Crop Residue Burning in the 2014 National Emissions Inventory

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  – Applied Science Program Grant #NNX09AP53G

• 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
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
- 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
  \[ E = \text{area burned} \times \text{combustion completeness} \times \text{emission factor} \times \text{fuel loading} \]
- 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
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 NEI Grass/Pasture Acres Burned

Max: 59360.0 Min: 40.0

Draft 2014 Grass/Pasture Acres Burned
Draft 2014 Crop Residue PM2.5 Emissions
Draft 2014 Grass/Pasture PM2.5 Emissions
Grassland/Pasture emissions are comparable in some places to ag burning and sometime exceed in magnitude.
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

Fraction of Activity

Hour of The Day

MCCARTY

SATELLITE HMS DERIVED

0 0.05 0.1 0.15 0.2 0.25

1 3 5 7 9 11 13 15 17 19 21 23
Comparison of PM2.5 Emissions from Crop Residue Burning

- 2002, 2005 NEI
- 2008 NEI
- 2011 NEIv1
- 2011 NEIv2
- 2011 this method
- 2014 this method
2011 NEIv2 Crop Residue PM2.5 Emissions vs This Method

Difference in 2011 PM2.5 Emissions

2011 NEIv2

2011 this meth
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
# Emission Factors, Fuel Loading, Combustion Completeness

<table>
<thead>
<tr>
<th>Crop Type</th>
<th>Fuel Loading (tons/acre)</th>
<th>Combustion Completeness</th>
<th>PM2.5 (lbs/ton)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kentucky bluegrass</td>
<td>2.91</td>
<td>0.85</td>
<td>23.23</td>
</tr>
<tr>
<td>Corn</td>
<td>4.19</td>
<td>0.75</td>
<td>9.94</td>
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<tr>
<td>Cotton</td>
<td>1.70</td>
<td>0.65</td>
<td>12.38</td>
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<tr>
<td>Rice</td>
<td>2.99</td>
<td>0.75</td>
<td>4.72</td>
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<tr>
<td>Soybean</td>
<td>2.50</td>
<td>0.75</td>
<td>12.38</td>
</tr>
<tr>
<td>Sugarcane</td>
<td>4.46</td>
<td>0.65</td>
<td>8.69</td>
</tr>
<tr>
<td>Wheat</td>
<td>1.92</td>
<td>0.85</td>
<td>8.07</td>
</tr>
<tr>
<td>Other/fallow/le  ntils</td>
<td>2.95</td>
<td>0.75</td>
<td>12.31</td>
</tr>
</tbody>
</table>
## Emission Factors (cont)

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

Fraction of Activity

Hour of The Day

MCCARTY  Satellite Derived