

Crop Residue Burning in the 2014 National Emissions Inventory

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2015 International Emission Inventory Conference
April 15, 2015

Acknowledgements

- NASA: providing satellite data and the NASA Applied Science program for providing support to the development of this work
 - Applied Science Program Grant #NNX09AP53G
 - “Linking NASA Satellite Data and Science To Enhance Fire Emissions within the EPA’s National Emissions Inventory: Developing Agricultural/Rangeland Fire Emissions Estimates, Connecting Models to Plume Injection Height Data, and Verifying Modeled Emissions Estimates”
- Computer Science Corporation: providing assistance to create county level maps



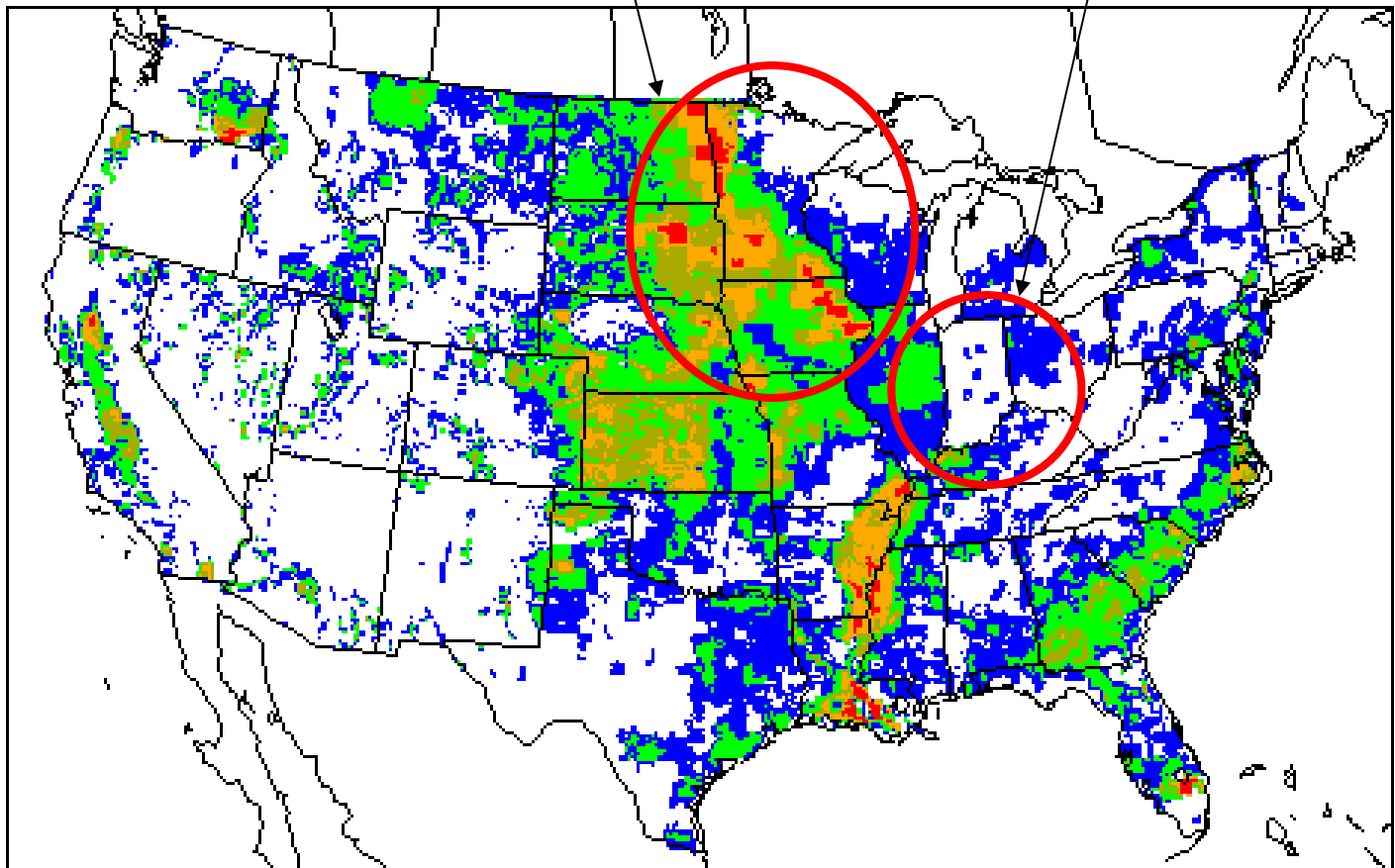
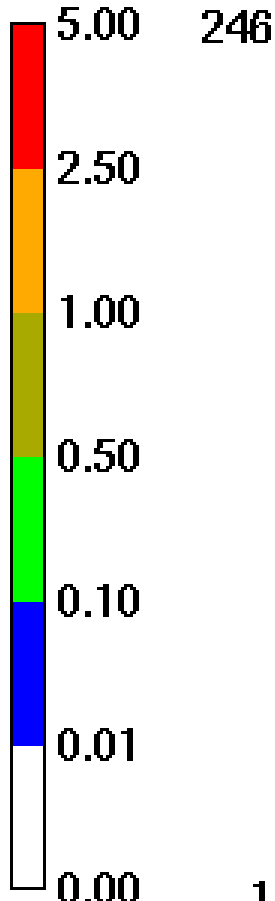
Crop Residue Burning: A Short History

- 2002 NEI
 - 23 states estimated emissions for this sector
 - no satellite information used
- 2005 NEI
 - this sector was not estimated, 2002 estimates used
- 2008 NEI
 - SMARTFIRE fire detections used
 - uncertain acres, emission factors
 - all mapped to one SCC
- 2011 platform (2011 NEI v1)
 - used methods from J. McCarty
 - satellite based on changes in land surface over 8-day period
 - estimates too high in areas with high rates of irrigation and dark soils in upper Midwest and Midwest states

2011 Platform 2011 NEIv1 Crop Residue Emissions Annual Estimates PM_{2.5}

Midwest states
too high based
on EPA methods

State submitted
data



3 kg/ha/yr



Method for 2014 NEI

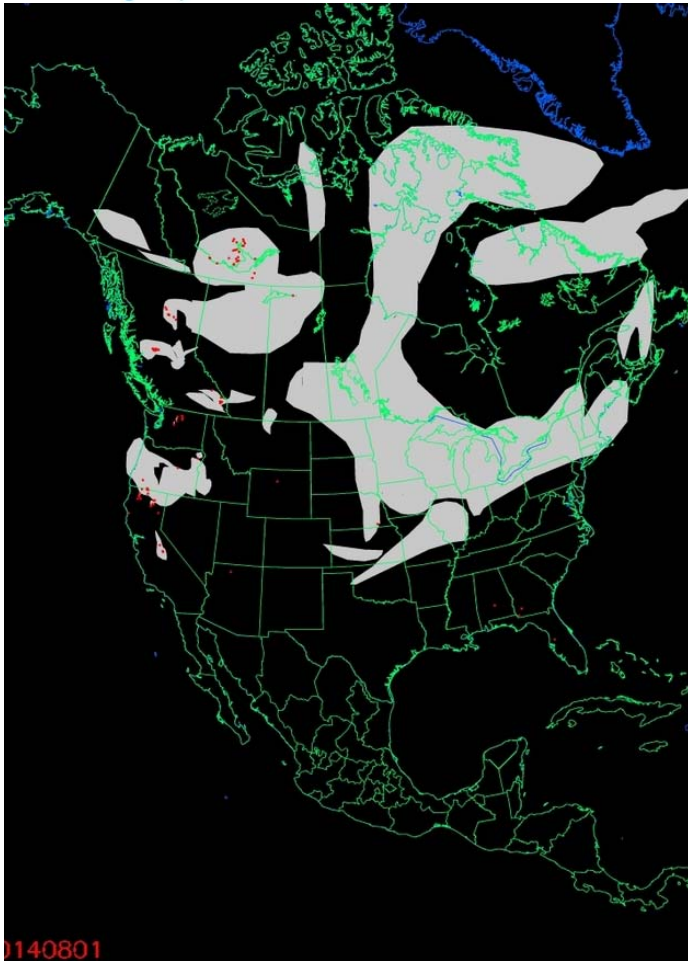
Input Data Sources for estimating agricultural burning emissions

- NOAA: HMS (Hazard mapping system) data (GOES, AVHRR, MODIS, VIIRS)
- USDA: Year specific cropland data layer
 - National Agricultural Statistics Service
 - <http://www.nass.usda.gov/research/Cropland/SARS1a.htm> [Available 1997-2014]
- EPA: Emission factors
- MTRI: Field size (per state)

Method to Compute Crop Residue Burning Emissions

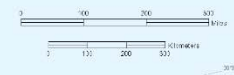
- Use HMS fire detections
- For GOES detects, remove “duplicate” detections (same time, locations within 2km)
- Remove duplicates with identical lat/lons on same day across all satellites (GOES, MODIS, AVHRR, VIIRS)
- Locate agriculture fires using a crop map with specific crop type maps. (NASS dataset directly)
- Identify crop type and determine emission factors and field size
- Calculate emissions
- $E = \text{area burned} * \text{combustion completeness} * \text{emission factor} * \text{fuel loading}$
- Separate Grass/Pasture from crop residue emissions using NASS crop layer map
- Average field size used is taken from USDA publications and estimations.

Example of Hazard Mapping System



8/1/2014 Fire/Smoke
Detections by Analyst

2012 Cropland Data Layers of the Continental United States



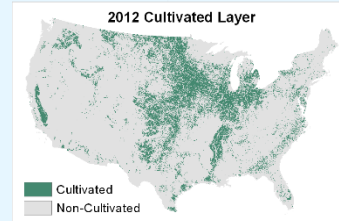
Land Cover Categories (by decreasing acreage)

Agriculture

- | | | |
|-------------------------|-------------------|--------------------|
| Pasture/Grass | Dry Beans | Peas |
| Corn | Canola | Other Small Grains |
| Soybeans | Peanuts | Millet |
| Winter Wheat | Sunflower | Rye |
| Fallow/Idle Cropland | Oats | Apples |
| Other Hay/Non Alfalfa | Sugarbeets | Pecans |
| Alfalfa | Potatoes | Lentils |
| Cotton | Almonds | Tomatoes |
| Spring Wheat | Grapes | Walnuts |
| Sorghum | Sugarcane | Aquaculture |
| Dbl Crop WnWht/Soybeans | Oranges | Pistachios |
| Barley | Misc Vgs & Fruits | Cherries |
| Rice | Other Crops | Citrus |
| Durum Wheat | Sod/Grass Seed | Blueberries |

Non-Agriculture

- | |
|--------------------|
| Forest |
| Shrubland |
| Developed |
| Wetlands |
| Open Water |
| Barren |
| Perennial Ice/Snow |



2012 Cropland Data Layer Produced by: U. S. Department of Agriculture, National Agricultural Statistics Service, Research and Development Division, Geospatial Information Branch, Spatial Analysis Research Section.

Cropland Data Layer CropScape Website: <http://nassgeodata.gmu.edu/CropScape/>

Data Sources: Landsat 5 TM, DTMos-1*, UK-DMC2*, Terra MODIS, *Courtesy of USDA Foreign Agricultural Service.

Image Processing: Rulequest SeeS and ERDAS Imagine software.

Ground Truth: The Farm Service Agency Common Land Unit for crops classes, and 2008 National Land Cover Dataset (NLCD) for non-agricultural classes.

Auxiliary Data: NLCD Impervious Surface, NLCD Forest Canopy, National Elevation Dataset.

Disclaimer: Small area crops may be less accurate, see CropScape metadata.

Cartographic Generalization: Smaller categories are combined with larger categories.

Projection: Albers Equal Area Conic Projection, NAD 1983 datum.

Map Production: ESRI ArcGIS 10.



Differences & Similarities between new method and 2011 NEIv1

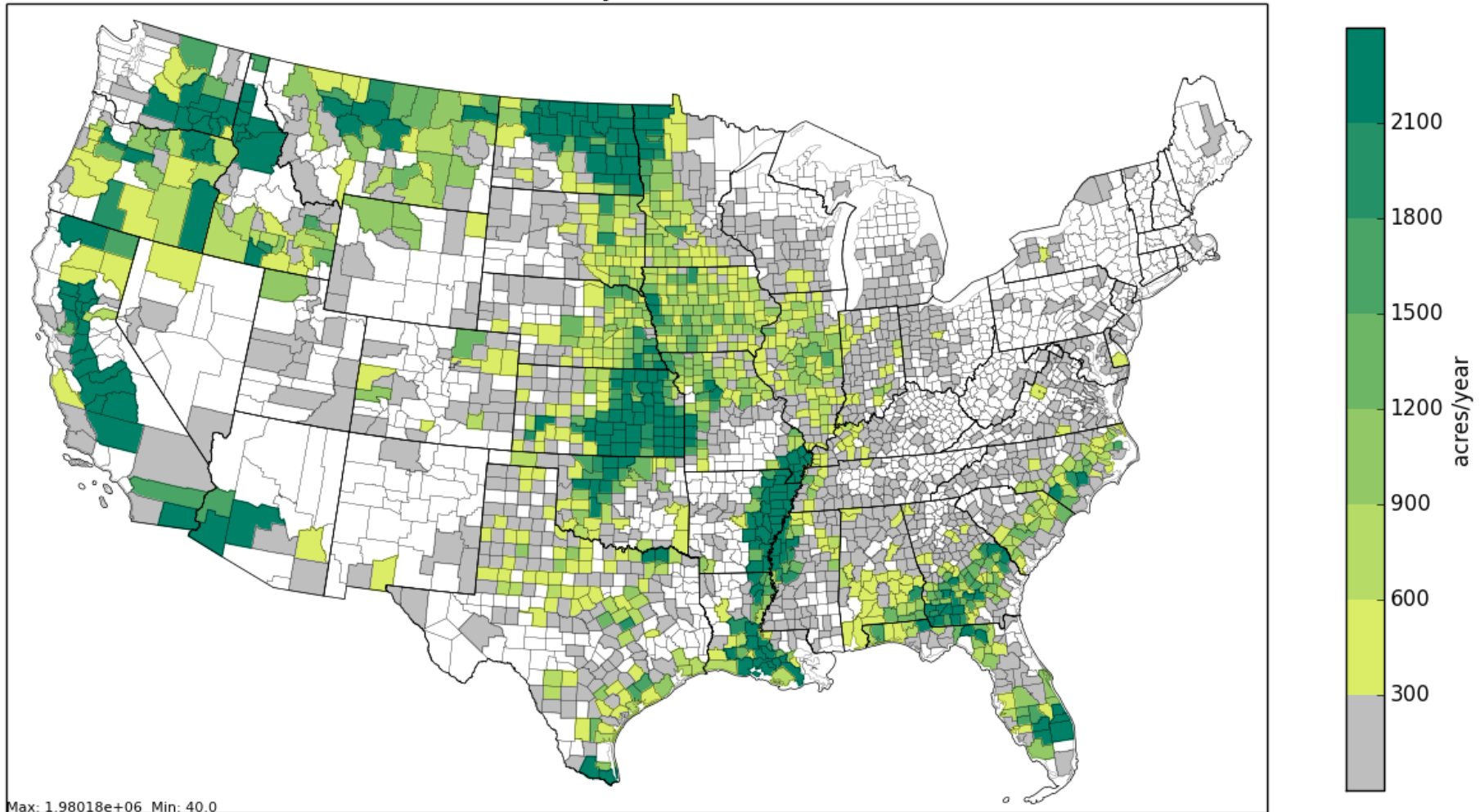
- Use daily HMS satellite product for fire detections (not 8-day MODIS land surface changes dNBR approach)
- Grass/Pasture in NASS Cropland Data Layer (CDL) was revised to remove inconsistencies in identification
- Grass/Pasture emissions estimated separately
- Not an exact apples-to-apples comparison (rangeland grass/pasture)
- Not as precise as MODIS land change difference (average field size per state vs shapefile)
- Emission factors unchanged
- Less spatial accuracy because we don't use a dNBR approach and instead rely on average field size
- dnBR approach has false detects that we do not have in this method

2014 NEI Time Line

- Feb/March 2015
 - Use 2014 updated USDA NASS Cropland Data Layer (CDL) (2/2/15 release date)
 - Create separate county-level daily estimates (by crop type) and grass/rangeland
- April 2015: post draft ag burning acres burned and emission estimate results on CHIEF for review by S/L/T's and other interested parties
- Refine and/or revise as needed based on comments received to move towards a set of EPA-based final emission estimates"

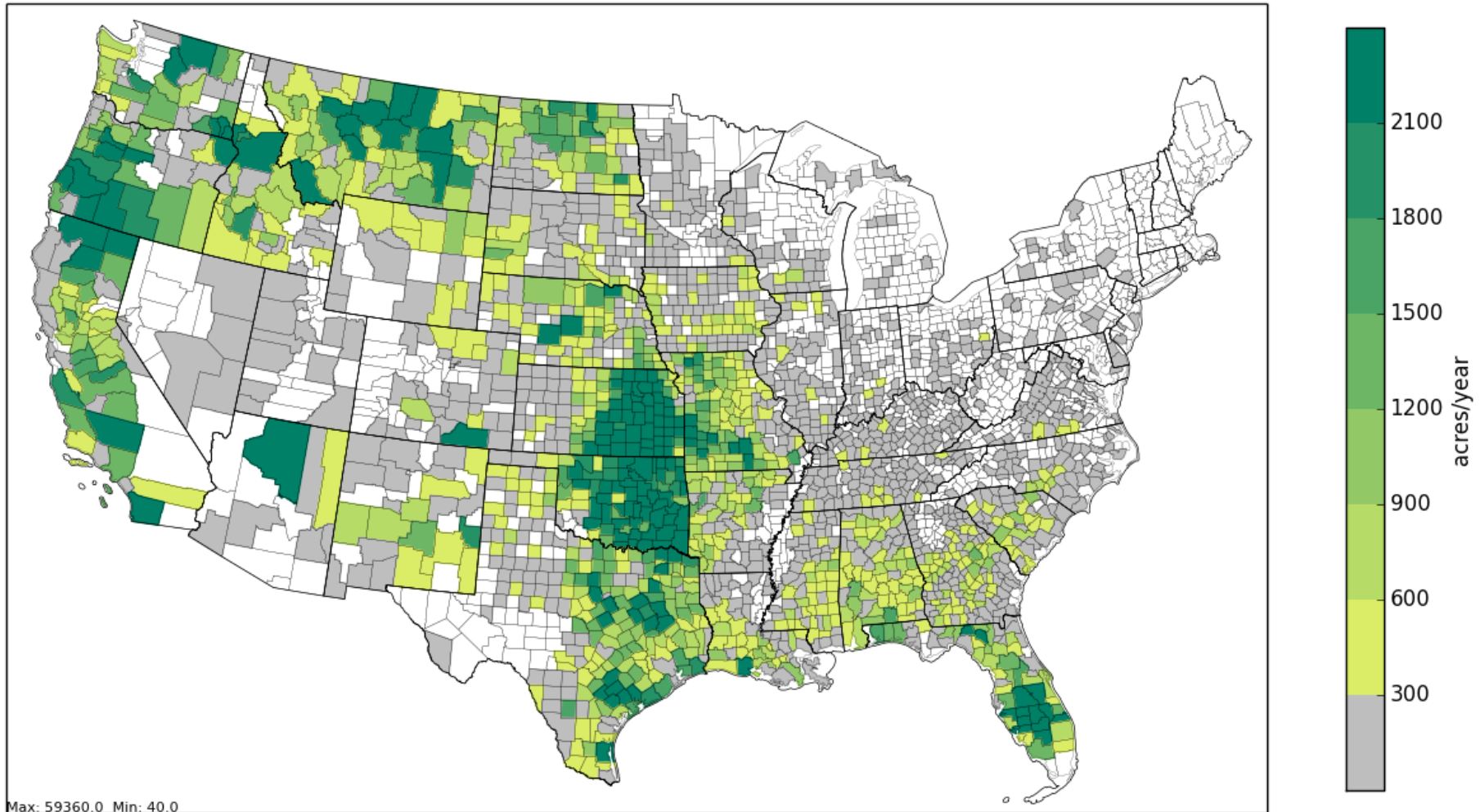
Draft 2014 Crop Residue Acres Burned

Draft 2014 NEI Crop Residue Acres Burned



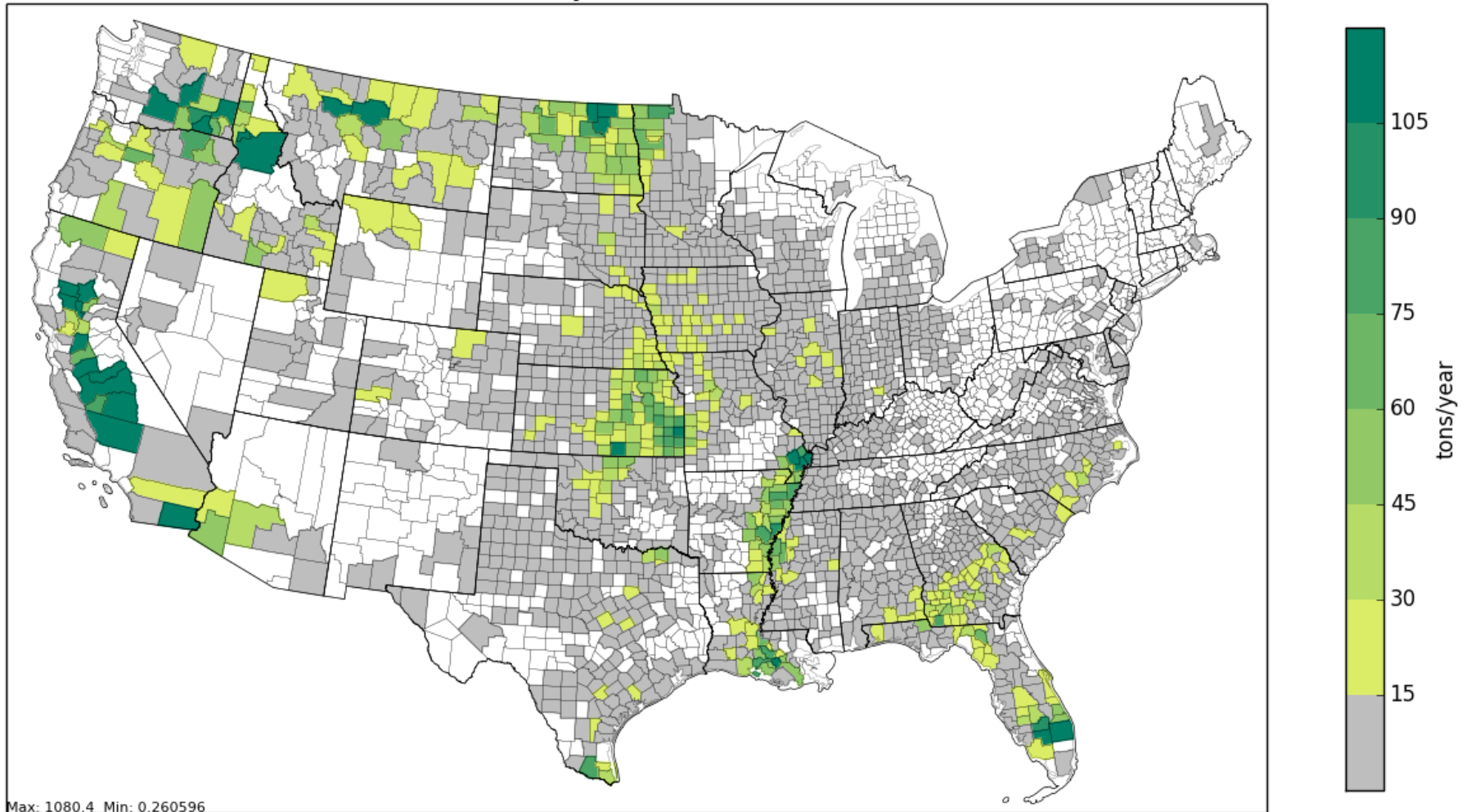
Draft 2014 Grass/Pasture Acres Burned

Draft 2014 NEI Grass/Pasture Acres Burned



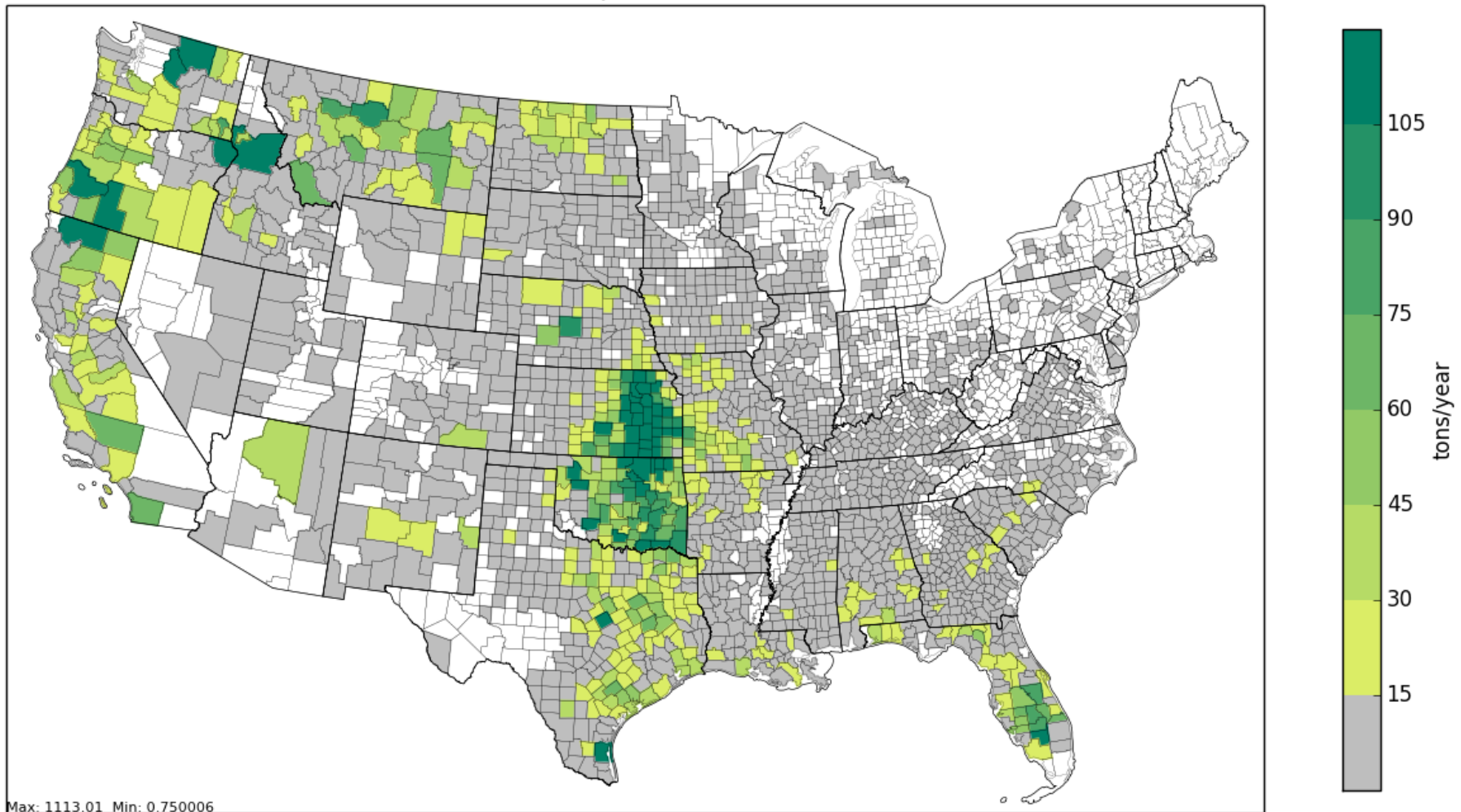
Draft 2014 Crop Residue PM2.5 Emissions

Draft 2014 NEI Crop Residue PM2.5 Emissions

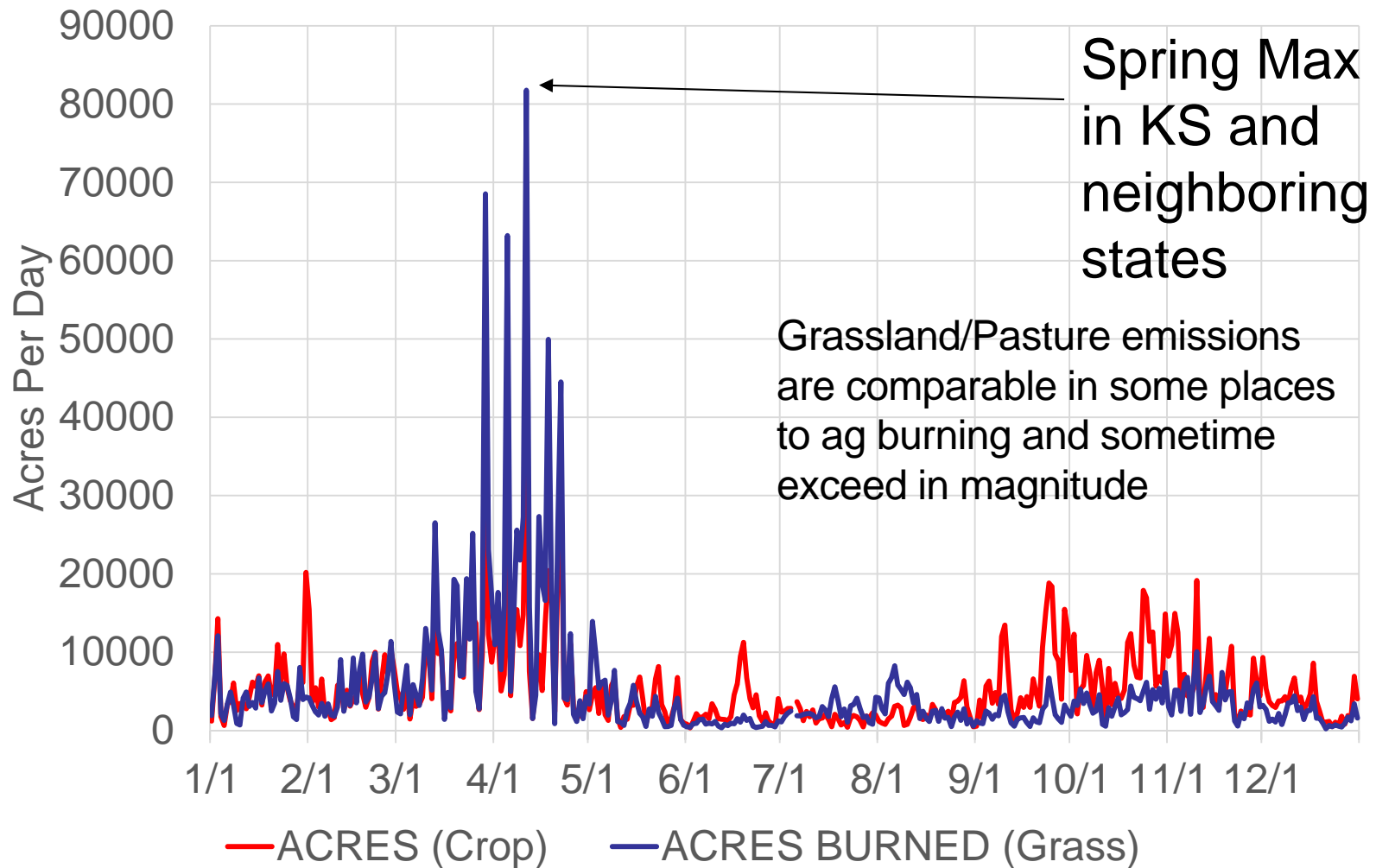


Draft 2014 Grass/Pasture PM2.5 Emissions

Draft 2014 NEI Grass/Pasture PM2.5 Emissions

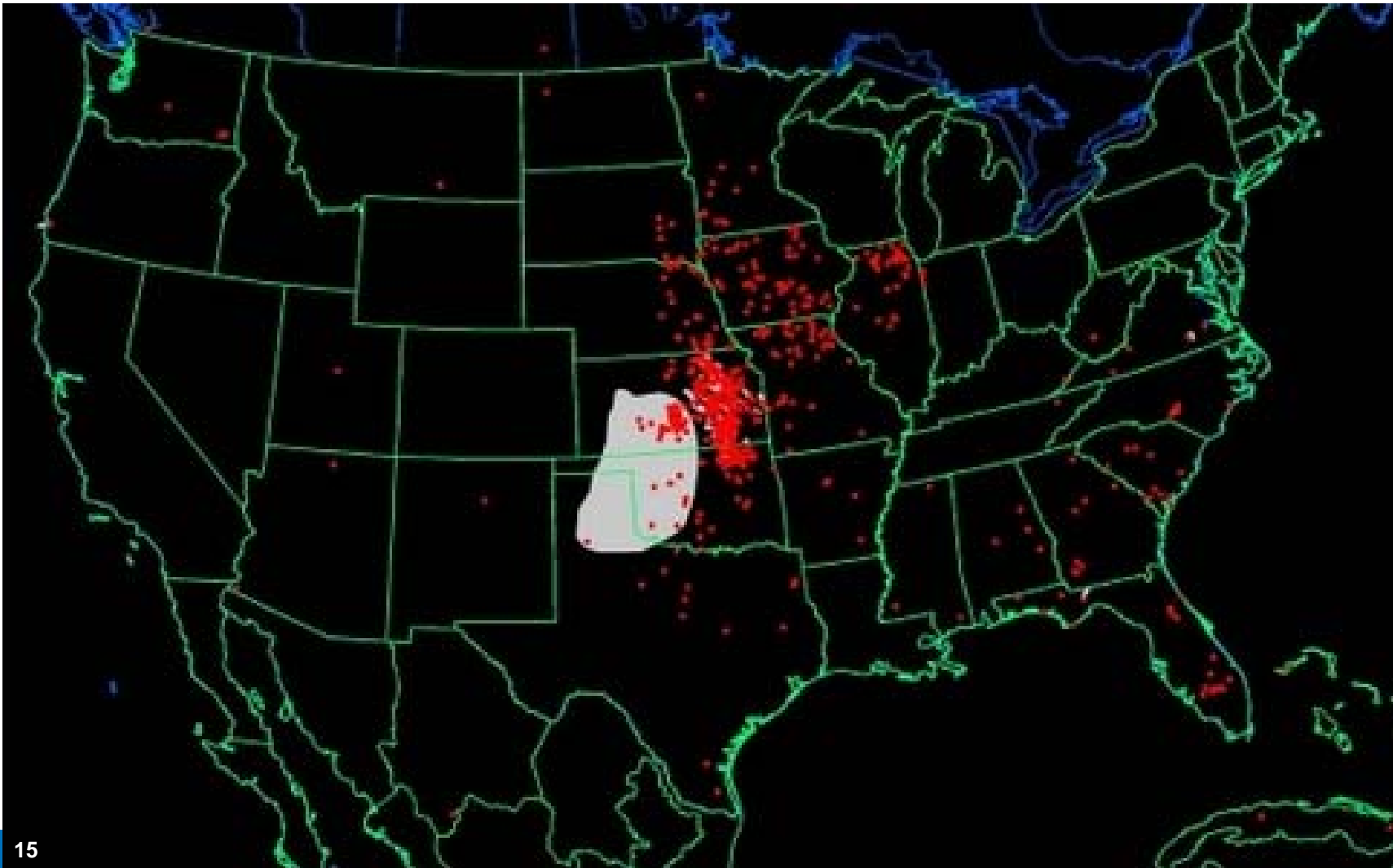


Time Series of Crop Residue and Grass/Pasture Acres Burned 2014



Example of Spring Maximum in Grass/Pasture

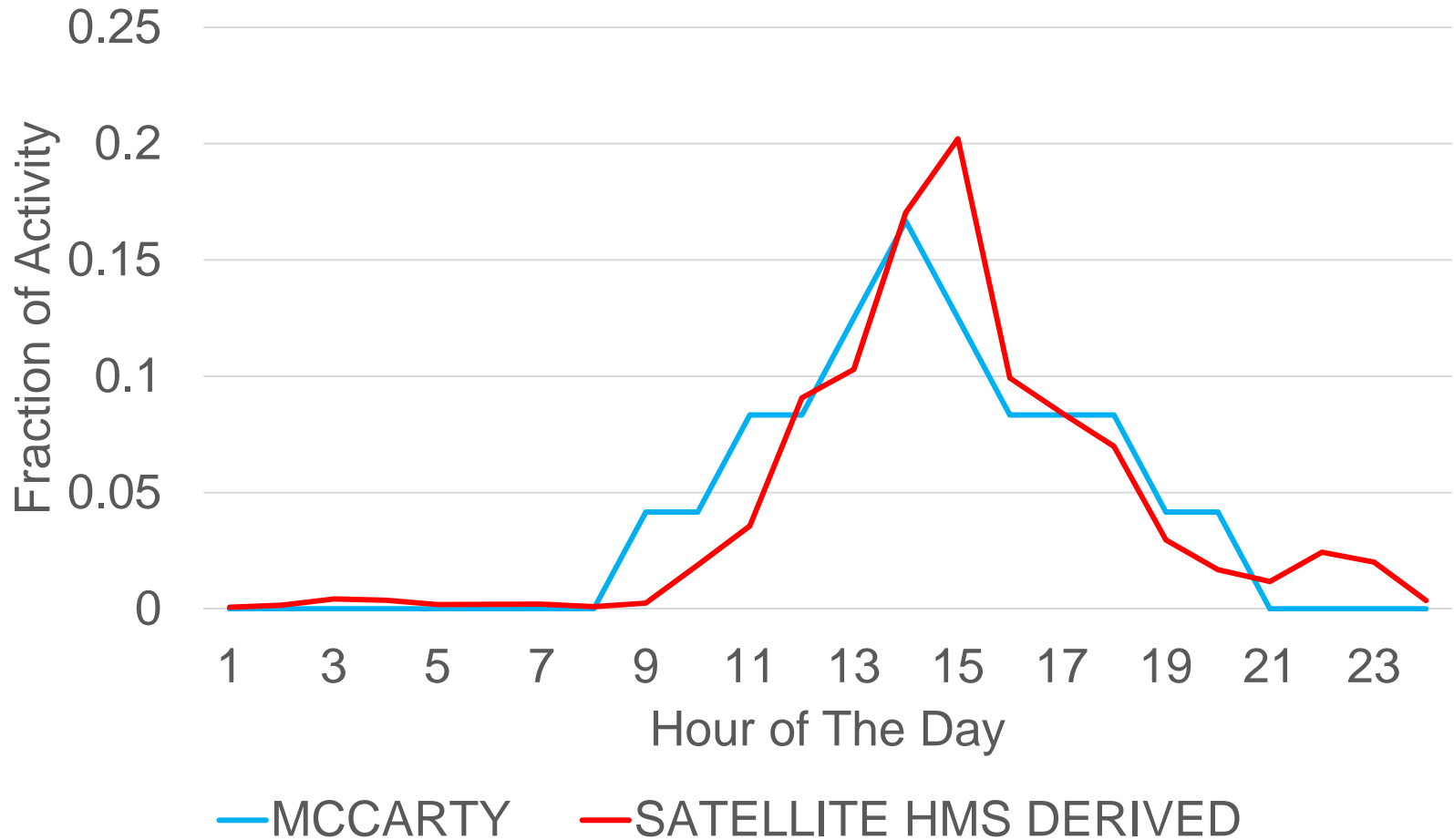
April 11, 2014 Hazard Mapping System Graphic



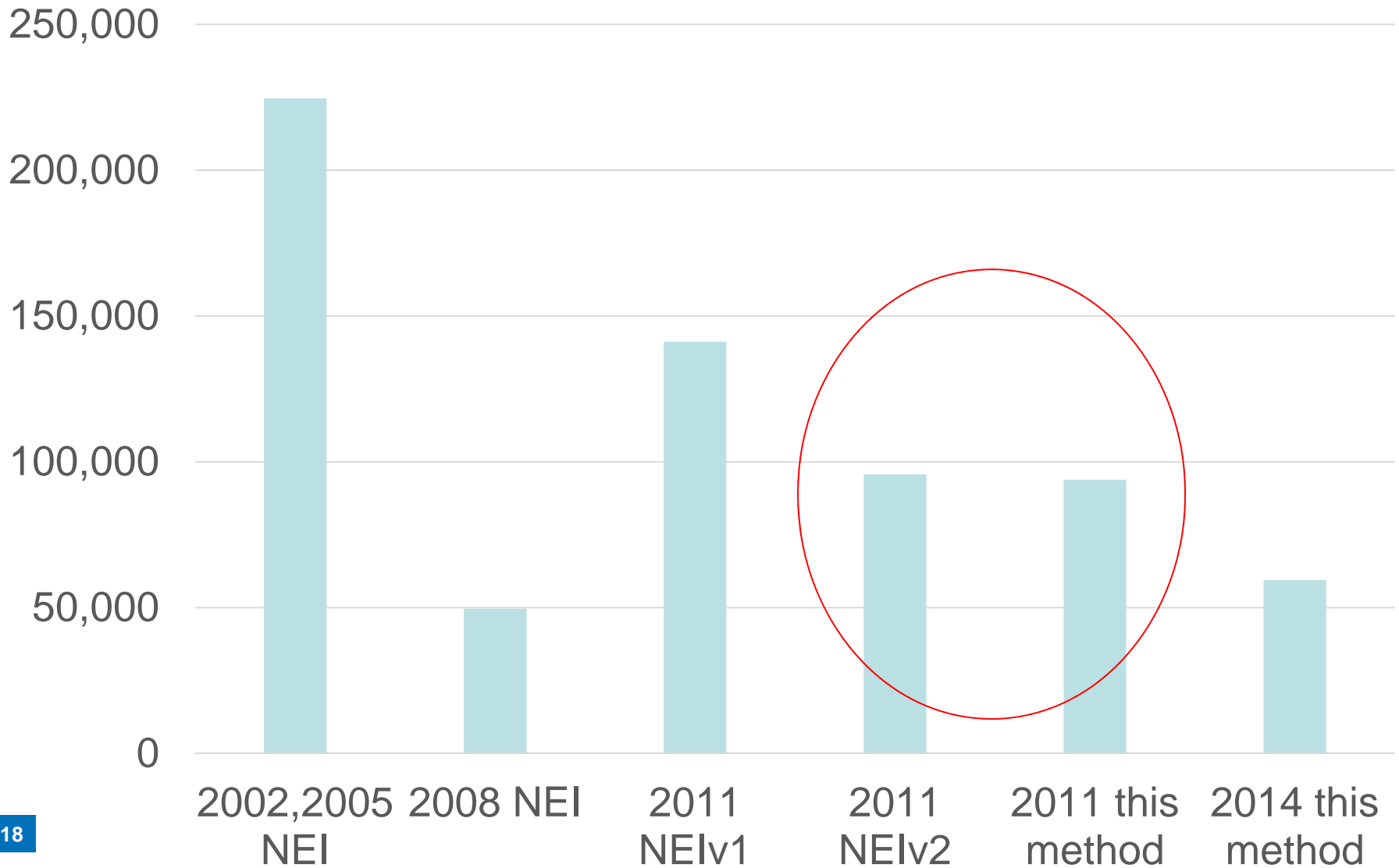
Diurnal Profile Analysis for Crop Burning

- Current 2011 emissions platform for crop residue burning: temporal profile based on field work of J. McCarty
- Use time of detect with ag burning identified fires and adjust to local time and sum up acres over the 24 hours.
- Compare with current temporal profile
- Good match!

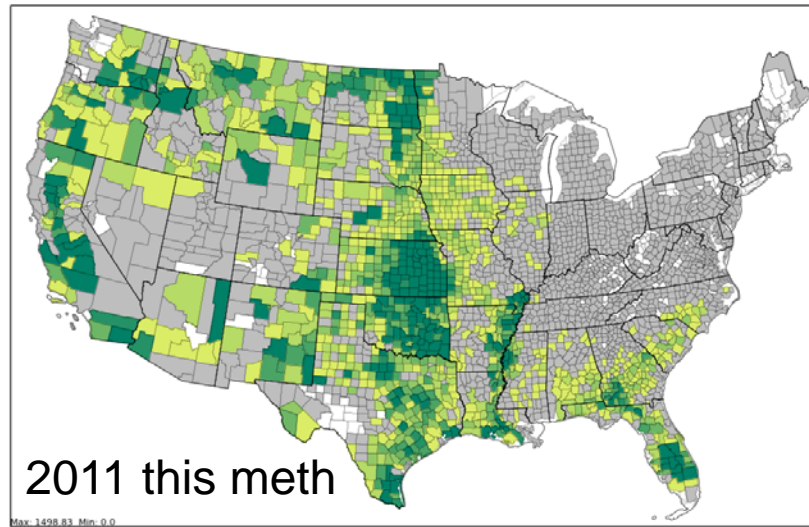
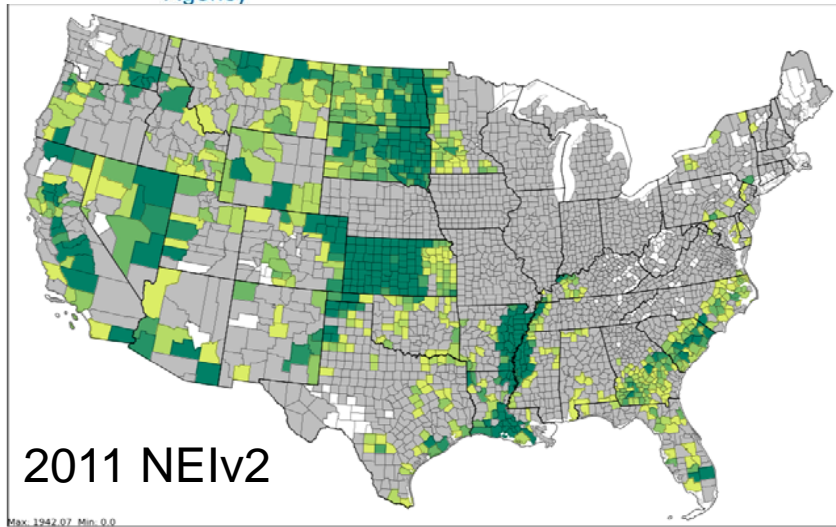
Verification of Crop Burning Diurnal Temporal Profile with Satellite Detections



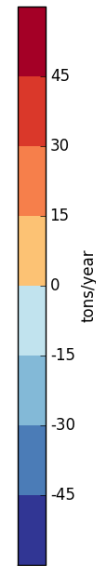
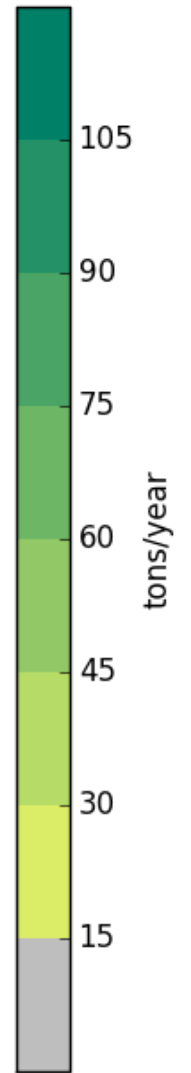
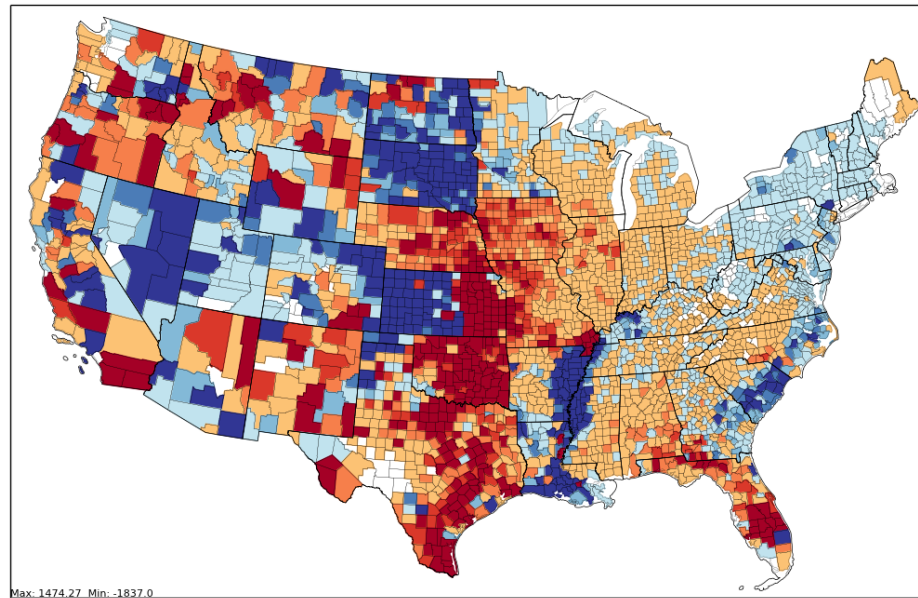
Comparison of PM_{2.5} Emissions from Crop Residue Burning



2011 NEIv2 Crop Residue PM2.5 Emissions vs This Method



Difference in 2011 PM2.5 Emissions



Next Steps

- Incorporate feedback from states
- Remove the ag and rangeland fires from HMS dataset before sending to SmartFire system to avoid double counting in the wildfire and prescribed fires
- Update and revise 2014 estimates
- Review time series and spatial maps of individual crop types
- Estimate emissions from additional years (e.g. 2012,2013) and look for year to year trends



Extra Slides



Emission Factors, Fuel Loading, Combustion Completeness

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/le ntils	2.95	0.75	12.31

Emission Factors (cont)

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

Definitions (1)

- **Croplands**
 - Established crop areas that produce food, fiber, and seeds
 - Fallow fields
 - Categories: Bluegrass, Corn, Cotton, Rice, Soy, Sugarcane, Wheat, Other, Fallow, Double Crops
- **Grass and Pasture**
 - Single Land use category in the underlying land use data set
 - Originally several categories that were merged into one (Jan 2014 update) due to inconsistency in reporting
- **Residue Burning**
 - Pre-harvest burning for removal of leaves and other biomass (sugarcane)
 - Post-harvest burning for removal of ground-level senescent vegetation.

Definitions (2)

- 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: Satellite Mapping Automated Reanalysis Tool for Fire Incident Reconciliation (Raffuse et al., 2009)

Grass/Pasture Diurnal Temporal Profile from Satellite Detections vs McCarty Profile

