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.

50+ years of NASA Fire Science and Applications

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, 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

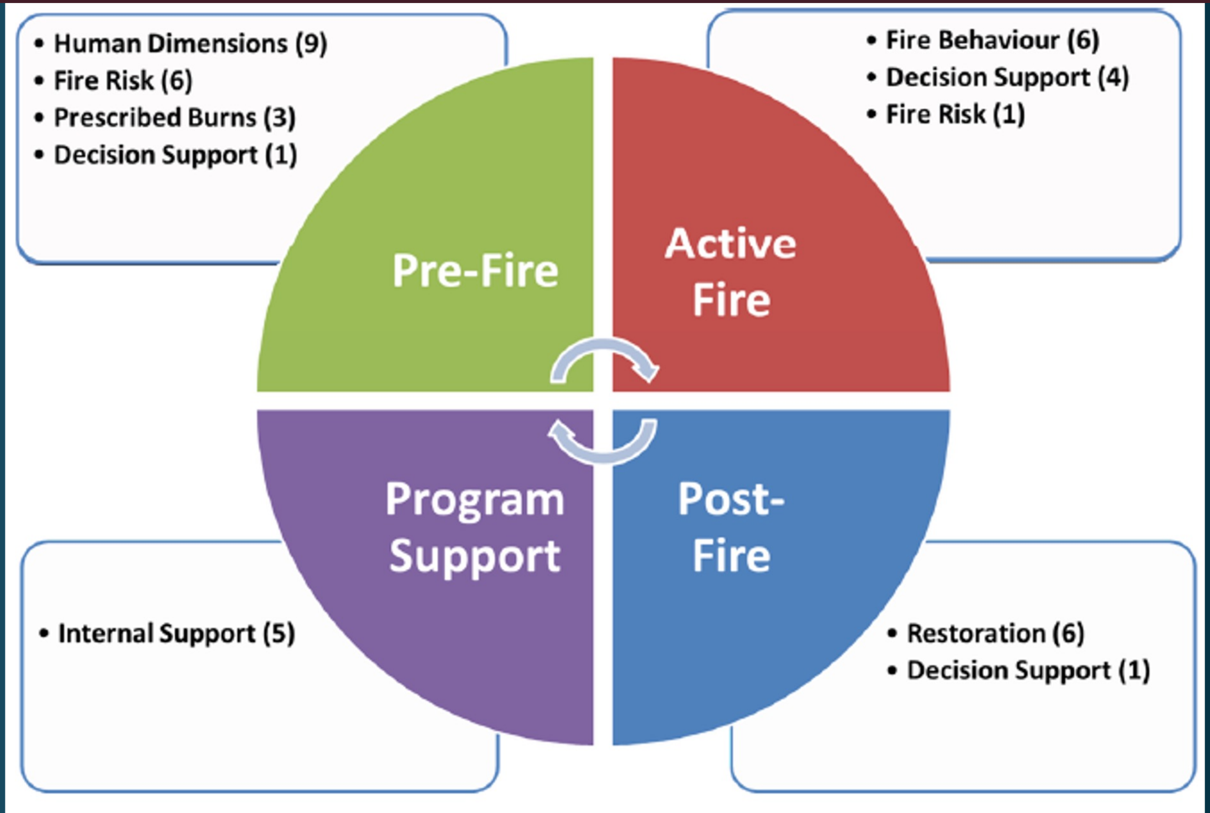
FIELD CAMPAIGNS

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

Rebirth of NASA SMD Wildland Fires: 2022-2023 Overview

40 projects selected & seeded across diverse wildland and prescribed fire community

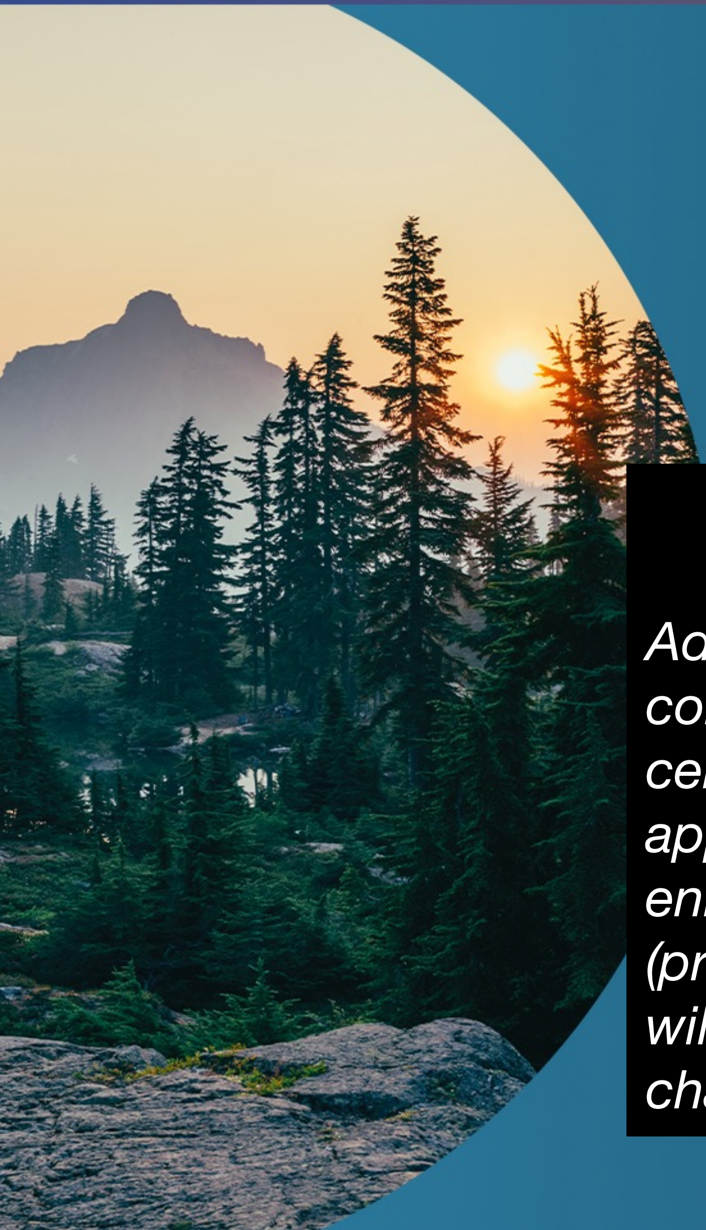
- Western, Central, Southern, Eastern U.S. + International



National Aeronautics and Space Administration

Wildland Fires Program
Applied Sciences

SMD Wildland Fires Program



VISION

Advance community-centered applications to enhance and solve (prescribed and) wildland fire challenges.

MISSION

Cooperatively co-develop information and knowledge that improves wildland fire management through transitioning science, data, models, and technology.

VALUES

Transparency
Respect
Kindness
Integrity
Collegial
Discipline
Honest
Straightforward

NASA FireSense

The NASA Science Mission Directorate (SMD) FireSense is focused on delivering NASA's unique Earth science and technological capabilities to operational agencies, striving towards measurable improvement in US wildland fire management. The NASA SMD FireSense project is part of a larger NASA wide Wildland Fire Initiative involving SMD, the Aeronautics Research Mission Directorate (ARMD), and the Space Technology Mission Directorate (STMD).

The FireSense project will include an airborne science 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 will begin by focusing on four uses-cases focused on characterization and measurement of (i) pre-fire fuels conditions, (ii) active fire dynamics, (iii) post fire impacts and threats, and (iv) air quality impacts and forecasting, each co-developed with identified stakeholders.

NASA FireSense is driven by Stakeholder Needs

NASA SMD Wildfire Stakeholder Engagement Workshop – Held Early Feb 2022

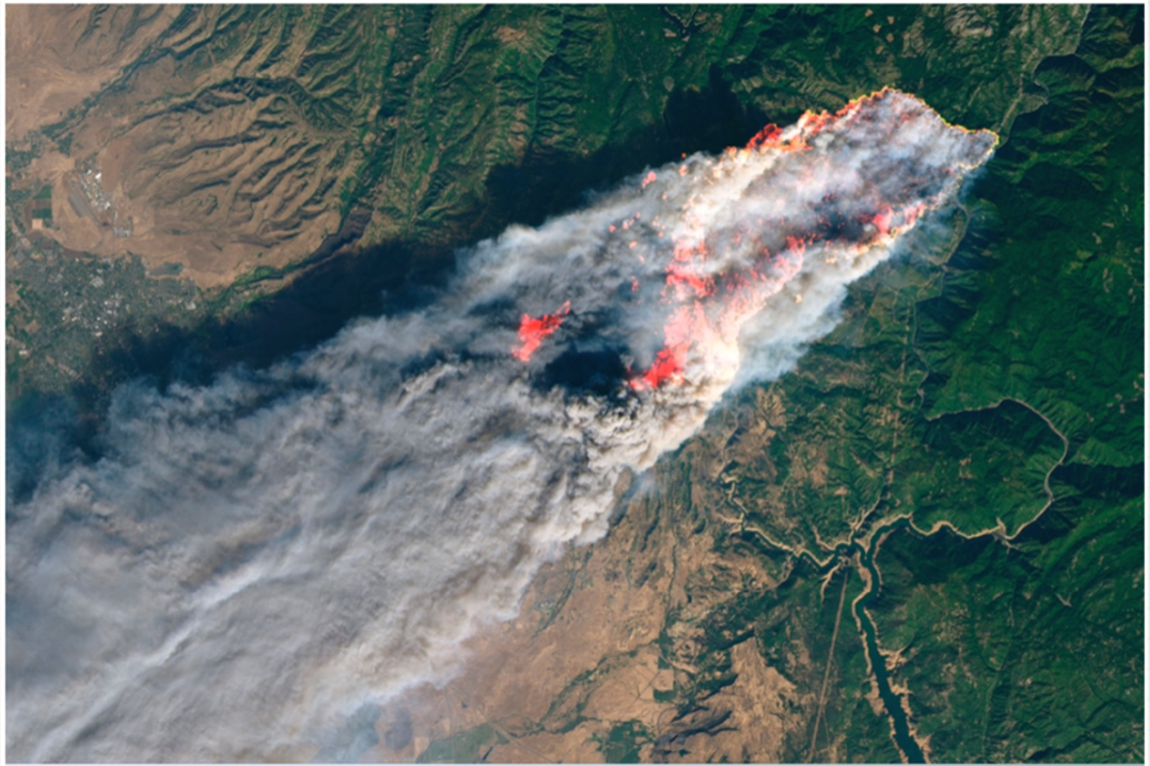
Workshop Purpose:
To hear wildland fire management stakeholders identify gaps and visions for successful wildland fire management.

Participants asked to identify the following:

- Barriers the community has in integrating science, technology, and knowledge into the fire management problem.
- Areas where NASA can help enable collaborative programs and partnerships across the fire lifecycle, including preparedness and adaptation, response, and recovery.
- Key opportunities and priorities to make progress in pre-, active, and post-fire management.
- Partners and programmatic activities that guide near- and long-term action in wildland fire management

Over 800 participants!

NASA SCIENCE MISSION DIRECTORATE (SMD) WILDFIRE STAKEHOLDER ENGAGEMENT WORKSHOP



Announcement:

Thank you to everyone who participated in the NASA SMD Wildfire Stakeholder Engagement Workshop and Breakout Groups! The discussions were very engaging and informative.

Note, this event has already occurred, however, please see the post workshop recordings and materials below.

NASA FireSense is driven by Stakeholder Needs

Workshop Outcomes: Primary deliverable - whitepaper describing current barriers faced by agencies responsible for managing fire across its life cycle (pre-, active-, and post-fire).

Some of What we heard*:

Pre-fire –

- Current fuels map of limited utility for operational management (increase accurate updates)
- Fire behavior models do not have the necessary fidelity and/or timeliness to accurately predict fire behavior and fire spread
- Current observations and forecasts of winds, humidity, and fuel moisture are insufficient for fire risk assessment and prediction

Active Fire –

- Must reduce of time from ignition to detection and response
- Need persistent (24/7) IR imagery of active fires to support fire management and monitoring (and fire science)
- Lack of Reliable, high-speed communications/data
- Need instruments capable of mass/power limitations of new suborbital platforms

Post-fire –

- Improved mapping of forest burn extent and fire severity
- Understand impacts to air and water quality and human health
- Reduce debris flow prediction uncertainty: landslides, floods, impacts to watersheds

NASA Science Mission Directorate (SMD) Wildfire Stakeholder Engagement Workshop: Summary and Key Findings

1. Introduction

Wildfire is a growing problem in the United States. In 2020 alone, there were over 58,000 wildfires resulting in over 10M acres burned. 5-year average fire suppression costs are about $2.35B, not including costs associated with property damage and impacts to human health, which are estimated to be far greater[1]. The wildfire problem and associated costs are only expected to grow under projected climate change. Therefore, it is critical to understand and manage wildfires across their entire lifecycle which includes the pre-fire, active fire, and post-fire environments. Improved understanding of these environments can lead to enhanced wildfire management including pre-fire risk reduction, efficient active fire suppression, and effective post-fire hazard mitigation, ultimately reducing negative ecosystem impacts and damage to property and people. Currently wildfire is managed across its life cycle by state, federal, and tribal agencies who leverage various information sets to make informed management decisions. However, these information sets are sometimes of limited utility for a myriad of reasons including accuracy, resolution, latency, effectiveness, and degree of technical innovation, among others. Given these constraints, the wildfire management problem could benefit from a new paradigm that takes full advantage of the best available science, technology, and capabilities to help overcome current barriers to more efficient and effective wildfire management: new science and technology are fundamental to anticipate and manage the new reality of extreme fires in a warming world.

In February of 2022, NASA hosted a two-day wildfire stakeholder engagement workshop with an objective of learning understanding barriers to wildfire management currently faced by federal, state, local, tribal, and territorial land management agencies in the United States. The ultimate goal is to use this information to inform how NASA science and technology can be more effetely applied to support timely decision making and operations in pre-, active and post-fire management environments. The workshop was comprised of a series of expert panel discussion and breakout groups that address different aspects of pre-, active, and post-fire management. The primary findings and emerging themes from these sessions are presented herein.

2. The Pre-fire Environment

2.1 Pre-fire weather and climate

https://aam-cms.marqui.tech/aam-portal-cms/assets/ki2yd52vavkccskc

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

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

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

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

FireSense Implementation

Technology Development

Enhance existing instruments used for monitoring pre-fire, active-fire, and post-fire environments

Develop next-generation aerial platforms as well as instruments for small spacecraft and aerial platforms for wildland fire applications

Enable measurements from multiple vantage points through model-directed, coordinated observations

Address computational challenges for modeling and for data acquisition, fusion, and real-time processing

AI for creation new data products needed for wildfire management and for management of of observing platform constellations

Capability Demonstration

Test existing and enhanced instruments used for monitoring pre-fire, active-fire, and post-fire environments

Evaluate existing and novel aerial platforms and next-generation instruments for wildland fire applications

Leverage airborne data to support research and application development in the for FireSense use cases

Demonstrate to key stakeholders the utility of existing and newly developed technology in the management of wildland fire across the pre-fire, active-fire, and post-fire environments

Capability & Information Delivery

Work with stakeholders to develop wildland fire data systems and solutions that are flexible and aligned with desired capabilities

Ensure existing and new datasets (static and real-time) can be integrated into existing user-friendly web platforms (e.g., USFS WildfireSAFE, FIRMS, etc.)

Work with NASA ARMD and commercial and agency stakeholders to bridge the current communication gap in wildland fire management

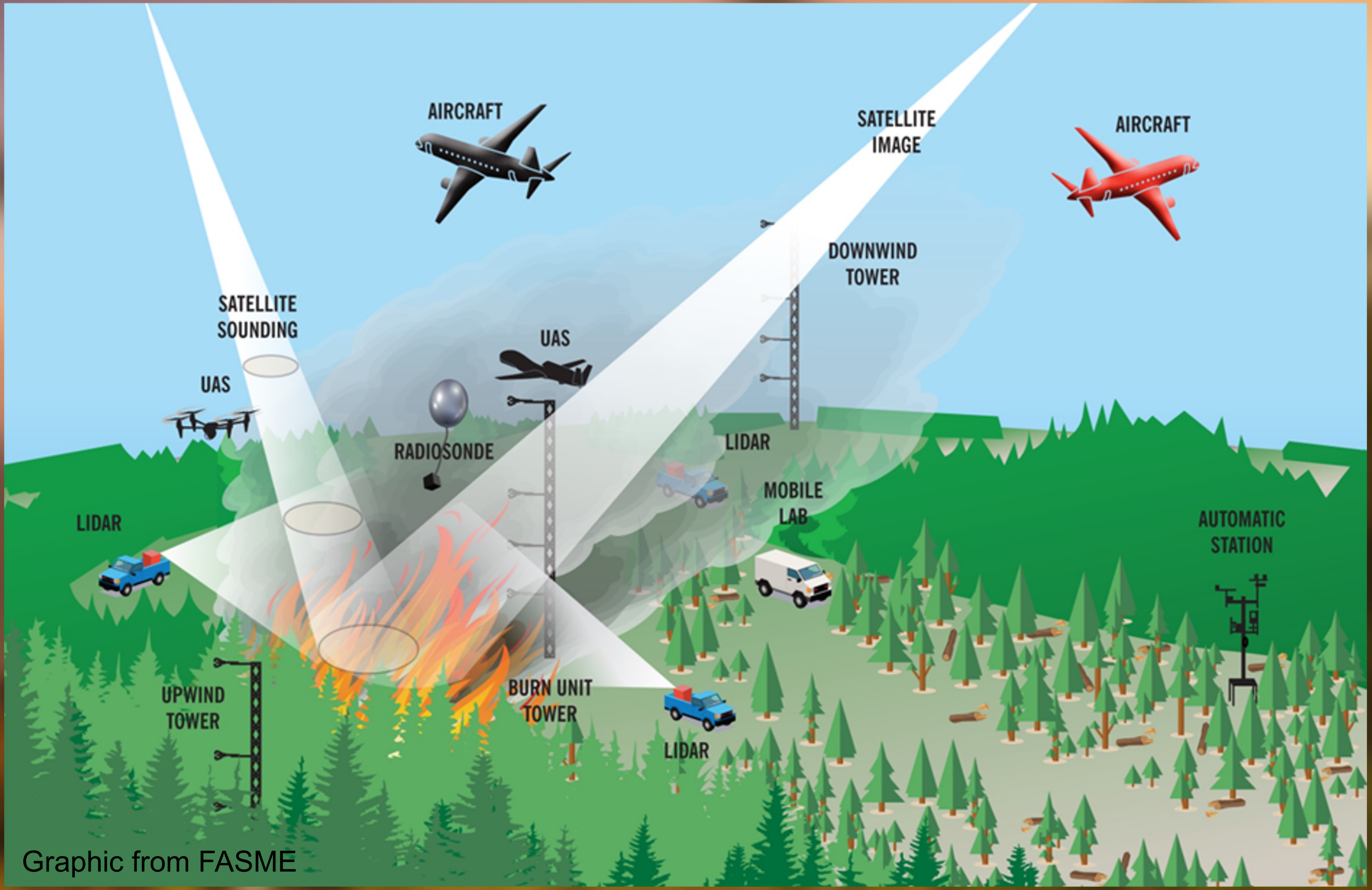
Enable the seamless exchange of information between spaceborne, airborne, and in situ assets

Demonstration Activities

Annual Field Campaigns (2023-28): Field campaigns will be conducted annually, with increasing sophistication in the sensors and platforms tested. Targeting areas across the US, not just western forests.

Capstone Field Campaign in Year 5 (2027-28): The Capstone Field Campaign will serve as a technology demonstration event for stakeholders to use/evaluate the tools, products, sensors, and capabilities developed during the first four years of FireSense.

The goal is that the success of the Capstone Field Campaign will enable the successful adoption/transition of FireSense developed capabilities by our stakeholder/operational agencies.

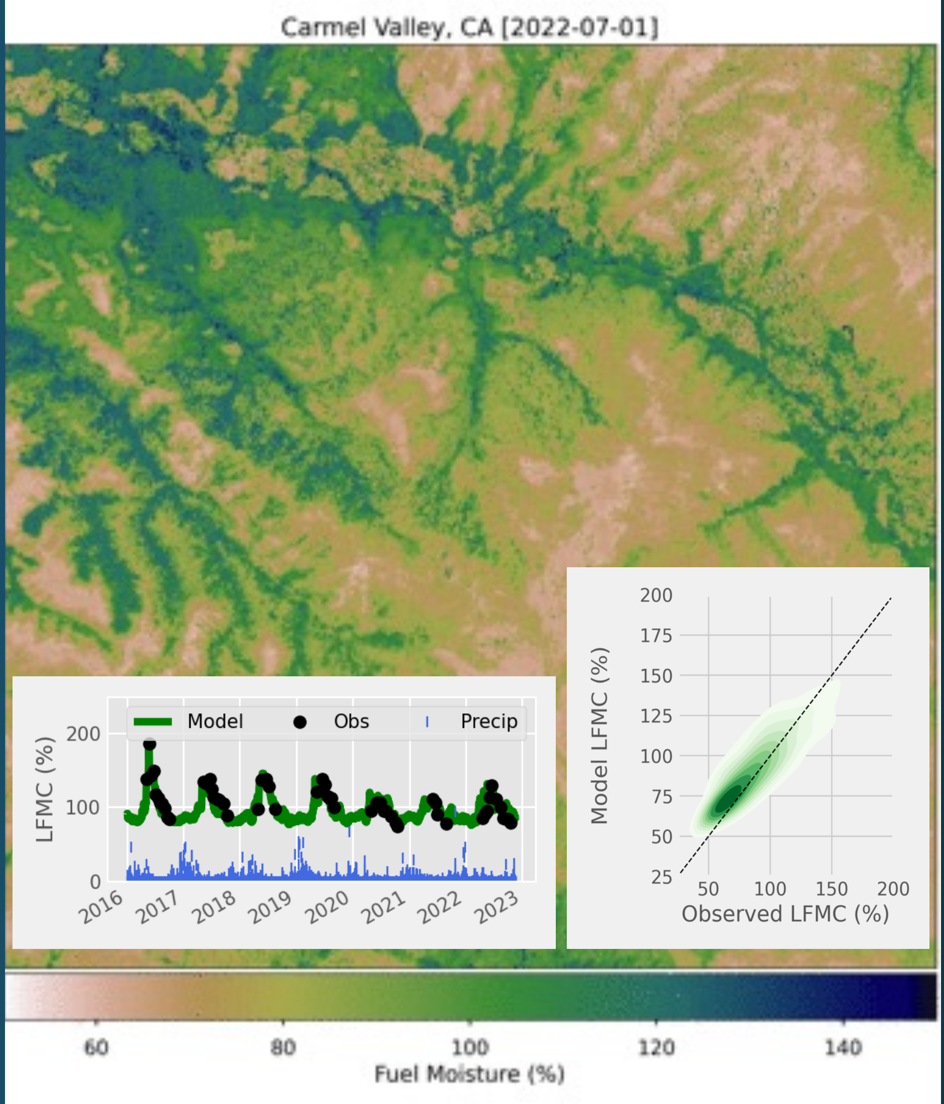


Graphic from FASME

Fuel Moisture Mapping

Mapping live fuel moisture content (an indicator of fire risk) to inform proactive management

- OpenET provides Landsat-based data on water use by vegetation via evapotranspiration
- Fuel moisture is estimated using a machine learning model using Open ET + meteorological data and trained on samples collected from the National Fuel Moisture Database
- With OpenET, we can map fuel moisture at temporal and spatial scales relevant for management; 30 m spatial resolution with two-week prediction window



Credit: AJ Purdy

OPENET

Fire Progression Mapping

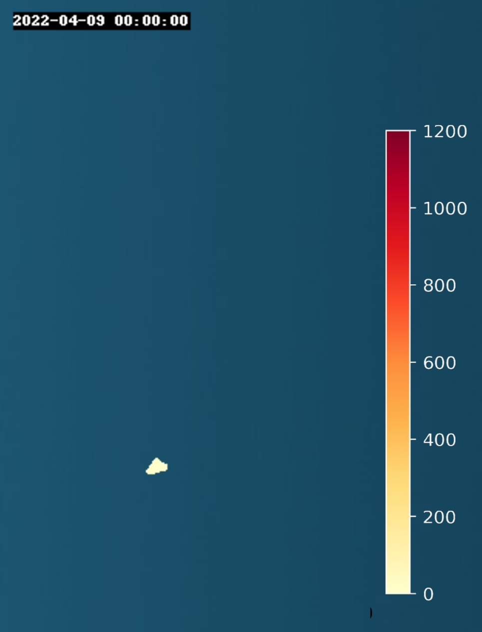
This visualization is based on the following paper: Chen, Y., Hantson, S., Andela, N. et al. California wildfire spread derived using VIIRS satellite observations and an object-based tracking system. Sci Data 9, 249 (2022). https://doi.org/10.1038/s41597-022-01343-0

Fire Severity Mapping

Fire Spread Model Benchmarking

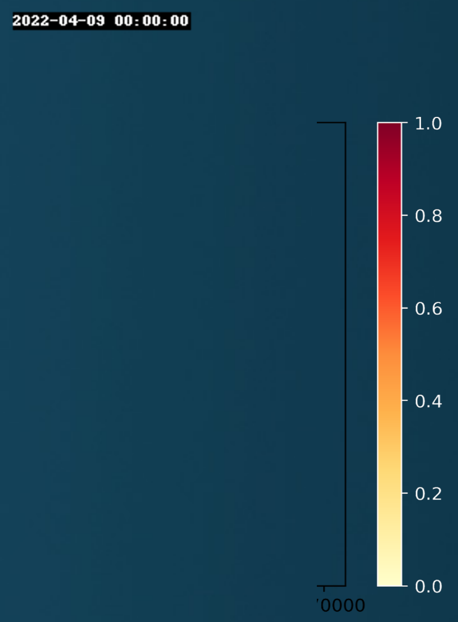
Fireline Progression

Connecting Fire Weather and Fuels to Fire Behavior and Emissions



Max Fire Radiative Power (FRP, MW)

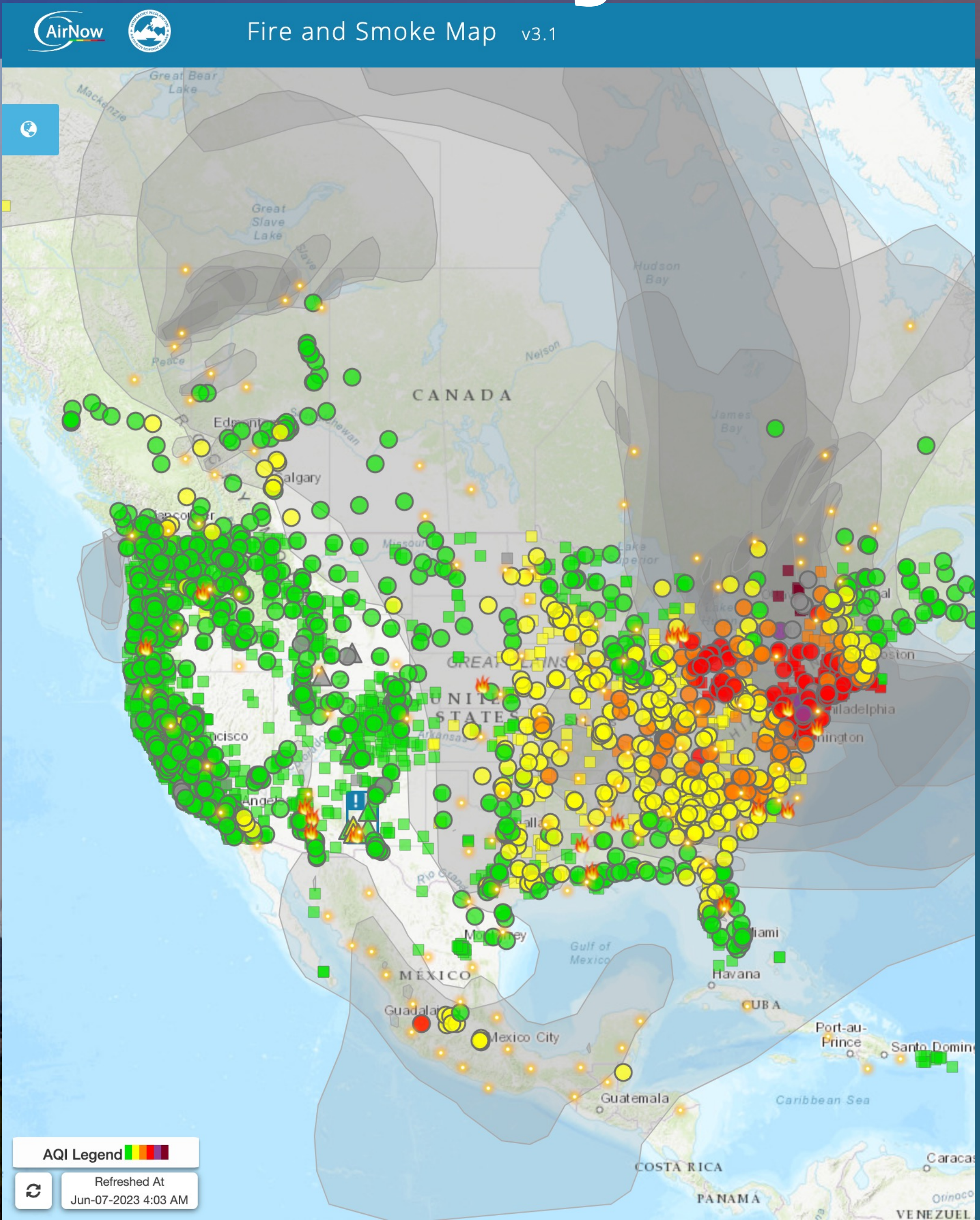
Connecting Fire Behavior to Post-Fire Burn Severity



Harmonized Landsat/Sentinel-2 difference Normalized Burn Index Mapping

2022 Hermit's Peak Wildfire, New Mexico

Air Quality Example



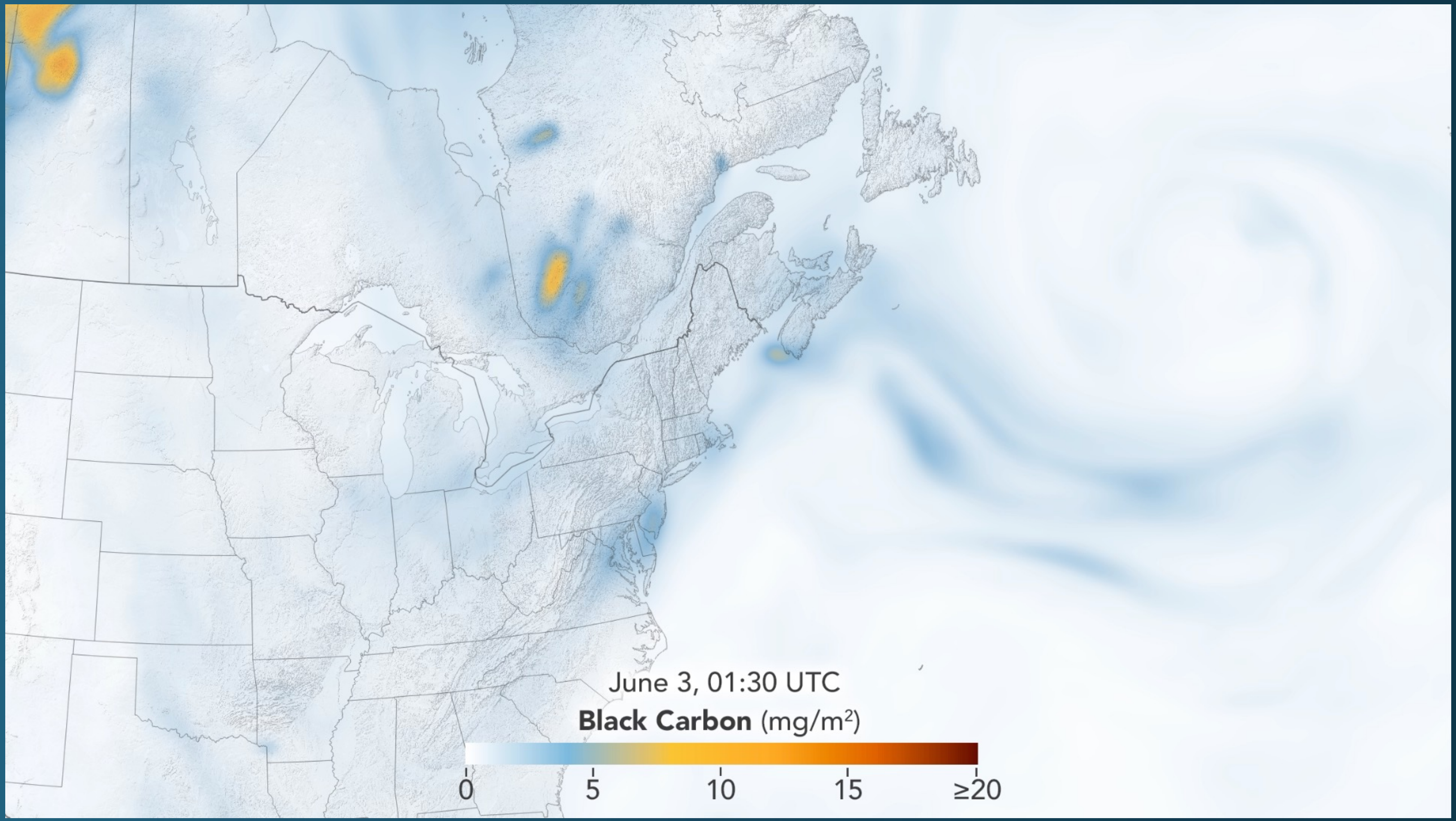


Figure Above: GEOS-FP model simulating black carbon aerosols in wildfire smoke transported from Canadian fires June 3-8, 2023. impacting air quality in Eastern U.S. The EPA estimated that more than 86 million Americans were breathing harmful levels of PM 2.5 during this event.

Figure to Left: Fire and Smoke forecast for June 7, 2023.
NASA working in partnership with EPA and NOAA together provide real-time air quality information for USFS and general public. https://fire.airnow.gov

Active Technology Projects

Organization	Title
University of Maryland, Baltimore County	Towards a NU-WRF based Mega Wildfire Digital Twin: Smoke Transport Impact Scenarios on Air Quality, Cardiopulmonary Disease and Regional Deforestation
Makel Engineering, Inc.	Chemical and Particulate Microsensor Instrument for UAV Airborne Measurements Near Wildfires (**SBIR**)
Xiomas Technologies, LLC	Thermal Mapping Airborne Simulator for Small Satellite Sensor (**SBIR**)
Bay Area Environmental Research Institute	**Distributed Spacecraft with Heuristic Intelligence to monitor Wildfire Spread for Responsive Control**
California Institute of Technology	**Pyro-Atmosphere Infrared Sounder: Monitoring Fire Weather Conditions with a Sub-Kilometer Spatial-Resolution Hyperspectral Infrared Sounder**

NASA's Wildland Fire Initiative

Multi-Disciplinary Collaboration in Wildfire

ARMD

- Concept of Operations Development
- Integrated Systems Architecture to ensure persistent communication and remote sensing
- Airspace Management Technologies
- UAS technology enabling communications, logistics, and 24-hour aerial suppression
- Aircraft and operations safety technologies

Aerial Suppression, Safe Airspace Operations, and Logistics

SMD

- Tools and technology to more effectively manage wildland fire across the entire fire life cycle (pre-, active, and post-fire)
- Improved fire prevention via improved risk assessments
- Better detection and tracking of fire
- Improved predictions of post fire hazards
- Improved monitoring and forecasting of air quality

Prediction, Detection and Tracking, Mitigation Support

STMD

- Early-Stage Technology Development, Maturation, and Demonstration
  - SBIR / STTR
  - Prizes, Challenges, and Crowdsourcing
- Transfer NASA Technology to spinoff products and service
- Flight Opportunities for technology testing through the TechFlights solicitation, TechLeap prize, and OGA partnerships

Technology Advancement

Thank You

Please contact Michael Falkowski for further information:

michael.falkowski@nasa.gov

FireSense Team

ESD FireSense Program (HQ)

Lead:
Michael Falkowski

Airborne Campaigns:
Melissa Martin and Barry Lefer, Research & Analysis

Modeling and Information Systems:
Michael Falkowski, Research & Analysis

Stakeholder Engagement and Capacity Building:
Emily Sylak-Glassman, Applied Sciences

Technology Development and Demonstrations:
Haris Riris **and** Teresa Kauffman, Earth Science Technology

ESD FireSense Project

Project Manager (ARC): Selection Announcement forthcoming

Project Scientist (ARC): Selection Announcement forthcoming
Systems Engineer (JPL): Justin Boland

FireSense Implementation Team Lead: Vacant
FireSense Science and Applications team lead and membership to be competed

FireSense Partners

NASA Partner Organizations:
ARMD and STMD

External Partner Organizations:
EPA, NOAA, USFS, USGS, EDF, CalFire, Many Others