

First look at smoke emissions from prescribed burns in long-unburned longleaf pine forests

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Abstract: While fire has long played a role in the longleaf pine ecosystem, there are still some stands in the southeastern United States where fire has not been reintroduced and fuels have accumulated for 50 years or more. As part of a larger study examining fuel loading and smoke emissions on Department of Defense installations in the southeastern U.S., fuels and trace emissions were measured during three prescribed burns at Ft. Jackson Army Base near Columbia, South Carolina in November 2011. These pine-forest understory fires provided valuable emissions data for fires that burned in stands that had little or no exposure to fire for decades. Smoke emissions were measured on the ground and from an aircraft by scientists from a large team of atmospheric researchers. (Akagi *et al.* 2013) To characterize initial emissions in the lofted plume and in point sources of residual smoldering combustion, trace-gas species were measured using an airborne FTIR and a ground-based FTIR, respectively. Whole-air sampling canisters were also collected from both ground- and airborne-based platforms. A total of 97 trace gases were quantified in this work, largely via infrared spectroscopy. Selected emissions data were compared with similar data collected from prescribed burns sampled in coastal North Carolina in 2010 in younger fuels beds of loblolly/longleaf stands near Camp Lejeune (Burling *et al.* 2011). The emission factors measured in this work differ by ~13-195% to EF measured from the managed stands at Camp Lejeune for organic and N-containing species, suggesting that fire emissions in similar ecosystems can exhibit large variability. Part of the differences, however, may be ascribed to burn conditions as well, since the NC burns were during the wet season whereas the SC stands were burned after an extended drought. We also report the first detailed FTIR emissions data for a suite of monoterpenes. Fig. 1 displays the emission factors (g/kg fuel) for several monoterpenes and isoprene as measured by the ground-based FTIR system. Due to their unsaturated structure, terpenes are highly reactive compounds emitted from plants thought to contribute to secondary organic aerosol formation (SOA) (Saathoff *et al.* 2009; Hennigan *et al.* 2011) and the formation of small oxygenated volatile organic compounds (OVOCs) (Jacob *et al.* 2002) in fire plumes. The known chemistry and measured abundance of monoterpenes suggests that these species impacted secondary plume processes including ozone, OVOC, and SOA formation in sampled plumes within the first few hours after emission.

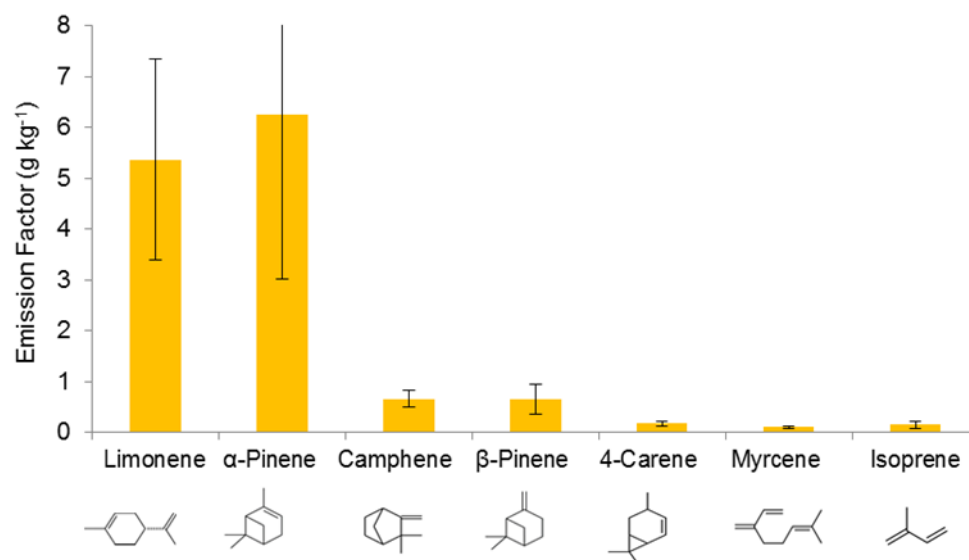


Fig. 1. Ground-based terpene emission factors (EF, measured in g analyte per kg fuel) of several monoterpenes and isoprene as measured during the 2 November 2011 prescribed burn at Fort Jackson, SC. The error bars in this graph show the variability all ground-based fires as a 1- σ standard deviation.

Additional keywords: Biomass burning, prescribed fire, monoterpenes, longleaf pine, residual smoldering combustion

References:

- Akagi SK, Yokelson RJ, Burling IR, Meinardi S, Simpson I, Blake DR, McMeeking GR, Sullivan A, Lee T, Kreidenweis S, Urbanski S, Reardon J, Griffith DWT, Johnson TJ, Weise DR (2013) Measurements of reactive trace gases and variable O₃ formation rates in some South Carolina biomass burning plumes. *Atmospheric Chemistry and Physics* **13**, 1141-1165
- Burling IR, Yokelson RJ, Akagi SK, Urbanski SP, Wold CE, Griffith DWT, Johnson TJ, Reardon J, Weise DR (2011) Airborne and ground-based measurements of the trace gases and particles emitted by prescribed fires in the United States. *Atmospheric Chemistry and Physics* **11**, 12197-12216
- Hennigan CJ, Miracolo MA, Engelhart GJ, May AA, Presto AA, Lee T, Sullivan AP, McMeeking GR, Coe H, Wold CE, Hao WM, Gilman JB, Kuster WC, de Gouw J, Schichtel BA, Collett Jr JL, Kreidenweis SM, Robinson AL (2011) Chemical and physical transformations of organic aerosol from the photo-oxidation of open biomass burning emissions in an environmental chamber. *Atmospheric Chemistry and Physics* **11**, 7669–7686
- Jacob DJ, Field BD, Jin EM, Bey I, Li Q, Logan JA, Yantosca RM, Singh HB (2002) Atmospheric budget of acetone. *Journal of Geophysical Research* **107**, 4110

Saathoff H, Naumann KH, Mohler O, Jonsson AM, Hallquist M, Kiendler-Scharr A, Mentel TF, Tillmann R, Schurath U (2009) Temperature dependence of yields of secondary organic aerosols from the ozonolysis of α -pinene and limonene. *Atmospheric Chemistry and Physics* **9**, 1551-1577