Wildland Fire Emission Modeling: Integrating BlueSky and SMOKE

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Outline of Presentation

- Why Link BlueSky with SMOKE?
- What is BlueSky and SMOKE?
- How the programs were linked
- Test case with model results
- Summary
US Forest Service (USFS) & US Environmental Protection Agency (US EPA)

Signed an interagency agreement to improve the **episodic modeling of fires** using:

- Improved fuel loading data
- Improved fire location information
- Improved fire behavior modeling (including plume behavior), using meteorological inputs
Why Link BlueSky and SMOKE?

- BlueSky used by Forest Service to forecast fires (wildfires and prescribed) (good temporal and spatial resolution)
- SMOKE creates emission estimates for chemical transport models
- Wild land fire inventory emissions known only at state level (spatially) and at monthly time resolution (temporally)
Linking BlueSky & SMOKE

- **BlueSky Framework**
  - Estimates emissions, incorporates meteorology, and uses dispersion models to forecast smoke impacts from fires.

- **Sparse Matrix Operator Kernel Emission Processor (SMOKE)**
  - Creates “model ready” inputs for chemical transport models
BlueSky Framework

**FIRE Characteristics**
- Area Burned
- Fuel Moisture
- Fuel Loadings
- Fire Location
- Fire Ignition Time

**Meteorology**
- Local Forecast (72 hour)
- 3-D description of Wind, Temperature, and Moisture fields

**Emissions**
- Calculate fuel consumption and variable rate emissions of: Heat Released, PM2.5, PM10, PM, CO, CO2, and CH4

**Smoke Dispersion**
- Visibility
- Chemistry
- PM Concentrations
- Plume Rise

**Web Display of Output Products**
- Animations, Zoom In/Out
- Concentration Fields, Trajectories
- Meteorological data, Overlay GIS Data

Source: http://www.fs.fed.us/bluesky/about/
Linking BlueSky & SMOKE

- BlueSky computes $Q$, Plume Rise in
- SMOKE needs $F$, buoyancy flux ($m^4/s^3$)
- $F = Q \times 0.00000258$ (from Fire Emission Production Simulator or FEPS documentation)
- $Q =$ heat flux (BTU/hr)
Wildland Fire Plume Rise

- Brigg’s layer by layer approach (see CMAQ Science Algorithms document)
- Smoldering Fraction
- \( S_{\text{fract}} = 1 - BE_{\text{size}} \)
- \( BE_{\text{size}} = 0.0703 \ln(\text{acres}) + 0.3 \)
  - derived from a “best fit” of WRAP tables)
Wildland Fire Emission Processing

- **Bluesky2Inv**: convert Bluesky output to ASCII format for SMOKE
- **Smkinven**: import inventory
- **Grdmat**: compute gridding matrix
- **Temporal**: compute temporal matrix
- **Laypoint**: compute vertical plume rise
- **Spcmat**: compute speciation matrix
- **Smkmerge**: multiply matrices to get emissions

Portions of BlueSky Framework

- **Bluesky2Inv**
- **Smkinven**
- **Grdmat**
- **Temporal**
- **Laypoint**
- **Spcmat**
- **Smkmerge**

**Mrggrid**
SMOKE Updates

- Create Bluesky2Inv Tool
  - Converts emission estimates into format for SMOKE (ASCII)
- Include plume rise for fires in LAYPOINT
  - Uses Briggs approach and heat release info from BlueSky
- Updated SMKINVEN for Fire Event Inventory
Test Case of BlueSky-EM

- Meteorological data for 2001 already available
- Detailed Fire Inventory available for Florida
- Focus on large fire event in Florida during May 2001
Mallory Swamp Fire

- 57,200 Acres Burned Total; 34,000 acres in one day (May 25, 2001)
- Started by lightning
- Florida's Biggest Fire In 15 Years
- Clear Signature of Fire in Satellite Photos
Mallory Swamp Fire

Source: http://www.dca.state.fl.us/bpr/Preparedness/Logistics/mallory_swamp_fires.htm
May 24, 2001 GOES Satellite

GOES-8 IMAGER - VISIBLE - 15:32 UTC 24 MAY 2001 - 1.0 KM - CIMSS

RESEARCH & DEVELOPMENT
Building a scientific foundation for sound environmental decisions
CMAQ results

- Used EPA’s 2001 CMAQ Annual simulation with CB4 mechanism, MM5 met simulation performed as part of Clean Air Interstate Rule (CAIR)

http://www.epa.gov/air/interstateairquality/technical.html

- Replaced Florida Fire Emissions in the National Emissions Inventory (NEI) with BlueSky Emission Estimates during May 2001
Primary Organic Particulate Matter

Layer 5

Min: 0.0 at (29,17), Max: 2.0 at (21,22)

May 23, 2001 5:00:00
BlueSky-EM documentation

- Documentation, code, test data sets
- Available online at
  - http://www.unc.edu/~cseppan/bluesky/
- Not tested completely
- No model evaluations with this tool yet
Summary

BlueSky-EM: Creates wildfire emissions for use in chemical transport models

Qualitatively reproduces plume from Mallory Swamp Fire in May 2001

Evaluation of plume rise and emission estimates needed on a continental annual basis (aerosol monitoring network coverage)

2002 NEI will include wildfires on a national basis; BlueSky-EM will be evaluated with this dataset