J12.3 REAL-TIME MESOSCALE MODEL FORECASTS FOR FIRE AND SMOKE MANAGEMENT: 2003

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1.0 INTRODUCTION

This is fourth in a series of continuing reports on involvement by the USDA Forest Service, Pacific Northwest Research Station in the Northwest Regional Modeling Consortium (NWRMC) toward integrating meteorological predictions with wildland fire and biomass smoke technologies (Ferguson 1998, 2000, and 2001). NWRMC is a group of federal, state, and local agencies and institutions that support high-resolution, real-time weather predictions in partnership with the University of Washington. Smoke and fire applications can be accessed readily from www.fs.fed.us/pnw/airfire/sf. Other related environmental activities are available through www.atmos.washington.edu/pnw_environ and are described in Mass et al. (in press).

The high-resolution, regional weather predictions are generated twice daily out to 72 hours in advance. The products are regularly used for:

- Predictive services (NIFC and GACCs),
- Fire weather forecasts (NWS),
- Spot weather forecasts (NWS),
- Incident meteorology (IMET),
- Local and state air regulation, and
- Fire operations and planning (land managers).

In addition, the consortium and its regional modeling activities are being emulated by all other USDA Forest Service Research Stations through the National Fire Plan's nationally coordinated Fire Consortia for Advanced Modeling of Meteorology and Smoke (FCAMMS: Riebau et al. 2003). Therefore, staying current with NWRMC's progress and understanding the breadth of its technology is of particular importance to land managers.

Since last reporting, we have made some significant improvements in the modeling environment and related applications that include:

- Began initializations with the GFS model, in addition to the early ETA.
- Added more members to the ensemble predictions.
- Generated probabilities of prediction from the ensembles.
- Created new methods of calculating a ventilation index.

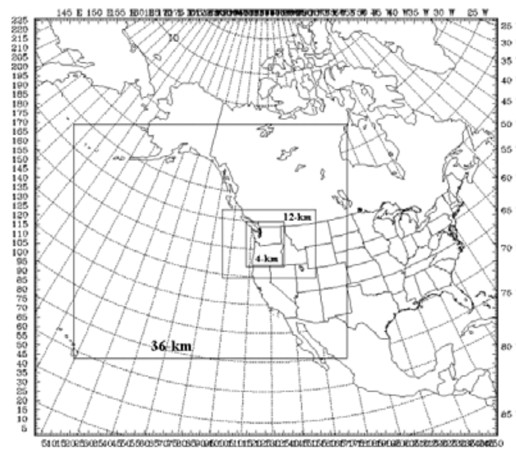

Figure 1. Current configuration of the northwest real-time modeling domains.

- Began predictions of the National Fire Danger Rating Index (NFDRS).
- Tested and implemented a new ice-physics scheme to improve winter precipitation.
- Began real-time predictions of smoke dispersion from wildland and agricultural fire
- Integrated meteorological output fields into web-access GIS map server.
- Demonstrated MM5's accuracy during the 2000 wildfire season.
- Began development of a new surface-layer scheme to improve boundary-layer simulations.
- Implemented version 3.5.3 of MM5
- Tested the new WRF model as a replacement for MM5.

2.0 THE REGIONAL MODELING SYSTEM

Although we've tested the new Weather Research Forecast (WRF) model (Michalakes et al. 2003 and www.wrf-model.org/) for real-time application, it is not quite ready. Therefore, we continue to use the fifth generation of the National Center for Atmospheric Research (NCAR) and Pennsylvania State University (PSU) Mesoscale Model (MM5: Grell et al 1994). For a complete description of the MM5 modeling system and its development visit (www.ucar.edu/ucar/), the NCAR / PSU MM5 website. A description of the NWRMC's

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MM5 configuration can be found at the website, www.atmos.washington.edu/mm5rt/.

The NWRMC-MM5 is initialized with the National Centers for Environmental Prediction (NCEP), “early” ETA 221 32-km and the Global Forecast System model (previously known as AVN/MRF), which began concurrently in 2003. Descriptions of ETA and GFS are at (www.emc.ncep.noaa.gov/modelinfo/index.html). When these are not available, the Navy NOGAPS model is used for initialization.

Most comparisons of model output with observations have shown that MM5 is a vast improvement over currently available prognostic tools used by the National Weather Service (NWS). Unfortunately, however, serious inaccuracies exist in MM5’s ability to simulate variables that are key to fire weather, especially the diurnal patterns of temperature and relative humidity (Hoadley et al. 2003). In response to this problem, McCaa et al. (2002) evaluated MM5’s surface layer scheme, which is similar to the new WRF model’s scheme, and found some obvious inconsistencies that are currently being fixed. In addition, a method of removing model biases will be implemented in 2004.

Currently, MM5 is configured as a “cold” start in that it begins without data assimilation. This is because most users have been interested in the longer-range predictions (out to 72 hours) and the delay caused by data assimilation has been too costly. Also, the first few hours, when data assimilation would be of value, are of less interest. As computing resources have improved, however, we are considering “warm” or “hot” start configurations and may implement data assimilation in the near future.

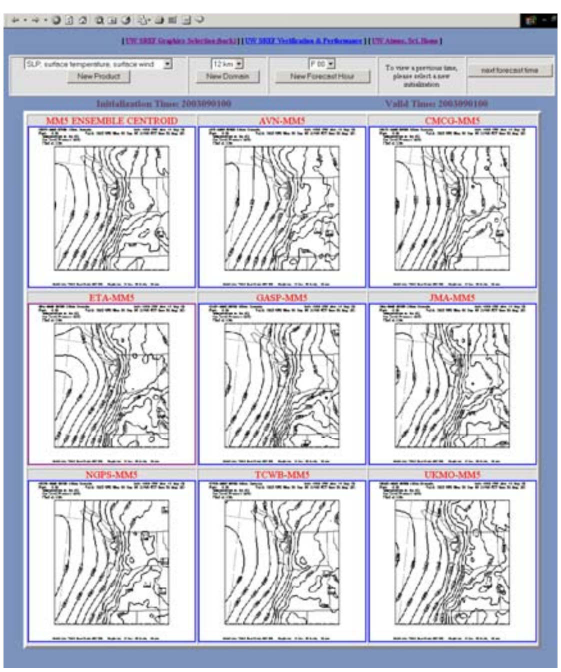

Figure 2. “Stamp” maps of NWRMC core ensemble predictions at forecast hour zero.

3.0 ENSEMBLES

One of the greatest advances NWRMC has made in recent years is use of short-range ensemble predictions. There are two groups of ensembles. One includes a number of different models to initialize the mesoscale predictions (Figure 2). The other runs the mesoscale model with different physics options. The ensemble means and standard deviations are used to estimate uncertainty, which is based on work by Eric Grimit. In addition, the ensembles are used to estimate probabilities of predicted events based on a weighted ranking scheme developed by Tony Ekel (Figure 3). All ensemble products and descriptions of both Grimit’s and Eckel’s work can be found at www.atmos.washington.edu/~emm5rt/pubs_n_pres.html

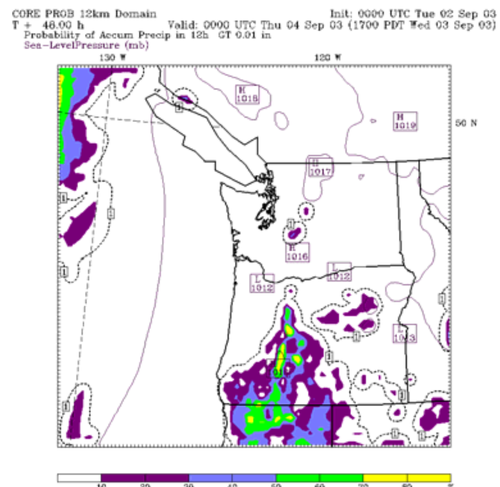

Figure 3. The probability of 12-hour precipitation accumulations exceeding 0.01” at forecast hour 48.

4.0 INDEX PREDICTIONS

Four years ago we began calculating a ventilation index as a product of the lowest sigma level wind (20 meters above ground level) and the height of the Planetary Boundary Layer as shown in Figure 4. The index is being used by states to help regulate much of the agricultural burning and some prescribed forest burning. Because of its important regulatory potential, we have experimented a second method of calculating an index based on the Brunt-Vaisala frequency (Figure 5). Both ventilation derivations are calculated hourly and averaged for 3, 6, and 12 hours.

While we continue to use MM5 for predictions of the Lower Atmosphere Stability Index (LASI: Haines and Sando 1995) and the Fire Weather Index (FWI: Fosberg 1978), we began deriving several index values from the National Fire Danger Rating System (Deeming et al., 1978). Each day observations from the Remote Automated Weather System (RAWS) network (www.fs.fed.us/raws/) are used to calculate the Keetch-Byram Drought Index and moisture indexes of the 100-

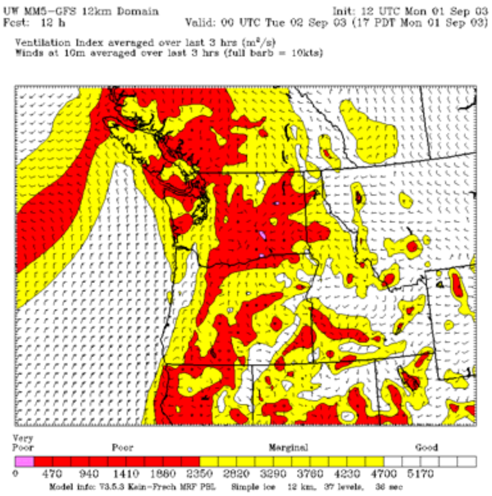

Figure 4. The ventilation index as a product of the 20-meter wind speed and height of the planetary boundary layer. The index is averaged over 3 hours from forecast hour 12.

hour (about 2.5 cm to 8 cm in diameter) and 1000-hour (about 8 cm to 20 cm in diameter) dead woody fuels. These data are spatially interpolated to 1-km (www.fs.fed.us/land/wfas) then re-projected to match the MM5 grid. Relative greenness maps are derived weekly from Normalized Difference Vegetation Index (NDVI) data observed by AVHRR satellites and provided by the EROS Data Center (EDC), U.S. Geological Survey. These maps are composited weekly, have 1.1-kilometer spatial resolution then are reprojected to the MM5 grid and used to estimate live fuel moistures (Burgan and Hartford 1993, Burgan and others 1996, Burgan and Hartford 1997). Each hour, fine fuel moistures (1-hour, < about 1 cm, and 10-hour, about 1 cm to 2.5 cm) are derived from MM5 predictions of wind, relative humidity, air temperature, and

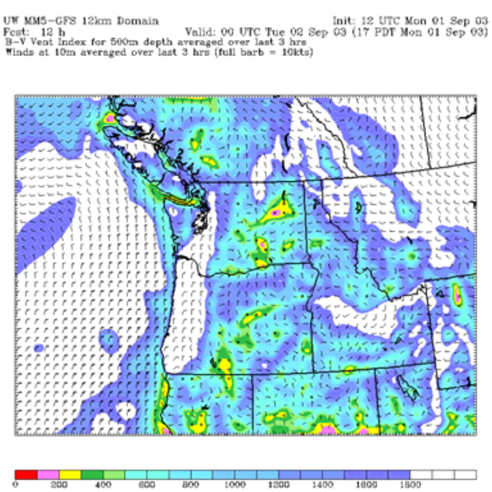

Figure 5. The ventilation index as a product of the Brunt-Vaisala frequency and average wind speed over 500-meter depth. It is averaged over 3 hours from forecast hour 12.

estimated cloudiness. Wind values are interpolated from the lowest sigma levels to 10 m above ground level (agl) while predictions of temperature and relative humidity are interpolated to 2 m agl. Cloudiness is derived from modeled moisture conditions in the upper atmosphere. The map projections of observed values and predicted values from MM5 are combined to predict hourly values of the Energy Release Component (ERC: Figure 6), Spread Component (SC), Burning Index (BI), and Ignition Component (IC). An example of how this system functioned during the 2000 wildfire season in Idaho and Montana can be found at www.fs.fed.us/pnw/airfire/mm5case.

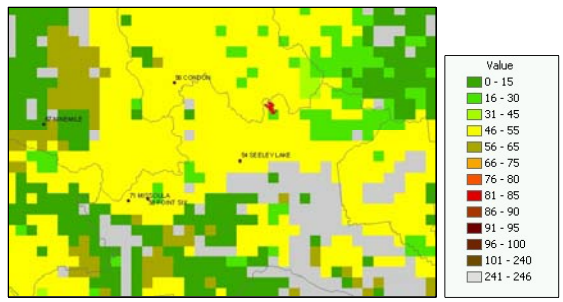

Figure 6. Energy Release Component of the NFDRS, predicted 12 hours in advance from the MM5 meteorological model at 4-km spatial resolution during the Monture/Spread Ridge fire complex in western Montana on 27 July 2000.

5.0 SMOKE DISPERSION PREDICTIONS

Version 3 of the NFSpuff smoke dispersion model (Harrison 1995) continues to be supported by MM5 output. In 2002, however, we were able to link the mesoscale predictions to the Hysplit trajectory model and the Calpuff dispersion model through the BlueSky smoke-modeling framework (www.fs.fed.us/bluesky). A complete description of this application can be found in O'Neill et al. (2003 and in press) but an example of the output is shown in Figure 7. During wildfire events, the BlueSky predictions are being used incident command teams and state and regional air managers to anticipate impacts and warn surrounding communities of impending hazards. In addition, the predictions have been tested for use in planning air attacks. During prescribed fire events, air regulators use BlueSky to help coordinate burn activities across land ownerships. In addition, land managers are testing the system for making decisions about the timing ignitions on prescribed burns and burnouts in control of wildfires.

6.0 VALUE-ADDED PRODUCTS

All graphical mesoscale weather products are available at www.atmos.washington.edu/mm5rt. In addition, since our last report, we created a new website that focuses the smoke and fire applications into one

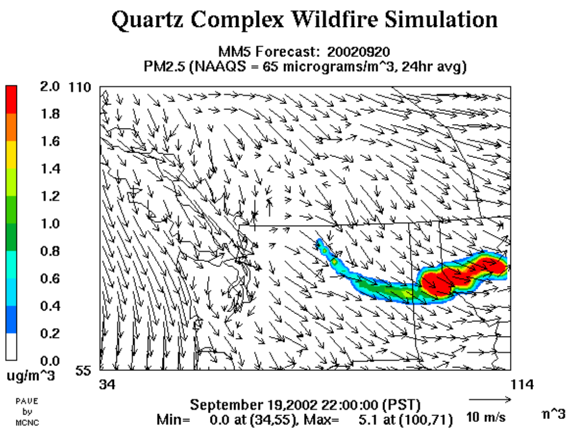

Figure 7. Hourly mass-concentrations near ground level of particulate matter less than 2.5 micrometers in diameter (PM2.5). As predicted by the BlueSky smoke modeling system 17 hours in advance from the Quartz Mountain wildfire complex on 19 September 2002.

location (www.fs.fed.us/pnw/airfire/sf). The new site includes a graphical interface for acquiring predicted soundings, meteorgrams (time series of surface values), and time-height profiles from a number of selected locations, which include many grid cells that coincide with RAWS locations (Figure 8).

Because many users require mapped products than can be used to determine locations of impact from changing weather features, we have begun ingesting MM5 output products into the BlueSky-Rapid Access Information System (www.BlueSkyRAINS.org). Mapped hourly predictions of relative humidity, mixing height, and surface wind currently are available. These are updated daily and can be viewed with other geographical or political information to help orient the viewer. Also, maps can be developed on-line (Figure 9) then imported into local ArcInfo projects to be incorporated into additional overlays.

In addition to smoke and fire applications, distributed hydrological predictions and ozone

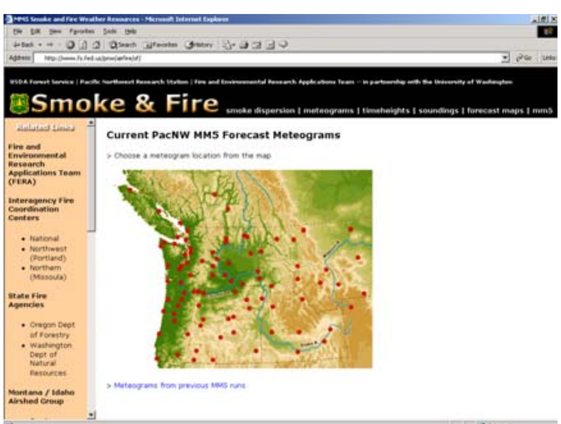

Figure 8. Graphical interface from the smoke and fire website for selecting predictions soundings, meteograms, and time-height from a number of locations.

predictions continue to be a valuable part of NWRMC's environmental modeling capability. (Ferguson 2001 and Mass in press).

7.0 CONCLUSION

While much work has been achieved over the last decade of functionality, the northwest regional modeling program continues to expand. In fall of 2003, we expect our 4km domain to be reach into Idaho and western Montana. In spring of 2004, we expect to implement the WRF mesoscale model and improve the boundary-layer physics with the new surface-layer scheme. We have been able to maintain consistent support for research and development, despite the fluctuating budget resources of individual agencies, because of the breadth of partners in the consortium. When one agency is lacking in funds, another is not.

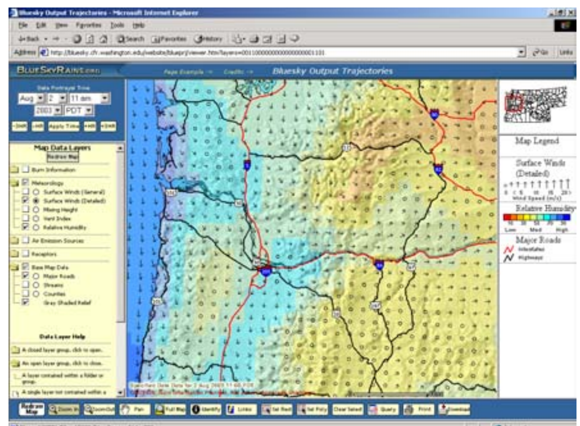

Figure 9. Predicted hourly surface wind and relative humidity from MM5 as seen through the BlueSky-RAINS map server for a region centered over the Columbia River gorge between Washington and Oregon. Major roads are shown to help show areas of impact.

Although we now have a broad range of interests from consortium members, developing applications that support fire and smoke management remain critical. We expect continuous improvements for years to come.

8.0 ACKNOWLEDGMENTS

This work would not be possible without significant effort from faculty, students, and staff at the University of Washington under the guidance of Prof. Clifford F. Mass. In particular, we appreciated the work by Eric Grimit and Tony Eckel in the ensemble forecasts and by Mark Albright and Dave Ovens in designing and maintaining the model runs and graphical and web products. Also, thanks to Larry Bradshaw for his help in NFDRS derivations and to Jeanne Hoadley, Ken Westrick, Scott Goodrick, Miriam Rorig, Ralph Foster, Jim McCaa, and Matt Wyant for helping understand and improve MM5's capabilities in the boundary layer. Linkage of MM5 to BlueSky would not be possible without the work of Miriam Rorig, Sim Larkin, Trent Piepho, and Susan O'Neill. We very much appreciate the work of the EPA team (Rob Wilson, Don Matheny, Ray Peterson, Sue McCarthy, and Bob Kotchenruther) and the USDA-FS team (Susan O'Neill, Lara Kellogg, Trent Piepho, Sim Larkin, Wes Adkins, and Candace Berg) in developing and maintaining BlueSky-Rapid Access Information System (RAINS). Special thanks to all NWRMC members whose support has maintained the project and whose needs, ideas, and enthusiasm have helped build the Northwest real-time mesoscale modeling project into a valuable operational tool.

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