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Particulate and gas sampling of prescribed fires in South Georgia, USA

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HIGHLIGHTS

- Emissions are sampled from two prescribed fires in southern Georgia, USA.
- Results are compared with other similar studies.
- Results are used as a biomass burning source profile for source apportionment.

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ABSTRACT

Gaseous and particulate species from two prescribed fires were sampled in-situ, to better characterize prescribed burn emissions. Measurements included gaseous and fine particulate matter ($PM_{2.5}$) species, particle number concentration, particulate organic carbon (POC) speciation, water-soluble organic carbon (WSOC) and water-soluble iron. Major $PM_{2.5}$ components included OC (~57%), EC (~10%), chloride (~1.6%), potassium (~0.7%) and nitrate (~0.9%). Major gaseous species include carbon dioxide, carbon monoxide, methane, ethane, methanol and ethylene. Particulate organic tracers of biomass burning, such as levoglucosan, dehydroabietic acid and retene, increased significantly during the burns. Water-soluble organic carbon (WSOC) also increased significantly during the fire and levels are highly correlated with total potassium (K) ($R^2 = 0.93$) and levoglucosan ($R^2 = 0.98$). The average WSOC/OC ratio was 0.51 ± 0.03 and did not change significantly from background levels. Thus, the WSOC/OC ratio may not be a good indicator of secondary organic aerosol (SOA) in regions that are expected to be impacted by biomass burning. Results using a biomass burning source profile derived from this work further indicate that source apportionment is sensitive to levels of potassium in biomass burning source profiles. This underscores the importance of quantifying local biomass burning source profiles.

1. Introduction

Biomass burning, such as wildfires, prescribed burns, and residential wood combustion, are important sources of air pollutants, which can impact health, lead to violations of air quality standards, and impair visibility [Lee et al., 2005; Sandberg et al., 2002]. Biomass burning emissions can be gaseous or particulates and include species that lead to secondary pollutants. Long-lived primary air pollutants from biomass burning can travel large distances (thousands of km), making populated areas potentially susceptible to impacts from remote fires [Sapkota et al., 2005; Wotawa and Trainer, 2000]. In the southeastern United States, emission inventories estimate that biomass burning contributes significantly to air pollutant emissions: ~8–20% of $PM_{2.5}$ (particulate matter

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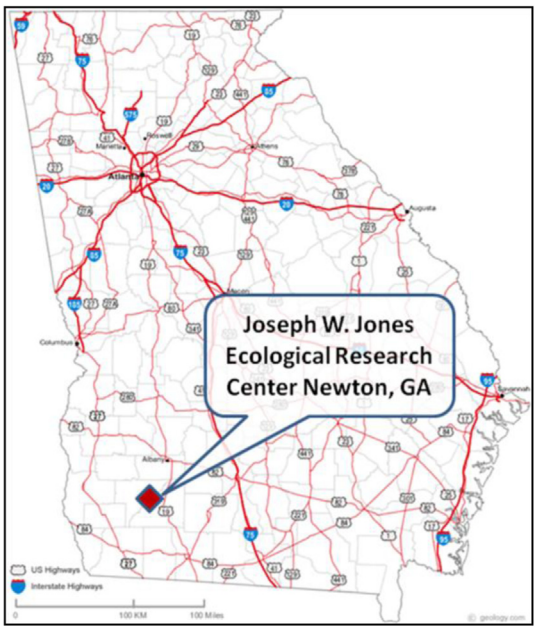

Fig. 1. Location of Jones Ecological Research Center in Southwestern Georgia.

that is aerodynamically less than 2.5 μm in diameter), ~8% of carbon monoxide (CO), and ~6% of volatile organic compounds (VOCs) [Barnard, 2003; Kim et al., 2004; Liu et al., 2005; Zhang et al., 2010].

Prescribed burning is widespread, especially in the southeastern US, and is used to manage forest ecosystems and protect endangered species by controlling growth and infestation while minimizing the risk of large-scale forest fires [Hardy et al., 2001]. In 2006, a total of 96,385 wild land fires were reported to have burned 9,873,429 acres in the U.S., 125% above the 10-year average [NIFC, 2008]. Of that, 2,720,545 acres were treated with prescribed fires, an increase of 410,000 acres from the previous year's total and the second highest since 1998. Most of the prescribed fires occurred in the Southern Geographic Area, which includes the area bounded by Kentucky and Virginia to the north and Texas and Oklahoma to the west [NIFC, 2008].

The dynamics of prescribed fires can differ significantly from wildfires and vary by region [Burling et al., 2011; Burling et al., 2010; Lee et al., 2005; Urbanski et al., 2011]. Fuels also vary by region. Such differences affect the composition and rate of emissions. Emissions also depend upon fire stage (e.g. flaming vs. smoldering). Since limited data exist on emission characteristics from active prescribed burning events in the U.S., emissions of $PM_{2.5}$ and VOCs from prescribed burning were sampled in-situ from two prescribed burns in South Georgia in March 2008. A major goal of this study was to update emissions factors for gaseous compounds and $PM_{2.5}$ in Georgia with regionally specific biomass burning air emissions data. A second goal was to better understand the role of water-soluble organic carbon (WSOC) as a tracer of both biomass burning and secondary organic aerosol. Third, tracers of prescribed burns were studied by characterization of organic chemical compounds. In addition, chemical speciation of $PM_{2.5}$ was used in a source apportionment study to test its applicability as a regionally specific biomass burning source profile. $PM_{2.5}$ constituents were quantified, including organic (OC) and elemental carbon (EC), ionic species, trace elements, water-soluble organic carbon (WSOC), water-soluble iron (FE (II)), and particle number concentration. PM OC speciation identified approximately 100 organic chemical compounds. Gases that were sampled included carbon monoxide (CO), carbon dioxide (CO_2), methane (CH_4) and other volatile organic compounds (VOCs).

2. Methods and materials

2.1. Site description

Emissions from two prescribed fires were sampled on March 5 and March 6, 2008 at the Joseph W. Jones Ecological Research Center in Newton, GA (Fig. 1). On March 5, a 495 acre area with one year of accumulated fuel was burned at Ichauway – North Boundary (N 31° 14′ 45.0″, W 84° 23′ 43.2″, Fig. S1). On March 6, a 225 acre area with two years of accumulated fuel was burned at Ichauway – Dub-East (N 31° 12′ 4.4″, W 84° 26′ 35.3″, Fig. S1). Fuel characteristics are described in the SI (Table S1).

2.2. Measurements and instrumentation

Two-channel, filter-based, particle composition monitors (PCMs), operating at a flow rate of 16.7 L min^{-1}, were used to collect $PM_{2.5}$ for quantifying metals (Teflon filters, 47 mm diameter, Whatman, Inc., Florham Park, NJ) and ions (nylon filters, 47 mm diameter, Gelman Sciences, Ann Arbor, MI). Each PCM used two denuders in series (URG, Inc., Chapel Hill, NC) coated with phosphoric acid and sodium carbonate to remove acidic and alkaline

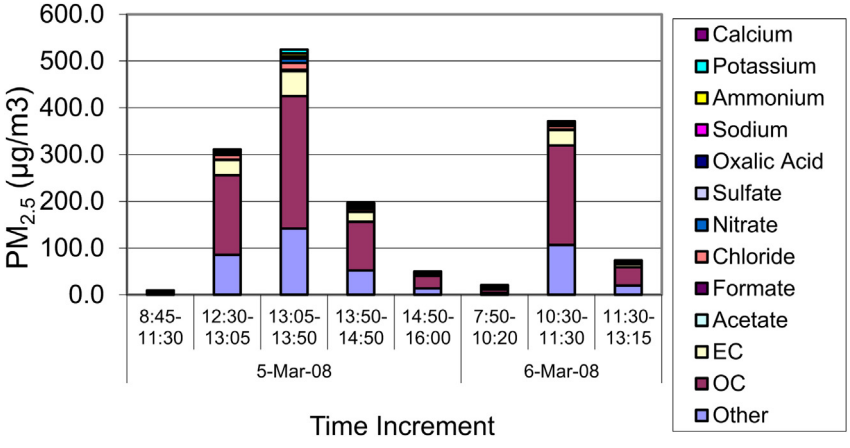

Fig. 2. $PM_{2.5}$ composition of the prescribed fires sampled in this study.