P1.11 Central Florida smoke and fog - Carnage on Interstate -4

Abstract for submission to The Symposium on Urban High Impact Weather, 11–15 January 2009, Phoenix, Arizona

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I. OVERVIEW

A. Summary

Drivers on central Florida's primary urban corridor, Interstate 4 (I-4) in Polk County, encountered a blinding mixture of smoke and fog that crept onto the highway during the early morning hours of 9 January 2008 (Fig. 1). Seventy cars and trucks collided near mile marker 47 resulting in five deaths and 38 injuries. Sheriff Grady Judd of Polk County described the conditions as "a wall of smoke and fog" (Lakeland Ledger, 2008). The dangerous conditions were the result of a prescribed burn and ensuing smoke that lacked surveillance. This paper examines the individual events leading to the deadly pileup and suggests methods to reduce chances of a future repeat occurrence.

Fig. 1. Looking west over the accident scene along I-4 after sunrise (Orlando Sentinel, 2008).

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B. Background

Unfortunately, eight other similar smoke and fog accidents on major highways in Florida involving at least 109 vehicles have occurred since 1996 leaving 17 dead and 88 injured, (NCDC). This region of Polk County has a history of problematic fires and smoke issues. This area was the site of a prior major wildfire lasting from February 18-24, 2001. During that wildfire over 44.5 km^2 were burned, mainly grass, cypress, pine and palmetto trees, and shrubs along and north of the I-4 corridor over mainly rural portions of northern Polk County. A ten mile stretch of I-4 was closed between Polk City and Lakeland due to the wildfire for nearly ten days. The wildfire smoke plume occasionally reduced visibility and deposited ash over 100 km away.

Fig. 2. Looking north at fire on east side of Old Grade Road (Lakeland Ledger).

Although widespread fog occurred the morning of the accident, it was the smoke combined with fog that created dangerously low visibility. Achtemeier (2003) coined the term "superfog" as a mixture of smoke or condensation nuclei and heated water vapor released from damp smoldering organic material mixing with cooler nearly saturated air, condensing and lowering visibilities to less than 3 meters. Under light wind conditions and lowered nighttime mixing heights, the dense smoke and fog concentrations meander with drainage flows through low terrain areas. Winds may vary considerably above and below shallow nighttime inversions. The standard NWS fire weather wind forecast level is 6.1m (20 feet) above the vegetation which can vary considerably with varying vegetation. In forested areas drainage flows can be below that level.

II. PRESCRIBED BURN OUT OF CONTROL

The dangerous early morning limited visibility conditions were the result of a prescribed burn just 2 km from the crash site. The Florida Fish and Wildlife Conservation Commission (FWC) initiated the proposed small 0.04 km^2 burn that went awry the previous afternoon. The Keetch Byram Drought Index (KBDI), Fig. 3, (Keetch and Byram, 1968) noted on the original burn permit was 550-589.

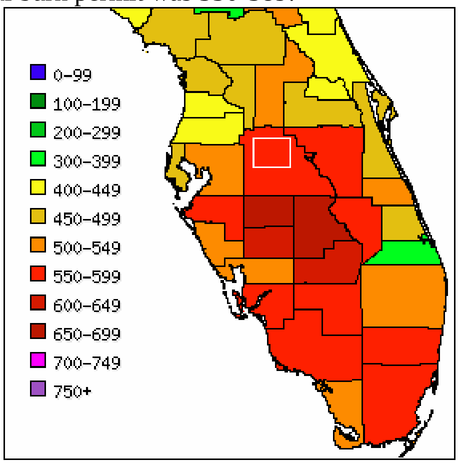

Fig. 3. KBDI 08 January 2008

A freeze occurred a few days before the incident killing many of the plants that were already dry due to drought conditions. This provided additional fine fuels for the prescribed burn, and ample opportunity for the blaze to grow out of control. At 1025 UTC on 8 January 2008, the burn manager obtained a spot weather forecast derived directly from the NWS MOS products through a web based computer program provided by the Division of Forestry. The lowest relative humidity forecast was 60 percent at 1800 UTC. Interestingly, just prior to the burn initiation at 1500 UTC, winds were south southeast at 1.5 ms^{-1} with a temperature of 25°C and a relative humidity of 63 percent. That humidity was already near the forecast minimum. The NWS planning forecast, covering a broader area, forecast east winds at 2.7 ms^{-1} becoming southeast at 3.6 ms^{-1} during the afternoon with a maximum temperature of 27.7°C and a minimum relative humidity of 44 percent.

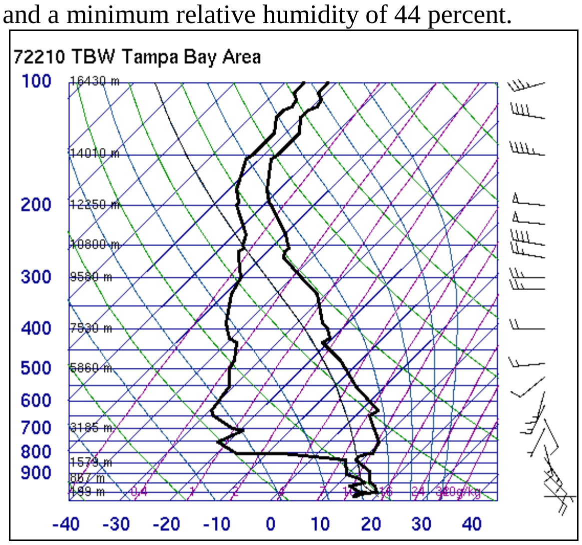

Fig. 4. TBW SkewT 1200 UTC 08 Jan 2008

At the next FWC observation time, 1800 UTC, the relative humidity had plummeted to 29 percent while winds remained south-southeast around 3.1 ms^{-1}. The sudden drop in humidity was caused in part by stronger winds up to 10 ms^{-1} just above the surface, mixing dry air above 1500 m with air at the surface (Fig. 4).

The circumstances surrounding the wildfire were investigated by a state of Florida multi agency review team. Its summary noted that one hour after initiation the fire began to burn erratically, escaping the prescribed area. At approximately 1630 UTC the burn manager requested Florida Division of Forestry (DOF) to respond. The DOF used mechanical, burn out and backfire suppression techniques in an attempt to control and contain the wildfire. The wildfire grew rapidly and was approximately 1.54 km^2 by 2200 UTC. Around 2200 UTC, the DOF notified Florida Highway Patrol and Department of Transportation of the fire and the potential for smoke on the highway. Polk County Emergency Management then requested an official site specific spot weather forecast, for this event, from the NWS. At approximately 2230 UTC the NWS Spot forecast headlined that patchy dense fog was expected overnight with a mixing height of 60m, near calm winds and a Low Visibility Occurrence Risk Index (LVORI: Lavdas, 1996) of 10, which is the most severe. Control of the blaze was regained before sunset but smoldering and spot fires occurred overnight as fog began to develop.

III. OVERNIGHT-THE PILEUP

A video image capture several hours after the accident (Fig. 5) clearly shows the area of smoke from the smoldering fire just north of I-4 mixing and spreading over a widespread but less dense area of fog. The smoke plume from the vehicle accident extends upward over a hill adjacent to the accident and over the superfog strata. This low level inversion with nearly calm winds at the surface and stronger southeasterly winds around 100 meters is reflected on the morning sounding from Ruskin, FL (Fig. 6).

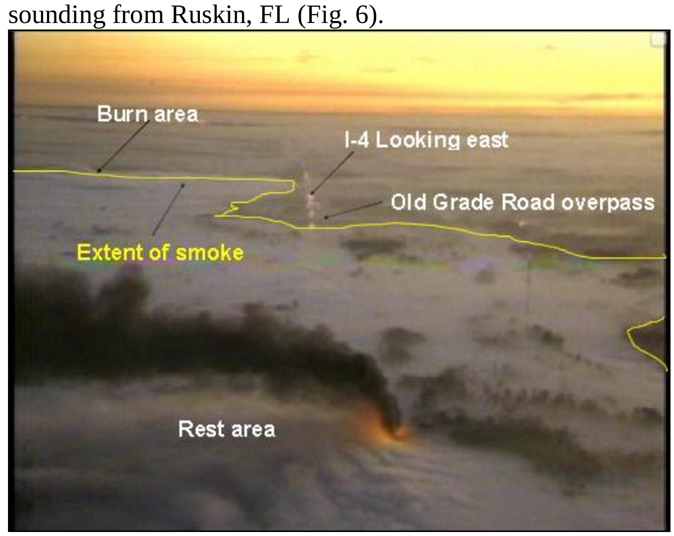

Fig. 5. Aerial video capture of the accident scene around sunrise 09 January 2008. Courtesy of BayNews9.

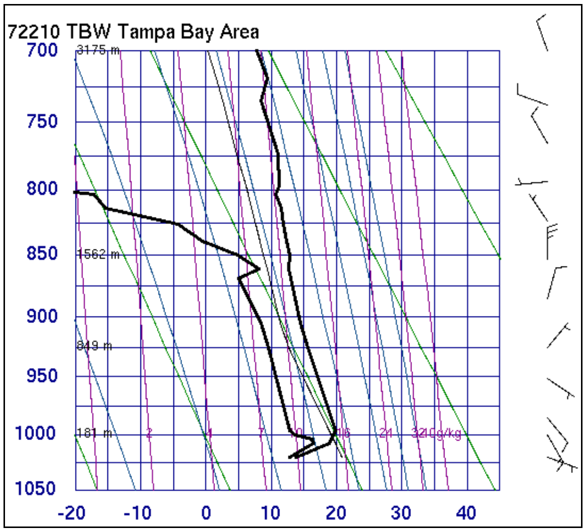

Fig. 6. TBW SkewT 1200 UTC 09 Jan 2008

In the evening hours of 8 January wind became light around sunset and remained near calm in the overnight hours while the relative humidity continued to increase to near 100 percent by 0900 UTC 9 January (Fig. 7).

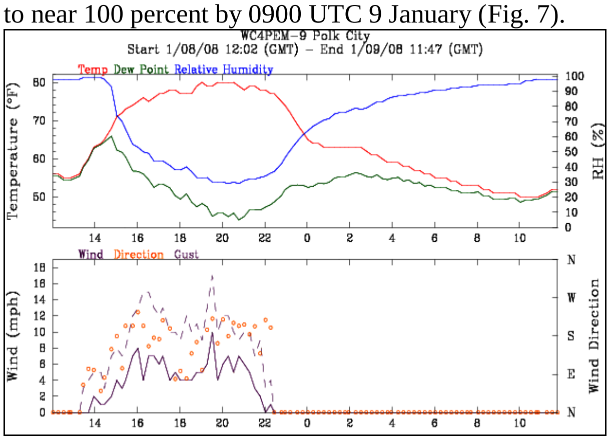

Fig. 7. Meteogram from WC4PEM-9 Polk City, FL (28.19650, -81.78567, 36.8m) approximately 4 km from crash site (Mesowest).

The terrain in this area is nearly flat with only subtle rises and swampy sinks. Vegetation changes with the terrain elevation from oaks in higher areas, cypress trees in the low areas and pine and palmetto in between.

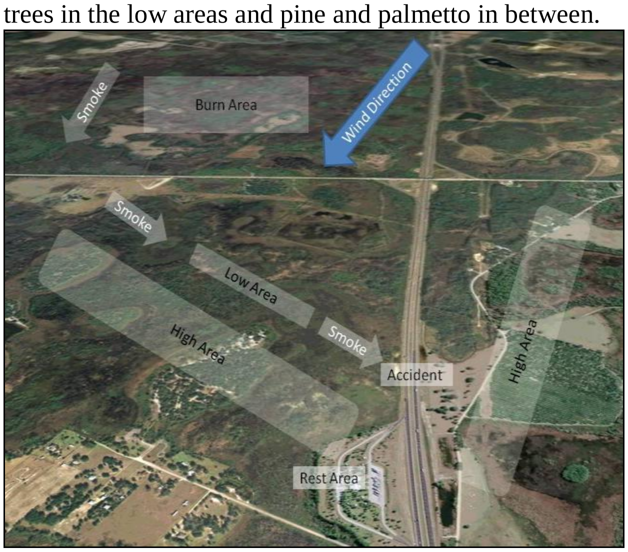

Fig. 8. Diagram of smoke path. Background image Google Earth.

Fig. 9 Looking northeast from the rest area towards the accident site.

Under very light easterly surface winds the smoke meandered through low lying areas but was partially corralled by a hill approximately 5 meters above the surrounding terrain. Pushed by light easterly winds, the blanket of smoke meandered across flat terrain of varying vegetation then crept south along the hill and drained over the highway just after 0900 UTC (Figs. 8 and 9). Visibility was further restricted as drivers went around an inclined curve prior to reaching the smoke. Soon after, the carnage occurred.

B. Satellite Sensing

Ellrod and Lindstrom (2006) looked at satellite fog detection techniques with major fog related highway accidents and found accidents occur with rapid changes in visibility from dense patches or narrow bands moving over roadways. They also found current satellite imagery lacking resolution particularly with shallow fog. Due to the small scale nature of this event traditional remote sensing technologies are also lacking. The GOES-12 fog/stratus product (NESDIS) offers little insight into this event indicated by the red circle (Fig. 10). The isolated smoke/fog pixels are present, but the smoke/fog density and visibility restrictions are difficult to ascertain. Cross referencing the closest NWS Automated Surface Observation System (ASOS) at Gilbert Field in Winter Haven, visibilities were reported as generally 1.6-3.2 km between 0700 and 1100 UTC, with a few intermittent reports of 0.8-1.2 km.

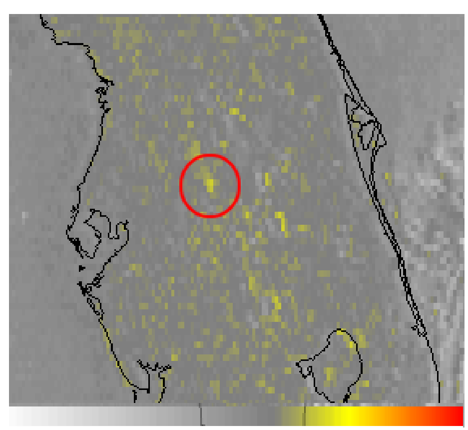

Fig. 10. GOES-12 fog/stratus product 1015 UTC 09 Jan 2008

IV. High resolution modeling

To illustrate wind effects during the overnight hours preceding the accident, the Weather Research and Forecasting Model (WRF, Michalakes et al., 2001) was run at 100 m resolution. The primary area of interest was around $2km^2$. The model shows the evolution of 2m winds from a southeast direction that would push smoke away from I-4. Later winds become near calm invoking very light drainage winds (Fig. 11). While the preliminary model results are promising higher horizontal and vertical resolution is important for this scenario.

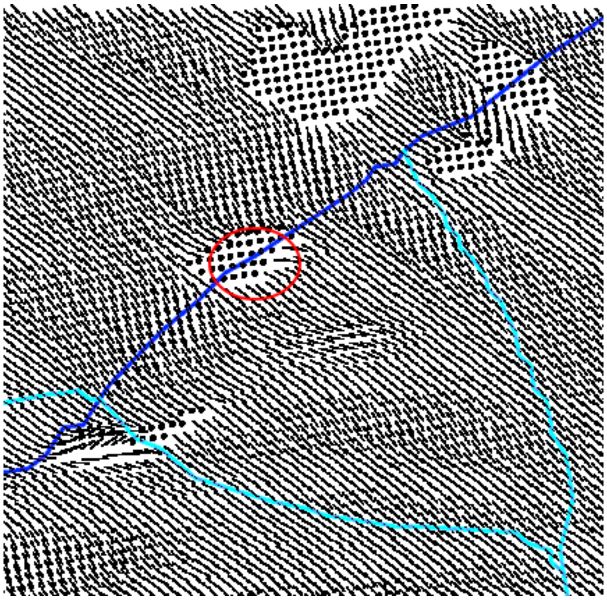

Fig. 11. High resolution (100m) WRF 2m winds. The red circle indicates the accident area.

V. FUTURE PREVENTION

As with most accidents many events converge. The prescribed burn grew out of control and was much larger than expected. Microscale processes affected smoke migration. Effective methods to monitor smoke and visibility were lacking. This disaster incurred the largest total for deaths and injuries compared to any of the other smoke or fog events in Florida. This event ranks fifth in the country in terms of injuries, and second for deaths for smoke related accidents. This illustrates the need for vigilance in monitoring hazardous visibilities on roadways.

Ellrod and Lindstrom (2006) concluded that roadway visibility assessments require use of surface observations. They suggested, in the absence of highway patrol officers, environmental roadway sensors to detect low visibilities to quickly inform traffic officials and weather forecasters who in-turn produce weather advisories to the media and to Variable Message Signs (VMS) that reduce speed limits. Although caution signs were erected along the interstate connecting the major urban centers of Tampa/St. Petersburg and Orlando and the Florida Highway Patrol made occasional passes through the area, it was not enough.

To avoid another similar mishap several courses of action exist. Automated forecasts for prescribed burns should have some level of human oversight, particularly when near the urban interface. When fires are near urban thoroughfares, smoke management tools including high resolution modeling could be used to indicate microscale circulations that may carry smoke in unexpected directions and impact smoke sensitive areas. This event was beyond the resolution of effective satellite monitoring but in-situ monitoring was possible if portable visibility sensors were available to report to the National Weather Service, Highway Patrol, and ultimately to roadway signage. When visibility sensors are not available, human roadway observers spaced at short intervals could provide critical smoke information. Web cameras could also be installed in fog prone areas and monitored by multi agency personnel to prevent such events from occurring. Information saves lives.

VI. References

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