North Atlantic
Fire Science Exchange

FIRESCIENCE.GOV
Research Supporting Sound Decisions

Research Brief for Resource Managers

Release: October 2016
Contact: Dr. Inga P. La Puma
Phone: 732-447-7168
Email: inga.lapuma@rutgers.edu

North Atlantic Fire Science Exchange | c/o Erin Lane USDA Forest Service, Northern Research Station, 271 Mast Rd. Durham, NH 03824 USA

Smoke science: Understanding turbulence effects on smoke during prescribed fires

Heilman WH, Clements CB, Seto D, Bian X, Clark KL, Skowronski NS and Hom JL. (2015) ***Observations of fire-induced turbulence regimes during low-intensity wildland fires in forested environments: implications for smoke dispersion*** *Atmos. Sci. Let. 16: 453–460.*

Click here to access the journal article.

Management Implications

- The presence of forest overstory vegetation can affect smoke plume behavior.
- Near-surface atmospheric turbulence measurements are needed for improved smoke dispersion models.

Sometimes it seems as if we have studied all there is to know about how smoke behaves during prescribed fires. However, scientists designing smoke forecasting models for the real world have found that we are still missing some of the information needed to understand smoke behavior when it comes to different fuel types, wind conditions, forest structure, and fire intensities. Smoke models can be extremely complex (see our smoke model review brief from January 2016), and real-world weather conditions and fuel sources are needed to 'fill in the blanks' and dramatically improve smoke dispersion models.

In this paper, Dr. Warren Heilman and colleagues set out to uncover essential information on smoke behavior during prescribed fires in the New Jersey pinelands. Dr. Heilman's team of researchers, funded by the Joint Fire Science Program, along with the help of the New Jersey Forest Fire Service, conducted two dormant season prescribed burns in the Brendan Byrne State Forest to measure wind turbulence generated by the fires at the surface, in the middle of the canopy, and at the top of the canopy. Measurements of turbulence (including along the prevailing wind, across the prevailing wind, and up and down drafts), were recorded before, during and after the fire moved through each site. Measurement towers were systematically placed throughout both sites.

The sites covered an area of pitch pine and mixed oaks in the canopy and typical pinelands shrubs in the understory, such as blueberry, huckleberry, and scrub oaks. Two research blocks, E1 and E2, were burned in March 2011 and March 2012, respectively. Of the two research blocks, E1 burned more intensely than the E2 surface fire. Temperature readings in E1 were significantly higher at 3, 10, and 20m above ground level.

In a comparison of horizontal and vertical wind-speed fluctuations between E1 and E2, the higher-intensity E1 fire measurements showed increased updrafts and downdrafts as the flame front passed, while the E2 fire showed little change in vertical wind speed. Interestingly, horizontal turbulence dominated both fires.

Overall turbulence, as quantified by turbulent kinetic energy (TKE)(see Figure 1), increased more at the top of the canopy than in the mid- or lower canopy for the E1 fire. In E2, there were no noticeable turbulence differences when the flame front passed. The results suggest that, depending on fire intensity, turbulent mixing of smoke as it exits the top of the canopy can be much more substantial than the mixing occurring near the surface fire front.

The observations from measurements at these sites improve our understanding of how fuels, forest structure, fire intensity, and fire-induced winds affect smoke dispersal and will be used in future modeling research in the pinelands ecosystem. Additionally, these measurements confirm the importance of smoke safety precautions in the vicinity of prescribed fires, such as road closures and notification of residents.

The Joint Fire Science Program is continuing to expand efforts to improve smoke models by establishing the Fire and Smoke Model Evaluation Experiment (FASMEE). FASMEE will add to real-world observations such as the ones conducted by Dr. Heilman and colleagues. As observations are improved and expanded to include more sites and conditions, smoke forecasting models will continue to improve.

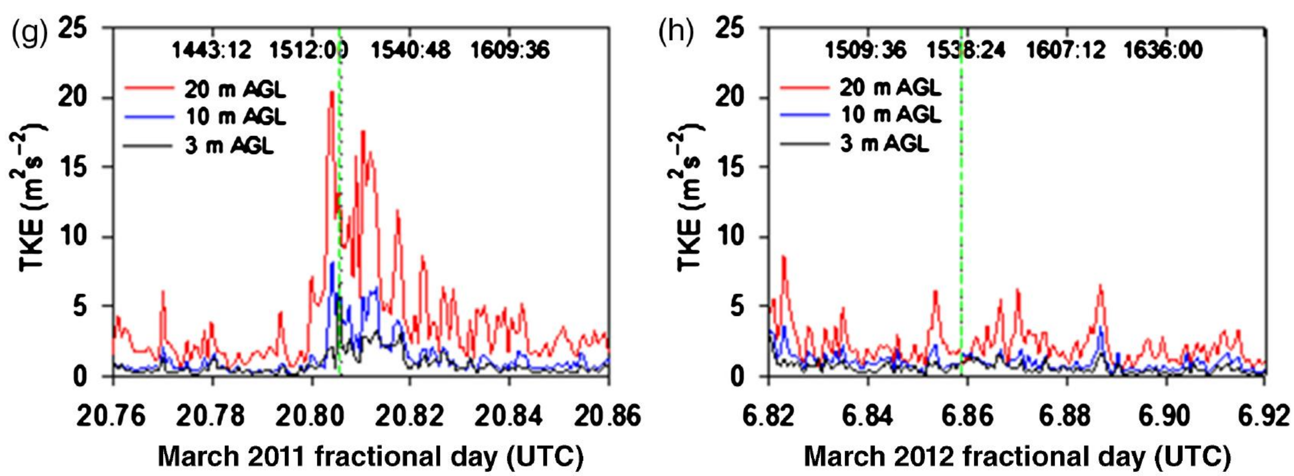

Figure 1. The left panel shows turbulence measurements at 3, 10 and 20 m above the surface in the higher intensity E1 fire. The right panel shows corresponding turbulence measurements during the E2 surface fire. Turbulence increases in E1 as the fire front passes (dashed green line), but there is no noticeable difference in turbulence for E2.