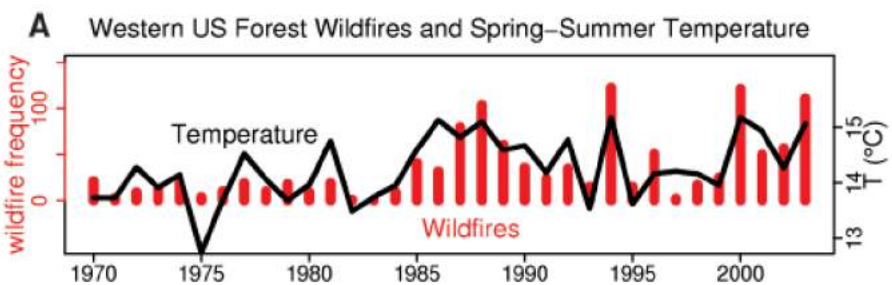
NOAA FIREX experiment

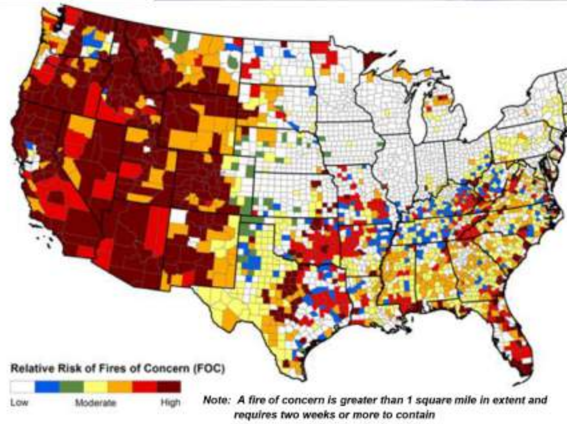
Identification of issue:
A combination of a warmer, drier climate with fire-control practices over the last century have produced a situation in which we can expect more frequent fires and fires of larger magnitude in the Western U.S. and Canada.



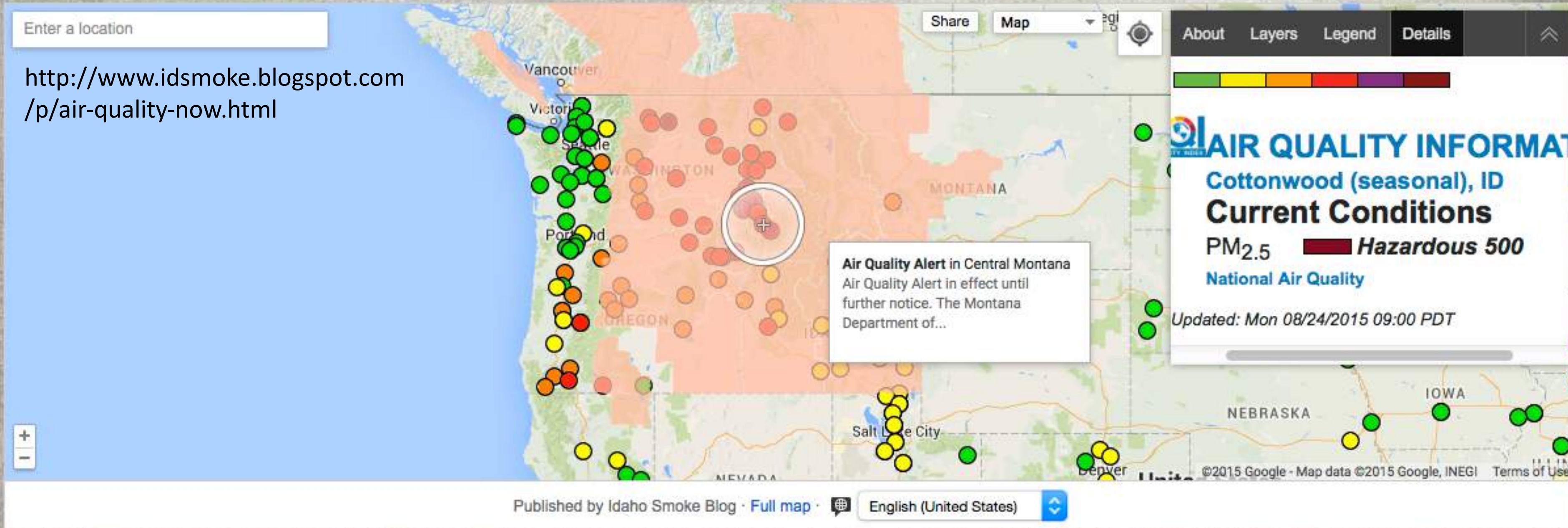
FIREX: Comprehensive Field Experiment from CIRES/NOAA ESRL Chemical Sciences Division
Contacts:
Carsten Warneke, James Roberts, Joshua Schwarz

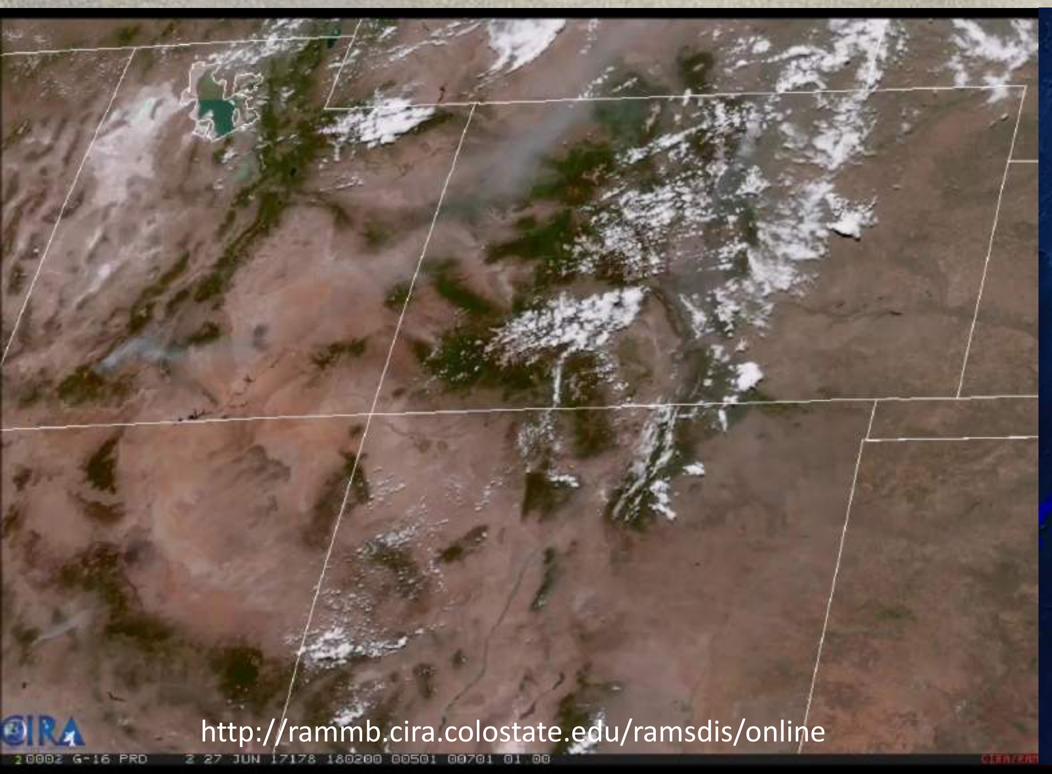
Fire **I**nfluence on **R**egional and Global **E**nvironments E**x**periment (FIREX)

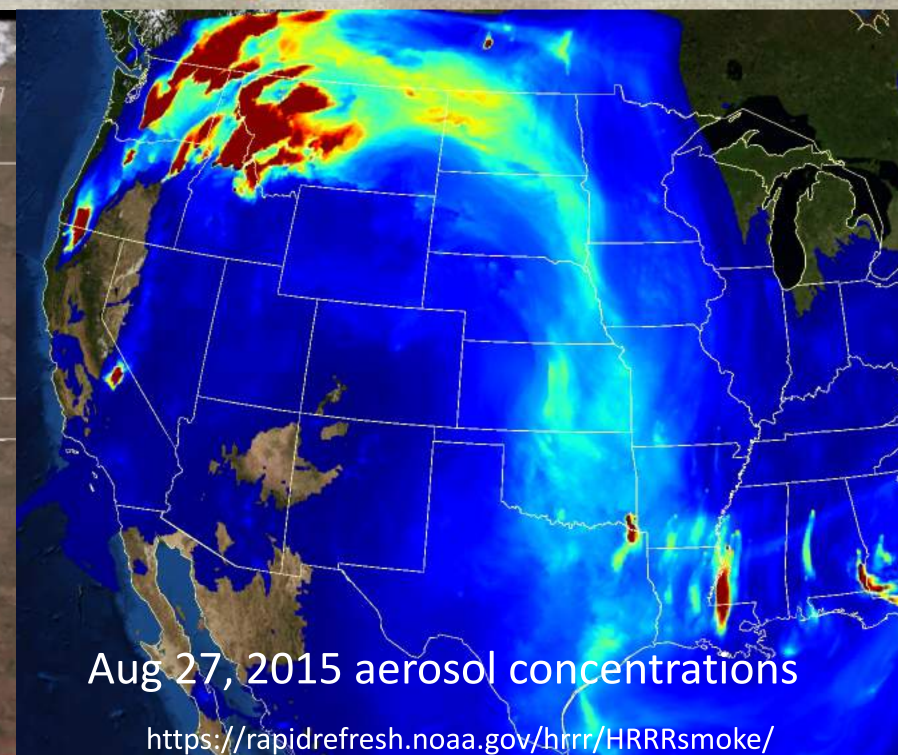
The Impact of Biomass Burning on Climate and Air Quality: An Intensive Study of Western North America Fires



NOAA Field and Laboratory Studies during 2015-2019


http://www.idsmoke.blogspot.com
/p/air-quality-now.html
Enter a location
Share
Map
About
Layers
Legend
Details
AIR QUALITY INFORMAT
Cottonwood (seasonal), ID
Current Conditions
PM2.5
Hazardous 500
National Air Quality
Updated: Mon 08/24/2015 09:00 PDT
Air Quality Alert in Central Montana
Air Quality Alert in effect until
further notice. The Montana
Department of...
Vancouver
Victoria
Portland
WASHINGTON
MONTANA
OREGON
NEBRASKA
IOWA
Salt Lake City
Denver
©2015 Google - Map data ©2015 Google, INEGI
Terms of Use
Published by Idaho Smoke Blog · Full map ·
English (United States)


http://rammb.cira.colostate.edu/ramsdis/online


Aug 27, 2015 aerosol concentrations
https://rapidrefresh.noaa.gov/hrrr/HRRRsmoke/

Outline

1) Planned FIREX activities and timing
2) Platforms and sites
3) JFSP FASMEE, NASA FIRE-Chem and WE-CAN
4) First results of FIREX:

Missoula Fire Lab: Oct 1- Nov 15 2016

NOAA Chemical Sciences Division: Who we are and what do we do

Provide the needed scientific understanding and information about our atmosphere to make optimal decisions in the interests of the well being of current and future generations.

Over 100 scientists working on: Air Quality, Climate Change, Ozone Hole
with
modeling, laboratory and small and large scale field work

Recent field work: Oil&Gas, urban air quality, anthropogenic/biogenic emissions and trends

Main FIREX Science Questions in 5 Categories

1) What are the emissions of gases, aerosols, aerosol precursors, air toxics and greenhouse gases from North American fires?

   What is the composition and volatility of the previously unidentified fraction of the emissions?

2) What is the chemical transformation of those emissions?

   What are the formation mechanisms for secondary species (ozone, SOA and sulfate)?

3) What is the local air quality and visibility impact of North American fires?

   How important is nighttime smoke for populated areas?

   How well do local air quality forecast models work?

4) What are the regional and long-term impacts of North American fires on climate?

5) What are the climate-relevant properties of BB aerosols?

   What role does brown carbon and coatings on black carbon particles play in the optical properties?

   What is the composition of PM2.5?

Main FIREX Science Questions in 5 Categories

1) What are the emissions of gases, aerosols, aerosol precursors, air toxics and greenhouse gases from North American fires?

Detailed Science Questions in White Paper

available at: http://esrl.noaa.gov/csd/projects/firex/

Additions from FIRE-Chem, WE-CAN and FASMEE!!!

4) What are the regional and long-term impacts of North American fires?

5) What are the climate-relevant properties of BB aerosols?
- What role does brown carbon and coatings on black carbon particles play in the optical properties?
- What is the composition of PM2.5?

New science of FIREX

1. New instrumentation and satellites
2. Comprehensive effort with large science community using ground, mobile, laboratory and aircraft and modeling/forecasting
3. Simultaneously deployments of platforms
4. Nighttime fires and smoke
5. Years building knowledge before large field experiment
6. Transfer new knowledge to partners outside US

Collaborations of FIREX

Aircraft:

- NASA DC 8: FIRE-Chem
- NASA B200: FIRE-Chem
- NCAR/NSF C130: WE-CAN

Mobile Labs:

- NOAA CSD
- Aerodyne

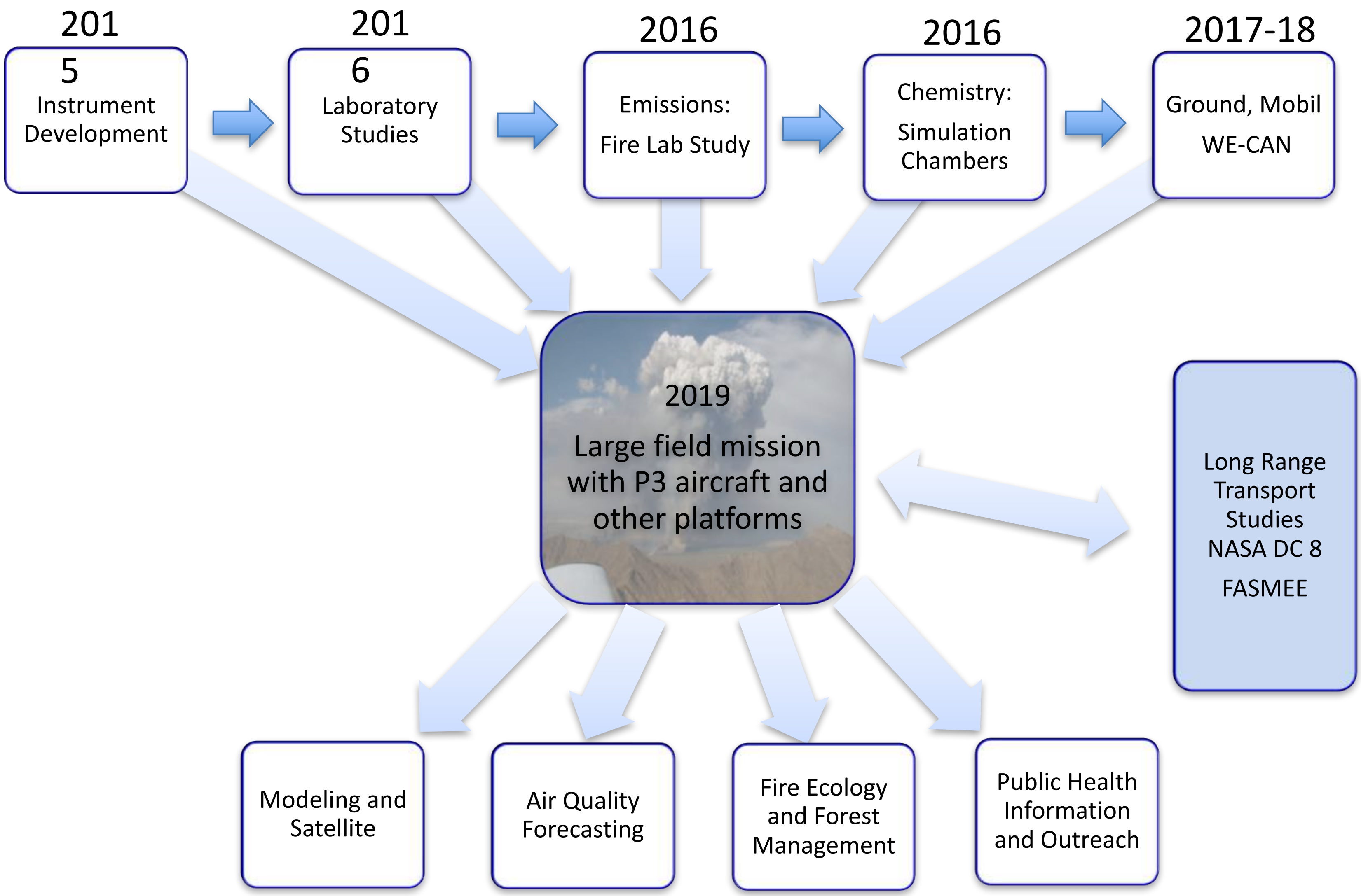
Joint Fire Science Program: FASMEE project

- several controlled burns in 2018-2021

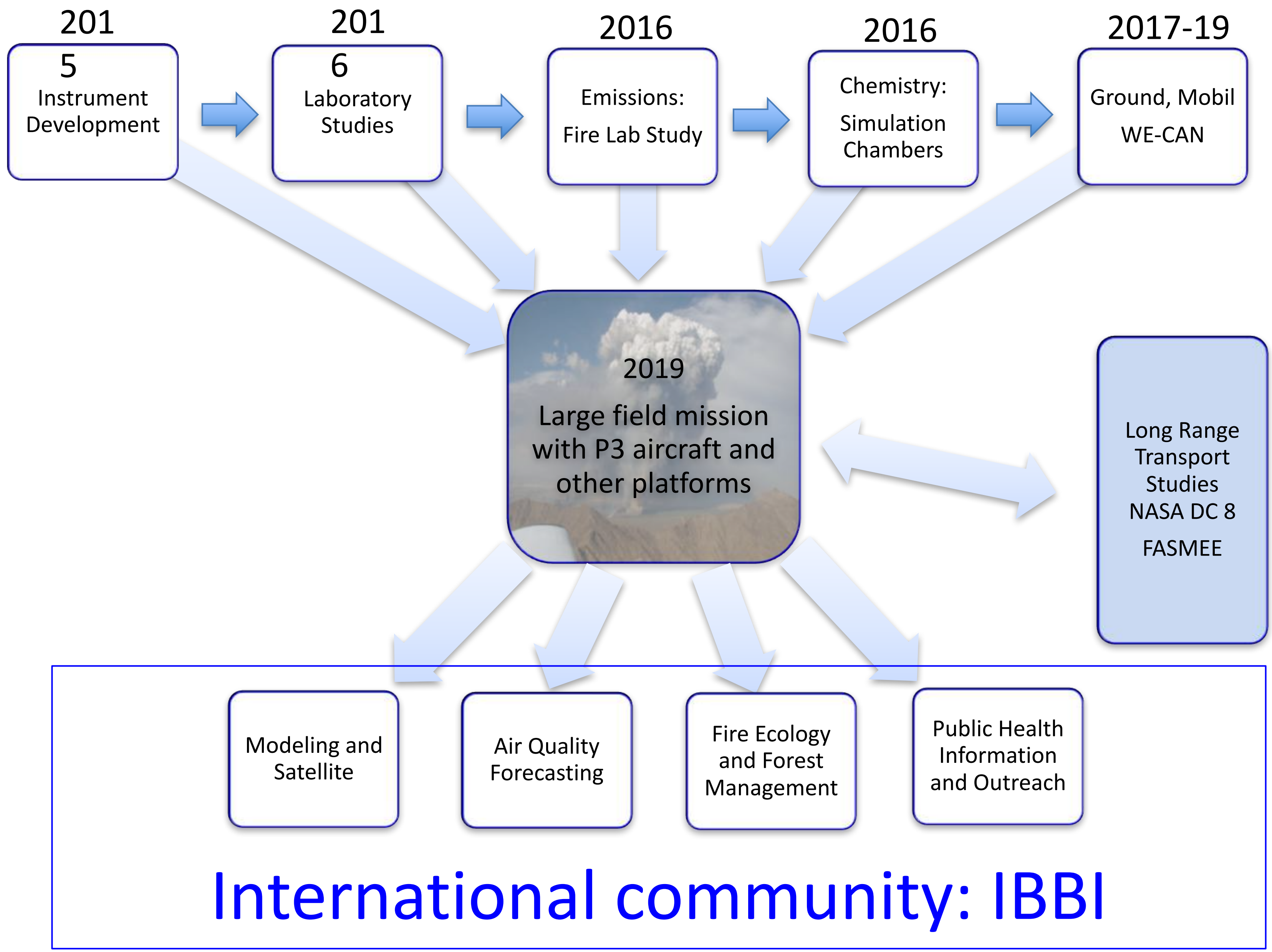
Ground and Lab (TBD/potentially)

IBBI/IGAC

FIREX workflow chart



FIREX workflow chart



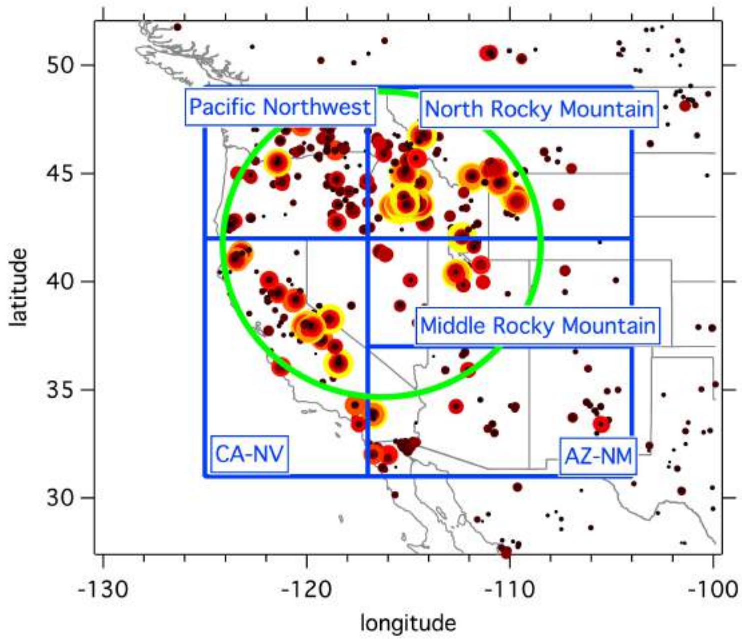
NOAA CSD FIREX Management
Points of Contact:
Carsten Warneke, James Roberts, Joshua Schwarz

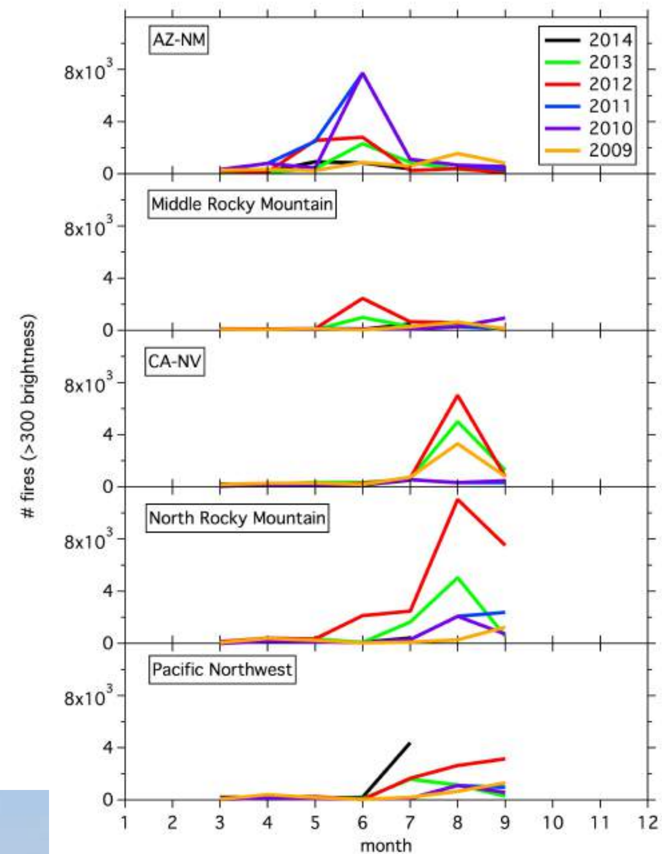
Carsten Warneke[1,2]	NOAA WP-3D gas phase measurements
James M. Roberts[1]	Fire Lab study, field observations with mobile labs
Joshua P. Schwarz[1]	NOAA WP-3D aerosol measurements
Robert J. Yokelson[3]	Fire Lab study, field observations
R. Bradley Pierce[4]	Modeling, data assimilation, and satellites
Barry Lefer[5]	FIREChem coordination
James H. Crawford[6]	FIREChem coordination
Kirk R. Baker[7]	EPA and FASMEE coordination
Amy P. Sullivan[8]	NSF/NCAR C130 coordination

NOAA ESRL Chemical Sciences Division, Boulder, CO
Cooperative Institute for Research in the Environmental Sciences (CIRES), University of Colorado, and NOAA, Boulder, CO
Department of Chemistry, University of Montana, Missoula, MT
NOAA NESDIS Center for Satellite Applications and Research (STAR), Cooperative Institute for Meteorological Satellite Studies, Madison, WI
NASA Earth Science Division, Tropospheric Composition Program, Washington, DC
NASA Science Directorate, Chemistry and Dynamics Branch, Langley Research Center, Hampton, VA
U.S. Environmental Protection Agency, Research Triangle Park, NC
Department of Atmospheric Science, Colorado State University, Fort Collins, CO

NOAA AC4 support of FIREX for several research groups
and coordination with other funding agencies

NOAA WP-3 aircraft in fire season 2019



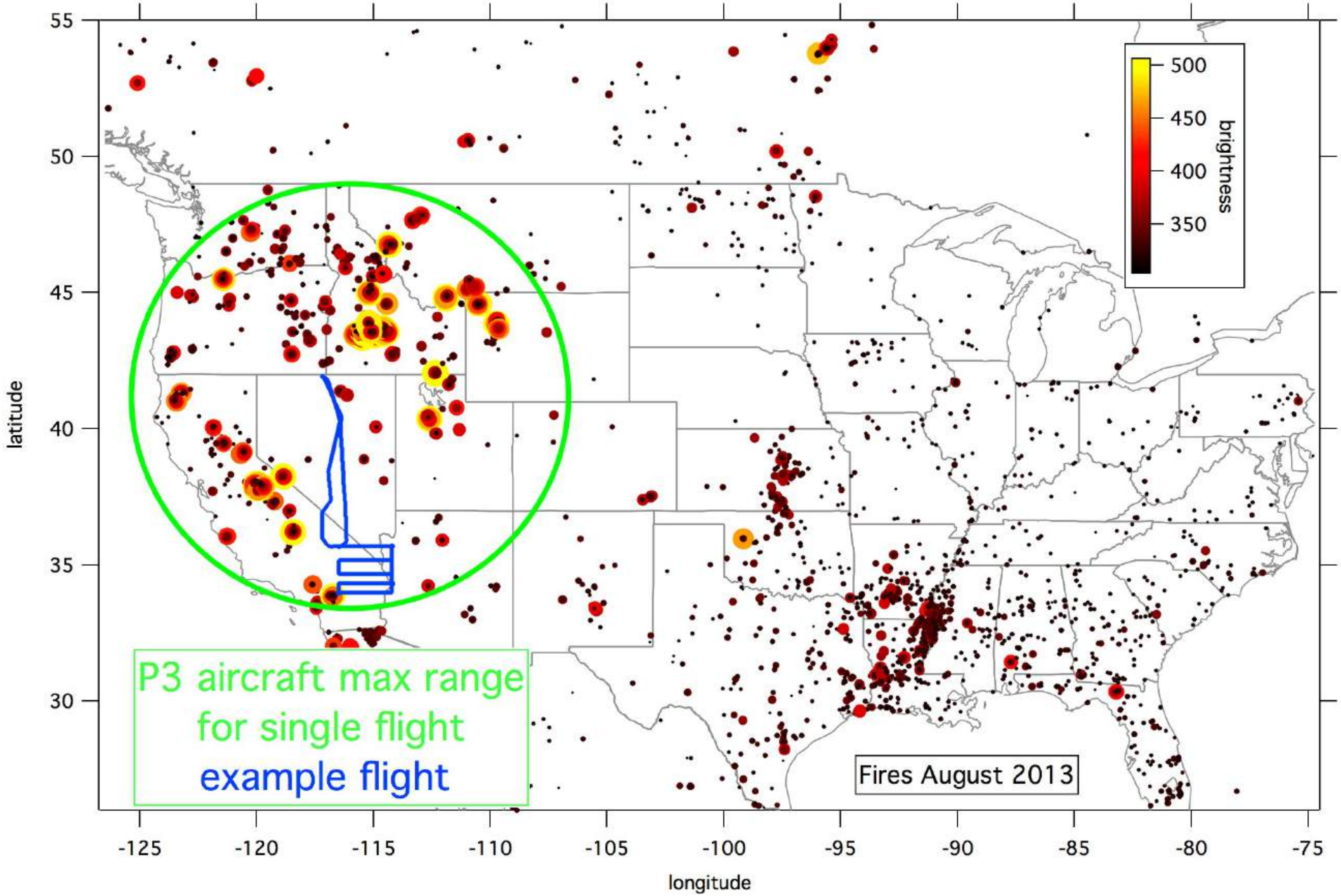


There have always been fires in the NW U.S. in range of the NOAA WP-3 aircraft in summer.

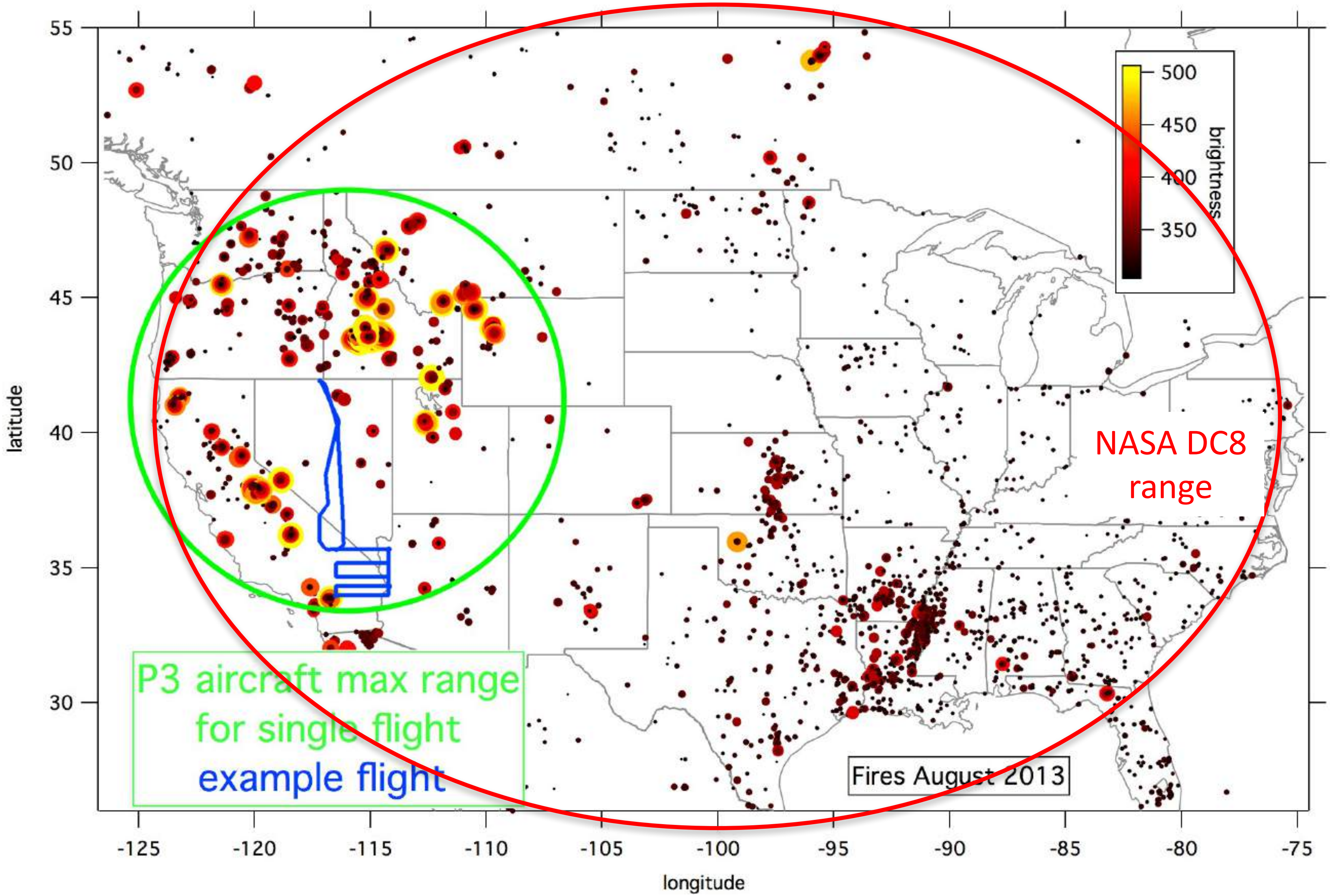
Highly instrumented aircraft used by NOAA CSD since 25 years

often used for hurricane research

NOAA WP-3 aircraft in fire season 2019



NOAA WP-3 aircraft in fire season 2019



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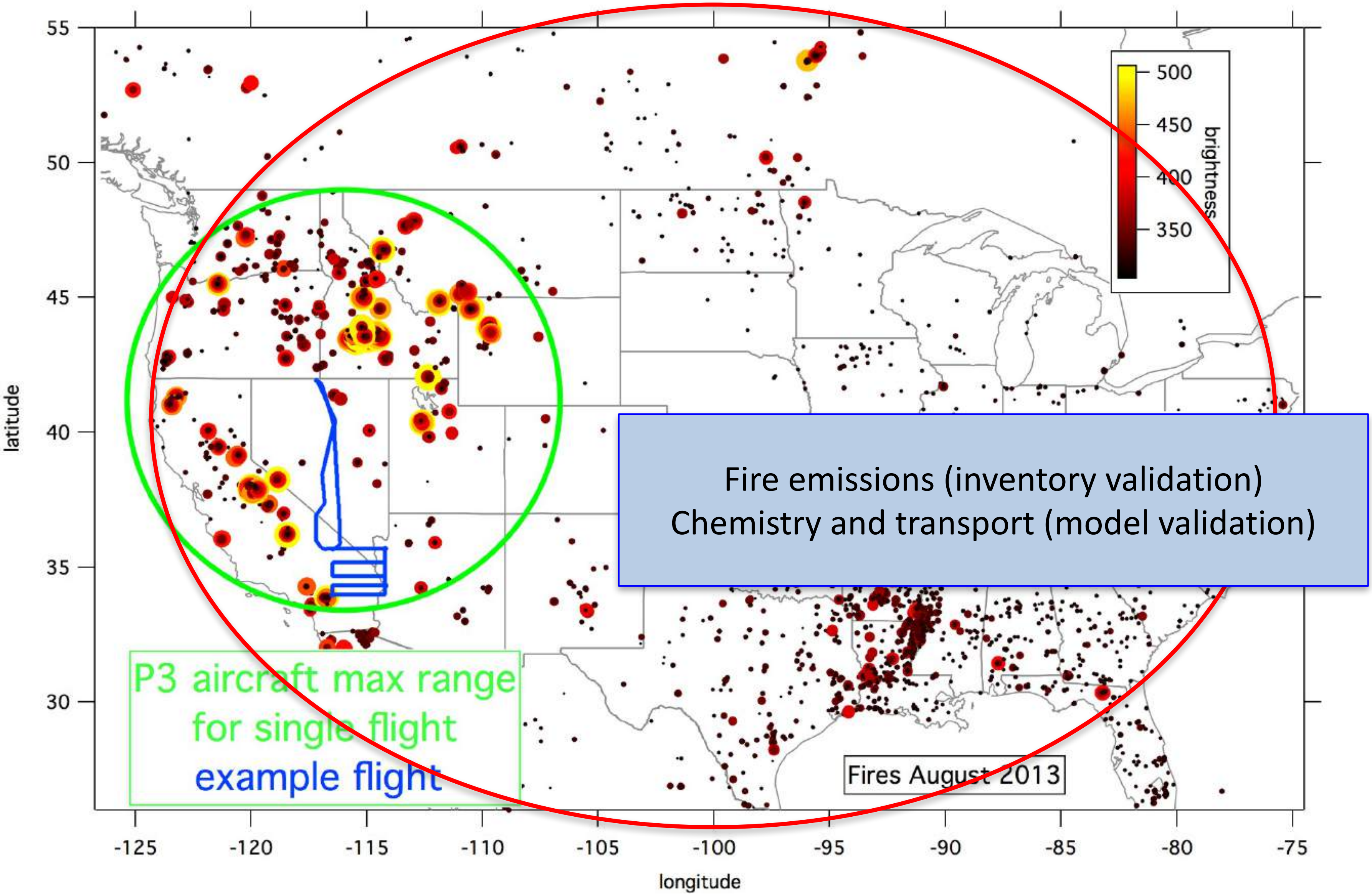


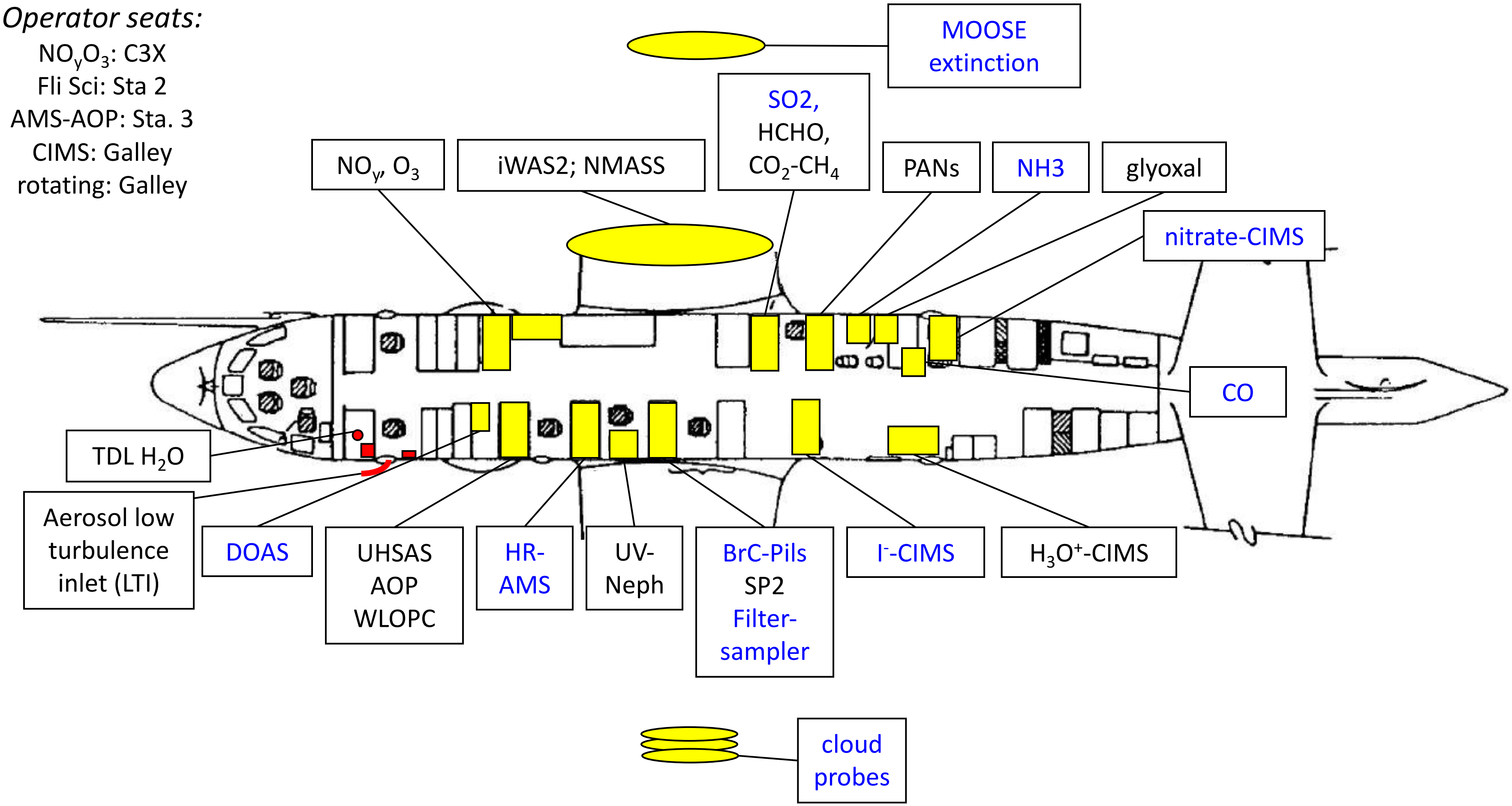
Fire emissions (inventory validation)
Chemistry and transport (model validation)

N43RF Payload- FIREX 2019

NOAA-CSD preliminary version08 06-20-2017

Operator seats:

NO_yO_3: C3X
Fli Sci: Sta 2
AMS-AOP: Sta. 3
CIMS: Galley
rotating: Galley



Tentative Instrument List NOAA P3 2019

on	Abbreviation	Full name	Description	PI	Affiliation
)	TDL H_2O	Tunable Diode Laser water vapor	water vapor using open-path fast-response tunable diode laser absorption spectrometer	Dana Naeher	NOAA/AOC
)	LTI	Low Turbulence Inlet	decelerating inlet to provide sample air to aerosol instruments in fuselage	Chuck Brock	NOAA/ESRL
) &	WLOPC	White-Light Optical Particle Counter	supermicron aerosol number and sizes; samples from LTI	Chuck Brock	NOAA/ESRL
d	DOAS	Column NO_2, HONO, HCHO, O_3, SO_2	trace gas columns 20km ahead of the aircraft	Jochen Stutz	UCLA
	CRD-AES	Cavity RingDown-Aerosol Extinction Spectrometer	total dry aerosol light extinction and extinction as f(RH); samples from LTI	Nick Wagner	NOAA/ESRL
	PSAP	Particle Soot Absorption Photometer	total aerosol light absorption by filter darkening; samples from LTI	Nick Wagner	NOAA/ESRL
	PAS	Photoacoustic Absorption Spectrometer	total aerosol light absorption by photoacoustics; samples from LTI	Nick Wagner	NOAA/ESRL
	UHSAS	Ultrahigh Sensitivity Aerosol size Spectrometer	counts and sizes 0.07-1.0 μm aerosol particles; samples from LTI	Chuck Brock	NOAA/ESRL
	HR-AMS	High resolution Aerosol Mass Spectrometer	Size resolved chemical composition of aerosol particles	Ann Middlebrook Katherine Hayden	Environ. Canada NOAA/ESRL
X	$NO/NO_2/NO_y/O_3$	Nitrogen oxides and ozone	chemiluminescence detection with photolytic or catalytic conversion	Chelsea Thompson, Tom Ryerson	NOAA/ESRL
	SP2	Single-Particle Soot Photometer	soot particles number, size, and coating	Joshua Schwarz	NOAA/ESRL
	BrC-Pils	BrownCarbon-Particle into liquid sampler	absorption and concentration of water-soluble organic carbon	Rebecca Washenfelder	NOAA/ESRL
	Filter samples	Filter samples for I/SVOCs	GCxGC/TOF-MS (EI) and LC/MC	Kelley Barsanti Lindsay Hatch	UC Riverside
	j-values	Filter Radiometers	j_{NO2} and j_{ozone} using filter radiometers	Chelsea Thompson	NOAA/ESRL
	ISAF HCHO	In-situ airborne formaldehyde	formaldehyde (HCHO) using laser-induced fluorescence	Glenn Wolfe, Thomas Hanisco	NASA GSFC
	CH_4, CO_2	Picarro CH_4, CO_2	CO_2 and methane with IR laser absorption in a high-finesse cavity	Jeff Peischl, Tom Ryerson	NOAA/ESRL
	SO_2	Sulfur dioxide	SO_2 using laser-induced fluorescence	Andrew Rollins	NOAA/ESRL
	PAN CIMS	PeroxyAcyl Nitrate CIMS	PANs using chemical ionization mass spectrometry with I^- as reagent ion	Patrick Veres	NOAA/ESRL
	NH_3	QC-TILDAS ammonia	ammonia using Quantum Cascade Tunable Infrared Laser Differential Absorption Spectroscopy	Jennifer Murphy	University of Toronto
	ACES	Airborne Cavity Enhanced Spectrometer	Glyoxal using Cavity Enhanced Absorption Spectroscopy	Kyle Zarzana, Steve Brown	NOAA/ESRL
	CO, H2O	Los Gatos CO	cavity enhanced absorption technique in high-finesse	Jeff Peischl	NOAA/ESRL

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Detailed instrument list/information
available at: http://esrl.noaa.gov/csd/projects/firex/

Phase 1 of FIREX
Missoula USFS Fire Science Lab
Oct 1- Nov 15 2016

Detailed smoke emission characterization in a controlled environment

First Results

Over 60 people from 20 institutions in Missoula!
9 NOAA funded projects

AMS
ACES
FTIR, PAX

I-CIMS
NO3-CIMS
Samplers

Samplers:
Gas: GCxGC-ToF-MS (EI)
Particle: GCxGC-ToF-MS (VUV)
DI-MS, PILS

Wind Tunnel:

Mini Chamber:	HR-AMS SP-HR-AMS CAPS, PASS CRD-PAS, SP2 CO, CO2, O3
Mixing Drum for BC and BrC:	SP2, CLAP, POPS PAX, SMPS WSOC-PILS

Burn Room

Room Burns:
BrC-PiLS
BBCEAS
CRDPAS
NEPH

Control Room:
H3O+CIMS
I-CIMS
PAM
GC-MS

Viewing Room:
PILS-ESI
Ny, NO, sampler

CSU Chamber

I-CIMS

Aerodyne Lab:
LToF-AMS
PTR-MS
ECHAMP
PAM
CO, CO2, NOx, HCHO, CH4, C2H6, C3H8, ..

Fuels:
- Ponderosa Pine and Lodgepole Pine
- Subalpine Fir and Douglas Fir
- Engelmann Spruce
- Chaparral: Manzanita and Chamise
- FASMEE: Subalpine Fir, Ft Stuart
- additional fuels from SE US, peat, dung, sage, excelsior

Emission factors (EF) for over 100 fires

Conditions:
- realistic with duff, litter, logs and canopy of NW US fuels
- separated burns for duff, litter, logs and canopy
- N-content and BC/BrC ratio variation

Stack burns for emissions

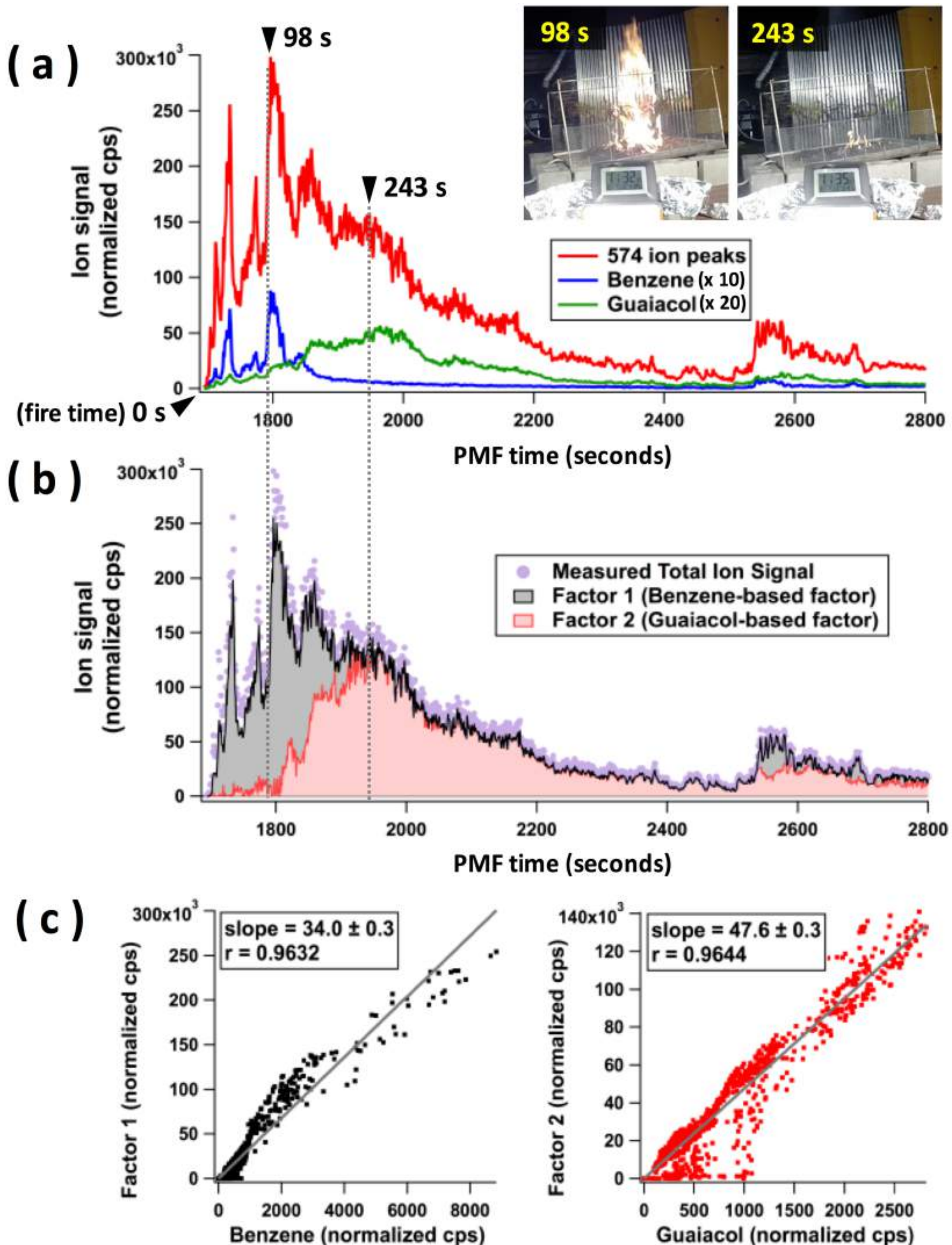
Room burns for detailed smoke characterization

Smoke aging in simulation chambers

→ Most detailed smoke, emissions and chemistry characterization to date

Example: Volatile Organic Compounds (VOCs) with H3O+CIMS

- Different fire stages
- Different fuels



Flaming versus Smoldering from Ponderosa Pine

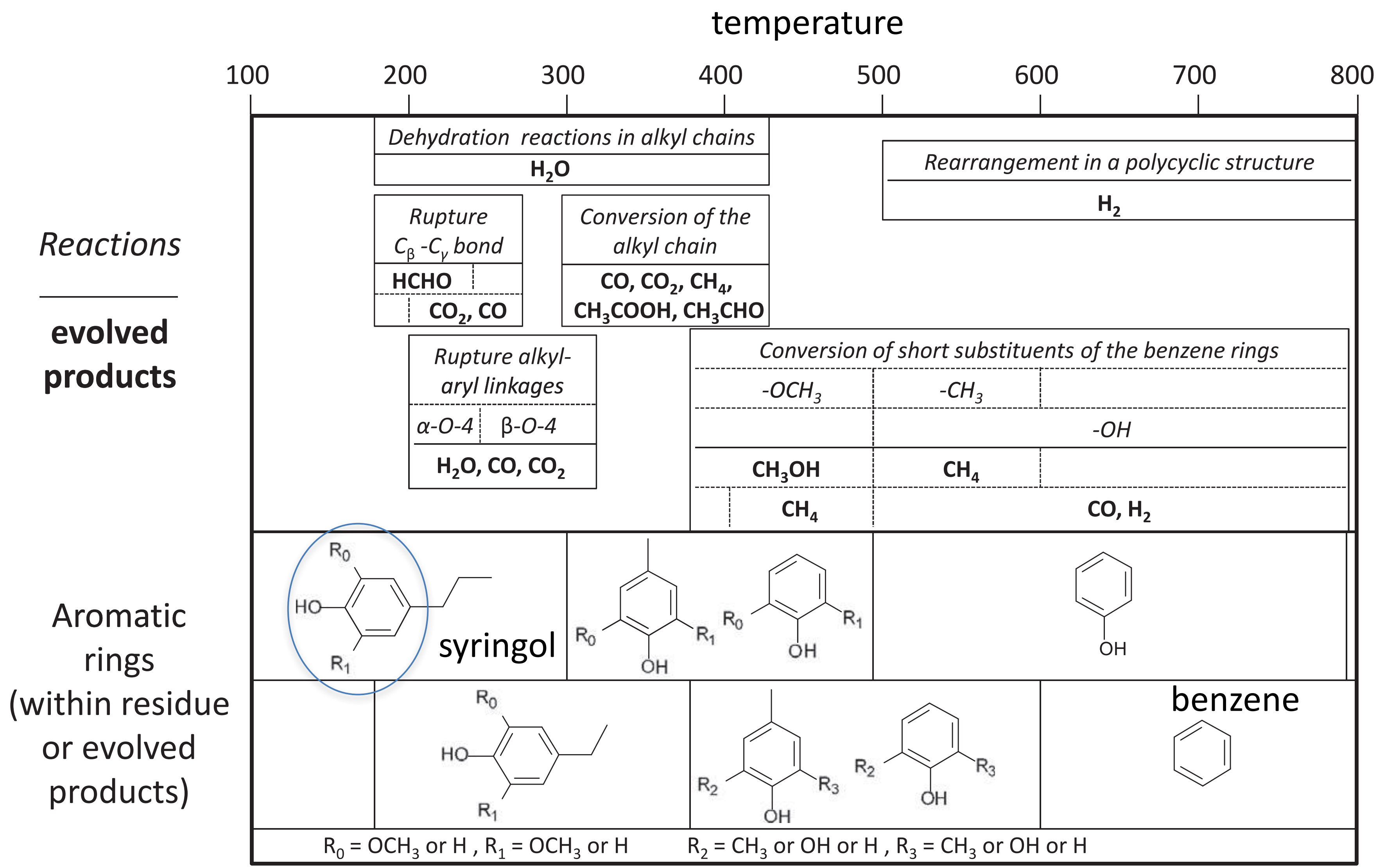
Example: Volatile Organic Compounds (VOCs) with H3O+CIMS

- Instrument detects VOCs by proton-transfer with H_3O^+
- >500 compounds detected

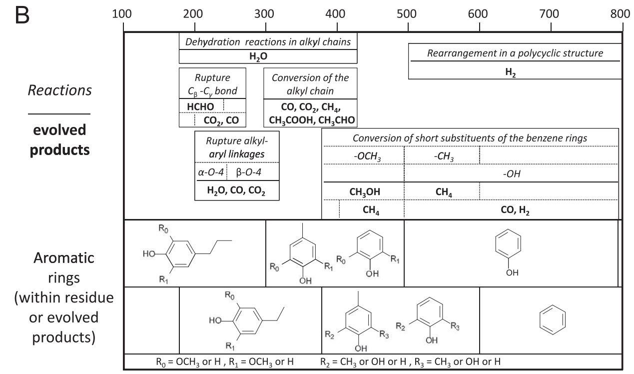
Positive Matrix Factorization statistical method determining contributions of compounds to the fire stages

Different compounds are emitted at different temps.

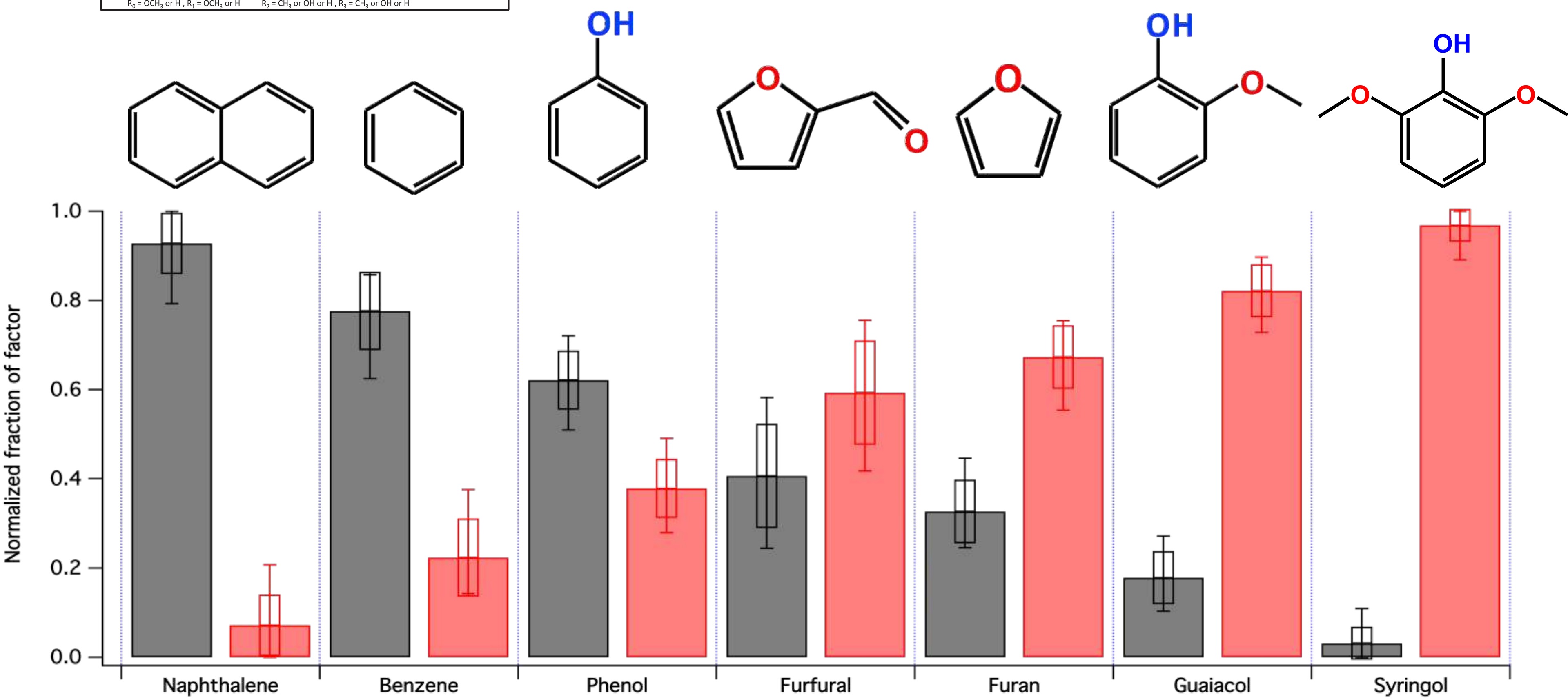
Products from Lignin Pyrolysis



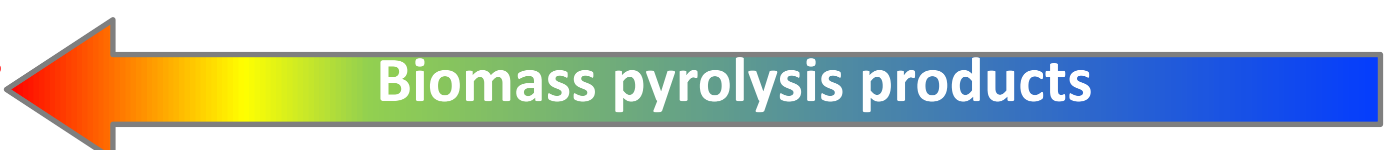
Collard and Blin [2014]



Products from Lignin Pyrolysis



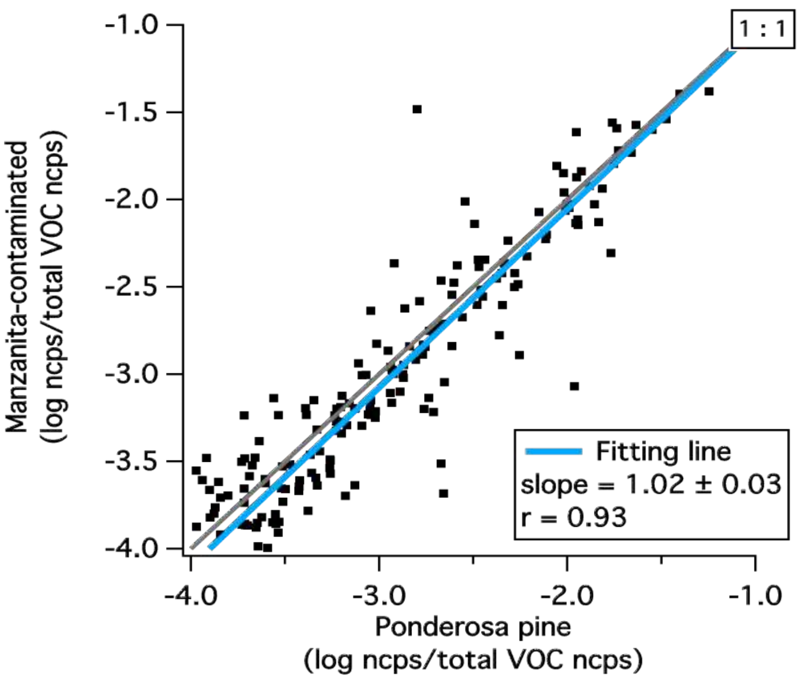
High temp. (~ 850 ℃)



Low temp. (~ 200 ℃)

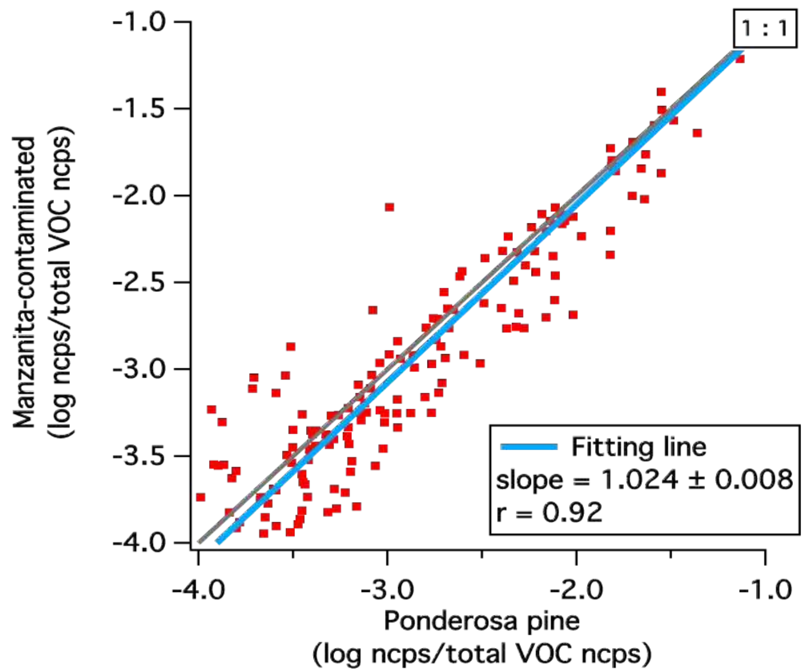
Ponderosa Pine versus Manzanita

Manzanita



Ponderosa pine

<u>**High-temperature**</u>



Ponderosa pine

<u>**Low-temperature**</u>

Different fuels emit similar compounds at similar temperatures

Special thanks to NOAA AC4 for funding!

More FIREX details and list of partners

available at: http://esrl.noaa.gov/csd/projects/firex/

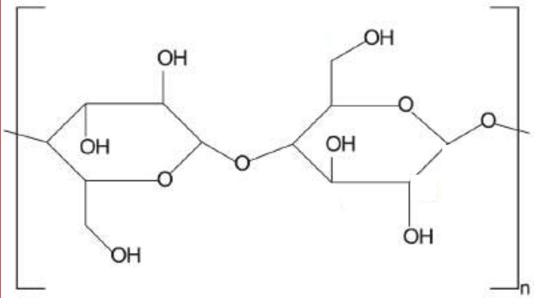
Please contact me for any FIREX related questions

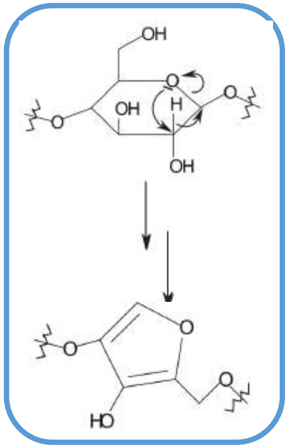
and potential collaborations!!!

Special thanks to NOAA AC4 for funding!

Many important VOCs we observe in fires reflect the polymer components of biomass

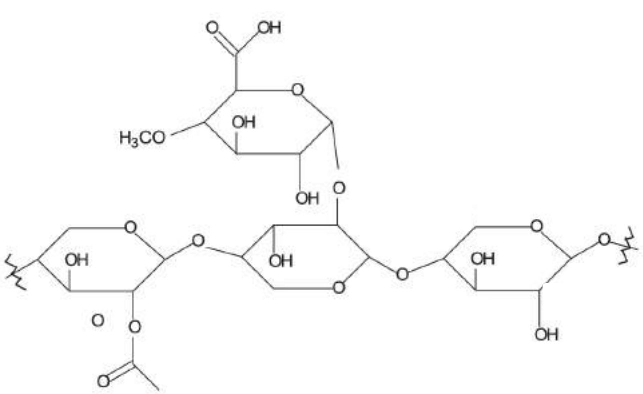
Cellulose



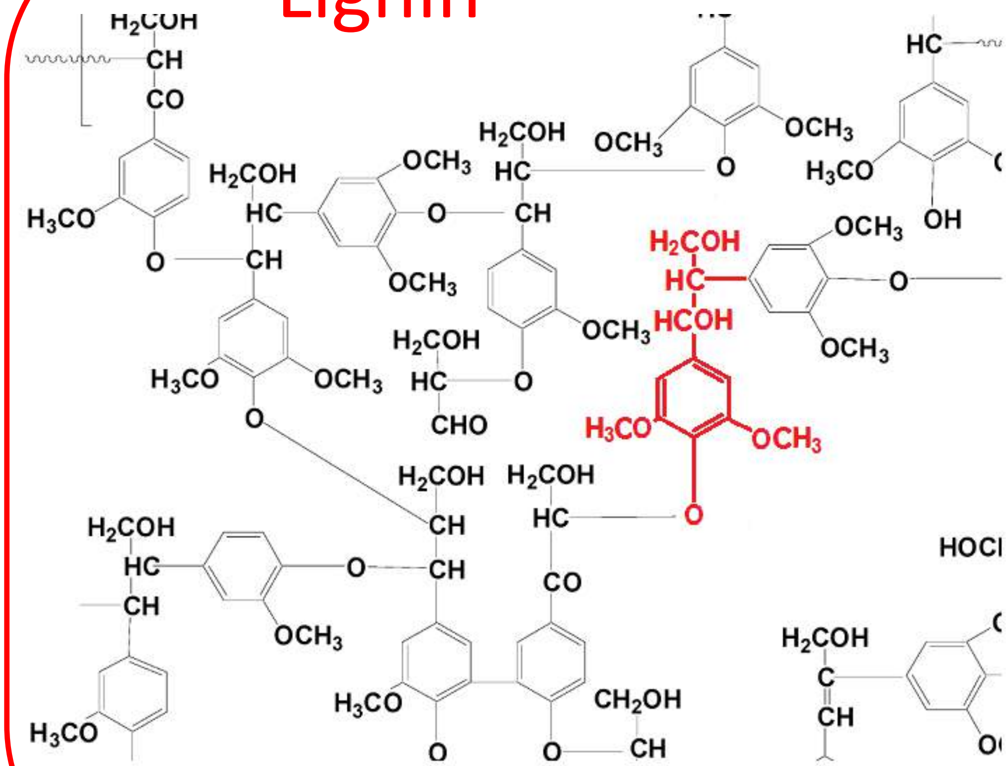


Collard & Blin, Renew. & Sust. Energy Rev. (2014)

Hemicellulose



Lignin



Mohan et al., Energy & Fuels (2006)