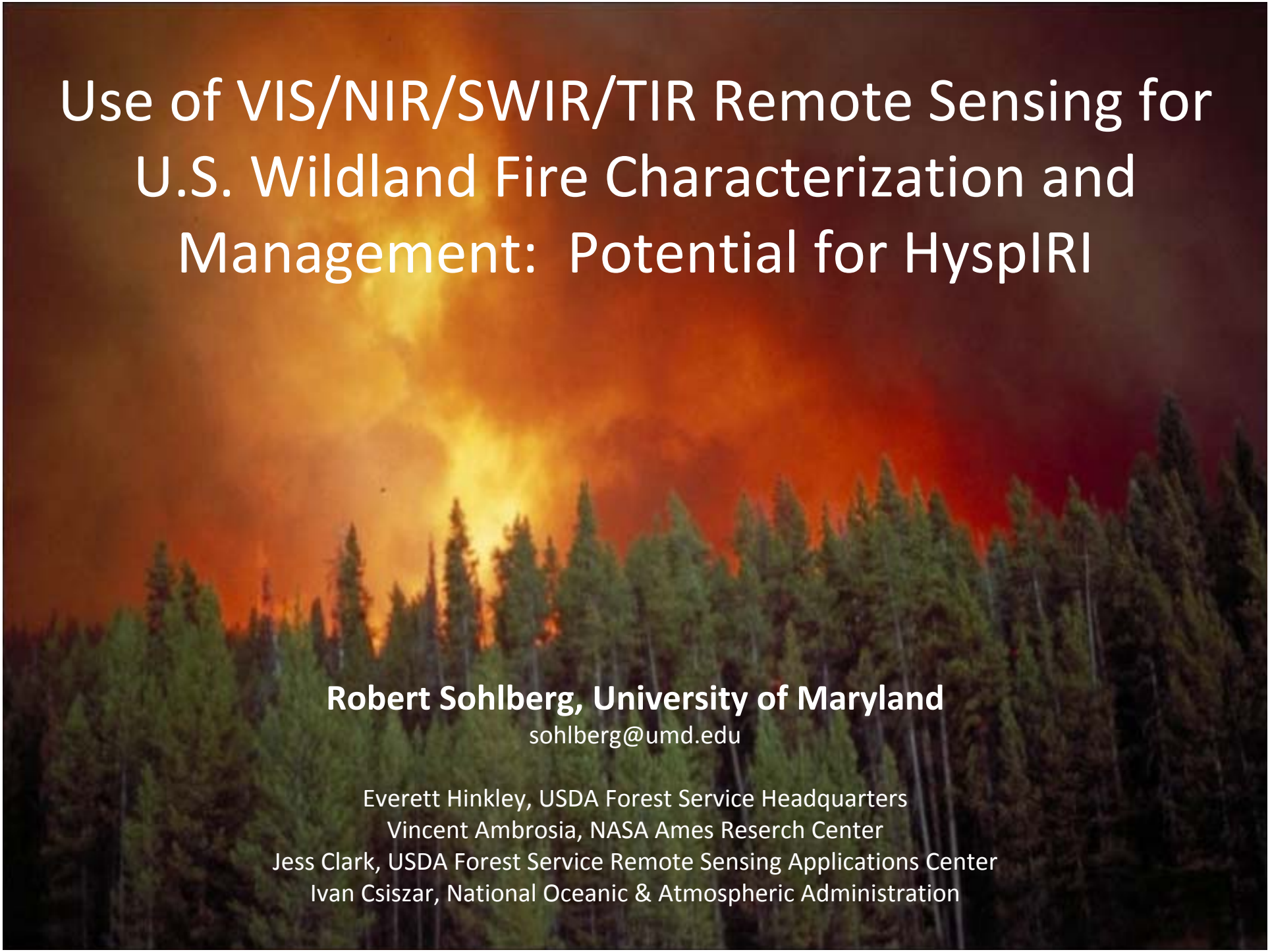

# Use of VIS/NIR/SWIR/TIR Remote Sensing for U.S. Wildland Fire Characterization and Management: Potential for HyspIRI

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Everett Hinkley, USDA Forest Service Headquarters
Vincent Ambrosia, NASA Ames Reserch Center
Jess Clark, USDA Forest Service Remote Sensing Applications Center
Ivan Csiszar, National Oceanic & Atmospheric Administration

# The Three Phases of Wildland Fire Mapping

- **Pre-fire**
  - Available fuels (type, size, arrangement, age)
  - Fuel Conditions (moisture, bug kill, blow down)
- **Active fire**
  - Detection of ignitions (primarily via ground report in the lower 48)
  - Movement of the fire front, breach of containment
- **Post-fire**
  - Fire effects on vegetation and soils
  - Mitigation of adverse impacts (mass wasting, water quality, invasive species)

# Mature Heritage

- Airborne Missions
  - Phoenix (beginning in latter 1960s)
  - MASTER
  - AVIRIS
  - AMS
  - Military Assets
- Geostationary Satellite Missions
  - GOES
- Polar Orbit Satellite Survey Missions
  - AVHRR
  - MODIS (will continue with VIIRS)
- Satellite Mapping Missions
  - Landsat
  - ASTER
  - Spot
  - ALI/Hyperion
  - IKONOS, Quickbird

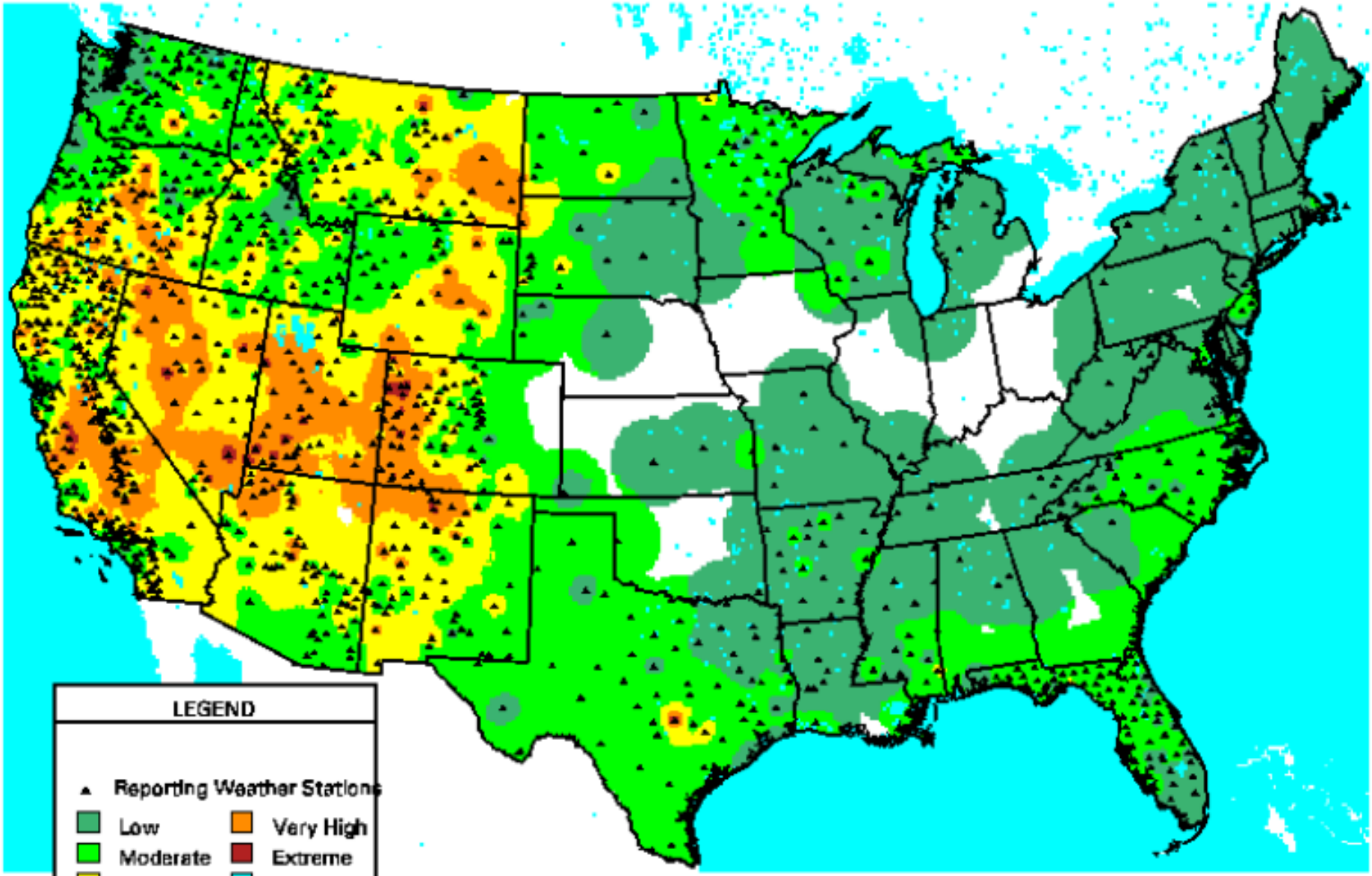
# Principal Users

- National Interagency Fire Center
- USDA Forest Service
- Bureau of Land Management
- National Park Service
- Alaska Fire Service
- Bureau of Indian Affairs
- Fish and Wildlife Service
- DoD (i.e. NORTHCOM)
- Department of Homeland Security
- FEMA
- States (i.e. CAL FIRE)

# Wildland Fire Assessment System

- Produced daily by USDA Forest Service Rocky Mountain Research Station.
- Dozens of variables and metrics reported
  - Fire Danger Rating
  - Lighting Ignition Efficiency
  - Haines Index (lower atmosphere stability)
  - Fire Weather
  - Fuel Moisture (10, 100 and 1,000 hour)
  - NDVI
  - Palmer Drought Index
  - And so on …

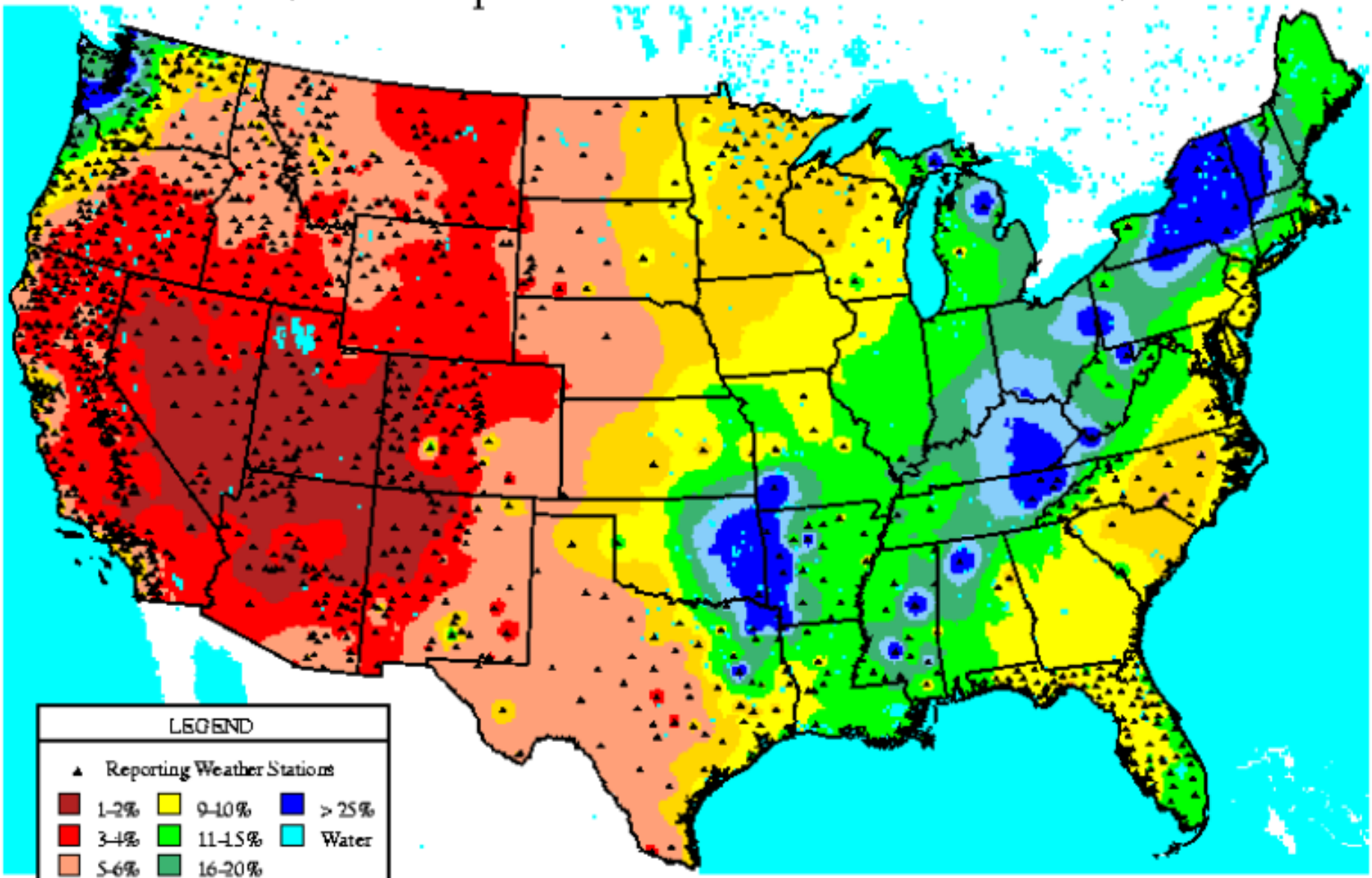
# Observed Fire Danger Class: 11-AUG-09




(Inv. Dist.$^2$ Interp.)

WFAS-MAPS Graphics FIRE BEHAVIOR RESEARCH MISSOULA, MT

# Obs. or Computed 10-Hour FM: 11-AUG-09

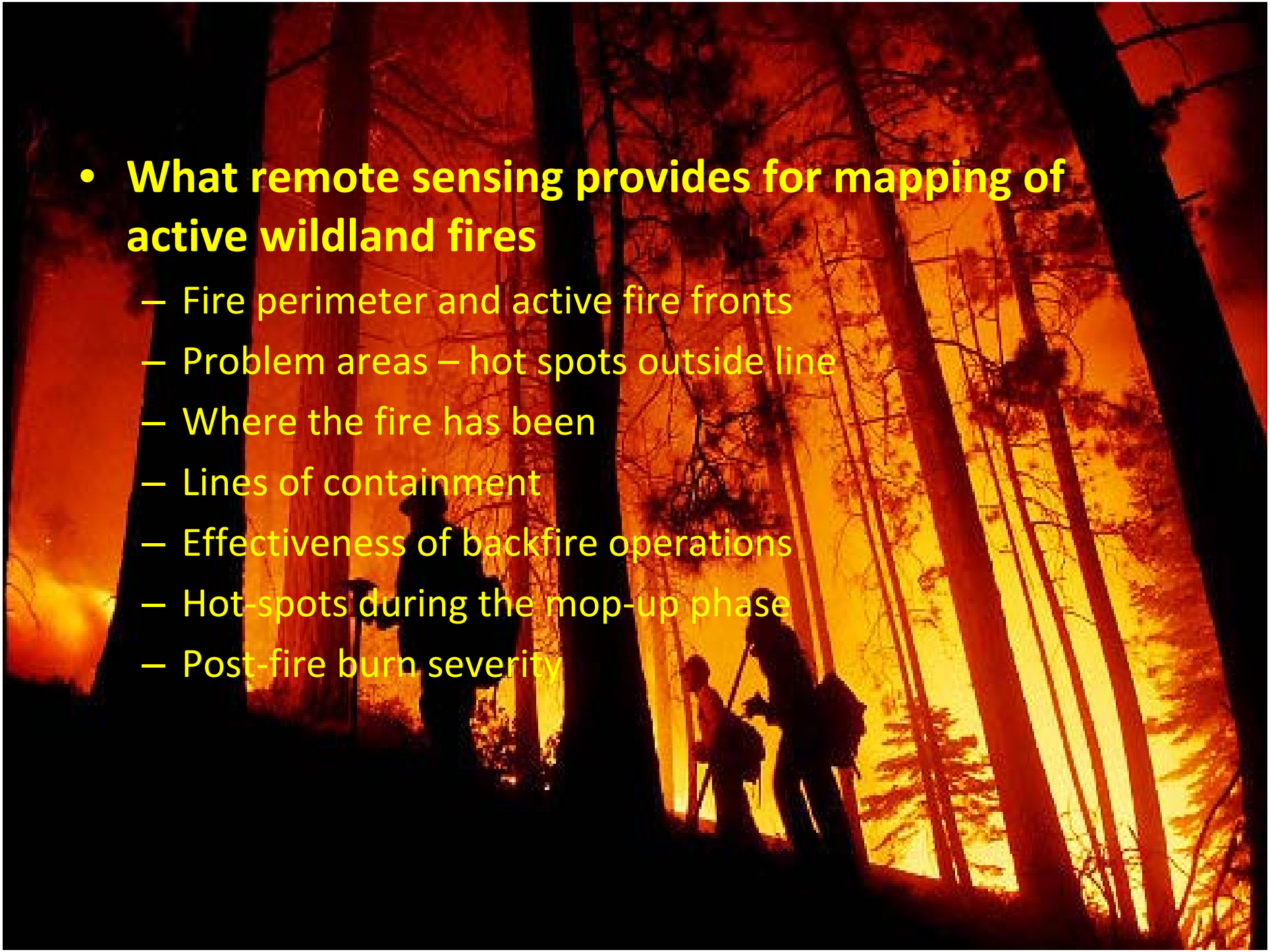



(Inv. Dist.$^3$ Interp.)

**WFAS-MAPS Graphics FIRE BEHAVIOR RESEARCH MISSOULA, MT**

Satellite Fuels and Fuel Condition Pre-Fire Characterization DSS all use the VIS / NIR / SWIR bands available on HyspIRI (in addition to a lot of wx data).

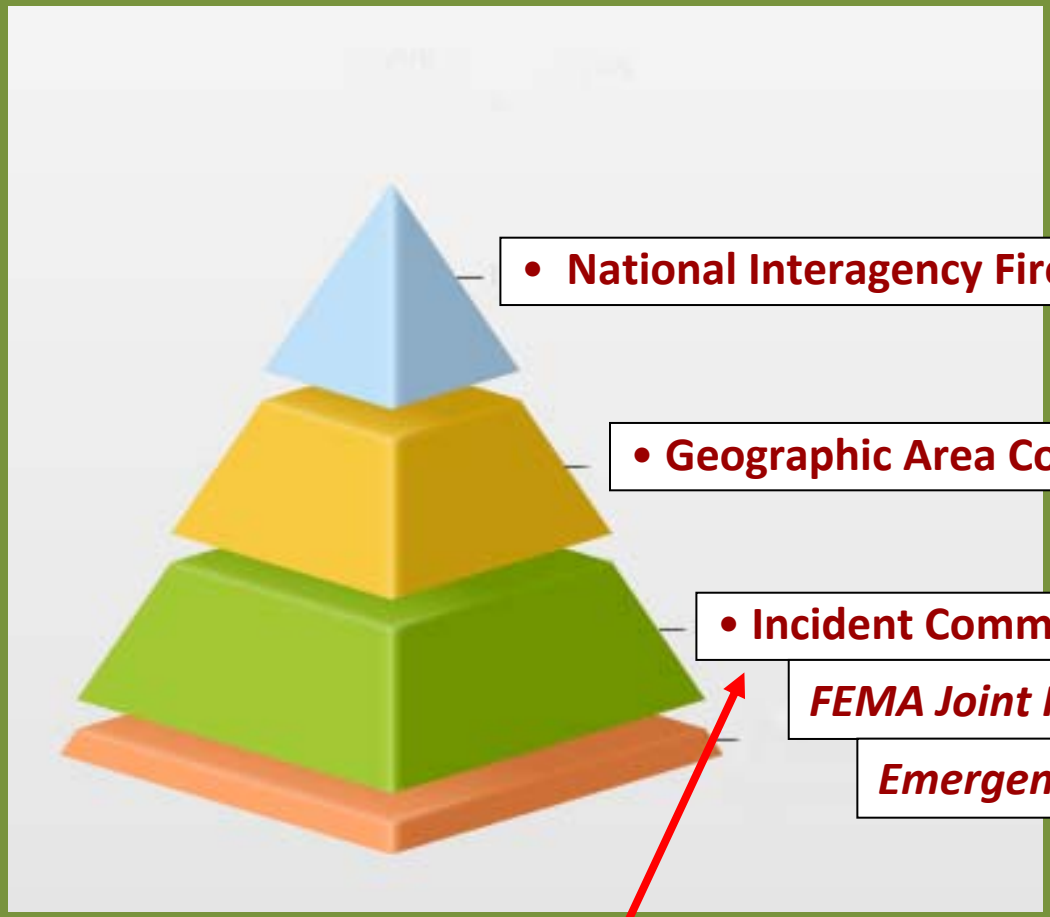
*Opportunity to develop new experimental methods using hyperspectral VIS/NIR/SWIR signal. TIR has potential for water balance.*



- **What remote sensing provides for mapping of active wildland fires**
  - Fire perimeter and active fire fronts
  - Problem areas – hot spots outside line
  - Where the fire has been
  - Lines of containment
  - Effectiveness of backfire operations
  - Hot-spots during the mop-up phase
  - Post-fire burn severity

# Command Structure & Customers

## Where the data goes

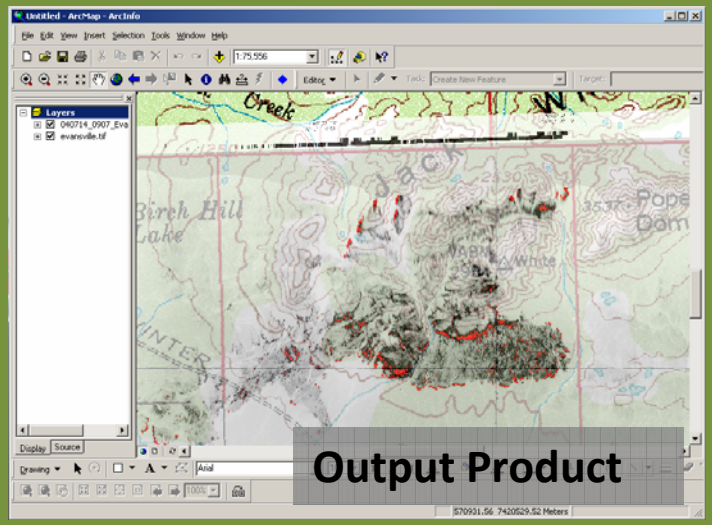



- **National Interagency Fire Center (NIFC)**
- **Geographic Area Command Center (GACC)**
- **Incident Command Posts (ICPs)**
- ***FEMA Joint Field Office (JFO)***
- ***Emergency Operations Centers (EOC)***

The ICP is the primary customer for TIR Data

# National Infrared Operations

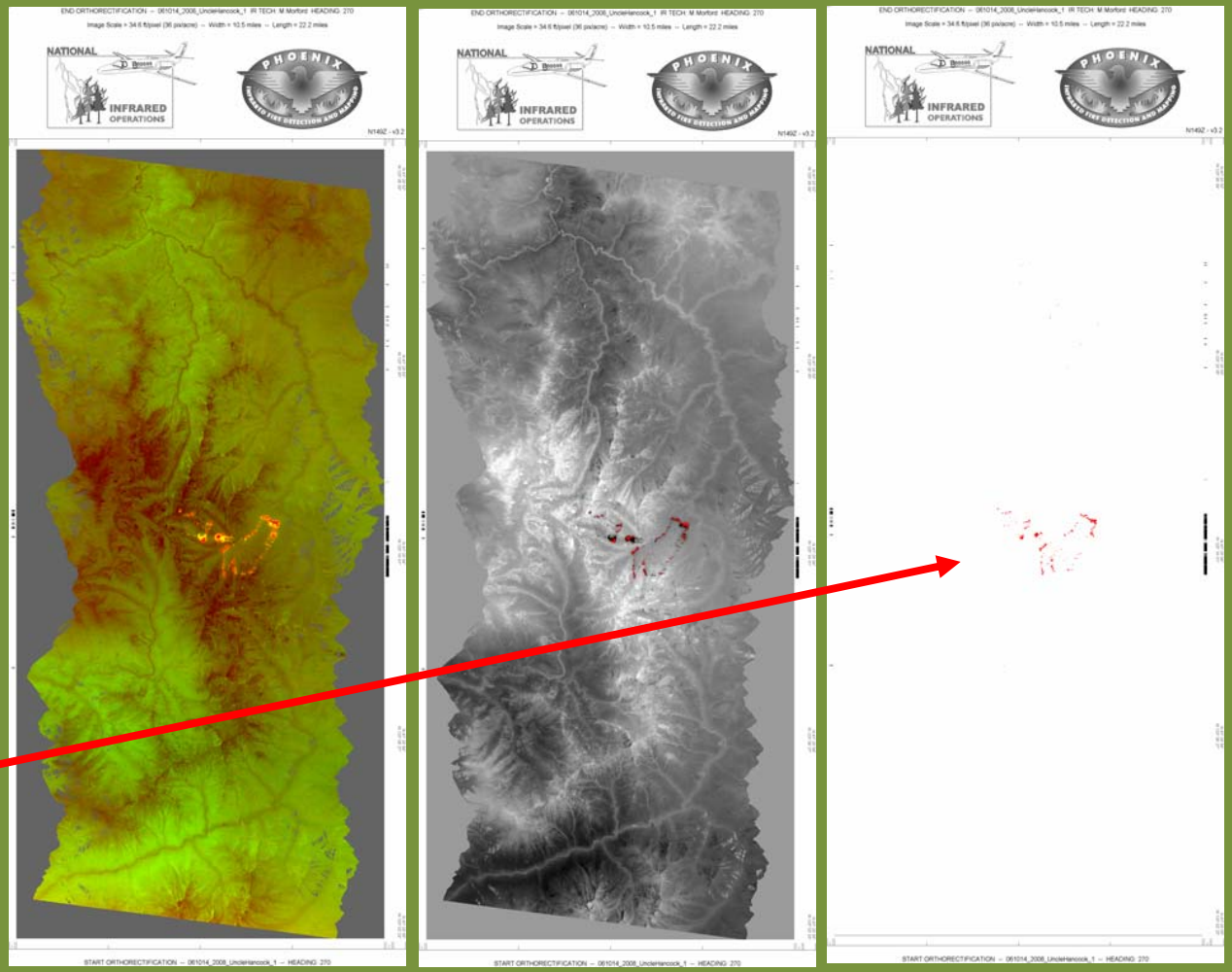


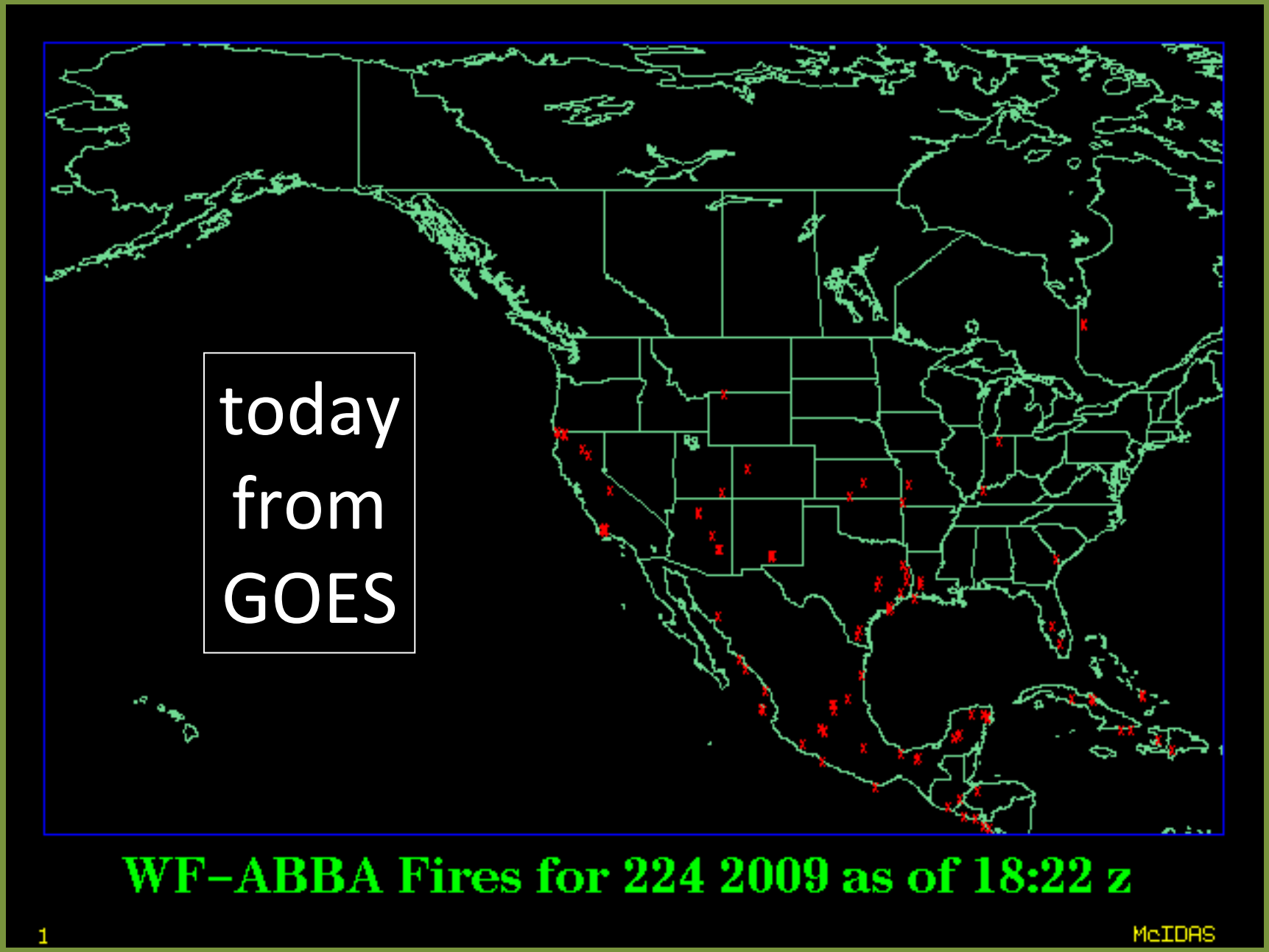


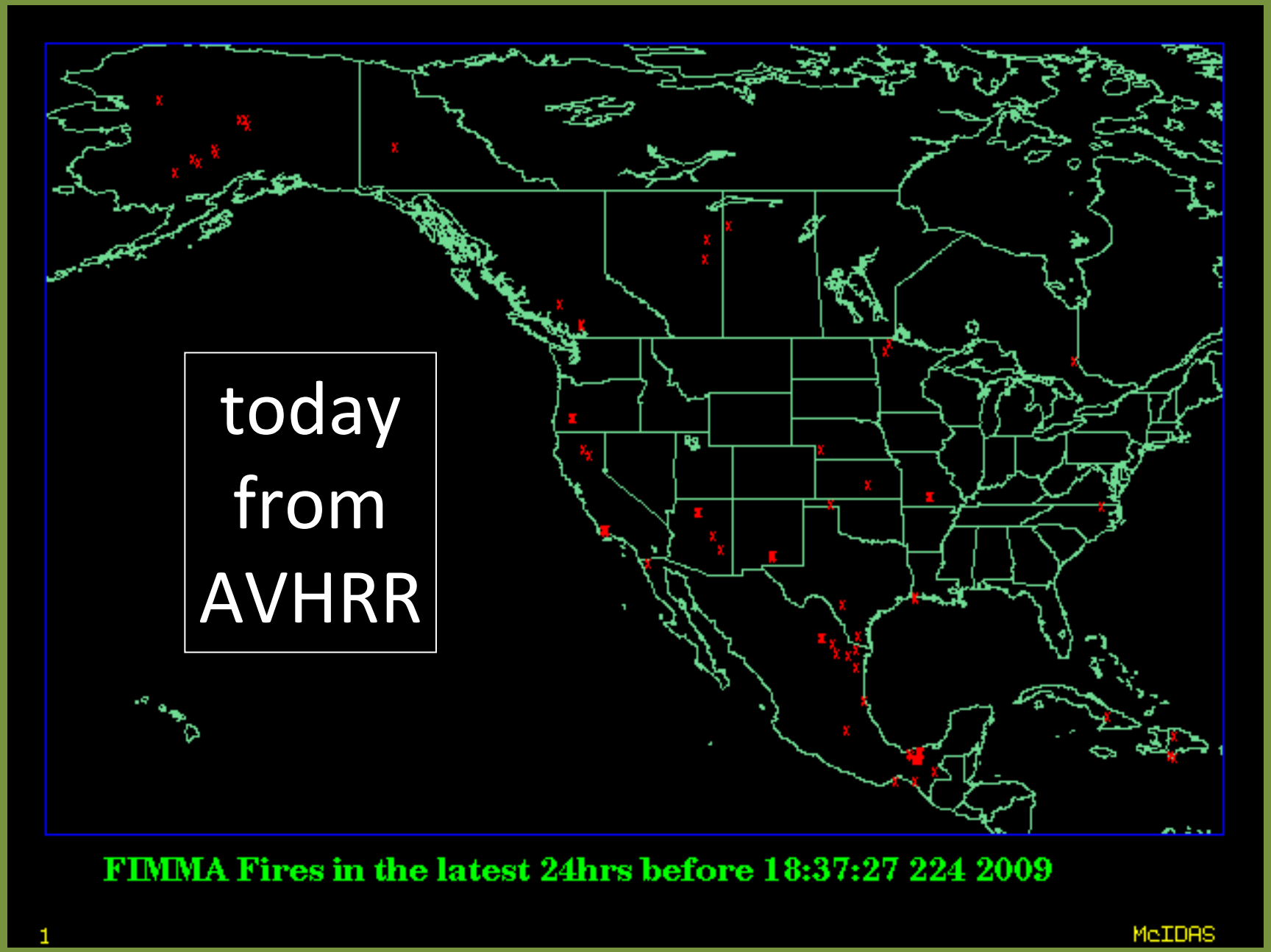

PHOENIX
INFRARED FIRE DETECTION AND MAPPING

# PHOENIX Output Products

- GeoTiffs
  - Color
  - Grayscale
- JPEGS
- Mosaics
- Active Heat Areas shape file

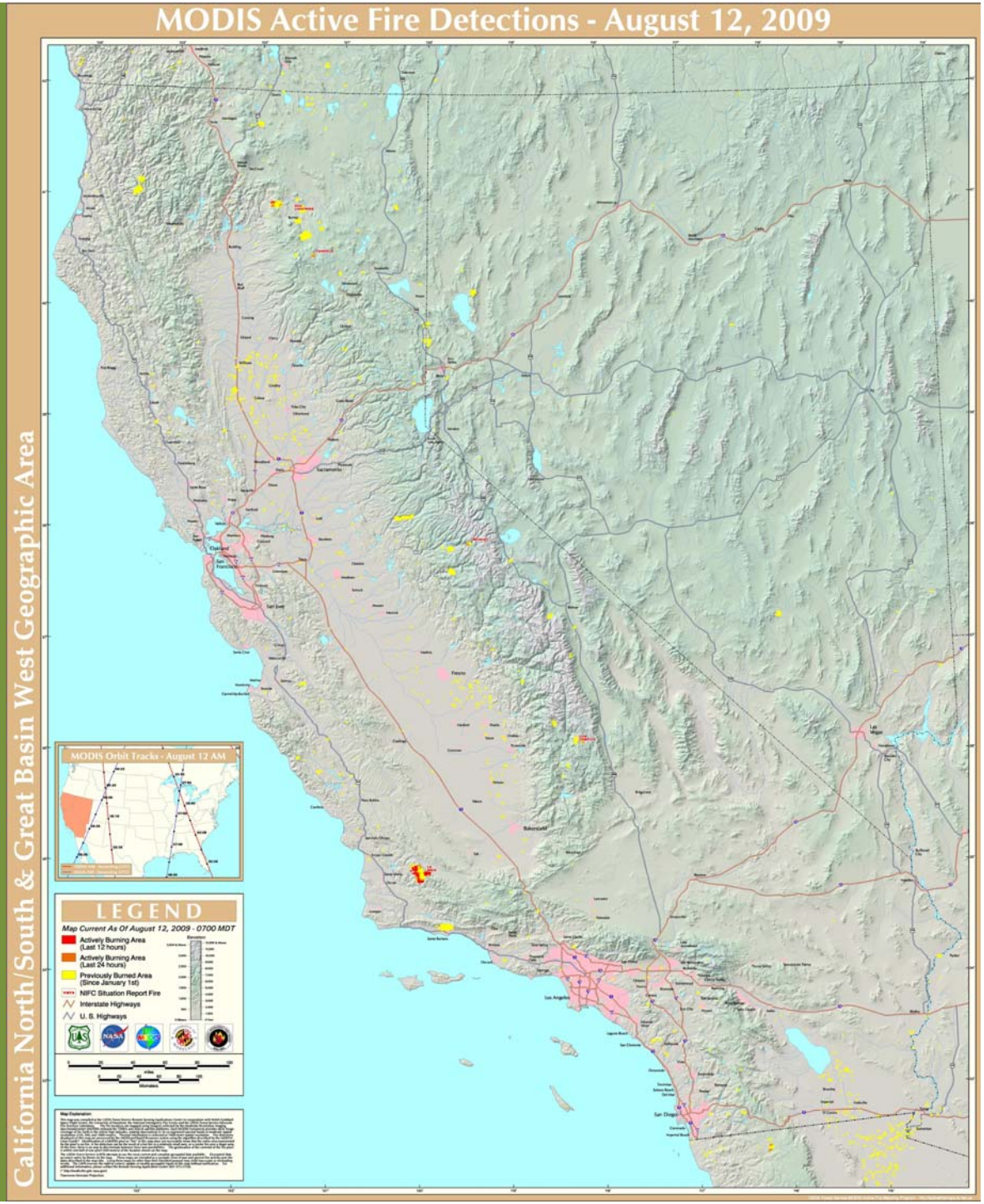


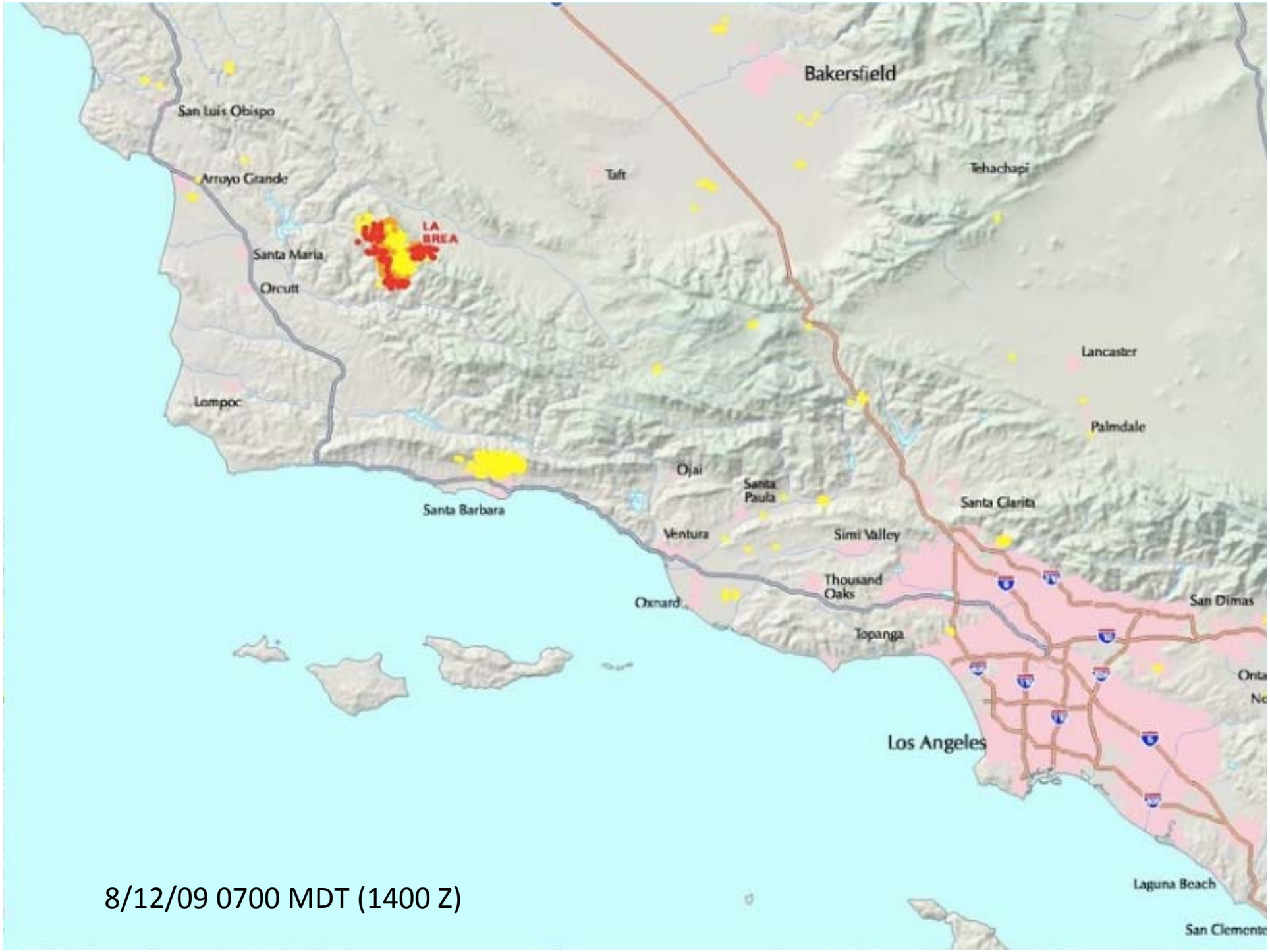

today
from
GOES
WF-ABBA Fires for 224 2009 as of 18:22 z
1
McIDAS


today
from
AVHRR
FIMMA Fires in the latest 24hrs before 18:37:27 224 2009
1
McIDAS

today
from
MODIS

Produced
via Direct
Readout
facility at
USFS-RSAC,
Salt Lake City.






8/12/09 0700 MDT (1400 Z)

# Sensor System:
# AMS Wildfire Instrument

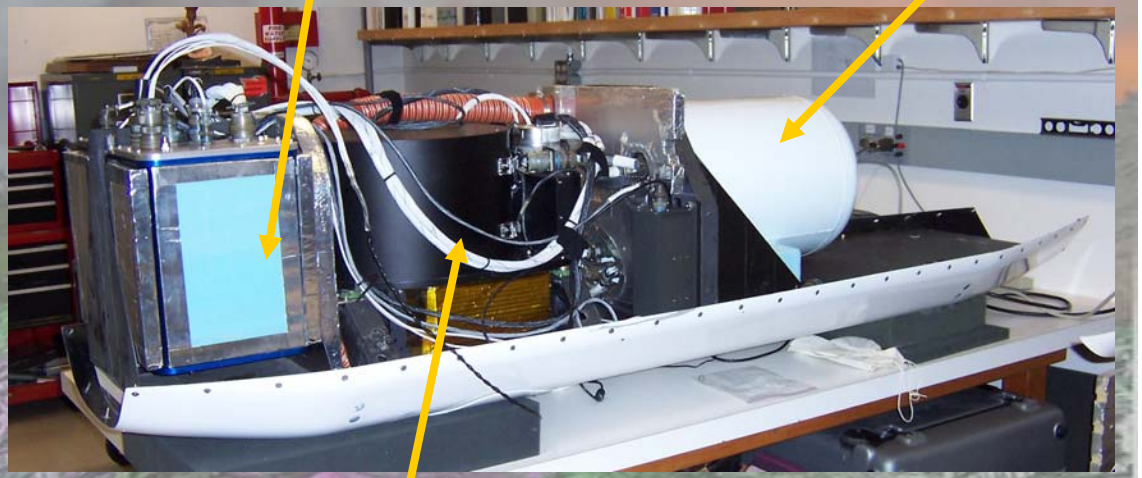
## AMS Wildfire Sensor

| Band | Wavelength μm | |
|---|---|---|
| 1 | 0.42- 0.45 | |
| 2 | 0.45- 0.52 | (TM1) |
| 3 | 0.52- 0.60 | (TM2) |
| 4 | 0.60- 0.62 | |
| 5 | 0.63- 0.69 | (TM3) |
| 6 | 0.69- 0.75 | |
| 7 | 0.76- 0.90 | (TM4) |
| 8 | 0.91- 1.05 | |
| 9 | 1.55- 1.75 | (TM5) |
| 10 | 2.08- 2.35 | (TM7) |
| 11 | 3.60- 3.79 | (VIIRS M12) |
| 12 | 10.26-11.26 | (VIIRS M15) |

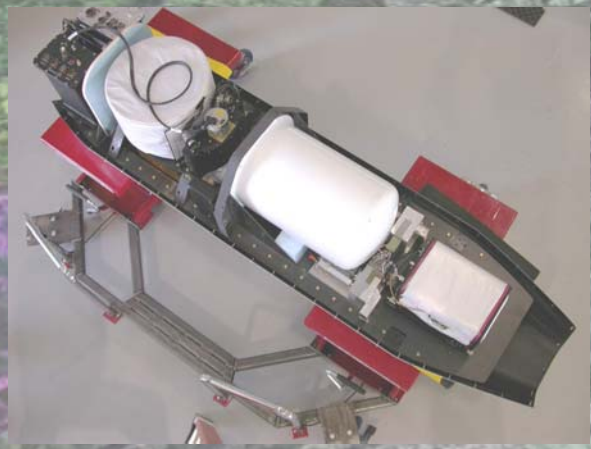
**Total Field of View:** 85.9 degrees
**IFOV:** 2.5mrad
**Altitude:** 25000'
**Spatial Resolution:** 20m (at sea level)

Two environmental enclosures (data disks & GPS; and power supplies & controllers)

Data System Enclosure



Scan Head



# Wildfire - Collaborative Decision Environment


Ikhana UAS

Google Earth

Weather
NWS, NRL, MIT

MODIS
USFS, NASA/UMD

Fire Incidents
NIFC, USFS, USGS

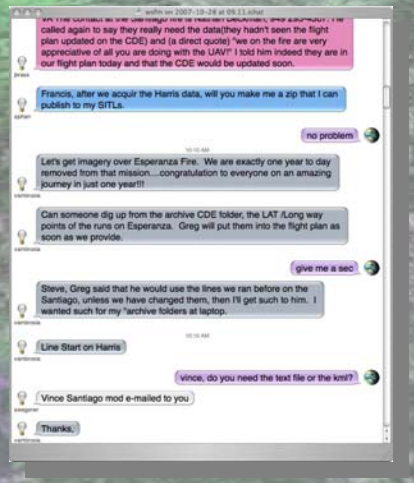
Airspace Restrictions
FAA, NASA

Internet

Satellite track prediction

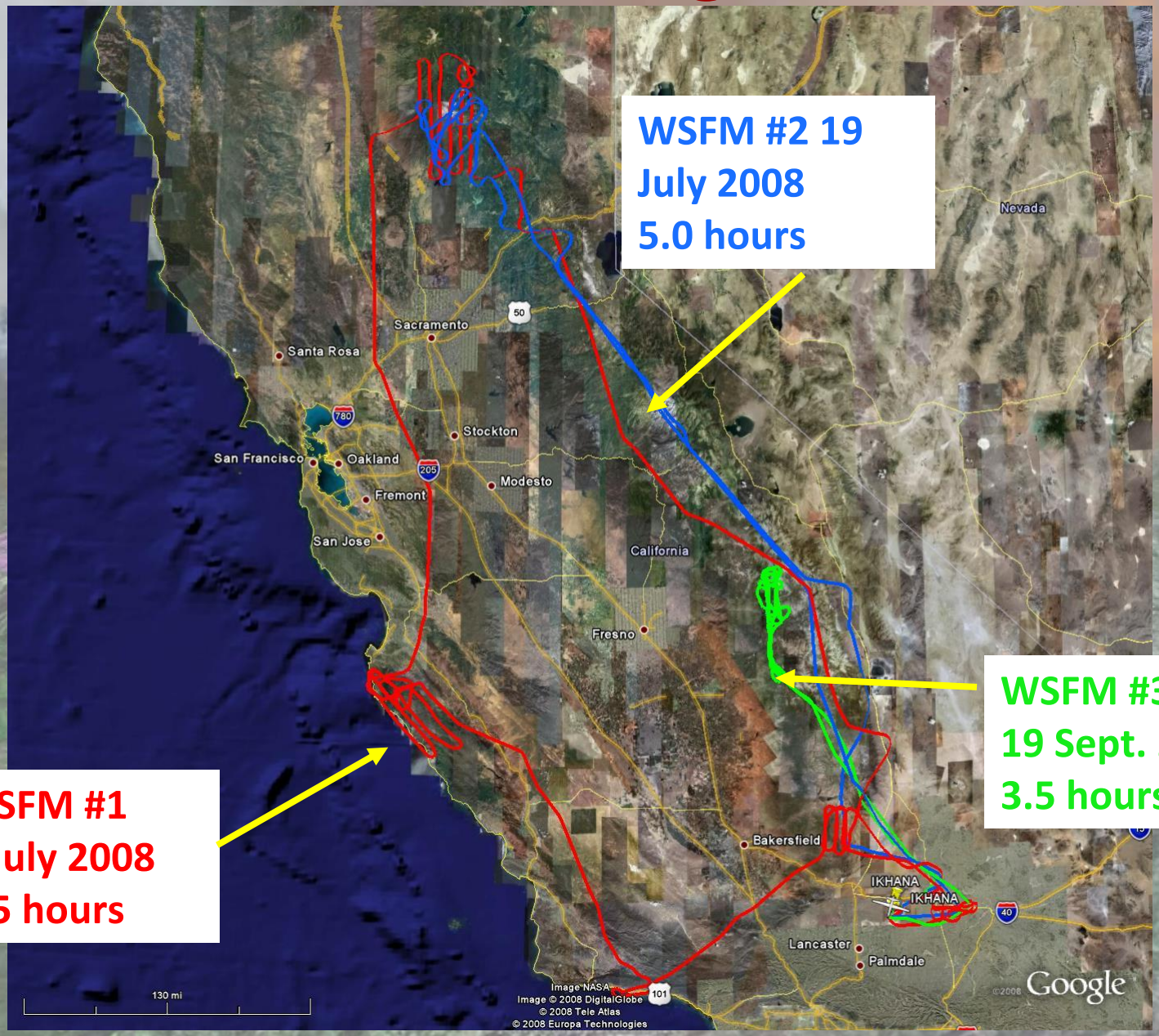

Visualization

Streaming Video

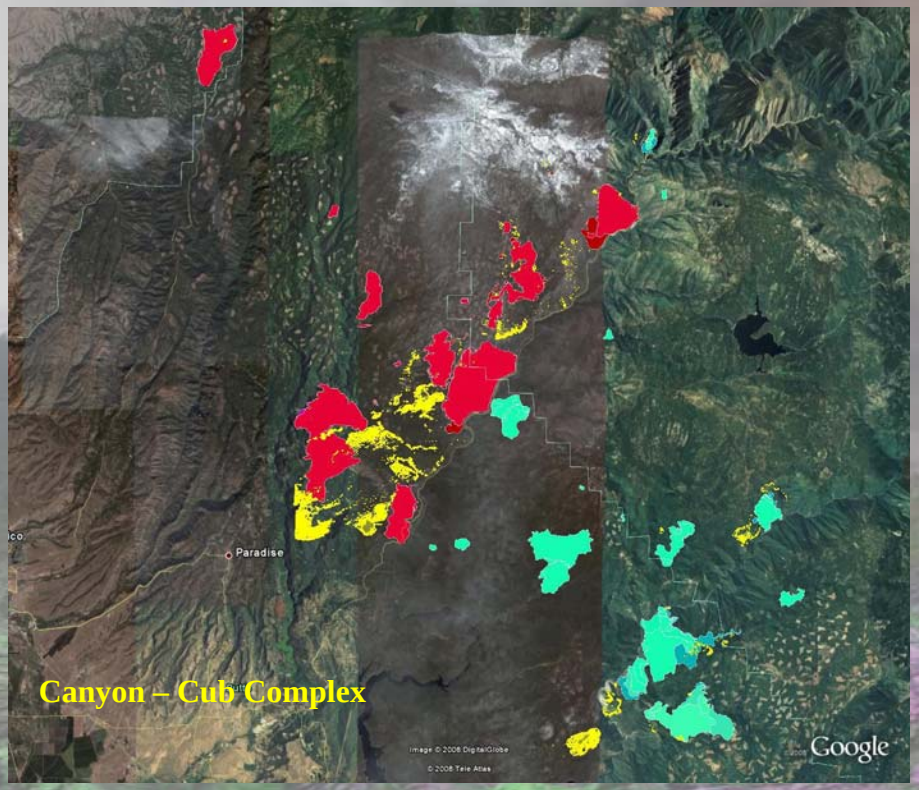



Group IM

# WSFM – 2008 Flight Tracks



# Northern California Firestorm - 2008





**Images From**

**8 & 19 July 2008**

Airborne and Satellite
Active Fire Detection Systems
all use the
4 and 11 μm TIR bands
available on HyspIRI.

# The goal of BAER mapping …

Identify those areas at greatest risk for adverse impacts on water quality and re-generation due to factors such as the formation of hydrophobic soils

which can result in severe erosion.

This must be done quickly and over large areas. Remote sensing is of great value to help rapidly focus on those areas with the most critical need.

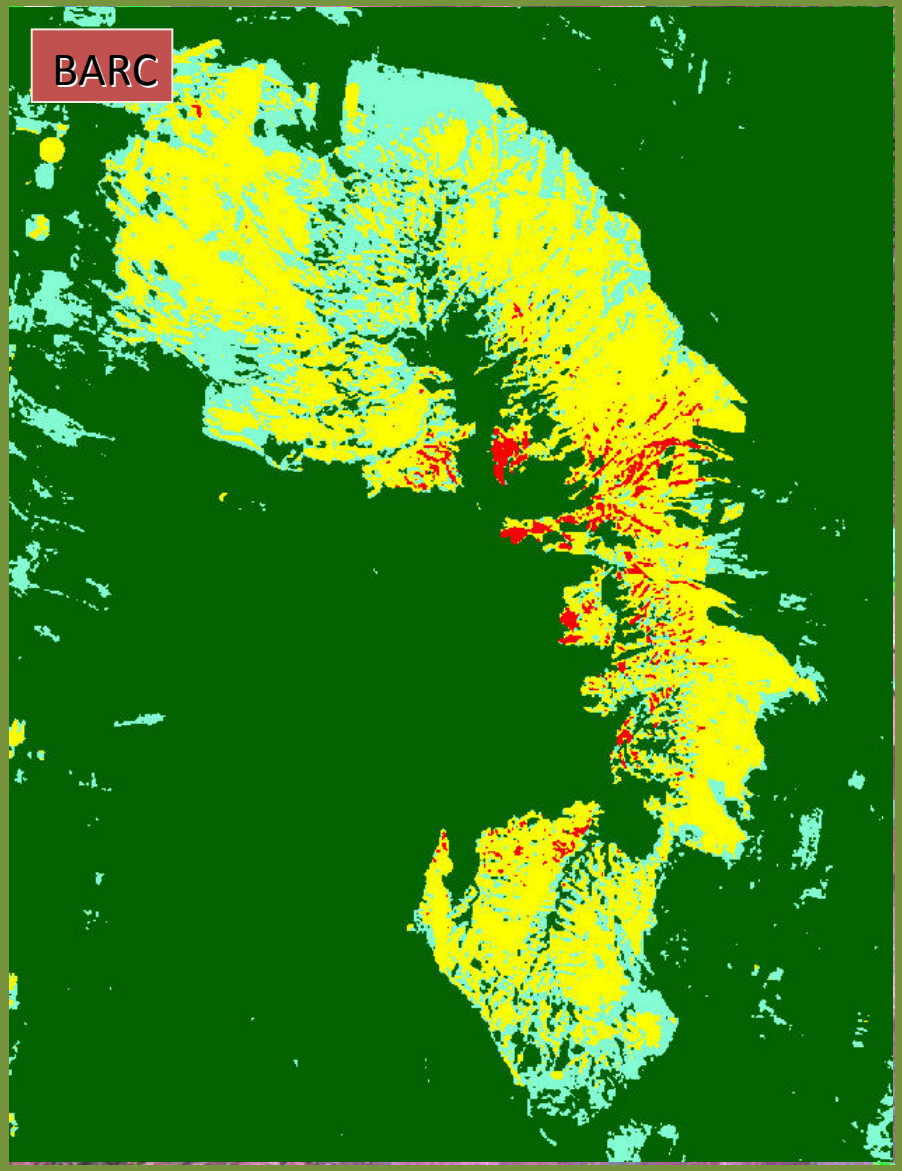
**unburned area**
Unburned landscape near the Eyerly Fire in Oregon, showing the wide variety of potential fuels, from the grasses in the foreground, to the low shrubs at the entrance of the heavily wooded areas beyond. In assessing burn severity, scientists consider the impact of fire on various vegetation types as one of many factors.

**low burn severity**
A low-severity burned landscape from Oregon's Winter Fire in summer 2002. Sage and scattered small trees covered this open area. Although the sage burned, it still has root mounds in place, and the trees are still standing and only slightly scorched.

**moderate burn severity**
A moderate-severity burned landscape at the site of Oregon's Biscuit Fire in the summer of 2002. Foliage on the trees is scorched, but not completely consumed. What remains provides for "needle-cast," in which the dead needles will drop, creating a layer of protective mulch on the forest floor.

**high burn severity**
A landscape near the Eyerly Fire in Oregon showing a high-severity burn. Trees are blackened and all foliage has been burned from the trees. All understory vegetation has been consumed.

# Creation of the BARC




Black Pine 2 Fire
Sawtooth NF
73,000 Acres

Normalized Burn Ratio (NBR)
Differenced Normalized Burn Ratio (dNBR)

NBR = (NIR – Mid IR) / (NIR + Mid IR)

dNBR = Pre NBR – Post NBR

Burned Area Reflecatance Classification (BARC) is a simplified dNBR

Dark Green = Unchanged
Cyan = Low
Yellow = Moderate
Red = High

# Operational Fire Support at RSAC

- Post-fire Assessment – Emergency, Rapid, and Extended Timing
  - BAER Image Support
    - BARC (Burned Area Reflectance Classification) creation
      - Emergency Assessment
  - Rapid Assessment of Vegetation Condition after Wildfire (RAVG)
    - For Forest Silviculturist
      - Rapid Assessment
  - Monitoring Trends in Burn Severity (MTBS)
    - National Fire Plan (NFP) and Healthy Forest Restoration Act (HFRA)
      - Extended Assessment

# Burned Area Emergency Response (BAER)

## Emergency Stabilization and Rehabilitation

- Fast-Track emergency assessment
- Assess effects of the fire on the soil and watershed hydrologic function (erosion and flood potential) for risks to:
  - life
  - property
  - long-term soil productivity
  - water quality
  - resources

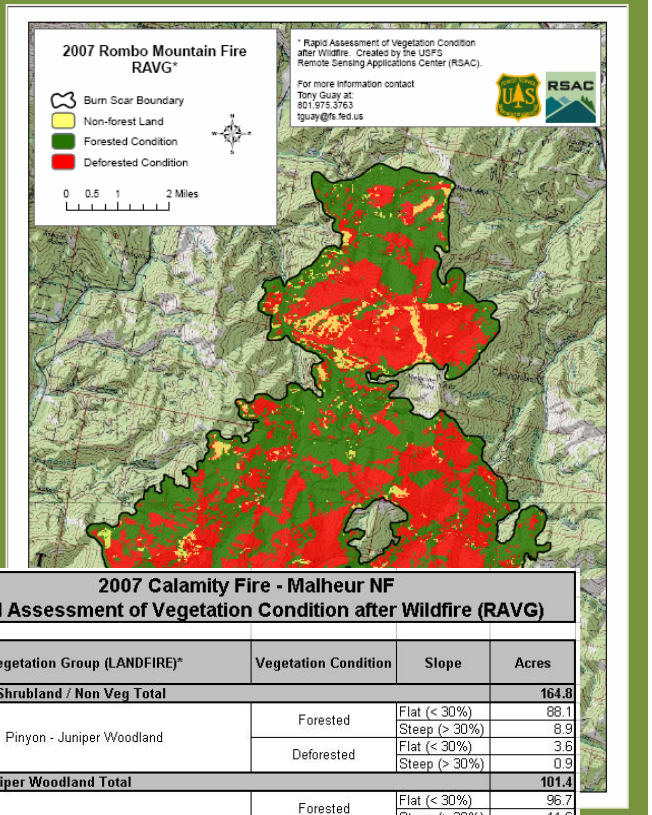
# BAER Fire Support Statistics

| | USGS-EROS | | USFS-RSAC | | Sum | |
|---|---|---|---|---|---|---|
| **Year** | Fires | Acres | Fires | Acres | Fires | Acres |
| **2001** | 5 | N/A | 15 | 310,500 | 20 | 310,500 |
| **2002** | 10 | 500,000 | 73 | 2,710,599 | 83 | 3,210,599 |
| **2003** | 17 | 307,034 | 54 | 1,637,471 | 71 | 1,944,505 |
| **2004** | 24 | 5,000,000 | 25 | 471,102 | 49 | 5,471,102 |
| **2005** | 23 | 800,000 | 46 | 734,559 | 69 | 1,534,559 |
| **2006** | 61 | 2,532,907 | 115 | 2,470,856 | 176 | 5,003,763 |
| **2007** | 48 | 2,422,130 | 106 | 3,508,407 | 154 | 5,930,537 |
| **2008** | 16 | 544,639 | 98 | 1,755,322 | 114 | 2,999,961 |
| **Sum** | **204** | **12,106,710** | **532** | **13,598,816** | **736** | **25,705,526** |


Collaborative effort between USFS-RSAC and USGS-EROS

# RAVG (Rapid Assessment of Vegetation Condition after Wildfire)

- RAVG Objectives
  - Rapid post-fire damage assessment due to wildfire
    - Calculate acres of land suitable for reforestation
    - Spatially represent forested vs. deforested areas following wildfire
  - Delivered 30 calendar days after fire containment
  - *Data helps determine reforestation needs*



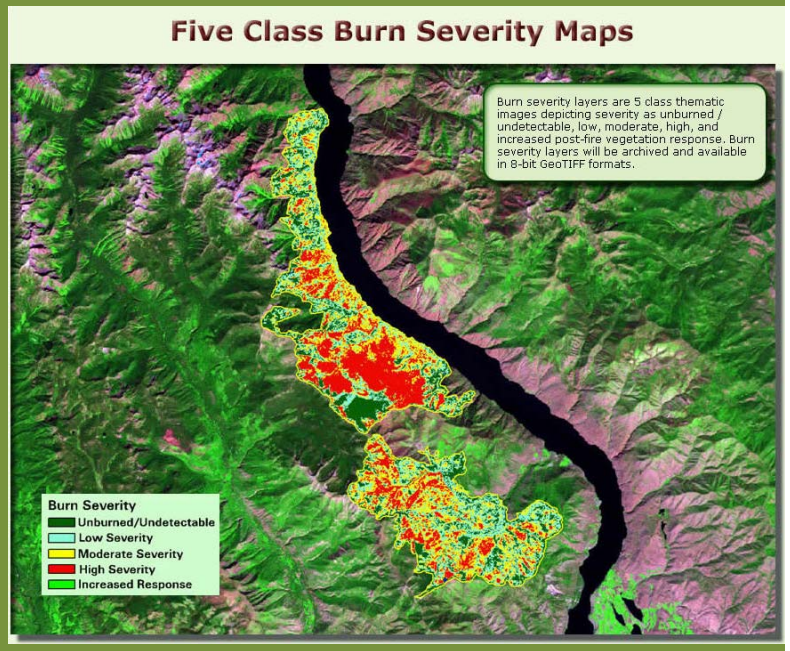

**2007 Calamity Fire - Malheur NF**
**Rapid Assessment of Vegetation Condition after Wildfire (RAVG)**

| Vegetation Group (LANDFIRE)* | Vegetation Condition | Slope | Acres |
|---|---|---|---|
| **Grassland / Shrubland / Non Veg Total** | | | **164.8** |
| Pinyon - Juniper Woodland | Forested | Flat (< 30%) | 88.1 |
| | | Steep (> 30%) | 8.9 |
| | Deforested | Flat (< 30%) | 3.6 |
| | | Steep (> 30%) | 0.9 |
| **Pinyon - Juniper Woodland Total** | | | **101.4** |
| Deciduous Open Tree Canopy | Forested | Flat (< 30%) | 96.7 |
| | | Steep (> 30%) | 11.6 |
| | Deforested | Flat (< 30%) | 12.2 |
| | | Steep (> 30%) | 1.6 |
| **Deciduous Open Tree Canopy Total** | | | **122.1** |
| Evergreen Closed Tree Canopy | Forested | Flat (< 30%) | 586.2 |
| | | Steep (> 30%) | 171.2 |
| | Deforested | Flat (< 30%) | 166.4 |
| | | Steep (> 30%) | 50.0 |
| **Evergreen Closed Tree Canopy Total** | | | **973.9** |
| Evergreen Open Tree Caopy | Forested | Flat (< 30%) | 697.0 |
| | | Steep (> 30%) | 132.8 |
| | Deforested | Flat (< 30%) | 95.2 |
| | | Steep (> 30%) | 13.3 |
| **Evergreen Open Tree Caopy Total** | | | **938.3** |
| Mixed Evergreen - Deciduous Open Tree Canopy | Forested | Flat (< 30%) | 83.4 |
| | | Steep (> 30%) | 10.5 |
| | Deforested | Flat (< 30%) | 9.6 |
| | | Steep (> 30%) | 0.7 |
| **Mixed Evergreen - Deciduous Open Tree Canopy Total** | | | **104.1** |
| **Grand Total** | | | **2,404.6** |

* See RAVG - LANDFIRE Crosswalk worksheet below for Vegetation Group definitions

# MTBS (Monitoring Trends in Burn Severity)

- MTBS Objectives
  - Map *all* fires > 1,000 acres (in West) and > 500 acres (in East) between 1984 – present
    - Aligned with Landsat data record
  - Mapped using extended assessment protocol
    - Postfire imagery acquired during next growing season
  - Severity classifications focused on vegetation effects
  - *Used to answer National Fire Plan (NFP) and Healthy Forest Restoration Act (HFRA) questions*



Airborne and Satellite
Post-Fire Characterization Systems
all use the
VIS / NIR / SWIR bands
available on HyspIRI.


Questions ???