Impact of Assimilating Satellite-derived Biomass Burning PM2.5 Emissions on CMAQ Air Quality Forecasts

Shobha Kondragunta
NOAA/NESDIS Center for Satellite Applications and Research

Acknowledgements:

X. Zhang and Q. Zhao (IMSG)

G. Pouliot, R. Mathur, T. Pierce (NOAA/OAR)

J. McQueen (NWS) and P. Lee (SAIC)

- Objective
  - To develop a near real time satellite-based biomass burning emissions product for assimilation into NWS air quality forecast model to improve PM2.5 and ozone forecasts
  - Other applications include retrospective air quality modeling work, EPA National Emissions Inventory, etc.

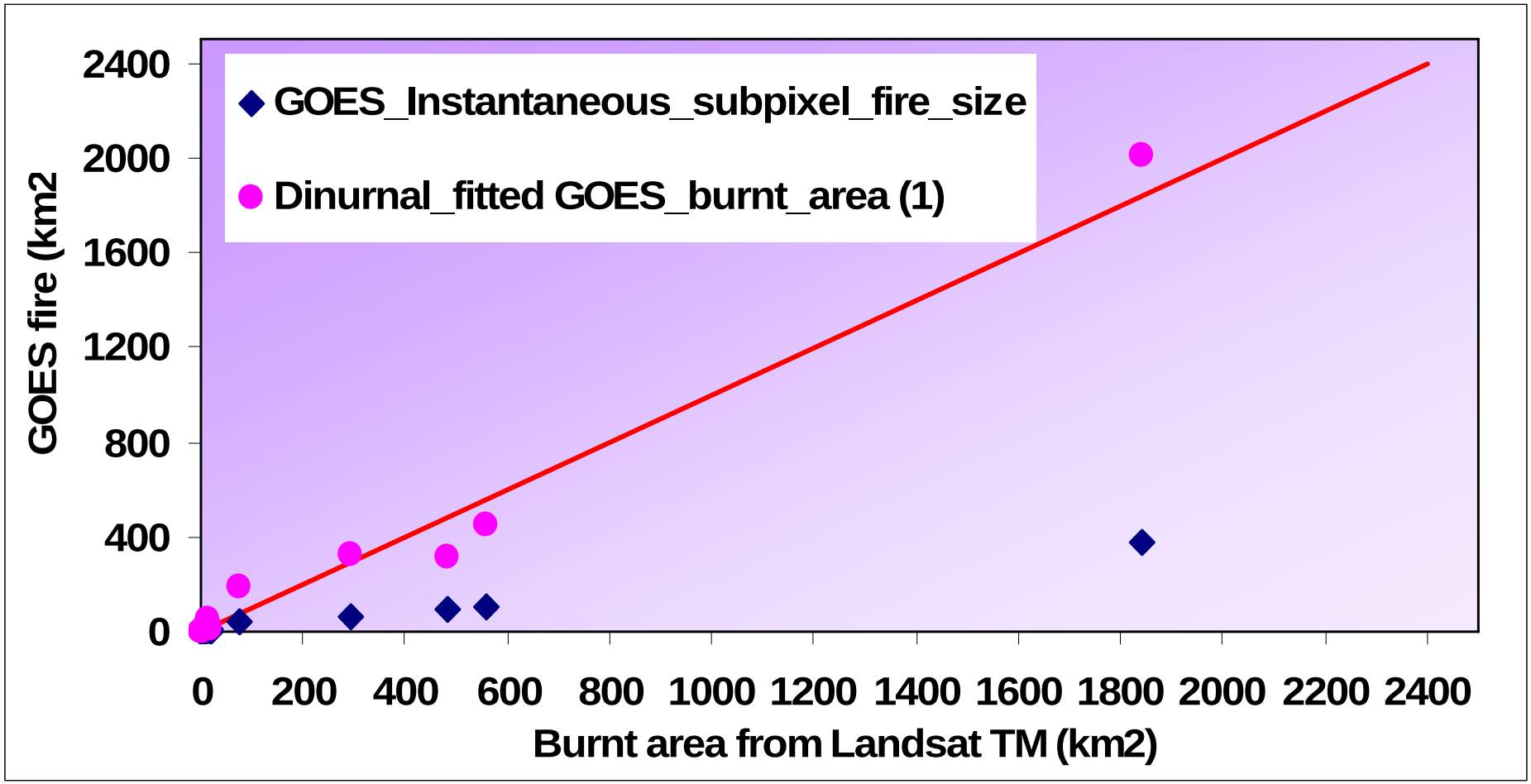
Emissions Algorithm

- Conventional
  - Based on burned area, available fuel loading, combustion efficiency, and emissions factors
- Inputs
  - MODIS Vegetation Property-based Fuel System (MVPFS) (NASA MODIS) – NESDIS product
  - Fire location and size (NOAA GOES) – NESDIS product
  - Fuel moisture category factor (NOAA AVHRR) – NESDIS product
  - Emissions factors - literature
- Outputs
  - PM2.5 emissions in tons/hour in near real time
  - CO, SO_2, NO_x, CH_4, etc. (as required by users)

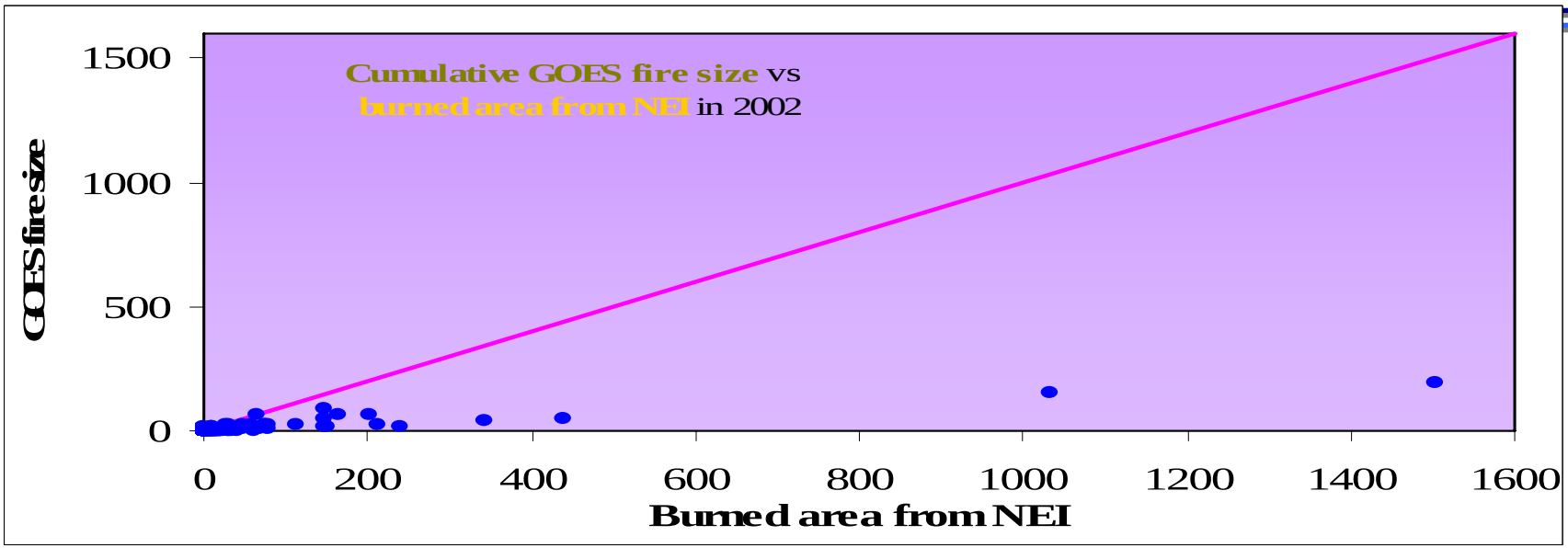
Major Accomplishments

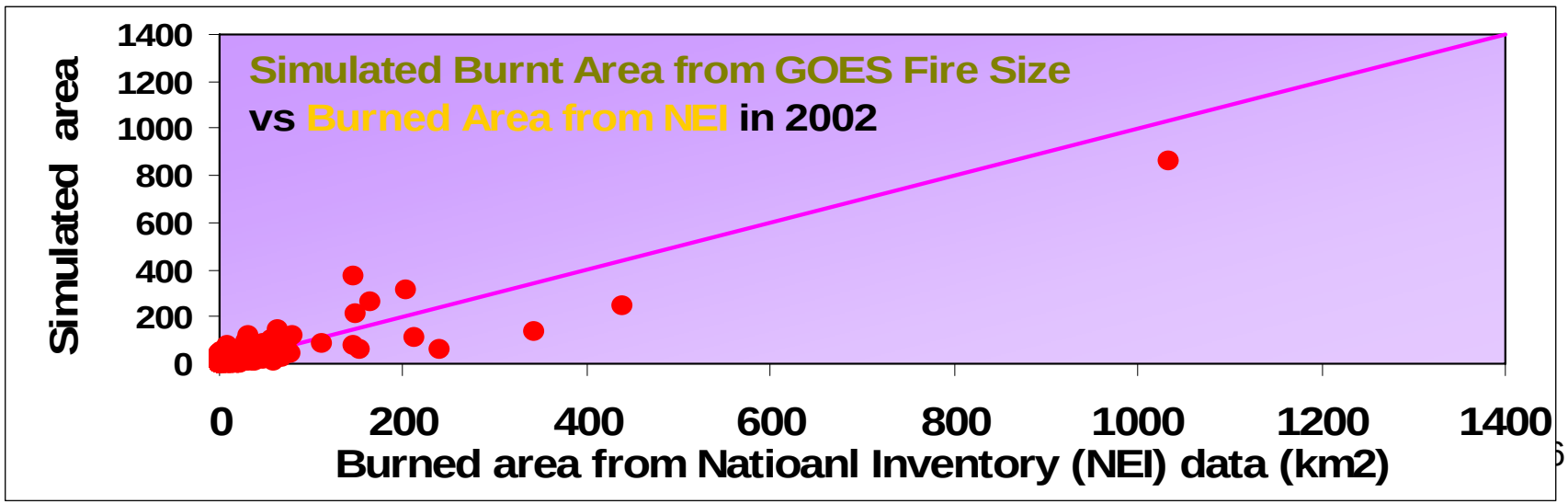
- Algorithm development to derive aerosol (PM2.5) and trace gas emissions during biomass burning events completed
  - Algorithm improvements, particularly for determining fire size
  - Data processed: GOES-E 2002 - present
  - Manuscript on the algorithm submitted to a peer-reviewed journal
  - Supported 2006 TEXAQS field campaign
- Worked with NOAA/OAR to conduct test air quality model simulations using satellite-derived emissions and WRF-CMAQ modeling system. Case study and results presented here

Evaluation of GOES Fire Size Product

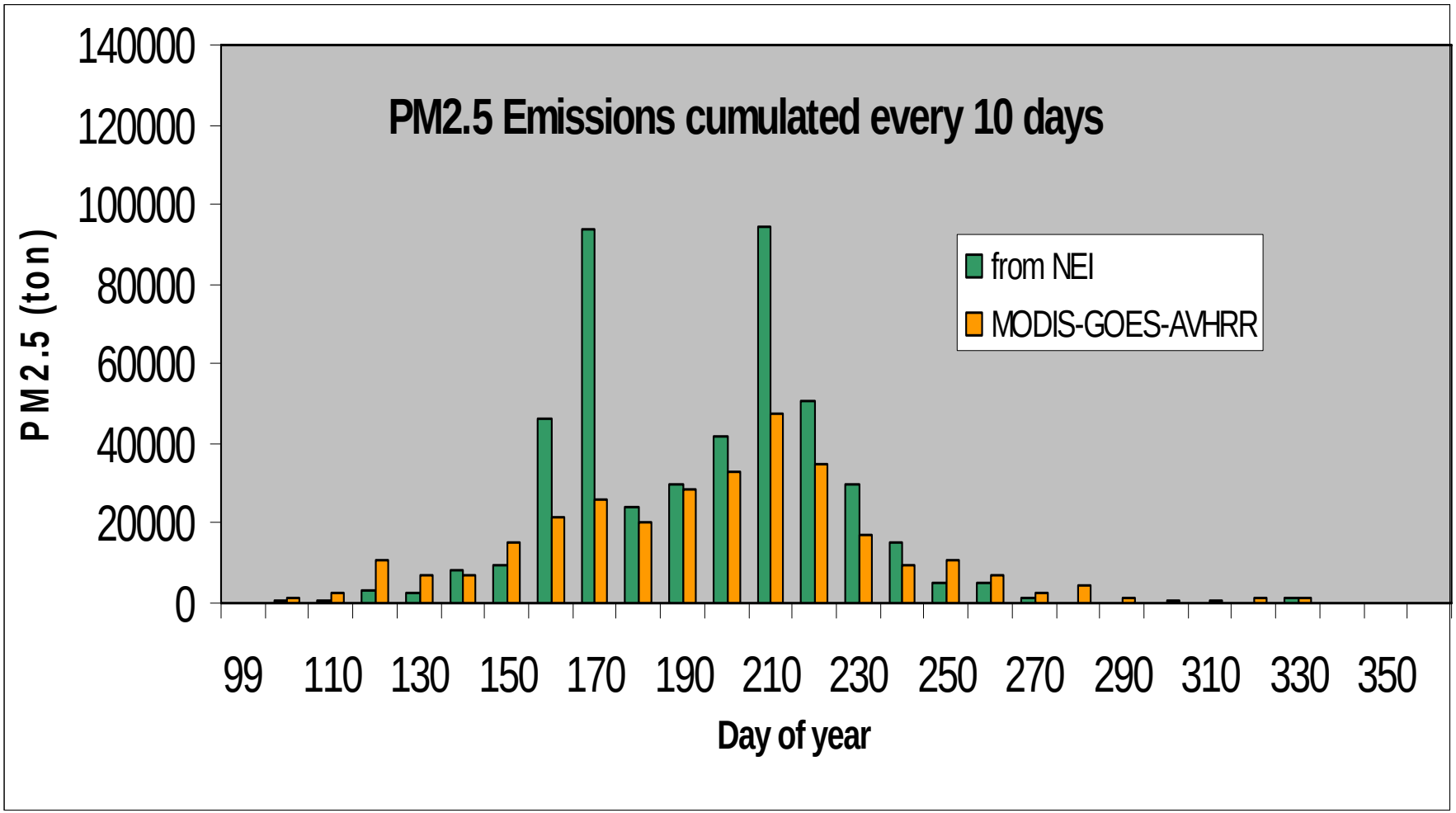


Comparison of GOES Fire Size with EPA NEI for 2002

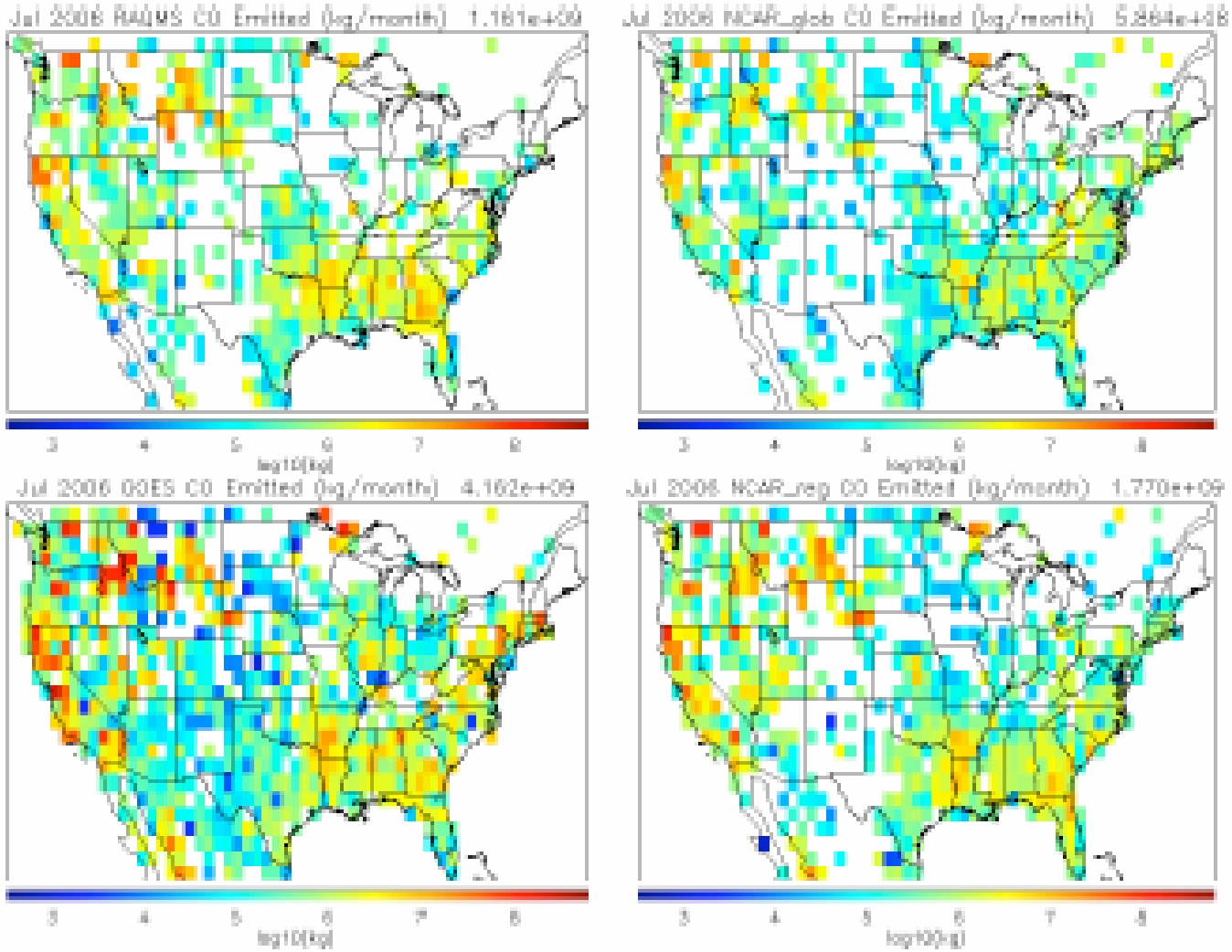




Verification of Satellite-based Biomass Burning PM2.5 Emissions



Intercomparison of CO Emissions from Different Methods

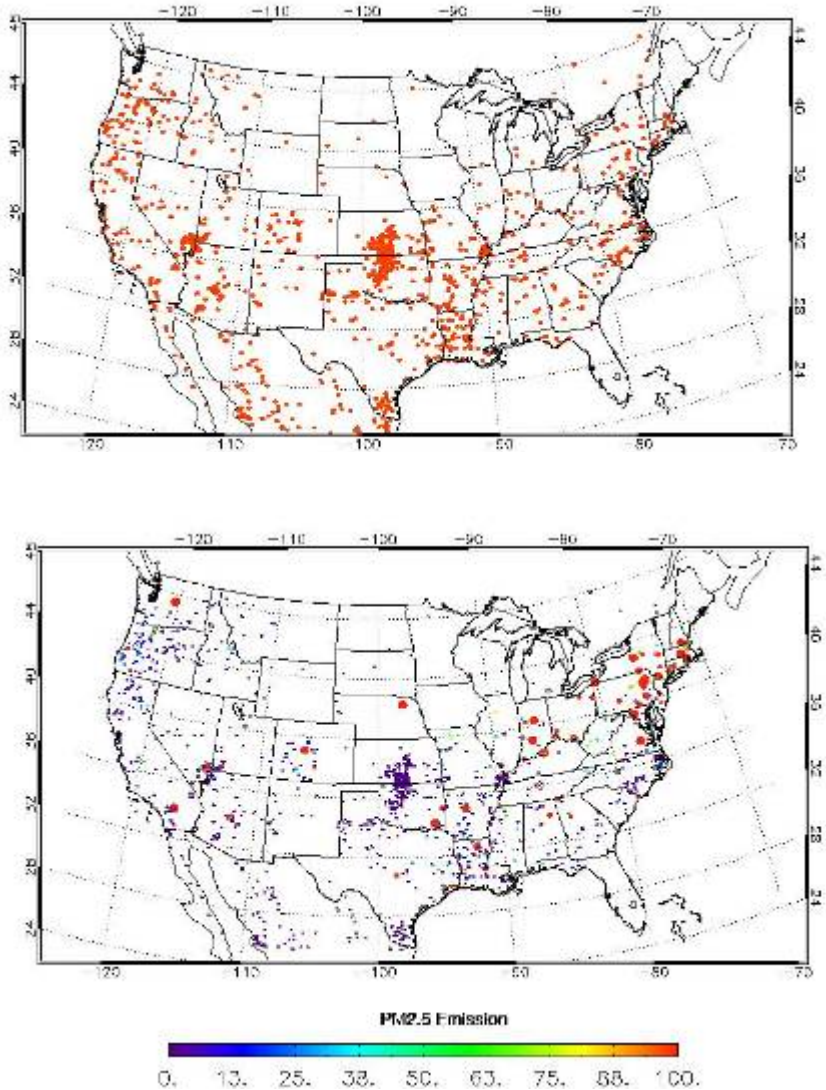


Case Study for June 21 – July 1, 2005

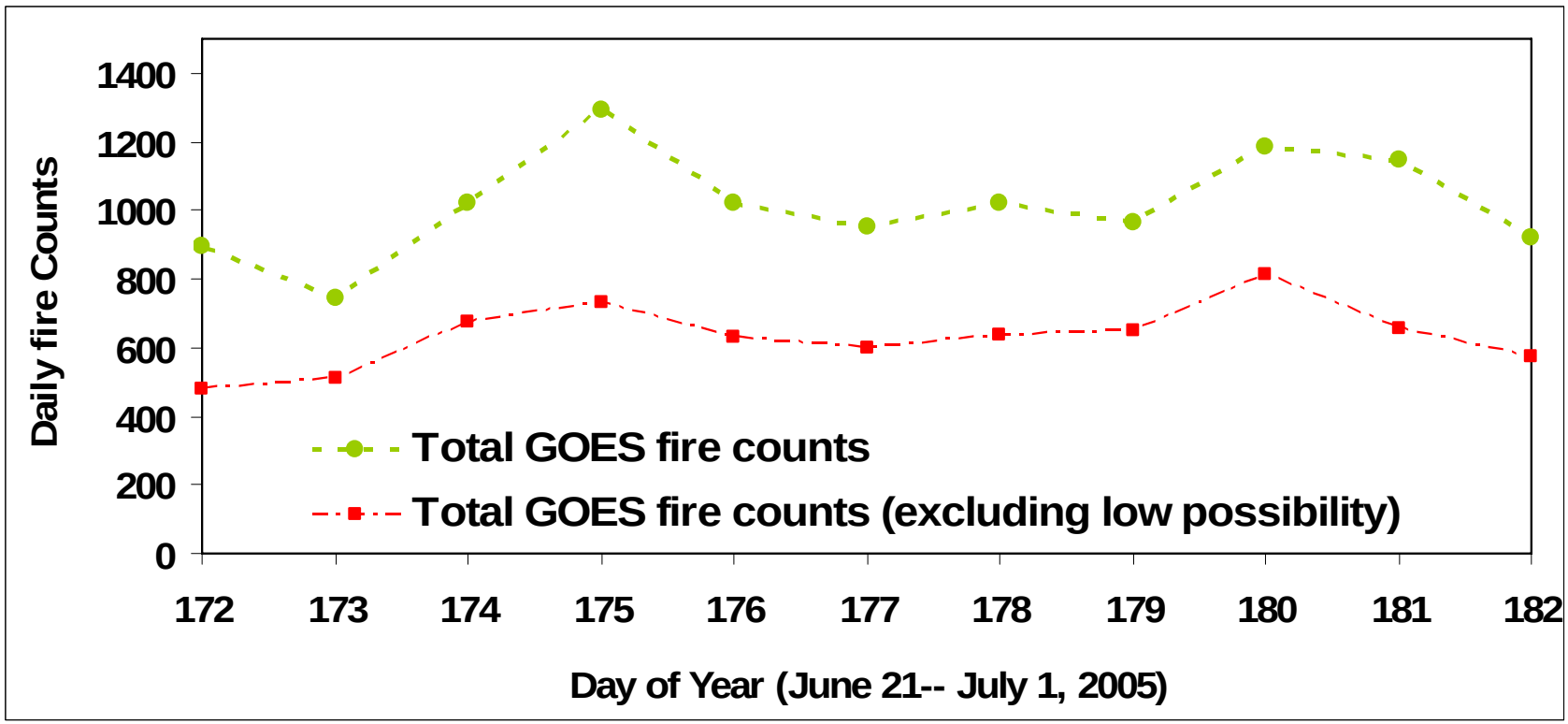
Top panel: **Composite of fire occurrence**

Bottom panel: **Total PM2.5 emissions (tons)**

- **Time period corresponded to widespread fire activity over the U.S.**
- **Emissions from most fires low with few fires emitting high amounts of smoke particles**



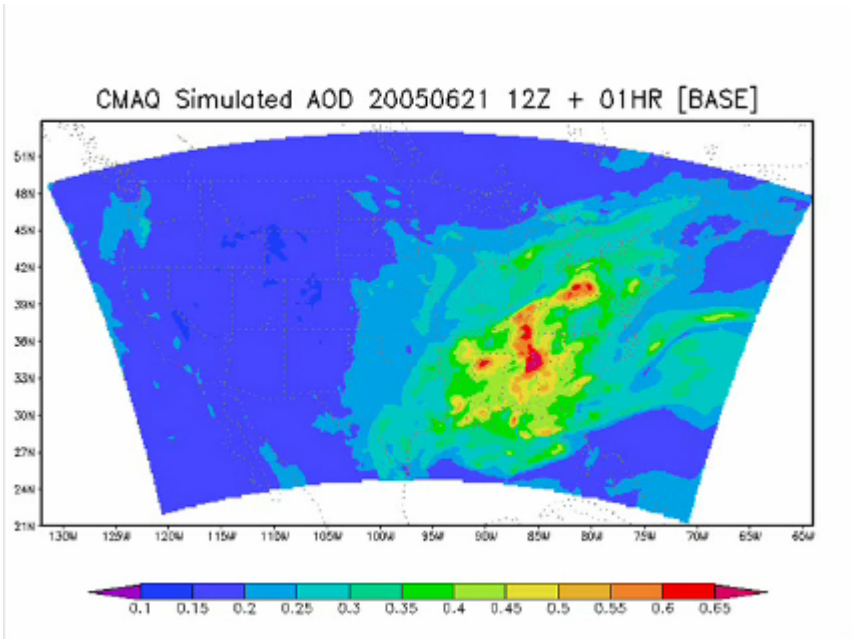
Temporal Variability in Observed Fire Occurrence

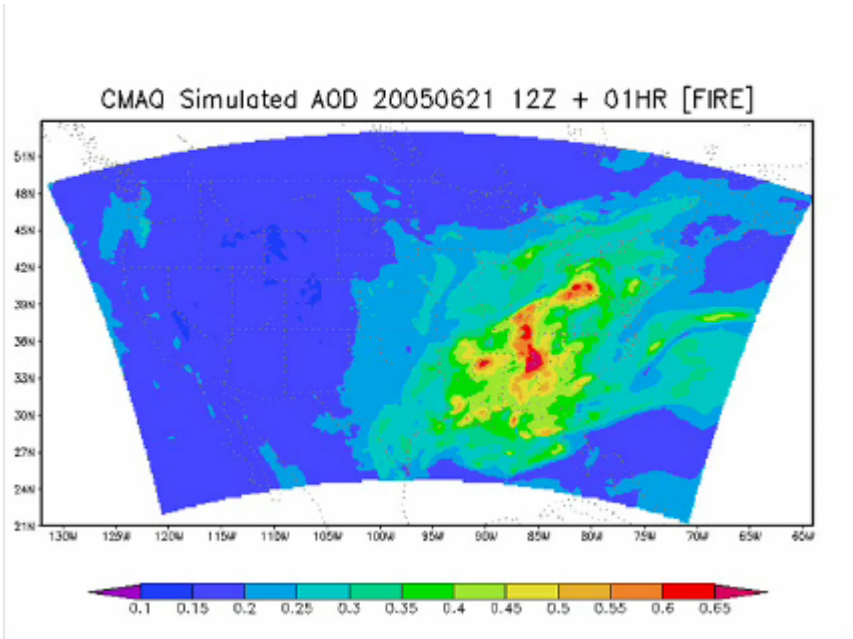


Assimilation Run

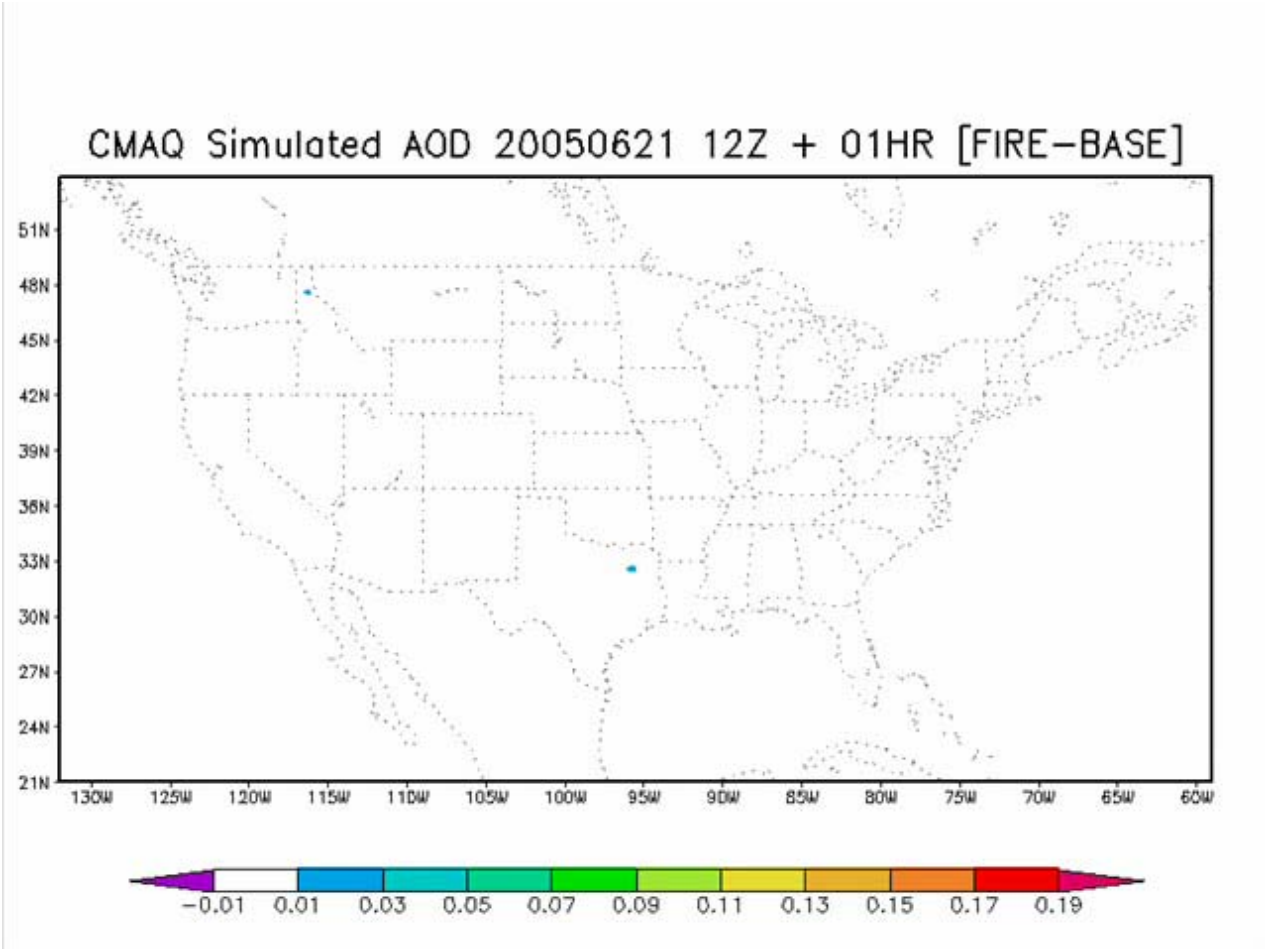
- AQF-aerosol version of CMAQ for the CONUS for June 2005
- Model grid was 12 km X 12 km
- Carbon-bond 4 chemistry
- 24-hour cycling period. Hourly forecasts for 48 hours beginning at 12Z
- Assumed emissions for a 24-hour time period persisted for the next 48 hours

Aerosol Optical Depth Movie Loop for June 21 – June 30, 2005





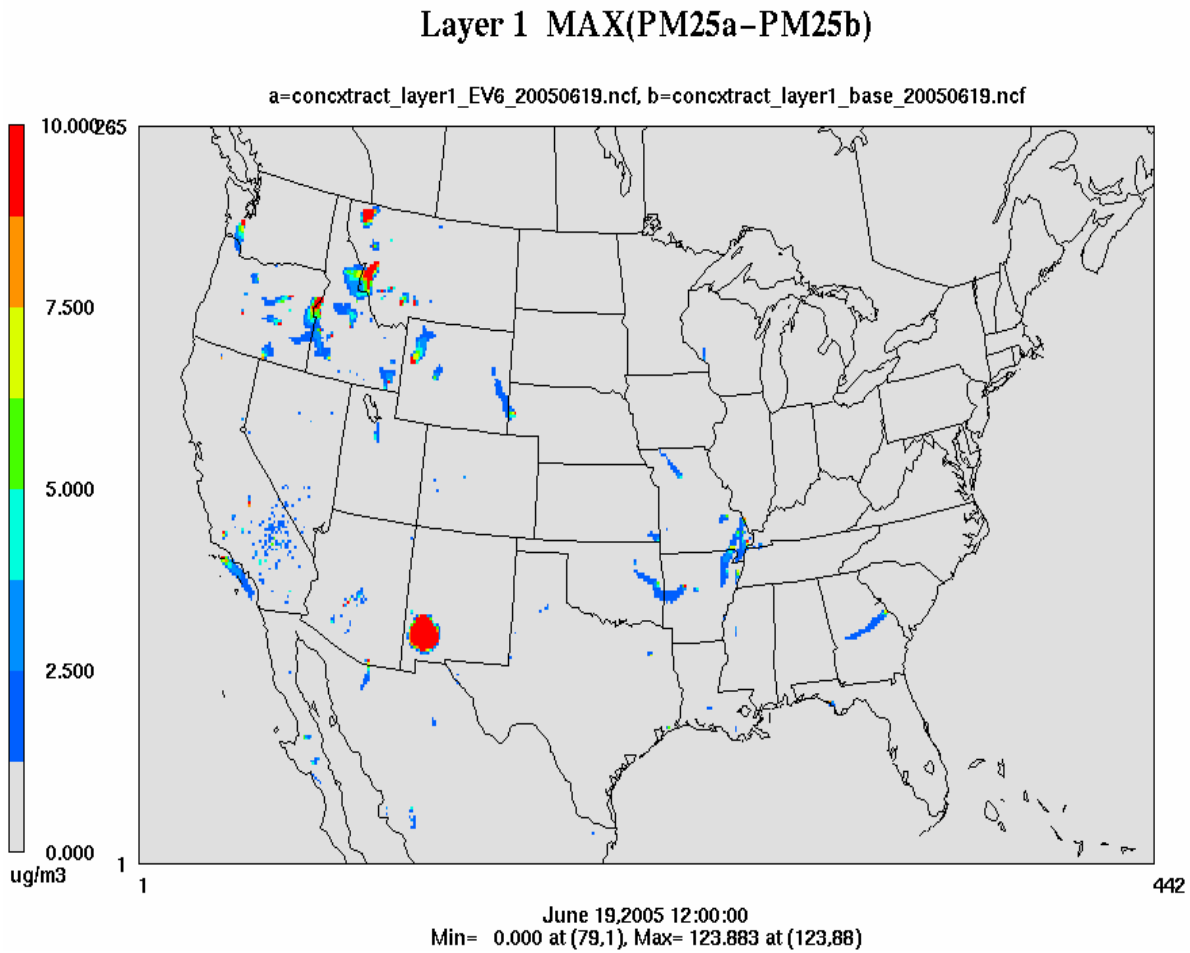
AOD Difference (Fire – Base)



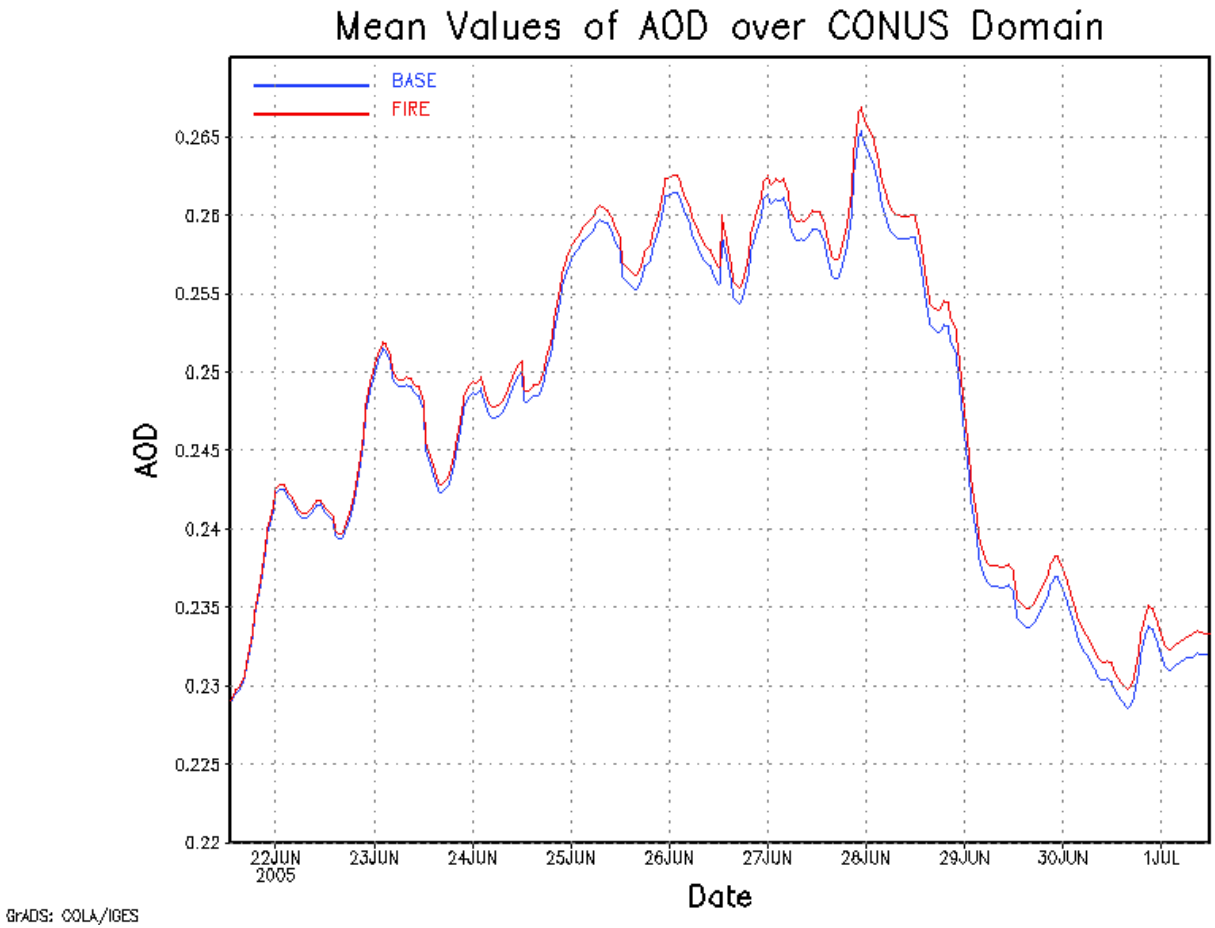
Surface PM2.5 Concentrations (Fire – Base)

Significance:

The new EPA standard for PM2.5 is a daily average of 35 μg/m³. Without assimilation of fire emissions, forecast will be biased low for these episodic events



Time Series of Mean AOD



Summary

- Despite intense fire activity in parts of the U.S., the episode we chose to do the simulation was dominated by a significant sulfate event. However, this case study demonstrated the applicability of using satellite-derived biomass burning emissions in a forecast model

FY07 Activities

- NOAA/OAR to conduct comparisons of surface PM2.5 concentrations with EPA AIRNOW observations
- STAR to conduct comparisons of column AOD with AERONET observations
- Conduct assimilation runs for a different time period where fires are more dominating than the urban haze/sulfate event
- Experiment with different schemes for persistence of fires during the simulation time period
- Assess the impact of assimilation on predicted PM2.5 and AOD fields for these various runs