2007/2008 Emissions Modeling Platform Components and New Tools

Rich Mason, Alison Eyth, Alexis Zubrow
U.S. EPA OAQPS
mason.rich@epa.gov

Zac Adelman
Institute for the Environment, UNC-CH

20th International Emissions Inventory Conference, Tampa FL

August 14, 2012

EPA United States Environmental Protection Agency

Emissions Modeling Platform

- "Platform" means the data and processing methods used to produce emissions inputs for AQ models
- EPA has worked to improve both data and methods for its version 5 (v5) emissions modeling platform
- The 2008 NEI v2 is the basis of the v5 platform
  - Version 2 includes improved HAPs, lat-lon locations, control device information, and other updates such as RWC, railyards, MOVES, o&g
- Both 2007 and 2008 versions of the platform are needed
  - The choice of year is based on the purpose of the study and the ambient air quality concentrations for the issue of interest
  - 2008 NEI stationary nonEGUs + nonpoint are used for both years for most source categories

2008 NEI v2

- Provides most of the emissions used in the platform
  - Earlier versions of the NEI were vetted through emissions and AQ modeling
  - Emissions are less than 2005 NEI for most pollutants
  - New web interface provides data access and summaries
- 2008 NEI first to use the Emission Inventory System (EIS)
  - supports merging data from various sources (e.g. state, local, EPA)
  - improves transfer of data between inventories and emissions modelers
  - provides greater transparency of data sources
  - has an underlying relational database
  - includes a sophisticated reporting system
  - exports inventories into new SMOKE inventory format "FF10"

Upcoming Applications of 2007/2008 Platforms

- PM NAAQS Final: now
  - Updated 2020 Base Case w/ National Rules
  - include all current rules (CSAPR, MATS, Boiler MACT reconsideration, RICE, ULSD, RFS2/LDGHG Phase 1, HDGHG)
- Tier 3 and Anti-backsliding Final Rule: early FY2013
- NAPA 2008: late 2012
  - Direct full HAP/CAP use of most elements of 2008v2 NEI
- CDC2009: early FY2013
- Ozone NAAQS REA: FY2013
- CMAQv5.0 evaluation

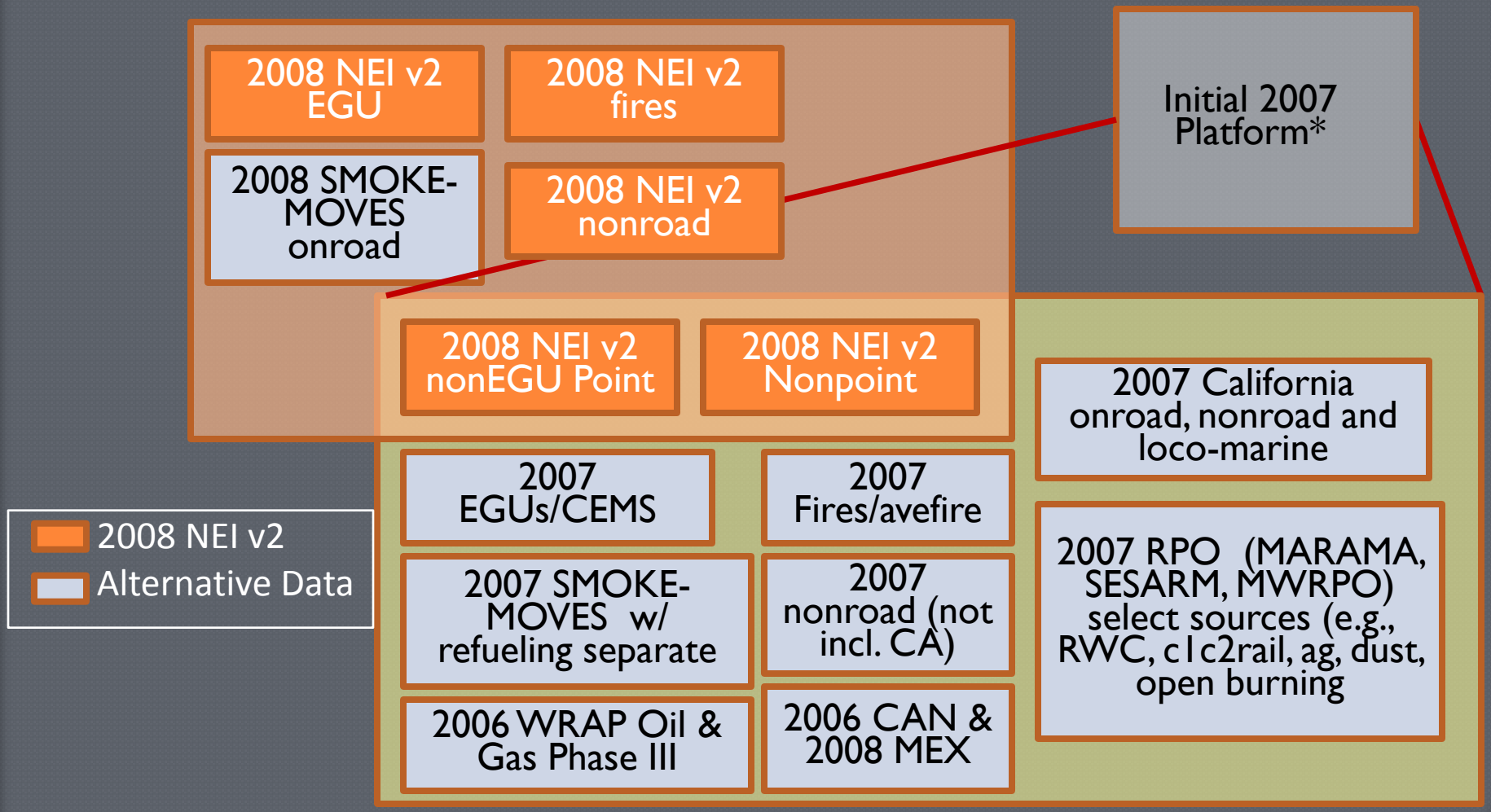
2007 Year-Specific Data

- Year-specific CEM data for EGUs
- 2007 meteorology and VMT
- NONROAD model outputs
- Onroad emission factors from MOVES
- Class 3 CMV projected from 2002
- Biogenic emissions
- Select RPO source categories:
  - some RWC and open burning
  - fugitive dust
  - monthly ag NH3
  - c1c2 CMV and rail
- CARB onroad, nonroad and c1c2 CMV and rail

Non-NEI Emissions Components

- RPO and CARB inventories
- Older versions of state-submitted data
- EPA default data where appropriate
- Biogenics BEIS 3.14 for 2007, 2008
- Canada: 2006 Inventory
- Mexico: projected 2008 from 1999
- Commercial Marine Class 3
  - currently using ECA-IMO projections from 2002 for consistency
- Area fugitive dust updated with land-use and meteorological adjustments

Emissions Components of the Initial 2007 & Evaluation & Regulatory Platforms



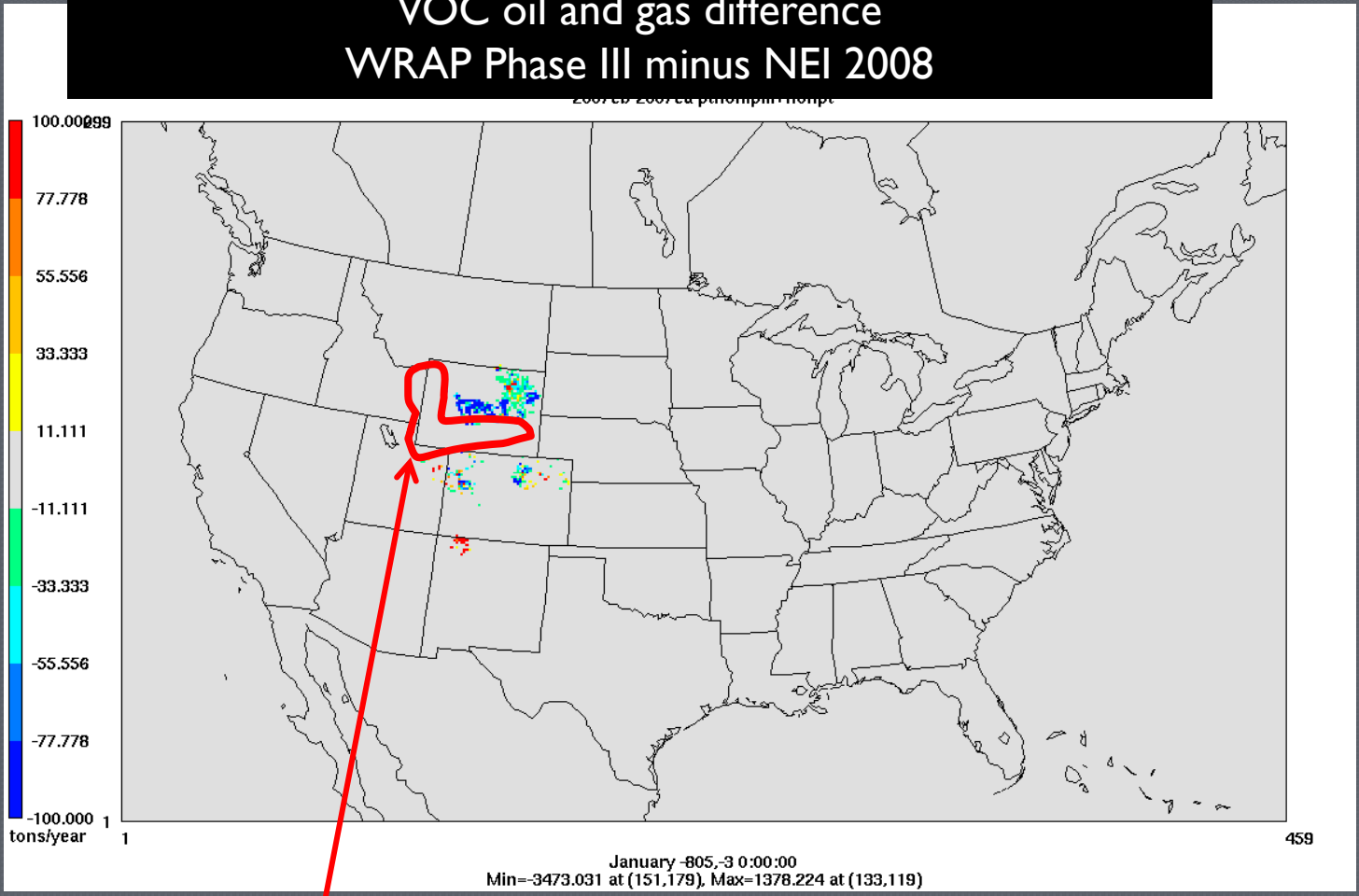
*Individual modeling projects may have a different mix of data, depending on the needs of the project

Alternative Inventories: Oil & Gas

- 4 states make up 97% of the reported 2008 NEI VOC emissions for oil & gas – TX, OK, WY, CO (most is in the nonpoint inventory)
- TX & OK have highest NO_X -approx 85% of national in 2008 NEI
- WRAP Phase III
  - 2006 base year for select basins in CO, NM, UT, WY and MT
  - detailed inventories based on survey data
  - includes drilling equipment, extraction and numerous other processes
  - Basin-specific spatial allocation and speciation
- Barnett Shale (NE TX) Phase II year 2009 via TCEQ ongoing:
  - http://www.tceq.texas.gov/airquality/point-source-ei/psei.html#barnett
- Other basins also ongoing and not currently available:
  - Marcellus Shale inventories in northeast
  - Permian (SE NM and west TX)

Alternative Inventories: Oil & Gas

VOC oil and gas difference
WRAP Phase III minus NEI 2008



does not reflect SW WY basin (new): double NO_X and 56% more VOC

New Methods: SMOKE-MOVES

MOVES:

- "Motor Vehicle Emissions Simulator" , replaces MOBILE6

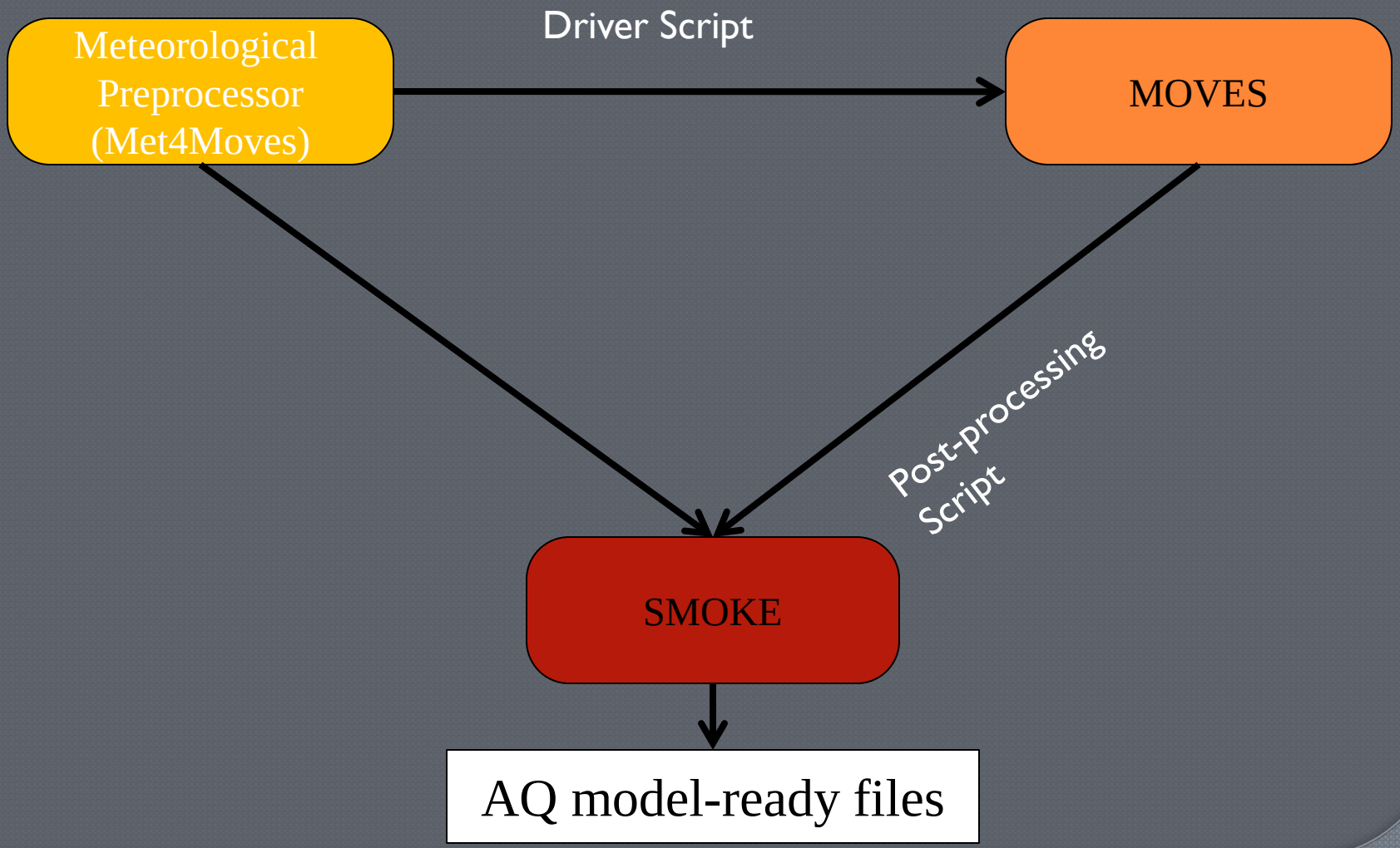
Historically:

- Run MOVES (previously MOBILE6) in inventory mode
- Produce state estimates to create monthly inventories, allocate to counties via NMIM estimates
- Process inventories through SMOKE as month-specific area/nonpoint sources

Motivation for SMOKE-MOVES:

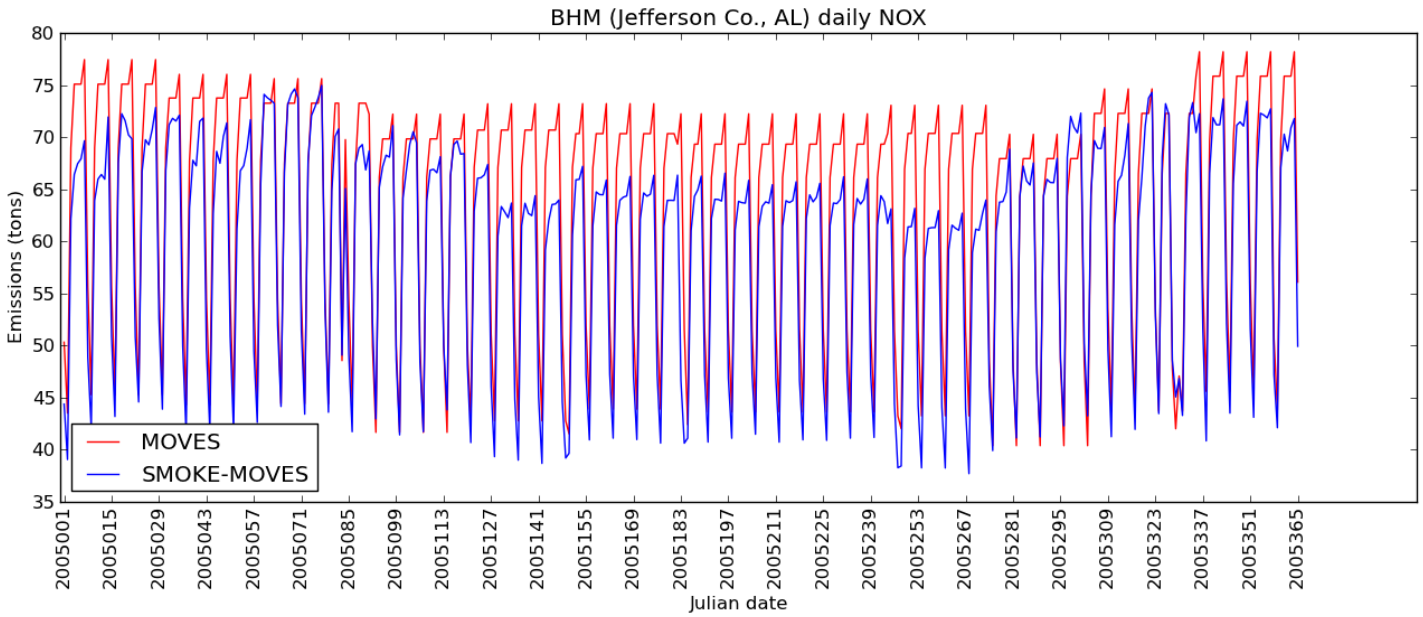
- More closely integrate MOVES into the emissions modeling process
  - Having the activity data has been very useful, emissions no longer "black box"
- Emission factors for multiple pollutants are sensitive to temperature
  - PM, VOC, NO_X, etc.
  - Want to include more temporally/spatially resolved temperatures
- Computational considerations
  - Keep computation demands "reasonable"
  - Representative counties reduce the number of runs needed
  - Use lookup tables for emission factors

New Methods: SMOKE-MOVES



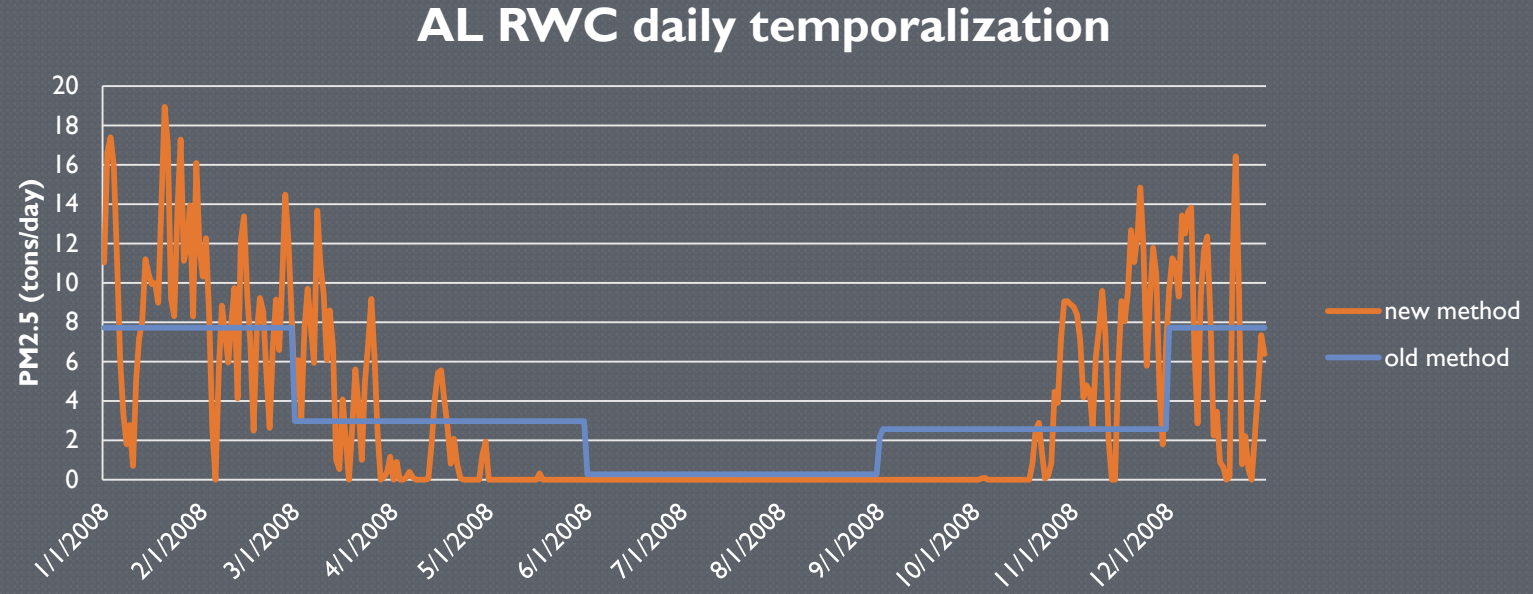
New Methods: SMOKE-MOVES

Emissions respond to day-specific temperature variations



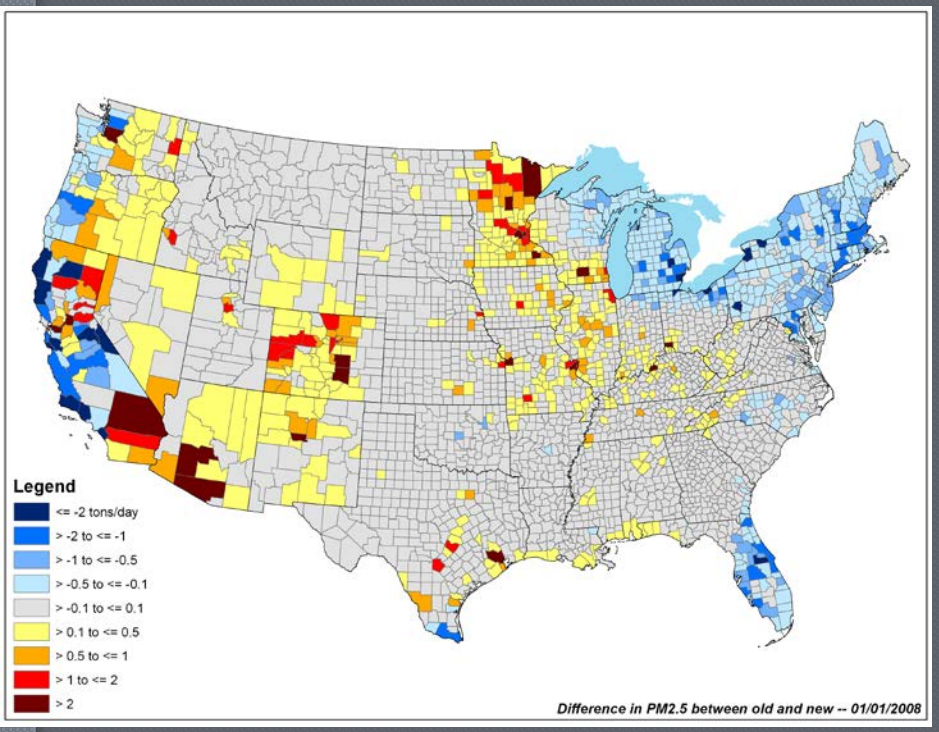
New Methods: Residential Wood Combustion

- Developed meteorology-based temporal allocation methods for RWC
- New SMOKE preprocessor (GenTPRO) creates daily temporal allocation factors
  - generates a temporal cross-reference file
  - uses regression equation relating ambient $PM_{2.5}$ and temperatures
  - T threshold of 50 F: if ambient T > 50, emissions = 0
  - T threshold user-defined by FIPS –next version SMOKE. We changed T threshold to 60 in southern states
- SMOKE applies day-specific temporal profiles to create daily emissions

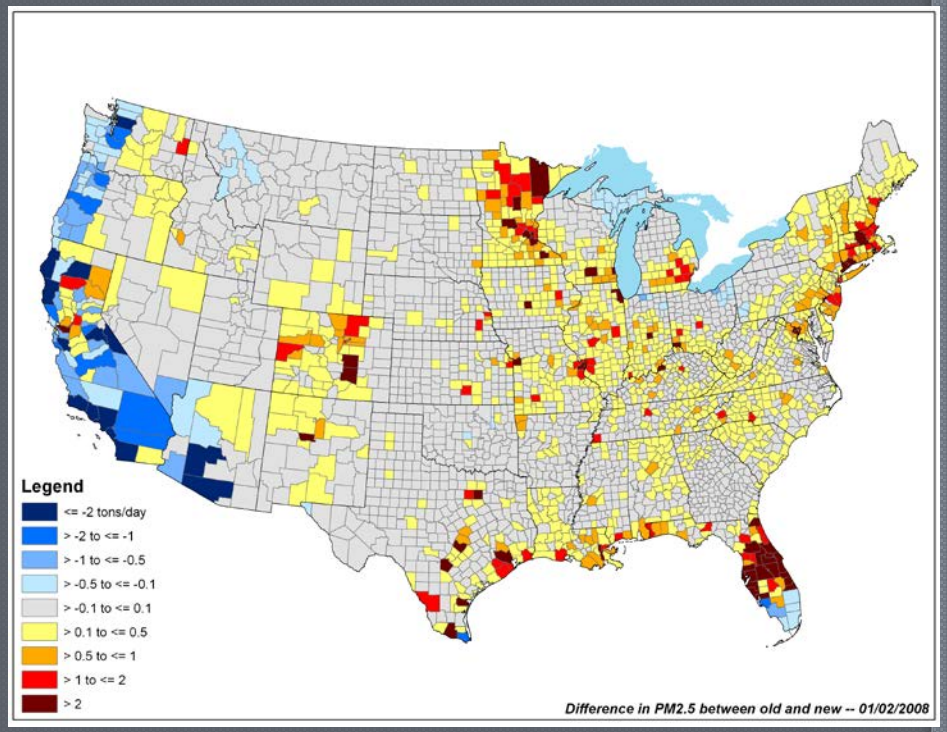


New Methods: RWC

RWC 2008 NEIv2: "old method" – "new method @50F"

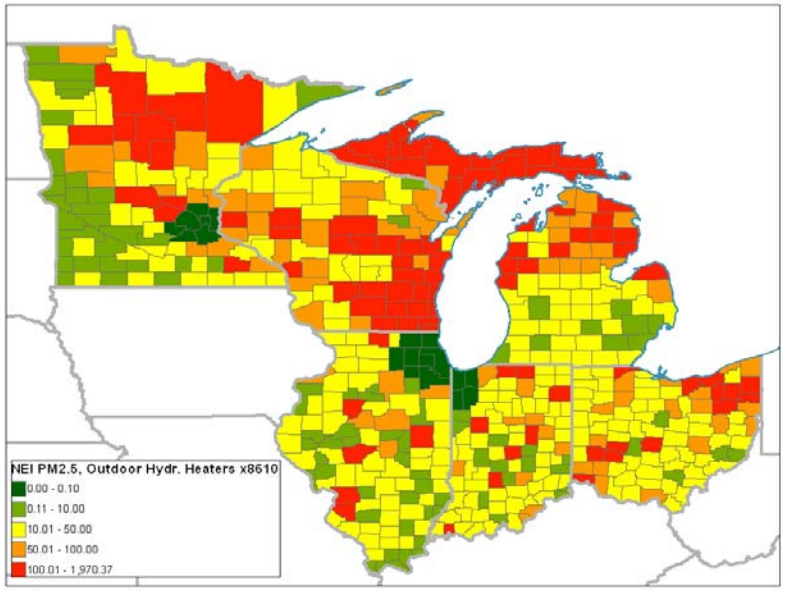


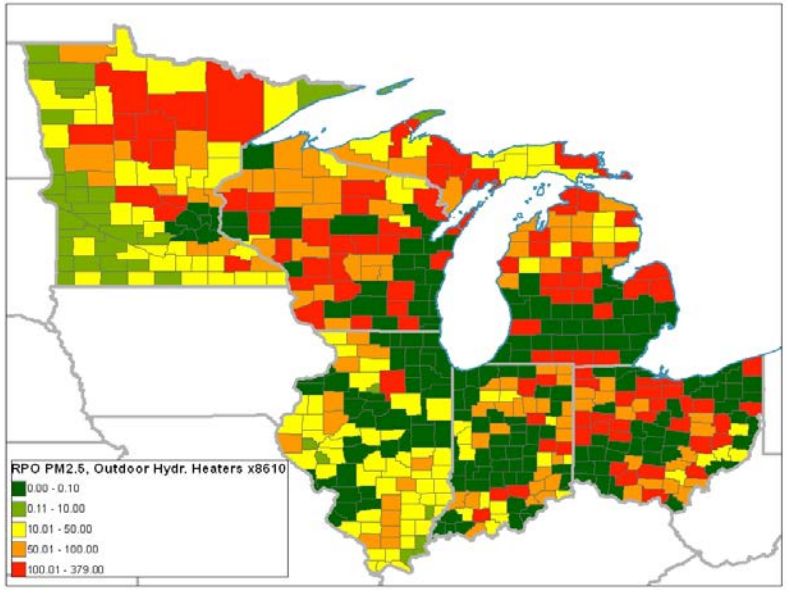
Jan 1

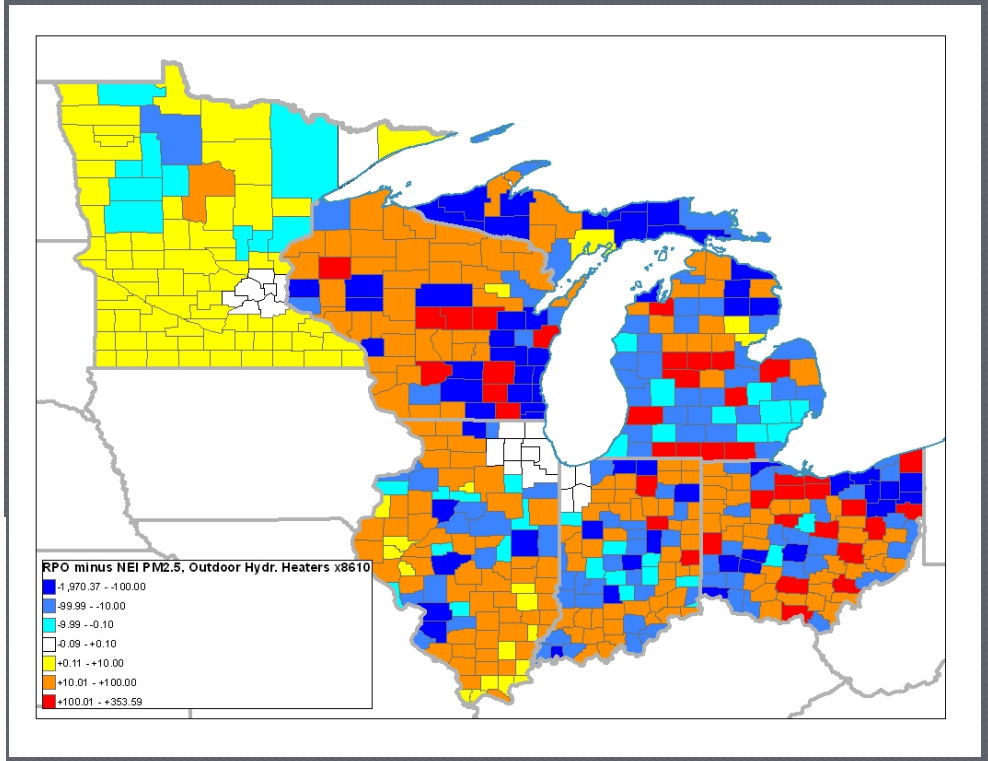


Jan 2

RPO vs NEI RWC Data Analysis

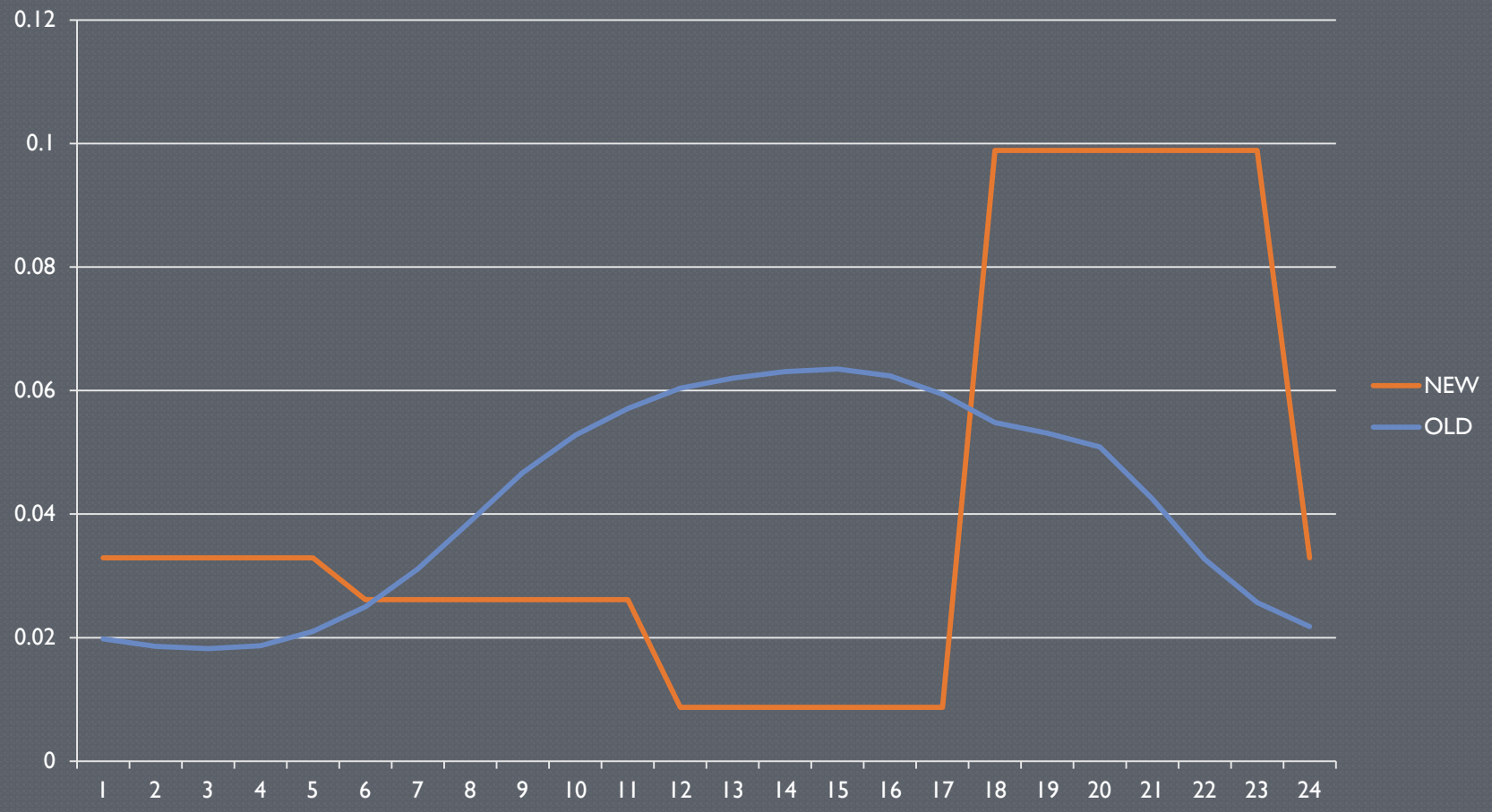






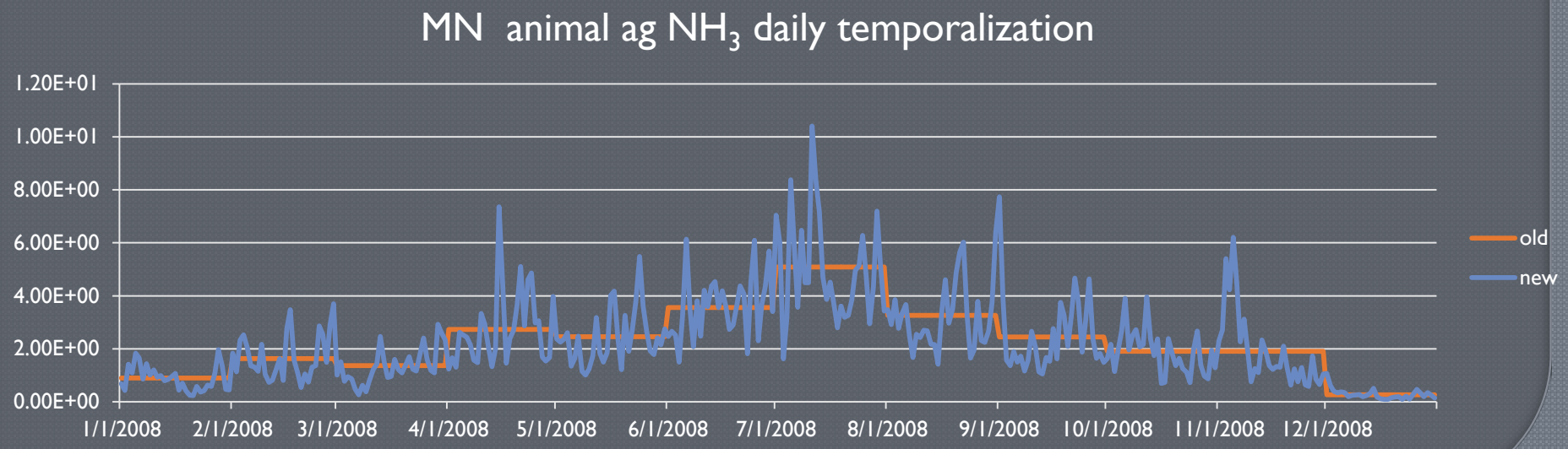
$PM_{2.5}$ Outdoor Hydronic Heaters
NEI (top left)
RPO (bottom left)
Difference RPO – NEI (above)

Temporal Allocation
Improved RWC Diurnal Profile



New Methods: animal ag NH_3

- ag NH_3 from animals (CAFO)
- GenTPRO uses Russell and Cass equation which relates emissions to temperatures and wind speed
- Create hour-of-month temporal profiles
  - previous annual to monthly allocation is retained



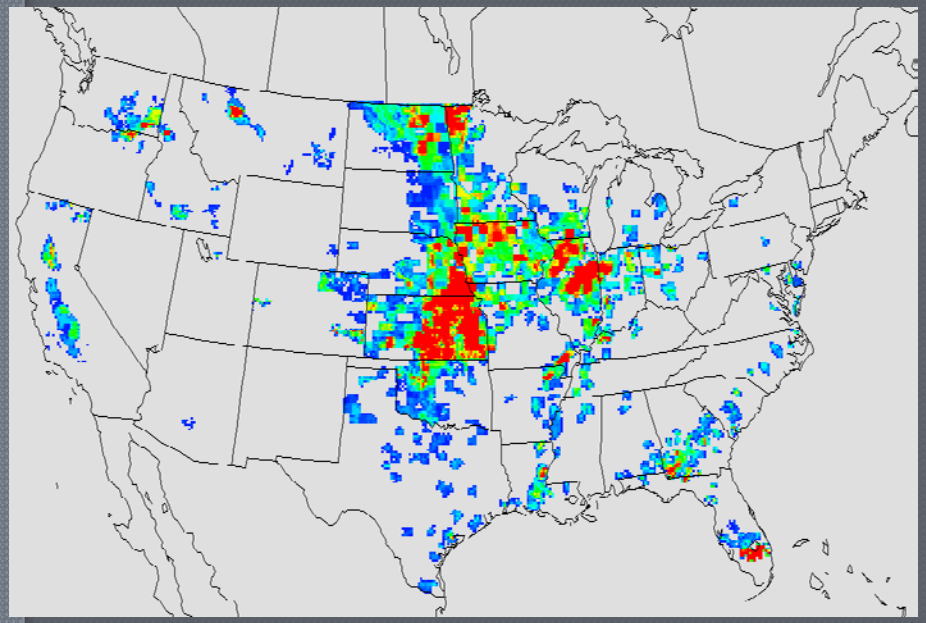
New Methods: fires

- SMARTFIRE 2.0
- Integrate satellite fire detects with ground-based databases
- Classifies fires as:
  - wildfires
  - prescribed
  - wildland fire use (WFU)
  - agriculture*
  - unclassified
- v2.0 improvements:
  - fire sizing algorithms
  - Classified all "unclassified" fires
  - Improving evaluation of cloud-cover interference
- 2008 and 2009 inventories SMARTFIRE v2.0
  - previous years SMARTFIRE v1.0
  - developing 2007 and 2010 using v2

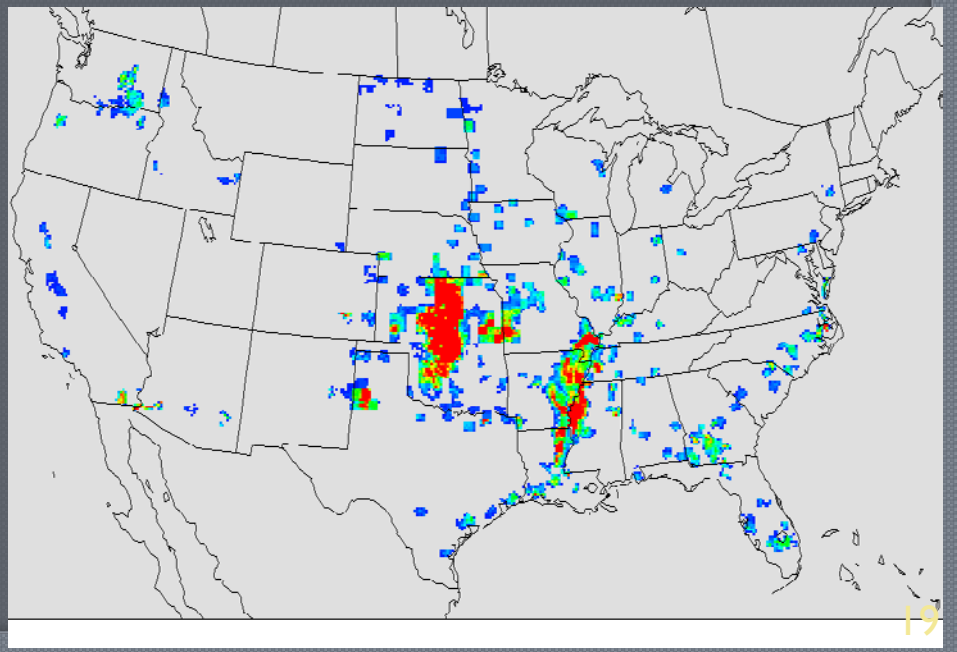
New Methods: ag fires

- ag fires based on SMARTFIRE v1.0
- NEI team applied EF and crop harvesting patterns
- 2008 daily emissions aggregated to monthly inventory for 2007 to minimize year-specific met-dependence

April

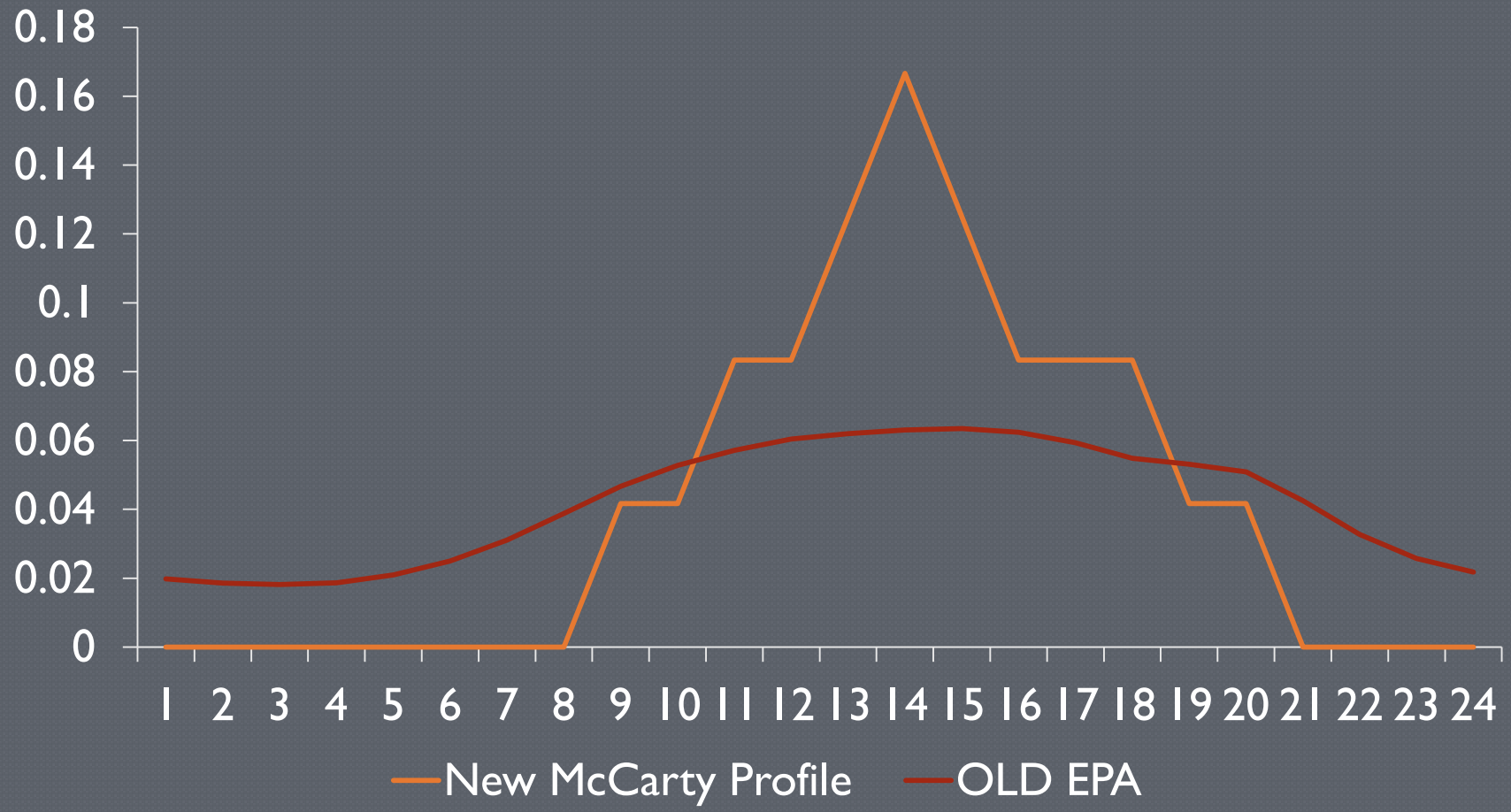


July



$PM_{2.5}$

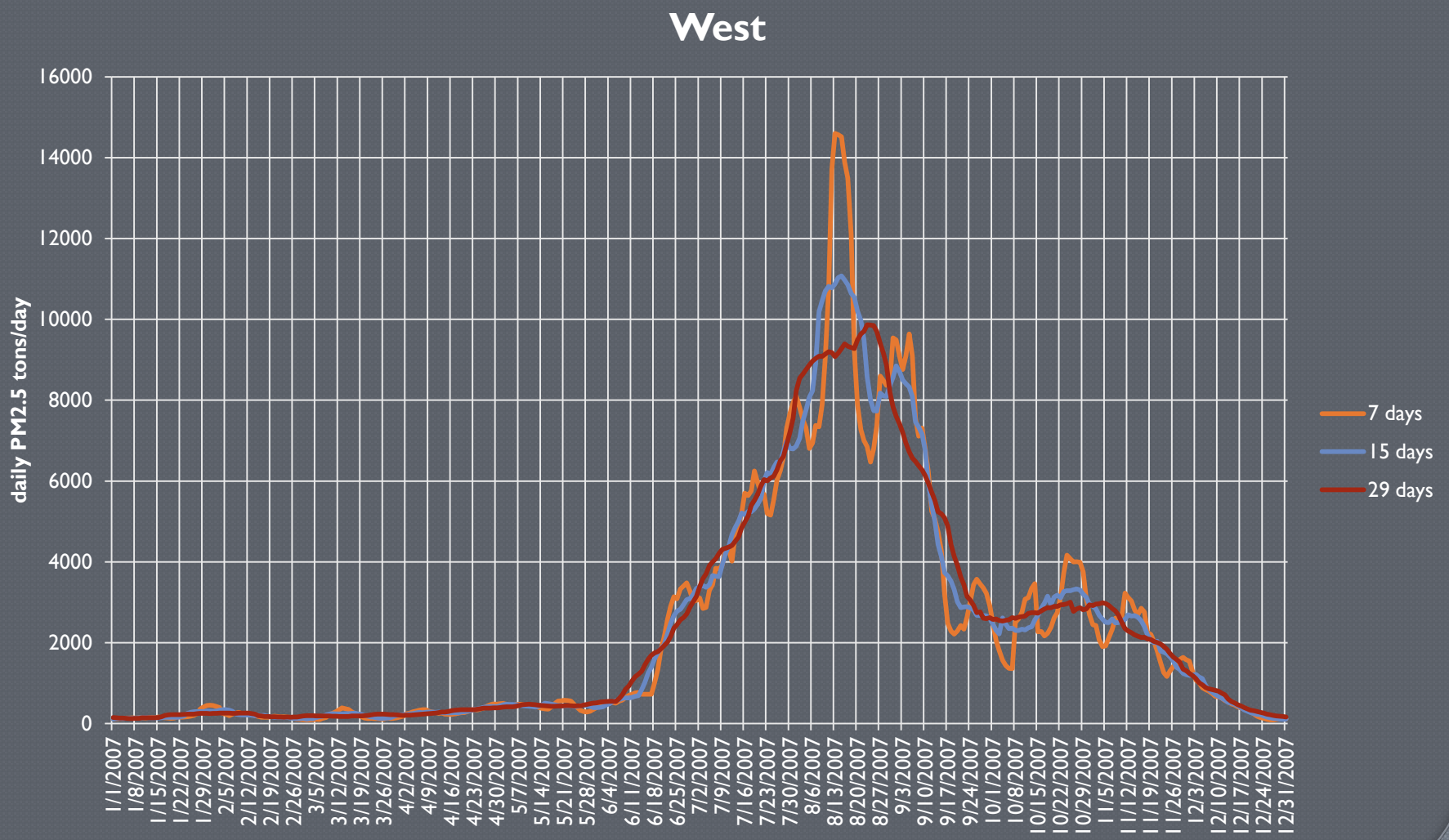
Temporal Allocation
Improved Ag Burning Diurnal Profile



New Methods: average fires

- Fire Averaging Tool (FAT)
- Processes point daily fires to produce emissions at daily/county resolution
- Purpose is for regulatory runs for base and future year
- Leverages point daily fires
- User controls:
  - range of years
  - grouping of SCCs
  - averaging period – FAT uses a rolling average (e.g., 1 week)

New Methods: Fire Averaging Tool (FAT)



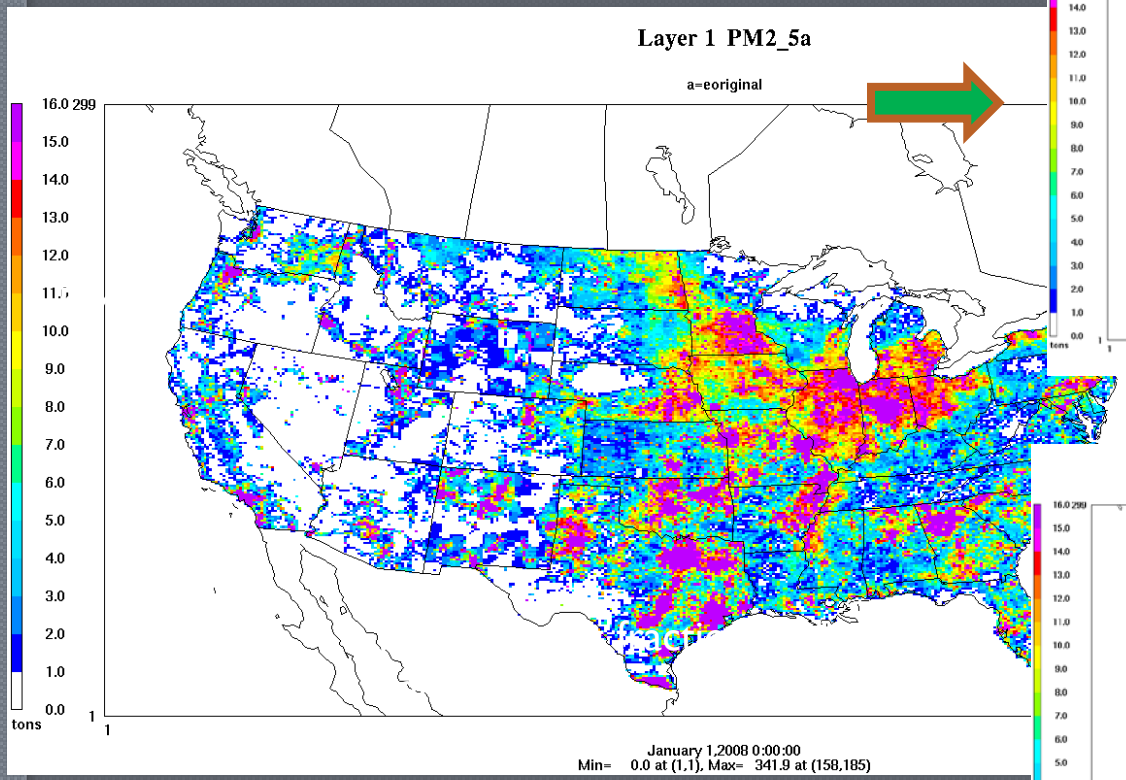
New Methods: afdust met adjustment

- Includes PM emissions from paved* and unpaved road dust, agricultural tilling, construction, etc.
- New adjustments developed by EPA ORD
- Transport fraction
  - Reduces PM based on land use via BELD3
- Meteorological adjustment
  - Snow and rain suppresses PM emissions
  - Snow on the ground OR top 1cm layer of soil >= 50 % saturated -> afdust emissions = 0

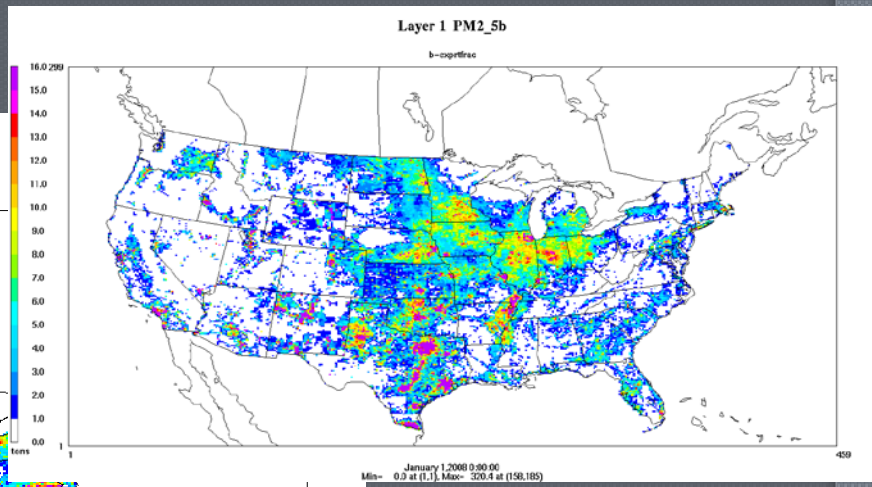
* paved roads inventory does not match met-adjusted NEI

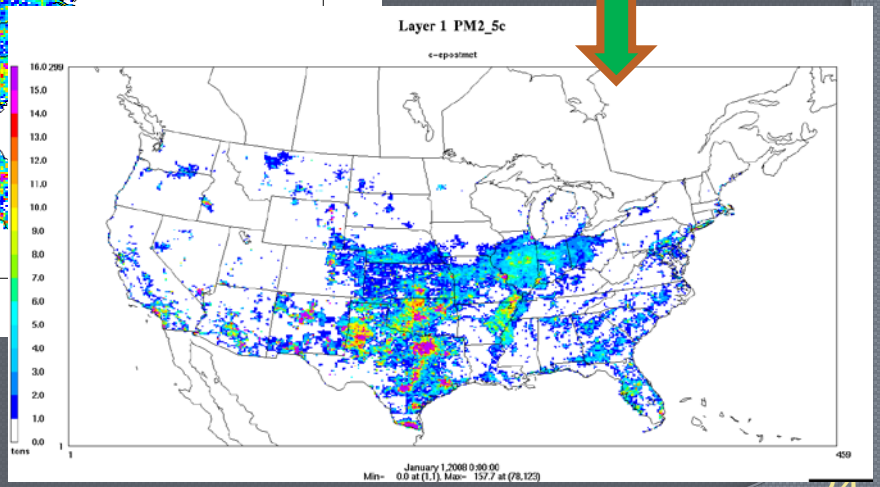
New Methods: afdust met adjustment

Jan unadjusted



Jan transport fraction adj.





Ancillary Data: Spatial Surrogates

- Allocate nonpoint and mobile sources to grid cells
- Census 2010 based surrogates
  - circa-2000 for old surrogates
- FEMA HAZUS (circa 2010) based surrogates
  - e.g. Industrial Land, Commercial + Industrial
- National Transportation Atlas Database (NTAD) 2011 based surrogates
- Other updates are being considered
  - National Land Cover Database (crop and pasture land, residential density)
  - Gas stations, TIGER-Line data (e.g. roads), etc.
- WRAP Phase III Oil & Gas: basin specific spatial surrogates

Ancillary Data: Speciation

- Speciation profiles are used to map inventory pollutants to AQ model species
- PM AE6 speciation
  - support for CMAQ v5.0
  - includes more specific speciation of PM (e.g. Al, Mg, etc.)
- Onroad speciation
  - updated profiles from OTAQ for VOC
  - permeation mode specific profiles for VOC
- WRAP Phase III Oil & Gas
  - basin-specific VOC profiles
- SPECIATE 4.3
  - process underway to systematically review new profiles

Projections

- Goal is to incorporate all "on the books" regulations
  - work with RPOs and states to identify these controls
- Updated non-EGU projections, controls and closures based on 2007/2008 platform
- Reviewed consent decrees
- Includes upstream impacts from EISA/RFS2
- Updates to methodology for several sources
  - RWC, ag NH_3, ULSD, RICE, Boiler MACT
- Oil & Gas projections *unavailable*
- Updated projection tools for FF10 and for monthly controls
- Later: Evaluate alternative methods for projecting select non-EGU industrial source categories based on AEO data

SMOKE updates

- SMOKE-MOVES
  - improved speed & temperatures out of range of EF
  - support for: MOVES2010b, refueling and for more HAPS
- Support for new inventory format: Flat File 10 (FF10)
  - monthly, daily, and hourly emissions and controls for point and nonpoint
  - monthly activity data (e.g. VMT)
  - EIS can produce the FF10 files
- New temporal profiles: GenTPro
  - Support for monthly profiles
  - Support for daily and hourly MET-derived profiles
- SMOKE v3.0 currently available, v3.1 updates coming soon:
  - movesmrg optimization/bug fixes:
    - option fast/slow for high/low memory
    - use correct reference month lookup table for last few local hours each month
    - apply control factor by FIPS/SCC/pollutant/mode/month
  - met4moves allow TEMP_BUFFER_BIN to cover wider temperature ranges in MOVES lookup tables
  - fixes/enhancements of FF10 daily/hourly inventory files, allow processing w/ other PTDAY/PTHOUR inventories

Next Steps

- Continue to include 2007 model platform improvements
  - CMAQ v5 testing (lightning NO_X, ag NH_3 bidirectional flux)
  - oil and gas
  - CEMs clean-up
  - RWC improvement via 2011 NEI project
  - C3 marine reconciliation
  - inventory controls QA and validation
  - MEGAN v2.10 biogenics
- Future year projections
  - updated consent decrees/settlements
  - available SIP control measures
  - Local RWC controls
  - oil and gas!
  - Begin construction of 2017/2030 base cases for Tier 3 FRM
  - RPO inventory projections

Acknowledgments

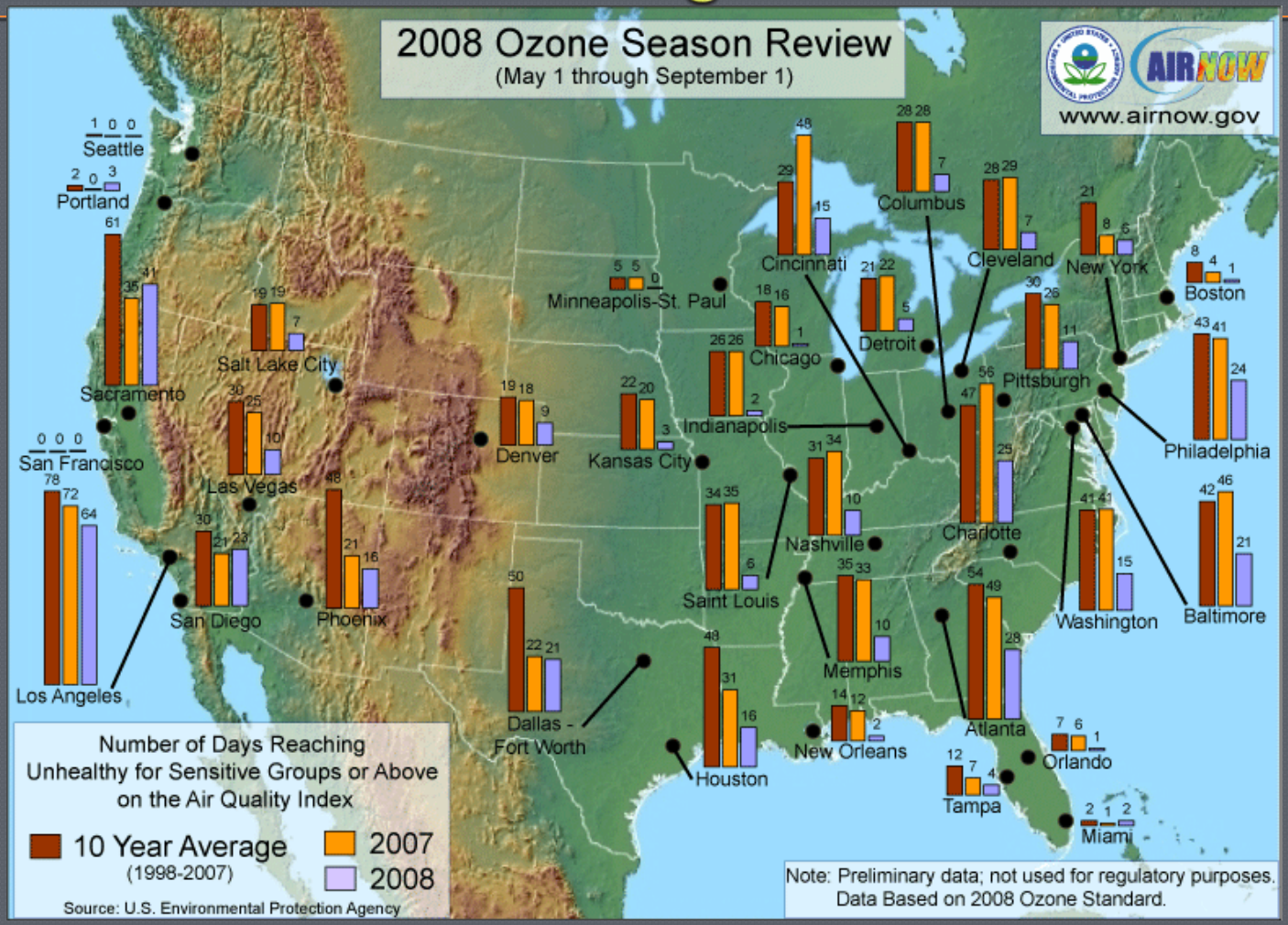
- UNC-Institute for the Environment
- ENVIRON
- CSC
- ERG
- RPOs and EPA regions
- CARB
- EPA's: OTAQ, ORD, AQM group, NEI team

Appendix

Why 2007?

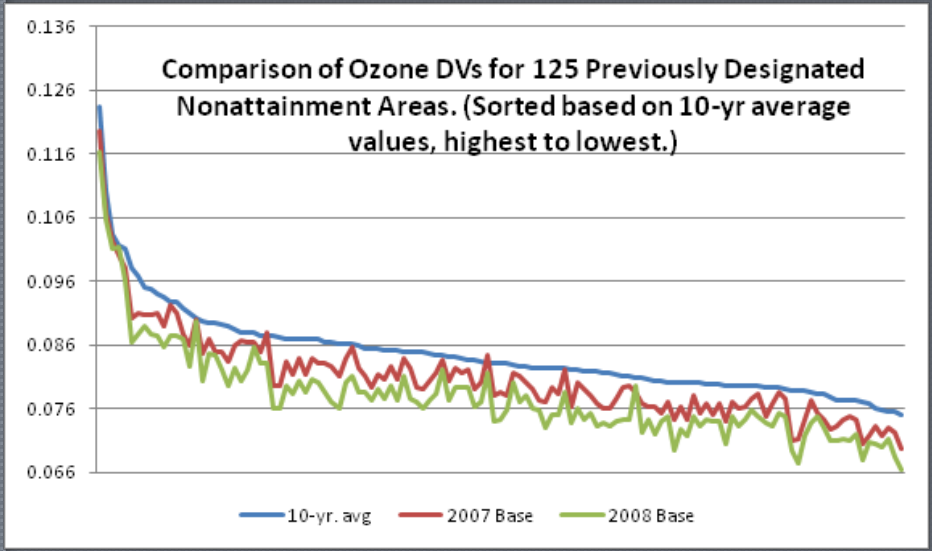
- Factors considered in choosing base year
  - Availability of year-specific emissions data
  - Ability to use recent ambient data in design value projections
  - Avoid years that are not conducive/representative regarding the formation of ozone and PM2.5 concentrations
- 2007 was selected because…..
  - We can utilize/leverage the 2008 NEI
  - 2007 AQ-related meteorology was more representative of average conditions than 2008 (2008 had generally "unconducive" met in most of the US)
  - We can use 2005 thru 2009 ambient data as the starting point for future projections

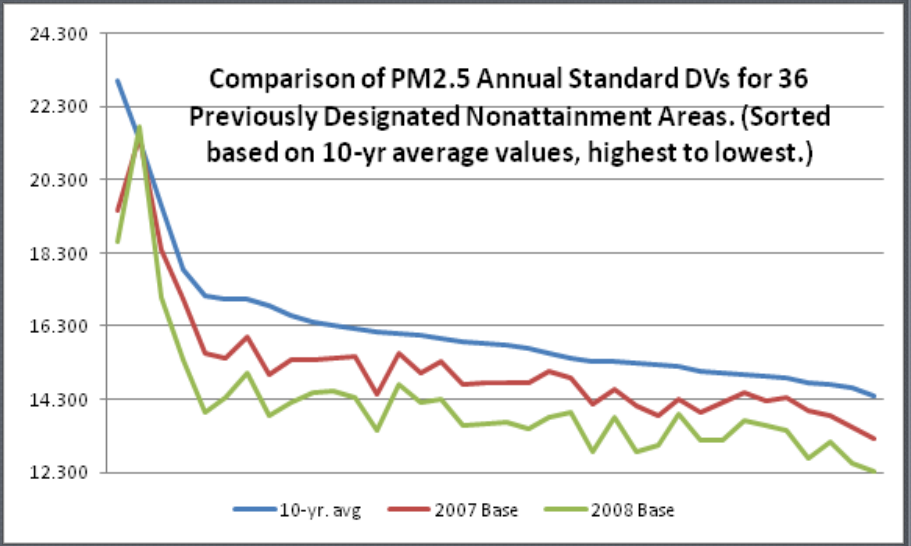
Representativeness of Air Quality in 2007 and 2008 vs Long-Term Concentrations



Number of days with AQI >100 in 2008 appears to significantly depart from the long-term average for many cities.

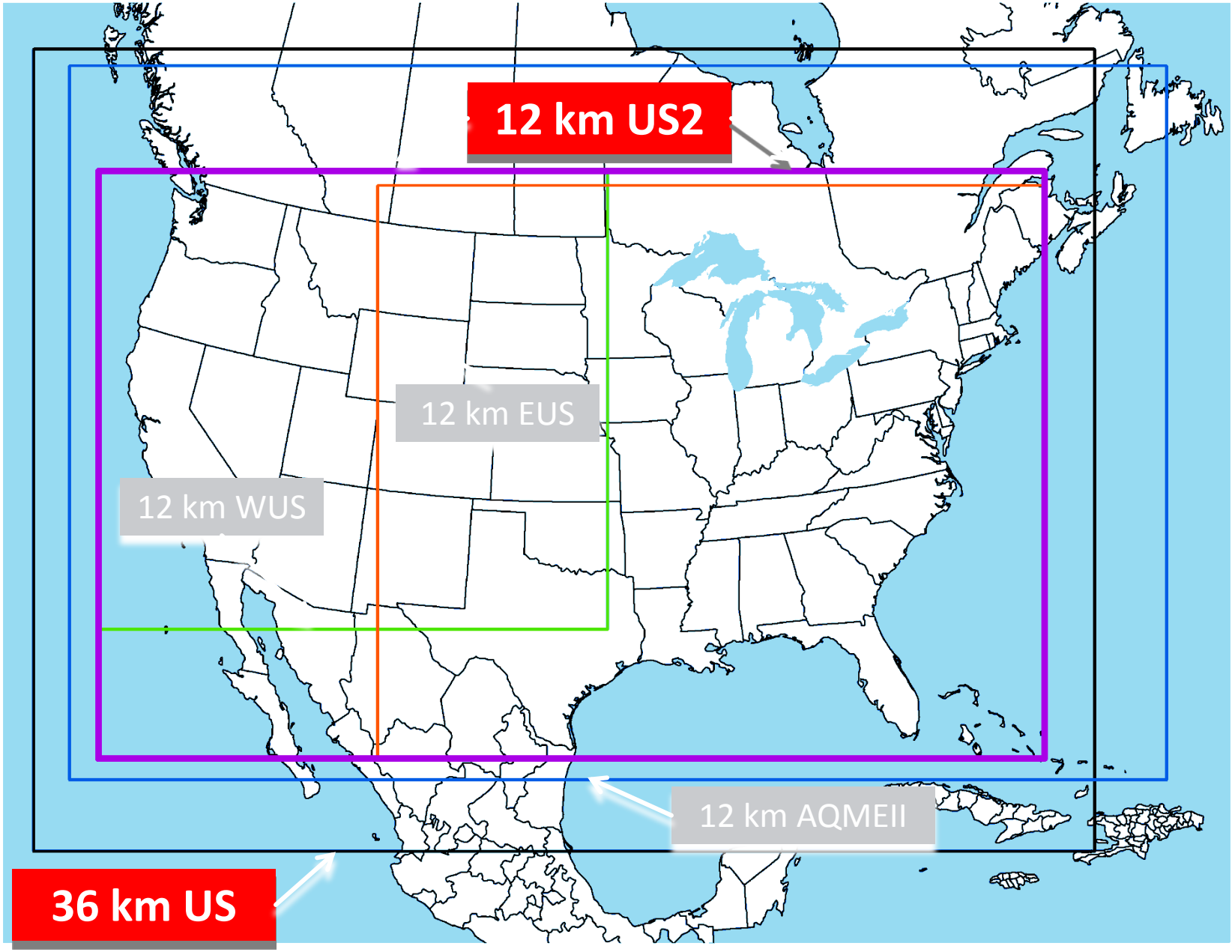
Why 2007?





Number of days with AQI >100 in 2008 appears to significantly depart from the long-term average for many cities.

AQ Modeling Domains



Emission Modeling Sectors

- Inventories are split into "sectors" for modeling based on:
  - emission source similarity (e.g. by SCC)
  - data availability
  - processing methodologies

Emission Modeling Sectors (1)

Source Cat	Description	Starting point
ptipm	EGU emissions (point)	2008 NEIv2 + CEMs
ptnonipm	Non-EGU emissions (point)	2008 NEIv2
c1c2rail	Class 1/Class 2 commercial marine, and railroad (area)	2008NEIv2
ag	Agriculture fertilizer and livestock NH3 only (area)	2008NEIv2
afdust	Area fugitive dust (area)	2008NEIv2
nonpt	Remainder of area-type emissions, e.g. RWC, refueling, smaller boilers, solvents (area)	2008NEIv2
avefire/ptfire	Smoothed grid-cell/point-daily fires: prescribed and wild (area/point)	SMARTFIRE daily-point

Emission Modeling Sectors (2)

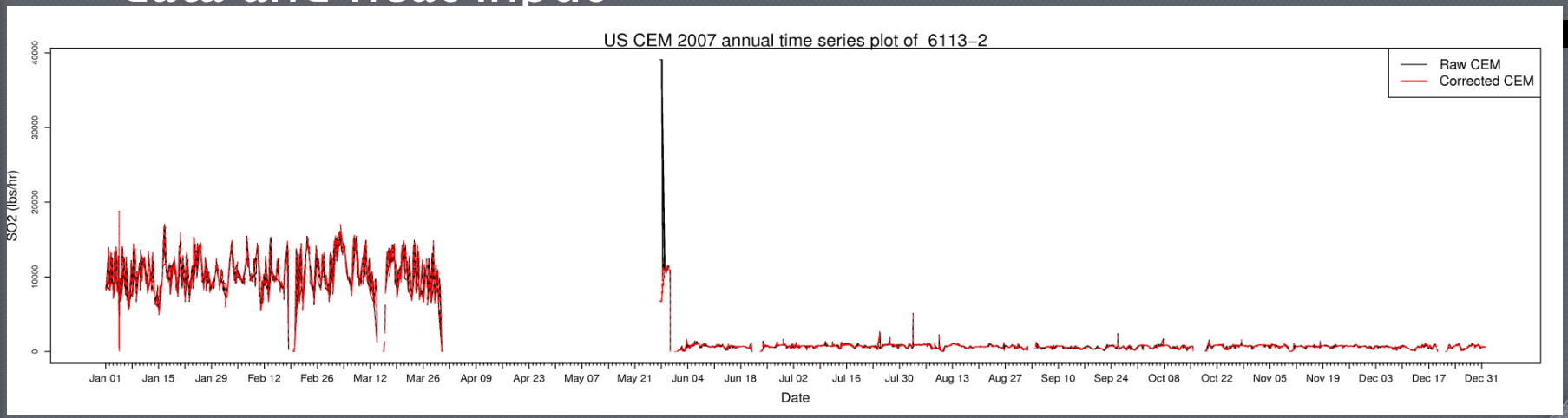
Source Cat	Description	Starting point
c3marine	Class 3 commercial marine (point)	ECA-IMO pollutant 2007 year-specific, grown from 2002
onroad	Mobile emissions on- and off-network (area)	2008 NEIv2
nonroad	Mobile emissions for off-road vehicles, e.g. construction, lawn mowers (area)	2008NEIv2
othpt	Canadian and Mexican emissions (point)	2006 Canadian and 2008 (grown from 1999) Mexican inventories
othon, othar	Canadian and Mexican mobile and nonpoint emissions (area)	2006 Canadian and 2008 (grown from 1999) Mexican inventories
biogenic	Biogenic emissions, e.g. forests (area)	BEIS3.14

Non-Emission Components

- Models
  - CMAQ v4.7.1 (plan to transition to v5.0 in early FY2013 depending outcome of evaluation of v5.0)
    CAMx v5.3 (checking with ENVIRON on timing and nature of updates)
- Meteorology
  - Existing 2007 WRF v3.1 w/ MCIP v3.6
  - Possibly update to WRF v3.3 later – depending on outcome of analysis/evaluation of updated version
- Domain
  - Smaller 12US2 12km national US domain nested within 36km CONUS
- Vertical Resolution
  - Existing 24 layer structure (may change with updated version of WRF)
- Initial and Boundary Conditions
  - Existing 2007 GEOSChem outputs

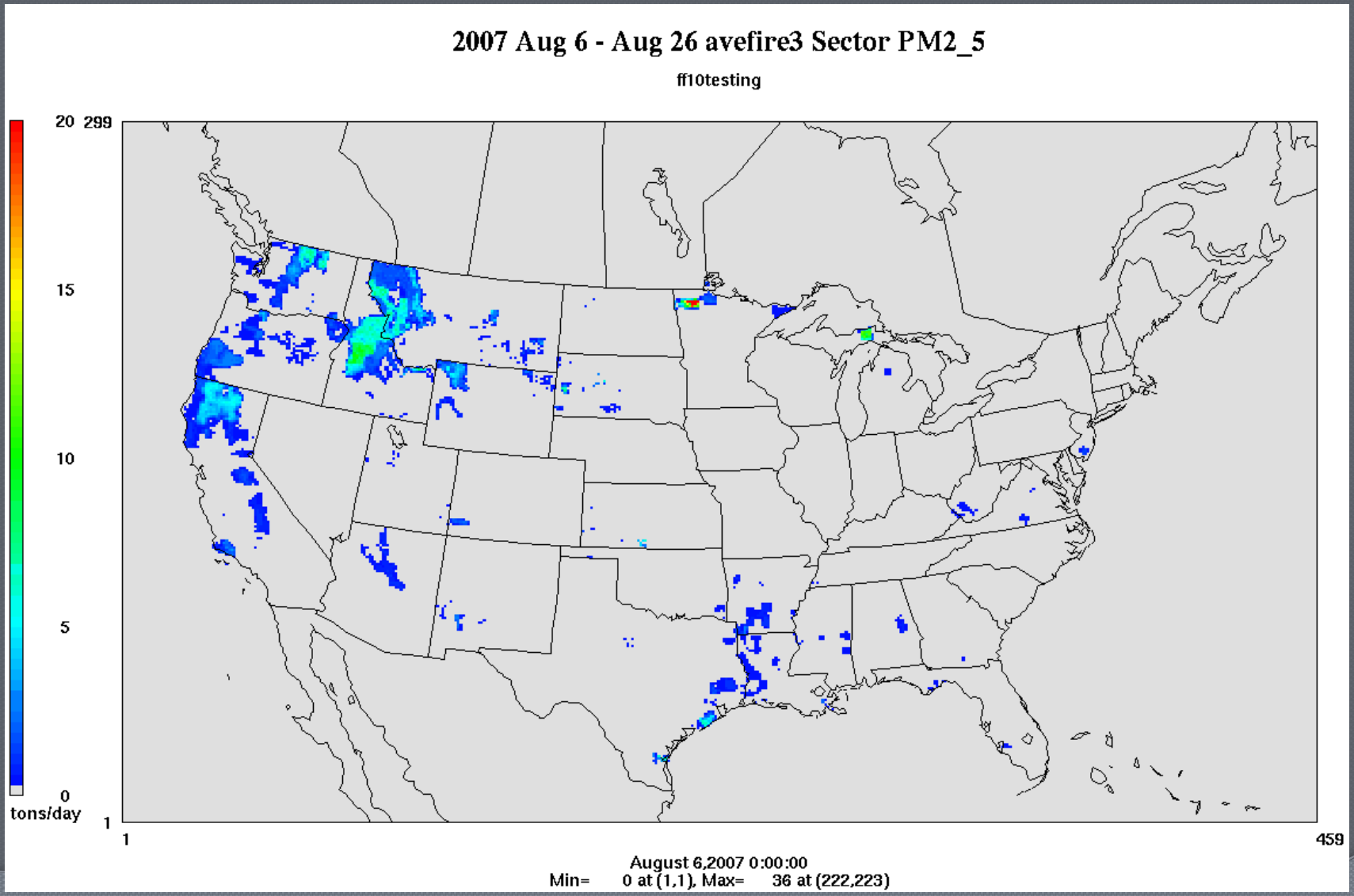
New Methods: EGU CEMs

- Continuous Emissions Monitoring (CEM) data reports NOx and SO2 emissions
- Missing emissions are filled with "calculated" values that are larger than actual emissions to satisfy the requirements and the goals of CAMD's trading programs
- Tool identifies "anomalous" data based on flags in the data and heat input



tool developed by SESARM and UNC-IE

FAT: Average Fires +/- 3 days



FAT: Average Fires +/- 14 days