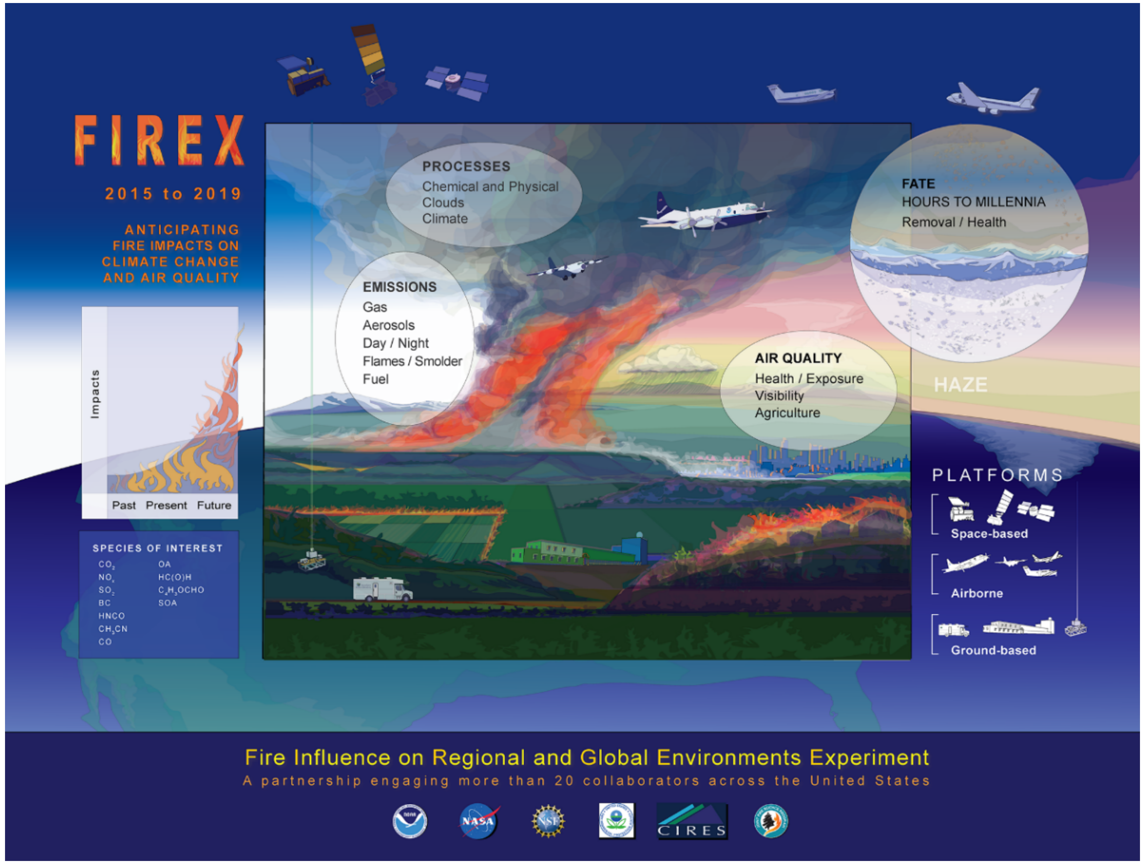
FIREX-AQ

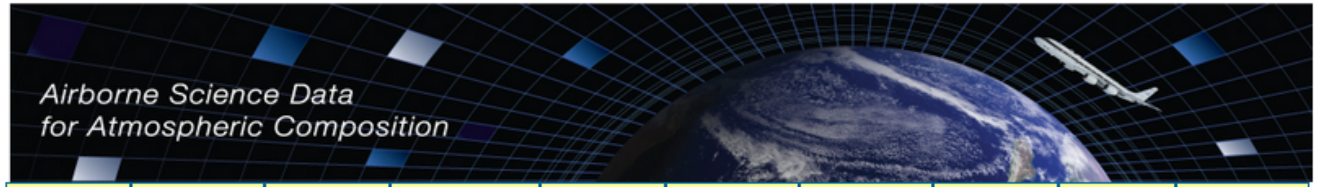
Fire Influence on Regional and Global Environments and Air Quality

~ July – August 2019

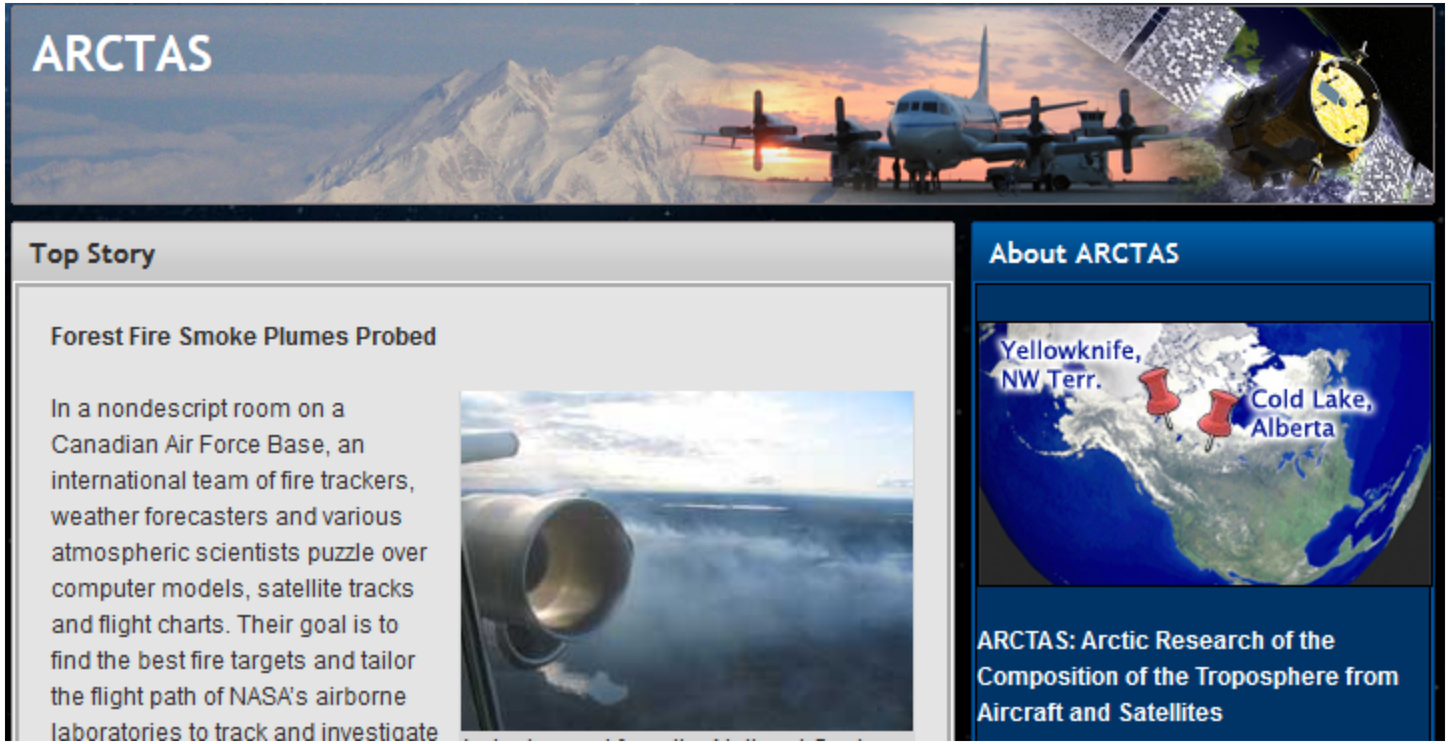
Partners



The ***Tropospheric Composition Program*** **(TCP)** seeks to improve the utility of satellite measurements in understanding of global tropospheric ozone and aerosols, including their precursors and transformation processes in the atmosphere. Ozone and aerosols are fundamental to both air quality and climate.



NASA Transport and Chemical Evolution over the Pacific (TRACE-P)



INTEX-NA aimed to understand the transport and transformation of gases and aerosols on transcontinental & intercontinental scales and assess their impact on air quality and climate. The primary constituents of interest are ozone and its precursors, aerosols and precursors, and the long-lived greenhouse gases.

FIREX-AQ Objectives

FIREX-AQ flights will contribute to the planned interagency collaboration in three areas:

1 – Sampling of wildfires with multiple coordinated aircraft

This will be the first priority, providing unprecedented detail in the sampling of fire emissions at the point of emissions, their chemical evolution downwind, and impacts on air quality.

2 – Sampling of medium to small fires to build statistics

Sampling as many fires as possible to assess variability in emission factors and fuels, plume rise, satellite detection, and integrated impacts. Accomplishing this goal requires liaison with state and local authorities to anticipate when and where to expect burning.

3 – Sampling of any large prescribed burns if scheduled

This objective provides the best chance for bridging laboratory and ambient conditions and takes priority when burns are announced.

FIREX-AQ Science Questions

1) What are the emissions of gases and aerosols from North American fires?

Will require observations at the point of emission, and to the greatest extent possible, information on the fuel conditions, fire intensity, and fire weather

2) What chemical transformations affect those emissions?

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

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

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

6) How can satellite measurements help with #1-5?

FIREX-AQ Science Questions

1) What are the emissions of gases and aerosols from North American fires?

2) What chemical transformations affect those emissions?

These will be facilitated by in-situ observations of unprecedented detail for gas and aerosol phase composition

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

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

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6) How can satellite measurements help with #1-5?

FIREX-AQ Science Questions

1) What are the emissions of gases and aerosols from North American fires?

2) What chemical transformations affect those emissions?

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

Fires with forecasted plumes that intersect populated areas will be a priority

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

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

6) How can satellite measurements help with #1-5?

FIREX-AQ Science Questions

1) What are the emissions of gases and aerosols from North American fires?

2) What chemical transformations affect those emissions?

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

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

Answering this question will rely on integrating observations with models to test model representation of fire impacts

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

6) How can satellite measurements help with #1-5?

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

Observations will enable an assessment of aerosol optical properties and the impact of aging on smoke composition and the spectral dependence of absorption and scattering

6) How can satellite measurements help with #1-5?

FIREX-AQ Science Questions

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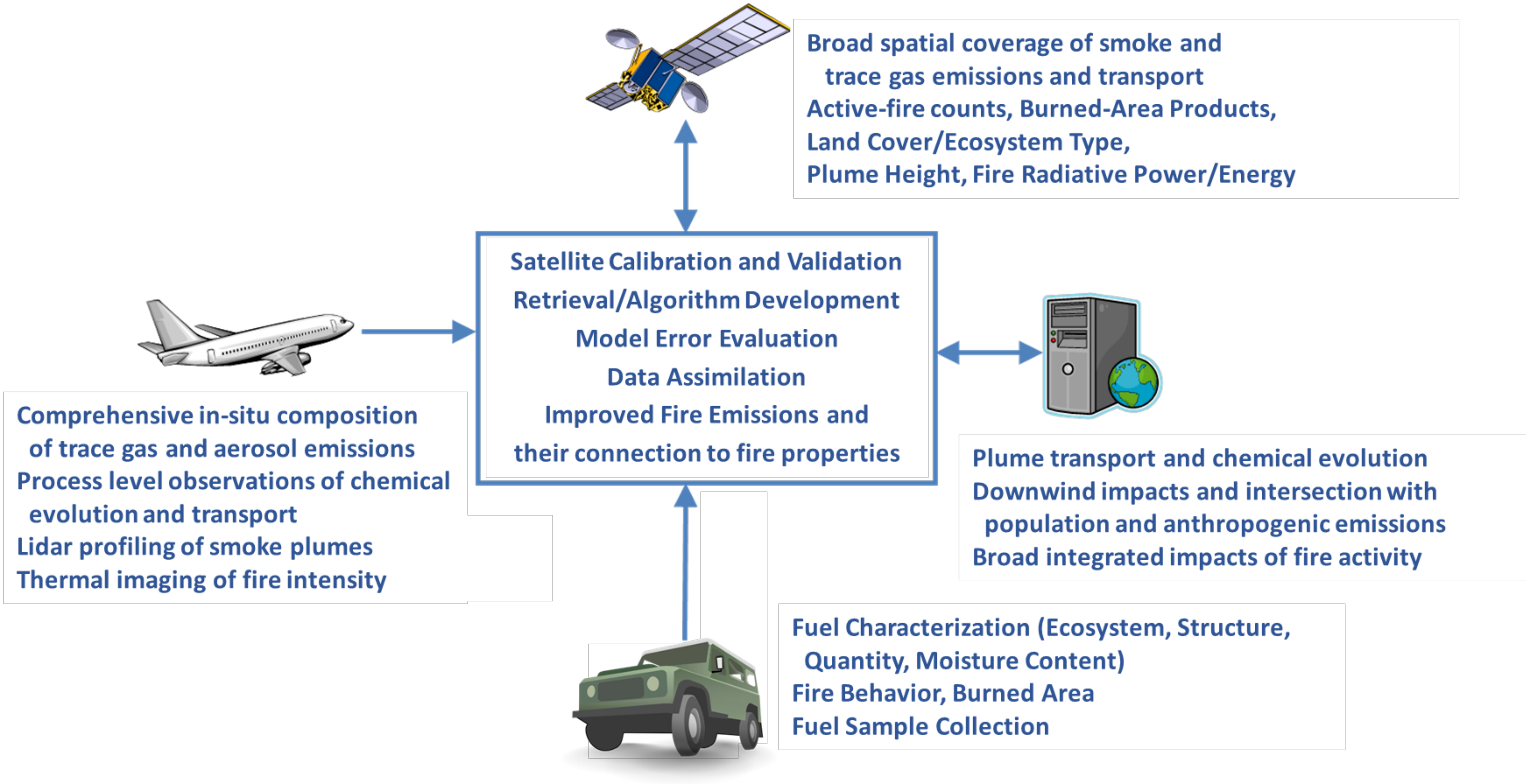
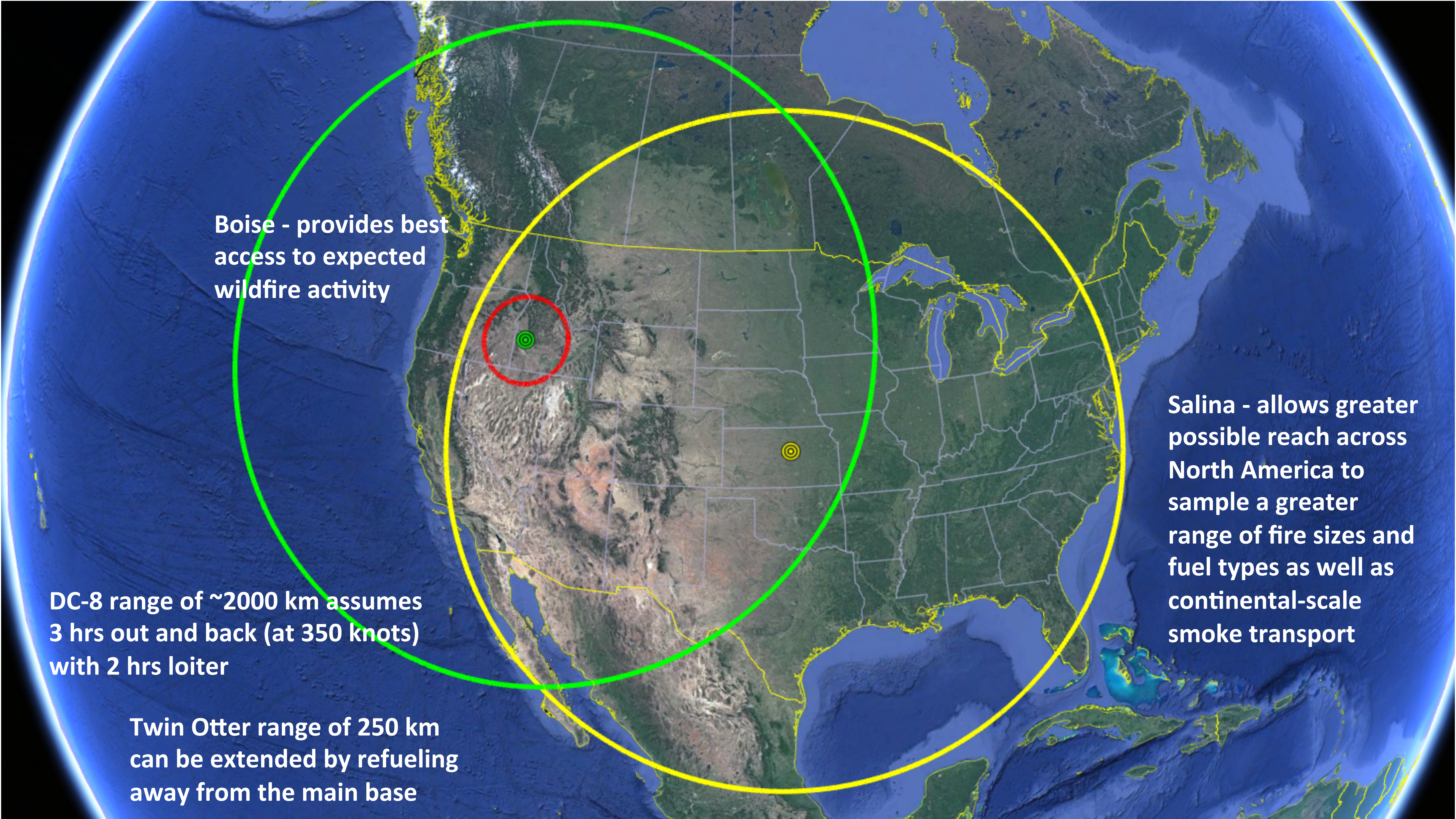
Direct observation of fires will support assessment of satellite information relating to fire detection, plume height, fire radiative power, and derivation of emissions from satellite observations.

FIRE-Chem seeks to inform integrated observing strategies.




Boise - provides best access to expected wildfire activity
Salina - allows greater possible reach across North America to sample a greater range of fire sizes and fuel types as well as continental-scale smoke transport
DC-8 range of ~2000 km assumes 3 hrs out and back (at 350 knots) with 2 hrs loiter
Twin Otter range of 250 km can be extended by refueling away from the main base

Details are tentative:

Dates: July – early September 2019

Location: Salina, Kansas and Boise, Idaho

Research Platform: NASA DC-8

Example: DC-8 Measurement Requirements and Priorities

Gas Phase In Situ	Priority	Detection Limit	Required Resolution	Desired Resolution
O_3	1	1 ppbv	1 s	5 Hz
H_2O*	1	10 ppmv	1 s	5 Hz
CO*	1	5 ppbv	1 s	5 Hz
CH_4*	1	10 ppbv	1 s	5 Hz
C_2H_6	1	50 pptv	1 s	5 Hz
CO_2*	1	0.1 ppm	1 s	5 Hz
NMHCs	1	<10%	1 min (full suite)	5 Hz (selected species)
NO	1	10 pptv	1 s	5 Hz
NO_2	1	20 pptv	1 s	5 Hz
HCHO*	1	50 pptv	1 s	5 Hz
CH_3CN	1	10 pptv	1 s	5 Hz
HCN	2	10 pptv	1 s	-
NH_3	2	30 pptv	1 s	-
HONO	2	50 pptv	1 s	-
Organic Acids	2	10 pptv	10 s	1 s
H_2O_2	2	50 pptv	10 s	1 s
ROOH	2	50 pptv	10 s	1 s
NOy	2	50 pptv	1 s	5 Hz
HNO_3	2	50 pptv	10 s	1 s
PANs	2	50 pptv	10 s	1 s
$RONO_2$	2	50 pptv	10 s	1 s
SO_2	2	10 pptv	1 s	-
OH reactivity	2	1 s^{-1}	10 s	1 s
OH, HO_2, RO_2	2	0.01/0.1/0.1 pptv	30 s	1 s
Halocarbons	3	Variable	1 min	-
N_2O*	3	1 ppbv	1 s	-

Aerosol In Situ	Priority	Detection Limit	Required Resolution	Desired Res.
Particle Number*	1	NA	1 s	5 Hz
Size Distribution (10 nm-5 µm)*	1	NA	10 s	1 s
Volatility*	1	NA	1 s	5 Hz
Scattering*	1	1 Mm^{-1}	1 s	-
Scattering Phase Function	1	3 Mm^{-1}	5 s	-
Hygroscopicity*	1	NA	10 s	1 s
Absorption*	1	0.2 Mm^{-1}	10 s	-
Brown Carbon Absorption	1	1 Mm^{-1}	per plume	30 s
Size-resolved Composition	1	100 ng m^{-3}	1 s	-
Organic mass	1	100 ng m^{-3}	10 s	1 s
Black Carbon	1	50 ng m^{-3}	1 s	5 Hz
Bulk Composition	2	50 ng m^{-3}	per plume	-
Single particle Composition	2	<4 µm dia.	1 s	-
CCN/IN	2	<4 µm dia.	1 s	-
Cloud particle size dist.*	2	0.05-1000 µm	1 s	-

***Denotes measurements to be provided by NASA facility instruments**

Example: DC-8 Measurement Requirements and Priorities

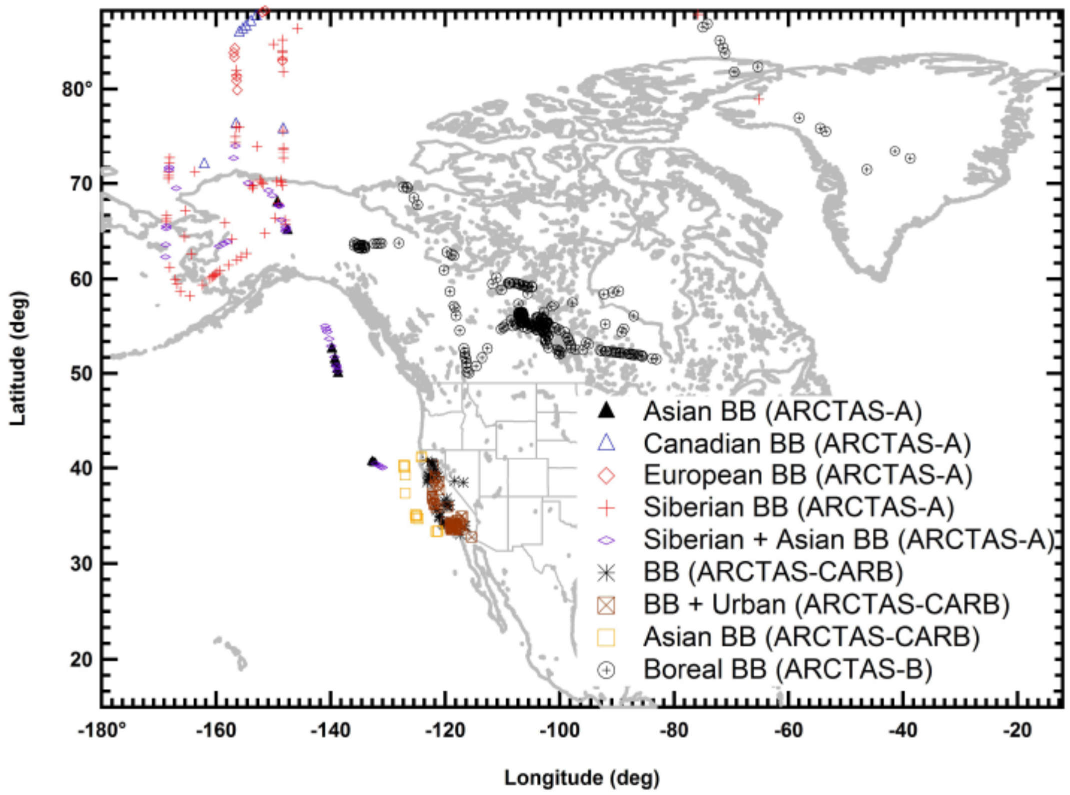
Remote Sensing, Radiation, and Met	Priority	Detection Limit	Required Resolution
Aerosol profiles of extinction*	1	10 Mm^{-1} or 10%	300 m
Aerosol profiles of backscatter*	1	3%	30 m
Aerosol profiles of depolarization*	1	3%	30 m
High Resolution Met (T, P, winds)*	1	0.3K, 0.3 mb, 1 ms^{-1}	10 Hz
UV spectral actinic flux (4π sr)	1	80° SZA equivalent	1 s
Surface IR Imaging (FRP)*	2	-	-
Ozone lidar (nadir/zenith)*	2	5 ppbv or 10%	300 m
Trace Gas Columns (O_3,NO_2,CH_2O)*	2	Variable	Variable
Multi-spectral Optical Depth*	3	0.01	1 s

IR imaging?

***Denotes measurements to be provided by NASA facility instruments**

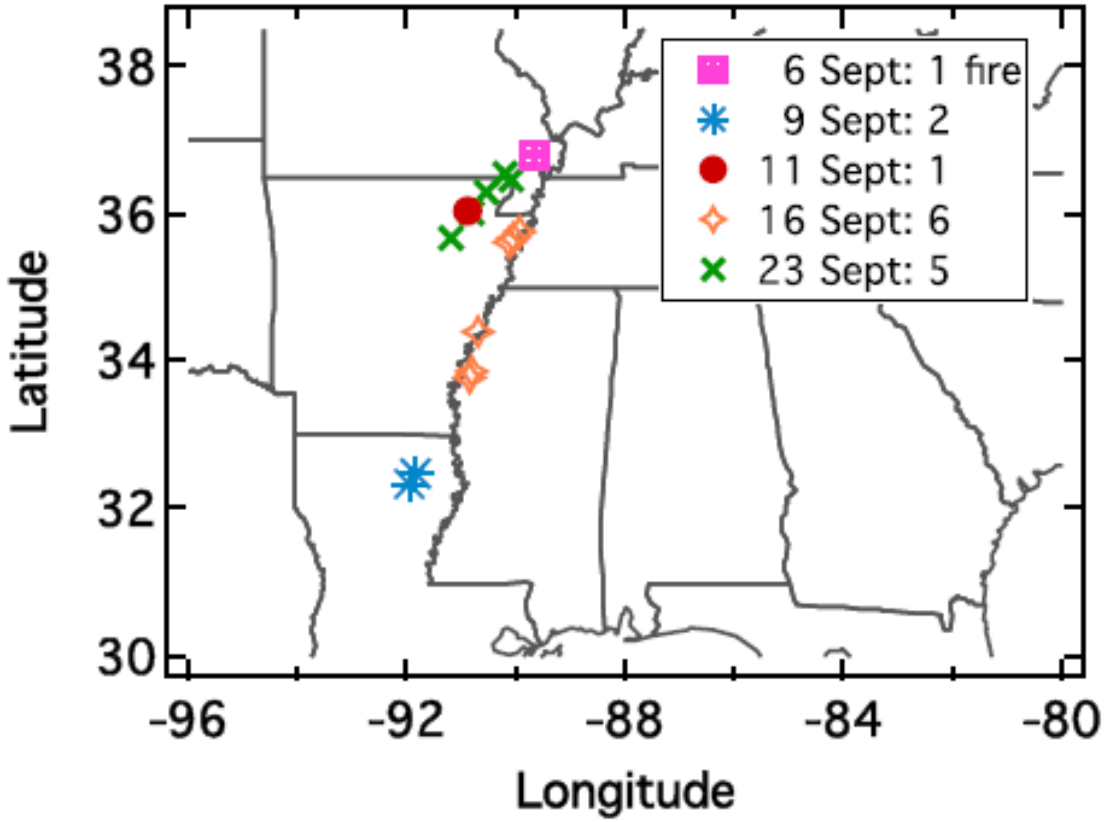
FIREX-AQ challenges us to sample differently.

Hecobian et al., ACP, 2011



495 detections of fire influence

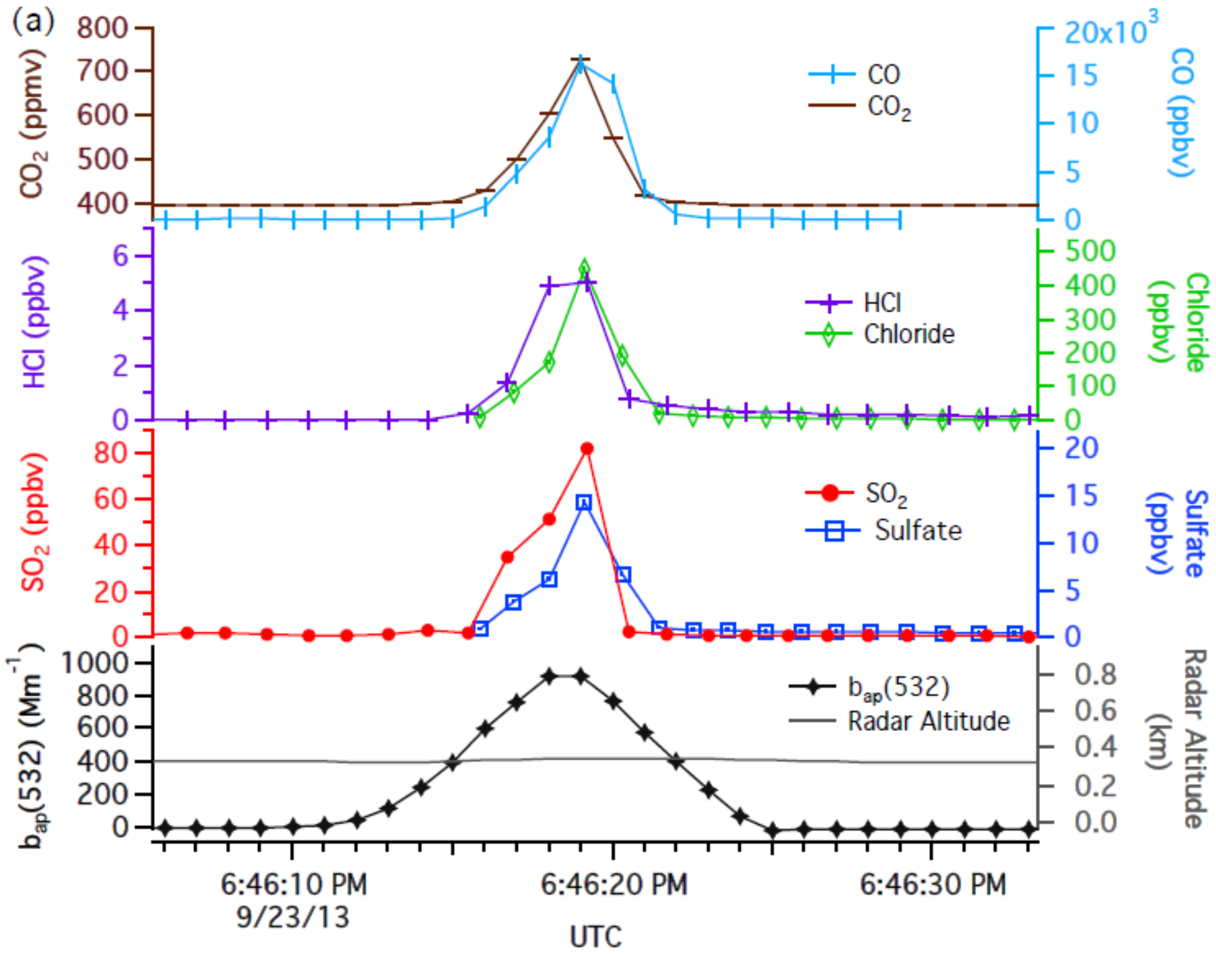
Liu et al., JGR, 2011



15 targeted samples of small fire emissions

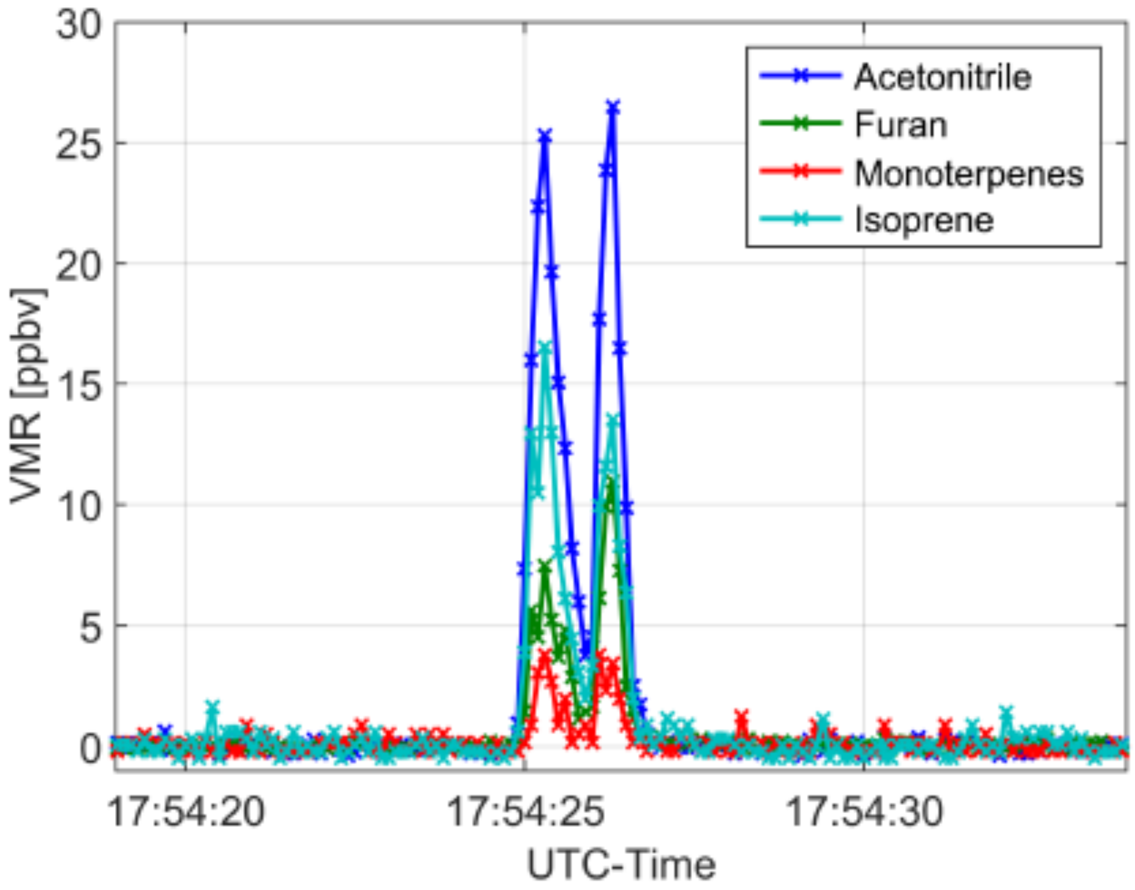
FIREX-AQ challenges us to sample differently.

Liu et al., JGR, 2011

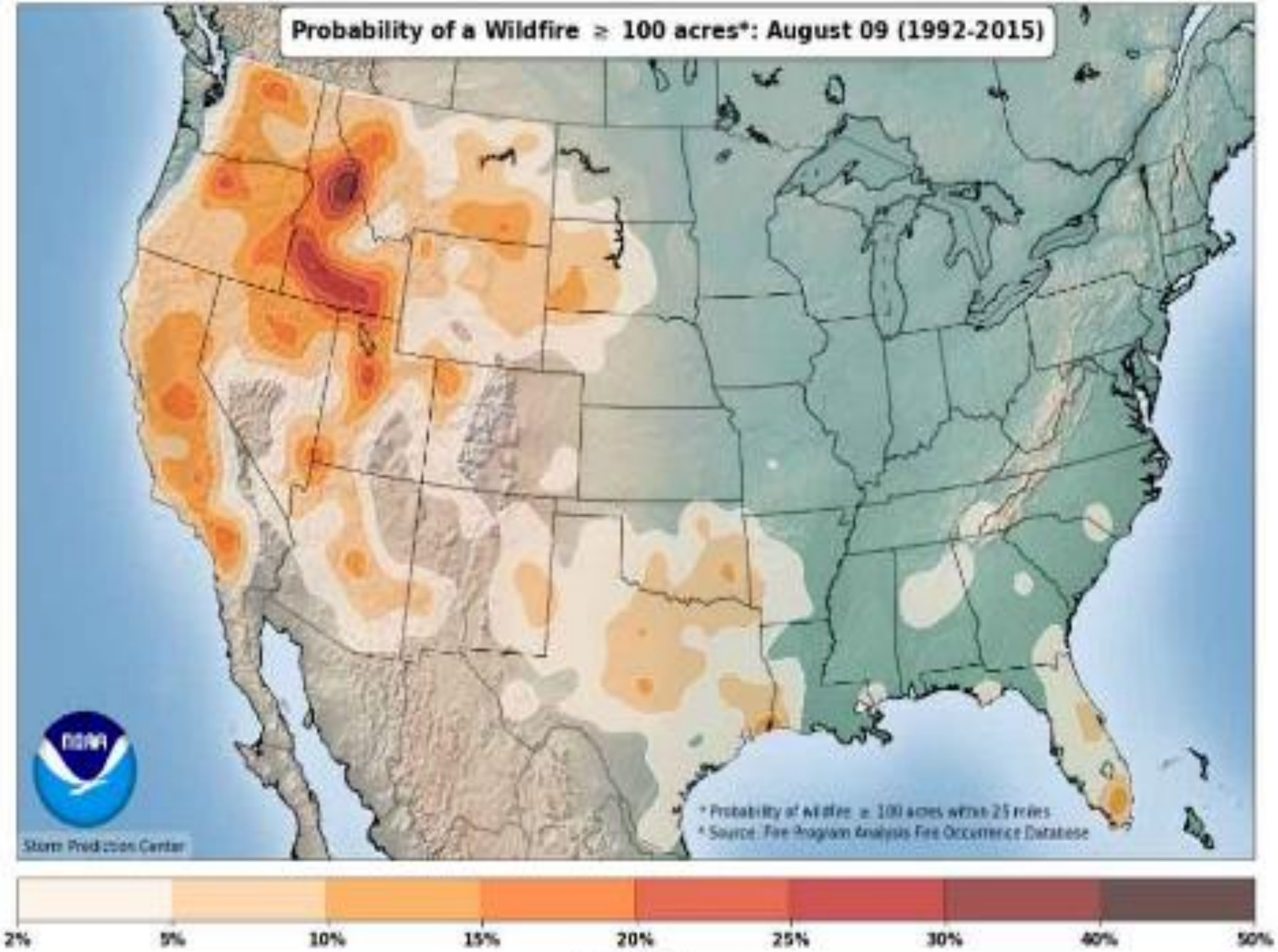


1 Hz sampling of small fire over 5 seconds

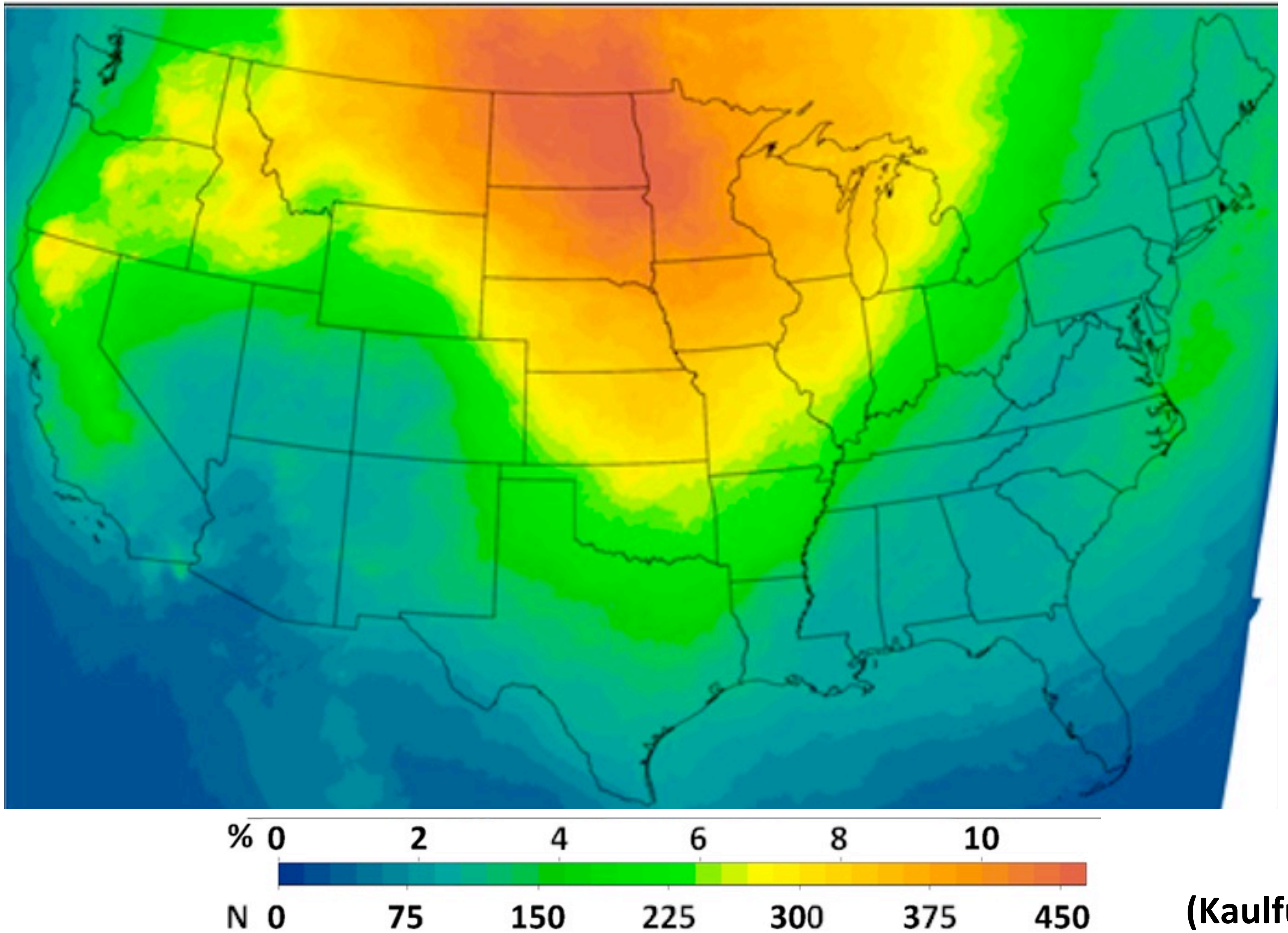
Muller et al., ACP, 2016



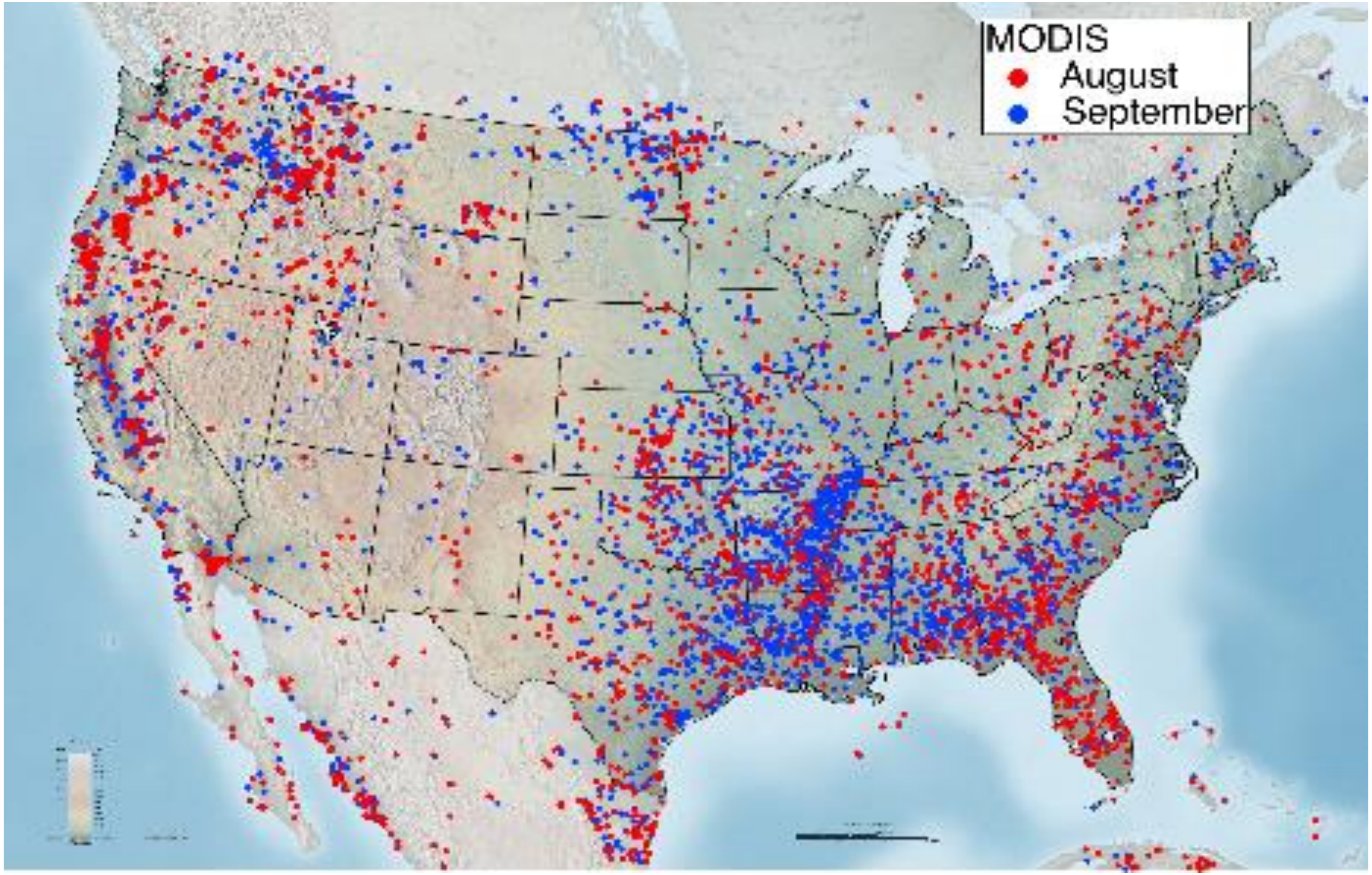
10 hz sampling of small fire over 2 seconds

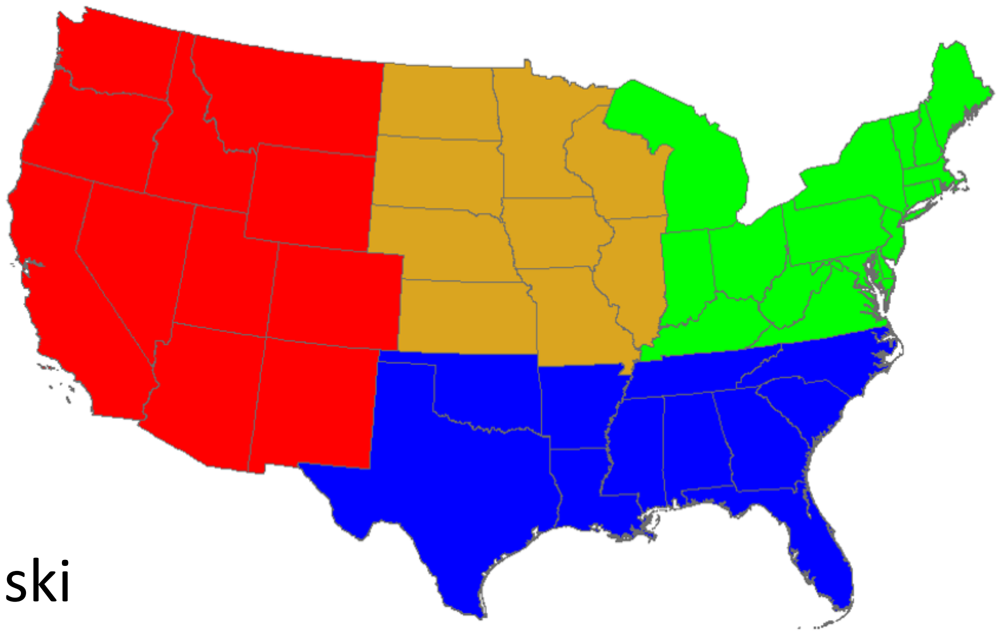

Probability of a Wildfire ≥ 100 acres*: August 09 (1992-2015)
* Probability of wildfire ≥ 100 acres within 25 miles
* Source: Fire Program Analysis Fire Occurrence Database
Storm Prediction Center
2%
5%
10%
15%
20%
25%
30%
40%
50%

Seasonal Smoke Climatology (JJA, 2005-2016)

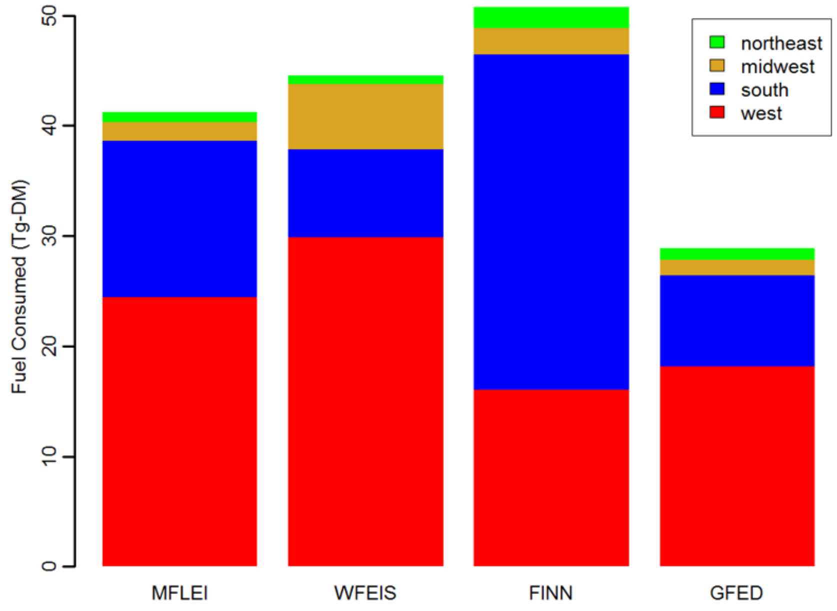


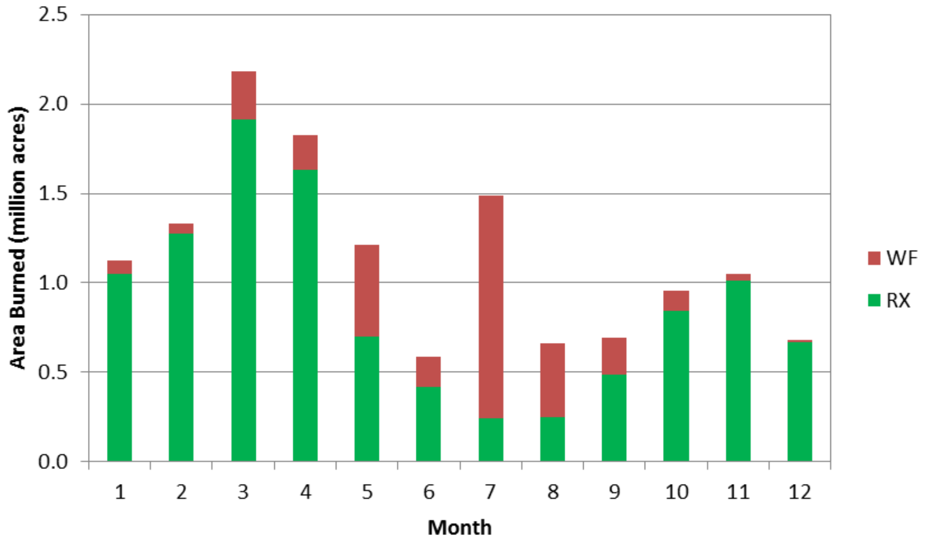
(Kaulfus et al., 2017 ES&T)

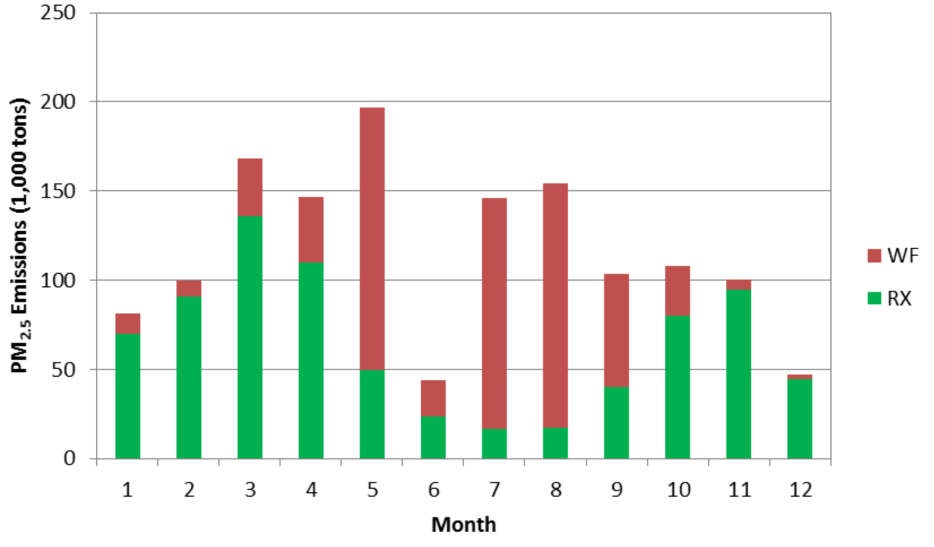

MODIS
August
September



S Urbanski







2014 NEI

FIREX-AQ: working with partners

1) **Help with airspace coordination (active control), especially for fires under active control. Obtaining permission, developing a plan for aircraft separation, etc.**

2) **Connection to ground conditions. Gathering information on what was burning, fuel loading, duration, etc.**

3) **Prediction of small fire activity. Are there organized plans for burning? When are fires expected to start? Where are conditions conducive to burning? Can GOES provide guidance or updates on burning progress?**

4) **Advice on selection of fires to target. Which fire is likely to yield more information. Is it in an area that is well characterized? Is it likely to persist?**

FIREX-AQ
Fueled from below:
Linking Fire, Fuels and Weather to Atmospheric Chemistry

The Team

Principle Investigator: Amber J. Soja
National Institute of Aerospace (NIA), resident at NASA Langley Research Center
Climate Science and Chemistry and Dynamics Branches

Andrew T. Hudak
USFS RMRS, Forestry Sciences Lab, Fuels, lidar, fuels structure

Jessica L. McCarty, Ancilleno Davis
University of Miami, Agricultural/ cropland burning connections, satellite data expertise

J. Kevin Hiers
Wildland Fire Scientist, Tall Timbers Research Station & Land Conservancy, Prescription burning

Collaborators: Kirk Baker, Ph.D. EPA FASMEE Modeling Team Lead; Emily Fischer, Ph.D. Colorado State, WE-CAN PI; Louis Giglio, Ph.D. UMD MODIS/VIIRS algorithm developer; Robert 'Brad' Pierce, Ph.D. NOAA Modeler/Meteorologist

Provide Intelligence to guide flight planning
(entire team, hopefully with guidance from you, as you are able)

Goal – Gather statistics from small to medium to large fires to include wildfire, prescribed, grasslands, rangelands, agricultural and cropland

Satellite data (Leads - Soja, McCarty, Davis, collaborators)

Can GOES, VIIIRS, MODIS, HMS smoke provide guidance or updates on burning progress?;

Is there available **NIROPS** data?; **GIS** data on fire movement?;
Ground-based information?; **Incident Command**?

Where are conditions conducive to burning (update fire weather)?

Provide Intelligence to guide flight planning
(entire team, hopefully with guidance from you, as you are able)

Prediction of small fire activity (Leads - McCarty, Hiers).
Are there organized plans for burning? When are fires expected to start?
What/where are conditions conducive to burning (GOES provide guidance)?

Hiers will leverage ongoing fire activities in Florida and the southeast (48-hr daily notices)
- Maintain a two-week moving window of burn planning with land owners

Connection to ground conditions.
Gather information on fuel conditions, fire behavior, duration, fraction of fuel burned, etc.;

Advise on selection of fires to target. What fire are likely to yield more information?

Provide Intelligence to guide flight planning
(entire team, hopefully with guidance from you, as you are able)

Prediction of small fire activity (Leads - McCarty, Hiers).
Are there organized plans for burning?   When are fires expected to start?
What/where are conditions conducive to burning (GOES provide guidance)?

McCarty establishing working relationships with land owners in Oklahoma, southern Kansas, Arkansas and the boot heel of Missouri – identifying potential burn units.

Connection to ground conditions.
Gather information on fuel conditions, fire behavior, duration, fraction of fuel burned, etc.;

Advise on selection of fires to target. What fire are likely to yield more information?

Provide Intelligence to guide flight planning
(entire team, hopefully with guidance from you, as you are able)

Fuels [Leads – Hudak (western wildfires), Hiers (prescriptions), McCarty (croplands, rangelands), Soja (large-scale), collaborators]

A criteria: where are the fuels best characterized (pre- and post-fire fuel mass, volume, or density in physical measurement units)

Hudak's team will collect traditional measures of fuels where coupled to remotely-sensed point cloud data (airborne lidar) to map fuel estimates.

Advise on selection of fires to target. What fire are likely to yield more information?





Post fire data collection (Leads - Soja, Davis, Hiers, Hudak, collaborators)

This list meant to be a living document. **Goal:** Provide information that will best connect the ground to the atmosphere, air quality, modeling and climate feedbacks.

Fire location, date, name (if available), local fire time (start, extent if known), size daily (fire rate of spread at aircraft overpass), plume injection height, local/observed ecosystem/land cover (fuel type), fuel structure (height/depth and cover, and moisture content), fire description type (surface, intermittent, crown, smoldering), fire-weather [National Fire Danger Rating System (NFDRS) and Canadian Forest Fire Weather Index System (FFMC, FWI, BUI), satellite overpass time (instruments MODIS, VIIRS, GOES-R minimally), active-fire detected (yes/no), number of active-fire detections, mean Fire Radiative Power (FRP), range FRP, land cover type (MODIS IGBP, plus USDA Cropland Data Layer for agricultural areas), fuel consumed (best available), ancillary data available, vegetation name (scientific name: Latin); active-fire or other available GIS progression maps; burned area; and other existing mapped data products or source data (e.g., Landsat scar, lidar profiles, MISR plume estimates, HMS smoke extent, worldview snapshots).