25 Years of IMPROVE Data: past lessons and future issues

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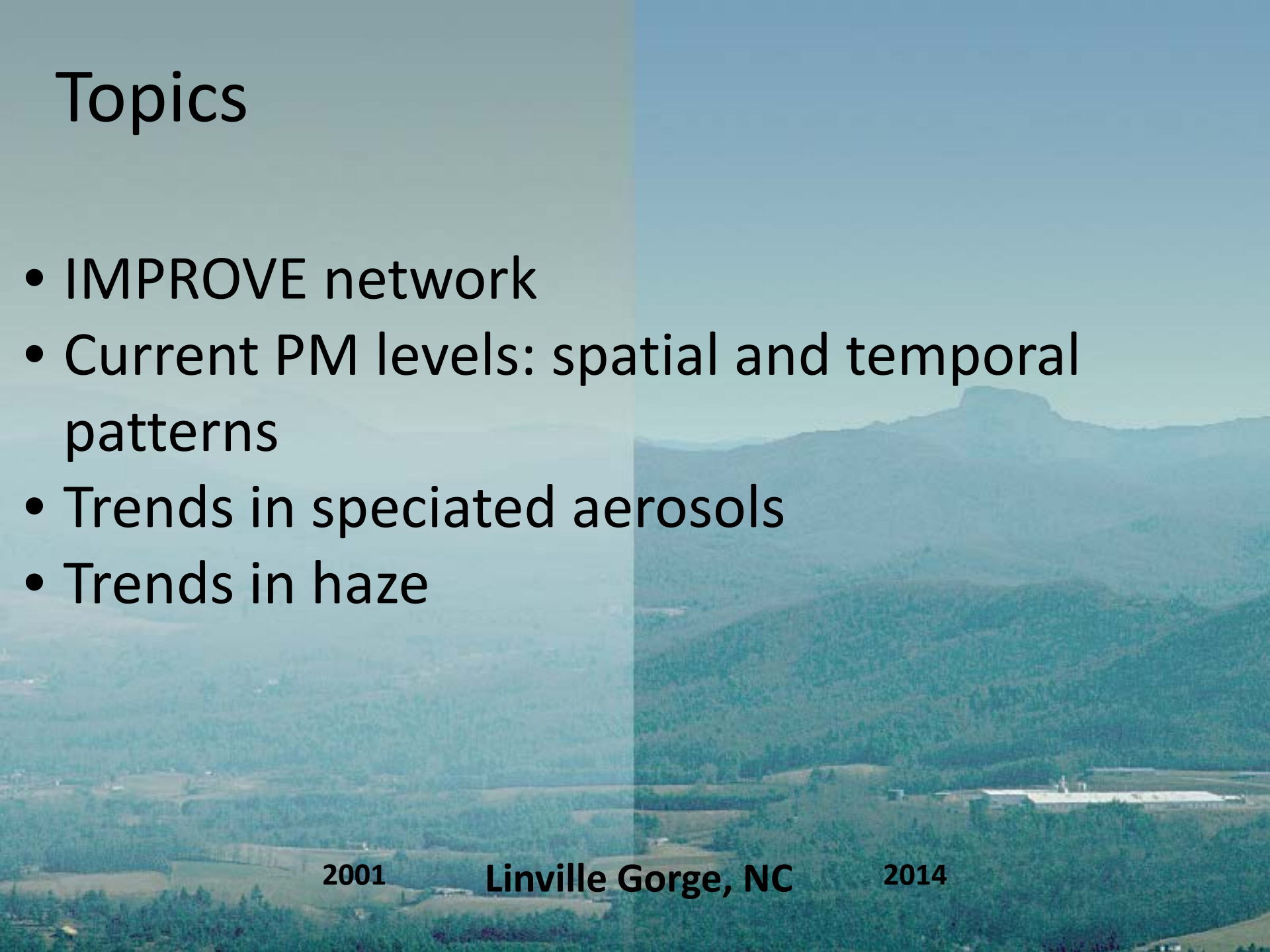
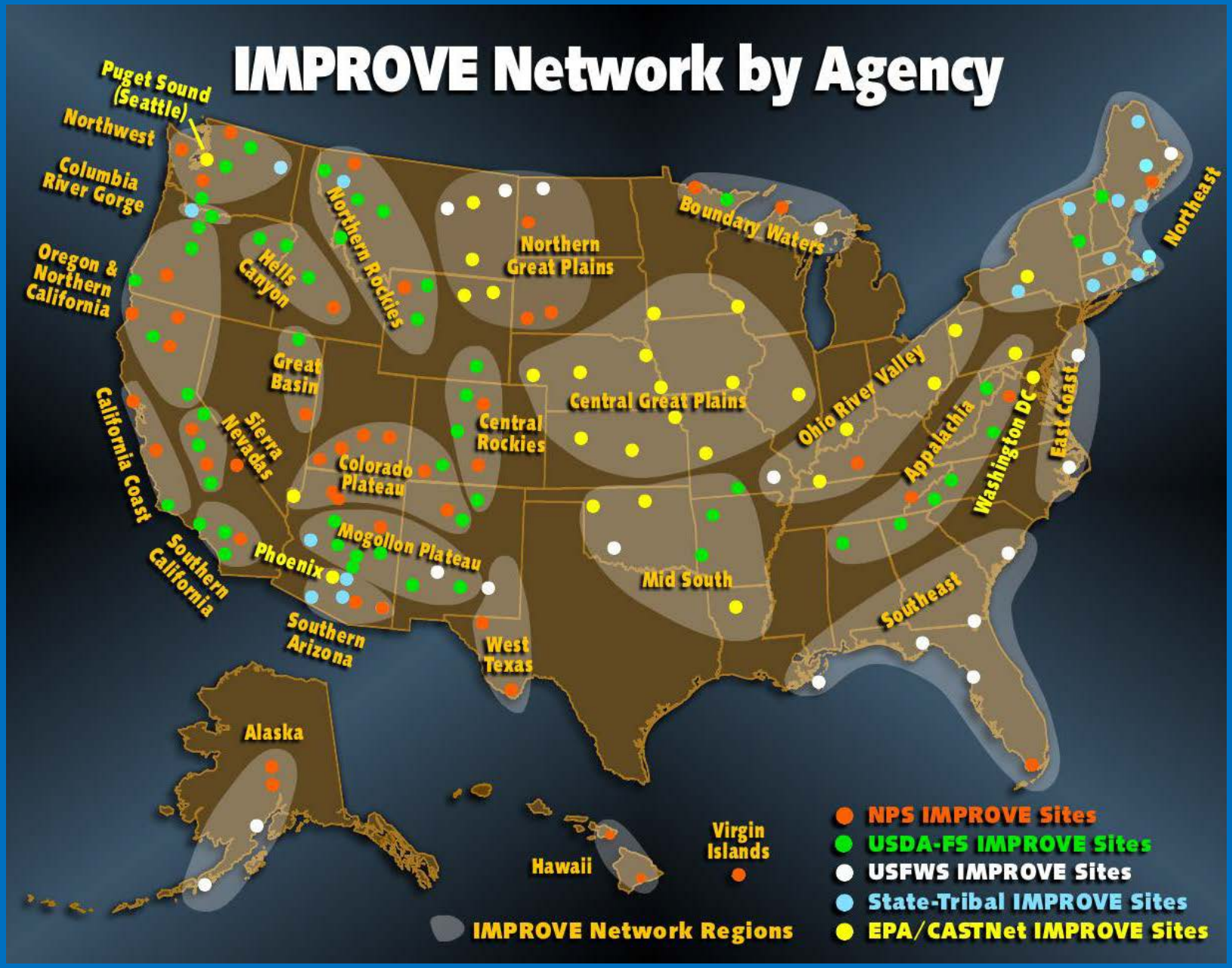
1990 **Acadia, ME** 2014

Topics

- IMPROVE network
- Current PM levels: spatial and temporal patterns
- Trends in speciated aerosols
- Trends in haze



Interagency Monitoring of Protected Visual Environments



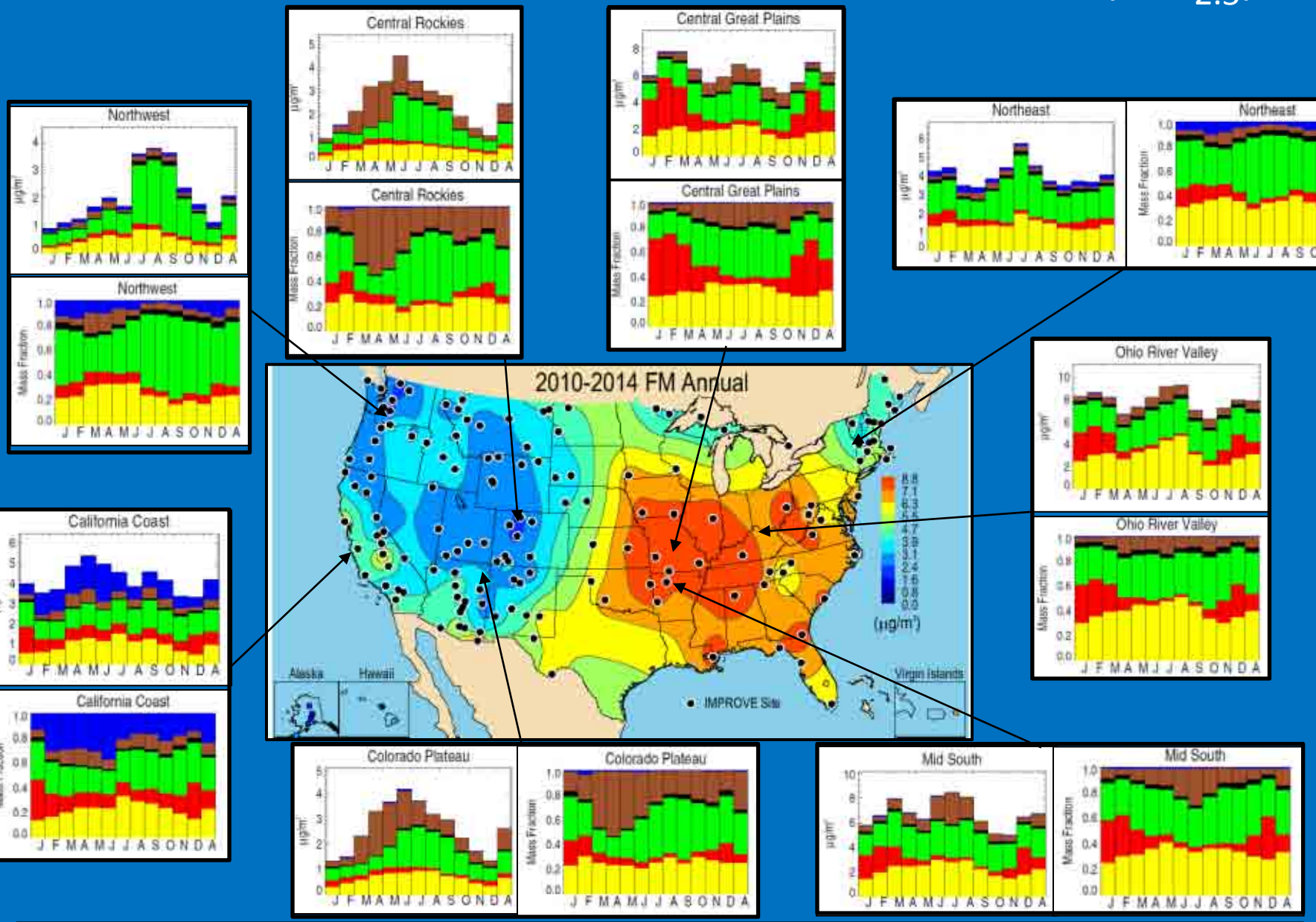
Routine monitoring: aerosol chemical properties

IMPROVE Sampler in Big Bend, TX

- Samples collected every third day
- Inorganic anions by IC
- Carbonaceous aerosols by TOR
- Elemental species by XRF

Download data:
http://views.cira.colostate.edu/fed/

2010-2014 IMPROVE Annual Mean Fine Mass ($PM_{2.5}$)

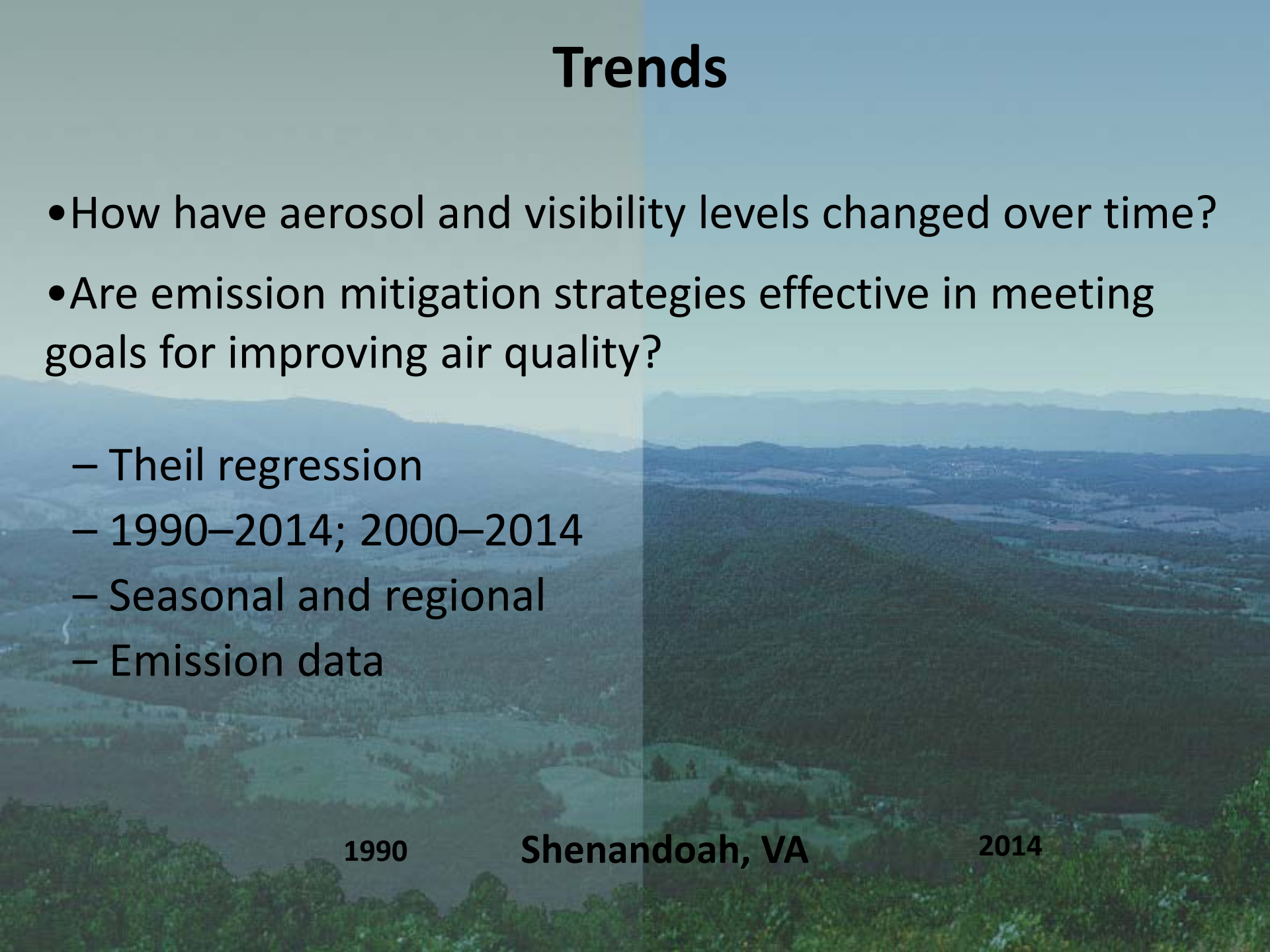


ammonium sulfate ammonium nitrate particulate organic matter elemental carbon dust sea salt

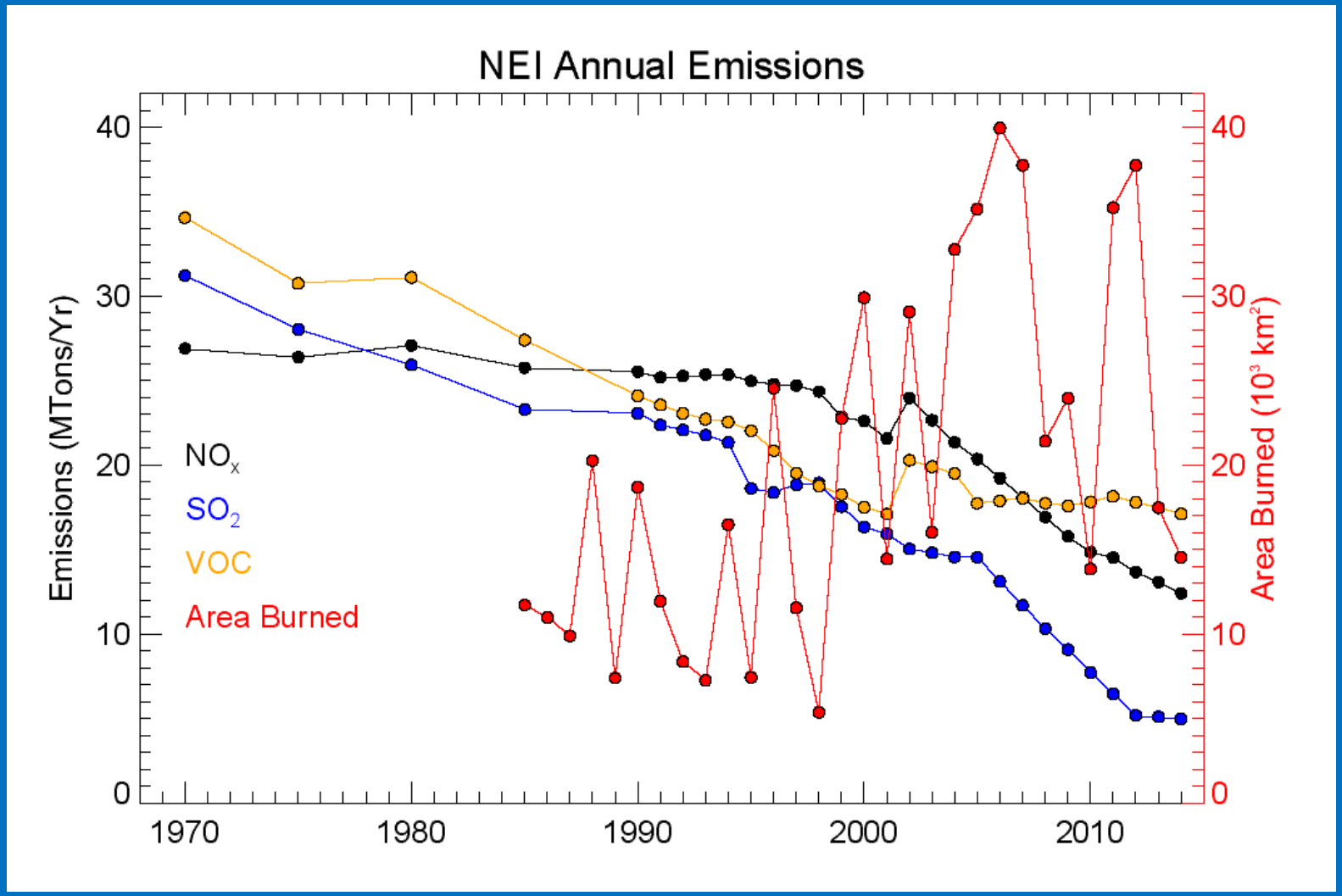
Hand et al., 2012, JGR

Trends

- How have aerosol and visibility levels changed over time?
- Are emission mitigation strategies effective in meeting goals for improving air quality?
  - Theil regression
  - 1990–2014; 2000–2014
  - Seasonal and regional
  - Emission data



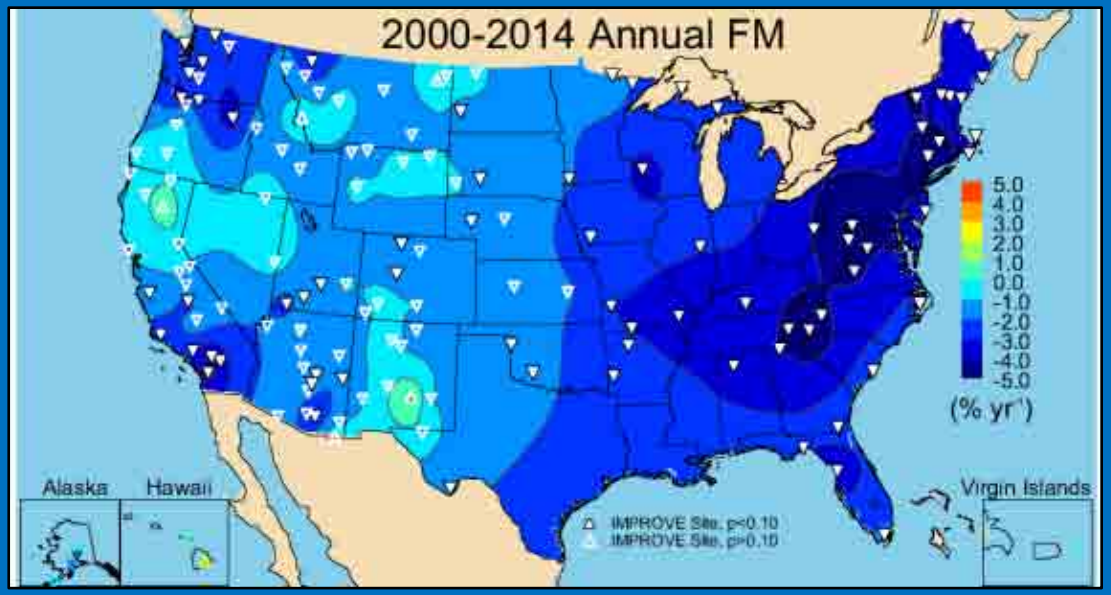
Trends in Emissions

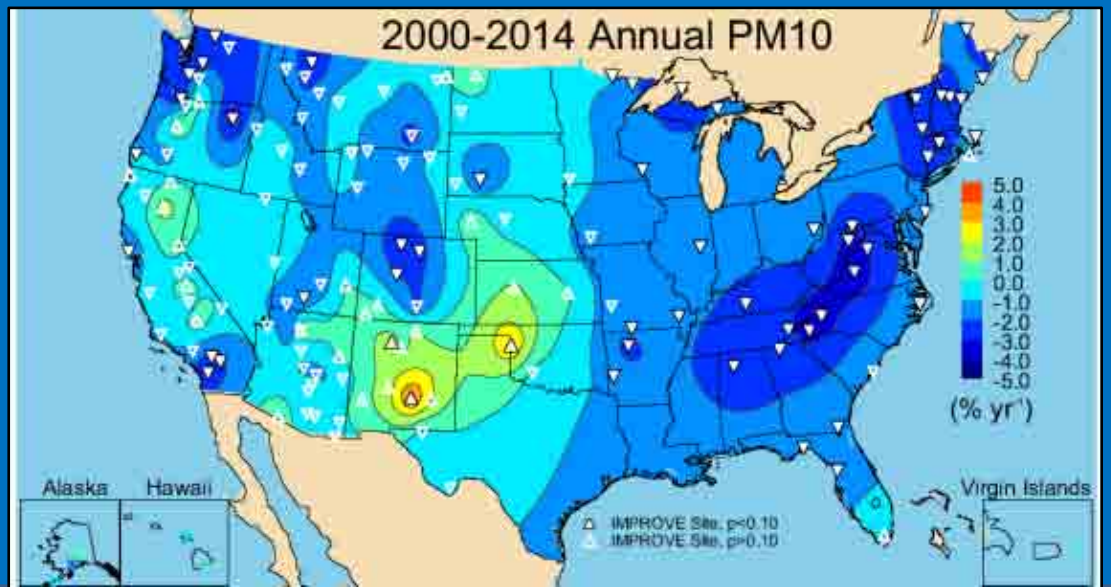


National Emission Inventory
(http://www3.epa.gov/ttnchie1/trends/)
National Interagency Fire Center (www.nifc.gov)

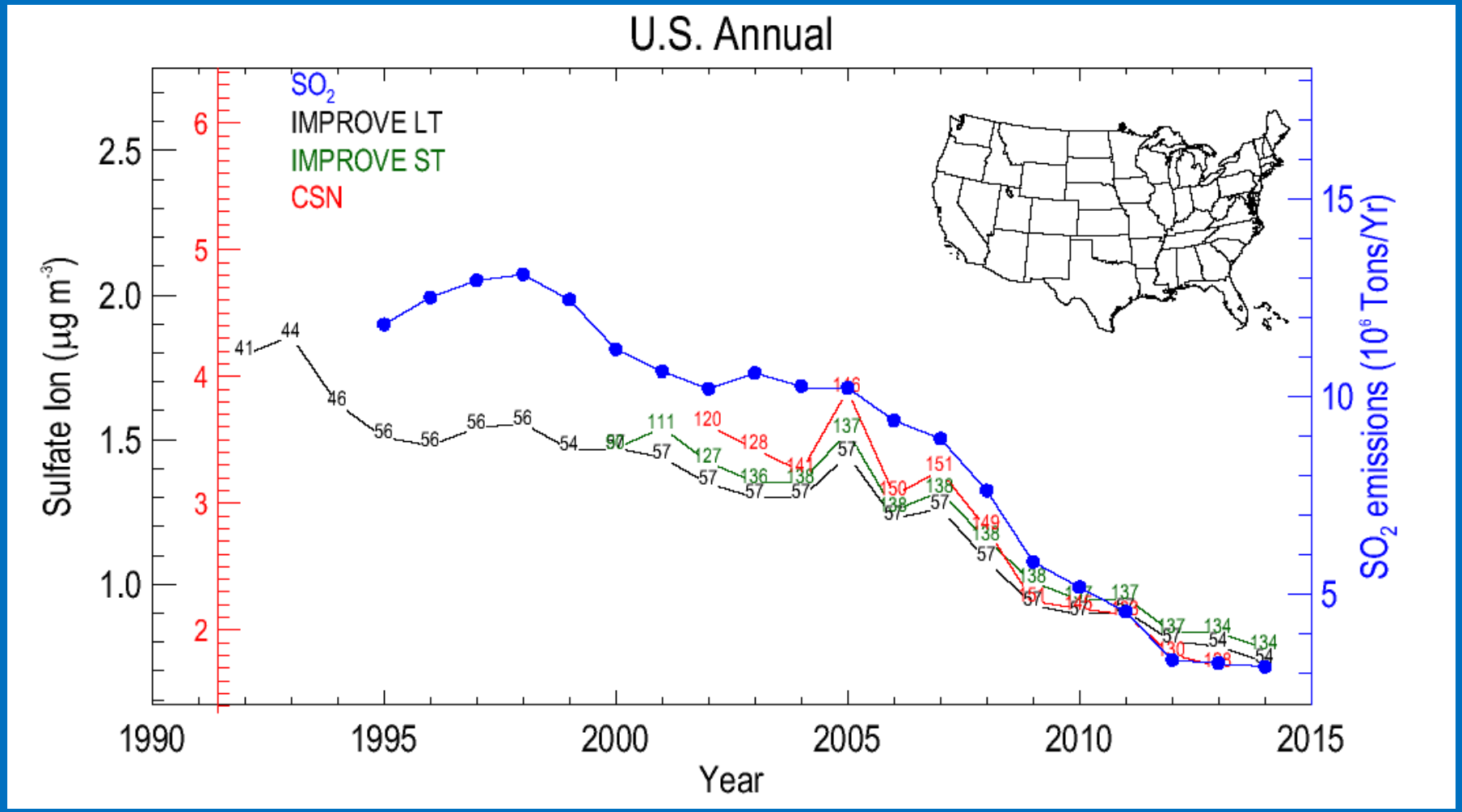
Hand et al., 2014. Atmos Environ

Trends in Annual Mean $PM_{2.5}$ and PM_{10} (2000-2014)



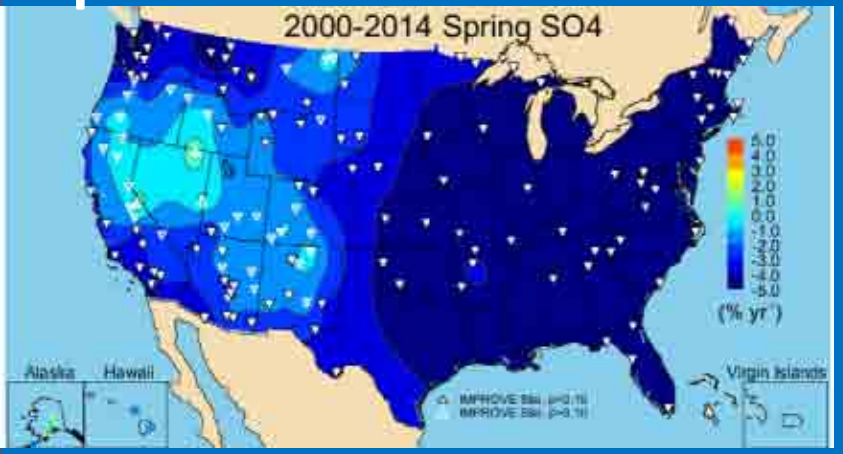


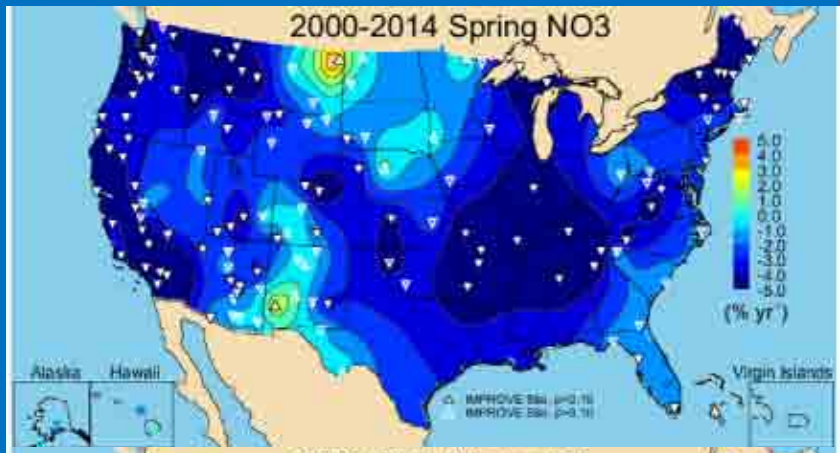
Trends in Annual Mean Sulfate



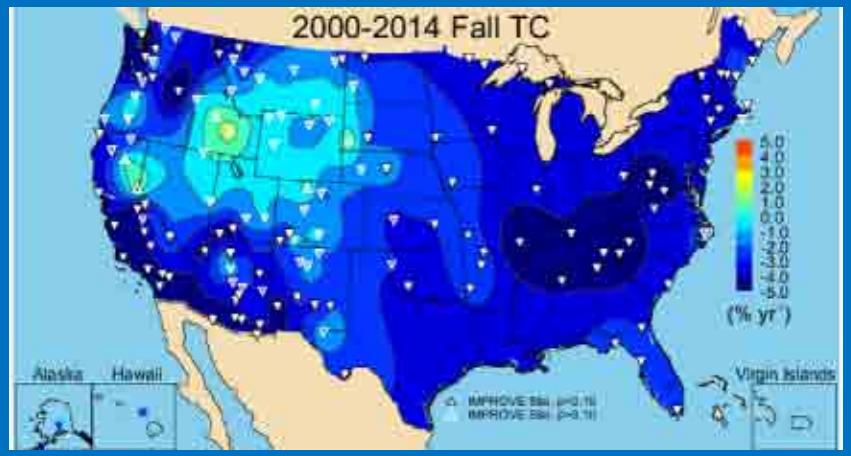
Hand et al., 2012b, ACP

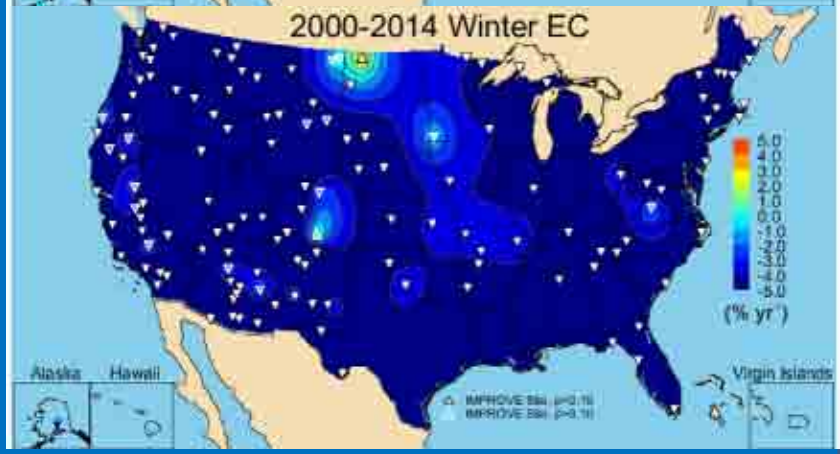
Specific seasons with increased trends

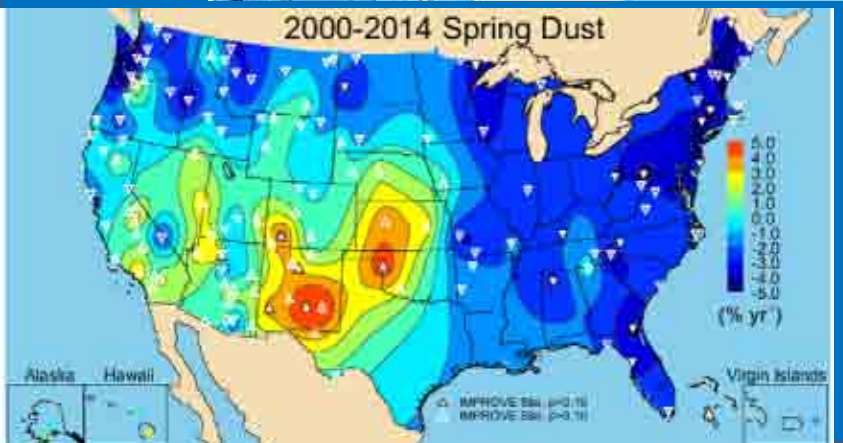




smoke

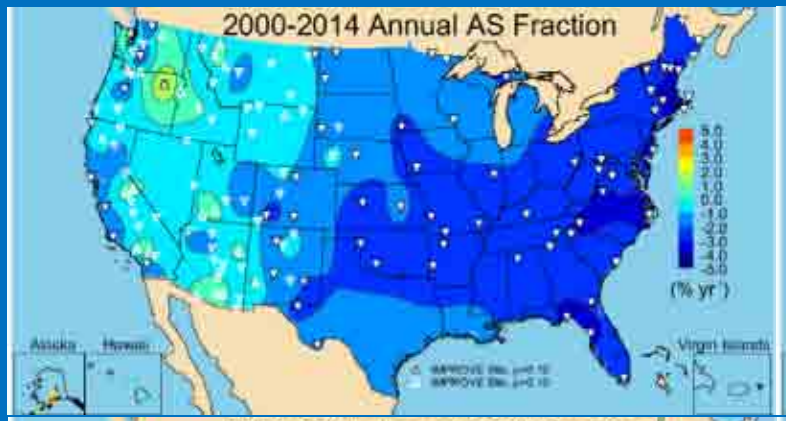


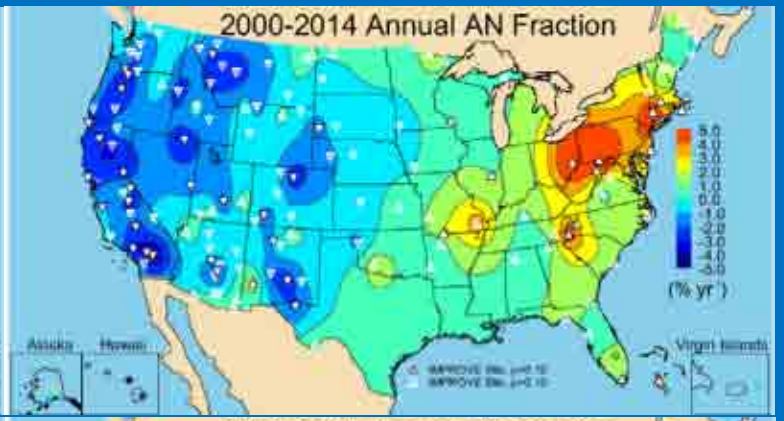


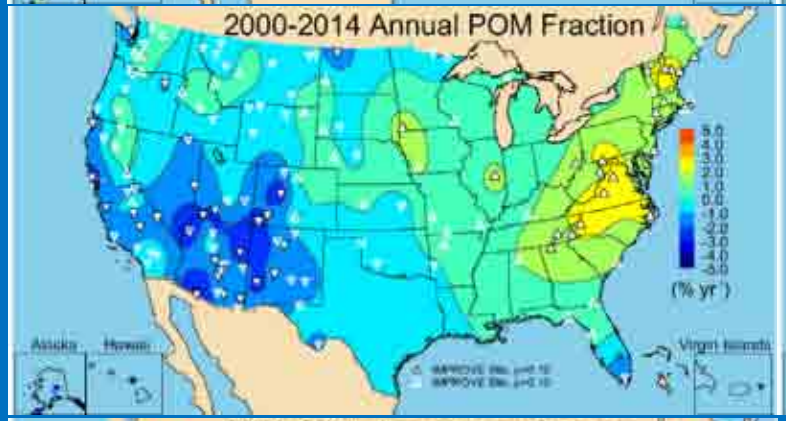


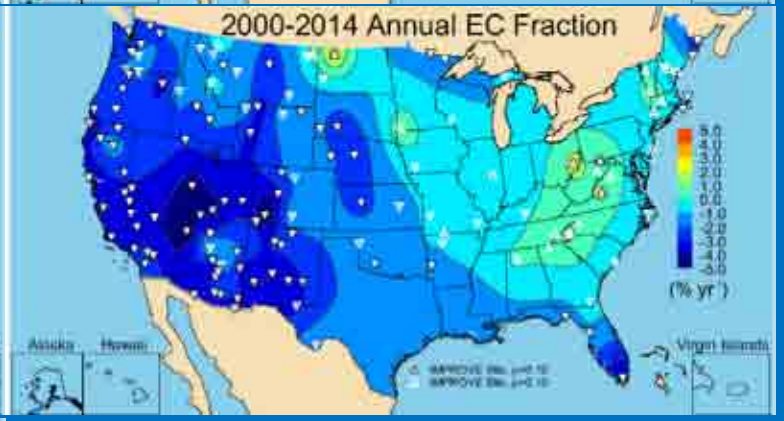
Oil and gas impacts

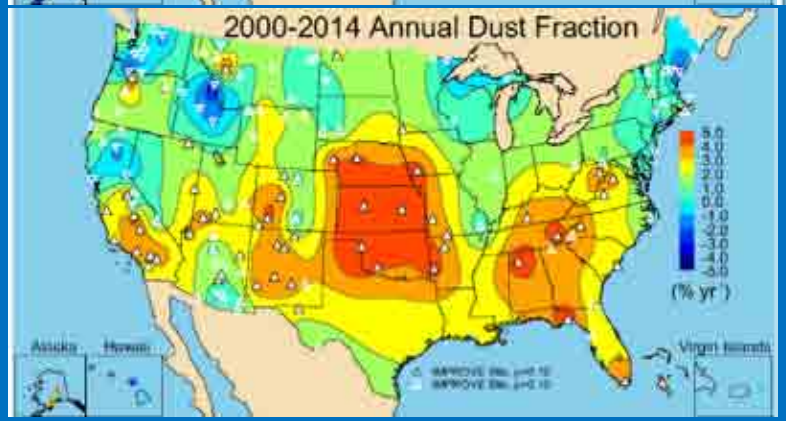
Trends in $PM_{2.5}$ Mass Fractions





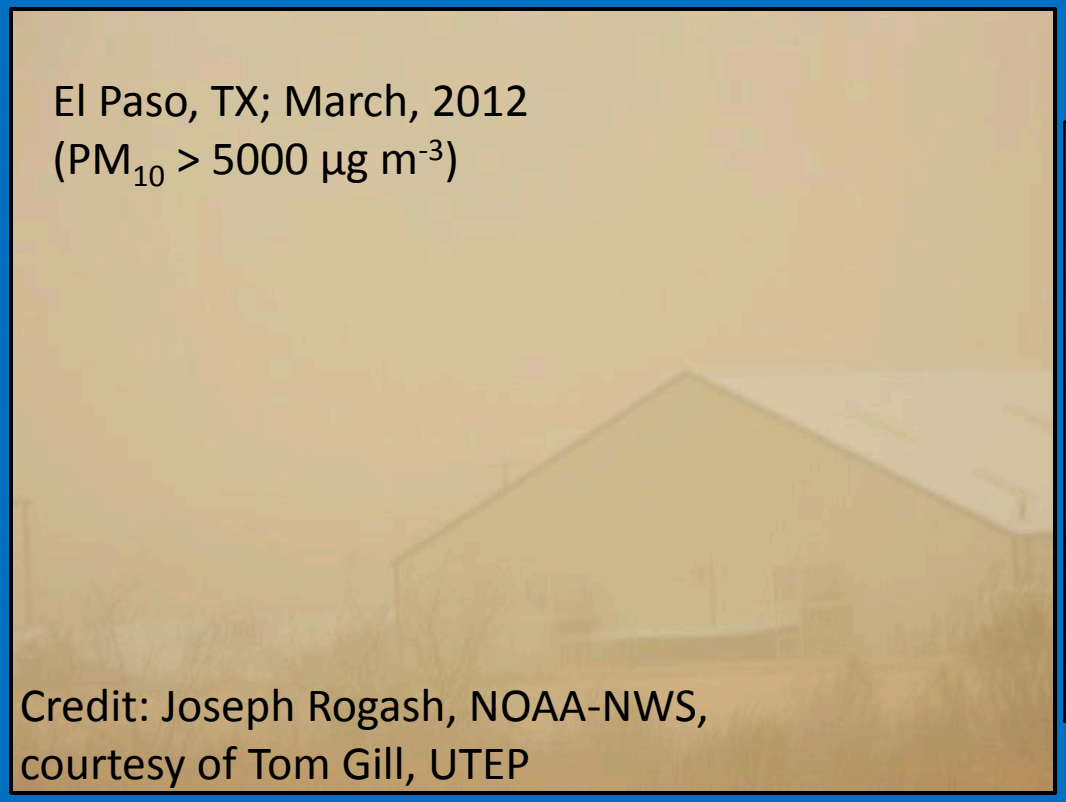






Visibility


Williston Basin, ND
Credit: Bill Malm


El Paso, TX; March, 2012
(PM_{10} > 5000 µg m^{-3})
Credit: Joseph Rogash, NOAA-NWS,
courtesy of Tom Gill, UTEP


High Park Fire, CO, June 2012
Credit: Kristi Gebhart

Reconstructing aerosol extinction (b_{ext})

b_{ext} (Mm^{-1}) = 3.0 f(rh) **[Sulfate] +**

3.0 f(rh) **[Nitrate] +**

4.0 **[Organics] +**

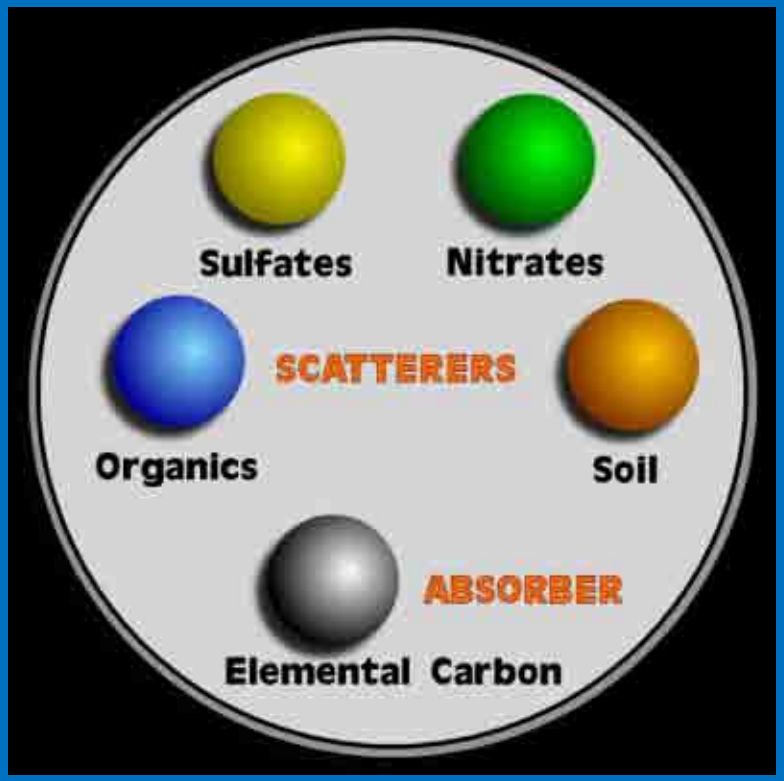
1.7 f_{SS}(rh) **[Sea Salt] +**

1.0 **[Dust] +**

0.6 **[Coarse Mass] +**

10.0 **[Elemental Carbon] +**

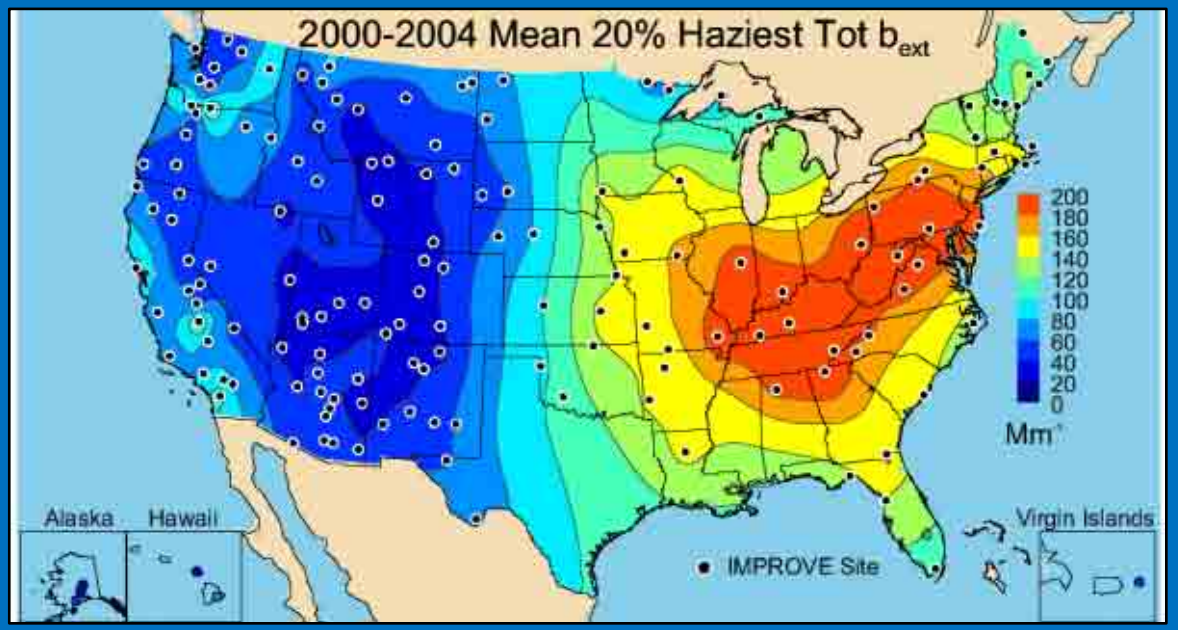
Rayleigh Scattering



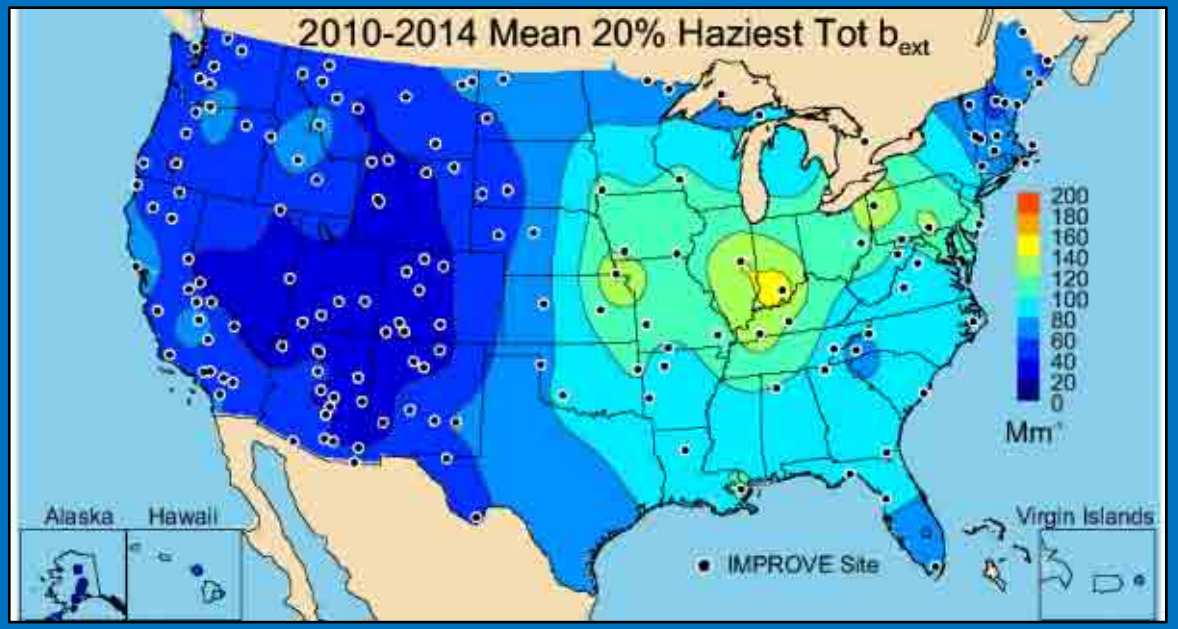
Major Contributors

Haziest b_{ext}

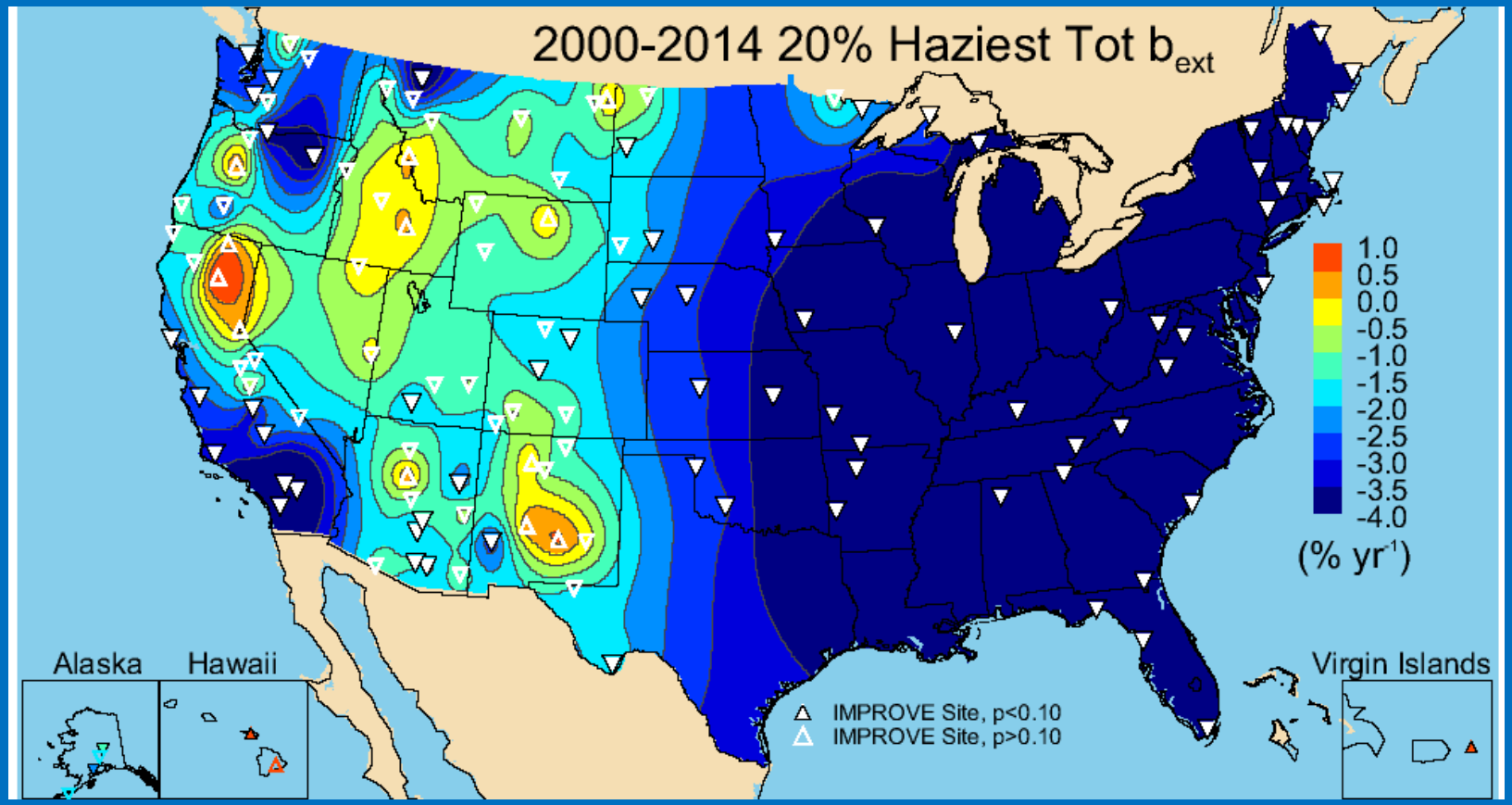
2000-2004



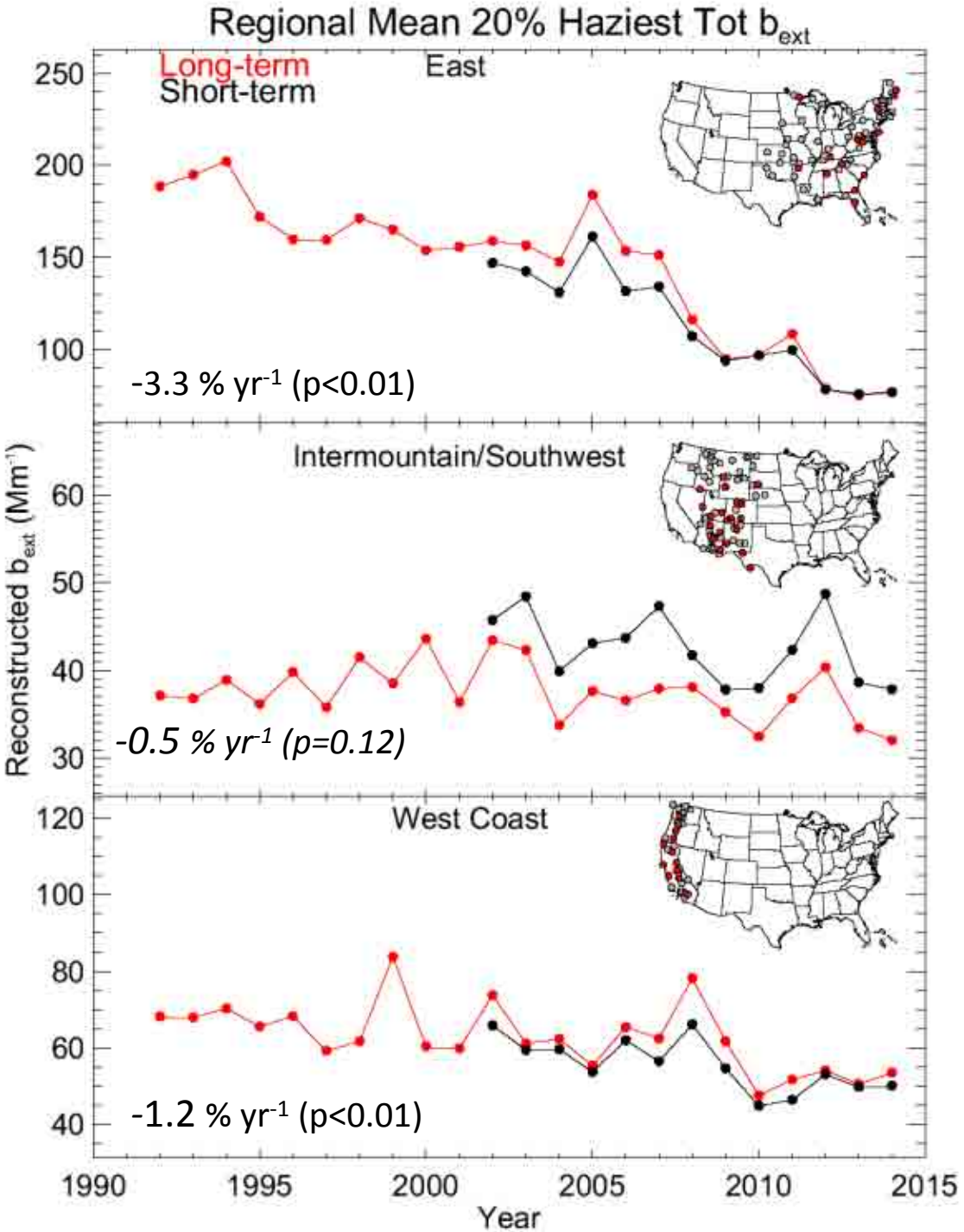
2010-2014



Trends in haziest b_{ext} (2000-2014)



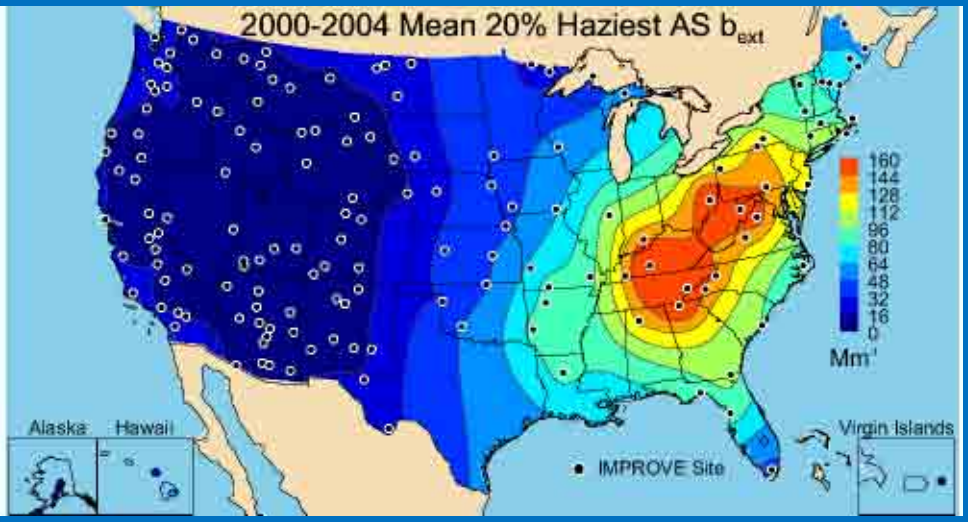
1992-2014


Regional Mean 20% Haziest Tot b_{ext}
Long-term
Short-term
East
-3.3 % yr^{-1} (p<0.01)
Intermountain/Southwest
-0.5 % yr^{-1} (p=0.12)
West Coast
-1.2 % yr^{-1} (p<0.01)
Reconstructed b_{ext} (Mm^{-1})
Year
250
200
150
100
60
50
40
30
120
100
80
60
40
1990
1995
2000
2005
2010
2015

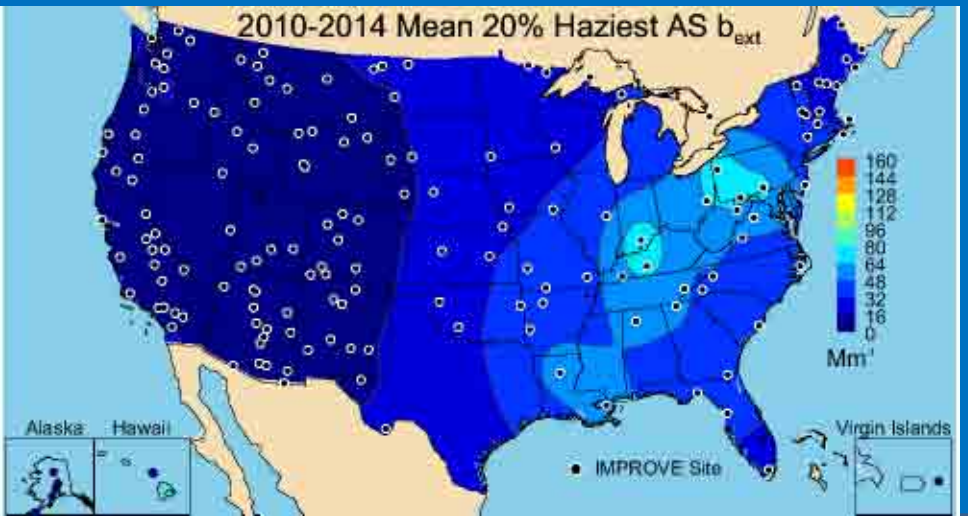
Changes speciated haziest b_{ext}

Ammonium Sulfate

2000-2004

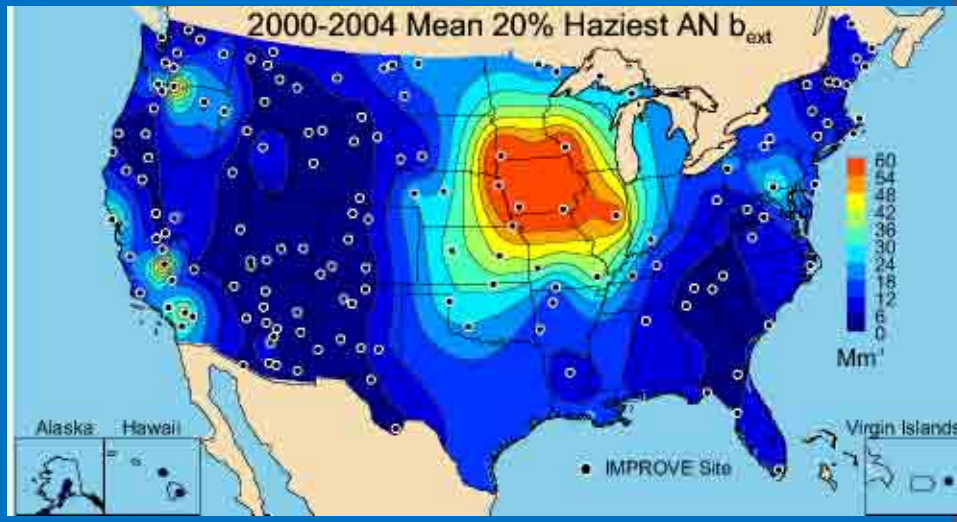


2010-2014

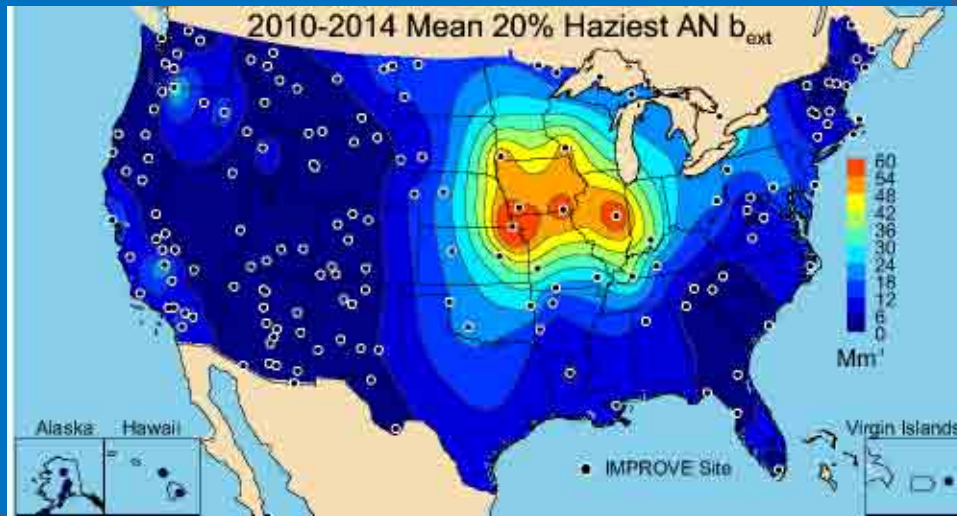


Ammonium Nitrate

2000-2004



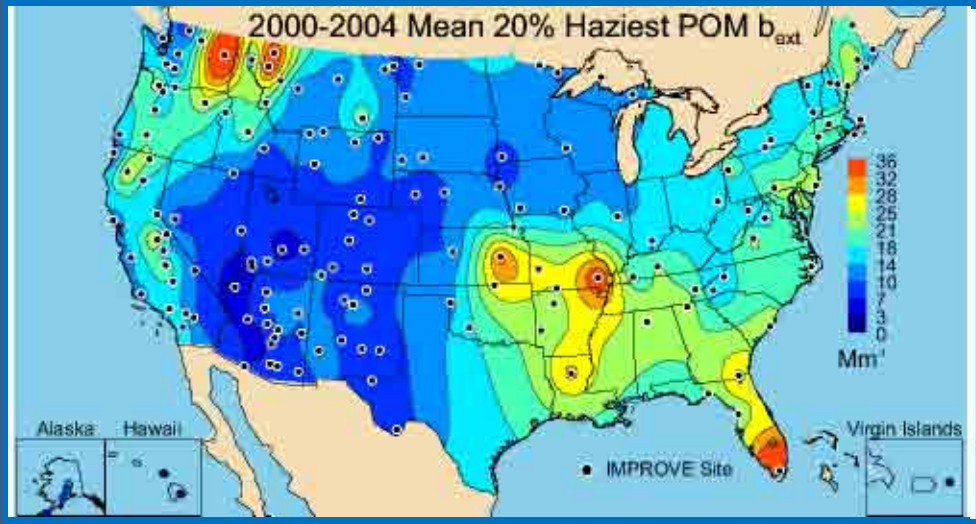
2010-2014



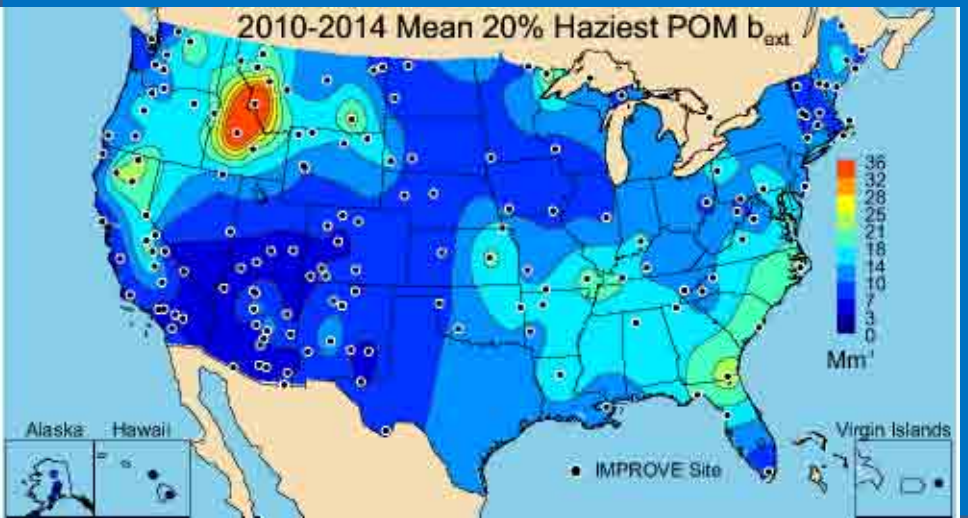
Changes in speciated haziest b_{ext}

Particulate Organic Matter

2000-2004

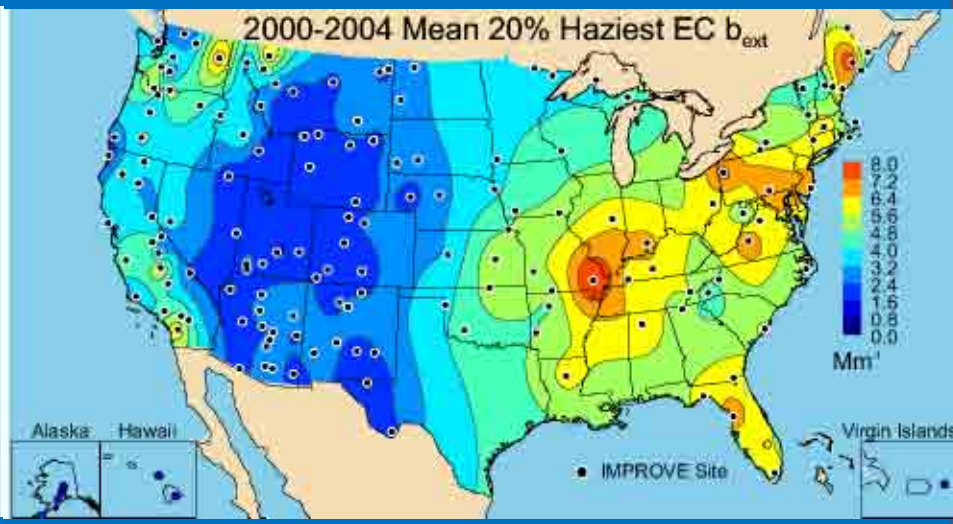


2010-2014

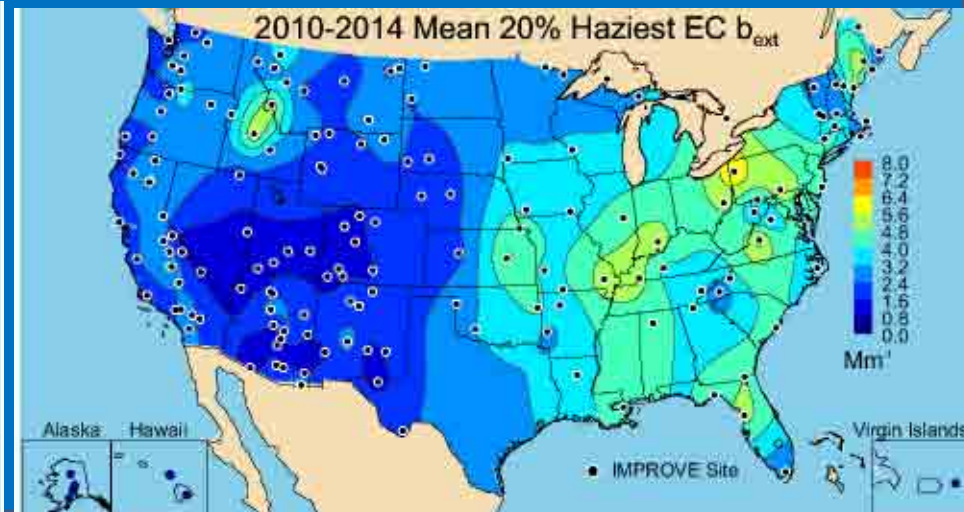


Elemental Carbon

2000-2004



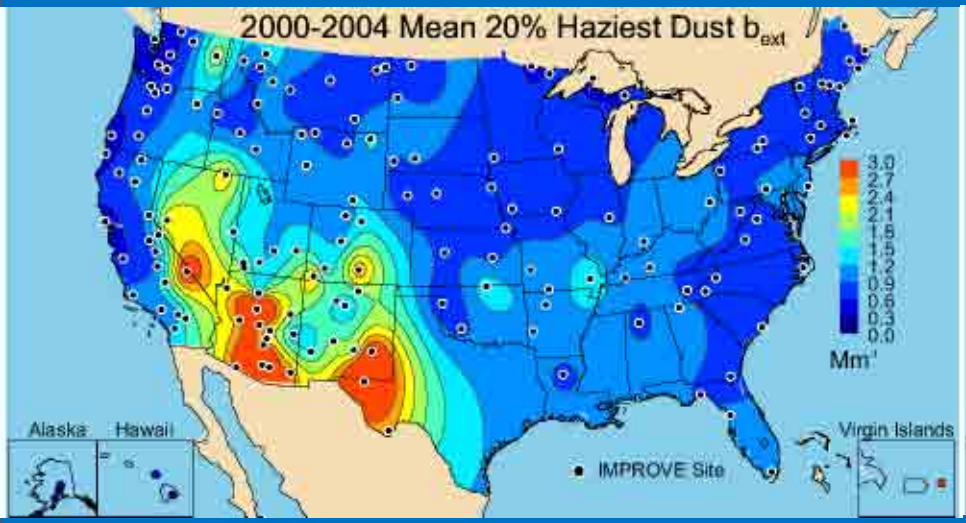
2010-2014



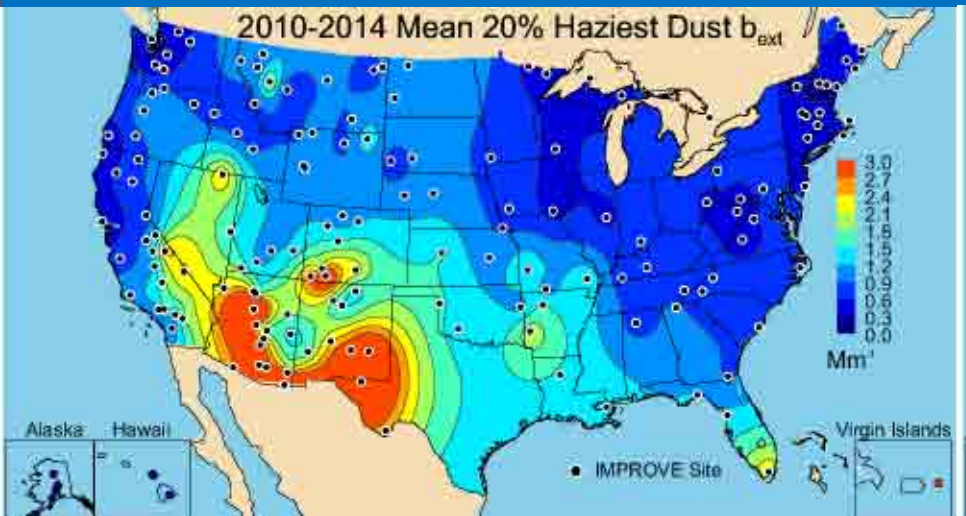
Changes in speciated haziest b_{ext}

Fine Dust

2000-2004

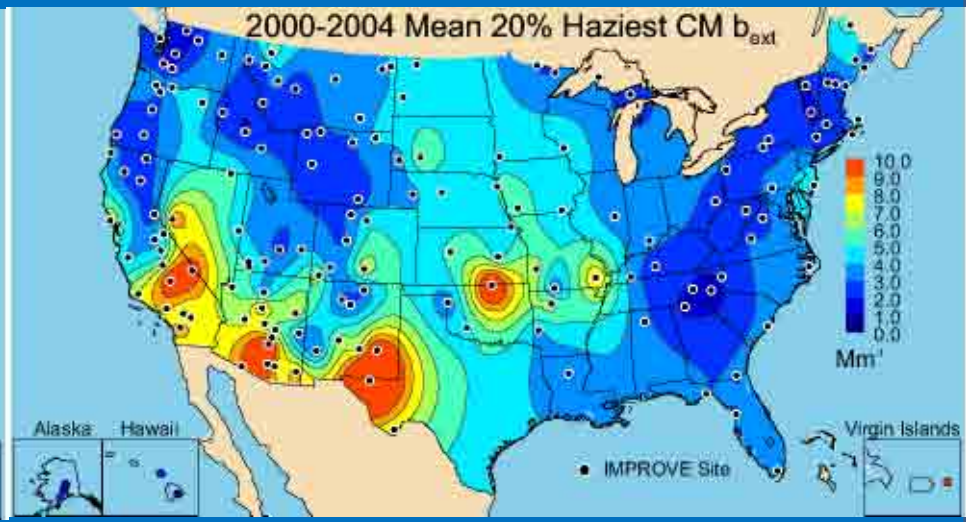


2010-2014

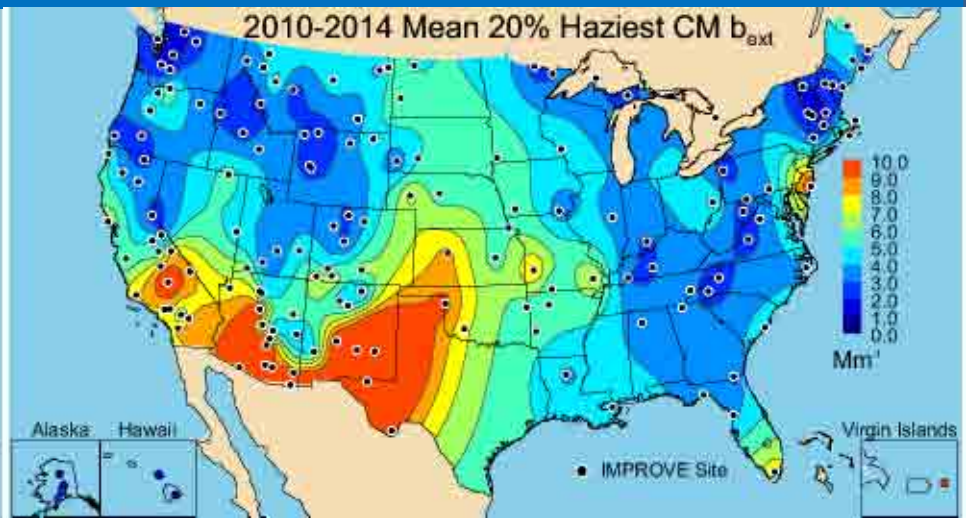


Coarse Mass

2000-2004



2010-2014



Implications

East: Emission reductions have resulted in a 77 % reduction (since 2000) in haziest b_{ext} and lower contributions from sulfate on the haziest days, making room for other species, such as POM and ammonium nitrate to contribute more substantially. This has implications for changes in seasonality and hygroscopicity of the aerosol.

IM/SW: Haziest b_{ext} has declined by 18%. Contributions from ammonium sulfate and ammonium nitrate have been steady and have actually increased in some areas. The contribution from non-controllable species such as carbonaceous aerosols from smoke, dust, and coarse mass are increasingly important.

West Coast: The haziest b_{ext} has declined significantly (28% reduction). Contributions from ammonium nitrate have decreased, likely due to reduced NO_x emissions. Ammonium sulfate contributions have remained fairly flat. Dust and coarse mass contributions have increased.

1990 **San Gorgonio, CA** **2014**

Acknowledgements

National Park Service
Air Resources Division

IMPROVE

CIRA/NPS Colleagues

WinHaze

(www.air-resource.com/resources/downloads.html)

jlhand@colostate.edu

Colorado Kansas

1/11/2013 MODIS