Evaluating the Wildfire Emission estimates in an Air Quality Simulation of the 2016 Southeastern United States Wildfires

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2016 Wildfires in the Southeast US

- Extreme drought in the SE US during fall of 2016 (AL, GA, TN, NC, SC)
- Tuscaloosa, AL -- longest streak of no precipitation (71 days)
- Birmingham, AL -- longest streak of no precipitation (61 days)
- Montgomery, AL; Atlanta, GA; Charleston, SC - no precipitation for 28 days in November
- Wildfires burned over 72,000 hectares during the month of November in the SE US
- Shifting winds during the wildfire period resulted in regional scale impacts
- Some of the more significant fires included:
  - Gatlinburg Fire (6,936 hectares)
  - Tellico Fire (5,534 hectares) (more details to follow)
  - Party Rock Fire (2,890 hectares)
• Boundary conditions from hemispheric WRF-CMAQ
• Fire INventory from NCAR (FINN) -- a daily fire emissions product for atmospheric chemistry models
• Coupled WRF-CMAQ simulations with and without FINN fire emissions. 24 Hour Simulations similar to standard retrospective simulations (no forecasting).
• CB05E51 mechanism
• Near-real-time (NRT) modeling with CMAQ version 5.2 beta
• WRF version 3.8
• Simulation period Nov 7-17, 2017. Does not include Gatlinburg Fire.
• First implementation of fires in our 12 km NRT modeling system
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- Implementation of fire emissions from FINN in the modeling system
- Download SAPRC99 FINN global emission dataset daily at 2:30 AM local time
- Convert data to SMOKE FF10 format with python script
  - No fuel loading or heat release in FINN data
  - Scale heat flux from PM$_{2.5}$ using constant emission factor for all fires (kg fuel per g emission) (0.14 kg fuel per gram of PM$_{2.5}$ emission)
  - Add FIPS codes to each fire (needed for SMOKE processing and temporal allocation)
  - Sum VOC and CH$_4$ to get TOG and apply wildfire TOG profile to get CB05E51 (or CB6) emissions
- Merge emissions with non-MODIS Hazard Mapping System (HMS) crop residue burning emission estimates (as in 2014 NEI) to avoid double counting.
- Use SMOKE to process fire emissions for CMAQ
- Compare CMAQ results to AIRNOW hourly PM2.5
CMAQ simulation of PM$_{2.5}$ from FINN fires

November 7-17, 2016

Min=-9.97 at (355,136), Max=29.62 at (314,108)
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- Six selected MODIS images comparing model results of PM$_{2.5}$ with observed smoke plumes for November 7, 10, 12, 14, 16, 17
- Days selected because they are mostly cloud free and readily available from the NASA archive (https://lance.modaps.eosdis.nasa.gov)
- 4 monitors near the fires selected for model evaluation
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November 7, 2016 18:30 UTC Aqua/MODIS

PM2.5 CMAQv5.0.2-NRT-FINN

November 7, 2016, 18:00 UTC
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Modeled vs. Observed PM2.5 Values - Nov 7

Daily Mean $\text{PM}_{2.5}$ Model vs Obs November 7
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PM2.5 CMAQv5.0.2-NRT-FINN

Good Qualitative Agreement
2016 Wildfires in the Southeast US

Modeled vs. Observed PM2.5 Values - Nov 10

Daily Mean PM$_{2.5}$ Model vs Obs November 10

ug/m$^3$
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- November 12, 2016 18:50 UTC

Wind direction different between observations and models (High Pressure and light winds)

- November 12, 2016 19:00 UTC
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Daily Mean PM$_{2.5}$ Model vs Obs November 12

Note: Some AIRNOW data missing
EPA

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PM2.5 CMAQv5.0.2-NRT-FINN

November 14, 2016 18:00 UTC

November 14, 2016 18:35 UTC
2016 Wildfires in the Southeast US

Daily Mean PM$_{2.5}$ Model vs Obs November 14
2016 Wildfires in the Southeast US

Modeled vs. Observed PM$_{2.5}$ Values - Nov 16

Daily Mean PM$_{2.5}$ Model vs Obs November 16

 ug/m³
2016 Wildfires in the Southeast US

PM2.5 CMAQv5.0.2-NRT-FINN
2016 Wildfires in the Southeast US

Daily Mean PM$_{2.5}$ Model vs Obs November 16

Modeled vs. Observed PM2.5 Values - Nov 17

- Modeled
- Observed

Harriman, LookRock, Knoxville, Bryson, LongCreek

 ug/m$^3$
Map created Nov 15th, 2016 by the Southern Area Incident Management Team

Source: https://inciweb.nwcg.gov/incident/map/5084/17/61209/
Tellico Fire

Daily Hectares Burned Tellico Fire
FINN vs INCIWEB

INCIWEB (National Wildfire Coordinating Group) vs FINN
Summary of Analysis

- Qualitative agreement between observed SMOKE plumes and WRF-CMAQ fire plumes using FINN data
  - Large fires produce plumes that have similar shape characteristics between the model and MODIS images (Nov 10)
- Poor model performance for magnitude of PM$_{2.5}$. Possible explanations:
  - Emissions too low or missing on cloudy days (emission factor, fuel loading, area burned)
  - Plume rise possibly too high, so emissions are transported away from the source
  - Model Resolution of 12 km cannot resolve the small details
  - Tellico Fire area burned underestimated by a factor of 4
- Not all fires produce a plume from satellite
- Wind direction sometimes incorrect (Nov 12)
Future Directions:

- **Sensitivity of model results to plume heights**
  - Use the 11-day period as a test case for future modeling improvements to plume rise
- **Extend simulations forward and backward into October/December**
- **Sensitivity of model results to filling in missing data on cloudy days**
- **Sensitivity of model to retrospective analysis of daily burn area**
- **Compare emissions with SMARTFIRE/Bluesky estimates**
- **Model evaluation of each emission and/or change to the system**
- **Compare Model AOD estimates with MODIS AOD**
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• Reference

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