Burn Modeling of Wildfire Impacts on Air Quality

Talat Odman*, Rushabh Sakhpara, Yongtao Hu, Michael Chang and Armistead Russell

Georgia Institute of Technology

8th AQAST Meeting
at Georgia Tech, 2-4 December 2014
Motivation / Objective

- Prescribed burning (PB), a preferred method of land management, is an important source of air pollution in Southeast US.

- PB may be more suitable for dynamic AQ management than electric generation or vehicular traffic.

- Dynamic management may not only abate adverse impacts of PB on AQ, it may also increase PB capacity.

- Our objective is to forecast AQ impacts of PB as a basis for dynamic PB / AQ management.
Impact as a Sensitivity

- Sensitivity is the local change in pollutant concentration due to a change in PB emissions.

- PB impact can be approximated as:
  \[
  \Delta C_i \approx S_{ij}(1) \Delta E_j
  \]

- It is important to estimate baseline PB emissions accurately.
“Typical” fire emissions for Southeast US generated by Fire Averaging Tool using 7-, 15-, and 29-day averaging with the 2003-2009 inventories and actual fire emissions from the 2007 inventory.
• Can burns be forecasted from weather?
• We analyzed the relation between permitted burn acreage for 2010-2013 and observations at 18 fire weather stations in Georgia.
• Burn acreage depends on rainfall, temperature, RH, KBDI (drought) and wind speed.
• We built a regression tree from 2010-2012 data and forecasted burn acreage in 2013.
Burn Forecast Statistics

- Assuming 100 ac. (± 30%) countywide is a burn day

<table>
<thead>
<tr>
<th>False Alarms</th>
<th>Hits</th>
</tr>
</thead>
<tbody>
<tr>
<td>111</td>
<td>571</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Correct Negatives</th>
<th>Misses</th>
</tr>
</thead>
<tbody>
<tr>
<td>5797</td>
<td>91</td>
</tr>
</tbody>
</table>

- Accuracy: 0.97
- Probability of detection: 0.86
- False alarm ratio: 0.16
- Critical success index: 0.74
Who are the burners?

USFS or DoD Plantations
Where do they burn?

NLCD Land Use Map around GA

Legend:
- Ocean
- Open Water
- Ice/Snow
- Developed, Open Space
- Developed, Low Intensity
- Developed, Medium Intensity
- Developed, High Intensity
- Barren Land
- Deciduous Forest
- Evergreen Forest
- Mixed Forest
- Shrub
- Grassland
- Pasture/Hay
- Cultivated Crops
- Woody Wetlands
- Emergent Wetlands

Author: Rushabh Sakhpale
How much do they burn?
What is the Fuel Load?
Forecasting PB Impacts on AQ

- Forecast burns from weather and burner information
  - County average for burn acreage
  - Burner type (institutional, commercial or small) for location
- Estimate emissions for forecasted burns
  - FCCS fuelbed maps for fuel loads
  - Fuel moisture observations for fuel consumption
  - Emission factors for Southeast US fuels
- Estimate vertical distribution of emissions
  - Plume rise calculations for fraction below/above PBL height
- Forecast impacts of PB emissions on PM$_{2.5}$ and O$_3$
  - Hi-Res2 with DDM-3D (1$^{st}$-order) for tracking PB emissions from pilot fire districts or counties
Example Forecast

- November 21, 2014
- “Burn day” (assumed) in pilot district **Flint North**
- Burn location randomly assigned
  - Acreage based on historical burn data
- Forecasts of PB Impacts on $\text{PM}_{2.5}$ and $\text{O}_3$
PM$_{2.5}$ & PB Impact on PM$_{2.5}$

24-hr Avg. PM$_{2.5}$

Flint North’s Impact
O₃ & PB Impact on O₃

8-hr Max. O₃

Flint North’s Impact

Daily max8hrO₃ Concentration on 20141121

PB Impact on Daily max8hrO₃ Concentration on 20141121
Evaluation: Williams Fire

<table>
<thead>
<tr>
<th>PM$_{2.5}$</th>
<th>Emissions (Mg)</th>
<th>Mean bias (µg/m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bottom-up</td>
<td>27.37</td>
<td>-86.3</td>
</tr>
<tr>
<td>Satellite</td>
<td>11.65</td>
<td>-102.2</td>
</tr>
<tr>
<td>Bottom-up FER</td>
<td>27.37</td>
<td>-13.6</td>
</tr>
</tbody>
</table>
Conclusions

• PB impact forecasting is potentially one of the most beneficial applications of source impact forecasting for dynamic AQ management.

• System being operationalized in HiRes2
  – Check if permits translate to actual burns
  – Track burned plots of land and exclude from future burn forecasts
  – Estimate fuel loads (e.g. MODIS-enhanced fuels)

• Evaluation in 2015 burning season
Acknowledgements

• NASA
• US EPA
• Georgia EPD

• Georgia Forestry Commission