The Role of Remote Sensing to Support Active Fire Mapping, Post Fire Rehabilitation, and Forest Monitoring within the USDA Forest Service

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USDA Forest Service
Remote Sensing Applications Center (RSAC)

2nd Workshop on Geostationary Fire Monitoring and Applications

Darmstadt, Germany
December 4-6, 2006

Topics

Active Fire Mapping

- National Scale Active Fire Mapping – MODIS Rapid Response
- Tactical Scale Fire Mapping – Airborne TIR

Post Fire Rehabilitation & Monitoring

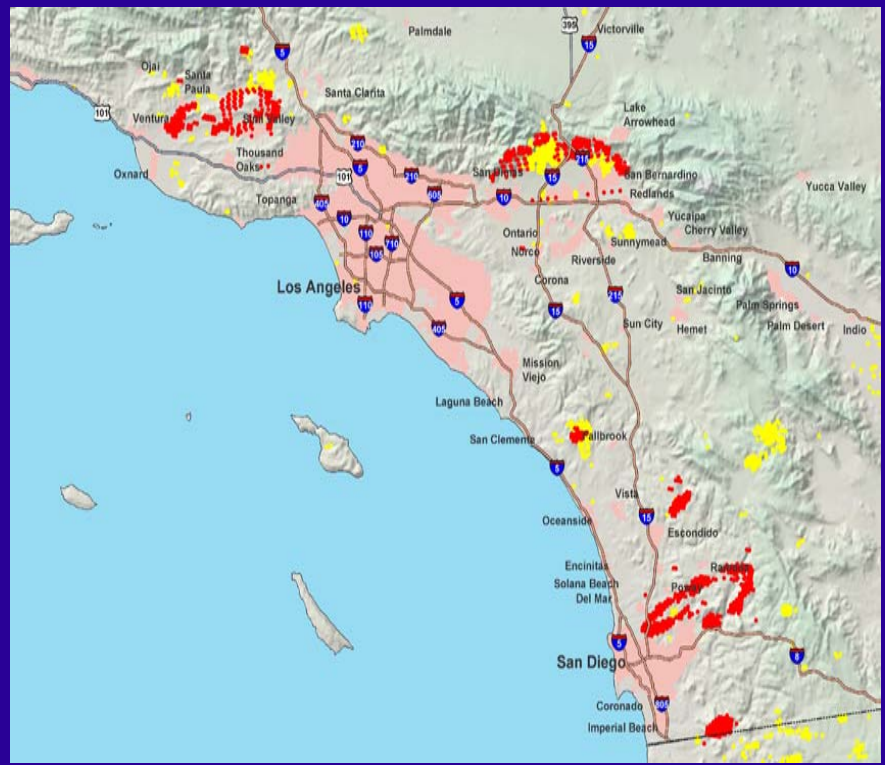
- Burn Area Emergency Response (BAER)
- Monitoring Trends in Burn Severity (MTBS)

Forest Monitoring

- Forest Health Change Detection

Forest Service MODIS Active Fire Mapping Program

- Developed in 2001- using MODIS Rapid Response Detection
- Comprehensive coverage of CONUS, Alaska, Hawaii & Canada
- Operational near real-time (NRT) acquisition/processing of MODIS data to meet needs of fire managers



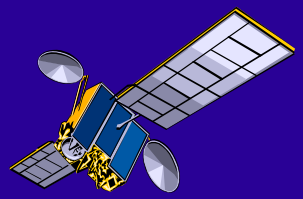
http://activefiremaps.fs.fed.us

MODIS Active Fire Mapping Program Objectives

- Generate "value added" geospatial fire products – National Interagency Fire Center (NIFC)
  - 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
- Aid wildfire strategic planning and response
  - Prioritize allocation of suppression assets
  - Focus tactical airborne reconnaissance & TIR mapping assets
- Detect and monitor fire activity in remote areas
- Support several other fire-related applications

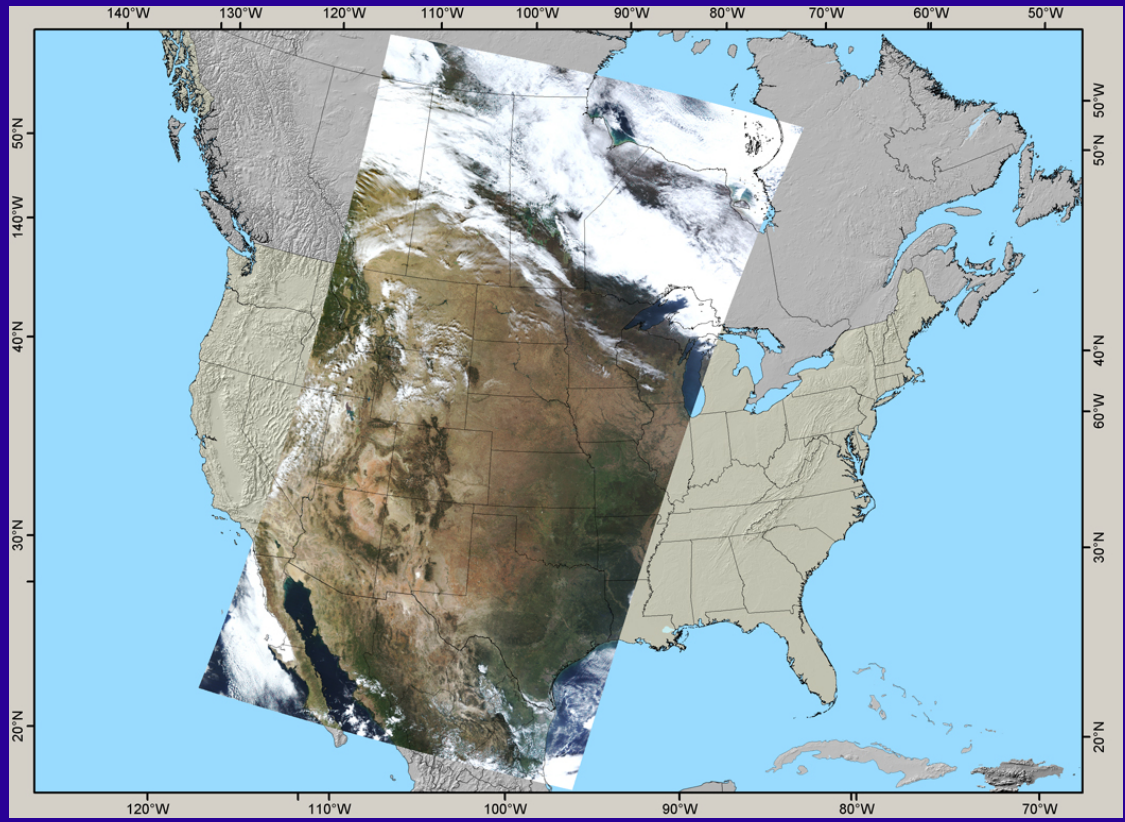
MODIS Direct Broadcast/Direct Readout

NRT MODIS Data Acquisition...



Terra / Aqua
Direct Broadcast

Direct Readout
Ground Station



Direct Broadcast (DB)

Real-time transmission of satellite data to the ground. As the Earth is being observed by the satellite, the data is formatted and transmitted to any user below in real-time.

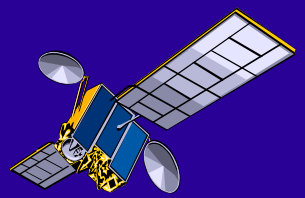
Direct Readout (DR)

Acquisition of freely transmitted live satellite data by users with compatible ground receiving equipment and direct line of sight to the satellite.

MODIS Ground Station Network

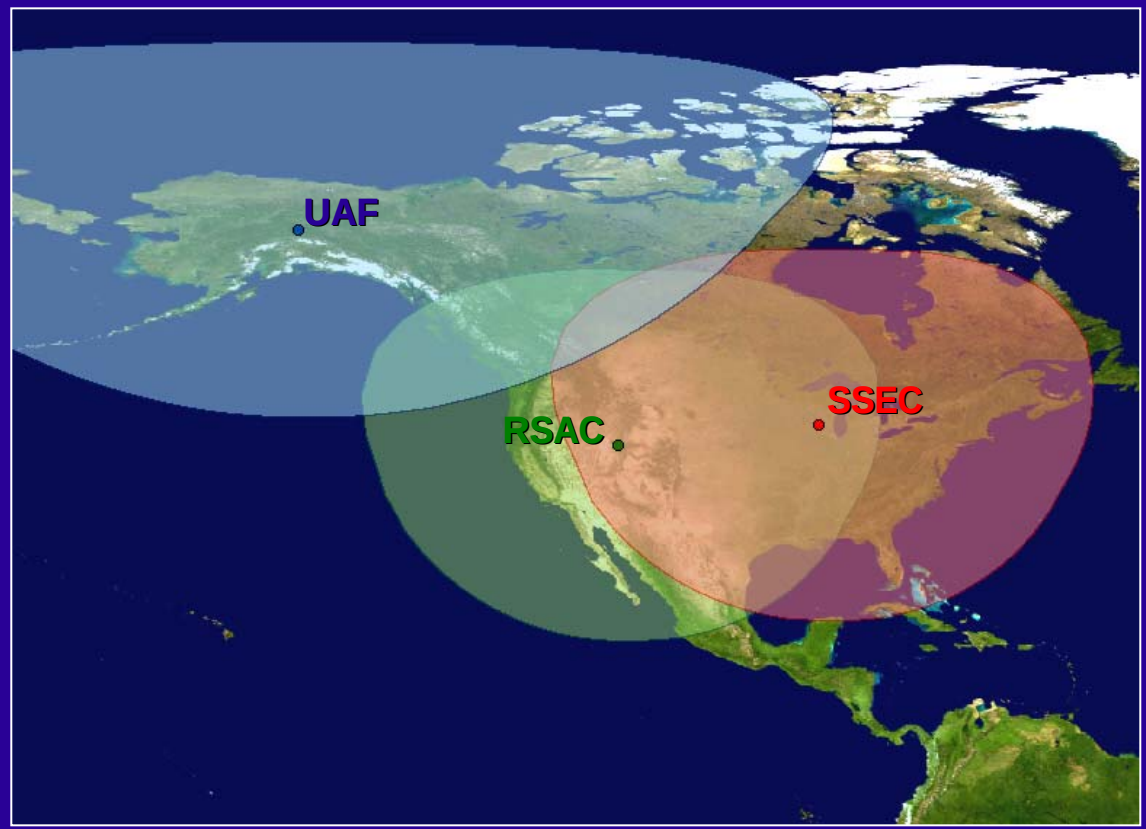
Primary data source for MODIS Active Fire Mapping Program...

- NRT MODIS data via Direct Broadcast/Direct Readout
- North America coverage provided by RSAC, University of Wisconsin-SSEC and University of Alaska-Fairbanks-GINA
- L2 surface reflectance and fire detection data processed on site

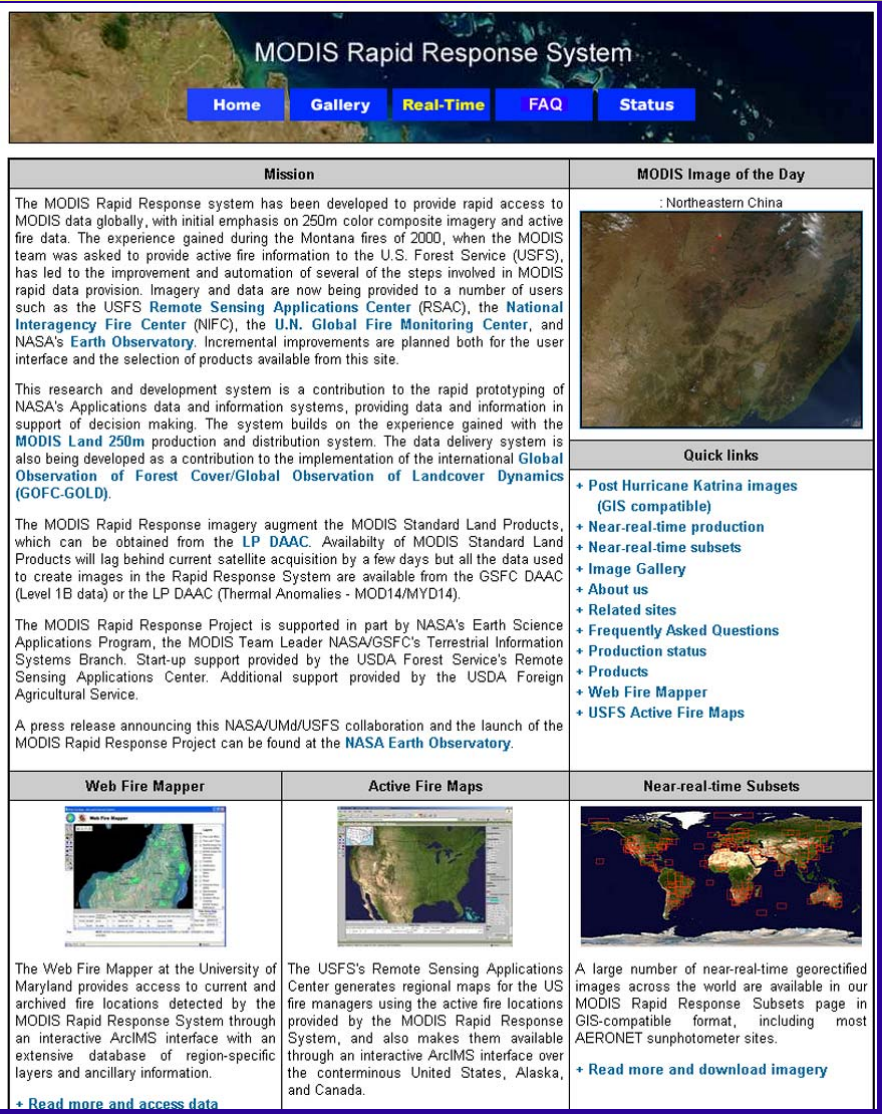


Terra / Aqua
Direct Broadcast

Direct Readout
Ground Station



MODIS Rapid Response (RR) System

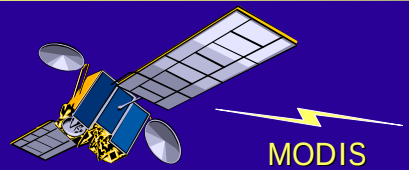


Additional data source...

- Developed in 2001 by NASA-GSFC/ University of Maryland
- Daily global MODIS coverage
- Access to MODIS data stream via NOAA MODIS Near Real Time Processing System
- Rapid generation of key MODIS products for operational objectives
  - L2 MODIS surface reflectance
  - L2 MODIS fire detections
- Available ~ 3 hours post acquisition

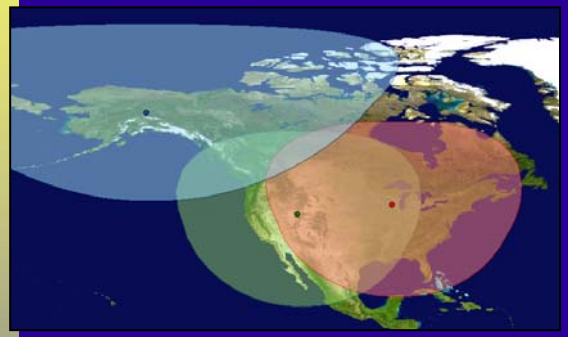
http://rapidfire.sci.gsfc.nasa.gov

Overview: MODIS Data Acquisition and Processing



Terra / Aqua

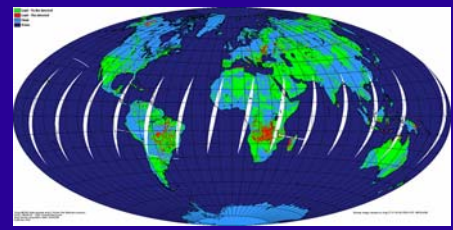
MODIS Raw Data



RSAC, SSEC & UAF
North America MODIS
Direct Readout Coverage

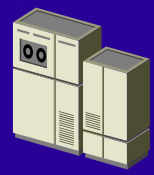
MODIS Ground Station Network (RSAC, SSEC & UAF)

White Sands, NM



GSFC MODIS RR World-wide Coverage

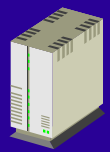
MODIS L0 Data



NOAA MODIS Real Time Processing System

MODIS L0 Data (< 1/2 hour)

MODIS L0 (~3 hours)



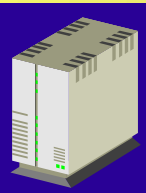
Ground Station Network Rapid Response Systems

Image & Active Fire Detection Processing

NASA/GSFC Rapid Response System

Image & Active Fire Detection Processing

Overview: MODIS Fire Mapping and Distribution



Ground Station Network
Rapid Response Systems

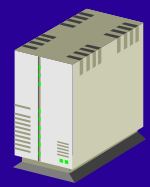
Image & Active Fire Detection Processing

Active Fire Detections & Imagery (Continental U.S., Alaska, Canada)

NASA/GSFC
Rapid Response System

Image & Active Fire Detection Processing

Active Fire Detections & Selected Imagery (North America)



USFS-RSAC
MODIS Active Fire Mapping System

Fire Maps
Image Subsets
GIS Data
Custom Products

Updated continuously

Forest Service MODIS Active Fire Maps Web Server

Updated Hourly

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

Links to Canada and Mexico Fire Maps

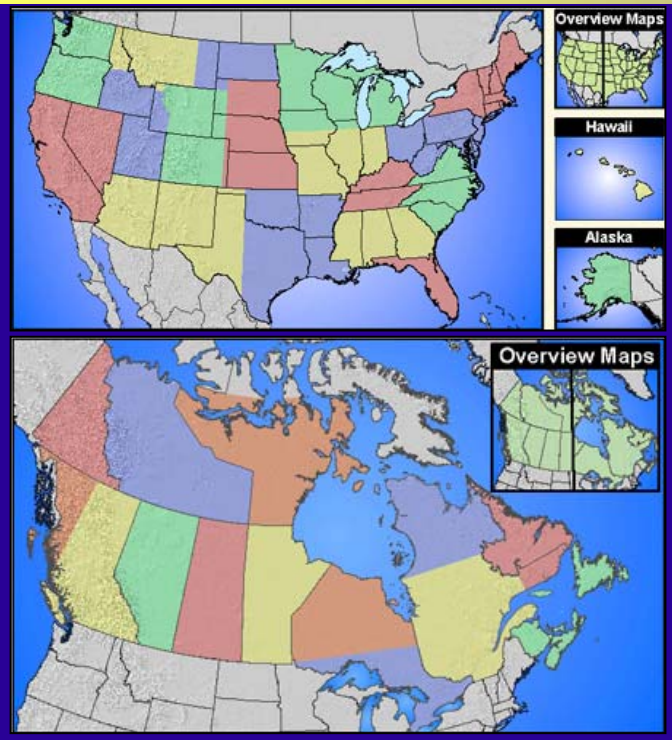
National Interagency Fire Center (NIFC) Incident Map

Project Cooperators

Current News Items of Interest

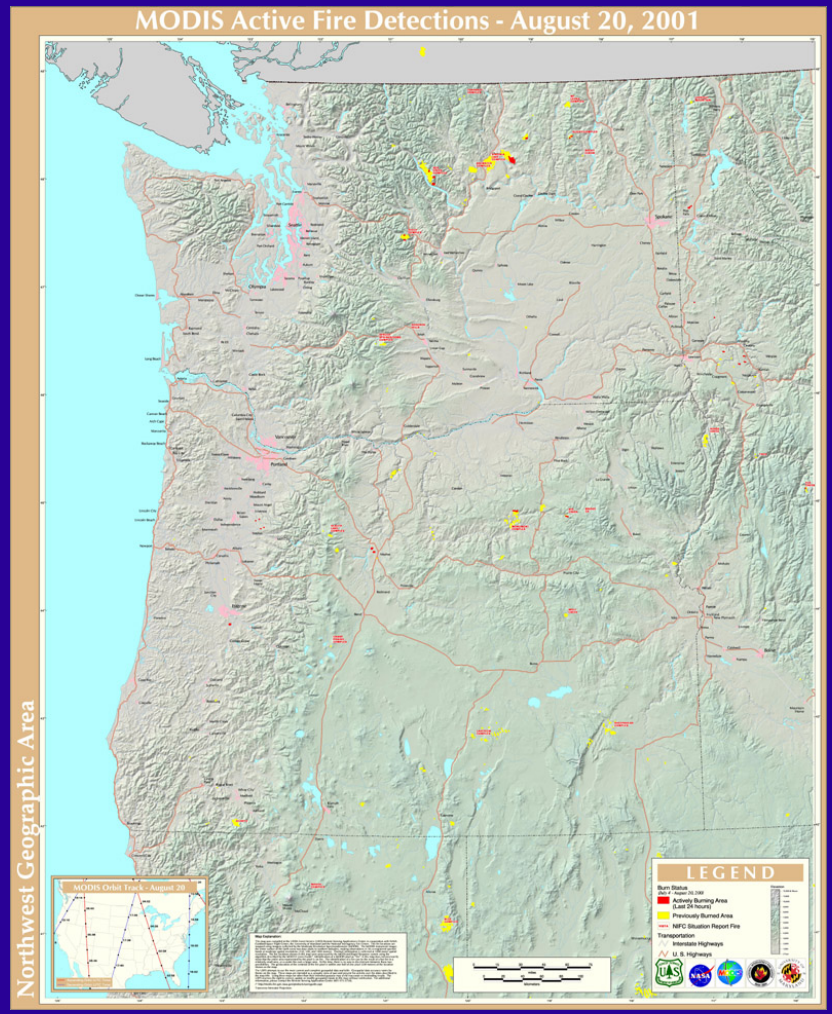
http://activefiremaps.fs.fed.us

Regional MODIS Active Fire Maps

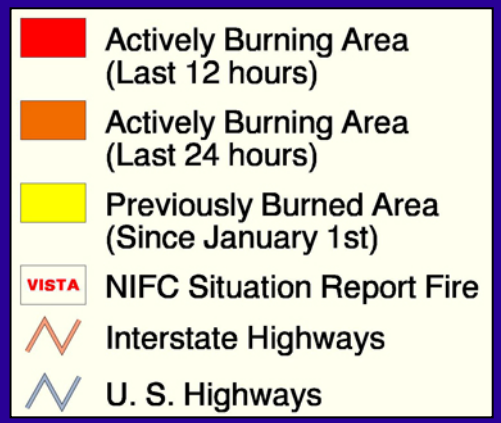


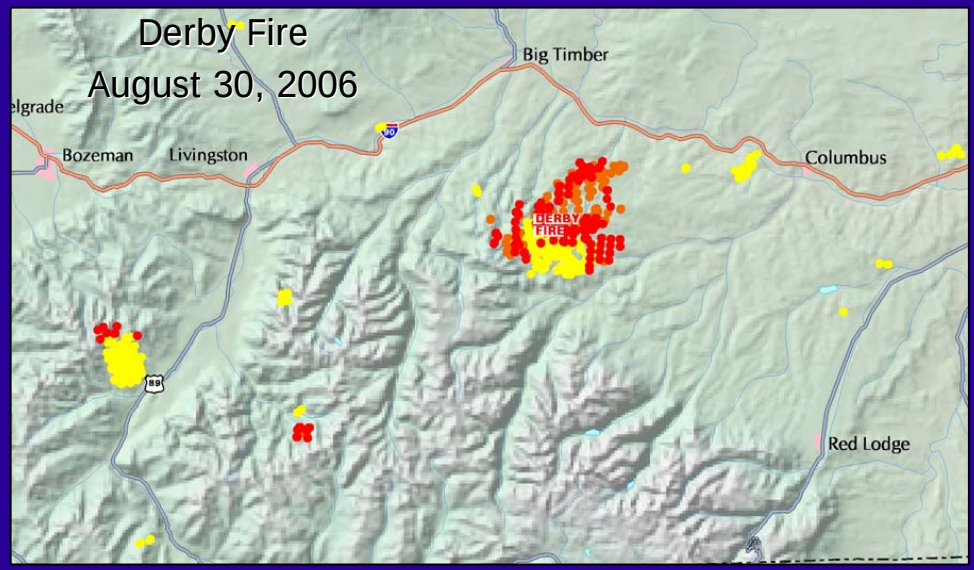
- Regional and overview maps for U.S. & Canada
- Updated several times daily
- Display current and cumulative fire activity
- Provided in JPG and PDF format
- ~30,000 maps produced annually
- Map archive available

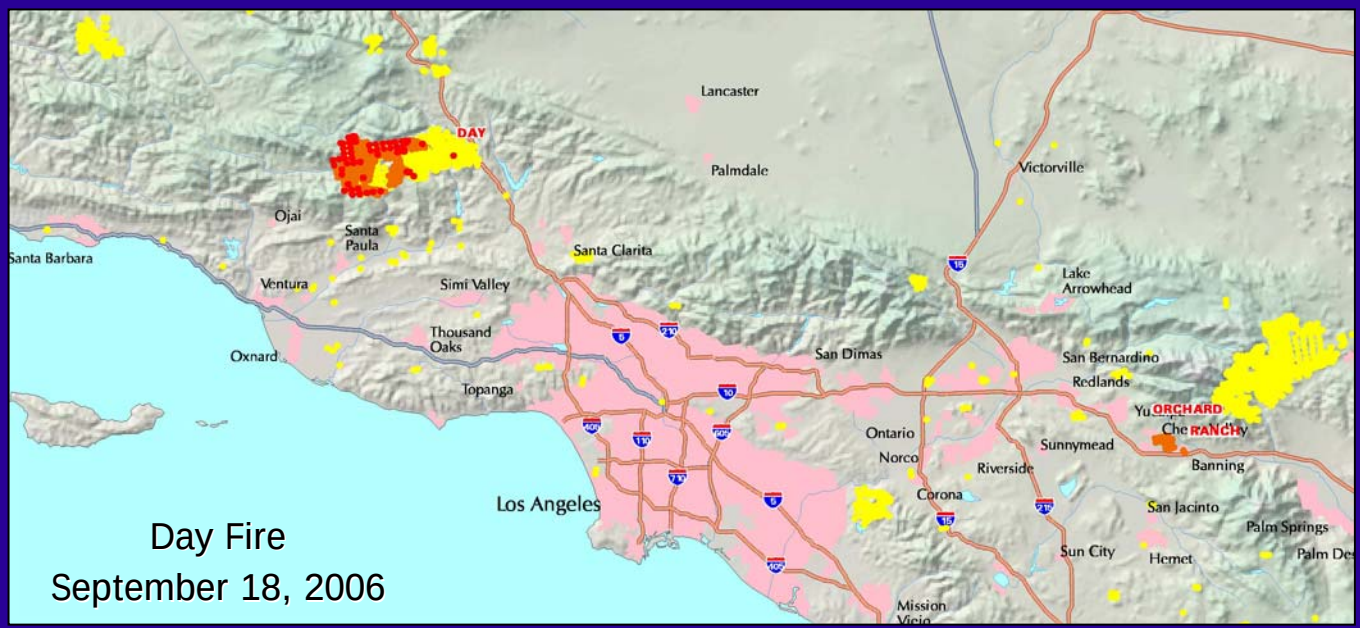
Northwest Geographic Area



MODIS Active Fire Map Examples

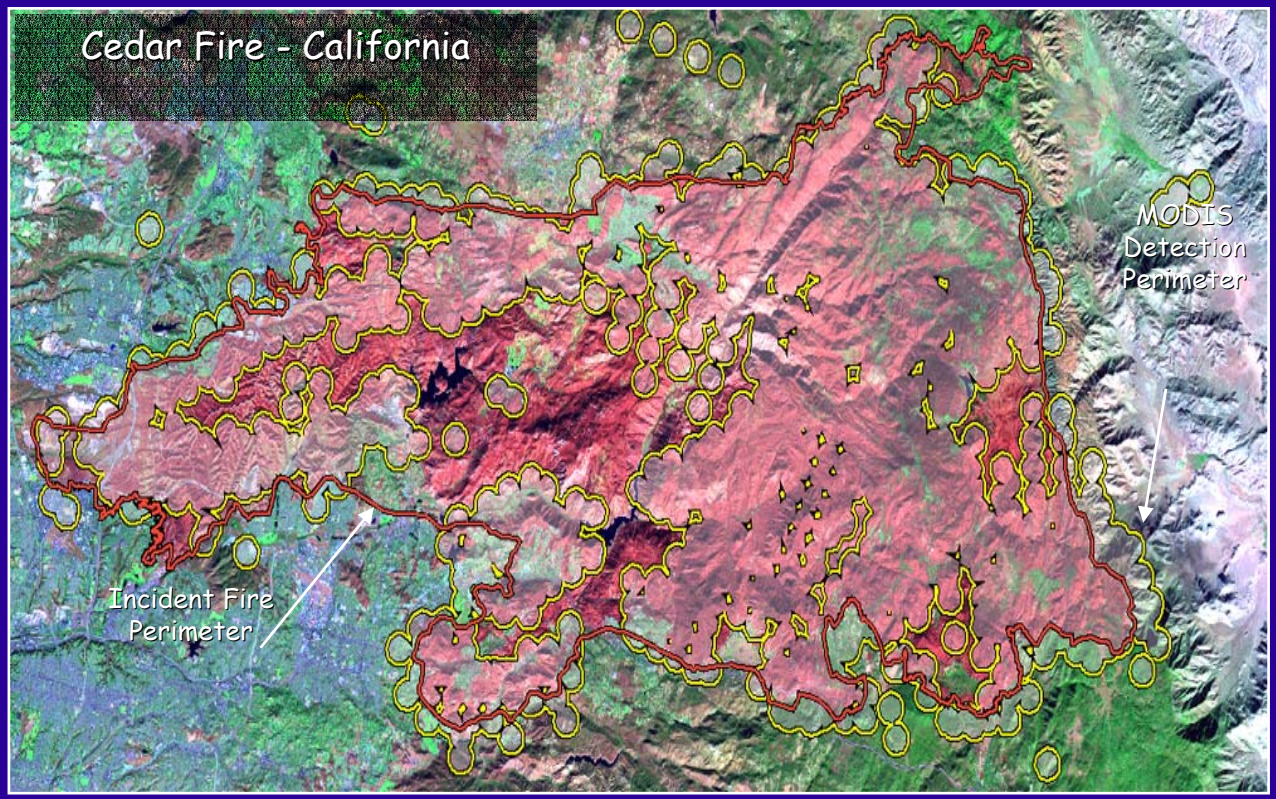






Fire Detections ≠ Burned Area

- Fire detections may over and underestimate burned area



Sources of Underestimation

Clouds obscuring fires

Fast moving fires

Polar orbit of sensor (not geostationary)

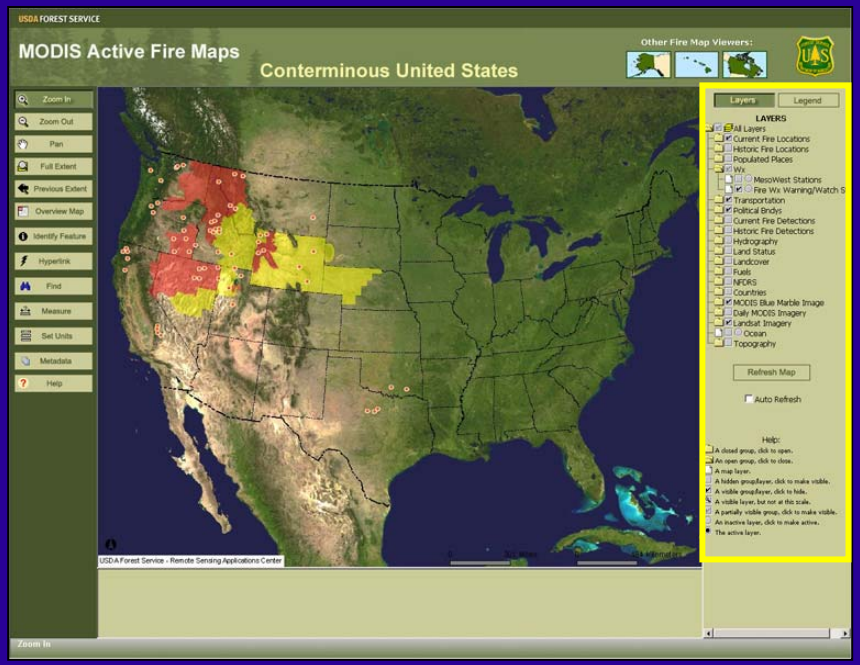
Sources of Overestimation

Spatial resolution

Entire pixel may not be on fire

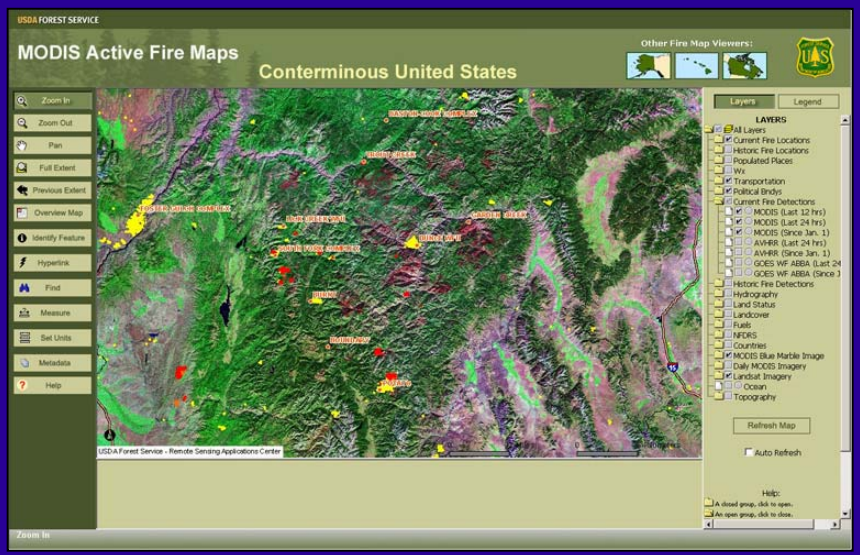
False detections

Interactive MODIS Active Fire Maps Examples



Available Layers

MODIS, AVHRR & GOES Fire Detections
National Fire Danger Rating System
NWS Wx Observations
NWS Fire Watch/Warnings
Daily Terra/Aqua MODIS Imagery
LANDSAT imagery
Fire Regime/Condition Class
Baseline Cartographic data



MODIS Fire Image Subsets

- Daily georeferenced image subsets
- Compiled from RSAC swath data
- MODIS “land bands”
- 3 band true and false color JPGs, GeoTiffs
- 7 band generic binary (BSQ)

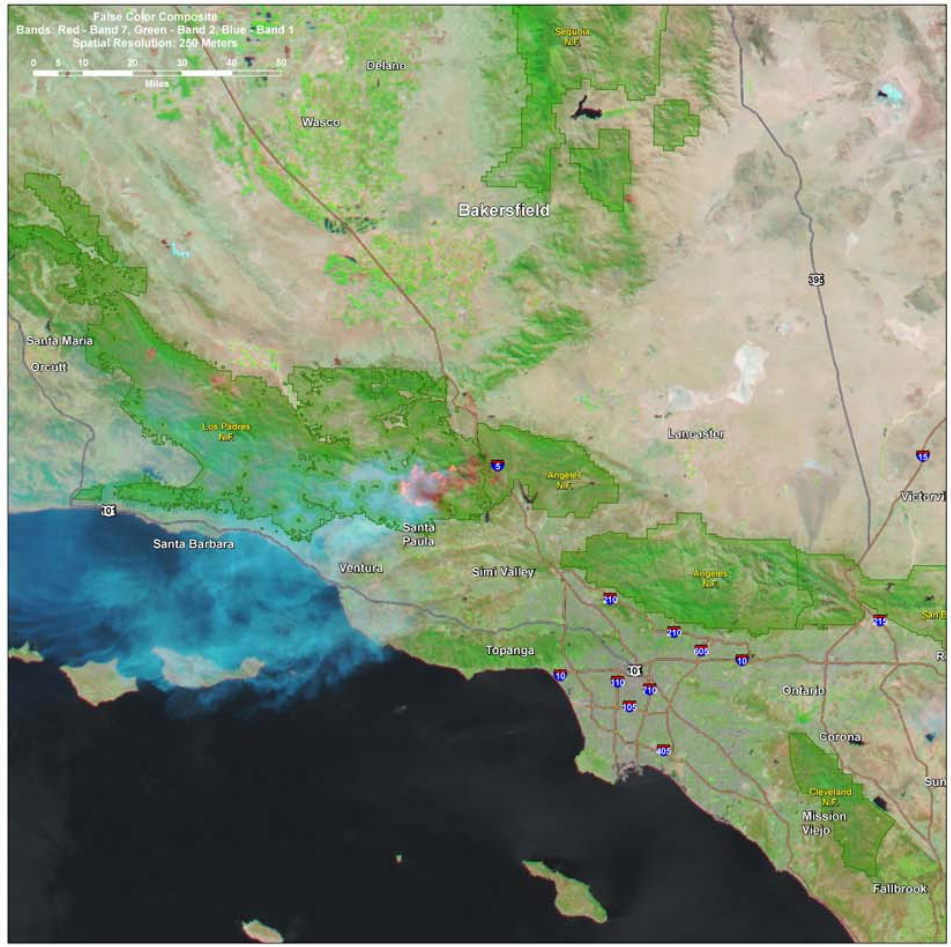
MODIS Fire Image Subset Examples

DAY FIRE

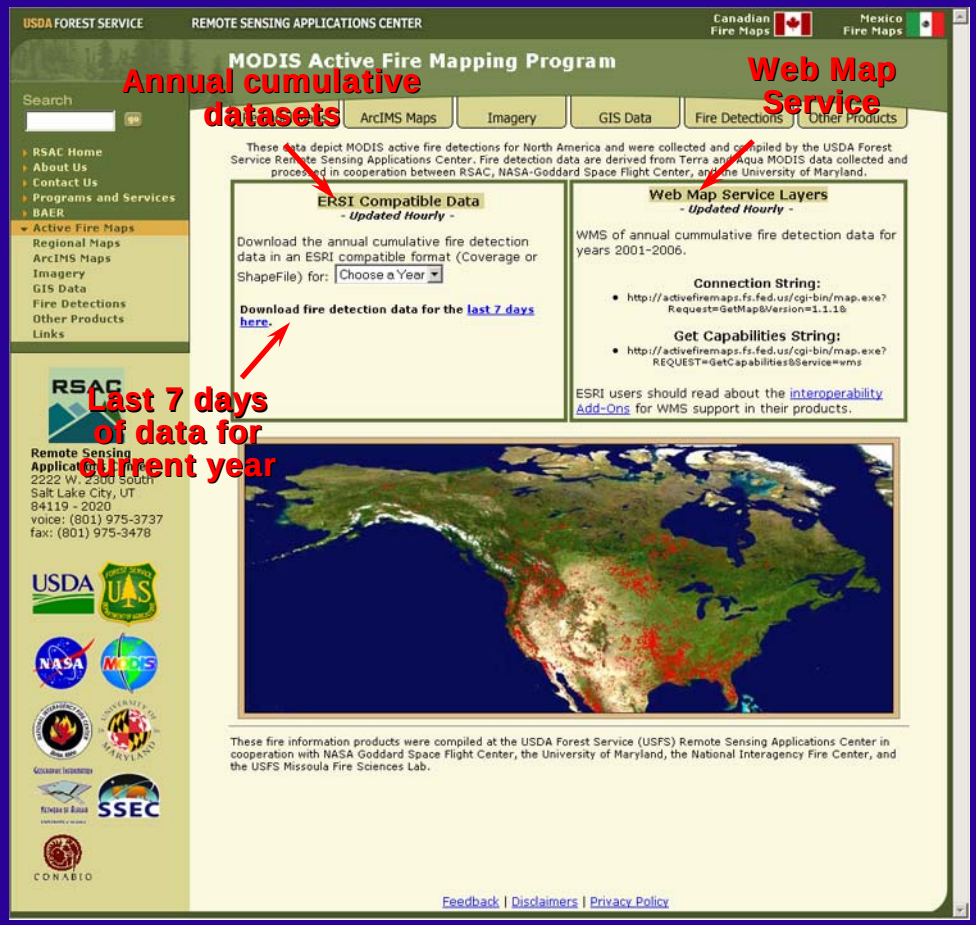
As Viewed By Aqua MODIS

September 17, 2006; 20:55 UTC

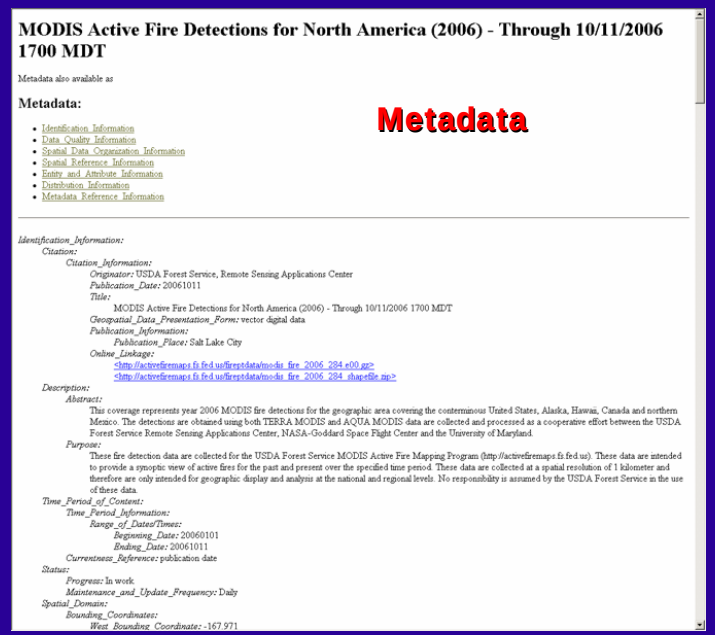
Produced by the USFS Remote Sensing Applications Center (RSAC)



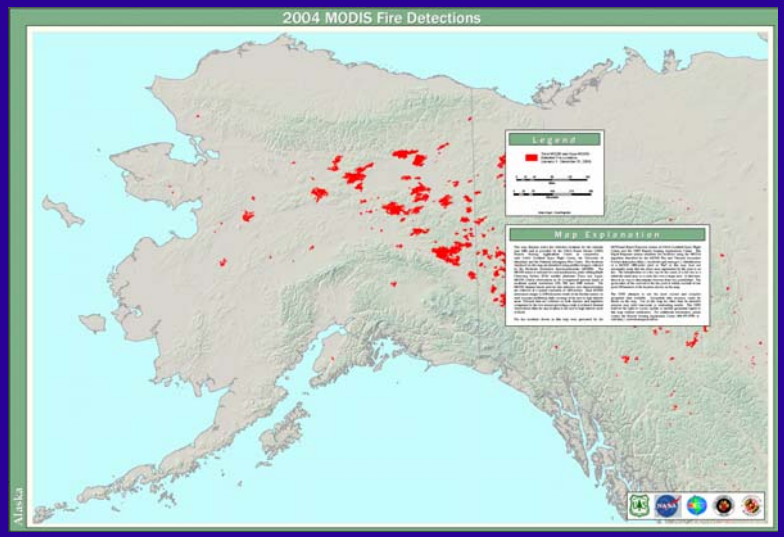
MODIS Fire Detection GIS Data



- Terra & Aqua MODIS fire detection GIS data for North America
- Compiled from GSFC, RSAC, SSEC & UAF MODIS Rapid Response
- Available for 2001 - 2006
- Updated hourly
- ESRI coverage & shapefile format
- FGDC Metadata
- Web Map Service (WMS)



MODIS Fire Detection GIS Data



Alaska Cumulative Fire Detections 2004

Fire Detection Attributes

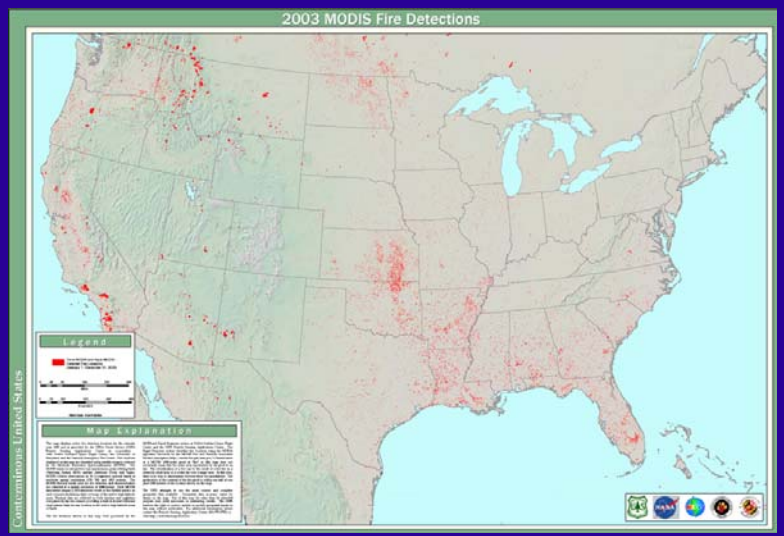
Acquisition date

Acquisition time

Pixel size (IFOV)

Observed brightness temperature

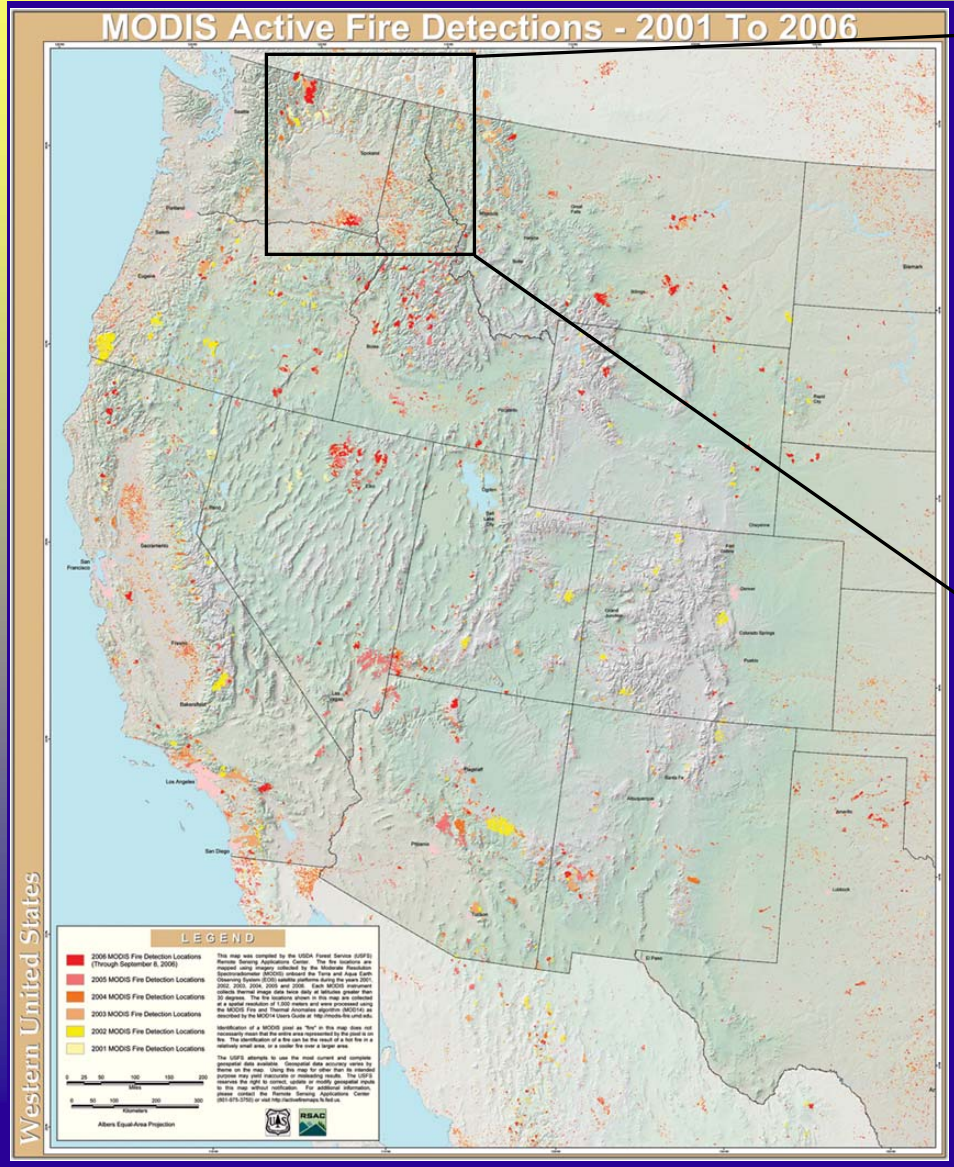
Ground station source

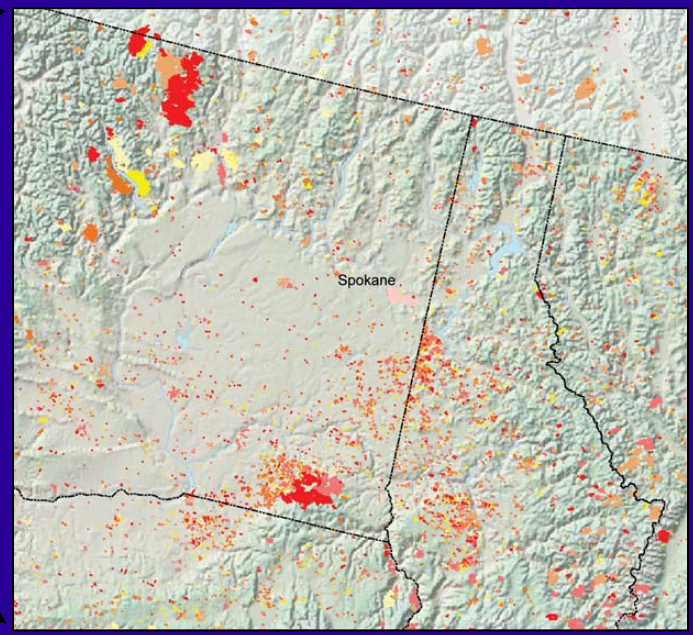


CONUS Cumulative Fire Detections 2004

Canada Cumulative Fire Detections 2004

MODIS Fire Detection GIS Data





2006 MODIS Fire Detection Locations (Through September 8, 2006)

2005 MODIS Fire Detection Locations

2004 MODIS Fire Detection Locations

2003 MODIS Fire Detection Locations

2002 MODIS Fire Detection Locations

2001 MODIS Fire Detection Locations

Annual Western U.S. MODIS Fire Detections (2001-2006)

User Community Depends On MODIS Active Fire Data

Usage of MODIS active fire data and products provided by Forest Service via USDA MODIS Active Fire Mapping Program website

	2001*	2002	2003	2004	2005	2006#
Hits	1.5 Million	3.3 Million	24.9 Million	18.7 Million	25.8 Million	32.6 Million
Users	42,000	502,000	1.5 Million	817,200	960,000	1.3 Million
Data Volume Transferred	12 GB	215 GB	750 GB+	1 TB+	4 TB	1.9 TB

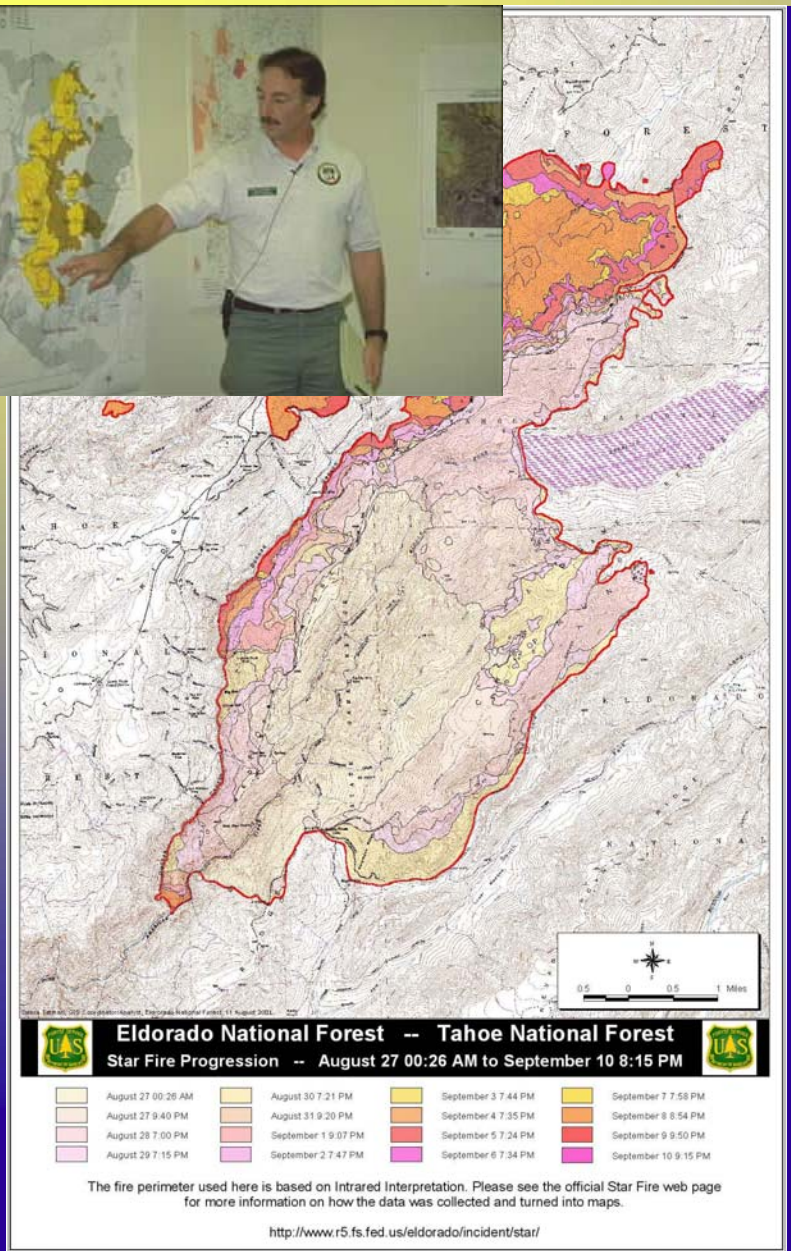
* - complete statistics not available for entire year

\# - through October 9, 2006

Critical source of timely wildfire data...

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

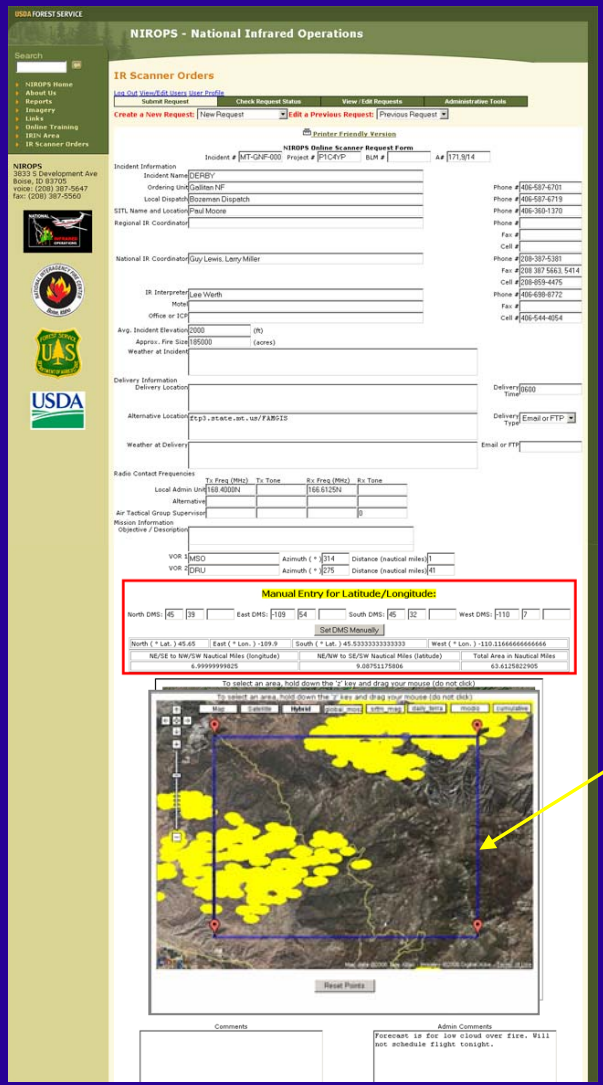
Tactical Scale Active-Fire Mapping



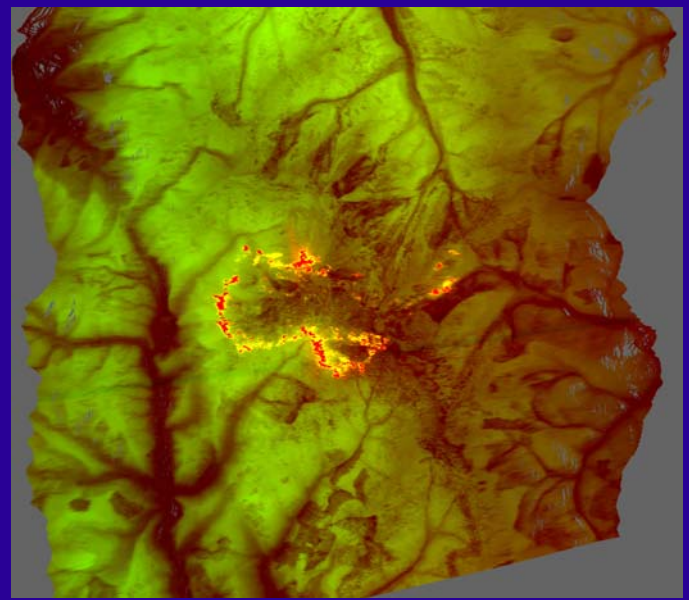
- High resolution fire map products needed for daily 6:00 AM Incident Command briefing
- Delineate fire perimeter and active fire fronts
- Determine line of containment
- Identify problem areas – hot spots inside & outside containment line
- Identify hot spots during the mop-up phase

Airborne TIR Mission Planning

Focus airborne TIR assets



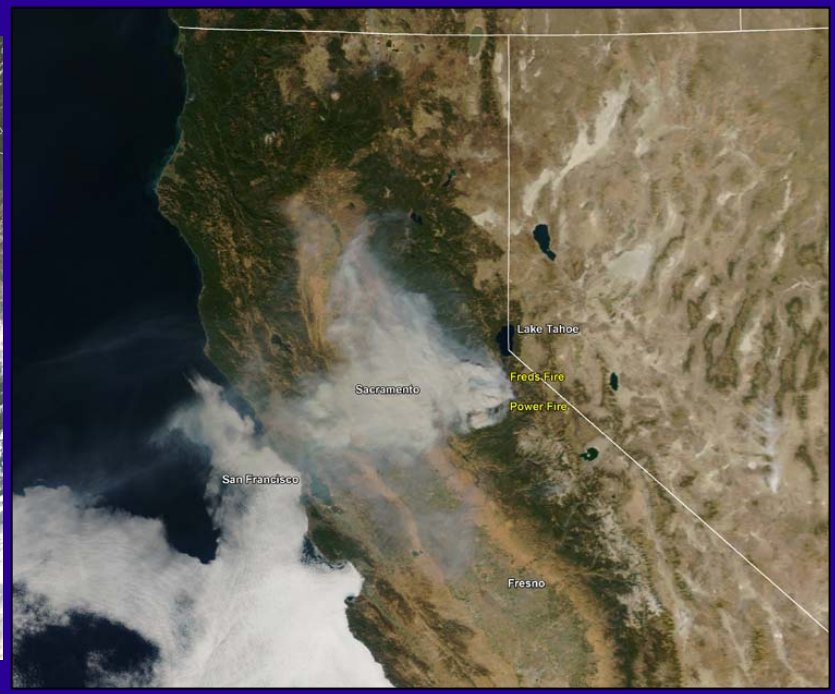
MODIS fire detections used for mission planning



Airborne TIR tactical fire mapping imagery

Other Applications of MODIS Data

Monitoring smoke transport



- Regional air quality managers monitor smoke from prescribed and wildfire activity

MODIS Active Fire Mapping Summary

- MODIS Active Fire Mapping Program supports 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

University of Maryland – Dept of Geography

NOAA

University of Alaska-Fairbanks

University of Wisconsin Space Science & Engineering Center

Post-Fire Rehabilitation & Monitoring

- Burn Area Emergency Response (BAER)
  - Satellite and airborne remote sensing systems used to support Burn Severity Mapping
- Monitoring Trends in Burn Severity (MTBS)
  - For wildland fires – 1984 to present

Burn Area Emergency Response (BAER) Support

- Objective is to prepare Burn Area Emergency Response plan within 10 days of fire containment
- Remotely sensed imagery - use best available
  - MODIS
  - AWiFS
  - Landsat 5,7
  - ASTER
  - SPOT 2,4,5
  - Ikonos, Quickbird, Digital Globe
  - Airborne MS scanners
  - Airborne CIR Digital cameras
- Critical factors:
  - Acquisition timing
  - Delivery from provider
  - Spectral properties – SWIR band

Post-Fire Rehabilitation

BAER Team prepares Response Plan

- Identifies priority areas to be treated

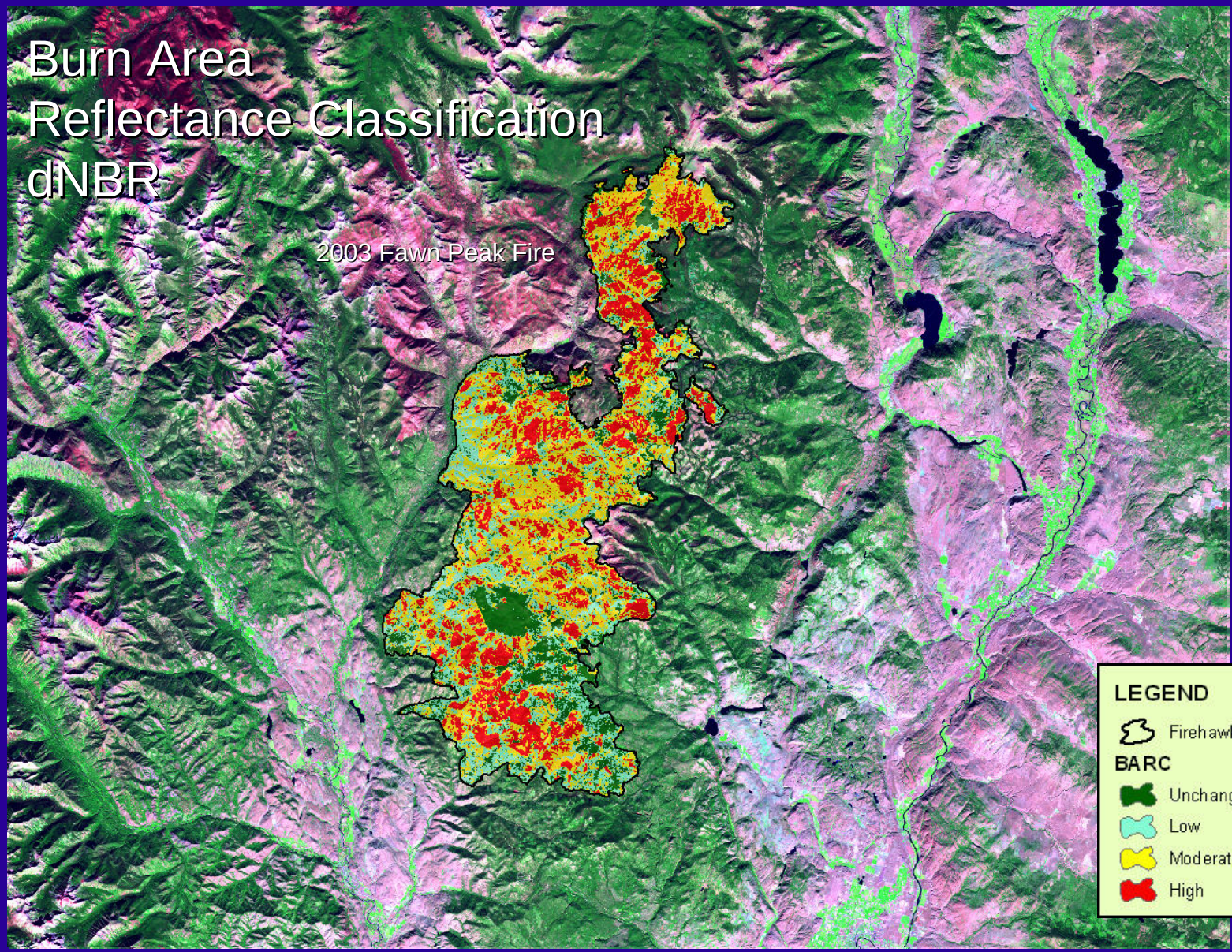
Installing soil erosion barriers

Aerial mulching and grass seeding

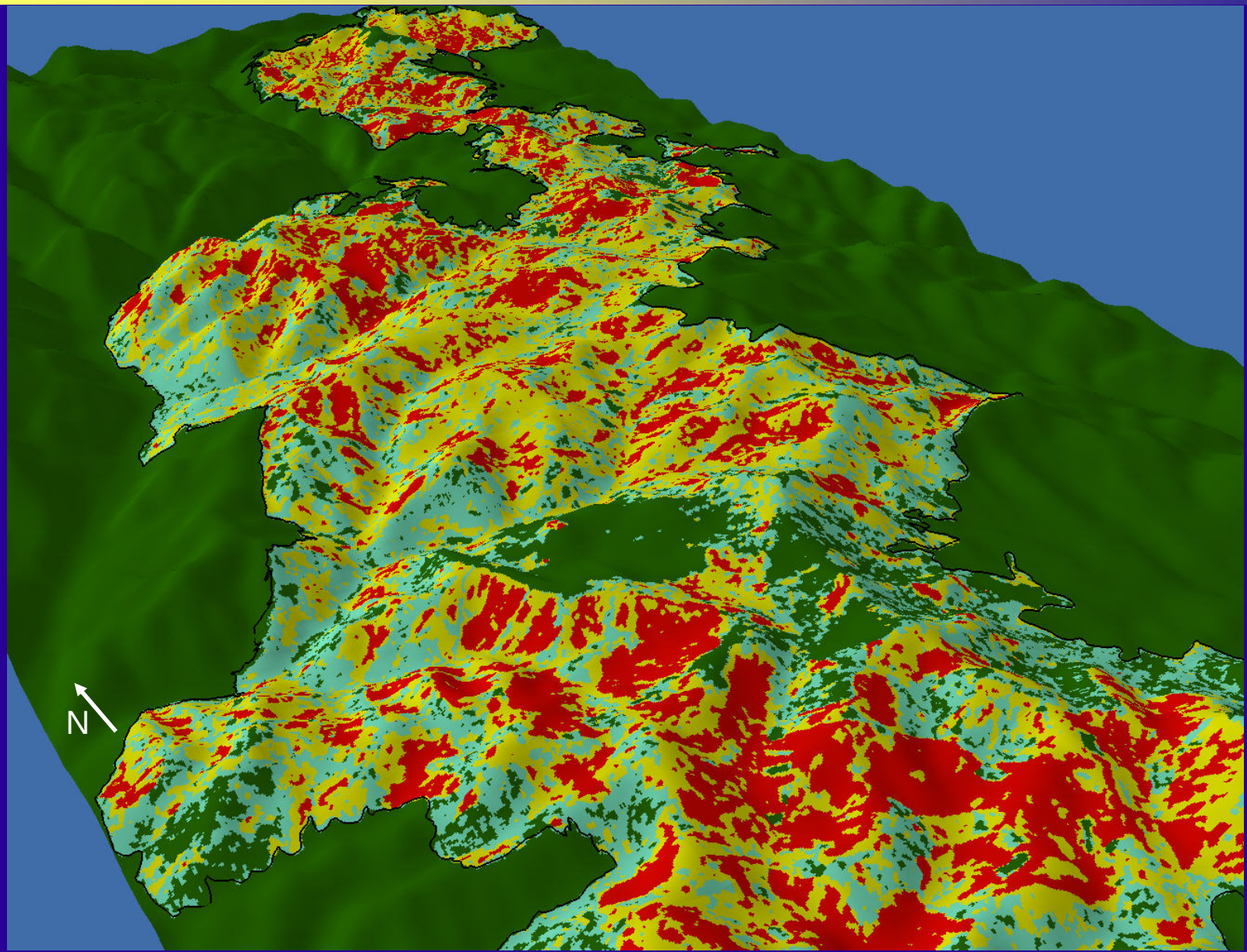
Burn Area Emergency Response (BAER) Support

- Imagery and Burn Area Reflectance Classification (BARC) used to:
  - Derive preliminary estimates of burn severity - rapidly
  - Identify areas of greatest concern
  - Predict runoff response in hydrologic models
  - Create 3-D models of the burned area
  - Prepare graphics for BAER team and public meetings
  - Since 2001 mapped 7.9 million acres on 281 BAER fires

Tripod Complex – Burn Area Reflectance Classification



Tripod Complex – Burn Area Reflectance Classification

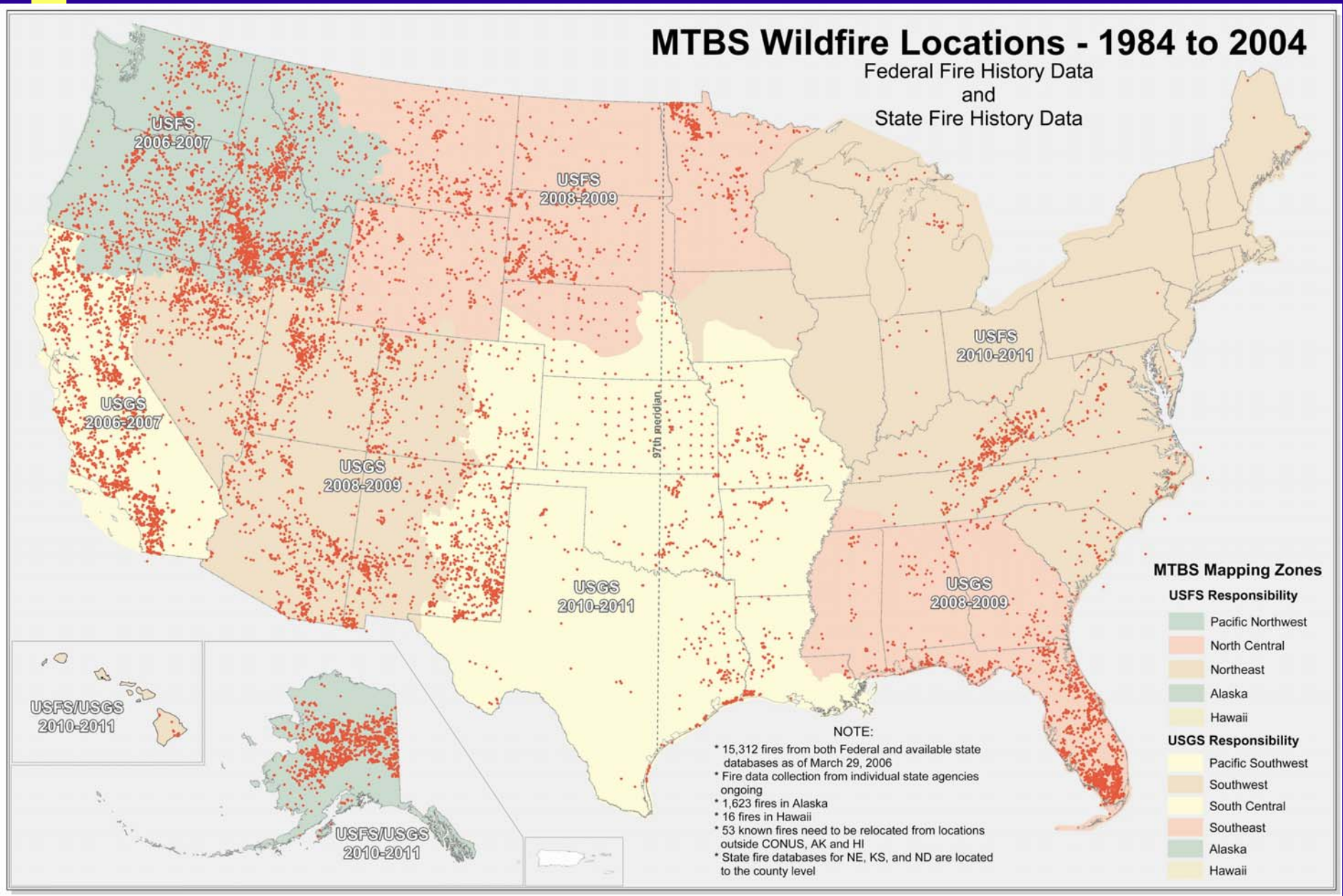


Monitoring Trends in Burn Severity (MTBS)

- Primary objective: Provide for a national analysis of trends in burn severity for the National Fire Plan
- Secondary objective: Provide consistent and comprehensive information about wildfire effects to land managers and the scientific community

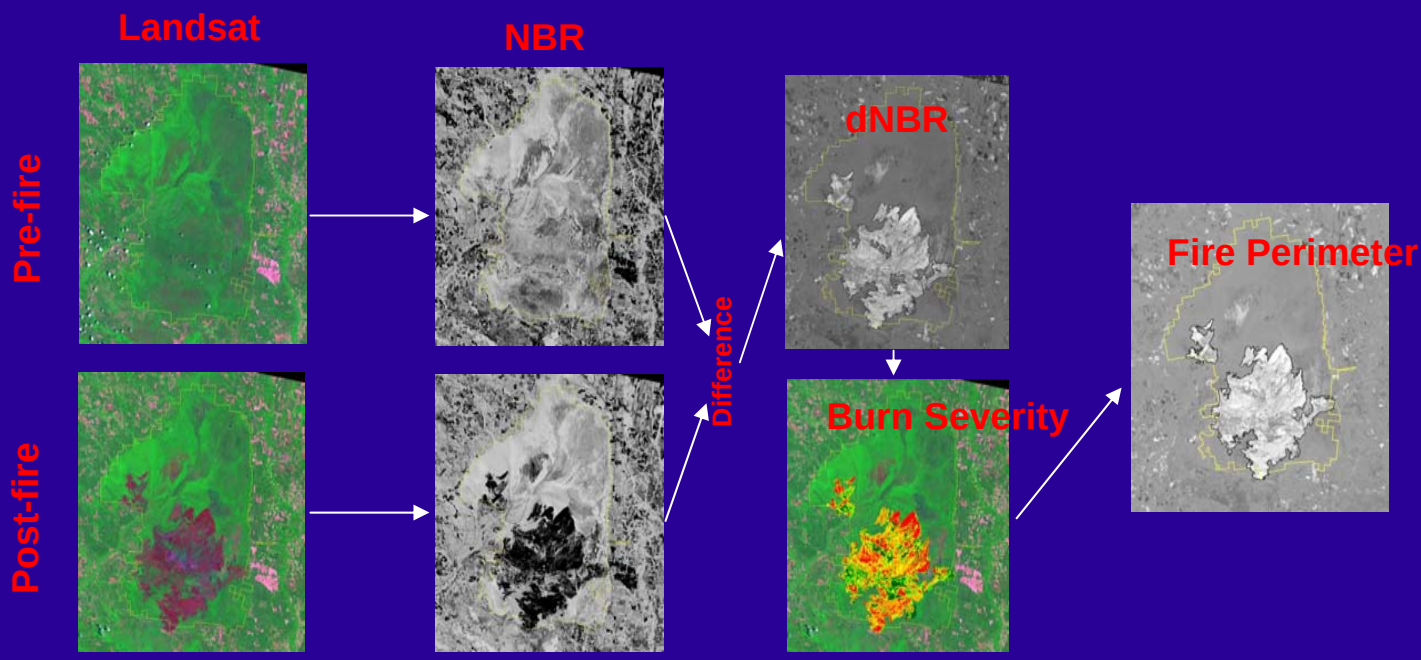
MTBS Products

- Burn severity data on all fires >1000 ac (385 ha) west of the 97th meridian and >500 ac (192 ha) east
  - Thematic and continuous Landsat TM, ETM 30m raster layers
- Fire perimeters
  - Shape files
- Tabular data summarizing burn severity acres by class
  - Additional stratification by vegetation type, treatment zones, condition classes, etc.
- Metadata
- Analysis performed by US Forest Service RSAC, and the US Geological Survey, EROS Data Center


MTBS Wildfire Locations - 1984 to 2004
Federal Fire History Data
and
State Fire History Data
USFS 2006-2007
USFS 2008-2009
USFS 2010-2011
USGS 2006-2007
USGS 2008-2009
USGS 2010-2011
USGS 2008-2009
97th meridian
USFS/USGS 2010-2011
USFS/USGS 2010-2011
NOTE:
* 15,312 fires from both Federal and available state databases as of March 29, 2006
* Fire data collection from individual state agencies ongoing
* 1,623 fires in Alaska
* 16 fires in Hawaii
* 53 known fires need to be relocated from locations outside CONUS, AK and HI
* State fire databases for NE, KS, and ND are located to the county level
MTBS Mapping Zones
USFS Responsibility
Pacific Northwest
North Central
Northeast
Alaska
Hawaii
USGS Responsibility
Pacific Southwest
Southwest
South Central
Southeast
Alaska
Hawaii

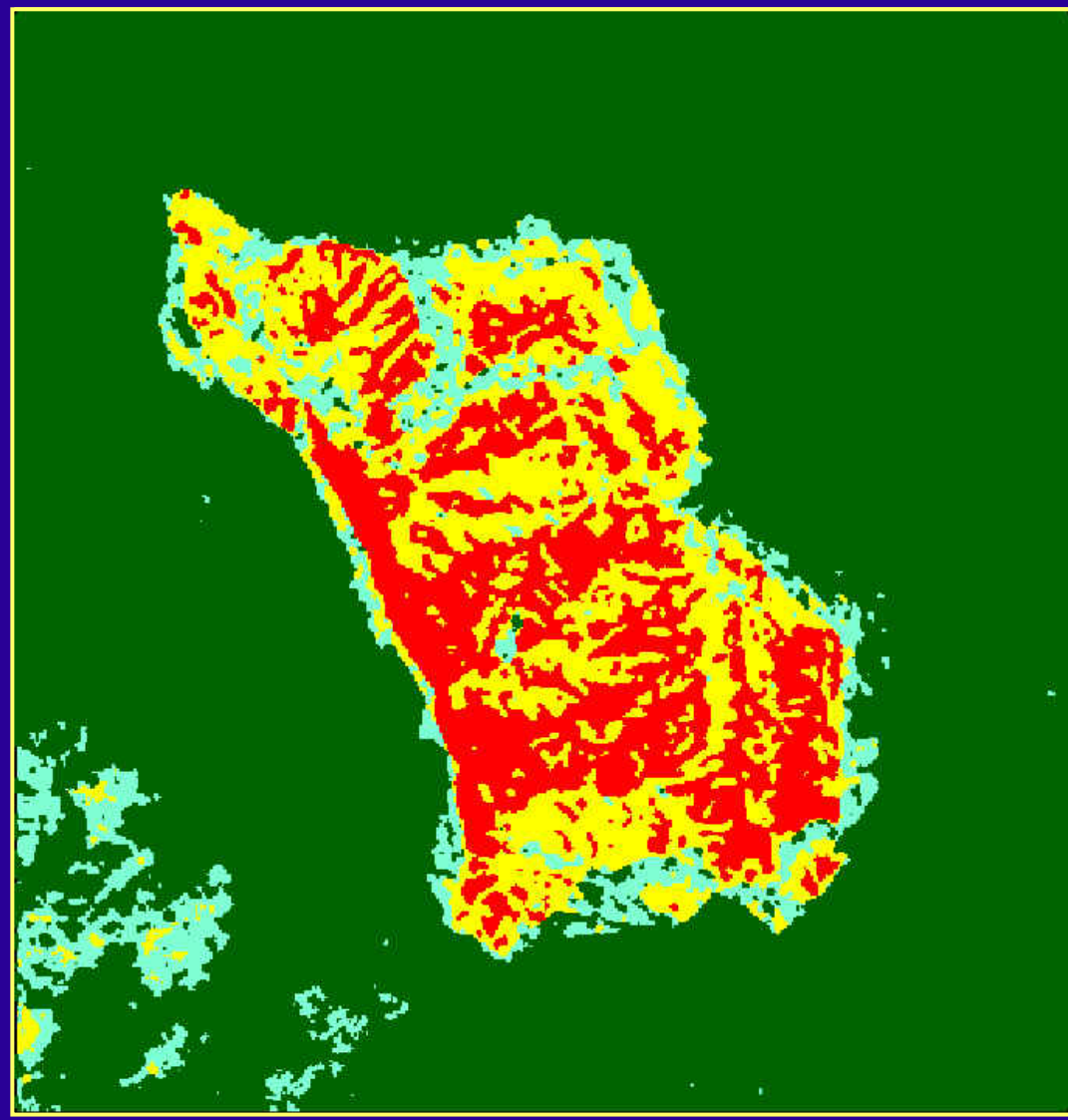
MTBS Method Outline

- Compile a single MTBS fire occurrence database from existing sources
- Based on fire occurrence database, select pre and post-fire LANDSAT TM, ETM scenes
- Data processed at EROS-terrain correction through NBR calculations
- EROS and RSAC analysts perform differencing and threshold dNBR images into burn severity classes
- Data summary and trends analysis



MTBS Methods - Burn Severity Map Development

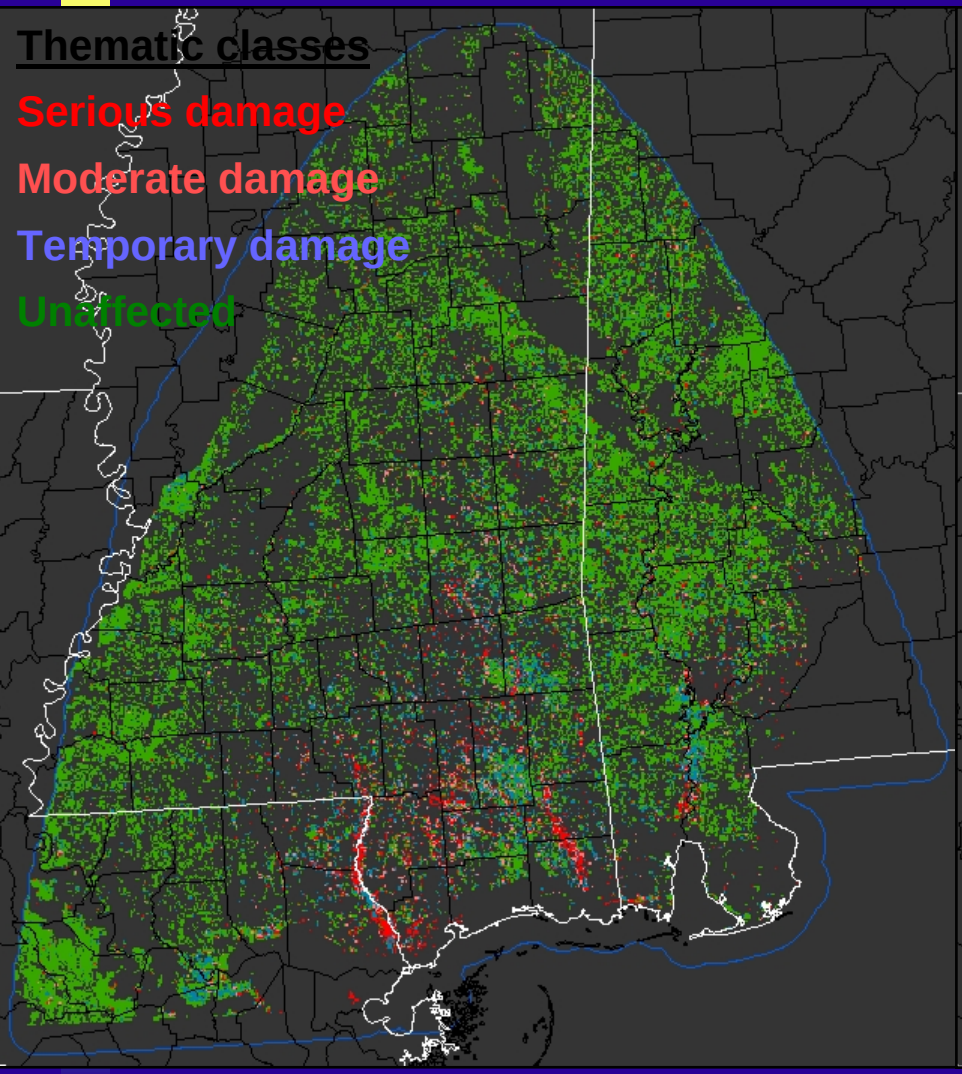
- Differenced NBR images are interpreted to derive 4 severity classes (unburned, low, moderate, high)
- Analysts use existing Composite Burn Index (CBI) thresholds (Key, 2001) as guidance for choosing severity thresholds

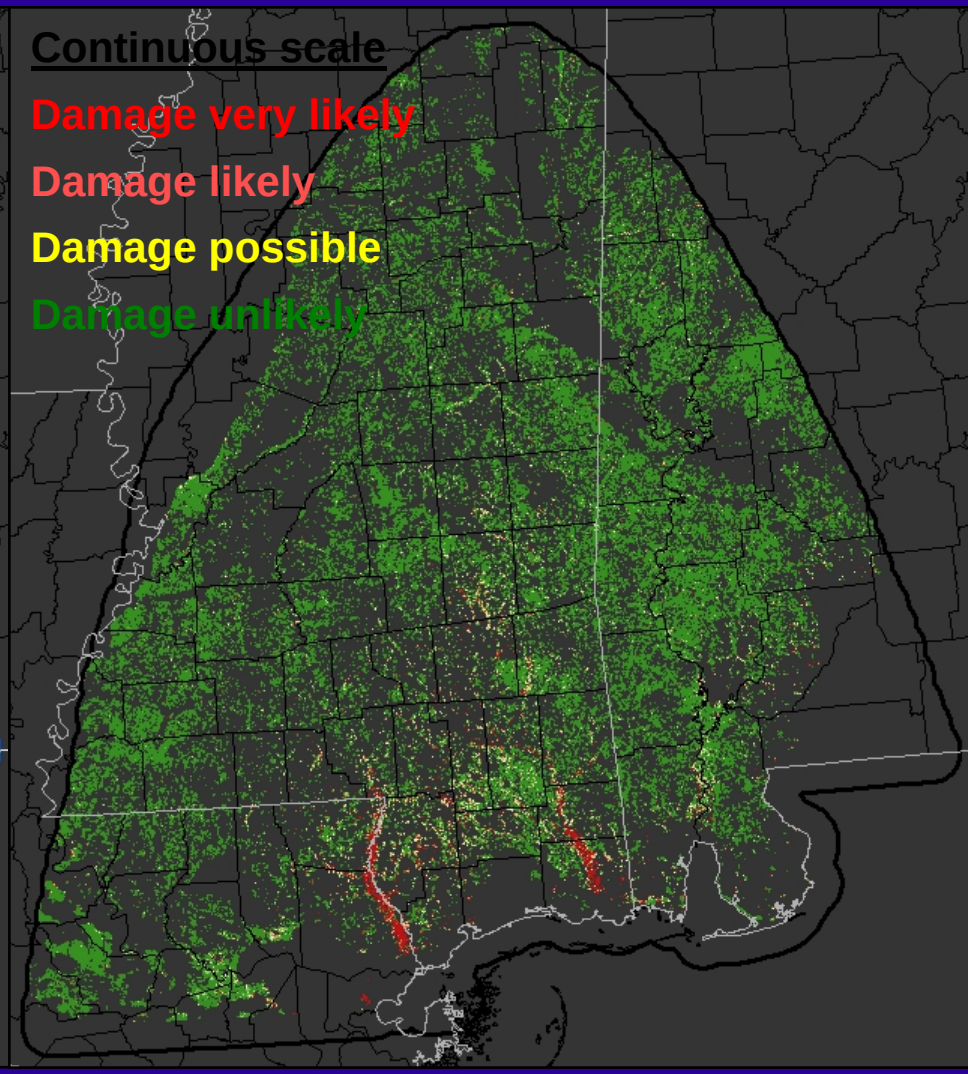


Forest Monitoring

- Storm Damage Assessment
- Forest Health Monitoring – Change Detection

MODIS 250 m Rapid Assessment Test - Katrina





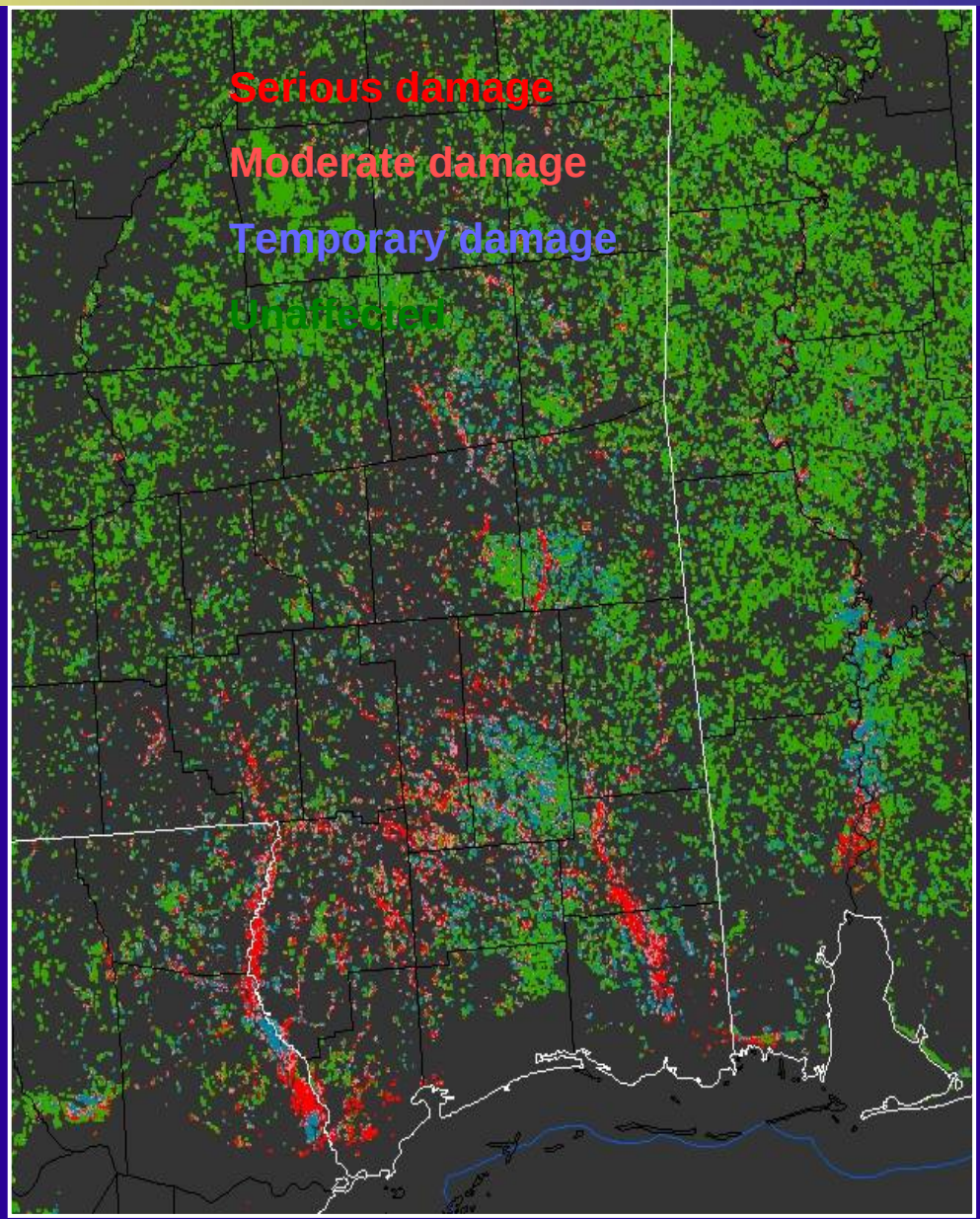
- Damage map produced using time-series data through 2.5 months after hurricane.

- Damage likelihood produced using data available 3 days after hurricane.

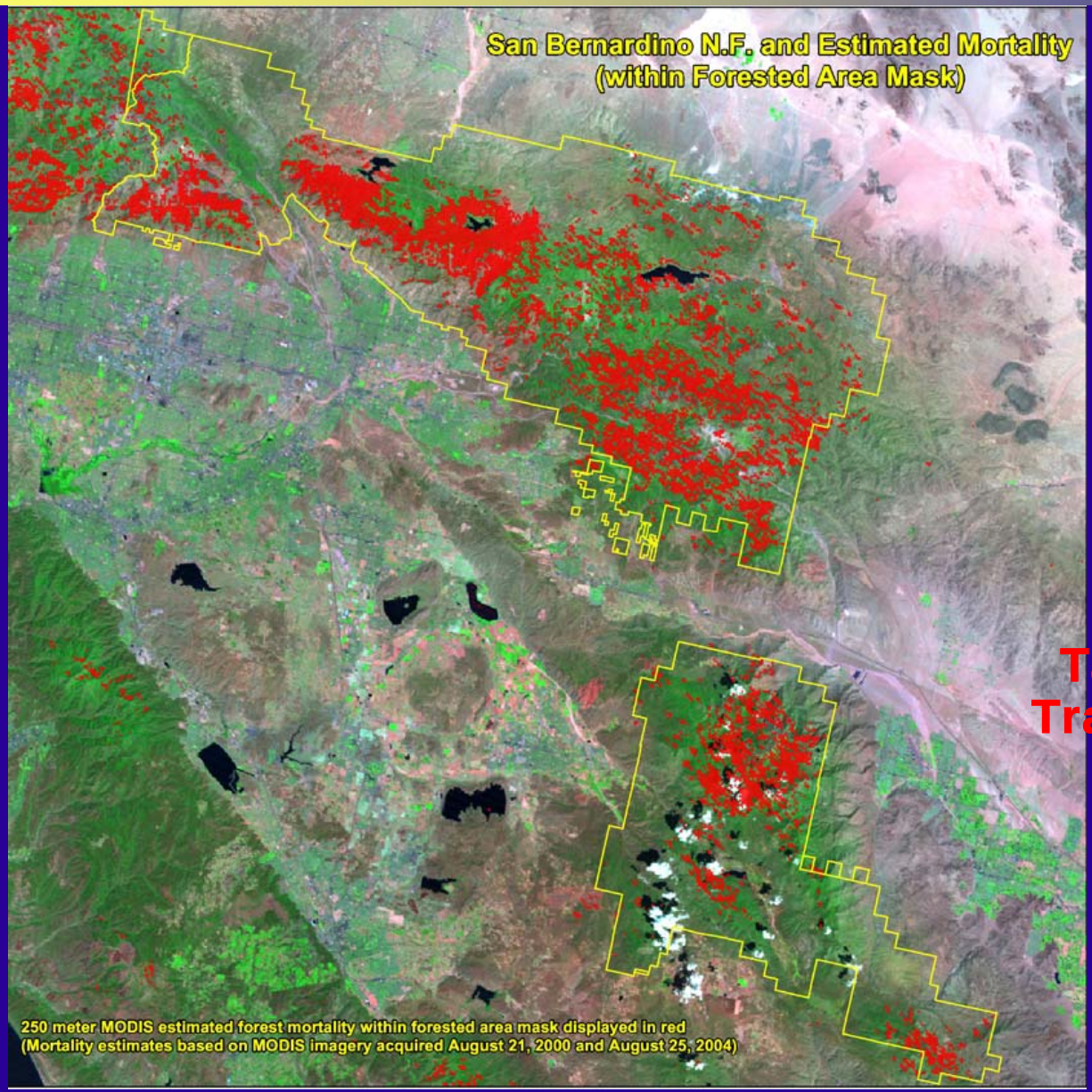
MODIS 250 m Rapid Assessment Test - Katrina

Closeup of heavily damaged coastal region.

Damage map produced using NDVI time-series data from before Katrina until 2.5 months after.

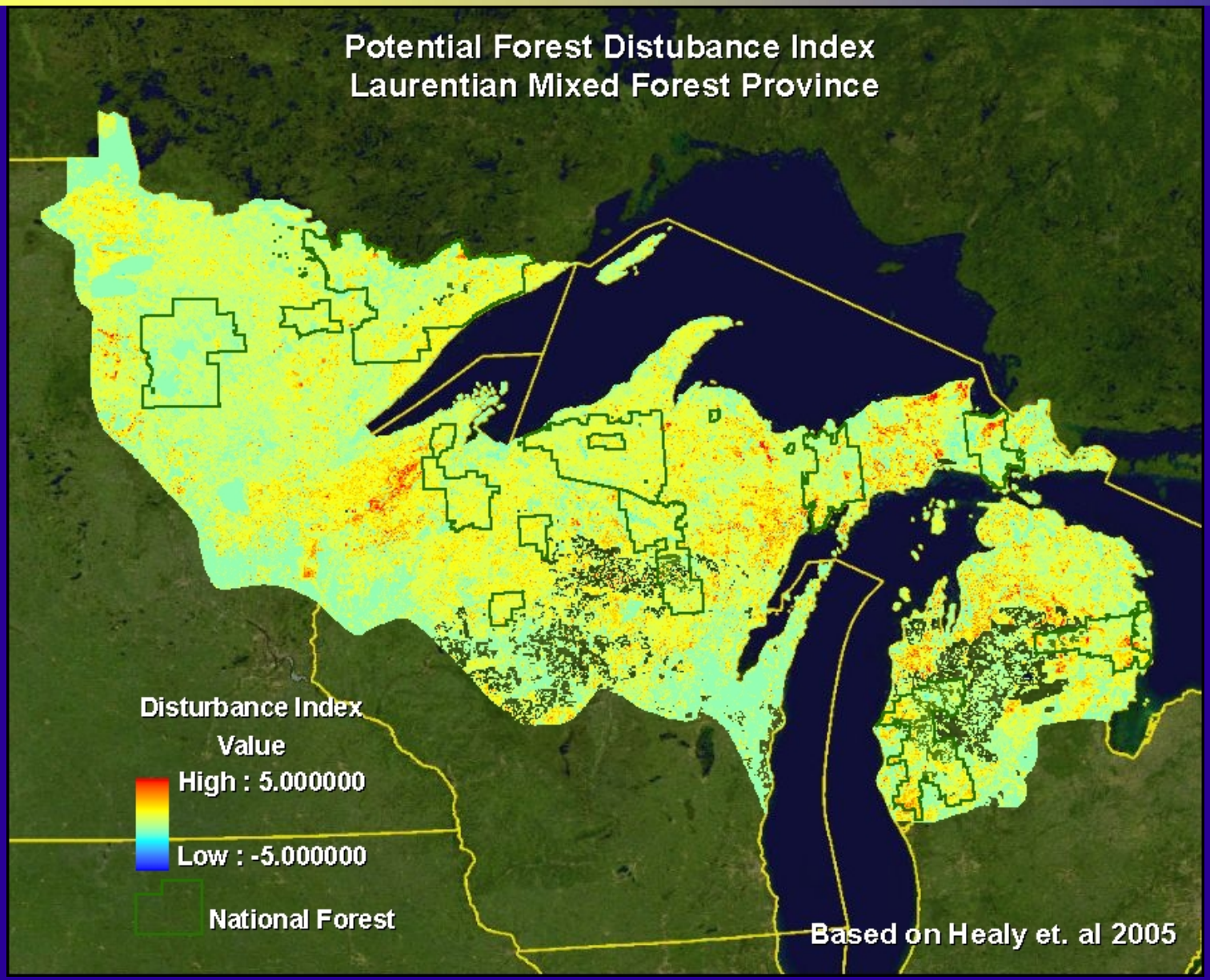


MODIS Derived Forest Mortality Mask



Tasseled Cap Transformation – 500 m

MODIS Derived Forest Disturbance Index



Additional Information

USDA Forest Service Remote Sensing Applications Center

http://fs.fed.us/eng/rsac

http://activefiremaps.fs.fed.us