Biomass Burning Emissions – The Importance of Reducing Uncertainties for Improved Regulatory Decision; an EPA Perspective

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Wildland Fire Emissions in Chemical Transport Models: Improving Input Resolution I A42D
AGU Fall Meeting
San Francisco, CA
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Outline Talk

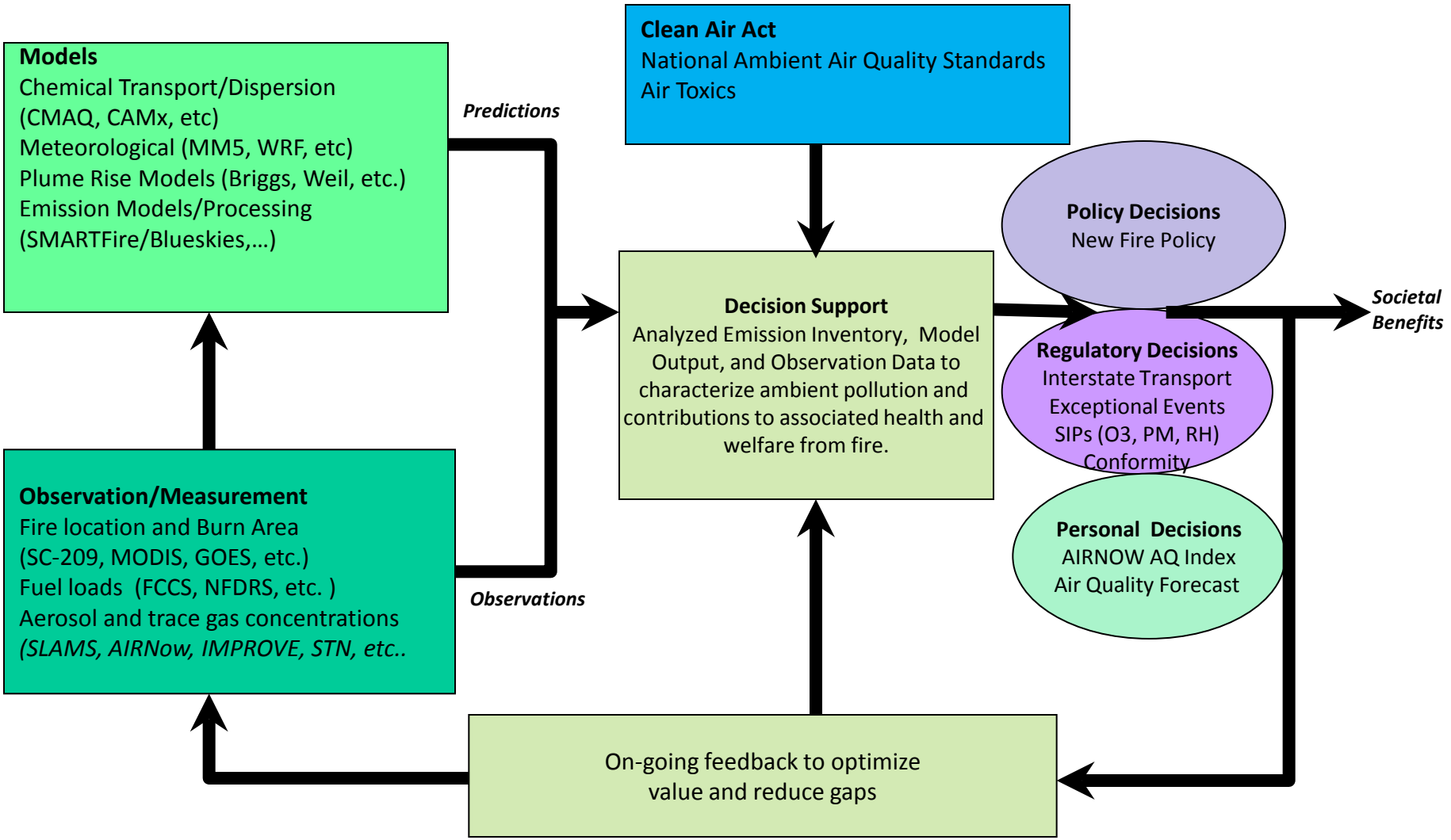
- Why is EPA interested in biomass burning?
- History of biomass burning in EPA's National Emission Inventory (NEI)
- Some areas of focus for reducing uncertainty

Current National Ambient Air Quality Standards

National Ambient Air Quality Standards

	Primary Standards		Secondary Standards	
Pollutant	**Level**	**Averaging Time**	**Level**	**Averaging Time**
Carbon Monoxide	9 ppm (10 mg/m^3)	8-hour [(1)]	None	
	35 ppm (40 mg/m^3)	1-hour [(1)]		
Lead	0.15 $\mu g/m^3$ [(2)]	Rolling 3-Month Average	Same as Primary	
	1.5 $\mu g/m^3$	Quarterly Average	Same as Primary	
Nitrogen Dioxide	0.053 ppm (100 $\mu g/m^3$)	Annual (Arithmetic Mean)	Same as Primary	
Particulate Matter (PM_{10})	150 $\mu g/m^3$	24-hour [(3)]	Same as Primary	
Particulate Matter ($PM_{2.5}$)	15.0 $\mu g/m^3$	Annual [(4)] (Arithmetic Mean)	Same as Primary	
	35 $\mu g/m^3$	24-hour [(5)]	Same as Primary	
Ozone	0.075 ppm (2008 std)	8-hour [(6)]	Same as Primary	
	0.08 ppm (1997 std)	8-hour [(7)]	Same as Primary	
	0.12 ppm	1-hour [(8)]	Same as Primary	
Sulfur Dioxide	0.03 ppm	Annual (Arithmetic Mean)	0.5 ppm (1300 $\mu g/m^3$)	3-hour [(1)]
	0.14 ppm	24-hour [(1)]		

How Fire Enters Into EPA's Research, Regulatory Structure and Air Quality Decisions



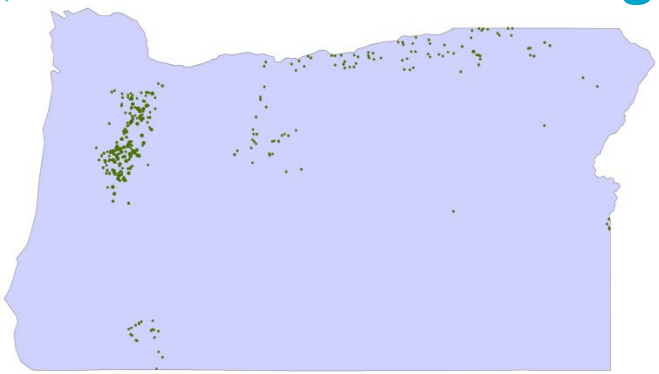
A Brief History of Fire Emissions Tracking by EPA

- **Prior to 2002 fire year, fire emissions relied on rudimentary allocation of USFS/DOI ground-based report of fires (many fires missing or mis-characterized)**

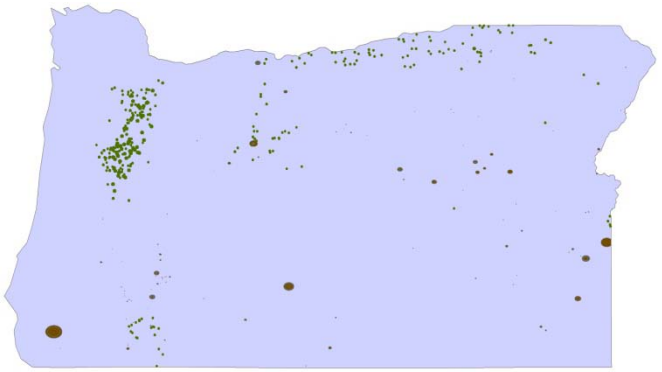
- **2002 Fires treated as point sources**
  - **Average daily emissions & 1st-day-of-fire location**
  - **QA & gap-filling was done on a 1-time basis at cost > $1M**
  - **Daily, spatially resolved fire emissions data is a continuing need – not just for 2002 - Cost effective method needed**

- **2003-2006 Fire EI prepared now using NOAA-HMS data**
  - **Fire emissions & daily geo-location**
  - **First use of SMARTFIRE….**

Spatial coincidence in satellite- and ground-based fire data

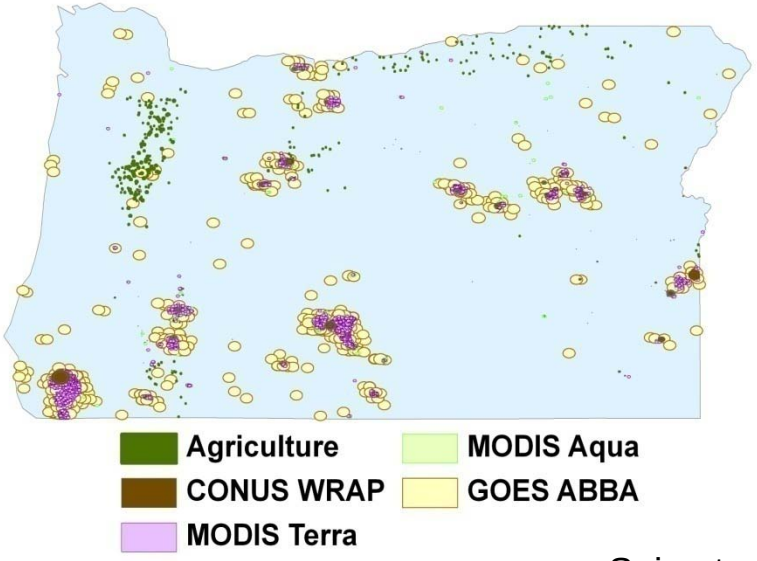


Agriculture Only



Agricultural, State, Federal and Private Ground-based Fire Data

Satellite- and Ground-based Fire Data

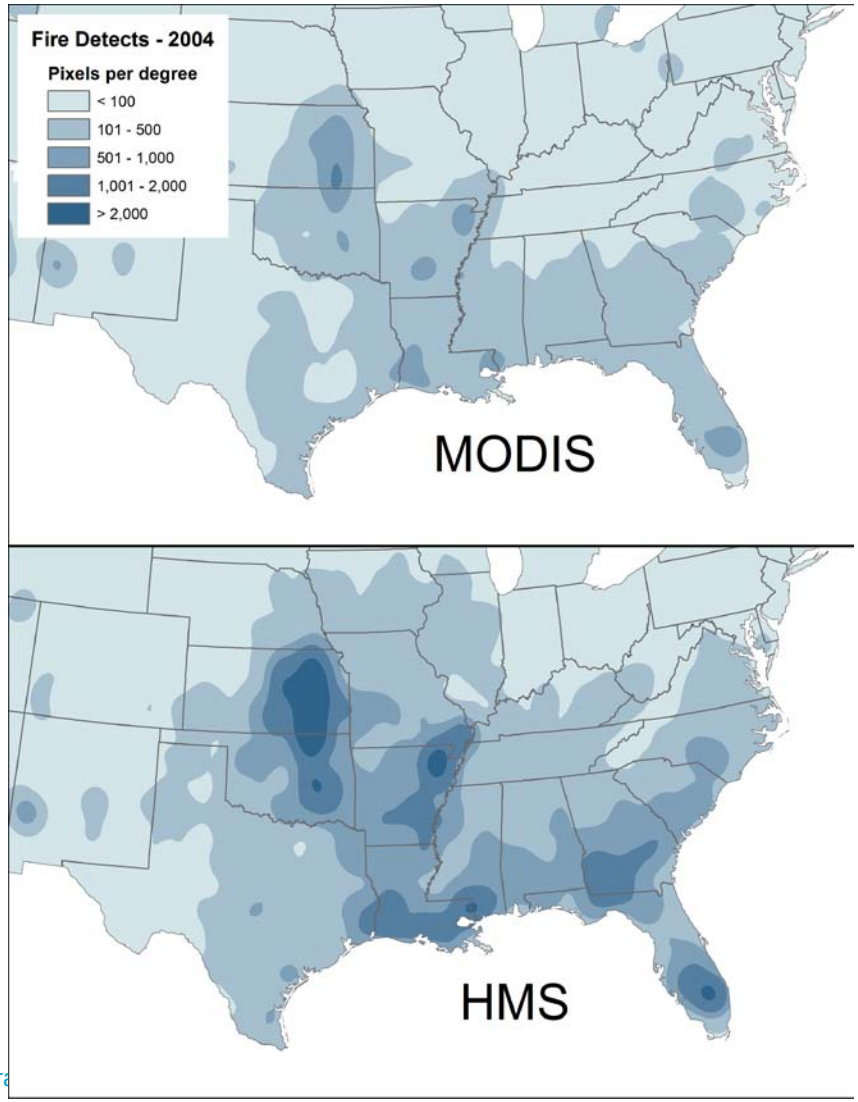


GOES WF-ABBA fire detections appear to capture smaller agriculture fires. Oregon, July 2002

Soja et. al., 2007 16th EPA Emission Inventory Conference

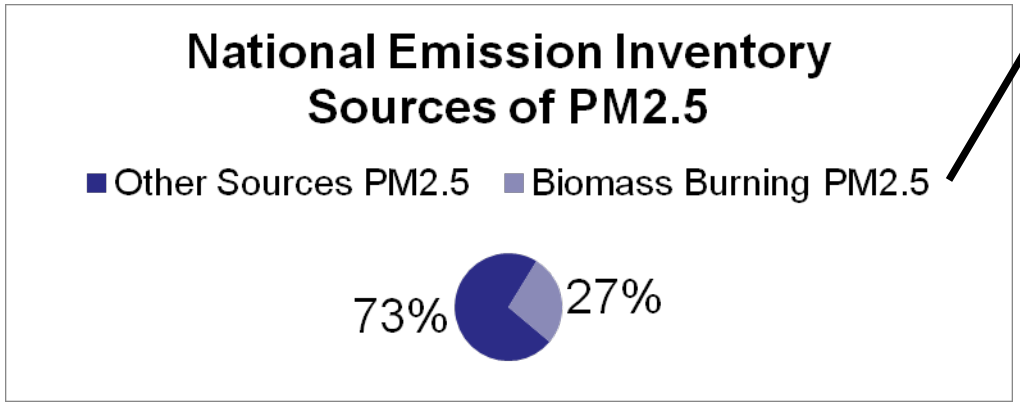
Differences Between MODIS and HMS

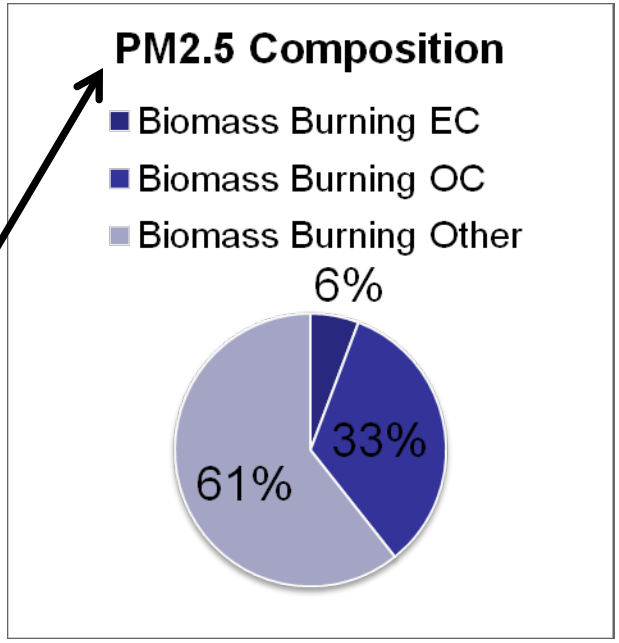
- Because HMS includes GOES and AVHRR derived fire pixels in addition to MODIS, it detects more fires overall.
- This is especially true in the southeast, where fires are often small and/or short lived.
- In addition to the increased coverage, HMS provides human quality control.



Significance of biomass burning in EPA's NEI

- **AQ Management of PM2.5, Ozone & HAPs**
  - PM & O_3 NAAQS ~ 24 hr (or less) averaging time
  - Some HAPS (e.g., acrolein) associated with short term exposures
- **Forecasting**
  - Fire impacts ~ consideration in AirNow forecasts
- **Fire emissions needed for both**
  - 20% of PM2.5 in 48-State EI
  - VOC, NOx important to Ozone formation
  - Selected HAPs also important



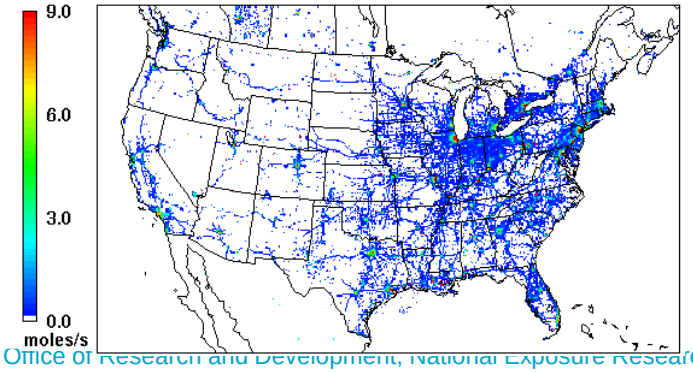


Characterization and Modeling of Emissions

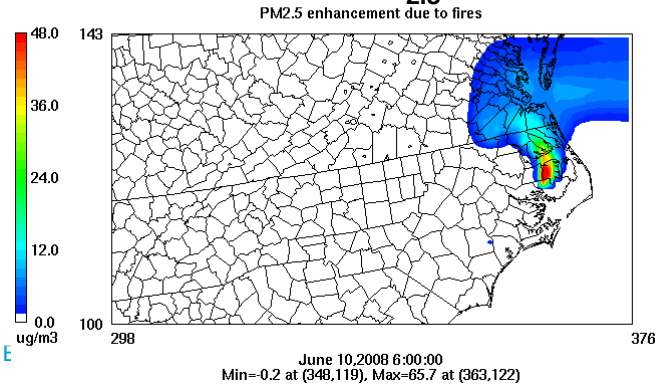
Uncertainties inherent in emission estimation influence the predictive accuracy of air quality models

- Characterize the relative contribution of anthropogenic and natural emissions to air quality degradation
- Anthropogenic emission estimates derived from EPA National Emission Inventory (NEI)
  - Improving spatial and temporal variability of source emissions affected by meteorological variability (e.g., plume rise, mobile emissions)
- Develop techniques to quantify emissions from non-traditional sources
  - Natural emissions (e.g., biogenic VOCs and NO_x, sea-salt, wildfires, dust)
  - Non-regulated sectors (e.g., seasonal and spatial variability in NH_3 emissions)

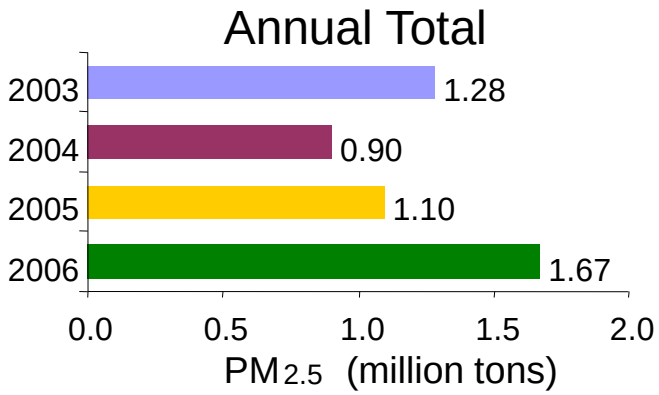
Anthropogenic NO_x Emissions



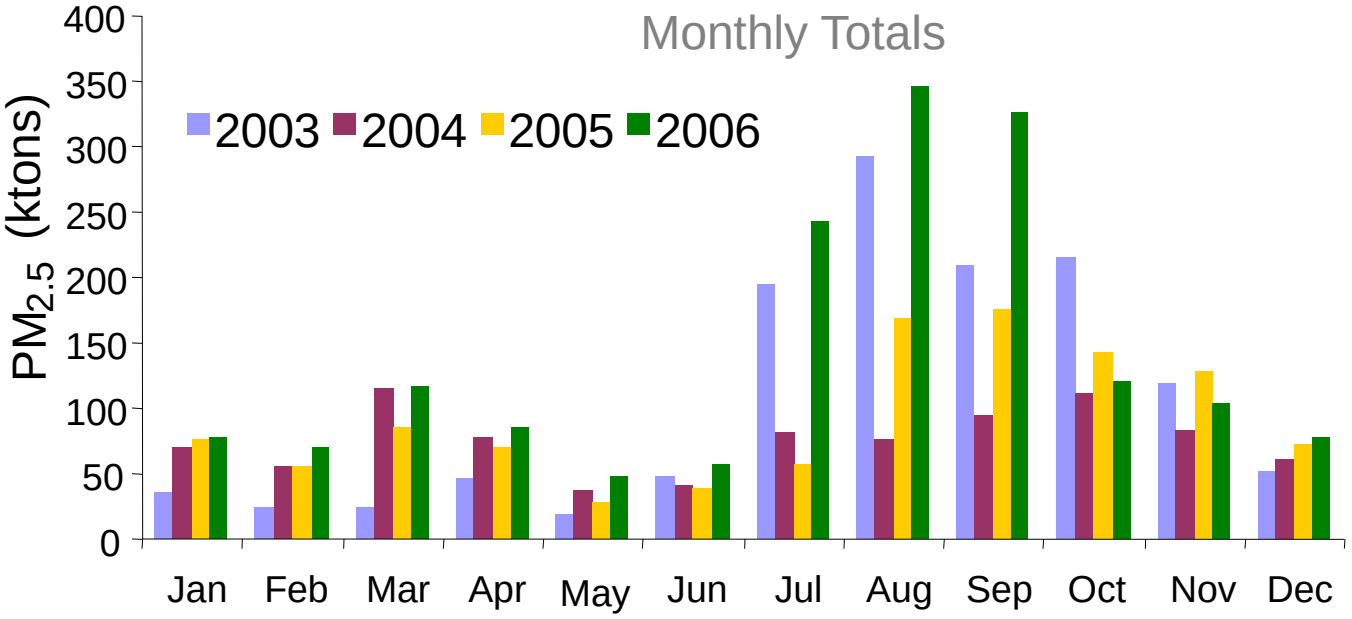
Combined satellite-ground based wildfire emission estimation: $PM_{2.5}$ enhancement



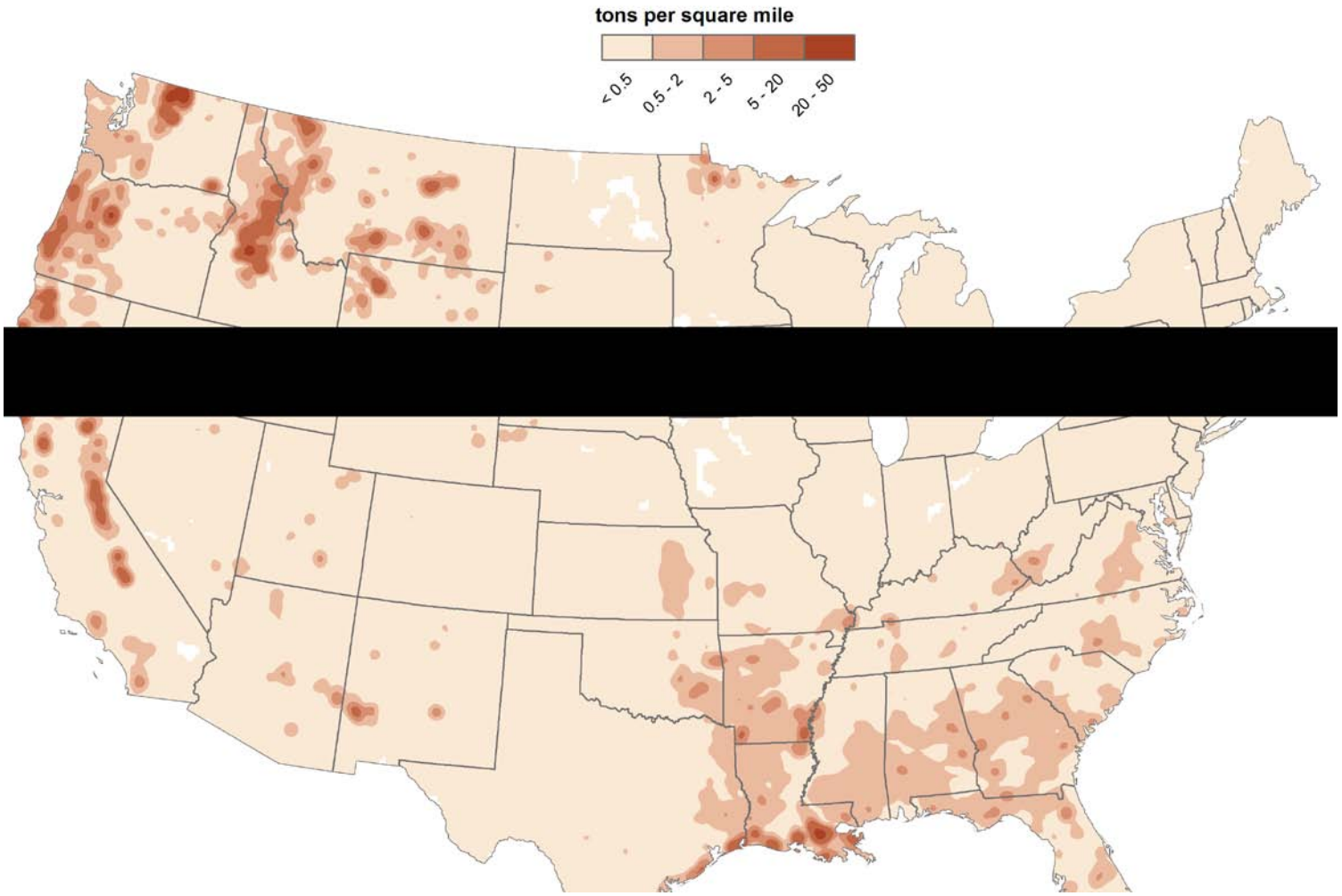
Annual $PM_{2.5}$ Primary Emissions



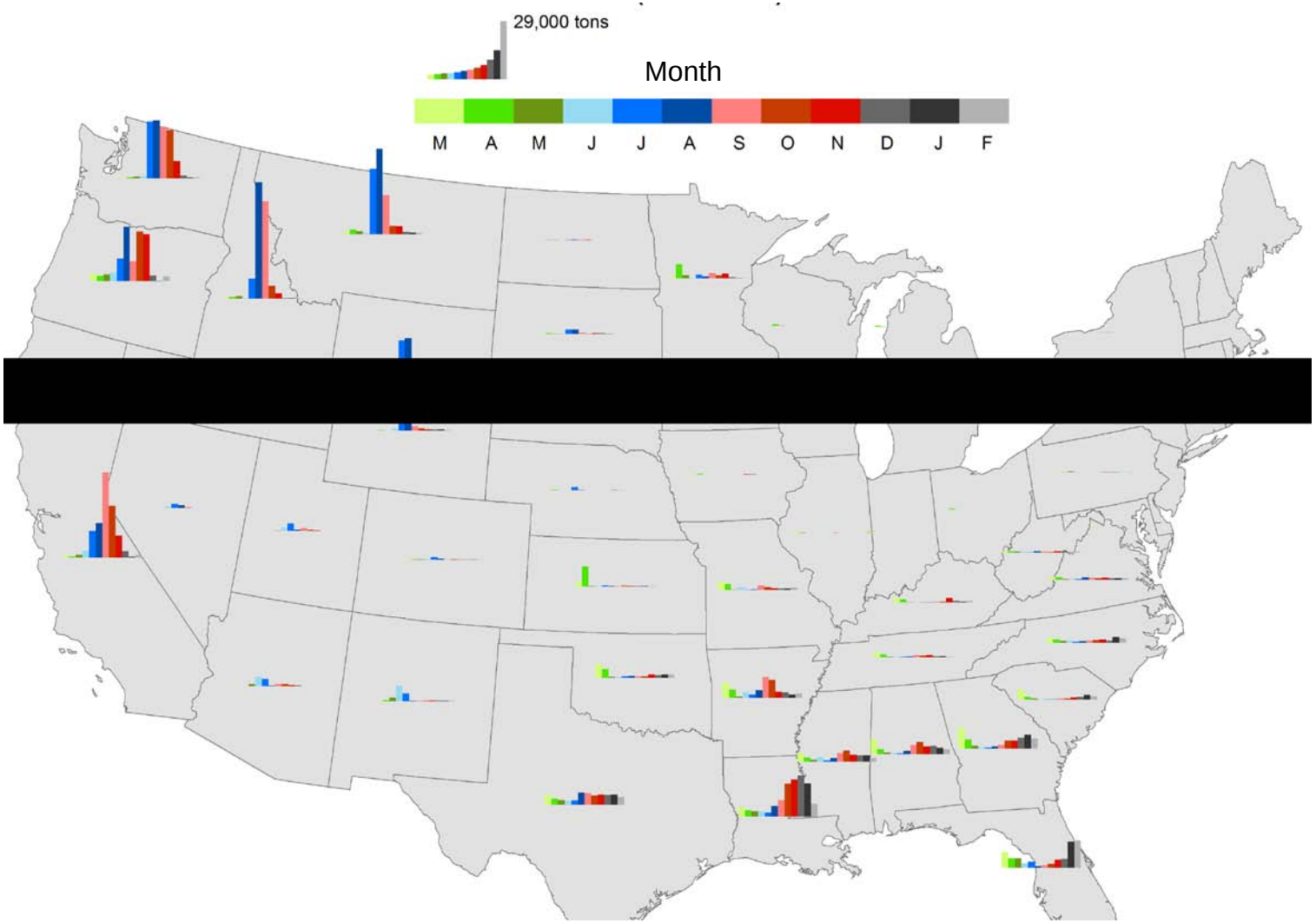
(2003 - 2006, Lower 48 States)



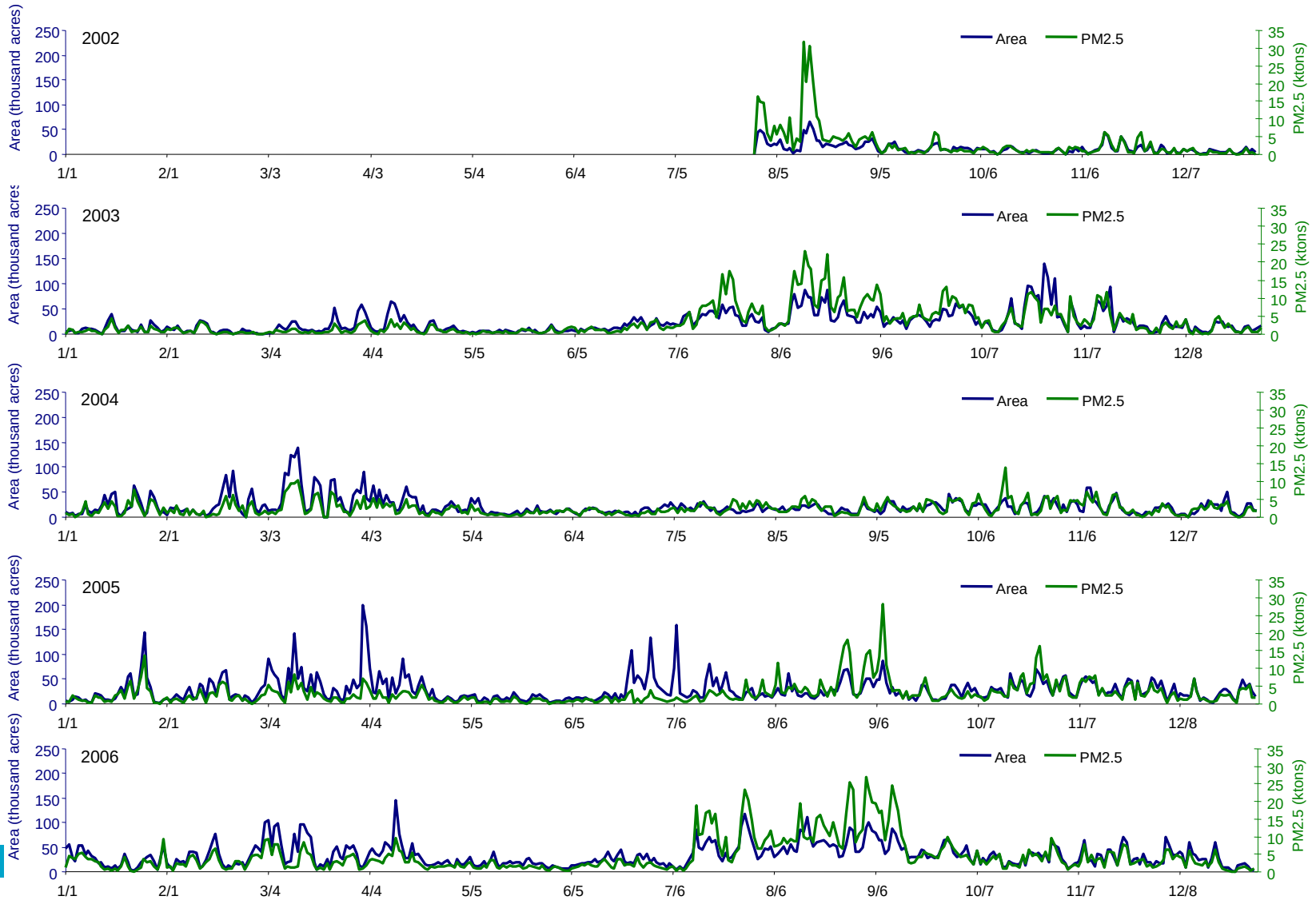
Annual Average $PM_{2.5}$ Wildland Fire Emission Density (2003 – 2006)



Monthly Wildland Fire $PM_{2.5}$ Emissions (2003-2006)

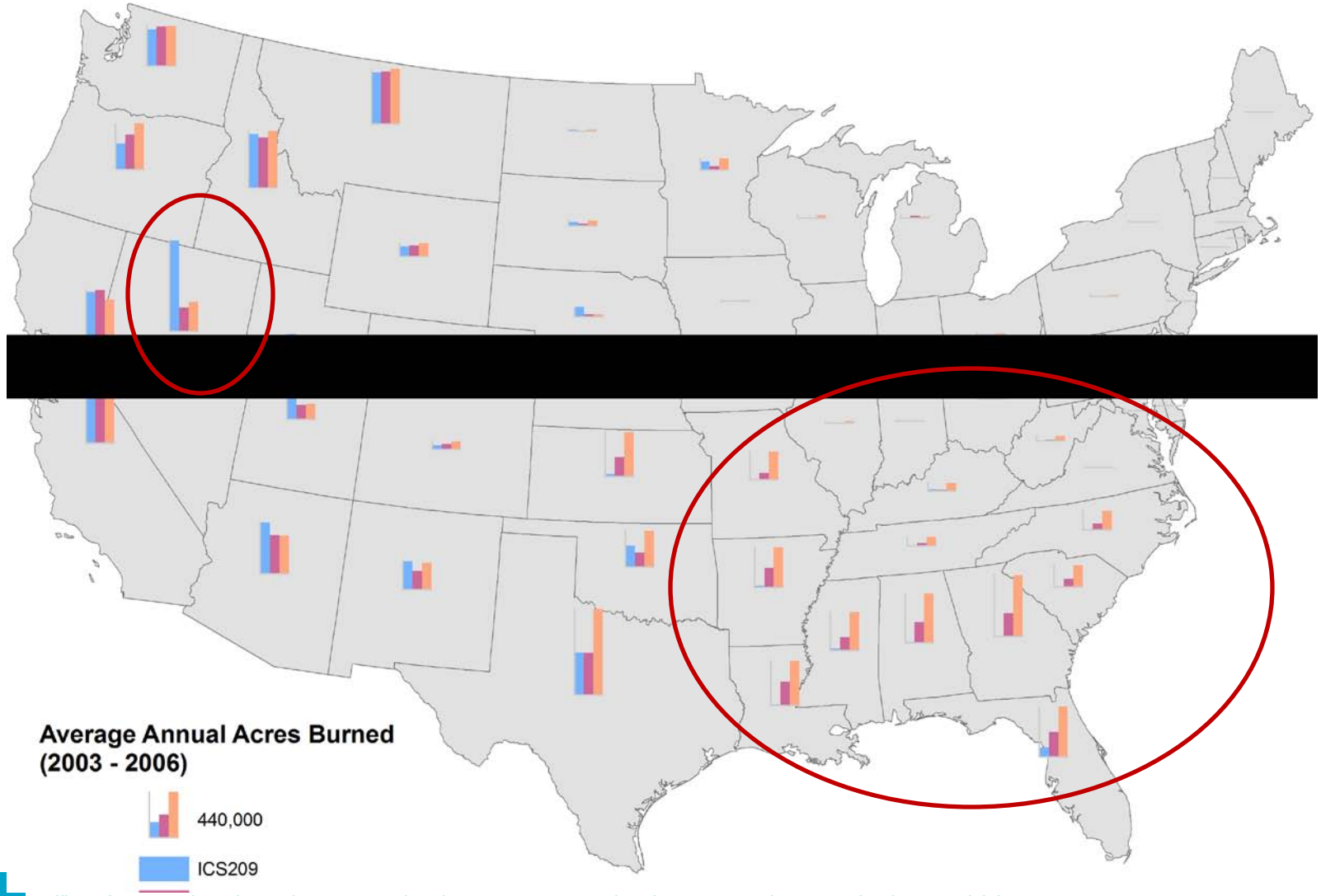


Daily Area Burned vs. $PM_{2.5}$ Emissions

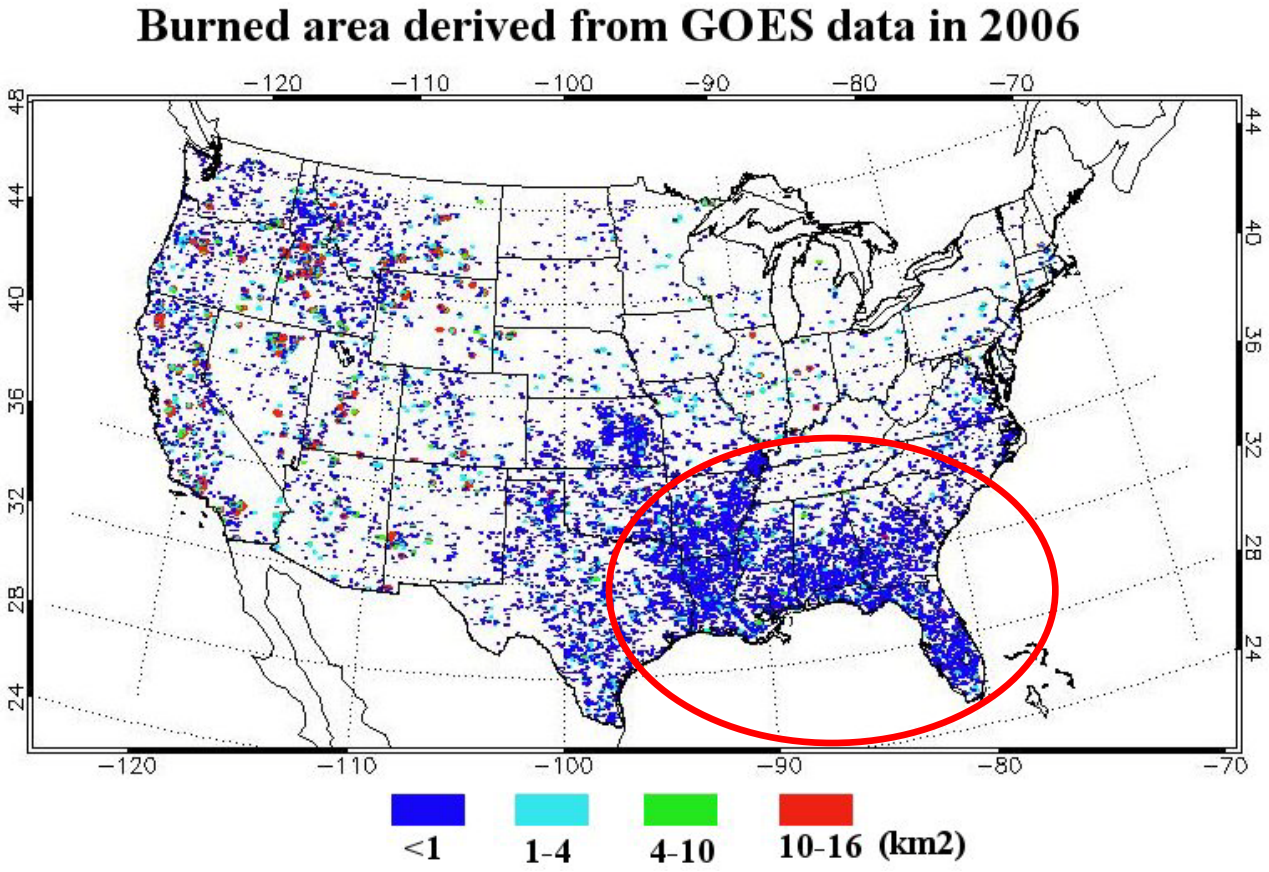


SMARTFIRE vs. MODIS vs. ICS-209

Area Burned



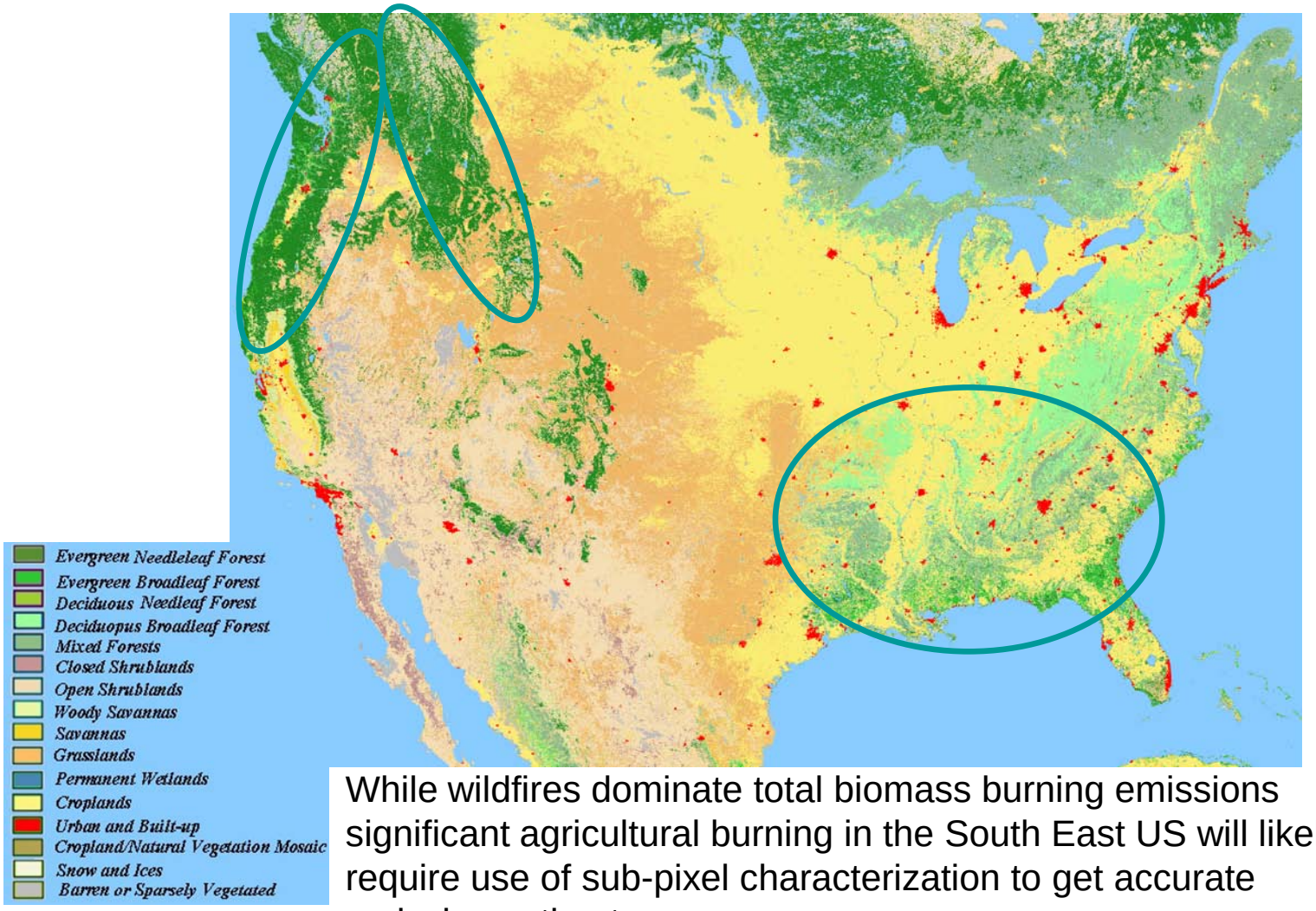
A Large Number of Small Fires



While wildfires dominate total biomass burning emissions significant agricultural burning in the South East US will likely require use of sub-pixel characterization to get accurate emission estimates.

Zhang and Kondragunta, RSE, 2008

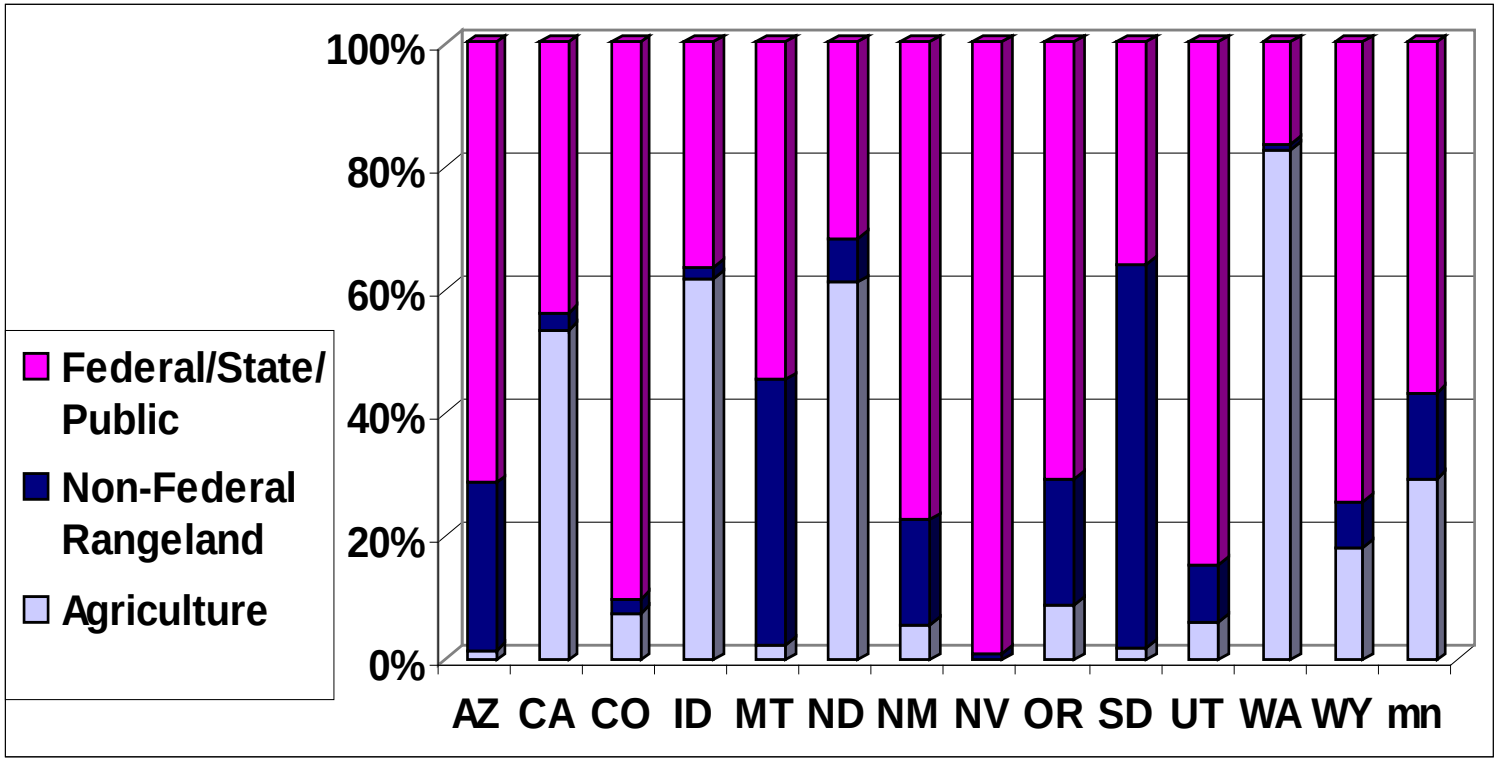
MODIS Land Cover Map



While wildfires dominate total biomass burning emissions significant agricultural burning in the South East US will likely require use of sub-pixel characterization to get accurate emission estimates.

Focus on poorly represented agricultural fires

- Percent of "reported" area burned in the WRAP region, 2002
  - 22% agricultural lands;
  - 16% non-federal rangelands; and
  - 63% private, state and federal lands



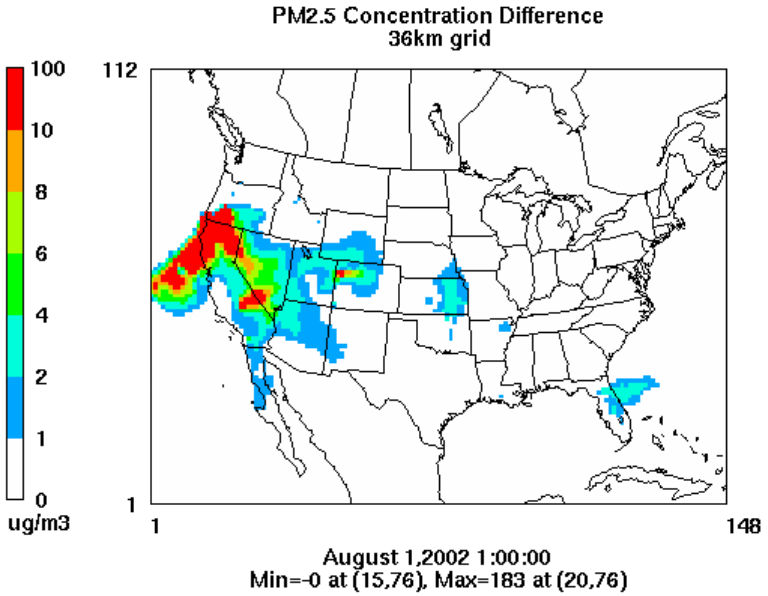
Soja et al., JARS 2009

United States Environmental Protection Agency

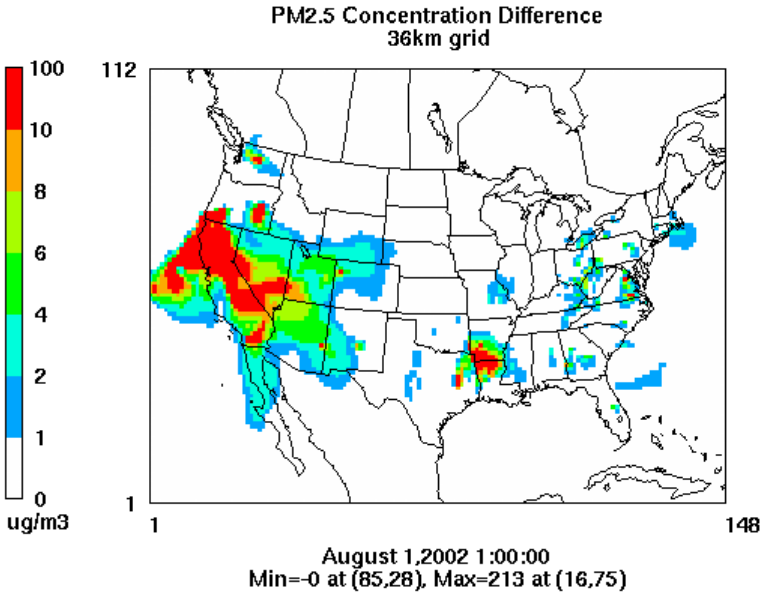
Comparison of CMAQ results for August 2002

- Difference in daily average PM2.5 concentrations between the four fire cases and the no fire case
- Compared model predictions with IMPROVE and STN observational networks, which measure PM2.5 every third day
- Compared the “NOFIRE” case with each inventory

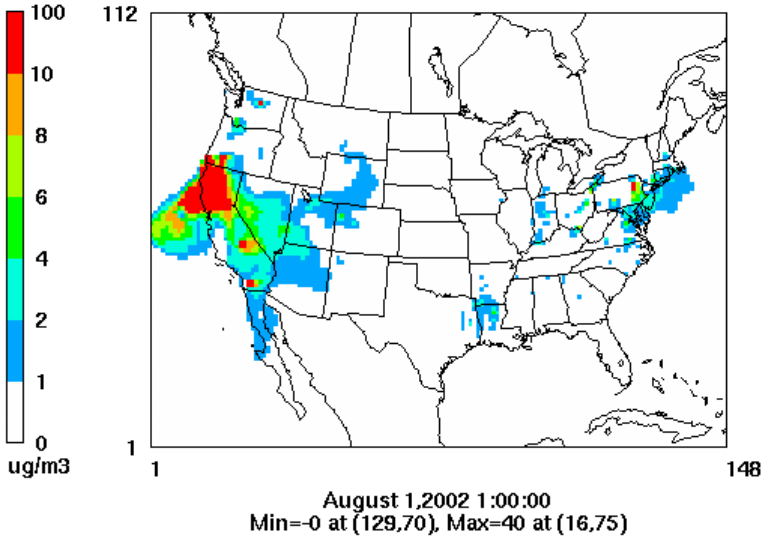
Aug 2002 Difference NEI



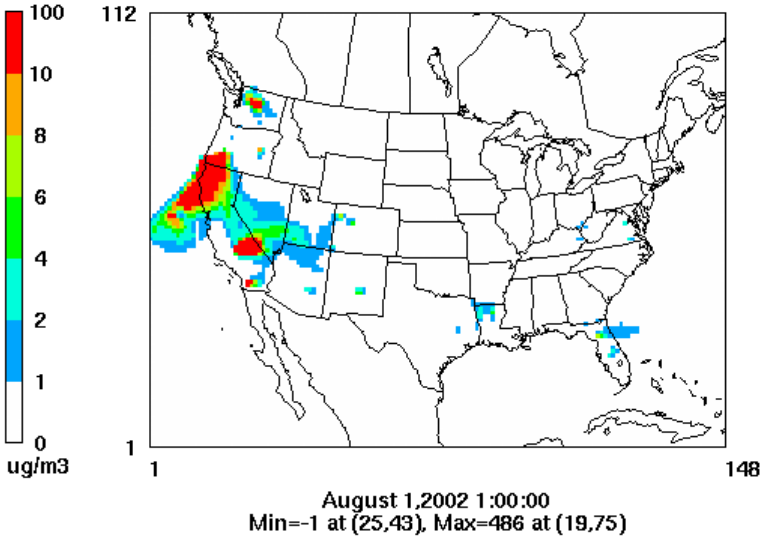
Aug 2002 Difference NCAR



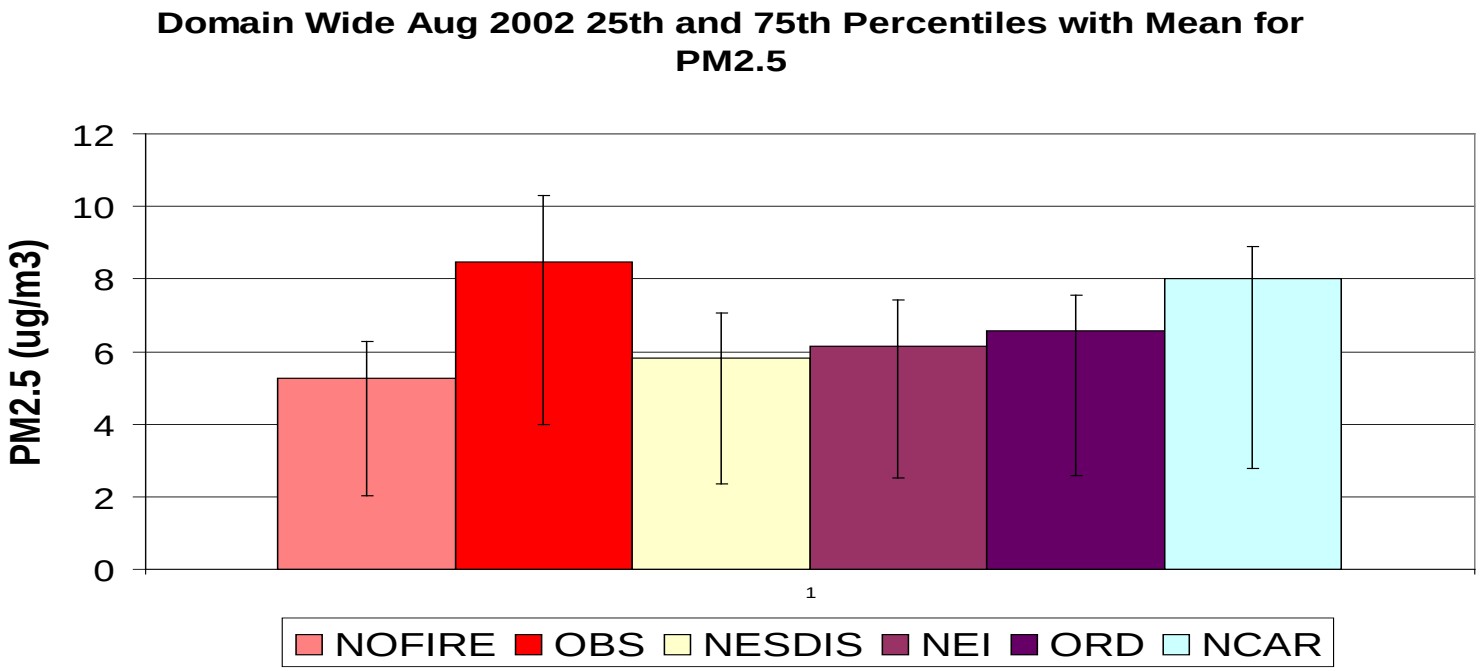
Aug 2002 Difference NESDIS



Aug 2002 Difference ORD

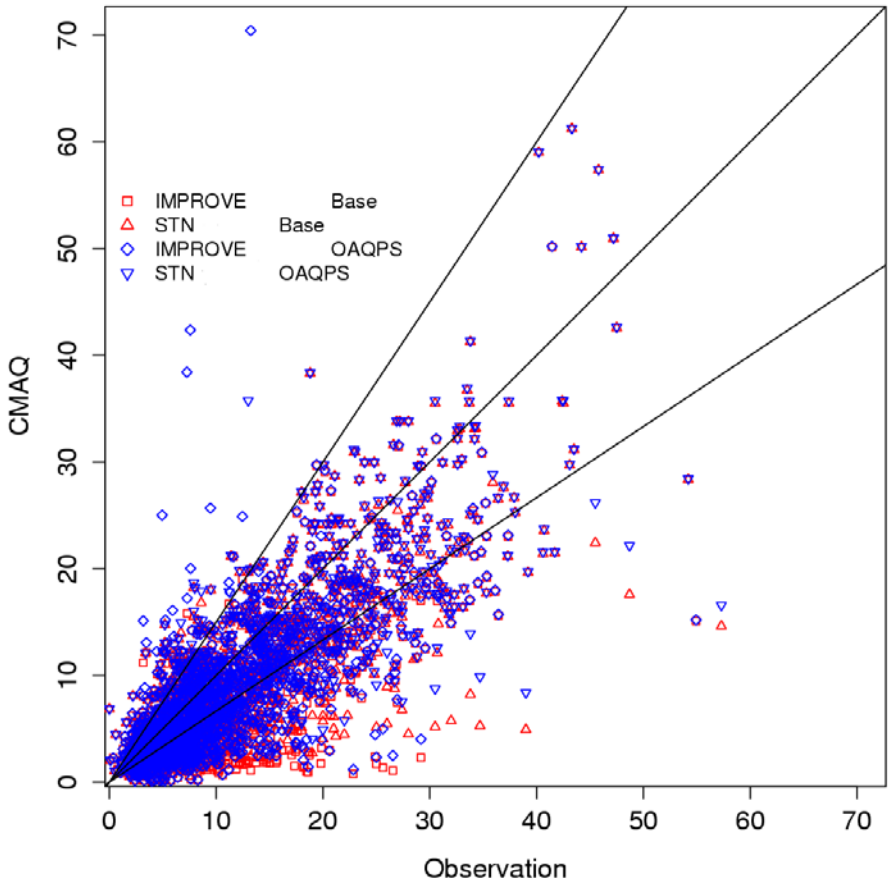


Comparison of CMAQ results (w/ and w/o fire emissions)



United States Environmental Protection Agency

Aug 2002 PM2.5 Modeled (NOFIRE and NEI) vs Observed



NOFIRE = Base
NEI = OAQPS

All fire inventories reduce the bias but do not improve correlation for the IMPROVE network August 2002

	R	RMSE	NMB (%)	NME (%)
NO FIRE	0.75	5.6	-38	46
NCAR	0.25	18.7	-5	52
NESDIS	0.75	5.3	-31	42
NEI	0.62	6.3	-28	43
ORD	0.49	8.3	-23	47

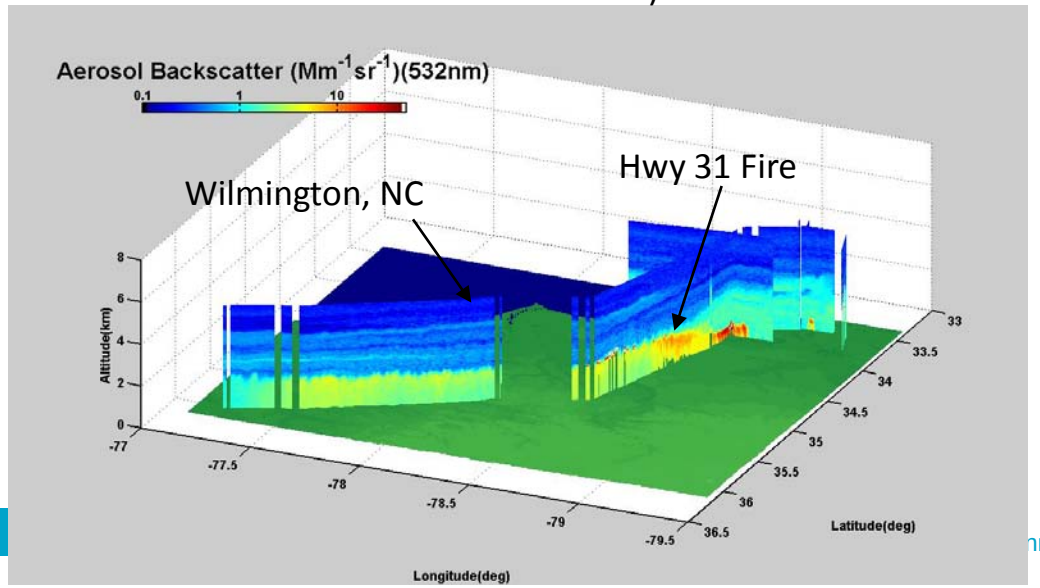
Why isn't there an obvious improvement in model results?

- Results are for one month at 36km. A longer simulation at higher resolution may show better results
- Plume heights and wind fields may be very important in capturing transport – was the plume injected below or above boundary layer?
- Plume rise algorithm needs refinement and improvement
- Most of the plume from the largest fire (Biscuit Fire) remained over the Pacific Ocean or did not impact monitors
- Fire inventories are being improved-need to examine other time periods with newer data.
- August 2002 had the most overlap of all methods but satellite sensors not fully calibrated

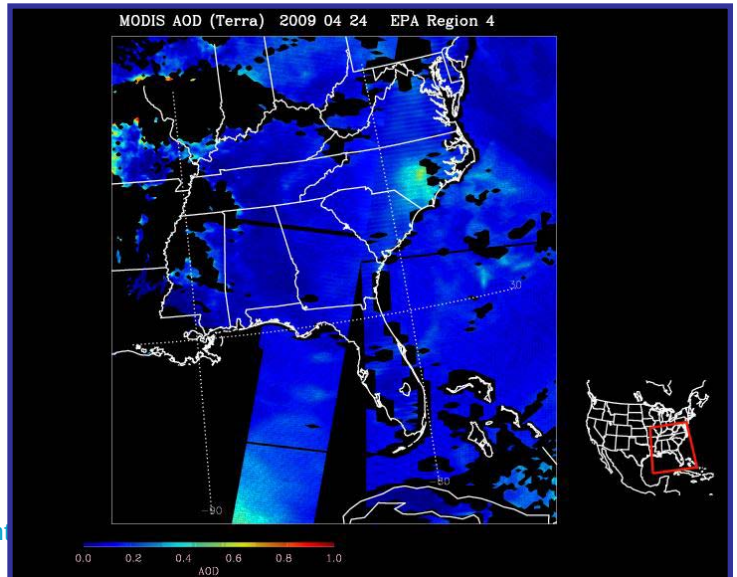
NASA B200 and High Spectral Resolution Lidar (HSRL): Measurements of Myrtle Beach Fires on April 24 for Plume Height and Aerosol Extinction Measurements

- April 23 US EPA requests HSRL overflights of SC fires using NASA B200 King Air
- Existing HSRL configuration allowed for rapid deployment from NASA LaRC on April 24
- Measurements data to be added to database for modeling studies on fire plume rise and aerosol extinction for biomass emission estimates.

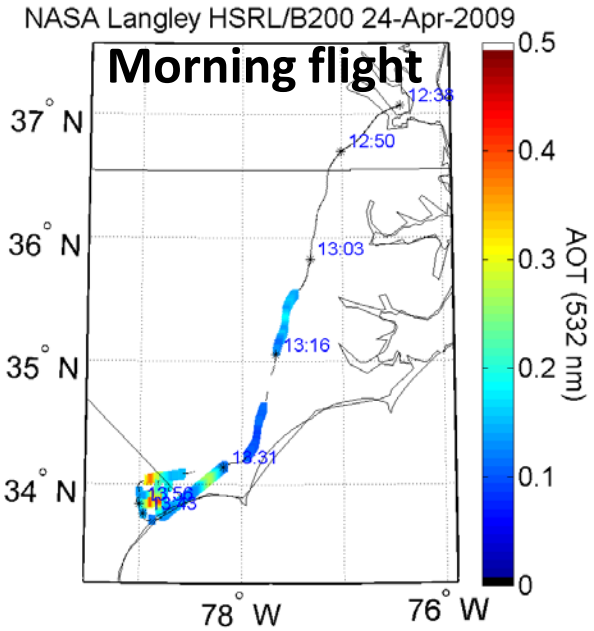
B-200-HSRL Overflights of SC Highway 31 Fire (17:45 – 19:20 UTC APR 24)

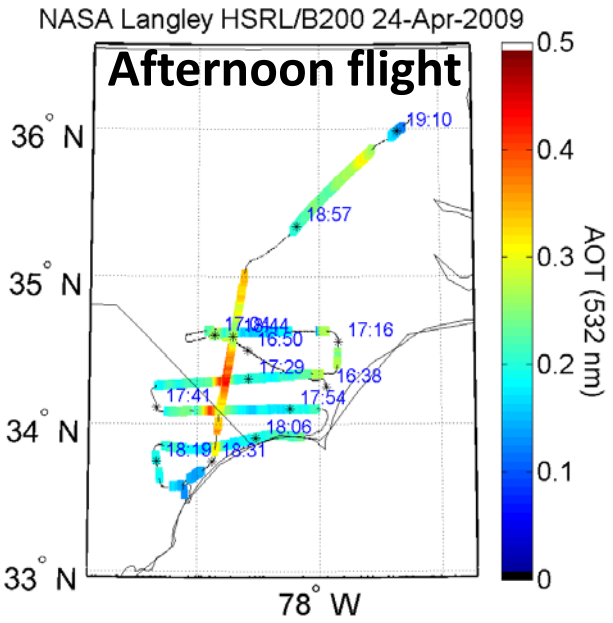


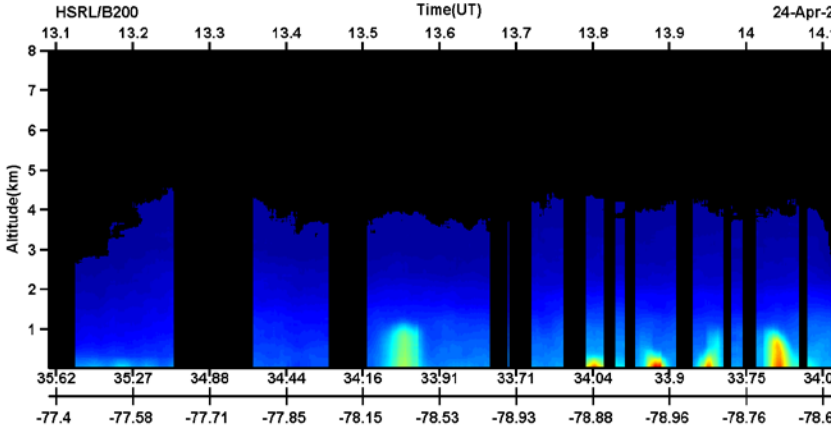
MODIS-TERRA AOD captures aerosols from SC fires - 15:30 UTC APR 24

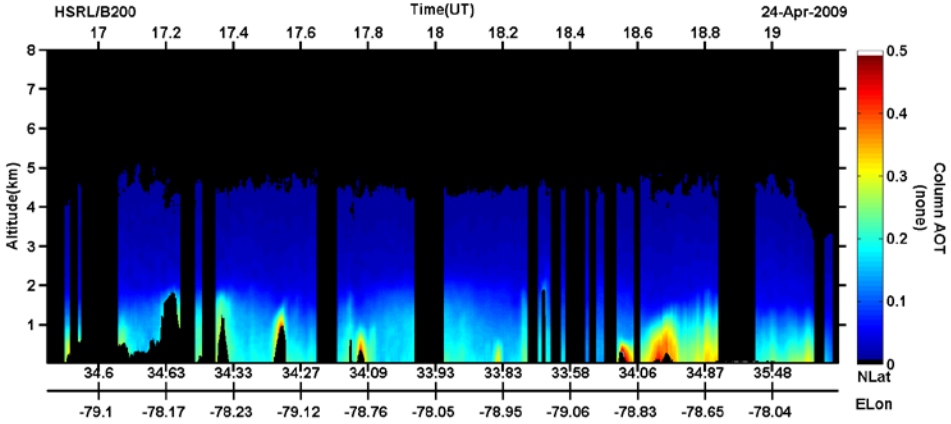


April 24th Morning and Afternoon B200 flights
HSRL captures the increase in afternoon aerosols





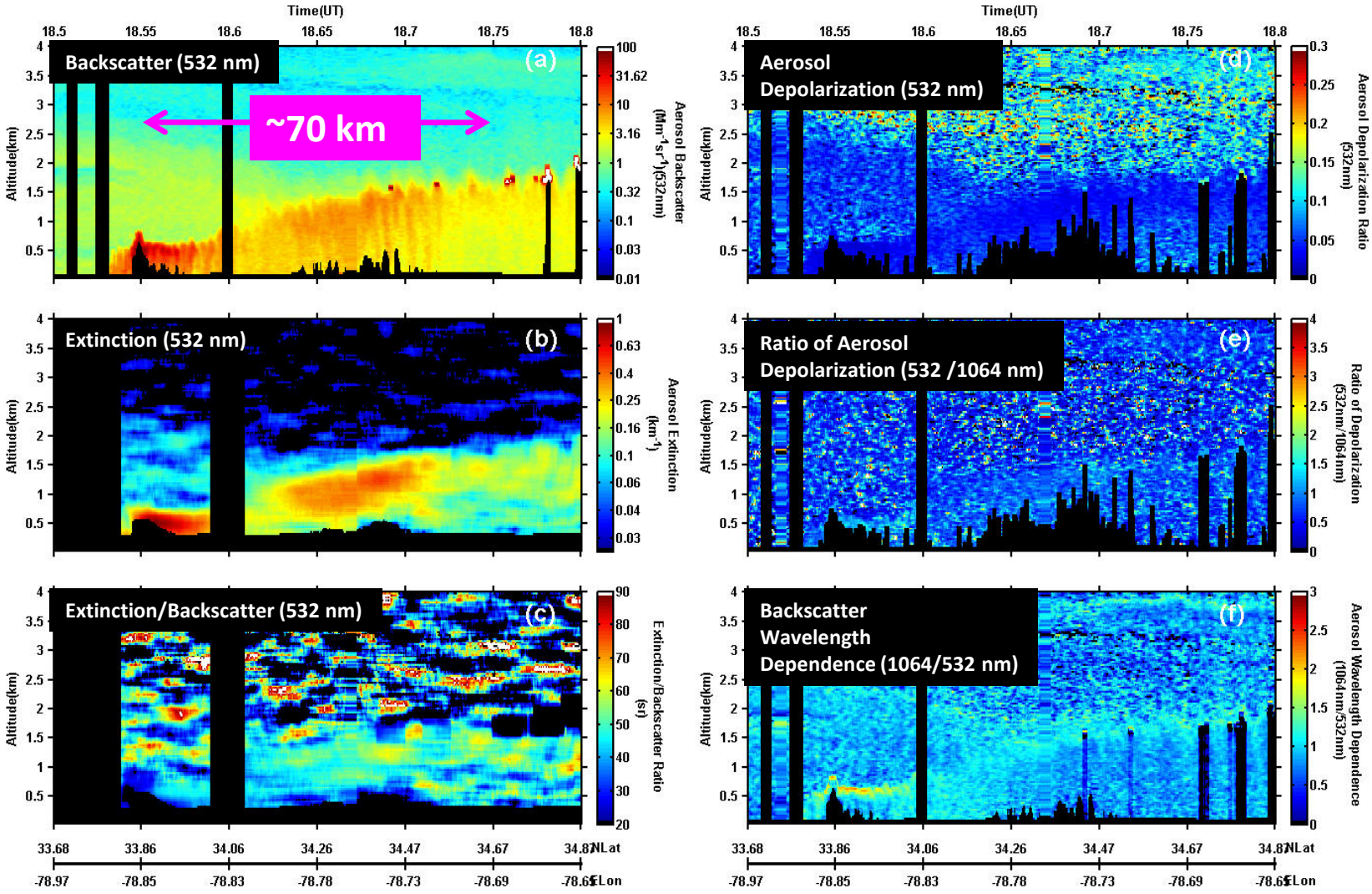




B200 HSRL - Column Aerosol Optical Thickness

Measurements of Smoke on April 24, 2009 Afternoon Flight

- Expanded view of HSRL measurements of Hwy 31 Fire



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