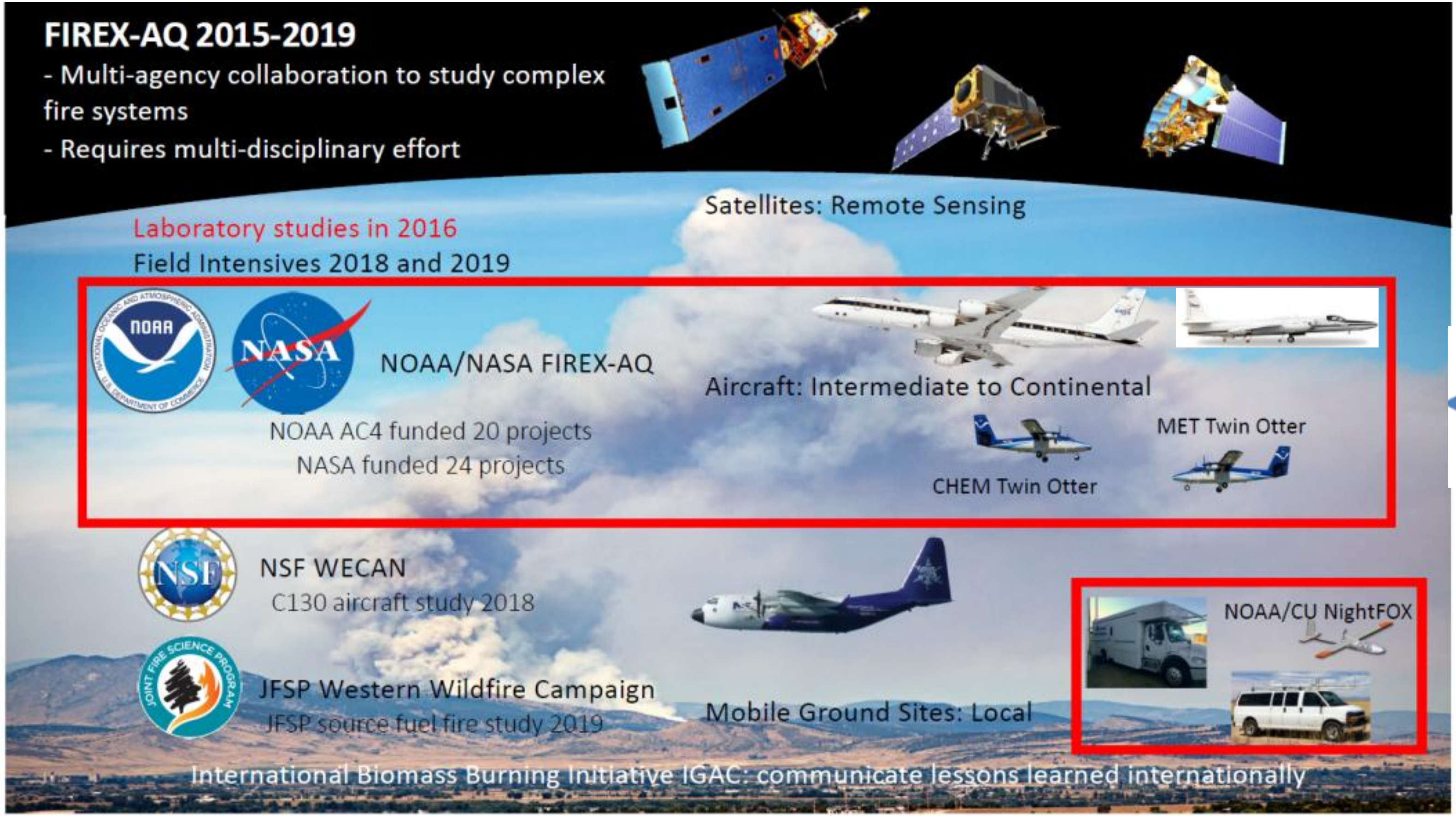
FIREX-AQ Overview
(Fire and Weather Forecasting Team)

David Peterson
U.S. Naval Research Laboratory – Monterey, CA

Edward Hyer	NRL – Monterey	Fire behavior and smoke forecasting
Bob Yokelson	Univ. Montana	Decisions for optimized fire sampling
Amber Soja	NASA LaRC/NIA	Real-time info on active/potential fires
Henry Fuelberg	Florida St. Univ.	Meteorologist
Chris Holmes	Florida St. Univ.	Smoke forecasting
Kevin Hiers & Kevin Robertson	Florida St. Univ.	Fire managers and fire ecologists

TFRSAC Meeting
NASA – Ames Research Center
29 May 2019

FIREX-AQ Research Platforms and Coordination



Modeling Teams

FIREX-AQ Schedule

Major events:

DC-8 Integration, 20 May-21 June (5 weeks), incl. Test Flight(s)

SARP, 24-27 June (4 days), 2-3 flights (limited seating)

EAA Oshkosh, 22-23 July, ????? (possible outreach opportunity)

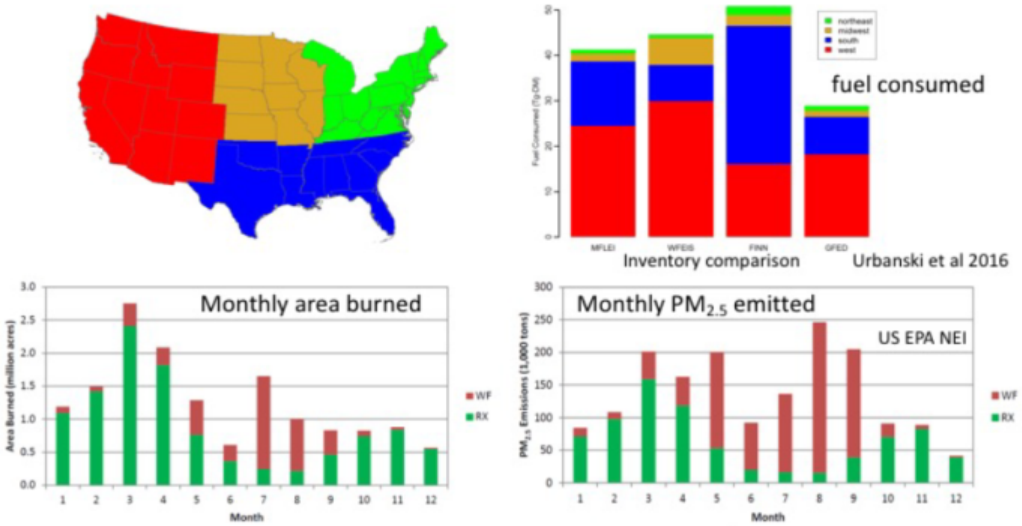
Deployment, 17 July-5 Sept (7.5 weeks), 150 flight hours

- Palmdale, 17-21 July, prep for deployment (test flight?)
- Boise, 22 July-18 Aug (4 weeks), ~11 flights
- Salina, 19 Aug-5 Sep (3 weeks), ~7 flights

FASMEE Controlled Burn, on call 1 Oct-15 Nov (45 days or less)

Objectives for Fire Season 2019

US Fire Emissions



- western wildfires consume more fuel and burn summer and fall
- prescribed fires account for the majority of the area burned in the US and burn all year round

FIREX-AQ 2019 objectives:

- western wildfires: emissions, chemical evolution, transport and evaluate downwind impacts of wildfires burning in the Northwest US in coordination with interagency partners
- southeastern prescribed fires: build statistics on emission factors and fuels, plume rise, satellite detectability, and integrated impacts
- Large prescribed burn: provides the best chance for bridging laboratory and ambient conditions and takes priority when announced

Main FIREX-AQ Science Questions

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

- What is the amount, composition, and volatility of aerosol precursors including the previously unidentified fraction of the emissions including SVOCs, IVOCs, and BC, BrC and OC aerosols?
- How well do inventories represent BB emissions and their radiative properties, and what are the largest uncertainties affecting the inventories?

2) What chemical transformations affect those emissions?

- What are the formation mechanisms for secondary species (ozone, SOA and sulfate)?
- What fraction of the organic aerosol is primary versus secondary at various time scales?
- How do nighttime chemical transformations involving NO_3, N_2O_5 and O_3 influence the composition and evolution and the production of secondary organic aerosol in smoke plumes?

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

- How well do local models predict the BB impact on air toxics including gases and aerosols, and visibility?

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

- How strongly are the composition and distribution of pollutants over North America influenced by BB?
- How far afield can BB emissions from prescribed fires impact air quality?

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

- What roles do brown carbon and black carbon, other light-absorbing species, and internal mixtures play in the climate-relevant properties of smoke?
- How can FIREX-AQ measurements improve remote retrievals of smoke?

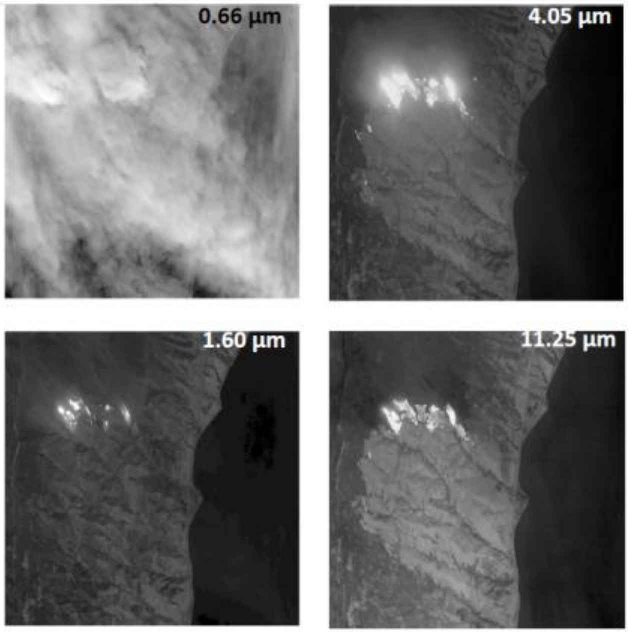
6) How can satellite measurements help with #1-5?

- How can improved measurements of plume height, fire intensity, and fire radiative power be used to adjust satellite retrievals?
- How accurate are NO_2, CH_2O and other trace gas retrievals?

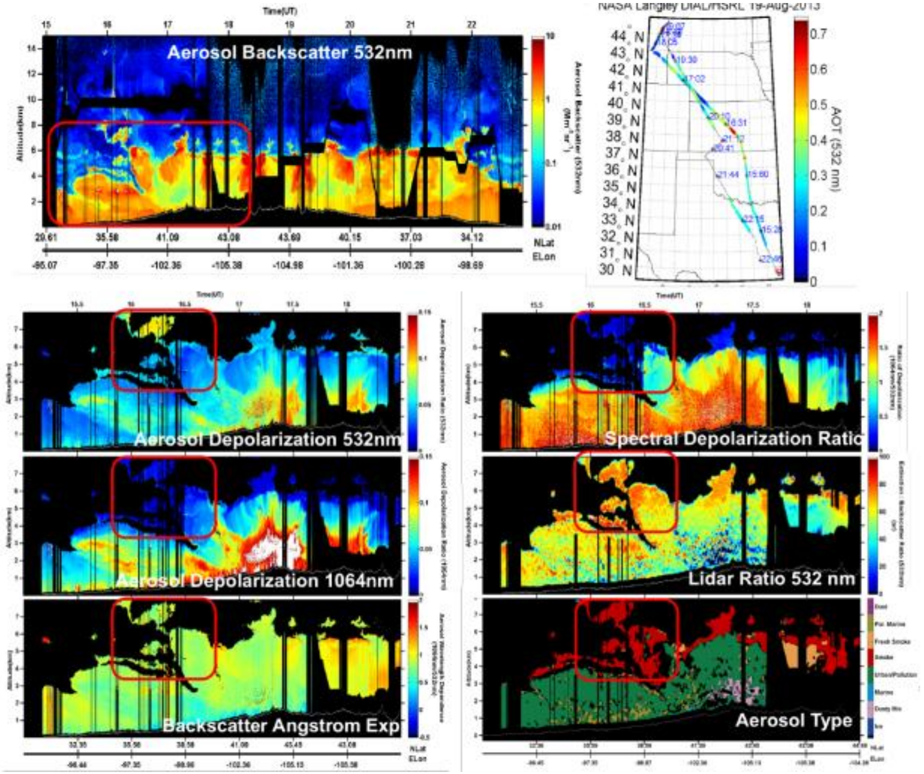
Remote Sensing (DC-8)

The MODIS/ASTER Airborne Simulator

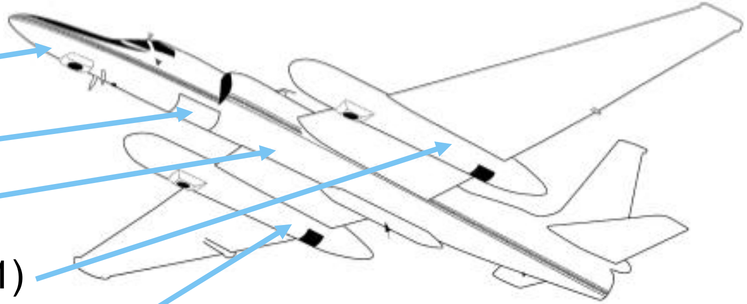
Sherpa Fire (17 June 2016)
Altitude: 29,000' MSL, Pixel Size: 22 m



DIAL-HSRL (Lidar)



Remote Sensing (ER-2)



- **Core Payload**
  - AirMSPI-1 (Nose)
  - AVIRIS-C (Q-bay)
  - S-HIS (Centerline)
  - CPL and EMAS (Wingpod-1)
  - NAST-I & GCAS [July 17-August 4] & HYTES [August 4-August 18](Wingpod-2)

AirMSPI (Similar to MISR, multi-angle): Smoke property characterization

AVIRIS-C (Infrared Imager): Fuels, temperature, and fire fraction

eMAS (MODIS Simulator): Aerosol and cloud characterization

CPL (Cloud Physics Lidar): Vertically-resolved smoke properties

GCAS (Chemistry): Geo-CAPE Airborne Simulator, NO_2 and HCHO enhancements in smoke

HYTES: Hyperspectral Thermal Emission Spectrometer, Fire temperature / CH_4 and NH_3 maps

NAST-I: National Airborne Sounder Testbed- Interferometer

S-HIS: The Scanning High-resolution Interferometer Sounder

FIREX-AQ Scope and Challenges

Variation in wildfire and smoke plume behavior is driven by meteorology…

- Forecasting requires information from multiple sources to understand synoptic to micro-scale impacts
- **Goal (flight-planning):** set the stage for subsequent discussion of smoke sources, chemistry, & transport

Synoptic:
- Significant pattern changes
- Frontal boundaries
- Cloud cover
- Smoke transport direction

Mesoscale
- Convection (thunderstorms)
- Impact of terrain on wind flow
- General fire-weather interaction

Micro-scale (individual fires)
- Specific fire front evolution
- Changes in fuel type
- Ongoing fire suppression activities

Basic Flow of FIREX-AQ Information

1. Fire Specialists
- Identify candidate regions
- Rank targets according to fire and field considerations

2. Weather Forecasters
- Evaluate targets in terms of desired conditions
- Suggest adjusted ranking of targets

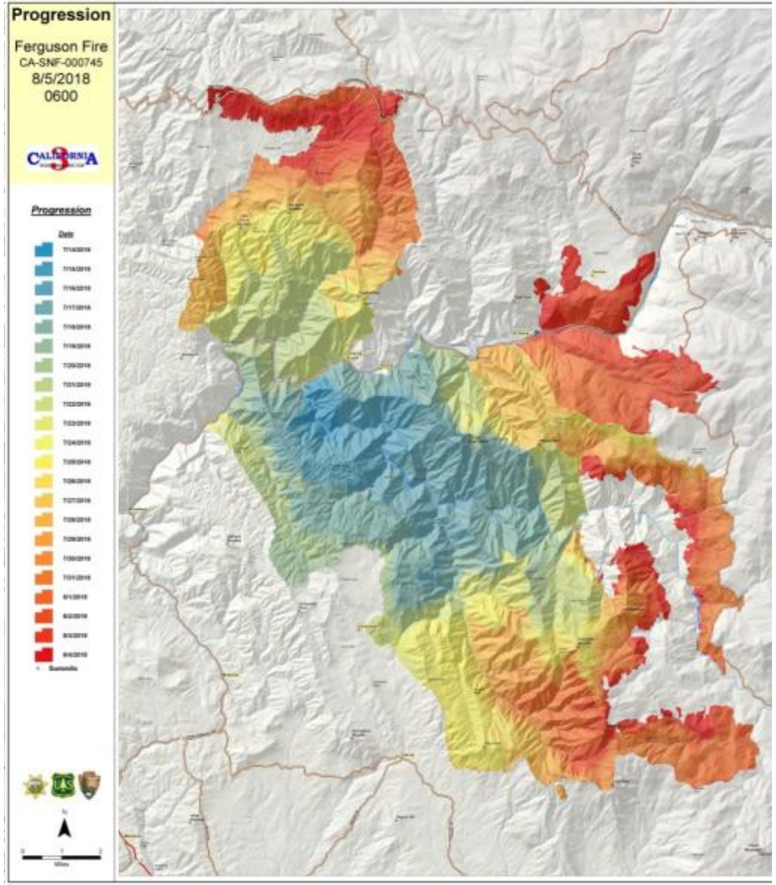
Fire and Weather Briefing Nowcasting

3. Modeling Teams
- Provide detailed chemistry and aerosol forecasts
- Map sampling targets to science objectives

Aerosol and Chemistry Briefs

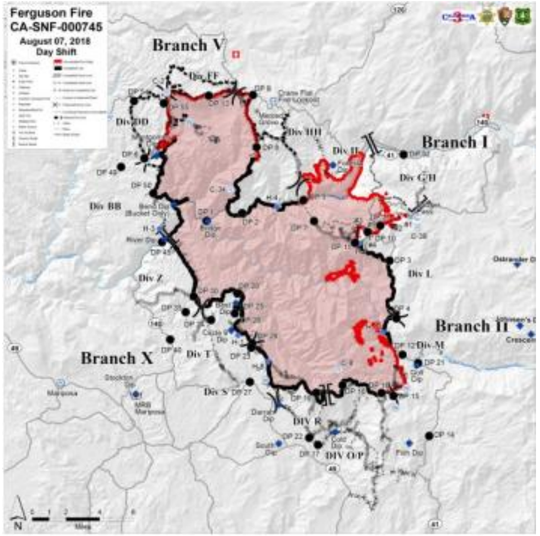
4. FIREX-AQ Flight Planning Process

Details of Individual Fires



Fire specialists provide information from multiple sources:

- Detailed fire perimeter and thermal maps for each fire of interest
- Impact of suppression activities on the life & behavior of each fire
- Vegetation characteristics and available fuel loading
- Details of local air traffic and overall firefighting effort



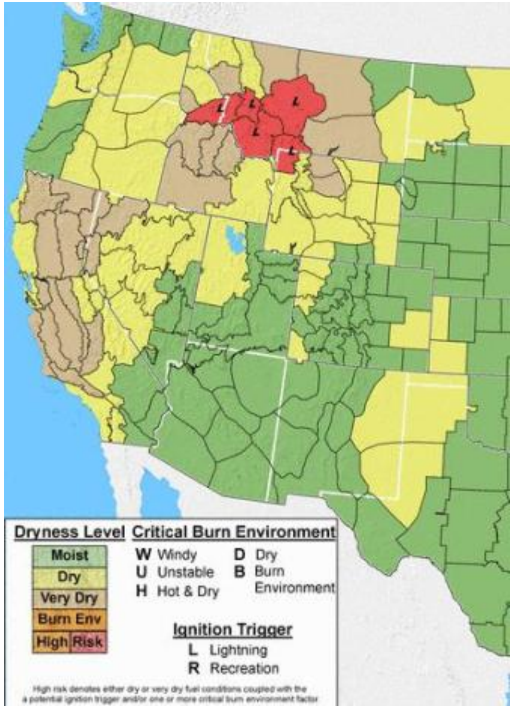
Past 24 hrs:

Incident Name	St	Unit	Size	Size Chge 24 Hrs	% Ctn
Rim	CA	STF	125,620	62,254	5
Gobblers	CA	BDF	349	14	55
Mission	CA	LPF	4,500	2,000	70
Aspen	CA	SNF	22,791	0	95
* Fish	CA	SQF	100	---	0
American	CA	TNF	21,189	3,393	66
Corral Complex	CA	SRF	10,364	334	0
Hough Complex	CA	PNF	513	-18	69
Butler	CA	SRF	20,596	100	39
Salmon River Complex	CA	KNF	14,377	0	95
Burney LCA	CA	SHU	196	0	100

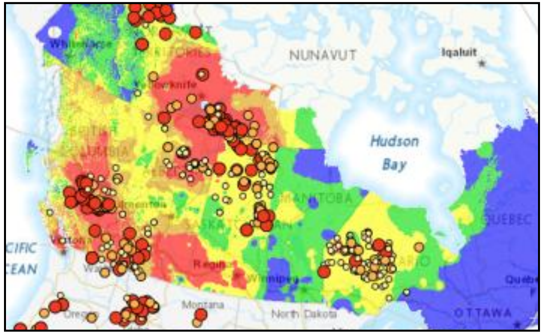
Forecasting Tools: Fire & Smoke Plume Behavior

Suite of Fire Weather Indices

US and Canada: We must forecast for both regions.



- Are new fire ignitions likely?
- What regions are at risk?
- Will ongoing fires experience growth or decay?
- Will fires be plume dominated?



Conceptual Model for PyroCb Development

Peterson et al. 2017, Mon. Wea. Review

Prescribed Fire Forecasting in Southeastern US

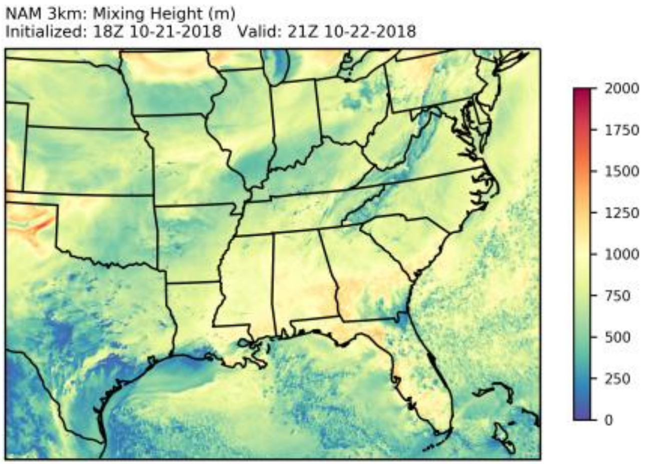
Prescribed fires last several hours so today's satellite hotspots don't tell us where tomorrow's fires will be. However, <u>we can forecast where weather will fall within prescription conditions.</u>

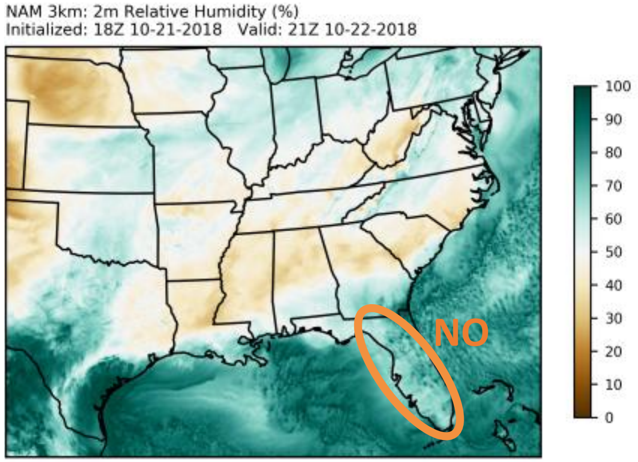
Typical Prescription Requirements (Wade, 1989 USFS)

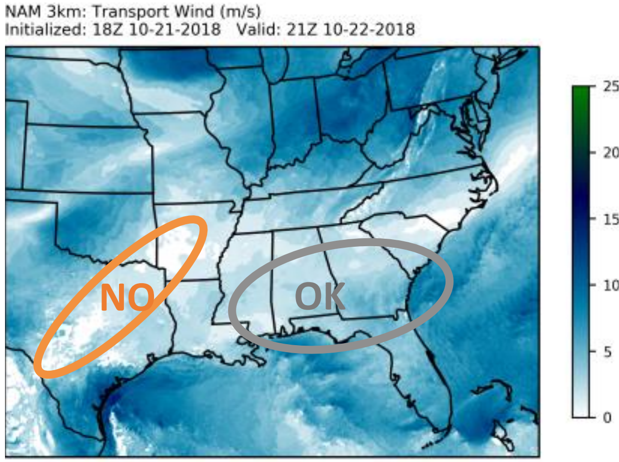
- Mixing depth 500-2000 m
- Relative humidity 25-50%
- Transport winds 5-15 mph
- Lavdas Dispersion Index 30-60

Team:

Henry Fuelberg (FSU)
Christopher Holmes (FSU)
Kevin Hiers (Tall Timbers)
Kevin Robertson (Tall Timbers)





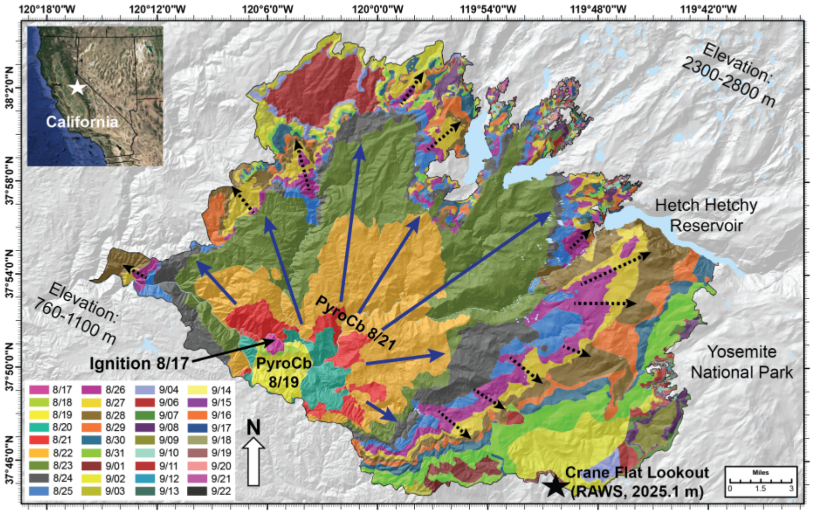


SHORT-TERM FORECASTING (24 - 48 hr)

Challenging aspects of fires to forecast…

- Extreme fire spread/rapid decay
  (rapid increase/decrease in total emissions)
- Deep pyroconvection
  (rapid change in injection altitude)

Extreme Fire Spread: 2013 Rim Fire



Smoke Injection Altitude

Ag. Fires (Boundary Layer)

Understory (Boundary Layer)

PyroCu (Mid-Troposphere)

PyroCb (Upper-Troposphere)

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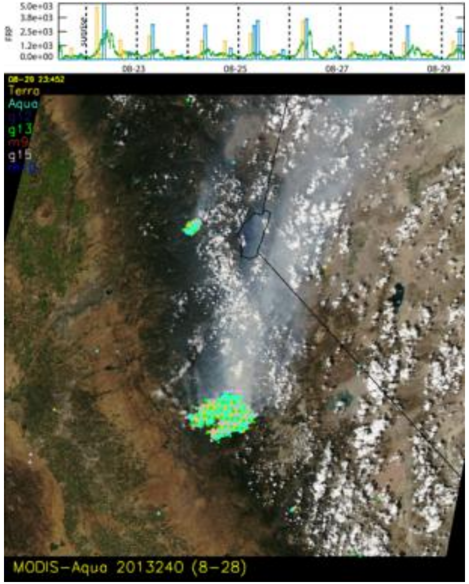
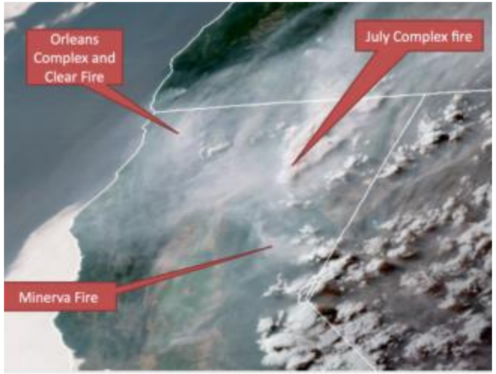
Example Nowcasting Tools (0-8 hr)

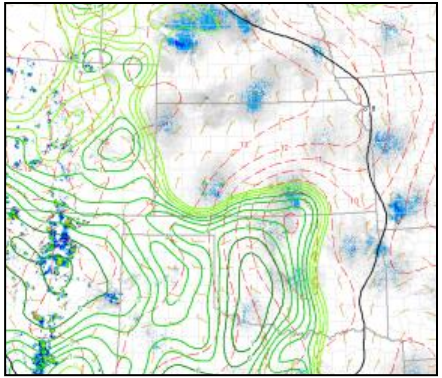
Satellite Fire Detections



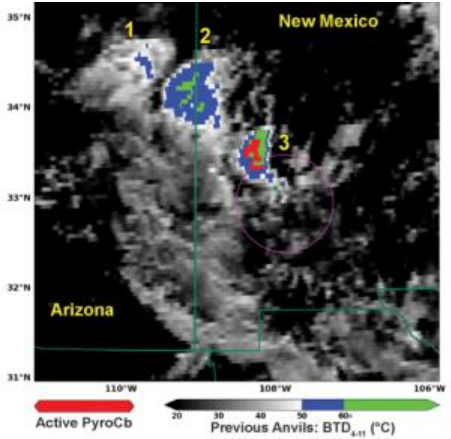
Satellite Imagery (GOES-16 & 17)



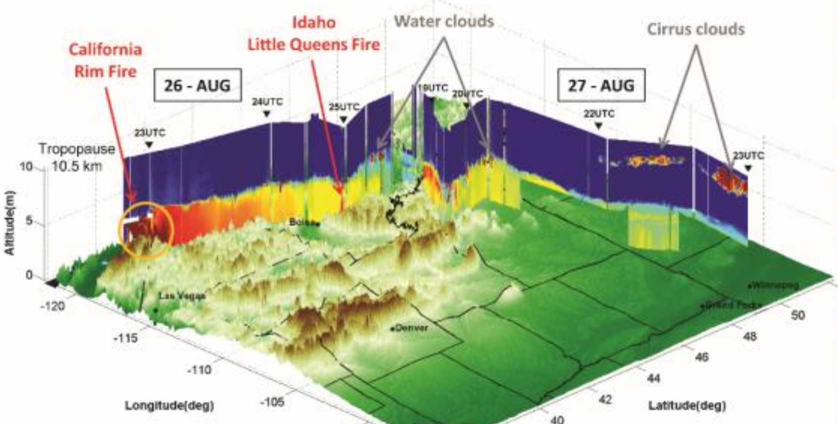
Near Real-Time Meteorology



NRL PyroCb Detections



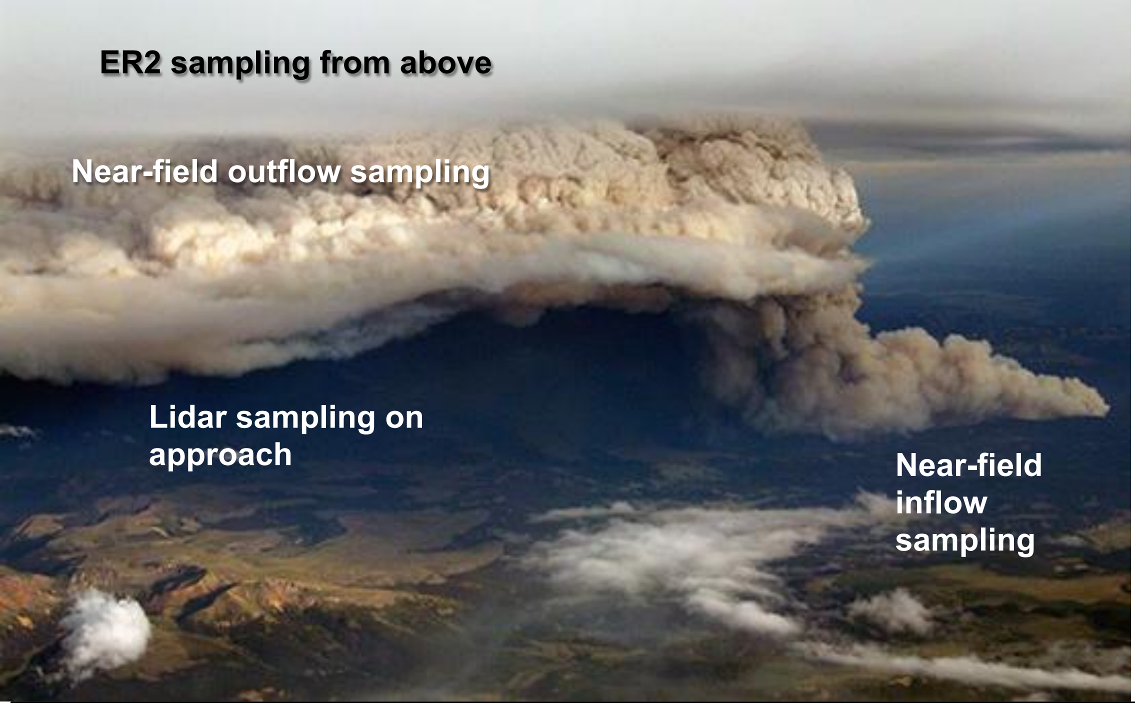
Airborne Lidar



Web Cameras

Radar

FIREX-AQ Strategy for PyroCb Sampling



1. Nowcasting team identifies a likely PyroCb event and provides guidance (e.g., estimated time for the event and likely direction of outflow)
2. Determine whether to sample immediately or wait until the next day, looking at factors such as expected downwind transport distance/ location
3. If approaching from downwind, fly under plume with upward looking lidar on approach to storm
4. If possible, descend to perform near-field smoke sampling upwind of the convective inflow
5. Ascend to plume altitude and conduct near-field outflow sampling, crossing the plume at multiple distances

Continuous guidance from Nowcasters will be critical

**We are hoping for many opportunities to increase our knowledge of PyroCb smoke!
FIREX-AQ is a good opportunity, but not the only one!**