Expanding BlueSkyRAINS to Support Emission Inventory Preparation

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ABSTRACT

The wildland and prescribed fire smoke prediction system, BlueSkyRAINS, shows promise as a tool for emission inventory preparation. In its current state, however, the system does not provide all the needed functionality. Several enhancements to BlueSkyRAINS are either planned or currently underway. One of the goals of these enhancements is to make BlueSkyRAINS more useful to the air quality community. This paper highlights coming enhancements of interest to those involved in the preparation of wildland, prescribed, and agricultural burn emission inventories.

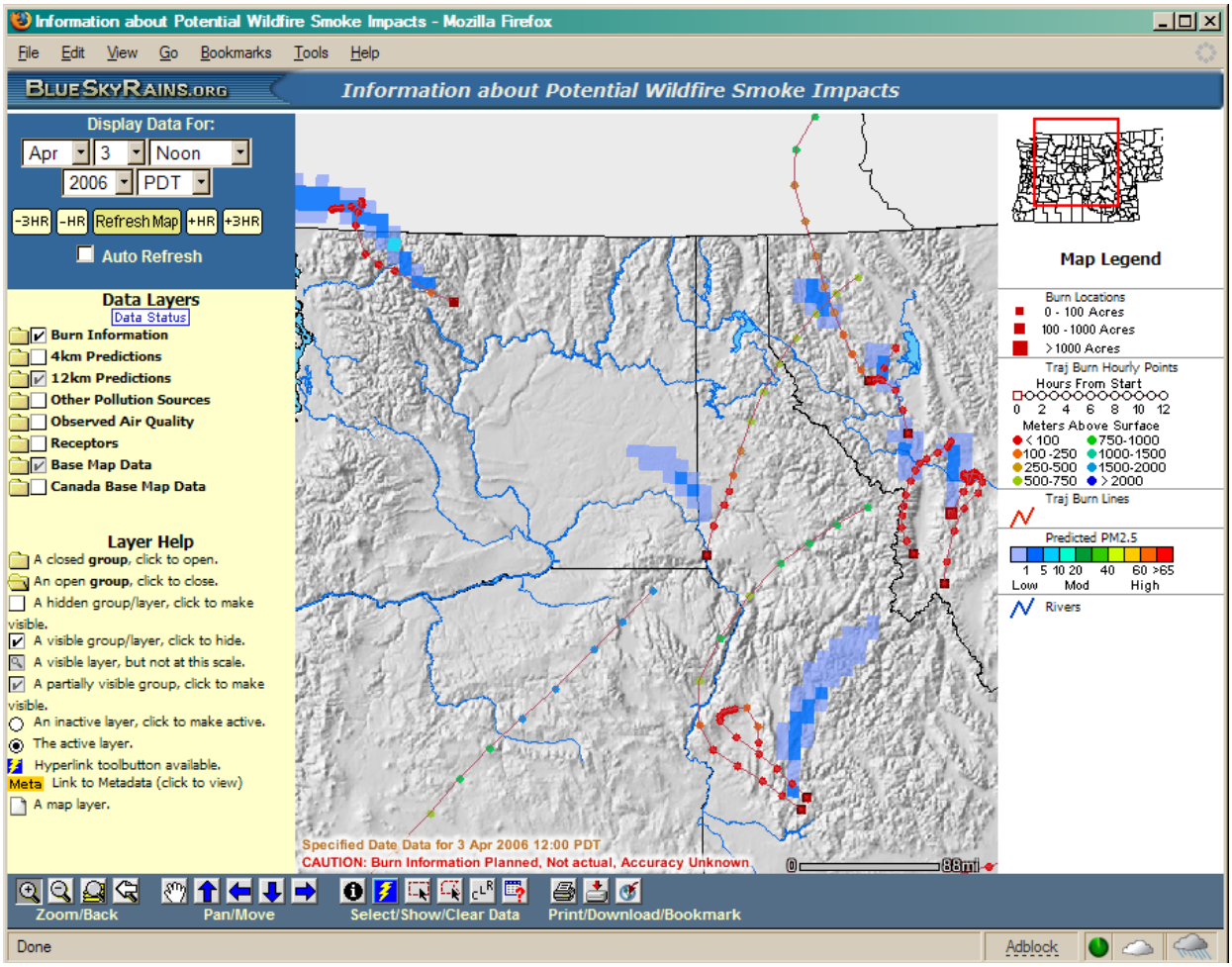
INTRODUCTION

BlueSky is a fire and smoke prediction tool used by land managers to facilitate wildfire containment and prescribed burning programs while minimizing impacts to human health and scenic vistas.[1] BlueSky links computer models of fuel consumption and emissions, fire, weather, and smoke dispersion into a system for predicting the cumulative impacts of smoke from prescribed fires, wildfires, and agricultural fires. Each night, BlueSky obtains regional meteorological predictions and reported burn information from state and federal agencies, merges these data with models of fuel consumption and emissions, and processes dispersion and trajectory models to produce regional estimates of smoke concentrations for the next two days. Smoke and fire managers access these predictions as a tool to aid their "go/no go" decisions for burning operations. BlueSky was developed by the Forest Service of the U.S. Department of Agriculture (USDA-FS).

RAINS, the Rapid Access Information System, offers Internet users the capability of using geographic information systems (GIS) technology to overlay and visualize geographic data. Developed by U.S. Environmental Protection Agency (EPA) Region 10, RAINS allows users to quantify smoke impacts by displaying $PM_{2.5}$ concentrations, meteorological parameters, burn information, and trajectories. The coupled BlueSkyRAINS system is available on the Internet (http://www.blueskyrains.org). Figure 1 shows a web page screenshot of BlueSkyRAINS predicting low concentrations of smoke downwind of several fires in Washington, Idaho, and Montana.

The daily estimates of smoke emissions and downwind concentrations produced by BlueSkyRAINS offer great potential value to the air quality community, particularly to support regional haze rules, State Implementation Plans (SIPs), and the preparation of emission inventories. However, the current capabilities of BlueSkyRAINS must be upgraded to provide output products of use to those beyond the smoke management community. This paper highlights the upcoming changes to BlueSkyRAINS that will make the system particularly useful to the emission inventory community.

Figure 1. Screenshot of BlueSkyRAINS predicting low smoke concentrations downwind of several fires.



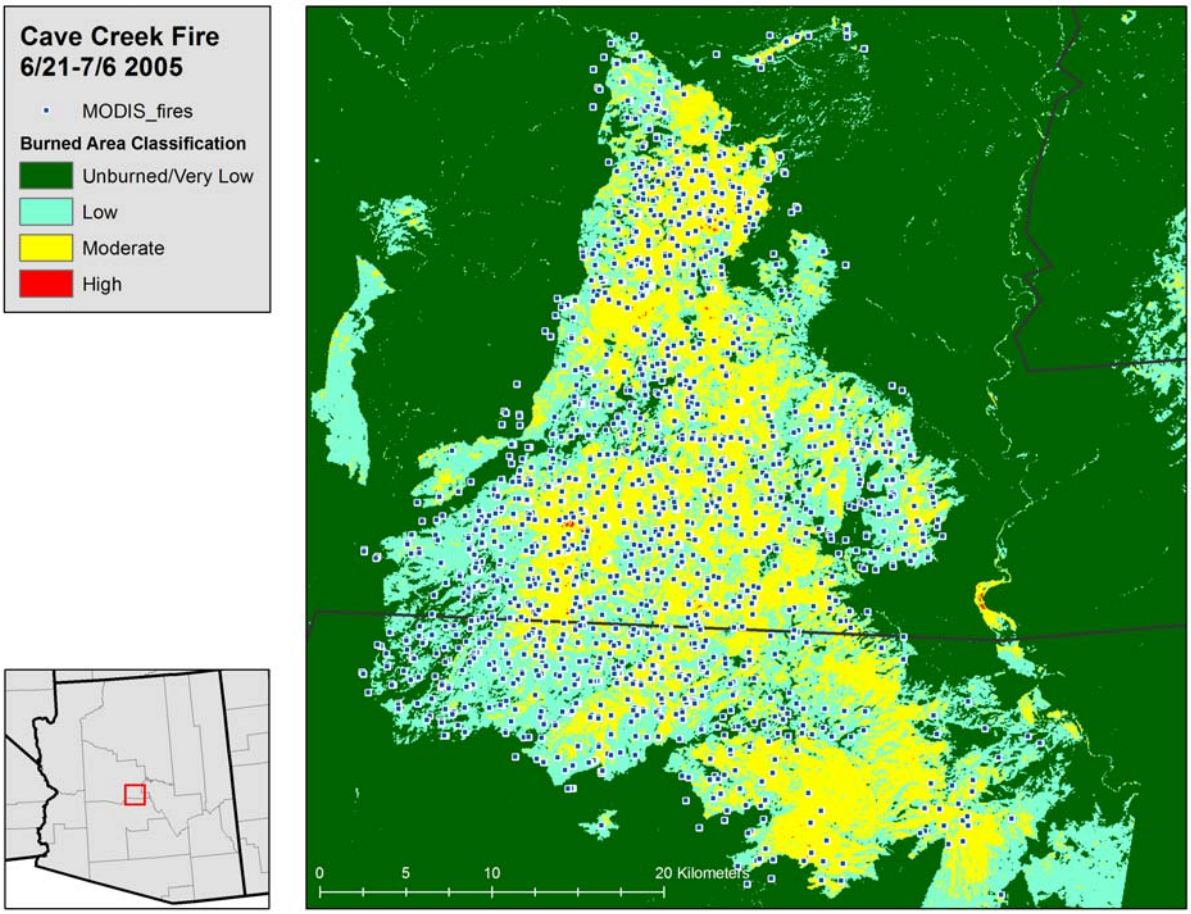
BLUESKYRAINS

Expanded Coverage

Currently, BlueSkyRAINS is available only for the Pacific Northwest (Washington, Oregon, Idaho, and western Montana). To be of use for preparation of national emission inventories, BlueSkyRAINS must be expanded to cover the United States. At present, BlueSky relies on reports of planned prescribed and agricultural fires from many agencies in the northwestern United States, including the USDA-FS, U.S. Department of Interior Bureau of Land Management (BLM), some tribes, regional consortia, and states. Reported data are highly variable because each tribe, state, and local regulatory body employs different reporting criteria.

As BlueSkyRAINS is expanded from the regional to national scale, a more streamlined and uniform method for determining fire sizes and locations will be needed. To facilitate this expansion, fires detected by remote sensors on-board several satellites will be incorporated. The National Oceanic and Atmospheric Administration (NOAA) integrates three satellite-derived fire data sets into a single, daily product—the Hazard Mapping System (HMS).[2] The HMS includes fires detected by Moderate Resolution Imaging Spectroradiometer (MODIS), Geostationary Operational Environmental Satellites (GOES), and Advanced Very High Resolution Radiometer (AVHRR). The combination of these three data sets provides excellent spatial and temporal coverage. Figure 2 shows fire "hot spot" pixels detected by MODIS overlaid on a map of burn intensity for a large fire in Arizona.[3] The MODIS pixels successfully capture the shape and overall area of the burn.

Figure 2. Map of burn intensity and detected fire pixels for the Cave Creek Fire in central Arizona.



Increased Flexibility

Several upgrades to BlueSkyRAINS are planned that provide users with more flexibility. Upgrades of specific benefit to the emission inventory community include (1) selection of fire emission models; (2) ad hoc, customized emission inventories and air quality predictions; and (3) output data products formatted for emission inventory use.

Fire Emission Models

BlueSkyRAINS uses the Emission Production Model (EPM) to generate modeled smoke emissions.[4] Integration of alternative fire emissions calculators will provide the latest fire emission calculation technology and give users the flexibility to use the system they think best reflects real-world conditions. Calculators to be added include the First-Order Fire Effects Model (FOFEM) and the Fire Emission Production Simulator (FEPS 1.0).[5,6]

Ad Hoc Model Runs

BlueSkyRAINS already allows interactive *browsing* of model results. The addition of interactive *modeling* will provide the user with the tools for modeling emissions and concentrations based on their own input data. For example, a state may want to use its own activity information about agricultural burns to develop a source category-specific emission inventory or examine the effect of that source on downwind $PM_{2.5}$ concentrations.

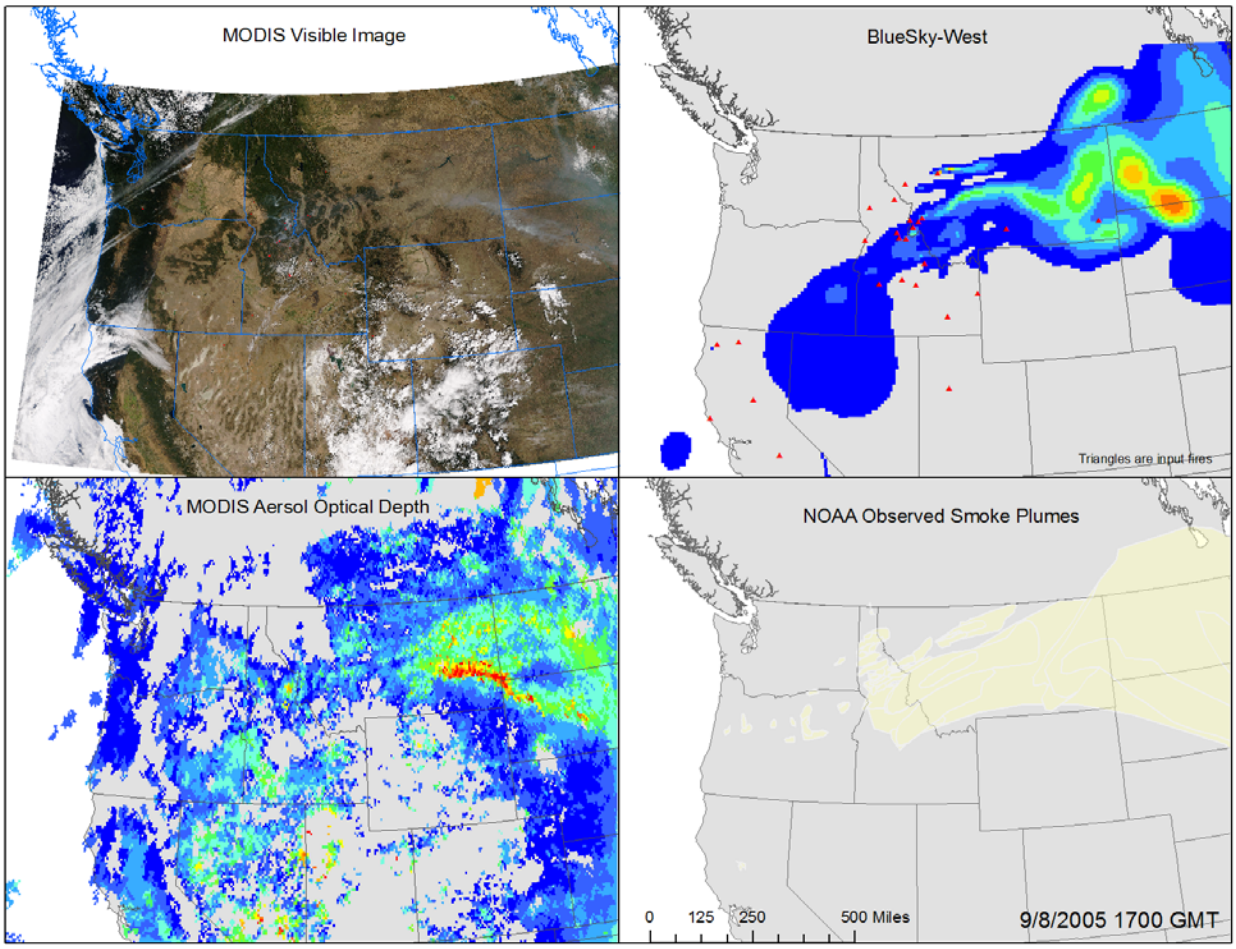
Output Data Products

The current output products available to the user include modeled meteorological fields, $PM_{2.5}$ surface concentrations, and air mass trajectories. To be of use to the emission inventory community, the calculated emissions will be made available as well. These emissions will be formatted with the goal of easy assimilation into existing emission inventory formats, such as the National Emission Inventory input format (NIF 3.0).

Improved/Validated Accuracy

Several small case studies have been undertaken to assess the performance of the BlueSky model.[7,8] These studies, and a recent unpublished evaluation by STI, indicate that BlueSky is underpredicting surface $PM_{2.5}$ concentrations along the plume centerline. It is still unclear as to whether the fire emissions calculator or the dispersion model contributes more to the underprediction. Work is already underway to make adjustments to the dispersion model. The meteorological model is doing an excellent job of capturing the long-range transport pattern. Figure 3 shows evidence of this performance on a day with several fires burning in Idaho and western Montana. The BlueSky model $PM_{2.5}$ concentration pattern matches very well with both visible imagery and aerosol optical depth data (related to $PM_{2.5}$ concentration) from the Moderate Resolution Imaging Spectroradiometer (MODIS) satellite sensor. In addition, smoke plume outlines observed by NOAA analysts from satellite data confirm the pattern. Performance evaluation, model improvement, and validation are ongoing.

Figure 3. Data from September 8, 2005. Clockwise from top-left: MODIS true-color visible image, BlueSky $PM_{2.5}$ surface concentration field, MODIS aerosol optical depth, NOAA analyst observed smoke plumes.



CONCLUSIONS

BlueSkyRAINS has already become a useful tool for smoke managers; however, enhancements must be made to make the tool more valuable for the emission inventory community. Several enhancements are underway or imminent. In particular, expanded coverage, increased flexibility, and improved accuracy and validation promise to make BlueSkyRAINS a valuable tool for the complex task of preparing wildland and prescribed fire emission inventories.

REFERENCES

1. O'Neill, S. M.; Ferguson, S. A.; Peterson, J. "The BlueSky smoke modeling framework", Presented at American Meteorological Society, 5th Symposium on Fire and Forest Meteorology, Orlando, FL, November 16-20, 2003
2. *Hazard Mapping System Fire and Smoke Product*. NOAA Satellite and Information Service, 2006. Available at: <http://www.ssd.noaa.gov/PS/FIRE/hms.html>.
3. *Remote Sensing Applications Center*. U.S. Department of Agriculture Forest Service, 2006. Available at: <http://www.fs.fed.us/eng/rsac/baer/barc.html>.
4. *EPM -- Emission Production Model*. U.S. Department of Agriculture Forest Service, 2006. Available at: <http://www.ssd.noaa.gov/PS/FIRE/hms.html>.
5. *FOFEM*. Systems for Environmental Management, 2006. Available at: <http://fire.org/index.php?option=content&task=category&sectionid=2&id=12&Itemid=31>.
6. *Fire Emission Production Simulator (FEPS)*. U.S. Department of Agriculture Forest Service, 2006. Available at: <http://www.fs.fed.us/pnw/fera/feps/index.html>.
7. Berg, C. M.; O'Neill, S. M.; Ferguson, S. A.; Adkins, J. W. "Application of the BlueSky smoke modeling framework to the Rex Creek wildfire", Presented at American Meteorological Society, 5th Symposium on Fire and Forest Meteorology, Orlando, FL, November 16-20, 2003
8. Adkins, J. W.; O'Neill, S. M.; Rorig, M.; Ferguson, S. A.; Berg, C. M.; Hoadley, J. L. "Assessing accuracy of the BlueSky smoke modeling framework during wildfire events", Presented at American Meteorological Society, 5th Symposium on Fire and Forest Meteorology, Orlando, FL, November 16-20, 2003

KEY WORDS

BlueSky, wildfire, emission inventory, smoke, prescribed burn

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