

WILDLAND FIRE EMISSION MODELING FOR CMAQ: AN UPDATE

George Pouliot*, Thomas Pierce*
Atmospheric Sciences Modeling Division
Air Resources Laboratory, NOAA
Research Triangle Park, NC

Jeffrey Vukovich
Carolina Environmental Program
The University of North Carolina
Chapel Hill, NC

*In partnership with National Exposure Research Laboratory, USEPA.



Outline of Presentation

- Emission Modeling Approaches
 - National Emission Inventory
 - Bluesky/EPM
 - Air Quality Forecasting
- Comparison of Emissions
- Plume Rise Approaches
- Preliminary Results
 - National Emission Inventory
 - Bluesky/EPM
 - National Emission Inventory with Plume Rise
 - Air Quality Forecasting
- Future Plans



National Emission Inventory

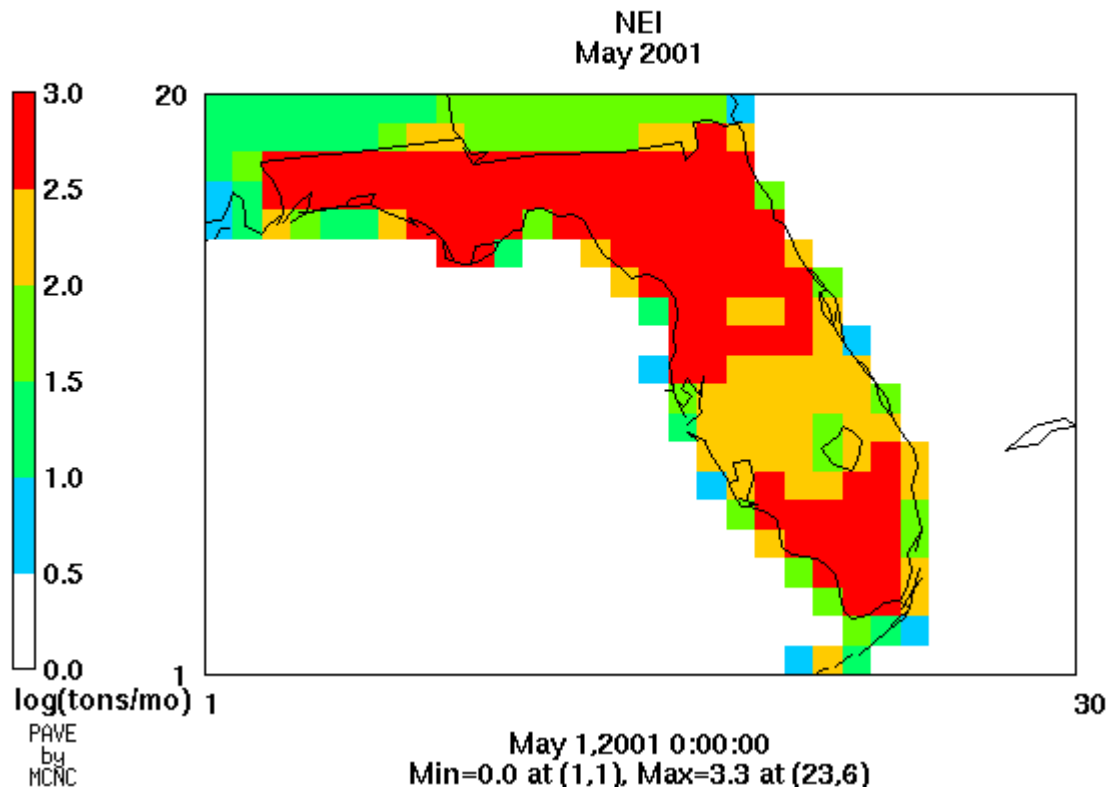
- Approach used for CMAQv4.4 evaluation (2001 annual simulation)
- Wildfire emission estimates by state on a monthly basis
- Allocated to county level using forest surrogate
- Mapped to grid cells using forest surrogate
- Emissions are modeled as **AREA** sources



CMAQV4.4 Annual Simulation for 2001

2001

LOG of Monthly PM2.5 Emissions from Wildfires



BlueSky/EPM Approach

- Background on BlueSky
- CONSUME/EPM Model in BlueSky
- Linking BlueSky and SMOKE
- Plume Rise for WildFires
- SMOKE updates needed to link with Bluesky



US Forest Service (USFS) & US Environmental Protection Agency (US EPA)

Via an interagency agreement, are collaborating to improve the **episodic modeling of fires** using

- Improved fuel loading data
- Improved fire location information
- Improved fire behavior modeling (including plume behavior), using meteorological inputs



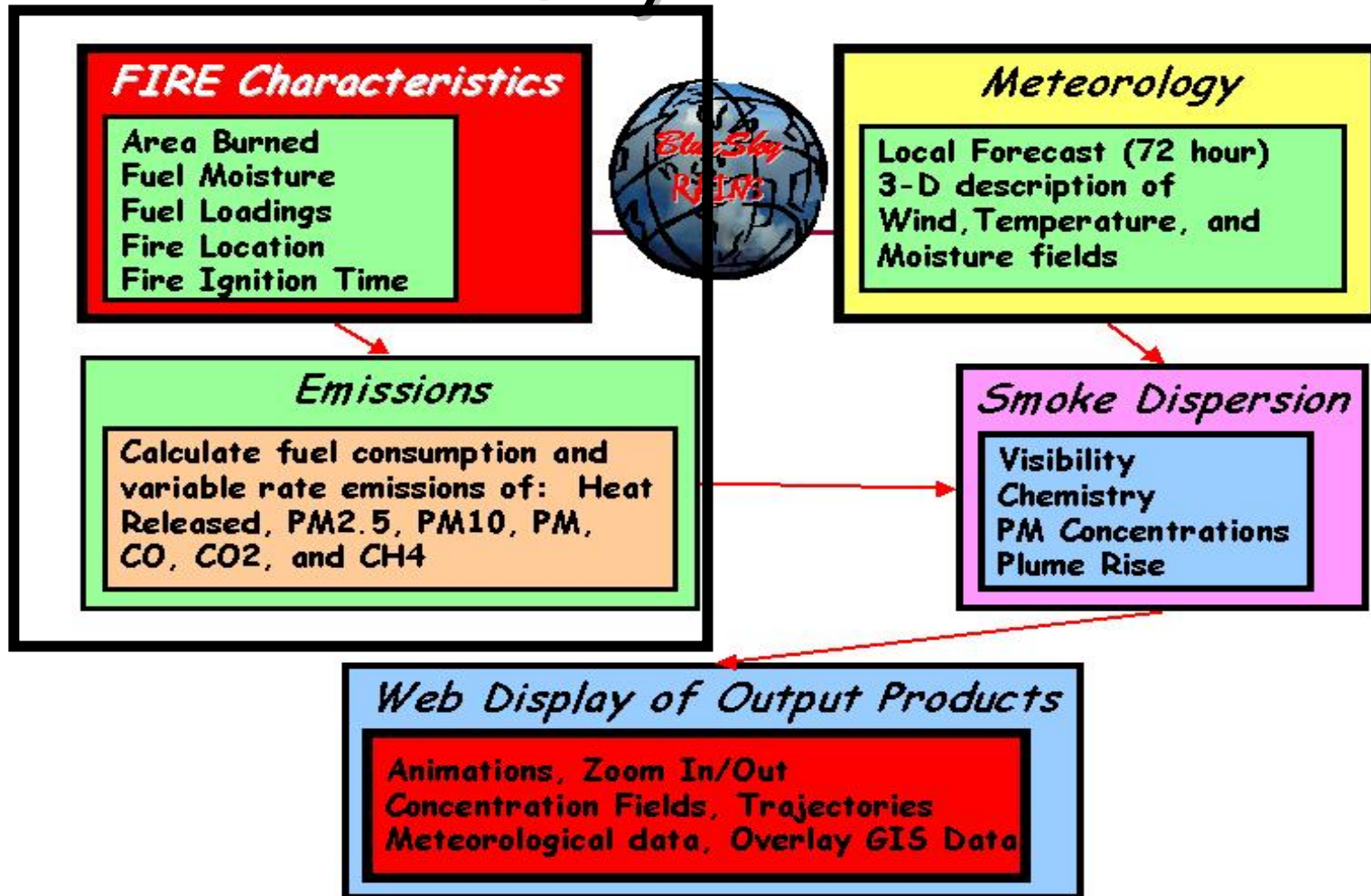
What is Bluesky?

- **BlueSky** is a modeling framework designed to predict cumulative impacts of smoke from forest, agricultural, and range fires. The **BlueSky** framework combines emissions, meteorology, and dispersion models to generate predictions of smoke impacts across the landscape. **BlueSky** is used by the U.S. Forest Service

Source: <http://www.fs.fed.us/bluesky/about/>



BlueSky Framework



Source: <http://www.fs.fed.us/bluesky/about/>



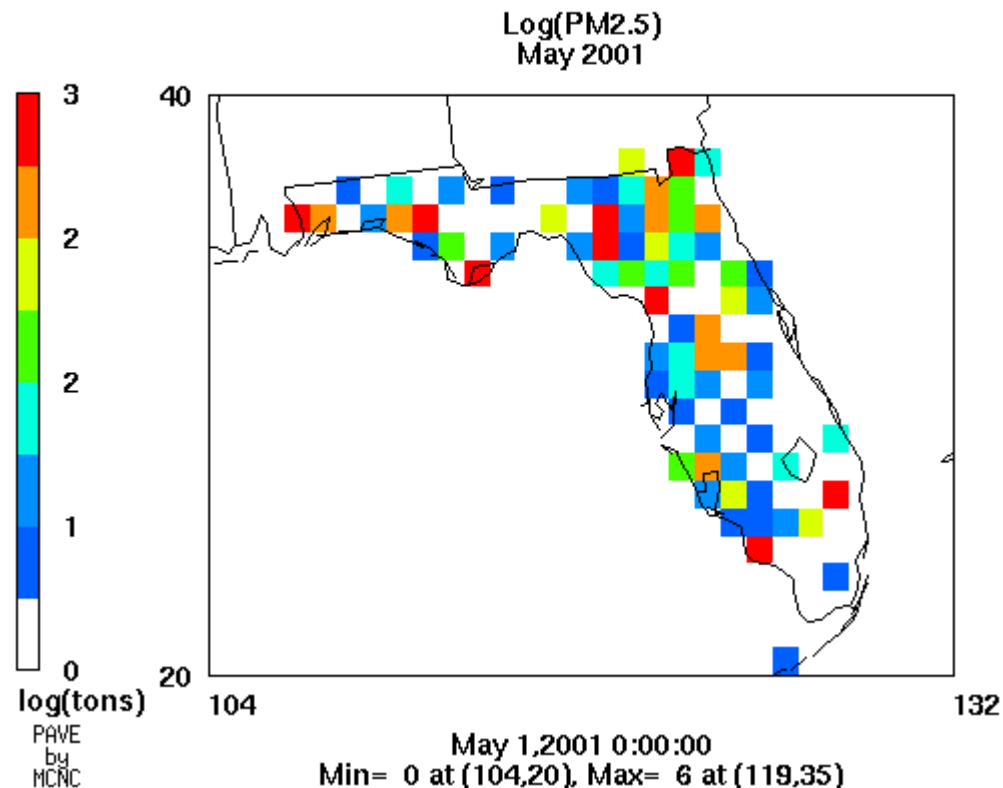
BlueSky

- Uses an old version of CONSUME/EPM for emission estimates. (early 1990s)
 - CONSUME is a fuel consumption model
 - EPM is a model that predicts the time rate of fuel consumption and emissions from wild-land biomass burns.
- Needs to be updated to FEPS (Fire Emission Production Simulator)
- From the FEPS user manual: “the CONSUME/EPM program uses an integral method of prediction rather than a dynamic simulation, so it is limited to simple fires where area growth rates do not change significantly over the burning period. Although still usable, EPM is technically deficient for long smoldering fires and for fires that burn in several different fuel types or fire growth rates and is not suitable for most freely spreading wild-land fires”.



Bluesky Emission Estimates

May 2001 Emission Estimates from Wildfires



Fire Emissions for Air Quality Forecasting

- Objective: Adapt and begin testing a “real-time” algorithm for estimating emissions from biomass burning (primarily wildland, prescribed, and agricultural fires) in the National Weather Service’s air quality forecast system to support implementation of a national PM_{2.5} air quality forecast.
- Use the SMOKE updates from the BlueSky-EM tool to create emissions for ETA/CMAQ system
- Hazard Mapping System (HMS) product is available daily in real-time from NOAA/NESDIS
- Use simple assumptions to create a real-time inventory for fires.



Assumptions for Realtime Fire Emissions

- Burn area for each “fire” set to 22.3 ha (based on analysis of EPA 2001 NEI dataset w/ total annual burn area and total number of fires). For operational forecasts, assume 16.7 ha/day (75% of total burn area).
- Heat output (used for plume rise) set to 725×10^6 BTUs/day (based on an aggregated set of BlueSky simulations).
- Diurnal profile for emissions and heat output from the WRAP.
- PM_{2.5} emission factor set to 225 kg/ha (review of existing emission factors, which exhibit a wide range [20-800 kg/ha]).
- Processed as an hourly 3D file for the ETA/CMAQ system for 14-16 August 2004 test case. (compare concentration field before and after)



Comparison of Emission Estimates BlueSky vs NEI for FL 2001

- 2001 NEI PM2.5 emission estimate for wildfires in Florida: **138,573** short tons/yr
- BlueSky PM2.5 emission estimate for wildfires in Florida: **10,667** short tons/yr
- Why such a big difference?
 - Acres Burned
 - Fuel Loading (Tons fuel consumed per acre)
 - Smoldering Augmentation Factor
 - Emission Factor (lbs of PM2.5 per ton of fuel consumed)



Wildfire Emission Calculation

- How NEI estimates emissions from wildfires (each factor is per state)

- Emissions = Acres Burned * Fuel Loading * Smoldering Augmentation Factor * Emission Factor

- Bluesky (per fire basis)

- Emissions = Acres * (Fuel Loading_{total} * fr_{flaming} Ef_{flaming} + Fuel Loading_{total} * fr_{smoldering} Ef_{smoldering})



NEI

- Activity Data poorly resolved in space and time.
- Will be much improved in 2002 inventory with specific location and time information per fire
- Review of NEI for Florida indicated an overestimate of fuel loading factor
- State-average fuel consumption for FL was changed from 19.7 to 6.6 on April 13, 2004 per followup memo from Bruce Bayle.*

*Source: EPA, 2003: "Data Needs and Availability for Wildland Fire Emission Inventories - Short-term Improvements to the Wildland Fire Component of the National Emissions Inventory."

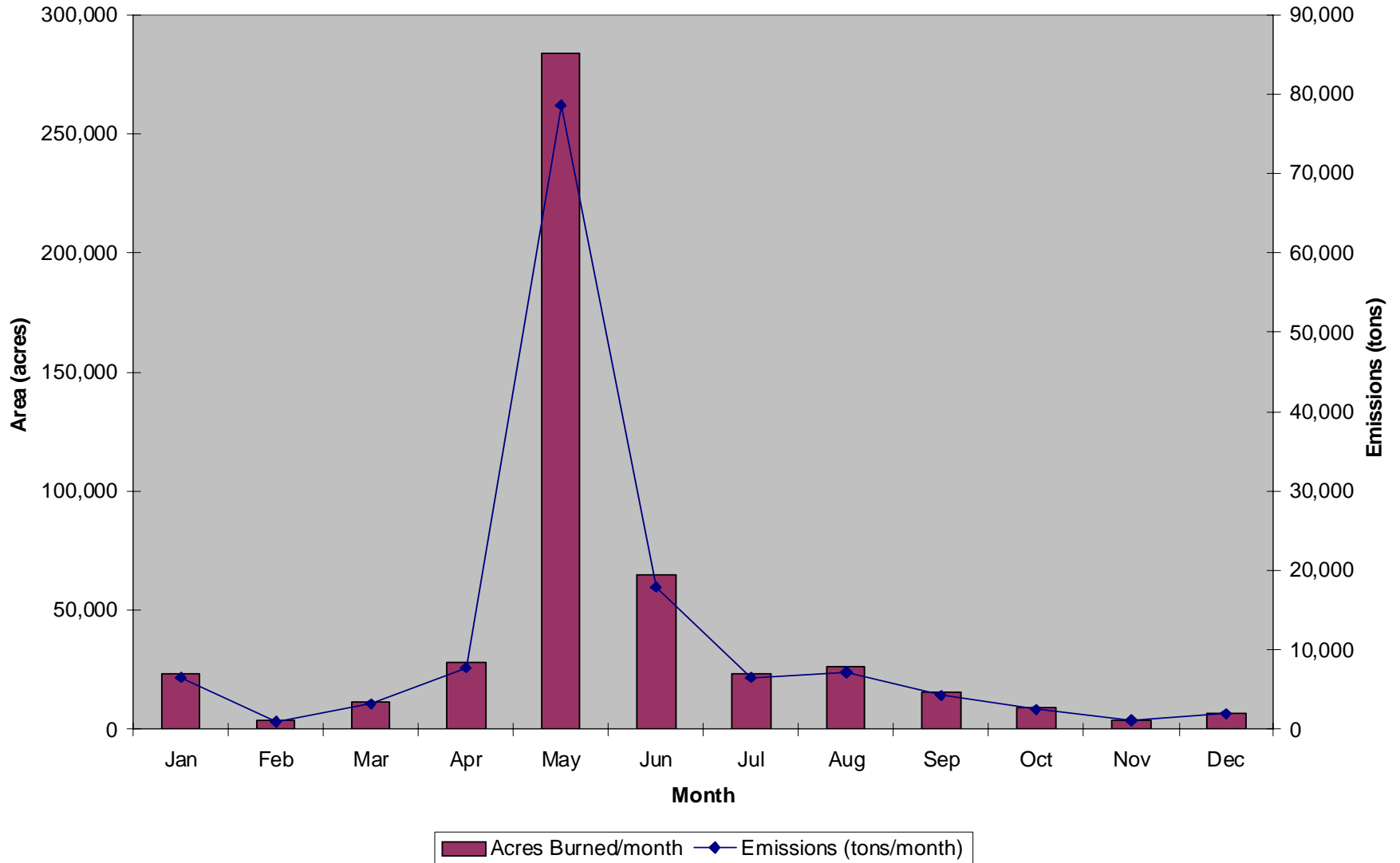


Comparison of NEI vs FL Dept of Forestry Activity Data

- NEI Acres Burned and PM2.5 Emission Estimates from NEI method
- FL Dept of Forestry Acres Burned and PM2.5 Emissions from Revised NEI fuel loadings (NEI method)



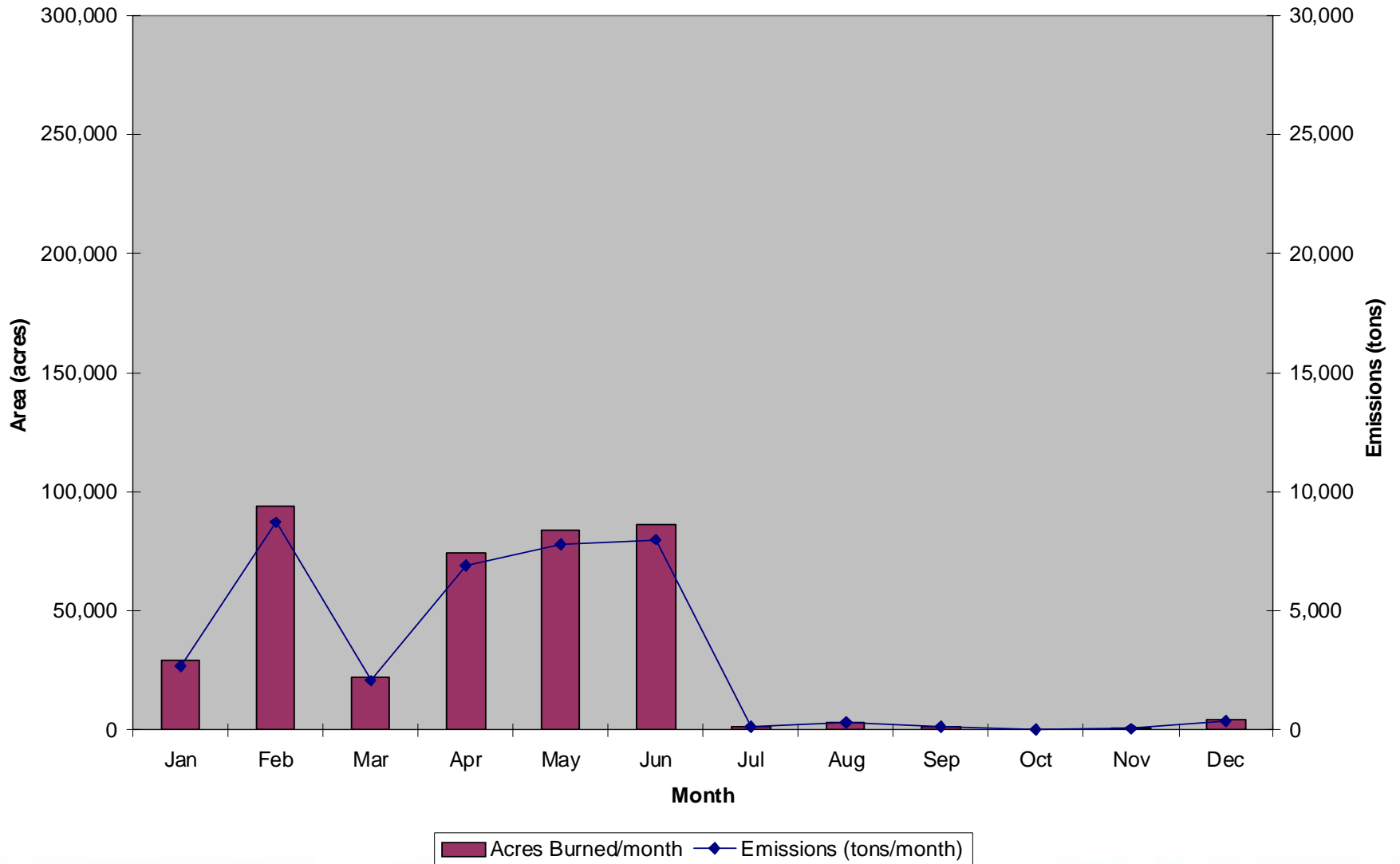
2001 NEI Florida Wildfire Emissions and Acres



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2001 NEI Florida Wildfires with FL activity and revised NEI Fuel Loadings



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Comparison of Annual Emission Estimates (using FL Dept of Forestry Activity Data)

	NEI	CONSUME/ EPM	NEI (revised)
Acres Burned	401,431	401,431	401,431
Fuel loading (tons/acre)	19.7	4.43 (average)	6.6
Smoldering augmentation factor	1.167	1.058 (average)	1.167
Emission factor (lbs PM _{2.5} /tons of fuel)	24.1	11.32 (average)	24.1
Total PM _{2.5} emissions (tons)	111,276	10, 667	37,280



Plume Rise Approaches

- Plume Rise for Wildfires added to SMOKE
 - Linkage of BlueSky & SMOKE
 - SMOKE updates
- WRAP approach



Linking BlueSky & SMOKE

- BlueSky computes Q, Plume Rise in SMOKE needs F, buoyancy flux (m^4/s^3)
- $F=Q*0.00000258$ (from Fire Emission Production Simulator or FEPS documentation)
- Q=heat flux (BTU/hr)

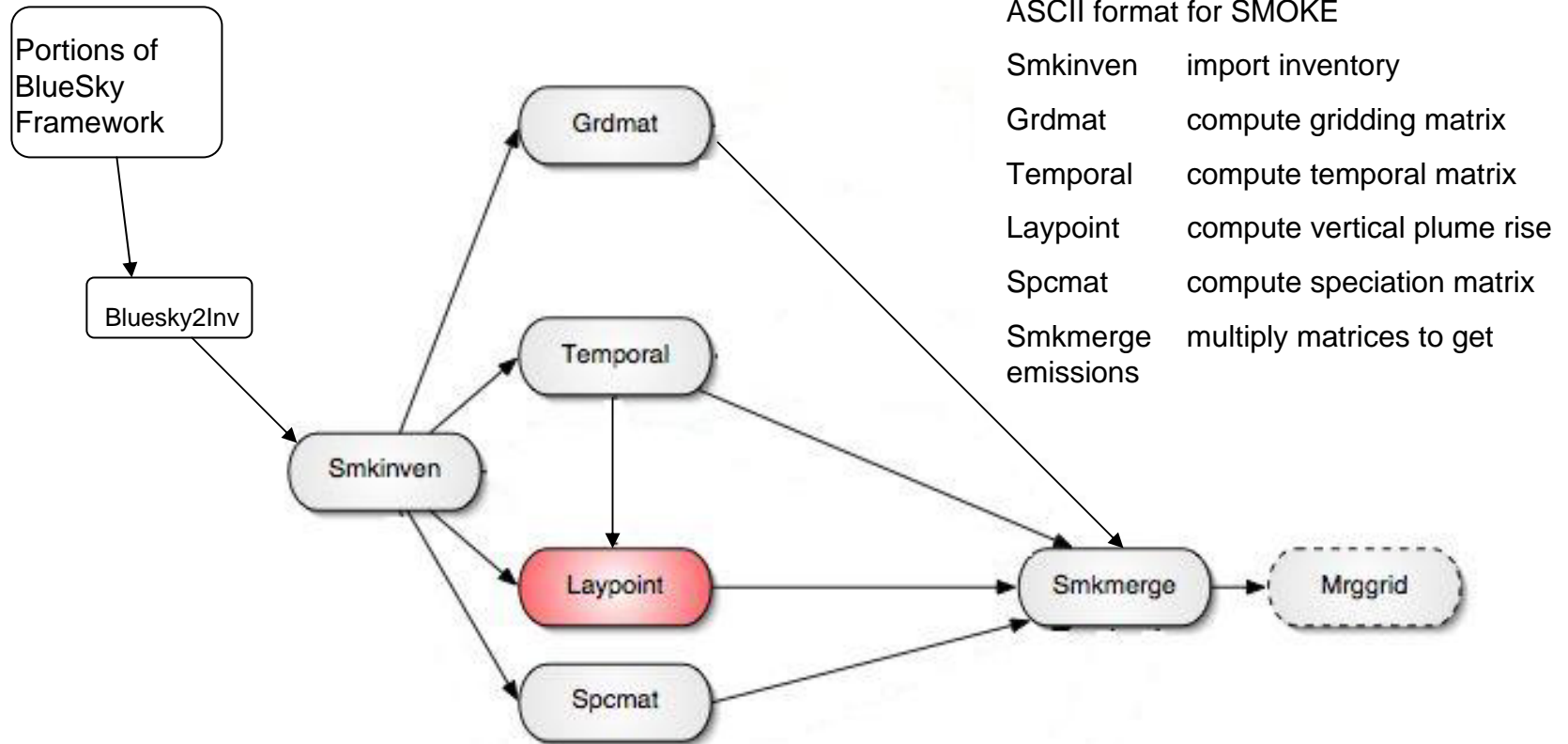


Wildland Fire Plume Rise

- Brigg's layer by layer approach (see CMAQ Science Algorithms document)
- Smoldering Fraction
- BE_{size} = Bouyant Efficiency
- $S_{fract} = 1 - BE_{size}$
- $BE_{size} = 0.0703 * \ln(\text{acres}) + 0.3$
 - derived from a “best fit” of WRAP tables



Wildland Fire Emission Processing



BLUESKY-EM



SMOKE Updates

- Create Bluesky2Inv Tool
 - Converts emission estimates into format for SMOKE (ASCII)
- Include plume rise for fires in LAYPOINT
 - Uses Briggs approach and heat release info from BlueSky
- Updated SMKINVEN for Fire Event Inventory



Preliminary Results

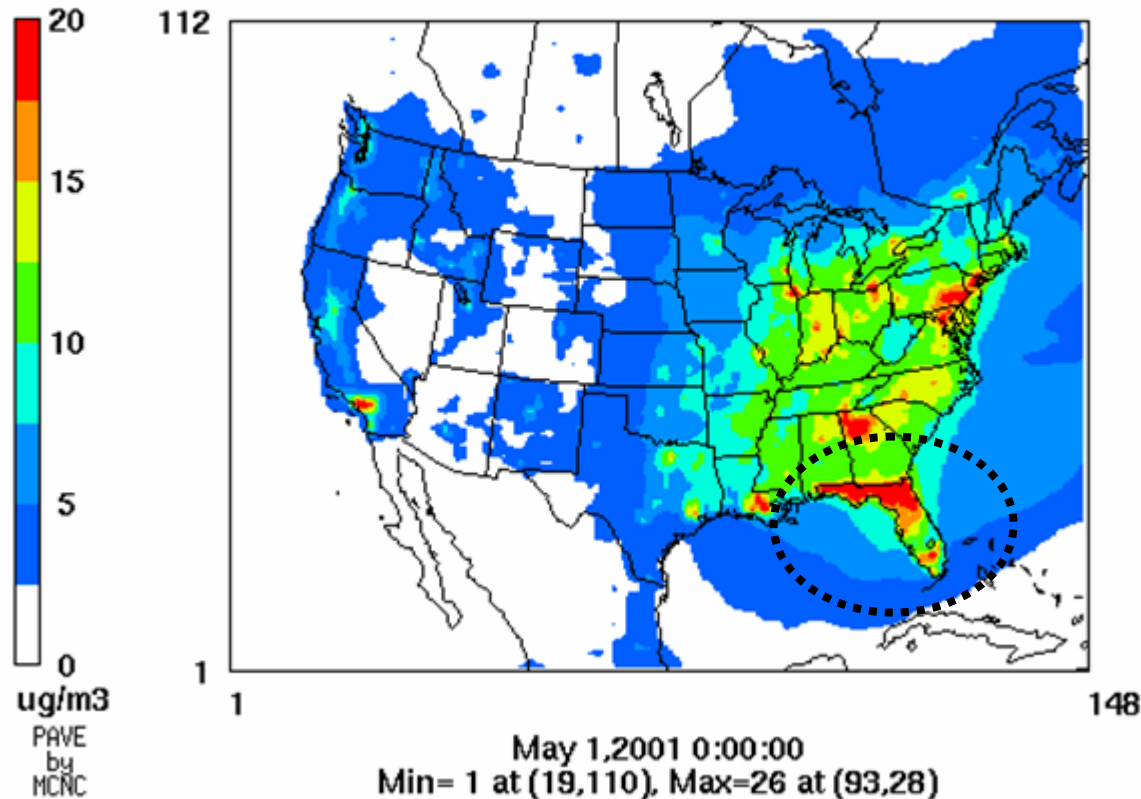
- 2001 Annual Simulation (2004 CMAQ release)
 - May 2001 for Florida
 - Mallory Swamp Fire
- Air Quality Forecasting



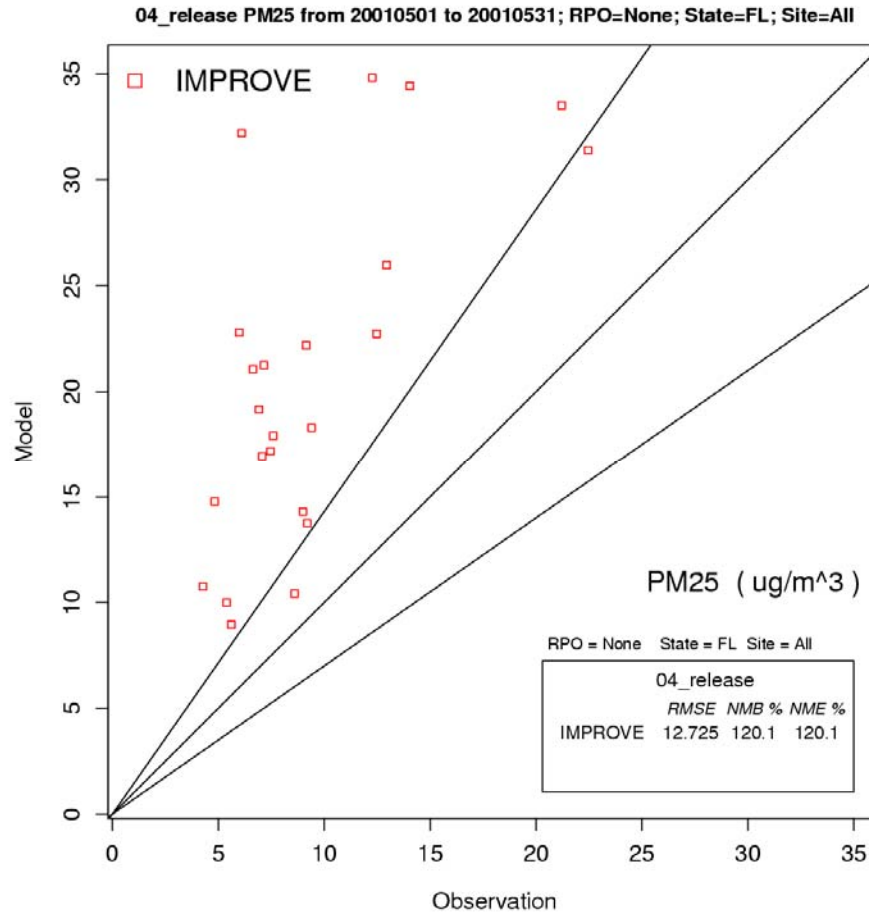
PM25 average concentration realistic in Florida?

PM25 concentration (layer1)

base NEI wildfire emissions
May 2001 monthly average



PM25 vs IMPROVE for May 2001 FL CMAQ 2004 release



Mallory Swamp Fire

- 57,200 Acres Burned Total; 34,000 acres in one day (May 25, 2001)
- Started by lightning
- Florida's Biggest Fire In 15 Years
- Clear Signature of Fire in Satellite Photos



Mallory Swamp Fire



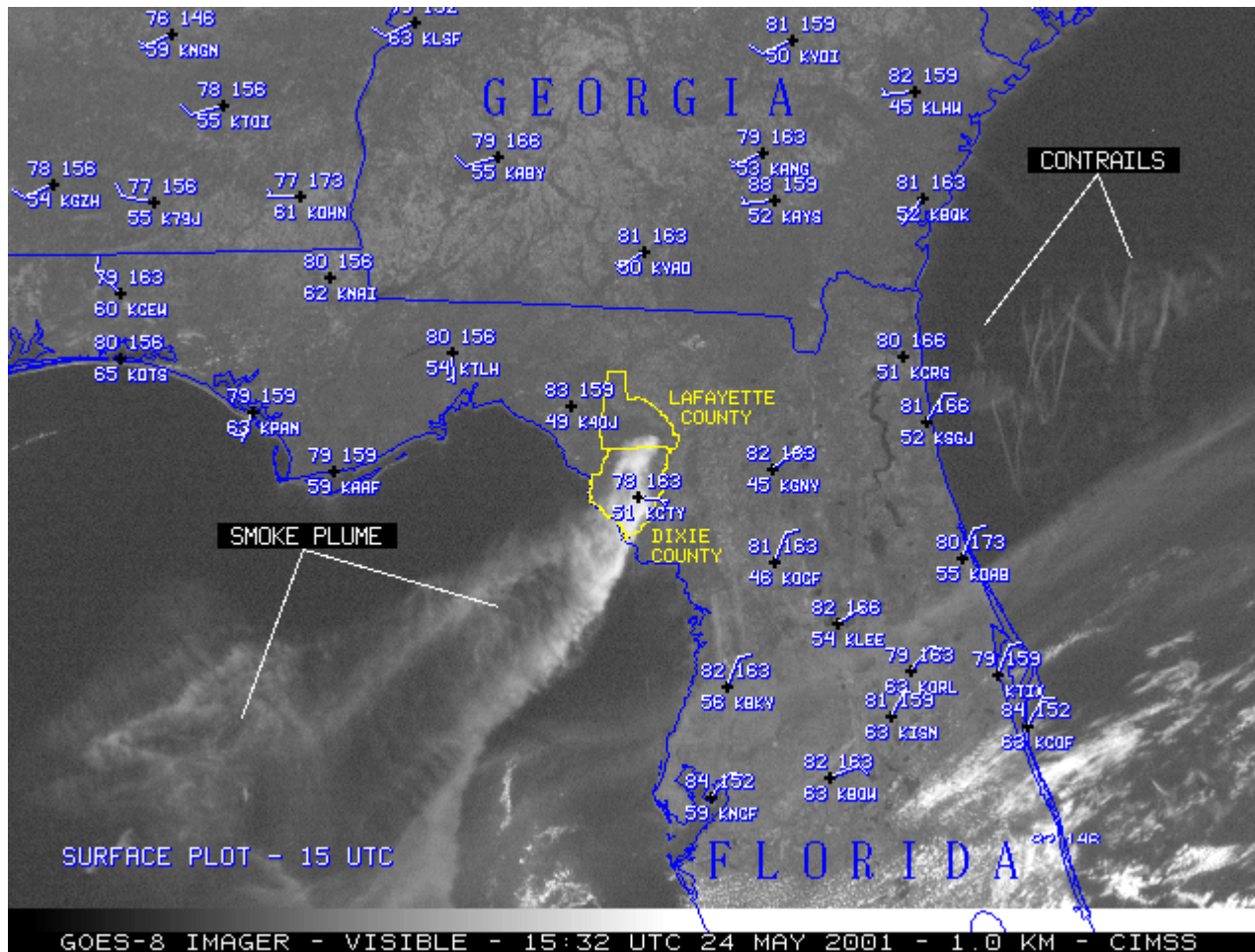
Source: http://www.dca.state.fl.us/bpr/Preparedness/Logistics/mallory_swamp_fires.htm



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May 24, 2001 GOES Satellite



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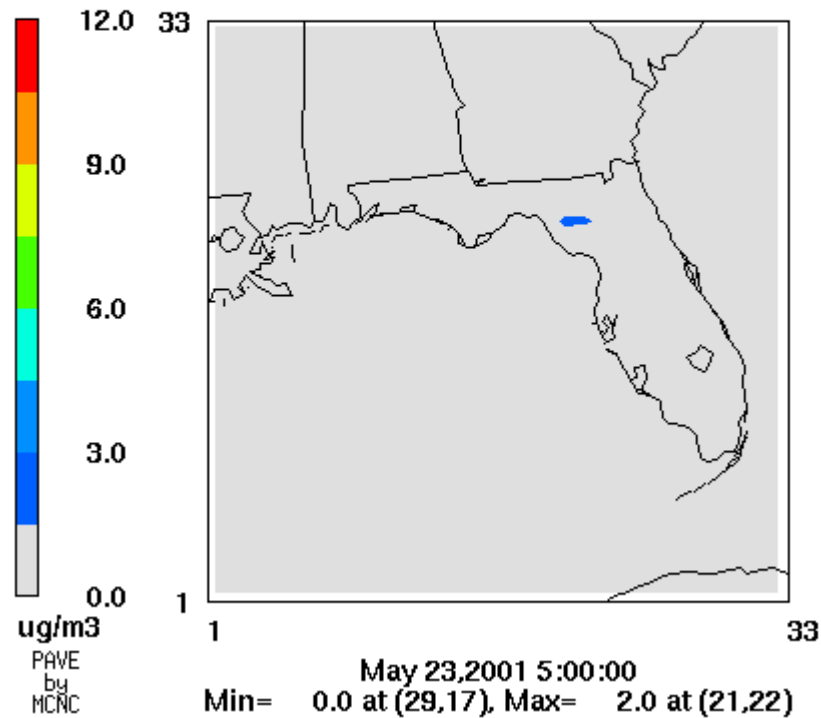
CMAQ results

- Used EPA's 2001 CMAQ Annual simulation with CB4 mechanism, MM5 met
- Simulation performed as part of Clean Air Interstate Rule (CAIR)
<http://www.epa.gov/air/interstateairquality/technical.html>
- Replaced Florida Fire Emissions in the National Emissions Inventory (NEI) with BlueSky Emission Estimates during May 2001



Primary Organic Particulate Matter

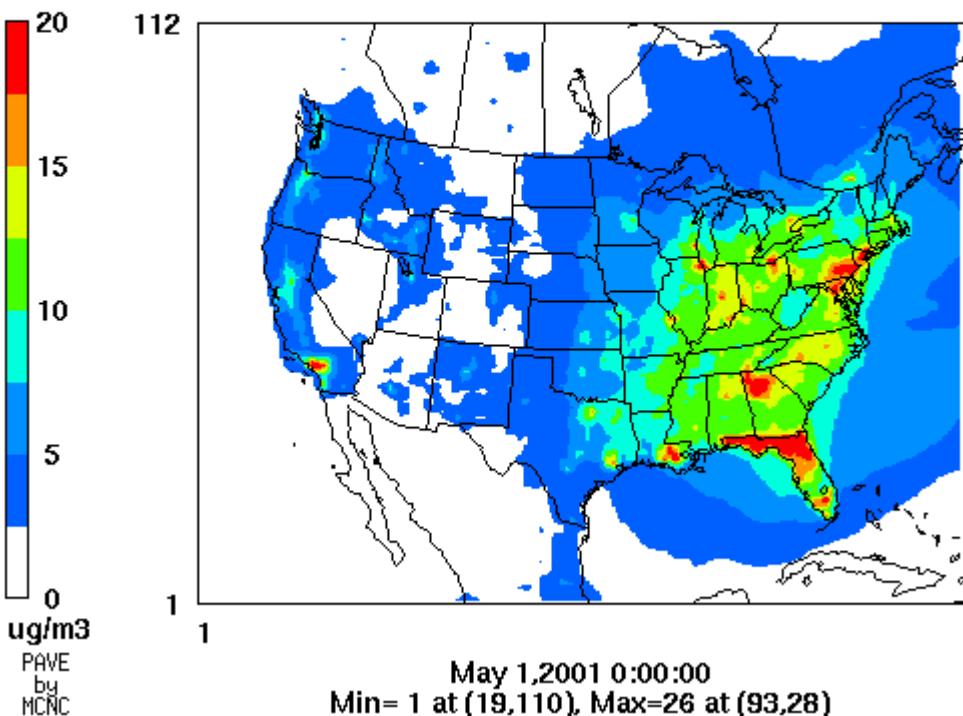
Layer 5



Monthly Average PM25 Concentration

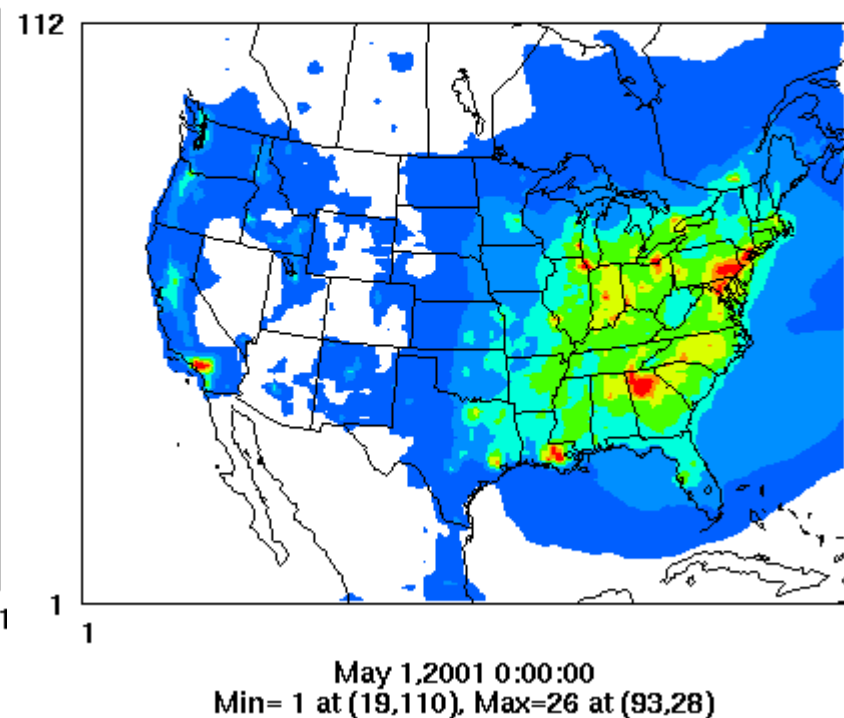
PM25 concentration (layer1)

base NEI wildfire emissions
May 2001 monthly average



PM25 concentration

with Bluesky-EM Wildfire emissions for FL
May 2001 monthly average



CMAQ Results for V4.5 evaluation

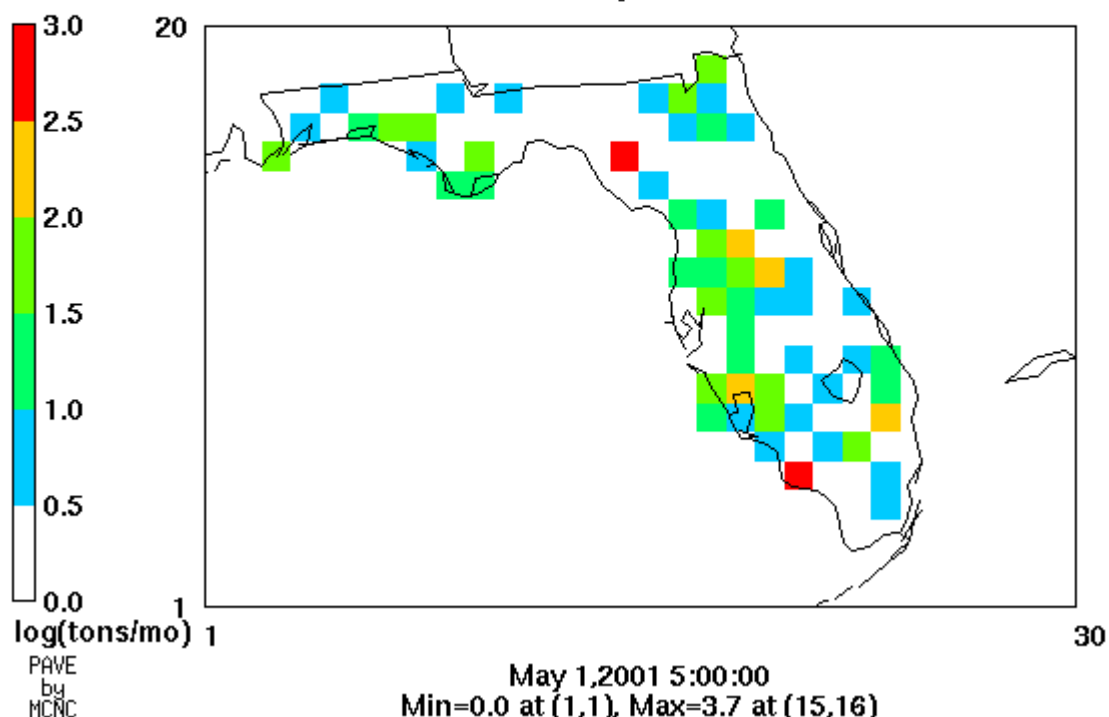
- Use the updated Fuel Loading Factor for Florida.
- Use the NEI method to calculate emissions
- Use the Activity data provided by Florida Dept of Forestry
- Use the SMOKE updates to calculate plume rise



Emission Estimate for May 2001 Florida (wildfires)

LOG of Monthly PM_{2.5} Emissions from Wildfires

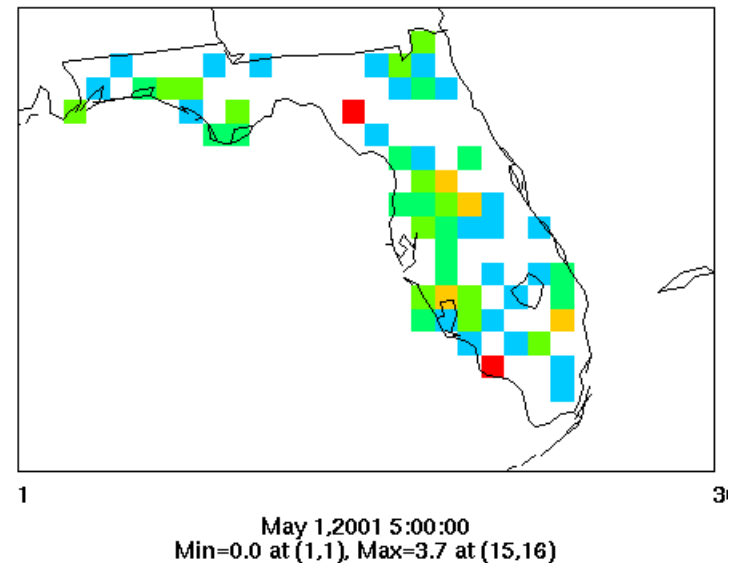
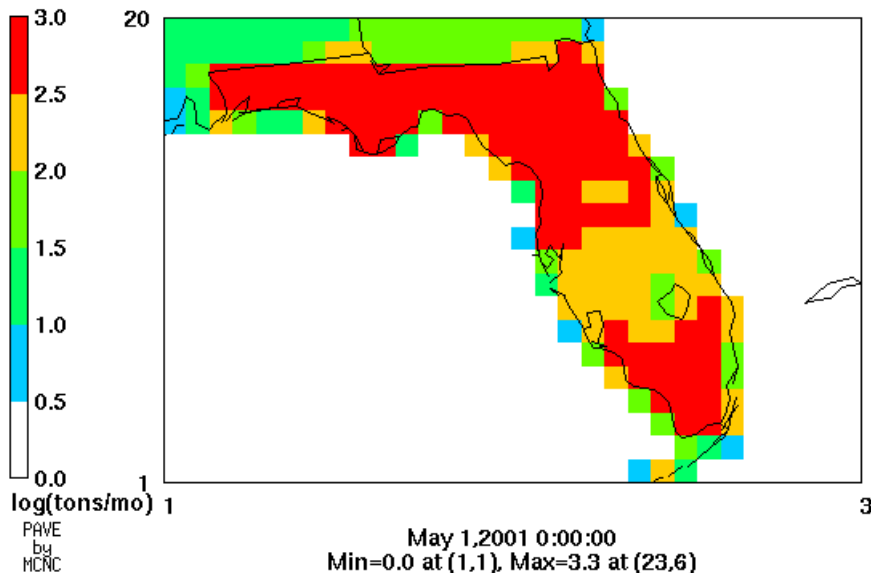
With Revised Fuel Loading and FL Dept of Forestry Activity Data
May 2001



Comparison of Monthly Emissions

NEI 2001 May 2001 Wildfire
Emissions CMAQ v4.4

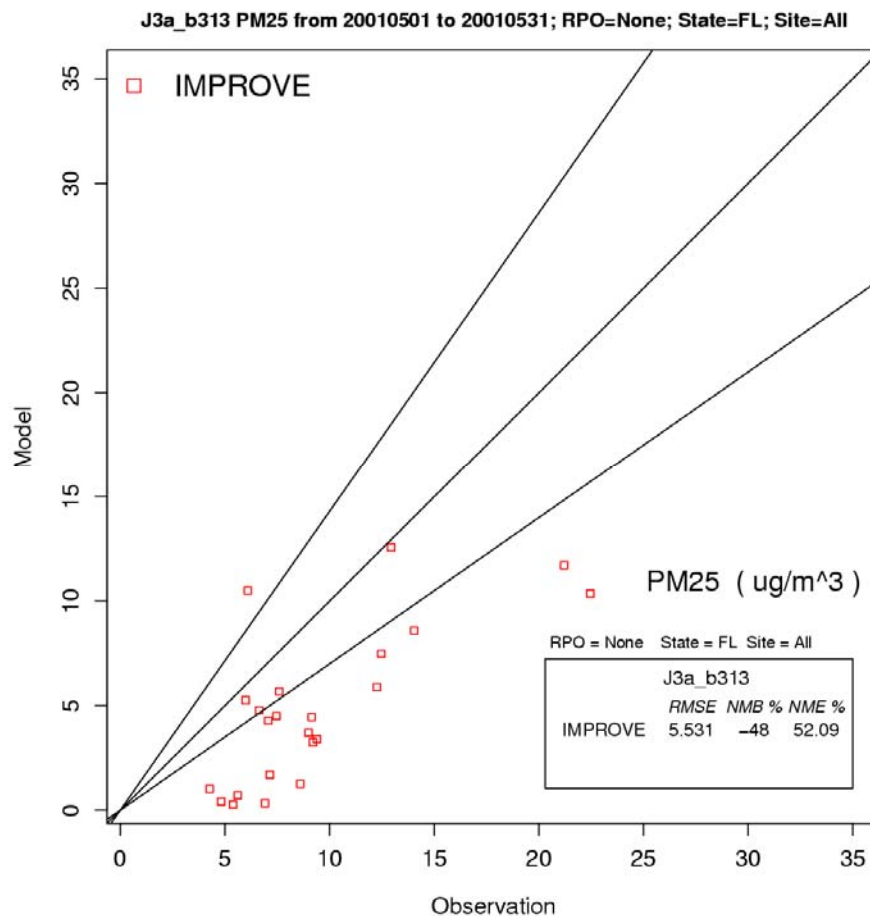
New Activity Data and Revised
Fuel Loading CMAQ v4.5



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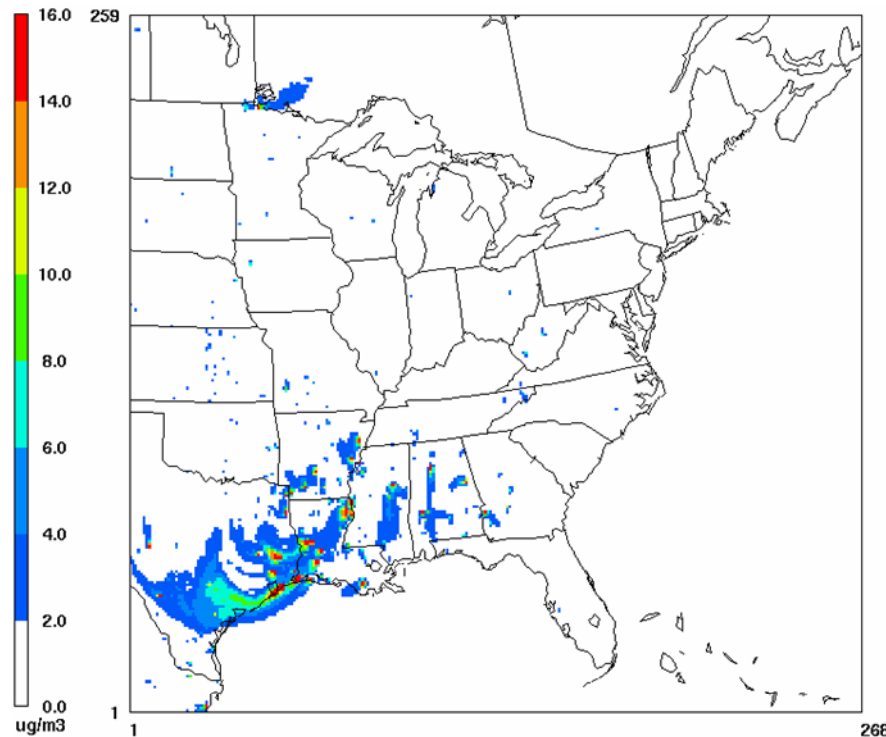
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IMPROVE vs CMAQv4.5 with Revised Fuel Loadings



CMAQ/Eta Test case for August 2004

Max Difference in surface PM_{2.5} over the 3 day period, Aug 14-16, 2004



Future Plans

- Review Bluesky when FEPS replaces CONSUME/EPM
- Use Bluesky-EM tool with the 2002 NEI inventory for Plume Rise calculations and comparison with BlueSky
- Further Testing of Air Quality Forecast System when there are significant fires in the domain (western us 04 or 05)



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Disclaimer

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