Sub-Canopy Smoke Dispersion: Measurements of fire-behavior, fuels, consumption, emissions, plume rise and dispersion near and in a prescribed fire-source

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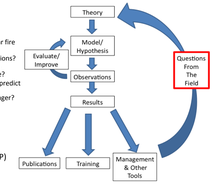
Abstract: Recent individual field programs, including FireFlux, In-canopy Plume Dynamics, Rapid Response, and Fuel Analyses, were combined in a comprehensive field study to measure in-canopy fire meteorological and thermodynamic parameters, determine smoke plume transport and dispersion near the active front, and to quantify emissions from the smoldering portions of the burn. These data were used to evaluate a simple puff dispersion model developed for in-canopy plume transport and to integrate the model into the BlueSky Smoke Modeling Framework. The end products are an extensive data base of emissions and smoke behavior from low-intensity/smolder fires and a new ability to simulate sub-canopy smoke concentrations. Results provided to the fire and air quality communities include a unique, replicated, in situ observation dataset of smoke plume emissions, transport, and dispersion collected in a long leaf pine forest canopy of uniform age, stand structure. Data have been used to evaluate an existing in-canopy, near-source puff dispersion model and three BlueSky pathways. The project has four major objectives: 1. Investigate sub-canopy meteorology and smoke plume dynamics as the flaming front moves through the burn unit; 2. Employ fuels, smoke, and tracer data to develop emission factors for PM and other pollutants from the smoldering phase of the burn and incorporate these into BlueSky; 3. Evaluate the in-canopy puff dispersion model for a) simulation of near source (≤10 km) smoke transport and dispersion and b) integration as a new module into BlueSky; and 4. Translate the model evaluations into a usable guide for decision makers.

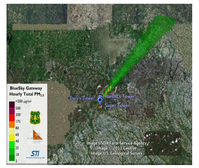
Introduction –what we do

- Studying fire-atmosphere interactions
  - How will a particular fire behave today?
  - What are the emissions?
  - How will the plume advect and disperse?
  - Do climate models predict any changes in fire behavior or fire danger?
- BlueSky Smoke Modeling Framework
- SMARTFIRE
- Arctic Black Carbon Analysis
- Smoke Emissions Modeling Intercomparison Project (SEMIP)

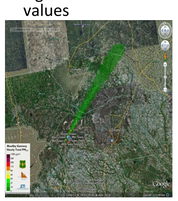


Dispersion Results

Real –Time

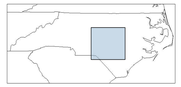


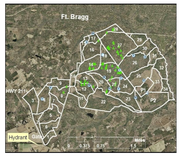
Using observed consumed values



Adding observations decreased concentrations and plume width

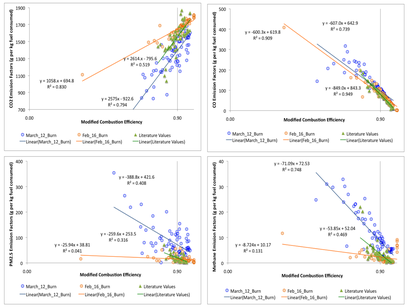
The Site: TNC Calloway Forest/ Sandhills Preserve



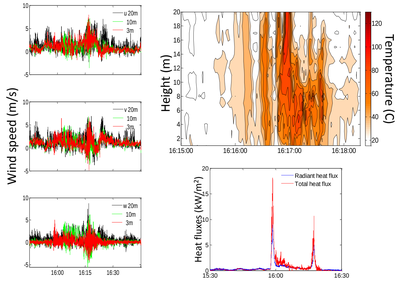


- Long-leaf pine (*Pinus palustris* Mill.)
  - natural regeneration in the areas burned
  - Average age is 80 years
- Fire encourages
  - Long-leaf height
  - Wiregrass (*Aristida stricta*) reproduction
  - Diversification of shrub species
  - Keeping turkey oak back

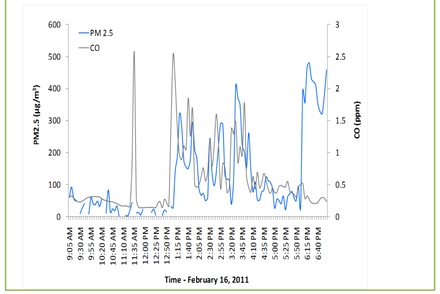
Emissions Factors



Vertical profiles of winds and temperature to characterize turbulence and heat flux

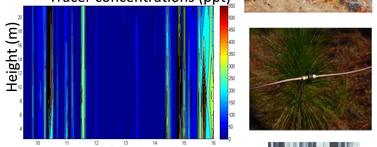


PM2.5 and CO (Near-Source)



Tracer Gas

Tracer concentrations (ppt)



Verification of plume source

Understanding dilution

Model evaluation and testing of theory

Flux tower instrumentation

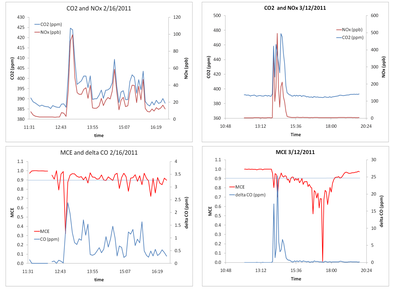
2 flux towers (20 m) instrumented to measure winds, heat, and H2O fluxes at a fine time-scale

A "Super tower" (26 m) was outfitted with additional instruments to measure trace-gas fluxes: CO, CO2, CH4, NOx, NH3, N2O and a tracer

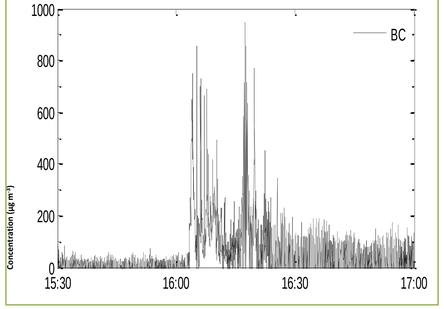
Concentrations

Near Source

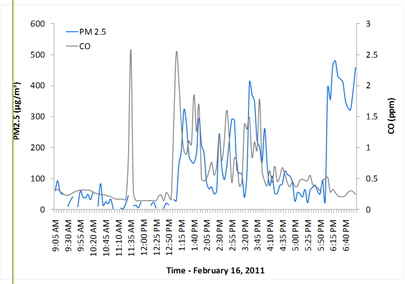
In Source



Concentrations: Black carbon in the source



PM2.5 and CO (Near-Source)



Fire Behavior-Temperature

- 2011 Callowy Rx Burn 1
  - CO Monitors and Small Tower
    - 589° F Mean
    - 250° F Min.
    - 1,200° F Max.
  - Transects
    - 537° F Mean
    - 250° F Min.
    - 1,200° F Max.
- 2011 Calloway Rx Burn 2
  - CO Monitors and Small Tower
    - 650° F Mean
    - 250° F Min.
    - 1,200° F Max.
  - Transects
    - 314° F Mean
    - 220° F Min.
    - 650° F Max.