How Prescribed Burning and Wildfires Can Impact Daily Air Quality Forecasting
• Air Quality Forecasting Overview
• Prescribed Fire Impacts Case Study
• 2016 Wildfires Lessons
• Conclusions
Air Quality Forecasting Overview
Forecast air quality for six regions within North Carolina:

- **Asheville** Valleys and Ridge Tops
- **Hickory**
- **Charlotte**
- **The Triangle**
  - Including: Raleigh/Durham/Chapel Hill
- **Rocky Mount**
- **Fayetteville**

- The Triad area is handled by the Forsyth County Office of Environmental Assistance and Protection
Air Quality Forecasting Overview
The Air Quality Index (AQI)

• We **classify air quality** using a number-based, color-coded system called the Air Quality Index (AQI)

• The AQI is a simple way of relaying to the public what the air quality currently is, or is forecast to be

• Forecast is issued 7 days per week

• Initially issued by 3:00 pm for next day; then revised, as needed, until next forecast is issued.

### Air Quality Index (AQI) Values

<table>
<thead>
<tr>
<th>Air Quality Index (AQI) Values</th>
<th>Levels of Health Concern</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 to 50</td>
<td>Good</td>
</tr>
<tr>
<td>51-100</td>
<td>Moderate</td>
</tr>
<tr>
<td>101-150</td>
<td>Unhealthy for Sensitive Groups</td>
</tr>
<tr>
<td>151-200</td>
<td>Unhealthy</td>
</tr>
<tr>
<td>201-300</td>
<td>Very Unhealthy</td>
</tr>
<tr>
<td>301 to 500</td>
<td>Hazardous</td>
</tr>
</tbody>
</table>
Forecasting the air quality is like solving a gigantic puzzle: many different atmospheric and human activity elements to consider:

- **Current state of the atmosphere and air mass**
  - Ambient monitoring data
  - Satellites
  - Radar
  - Media reports

- **Meteorological forecast** of atmospheric changes
  - Pattern changes such as cold or warm frontal passages, precipitation events, wind speed and directional changes

- **New or ongoing sources of polluted air mass** both locally and further away
  - Mobile emissions (work week commute, holiday travel, etc.)
  - Smoke from wildfires, prescribed burns, agricultural burns
  - Pollution transport from other locations (as far away as Canadian wildfires or African dust!)
**Air quality forecasting** is further complicated by prescribed & agricultural burns

- Not well-announced or known
- Emissions not considered in Air Quality Models
- Leads to under-prediction of PM2.5 and PM10 concentrations in forecast
Prescribed Fire Impacts on Air Quality Forecast

Case Study: Region-wide Prescribed Burn Event
Prescribed Fire Impacts on Air Quality Forecast
March 16, 2013 Regional Event – The Forecast

PM2.5 Concentrations @ 2pm, 3/15/2013

Used Friday, 3/15/2013 hourly PM2.5 concentrations for Saturday, 3/16/2013 forecast (primarily Code Green across the southeastern U.S.)
Meteorological analysis and model projections supported a continuation of Code Green conditions on Saturday, 3/16/2013.
• Hourly PM2.5 concentrations early on 3/16 were elevated well within the Code Yellow range across the state

• 24 hour backward air parcel trajectory analysis shows air parcels over NC early on 3/16 were originating from central and northern MS/AL 24 hours prior

<table>
<thead>
<tr>
<th>AQI Category</th>
<th>Index Values</th>
<th>Revised Breakpoints (µg/m³, 24-hour average)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Good</td>
<td>0 - 50</td>
<td>0.0 – 12.0</td>
</tr>
<tr>
<td>Moderate</td>
<td>51 - 100</td>
<td>12.1 – 35.4</td>
</tr>
<tr>
<td>Unhealthy for Sensitive Groups</td>
<td>101 – 150</td>
<td>35.5 – 55.4</td>
</tr>
<tr>
<td>Unhealthy</td>
<td>151 – 200</td>
<td>55.5 – 150.4</td>
</tr>
<tr>
<td>Very Unhealthy</td>
<td>201 – 300</td>
<td>150.5 – 250.4</td>
</tr>
<tr>
<td>Hazardous</td>
<td>301 – 400</td>
<td>250.5 – 350.4</td>
</tr>
<tr>
<td>Hazardous</td>
<td>401 – 500</td>
<td>350.5 – 500</td>
</tr>
</tbody>
</table>
A review of high resolution satellite imagery reveals numerous small fires burning across the Deep South on Friday afternoon (3/15).

- Including central and northern MS and AL, where 24 hour back trajectories from NC on 3/16 originated.
- Some clouds over northern MS/AL/TN/GA makes it difficult to discern all of the fire activity there.
Prescribed Fire Impacts on Air Quality Forecast
March 16, 2013 Regional Event – Summary

- Background particle pollution levels on Friday, 3/15/2013 were in the Code Green range across the southeastern U.S.

- Numerous small, prescribed burns during the afternoon almost doubled the background PM2.5 concentrations across the region

- Air quality models have no inherent way to “see” fires unless the data is programmatically ingested into them, so they run as if the fires do not exist:
  - In this case, model simulations essentially showed what concentrations would have been without the prescribed burns (Code Green)
Prescribed Fire Impacts on Air Quality Forecast

Case Study: Localized Prescribed Burn Event
Prescribed Fire Impacts on Air Quality Forecast
March 21, 2017 Local Prescribed Burn Event

• Prescribed burn conducted at Fort Bragg AFB, NC on 3/21/17
  - Smoke trapped near the surface due to collapse of the planetary boundary layer
  - Effect similar to putting a lid on a steaming pot trapping steam inside

• Early the next morning smoke drifted northeast
  - PM2.5 monitor readings spiked at 66 µg/m³
  - Areas along the back trajectory corridor were experiencing Code Orange to Code Red PM2.5 concentrations for several hours until smoke could mix out as the boundary layer rose due to surface heating
Prescribed burn occurred on 3/21/17 and resulted in smoke being trapped near the ground.

Particle pollution concentrations – though slightly elevated into the low Code Yellow range elsewhere across NC – were doubled in the corridor where smoke was trapped.

Air quality forecasters had no prior knowledge of this burn, so the forecast was for only low Code Yellow PM2.5 concentrations.
Wildfire Impacts on Air Quality Forecast

Lessons from the Western NC wildfires of 2016
~30 Wildfires
>80,000 Acres
October 23 ~ November 28
>$50 million (NC Fires)
State of Emergency in 47 NC Counties
2300 firefighters (USFS-NC led fires)
Multiple large, dynamic fires burned across the Appalachians, fall 2016. Several important lessons learned.

- Improving communication among official channels.
  - County Emergency Management officials
  - Joint Information Center (JIC)
  - U.S. Forest Service
- Forecast regions too broad spatially; county-based forecasting needed statewide.
Mobile Monitoring - $PM_{2.5}$

**WNC Permanent monitors:**
- Bryson City
- Cherokee (Tribal monitor)
- Asheville (WNCRAQA)
- Spruce Pine
- Hickory

**NCDAQ Mobile Monitor Sites:**
- Sylva
- Lake Lure
- Rutherfordton
- Marion
- Hendersonville

**USFS Mobile Monitors**
- Robbinsville
- Andrews
- Franklin
- Brevard
- Burnsville
- Murphy
Portable PM$_{2.5}$ Monitors

Monitors obtained from National cache, Regional/Forests, NC DAQ and NC Forest Service.

USFS - Air Resource Management
Department of Environmental Quality
Conclusions

• Prescribed Burning:
  • Can have a profound impact on air quality at the local and regional levels.
  • Air quality forecasts can be improved if the forecast team has information on prescribed burning the day before it occurs:
    • For example, when, where, how many, and how large is the prescribed burning activity?
    • Timely access to NCFS Smoke Management Database will be most helpful
    • Satellite imagery (Terra and Aqua) has limitations for identifying fire activity:
      • Cloudy days can obscure imagery
      • Delays in receiving imagery (2-3 hours)
Conclusions

• **Wildfires:**
  • Communication with sister agencies critical
    • NCFS, USFS, JIC, local programs
  • Use of mobile PM$_{2.5}$ monitors important to forecast accuracy for local areas
    • Ground truth

• **Current DAQ Priorities:**
  • Updating AQ forecast page to enable county-level forecasting
  • Developing wildfire information page to point user to key information
    • NCDAQ Air Quality Forecast Page
  • Keeping contact lists for local authorities updated (e.g., EMS staff)
Acknowledgements

• North Carolina’s Air Quality Forecast Team:
  • Bradley McLamb, Meteorologist I
  • Elliot Tardif, Meteorologist II
  • Nick Witcraft, Meteorologist II
Health Concerns

Particulate matter (PM$_{2.5}$)

The principal pollutant of concern from wildfire smoke

- **PM$_{2.5}$**: Combustion particles, organic compounds, metals, etc. (<2.5 μm (microns) in diameter)
- **PM$_{10}$**: Dust, pollen, mold, etc. (<10 μm (microns) in diameter)
- Human Hair: 50-70 μm (microns) in diameter
- Fine Beach Sand: 90 μm (microns) in diameter
Health effects:
- eye and respiratory tract irritation
- persistent cough, phlegm, wheezing
- difficulty breathing
- reduced lung function
- bronchitis
- exacerbation of asthma
- premature death
Health Concerns

Cardiac Arrest

**JAHA:** \( PM_{2.5} \) exposure was associated with increased risk of out-of-hospital cardiac arrests and IHD during the 2006–2007 wildfires in Victoria.

Source: Anjal et al; Impact of Fine Particulate Matter (PM2.5) Exposure During Wildfires on Cardiovascular Health Outcomes; Journal of the American Heart Association. 2015

**EPA Peat Bog Fire Study NC (2008):** The study found a 37 percent increase in emergency room visits for people with symptoms of heart failure …

Wildfires and Air Quality

The Context...

- One in three households has someone with respiratory issues: child with asthma, COPD, emphysema, etc. 26 million have asthma in US.
- Conditions: asthma (7.3% prevalence), COPD (6.3% prevalence), chronic rhinitis (20% prevalence), pneumonia, lung cancer & other (CDC).
- Sensitive groups at risk: people with asthma, older adults and those of low income. Science indicates: pregnant women, diabetics.

- And now wildland and agricultural fires contributing to more than 40% of PM2.5 based on the EPA’s 2011 National Emission Inventory
Wildfires and Air Quality

Acres by Percent

- Forestry - 8,946,900 Acres
- Agriculture - 2,795,099 Acres

Department of Environmental Quality