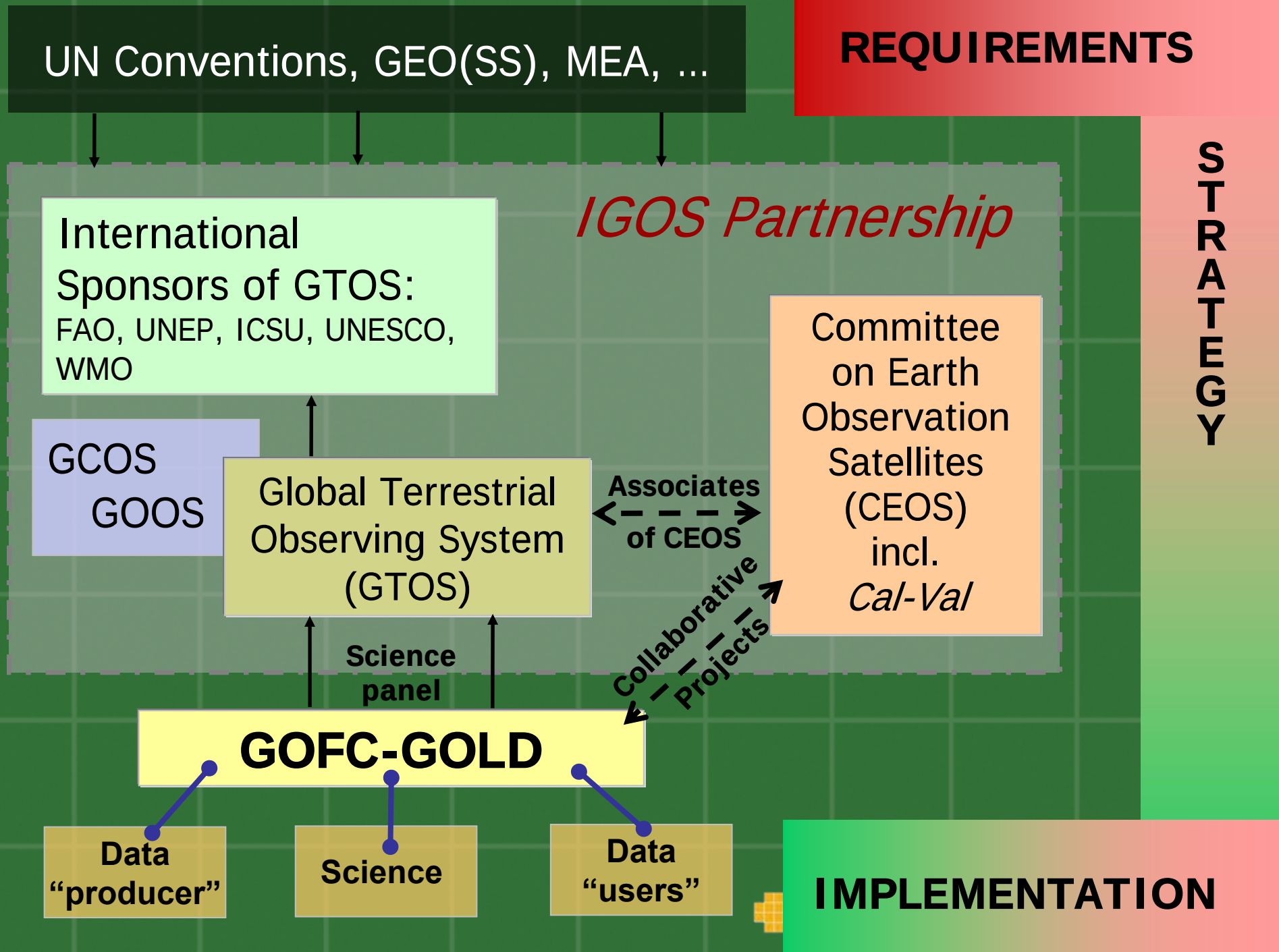
GOFC-GOLD

Global Observation of Forest and Land Cover Dynamics

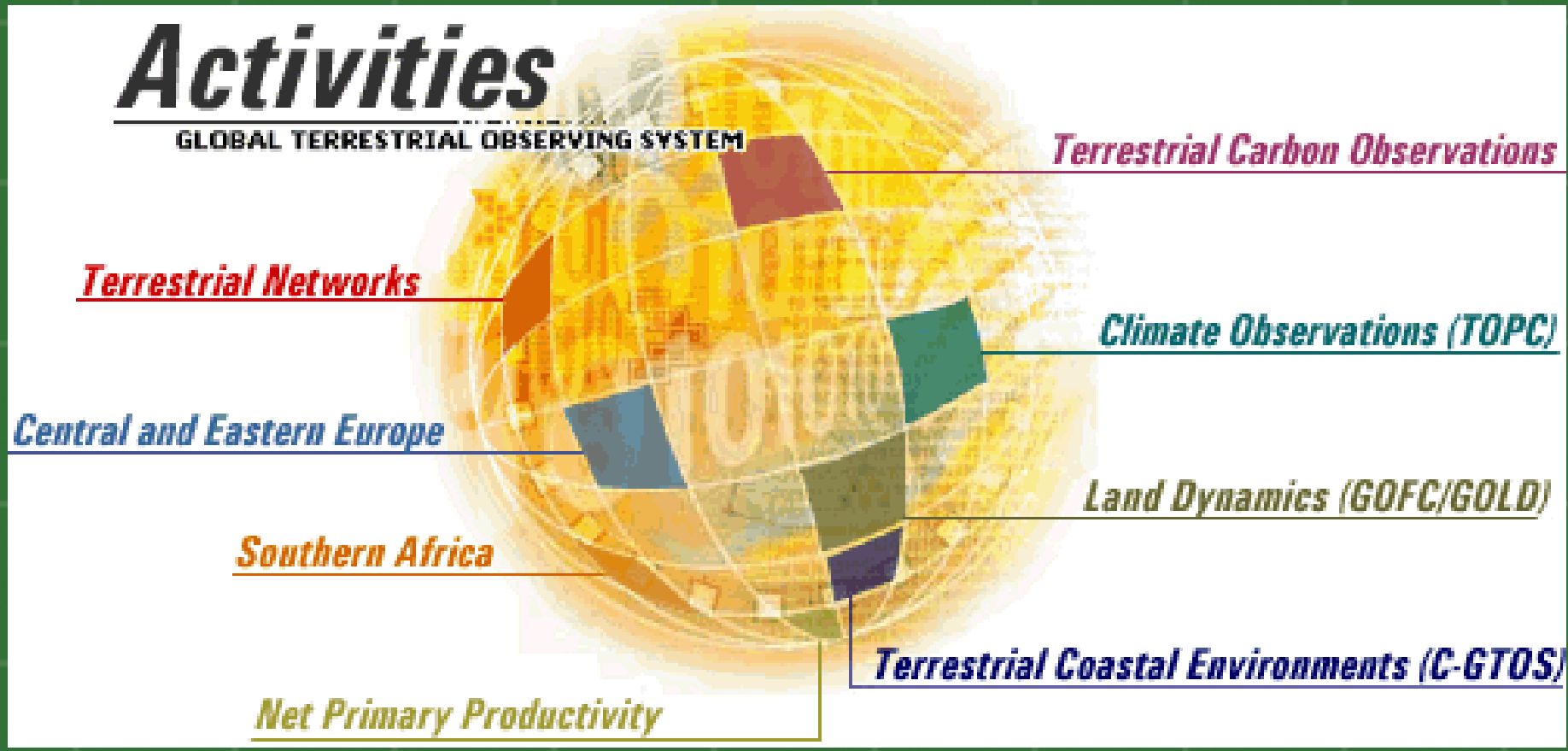
GOFC-GOLD: linkages to international programs and validation needs

Ivan Csiszar
CEOS 25th WGCV meeting
May 9-12th 2006
with contribution from J. Townshend, M. Brady, C. Justice, M. Harold, D. Roy, J. Morisette and others

GTOS

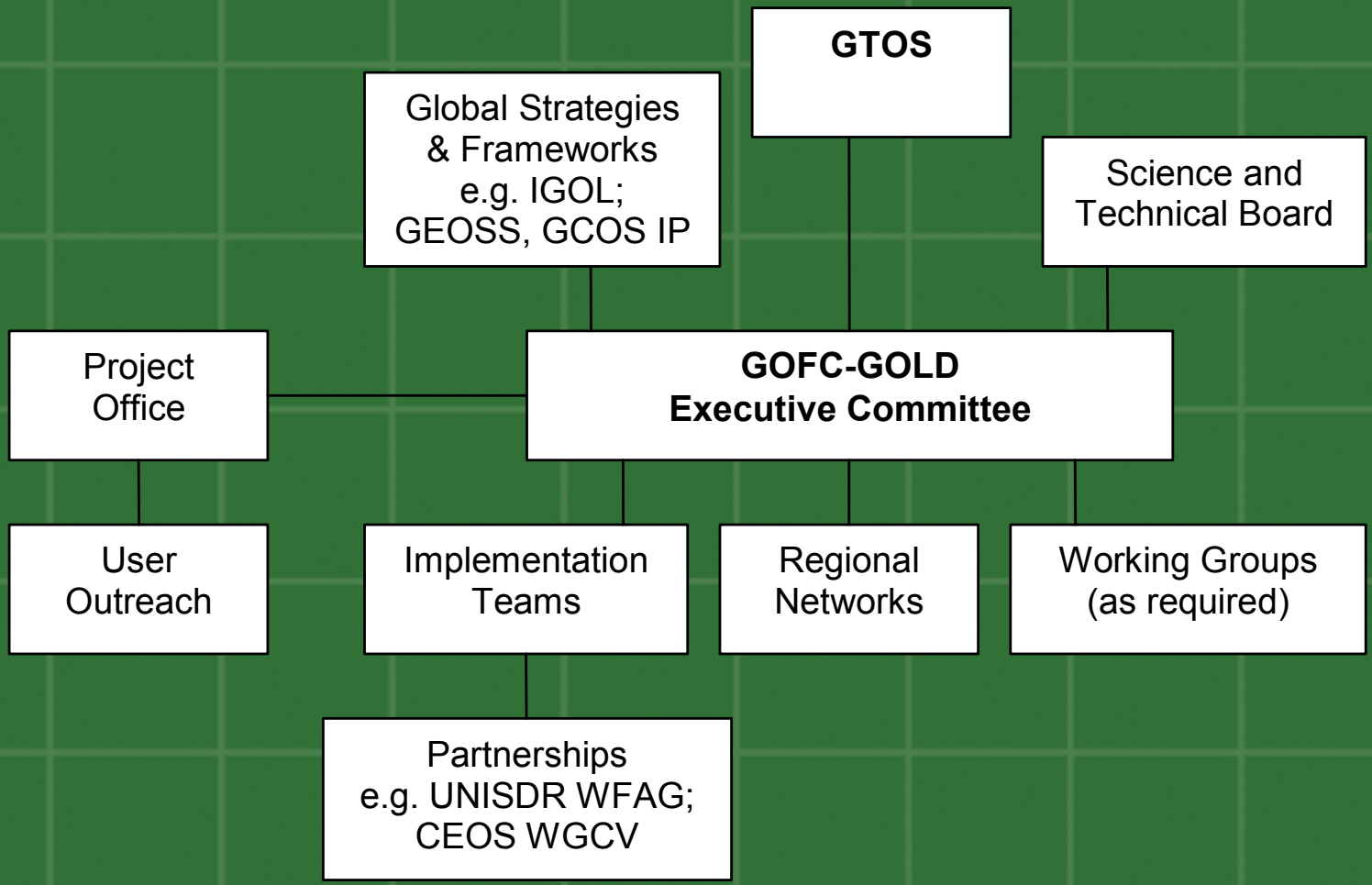

UN Conventions, GEO(SS), MEA, ...
REQUIREMENTS
STRATEGY
IGOS Partnership
International Sponsors of GTOS:
FAO, UNEP, ICSU, UNESCO, WMO
GCOS
GOOS
Global Terrestrial Observing System (GTOS)
Associates of CEOS
Committee on Earth Observation Satellites (CEOS) incl. Cal-Val
Collaborative Projects
Science panel
GOFC-GOLD
Data "producer"
Science
Data "users"
IMPLEMENTATION

GTOS



GOFC-GOLD

Management Structure



Principal Sponsors

- Canadian Space Agency
- Canadian Forest Service
- NASA
- European Space Agency
- GTOS
- FAO
- European Commission

Functions of GOFC-GOLD

1999 Strategy revisited in 2005 to ensure the global systematic collection of observations of land cover and fire

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

Extending Global Interactions - New Drivers

- International environmental conventions
- GCOS implementation plan
- GEO & GEOSS reference plan
- IGOS-P Land Theme (IGOL)
- FAO-FRA

International coordination

- Committee on Earth Observation Satellites (CEOS)
  - Increasing the use of and support for satellite observations
  - *Need to engage users*
- Integrated Global Observing System
  - Space agencies with UN operational partners – WMO, FAO, etc
  - Recognizes the need to integrate space and in-situ observations
  - GCOS- climate, GOOS-ocean, GTOS-land
  - IGOS Themes – Carbon, Water, GeoHazards, Coastal Zones,
  - **IGOS Land Theme = IGOL**
    - Landcover, Land Use, Agriculture, Forestry, Soils, Biodiversity, etc
    - Defining the necessary Land Observation improvements – 06 report
  - *Need to engage donors (nations)*
- Global Earth Observations System of Systems GEO SS
  - Ministerial support / national commitments
  - Focus on Societal Benefits – Disasters, Agriculture/Forestry etc
  - Established workplan tasks for 06

GOFC-GOLD

GCOS Implementation Plan

- Establish international standards for land-cover characterization
- Reliable methods for land-cover map accuracy assessment
- Develop an in situ reference network and apply validation protocols
- Generate annual products documenting global land-cover characteristics

2005 Progress Report

Selected Terrestrial Variables of the Implementation Plan for the Global Observing System for Climate

- Land Cover actions:
  - standards and specifications for land-cover characterization maps (T22)
  - methods for land-cover map accuracy assessment (T23)
  - continuity of fine resolution datasets (T24)
- Fire Disturbance actions:
  - reanalyze historical fire disturbance data (T32)
  - generation of active fire and burnt area products (T33)
  - apply CEOS WGCV and GOFC-GOLD validation protocol to fire disturbance data (T34)
  - make gridded fire and burnt area products available through a single International Data Centre (T35)

GOFC-GOLD

UNFCCC-SBSTA

- CEOS: Detailed specification of variables for climate studies:
  - Land cover and cover change
  - Active fire, radiative power and burnt area
- GTOS: Guidance materials, standards, and reporting guidelines for terrestrial ECVs
- GOFC/GOLD input through TOPC
  - not everything in current GCOS document

GOFC-GOLD Product Specifications for Terrestrial ECVs

Variable	Product
Land cover	- Land cover 250 m
	- Land cover change 10 m
	- Land cover change history
Fire disturbance	- Active fire
	- Burnt area
	- Fire radiative power
Biomass?	- *Biomass/NPP*

GOFC-GOLD

Where are we now in relation to remote sensing observations?

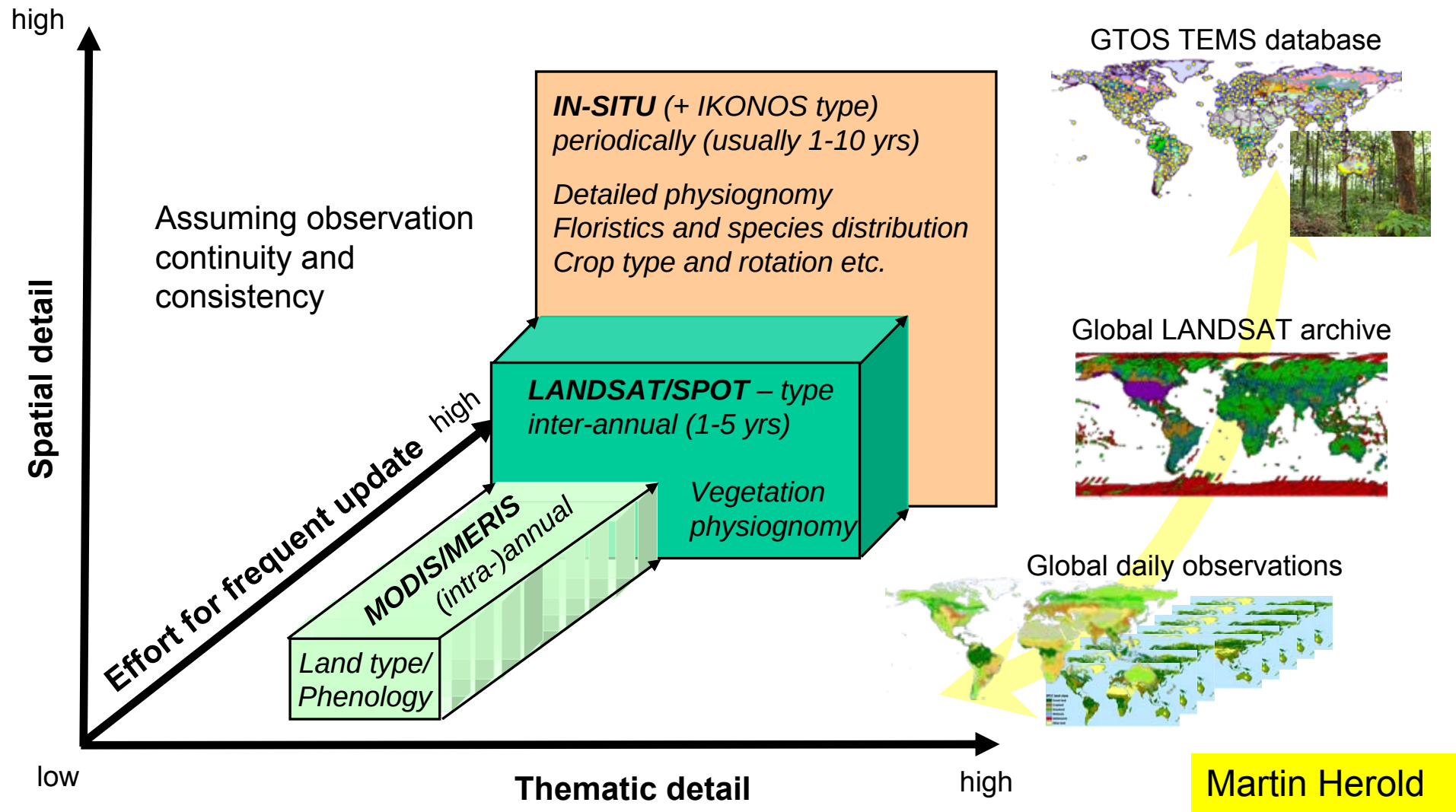
- Large numbers of mission in orbit.
- Many have no continuity planned.
- Many have poor data policies and weak distribution.
- Overall cooperation in use satellites is weak compared with weather satellites.

Examples of status of some key terrestrial observing systems

	Technical Challenge	Continuity Challenge	Distribution Challenge
Ultra-fine resolution	**No**	Probably not	Y
Landsat-class	**No**	Y now	Y
Thermal	**No**	Y	Y
Mod Res.	**No**	**No**	**No**
Radar	**No**	Y	Y
Canopy Lidar	Y	Y	Y
City Lights	**No**	Y	Y

GOFC-GOLD

Integrated and operational observations



Martin Herold

GEO & GEOSS Reference Plan

GEOSS Societal Benefit Area	Specific land-related examples
Reducing Loss of Life and Property from Natural and Human Induced Disasters	Early warning systems for fires
Understanding Environmental Factors Affecting Human Health and Well-Being	Impact of fires on air quality; Locust forecasting
Understanding, Assessing, Predicting, Mitigating and Adapting to Climate Variability and Change	Role of forest change on carbon sequestration; monitoring compliance with Kyoto Protocol
Improving Water Resource Management through Better Understanding of the Water Cycle	Improved depiction of topography; impact of vegetation including root zone on hydrological cycle
Improving the Management and Protection of Terrestrial, Coastal and Marine Ecosystems	Monitoring of terrestrial ecosystems using satellite observations
Supporting Sustainable Agriculture and Combating Desertification	Reducing poverty and land degradation for more sustainable uses of agriculture
Understanding, Monitoring and Conserving Biodiversity	Monitoring protected areas and the landscapes within which they are found

GOFC-GOLD

2006 GEOSS Implementation Plan

- Contribute to 8 tasks (agriculture, disasters, climate, biodiversity, ecosystems)
- Co-lead 5
  - warning system for fire and monitoring for forest conversion
  - establishing continuity for near real-time, 30-m (or better) resolution, multi-spectral remote-sensing coverage
  - assessment on forests and forest changes utilizing ongoing land cover mapping projects
  - production of a high-resolution global land-cover change dataset
  - develop a network of organization-networks for ecosystems

GOFC-GOLD

GTOS/GOFC-GOLD Tasks for GEO

GEO Comm.	GEO Task (and role)	Priority* (HML)
ADC	DI-06-13 Initiate a globally coordinated warning system for fire and monitoring for forest conversion, including the development of improved information products and risk assessment models. (co lead with Portugal)	H
ADC	AR-06-09 Advocate establishing continuity for near real-time, 30-m (or better) resolution, multi-spectral remote-sensing coverage everywhere on the Earth's surface, including support for the launch of a Landsat-equivalent follow-on mission. (co lead with CEOS, USGS)	M
ADC	AG-06-04 Initiate an international assessment effort on forests and forest changes utilizing ongoing land cover mapping projects (e.g. GLOBCOVER). Ensure application of standardized classifications and harmonization of existing datasets. (co lead with GTOS, FAO & USGS)	M
UIC	US-06-02 Initiate pilot communities of practice to identify and further refine users' needs, in particular on cross-cutting areas, building upon the initial experience of community of practice and on information provided by national, regional and project-level surveys. (contribute)	H
UIC	DI-06-09 Expand the use of meteorological geostationary satellites for the management of non-weather related hazards. (contribute)	M
STC	AG-06-03 Utilizing global and regional high resolution land-cover datasets (e.g. GLOBCOVER) and earlier 1-km resolution land cover data sets (e.g. Global Land Cover 2000), implement production of a high-resolution global land-cover change dataset and report. Propose mechanisms for regular analysis and reporting on land cover change building on current efforts and promulgate the use of these products, especially in developing countries. (co lead with USGS)	H
CBC	EC-06-07 Build upon existing initiatives (e.g. ANTARES in South America for oceans and GOFC-GOLD regional networks for terrestrial domains) to develop a global network of organization-networks for ecosystems, and coordinate workshops to strengthen observing capacity in developing countries. (co lead with POGO, USGS)	M
CBC	DI-06-12 Initiate a knowledge-transfer programme to developing countries, to ensure basic capacity to utilize Earth observations for disaster management. (contribute)	L

ADC: Architecture and Data; CBC: Capacity Building; STC: Science and Technology; UCI: User Interface

GOFC-GOLD

Global Observation of Forest and Land Cover Dynamics

Land Cover Characteristics and Change

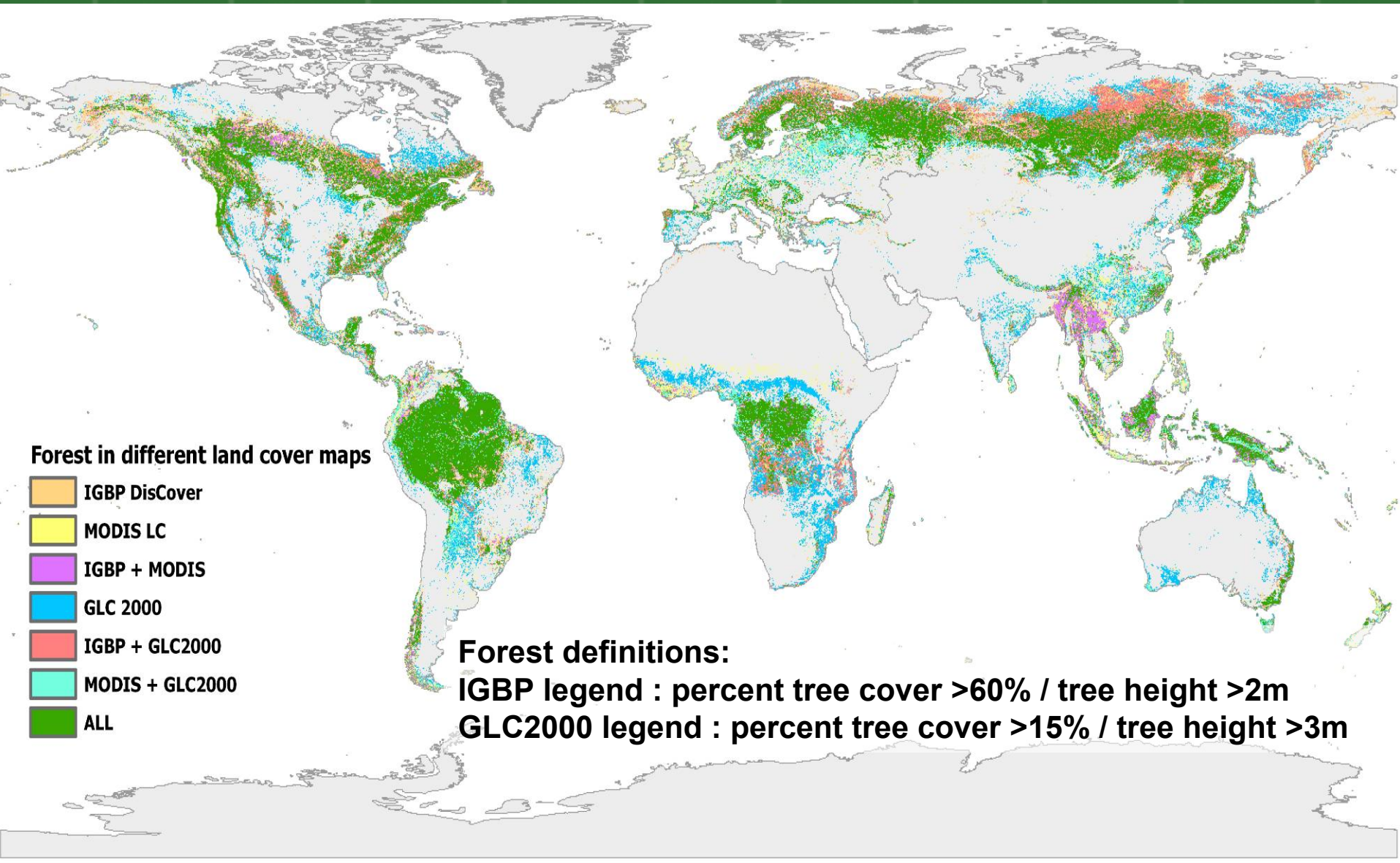
The Land Cover Characteristics and Change theme promotes the use and refinement of land cover data and information products for resource managers, policy makers, and scientists studying the global carbon cycle and biodiversity loss.

GOFC-GOLD has proposed a program of coarse resolution earth observations, fine-scale land cover mapping, and integration with in-situ observations on global scales.

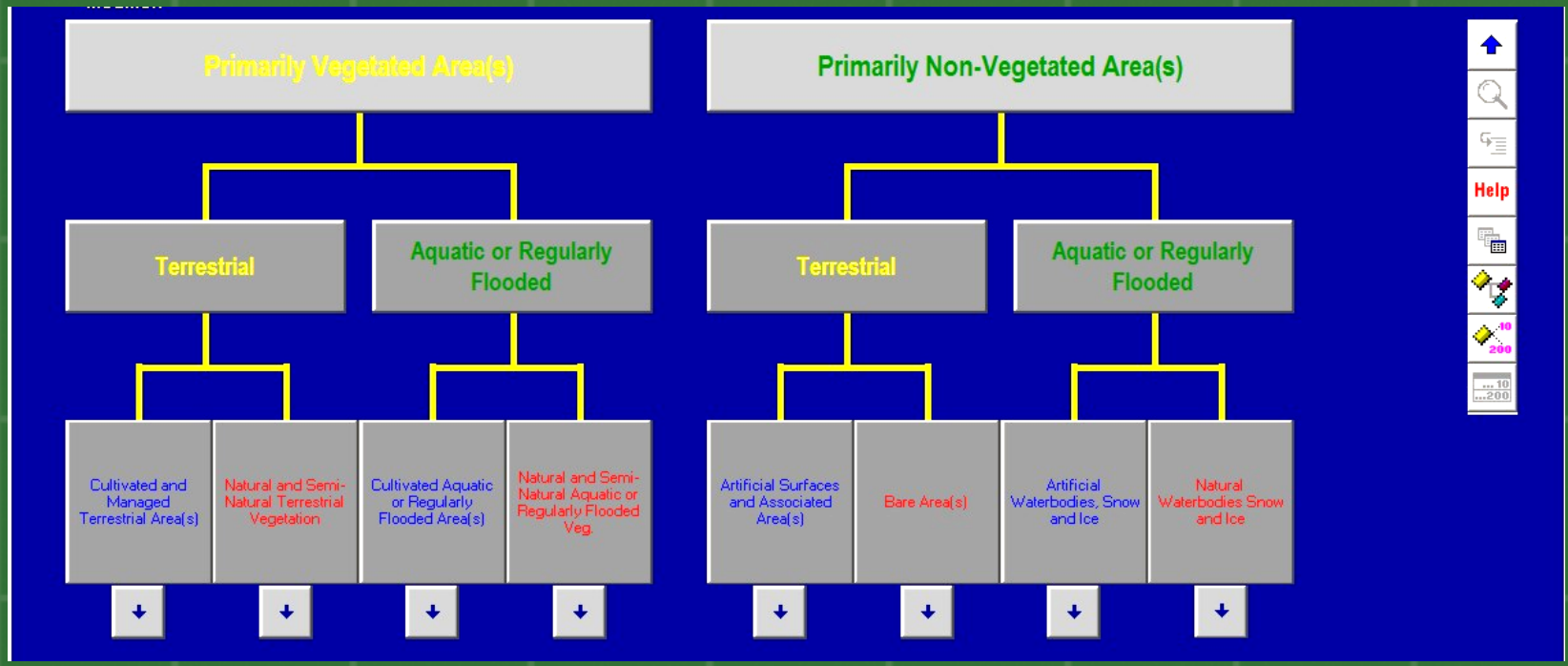
The Land Cover theme is carried out by an implementation team that works with the GOFC-GOLD regional networks to secure acquisition of quality land cover data and interacts with users and regional experts for the development and implementation of mapping standards, data assimilation, and product dissemination.

http://www.gofc-gold.uni-jena.de

Forest areas in global land cover maps



LCCS-2 user interface at the initial dichotomous classification phase



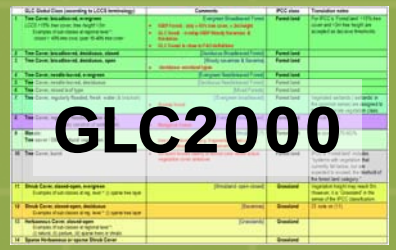
LCCS is a world-wide reference system for land cover able to combine high flexibility with an absolute level of standardization of class definitions between different users. The system allows a dynamic creation of classes without the user having to relate to a pre-defined list of names by a dynamic combination of land cover diagnostic attributes called classifiers.

LCCS: Land Cover Classification System

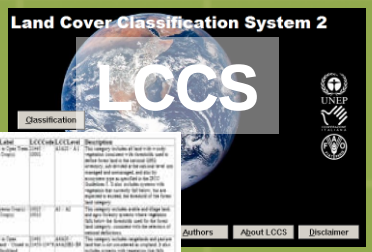
GOFC-GOLD

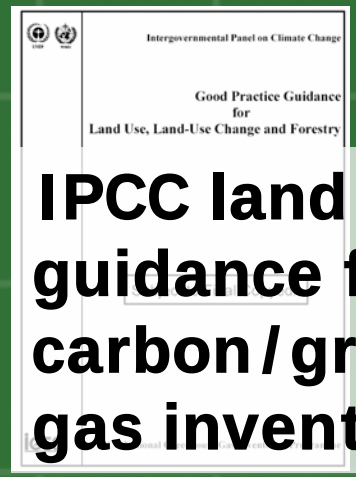
Harmonization mechanisms

Legend



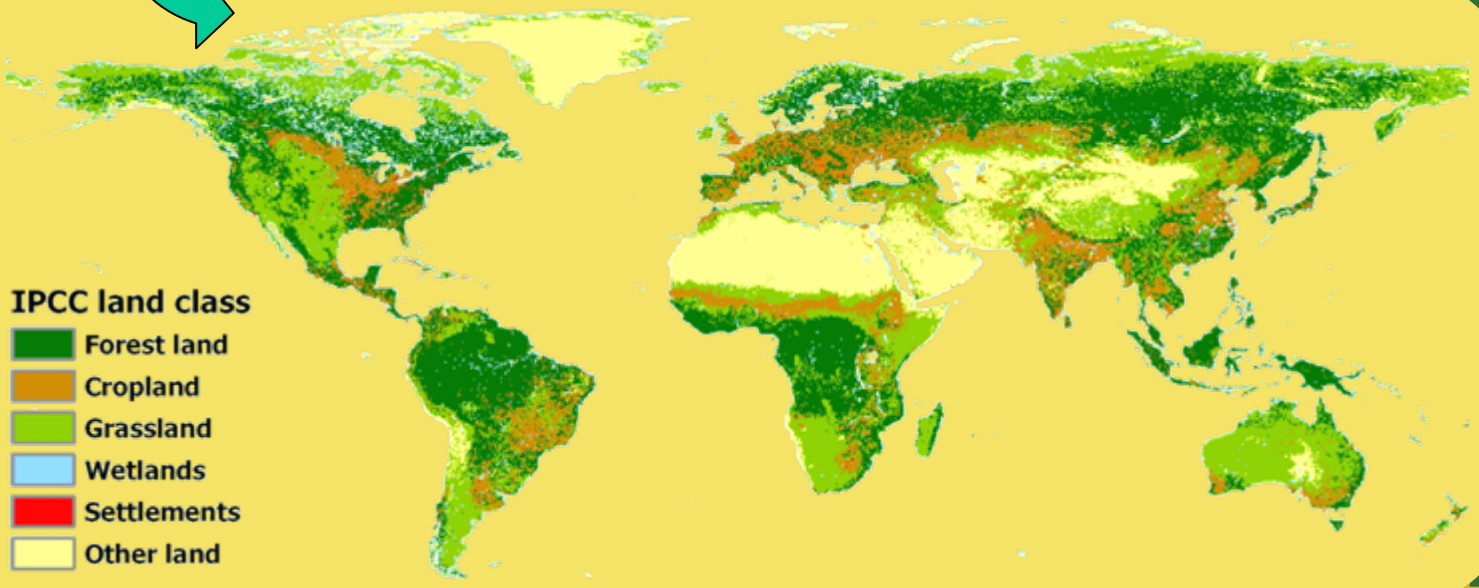
Translator



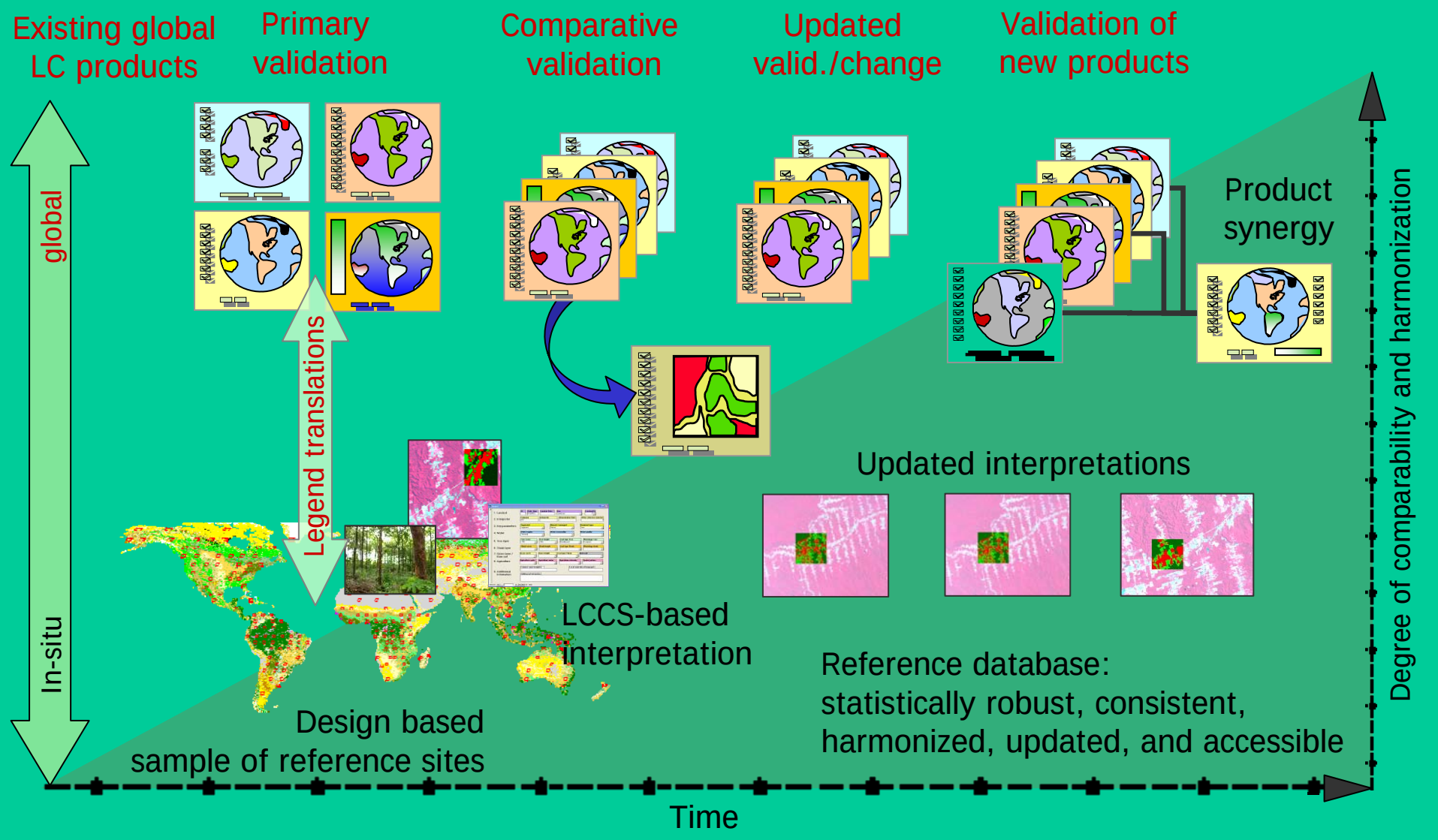


IPCC land use guidance for carbon / greenhouse gas inventory calc.

Harmonized map



Framework for joint GOFC-GOLD/CEOS Harmonization/Validation initiative



Top Priorities for Land Cover

- International harmonization and validation framework (CEOS WGCV)
  - Harmonization for using LCCS – crosswalking classifications to IPCC needs
  - Procedures for global classification validation about to be published (Alan Strahler, BU)
  - Validation procedures for continuous fields starting (Matt Hansen, SDSU)

GOFC-GOLD

Global Observation of Forest and Land Cover Dynamics

Fire Mapping and Monitoring

The Fire Mapping and Monitoring theme focuses on refining international requirements for fire-related observations and making the best possible use of fire products from existing and future satellite observing systems to support fire management, policy decision-making, and global change research.

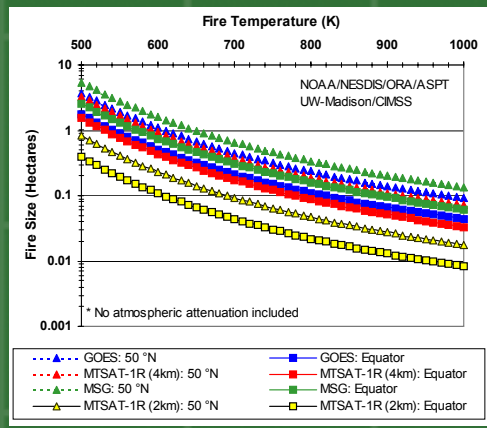
Key goals are to ensure enhanced operational fire monitoring from space and ground measurements, better access and use of data, and standard products of known accuracy.

The Fire theme is carried out by an implementation team that works with the GOFC-GOLD regional networks to bring together fire data providers and users to exchange information on capabilities and needs and to promote strengthening of regional and national fire activities.

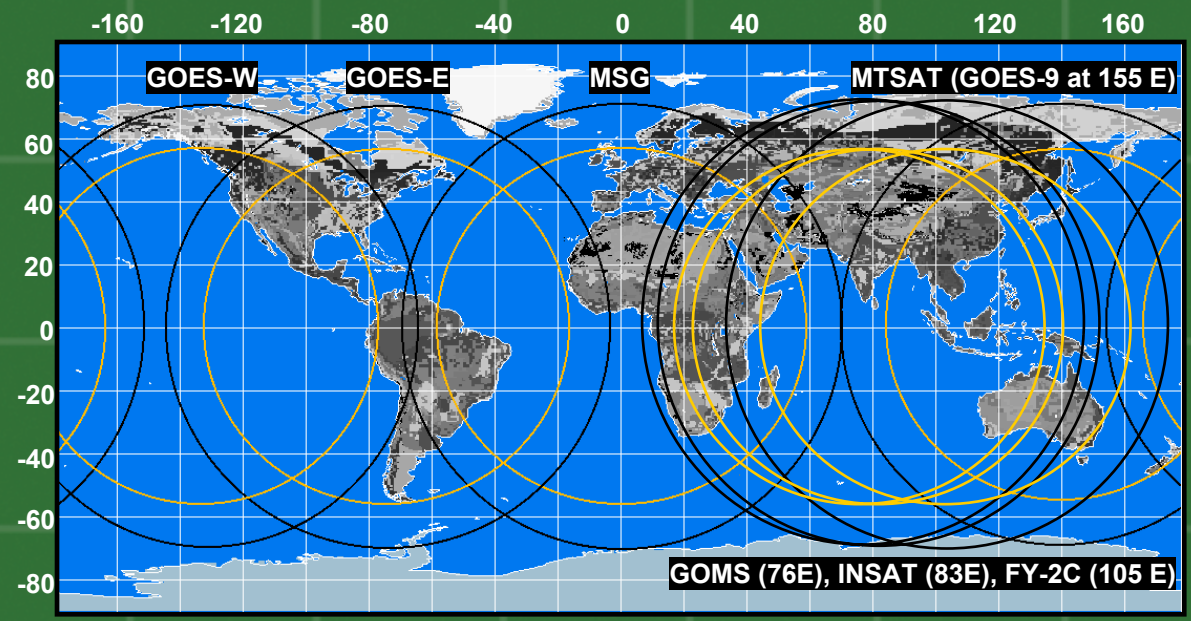
http://gofc-fire.umd.edu

Fire Monitoring and Mapping Products

- Emerging Geostationary Global Fire Network
- Near Real Time Global Daily Active Fire Monitoring
- Web based Fire and Imagery Distribution Systems
- Multi-source fire information integration
- Regional / Global Burned Area Monitoring
- Systematic product validation
- Near real-time and Regional fire emissions modeling
- Regional Fire Danger Rating Development
- Sensor Web Demonstration (BIRD technology demonstration for Fire Characterization)
- Planning Fire Monitoring on Next Generation Polar Orbiters



GOFC-GOLD

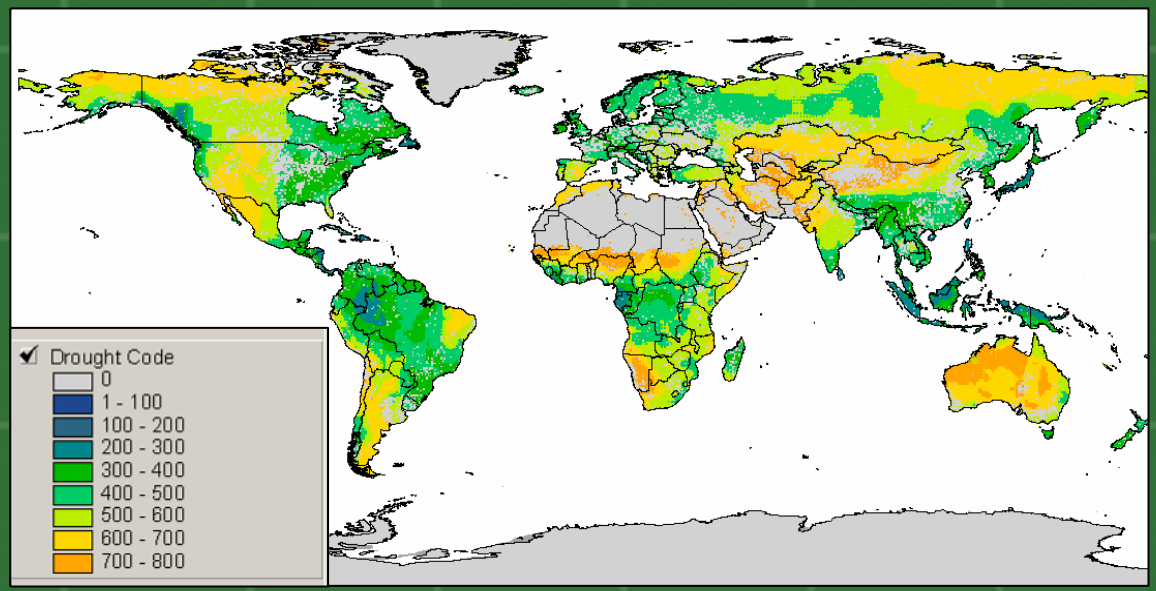


Global Geostationary Active Fire Monitoring Capabilities

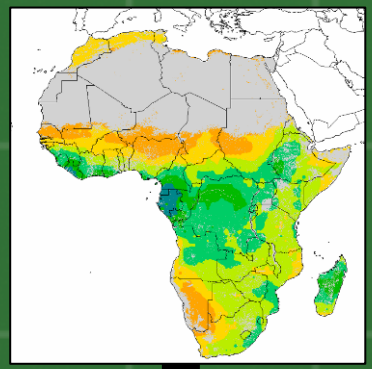
Satellite	Active Fire Spectral Bands	Resolution IGFOV (km)	SSR (km)	Full Disk Coverage	3.9 μm Saturation Temperature (K)	Minimum Fire Size at Equator (at 750 K)
GOES-12 Imager	1 visible 3.9 and 10.7 μm	1.0 4.0 (8.0)	0.57 2.3	3 hours	~335 K	0.15 ha
GOES-9 & GOES-10 Imager	1 visible 3.9 and 10.7 μm	1.0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

GOFC-GOLD

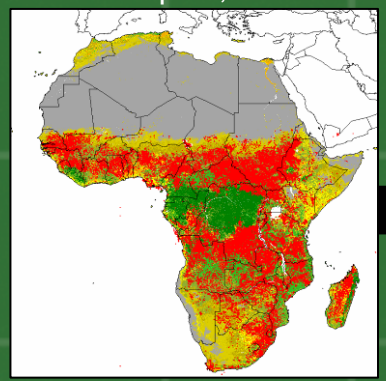
Global Fire Danger Rating System



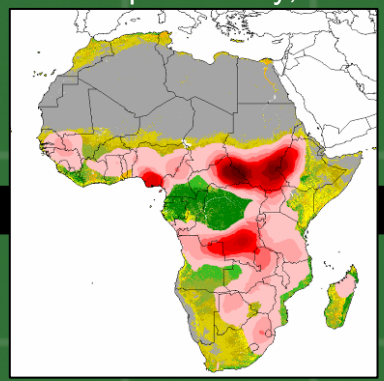
Drought masked by fuel



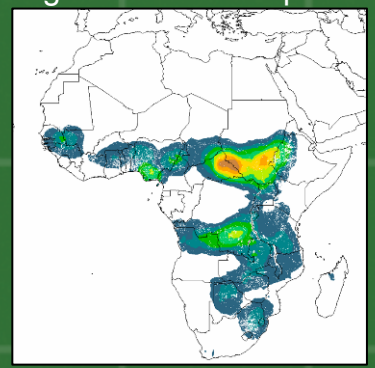
ATSR Hotpots, 1995-2000



ATSR Hotspot Density, 1995-2000



Drought x Fuel x Hotspot Density

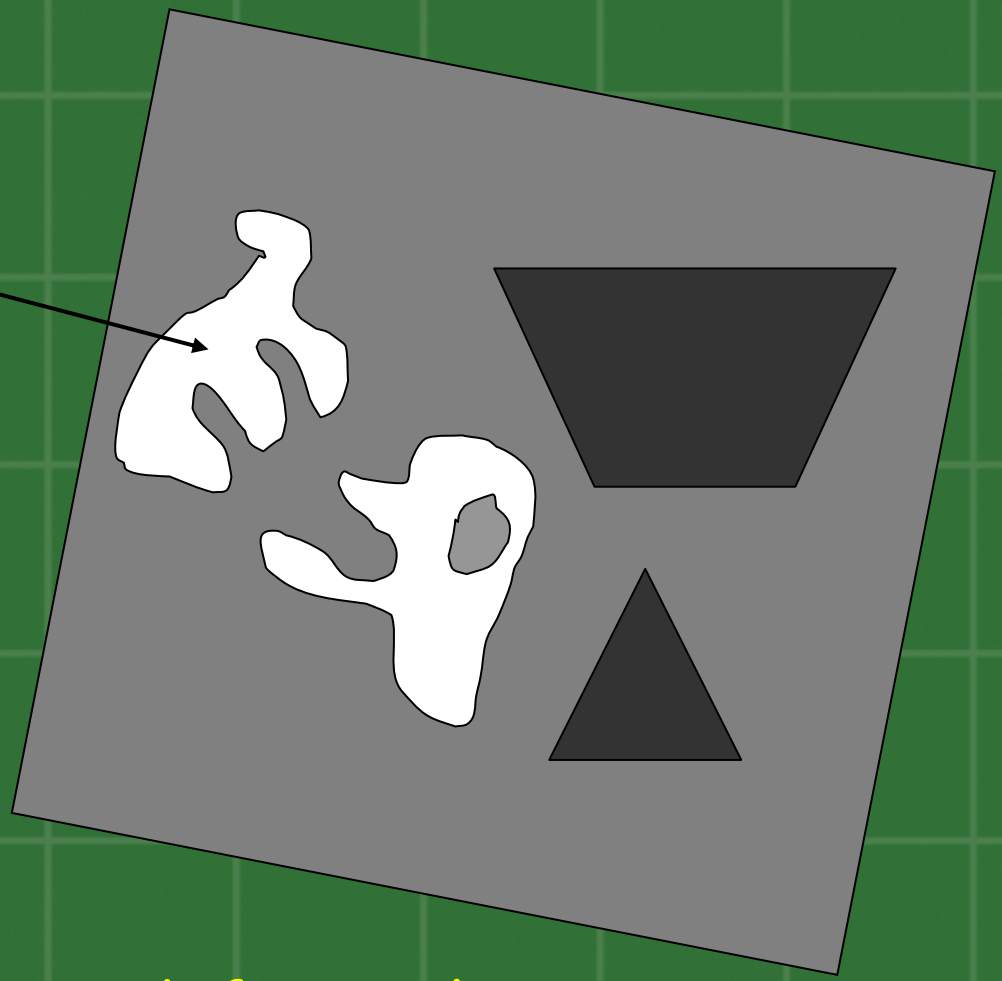


GOFC-GOLD

GOFC-GOLD SAFNet burned area 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

Map the areas that burned between 2 Landsat acquisitions



Minimum Mapping Unit = 240m

Derive 3 vector data sets defining the

- mapped region (light grey)
- burned areas (white)
- not mapped areas (dark grey)

GOFC-GOLD

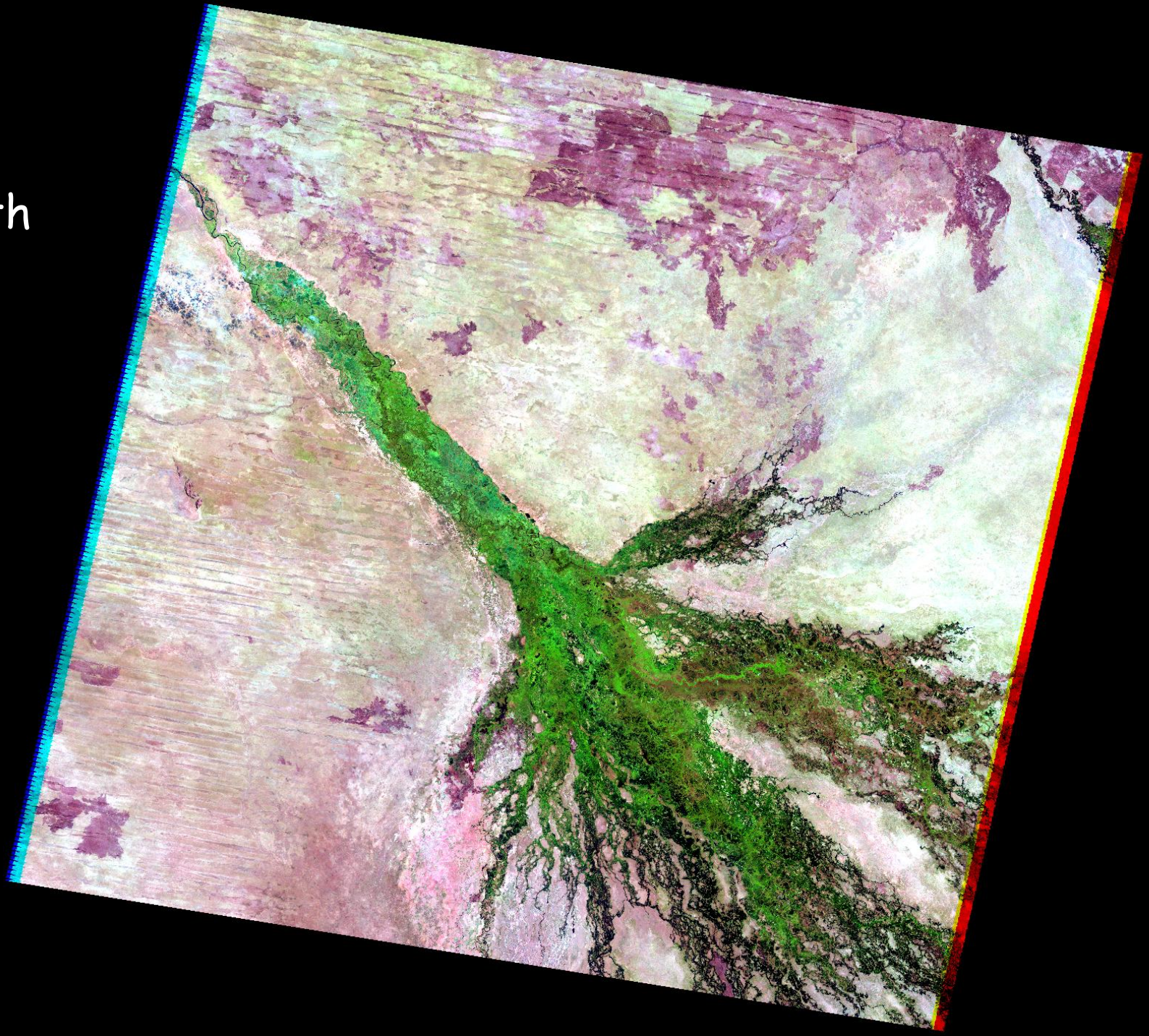
Example southern African MODIS burned area product validation example at one Landsat ETM+ scene

- Botswana, Okavango Delta, 2001
- Landsat ETM+ path 175 row 073

- Cloud-free scenes acquired 32 days apart:
  - September 4th
  - October 6th

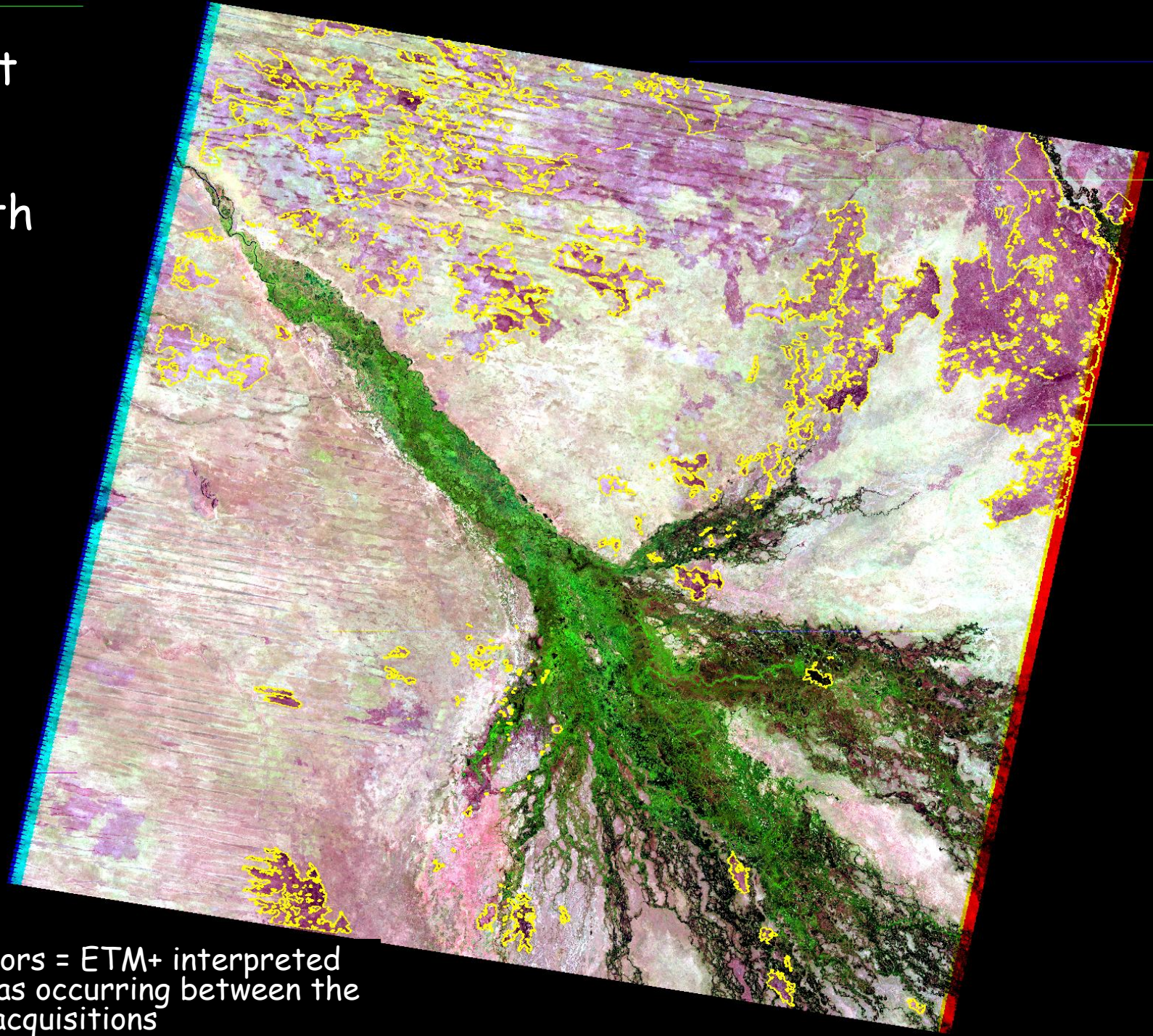
Landsat
ETM+

Sept. 4th

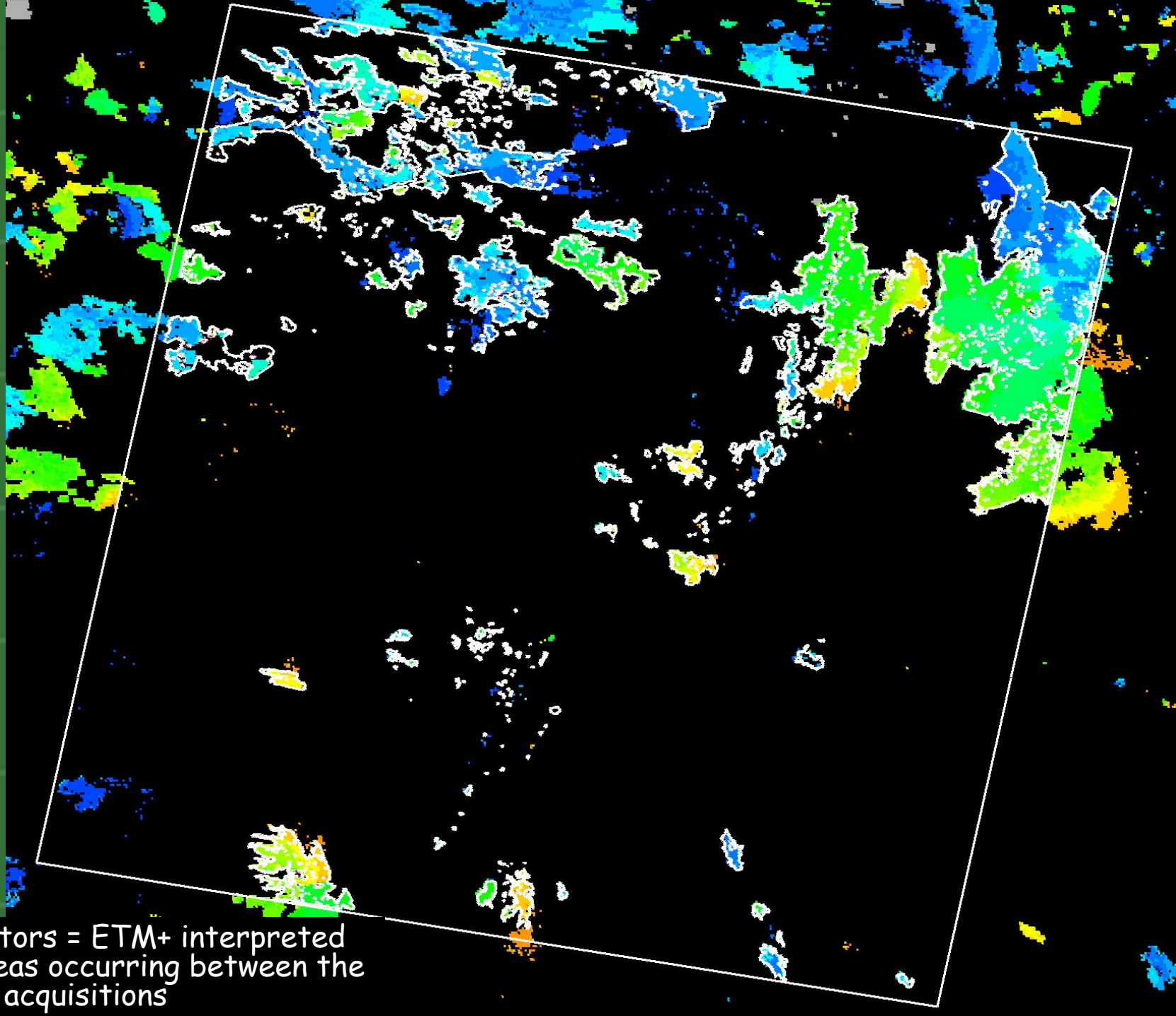


Landsat
ETM+

Oct. 6th



Yellow vectors = ETM+ interpreted burned areas occurring between the two ETM+ acquisitions

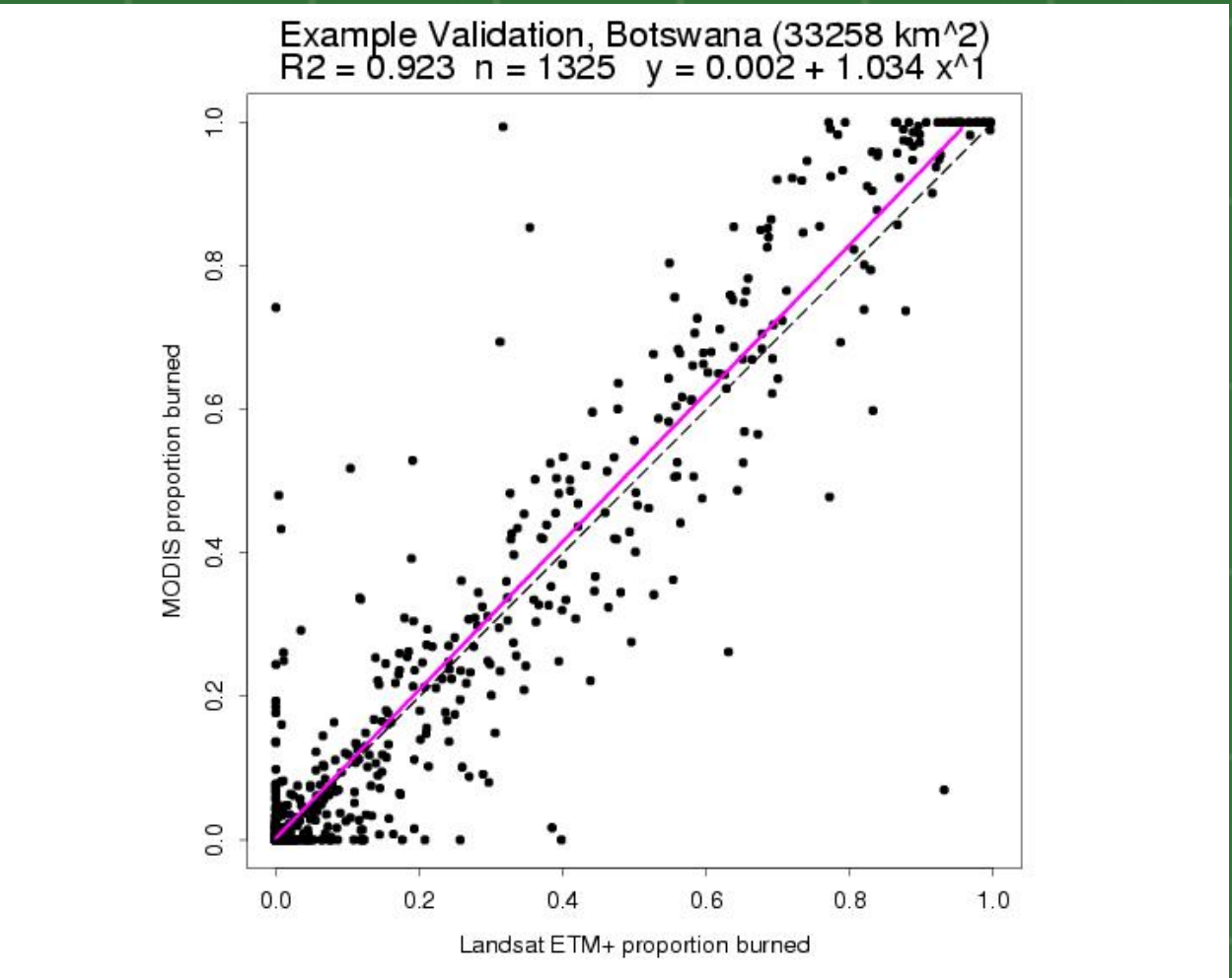

MODIS
500m
Burned
Areas
Sept. 4
to
Oct. 6
White vectors = ETM+ interpreted
burned areas occurring between the
two ETM+ acquisitions

Example Statistical Validation Analysis: Confusion Matrix comparison of MODIS and ETM+ data (30m pixels, MODIS data resampled to 30m)

	# MODIS burned pixels	**# MODIS unburned pixels**	total
# ETM+ burned pixels	**3617530**	**701992**	4319522
# ETM+ unburned pixels	**996970**	**33218960**	34215930
total	4614500	33920952	38535452

Percent correct {0-100%} = 95.6%
Kappa {0-1} = 0.785

Botswana 2001 example



Each point illustrates the proportion of a 5.0x5.0 km cell mapped as burned

5.0x5.0km =

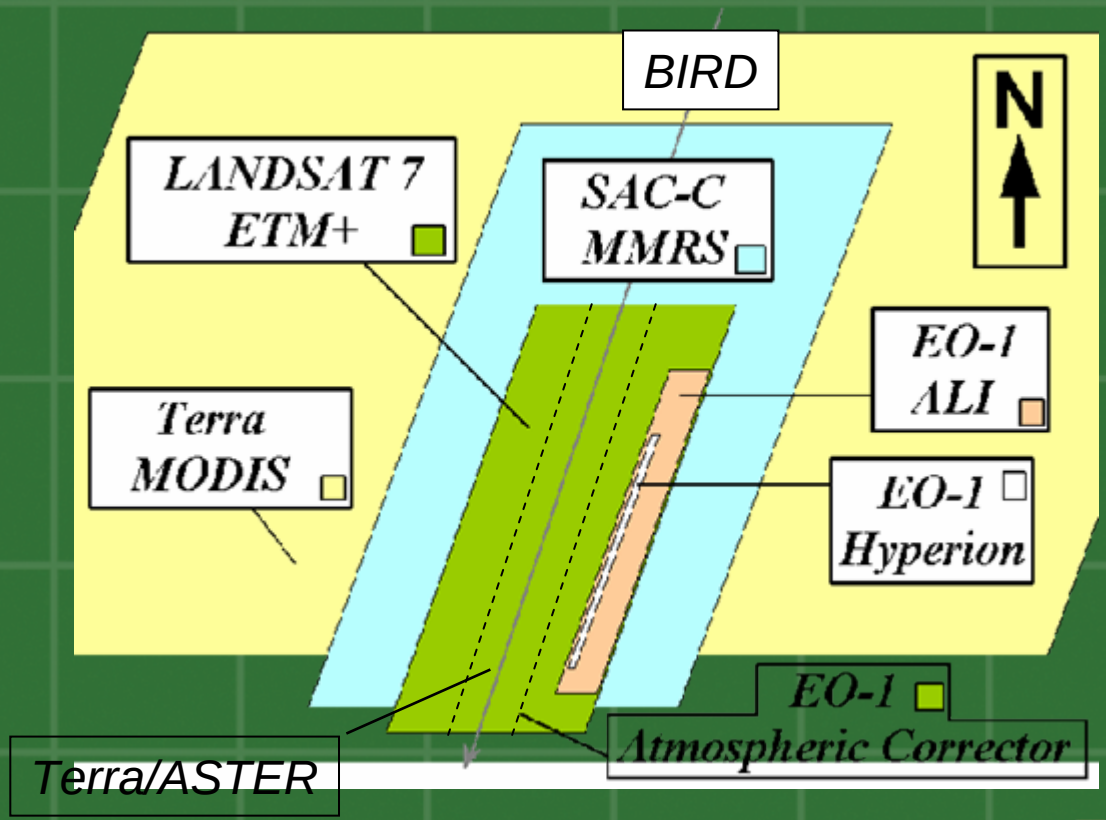
167x167 30m ETM pixels

10x10 500m MODIS pixels

GOFC-GOLD

Active fire validation using coincident high resolution observations

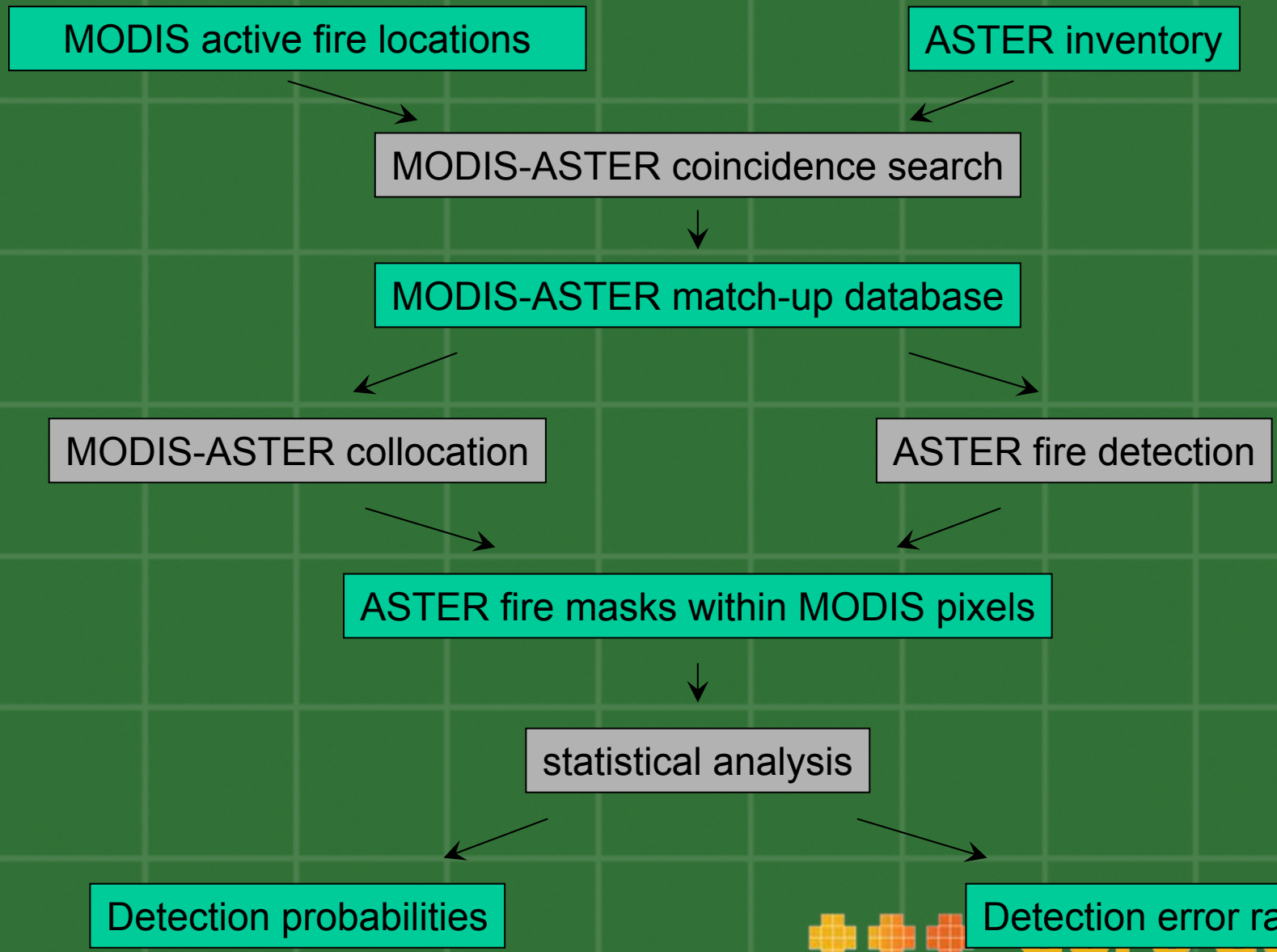
AM satellite constellation



collocated high resolution observations are used for product evaluation

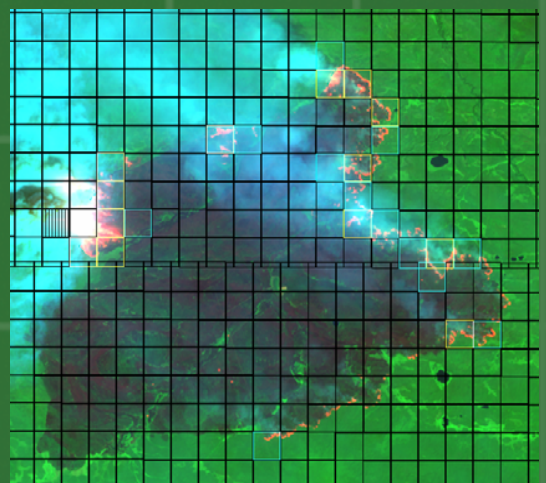
GOFC-GOLD

The MODIS validation process



MODIS active fire validation protocol

- Generate and visually verify fire masks from ASTER
- Co-register ASTER and MODIS
- Derive summary statistics of ASTER fire pixels
  - total number of fire pixels
  - average number of fire pixels in fire clusters
- Calculate detection probabilities using statistical modeling
  - currently logistic regression
- Derive accuracy assessment curve (omission error rates as a function of fire classification threshold)
- Derive commission error rate

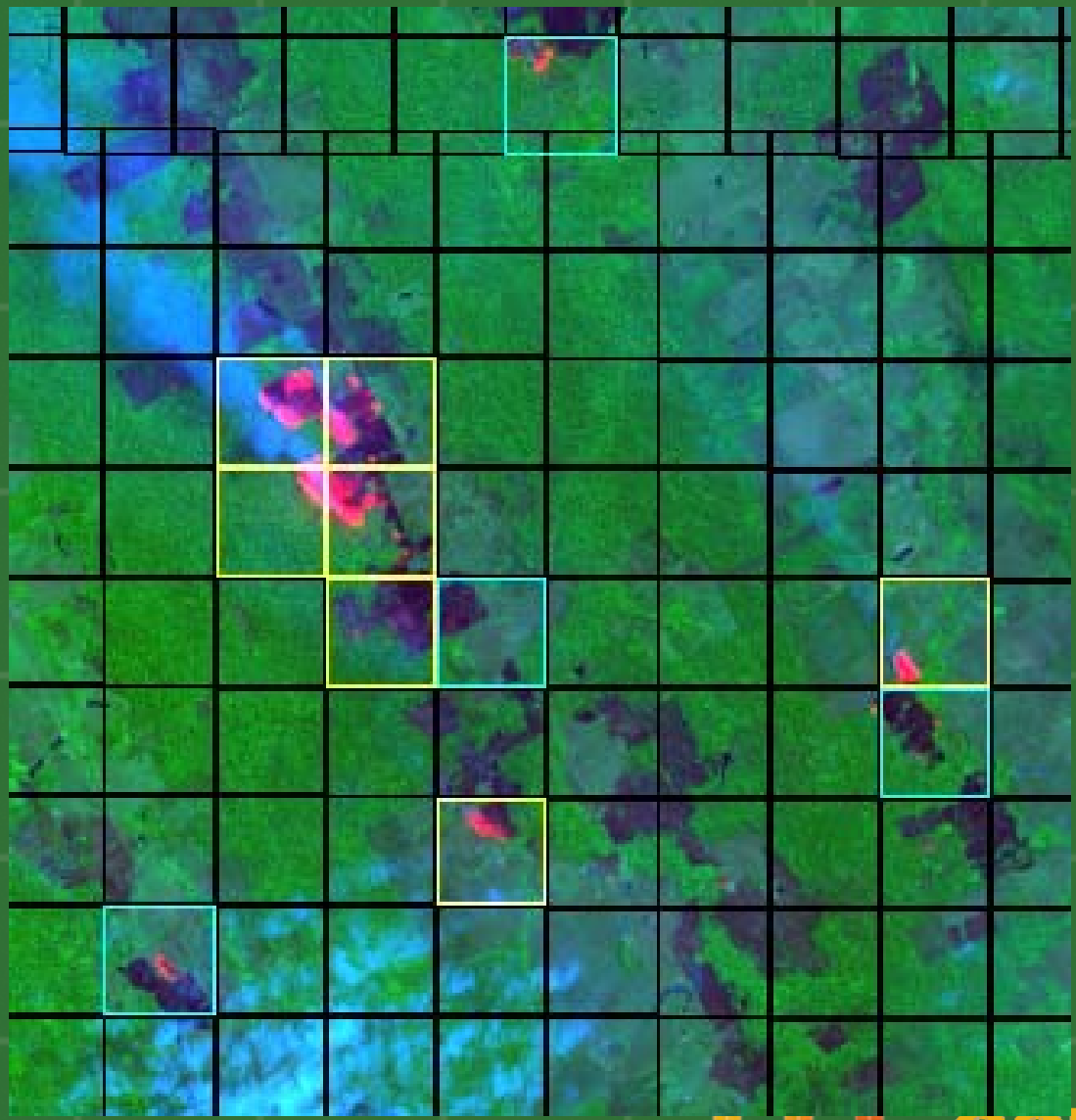


ASTER (30m)
1km MODIS grid

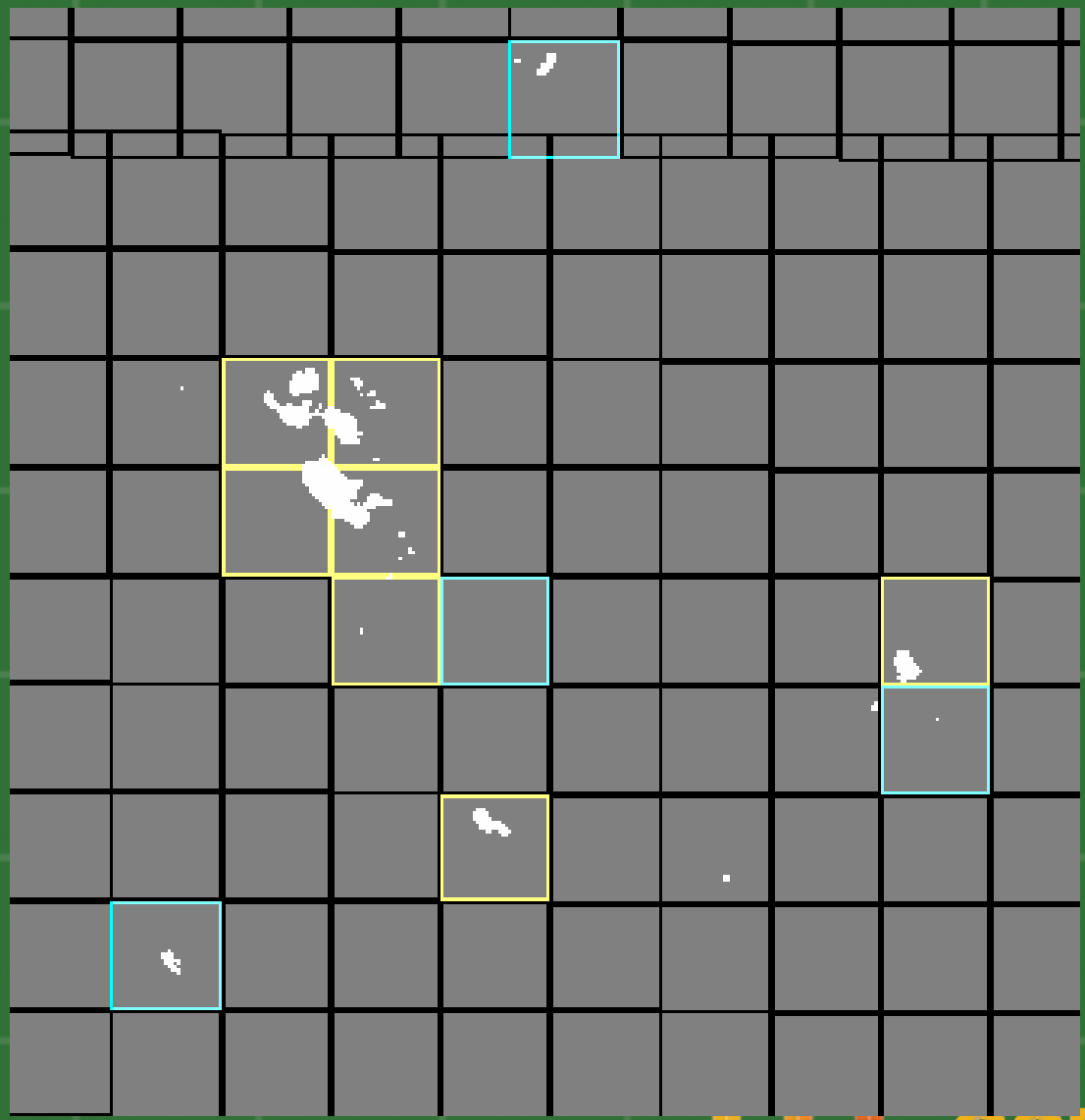
- Convert ASTER pixel - based statistics to physical fire/background characteristics (under development)

GOFC-GOLD

ASTER image + MODIS fire mask

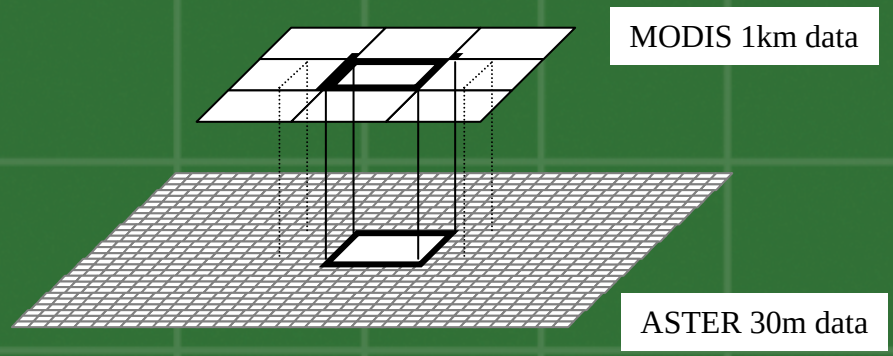


ASTER fire mask + MODIS fire mask



Detection probabilities: logistic regression

$$\pi(x_i) = \frac{e^{\beta_0 + \sum_{j=1}^{p} \beta_j x_{ij}}}{1 + e^{\beta_0 + \sum_{j=1}^{p} \beta_j x_{ij}}}$$



2x1 along-scan along-track areas to account for MODIS triangular response

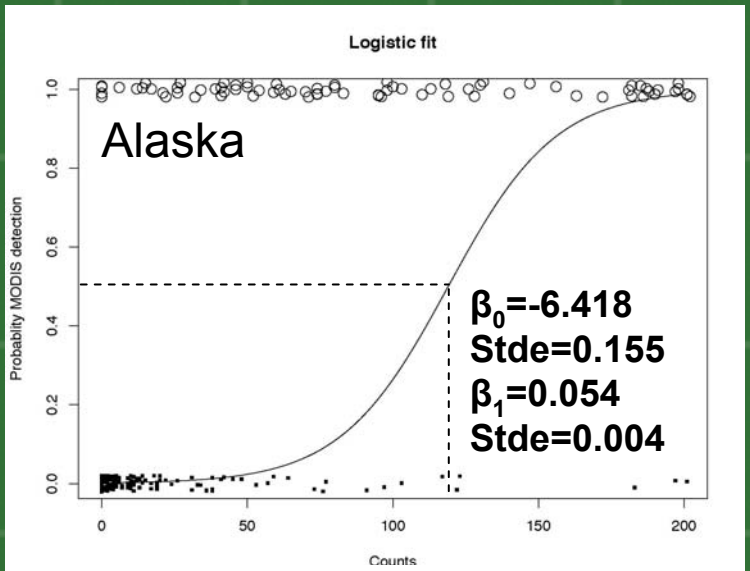
$\sum_{j=1}^{p} \beta_j x_{ij}$ **linear combination of *p* ASTER summary statistics within MODIS pixel *i***

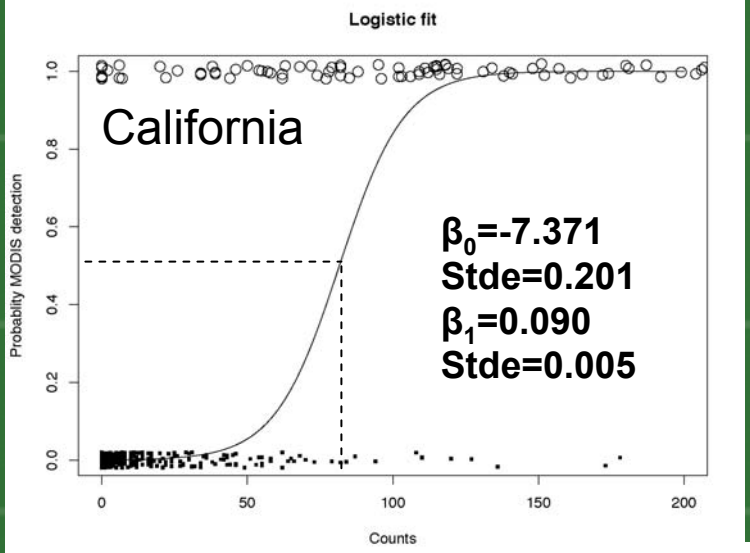
$\pi(x_i)$ **the probability that MODIS pixel *i* will be equal to 1 (i.e. labeled as "fire") given the values of x_i**

β_0, β_j **parameters estimated from the data**

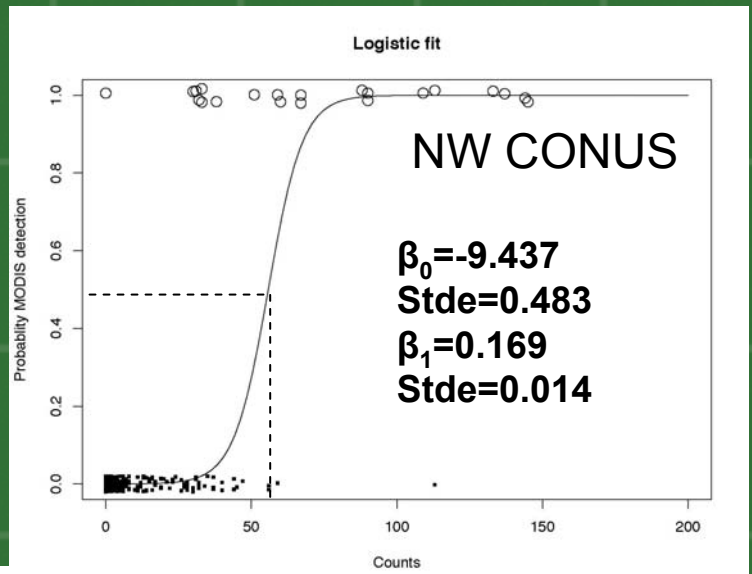
GOFC-GOLD

Detection probabilities





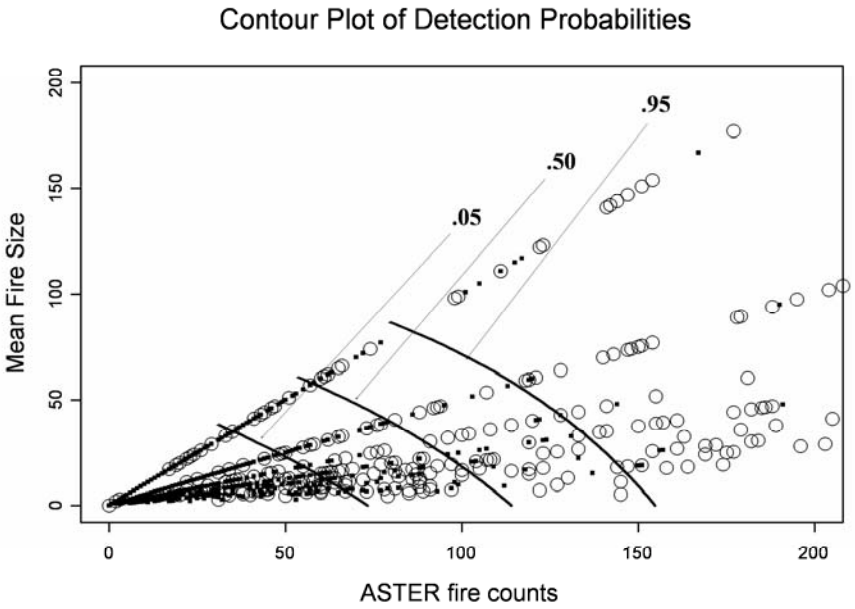
Number of ASTER fire pixels required for 50% detection probability varies by region



○:MODIS “fire” ●:MODIS “no fire”

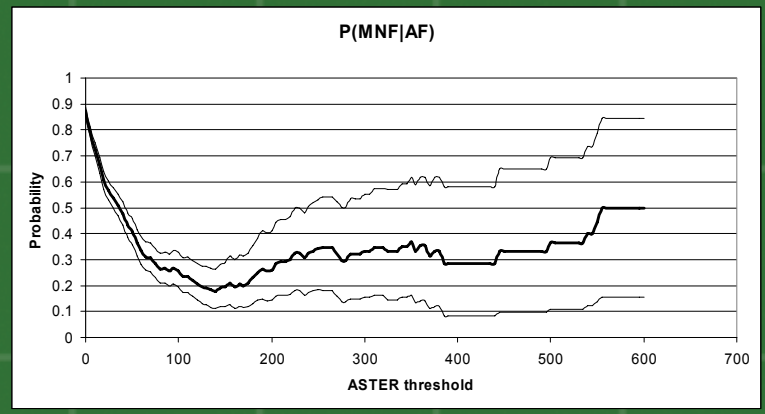
GOFC-GOLD

MODIS Active Fire Validation



○: MODIS “fire”; ●:MODIS “no fire”

Probabilities of detection as a function of ASTER fire pixels within MODIS pixel



Pixel-based accuracy assessment curve with 95% exact confidence intervals: omission error rate

- ***Similar approach proposed for NPOESS/VIIRS***
- ***Development of multi-platform approach needed***
- ***Sensors operated by international partners and agencies (IRS, CBRS etc.)***

GOFC-GOLD

Summary: top GOFC/GOLD priorities

- global, continuous, near-real-time, 30m resolution (or better) multi-spectral remote sensing coverage
- global, coordinated observing system from geostationary satellites
- documentation and implementation of consensus validation protocols and procedures