

Pacific
Northwest
Research
Station

Science Update

A CLEAR PICTURE OF SMOKE: BLUESKY SMOKE FORECASTING



Tom Iraci

IN SUMMARY

Over the last several decades, the overall air quality goal in the United States has been to protect public health and clear skies by reducing emissions. At the same time, however, the risk of catastrophic fire has been rising in forests around the country as overly dense trees and understory brush crowd the stands. Prescribed fire—planned, controlled burning within specified conditions—is one important tool used to reduce hazardous fuels in forests, woodlands, and grasslands. Land managers are faced with the challenge of reducing fire risk while meeting air quality standards.

Effective smoke management for prescribed burning requires reliable forecasting of potential smoke effects. Although forest fire managers have long known the basics of smoke movement, it is far more difficult to predict how much particulate matter and emissions will be produced, what the smoke will do a long way from the source, what the smoke will do the next day, and what the cumulative

effects of smoke from multiple prescribed fires or wildfires will be.

Scientists from the USDA Forest Service Pacific Northwest (PNW) Research Station, along with many partners, have developed the BlueSky framework to meet these management needs for accurate smoke forecasting. Started as a regional project in the Pacific Northwest, BlueSky has been expanded to provide real-time predictions from large wildfires throughout the contiguous United States and from prescribed fires in some regions.

BlueSky is a framework that contains and combines models and data about weather, fires and fuels, emissions, and terrain. By integrating these models into a unified framework, BlueSky is able to predict smoke concentrations and trajectories, and can be used to create forecasts helpful to land and fire managers. The story continues inside of what has been accomplished so far in smoke forecasting.



Why is smoke a forest management issue?

People care about clean air. The Nation's anchor legislation for air quality is the Clean Air Act, which requires the federal government, states, and tribes to maintain the National Ambient Air Quality Standards set by the Environmental Protection Agency (EPA) for specific pollutants. These standards are based on science and designed to protect human and ecosystem health. The states have primary responsibility for managing clean air, and land managers (federal, state, tribes, and private) work with the states in smoke management programs.

Over the last several decades, the risk of catastrophic fire has been rising in forests around the country as dead fuels, overly dense trees, and understory brush crowd the stands. Prescribed fire is one of the main tools available to land managers to reduce fuels, but prescribed burning has been the subject of several lawsuits, as the public's tolerance for smoke has diminished over time.

Purpose of PNW Science Update

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Through the Healthy Forests Initiative, Healthy Forests Restoration Act, and the National Fire Plan, the federal land management agencies are charged with reducing hazardous fuels in forests, woodlands, and grasslands. Nationally, these agencies reported that they treated fuels on over 4 million acres of federal land in 2005, with nearly 70 percent of the total treated in areas around homes, communities, and high-value sites, and the remaining acres treated in high-priority areas for natural resources at greatest risk of catastrophic wildland fire.

Smoke Basics

Particulate matter in smoke is what makes people's eyes water and their lungs burn. These small particles are typically described by their diameter. For example, PM 2.5 is particulate matter less than or equal to 2.5 microns in diameter, equivalent to about 1/30 the diameter of the average human hair. The quantity of particulate matter is measured in micrograms (millionths of a gram) per cubic meter of air.

The particulate matter in smoke from prescribed fire and wildfire can cause burning eyes, phlegm, coughing, and bronchitis, and it can aggravate asthma, emphysema, other respiratory ailments, and heart disease conditions. Children and elderly people are most affected. Particulate matter also reduces visibility, making smoke a safety concern for highways and airports.

Smoke also includes gases produced by incomplete combustion. Some emissions of concern in wildland smoke include carbon monoxide, carbon dioxide, and methane.

Although smoke is becoming a more significant issue nationally, the tools available to land managers to manage smoke from prescribed fire have been limited. At the PNW Research Station's Pacific Wildland Fire Sciences Laboratory in Seattle, Washington, the AirFire team accepted the research challenge of developing the next-generation decision-support tool that would allow land managers, air regulators, and others to understand not only where the smoke from their fire would go, but also the cumulative impacts from all of the fires burning in the region. Such a tool would allow different users with different interests a common starting point for communicating with each other about how best to predict and mitigate smoke.

Sue Ferguson, research atmospheric scientist, started this research in the 1990s, developing tools to help land managers better plan and mitigate smoke impacts from fire. Ferguson was a leader in technology transfer, organizing researchers and managers to work together on making the new science tools useful.

Physical climatologist Sim Larkin, who worked with Ferguson, and the rest of the AirFire team have continued the smoke modeling research since Ferguson's death in 2005. "Smoke

is a growing issue,” Larkin says, “especially with more and more sources including prescribed burning competing for the airshed.”

Land managers, fire managers, air quality regulators, and others want information about potential smoke effects. For example:

- What is the maximum smoke concentration that could be expected downwind in areas of concern?
- When is the smoke likely to arrive at a location?
- Will the National Ambient Air Quality Standards be exceeded?
- In what locations should public health alerts potentially be issued?
- Where will visibility most likely be affected by smoke?
- What roads are at greatest risk from smoke incursion?
- What potential actions might be taken (or avoided) to mitigate smoke impacts?

Effective smoke management is essential for accomplishing National Fire Plan goals, and prescribed burning smoke cannot be managed responsibly without reliable smoke forecasting.

Key Findings

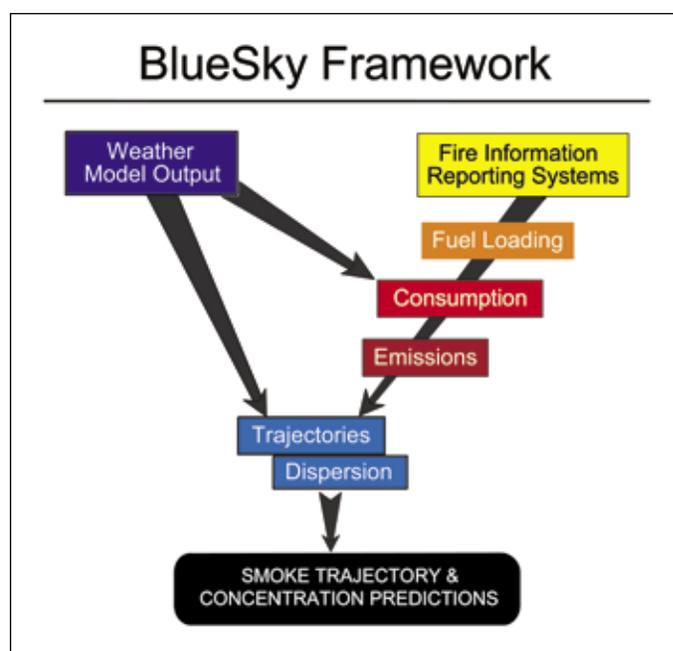
- The ventilation climate information system (VCIS) shows local, regional, and national patterns of the potential for smoke to be transported downwind or stagnate and collect near its source. Patterns are split out by location and calendar month. Good ventilation conditions can occur on at least some days in every part of the continental United States.
- Despite their different parameters, computer models of fuels, fire, weather, and emissions can be linked into one framework for predicting the cumulative impacts of smoke from multiple sources. The BlueSky framework integrates these models, allowing real-time smoke forecasting.
- The modular structure of the BlueSky framework allows the substitution of different models for a given parameter such as plume rise or emissions, making it possible to test and compare models and identify sources of uncertainty. This approach makes it possible to more rapidly improve the accuracy of smoke forecasting.
- In a 2005 field trial covering 11 Western States, BlueSky was found to be a useful tool to integrate fire occurrence, fuels, and weather data from multiple fires to calculate smoke emissions, trajectories, and concentrations. The field data collected are helping identify needed model improvements and research areas.



Tom Iraci

How is smoke forecasting different from weather forecasting?

Fire managers have long known the basics of smoke movement. Air and smoke move upslope and up valley during the day and downslope and down valley at night. Large smoke plumes, of course, are carried on the wind—everyone can see the massive smoke columns rising from big fires and traveling downwind. What has been more difficult to predict, Larkin explains, is where the smoke will go once it leaves the area of the fire. Smoke can travel hundreds of miles, affecting populations and ecosystems far downwind. Sometimes the smoke can remain aloft over long distances, not reaching the ground, and then collapse, causing significant smoke events in towns far downwind from the source fire. Smoke forecasting requires data on weather, terrain, and fires and fuels. Each of these categories includes many specific data needs (see figure).



The BlueSky framework uses data on weather, fires and fuels, emissions, and terrain. BlueSky calculates smoke plume rise, particulate matter concentrations, visibility, and chemistry. Its final outputs are forecasts of smoke trajectories and concentrations, with Web displays.

Smoke weather and terrain. Smoke weather refers to the conditions that affect the transport, pooling, and dispersion of smoke. Numeric models are needed to predict the wind direction and windspeed as well as the mixing heights and atmospheric stability needed to understand where smoke will go.

The vertical rise of smoke is controlled by the buoyancy of the smoke plume and atmospheric stability. In unstable air, smoke can rise into the sky, but a stable layer of air can trap smoke at lower elevations. Inversions are highly stable layers of air. Smoke plumes from hot fires can break through weak inversions, but stronger inversions act as “lids,” trapping smoke in air layers close to the ground.

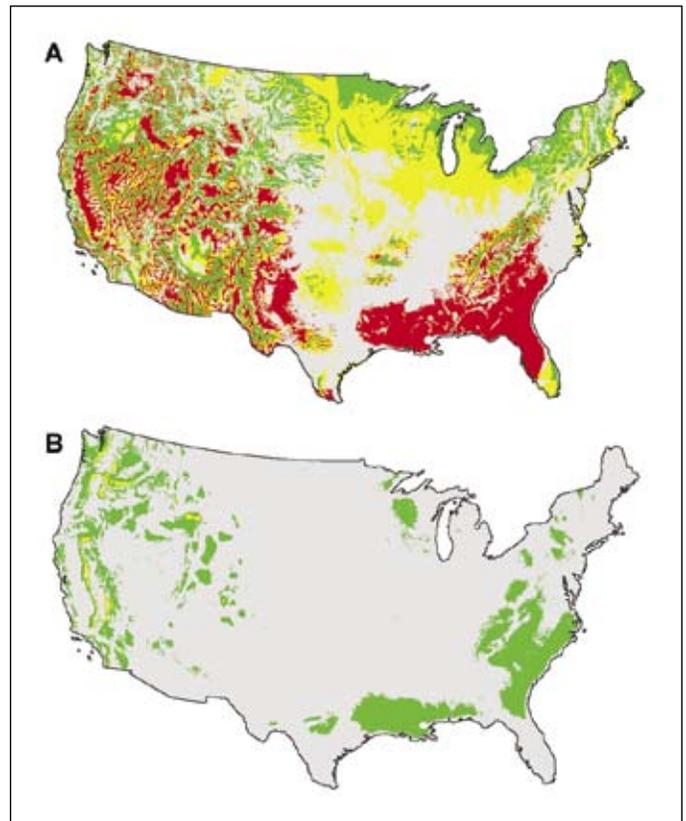
The horizontal transport of smoke is controlled by wind. Surface winds are strongly influenced by topography as mountains, valleys, and other features block, channel, or accelerate moving air. Small changes in terrain can have strong influences on smoke trajectories, especially at night when smoke tends to stay closer to the ground. Windspeed usually increases with height, as the air is no longer impeded by ground friction. Wind patterns and speeds become complicated in mountains, where air is squeezed through mountain passes or funneled through gorges. The full characterization of a smoke plume requires knowing the horizontal and vertical patterns of wind, humidity, and temperature, including very fine-scale information such as the stability and turbulence within the air column.

As smoke rises and travels, it also mixes with the air. Stagnant air has a low mixing height, and particulate matter and emissions are trapped near the ground. High mixing heights allow smoke to mix with the atmosphere along a considerable vertical distance, with better dispersion as a result.

Ventilation indices were among the first ways to characterize the interaction of the atmosphere and smoke. Ventilation indices, typically the product of mixing height and windspeed, are simple measures defined as the potential for smoke from prescribed fire or wildfire to be carried away from the source area. Firefighters already knew the general patterns for smoke ventilation: mixing heights are usually lowest in the late night and early morning hours and highest from mid to late afternoon, at the peak of daytime heating. This daily pattern often causes smoke to be concentrated in basins and valleys during mornings and dispersed aloft in afternoons.

In the 1990s, the AirFire team developed measures of the likelihood that poor ventilation would occur on any given day at any selected spot on the landscape. The ventilation study, led by Ferguson, developed the first map of ventilation conditions to cover the entire continental United States. The team built a database that included 40 years of weather records and used it to develop an interactive ventilation climate information system (VCIS).

The interactive VCIS model produces maps of smoke ventilation potential by generating and analyzing the average (mean) values of daily and nightly surface winds, mixing heights, and dispersion potential. Maps for these variables can be produced on local, regional, and national scales (see figure). With VCIS, users can study patterns for poor, marginal, fair,



Map shows the monthly average ventilation index for October in the contiguous United States, for (a) morning and (b) afternoon. Red represents potentially poor ventilation conditions, yellow is marginal, green is fair, and gray is good. Large areas have poor ventilation potential in low-lying areas during the morning. Ventilation potential improves dramatically in the afternoon, except in the lee of several mountain ranges.

and good ventilation conditions by location, time of year, and under varying conditions—useful information for planning prescribed burning programs.

The national ventilation database showed some regional patterns. Poor and marginal ventilation conditions are most frequent in the Southeastern United States, which also has the most smoke-sensitive locations. The Southeast has some of the Nation’s highest levels of particulate matter and ozone, but prescribed burning is used extensively in the region to reduce fuel loads and wildfire risk. In the coastal areas of the United States, moist marine air increases the stability of air layers, with the result that low mixing heights and poor ventilation are common. In the Western United States, northern plains and deep valleys can have poor or marginal ventilation conditions, especially during the winter. High desert regions show the best potential for good ventilation conditions, with the

BlueSky framework aimed at modeling the full complexity of all the factors affecting long-distance smoke movement and the cumulative effects from multiple smoke sources.

least risk to air quality and visibility. The AirFire team found, however, that good ventilation conditions can occur on at least some days in every part of the continental United States.

A new approach. The VCIS model, a first-generation tool for understanding smoke movement, was a simple system that, in essence, estimated how high smoke would go and how fast the wind transporting the smoke was moving. The BlueSky framework started with an entirely different approach, aimed at modeling the full complexity of all the factors affecting long-distance smoke movement and the cumulative effects

from multiple smoke sources. To do this, scientists in the Air-Fire Team created a research consortium to partner with land managers, fire managers, and others, thereby gaining the benefit of their collective experience to develop the more complex BlueSky framework.

The BlueSky approach began with weather forecasting. In the development of existing models for weather forecasts, the focus had been on predicting winter storms, the weather of most concern to the general public. “We were concerned with hot, dry conditions in the summer,” Larkin explains.

Regional Domains for Fire Weather and Smoke Research

Under the National Fire Plan, regional modeling centers were organized to meet critical needs for research on fire weather, fire danger, fire behavior, and smoke management. These centers are called the fire consortia for the advanced

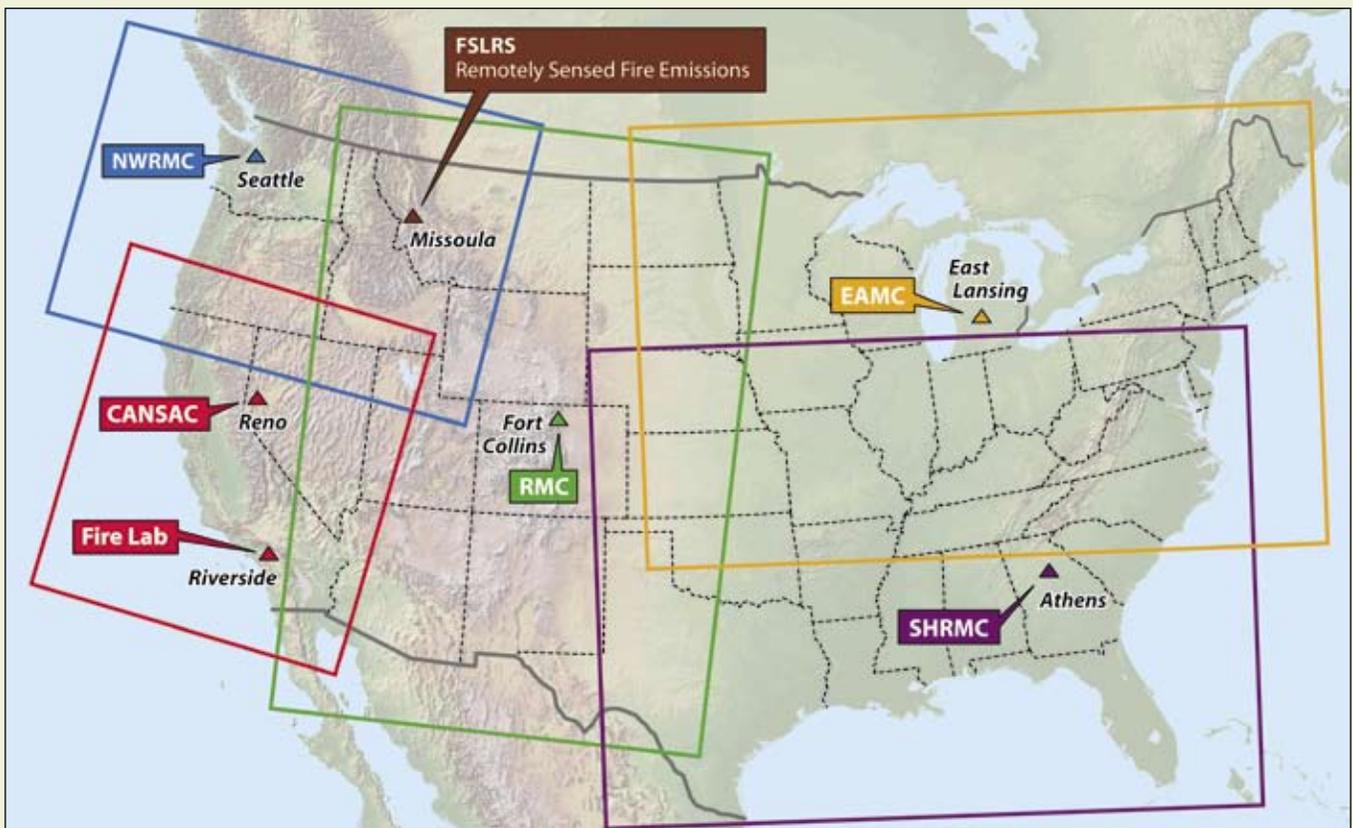
modeling of meteorology and smoke (FCAMMS). The FCAMMS domains (see map) are based on weather forecast domains; the continuous nature of weather influence is the reason for the overlap.

FCAMMS

- CANSAC California and Nevada Smoke and Air Committee (Reno, Nevada, and Riverside, California)
- EAMC Eastern Area Modeling Consortium (East Lansing, Michigan)
- NWRMC Northwest Regional Modeling Consortium (Seattle, Washington)
- RMC Rocky Mountain Center (Fort Collins, Colorado)
- SHRMC Southern High Resolution Modeling Consortium (Athens, Georgia)

Other map features

- FSLRS Fire Science Laboratory (Missoula, Montana)—provides remote sensing products



The Pacific Northwest consortium worked first on improving the forecasting of summer weather conditions, which were of most concern for smoke forecasting.

Understanding smoke movement, however, required knowing about the fire as well as the weather. “BlueSky is an extension of weather forecasting,” Larkin says, “but it also uses fuels, fire behavior, fire emissions, dispersion, and trajectory models. It is several steps beyond weather forecasting.”

Smoke forecasting requires data about fire locations and sizes, fuel loads and consumption, and fire behavior. Some of this information is reported from the field, and other data are generated through computer analysis.

The BlueSky framework pulls data on fire locations and sizes from prescribed burn and wildfire reporting systems. BlueSky automatically downloads wildfire location and size information from the daily ICS-209 reports filed in the National Interagency Fire Center database. The ICS-209 reports are daily updates on active, large wildfires and wildland fire use fires (lightning-ignited fires allowed to burn under certain conditions). The reporting of prescribed fires and agricultural burns differs among the FCAMMS domains owing to variations in state requirements, and as a result, not all BlueSky domains have information available on these smoke sources. BlueSky routinely downloads the burn information from several Northwest sources, including FASTER in Oregon and Washington, the Washington State Department of Natural Resources, the Oregon Department of Forestry, fires in British Columbia, and the RAZU system for Montana and Idaho.

Fuel load data are also essential inputs for BlueSky. For default values, BlueSky uses fuel types from the fuel characteristic classification system (FCCS), which has extensive data and maps on wildland fuels throughout the United States. The FCCS system was developed by the PNW Research Station Fire and Emissions Research Applications (FERA) team, with partners. The geographical diversity in fuelbeds across the country—from southern pine forests to rangeland and chaparral to Pacific Northwest Douglas-fir forests—is captured in the nearly 200 fuel classes in FCCS. Site-specific fuel data or customized fuel classes can be used if available.

The amount of fuel actually burned is critical, of course, and this depends on fuel moisture, humidity, windspeed, and slope, among other factors. BlueSky uses an emissions production model that takes data on fuel load, fuel moisture, burn area, and windspeed, and predicts the amount of fuel consumption and emissions that will occur. New emissions models calculate the emissions from smoldering wood and duff as well as from flaming wood, brush, and grass. The emissions model produces estimates of the total particulate matter, PM 2.5, PM 10, carbon monoxide, carbon dioxide, methane, and heat generated from the fires.

The next step is calculating the long-range transport of the smoke plume and its gradual dispersion. BlueSky uses Calpuff, a smoke dispersion model developed and distributed by Earth Tech, Inc., originally built for California and adopted by EPA for national use, and Hysplit, a smoke trajectory



Managing Disturbance Regimes Program

To calculate how far smoke will travel, scientists work on understanding not only how smoke travels on the wind, but also how it disperses and deposits.

model developed by the National Oceanic and Atmospheric Administration (NOAA).

The Calpuff program is a puff-based model. It characterizes the smoke plume as parcels of air—for example, parcels of air at 9:00 AM, 9:05 AM, and so forth—and calculates how each puff is moved by the wind. “The model takes thousands of parcels of air, from many locations and at many time intervals,” Larkin explains, “and calculates how they move and spread, and then combines all this information for the forecast.” Each puff moves slightly differently as wind and meteorological conditions change.

The BlueSky framework uses all of the data and all of the analysis from the component models. Every night BlueSky obtains regional weather forecasts produced by the MM5 model, which is a midscale weather forecasting model used by the FCAMMS, and burn information from state and federal agency reporting systems. (Completeness of burn information differs among states.) After these data are downloaded, BlueSky processes the data for Calpuff and Hysplit. Twelve-hour smoke trajectories are computed from each burn location, and Calpuff is run using the emission estimates from the emissions production model and the weather forecast from MM5. BlueSky then produces a regional forecast of smoke concentrations for the next 3 days.

BlueSky requires significant computer resources to operate and is too large a model to be run on personal computers. It uses complicated algorithms that make all the data work together to correctly model the interactions of the many factors. Although BlueSky can pull data automatically, expertise is required to give meaningful assessments of the products.

What are the results from BlueSky so far?

The smoke modeling work that led to BlueSky began as a regional project in the Pacific Northwest, in response to public concerns about prescribed burning smoke. In 2000, funding for smoke modeling was received through the National Fire Plan, and in 2001, the AirFire Team made the

first smoke predictions for the Pacific Northwest domain using the BlueSky framework. Over the next several years, the partners working on BlueSky continued to use it in the Pacific Northwest and gradually expanded it in response to interest from air quality regulators and land managers.

The BlueSky partners tested the system through several field trials on large wildfires, including the 2002 Hayman Fire in Colorado, which poured heavy concentrations of smoke into the Denver metropolitan area. Comparison of the BlueSky forecasts with actual smoke concentrations showed that the model was reasonably accurate for the large-scale smoke transport but predicted significantly lower concentrations of particulate matter than actually occurred. The AirFire team used data from the Hayman Fire and other field trials to improve BlueSky.

The graphical displays with early versions of BlueSky were difficult for users to interpret. In 2002, the PNW Research Station formed a partnership with EPA to modify their Rapid Access INformation System (RAINS), a geographical information system (GIS) application, for use with BlueSky. The RAINS visualization system shows the BlueSky forecasts as easily read and understandable maps. Together, the tools form a complete system for creating and delivering smoke predictions.

The BlueSkyRAINS maps display smoke concentration fields and trajectories (see map on next page). The user can zoom in

on areas of interest and run simulations over the time period of the forecast. Because RAINS is a GIS system, a user can overlay the smoke forecasts with other GIS data layers such as communities and wilderness areas. The user can also run specific data queries, such as asking for the predicted PM 2.5 concentration of a particular grid cell on the map.

By 2003, BlueSky was made available to all Forest Service research stations through the FCAMMS for collaborative development and evaluation. In 2005, BlueSky was improved to provide real-time predictions from large wildfires throughout the contiguous United States. The system also was modified to automatically include wildfire information from the nationwide incident status summaries (ICS 209s). BlueSky's scientists migrated the tool to all of the agency's other research stations.

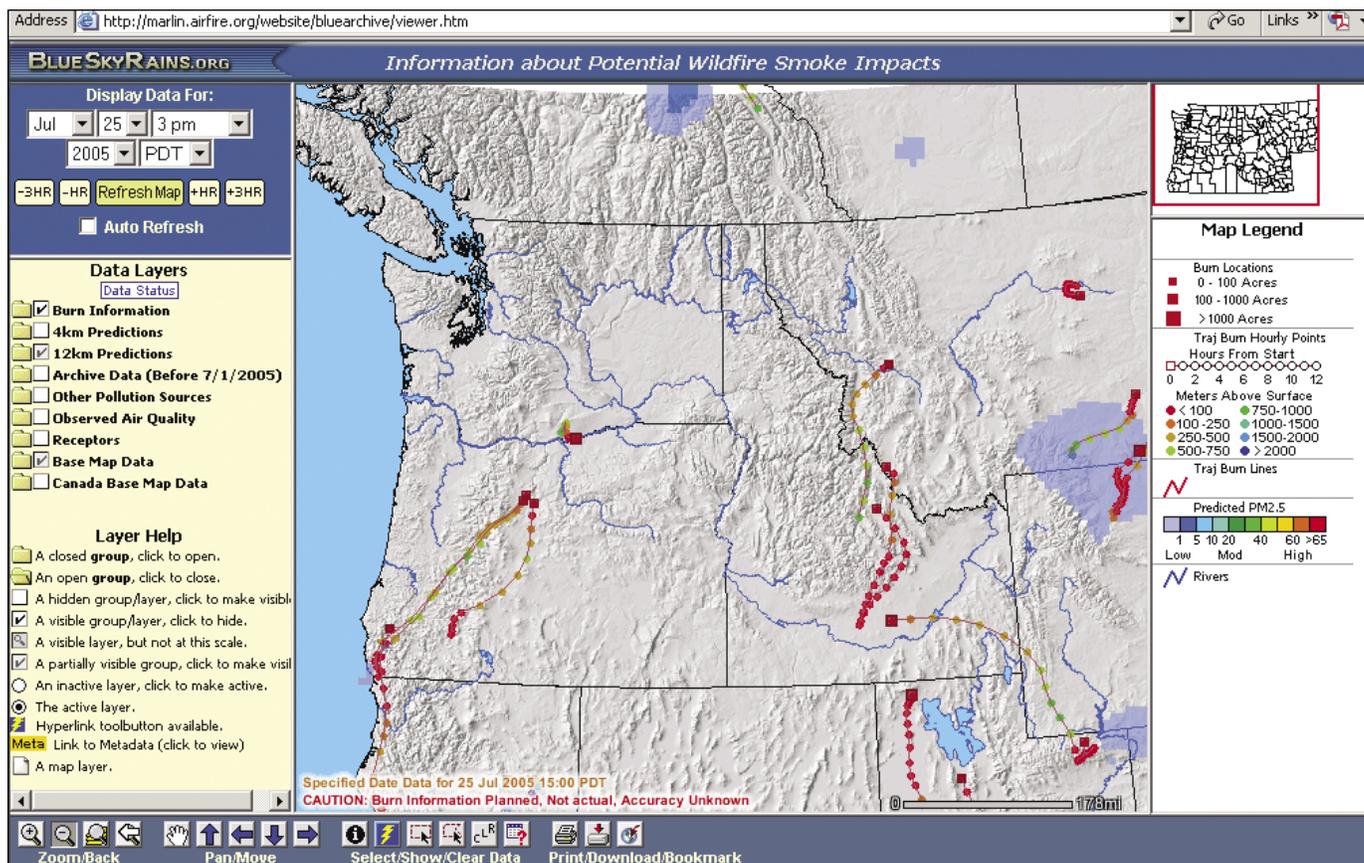
Also in 2005, a multiagency group carried out a large demonstration project, in which BlueSkyRAINS was used to predict smoke impacts from wildfires over the 11 Western States. The project area was the entire contiguous Western United States, and included the states of Washington, Oregon, California, Idaho, Nevada, Montana, Wyoming, Utah, Colorado, Arizona, and New Mexico.

The field trial was carried out by the USDA Forest Service's PNW and Rocky Mountain Research Stations and EPA. Work on the demonstration project developed a new partnership among the USDA Forest Service PNW, Rocky Mountain, and



Candace Krull

This air quality instrument is used to monitor weather and fine particulate concentrations in smoke. Scientists deploy an array of these instruments downwind of wildfires and prescribed burning to verify and improve the BlueSky framework.



The RAINS graphical interface for BlueSky produces GIS-based, interactive maps. Work is underway to make RAINS or a similar interface available for BlueSky throughout the contiguous United States by spring 2007.

Southern Research Stations; EPA; and the Department of the Interior. The PNW Research Station's AirFire team provided expert help and technical guidance for this large project.

The project team set up the BlueSky framework to be run at Rocky Mountain Center on its supercomputers and RAINS was implemented by EPA at Research Triangle Park, North Carolina. For daily weather inputs, the demonstration project used predictions from the MM5 weather model, updated twice daily. For fire inputs, the project used automated input of wildfire and wildland fire use data from the national ICS-209 reports. The FCCS fuel loadings were used as default values.

By mid-April 2005, the weather forecasts and the entire BlueSky framework were operating at Rocky Mountain Center as planned, producing 48-hour forecasts at 0600 and 1800 daily (6:00 AM and 6:00 PM). Implementation of the RAINS system was delayed, with visual display of the BlueSky products limited to static and animated graphic interchange format files until RAINS was operational in August, 2005. The Westwide BlueSkyRAINS system continued to operate through December, 2005.

BlueSky was found to be a useful tool to integrate fire occurrence, fuels, and meteorological data from multiple fires to calculate emissions, trajectories, and concentrations.

Field studies were conducted for two large fires during the demonstration project. The first, in late June, was the Black Range Complex, a wildland fire use incident on the Gila National Forest in New Mexico. The second was the Frank Church Fire Complex and Salmon-Selway Complex, September 3–14, on the Salmon-Challis National Forest in Idaho.

The team assessment of the demonstration project found that BlueSkyRAINS operated Westwide successfully. Overall, BlueSky was found to be a useful tool to integrate fire occurrence, fuels, and meteorological data from multiple fires to calculate emissions, trajectories, and concentrations. The team identified several model improvements that could be made and is working on these changes.

Full validation of BlueSky—or any air quality model—requires many field experiments, as each field trial can address only a small portion of the variability in fuels, fuel loading, weather, heat release, and terrain that may be encountered.

As of spring 2006, the BlueSky framework continues to offer wildfire coverage for the contiguous United States. It has prescribed fire coverage in some domains, and agricultural burning only in the Pacific Northwest. Because of regional differences in the availability of fire information and weather predictions, the implementation of BlueSkyRAINS has necessarily differed somewhat by region (see table). Weather forecast domains and resolutions define those parameters for BlueSky predictions.

Because BlueSky is a framework of models, multiple models are available for each step in the framework, and newer models can be added easily. Individual models currently in BlueSky can be replaced with others. “It stacks models that mimic physical processes on top of each other in a modular way,” Larkin explains. The modular approach means that for a given parameter, such as plume rise or emissions, different models can be directly compared, allowing scientists a unified way to examine how well various model choices and combinations work. Scientists can run BlueSky testing one plume-rise model against another, compare modeling results to field data, and see which model is most accurate. Thus the modular framework makes it easier to identify sources of error and more rapidly improve the accuracy of BlueSky.

The modular structure also makes it possible to update individual parts of BlueSky separately. “If a better weather or fuels model becomes available,” Larkin says, “it can be easily put in and the old model pulled.” The RAINS visualization system could also be replaced if a more effective system were found.

The uses for BlueSky have expanded beyond the original purpose of helping land managers with prescribed burning decisions. In the Pacific Northwest, land managers and state air quality regulators are using BlueSky smoke forecasts to help them make go/no-go decisions on prescribed burning, regulate the number and locations of burns allowed, and

On wildfires, incident command teams can use smoke forecasts to issue public safety notifications for both respiratory health and road visibility, allocate aircraft, and plan burnout operations.

monitor cumulative effects. The smoke forecasts can be a common basis for communication among air quality regulators, different landowners, and the public. BlueSky is used as a decision-support tool, meaning that it analyzes volumes of data and produces forecasts, but people still weigh the facts and make the decisions.

On wildfires, incident command teams can use smoke forecasts to issue public safety notifications for both respiratory health and road visibility, allocate aircraft, and plan burnout operations. For wildland fire use, smoke forecasts can be used in deciding whether a lightning fire is allowed to reduce fuels or is aggressively suppressed.

In just the last few years, federal, state, tribal, and local agencies have used BlueSky on many wildfires and prescribed fires. Through workshops, the AirFire team has introduced BlueSky to hundreds of managers and regulators from local, state, regional, and federal agencies in many states.

Domain	Resolution	Forecast period	FCAMMS	Station	Wildfire	Prescribed burning	Agricultural fire	RAINS	In operation since
Northwest	12 km	72 hrs	NWRMC	PNW	X	X	X	X	2002
	4 km	48 hrs			X	X	X	X	
California/Nevada	4 km	48 hrs	CANSAC	PSW	X	M	—	*	2004
Northeast	12 km	48 hrs	EAMC	NCRS	X	M	—	*	2004
Rocky Mountain	12 km	48 hrs	RMC	RMRS	X	M	—	*	2004
	8 km				X				
Southeast	12 km	48 hrs	SHRMC	SRS	X	M	—	*	2006
West (demo)	36 km	48 hrs	NWRMC/RMC	RMRS/PNW	X	M	—	X	Operated in 2005
	12 km				X			X	

FCAMMS = Fire Consortia for the Advanced Modeling of Meteorology and Smoke.

X = in operation.

— = not yet available.

M = manual only.

* = implementation of RAINS is in progress as of June 2006.

FCAMMS information: <http://www.fs.fed.us/fcamms/>

BlueSky information: <http://www.fs.fed.us/bluesky/>

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Tom Iraci

Smoke management can play a role in firefighting decisions as well as prescribed burning. For example, smoke forecasts can be useful in planning burnout operations. During multiple large-fire situations, smoke forecasts can be used to issue public health alerts to communities.



Jim Cronan, Yale University

Researchers collect smoke samples immediately after a crown fire on the Porcupine Fire in Alaska. Data contribute to a computer model that estimates smoke and carbon emissions from wildland fires.

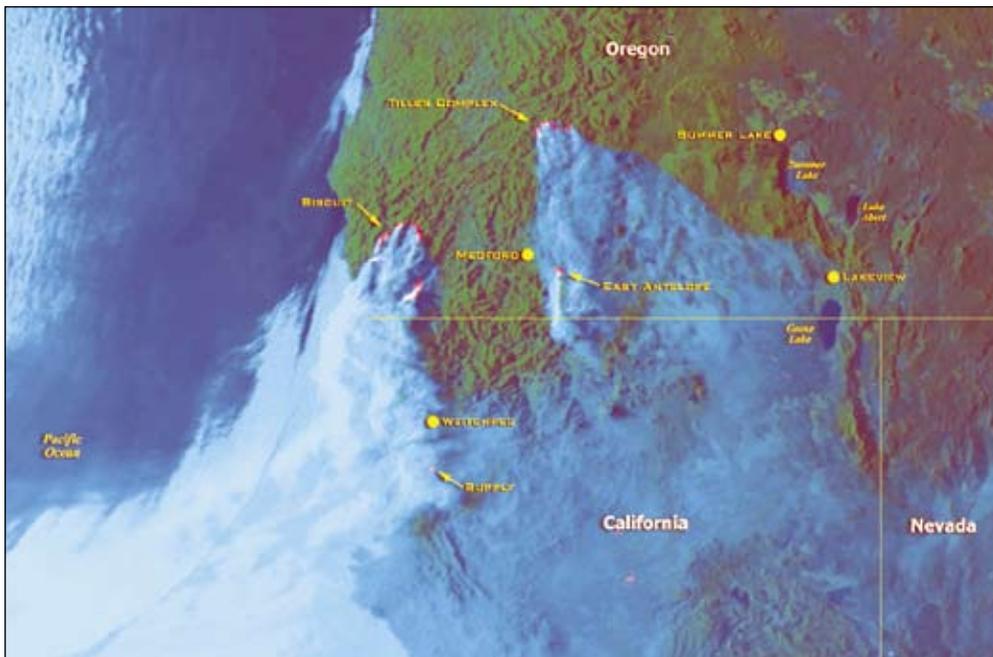
Extending the range of smoke forecasting

A model that attempts to forecast something as complex as regional smoke movement from multiple sources will always have some prediction error, just as regional weather forecasts do. Even so, scientists think that the accuracy of BlueSky forecasts can be increased. Over the next several years, scientists will be refining the framework's calculations, testing modeling results against monitoring data from prescribed and wildfires, and conducting specialized field experiments as needed.

The scientists expect that they can improve the reliability of BlueSky forecasts in the rough, mountainous terrain where so much fire occurs, increase its accuracy at distances closer to

fires, and increase its accuracy for both near-term periods and for predictions several days into the future. They are working on extending BlueSky's range to Alaska for smoke management needs there.

Work is underway with Sonoma Technologies to use satellite information for fire detection and forecast evaluation through a grant from National Aeronautics and Space Administration (NASA). One product will be to add BlueSky smoke forecasts to the EPA's highly successful air quality AirNow Web site (<http://www.airnow.gov>). Also, the Joint Fire Science Program has funded more field work to validate and calibrate the smoke forecasts. "We're very excited about the developments underway," Larkin comments. "We expect the usefulness of BlueSky will increase rapidly as we get these improvements in place."



National Oceanic and Atmospheric Administration

Satellite images are one tool used to monitor smoke from large fires and verify BlueSky smoke forecasts. However, the view from a satellite may be obscured by clouds or high-level smoke. This photo, taken August 15, 2002, shows heat signatures (red) and smoke (light blue haze) from fires burning in Oregon and California. On that date, the Biscuit Fire in southwest Oregon had burned 396,845 acres and was 28 percent contained.

The modular framework of BlueSky allows individual components to be replaced as improved models are available. Currently, the FCAMMS are developing a new weather forecast model that may eventually replace MM5, and other visualization software besides RAINS could be tested in the future.

"At this point," Larkin says, "BlueSky is still a research project but is available to users for testing and evaluation." The National Weather Service now uses the BlueSky framework to calculate emissions for its experimental smoke forecasts. A number of outside groups in the federal government and at universities are using BlueSky for research studies on emissions.

The scientists' goal is to develop a fully tested and operational BlueSky framework that would provide consistent and reliable real-time forecasts of the local and remote effects on air quality from wildfires, prescribed fires, and wildland-use fires. It would operate reliably on a daily basis for the entire United States with minimal human oversight. If this goal can be achieved, BlueSky could potentially be developed into a standard smoke forecasting tool used in air quality permitting.

Huge smoke columns rising from wildfires and irritating smoke at ground level have become all too familiar to many people over the past decade. The public has been very clear that they don't like the smoke and they would like fire risk reduced. Lowering fire risk, however, requires balancing fuel treatment and air quality needs. "BlueSky provides a way to understand the smoke impacts," Larkin states. "That enables a dialogue among burners, airshed regulators, and the public on how to balance various interests."

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BlueSky Partners

Early funding for the development of BlueSky came from the National Fire Plan, which has continued to be the main funding source. The Joint Fire Science Program, USDA Forest Service, EPA, Department of the Interior, and NASA have funded additional development, training, and evaluation.

As BlueSky coverage has increased and interest has grown in smoke forecasting, more partners have gotten involved, with some in development and others as users and evaluators. The current list of partners includes all the FCAMMS, and many federal, state, and local agencies and tribes. Some leading partners are Bureau of Land Management; EPA; Montana/Idaho Airshed Group; Nez Perce, Quinault, and Colville Tribes; NOAA; Northwest Airquest Consortium; Northwest Regional Modeling Consortium; Oregon Department of Forestry; USDA Forest Service, Rocky Mountain, Southern, North Central, and Pacific Southwest Research Stations, and Pacific Northwest and Northern Regions; University of Washington; Washington Departments of Ecology and Natural Resources; Washington State University.

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Layout — Keith Routman



Tom Iraci

Fuel treatment, including prescribed burning, is used to create firesafe, defensible spaces around homes in or near forests and woodlands. Prescribed burning smoke, however, can clog airsheds. BlueSky provides a way to forecast smoke impacts, information that managers can use in planning prescribed burns.

For Further Reading

Ferguson, S.A.; McKay, S.J.; Nagel, D.E. [et al.] 2003. Assessing values of air quality and visibility at risk from wildland fires. Res. Pap. PNW-RP-550. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 59 p.

Larkin, N.K.; O'Neill, S.M.; Solomon, R. [et al.] [N.d.] The BlueSky smoke modeling framework. Submitted in 2006 to Atmospheric Environment.

O'Neill, S.M.; Hoadley, J.; Ferguson, S.A. [et al.] 2005. Applications of the BlueSkyRAINS smoke prediction system. Journal of the Air and Waste Management Association. Sept: 42–45.

Resources on the Web

BlueSkyRAINS Web site. <http://www.blueskyrains.org>. Sponsored by the USDA Forest Service and EPA. Access to current Northwest forecast data, archived products, and RAINS information. (23 August 2006).

Fire Consortia for the Advanced Modeling of Meteorology and Smoke Web site. <http://www.fcammms.org>. Sponsored by the USDA Forest Service. Access to forecast data, national coordination, and weather. (23 August 2006).

U.S. Department of Agriculture, Forest Service, AirFire Team. <http://www.fs.fed.us/pnw/airfire/>. Information about all of the AirFire team's projects including BlueSky, VCIS, and others. (23 August 2006).

U.S. Department of Agriculture, Forest Service, BlueSky home page. <http://www.fs.fed.us/bluesky>. BlueSky news, technical information, publications, team members, etc. (23 August 2006).

U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. <http://www.fs.fed.us/pnw>. Information about all the Station's research and access to all Station publications. (23 August 2006).

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