REDD+ and Fire

in the GOFC Sourcebook

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SOURCEBOOK

COP 16 version 1

A sourcebook of methods and procedures for monitoring and reporting anthropogenic greenhouse gas emissions and removals caused by deforestation, gains and losses of carbon stocks in forests remaining forests, and forestation

GOFC-GOLD

Global Observation of Forest and Land Cover Dynamics

Why this effort by GOFC-GOLD ?

- GOFC-GOLD is a coordinated international effort developed to help ensure a continuous program of space-based and on-the-ground forest, fire and land cover observations.

- GOFC-GOLD has a vision to share data, information and knowledge, leading to informed action and decision support,

- is part of a long term process of building an improved match between Satellite Observations, Data Products & User Needs.

Background – History of Sourcebook

- Consistent with IPCC guidelines
- Provides additional explanation, clarification and methodologies to support REDD+ actions
- The sourcebook has been regularly updated from 2005 (current version presented at COP 16, Cancun 2010)
- Ad hoc working group within GOFC

Target audience

Two main user groups:

- Policy makers and negotiators
- Technical bodies at national level, in countries with little background in generating country level satellite products

Focus on the use of existing, readily accessible data and products

Remote sensing and REDD+

The role of remote sensing in national monitoring systems is recognised in decision 4 of COP15

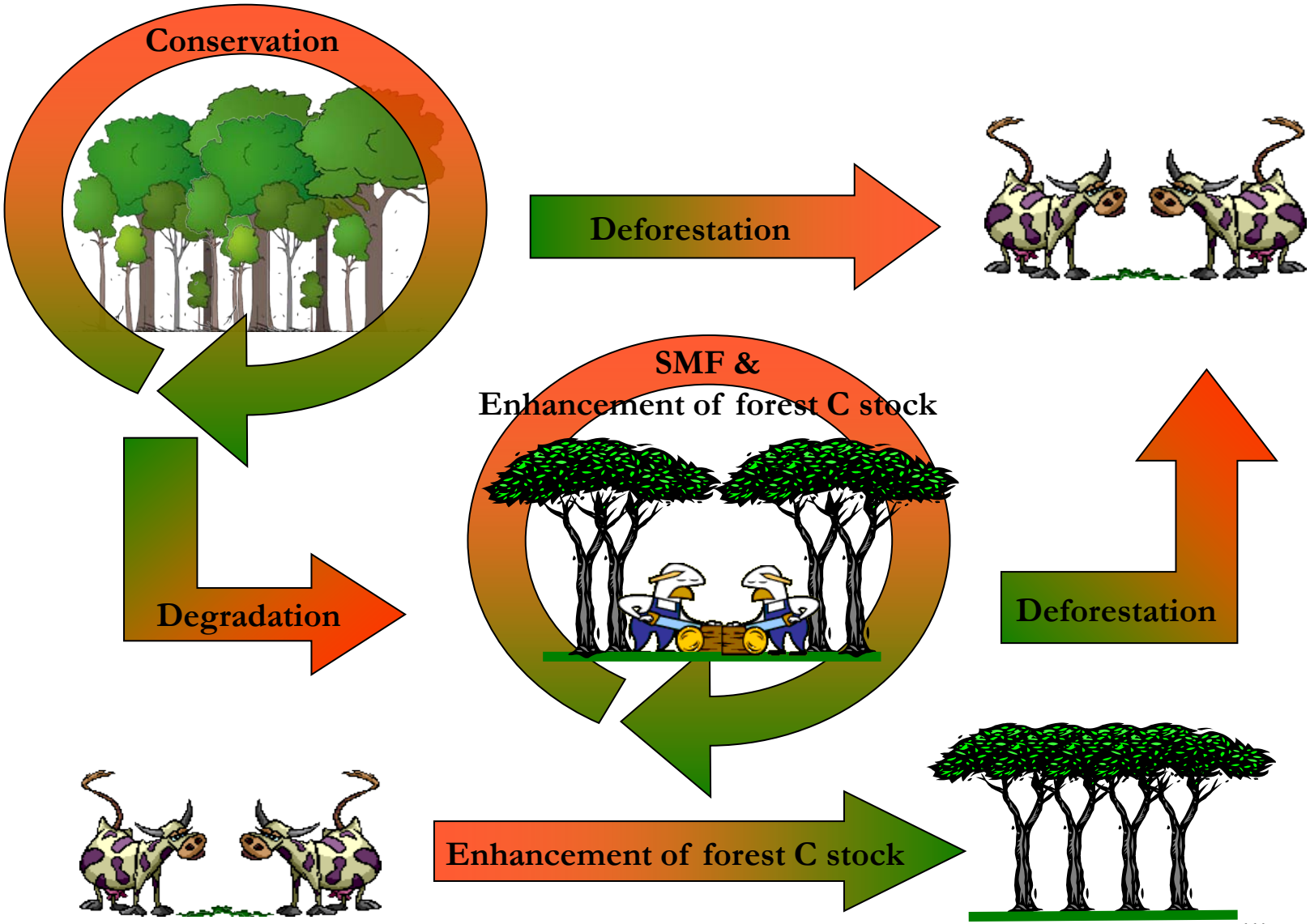
- **Article 1 (d):**
  To establish, according to national circumstances and capabilities, robust and transparent national forest monitoring systems and, if appropriate, sub-national systems as part of national monitoring systems that:

(i) **Use a combination of remote sensing and ground-based forest carbon inventory approaches** for estimating, as appropriate, anthropogenic forest-related greenhouse gas emissions by sources and removals by sinks, forest carbon stocks and forest area changes;

(ii) Provide estimates that are transparent, consistent, as far as possible accurate, and that reduce uncertainties, taking into account national capabilities and capacities;

(iii) Are transparent and their results are available and suitable for review as agreed by the Conference of the Parties;

REDD+ forest related activities



D.Mollicone, FAO

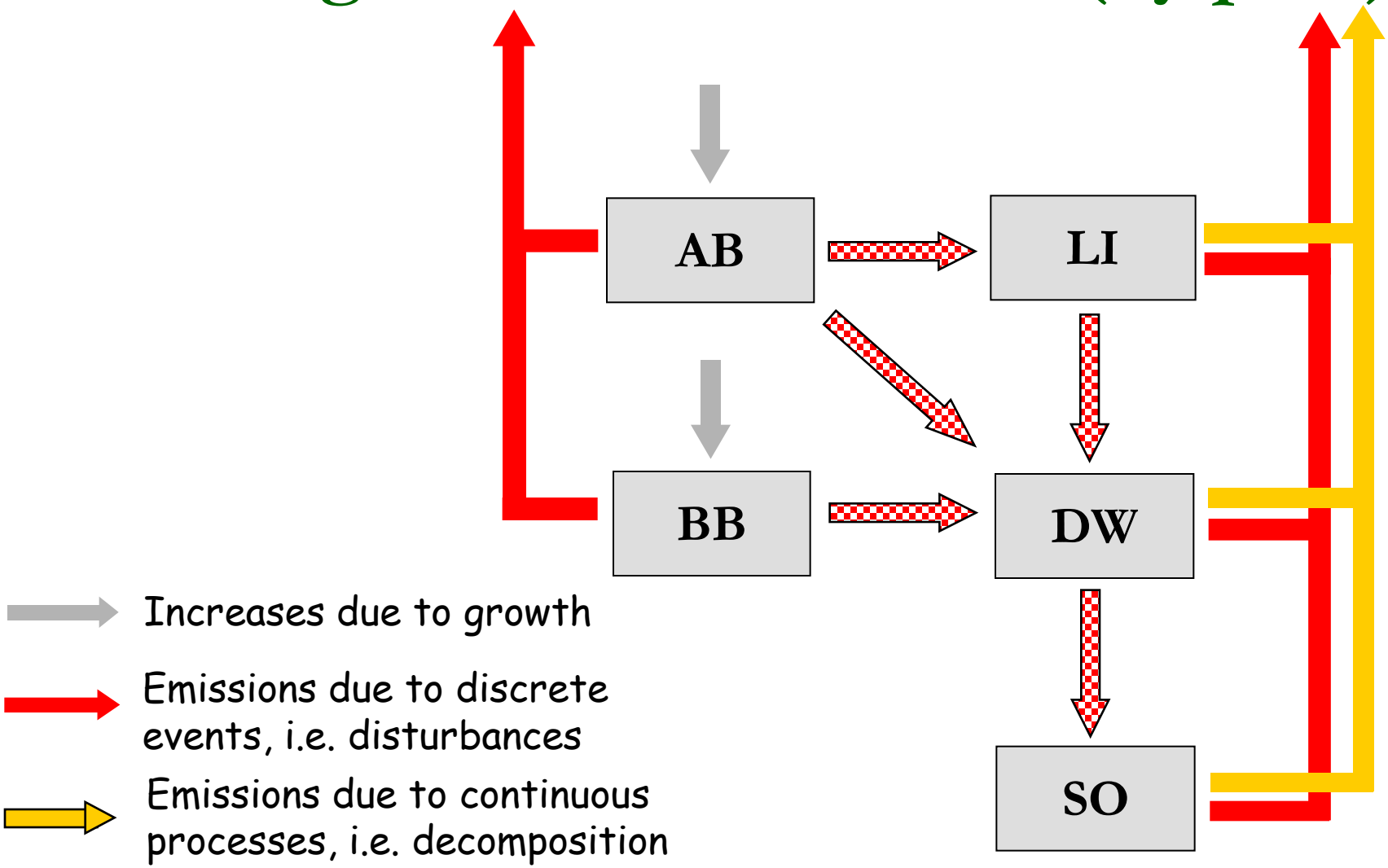
IPCC has identified five carbon pools

Above-ground biomass

Below-ground biomass

Litter, dead wood
and soil organic matter

Changes = Gains – Losses (by pool)



D.Mollicone, FAO

REDD+ potential activities		**= Forest sector (AFOLU / IPCC)**
Deforestation		= Forest land converted to other land
Degradation SMF Conservation Enhancement F C S	}	= Forest land remaining forest land
Enhancement F C S		= Other land converted to forest land

Fire chapter

2.5 METHODS FOR ESTIMATING GHG'S EMISSIONS FROM BIOMASS BURNING

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Chris Justice, University of Maryland, USA
David Roy, South Dakota State University, USA
Ivan Csiszar, NOAA, USA
Emilio Chiuvieco, University of Alcala, Spain
Allan Spessa, University of Reading, UK
Anja A. Hoffman, L.M. University of Munich, Germany
Jeremy Russell-Smith, Charles Darwin University, Australia
Marc Paganini, European Space Agency
Olivier Arino, European Space Agency

2.5.1 Scope of chapter

Chapter 2.5 is focused on fires in forest environments and how to calculate greenhouse gas emissions due to vegetation fires, using available satellite-based fire monitoring products, biomass estimates and coefficients.

Section 2.5.2 introduces emissions due to fire in forest environments and approaches to estimates emissions from fires.

Section 2.5.3 focuses on the IPCC guidelines for estimating fire-related emission.

Section 2.5.4 focuses on Systems for observing and mapping fire.

Section 2.5.5 describes the potential use of existing fire and burned area products.

2.5.2 Introduction

2.5.2.1 REDD and emissions due to fire in forest environments

Fire is a complex biophysical process with multiple direct and indirect effects on the

Fire observations and their usefulness for national REDD implementation

Approach	Information	REDD objective	Suitability
Pre-fire	Early warning system	Protect forest areas at risk and address leakage and permanence	Most suitable for countries with significant amount of wildland fires and known fire regimes
Active fire	Hot spot satellite data	Fire relief and active emissions reduction Support of in-situ actions	Most suitable for countries with large number of small-scale deforestation fires
Post-fire	Burned area estimates	Support estimation of areas of deforestation and degradation	All countries with forest loss due to fire

REDD+ potential activities		**= Forest sector (AFOLU / IPCC)**
Deforestation		= Forest land converted to other land
Degradation SMF Conservation Enhancement F C S	}	= Forest land remaining forest land
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REDD and fire emissions

- Fire as
  - Ecological change agent
  - A disturbance
  - Process associated with land cover conversion
  - A land management tool
- For now, limited to above ground biomass

REDD+ and fire emissions

What fire activities can be relevant to REDD+ in developing countries?

- Mapping and monitoring fire as a disturbance for carbon accounting (forest loss and forest degradation) as well as permanence and leakage monitoring
- Fire management in fire-prone savannah ecosystems

Crucial question for country level actions

- The Marrakech accords mandate that ecosystems with 10% to 30% tree cover might be considered as forest or not
- This would include most of the fire-prone savannah ecosystems.
- Emission reduction through fire management could be part of REDD+ actions (example of Australia).

Implications for emissions

- If fire is a disturbance in forest ecosystems, computation of the emissions from deforestation and forest degradation (CO_2 and other gases)
- In savannah and grassland, the IPCC guidelines assume that there is full regrowth within the year, so CO_2 emissions are balanced by carbon absorption (but CH_4 and N_2O are not!)

Emission computation

- " Bottom up": for IPCC,

$$Lfire = A \times Mb \times Cf \times Gef$$

L emission for each gas

A area burned

Mb fuel load

Cf combustion factor

Gef amount of gas released per unit of biomass consumed by the fire

Estimation of fire radiative power from satellite now allows for "top down" direct estimation of the biomass burned. Research topic, not operational yet.

Emission Estimation

- We need spatially and temporally distributed
  - Burned areas (almost there)
  - Biomass (almost there – models and landcover maps)
  - Combustion completeness (very uncertain)
  - Emission factors (almost there, but not temporal variation)

Tier 2 and tier 3 assessments are possible, but cannot rely solely on available global products!

Satellite data

- The nature of fire as non-permanent land cover change poses requirements on temporal sampling more strict that for other disturbances
- Available sensors (tradeoff between spatial and temporal resolution):
  - Hyperspatial: 1-10 m pixel, available sporadically
  - Moderate / high: 10-30 m, available weekly/monthly
  - Coarse: over 100m, available daily

Satellite products

- Do we have those data with the accuracy needed? e.g., mapping forest loss at 1ha
  - Plenty of systematic fire products, none at the moment with sufficient spatial resolution (not to mention the validation)
  - Some high resolution mapping systems (e.g. ESA supported Landsat scale mapping in Mediterranean, EFFIS, MTBS) but not systematic, and not in many countries that would need it

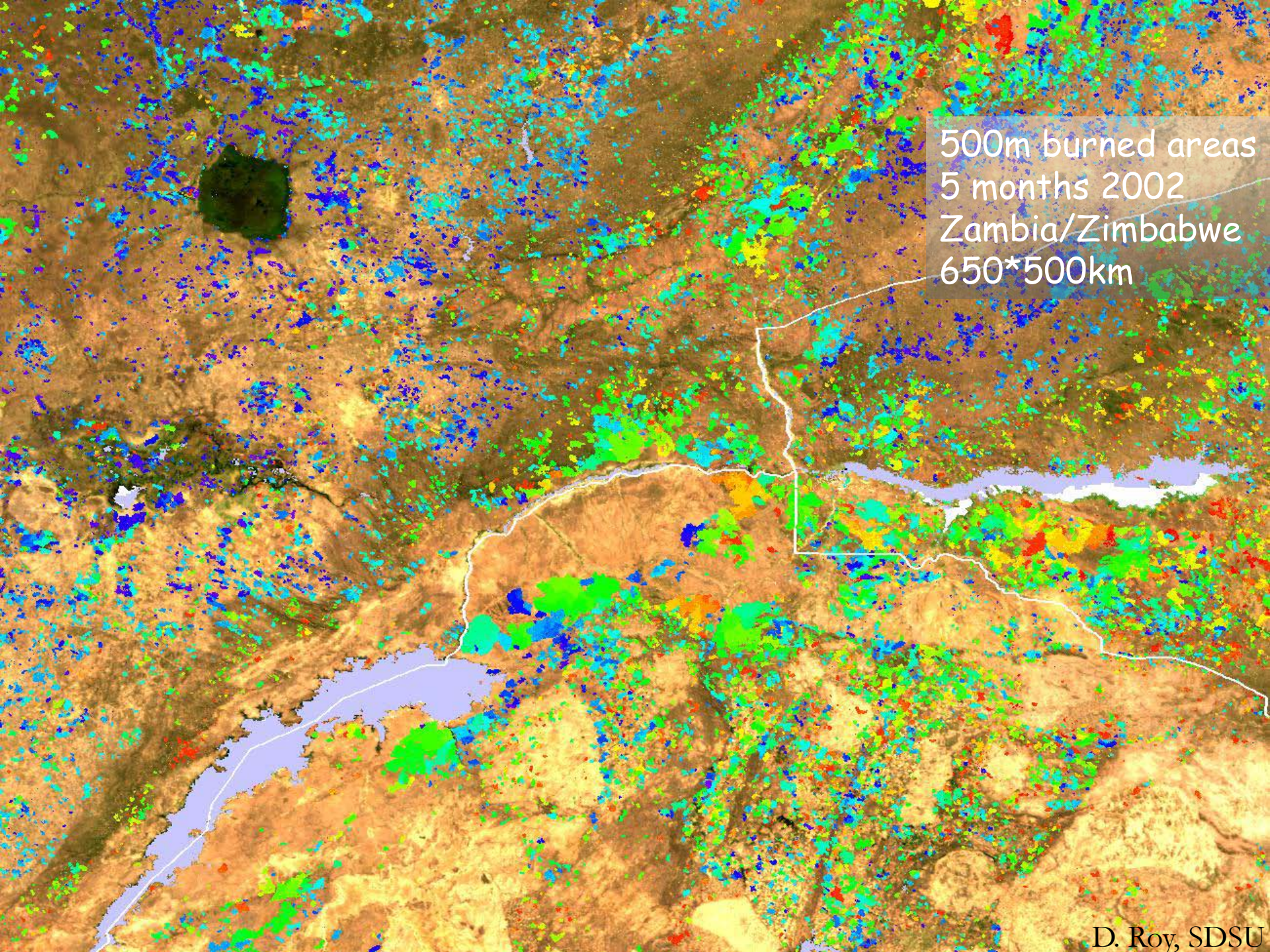
Satellite products

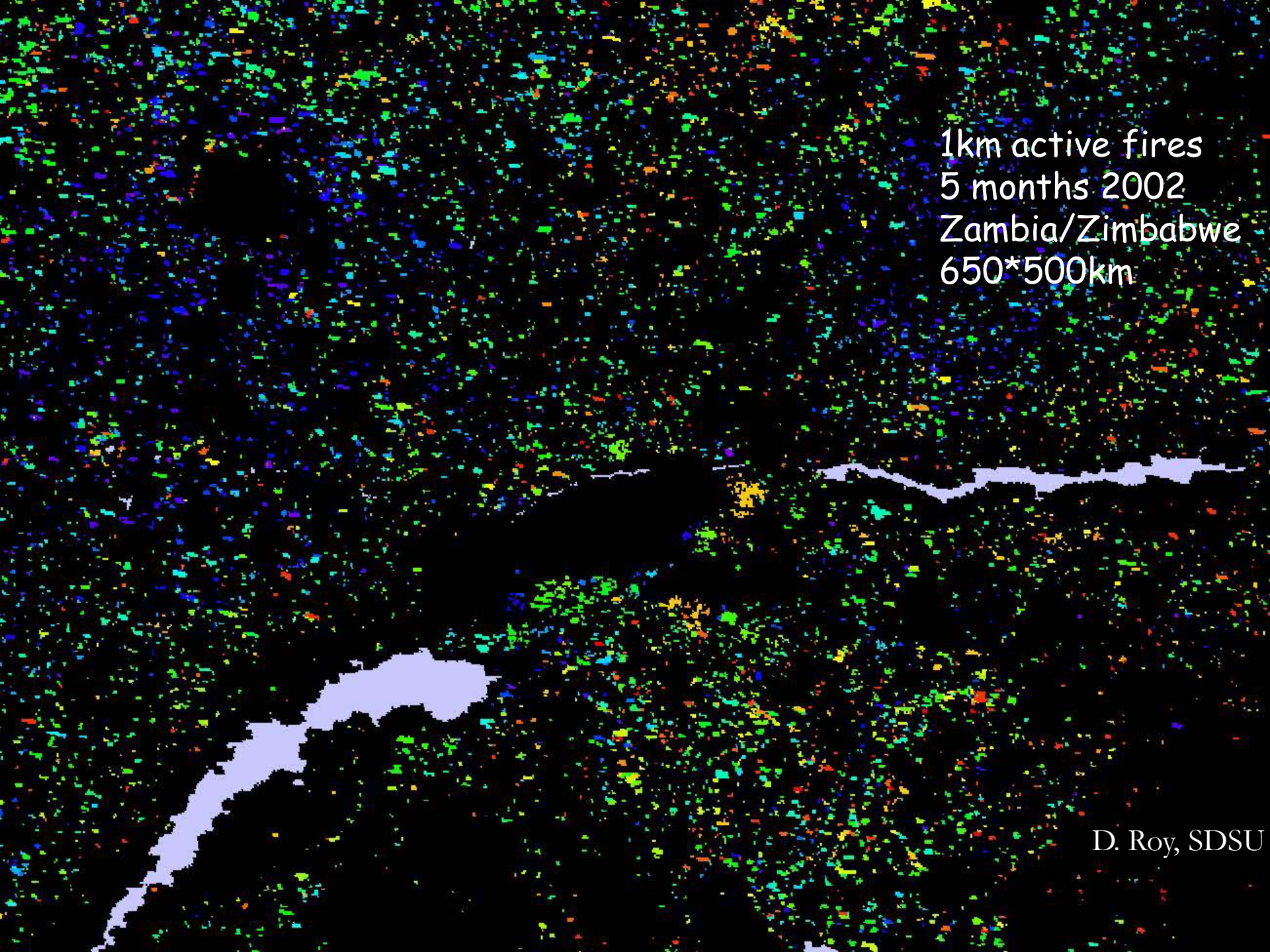
Global burnt areas 2000-2007: L3JRC (EC Joint Research Center)
http://bioval.jrc.ec.europa.eu/products/burnt_areas_L3JRC/GlobalBurntAreas2000-2007.php
MODIS active fires and burned areas (University of Maryland /NASA)
http://modis-fire.umd.edu
FIRMS: Fire Information for Resource Management System (University of Maryland /NASA/UN FAO), distribution of MODIS fire products
http://maps.geog.umd.edu/firms
Globcarbon products (ESA)
http://www.fao.org/gtos/tcopjs4.html
World Fire Atlas (ESA)
http://dup.esrin.esa.int/ionia/wfa/index.asp
Global Fire Emissions Database (GFED3) - multi-year burned area and emissions By NASA
http://ess1.ess.uci.edu/%7Ejranders/data/GFED3/
TRMM VIRS fire product (NASA)
ftp://disc2.nascom.nasa.gov/data/TRMM/VIRS_Fire/data/
Meteosat Second Generation SEVIRI fire monitoring (EUMETSAT)
http://www.eumetsat.int/Home/Main/Access_to_Data/Meteosat_Meteorological_Products/Product_List/index.htm#FIR
Experimental Wildfire Automated Biomass Burning Algorithm: GOES WF-ABBA (University of Wisconsin-Madison / NOAA)
http://cimss.ssec.wisc.edu/goes/burn/wfabba.html
Wide Area Monitoring Information System (*WAMIS*) portal –Advanced Fire information System (CSIR, Meraka Institute South Africa)
http://www.wamis.co.za/

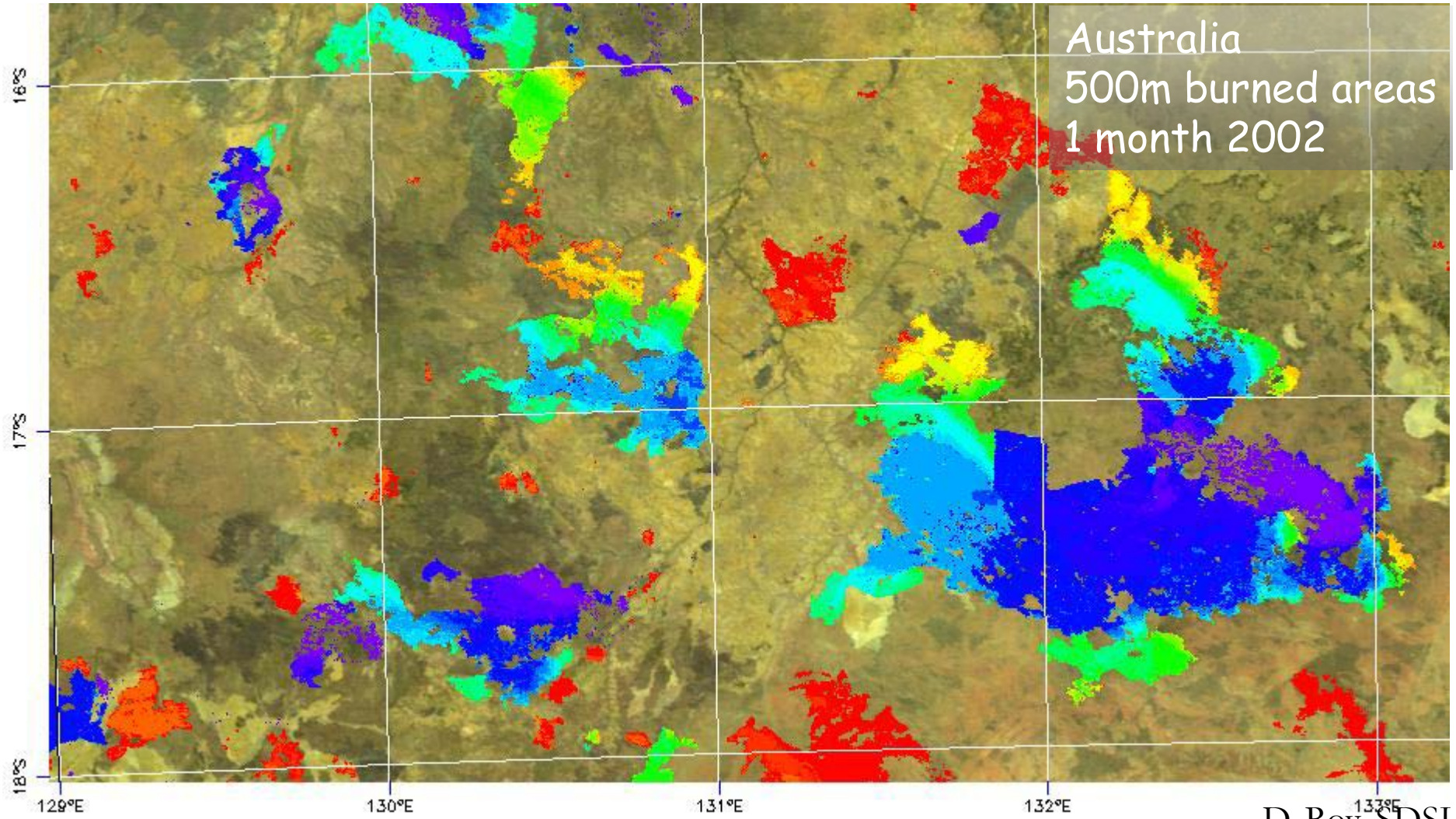
Active fires vs. burned areas

- Active fires = fires actively burning at the overpass time of the satellite (example: MOD14); detection mostly based on mid-IR and TIR.
- Burned areas = areas affected by fire within a certain time interval (example: MCD45); detection based on time series processing of near and short-wave infrared optical data, looking for the effects of fire on vegetation.

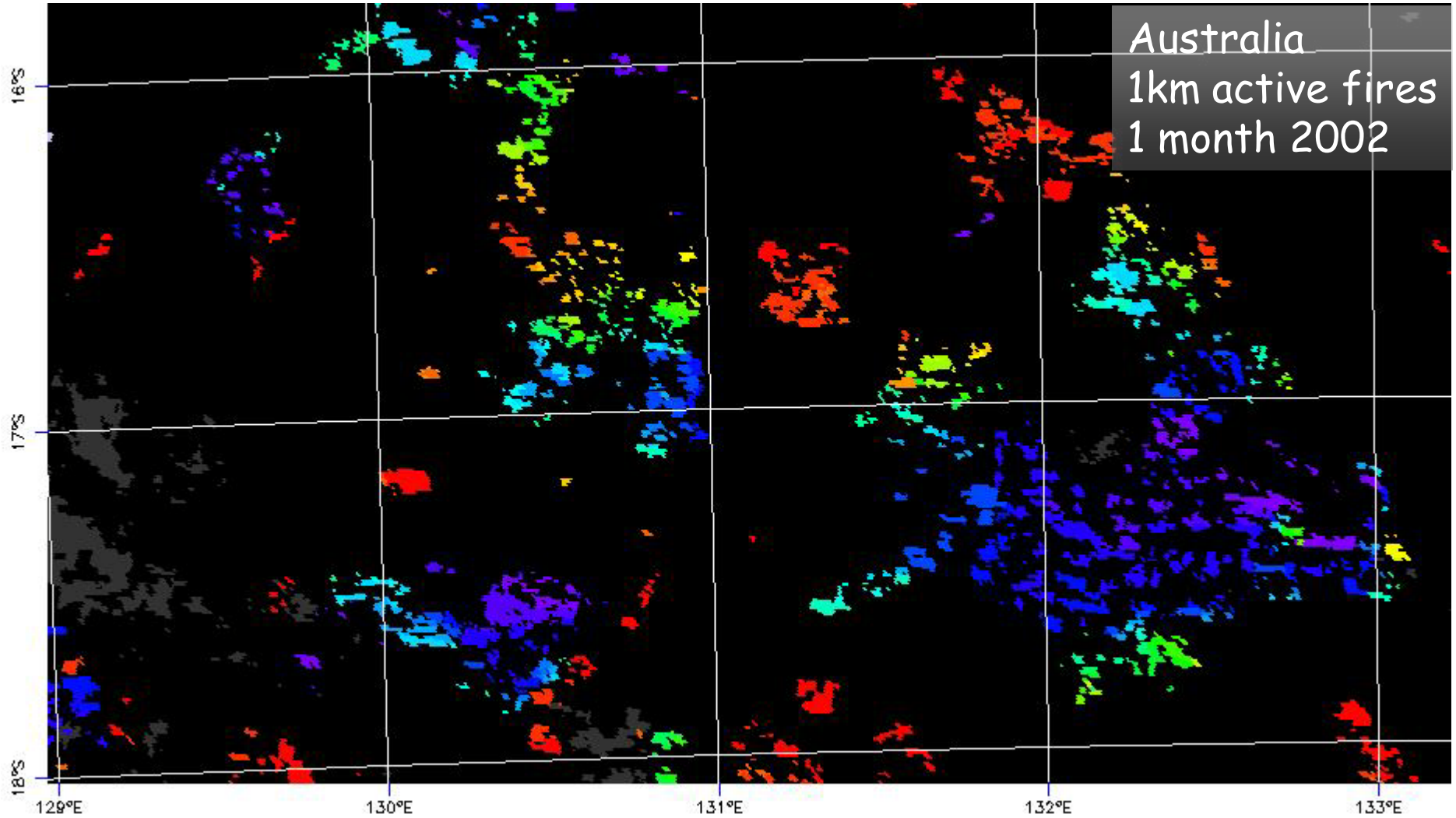
The issue of calibration: what is the 'true' area burned?


500m burned areas
5 months 2002
Zambia/Zimbabwe
650*500km
D. Roy, SDSU


1km active fires
5 months 2002
Zambia/Zimbabwe
650*500km
D. Roy, SDSU


Australia
500m burned areas
1 month 2002
16°S
17°S
18°S
129°E
130°E
131°E
132°E
133°E

D. Roy, SDSU


Australia
1km active fires
1 month 2002
16°S
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129°E
130°E
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132°E
133°E

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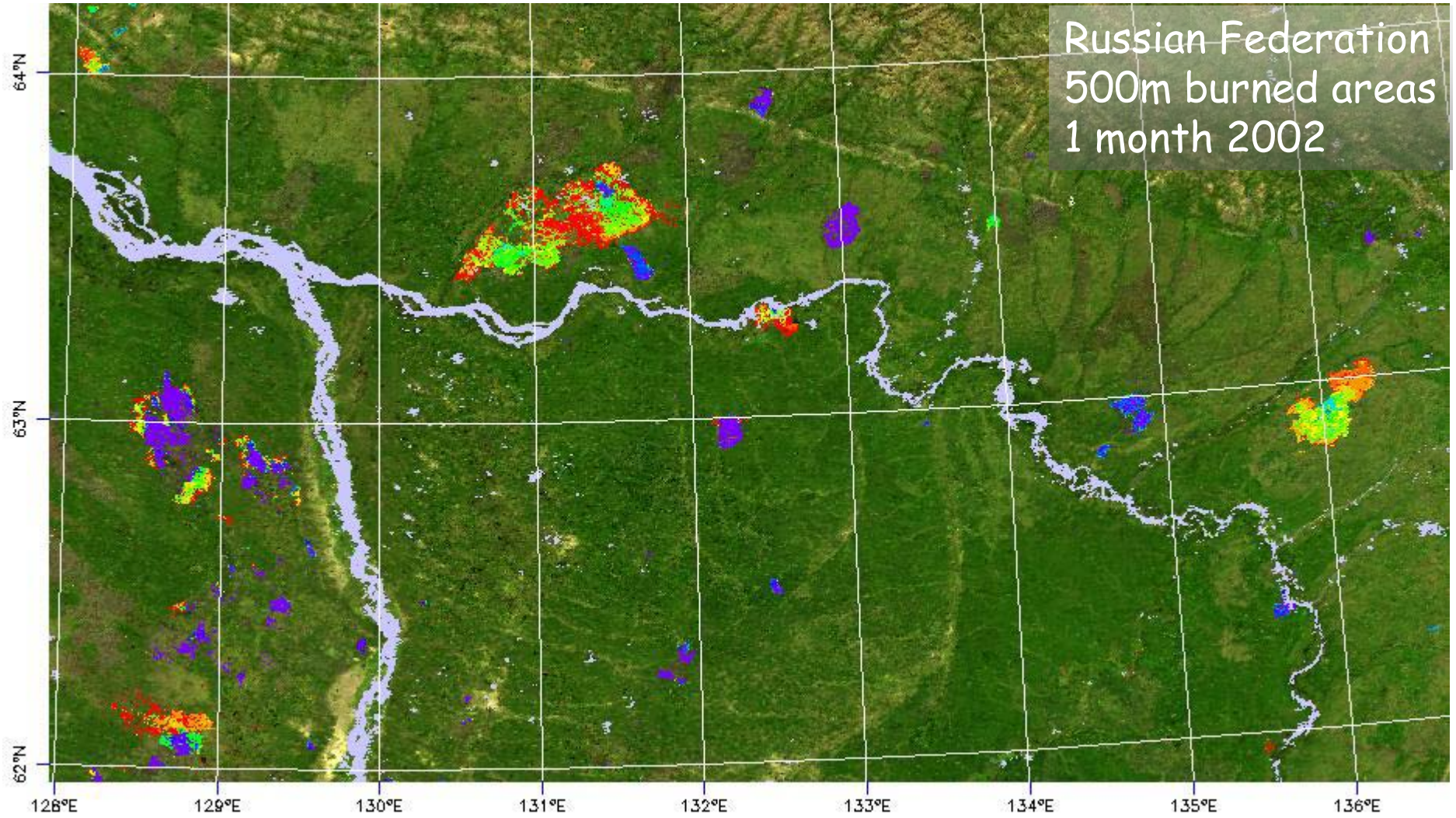
Russian Federation
500m burned areas
1 month 2002
64°N
63°N
62°N
128°E
129°E
130°E
131°E
132°E
133°E
134°E
135°E
136°E

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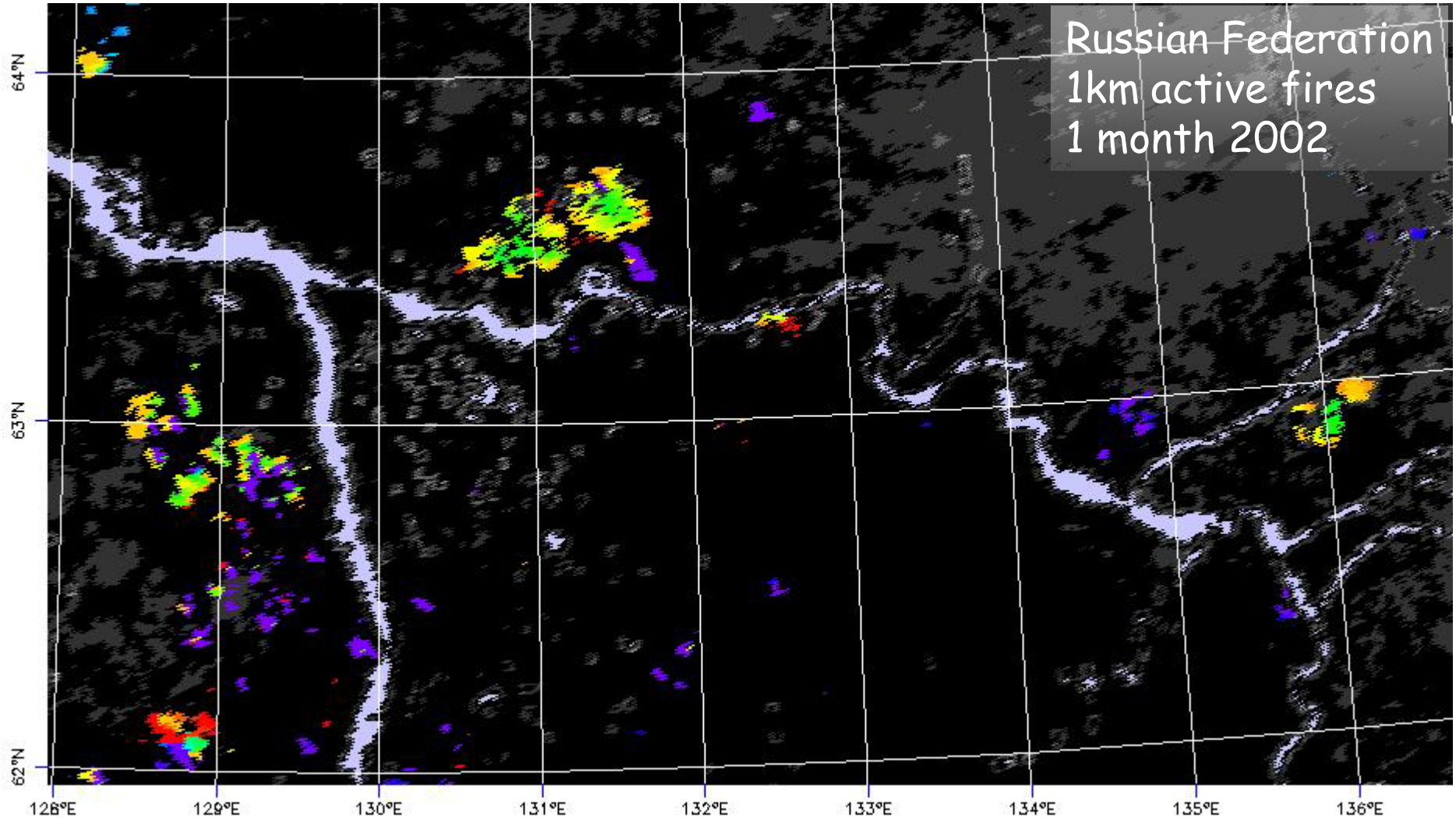
Russian Federation
1km active fires
1 month 2002
64°N
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129°E
130°E
131°E
132°E
133°E
134°E
135°E
136°E

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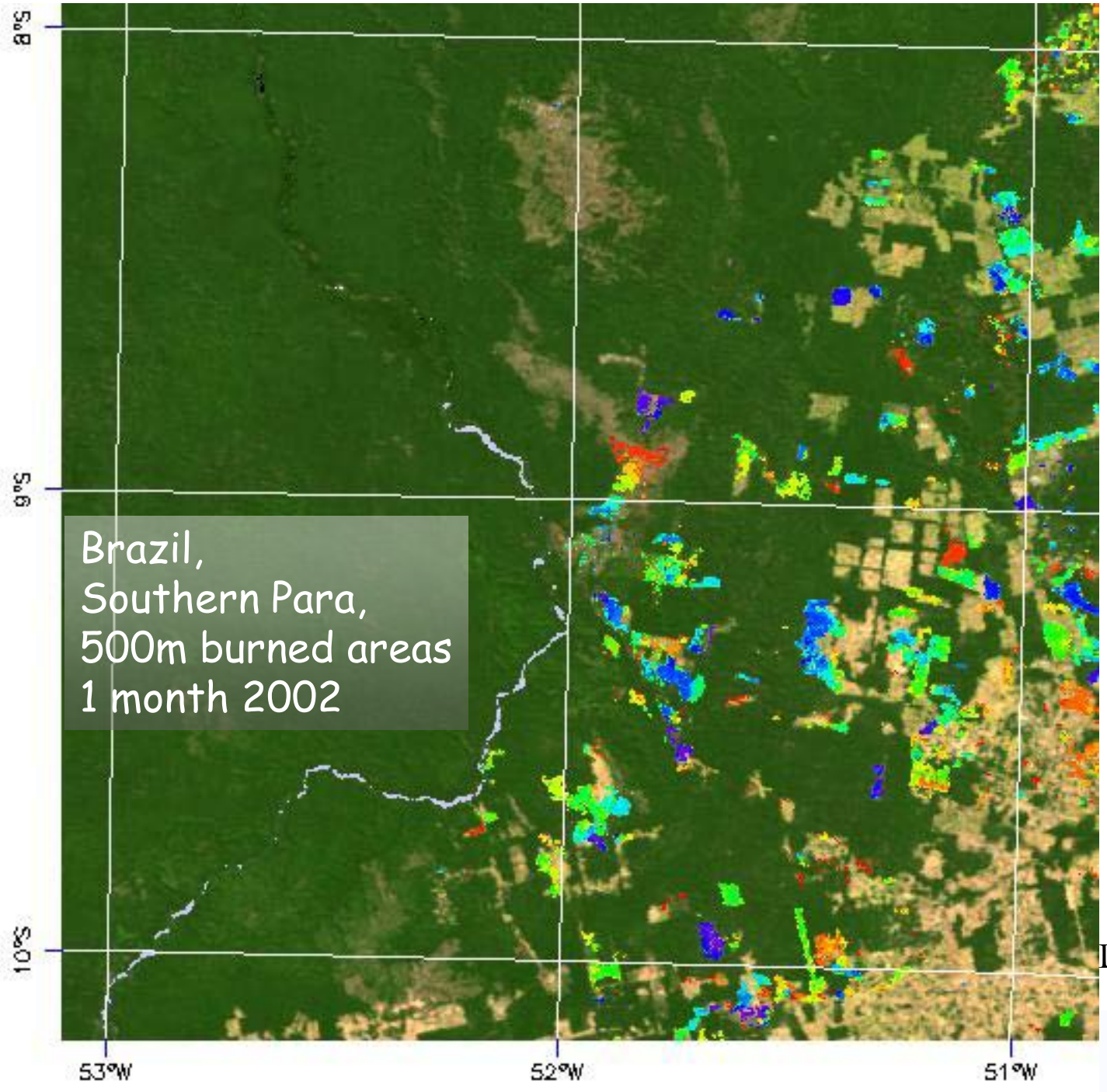
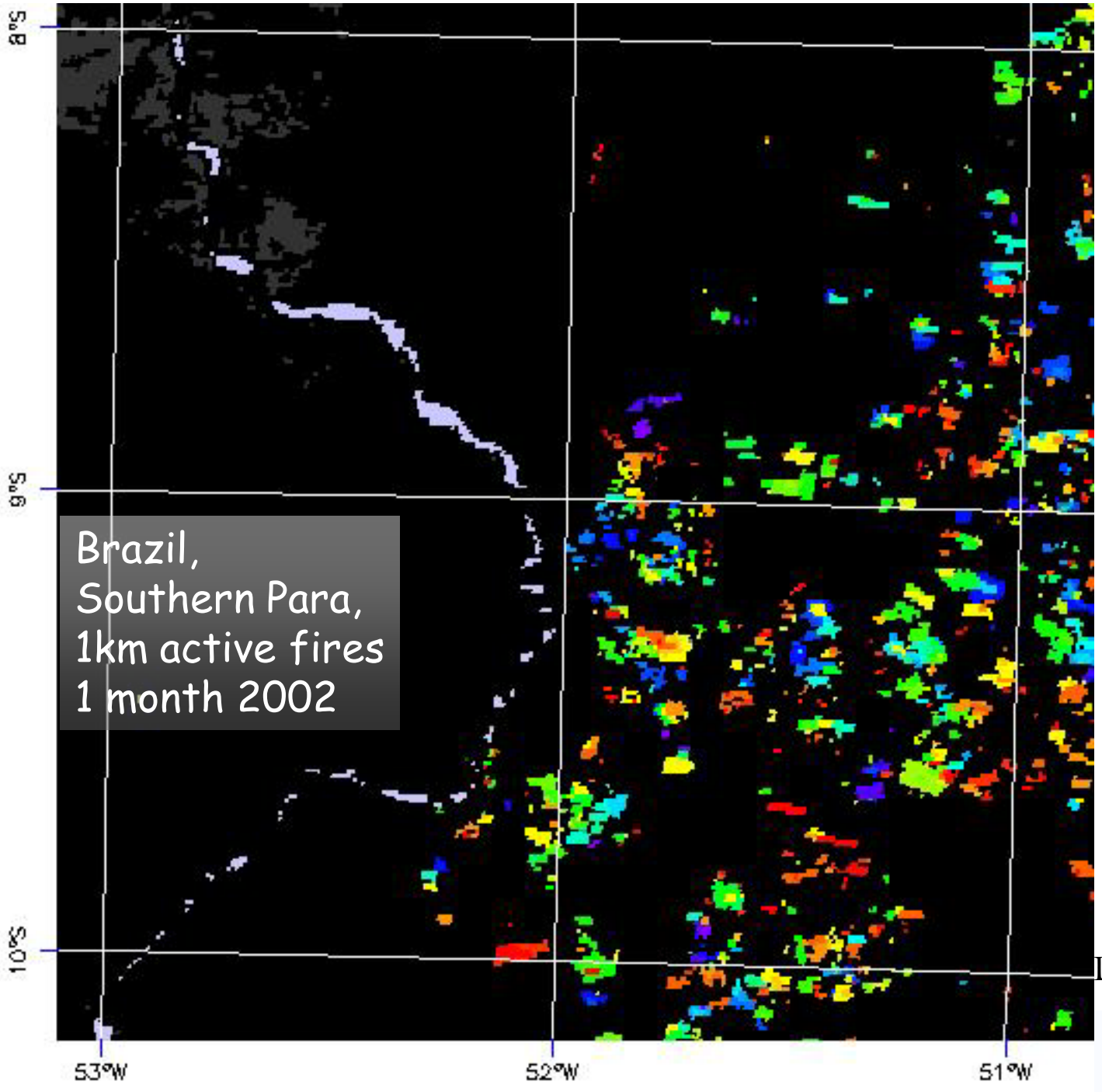
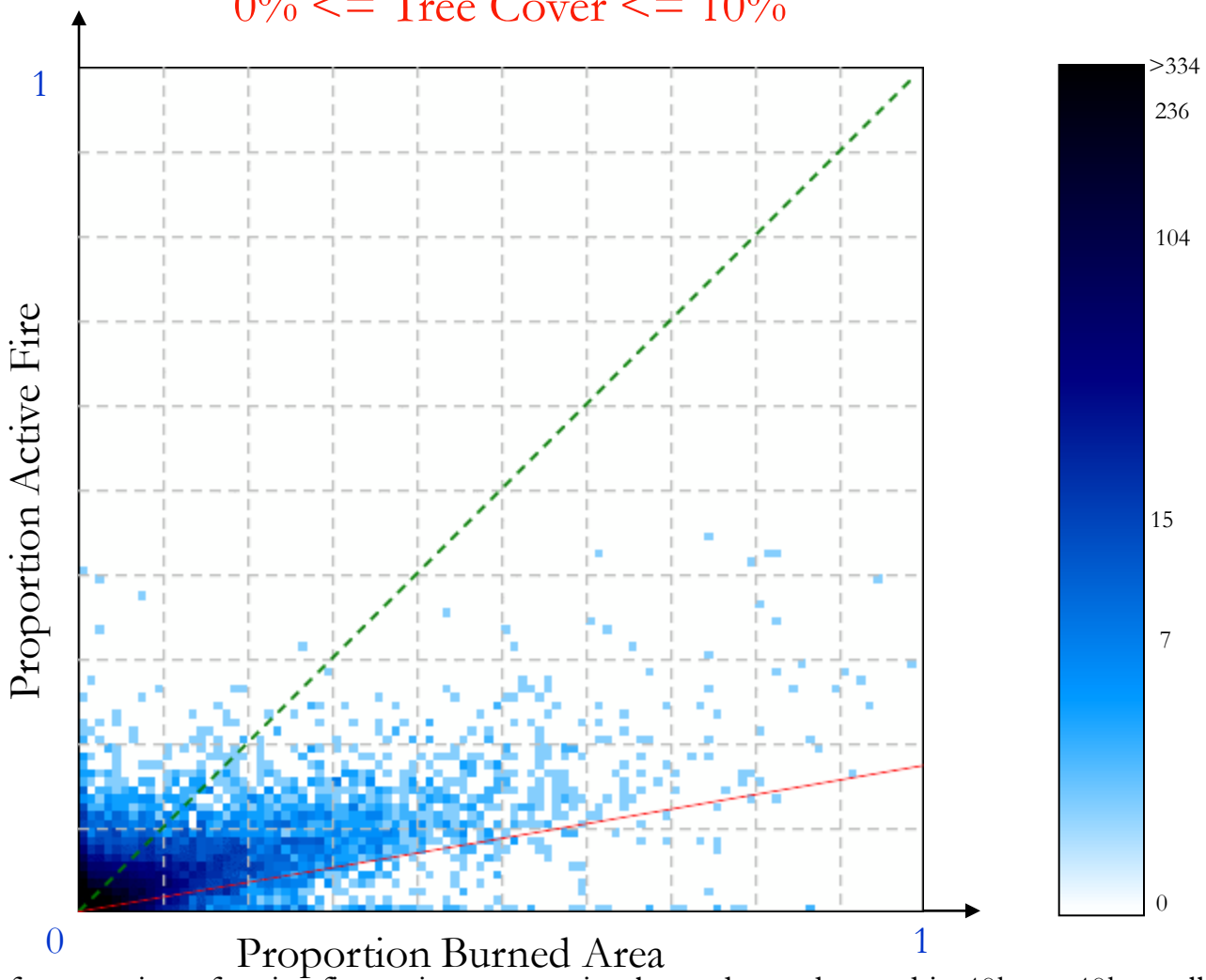


Brazil,
Southern Para,
500m burned areas
1 month 2002

D. Roy, SDSU


8°S
9°S
10°S
53°W
52°W
51°W
Brazil,
Southern Para,
1km active fires
1 month 2002

D. Roy, SDSU



61,523 cells

mean tree cover
= 3.84 %

Slope = 0.173

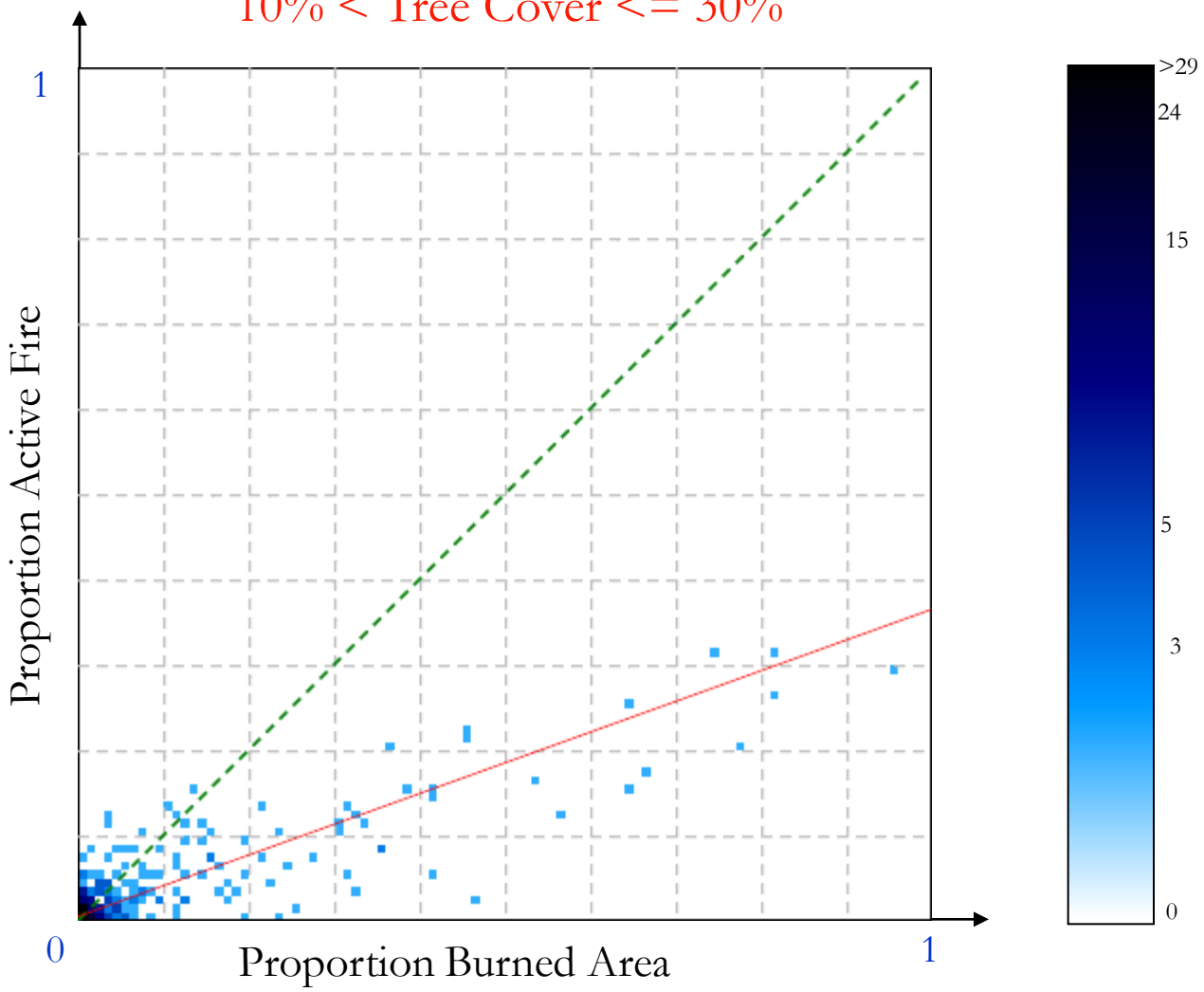
Intercept = 0.002

r = 0.71

Global

2001-2002

Scatter plot of proportion of active fire against proportion burned area detected in 40km x 40km cells. Robust (Theil Sen) regression line is plotted in red; the white blue logarithmic color scale represents the point density distribution of the scatter plot.



417 cells

mean tree cover
= 22.5 %

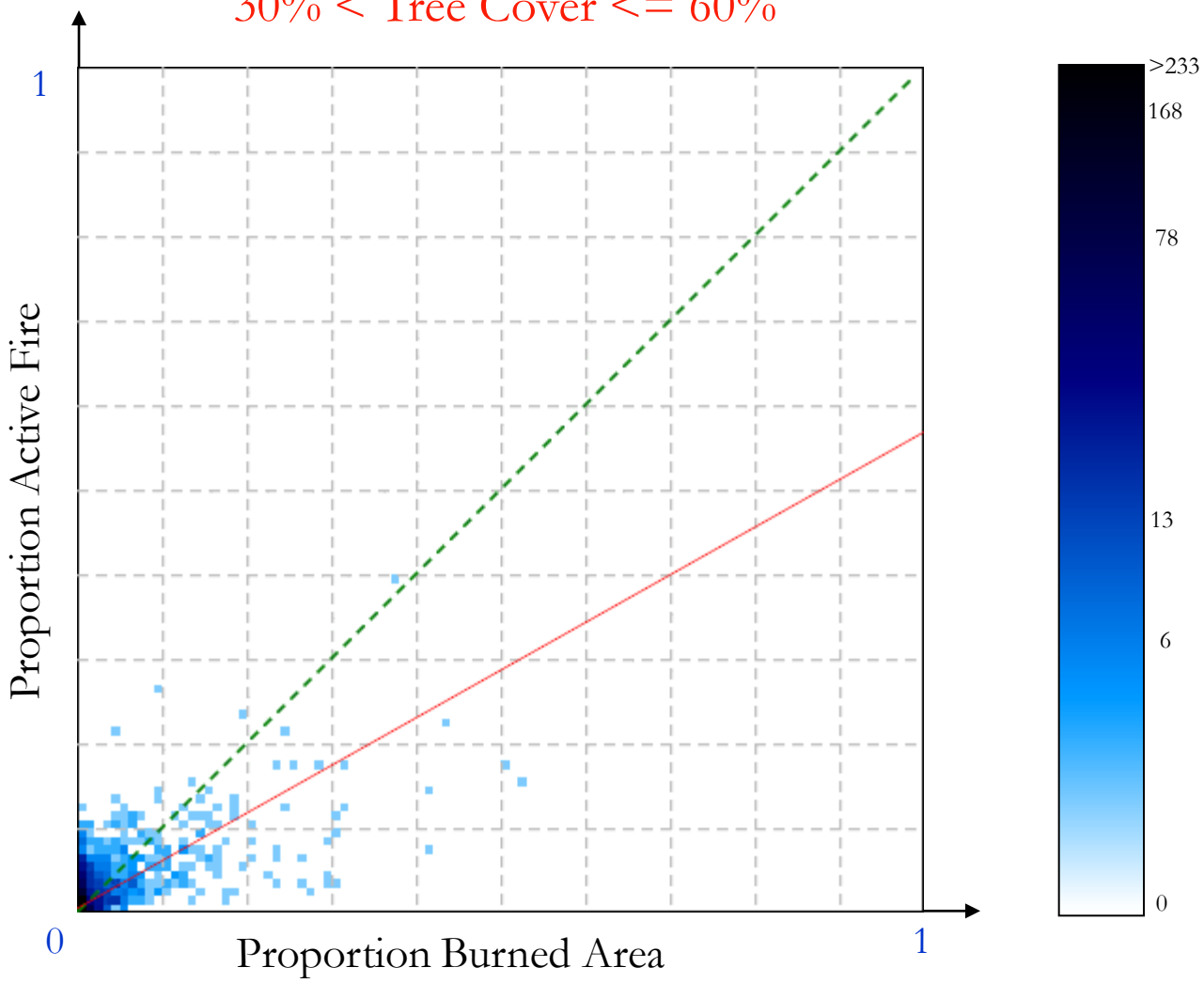
Slope = 0.359

Intercept = 0.006

r = 0.87

Global

2001-2002



2,197 cells

mean tree cover
= 43.2 %

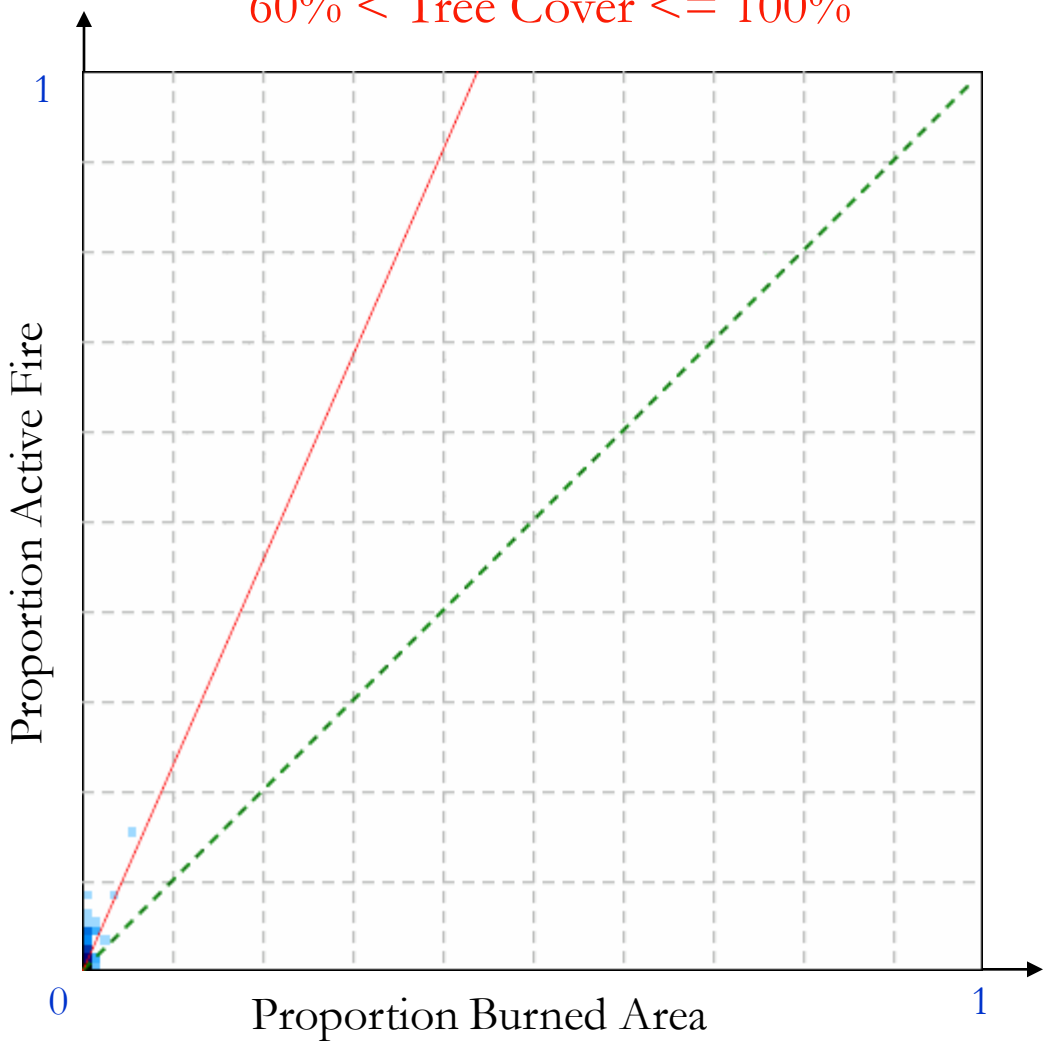
Slope = 0.562

Intercept = 0.006

r = 0.65

Global

2001-2002



1,403 cells

mean tree cover
= 76.2 %

Slope = 2.276

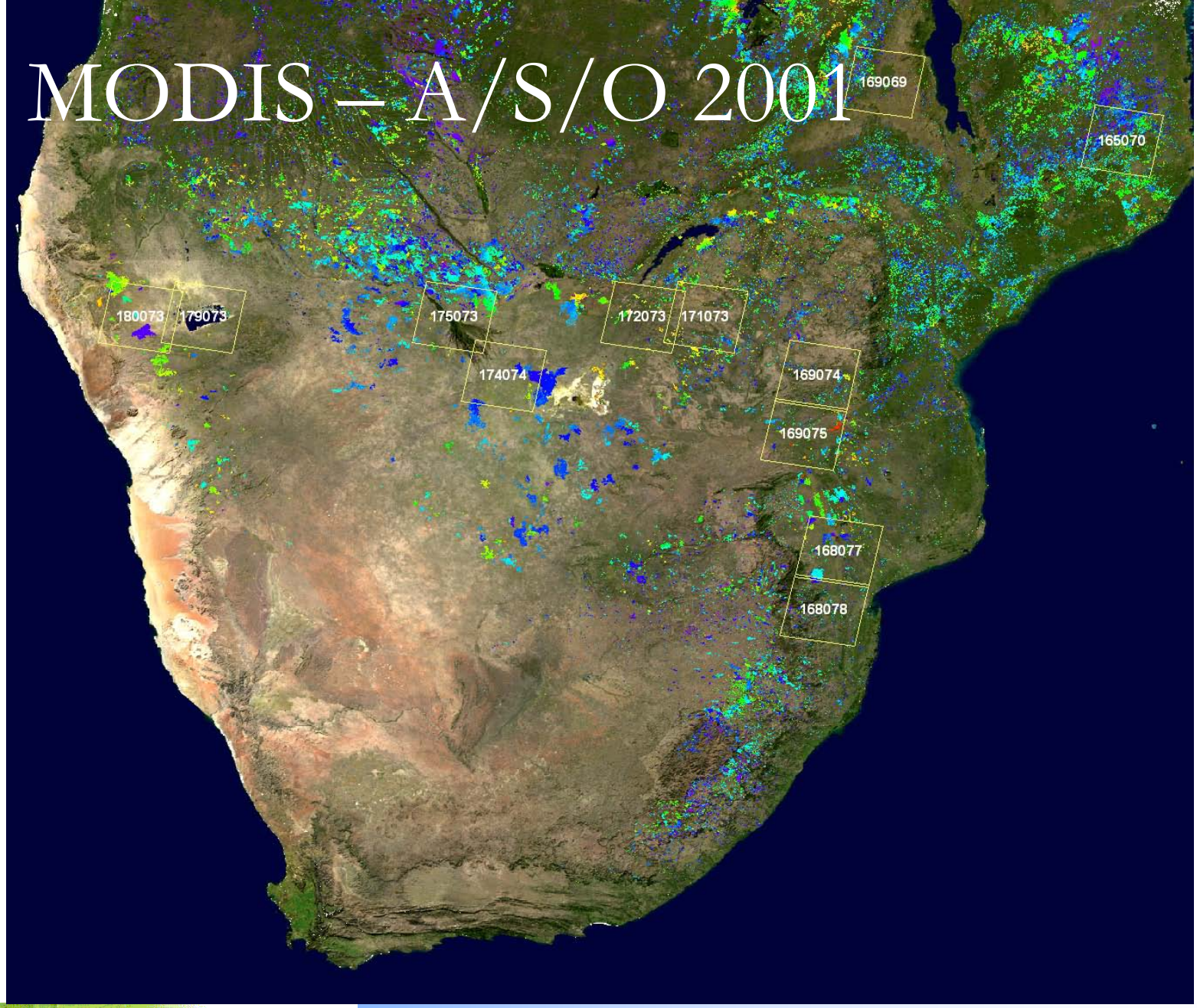
Intercept = 0.002

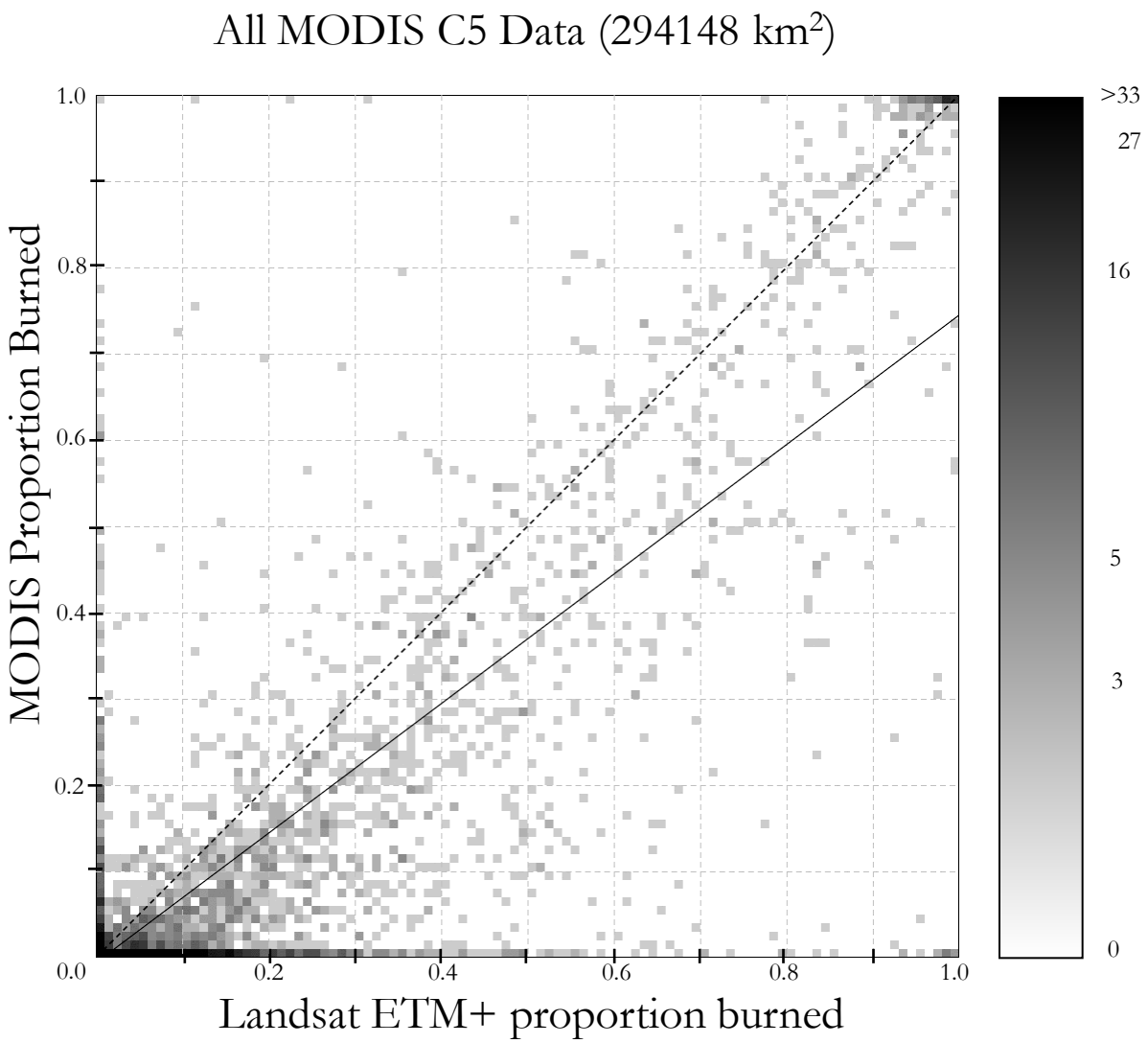
r = 0.67

Global

2001-2002

MODIS – A/S/O 2001





Africa 2001

5km x 5km

grid cells

Slope = 0.75

Intercept = -0.005

r^2 = 0.746

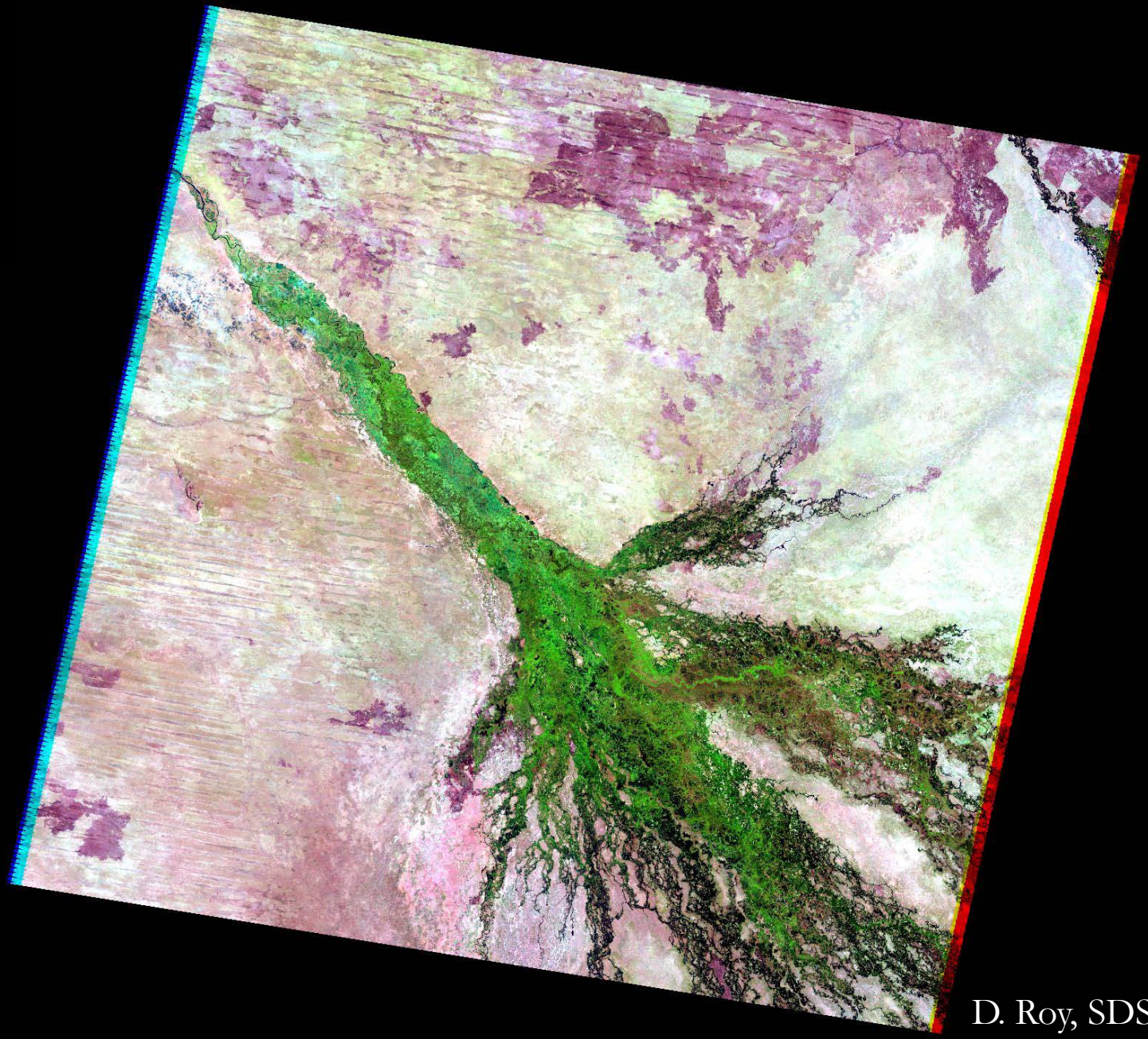
Fire mapping on High Resolution Data

- It is the standard procedure for generating validation datasets for coarse resolution products
- Image classification and on-screen digitization, large TM heritage
- Time consuming, but very accurate

Time 1:

Landsat ETM+

Sept. 4th



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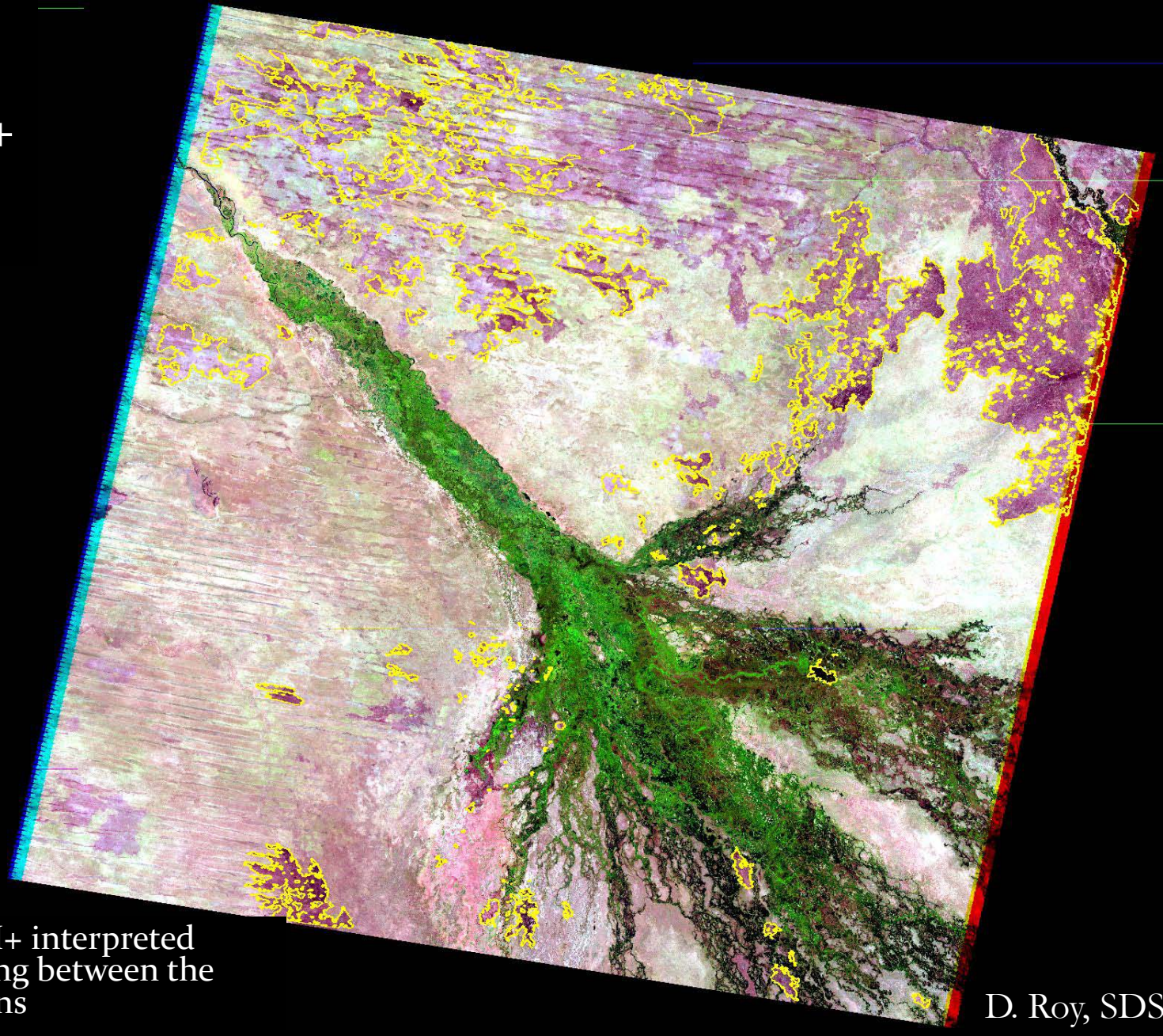
Time 2:

Landsat ETM+

Oct 6th



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

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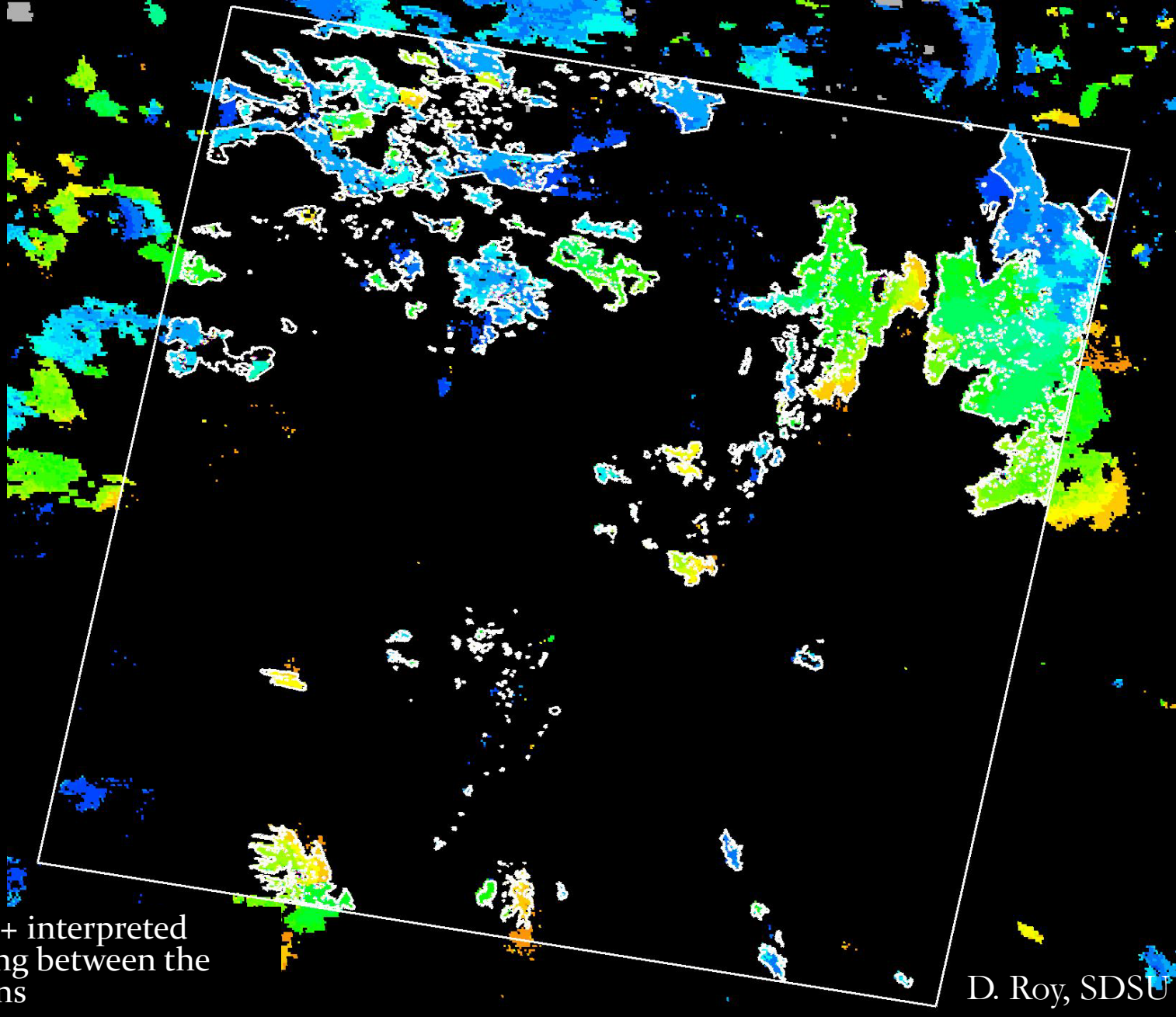
MODIS 500m Burned Areas

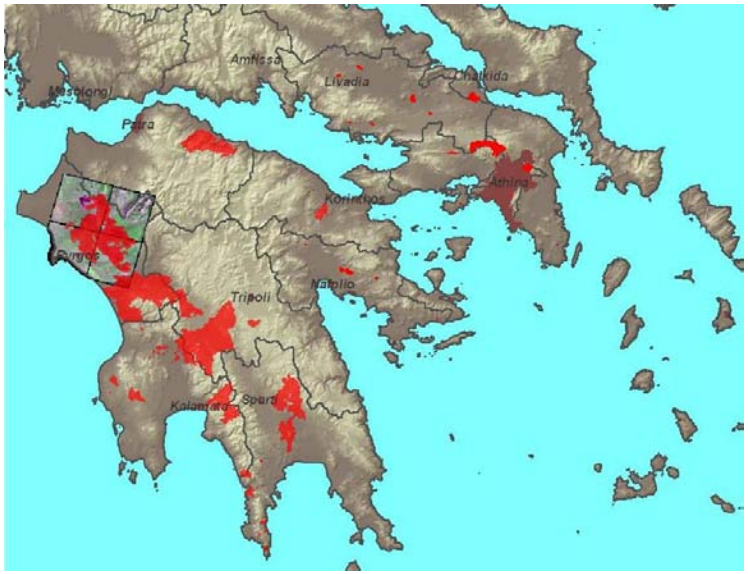
Time 1 Sept. 4
to
Time 2 Oct. 6

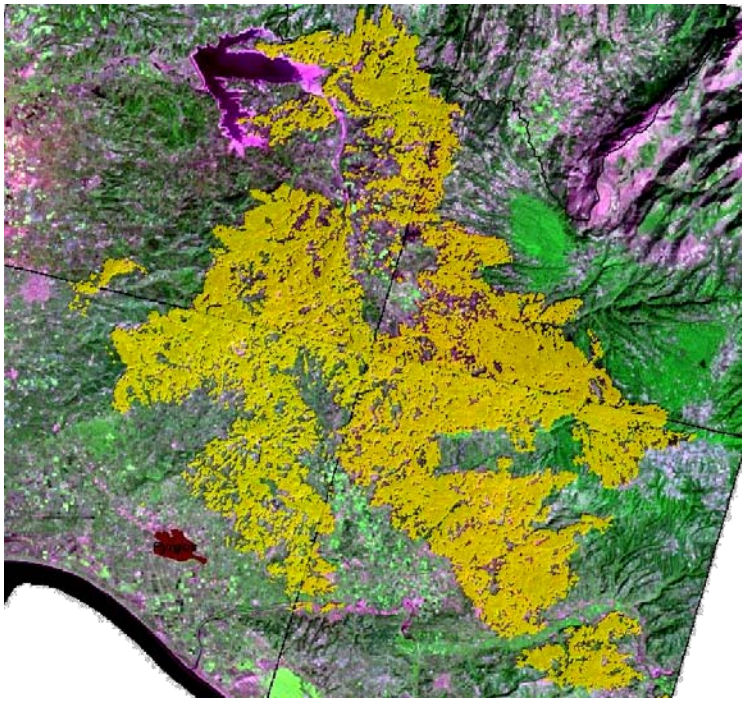


White vectors = ETM+ interpreted burned areas occurring between the two ETM+ acquisitions

D. Roy, SDSU

Case studies of national systems using high resolution data - will this ever become operational?



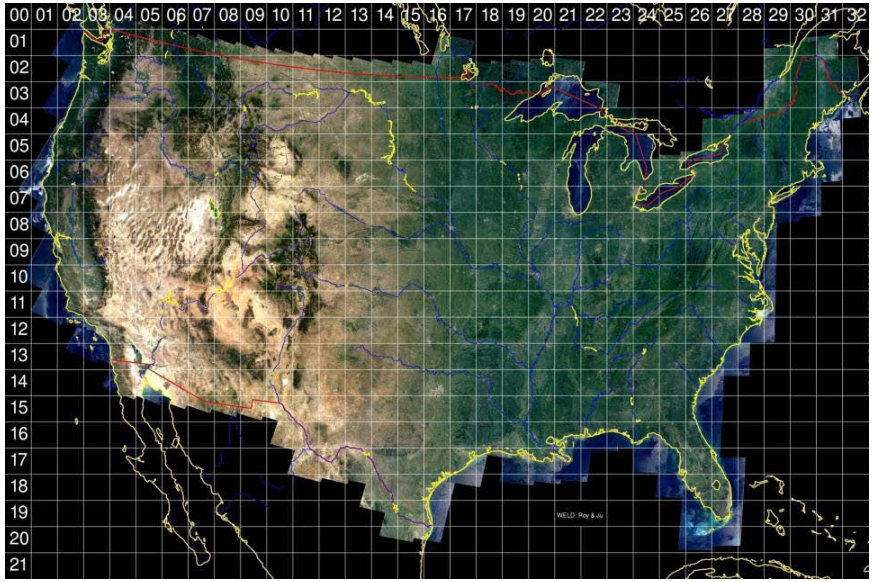


Olympia site, mapped from Formosat-2
(M.Paganini, ESA)

- ESA Risk –EOS high resolution maps for 2007 Greece fires

Systematic processing of Landsat-Class datasets is now possible

- WELD dataset (PI: David Roy): systematically preprocessed and tiled, every acquiusition for the whole US
- Opportunity for "MODIS-Style" generation of thematic products



D.Roy

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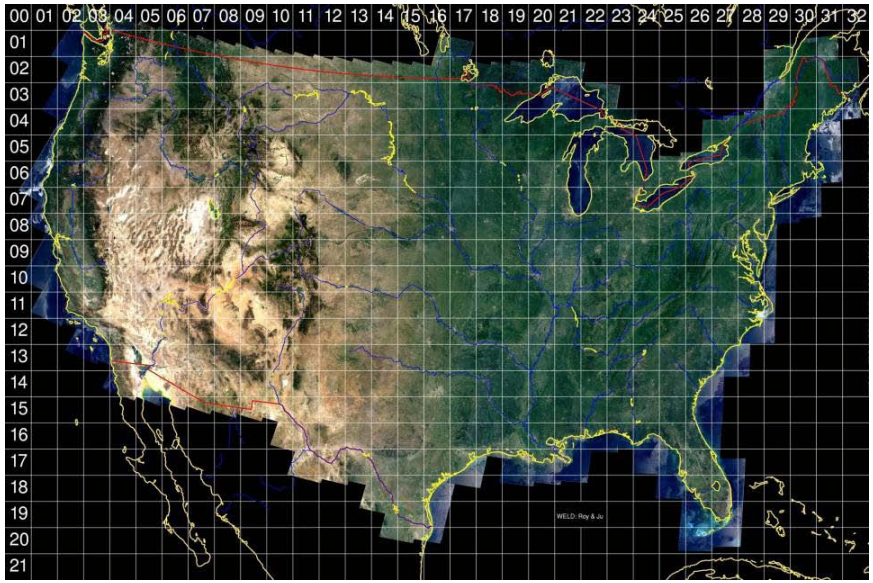

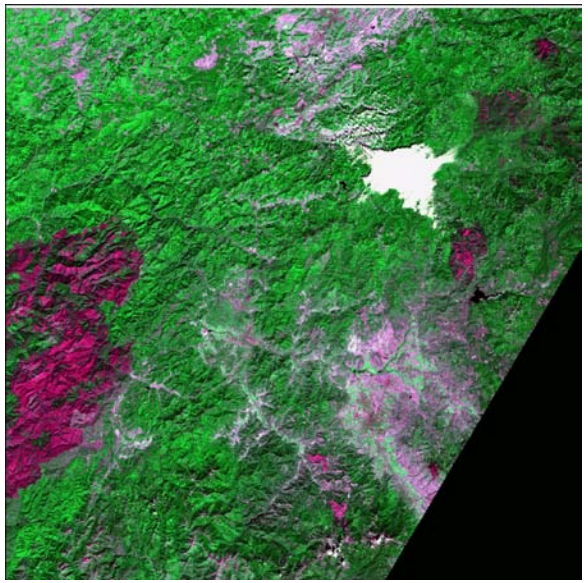

Example of fires, tile h02v05, 2002

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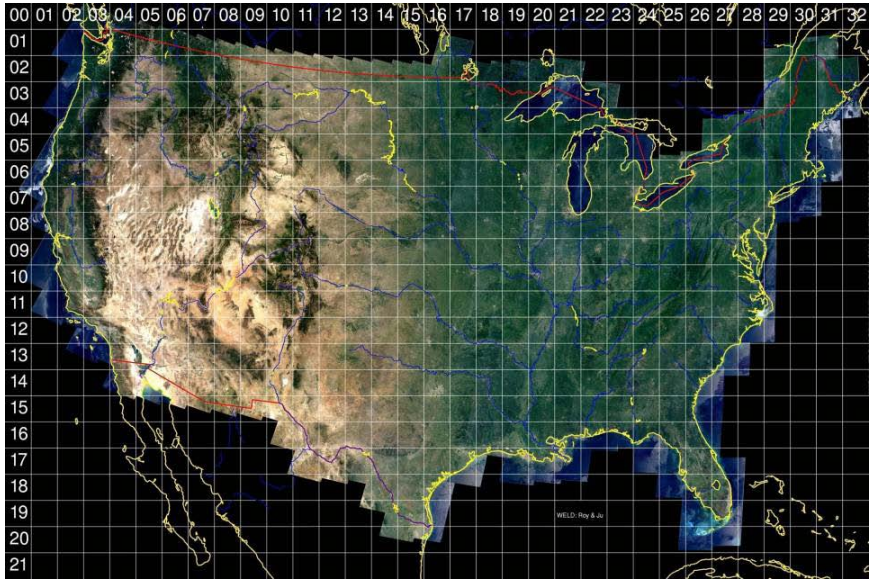

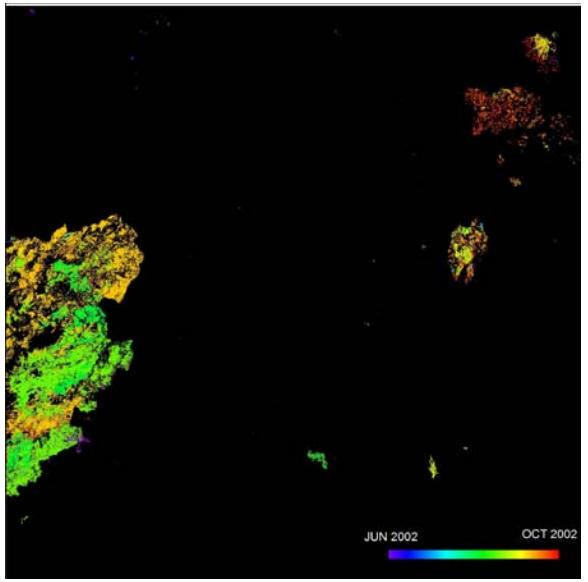

Automatic processing of WELD data

Systematic processing of Landsat-Class datasets is now possible

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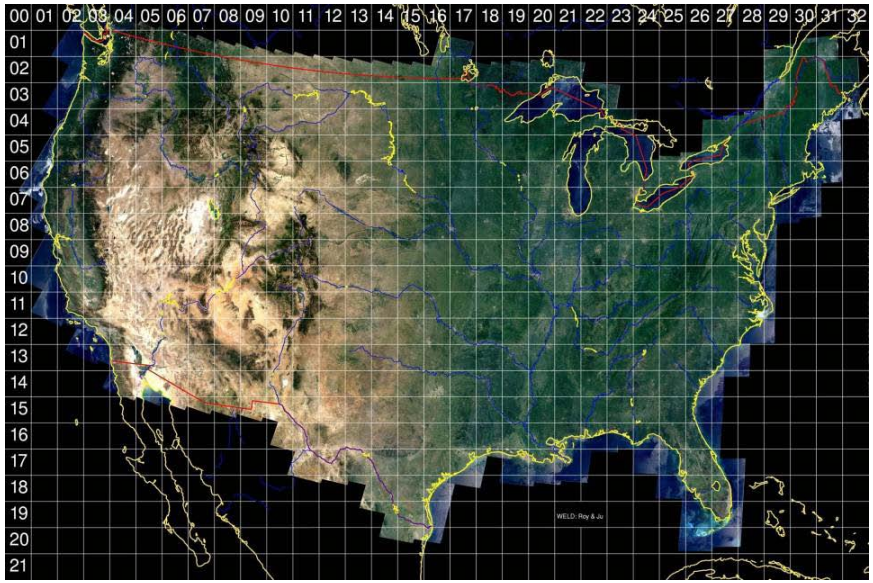
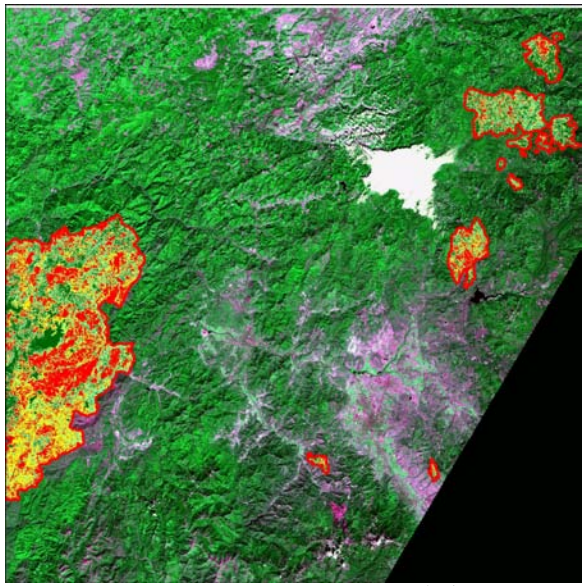
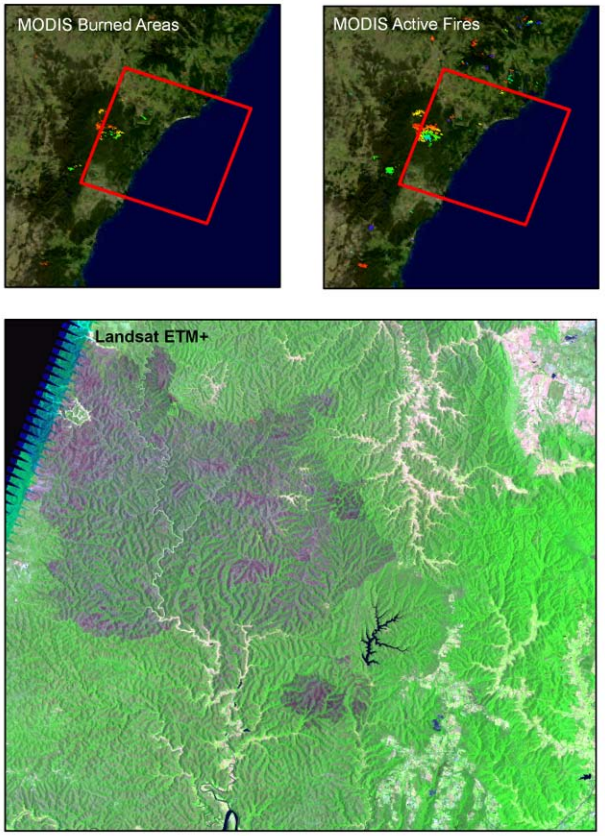




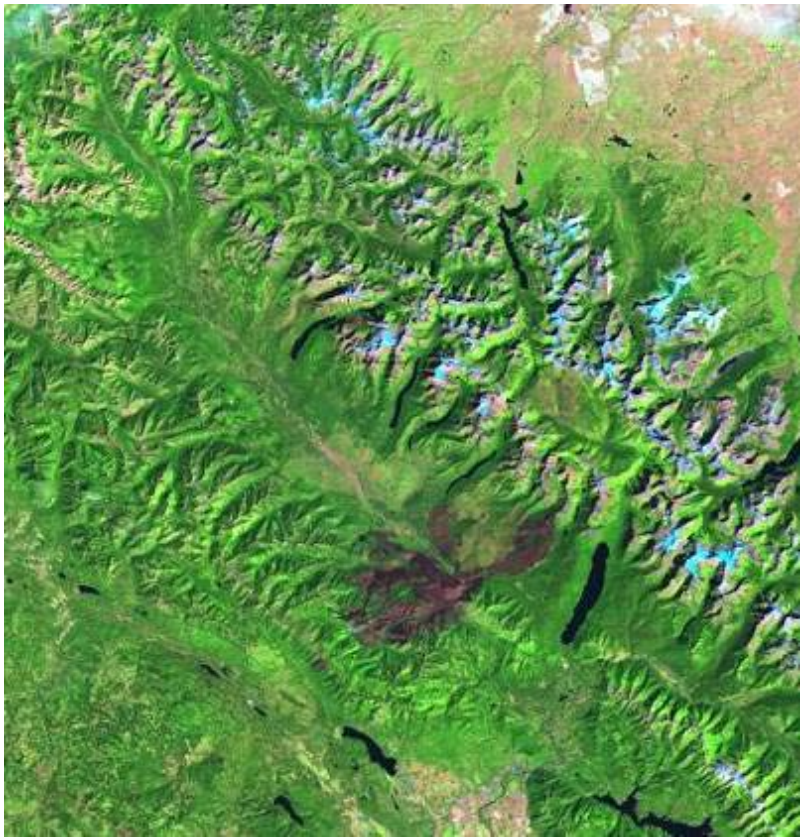
Manual interpretation, MTBS dataset

Using fire products for hotspot detection

- Identification of areas where forest fires occurred, to guide acquisition of high resolution imagery
- The mapping is refined on the high resolution imagery



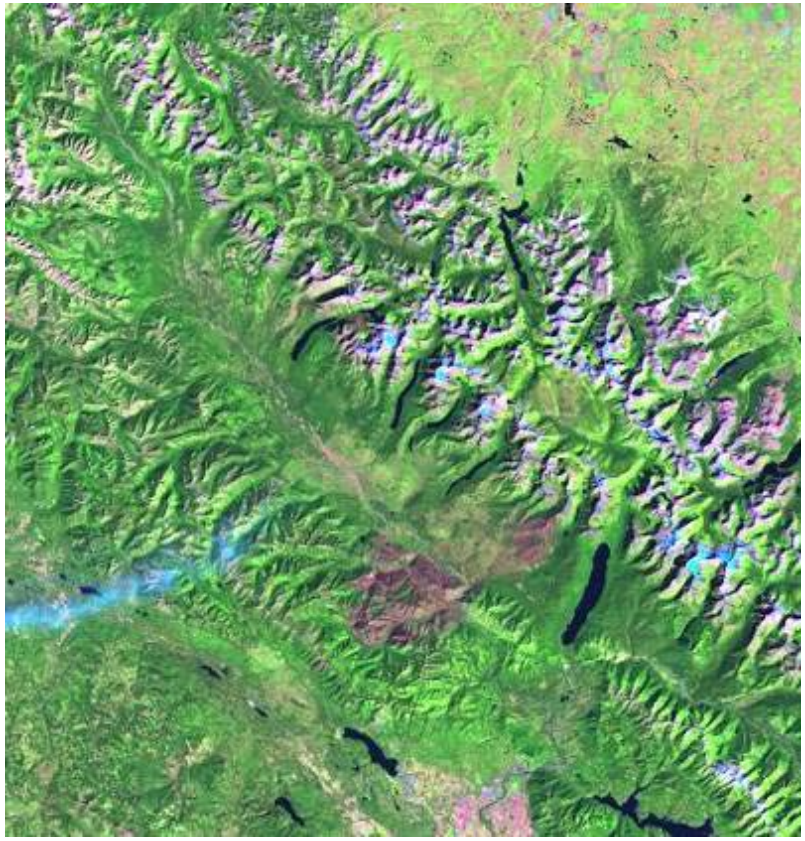
Satellite data for post-fire characterization



2001

Conversion from forest to other use after fire?

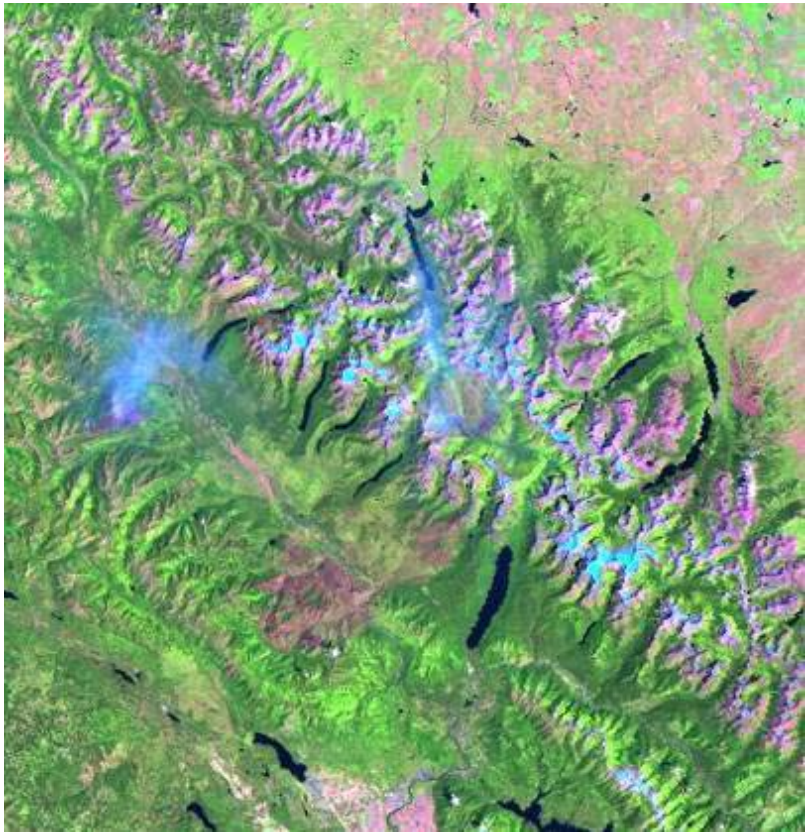
Satellite data for post-fire characterization



2002

Conversion from forest to other use after fire?
1 year later: no

Satellite data for post-fire characterization

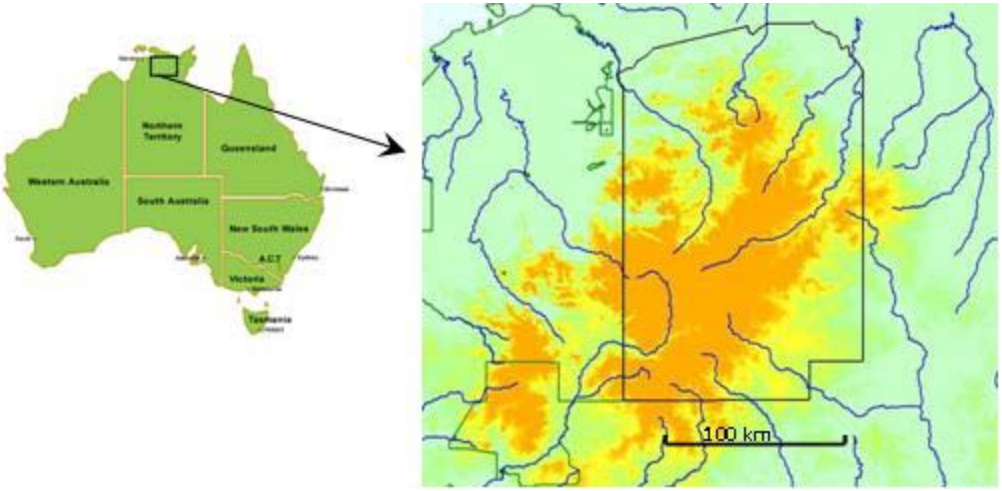


2003

Conversion from forest to other use after fire?
1 year later: no
2 years later: no

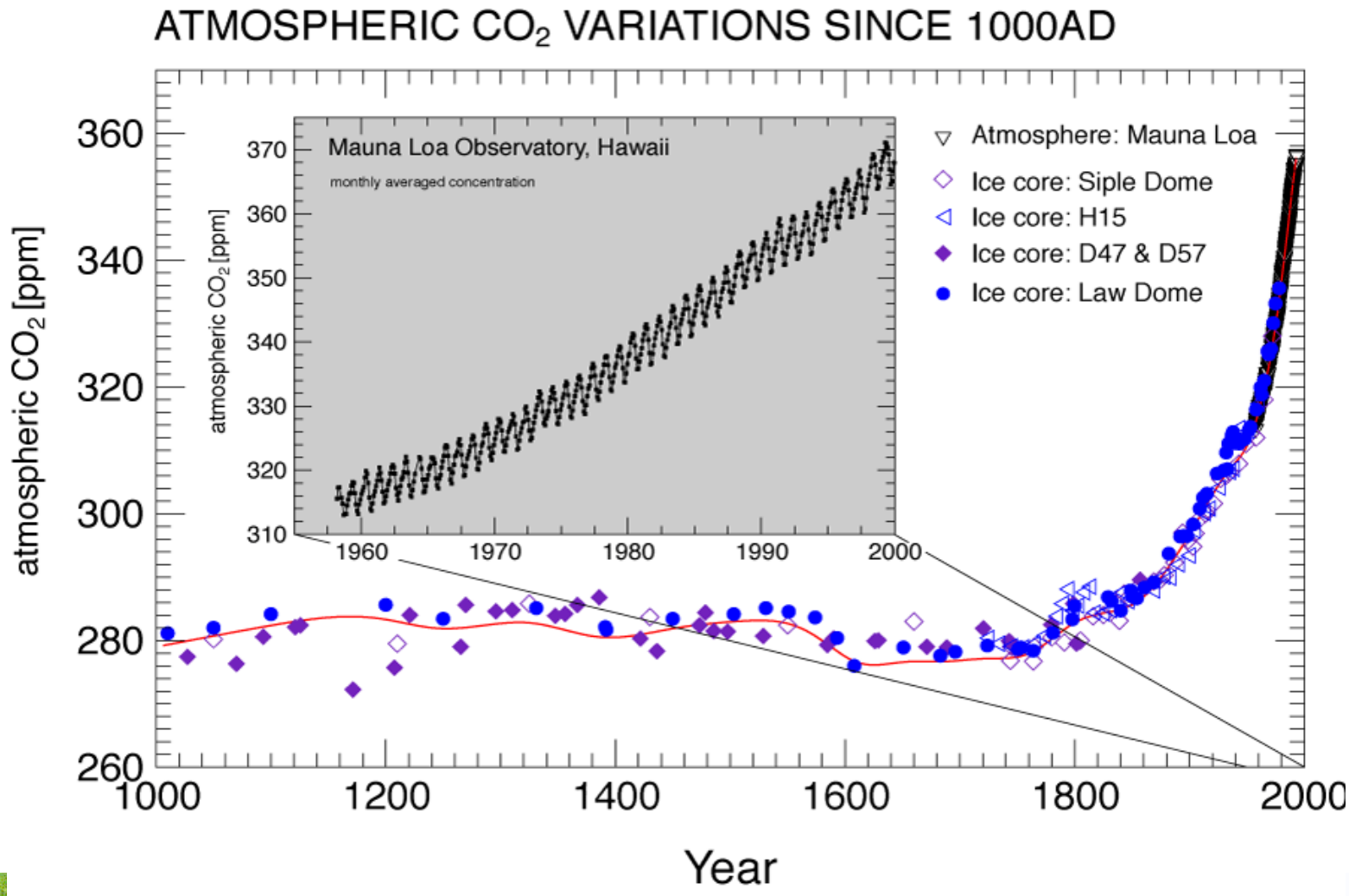
Alternative view: fire management

- What is forest? Tree cover between 10% and 30% can be considered.
- Change in total annual emissions by managing fire and changing the seasonality (early versus late fires)
- Example: WALFA in Northern Australia

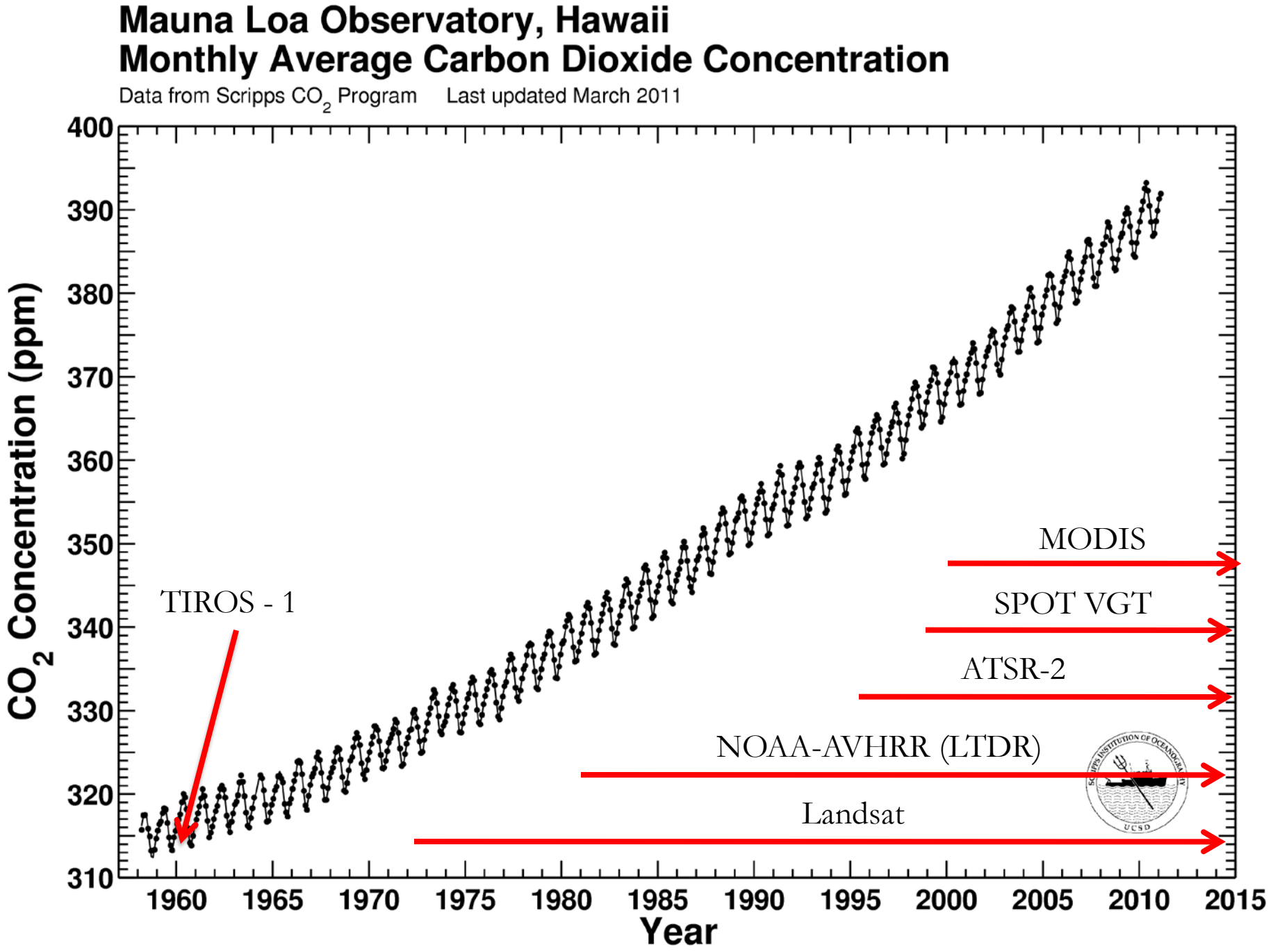


A Baseline for Fire Activity

This is recent history for the Earth

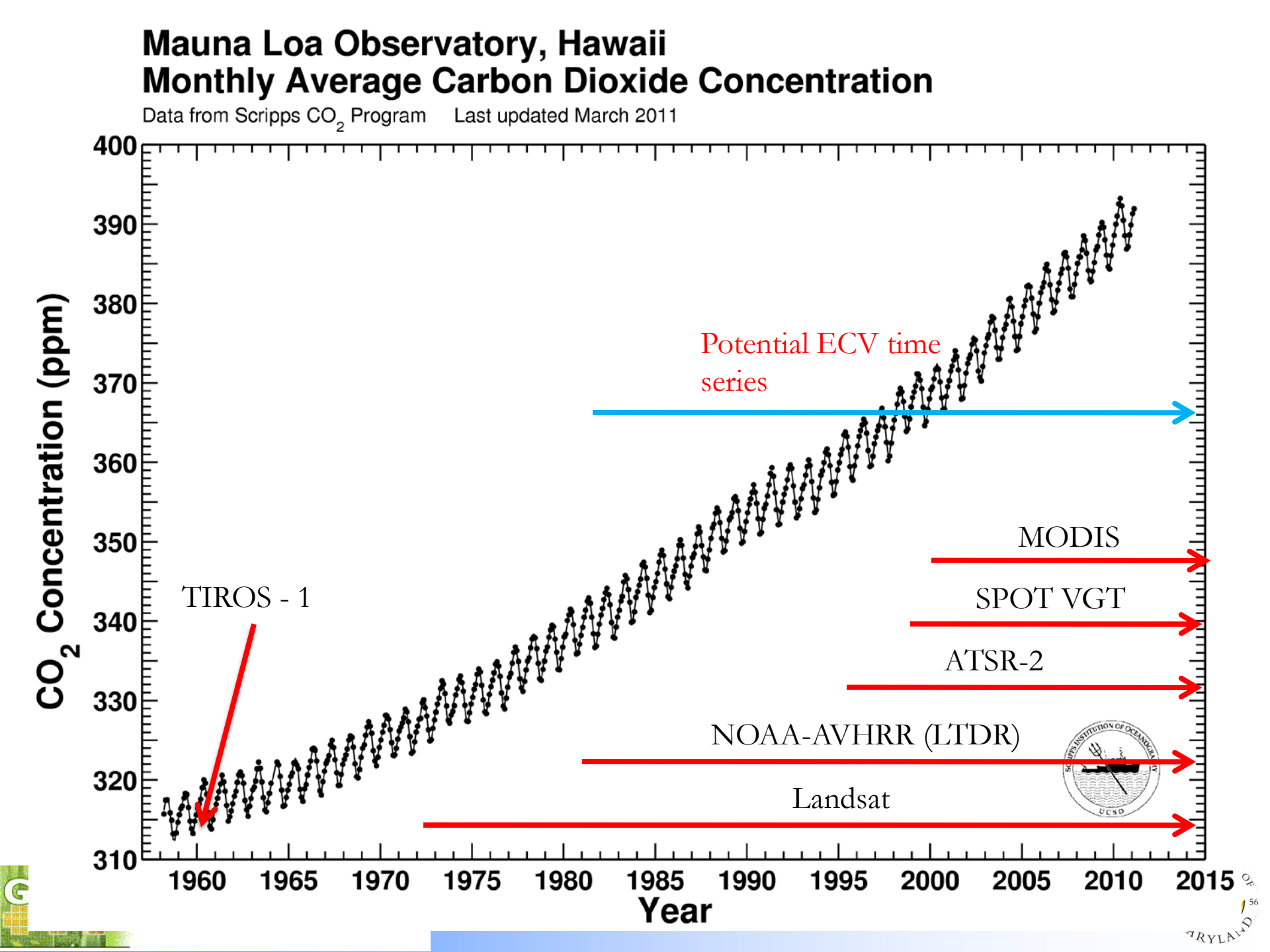


Sarmiento and Gruber (2002)


Mauna Loa Observatory, Hawaii
Monthly Average Carbon Dioxide Concentration
Data from Scripps CO2 Program Last updated March 2011
CO2 Concentration (ppm)
400
390
380
370
360
350
340
330
320
310
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
Year
TIROS - 1
MODIS
SPOT VGT
ATSR-2
NOAA-AVHRR (LTDR)
Landsat

Long term data records

- Essential Climate Variables are defined by GCOS (under WMO)
- Integration of existing data sources
- Intercalibration of existing thematic products
- International cooperation for harmonization of future products
- Potential for series starting in 1980, with local test dataset with Landsat data from 1970s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Potential ECV time series
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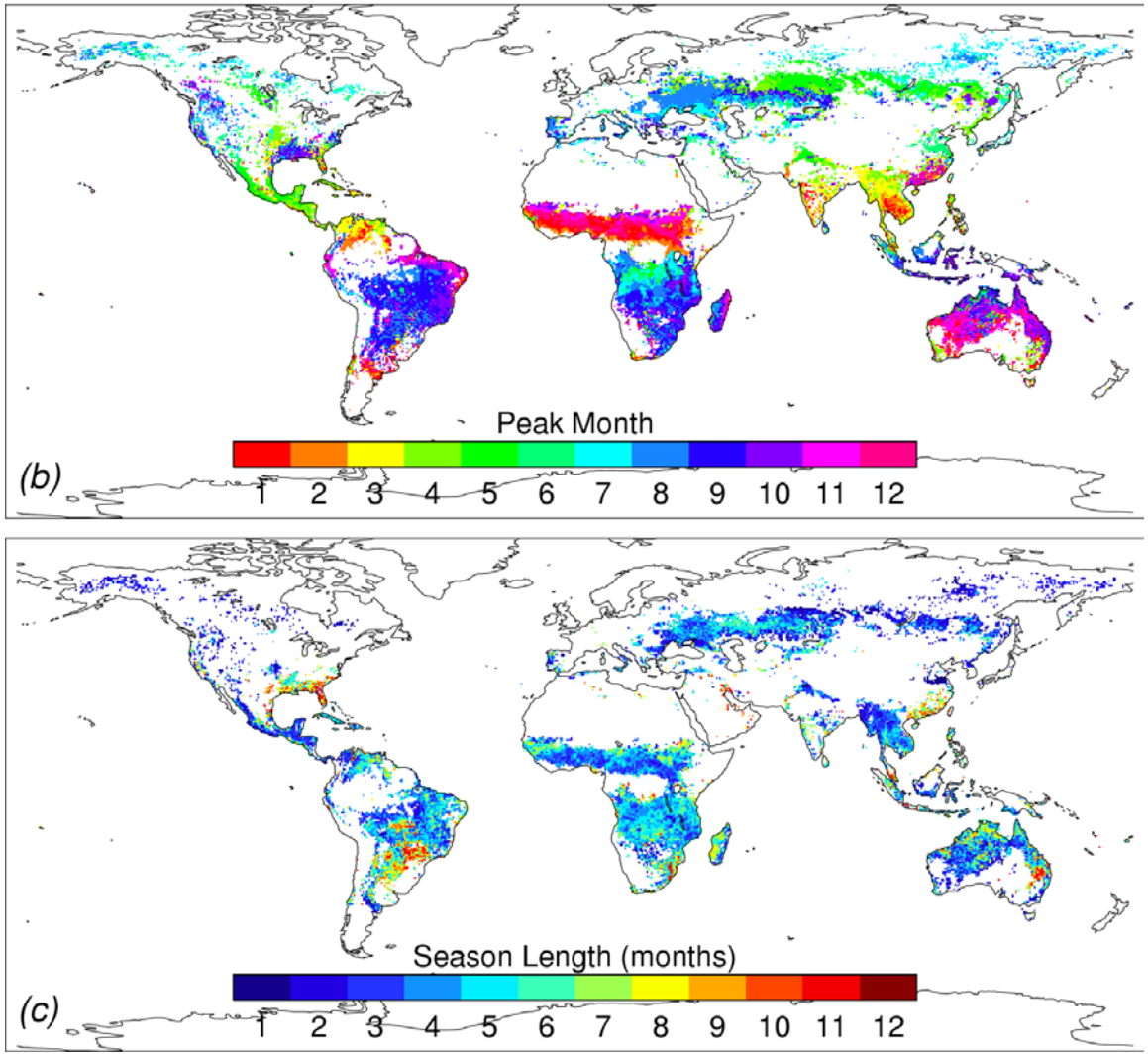
TIROS - 1

Long term data records

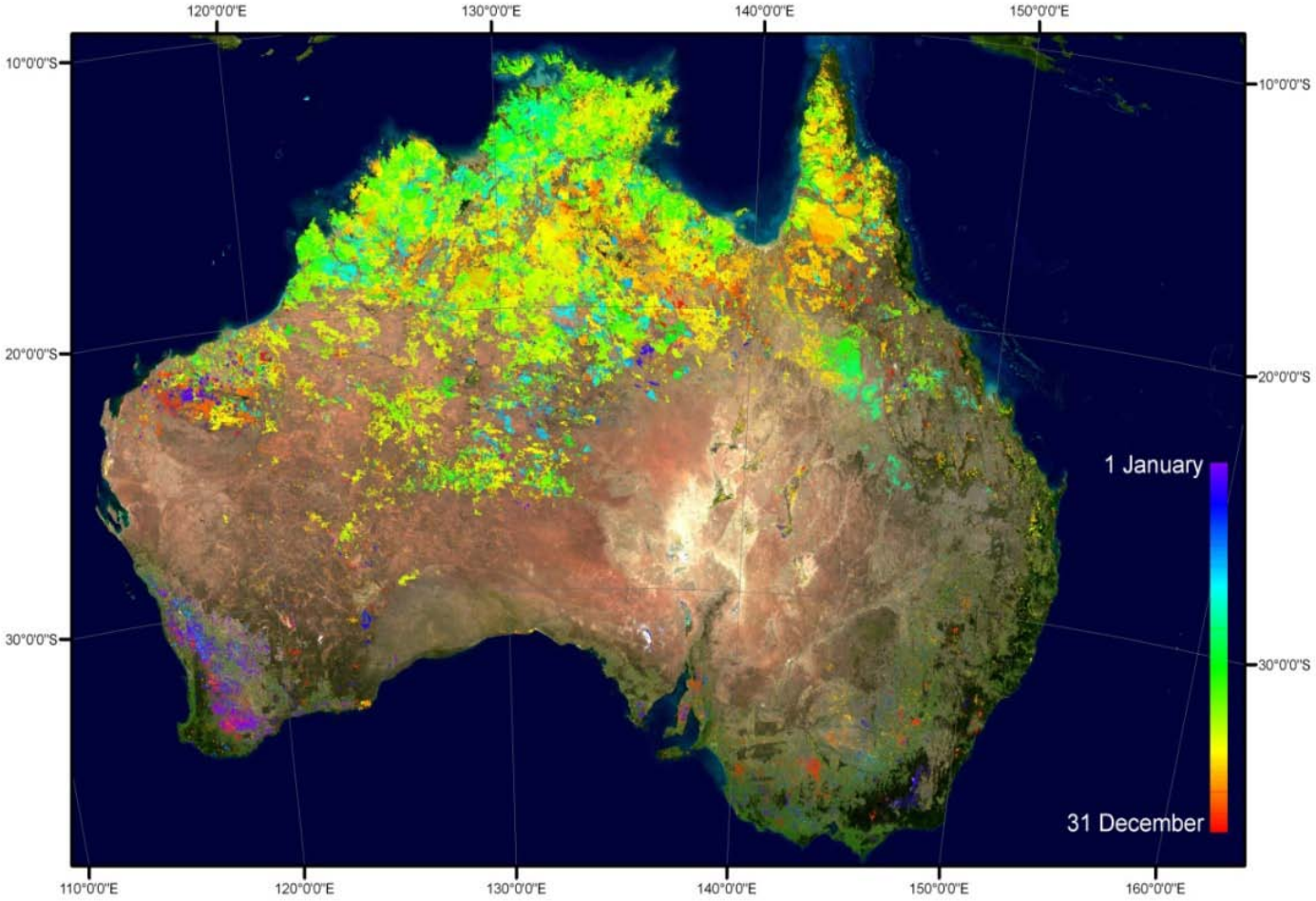
ECVs essential for answering the fundamental science question of the baseline of fire activity.

- Fire Assessment at global, continental and country level
- Analysis of fire regime interannual variability

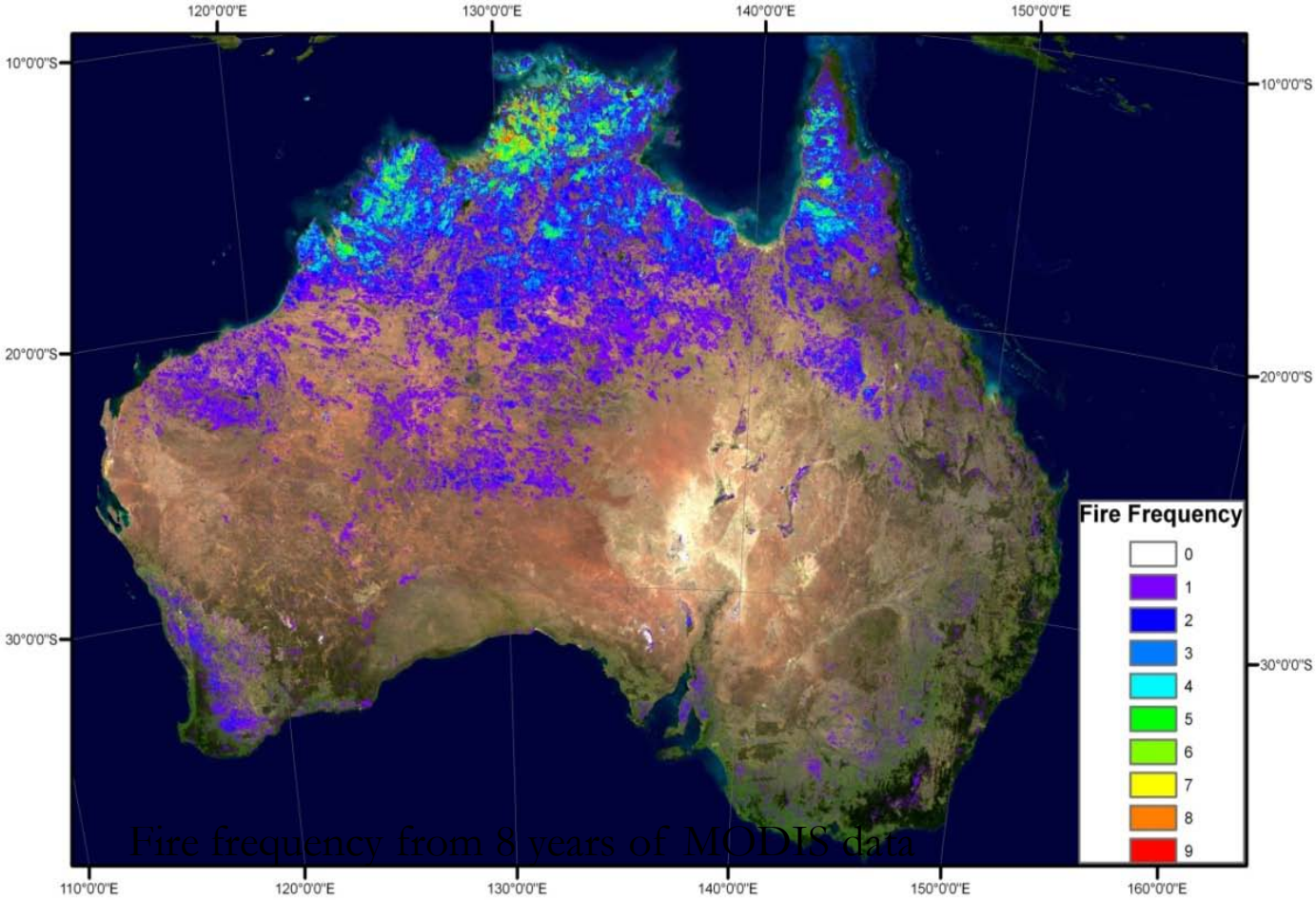
Main issue: work needed for calibration and validation of the products



Climatological fields derived from the first 5 years of Terra MODIS fire observations. (November 2000 to October 2005). (b) month of maximum climatological fire activity, and (c) fire season length. (source: Giglio et al., 2006).



Median day of burning from 8 years of MODIS burned area data



Fire frequency from 8 years of MODIS data

Fire frequency from 8 years of MODIS burned area data

Conclusion

- Burned area mapping has improved, but fire characterization (ground/crown) and biomass consumption cannot be determined reliable from satellite data alone.
- The existing satellite products can be integrated in carbon monitoring systems
  - Information on location and timing of fires
  - Areal estimates (with uncertainties)
  - Post-fire monitoring
- The moderate resolution products are the only time series for a baseline of fire activity (Global Fire Assessment)
- The free access to Landsat class data (potentially Sentinel-2) gives the opportunity of generating automatic fire products at the resolution needed for national inventories

Links

- Downloadable Sourcebook:

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

This is a collaborative effort – new contributions are very welcome!