Mobile Radar Observations of the Big Elk (2002) and Roberts (2003) Fires

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1. Introduction

There is a compelling need for meteorological observations of both fire plumes and the environment surrounding fires. Three dimensional observations, with rapid temporal updates, would permit characterizations of the windflows in the smoke plumes, permitting a better understanding of the transport of heat, particulates and gasses. Accurate characterization of the volumes of plumes would aid in chemical transport studies. Accurate characterization of the vector windfield in the fires and in the surrounding region would permit detection (warning) of windshifts that could prove hazardous or otherwise complicate firefighting efforts. Additionally, these fields would permit accurate initialization and data assimilation into small scale and mesoscale fire weather models (Clark et al., 1996), permitting better predictions of windshifts and other fire-impacting weather.

While fires have been observed by stationary radars at relatively long range (Banta et al, 1992), and by UHF and vertically pointing radars (Rogers and Brown, 1996), until recently there was a paucity of three dimensional high resolution observations.

2. Doppler On Wheels DOW Mobile Radars

The Doppler On Wheels (DOWs) are mobile, pencil-beam quickly-scanning Doppler radars.

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Figure 1: The DOW2 radar deployed at the Roberts Fire in Montana in August 2003. The near edge of the fire is approximately 3 km distant.

One of these, DOW2, is shown in Figure 1, deployed near the Roberts Fire in 2003. The radars have 2.44 m parabolic antennas resulting in 0.93° beamwidths, 250 kW transmit pulses that can be as short as 0.1 μs, and rapid sampling and signal processing resulting in true, non-oversampled, resolution volumes as small as 16 m x 16 m x 12.5 m at a range of 1 km. Oversampling in azimuth can provide several samples per 16 m beamwidth at 1 km range, further enhancing resolution. Processed data include Doppler velocities,

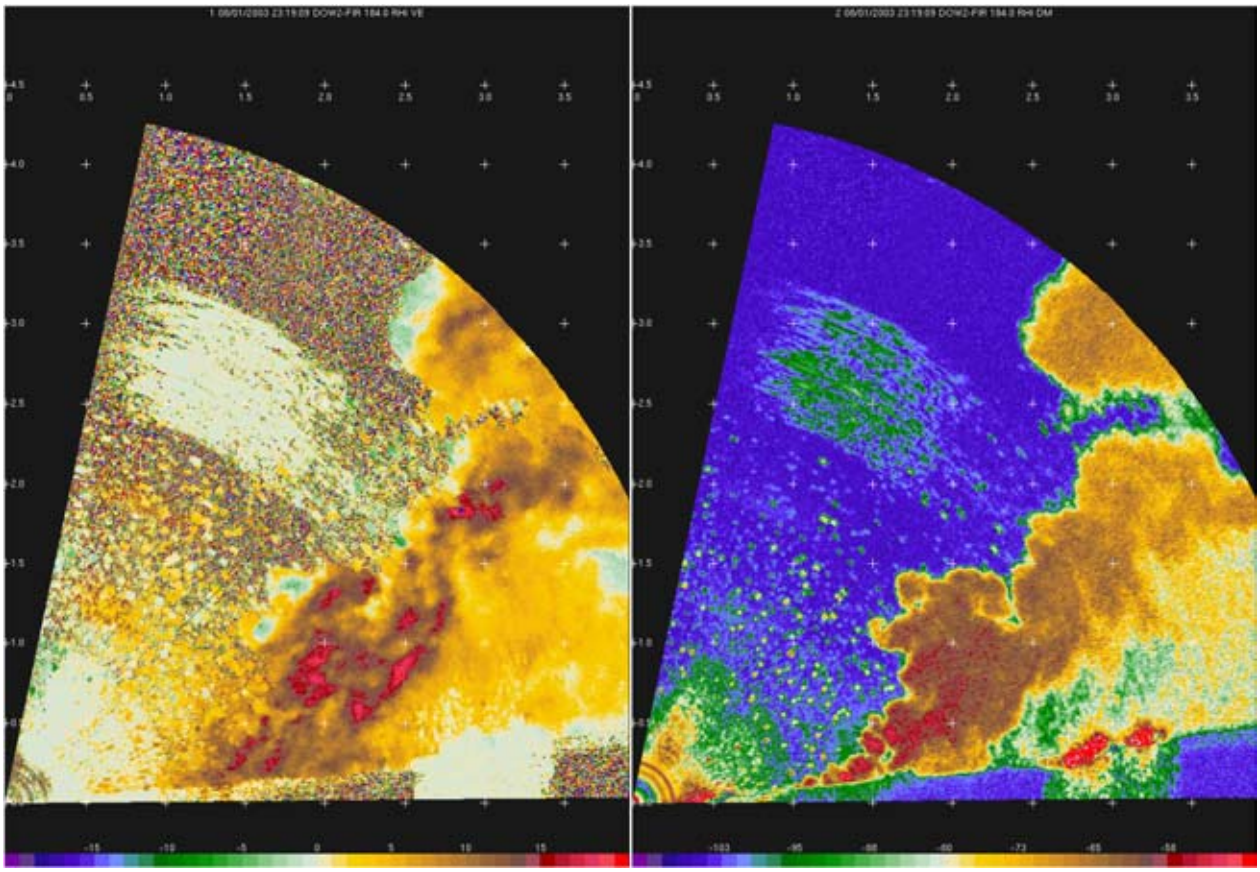


Figure 2: Vertical slices through the Roberts Fire plume. Doppler velocities (left) and returned power (right). Tick marks are at 1 km intervals.

reflectivity (power), spectral width (turbulence), and other parameters. Volumetric updates can be obtained in < 60 s with the DOW2 and DOW3, and in 5-10 s with the newer 6-12 beam Rapid-DOW/DOW5.

The DOW radars have been used in a variety of meteorological applications including the intercepts of about 58 tornadoes, 5 hurricanes, mountain and valley meteorology, boundary layer meteorology, and hydrology. Recently, the DOWs have been exploring non-meteorological phenomena, including fires.

3. Observations of Roberts Fire (2003)

The DOW2 radar was deployed to central Saskatchewan, Canada, to Prince Albert Park, in August 2002. The mission, funded by the Wildland Fire Research and Development Collaboratory, was to observe a prescribed burn in the park. Wet conditions, however, resulted in the cancellation of the burn.

During the return drive to Boulder, Colorado, the DOW deployed at a target of opportunity, the Roberts Fire in Montana. The DOW deployed at various locations near the fire collecting data in both vertical and horizontal slices and in three-dimensional volumes.

No substantial analysis has been performed to date, but the data illustrate the great promise that high resolution mobile radar observations hold for characterizing the detailed structure and evolution of fire plumes and the surrounding environment. Some sample data images are shown in Figures 2 and 3.

Vertical slices (Figure 2) reveal strong, apparently tilted updrafts, with Doppler

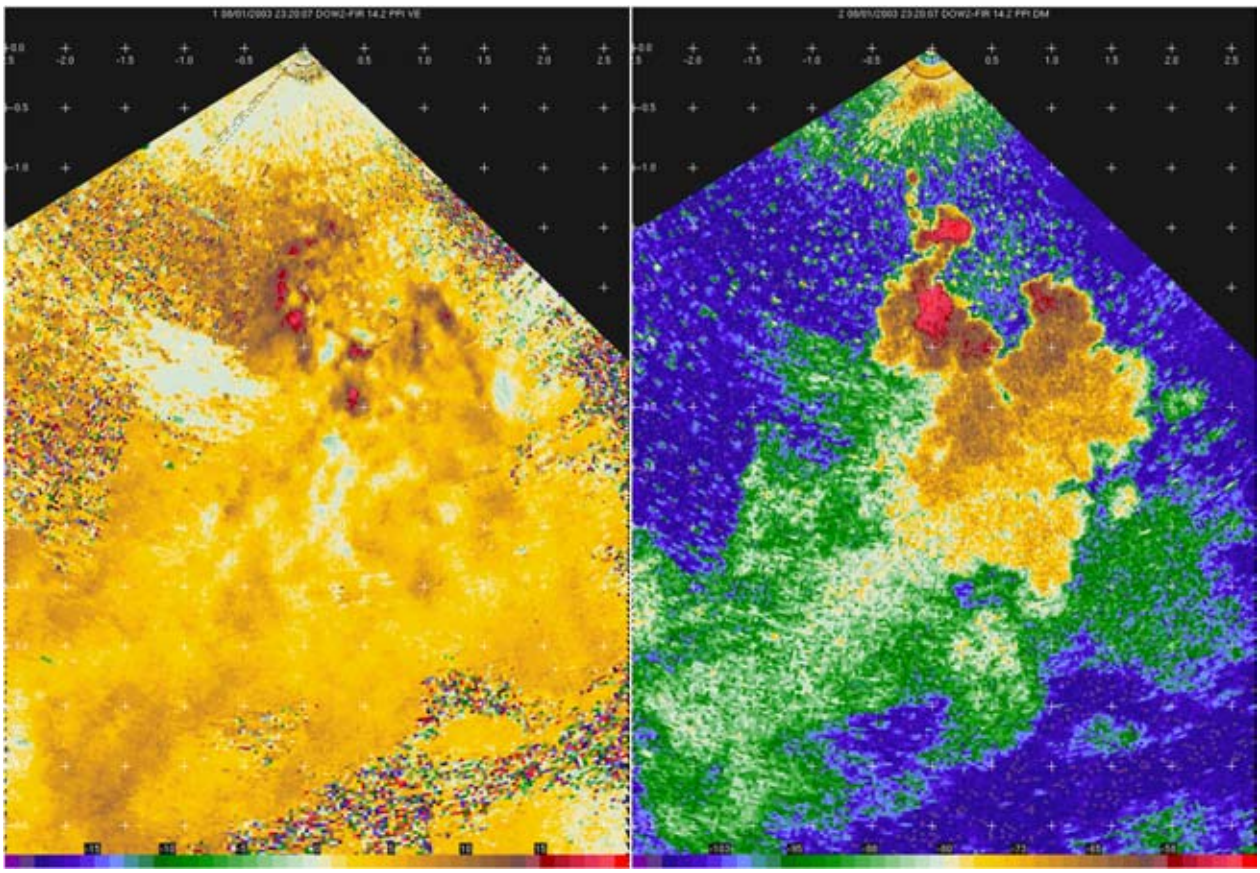


Figure 3: Horizontal slices through the Roberts Fire plume. Doppler velocities (left) and returned power (right). Tick marks are at 1 km intervals.

velocities exceeding 20 ms^{-1}, as well as divergent features a the top of the plumes at about 3-4 km agl. Horizontal slices (Figure 3) reveal several regions of intense return and strong velocities, as well as some areas of apparently strong rotation. Three-dimensions reconstructions from these slices could reveal the complete structure of the updrafts, their intensity, rotation, and permit fluxes of heat and other quantities to be calculated.

4. Observations of Big Elk Fire (2002)

The DOW2 mobile radar was deployed at the Big Elk fire to the northwest of Lyons, Colorado in the late summer of 2002. Data were collected from a range of about 3 km to the fire, which was obscured by intervening hills (Figure 4). Closer deployments were not practical since the nearest road was in a valley and surrounded by dense forest. These were the first exploratory deployments of a DOW near a fire, so the mission goals were logistical as much as scientific, concerning whether such deployments were, in fact, practical. The radar data indicated updrafts of at least 30 ms^{-1} in some regions of the plumes (Figure 5).

5. Future observations and programs

In order to accurately characterize the three dimensional wind field, both horizontal and vertical components, dual-Doppler observations, with two or more mobile radars, will be necessary. It is hoped that future experiments will be attempted with multiple radars. In order to accurately characterize individual plume and updraft elements, very rapid time-updates will be required. The new Rapid-DOW/DOW5 can accomplish this.

The full benefit of high resolution fire observations will be realized by ingesting real-time dual-Doppler vector wind analyses into warning and predictive models as illustrated schematically in Figure 6.

Figure 4 (top): DOW2 radar with Big Elk 2002 fire in background. Near edge of fire is approximately 3 km distant.

Figure 5 (below): Vertical slices through the Roberts Fire plume. Doppler velocities (left) and returned power (right). Tick marks are at 1 km intervals.

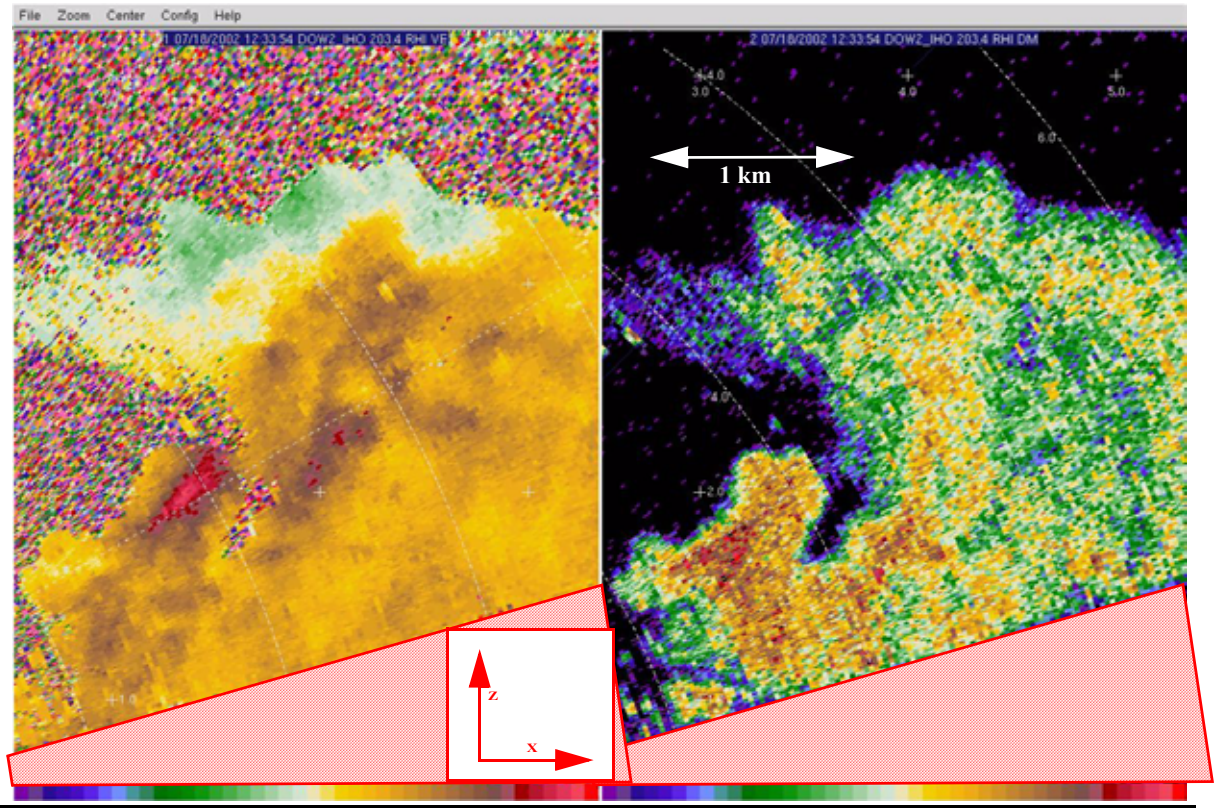
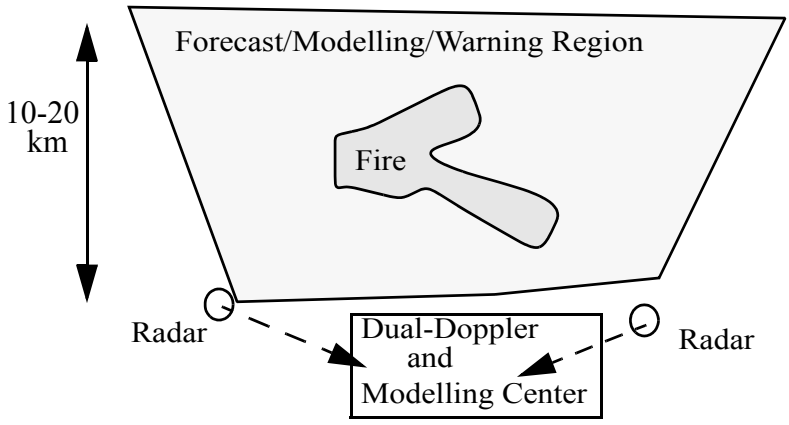


Figure 6: Schematic of radar-based dual-Doppler warning and model-based forecast center. Dual-Doppler analyses based on radar data are used for warnings and for initialization and data assimilation in mesoscale and fire-scale models



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