Subcommittee on Disaster Reduction
Wildland Fire Science and Technology Task Force Workshop

NASA Fire Science: Satellite, Model and Airborne Data, Technology and Applications to support pre-, active- and post-fire.

Amber Soja with contributions from

Lawrence Friedl, Vince Ambrosia, Frank Lindsey, Johnathan Hair, Sharon Burton, Andreas Beyersdorf, Jason Tackett, Dave Winker, Duncan Fairlie, Ralph Kahn, and Charles Ichoku

Washington, DC
17-19 June 2014

NASA Earth Science

The NASA Earth Science Division (ESD) supports basic and applied research on the Earth system and its processes.

Primary efforts are to characterize, understand, and improve predictions of the Earth system.

In parallel with research, NASA pursues innovative and practical uses of Earth science data and results to inform and support decisions of government, business, and civil society.

Science

Technology

Data – Satellite, Model and Surface

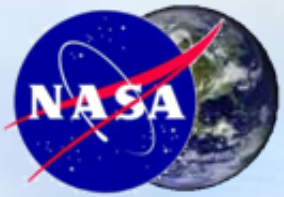
Flight Missions

Research

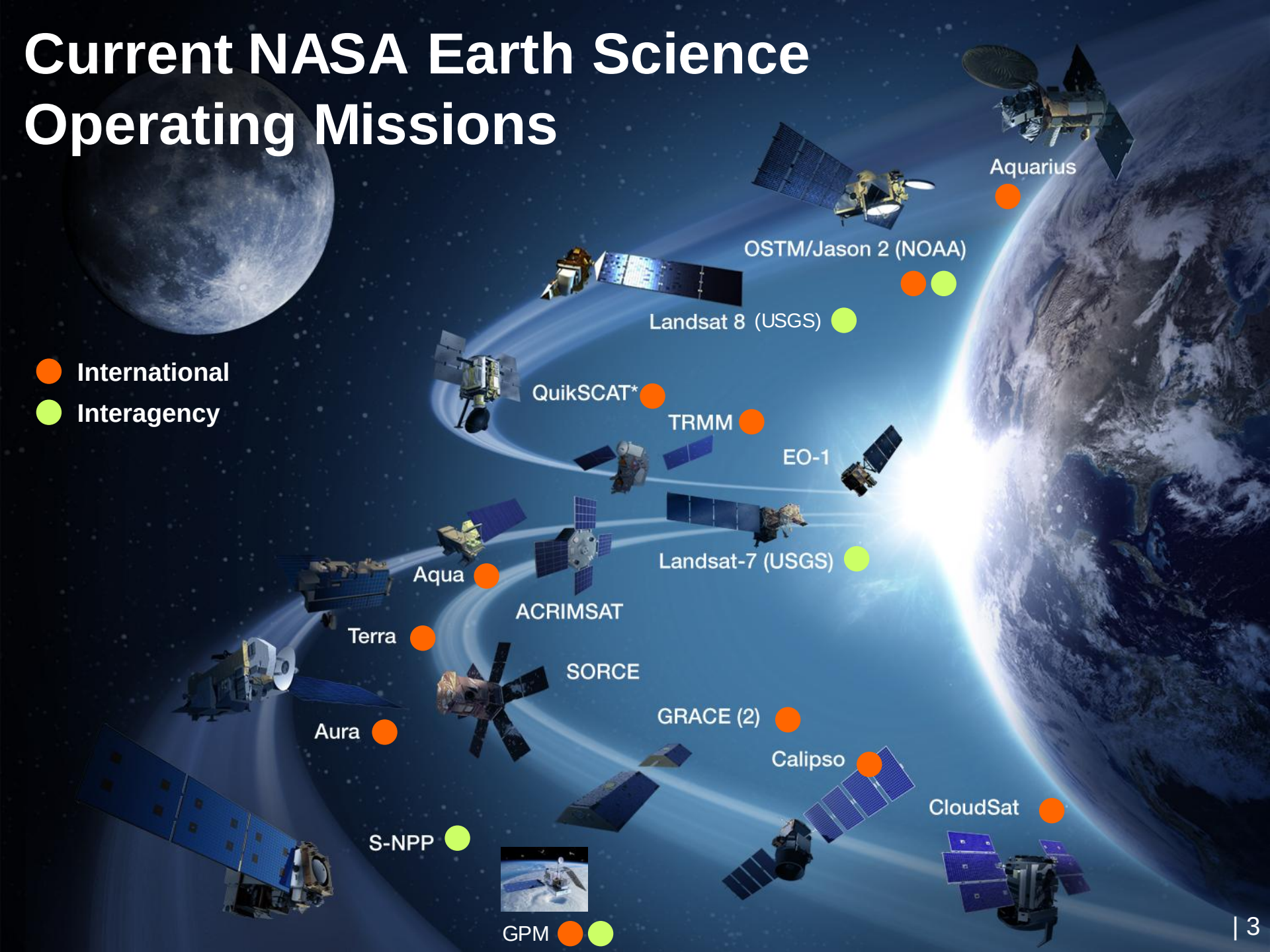
Data Systems - DAACs, NEX, IT

Education

Applications

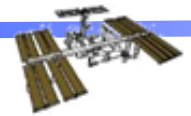


Current NASA Earth Science Operating Missions



Near Term Mission Plans

GPM
Feb 2014
w/ JAXA; Precip

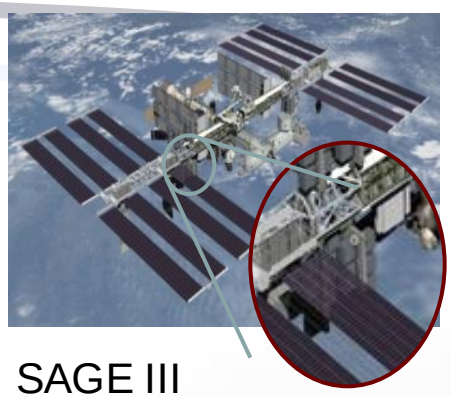


RapidScat
Ocean winds
June 2014

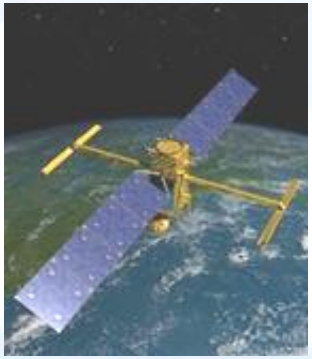
OCO-2
July 2014
Global CO_2

CATS
Aerosols
Sept.2014

SMAP (w/ CSA)
Nov. 2014
Soil Moist.,Frz/Thaw

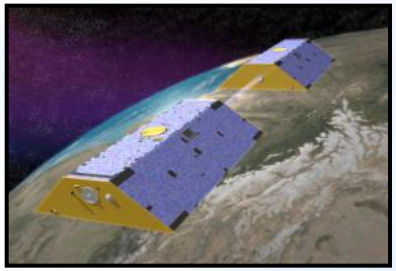


SAGE III
Mar 2015; on ISS
Ozone & Trace Gases



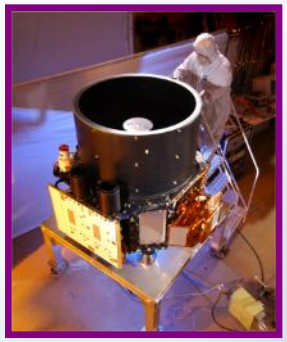
SWOT
Oct 2020
w/CNES; Sea surface &
Fresh water height, slope

TEMPO
2019
Hosted Payload:
Tropospheric
pollution



GRACE FO
Aug 2017
w/Germany; Global Mass
& Water Variation

CYGNSS
2016
Cyclone
Generation



ICESat-2
2016
Ice Dynamics

NASA Earth Science Missions
Current & Planned

NASA Supports Fire Science

- Science Mission Directorate
- Earth Science Programs
  - Carbon Cycle and Ecosystems (e.g. Carbon Cycle, Land Cover Land Use Change, Terrestrial Ecology, Biodiversity, Climate and Biological Response, HyspIRI, Terra and Aqua, Ocean Biology Biogeochem.)
  - Climate Variability and Change
  - Water and Energy Cycle
  - Atmospheric Composition
  - Interdisciplinary Science
  - Weather
  - Applied Science

Science Mission Directorate

⇩

Earth Science Programs

⇩

Fire Science

(wildland, agricultural, prescribed, air quality, fire weather and climate, modeling, transport, feedbacks to ice, clouds, snow)

Funding through ROSES

http://nspires.nasaprs.com/external/

Satellite Data and Models Inform the Science that then Inform the Data

MODIS Fire Detection

Landsat Fire Scar data

Bastrop
County Fire

Mom and baby
black bear

Endangered
Canebrake

Air Quality
Climate forcing

November 11, 2011
Texas counties with burn bans:
206 of 254

Ozone DIAL & Aerosol/Cloud HSRL – DC-8

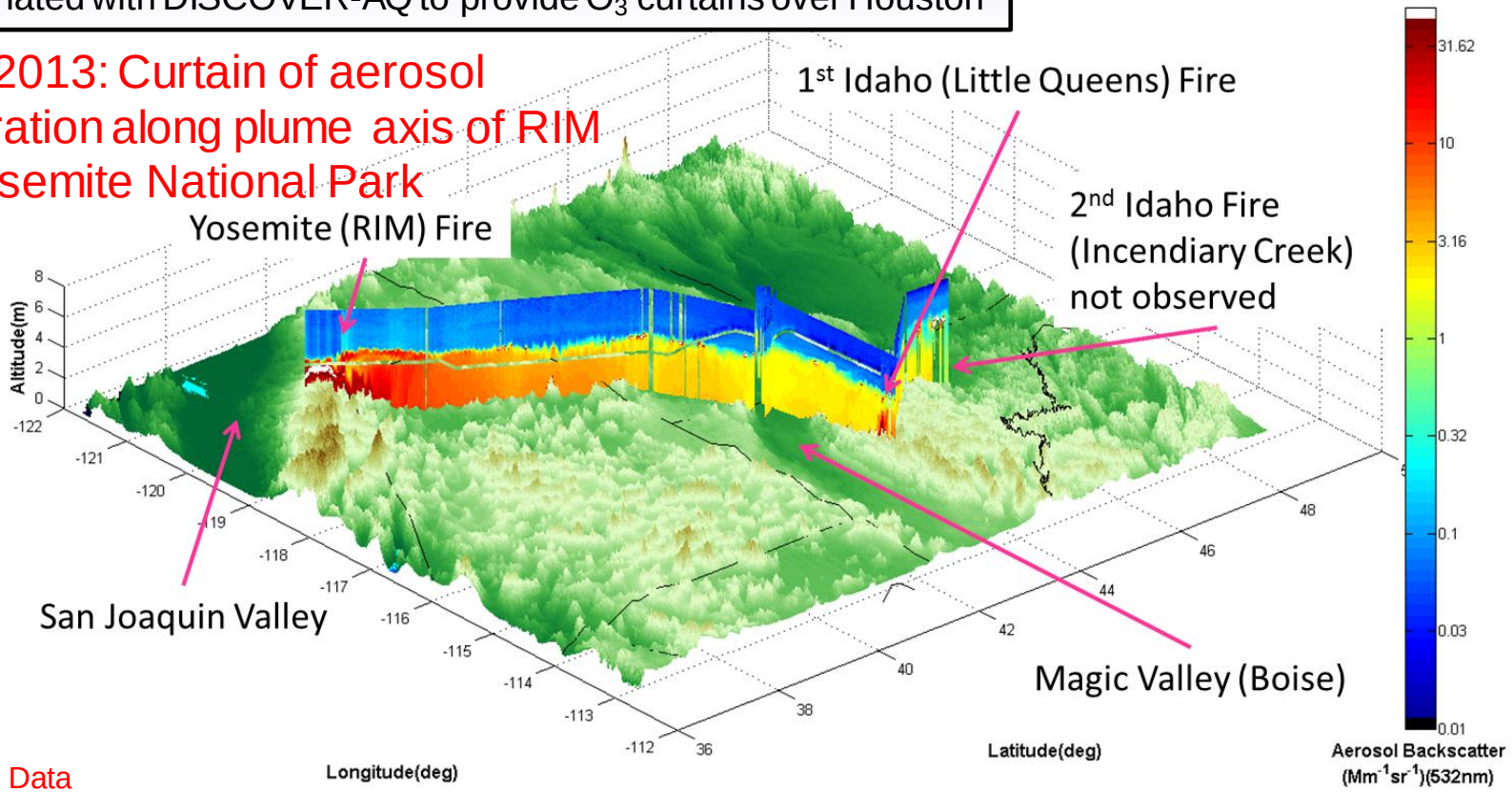
Johnathan Hair - PI NASA LaRC

- ✓ Measured O3 and aerosols profiles on all SEAC4RS flights
- ✓ Provided real-time O_3 & aerosol data for in-flight guidance
- ✓ Provided O3 and aerosol curtains for comparison to CTMs
- ✓ Made UTLS O3 & aerosol measurements for NAM assessments
- ✓ Made HSRL multi-wavelength lidar observations of fire emissions
- ✓ Provided HSRL measurements relevant to CALIOP assessments
- ✓ Provided data for comparison and assessment of remote sensors retrievals on ER-2 (extinction, AOT)
- ✓ Coordinated with DISCOVER-AQ to provide O_3 curtains over Houston

Profile Measurements:

- Ozone Concentrations
- Aerosol Extinction (532nm)
- Layer AOD at 532nm
- Aerosol/Cloud Backscatter (355,532,1064nm)
- Aerosol/Cloud Depolarization (355,532,1064nm)

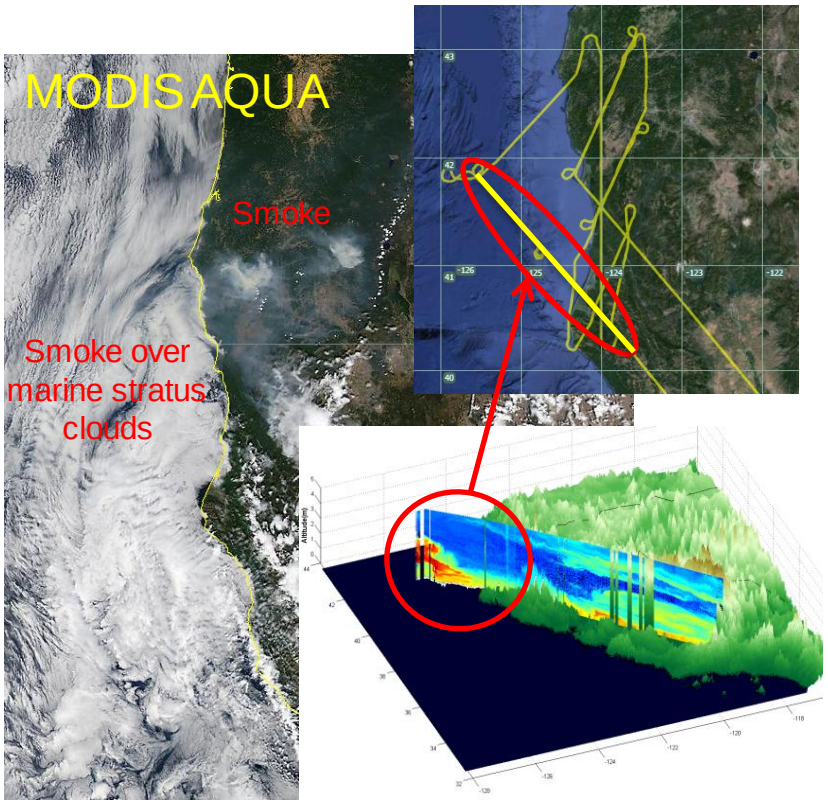
26 Aug. 2013: Curtain of aerosol concentration along plume axis of RIM fire in Yosemite National Park



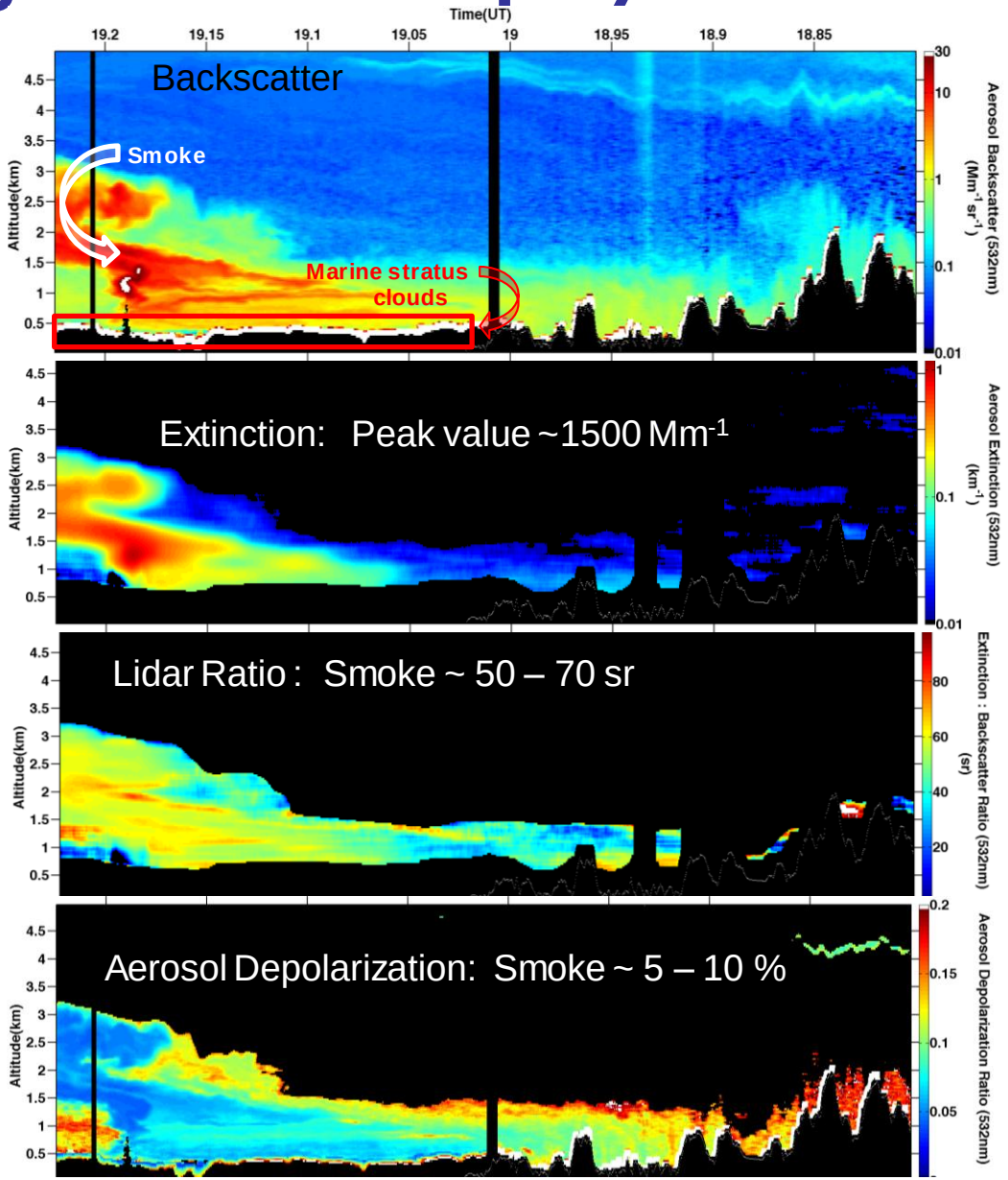
Preliminary Data

DC-8 & ER2 over flight of smoke above cirrus clouds (6 Aug. 2013 Example)

- Oregon/Washington fire emissions sampled off the coast over status clouds providing excellent dataset for evaluating remote sensor retrievals
- Lidar data shown during high altitude leg highlighting the spatial variability in aerosol loading and mixing



Preliminary Data

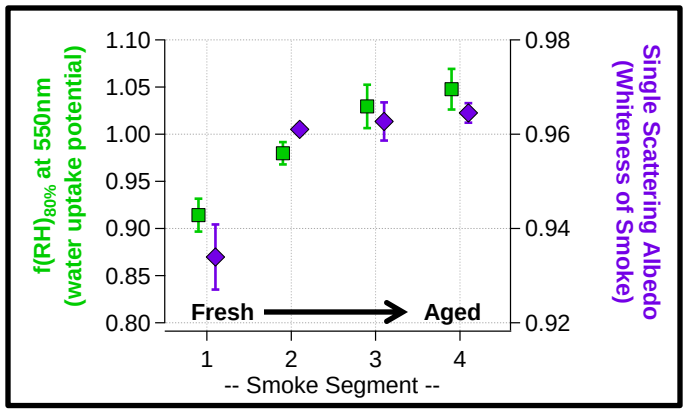


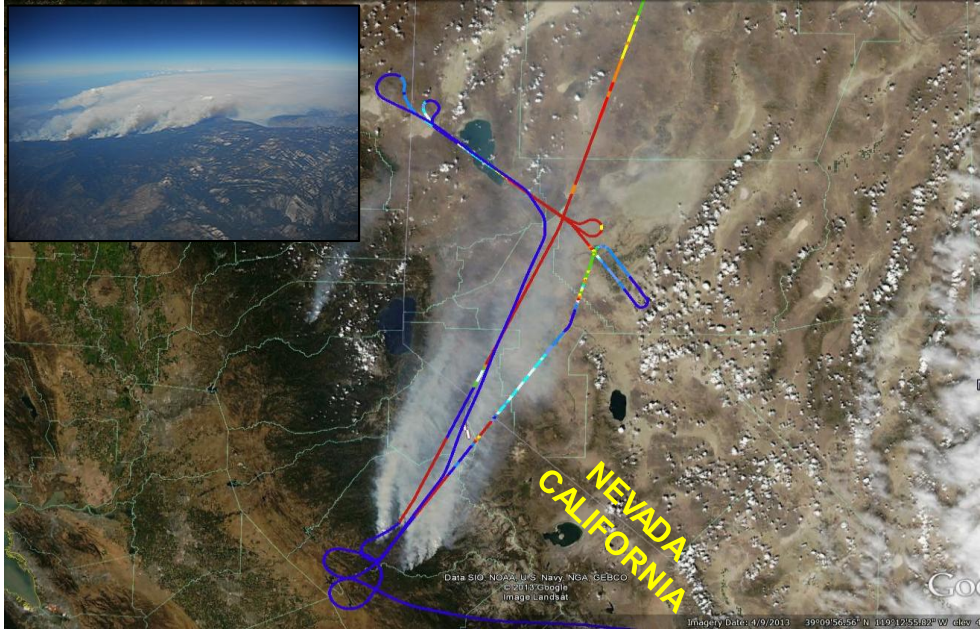
August 2013 Rim Fire (Sierra Nevada, CA)

- Burned for 38 days over 257,314 acres
- Sampled by the NASA DC-8 during the SEAC4RS airborne project
  - Directly at the fire (top)
  - Several days downwind (bottom)

Atmospheric Effects

- Downwind smoke affects ground-level air quality & alters Earth's radiative budget
- Changes in smoke properties were measured as it is transported and ages
  - Aerosols uptake more water (increasing visibility degradation)
  - Albedo of the smoke increases (less absorption of sunlight)





Flight track colored by the smoke concentration (NASA Langley)

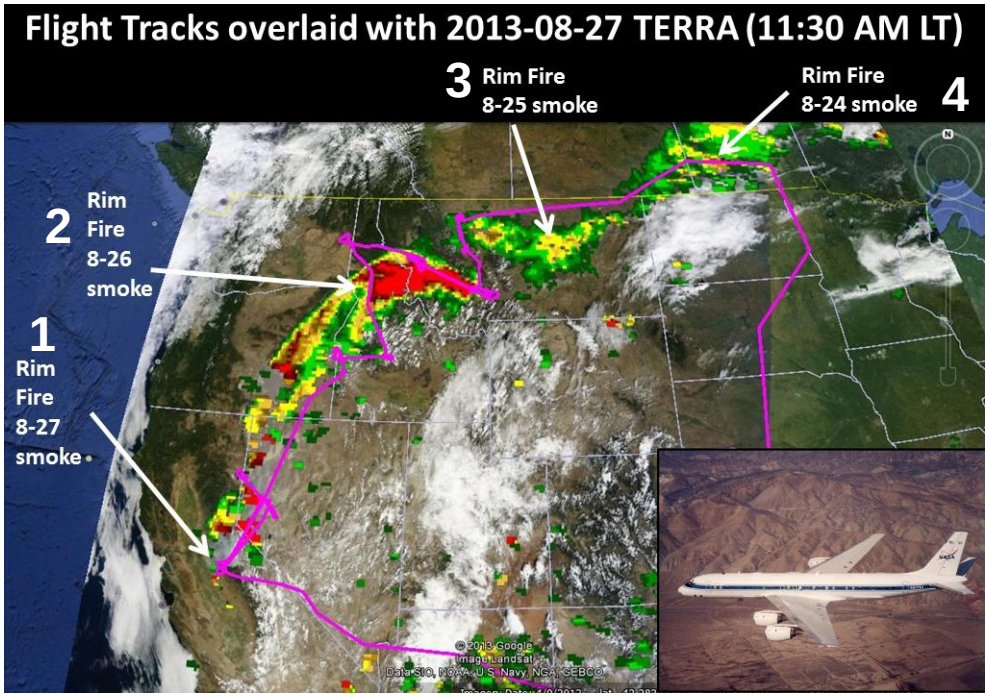
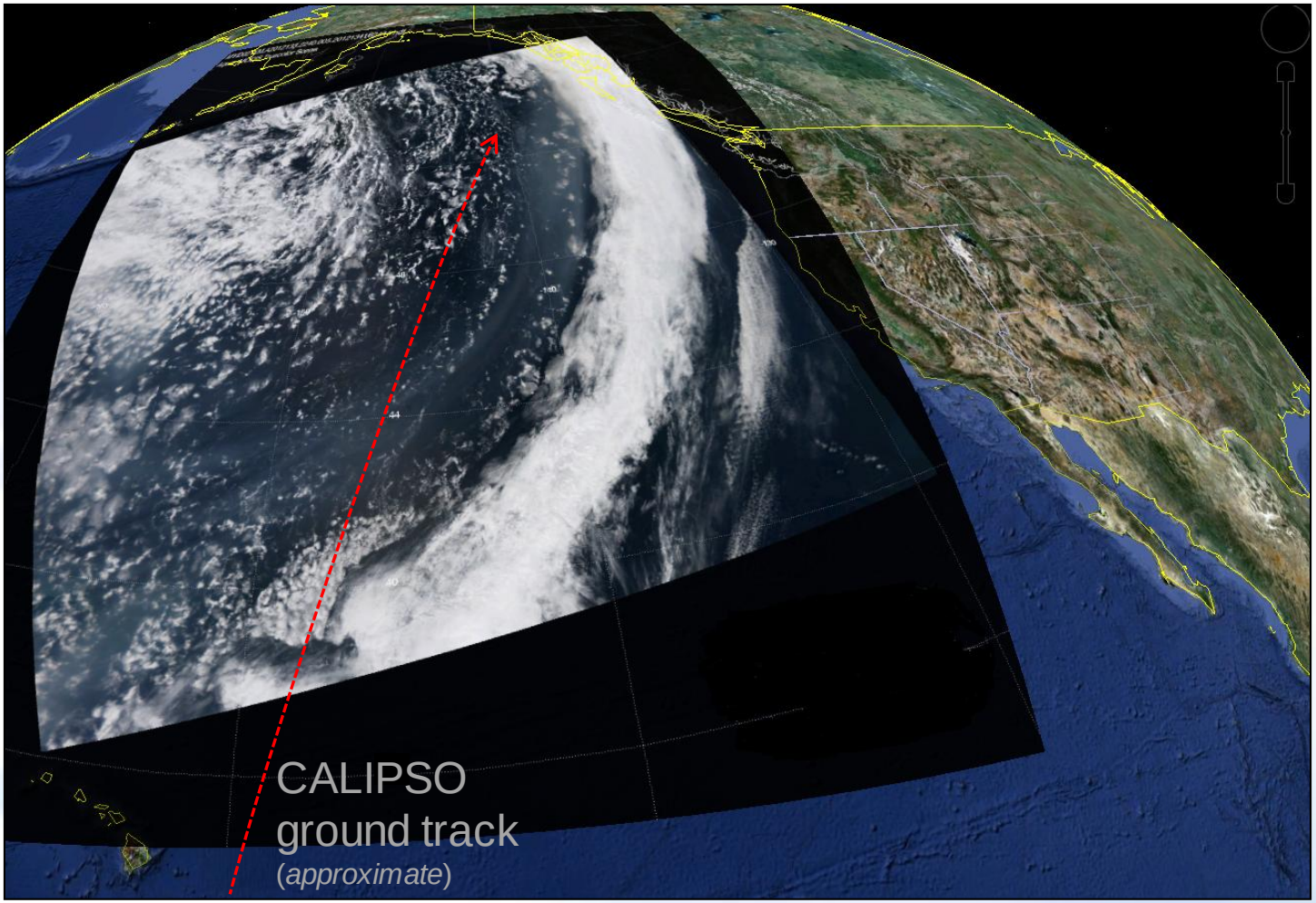


Image courtesy of NASA ESPO

Aerosols Travel Far!

Siberian Fire Smoke

May 12th, 2012



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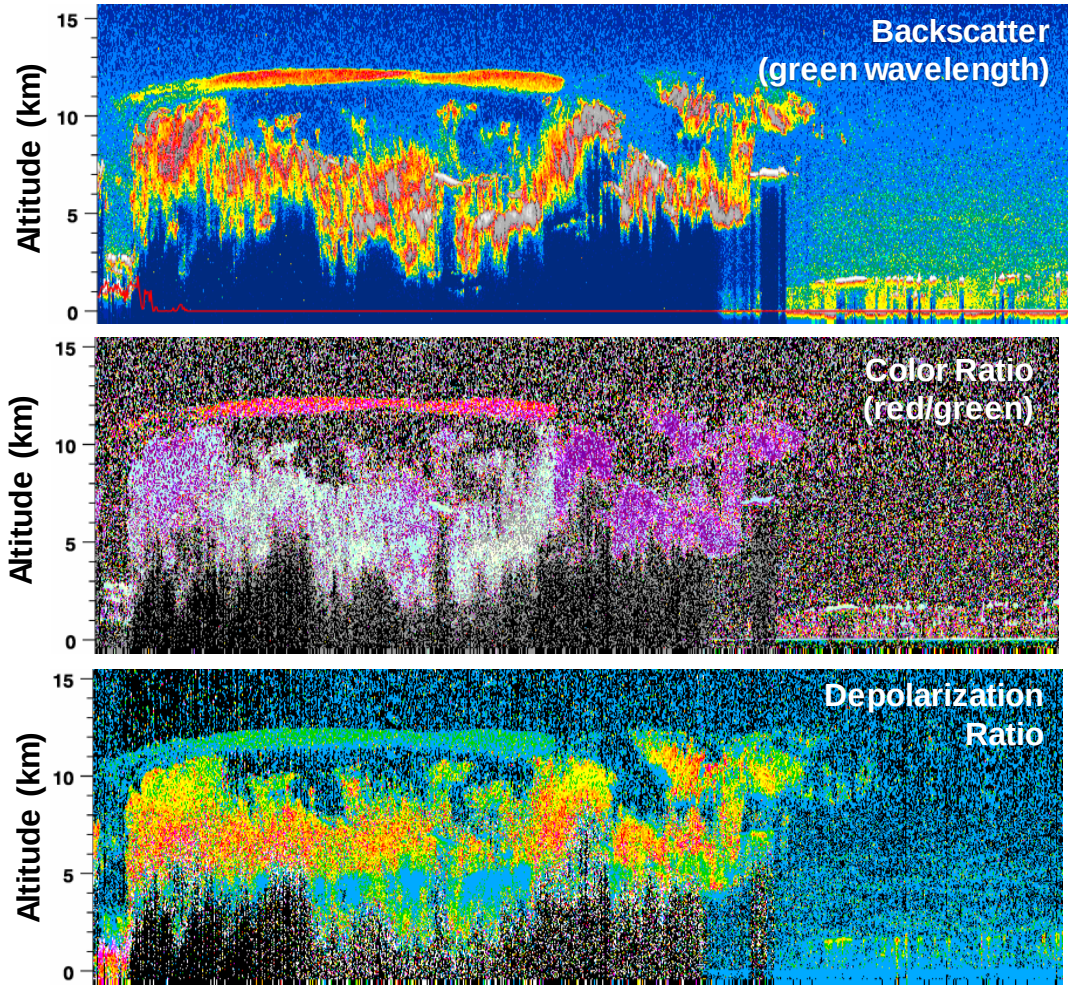
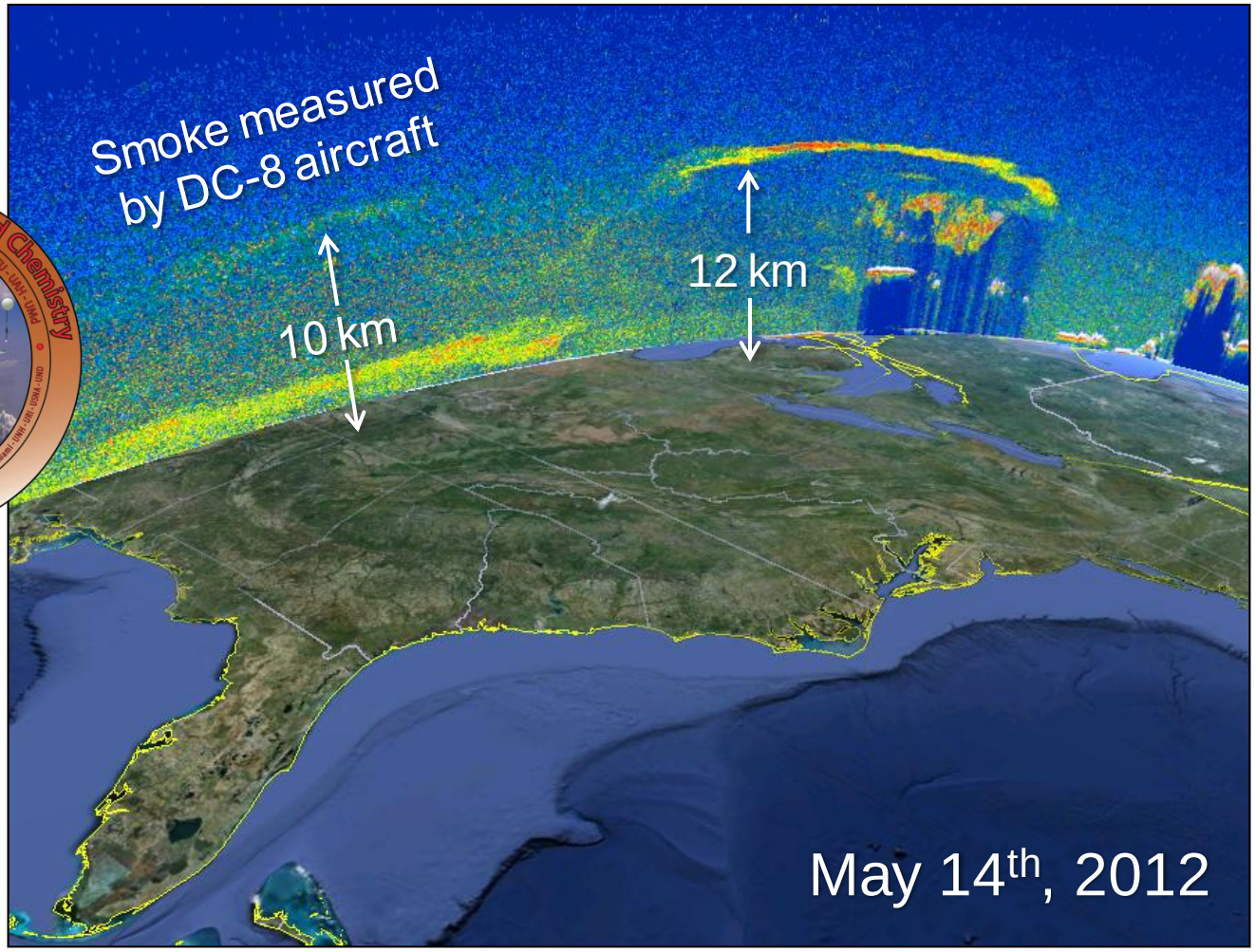
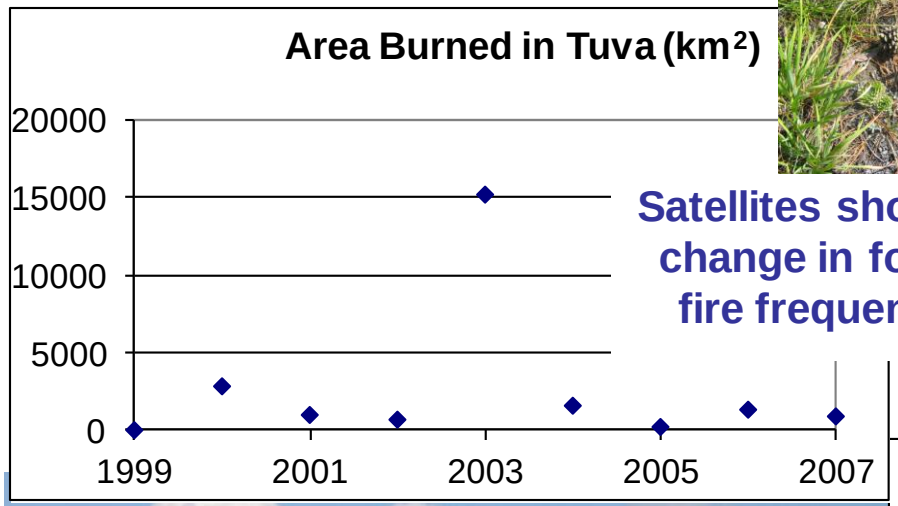


Aerosols Travel Far!
2 days later

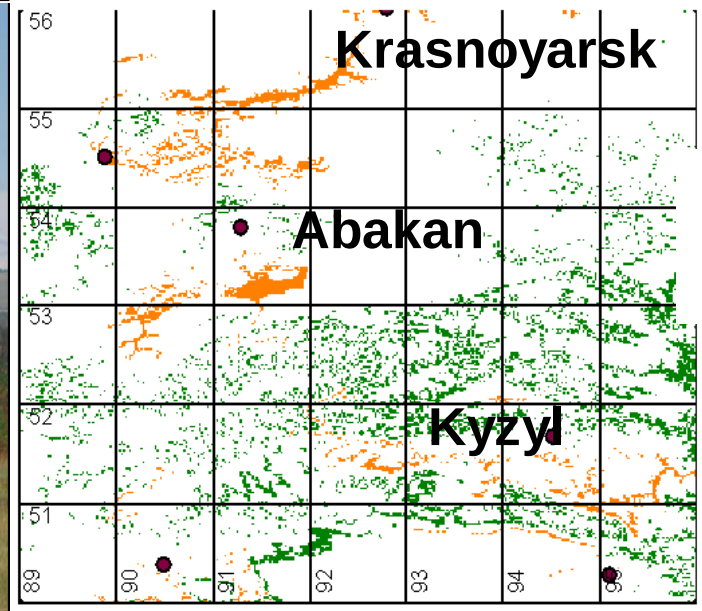
Smoke from Siberia over United States



IDS: Tyva, Siberia: Locals report forests are disappearing; Models predict this area should exhibit the initial signs of climate change; Field research results - severity of fire increasing & sapling growing conditions hotter and dryer.



Satellites show no change in forest fire frequency.



Steppe
Forest

SiBCliM Results

Soja, Tchebakova, Parfenova and more

Science Mission Directorate
Earth Science Division

Applied Sciences Program

NASA Applied Sciences Program

Vision

Public and private organizations routinely and seamlessly integrate Earth observations in their decisions and actions, and they demand additional observation types and Earth science knowledge.

Applications Areas

Emphasis in 4 Applications Areas

Health & Air Quality

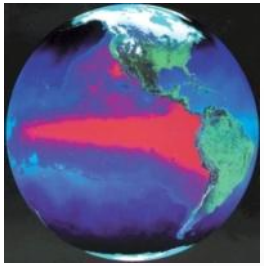
Water Resources

Disasters

Ecological Forecasting

Support opportunities in 5 additional areas

Agriculture



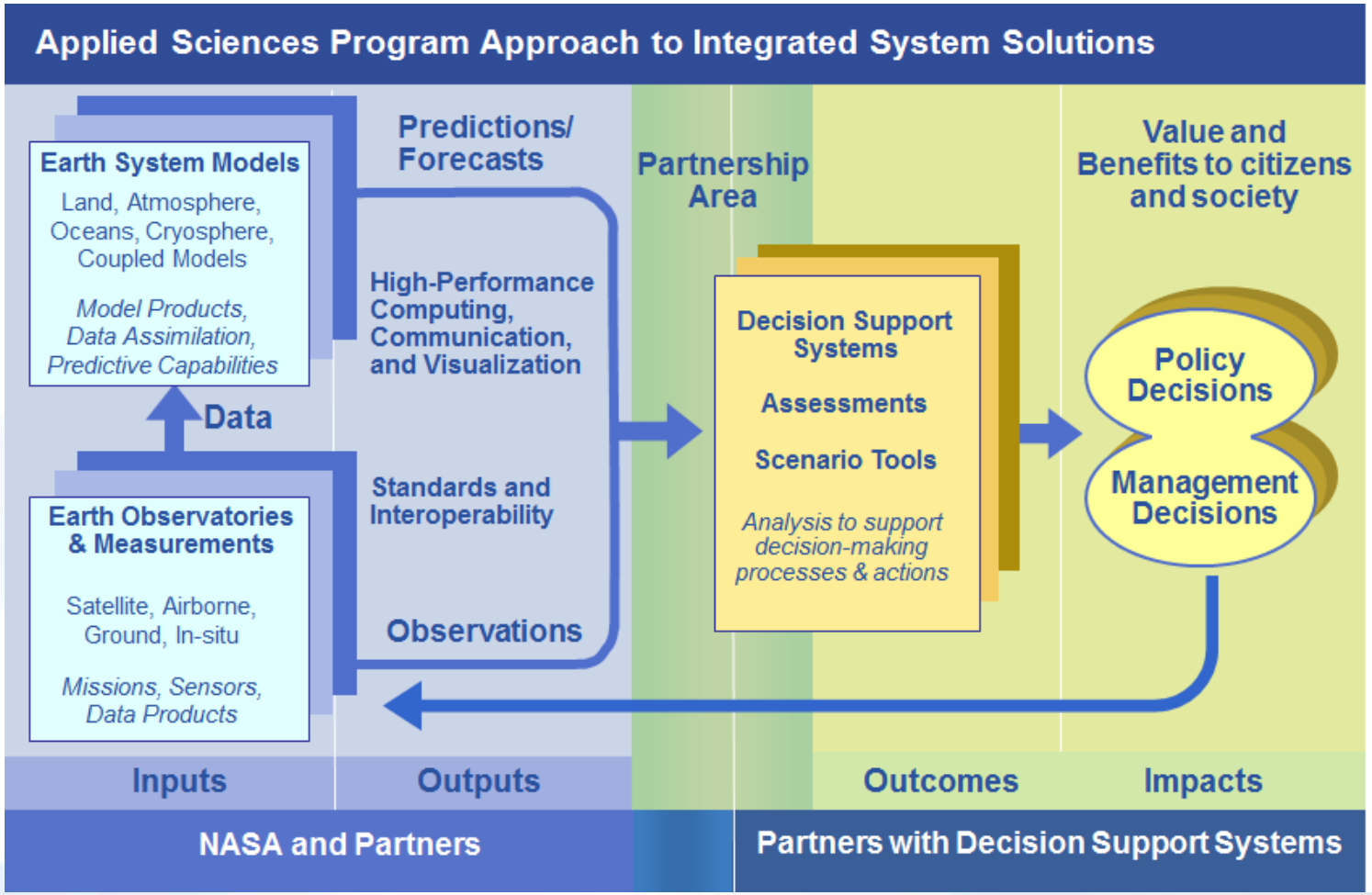
Climate

Weather

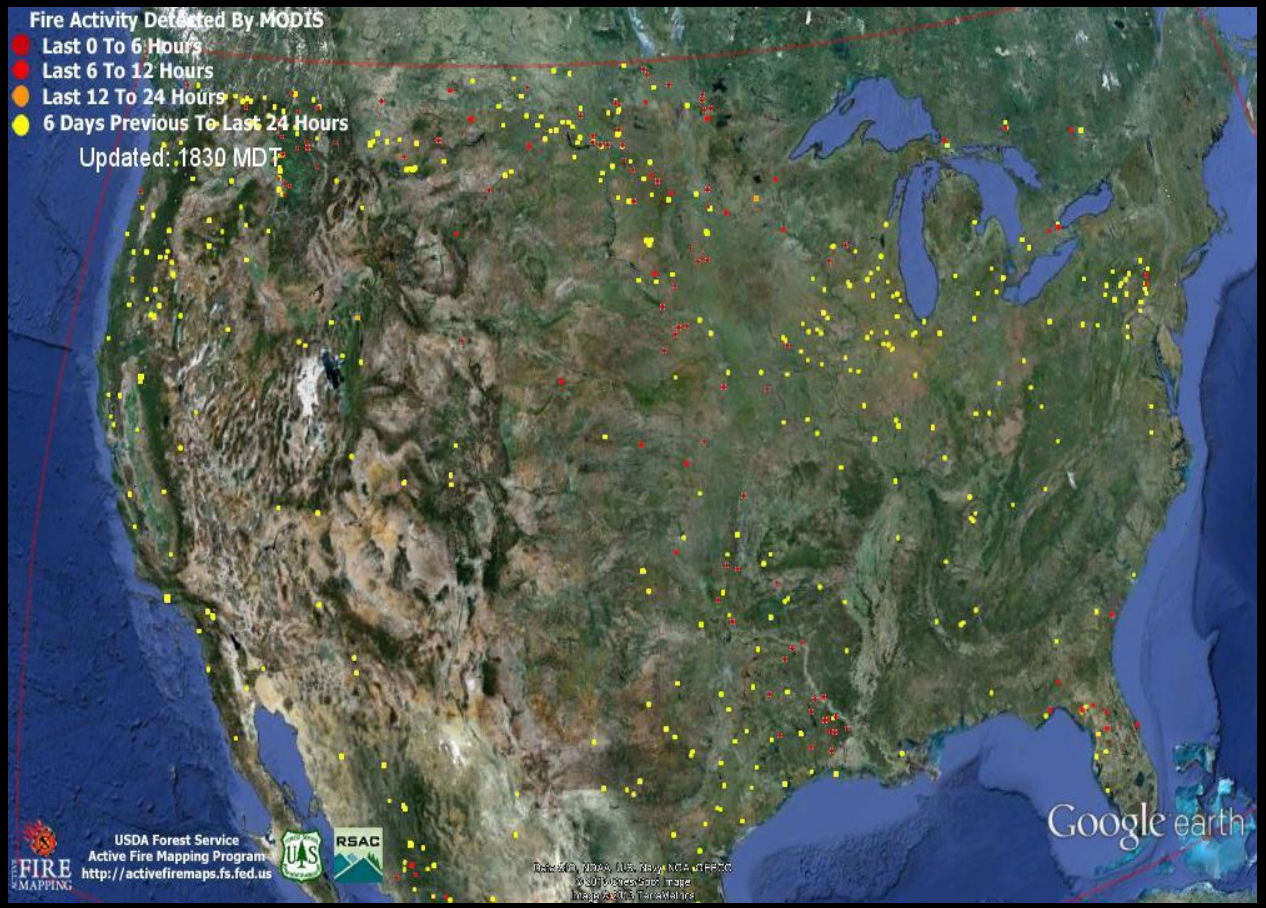
Energy

Oceans

Inform Decisions and Actions



Advance knowledge on how to effectively apply Earth science to serve society. Improve decisions and actions. Support innovation (technical and organizational). Transition applied knowledge. Induce demand.



Active Fire Mapping (AFM) Program

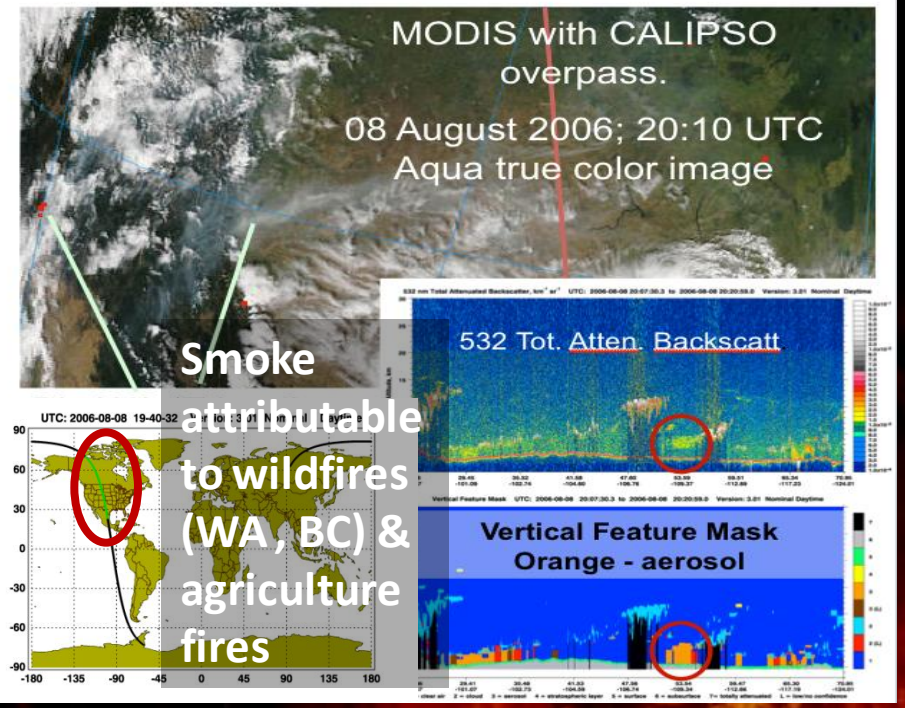
USFS operational use of NASA MODIS for wildfire activity in CONUS, Alaska, Hawaii & Canada

Facilitates decision support for strategic planning & response for U.S. and Canadian fire agencies

VIIRS coming soon!

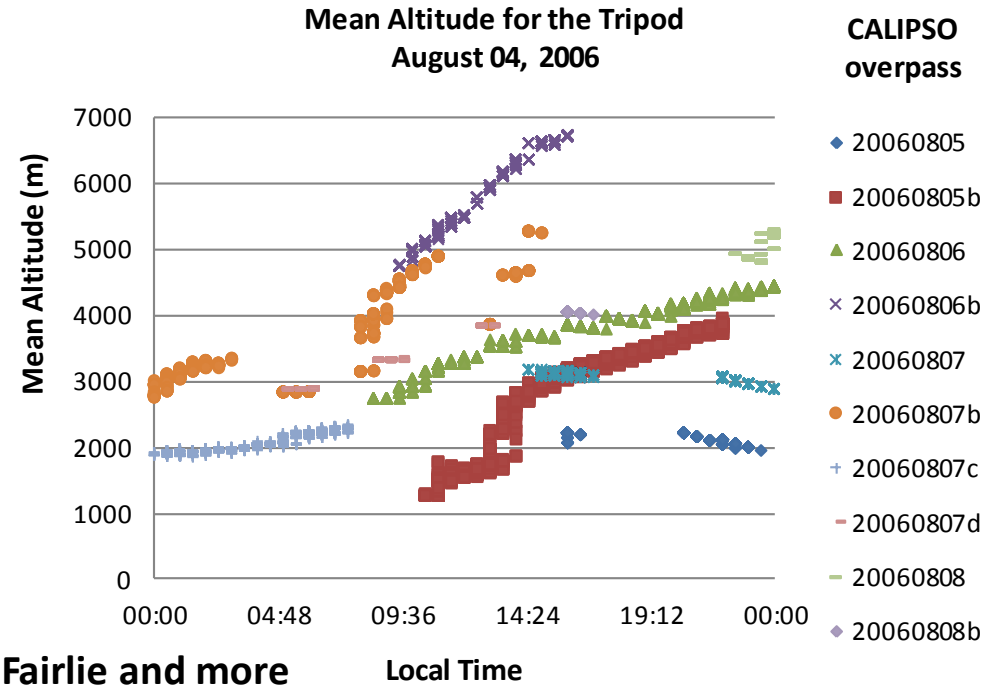
Application of CALIOP data to define smoke plume evolution and establish plume injection height and fire weather statistics under a NASA Air Quality project

w/ LaRC trajectory model & MODIS.



❖ Plume statistics previously unavailable, MISR (morning only) and CALIOP currently available.

❖ CALIPSO provides a random view of complicated 3-D temporal and spatial fire plume data, one that represents a range of fire types from agricultural to large wildfires and is not limited by a particular time of day.



Soja, Fairlie and more

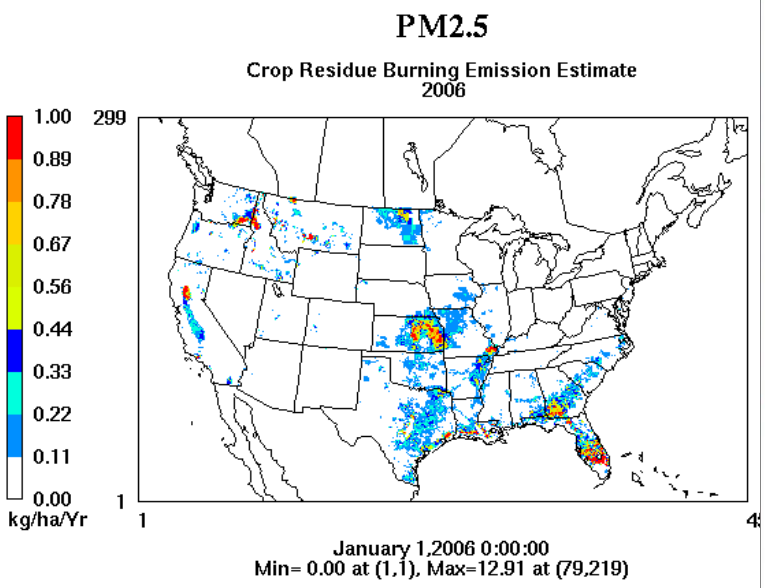
Quantifying Cropland Burning and Related Emissions Using NASA Sensors

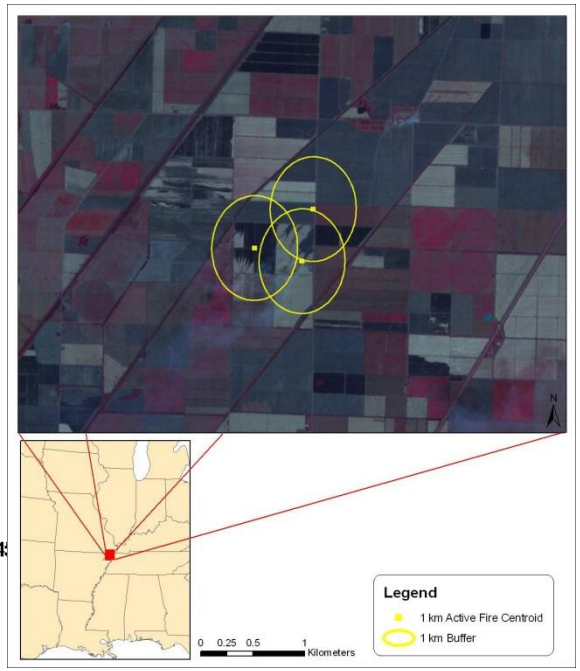
Jessica L. McCarty, PhD

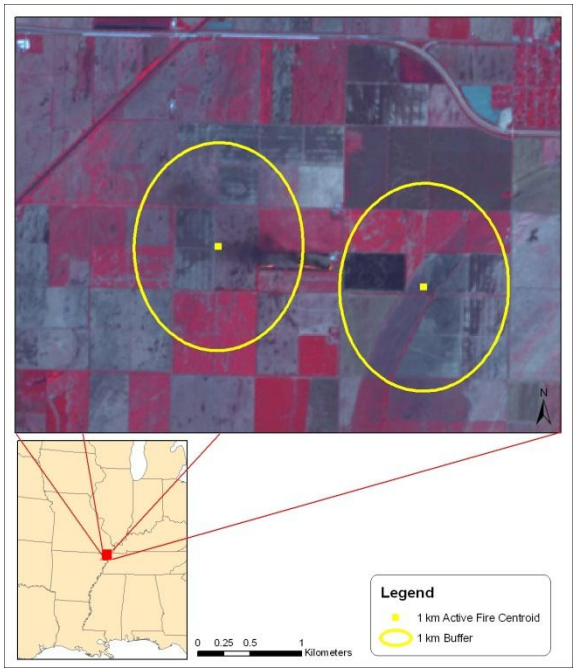
Cropland burning affects local and regional air quality, is a consistent source of emissions, and, as source of GHG /short-lived climate forcers, its impact on climate is not well understood (photo by J. McCarty).

Informing U.S. Emissions Inventories:

- McCarty refined MODIS based cropland burned algorithm to produce county, state, and lat/long specific emission estimates for contiguous U.S. (CONUS) for 25 atmospheric species and 21 crop types (Figure 1).
  - Include as the official source of cropland burning emissions for 2011EPA's National Emissions Inventory.
  - Provided detailed uncertainty analyses upon request from state environmental agencies.
  - NASA Applications contract # NNX12AQ90G; PI: Soja.







Earth Science Serving Society: NASA Earth Science Applications Program - Wildland Fire

Amber Soja and Vince Ambrosia
Associate Program Managers
NASA Applied Science Program
Wildland Fire

Lawrence Friedl
Director
NASA Applied Science Program

Science Directorate

Earth Science

Applications Science

Wildland Fire

http://www.nasa.gov/applied-sciences/

Wildfires Solicitation

Purpose of Solicitation

The objective of this solicitation was to select applications and applied research projects to improve decision-making activities and actions on topics related to wildland fires, such as wildfires, rangeland fires, and prescribed fires.

Successful projects must advance organizations' use and application of Earth observations in analysis and assessments, management strategies and actions, business practices, and policy analysis and decisions associated with wildland fires.

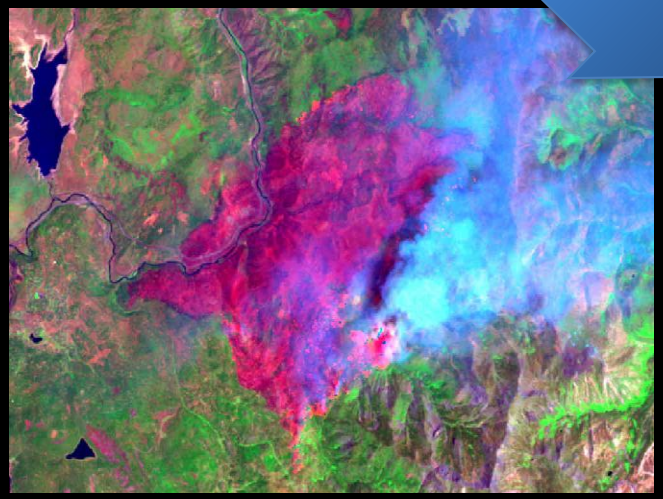
Without you, the greater fire community,
we have nothing…
and we have considerable to offer.

Applied Sciences Program ROSES-2011: A.35 Wildland Fires

SOLICITATION OBJECTIVES

Improve decision-making activities and actions on topics related to wildland fires, such as wildfires, rangeland fires, and prescribed fires.

DEVELOP A TWO-PHASE APPROACH



PHASE 1: FEASIBILITY -

- Develop baseline, fire-related applications tools, information, models, or technologies;
- Early partnership engagement

PHASE 2: IMPLEMENTATION -

- Transitioning feasible, beneficial applications to an operational status with the partner organization and/or end users.

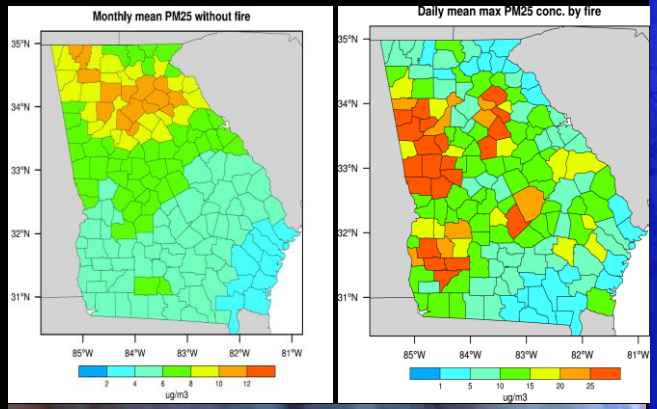
RESULTS

- *Focuses investments on projects with high-reward potential.*
- *Prioritizes partners with commitment to adopting project results.*

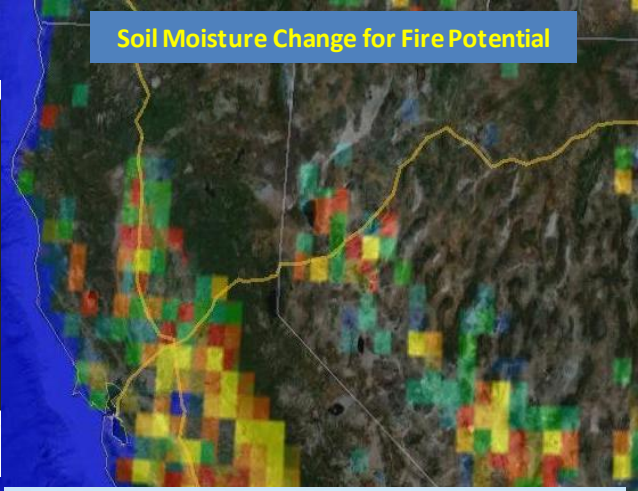
2011 NASA Applied Science Program: ROSES A.35 Wildland Fire

2013 - 17 Applications Feasibility Projects

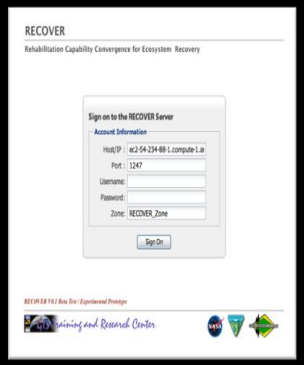
NRT Forecast of Rx burning on PM2.5

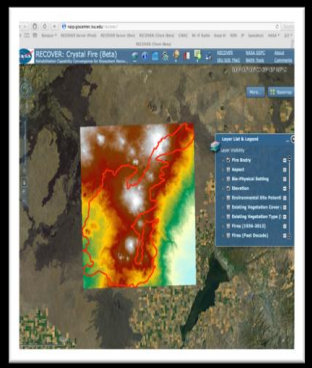


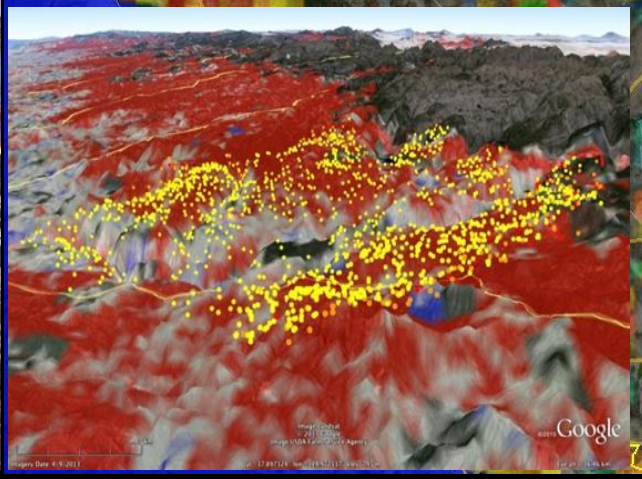
Soil Moisture Change for Fire Potential



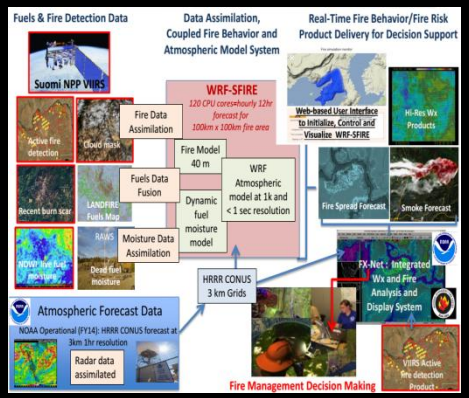
Web-enabled Post-Fire Rehabilitation Planning Application



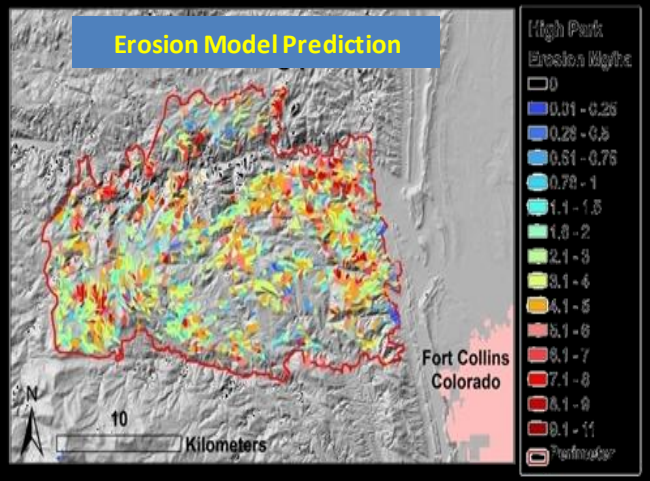




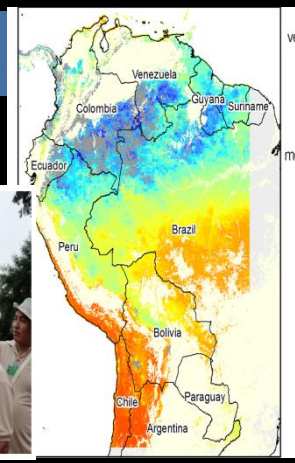
Fire Behavior and Risk Forecasting



Erosion Model Prediction



International R/T Fire Alerts



Selections: 17 Feasibility Studies

RECOVER: Rehabilitation Capability Convergence for Ecosystem Recovery
Daily Forecasts of Wildland Fire Impacts on Air Quality in the Pacific Northwest: Enhancing the Air Indicator Report for Public Awareness and Community Tracking (AIRPACT) Decision Support System
Utilization of Multi-Sensor Active Fire Detections to Map Fires in the US. The Future of Monitoring Trends in Burn Severity
Enhanced Wildland Fire Management Decision Support Using Lidar-Infused LANDFIRE Data
Enhancing Wildland Fire Decision Support and Warning Systems
Applications of satellite measurements to improve prescribed fire management
Improving national shrub and grass fuel maps using remotely sensed data and biogeochemical modeling to support fire risk assessments
Improving agricultural and wildland fire source emission products and access to information for atmospheric science and smoke modeling applications
Linking remote sensing and process-based hydrological models to increase understanding of wildfire effects on watersheds and improve post-fire remediation efforts.
Classification of Whitebark Pine and Spruce-fir Forests to Improve Wildland Fire Decision Support Tools in the USFS Northern Region
A Prototype System for Predicting Insect and Climate-Induced Impacts On Fire Hazard in Complex Terrain
An integrated forest and fire monitoring and forecasting system for improved forest management in the tropics
Wildland Fire Behavior and Risk Prediction
Wildfire risk and treatment effectiveness of protecting highly valued resources and assets with fuels management
Development of New Geospatial Tools for Wildland Fire Management and Risk Reduction
AFTEERS: Automated Fuels Treatment Effectiveness Evaluation Using Remote-Sensing Information
Development and application of spatially refined remote sensing active fire data sets in support of fire monitoring, management and planning

Selections: 9 Decision Support Projects

Principal Investigator	Organization	Partner	Title
Wilfrid Schroeder	University of Maryland	USFS (RSAC), NCAR, DLR	Development and application of spatially refined remote sensing active fire data sets in support of fire monitoring, management and planning
Birgit Peterson	USGS EROS Center	USFS, USGS, U. Montana	Enhanced Wildland Fire Management Decision Support Using Lidar-Infused LANDFIRE Data
Sher Schranz	NOAA/ESRL	NOAA NWS, NIFC, BLM, USFS	Wildland Fire Behavior and Risk Prediction
Zachary Holden	USDA Forest Service	USFS, Washington Dept. National Resources, U Montana, CALFIRE	A Prototype System for Predicting Insect and Climate-Induced Impacts On Fire Hazard in Complex Terrain
James Vogelmann	USGS EROS Center	LANDFIRE (USFS, DOI)	Improving national shrub and grass fuel maps using remotely sensed data and biogeochemical modeling to support fire risk assessments
Keith Weber	Idaho State University	BLM, Idaho Dept. of Lands	RECOVER: Rehabilitation Capability Convergence for Ecosystem Recovery
Mary Miller	Michigan Tech	USFS, Mariposa Natural Resource District, Coconino National Forest	Linking remote sensing and process-based hydrological models to increase understanding of wildfire effects on watersheds and improve post-fire remediation efforts.
Karen Tabor	Conservation International	REDD+, Disney, Moore Foundation, USAID, ESPA	An integrated forest and fire monitoring and forecasting system for improved forest management in the tropics
Stephen Howard	SAIC (USGS-EROS)	NPS (GRCA), USGS, USFS (RSAC), LANDFIRE (USFS, DOI)	Utilization of Multi-Sensor Active Fire Detections to Map Fires in the US. The Future of Monitoring Trends in Burn Severity

Two-Stage Approach

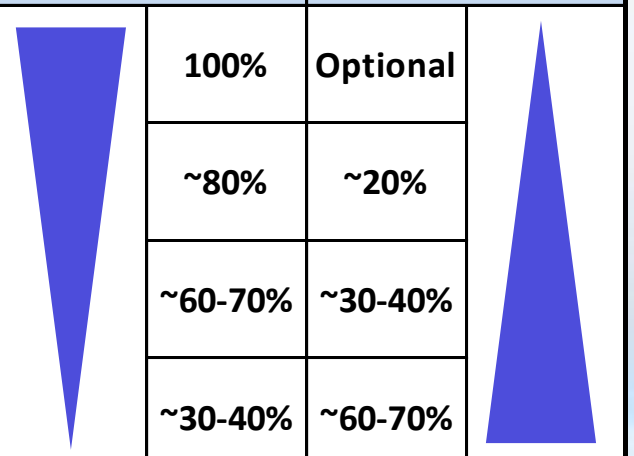
Feasibility-to-Decision Support Projects

A two-stage approach to identify more high-reward projects with strong commitment by partner organizations. **Start with multiple feasibility studies** of possible applications ideas. After a year, **the Program selects a subset** of successful studies to pursue as **in-depth applications projects**.

Approach generates numerous applications ideas and focuses investments on those with high-reward potential.

Approach prioritizes partners' "skin-in-the-game" to increase their involvement in project and commitment to adopting the project results.

Year	Stage	Activity	NASA Share	Partner Share
Year 1	Feasibility	Prove out application potential	100%	Optional
Year 2	Decision Support	Develop application	~80%	~20%
Year 3	Decision Support	Continue development	~60-70%	~30-40%
Year 4	Decision Support	Complete application and transition	~30-40%	~60-70%



Key Questions for Evaluation

Is it feasible?

Is it valuable?

Is there commitment?

A successful applications project needs to be scientifically and technically developed and achievable (not basic research), useful, and wanted by partner organizations.

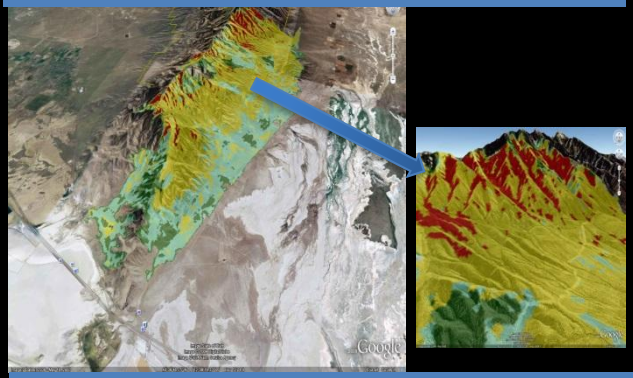
Applications Readiness Level

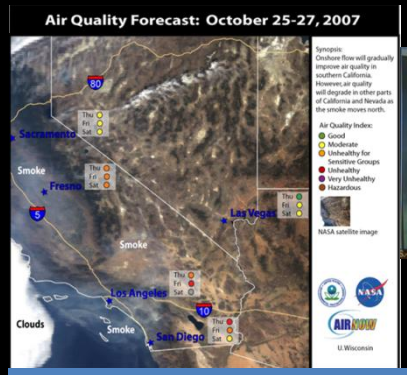
Applications Readiness Levels (ARL)

9. **Approved, Operational Deployment and Use in Decision Making**
8. **Application Completed and Qualified**
7. **Application Prototype in Partners' Decision Making**
6. **Demonstrate in Relevant Environment**
5. **Validation in Relevant Environment**
4. **Initial Integration and Verification**
3. **Proof of Application Concept**
2. **Application Concept**
1. **Basic Research**

Transitioned NASA Data, Models, Technologies to Operational Fire Management Support

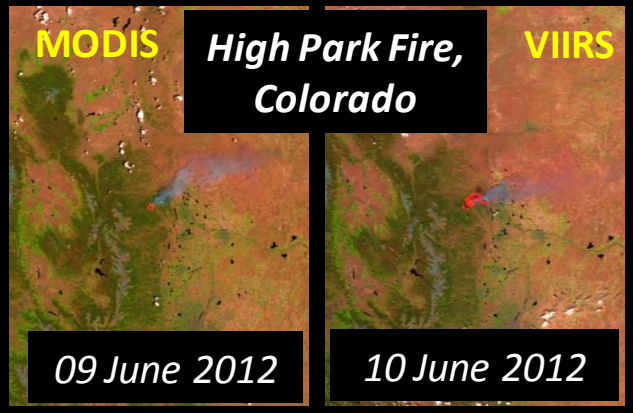
Burned Area Reflectance Classification - Landsat





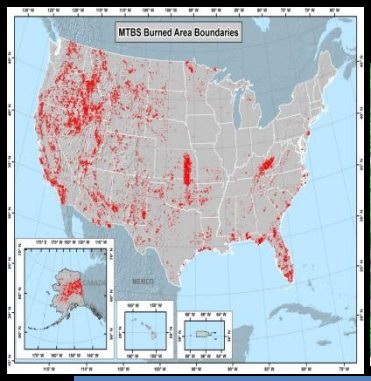
Satellite Observations Support Air Quality Estimates & Forecast

Fire Detections and Satellite Continuity



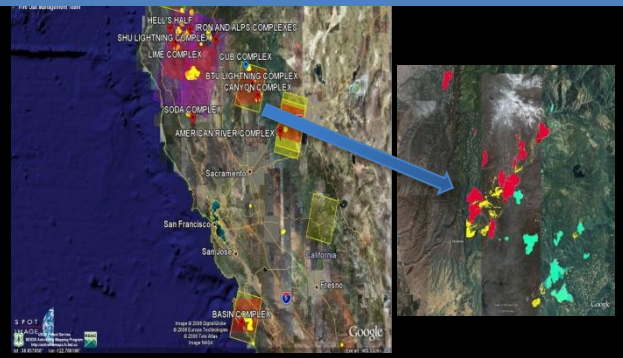
Improved Airborne Fire Imaging

UN FAO Global Fire Information Management System



Monitoring Trends in Burn Severity (MTBS)

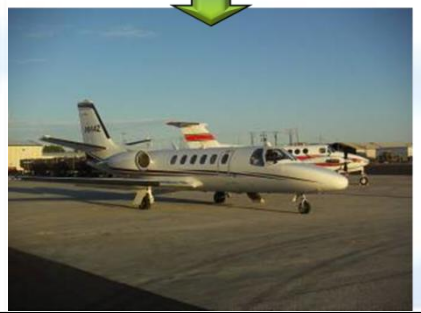
Collaborative Decision Environment for NRT Fire Monitoring

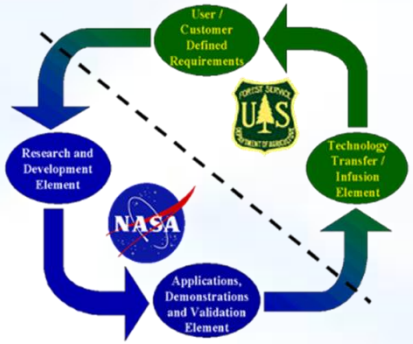


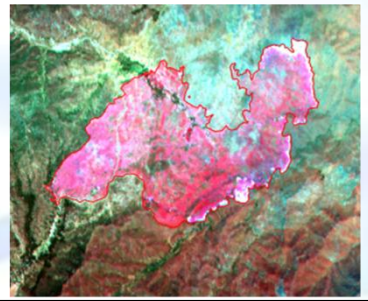
Supports improved management strategies for mitigation of wildfire effects on ecosystems, infrastructure and human lives!!

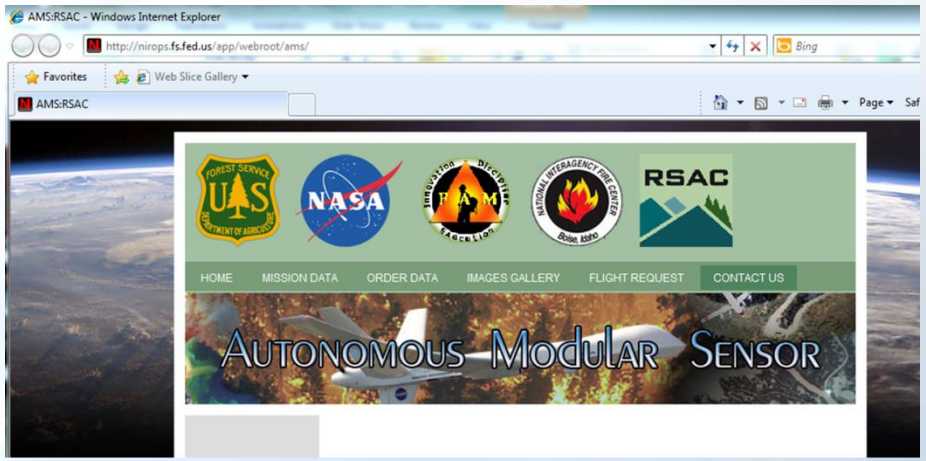
NASA AMS Sensor to USFS Fire Operations

- NASA airborne Autonomous Modular Sensor (AMS) transferred to the USFS National Infrared Operations (NIROPS) and USFS Remote Sensing Applications Center (RSAC) for operations supporting fire and other research / applications needs.
  - » Joint press announcement (NASA and USFS) released on 16 April 2013.
- AMS installed on a USFS Cessna Citation jet (FY2013); Flew a series of missions in support of data collection for partners in USDA Ag Research and the USGS Water Quality.
- AMS was not used in 2013 to support US wildfire events
  - » USFS felt their staff training was too short for adaptation into immediate operations.
- USFS funded $100K to NASA-ARC to support FY13-15 training, sensor calibration, and enhancements, to ready staff for AMS operations in FY2014 (and further support)



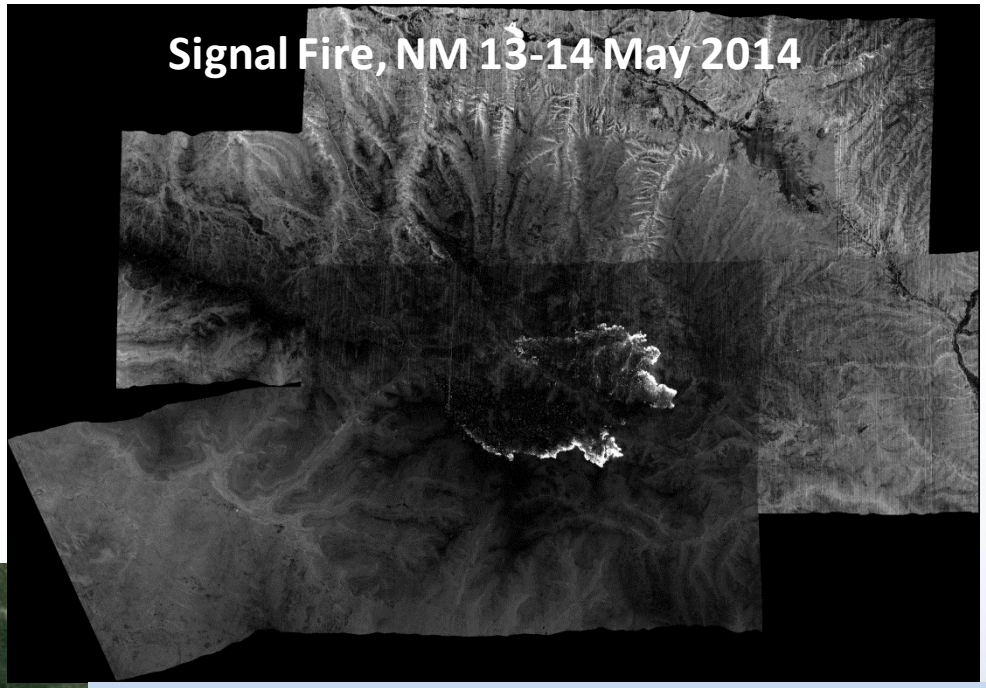


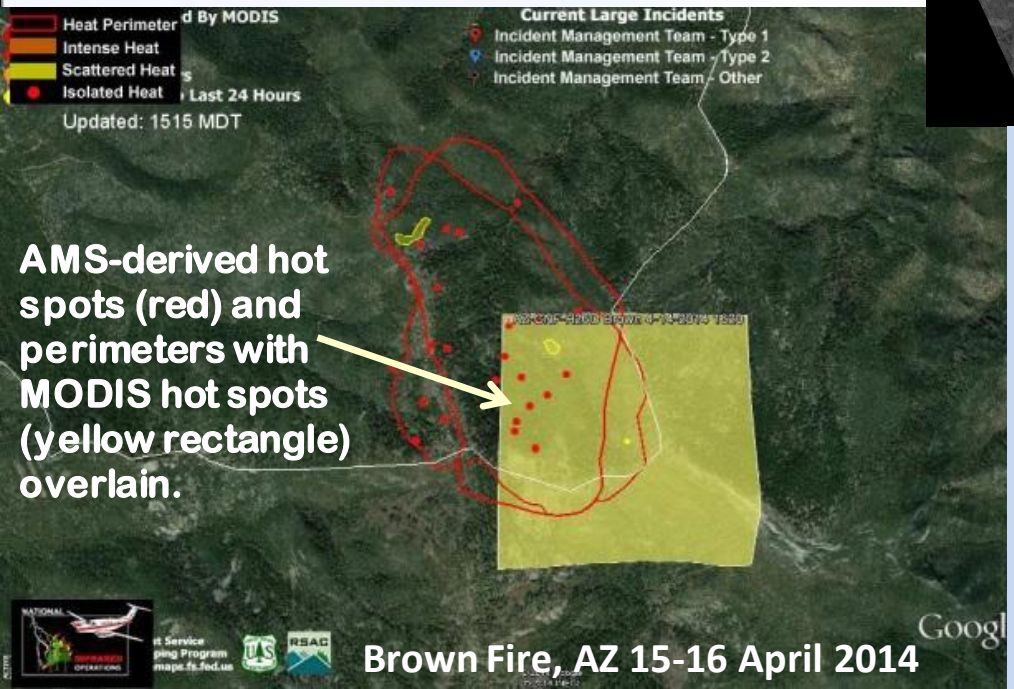




http://nirops.fs.fed.us/ams/

AMS Supports Operational Fire Monitoring in 2014

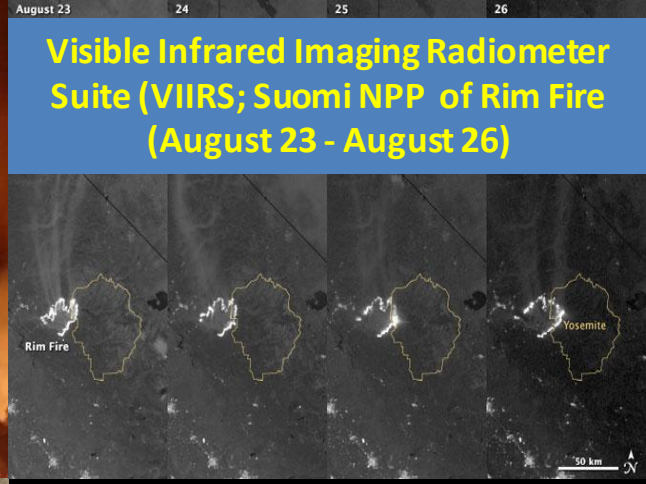




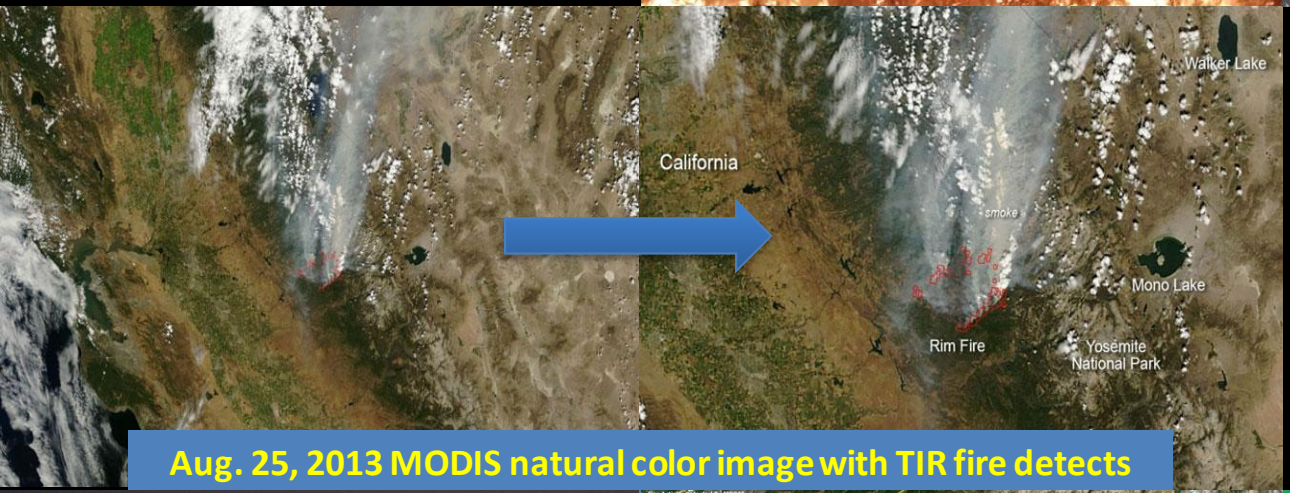
SIGNIFICANT RESULTS:

- **Brown Fire (AZ): Fire acreage down-graded after AMS multi-night mission collections confirms limitation of fire spread; allows reduction in fire crews and cost-savings to agency.**
- **Signal Fire (NM): First IR mission flown by NIFC on Signal Fire. Isolated heat sources identified outside perimeter allowed suppression activity focus the next morning.**
- **USFS team adapting readily to AMS data and capabilities**

Rim Fire, California, August / September 2013

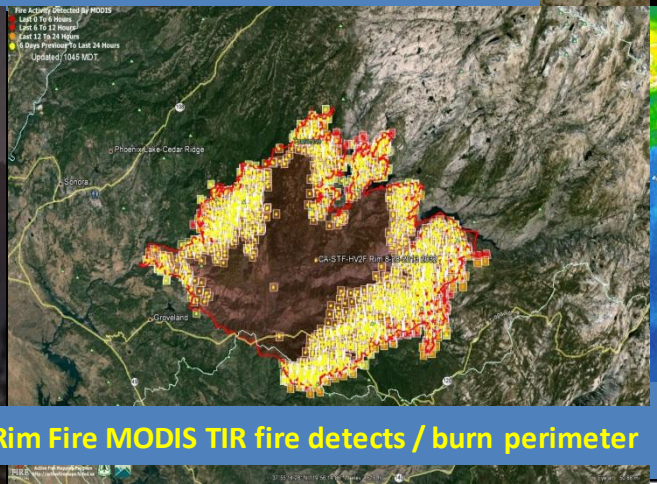


Visible Infrared Imaging Radiometer Suite (VIIRS; Suomi NPP of Rim Fire (August 23 - August 26)

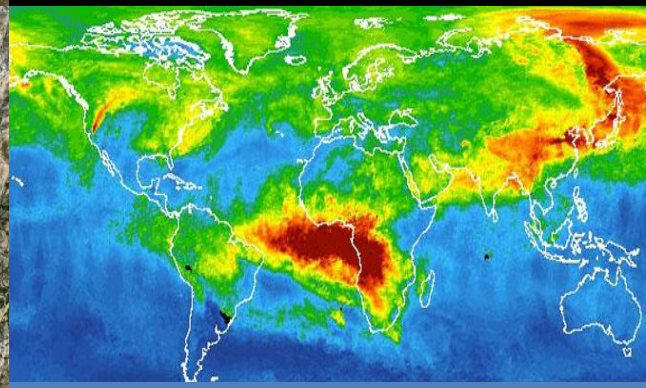


Aug. 25, 2013 MODIS natural color image with TIR fire detects

- *Rim Fire burned for over two months (8/17 to ~ 11/1);*
- *257,314 acres (104131 hectares);*
- *3rd largest fire in CA history;*
- *Peak # of firefighters: 5,100*
- *Impacts seen across continent!*



Rim Fire MODIS TIR fire detects / burn perimeter



Aug. 26, 2013 CO Plume; Atmospheric Infrared Sounder (AIRS); NASA's Aqua

Questions?

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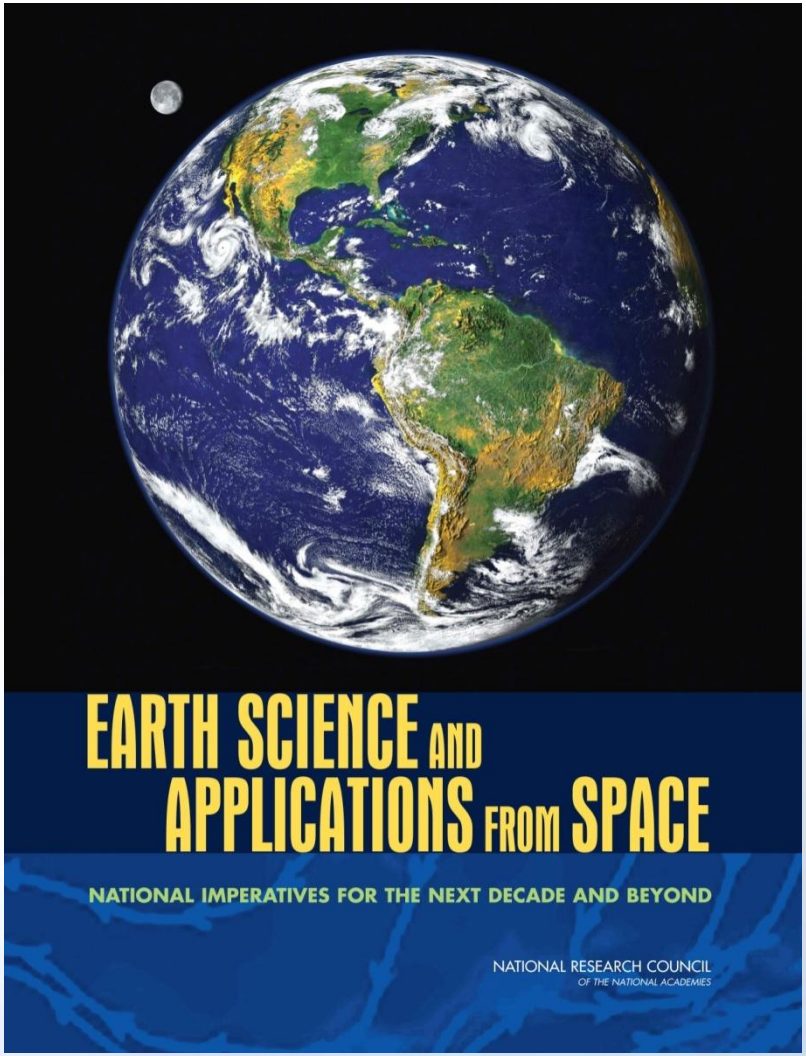
Earth Science & Applications

The national strategy outlined here has as its overarching objective a program of scientific discovery and development of applications that will enhance economic competitiveness, protect life and property, and assist in the stewardship of the planet for this and future generations.

Earth Science Decadal Survey



Earth Science Missions – Early Adopters

Early Adopters: *New with SMAP*

Purpose is to conduct pre-launch applications research to accelerate use of data after launch.

Organizations with clearly-defined needs for *SMAP*-like data products evaluate & demonstrate the utility of *SMAP* data for their application and decision making.

Early Adopters:

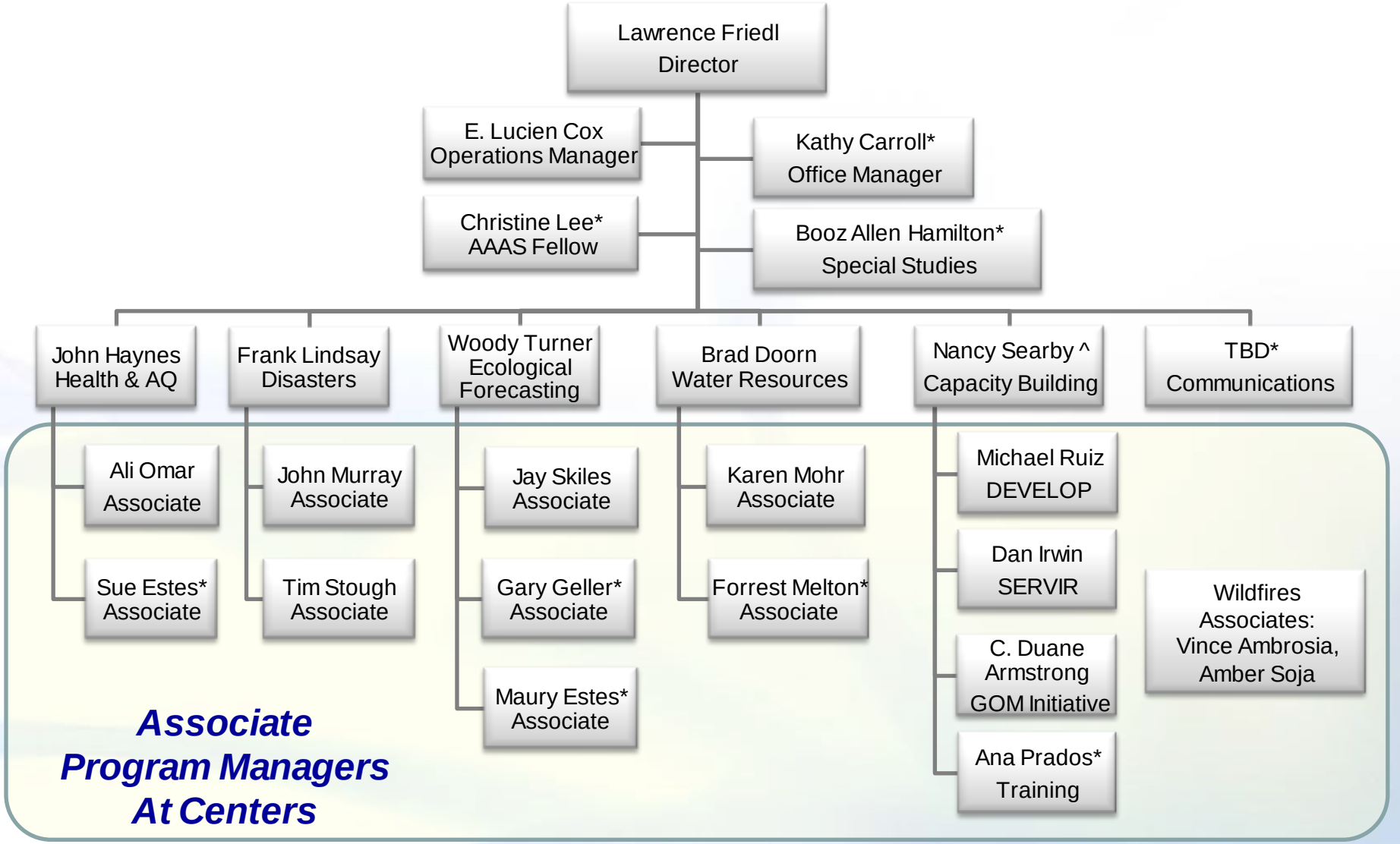
- » Use data products prior to launch (simulated data and cal/val data from field campaigns)
- » Provide feedback on products and formats to increase applications value of mission
- » Streamline and accelerate use of data soon after launch and check-out
- » Supply own resources to do these activities

***** ICESat-2 started Early Adopters in 2013 *****

25+ organizations are currently EAs from public & private-sector, domestic & foreign

SMD/ESD Applied Sciences Program

Organization Chart (February 2014)



** IPA or Contractor - ^ Nancy Searby on detail.*

Additional people serve as Deputy Program Applications leads for satellite missions