Southern Smoke Issues

US Forest Service – Southern Research Station – Center for Forest Disturbance Science & Southern High Resolution Modeling Consortium

In this issue...

Southern High Resolution Modeling Consortium:

http://www.shrmc.org

Center for Forest Disturbance Science:

http://www.forestdisturbance.net

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Ouachita and Ozark-St. Francis National Forests - Advancing Smoke Management Practices

The National Forests of Arkansas and Oklahoma manage one of the largest prescribed fire programs in mountainous terrain, burning approximately 200,000 acres each year. Much of this burning is accomplished through the use of aerial ignition with an average burn unit size of around 1,500 acres. Aerial ignition alleviates most local smoke problems by generating enough heat to allow the smoke column to punch through the mixed layer and inject most of the smoke into the free atmosphere above the mixed layer. During periods of high transport winds and low mixing heights, the strong winds prevent the development of a strong vertical smoke column by tilting the column which helps keep the smoke confined to the mixed layer. When this smoke is trapped within the mixed layer, it often mixes back down to the ground, leading to potential air quality problems.

On February 27, 2004 a prescribed fire was conducted on Mount Magazine in west central Arkansas. The total burned area was 4,500 acres. The burn started at 10am with ignition along the ridge top progressing down the slope from north to south. As the fire progressed down the slope, the fuels changed from hardwood leaf litter on the upper slopes to pine litter towards the base. A fair amount of ice damaged timber added to the fuel load.

In Fayetteville, AR, approximately 70 miles away, hourly particulate matter concentrations (PM2.5, those particles smaller than 2.5 microns) peaked at over 240 micrograms per cubic meter that evening. While these elevated values only lasted for a few hours and was a rare event, it was enough to raise the 24 hour PM2.5 concentration to over 40 micrograms per cubic meter, exceeding the National Ambient Air Quality standard of 35. Strong transport winds (15-18 mph) prevented the development of a well defined vertical smoke column (see picture). This smoke was trapped within the mixed layer and as the smoke was transported to the north, the mixed layer depth decreased from 4,000 feet down to below 3,000 feet, concentrating more smoke near the surface.

Panoramic view of Mount Magazine prescribed burn February 27, 2004 (courtesy of Todd Hoopes of the Mt Magazine Ranger District)

From the Editor...

The *Guide for Prescribed Fire in Southern Forests* is currently being updated to include new research findings and expand the focus of the original guide beyond the coastal plain of the southeast.

During this revision I would like to incorporate as much feedback from the field as possible in the fire weather and smoke management sections to try and keep this guide focused on being a "how to" guide rather than an encyclopedia. If people feel there is a need we could also update the *Southern Forestry Smoke Management Guidebook* to serve as a more comprehensive reference text.

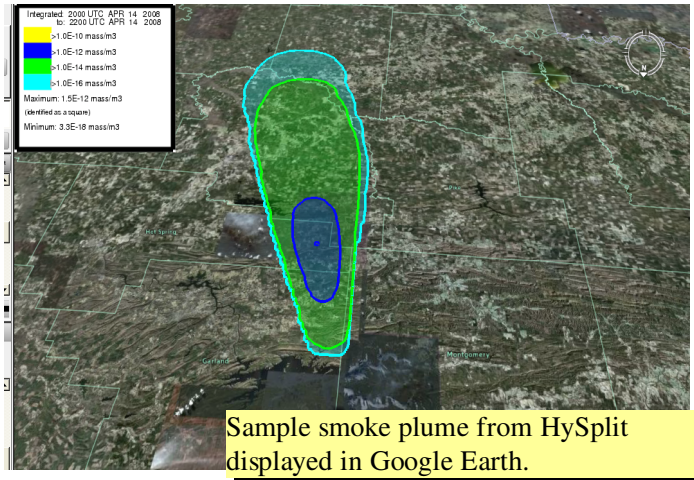
Please send any comments you have regarding revising the guide to me at sgoodrick@fs.fed.us. In addition if anyone would like to help with the revisions, either writing or reviewing, please send me a message as well.

Thanks,
Scott Goodrick
Editor
Southern Smoke Issues

While predicting all of the plume dynamics that contributed to the Fayetteville smoke incident is still an active area of research, the Ouachita and Ozark-St. Francis National Forests are trying to take advantage of all the technology available to try and reduce the chances of another such incident. Roger Fryar, Deputy Fire Team Leader for the Ouachita and Ozark-St. Francis National Forests has been a leader in advancing smoke management practices for this area. Through the website www.aokforests.com the public has access to information regarding all of the prescribed burns conducted by the forests along with maps highlighting potential smoke impact areas. While these smoke impact areas are currently determined using the geometric smoke screening system employed in the *Guide for Prescribed Fire in Southern Forests*, vsmoke-gis is also used extensively in planning burn operations.

Over the past year or so Roger has begun making extensive use of NOAA's Hazard Mapping System (www.firedetect.noaa.gov/viewer.htm) and HySplit dispersion model. The Hazard Mapping System provides daily snapshots of fires and smoke detected by satellites. While the smoke mapping does not allow one to estimate the ground level concentration, it does provide a means of validating whether smoke forecasts moved the smoke in the right direction. HySplit is a dispersion model developed by NOAA that can be downloaded and run on a PC or used over the internet (http://www.arl.noaa.gov/ready/hysplit4.html) to examine historical smoke incidents and produce forecasts of potential impacts on the day of the burn (requires registration). Output from HySplit is available in various GIS formats and can be easily viewed using Google Earth.

Combining an easily accessible website along with other means of communication has allowed the Ouachita and Ozark-St. Francis National Forests to inform the public about where smoke from prescribed fires is likely to impact. Prediction of these impact areas is improving through the use of new modeling tools. The forests are even going the extra yard and deploying EBAM monitors to help them determine the impact of their smoke on an area. Every burn is carefully planned using the best available forecast information; however, when conditions develop that were not forecast, smoke incidents are still a possibility. The Forests will continue to use the latest technology, such as HySplit, to reduce the chance of these events.



Sample smoke plume from HySplit displayed in Google Earth.

Upcoming meetings...

The '88 Fires: Yellowstone and Beyond in Jackson, Wyoming on September 22-27, 2008. This conference commemorates the 20th anniversary of the 1988 fires in Yellowstone and the northern Rocky Mountain area. This event is presented by the International Association of Wildland Fire in association with the National Park Service 9th Biennial Scientific Conference on the Greater Yellowstone Ecosystem with the support of a consortium of partners. For more info visit http://www.iawfonline.org/yellowstone/

Effective Communication for Smoke Management in a Changing Air Quality Environment, Great Smoky Mountains National Park, September 16th 18th 2008. This training is the work of the The Fire Air Coordination Team. The objective of this training to give fire staff personnel a better understanding of how smoke management regulations are made and support the formation of state and local level groups to work on smoke regulations and implementation. The target audience for this training is agency personnel responsible for coordination and collaboration with air regulatory agencies at the state level. For more info visit http://www.cnr.uidaho.edu/wildlandfire/regional_workshop_1.htm

Paper of Interest...

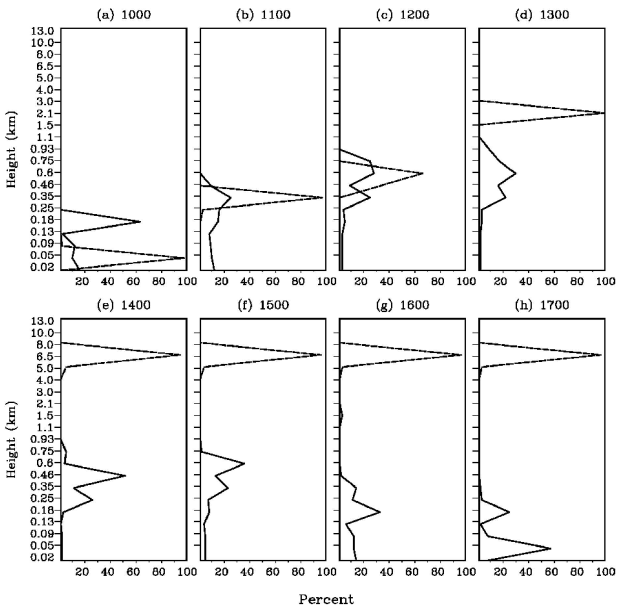
Sensitivity of air quality simulation to smoke plume rise

Yongqiang Liu, Gary Achtemeier, and Scott Goodrick
Center for Forest Disturbance Science
Forestry Sciences Laboratory
USDA Forest Service
Athens, Georgia 30602, USA

Plume rise is the height which smoke plumes can reach. This property is needed by air quality models such as the Community Multiscale Air Quality (CMAQ) model to simulate physical and chemical processes of point-source fire emissions. Emissions, if injected into higher elevations, are likely to be transported out of the burn area by prevailing winds, meaning relative smaller local ground concentrations and therefore reduced chances for exceeding the National Ambient Air Quality Standards (NAAQS) standards, which are measured by ground concentration. The objective of this study was to understand the importance of plume rise to CMAQ air quality simulation of prescribed burning to plume rise.

Three simulations with CMAQ were conducted for a Florida prescribed burning case. For the first simulation the burns were represented as area sources with all emissions released at the surface. The other two simulations treated each fire as a point sources. These two simulations differed in their plume rise formulation; one used the Briggs plume rise scheme while the other used the Daysmoke plume model developed by Gary Achtemeier.

Plume rise calculated with Daysmoke gradually increases from about 180 m at 1000 EST to nearly 1 km by 1300, and then gradually decreases. Substantial amounts of smoke particles are found within two or more layers in the upper portion of the plume until 1700. In comparison, plume rise calculated with the Briggs scheme is lower from 1000-1200; but it then doubles by 1300 and continues to increase up to about 6.5 km.



Vertical distribution of smoke particles (in %) with height at the hours from 1000 throughout 1700. Real and dashed lines represent the estimates using Daysmoke and Briggs scheme, respectively.

Upcoming meetings (cont)...

The 24th Fire Ecology Conference, 11-15 January 2009, Tallahassee, FL. The conference objective is to present and publish current scientific research on topics that will likely influence the future of prescribed fire. For more information visit the conference website http://www.talltimbers.org/FEconference/

Research Update

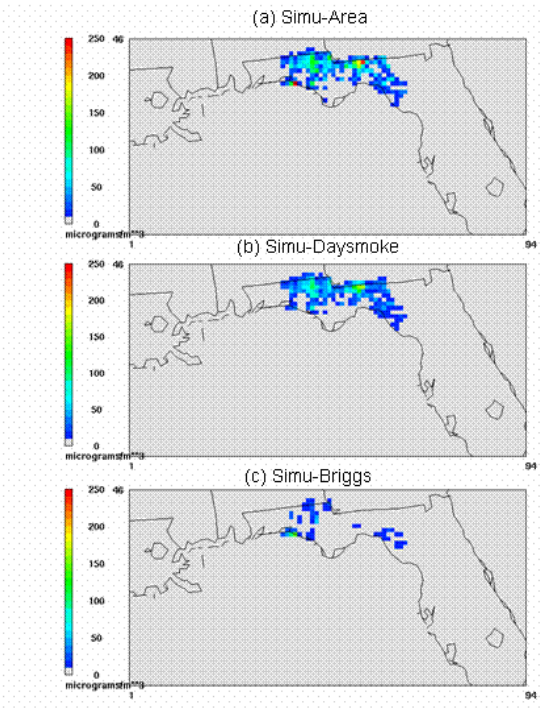
The Atmospheric Science Team of the Southern Research Station's Center for Forest Disturbance Science currently has a number of smoke related research projects underway.

The USDA Cooperative State Research, Education and Extension Service's Air Quality program has been funding the team over the past three years to examine the sensitivity of air quality models to the vertical distribution of smoke from wildland fires. Plume rise controls the vertical distribution of smoke and can therefore have a large impact on surface smoke concentrations. Plume rise formulas developed for industrial stacks are not capable of reflecting the complex array of plume behaviors produced by wildland fires.

This past year the team has received funding for four new research projects. The first project is funded by the Strategic Environmental Research and Development Program (SERDP) to

The simulated ground level $PM_{2.5}$ concentrations are largest when the fires are represented as area sources. Values over 200 μg m^{-3} are found near the Florida-Georgia border and along the northern Gulf coast. The maximum value is 300 μg m^{-3}. The simulations where fires are treated as point sources also produces large $PM_{2.5}$ concentrations in these areas; however the magnitudes are much lower. For the Daysmoke simulation the maximum value is 164 μg m^{-3}. The Briggs scheme simulation produced the lowest $PM_{2.5}$ concentrations in most areas with a peak value of 142 μg m^{-3}.

The results indicate large sensitivity in CMAQ simulation results to plume rise for the examined Florida prescribed burning case. The ground PM2.5 concentrations with area emissions (zero plume rise) are far larger than those with fires treated point sources. This sensitivity to plume rise could have important implications for assessing the air quality effects of wildland fire cases using CMAQ. With area emissions, more smoke particles are trapped near the ground during the simulation, leading to more severe air quality effects in the burning area. Representing fires as point sources and using the Briggs plume rise scheme yielded the smallest air quality impact. A large portion of the smoke particles in this simulation are injected at high elevations due to large plume rise values. It is likely that these plume rise values are unrealistically large as they are well above the planetary boundary layer which may be acceptable for wildfires, but not for the average prescribed fire.. This may be related to differences between fire smoke plumes and the power plant stacks for which Briggs Scheme was designed. Fire plumes usually have a larger initial temperature contrast with the ambient atmosphere which leads to larger plume rise values with the Briggs scheme. On the other hand, fire smoke plumes usually are much large in size. Thus, their interactions with the ambient atmosphere through entrainment are more significant. These interactions would tend to suppress the upward motion and therefore lead to smaller plume rise values. These interactions are better accounted for in Daysmoke (see the Smoke Tools section for more information on Daysmoke) which should yield more realistic plume rise estimates that either the area source or the Briggs scheme.



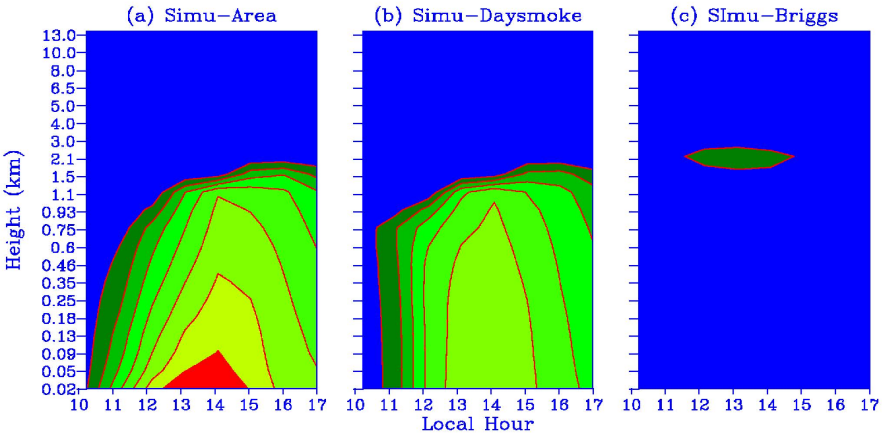
Spatial distribution of ground level $PM_{2.5}$ concentration (μg m^{-3}). The top panel shows simulation results when fires are represented as area sources. The middle panel show results when Daysmoke is used for plume rise and the bottom panel shows results when Briggs is used.

Research Update (continued)

characterize emissions and predict air quality impacts of prescribed burns on Department of Defense lands. (Partners: Georgia Institute of Technology, and the University of Georgia).

The second project involves the team in modeling smoke transport from rangeland fires in Kansas. The USDA CSREES Air Quality program funded Kansas State University to develop a smoke management program to minimize the air quality impact of smoke from rangeland burning. The U.S. Forest Service will be providing smoke modeling expertise and computational resources to the project.

The remaining two projects were funded by the Joint Fire Science Program as part of a larger umbrella project, the *Smoke & Emissions Model Inter-comparison Project* (SEMIP) awarded to the Pacific Northwest Research Station that seeks to establish performance standards for smoke modeling tools. Our projects which will contribute to SEMIP are the *Evaluation and Improvement of Smoke Plume Rise Modeling* and the *Evaluation of Smoke Models and Sensitivity Analysis for Determining their Emissions Related Uncertainty.* Results from these projects will help build confidence in smoke model predictions and also identify areas of weakness in the models to focus further research and development.



Time-height cross section of $PM_{2.5}$ concentration ($\mu g\ m^{-3}$).

Panels (a-c) are results for three simulations

Liu, Y-Q., G. Achtemeier and S. Goodrick, 2008, Sensitivity of air quality simulation to smoke plume rise. Journal of Applied Remote Sensing Vol. 2, 021503 (20 May 2008) DOI: 10.1117/1.2938723

See this space? We need your help to fill it!
Do you have any...
Information you would like to share with the smoke management community?
Ideas for articles?
Interesting smoke plume pictures?
Any upcoming meetings or training?
Questions about smoke management that you need answered?
Send them to Southern Smoke Issues at *sgoodrick@fs.fed.us*

Smoke Management Tools			
Tool Name	**Description**	**Status**	**Contact**
CONSUME	Software application designed to convert inputs of fuel characteristics, lighting patterns, fuel conditions, and meteorological attributes into estimates of fuel consumption and emissions by combustion phase. http://www.fs.fed.us/pnw/fera/research/smoke/consume/index.shtml	V3.0	Roger Ottmar (rottmar@fs.fed.us)
FEPS	Fire Emission Production Simulator (FEPS) is a user-friendly computer program designed to help managers estimate and mitigate the rates of heat, particles, and carbon gas emissions from controlled burns. Total burn consumption values are distributed over the life of the burn to generate hourly emission and release information. http://www.fs.fed.us/pnw/fera/feps/index.shtml	V1.1	Ellen Eberhardt (eeberhardt@fs.fed.us)
Vsmoke-GIS	VSMOKE and VSMOKE-GIS smoke dispersion models are classified as Gaussian dispersion models and predicts downwind PM2.5 (fine particle) concentrations, and provide visibility estimates. Hourly emissions and heat release rates estimates from FEPS are utilized by VSMOKE and VSMOKE-GIS.	V2.1.1	Bill Jackson (bjackson02@fs.fed.us)
BlueSky	BlueSky is a modeling framework designed to predict cumulative impacts of smoke from forest, agricultural, and range fires across the landscape. By utilizing predictions from a weather forecast model and fire information, BlueSky can create forecasts of ground concentrations of smoke. http://www.getbluesky.org and http://www.fcamms.org	V3.0 Research	Sim Larkin (larkin@fs.fed.us)
PB-Piedmont	PB-Piedmont is a Lagrangian smoke particle model designed to predict and monitor smoke movement along the ground at night over complex terrain of ridges and valleys typical of the Piedmont of the southeastern United States. PB-Piedmont maps smoke along with terrain in a GIS display that comes with the model. Roads and locations of key target may also be added to the display.	Research	Gary Achtemeier (gachtemeier@fs.fed.us)
Daysmoke	Daysmoke is designed to simulate plume rise and smoke dispersion from the daytime active burning period of prescribed fires. Daysmoke simulates smoke dispersion within the mixing layer and the amount of smoke injected into the free atmosphere above. Daysmoke also includes time varying and vertical veering/shearing winds. Daysmoke can be used as a "stand-alone" smoke concentration model or as a "smoke injector" for regional scale smoke modeling systems such as the Southern Smoke Simulation System.	Research	Gary Achtemeier (gachtemeier@fs.fed.us)
Southern Smoke Simulation System	Southern Smoke Simulation System (SHRMC-4S) is a regional smoke and air quality framework developed at the Southern High-Resolution Modeling Consortium (SHRMC). It provides land managers with information on concentrations and spatial patterns and temporal variations of smoke pollutants (PM, ozone etc.) from wildland fires. Applications of SHRMC-4S have been focused on simulating prescribed burns in the South. The prediction will be displayed using Google-Earch and made availble at SHRMC website.	Research	Yong Liu (yliu@fs.fed.us)
CalSmoke	A user interface to compile the necessary information needed to operate the CALPUFF atmospheric dispersion model when planning future prescribed fires in Region 8 of the USDA Forest Service. Preprocessed meterological files have been prepared for 3 years, and a software tool will allow the user to identify days that meet specified meteorological parameters at the proposed burn location. ArcGIS is being utilized to develop the inputs need for the modeling receptors and defining the burn units. The GIS information about the burn units and hourly emissions and heat release rates estimates from FEPS are utilized to build the area source emissions file needed by CALPUFF. CALPUFF results include PM2.5, CO, and CH4 concentration estimates, and visibility estimates. CALPUFF results can be viewed in ArcGIS.	V1.0 (alpha)	Bill Jackson (bjackson02@fs.fed.us)
HYSPLIT	The HYSPLIT (HYbrid Single-Particle Lagrangian Integrated Trajectory) model is a complete system for computing simple air parcel trajectories and conducting complex dispersion and deposition simulations. The model can be run interactively on the Web through the READY system or the code executable and meteorological data can be downloaded to a Windows PC. http://www.arl.noaa.gov/ready/hysplit4.htm	V4.8	http://www.arl.noaa.gov/cgi-bin/feedback.pl
Simple Smoke Screening Tool	A simple web-based screening tool derived from the 1976 Southern Forestry Smoke Management Guidebook. http://shrmc.ggy.uga.edu/maps/screen.html	Research	Scott Goodrick (sgoodrick@fs.fed.us)
RS Smoke Detection	MODIS sensor is used to detect smoke from wildfires in near real-time by the EastFIRE Laboratory of George Mason University as part of a collaboration with the Forest Service Southern Research Station. http://eastfire.gmu.edu/temp/eastfirewatch/index.htm	Research	John Qu (jqu@cos.gmu.edu)