Investigating the December 2015 Central North Carolina “Superfog” Event

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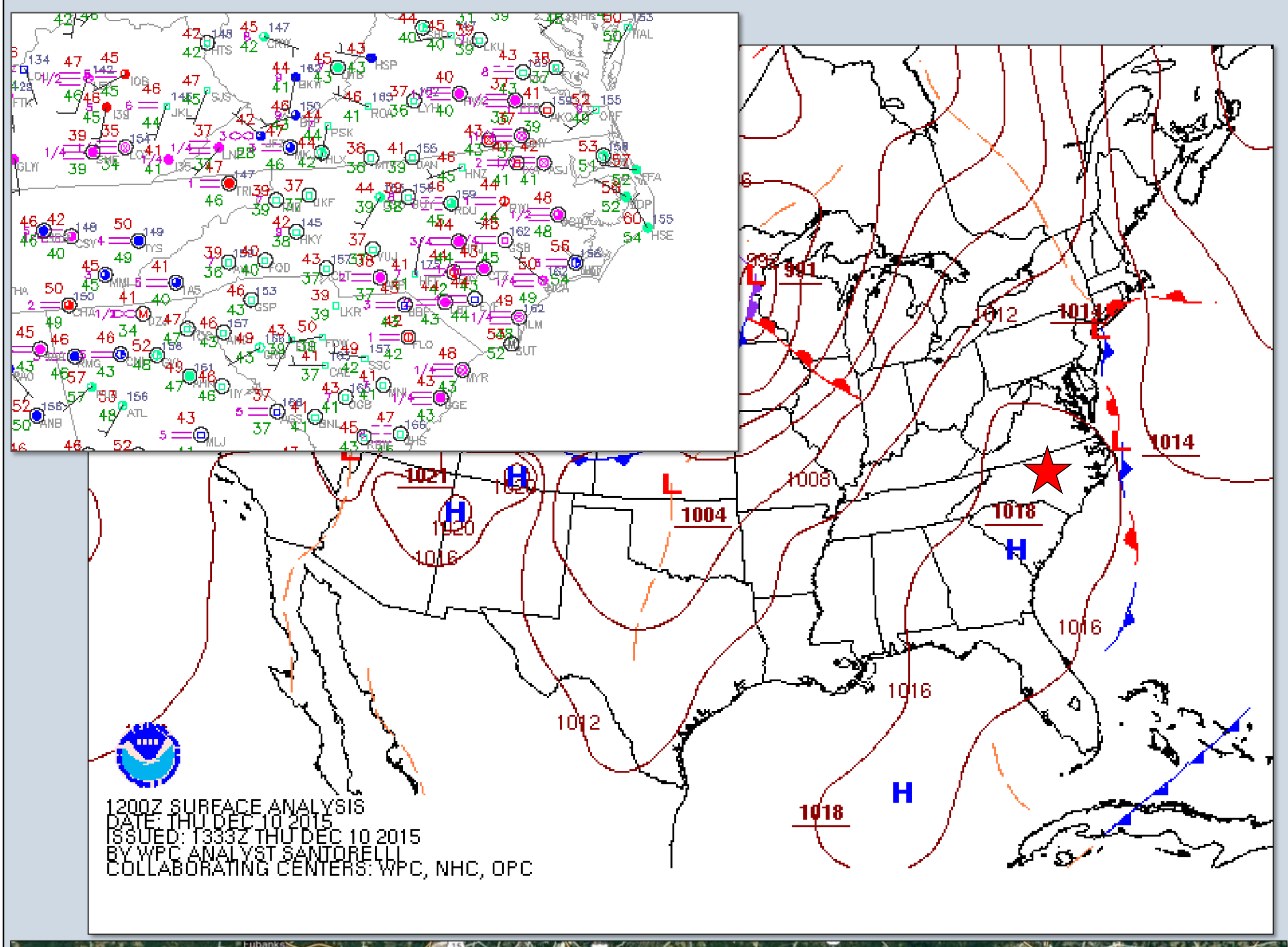
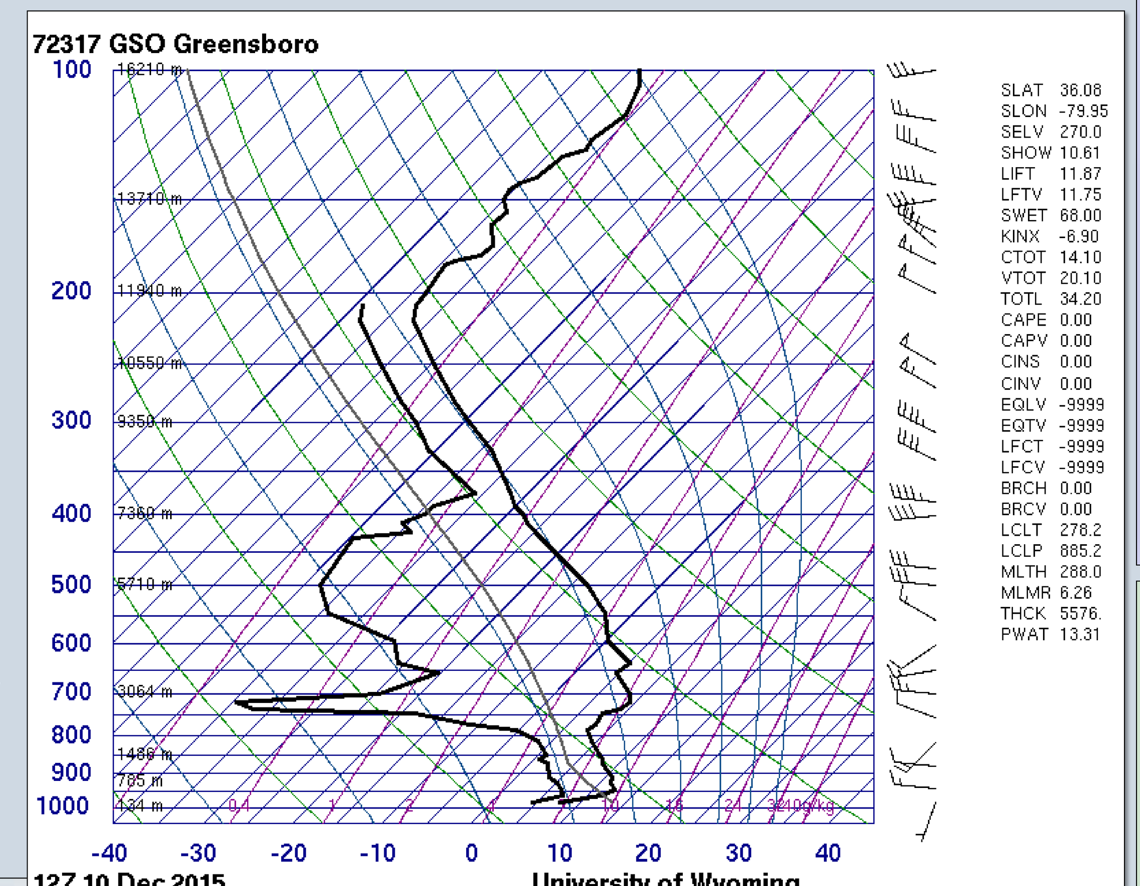
Overview: On 10 December 2015, a mulch fire on a construction site near the border of the towns of Cary and Apex in North Carolina spawned a dangerous “superfog” event. Despite occurring in a relatively rural area, the dense fog caused multiple traffic accidents, with visibilities just a few feet during the peak of rush hour, in an area that is well-traveled at that time of day. Law enforcement officers closed several roads in the area from about 1200 UTC (7:00 AM) until just before 1600 UTC (11:00 AM), with officers very slowly escorting stranded drivers out of the area.

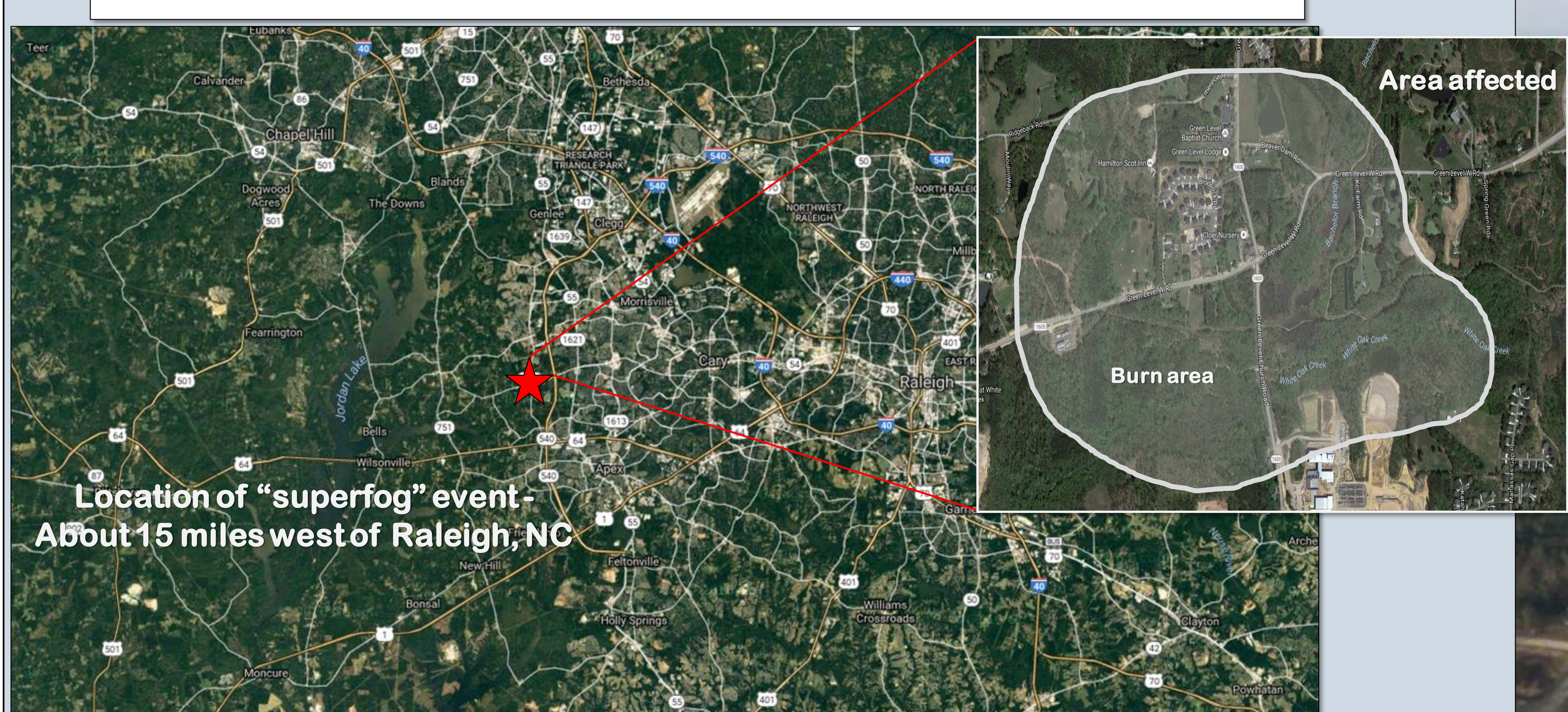
Synoptic overview and observed conditions.

Meteorological conditions were ideal for fog development, with a surface ridge in place across the region, yielding light surface winds and a stable surface-based layer, allowing for little to no dispersion in the horizontal or vertical during the early morning hours. As surface dewpoint depressions across the area fell to around zero, widespread fog developed by 0400 UTC (12:00 AM). WFO Raleigh issued a dense fog advisory at 0656 UTC (1:56 AM) early that morning, warning that visibilities “will be reduced to less than one-quarter mile, and in some locations less than a few hundred feet”, and warned of “dangerous travel conditions during the morning rush hour” in the impacted area.

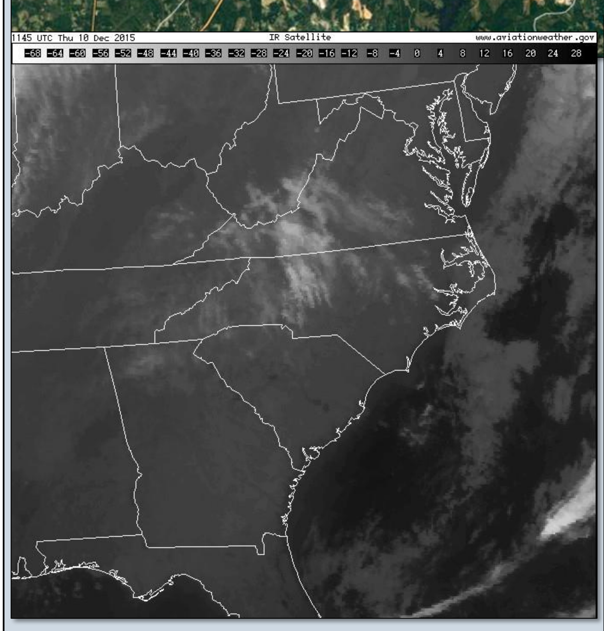


Left: MSL pressure and frontal analysis from the Weather Prediction Center, valid 1200 UTC 10 December 2015. Top left inset: Surface observations across North Carolina, valid 1107 UTC 10 December 2015. Right: GSO Skew-T, 1200 UTC 10 December 2015.

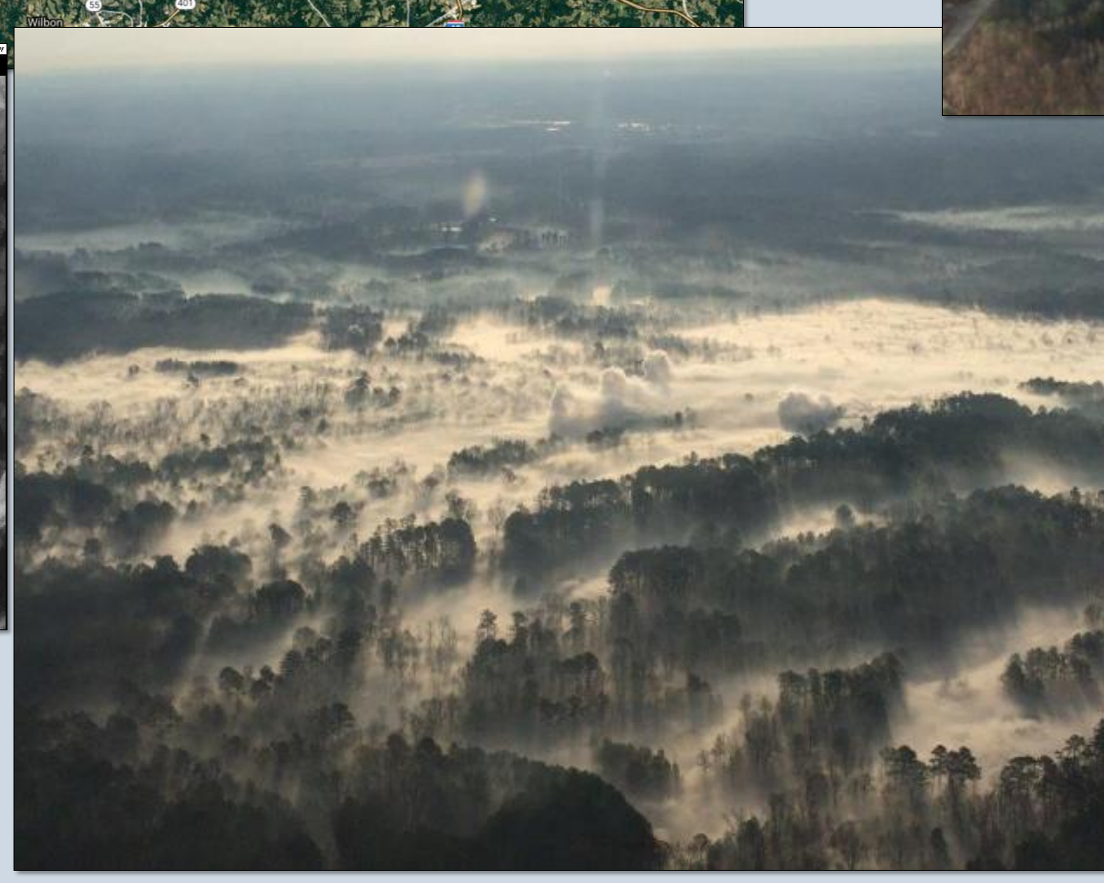




The mulch fire which prompted this event was burning in a subtle drainage basin (White Oak Creek) with adjacent wetlands, which facilitated fog development. The smoke settled into the low areas, concentrating the most dense fog here.



The scale of this event was too small to be captured on traditional satellite imagery, such as the above IR image from 1145 UTC 10 December 2015. 11-3.9μm fog imagery was unavailable for this event.



Above and left: Aerial images of the fire-fueled “superfog”, taken shortly after sunrise on 10 December 2015.

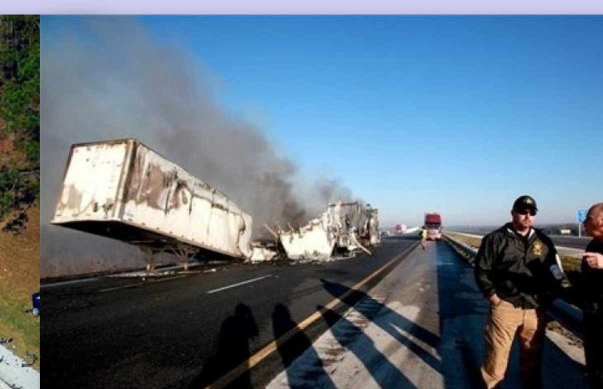
What is a “superfog”?

A “superfog” occurs when hygroscopic smoke particles (cloud condensation nuclei) released from warm, damp, smoldering material combines with cooler, saturated air, leading to dense obstructions reducing visibilities to less than 3 m (Achtemeier 2007). Modeling and laboratory studies (e.g., Bartolome 2014) have indicated that “superfogs” typically possess a large number of small droplets, efficient at scattering light; ambient temperatures under 40°F; RH over 80%; fuel moisture content over 40%; and wind velocities under 1 m s^{-1}.

Several such “superfog” events in recent years have been deadly.

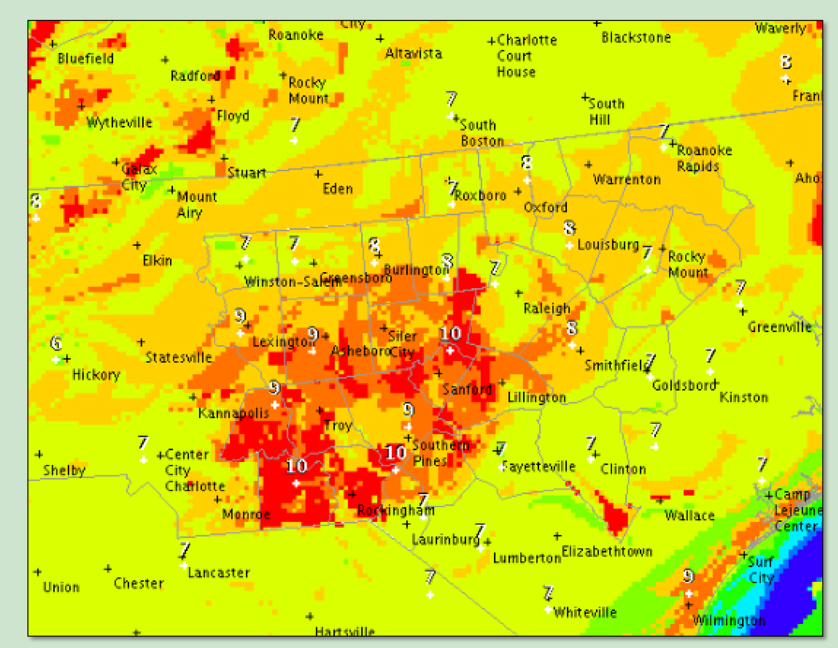
Ashley et al. (2015) discovered that the Appalachians and mid-Atlantic region are among those that experience the greatest frequencies of vision-obscured fatal crashes. Mobley (1989) reported 28 fatalities and more than 60 serious injuries in fog/smoke visibility obstructions from 1979 to 1988. Most such events occur during the winter months (Dec/Jan/Feb), overlapping with a period of typically high prescribed burn activity. Widespread adverse air quality can also pose a significant health hazard.

February 2013	January 2012	December 2011	January 2008
Interstate 16, GA	Interstate 75, FL	Interstate 10, LA	Interstate 4, FL
27 vehicle pileup	26 vehicle pileup	40 vehicle pileup	70 vehicle pileup
4 deaths	11 deaths	2 deaths	5 deaths

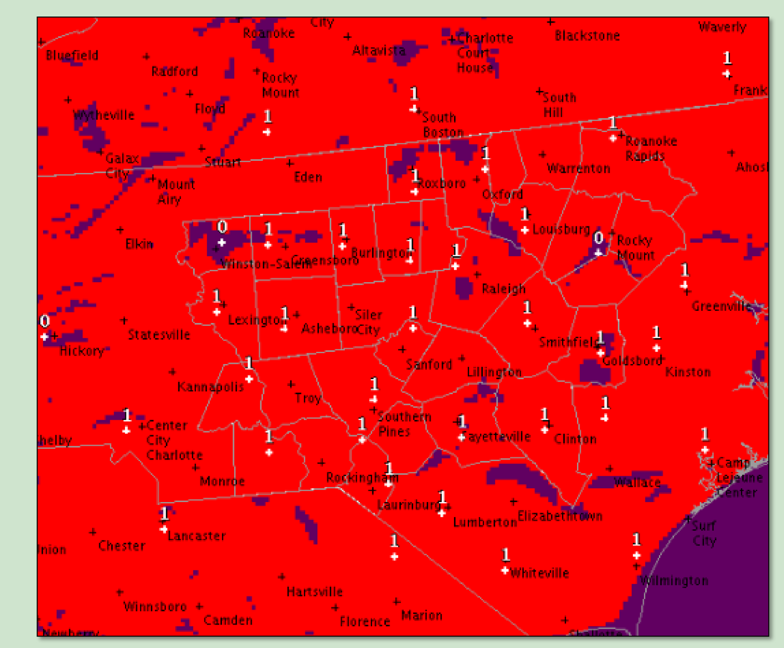


AWIPS Graphical Forecast Editor (GFE) tools can help forecasters better anticipate “superfog” potential.

Forecasting “superfog” events with lead time can be difficult, requiring accurate prediction of ideal conditions for dense fog in the vicinity of ongoing or smoldering fire activity. These GFE tools can help raise forecasters’ awareness and prompt appropriate coordination with partners and users.



The Low Visibility Occurrence Risk Index (LVORI; Lavdas 1996) is derived from relative humidity and the atmospheric dispersion index (ADI, a function of mixing height and stability class); it is scaled from 1 to 10, with 10 as the most severe condition. Values near this “superfog” event, above, were 8-10, suggesting a very high threat of visibility restrictions.



The Superfog tool (Josh Weiss, WFO ILM), based on work by Reardon and Curcio (2011), uses forecasts of temperature, relative humidity, surface wind, ADI, LVORI, sky cover, and stability class to determine the threat for a “superfog”. Zero means no risk;1 means the threat is high, given the presence of smoke particulates. Indeed, the tool output for this event, above, indicated a high “superfog” threat.

How can we better anticipate these events and tailor messaging to reduce the danger?

- Ensure forecasters’ situational awareness of a “superfog” risk
- Improve communication with forestry, land managers, and others conducting burns
- Inform local officials when a fog threat exists in conjunction with an ongoing or recent burn
- Utilize environmental road sensors, web cams, and/or other remote sensing tools for monitoring
- Deploy informational signs in high-risk locations, and emergency/variable message signs when “superfog” is imminent
- Develop specific calls-to-action for near-zero visibility events

Acknowledgements: We gratefully acknowledge the NC Highway Patrol for providing imagery and information concerning this event. Other imagery courtesy of the NOAA/Weather Prediction Center, University of Wyoming, Google, Associated Press, and the Times-Picayune. References available upon request.