NASA's New Wildland Fire Earth Observation Science & Applications Program Developments: "FireSense"

Vince Ambrosia, David Green, Michael Falkowski, Barry Lefer, Parimal Kopardekar, & Laurie Grindle

NASA Science Mission Directorate (SMD) - Earth Science Division
and
Aeronautics Research Mission Directorate (ARMD)
NASA HQ

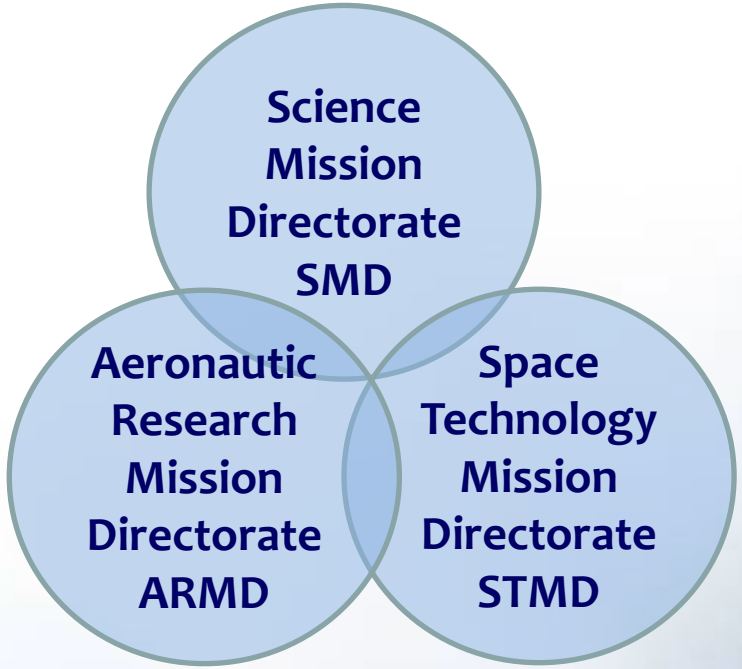
5TH GWIS & GOFC GOD FIRE IMPLEMENTATION TEAM MEETING
Stresa, Italy
21-23 June 2022

A NASA-WIDE APPROACH

A NASA Wildfire Research, Development, and Technology Transition Program

A Whole of NASA Solution (ARMD,SMD,STMD)

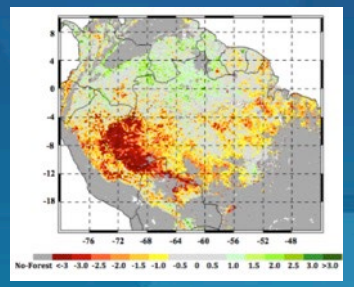
To advance our nation's ability to predict and manage wildfires and mitigate their impacts

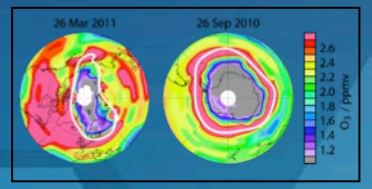


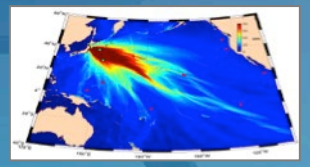
NASA is working with the Wildfire community to provide science and technology infusion to develop strong foundations upon which that community can advance their management capabilities; a five-year NASA-wide program

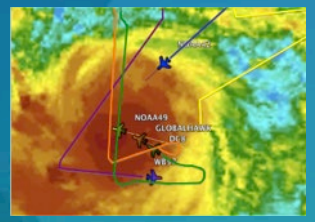
NASA's Earth Science Division

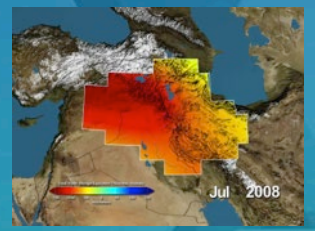
Research





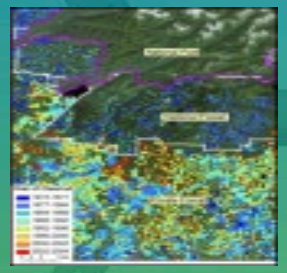


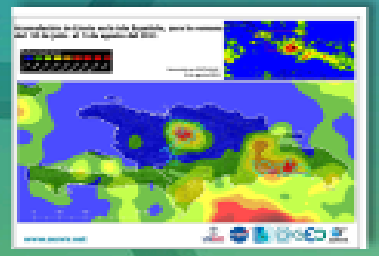


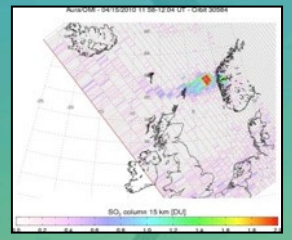


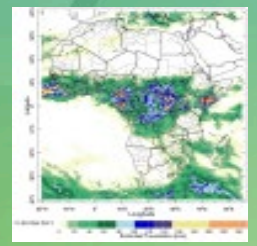
Flight

Applied Sciences

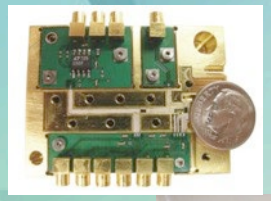


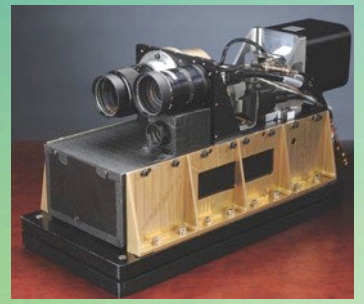






Technology





NASA Earth Division Science: Coming Together on Wildfire Capabilities

Airborne Sensors / Instruments :: Miniaturization & Uncrewed (UAS) Systems Technology

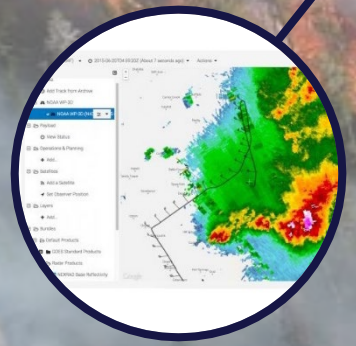
Earth System Science :: Data Fusion, Modeling, Visualization, Validation

Constellations :: Fire Science & Ecology

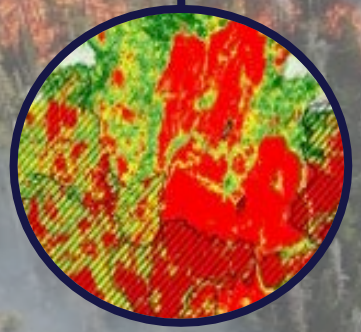
Earth Science Division

Airborne sensors / instruments & campaigns

Technology: Miniaturization & UAS platforms



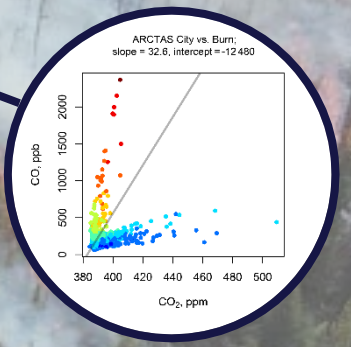
Wildfire Information System & Situational Awareness



Fire management support: drought & fire risk prediction, fire impact assessments

Partnerships

Wildfire data integration, modeling, & visualization



Earth system science: atmospheric science, ecosystem science, hydrology

National Park Service

Research to Application R2A

- Outreach and Engagement
- Community and Coalition Building
- Regime Studies and Research
- Hazard and Risk Assessment
- Analytics and Simulation
- Pilot Programs and Demonstration
- Transition to Operations

https://nari.arc.nasa.gov/smdwildfire

FireSense: Integrating Tools for Earth System Solutions

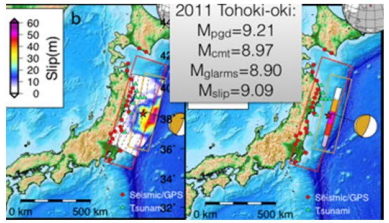
Pre-Fire
Landsat, NISAR, MC, SBG, SDC, G-LiHT

Active-Fire
MODIS, VIIRS, GOES, AOS

Post-Fire
Landsat, MODIS, SBG, SDC, NISAR, AVIRIS-NG

Integration & Innovation Approach

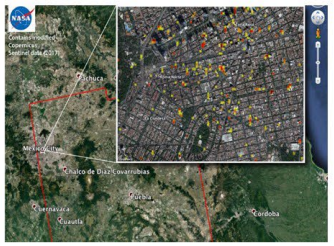
Observational and Collection Systems

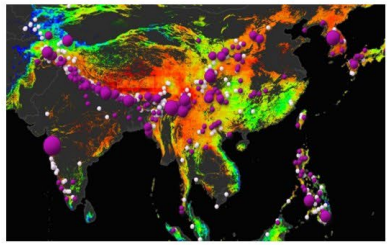


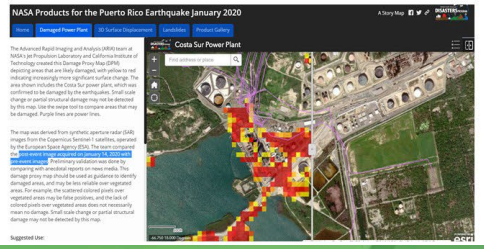
How We Work

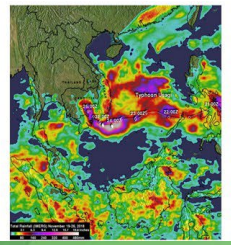
End-to-End Innovation and Integration

Advanced Modeling and Risk Analysis

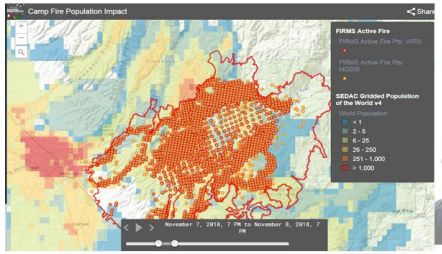


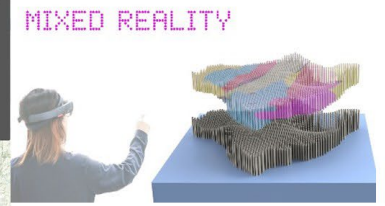


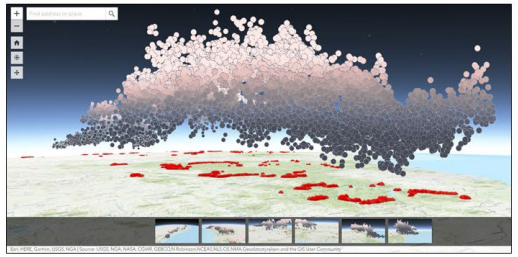




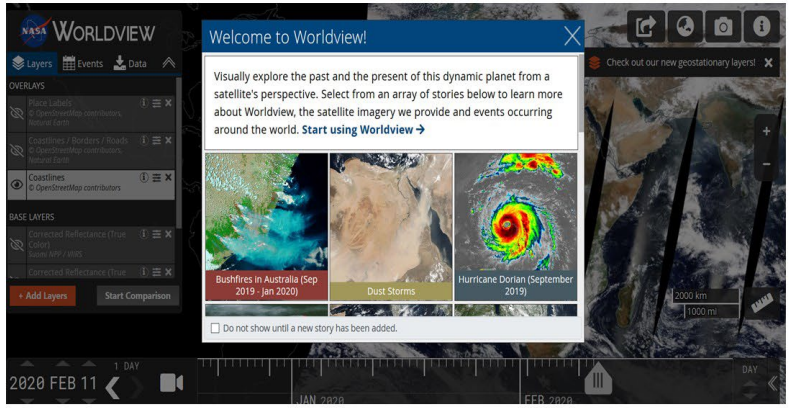
GIS and visualization systems







Computing and Communication Technologies



NASA Applications Themes & Societal Benefit Areas

APPLIED SCIENCES PROGRAM

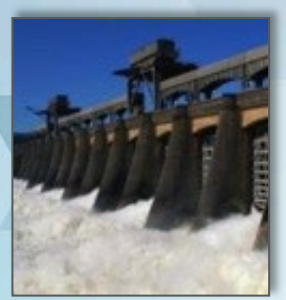
APPLICATIONS AREAS

Agriculture

Disasters

Ecosystems

Health &
Air Quality



Water Resources

EMERGING PROGRAMS IN FY 2022

Energy

FireSense

Climate & Resilience

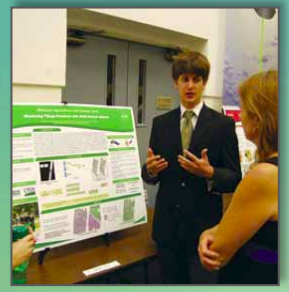
Environmental Justice

CAPACITY BUILDING

Activities span all of the applications themes

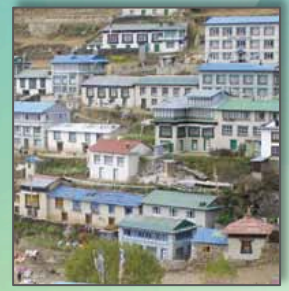
ARSET

Training



DEVELOP

Workforce



SERVIR

Intl. Development

Emerging

Indigenous People

Professional Schools

NASA ARMD & STMD Wildfire Capabilities

NASA Aeronautics Research Mission Directorate (ARMD):

- Scalable Traffic Management for Emergency Response Operations (STEReO) demonstrations of prototype capabilities for integration of UAS into wildfire response operations USFS, CalFire, 2021
- Hosted workshops with Flight Safety Foundation to develop wildfire and disaster response use cases for In-time Systemwide Safety Assurance capabilities, January 2020
- Collaborative agreements with US Fire Service, CalFire and JAXA to help modernize aerial operations associated with emergency response.

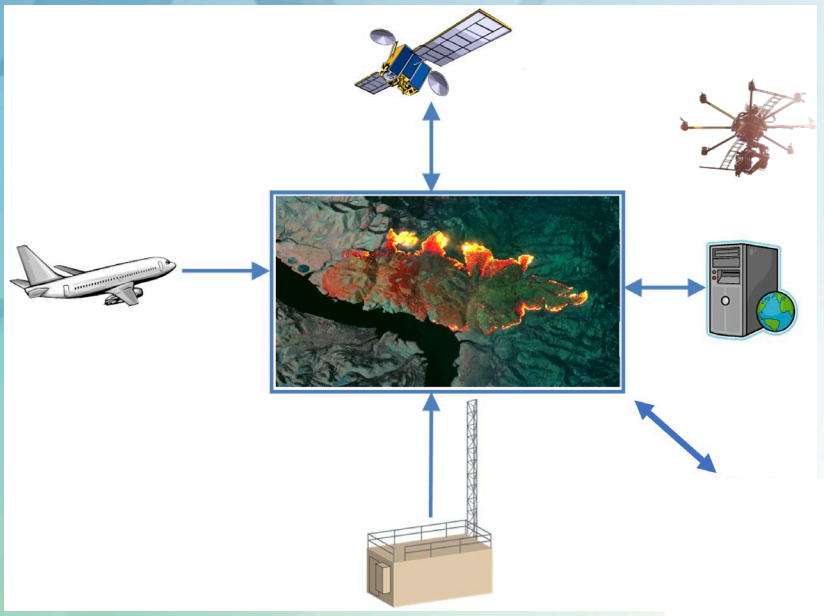
NASA Space Technology Mission Directorate (STMD):

- SBIR-STTR – Wildfire-related awards to small business and wildfire-related subtopics proposed for recent solicitations
- Space Technology Research Grants – have included wildfire-related grants
- Possible directed funding opportunities
  - SBIR Phase II Sequential
  - Prizes and Challenges
  - Technology / Commercialization acceleration

Key Areas of NASA Impact on Wildfire Management

Sensing, data fusion and multi-model integration for societal benefit

- Facilitates comprehensive data collection and development of innovative miniaturized advanced sensors/models to better detect wildfire risk, propagation, and impacts
- Predict fire spread to enhance suppression and emergency response efforts and real time resource optimization
- Integrate remote sensing and modeling to predict and mitigate wildfire impacts such as debris flows and degraded vegetation as well as air & water quality



Comprehensive pre-, active-, & post-wildfire integrated observing system

Provide *open-source* tools for actionable information needed by stakeholders to make informed decisions

Persistent, integrated, diverse crewed & uncrewed observations

Integrated system requirements, design and prototype for persistent observations with multiple diverse vehicles for increased and rapid aerial response to wildfire

Coordinated Wildfire Research Activities

Multi-agency collaborations to study complex fire systems

Satellites: Remote Sensing

NOAA GOES-R | NOAA/NASA JPSS | NASA TERRA

NOAA/NASA FIREX-AQ

Laboratory study: 2016
Field intensive: 2019
Funding from NOAA/OAR & NASA/SMD
Scientists from NOAA, NASA, Academia and private sector

NASA DC-8

NASA ER-2

Aircraft: Local to Continental In-situ & Remote Sensing

CHEM Twin Otter

MET Twin Otter

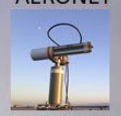
NOAA/CU NightFOX

Mobile Ground Sites: Local

Aerodyne

NASA

NOAA

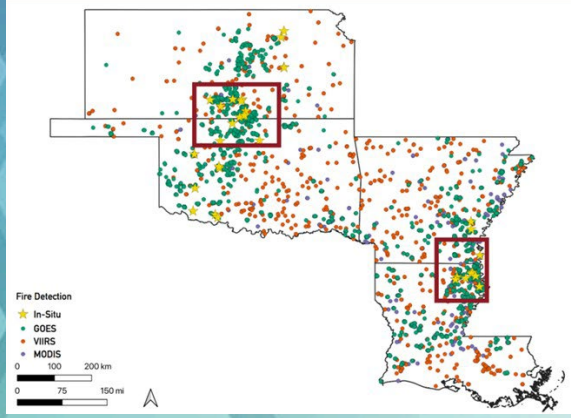


AERONET

NSF WE-CAN 2018
NCAR C130 aircraft
Wyoming King Air (BB-FLUX)

JFSP Western Wildfire Campaign (FASMEE)
Source fuel fire studies: 2019+

Where's the fire?



41% of small fires during FIREX-AQ field campaign **not detected by GOES, VIIRS, and MODIS** active fires.

If GOES detections excluded, **only 5% of the field-verified fires detected.**

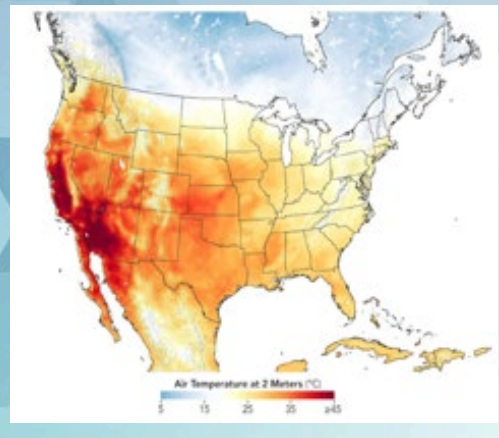
To inform integrated observing strategies

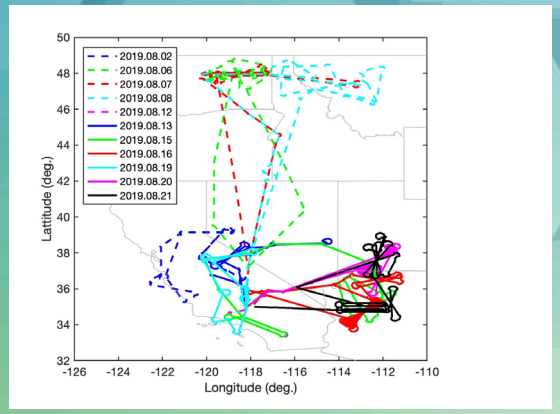
A multi-disciplinary collaboration between different NASA Centers and external partners to address wildfire needs

NASA Earth Science Division

- Satellite assets
- Earth sensing payloads
- Miniaturization of key sensors for UASs
- Data fusion and modeling
- Decision support tools
- Crewed and Un-crewed airborne fleet
- On-going collaborations with multiple agencies in disaster response
- Open-source science
- New integrated observing strategies from ground, to air, to LEO/GEO and beyond with model fusion.

California Heat Wave - Trends





ER-2 flight tracks of NASA sensors collecting data

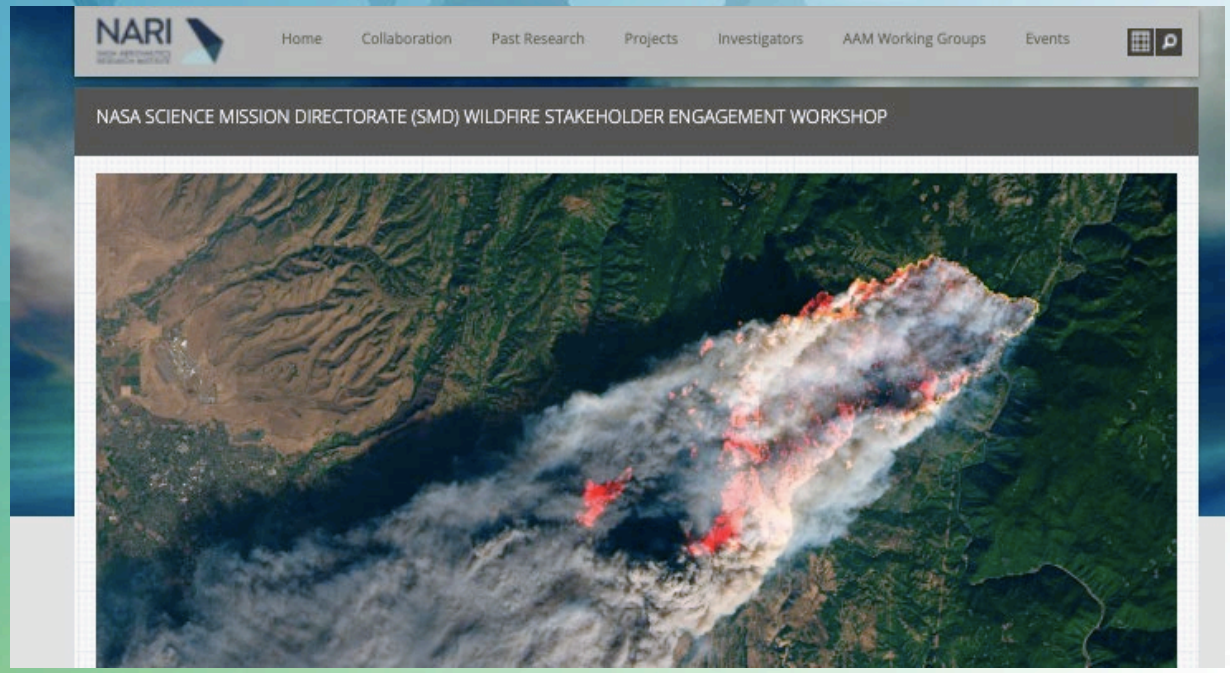
Blackswift UAS Platforms

NASA Wildfire Management Workshops

May 2021

https://nari.arc.nasa.gov/tfrsac-wildfire

February 2022



https://nari.arc.nasa.gov/smdwildfire

NASA SMD Wildfire Stakeholder Engagement Workshop

NASA SMD Wildfire Project Long-term Goal:

Integration of information and capabilities to support timely decision making and operations for all fire phases. Promote science and technology to anticipate & manage the new reality of extreme fires in a warming world.

Workshop Purpose:

- Listen to wildfire management stakeholders articulate their visions for successful wildfire management.
- Create and strengthen the diverse interdisciplinary community through areas of technology, social science, commercialization, geography, land and resource management, ecosystem and land planning, health and air quality, risk and resilience assessment, and more.
- To identify :
  - Community barriers for integrating science, technology, and knowledge.
  - 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-, during, and post-fire.
  - Partnerships and programmatic activities to guide near-term action.

3-4 May 2022

https://nari.arc.nasa.gov/smdwildfire

Wildfire Management Challenges, Gaps & Barriers

Detection Tracking, Surveillance, and Prediction

- Surveillance - infrequent high spatial resolution satellite (LEO) or aircraft observations miss much of the fire progression; more frequent coarse resolution satellite (GEO)
- Fire detection and location accuracy is not always precise enough
- Few reliable models for tracking and predicting fire progress
- Better sensing is needed, difficult to observe through clouds and at night
- Data and model fusion is limited, need for an integrated observing system
- Lack of miniaturized sensor for UAS
- Rogue drone operations result in grounding of aerial fire suppression missions

Multi-Agency Planning

- Multi-agency collaboration for resource and technology roadmap needs to be improved
- Budgets to support forest management and strategic planning are often redirected in season for tactical firefighting (limits adoption of new research and tools in fire management).

NASA Collaboration with the Wildfire Community

Community Collaborations

- Continue established working relationships: From agency level to individual researchers;
- Build on USFS-NASA led TFRSAC committee (established in 2003);
- Join *Joint Fire Science Program*:
  - Ensure NASA alignment with high-priority fire science research needs; Leverage established networks; Multiplier effects
- Engage JFSP's 15 regional *Fire Science Exchanges* connecting managers, practitioners, scientists;
- Challenge: Growing size of actors in wildfires community.

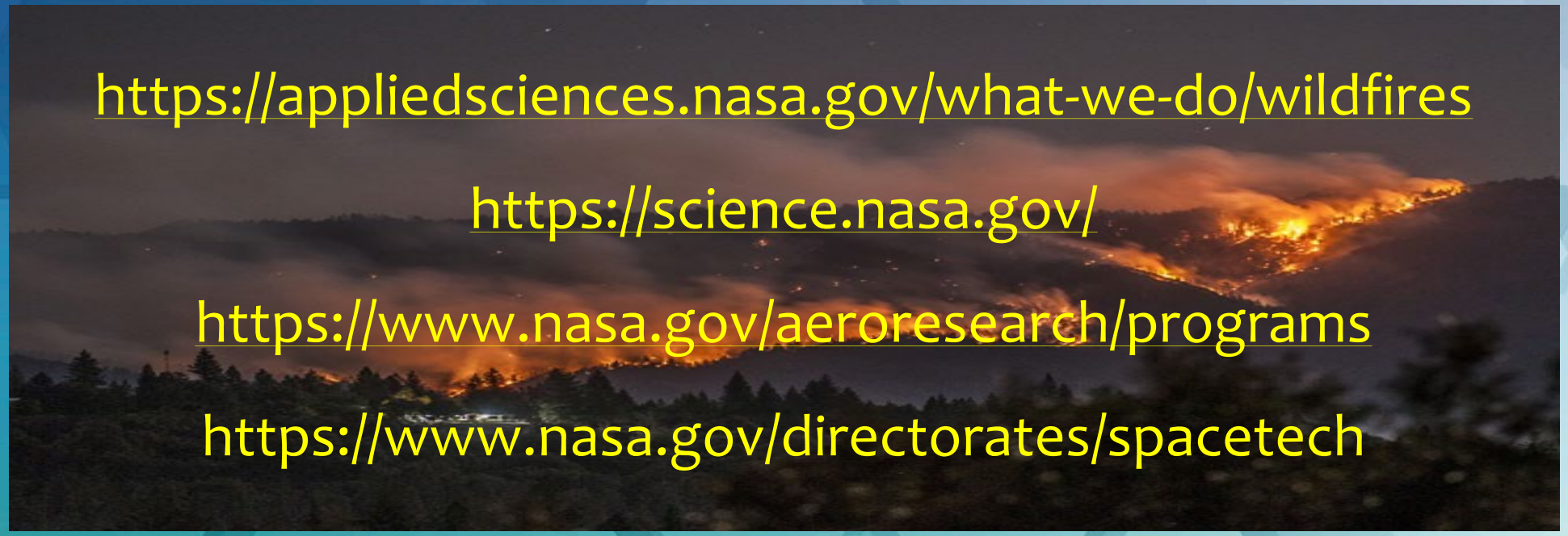
Actionable, Responsive Science

- Fire Community Testbeds: Co-develop and validate new technologies, datasets, and tools through established research centers: Missoula Fire Lab, Riverside Fires Lab, GTAC, etc.;
- Distribution of data and info products through established, trusted portals and processes;
- Support efforts so fire managers receive most relevant research and tools for their local issue;
- Managers' feedback guide NASA research questions and pursuits

Capacity Building

- Support familiarity and skill building in wildfires community when introducing new NASA datasets, info products, and tools;
- Collaborate at multiple levels on:
  - Fire training exercises and classes;
  - Situation Unit Leader classes;
  - Incident Command trainings;
- Engage in field exercises, simulations to understand uses, educate line managers, and infuse into operations;
- NIFC Predictive Services: Create & staff a NASA Service Desk; be rapidly responsive in fire season
- Increase "cleared" NASA scientists.

Contact Information



https://appliedsciences.nasa.gov/what-we-do/wildfires

https://science.nasa.gov/

https://www.nasa.gov/aeroresearch/programs

https://www.nasa.gov/directorates/spacetech

Dr. David Green – david.s.green@nasa.gov

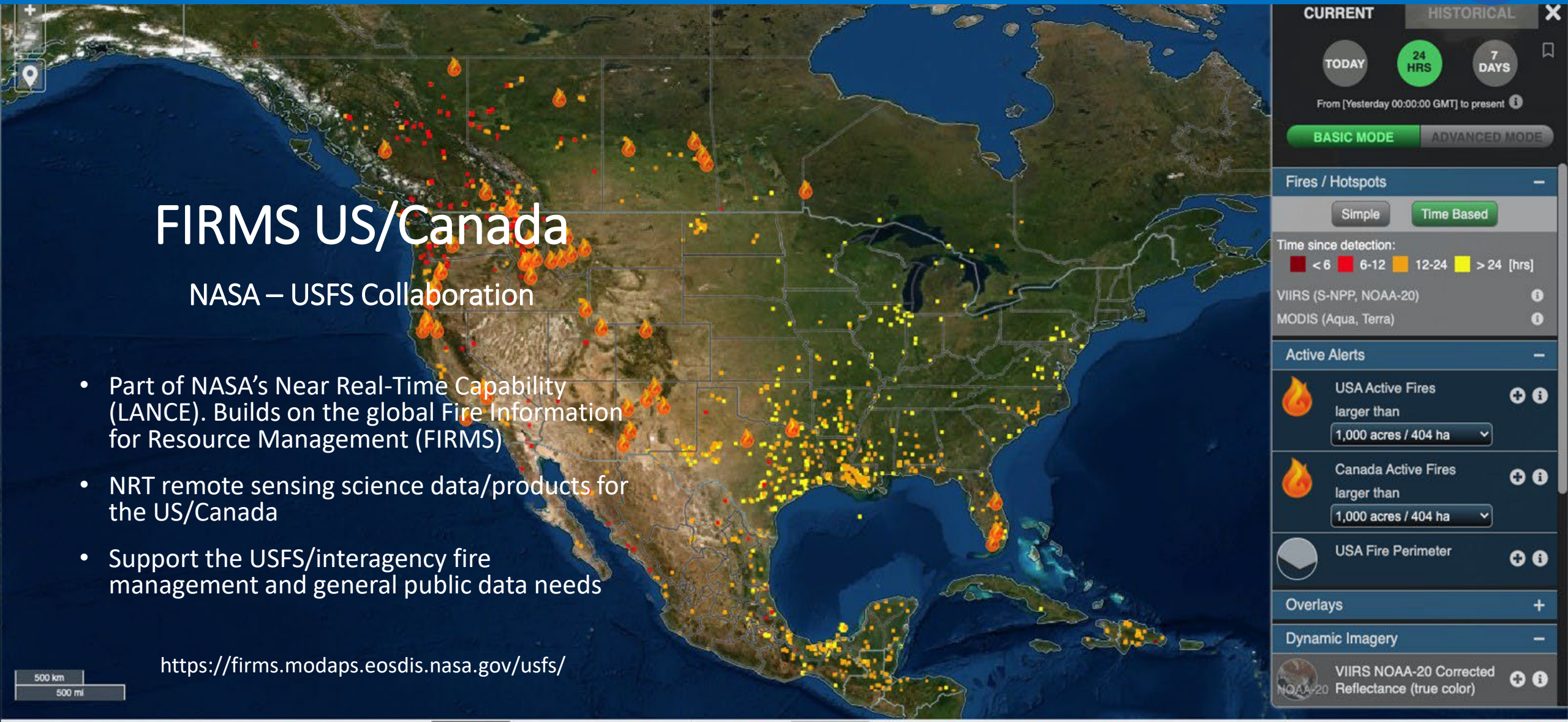
Vince Ambrosia -- vincent.g.ambrosia@nasa.gov

Barry Lefer – barry.lefer@nasa.gov

Mike Falkowski – Michael.falkowski@nasa.gov

Mike Seablom – Michael.s.seablom@nasa.gov

Wildland FireSense to Co-Develop Trusted Tools



FIRMS US/Canada

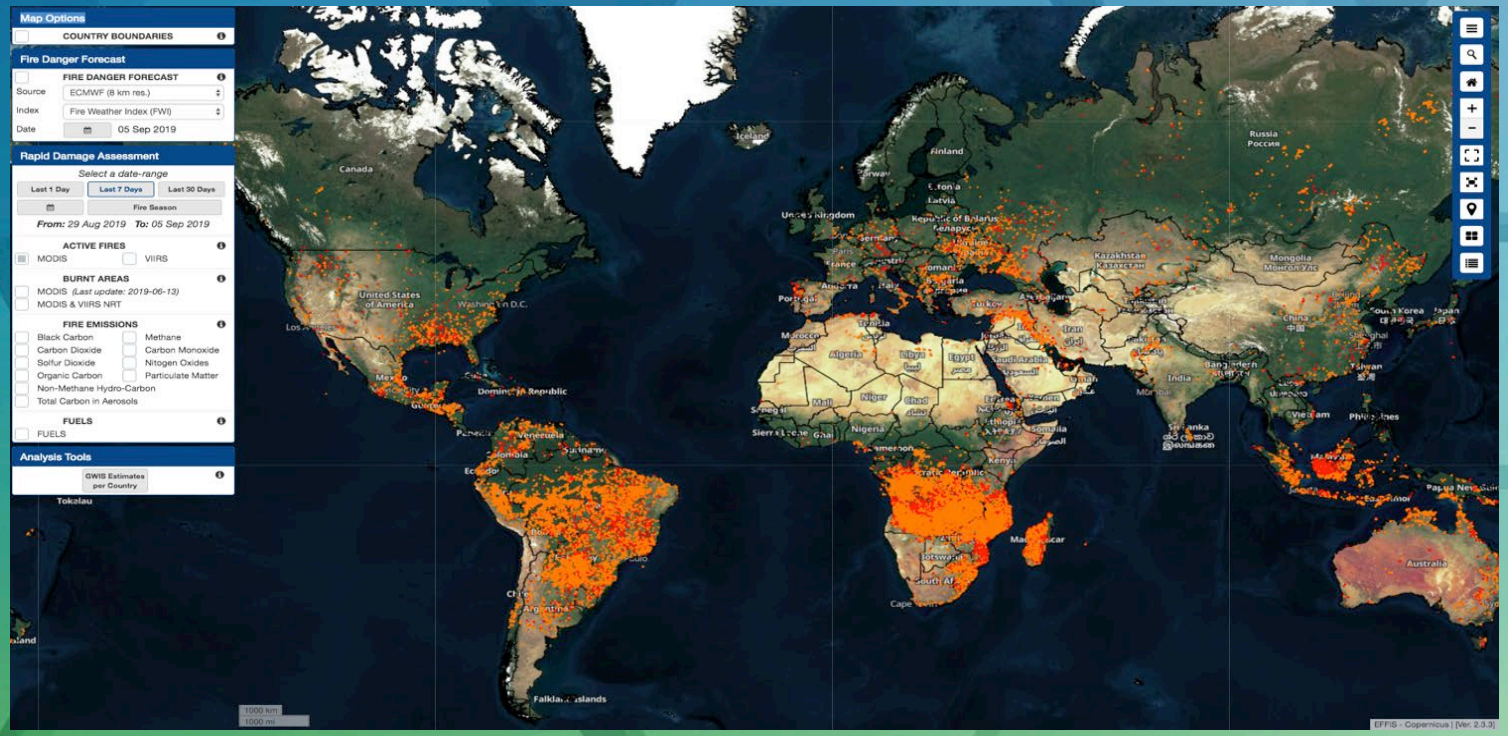
NASA – USFS Collaboration

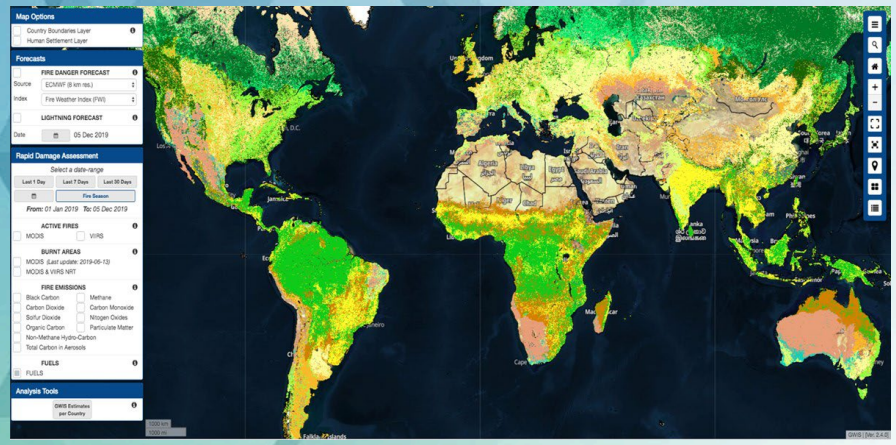
- Part of NASA's Near Real-Time Capability (LANCE). Builds on the global Fire Information for Resource Management (FIRMS)
- NRT remote sensing science data/products for the US/Canada
- Support the USFS/interagency fire management and general public data needs

https://firms.modaps.eosdis.nasa.gov/usfs/

Global Wildfire Information System

GWIS is a joint initiative of the Group on Earth Observations (GEO) and the EC Copernicus Work Programs and is supported by NASA Earth Observations data and modeling





Global Fuels

https://gwis.jrc.ec.europa.eu/

Bringing FireSense to All Fire Phases

Pre-Fire

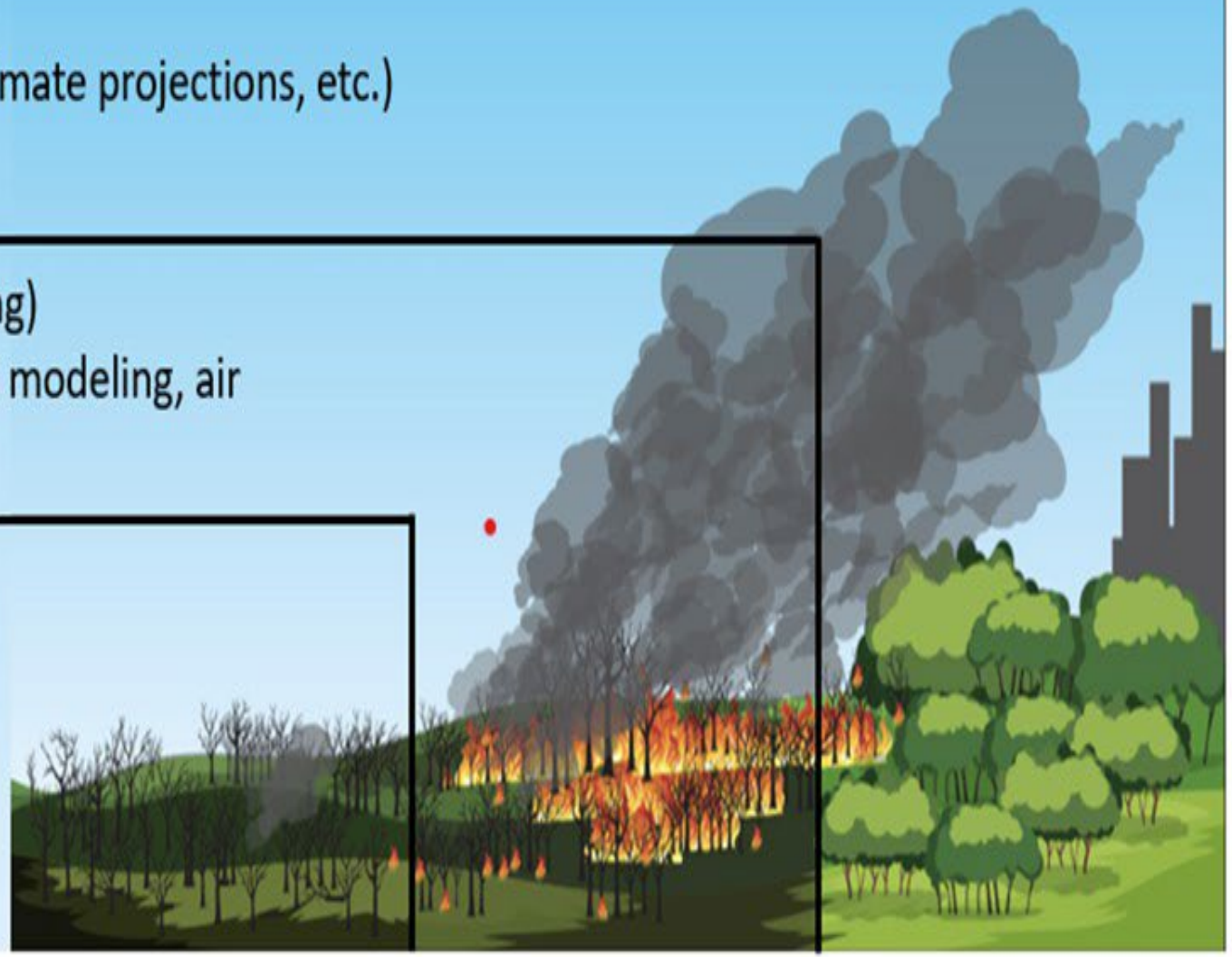
- **Mitigation and adaptation** (fuels management, climate projections, etc.)
- **Fire prediction** (potential and intensity)

Active Fire

- **Detection and monitoring** (strategic fire monitoring)
- **Firefighting** (tactical fire monitoring, fire behavior modeling, air traffic control, smoke and air quality, etc.)

Post-Fire

- **Post-fire assessment** (severity assessment, landslide potential, carbon release, etc.)
- **Rehabilitation and restoration** (land cover, ecosystems, etc.)



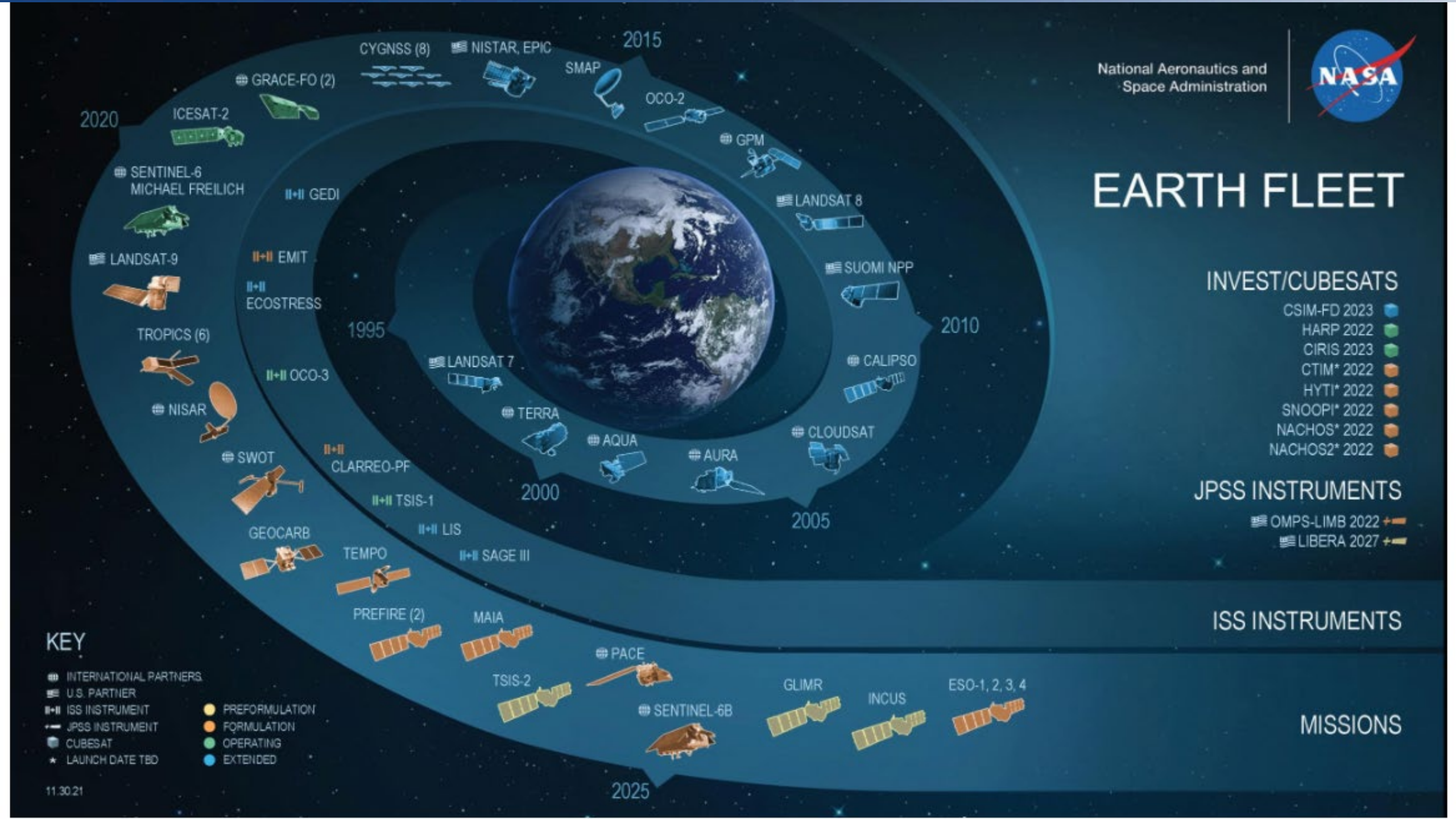
Post-Fire Active Fire Pre-Fire

Wildfire Response is a Multi-Organizational Effort

Requires coordination among numerous local, county, state and federal authorities:

- National Interagency Fire Center
- Federal Aviation Administration
- United States Department of Interior
- United States Department of Agriculture
- Joint Fire Science Program
- National Guard
- United States Department of Defense
- United States Forest Service
- Bureau of Land Management
- National Oceanic and Atmospheric Administration
- Cal Fire

… in addition to many others


National Aeronautics and Space Administration
NASA
EARTH FLEET
2015
2020
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2025
CYGNSS (8)
NISTAR, EPIC
SMAP
OCO-2
GRACE-FO (2)
ICESAT-2
GPM
SENTINEL-6 MICHAEL FREILICH
GEDI
LANDSAT 8
LANDSAT-9
EMIT
ECOSTRESS
SUOMI NPP
TROPICS (6)
LANDSAT 7
CALIPSO
OCO-3
NISAR
TERRA
AQUA
AURA
CLOUDSAT
SWOT
CLARREO-PF
TSIS-1
LIS
GEOCARB
TEMPO
SAGE III
PREFIRE (2)
MAIA
PACE
TSIS-2
SENTINEL-6B
GLIMR
INCUS
ESO-1, 2, 3, 4
INVEST/CUBESATS
CSIM-FD 2023
HARP 2022
CIRIS 2023
CTIM* 2022
HYTI* 2022
SNOOPI* 2022
NACHOS* 2022
NACHOS2* 2022
JPSS INSTRUMENTS
OMPS-LIMB 2022
LIBERA 2027
ISS INSTRUMENTS
MISSIONS
KEY
INTERNATIONAL PARTNERS
U.S. PARTNER
ISS INSTRUMENT
JPSS INSTRUMENT
CUBESAT
LAUNCH DATE TBD
PREFORMULATION
FORMULATION
OPERATING
EXTENDED
11.30.21

Needs Assessment Workshop (May 2021)

In conjunction with the bi-annual TFRSAC meeting, NASA and US Forest Service, conducted a workshop to understand state-of-the-art, needs, and opportunities to improve wildfire management

- Identify the needs and challenges of stakeholders at various decision cycles from planning, prediction, detection, tracking, mitigation, suppression, and post-fire remedial efforts
- 154 attendees from other government organizations, academia, industry, and NASA

Main Findings

- Lack of persistent communications, aerial operations, & surveillance for fire detection and tracking
- Lack of airspace technologies to enable multiple types of aircraft operating simultaneously
- Lower aircraft safety record than other areas of aviation
- Lack of adequate coordination among multiple government agencies
- Need a clear plan to mature research for operational use in field
- Need for additional remote sensing observations for pre-, active-, and post-fire conditions
- Need for actionable information on fire risk, fire behavior, and fire impacts

Findings offer insights where NASA research and technology development could make a significant impact

NASA and Community of Practice

- Create and build community **buy-in** at all levels; **co-develop, pilot and demonstrate** integrated earth system framework and geographical approach
  - "Kick Ash" A Geospatial sandbox for collaboration
- Foster cooperation and regional focus
- More effective products, services and tools
- **Improved and sustained comprehensive** management actions
- Faster delivery of capabilities that are prototyped, field tested and scaled

NASA Earth Science Division Deliverables

Early actions (first 2 years):

- Engage with multi-organization partnership to understand stakeholder needs
- Leverage existing wildfire modeling and observations to develop integrated wildfire dashboard
- Collect targeted remote sensing observations of pre-, active-, and post-fire conditions for key partners (using existing sensors and aircraft)

Longer term impacts:

- Multi-organizational, end-to-end systems approach for a stakeholder solution
- Provide a fused wildfire information system for stakeholders leveraging autonomous/affordable/miniaturized sensors and modeling tools
- *Persistent aerial operations and communications systems to enable near 24X7 observations* **(NASA ARMD)**
- Engagement with stakeholders to transfer the benefits of NASA research and technology

Some Additional Details

- Overguide Plan base on funding to start in FY23 (for 5-years);
- NASA Earth Science Technology Office(ESTO) released a ROSES Element for technology development using overguide funds in early June 2022;
- NASA R&A is planning a ROSES call on Wildfire science.