Development of training resources for application of BlueSkyRAINS in smoke management and fire operations

Final Report to the Joint Fire Sciences Program
Project 04-4-1-04
September 30, 2006

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Project Website: http://www.airfire.org/jfsp/bsrtt

Purpose of Project:

Development of print, web, and classroom training material to help with training and adoption of the BlueSkyRAINS smoke forecast system.

Summary of Results:

- A written User's Guide was completed and linked to the BlueSkyRAINS website. Because development is ongoing and further changes in the system can be expected, we felt that a pdf version of the User's Guide would allow more flexibility in keeping users up to date on BlueSky operations than a printed version.

- An on-line help system including much of the information available in the User Guide but in a searchable format. A glossary, and an expandable set of Frequently Asked Questions, have been completed.

- A two hour lesson plan to be incorporated into RX-410 Smoke Management classes has been prepared, complete with accompanying Powerpoint and a one hour exercise. This material was tested in two RX-410 classes during the January – March 2006 timeframe and was well received by participants.

- A web based tutorial framework has been developed. Some further work is necessary to complete all of the content outlined in our proposal.

- Two workshops have been held to test scenarios to be included in the on-line tutorial. Materials and a training process were also developed which can easily be applied in future workshops.

Availability of Materials:

The users' guide, FAQs, and tutorials are links on the main BlueSkyRAINS website (click on the "User's Guide" and "Help" buttons on the left):

http://www.blueskyrains.org

All materials developed, including the RX-410 classroom materials, as well as general information about the project, are available at the project website:

http://www.airfire.org/jfsp/bsrtt

Background:

BlueSkyRAINS is a smoke modeling system that allows users to view smoke forecasts from fire. These smoke predictions have a large number of potential uses, from informing go/no-go decisions on prescribed fires to wildland fire use/wildfire categorization decisions to information dissemination to the public.

Adoption of BlueSkyRAINS as an operational tool by fire and land managers has been limited primarily by the complexity of the system. This complexity requires users to understand significant amounts of information before they can navigate the system to obtain the information they want, or understand the inherent limitations of any predictive model. Both problems must be overcome before smoke predictions such as those produced by BlueSkyRAINS are useful in decision support.

The goal of this project was to develop training and reference materials to overcome these hurdles. Several types of materials were developed: web-based help pages, FAQs, tutorials, a print-based user's guide, and a course-based module for the RX-410 Smoke Management course.

These materials needed to include information covering a number of topics. First, BlueSky is a smoke modeling framework that combines existing meteorological, fire, fuels, emissions, and dispersion models to produce smoke concentration and trajectory information. This type of framework is inherently complex and has multiple sources of potential error that must be understood. Second, the Rapid Access INformation System (RAINS) is a GIS-based web display system that combines multiple data layers with a wide variety of user selectable tools. Users need to be able to navigate the system to obtain the information they need. Finally, the full value of smoke predictions, meteorological forecasts, and ventilation index information has not been realized because of obstacles to accessibility for users. BlueSkyRAINS, by making such information available, allows a new array of data to be added into the decision matrix. Users need to understand how this information can benefit them the most.

The materials developed in this project provide a significant advance towards achieving this understanding. However, because the system development is ongoing, all of the materials were created to be flexible and easily modified.

Project Accomplishments:

A users' guide, FAQ, help pages, glossary, tutorials, and RX-410 module were created. The project was presented both formally and informally to users at a variety of forums including the BlueSky Annual Meetings, two user training workshops, and two RX-410 courses. Materials have been tested and modified based on user feedback and suggestions. All materials developed for the project are available on the website. A full deliverables crosswalk follows.

The major lesson learned from this project was that multiple ways of presenting the same material are needed because not all users learn in the same way. For this reason multiple scenarios were created for the class exercises, and the same information was captured in a variety of media – print, video (Flash), and hypertext.

Additionally, easily modifiable documents were found to be critical. For this reason, significant effort was placed on coming up with reusable Flash templates for tutorials. Electronic (PDF) rather than print versions of the users' guide were preferred. Extensible database driven help, glossary, and FAQ webpages were designed. The result is a collection of materials that can more easily keep paced with a dynamic BlueSkyRAINS prediction system undergoing significant revisions.

Intersection with Other Projects:

The development of training materials under this project intersects with several other efforts underway and planned.

Separate efforts including those funded by the National Fire Plan (PNW-01-#4), the Joint Fire Sciences Program (, US Forest Service Fire and Aviation Management, and the BlueSkyRAINS-West multi-agency (US DOI, US EPA, USFS) demonstration project sponsored by the Wildland Fire Leadership Council (WFLC) have focused on evaluation of the BlueSky smoke forecasts and the potential for a national BlueSkyRAINS derived smoke forecasting tool. The results of these efforts have led to the recommendation to WFLC that BlueSkyRAINS be implemented nation-wide in 2007 (BlueSkyRAINS West Final Report, 2006). This effort is currently underway with funding from the National Fire Plan and USFS Fire and Aviation Management.

Nationwide implementation of BlueSky requires distributable training materials. This has been acknowledged in reports and recommendations from every evaluation of the system. This project has developed the first such materials. Implementation of the RAINS system in a nationally consistent manner will require relatively minor modifications to the website design. However, the materials developed here will have to be modified to reflect these changes. These modifications will be performed in early 2007 in time for a spring training course in March 2007.

Next Steps:

BlueSkyRAINS is currently undergoing significant modifications, to both the underlying model framework as well as to the website interface. The modifications are being implemented based several evaluations and user needs assessments of BlueSkyRAINS culminating in BlueSkyRAINS-West demonstration project of 2005. Specific modifications include:

- A re-write of the underlying framework to make it more modular and robust. The result will be more flexible and manageable code base that is easier to port to external applications.
- Incorporation of the Fire Emissions Production System (FEPS) model. This will increase the ability of BlueSky to model smoldering emissions.
- Incorporation of BlueSky predictions into the EPA's AirNow website. This will greatly increase the number of users with knowledge of BlueSky's smoke predictions.
- Development of a nationally consistent BlueSkyRAINS implementation. Currently on the Pacific Northwest and the Rocky Mountain regions have the RAINS display system operating. While BlueSky predictions are available throughout the contiguous 48 states, these are not presented using the RAINS interface except in these two areas. This work will create a nationally consistent RAINS implementation available throughout the coterminous U.S.

Plans are to have these changes in place by early 2007 and available for the 2007 wildfire season. Because they will substantially alter the access, interface, and utility of BlueSkyRAINS, the materials developed for this project will need to be modified to reflect these changes. This work is currently being planned and revised materials will be made available as these changes are rolled out in early 2007. Additionally, once these changes are complete, other lessons and tutorials will be developed using the templates created under this project. Another user training course is being planned for early 2007.

As the above paragraphs illustrate, the materials developed for this project are not static or complete, but are instead living documents that will be regularly updated with new ideas and information as appropriate.

Deliverables Crosswalk:

Proposed	***Delivered***
1) A web based tutorial for BlueSkyRAINS which includes: - A discussion of dispersion models and their application in the BlueSky framework. - A description and applications guide to MM5 Mesoscale meteorological model products available through BlueSkyRAINS. - A detailed discussion of smoke trajectories and surface concentrations as forecast by the BlueSky system. - A discussion of Ventilation Index and its application to smoke forecasting. - Detailed instructions on how to access information using BlueSkyRAINS. - Interactive exercises using real world examples in applications of BlueSkyRAINS. - Scenarios demonstrating a variety of applications from the viewpoint of different users.	A framework has been developed for the tutorial including several prototype lessons. Some lessons are now available on the website. Further tutorials will be developed utilizing this framework to reflect upcoming changes in the BlueSkyRAINS system expected in early 2007. The tutorial framework has been deliberately designed to allow editing and expansion of the tutorial lessons so that material can be added and changed as BlueSkyRAINS continues to develop and further applications and examples are discovered. All of the topics outlined in the proposal are addressed in the pdf user's guide. This content should be easily transferred to the tutorial format, but some of the look and feel will be changing as a nationally consistent BlueSkyRAINS application (currently under development with funding from USFS F&AM) is implemented in late 2006/early 2007.
2) A CD version of the tutorial available for users without high speed internet connections.	Although this seemed like a good idea at the time the proposal was written because many users still had slow telephone connections, in

	the ensuing two years high speed internet has become widely available even in remote locations. Because a high speed internet connection is virtually a requirement for effective use of the BlueSkyRAINS interface, it no longer makes sense to provide seperate training materials by CD.
3) An on-line help system which will include a description of each of the overlays available in BlueSkyRAINS.	A searchable on-line help system, FAQs and Glossary have all been incorporated into the BlueSkyRAINS website. All data layers are described in detail and many other topics are addressed as well.
4) A 2 hour lesson plan for presentation in smoke management training courses.	A lesson plan including a one hour lecture and a one hour hands on exercise has been completed and packaged as Unit 9B for presentation in RX-410.
5) A printed user's guide.	A pdf version of a draft user's guide has been linked from the blueskyrains.org main web page. Because BlueSky is still under development and subject to frequent changes and upgrades, it was decided that it made more sense to provide an electronic user's guide that could be updated easily as new features and functionality are added to the system.
6) As part of our tutorial development effort two workshops will be held to provide hands on testing and feedback from field practitioners.	Workshops were held in Edmonds, Washington in June 2005 and in Missoula, Montana in December 2005. Scenarios to be developed into tutorial lessons were presented and were well received by students.

Continued support and development:

We are grateful to the Joint Fire Science Program for supporting this work. Under this project we have established a framework for further development of training materials and tutorials that can be easily expanded and edited as BlueSky development continues. We will be able to apply this framework to other projects as well and provide training materials in a more timely fashion based on the lessons learned in this project.

Attachment:
BlueSky User's Guide and Operating Manual

The pages that follow are the current version of the BlueSky User's Guide and Operating Manual (v. 1.1) prepared for this project. Note that sections and page numbers do not follow the main report, but are consistent within the attachment scope.

*BlueSky and BlueSky*RAINS

User's Guide and Operating Manual

Version 1.1
September 2006

AirFIRE Team
Pacific Wildland Fire Sciences Laboratory
Pacific Northwest Research Station
USDA Forest Service

&

Region 10
Environmental Protection Agency

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Chapter 1
Introduction and Background

I. Introduction

What is BlueSky?

BlueSky is a modeling framework which brings together the latest state of the science for modeling fuels, fire, smoke, and weather into one centralized processing system. It makes sophisticated emission, dispersion and weather prediction models and model output easily accessible to the operational fire and air quality management communities. The modeling framework is designed to predict cumulative impacts of smoke from forest, agricultural, and range fires, including both prescribed fire and wild fire. To view BlueSky output and publications go to http://www.fs.fed.us/bluesky.

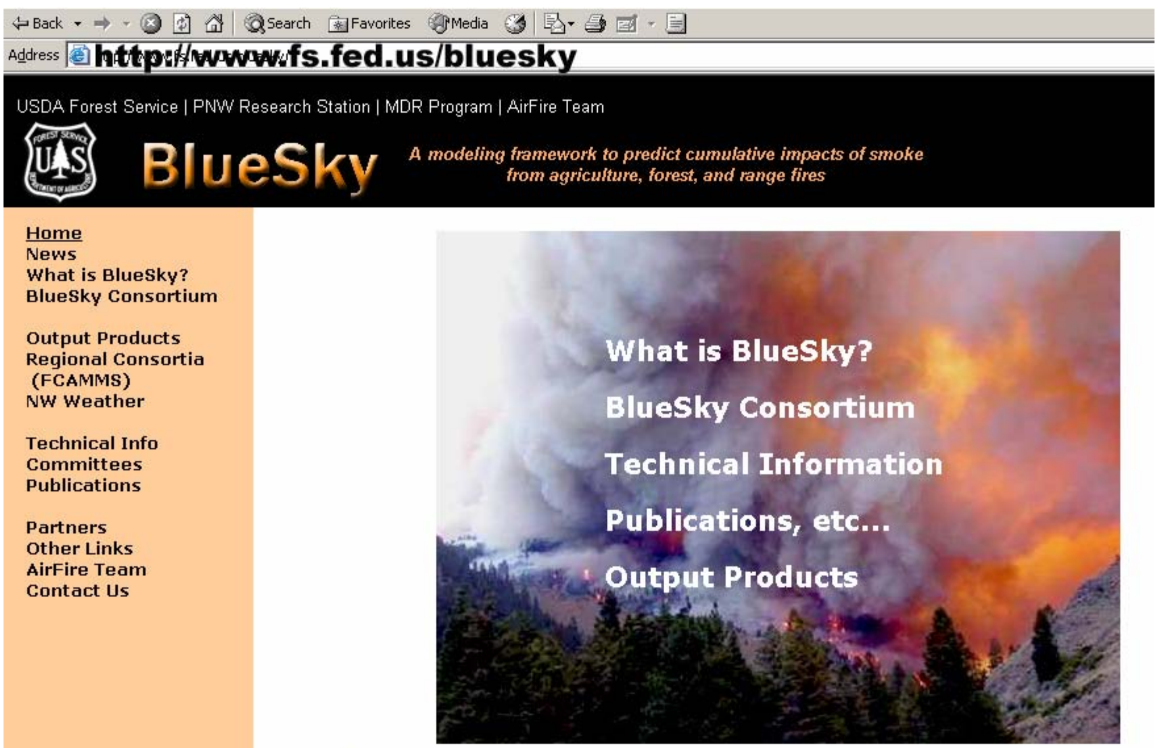


Figure 1. The BlueSky home page

What is BlueSky RAINS?

RAINS is the Rapid Access Information System. Developed by the U.S. Environmental Protection Agency, RAINS takes advantage of Geographic Information System (GIS) technology to display maps and data via the internet. BlueSkyRAINS builds on the RAINS concept as an avenue for making BlueSky model output available to users in an interactive ***ArcIMS*** format. Go to http://blueskyrains.org to access BlueSkyRAINS.

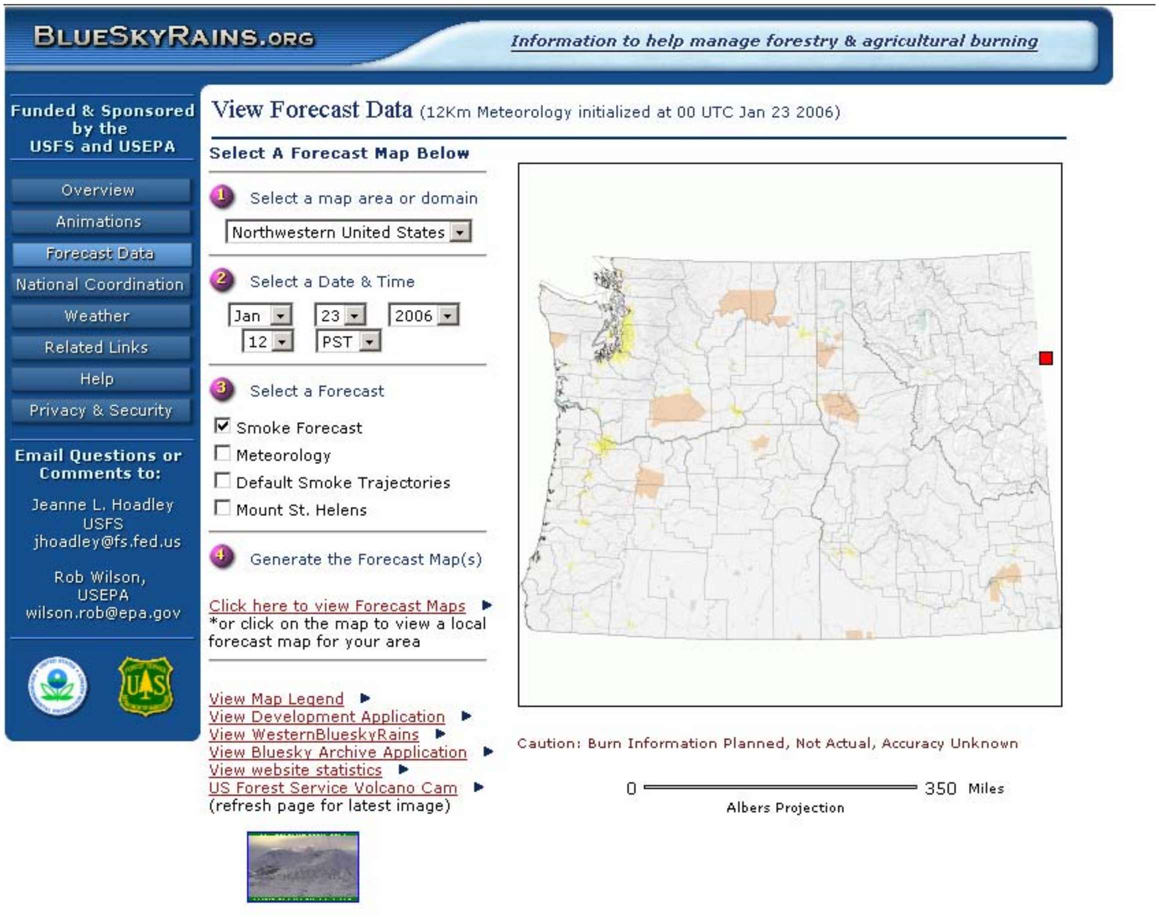


Figure 2. The BlueSky RAINS homepage

What Can BlueSky Do?

The BlueSky system was designed as a tool to aid land managers using fire on the landscape in making go/no-go/go slow decisions with regard to smoke management. BlueSky provides hourly predictions of ***PM2.5*** concentrations based on information available from multi-agency tracking systems such as ***FASTRACS*** and ***RAZU***, from wildfire 209 reports, and in some cases from manually entered burn data. ***Trajectory*** predictions available in BlueSky RAINS indicate the direction and height of smoke plumes 12 hours out in time.

Centralized collection and processing of model data relieves the user of the need to download data and learn complex modeling systems. It also allows for analysis of multiple burns and wildfires so that air quality managers can see the combined impacts within shared airsheds. Output is posted to the web daily for easy access by burners, air resource specialists, and the public. In order to provide quality output, the BlueSky system relies on the collaboration of many agencies at the federal, state, and local level.

What Can't BlueSky Do?

BlueSky is meant to be a short term planning tool. Because it relies on state of the art weather modeling to calculate winds and dispersion, it can provide a detailed assessment of smoke impacts based on predicted weather for about two days into the future. BlueSky cannot currently be used to test alternate scenarios for burning, nor is it a useful tool for generating NEPA documentation, or for long range planning. For these applications we recommend other tools such as the Smoke Impact Spreadsheet (SIS) or the Ventilation Climate Information System (VCIS).

Although you can tap into quantitative information through the BlueSkyRAINS identify tool, BlueSky does not provide tabular output showing concentrations by distance from source. For this type of presentation try SIS or SASEM.

How does BlueSky compare with other smoke emissions modeling systems?

Because BlueSky is run on a state of the art centralized cluster processing system, it is able to process large amounts of data including detailed, high resolution inputs of three dimensional weather from the **MM5** mesoscale meteorological model, fuels from the Fuel Characteristics Classification System (FCCS), and to model multiple burns and wildfires over a large geographic area using sophisticated dispersion models.

Emissions models typically available for use by fire practitioners are not able to handle the volumes of data that BlueSky routinely processes and are consequently not able to provide the same level of detail in their output. They also may lack detail with regard to input parameters which may result in less accurate predictions. Such models generally do not provide information about multiple burns for analysis of cumulative effects. In addition, because BlueSky is run daily at a centralized processing facility, the only effort required on the part of the burner is to consult the daily output via the internet.

How does BlueSky work?

The BlueSky modeling framework has 5 components as shown in Figure 3. Although the specific models used within each component may change over time as the modeling science advances, the basic structure will remain the same. As of January 2006, fire characteristics are processed through the Emissions Production Model (EPM) to give emission estimates of particulates ($PM_{2.5}$, PM_{10}, and total PM), carbon compounds (CO, CO_2, CH_4, non-methane hydrocarbons), and heat generated. The emission estimates from EPM along with meteorology from MM5 are processed for the **CALPUFF** dispersion model and the **HYSPLIT** trajectory model. The BlueSky system framework merges meteorology with emission estimates to yield an integrated regional-scale analysis of smoke dispersion and aerosol concentrations.

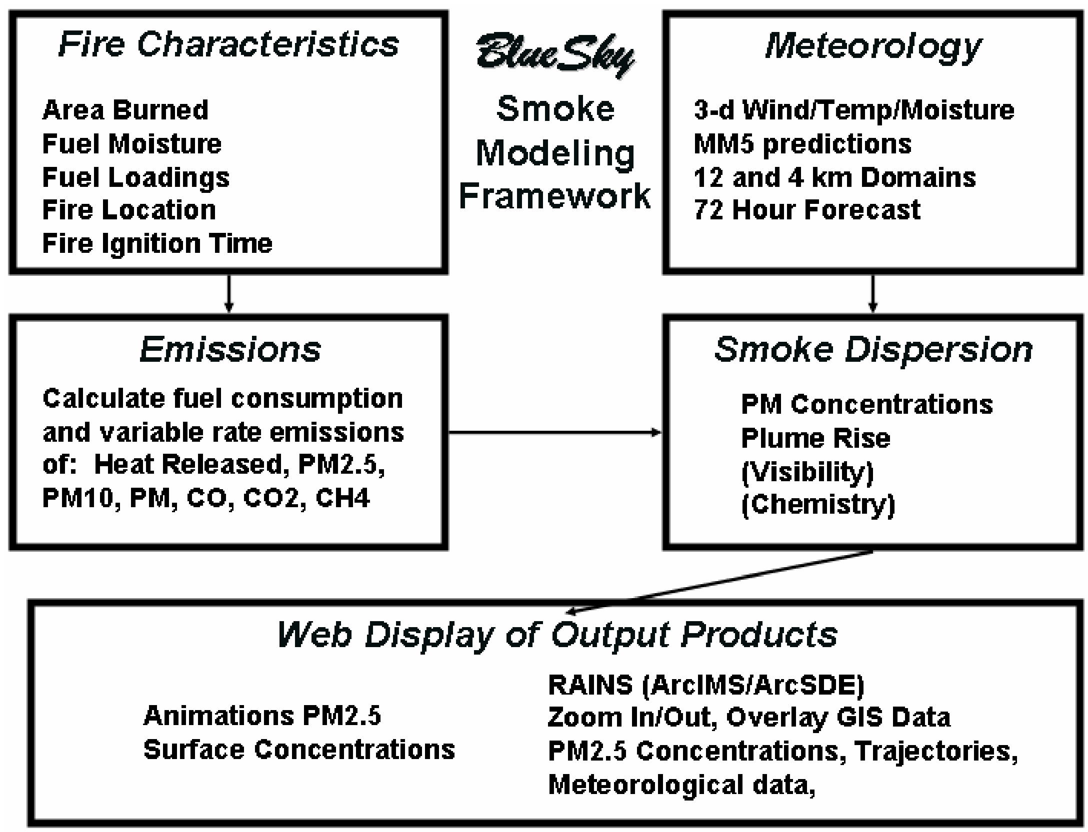


Figure 3. Components of the BlueSky modeling Framework

The BlueSky concentration fields and trajectories are displayed on the Web in the Rapid Access INformation System (RAINS); a Geographic Information System (GIS) application developed by the US EPA. Integrating BlueSky with RAINS, allows the user to zoom in on areas of interest, step through time, and overlay GIS data layers such as sensitive receptors, boundaries, roads, rivers and topography. GIS layers are also downloadable for viewing within the ArcGIS application on a personal computer.

Primary inputs to BlueSky include weather, fire characteristics, and fuels. This section briefly describes the sources for each of these input parameters. More detailed information is available in the Appendices.

Weather – Predictions of wind speed and direction as well as ***mixing height*** are required to determine smoke trajectories and PM2.5 concentrations. Weather inputs come from the MM5 mesoscale meteorological model. See Appendix B for more detail on the MM5.

Fire Characteristics – In order to arrive at an accurate prediction of smoke emissions it is necessary to get detailed information about the size, location and timing of a prescribed burn or wildfire. This information is retrieved from interagency reporting systems such as FASTRACS in the Pacific Northwest, RAZU in Montana and Idaho and will eventually be available from ***PFIRS*** in California. Alternative ways of providing input on prescribed burns for BlueSky are also being developed in other parts of the country. Wildfire information is also accessed automatically each day from 209 reports available from the National Interagency Fire Center (NIFC).

Fuels – Fuel model and fuel loading information is essential to emissions modeling. BlueSky uses fuel characteristics derived from the Fuel Characteristic Classification System (FCCS) to arrive at this information. For more information about FCCS go to http://www.fs.fed.us/pnw/fera/fccs/index.html.

Emissions and Dispersion Modeling

Emissions are computed using the Consume software (http://www.fs.fed.us/pnw/fera/products/consume.html) and the Emissions Production Model (EPM) v1.03 which calculate the heat release rate and emissions for particulate matter and carbon compounds as a function of time after fire ignition. These emission values are input data for CALPUFF v5.711 which calculates the dispersion and plume rise. Trajectories are computed using the HYSPLIT model. HYSPLIT uses the full 3-dimensional wind field for computational purposes but does not include any heat or buoyancy effects from the fire.

Web Products

BlueSky output products can be viewed as animations or as static hourly images using BlueSky RAINS. It is also possible to animate the BlueSky RAINS images but you need a high speed internet connection and the latest version of Java software to make this work. This section describes how to access these products and some of the advantages and disadvantages of using each type.

Animations

BlueSky output can be viewed as either a Java Script animation (recommended for high speed internet connections) or Gif animation (recommended for dial up internet connections). Figure 5 shows the menu for selecting output products for the Pacific Northwest. Users must select a ***resolution*** and the type of animation then click on the appropriate square.

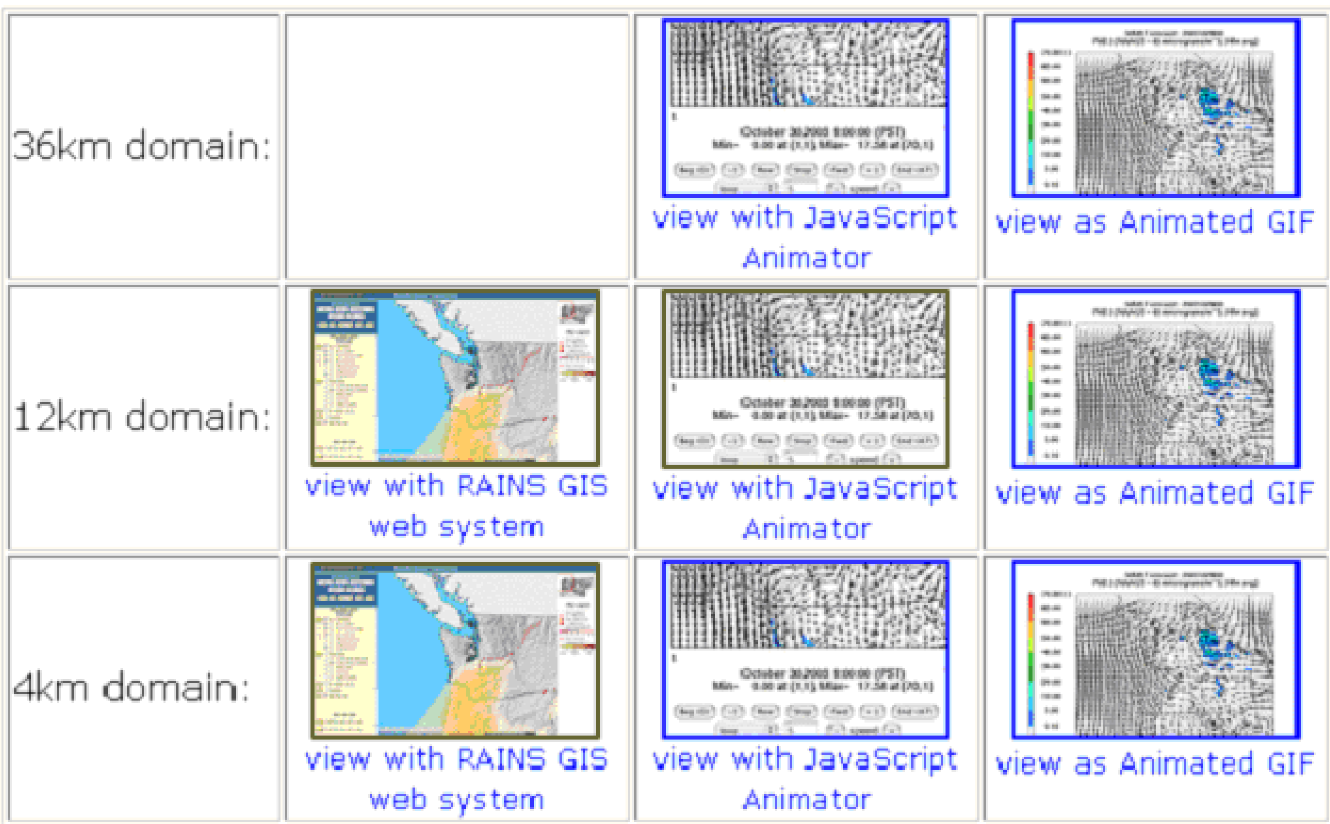


Figure 5. Menu to Select animations

The animations show model predicted PM2.5 concentrations and wind flow patterns at the surface. Animations are useful for getting a big picture look at predicted PM2.5 over time for all the fires and burns in the system for a given run. While it is possible to stop the loop and look at individual frames, it is not possible to zoom in or add information to the images. Figure 6 shows the Java

Script animator. At the bottom of the Animation page is a dropdown menu which allows the user to select animations from any BlueSky run going back to September of 2002.

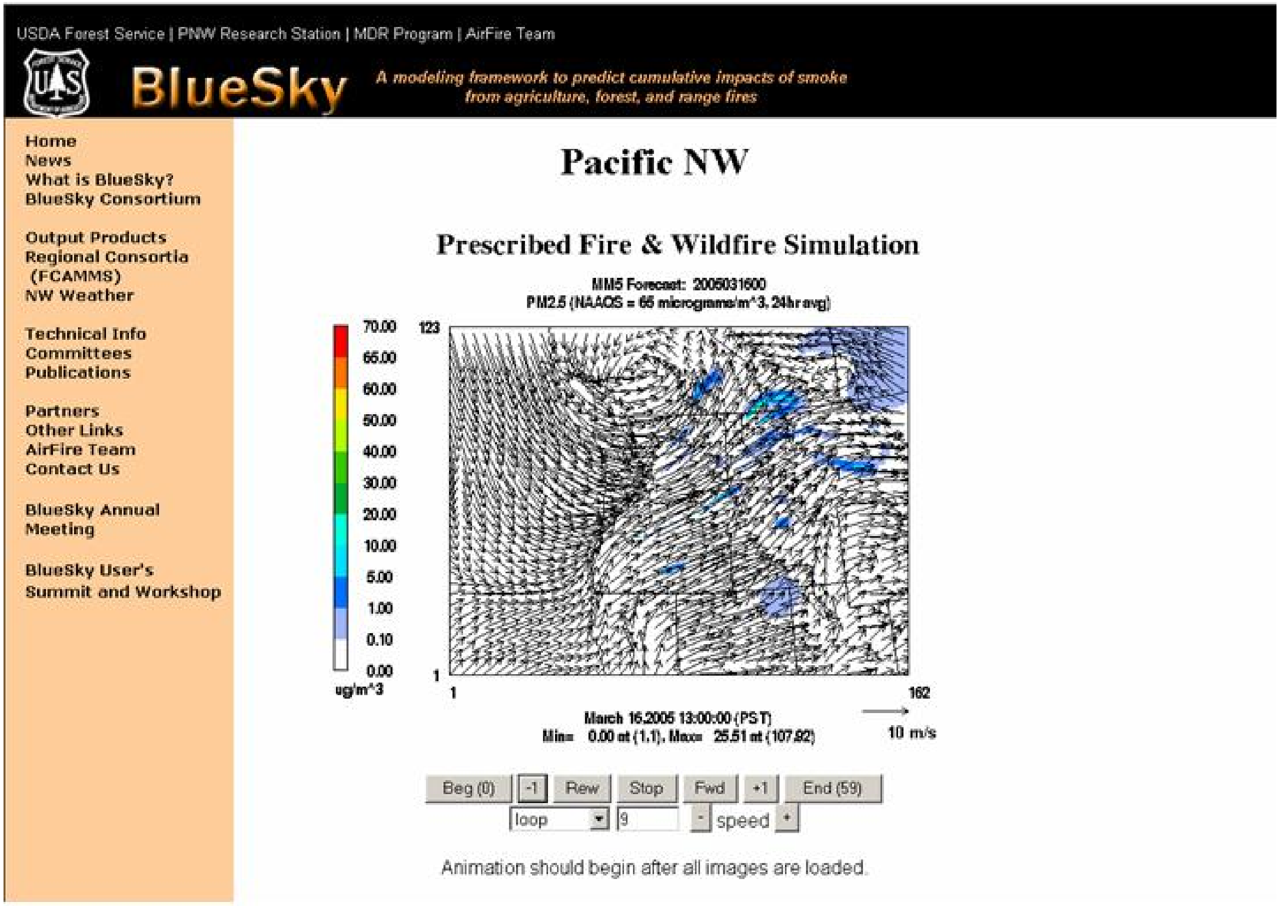


Figure 6. Java Script animation screen.

BlueSky RAINS

BlueSky RAINS brings the output from the modeling framework into an interactive GIS environment so that the user can optimize the display for his or her needs. Displays can be zoomed in to the individual project level or out to the regional level. In addition to PM2.5 concentrations, trajectories showing the direction, height, and timing of smoke movement can be shown. Meteorological output for a number of parameters is also available in RAINS. Maps showing roads, rivers, boundaries, and a variety of smoke sensitive receptors can be selected. Figure 7 shows an example of the BlueSkyRAINS web interface. The next chapter provides detailed instruction on how to use the interface and understand the information available there.

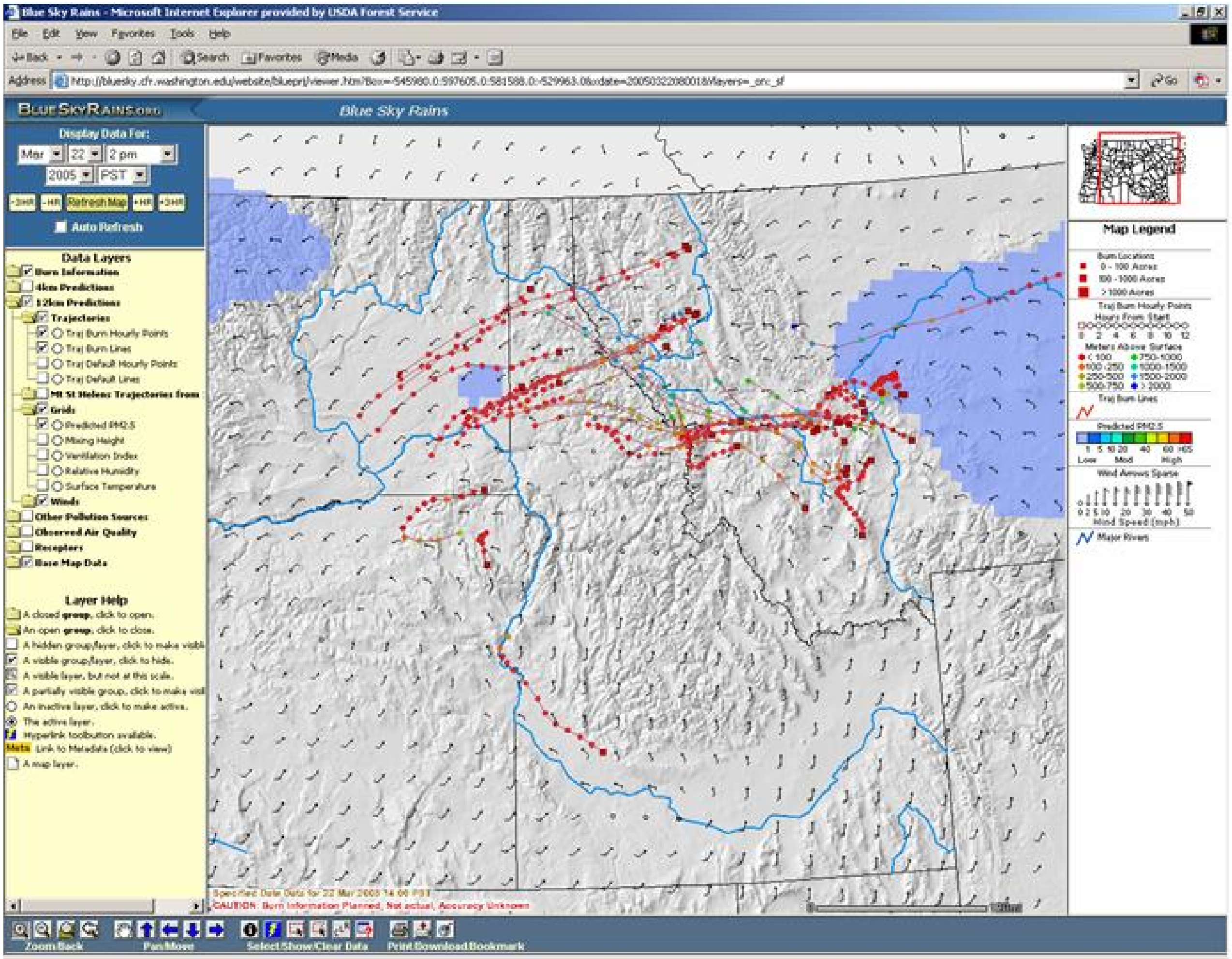


Figure 7. BlueSkyRAINS web interface showing trajectories and PM2.5 concentrations

Chapter 2
How to Use BlueSkyRAINS

This section will provide a detailed description of all the available map layers and display tools in the BlueSkyRAINS (BSR) interface. The next Chapter contains scenarios which include hands on exercises to highlight specific application of the information available using BlueSkyRAINS.

To access BlueSkyRAINS enter blueskyrains.org as the URL in your internet browser software. If Internet Explorer is your browser you should check to see if it is set properly to most efficiently display BlueSkyRAINS. To do this, open Internet Explorer. Go to the Tools menu and select "*internet options".* A dialog box will appear. Near the center of the box, under "t*emporary internet files*", click on "*settings.*" Under Check for newer versions of stored pages, ensure the radial button next to "*Every time you start Internet Explorer*" or "*Never*" is checked. Then click OK twice. This will ensure the browser does not refresh each time you make a new selection in BSR.

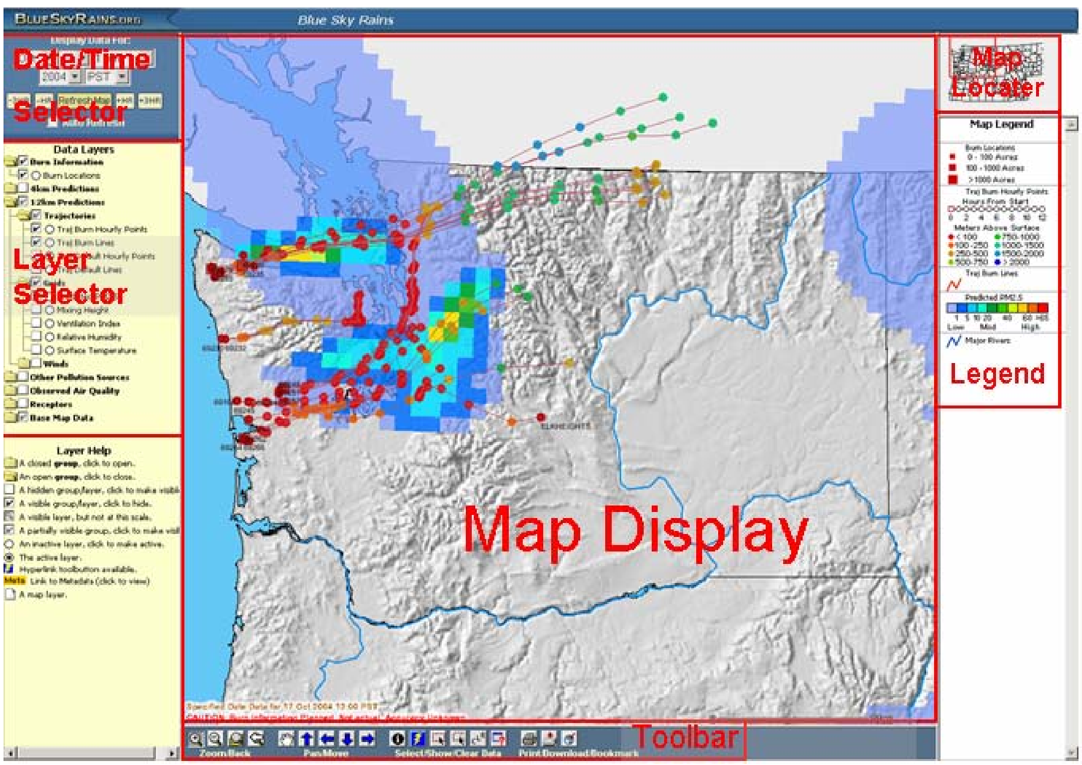
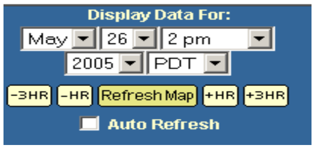


Figure 8. The ArcIMS Interface functional areas

The ArcIMS interface

ArcIMS is software available from the ESRI corporation to provide maps over the internet. The ArcIMS Interface for BlueSky RAINS can be divided into six functional areas as shown in Figure 8. The purpose and general characteristics of each functional area are discussed in detail below.

The Date/Time Selector



The Date/Time selector is located in the upper left corner of the screen. Drop down menus allow the user to select the valid time and date of any forecast map in ther BlueSkyRAINS (BSR) database. Maps are available going back about six months.

The Date/Time selector also contains navigation tools which allow the user to advance or go back in time by one or three hours without resetting the valid time. The refresh map button turns red whenever a change is made to notify the user that the requested updates are not yet displayed. Clicking on the refresh button will cause the requested changes to be made in the map display. If you check the Auto refresh box the map will automatically update every time you activate a new layer. This can be annoying if you want to change more than one layer at a time.

The Layer Selector

The layer selector, located directly below the Date/Time selector, allows the user to select which layers will appear in the map display. Layers are turned on by checking the square box next to the layer and turned off by unchecking the box. Layers are stored in folders which group them according to common functions or characteristics. To activate most layers it is necessary to first open a folder.

Although most layers can be displayed together, the grid layers, which represent PM2.5 concentrations and several of the meteorology fields, are incompatible because of the color shading used by each and cannot be displayed together. An alternate method for comparing grid layers might be to open BSR in more than one window and displaying different grids in each window.

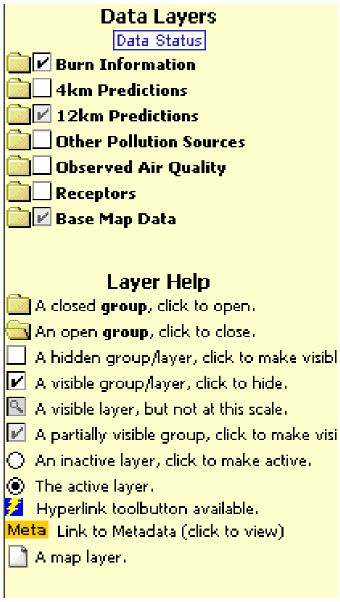


Figure 9. Layer selector

The layer help menu (Figure 9), displayed below the layer selector, gives some useful information about how to interpret icons showing the status of a layer selection. The data status button allows the user to check the status of a day's BlueSky run. When all the elements in the data status screen are black everything is going well. Red items alert the user that there may be some problems with the current run or the run is not complete. Items in red may be missing or old.

The Map Display

The large area in the center of the screen is the map display. Using the layer selector and pan and zoom tools on the toolbar the user can customize the display to fit their needs. When entering BSR the user can select from three default maps or sets of maps to appear in the map display (four including the recently added Mt St. Helens trajectory map). Figure 10 shows the default layers for the smoke forecast map. These include burn locations, trajectories points and lines, predicted PM2.5, rivers and streams, and gray shaded relief.

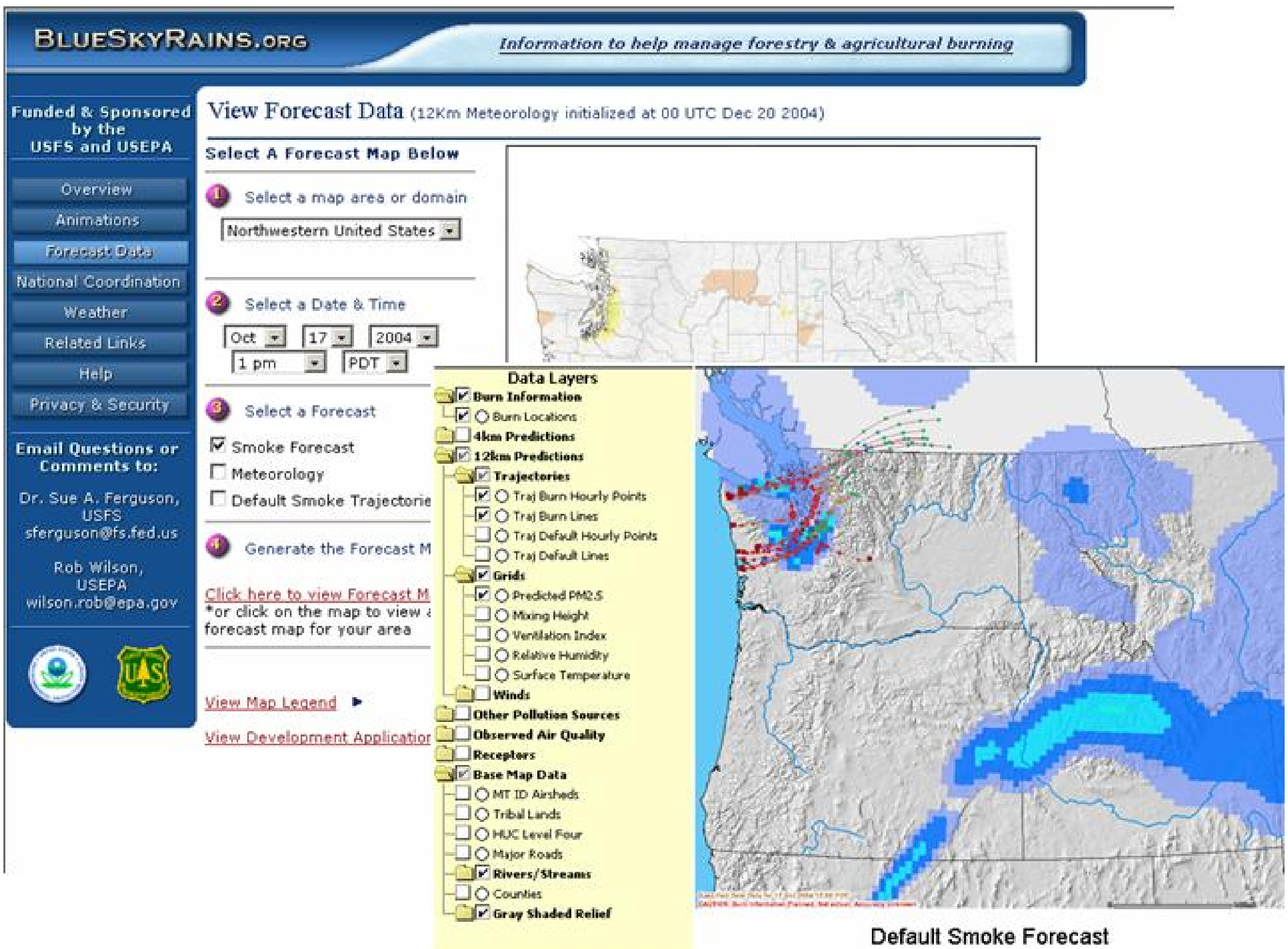


Figure 10. Smoke Forecast layers in the map display

The default layers for the Meteorology map include Ventilation Index, winds, rivers and streams and gray shaded relief. For Default Smoke Trajectories the layers displayed include default smoke trajectories lines and points, rivers and streams and grey shaded relief. These maps are shown in figures 11 and 12 respectively.

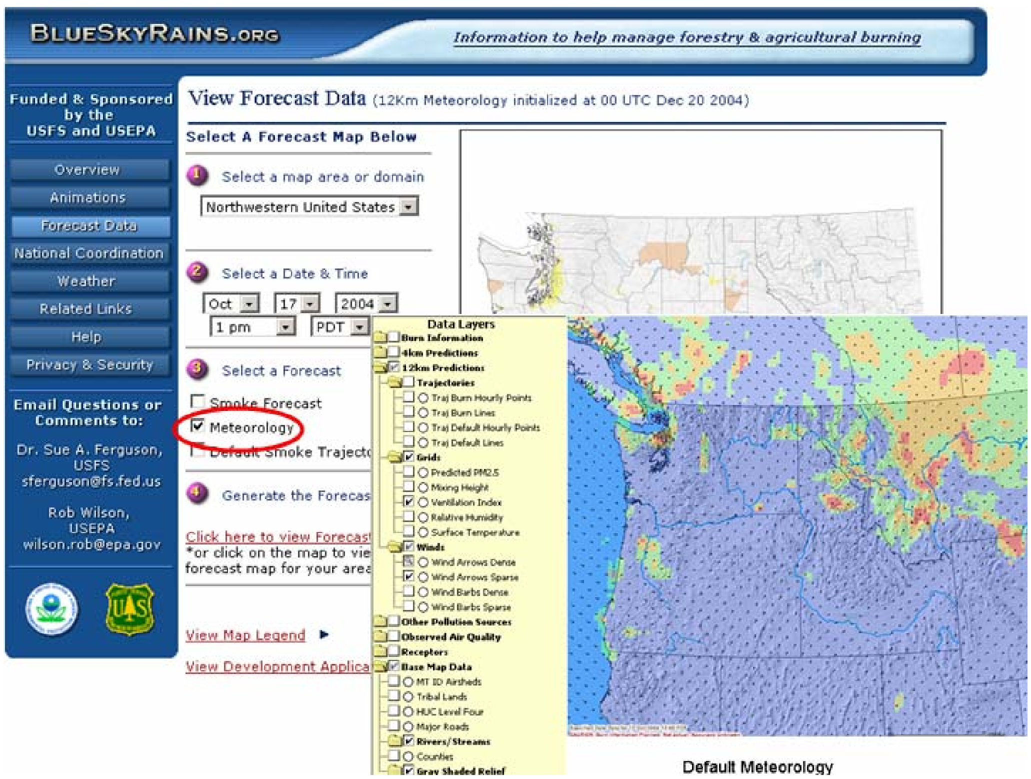


Figure 11. Meteorology layers in the map display

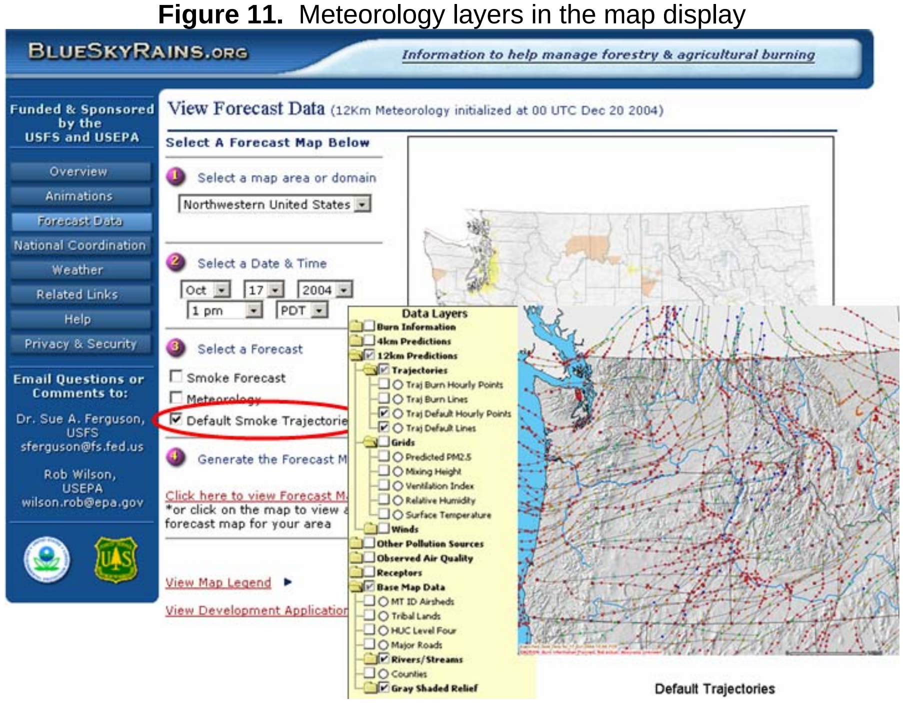


Figure 12. Default smoke trajectory layers in the map display

The Map Locator

The map locator is a small map located in the upper right corner of the screen. The map locator provides a reference for where you are on the display map. A red rectangle on the small outline map indicates the area shown in the Map Display. In Figure 13 below the red rectangle initially encompasses the entire map. As we zoom in to the PM2.5 plumes in Northwest Washington, the rectangle shrinks to outline the area shown in detail on the display map.

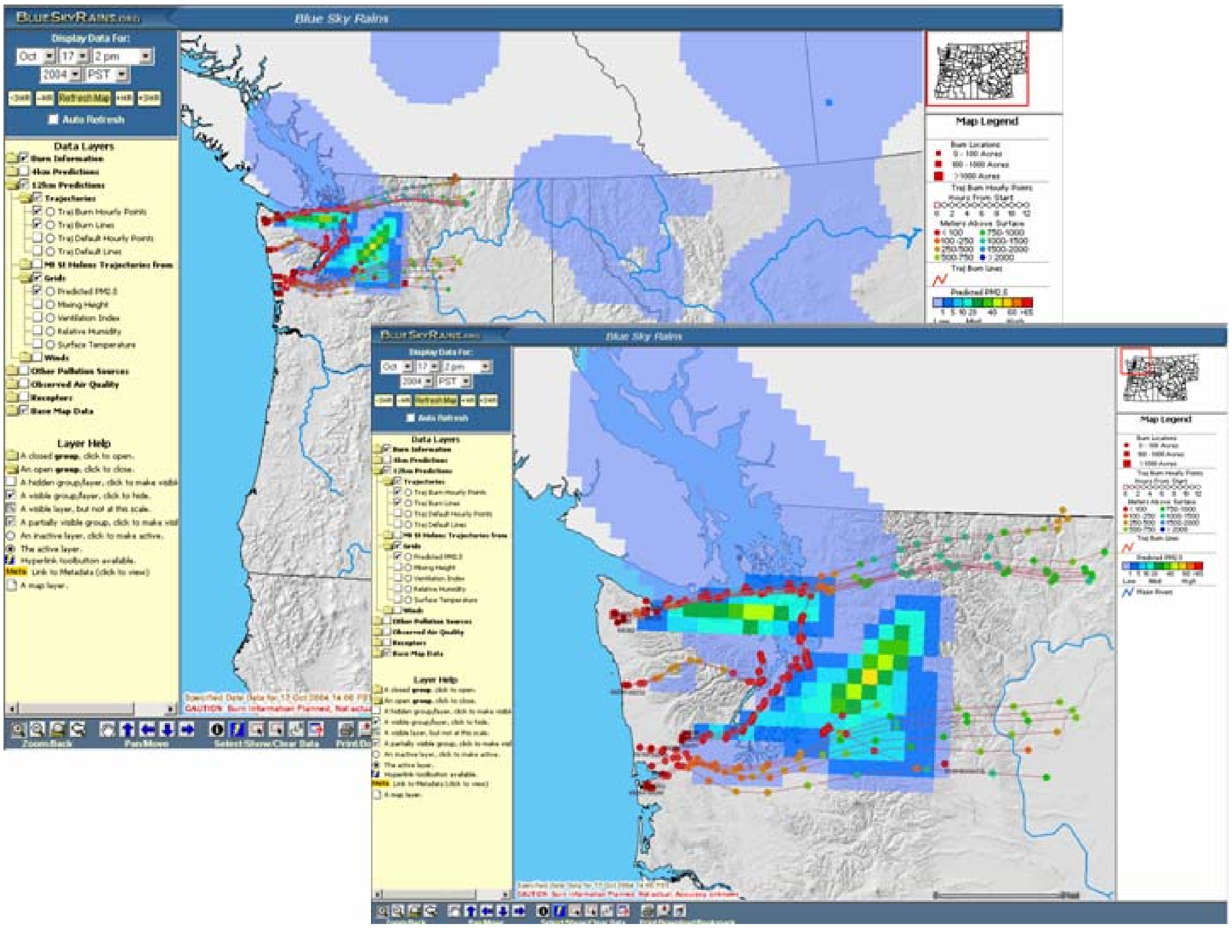


Figure 13. Locator Map shows the current extent of the map display

The Map Legend

The map legend appears directly below the map locator. The map legend provides an explanation of the symbols used on the data and map layers displayed in the Map Display. Only those layers opened in the layer selector will be shown in the legend. From the legend the user can determine relative quantitative values such as size of a burn, height of a smoke trajectory, wind speed or concentration of PM2.5.

The Toolbar

The toolbar (Figure 14) provides a number of useful functions for navigating around the map display and interrogating data within the displayed layers. A detailed description of the function of each tool is given below.

Figure 14. Toolbar

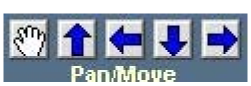
The Zoom/Back tools allow the viewer to zoom in and out, return to full extent, and return to the last zoom level.

**zoom in -** provides a more detailed view of a smaller portion of the map. With the left mouse button held down draw a rectangle around the area you wish to see enlarged. Or with the zoom tool selected you can just click on the Map Display and the image will zoom to the next level with the point you click on at the center.

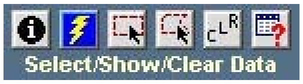
**zoom out -** enlarges the area viewed with less detail shown. Click on the map with the zoom out tool active to zoom with map centered on the point where you click.

**zoom to full extent -** Click on this tool to return to the full map extent.

**zoom back to last extent -** If you change your zoom level and want to return to where you just were click on this tool. Multiple clicks will allow you to toggle back and forth between two zoom levels rather than moving back through multiple zooms.



The **Pan/Move** keys allow the viewer to navigate around the map. Click on the hand to activate the pan tool which allows you to move the map around as you please using the mouse with the left button depressed. The arrow keys cause the map center to shift in the direction indicated by the arrow. So, for example, if you click on the up arrow, the map will shift down on the screen as its center shifts up. Another way to look at this is if you want to see further north on the map, click on the north arrow; if you want to see further east on the map, click on the arrow pointing to the right or easterly direction on the map.



The tools in this section of the toolbar allow the user to selectively interact with the data contained in the data layers.

**identify -** This tool allows the user to access information about an object on the map by clicking on the map. You must first specify an active layer in order to get information about that layer using the identify tool. For example in Figure 15 the radio button next to PM2.5 has been clicked making it the active layer which is obvious because it is shaded in dark yellow. You can then click on the identify tool, click on any PM2.5 pixel on the display screen and a table showing the value of that pixel pops up. Now you can click on the chart link to see a 24 hour graph of predicted PM2.5 at that location. When using the identify tool on any meteorological map, charts for all available meteorology parameters will be displayed in chart form when the chart link is selected.

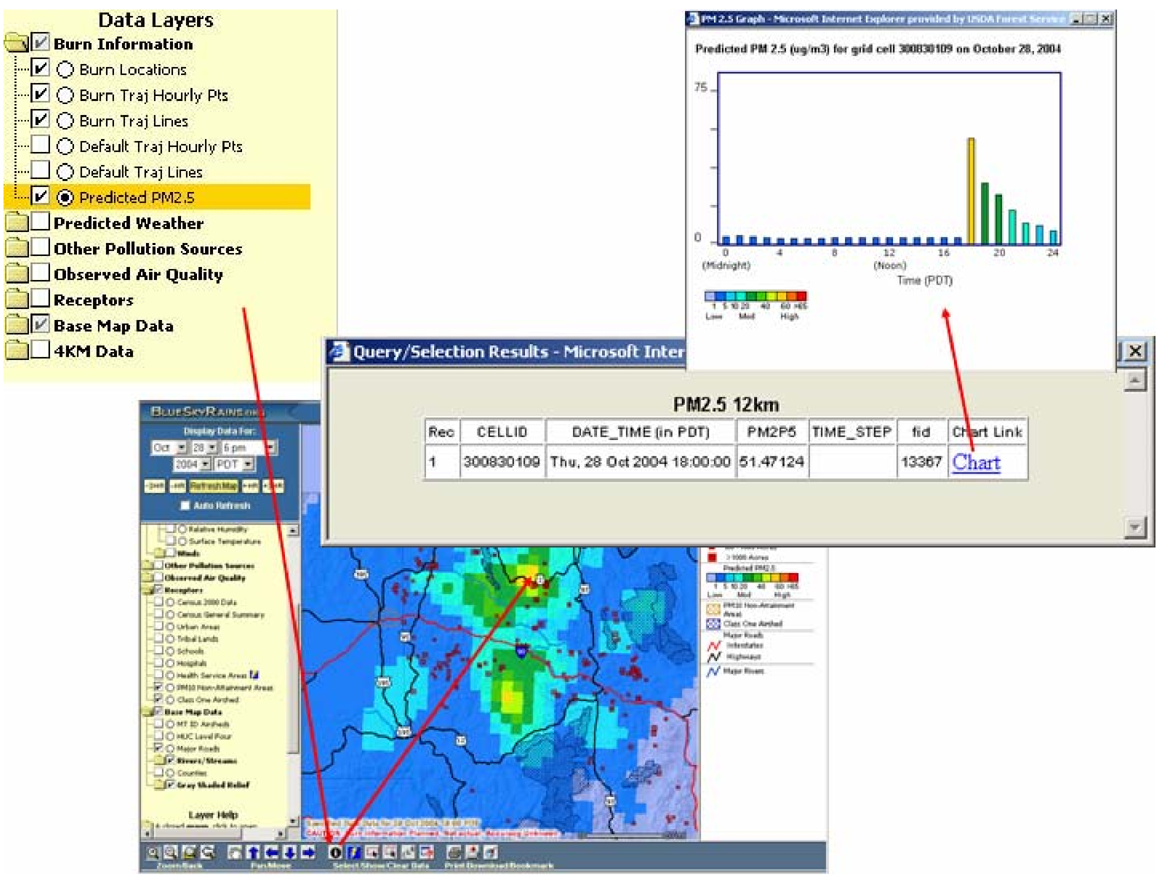


Figure 15. Using the Identify tool

Hyperlink - This tool can only be used with a layer that has the hyperlink symbol (lightning bolt with blue background) next to it. Currently only the Washington state PM monitoring sites and EPA health services areas (found under receptors) are hyperlinked. As with the identify tool, a layer must be made active by clicking on the round radio button next to the layer name in order to access data using the hyperlink tool. In Figure 16, the Washington PM Monitor layer is made active by clicking on the radio button next to the layer name. You can then activate the hyperlink tool and click on any of the monitoring sites indicated by small red triangles. You are then linked to the Washington Department of Ecology website to view data from the selected monitor. Note that, regardless of the valid date and time on the BSR map, only the current air quality monitor data is available.

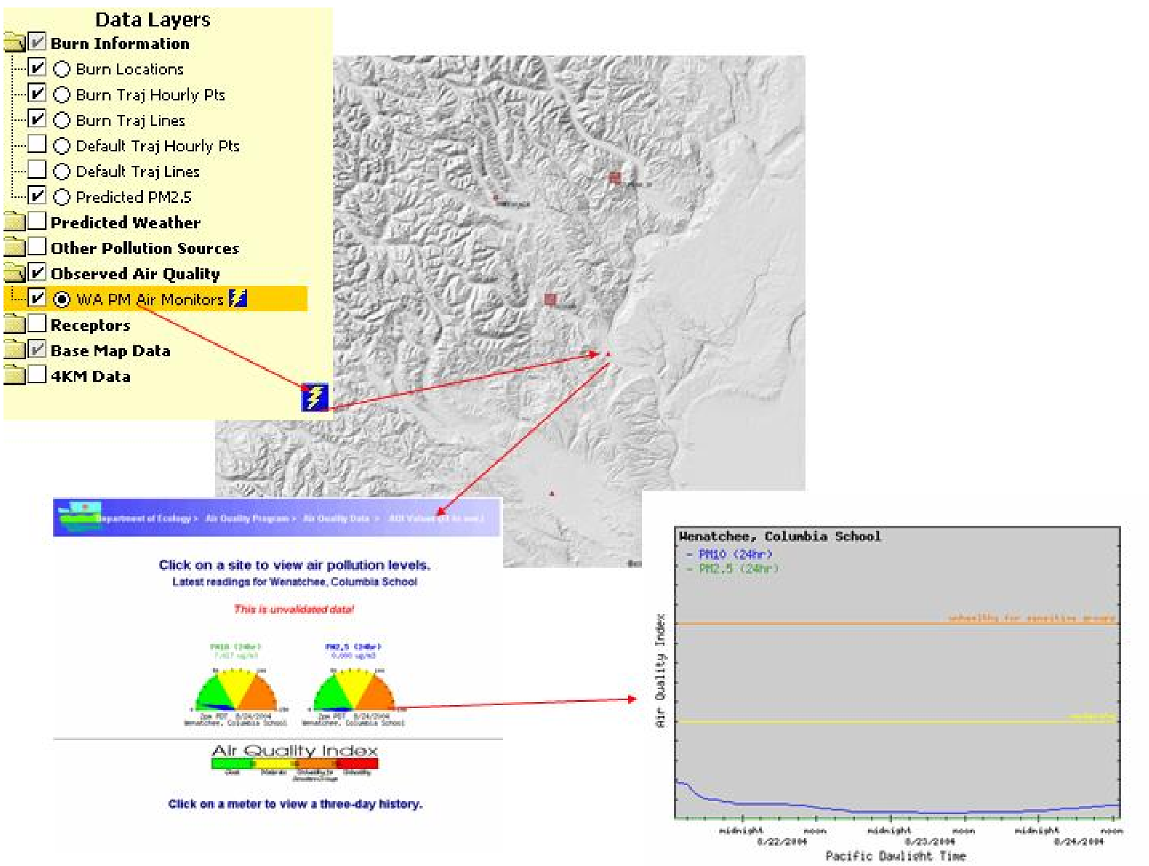
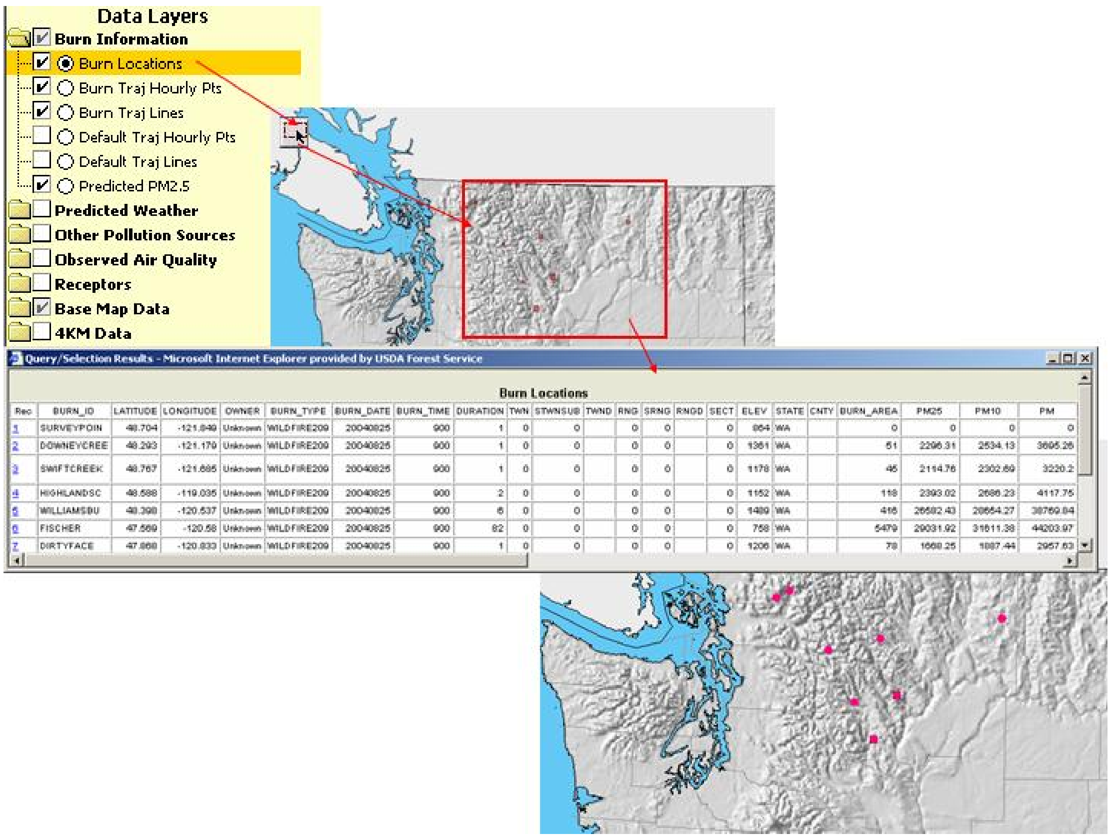


Figure 16. Using the hotlink tool

Select by Rectangle or Polygon - The next three keys allow the user to make a data selection by either drawing a rectangle or polygon around an area of interest and to clear such selections. As with the other selection tools the user must first make active the layer they wish to extract information from. In the example in Figure 17 the burn location layer is the active layer. With the select by rectangle tool activated the user can now draw a rectangle around the wildfires in Washington State in order to learn more about them. A table appears with information about each fire within the rectangle and all selected fires are designated with a pink dot.

The polygon tool works in much the same way except that it allows the user to designate an irregular shaped area such as a county boundary by clicking from point to point to designate the shape of the polygon. The CLR key allows the user to clear the selection.



Rec	BURN_ID	LATITUDE	LONGITUDE	OWNER	BURN_TYPE	BURN_DATE	BURN_TIME	DURATION	TWN	STWNSUB	TWND	RNG	SRNG	RNGD	SECT	ELEV	STATE	CNTY	BURN_AREA	PM25	PM10	PM
1	SURVEYPOIN	48.704	-121.849	Unknown	WILDFIRE209	20040825	900	1	0	0		0	0		0	864	WA		0	0	0	0
2	DOWNEYCREE	48.293	-121.179	Unknown	WILDFIRE209	20040825	900	1	0	0		0	0		0	1361	WA		51	2296.31	2534.13	3695.26
3	SWIFTCREEK	48.767	-121.685	Unknown	WILDFIRE209	20040825	900	1	0	0		0	0		0	1178	WA		46	2114.76	2302.69	3220.2
4	HIGHLANDSC	48.588	-119.035	Unknown	WILDFIRE209	20040825	900	2	0	0		0	0		0	1152	WA		118	2393.02	2686.23	4117.75
5	WILLIAMSBU	48.398	-120.537	Unknown	WILDFIRE209	20040825	900	6	0	0		0	0		0	1489	WA		416	26582.43	28664.27	38769.84
6	FISCHER	47.569	-120.58	Unknown	WILDFIRE209	20040825	900	82	0	0		0	0		0	758	WA		5479	29031.92	31611.38	44203.97
7	DIRTYFACE	47.868	-120.833	Unknown	WILDFIRE209	20040825	900	1	0	0		0	0		0	1206	WA		78	1668.25	1887.44	2957.63

Figure 17. Select by rectangle

Query - The query key allows the user to define detailed selection parameters. Notice in the example above the select by rectangle tool produced information on many fires of varying size. The Query function allows us to identify fires with specific characteristics such as those over a certain size, or those being planned by the Bureau of Land Management. In the example illustrated in Figure 18 fires over 100 acres are selected.

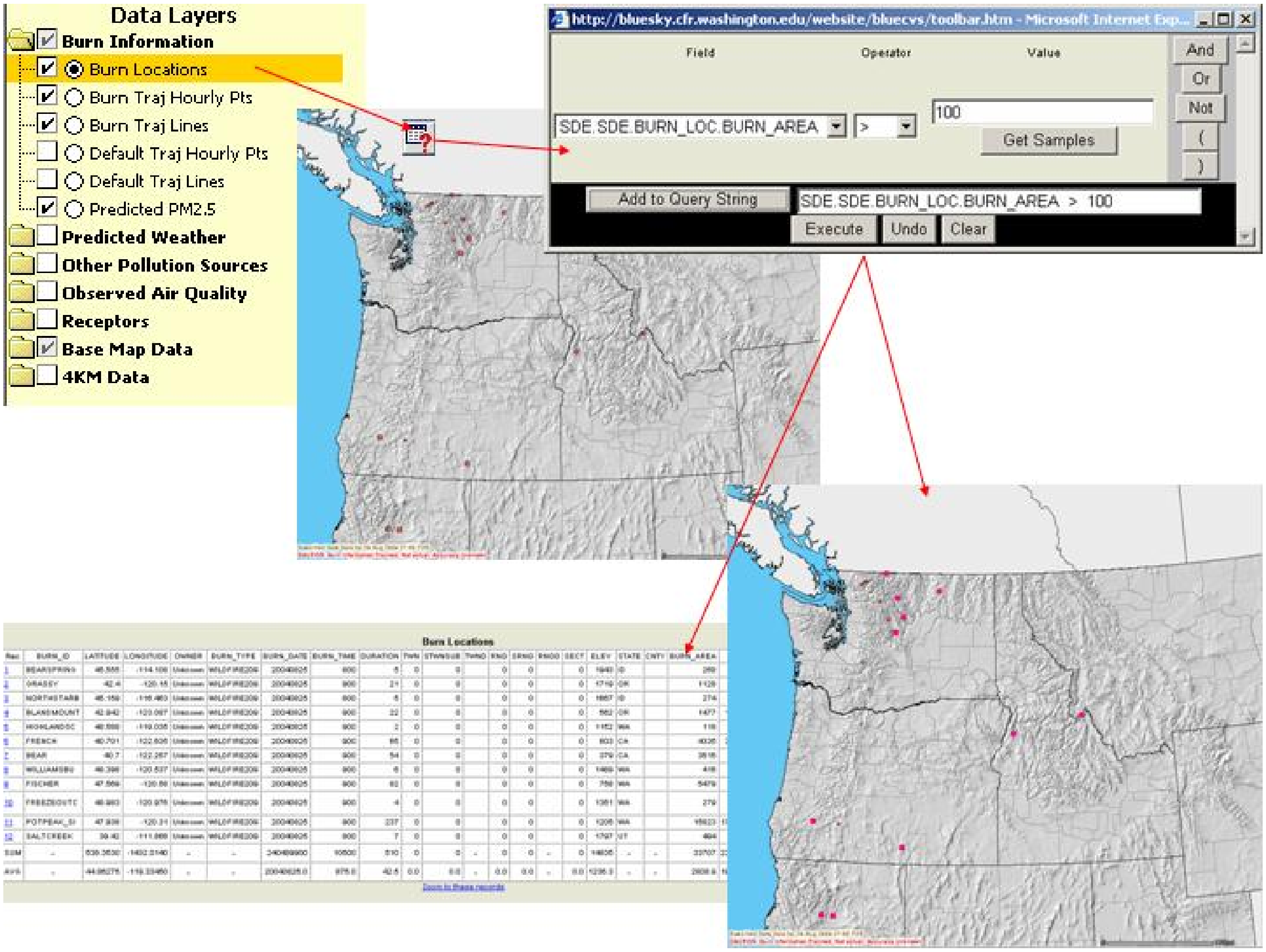


Figure 18. Querying for fires >100 acres

The last three keys on the toolbar allow the user to print, download data, and personalize map settings using the bookmark tool.

**Print -** The print key does not immediately start printing but rather formats the mapped image so that it can be printed using the browser print function. You will be given the opportunity to specify a title for the map and change the size of the printable map.

**Download –** The download option allows the user to download displayed layers as ArcGIS compatible shapefiles. When the download tool is clicked the user will be given an opportunity to specify which of the displayed layers they wish to download. Check all boxes that apply then click on extract and the data will be packaged into a zip file to be downloaded.

Bookmark - This function allows the user to create their own default map to call up on entering BlueSkyRAINS or to save a map of particular interest. Once all the desired layers are displayed, click on the bookmark tool. A screen comes up with options for creating the bookmark so that it displays exactly the same information as shown including date and time, or the same map layers for the current date. Right click on the desired option, give your map a name and it will be added to your favorites list in your web browser. Selecting that favorite will always take you back to the set of map layers displayed when the bookmark was created.

Understanding trajectories

Trajectories show the direction of travel of an air parcel based on the three dimensional wind flow patterns predicted by the MM5. Hysplit, the model used to compute forecast trajectories, does not take into account any changes in buoyancy which may be caused by the heat of the fire. This may result in errors, especially with regard to initial heights in the vicinity of the fire which in turn could lead to errors in the direction and speed of transport. Thus, the trajectories presented in BlueSkyRAINS should be considered as a good first guess for the direction, height, and movement of a smoke plume but should not be relied upon for precise predictions, especially for large hot fires.

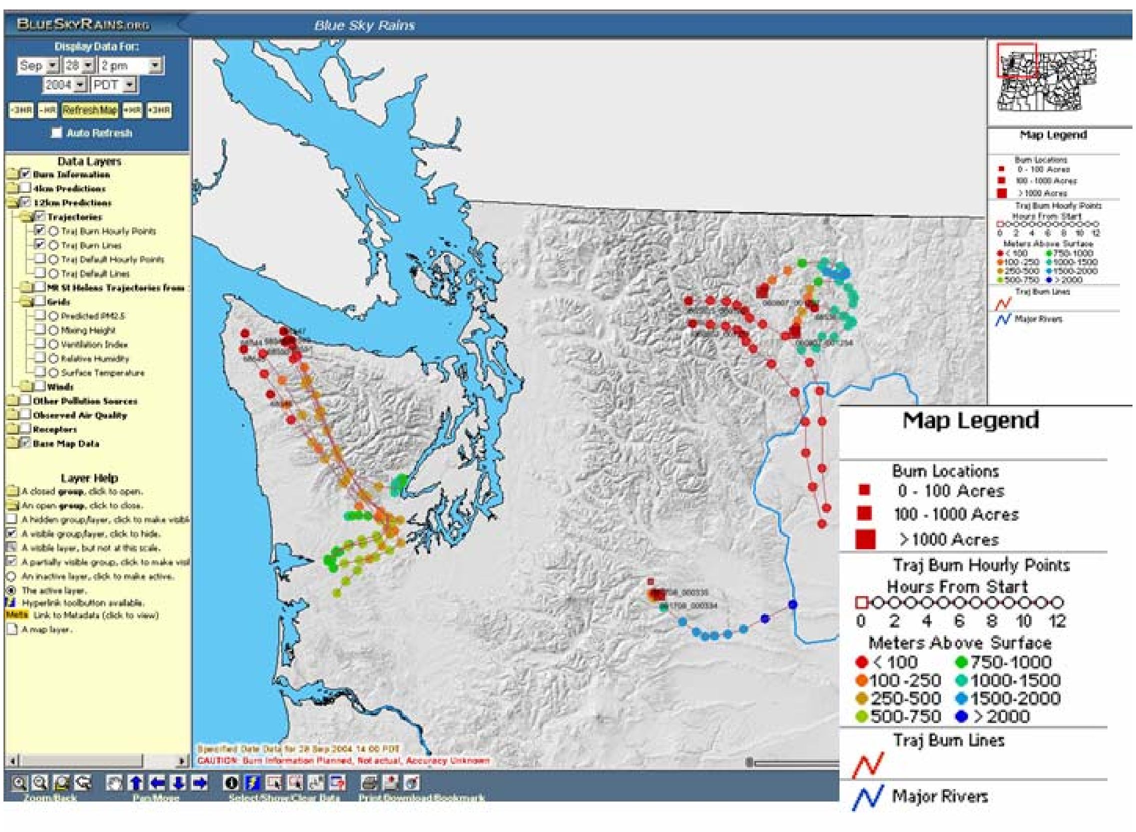


Figure 19. Trajectories

Figure 19 shows predicted trajectories for several prescribed burns in Washington state. The red square at one end of each trajectory line indicates the location of the burn. (Note that when the first trajectory point is red and the burn is relatively small the square is sometimes obscured). Along each trajectory line there are 12 colored dots. Each dot represents the location of the smoke plume one hour further out in time. Thus in this example with a map valid time of 2pm, the trajectory points represent hourly predictions of both height and location from 2pm through 2am the next morning. The color of the dots, as can be seen in the enlarged legend in Figure 19, indicate the height above the ground of the smoke expressed in meters. Warm colors (reds and oranges) indicate the smoke plume is close to the ground, while cooler colors (greens and blues) indicate smoke that has moved higher into the atmosphere.

As we zoom in on the trajectories (Figure 20) the predicted height of the smoke plume at each point becomes visible. These heights are presented in meters, to convert to feet multiply by 3.28.

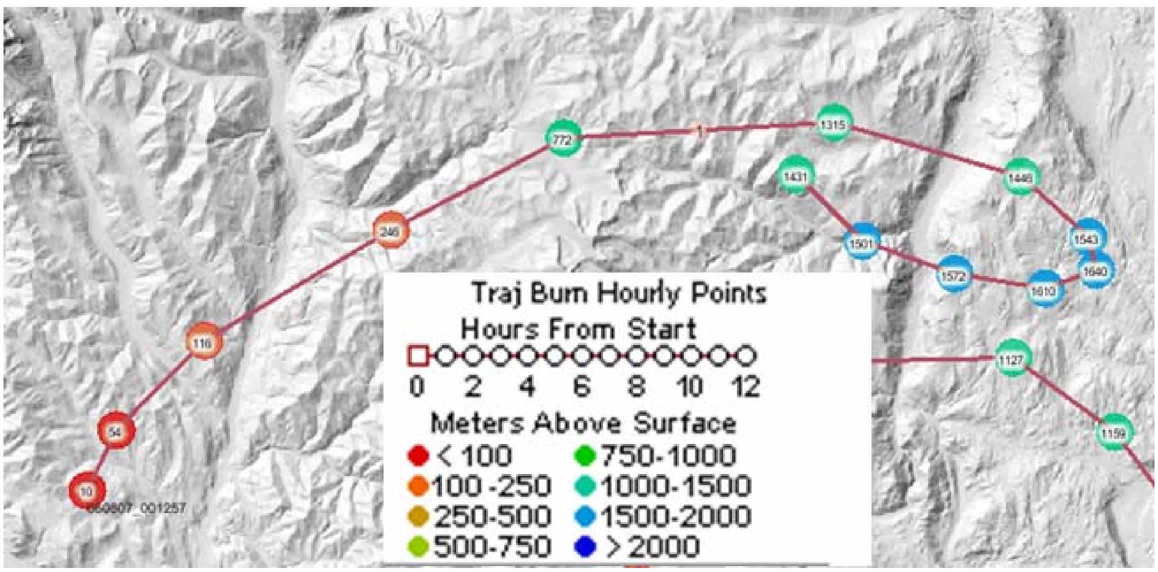


Figure 20. Zoom in to see predicted height of the smoke plume over 12 hours

Default Trajectories

Each time BlueSky is run trajectories are computed for predefined grid points. This allows the user to plan ahead for burns which may not appear on the screen by interpolating between the grid points. Default trajectories are interpreted and presented in the same way as trajectories associated with a specific burn. Figure 21 shows default trajectories for the full domain and zoomed in to a local area.

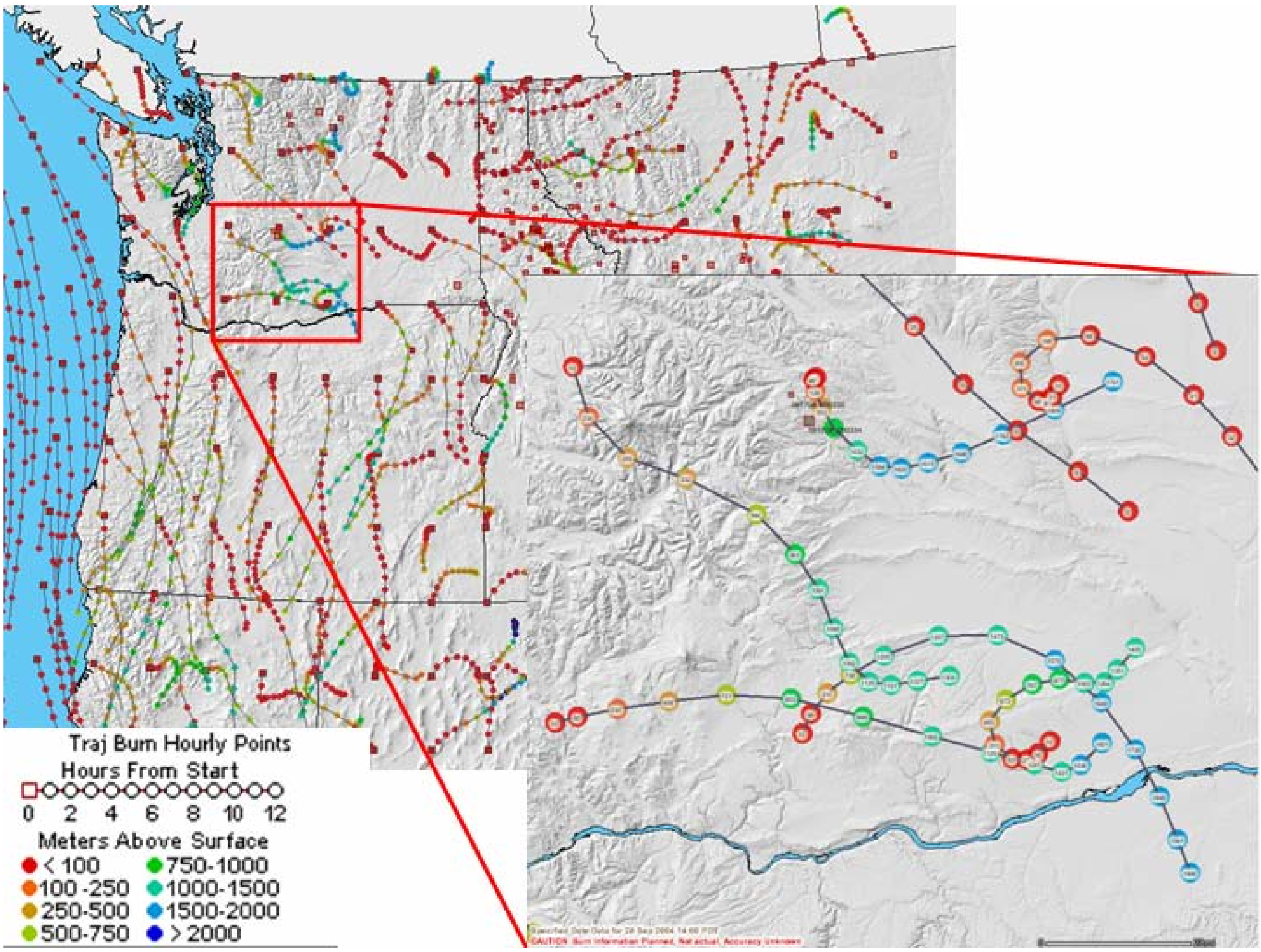


Figure 21. Default Trajectories Full screen and zoomed in

Mt. St. Helen's trajectories

Although Mt. St. Helen's trajectories may not be of interest to many burners, National Forests in the Pacific Northwest are vulnerable to the impacts of ashfall should the volcano erupt again. We have taken advantage of BlueSky's capabilities to produce predictions of Mt. St. Helen's trajectories. Monitoring actual steam and ash flow also help in evaluating BlueSky's performance in predicting trajectories.

Because the strength and direction of the blast will determine how high the ash column might move into the atmosphere, trajectories are calculated at several levels above the top of the mountain. Trajectory lines are color coded by height. Figure 22 shows the predicted Mt. St. Helens trajectories for March 24, 2005 at 2pm.

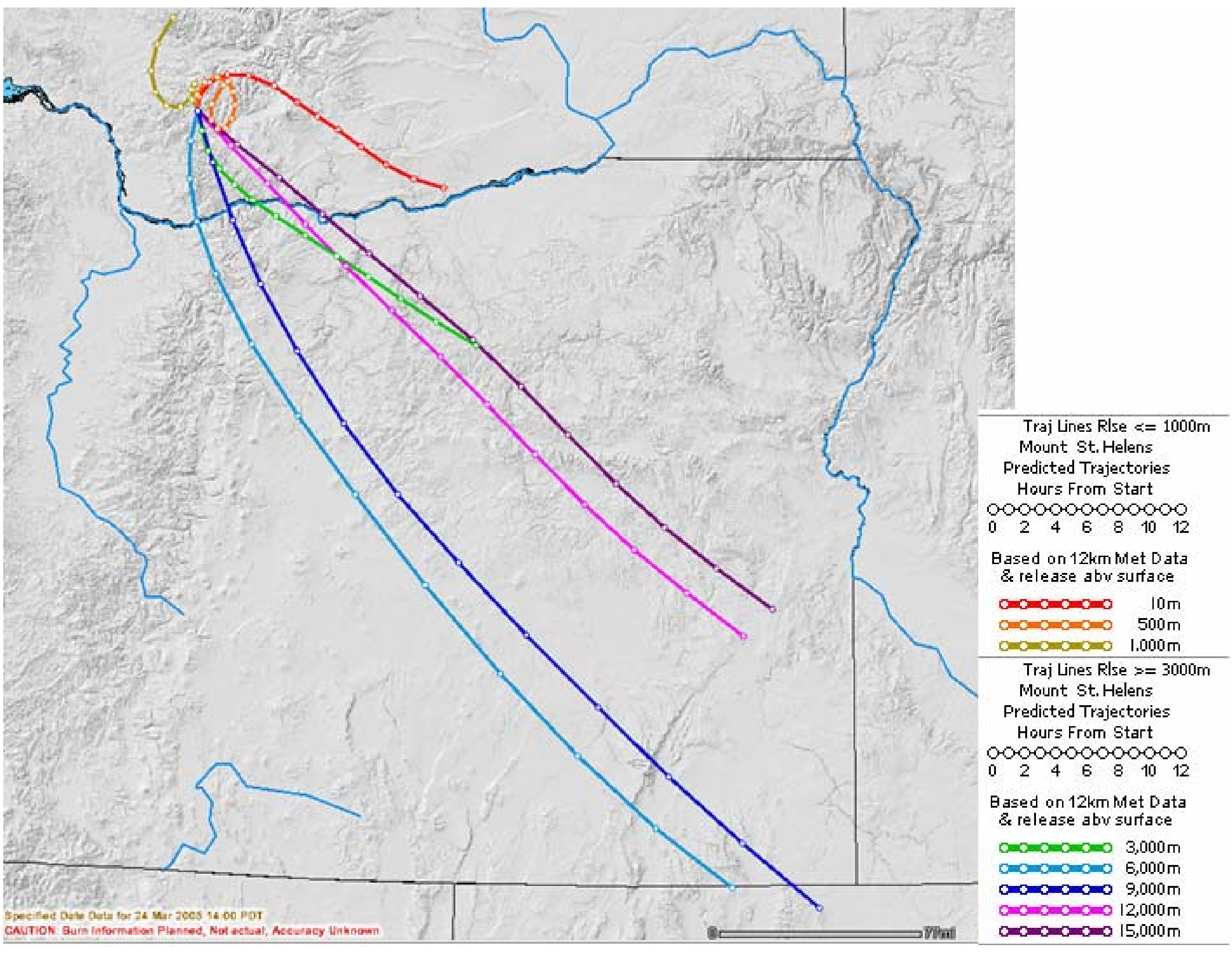


Figure 22. Mt. St. Helen's trajectories

Understanding PM2.5 Concentrations

The most significant pollutant, in terms of human health, produced by wildland fire is particulate matter less than 2.5 microns in diameter or PM2.5. Although smoke contains particulate matter of larger sizes, it is the PM2.5 that can lodge deep in our lungs to cause or exacerbate respiratory problems. PM2.5 is the only pollutant currently displayed in BSR. Figure 23 illustrates the relative size of PM2.5 particles

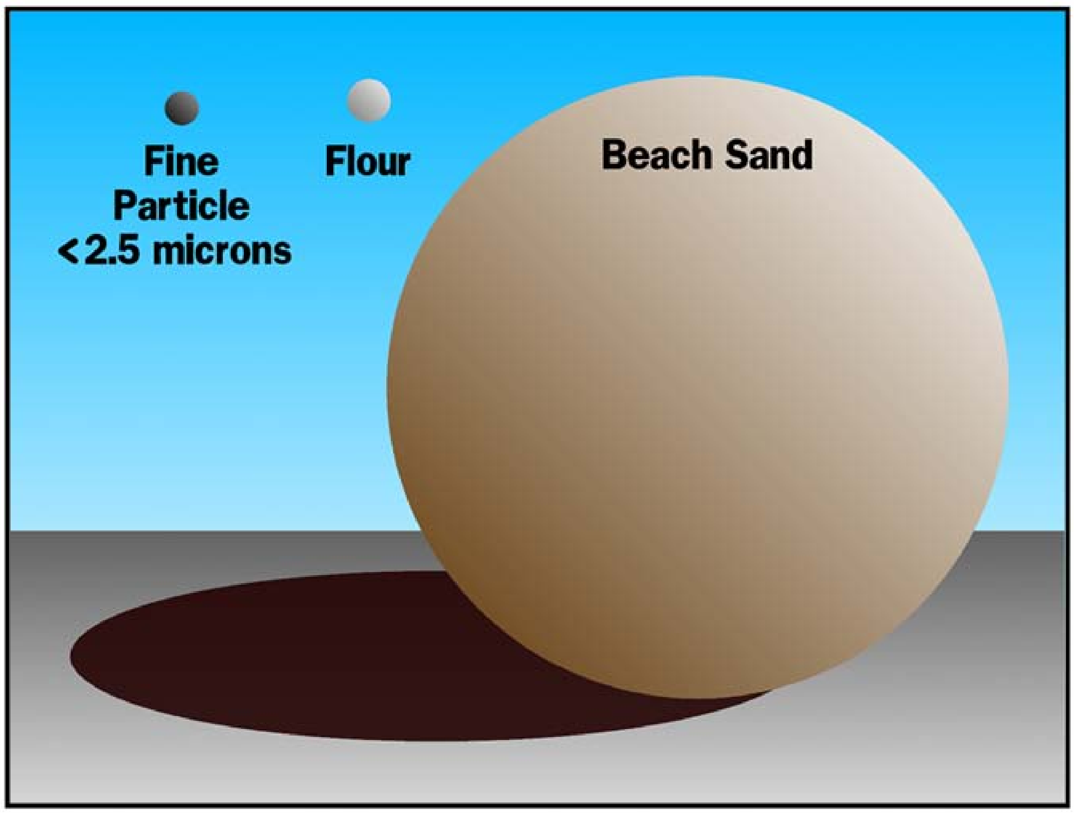


Figure 23. Relative size of PM2.5 particles

The PM2.5 concentrations shown in BSR are calculated using the CALPUFF air quality dispersion model. CALPUFF is the EPA's preferred model for assessing long range transport of pollutants and impacts to Class I areas. For each hour of the prediction period concentrations are recalculated based on burning and transport that has occurred over the preceding hours. PM2.5 concentrations are expressed in micrograms/cubic meter (ug/m^3). Remember that all information displayed in BSR is a prediction based on the best available science and modeling technology.

Figure 24 shows a display of PM2.5 concentrations valid at 6pm October 28, 2004. As the colors range from cool to warm (blue to red) they represent increasing concentrations. Only concentrations predicted at the surface are shown.

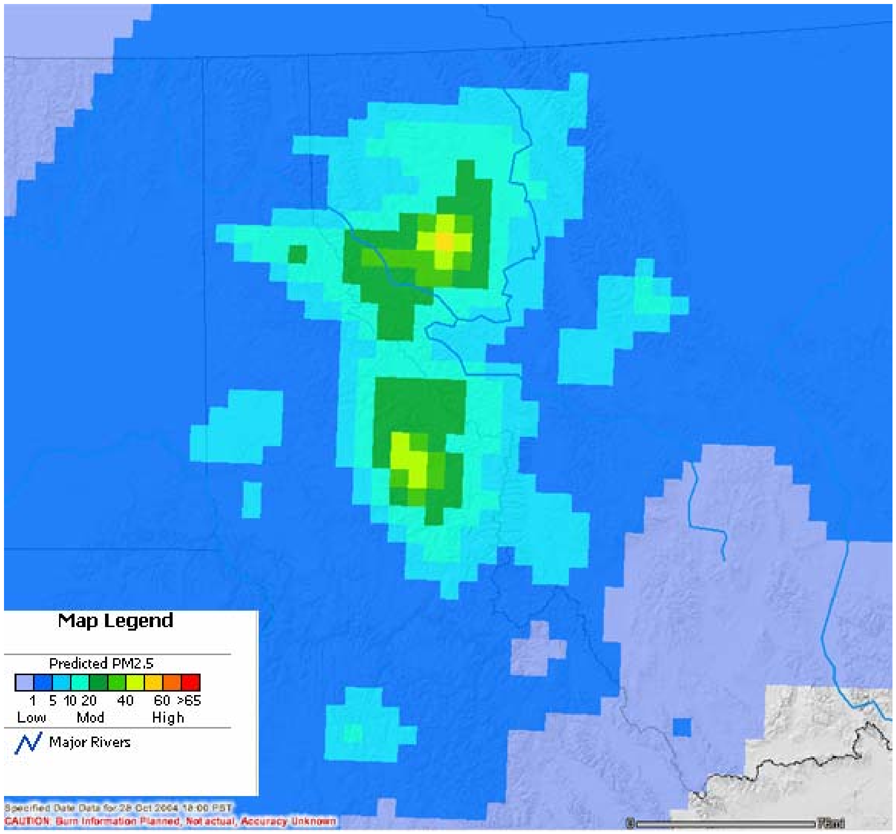


Figure 24. PM 2.5 concentrations

Evaluation studies have show that BlueSky predictions of concentrations tend to be too low near the burn and too high at a distance from the burn. In additions some features of the MM5 model cause the mixing height to be dropped to the surface very quickly around sunset resulting in an over prediction of PM2.5 concentrations at that time.

Meteorology Layers

The meteorology layers available for display in BlueSkyRAINS are based on output from the 0000 UTC (4pm PST) runs of the mm5 mesoscale model conducted by the University of Washington department of Atmospheric Sciences. The meteorological parameters most critical to smoke management are wind speed and direction and mixing height. Ventilation Index, which combines the two is also available (See Appendix D for a detailed discussion of the application of Ventilation index in smoke management). In addition, temperature and relative humidity predictions are provided for convenience in evaluating fire weather conditions. Because the data in all the meteorology (met) layers except winds are displayed using shaded grid cells they are incompatible for overlay with any other met layer except winds. Each met layer type is illustrated and explained in detail in this section.

Wind Speed and Direction

Wind speed and direction are depicted by a symbol which combines wind barbs with arrows. The arrow points in the direction of wind flow, while the number and length of lines on the wind barb indicate speed in miles per hour.

Figure 25 shows an example of a wind layer showing southwest wind near the Columbia River gorge at between 20 and 25 mph. Remember that winds are the only met layer that can be displayed on the same screen with another met layer. If the user wishes to compare met layers such as temperature and relative humidity, this can be done by opening BSR in two separate windows side by side.

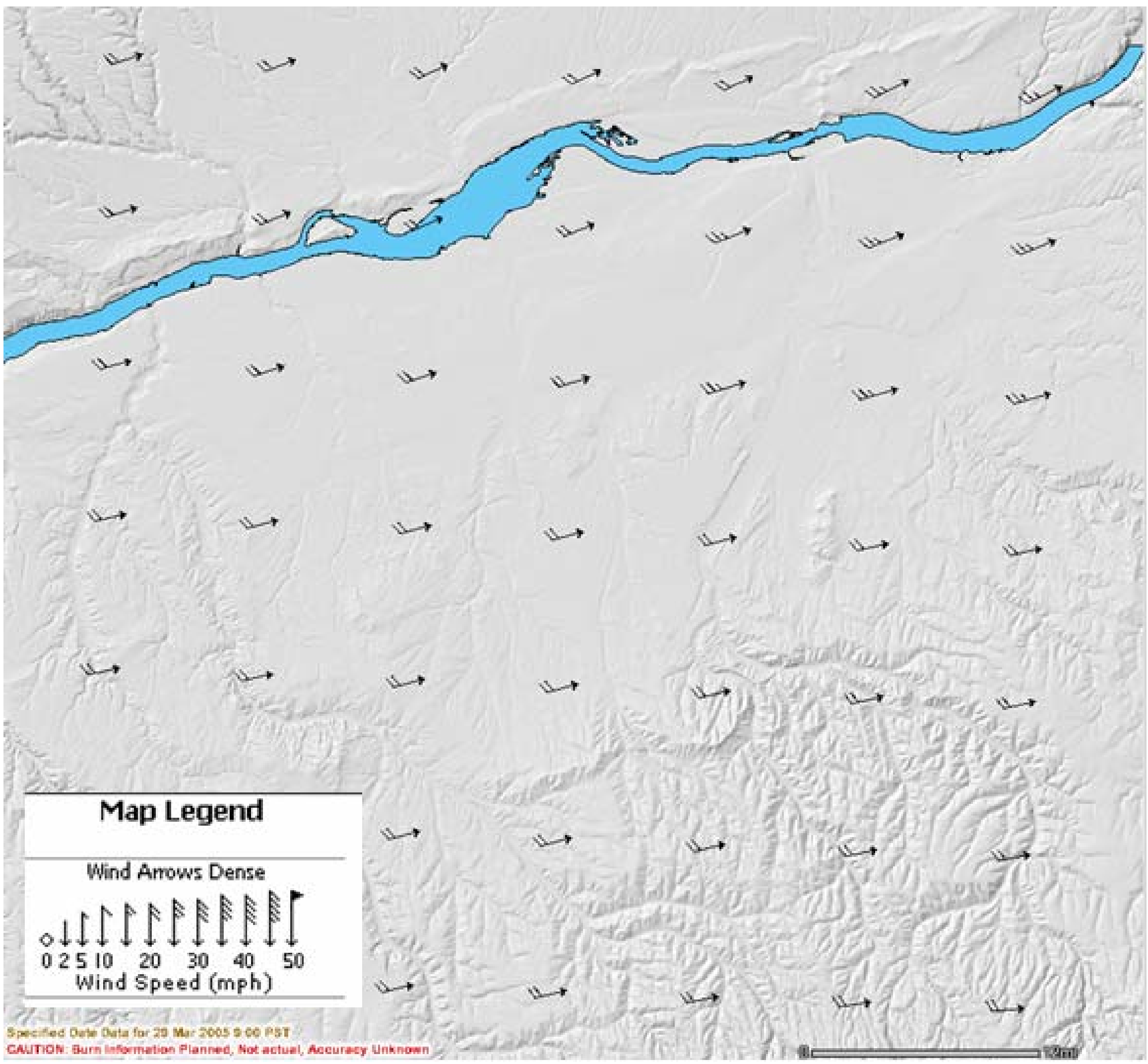


Figure 25. Wind Speed and Direction

Mixing Height

Mixing height shows the level to which pollutants can be expected to be mixed vertically based on the stability of the atmosphere. In general, mixing heights can be expected to drop off after sunset and reach a minimum around sunset. Because high pressure is associated with more stable air and low pressure with less stable air, mixing heights will usually be lower under high pressure and higher under low pressure. Mixing height maps available in BSR show mixing heights in meters above ground level. It should be noted that in this case ground level is defined by the model terrain which is only a generalization of the actual terrain. Figure 26 shows predicted mixing heights on a spring morning in the Pacific Northwest. Note that because the grid map is overlain on a grey background the colors are distorted slightly from those shown on the legend.

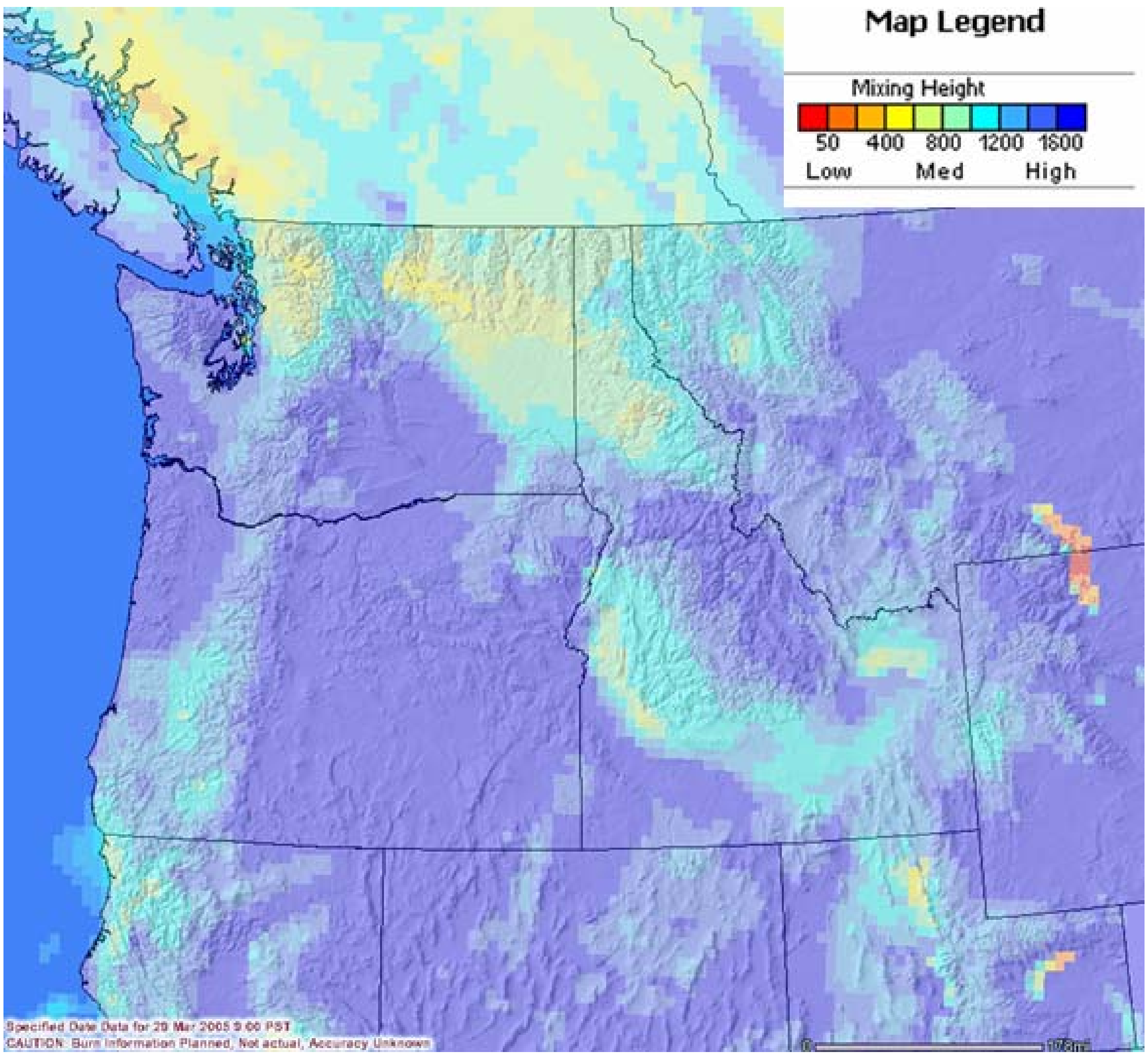


Figure 26. Mixing Height

Ventilation Index

Several Ventilation Indexes have been developed over the years to combine wind speed and mixing height in order to arrive at a single number to represent dispersion. Ventilation Index values are generally grouped into categories to simplify interpretation. The Ventilation Index maps available in BSR depict a simple product of mixing height (sometimes referred to as planetary boundary layer) and wind speed at 20 meters above the ground. This gives a somewhat more conservative estimate of dispersion conditions than more traditional ventilation indexes which use transport winds, or an average of wind speed from ground level to the top of the mixed layer. Figure 27 shows predicted ventilation index values for a spring morning.

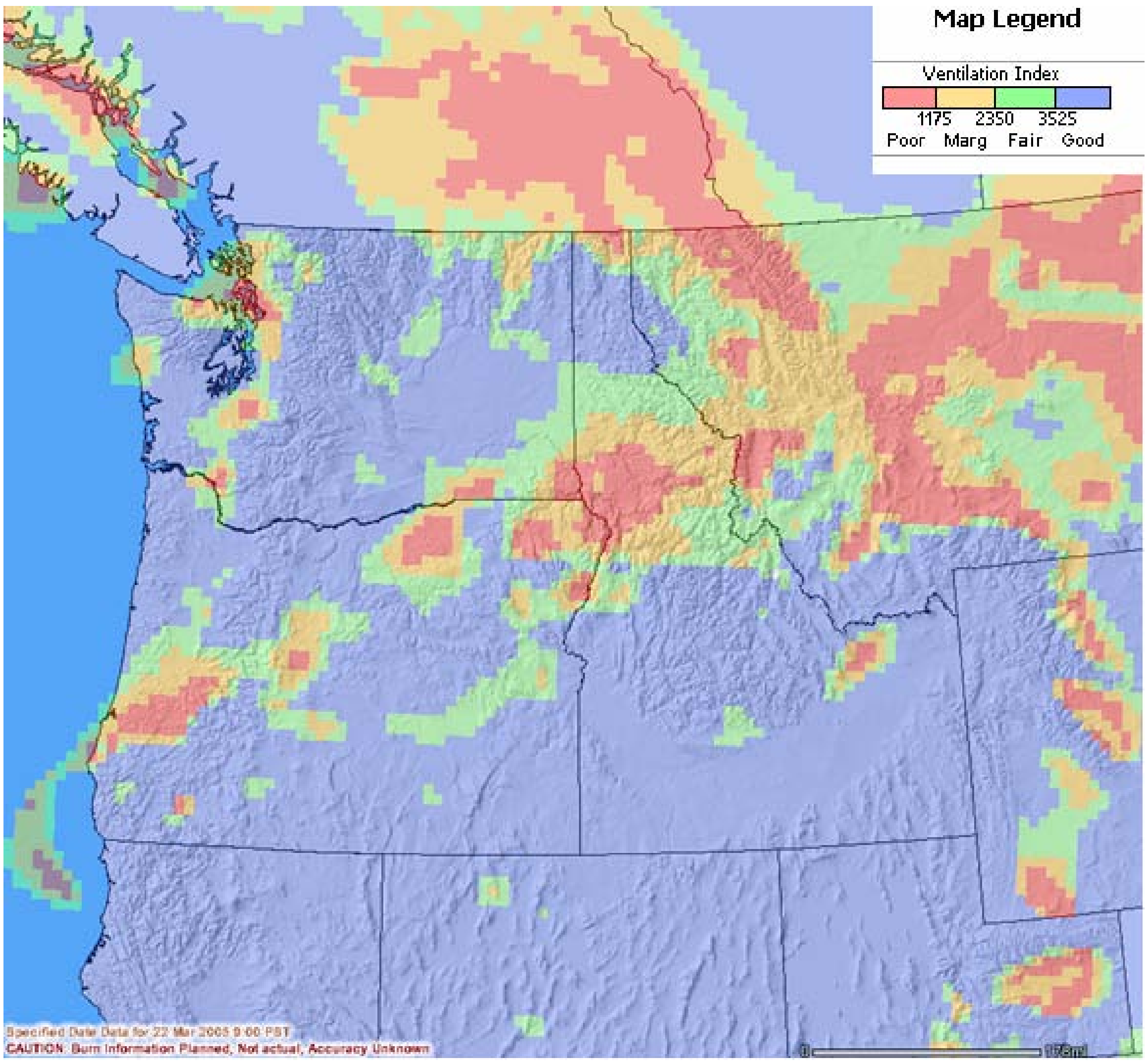


Figure 27. Ventilation Index

Temperature

Surface air temperature is portrayed by a gradation of colors from cool (blues and greens) to warm (reds and oranges). The temperature scale in the legend allows the user to interpret values in either Celsius or Fahrenheit. Studies have shown that the MM5 tends to be a little low in predicting afternoon maximum temperatures and a little high with overnight minima. Figure 28 shows an example of a temperature prediction for a spring afternoon.

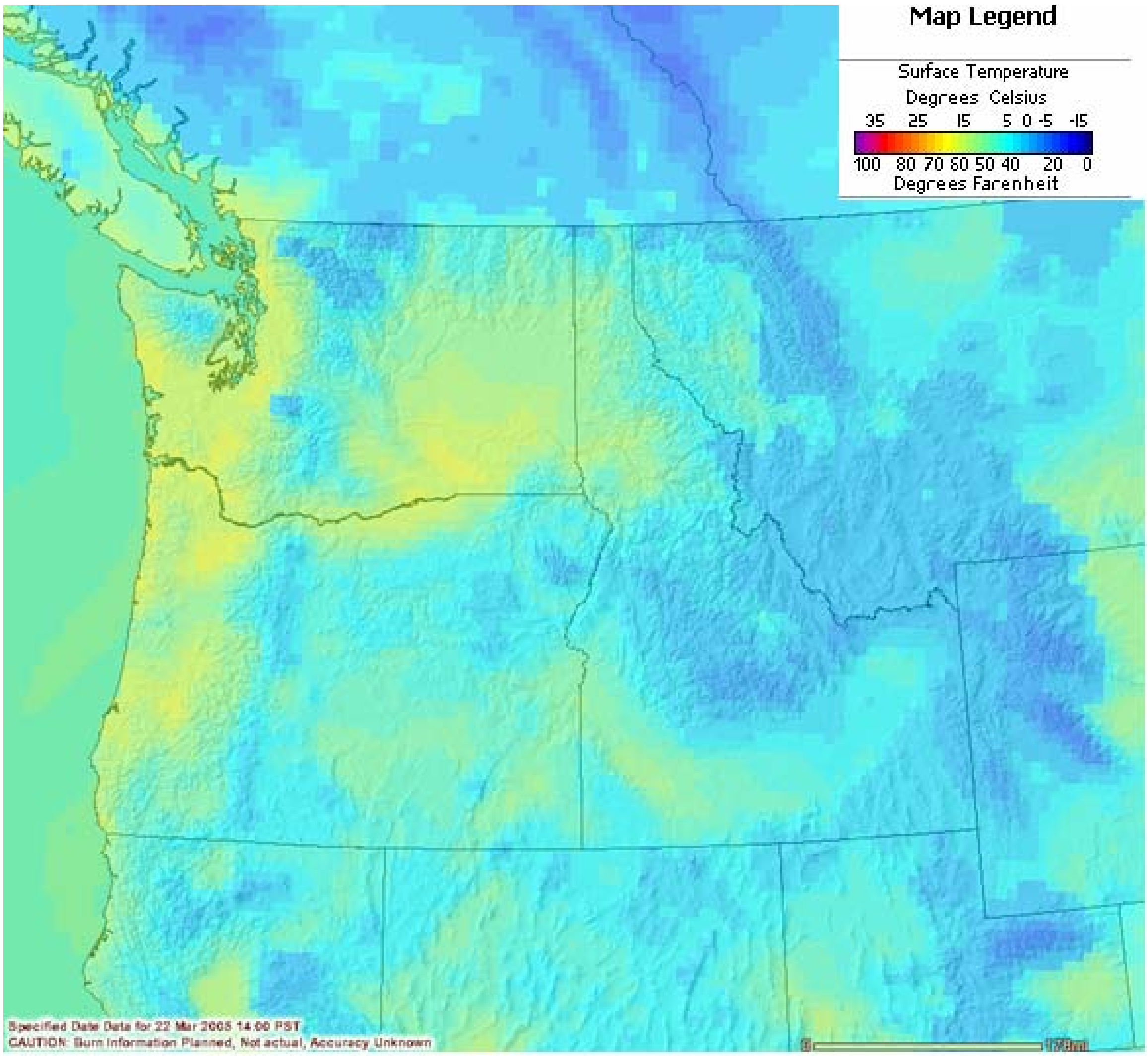


Figure 28. Temperature

Relative Humidity

Relative Humidity refers to the amount of moisture in the air relative to the amount it could hold if fully saturated. In BSR low relative humidity is depicted by warm colors(reds and oranges) and more saturated conditions by cooler colors (greens and blues). Figure 29 is an example showing relative humidity in the Pacific northwest on a summer afternoon.

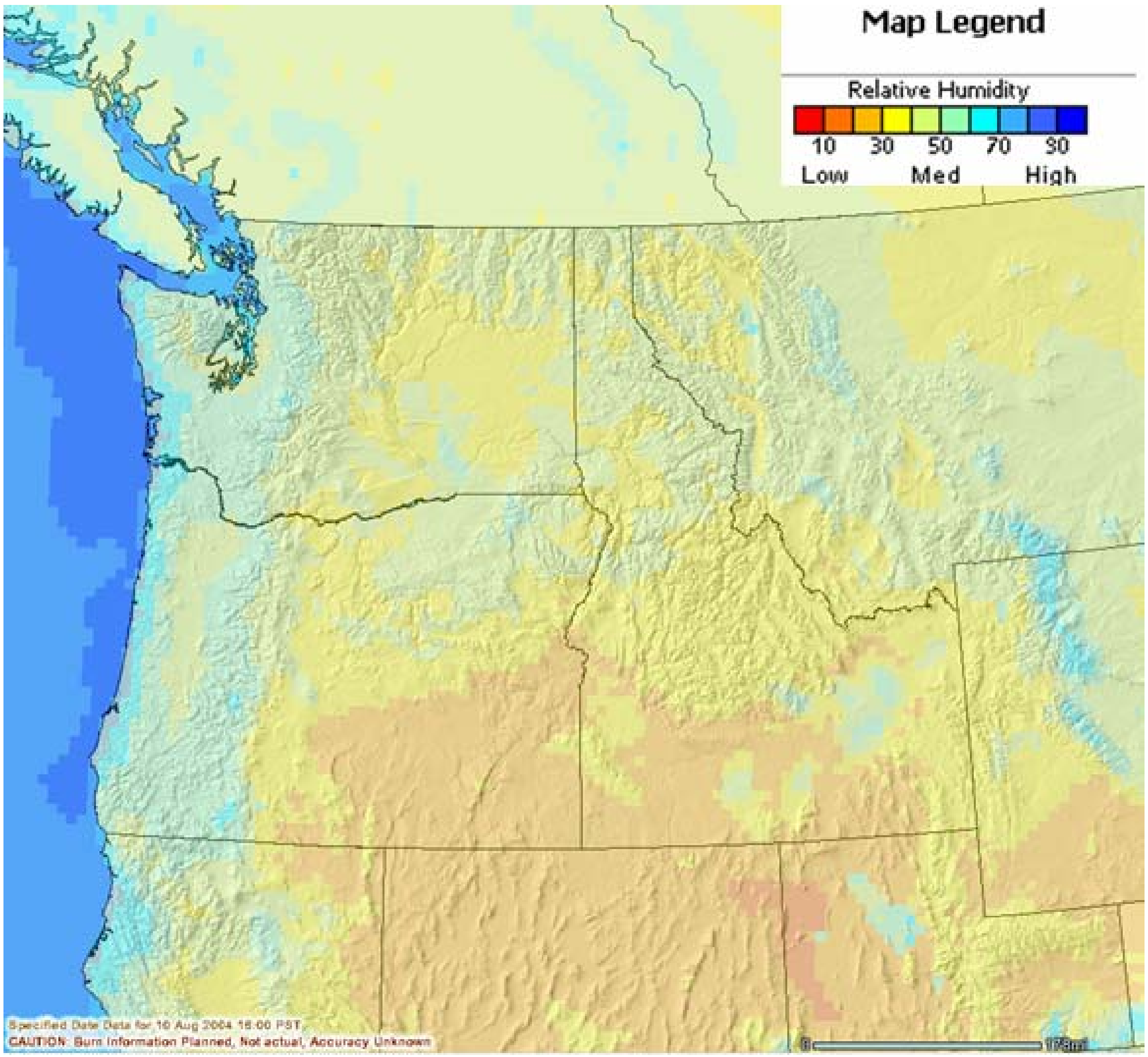


Figure 29. Relative Humidity

Meteorology Graphs

To view a 24 hour graph of any of the meteorological parameters, simply make a meteorological layer active, click on the identify tool and click on a pixel of interest on the meteorological map. A table showing the values of all the meteorology predictions for the valid time of the map will be shown. Then click on the chart link to see the 24 hour graphs (Figure 30). You can scroll down to see a graph of each of the meteorology parameters.

Vent Index 12km

Rec	DATE_TIME (in PDT)	FCASTHR	WSPD_MPH	WDIR	RH	PBLHEIGHT	VENTINDEX	SFCTEMP_F	CELLID	Chart Link
1	Tue, 10 Aug 2004 16:00:00	23	2	63	37	2344	2224	77	300750116	Chart
2	Tue, 10 Aug 2004 16:00:00	23	0	150	38	2431	249	76	300[illegible]16	Chart
3	Tue, 10 Aug 2004 16:00:00	23	3	75	39	2277	3098	76	300750117	Chart
4	Tue, 10 Aug 2004 16:00:00	23	2	116	40	2392	2148	74	300760117	Chart
SUM	-	92	7	404	154	9444	7719	303	-	
AVG	-	23.0	1.8	101.0	38.5	2361.0	1929.8	75.8	-	

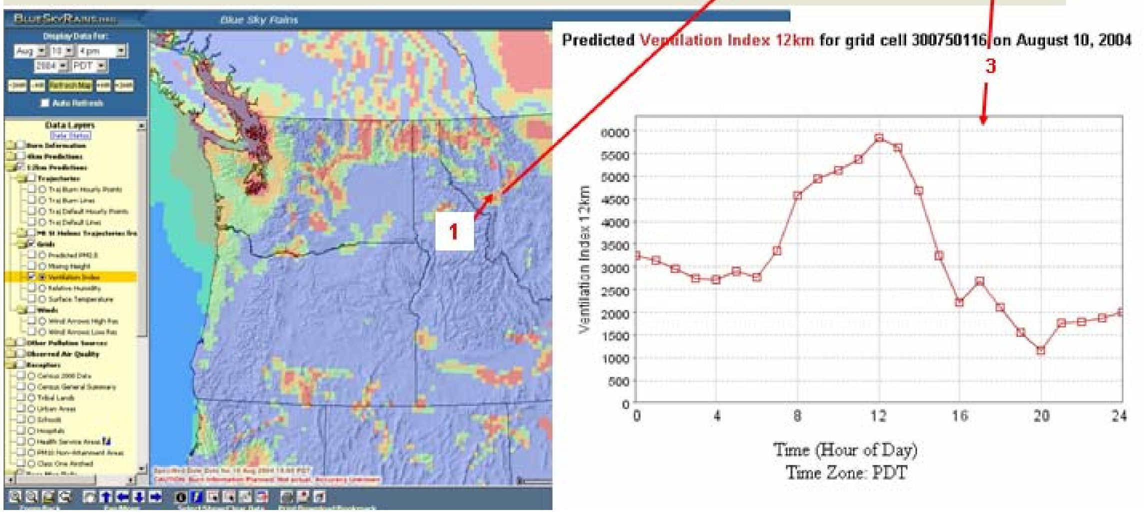


Figure 30. Table of meteorology predictions and 24 hour graph of Ventilation Index called up using the identify tool.

Receptors

One of the category folders for overlay maps in BSR is receptors. These maps provide information about locations where it is desirable to avoid smoke impacts. Figure 31 shows the menu for receptor overlay maps.

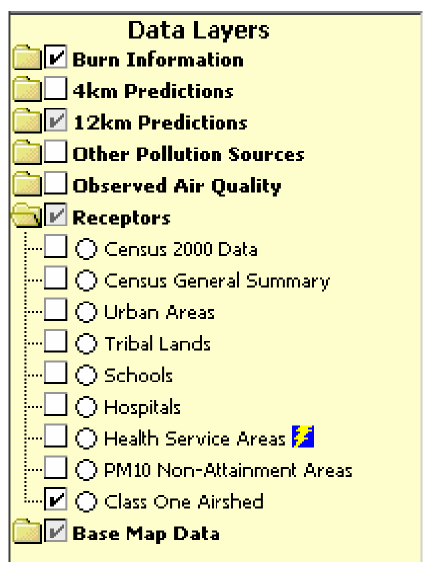


Figure 31. Receptor Menu

Census 2000 Data

The census 2000 data layer shows population density for the year 2000 with light shading representing low population density and darker shading high density. This layer does not show up unless the map display is zoomed in.

The Census general summary layer summarizes the data in the census 2000 layer and can be seen only when the map display is zoomed out. For simplicity it is best to turn on both census layers, you can then see the data regardless of the zoom level.

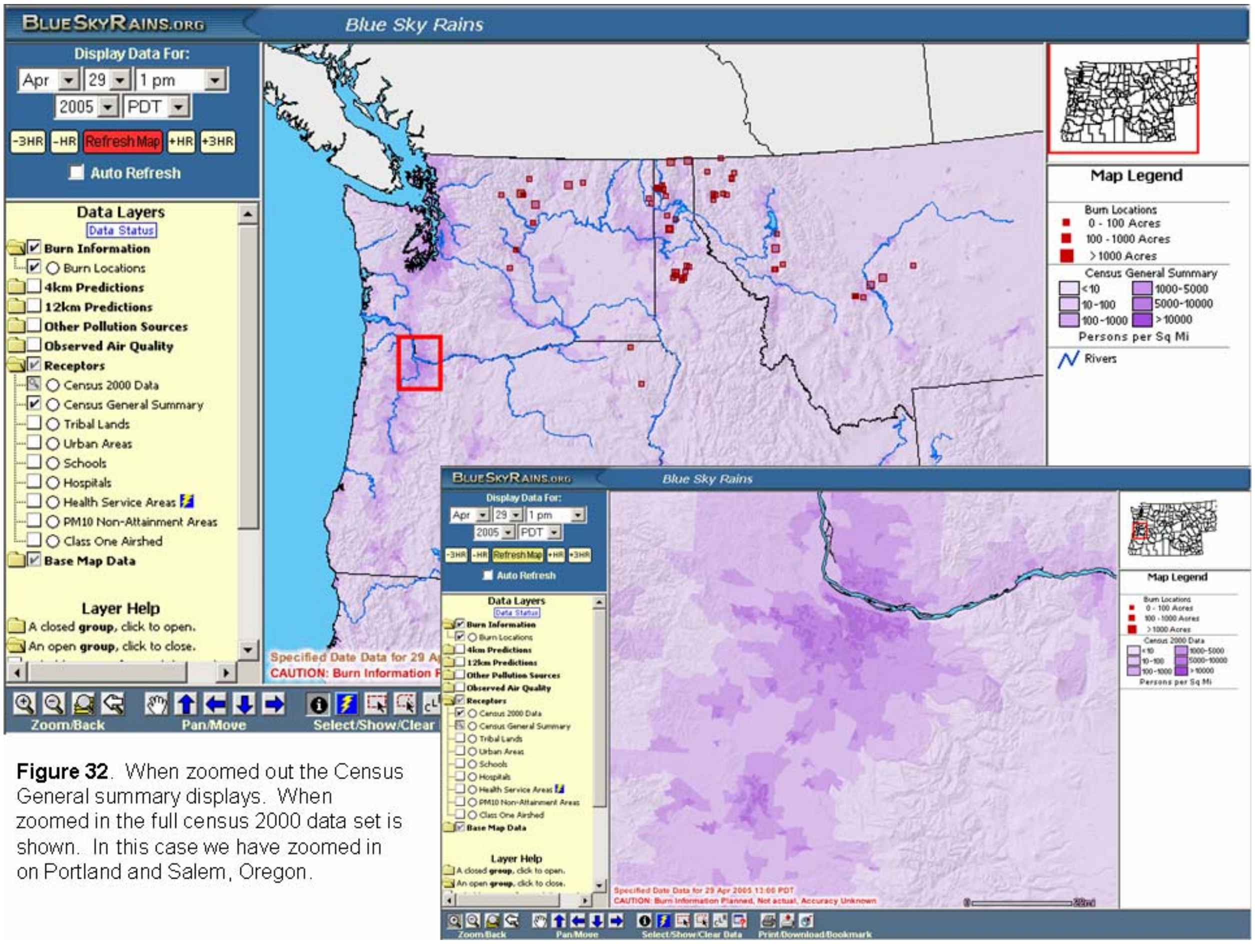


Figure 32. When zoomed out the Census General summary displays. When zoomed in the full census 2000 data set is shown. In this case we have zoomed in on Portland and Salem, Oregon.

The urban areas layer is another way of getting at the same information. Only the boundaries of larger communities are shown however, so some of the smaller cities (less than 10,000 population) will not be seen on the urban areas layer but may be discerned from increased population density on the census data layer.

Tribal Lands, PM10 Non-Attainment Areas, Class One Airsheds

These layers all show geographic areas which are particularly sensitive to smoke because of requirements to keep clean air clean, as is the case for tribal lands and class one areas; or to improve air quality in polluted locations as is the case with PM10 Non-Attainment areas. Because PM2.5 standards are just being established by the EPA, PM2.5 non-attainment areas have not yet been defined. Figure 33 shows an area in the vicinity of Yakima Washington which contains all three types of receptors. Mt. Rainier National Park, Goat Rocks Wilderness area and Mt. Adams Wilderness area are all Class one areas. The Yakima Reservation represents a large area of tribal lands and the city of Yakima is a PM10 non-attainment area.

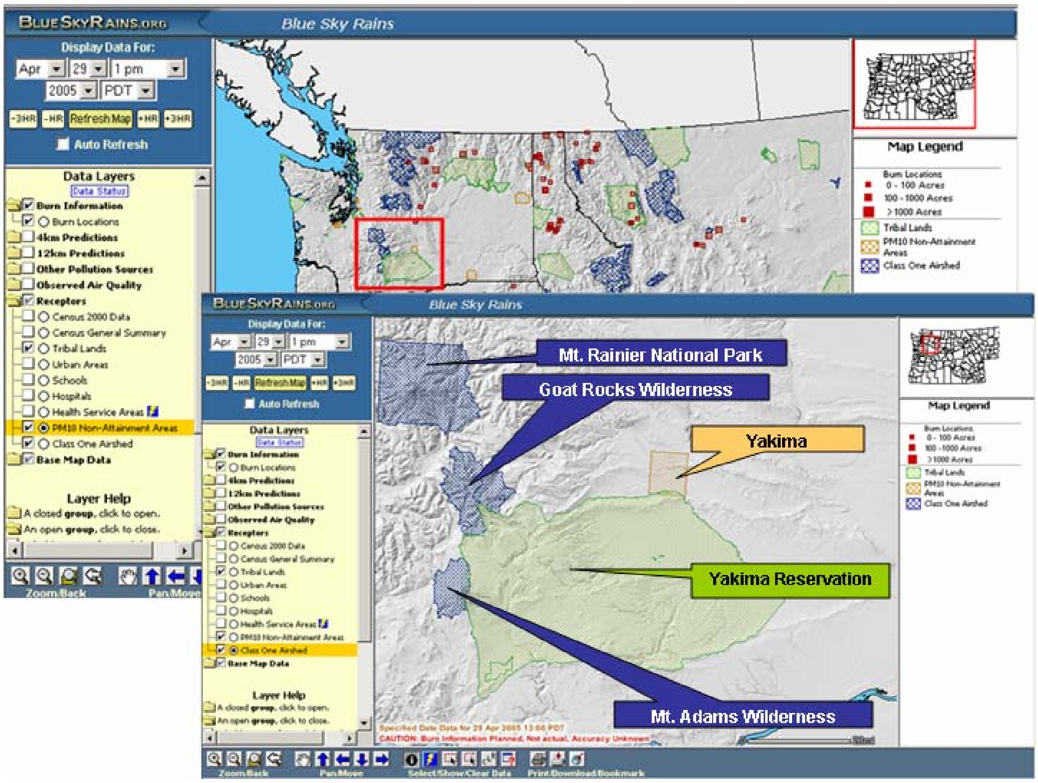


Figure 33. Class 1 areas, PM 10 non-attainment area and tribal lands.

Schools, Hospitals, Health Service Areas

These layers give a surrogate for population density. Wherever schools and hospitals are clustered it can be assumed that population density is high. The Health Service areas are hyperlinked to an EPA web site which also provides maps of population density as well as information about the rates of pulmonary and heart disease. This data can give burners and air quality regulators some information about the relative impacts of smoke on a local population.

In Figure 34 we have zoomed in on Northwest Oregon where we can pick out individual cities based on the clustering of schools and hospitals. Then using the hyperlink we clicked on a location near Salem, Oregon which takes us to the EPA population density and health statistics site for that area.

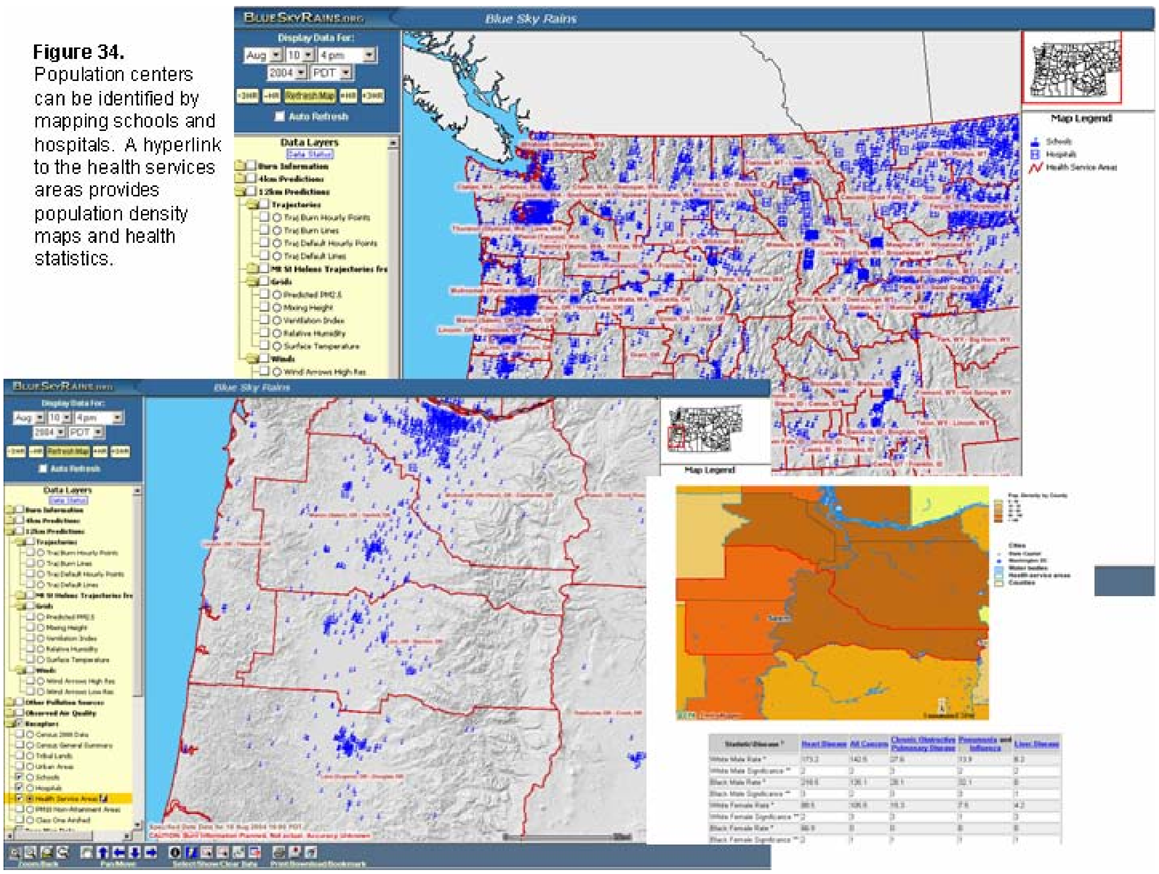


Figure 34. Population centers can be identified by mapping schools and hospitals. A hyperlink to the health services areas provides population density maps and health statistics.

Other Pollution Sources/Observed Air Quality

These layers allow the user to evaluate smoke in the context of other pollution sources and current PM2.5 readings. At this time observed air quality data is available only for the state of Washington. In Figure 35 the blue squares are known sources of PM10. The red triangles are PM2.5 monitoring stations. Using the hyperlink feature you can make the air quality monitor layer active, click on a red triangle and you will be directed to a web site with PM2.5 readings for the past three days. Note that even if you are looking at historic data in BlueSky you will only see the current readings for air quality on the Washington Department of Ecology web site.

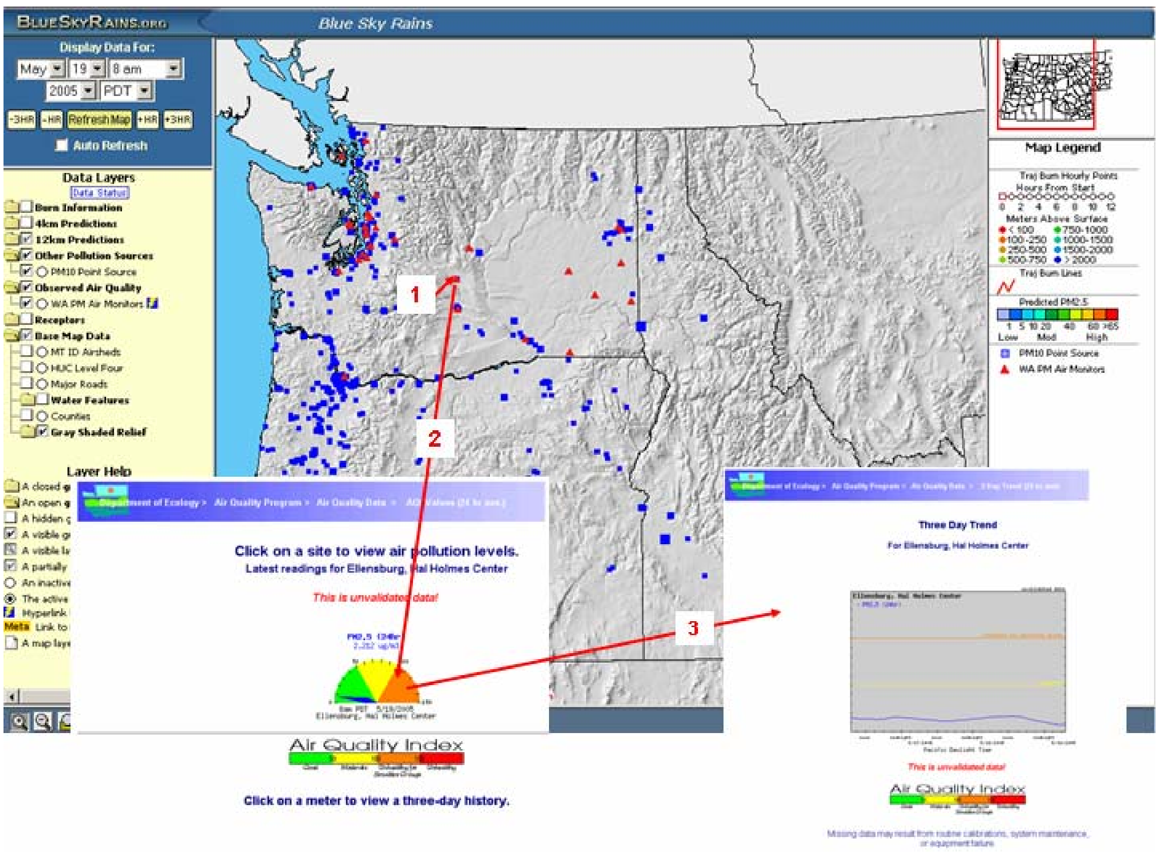
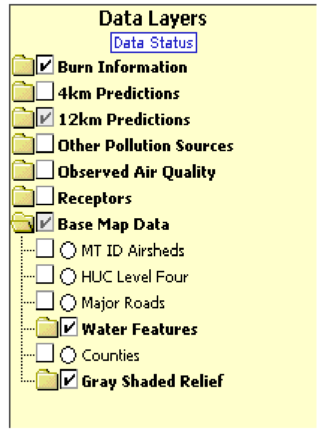


Figure 35. Blue squares show known PM10 sources. Red Triangles are Washington Air quality monitoring stations. Hyperlink feature allows access to real-time air quality observations.

Base Maps



Base maps are provided to help the user locate areas of interest by referencing known boundaries or features such as rivers and roads. By default the smoke forecast maps come up with grey shaded relief as the background and hydrologic features turned on (Figure 36).

MT ID Airsheds/HUC Level Four

The Montana Idaho Airshed group has defined geographic areas with similar dispersion characteristics for purposes of smoke management. These can be shown by turning on the MT ID Airsheds layer. For other areas airsheds can be approximated by looking at watersheds. These are represented by the level four Hydrologic Unit Code maps (HUC Level Four) as defined by the U.S. Geological Survey. These layers are shown in Figure 36.

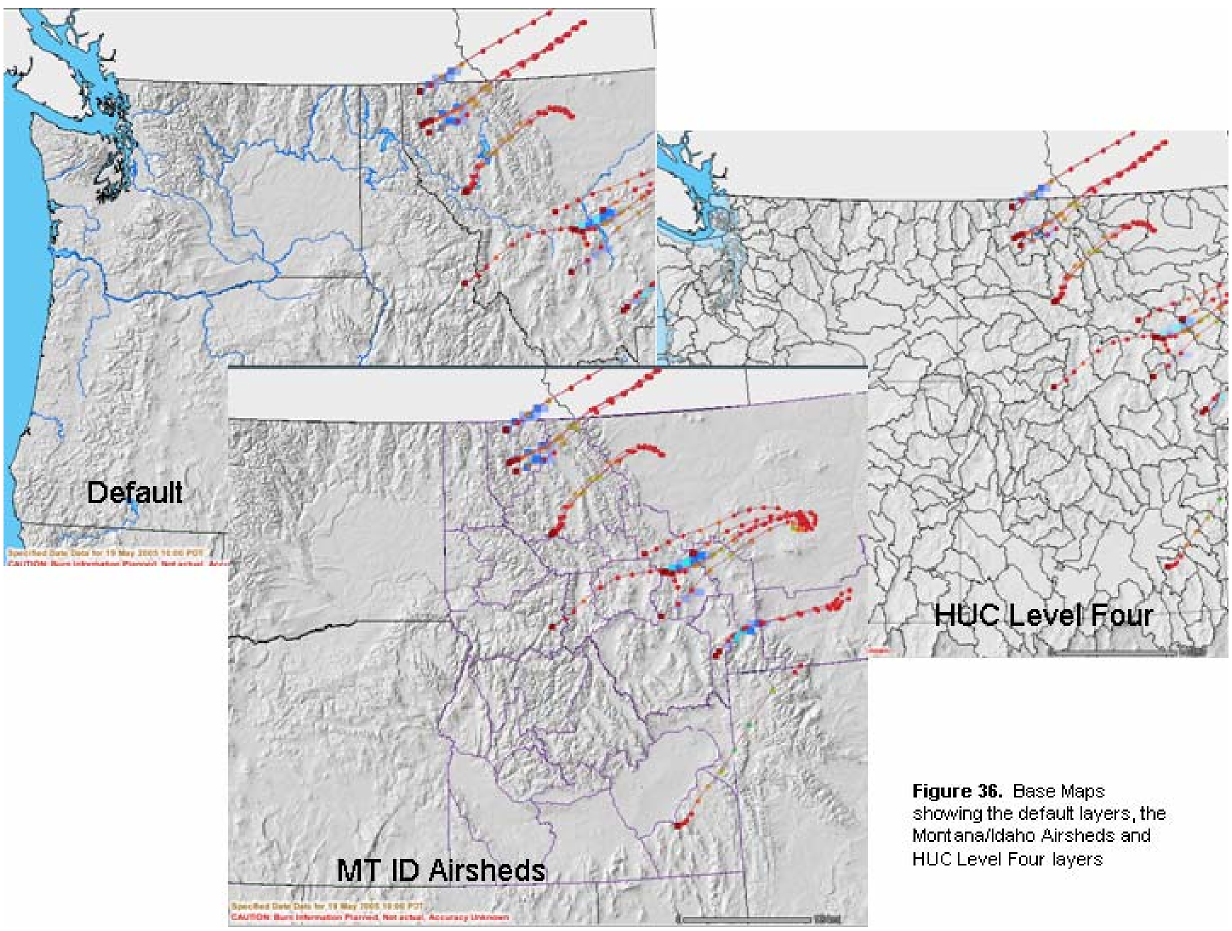


Figure 36. Base Maps showing the default layers, the Montana/Idaho Airsheds and HUC Level Four layers

Major Roads/Counties

Major Road and county boundary layers can also be displayed for reference. See Figure 37.

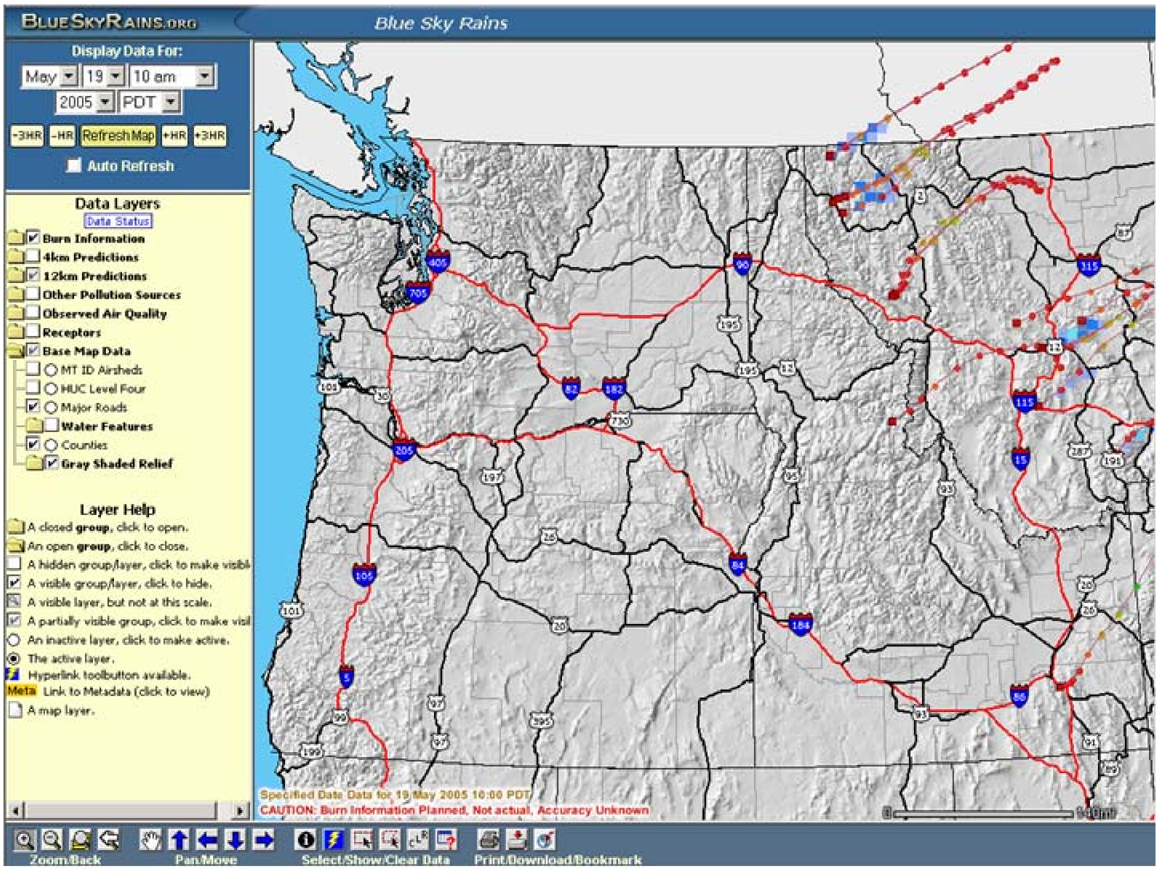


Figure 37. County boundaries and major roads can be added for reference

Chapter 3
Scenarios

This chapter contains a series of scenarios taken from real world cases that are designed to help the user understand how BlueSky and BlueSkyRAINS can be applied to operational smoke management problems.

The scenarios are organized into two sections, Prescribed Fire and Wildfire. However, there are techniques in each section which may apply either way and will help you to understand the full range of BlueSkyRAINS capabilities so it would be useful to review all of the scenarios regardless of your intended applications.

Prescribed Fire

Prescribed Fire Scenario 1
It's a Good Day to Burn!
September 15, 2005

Objective: Evaluate dispersion conditions using BlueSkyRAINS ventilation index predictions. This is an example of good dispersion conditions.

1. Go to the BlueSkyRAINS main page
2. Under step 1 leave map on Northwest
3. Under step 2 select September 15, 2005 at 8am
4. Under step three uncheck smoke forecast and check meteorology
5. Click on view forecast maps under step 4
6. Zoom in on Idaho and Western Montana.
7. Look at 8am, noon, and 2pm
8. Now turn off vent index and turn on mixing height
9. Look at 8am noon, and 2pm
10. Turn off 12 km products and turn on 4km VI and surface winds
11. Repeat steps 7 through 9
12. What conclusions do you draw about dispersion conditions in Idaho and Western Montana.

13. Read Forecast for September 15 and see if you agree with the forecast.

September 15, 2005
THURSDAY DISCUSSION: An upper level disturbance moving down the coast of British Columbia will bring ridging and a change to the upper flow over the airsheds. West to southwest flow will dominate with warmer and drier conditions. Smoke dispersion should be GOOD to EXCELLENT across the airsheds once again. Expect valley inversions to mix out by mid day.

THURSDAY SEPTEMBER 15 - DISPERSION FORECAST:
MONTANA:
All Montana airsheds should be GOOD to EXCELLENT.

IDAHO:
All Idaho airsheds should be GOOD to EXCELLENT except portions of Snake River Valley in AS 22, 25 and western portion of AS 19 with POOR to MODERATE.

Discussion: Ventilation conditions are a result of a combination of mixing height and wind speed. High mixing heights and stronger winds allow smoke to be moved out of an area faster and result in good ventilation conditions. The ventilation index displayed in BlueSky is a simple product of mixing height and surface wind speed giving a somewhat more conservative estimate of ventilation conditions than ventilation indexes which use an average wind speed throughout the mixed layer.

Prescribed Fire Scenario 2
It's NOT a Good Day to Burn!
November 17, 2005

Objective: Evaluate dispersion conditions using BlueSkyRAINS ventilation index predictions. This is an example of poor dispersion conditions, under which burning is not recommended due to the likelihood of negative smoke impacts.

1) Go to BlueSkyRAINS main page (blueskyrains.org)
2) Change date to November 17, 2005 at 8am
3) Uncheck smoke forecast and check meteorology
4) Click on view forecast map
5) Look at 8am, noon, and 2pm
6) Now turn off vent index and turn on mixing height
7) Look at 8am noon, and 2pm
8) Turn off 12 km and turn on 4km vent index and surface winds
9) Repeat steps 5 through 7
10) Read Forecast for November 17, 2005 and see if you agree with the forecaster.

November 17, 2005
THURSDAY DISCUSSION: Upper level ridge axis approaches from the west. Northwest flow continues to dominate with weak disturbances producing snow showers for Thursday morning. Surface high pressure builds over the western airsheds with clearing skies and light transport winds. Smoke dispersion will be generally POOR for the forseeable future with strong high pressure, valley inversions, fog and no transport winds.

THURSDAY NOVEMBER 17 - DISPERSION FORECAST

MONTANA:
Northwest (AS 1, 2): POOR to MODERATE
West Central (AS 3A, 3B, 4, 5, 6) POOR to MODERATE.
Southwest (AS 7, 8A, 8B): POOR
Eastern Montana (AS 9 and 10): GOOD to EXCELLENT
IDAHO:
North (AS 11): POOR
North Central (AS 12A, 12B, 13):POOR
West Central (AS 14, 15, 21A): POOR
East Central (AS 16, 17): POOR
Northeast (AS 18, 19): POOR to MODERATE.
Southeast (AS 20): MODERATE
Southwest (AS 21B, 22, 23, 24, 25): MODERATE except POOR Boise impact zone

Discussion: Ventilation conditions are a result of a combination of mixing height and wind speed. Low mixing heights and light winds result in poor ventilation conditions. The ventilation index is a simple product of mixing height and wind speed. The ventilation index displayed in BlueSky is a simple product of mixing height and surface wind speed giving a somewhat more conservative estimate of ventilation conditions than ventilation indexes which use an average wind speed throughout the mixed layer.

Prescribed Fire Scenario 3
Sharing the airspace
September 10, 2005
Northwest Montana

The Problem: You are planning a burn on the Kootenai National Forest. You are aware there are some wildfires in Idaho and Montana but they are all well to the south of you and it looks like tomorrow will be a good day to burn in your area so you propose to do a 30 acre understory burn and expect that there should be no problem getting approval from the SMU. Your burn is not approved. You look at the BlueSky ventilation index forecast and see that it is in the fair to marginal category but your burn is the only one on the map in northwest Montana and you can't see the problem. You call Dave Grace and he tells you that there's nothing he can do because Montana DEQ has shut down all burning in the state due to smoke from WFU fires in Idaho. You go back and look at the smoke forecast.

1. Go to BlueskyRAINS mainpage
2. Under Step 1 leave map on Northwestern U.S.
3. Under Step 2 select September 10, 2005 at 8am
4. Under Step 3 uncheck smoke forecast and check meteorology forecast
5. Click View Forecast Map
6. Zoom in on Idaho and western Montana

7. Under base maps turn on major roads and MT/ID airsheds
8. Turn on Burn Information
9. Step through the day looking at Ventilation Index
10. Now turn off VI and turn on trajectory lines and points and PM2.5.
11. Step through the day and see where your smoke is likely to go.

Was DEQ right to shut down burning?

Would smoke from your burn have been a problem?

Prescribed Fire Scenario 4
Whose Smoke Was That?
September 21, 2005
Grangeville, Idaho

The Problem: You completed a prescribed burn on September 21st. On the morning of September 22 there was smoke in Grangeville and Idaho DEQ says it was from your fire. You don't think your smoke was going toward Grangeville and you know there were agricultural burns in the area on the 21st. Take a look at BlueSky and see if you can figure out who smoked in Grangeville.

1. Go to BlueskyRAINS mainpage
2. Under Step 1 default to Northwestern U.S.
3. Under Step 2 select September 21, 2005 at 8am
4. View smoke forecast
5. Under base maps turn off water features and turn on major roads
6. Under receptors turn on urban areas, Grangeville is located at the tip of an eastward point of Hwy 95 just south of where the Oregon border would be if extended into Idaho zoom in on this area to include the Northeast corner of Oregon.
7. Turn off 12 km predictions and turn on trajectory points and lines, SUM of PM2.5 and surface winds
8. Refresh map.
9. Your burn is 63632 southeast of Grangeville.
9. Step through 24 hours hour by hour and watch trajectories, PM2.5 concentrations and wind direction.

Whose smoke do you think is causing a problem in Grangeville the morning of September 22?

Prescribed Fire Scenario 5
Avoid Impact to sensitive receptors
November 10, 2005
Southwest, Oregon

The Problem: Balancing the conflicting goals of complying with the requirement of the Clean Air Act and managing hazardous fuels has become an increasing challenge for land managers across the west. To help meet the challenge state and federal agencies have joined forces with private timber companies to form the Southwest Oregon Airshed Unit. You have been appointed smoke coordinator with responsibility to ensure that as much burning as possible is accomplished without negatively impacting the many PM10 non-attainment areas and Class 1 areas in this region. You have been told that PM2.5 levels in excess of 20 mg/m^3 is too much.

On the morning of November 10 you look at the BlueSky forecast and see PM2.5 concentrations forecast to be in excess of 50 mg/m^3 by 7pm directly over Crater Lake National Park. Take a look at the BlueSky forecasts for that day and determine which, if any, of the proposed burns should be restricted.

1. go to the BlueSky main page.
2. Set date to November 10 at 8am.
3. View smoke forecast
4. With trajectories, winds and PM2.5 turned out step through hour by hour and see if you can determine where the smoke over Crater Lake is coming from
5. You may want to look at 4km predictions as well as 12km.

Where is the smoke coming from?

Should you restrict burning?

Wild Fire Scenario 1
Public Health
September 9, 2005
North Central, Montana

The Problem: You are a Public Health official in Toole County, Montana. You notice elevated PM2.5 readings predicted over your county at 7pm. You county has a policy to issue a public health alert if PM2.5 is expected to be above 45 mg/m^3 anywhere in the county for a period of 2 hours or more. You look carefully at the 12km and 4km predictions including the use of the charting function at 12km.

Do you need to issue an alert?

If so for what time frame?

Wildfire Scenerio 2
Protection of Aviation Resources

The problem: During fire season in western Montana smoke accumulates in valleys causing reductions to visibility. Aircraft cannot take off or land if visibility falls below certain levels specified at each airport. Aviation resource managers become concerned that aircraft will be grounded and become unavailable as fire fighting resources if smoke accumulations became too great. Using BlueSky and BlueSkyRAINS you must determine if it is safe to leave aircraft in Missoula or if they should be moved to alternate locations at Kalispell or Butte, Helena, or Great Falls any of which may also be subject to reduced visibility in smoke.

Today is September 8, 2005. You are the aviation resources manager in Missoula. Your forecaster is calling for increasing high pressure for stronger inversions and reductions in visibility. Looking at the forecast for the next five days determine the best place to locate your planes on each day. Hint: smoke will be worse from sunset to sunrise.

View BlueSky Animation

1. Go to the BlueSkyRAINS main page

2. Click on animations

3. Select 12km Javascript animator

4. Scroll to the bottom of the page.

5. In the select date of forecast initialization drop down box scroll to September 8, 2005 and click on view.

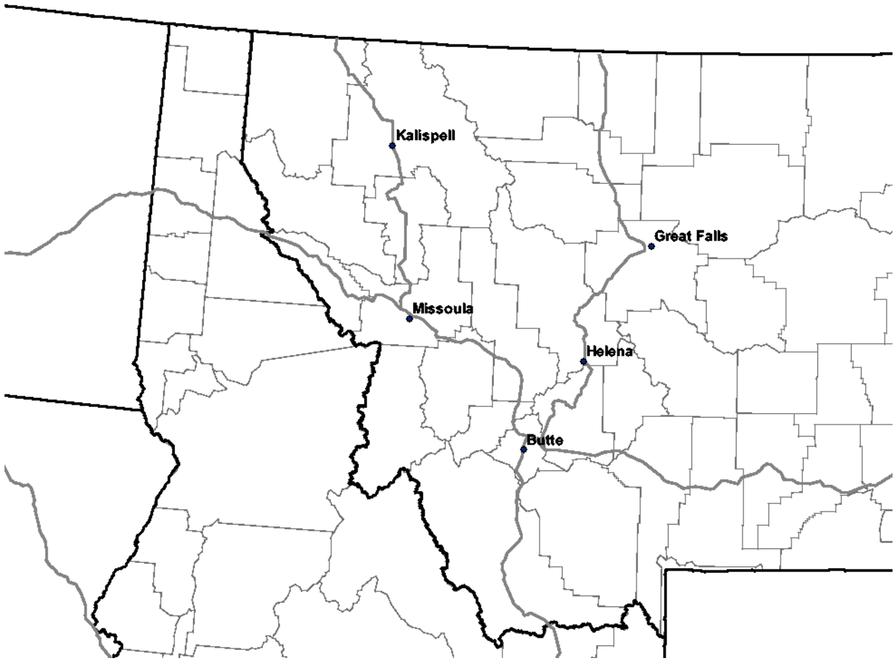
6. View the loop and get a feel for the changing conditions then click on STOP and Beg (0) to go to beginning of loop.

7. Now use the +1 button to step through the frames one at a time to see how conditions will be today (September 1) and tomorrow (September 2).

8. Look at loops for September 9, 10 and 11 if you want.

Get a closer look with BlueSkyRAINS

Turn on counties, roads and major cities for reference.



Where will you locate your aircraft each night

Date	**Missoula**	**Kalispell**	**Butte**	**Helena**	**Great Falls**
Sept 8					
Sept 9					
Sept 10					
Sept 11					
Sept 12					

Glossary

ArcIMS – An Internet Mapping Service developed by ESRI for display of maps and Geographic Information System data via the internet.

BlueSky – A smoke modeling framework which brings together the latest science for forecasting smoke from wildland fire.

BlueSkyRAINS – An internet based Geographic Information System used to interactively access BlueSky predictions.

CALPUFF – A state of the art air quality dispersion model used by BlueSky to calculate PM2.5 concentrations.

Domain – The geographic area covered by a model and its associated resolution.

FASTRACS – Fuel Analysis, Smoke Tracking and Report Access Computer System used by land management agencies in Forest Service Region 6 (Oregon and Washington) to collect and share information about proposed burns and smoke management approvals.

HYSPLIT - (HYbrid Single-Particle Lagrangian Integrated Trajectory) model used by BlueSky to compute simple air parcel trajectories.

Mixing height – The elevation above ground level to which air can be expected to mix based on turbulence and stability characteristics of the atmosphere.

MM5 – The 5th generation Pennsylvania State University/National Center for Atmospheric Research Mesoscale Model. This model is used to produce weather predictions at relatively fine scales, usually centered over limited geographic areas.

PFIRS - Prescribed Fire Incident Reporting System. A system under development for use by land management agencies in California to collect and share information about proposed burns and smoke management approvals.

PM2.5 – Particulate matter with diameters less than or equal to 2.5 micrometers. A micrometer is equal to 1/1000 of a millimeter.

RAINS – The Rapid Access Information System developed by the Environmental Protection Agency which uses ArcIMS technology to display geographic information via the internet.

RAZU – A system used by the Montana/Idaho Airshed Group to collect and share information about proposed burns and smoke management approvals.

RAZU is not an acronym but rather an adjective, as in “This is a really RAZU system!”

Receptors – Any location, institution, or population group which may be negatively impacted by smoke. Sometimes termed sensitive receptors, these may include Class 1 areas, non-attainment areas, schools, hospitals, or communities.

Resolution – The size of the smallest grid cell for which data is resolved. In the Pacific Northwest BlueSky is available as animated output in resolutions of 36km, 12km, and 4km and in BlueSkyRAINS at 12km and 4km. In general finer resolution predictions (i.e. 4km) can be expected to be more accurate but in complex terrain the more generalized predictions at larger resolution may be more useful for point forecasts.

Trajectory – The three dimensional path that an air parcel follows as it moves through space.

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Appendix A – The Science Behind BlueSky

BlueSky is a framework linking together existing models of fuel, combustion, fire emissions, dispersion, and meteorology. It is designed to be flexible in order to allow integration of the latest science, models, and knowledge. BlueSky provides daily predictions of smoke plumes and relative areal impact information by predicting concentrations of particulate matter with aerodynamic diameters less than or equal to 2.5 micrometers (PM2.5). Five major components comprise the BlueSky modeling framework: Inputs (Fire Characteristics, Meteorology), Fuel loadings, Consumption and Emissions Estimation, Smoke Dispersion, and Trajectories (see Figure 3, Chapter 1).

A. Inputs – Fire Characteristics and Meteorology

Fire characteristics and meteorology are the two primary inputs to BlueSky. Meteorology is obtained from the mesoscale meteorological model (MM5)(Grell et al., 1994). The MM5 domain (see Appendix B for more on the MM5 and the domains used in BlueSky) also defines the BlueSky domain and the domain information is processed automatically through the BlueSky framework making it portable to other regions. Table A1 lists the domains that BlueSky and BlueSkyRAINS are operational for as of June 2005.

Table A1. BlueSky and BlueSkyRAINS Operational Domains.

System	**Resolution**	**Domain Coverage**	**Type of Fire**
BlueSkyRAINS	12 km	Northwest	Wildfire, Prescribed
BlueSkyRAINS	4 km	Northwest	Wildfire, Prescribed, Agriculture
BlueSky	36 km	Western U.S.	Wildfire
BlueSky	12 km	Western U.S.	Wildfire, Prescribed (manual entry)
BlueSky	4 km	Northern California	Wildfire
BlueSky	4 km	Southern California	Wildfire
BlueSky	12 km	Northeast U.S.	Prescribed (manual entry)

Fire characteristics include fire location, acres burned, date and time of ignition, ignition duration, and fuel loading and moisture information. Most of these data are provided by burn reporting systems. Table A2 lists the burn reporting systems that BlueSky is integrated with in the Northwest. The four prescribed fire burn reporting systems are operated by state and federal land management agencies in Oregon, Washington, Montana and Idaho. These systems are designed to share information with neighboring agencies in order to better coordinate regional smoke management efforts. The databases contain detailed information about proposed burn operations including the size and timing of burns and the type of fuel being treated.

Table A2. Burn reporting systems used by BlueSkyRAINS in the Northwestern U.S.

Burn System	**Region**	**Type of Agency**	**Type of Fire**
FASTRACS	Washington, Oregon	Federal	Prescribed
SMOKEM2	Washington	State, Private	Prescribed
RAZU	Montana, Idaho	Federal, State, Private	Prescribed
ODF	Oregon	State, Private	Prescribed
209	National	Federal	Wildfire
ClearSky	Washington, Idaho, Oregon	State, Tribes	Agriculture

FASTRACS is used by federal land managers in the states of Oregon and Washington. RAZU is used in Montana and Idaho by federal, state, and private land managers. SMOKEM2 provides state and private burn information for the state of Washington to BlueSky, and also tracks federal burns from the FASTRACS system. BlueSky downloads predicted burn information from these burn reporting systems each night. As of June 2005, tests implementing the Oregon Department of Forestry (ODF) system have started. The Oregon data is not available until after the BlueSky run is complete(9 AM), thus a second update run of BlueSky is executed to incorporate the ODF burns. FASTRACS provides detailed fire characteristic information, while the information from the other systems is less detailed, therefore assumptions and calculations are made to allow for the full functionality of BlueSky.

Several utility programs are built into BlueSky to obtain necessary data if that information is not provided by the burn reporting system. A latitude/longitude location will be computed given a township/range/section input. The terrain elevation from MM5 is processed so that elevation at a fire location can be approximated. GIS coverages of county FIPS codes, state boundaries, and time zone boundaries are implemented so that given a latitude/longitude location, the county FIPS code, 2 character state ID, and time zone offset from GMT can be obtained. Ignition duration is a necessary parameter for prescribed burns, and currently only the FASTRACS system provides such information. Therefore a default set of equations was derived from the FASTRACS data. Based on burn type and number of acres, ignition duration is calculated for a particular burn type given the number of acres. Finally, if fuel moisture information is not provided by the burn reporting system, a10 hr fuel moisture of 9 and 1000 hr fuel moisture of 12 is assumed.

Wildfire information is provided by the “209” wildfire reporting system. This system tracks approx 95% of all wildfires in the US once they have reached approximately 100 acres in size (Ervin, 2004). The data that BlueSky gets via the 209 reports can be up to 2 days old and only total fire size is reported, therefore assumptions regarding how many acres are burning on any given day must be made. Currently it is assumed that 1/3 of the total acres reported are burning. Further work is necessary to refine this assumption or access more accurate information. Wildfire emissions are allocated temporally based on the work of the Western Regional Air Partnership (WRAP). Table A3 gives the percent burned per hour of the total acres burning for a day.

Table A3. Temporal allocation of acres burned in a day for wildfires. Data developed by the Western Regional Air Partnership (WGA/WRAP, 2005).

Hour	Percent
0-9	0.57
10	2.00
11	4.00
12	7.00
13	10.00
14	13.00

Hour	Percent
15	16.00
16	17.00
17	12.00
18	7.00
19	4.00
20-23	0.57

The ClearSky (Jain et al., 2005) agricultural smoke prediction system provides a single “most likely” scenario of what could be occurring with agricultural burns in the Northwest to BlueSkyRAINS. ClearSky was developed by Washington State University (WSU) under contract with the State of Idaho to address smoke problems from agriculture burning on the Coeur d’Alene Indian Reservation and the Rathdrum Prairie. Its success has led to expansion to include the Nez Perce tribal lands and the state of Washington’s agricultural burn program in Eastern Washington.

B. Fuel loading

Fuel loading information is available from three sources if the burn reporting system does not supply the data. The default fuel loading used in BlueSky is the 1 km resolution mapping of the Fuel Characteristic Classification System (FCCS, Sandberg et al., 2001) for the Western U.S. (McKenzie et al, 2003). Also available is a fuel load mapping by Hardy et al. (1998) developed at a 1-km resolution for 11 western U.S. states. The National Fire Danger Rating System (NFDRS, http://www.fs.fed.us/land/wfas/nfdr_map.htm) fuel loadings (Cohen and Demming, 1985), modified to include drought fuels are also available in BlueSky. The NFDRS data are mapped for the entire U.S. It is expected that a national map of the FCCS fuel loadings will be implemented in BlueSky Summer 2005.

C. Consumption and Emissions

Fire characteristics are processed through the Emission Production Model (EPMv1.02, Sandberg and Peterson, 1984) to give emission estimates of particulates ($PM_{2.5}$, PM_{10}, and total PM), carbon compounds (CO, CO_2, CH_4, NMHC), SO2, NOx, NH3 and heat generated. The emission estimates from EPM along with meteorology from MM5 are processed for the CALPUFF Gaussian dispersion model (Scire et al. 2000b) and the HYSPLIT trajectory model (Draxler et al., 1997).

D. Dispersion and Plume Rise

CALPUFF (Scire et al. 2000b) is a puff dispersion model that simulates point, volume or area sources, assuming that plume dispersion occurs in a Gaussian pattern (i.e. has a normal distribution). CALPUFF also estimates plume rise and accounts for density differences between the plume and the ambient air. A pre-processing program, EPM2BAEM, converts the emissions from EPM into an area emission source suitable for input into CALPUFF. It calculates flame height (Cetegen et al., 1982) using the heat-release estimates from EPM and vertical velocity of the smoke plume, assuming conservation of buoyancy flux proportional to heat-release rate.

E. Trajectories

Twelve-hour trajectories are computed using the HYSPLIT (Draxler et al., 1997) model from each of the burn locations and at evenly spaced ("default") intervals across the domain. These default trajectories are used to give an indication of where smoke from a fire would go if a burn were ignited near the location of the default trajectory. This is useful for the case where a land manager did not get their burn information into the BlueSky system. All trajectories are initiated at a 10 m height and therefore do not account for any initial buoyancy effects due to the heat of the fire.

The trajectories and concentration fields yield subtly different pieces of information. Surface concentration fields show only those portions of a plume that fall onto the ground, while the corresponding trajectories represent motion in the neutrally buoyant portion of the plume that can rise and fall in the atmosphere. Furthermore, trajectories at a given time are a product of the current and future meteorology (currently a 12 hr period) while concentration fields at a given time are a product of dispersion from a fire ignition time to the current display time. Thus, the trajectories and concentration fields offer two distinctly different pieces of information. Having two such pieces of information located together in time and space is yielding insights into how to model and predict smoke concentrations from fire on a regional scale.

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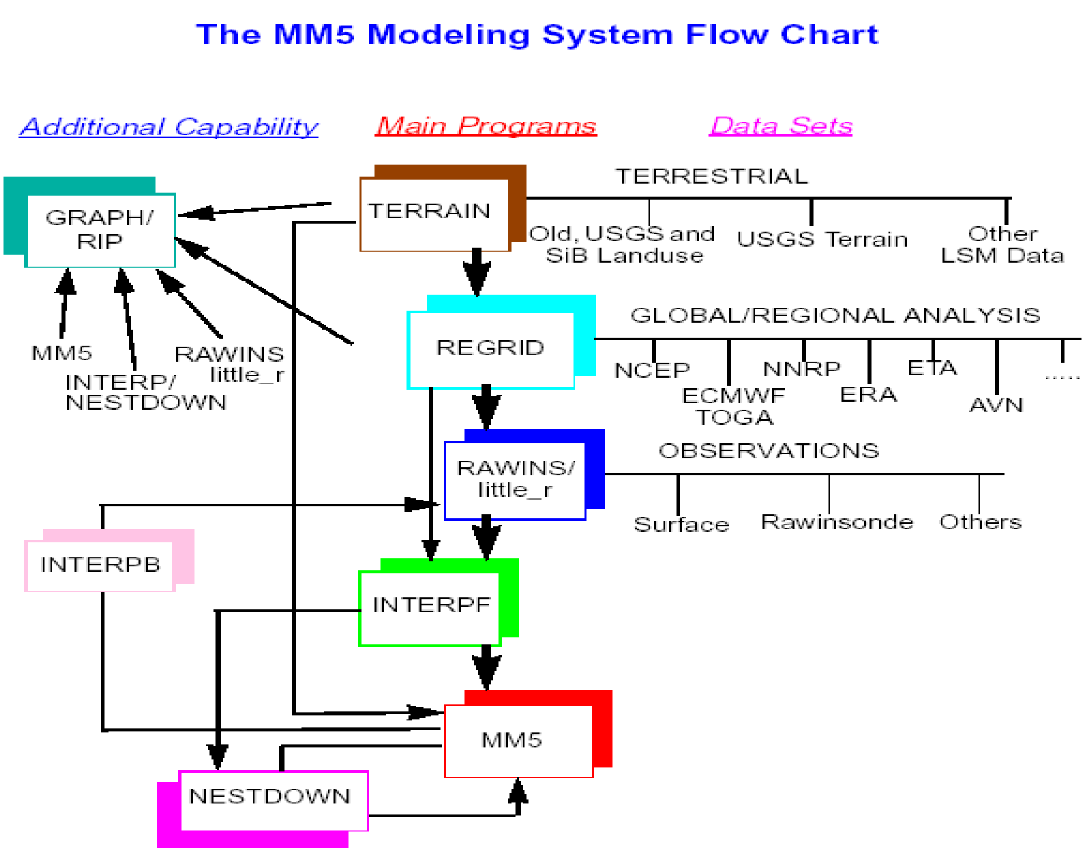
Appendix B – MM5 Mesoscale Model

The Pennsylvania State University(PSU)/ National Center for Atmospheric Research (NCAR) mesoscale model (known as MM5) is a limited-area, nonhydrostatic, terrain-following (sigma-coordinate model) designed to simulate or predict mesoscale and regional-scale atmospheric circulation. The model is supported by several pre- and post-processing programs, which are referred to collectively as the MM5 modeling system and are predominately written in Fortran. It has been developed at Penn State and NCAR as a community mesoscale model.

The Fifth-Generation NCAR / Penn State Mesoscale Model (MM5) is the latest in a series that developed from a mesoscale model used by Anthes at Penn State in the early 70's that was later documented by Anthes and Warner (1978). Since that time, it has undergone many changes designed to broaden its usage. These include (1) a multiple-nest capability, (2) non-hydrostatic dynamics, which allows the model to be used at a few-kilometer scale, (3) multitasking capability on shared- and distributed-memory machines, (4) a four-dimensional data-assimilation capability, and (5) more physics options.

A schematic diagram is provided to facilitate discussion of the complete modeling system. It is intended to show the order of the programs and the flow of the data, and to briefly describe their primary functions. Documentation for various programs in the modeling system is available.



Terrestrial and upper air meteorological data are horizontally interpolated (programs TERRAIN and REGRID) from a latitude-longitude mesh to a variable high-resolution domain. Mercator, Lambert conformal, or polar stereographic projections are available. Because the interpolation does not provide mesoscale detail, the interpolated data may be enhanced (program RAWINS or little_r) with observations from the standard network of surface and rawinsonde. Program INTERPF performs the vertical interpolation from pressure levels to the sigma coordinate system of MM5. Sigma surfaces near the ground closely follow the terrain, and the higher-level sigma surfaces tend to approximate isobaric (levels of constant pressure) surfaces. Because the vertical and horizontal resolution and domain size are variable, the modeling package programs employ parameterized dimensions requiring a variable amount of core memory. Some peripheral storage devices are also used.

Because MM5 is a regional model, it requires an initial condition as well as lateral boundary condition to run. To produce lateral boundary condition for a model run, one needs gridded data to cover the entire time period that the model is integrated.

Features of the Modeling System

- Globally re-locatable
    - Three map projections: Polar stereographic, Lambert conformal, Mercator.
    - Support different true latitudes.
    - Variable resolution terrain elevation, landuse, soil type, deep soil temperature, vegetation fraction, and land-water mask datasets are supported.
- Flexible and multiple nesting capability
    - Can be configured to run from global scale down to cloud scale in one model
    - Nest domain can start and stop at any time.
    - Nest terrain file may be input at the time of nest start-up in the model.
- Real-data inputs
    - Use routine observations
        - Upperair and surface reports, including wind, temperature, relative humidity, sea-level pressure, and sea surface temperature.
    - Couple with global models and other regional models
        - Use other model's output either as first guess for objective analysis, or as lateral boundary conditions.
- Terrain-following vertical coordinates.
- Choices of advanced physical parameterization.
- Four-dimensional data assimilation system via nudging.
- Adjoint model and 3DVAR.
- The MM5 modeling system runs on various computer platforms:
    - Cray, SGI, IBM, Alpha, Sun, HP, and PCs running Linux.

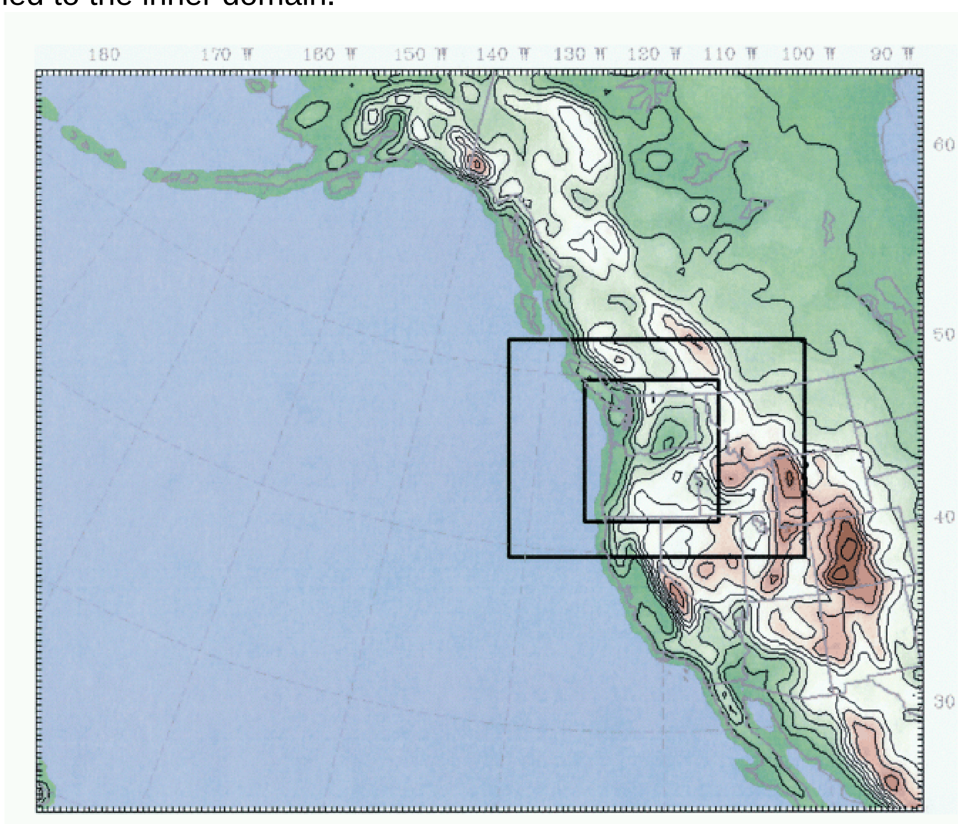
- Parallelization
  - Parallelize on shared-memory machines:
  - Parallelize on distributed-memory machines:
- Well-documented, and user-support available.

Characteristics of the University of Washington MM5 Data

Bluesky products use MM5 output generated by the University of Washington. Collection of input observations are obtained from approximately two dozen networks with initial and boundary conditions provided by the National Centers for Environmental Prediction's Global Forecast System. MM5 output data has 37 vertical levels (unequally spaced with more points toward the surface) and three horizontal scales (see figure below):

- 36km grid that extends several thousand kilometers over the eastern Pacific and western North America
- 12km grid over the entire Pacific Northwest
- 4km grid over western Washington

Forecasts are run for 72 hours over the 36- and 12-km grids and 36 hours over the 4-km domain. Cumulus clouds are parameterized (Kain-Fritsch) only over the outer domains. A parameterized microphysical scheme (Reisner II with graupel) is applied to the inner domain.



Model domains for the UW MM5 forecasts: Grid spacing is 36 km for the outer domain, 12 km for the middle domain and 4 km for the inner domain. Terrain contours are given every 300 m. (Taken from Mass, et al 2003: Regional Environmental Prediction over the Pacific Northwest, American Meteorological Society)

Appendix C - Ventilation Index and Smoke Management

Ventilation or dispersion indexes have been developed to help provide a first approximation of the capacity of the atmosphere to effectively disperse smoke. Traditionally, the Ventilation Index is a simple product of the mixing height times the average wind within the mixed layer of the atmosphere. However, some model generated Ventilation Indexes, including those available from the University of Washington MM5 model and displayed in BlueSkyRAINS, use the product of the height of the top of the planetary boundary layer (which is virtually synonymous with the mixing height) and the lowest level winds above the ground (Ferguson, 2001). Because winds near the ground tend to be lighter than winds averaged over the depth of the mixed layer, model derived ventilation index values tend to be smaller than those derived from atmospheric soundings. In either case, the final product is an attempt to quantify the relative capacity of the atmosphere to absorb smoke under varying meteorological conditions.

Adjective categories of dispersion conditions (poor, marginal, fair, good) have been assigned to the numerical results of Ventilation Index calculation in order to simplify its interpretation. It should be understood that these categories and their assigned values may vary from product to product depending on units used and method of calculation. Also, the ability of the atmosphere to disperse smoke is a continuous rather than a discrete condition so there may be grey areas between, for example, a moderate and a good dispersion forecast. Thus, while adjective values can be useful as a tool in discriminating between good and bad dispersion conditions, they should not be taken as hard and fast boundaries and should be considered in the context of changing meteorological conditions, the amount of smoke expected to be produced, and the local geographic situation.

Understanding the Science

In order to understand how the Ventilation Index is applied to smoke management it is necessary to have a basic understanding of the science behind it. The key to dispersion is how much and how fast will a smoke plume spread out so that the smoke particles become diluted within the atmosphere. Because the atmosphere is 3-dimensional there is a vertical and a horizontal component to the spreading out of smoke

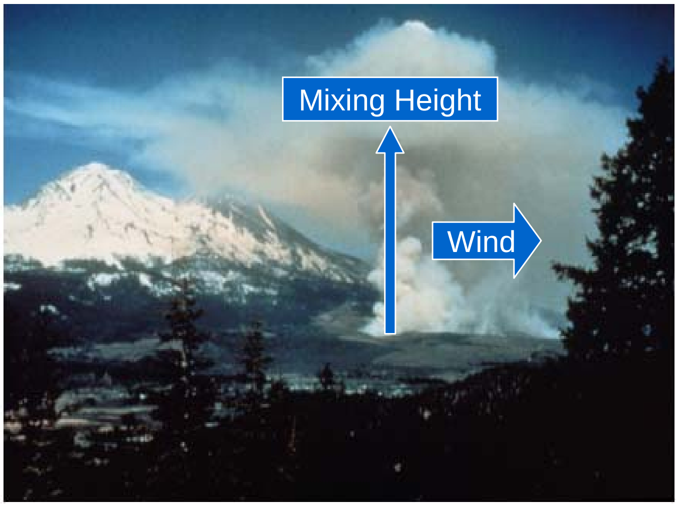


Figure E-1. Ventilation Index is a product of Mixing Height and Wind Speed.

plumes. The horizontal component is dependent on wind speed which is fairly easy to understand. With faster wind speeds smoke particles are carried further away faster and thus become mixed with the atmosphere for better ventilation. The vertical component is defined by mixing height which tells us something about how high into the atmosphere smoke will be carried based on the stability of the day's atmospheric conditions. Mixing Height and its component meteorological influences is discussed in some detail below.

Wind - The horizontal component

Most burners have a good understanding of wind because of its effect on fire behavior but a review of the science behind variations in wind is included speed in order to be thorough in explaining the science behind Ventilation Index. In general, variations in wind speed are caused by variations in atmospheric pressure gradient. Under low pressure systems the pressure gradient is usually stronger than under high pressure and therefore the winds are stronger under low pressure conditions. The strongest winds tend to be associated with cold frontal passages where the sharp difference in temperature on either side of the front results in a large difference in pressure.

Local winds may also occur when surfaces with different orientations to the direct rays of the sun experience differences in heating which results in localized pressure differences. For example, slope and valley winds occur because hillsides facing the sun receive more direct solar radiation and therefore heat up more than adjacent flat areas, the warmer air near the slope rises and cooler air from below moves in to take its place. At night air cools more rapidly at higher elevations. Because cooler air is denser and heavier than warm air it will slide down slope into the valley bottoms overnight. Sea and lake breezes are a result of differential heating between land and water surfaces. Because they depend on heating from the sun, local winds are more pronounced in the summer time when the sun is higher above the horizon and daylight hours are longer with less cloud cover in many locations. Similarly, local winds are stronger on sunny days than cloudy days.

During the course of the day wind speed tends to vary in a predictable pattern. Changes in the pressure gradient, frontal passages, thunderstorms, and other meteorological phenomena may cause some disruption in these patterns. But in general, as the sun heats the earth during the course of the day, eddies develop near the surface which create a mixing affect in the atmosphere. As a result, the air movement near the surface increases, winds from aloft are mixed to the surface and winds become stronger in the afternoon. After the sun sets mixing decreases and winds diminish during the night, becoming generally calm by early morning barring any outside disturbances, such as frontal passages.

Because both mixing and local winds are generally stronger during the afternoon, ventilation, and therefore smoke dispersion, will, as a rule, be best in mid to late afternoon. Also, because winds near the surface are slowed by the frictional drag of objects such as trees and buildings, winds aloft tend to be stronger than winds at the surface.

Mixing Height - The vertical component

Mixing height defines the depth of the atmosphere through which turbulent eddies will carry an air parcel in a vertical direction. Mixing height is closely related to stability in the atmosphere. The more stable the atmosphere is the lower the mixing height will be, the more unstable the higher the mixing height.

In general, low pressure is associated with unstable air and upward vertical motion and high pressure is associated with stable air and downward vertical motion. Thus, mixing heights tend to be higher under low pressure and lower under high pressure. However, solar radiation heating the earth's surface under clear skies, which are generally associated with high pressure, can contribute to increasing instability, so it must be understood that these relationships can be complex and may vary during the course of the day.

Temperature inversions are a special case of very stable conditions which may result in very low or zero mixing heights in a local area. Valleys are especially susceptible to inversions, especially in winter. When a temperature inversion occurs, the profile of temperature in the atmosphere is reversed from its normal condition of decreasing with height to one of increasing with height.

Under these conditions, when a surface air parcel is lifted it moves into air that is warmer. Because the cooler air parcel is denser and heavier than the surrounding air it sinks back to the surface. Thus pollutants such as smoke are trapped in the lower levels of the atmosphere with no opportunity to "mix out". Inversions develop at night under conditions of high pressure with calm winds and clear skies when the earth's surface and the layers of air immediately above it cool more rapidly than those above. Inversions may begin forming soon after sunset and strengthen during the night. They are generally strongest in the early morning around sunrise and weaken or disappear during the day as solar heating warms the lower layers of air near the earth's surface.

Under high pressure conditions morning inversions are common in both summer and winter. However, in summer the increased solar heating, longer days, and more direct radiation from the sun allow the inversions to break or "burn off" much earlier than in winter. In many locations, especially narrow mountain valleys, winter inversions never receive enough energy from the sun to warm the lower levels enough to break down the inversion and only the winds of a strong cold front are sufficient to clear accumulated smoke and pollutants from the valley.

Putting it all together

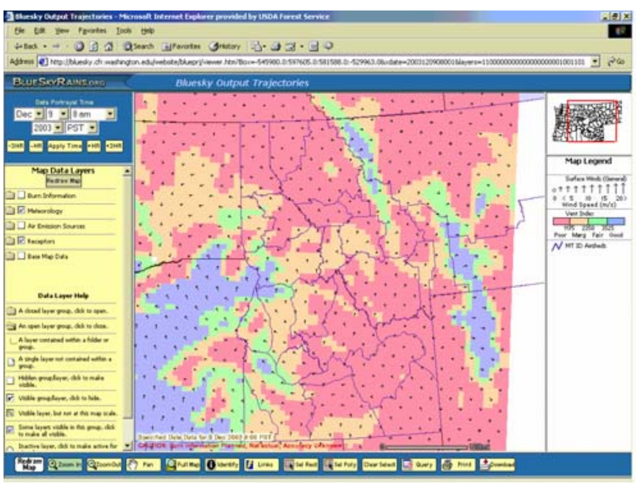
Remember that the Ventilation Index is the simple product of wind speed times mixing height. Low pressure systems are associated with stronger pressure gradients, often associated with cold fronts; increased winds; upward air movement and higher mixing heights. This all adds up to better Ventilation conditions (or lower Ventilation Index values) under low pressure. Unfortunately, low pressure also brings rain and stormy conditions and may not be the most suitable time for burning.

High pressure, on the other hand, is associated with weaker pressure gradients, lighter winds, downward air movement, lower mixing heights and increasing potential for strong nighttime inversions, which may persist through the day, especially in winter. Thus Ventilation conditions will normally be worse (reflected by a lower Ventilation Index value) under high pressure.

Ventilation Index Applications in BlueSkyRAINS

To access Ventilation Index forecasts using the BlueSkyRAINS system go to http://www.blueskyrains.org. Check the meteorology box in Step 3 and click on View Forecast data. By default a map will be drawn that shows the Ventilation Index forecast at 12 km resolution for the current time (Figure E-2).

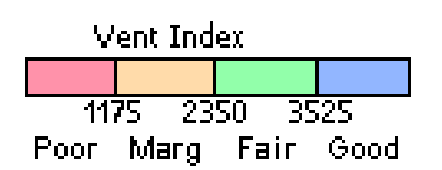
Figure E-2. **Ventilation Index as displayed by BlueSkyRAINS**



BlueSkyRAINS is updated only once a day so the data displayed is always from the 5pm model run. In most cases the forecast will not change too much but it is a good idea to check the latest output from the University of Washington (UW) VI products (http://www.atmos.washington.edu/mm5rt/rt/gfsinit.aq.html#12km) just to be sure you have the most up to date forecast.

Ventilation Index as displayed in BlueskyRAINS is calculated in the same way as the UW (20 meter wind speed x height of the top of the Planetary Boundary Layer), however they are scaled differently. The cutoff between poor and marginal in the BlueSkyRAINS product is half that used in the UW

Figure E-5. Ventilation Index categories as displayed in BlueSky RAINS.



product., while the cutoff between marginal and fair is the same as the cutoff between poor and marginal on the UW product. Another way to look at this is that the UW product provides a more conservative forecast of Ventilation Index, while BlueSkyRAINS suggests more positive ventilation conditions. These differences serve to emphasize that the numerical values do not represent cut and dried categories of dispersion conditions but rather provide a tool for comparing relative differences.

Appendix D - BlueSky Consortium

The BlueSky modeling framework has been developed through the efforts and cooperation of many individuals from a variety of federal and state agencies and tribal governments who have come together as the BlueSky Consortium. The committee structure of this consortium is shown in figure F-1

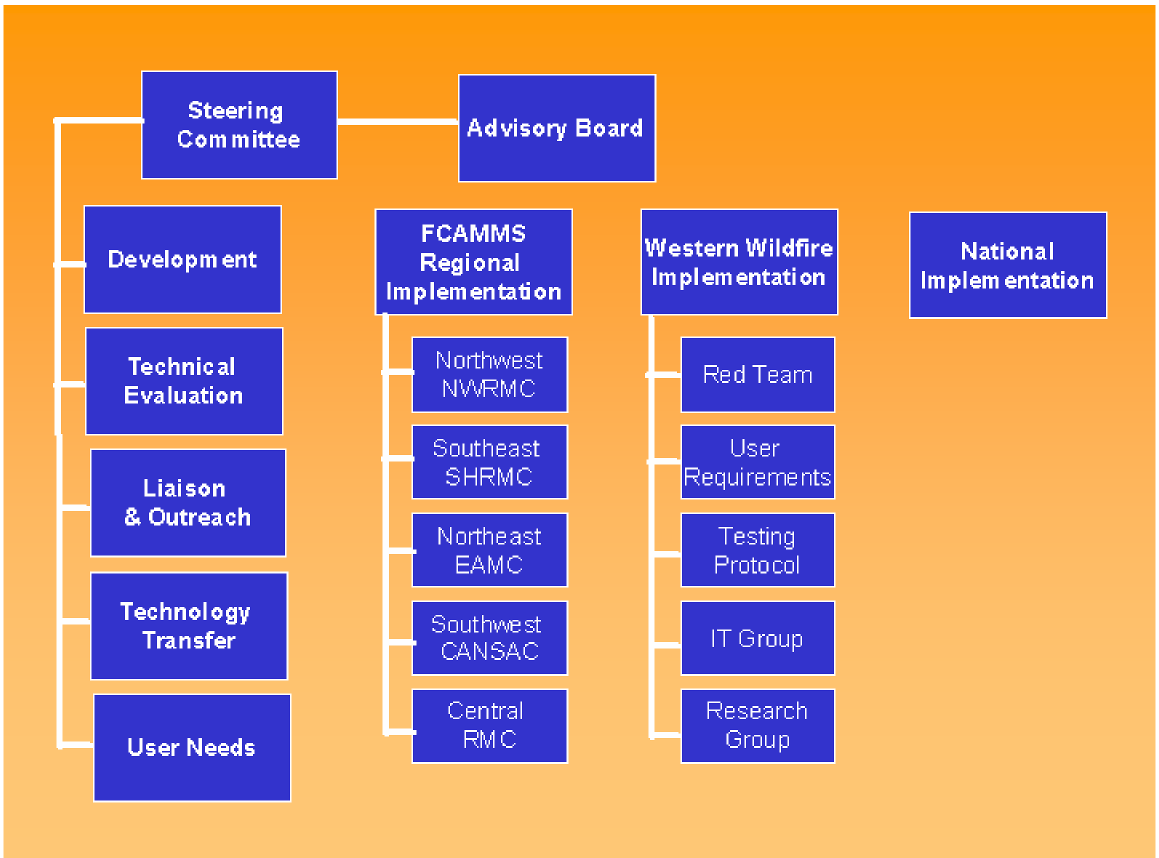


Figure F-1 The BlueSky Consortium committee structure