New Technologies from NASA's FireSense Technology Program

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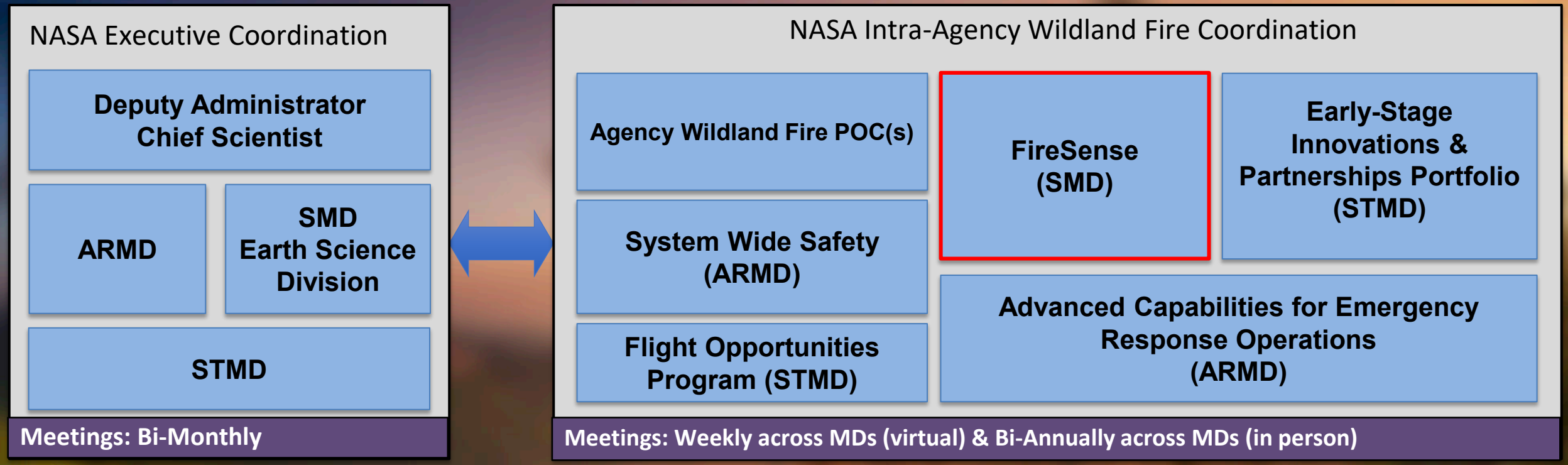
Outline

- NASA Wildland Fire Initiative
- NASA Science Mission Directorate (SMD) FireSense Program and Stakeholder Engagement
- NASA FireSense Technology Projects
- Airborne campaign 2023

NASA Wildland Fire Initiative

- NASA's Wildland Fire Initiative, is a NASA-wide effort focused on delivering NASA's unique science and technological capabilities to operational agencies, striving towards measurable improvements in US wildland fire management.
- The initiative involves the Science Mission Directorate (SMD), Aeronautics Research Mission Directorate (ARMD), the Space Technology Mission Directorate (STMD), including the Small Business Innovative Research (SBIR) program.
- NASA works with interagency partners such as the National Oceanic and Atmospheric Administration (NOAA), the U.S. Department of Agriculture Forest Service (USFS), the California Department of Forestry and Fire Protection, the National Interagency Fire Center, and commercial partners.

NASA Wildland Fire Management Initiative



- Regular Interactions for Coordination and Development of Joint Products and Activities
- Multi-Center Collaboration
- Community Stakeholder Engagements

NASA SMD FireSense

- The Science Mission Directorate (SMD) FireSense project includes a science, technology, and an airborne component (annual campaigns) where improved capabilities and technologies will be developed and evaluated, and ultimately demonstrated to agency stakeholders in a large capstone airborne campaign in year 5 of the project (2027-2028).
- Through initial stakeholder engagement activities, the FireSense project is focusing on four use-cases, co-developed with stakeholders, focused on characterization and measurement of:
  - pre-fire, (ii) active fire, (iii) post fire, and (iv) air quality

50+ years of NASA Fire Science

1972 - Landsat used for forest and fire scar inventory
1980 - AgRISTARS tech demos with USDA & DOI
1987 - Sentinel manuscript, hypothesized O_3 from fire

FIELD CAMPAIGNS

1986 - Prescribed Chaparral fire, California
1992 - SAFARI & TRACE-A (verified ozone chemistry)
1993 - Bor Island, Krasnojarsk, Siberia
1994 - BOREAS, Canada
1998 - LBA, Brazil

1999 - MODIS 1st instrument design: fire detection, measured fire energy / FRP
2001 - MODIS Rapid Response Active Fires (FIRMS)
2006 - Western States Fire Mission (IKHANA with AMS)
2013 - 1st Applied Sciences Wildland Fire Program

FIELD CAMPAIGNS

2014 - Arctic-Boreal Vulnerability Experiment (ABoVE)
2019 – FIREX-AQ (NASA and NOAA)

50+ Years of NASA Fire Science (arcgis.com)

Delivering improved technology and capabilities to operational agencies through technology development, capability demonstration and transfer to operations.

Demonstrate new observation capabilities through the
use of next-generation platforms that will enable high resolution measurements while effectively “staring” at critical targets for days to months.

Co-development with operational agencies and stakeholders for improvements across fire life cycle:

- Updated characterization of fuels
- Better forecasts for risk assessment
- Faster fire behavior models
- Increased detection and tracking of active fire dynamics and smoke plumes
- Improved mapping of burn severity
- Reduced uncertainty for post-fire hazards to air, land and watersheds

Implementation

Technology Development

Enhance existing instruments used for monitoring

Develop next-generation instruments

Enable measurements from multiple vantage points through model-directed, coordinated observations and new aerial platforms

Address computational challenges

AI for creation of new data products

Capability Demonstration

Test existing and enhanced instruments

Evaluate aerial platforms and next-generation instruments

Leverage airborne data to support research and application

Demonstrate to key stakeholders the utility of existing and newly developed technology

Capability & Information Delivery

Co-develop flexible data systems

Ensure integration of datasets (static and real-time) into web platforms

Work with NASA ARMD, commercial and agency stakeholders to bridge communication gap

Enable the seamless exchange of information between spaceborne, airborne, and in situ assets

NASA ESD Wildland Fire Earth Science to Action Strategy

FireSense Project – Targeted implementation and transition of vetted wildland fire management solutions to operational agency stakeholders. US footprint. State and Federal partners.

Research and Analysis - Foundational research focused on understanding the role fire plays in the earth systems. Multiple programs contribute to this effort.

Applied Science - Incubate and co-develop solutions to the wildland fire management problem. Global Footprint. Broad set of stakeholders.

Foundational earth observations used to characterize fire across its entire life cycle including pre-fire conditions, active fire properties, and post-fire impacts to ecosystems and communities.

FireSense Use Cases

Pre-fire: Improved fire prevention by providing fire fuel maps with higher accuracy and resolution.

Provision of near real-time fire risks assessments based on fuel conditions, soil moisture, surface temperature, etc.

Stakeholders: USFS and USGS

Active Fire: Better detection and tracking of fire via satellite and airborne imagery with higher spatial resolution and update frequency

Development of new, innovative sensors and models for precisely tracking and locating fires, fuels conditions, and smoke.

Stakeholders: USFS, CalFire, FEMA

Post-Fire: Improved maps of burn severity to aid in post-fire ecosystem rehabilitation efforts.

Predictions of post fire hazards and impacts including debris flow and landslide risks and water quality impacts.

Stakeholders: USFS and USGS

Air Quality: Enhanced tracking and characterization of smoke plumes and smoke transport.

Improved forecasts of air quality impacts to human health and safety.

Stakeholders: NOAA and EPA

Active FireSense Technology Projects

PI	PI Org (Co-Is/Collaborators)	Title
Milt Halem	UMBC (SJSU, CU Denver, Howard University, UMD, GSFC, UMB)	Towards a NU-WRF based Mega Wildfire Digital Twin: Smoke Transport Impact Scenarios on Air Quality, Cardiopulmonary Disease and Regional Deforestation
Sreeja Nag	BAERI (ARC, CU-Denver, USC, SJSU, USGS, U Mich, Univ of Utah, USFS, Spire, BrainAid)	Distributed Spacecraft with Heuristic Intelligence to monitor Wildfire Spread for Responsive Control
Sun Wong	JPL (Sierra Lobo Inc, NRL, USFS, UCLA, Cal State Univ)	Pyro-Atmosphere Infrared Sounder: Monitoring Fire Weather Conditions with a Sub-Kilometer Spatial-Resolution Hyperspectral Infrared Sounder
Doug Morton	GSFC (UC-Irvine, CU-Boulder, UMD)	The airborne Compact Fire Imager (CFI) for measurements across the entire fire lifecycle
Kyle Hilburn	CO State (LaRC, SJSU, ARC, USC, CU Denver, CropSnap LLC, Univ of Utah)	Technology Development to Integrate Innovative Observation Capabilities into Coupled Wildfire Models for Improved Active Fire Forecasting

Active FireSense Technology Projects

PI	PI Org (Co-Is/Collaborators)	Title
James Thompson	UT Austin (Univ of Pittsburgh, US Fish and Wildlife Service)	UAS thermal infrared spectroscopy will improve real time evaluation of hazards and environmental impacts of wildfires
Fatemeh Afghah	Clemson (USFS, Univ of Nevada, DRI, UCAR)	AI-enabled Drone Swarms for Fire Detection, Mapping, and Modeling
Simon Hook	JPL (Planet, ARC)	Wildfire Thermal Detection Instrument Development Step 2
Rashmi Shah	JPL and commercial companies	Wildland Fire Pre-Formulation Concept Study **Wildland Fire Pre-Formulation Concept Study Request for Information*
Makel Engineering	SBIR	Chemical and Particulate Microsensor Instrument for UAV Airborne Measurements Near Wildfires **NASA Small Business Innovation Research*
Xiomas Technologies	SBIR	Thermal Mapping Airborne Simulator for Small Satellite Sensor **NASA Small Business Innovation Research*

Active FireSense Technology Projects

PI	PI Org (Co-Is/Collaborators)	Title
Alicia Kinoshita	San Diego State University	*Impacts of changing wildfire regimes on human communities and water security*
Mark Cochrane	University Of Maryland, Cambridge	*Characterizing and monitoring changing fire regimes and the risk of extreme wildfire events in the United States using biophysical models and satellite*
Gregory Okin	University of California, Los Angele	*Fire impacts on precipitation through land-atmosphere interactions in savannas*
Volker Radeloff	University of Wisconsin	*Wildfire impacts on communities in the Wildland Urban Interface and ecosystems in protected areas*
Pablo Sadie	University of California, Los Angeles	*Wildfire drivers and impacts on air pollution and vegetation in a changing climate: an integrated remote sensing and modeling approach*
Nancy French	Michigan Technological University	*Informing human risk perception of and response to wildland fire smoke using new satellite-derived extreme smoke event data*
Marcia Macedo	Woodwell Climate Research Center, Inc.	*Improving Amazon fire risk forecasts to minimize impacts on tropical forest ecosystems and human health*

SMD FireSense Recent Solicitations

- Technology (ROSES-23 A.59):
  - Closed March 29, 2024
  - 2 step process (non-binding)
  - No due date (NODD)
  - Using the dual-anonymous peer review (DAPR) process for the second step proposals
  - Current project selections: https://esto.nasa.gov/firesense2022final/

- Implementation Team (ROSES-23 A.65):
  - Closed January 18, 2024
  - Solicitation calls for team memberships, and in the future team members can propose projects

MSI Incubator

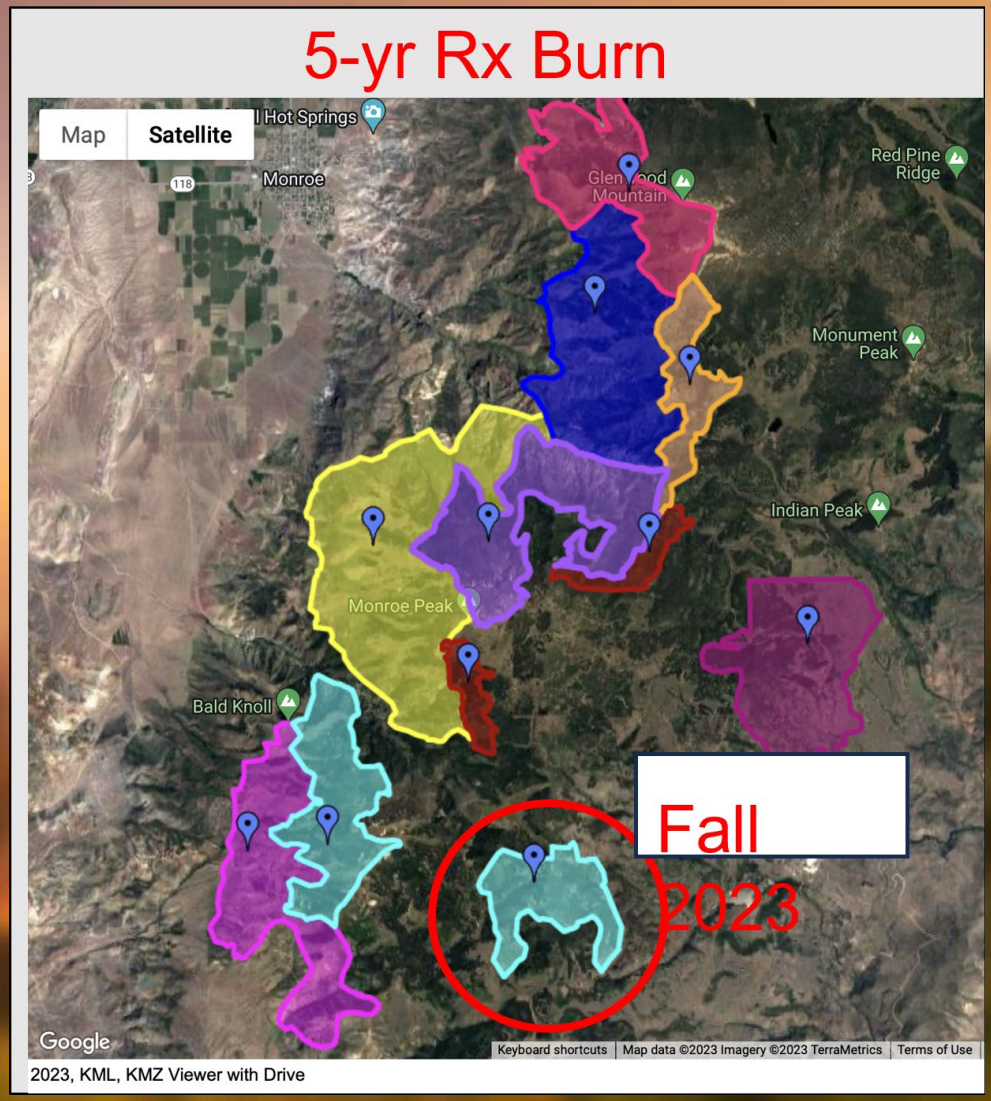
Three finalists will join a startup incubator program and receive $100k each
Three runners-up from the Wildfire Semi-Finalists Pitch Event will be invited to the NASA I-Corps Accelerator program.

FireSense 2023 Airborne Campaign
USFS FASMEE component

NASA FireSense
partnership US Forest Service (USFS) and
Fish Lake National Forest (FLNF) and
USFS FASMEE
(Fire And Smoke Model Evaluation Experiment)

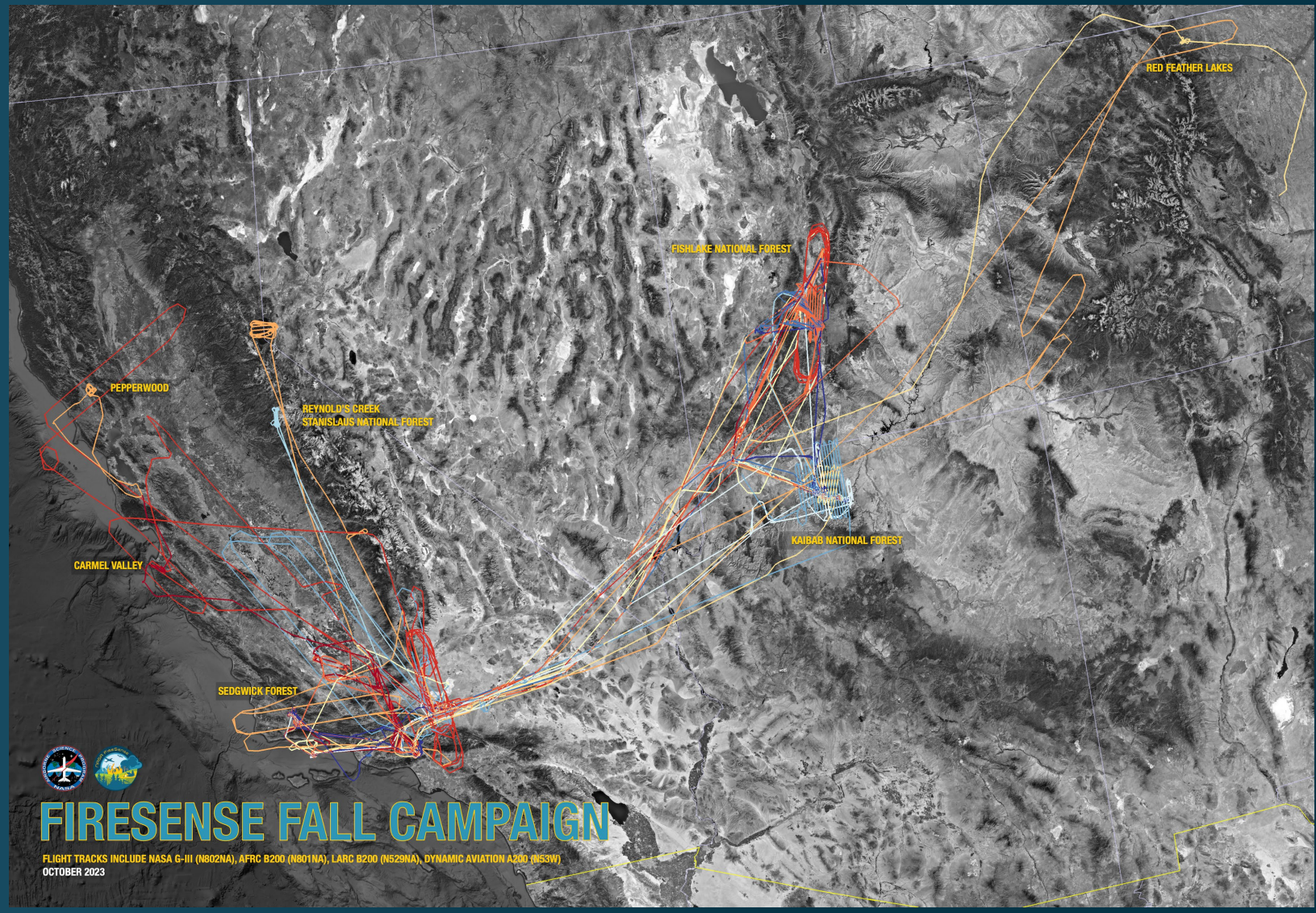
2023 fall prescribed burn
stand replacing crown fire
restore aspen to improve elk habitat
reduce hazardous fire fuels
measure extreme fire behavior and smoke plumes
improve fire behavior and smoke models

NASA instruments coordinated with ground sampling
airborne sampling with
UAVSAR, AVIRIS, SLAP, MASTER, SWIS
measurements of pre-fire fuel type and moisture
active fire dynamics (e.g., intensity)
post-fire effects (e.g., burn severity)

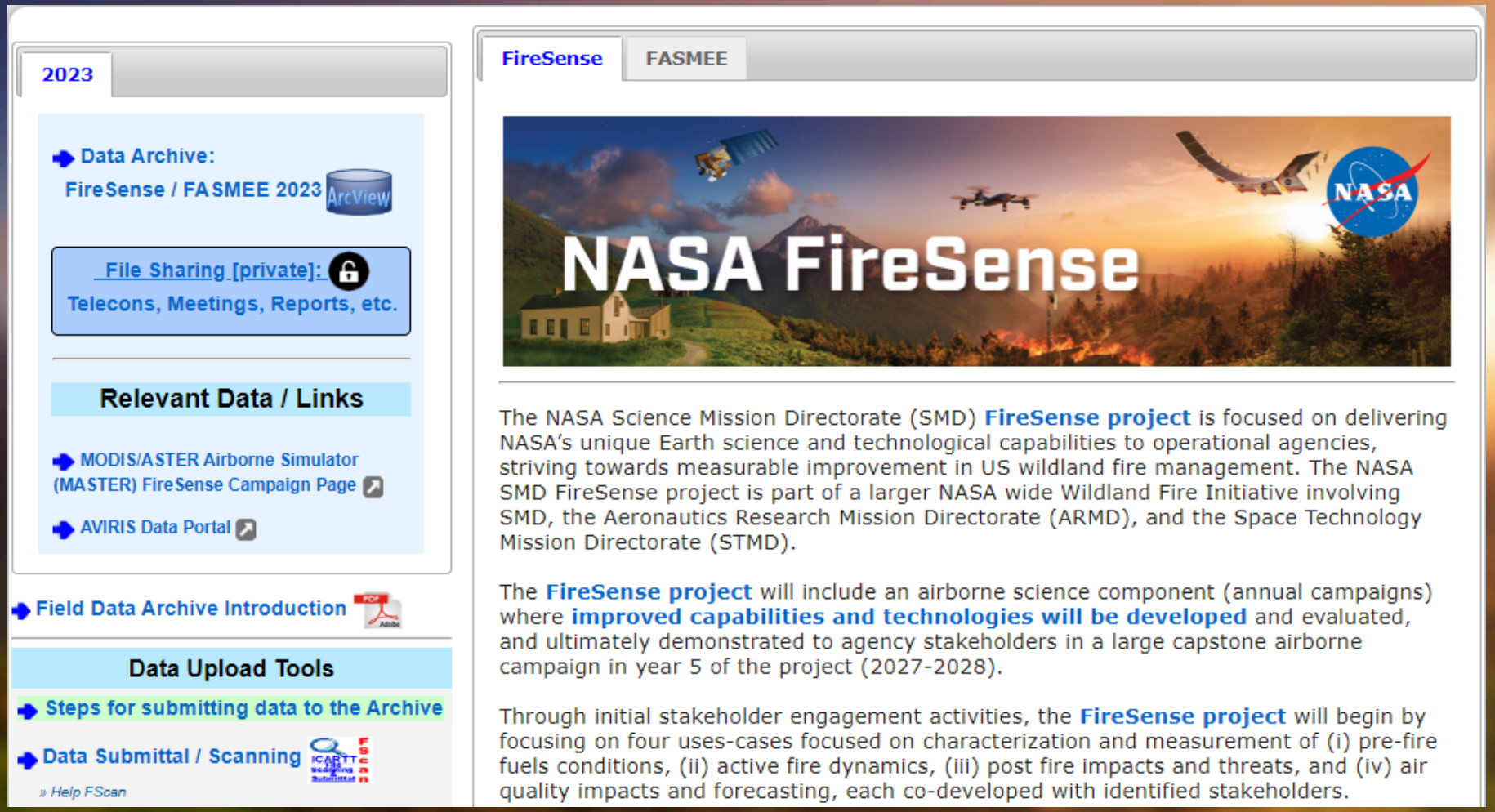


2023 FireSense airborne Campaign

- ~8 weeks at 9 locations across 4 states
- Over 45 participants from 21 institutions
- Community field day with 3 aircraft and 4 sensors
- **Pre-fire**
  - Fuel structure and composition soil and fuel moisture sampling from air and field
- **Active fire**
  - Spatially coincident thermal IR and imaging spectroscopy from air
- **Post-fire**
  - SAR and imaging spectroscopy for fuel consumption from air and field
- 4 instrumented aircraft
  - NASA AFRC B200 (MASTER + SWIS)
  - NASA C-20 (UAVSAR)
  - Dynamic Aviation (AVIRIS-3)
  - NASA Langley B200 (SLAP)
- Coordination with USFS
  - USFS FLIR (day)
  - USFS NIROPS Phoenix (night)



FireSense 2023 Campaign Data Products



LaRC Airborne Science Data for Atmospheric Composition:
FireSense Data Archive

NASA SMD FireSense

https://cce.nasa.gov/firesense/index.html