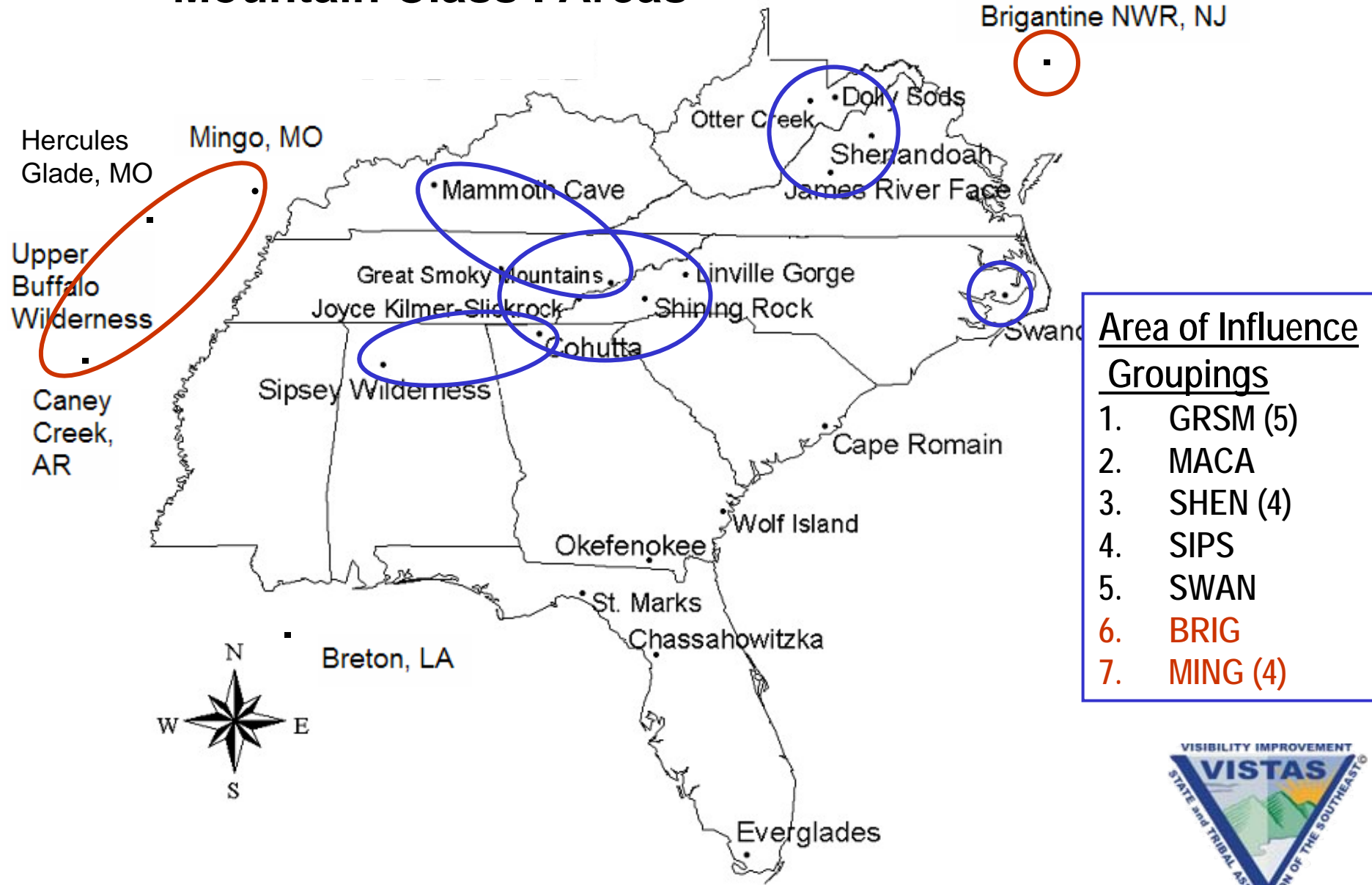




Sipsey Contribution Assessment

Draft May 29, 2007

Mountain Class I Areas

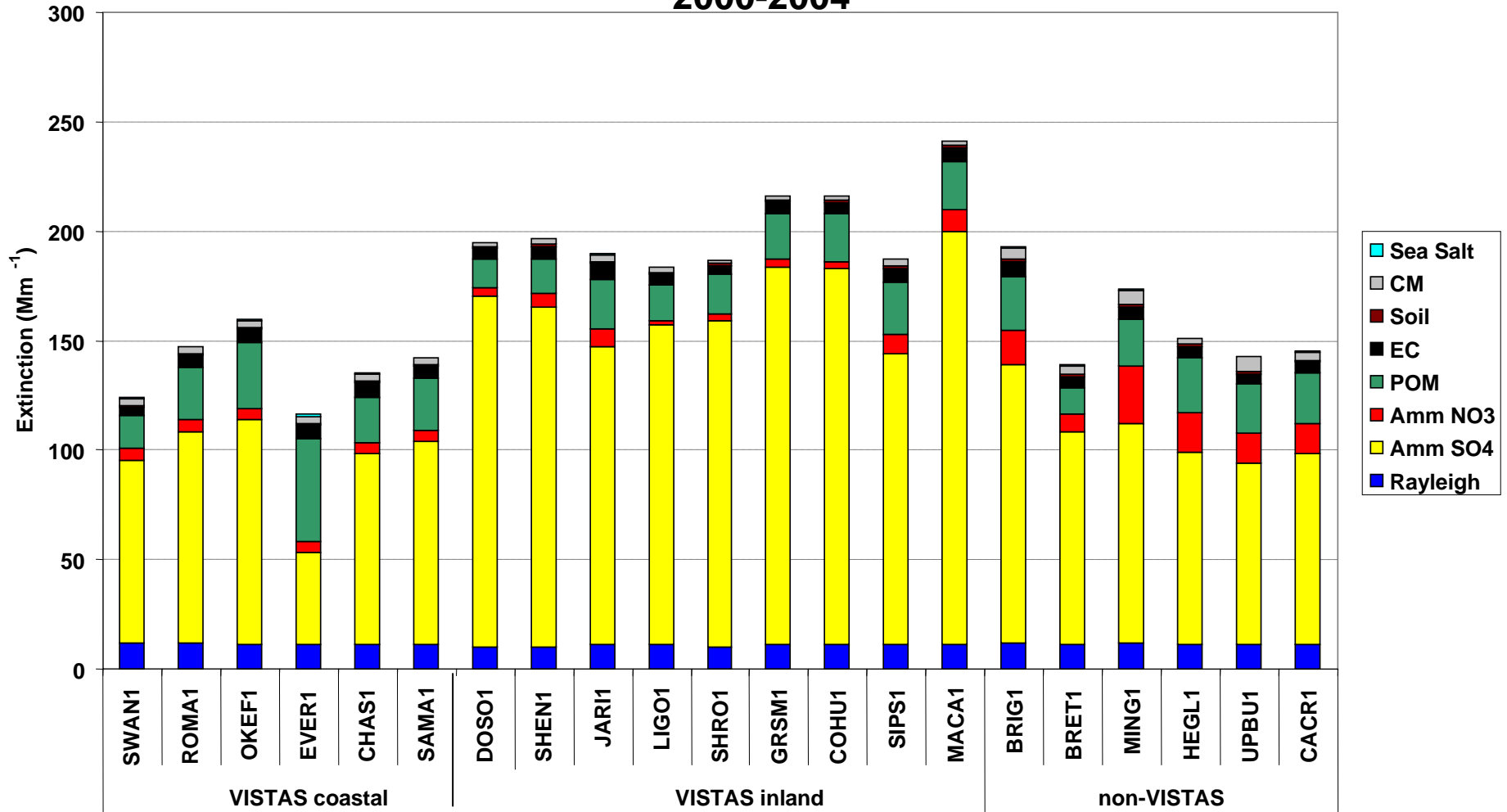




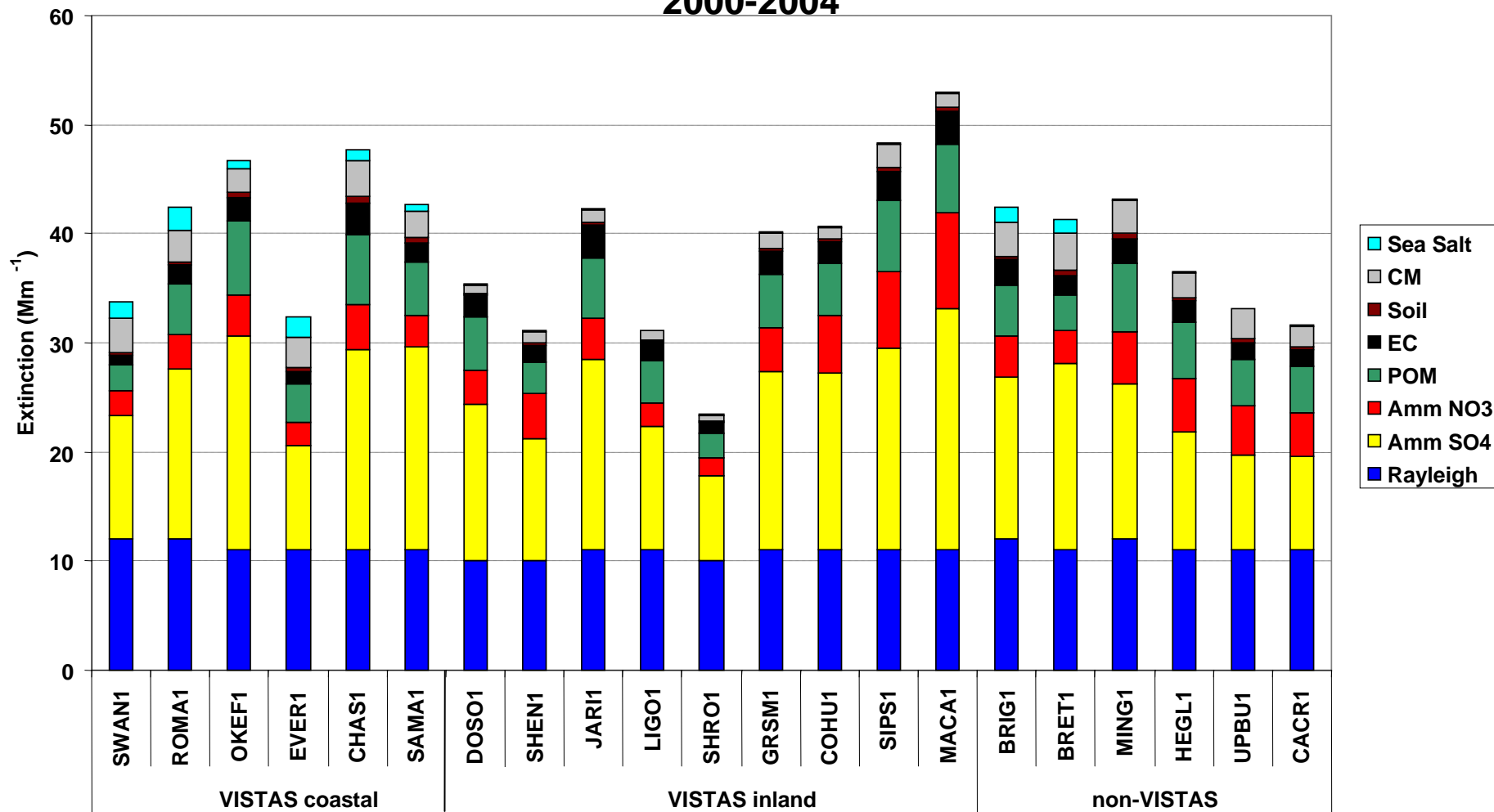
Objectives

- Pollutant Contributions: 2000-2004 20% Best and Worst Days
- New IMPROVE equation
 - Natural Background Calculations
- Glidepath and Progress in 2018
- Emissions Sensitivities
- Areas of Influence
 - Back Trajectory, Residence Time
 - Source Sector Emissions
 - List of Contributing Sources (states to supply)

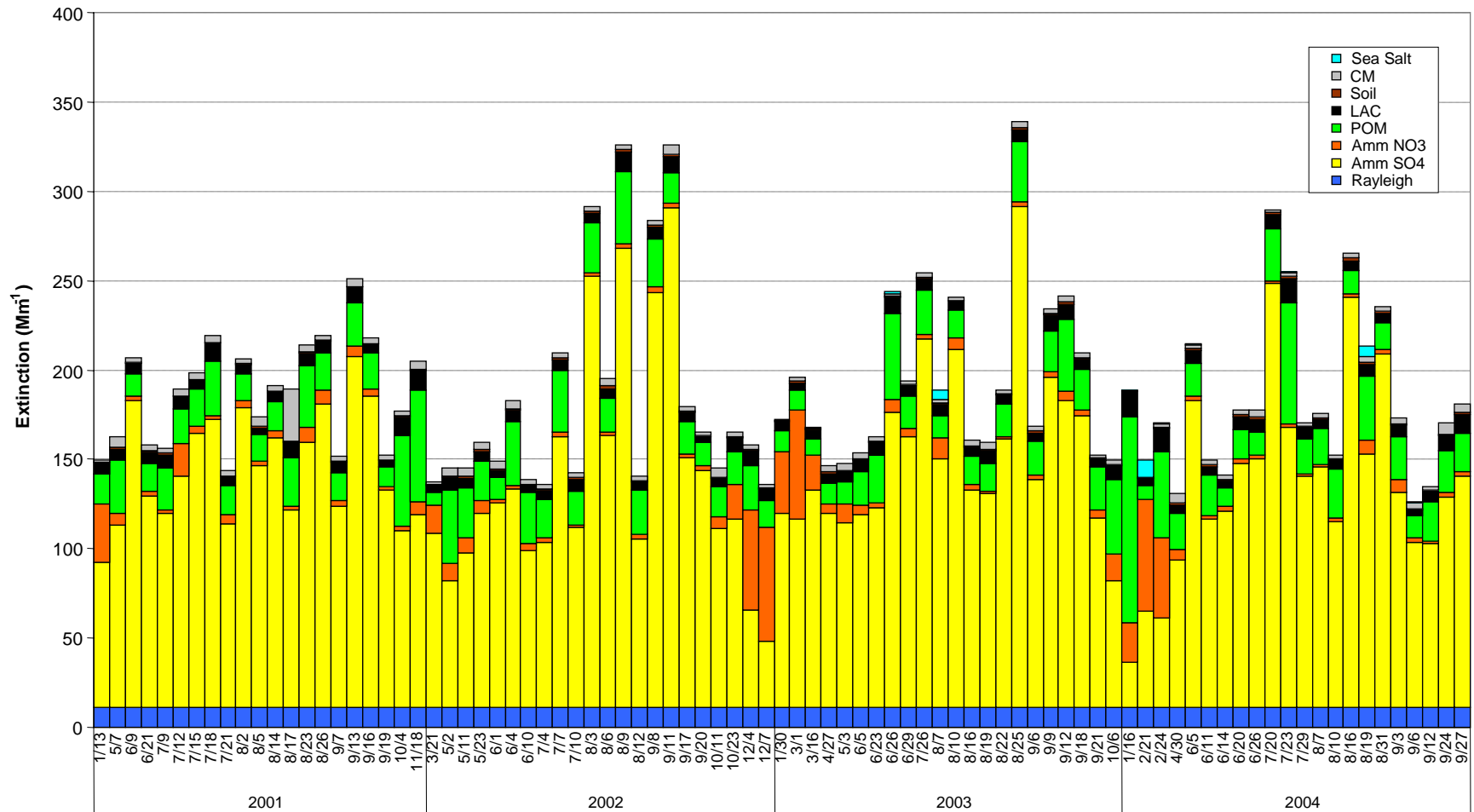
Average Extinction for 20% Worst Days New IMPROVE Algorithm (nia) 2000-2004



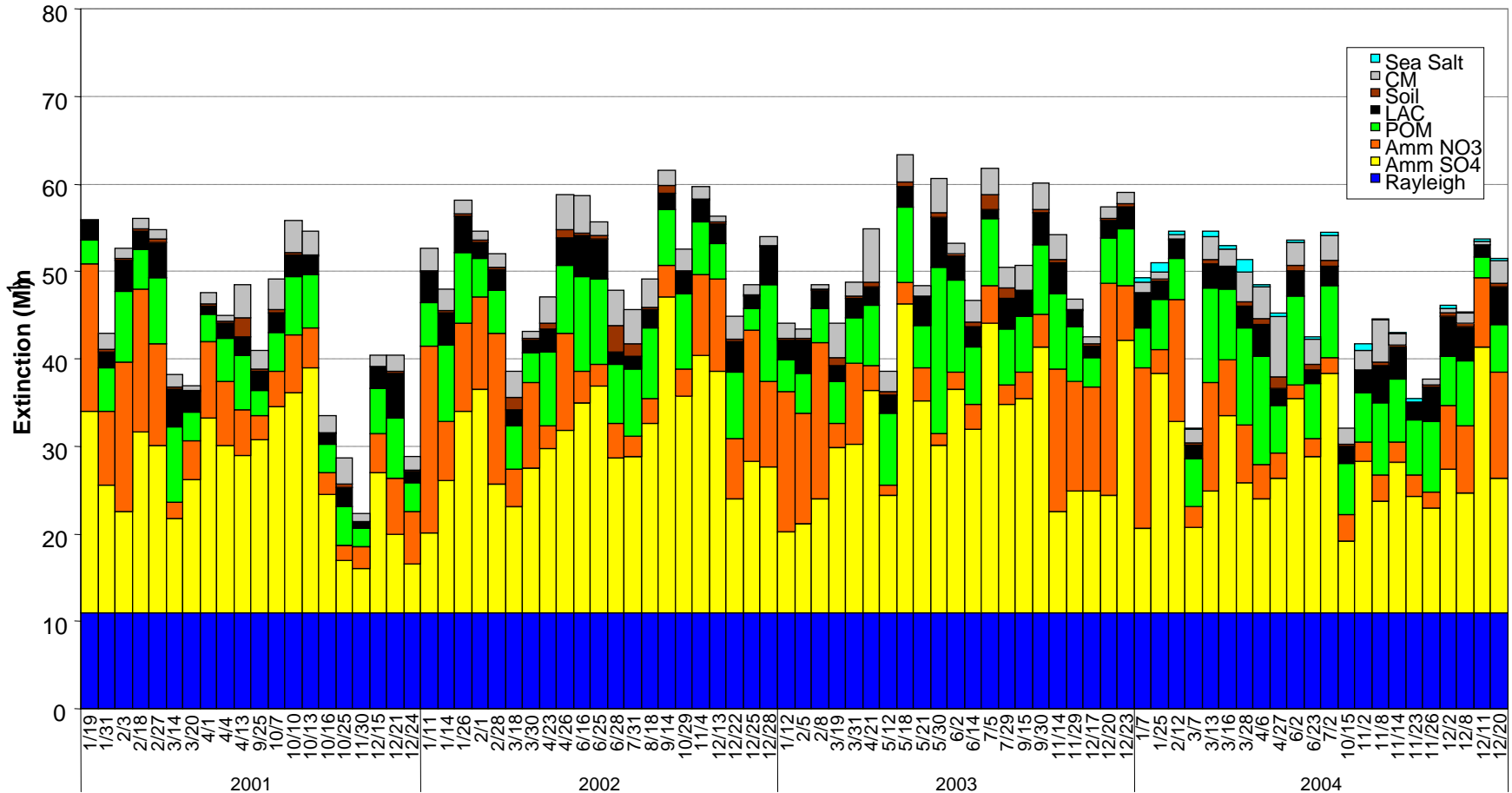
Average Extinction for 20% Best Days New IMPROVE Algorithm (nia) 2000-2004



2000-2004 Reconstructed Extinction
New IMPROVE Algorithm
20% Worst Days
Sipsey, AL



2000-2004 Reconstructed Extinction
New IMPROVE Algorithm
20% Best Days
Sipsey, AL





Conclusions: Contributions

- On 20% Worst Days
 - SO₄ dominates light extinction most days
 - Organic carbon smaller contribution; fire indicated on few days
 - NO₃ contribution on some winter days
- SO₄ also dominates 20% Best Days
- Conclude: Focus on reducing SO₂ emissions



New IMPROVE Equation

- Endorsed by IMPROVE Steering Committee as accounting for latest science
 - Defines two terms each for SO₄, NO₃, and OC with higher extinction efficiencies (b_{ext}) associated with high mass and lower b_{ext} associated with low mass
 - Increases mass multiplier for organic carbon from 1.4 to 1.8
 - Adds term for fine mass sea salt
 - Adds term for absorption due to NO₂ (only if NO₂ measurements available)
 - Calculates site specific Rayleigh scattering



New IMPROVE Equation

- Light scattering measured by nephelometer and calculated using new IMPROVE equation show good correlation
 - Original equation under estimated scattering on highest days and over estimated scattering on lowest days
- New equation generally indicates higher extinction on 20% worst days and lower extinction on 20% best days

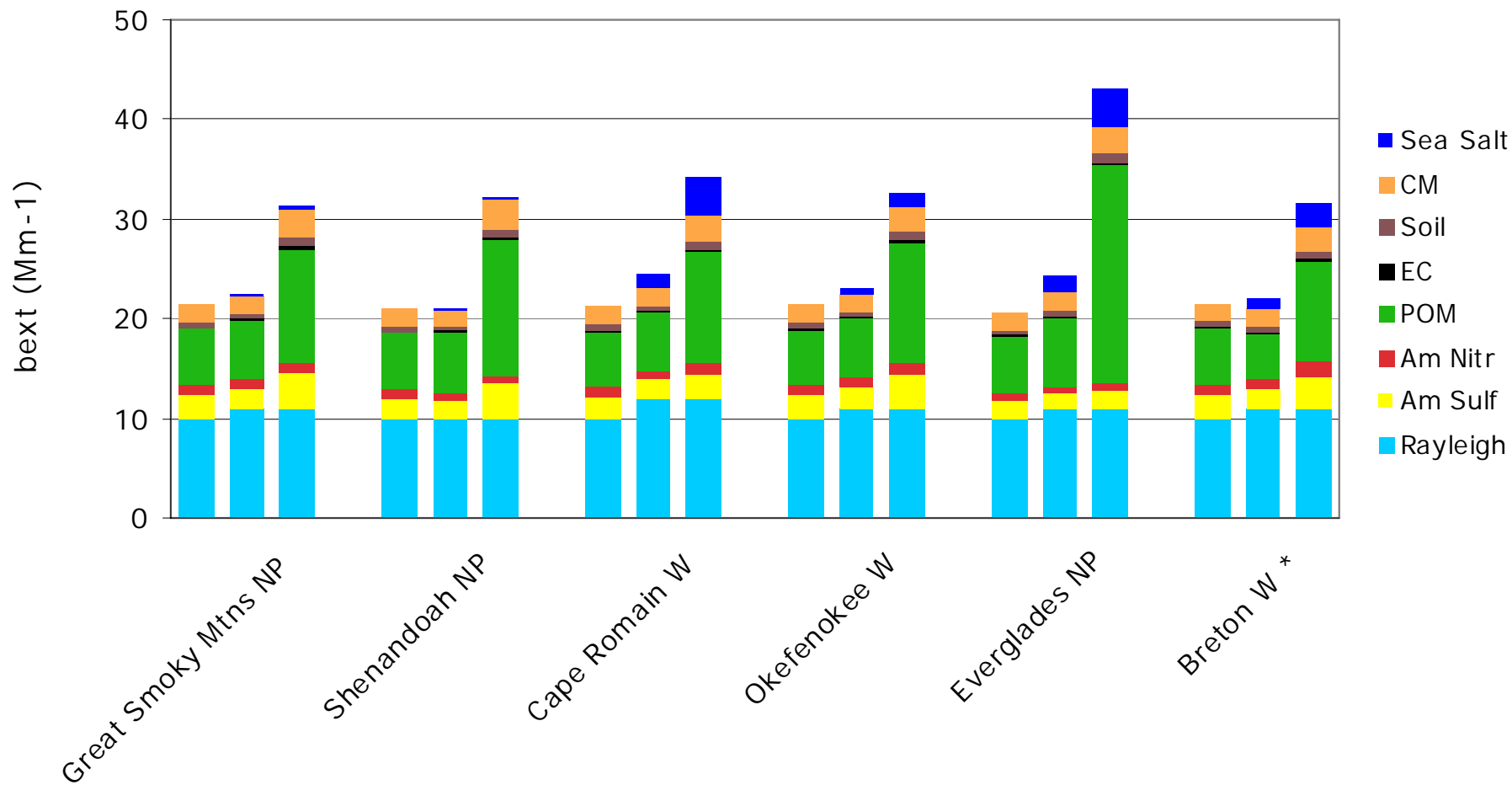


Natural Background Visibility

- Tombach reviewed for VISTAS the original assumptions by Trojonis et al. 1990 used to define natural background levels of visibility impairing pollutants and recent scientific developments. He also made recommendations for changes in assumptions. (Tombach and Brewer, 2005)
- Hand and Malm (2005) reviewed assumptions for calculating light extinction in the original IMPROVE equation and made recommendations for revisions.
- The IMPROVE Steering Committee reviewed and approved new equation for calculating light extinction (2005).
- Ames (2006) reviewed methods to project natural background levels for 20% worst visibility days using the new IMPROVE equation and IMPROVE approved revised methods
- Revised glide paths calculated for reaching natural background conditions at Class I areas by 2064.

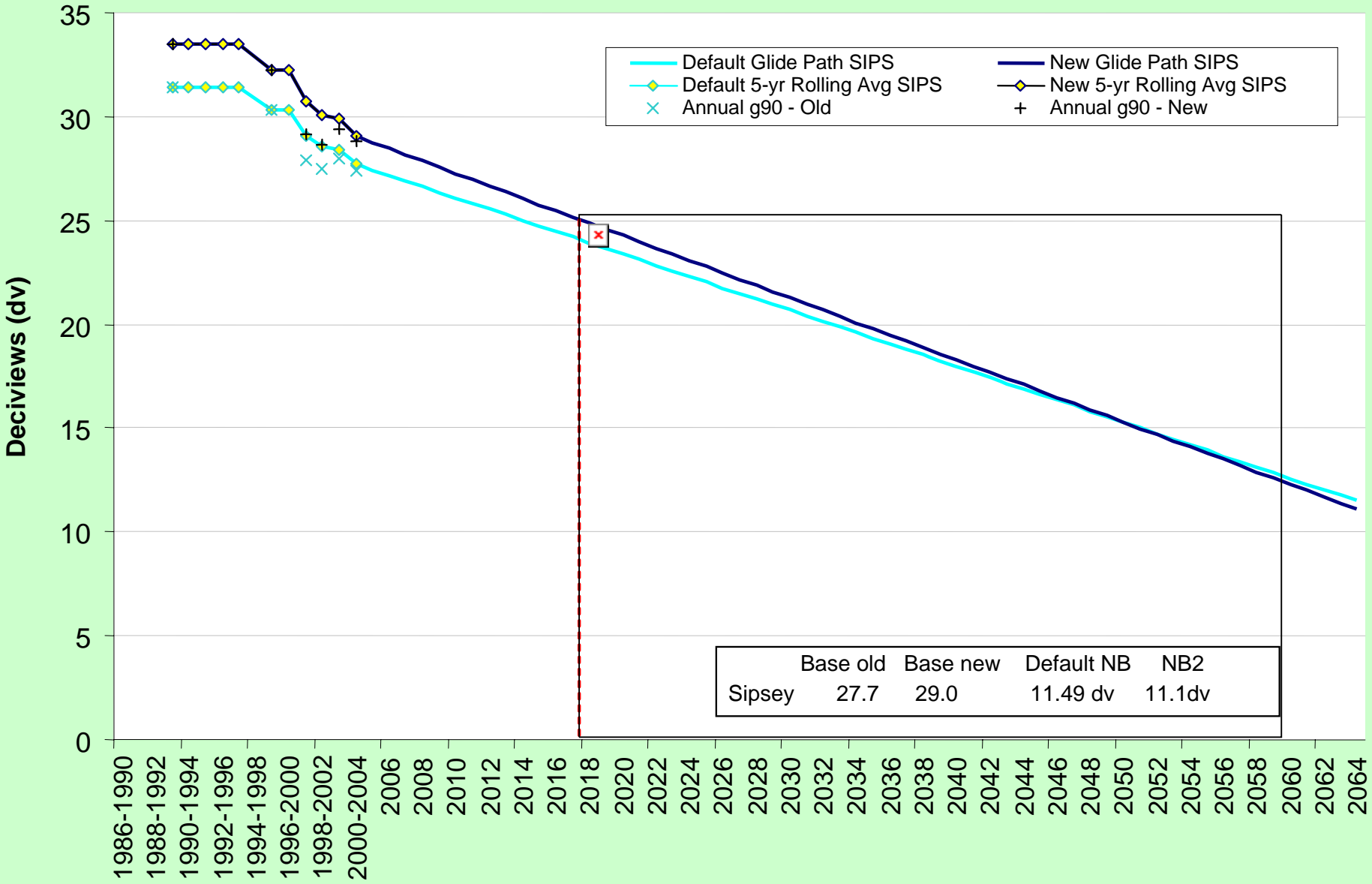
Natural Conditions

Left = Default Natural Conditions; Center = New IMPROVE Algorithm;
Right = W20 with New IMPROVE Algorithm



Sipsey Glide Path to Natural Conditions (2004-2064)

(5-yr Rolling Average for 20% Hazeiest Days - New IMPROVE equation and NB II)





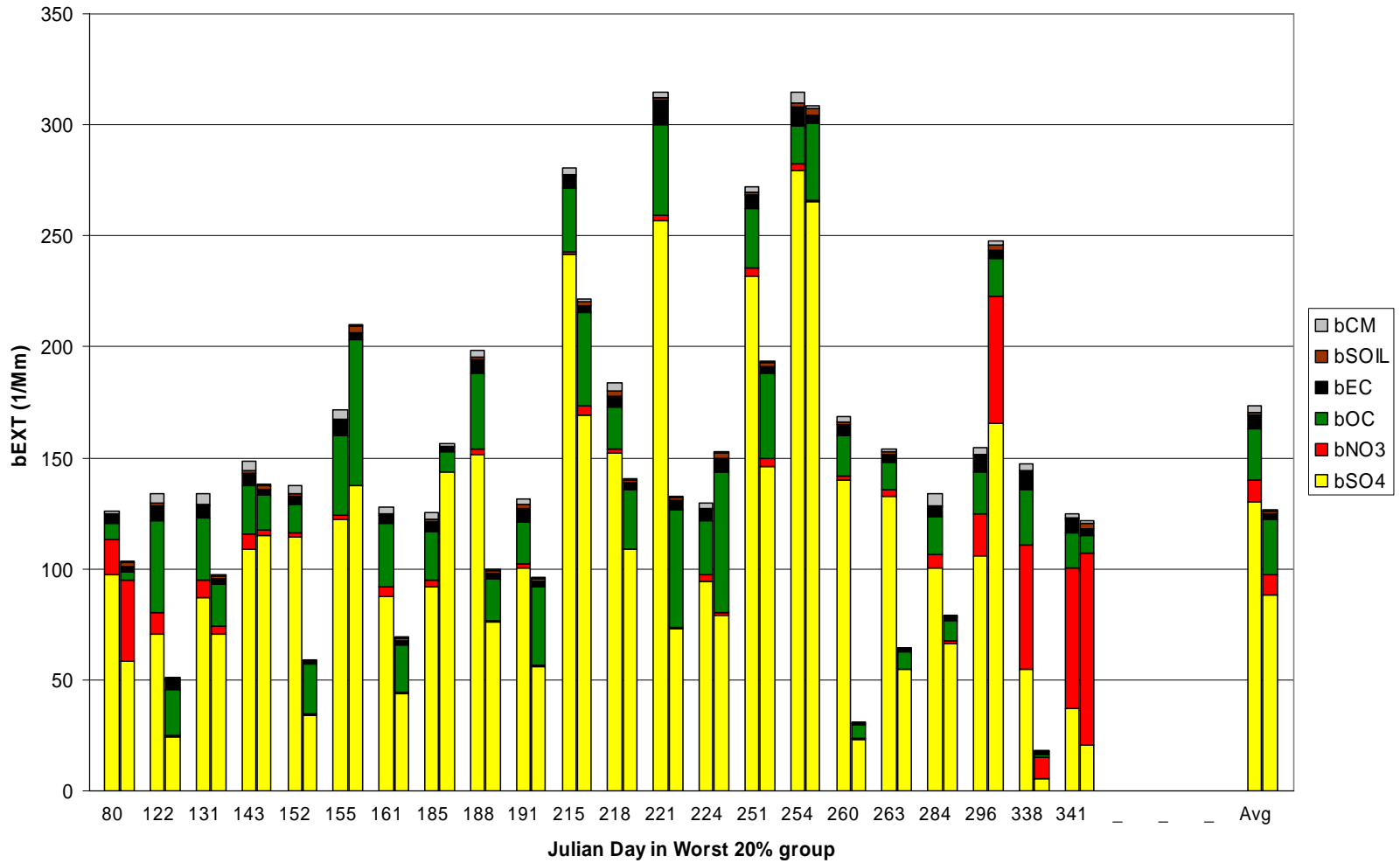
VISTAS 2018 Base G2 Visibility Projections (Delivered Mar 2007)

- CMAQ Air Quality Model 2018 Run
 - Accounts for Clean Air Interstate Rule (utility controls)
 - Does not include controls for BART (Best Available Retrofit Technology)
 - VISTAS states inventories as of Feb 2007
 - Inventories for neighboring states effective Aug 2006

Model Performance 20% Haziest Days in 2002

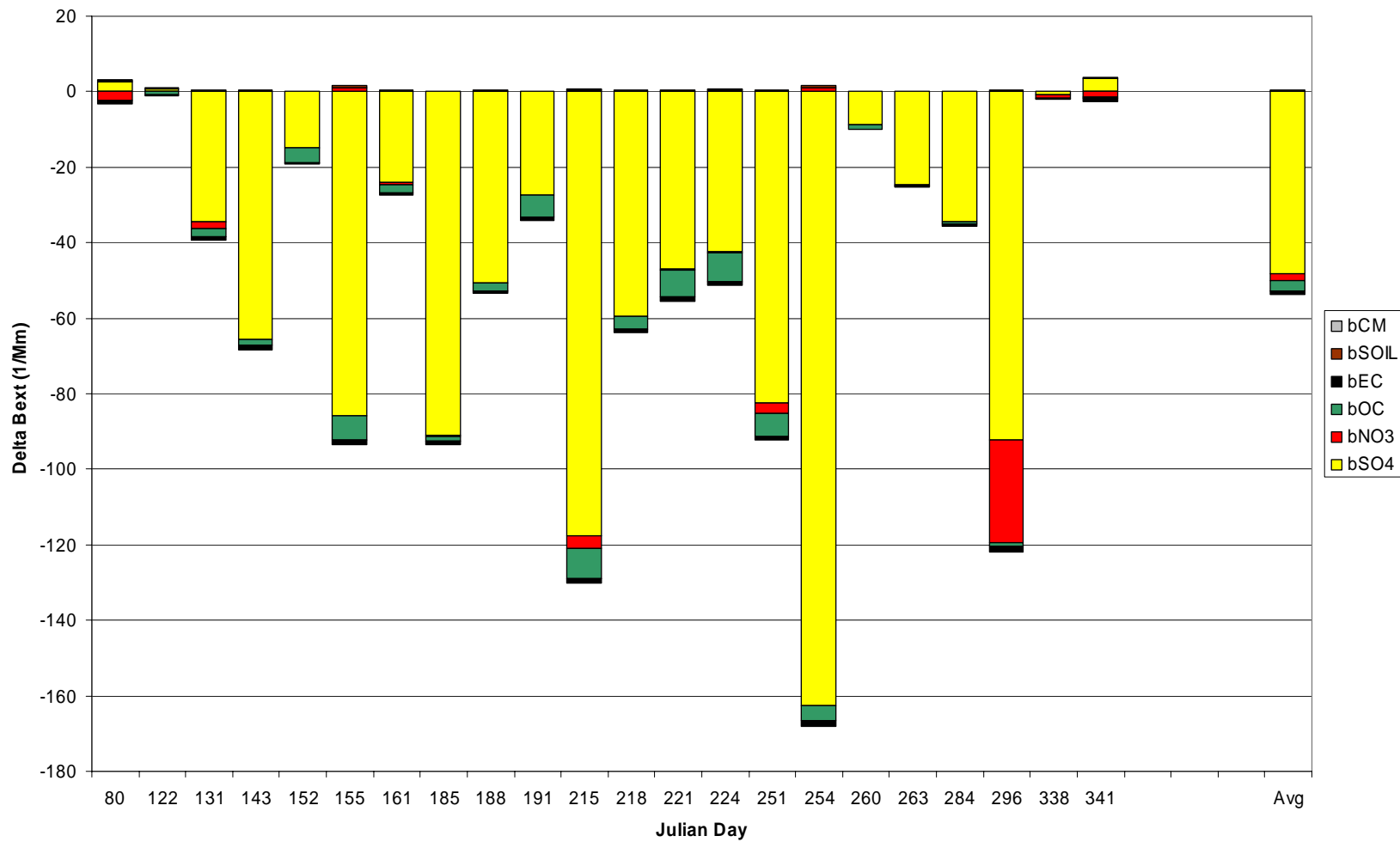
Observations (left) vs Modeled Base G2a (right)

Sispey, AL



Modeled Responses to 2018 Base G2a Emissions on 20% Haziest Days

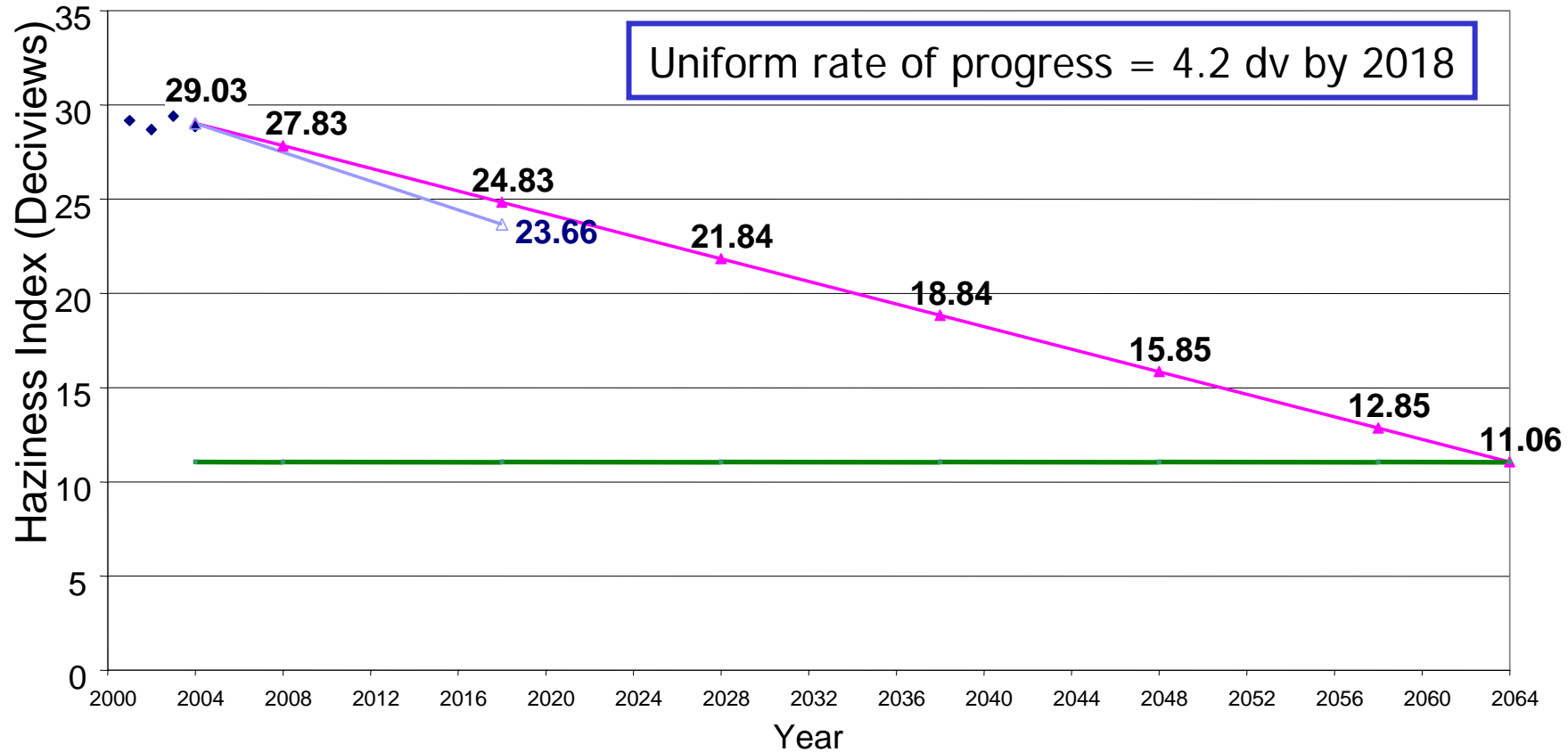
Sispey, AL



Uniform Rate of Progress Glide Path

Sipsey - 20% Worst Days

New IMPROVE equation



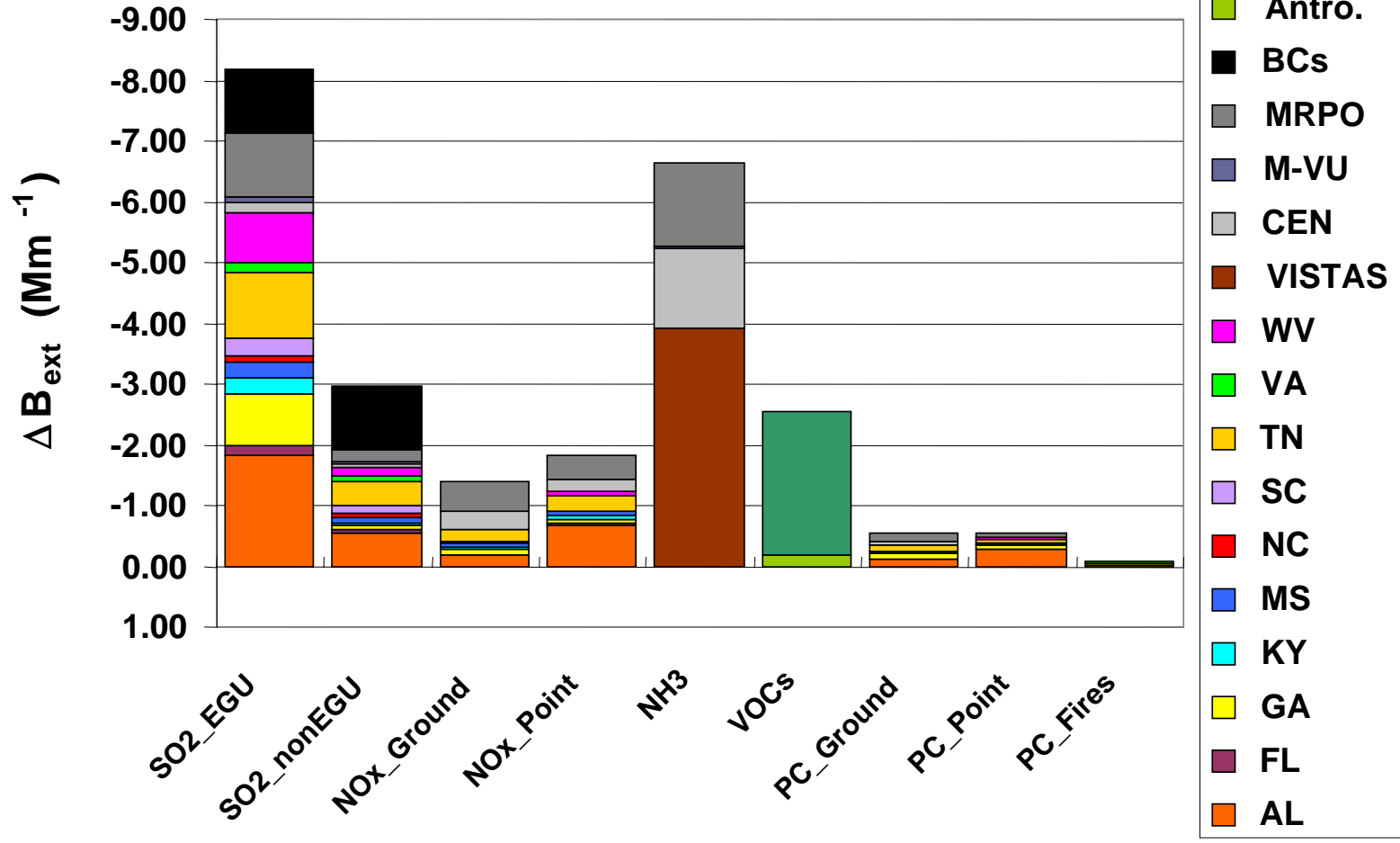
◆ Observation ▲ Method 1 Prediction ▲ Glide Path — Natural Condition (Worst Days)

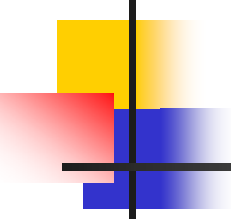


VISTAS Source Sector Emissions Sensitivities (Delivered Jan 2006)

- Evaluated responses to emissions reductions for specific pollutants and source sectors
- Greatest visibility improvement from further reducing SO₂ emissions from utilities and industries

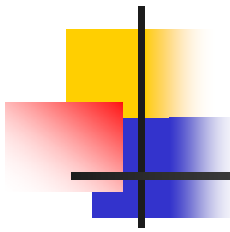
Sipsey, AL (20% Worst Days)





Conclusion: Source Sector Emissions Sensitivities

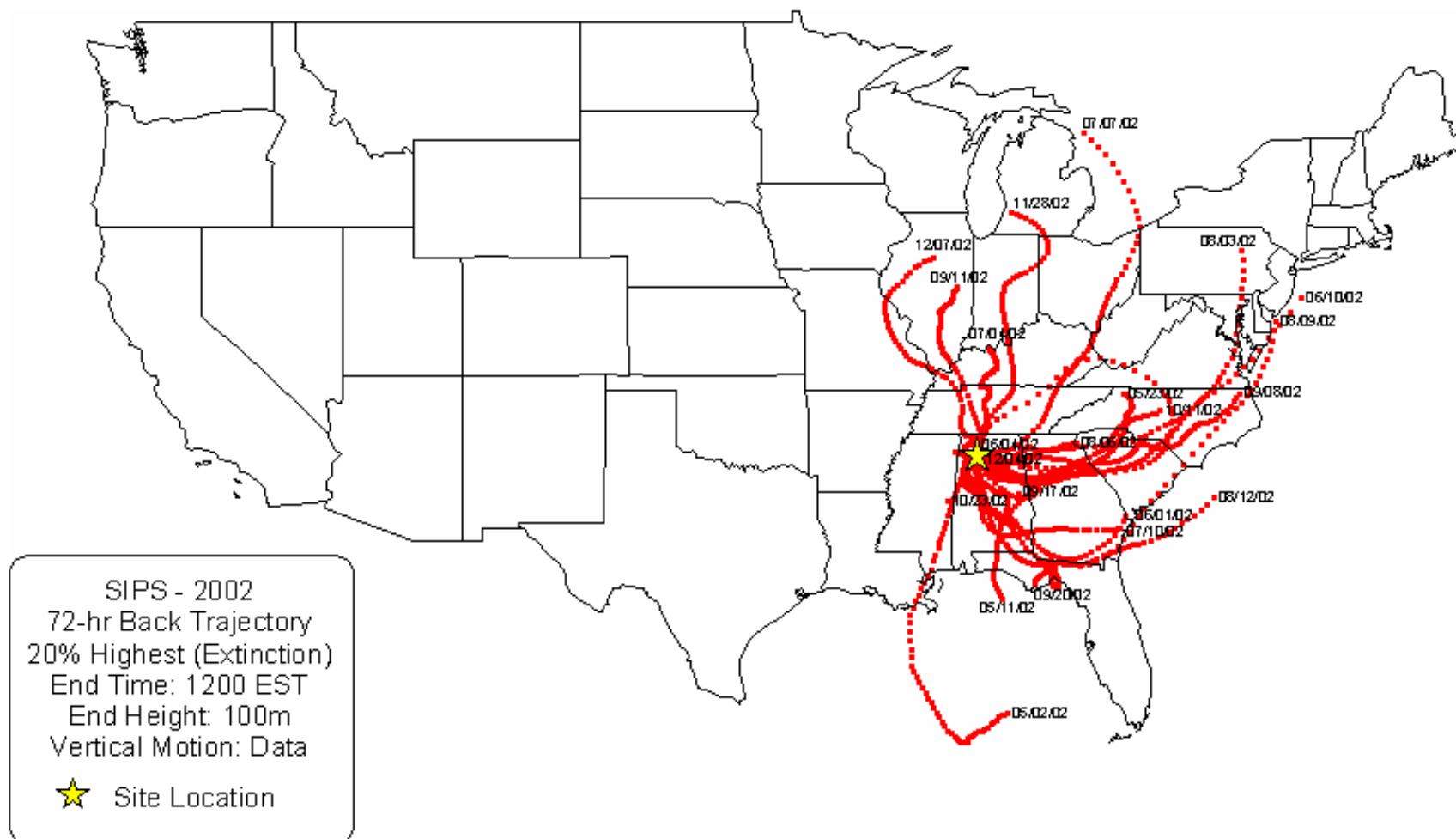
- Reductions in SO₂ emissions from EGU and non-EGU show largest improvements in visibility
 - Several VISTAS states contribute
 - Contributions from MRPO and Boundary Conditions (outside VISTAS 12 km domain)
- Small benefits from reducing NO_x, anthropogenic VOC or primary carbon



VISTAS Geographic Areas of Influence

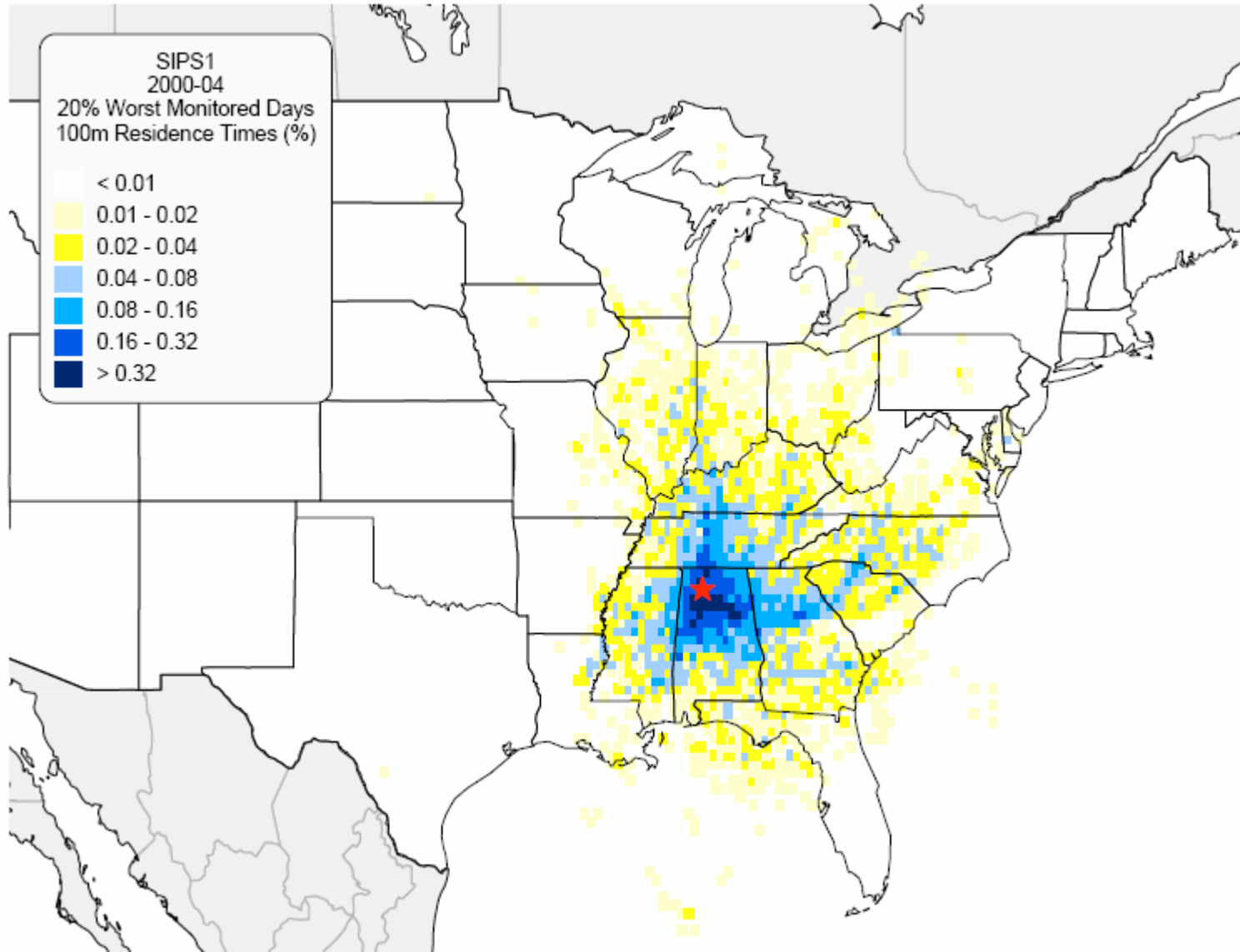
- Hysplit model used to generate back trajectories for Class I areas (Air Resource Specialists)
 - Back trajectories for individual 20% worst days in 2002
 - Helpful for evaluating model performance in 2002
 - Residence time plots for 20% worst days in 2000-2004 indicate probable contribution
 - Helpful to understand geographic area most likely to influence Class I areas
 - SO₂ Area of Influence defined from residence weighted by SO₄ extinction and considering SO₂ emissions

Back Trajectories for 20% Worst Days for 2002 Sipsey, AL

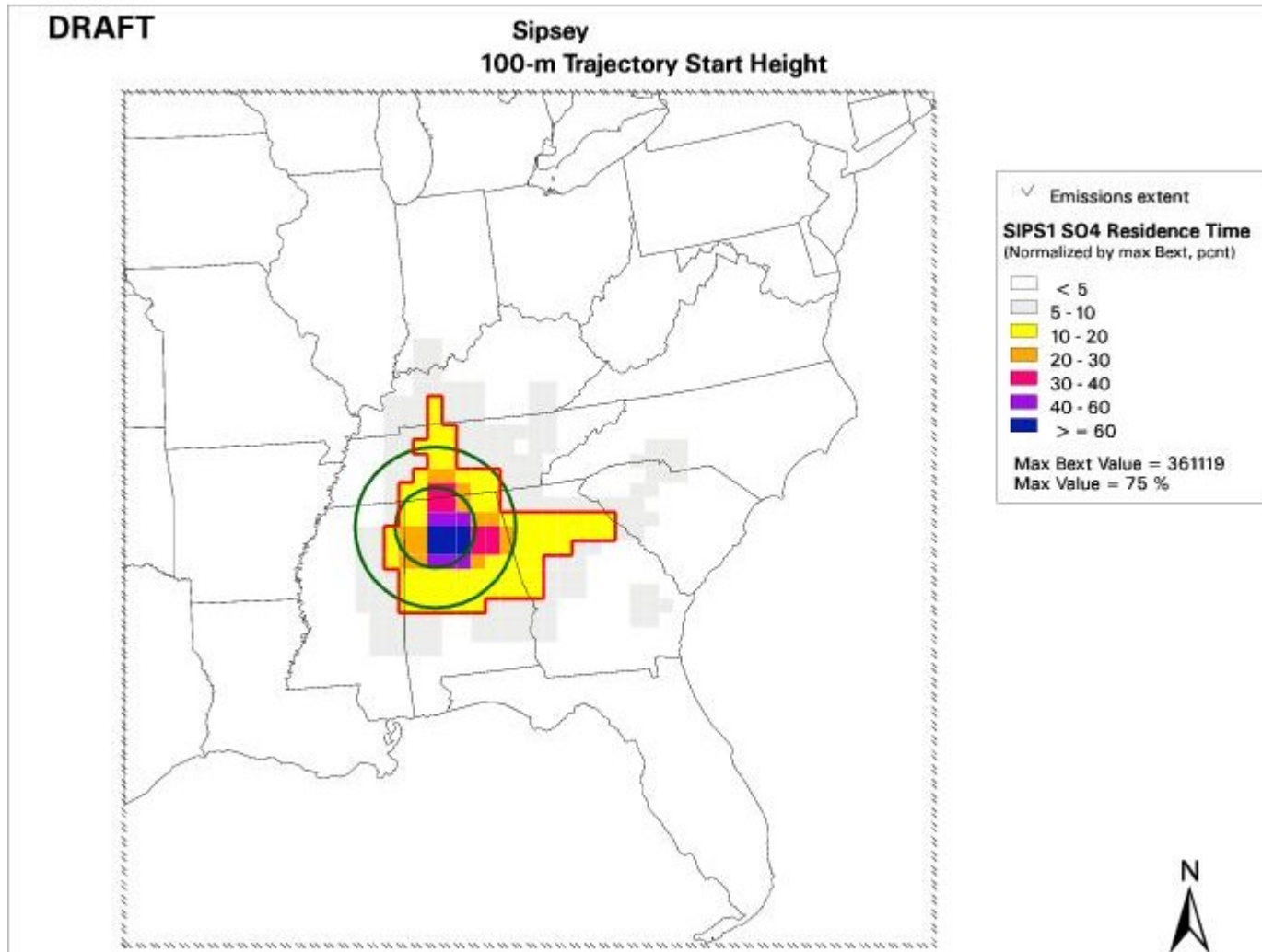


Residence Time for 20% Worst Days in 2000-2004

Sipsey. AL



SO2 Area of Influence for Sipsey, AL

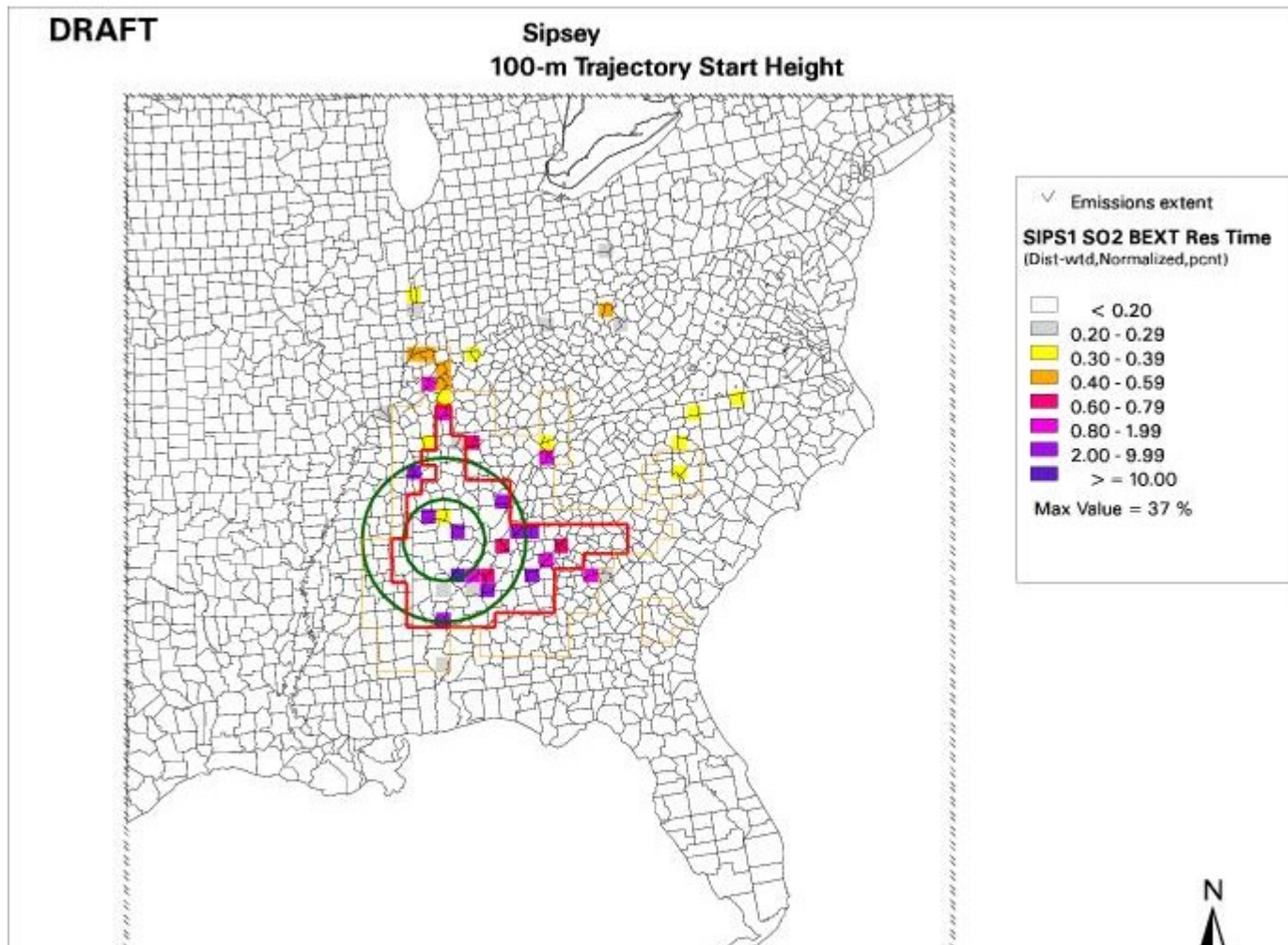


Green circles indicate 100-km and 200-km radii from Class I area.

Red line perimeter indicate Area of Influence with Residence Time $\geq 10\%$

Orange line perimeter indicate Area of Influence with Residence Time $\geq 5\%$.

2018 SO2 Emissions weighted by Residence Time Sipsey, AL



Green circles indicate 100-km and 200-km radii from Class I area.

Red line perimeter indicate Area of Influence with Residence Time $\geq 10\%$.

Orange line perimeter indicate Area of Influence with Residence Time $\geq 5\%$.



Reasonable Progress Analysis

- States consider 4 Statutory Factors to determine what controls are reasonable
 - Costs of Compliance
 - Time to Comply
 - Remaining Useful Life
 - Energy and Other Environmental and Impacts

Annual 2018 BaseG2 Emissions (%) Within Area of Influence Sipsey, AL

| Tier | SO2 |
|--|------------|
| Fuel Comb. Elec. Util.-Coal | 58% |
| Fuel Comb. Elec. Util.-Oil | 0% |
| Fuel Comb. Elec. Util.-Gas | 0% |
| Fuel Comb. Elec. Util.-Other | 0% |
| Fuel Comb. Elec. Util.-Internal Combustion | 0% |
| Fuel Comb. Industrial-Coal | 15% |
| Fuel Comb. Industrial-Oil | 4% |
| Fuel Comb. Industrial-Gas | 2% |
| Fuel Comb. Industrial-Other | 1% |
| Fuel Comb. Industrial-Internal Combustion | 0% |
| Fuel Comb. Other- Commercial/Institutional Coal | 2% |
| Fuel Comb. Other- Commercial/Institutional Oil | 3% |
| Fuel Comb. Other-Commercial/Institutional Gas | 0% |
| Fuel Comb. Other-Misc. Fuel Comb. (Except Residential) | 0% |
| Fuel Comb. Other-Residential Wood | 0% |



4 Statutory Factors

- For Utilities and Industrial Boilers
 - Switch to fuel with lower sulfur content
 - Coal or Oil
 - Post-combustion controls
 - Flue Gas Desulfurization
 - Modification trigger PSD review?



4 Statutory Factors (continued)

- Costs of Compliance
 - Fuel switch for coal or oil
 - May have to blend low S fuel to maintain boiler performance
 - Price difference for lower S fuel
 - Cost of boiler modifications for lower S fuel
 - <\$1000/ton



4 Statutory Factors (continued)

- Costs of Compliance
 - Flue Gas Desulfurization
 - Construction costs: absorber tower, sorbent, waste handling facility
 - Operational and maintenance costs
 - Costs per ton vary with boiler size, type, facility
 - Utility costs range \$1,000 - \$5,000/ton
 - Industrial costs range \$3,000 - \$20,000+/ton



4 Statutory Factors (continued)

- Time for Compliance
 - 2+ years for fuel switching
 - 3+ years for post-combustion control
(dependent on market and availability of labor and materials)
- Remaining Useful Life
 - Facility specific



4 Statutory Factors (continued)

- Energy and Non-Air Environmental Impacts
 - Lower sulfur fuel may affect boiler operations
 - FGD slightly reduces energy production
 - Burn more coal per unit energy produced
 - Increase disposal of sludge, wastewater
 - Increase carbon emissions
 - CO₂ is released as byproduct from CaSO₄ formation