EPA
United States
Environmental Protection
Agency

Development of a Crop Residue Burning Emission Inventory for Air Quality Modeling

George Pouliot, Jessica McCarty,
Amber Soja, Alfreida Torian

20th International Emission Inventory Conference
Tampa FLAugust 14-16, 2012

Office of Research and Development
National Exposure Research Laboratory, Atmospheric Modeling and Analysis Division

Motivation and Purpose

- Historically, state-reported data for agricultural burning emissions have been spotty.
- The current SMARTFIRE system does not include emissions from agricultural emissions.
- Can the PhD work of McCarty be adapted to build a relatively inexpensive satellite-based approach that would produce spatially and temporally resolved emissions from agricultural burning?

Definitions

- MODIS: Moderate Resolution Imaging Spectroradiometer on aboard the Aqua and Terra satellites
- HMS: Hazard Mapping System is a blended operational daily NOAA product using algorithms from GOES, AVHRR, and MODIS. Quality Control is performed by an analyst.
- SMARTFIRE (v1): Satellite Mapping Automated Reanalysis Tool for Fire Incident Reconciliation version 1 (Raffuse et al., 2009)

United States Environmental Protection Agency

Input Data for estimating agricultural burning emissions

- HMS Data
- Cropland Map (fall and spring)
- Emission Factors
- Field Size (per state)

Method to compute crop residue burning emissions

- Use HMS fire detections
- For GOES detects, remove “duplicate” detections (same time, locations within 2km)
- Locate Agriculture Fires using a crop map with specific crop type maps.
- Identify crop type and determine emission factors and field size
- Calculate Emissions
- E=area burned*combustion completeness*Emission Factor*Fuel Loading

Emission Factors, Fuel Loading, Combustion Completeness

Factors derived from McCarty (2011). PM2.5 adjusted based on consistent PM2.5/PM10 ratios applied to PM10 factors. Used Mean Values from McCarty (2011)

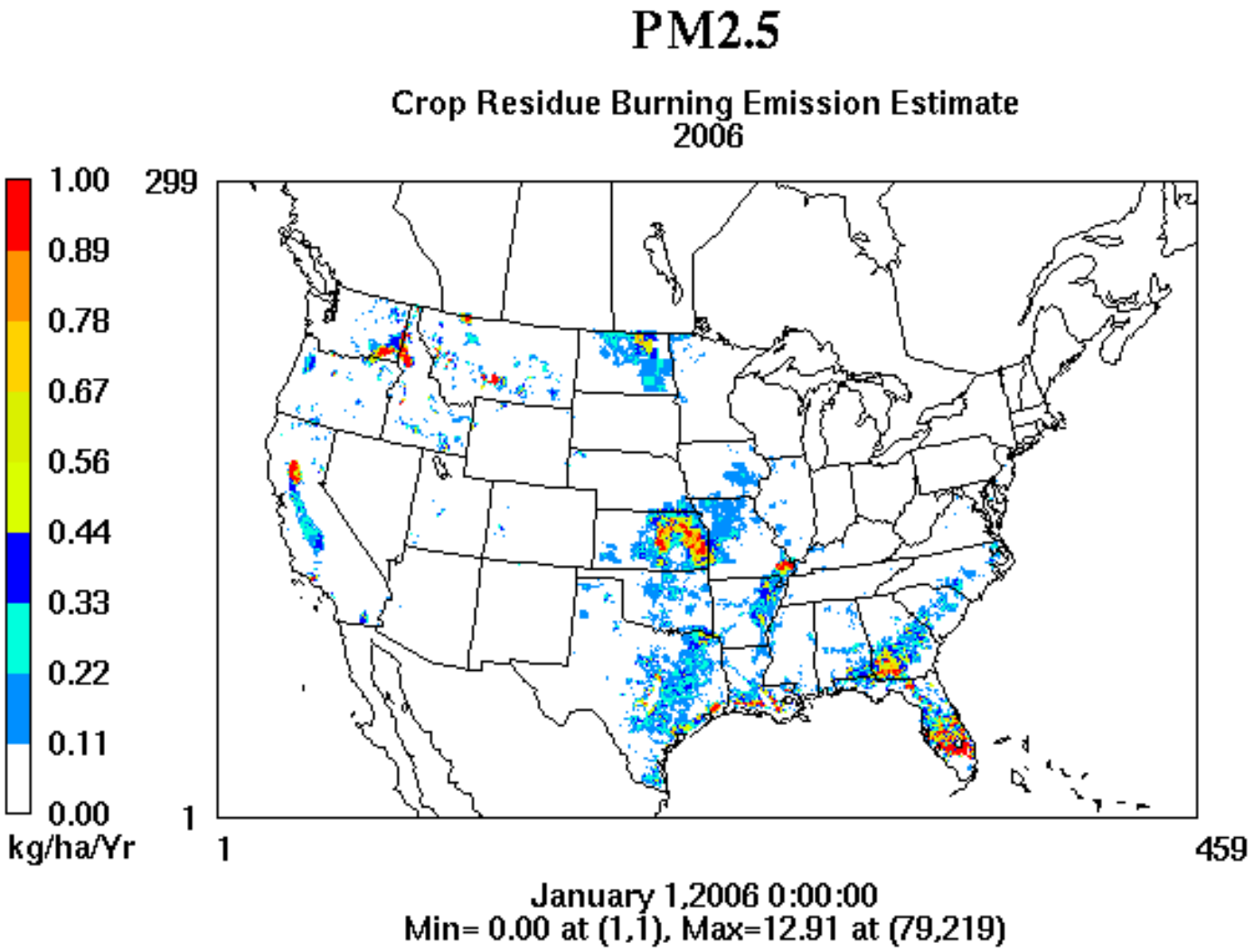
Crop Type	Fuel Loading (tons/acre)	Combustion Completeness	PM2.5 (lbs/ton)
Kentucky bluegrass	2.91	0.85	23.23
Corn	4.19	0.75	9.94
Cotton	1.70	0.65	12.38
Rice	2.99	0.75	4.72
Soybean	2.50	0.75	12.38
Sugarcane	4.46	0.65	8.69
Wheat	1.92	0.85	8.07
Other/fallow/lentils	2.95	0.75	12.31

Emission Factors (cont)

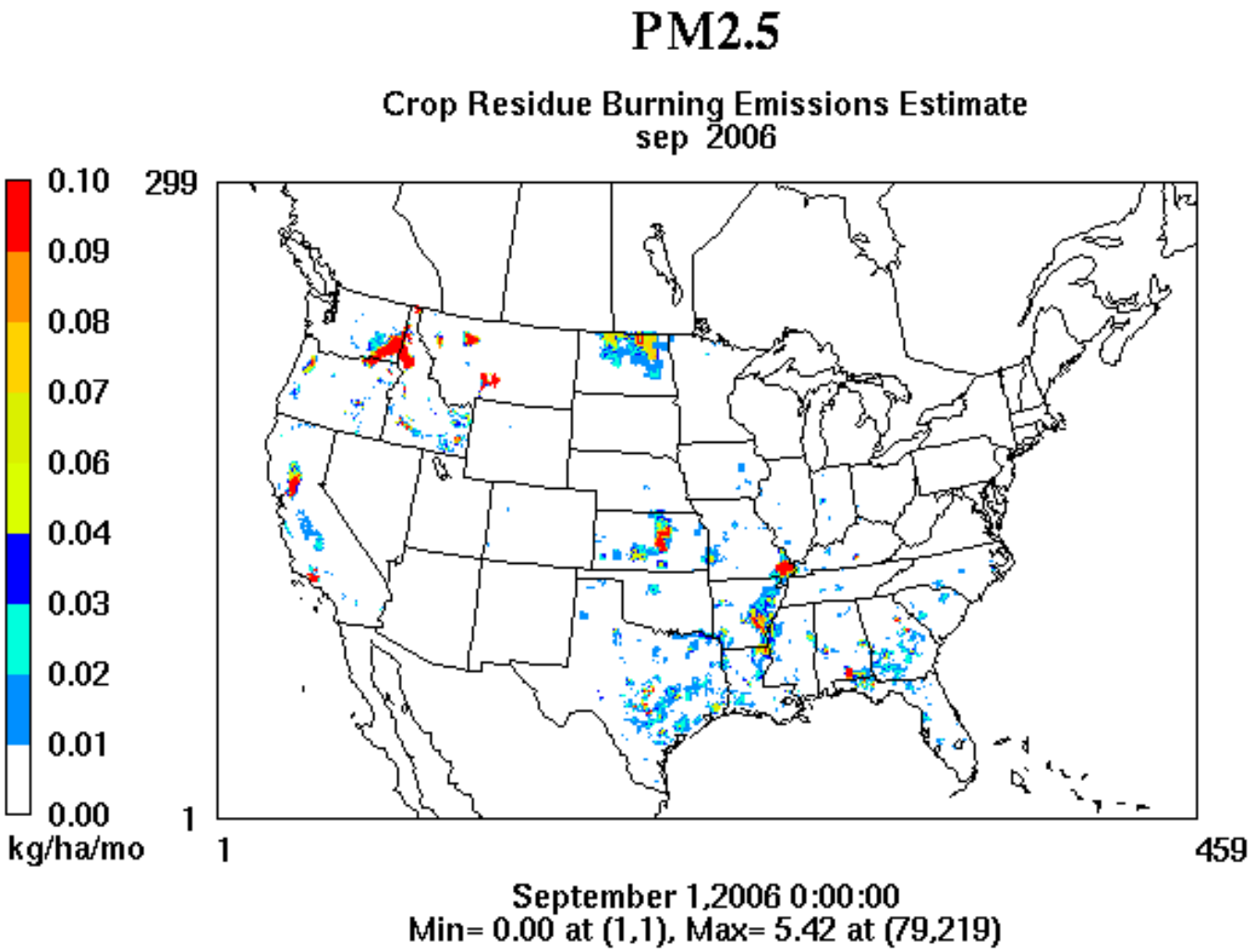
- Used AP-42 emission factor ratios to estimate VOC for specific crop types using VOC/CO ratios (lbs/ton)

Crop Type	CO	NOX	VOC	SO2	NH3	PM10
Kentucky bluegrass	182	43	9.1	0.80	13	32
Corn	106	46	19	2.4	19	22
Cotton	146	69	10	3.1	49	18
Rice	105	62	11	2.8	26	6.6
Soybean	128	63	19	3.1	45	18
Sugarcane	117	61	13	3.3	43	10
Wheat	110	48	11	0.88	34	10
Other/fallow /lentils	128	56	6.4	2.3	16	17

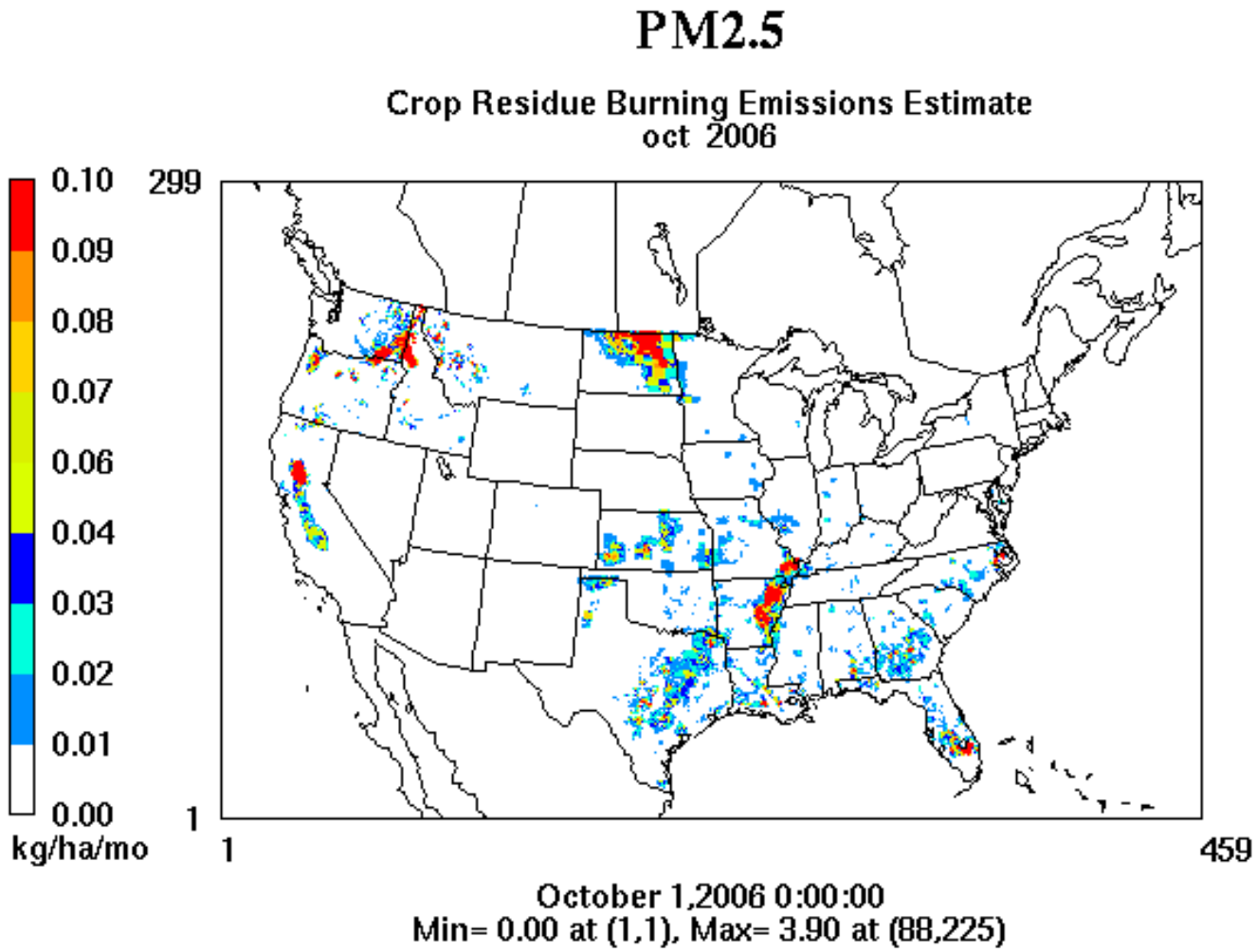
2006 emissions estimate



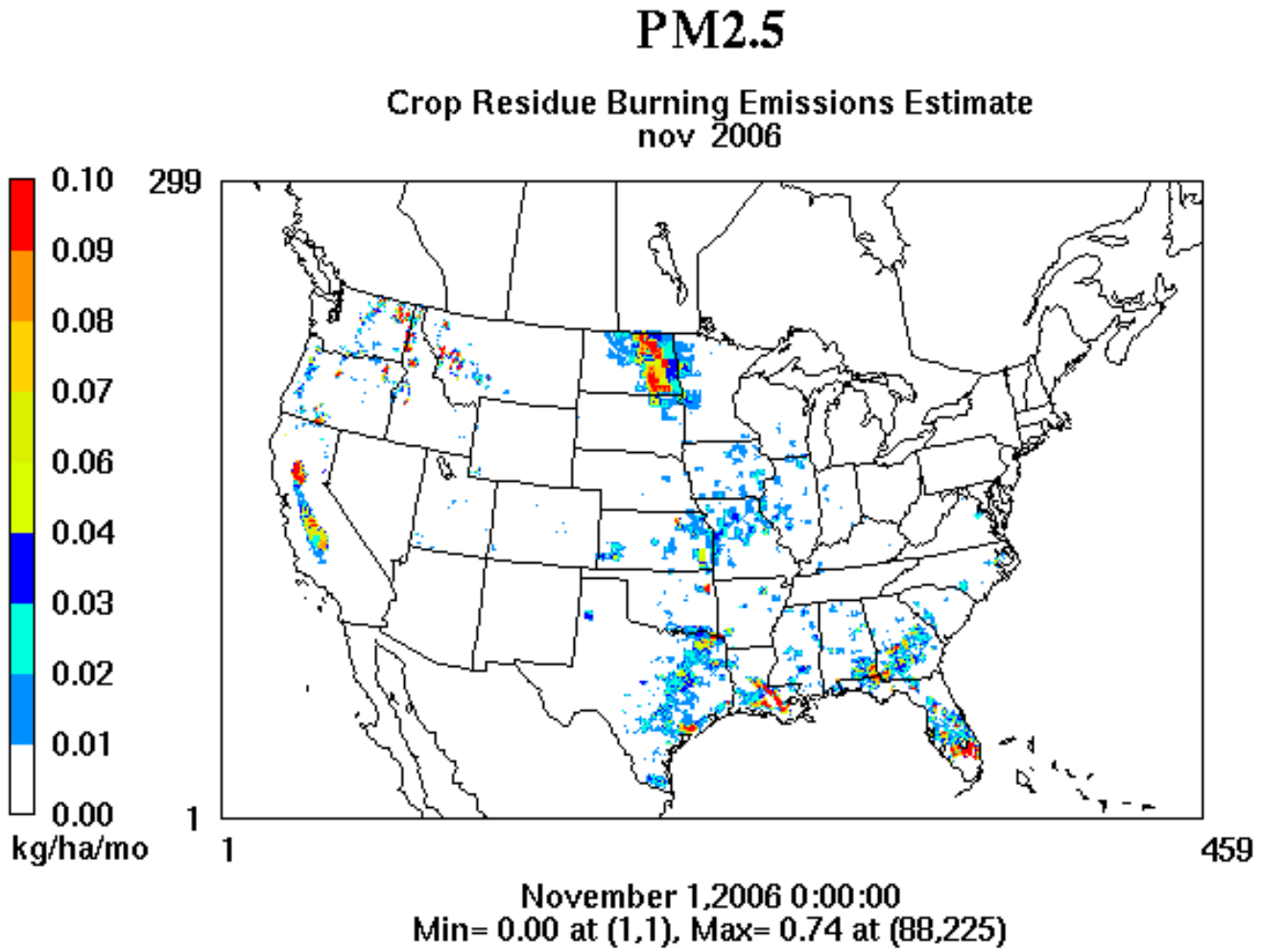
September 2006 emissions



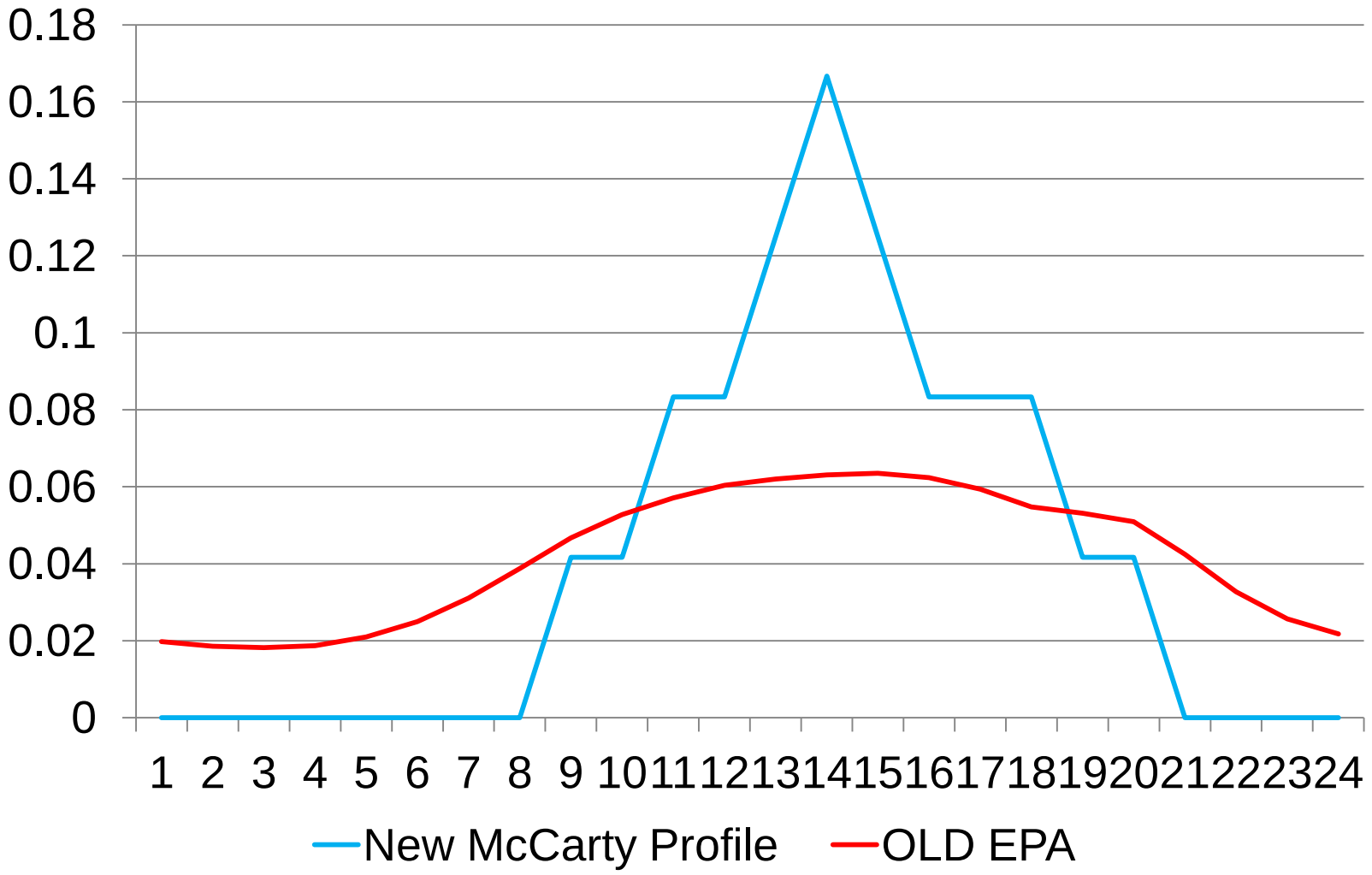
October 2006 emissions



November 2006 emissions



Updated diurnal profile



EPA United States Environmental Protection Agency

Processing Emissions

- Computed daily county-level estimates by crop type
- Applied diurnal profile
- Used current EPA Speciation for VOC and PM2.5
- Allocated county averages to model grid using spatial surrogates (agriculture mask)
- Assumed emissions in layer 1 (no plume rise)

United States Environmental Protection Agency

Model Configuration

- CMAQ 5 (Beta)
- 12-km CONUS Domain
- WRF meteorology used in CMAQ5 beta testing
- 34 vertical layers, layer 1 thickness = 40 m
- GEOS CHEM boundary conditions
- Two model runs were compared:
  - Zero crop residue emissions (NOAGB)
  - Emissions using new emission factors and new temporal profile (AGB)

EPA United States Environmental Protection Agency

Purpose of CMAQ runs

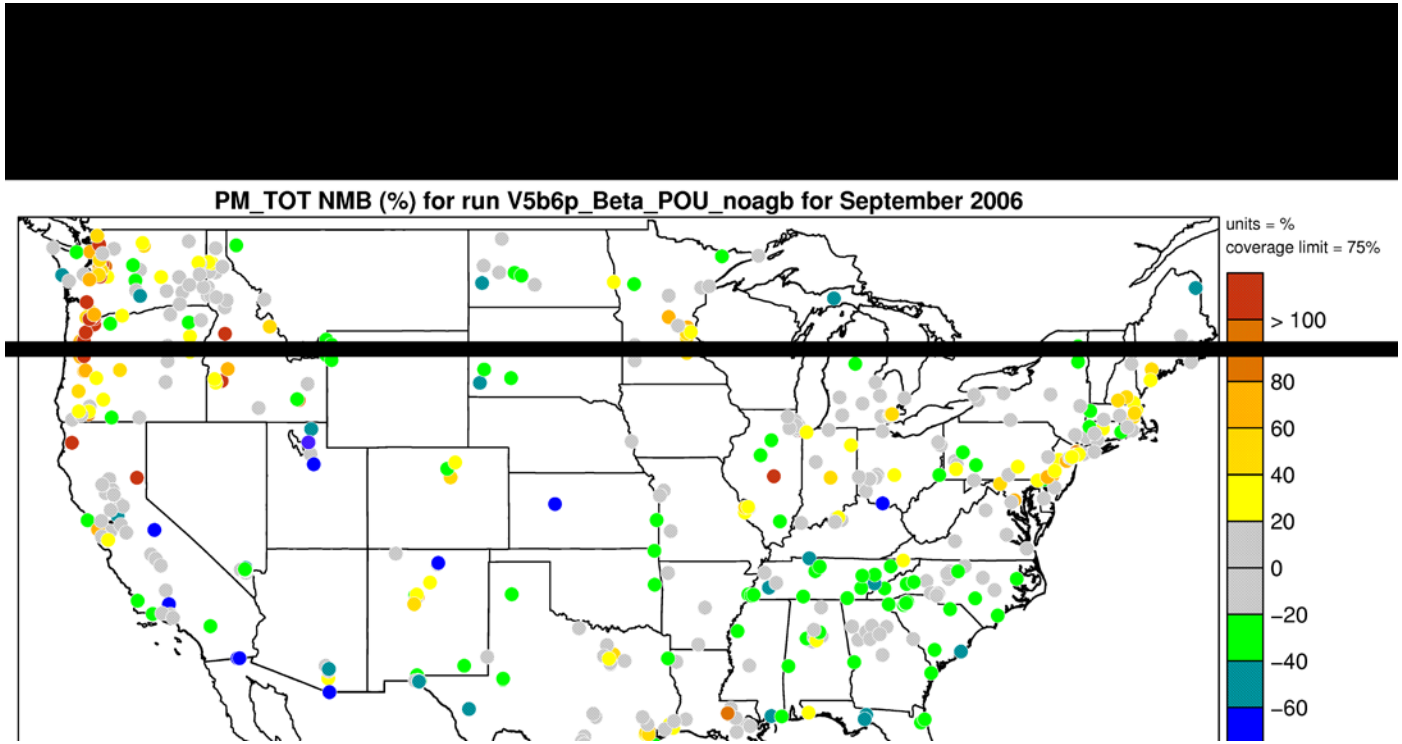
- Identify monitors where CMAQ run with ag burning (AGB) responds to emissions by comparing to run without ag (NOAGB) burning emissions
- Note: Ag burning is only a small portion of total PM2.5 emissions and does not have a large spatial extent. Most monitor/model pairs show zero or negligible differences.
- September, October and November runs complete
- Focus on total PM2.5
- Compared model runs AGB vs NOAGB

EPA United States Environmental Protection Agency

Limitations of Analysis

- Cannot determine if there are missing emissions from AGB since we are looking only at total PM2.5
- If Model is biased high without the AGB emissions, Cannot tell if this method is improving model performance
- We want to find dates & locations with large AGB emissions and model underpredicts PM2.5 without AGB and the model responds with the addition of the AGB emissions

PM2.5 Model NMB (without AGB emissions) AQS Sites for September 2006



Even without crop residue burning emissions, CMAQ has high bias for PM2.5 at certain monitors.

Method to Identify Episodes of Interest

- For the 3 month period, found the top 5 days of emissions with PM2.5
- Looked at Spatial Map of Difference in Errors between AGB and NOAGB runs
- Found specific regions where the model error was reduced with the AGB runs. Selected AQS sites with the largest changes in model error between runs

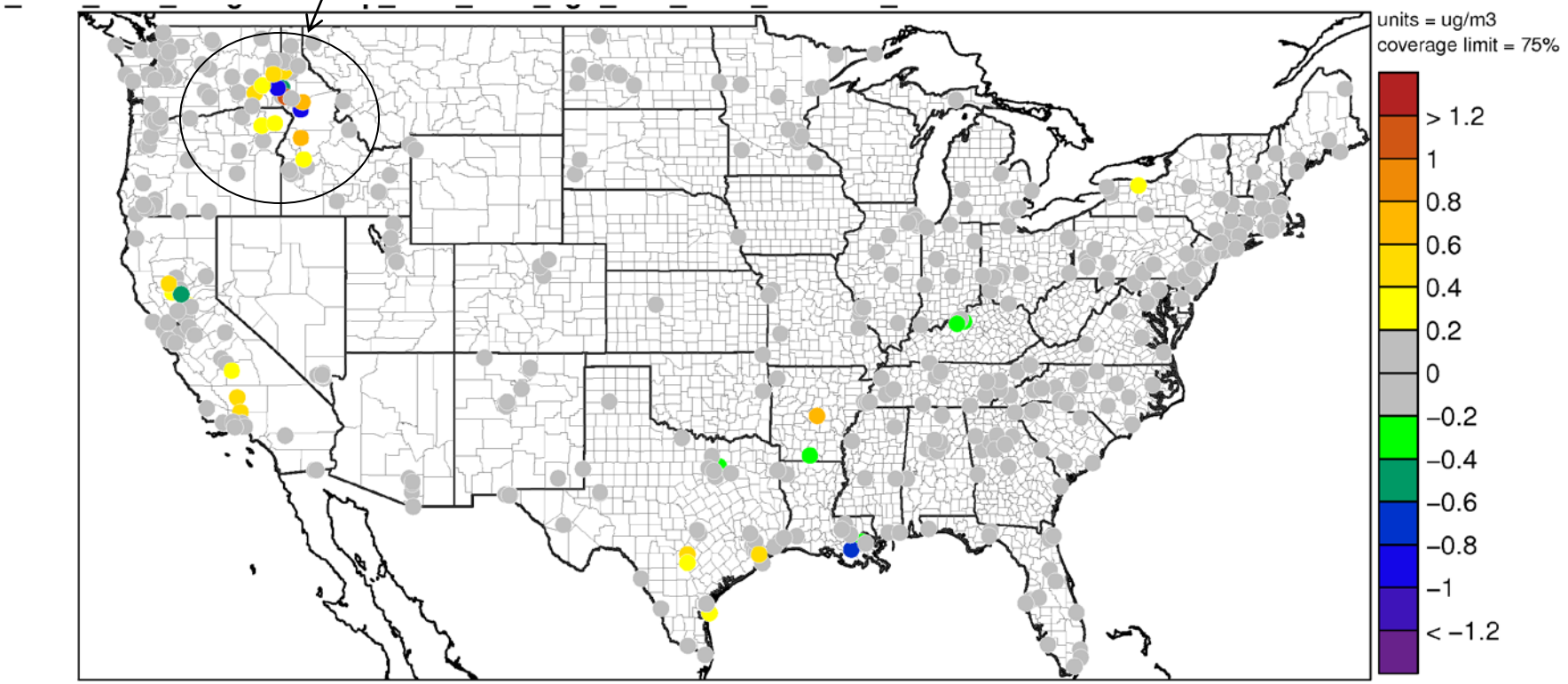
EPA United States Environmental Protection Agency

List of Episodes of Interest

- Top 5 days with Emissions (Oct-Nov)
- Nov 21, Oct 7,Nov 22, Sep 28, Oct 14
- Found that model was biased high in Nov 21 and Nov 22 so did not look at these two days.
- Focused on Oct 7, Sep 28 and Oct 14

- Sep 28, Oct 7: Pacific Northwest (ID,WA) Bluegrass
- Oct 14: Wheat burning in TN

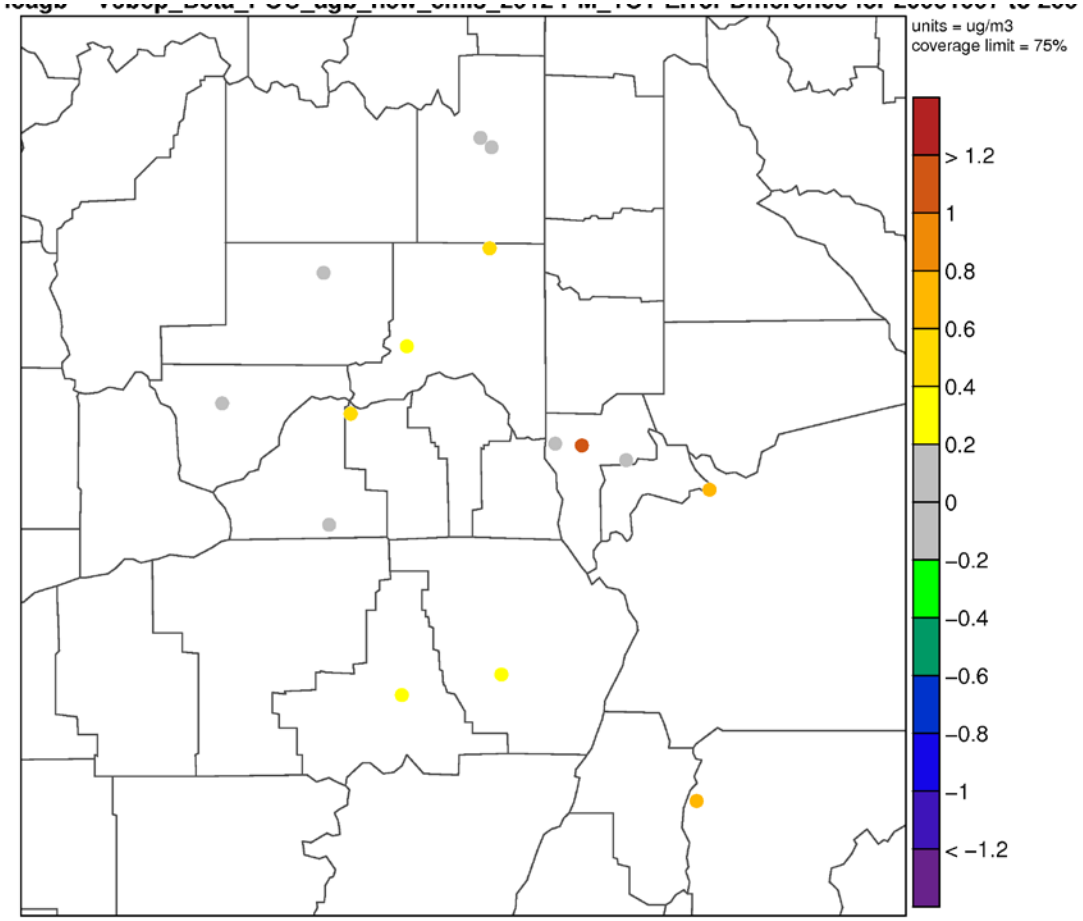
Difference in Model Errors NOAGB-AGB (Oct 7)



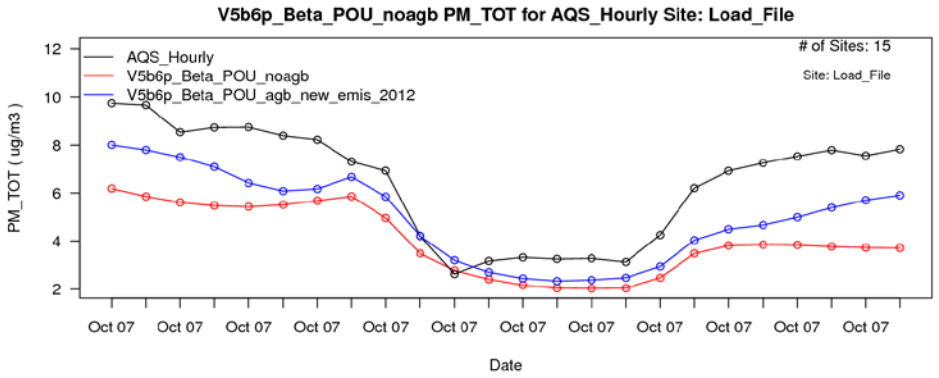
A positive difference means NOAGB error was larger than AGB run

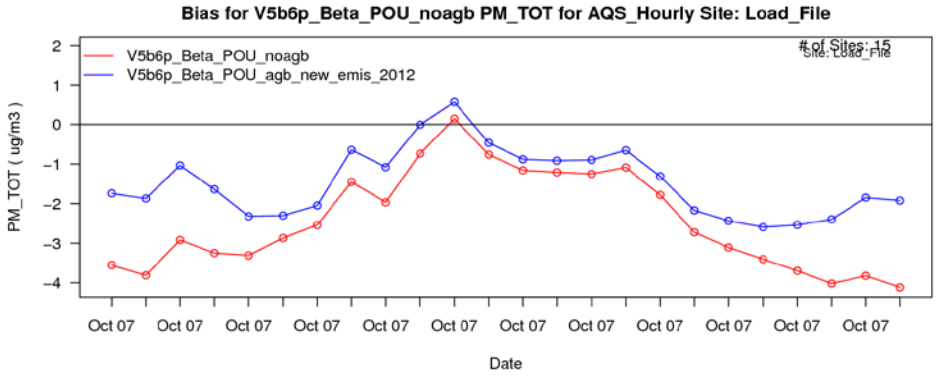
United States Environmental Protection Agency

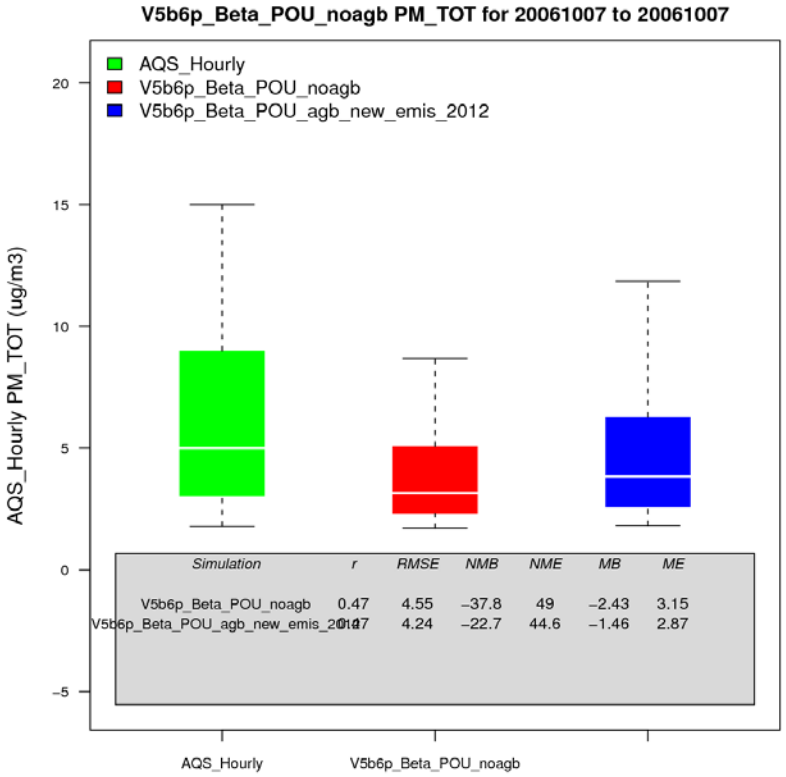
Focus on Pacific Northwest and select sites with model error reduced



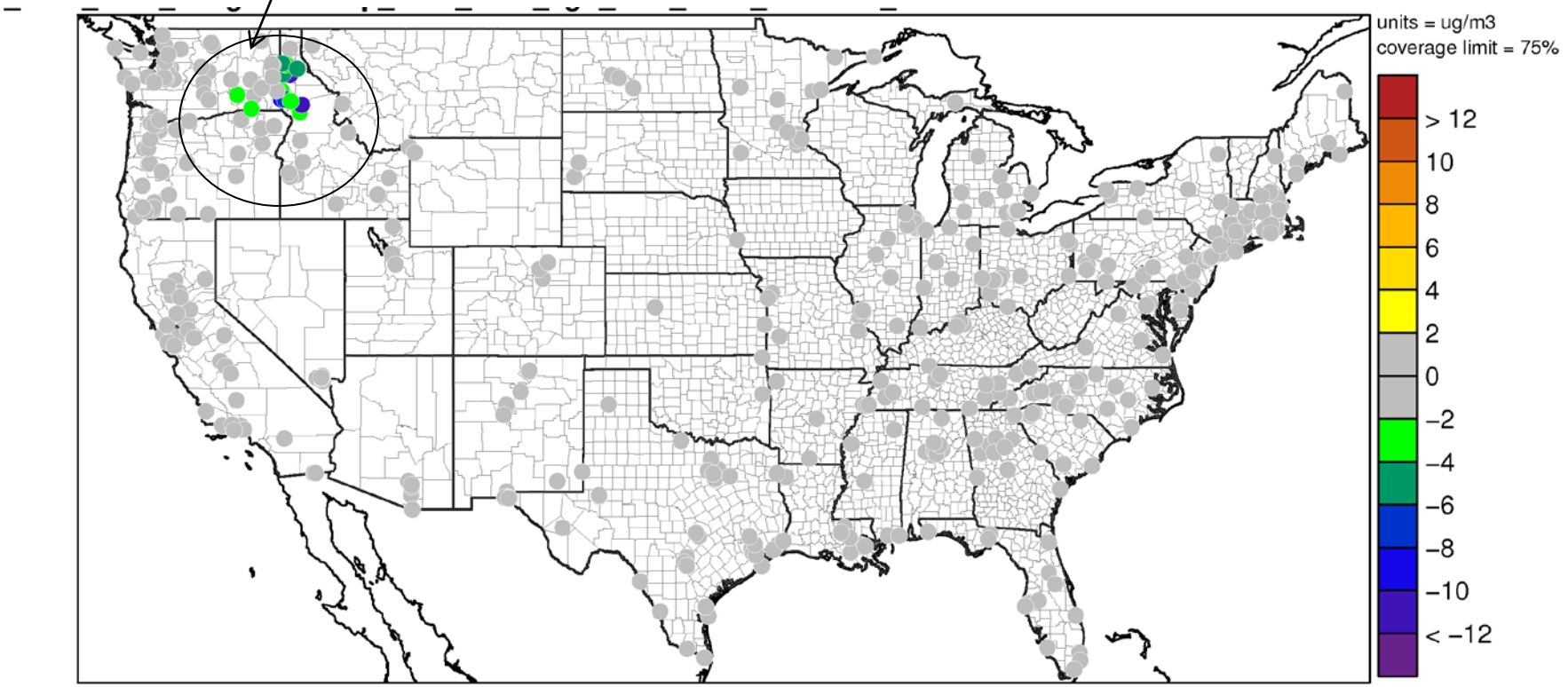
Time Series and Model Performance (Oct 7)



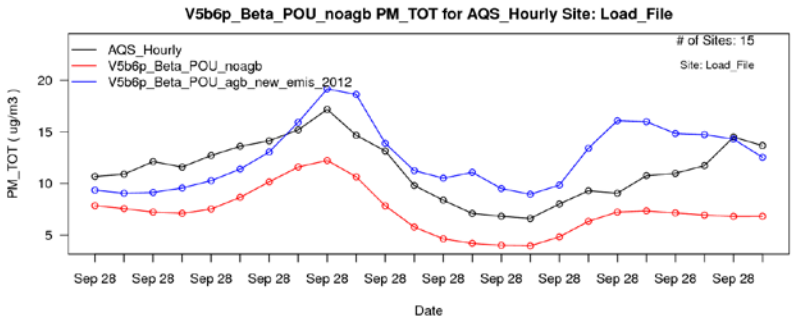


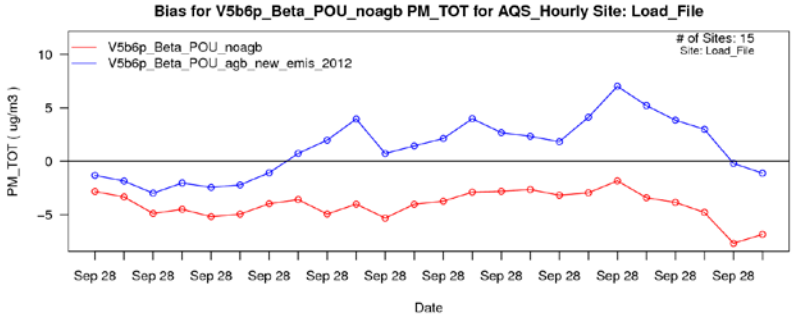


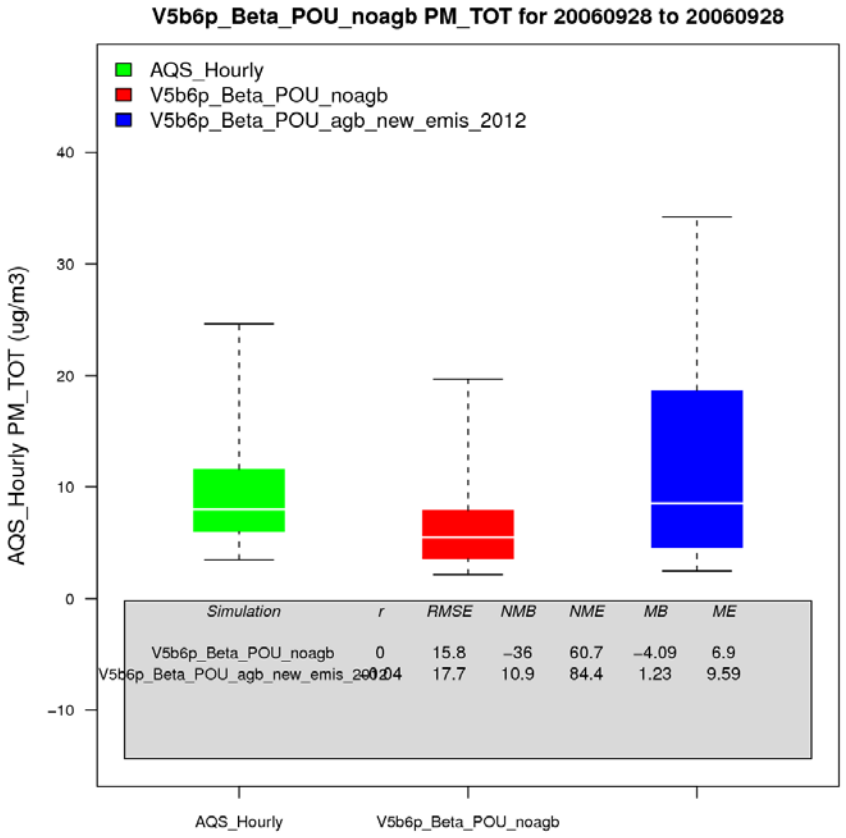
Difference in Model Errors NOAGB-AGB (Sep 28)



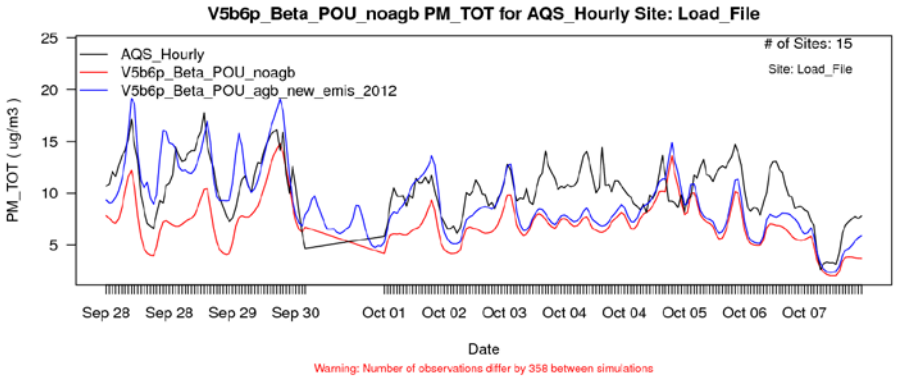
Time Series and Model Performance (Sep 28)

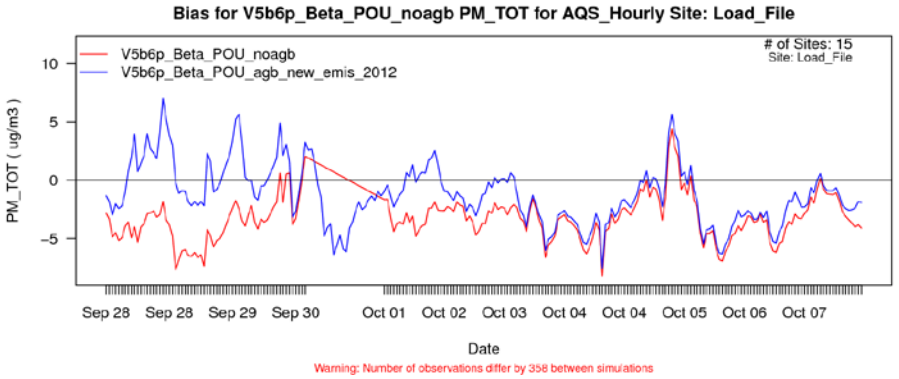


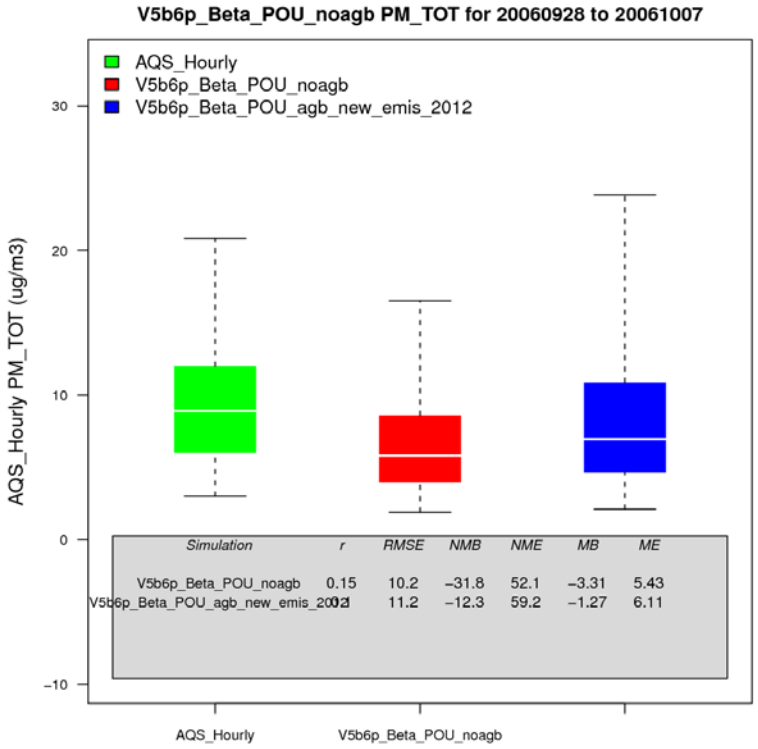




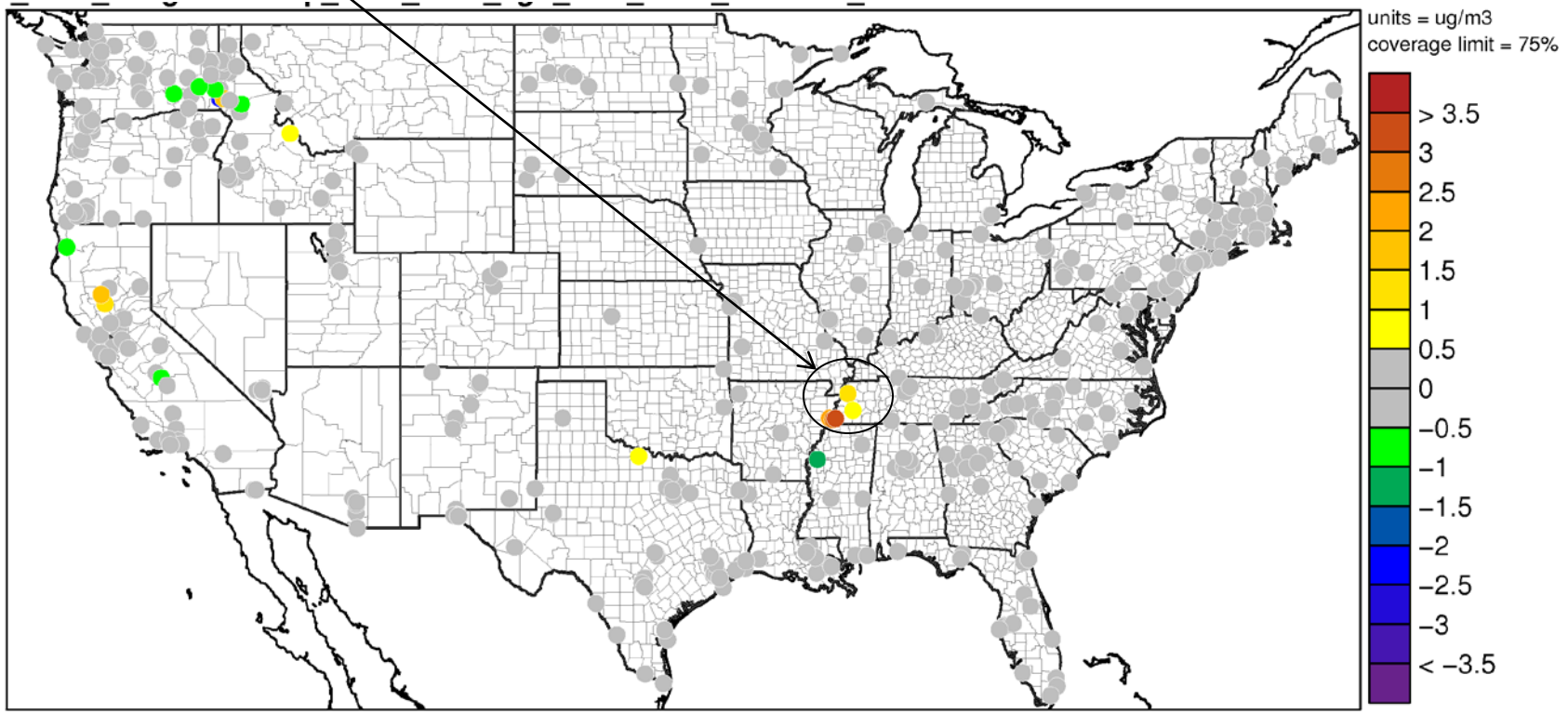
Decided to look at these 15 sites for the entire Sep 28 to Oct 7 period



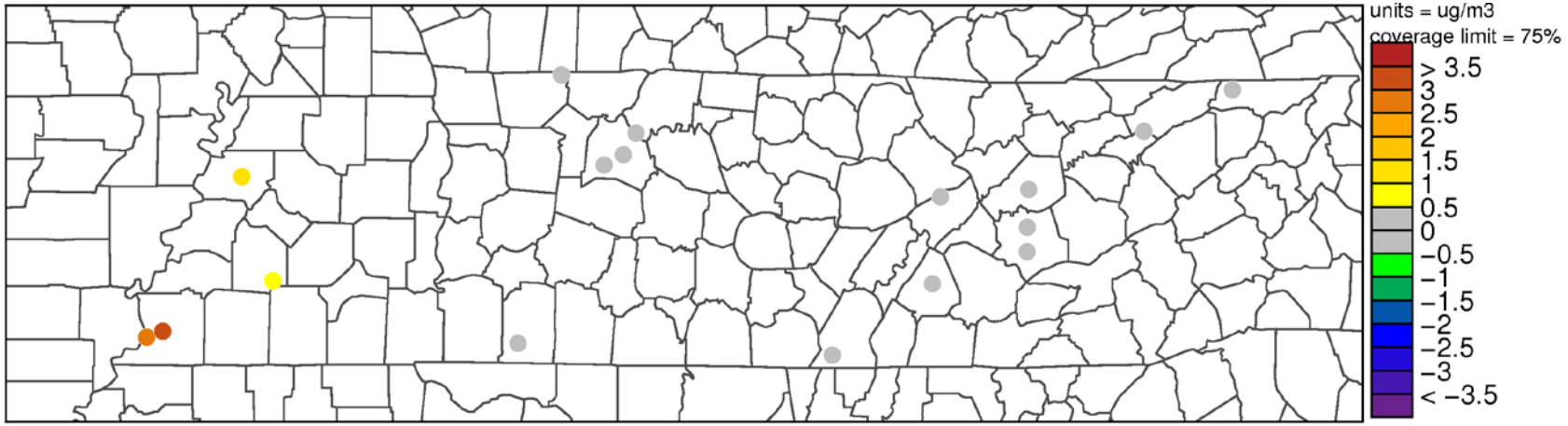




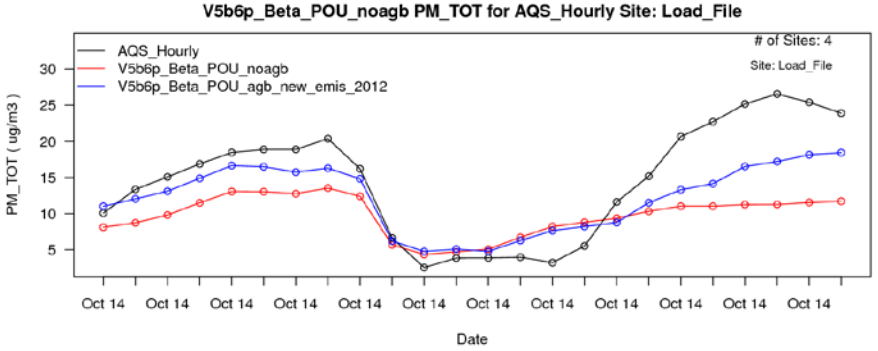
Difference in Model Errors NOAGB-AGB (Oct 14)

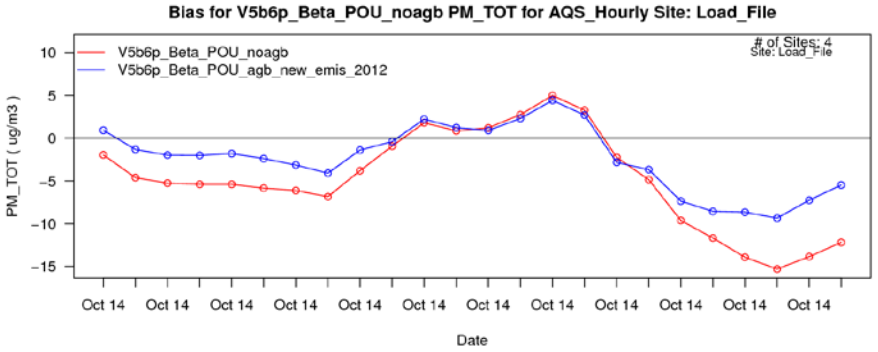


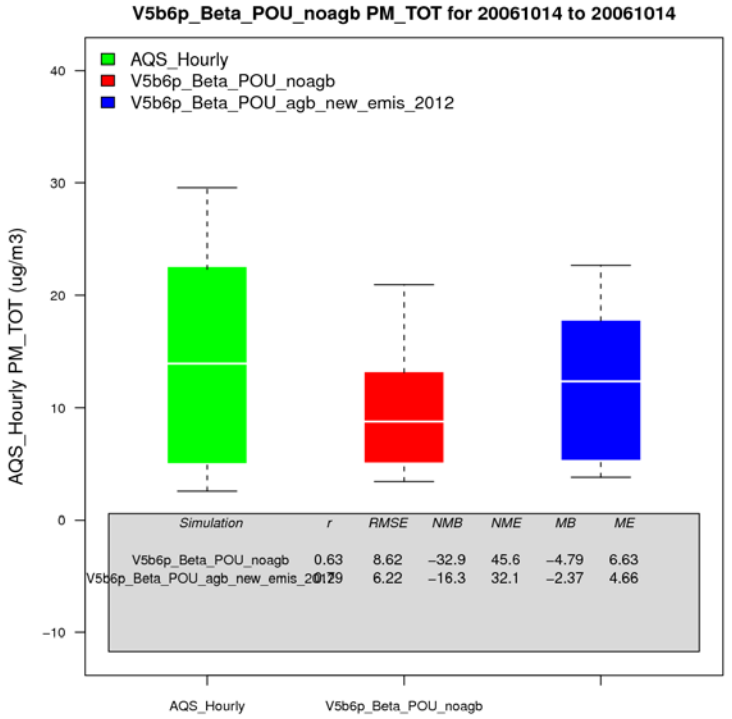
Focus on western TN and select sites with model error reduced (Oct 14)



Time Series and Model Performance (Oct 14)







Summary of Results

	#	Without AGB			With AGB emissions		
Episode	# sites	RMSE	NMB	NME	RMSE	NMB	NME
10/7/06	15	4.55	-37.8	49	4.24	-22.7	44.6
9/28/06	15	15.8	-36	60.7	17.7	10.9	84.4
9/28 to 10/7	15	10.2	-31.8	52.1	11.2	-12.3	59.2
10/14/06	4	8.62	-32.9	45.6	6.22	-16.3	32.1

For two days, Oct 7 and Oct 14 at selected sites, the AGB inventory reduced the NMB on 15-17%. For 9/28 to 10/7 NMB was reduced by 20%

EPA United States Environmental Protection Agency

Some thoughts….

- Pacific NW episode – Sep 28 – Oct 7, 2006
- Model captures some aspects of episode perhaps need to improve meteorology (i.e. wind flow fields)

- Tennessee episode -- Oct 14, 2006
  - Emissions seem to be well represented for crop residue burning (wheat)

EPA
United States
Environmental Protection
Agency

Summary of results (based on analysis of Sept-Nov 2006)

- Crop residue burning is small part of PM2.5 inventory
- Emissions appear to produce only a small signal in PM2.5 concentrations for most places/times
- A few notable episodes that can assist in analyzing impact of crop residue emissions in AQ modeling
- Analysis of emission inventory limited when model is biased high without AGB emissions. Many locations however are biased low, so we can see model improvement with AGB emissions

EPA
United States
Environmental Protection
Agency

Further Work

- Continue to review emission factors and estimates
- Review VOC speciation
- Produce and examine inventories for other years (2003,2004,2005,2008, 2009,2010,**2011**)
- Include estimates into the 2011 NEI

EPA
United States
Environmental Protection
Agency

Acknowledgements

- AMAD: S. Roselle, W. Appel
- CSC: R. Cleary, C. Chang