

## Assessing the value of mesoscale models in predicting fire danger *Final Report for the Joint Fire Sciences Program*

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### **Introduction:**

Numerical weather models are being relied on more and more to develop fire weather forecasts and predict fire behavior and fire danger. Their accuracy in these applications, however, has heretofore been unknown. The purpose of this project was to study model predictions during the 2000 fire season to identify the effectiveness of mesoscale weather models in predicting fire danger and related fire weather and to integrate the National Fire Danger Rating System (NFDRS) with a fine scale numerical weather prediction model (MM5). A summary of the case study can be found at <http://www.fs.fed.us/pnw/airfire/mm5case>. For the case study, the MM5 model was configured similarly to that used by real-time MM5 predictions for the Northwest Regional Modeling Consortium, a description of which can be found at <http://www.atmos.washington.edu/mm5rt>. Real time NFDRS predictions based on the MM5 model can be found at <http://www.fs.fed.us/pnw/airfire/sf>. The NFDRS program files and predictive capability are now available in every region of the country through the Fire Consortia for Advanced Modeling of Meteorology and Smoke (FCAMMS) at <http://www.fs.fed.us/fcamms>.

### **Summary of Results:**

- In general, we found that mesoscale meteorological models produce reasonably accurate simulations of trends in weather. Consistent biases, however, prevent accurate prediction of quantitative values, especially in surface temperature and relative humidity that are important for predicting fire danger.
- Wind direction is the only meteorological value that increased in accuracy as model resolution increased. There is very little difference in accuracy between observations and modeled values of surface temperature, wind speed, and relative humidity as model resolution increased from 36 km to 12 km to 4 km.
- Modeled predictions of temperature were generally warmer than observed at night and cooler than observed during the day.
- Modeled predictions of relative humidity generally increased more rapidly and were held constant longer than observed at night.
- Modeled predictions of wind speed were generally higher than observed. Errors in the model simulations are thought to be caused by the way MM5 calculates boundary-layer processes and the land-use data it uses to initialize the model.
- NFDRS predictions for fuel model G were evaluated by sampling within actual fire perimeters. The 4-km predictions consistently showed better verification scores than the 12-km and 36-km, but the size of the errors were large at all resolutions and consistent with the errors found for the meteorological parameters.
- In general NFDRS model predictions were lower than observed and more useful in predicting zonal averages than interpolated point values or closest RAWS.
- The methodology and guidelines for implementing NFDRS into numerical meteorological models has been packaged for delivery and implementation

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through the national network of Fire Consortia for Advanced Modeling of Meteorology and Smoke (FCAMMS).

#### **Model Improvements:**

Although mesoscale meteorological models are much more accurate than other models available for fire weather prediction, they do not perform as well as we think is needed. Therefore, we have leveraged our results from the Joint Fire Science Program to embark on several research and development projects that we hope will greatly improve future fire prediction.

- Understanding and improving the way mesoscale meteorological models determine the nocturnal boundary layer through a cooperative research agreement with boundary-layer physicists at the University of Washington Applied Physics Laboratory. Four new options for improvements are being tested in the Northwest Regional Modeling Consortium's ensembles (<http://www.atmos.washington.edu/~ens/uwme.cgi>). Results will be implemented in the real-time runs and shared with others through peer review.
- Improving the land use data that initializes MM5 and other mesoscale weather models by developing new ways of importing satellite-derived and measured soil moisture into the model configuration.
- Add a bias correction to the real-time MM5 predictions. This will correct many of the errors before the boundary layer and land use schemes can be improved.
- Testing the new Weather Research Forecast (WRF) model that will replace MM5 within the next year. WRF includes similar boundary layer and land use schemes as MM5. Therefore, our improvements will apply to WRF as well as MM5. WRF contains a few new physics options and uses different numerics, however, so it may have slightly different results.

All model improvements will be shared with colleagues through peer reviewed literature, conferences, and shared code. We are working especially closely with colleagues at each Fire Consortia for Advanced Modeling of Meteorology and Smoke (FCAMMS) to ensure the best possible results for mesoscale meteorological support of fire weather, fire danger, and smoke impact predictions throughout the country.

#### **Technology Transfer:**

Real time NFDRS predictions are now available for portions of 8 states included in 4 National Forest Regions and 7 BLM Administrative Jurisdictions. This covers over 45 National forests and 30 BLM field offices in Washington, Oregon, Idaho and Montana alone. Fire management officers and dispatchers throughout this area and beyond are beginning to use the products. In addition, Fire Weather Meteorologists at 5 Geographic Area Coordination Centers and 14 National Weather Service Warning and Forecast Offices are beginning to reference our predictions within their areas of concern. In all we expect these products to be viewed by several hundred people each day.

#### **Publications:**

- Hoadley, et. al., 2003, Assessing the value of increased model resolution in Forecasting Fire Danger, Proceedings of the Fifth Symposium on fire and Forest Meteorology, American Meteorological Society, Orlando, FL. [Poster abstract](#)
- Hoadley, et. al., 2004, The effect of model resolution in predicting meteorological parameters used in fire danger rating, Journal of Applied Meteorology, Vol. 43, No.10, pp 1333-1347, American Meteorological Society. [abstract](#)

- Hoadley, et. al., in Review, Assessing the value of model resolution in automation of the National Fire Danger Rating System, for submission to the International Journal of Wildland Fire. abstract

Websites:

- [www.fs.fed.us/pnw/airfire/mm5case](http://www.fs.fed.us/pnw/airfire/mm5case) - for a description of the 2000 fire season case study
- [www.fs.fed.us/pnw/airfire/sf](http://www.fs.fed.us/pnw/airfire/sf) - for access to NFDRS and MM5 predictions in the northwestern U.S.
- [www.fs.fed.us/fcamms](http://www.fs.fed.us/fcamms) - for access to NFDRS predictions in other regions as it becomes implemented

Presentations:

- Joint meeting of the 5<sup>th</sup> Symposium on Fire and Forest Meteorology and the 2<sup>nd</sup> International Wildland Fire Ecology and Fire Management Congress, Orlando, FL, November, 2003. Approximately 25 individuals made direct contact to discuss the poster and an estimated 100 more viewed the poster during the conference.
- Pacific Northwest Weather Workshop, Seattle, WA, March 2003. Approximately 100.
- Region 6 Fuels Workshop, Welches, OR, April 2004. Approximately 50.

**Continued support and development:**

We are grateful to the Joint Fire Science Program for supporting this work so we could prove the validity of weather prediction and identify clear directions for improving predictive capability. Through the Northwest Regional Modeling Consortium (funded by multiple agencies) and the Fire Consortia for Advanced Modeling of Meteorology and Smoke (funded by the National Fire Plan) we will be able to continue support and development of mesoscale modeling and fire danger prediction. For example, we are modifying the NFDRS code to output hourly fuel moisture and will be creating time series plots for each of our FCAMMS websites to help users anticipate the timing of expected changes.