Applying MODIS Direct Readout Data for Wildland Fire Management

The USDA Forest Service MODIS Active Fire Mapping Program

Brad Quayle

USDA Forest Service
Remote Sensing Applications Center (RSAC)

17th Seaspace Conference

Mexico City, Mexico
October 8 & 9, 2007

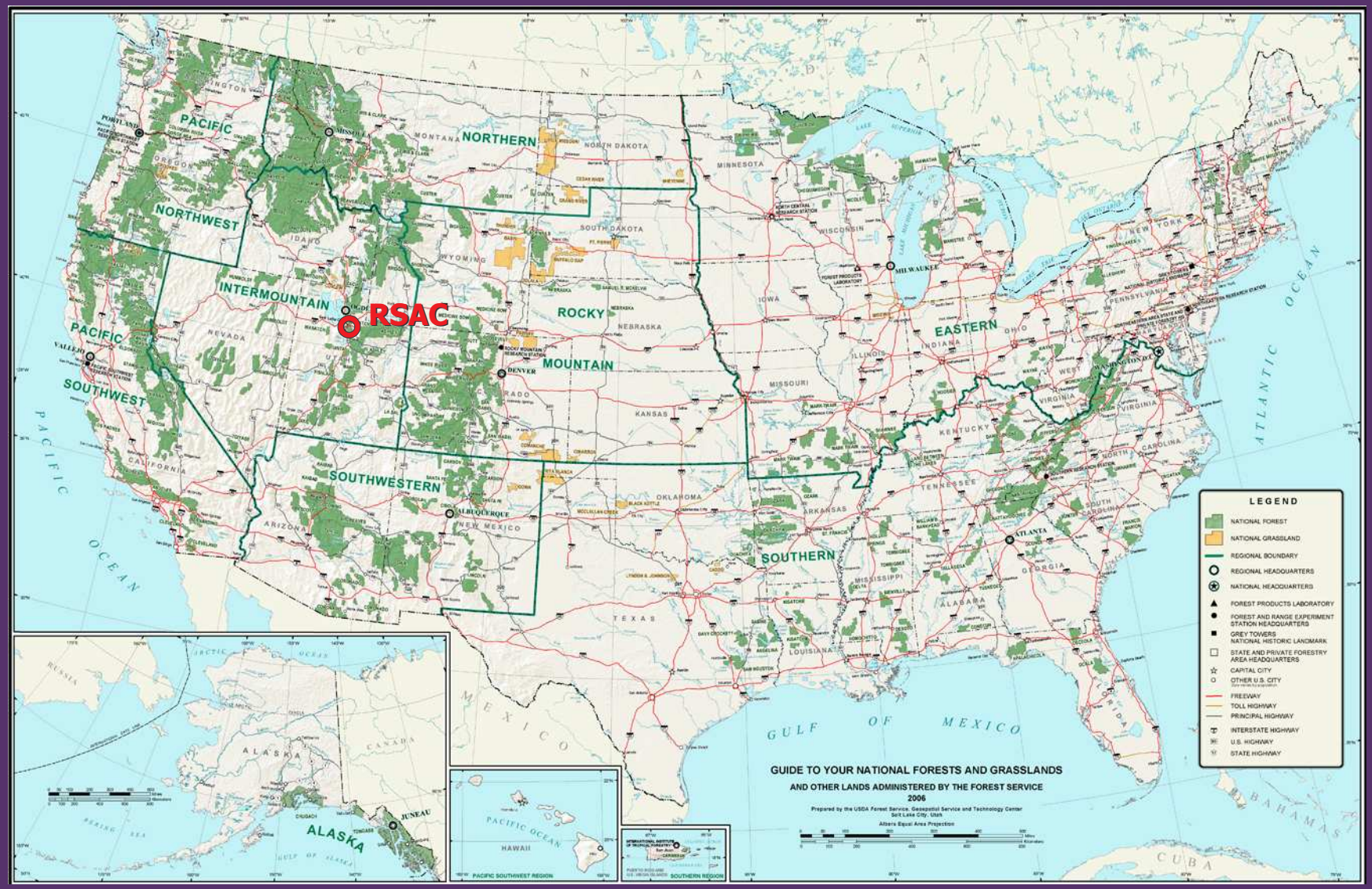
Outline

- USDA Forest Service/Remote Sensing Applications Center
- RSAC Direct Readout Ground Station Facility
- Wildland Fire/Wildland Fire Management
- USDA Forest Service MODIS Active Fire Mapping Program
  - Process/Methods
  - Products
  - Applications

USDA Forest Service Remote Sensing Applications Center (RSAC)

- National Technical Center
- Detached Washington Office unit of Engineering staff
- Located in Salt Lake City, Utah
- *Mission:* Provide national assistance to agency field units in applying the most advanced geospatial technology toward improved monitoring and mapping of natural resources

USDA Forest Service



RSAC X-Band Ground Station

History:

- Operational MODIS direct broadcast data collection since 2002

Antenna:

- 2.4 meter, 3 axis SeaTel antenna; radome enclosure

Coverage:

- Majority of CONUS; western Canada & northern Mexico

Objectives:

- Wildland fire detection/monitoring
- Resource management applications (i.e. monitoring, change detection, cover type mapping, etc.)

Seaspace 2.4m Antenna Installation

Panoramic View From RSAC X-Band Antenna

September 2007

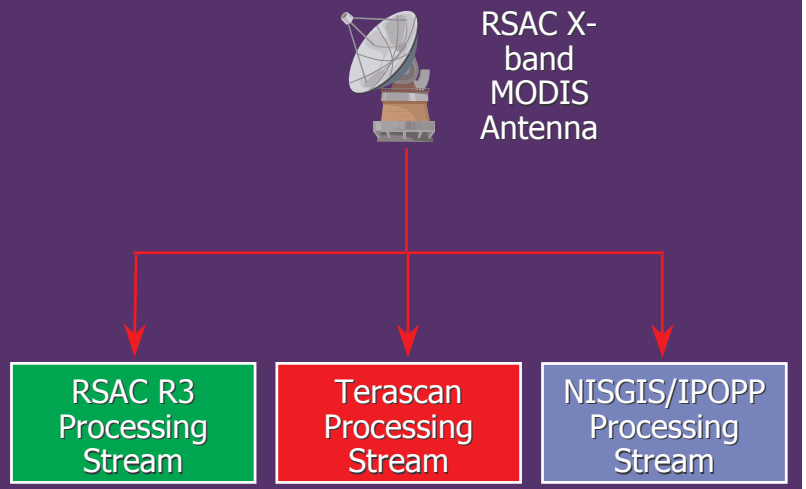
RSAC X-Band Ground Station - Data Processing

Data Processing Systems:

- RSAC Rapid Response (R3) System
  - Selected MODIS land products
  - Coordination w/NASA MODIS Rapid Response, NASA Direct Readout Lab and MODIS Land Science Team
- Terascan System
  - Terascan MODIS products
- NISGS/IPOPP Alpha Testing
  - MODIS land, atmosphere and ocean products
  - Coordination w/NASA Direct Readout Lab

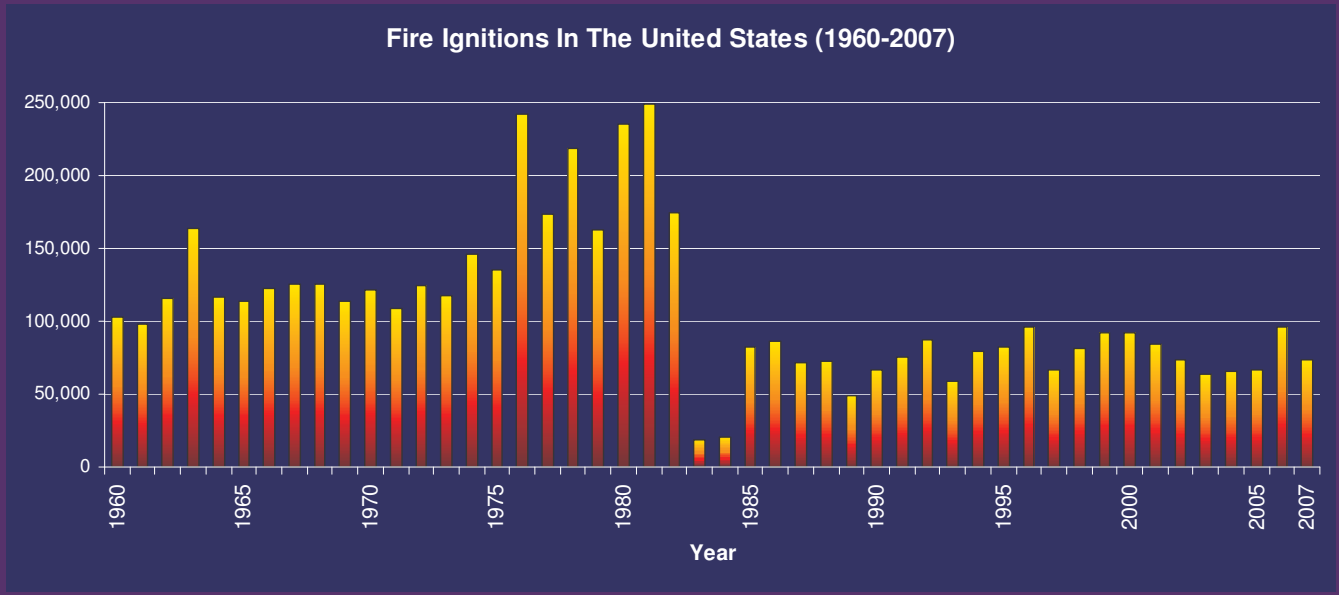
Hardware:

- 7 Linux servers
- 3 Windows servers/workstations



Wildland Fire

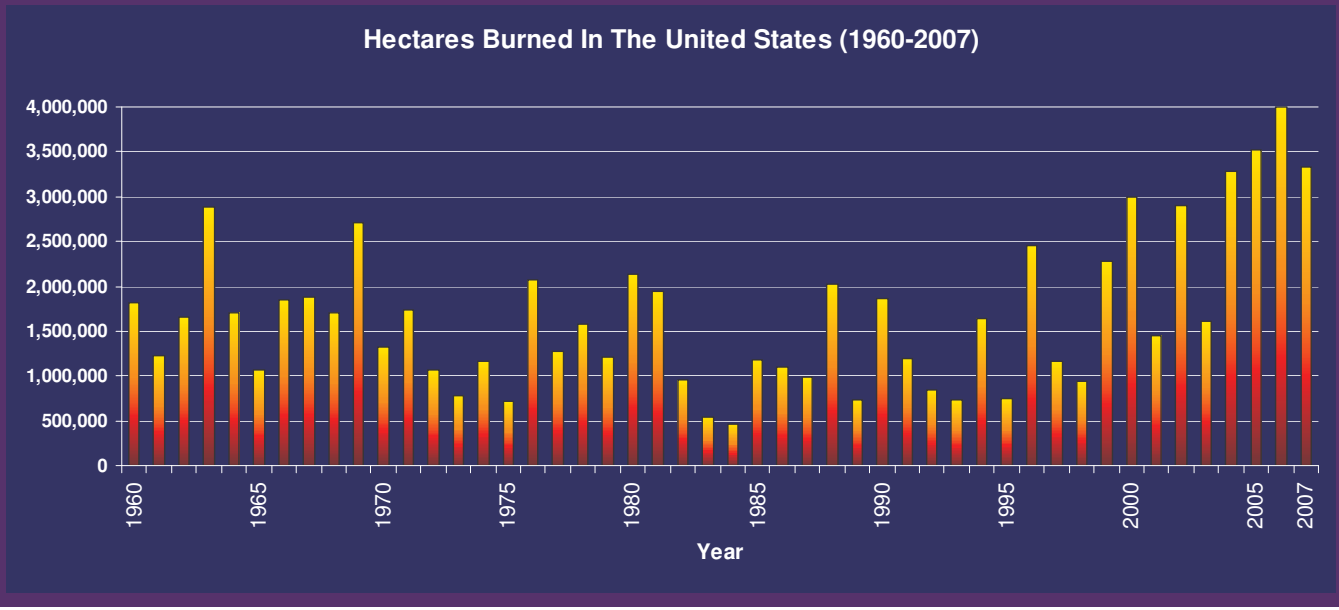
Wildland Fire Activity in the United States



Annual Average
108,525
ignitions

5 Yr Average
64,812
ignitions

10 Yr Average
67,557
ignitions



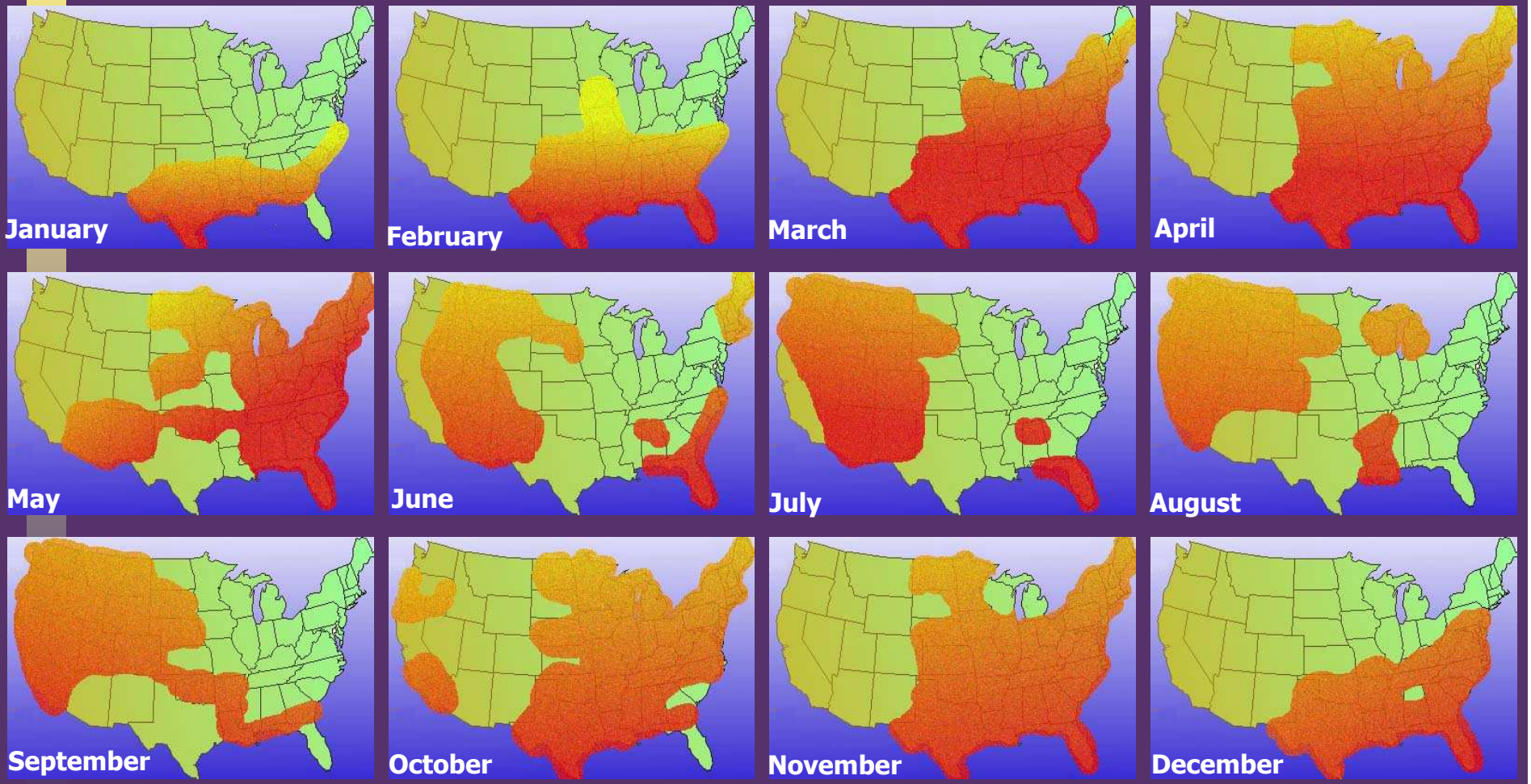
Annual Average
1.7 million
hectares

5 Yr Average
2.95 million
hectares

10 Yr Average
2.32 million
hectares

Wildland Fire Activity in the United States

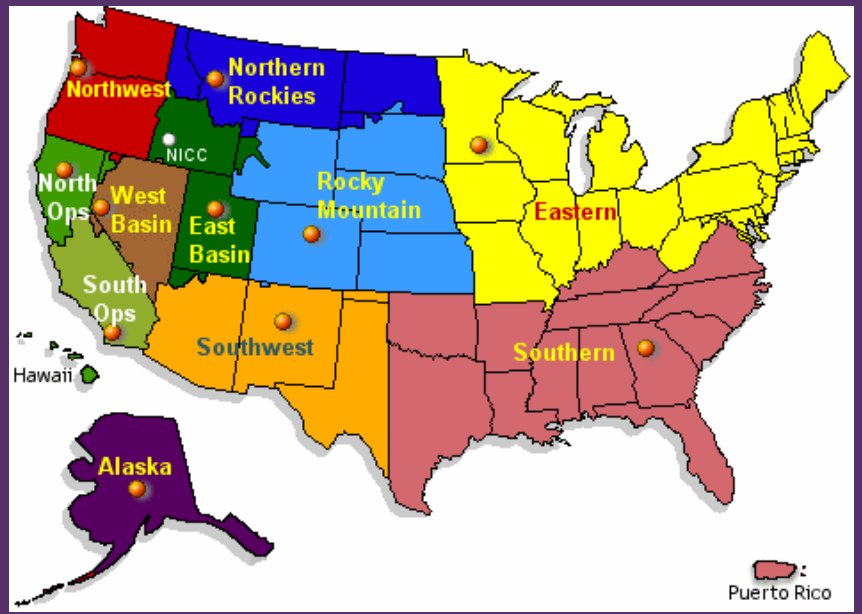
CONUS Normal Peak Wildfire Seasons



Source: NOAA, USDA Forest Service

Wildland Fire Management

- U.S. divided into 11 interagency Geographic Areas
  - Federal, state and local fire coordination
- Geographic Area Coordination Centers (GACCs)
  - Manage wildland fires
  - Mobilize firefighting resources
  - Provide predictive services and intelligence products
- Remote sensing technologies are key for fire management



RSAC Operational Wildland Fire Support

A focal point of remote sensing support for wildland fire management…

Remote Sensing for the Fire Community

USDA FS-RSAC Programs Supporting the Information Needs of Resource Planners, Incident Managers, and the Public

MODIS — MODIS Active Fire Mapping Program

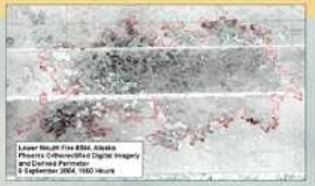
This program provides operational fire detection and monitoring of current wildland land fire activity. Fire managers use MODIS products to support strategic wildland fire management at regional and national scales.

- Acquire and process near real-time Moderate Resolution Imaging Spectroradiometer (MODIS) imagery from Terra and Aqua satellites
- Generate daily MODIS imagery, maps, fire detection geospatial data and analytical products
- Comprehensive coverage of the continental United States, Alaska and Canada

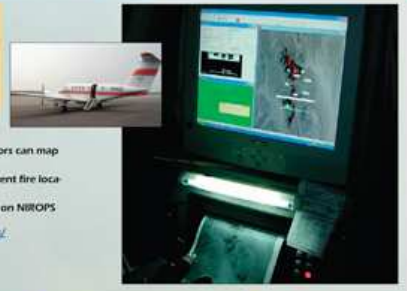
http://activefiremaps.fs.fed.us/

NIROPS — National Infrared Operations Group

NIROPS has provided wildland fire fighters accurate, timely and cost effective infrared intelligence for over 40 years.

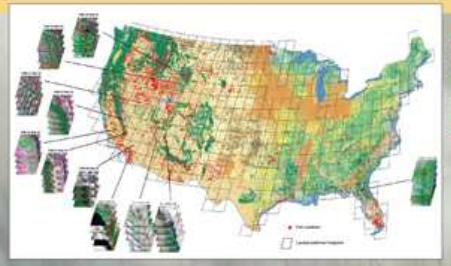


- Two aircraft and sensors can map over 30 fires a night
- Imagery provides current fire location and activity
- For more information on NIROPS visit their webpage at http://nirops.fs.fed.us/

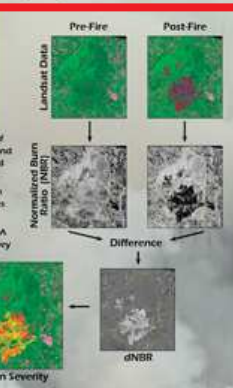


MTBS — Monitoring Trends in Burn Severity Project

This project monitors the recent trends in wildland fire burn severity. Results will be used by the Wildland Fire Leadership Council (WFLC) to assess the effectiveness and effects of the National Fire Plan (NFP) and Healthy Forests Restoration Act (HFRA).



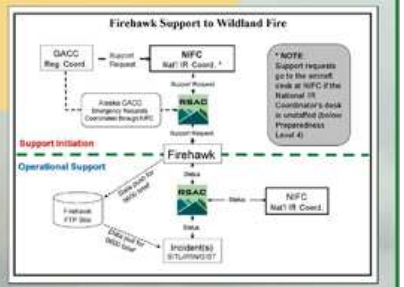
- Compile a comprehensive database of satellite imagery, derived burn severity and fire perimeters for fire areas in the United States since 1984
- Map all fires greater than 500 acres in the eastern United States and 1,000 acres throughout the rest of the country
- Cooperative effort between the USDA Forest Service and the US Geological Survey



FIREHAWK — Firehawk Support Liaison

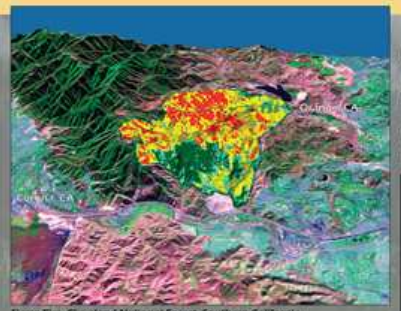
Firehawk has provided emergency wildland fire mapping support for over 10 years. The asset is utilized when fire activity in the continental United States and Alaska exceed the NIFC/NIROPS aircraft capabilities. RSAC acts as liaison between the National Infrared Coordinator, the incidents being supported and the Firehawk staff.

- Typically utilized when the National Preparedness Level is at 4 or 5
- Timely, accurate vector data showing fire location and activity
- Daily coordination with the incident staff and National Infrared Operations

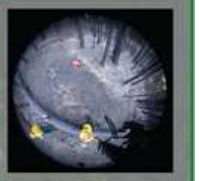


BAER — Burned Area Emergency Response

This program provides operational image support to USDA Forest Service BAER teams. BAER teams use rapid response imagery and derived data to assess post-fire conditions.



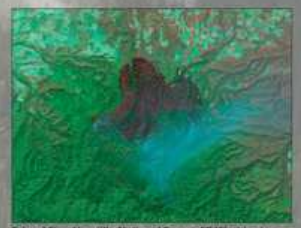
- Acquire and process post-fire, high-resolution satellite imagery for wildland fire areas
- Generate burned area reflectance classification (BARC) maps and other geospatial products of burned areas
- Rapid delivery of products to all USDA Forest Service BAER teams on wildland fire incidents throughout the United States



UAS — Unmanned Aerial Systems

The USDA Forest Service is working with NASA to evaluate UAS as cost effective platforms for fire imaging and communication support.

- Not to replace manned aircraft, but to augment current capabilities in underserved niches
- Where manned aircraft are not practical because of safety concerns and/or long duration
- To provide the right information to the right people at the right time



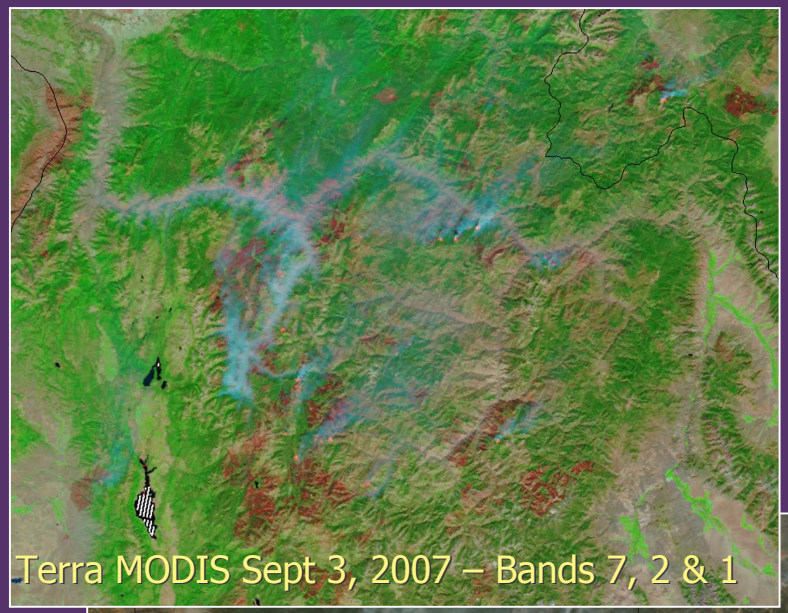
USFS MODIS Active Fire Mapping Program

Objectives:

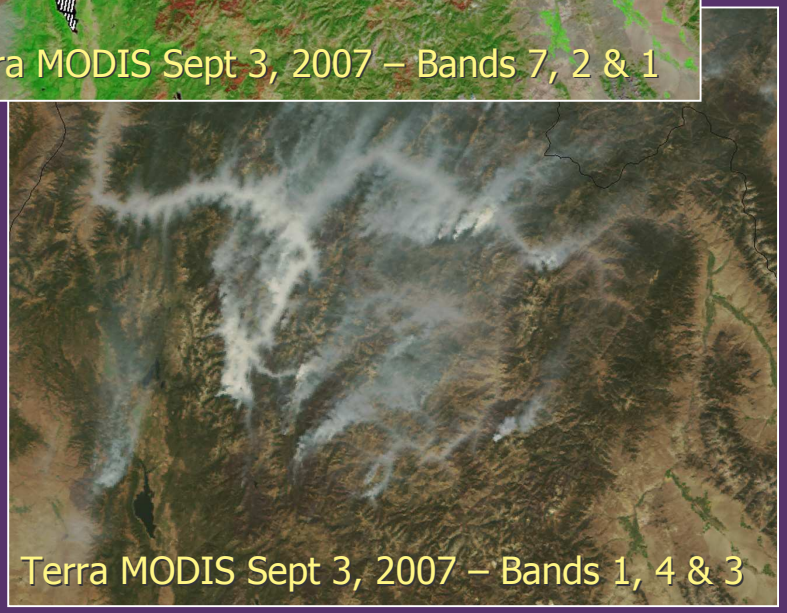
- Near real-time (NRT) acquisition/processing of MODIS data
- Detect and monitor wildland fire activity
  - Comprehensive; All administrative land ownerships
- Integrate ancillary data w/MODIS data products to generate timely "value added" geospatial fire mapping and visualization products
  - Current, synoptic view of the wildfire situation in a geospatial context
  - Accurate and current information on fire locations, fire intensity, burned area extent and smoke conditions
  - Easy to access (via Internet)
- Decision support tool for wildfire strategic planning and response
  - Prioritize allocation of fire suppression assets

USFS MODIS Active Fire Mapping Program

Key MODIS Data Products: Surface Reflectance



Terra MODIS Sept 3, 2007 – Bands 7, 2 & 1

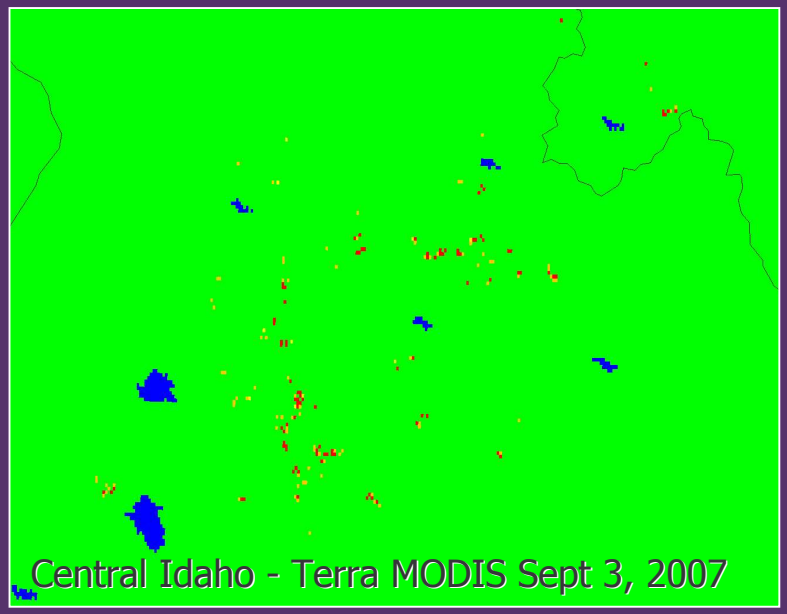


Terra MODIS Sept 3, 2007 – Bands 1, 4 & 3

- NASA Rapid Response System version
- Basic atmospheric correction
- "Land bands"; bands 1 – 7
- 250m/500m spatial resolution
- See http://rapidfire.sci.gsfc.nasa.gov

USFS MODIS Active Fire Mapping Program

Key MODIS Data Products: Fire & Thermal Anomalies



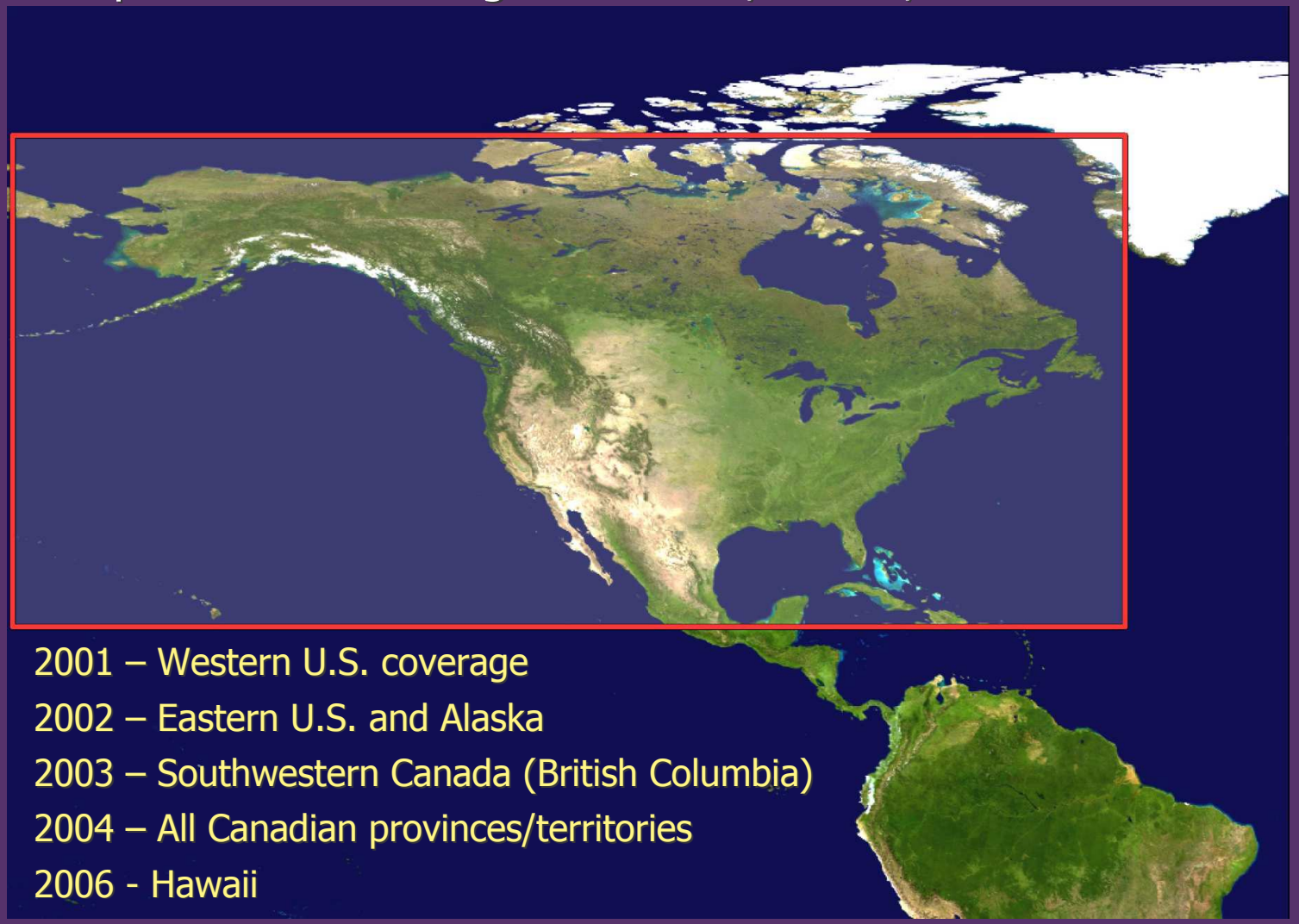
- No Data
- Water
- Cloud
- Non-Fire
- Fire (low confidence)
- Fire (nominal confidence)
- Fire (high confidence)

- MOD14 - MODIS Fire and Thermal Anomalies Product
- 1km spatial resolution
- Based on heritage fire detection algorithms
- Leverages response in 4 and 11 micron bands to fire
- Absolute thresholds and contextual analysis
- See http://modis-fire.umd.edu/ and Giglio et al, 2003 *Remote Sensing of Environment*

USFS MODIS Active Fire Mapping Program

Geographic Extent:

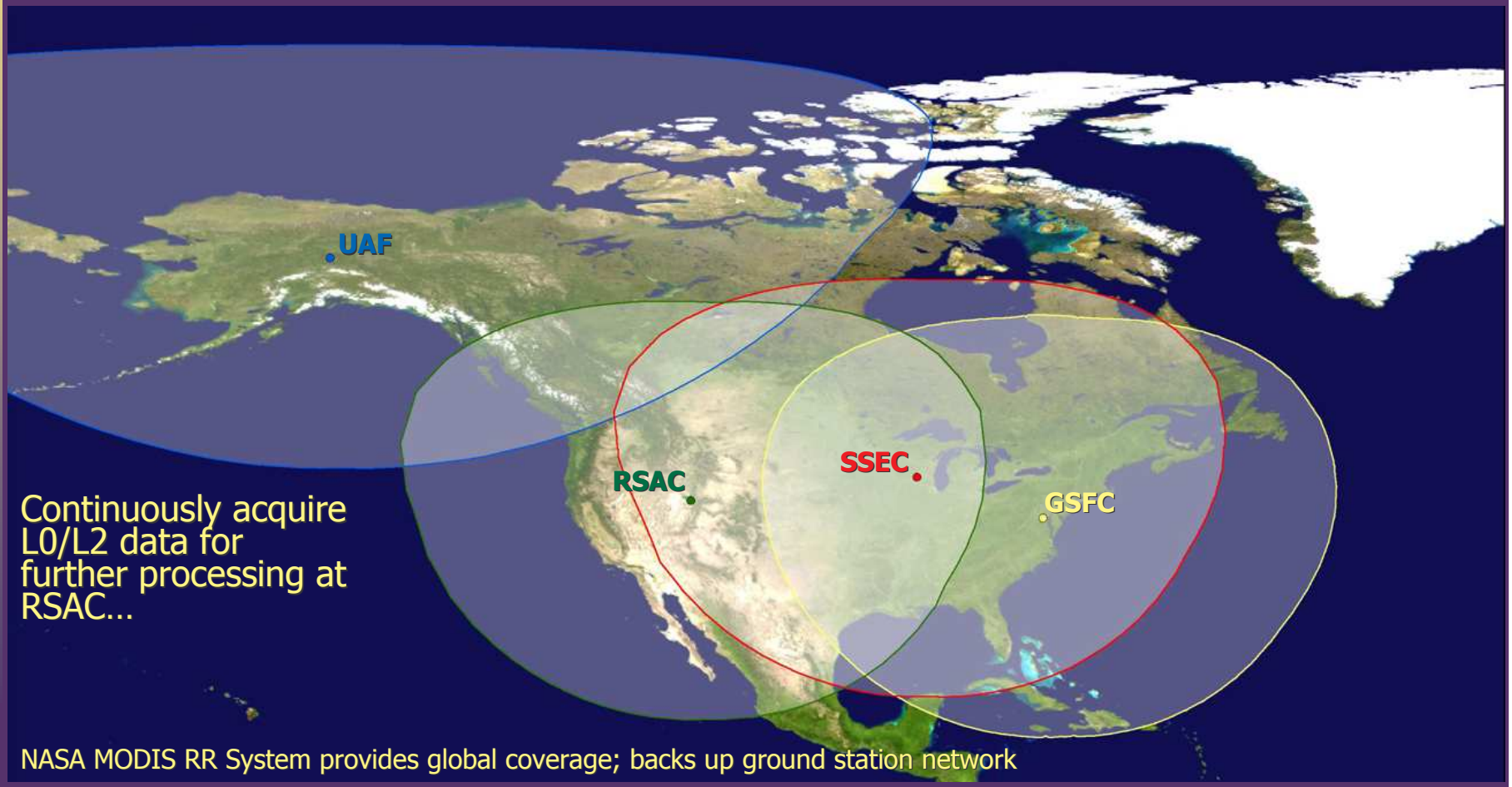
- Comprehensive coverage of CONUS, Alaska, Hawaii & Canada



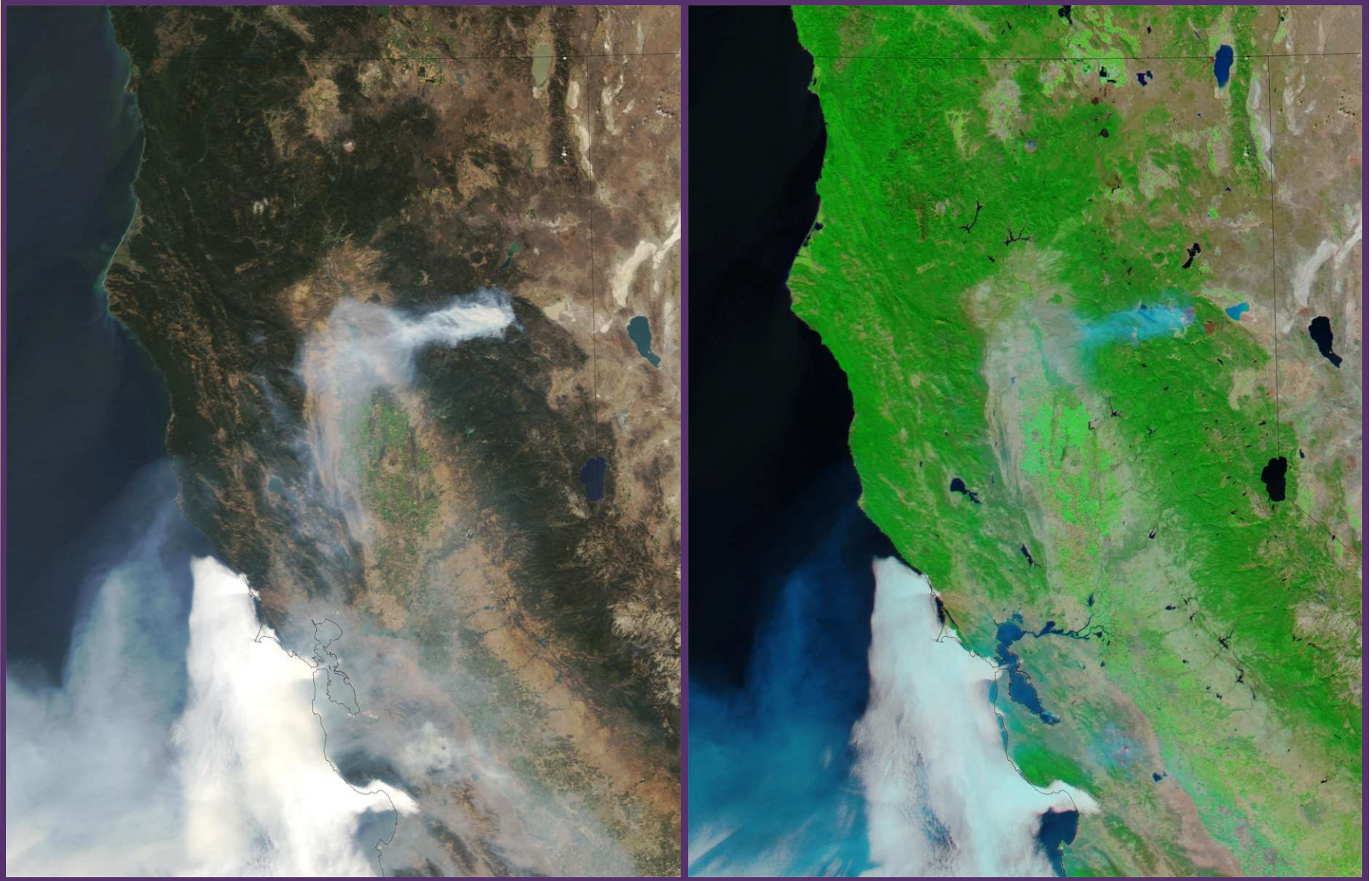
USFS MODIS Active Fire Mapping Program

Primary Data Sources:

- Ground station network – RSAC, SSEC, UAF, NASA/GSFC DRL
- NASA MODIS Rapid Response (RR) System

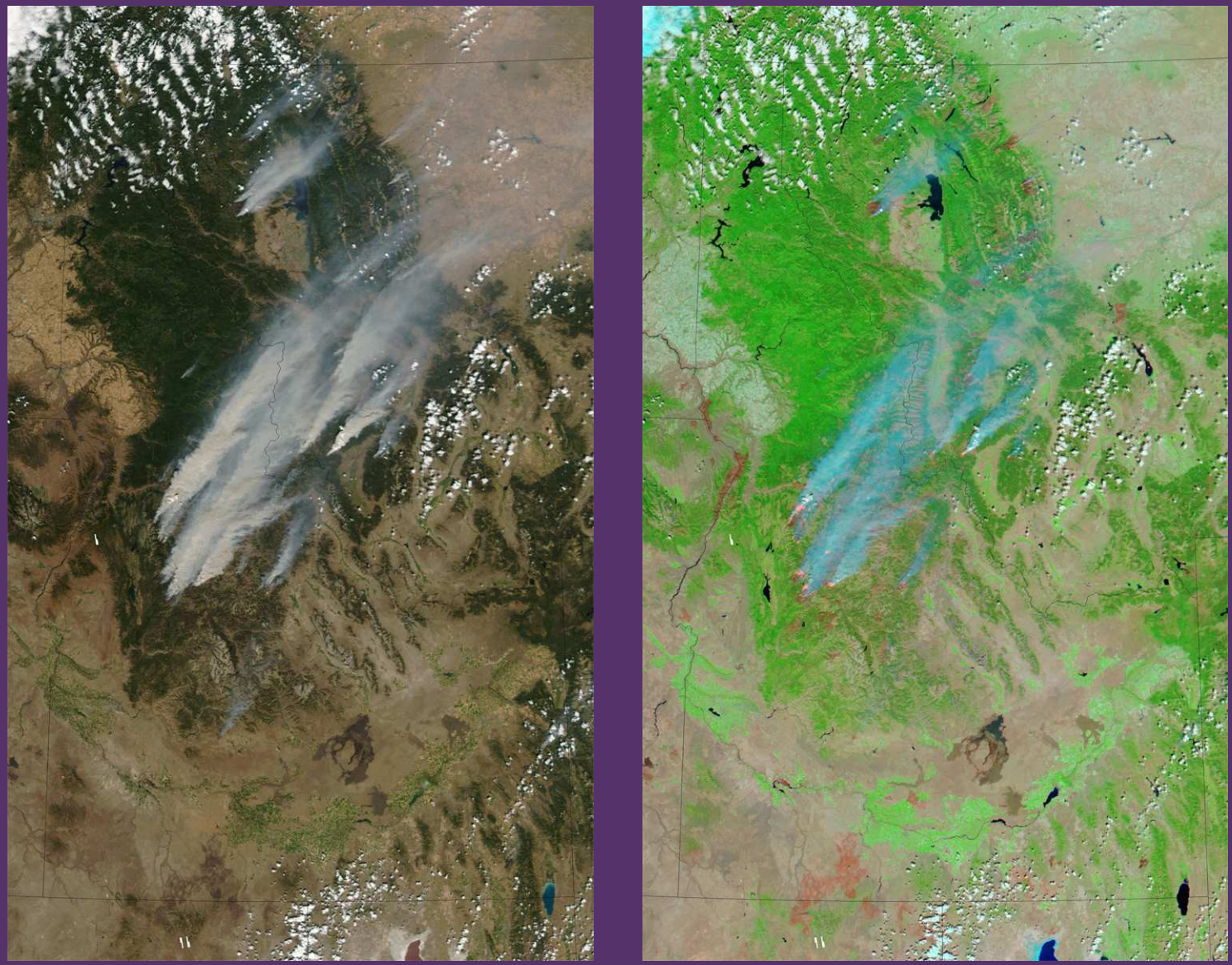


Fire Activity Observed by MODIS



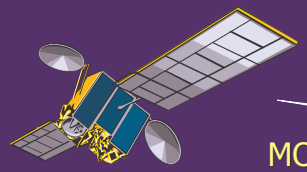
Aqua MODIS acquisition of Northern California – Sep 6, 2007

Fire Activity Observed by MODIS



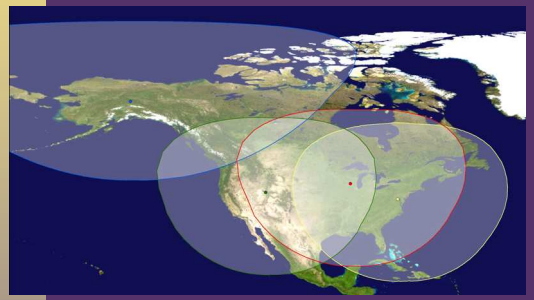
Aqua MODIS acquisition of Idaho – August 12, 2007

Overview: MODIS Data Acquisition and Processing



Terra / Aqua

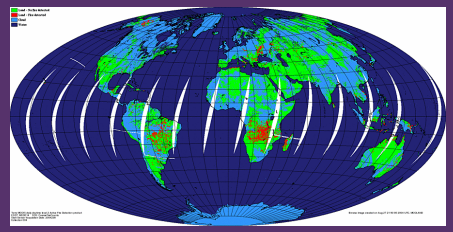
MODIS
Raw Data



North America MODIS
Direct Readout Coverage

MODIS Ground
Station Network
(RSAC, SSEC,
GSFC-DRL & UAF)

White Sands, NM



GSFC MODIS RR World-wide
Coverage

MODIS
L0 Data

NOAA MODIS
Real Time
Processing System

MODIS L0/L2 Data
(< 1/2 hour)

MODIS L0
(~ 3 hours)

Ground Station Network
Rapid Response Systems

Image & Active Fire
Detection Processing

Fire Detections &
Imagery
(CONUS, Alaska,
Canada)

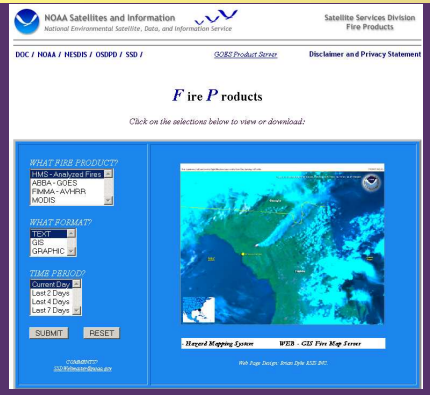
USFS-RSAC
MODIS Active Fire
Mapping System

Fire Detections &
Selected Imagery
(North America)

NASA/GSFC
Rapid Response System

Image & Active Fire
Detection Processing

Overview: MODIS Fire Mapping/Data Integration



NOAA-NESDIS

AVHRR & GOES Fire Detections

NIFC-NICC

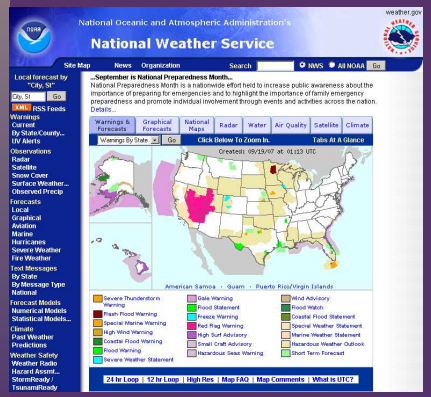
Incident specific information

WFAS

Wx & fuels forecasts and observations

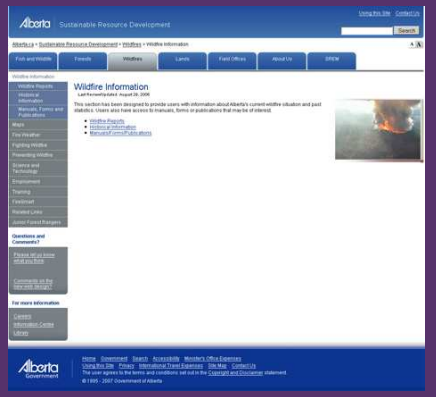
USFS-RSAC
MODIS Active Fire Mapping System

Fire Maps
Imagery Subsets
GIS Data
Custom Products & Analysis



NWS

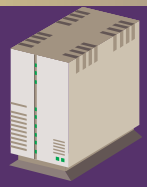
RAWS observations; Fire Wx watches and warnings



Canada

Incident specific information from provinces & territories

Overview: MODIS Fire Mapping Product Distribution



USFS-RSAC
MODIS Active Fire
Mapping System

Fire Maps
Imagery Subsets
GIS Data
Custom Products
& Analysis

MODIS Active Fire
Maps Web Server
http://activefiremaps.fs.fed.us

GEOMAC WILDLAND FIRE SUPPORT

geodata.gov
U.S. Maps & Data

geography network

Fire Information Engine
California Active Fire Mapper

Other Fire Geospatial
Applications/Data Services

MODIS Active Fire Mapping Program Products

Links to Products

Project Cooperators

NIFC Large Incident Map

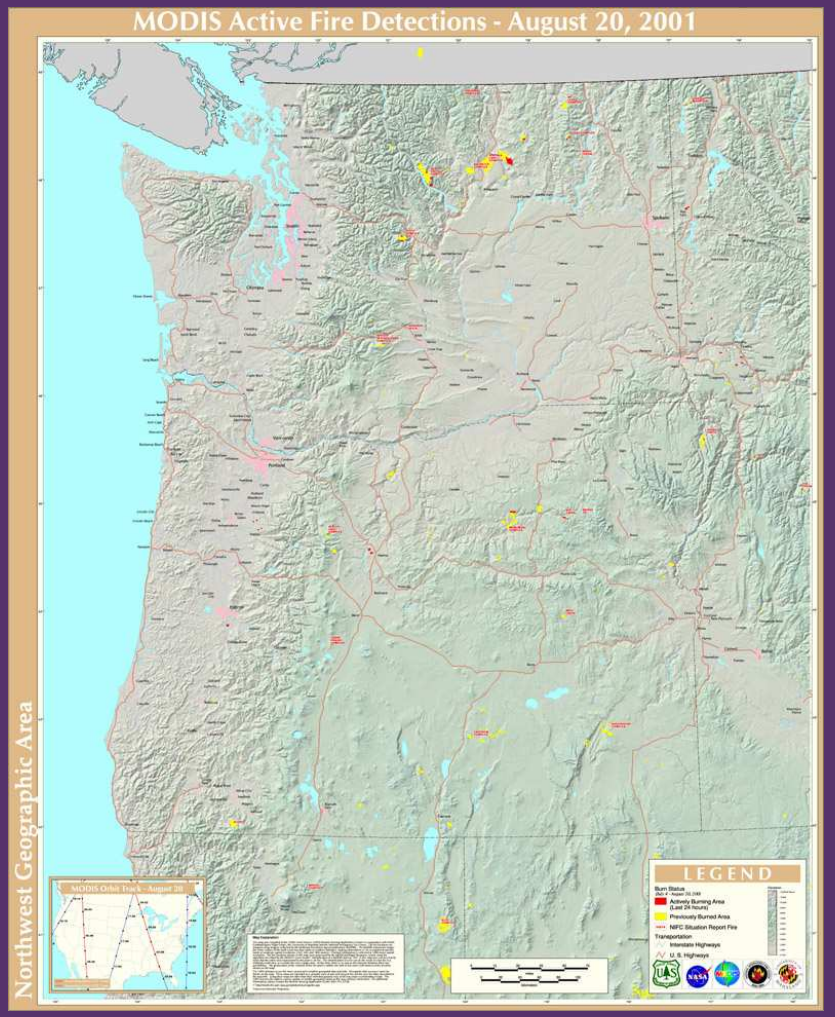
Current News Items of Interest

http://activefiremaps.fs.fed.us

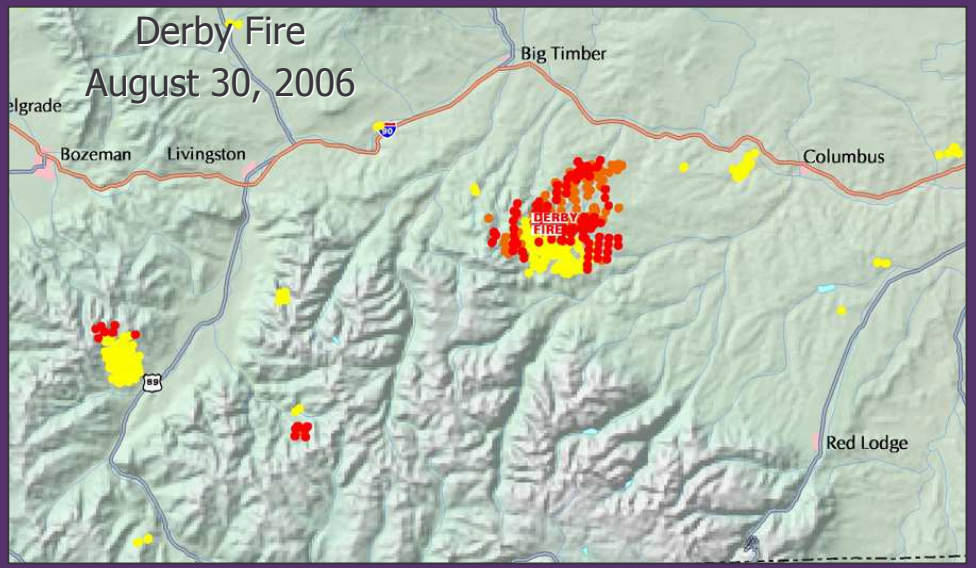
Regional MODIS Active Fire Maps

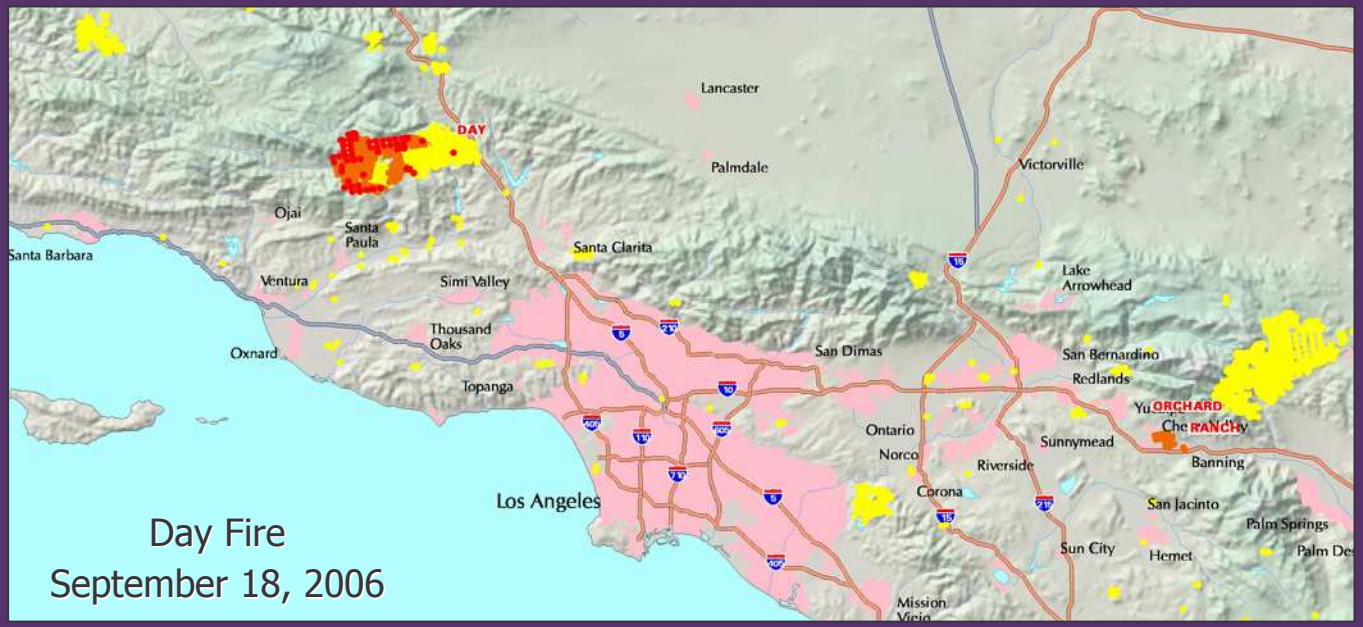
- Regional maps for U.S. & Canada
- Updated several times daily
- Display current and cumulative fire activity
- Provided in JPG and PDF format
- ~30,000 maps produced annually
- Map archive available

Northwest Geographic Area



MODIS Active Fire Map Examples





Interactive MODIS Active Fire Maps

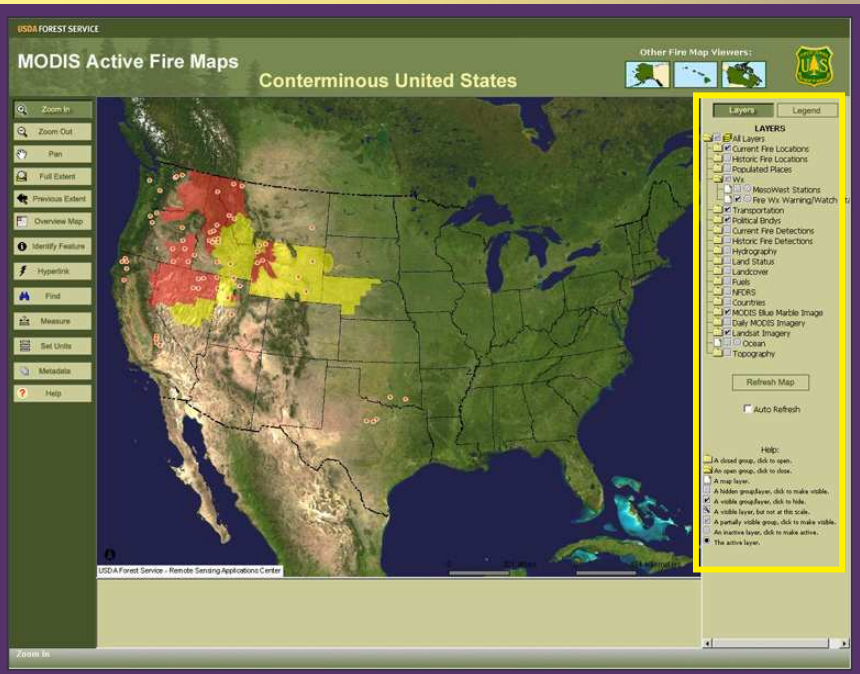
CONUS

Alaska

Hawaii

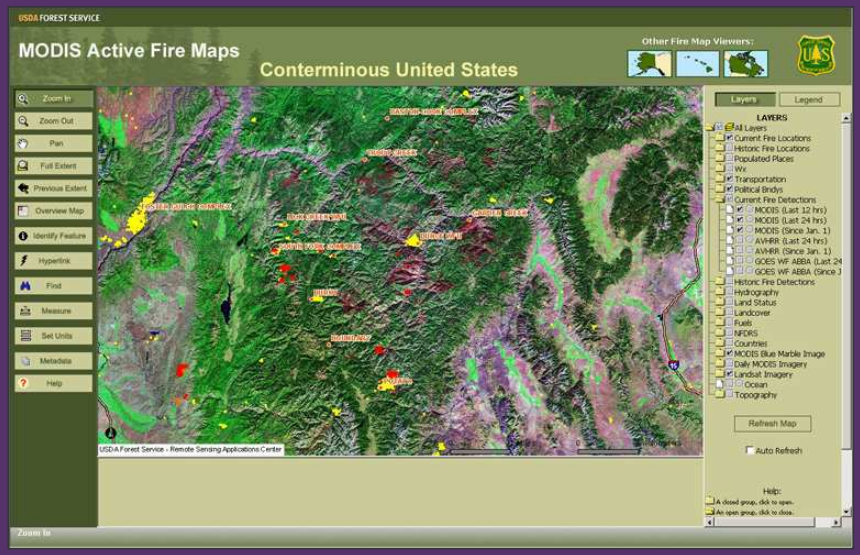
Canada

Interactive MODIS Active Fire Maps Examples

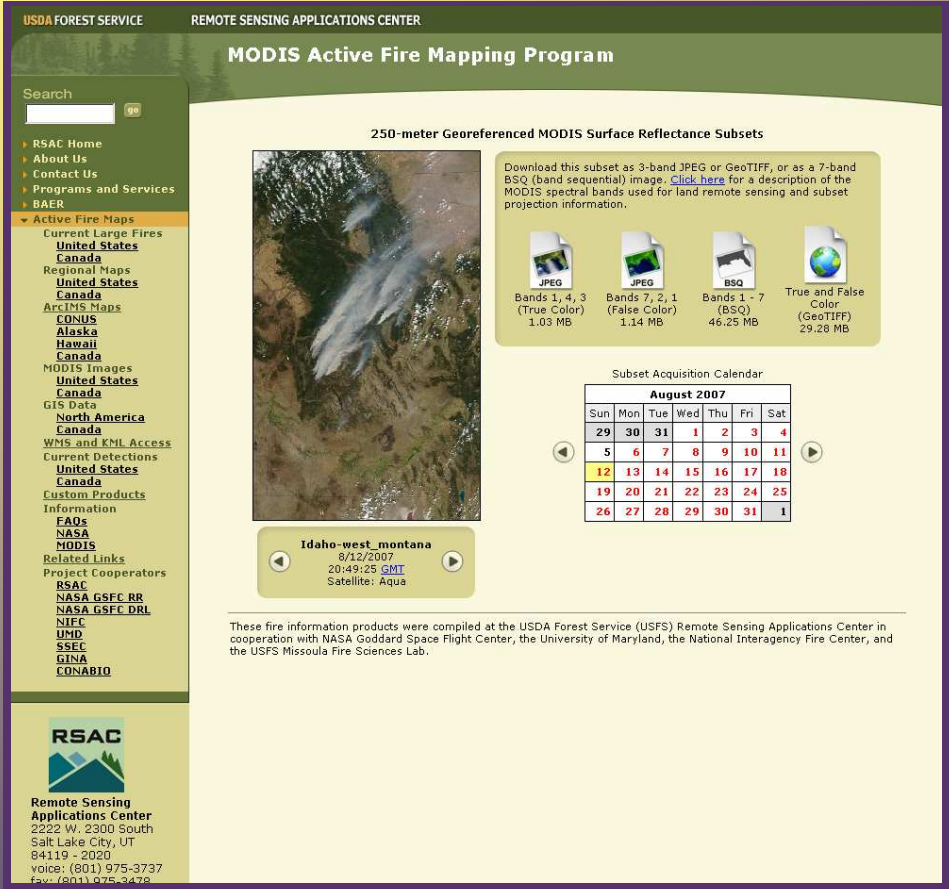


Available Layers

- MODIS, AVHRR & GOES Fire Detects (updated hourly)
- NWS Wx Observations (updated continuously)
- NWS Fire Watch/Warnings (updated hourly)
- National Fire Danger Rating System (updated daily)
- Daily Terra/Aqua MODIS Imagery (updated daily)
- LANDSAT imagery
- DRG Topographic Maps
- Fire Regime/Condition Class
- Baseline Cartographic data

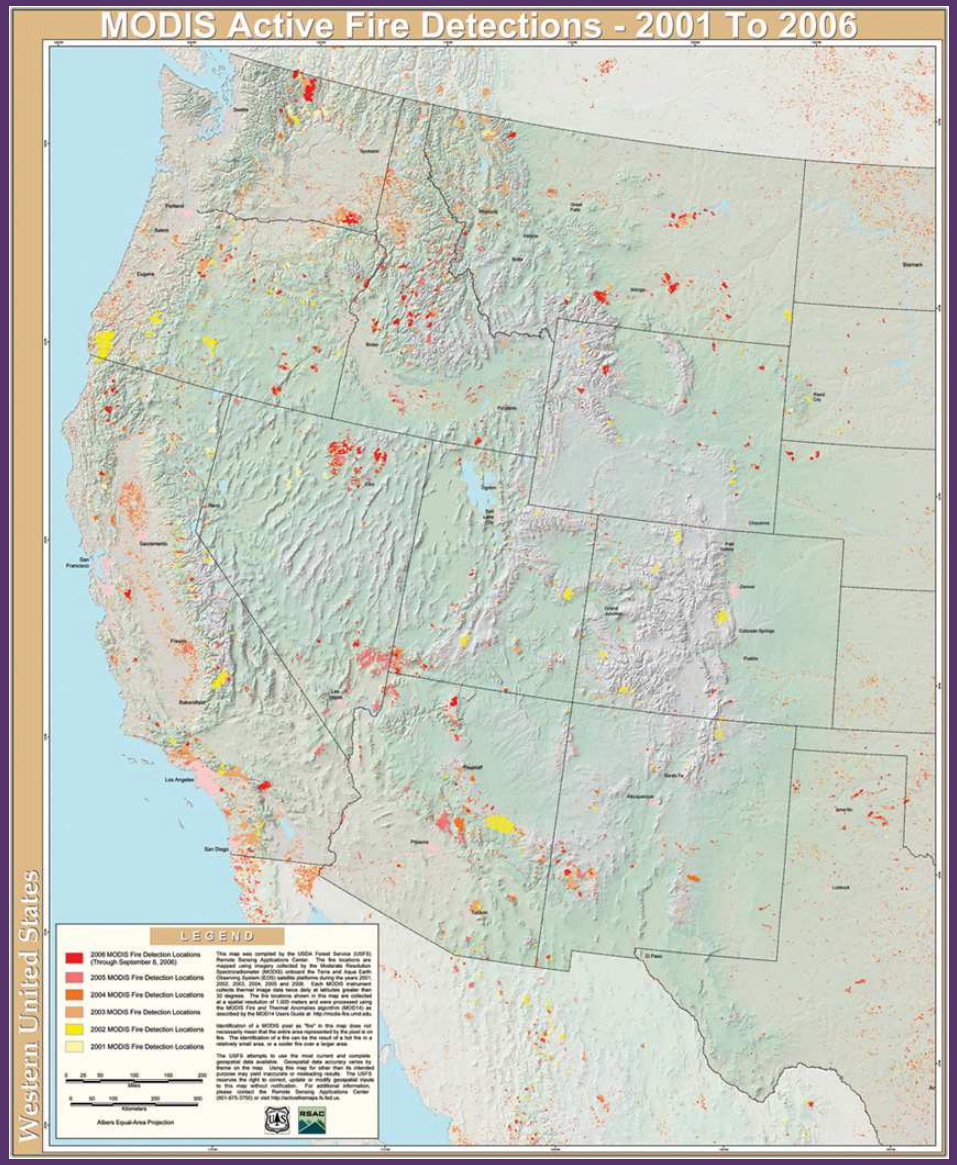


MODIS Fire Image Subsets



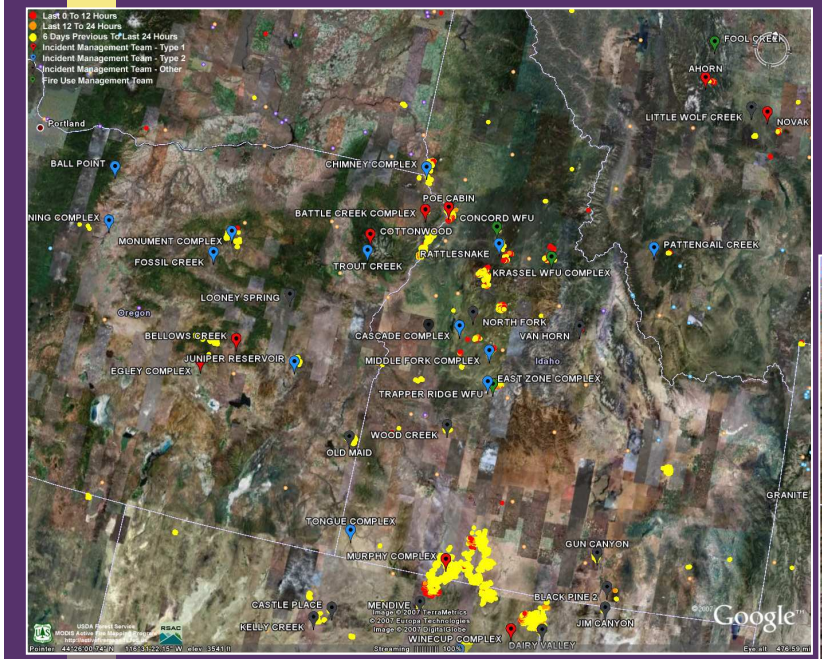
- Georeferenced MODIS image subsets
- Provided daily for each state; year round
- Compiled from Terra & Aqua swath data, B1-7
- JPGs, GeoTiff, generic binary (BSQ)
- Browse images; Archive available

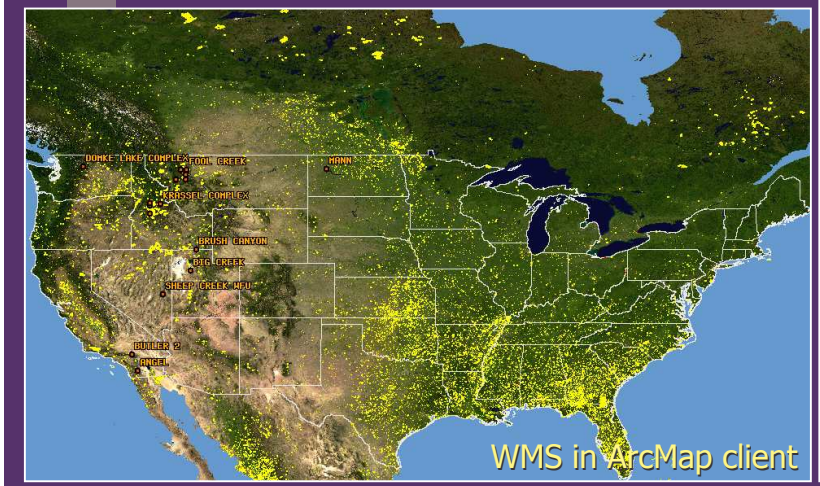
MODIS Fire Detection GIS Data



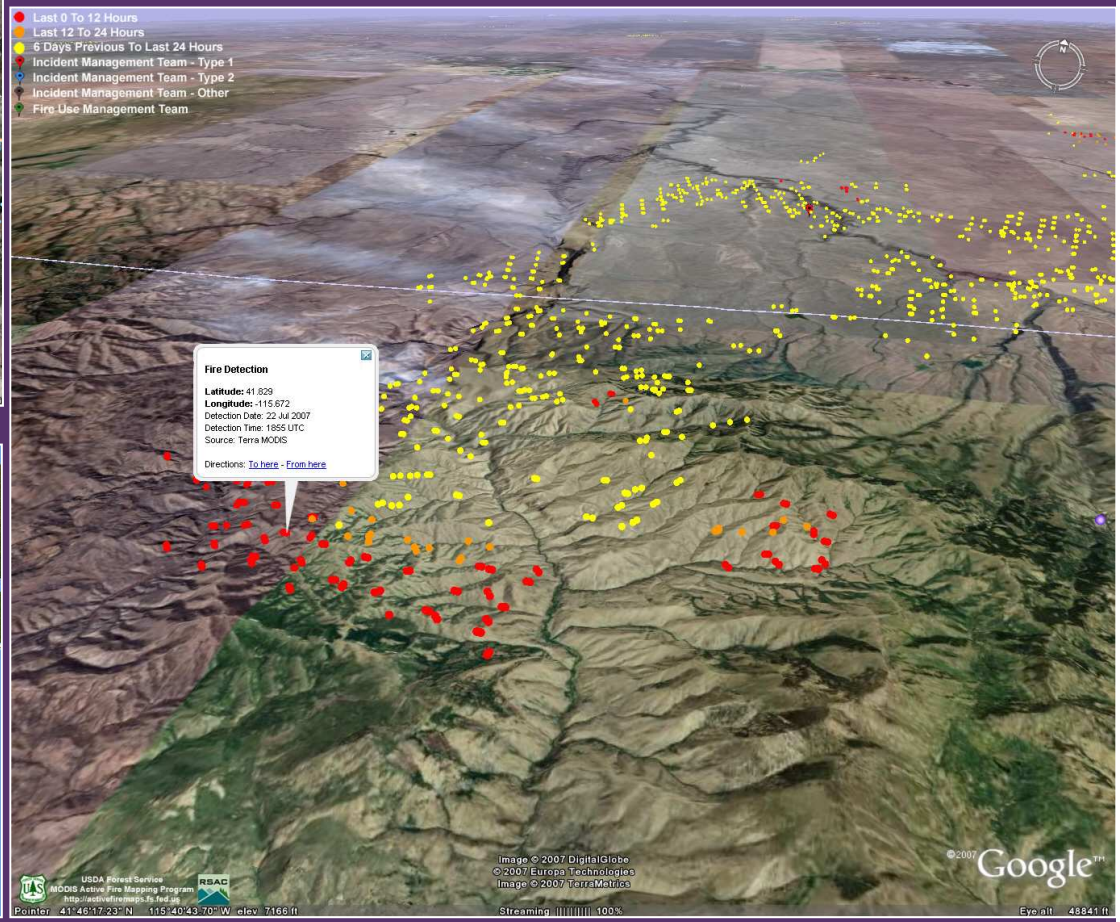
- Terra & Aqua MODIS 1KM MOD14 fire detection GIS data
- Subsets for CONUS, AK, HI, Canada & North America
- 2000-2007 data available
- Updated hourly
- FGDC Metadata

MODIS Fire Detection WMS/KMZs





- WMSes and KMZs for CONUS, AK, HI, Canada
- Updated hourly
- MOD14 data and incident specific information



User Community Depends On MODIS Active Fire Mapping

USDA MODIS Active Fire Mapping Program Website Stats 2001-2007

	2001*	2002	2003	2004	2005	2006	2007#
Hits	1.5 Million	3.3 Million	24.9 Million	18.7 Million	25.8 Million	35.9 Million	35.9 Million
Users	42,000	502,000	1.5 Million	817,200	960,000	1.54 Million	2.2 Million
Data Volume Transferred	12 GB	215 GB	750 GB+	1 TB+	4 TB	2 TB	3.8 TB

* - complete statistics not available for entire year
# - through September 30, 2007

Critical source of timely wildfire geospatial data…

Data provided by MODIS Active Fire Mapping Program is also relayed to other fire support websites and data portals

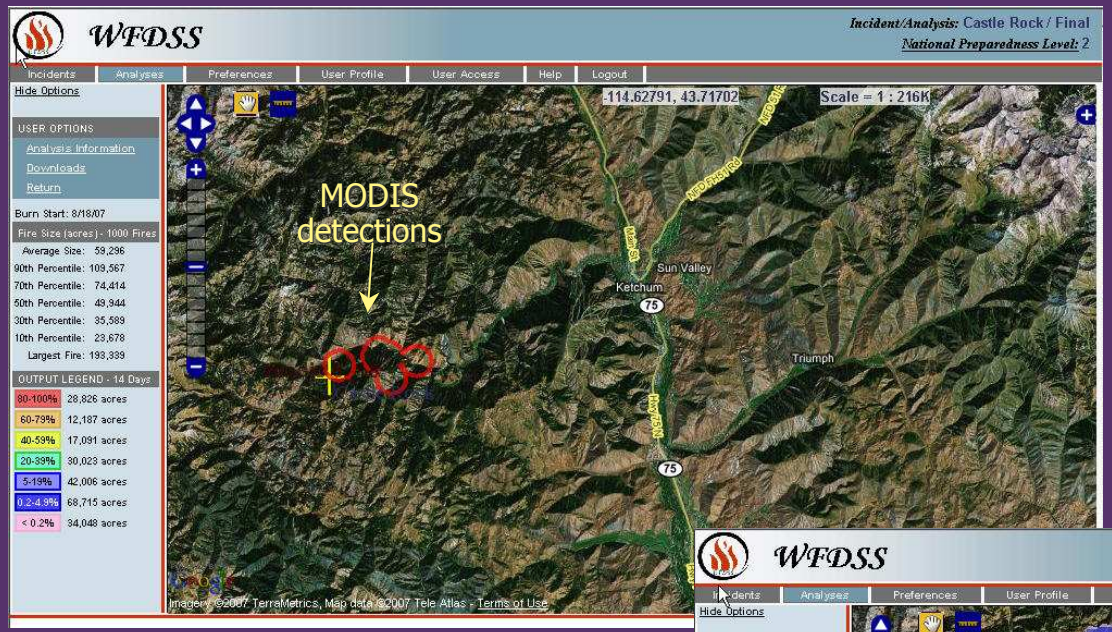
MODIS Active Fire Program Data Applications

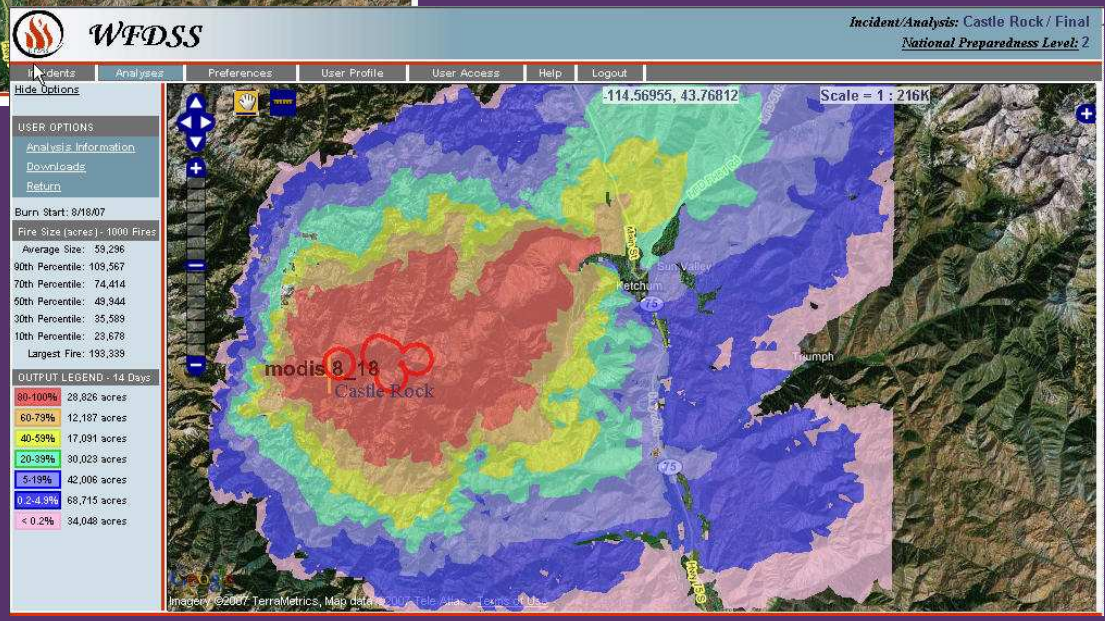
Contributes to several active fire and post-fire application needs…

- Strategic fire management/planning
- Spatial fire behavior systems/models
- Focus tactical fire detection and monitoring assets
- Space-borne/airborne "sensor web" applications
- Detection and monitoring in remote areas/non-response zones
- Air quality monitoring
- Burn area mapping/characterization
- Emission estimates
- Dissemination of fire information to the general public
- Monitoring fire threat to infrastructure
- On and on…

Example Application

Spatial Fire Behavior Systems/Models - WFDSS





MODIS data provides fire locations for initial model runs when other sources of intelligence are lacking.

FS-Pro results are critical in the early stages of a fire to ensure that adequate resources are provided for containment.

FS-Pro (Fire Spread Probability) Model

- Probability of fire spread from a known location
- Used for long-term projections of ongoing fires
- Used in conjunction with information about values at risk

Example Application

WRAP Wildfire Research and Applications Partnership

Integration with UAS Tactical Fire Information DSS

Ikhana UAS

Terra & Aqua
MODIS imaging fires

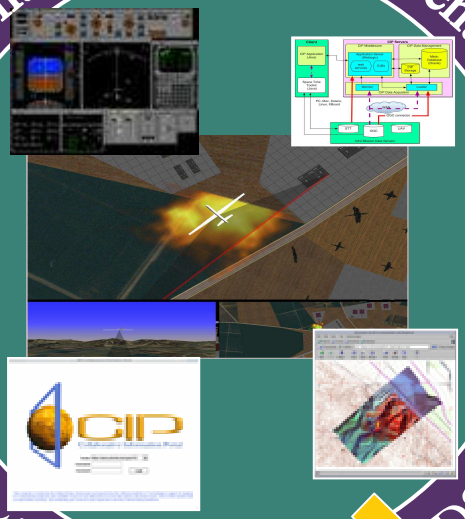
UAS Platform
Fire Imaging

COMSAT Telemetry
& Platform C&C

GOES Weather Data

Asset Tracking

Intelligent Mission Management / CDE



Telemetry /
C&C Downlink

Aircraft Operations

Payload Operations

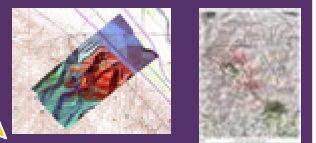
Define aircraft ops

Direct Broadcast
Receiving Station
USFS RSAC

MODIS Active Fire Maps
http://activefiremaps.fs.fed.us

Tactical Fire Information DSS

Tactical Fire Products



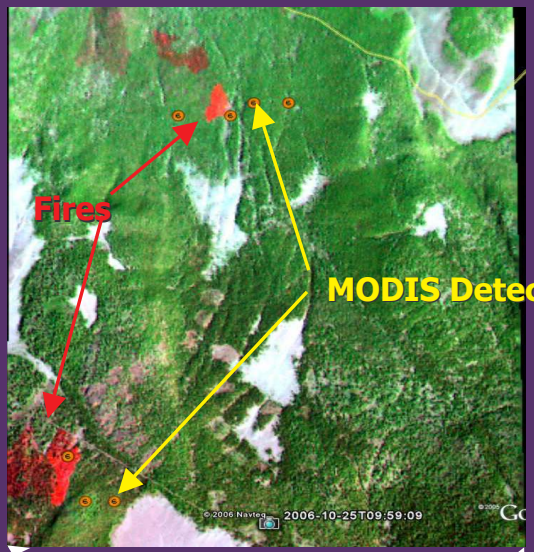
GeoTiff & Perimeter File

Example Application

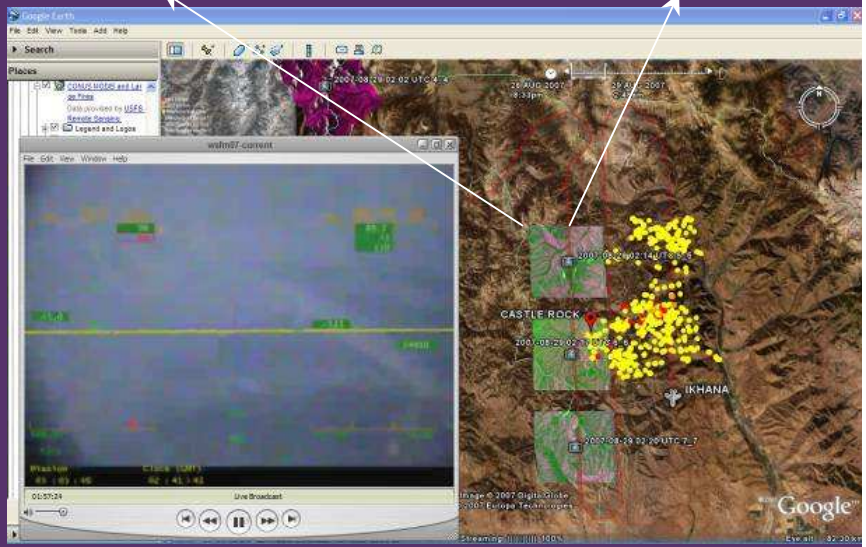
Integration with UAS Tactical Fire Information DSS

MODIS data are used for:

- Pre-mission planning
- In-flight mission revisions for "targets of opportunity" (i.e. investigate new MODIS detections within the flight certificate of authorization (COA))



2007 Western States Mission Flight Plan



UAS In-flight MODIS Data Integration

MODIS Active Fire Mapping Summary

- MODIS Active Fire Mapping Program products support strategic fire management in North America
  - Direct broadcast/direct readout technologies are critical
  - "Value added" geospatial products
  - Operational; 24/7 year round
- Supports several additional fire mission objectives
- Looking forward
  - Continued program development and enhancement
  - Integration of future satellite sensors (VIIRS, etc.)
- Collaborative effort:

USDA Forest Service Remote Sensing Applications Center

National Interagency Fire Center

NASA Goddard Space Flight Center

NASA Direct Readout Laboratory

University of Maryland – Dept of Geography

NOAA

University of Alaska-Fairbanks

University of Wisconsin Space Science & Engineering Center

Additional Information

USDA Forest Service MODIS Active Fire Mapping Program

http://activefiremaps.fs.fed.us