Analysis of High-Resolution Model Output for the Yakima Smoke Intrusion Case Study, 28 September 2009

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Photo by Julia Ruthford
9/28/2009 – Naches Ranger District received approval for 2000 acre prescribed burn (est. 1800 acres blackened)

- Ignition started about 12:30 PDT, ended about 15:30.

- Smoke rose to a level of 2,000 – 4,000’+ AGL above the 6,000’ ridge top, moving to the N – NE from the burn location.

- At 14:30 smoke still observed to be dispersing to the N – NE

- At approximately 16:30, smoke was beginning to settle into the Wenas Valley and into downtown Yakima.

- As a result of this intrusion, new restrictions on prescribed burning have been imposed.

Could this smoke intrusion have been hindcast using tools/forecasts that were available in real time? If not, how about with enhanced forecasts available after the event?
Spot Forecast for 9/28/2009:

Today’s general discussion:
Cold front breezy winds SW-W w/chance of precip increasing
CWR: 0%
LAL: 1
Haines: 4L
Max Temp, mountains: 67
Min RH, mountains: 28
20’ Winds: 3-5 mph increasing to 6-9 mph, Gusts 13 mph, from SW
Mixing Height: 4,500’
Winds Aloft: 9-13 mph from SW

Tonight:
CWR: 5%
LAL: 1
Haines: 2VL
Min Temp, mountains: 41
Max RH, mountains: 88
20’ Winds: 9-13, Gusts 25 mph, from W
Mixing Height: 1,500’
Winds Aloft: 13-17 from W
Obs/Models used for this study:

• Surface weather observations – RAWS, NWAC, Yakima Airport
• Upper-air observations (Spokane)
• WRF model predictions – 4km domain, 10-minute output intervals
• WRF model prediction – 1.33km domain, 10-minute output intervals
• BlueSky Smoke Modeling Framework output (using WRF 1.33km output)
Elevated hourly PM$_{2.5}$ concentrations in Yakima, from 16:00 to 23:00 PDT.
Max hourly value $\sim$110 µg/m$^3$.
24-hr average of 23.2 µg/m$^3$ did not exceed NAAQS (35 µg/m$^3$).
Observed surface winds
Chinook Pass, White Pass, Sawmill Flats, Yakima
Modeled 10-meter winds
Kaboom burn unit
Modeled 10-meter winds
Downtown Yakima
Modeled PBL Heights
Kaboom burn unit
Modeled PBL Heights – old 1.33 km domain
Downtown Yakima
Modeled PBL Heights
Downtown Yakima

[Graph showing modeled PBL heights with two lines representing different heights (4 km and 1.33 km) over a date range from 9/27/2009 to 9/29/2009.]
BlueSky predicted surface PM$_{2.5}$ concentrations using WRF 1.33 km /10-min output
Key Findings

• It is likely that if enhanced meteorological and smoke dispersion modeling output had been available on the day of the burn, the same decision to ignite the burn would have been made.

• The surface meteorological observational data from the day of the burn indicated the National Weather Service forecasts were reasonably accurate in predicting surface and transport wind direction, mixing heights, and frontal passage on the day of the burn.

• WRF model output at a 1.33 km spatial and 10-minute temporal resolution did not provide any significant additional information about wind shifts or changes in the mixing heights than the 4 km hourly WRF output that was available on the day of the burn.
Management Implications

• More observations/field studies are needed to better understand local terrain effects and the transition from synoptic- to terrain-driven flows.

• Consider using IMETs on large, complex burns – need familiarity with local terrain effects and with limitations in the meteorological models.

• Despite improved forecasts based on higher-resolution models, burn bosses, regulators, and the public need to understand there will still be inaccurate forecasts that result in negative smoke impacts.
Repercussions

• Initially state regulators imposed five additional conditions that had to be met prior to burning – which essentially shut down prescribed burning on the Naches Ranger District.

• Subsequent discussions resulted in rescission of the five conditions, replacing them with the requirements that (1) all burns must be completed in a single day; and (2) all burns are limited to a total consumption of 6000 tons.
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