Lab Experiment Overview

Kelley Barsanti, unofficially representing studies at the Missoula Fire Lab

ACOM/ACCORD Fire Workshop

July 13th - 14th, 2017

Missoula Fire Lab

Missoula Fire Sciences Lab, Missoula, Montana

https://www.firelab.org

Established in 1960 (50 year dedication: https://www.fs.fed.us/rm/pubs/rmrs_gtr270.pdf)

The research conducted at the Fire Lab over the past 50 years has been diverse, complex, and multi-dimensional, involving hundreds of scientists, engineers, skilled technicians, and support personnel. Researchers have focused on everything from fundamental physics to the effects of fire on ecosystems over time, and have examined questions at a variety of scales from the microscopic to satellite images of the earth. Some researchers have looked to the past to understand the history of fire, while others have investigated the effects of fire on global climate change and, thus, on the long-term future of the planet.

Two Campaigns: FLAME-IV and FIREX

- Fourth Fire Lab at Missoula Experiment (FLAME-IV)
- Oct. – Nov. 2012
- ~ 40 instruments
- grasses, peat, coniferous canopy fuels, cooking stove fuels, tires, and trash(!)
- focus on: historically undersampled fuels, application of advanced instrumentation
- gas and particle emissions and evolution
- organizational support: CMU and CSU
- funding support: NASA, NSF

- Fire Influence on Regional and Global Environments Experiment (FIREX)
- Oct. – Nov. 2016
- ~ 60 instruments
- western wildfire fuels
- focus on: atmospheric impacts of fires -air quality and climate; linking laboratory and field studies
- gas and particle emissions and evolution, particle properties; nitrogen budget
- organizational and funding support: NOAA CSD, NOAA AC4

Burn Configurations

- Fuels chosen to represent "field" conditions (moisture levels, loadings)
- Stacked to burn under "field" conditions (combustion efficiency)

- Combustion chamber: 12.5 m x 12.5 m x 22 m
- **Room** burns: chamber sealed for tens of minutes, smoke well-mixed in room

http://ciresblogs.colorado.edu/firex/2016/
https://christinajwilliamson.wordpress.com/2016/11/12/setting-stuff-on-fire-for-science/

- Inverted funnel (3.6 m diam.) connected to exhaust vent (1.6 m diam.), opening 2 m above fuel bed, sampling platform 17 m above fuel bed
- **Stack** burn: emissions travel through stack, sampling at ~5 s, 2-30 min duration

FLAME-IV: Instrument List and Fuels

Preliminary instrument/ participant list:

LAAP-TOF	CMU
HR-TOF-AMS	CMU
SMPS	CMU
SP2 (?)	CMU
PTRMS	CMU
Criteria gases (NOx, CO2)	CMU
Aethalometer (?)	CMU
	CMU
CFDC	CSU
SP2	CSU
H-TDMA	CSU
HR-TOF-AMS	CSU
PILS (inc pump)	CSU
PTR-TOF-MS	U-MONT
OP-FTIR	U-MONT
LAFTIR (Opt)	U-MONT
AFTIR (Opt)	U-MONT
WAS>GC-XX	UCI/RSMAS
OH REACTIVITY	MPI
THC	MPI
MOUDI	PNNL
PILS (inc pump)	PNNL
UV-EXT-AEROSOL	NOAA
ASTER	U-WYO
CAPS	U-WYO
PAS	U-WYO
N2O5	U-WASH
PASS-3a (Ambient)	LANL
PASS-3d (Ambient/Denuded)	LANL
PASS-UV	LANL
SP2	LANL
LAS (optical sizer)	LANL
SMPS (with pump)	LANL
PICARRO	LANL
CAPS-Blue	LANL
SEM	LANL
MOVI-CIMS ?	AERODYNE
CRDS ?	U-WISC
GC-2D	PSU

Fuels list:

Table 1. Summary of fuels burned and fuel elemental analysis (see Sect. 2.2 for fuel descriptions).

Fuel	Stack exp.	Room exp.	Environmental chamber exp.	Fuel type	Sampling location (s)
African grass (tall)	11	1	0	Savanna/sourveld/tall grass	Kruger National Park, R.S.A.
African grass (short)	8	0	0	Savanna/sweetveld/short grass	Kruger National Park, R.S.A.
Giant cutgrass	5	3	2	Marsh	Jasper Co., SC
Sawgrass	12	1	0	Marsh	Jasper Co., SC
Wiregrass	7	2	1	Pine forest understory	Chesterfield Co., SC
Peat (CAN)	3	0	0	Boreal peat	Ontario and Alberta, CAN
Peat (NC)	2	1	0	Temperate peat	Green Swamp and Alligator River NWR, NC
Peat (IN)	2	1	1	Indonesian peat	South Kalimantan
Organic alfalfa	3	0	0	Crop residue	Fort Collins, CO
Organic hay	6	2	1	Crop residue	Fort Collins, CO
Organic wheat straw	6	2	0	Crop residue	Fort Collins, CO
Conventional wheat straw	2	0	0	Crop residue	Maryland
Conventional wheat straw	2	1	0	Crop residue	Walla Walla Co., WA
Sugar cane	2	1	0	Crop residue	Thibodaux, LA
Rice straw	7	4	1	Crop residue	CA, China, Malaysia, Taiwan
Millet	3	0	0	Crop residue and Cookstove fuel	Ghana
Red oak	5	0	0	Cookstove fuel	Commercial lumberyard
Douglas fir	3	0	0	Cookstove fuel	Commercial lumberyard
Okote	2	0	2	Cookstove fuel	Honduras via commercial lumberyard
Trash	2	0	0	Trash or waste	Missoula, MT
Shredded tires	2	0	0	Trash or waste	Iowa City, IA
Plastic bags	1	0	0	Trash or waste	Missoula, MT
Juniper	2	0	0	Temperate forest	Outskirts Missoula, MT
Ponderosa pine	11	5	10	Temperate forest	Outskirts Missoula, MT
Black spruce	5	7	9	Boreal forest	South of Fairbanks, AK
Chamise	7	1	0	Chaparral	San Jacinto Mtns, CA
Manzanita	3	1	0	Chaparral	San Jacinto Mtns, CA
Total	124	33	27		

Stockwell et al., *ACP*, 2014, 14: 9727-9754

FLAME-IV: Publications (*Not* Comprehensive)

Atmos. Chem. Phys., 14, 9727–9754, 2014
www.atmos-chem-phys.net/14/9727/2014/
doi:10.5194/acp-14-9727-2014

Atmospheric
Chem
and Phy

Trace gas emissions from combustion of peat, crop residue, domestic biofuels, grasses, and other fuels: configuration and Four transform infrared (FTIR) component of the fourth Fire Missoula Experiment (FLAME-4)

C. E. Stockwell[1], R. J. Yokelson[1], S. M. Kreidenweis[2], A. L. Robinson[3], P. J. DeMott[2], R. C. Sulliva
K. C. Ryan[4], D. W. T. Griffith[5], and L. Stevens[6]

Rapidly evolving ultrafine and fine mode biomass smoke physical properties: Comparing laboratory and field results

By: Carrico, Christian M.; Prenni, Anthony J.; Kreidenweis, Sonia M.; et al.
JOURNAL OF GEOPHYSICAL RESEARCH-ATMOSPHERES Volume: 121 Issue: 10 Pages: 5750-5768 Published: MAY 27 2016

Multi-instrument comparison and compilation of non-methane organic gas emissions from biomass burning and implications for smoke-derived secondary organic aerosol precursors

By: Hatch, Lindsay E.; Yokelson, Robert J.; Stockwell, Chelsea E.; et al.
ATMOSPHERIC CHEMISTRY AND PHYSICS Volume: 17 Issue: 2 Pages: 1471-1489 Published: JAN 31 2017

Characterization of biomass burning emissions from cooking fires, peat, crop residue, and other fuels with high-resolution proton-transfer-reaction time-of-flight mass spectrometry

By: Stockwell, C. E.; Veres, P. R.; Williams, J.; et al.
ATMOSPHERIC CHEMISTRY AND PHYSICS Volume: 15 Issue: 2
Published: 2015

Relative importance of black carbon, brown carbon, and absorption enhancement from clear coatings in biomass burning emissions

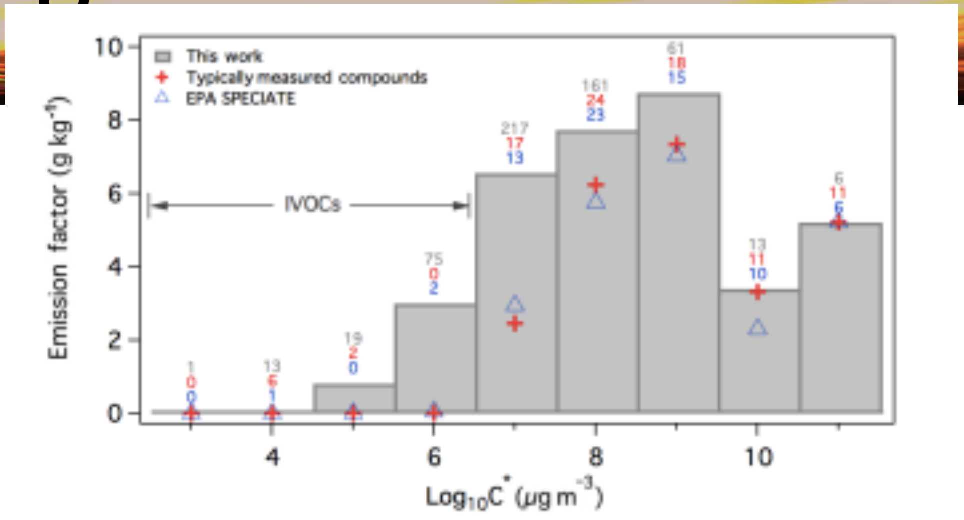
By: Pokhrel, Rudra P.; Beamesderfer, Eric R.; Wagner, Nick L.; et al.
ATMOSPHERIC CHEMISTRY AND PHYSICS Volume: 17 Issue: 8 Pages: 5063-5078 Published: APR 19 2017

FLAME-IV: Findings

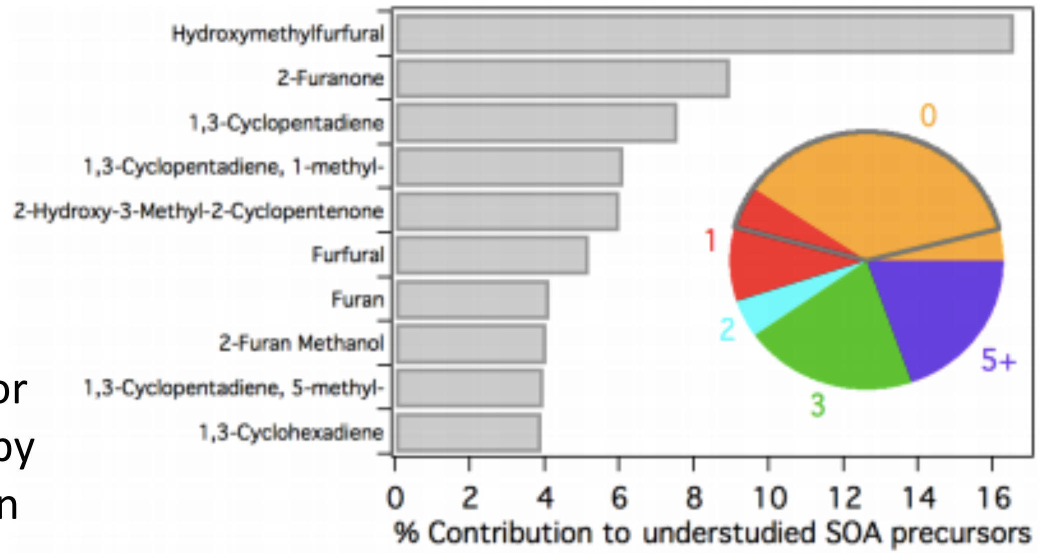
Hatch et al., *ACP*, 2017, 122: 6043-6058

- Proton-transfer-reaction time-of-flight mass spectrometry (PTR-TOFMS), two-dimensional gas chromatography–time-of-flight mass spectrometry (GC×GC-TOFMS), Open-path Fourier transform infrared spectroscopy (OP-FTIR), whole-air sampling (WAS) + gas chromatography–mass spectrometry (GCMS) analysis
- Highly complementary, cover a range of compositional space
- Database of >500 non-methane organic gases, 6-11% of EF IVOC, 55-77% total reactive carbon SOA yields understudies or unknown

Intermediate Volatility Compounds Missing from Inventories



Priority Compounds for Study (scaled by EF, k_{OH}, carbon number)

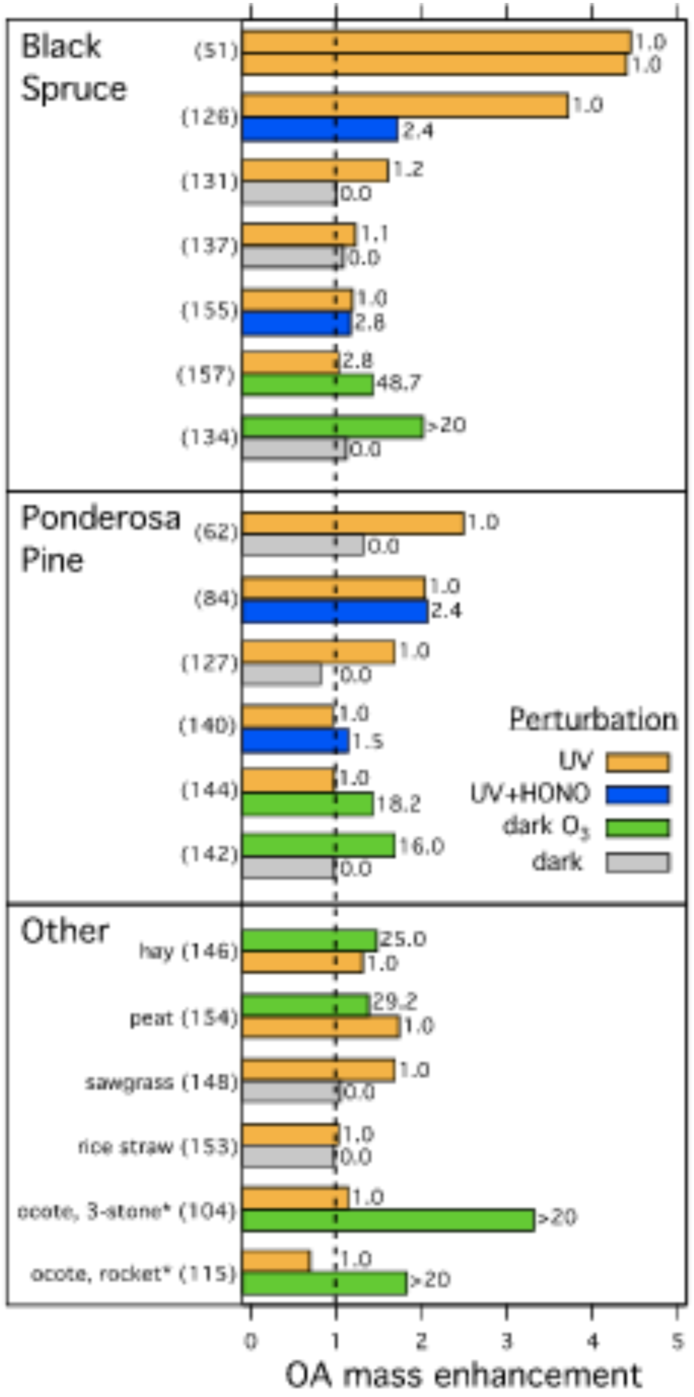


FLAME-IV: Findings

Tkacik et al., *JGR*, 2017, 122: 6043-6058

- SOA formation in nearly every experiment, average organic aerosol (OA) mass enhancement ratio of 1.78 ± 0.91
- Highly variable; no apparent relationship between OA enhancement and perturbation type, fuel type, and modified combustion efficiency.
- Gas measurements substantial burn-to-burn variability in the magnitude and composition of SOA precursor emissions

OA mass enhancement = $\frac{OA_t/BC_t}{OA_0/BC_0}$



FIREX: Instrument/Participant List (Gas Phase)

Gas Phase Species				
CO, CO_2, CH_4, HCHO, NO, NO_2, NH_3, HCN, HONO, etc.	OP-FTIR	Open path FTIR spectrometer, situated at the top of the stack. Can also sample room burns.	B. Yokelson	U. Montana
CO, CH_4, C_2H_6, HCN, HCHO, N_2O	TILDASs	Tunable IR laser direct absorption spectroscopy	S. Herndon, T. Yacovitch, J. Roscolli	Aerodyne
CO_2	LiCOR CO_2	Non-dispersive Infrared detection	T. Yacovitch	Aerodyne
VOCs	PTR-MS	Proton-Transfer Reaction Mass Spectrometry	B. Knighton	Aerodyne
Total Hydrocarbons	THC	Flame ionization detection	T. Yacovitch, B. Knighton	Aerodyne
NO, NOy	NOx box	O_3 Chemiluminescence, catalytic conversion	C. Daube	Aerodyne
$HO_2 + RO_2$	ECHAMP	C_2H_6 + NO chemical amplification	E. Wood	U. Mass
VOCs, SVOCs, HONO, PA radical	I^- CIMS	Iodide ion chemical ionization mass spectrometry, may be converted to NO_3^- ion CIMS for stack measurements	John Nowak	Aerodyne
Gas and Particle partitioning	FIGAERO	Filter Inlet for Gases and AEROsols collector module with I^- CIMS	John Nowak	Aerodyne
Total Fixed Nitrogen	Ny	Catalytic conversion of all N-containing species (except N_2 and N_2O)	Jim Roberts, Y. Liu	NOAA ESRL CSD, CU Denver
Glyoxal, NO_2, HONO	ACES	Broadband cavity enhanced spectroscopy	Kyle Zarzana, Steve Brown, Rebecca	NOAA ESRL CSD
VOCs	H_3O^+ ToF	Various VOCs using chemical ionization mass spectrometer using H_3O^+ as reagent ion	Bin Yuan, Abby Koss, Matt Coggon, Carsten Warneke	NOAA ESRL CSD
VOCs	GC/MS	Gas chromatograph/Mass spectrometer, direct or canister sampling	Jessica Gilman, Brian Lerner	NOAA ESRL CSD
VOC/LVOC	Gas/Particle Sampling	GCxGC-HRTOFMS including both Electron Impact (EI) ionization and softer vacuum ultraviolet (VUV) ionization	Allen Goldstein	UC Berkeley
VOC/LVOC/ELVOC	I^- ToF	Iodide ion CIMS especially for N- and Cl-containing VOCs	Bin Yuan, Carsten Warneke, Joost de Gouw, Jose Jimenez	NOAA ESRL CSD, CU
LVOC/ELVOC	Various Methods	GC/MS, UPLC/DAD-ESI-QToFMS, ACSM, and FIGEARO-CIMS	Barbara Turpin, Jason Surrat	UNC Chapel Hill
Gas Phase compounds	Mist Chamber	WSOC, ES-MS/MS	Barbara Turpin, Jason Surrat	UNC Chapel Hill
I/SVOC	Cartridge	GCxGC/TOF-MS (EI) and LC/MC	Kelley Barsanti, Lindsay Hatch	UC Riverside
Nitrogen Isotopes of Nitrite and Nitrate	MC/IC	Mist Chamber/ Ion Chromatograph with off-line isotope MS	Meredith Hastings, Jack Dibb	Brown, UNH

FIREX: Instrument/Participant List (Particle Phase)

Aerosol Measurements				
Fine Mode Composition	ToF AMS	Aerosol mass spectrometer with time-of-flight MS, and light-scattering module	Ann Middlebrook	NOAA ESRL CSD
Fine Mode Composition	LToF SP-AMS	Aerosol mass spectrometer with high resolution time-of-flight MS, with Soot particle mode	T. Onasch	Aerodyne
Particle size and number	SMPS, OPC, CPC	Scanning mobility particle sizer, Optical particle counter, Particle number concentration	T. Onasch	Aerodyne
SP2	rBC	Soot photometer	A. Sedlacek	BNL
Black Carbon/Brown Carbon	Intercomparison	Numerous Methods, e.g. EC/OC, light scattering and absorption, CO/CO_2, SP2	Gavin McMeeking, Andy May	Droplet Measurement Technologies
Particle chemistry	BBOA measurements	2 MOUDI impactors, off site analysis by DI/MS	Alex Laskin, Sergey Nizkorodov	PNNL, UC Irvine
Particle chemistry	BBOA measurements	PiLS with HPLC/UV-Vis/ESI-HRMS analysis of water soluble constituents	Alex Laskin, Sergey Nizkorodov	PNNL, UC Irvine
Particulate light absorption	CRD-PAS	Dual-wavelength cavity ringdown + photoacoustic spectrometer	Chris Cappa	UC Davis
Particle mobility and aerodynamic size distribution	SEM or SMPS, APS		Chris Cappa	UC Davis
Brown Carbon Absorption	BrC-PiLS	PiLS sampler with long path liquid phase UV-vis absorption spectrometer	Rebecca Washenfelder	NOAA ESRL CSD
Brown Carbon Absorption	BrC-PiLS	PiLS sampler with long path liquid phase UV-vis absorption spectrometer	Rebecca Washenfelder	NOAA ESRL CSD
Aerosol Absorption, UV-vis	BBCEAS	Broadband cavity absorption spectrometer	Rebecca Washenfelder, Carrie Womack	NOAA ESRL CSD
Particle absorption/extinction	aCRD-PAS	Cavity ring-down and Photo acoustic spectrometers	Nick Wagner	NOAA ESRL CSD
Imaging Nephelometer	Aerosol scattering	Scattering as a function of angle	Katherine Manfred	NOAA ESRL CSD
Aerosol chemical composition	PiLS-ESI/MS	PiLS sampling with electrospray ionization negative ion mass spectrometry	Chelsea Stockwell, Jim Roberts	NOAA ESRL CSD
BC/BrC/Optical Prop	SP-AMS CAPS-SSA CRD/PAS	Soot particle Aerosol Mass Spectrometer Cavity Attenuated Phase-Shift, Single Scattering Albedo Cavity Ring Down Photoacoustic Spectrometer	Chris Cappa Jesse Kroll Collette Heald	UC Davis MIT
Aerosol Chemistry	Filter Sampler	ESI-MS/MS, Brown carbon (absorbance 200-800nm)	Barbara Turpin, Jason Surratt	UNC Chapel Hill
Particle phase compounds	PiLS	WSOC, ES-MS/MS	Barbara Turpin Jason Surrat	UNC Chapel Hill
Aerosol Extinction	PAX	Photoacoustic extinction at two wavelengths	Bob Yokelson	U. Montana

FIREX: Instrument/Participant List (Processing)

Smoke Processing				
Potential Aerosol Mass	PAM	Measure of changes in aerosol mass, chemistry and other properties in a flow reactor at high reactant (e.g. OH) concentrations	Matt Coggan Jose Jimenez	NOAA ESRL CSD CU
Potential Aerosol Mass	PAM	Measure of changes in aerosol mass, chemistry and other properties in a flow reactor at high reactant (e.g. OH) concentrations	Lambe, T. Onasch, S. Herndon	Aerodyne
Particle Aging Reactor	SP-AMS, CAPS-SSA	Batch reactor photochemical aging of particles with chemical and optical measurements, opportunities for other measurements	Jesse Kroll Chris Cappa	MIT UC Davis
Photochemical processing	Photochemical Chamber(s)	1 or 2 portable chambers for gas phase and SOA processing studies. Instrumentation will include CO_2, O_3, NOx, SMPS, and oxidative potential (OPA), other measurements will provided by the study participants	Shantanu Jathar	CSU

FLAME-IV: Data Archive

https://esrl.noaa.gov/csd/groups/csd7/measurements/2016firex/FireLab/DataDownload/ (Password Required)

Fire Lab Data Download

Data options:

- Read about data updates (Notices)
- The Fire Lab log file contains dates and times (CO local time) of data submitted.
- The Fire Lab metadata file (V4) contains fire number, times, fuel info, and more. *(UPDATED 20170612)*
- Download a parameter for all fires.
- The DataID file contains the data IDs used in filenames, and in the data download table.
- The timewave page contains the start/stop times for each fire.

Search for fires by fuel type...

Select sample type | Select a fire fuel type | Find Fires

or enter fire number directly.

Fire number (i.e. 035) | Get Fire

FLAME-IV: Data Log

Fire001
ACES_Fire001_20161004_RA.ict 20170222 1132
FTIR_Fire001_20161004_RA.ict 20161007 1144
FTIR_Fire001_20161004_R0.ict 20170612 1544
H3OCIMS-no-ID_Fire001_20161004_RA.ict 20170509 1114
H3OCIMS-no-ID_Fire001_20161004_R0.ict 20170629 1810
H3OCIMS_Fire001_20161004_RA.ict 20161007 1647
H3OCIMS_Fire001_20161004_RB.ict 20170509 1015
H3OCIMS_Fire001_20161004_R0.ict 20170628 1446
Ny_Fire001_20161004_RA.ict 20161007 1145
Ny_Fire001_20161004_RB.ict 20161229 1356
PAXUMT_Fire001_20161004_RA.ict 20161007 1638

Fire002
ACES_Fire002_20161005_RA.ict 20170222 1133
FTIR_Fire002_20161005_RA.ict 20161007 1145
FTIR_Fire002_20161005_R0.ict 20170612 1544
H3OCIMS-no-ID_Fire002_20161005_RA.ict 20170509 1114
H3OCIMS-no-ID_Fire002_20161005_R0.ict 20170629 1810
H3OCIMS_Fire002_20161005_RA.ict 20161007 1516
H3OCIMS_Fire002_20161005_RB.ict 20170509 1015
H3OCIMS_Fire002_20161005_R0.ict 20170628 1446
MCICON_Fire002_20161005_RA.ict 20161020 1619
Ny_Fire002_20161005_RA.ict 20161007 1204
Ny_Fire002_20161005_RB.ict 20161229 1350
PAXUMT_Fire002_20161005_RA.ict 20161010 0942

Fire003
ACES_Fire003_20161005_RA.ict 20170222 1133
FTIR_Fire003_20161005_RA.ict 20161010 0934
FTIR_Fire003_20161005_R0.ict 20170612 1545
H3OCIMS_Fire003_20161005_RA.ict 20161007 1648
MCICON_Fire003_20161005_RA.ict 20161020 1620
Ny_Fire003_20161005_RA.ict 20161007 1445
Ny_Fire003_20161005_RB.ict 20161229 1350
PAXUMT_Fire003_20161005_RA.ict 20161010 0943

Fire103
CRDPASNOAA_Fire103_20161110_RA.ict 20170316 1649
InletNOAA_Fire103_20161110_RA.ict 20170224 1519
Ny_Fire103_20161110_RA.ict 20161117 1551
Ny_Fire103_20161110_RB.ict 20161229 1433

Fire104
CRDPASNOAA_Fire104_20161111_RA.ict 20170316 1649
FTIR_Fire104_20161111_RA.ict 20170612 1534
InletNOAA_Fire104_20161111_RA.ict 20170224 1519
Ny_Fire104_20161111_RA.ict 20161117 1551
Ny_Fire104_20161111_RB.ict 20161229 1433

Fire105
CRDPASNOAA_Fire105_20161111_RA.ict 20170316 1649
FTIR_Fire105_20161111_RA.ict 20170612 1534
InletNOAA_Fire105_20161111_RA.ict 20170224 1519
Ny_Fire105_20161111_RA.ict 20161117 1551
Ny_Fire105_20161111_RB.ict 20161229 1433

Fire106
CRDPASNOAA_Fire106_20161112_RA.ict 20170316 1649
FTIR_Fire106_20161112_RA.ict 20170612 1534
InletNOAA_Fire106_20161112_RA.ict 20170224 1519
Ny_Fire106_20161112_RA.ict 20161117 1551
Ny_Fire106_20161112_RB.ict 20161229 1433

Fire107
CRDPASNOAA_Fire107_20161112_RA.ict 20170316 1649
FTIR_Fire107_20161112_RA.ict 20170612 1534
InletNOAA_Fire107_20161112_RA.ict 20170224 1519
Ny_Fire107_20161112_RA.ict 20161117 1551
Ny_Fire107_20161112_RB.ict 20161229 1433

FLAME-IV: Data Search

Search for fires by fuel type...

Stack Burn | Douglas fir | Find Fires

Found 10 fires.

Fire014 | 20161008 | Show Data Download Table

The indicates files in Igor binary format.

The indicates no files will be available - contact the PI.

Download the entire data set (be patient as these files can be large and slow):

Gas Phase	
FTIR	R0
NO3CIMS	
Ny	RB
ACES	RA
H3OCIMS	R0
H3OCIMS-no-ID	R0
GCMS	
ICIMSCU	
CIMSUNC	
MC	
MCICON	RA
MCICOFF	
RN	
GCGCR	
SPE	

Aerosol	
GCGCB	
SPOT	
AMSNOAA	
DIMS	
PILSPNNL	
BrCPiLS	
BBCEAS	
CRDPASNOAA	
NEPH	
PILSESI	
FilterSampler	
PiLSUNC	
PAXUMT	RA
InletNOAA	

Smoke Proccessing
AMLGAS
PTRMS
ECHAMP
ICIMSAero
LTOFAMS
SMPS
OPC
TDCAPS

BC Intercomparison
ECOC
PAX870
AE31
microAETH
ABCD
TAP
CLAP
SMPSOSU
POPS
SP2NOAA
COOSU
CO2OSU

Mini Chamber
SPAMSMIT
AMSMIT
CAPSMIT
SP2UCD
CRDPASUCD
SEMSUCD
PASS3UCD
H3OCIMS
ICIMSCU