



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

George Pouliot  
Rob Gilliam  
Brian Eder  
Ian McDowell  
Joe Wilkins  
Tom Pierce

International Emissions Inventory Conference  
Baltimore MD  
August 18, 2017



## 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)**



## 2016 Wildfires in the Southeast US

- **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).**
- **CB05E5I 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**

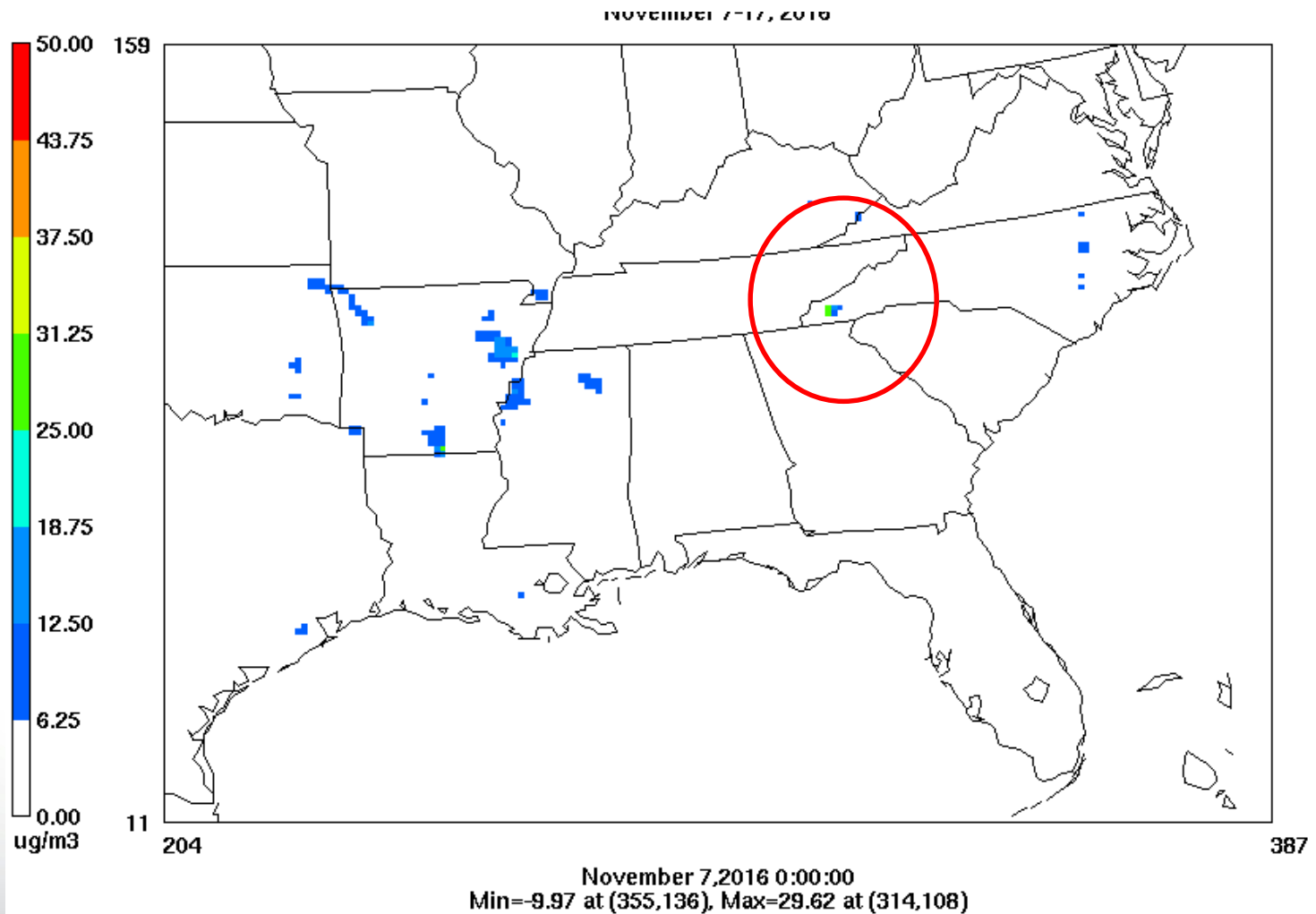


## 2016 Wildfires in the Southeast US

- **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  $PM_{2.5}$**



# CMAQ simulation of PM<sub>2.5</sub> from FINN fires





# 2016 Wildfires in the Southeast US

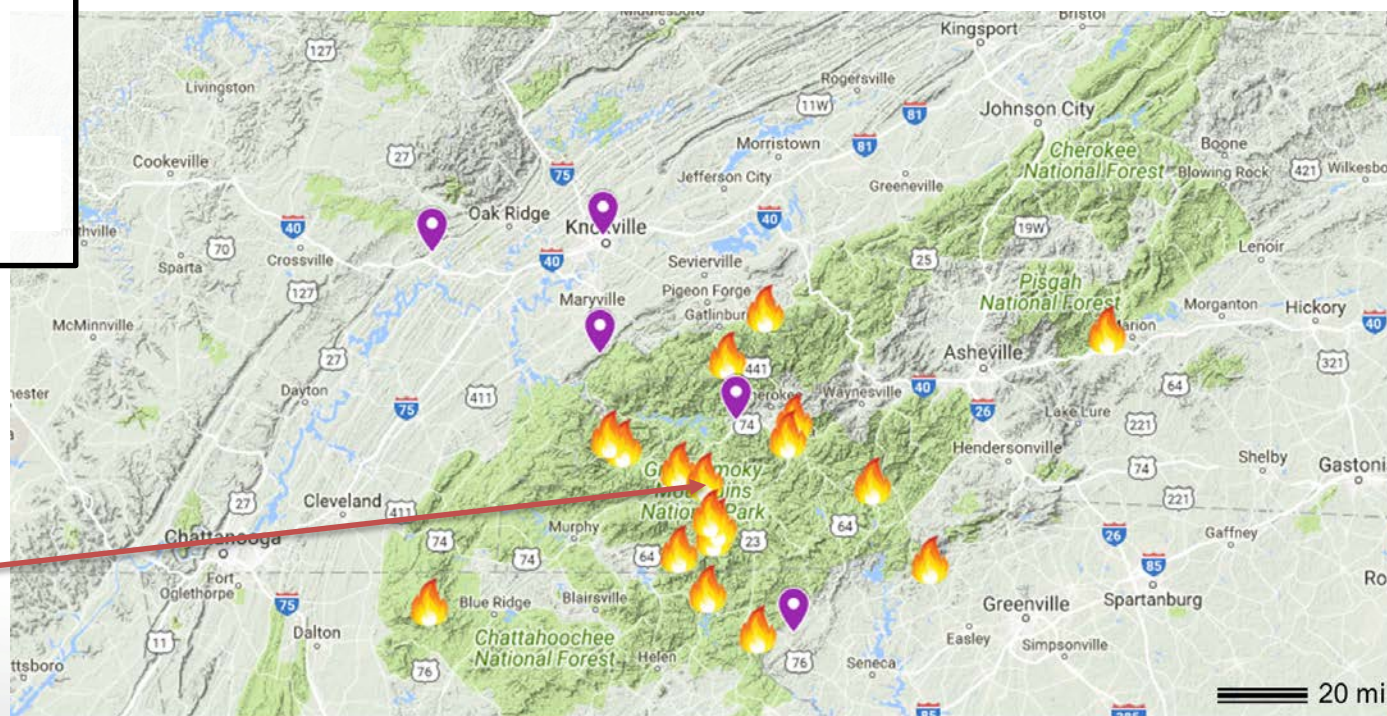
- Six selected MODIS images comparing model results of  $PM_{2.5}$  with observed smoke plumes for November 7, 10, 12, 14, 16, 17
- Days selected because they are mostly cloud free and readily available from the NASA archive (<https://lance.modaps.eosdis.nasa.gov>)
- 4 monitors near the fires selected for model evaluation



Fire Site



Monitor Site

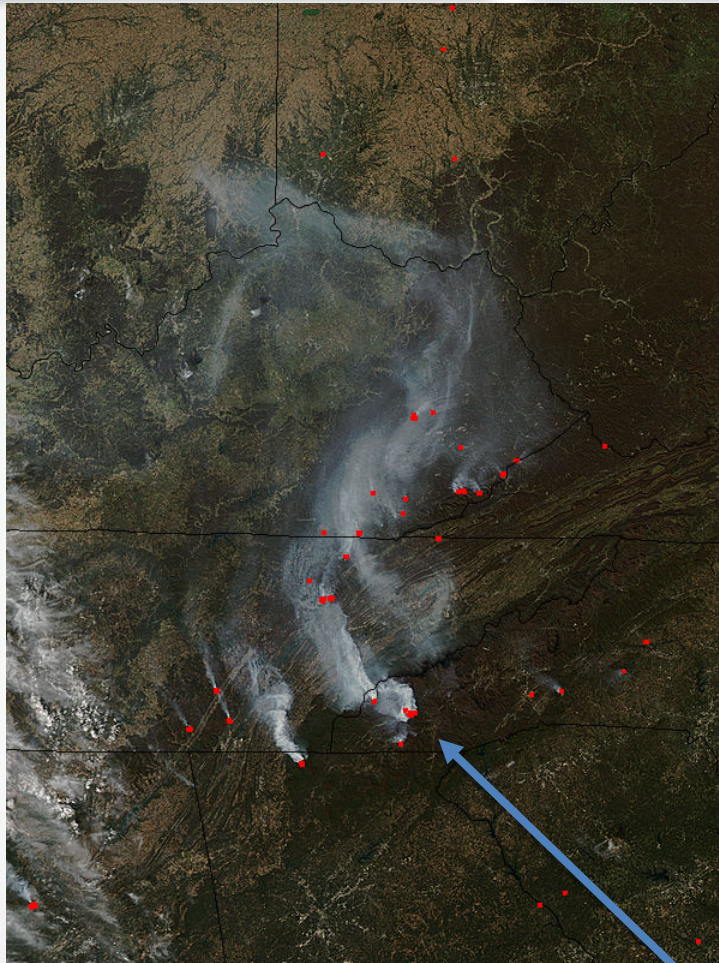


Tellico Fire



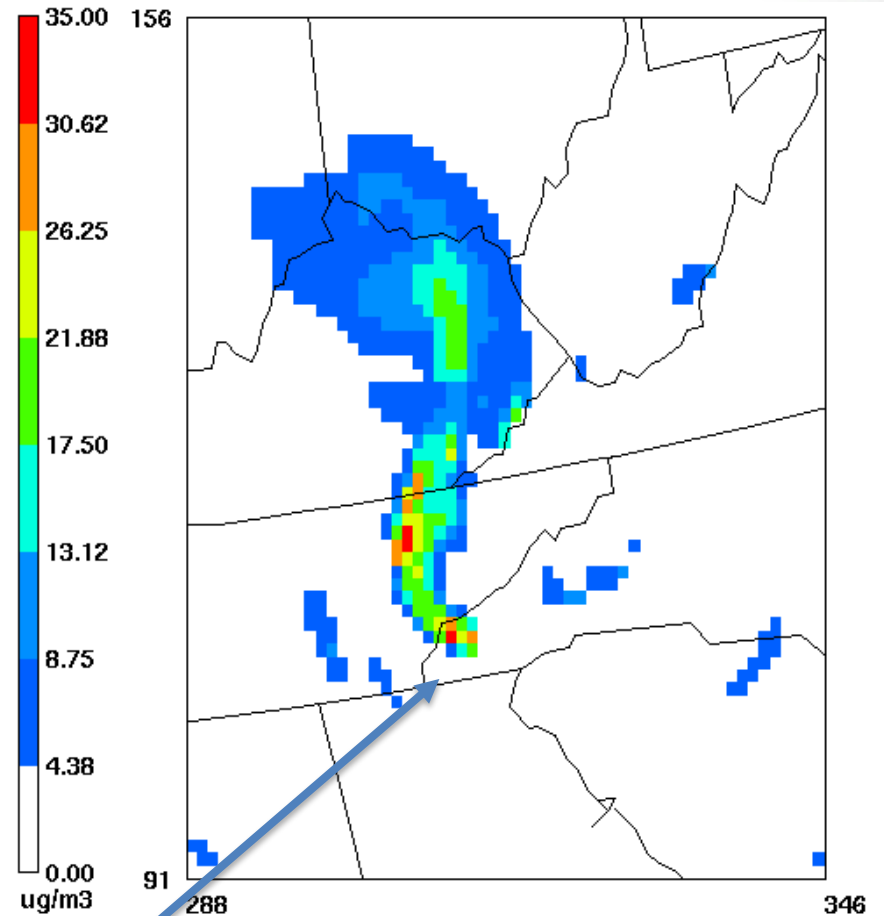


# 2016 Wildfires in the Southeast US



November 7, 2016 18:30 UTC Aqua/MODIS

### PM2.5 CMAQv5.0.2-NRT-FINN

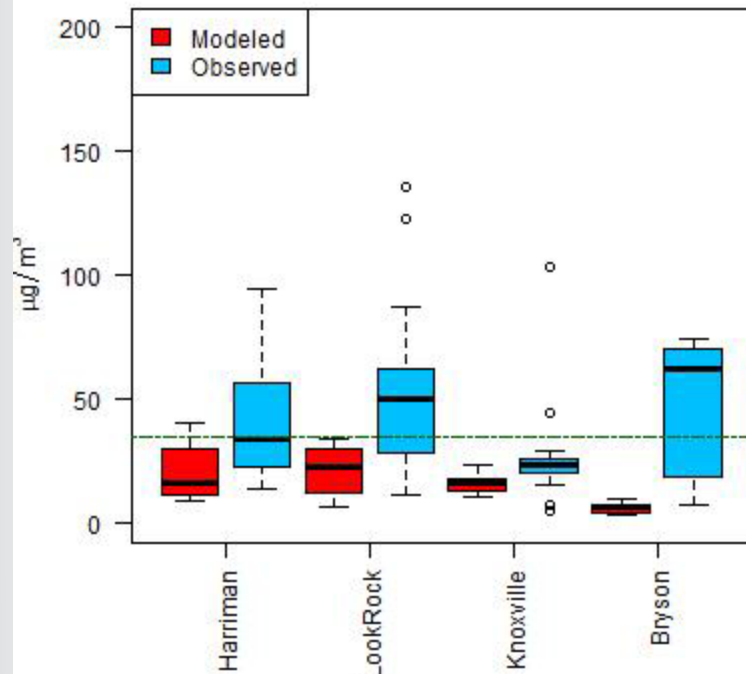


November 7, 2016, 18:00 UTC

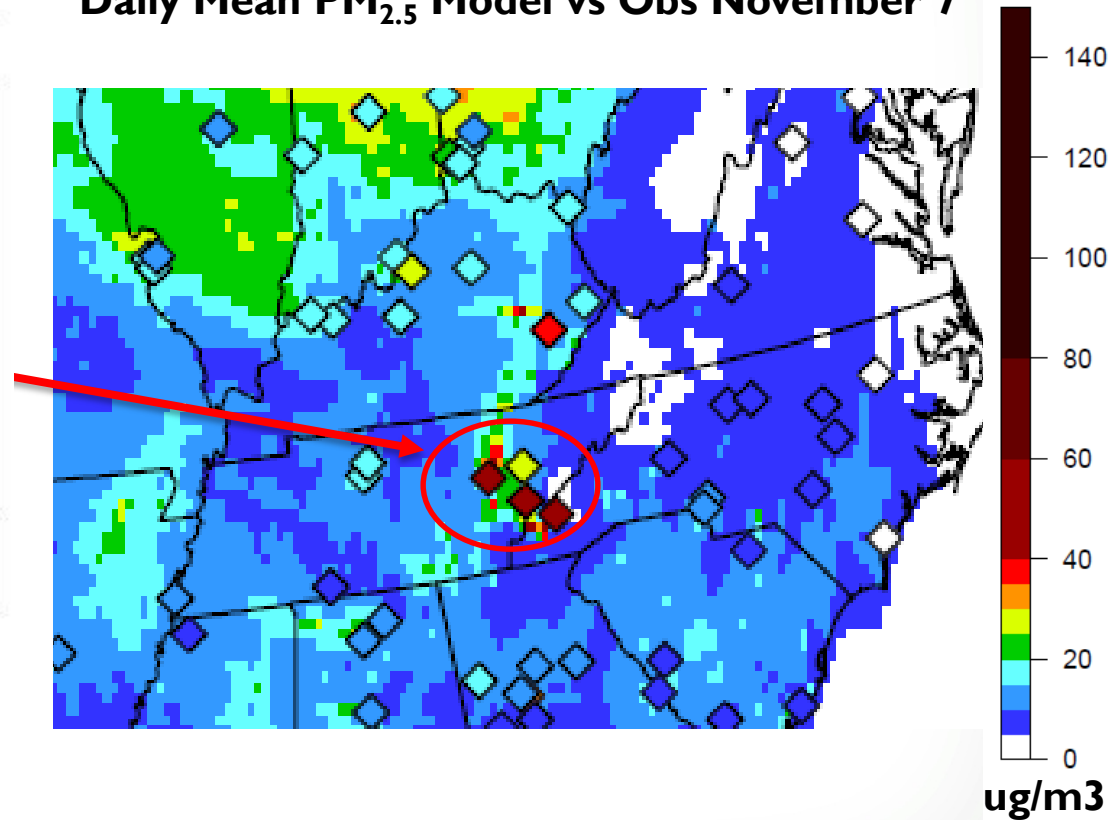


# 2016 Wildfires in the Southeast US

Modeled vs. Observed PM<sub>2.5</sub> Values - Nov 7



Daily Mean PM<sub>2.5</sub> Model vs Obs November 7

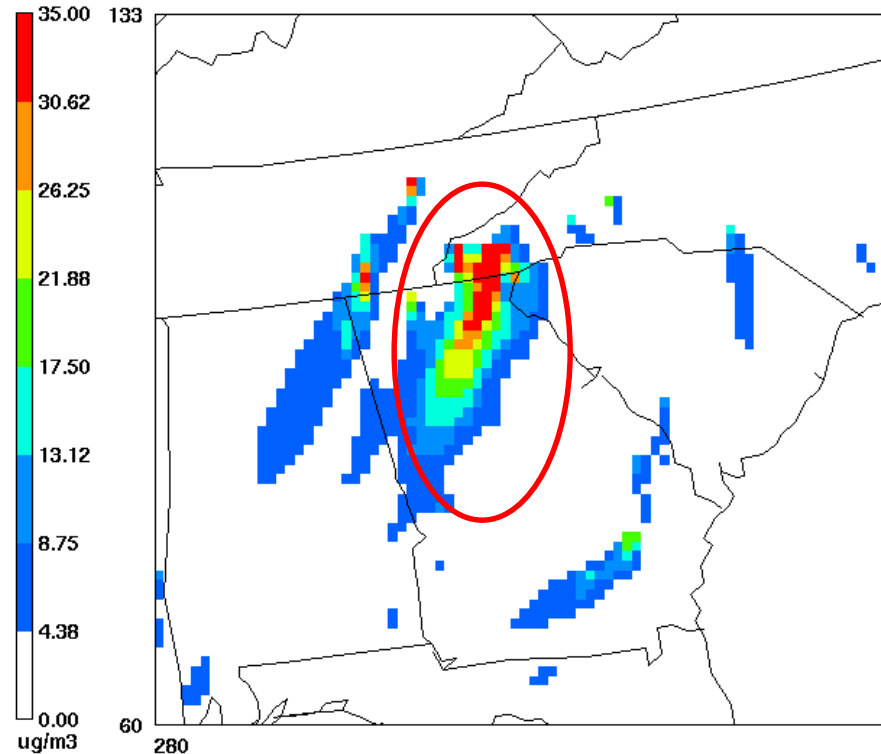
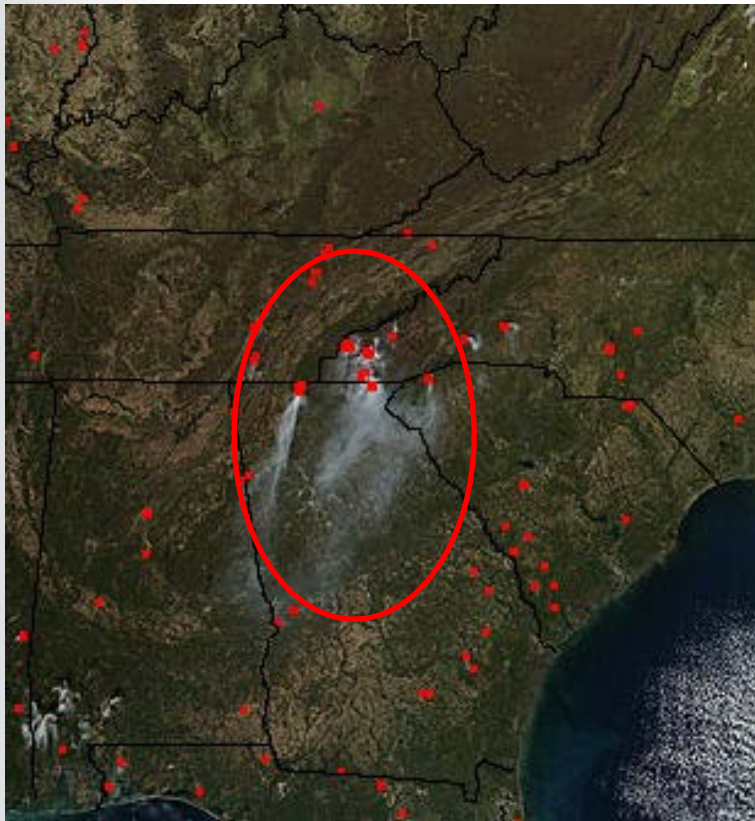






# 2016 Wildfires in the Southeast US

## PM2.5 CMAQv5.0.2-NRT-FINN



November 10, 2016, 19:00 UTC

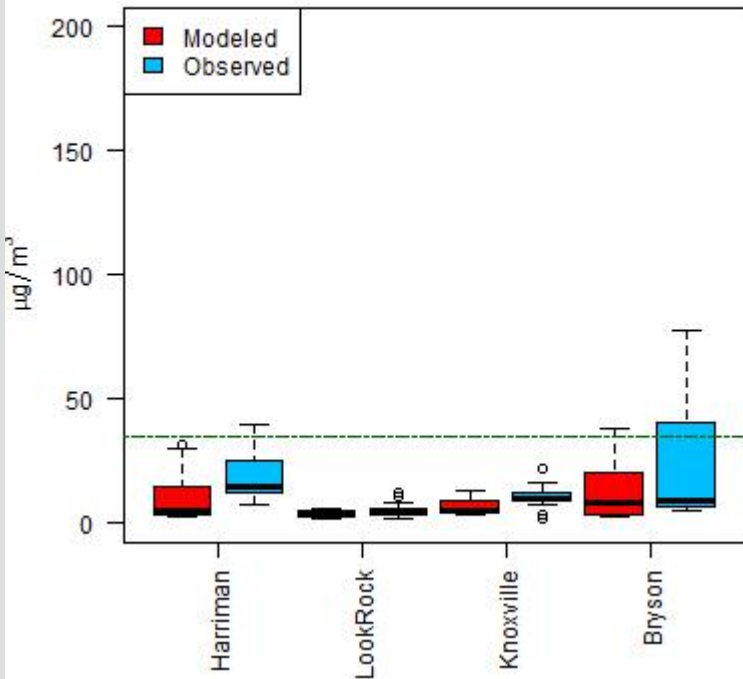
November 10, 2016 19:00 UTC

Good Qualitative Agreement

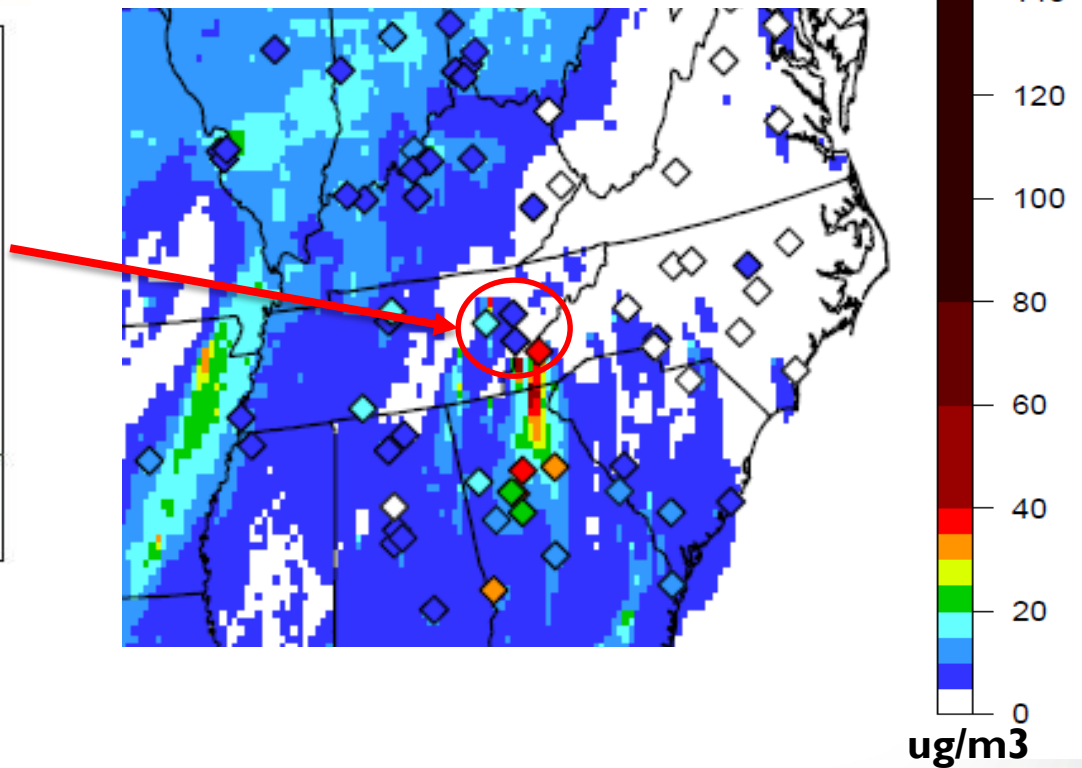


# 2016 Wildfires in the Southeast US

Modeled vs. Observed PM<sub>2.5</sub> Values - Nov 10

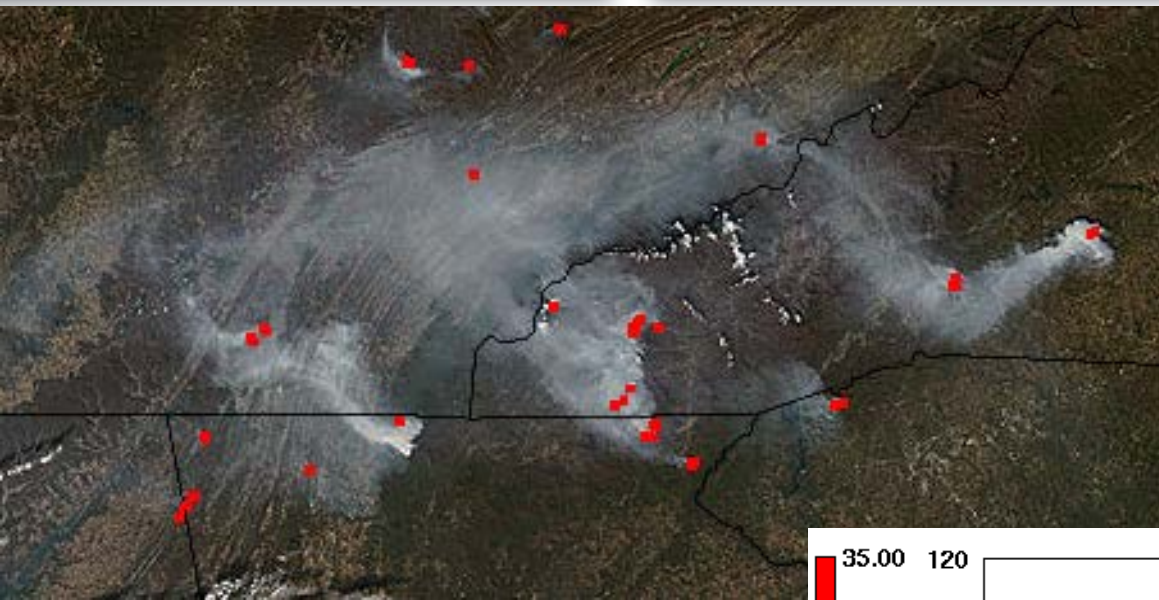


Daily Mean PM<sub>2.5</sub> Model vs Obs November 10

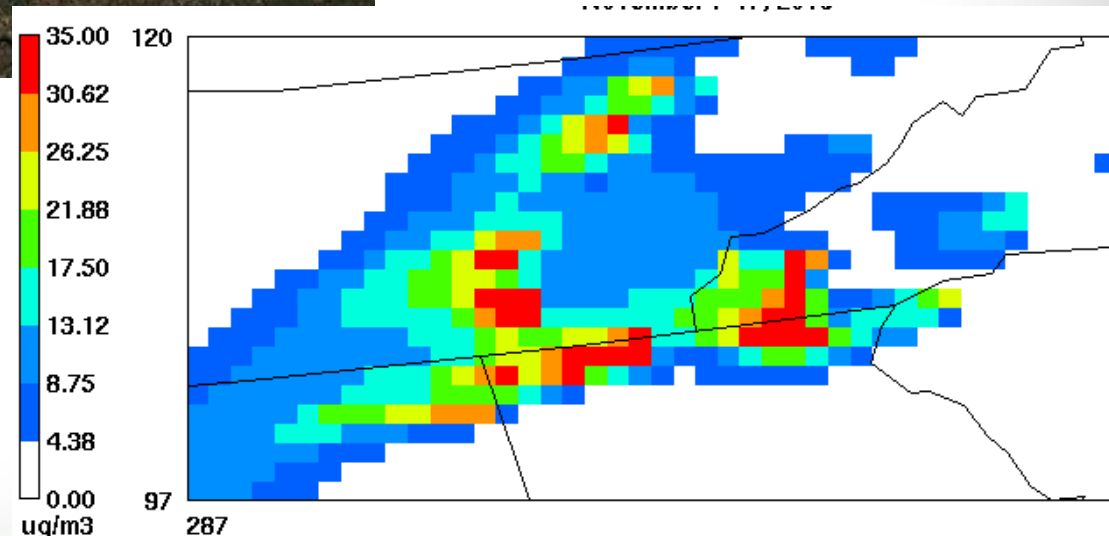




# 2016 Wildfires in the Southeast US



PM2.5 CMAQv5.0.2-NRT-FINN

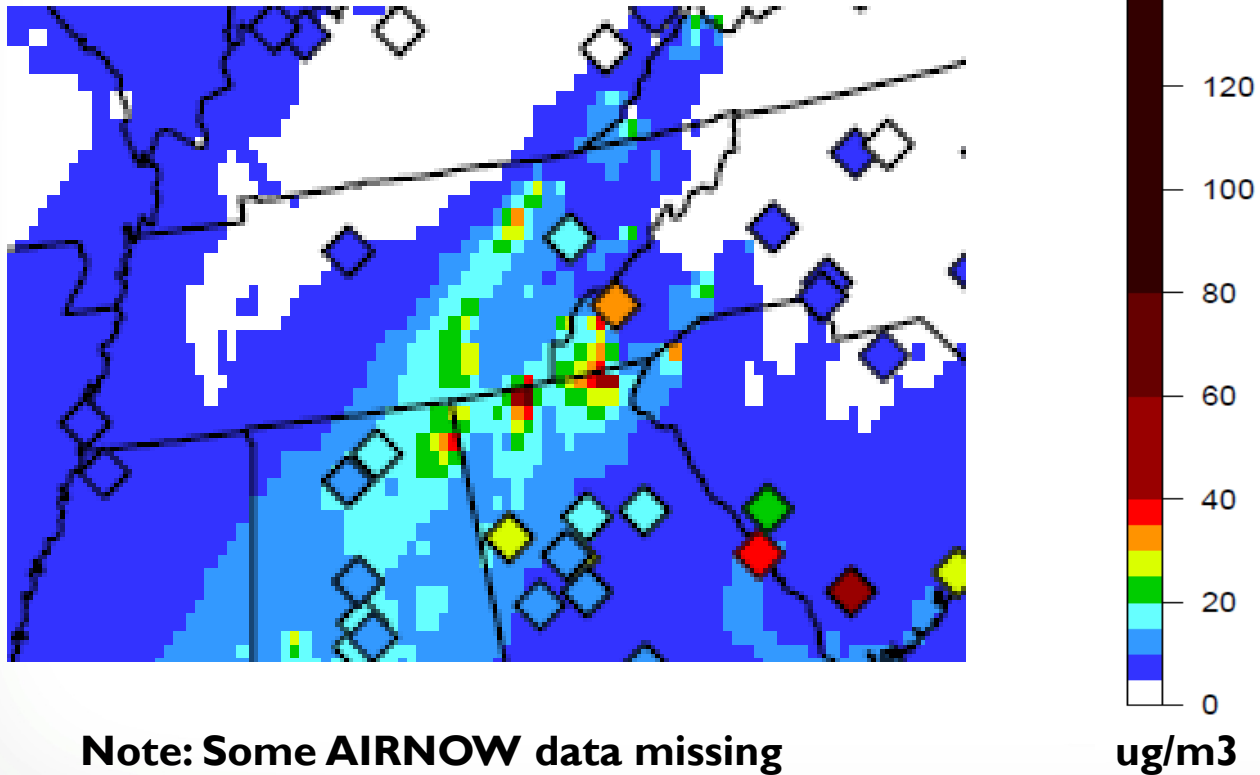


November 12, 2016 18:50 UTC

November 12, 2016 19:00 UTC

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

Daily Mean PM<sub>2.5</sub> Model vs Obs November 12

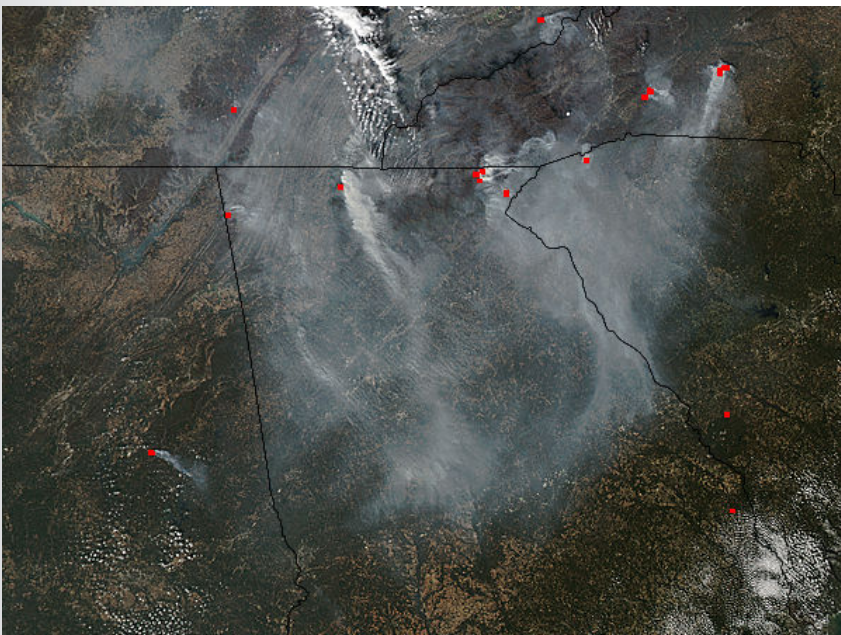


Note: Some AIRNOW data missing



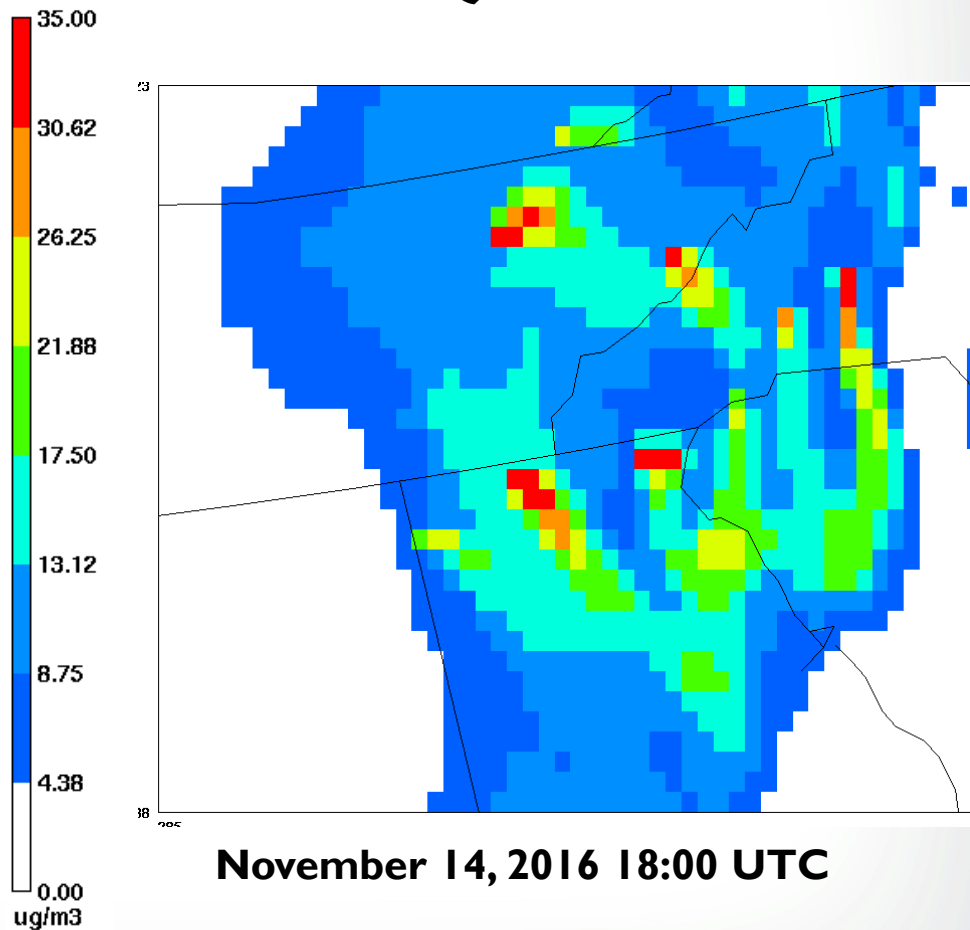


# 2016 Wildfires in the Southeast US



November 14, 2016 18:35 UTC

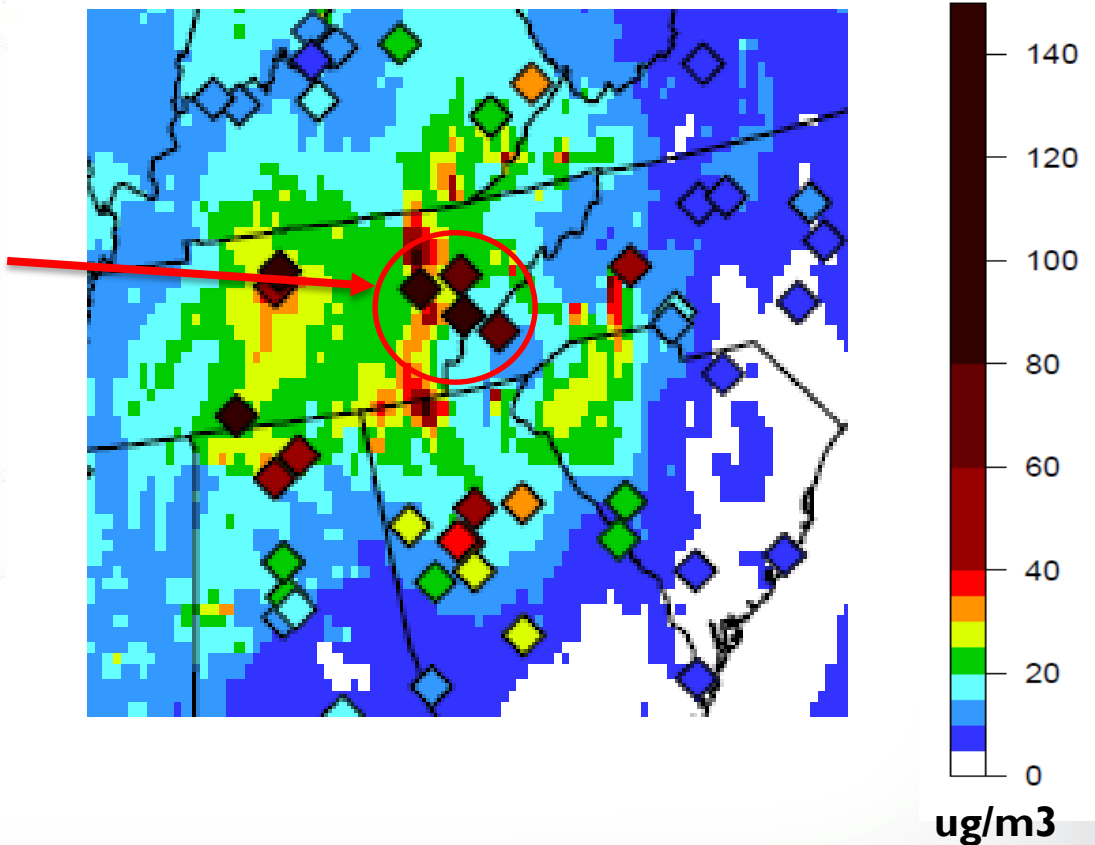
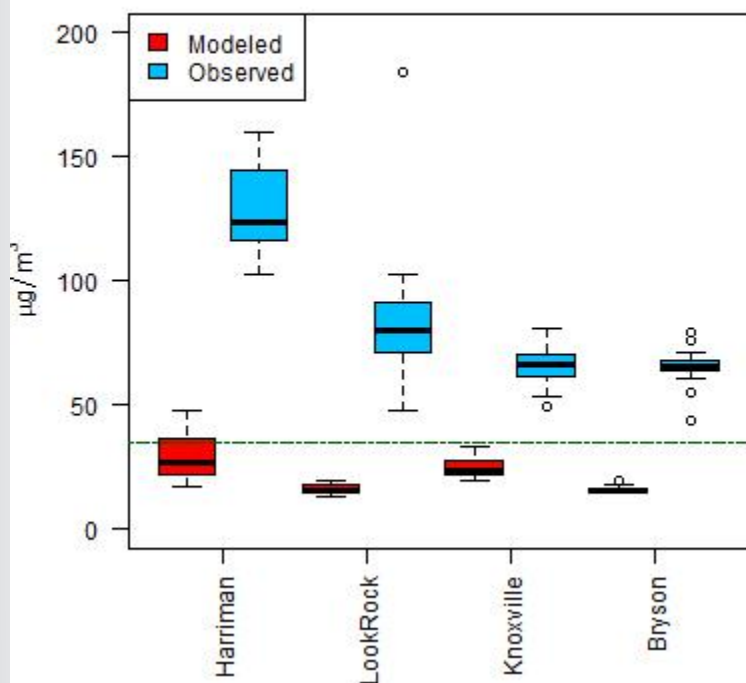
## PM2.5 CMAQv5.0.2-NRT-FINN





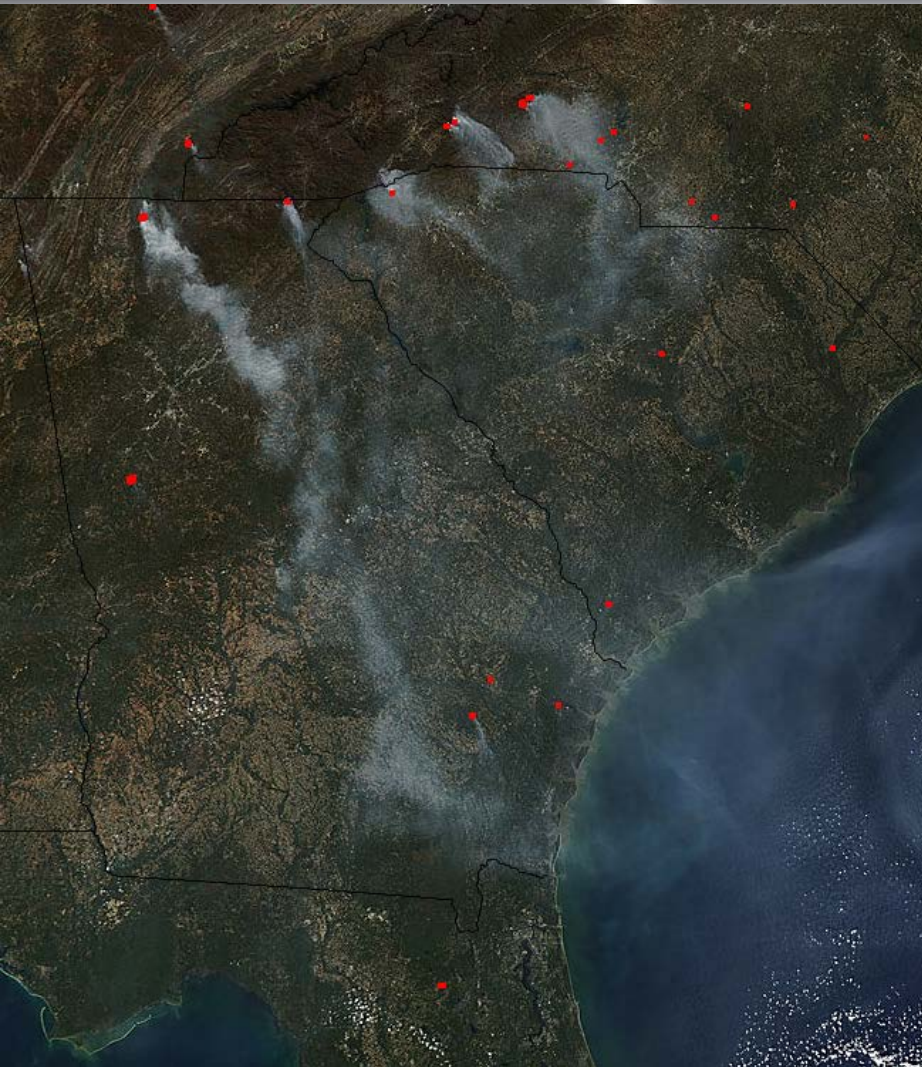
## Daily Mean PM<sub>2.5</sub> Model vs Obs November 14

Modeled vs. Observed PM<sub>2.5</sub> Values - Nov 14



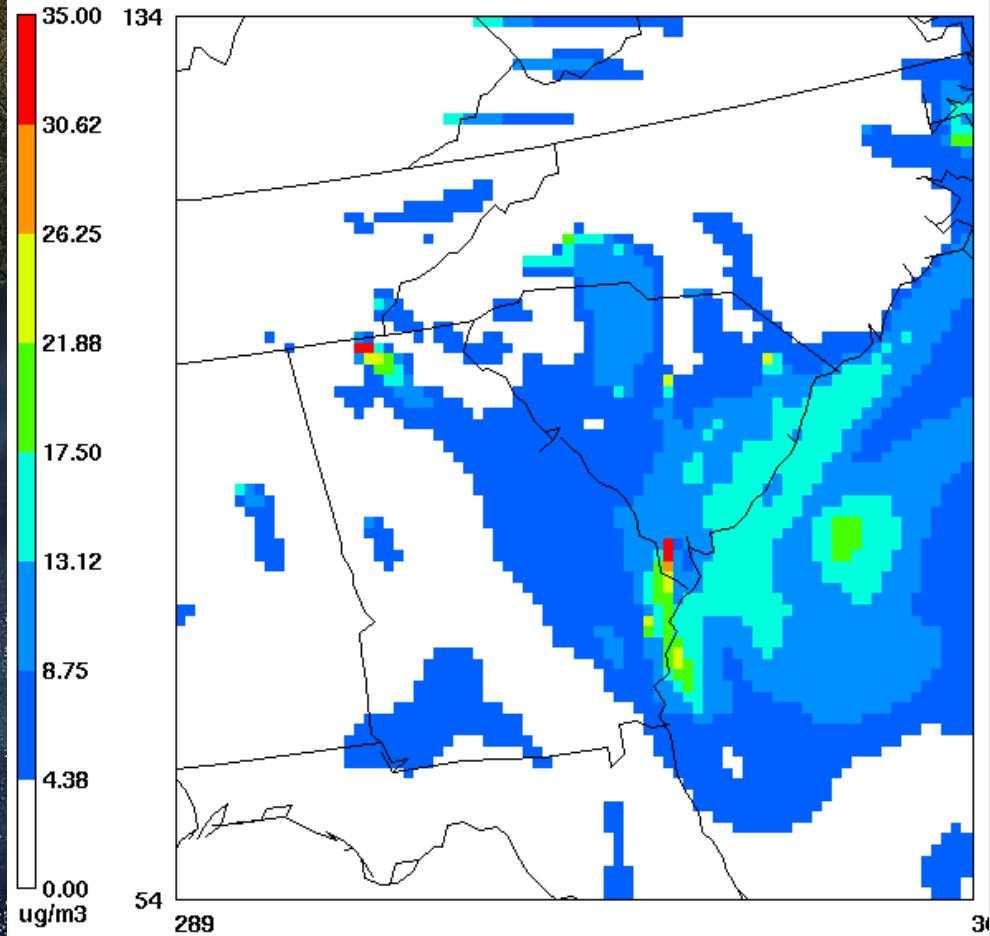


# 2016 Wildfires in the Southeast US



November 16, 2016 18:25 UTC

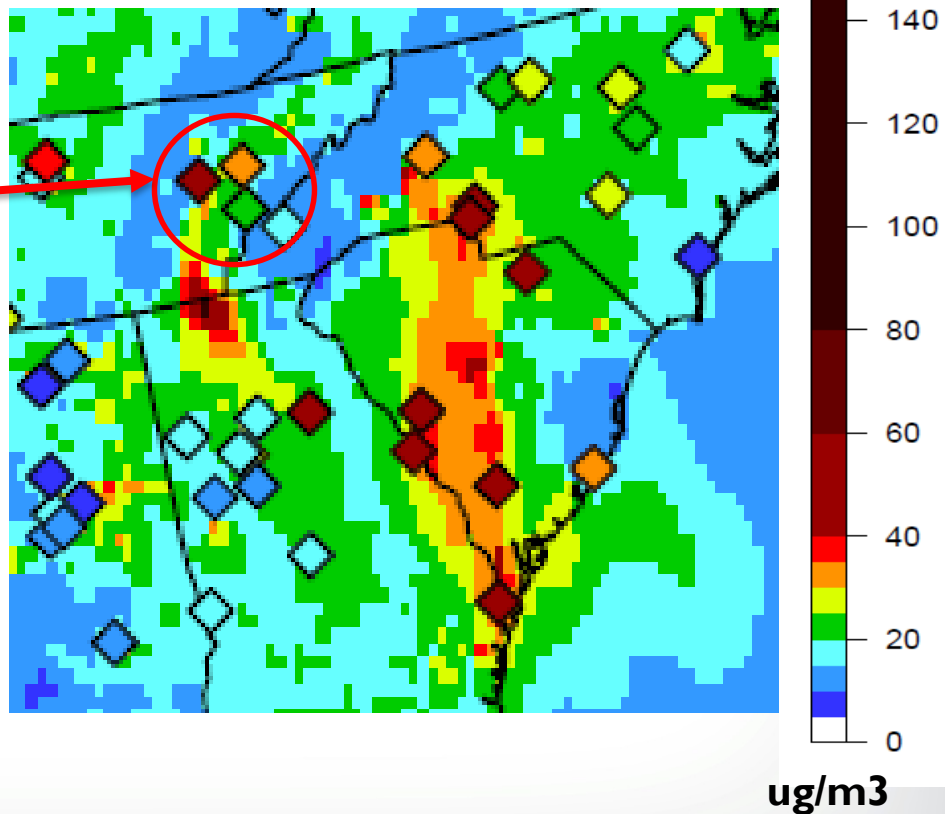
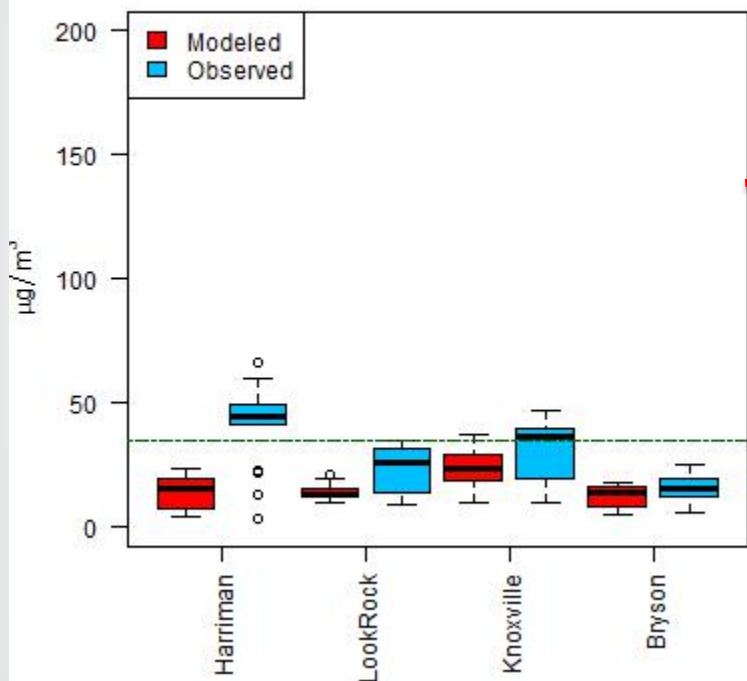
## PM2.5 CMAQv5.0.2-NRT-FINN



November 16, 2016 18:00 UTC

## Daily Mean PM<sub>2.5</sub> Model vs Obs November 16

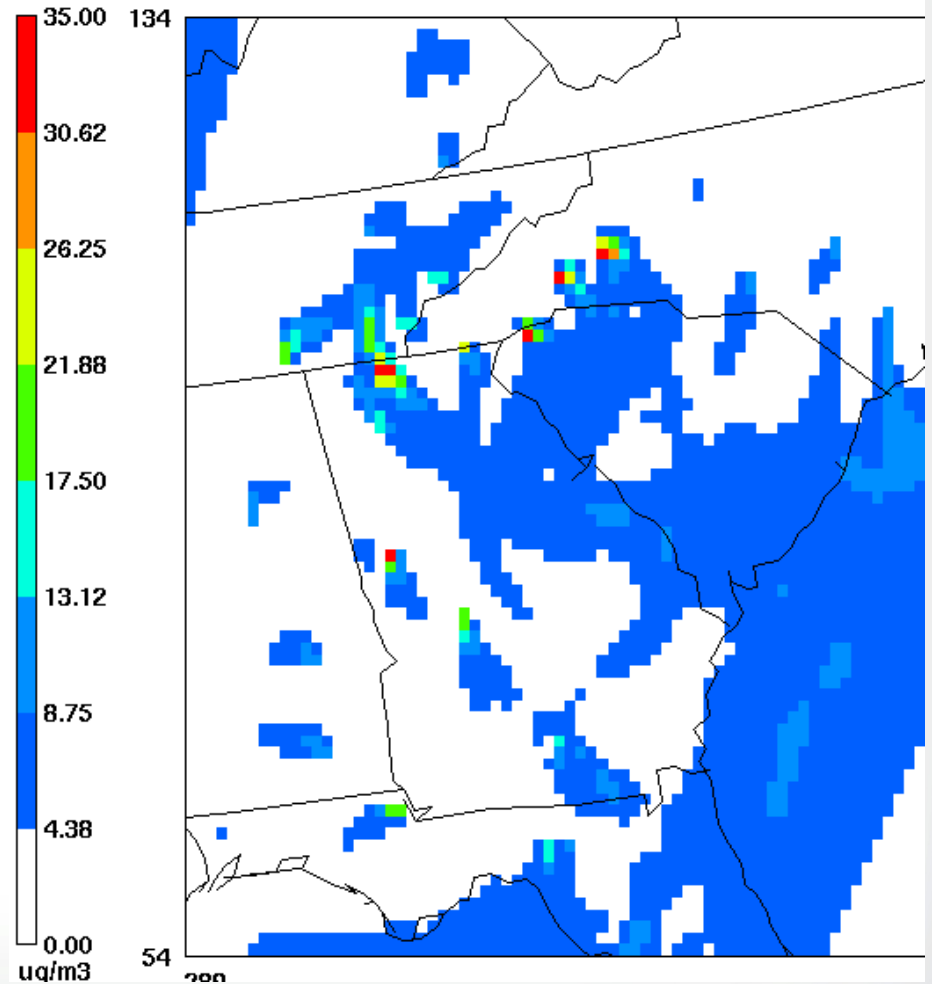
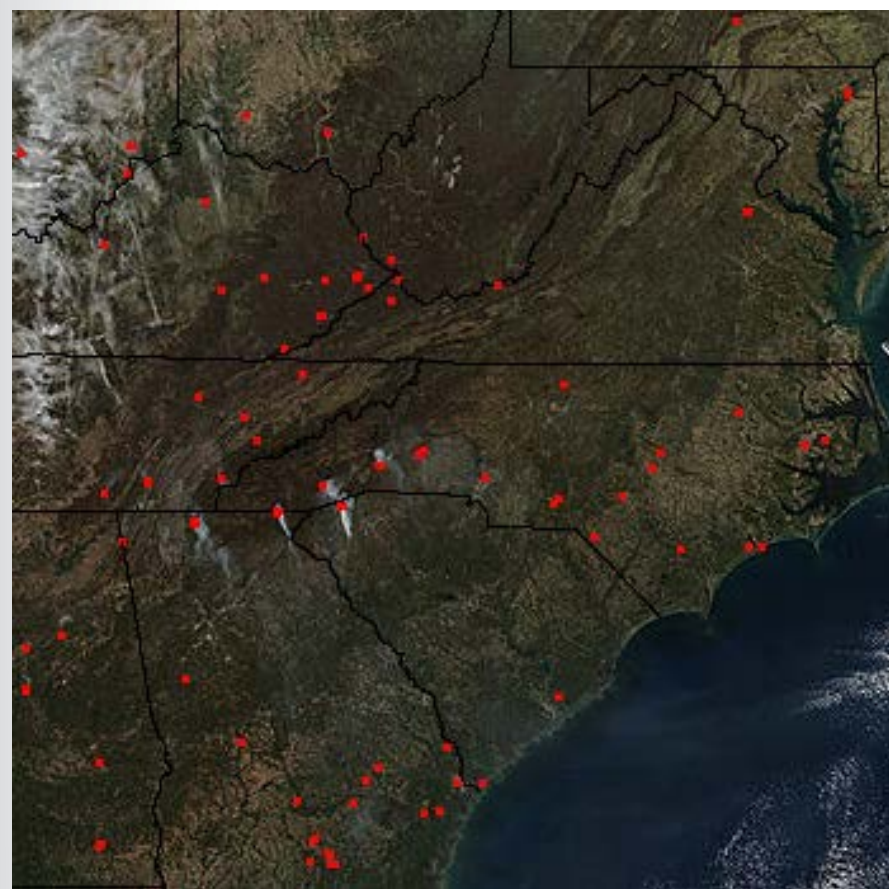
### Modeled vs. Observed PM2.5 Values - Nov 16





# 2016 Wildfires in the Southeast US

### PM2.5 CMAQv5.0.2-NRT-FINN



● November 17, 2016 18:24 UTC

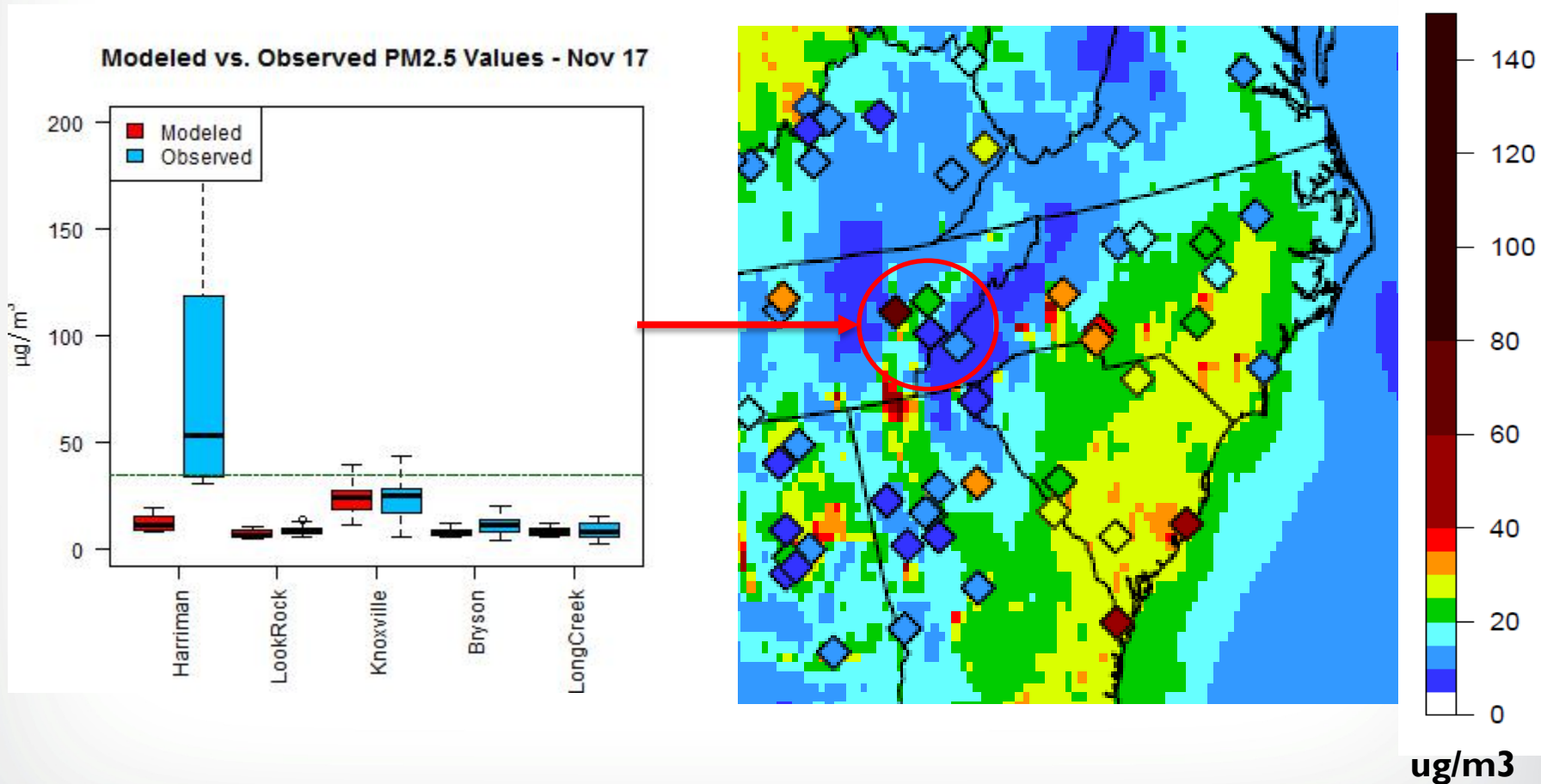
● November 17, 2016 18:00 UTC





# 2016 Wildfires in the Southeast US

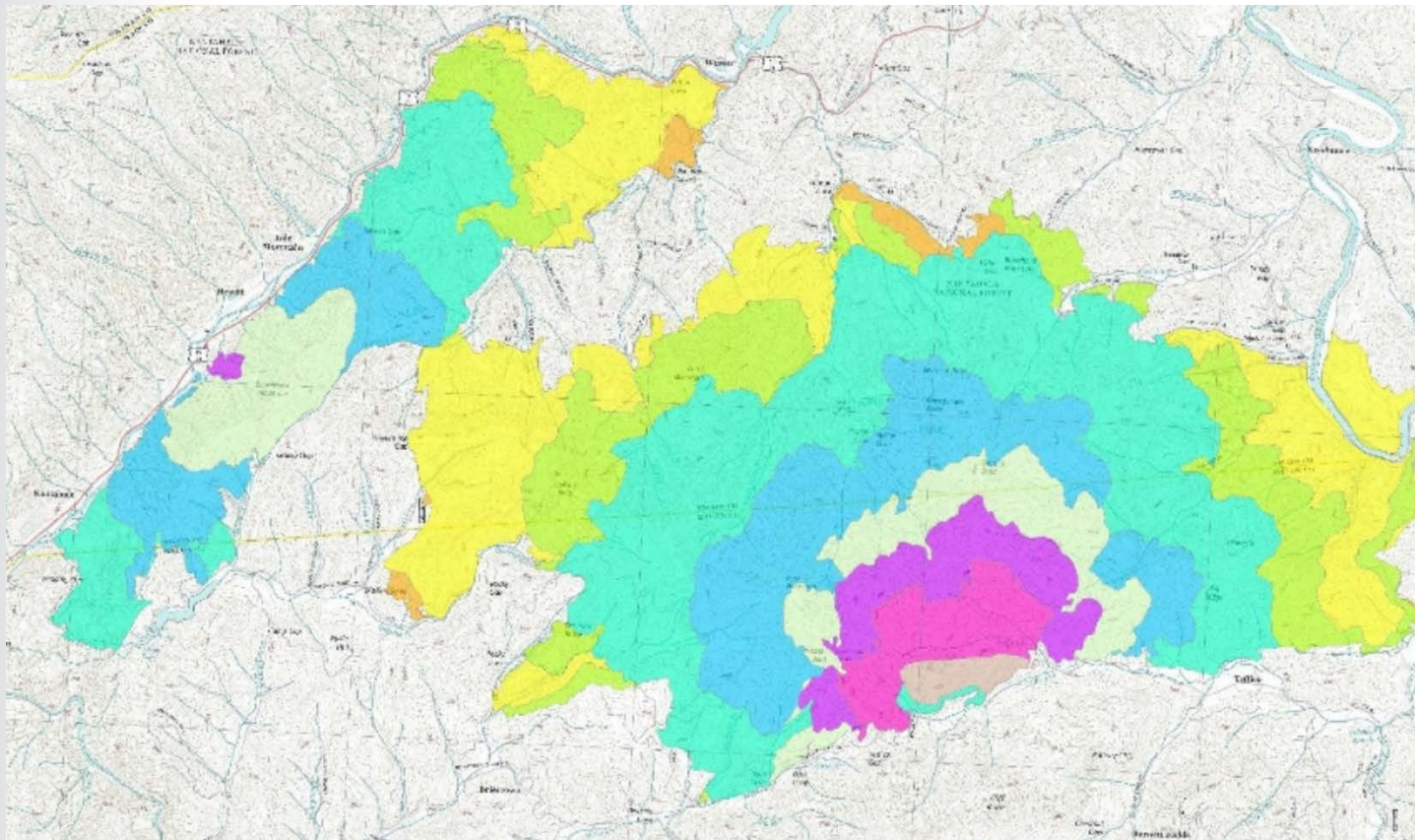
## Daily Mean PM<sub>2.5</sub> Model vs Obs November 16







# Tellico Fire Progression Map



## Day Shift 11/15/2016

- 11/4/2016 Fire Polygon
- 11/5/2016 Fire Polygon
- 11/6/2016 Fire Polygon
- 11/7/2016 Fire Polygon
- 11/8/2016 Fire Polygon
- 11/9/2016 Fire Polygon
- 11/10/2016 Fire Polygon
- 11/11/2016 Fire Polygon
- 11/12/2016 Fire Polygon
- 11/13/2016 Fire Polygon
- 11/14/2016 Fire Polygon

Map created Nov 15<sup>th</sup>, 2016 by the Southern Area Incident Management Team

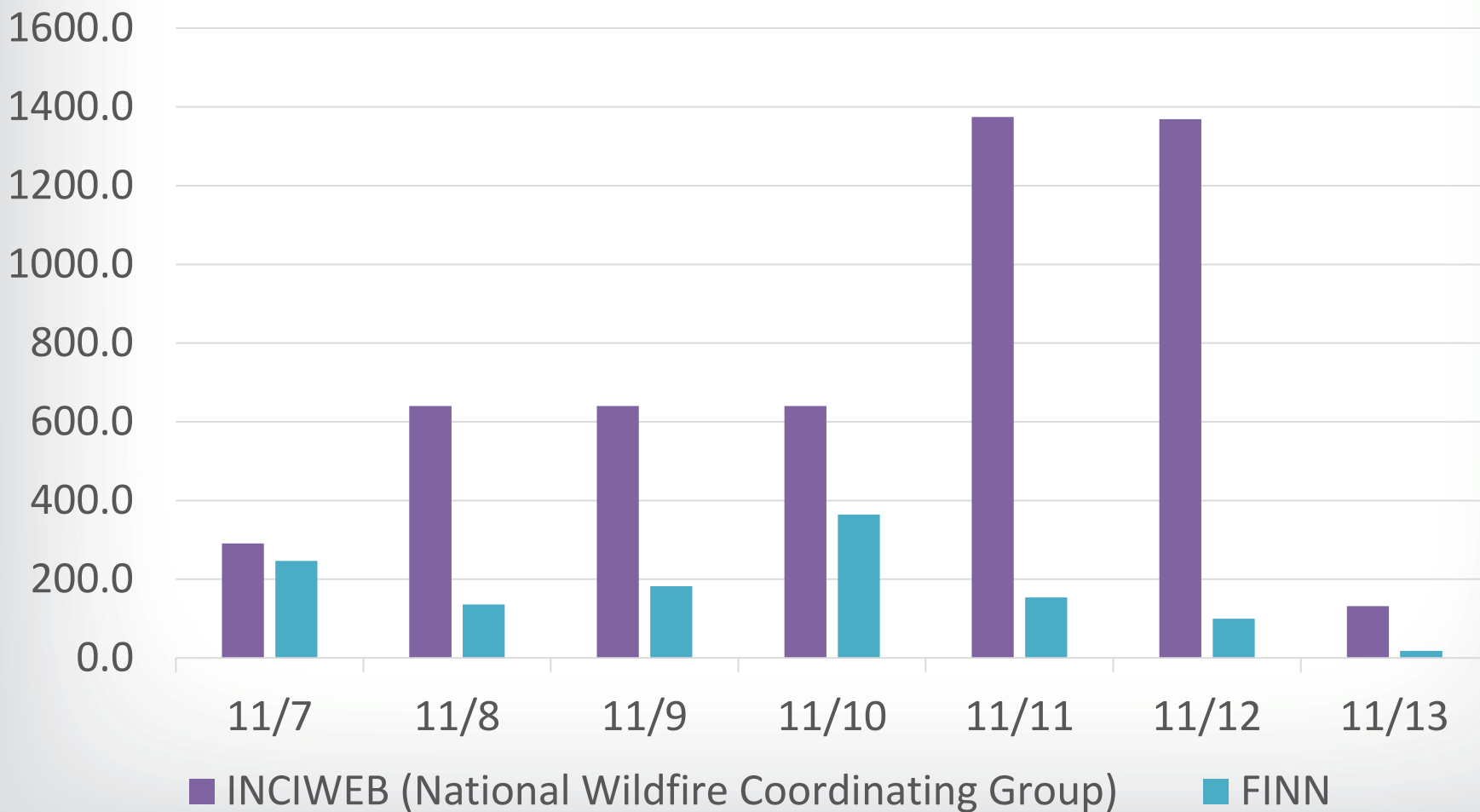
Source: <https://inciweb.nwcg.gov/incident/map/5084/17/61209/>





# Tellico Fire

Daily Hectares Burned Tellico Fire  
FINN vs INCIWEB





## 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<sub>2.5</sub>. 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)**



## 2016 Wildfires in the Southeast US

- **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**



# 2016 Wildfires in the Southeast US

- **Reference**
  - **Wiedinmyer, C., S. K. Akagi, R. J. Yokelson, L. K. Emmons, J. A. Al-Saadi, J. J. Orlando, and A. J. Soja. "The Fire Inventory from Ncar (Finn): A High Resolution Global Model to Estimate the Emissions from Open Burning." Geoscientific Model Development 4, no. 3 (2011): 625-41. (<http://www.geosci-model-dev.net/4/625/2011/gmd-4-625-2011.html>)**
- **Disclaimer – The views expressed in this presentation are those of the authors and do not necessarily represent the views or policies of the U.S. Environmental Protection Agency.**