USDA Forest Service Remote Sensing Applications Center
Operational Remote Sensing Support Programs

USDA Imagery Planning and Coordination
December 2-4, 2008

Remote Sensing Applications Center (RSAC)

RSAC Mission:

- Technical support - evaluating and developing remote sensing, image processing, GPS, and related geospatial technologies.
- Project support and assistance using remote sensing technologies.
- Technology transfer and training to field users.
- Operational support for active wildland fire management and post-fire assessment.

RSAC Operations Program Support

Active Fire Assessment

- MODIS Active Fire Mapping Program
  - Support USFS and all wildland fire management agencies
    - Near Real-time Assessment

Post-fire Assessment

- Burned Area Emergency Response (BAER) Imagery Support
  - Support USFS BAER teams
    - Emergency Assessment
- Rapid Assessment of Vegetation Condition after Wildfire (RAVG)
  - Support Forest Silviculturists
    - Rapid Assessment

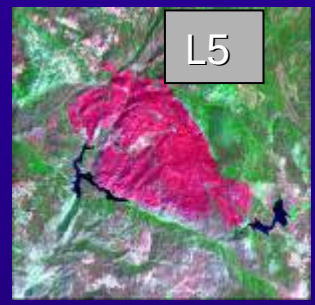
Post-Catastrophic Wx Event Assessment

- Rapid Assessment of Forest Damage
  - Support USFS units (National Forests/Districts)
    - Rapid Assessment

RSAC Operations Program Support

Currently Leveraged Sensor Assets

Landsat 5 and Landsat 7 (SLC-Off)
ASTER
SPOT 4 and 5
AWiFS
NASA Ikhana AMS
Disaster Monitoring Constellation (DMC)
MASTER
IKONOS
Quickbird
MODIS
AVHRR
GOES



Forest Service MODIS Active Fire Mapping Program

- Satellite-based operational detection and monitoring of wildland fire activity in CONUS, Alaska, Hawaii & Canada
- Generate and provide "value added" fire mapping and visualization products, and geospatial data
- Facilitates decision support for strategic wildfire planning and response for U.S. and Canadian fire agencies
  - Prioritize allocation of fire suppression assets
  - Focus tactical airborne reconnaissance assets
  - Supports several fire-related applications and decision support systems

Forest Service MODIS Active Fire Mapping Program

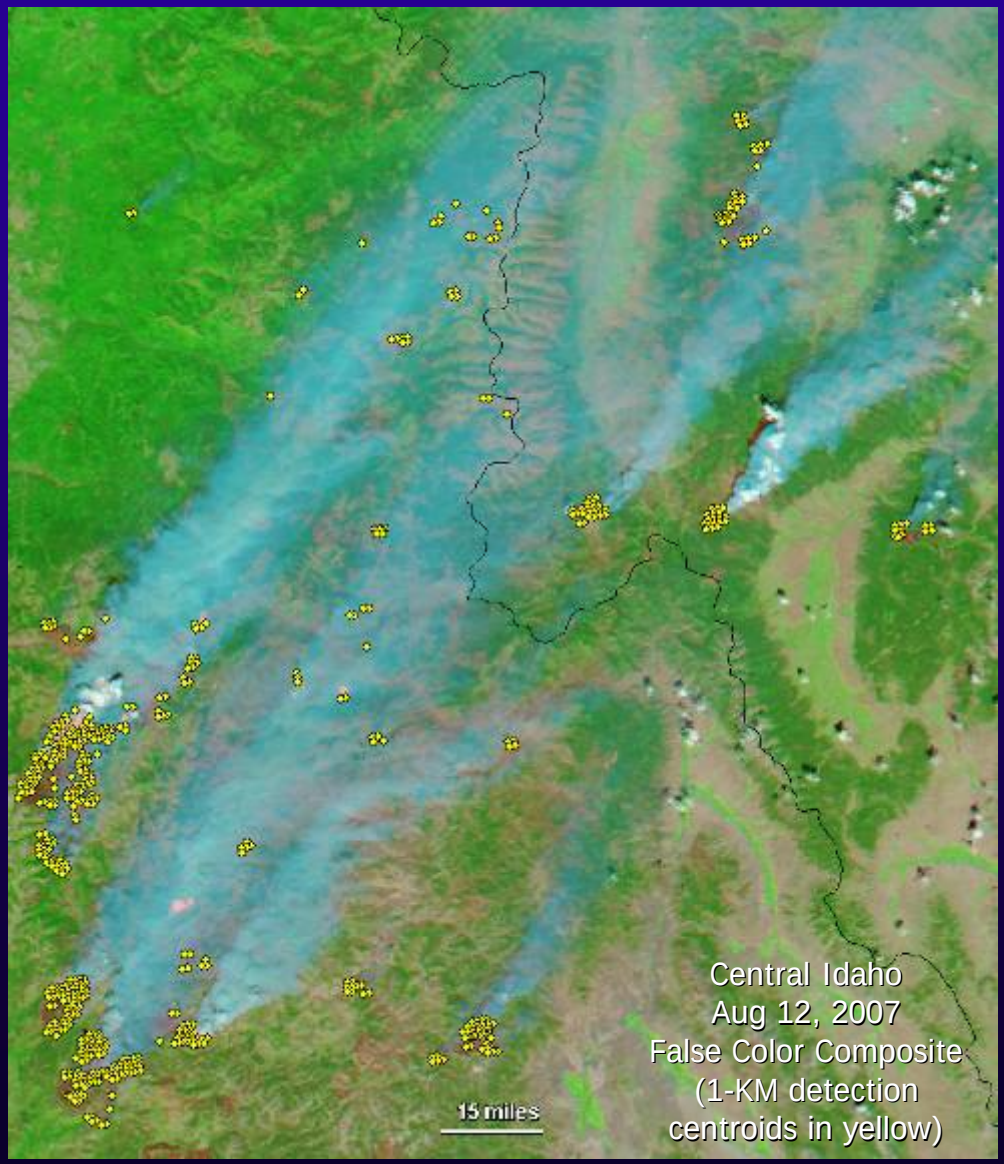
Currently Leveraged Sensor Assets

Sensor	Platform Type	Spatial Resolution (Reflectance/TIR Bands)	Temporal Resolution (per instrument)	Fire Algorithm	Data Source
MODIS	Polar orbiting	250m, 500m, 1km/1km	2 times daily	MOD14/MYD14	Direct Readout; NASA Rapid Response System
AVHRR	Polar orbiting	1km/1km	2 times daily	FIMMA	NOAA NESDIS
GOES	Geostationary	1km/4km	4 times hourly	WF-ABBA	NOAA NESDIS
VIIRS*	Polar orbiting	375m/750m	2 times daily	TBD	Direct Readout; Rapid Response
GOES-R#	Geostationary	500m, 1km/2km	4 times hourly	TBD	Direct Readout; NOAA NESDIS

* VIIRS launch on NPOESS Preparatory Project (NPP) mission in June 2010 and subsequent NPOESS missions

GOES-R launch in 2015 and subsequent missions

MODIS Fire & Thermal Anomalies (MOD14/MYD14)

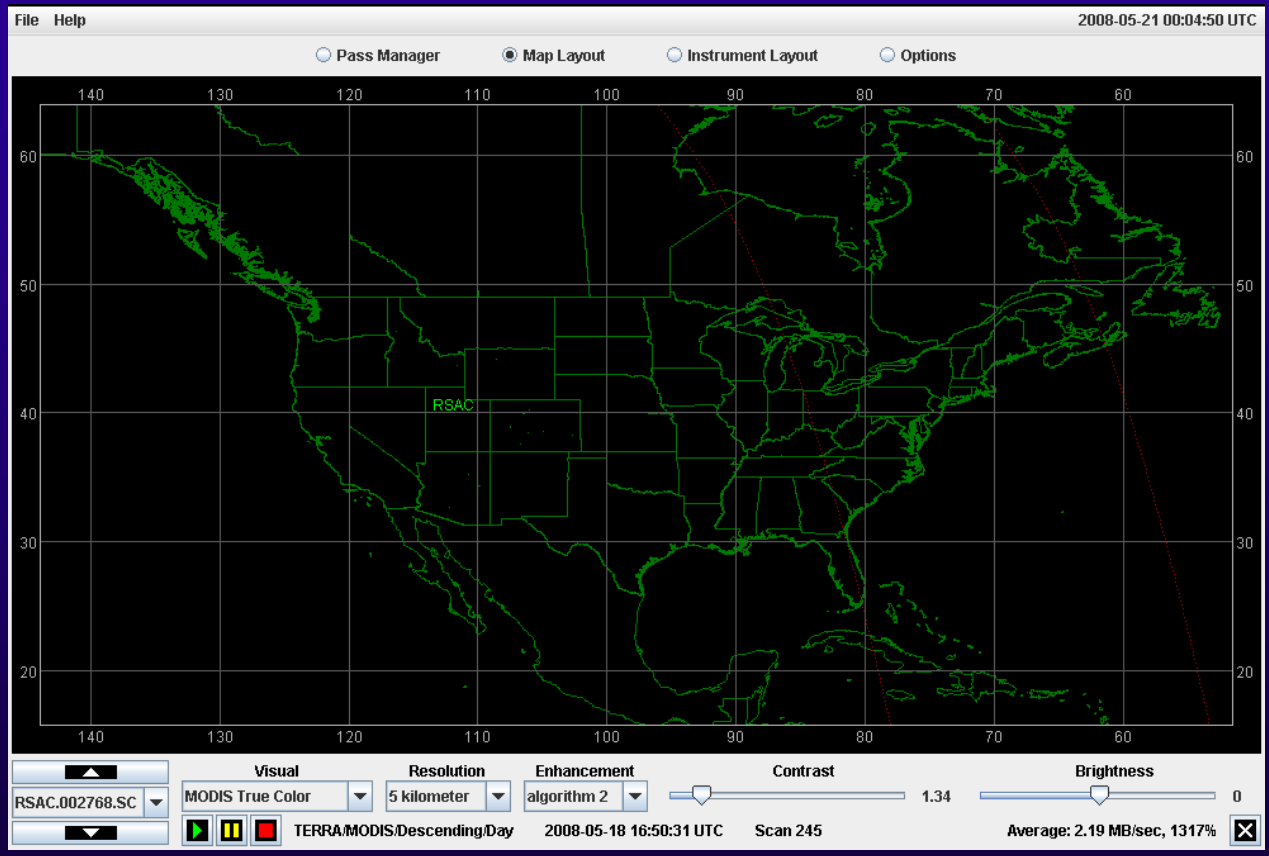


Central Idaho
Aug 12, 2007
False Color Composite
(1-KM detection
centroids in yellow)

- See Giglio et al. (2003) in *Remote Sensing of Environment*
- Detects & characterizes fire at 1km spatial resolution
- Leverages response of 4μm and 11μm bands to fire
- Absolute thresholds and contextual analysis
- Fire detection is affected by several variables
  - Atmospheric conditions, view angle, land cover, overpass time relative to fire activity, etc.
- Fire activity smaller than 1km can be detected
  - $100m^2$ flaming fire (50% probability)
  - $50m^2$ flaming fire in ideal viewing conditions (~100% probability)

RSAC MODIS Direct Broadcast/Direct Readout

May 18, 2008 daytime MODIS acquisitions by RSAC ground station



NASA Simulcast Viewer

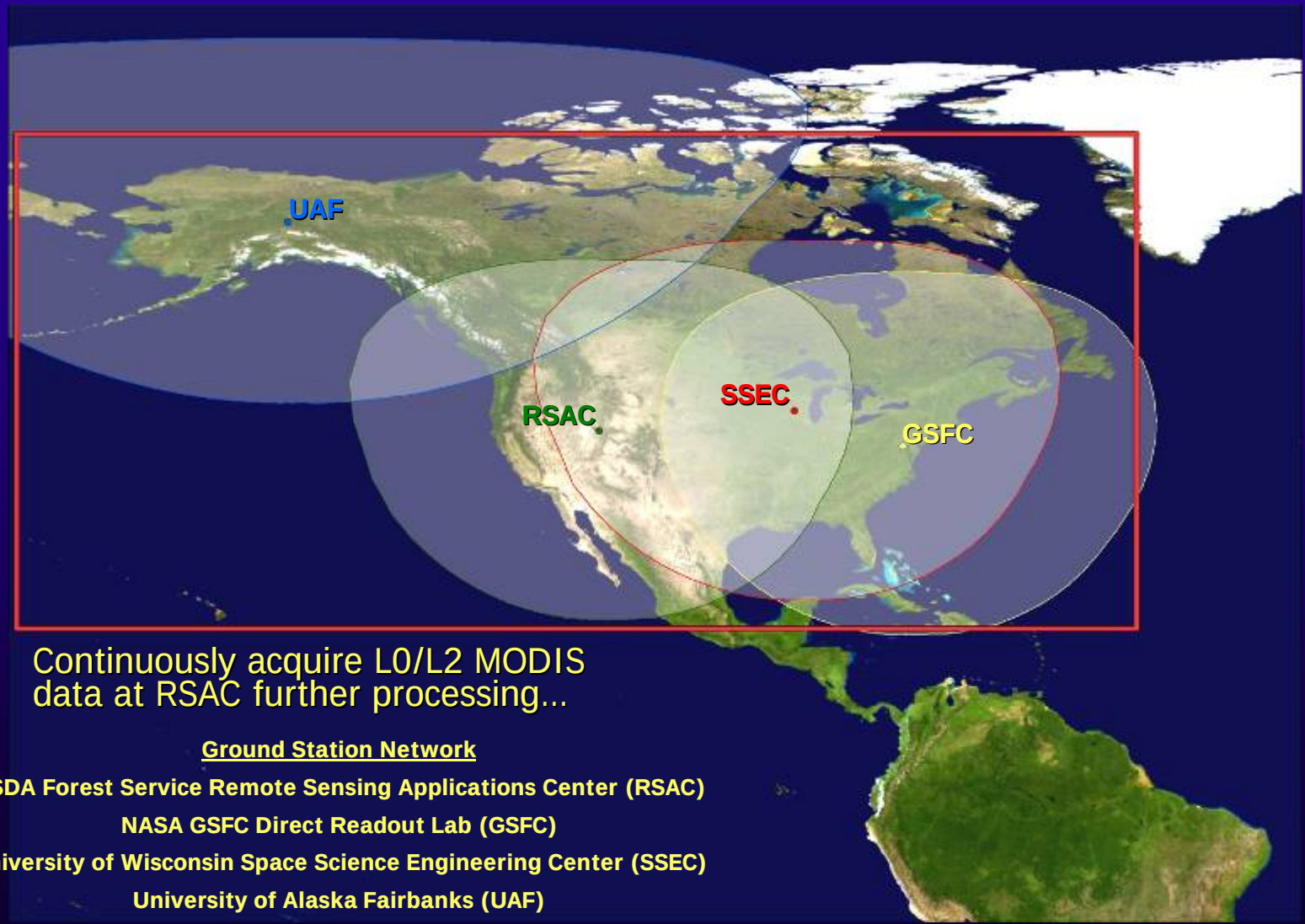
Direct Broadcast (DB)

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 Direct Readout Ground Station Network



Continuously acquire L0/L2 MODIS data at RSAC further processing...

Ground Station Network

USDA Forest Service Remote Sensing Applications Center (RSAC)

NASA GSFC Direct Readout Lab (GSFC)

University of Wisconsin Space Science Engineering Center (SSEC)

University of Alaska Fairbanks (UAF)

NASA MODIS Rapid Response System provides global coverage; backs up ground station network

Forest Service MODIS Active Fire Mapping Program

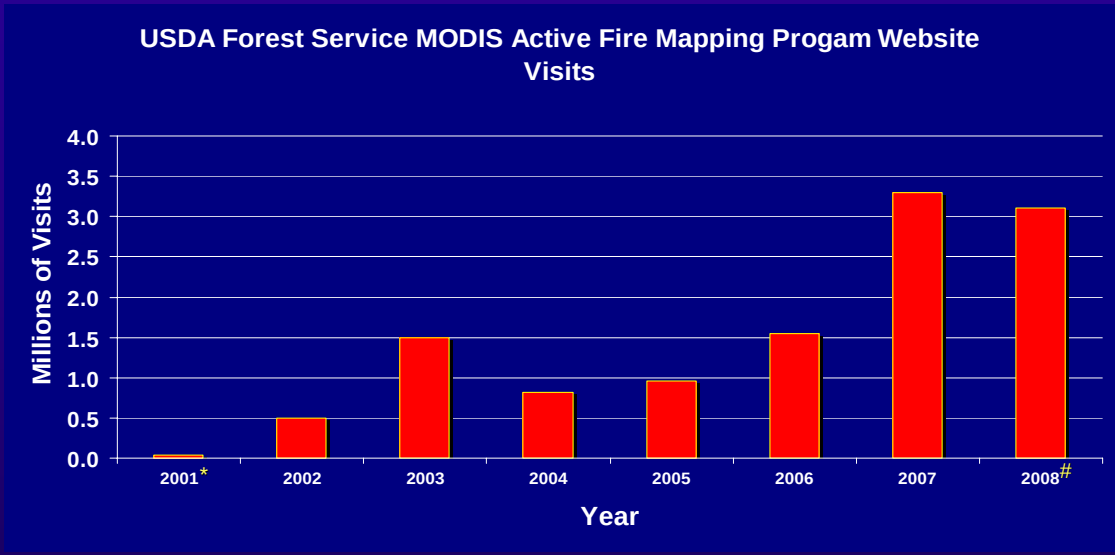
Value-Added Mapping/Visualization Products and Geospatial Data

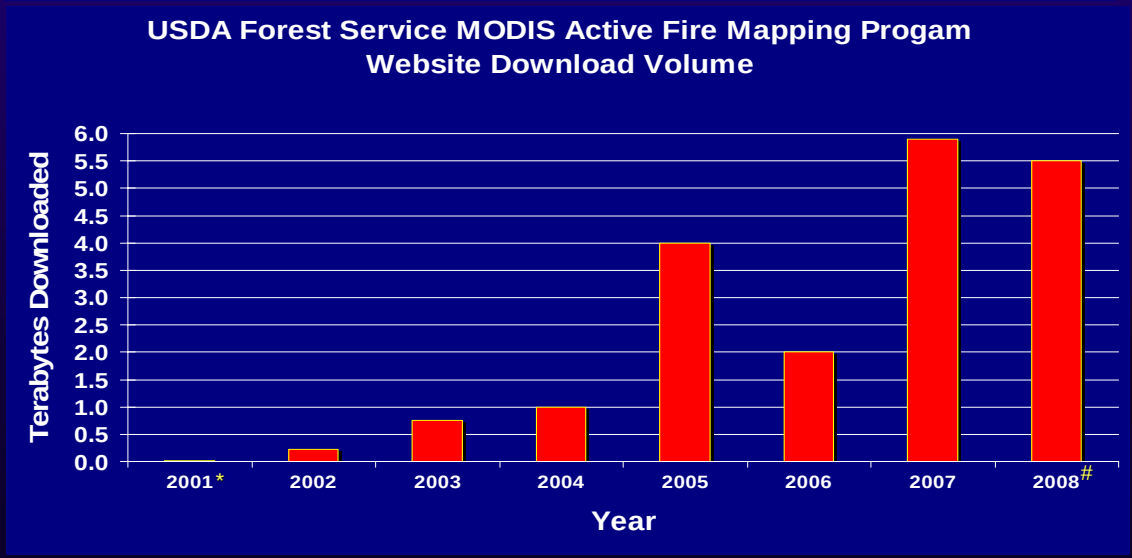
- Printable maps
- Interactive web maps
- KMLs
- Fire detection GIS data
- True & False color image subsets
- Analysis Products

Northern California – June 27, 2008

MODIS Active Fire Mapping Program Usage

USDA MODIS Active Fire Mapping Program Website Stats 2001-2008





* - complete statistics not available for 2001; # - statistics through November 27, 2008

Burned Area Emergency Response (BAER)

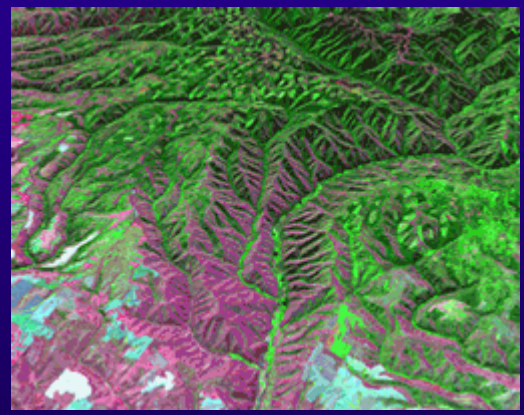
- Objective is to prescribe and implement emergency stabilization measures in order to prevent further damage to life, property and natural resources
- BAER teams are deployed to fires where special efforts are required to mitigate potential hazards resulting from fire effects
- Post-fire damage assessment
  - Focus on soil and water quality effects
  - Calculate potential erosion and debris flows
  - Determine values at risk downstream
  - Identifies priority areas to be treated
  - Determine appropriate treatments that help to mitigate some of the risk
- Response plan is required within 7 days of fire containment
- RSAC remote sensing support is critical in generating the BAER response plan


Straw waddles on Pike-San Isabel NF


Contour logging on Shasta-Trinity NF

Burned Area Emergency Response Imagery Support

- Objective is to provide rapid delivery of remote sensing products to Forest Service BAER teams
  - Pre-/Post-fire satellite imagery
  - Burned Area Reflectance Classifications (BARC)
  - Other relevant geospatial data and products
- RSAC remote sensing support provided at or immediately after fire containment
- RSAC provides imagery and data products within 24 hours of image acquisition
- Multiple BAER teams/wildland fire incidents are supported simultaneously by RSAC
- Critical technical factors:
  - Spatial resolution – 20 to 30m
  - Spectral resolution – SWIR band
  - Acquisition timing – at or near fire containment
  - Delivery from provider – FTP; same day of acquisition



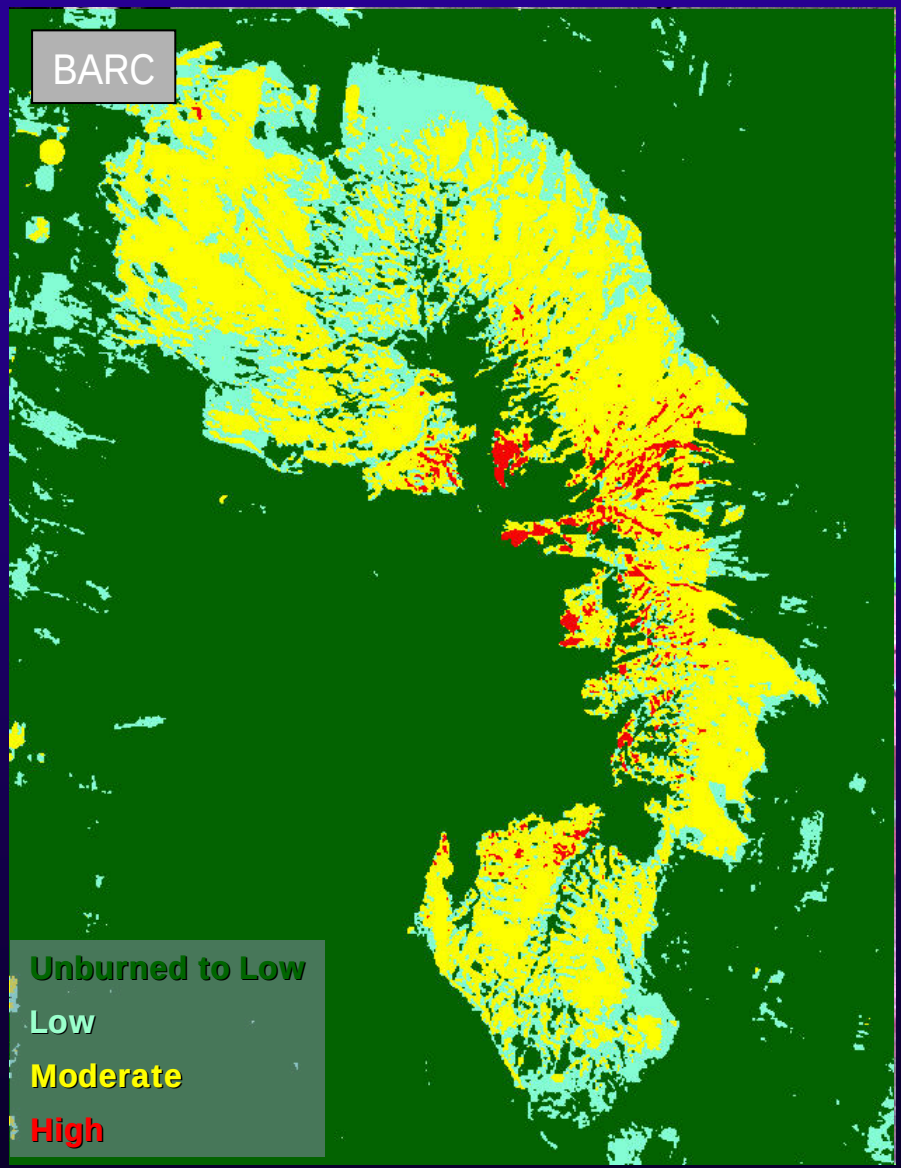
Burned Area Emergency Response Imagery Support

Frequently Leveraged Sensor Assets

Sensor	Platform Type	Spatial Resolution (Reflectance Bands)	Temporal Resolution (per instrument)	Data Source
Landsat 5	Polar orbiting	30m	16 days	USGS EROS
Landsat 7 (SLC-off)	Polar orbiting	30m	16 days	USGS EROS
AWiFS	Polar orbiting	56m	5 days	USDA-FAS-SIA
SPOT 4	Polar orbiting	20m	2-3 days (pointable)	SPOT Image
SPOT 5	Polar orbiting	10m/20m	2-3 days (pointable)	SPOT Image
ASTER[1]	Polar orbiting	15m/30m	4-16 days (pointable)	NASA/USGS EROS
NASA AMS	Airborne (UAV)	~ 21m	--	NASA
LDCM[2]	Polar orbiting	30m	16 days	USGS EROS

1 – Anomalous SWIR band issues since April 2008; 2 - LDCM launch currently scheduled for July 2011

Creation of the BARC



Black Pine 2 Fire
Sawtooth NF
73,000 Acres

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

NBR = (NIR – SWIR) / (NIR + SWIR)

dNBR = Pre NBR – Post NBR

Normalized Difference Vegetation Index (NDVI)
Differenced NDVI (dNDVI)

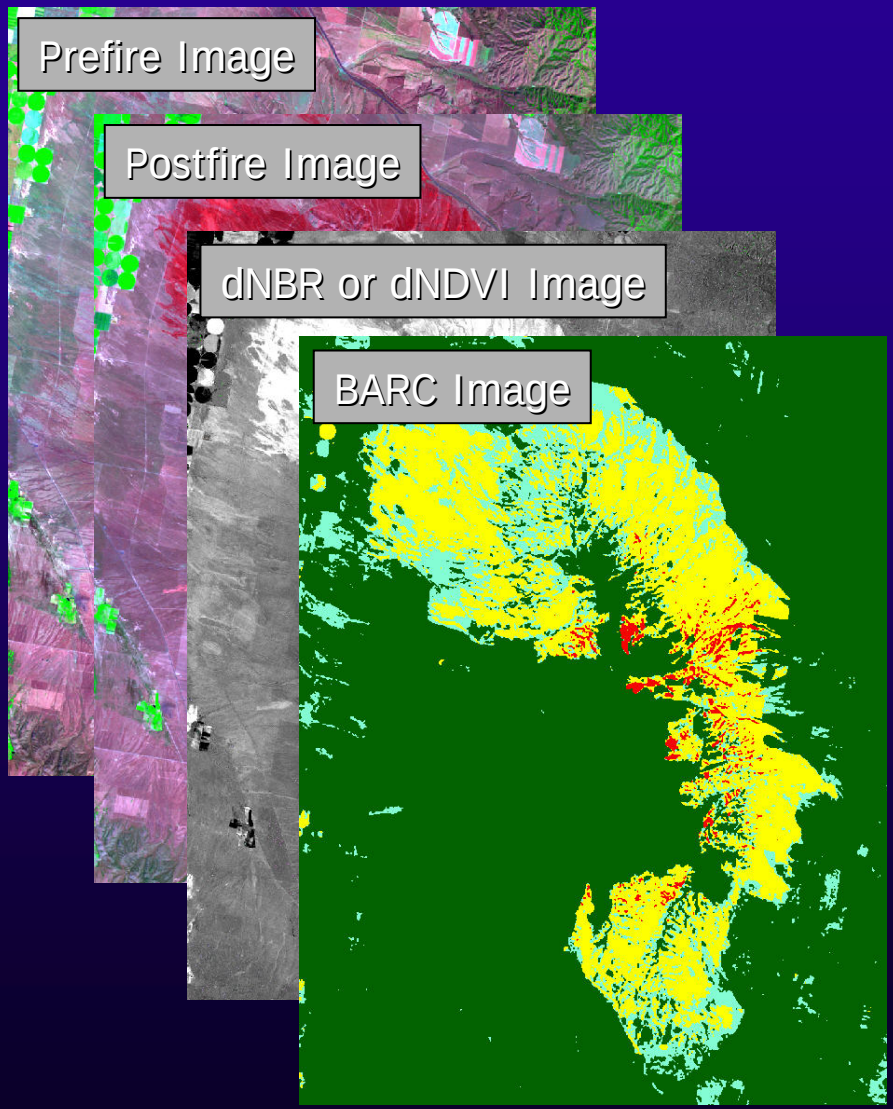
NDVI = (NIR – Red) / (NIR + Red)

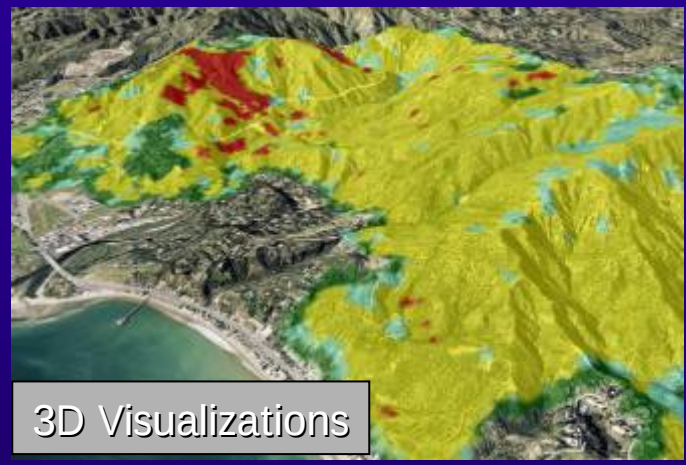
dNDVI = Pre NDVI – Post NDVI

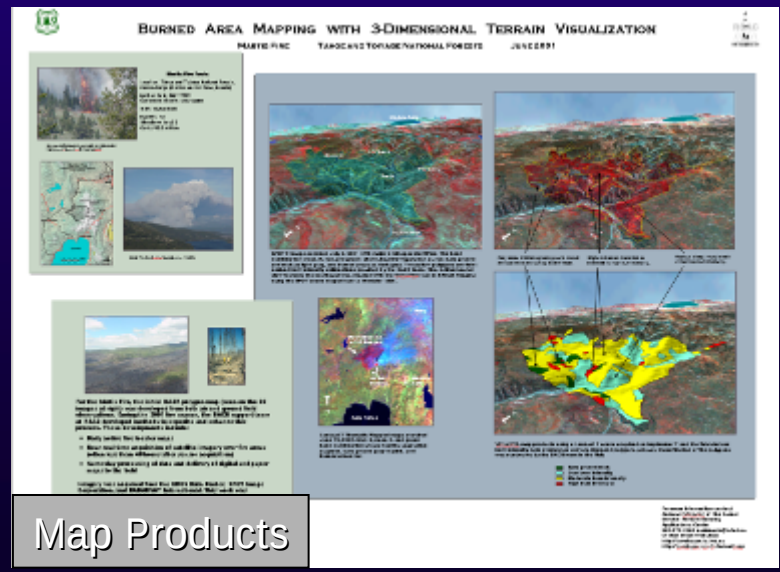
dNDVI is utilized when appropriate SWIR band is not available

Burned Area Emergency Response Imagery Support

BAER Support Rapid Delivery Products







Burned Area Emergency Response Imagery Support

BAER Imagery Support Statistics (2001-2008)

	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
Sum	**188**	**11,562,071**	**434**	**11,841,324**	**622**	**23,405,565**

Collaborative effort between USFS-RSAC and USGS-EROS

So far this year (2008): 97 fires, 1.7 million acres of USFS support

Post-Fire Vegetation Management on National Forest System Lands

- Available resources to support reforestation in burned areas are limited, consequently, better prioritization is needed
- USFS Region 5 facilitated a protocol for rapid identification of deforestation and reforestation need on National Forest System lands
- Post-fire damage assessment
  - Leverage relationship of satellite-based burn severity observations to CBI field data that quantify fire effects to vegetation (deforestation)
  - Spatially represent forested vs. deforested areas following wildfire
    - Levels of deforestation
  - Silviculturists use as a tool to identify and prioritize land suitable for reforestation
    - Natural Recovery
    - Assisted Recovery (planting, seeding or site preparation for natural recovery)

Ken Marchand (USFS)

Rapid Assessment of Vegetation Condition after Wildfire (RAVG)

- Objective is to provide timely geospatial and tabular summary products of fire effects on forest resources to silviculturists
  - Pre-Fire/Post-fire imagery and burn severity data
  - % basal area loss data/maps
  - Summary tables of vegetation groups, by % basal area change (basal area loss) land status and slope
- RSAC conducts a RAVG assessment on fires where > 1,000 acres of NFS forested land is affected
- RSAC provides RAVG data and summary products within 30 days of fire containment
- Multiple fires are supported simultaneously by RSAC
- Critical technical factors:
  - Spatial resolution – 20 to 30m
  - Spectral resolution – SWIR band
  - Acquisition timing - ~ 2 weeks following fire containment

Rapid Assessment of Vegetation Condition after Wildfire

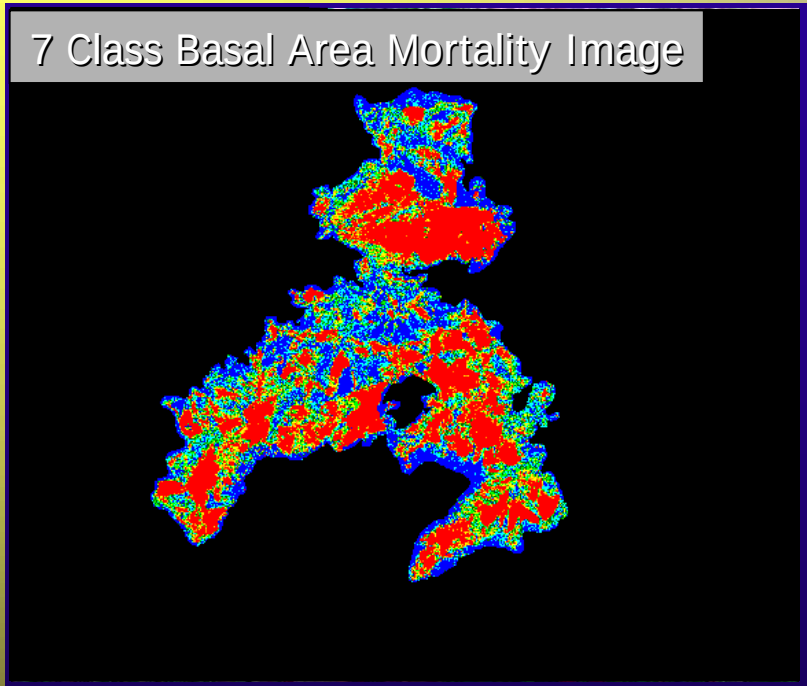
Frequently Leveraged Sensor Assets

Sensor	Platform Type	Spatial Resolution (Reflectance Bands)	Temporal Resolution (per instrument)	Data Source
Landsat 5	Polar orbiting	30m	16 days	USGS EROS
Landsat 7[1] (SLC-off)	Polar orbiting	30m	16 days	USGS EROS
AWiFS	Polar orbiting	56m	5 days	USDA-FAS-SIA
LDCM[2]	Polar orbiting	30m	16 days	USGS EROS

1 - Used only if fire area is outside of SLC-off affected area of image

2 – LDCM launch currently scheduled for July 2011

Creation of RAVG Analysis Products



Rombo Mtn Fire
Bitterroot NF
28,000 Acres

Normalized Burn Ratio (NBR)

$$NBR = (NIR - SWIR) / (NIR + SWIR)$$

Relative Differenced Normalized Burn Ratio (RdNBR)

$$RdNBR = \frac{(Pre\ NBR - Post\ NBR)}{SquareRoot(ABS(Pre\ NBR / 1000))}$$

Summary GIS Analysis Using:

- 7 Class % Change in Basal Area
- Ownership / Land Status
- LANDFIRE Existing Vegetation Groups
- Slope

Rapid Assessment of Vegetation Condition after Wildfire

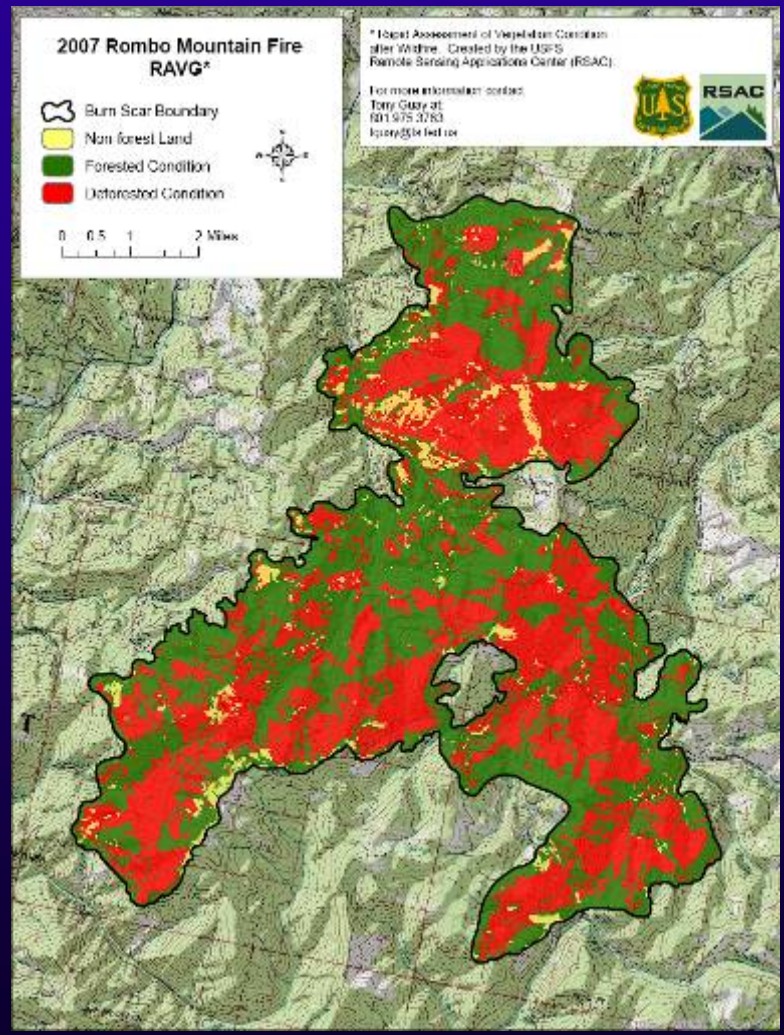
Primary RAVG Product Deliverables

2007 Rombo Mountain Fire - Bitterroot NF
Rapid Assessment of Vegetation Condition after Wildfire (RAVG)

Vegetation Group (LANDFIRE)*	Ownership / Status	Vegetation Condition	Slope	Acres
Grassland / Shrubland / Non Veg Total				**1,578**
Deciduous Open Tree Canopy	USFS	Forested	Flat (< 30%)	3
			Steep (> 30%)	2
		Deforested	Flat (< 30%)	2
			Steep (> 30%)	3
Deciduous Open Tree Canopy Total				**9**
Evergreen Closed Tree Canopy	USFS	Forested	Flat (< 30%)	4,116
			Steep (> 30%)	4,446
		Deforested	Flat (< 30%)	3,284
			Steep (> 30%)	4,217
Evergreen Closed Tree Canopy Total				**16,062**
Evergreen Open Tree Canopy	USFS	Forested	Flat (< 30%)	2,717
			Steep (> 30%)	3,277
		Deforested	Flat (< 30%)	2,279
			Steep (> 30%)	3,197
Evergreen Open Tree Canopy Total				**11,470**
Mixed Evergreen - Deciduous Open Tree Canopy	USFS	Forested	Flat (< 30%)	197
			Steep (> 30%)	58
		Deforested	Flat (< 30%)	85
			Steep (> 30%)	28
Mixed Evergreen - Deciduous Open Tree Canopy Total				**368**
Grand Total				**29,488**

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

Vegetation/Burn Severity Summaries



Forested/Deforested Map Products

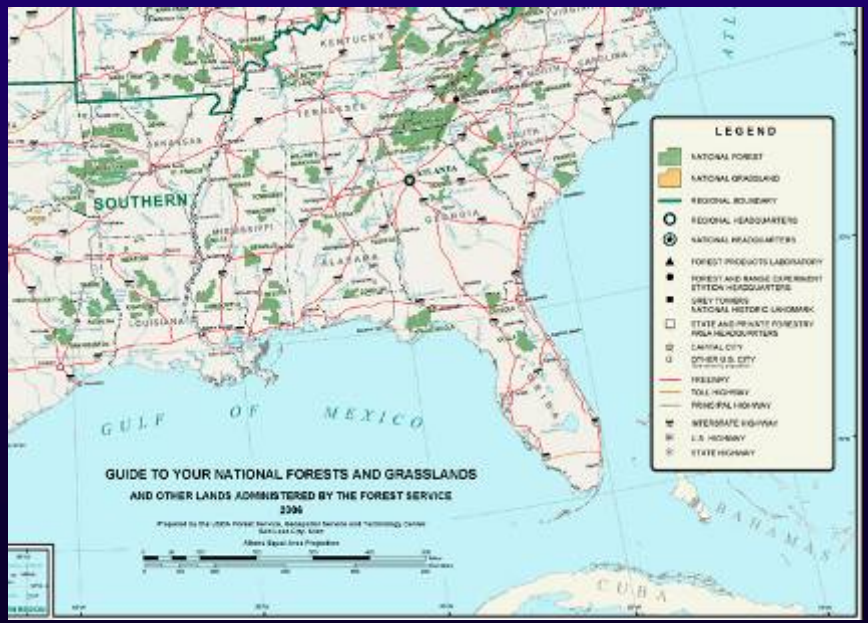
Rapid Assessment of Vegetation Condition after Wildfire

RAVG Support Statistics (2007-2008)

Year	Fires	Acres
2007	63	2,819,158
2008	54	1,369,677
Sum	**117**	**4,188,835**

Post-Catastrophic Wx Event Assessments

- Hurricanes can cause significant forest damage in National Forest System Lands of the southeastern United States
- RSAC is currently evaluating rapid response, moderate resolution change detection assessments for forested areas in the immediate aftermath of hurricanes and other catastrophic weather events (ice storms, etc.)
- Post Wx event damage assessment
  - Identify areas of potential forest damage that can be targeted/evaluated for salvage harvesting, fuel treatments and habitat restoration



Post-Catastrophic Wx Event Assessments

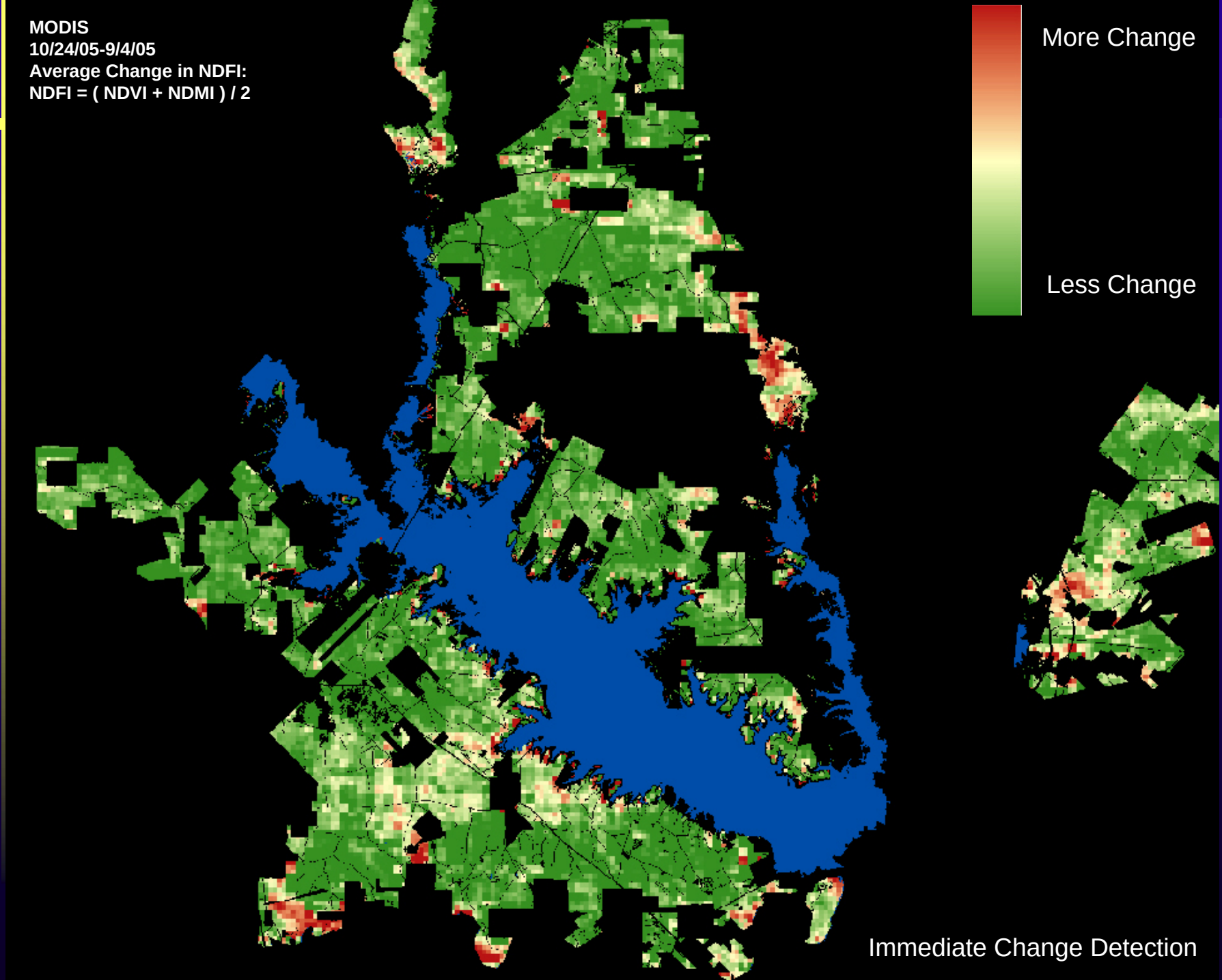
- Objective is to provide change detection products to NFS units within two weeks of storm event
  - Pre-Fire/Post-event imagery
  - Change detection products
- Feasibility evaluation is ongoing
  - Analysis of 2008 events
  - Analysis of selected pre-2008 events
- Conduct on impacted NFS lands and utilize field verification data provided by National Forests
- Critical technical factors:
  - Spatial resolution –moderate to coarse
  - Spectral resolution – SWIR band is desirable
  - Acquisition timing - ~ 2 weeks following fire containment
  - Pre/Post-event images – near nadir observations (optimum) with similar sensor geometry characteristics

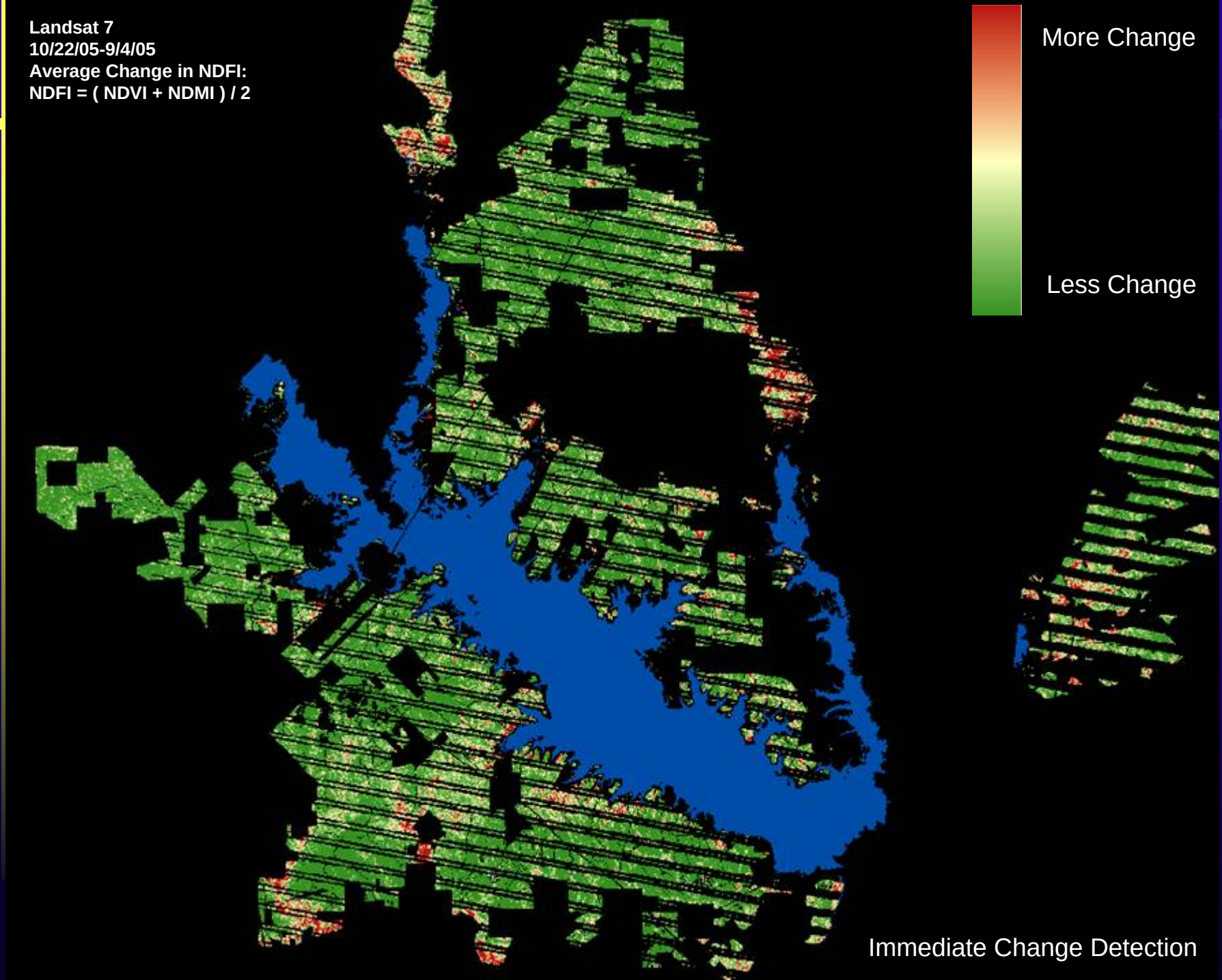
Post-Catastrophic Wx Event Assessments

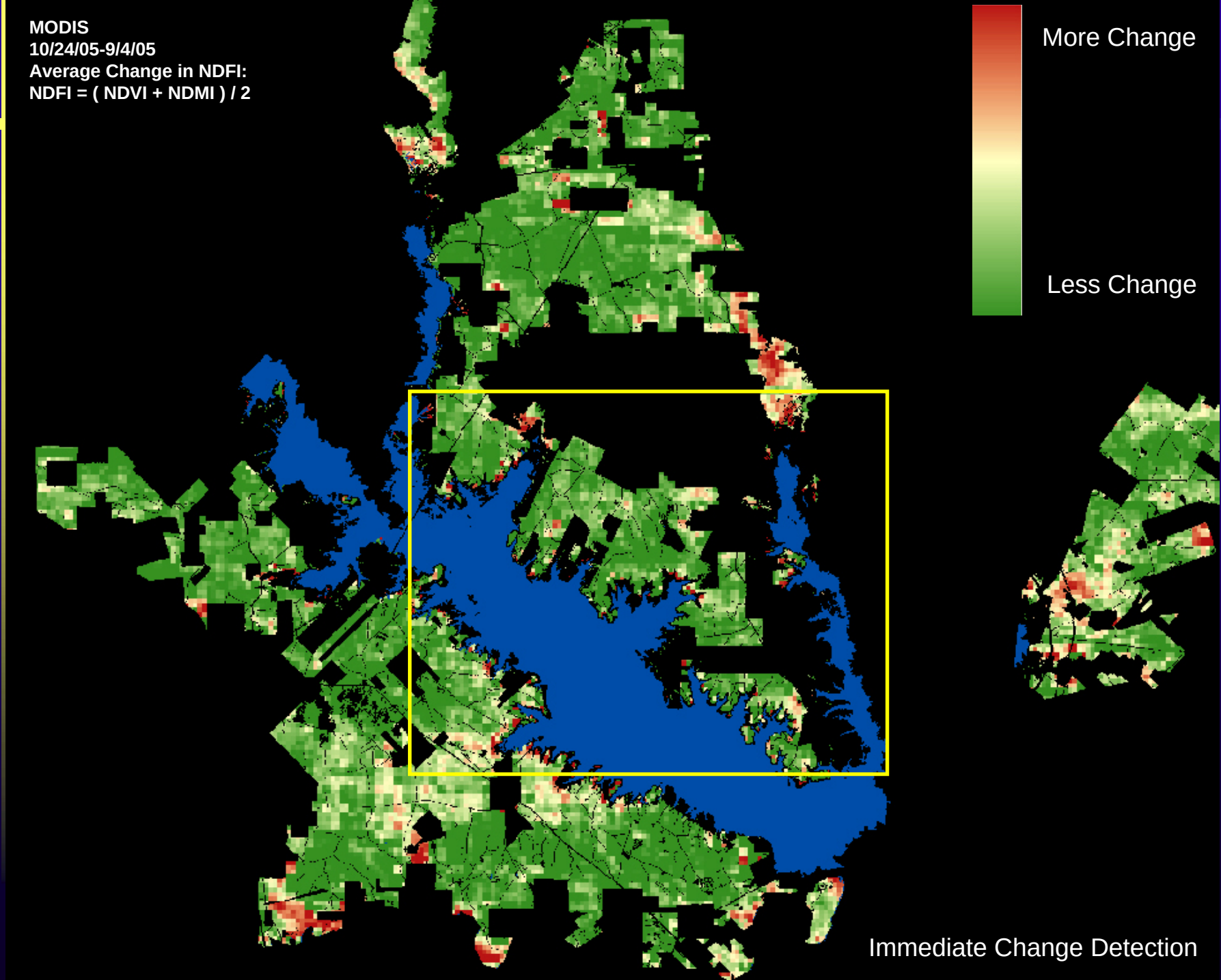
Frequently Leveraged Sensor Assets

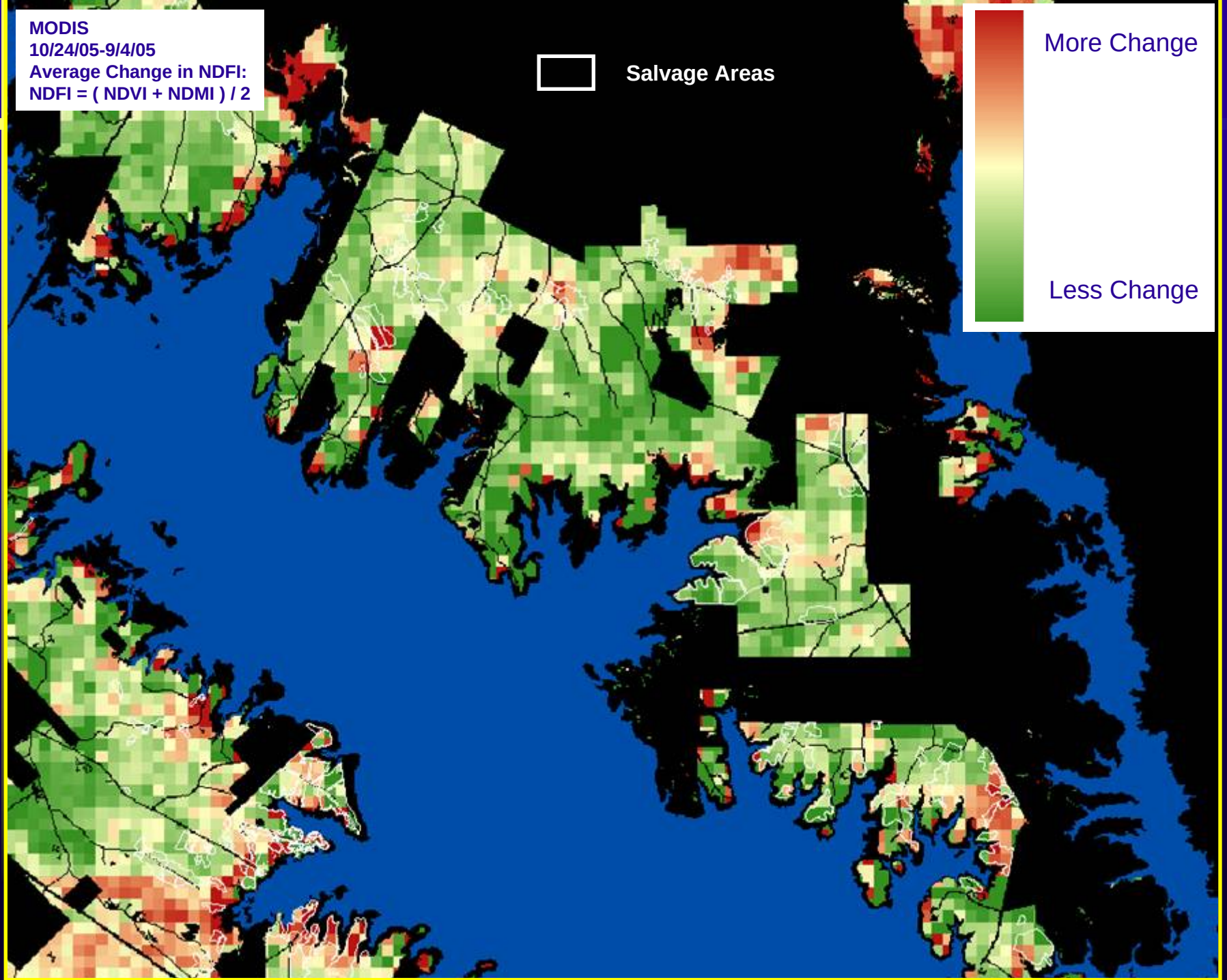
Sensor	Platform Type	Spatial Resolution (Reflectance Bands)	Temporal Resolution (per instrument)	Data Source
MODIS	Polar orbiting	250m/500m	2 times daily	RSAC/NASA
AWiFS	Polar orbiting	56m	5 days	USDA-FAS-SIA
VIIRS[1]	Polar orbiting	375m	2 times daily	Direct Readout; NOAA/NASA

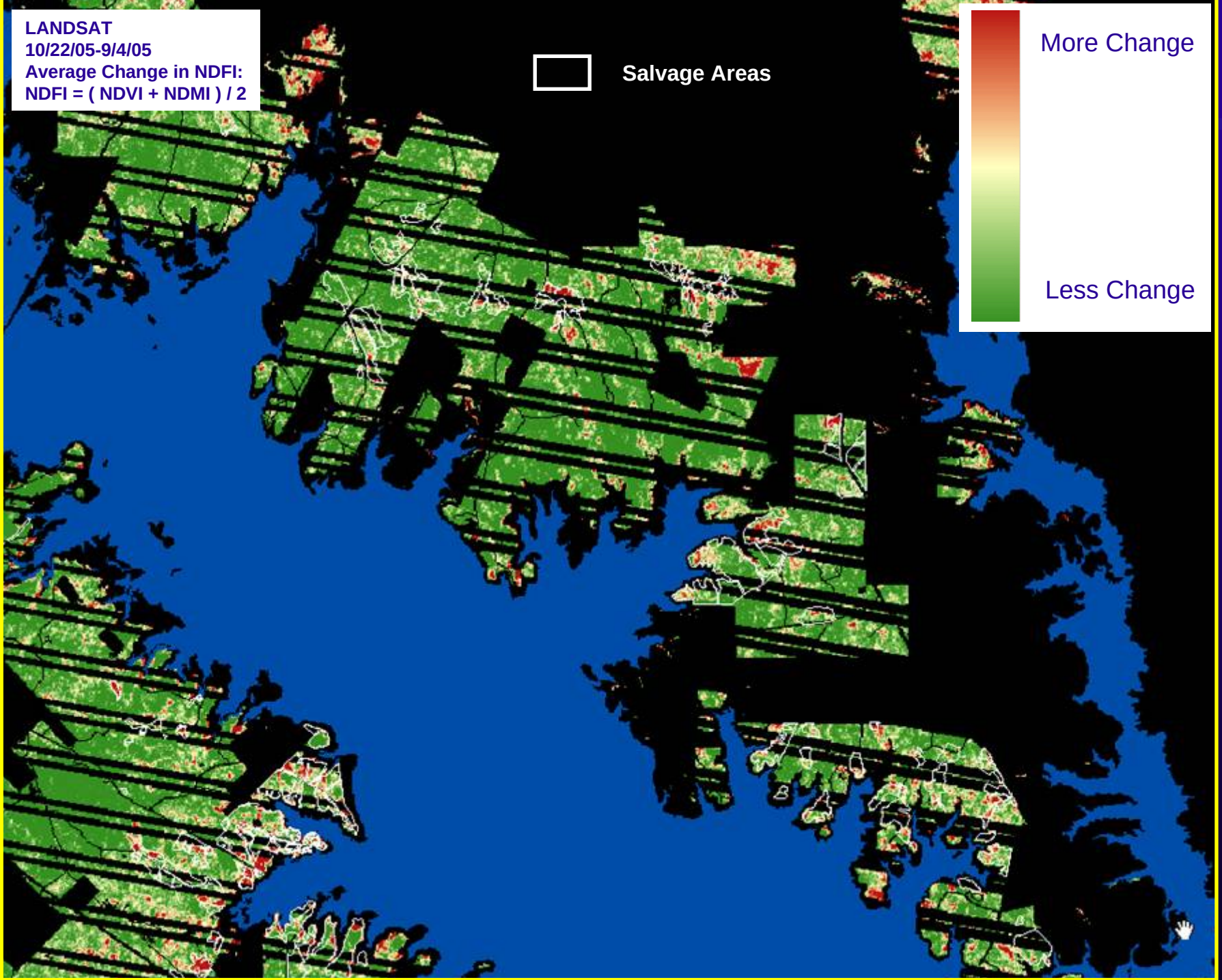
1 - VIIRS launch on NPOESS Preparatory Project (NPP) mission in June 2010 and subsequent NPOESS missions


MODIS
10/24/05-9/4/05
Average Change in NDFI:
NDFI = (NDVI + NDMI) / 2
More Change
Less Change
Immediate Change Detection


Landsat 7
10/22/05-9/4/05
Average Change in NDFI:
NDFI = (NDVI + NDMI) / 2
More Change
Less Change
Immediate Change Detection


MODIS
10/24/05-9/4/05
Average Change in NDFI:
NDFI = (NDVI + NDMI) / 2
More Change
Less Change
Immediate Change Detection


MODIS
10/24/05-9/4/05
Average Change in NDFI:
NDFI = (NDVI + NDMI) / 2
Salvage Areas
More Change
Less Change


LANDSAT
10/22/05-9/4/05
Average Change in NDFI:
NDFI = (NDVI + NDMI) / 2
Salvage Areas
More Change
Less Change

RSAC Operations Program Support

Challenges and Concerns

- Landsat data continuity
  - Landsat 5 longevity
  - LDCM launch schedule
- Transition to commercial assets
  - Availability of 2.1 micron SWIR band
  - Image costs
  - Timely product delivery
  - Availability of data archive
- Transition from MODIS to VIIRS
  - Terra and Aqua MODIS longevity
  - Launch schedule for NPP/NPOESS VIIRs
  - VIIRS technical issues

Additional Information

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RAVG Support
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Post-Catastrophic Storm Assessment
Chuck Werstak
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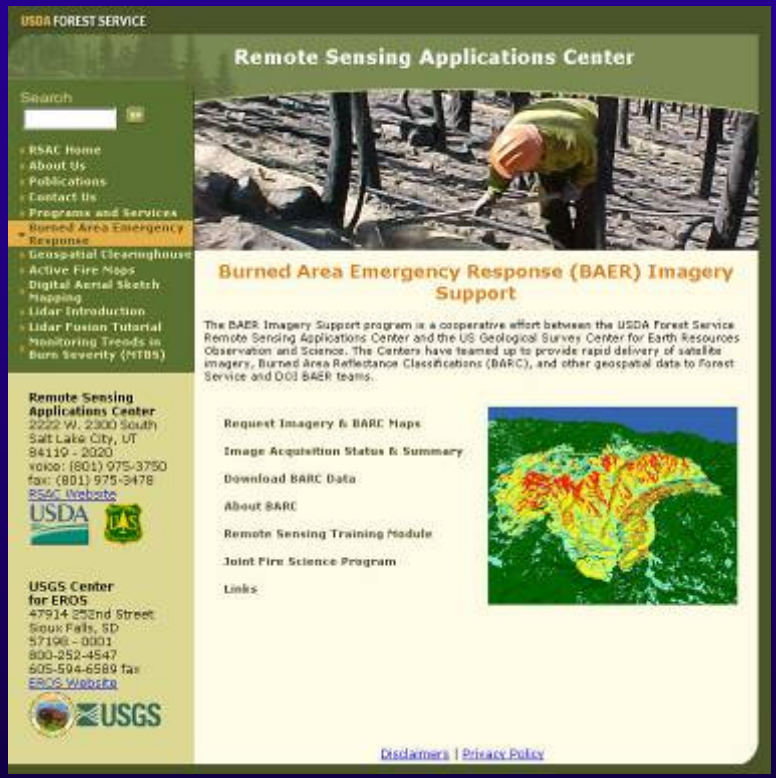
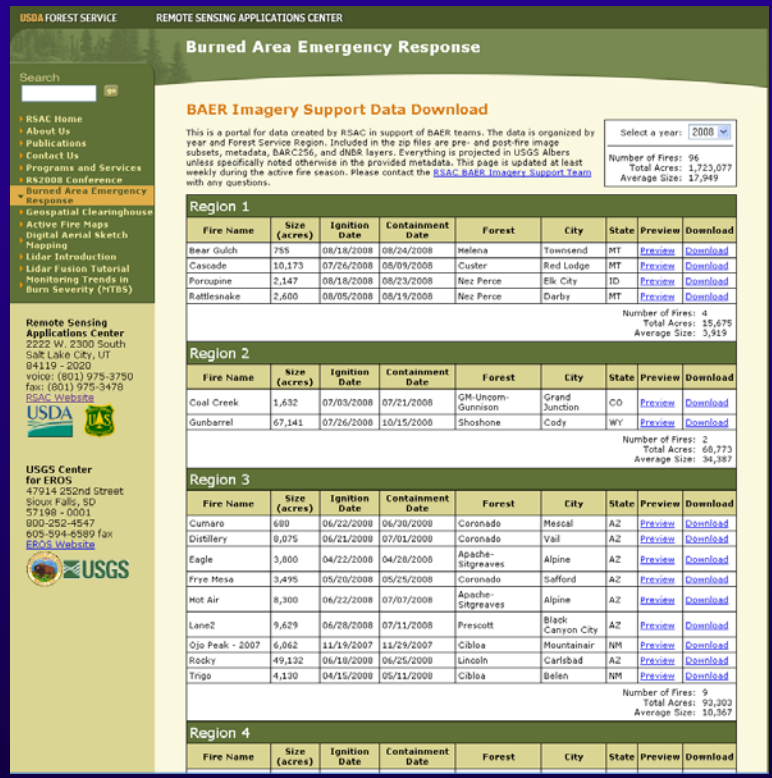
Extra

Burned Area Emergency Response Imagery Support

Web site and product distribution

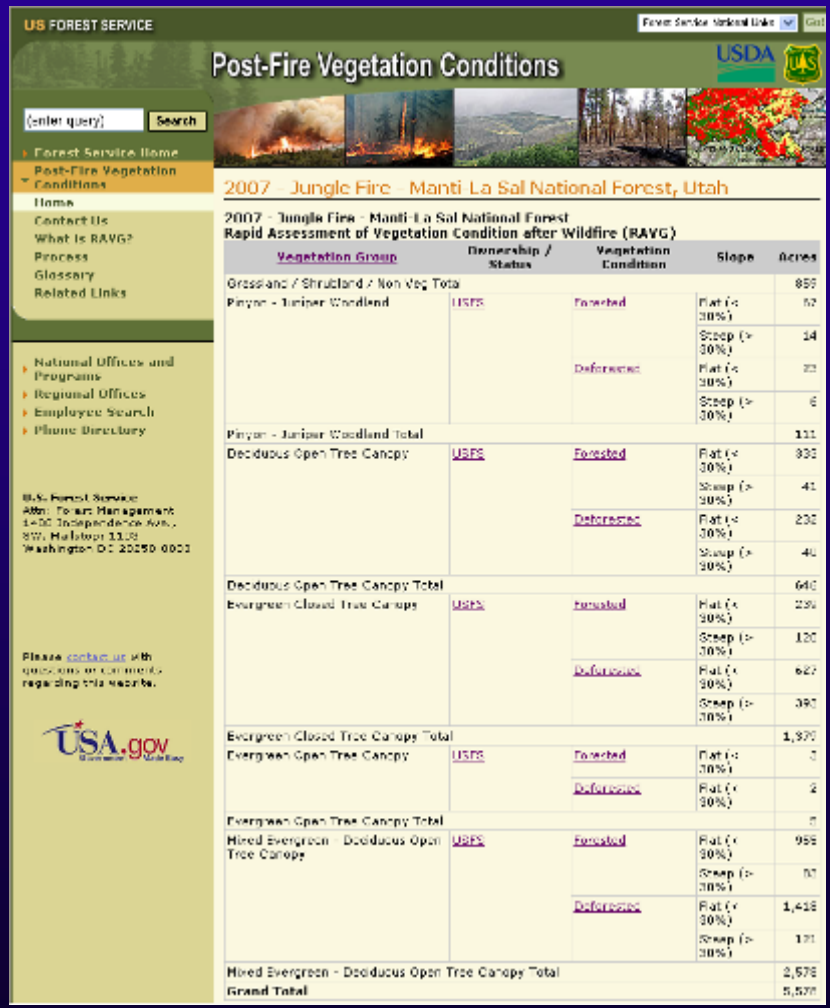




http://www.fs.fed.us/eng/rsac/baer

Rapid Assessment of Vegetation Condition after Wildfire

Web site and product distribution



http://frdev.ftcol.wo.fs.fed.us/postfirevegcondition/index.php