OH	PA	PA
OH	OH	OH	NY	NY	OH
NY	NY	NY	CANADA	CANADA	NY
IN	IN	IN	IN	IN	WV
WV	WV	WV	MI	WV	IN
MI	MI	MI	WV	CENRAP	KY
KY	MD	IL	KY	MI	IL
IL	MA	GA	CENRAP	KY	MI
MD	IL	KY	IL	IL	VA
CENRAP	KY	NC	WI	MD	CENRAP
NC	VA	MD	NC	NC	GA
VA	NC	CENRAP	MD	MA	NJ
GA	NH	TN	VT	VA	MD
WI	CENRAP	VA	VA	TN	WI
TN	WI	AL	TN	WI	TN
MA	NJ	WI	GA	GA	NC
NJ	GA	MA	MA	NJ	MA
AL	TN	SC	AL	AL	NH
VT	VT	NJ	SC	DE	AL
NH	DE	DE	NJ	SC	CT
SC	AL	CT	NH	NH	DE

Attribution/Consultation

Brigantine

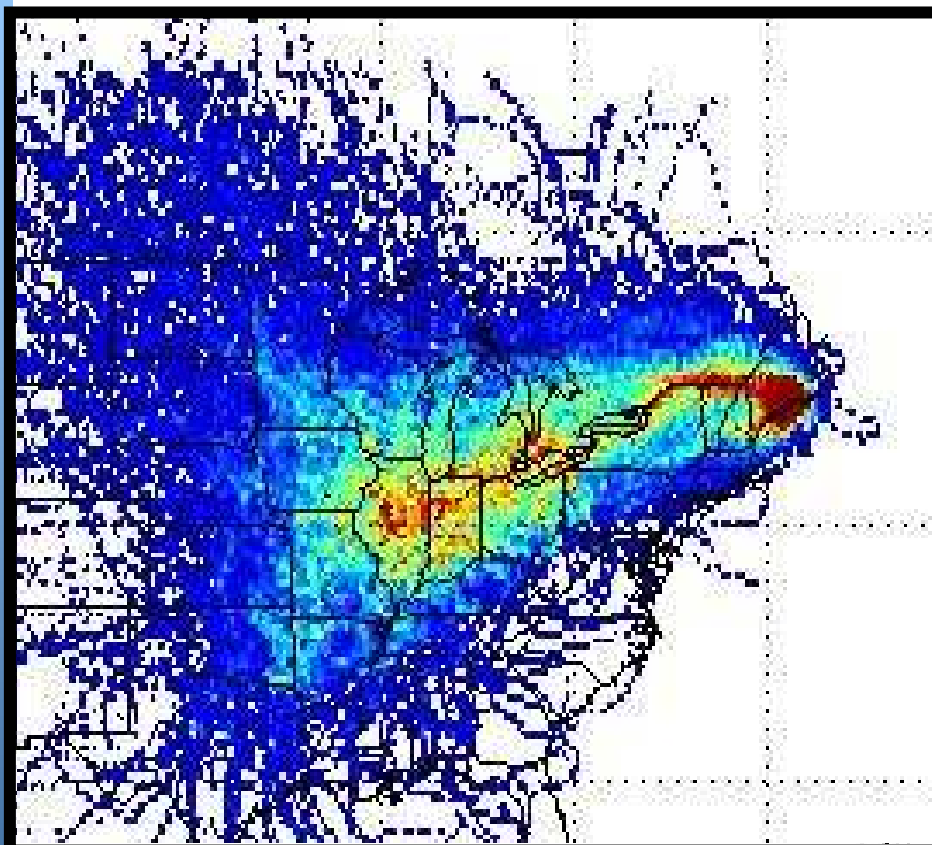
Average	REMSAD	Q/d	CALPUFF (VT)	CALPUFF (MD)	E x RTP
PA	PA	PA	PA	PA	PA
OH	OH	OH	OH	OH	OH
WV	CANADA	MD	VA	WV	WV
MD	NY	CANADA	NC	MD	CANADA
CANADA	MD	WV	WV	VA	NJ
VA	WV	NY	MD	IN	VA
NC	VA	VA	NY	NY	KY
NY	NC	IN	IN	NC	IN
NJ	NJ	NJ	NJ	NJ	NC
IN	IN	NC	KY	KY	NY
KY	DE	KY	CANADA	DE	IL
GA	MI	GA	IL	CANADA	GA
DE	MA	DE	CENRAP	MI	MD
IL	GA	IL	MI	CENRAP	MI
MI	KY	TN	TN	TN	TN
TN	IL	MI	GA	MA	CENRAP
CENRAP	SC	AL	WI	IL	SC
SC	TN	CENRAP	DE	GA	DE
MA	WI	SC	SC	SC	AL
AL	CENRAP	MA	MA	WI	WI
WI	AL	WI	AL	AL	MA

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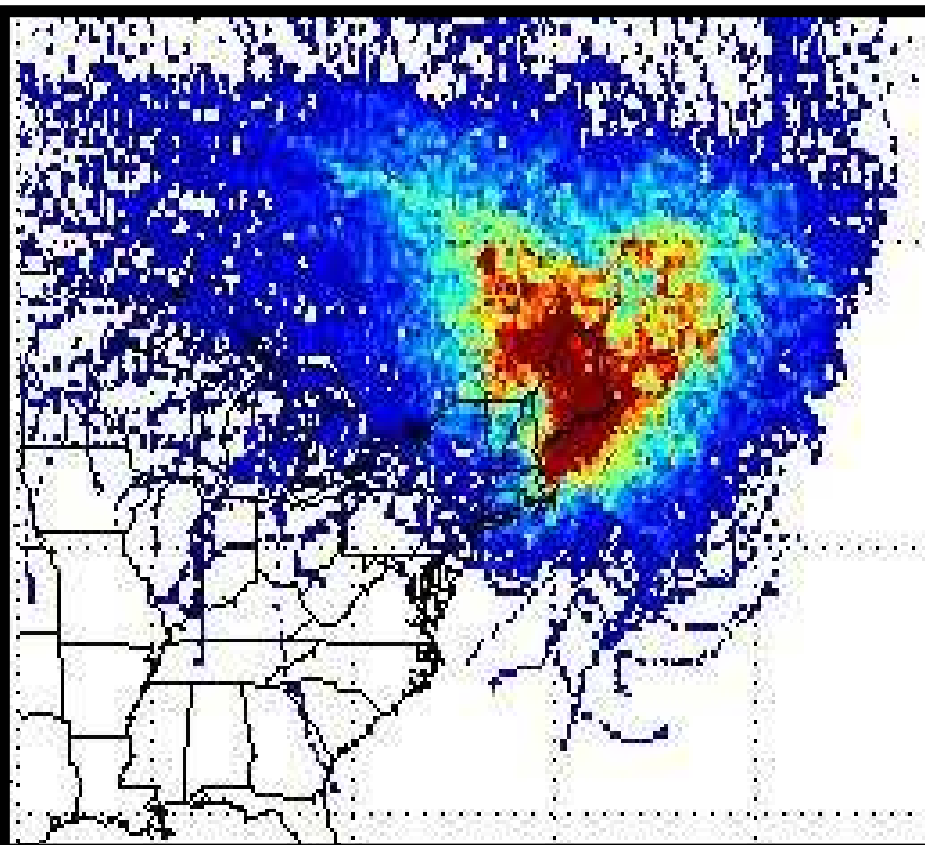
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Acadia National Park, Maine

Trajectory Clusters



Highest
Sulfate – 3.19ug/m³

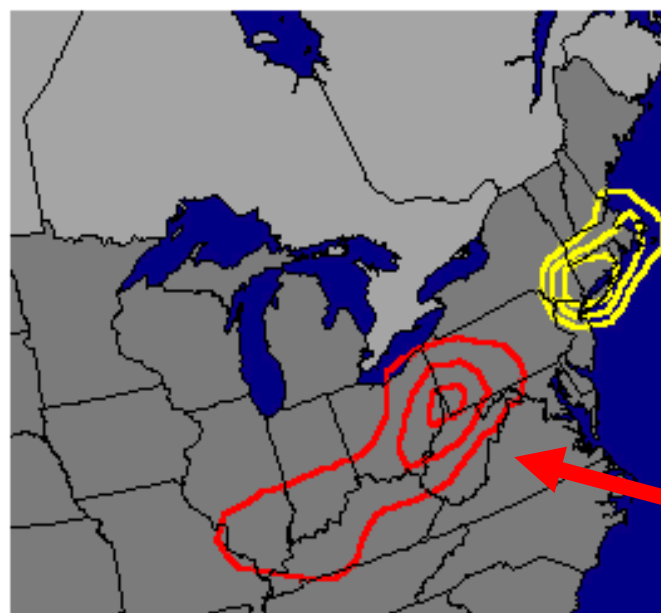


Lowest
Sulfate – 1.4 ug/m³

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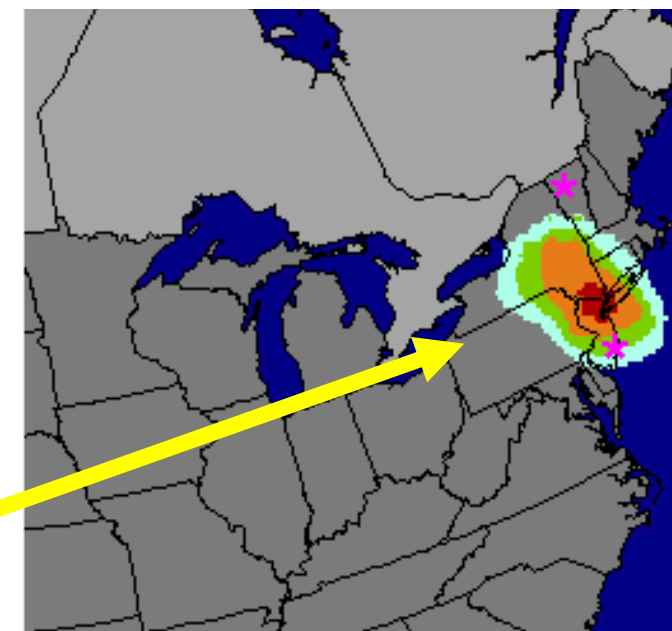
Source Apportionment/ Factor Analysis



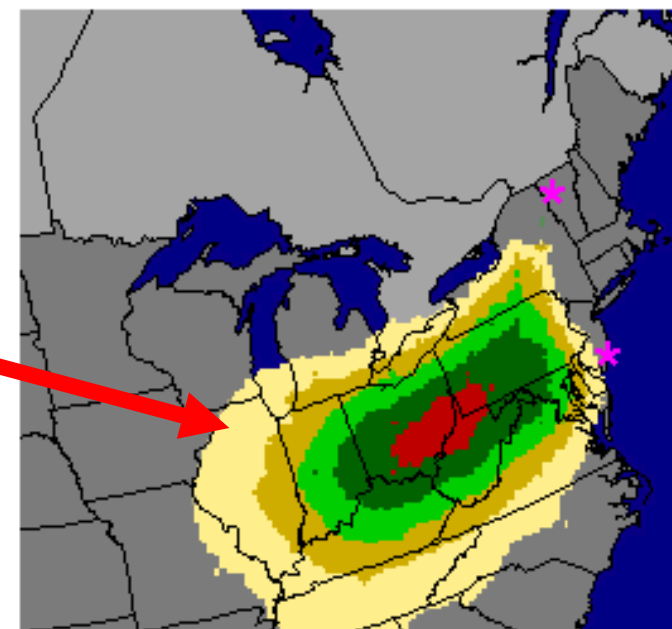
Interpolated Oil and Coal
SO₂ Emissions Fields
(oil x 10!)

Oil

Coal

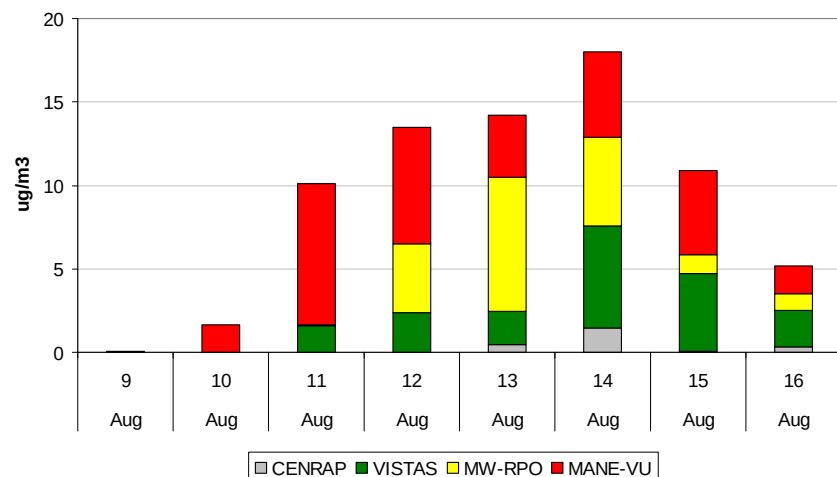


“Oil” and “Coal” Factors

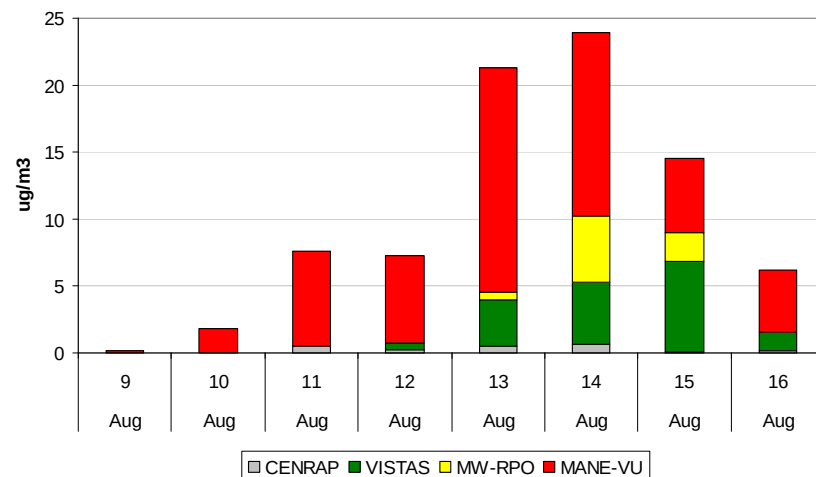


Contribution Day-by-Day

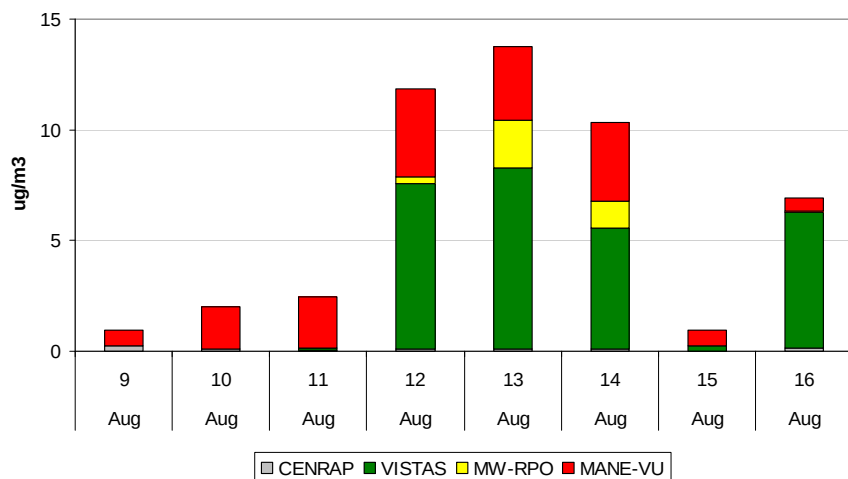
Lye Brook, VT



Acadia, ME



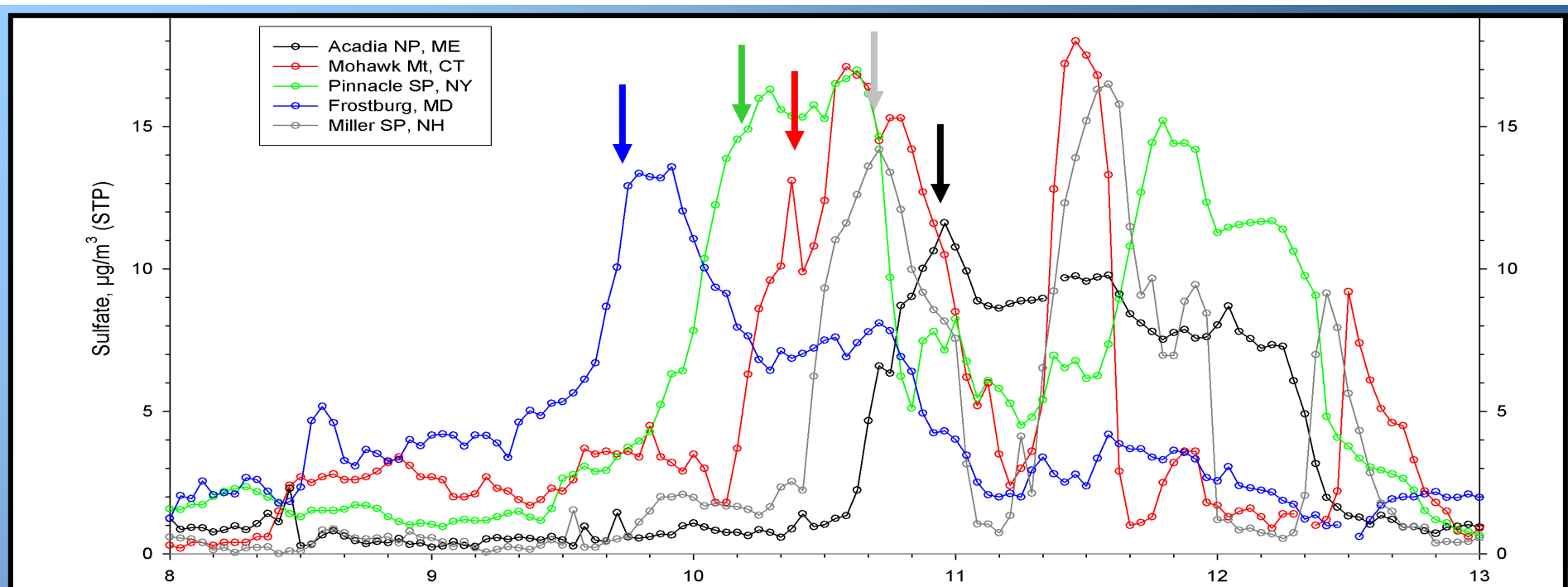
Brigantine, NJ



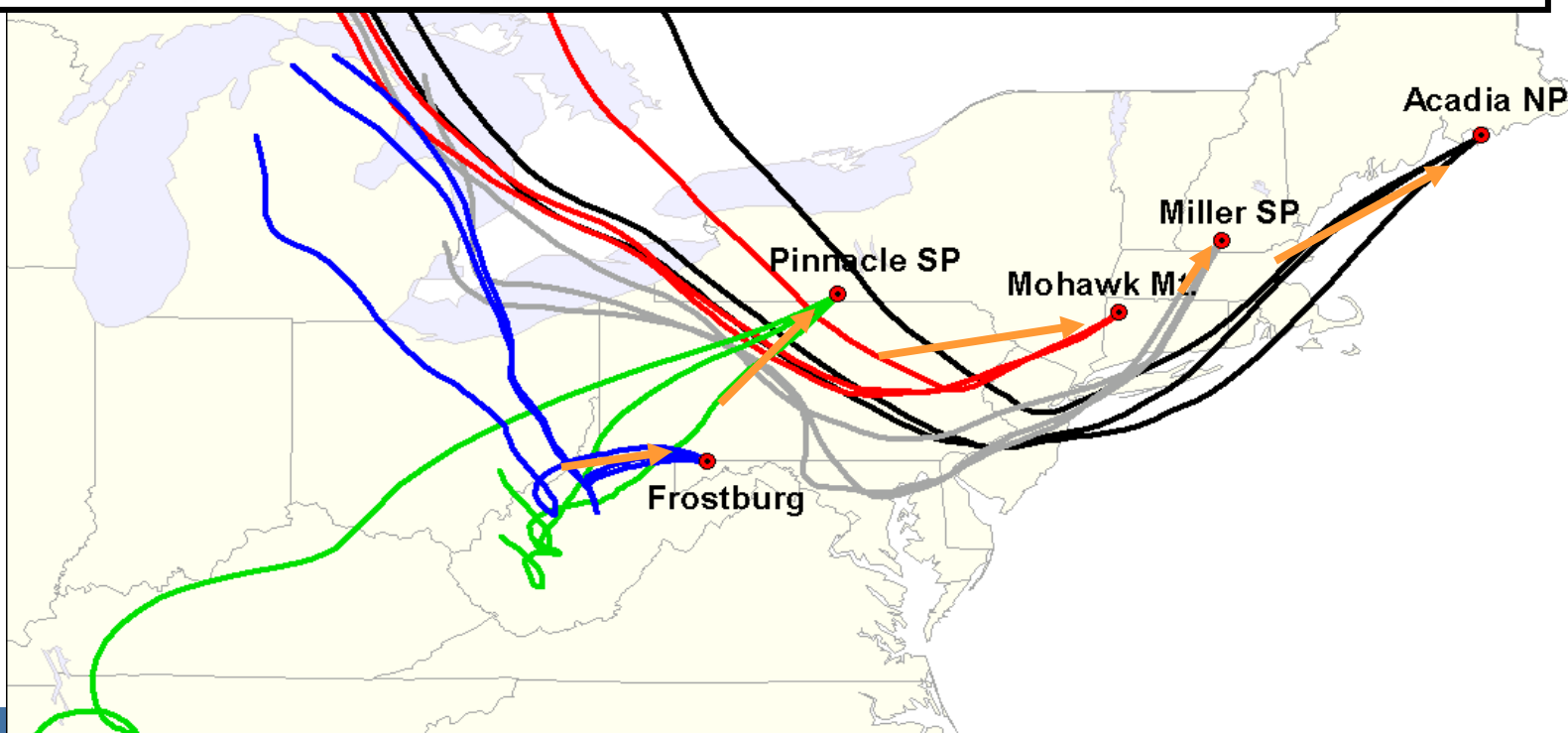
August 9-16, 2002
3 sites, 3 influences

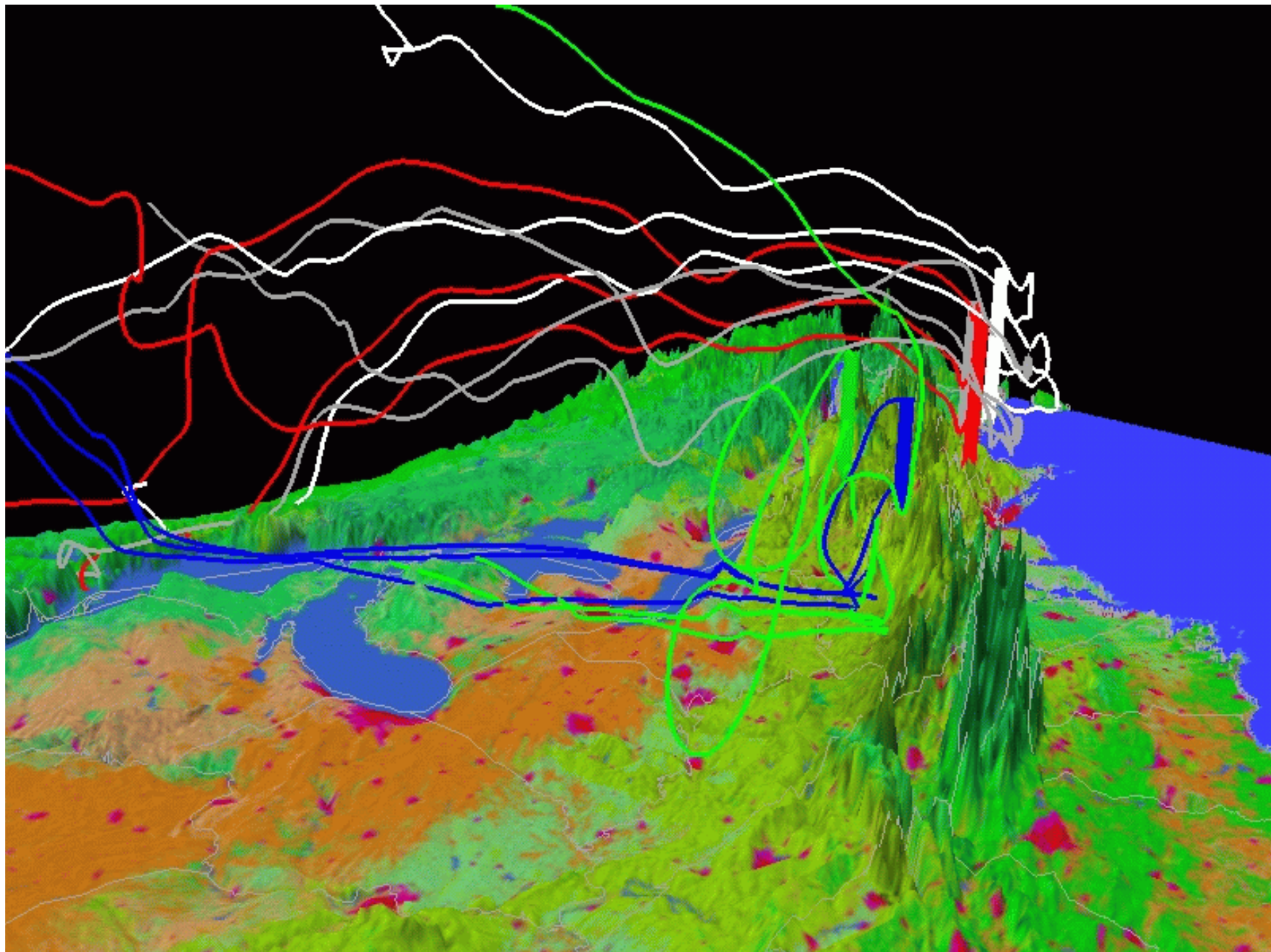
See Multi-RPO Animation

- See animation in web browser...



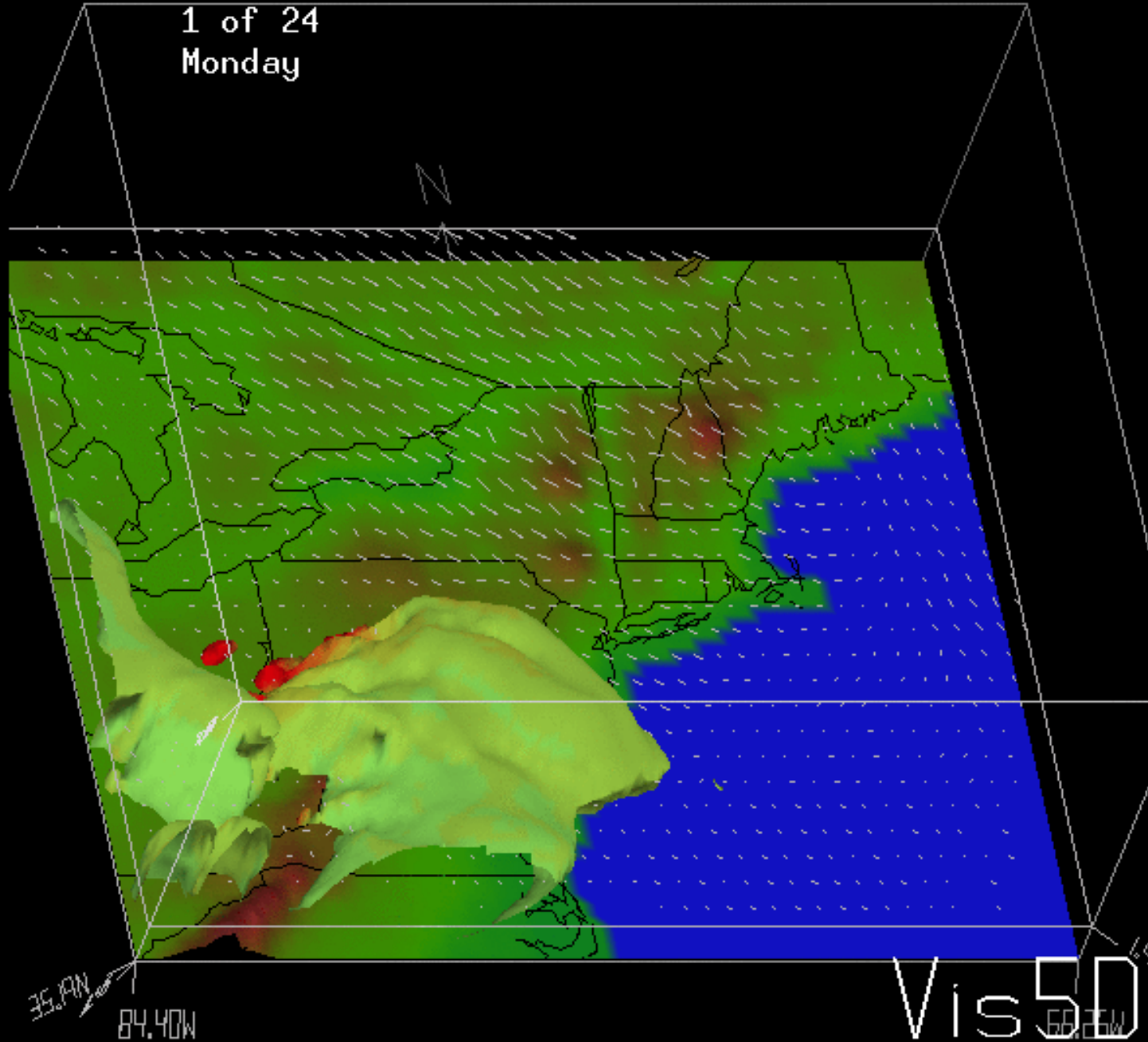
Put them
together
and...





Mid-Atlantic/

03:00:00
09 Aug 04
1 of 24
Monday





Final Thoughts

- Modeling/Visualization capability is expanding rapidly
- Accurate inventories appear to be the limiting step in the process
- Weight of evidence approaches provide confidence in results

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The Clean Air Association of the Northeast States

The NESCAUM logo features the word "NESCAUM" in a bold, black, sans-serif font. Above and below the text are two blue, wavy, horizontal lines that curve upwards at their ends, resembling stylized waves or a bridge.

NESCAUM

www.nescaum.org