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"Super-Fog" -A Combination of Smoke and Water Vapor That Produces Zero Visibility over Roadways

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, . INTRODUCTION

Forest and agricultural burning release chemical compounds and particulate matter into the atmosphere. Although most of this material contributes to visibility reductions through haze and provides chemical constituents available for reactions with other atmospheric pollutants, there are occasions when smoke is entrapped locally and combines with water vapor to produce zero visibility smoke/fog or super-fog. Super-fog threatens transportation when it drifts over roadways -- a problem in the South, especially at night.

Most serious accidents occur during the night or at sunrise as smoke trapped in stream valleys and basins drifts across roadways. Mobley (1989) conducted a comprehensive study on smoke related highway incidents that occurred in the South from 1979—88. During this period, Mobley found that visibility reduction caused by smoke or a combination of smoke and fog caused 28 fatalities, over 60 serious Injuries, numerous minor injuries, and litigation expenses into the millions. More recently, smoke and fog from a small wildfire located near Interstate 10 in southeastern Mississippi on 8 May 2000 caused an pre-dawn accident that killed five and injured 24 (Twilley, 2000).

2. SOLUTION - NUMERICAL MODELING OF NOCTURNAL SMOKE MOVEMENT

Simulating smoke movement at night is a complex, time-dependent problem. Wind shifts transport smoke to different locations at various times during the same night. Land management personnel charged with alerting the appropriate authorities of pending transportation hazards must know where and when smoke will arrive. Wind observations from nearby weather stations are often unreliable because of the local nature of night winds. Furthermore, weather stations report wind speeds less than 2 miles Per hour (1 m/sec) as calm. A wind speed of 2 miles Per hour (1 m/sec) blowing for 10 hours at night can move smoke 20 miles (32 km) from its origination Point thus potentially affecting roadway visibility at many locations and at great distances.

Numerical modeling constraints imposed by the forest managers were stringent. The models have to fit on laptop PC computers and run in faster-than-real-time yet be able to model smoke on the terrain scales that the smoke "sees". Smoke can move through shallow gaps in ridges and down road and stream cuts. Therefore, the mesh size for the model can be as small as 30 m, the minimum resolved grid distance in the digital elevation models (OEM) provided by the U.S. Geological Survey. The need for speed for this very fine mesh model is realized by minimizing the number of computations. It is required that the mathematics be simple and the physical terms describing complex processes be simplified or replaced with empirical terms.

Two models are under development - PB-Piedmont and PB-Coastal Plain. PB-Piedmont is designed to simulate smoke movement over complex inter-locking ridges and valleys with ridge to valley elevation differences less than 50 m - elevations typical of the Piedmont and upper coastal plain of the southern and eastern United States. PB-Coastal Plain is designed to simulate smoke movement over forest land within 20 miles (32 km) of coastlines where land/water circulations can significantly impact smoke movement.

The prototype models are updated hourly with surface weather when it becomes available. Users can upload the data from Internet. Both models include software for data decoding and extraction of data needed to run the models. Thus in current form, PB-Piedmont and PB-Coastal Plain are "nowcast" mbdels.

In 2001, the Forest Service, as part of the National Fire Plan, set up five regional modeling consortia to provide for its customers products derived with high-resolution weather data. The Southern High-Resolution Modeling Consortium located at the University of Georgia will make it possible for PB-Piedmont and PB-Coastal Plain to be made predictive out to 48-hours.

3. PB-PIEDMONT VALIDATION AND SUPER-FOG

A light intensified multi-spectral video camera equipped with an infrared cutoff filter was mounted in a Beech Craft King Air aircraft and flown over test fires at the Oakmulgee Wildlife Management Area located in the Talladega National Forest in western Alabama. The site was selected for terrain typical of the Piedmont, safety, and the absence of light sources. The flights were conducted during periods of full moon.

Smoke was successfully observed and

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recorded during the evenings of 20 and 21 March 1997. Raw video images, methods of image analysis, and resulting smoke distribution relative to surrounding landforms were described for 20 March 1997 by Achtemeier (1998) and Achtemeier, Adkins, and Greenfield (1998).

On both evenings, Forest Service ground personnel ignited 50 bales of hay soaked in diesel fuel along a road next to a stream basin that flowed to the northeast. Once the hay bales were flaming vigorously, the fire was extinguished with water. The bales then smoked profusely. Ground crews' also detonated 60 smoke bombs that had burn lifetimes of approximately two minutes each. Aircraft overflights at approximately 1,500 m (5,000 ft) commenced at 2148 CST on March 20 and 2121 on March 21 and continued at seven minute intervals for two hours.

On March 20, the project forecast called for winds to decrease to near-calm with rapid cooling in the basin to entrap smoke there. Drainage and valley flows that favored slow movement of smoke down-valley to the northeast were opposed by weak synoptic scale pressure forces.

Figure 1 shows video imagery of the smoke plume at 2258 CST 20 March 1997. The brilliant white cloud extending southward from the burn site at the top of the image is a combination of smoke and dense fog - super-fog. The super-fog was inadvertently produced during the experimental burn. Observers at the ground encountered super-fog with zero visibility - meaning they were unable to see beyond the hood of their vehicle Though traveling on a narrow, tree-lined service road, they were unable to see the trees and drove off the road.

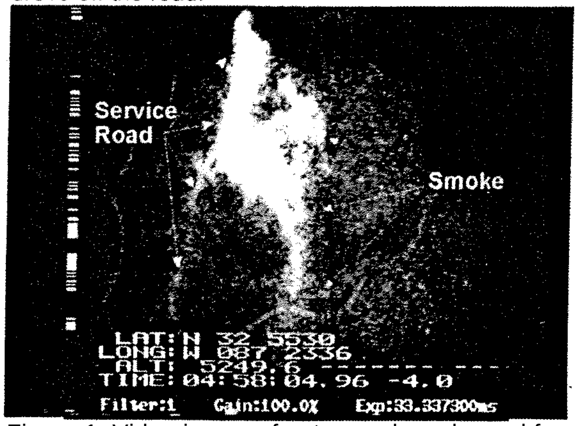

Figure 1. Video image of entrapped smoke and fog (super-fog) within a stream valley located on the Oakmulgee National Wildlife Refuge on the Talladega National Forest near Tuscaloosa,. AL. Image taken at an elevation of approximately 1500 m agl at 2258 CST. 20 March 1997.

Figure 2 shows the smoke plume at 2141 on 21 March 1997. The project forecast called for winds to decrease to near-calm with rapid cooling in the basin to entrap smoke there. Drainage and valley flows favored slow movement of smoke down-valley to the northeast. Synoptic scale pressure forces reinforced the drainage flows to drive Smoke down valley. The image has been enhanced to show the faint plume of smoke that drifted north of the burn site along the service road.

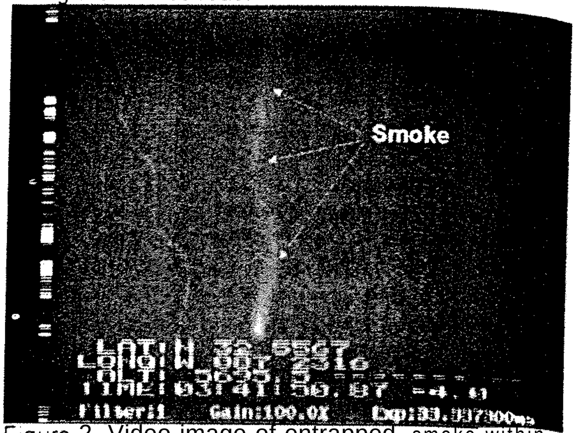

Figure 2. Video image of entrapped smoke within a stream valley located on the Oakmulgee National Wildlife Refuge on the Talladega National Forest near Tuscaloosa, AL Image taken at an elevation of approximately 1500 m agl at 2141 CST, 21 March 1997.

Although weather conditions (temperature and moisture) were the same on both nights, super-fog formed during the first night and not the second, Hypotheses for super-fog are under development.

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