

Trends in Haze (1990-2013)

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1995 Cape Romain, SC 2012



Trends

- How has haze and its constituents changed over time?
 - Regional Haze Rule data: 20% haziest b_{ext}
 $b_{\text{ext}} = b_{\text{ext}} (\text{AS, AN, POM, EC, Soil, CM, SS})$
 - Theil regression
 - 1990–2013; 2000–2013
 - Regional (East, Intermountain/Southwest, West Coast)

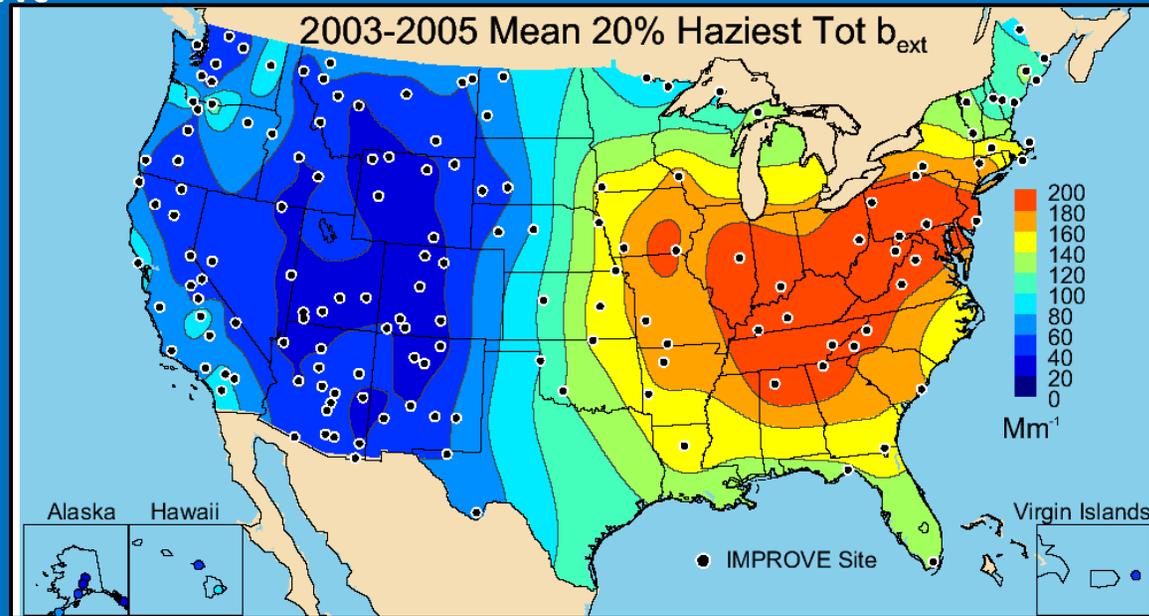
1990

Great Smoky Mountains, TN

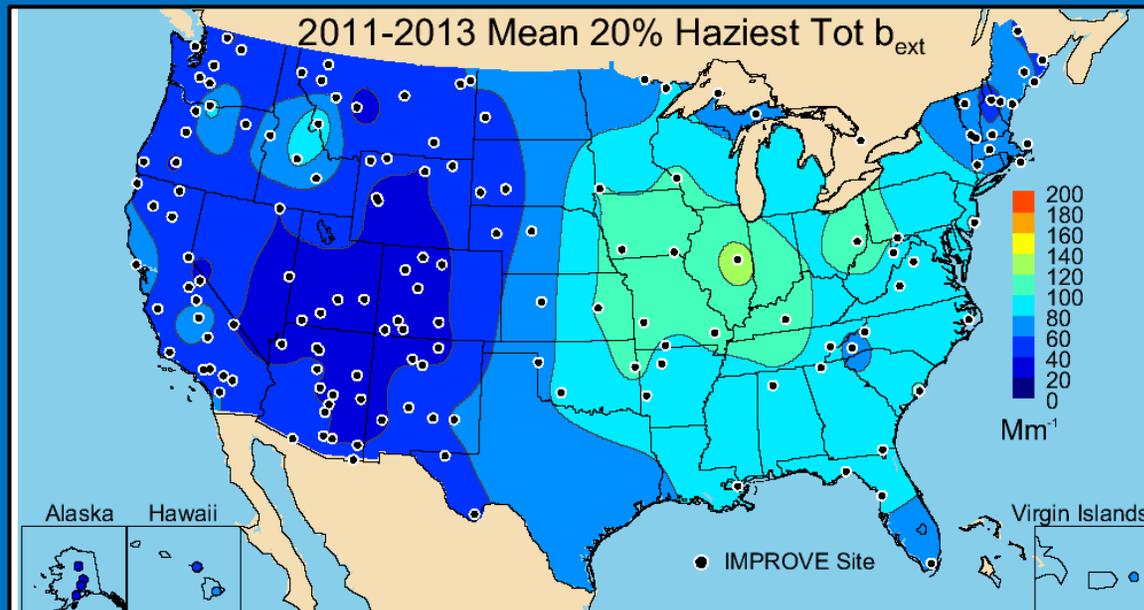
2013

Haziest b_{ext}

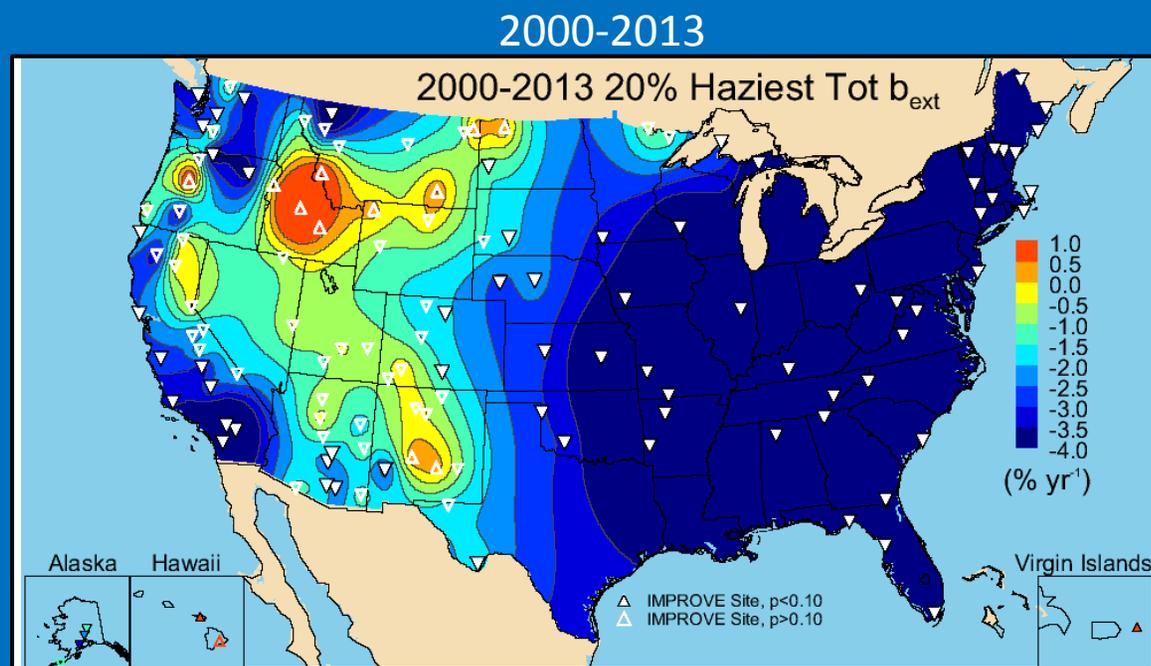
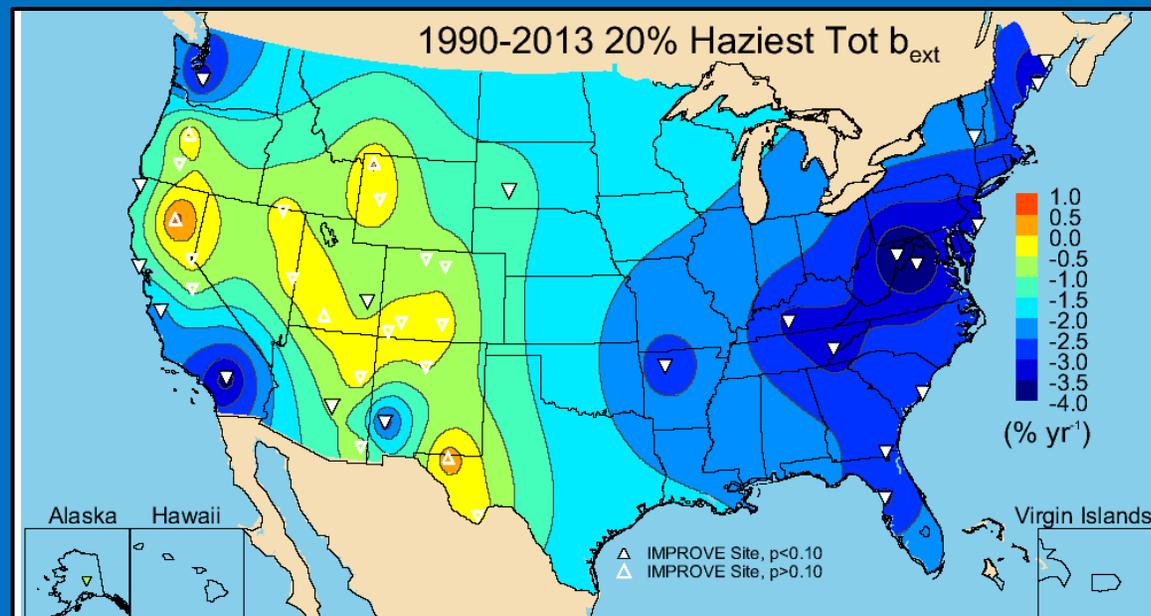
2003-2005



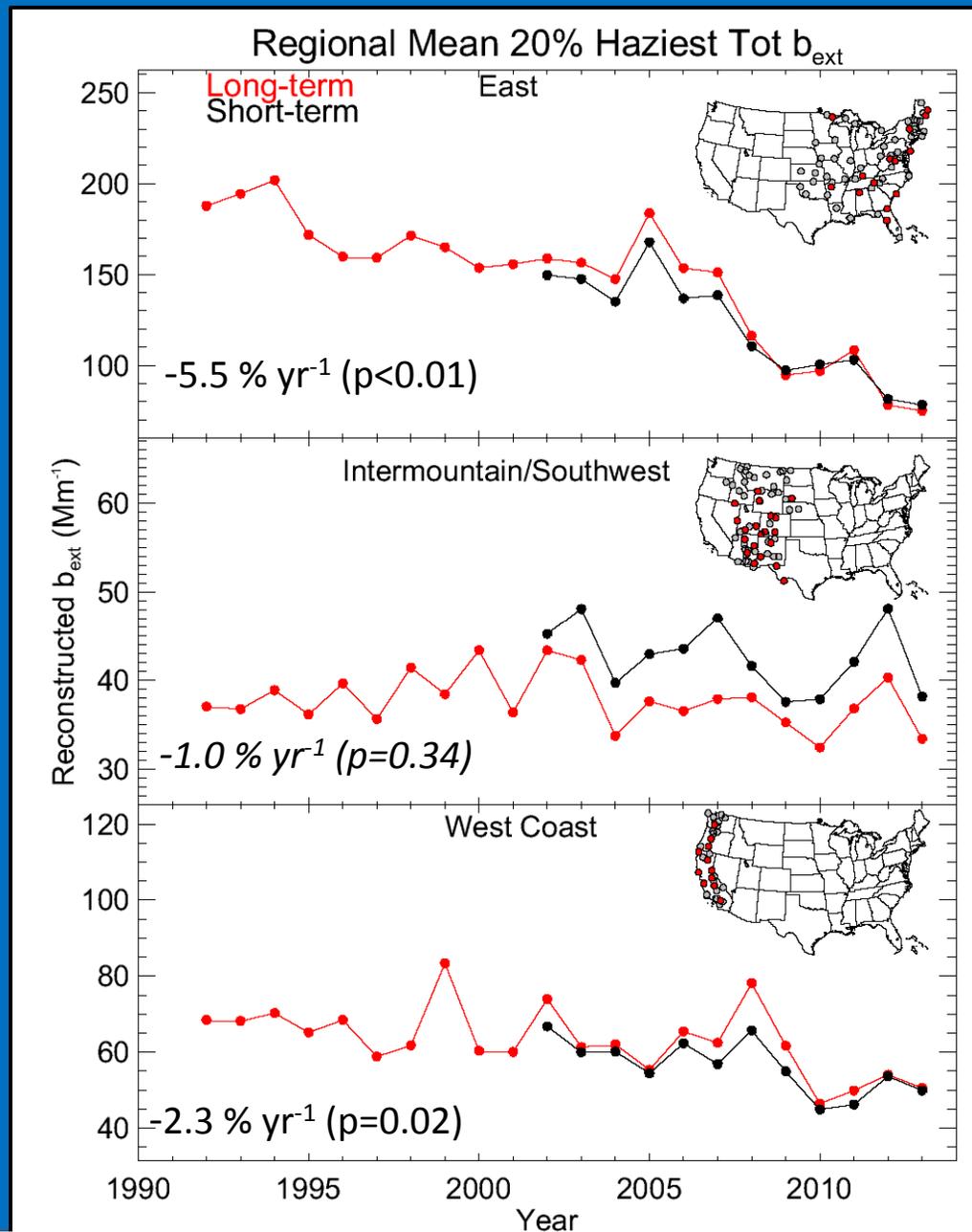
2011-2013



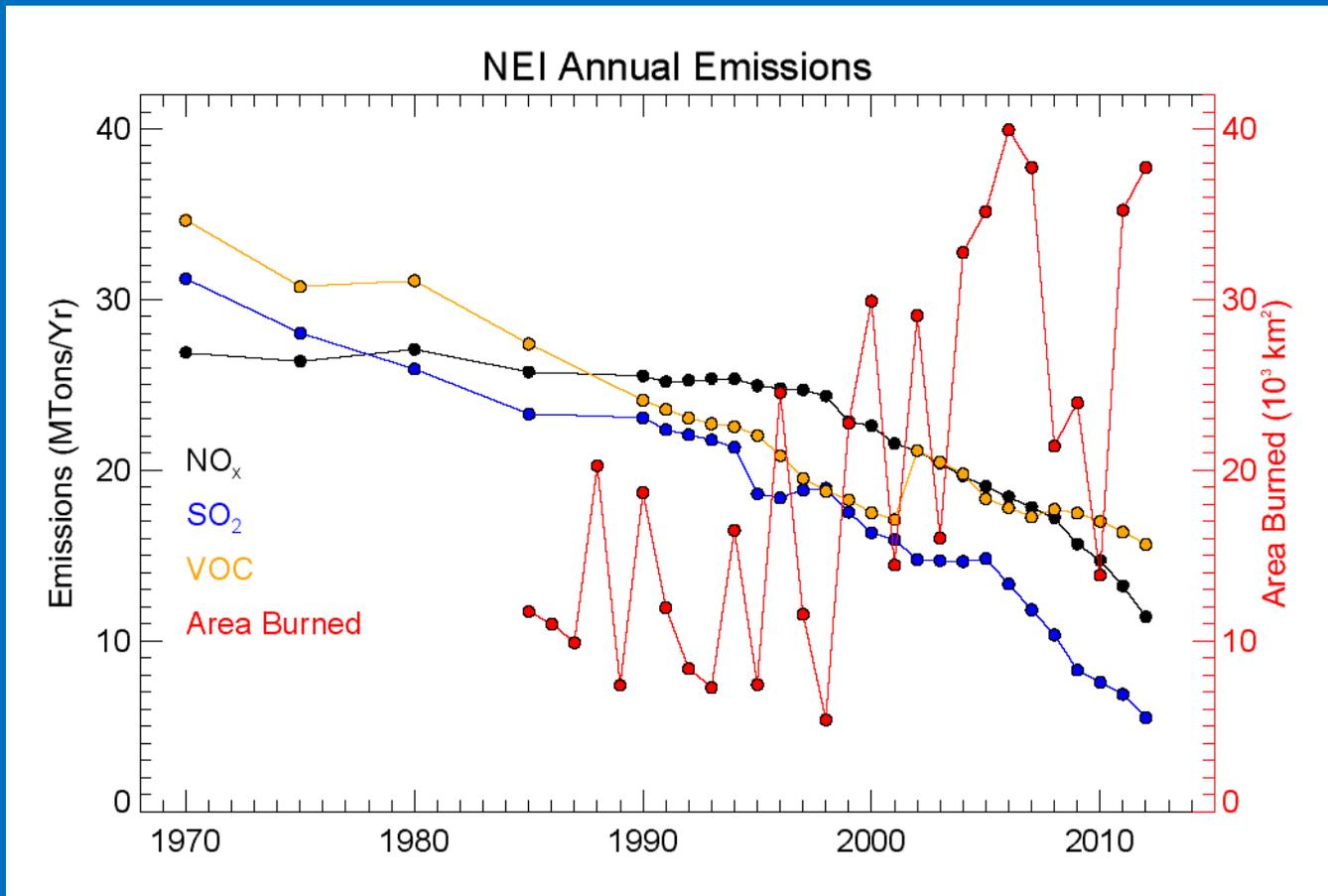
Trends in haziest b_{ext} 1990-2013



Regional Mean Haziest b_{ext}



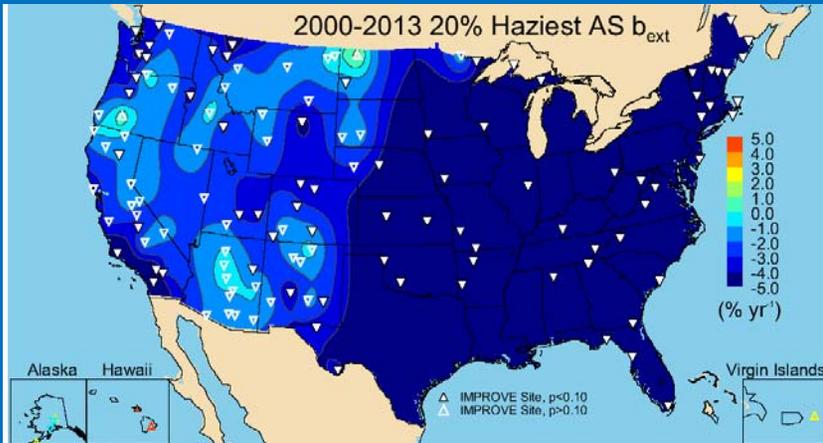
How are the contributions from each species changing?



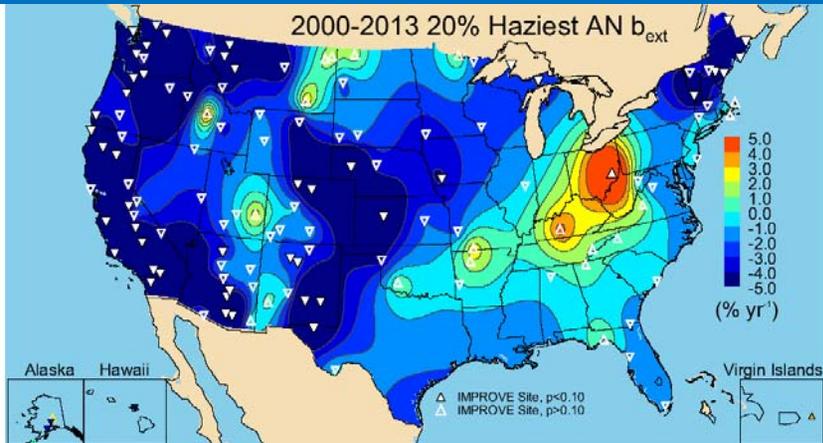
Sources: EPA's National Emissions Inventory, National Interagency Fire Center

2000-2013 Trends in Haziest Speciated b_{ext}

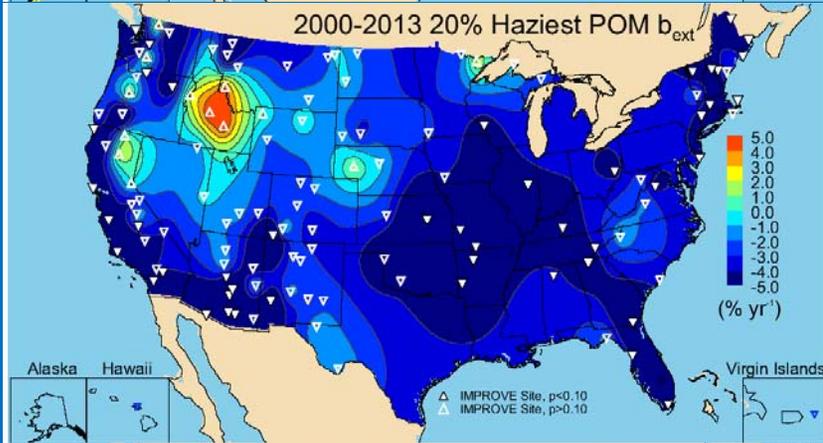
AS



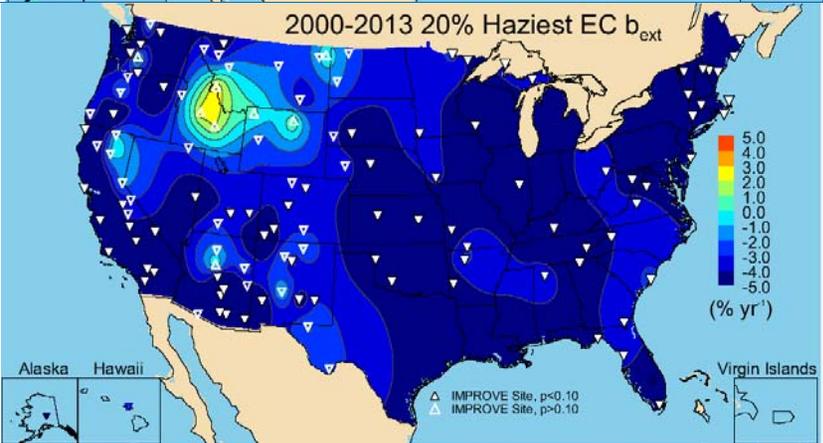
AN



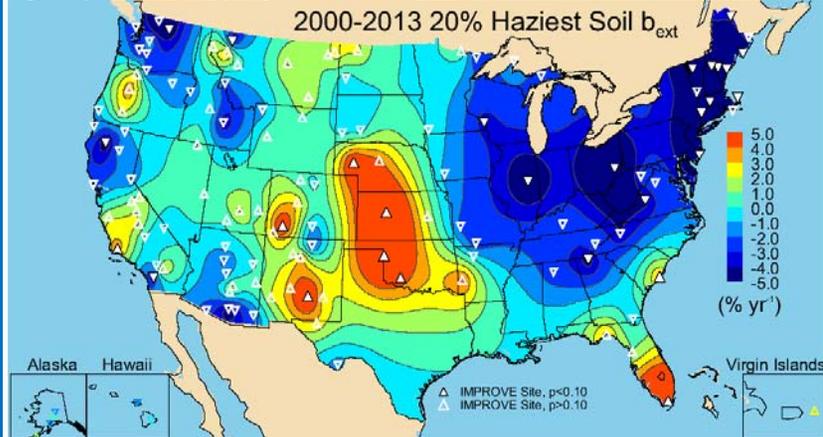
POM



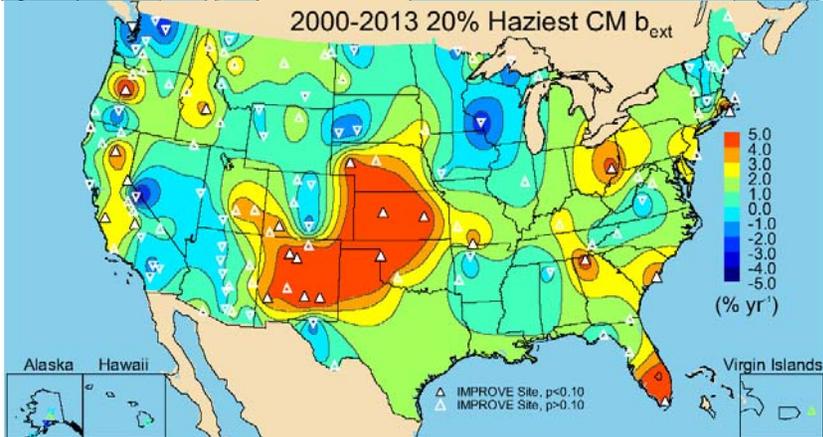
EC



Soil



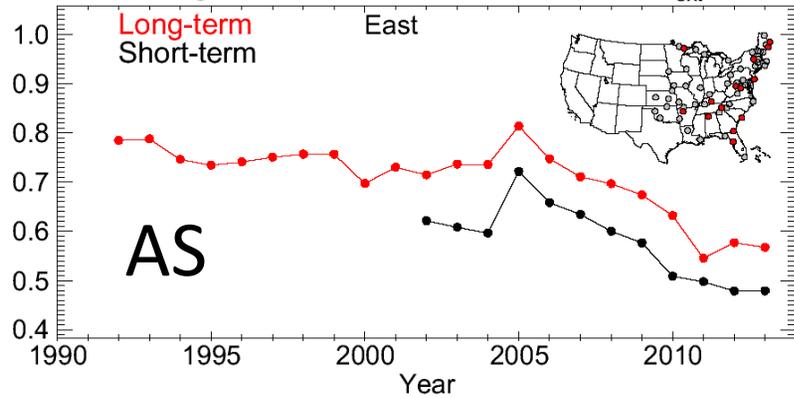
CM



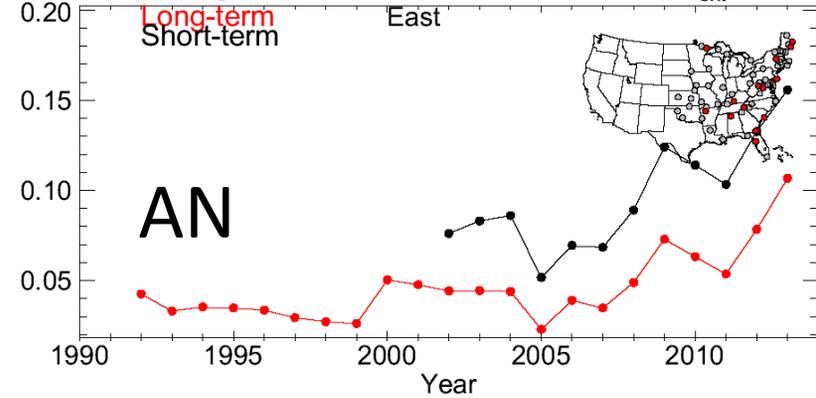
Eastern Regional Mean
Contribution to b_{ext}

Eastern Regional Mean Contribution to Hazeiest b_{ext}

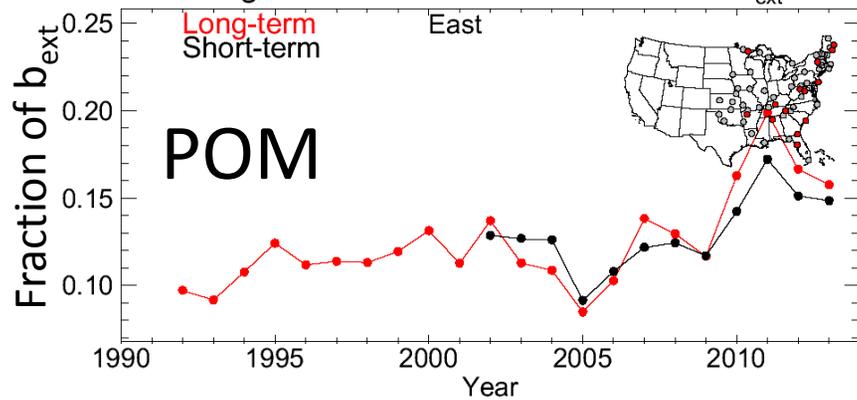
Regional Mean 20% Hazeiest XAS b_{ext}



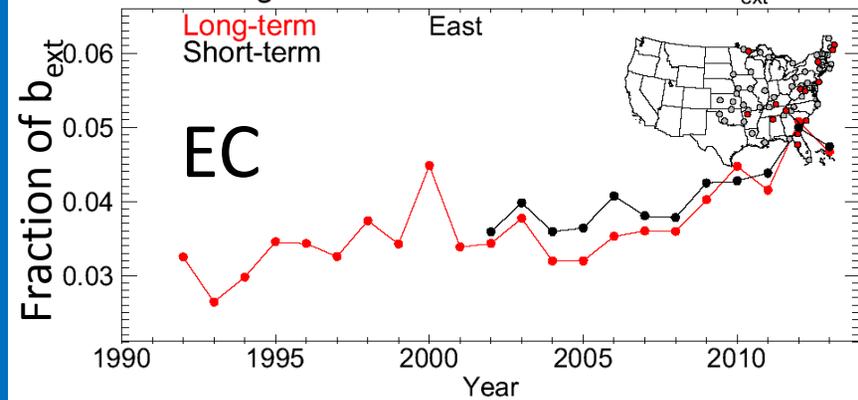
Regional Mean 20% Hazeiest XAN b_{ext}



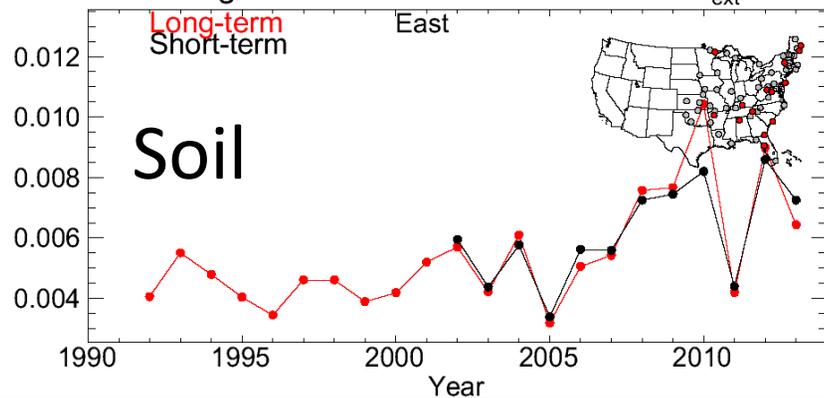
Regional Mean 20% Hazeiest XPOM b_{ext}



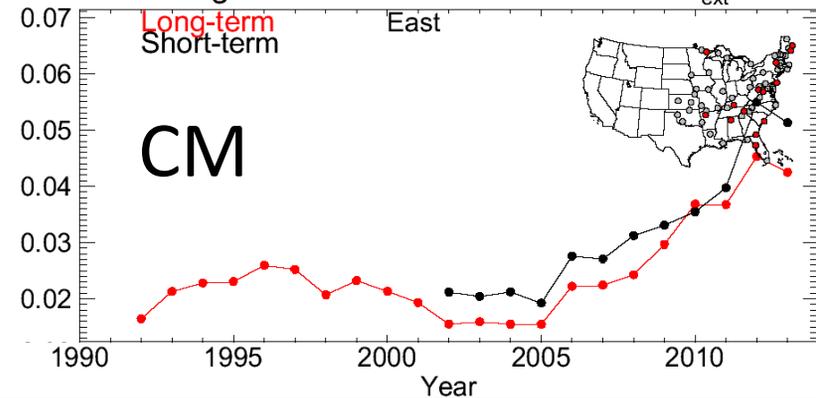
Regional Mean 20% Hazeiest XEC b_{ext}



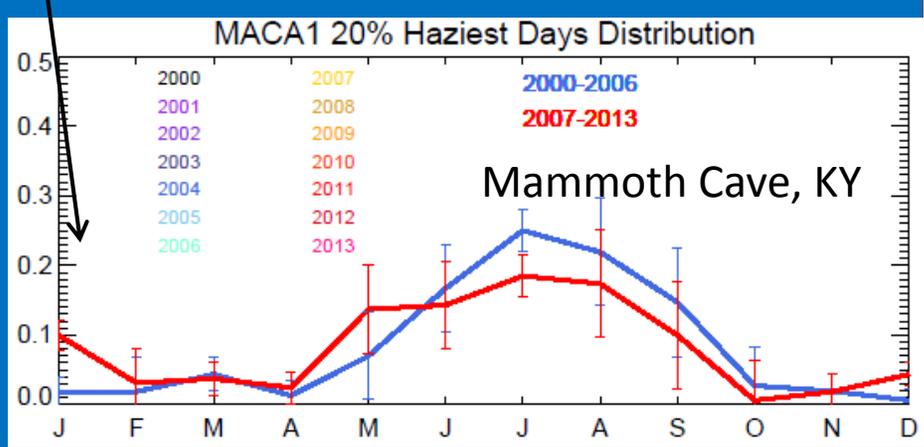
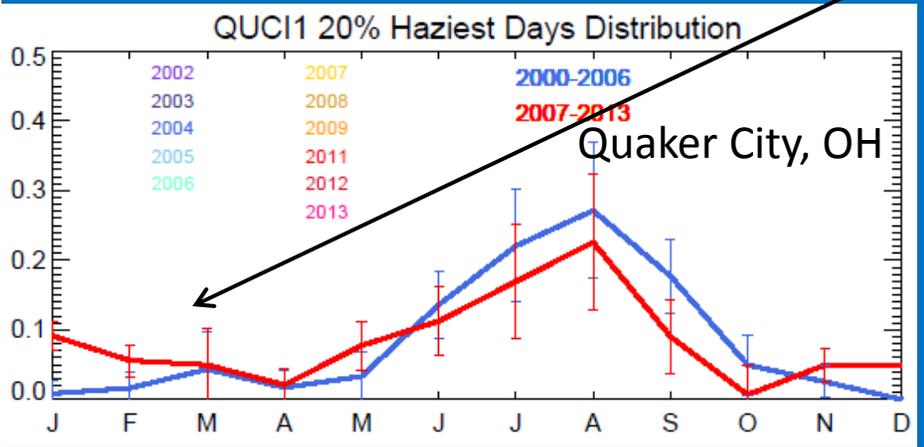
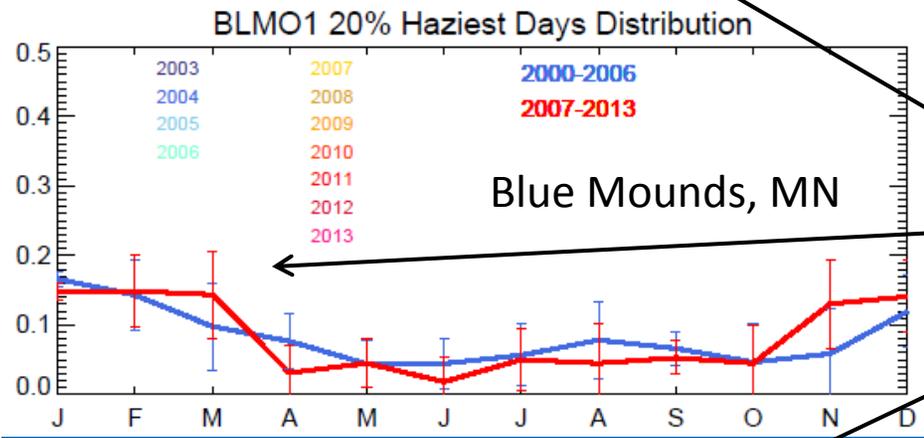
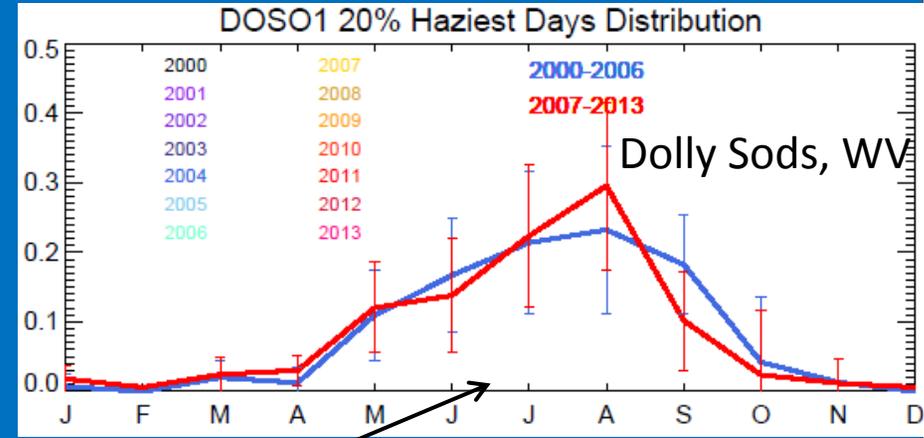
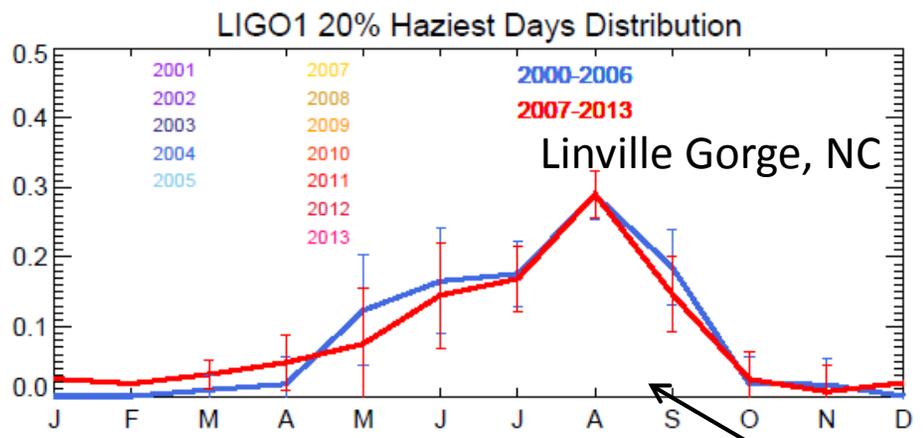
Regional Mean 20% Hazeiest XSoil b_{ext}



Regional Mean 20% Hazeiest XCM b_{ext}



Monthly Distribution of Haziest days in the East



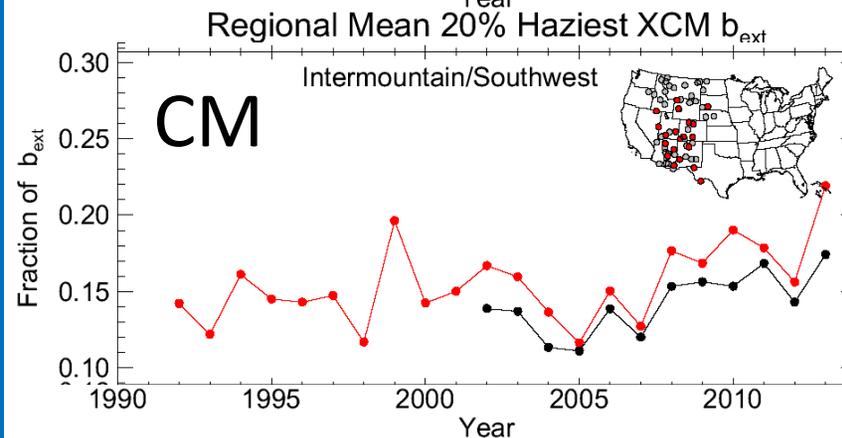
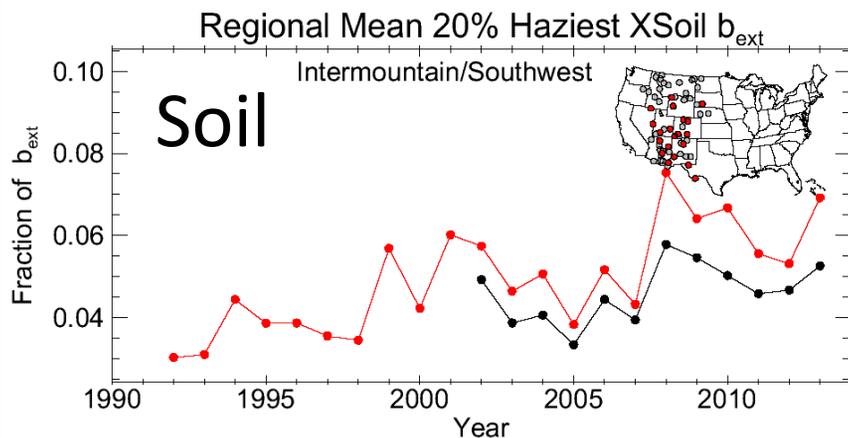
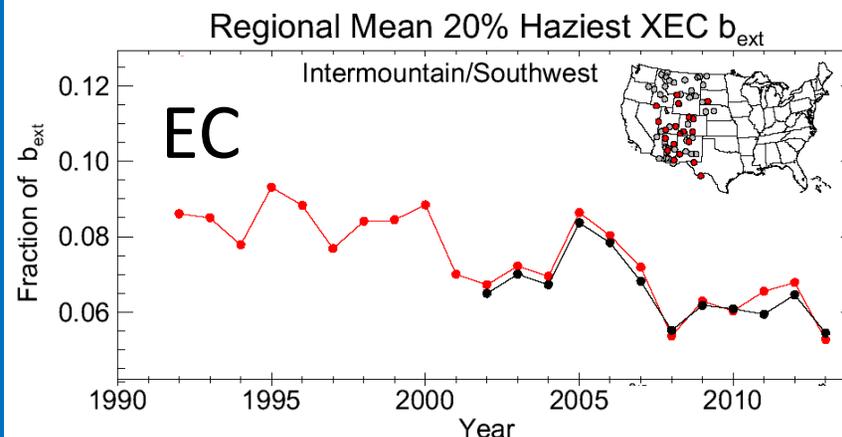
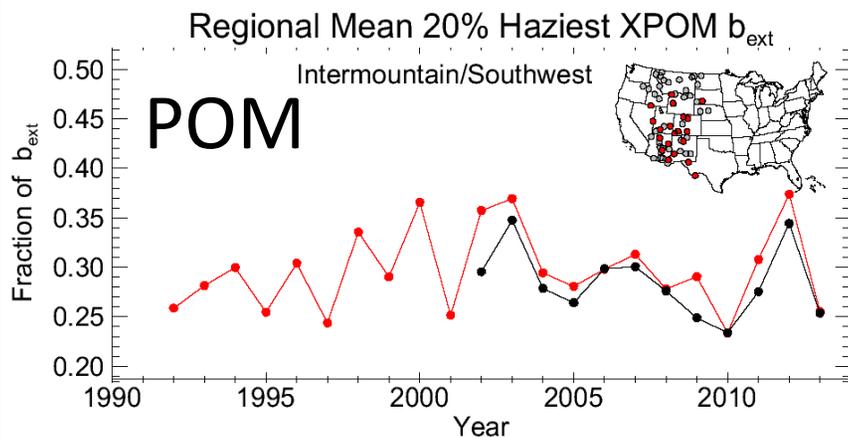
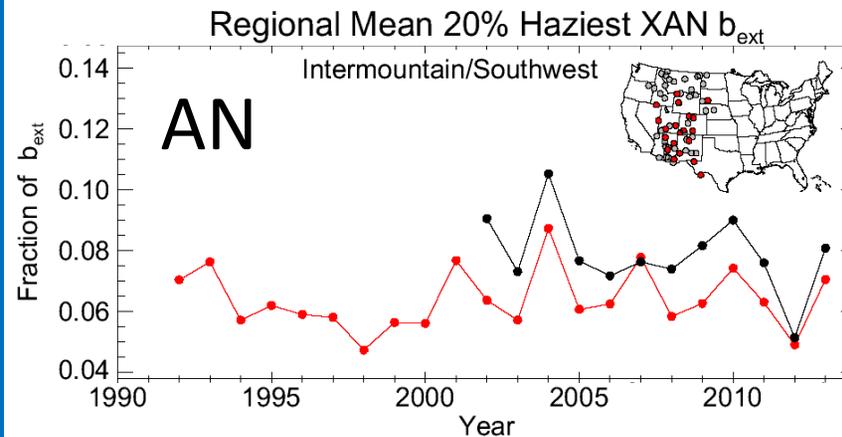
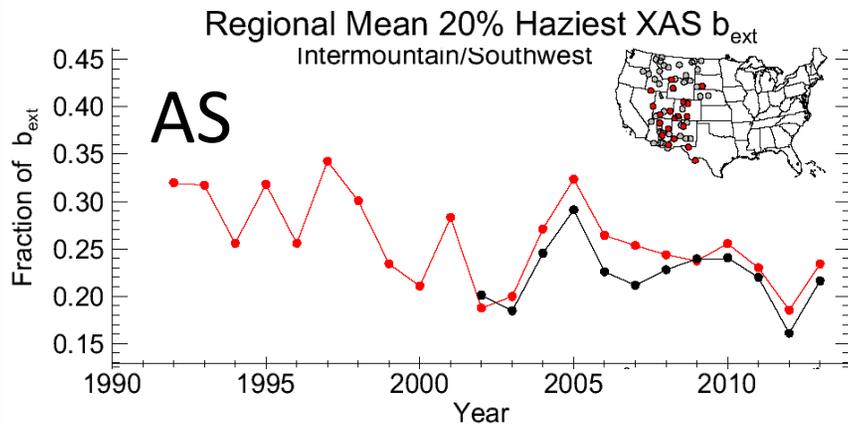
“Summer site” more hazy days in summer

“Winter site”: More hazy days in winter

Later years with more hazy days in winter:
effects of nitrate?

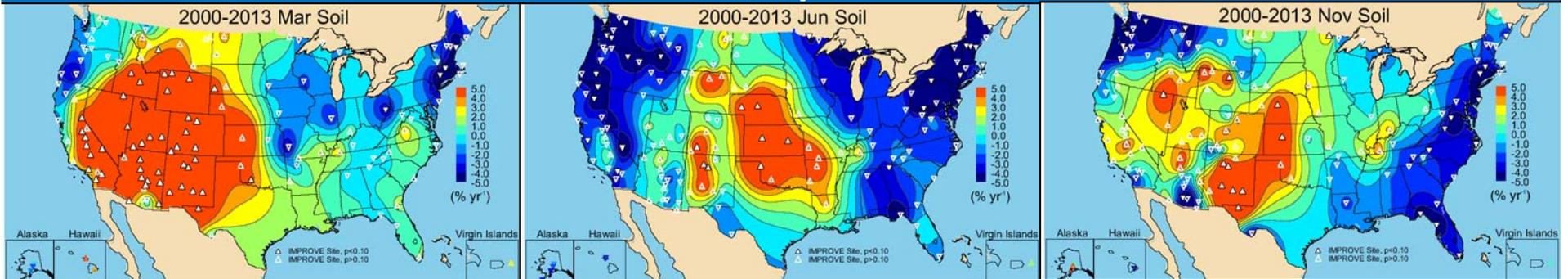
Intermountain/Southwest Regional
Mean Contribution to b_{ext}

IM/SW Regional Mean Contribution to Haziest b_{ext}

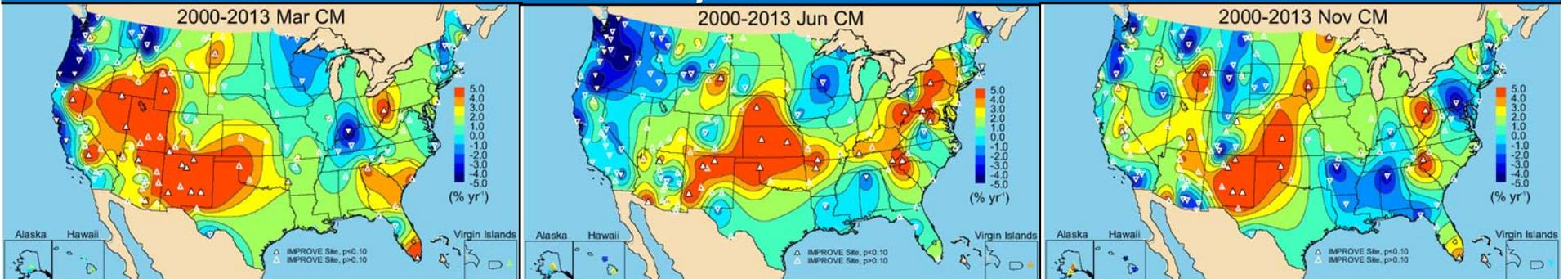


What's happening with soil and CM?

2000-2013 monthly mean soil mass trends

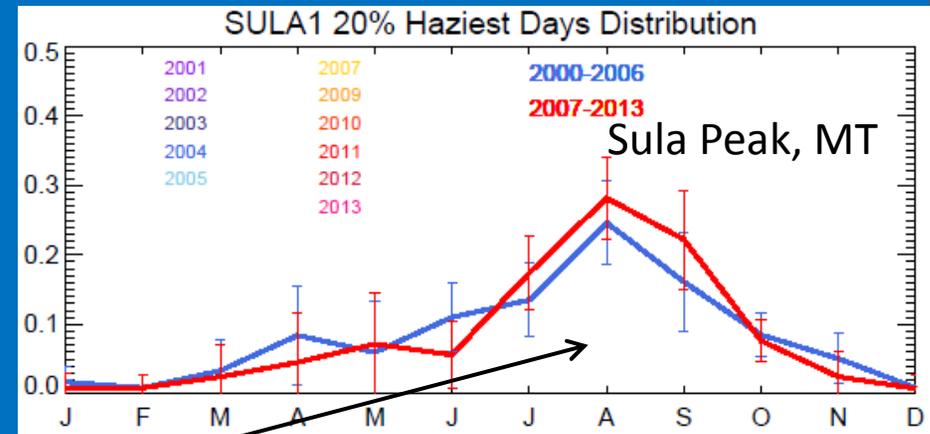
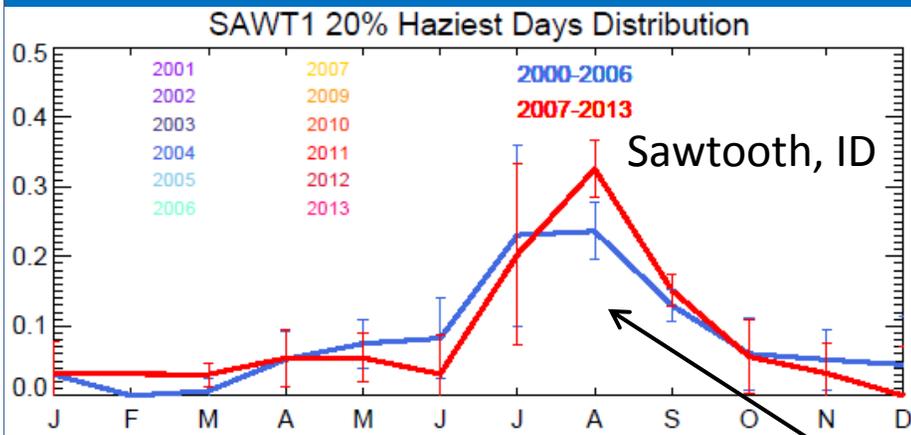


2000-2013 monthly mean coarse mass trends



- Soil and coarse mass have increased across the West in spring, and in the central U.S. in summer and fall

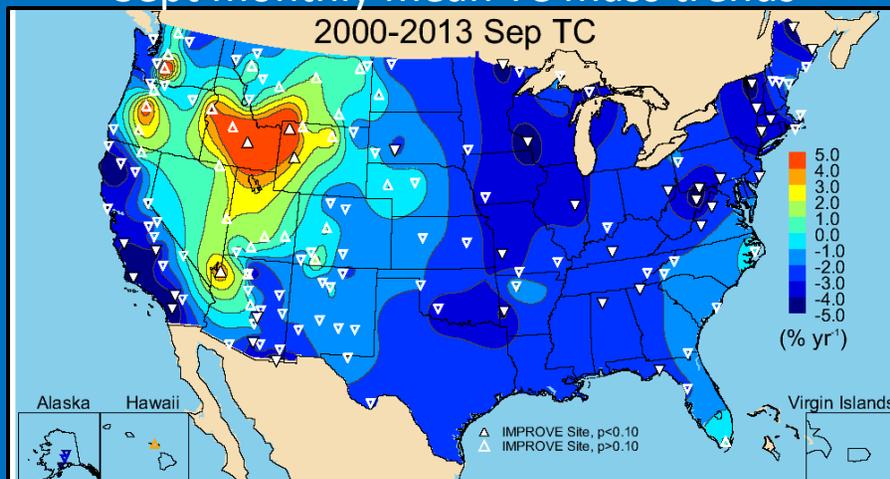
Monthly Distribution of Hazyest days in the IMW/SW



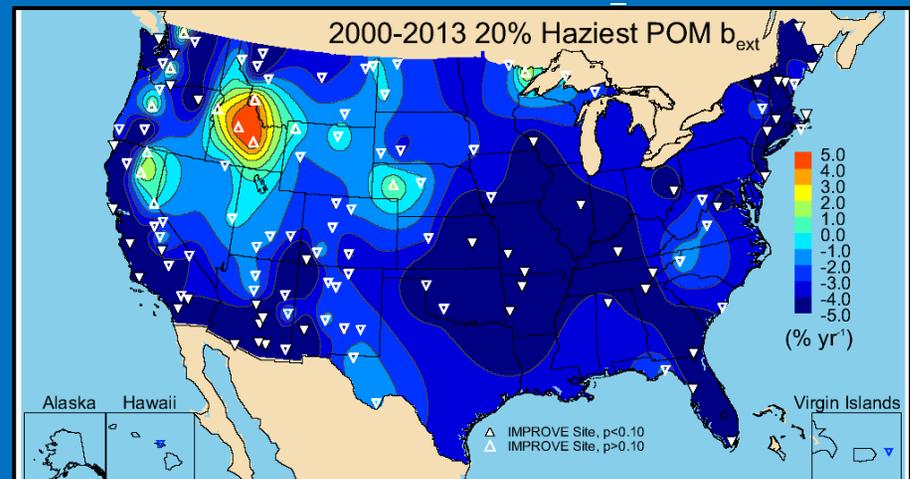
Impacts from biomass smoke

Total carbon mass has increased during fire season

Sept monthly mean TC mass trends

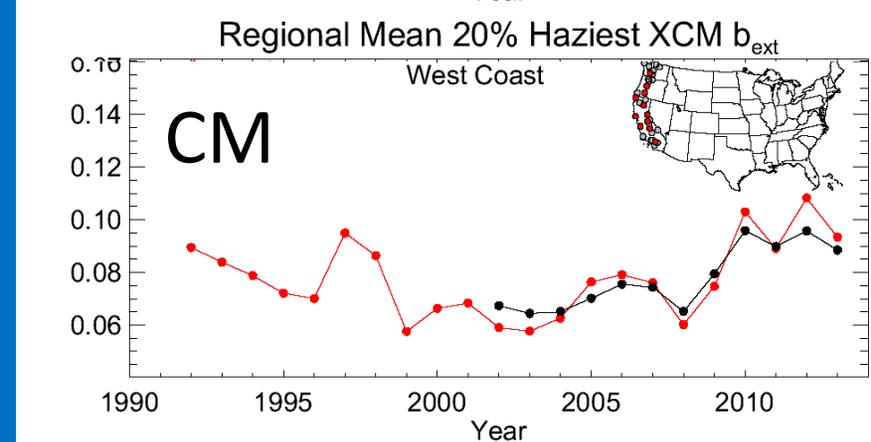
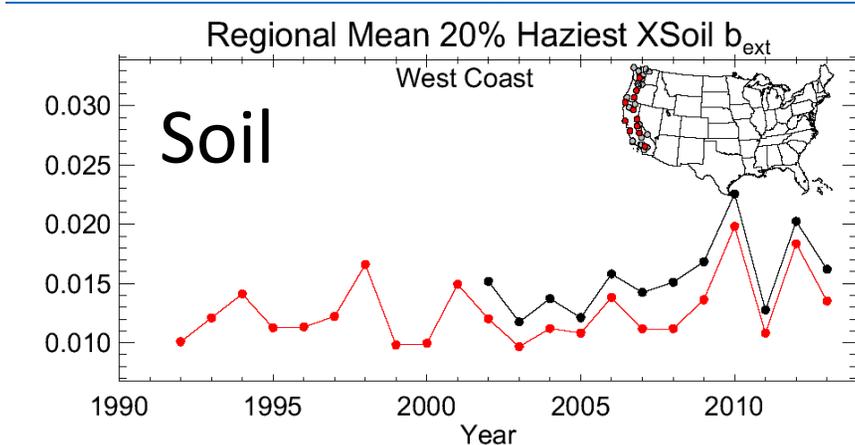
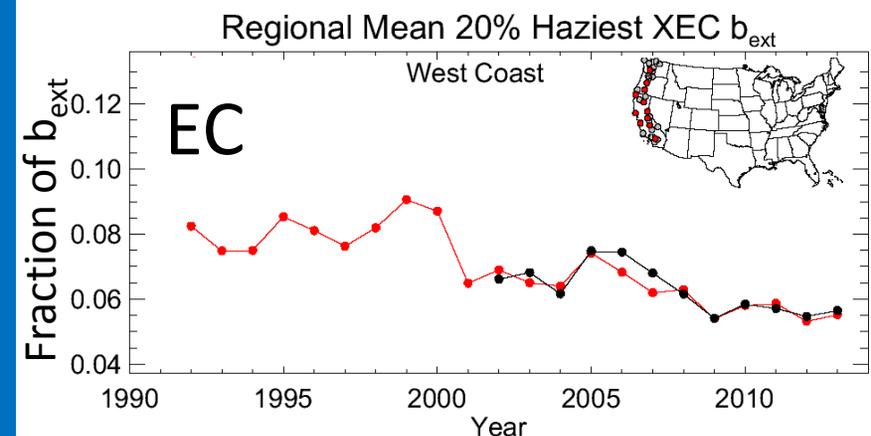
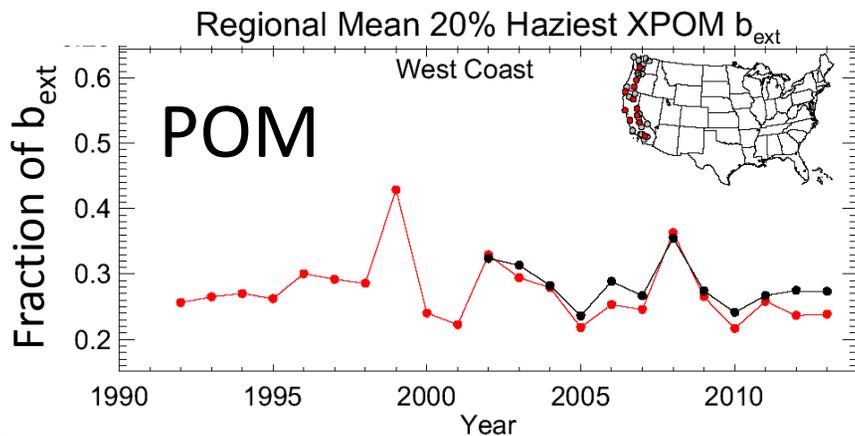
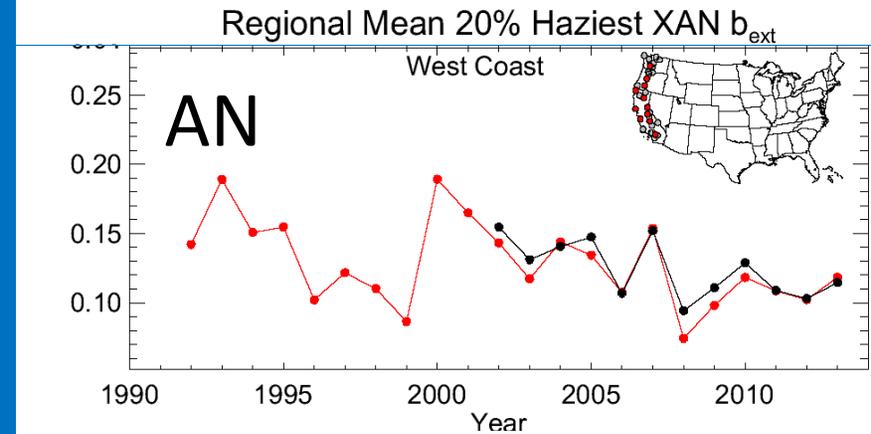
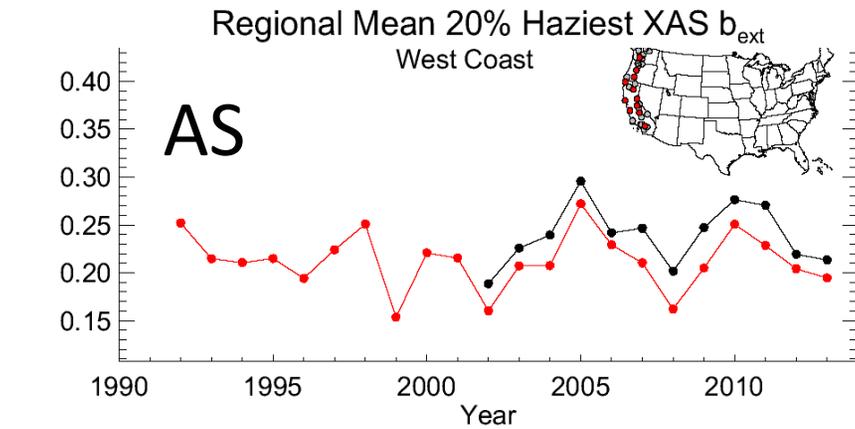


Trends in hazyest b_{ext_POM}

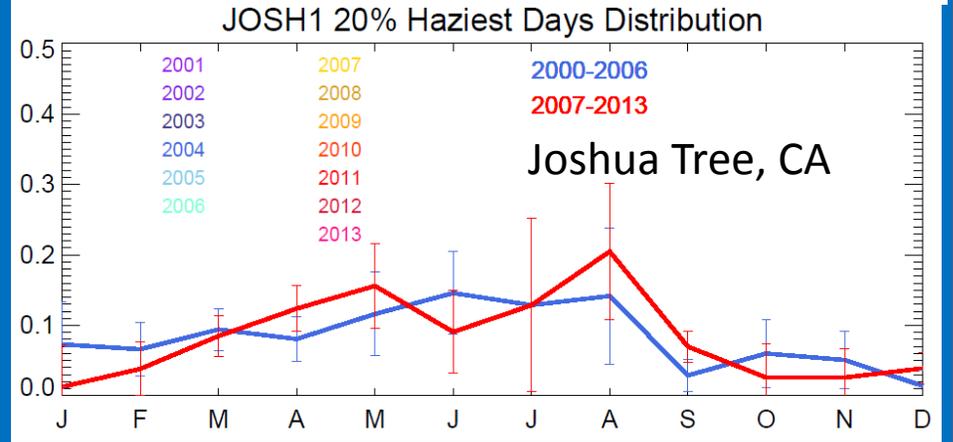
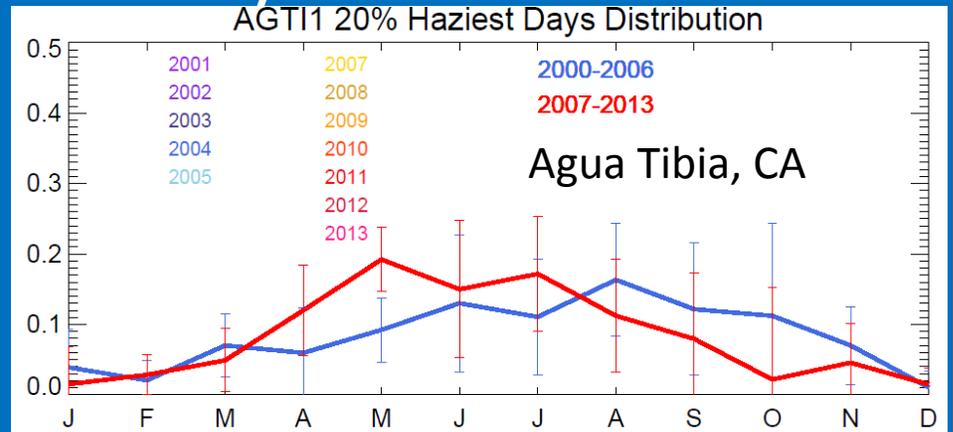
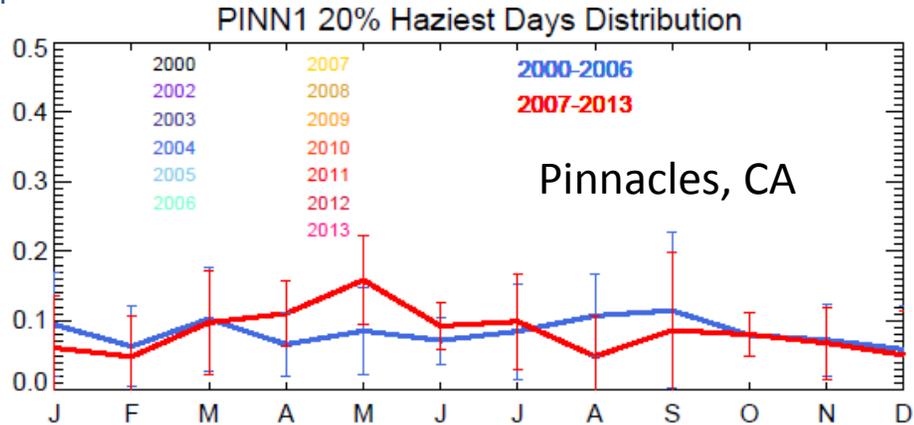
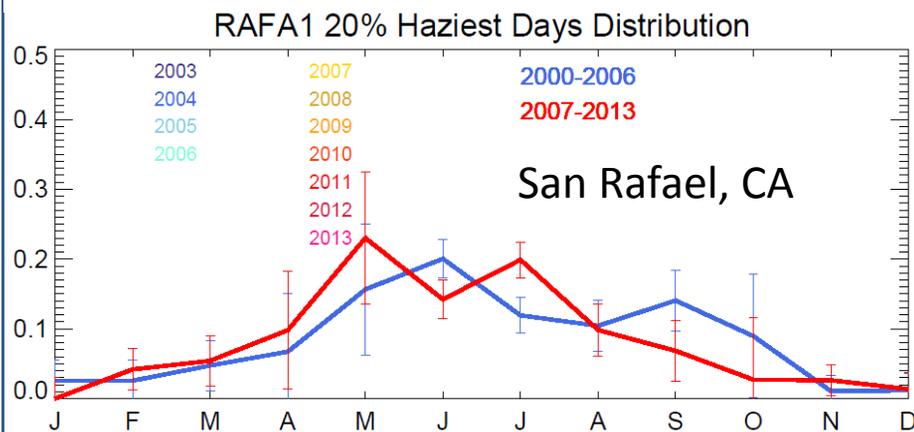
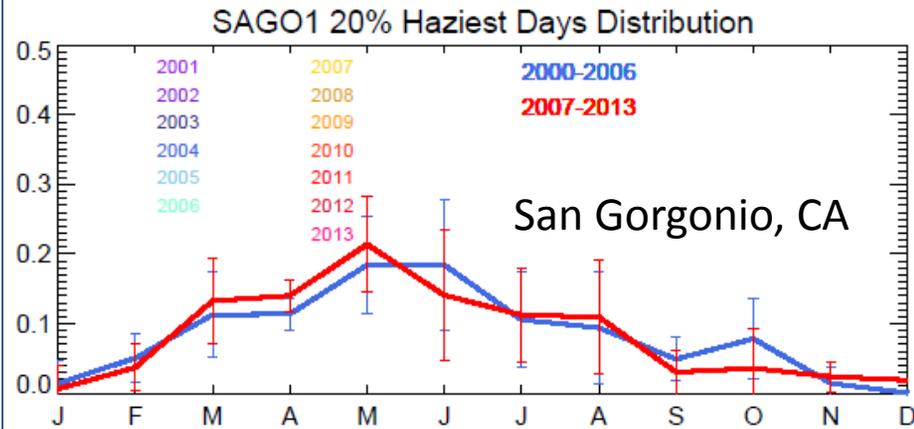


West Coast Regional Mean
Contribution to b_{ext}

West Coast Regional Mean Contribution to Hazeiest b_{ext}



Monthly Distribution of Haziest days in the West Coast



Haziest days shift toward spring?

Summary

East: Emission reductions have contributed to a 66% reduction in haziest b_{ext} and lower contributions from sulfate on the haziest days, making room for other species, such as POM and AN to contribute more substantially. This has implications for changes in seasonality and hygroscopicity of the aerosol.

IM/SW: Haziest b_{ext} has declined by 12%. Contributions from AS and AN have been steady and have actually increased in some areas. The contribution from non-controllable species such as carbonaceous aerosols from smoke continue to be important, and dust and CM aerosol contributions have increased.

West Coast: The haziest b_{ext} has declined significantly (28% reduction). Contributions from AN have decreased, likely due to reduced NO_x emissions. AS contributions have remained fairly flat. Soil and CM contributions have increased, but still contribute less than 10% to total b_{ext} on the haziest days.

1990

San Geronio, CA

2013

Acknowledgments:



WinHaze, ARS

1990

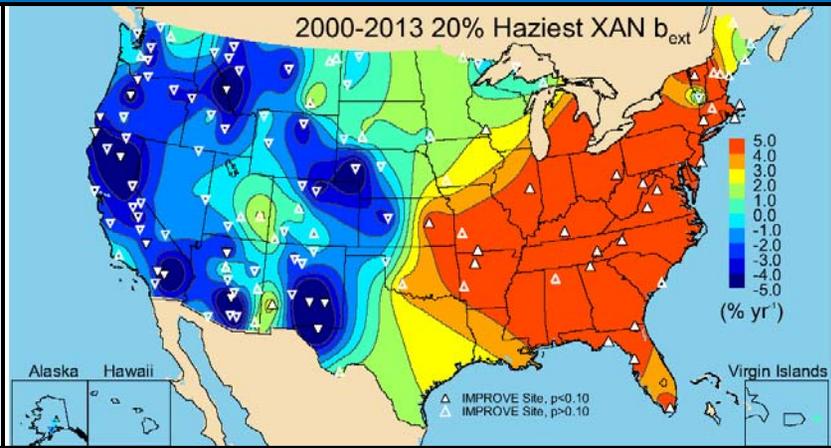
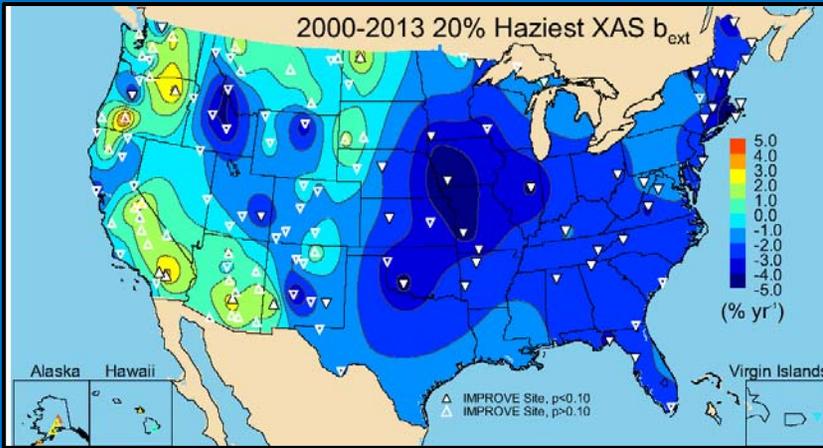
Acadia, ME

2013

Extras

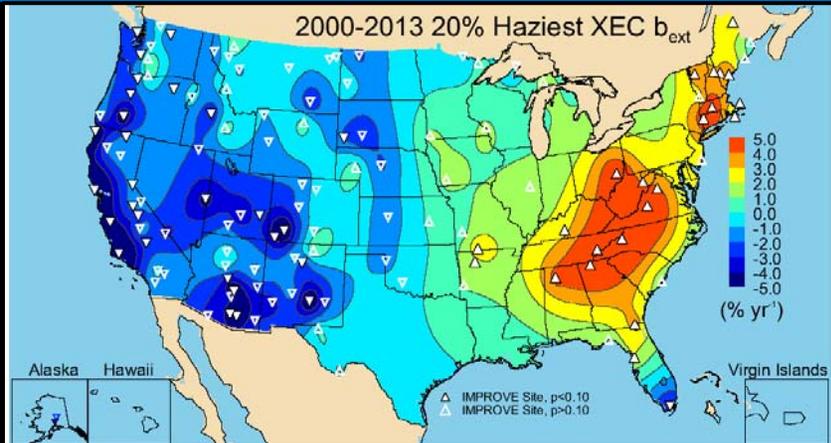
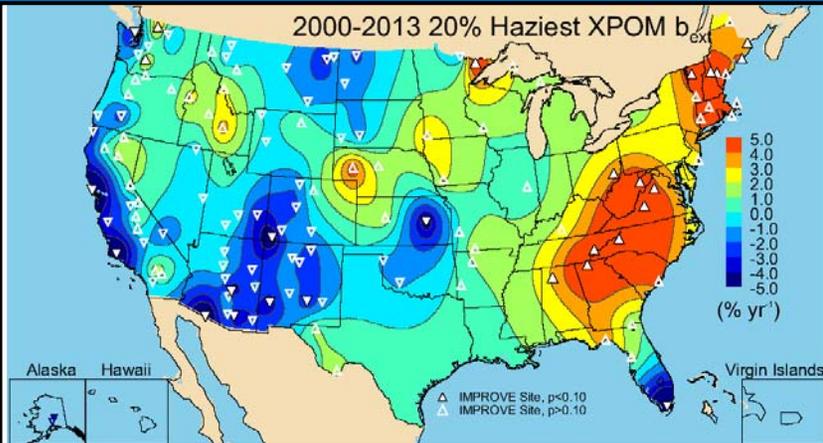
2000-2013 Trends in Fractional Contribution to Haziest b_{ext}

AS



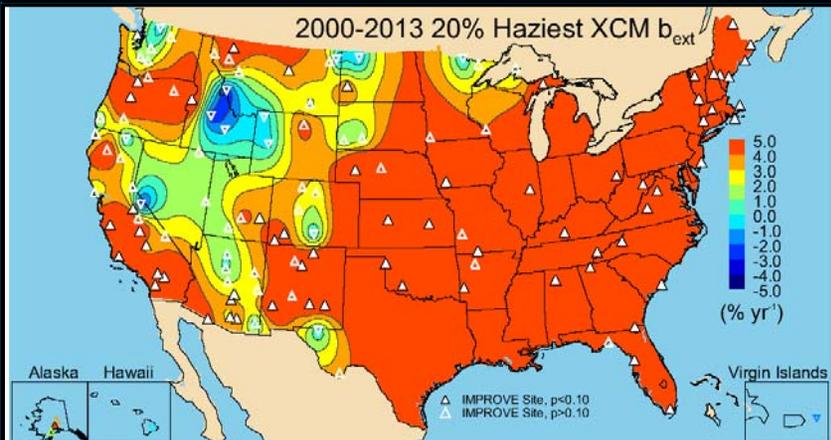
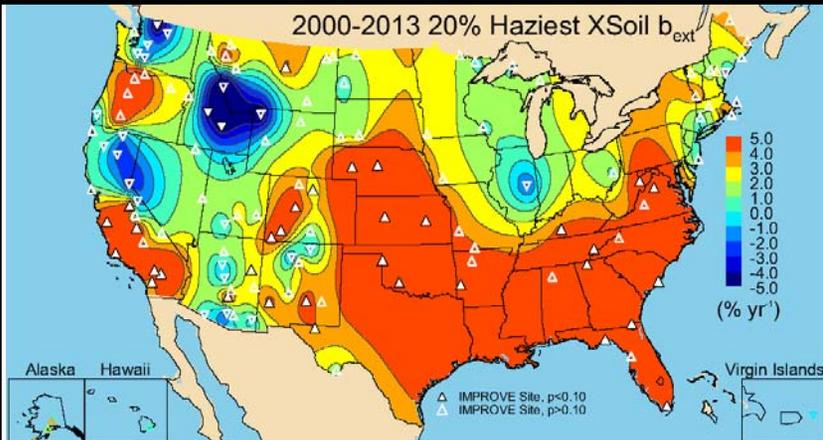
AN

POM



EC

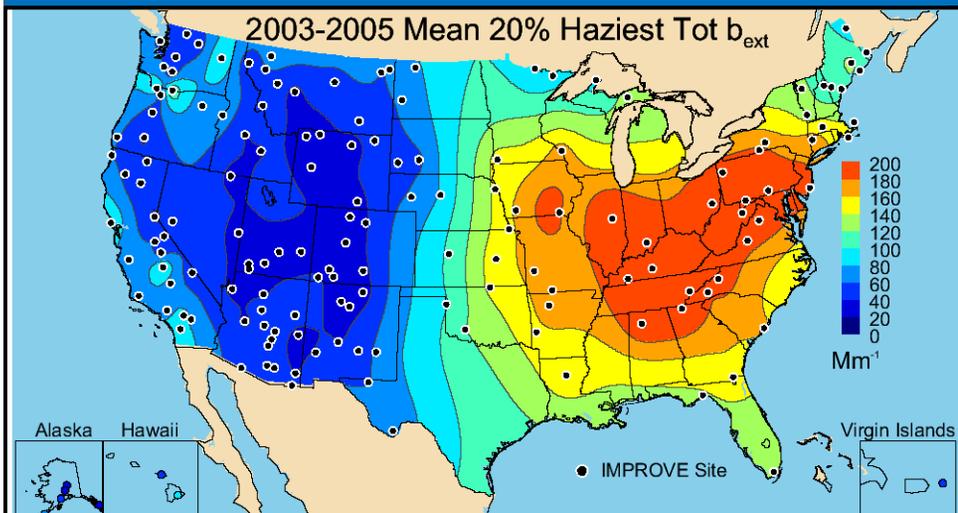
Soil



CM

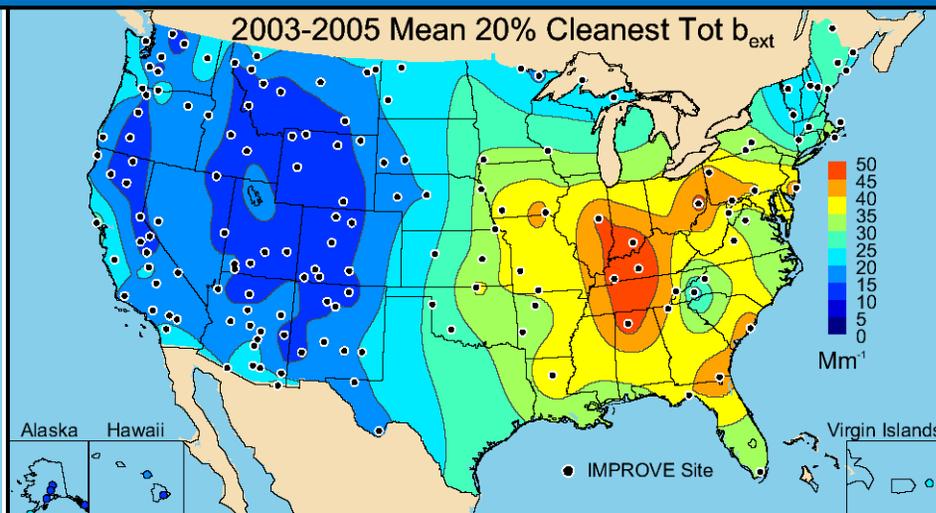
Haziest b_{ext}

2003-2005

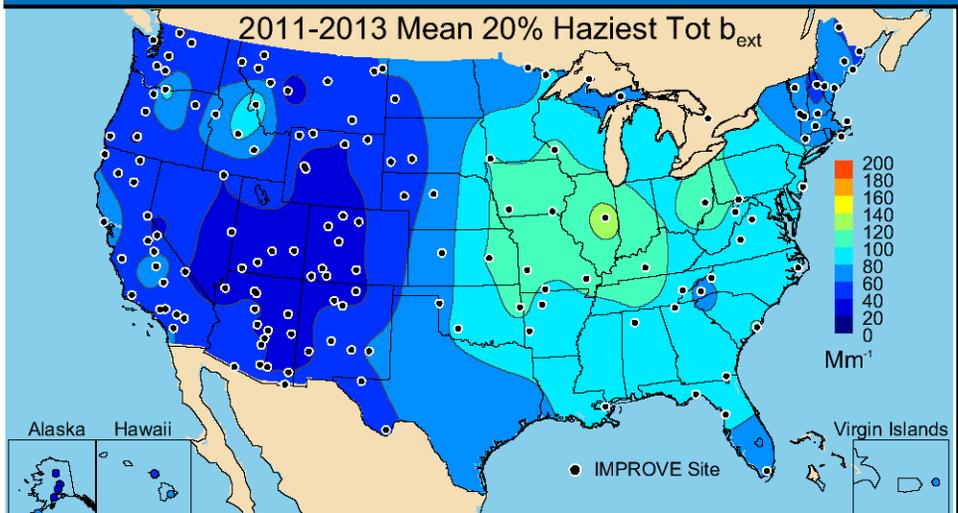


Cleanest b_{ext}

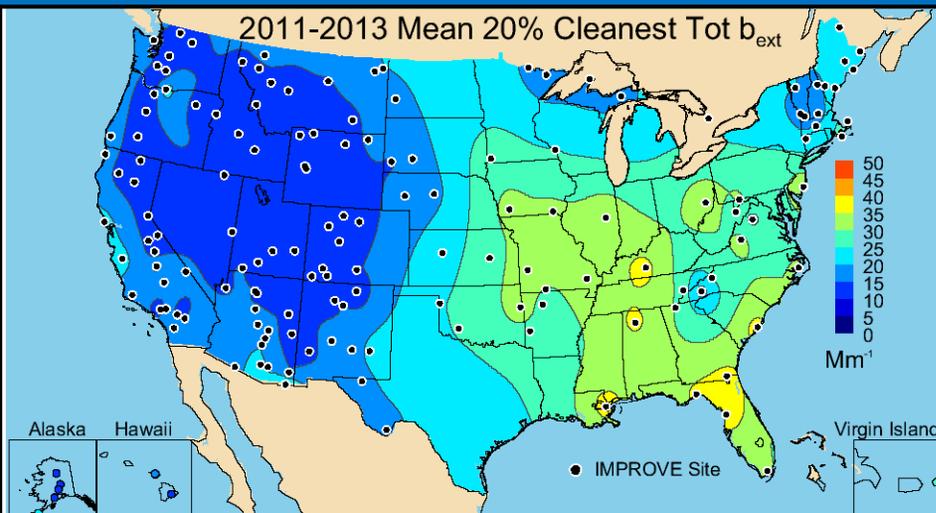
2003-2005



2011-2013



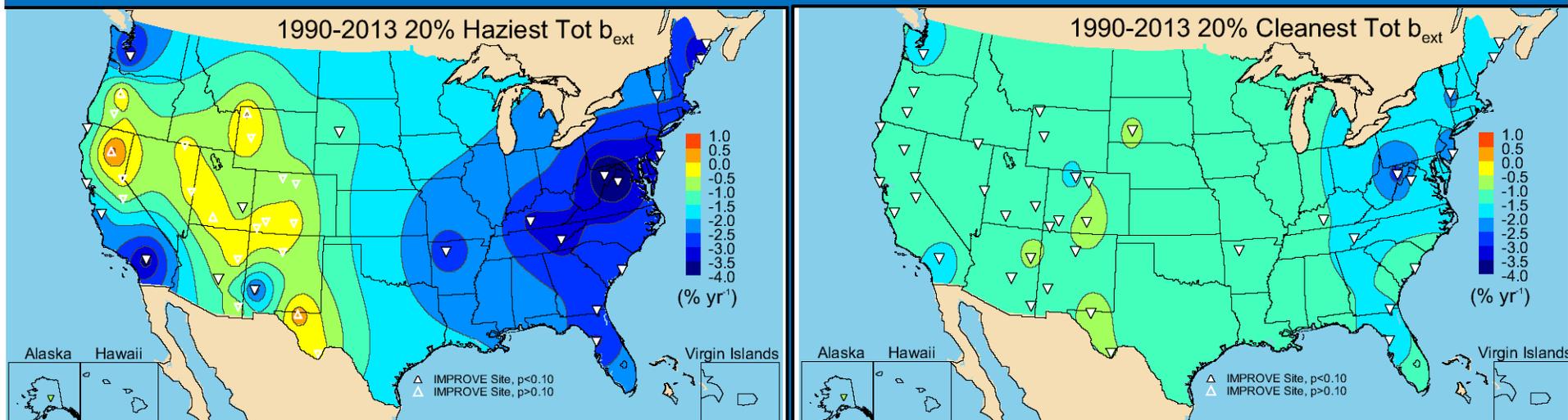
2011-2013



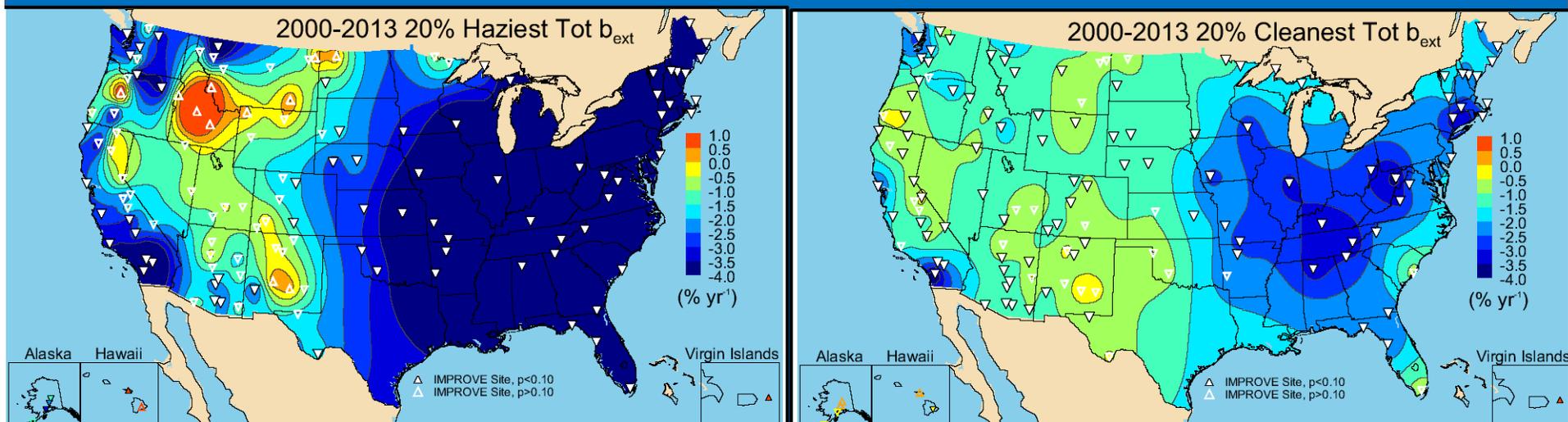
Trends in haziest b_{ext}

Trends in cleanest b_{ext}

1990-2013

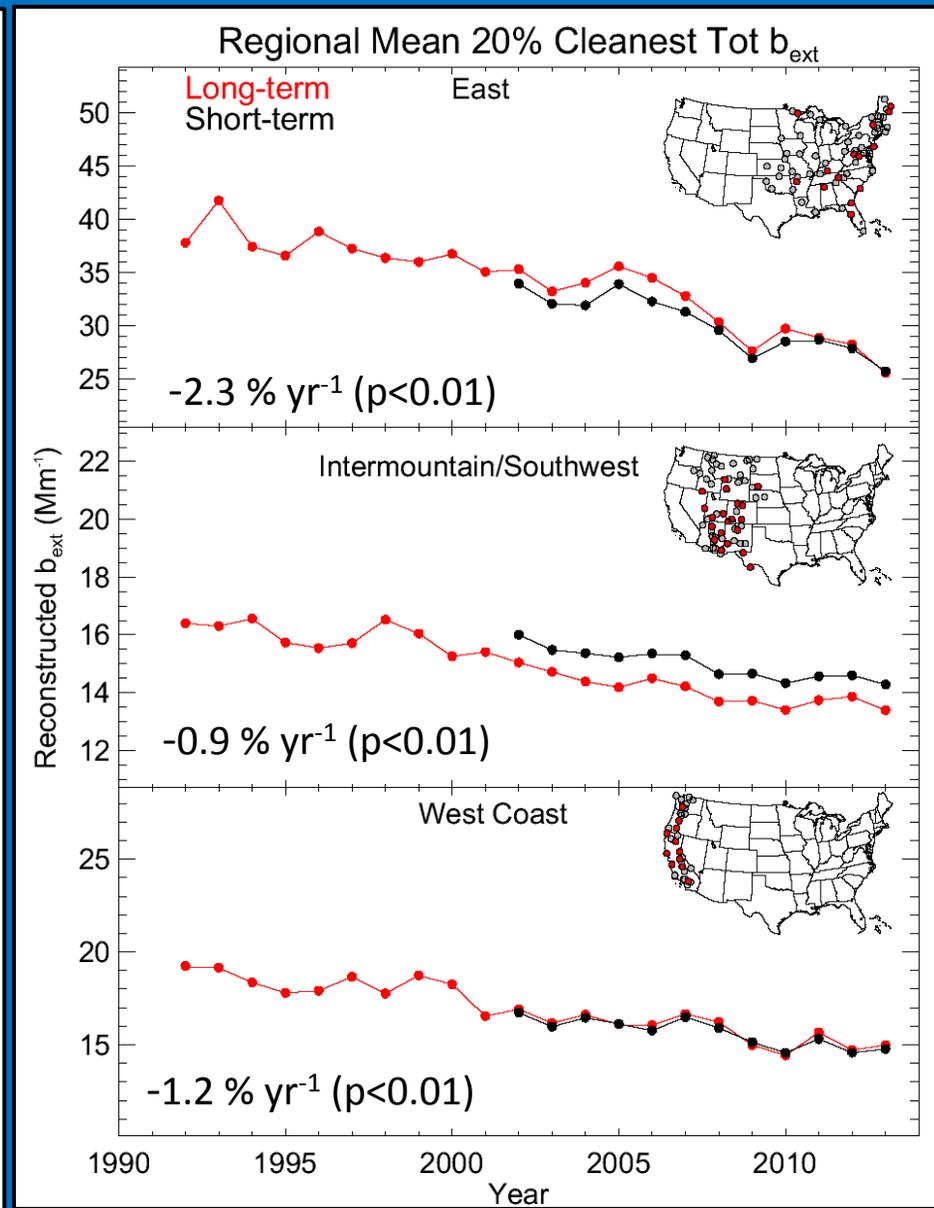
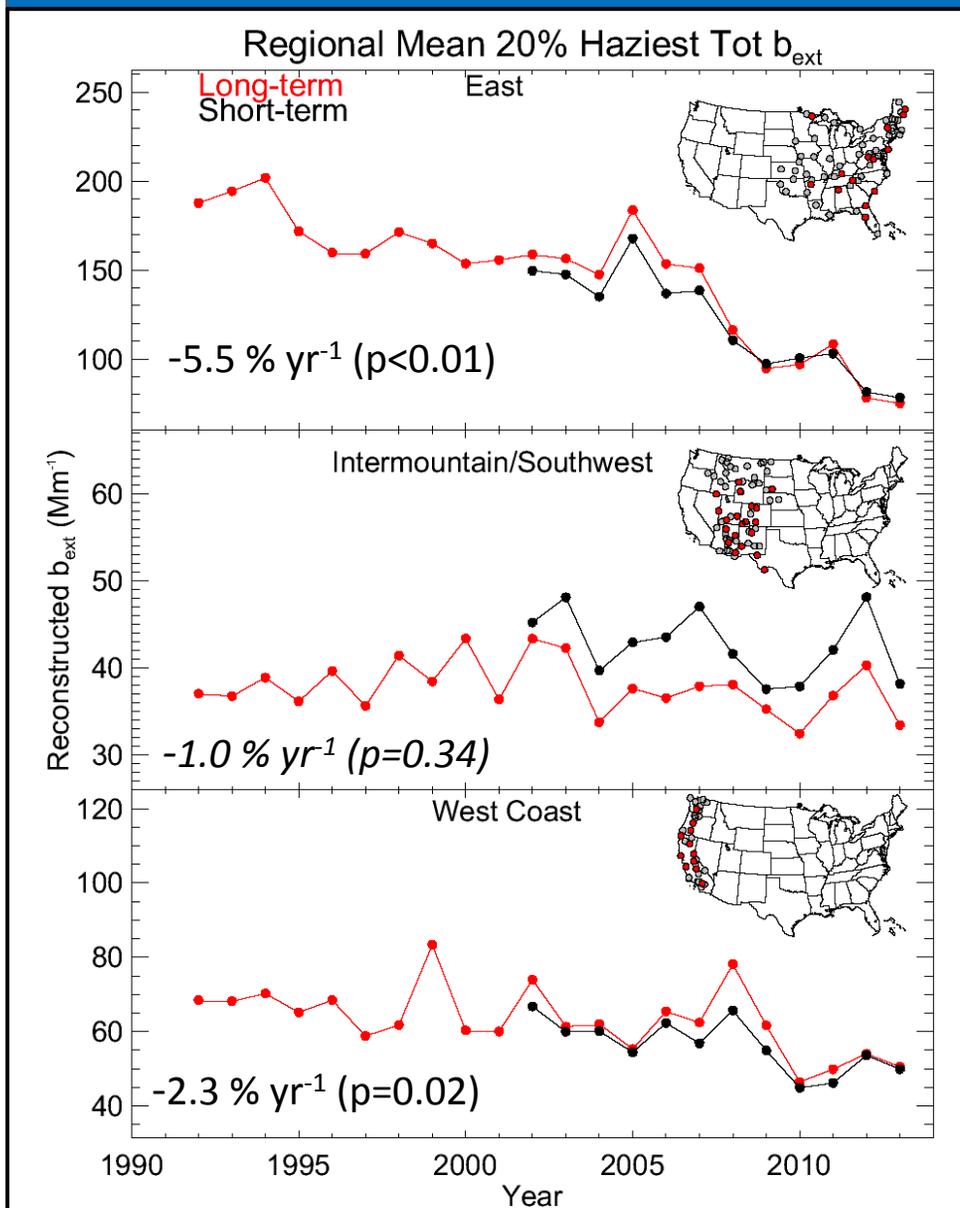


2000-2013



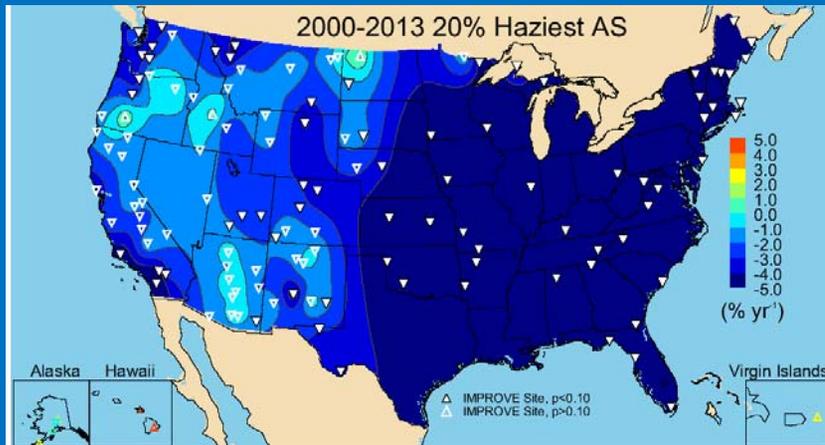
Haziest b_{ext}

Cleanest b_{ext}

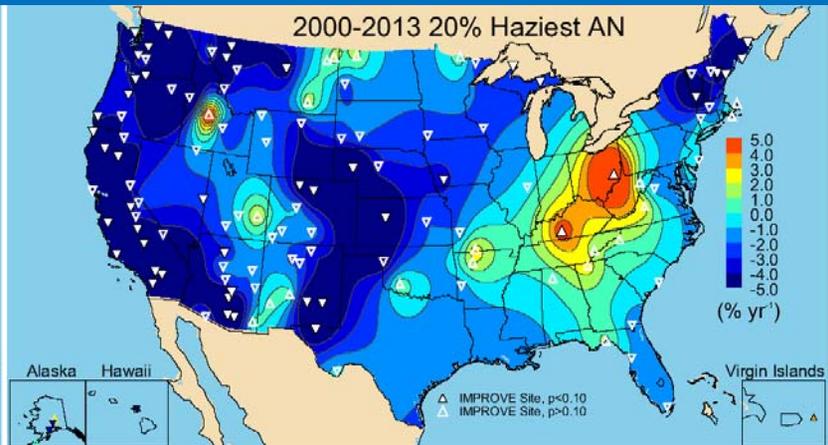


2000-2013 Trends in Haziest Speciated Mass

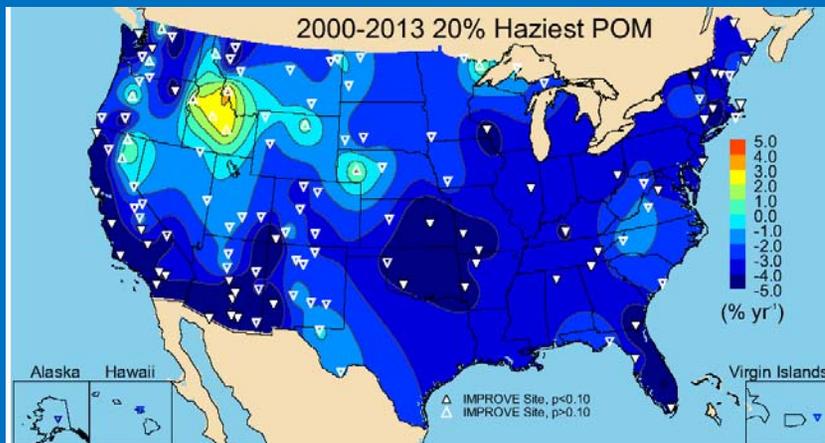
AS



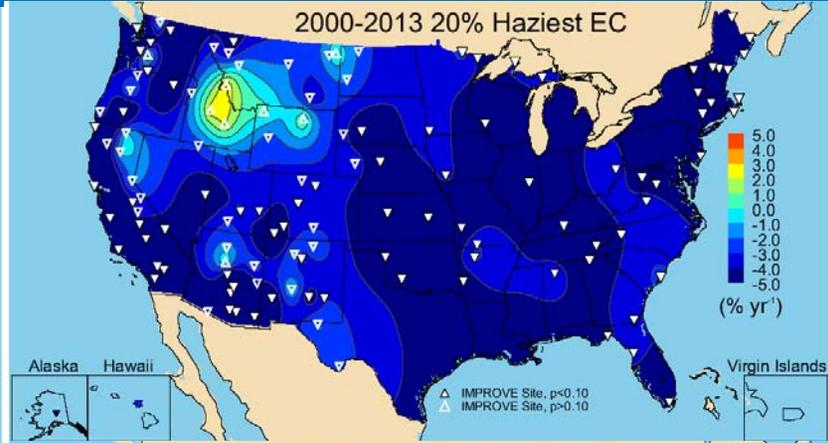
AN



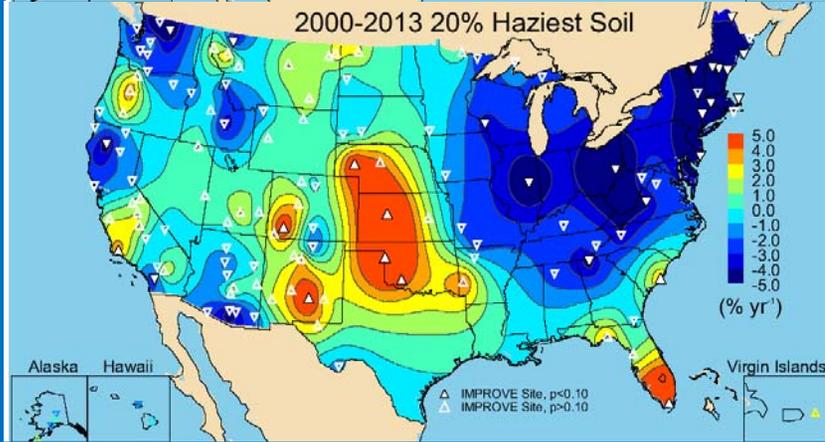
POM



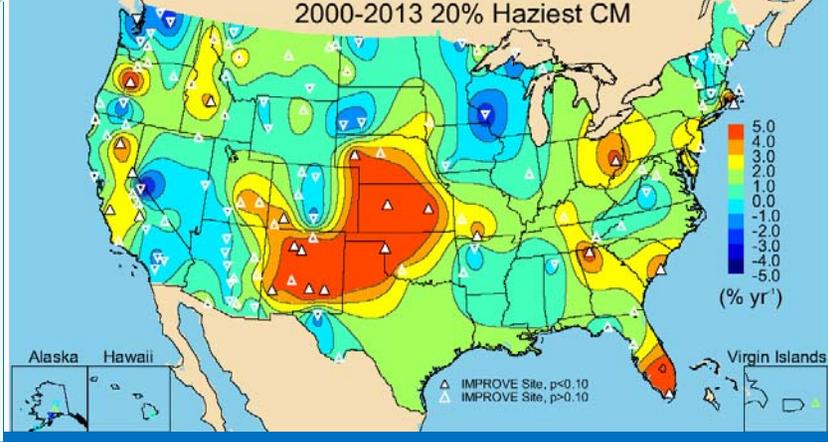
EC



Soil

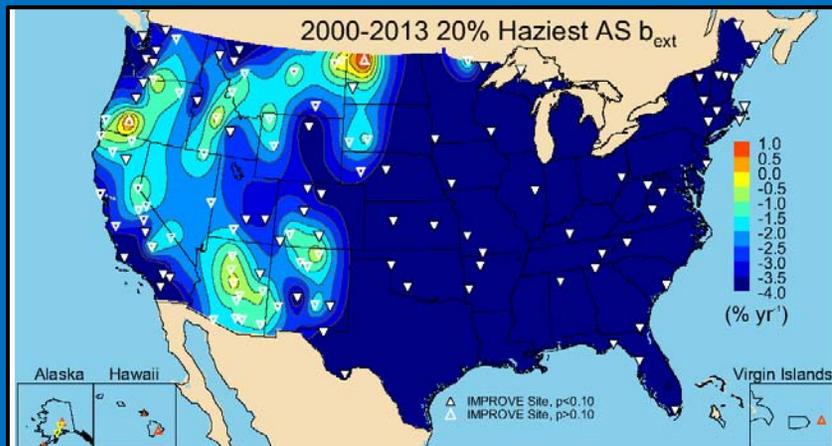


CM

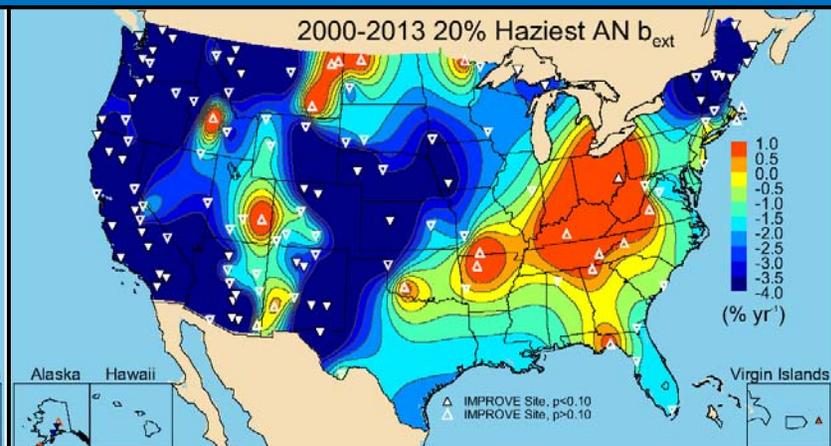


2000-2013 Trends in Haziest Speciated b_{ext}

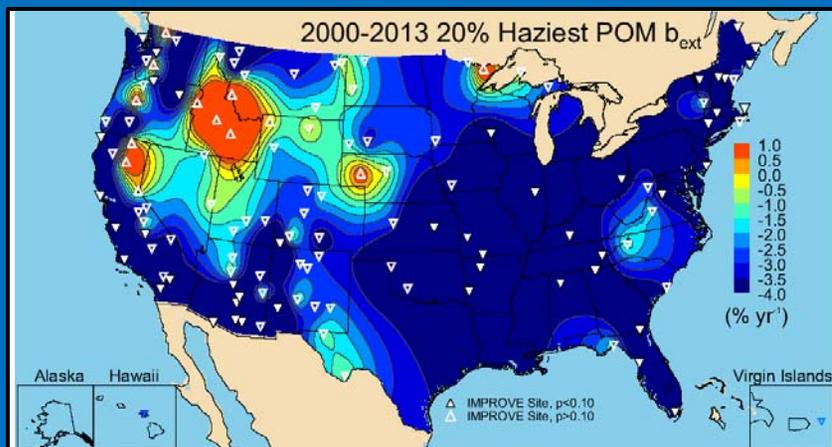
AS



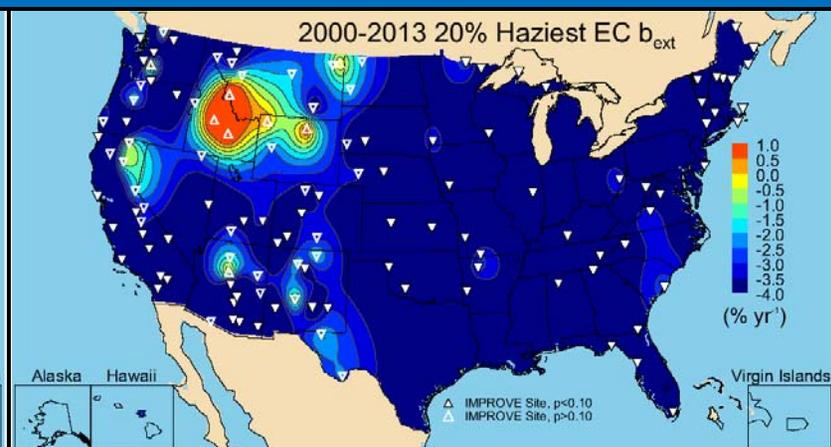
AN



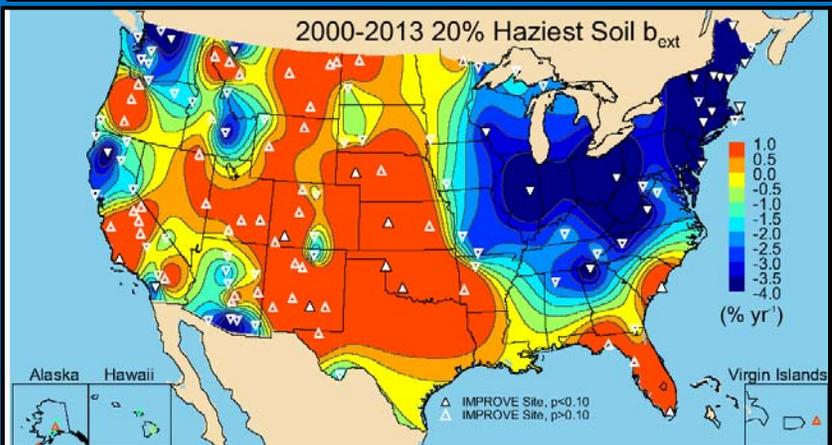
POM



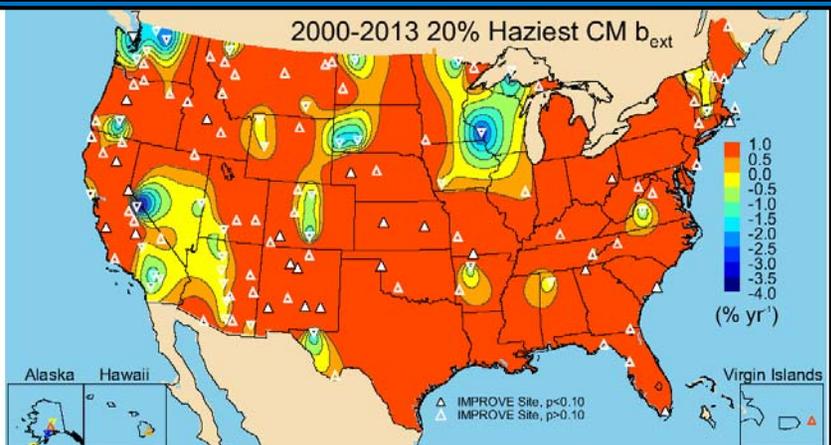
EC



Soil



CM

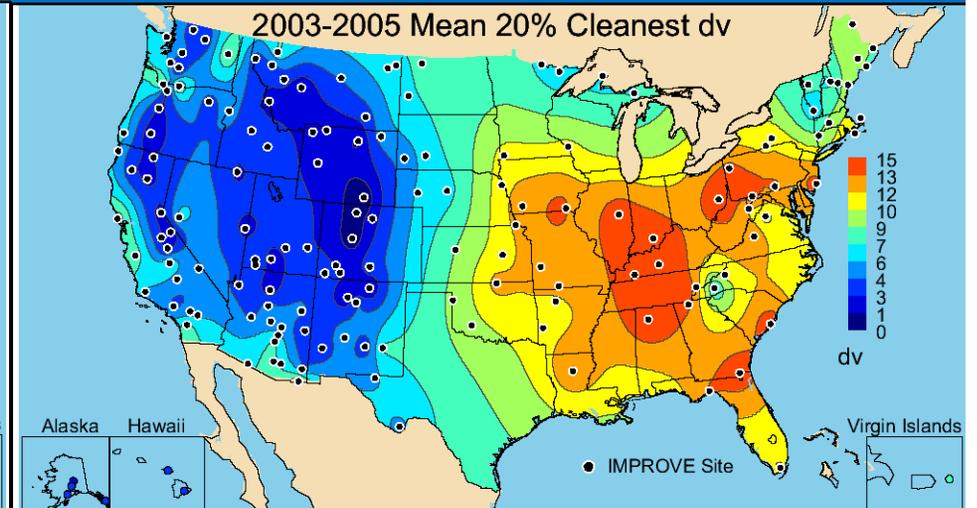
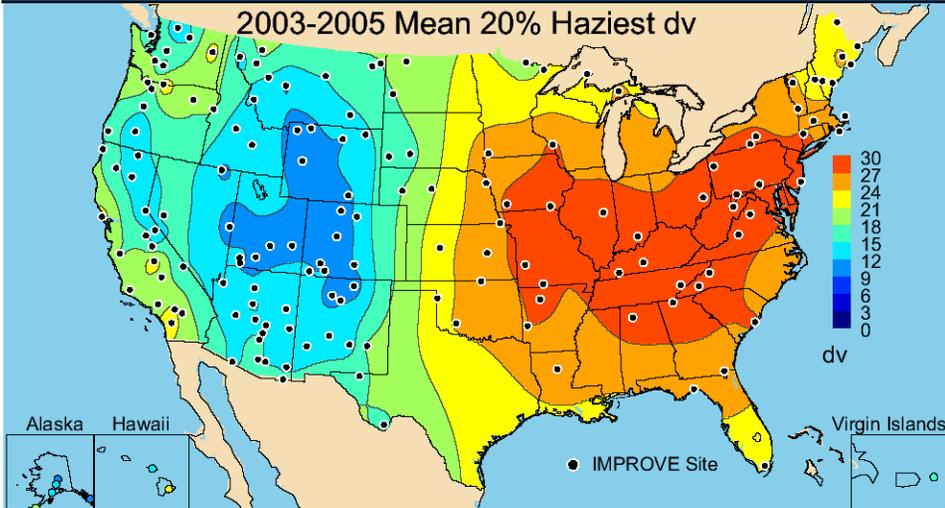


Haziest dv

Cleanest dv

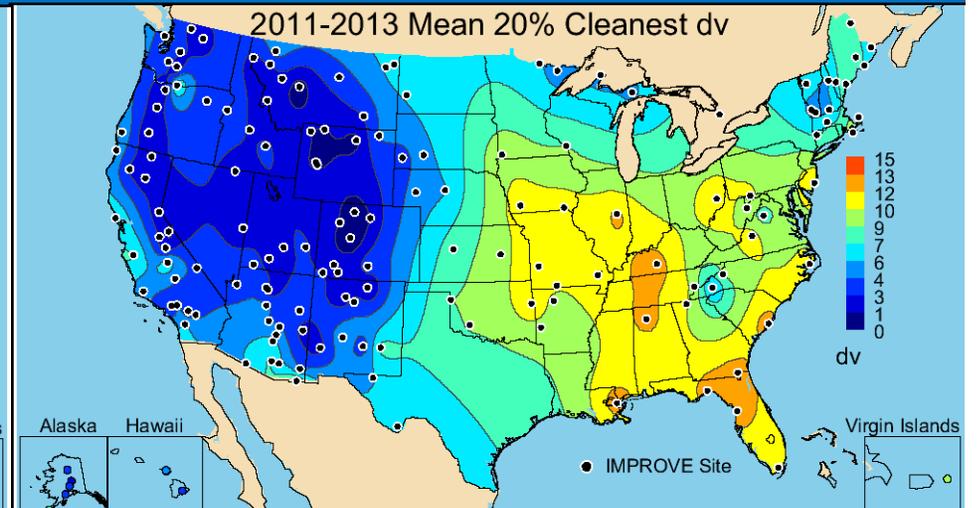
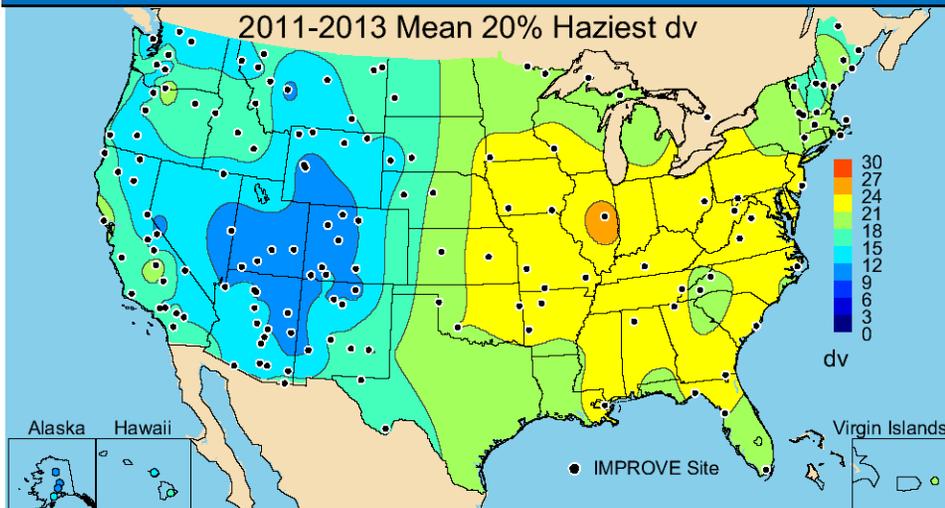
2003-2005

2003-2005



2011-2013

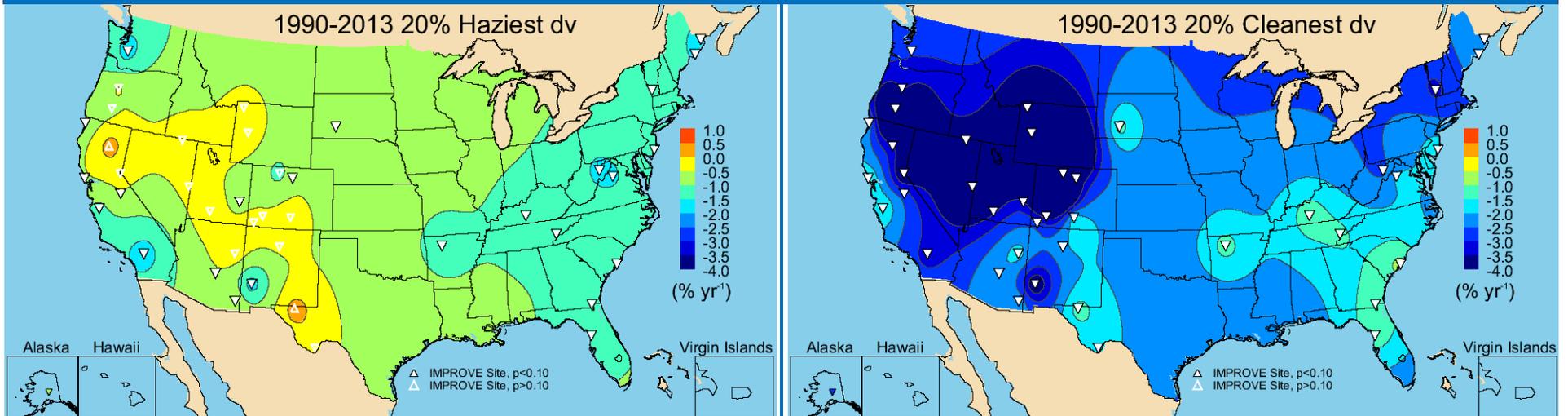
2011-2013



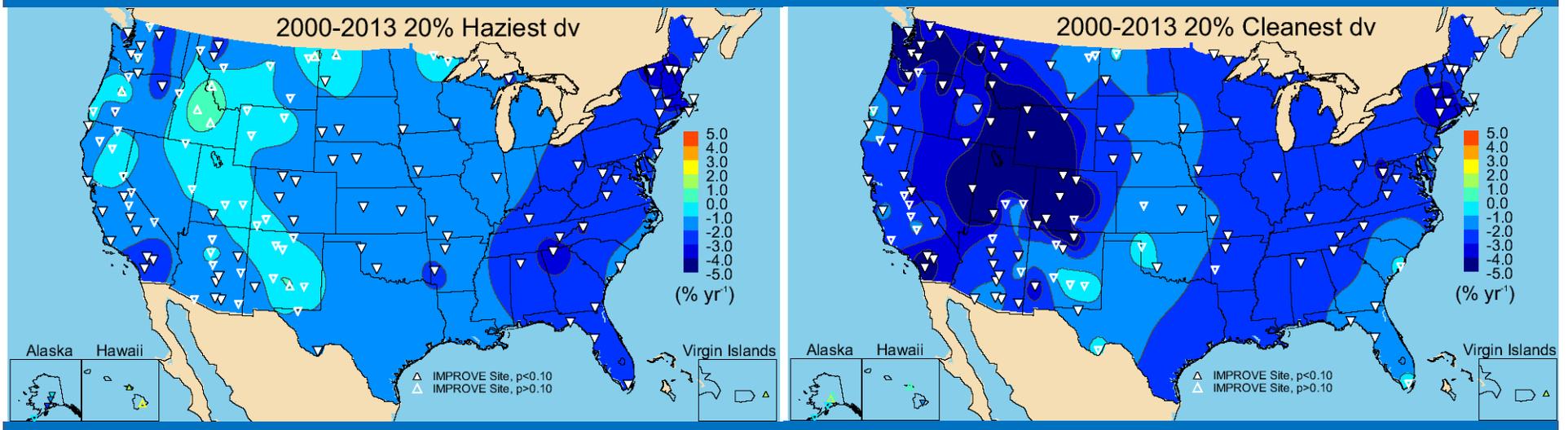
Trends in haziest dv

Trends in cleanest dv

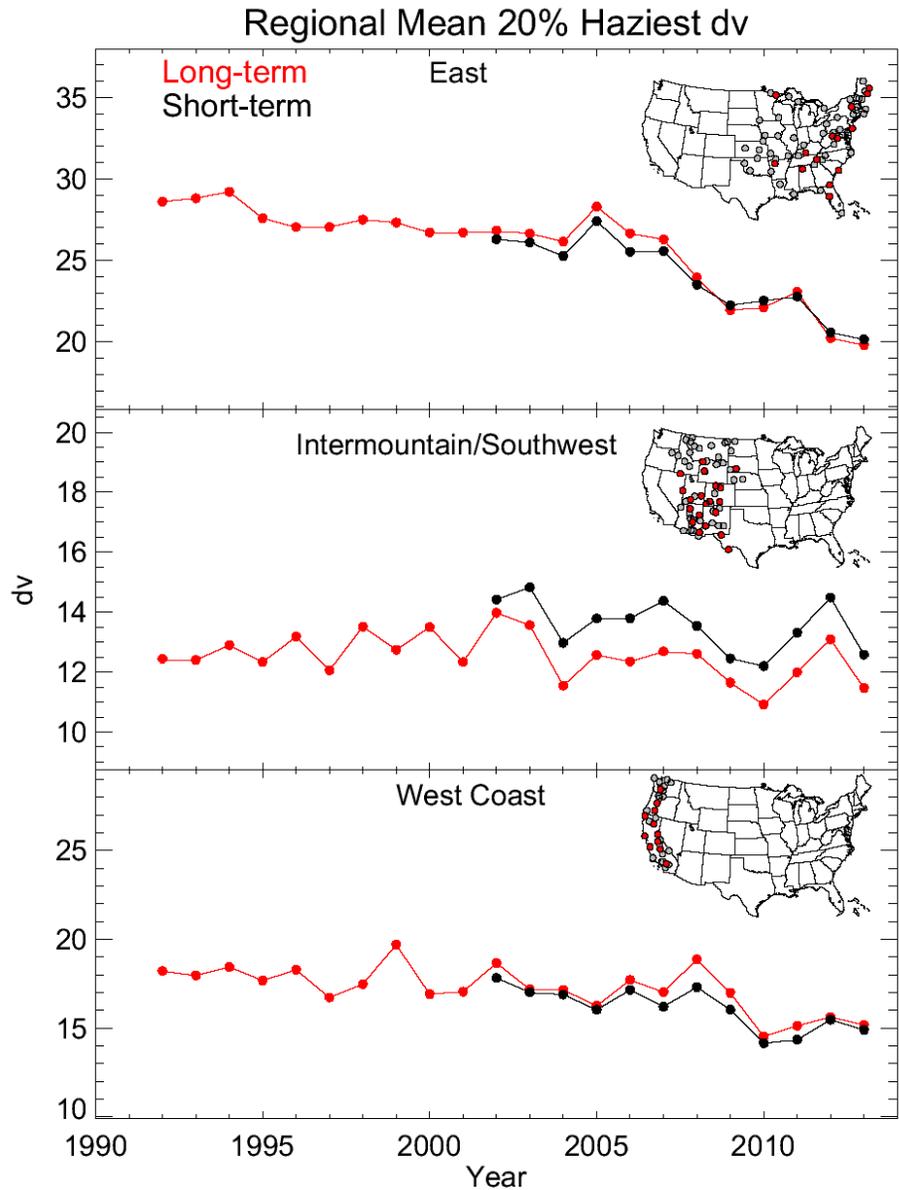
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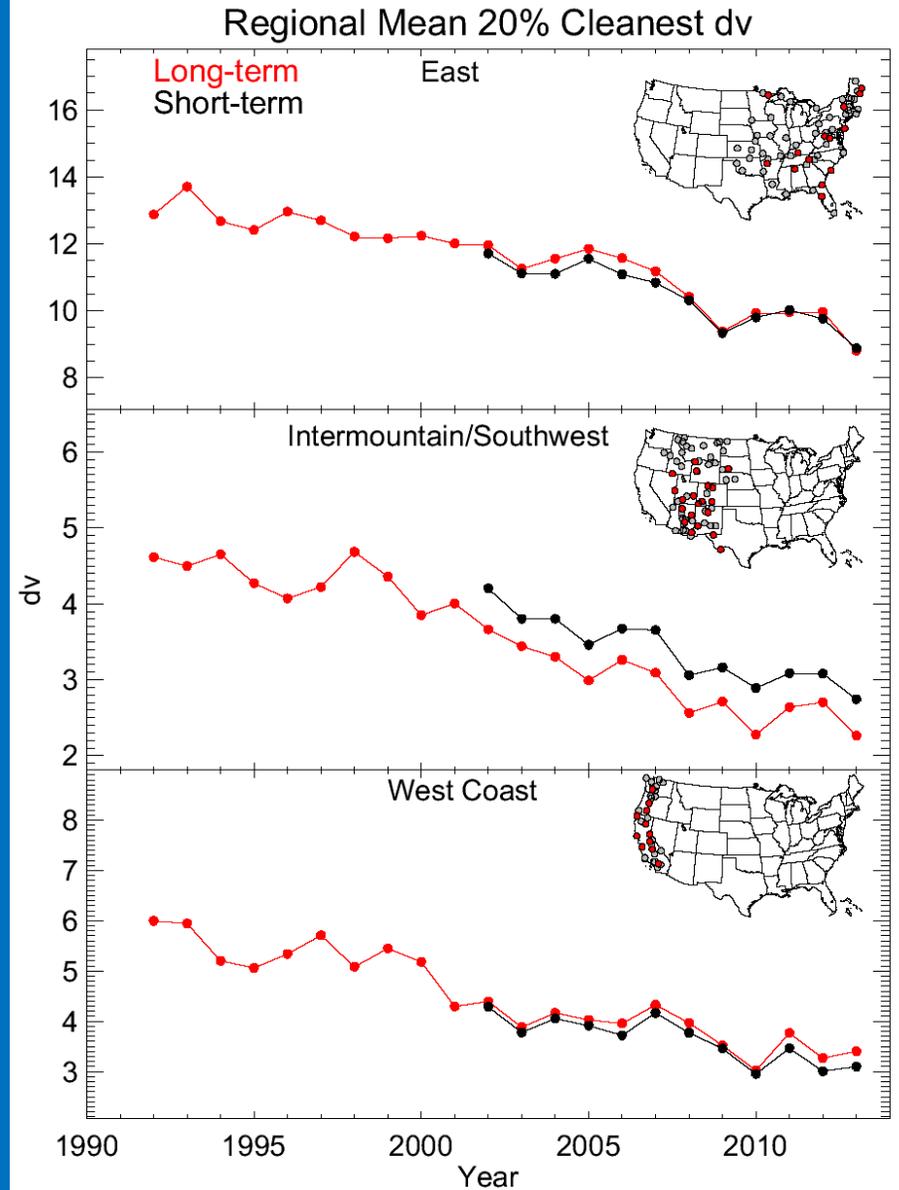
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Haziest dv

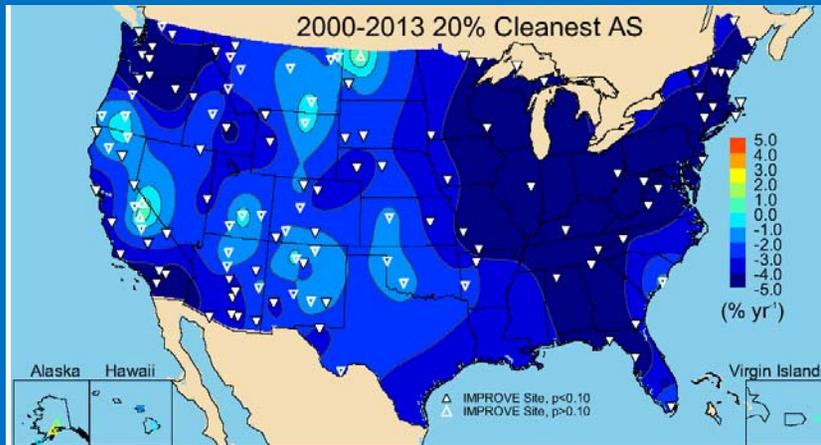


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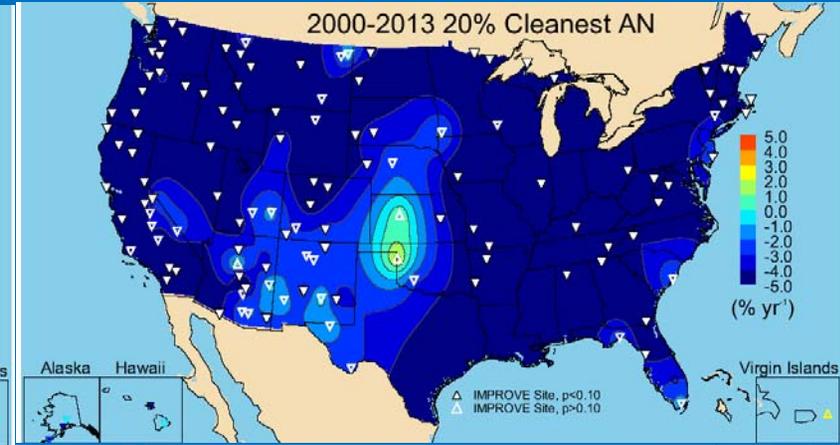


2000-2013 Trends in Cleanest Speciated Mass

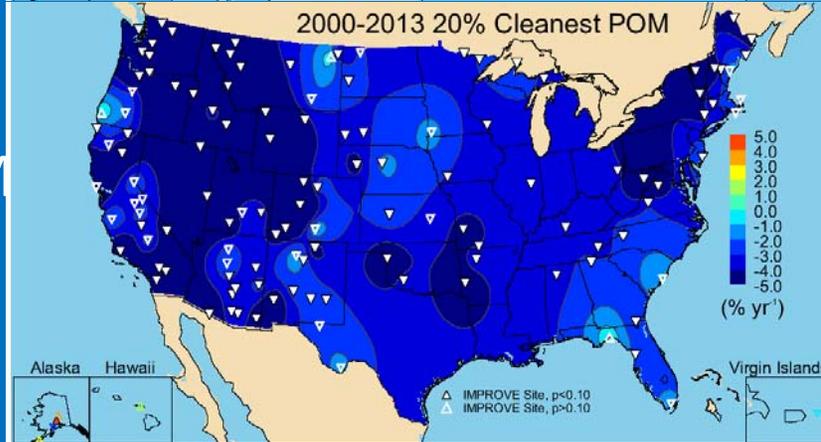
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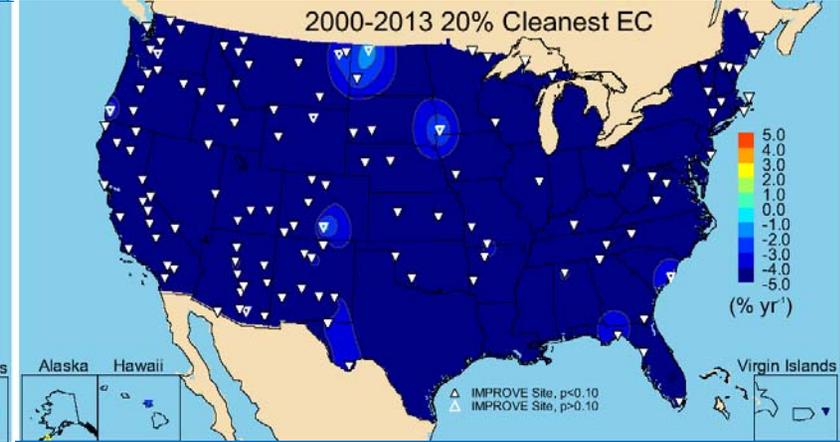
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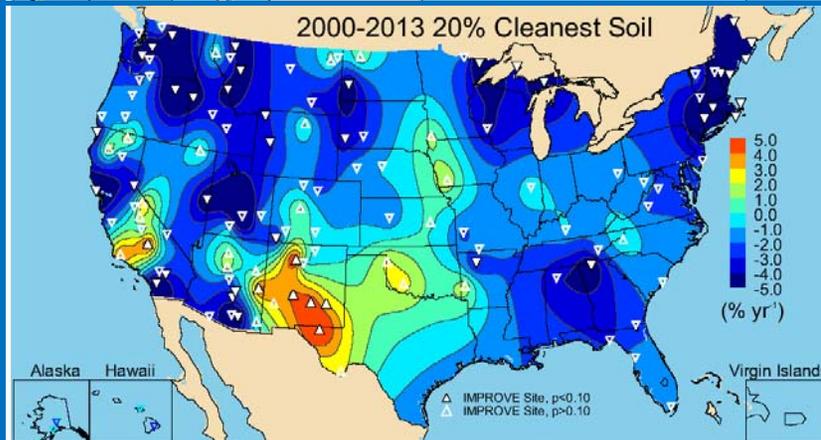
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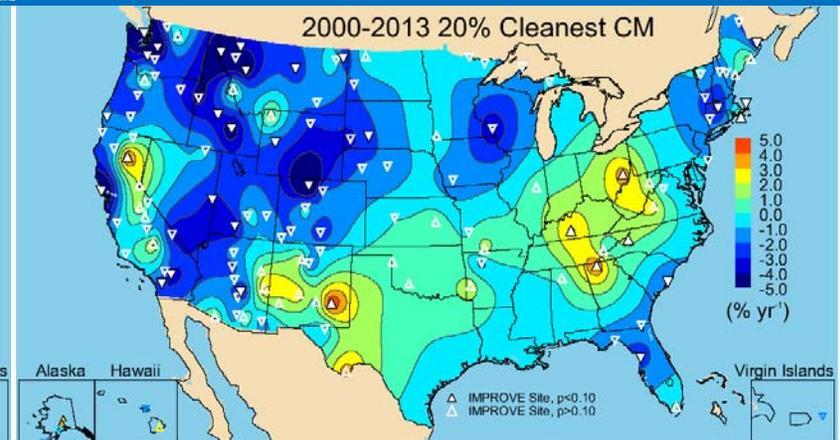
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Soil

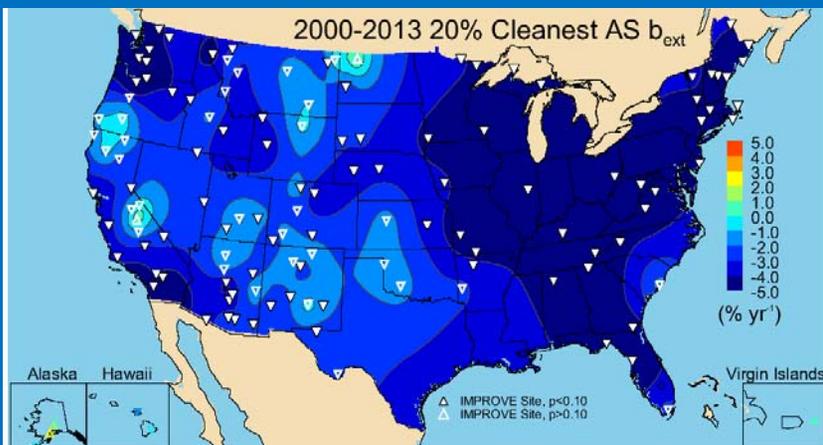


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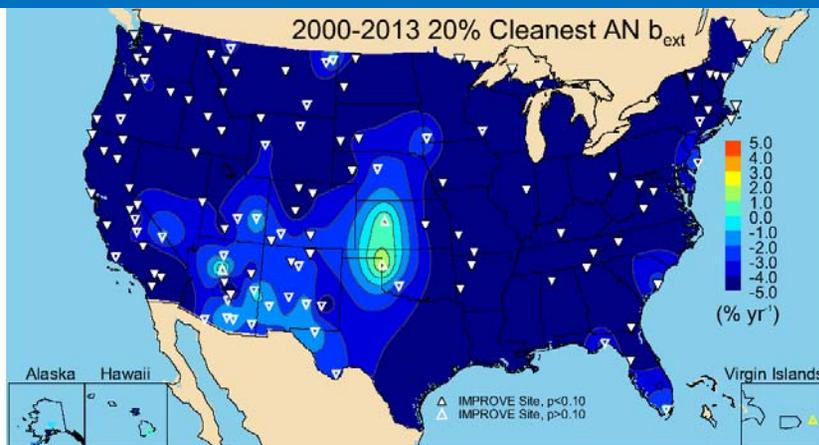


2000-2013 Trends in Cleanest Speciated b_{ext}

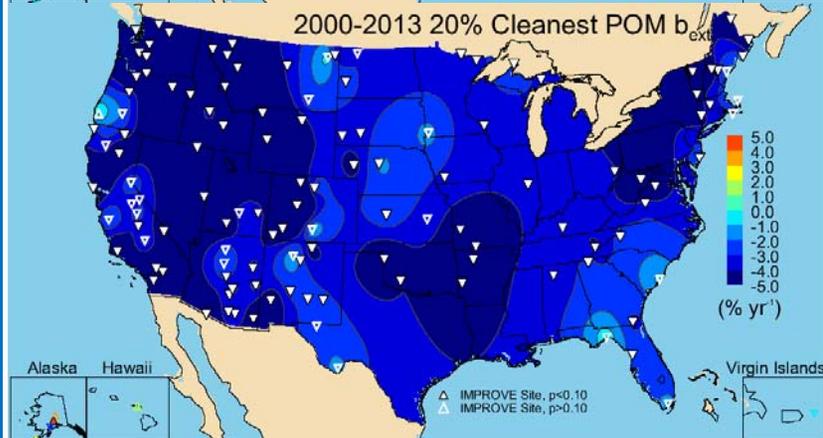
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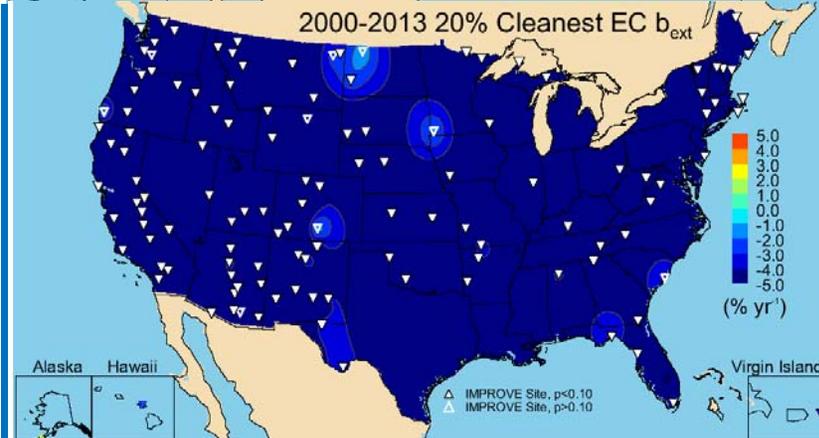
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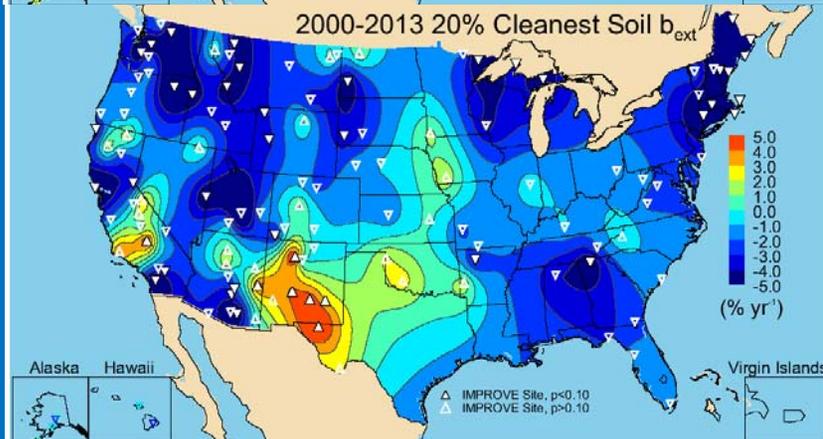
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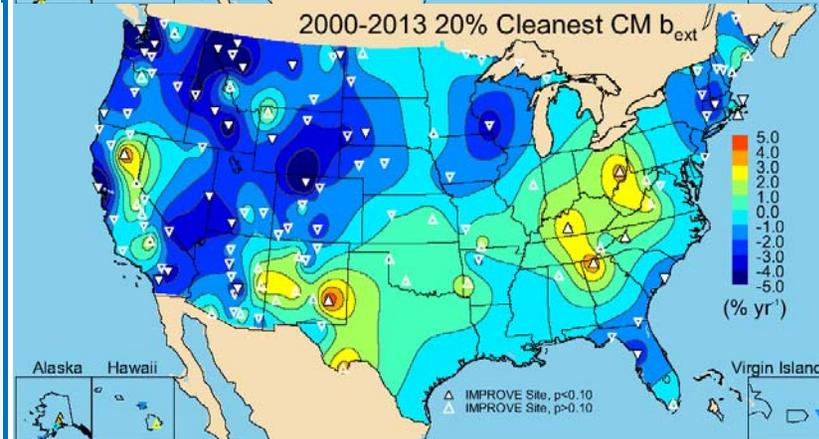
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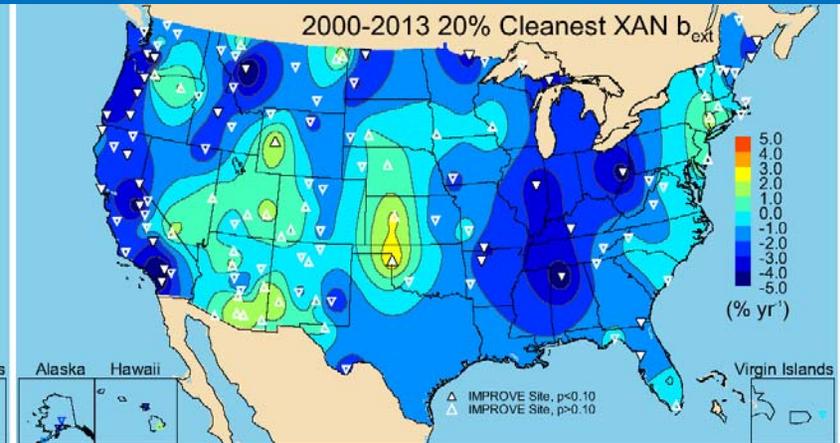
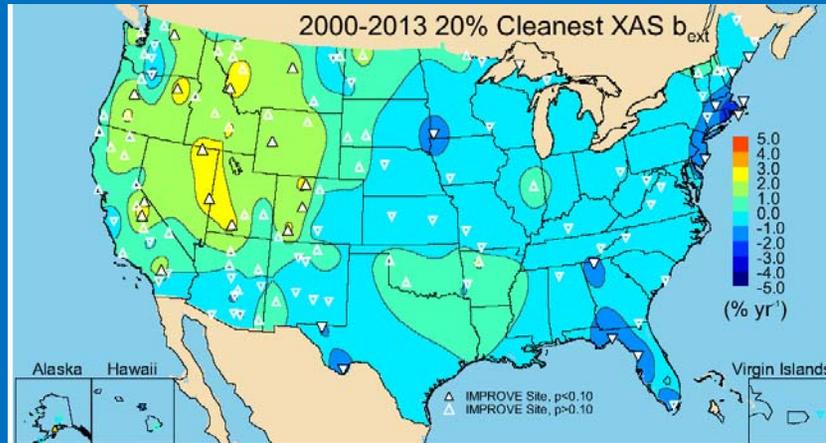


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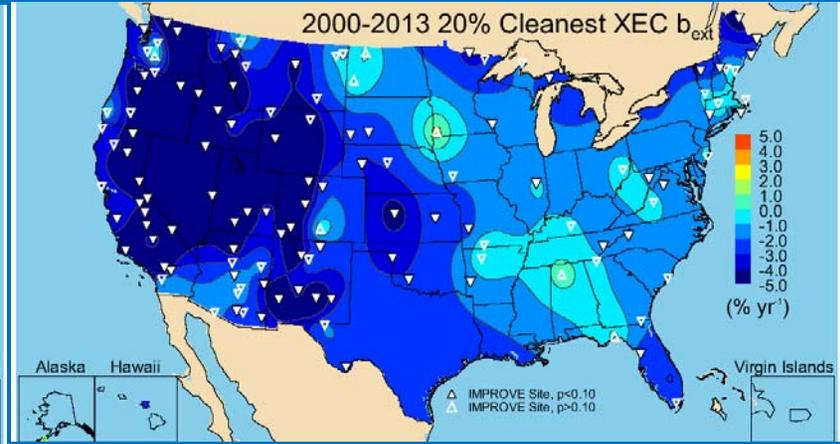
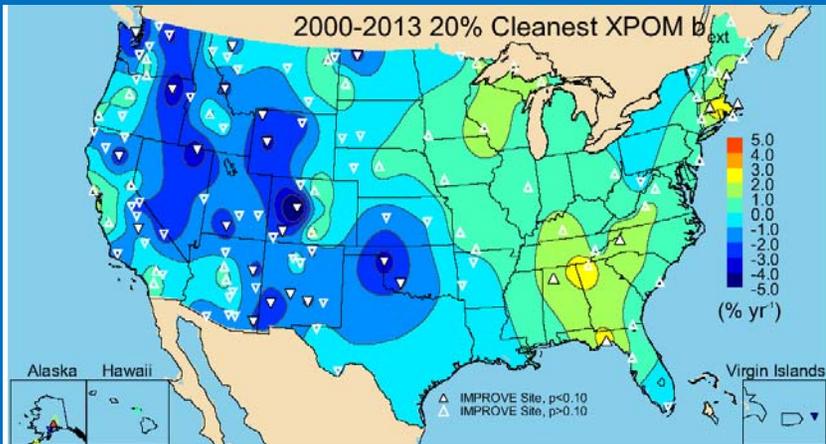
2000-2013 Trends in Contribution to Cleanest Speciated b_{ext}

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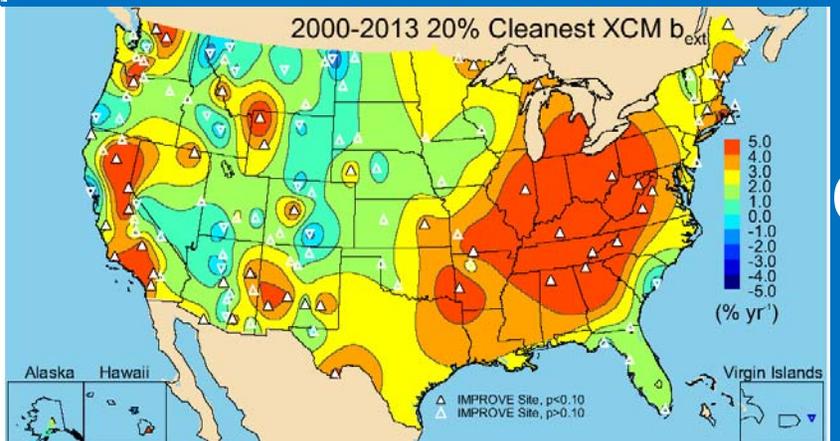
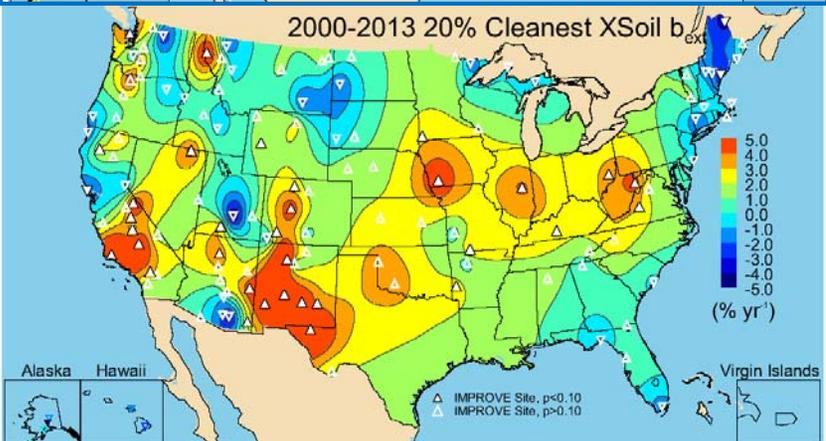
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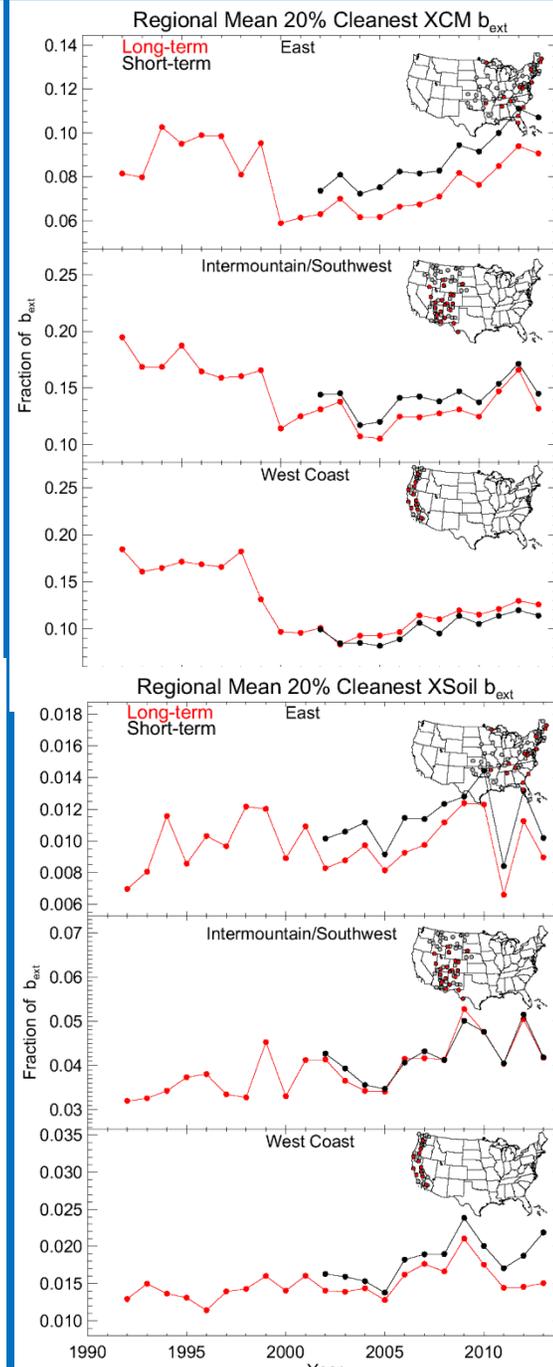
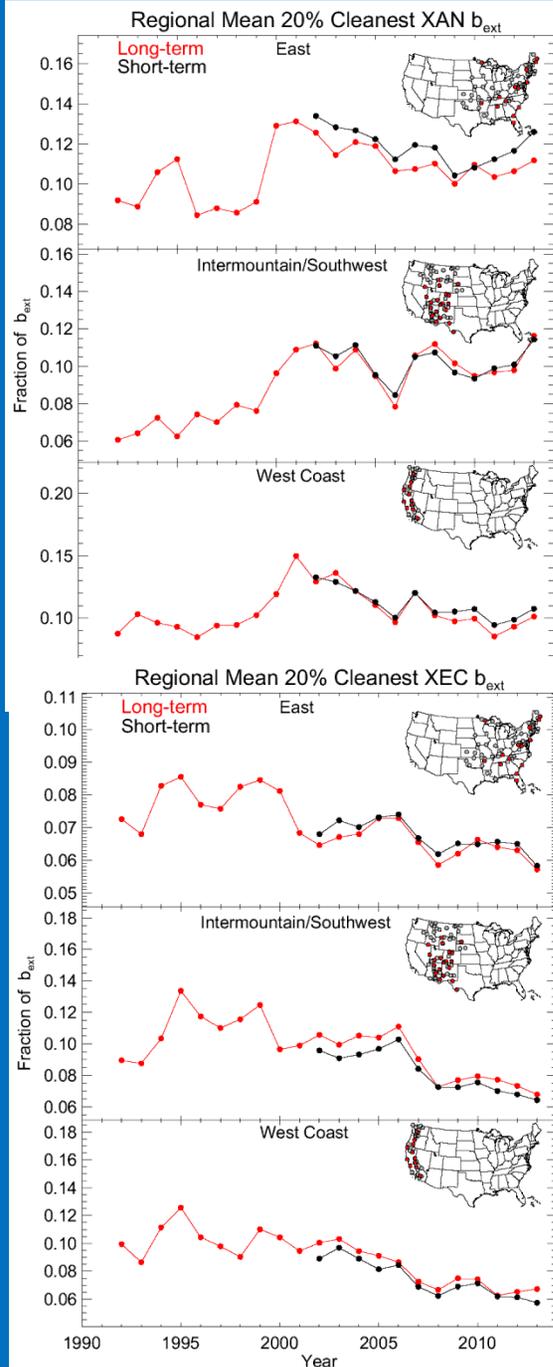
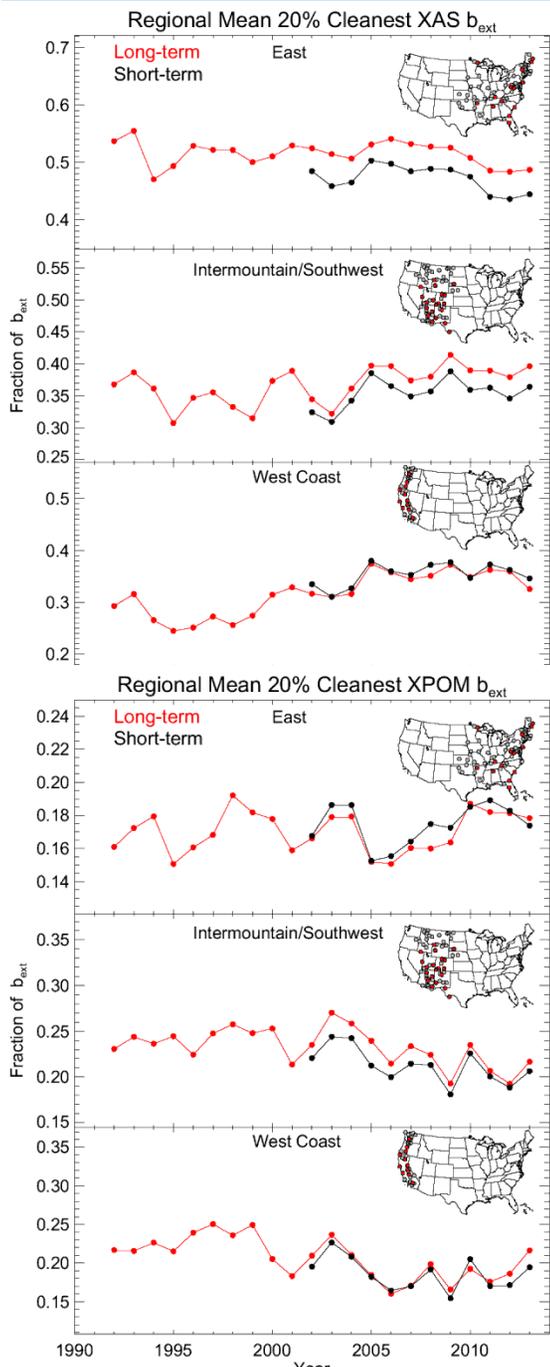
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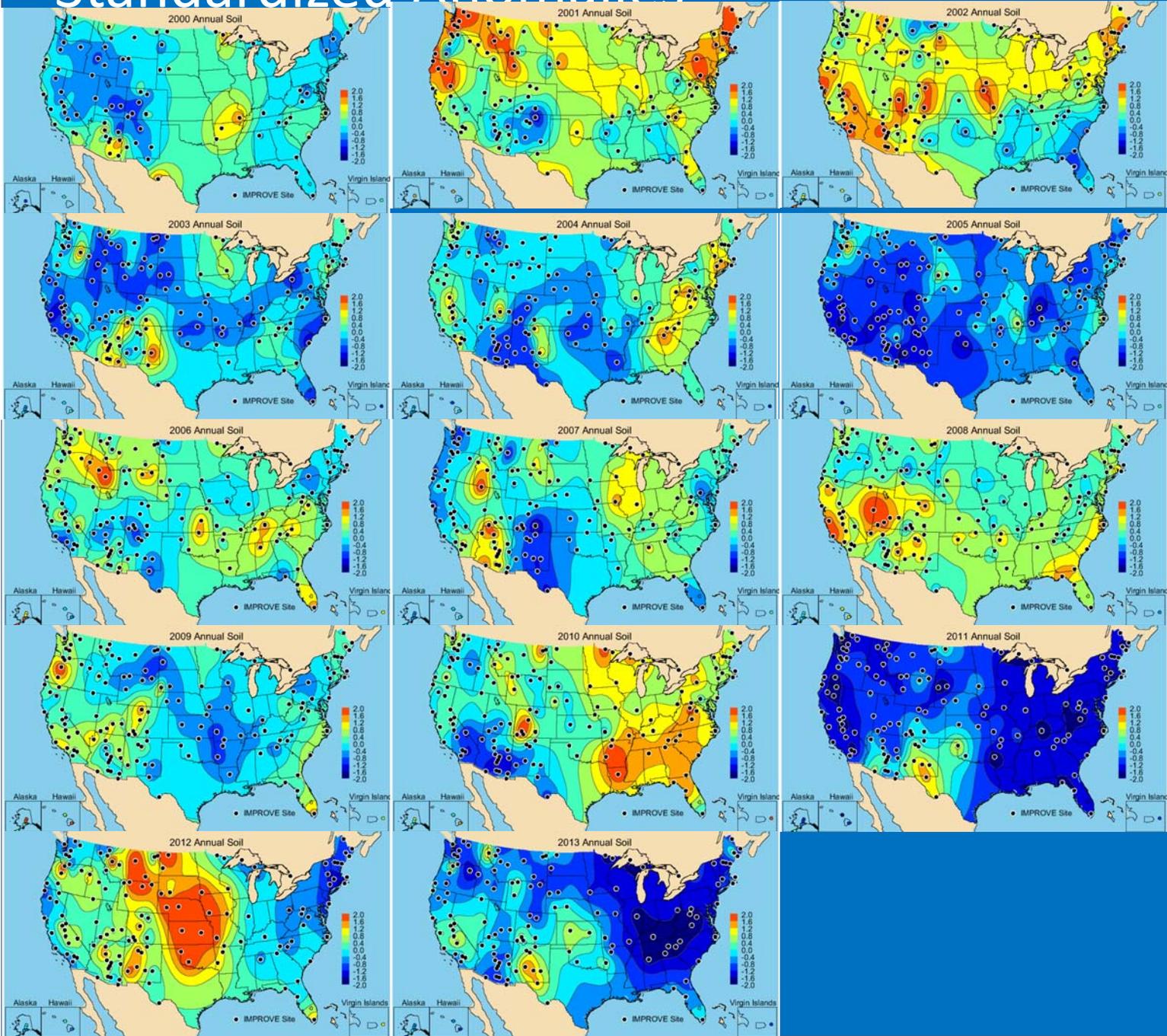


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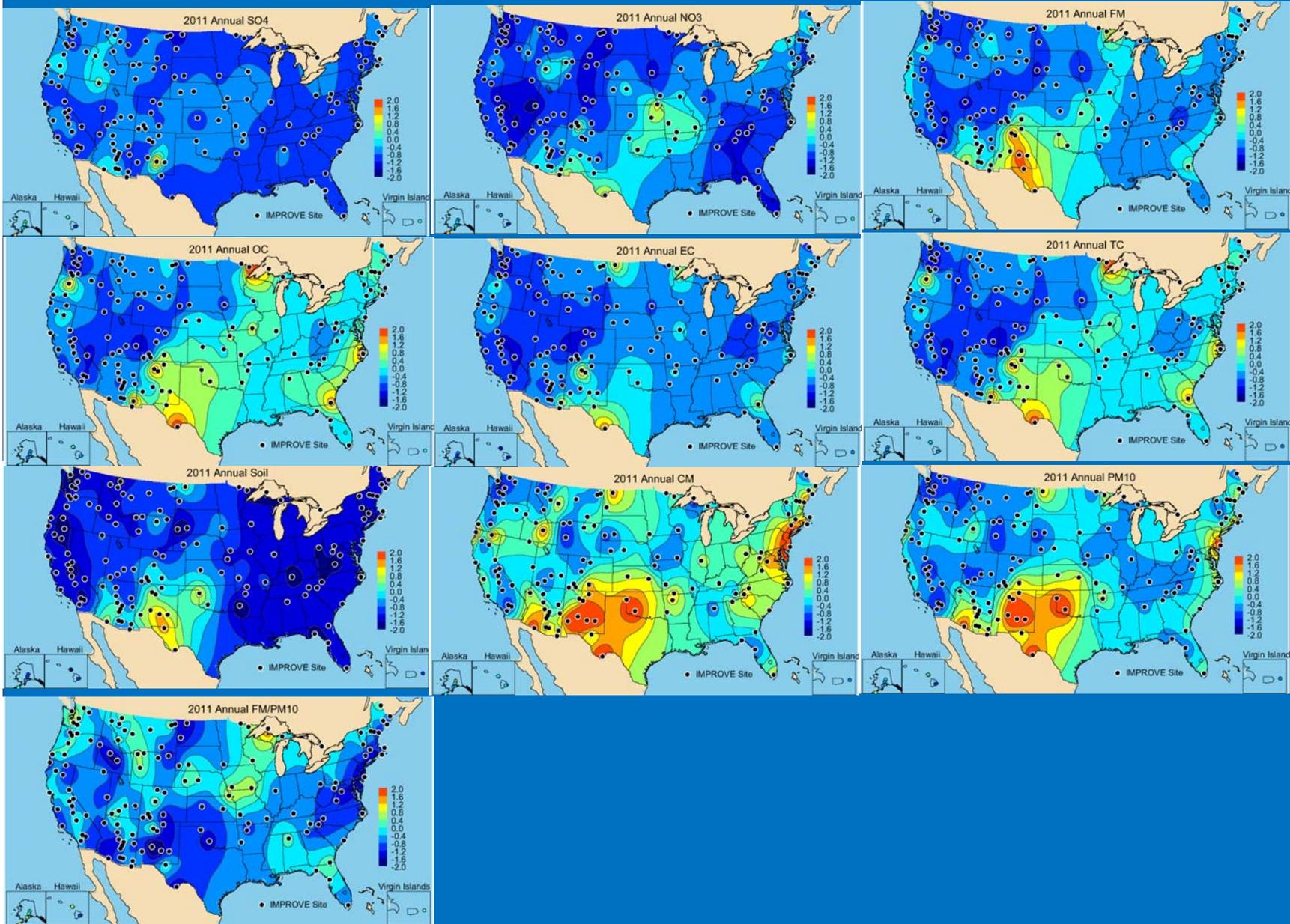
Regional Mean Trends in Contribution on cleanest days



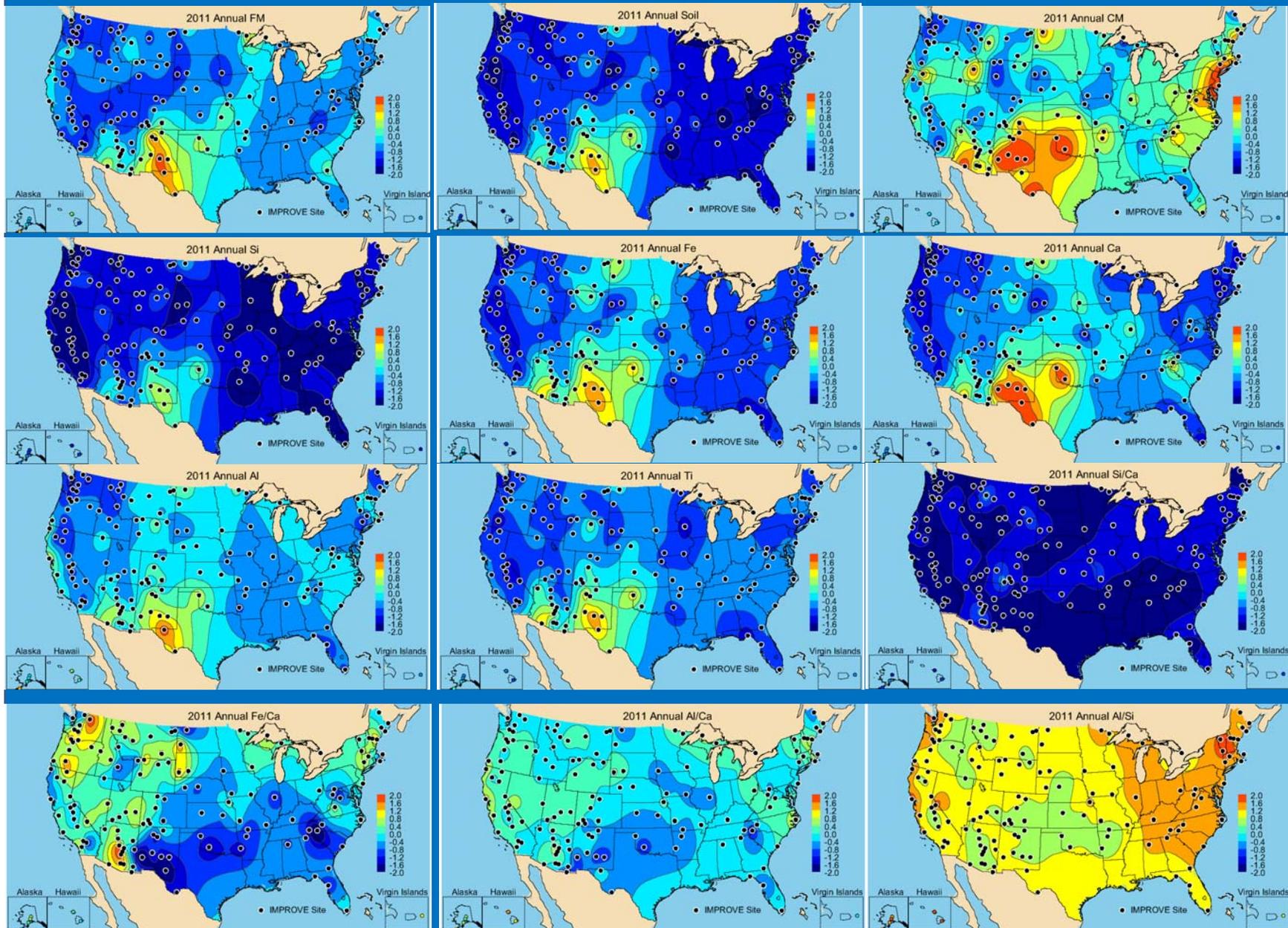
Standardized Anomalies

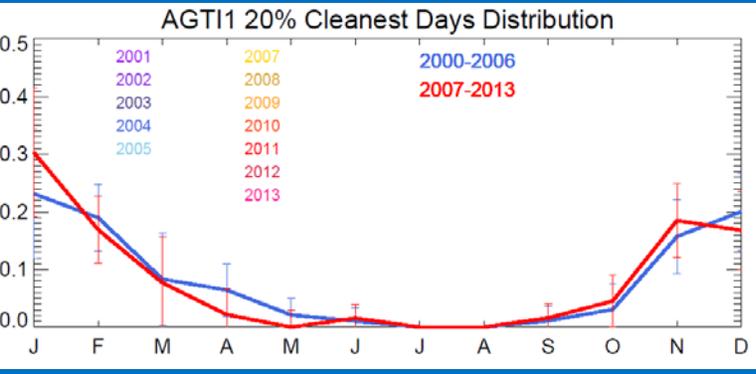
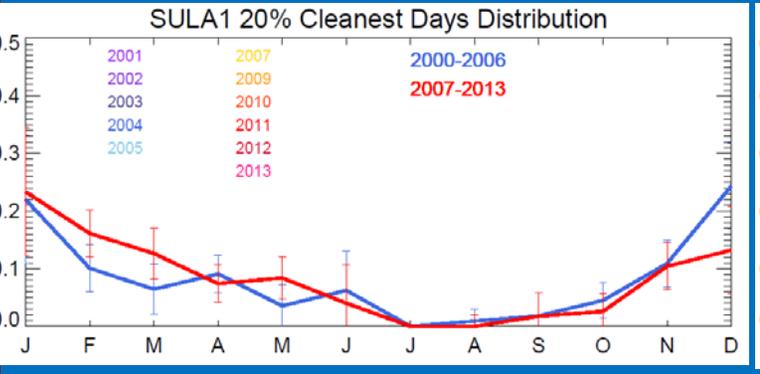
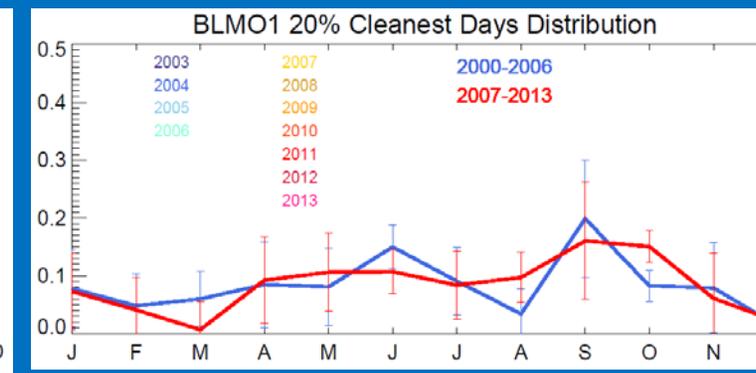
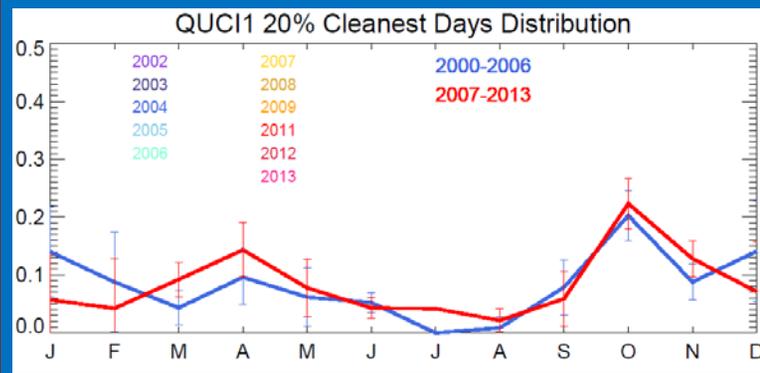
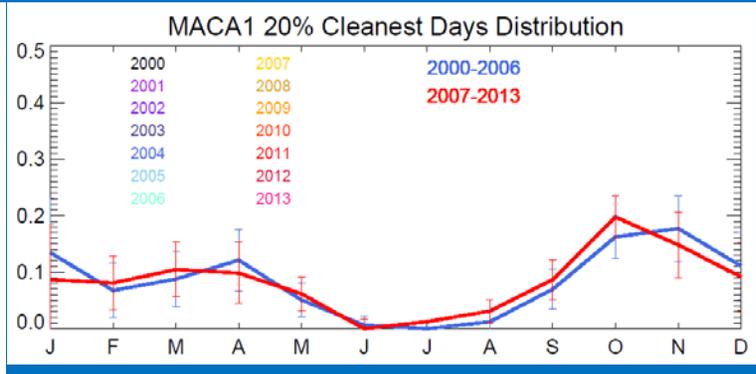
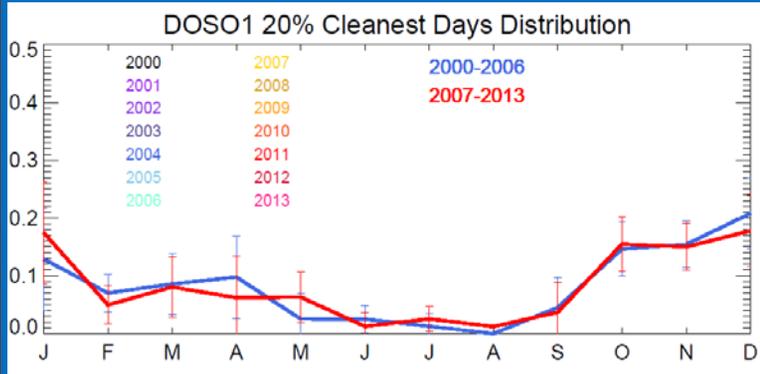


2011 Annual Mean Standardized Anomalies

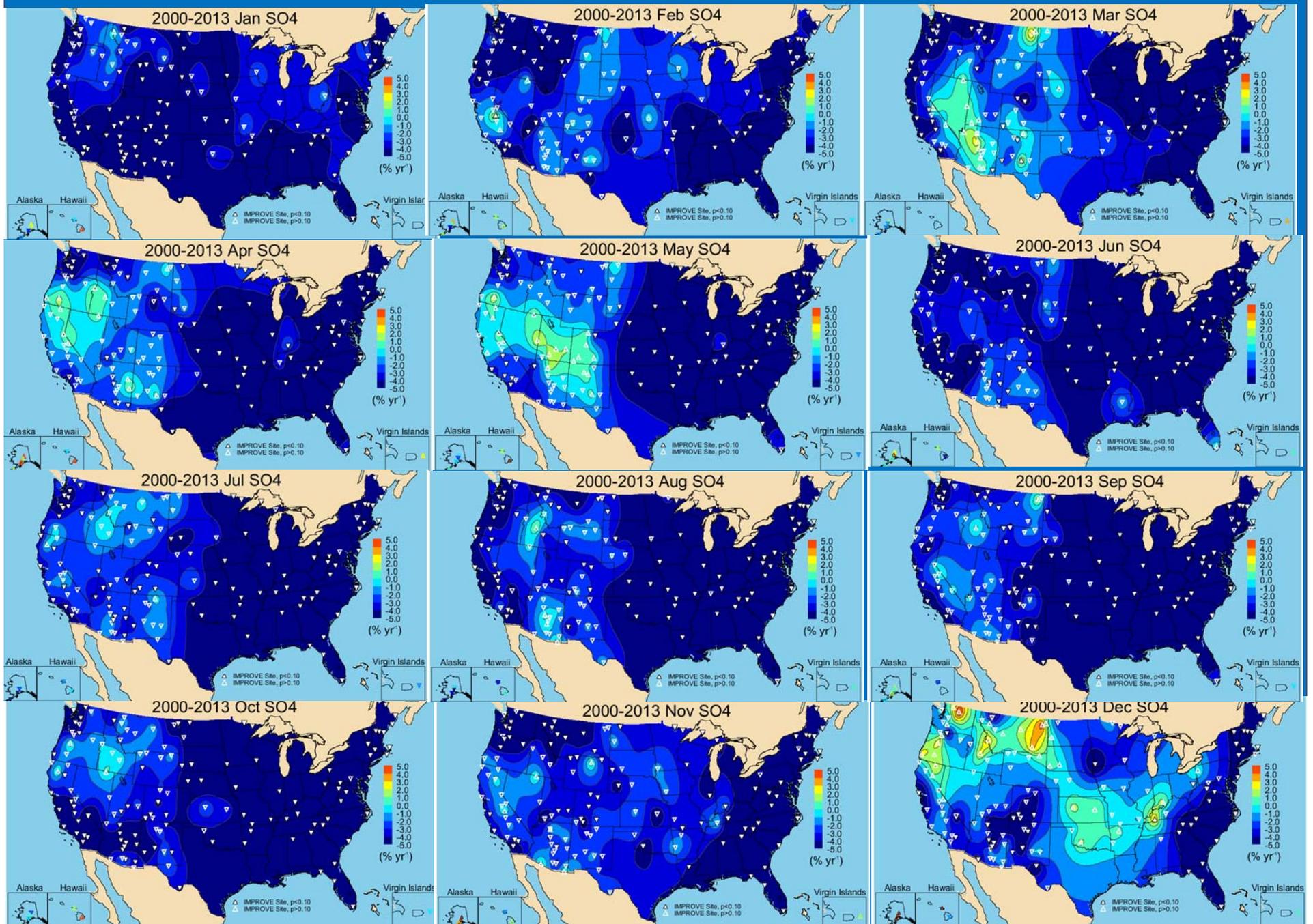


Standardized Anomalies

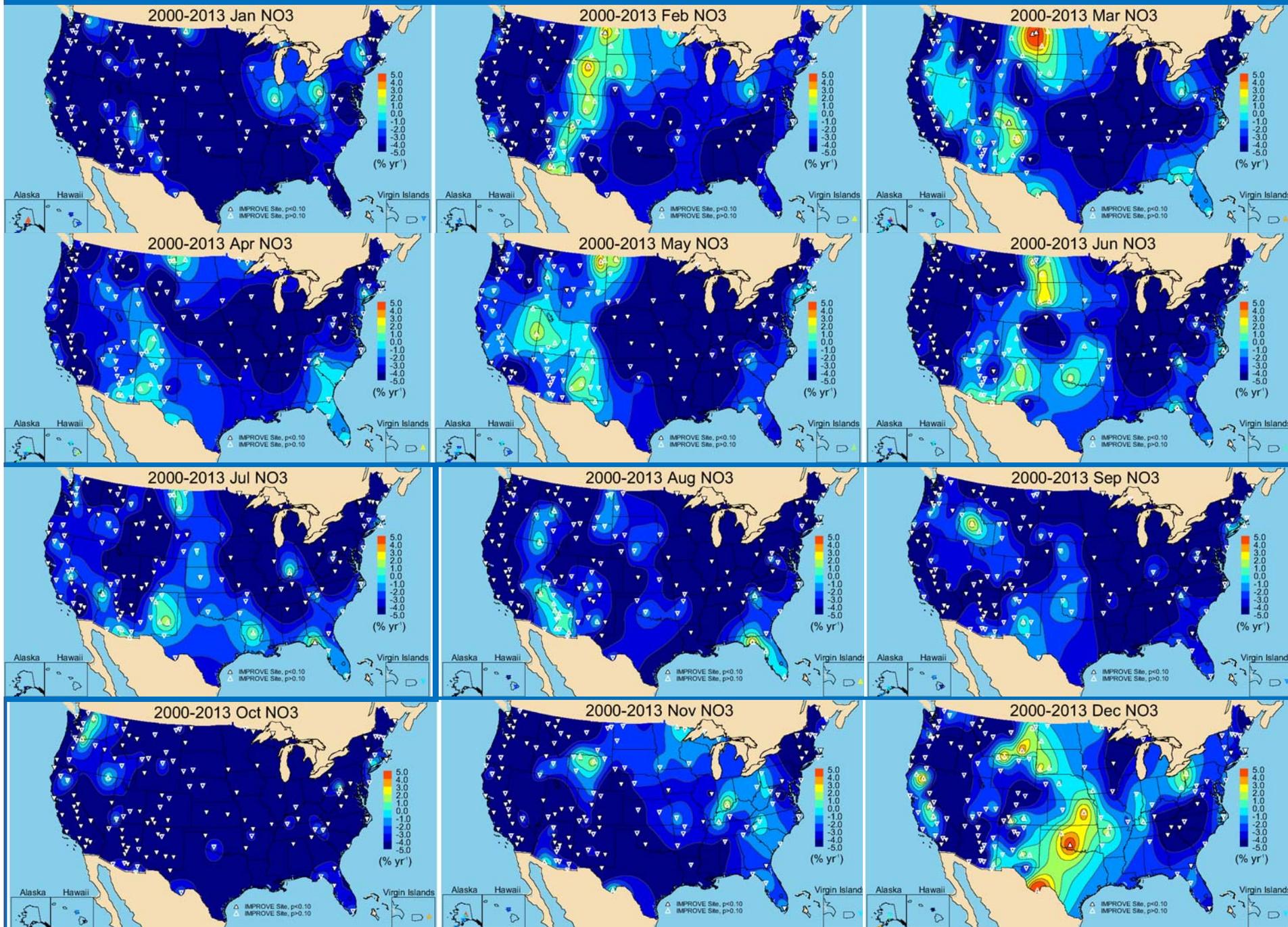




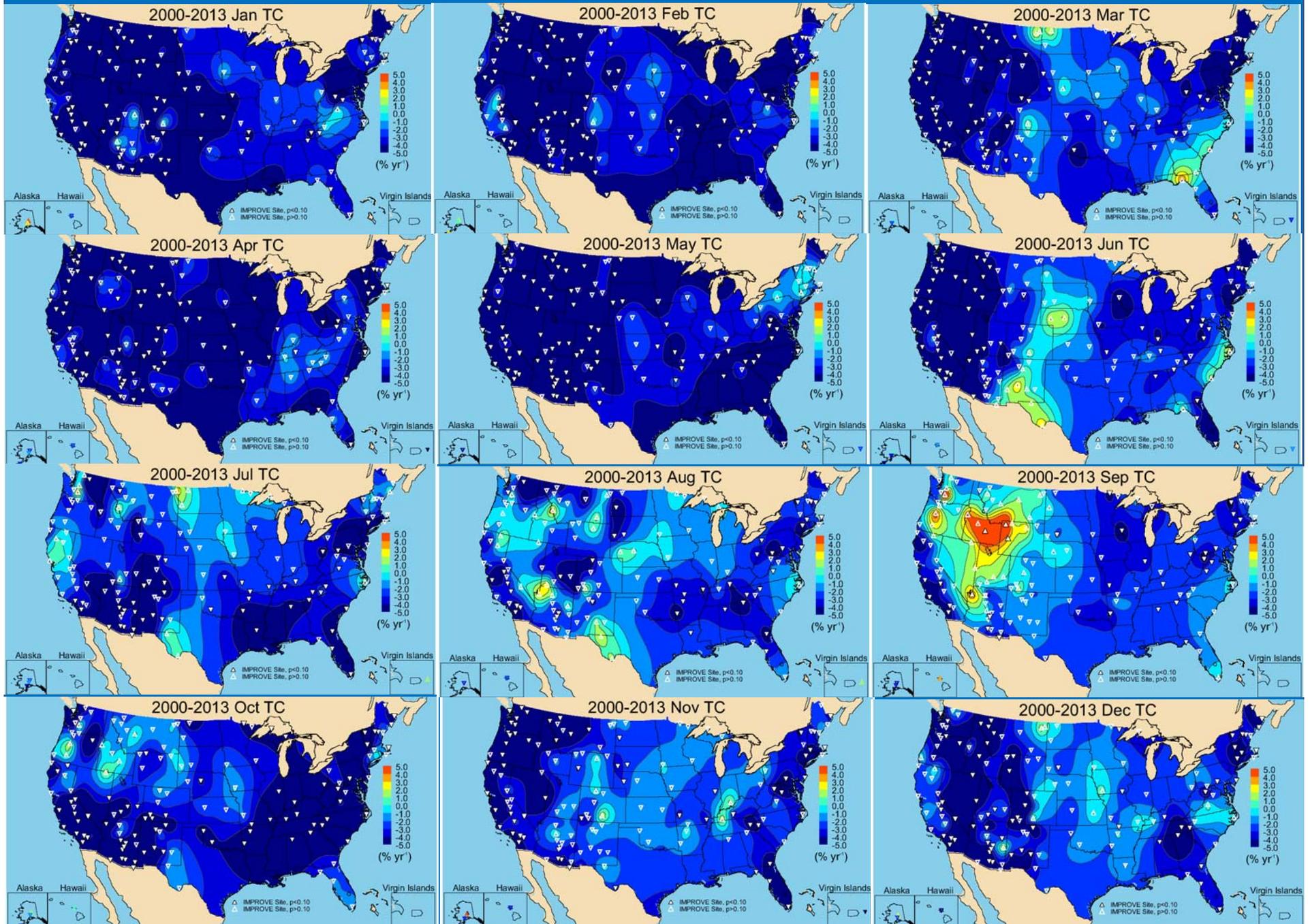
2000-2013 Trends in Monthly Mean Sulfate



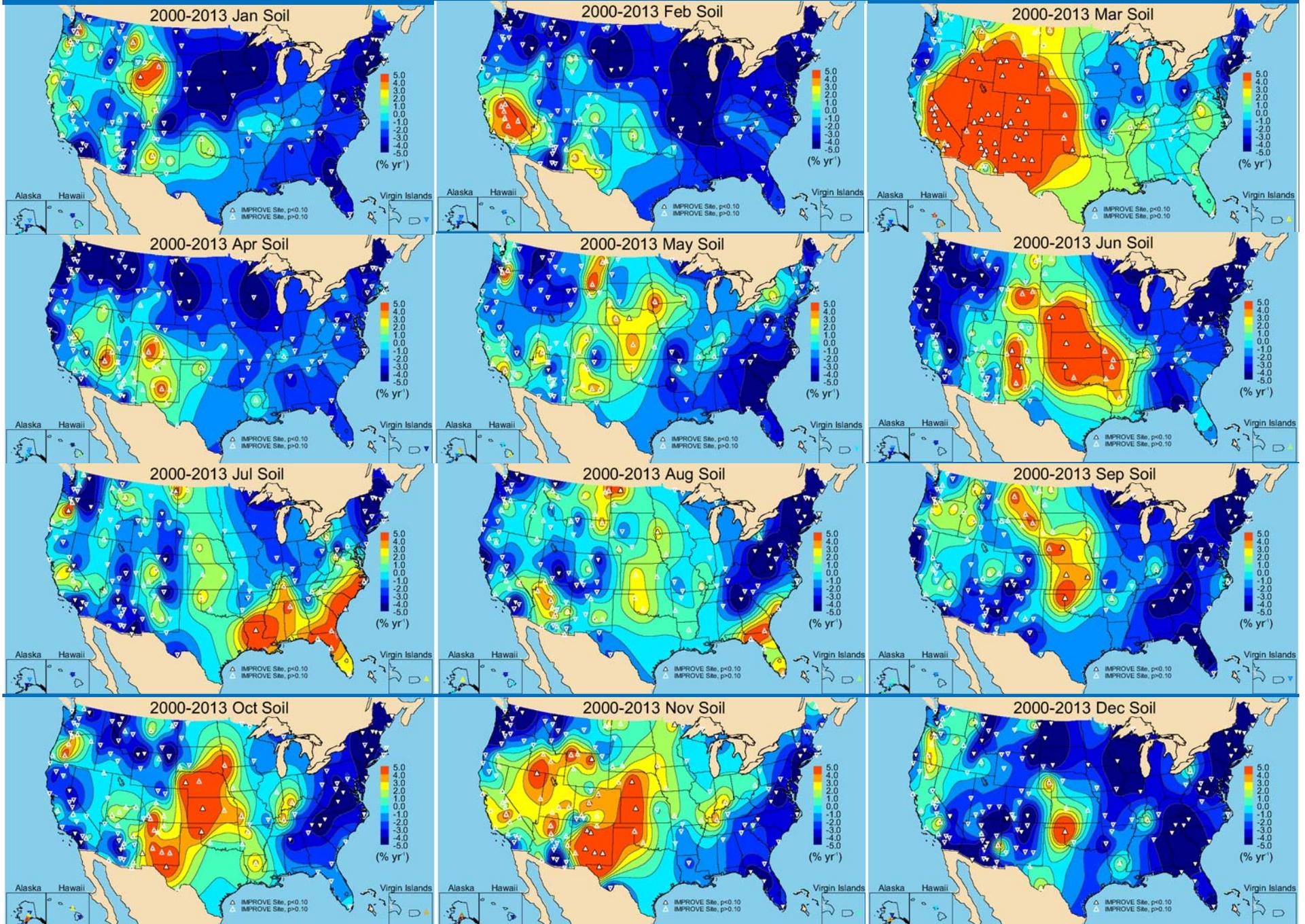
Nitrate



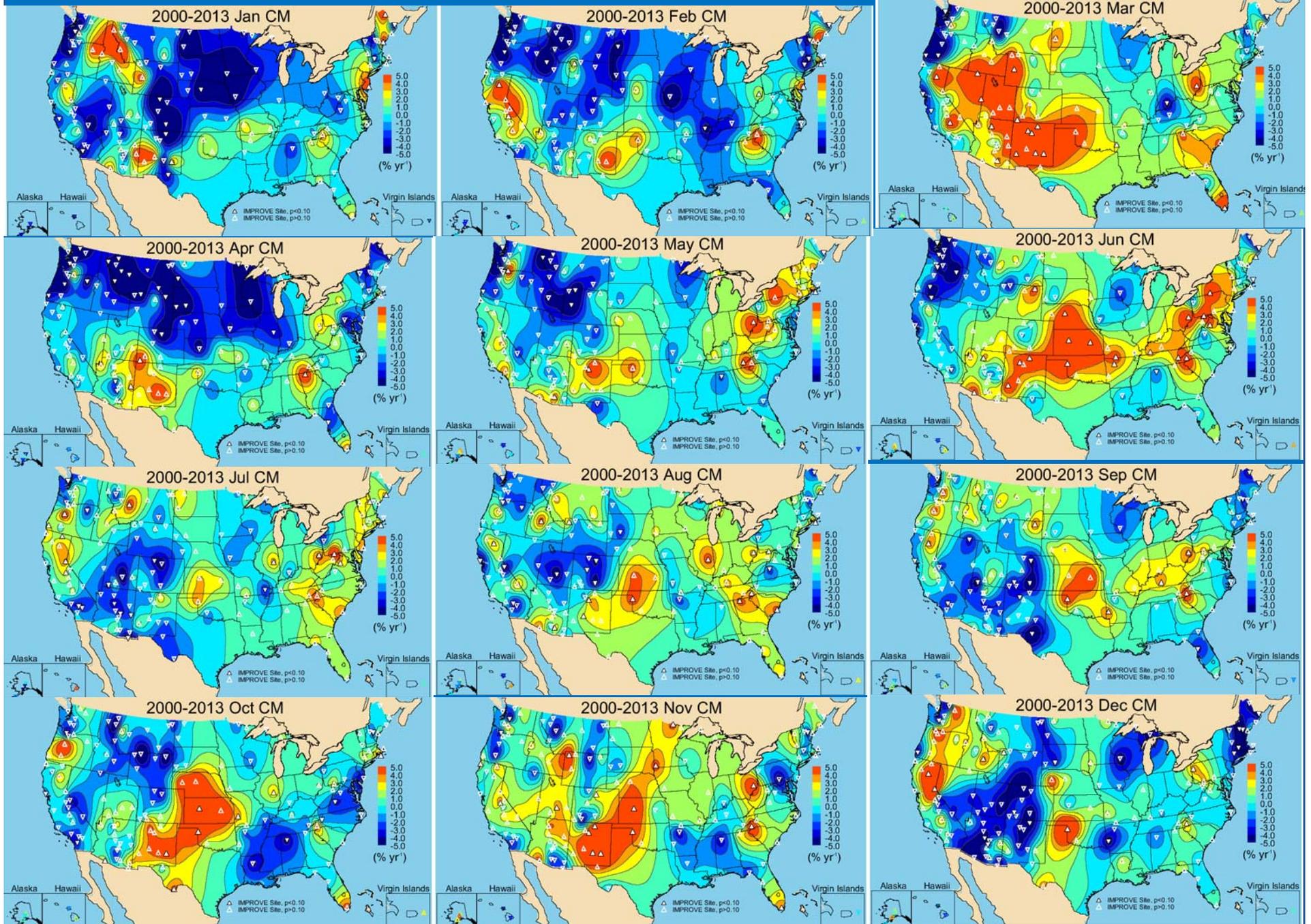
TC



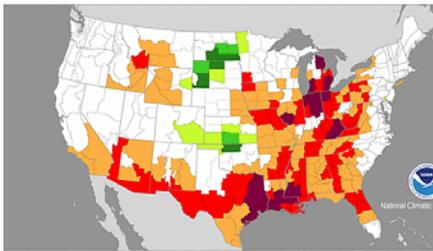
2000-2013 Trends in Monthly Mean Soil



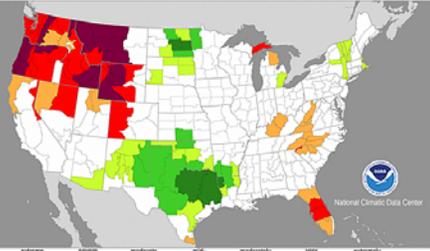
2000-2013 Trends in Monthly Mean Coarse Mass



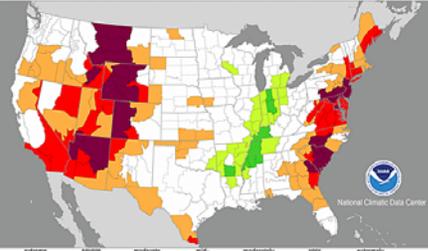
Palmer Modified Drought Index
March, 2000



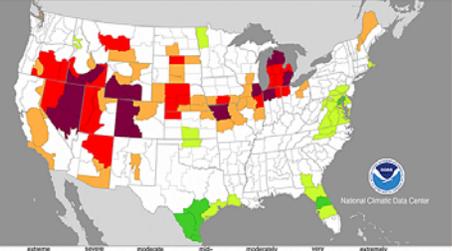
Palmer Modified Drought Index
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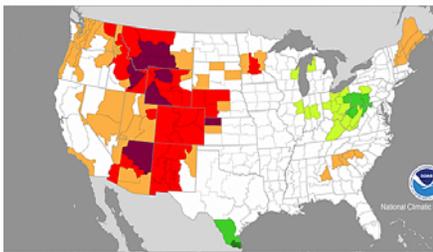
Palmer Modified Drought Index
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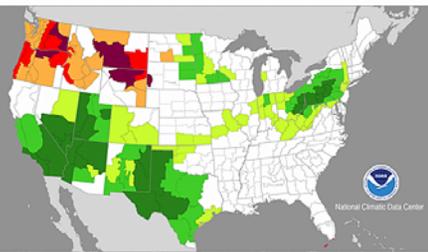
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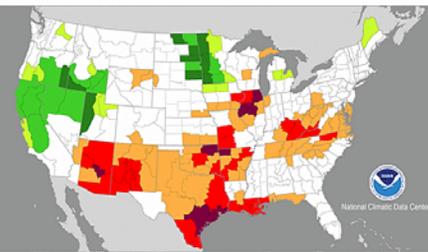
Palmer Modified Drought Index
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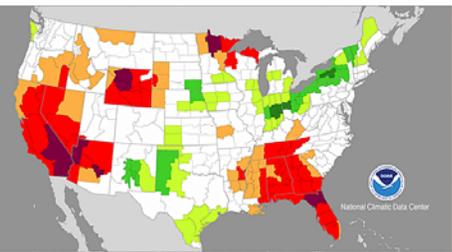
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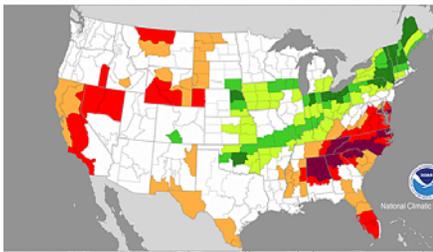
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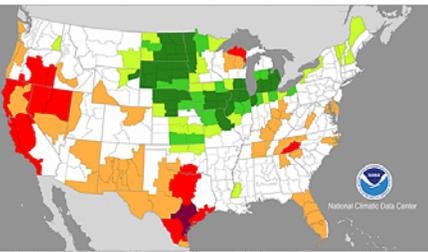
Palmer Modified Drought Index
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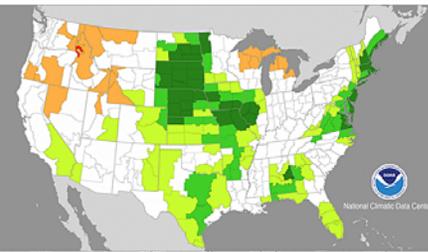
Palmer Modified Drought Index
March, 2008



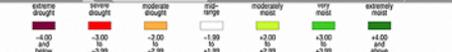
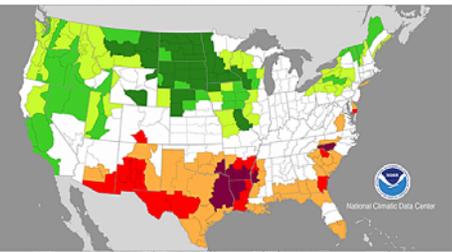
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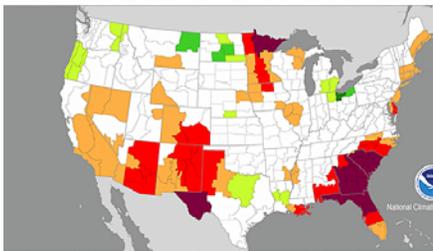
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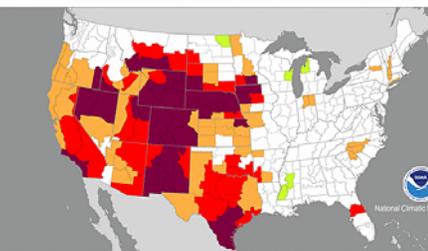
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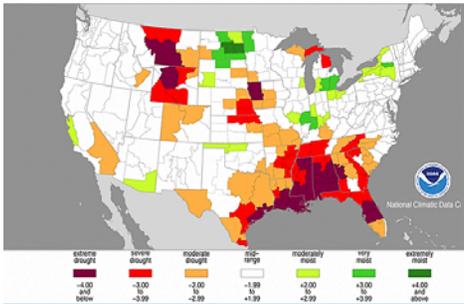
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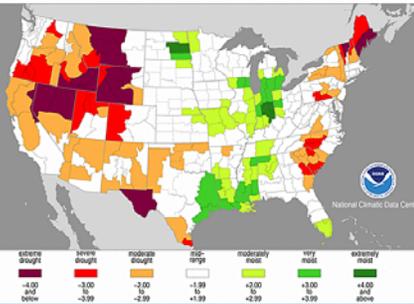
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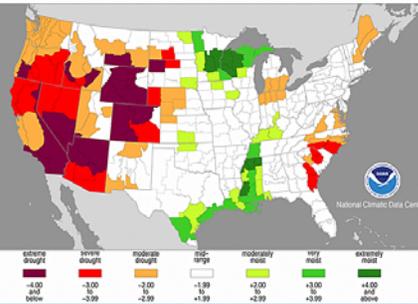
Palmer Modified Drought Index
October, 2000



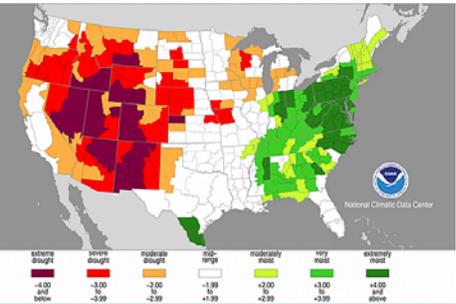
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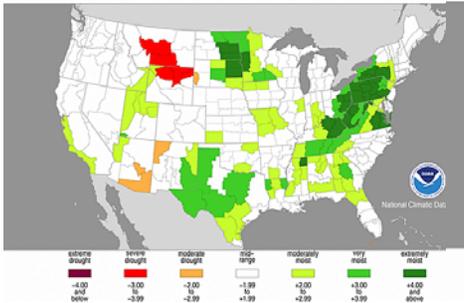
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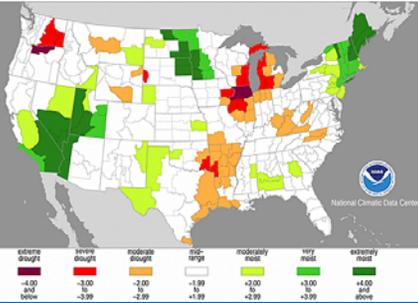
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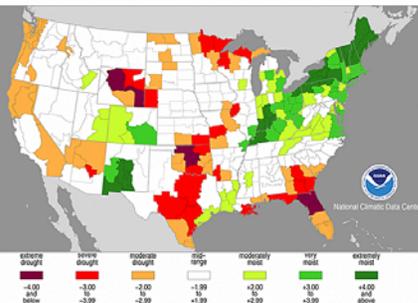
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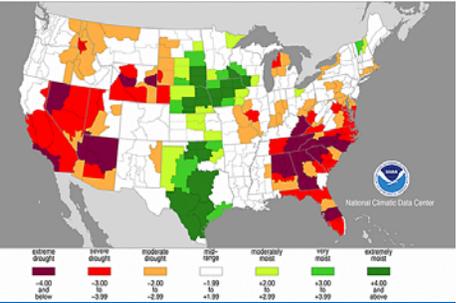
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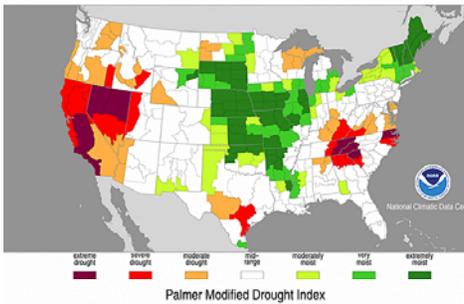
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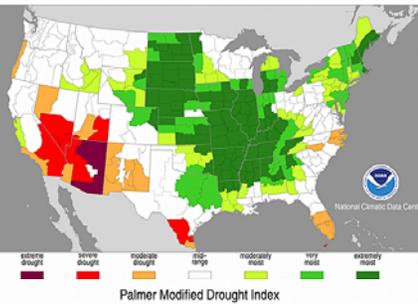
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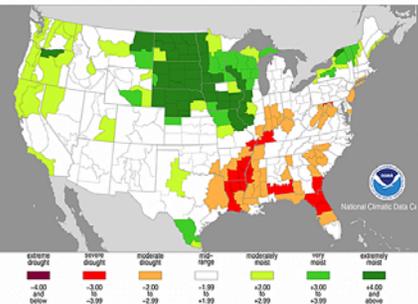
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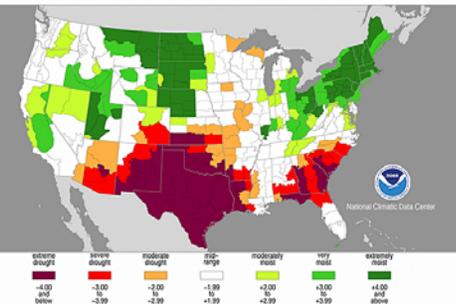
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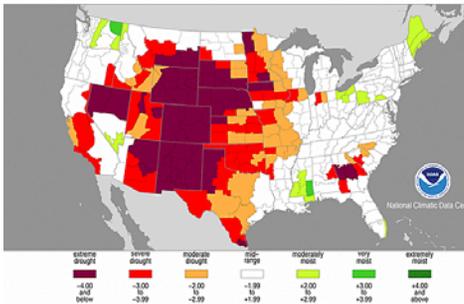
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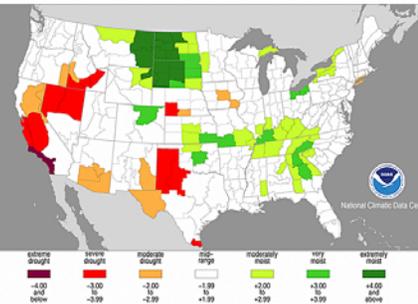
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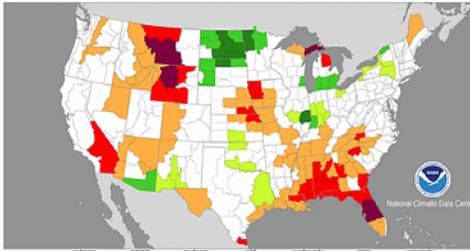
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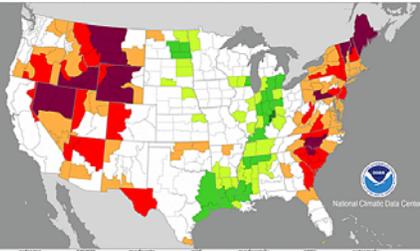
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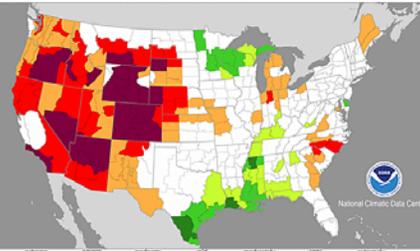
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November, 2000



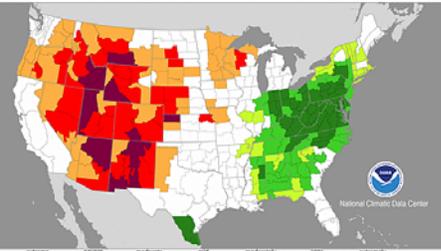
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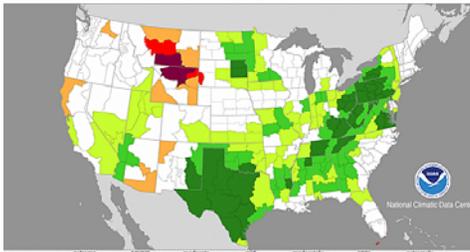
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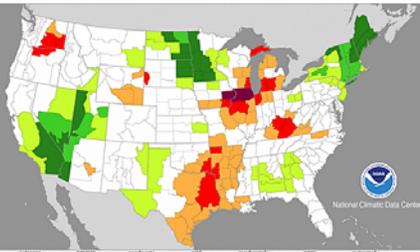
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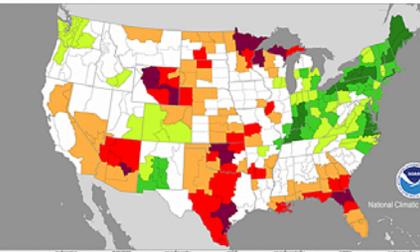
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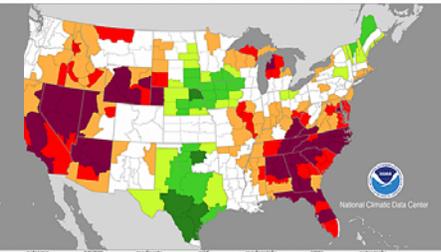
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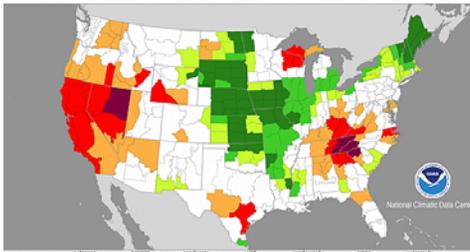
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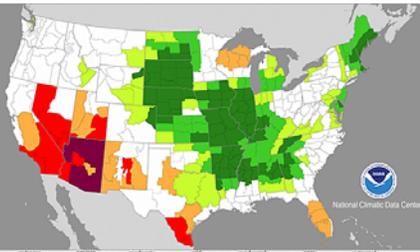
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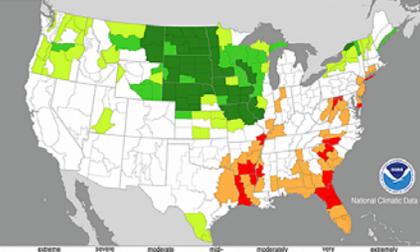
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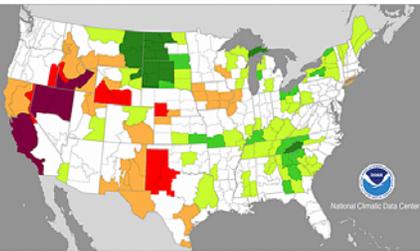
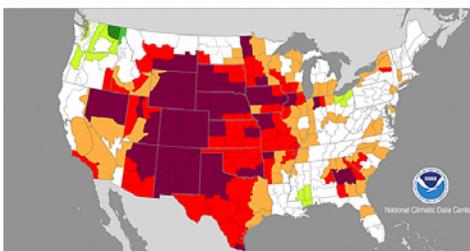
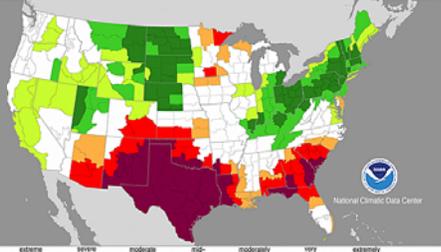
Palmer Hydrological Drought Index
November, 2009



Palmer Hydrological Drought Index
November, 2010

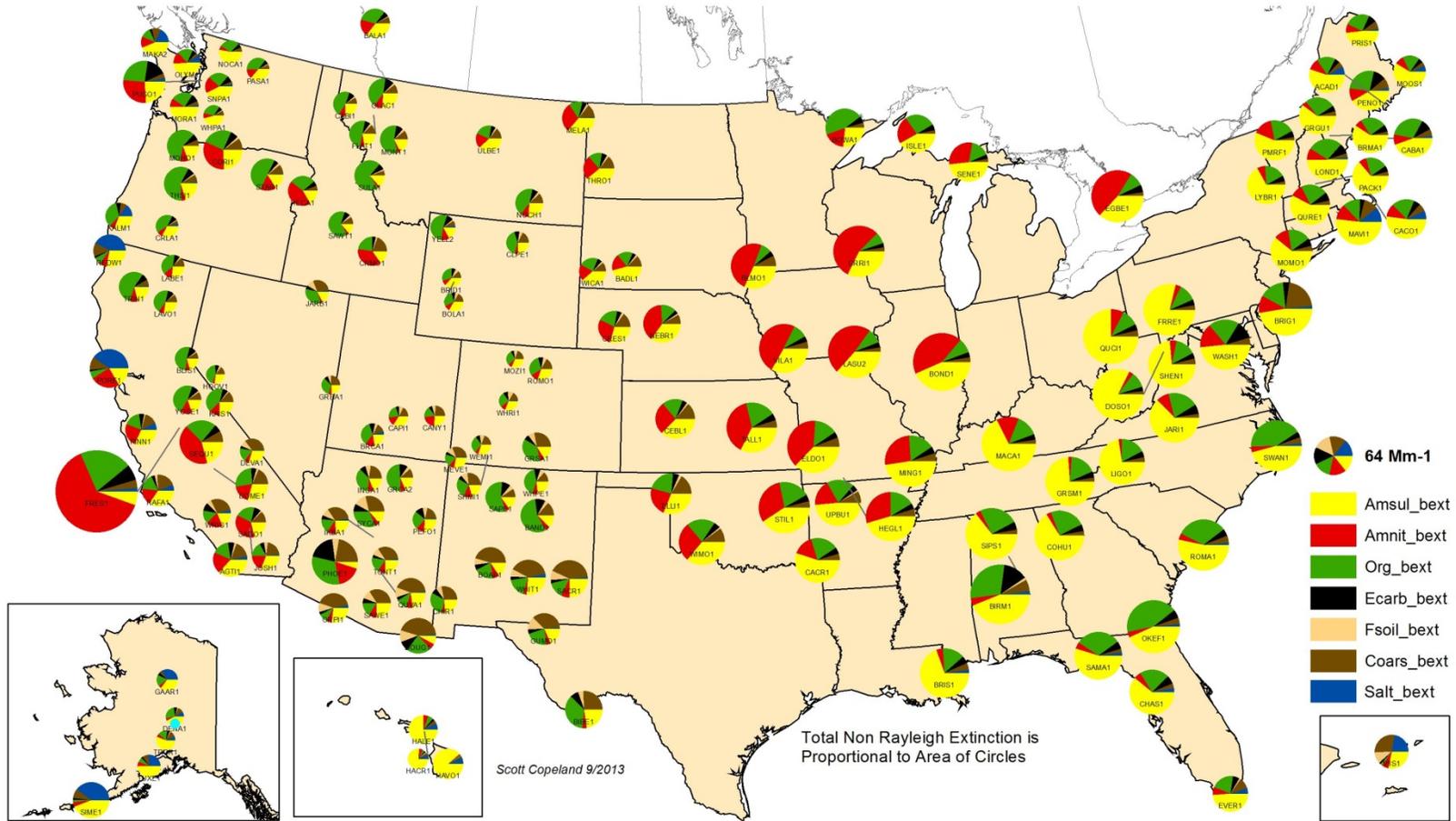


Palmer Hydrological Drought Index
November, 2011



IMPROVE Data - 2011 Second IMPROVE Algorithm

Non-Rayleigh Mean of Hazeiest 20% Days



IMPROVE Data - 2012 Second IMPROVE Algorithm

Non-Rayleigh Mean of Hazeiest 20%

