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APPLICATION OF THE BLUESKY SMOKE MODELING FRAMEWORK TO THE REX CREEK WILDFIRE

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1. INTRODUCTION

The Rex Creek wildfire case study was performed to examine how well the BlueSky modeling framework predicts the concentrations of particulate matter of diameter less than 2.5 micrometers (PM2.5) produced by the wildfire. Rex Creek was chosen for case study analysis because it was a single wildfire occurring in rural area of complex terrain that impacted a network of Forest Service nephelometers. To complete the verification of BlueSky, smoke concentration data from these nephelometers and available fire perimeter data were necessary. The steps and results of BlueSky modeling framework applied to Rex Creek wildfire will be discussed and further improvements will be noted. Additional details regarding BlueSky; its components and forecast applications in the Pacific Northwest and Rocky Mountains can be found in O'Neill et al. (2003, this issue).

2. BACKGROUND

Dry lightning on August 12, 2001 ignited the Rex Creek wildfire which burned over 45,000 areas on the eastern side of the Cascade Mountain range. The wildfire started approximately 40 miles northwest of the town of Wenatchee, along the northeastern shores of Lake Chelan. Figure 1 shows the location of the fire and the sites of the Forest Service nephelometers.

Persistent low humidity and high temperatures throughout the summer resulted in very low fuel moistures and flammable vegetation consisted mainly of medium density pine. With little rainfall during the course of the wildfire, the Rex Creek fire raged for almost a month, becoming the largest fire in Washington State in 2001.

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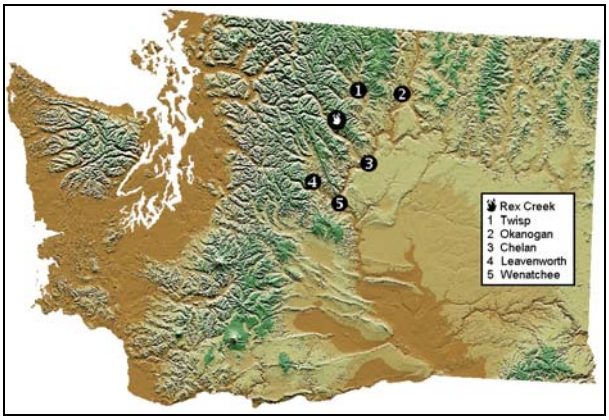

Figure 1. The Rex Creek wildfire location (fire symbol) on the eastern slopes of the Cascade Mountains in Washington State and the network of five Forest Service nephelometers (numbered 1-5).

Westerly down-slope winds flowing from the Cascade Crest funneling along the canyon walls of Lake Chelan helped spread the wildfire eastward. Winds at ridge-tops were observed at speeds of 15 to 20 mph with gusts of 30 mph. These winds aided in the migration of smoke to envelop towns such as Twisp and Chelan. Figure 2 shows the observed 24-hour average PM2.5 concentrations for Twisp and Chelan as calculated from light scattering (β_{scat}) measurements made by the Forest Service nephelometers.
The nephelometers have been calibrated to a federal reference method to allow conversion of β_{scat} to PM2.5 concentrations.

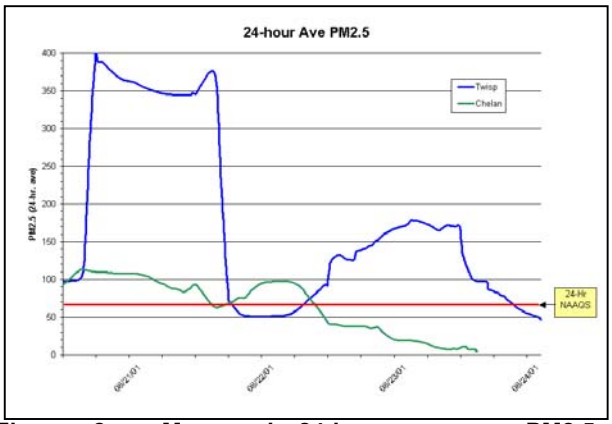

Figure 2. Measured 24-hour average PM2.5 concentrations at Twisp and Chelan for the period from August 20-24, 2001.

Both towns experienced extended periods of PM2.5 concentrations greater than the National Ambient Air Quality Standard (NAAQS) of 65 μg/m^3. Twisp in particular exceeded the NAAQS for approximately four days from August 19-23. One-hour concentrations ranged from 200 to over 600 μg/m^3 for the two towns during the same four-day period.

3. MODELING FRAMWORK

Operational in the Pacific Northwest since July of 2002, the BlueSky smoke-modeling framework is designed to use the best available models to obtain smoke impacts from prescribed, wild, and agricultural burn activities. Specific case study analyses allow us to investigate the various model components to help determine where the system performs well and where improvements are needed. The Rex Creek wildfire case study was key in the verification process of the BlueSky components, particularly components that predict PM2.5 concentrations. Adkins et al. (2003, this issue) offers another larger scale case study analysis of BlueSky for the 2000 wildfire season in Montana and Idaho.

The two major inputs necessary for BlueSky are burn information and meteorology. For the Rex Creek wildfire, meteorology was obtained from the University of Washington's Atmospheric Sciences Department MM5 forecast system (Mass et al., 2003). Specifically, the 4-km domain covering the States of Washington and Oregon was utilized. This meteorology was then downscaled using the CALMET diagnostic model (Scire et al., 2000a) to a 95 column by 110 row, 1-km resolution domain centered over Wenatchee, Washington (see Figure 3).

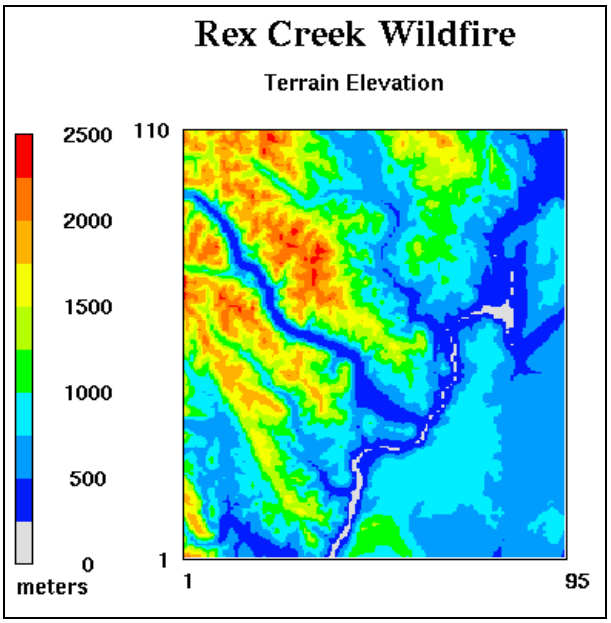

Figure 3. 1-km resolution CALMET domain centered over Wenatchee, Washington. 95 columns by 110 rows.

Burn information was obtained from the detailed fire perimeter information from the Forest Service (see Figure 4). Fuel loading information was obtained from Hardy et al. (1998): a 1-km analysis of the Fuel Characteristic Classification System (FCCS) for the western US. The burn information were then processed through the Emission Production Model v1.02 (EPM, Peterson and Sandberg, 1984) which is also coupled with the CONSUME fuel consumption model to yield emission rates of PM2.5, PM10, total PM, CO, CO2, CH4, and heat released. The meteorology and PM2.5 emissions were then input into the CALPUFF dispersion model (Scire et al., 2000b) to yield a prediction of PM2.5 concentrations across the domain (Figure 5).

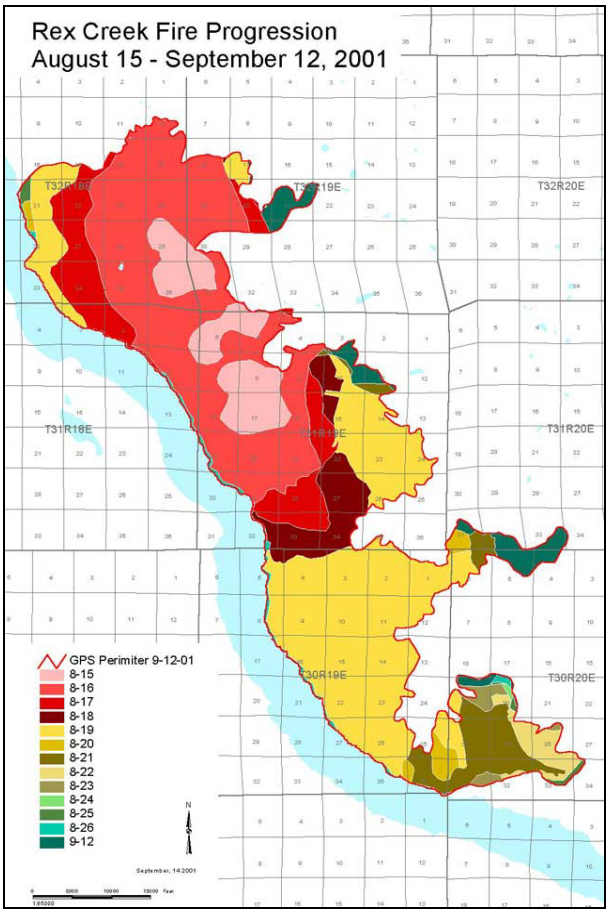

Figure 4. Rex Creek wildfire daily fire perimeter growth from August 15 through September 12, 2001.

4. RESULTS

Initial results are shown in Figures 5 and 6. Figure 5 shows surface PM2.5 concentrations from the Rex Creek wildfire at 3 am GMT, on August 19, 2001 where plume centerline concentrations were greater than 100 μg/m^3. Figure 6a compares the predicted and observed hourly PM2.5 concentrations at Twisp for the fifteen-day period of August 19 – September 3, 2001. The predicted PM2.5 concentration levels did not rise above 50 μg/m^3 during the period when observed

concentrations ranged from 200 to 400 μg/m^3. Similarly, at Chelan (Figure 6b), modeled concentrations ranged between 1 and 10 μg/m^3, well below the observed 100-300 μg/m^3 over the same fifteen-day period.

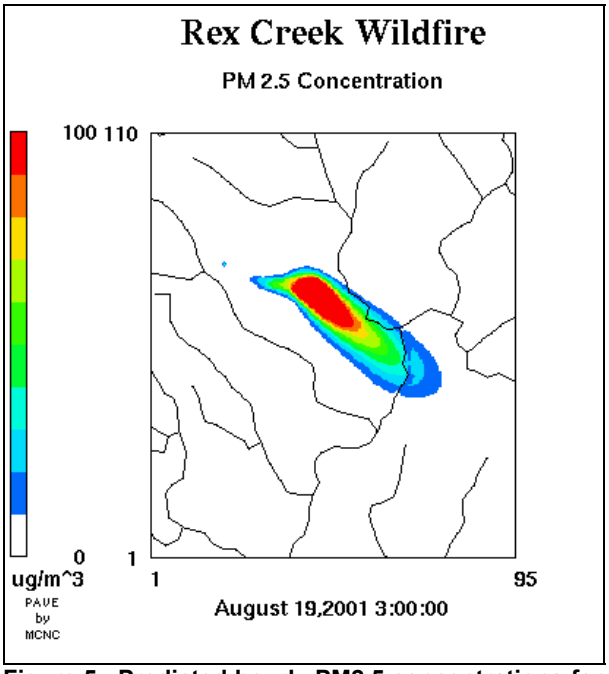

Figure 5. Predicted hourly PM2.5 concentrations for the Rex Creek wildfire for August 19, 2001, 3:00 am GMT.

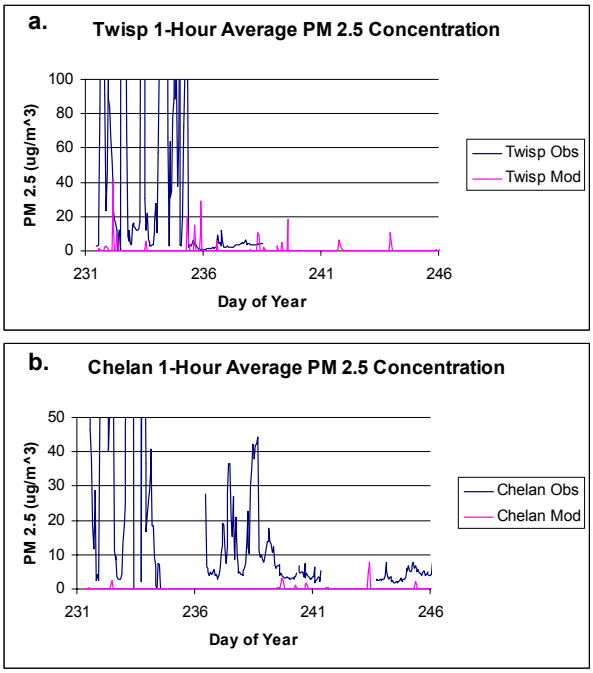

Figure 6. Time series of predicted and measured PM2.5 concentrations from August 19th (day 231) through September 3rd (day 246) at a) Twisp and b) Chelan.

It should be noted that the peak modeled PM2.5 concentration levels did approach the maximum measured concentrations, however small error in timing and location of the modeled plume can cause the plume to narrowly miss the receptors of interest (Twisp and Chelan) resulting in an under-prediction of concentration at that location. Comparing the satellite data in Figure 7 with the modeled plume in Figure 5, the smoke location appears similar but separated by an eight-hour time difference. These timing and concentration level differences in the modeled and observed data could be due to many factors; uncertainty in predicting fire behavior and fuel loadings, improper application of the EPM emissions model which was originally designed for prescribed burn activities, poor meteorological characterization of the period, and poor characterization of the complex terrain (even at a 1-km resolution).

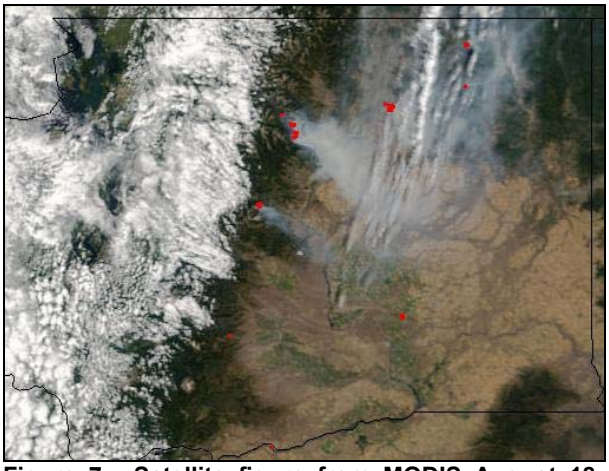

Figure 7. Satellite figure from MODIS August 18, 2001, 7:25 pm.

5. SUMMARY

The BlueSky smoke-modeling framework was applied to the Rex Creek wildfire event to investigate the system's performance predicting PM2.5 concentrations. The Rex Creek wildfire was the largest wildfire in Washington State in 2001 and severely impacted the rural communities of Twisp and Chelan. At the towns of Twisp and Chelan, initial results indicate that the system under-predicts the PM2.5 concentrations although plume surface centerline concentrations did approach observed values. The behavior could be due to many factors such as uncertainty in predicting fire behavior and fuel loading, improper application of the EPM emissions model, poor meteorological characterization of the period, and poor characterization of the complex terrain. All these aspects are under further investigation.

6. REFERENCES

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