AC4 Program and JPSS

sub-focus on FIREX

Monika Kopacz, Kenneth Mooney
Climate Program Office AC4 Program

November 18, 2016

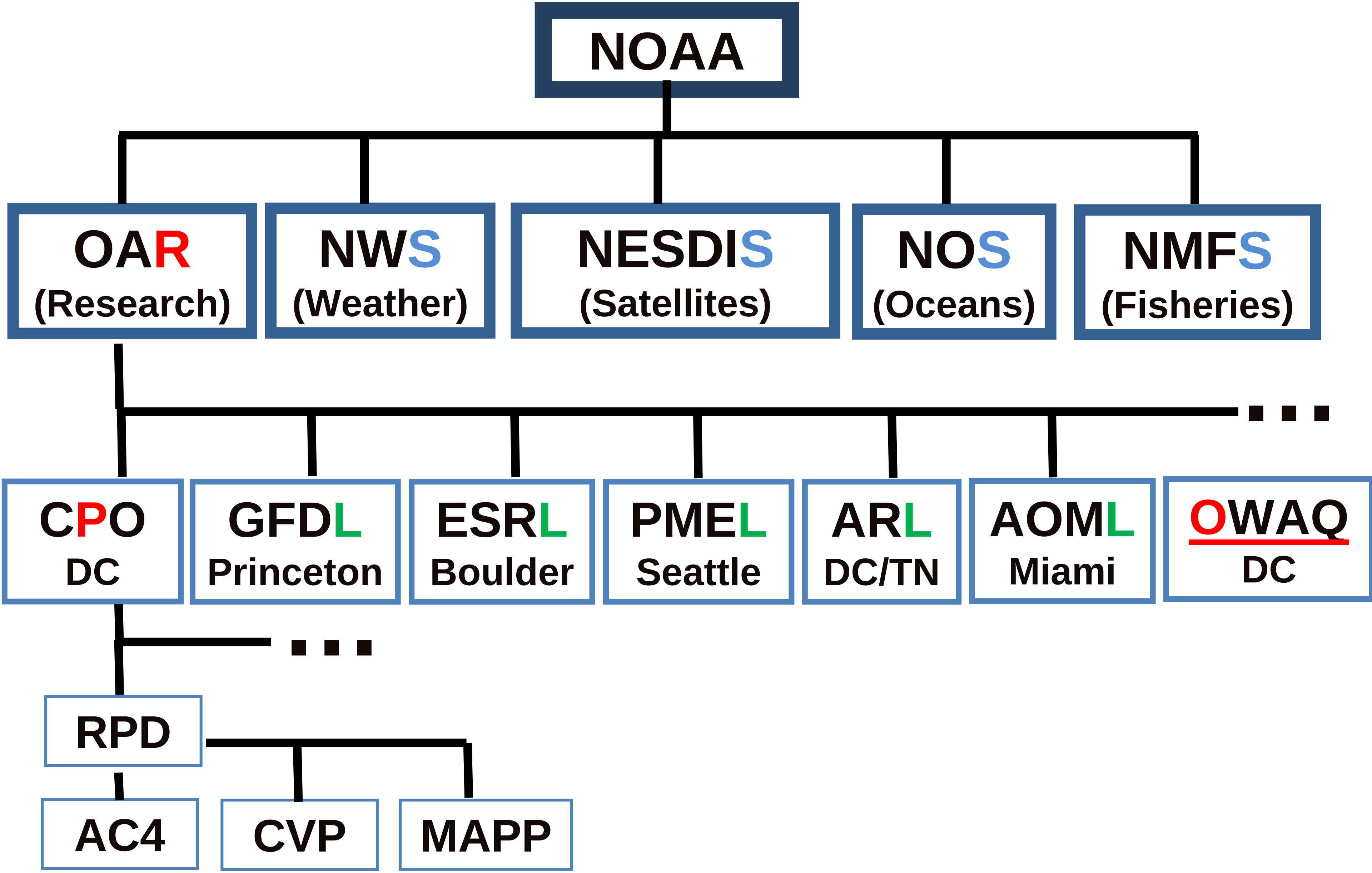
Atmospheric Chemistry, Carbon Cycle and Climate (AC4) Program

AC4 is a competitive research program which manages a portfolio of multi-year projects

AC4 Goal: Determine the processes governing atmospheric concentrations of greenhouse gases and aerosols in the context of the Earth System and climate

Atmospheric Chemistry, Carbon Cycle and Climate
AC4
Climate Program Office

Where is AC4?



NOAA

OAR (Research)

NWS (Weather)

NESDIS (Satellites)

NOS (Oceans)

NMFS (Fisheries)

…

CPO DC

GFDL Princeton

ESRL Boulder

PMEL Seattle

ARL DC/TN

AOML Miami

OWAQ DC

…

RPD

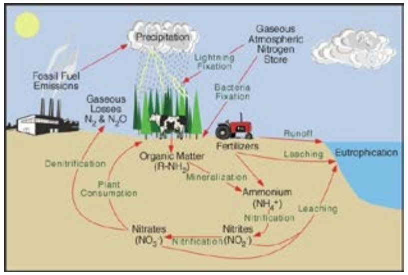
AC4

CVP

MAPP

FY13-FY16 Atmospheric Chemistry, Carbon Cycle, and Climate (AC4) Research Portfolio

Nitrogen Cycle



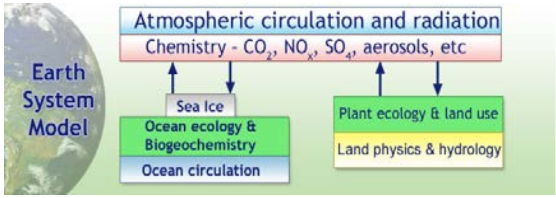
Urban Emissions

ESRL/CSD, PMEL, ARL Field Campaigns

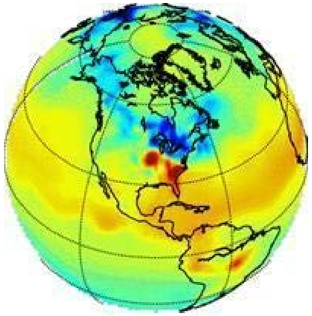
Atmospheric composition from space

Emissions and Chemistry of Wildfires

GFDL Nitrogen Modeling



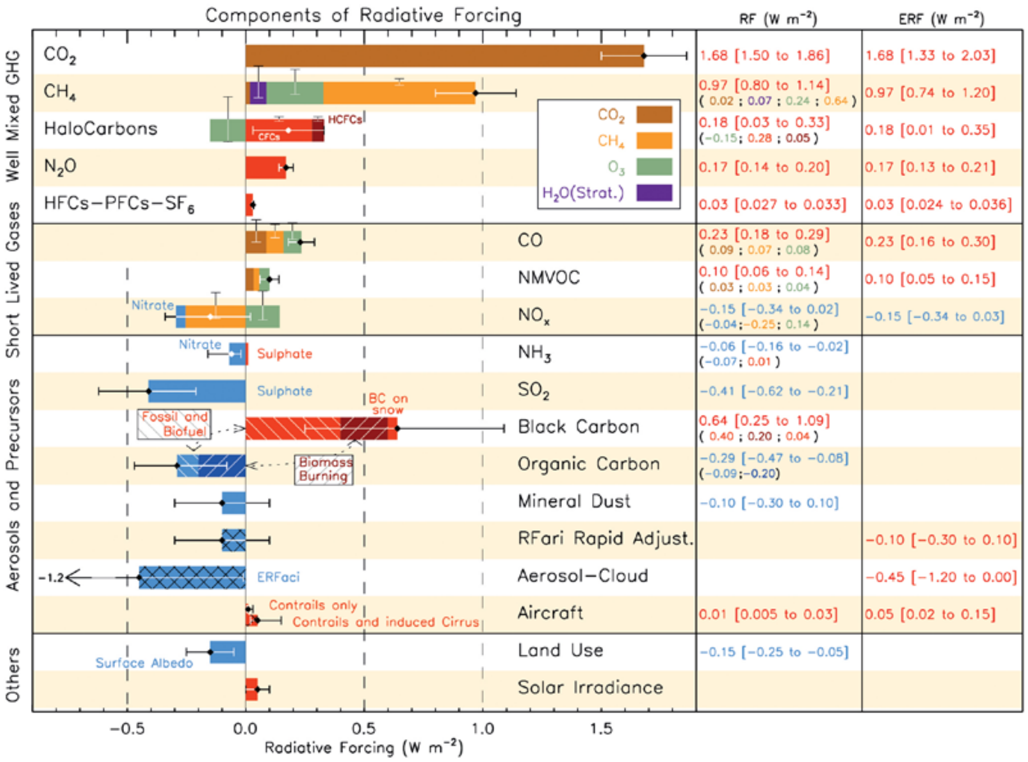
CarbonTracker



Oil & Gas Emissions

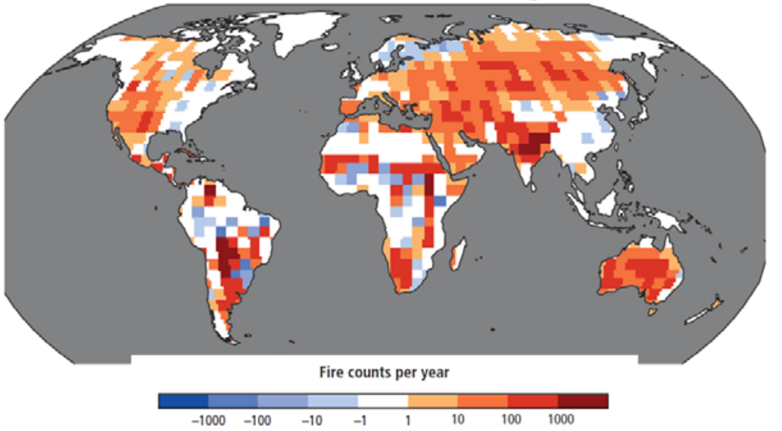
ESRL/GMD Monitoring

FIREX background: fires and climate



Large Global Forest Fire Increase at 1.8°C Warming

Global mean from 1850

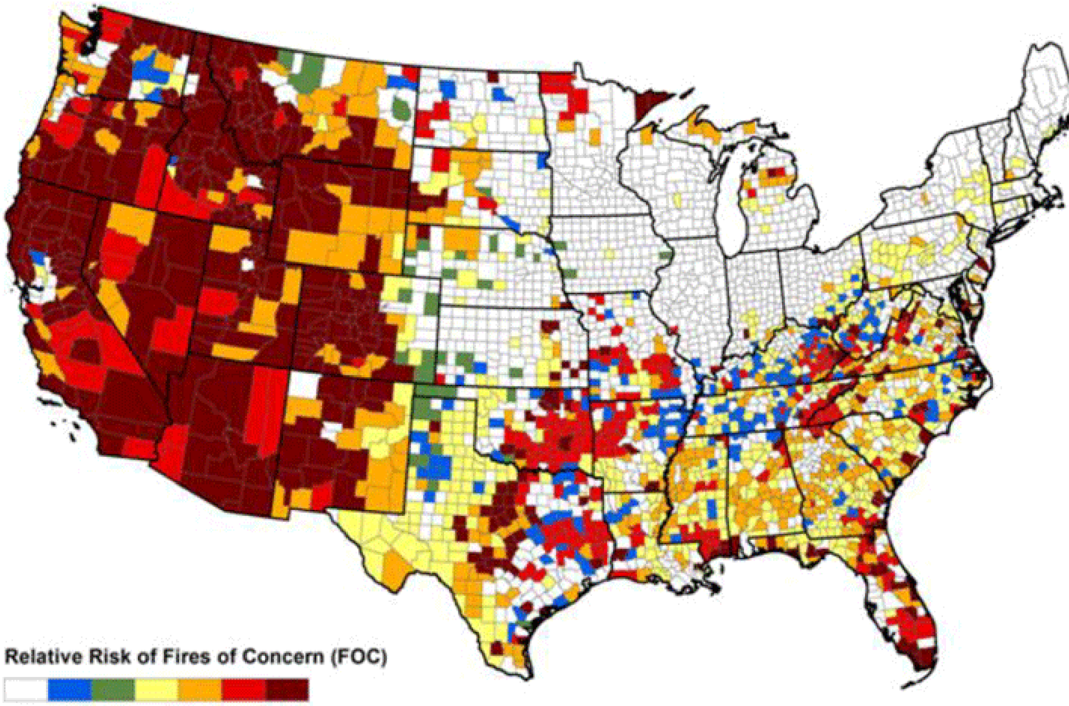


Change in fire frequency B1 2004 and 2100 (1.8°C at 2100

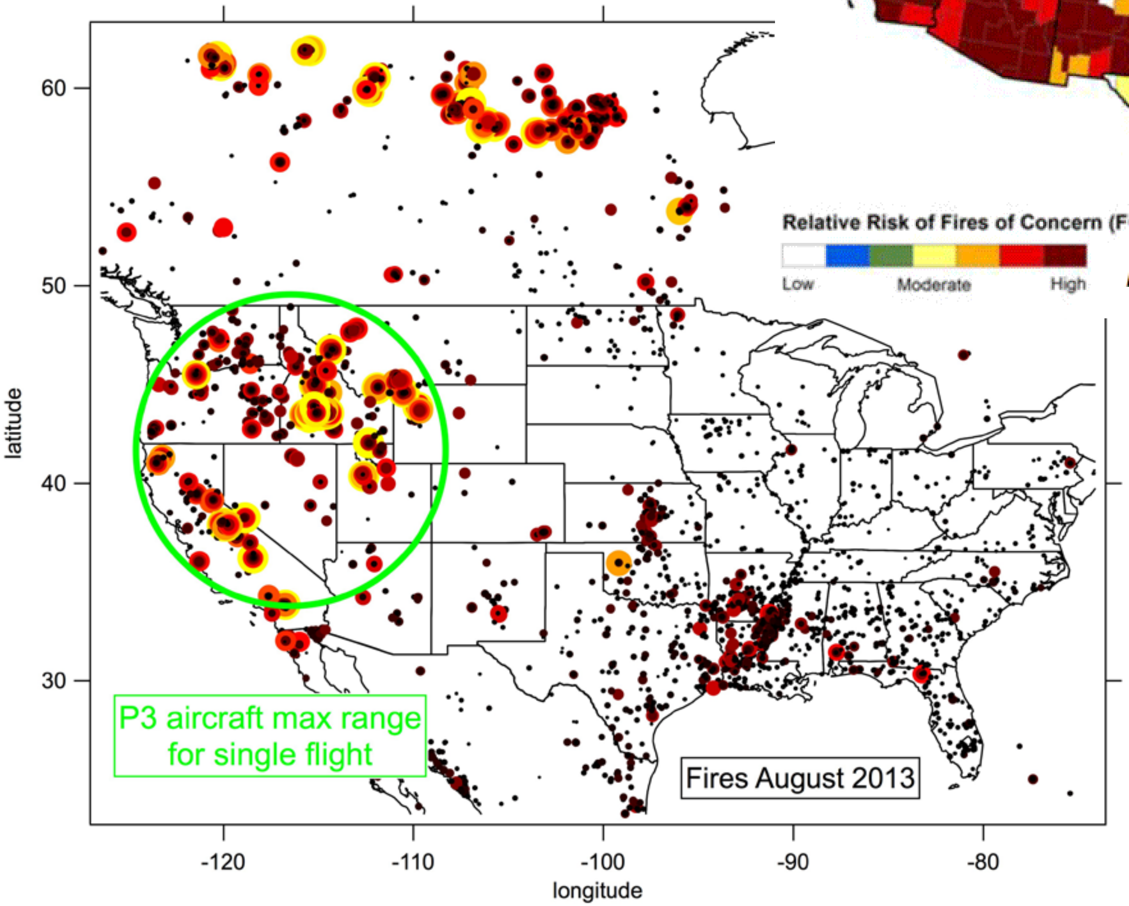
IPCC AR5 WG2 Figure 4-6 | Projected changes in meteorological fire danger, fire probability, and fire frequency

- Fires emit greenhouse gases and aerosols, and their precursors
- Fires are projected to increase with warming climate
- Fires are one of the largest uncertainty due to their interannual variability, complicated chemistry and physics, and unknown emissions

Fires in US



Note: A fire of concern is greater than 1 square mile in extent and requires two weeks or more to contain



A big problem in Western US!

FIREX (2015-2019): studying western wildfires

ESRL/CSD led 5 year effort that includes instrument development, laboratory experiments, field deployment (P3, mobile labs, other aircrafts) and modeling

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

What is AC4 FIREX? Scientific Priorities

FIREX: CSD led and designed field experiment

AC4 FIREX: AC4 supported research relevant to some of FIREX goals

FIREX science questions*

1. What are the **emissions** of trace gases and aerosols?
2. What is the **chemical transformation** of those emissions?
3. What is the local air quality and visibility **impact** of fires?
4. What are the regional and long-term **impacts** of fires?
5. What are the **climate-relevant** properties of biomass burning aerosols

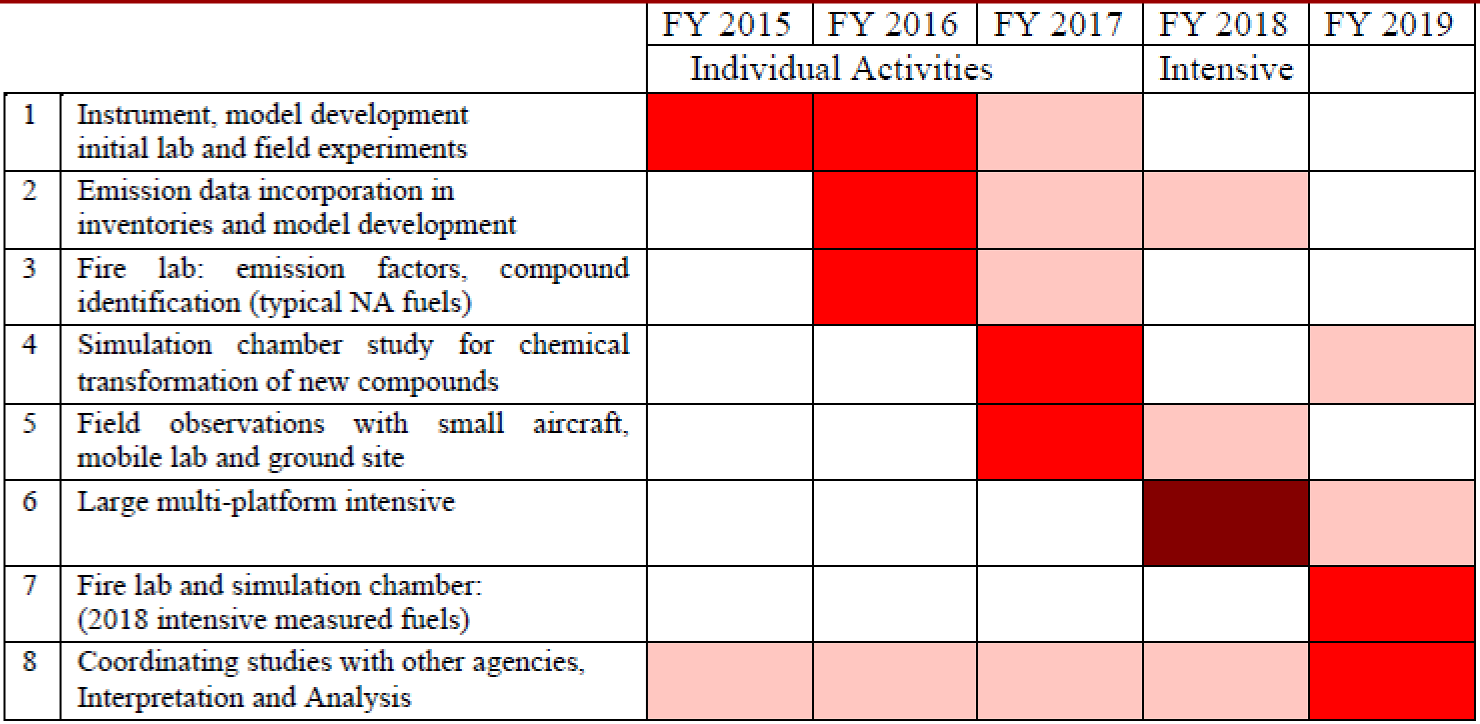
*As contained in FIREX white paper

AC4 FIREX foci*

1. **Collect, analyze and/or model** data from FIREX or related field or laboratory experiments
2. Exploit multiple data sets - in situ, remote, and /or satellite, especially from **CrIS instrument**
3. Focus on the effects of biomass burning on **nitrogen cycle**
4. Contribute to improving the prediction of smoke from wildfires, especially in NOAA's **Air Quality Forecasting** system

*As contained in AC4 FY16 solicitation

AC4 contribution to FIREX



		FY 2015	FY 2016	FY 2017	FY 2018	FY 2019	Supported by AC4:
		Individual Activities			Intensive		
1	Instrument, model development initial lab and field experiments	🟥	🟥	▨			
2	Emission data incorporation in inventories and model development		🟥	▨	▨		
3	Fire lab: emission factors, compound identification (typical NA fuels)		🟥	▨			9 investigators
4	Simulation chamber study for chemical transformation of new compounds			🟥		▨	4 investigators
5	Field observations with small aircraft, mobile lab and ground site			🟥	▨		4 investigators
6	Large multi-platform intensive				■	▨	3 investigators
7	Fire lab and simulation chamber: (2018 intensive measured fuels)					🟥	3 investigators
8	Coordinating studies with other agencies, Interpretation and Analysis	▨	▨	▨	▨	🟥	

AC4 supported projects:

Missoula Fire Lab, chamber experiments, mobile/ground sites, small aircraft: NOx emissions and chemistry, nitrogen isotopes; comprehensive nighttime chemistry; BC aging and BrC chemistry; O_3 and SOA chemistry; aqueous/multiphase chemistry; speciated LVOCs; intercomparison of BC instrumentation (MFL only)

Large aircraft: emissions and chemistry of formaldehyde; HONO and formaldehyde by DOAS; nighttime chemistry of NMOC; reactive chlorine

Complementary: O_3 and PM in urban areas – AQ impacts via unique tracer (acetonitrile)

Modeling: aerosol composition and size distribution, NMOC, WRF/FINN, GEOS-Chem

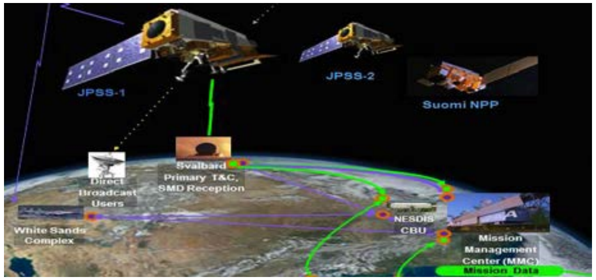
Satellite: O_3 retrieval from CrIS/OMPS

Product needs from JPSS

Latency: near real time during summer 2018; otherwise high latency – at reprocessing time or about 6 months latency;
Data time frame: all data will be useful
Special needs: Level 2 profiles + averaging kernels; ideally <=10 levels or so
Instruments and species:

- CrIS: trace gases (CO, O_3, NH_3, CH_4, CO_2, N_2O, SO_2, HNO_3, CH_3OH etc.)
- OMPS: trace gases (O_3, NO_2)
- VIIRS: AOD, burn area etc.

OAR customers: CPO/AC4, ESRL/CSD, ESRL/GMD? GFDL? ARL?

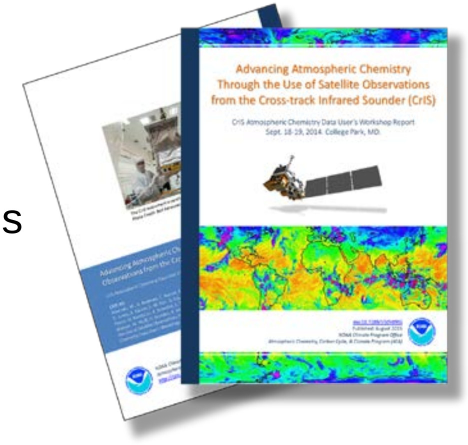


CrIS workshop recommendations (2015)

Scientific community uses TIR satellite observation, so far provided by NASA and EUMETSAT from **MOPITT, TES, AIRS and IASI**. All are past expiration and there are no plans to replace them.

Recommendation 1: Need data
- Provide calibrated radiances Level 1b data at full spectral resolution.

Recommendation 2: Special needs for atmospheric chemistry
A. Provide reduced file size (like TES “lite) with retrievals for individual trace gases and their observation operators at a reduced vertical resolution.
B. Provide essential information: a priori, averaging kernels, estimated retrieval error.
C. Allow rapid multi-file download from CLASS



Advancing Atmospheric Chemistry Through the Use of Satellite Observations from the Cross-track Infrared Sounder (CrIS)

CrIS Atmospheric Chemistry Data User's Workshop Report
Sept. 18-19, 2014. College Park, MD.

Recommendation 3: Validation
A. Coordinate validation with upcoming field campaigns (e.g. FIREX)
B. More frequent ESRL flights to validate trace gases
C. Plan additional field campaigns with retrieval and user communities

Recommendation 4: Future
A. Explore the possibility of new species/products
B. Close spectral gap
C. Reduce noise and increase resolution for future instruments

Most apply to all of JPSS!

Discussion

- What can and will JPSS do?(to address users’ recommendations)
- What can and will CPO/AC4 do? (building on what’s available at NESDIS)
- When?

Atmospheric Chemistry, Carbon Cycle and Climate
AC4
Climate Program Office

FIREX 2016 FIRE-LAB Experiment

http://www.esrl.noaa.gov/csd/projects/firex/firelab/

Species	Name	Description	PI	Affiliation
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	NO_3^- CIMS	Nitrate ion chemical ionization mass spectrometry	Paola Massoli	Aerodyne
Total Fixed Nitrogen	N_y	Catalytic conversion of all N-containing species (except N_2 and N_2O)	J. Roberts/Y. Liu	NOAA/ESRL, CU Denver

VOCs	**H_3O^+ ToF**	**Various VOCs using chemical ionization mass spectrometer using H_3O^+ as reagent ion**	**Abby Koss, Matt Coggon, Carsten Warneke**	**NOAA/ESRL**
VOCs	GC/MS	Gas chromatograph/Mass spectrometer, direct or canister sampling	J. Gilman/ Brian Lerner	NOAA/ESRL
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, w/ FIGAERO Inlet	Iodide ion CIMS especially for N- and Cl-containing VOCs	Bin Yuan, Carsten Warneke, Joost de Gouw, Jose Jimenez	NOAA/ESRL, 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

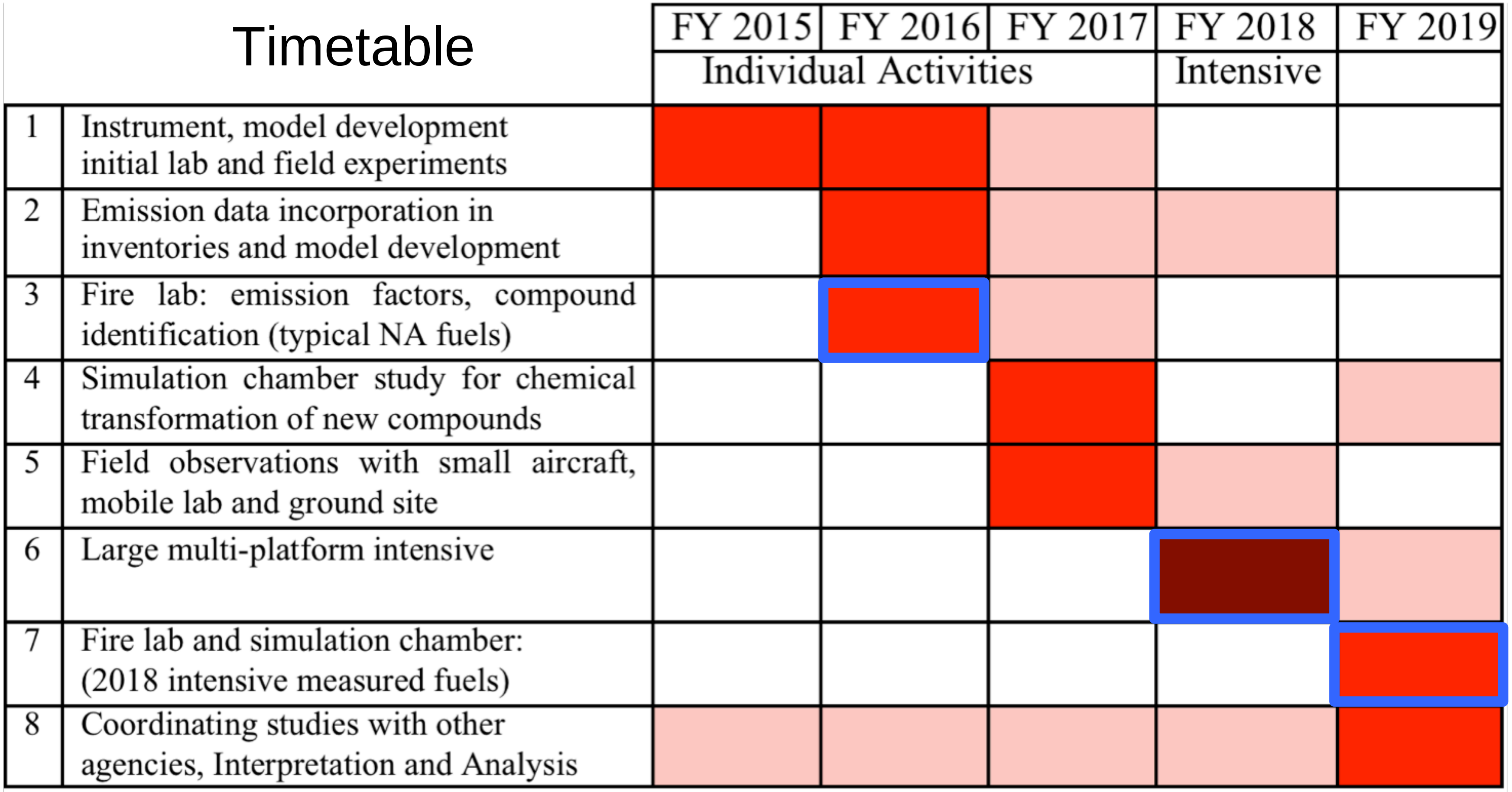
AEROSOL MEASURMENTS

Fine Mode Composition	ToF AMS	Aerosol mass spectrometer with time-of-flight MS, and light-scattering module	A. Middlebrook	NOAA/ESRL
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	DMT
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 distr.	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
Aerosol Absorption, UV-vis	BBCEAS	Broad-band cavity absorption spectrometer,	Rebecca Washenfelder, Carrie Womack	NOAA/ESRL
Particle absorption/extinction	aCRD-PAS	Cavity ring-down and Photo acoustic spectrometers	Nick Wagner	NOAA/ESRL

Imaging Nephelometer	**Aerosol scattering**	**Scattering as a function of angle**	**Katherine Manfred**	**NOAA/ESRL**
Aerosol chemical composition	PiLS-ESI/MS	PiLS sampling with electrospray ionization negative ion mass spectrometry	Chelsea Stockwell, Jim Roberts	NOAA/ESRL
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
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, 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	Shantanu Jathar	CSU

How FIREX will work

Time needed to: Digest previous results
Develop new approaches and instruments
Demonstrate effectiveness



Timetable

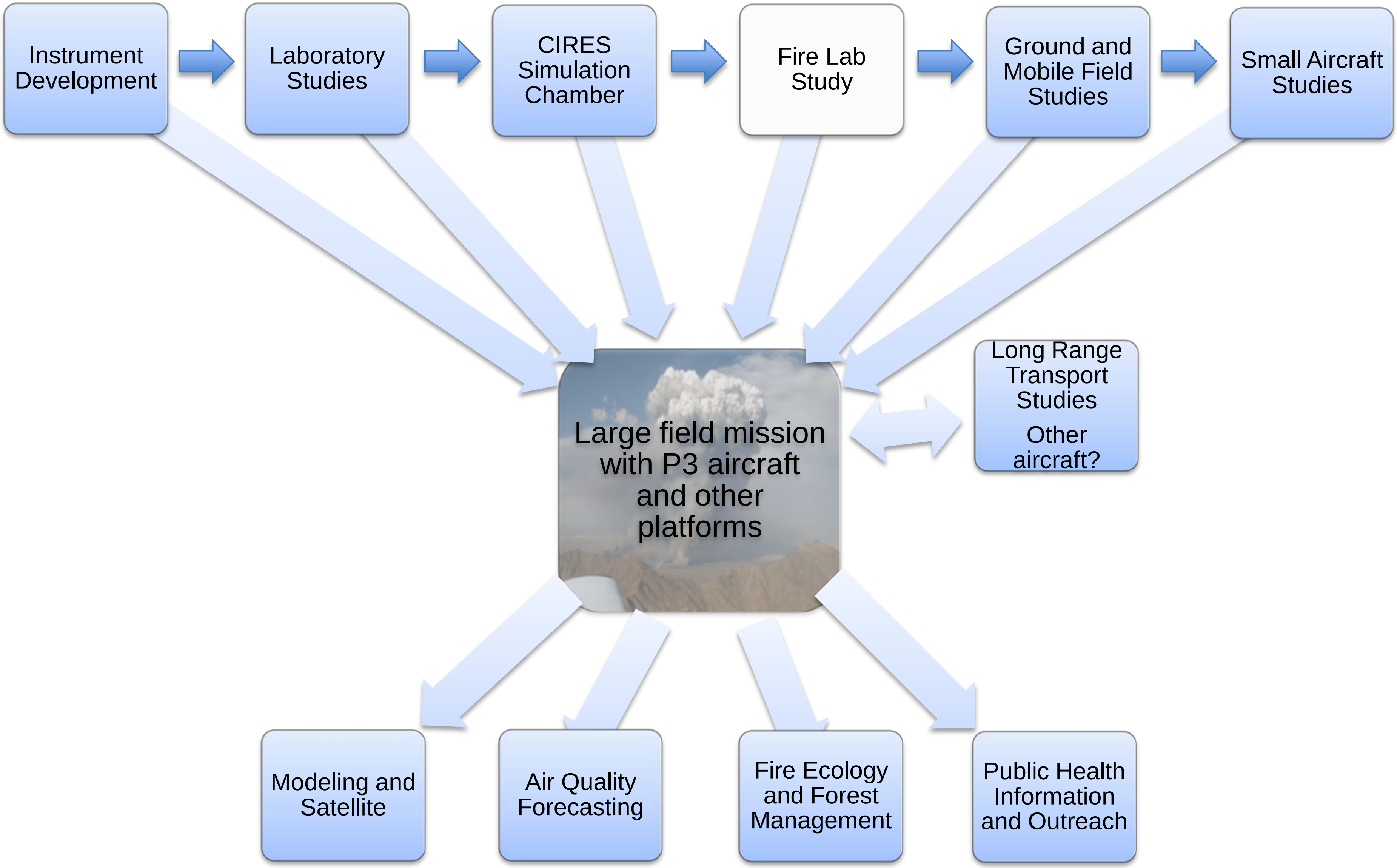
		FY 2015	FY 2016	FY 2017	FY 2018	FY 2019
		Individual Activities			Intensive	
1	Instrument, model development initial lab and field experiments	🟥	🟥	▨		
2	Emission data incorporation in inventories and model development		🟥	▨	▨	
3	Fire lab: emission factors, compound identification (typical NA fuels)		🟥 ☐	▨		
4	Simulation chamber study for chemical transformation of new compounds			🟥		▨
5	Field observations with small aircraft, mobile lab and ground site			🟥	▨	
6	Large multi-platform intensive				■ ☐	▨
7	Fire lab and simulation chamber: (2018 intensive measured fuels)					🟥 ☐
8	Coordinating studies with other agencies, Interpretation and Analysis	▨	▨	▨	▨	🟥

🟥 FY with major work for activity
▨ FY with minor work for activity
■ FY with large-scale field experiment

CSD Lead Activity ☐

FIREX (Core) Steering Committee

Carsten Warneke, Jim Roberts, Joshua Schwarz, Bob Yokelson



Instrument Development

Laboratory Studies

CIRES Simulation Chamber

Fire Lab Study

Ground and Mobile Field Studies

Small Aircraft Studies

Large field mission with P3 aircraft and other platforms

Long Range Transport Studies

Other aircraft?

Modeling and Satellite

Air Quality Forecasting

Fire Ecology and Forest Management

Public Health Information and Outreach

How did we get here: AC4 FIREX timeline

AC4 target/focus for AC4 FIREX: FY16 Program announcement

2013

- Meeting with ARL (fall 2013)
- GFDL Nitrogen Cycle Modeling White Paper (winter 2013/2014)
- **Discussion with CSD (spring 2014)**

2014

- JPSS/CrIS Satellite (workshop, fall 2014; report, summer 2015)
- **Letters of Interest (51) (winter 2014/2015)**
- FIREX white paper (winter 2014)
- AGU Town Hall (winter 2014)
- Interagency Field Campaign Meetings (Feb. 2015)

2015

- **Development and publication of RFP (spring 2015)**
- Discussions with John Cortinas/OWAQ (spring/summer 2015)
- **Submission of LOIs (74) and Proposals (64) (summer 2015)**
- **Virtual Town Hall (summer 2015)**
- Interagency Field Campaign Meeting (Sept. 2015)
- **Proposal Review and Selections – 20 projects selected (winter 2015/2016)**

2016

- Interagency AQRS discussion on other agency interest (NASA, EPA, NSF)
- **AC4 FIREX projects begin (summer 2016)**
- NASA commits DC8 for 2018 (FIRE-Chem)
- First field phase of FIREX: Missoula Fire Lab (fall 2016) - >70 investigators, ~900 compounds, $25+ million of equipment

AC4 FIREX core activities
Other relevant activities

CSD target/focus for FIREX: FY18 field deployment

AC4 Letters of Interest (~50)

i.e. Voice of the community (as of January 2015)

Topics of interest identified in response to FIREX science questions:

- All aspects of emissions and chemistry research, measurements and modeling
- Complementary laboratory studies disconnected from FIREX effort
- Complementary measurements in other regions of US and of other types of burning, especially prescribed burning
- Optical properties of aerosols
- Application of satellite data (well beyond CrIS/SNPP)
- Cloud formation, aerosol-cloud interactions
- Flight planning
- Air quality forecasting
- Climate impacts of fires
- Health impacts of fires