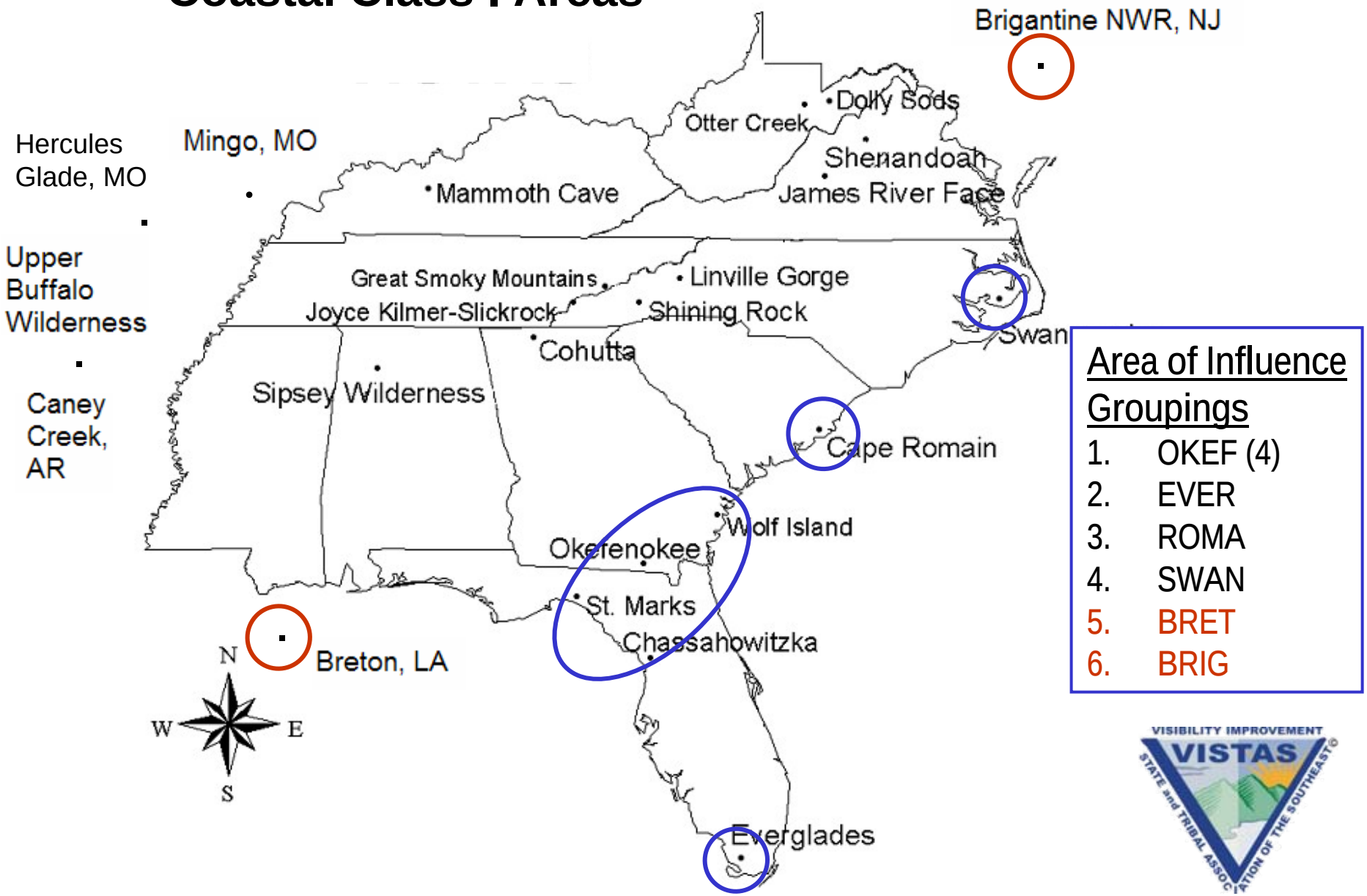
Everglades Contribution Assessment

Draft May 29, 2007

Coastal Class I Areas

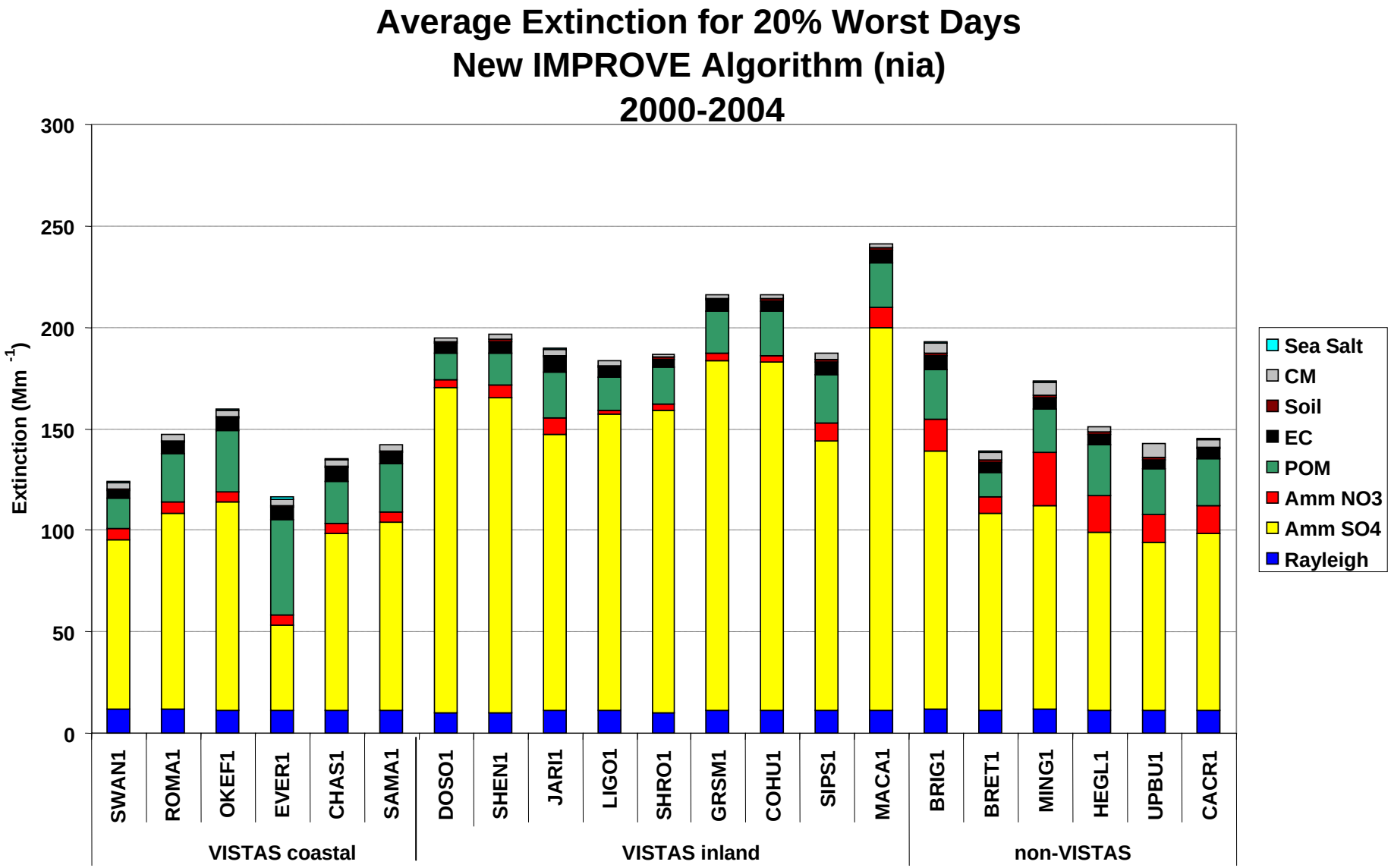


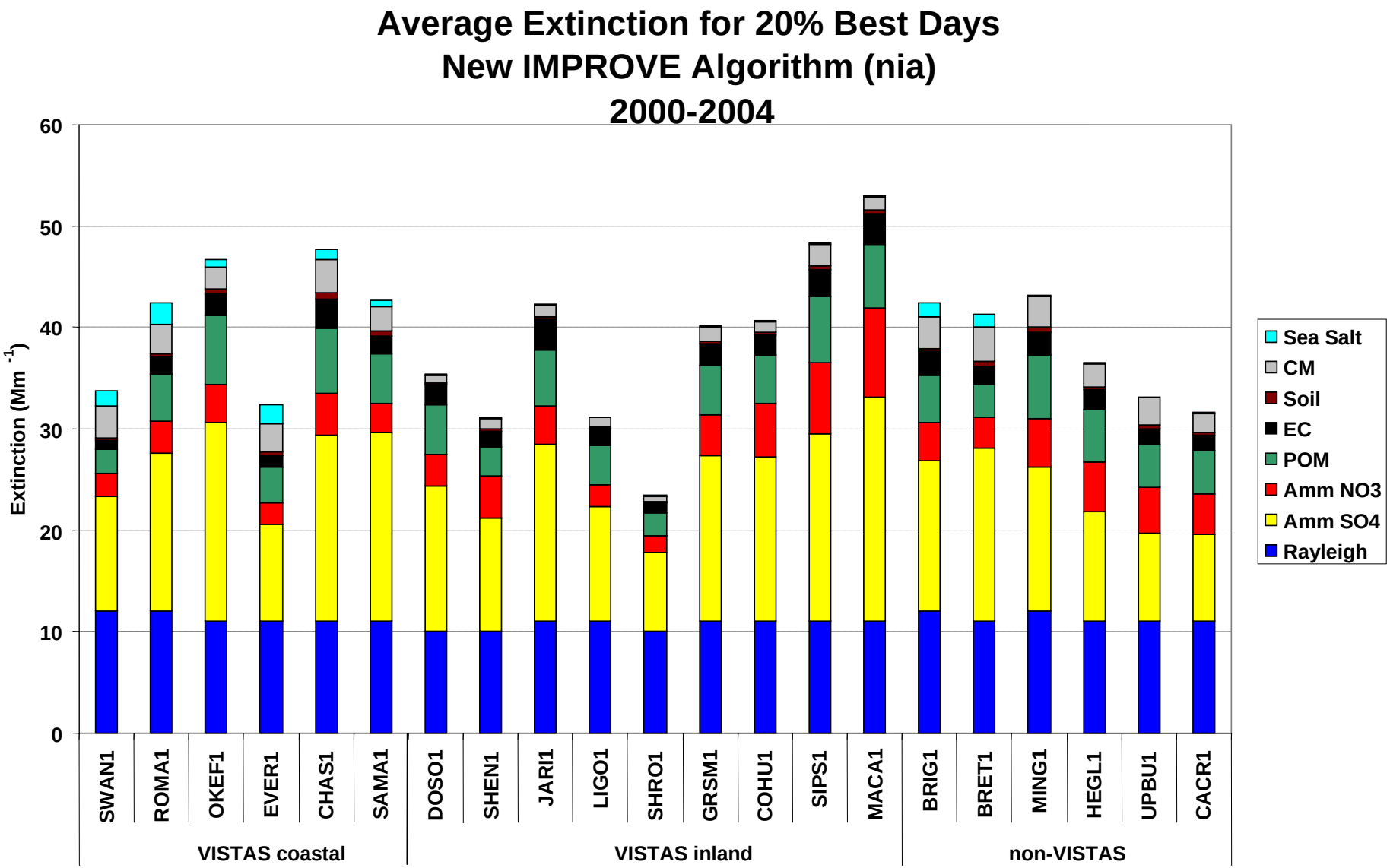
Area of Influence Groupings

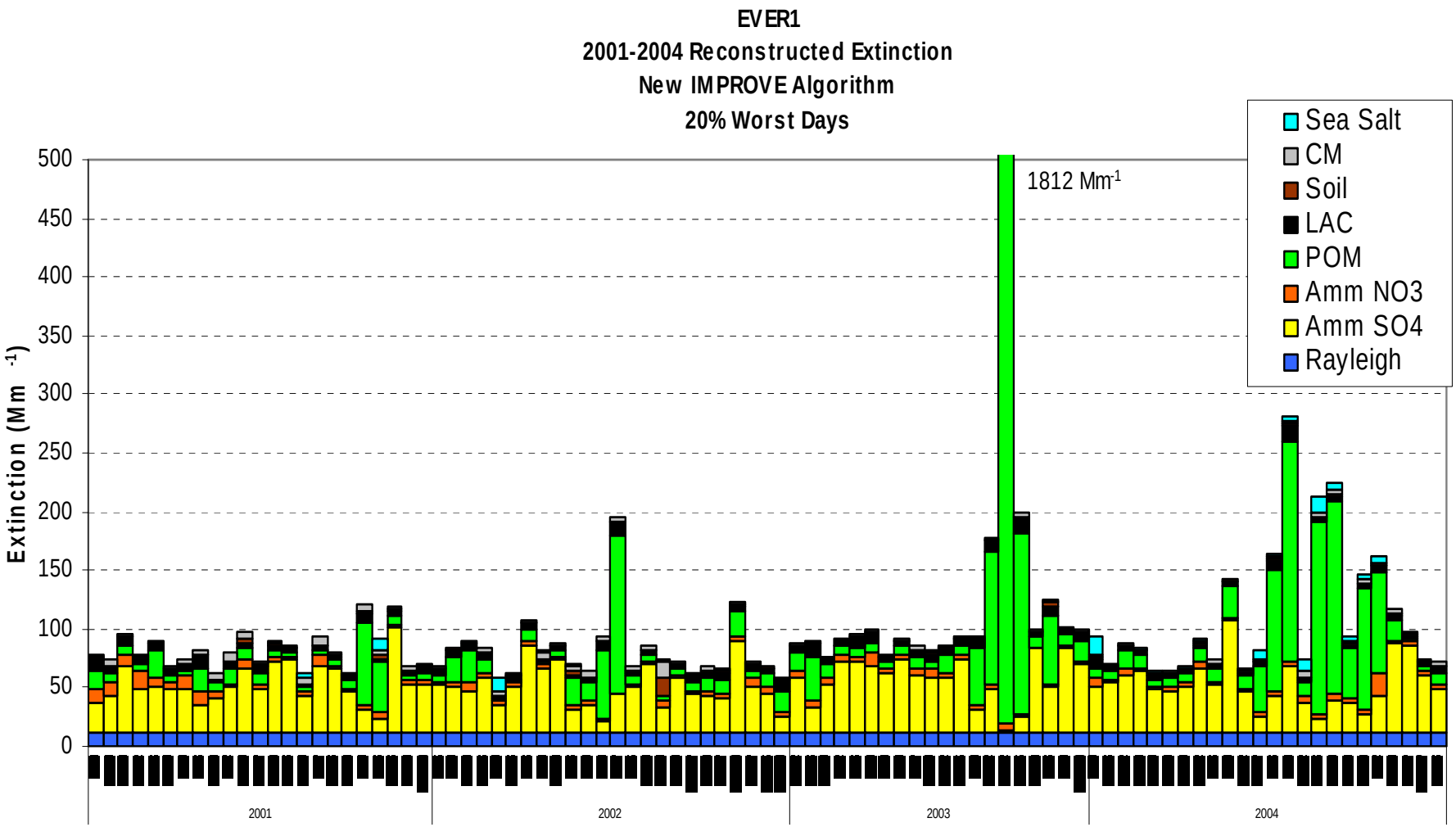
1. OKEF (4)
2. EVER
3. ROMA
4. SWAN
5. BRET
6. BRIG

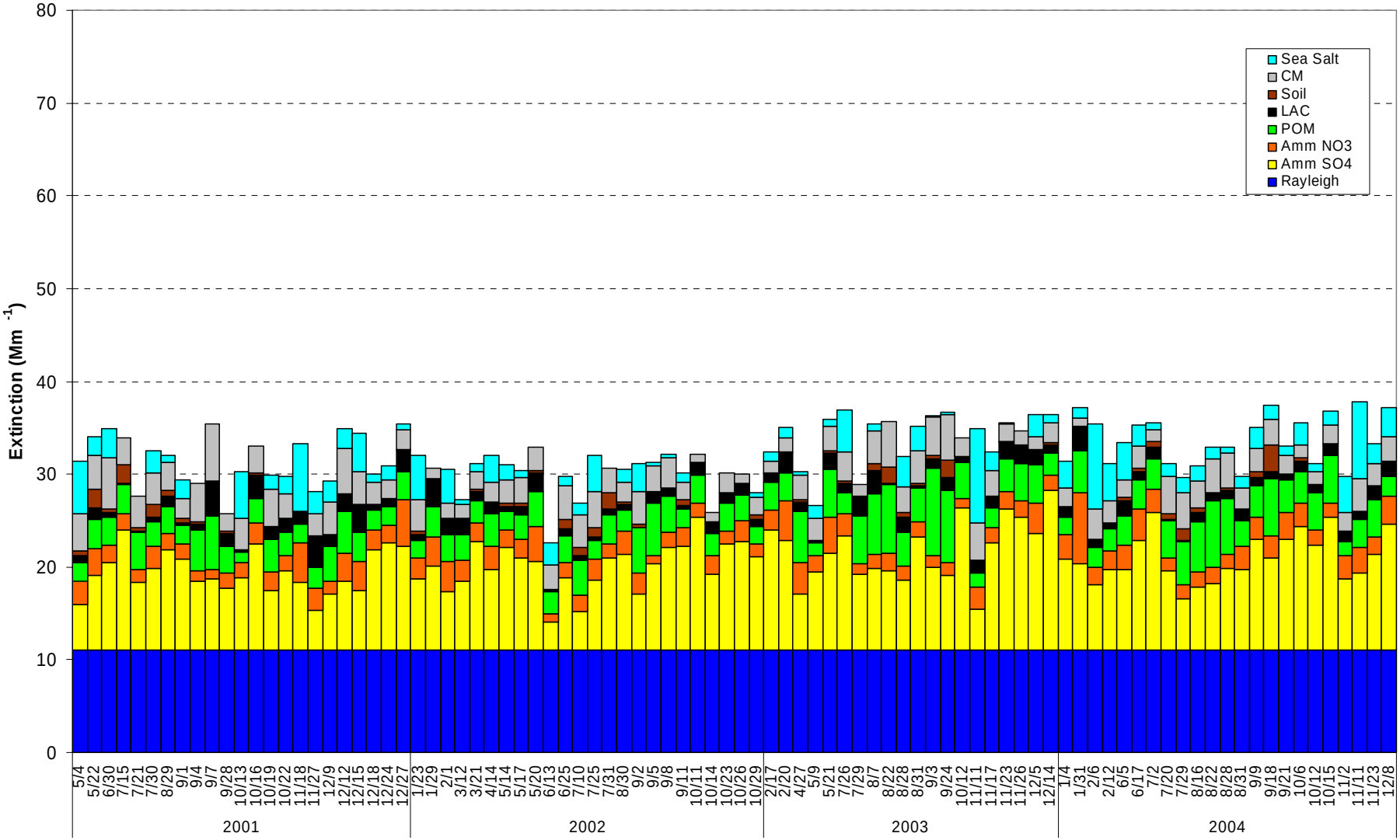
Objectives

- 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
Extinction (Mm -1)
300
250
200
150
100
50
0
SWAN1
ROMA1
OKEF1
EVER1
CHAS1
SAMA1
DOSO1
SHEN1
JARI1
LIGO1
SHRO1
GRSM1
COHU1
SIPS1
MACA1
BRIG1
BRET1
MING1
HEGL1
UPBU1
CACR1
VISTAS coastal
VISTAS inland
non-VISTAS
Sea Salt
CM
Soil
EC
POM
Amm NO3
Amm SO4
Rayleigh


Average Extinction for 20% Best Days
New IMPROVE Algorithm (nia)
2000-2004
Extinction (Mm -1)
60
50
40
30
20
10
0
SWAN1
ROMA1
OKEF1
EVER1
CHAS1
SAMA1
DOSO1
SHEN1
JARI1
LIGO1
SHRO1
GRSM1
COHU1
SIPS1
MACA1
BRIG1
BRET1
MING1
HEGL1
UPBU1
CACR1
VISTAS coastal
VISTAS inland
non-VISTAS
Sea Salt
CM
Soil
EC
POM
Amm NO3
Amm SO4
Rayleigh


EVER1
2001-2004 Reconstructed Extinction
New IMPROVE Algorithm
20% Worst Days
Sea Salt
CM
Soil
LAC
POM
Amm NO3
Amm SO4
Rayleigh
1812 Mm-1
Extinction (Mm -1)
500
450
400
350
300
250
200
150
100
50
0
2001
2002
2003
2004


EVER1
2001-2004 Reconstructed Extinction
New IMPROVE Algorithm
20% Best Days
Extinction (Mm -1)
0
10
20
30
40
50
60
70
80
Sea Salt
CM
Soil
LAC
POM
Amm NO3
Amm SO4
Rayleigh
2001
2002
2003
2004

Conclusions: Contributions

- On 20% Worst Days
  - SO4 dominates light extinction most days
  - Organic carbon dominates some days; fire indicated
  - NO3 contribution comparatively small
- 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

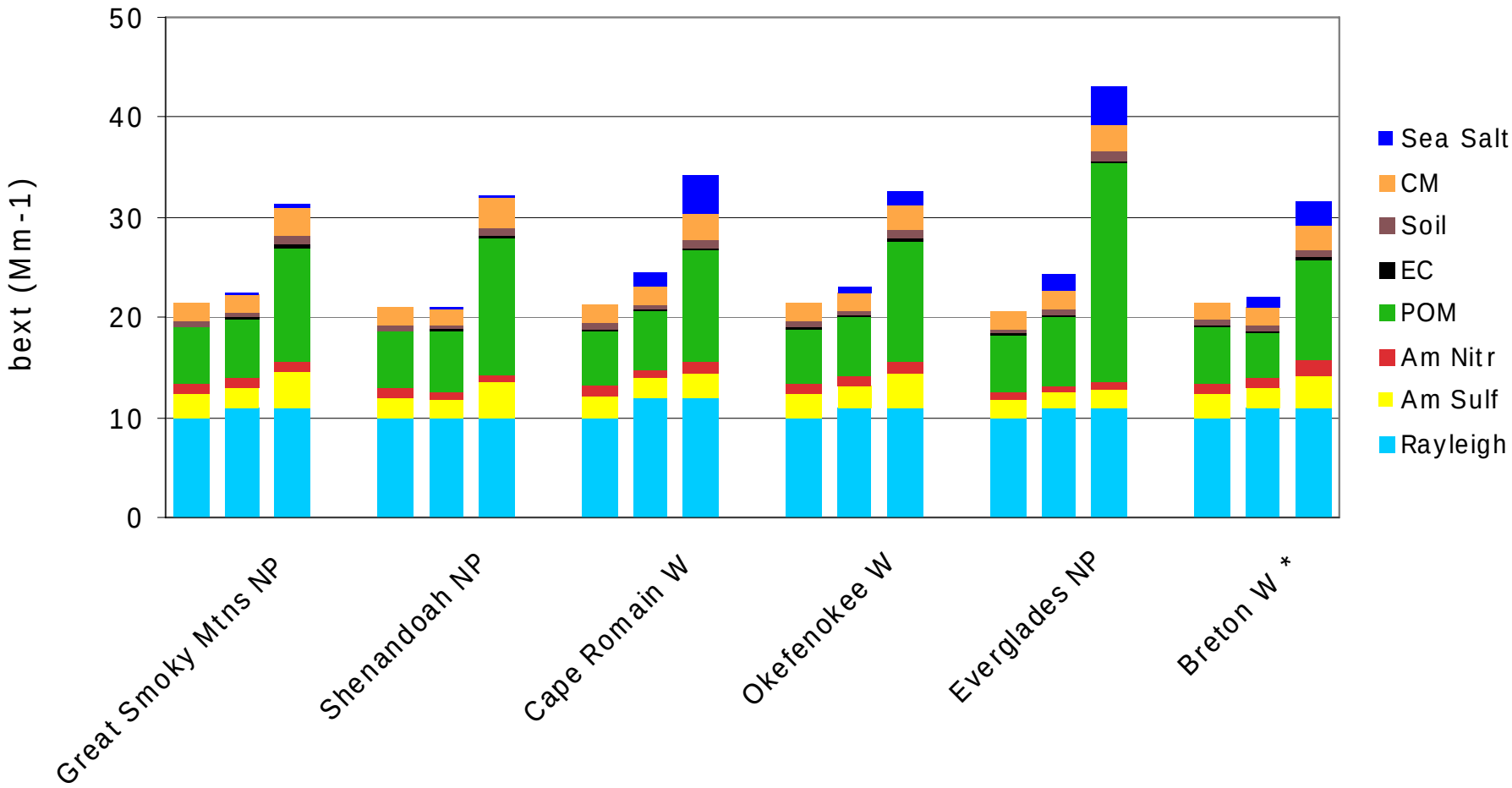
- Light scattering measured by nephelometer and calculated using new IMPEOVE equation show good correlation
  - Original equation under estimated scattering on highest days and over estimated scattering on lowest days
- New equation generally indicates higher extinction on 20% worst days and lower extinction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

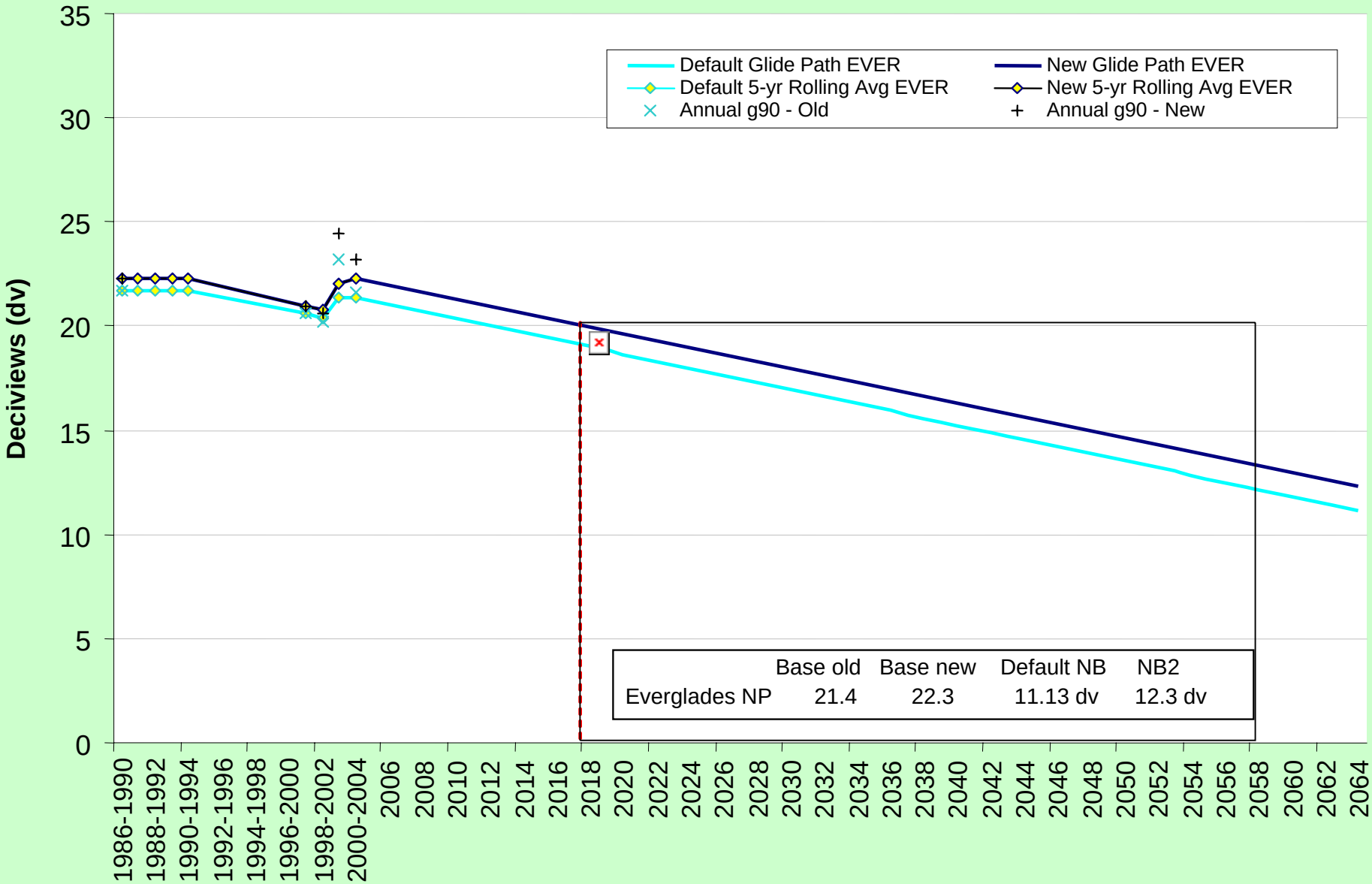
Natural Conditions

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



Everglades Glide Path to Natural Conditions (2004-2064)

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



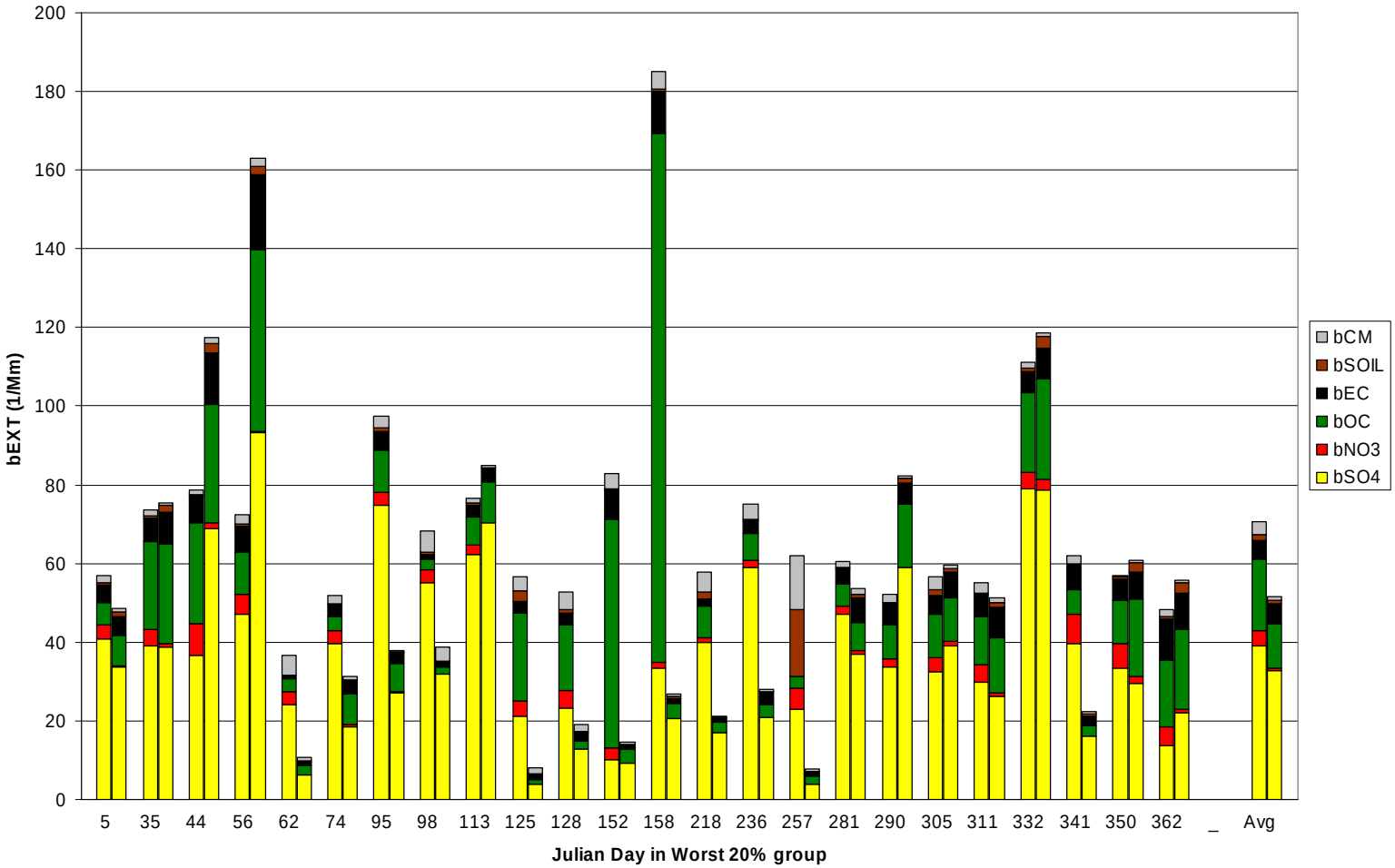
VISTAS 2018 Base G2 Visibility Projections (Delivered Mar 2007)

- 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

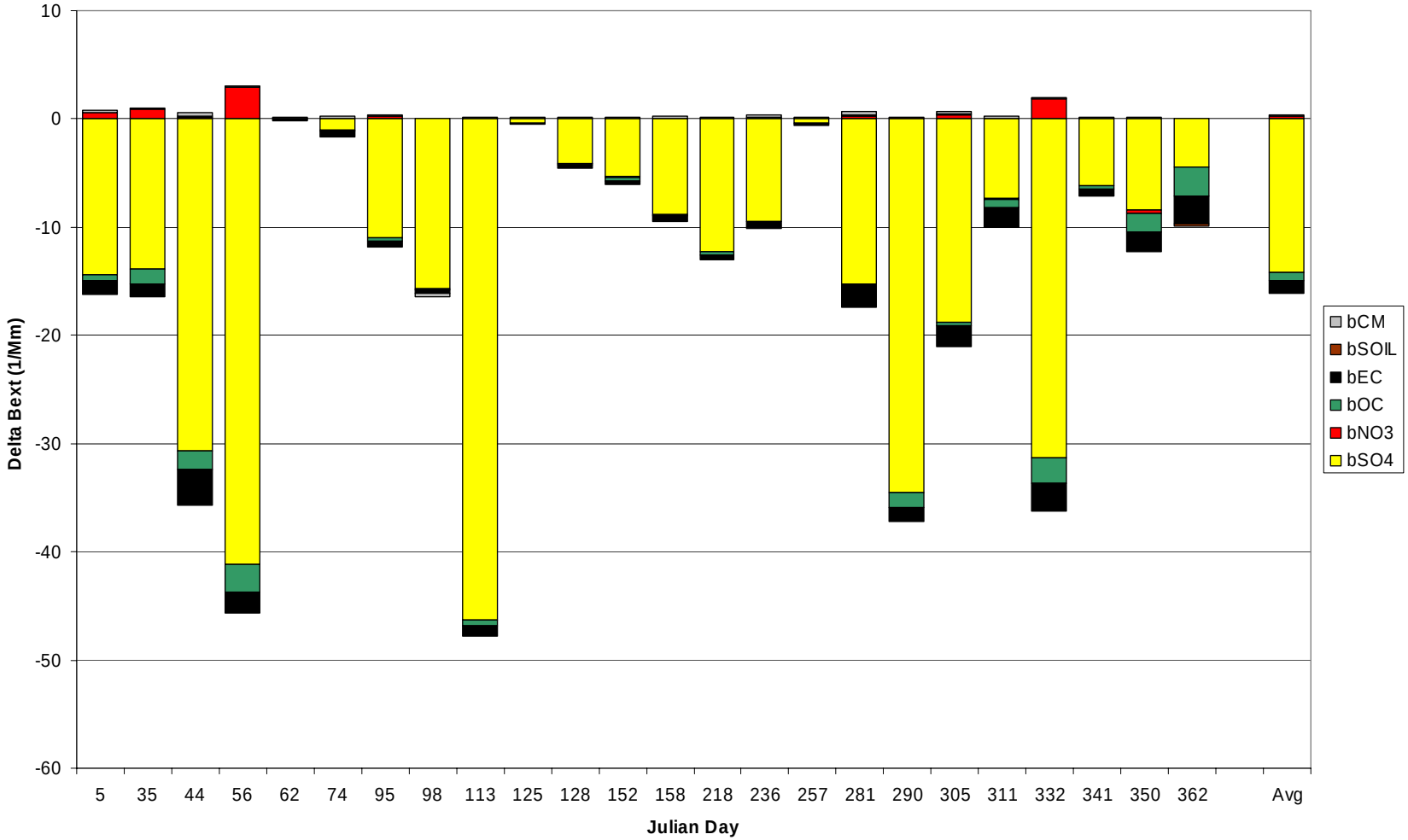
Observations (left) vs Modeled Base G2a (right)

Everglades, FL



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

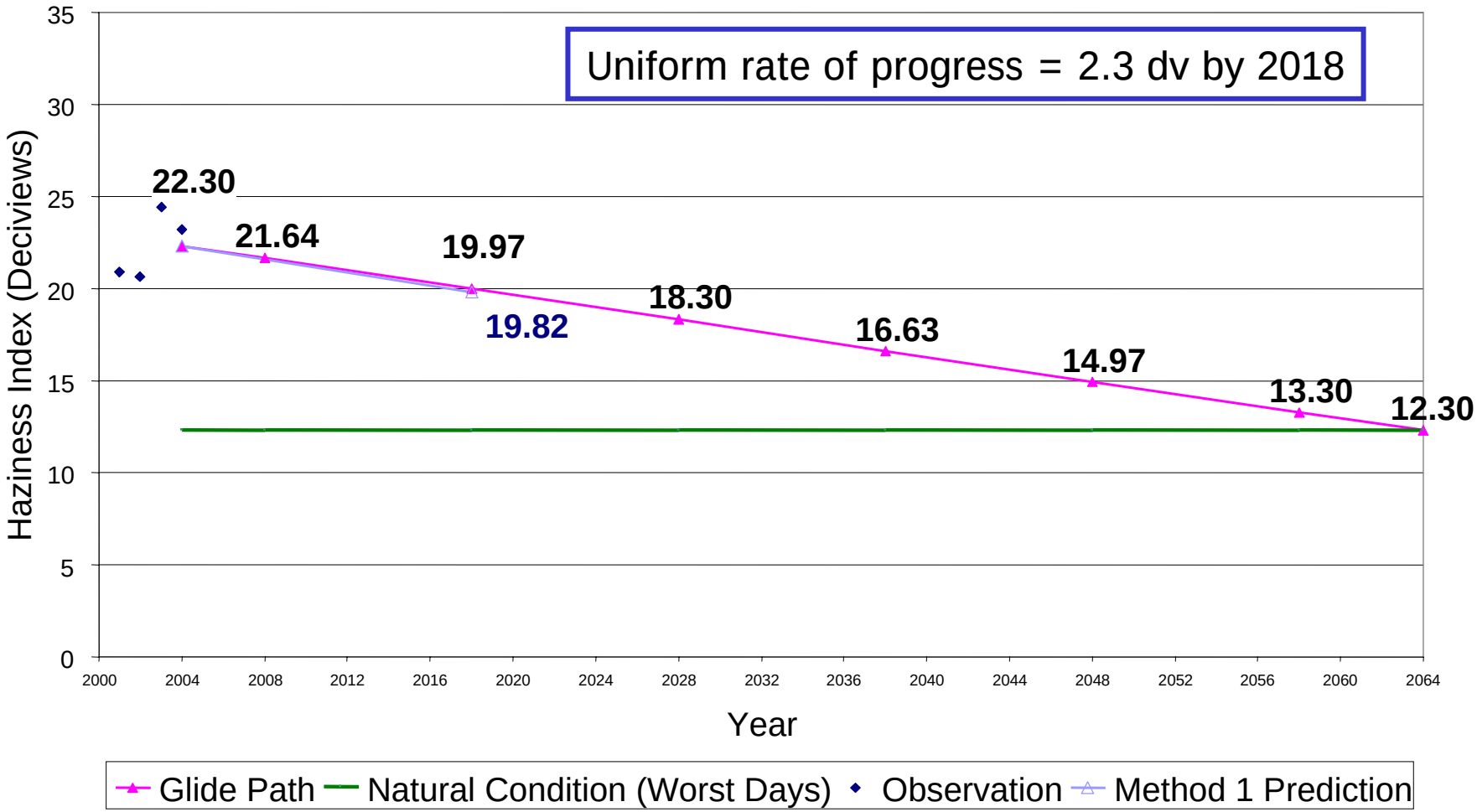
Everglades, FL



Uniform Rate of Progress Glide Path

Everglades - 20% Worst Days

New IMPROVE equation



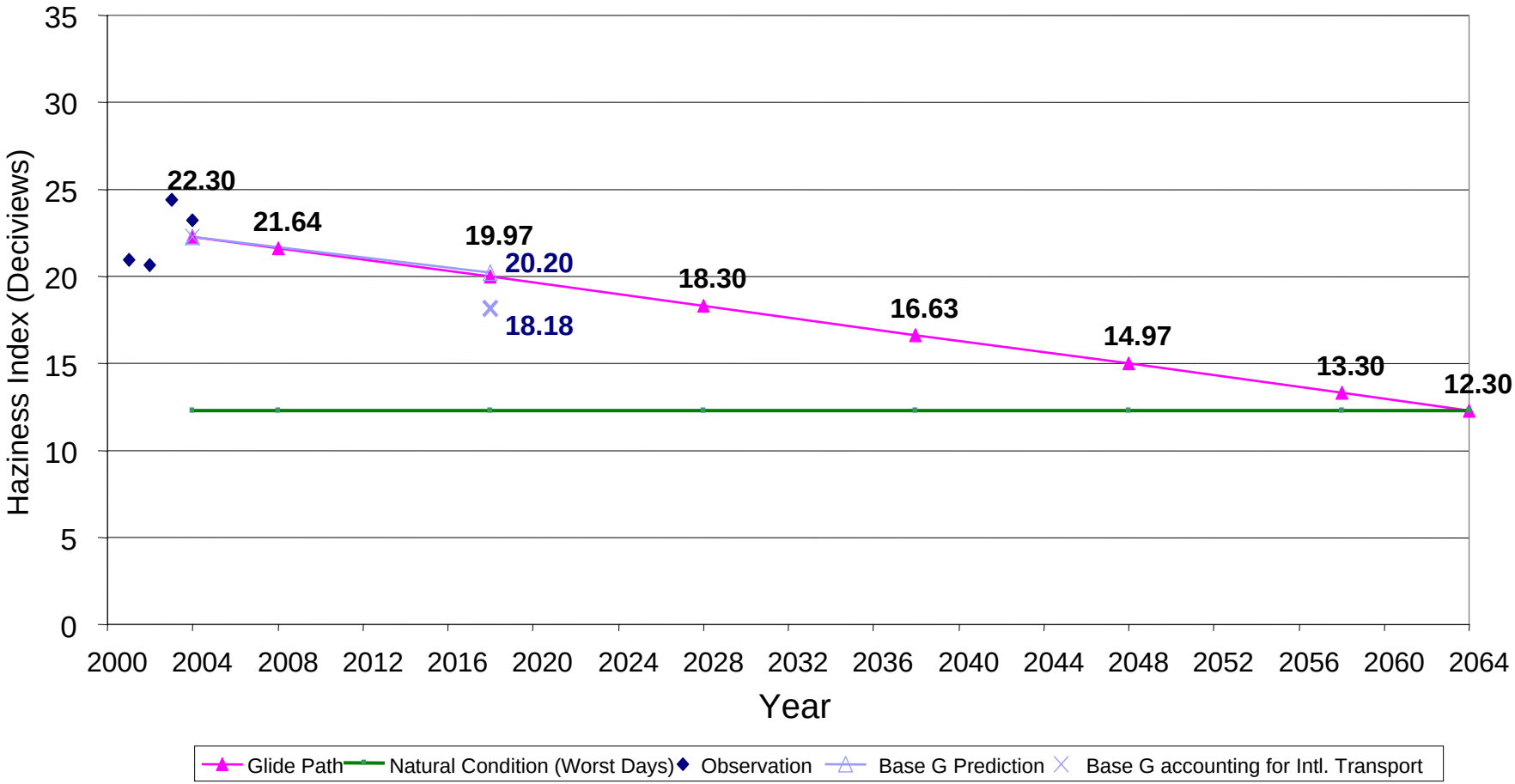
Contribution from International Emissions

- Objective: Account for contribution from international emissions in evaluating progress toward visibility improvement goals by 2018
- Approach: GEOS-CHEM global model used to define boundary conditions for CMAQ 36-km modeling for continental US
  - Zero out Boundary Conditions, Mexican, and Canadian emissions from VISTAS 2018 CMAQ run

Uniform Rate of Progress Glide Path (Base G2 projections)

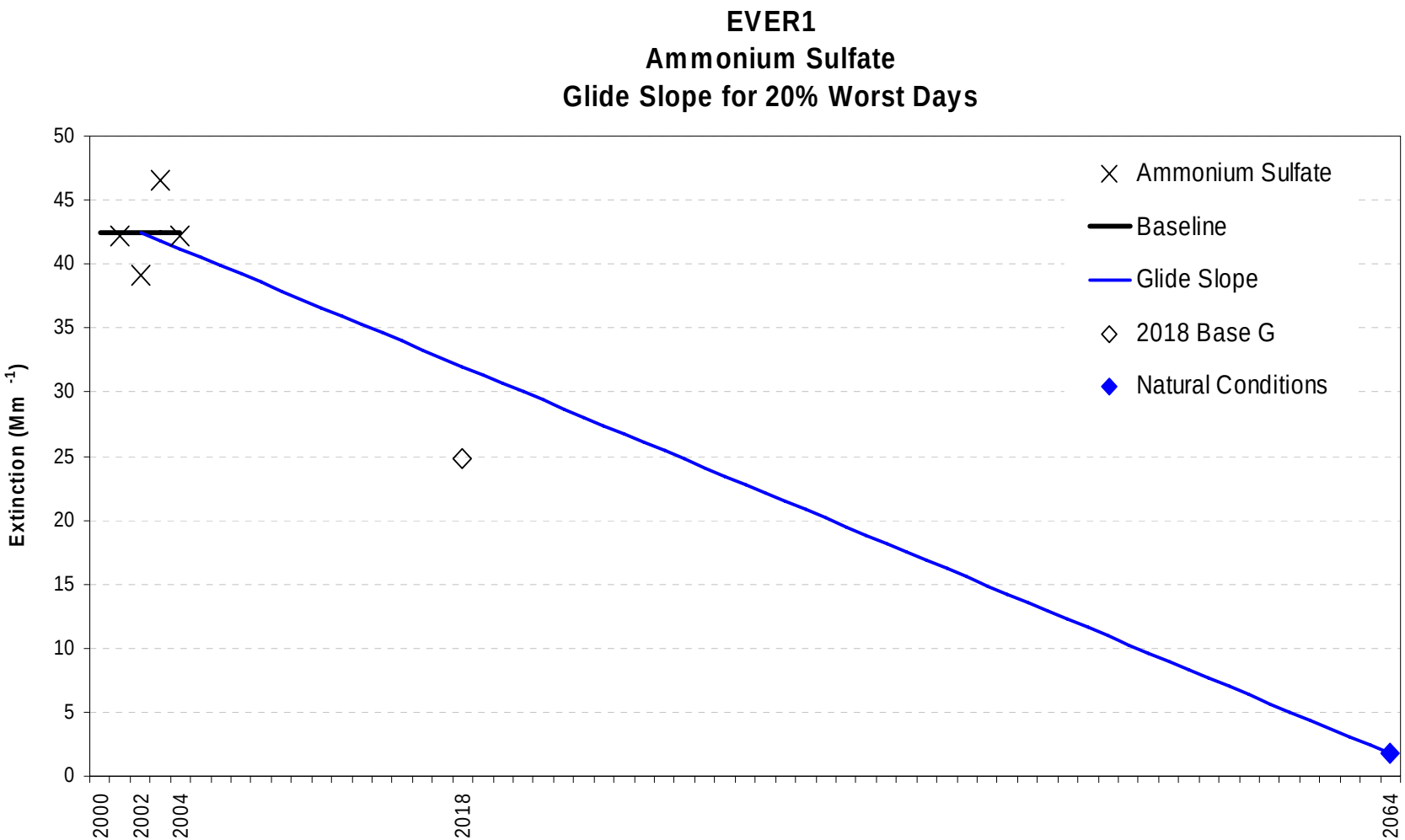
Everglades, FL - 20% Worst Days New IMPROVE equation

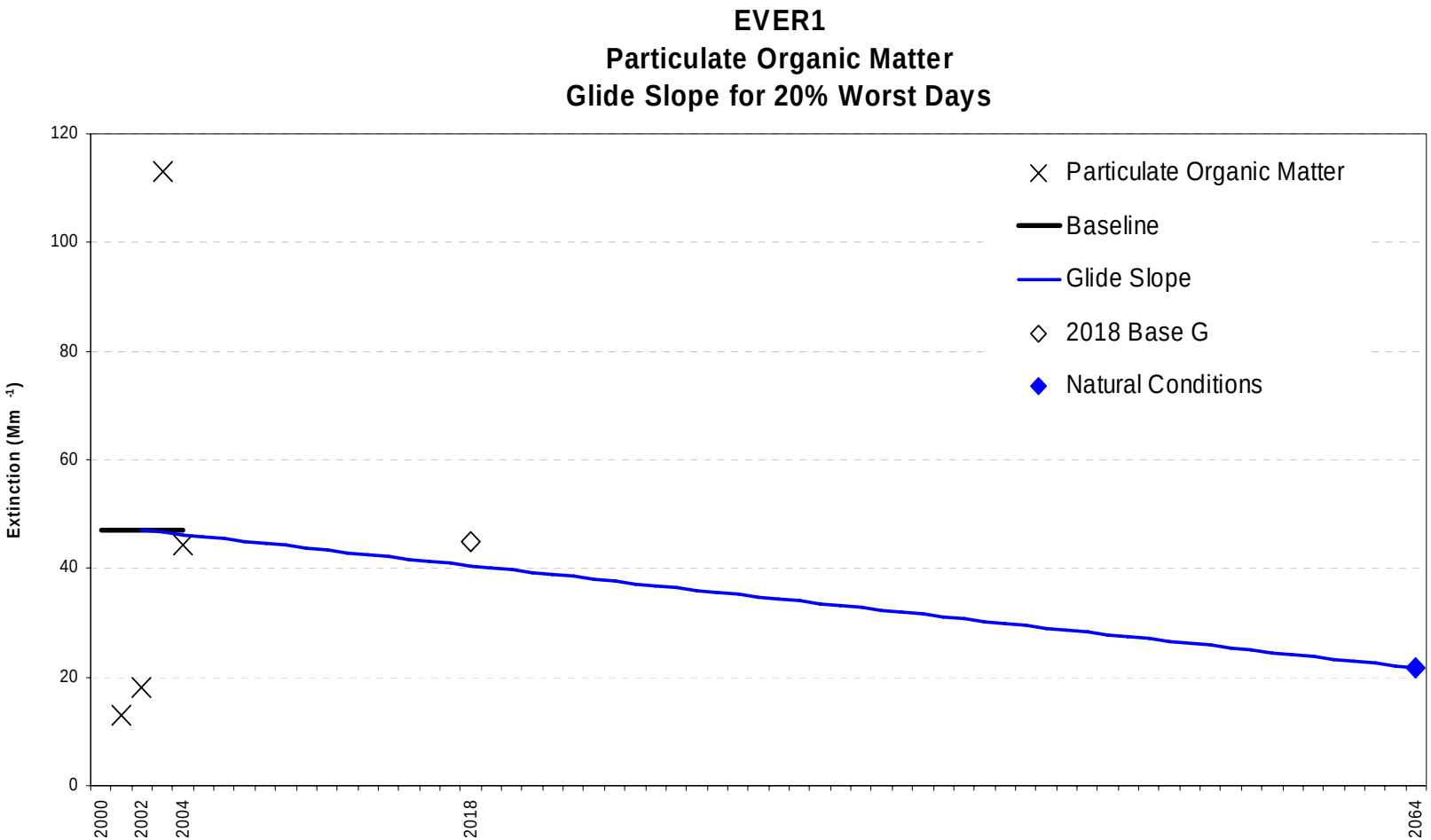
Accounting for International Transport

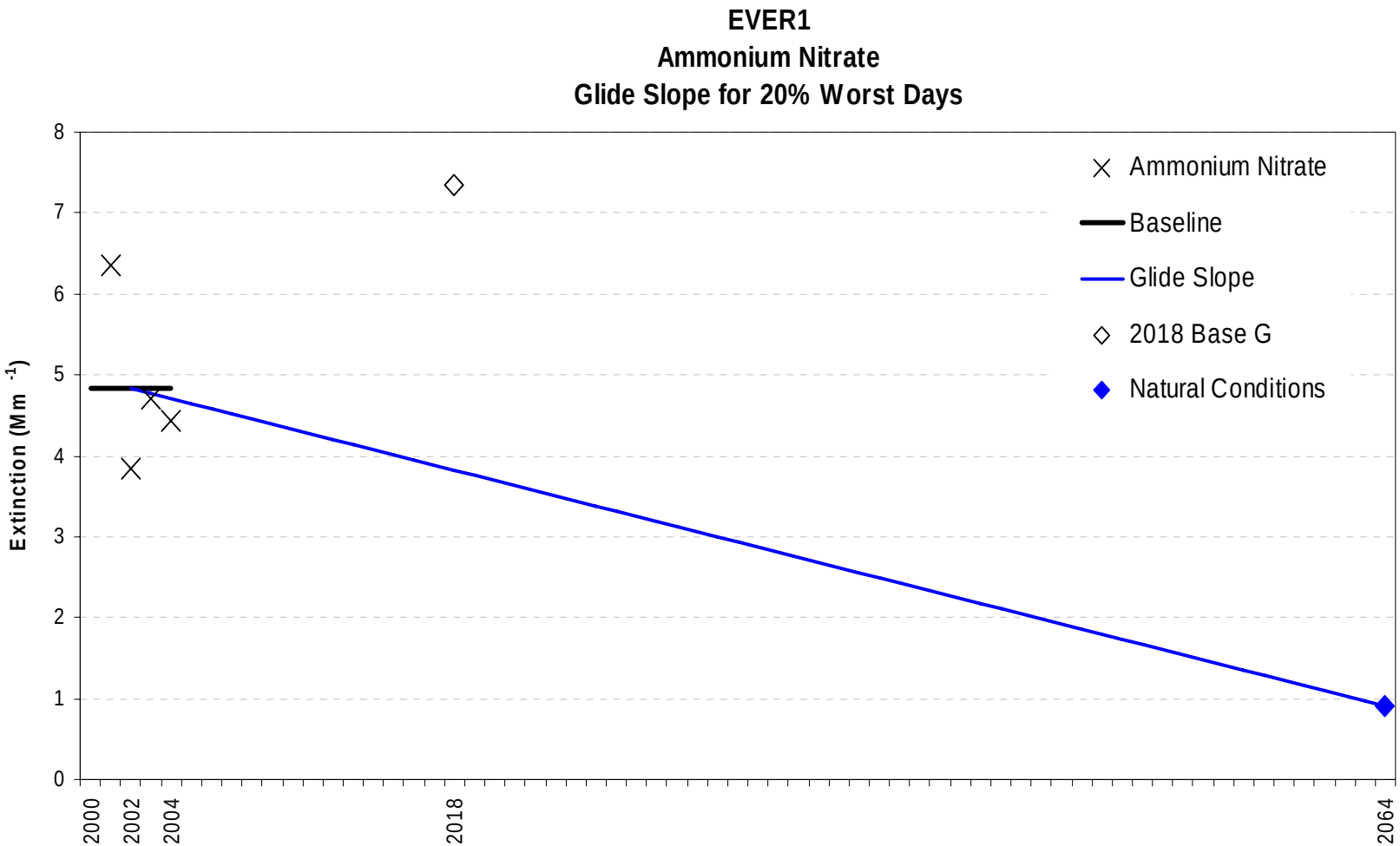


Species Contributions to Rate of Visibility Improvement

- Examine rate of visibility improvement for each major component of PM2.5
  - Calculate natural background value for each component for 20% worst days and draw glidepath from current to natural conditions
  - Compare species glidepath to rate of improvement in 2018
- Consider as part of weight-of-evidence analysis


EVER1
Ammonium Sulfate
Glide Slope for 20% Worst Days
Extinction (Mm -1)
50
45
40
35
30
25
20
15
10
5
0
2000
2002
2004
2018
2064
Ammonium Sulfate
Baseline
Glide Slope
2018 Base G
Natural Conditions


EVER1
Particulate Organic Matter
Glide Slope for 20% Worst Days
Extinction (Mm -1)
120
100
80
60
40
20
0
2000
2002
2004
2018
2064
Particulate Organic Matter
Baseline
Glide Slope
2018 Base G
Natural Conditions


EVER1
Ammonium Nitrate
Glide Slope for 20% Worst Days
Extinction (Mm -1)
0
1
2
3
4
5
6
7
8
2000
2002
2004
2018
2064
Ammonium Nitrate
Baseline
Glide Slope
2018 Base G
Natural Conditions

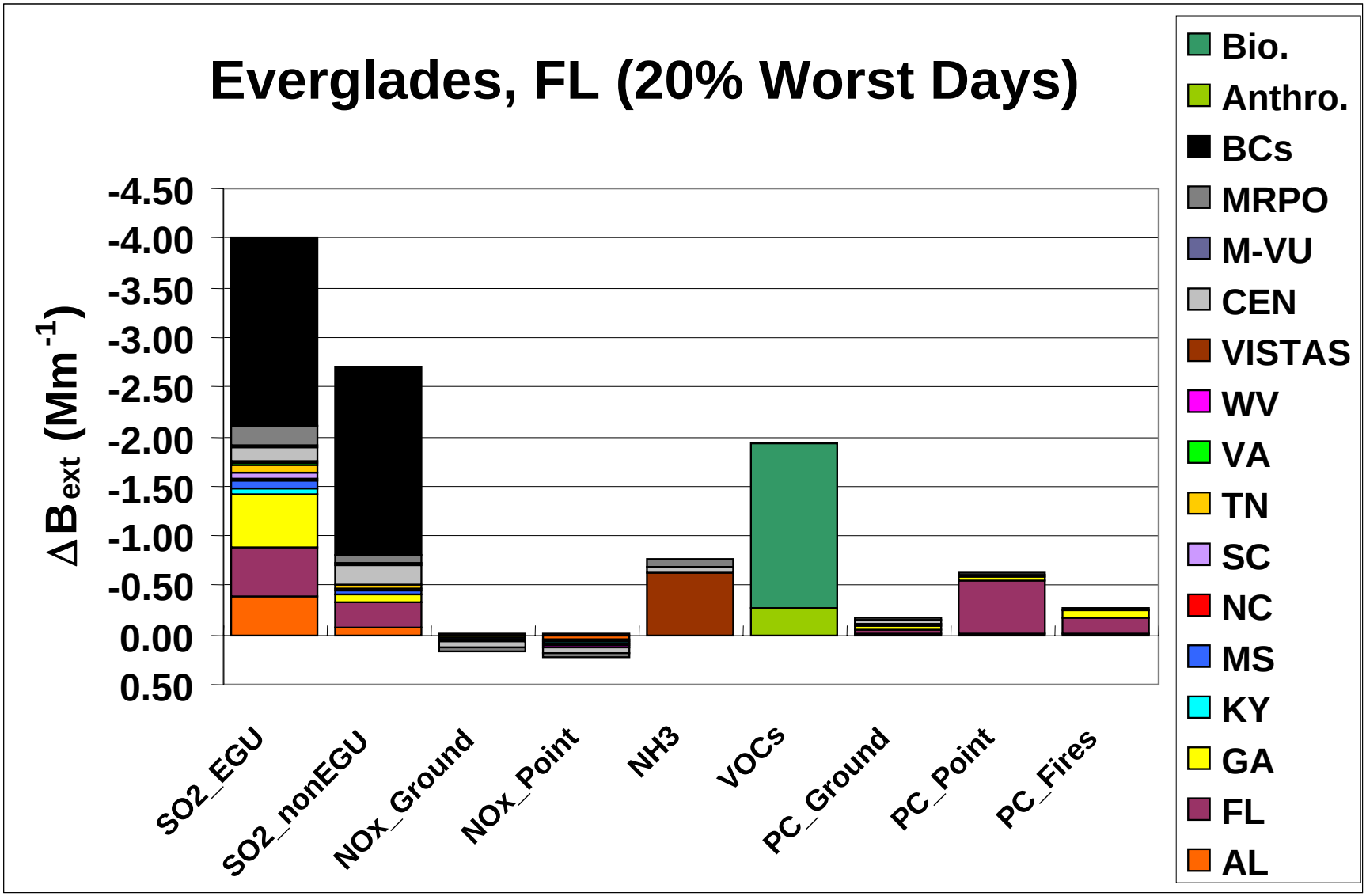
Conclusion: Species Rate of Improvement

- SO4 improvement for 20% worst days better than uniform rate of progress for SO4
- Particulate Organic Matter (POM) reflects fire influence and highly variable in 2000-2004.
  - For EVER, POM contribution for average 20% worst days in 2000-2004 is larger than SO4 contribution
  - POM in 2018 little changed from 2000-2004 average
- NO3 small contribution compared to SO4 and POM
  - NO3 not meet uniform rate of progress

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

Responses to 30% reductions in 2009 emissions



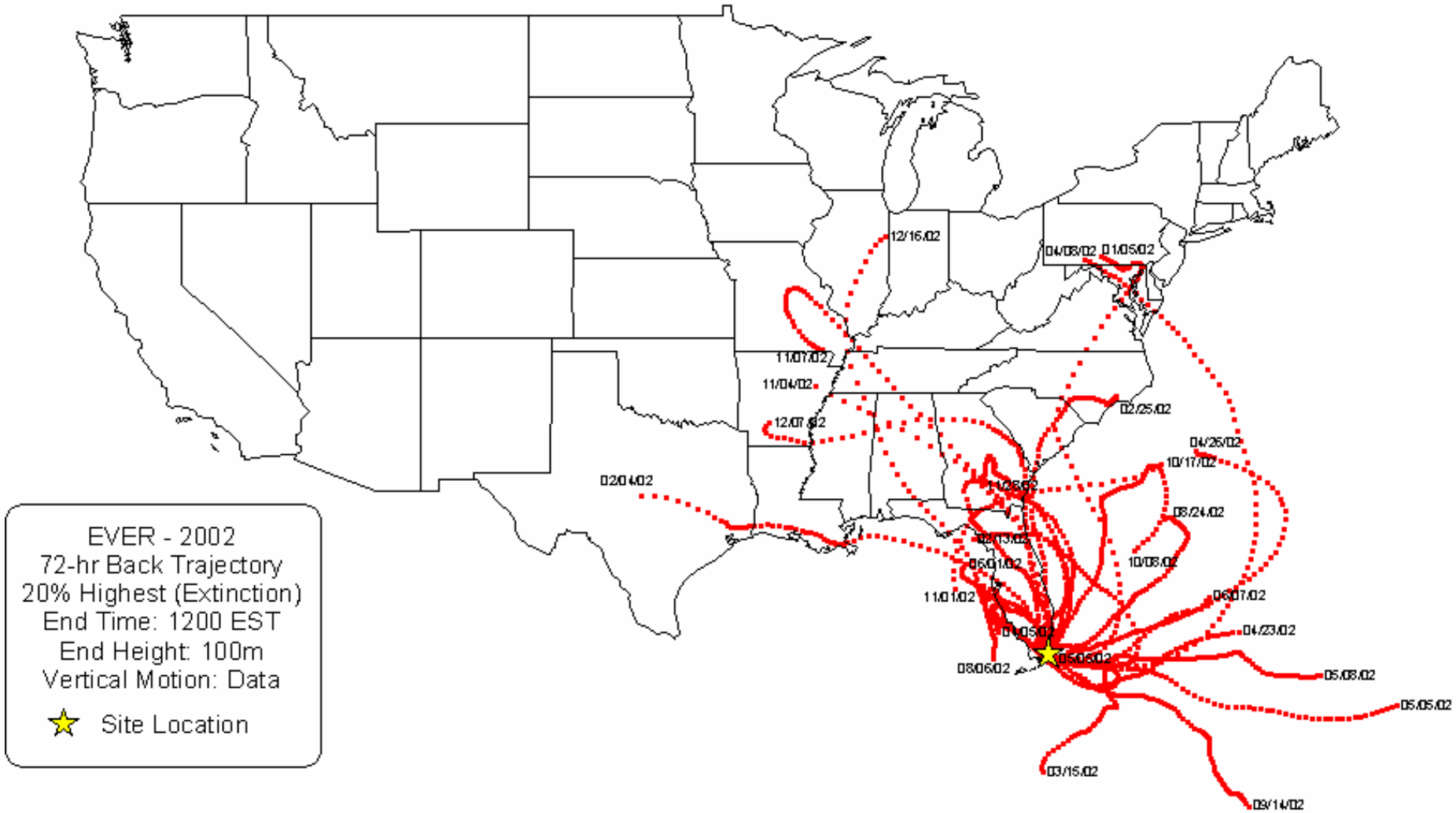
Conclusion: Emissions Sensitivities

- SO2 emissions from EGU and non-EGU are most important contributors to visibility impairment
- SO2 from Boundary Conditions has large contribution to conditions at EVER

VISTAS Geographic Areas of Influence (Delivered 2005)

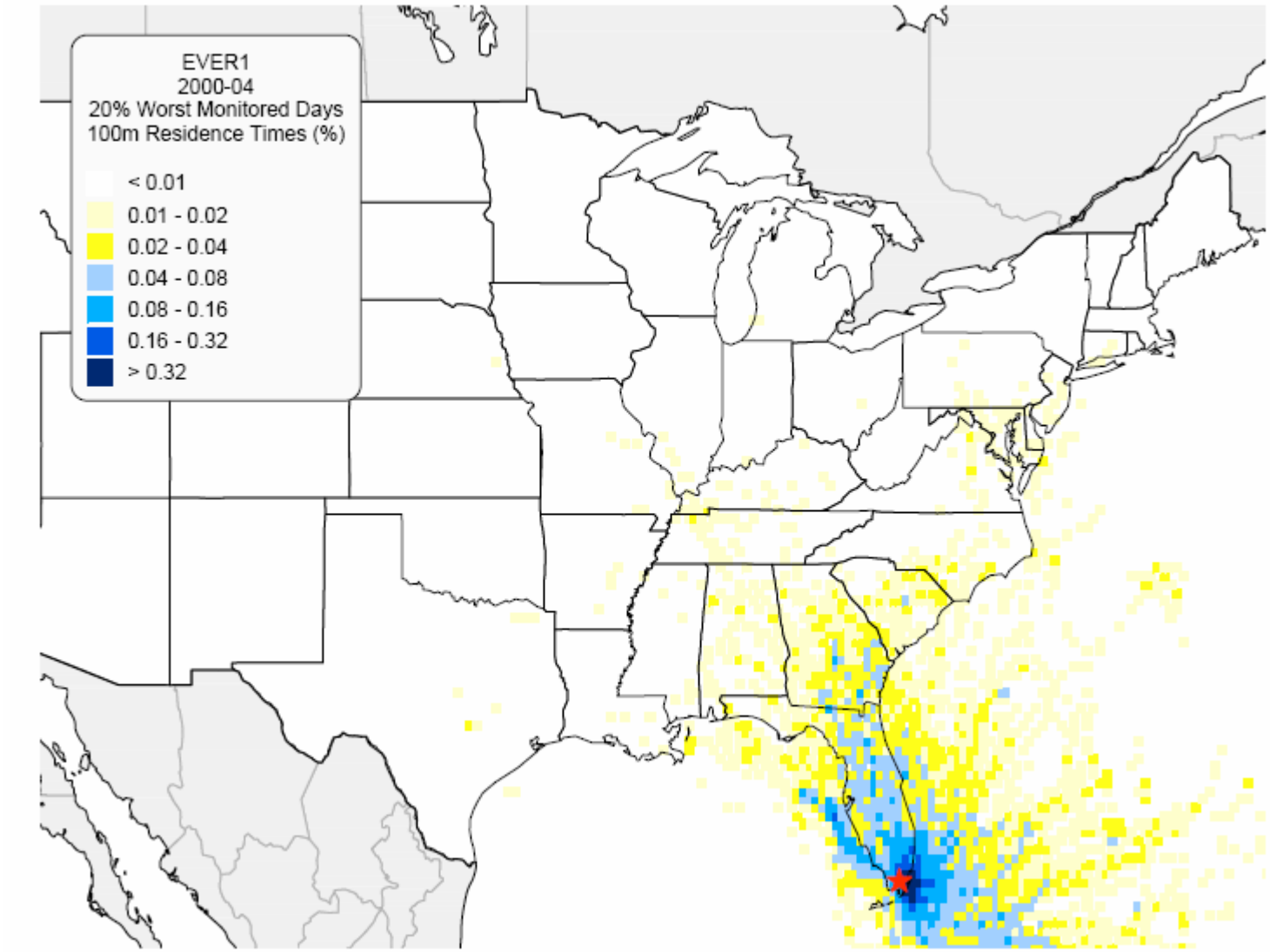
- Hysplit model used to generate back trajectories for Class I areas (Air Resource Specialists)
  - Back trajectories for individual 20% worst days in 2002
    - Helpful for evaluating model performance in 2002
  - Residence time plots for all days and 20% worst days indicate probability of contribution
    - Helpful to understand geographic area most likely to influence Class I areas

Back Trajectories for 20% Worst Visibility Days in 2002 - Everglades

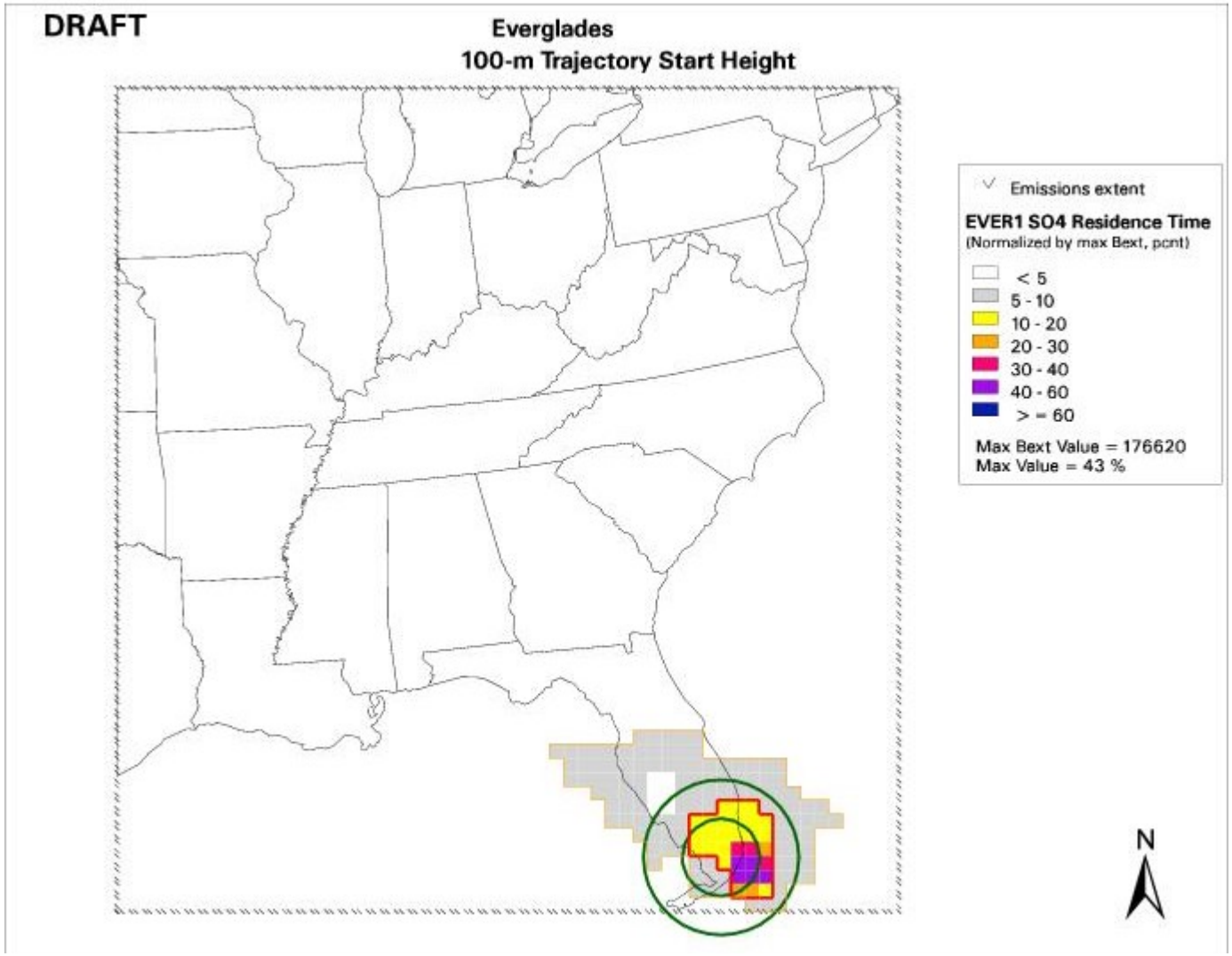


Residence Time for 20% Worst Days in 2000-2004

Everglades, FL

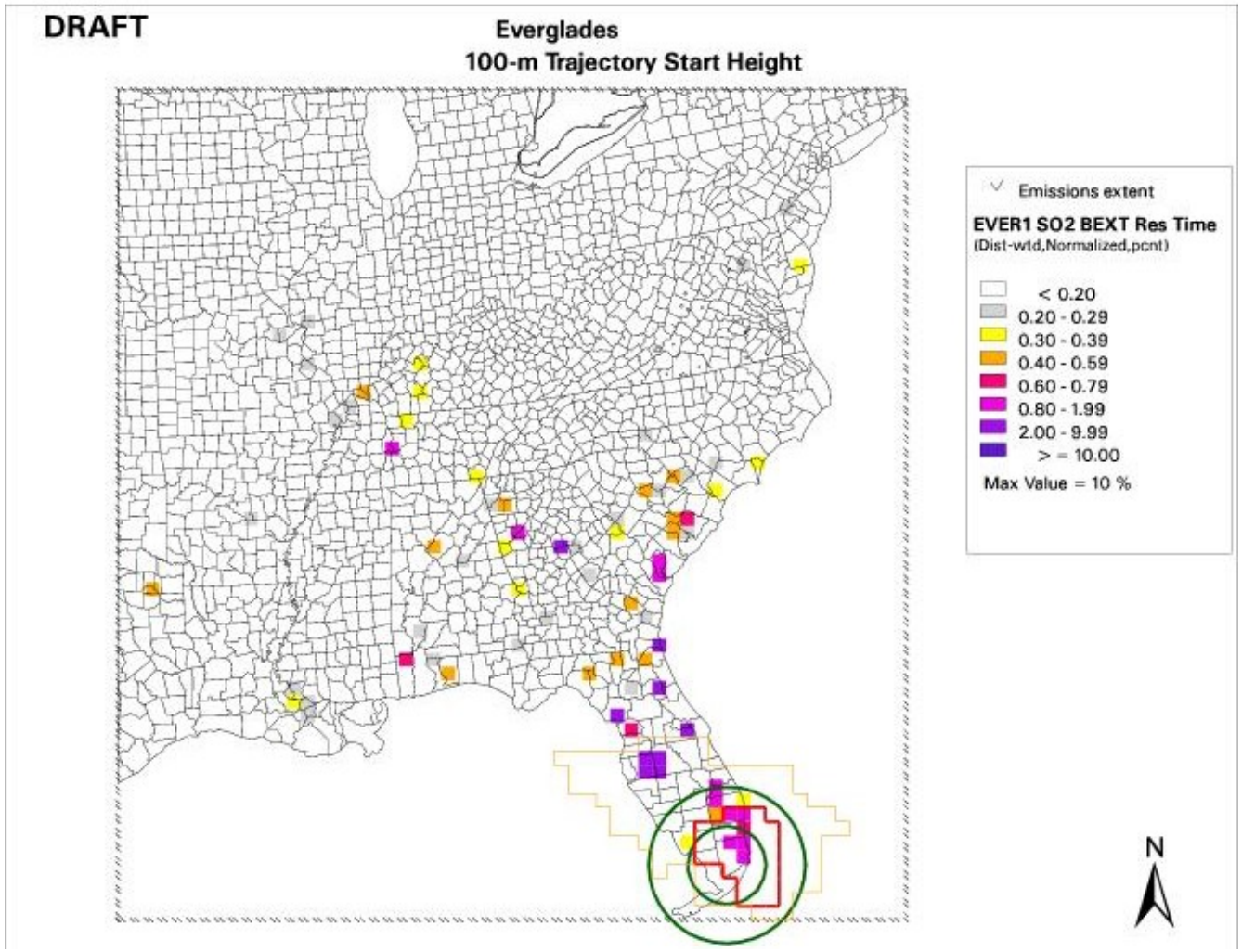


SO2 Area of Influence for Everglades, FL



Green circles indicate 100-km and 200-km radii from Class I area.
Red line perimeter indicate Area of Influence with Residence Time ≥ 10%
Orange line perimeter indicate Area of Influence with Residence Time ≥ 5%.

2018 SO2 Emissions weighted by Residence Time Everglades, FL



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

Red line perimeter indicate Area of Influence with Residence Time ≥ 10%.

Orange line perimeter indicate Area of Influence with Residence Time ≥ 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
Everglades, FL

Tier	VOC	NOX	CO	SO2	PM-10	PM-2.5	NH3
Fuel Comb. Elec. Util.	0%	15%	1%	34%	3%	5%	6%
Fuel Comb. Industrial	1%	8%	2%	11%	4%	11%	0%
Fuel Comb. Other	1%	4%	0%	9%	2%	4%	0%
Chemical & Allied Product Mfg	0%	0%	0%	36%	0%	0%	3%
Metals Processing	0%	0%	0%	1%	0%	0%	0%
Petroleum & Related Industries	0%	0%	0%	0%	0%	0%	0%
Other Industrial Processes	3%	1%	0%	1%	2%	2%	0%
Solvent Utilization	40%	0%	0%	0%	0%	0%	0%
Storage & Transport	10%	0%	0%	0%	0%	1%	0%
Waste Disposal & Recycling	1%	0%	1%	0%	2%	5%	1%
Highway Vehicles	21%	34%	41%	1%	2%	3%	37%
Off-highway	20%	34%	45%	5%	3%	9%	0%
Miscellaneous	3%	3%	10%	2%	82%	60%	52%
VISTAS Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

Annual 2018 BaseG2 Emissions (%) Within Area of Influence
Everglades, FL

Tier	SO2
Fuel Comb. Elec. Util.-Coal	32%
Fuel Comb. Elec. Util.-Oil	0%
Fuel Comb. Elec. Util.-Gas	0%
Fuel Comb. Elec. Util.-Other	1%
Fuel Comb. Elec. Util.-Internal Combustion	0%
Fuel Comb. Industrial-Coal	3%
Fuel Comb. Industrial-Oil	6%
Fuel Comb. Industrial-Gas	0%
Fuel Comb. Industrial-Other	1%
Fuel Comb. Industrial-Internal Combustion	0%
Chemical & Allied Product Mfg-Organic Chemical Mfg	0%
Chemical & Allied Product Mfg-Inorganic Chemical Mfg	36%
Chemical & Allied Product Mfg-Polymer & Resin Mfg	0%
Chemical & Allied Product Mfg-Agricultural Chemical Mfg	0%
Chemical & Allied Product Mfg-Paint, Varnish, Lacquer, Enamel Mfg	0%
Chemical & Allied Product Mfg-Pharmaceutical Mfg	0%
Chemical & Allied Product Mfg-Other Chemical Mfg	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
      - CO_2 is released as byproduct from $CaSO_4$ formation