Active fire observations from MODIS to support decision making

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Different Aspects of Fire

- Wildfire is a hazard with large costs
- Fire is an important land management tool used for agriculture, rangelands and forests
- Fire plays a role in global biogeochemical cycling and radiative forcing
- Fire is an agent and an indicator of land cover change
- Fire is an ecological disturbance
- Fire impacts air quality and has health implications

Outline

1. MODIS fire product overview

2. MODIS fire product validation

3. MODIS fire product applications

4. GOFC/GOLD Fire and MODIS fire

5. Conclusions

The MODIS sensor

- On the experimental Terra and Aqua satellites
- Dedicated bands for the detection of hot objects (fires, volcanoes, industry)
- Systematic production of "Fires and thermal anomalies" product
  - Terra: since late 2000
  - Aqua: since mid 2002
- Precursor of the future sensors on operational satellite systems
  - VIIRS: Visible Infrared Imager Radiometer Suite
    - NPP: NPOESS Preparatory Program
    - NPOESS: National Polar Orbiting Environmental Satellite System
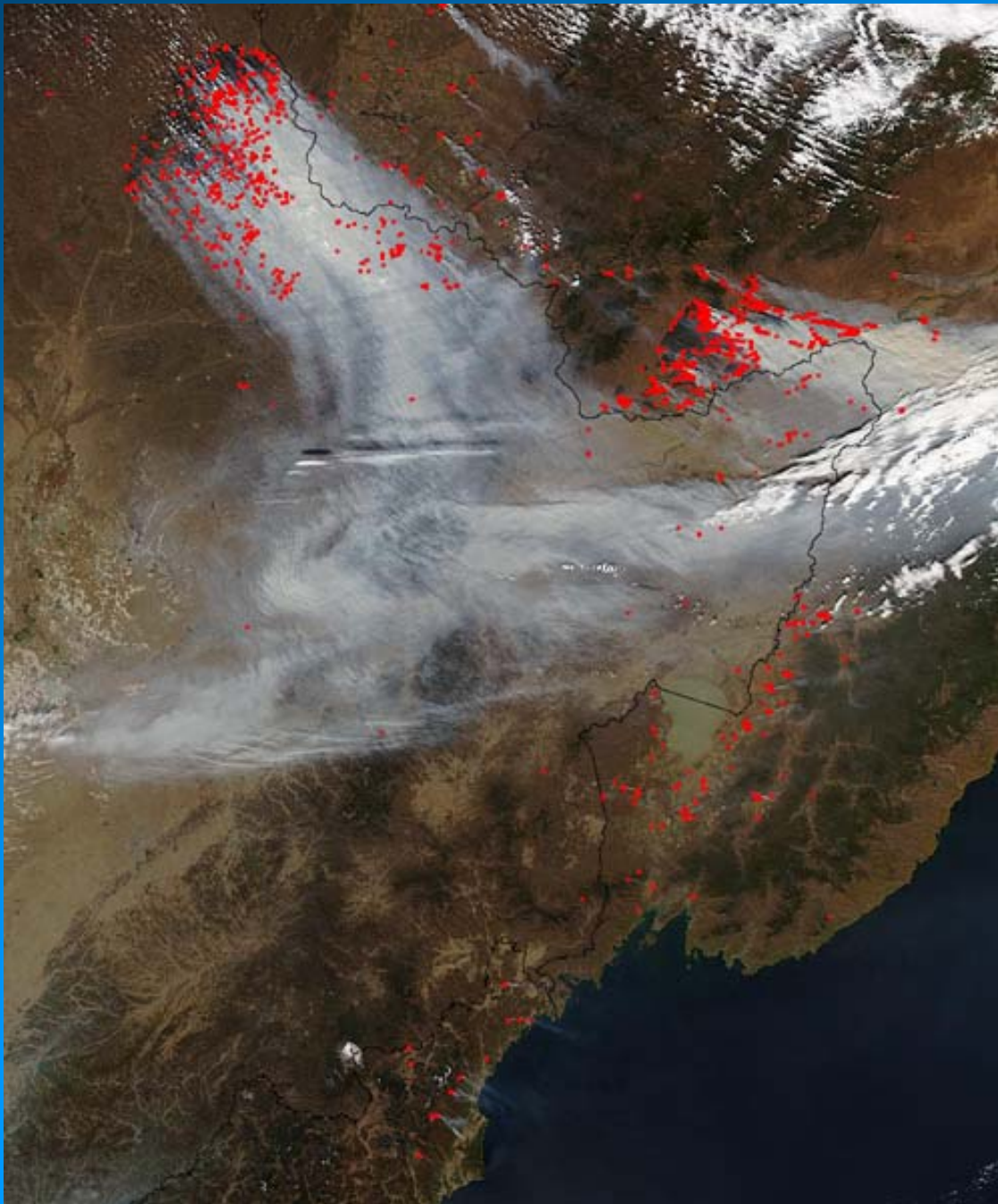
Central-Eastern Asia in 2004:

Wildfires in NE China / Far East of Russia
18 October 2004

MODIS fire product overview

- Basic information: flagging of MODIS pixels containing detectable amount of thermal radiation from hot objects
- Level 2 product
  - 5-min granule (orbital segment)
  - fire detection (three confidence levels) and Fire Radiative Power (FRP)
  - cloud
  - clear land
  - auxiliary QA and radiometric information
- Level 3 products
  - 1-km grid
  - daily and 8-day time periods
  - 10° × 10° tiles covering the land surface
- Climate Modeling Grid (CMG)
  - 0.5° grid
  - 8-day and monthly
  - corrected fire pixel counts
  - mean FRP
  - mean fire detection confidence
  - mean cloud fraction
  - land use / land cover information

Validation hierarchy

Stage 1 Validation: Product accuracy has been estimated using a small number of independent measurements obtained from selected locations and time periods and ground-truth/field program effort.

Stage 2 Validation: Product accuracy has been assessed over a widely distributed set of locations and time periods via several ground-truth and validation efforts.

Stage 3 Validation: Product accuracy has been assessed and the uncertainties in the product well established via independent measurements in a systematic and statistically robust way representing global conditions.

Product validation: ASTER image and MODIS grid

MODIS v4 detection:

Yellow gridcells: "fire", high confidence

Blue gridcells: "fire" nominal confidence

Gridcell with vertical shading: "cloud"

Black gridcells: "clear land"

Aug 29 2003 14:56 UTC 9.71S 67.15W (Brazil)

Morisette et al., 2005

ASTER fire mask and MODIS grid

MODIS v4 detection:

Yellow gridcells: "fire", high confidence

Blue gridcells: "fire" nominal confidence

Gridcell with vertical shading: "cloud"

Black gridcells: "clear land"

Aug 29 2003 14:56 UTC 9.71S 67.15W (Brazil)

ASTER fire detection algorithm developed by L. Giglio

Morisette et al., 2005

Validation hierarchy

- **Beta Data Product:**
  - early release product, <u>minimally validated</u> and may still contain significant errors
  - available to allow users to gain familiarity with data formats and parameters
  - product is not appropriate as the basis for quantitative scientific publications
- **Provisional Data Product:**
  - product quality may not be optimal
  - incremental product improvements are still occurring
  - general research community is encouraged to participate in the validation and QA of the product, but need to be aware that product
  - <u>validation and QA is ongoing</u>
  - users are urged to contact science team representatives prior to use of the data in publications
  - may be replaced in the archive when the validated product becomes available
- **Validated Product:**
  - <u>formally validated</u> product, although validation is still ongoing
  - uncertainties are well defined
  - ready for use in scientific publications, and by other agencies
  - there may be later improved versions
  - earlier validated versions will be deleted from the archive after a 6 month overlap period, but code for earlier versions will be maintained indefinitely

MODIS fire product delivery

- Standard processing and delivery
  - Distributed Active Archive Centers (DAAC's)
    - some delay in data availability and delivery
    - somewhat complex data format
- Near-real-time processing and delivery
  - NASA-GSFC/NOAA "bent pipe" processing
    - MODIS Rapid Response System
  - Direct Broadcast stations duplicating and enhancing the RR system for local and regional use around the World

MODIS Rapid Response Project Overview

Terra

Direct Broadcast
Receiving Station

L1B Data

T+30min

USDA Forest Service
Remote Sensing
Application Center

Active Fire Maps
http://activefiremaps.fs.fed.us
Three times per day

Backup Feed
L1B Data

EDOS

MODIS
L0 Data

T+2-5hrs

Rapid Response System
NASA/GSFC

Active Fire
Locations

T+5hrs

Burn Severity Maps
Handcrafted Imagery

Active Fire Locations
Selected Imagery

Active Fire
Locations
GOFC Fire Partners

T+5hrs

University of Maryland
Geography Dept

GES DAAC
NASA/GSFC

NOAA

Active Fire and
Corrected Reflectance
http://rapidfire.sci.gsfc.nasa.gov

NASA Earth
Observatory
http://earthobservatory.nasa.gov

MODIS home page
http://modis.gsfc.nasa.gov

Web Fire Maps and Fire
Feature Server
http://firemaps.geog.umd.edu

Global data sets: NASA MODIS Rapid Response

Global Observations
4 times
per day
250m – 1km

Web Fire Mapper

An internet mapping tool (WEB GIS) that displays near-real time active fires using data from the MODIS Rapid Response System

customized interactive maps can be viewed and queried for the world or selected regions and countries

Web Fire Mapper - Namibia service

Fires are shown in red on the most recent MODIS background image

Email alerts with JPEG images

AFIS - WEB FIRE MAPPER
Email Generated 8/23/2004 4:15:10 PM
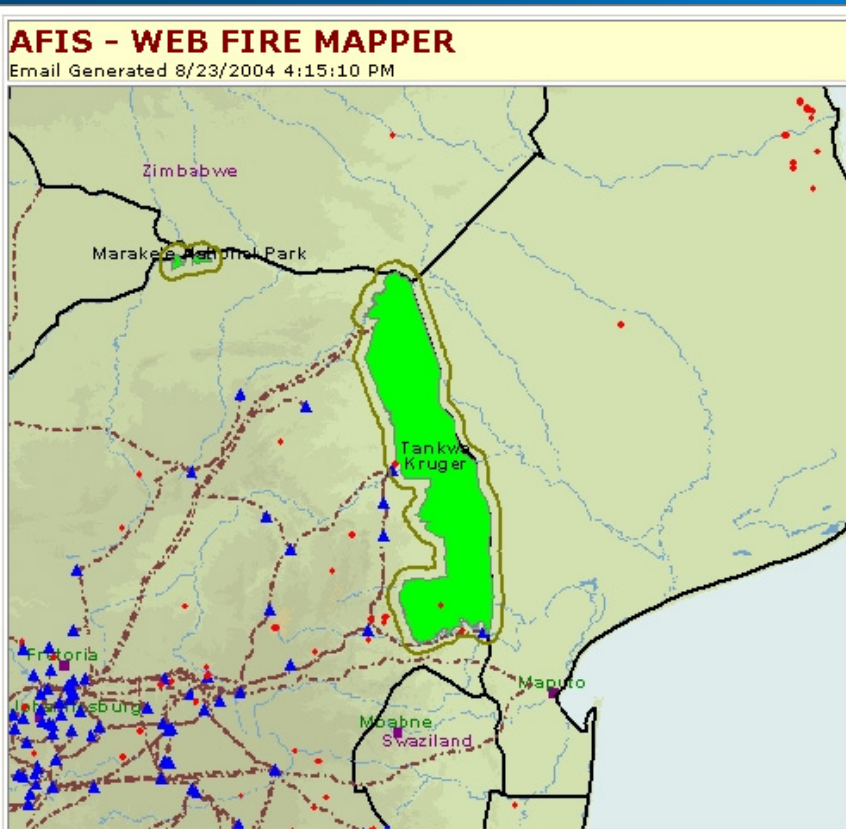
Latitude	Longitude	BT	Scan	Track	Date	Time	Sat	Conf
-25.203	31.564	317.8	1	1.1	2004-07-15	1143	A	76
-23.986	31.155	310.8	1	1	2004-07-16	0806	T	48
-25.412	31.76	312.8	1	1.1	2004-07-16	0806	T	62
-25.414	31.77	313.6	1	1.1	2004-07-16	0806	T	65

4 Active fire records detected/processed in your region of interest
Region of Interest:
Kruger

BT= Brightness Temperature (Kelvin)
Date= Date of MODIS acquisition
Sat=Satellite (A=Aqua,T=Terra)
Conf=Confidence

SMS text messages (cell phones)

(●) +278200700430...

MODIS fires near
"National Towers":
0.56 km from 1AP-
CB 1249, 10:54UTC

Options   Reply   Back

9   8:00PM

Short text messages (email)

Fire Alert! (beta long version) - Message (Plain Text)

File   Edit   View   Insert   Format   Tools   Actions   Help   Type a question for help

Reply   Reply to All   Forward

Extra line breaks in this message were removed. To restore, click here.
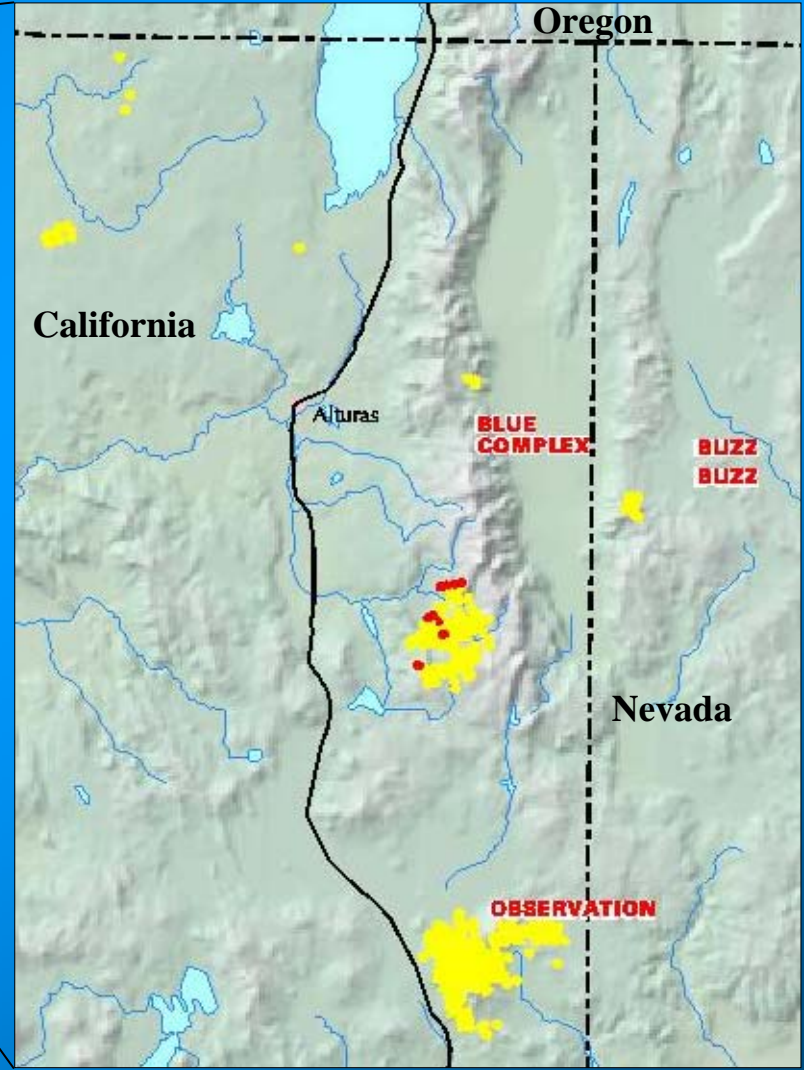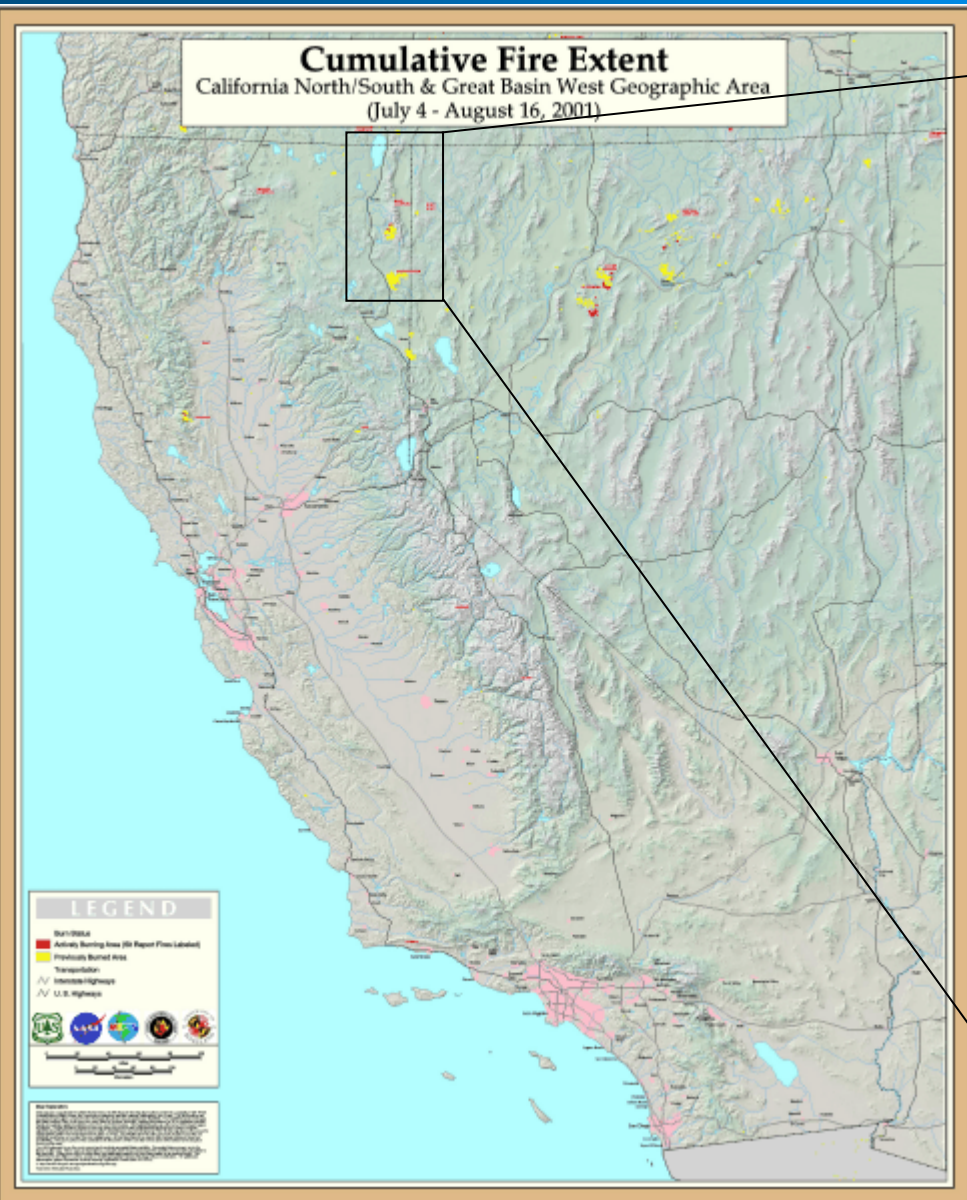
From: ipasa@sac.co.za   Sent: Mon 8/2/2004 8:22 AM
To: Jacques Descloitres; jschmaltz@ltpmail.gsfc.nasa.gov; pfrost@csir.co.za; Suresh Kumar;
         Diane Davies
Cc:
Subject: Fire Alert! (beta long version)

Distance from 30.345,-29.6 to ESKOM distribution grid: 0.07
km - Closest point: 30.346,-29.600 on segment "181713",
08/02/2004/11:30 Distance from 27.834,-26.828 to ESKOM
distribution grid: 0.32 km - Closest point: 27.837,-26.827 on
segment "525689", 08/02/2004/11:30 Distance from 31.03,-25.72
to ESKOM distribution grid: 0.41 km - Closest point: 31.034,-
25.721 on segment "412492", 08/02/2004/11:30

Strategic Maps For Each Fire Management Region 3 Times / Day
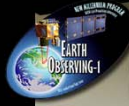
Example: Blue Complex Fire

16 August 2001

Cumulative Fire Extent
California North/South & Great Basin West Geographic Area
(July 4 - August 16, 2001)

LEGEND

Oregon

California

Alturas

BLUE COMPLEX

BUZZ BUZZ

Nevada

OBSERVATION

Active Fire in RED   **Previously Burned in YELLOW**

EO-1 Wildfire Sensor Web Experiment

Detection and Tasking

EARTH OBSERVING-1 — Use National Inter-agency Fire Center ICS209 database to identify national priority fires.
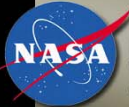
NASA — Locate fire precisely with MODIS Active Fire detections from Terra and Aqua.

MODIS — Automatically task EO-1 to acquire image data

Data Processing

USGS — science for a changing world

Downlink data

Perform Level 0 processing

Perform Level 1 processing

Geo-rectification

UNIVERSITY OF MARYLAND 1856

Precisely match image to earth coordinates

Enhance vegetation image to highlight burned areas (red)

Assessment, Planning and Implementation

FOREST SERVICE US DEPARTMENT OF AGRICULTURE

Classify burned areas into color coded burn severity, augmented with ground verification

Ground Verification

Plan deployment of rehabilitation resources to highest risk areas (red in overlay)

Apply treatments to control things such as erosion, invasive species etc.

Glacier National Park

August 21, 2003

Two Burned Area Reflectance Classification (BARC) map overlays are shown on top of Advanced Land Imager (ALI) data taken semi-autonomously by the EO-1 Sensor Web. The EO-1 image request was generated automatically based on fire location triggers detected by MODerate-resolution Imaging Spectro-radiometer (MODIS) Instruments onboard Terra and Aqua satellites. The upper left Overlay is the BARC map for the Robert fire and the lower right. Overlay is the BARC map for the Middle Fork Complex fire. The overlays were created by the Forest Service Burn Area Emergency Response teams to identify areas at high risk and to contract rehabilitation treatments. Satellite data such as this assists in efficient use of resources.
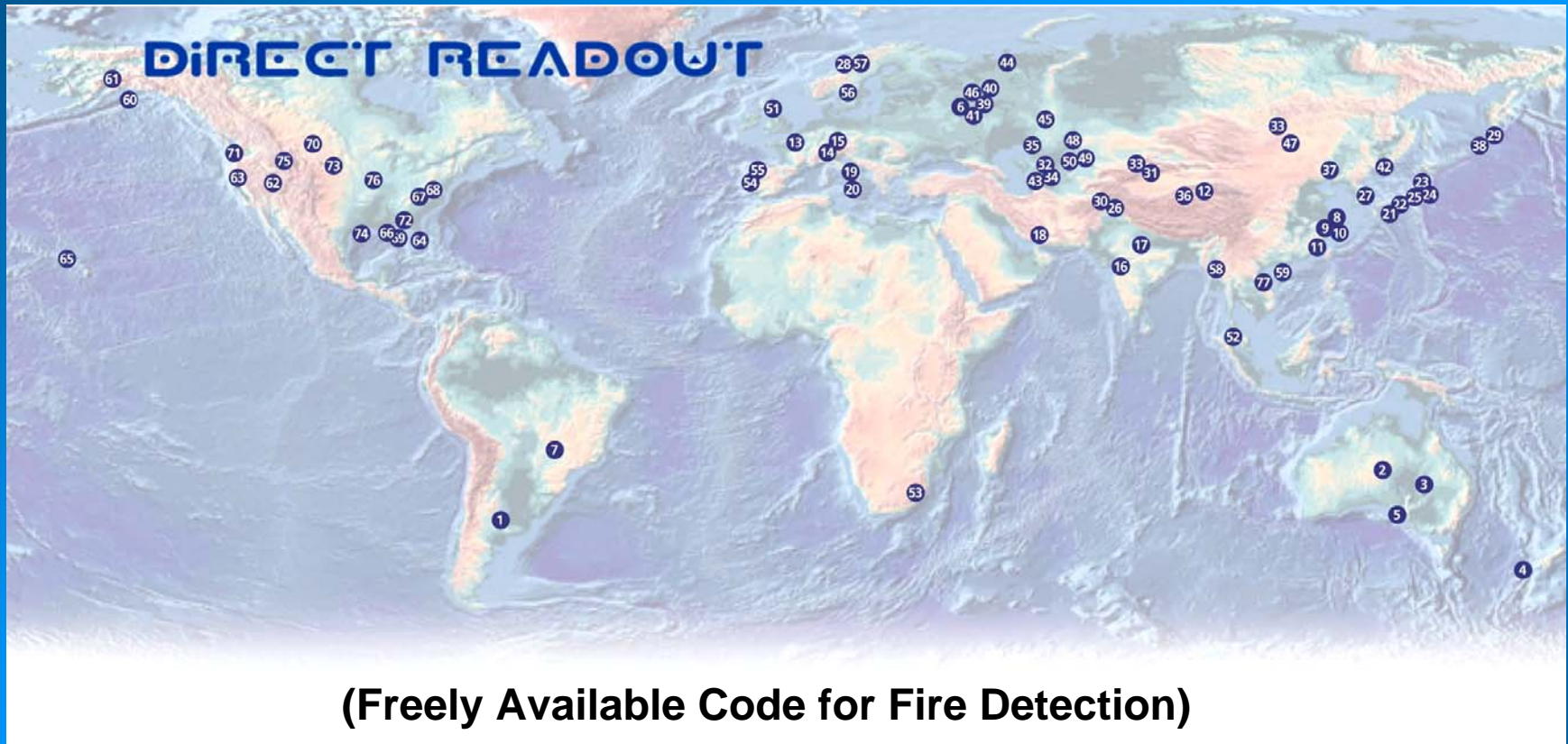
Burn Severity

- Unburned
- Low/Unburned
- Low
- Medium
- High

Increasing Number of MODIS Direct Broadcast Sites

(Freely Available Code for Fire Detection)

- 82 Ingest sites around the world for Terra/Aqua DB downlink
- Over 900 Users of data extending from 82 ingest sites
- List is located on the Direct Readout Portal

(P. Coronado/GSFC)

Distributed Ground Stations
Near realtime data - www.sentinel.csiro.au

WEB BASED Distribution

BRAZIL

Fire "climatology"

Terra MODIS CMG product 2001-2004

Building a Long Term Data Record

Giglio et al., submitted
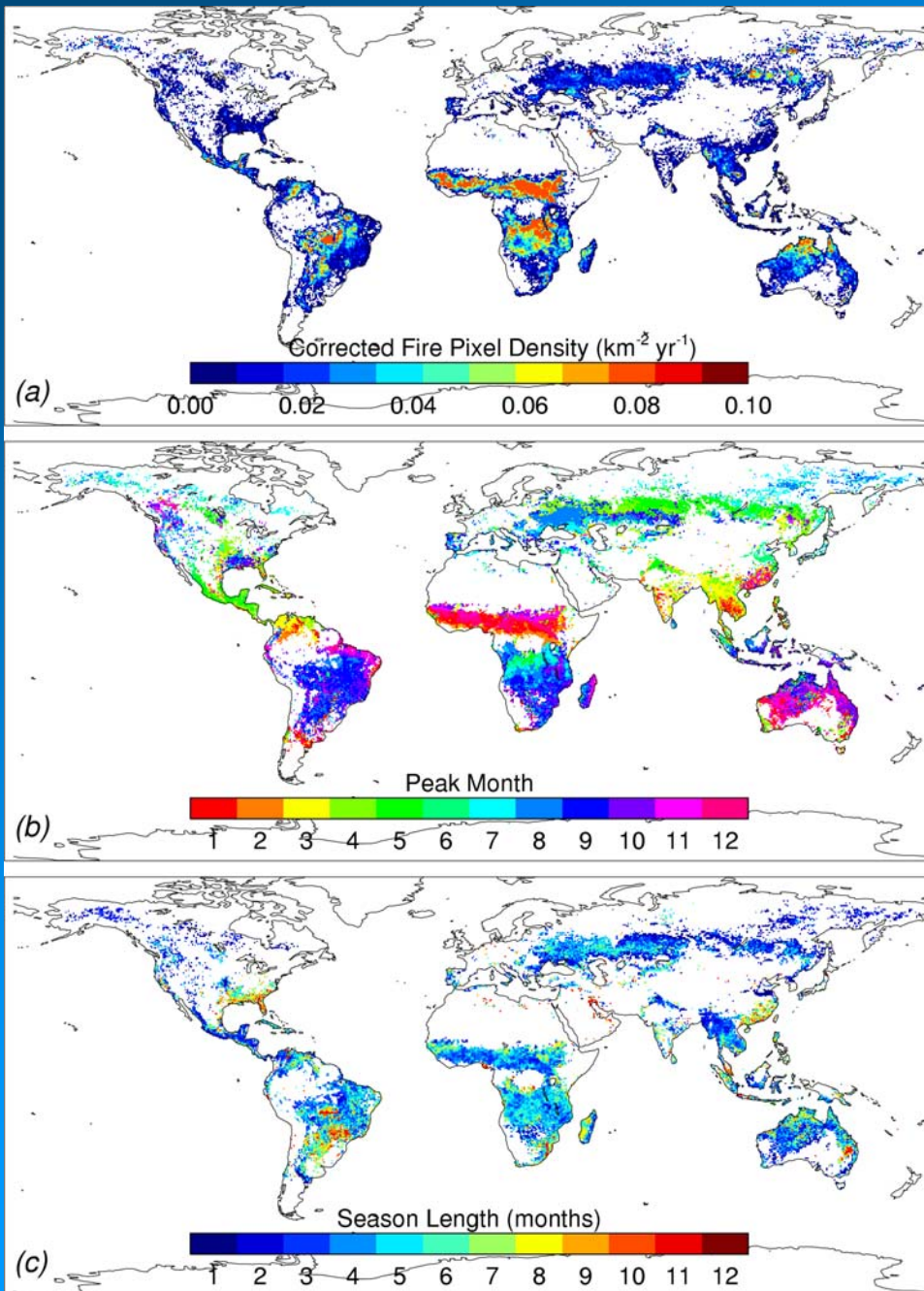
Fire "climatology"

Terra MODIS CMG product 2001-2004

Giglio et al., submitted
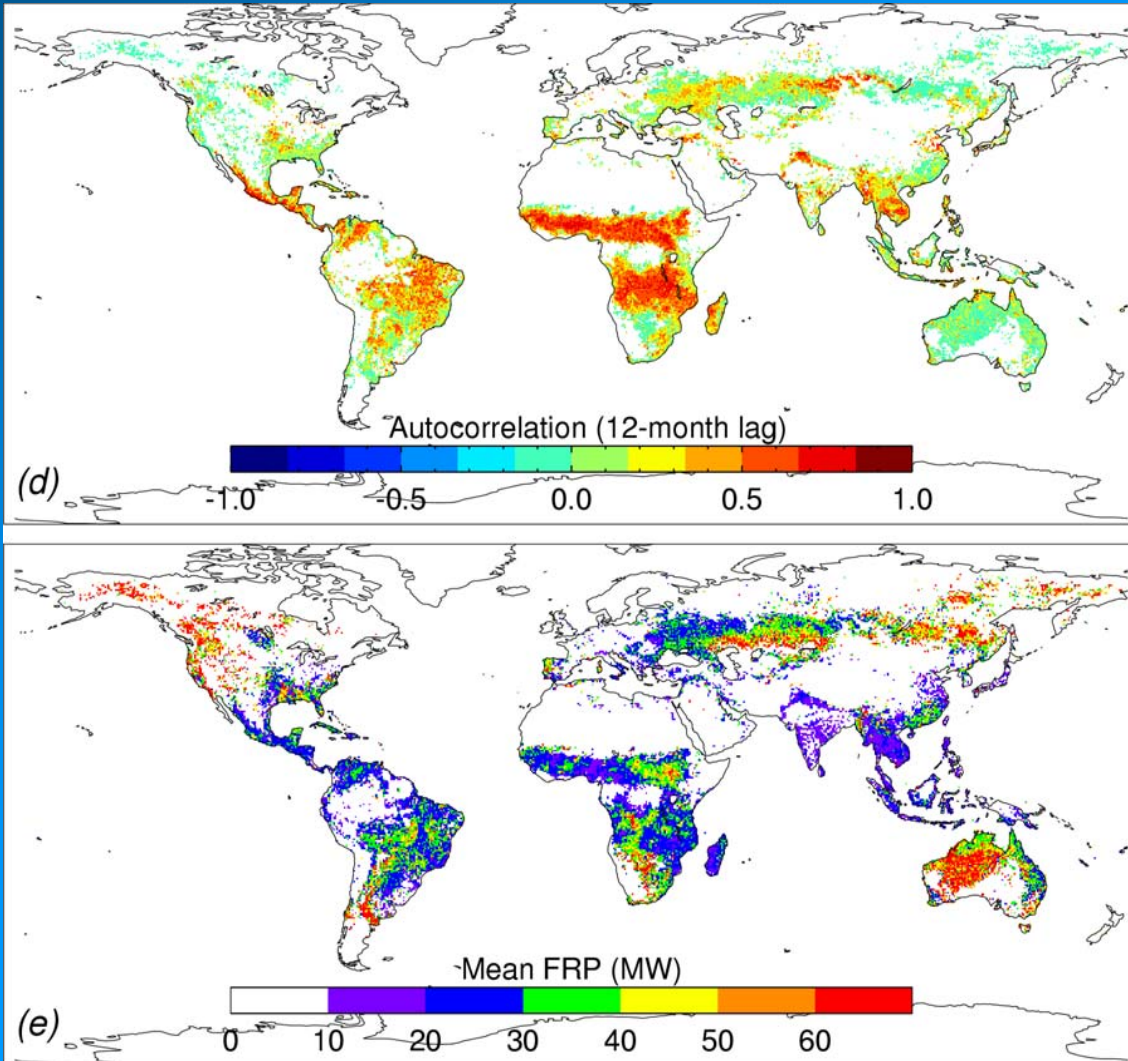
Global fire dynamics

Fire counts at 15° intervals in the tropics

- global minimum: March

- global maximum: August
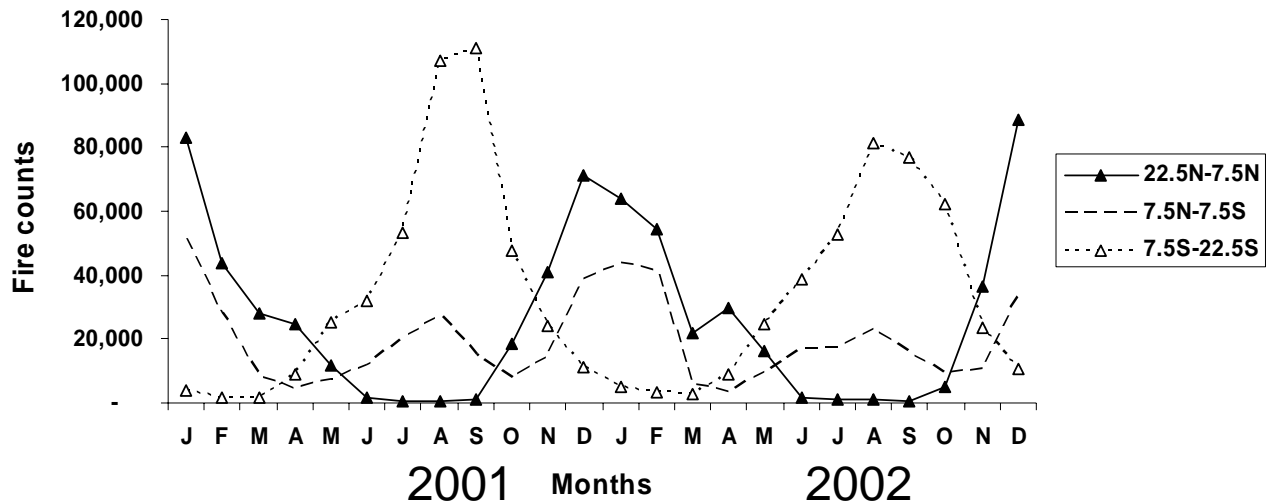
Fire counts at 15° intervals in the extratropics

Csiszar et al., 2005
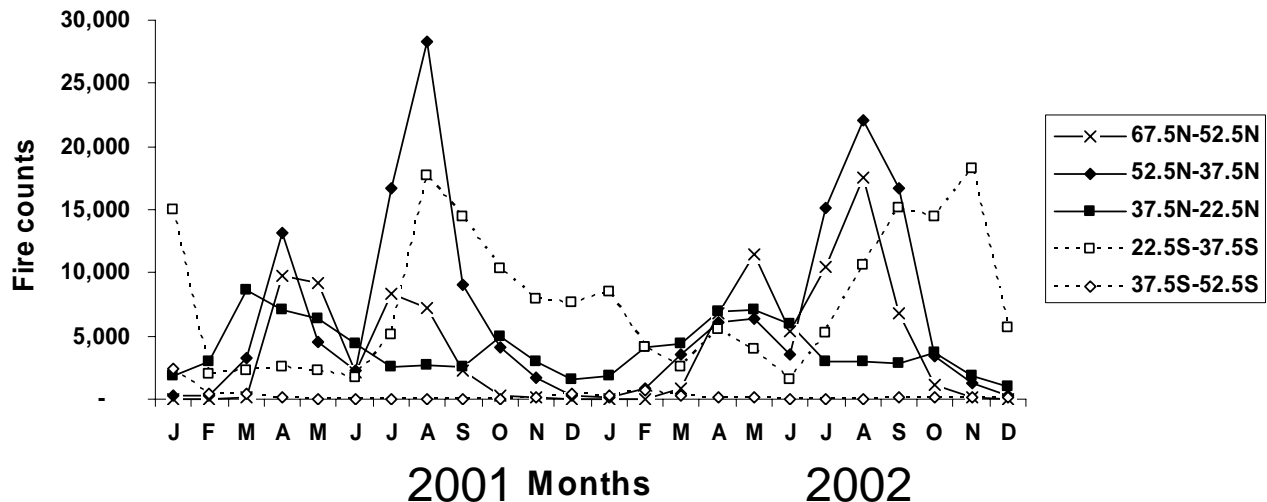
Regional fire dynamics

Southern Hemisphere Subequatorial Tropics 2001
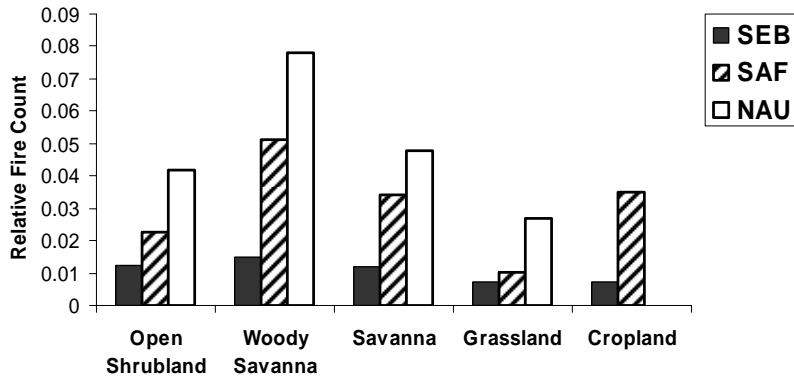
SEB: South-East Brazil
SAF: Southern Africa
NAU: Northern Australia

Southern Hemisphere Subequatorial Tropics 2002
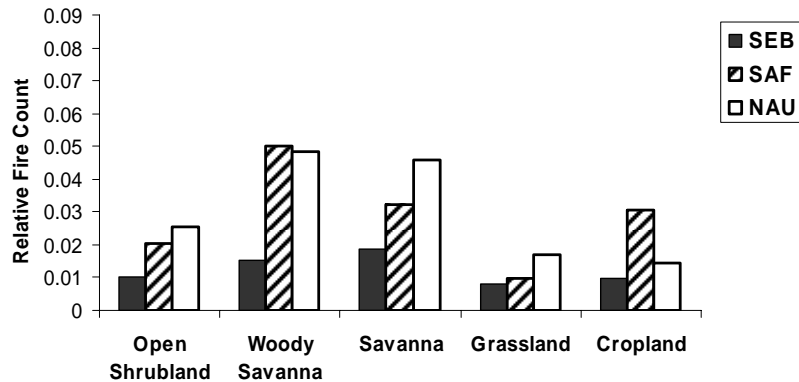
South-East Asia January 2001
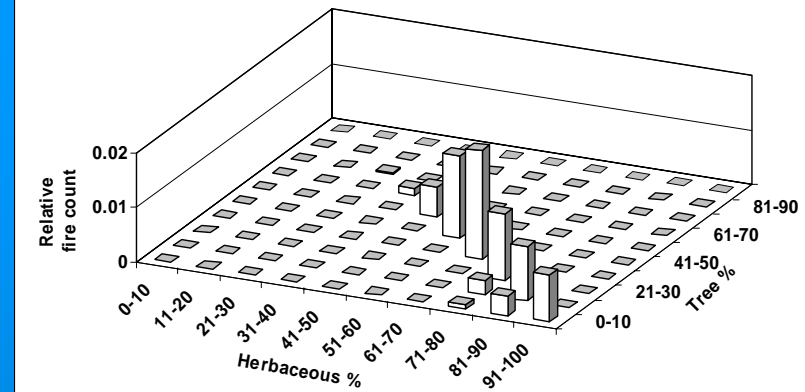
by UMd MODIS Vegetation Continuous Fields

Csiszar et al., 2005

by UMd/BU MODIS land cover types

Diurnal cycle of fire activity

West Africa

West Africa
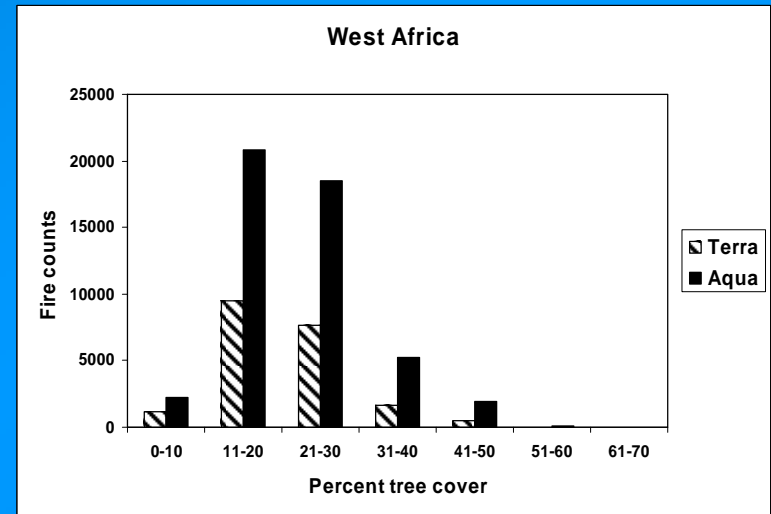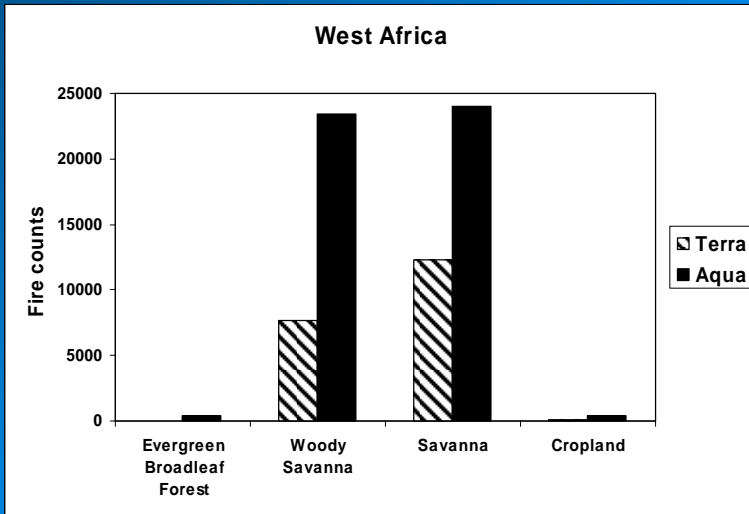
Csiszar et al., 2005
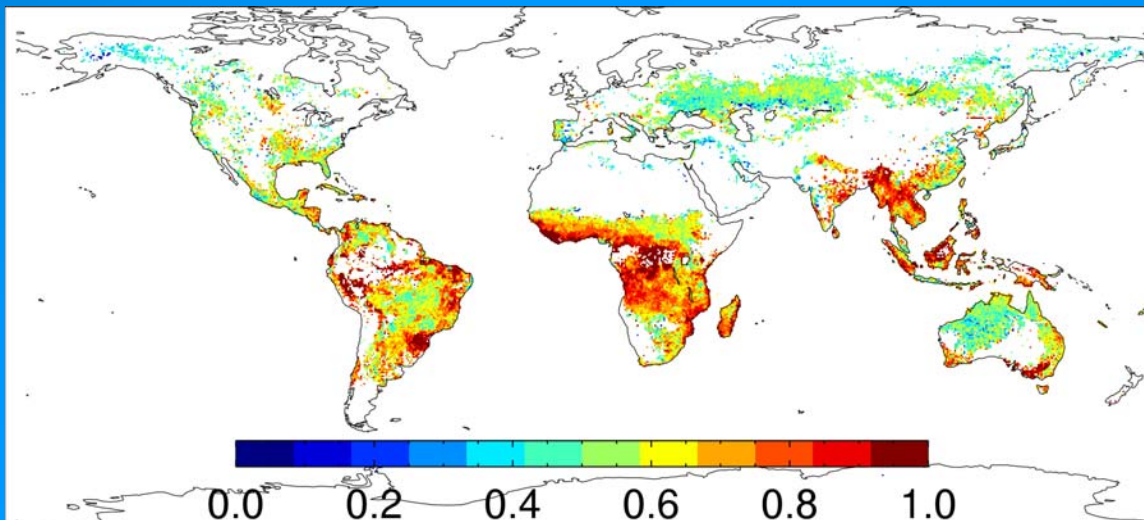
Ratio of cloud-corrected Aqua fire pixel counts to total (Aqua + Terra) cloud-corrected fire pixel counts from July 2002 through December 2004

Giglio et al., submitted

MODIS Burned Area Product 500m

Australia
500m burned areas
1 month 2002
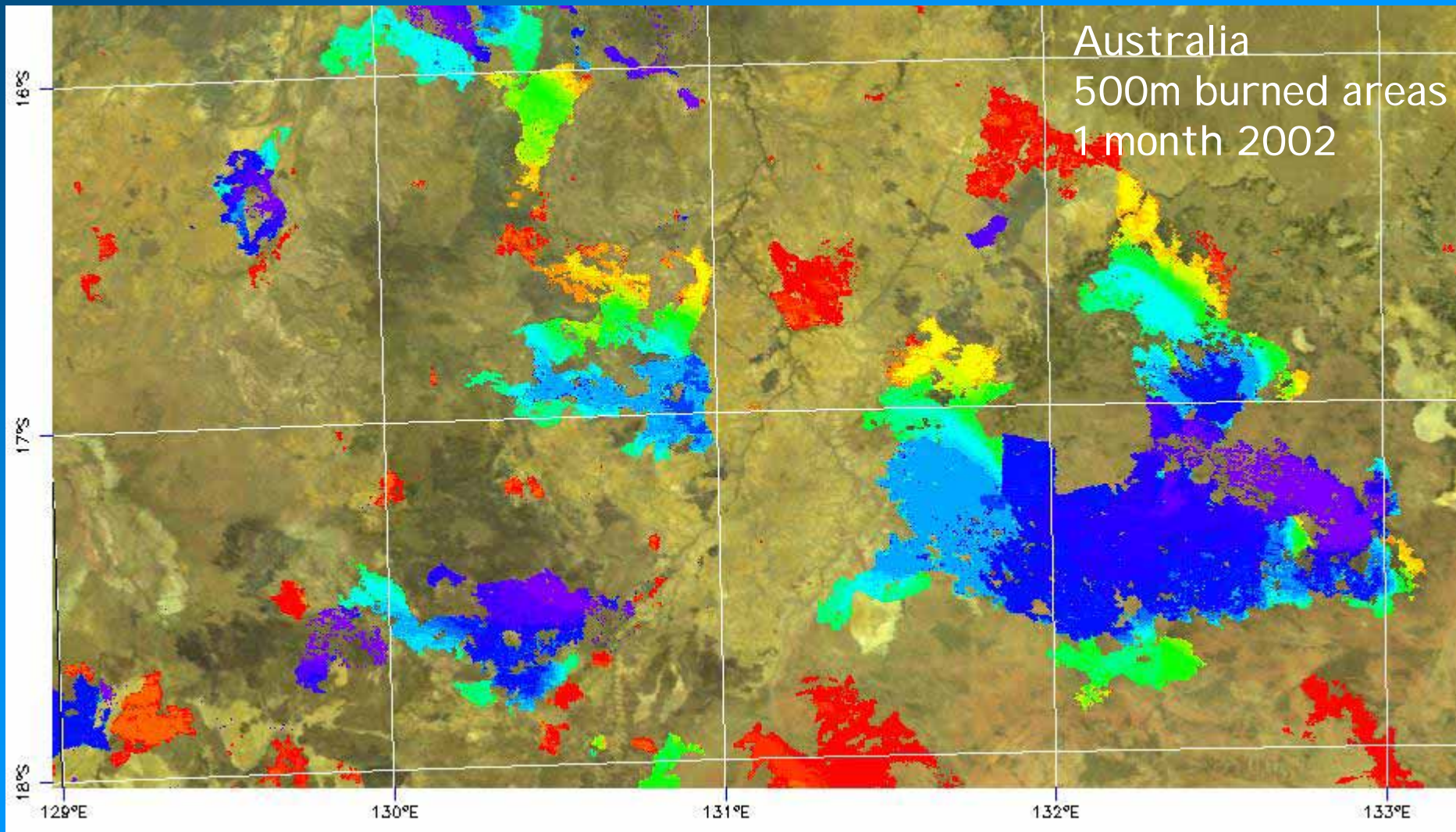
Australia
1km active fires
1 month 2002
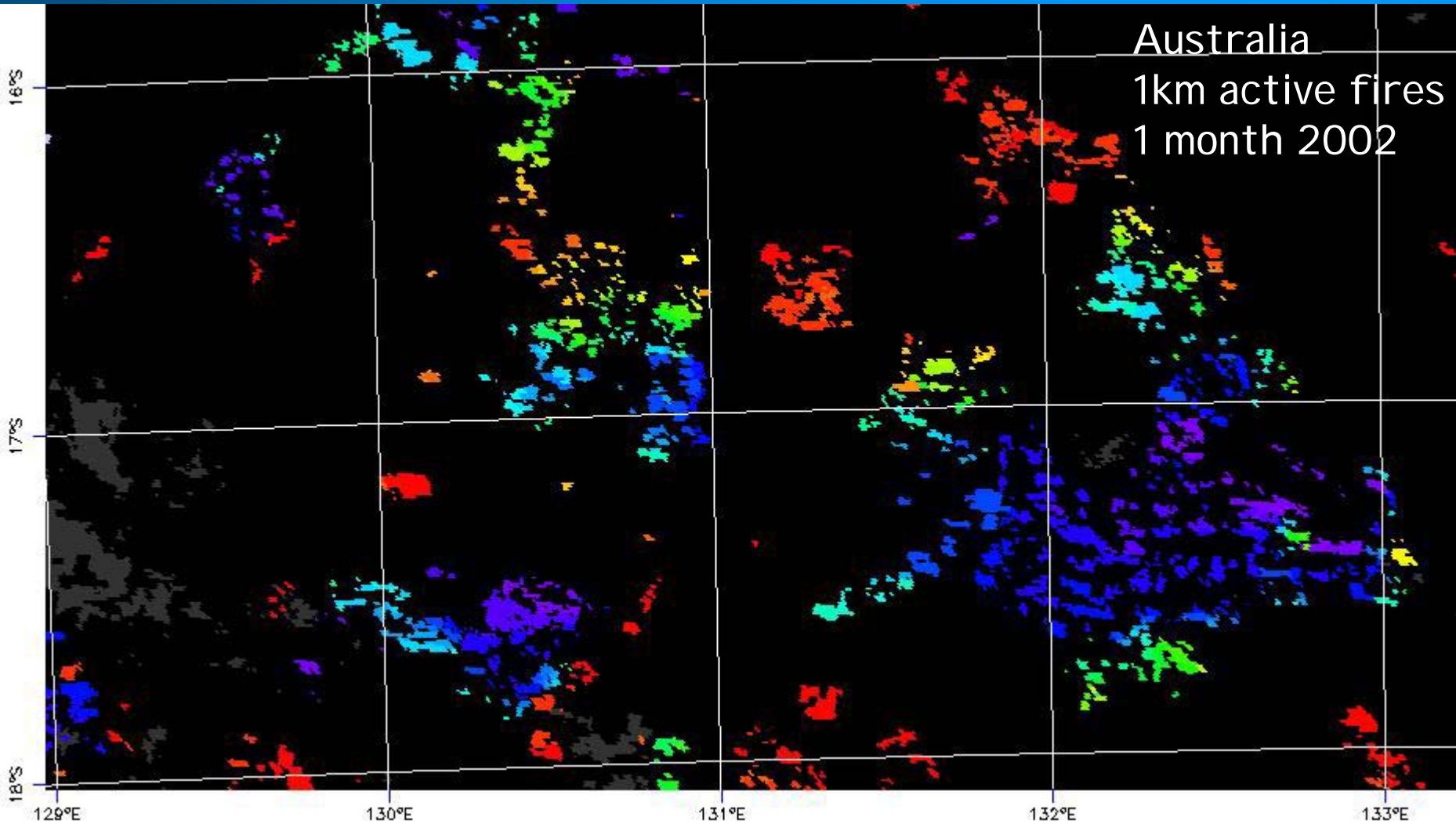
US NPOESS Fire Monitoring Capabilities

- NPOESS is a NASA-NOAA-DoD program
- Moderate Resolution (VIIRS)
  - First VIIRS will fly on the NPOESS Preparatory Project (NPP) circa 2007
  - VIIRS processing, archive and access for civil and science communities will be done by NOAA
  - Will have near real time global thermal anomalies (Active Fire) and Vegetation Index products
  - 11 um band saturation problems
- High Resolution (30m Landsat Class Instrument)
  - For local fire characterization and validation of the global products (an operational Landsat Class Instrument co-located with VIIRS would be preferable for fire)
  - Higher temporal frequency needed than Landsat 16 day repeat
  - Need to ensure 2.2 micron capability for fire detection on future systems – building on ASTER/MODIS synergy

GOFC/GOLD-Fire
International Coordination of Fire Observations

What is GOFC/GOLD – Fire

- The Fire component of the Global Observation of Forest Cover / Global Observation of Landcover Dynamics (GOFC/GOLD)

- GOFC/GOLD is a Panel of the Global Terrestrial Observing System (GTOS) – part of the Integrated Global Observing Systems (IGOS)

- GOFC/GOLD is a component of the IGOS Integrated Global Observations of Land (IGOL) theme

- GOFC/GOLD is a contribution from the IGOS Partners to the Global Earth Observation System of Systems (GEOSS)

Promote interaction between a number of major communities

Remote Sensing and Operational R and D

Fire Observation Systems
- Experimental
- Operational

GOFC/GOLD Fire

Fire Research and Global Change Research

Operational Fire and Resource Management and Policy
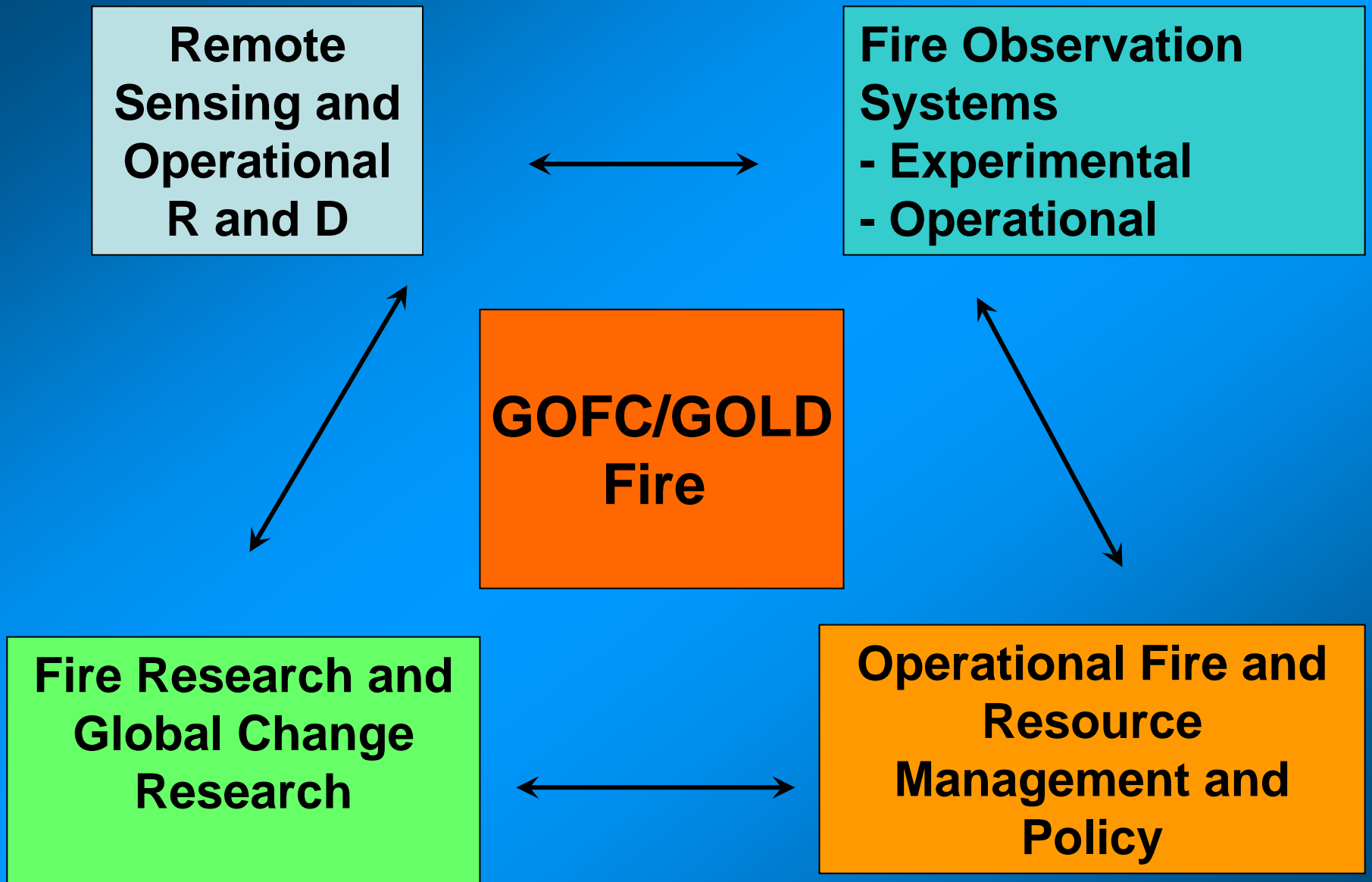
GOFC/GOLD-Fire Goals

- ## Increase user awareness and data use
  - develop an increased understanding of the utility of satellite fire products and their use for global change research, resource management and policy (UN, Regional, National, Local)

- ## Establish a geostationary global fire network
  - providing operational high temporal resolution standard fire products of known accuracy

- ## Secure *operational* polar orbiters with adequate fire monitoring capability
  - providing operational moderate resolution long-term global fire products to meet user requirements and serving a network of distributed ground stations
  - providing improved fire products (fuel moisture content/active fire/burned area/fire characterization) in a timely fashion
  - providing operational high resolution acquisition allowing active fire, burned area, fire characterization and post-fire assessments

GOFC/GOLD-Fire Goals (Cont'd)

- **Determine product accuracies**
  - operational network of fire validation sites and protocols established providing accuracy assessment for operational products and a test bed for new or enhanced products – leading to standard products of known accuracy

- **Develop a set of global fire danger / susceptibility products**
  - combining meteorological data, remote sensing, and ground based information

- **Develop fire emissions product suites**
  - providing annual emission estimates of known accuracy with the associated input data

- **Develop Long-Term fire data records**
  - Combining data from multiple satellite sources

- **Establish enhanced user products and improved data access**
  - operational multi-source fire / GIS products, Web based data access, Improved national fire reporting, Fire characterization

- **Promote experimental fire observation systems and related research**
  - in new areas focused on meeting current information gaps

MODIS and GOFC/GOLD-Fire

- **Increase user awareness and data use (√)**
  - user outreach; domestic and international partnerships
- **Establish a geostationary global fire network (√)**
  - reference / bridging data for geostationary sensor/product intercalibration
- **Secure *operational* polar orbiters with adequate fire monitoring capability (√)**
  - NPP/NPOESS/VIIRS
- **Determine product accuracies (√)**
  - extensive, continuous validation activity
- **Develop fire emissions product suites (√)**
  - fire counts used in emission modeling
- **Develop long-term fire data records (√)**
  - CMG product, time series analysis
- **Establish enhanced user products and improved data access (√)**
  - Rapid Response System / Web Fire Mapper
- **Promote experimental fire observation systems and related research (√)**
  - experimental mission; reference for new generation sensor product evaluation (e.g. BIRD)

Near Term Opportunity for GEOSS

- Build on the GOFC/GOLD fire initiatives and the international success of MODIS

- Enhance Near-Real Time Fire Data Delivery Systems

- International Coordination for Validated Global Burned Area Products

- Transition MODIS system capabilities to the operational domain – NPP VIIRS

- Establish Coordinated International Geostationary and High Resolution Fire Monitoring Systems

- Strengthen interaction with fire user community through established regional networks

Some Relevant URL's

- MODIS fire website
  - http://modis-fire.umd.edu/index.asp
- MODIS Land Rapid Response website
  - http://rapidfire.sci.gsfc.nasa.gov/
- MODIS Web Fire Mapper website
  - http://maps.geog.umd.edu/
- GOFC/GOLD Fire website
  - http://gofc-fire.umd.edu/