



Smoke Modeling Validation Field Design: CO, PM_{2.5}, CO₂ and Smoke Monitoring from Low Intensity Fires

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Introduction

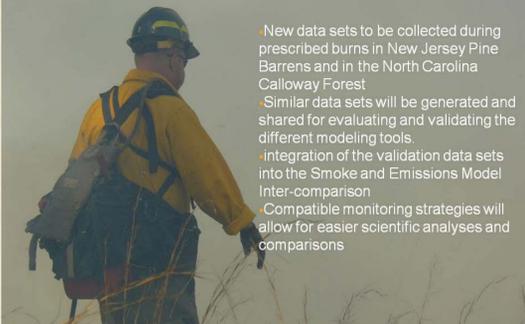
The purpose of this study is to monitor low level smoke from prescribed burn: wind turbulence, temperature profile, PM_{2.5} for validation of smoke transport models.

The approach is a three year modeling and field validation study using tall towers (10m, 20m, 30m), and short towers (10m) inside and outside of fire perimeter equipped with smoke, temperature, RH sensors and sonic anemometers. We will give preliminary results from field tests, comparing the performance of low cost CO monitors, modified smoke monitors, and CO₂ analyzers against reference PM_{2.5} monitors at prescribed fires in Calloway Forest, NC and the New Jersey Pine Barrens..

Joint Fire Sciences Program Task D. Smoke dispersion from low intensity fires.

This work is to provide field validation and support for the development of modeling tools for predicting smoke dispersion from low-intensity fires. Joint Fire Sciences Program. Warren Heilman, PI, JFSP grant # 09-1-04-1. In addition, data and smoke model comparisons will be done in cooperation with Tara Strand, PI, JFSP grant #09-1-04-2.

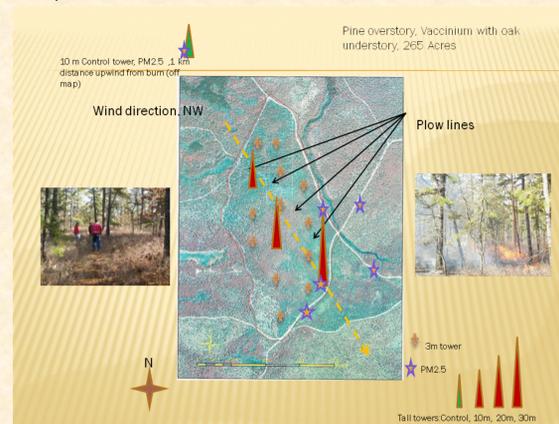
TWO STUDIES: MODEL INTERCOMPARISON



- New data sets to be collected during prescribed burns in New Jersey Pine Barrens and in the North Carolina Calloway Forest
- Similar data sets will be generated and shared for evaluating and validating the different modeling tools
- Integration of the validation data sets into the Smoke and Emissions Model Inter-comparison
- Compatible monitoring strategies will allow for easier scientific analyses and comparisons

Field Study Experimental Design, NJ Pine Barrens at Butler Place , 265 acres

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Pitch Pine overstory, Vaccinium and shrub oak understory

JFSP SMOKE MODELING- FIELD DESIGN: DATA SETS FOR EFFECTIVE MODEL VALIDATION

- Monitor low level smoke from prescribed burn: wind turbulence, temperature profile, RH, PM_{2.5}/ CO / CO₂
- 4 tall towers:
 - 1 control tower (10m)
 - 1 mobile tower (30m) outside of fire perimeter
 - 2 towers inside of fire perimeter (10m, 20m)

Burn site was part of NJ prescribed burn management plan. Controlled burn season in NJ is typically mid-Oct to mid-March. Burn site was inaccessible until first week of March due to record setting regional snowfall. Despite the conditions, all towers and instrumentation were put up and operational within 2 weeks of access into site.

Objective

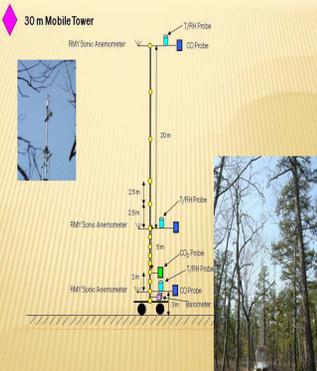
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Field Site Requirements

- Three year study, 1 burn per year, 3 burns - 2009-2012
- Need 50-200 acre low level prescribed burns, to produce smoke.
- Tall towers downwind from burn.
- Access to install control and tall tower outside of perimeter, i.e. along road.
- Interior towers (2) in the fire will need to be accessible to assemble tower and maintain battery power.
- Back perimeter will the PM_{2.5} monitors downwind

INSTRUMENTATION

- 1-30-m Mobile Tower
- 1-20-m Tower
- 2-10-m Towers
- 12-3-m Towers
- 6-PM_{2.5} Monitors : 2 Met One EBAM, 4 DataRam 4000
- 3 UCB-PM particulate monitors
- 63 Fine Wire Thermocouples
- 6 Soil Thermocouples
- 10 Temperature/RH Probes on profile
- 10 RMY Sonic Anemometers, 2 ATI Sonic Anemometers
- 2 Heat Flux Radiometers
- 4 CO₂ Probes
- 22 CO Probes
- 12 digital Temp /RH probes on short towers
- 1 Barometer
- 1 Mini-SCDAR
- 13 Digital/Analog/TC Data Loggers with external storage
- 30 deep cycle batteries, 30 gel cell batteries



Smoke monitoring

Smoke models rely on measurements such as carbon monoxide (CO), PM_{2.5}, and CO₂ as analogs for smoke. A spatial grid of tall and short towers was designed in cooperation with NJ fire managers and researchers.

Typically PM_{2.5} monitors are used to monitor smoke and particulates. However placing these monitors within the fire would be prohibitively expensive. The use of inexpensive, fast response, low power and reliable CO sensors, commonly used in residential CO detectors have been shown to have good correlation with PM_{2.5}.

An array of CO sensors, based on the Figaro TGS5042 carbon monoxide transducer were designed and built with a signal conditioning and amplifier board (Data Design Group, La Jolla) Each is individually calibrated using CO known gas.

MONITORING

- 12 short towers (3m) spatial array for interior smoke monitoring – CO, T, RH
- 6 PM_{2.5} monitors around perimeter of burn
- 3 UCB particulate monitors for comparison with PM_{2.5}, CO₂ and CO monitors



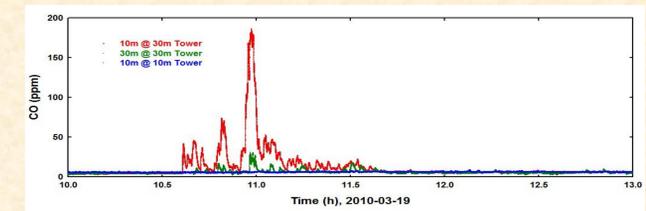
Particulate monitors based on smoke detector technology (UCB sensor, EME Systems) have been shown to have good correlation with PM_{2.5} also. Inexpensive CO₂ monitors, based on a passive design by DCS model 305E were also incorporated in the equipment.

BUTLER PLACE BURN: PARTIAL BURN AROUND 30M TOWER MARCH 19TH, 2010

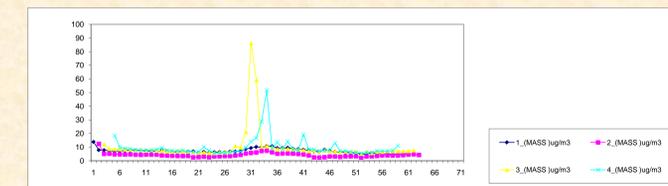


Test burn and burning around base of 30 m mobile tower was initiated at 10am Mar. 19, 2010. Unfortunately, the burn was put out after two hours and crews were put on alert due to a change in wind direction (sea breeze) causing cancellation of all controlled burns due to unsafe conditions. The research burn was not completed before the end of the prescribed season and will be used in 2011.

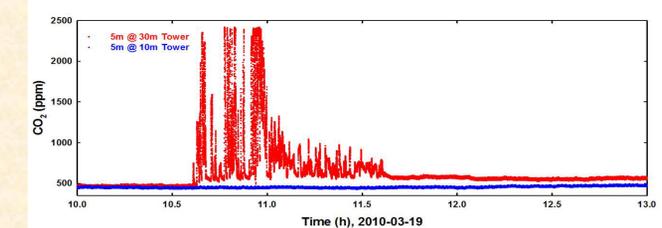
Preliminary results: The results are from the limited burn around the 30 m tower in comparison to a control tower 1 km upwind.



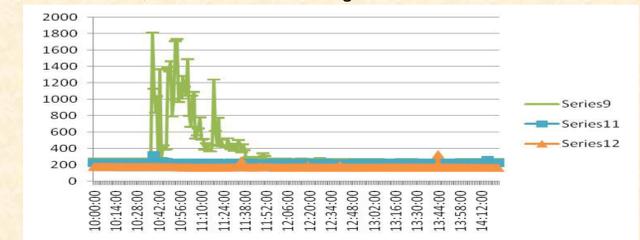
Inexpensive Figaro CO sensors show good response and wide range but must be in the smoke plume, as seen in difference in response with position on 30 m tower.



DataRam 4 PM_{2.5} monitors on perimeter show good sensitivity farther away from plume (ug/m3), with similar time series response as the inexpensive CO sensors



Inexpensive DCS CO₂ monitors shows that the 2500 ppm upper limit was exceeded during the burn. Auto calibration function complicates observations, as seen in the change between baselines



UCB monitor (EME Systems) modified smoke alarm photocell (mv) shows broad response, more similar to CO₂ monitor (outside perimeter). It has been well correlated with other CO and with PM_{2.5} monitors.

In general, inexpensive CO and PM sensors for within burn smoke monitoring yielded good, encouraging results compared to more expensive PM_{2.5} monitors. Larger, repeated samples will improve correlations between PM_{2.5} and CO, PM and CO₂ sensors.

Acknowledgements

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