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

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• **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

![Graph showing the relationship between GOES fire size (km²) and burnt area from Landsat TM (km²). The graph includes data points for GOES_Instantaneous_subpixel_fire_size and Dinurnal_fitted GOES_burnt_area (1).]
Comparison of GOES Fire Size with EPA NEI for 2002

**Cumulative GOES fire size vs burned area from NEI in 2002**

**Simulated Burnt Area from GOES Fire Size vs Burned Area from NEI in 2002**
Verification of Satellite-based Biomass Burning PM2.5 Emissions

PM2.5 Emissions cumulated every 10 days

- From NEI
- MODIS-GOES-AVHRR
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

Day of Year (June 21--July 1, 2005)

- Total GOES fire counts
- Total GOES fire counts (excluding low possibility)
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

CMAQ Simulated AOD 20050621 12Z + 01HR [BASE]

CMAQ Simulated AOD 20050621 12Z + 01HR [FIRE]
AOD Difference (Fire – Base)
Surface PM2.5 Concentrations (Fire – Base)

Significance:

The new EPA standard for PM2.5 is a daily average of 35 \( \mu \text{g/m}^3 \). Without assimilation of fire emissions, forecast will be biased low for these episodic events.
Time Series of Mean AOD

Mean Values of AOD over CONUS Domain

- BASE
- FIRE

AOD

Date

25 Jun 2009
26 Jun 2009
27 Jun 2009
28 Jun 2009
29 Jun 2009
30 Jun 2009
1 Jul 2009
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