

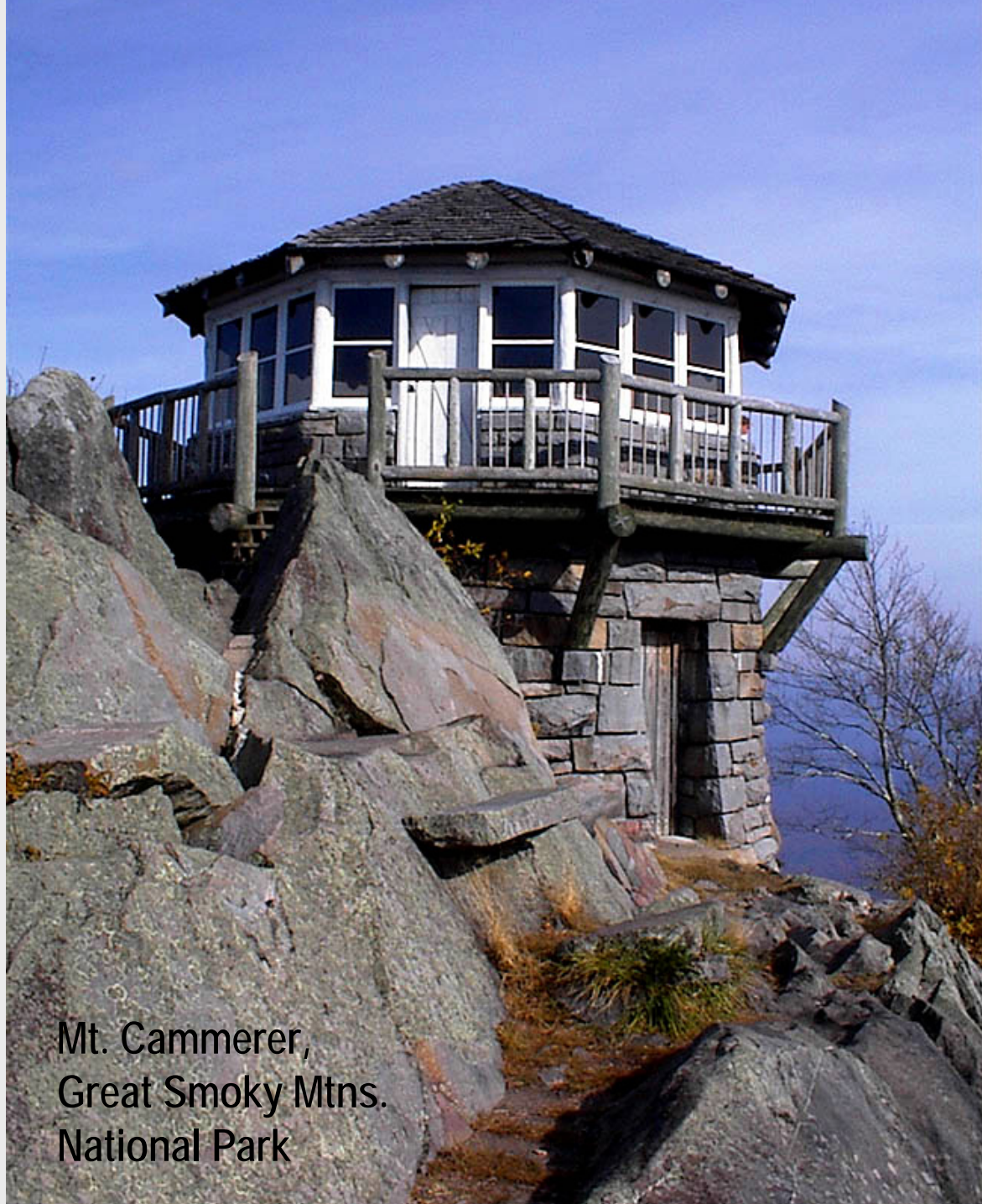


# Source Attribution for Southeastern US: Weight of Evidence

June 9, 2005

National RPO Meeting  
Denver, CO

Pat Brewer  
VISTAS



Mt. Cammerer,  
Great Smoky Mtns.  
National Park

Regional Haze Rule requires states to protect visibility in 156 "Class I" natural parks and wilderness areas.

VISTAS is evaluating visibility and sources of fine particle mass in the Southeastern US

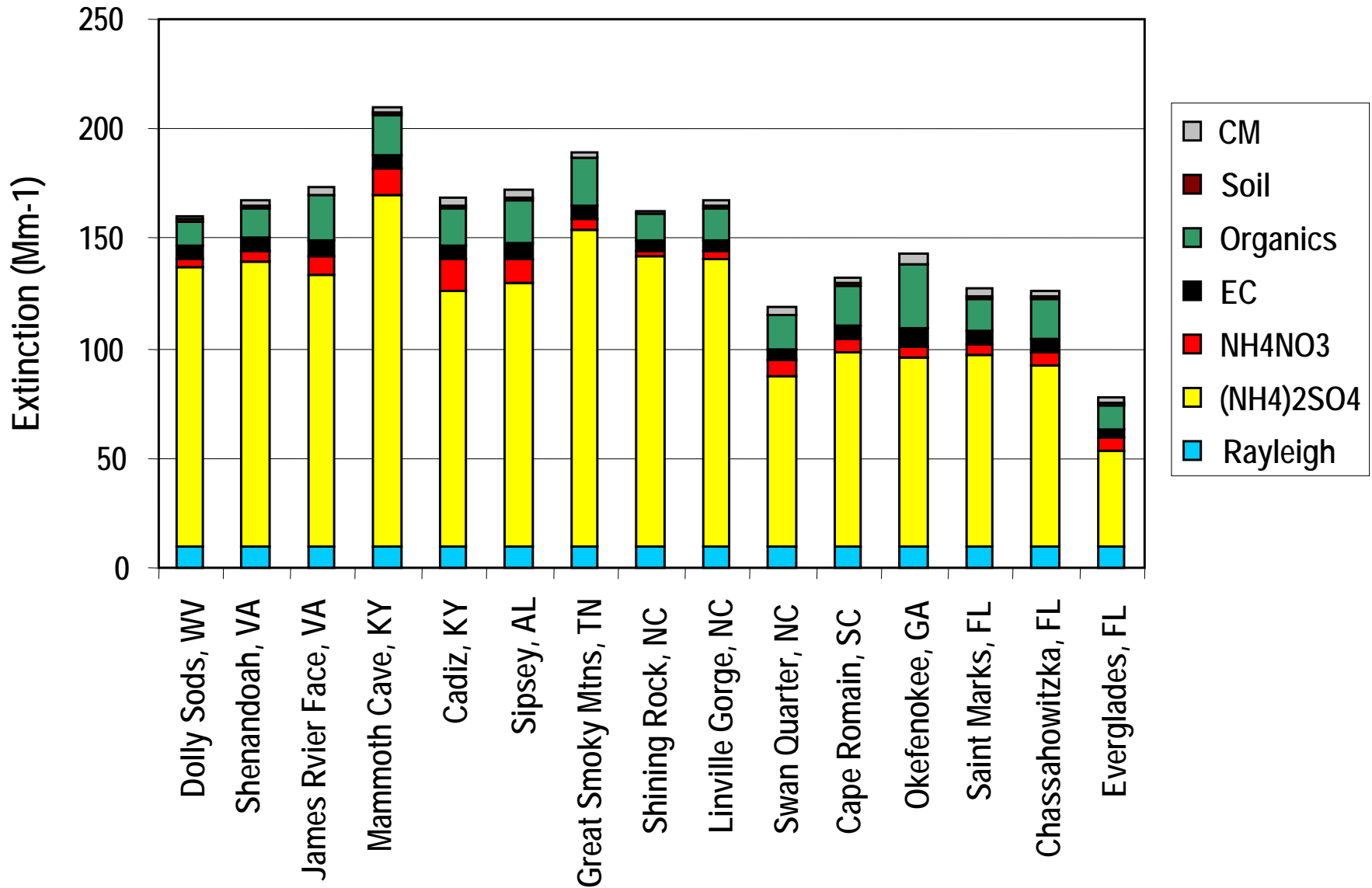


# Weight of Evidence

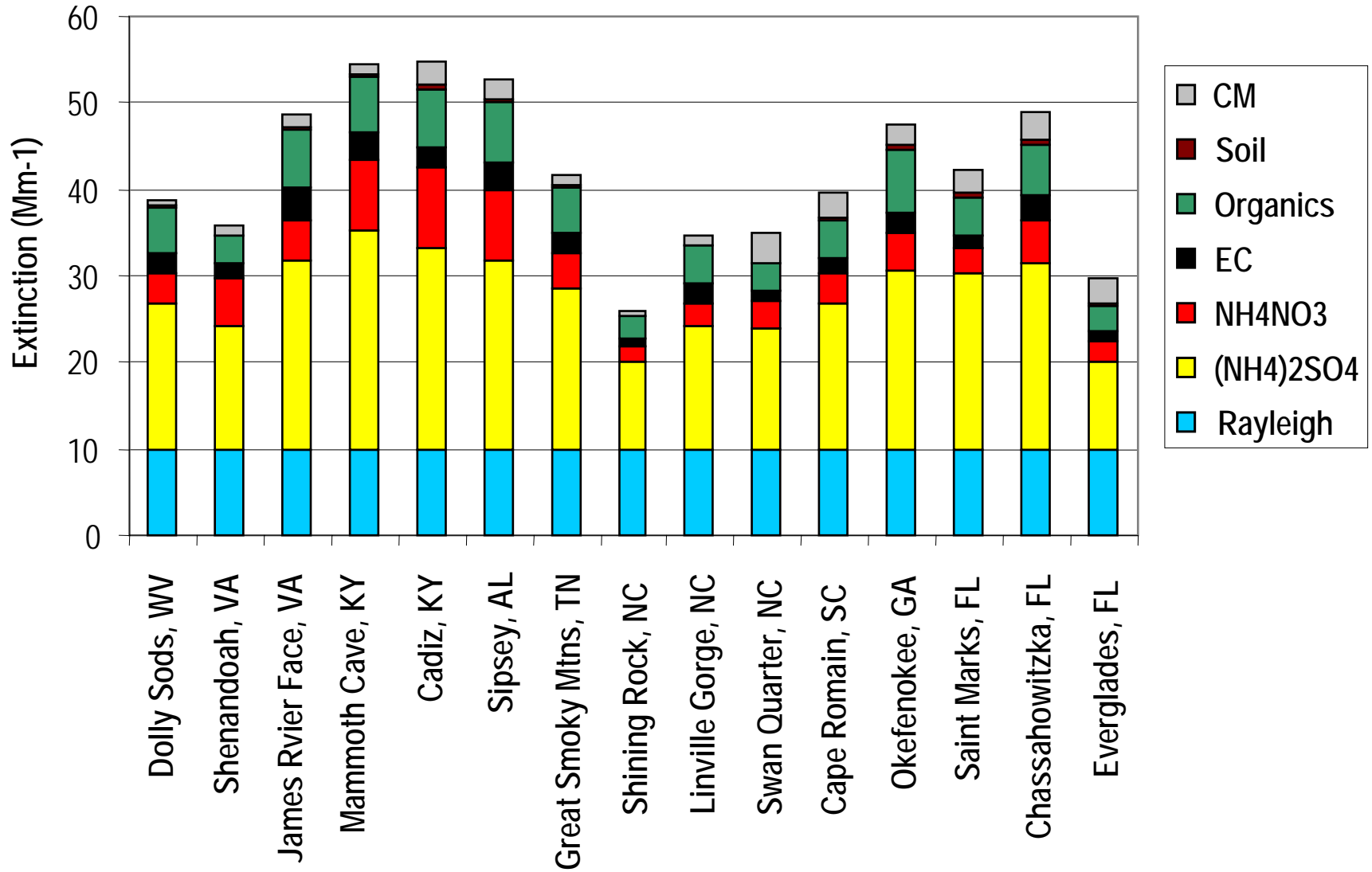
- Monitoring Trends
- SAMI Modeling Results for 2010
- Emissions Sensitivities using 2018 initial inventory for July 2001 and Jan 2002 episodes
- Back Trajectory and Residence Time Analyses
- Meteorological Classification – CART analyses
- Receptor Modeling (MRPO-MARAMA 2003)
- Regional Air Quality Modeling (CMAQ, CAMx, REMSAD)
- Evidence for Role of Fire



# Light Extinction on 20% Hazyest Days - IMPROVE 2000 - 2002

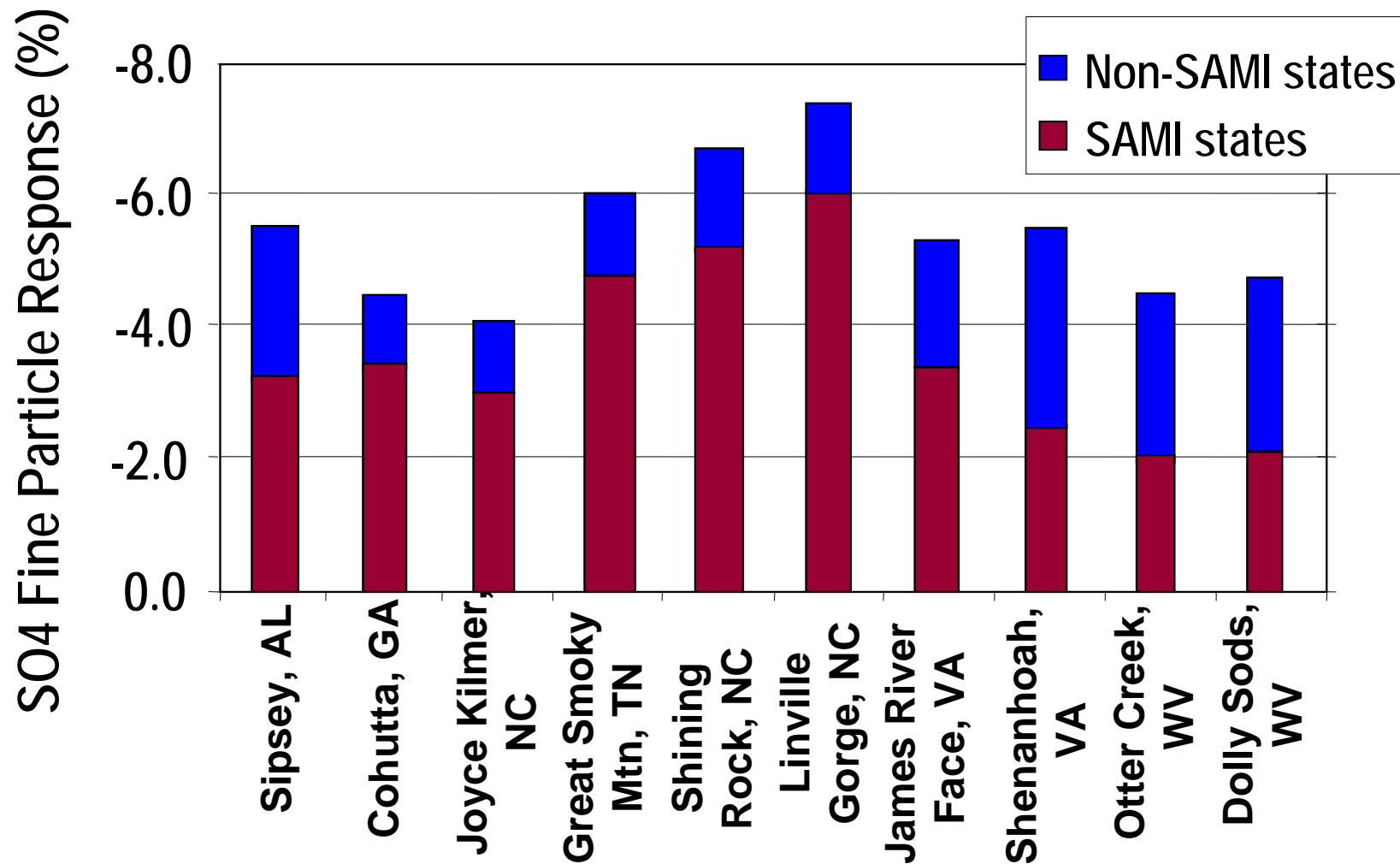


# Light Extinction on 20% Clearest Days - IMPROVE 2000 - 2002



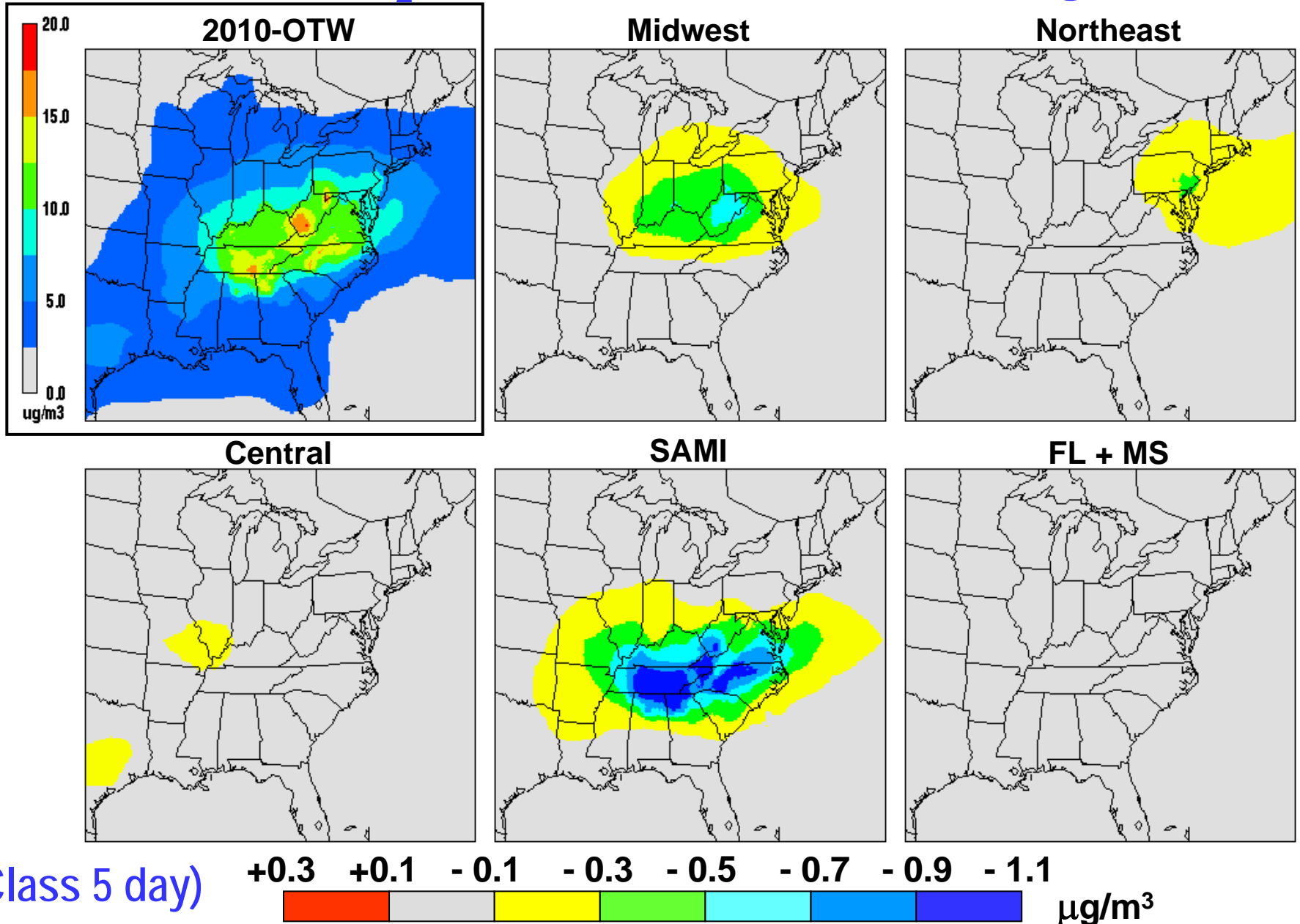
# SAMI Final Report 2002

Annual SO<sub>4</sub> Fine Particles Response to 10% Reduction in SO<sub>2</sub> Emissions from 2010 A2 strategy

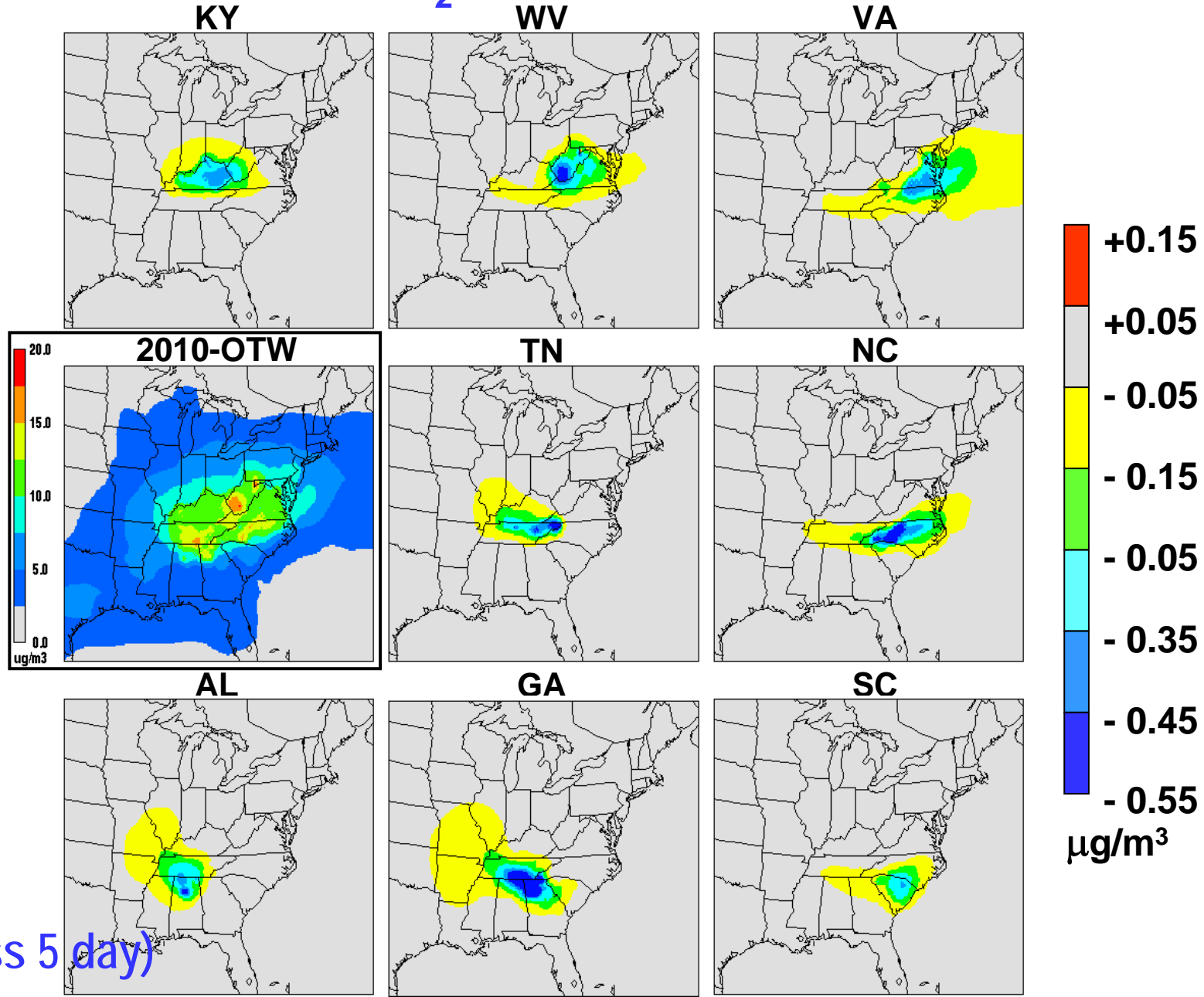


used Urban-Regional Multiscale (URM) Model and 9 episodes 1991-1995

# SO<sub>4</sub> & its Change on July 15, 1995 for a 10% Reduction of 2010-A2 SO<sub>2</sub> Emissions from Different Regions

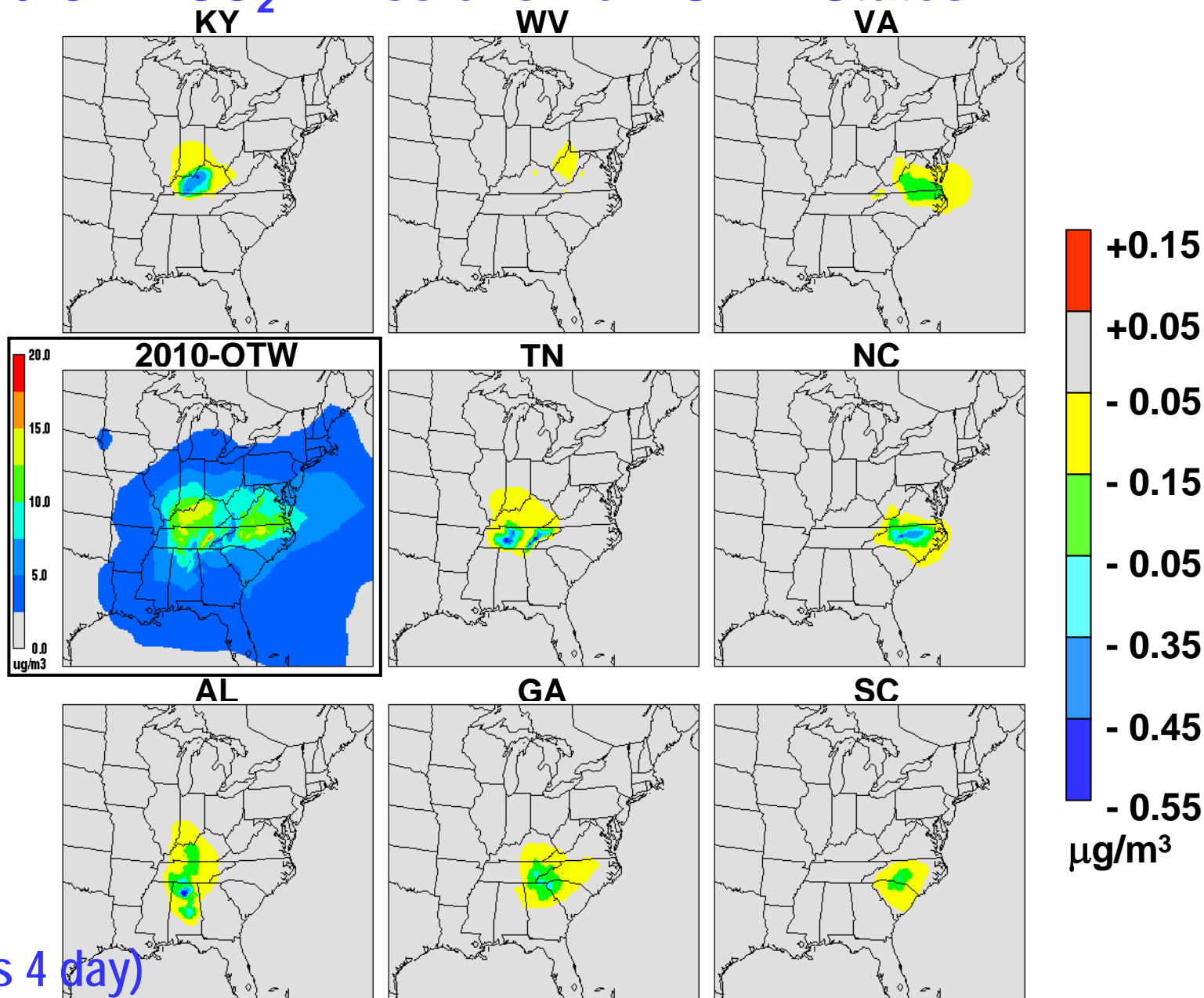


# SO<sub>4</sub> & its Change on July 15, 1995 for a 10% Reduction of 2010-OTW SO<sub>2</sub> Emissions from SAMI States



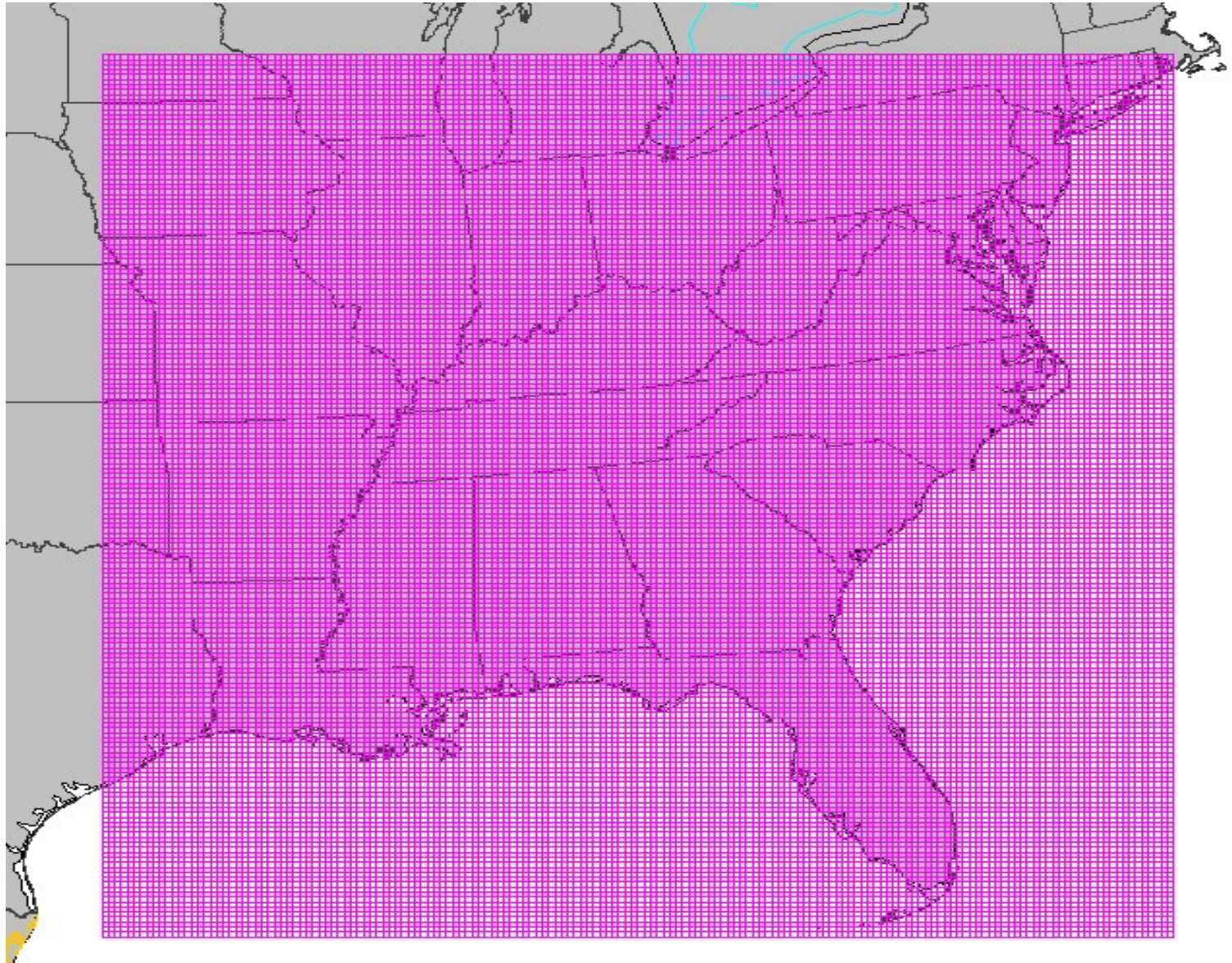
(Class 5 day)

# SO<sub>4</sub> & its Change on May 27, 1995 for a 10% Reduction of 2010-OTW SO<sub>2</sub> Emissions from SAMI States



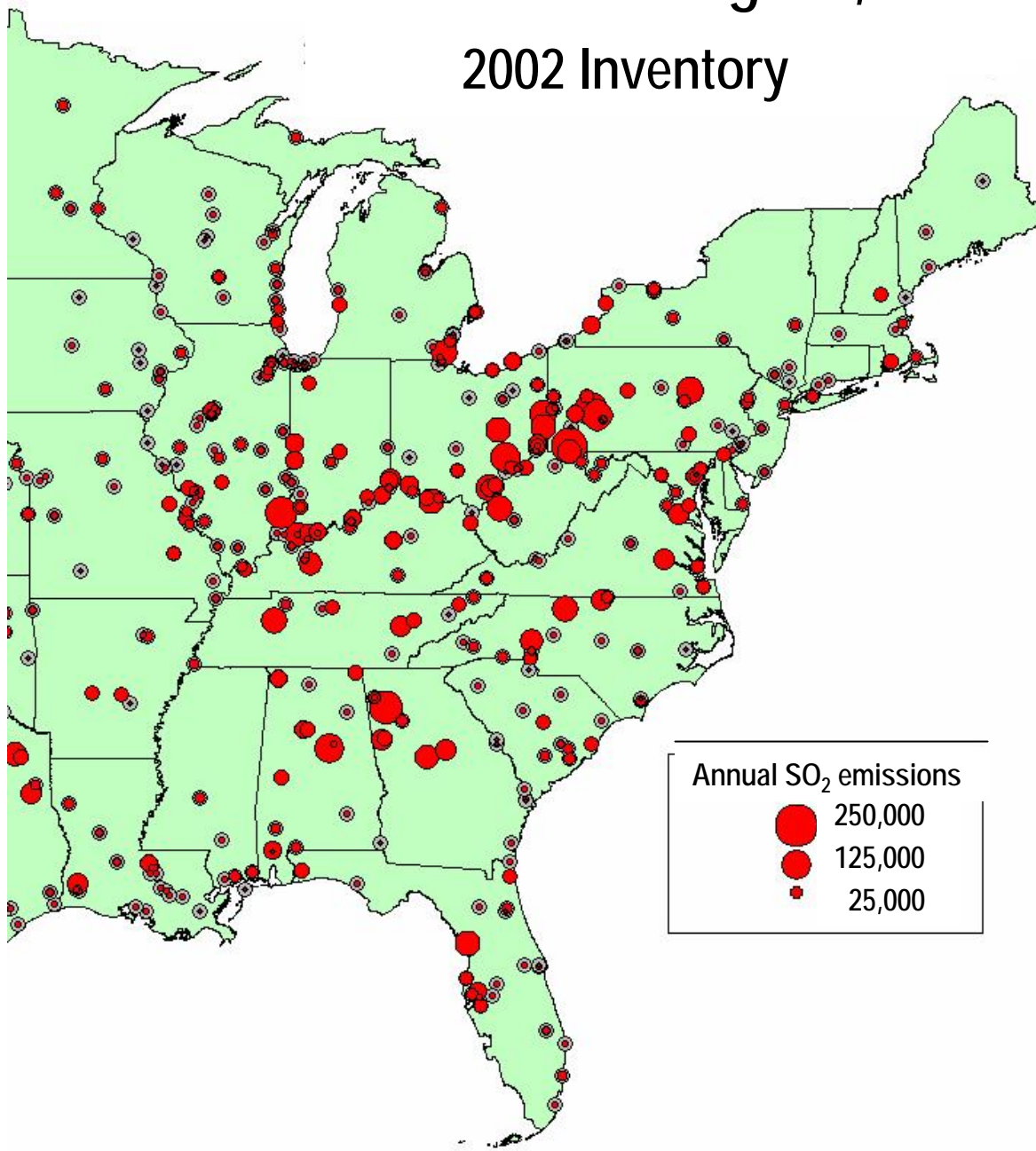
(Class 4 day)

# VISTAS 12-km CMAQ Modeling Domain



# SO<sub>2</sub> Point Sources emitting > 5,000 tons per year

## 2002 Inventory



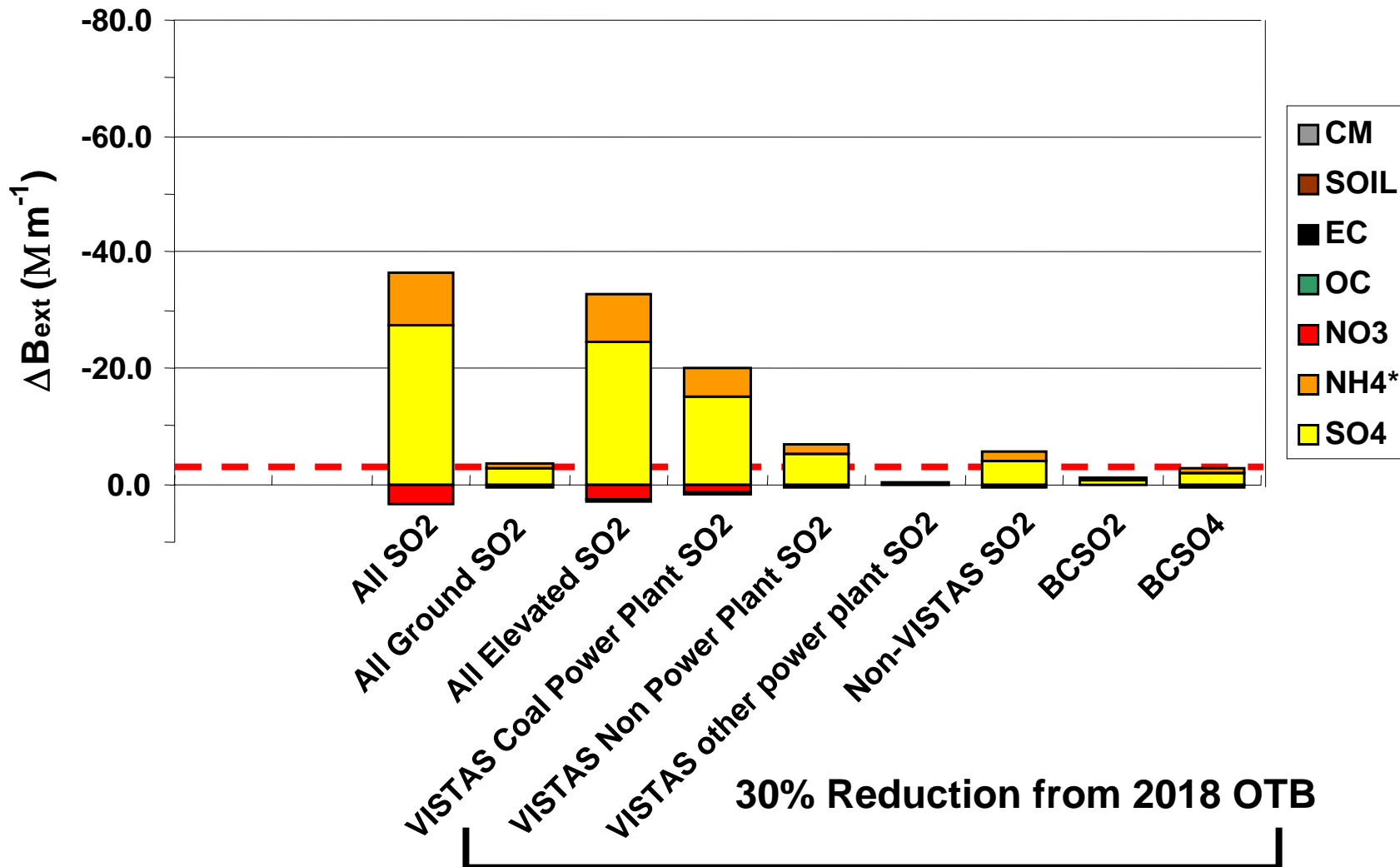


# 2018 Emissions Sensitivities

- In 2004, initial 2002 and initial 2018 inventories modeled by Georgia Tech for July 2001 and Jan 2002 episodes.
- For Southern Appalachian sites, 20% worst visibility days in summer, 20% best in winter
- For coastal sites, 20% best and worst days could be in either summer or winter
- Can interpret relative importance of pollutant or source sector reductions
- Not all Key meteorological conditions were represented

# Great Smoky Mtns (TN) – 2 days

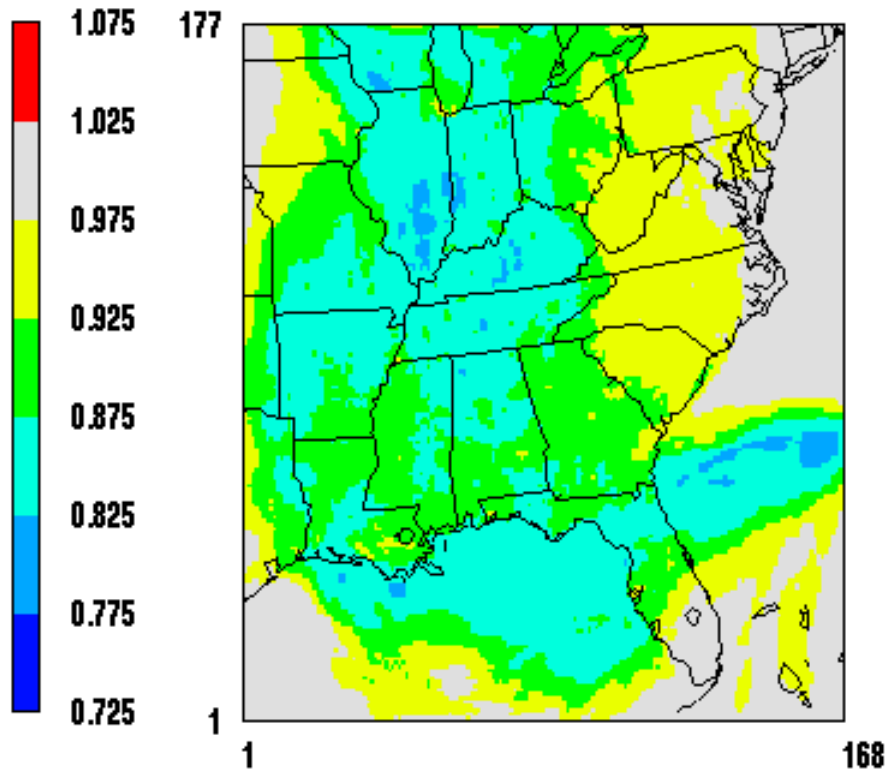
Weighted  $B_{ext}$  Response on 20% Haziest Days



# Elevated SO<sub>2</sub> Emissions

## PM2.5 RRF

2018 OTB (B1) - 30% Elevated SO<sub>2</sub>  
(Created at GaTech, Dec. 2004)

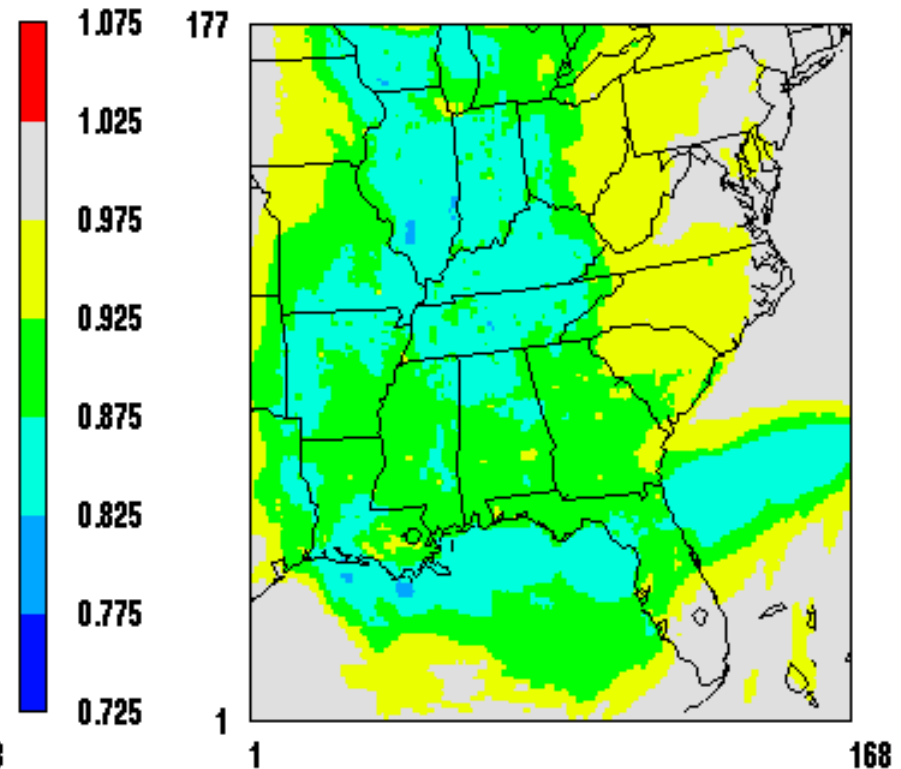


PAVE  
by  
MCNC

July 21, 2001 5:00:00  
Min= 0.812 at (62,134), Max= 1.002 at (3,34)

## PM2.5 RRF

2018 OTW (B2A) - 30% Elevated SO<sub>2</sub>  
(Created at GaTech, Dec. 2004)



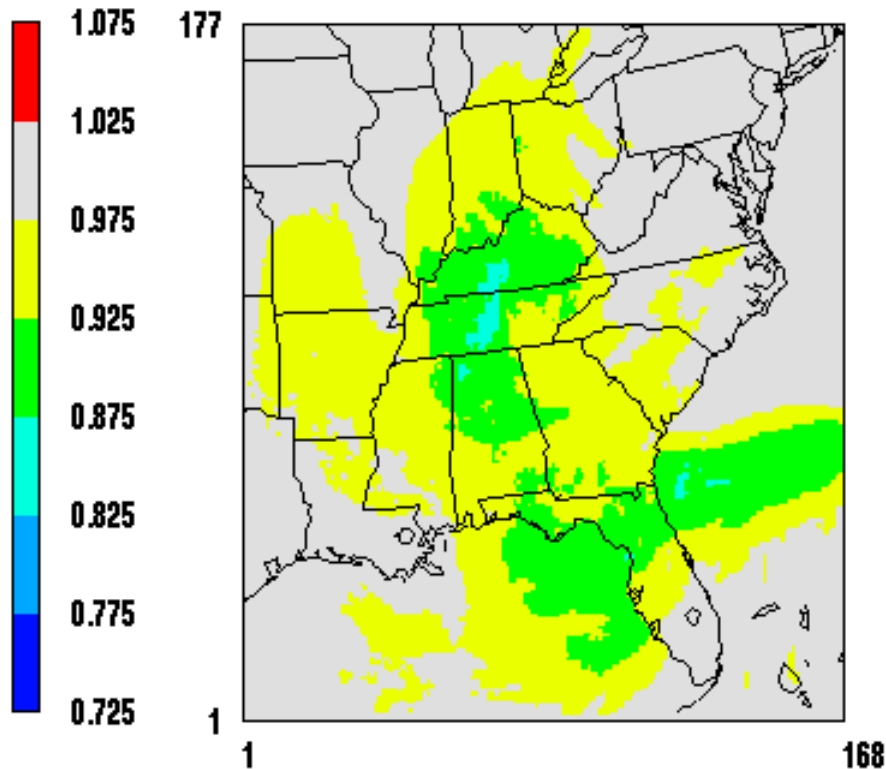
PAVE  
by  
MCNC

July 21, 2001 5:00:00  
Min= 0.811 at (43,35), Max= 1.001 at (122,5)

# VISTAS CPP SO<sub>2</sub> Emissions

## PM2.5 RRF

2018 OTB (B1) - 30% VISTAS CPP SO<sub>2</sub>  
(Created at GaTech, Dec. 2004)

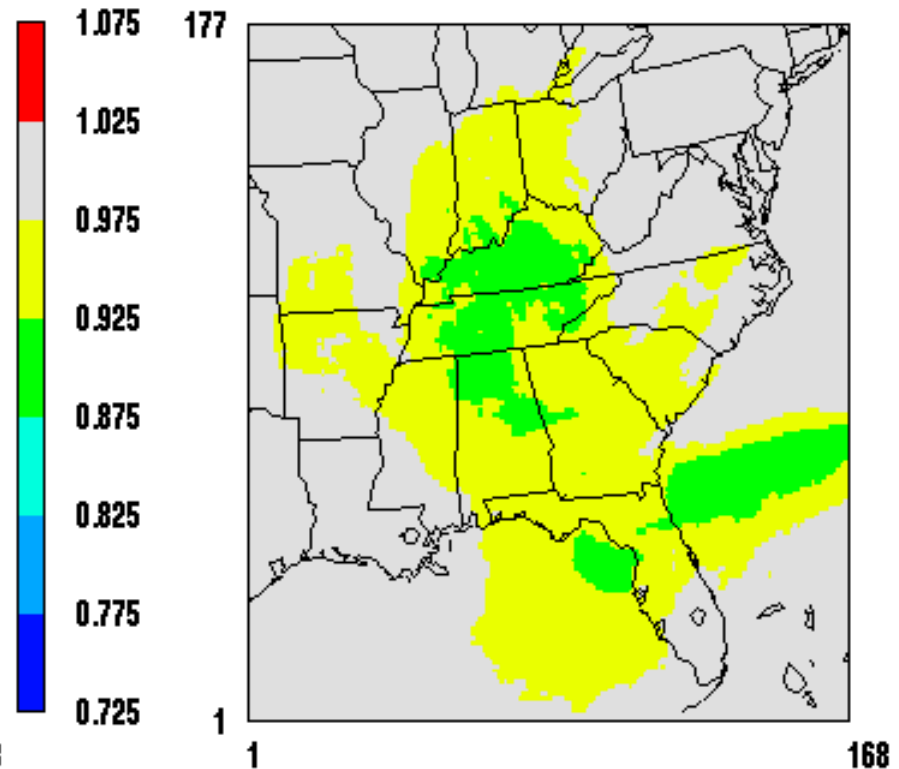


PAVE  
by  
MCNC

July 21, 2001 5:00:00  
Min= 0.854 at (68,101), Max= 1.002 at (138,93)

## PM2.5 RRF

2018 OTW (B2A) - 30% VISTAS CPP SO<sub>2</sub>  
(Created at GaTech, Dec. 2004)



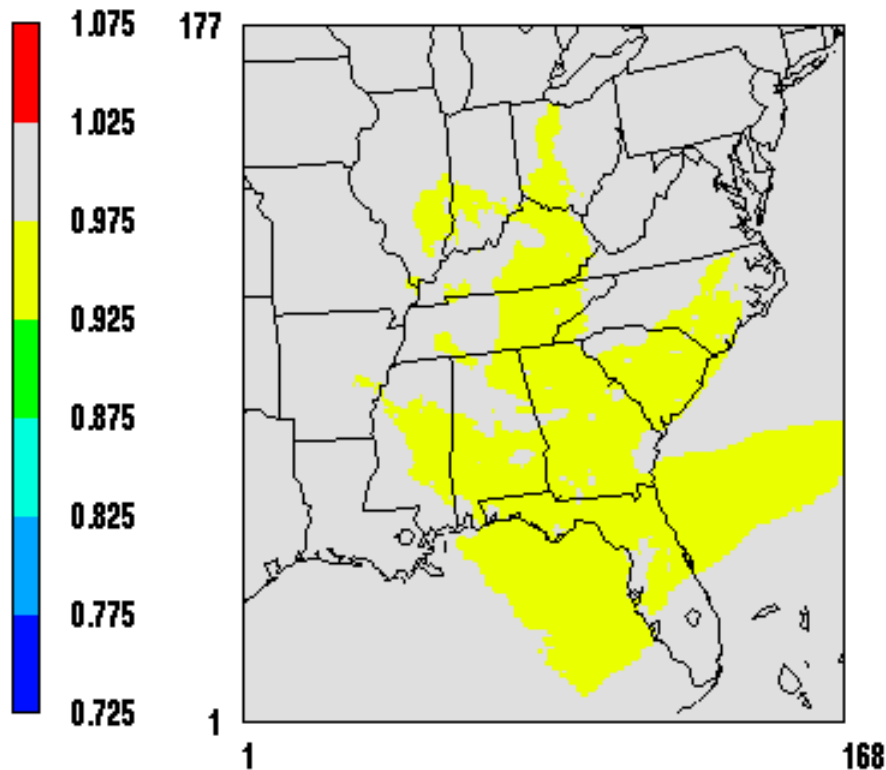
PAVE  
by  
MCNC

July 21, 2001 5:00:00  
Min= 0.877 at (68,101), Max= 1.003 at (149,162)

# VISTAS NPP SO<sub>2</sub> Emissions

## PM2.5 RRF

2018 OTB (B1) - 30% VISTAS NPP SO<sub>2</sub>  
(Created at GaTech, Dec. 2004)

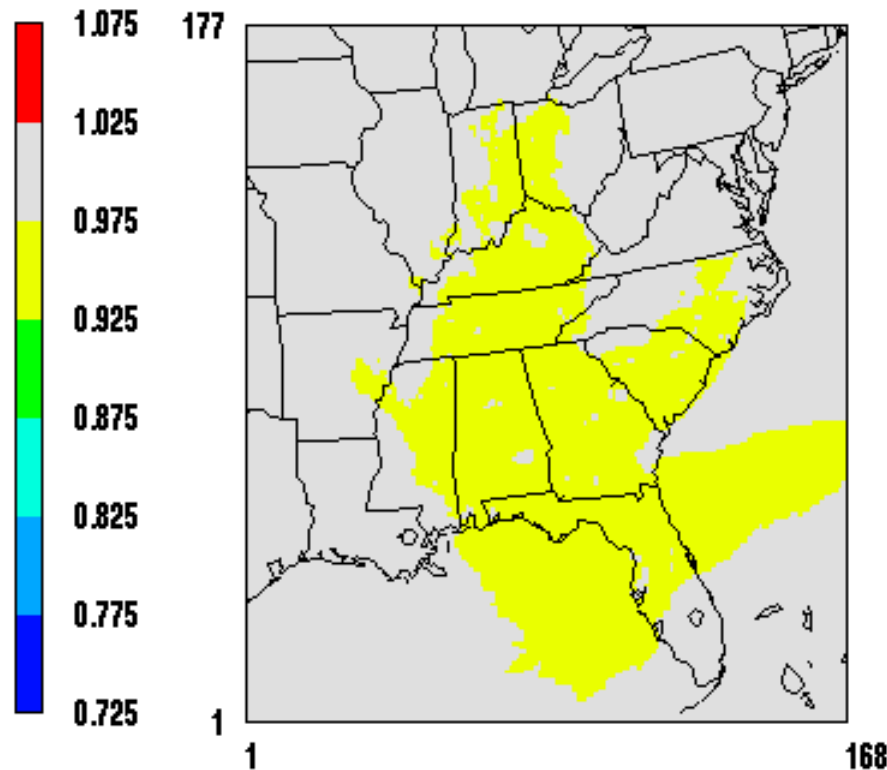


PAVE  
by  
MCNC

July 21, 2001 5:00:00  
Min= 0.940 at (130,43), Max= 1.001 at (136,136)

## PM2.5 RRF

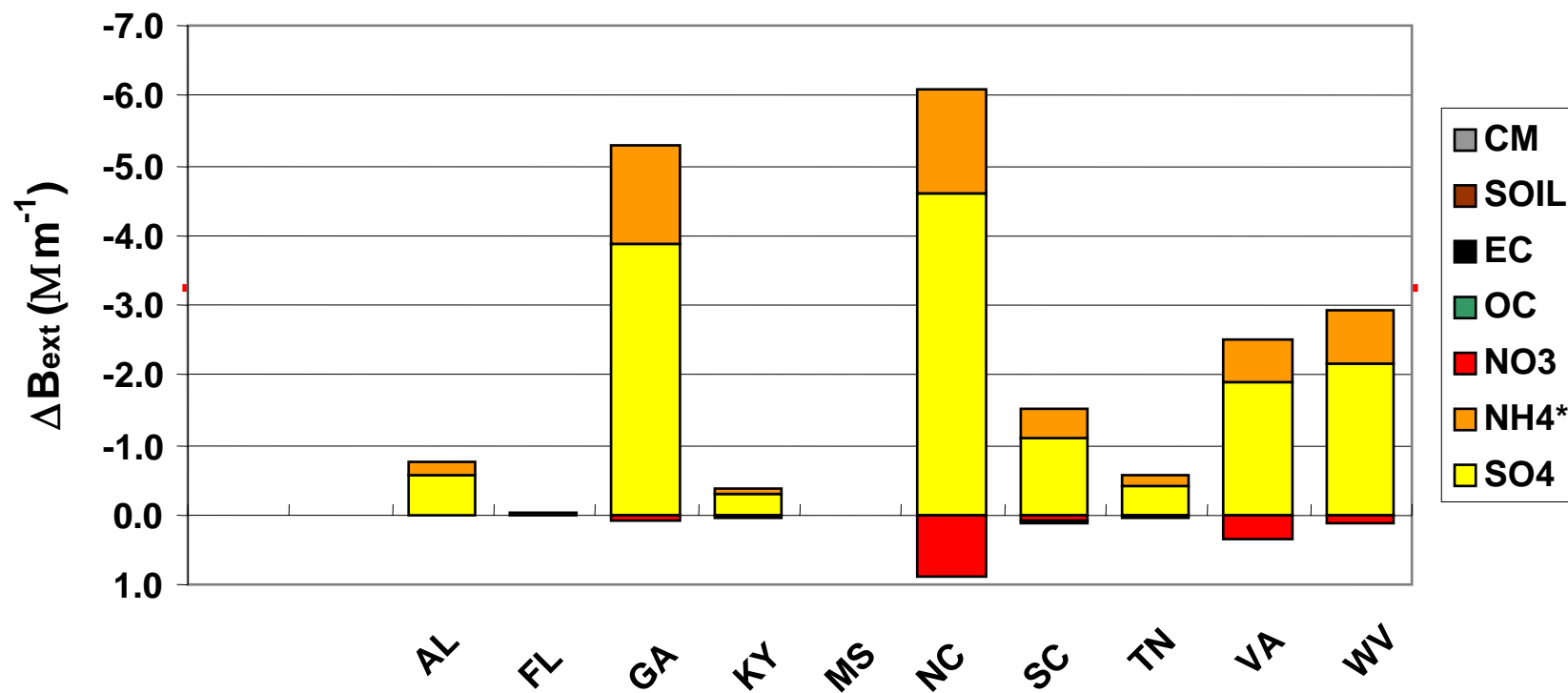
2018 OTW (B2A) - 30% VISTAS NPP SO<sub>2</sub>  
(Created at GaTech, Dec. 2004)



PAVE  
by  
MCNC

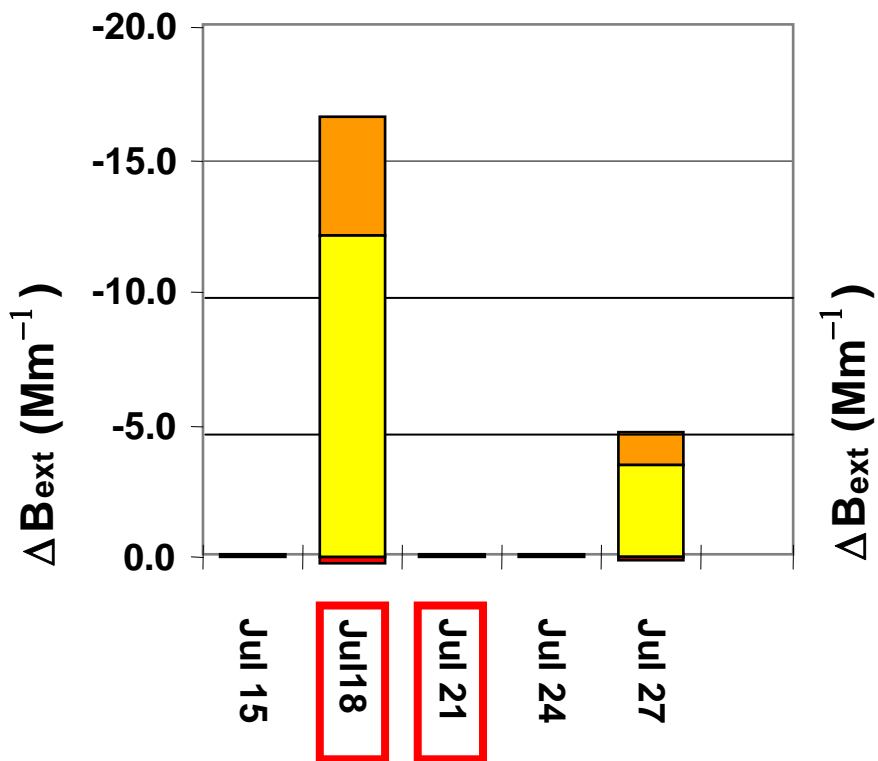
July 21, 2001 5:00:00  
Min= 0.936 at (116,61), Max= 1.001 at (152,158)

Weighted  $B_{ext}$  Response on Worst 20% days (July 01)  
30% Reduction in SO<sub>2</sub> emissions from 2018 OTB  
For Coal Fired Power Plants from VISTS states  
Great Smoky Mtns

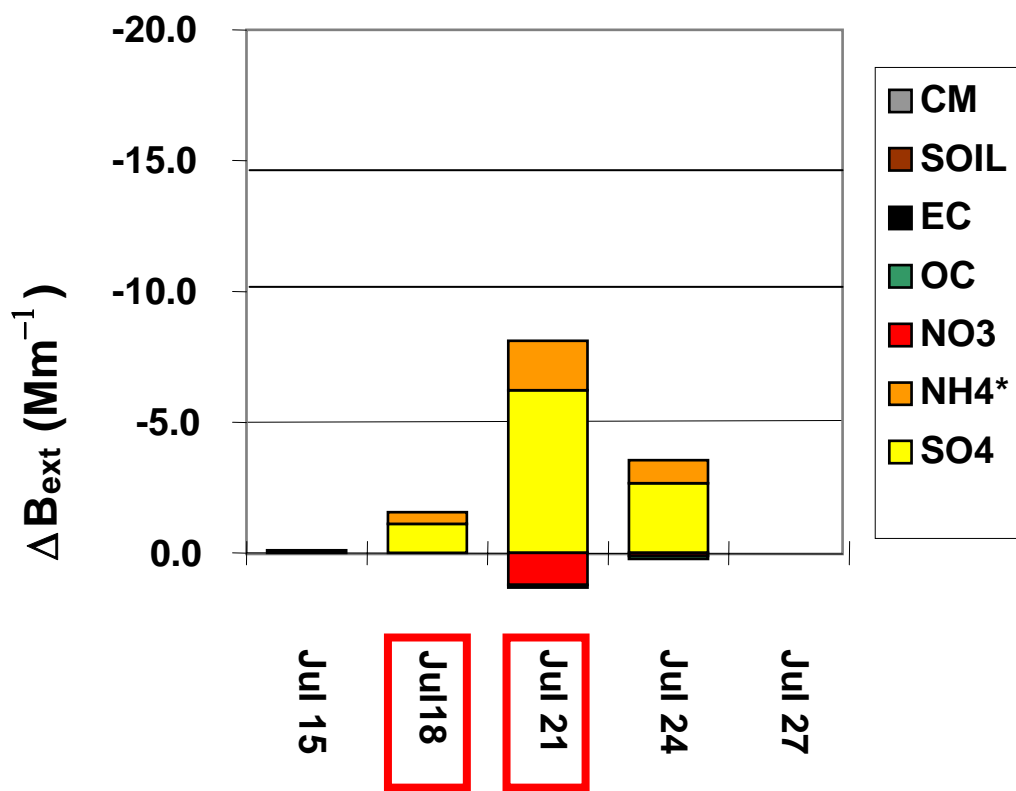


# Bext Response to 30% Reduction from 2018 OTb in Elevated SO<sub>2</sub> from Coal Fired Power Plants Great Smoky Mtn.

## Georgia



## North Carolina

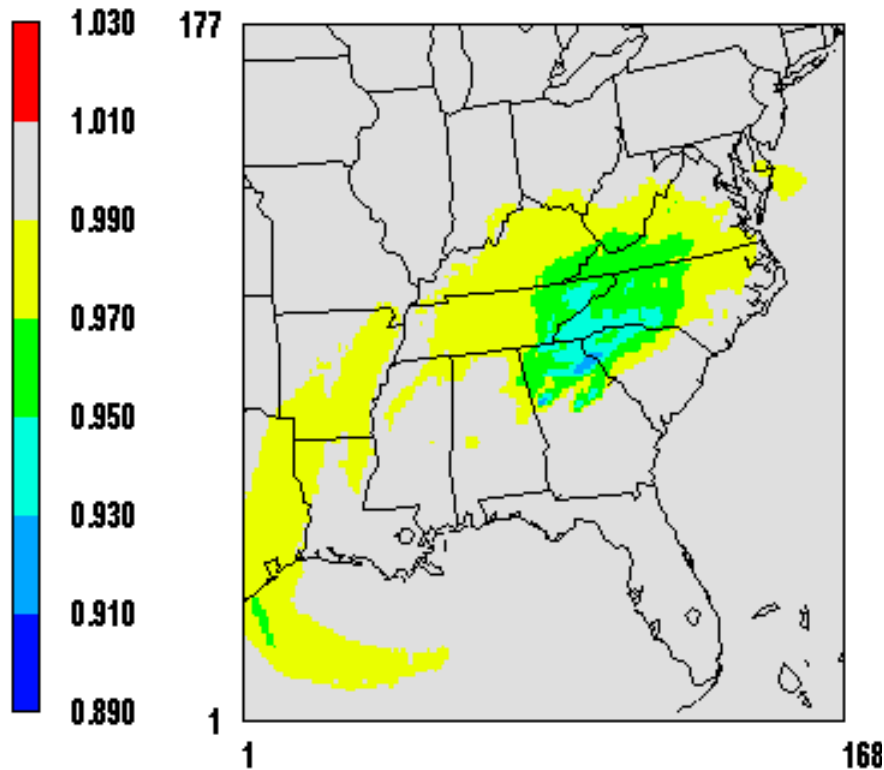


- CM
- SOIL
- EC
- OC
- NO<sub>3</sub>
- NH<sub>4</sub><sup>\*</sup>
- SO<sub>4</sub>

# GA & NC CPP SO<sub>2</sub> Emissions

## PM2.5 RRF

2018 OTB (B1) - 30% GA CPP SO<sub>2</sub>  
(Created at GaTech, Dec. 2004)

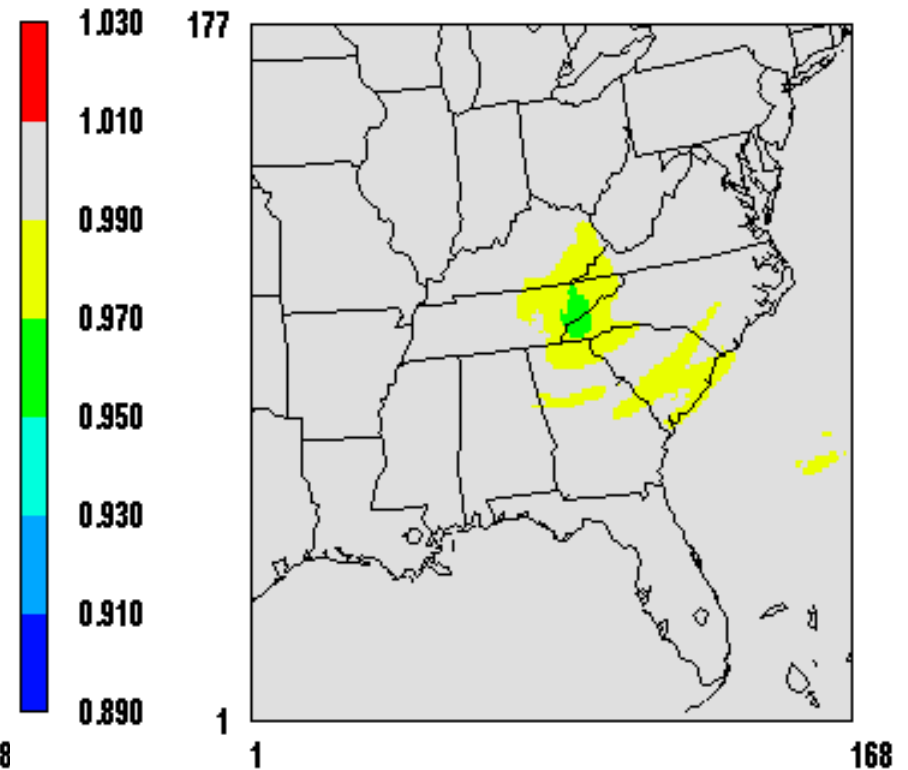


PAVE  
by  
MCNC

July 18, 2001 5:00:00  
Min= 0.918 at (98,91), Max= 1.001 at (6,141)

## PM2.5 RRF

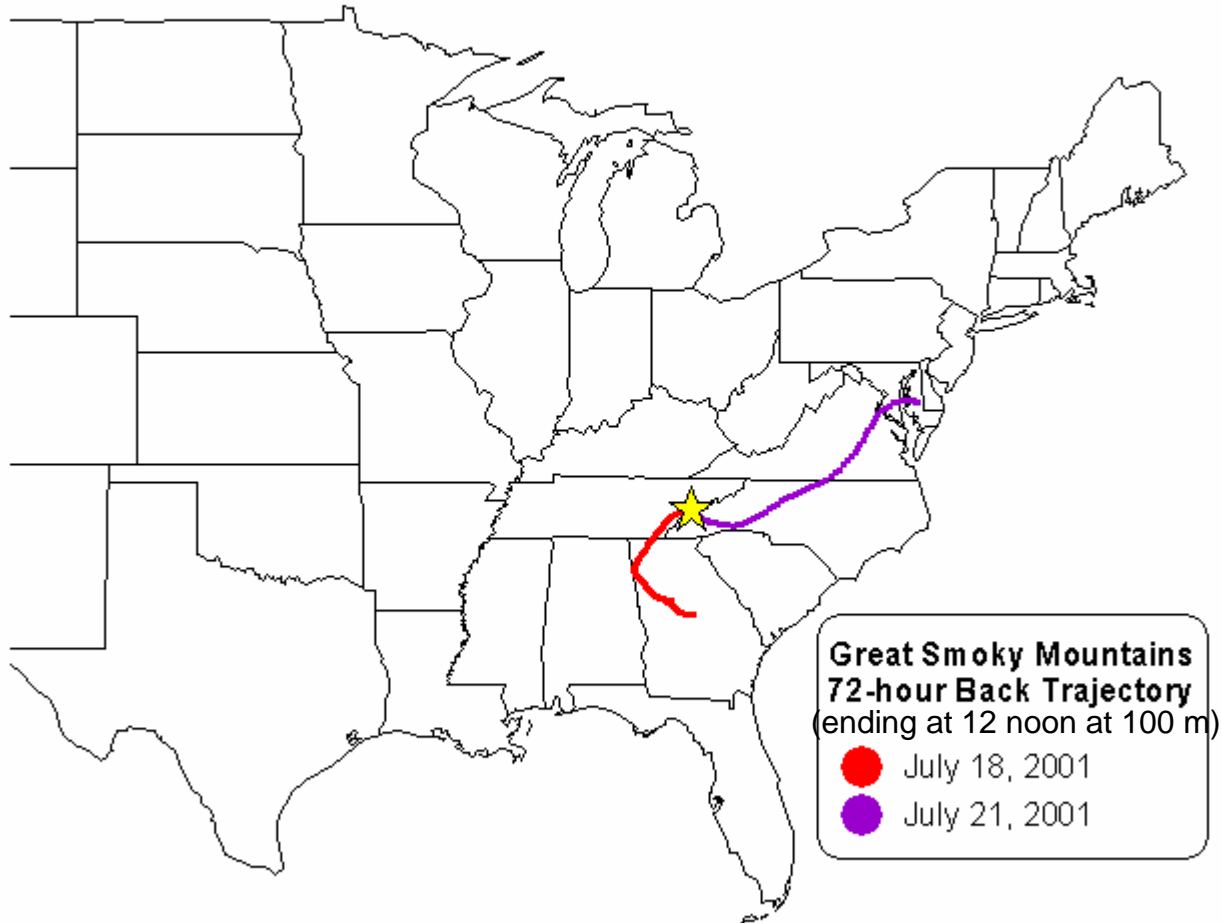
2018 OTB (B1) - 30% NC CPP SO<sub>2</sub>  
(Created at GaTech, Dec. 2004)



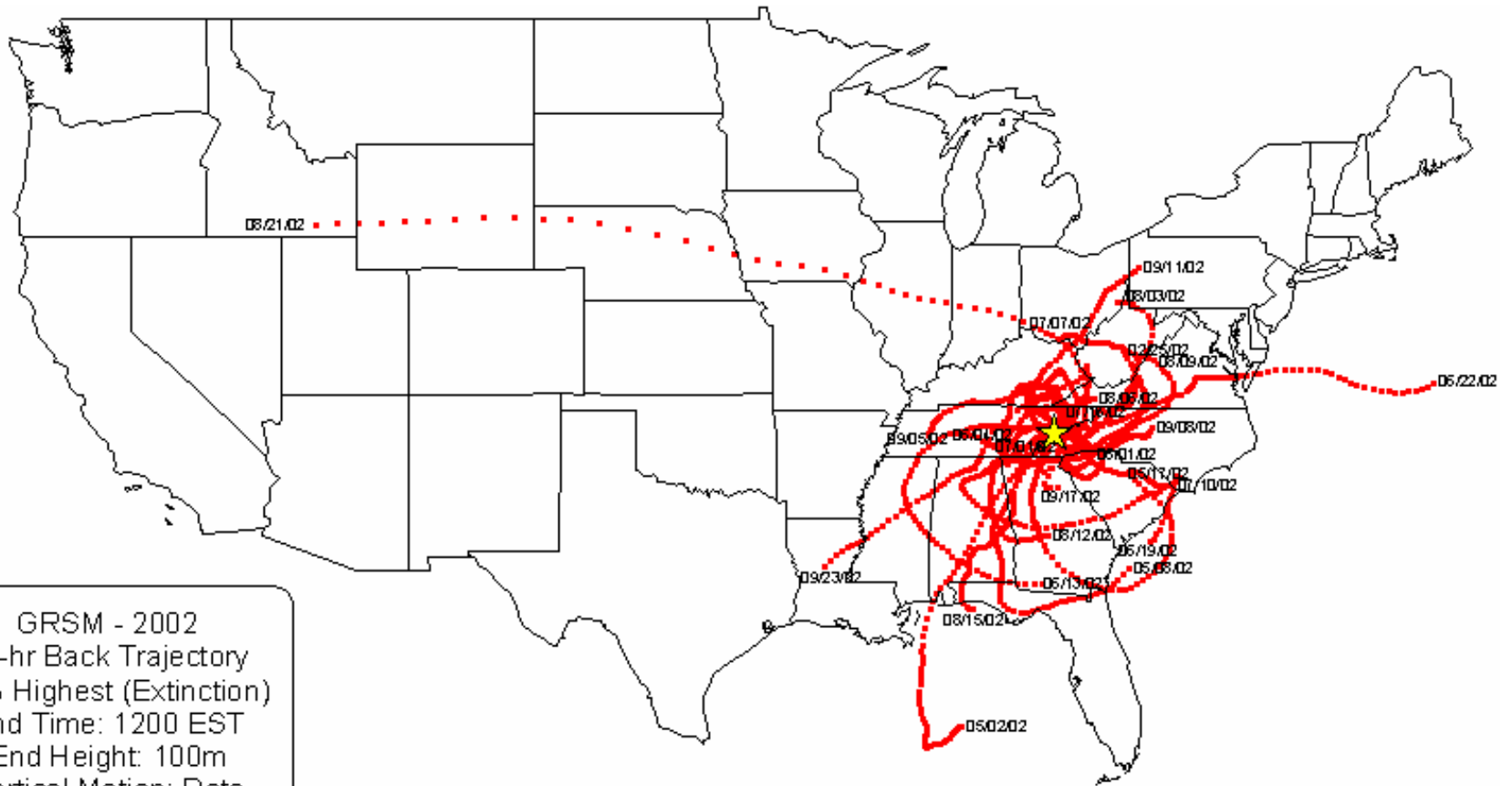
PAVE  
by  
MCNC

July 21, 2001 5:00:00  
Min= 0.956 at (90,104), Max= 1.002 at (138,93)

# Back Trajectories for Great Smoky Mtns. National Park



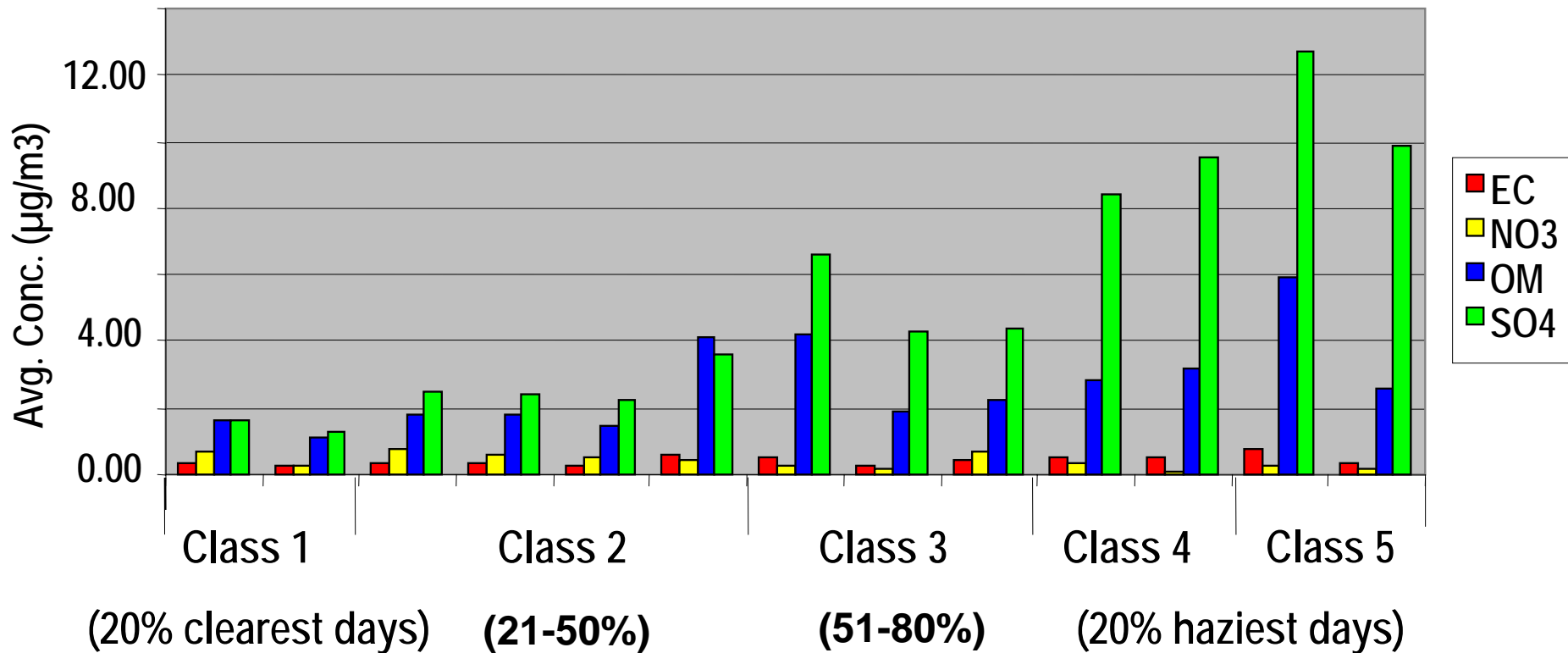
# Back Trajectories for Great Smoky Mtns. National Park



GRSM - 2002  
72-hr Back Trajectory  
20% Highest (Extinction)  
End Time: 1200 EST  
End Height: 100m  
Vertical Motion: Data

★ Site Location

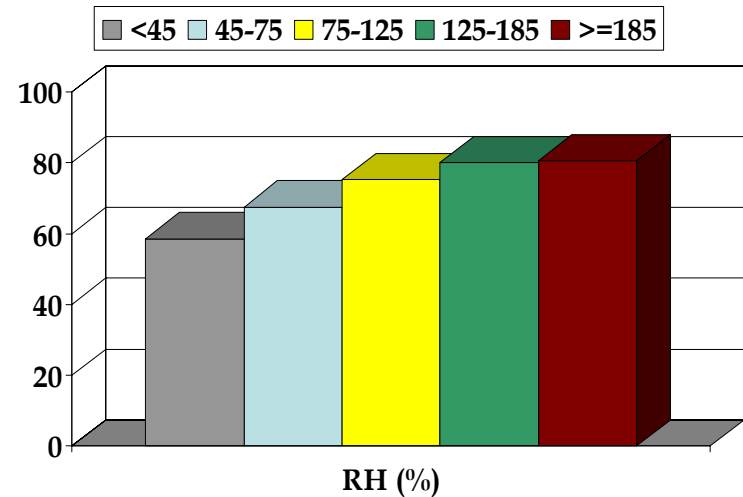
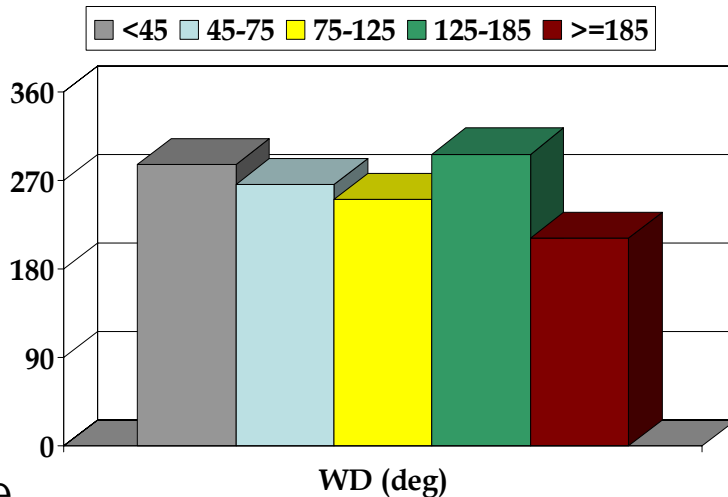
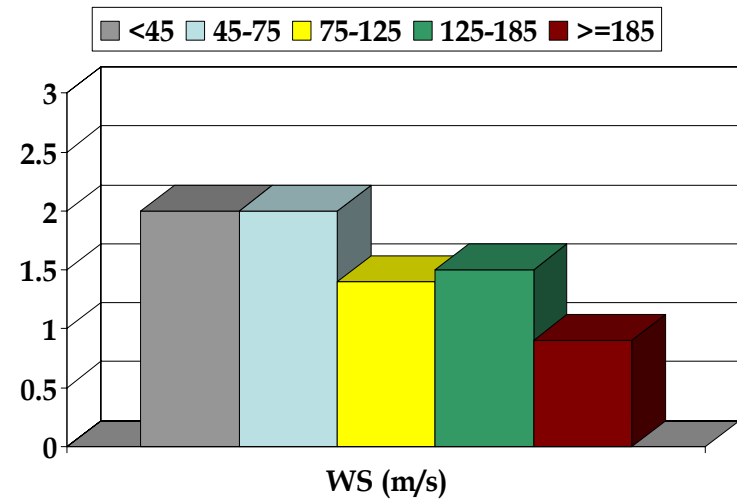
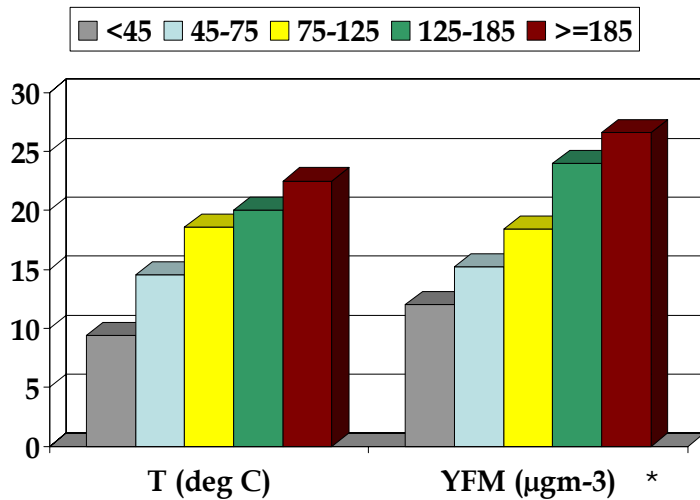
# Average PM2.5 Components for Key Visibility Bins - Great Smoky Mtns., TN



(Days ranked in bins and classes from clearest to haziest days)

# Categorical Comparisons

Surface Characteristics: All Days (2000-2003)/5 Ex. Coeff. Categories

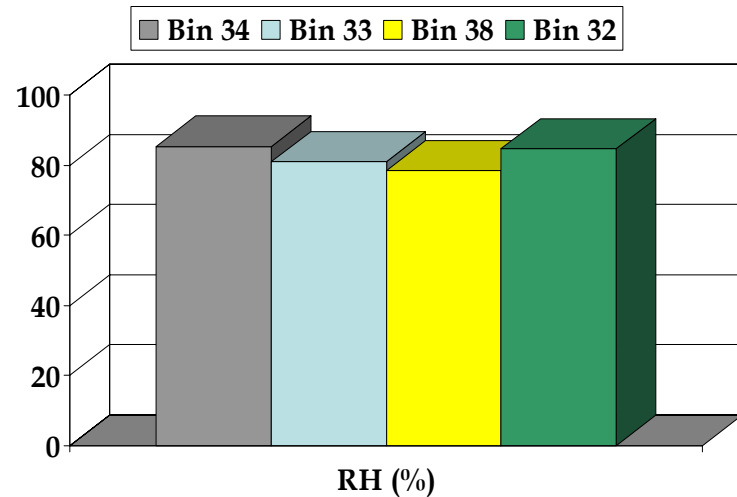
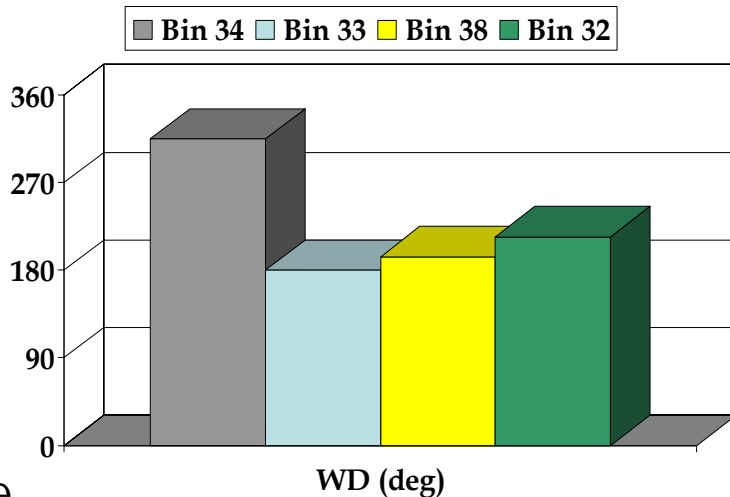
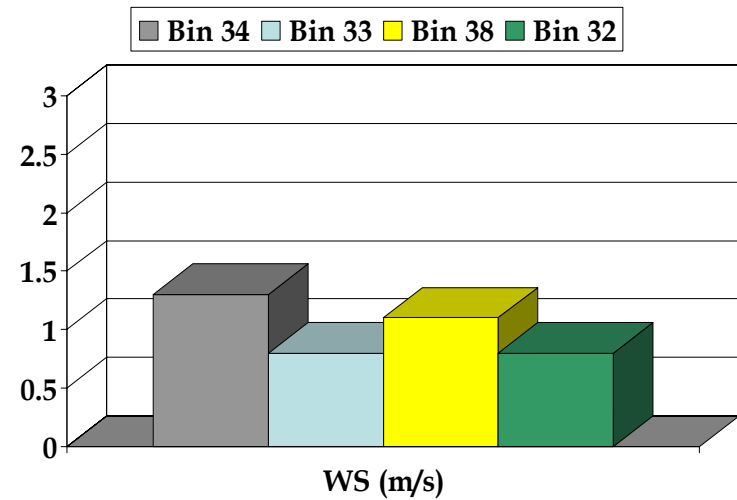
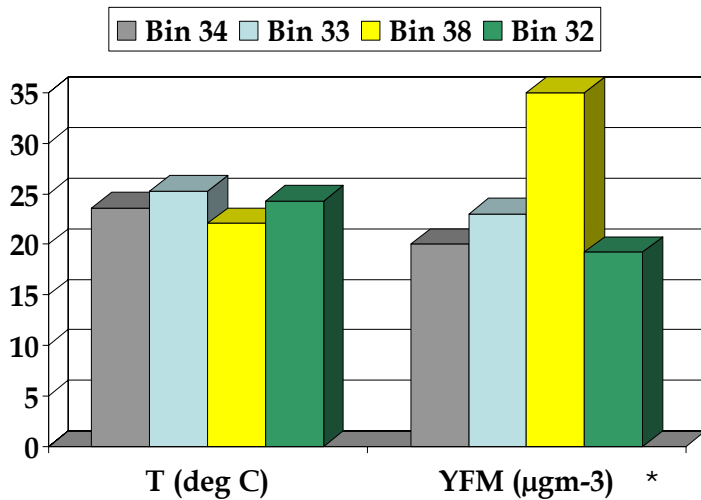


\* Knoxville

# Key Visibility Bins: 20% Worst Days Great Smoky Mtns.

Bin 39 (7 days): July 18 (31.3%)  
Bin 38 (11 days): July 21 (68.7%)

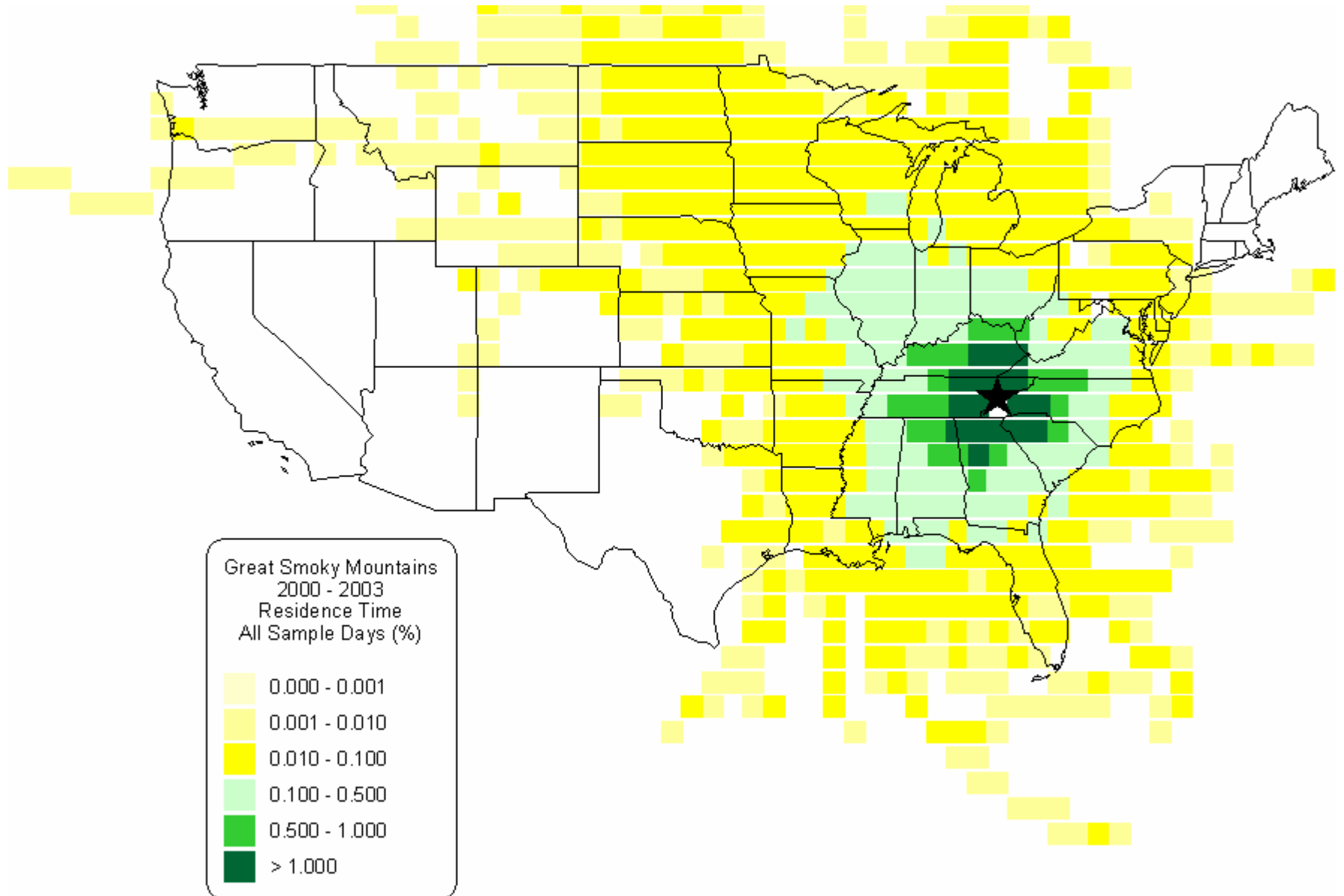
Surface Characteristics: All Days (2000-2003)/5 Ex. Coeff. Categories



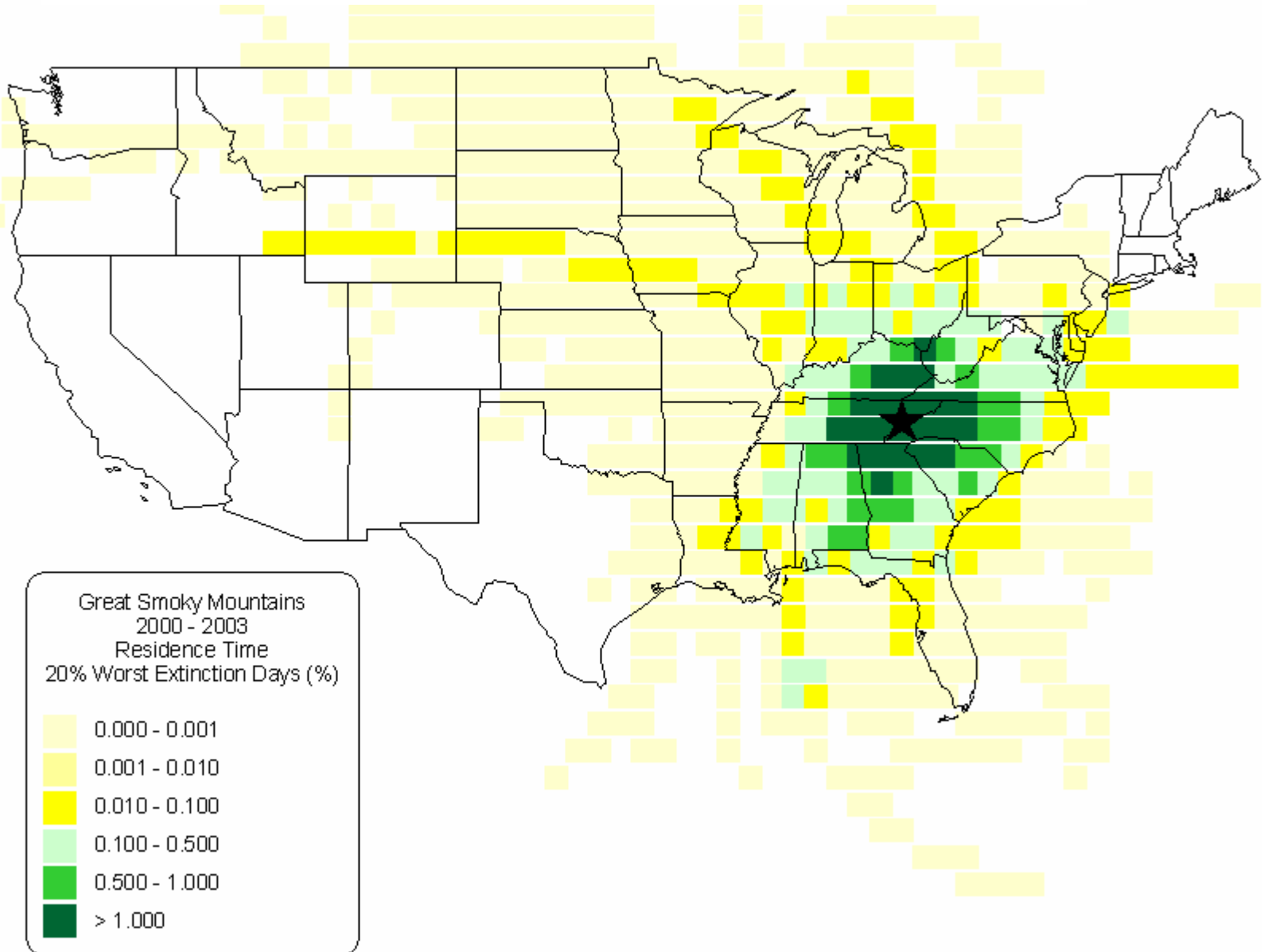
\*Knoxville

# Residence Time based on Back Trajectories – All Days 2000-2003

## Great Smoky Mtns. National Park

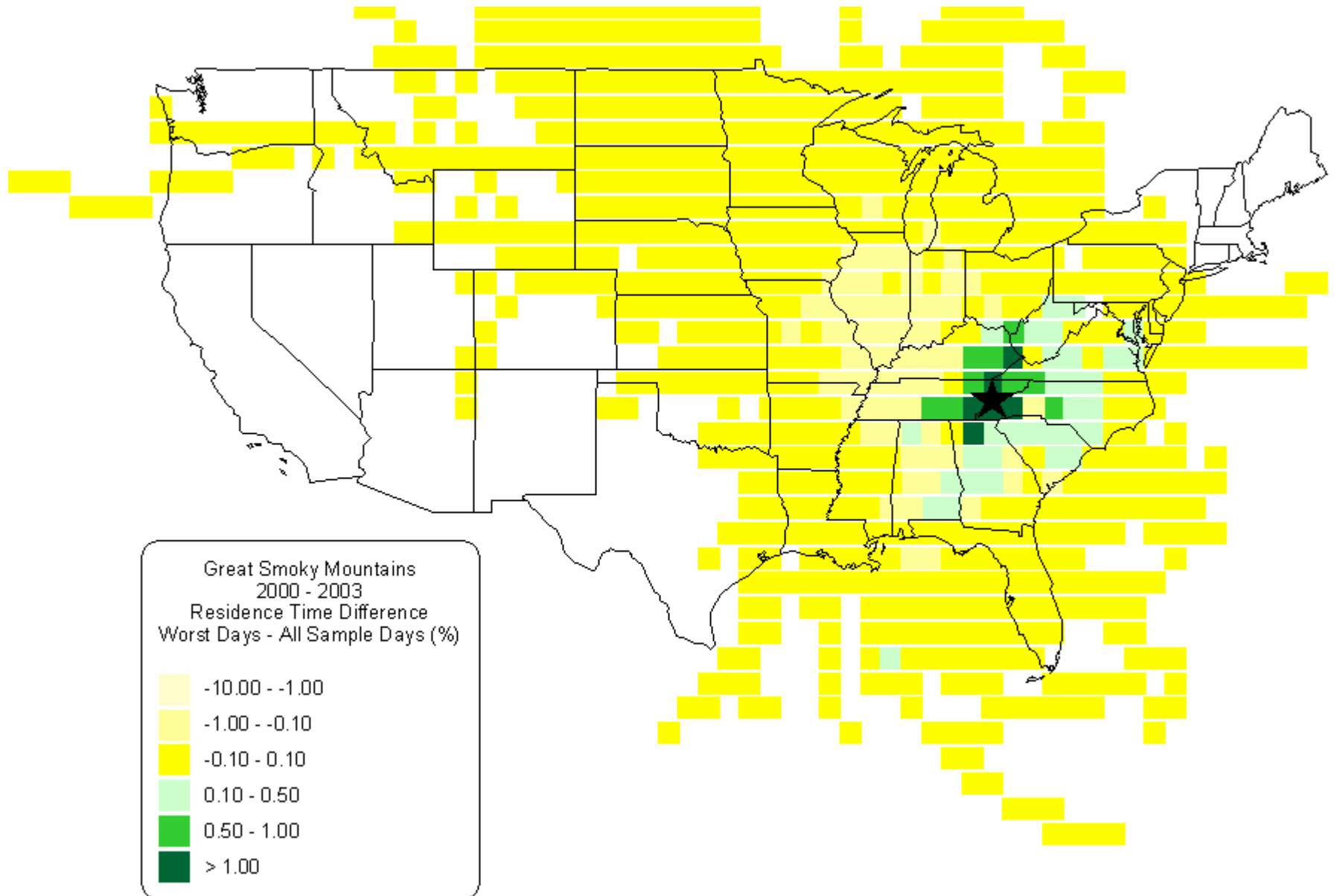


# Residence Time – 20% Worst Days 2000-2003 Great Smoky Mtns. National Park



# Residence Time Difference Worst Days – All Sample Days 2000-2003

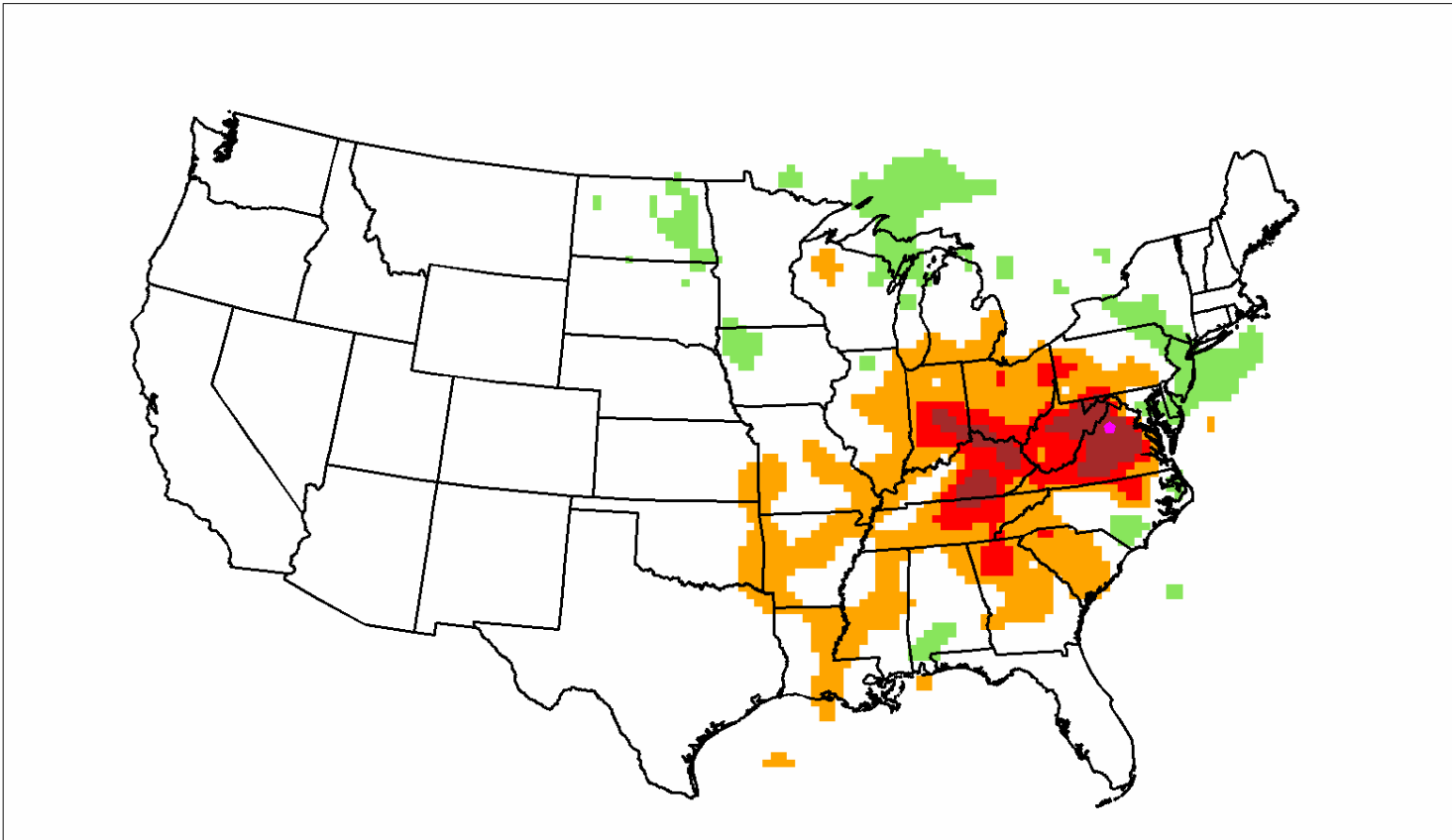
## Great Smoky Mtns. National Park



# Probable Source Areas for Secondary Sulfate

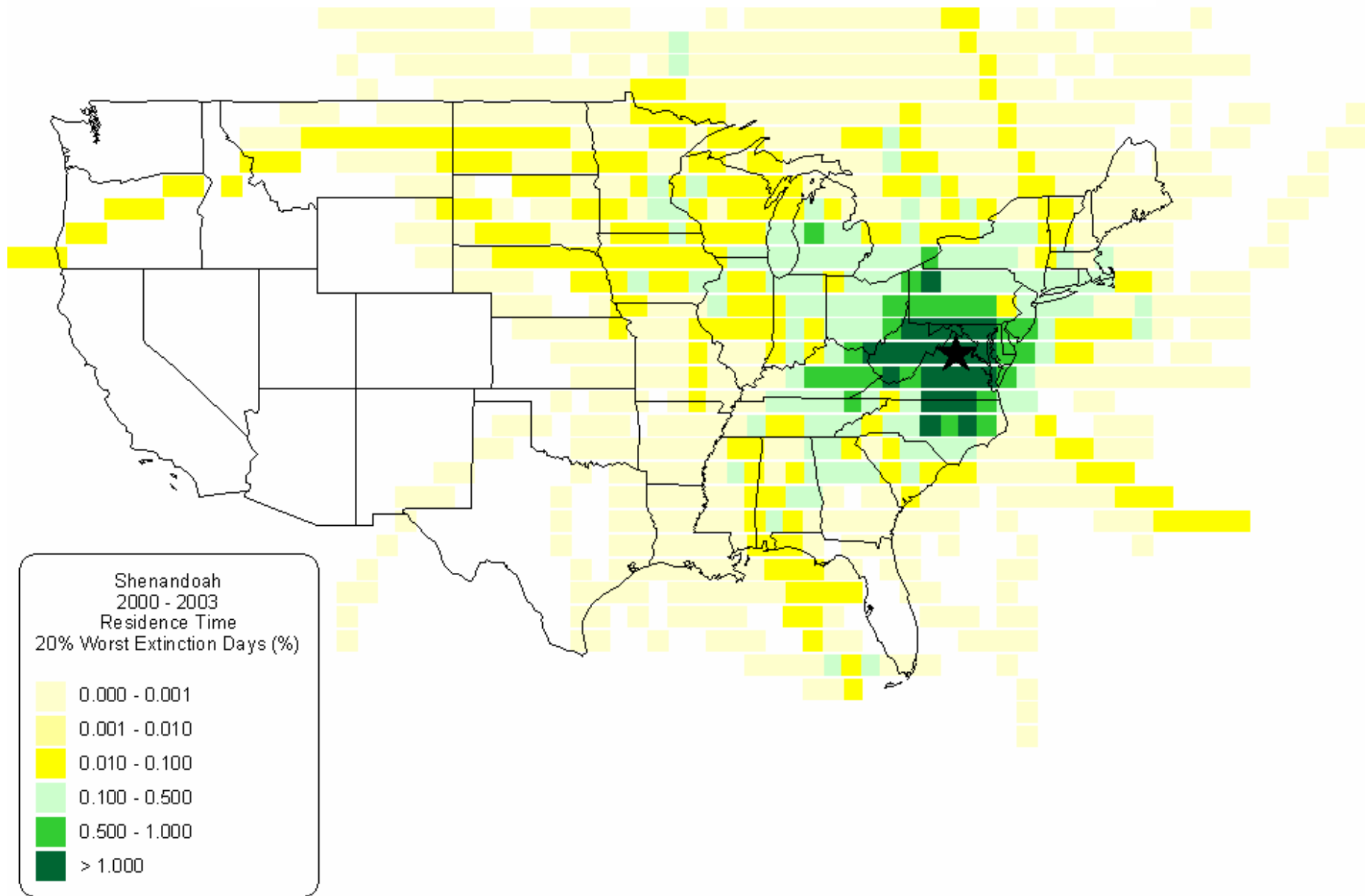
(work by Batelle for Midwest RPO, provided to VISTAS Jan 2003)

Site: Shenandoah National Park Source: 4



Percent Difference	■ -0.168	■ -0.084	■ 0.000
	■ 0.084	■ 0.168	■ 0.252

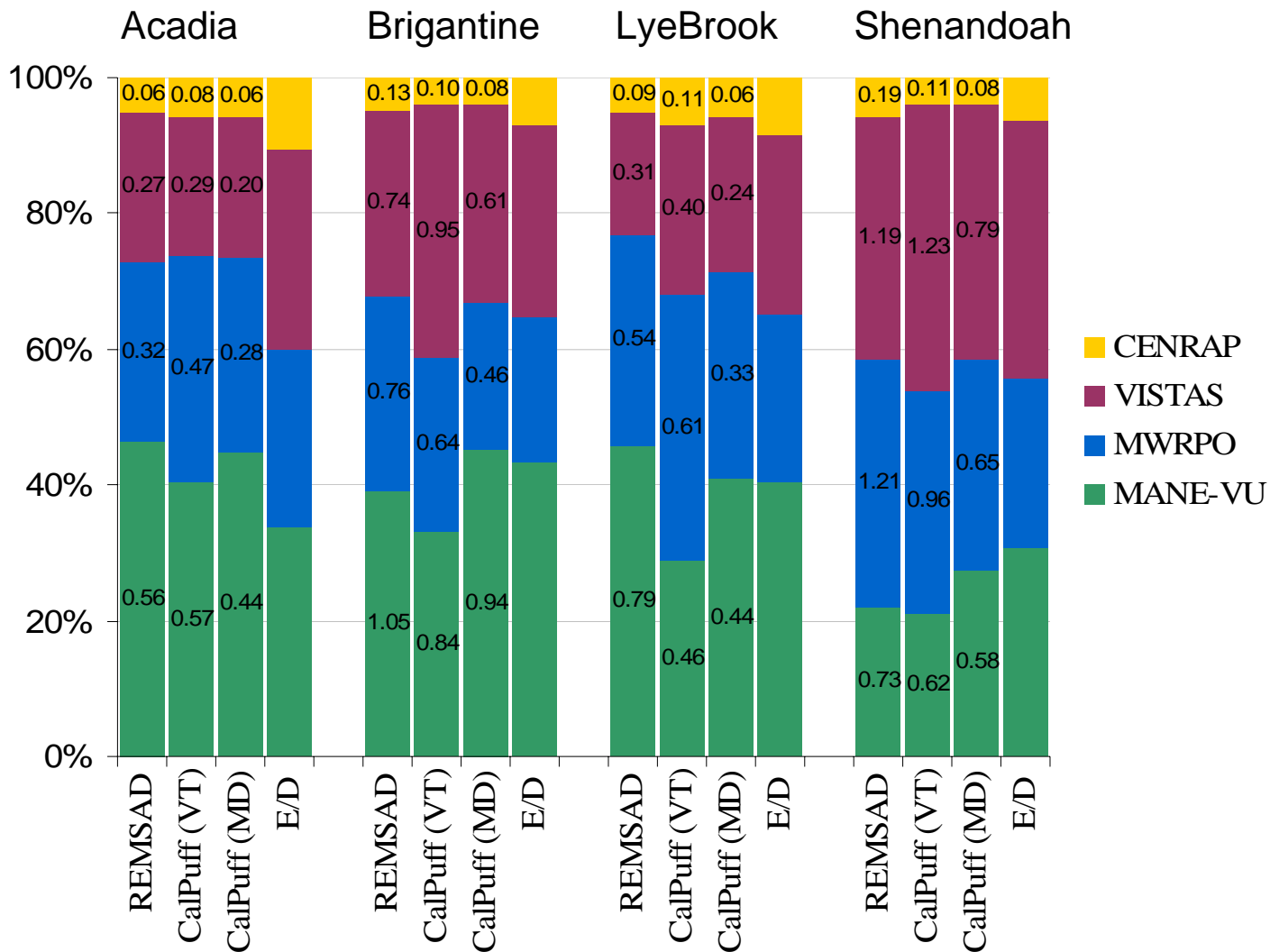
# Residence Time – 20% Worst Days 2000-2003 Shenandoah National Park



# 2002 MANE-VU Weight of Evidence

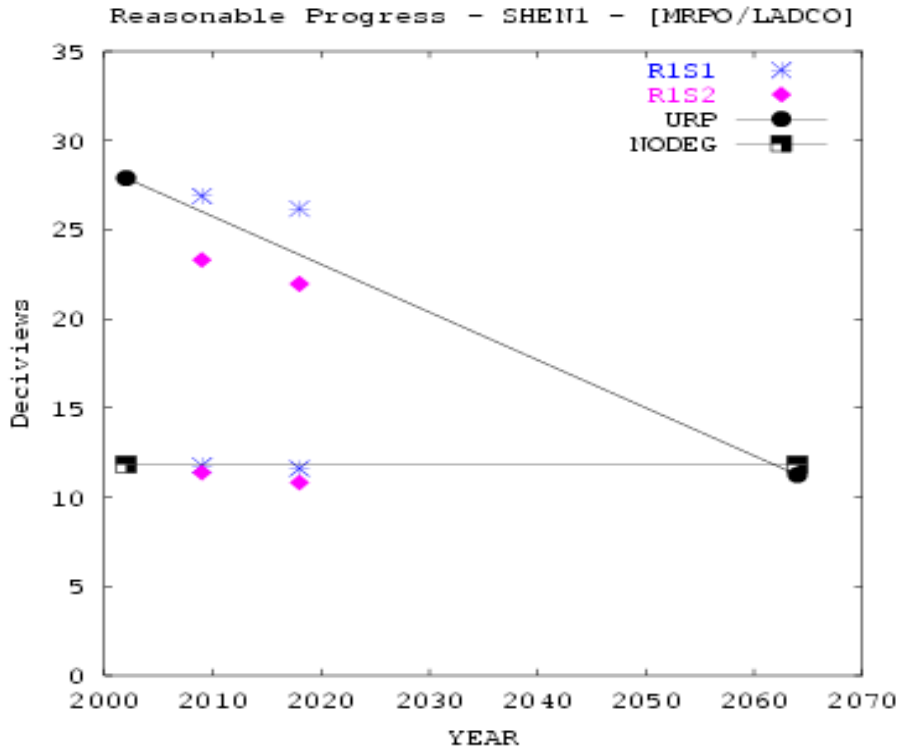
## Relative RPO Contributions

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

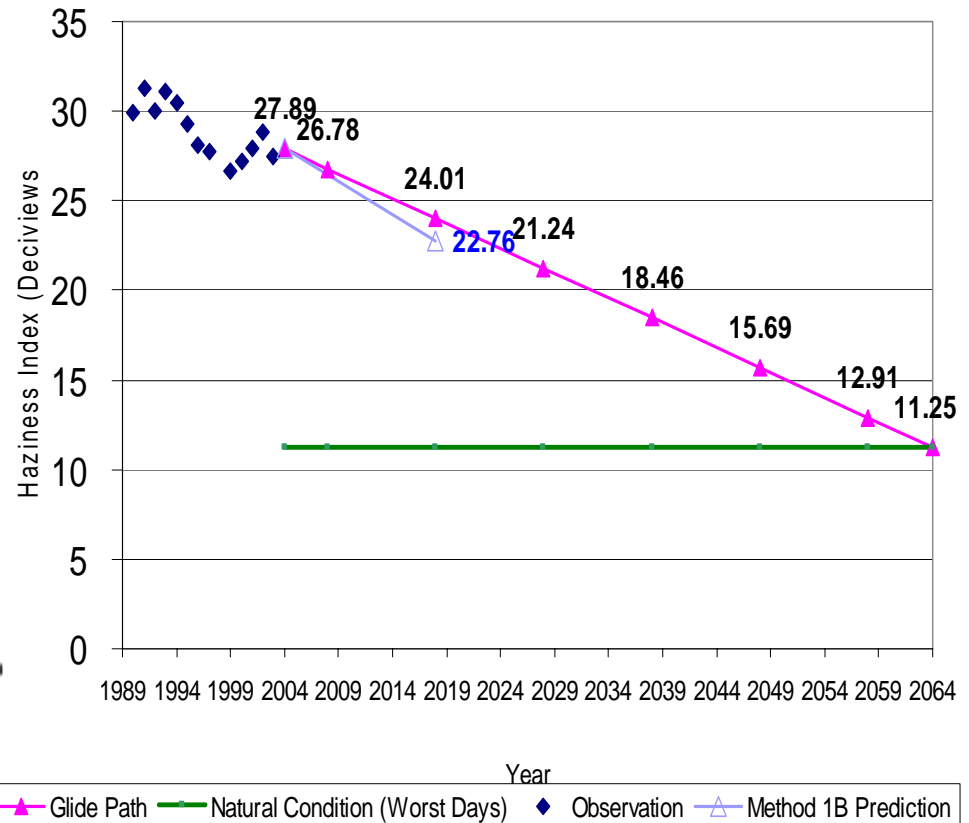


# Uniform Rate of Reasonable Progress Glide Path Shenandoah, VA – 20% Worst Days

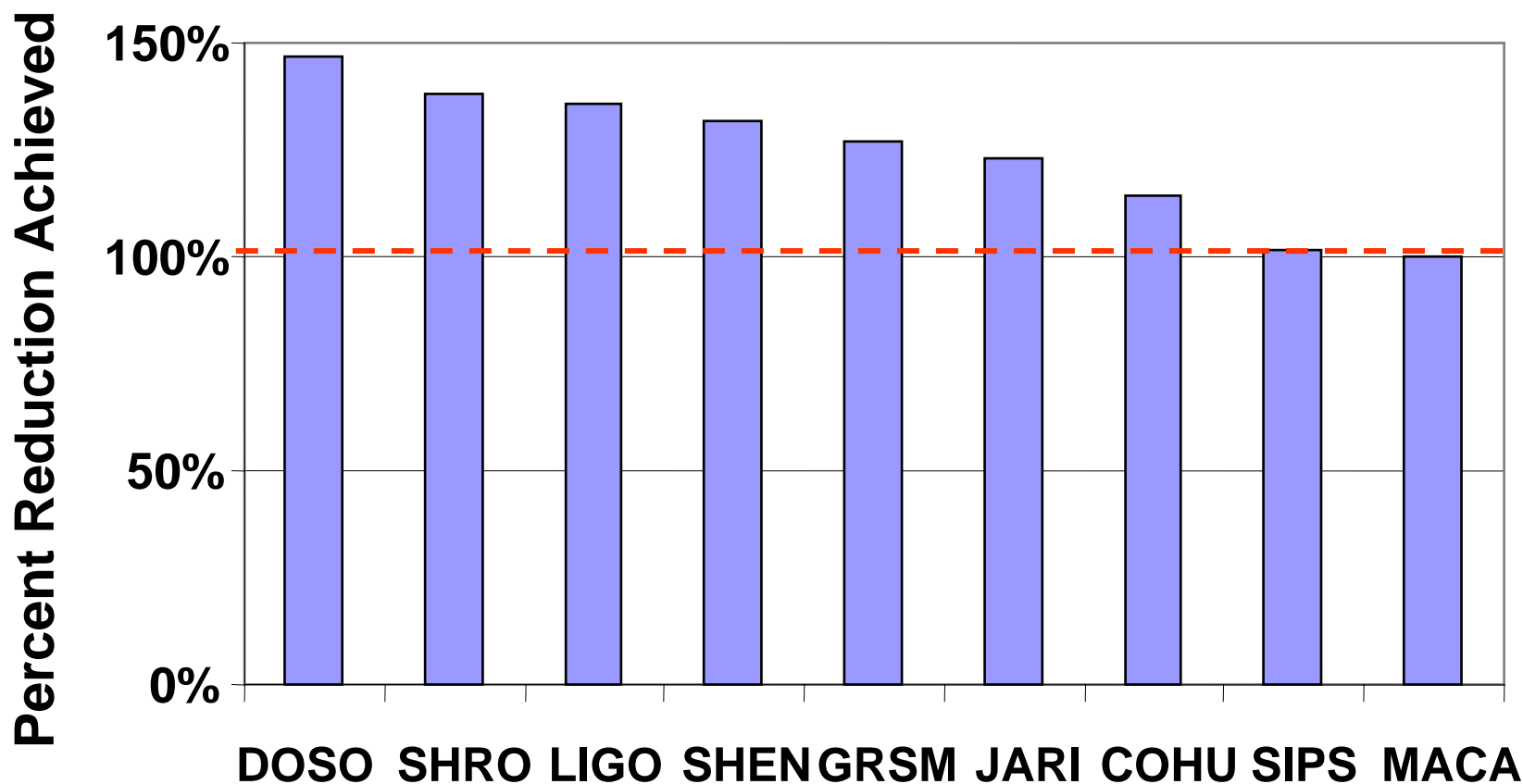
## MRPO



## VISTAS 2018 OTW-d



# Percentage Reduction in 2018 (OTW-d) Compared to Reasonable Progress Goal Southern Appalachian Sites



Assumes Method IB: average of 20% worst days in 2000-2003 with monthly RH

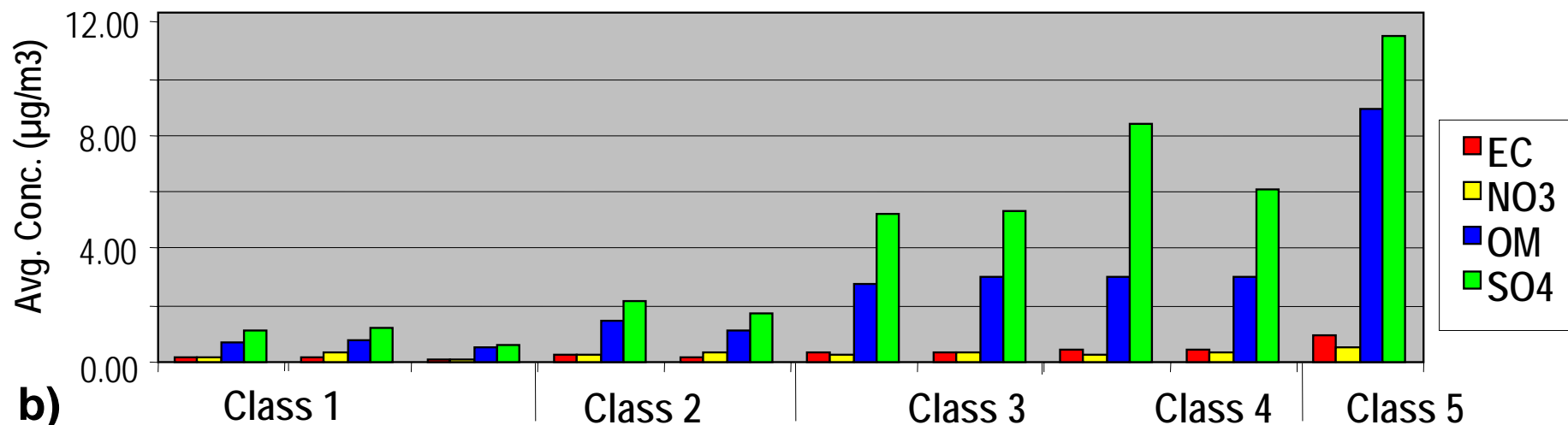


# Average PM2.5 Components for Key Visibility Bins -

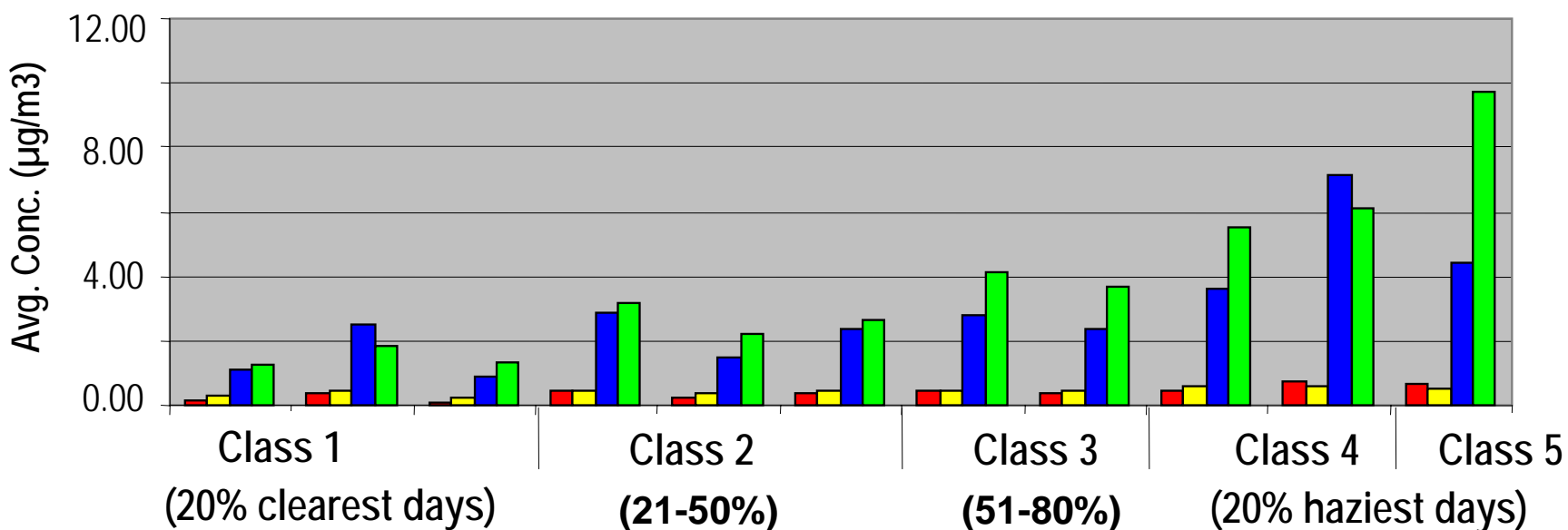
a) Shining Rock, NC

b) Cape Romain, SC

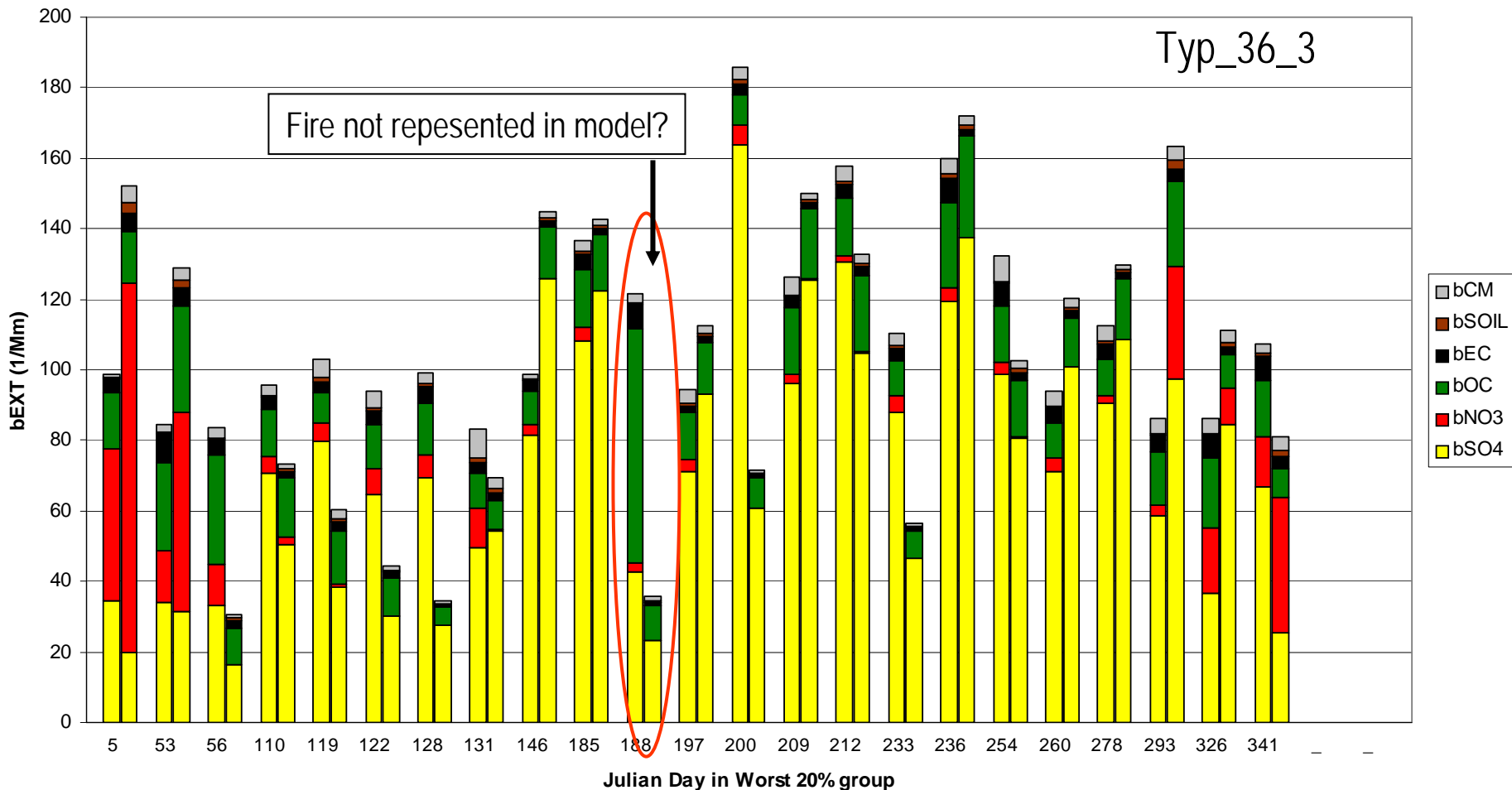
a)



b)

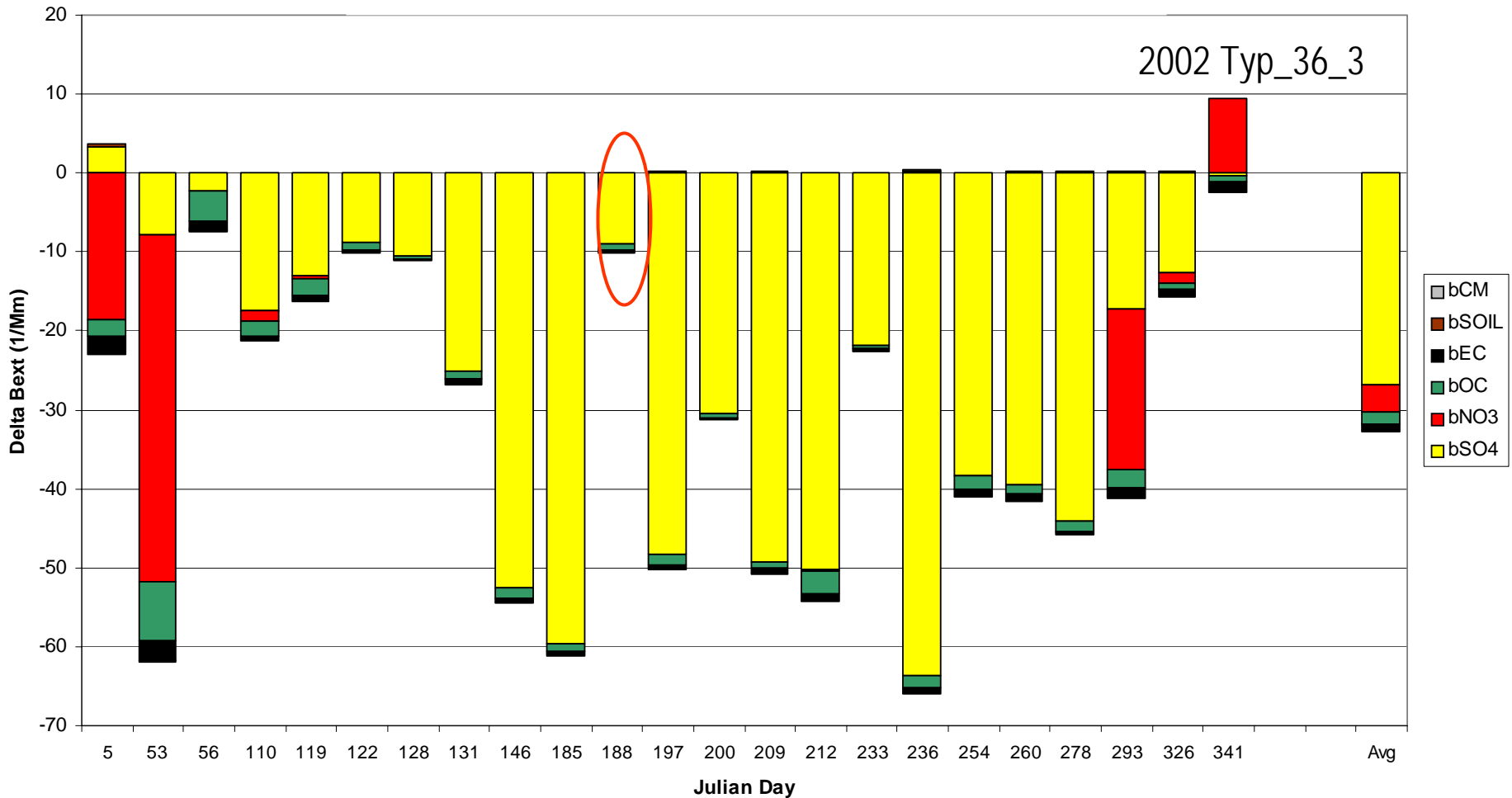


# 2002 20% Haziest Days at Swanquarter, NC Observations vs CMAQ 2002 Typical



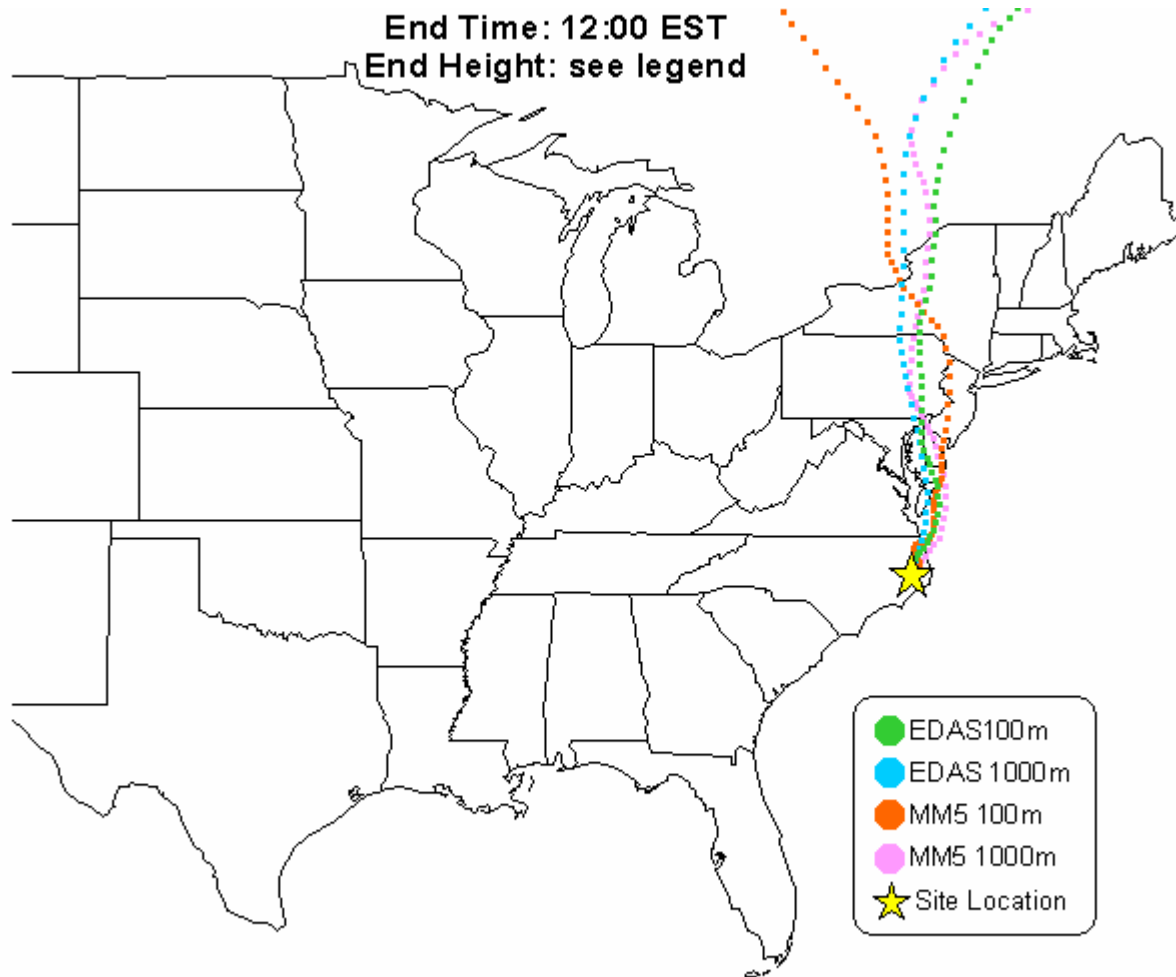
Model performance example for coastal site within +/-10% of reasonable progress goal.

# 2002 20% Haziest Days at Swanquarter, NC Reduction 2018 OTWc - 2002 Typical



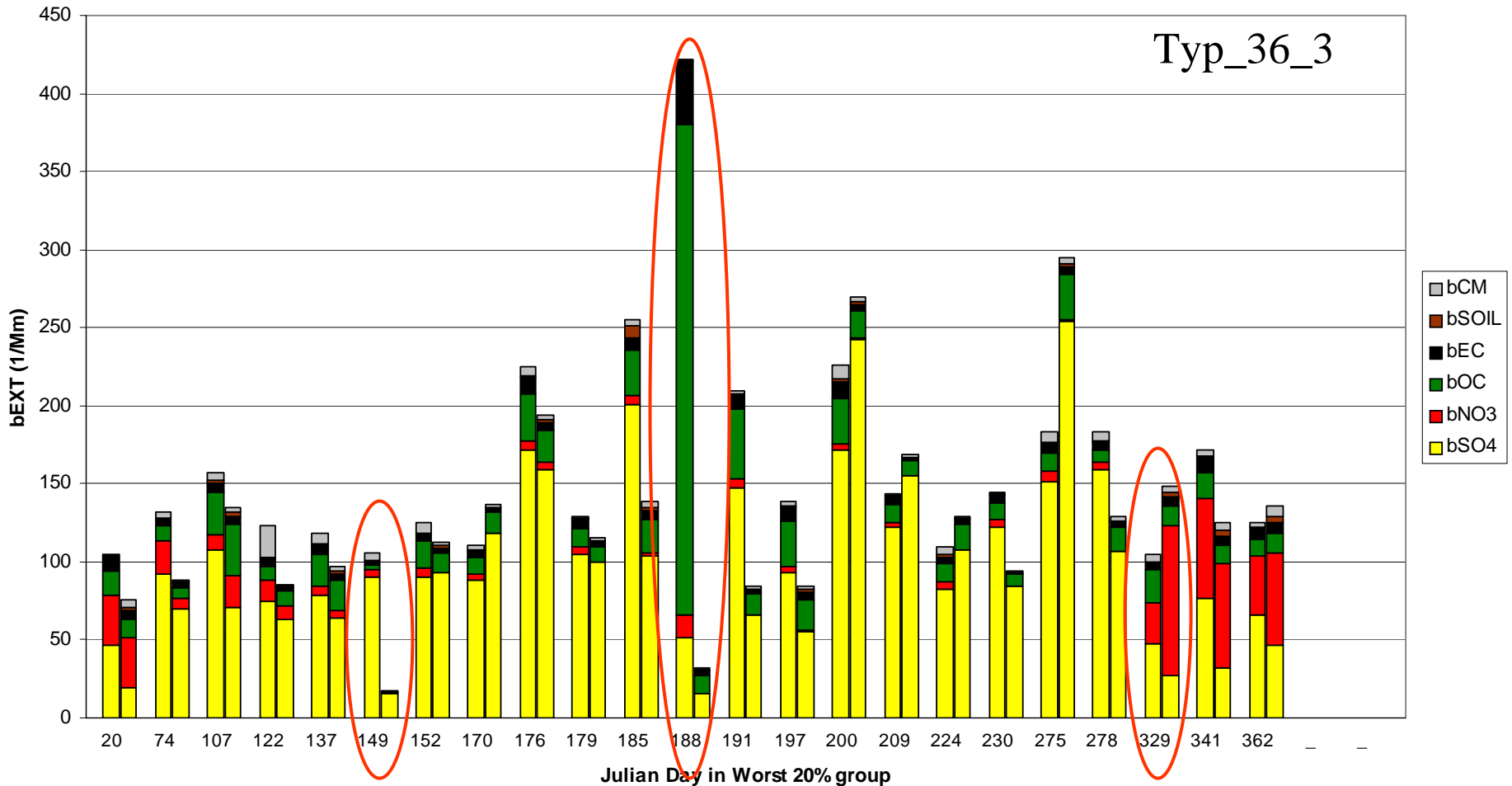
20% worst days occur between Jan and Dec; NO3 contributes on winter days

# Example Back Trajectory Analysis for Day with Poor Model Performance (July 7, 2002) Swanquarter, NC



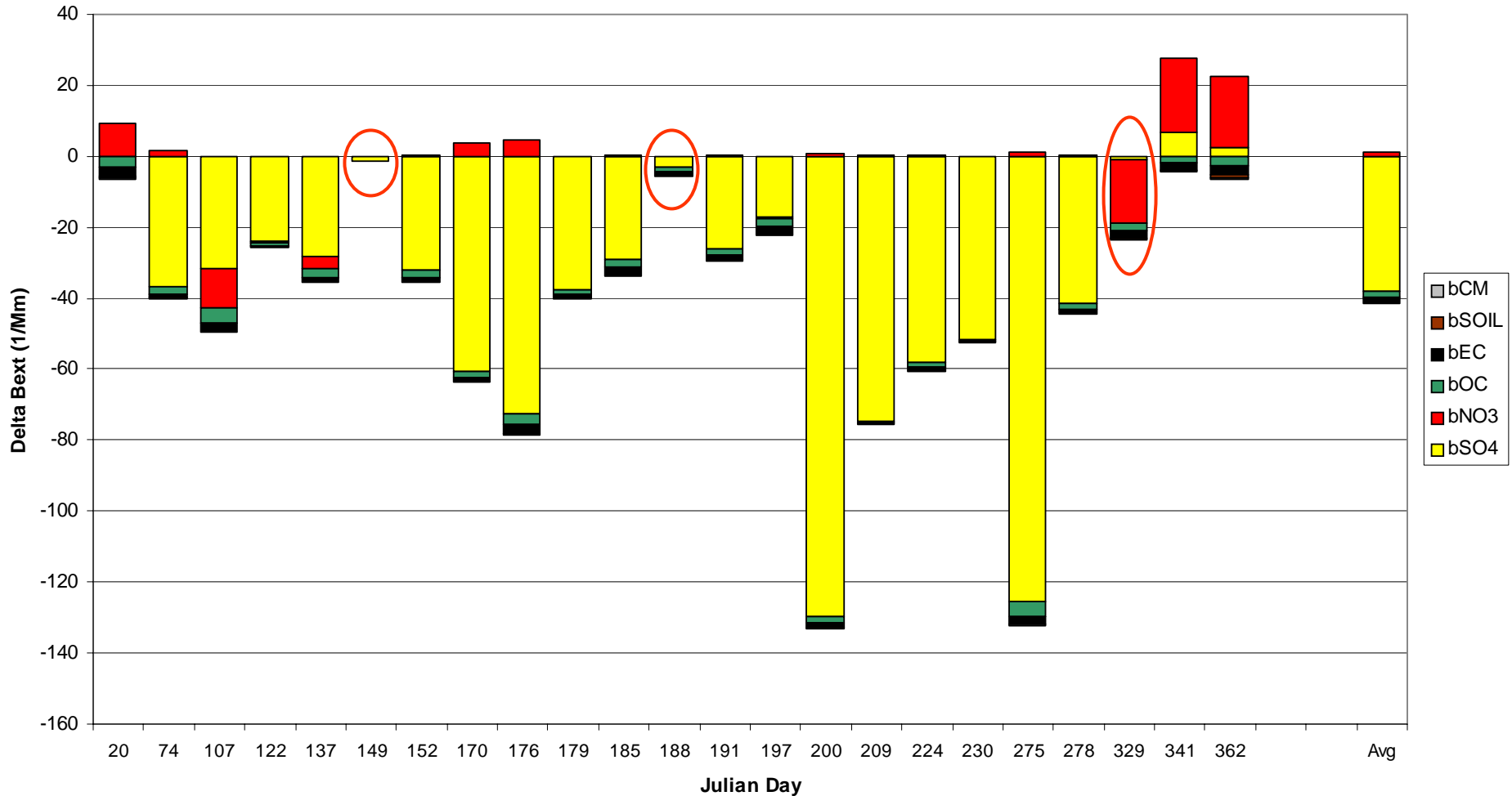
HYSPLIT using EDAS (observations) or MM5 (model) meteorology

# 2002 20% Haziest Days at Brigantine, NJ Observations vs CMAQ 2002 Typical



Model performance example for non-VISTAS site > 10% below reasonable progress goal.

# 2002 20% Haziest Days at Brigantine, NJ Reduction 2018 OTWc - 2002 Typical

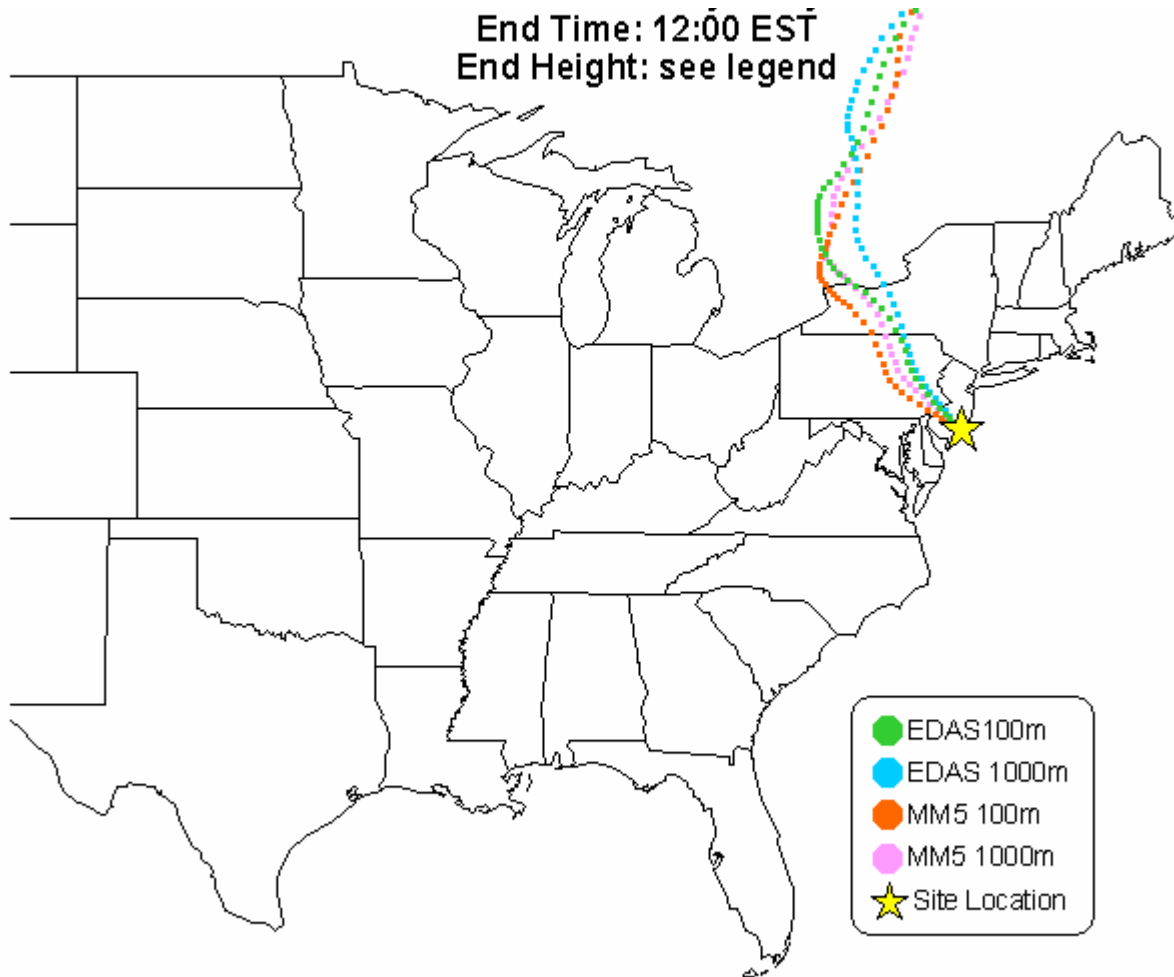


20% worst days occur between Jan and Dec; mostly responses to SO4 and NO3

# Example Back Trajectory Analysis for Day with Poor Model Performance (July 7, 2002)

Brigantine, NJ

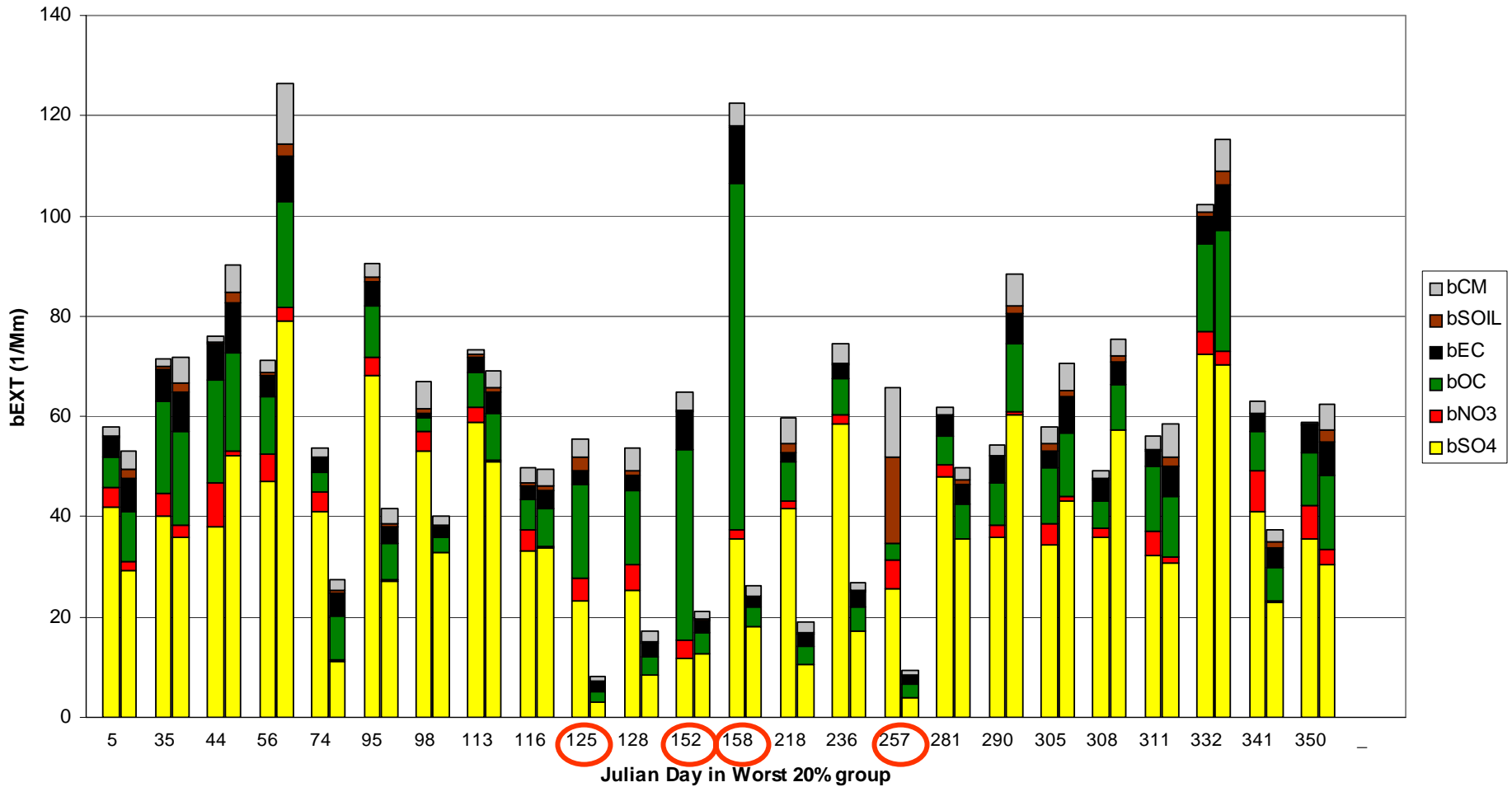
End Time: 12:00 EST  
End Height: see legend



HYSPLIT using EDAS (observations) or MM5 (model) meteorology

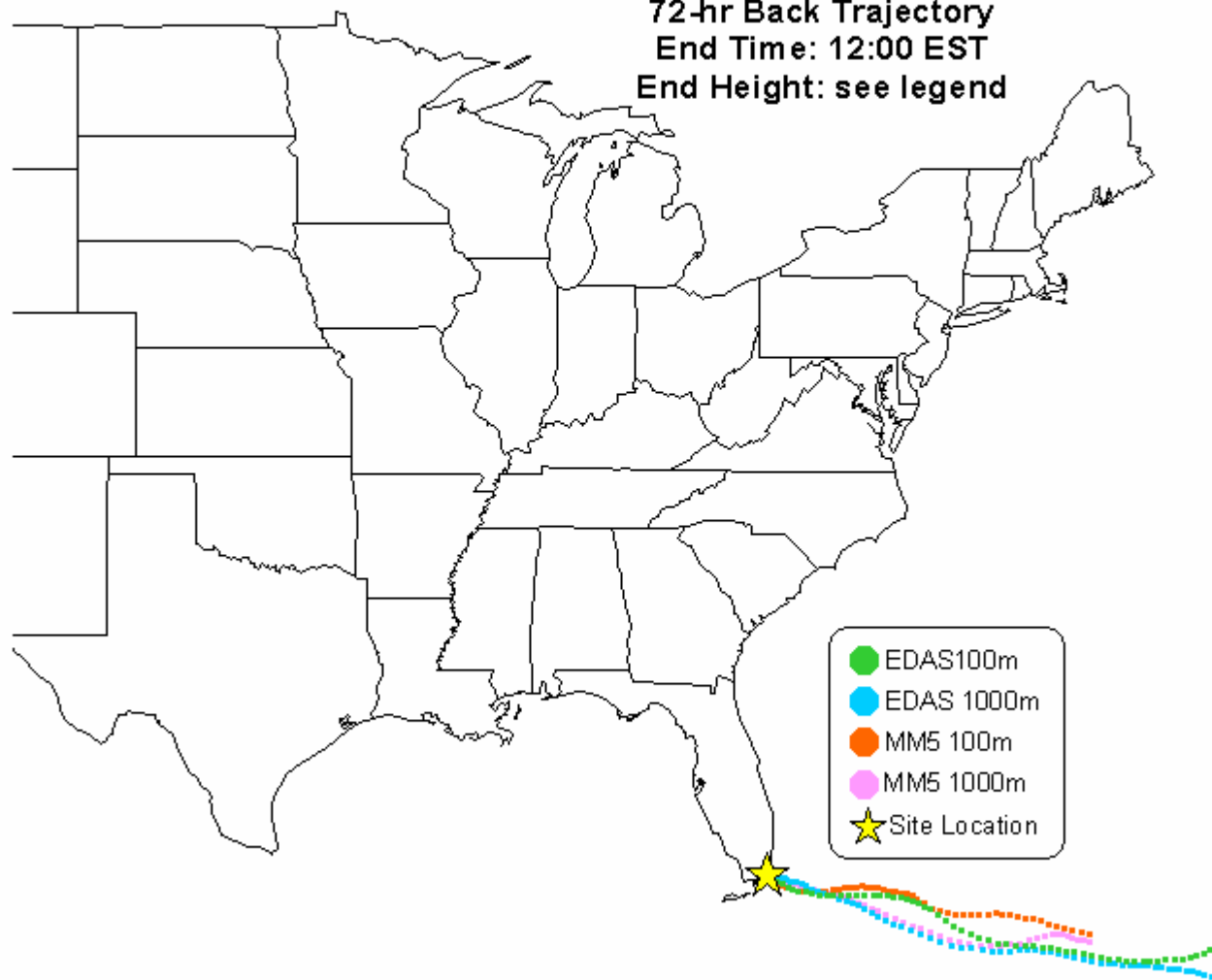
# 2002 20% Haziest Days at Everglades, FL Observations vs CMAQ 2002 Typical

Typ\_36\_3



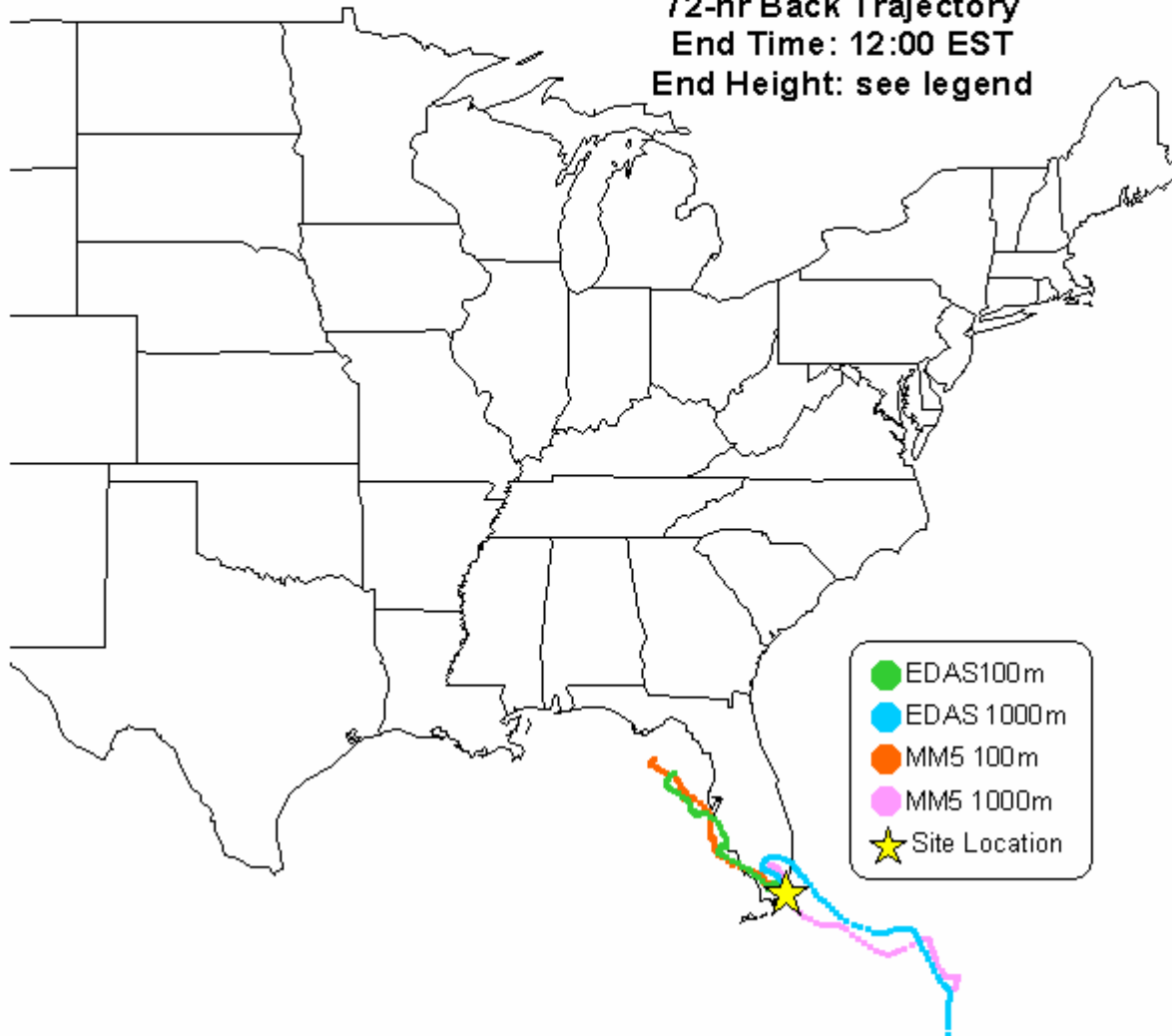
Julian Date 125

**Everglades**  
**May 5, 2002**  
**72-hr Back Trajectory**  
**End Time: 12:00 EST**  
**End Height: see legend**



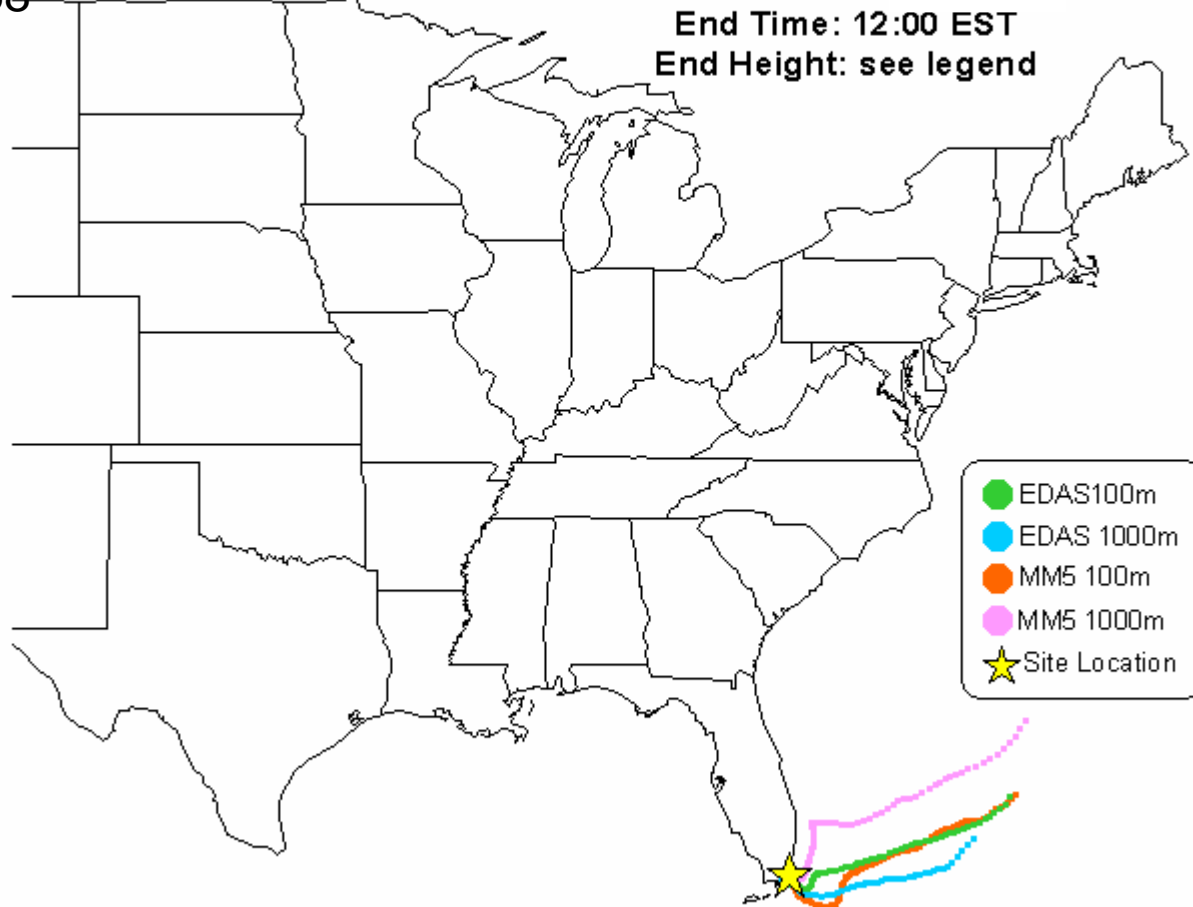
Julian Date 152

**Everglades**  
**June 1, 2002**  
**72-hr Back Trajectory**  
**End Time: 12:00 EST**  
**End Height: see legend**



# Example Back Trajectory Analysis for Day with Poor Model Performance (June 7, 2002) Everglades, FL

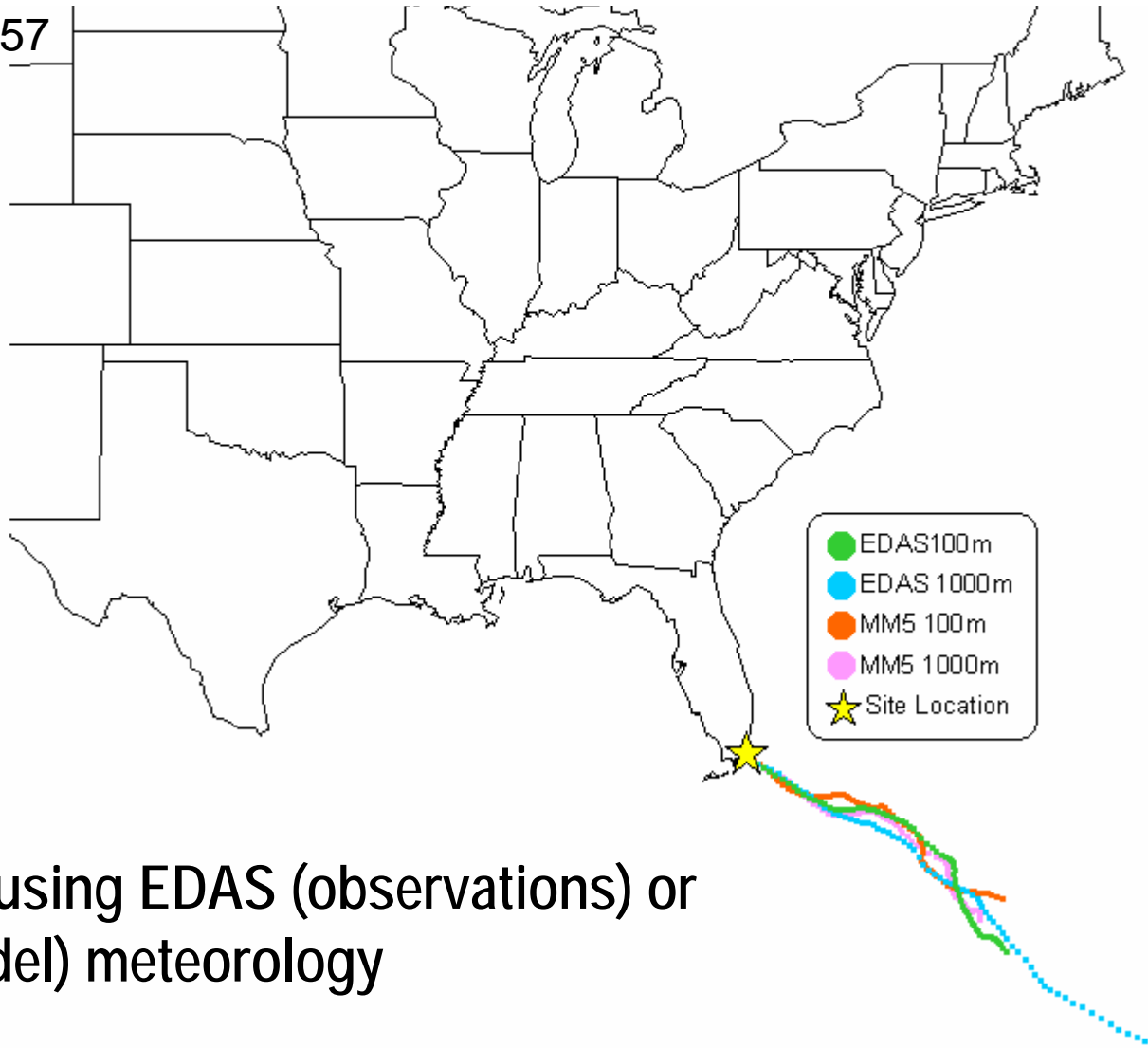
Julian date 158



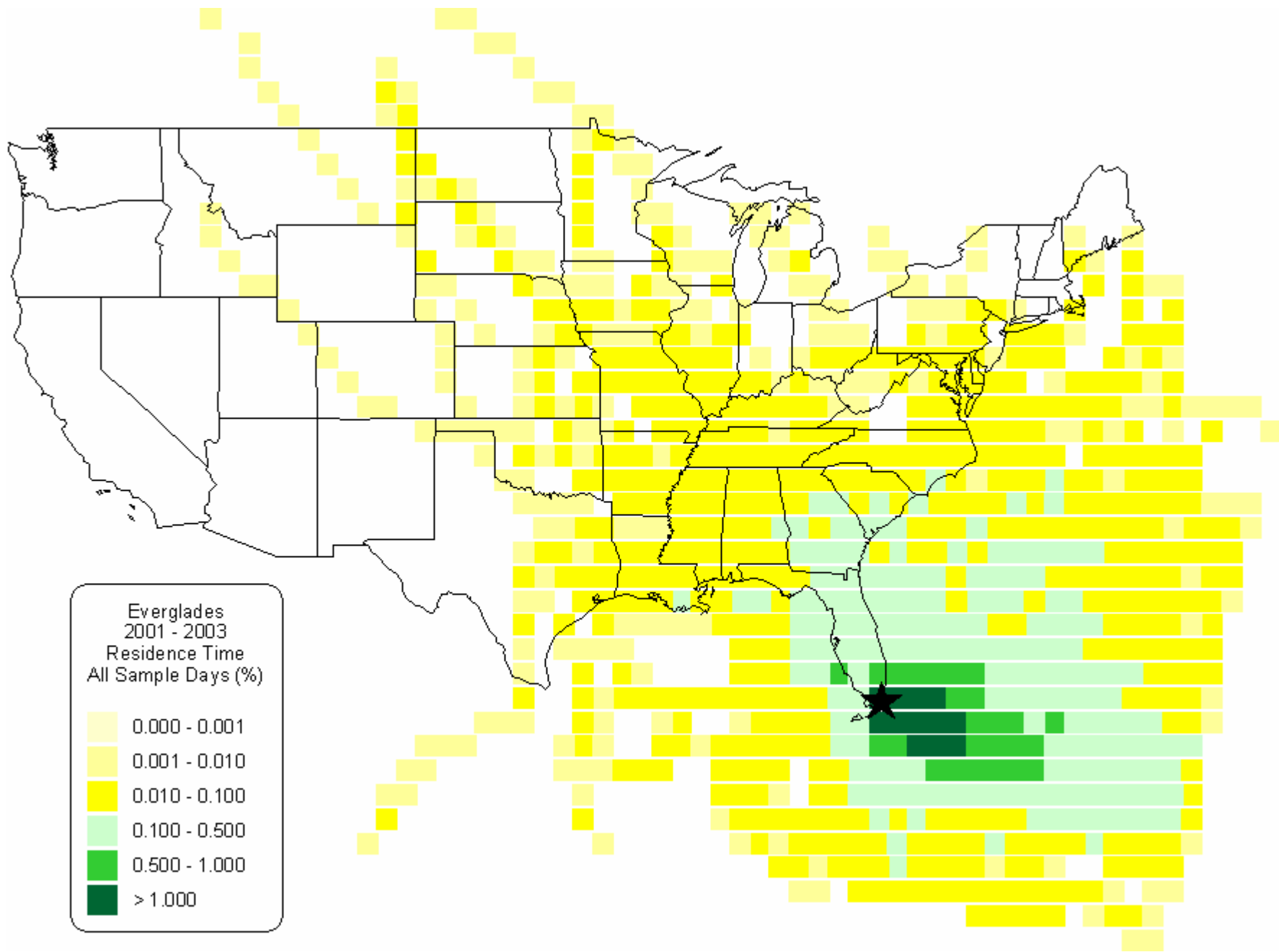
HYSPLIT using EDAS (observations) or MM5 (model) meteorology

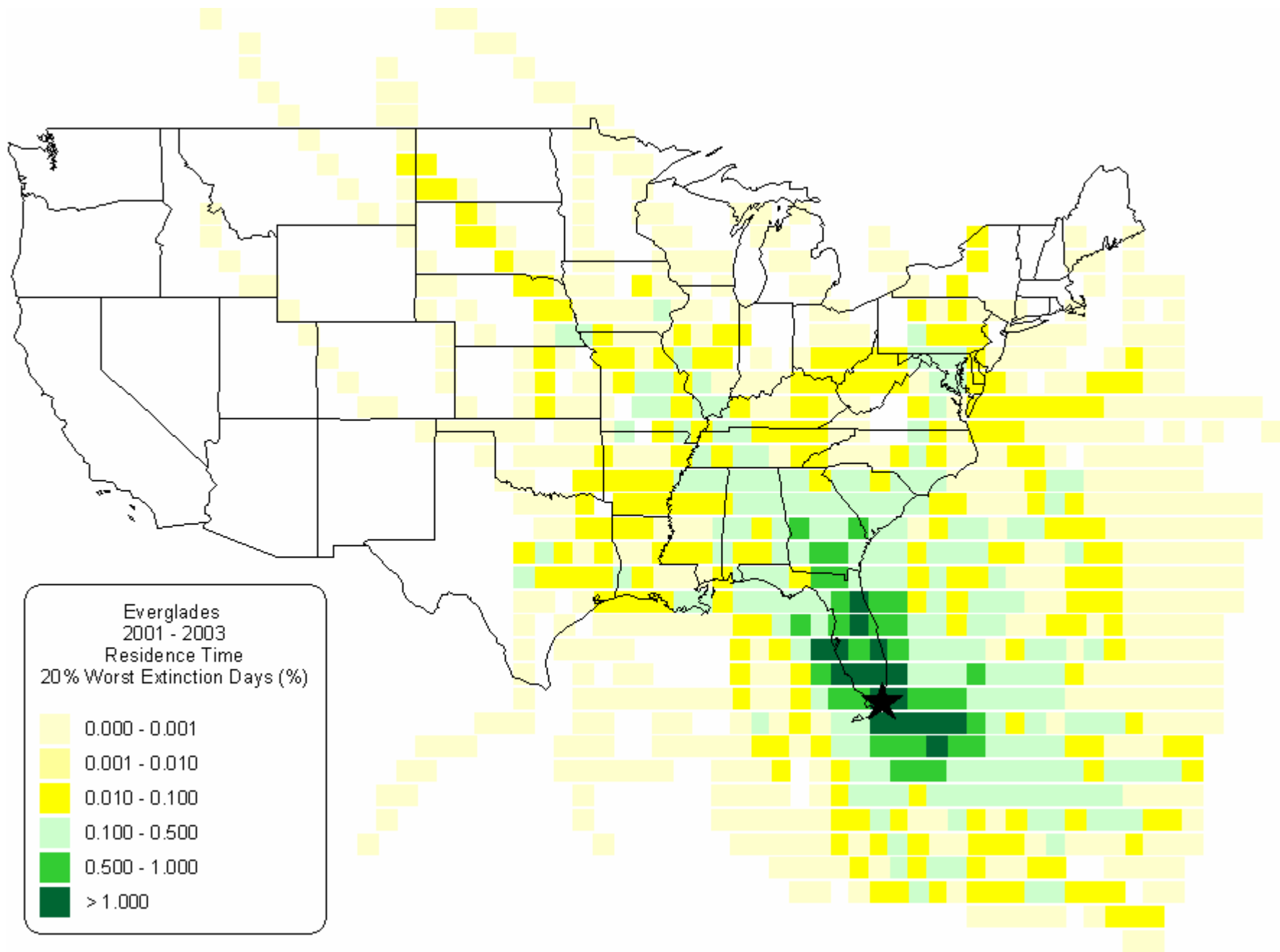
# Example Back Trajectory Analysis for Day with Poor Model Performance (Sep 14, 2002) Everglades, FL

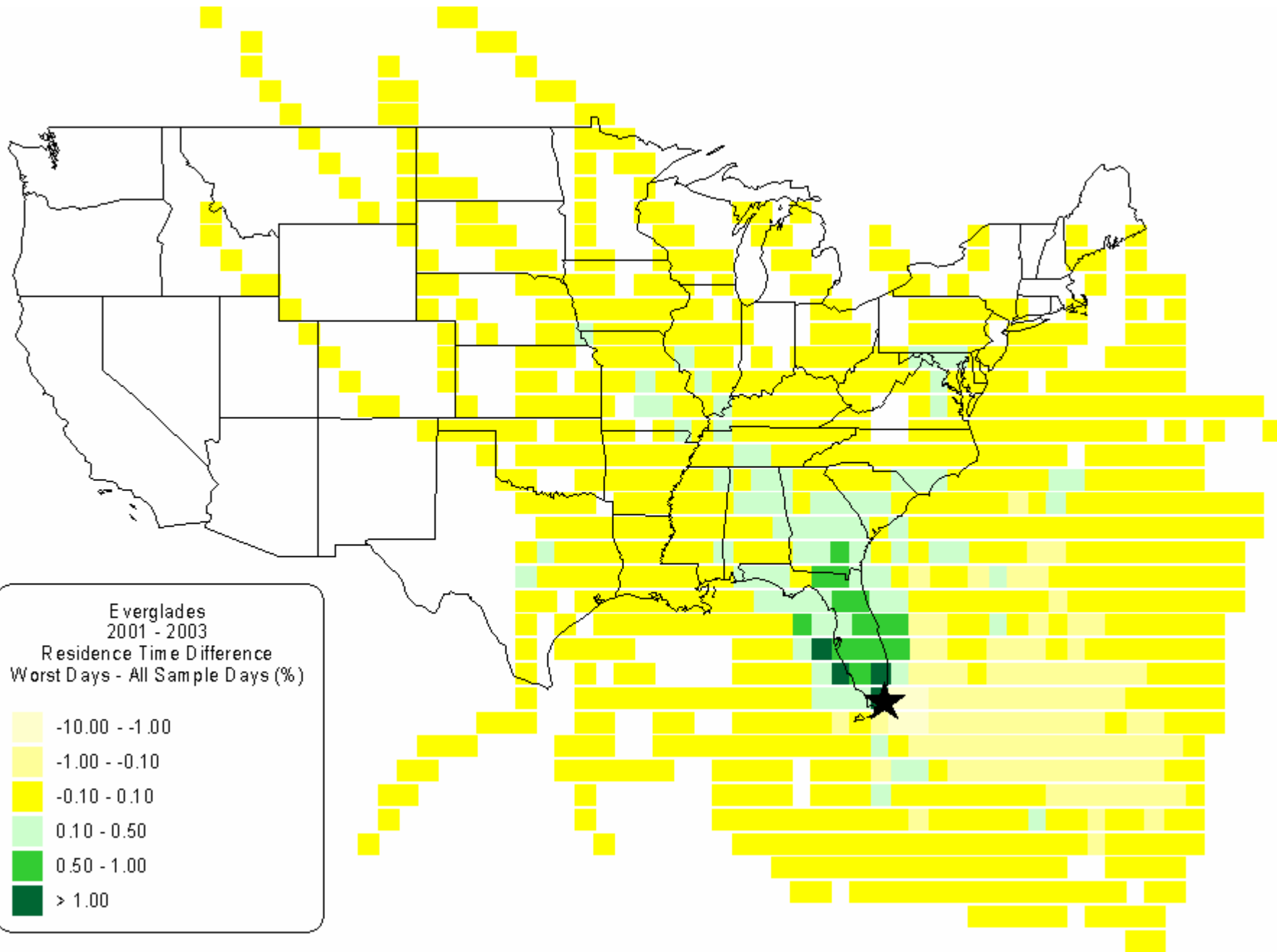
Julian Date 257



HYSPLIT using EDAS (observations) or  
MM5 (model) meteorology







# Percentage Reduction in 2018 (OTW-d) Compared to Reasonable Progress Goal Southern Coastal Sites

