GOFC-GOLD Fire Activities

With Some Examples of US Contributions to the program

Chris Justice
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University of Maryland

Land Use Fires in Myanmar – Aqua, March 22, 2007
Station Fire
Aug 31 09

Burned 200 Sq Miles
95 Miles of fire-lines
2 firemen killed
$102 Million spent since July
Los Angeles Skyline
6000 People Evacuated
Athens Fires 2009
Fires are a Global Phenomenon

MODIS Active Fire Detections – Rapid Response System

Fires Burning Aug 8 – Aug 19 2009
Global Agricultural Fires

Korontzi et al. 2007
Example Areas of Fire Science

**Global to Regional Scales**

- **Fire, Climate and Land Use**
  - Changing Fire Regimes, Monitoring and Modeling
- **Fire Ecosystems, Disturbance and Recovery**
  - Changing fire succession, Multiple stressors, Insect/fire relationships, Woody encroachment, Nutrient cycling
- **Fire related Radiative Forcing**
  - Land surface, smoke/cloud interactions
- **Fire and Atmospheric Chemistry and Composition**
  - Tropospheric ozone precursors
- **Fire Trace Gas and Particulate Emissions**
  - Biogeochemical cycling, Emissions estimation and budgets, National emission inventories
Fire and the Atmosphere

Biomass burning and fossil fuel emissions release $\sim 10^{15}$ g of carbon (C) to the atmosphere each year. Biomass burning constitutes $\sim 35\%$ of all global C emissions.

<table>
<thead>
<tr>
<th>Region</th>
<th>Fire emissions 1997-2001 average ($10^{15}$g C yr$^{-1}$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Central and northern South America</td>
<td>0.27</td>
</tr>
<tr>
<td>Southern South America</td>
<td>0.80</td>
</tr>
<tr>
<td>Northern Africa</td>
<td>0.80</td>
</tr>
<tr>
<td>Southern Africa</td>
<td>1.02</td>
</tr>
<tr>
<td>Southeast Asia</td>
<td>0.37</td>
</tr>
<tr>
<td>Boreal (north of 38°N)</td>
<td>0.14</td>
</tr>
<tr>
<td>Other</td>
<td>0.13</td>
</tr>
<tr>
<td>Global</td>
<td>3.53</td>
</tr>
</tbody>
</table>

Source: Van der Werf et al., 2004
Regional to Global Scale Emission Estimates

Figure 2. Fire emissions and the C4 fraction of fire emissions from (a) Southeast Asia, (b) Central and northern South America, (c) southern South America, and (d) southern Africa. Fire emissions (left panel, left axis, solid line) are for total carbon and have units of Tg C/month. The C4 fraction of fire emissions (left panel, right axis, dashed line) is unitless. Precipitation anomalies for each region (right panel, solid line) have units of mm/month. The precipitation anomalies were constructed by removing a mean seasonal cycle from 1997–2001 from each region.
The FRE has been shown to be linearly related to the total biomass burned.

Energy (MJ) = 2 * Mass^{1.05}

$R^2 = 0.964$

Alternative approach for estimating fire emissions?
Estimated annual mean FRE (MJ/m²/yr)
MODIS Aqua 2001-2007

Diurnal cycle of hourly FRP was estimated in each climate modeling grid cell, and integrated over time (24 hours) and space (0.5°) to estimate FRE.
Fire Science: Example Areas

Regional to Local Scales *

- Fire and Air Quality
  - Wildfires and Land Management Fires (inc. Agriculture)
- Fire and Water Quality
  - Watershed impacts, Nutrient cycling, Erosion
- Fire Danger and Risk Modeling
  - Weather, Fuels and conditions, Fire at the urban interface
- Fire and extreme weather events
  - Monitoring and prediction, Atmospheric processes
- Fire Behavior Modeling
  - Fuels Mapping and Characterization, Fire spread, etc
- Fire Ecology and Biodiversity
  - Fire impacts, species composition, species threats, adaptation
- Impacts of Fire Different Fire Policies
  - Monitoring, modeling and assessment
- Fire and Land Use
  - Indicator of LU change, Slash and Burn, Fuel wood, Sustainability Science, Competing Land Use Conflict, Fire Policy and Management

* in most cases with linkages to applications
Land Use Fires and Conflict – Albaja, Sudan

MODIS Fire History, Albaja, ’00-05

Use ASTER data to look at interface between crop (farmers) / rangeland (nomads)

(M. Elgamri, Sudan Univ, S. Trigg, Cranfield College, Jan Dempenwolf UMD)
2000

Nomadic rangeland

Burned area
Types of Fire Information Needed

**Pre-Fire**
- Fire History
- Fire Danger/Susceptibility (Weather and Satellite data)
  - Fuel type, structure, fuel condition, fire weather
- Fire Behavior related information
  - Weather, topography, fuel load and condition

**Active Phase**
- Fire Occurrence / Location
  - Tactical (within 15 minutes, local)
  - Strategic (daily briefings, regional coverage)
- Fire Emissions and Related information (NRT and Regional)
  - Fuel load and condition, combustion completeness
  - Distributions of emissions products (trace gases, particulates) - air quality, atmospheric composition
- Fire Characterization (fire intensity)

**Post-Fire**
- Burned Area (near real time, monthly, annual)
- Fire Severity
- Immediate Post Fire Assessment
  - Fire severity > ecosystem damage – remedial actions
  - Fire recovery
- Long-term trends in fire regimes
Fire Related Observations

• Satellite Sensors
  – Coarse, Moderate, Fine Resolution
  – Optical, Microwave
  – Polar orbiting, Geostationary

• Airborne Sensors inc. UAV’s
  – Imaging (active fire, post fire)
  – Lidar (vegetation structure)
  – RT Fire fronts

• Ground-based (in-situ) Observations
  – Weather conditions, met stations
  – Atmospheric Profiles (lidar, aeronet)
  – Lightning Detection / Ground Based Fire Detection

• Field Measurements
  – Fuel Load, Emission Factors, Post Fire Assessments (area, severity), etc
Satellite Fire Monitoring

• Current Global Capabilities
  – Vegetation Type and Condition (moisture content)
  – Active Fire Detection
  – Burned Area Estimation
  – Fire Radiative Power
  – Direct measurement of fire products (aerosol optical thickness, trace gases)
Examples of Types of Fire Related Modeling

- **Model Types**
  - Fire Danger
  - Fire Weather
  - Fire Behavior
  - Fire Emissions (NRT, Annual)
  - Projected Fire Regimes and Emissions
  - Dynamic Global Vegetation Models (disturbance)

- **Observations can be used as input and in some cases for model validation**
  - Important to understand product accuracy – requires product validation
  - Can we refine the requirements by model suite?
Examples of Current and Planned Satellite Sensing Systems Relevant to Fire Monitoring

• **Active Fire Detection and Characterization (mid IR)**
  – AVHRR, GOES, DMSP, MSG (operational)
  – TRMM, MODIS (AM/PM), AATSR, BIRD, ASTER, MERIS (experimental)

• **Burned Area, Fire Danger, Post Fire Assessments (VIS, NIR)**
  – Coarse/moderate Resolution
    • AVHRR/METOP, MODIS, SeaWiFS, ATSR, VEGETATION
  – High Resolution
    • Landsat 5/7, SPOT, IRS AWiFs, Formosat, CBERS
    • ASTER – high resolution optical and thermal
    • Radarsat
  – Hyperspectral data – EO1
  – Hyperspatial Resolution – Ikonos, QuickBird, Rapideye, DMC Surrey etc

• **Emission products** (optical and sounding)
  – MODIS, MISR – Aerosol Optical Depth
  – AIRS, MOPITT – CO, etc

• **Examples of Planned Systems**
  – NPP/NPOESS VIIRS (2011) – active fire and energy - burned area
  – LDCM OLI (2012) and Sentinel 2 (2012) – burned area / severity?
  – HyspIRI (2013) – hyperspectral + multispectral thermal
  – Sentinel 3 (2013) – active fires
Monitoring Transport of Biomass Burning Aerosols

Smoke Transport Across Pacific from Siberia
6 May 2003

Smoke Transport Across Gulf of Mexico
9 May 2003

Quebec, Canada
6 July 2003 at 17:45 UTC

GoES Geostationary Monitoring

GOES-11 Rapid Scan Visible Imagery (1 km)
22:07, 9 June 2002 – 00:50, 10 June 2002
Courtesy of CSU - CIRA

Wildfires in Quebec, Canada
6 July 2003 at 17:45 UTC

(Prins et al)
MODIS Burned Area Product 500m

Australia
500m burned areas
1 month 2002

Roy et al
Global Burned Area (MODIS)

- Global Product 500m
- Monthly Composite – showing date of burning

( Roy and Boschetti)
Hyperspatial Resolution Data: Quickbird

60cm Resolution Imagery of the Esperanza Fire, Twin Pines, Ca
October 2006
(courtesy Digital Globe)
Smoke Plumes, B and B Complex Fire, Oregon 2003
ERS- SAR

Fire damage classification of the 1997-98 fires in East Kalimantan, Indonesia
Transitioning Research to Operations

Fundamental and Global Change Science

User Driven Research and Development Operational Prototyping

Operational Use of the Data and Information Products

Resource Management and Policy

Peer Review Publications

Experimental RS Systems e.g. MODIS, LDCM, EO1,

Operational RS Systems e.g. AVHRR, NPOESS VIIRS,
GOFC-GOLD
An International Program for the Coordination of Observations
Land Cover, Fire, Biomass
A project of GTOS

http://gofc-fire.umd.edu
Functions of GOFC-GOLD

1. Specifying requirements for products
2. Assessing algorithms and data assimilation procedures
3. Ensuring the availability of observations
4. Harmonization and the development of protocols and standards
5. Ensuring that operational products meet accuracy requirements
6. Capacity building and the role of regional networks
7. Creating GOFC-GOLD products and services
8. Providing information to support international assessments
9. Advocacy role, especially in relation to the continuity of observations and validation
Promote interaction between a number of major communities

Remote Sensing and Operational R and D

Space Agencies Fire Observation Systems
- Experimental
- Operational

GOFC/GOLD Fire

Fire Research and Global Change Research

Operational Fire and Resource Management and Policy
Regional Networks

a critical component of the implementation of GOFC-GOLD

Providing the interface between the panel and national level data users and needs

GOFC-GOLD
STB and IT’s

GOFC-GOLD
National Needs and Users

GOFC-GOLD
Regional Networks

1. SEARRIN - South East Asia
2. OSFAC - Central Africa
3. Miombo - Southern Africa
4. SAFNET – Southern Africa
5. NERIN – Northern Eurasia
6. REDLATIF Latin America
GOFC Fire Community Priority Areas

- Improved Fire Data and Information Products (of known Accuracy)

- Data Continuity and Sensor Improvements
  - Operational Spaceborne Assets

- Improved Data Policies, Access and Distribution

- Improved Capacity Building for Data Utilization
Examples of GOFC/GOLD-Fire Strategic Partnerships

- UN ISDR WG IV on Wildland Fire (Fire Management and Policy, Regional Network Support)
- Global Fire Monitoring Center (Global Fire Outreach)
- CEOS Land Product Validation Working Group (Satellite Product Validation Protocols)
- EARSeL Special Interest Group on Forest Fire (European Research)
- ACRSP (Australian Remote Sensing Research Groups)
- ILDRC (International Land Direct Readout Committee)
- Selected Individual Fire Research and Management Organizations critical to meeting GOFC Fire goals (e.g. USFS, IBAMA, CFS, CSIRO)
- Regional Science Initiatives (e.g. SAFARI, LBA, NEESPI, NACP)
Improved Fire Data and Information Products

- Products to meet International Convention data needs (w. GCOS/GTOS – ECVs)
- Regional / Global (Burned Area) Products with Systematic Product Validation (w. CEOS LPV)
- Global near real-time data (e.g. MODIS Rapid Response)
- Global Fire Danger Rating System (w. UN ISDR)
- Multi-source fire information integration
- Long Term Fire Data Records
- GOFC - Global Fire Assessment 2010
Increasing Satellite Fire Time Series

NASA
MODIS
Active Fire
2000-2008

Peak Month

TRMM VIRS Annual Corrected Fire Counts

Globscar 2000

ESA GLOBCARBON 1998-2003

MODIS Burned Area 2000-2008
Burned Area Product Validation Protocol

• Compare MODIS burned area product with independent spatially explicit burned area data derived from multitemporal Landsat ETM+ data

• SAFNet field trip held to develop the mapping protocol and to discuss southern African fire information needs, Zimbabwe-Zambia, July 2000

• SAFNet members map the areas burned between 2+ Landsat acquisitions, augmented by limited fieldwork

• Consensus mapping protocol to ensure regionally consistent independent validation data

• protocol followed 2000-2002 at ~11 ETM+ scenes/year

Landsat ETM+
Sept. 4th
Yellow vectors = ETM+ interpreted burned areas occurring between the two ETM+ acquisitions
MODIS 500m Burned Areas

Sept. 4 to Oct. 6

White vectors = ETM+ interpreted burned areas occurring between the two ETM+ acquisitions
Landsat ETM+ validation scenes distributed from dry savanna to wet miombo woodland to quantify product accuracy over range of representative biomass burning conditions.

Modis 1km land cover product: Of the 17 MODIS land cover classes, predominant classes illustrated include: evergreen broadleaf forest (dark green), barren or sparsely vegetated (gray), woody savannas (light green), open shrublands (cream), grasslands (light brown), savannas (orange), croplands (yellow), cropland/natural vegetation mosaic (olive brown), urban (red).
L3JRC Burned Area product Validation

The slope of the regression line is 0.136, The intercept is 0.001 and the r^2 is 0.128
GLOBCARBON Burned Area product Validation.
The slope of the regression line is 0.595,
The intercept is 0.013 and the r2 is 0.509
MODIS Burned Area product Validation
The slope of the regression line is 0.75,
The intercept is -0.005 and the r² is 0.746
Satellite Fire Monitoring

- Data Product Progression
  - Algorithm Development and Testing (ATBD peer review)
  - Data Set Generation
  - Product Quality Control (QA metadata)
  - Product Validation (independent measurements)
  - Product Documentation and Distribution
  - Algorithm Refinement and Reprocessing
Established in 2000 as a subgroup of the Committee on Earth Observing Satellites: Working Group on Calibration/Validation

Linked through www.wgcvceos.org

Chair: jeff.morisette@nasa.gov

(Validation = independent Accuracy Assessment)
# LPV Structure cont.

<table>
<thead>
<tr>
<th>Focus Group</th>
<th>North America</th>
<th>Europe (Other)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Land Cover / Dynamics</td>
<td>Mark Friedl (Boston University)</td>
<td>Martin Herold (GOFC/GOLD)</td>
</tr>
<tr>
<td>Fire</td>
<td>Luigi Boschetti (University of Maryland)</td>
<td>Kevin Tansey (University of Leicester, UK)</td>
</tr>
<tr>
<td>Biophysical</td>
<td>Joanne Nightingale / Richard Fernandes (NR Canada)</td>
<td>Stephen Plummer (ESA/ESRIN, IT)</td>
</tr>
<tr>
<td>Surface Radiation</td>
<td>Crystal Schaaf (Boston University)</td>
<td>Gabriela Schaepman (University of Zurich, SW)</td>
</tr>
<tr>
<td>Land Surface Temperature</td>
<td>Ana Pinheiro (NOAA)</td>
<td>Jose Sobrino (University of Valencia, SP)</td>
</tr>
<tr>
<td>Soil Moisture</td>
<td>Tom Jackson (USDA)</td>
<td>Wolfgang Wagner (Vienna Uni of Technology, AT)</td>
</tr>
</tbody>
</table>
**LPV Web Site:** http://lpvs.gsfc.nasa.gov

**Communication:**

- Process for data / information collection and sharing
- Mailing lists
- Group communication via LPV wiki
- Information sharing via LPV website
Validation of Satellite Based Fire Products for Central Asia

• Is this something of interest to the audience?

Tatiana Laboda’s Fire Training Session
Early warning allows implementation of:

- fire prevention
- fire detection
- resource mobilization

before wildfire disasters occur.
Global EWS – Fire: System Structure

Uni. Maryland
NOAA/NESDIS
Active fire monitoring,
fire radiative energy

CAWCR
Global FDR Model
(current and forecast
FDR using ensemble
models)

CFS
Global EWS Fire Mgt
Products (prevention,
detection, resource-
sharing tools)

Other agencies
Vegetation and fuels
mapping, fire
mapping, etc.

Global EWS Modeling and
Data Coordination

Global Fire
Monitoring Centre
• Global Compilation of
National FDRS's
• Forecast Global FDR,
weather data and EWS
Products

Regional
Wildland Fire
Networks
13 Regional Networks

National Fire
Organizations
Nations with FDRS
Nations w/out FDRS

Sub-national
and/or Local
Capable of operating
FDRS locally, or as
part of larger Network

UN/ISDR, FAO,
UNEP, WHO
Early Warning of Fire
Disaster - safety;
Resource-Sharing
coordination;
Health warnings
A Satellite-based Global Fire Assessment 2010

- GOFC/GOLD, ISDR and GFMC are initiating a satellite-based global fire assessment using the available validated fire data records
- Global Trends in fire activity (10 year record)
  - Developing the most useful metrics
- The assessment would be undertaken working closely with regional fire scientists and management community to design and evaluate the assessment
  - Recent trends in fire activity, consistent method
  - Complement FAO’s compilation of national fire statistics
Seasonal Variability (2005)

MODIS Rapid Response Fire Detections for 2005

Active fires are detected using MODIS data from the Terra satellite.
Web Fire Mapper http://meps.geog.umd.edu

- MODIS Active Fire Detections
- World Countries
Global Fire Regime Characterization

Mean Peak Fire Month (2000-2005)

Giglio et al 2007
Global Fire Regime Characterization

Peak Fire Month Mean Fire Pixel Density
(Terra MODIS mean ; Nov. 2001 - Oct. 2005)
Fire radiative power from MODIS active fires (2000-2005)

Giglio et al., 2006, JGR
Data Continuity and Improved Observations for Fire Monitoring

- Geostationary Global Fire Network (GOES-R)
- Fire Monitoring with next generation Operational Polar Orbiters (NPP VIIRS)
- High/Mod Resolution Data Continuity (NASA/USGS LDCM OLI and TIRS (Landsat 8))
- New Technology Development (UAV Fire, NASA Sensor Web, New Decadal Survey Missions)

GOFC Fire Initiatives (US Examples)
### Satellite Active Fire Spectral Bands

<table>
<thead>
<tr>
<th>Satellite</th>
<th>Active Fire Spectral Bands</th>
<th>Resolution IGFOV (km)</th>
<th>SSR (km)</th>
<th>Full Disk Coverage</th>
<th>3.9 µm Saturation Temperature (K)</th>
<th>Minimum Fire Size at Equator (at 750 K) (hectares)</th>
</tr>
</thead>
<tbody>
<tr>
<td>GOES-12 Imager</td>
<td>1 visible 3.9 and 10.7 µm</td>
<td>1.0 4.0 (8.0)</td>
<td>0.57 2.3</td>
<td>3 hours</td>
<td>~335 K</td>
<td>0.15</td>
</tr>
<tr>
<td>GOES-9 &amp; GOES-10 Imager</td>
<td>1 visible 3.9 and 10.7 µm</td>
<td>1.0 4.0 (8.0)</td>
<td>0.57 2.3</td>
<td>1 hour (G-9) 3 hours (G-10)</td>
<td>~324 K (G-9) ~322 K (G-10)</td>
<td>0.15</td>
</tr>
<tr>
<td>MSG SEVIRI</td>
<td>1 HRV 2 visible 1.6, 3.9 and 10.8 µm</td>
<td>1.6 4.8 4.8</td>
<td>1.0 3.0 3.0</td>
<td>15 minutes</td>
<td>~335 K</td>
<td>0.22</td>
</tr>
<tr>
<td>FY-2C SVISSR (Fall 2004)</td>
<td>1 visible, 3.75 and 10.8 µm</td>
<td>1.25 5.0</td>
<td></td>
<td>30 minutes</td>
<td>~330 K (?)</td>
<td></td>
</tr>
<tr>
<td>MTSAT-1R JAMI (2005)</td>
<td>1 visible 3.7 and 10.8 µm</td>
<td>0.5 2.0</td>
<td></td>
<td>1 hour</td>
<td>~320 K</td>
<td>0.03</td>
</tr>
<tr>
<td>INSAT- 3D (2006)</td>
<td>1 vis, 1.6 µm 3.9 and 10.7 µm</td>
<td>1.0 4.0</td>
<td>0.57 ? 2.3 ?</td>
<td>30 minutes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>GOMS Electro N2 MSU-G (2006)</td>
<td>3 visible 1.6, 3.75 and 10.7 µm</td>
<td>1.0 km 4.0 km</td>
<td></td>
<td>30 minutes</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
What Happens After MODIS?

NPOESS Preparatory Project (NPP) Status

A CONVERGED SYSTEM
NASA / NOAA / DOD

National Polar-orbiting Operational Earth Satellite Suite Preparatory Project

NPP

Visible Infrared Imaging Radiometer Suite

VIIRS
Visible Infrared Imaging Radiometer Suite
IPO /NGST/ Raytheon Santa Barbara Remote Sensing

Description

• **Purpose:** Global observations of land, ocean, & atmosphere parameters at high temporal resolution (~ daily)
• **Predecessor Instruments:** AVHRR, OLS, MODIS, SeaWiFS
• **Approach:** Multi-spectral scanning radiometer (22 bands between 0.4 µm and 12 µm) 12-bit quantization
• **Swath width:** 3000 km

Status

• EDU Finished T/Vac testing
• Flight Unit #1 Development continues

Launch early 2011
### Comparison of MODIS & VIIRS Bands

<table>
<thead>
<tr>
<th>MODIS</th>
<th>VIIRS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Band</td>
<td>λ</td>
</tr>
<tr>
<td>1</td>
<td>620 - 670</td>
</tr>
<tr>
<td>2</td>
<td>841 - 876</td>
</tr>
<tr>
<td>3</td>
<td>459 - 479</td>
</tr>
<tr>
<td>4</td>
<td>545 - 565</td>
</tr>
<tr>
<td>5</td>
<td>1230 - 1250</td>
</tr>
<tr>
<td>6</td>
<td>1580 - 1670</td>
</tr>
<tr>
<td>7</td>
<td>2105 - 2155</td>
</tr>
<tr>
<td>8</td>
<td>405 - 420</td>
</tr>
<tr>
<td>9</td>
<td>438 - 448</td>
</tr>
<tr>
<td>10</td>
<td>483 - 493</td>
</tr>
<tr>
<td>11</td>
<td>526 - 536</td>
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<td>12</td>
<td>546 - 556</td>
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<td>13</td>
<td>662 - 672</td>
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<td>673 - 683</td>
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<td>743 - 753</td>
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<td>16</td>
<td>862 - 877</td>
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<td>17</td>
<td>890 - 920</td>
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<td>931 - 941</td>
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<tr>
<td>19</td>
<td>915 - 965</td>
</tr>
<tr>
<td>20</td>
<td>3.660 - 3.660</td>
</tr>
<tr>
<td>22</td>
<td>3.920 - 3.920</td>
</tr>
<tr>
<td>24</td>
<td>4.430 - 4.430</td>
</tr>
<tr>
<td>25</td>
<td>4.440 - 4.440</td>
</tr>
<tr>
<td>26</td>
<td>1.360 - 1.360</td>
</tr>
<tr>
<td>28</td>
<td>7.175 - 7.175</td>
</tr>
<tr>
<td>29</td>
<td>8.400 - 8.400</td>
</tr>
<tr>
<td>31</td>
<td>10.780 - 10.780</td>
</tr>
<tr>
<td>33</td>
<td>13.185 - 13.185</td>
</tr>
</tbody>
</table>

MODIS Bands 1-2 are 250 m at Nadir
MODIS Bands 3-7 are 500 m at Nadir
MODIS Bands 8-36 are 1,000 m at Nadir

VIIRS Bands I1-I5 are 371 m at Nadir
VIIRS Bands M-1-M-16 are 742 m at Nadir
VIIRS EDRs, IPs, and ARPs

EDR-Environmental Data Record | IP-Intermediate Product | ARP-Application Related Product

**Land**
- Active Fire [ARP]
- Land Surface Albedo
- Land Surface Temperature Ice Surface Temperature
- Sea Ice Characterization
- Snow Cover/Depth
- Vegetation Index
- Surface Type

**Imagery & Cloud**
- Imagery
- Cloud Mask [IP]
- Cloud Optical Thickness
- Cloud Effective Particle Size Parameter
- Cloud Top Parameters
- Cloud Base Height
- Cloud Cover/Layers

**Ocean**
- Sea Surface Temperature
- Ocean Color/Chlorophyll

**Aerosol**
- Aerosol Optical Thickness
- Aerosol Particle Size Parameter
- Suspended Matter

Other Land products in planning phase
VIIRS Spatial Resolution –
requirement for uniform pixel size across scan

HSI for imaging bands
(aggregation in scan direction)

Track HSI
(no aggregation)

Scan HSI

Horizontal Sample Interval (m)

Scan angle from nadir (degrees)

Nadir:
Aggregate 3 in-scan

1014 km from nadir:
Aggregate 2 in-scan

1500 km from nadir:
No aggregation

371 m

129 m

388 m

606 m

388 m

776 m

800 m

789 m
The Landsat Data Continuity Mission

Operational Land Imager

(aka Landsat 8)

Launch Date Planned for Dec 2012
OLI Maintains Landsat Legacy

- **Landsat Continuity Mission demands**
  - Accurate spectral and spatial information
  - Frequent synoptic earth views
  - NIST calibrated over time
  - Precise geo-referenced data

- **Key instrument parameters**
  - Cross-track FOV: 185 km
  - S/C altitude: 705 km
  - Geodetic accuracy*
    - Absolute: 65 m
    - Relative: 25 m
  - Geometric accuracy**
    - Absolute: 12 m

<table>
<thead>
<tr>
<th>Band Name</th>
<th>Band (nm)</th>
<th>Bandwidth (nm)</th>
<th>GSD (m)</th>
<th>SNR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coastal/Aerosol</td>
<td>443</td>
<td>20</td>
<td>30</td>
<td>130</td>
</tr>
<tr>
<td>Blue</td>
<td>482</td>
<td>65</td>
<td>30</td>
<td>130</td>
</tr>
<tr>
<td>Green</td>
<td>562</td>
<td>75</td>
<td>30</td>
<td>100</td>
</tr>
<tr>
<td>Red</td>
<td>655</td>
<td>50</td>
<td>30</td>
<td>90</td>
</tr>
<tr>
<td>NIR</td>
<td>865</td>
<td>40</td>
<td>30</td>
<td>90</td>
</tr>
<tr>
<td>SWIR 1</td>
<td>1610</td>
<td>100</td>
<td>30</td>
<td>100</td>
</tr>
<tr>
<td>SWIR 2</td>
<td>2200</td>
<td>200</td>
<td>30</td>
<td>100</td>
</tr>
<tr>
<td>PAN</td>
<td>590</td>
<td>180</td>
<td>15</td>
<td>80</td>
</tr>
<tr>
<td>Cirrus</td>
<td>1375</td>
<td>30</td>
<td>30</td>
<td>50</td>
</tr>
</tbody>
</table>

*No terrain compensation
**w/ terrain compensation
Driving Performance Requirements

- **Radiometric**
  - Signal-to-noise radiometric stability (16-day, 60 sec, 5 year)
  - Pixel-to-pixel uniformity
  - Absolute radiometric accuracy
    - Absolute radiance – 5%, absolute reflectance – 3%

- **Spectral**
  - Spectral band edges and center wavelength tolerance
  - Integrated out-of-band (OOB) response (<2%)
  - Spectral uniformity (FWHM) (± 3%)

- **Spatial – Pushbroom**
  - Edge response
  - Aliasing
  - Light rejection and internal scattering
  - Ghosting

- **Geometric**
  - Band-to-band co-registration (4.5 m)
  - Absolute geodetic accuracy (65 m)

### OLI Band and SNR Specs

<table>
<thead>
<tr>
<th>#</th>
<th>Minimum Lower Band Edge (nm)</th>
<th>Maximum Upper Band Edge (nm)</th>
<th>SNR at LTypical</th>
<th>SNR at LHigh</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>433</td>
<td>453</td>
<td>130</td>
<td>290</td>
</tr>
<tr>
<td>2</td>
<td>450</td>
<td>515</td>
<td>130</td>
<td>360</td>
</tr>
<tr>
<td>3</td>
<td>525</td>
<td>600</td>
<td>100</td>
<td>390</td>
</tr>
<tr>
<td>4</td>
<td>630</td>
<td>680</td>
<td>90</td>
<td>340</td>
</tr>
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<td>5</td>
<td>845</td>
<td>885</td>
<td>90</td>
<td>460</td>
</tr>
<tr>
<td>6</td>
<td>1560</td>
<td>1660</td>
<td>100</td>
<td>540</td>
</tr>
<tr>
<td>7</td>
<td>2100</td>
<td>2300</td>
<td>100</td>
<td>510</td>
</tr>
<tr>
<td>8</td>
<td>500</td>
<td>680</td>
<td>80</td>
<td>230</td>
</tr>
<tr>
<td>9</td>
<td>1360</td>
<td>1390</td>
<td>50</td>
<td>N/A</td>
</tr>
</tbody>
</table>

**Global Acquisition Strategy**

**Free Data Download**
120 m resolution was felt to be sufficient to resolve most center-pivot irrigation fields in U.S. West - typically 400 to 800 m in diameter

Landsat satellites provide 16 day repeat imaging -- sufficient for water consumption estimation

Landsat 4 & 5 TM’s provided 120 m thermal images for a single thermal band

Landsat 7 ETM+ provided 60 m thermal images for a single thermal band

A two band instrument will enable atmospheric correction so that more accurate surface temperatures can be derived.

<table>
<thead>
<tr>
<th>Band</th>
<th>Center Wavelength (m)</th>
<th>Spatial Resolution At Nadir (m)</th>
<th>NE ∆T Requirements At TTyp &amp; AtTHigh</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermal 1</td>
<td>1.08</td>
<td>120</td>
<td>0.4 K</td>
</tr>
<tr>
<td>Thermal 2</td>
<td>1.20</td>
<td>120</td>
<td>0.4 K</td>
</tr>
</tbody>
</table>

### LDCM Thermal – TIRS Instrument

**Band**

<table>
<thead>
<tr>
<th>Thermal 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Center Wavelength (m)</td>
</tr>
<tr>
<td>Spatial Resolution At Nadir (m)</td>
</tr>
<tr>
<td>NE ∆T Requirements At TTyp &amp; AtTHigh</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Thermal 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Center Wavelength (m)</td>
</tr>
<tr>
<td>Spatial Resolution At Nadir (m)</td>
</tr>
<tr>
<td>NE ∆T Requirements At TTyp &amp; AtTHigh</td>
</tr>
</tbody>
</table>
Improved Data Access and Distribution

– Free and Open sharing of Data *(Landsat Archive, MODIS Products)*
– User Friendly Products *(GLS 2000-2010)*
– Near Real-Time Global Daily Active Fire Monitoring *(MODIS Rapid Response)*
– Web based Fire and Imagery Distribution Systems *(FIRMS Web GIS)*
U.S. Landsat Archive Overview
(Useable Scenes through December 31, 2008)

- **ETM+: Landsat 7**
  - 892,051 scenes
  - 828 TB RCC and L0Ra Data
  - Archive grows by 260 GB Daily

- **TM: Landsat 4 & Landsat 5**
  - 780,191 scenes
  - 391 TB of RCC and L0Ra Data
  - Archive Grows by 40 GB Daily

- **MSS: Landsat 1 through 5**
  - 652,173 scenes
  - 20 TB of Data
Downloads through EE/Glovis (ETM+)

1 Million Scenes Downloaded – Aug 2009
Global Land Survey Data Sets

Global cloud-free, orthorectified Landsat data sets centered on 1975, 1990, 2000, 2005, and 2010

- Partnership between USGS and NASA, in support of CCSP
- Support global assessments of land-cover, land-cover change, and ecosystem dynamics (disturbance, vegetation health, etc)
- Pilot project for routine global monitoring in LDCM era
For More Information

GLS2005 Web Site:
http://mdgls.umd.edu

January 2008
Photogrammetric Engineering & Remote Sensing
MODIS Land Rapid Response

- Browse-and-click interface
- Calendar-based layout
- Multiple spatial resolutions, multiple band combinations, multiple products
- Gallery images keyword-searchable and georeferenced ("world file" available for GIS users)
- Link to L1 data at the LAADS

http://ladsweb.nascom.nasa.gov/
Overview of FIRMS Products

FIRMS delivers MODIS hotspots/active fire locations in 4 ways:

- Email Alerts
- Web Fire Mapper
- Shape Files
- MODIS Subsets

All of which are delivered in near real time (approx 2 hours after satellite overpass), with relatively small file sizes and in easily accessible formats.
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 6/23/2004 4:15:10 PM

SMS text messages (cell phones)

Short text messages (email)

<table>
<thead>
<tr>
<th>Latitude</th>
<th>Longitude</th>
<th>BT</th>
<th>Scan</th>
<th>Track</th>
<th>Date</th>
<th>Time</th>
<th>Sat</th>
<th>Conf</th>
</tr>
</thead>
<tbody>
<tr>
<td>-25.203</td>
<td>31.564</td>
<td>3:17.8</td>
<td>1</td>
<td>1.1</td>
<td>2004-07-15</td>
<td>1143</td>
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<td>76</td>
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<td>0800</td>
<td>T</td>
<td>48</td>
</tr>
<tr>
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<td>0806</td>
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<tr>
<td>-25.414</td>
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<td>3:13.8</td>
<td>1</td>
<td>1</td>
<td>2004-07-16</td>
<td>0806</td>
<td>T</td>
<td>66</td>
</tr>
</tbody>
</table>

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

Distance from 30.345, -29.6 to ESKOM distribution grid: 0.07 km - Closest point: 30.345, -29.600 on segment "131713", 08/02/2004/11:30 Distance from 27.834, -26.888 to ESKOM distribution grid: 0.32 km - Closest point: 27.837, -26.887 on segment "525669", 08/02/2004/11:30 Distance from 31.034, -25.721 to ESKOM distribution grid: 0.11 km - Closest point: 31.034, -25.721 on segment "412492", 08/02/2004/11:30
Satellite Active Fire Product is appearing like Weather Data

(Philip Frost, CSIR)
What is GOFC/GOLD-Fire?

GOFC/GOLD (Global Observations of Forest and Land Cover Dynamics) is a project of the Global Terrestrial Observing System (GTOS) program, which is sponsored by the Integrated Global Observing Strategy (IGOS). The main goal of GOFC/GOLD is to provide a forum for international information exchange, observation and data coordination, and a framework for establishing the necessary long-term monitoring systems.

The GOFC/GOLD-Fire Mapping and Monitoring Theme is aimed at refining and articulating the international observation requirements and making the best possible use of fire products from the existing and future satellite observing systems, for fire management, policy decision-making and global change research.

GOFC/GOLD is promoting self-organized regional networks of data users, data brokers and providers, where closer linkages and collaborations are established with emphasis on an improved understanding of user requirements and product quality. GOFC/GOLD-Fire is pursuing, in a joint effort with the Committee on Earth Observation Satellites (CEOS) Working Group on Calibration and Validation (WGCV) Land Product Validation (LPV) subgroup, the coordinated validation of fire products by standardized protocols.

GOFC/GOLD-Fire is partnering with the Global Fire Monitoring Center (GFMC), and the United Nations International Strategy for Disaster Reduction (UNISDR) Wildland Fire Advisory Group / Global Wildland Fire Network.

Latest meeting information. Click here for latest news.

- International BOS/APP Direct Readout Meeting

- Wildfire sessions at EGU 2006
  4/13/2006 - 4/18/2006 (Vienna, Austria)

- International Conference on Modelling, Monitoring and Management of Forest Fires
  9/17/2008 - 9/19/2008 (Toledo, Spain)

- 14 Australian Remote Sensing and Photogrammetry Conference
  5/29/2003 - 10/3/2003 (Canberra, Australia)