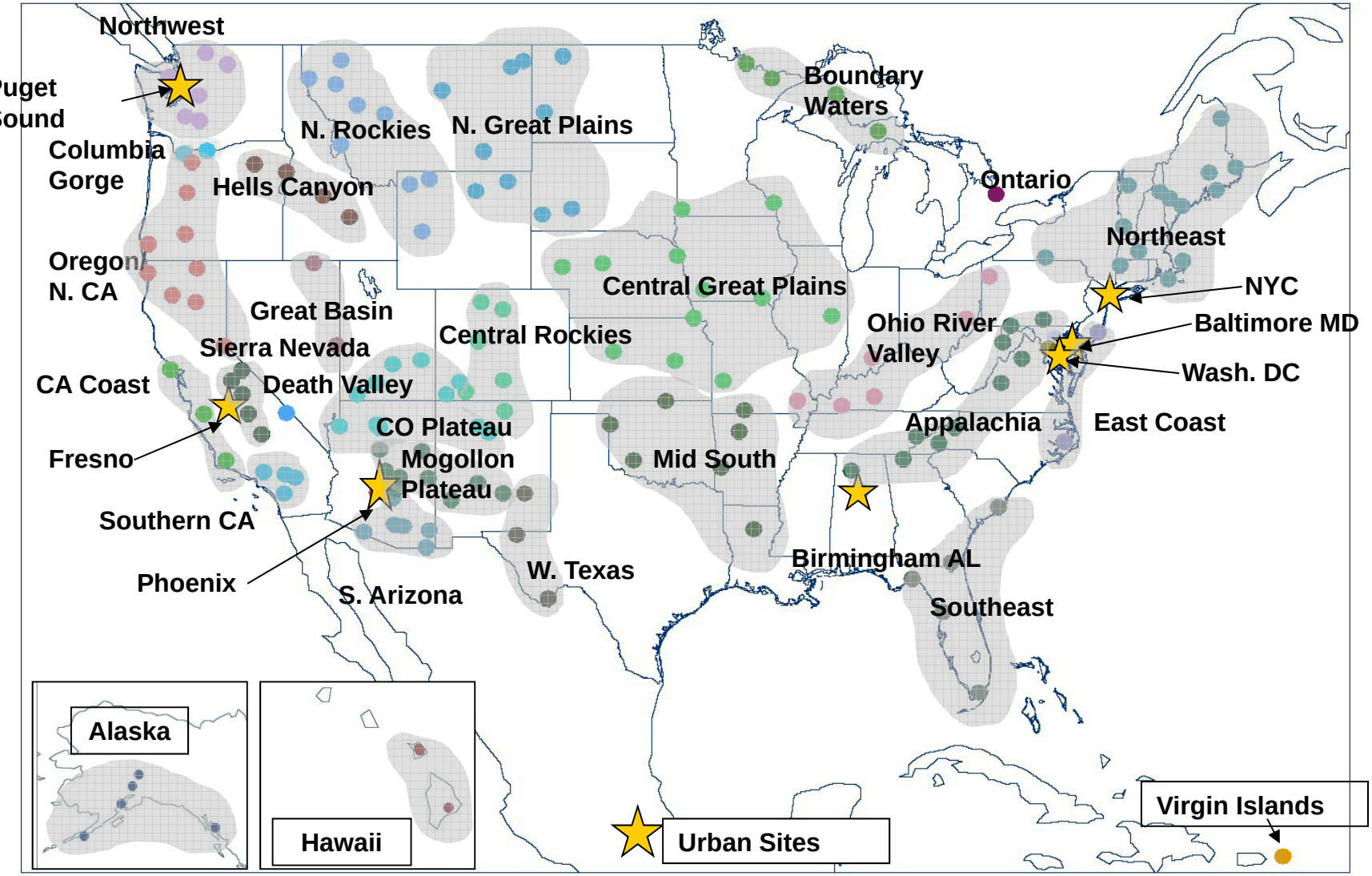
# IMPROVE

CANY 03/22/2004
Nitrate 4%
Sulfate 37%
EC 7%
Coarse 25%
Organic 18%
Soil 9%

# IMPROVE Network (Rural/Remote)

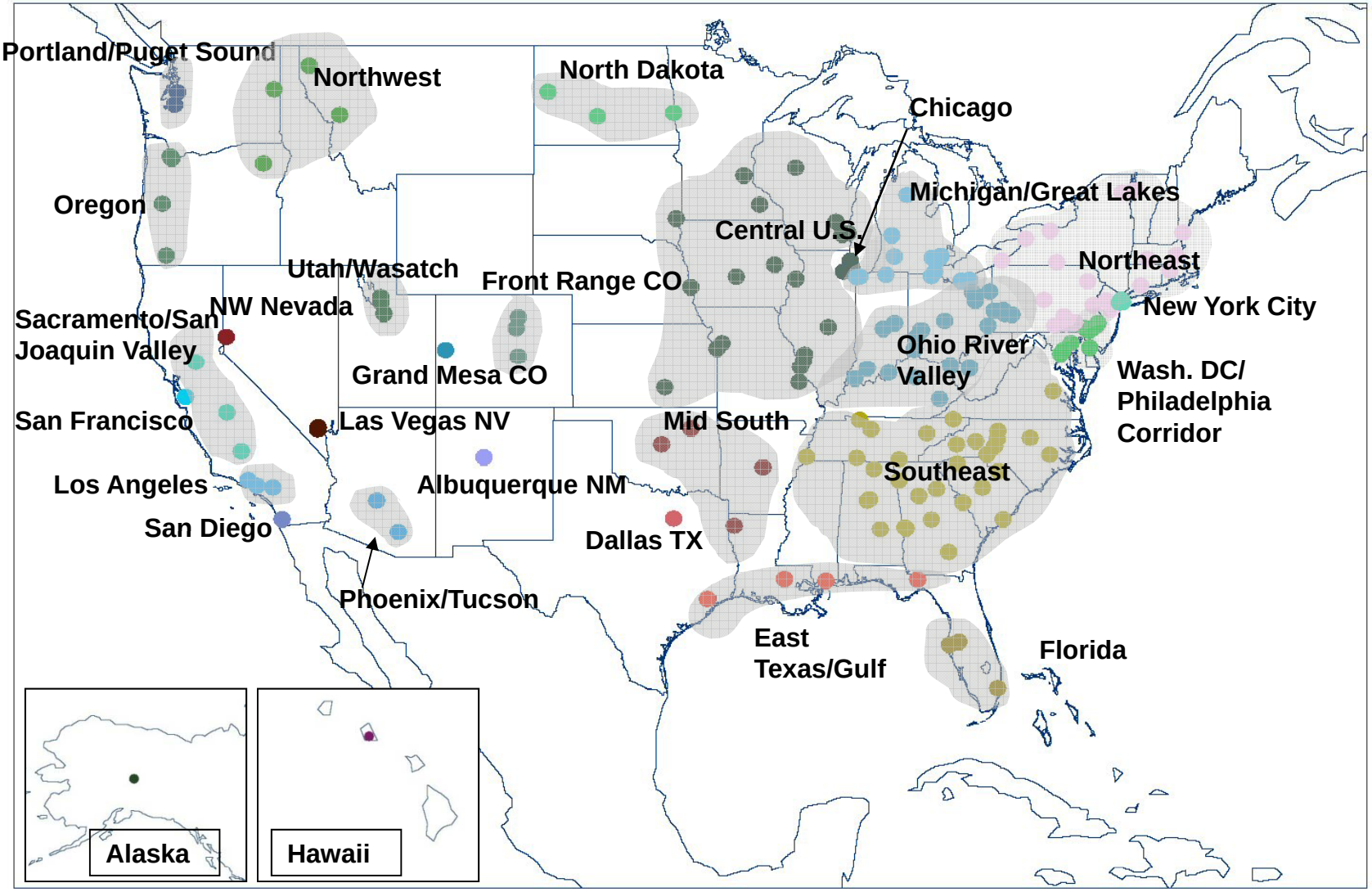



- Began operating in spring of 1988 with 20 monitoring sites
- Today has ~170 sites – 100+ sites with 9 or more years of data.

# *Mandatory Class I Areas*

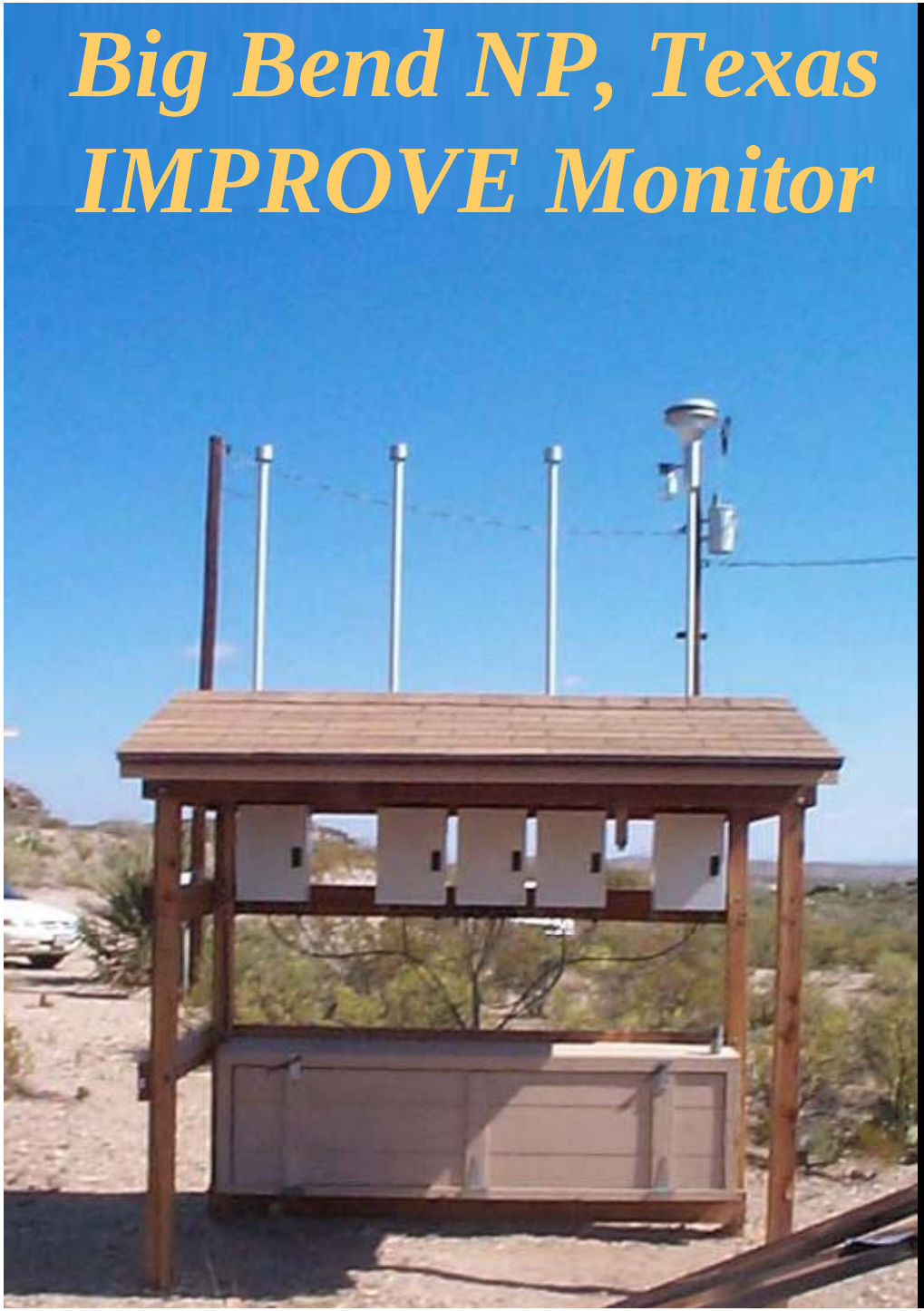
- 158 Class I Areas – 5k WA 6k NP 8/7/1977
  - 88 USFS
  - 48 NPS
  - 21 FWS
  - 1 International Park
- 156/158 where visibility important attribute
- 155/156 monitored with 110 IMPROVE sites

# CSN Network (urban/suburban)




- Began operation in 2000
- About 200 sites in 2006

# *Big Bend NP, Texas IMPROVE Monitor*



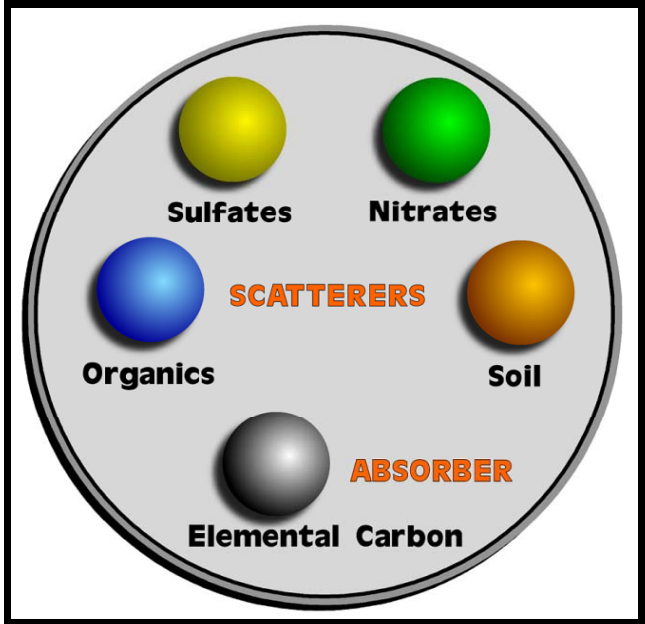
**IMPROVE sampler/filter analyses**

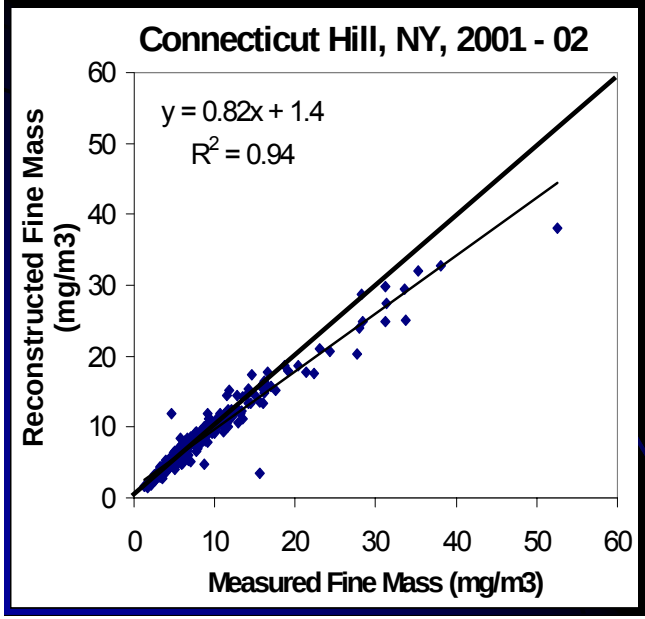
- 4 modules collect 24-h PM samples every third day
- A: PM2.5 Gravimetric mass, elements (Na-PB – XRF, H – PESA), absorption – HIPS
- B: PM2.5 SO4, NO3, Cl by ion chromatography
- C: PM2.5 Organic and elemental carbon – Thermal Optical Reflectance (TOR)
- D: PM10 gravimetric mass

**CSN sample/filter analyses**

- Similar sampler and filter analysis as IMPROVE
- Carbon analysis used TOT now uses TOR. Earlier data were reconciled

# *Aerosol Composite Components*

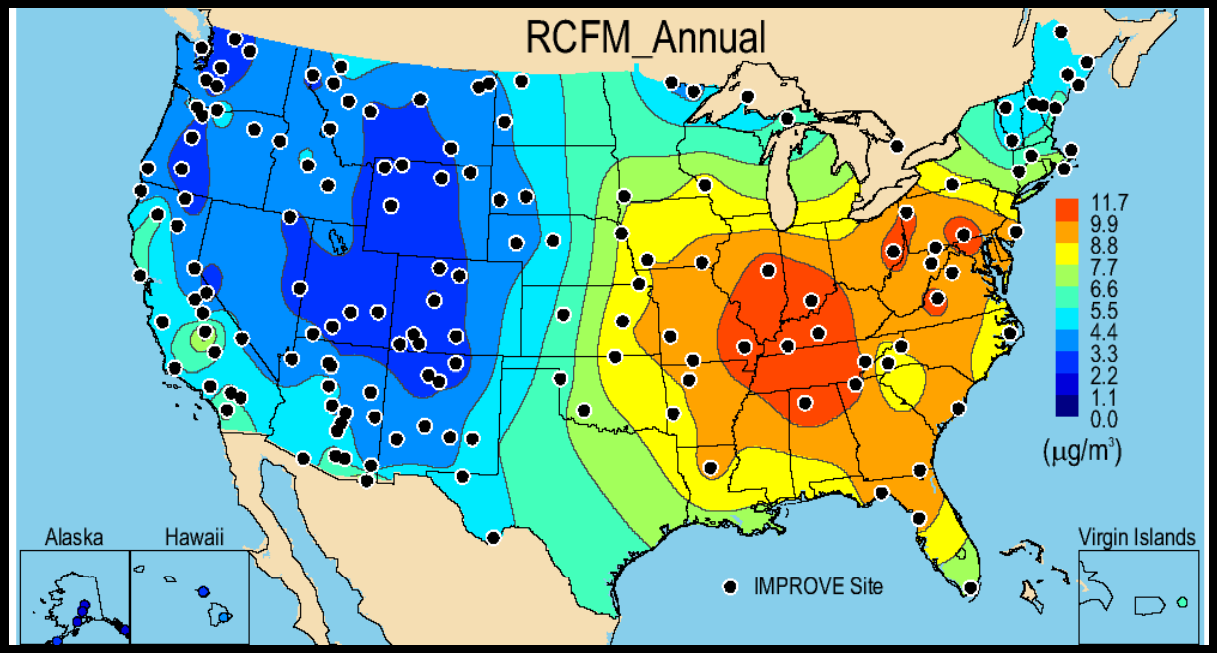


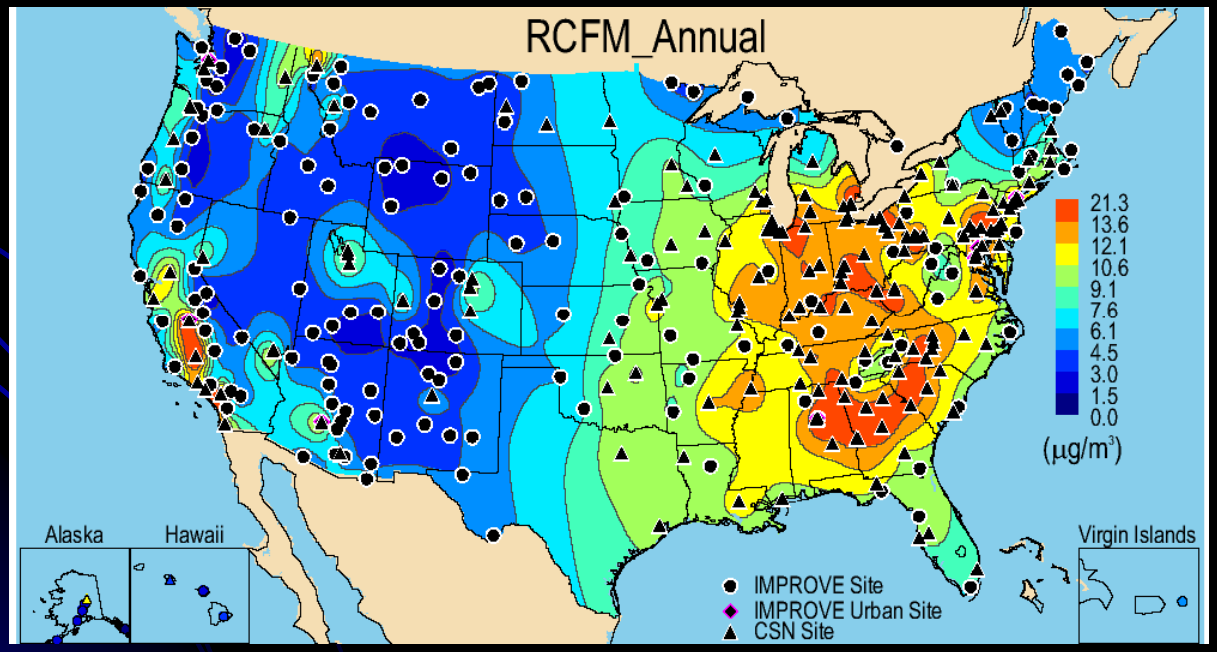



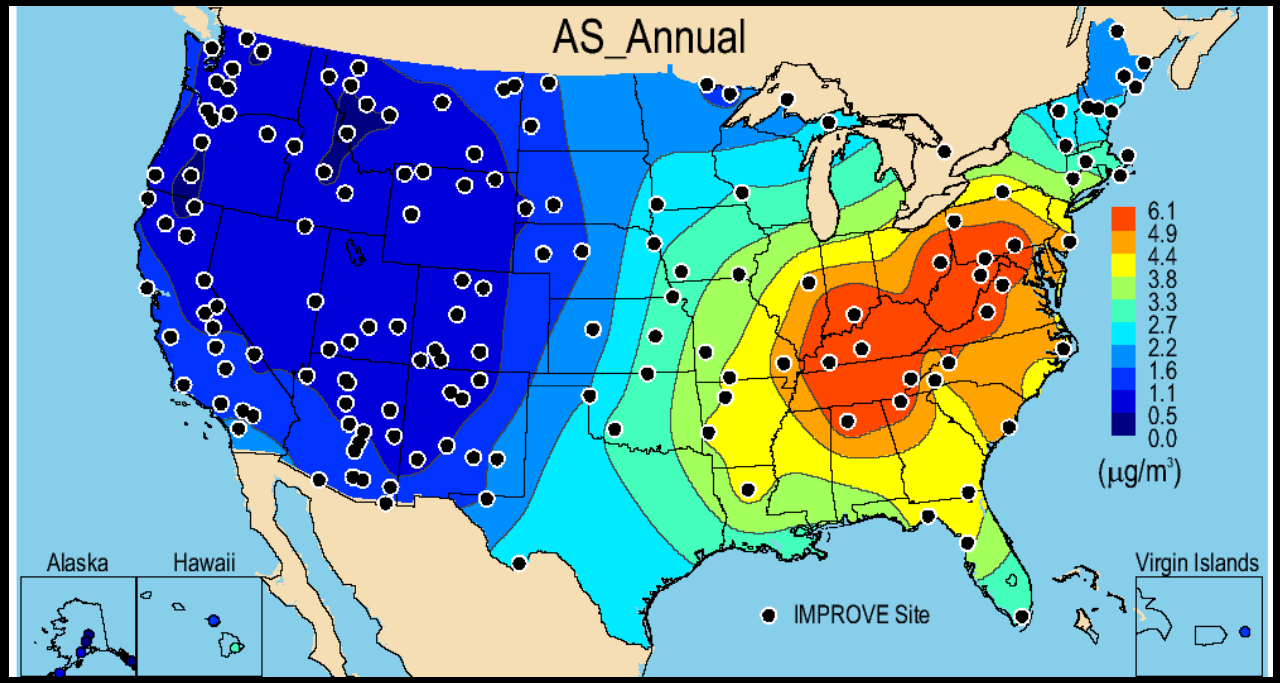

- Ammonium Sulfate = 1.375 * $[SO_4]$
- Ammonium Nitrate = 1.29 * $[NO_3^-]$
- Organics = 1.8 [OC]
- Light Absorbing Carbon = [EC]
- Soil = 2.2[Al]+2.49[Si]+1.63[Ca]+2.42[Fe] +1.94[Ti]
- Sea Salt = 1.8 * [Cl-]

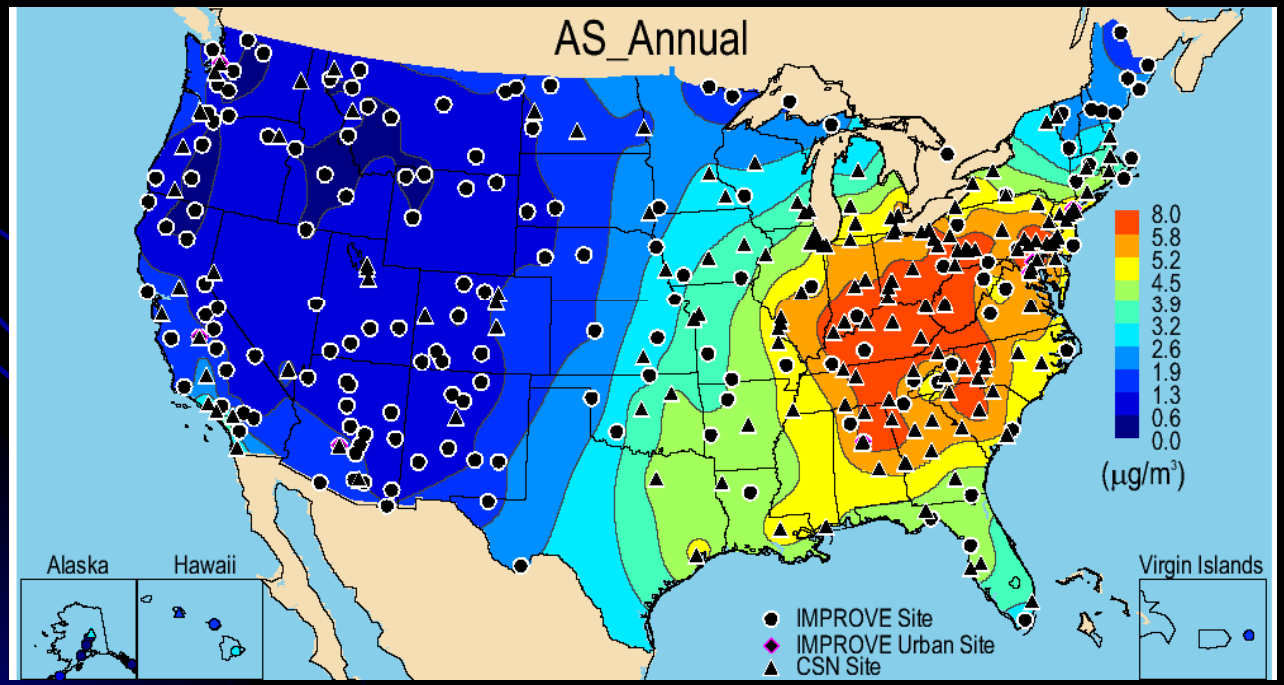
# *Calculation of $b_{ext}$*

bext = 2.2 × $f_S(RH)$ × [Small Sulfate] + 4.8 × $f_L(RH)$ × [Large Sulfate]
+ 2.4 × $f_S(RH)$ × [Small Nitrate] + 5.1 × $f_L(RH)$ × [Large Nitrate]
+ 2.8 × [Small Organic Mass] + 6.1 × [Large Organic Mass]
+ 10 × [Elemental Carbon]
+ 1 × [Fine Soil]
+ 0.6 × [Coarse Mass]
+ 1.7 × $f_{SS}(RH)$ × [Sea Salt]
+ Rayleigh Scattering (Site Specific)
+ 0.33 × [$NO_2$ (ppb)] {or as: 0.1755 × [$NO_2$ (μg/$m^3$)]}

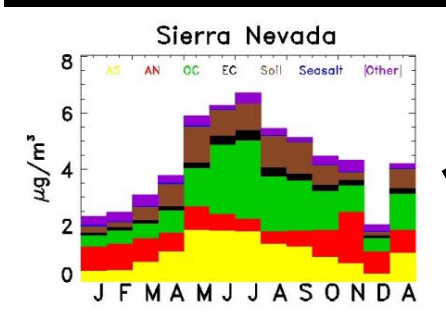

RCFM_Annual
11.7
9.9
8.8
7.7
6.6
5.5
4.4
3.3
2.2
1.1
0.0
(μg/m³)
Alaska
Hawaii
Virgin Islands
IMPROVE Site

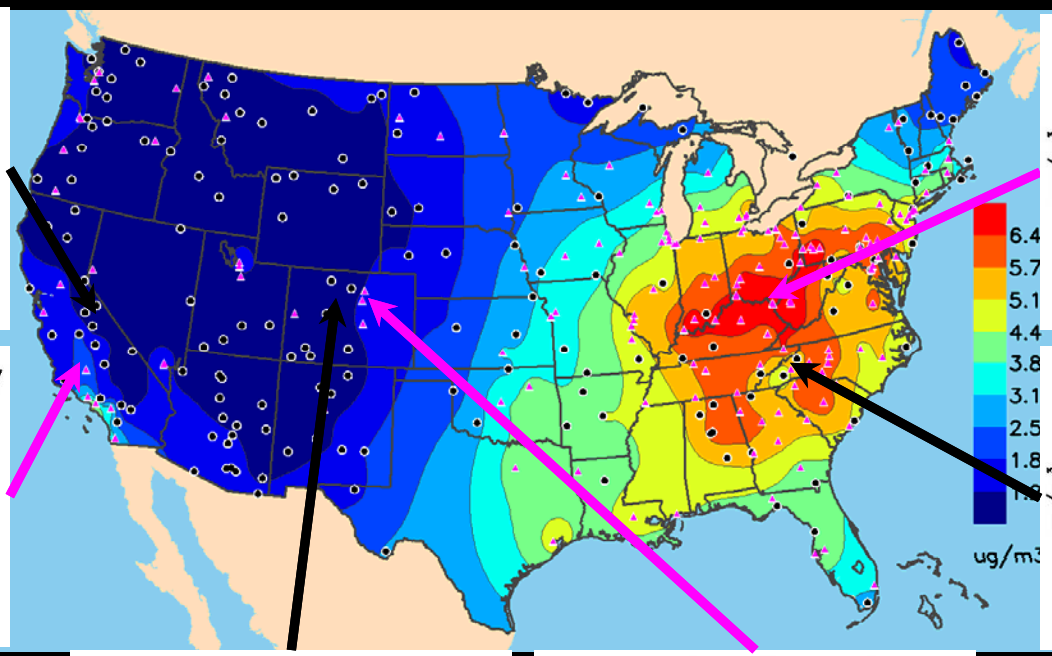

RCFM_Annual
21.3
13.6
12.1
10.6
9.1
7.6
6.1
4.5
3.0
1.5
0.0
(μg/m³)
Alaska
Hawaii
Virgin Islands
IMPROVE Site
IMPROVE Urban Site
CSN Site


AS_Annual
6.1
4.9
4.4
3.8
3.3
2.7
2.2
1.6
1.1
0.5
0.0
(μg/m³)
Alaska
Hawaii
Virgin Islands
IMPROVE Site

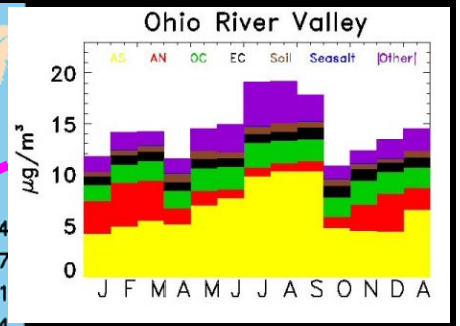

AS_Annual
8.0
5.8
5.2
4.5
3.9
3.2
2.6
1.9
1.3
0.6
0.0
(μg/m³)
Alaska
Hawaii
Virgin Islands
IMPROVE Site
IMPROVE Urban Site
CSN Site

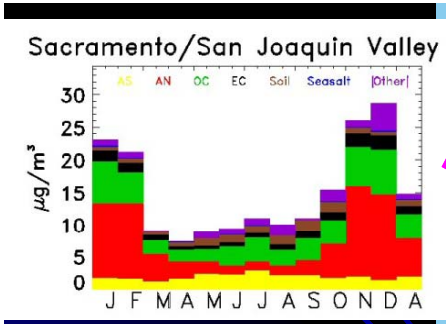
# *Ammonium Sulfate*



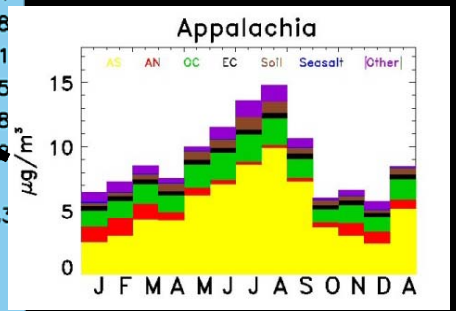



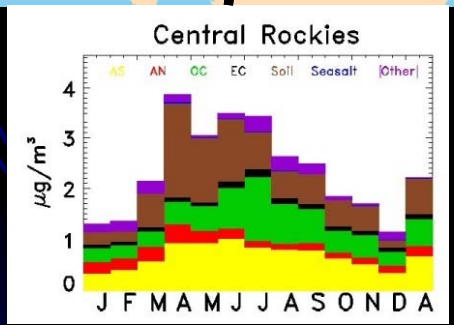

Urban

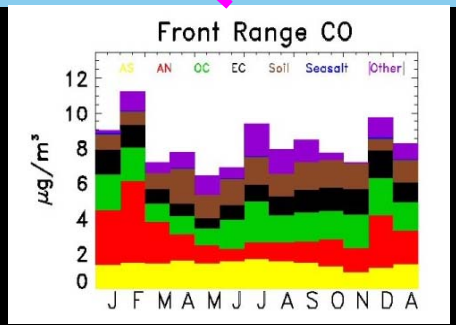


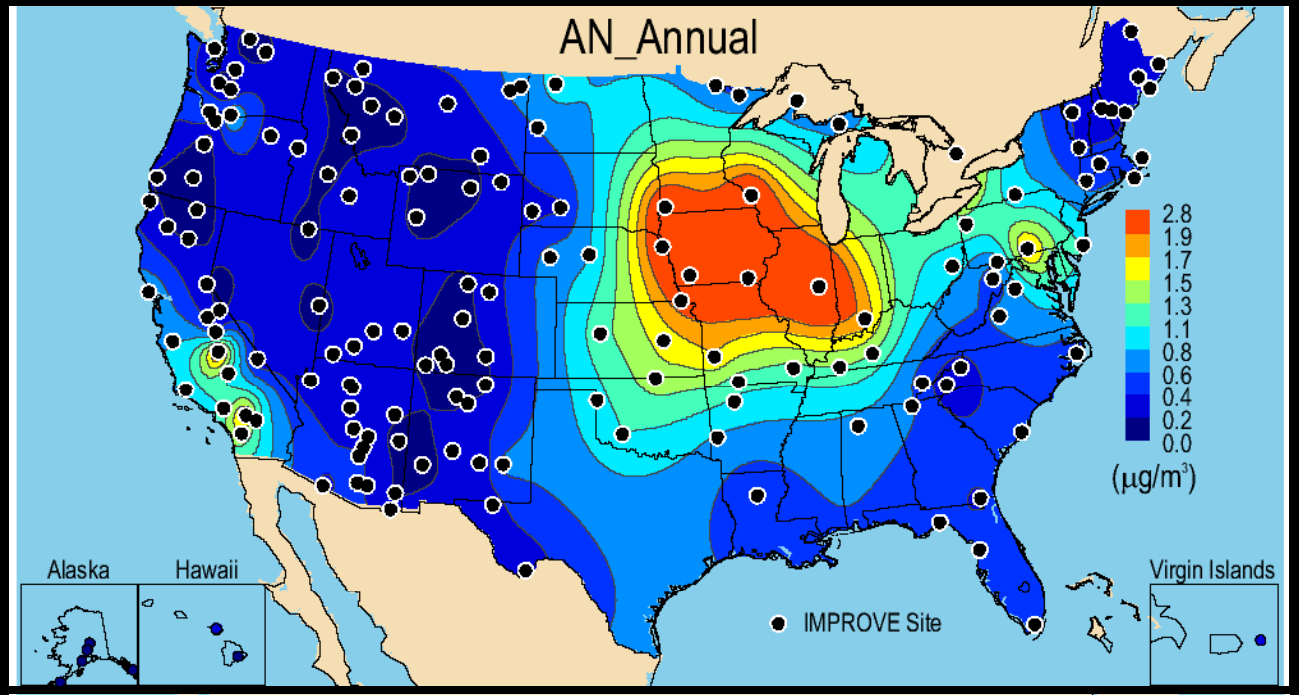

Urban

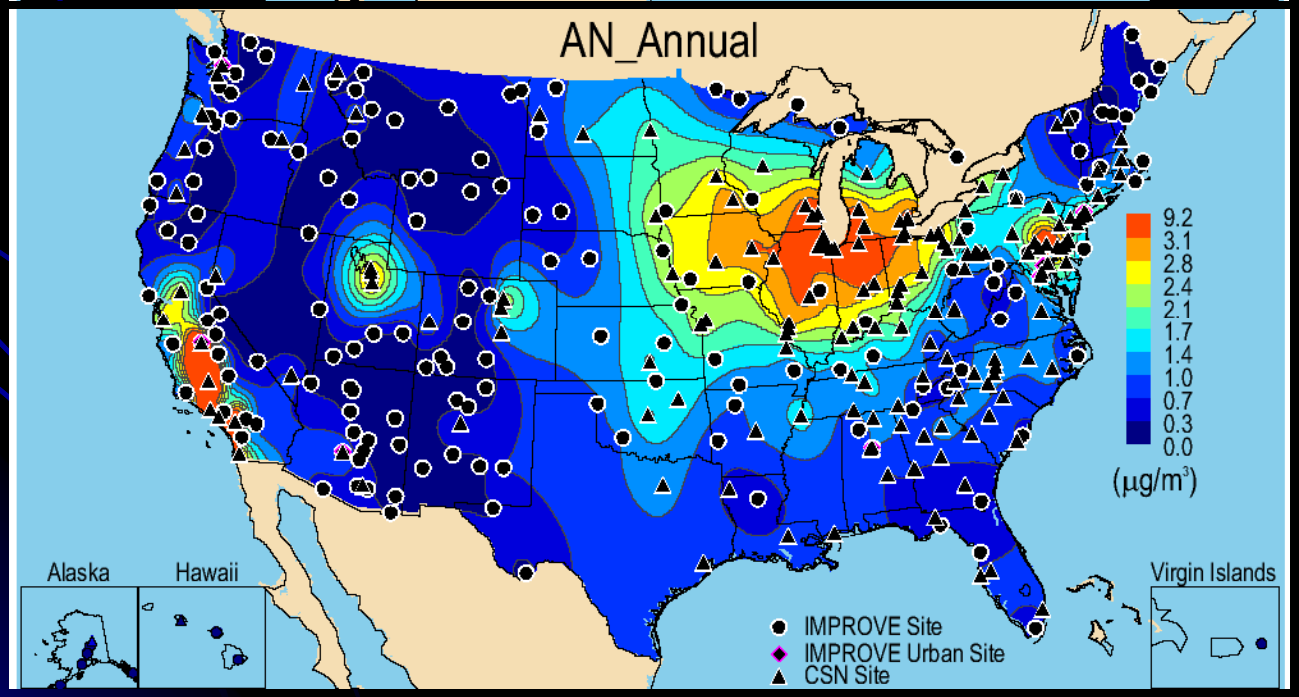


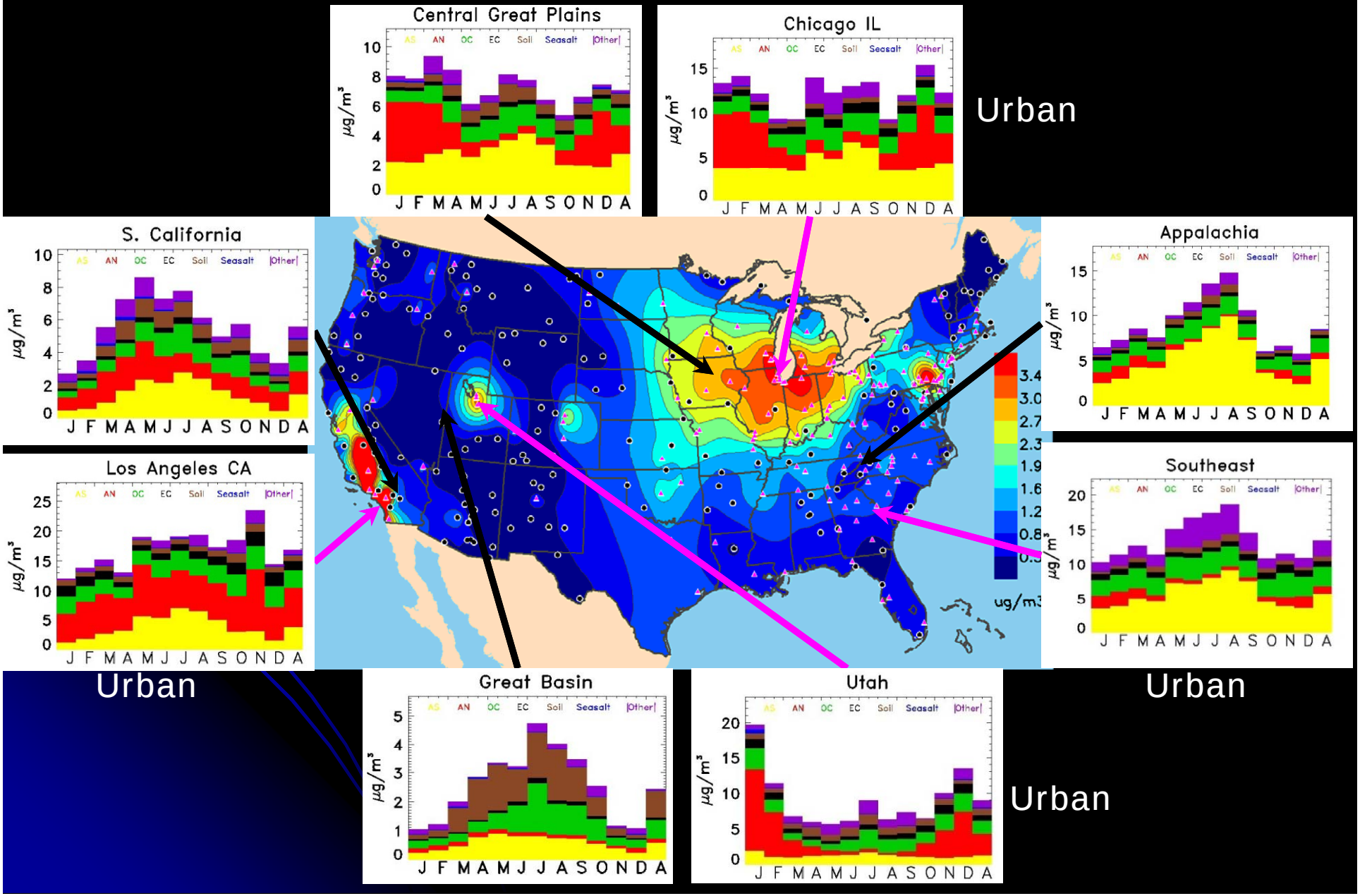



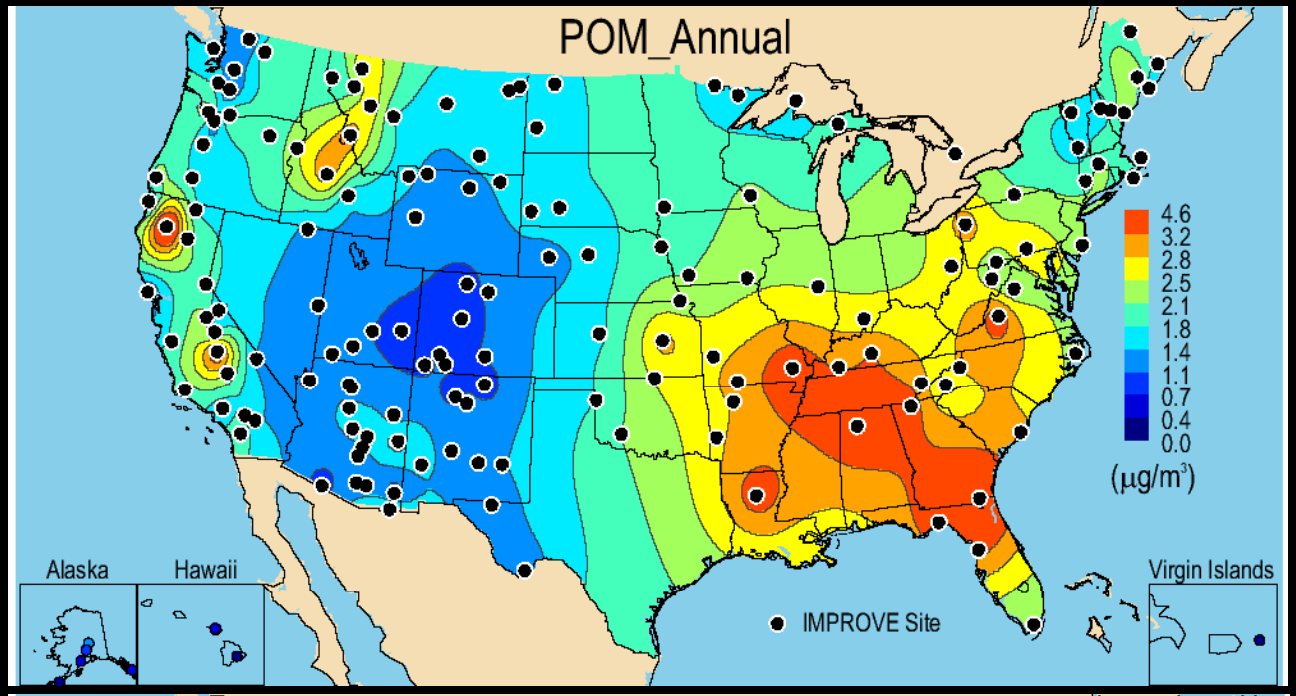

Urban

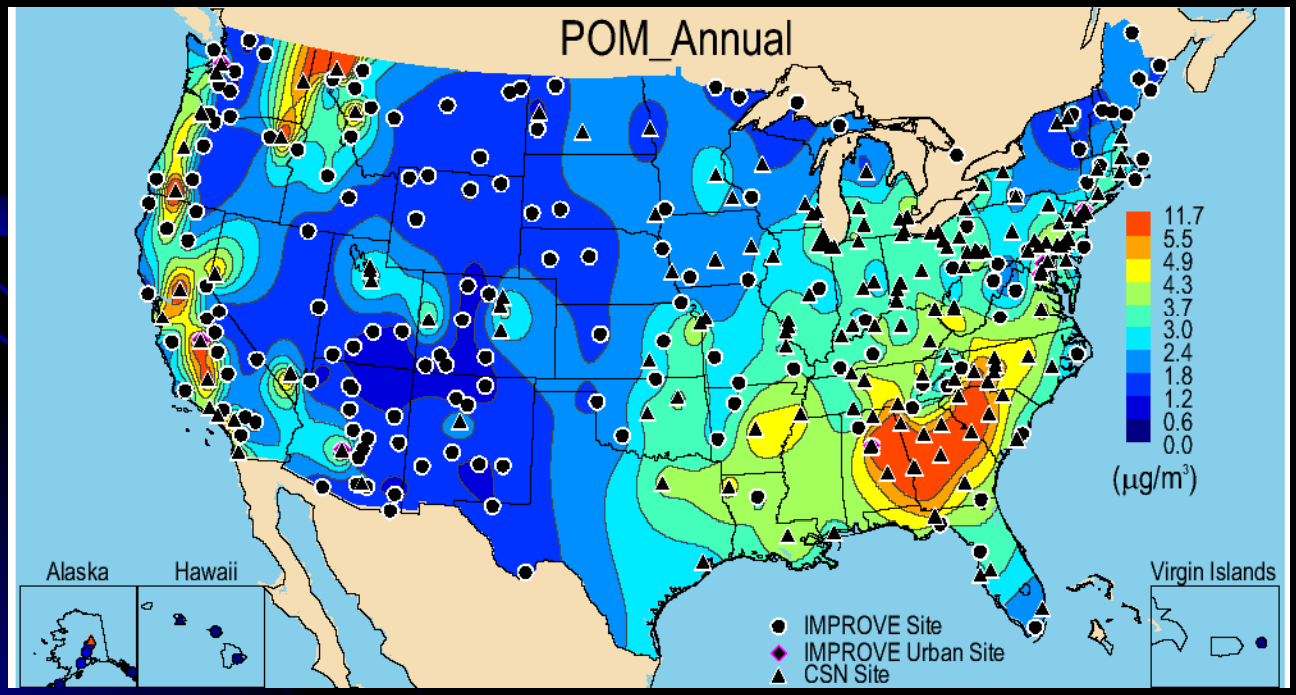

AN_Annual
2.8
1.9
1.7
1.5
1.3
1.1
0.8
0.6
0.4
0.2
0.0
(μg/m³)
Alaska
Hawaii
Virgin Islands
IMPROVE Site


AN_Annual
9.2
3.1
2.8
2.4
2.1
1.7
1.4
1.0
0.7
0.3
0.0
(μg/m³)
Alaska
Hawaii
Virgin Islands
IMPROVE Site
IMPROVE Urban Site
CSN Site

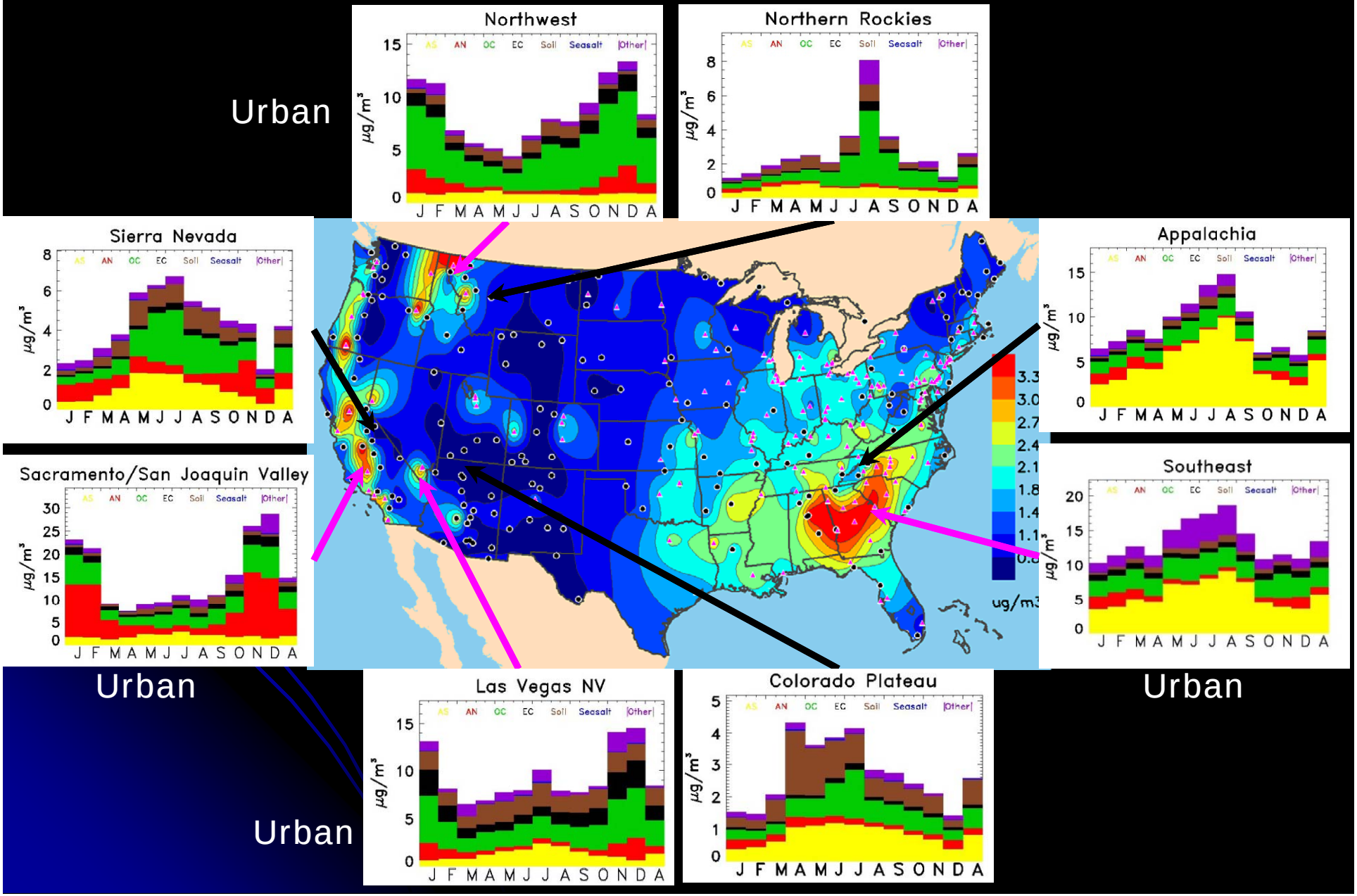
# *Ammonium Nitrate*



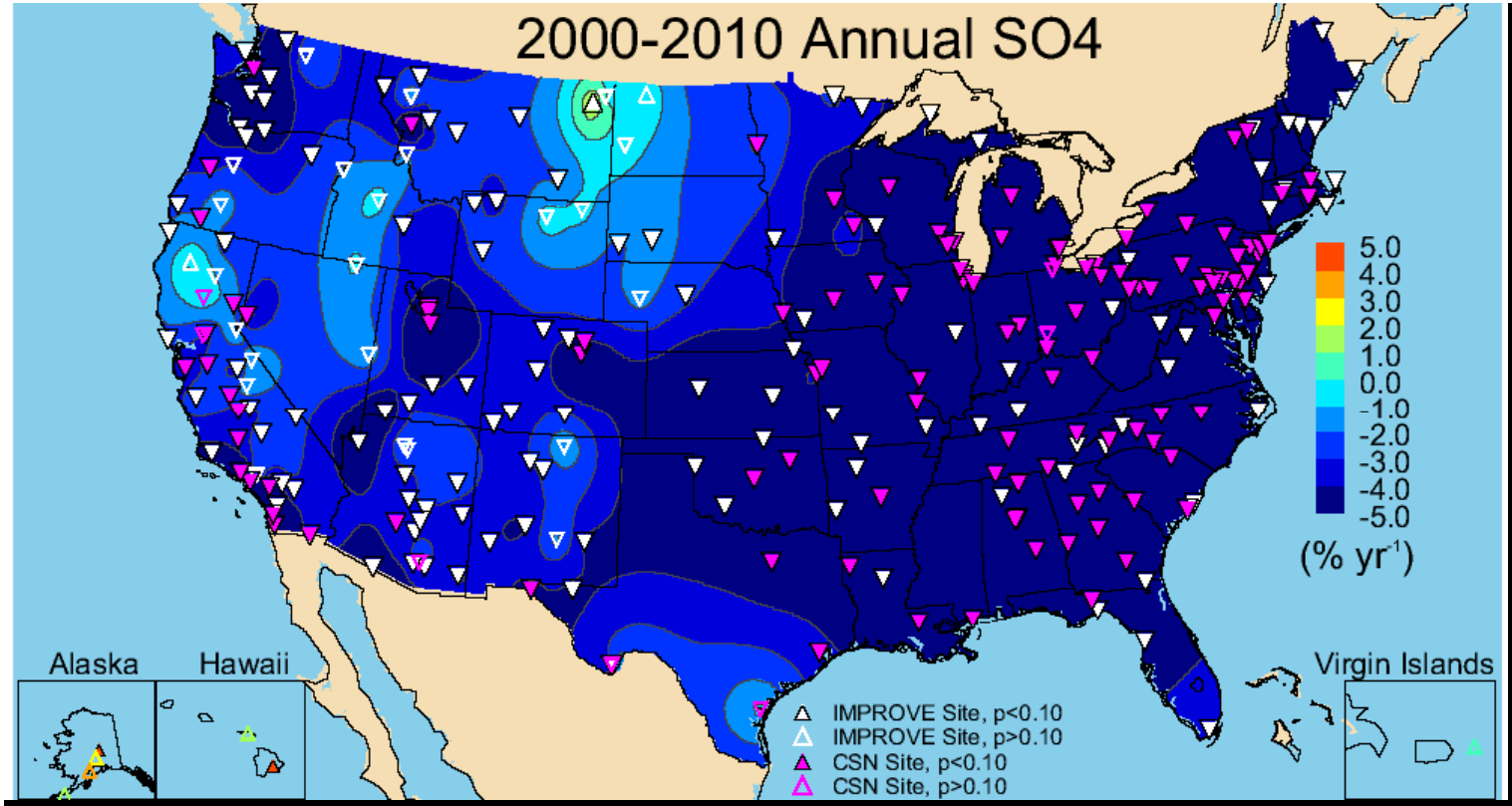

POM_Annual
4.6
3.2
2.8
2.5
2.1
1.8
1.4
1.1
0.7
0.4
0.0
(μg/m³)
Alaska
Hawaii
Virgin Islands
IMPROVE Site

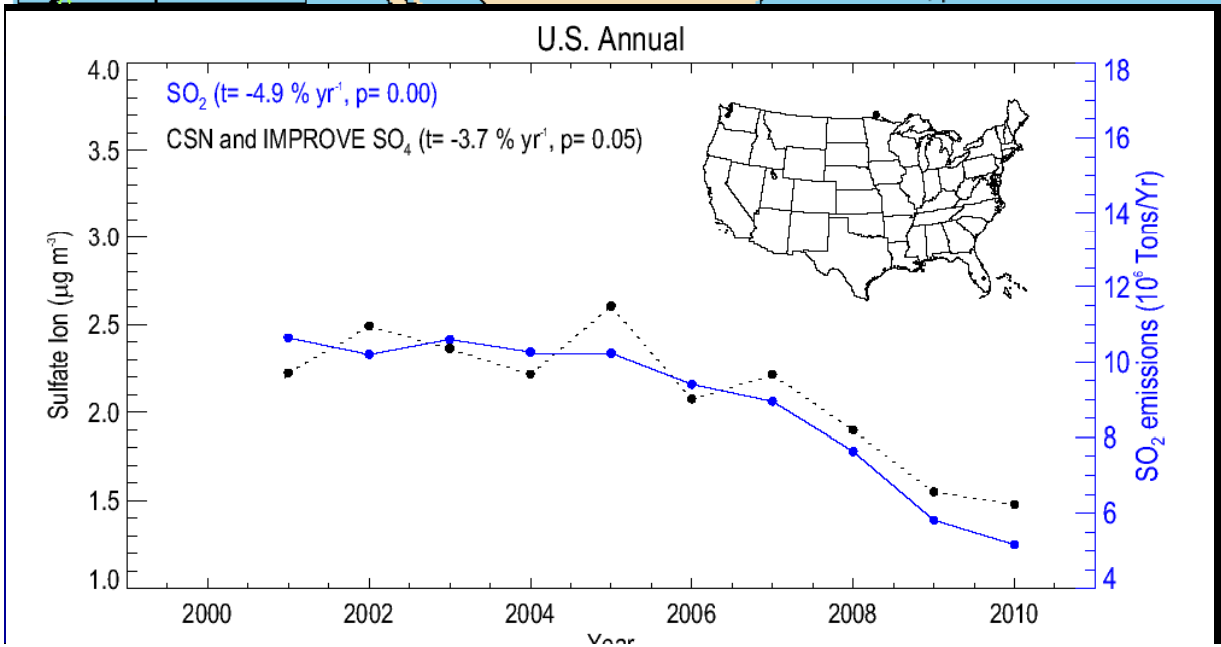

POM_Annual
11.7
5.5
4.9
4.3
3.7
3.0
2.4
1.8
1.2
0.6
0.0
(μg/m³)
Alaska
Hawaii
Virgin Islands
IMPROVE Site
IMPROVE Urban Site
CSN Site

# Organic Carbon



# *Annual Trends*

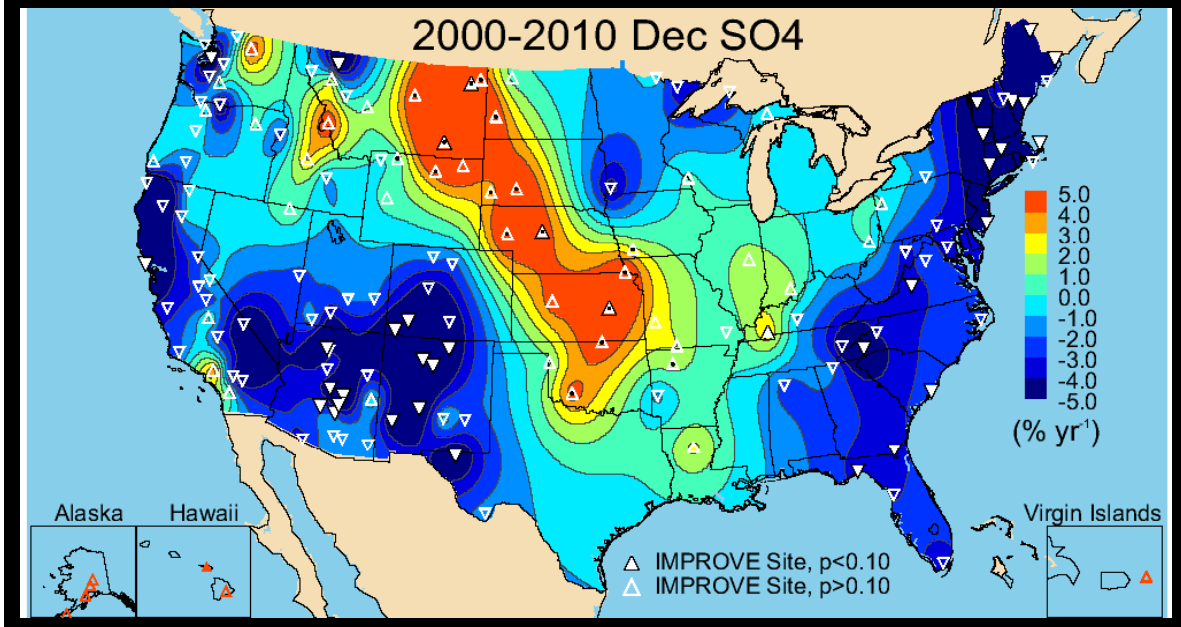


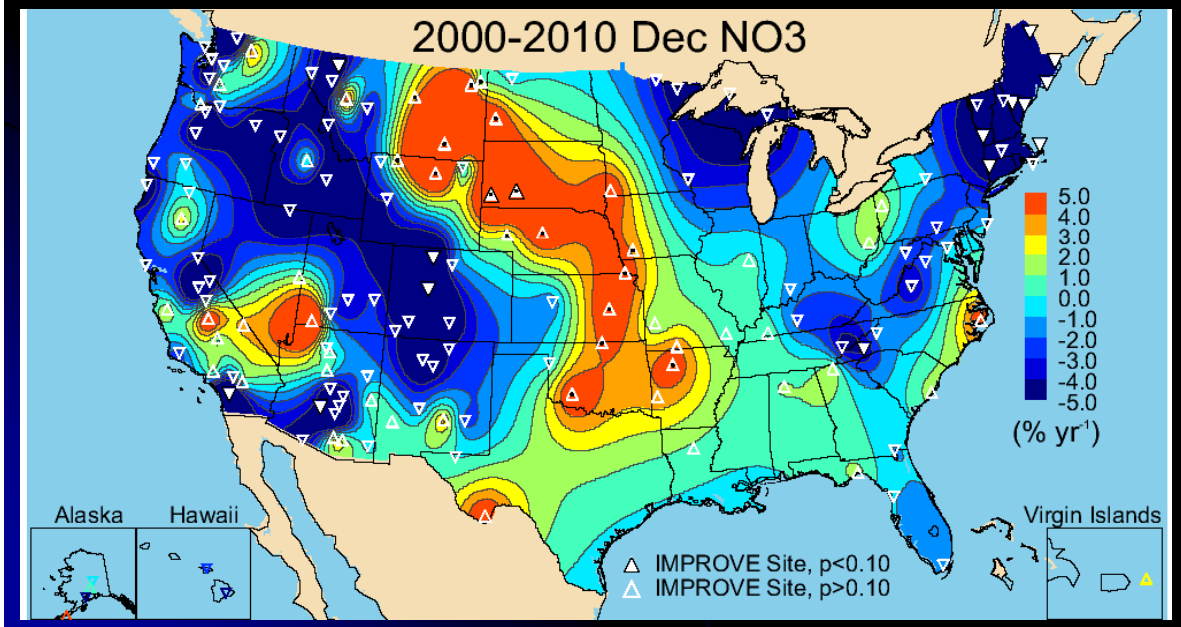




- Sulfate concentrations and $SO_2$ emissions have similar decreasing patterns
- ~30% greater decrease in emissions than concentrations

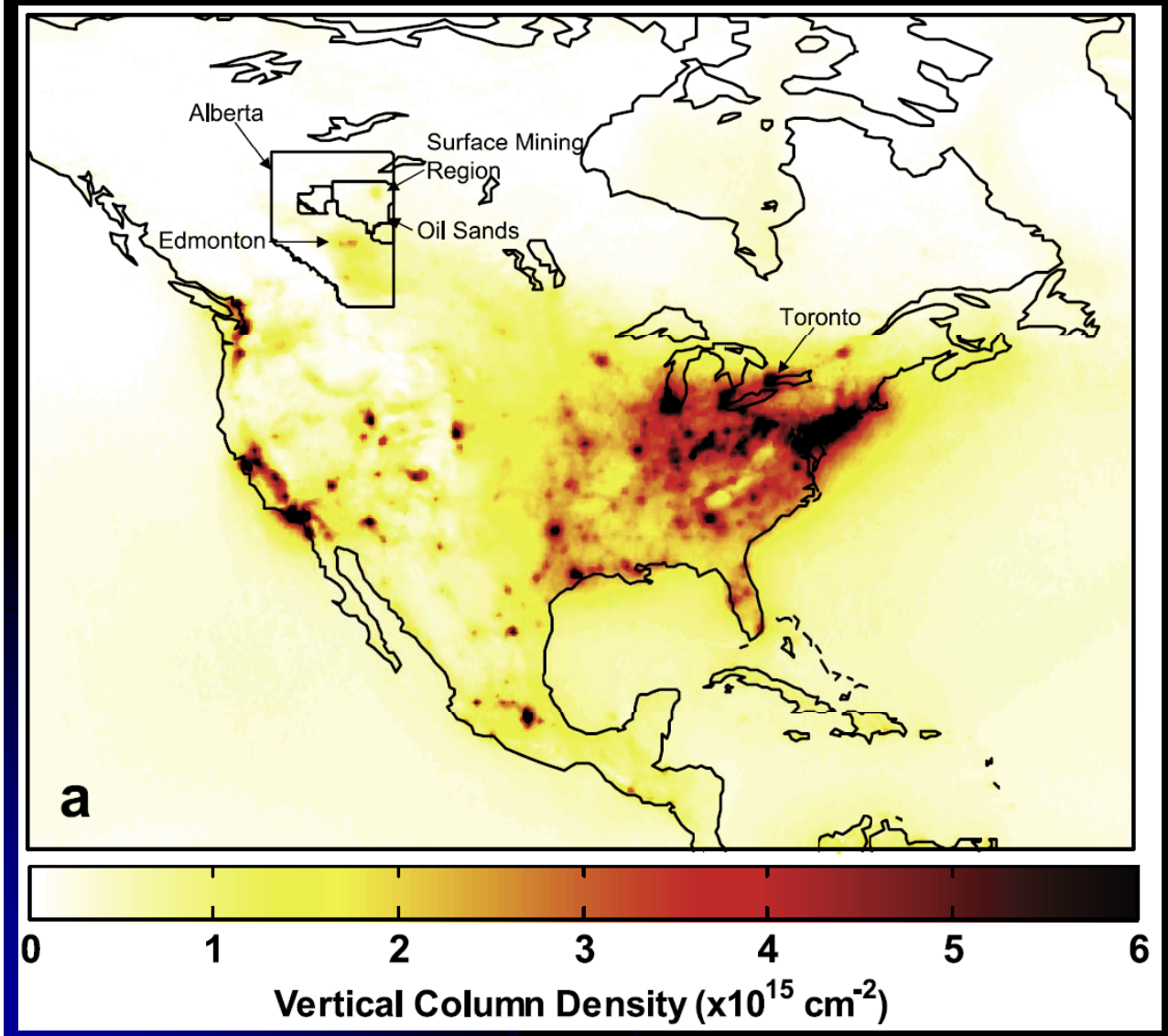
(Hand et al., 2012)

# *Wintertime Trends 2000 - 2010*



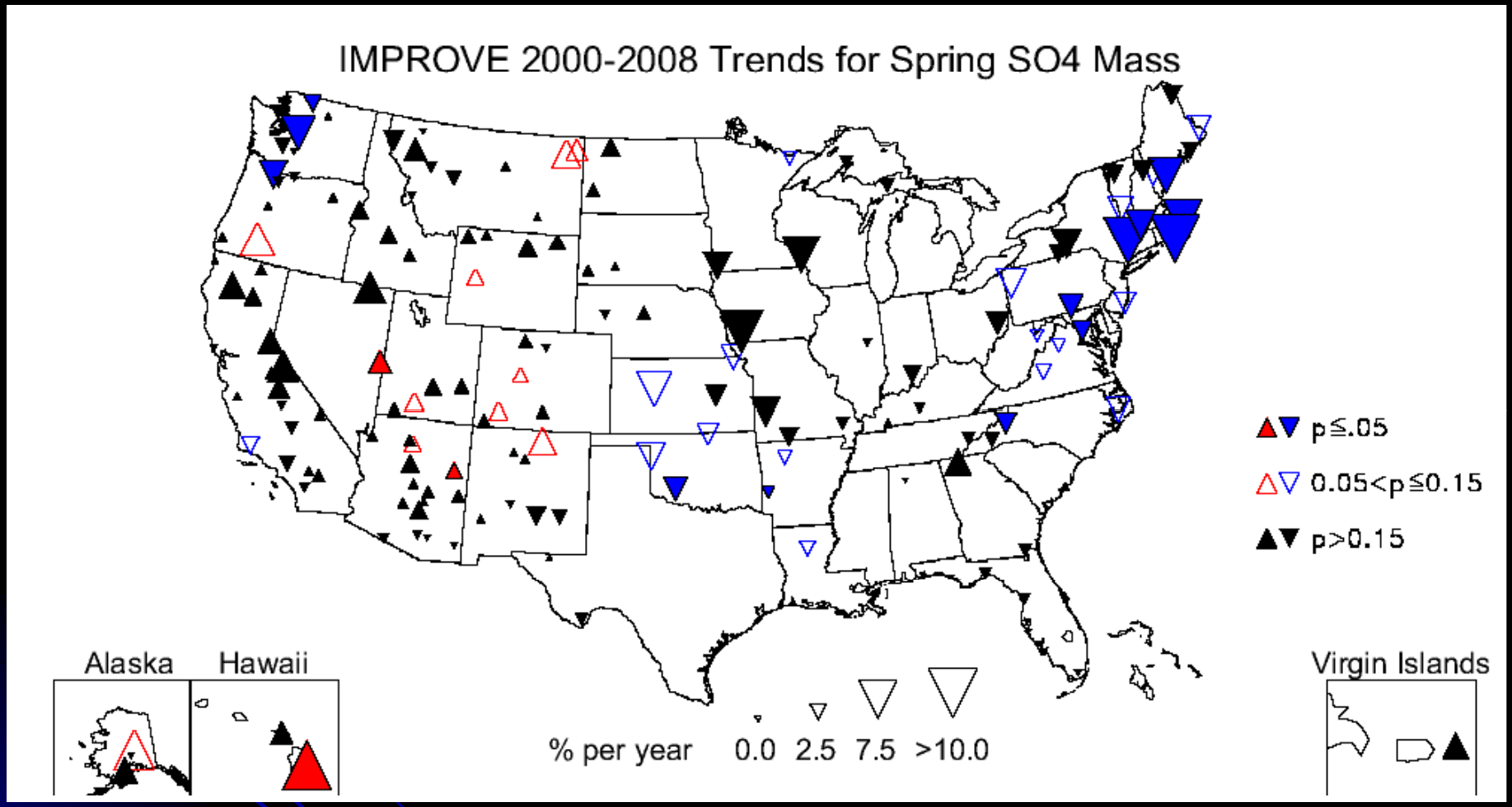



# $NO_2$ Column Concentrations



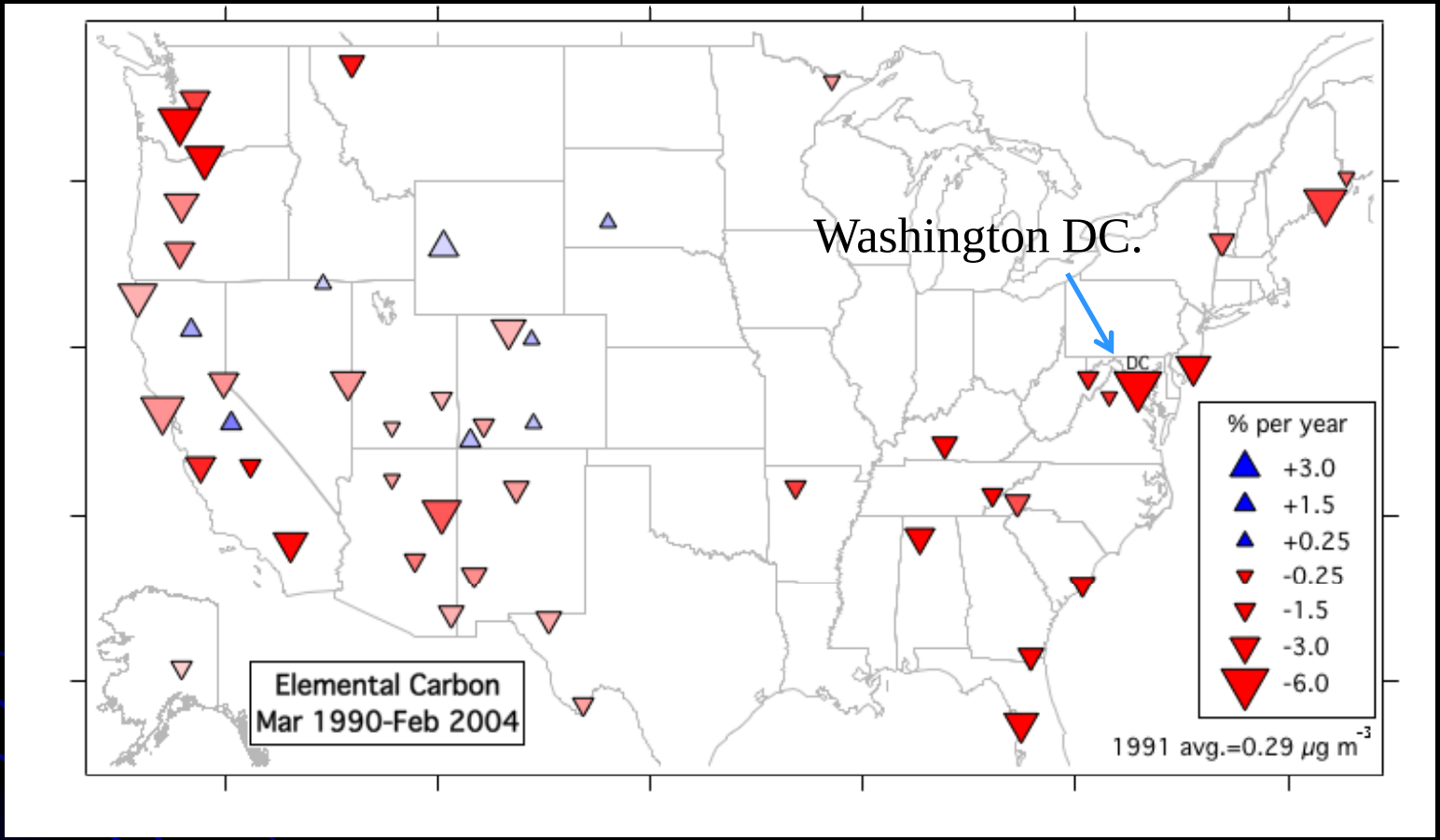

- North American, annual-mean tropospheric NO2 VCDs (2005–2010)
- Derived from the OMI sensor on the AURA satellite

McLinden et al., 2012, GRL




Hand et al., 2011
(http://vista.cira.colostate.edu/IMPROVE/Publications/Reports/2011/2011.htm)

# *Decreasing Elemental Carbon, 1990 – 2004*



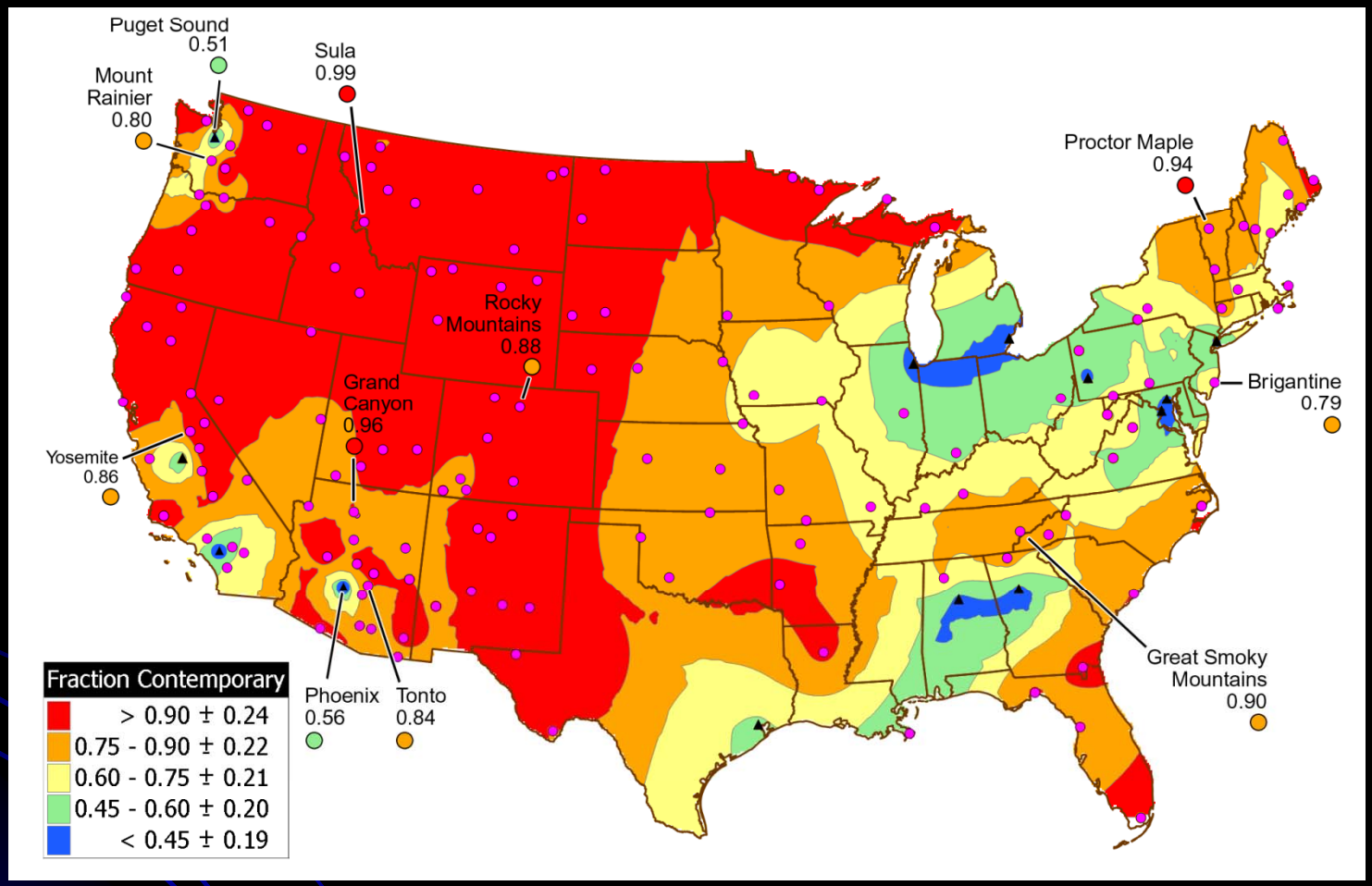

Symbol size: magnitude of trend

Color saturation: absolute amount of EC

- Organic carbon is generally trending downward though at a lower rate as elemental carbon

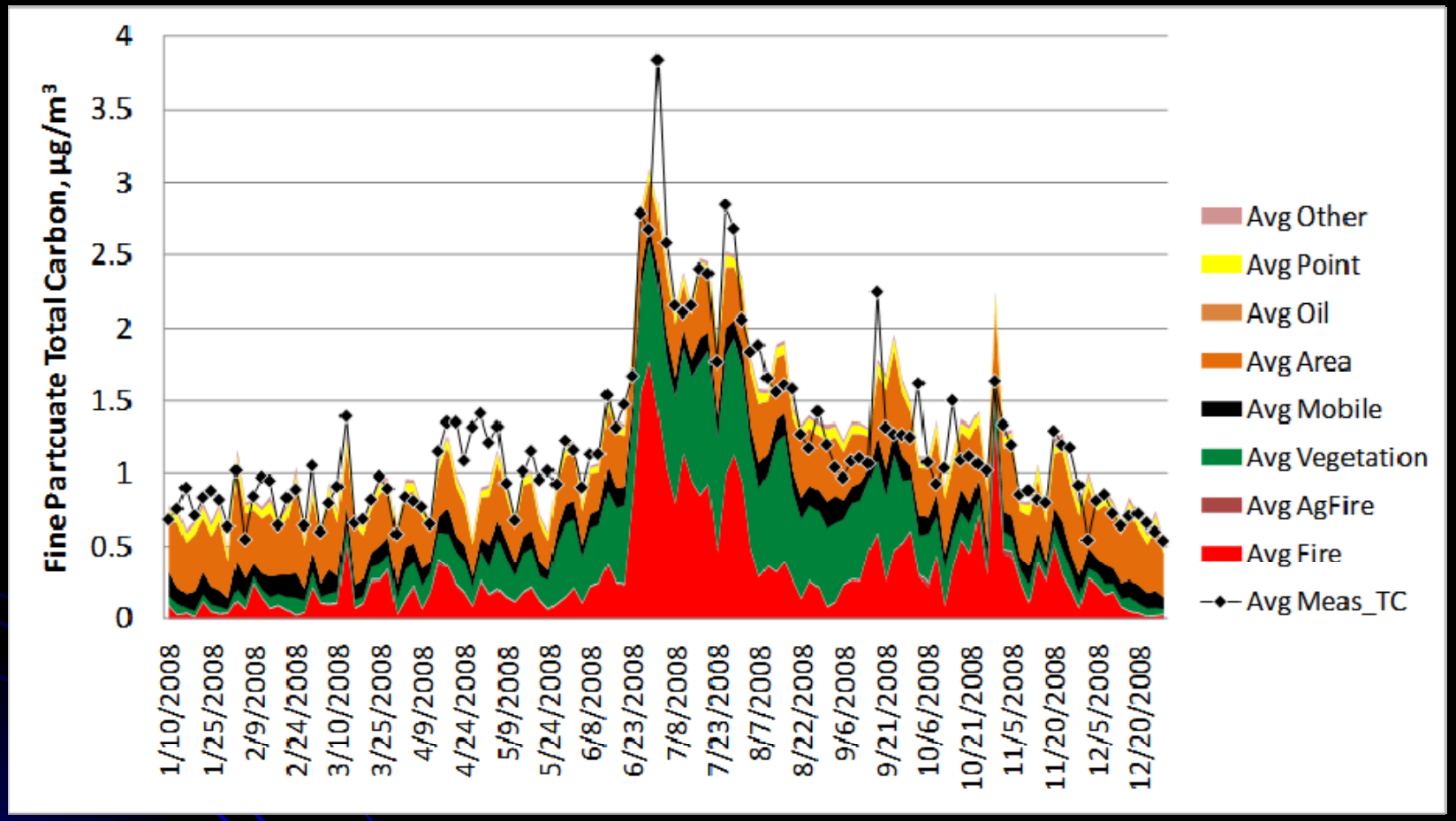
- Murphy et al., 2011

# *Fraction Biogenic Carbon - Summer 2004-05*



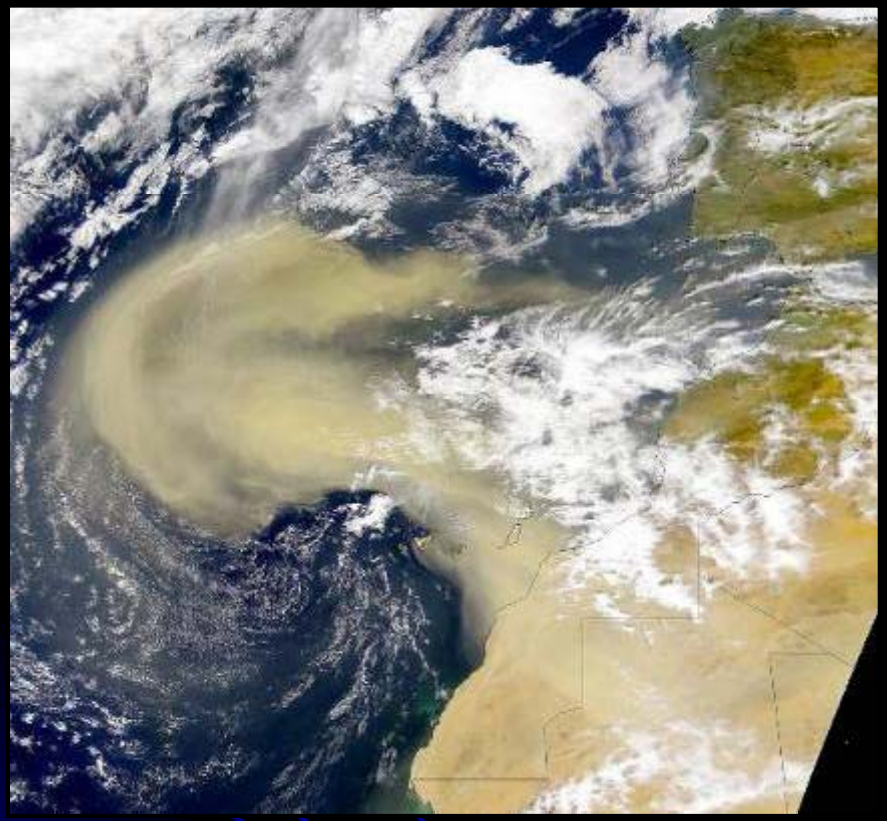

- Radiocarbon measurements were used to calibrate IMPROVE EC/TC to apportion particulate carbon into a fossil and biogenic fraction
- Winter biogenic fractions patterns are similar to summer but are generally smaller

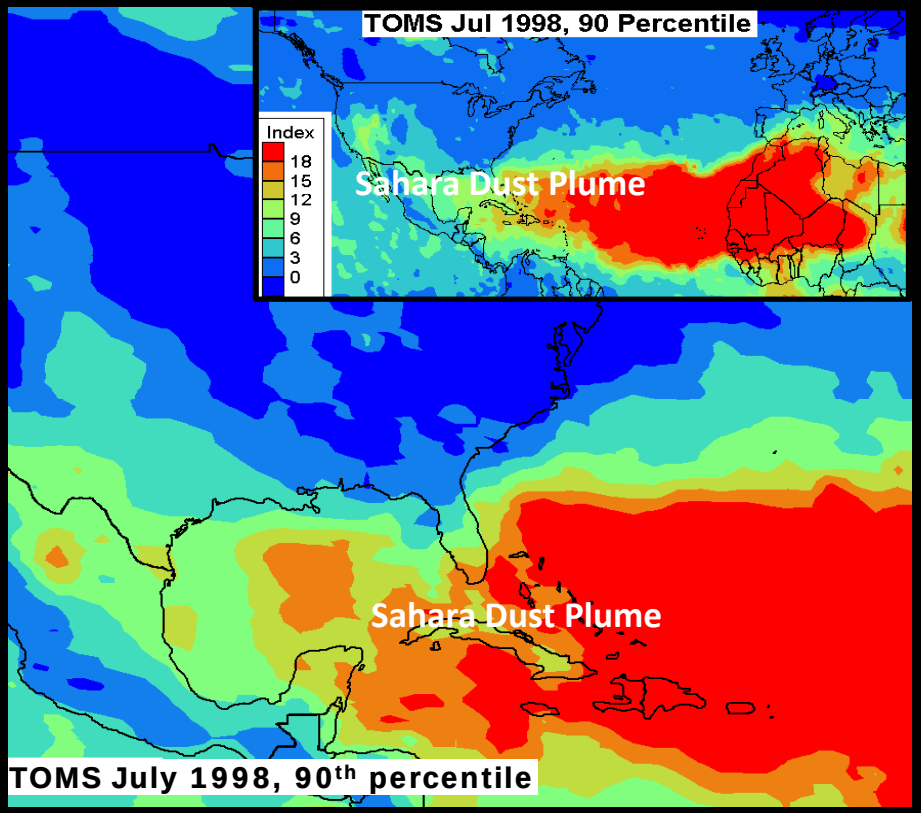
# *IMPROVE Simulated TC, 2008*




- Biomass burning and secondary organic aerosol from vegetation are largest contributors to rural TC in the spring – fall
- Area sources are the largest contributor in the winter months
- Oil and gas and point sources are small contributors

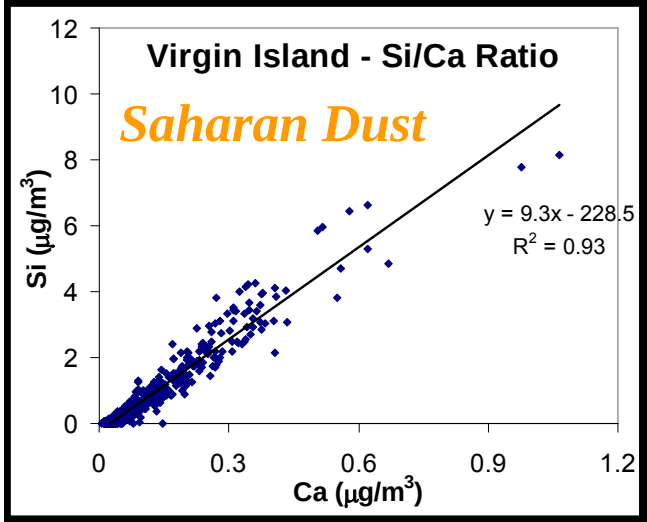
# *Sahara Dust Transport to North America, July*

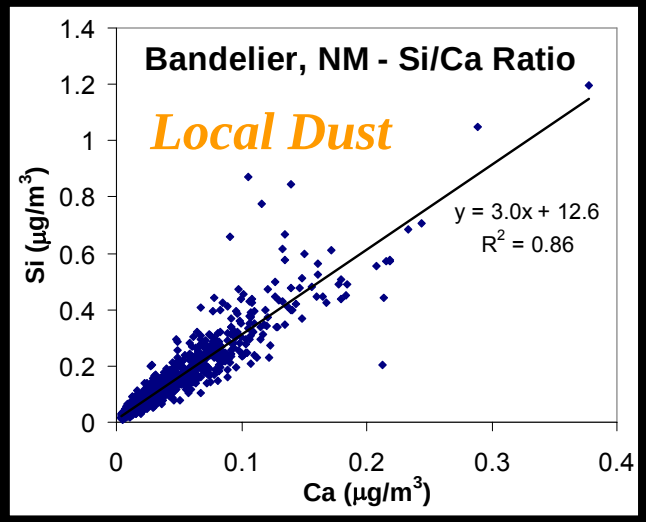


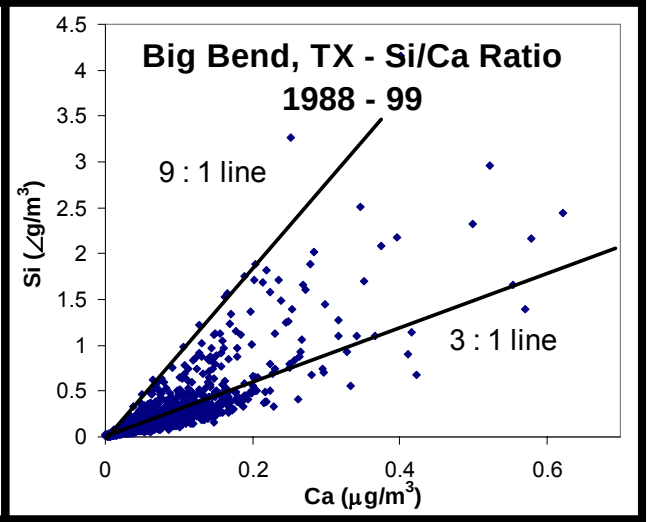


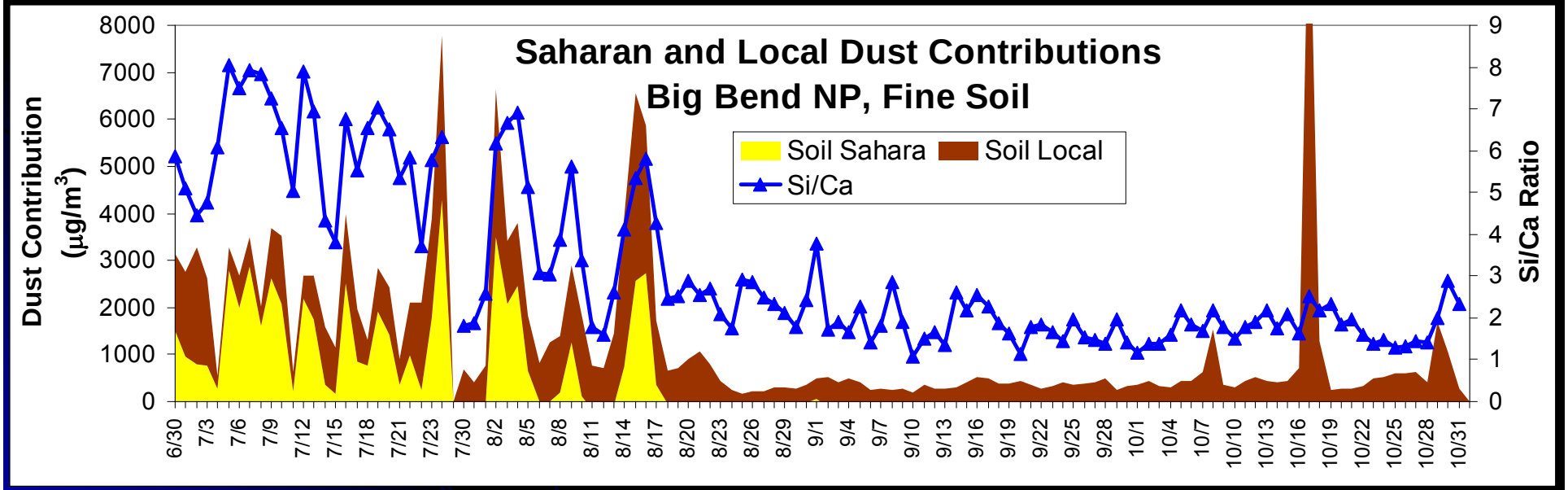

- Elevated levels of absorbing aerosol (Sahara Dust) reaches the Gulf of Mexico and evidently, enters the continent along the US-Mexican borders, reaching New Mexico.
- Higher levels cover the Caribbean Islands and S. Florida.

# *Estimation of Saharan and Local Dust to Big Bend*




Al-Harb et al., 2002

# Homepage

Introduces visitors to the purpose of IMPROVE and visibility issues. Also provides a navigation path for browsing the website.

**Http://vista.cira.colostate.edu/IMPROVE**

# IMPROVE Data Advisories

This is an IMPROVE data user community supported page meant to document interesting findings from the IMPROVE database including data anomalies, potential problems, and new uses for the IMPROVE data. These advisories are not meant to be comprehensive or complete. In addition, unless explicitly stated the data advisories are not necessarily endorsed by the IMPROVE steering committee, National Park Service, CIRA or others.

Contact Bret Schichtel to submit a data advisory.

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| | | | |
|---|---|---|---|
| **Bias between masked and unmasked light absorption measurements** | *Submitted by:* W. H. White | *On:* 03/2010 | *Doc #:* da0028 |
| *Sites:* All | *Time Period:* Before 2008 | *Module/Species: A/ fabs* | |
| **Suspect light-absorption data from three months in 2000** | *Submitted by:* W. H. White | *On:* 03/2010 | *Doc #:* da0027 |
| *Sites:* All | *Time Period:* 9/1/2000 - 11/30/2000 | *Module/Species: A/ fabs* | |
| **Marginal detection of heavy elements by PIXE analysis** | *Submitted by:* W. H. White | *On:* 03/2010 | *Doc #:* da0026 |
| *Sites:* All | *Time Period:* Before 6/1/1992 | *Module/Species: A/ Pb, Sr, Se, Rb* | |
| **Arcane flagging of early hydrogen and fine mass data** | *Submitted by:* W. H. White | *On:* 03/2010 | *Doc #:* da0025 |
| *Sites:* All | *Time Period:* 9/1/1990 – 2/26/1992 | *Module/Species: A/ MF, H* | |
| **Under-correction of chloride concentrations for filter blank levels - historical Advisory: Applies to downloads before 11/23/2009** | *Submitted by:* W. H. White | *On:* 08/2009 | *Doc #:* da0024 |
| *Sites:* All | *Time Period:* 2005 - 2008 | *Module/Species: B/ Cl* | |
| **Inconstant bias in XRF sulfur - Advisory Update to da0012** | *Submitted by:* W. H. White | *On:* 05/2009 | *Doc #:* da0023 |
| *Sites:* All | *Time Period:* All | *Module/Species: A/ S* | |
| **Data losses during episodes of heavy smoke** | *Submitted by:* W. H. White | *On:* 01/2009 | *Doc #:* da0022 |
| *Sites:* All | *Time Period:* All | *Module/Species: A/ MF, elements, fabs* | |
| **Mis-reporting of light-absorption on masked filters - Historical Advisory: Applies to downloads before 4/17/2009** | *Submitted by:* W. H. White | *On:* 09/2008 *Modified on:* 04/2009 | *Doc #:* da0021 |
| *Sites:* BRID1, DENA1, HALE1, HANC1, HAVO1, MEVE1, MORA1, NOAB1, NOCA1, OLYM1, PETE1, SIME1, SNPA1, TRCR1, TUXE1, VIIS1, WEMI1, WHIT1, WHPA1, WHPE1, WHRI1, ZICA1 | *Time Period:* 2005 – 2006 | *Module/Species: A/ fabs* | |
| **Invalid data for collocated (POC = 2) samples - Historical Advisory: Applies to downloads before 4/17/2009** | *Submitted by:* W. H. White | *On:* 09/2008 *Modified on:* 04/2009 | *Doc #:* da0020 |
| *Sites:* MEVE1, OLYM1, PMRF1, SAFO1, SAMA1, TRCR1 | *Time Period:* January – July, 2005 | *Module/Species: A/ H, Na, Mg, Al, Si, P, S, Cl, K, Ca, Ti, V, Cr, Mn, Fe* | |

CANY 03/22/2004
Nitrate 4%
Soil 9%
Organic 18%
Sulfate 37%
Coarse 25%
EC 7%

# *IMPROVE*

- Many interesting questions can be identified and answered
- Strength in interagency approach
- Internal checks
- Analyze and identify issues
- Long-term robust data

# *Adjustments*

- Looking at cost savings
- Operational costs are going up
- PESA has been discontinued (routine)
- Steering committee will be exploring options

# Questions?

Monument Valley, AZ

Manti la Sal near arches, UT

Grand Canyon, AZ

Bridger Wilderness, WY