NASA MODIS Global Fire Monitoring and its applications in Northern Eurasia

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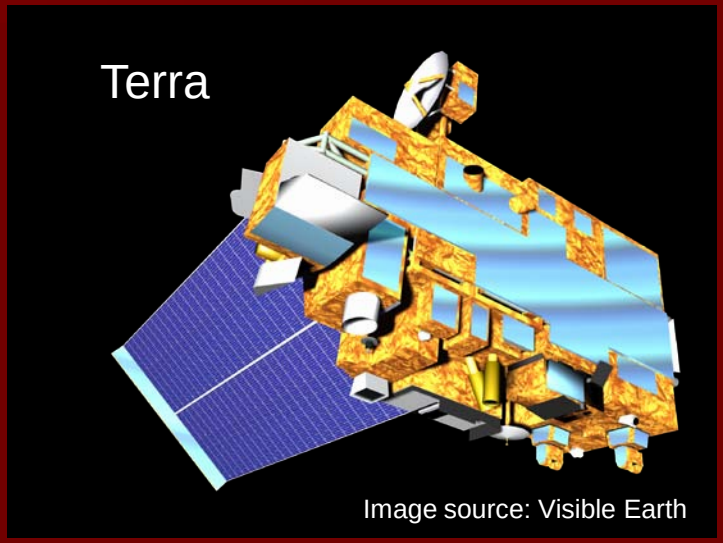
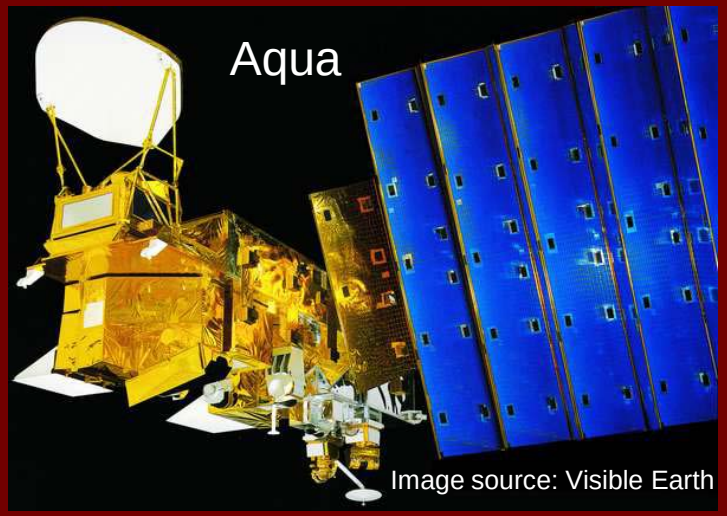
Joint NASA LCLUC Science Team Meeting and

GOFC-GOLD/NERIN, NEESPI, MAIRS Workshop

MODIS instrument

- Moderate Resolution Imaging Spectroradiometer (MODIS)
- On board two polar orbiting satellites
  - Terra launched in 1999
  - Aqua launched in 2002





MODIS data acquisition

- Global twice daily imaging (Terra and Aqua)
- Overpass overlaps over higher latitudes – multiple imaging opportunities
- A large number of bands at different resolutions
- Specifically designed bands for fire monitoring purposes

MODIS bands 1-19

Primary Use	Band	Bandwidth[1]	Spectral Radiance[2]	Required SNR[3]
Land/Cloud/Aerosols Boundaries	1	620 - 670	21.8	128
	2	841 - 876	24.7	201
Land/Cloud/Aerosols Properties	3	459 - 479	35.3	243
	4	545 - 565	29.0	228
	5	1230 - 1250	5.4	74
	6	1628 - 1652	7.3	275
	7	2105 - 2155	1.0	110
Ocean Color/ Phytoplankton/ Biogeochemistry	8	405 - 420	44.9	880
	9	438 - 448	41.9	838
	10	483 - 493	32.1	802
	11	526 - 536	27.9	754
	12	546 - 556	21.0	750
	13	662 - 672	9.5	910
	14	673 - 683	8.7	1087
	15	743 - 753	10.2	586
	16	862 - 877	6.2	516
Atmospheric Water Vapor	17	890 - 920	10.0	167
	18	931 - 941	3.6	57
	19	915 - 965	15.0	250

MODIS bands 20-36

Primary Use	Band	Bandwidth[1]	Spectral Radiance[2]	Required NE[delta]T(K)[4]
Surface/Cloud Temperature	20	3.660 - 3.840	0.45(300K)	0.05
	21	3.929 - 3.989	2.38(335K)	2.00
	22	3.929 - 3.989	0.67(300K)	0.07
	23	4.020 - 4.080	0.79(300K)	0.07
Atmospheric Temperature	24	4.433 - 4.498	0.17(250K)	0.25
	25	4.482 - 4.549	0.59(275K)	0.25
Cirrus Clouds Water Vapor	26	1.360 - 1.390	6.00	150(SNR)
	27	6.535 - 6.895	1.16(240K)	0.25
	28	7.175 - 7.475	2.18(250K)	0.25
Cloud Properties	29	8.400 - 8.700	9.58(300K)	0.05
Ozone	30	9.580 - 9.880	3.69(250K)	0.25
Surface/Cloud Temperature	31	10.780 - 11.280	9.55(300K)	0.05
	32	11.770 - 12.270	8.94(300K)	0.05
Cloud Top Altitude	33	13.185 - 13.485	4.52(260K)	0.25
	34	13.485 - 13.785	3.76(250K)	0.25
	35	13.785 - 14.085	3.11(240K)	0.25
	36	14.085 - 14.385	2.08(220K)	0.35

[1] Bands 1 to 19 are in nm; Bands 20 to 36 are in μm

[2] Spectral Radiance values are (W/m^2 -μm-sr)

[3] SNR = Signal-to-noise ratio

[4] NE(delta)T = Noise-equivalent temperature difference

Note: Performance goal is 30-40% better than required

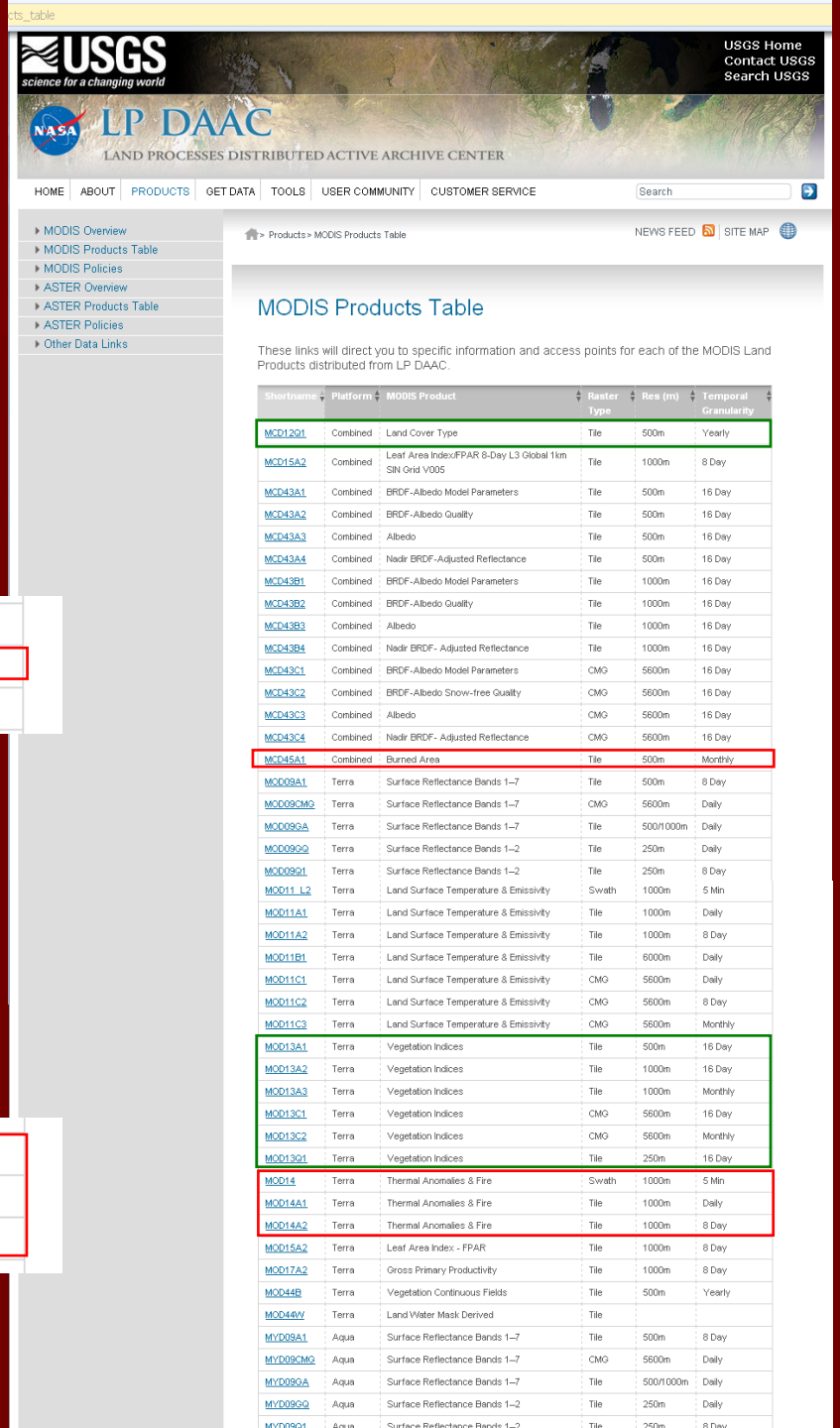
MODIS fire data products

- Global algorithms –different performance in different areas
- Standard products – science datasets
- Fire was a priority in instrument design and product development

MODIS Fire products

MCD43C4	Combined	Nadir BRDF- Adjusted Reflectance	CMG	5600m	16 Day
MCD45A1	Combined	Burned Area	Tile	500m	Monthly
MOD09A1	Terra	Surface Reflectance Bands 1–7	Tile	500m	8 Day

MOD14	Terra	Thermal Anomalies & Fire	Swath	1000m	5 Min
MOD14A1	Terra	Thermal Anomalies & Fire	Tile	1000m	Daily
MOD14A2	Terra	Thermal Anomalies & Fire	Tile	1000m	8 Day



MODIS Active Fire detections

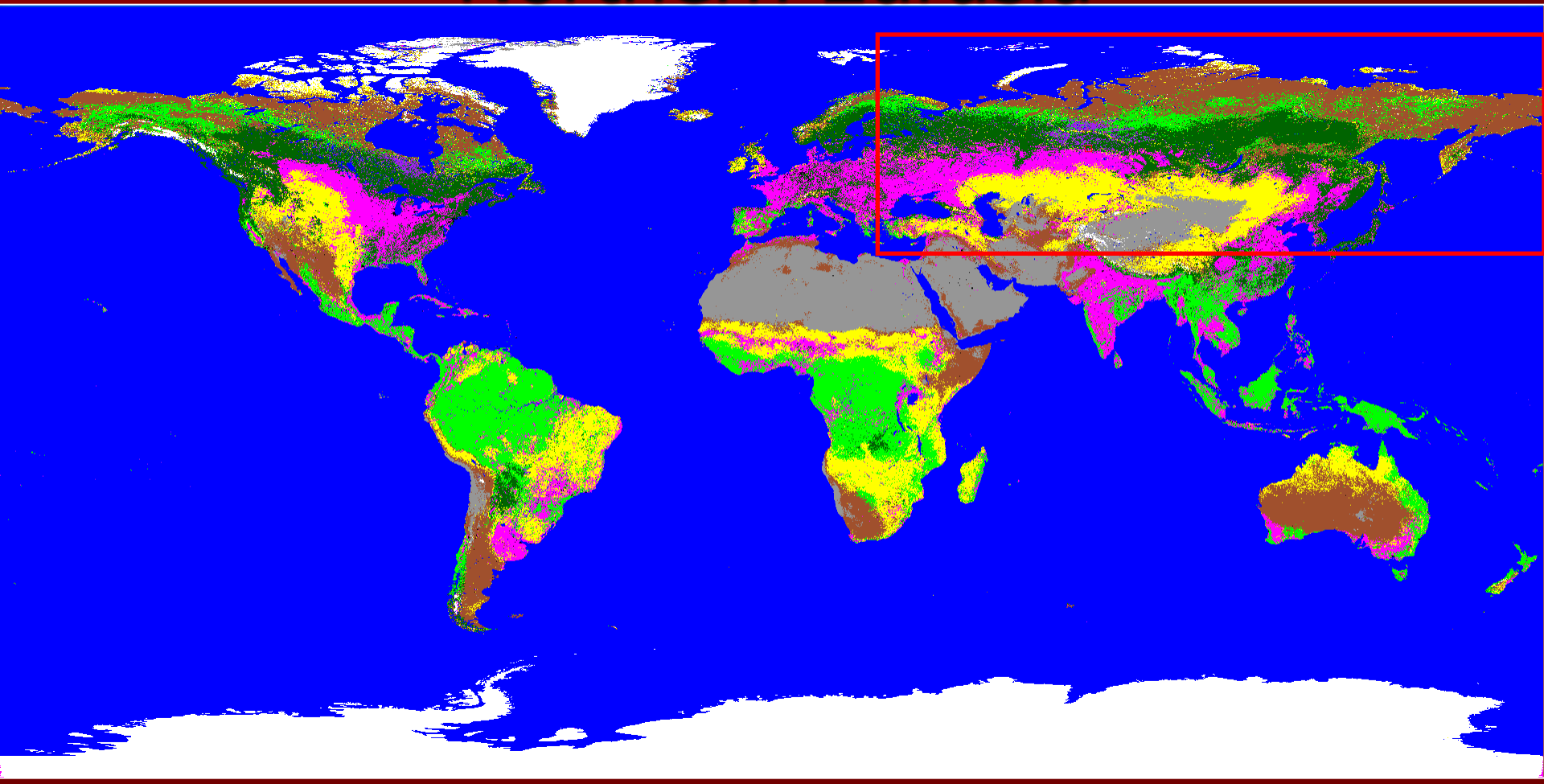
- MOD(MYD)14 group – Thermal Anomalies and Fire – 1000 m nominal resolution
  - MOD14 – 5 min swath
  - MOD14A1 – tiled daily
  - MOD14A2 – tiled 8day

  } LP DAAC

  - MCD14ml – fire detection points
  - CMG – 0.5 degree grid:
    - MOD14C8H – 8-day
    - MOD14CMH - monthly

  } ftp site

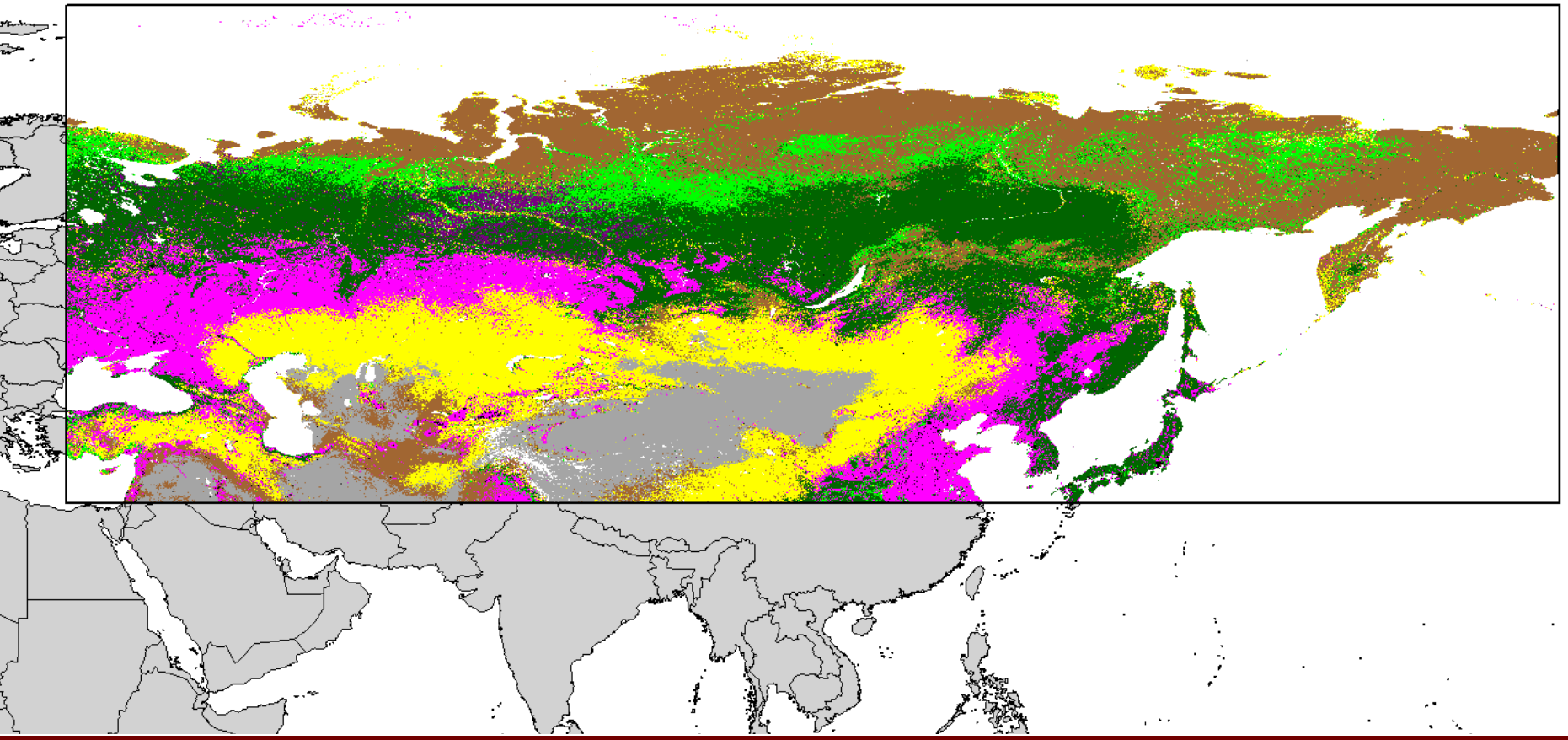
Northern Eurasia



MODIS land cover 2005 in IGBP classification: aggregated classes

- forests
- shrublands
- woodlands
- grasslands
- wetlands
- crop complexes
- urban
- snow and ice
- barren
- water

Northern Eurasia



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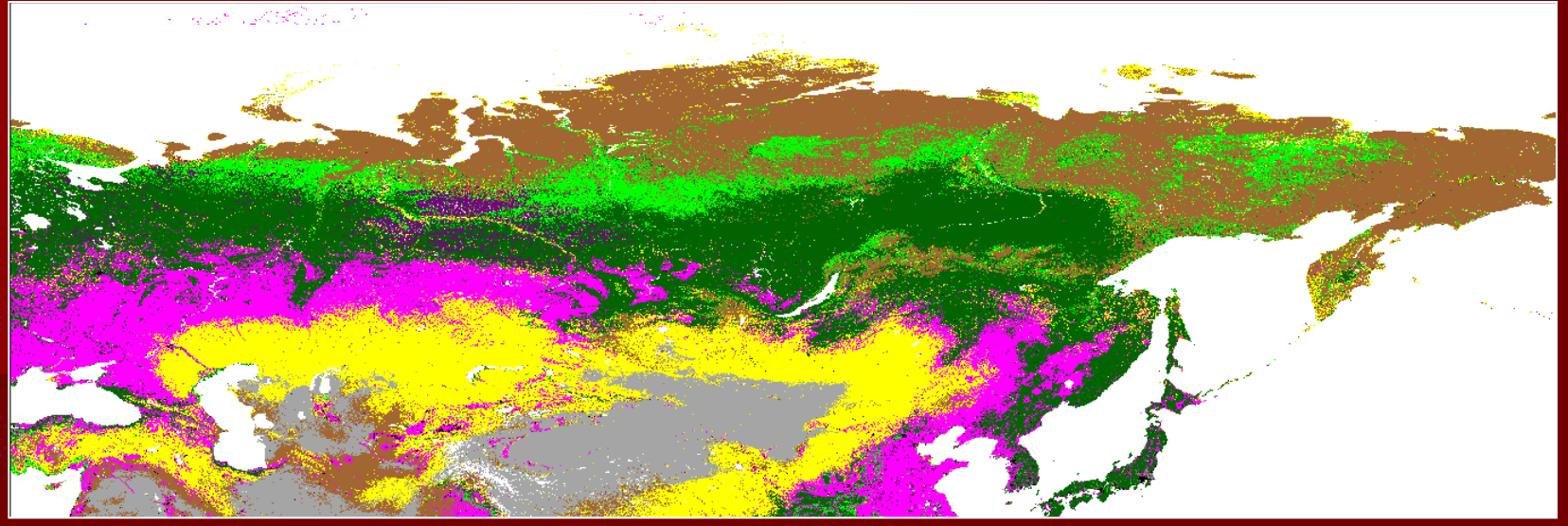

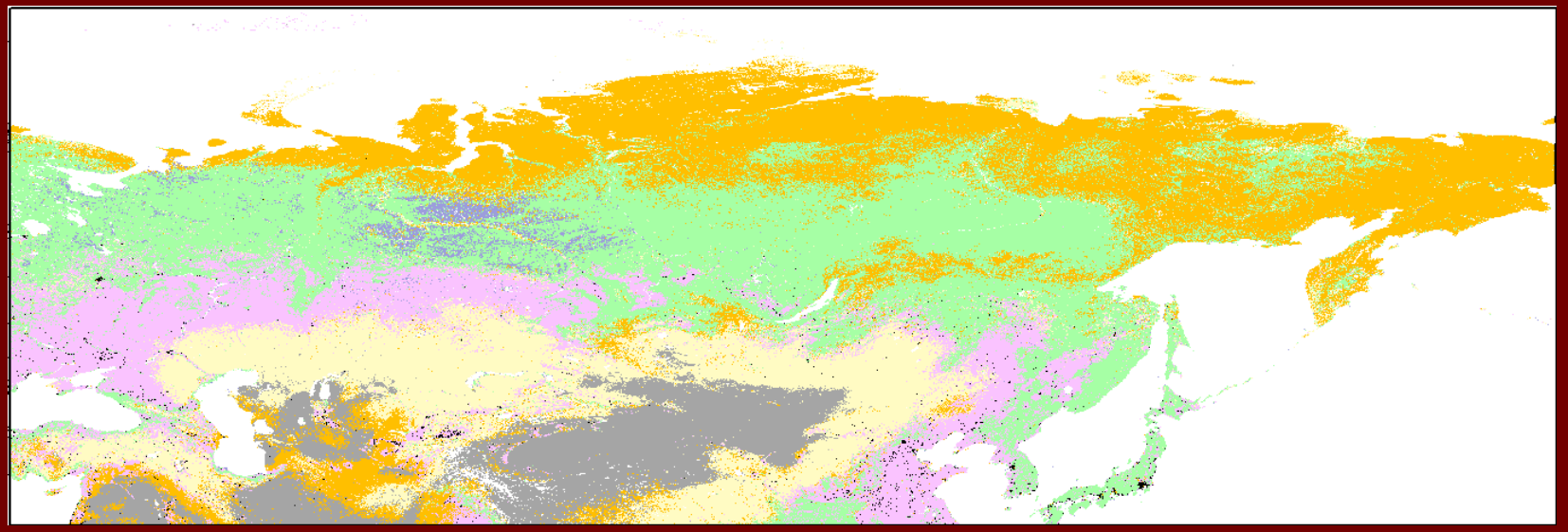

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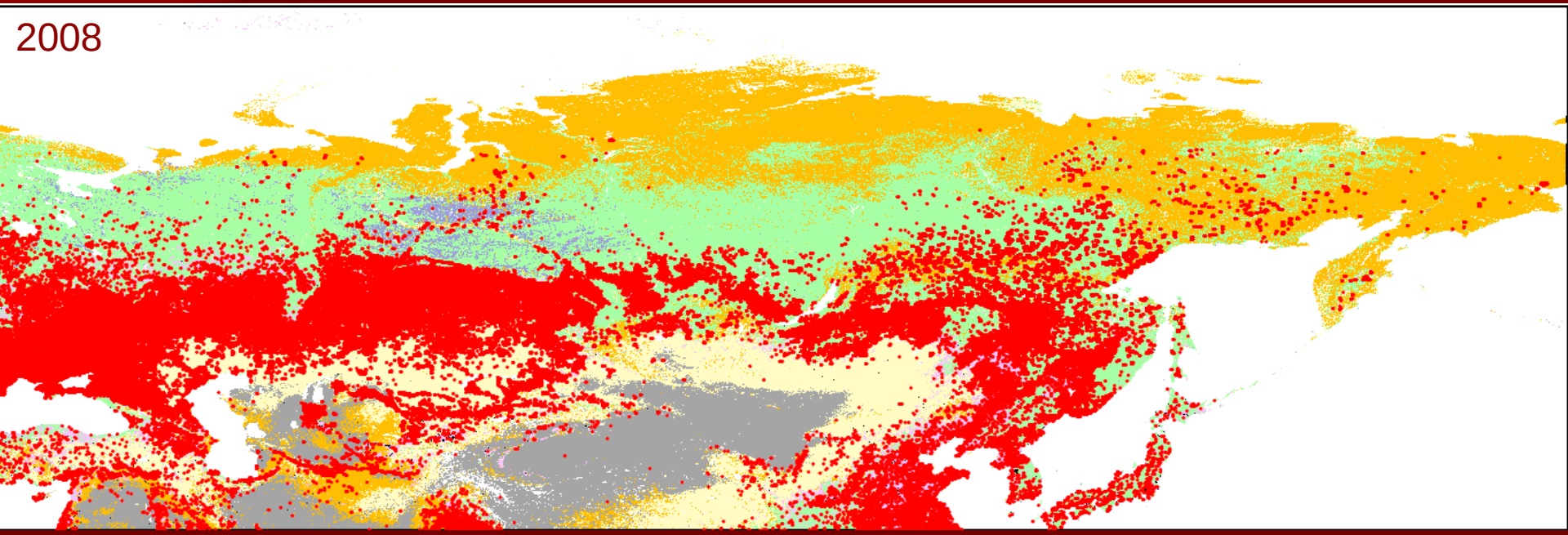
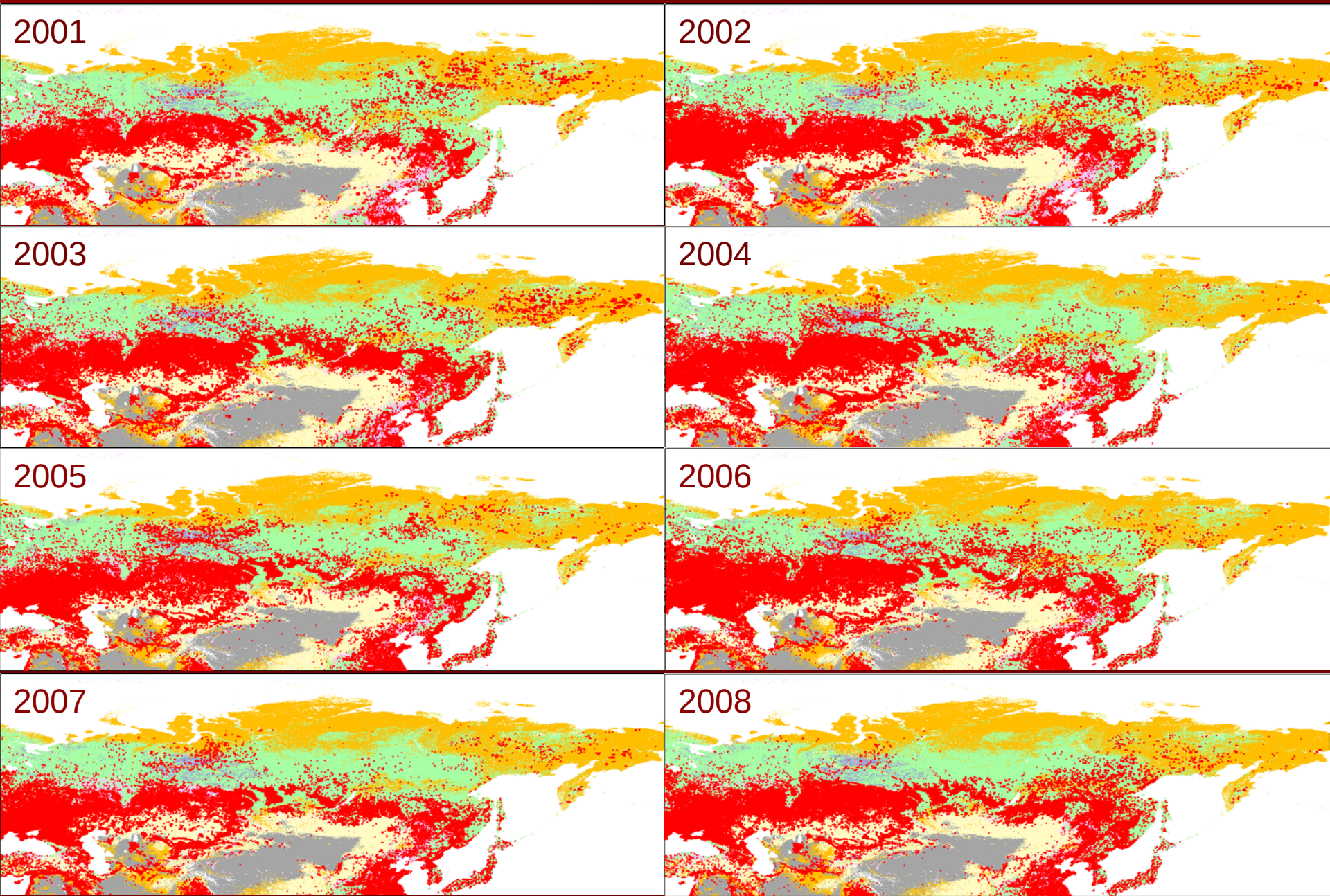
MODIS fire detections

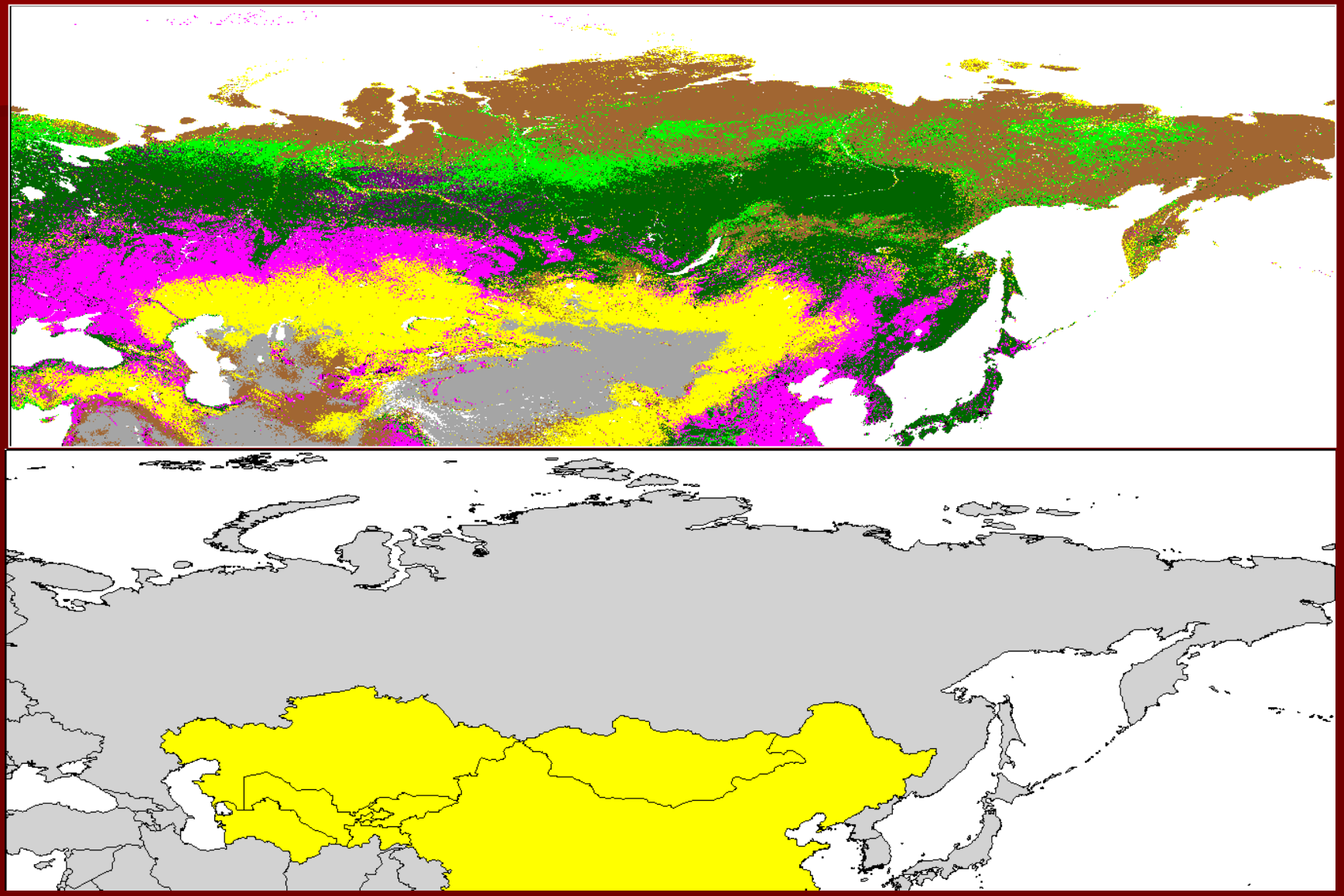


- MODIS active fire detections

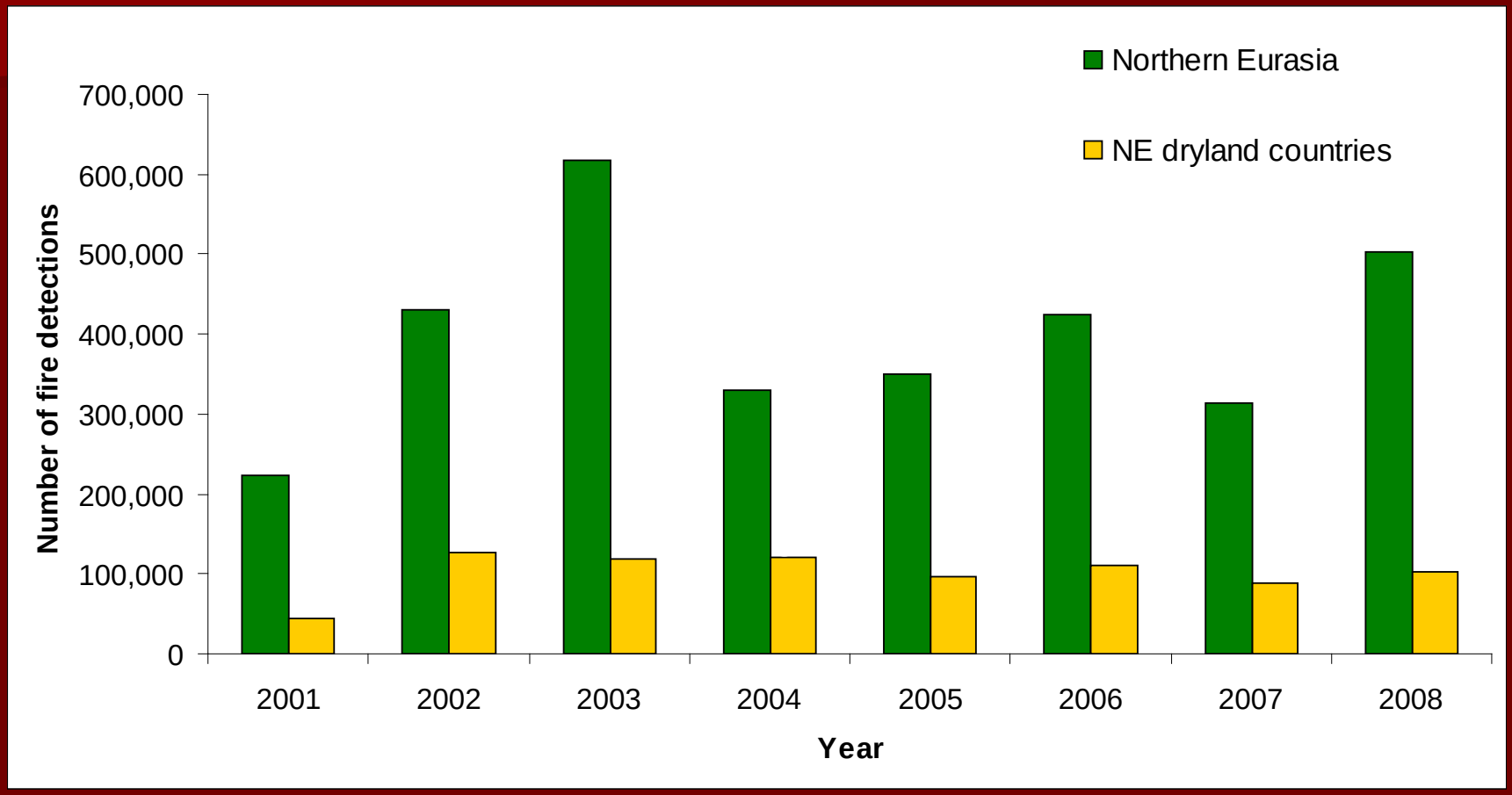
MODIS fire detections



Dryland countries of Northern Eurasia

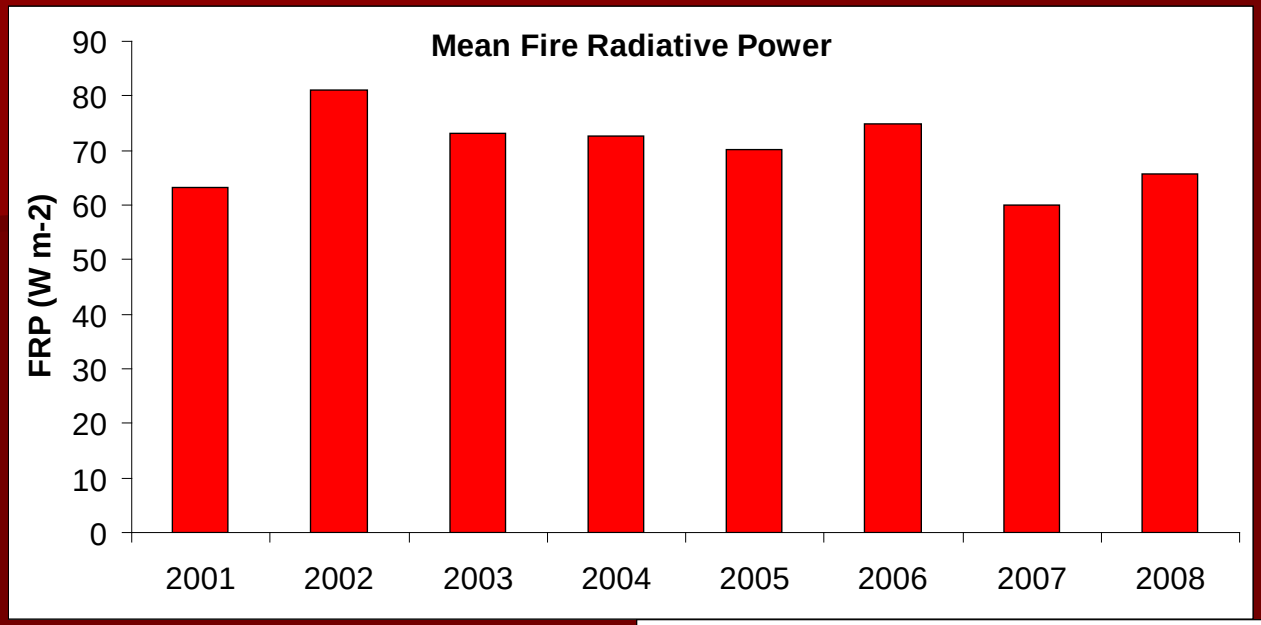


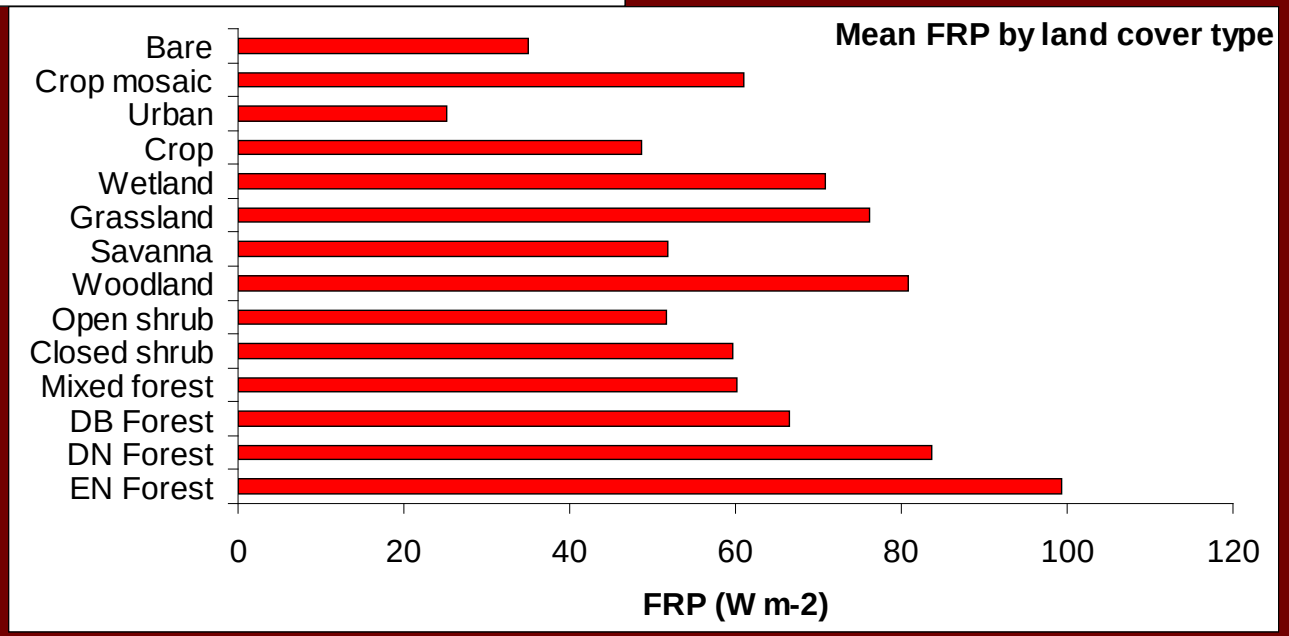
Annual Fire Activity



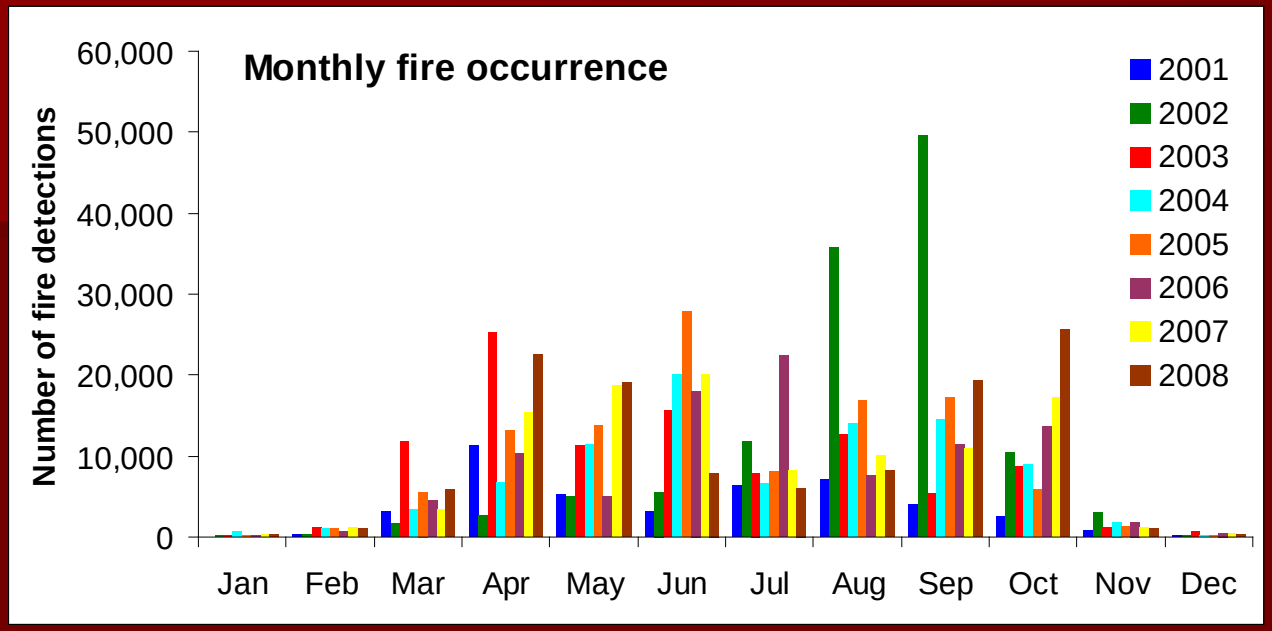
On average fires in drylands ~ 25% of fires in NE

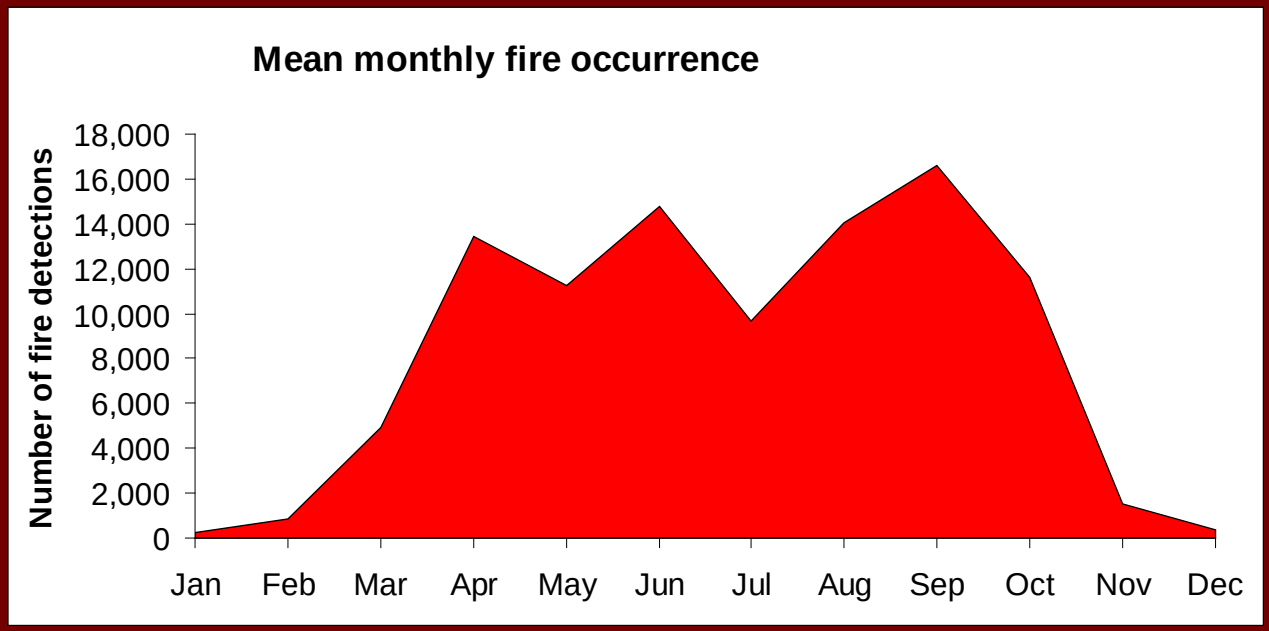
Fire Radiative Power



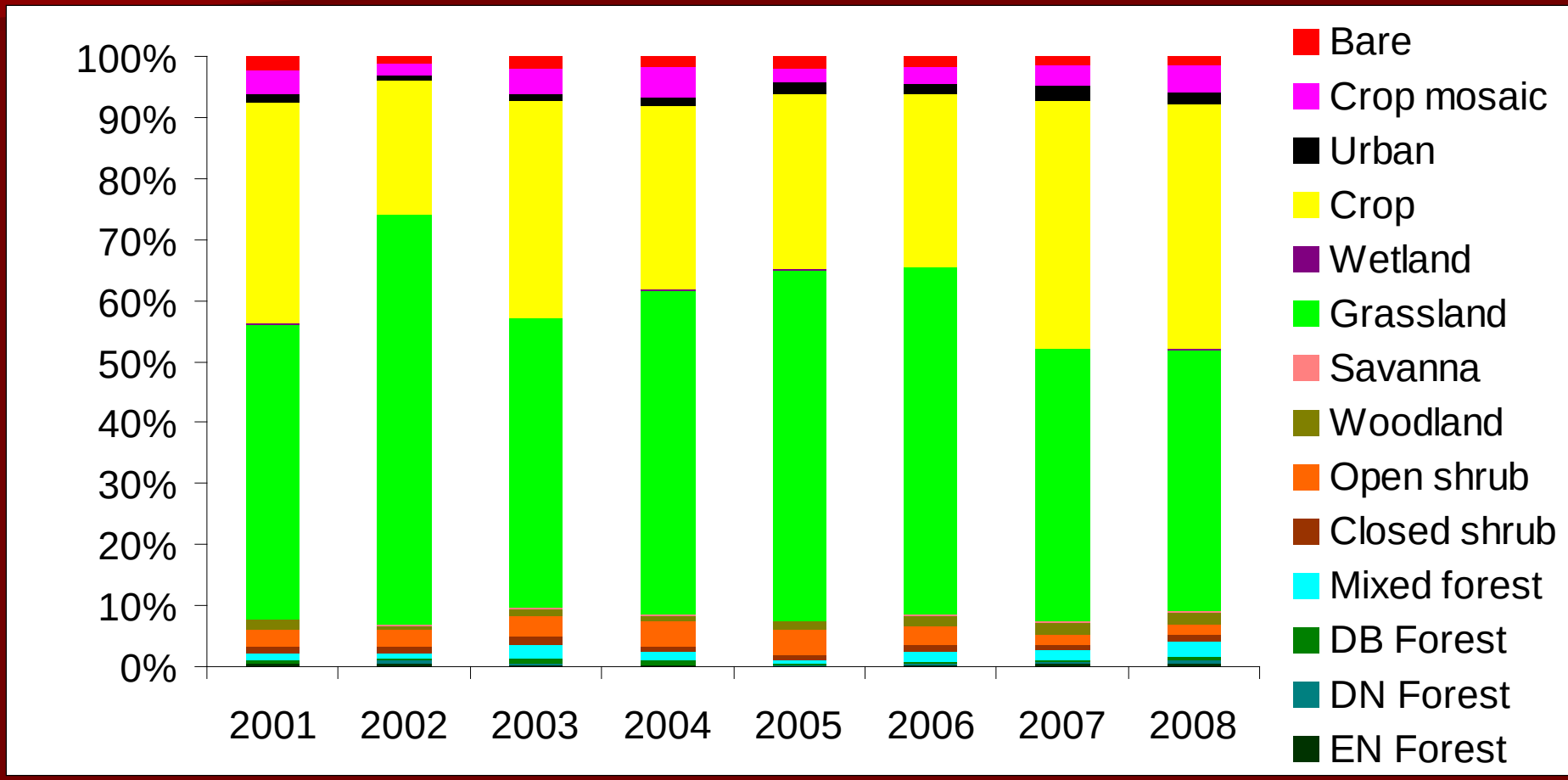


Fire occurrence seasonality

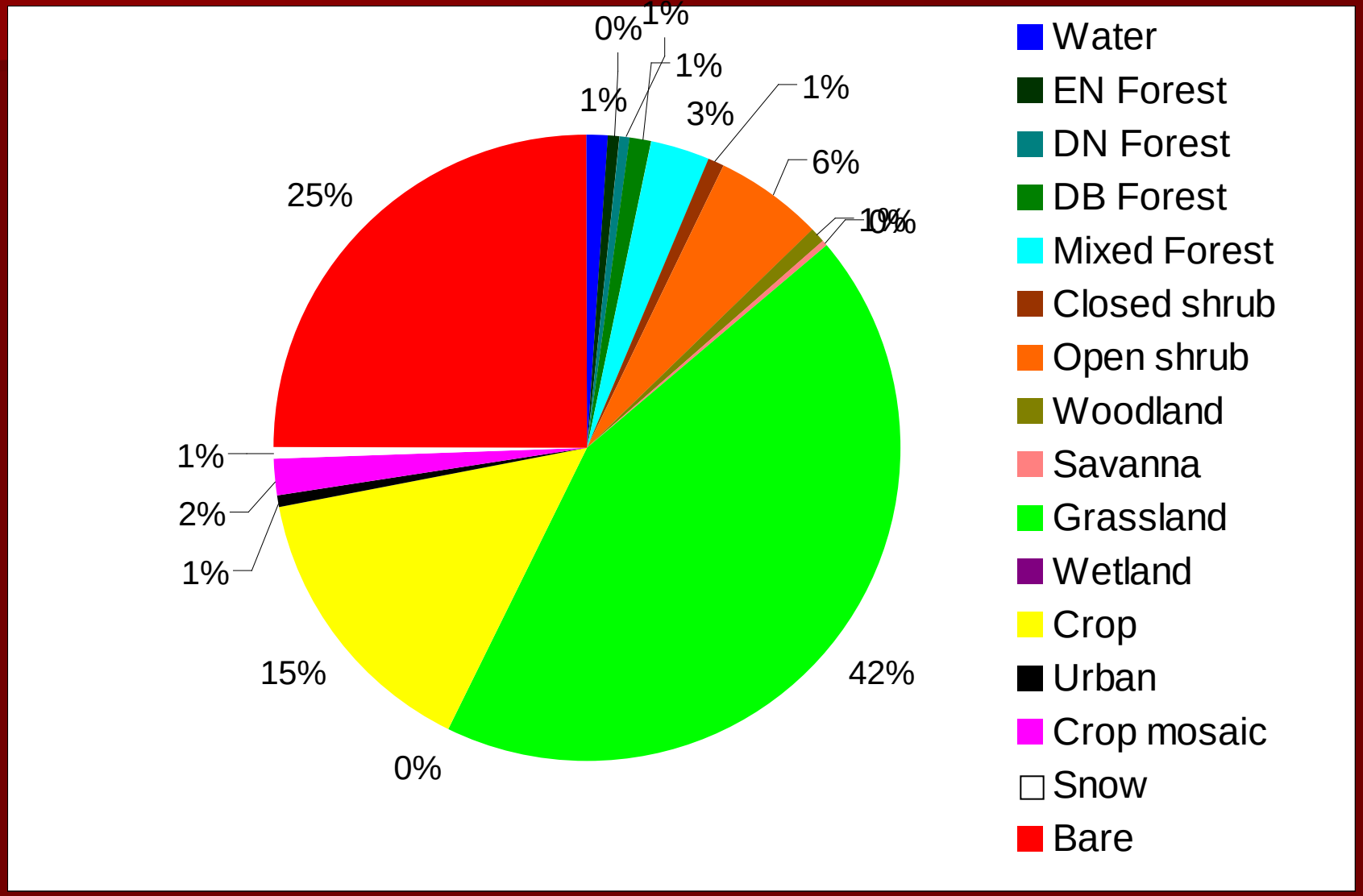




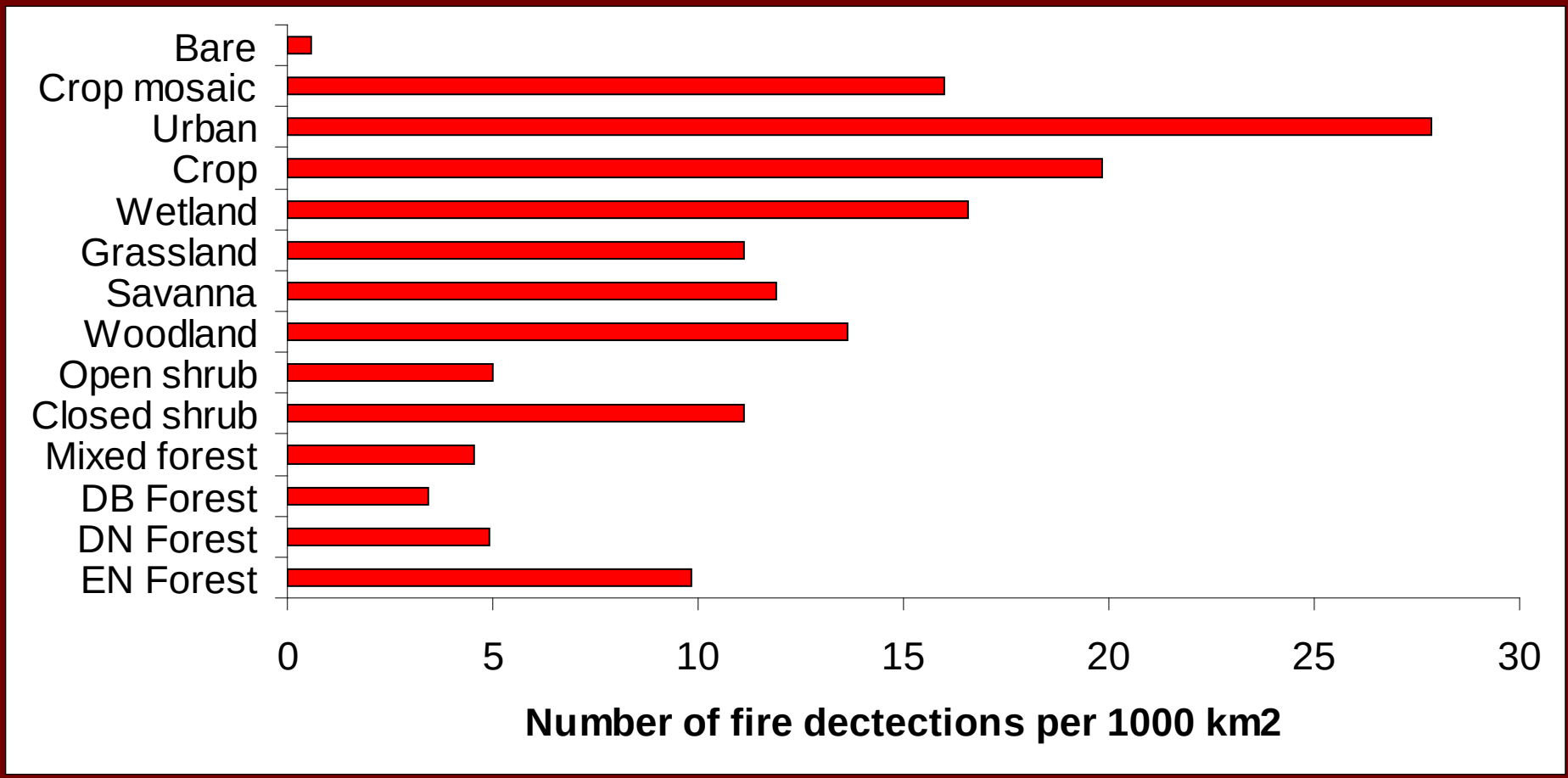
Fire occurrence as a function of land cover and land use



Land cover and land use in dryland countries of NE



Fire occurrence per 1000 km^2 of different land cover and land use types



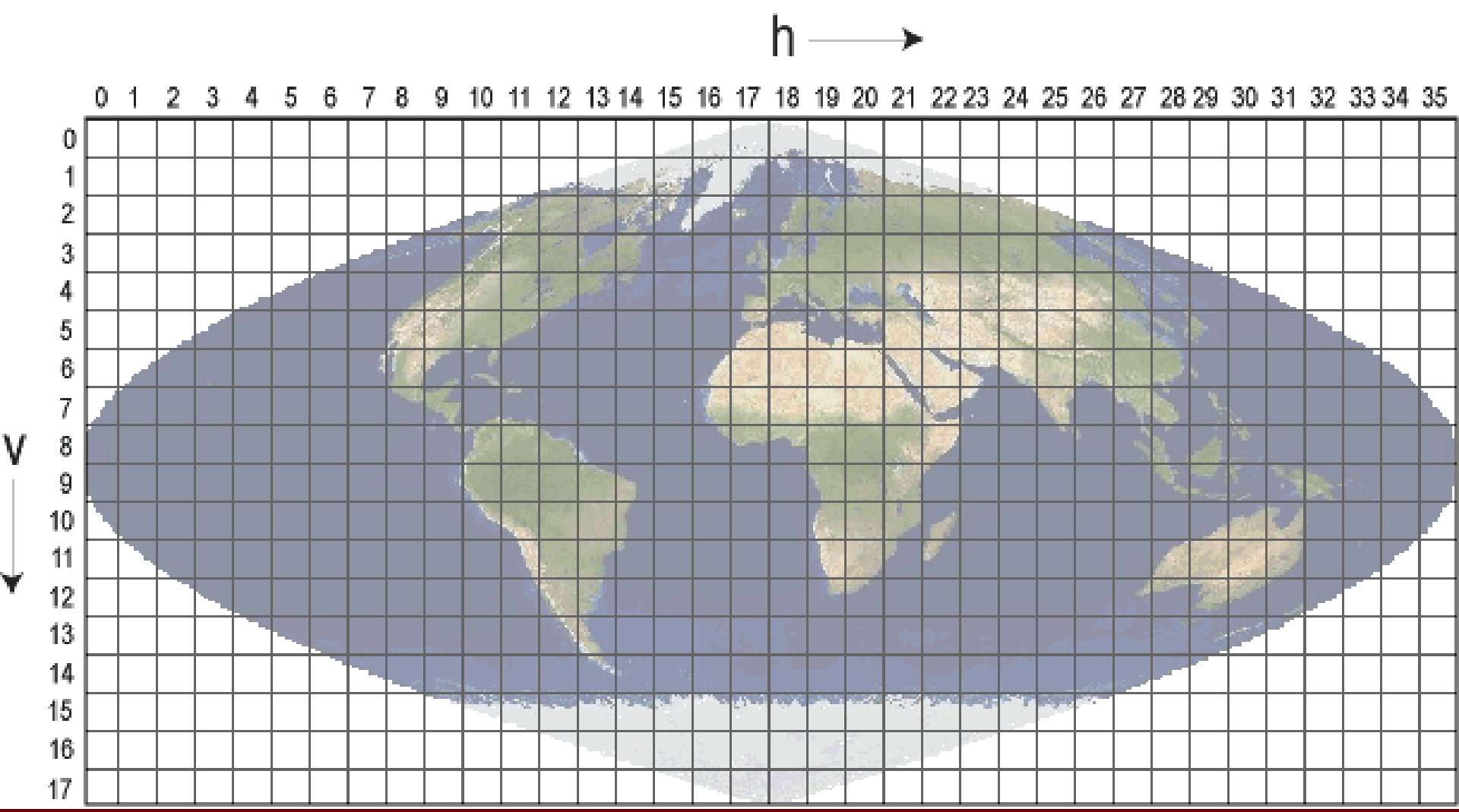
MODIS Burned Area products

- MCD45A1 – 500 m combined Terra and Aqua burned area monthly
- MODIS GFED burned area – 500 m annual

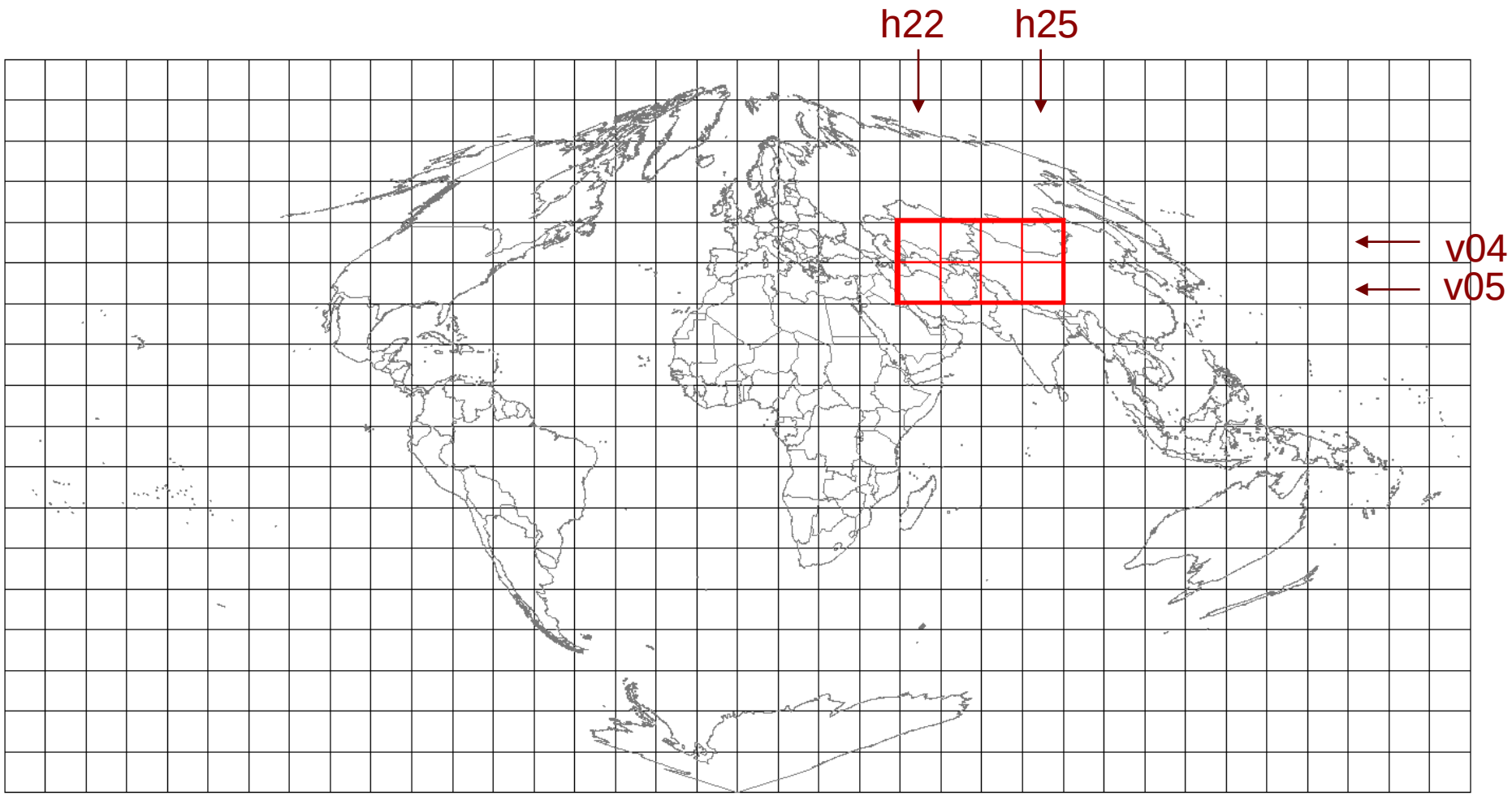
Non-standard

- Potential for MODIS regional burned area algorithms

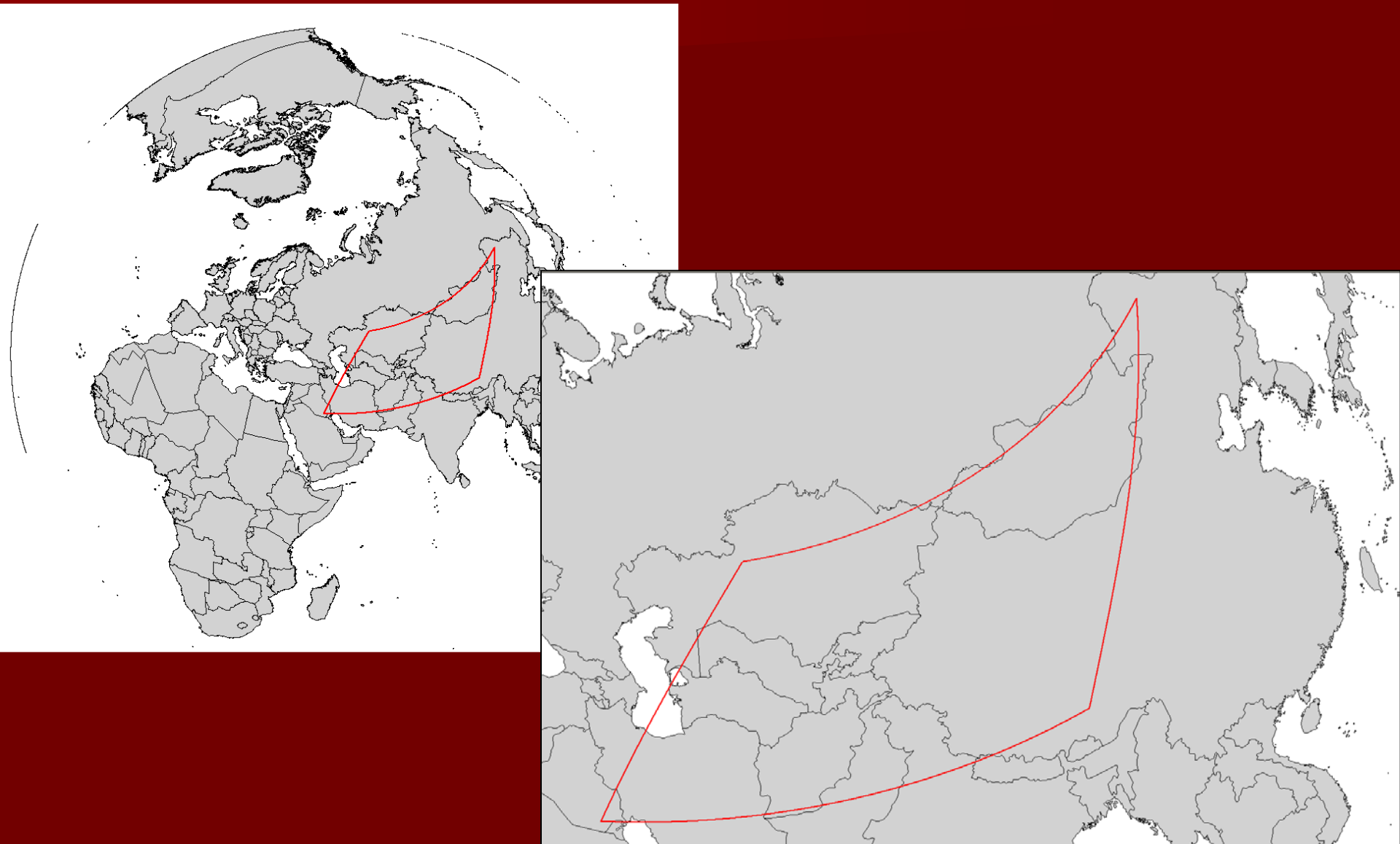
MODIS Sinusoidal grid



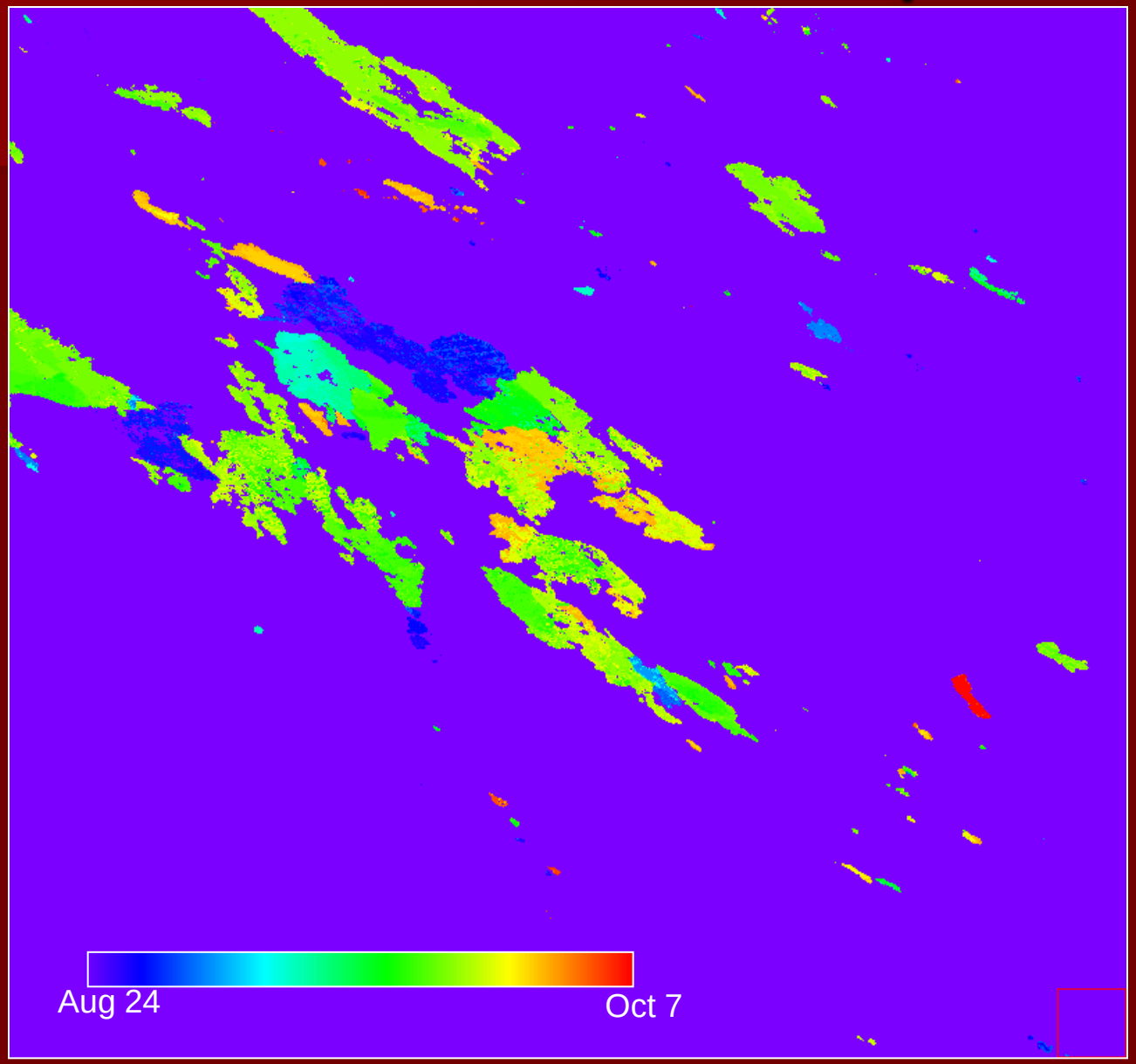
Drylands of Northern Eurasia on the MODIS grid:



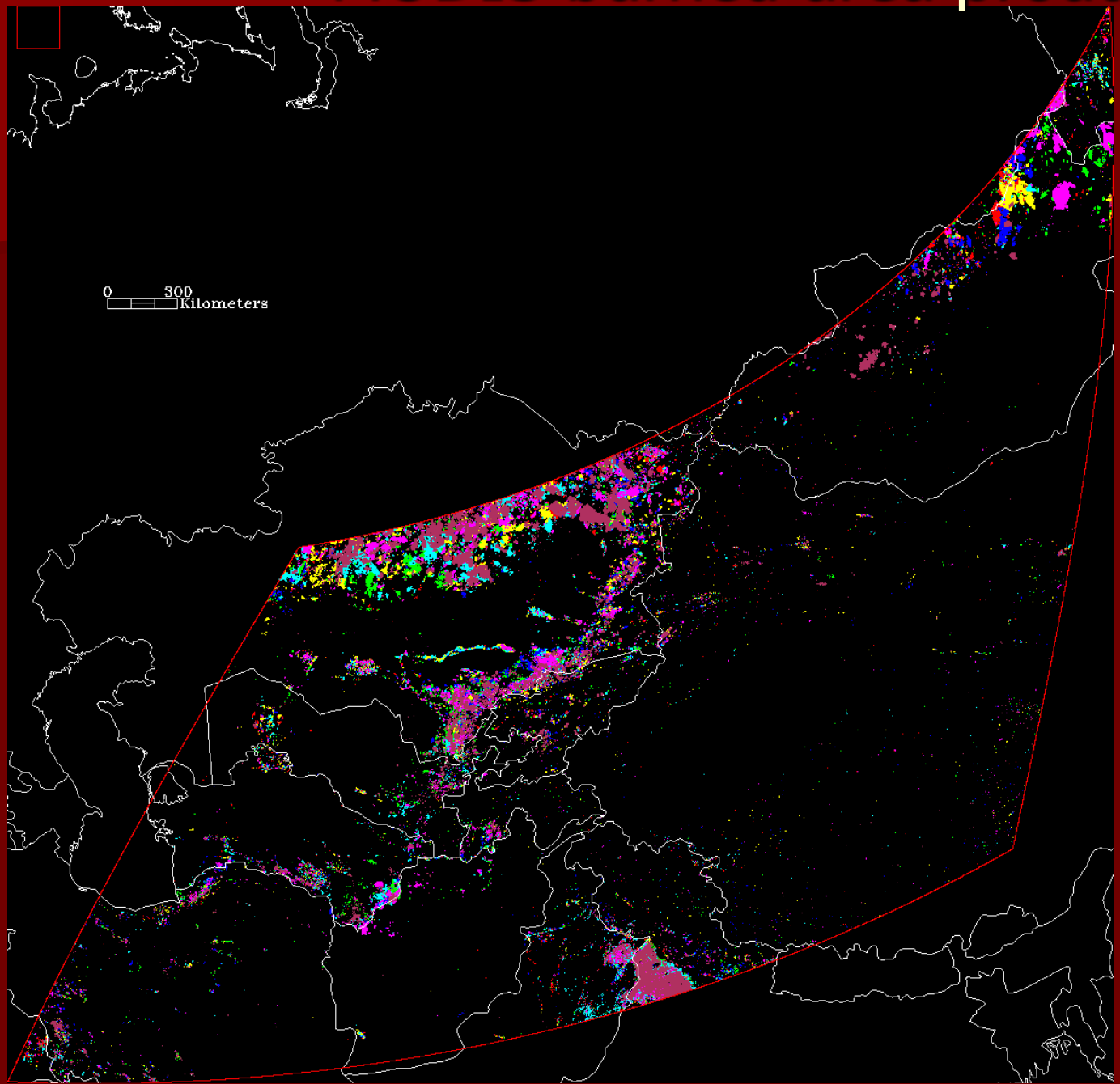
Analysis area for MODIS tiles h22 – h25 v04-v05 in Lambert Azimuthal Equal Area



MCD45A1: h23v04 Sept 2002

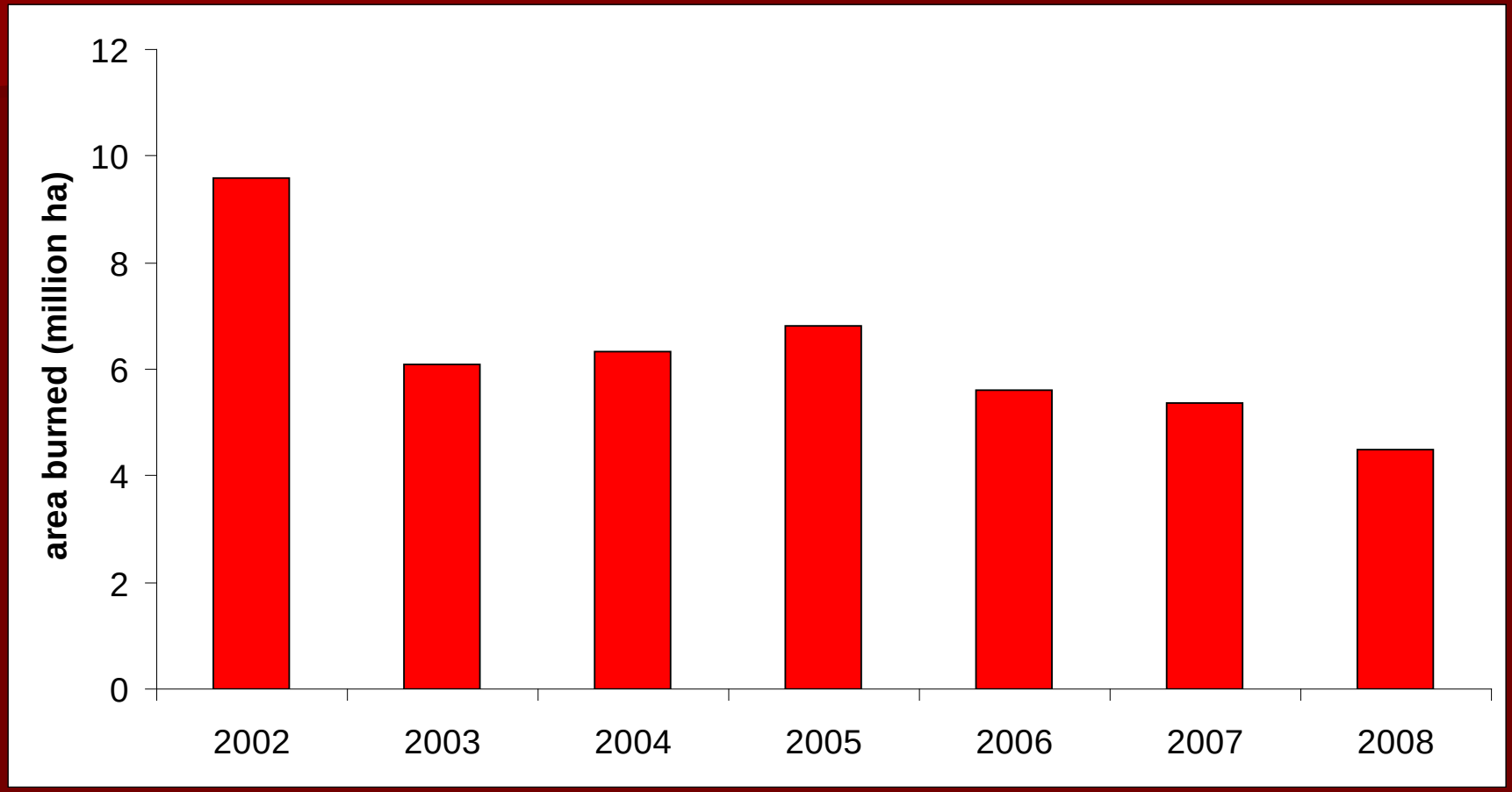


MODIS burned area product



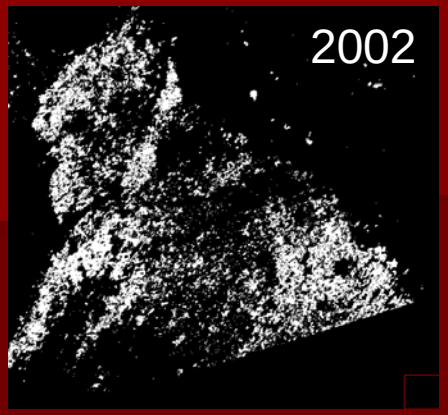
2002
2003
2004
2005
2006
2007
2008

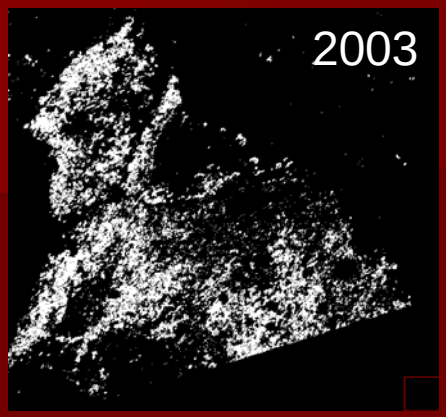
MCD45A1: annual burned area

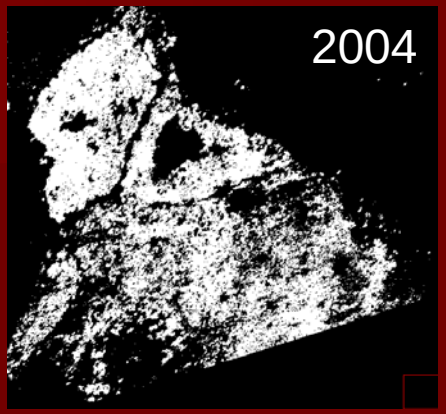


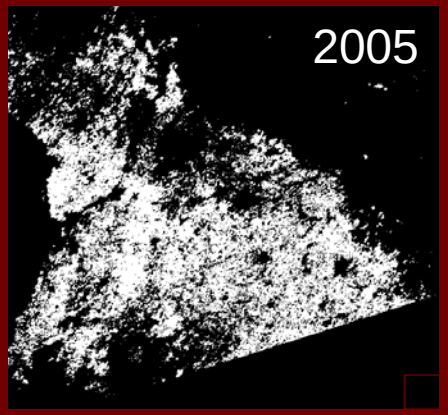
Area burned reported by MCD45 product over tiles h22 – h25, v04 – v05

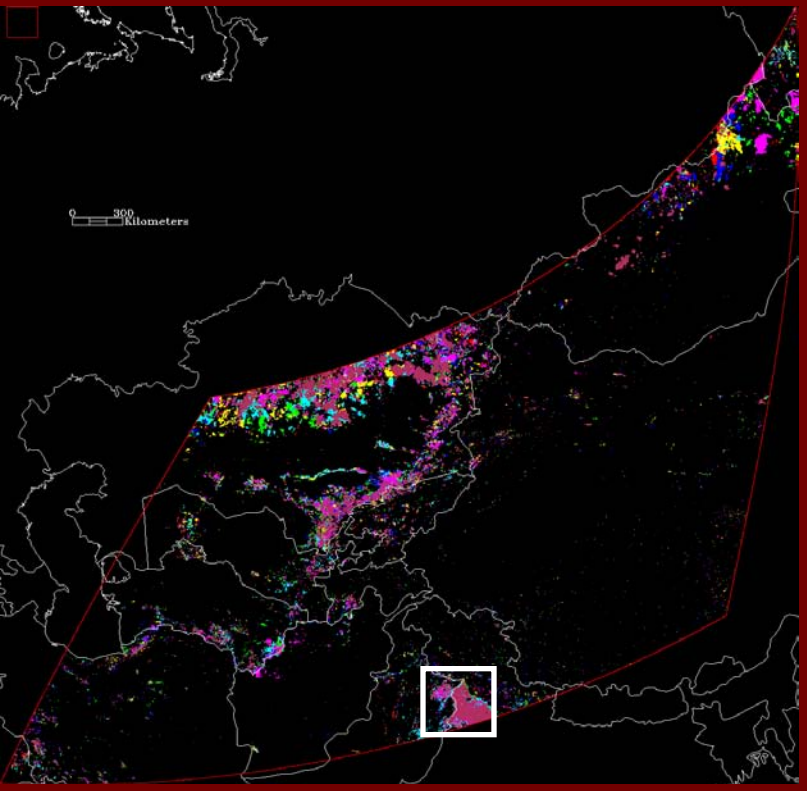
MCD45A1: known problems

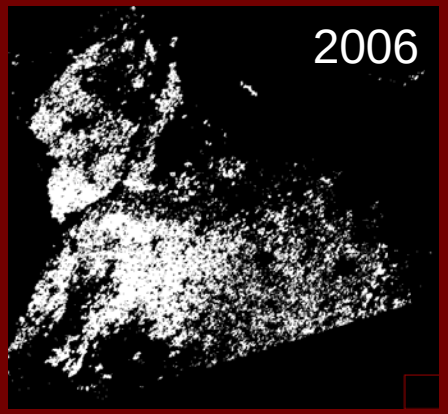


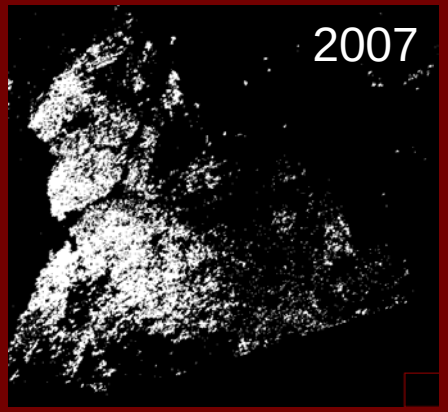


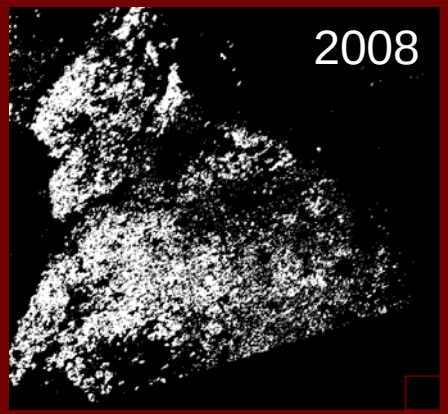




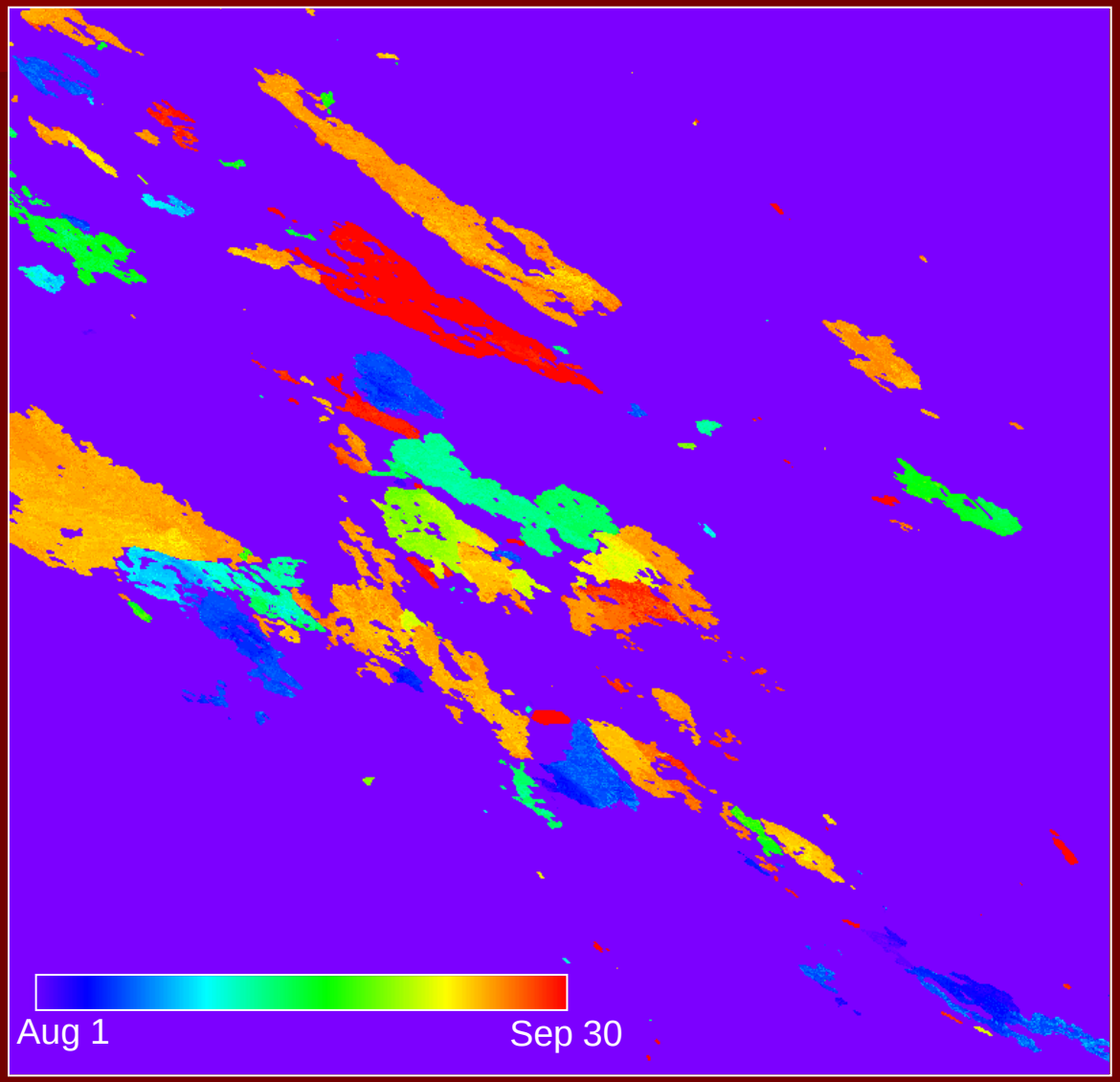




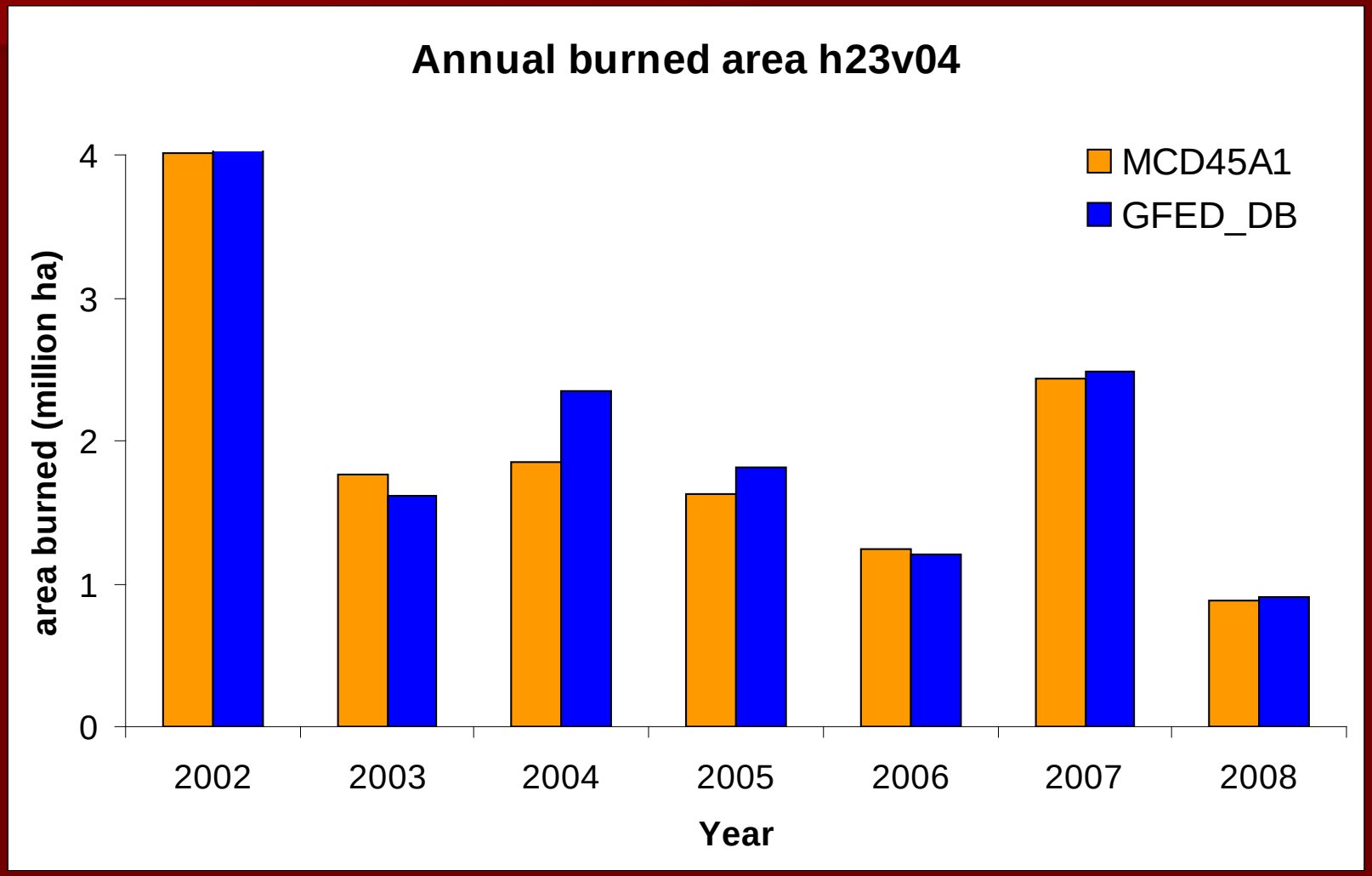




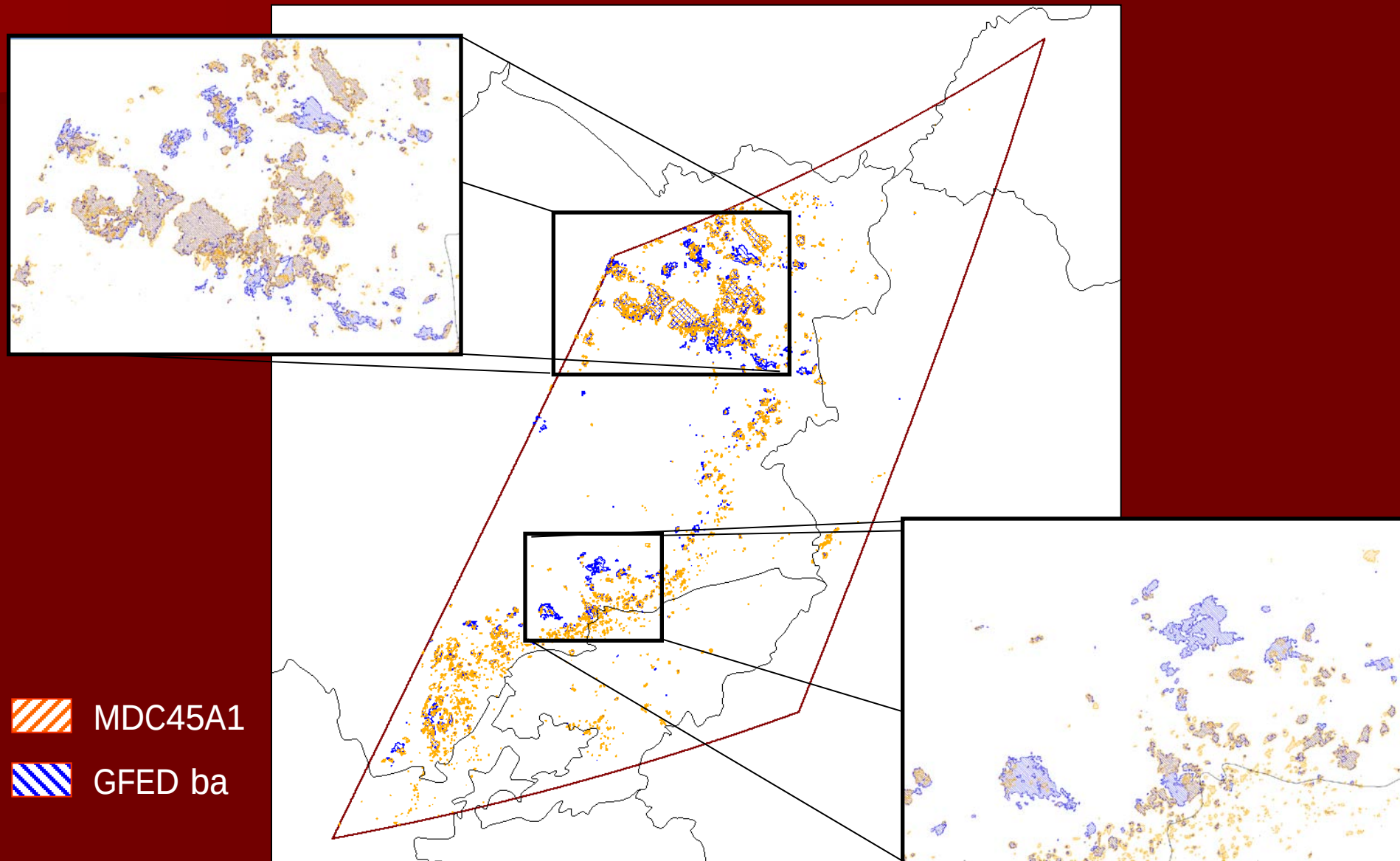
MODIS GFED burned area: h23v04 August-September 2002



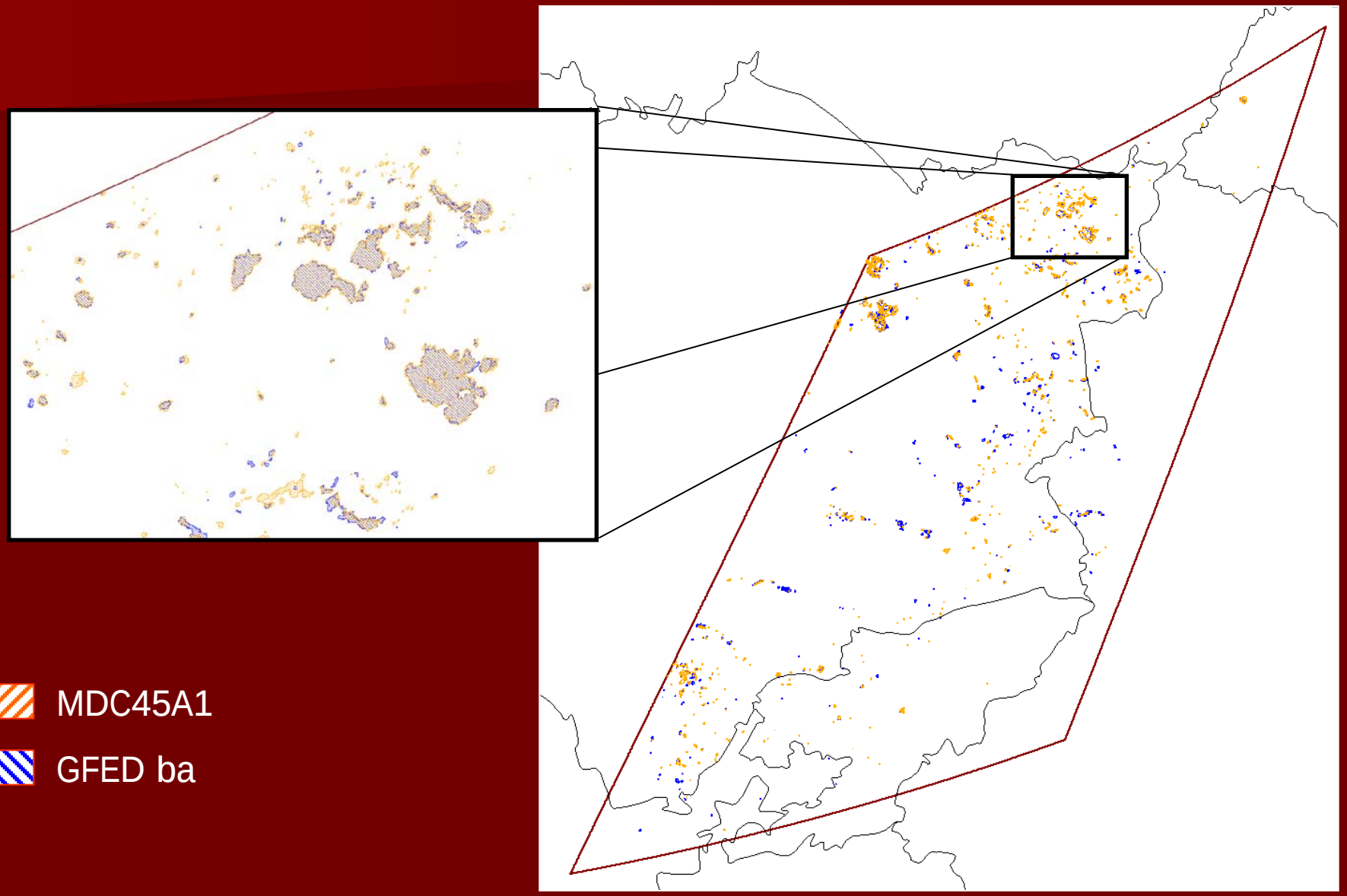
MODIS global burned area products comparison



MDC45A1 and GFED burned area mapping Differences: h23v04 2002



MDC45A1 and GFED burned area mapping Differences: h23v04 2008



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

C5 Burned Area Product Validation Protocol

Priorities:

1- ensure the accuracy of the reference data: local partners involved in the interpretation of the high resolution data

2- temporal consistency: map the changes between two acquisitions

3- spatial consistency: differentiate between unburned areas and areas that could not be interpreted due to data quality issues, or not visible because of clouds or shadows

Image 1:

Landsat ETM+

Sept. 4th

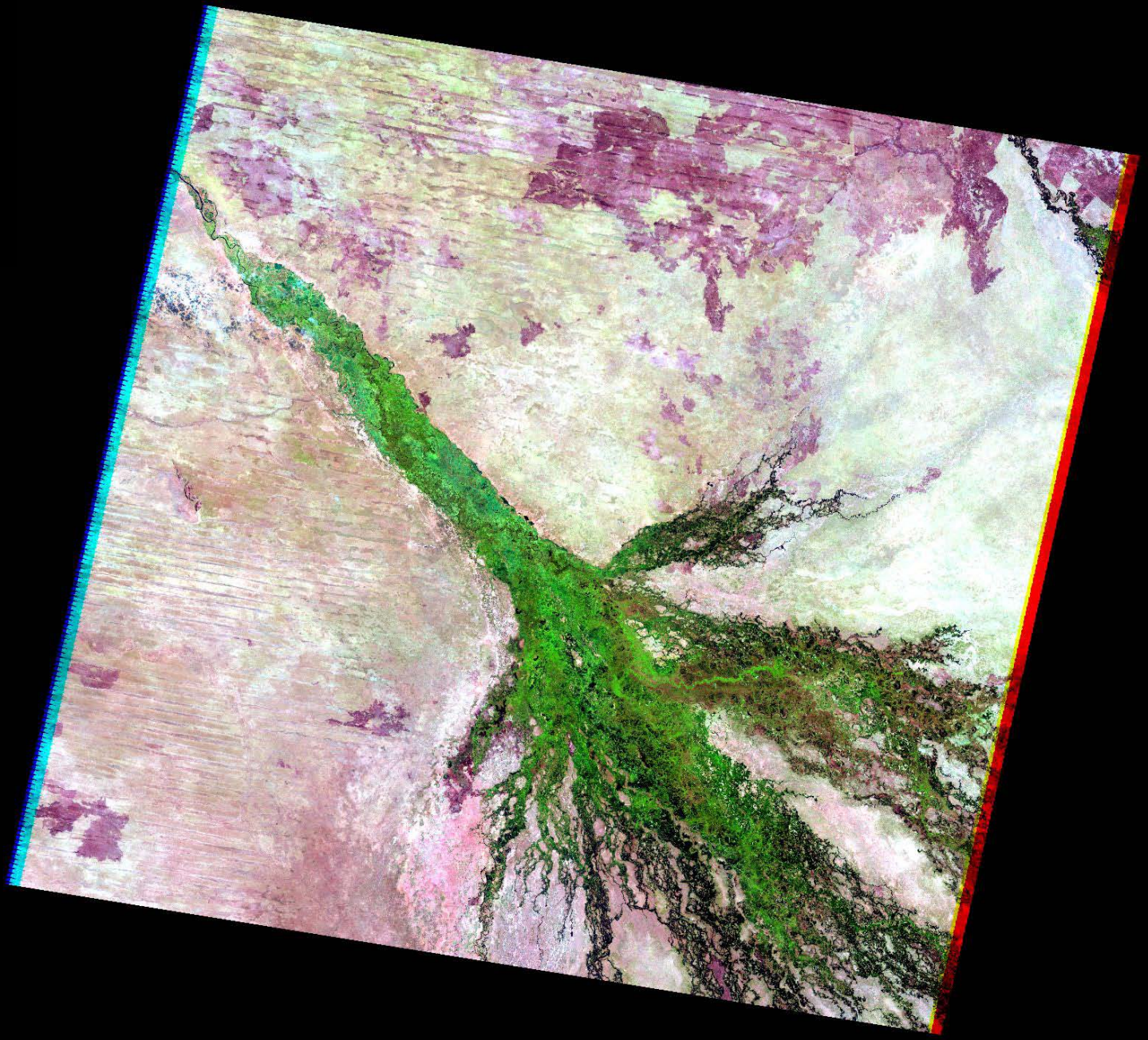
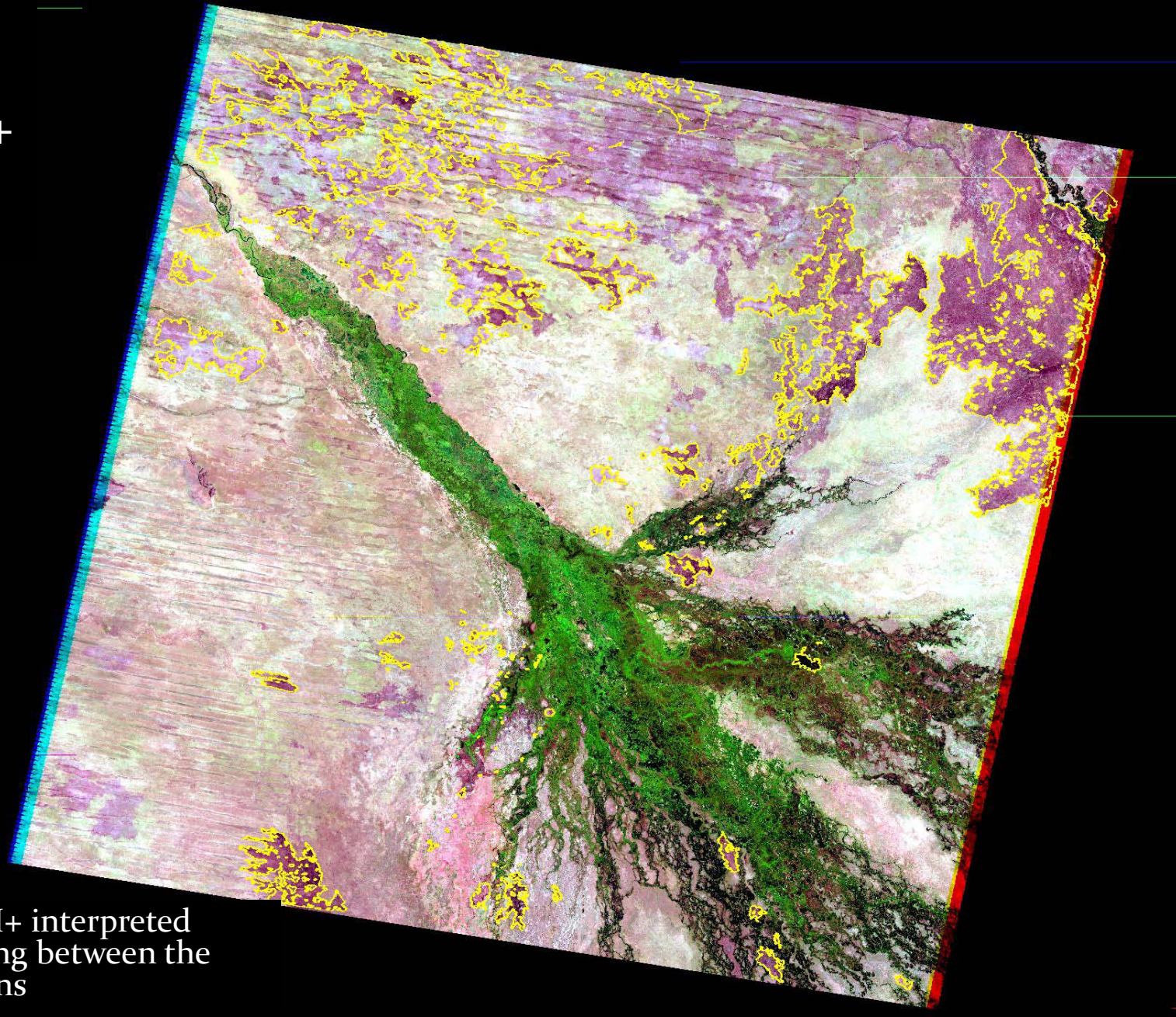


Image 2:

Landsat ETM+

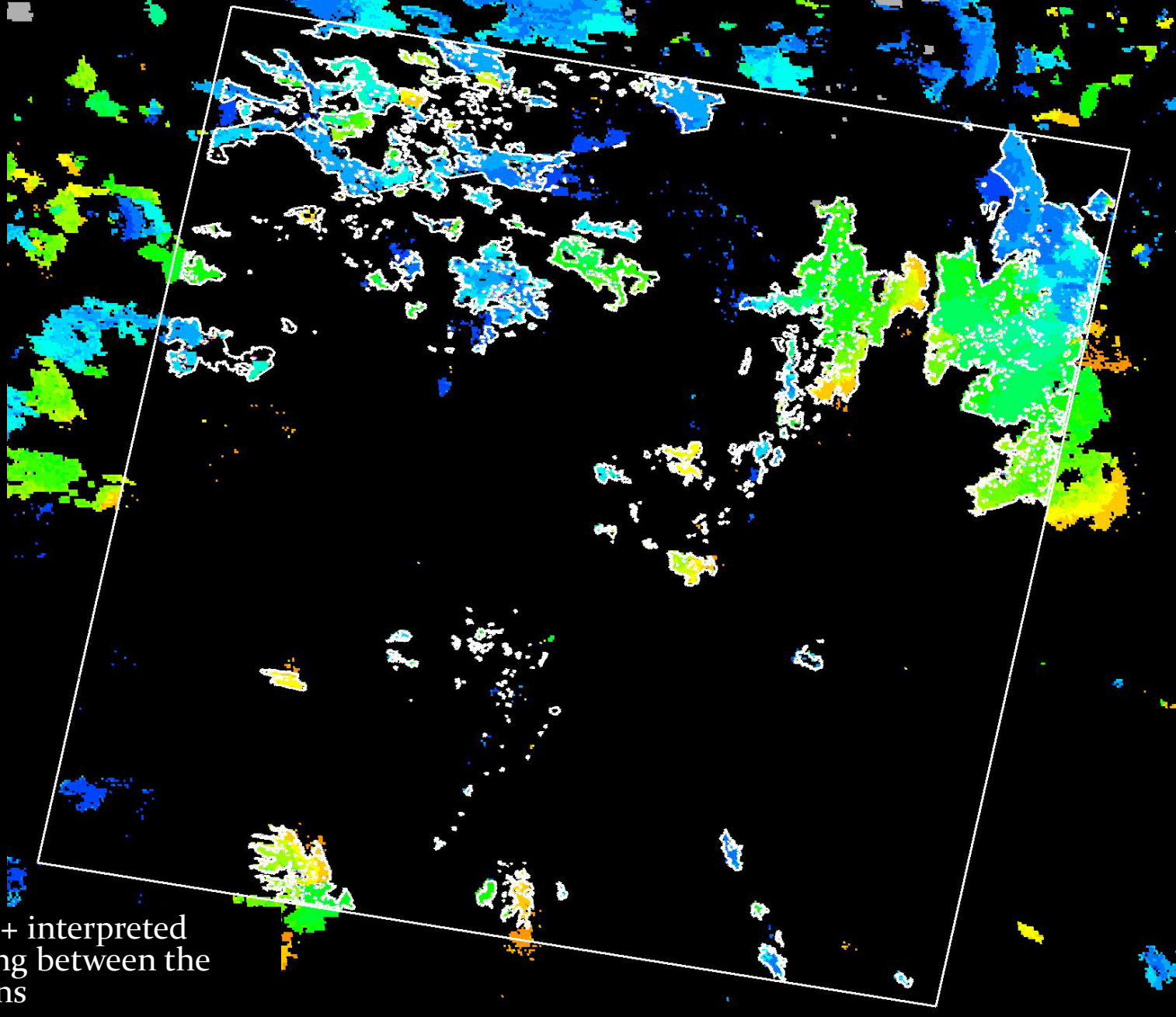
Oct 6th



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

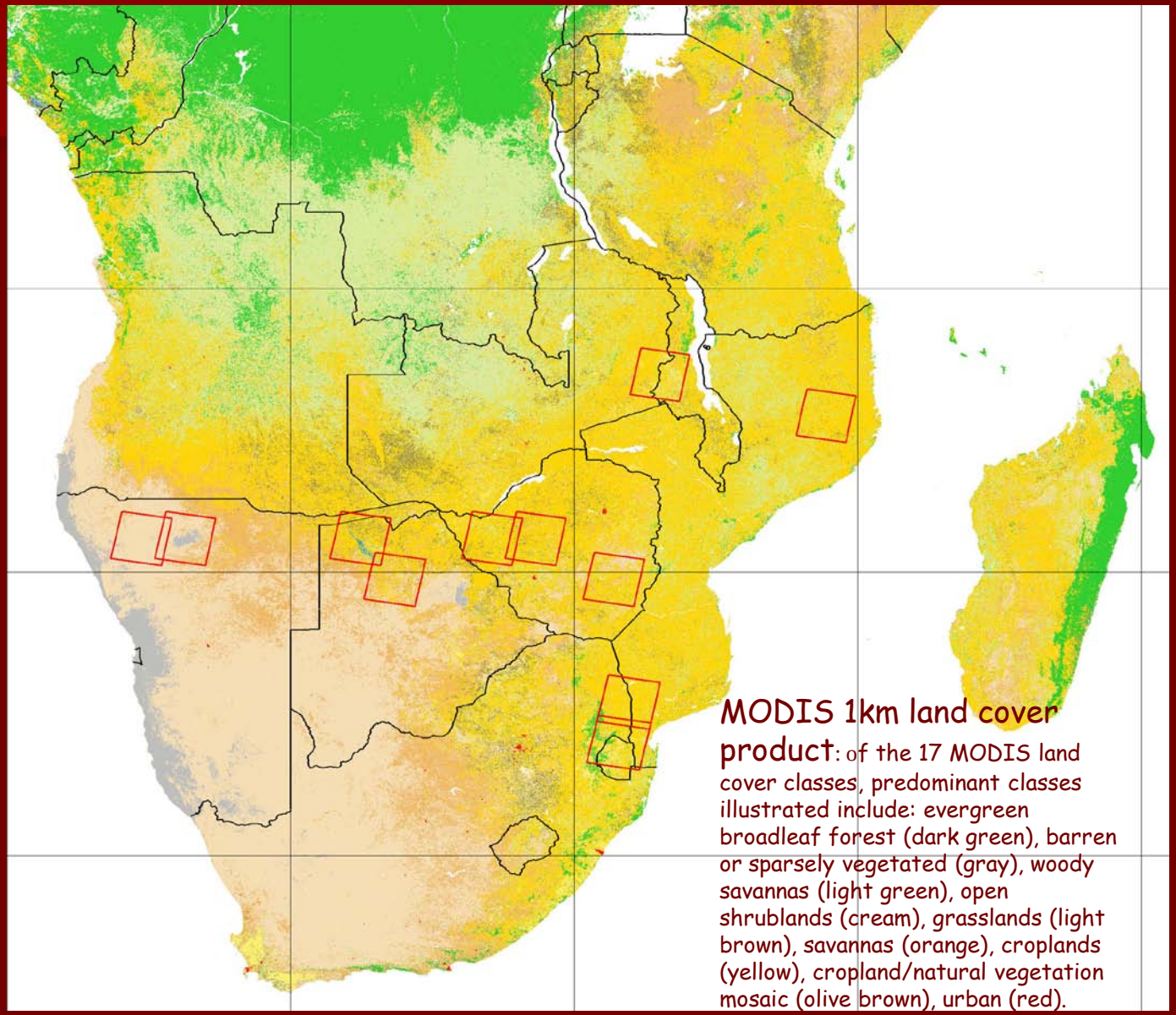
MODIS
500m
Burned Areas

Sept. 4
to
Oct. 6



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

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).

ETM+ scene ~185 * 185 km

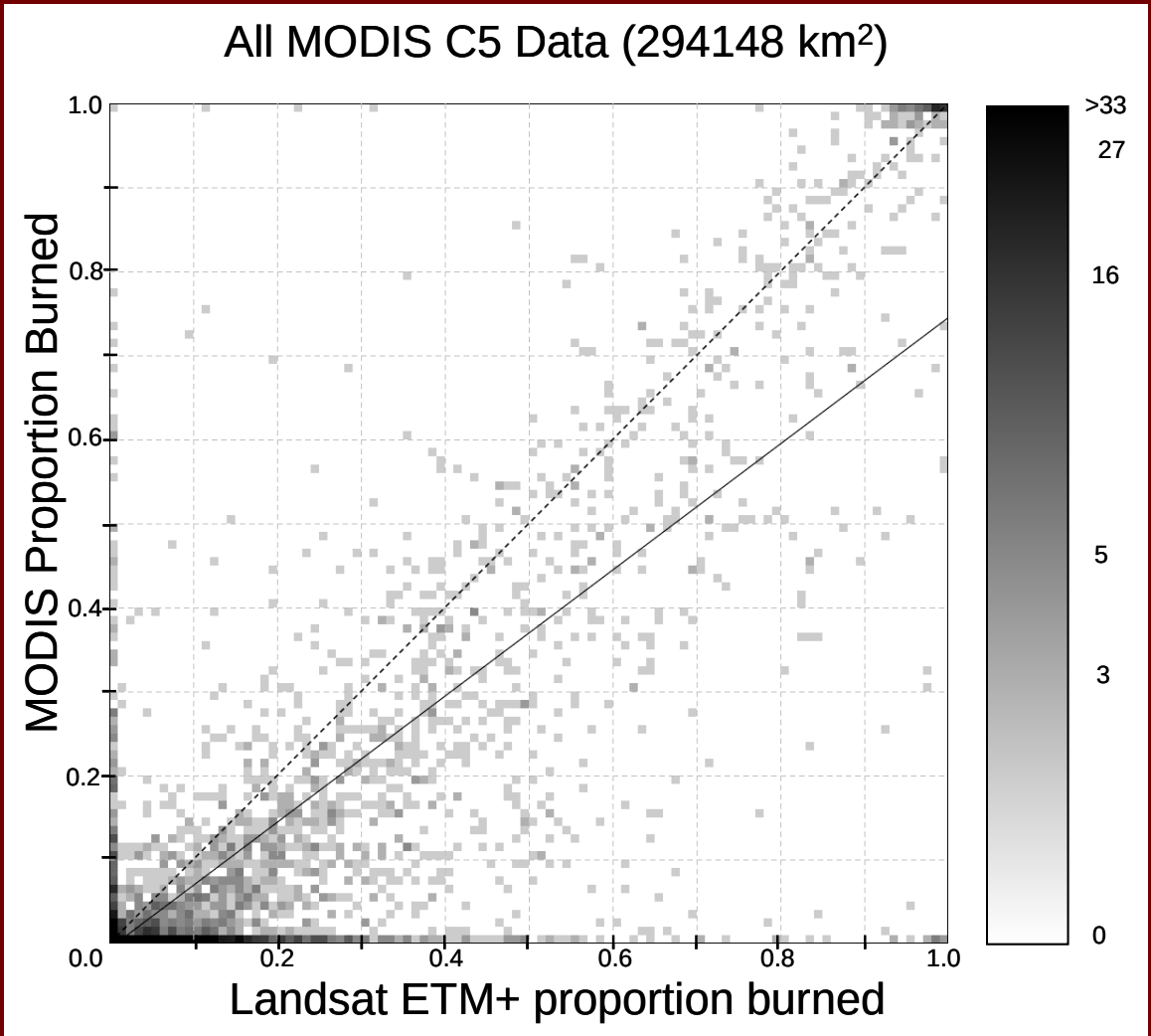
Each ETM+ scene has a local SAFNet collaborator

11 scenes = ~3% of southern African surface

MODIS Burned Area product Validation

The slope of the regression line is 0.75,

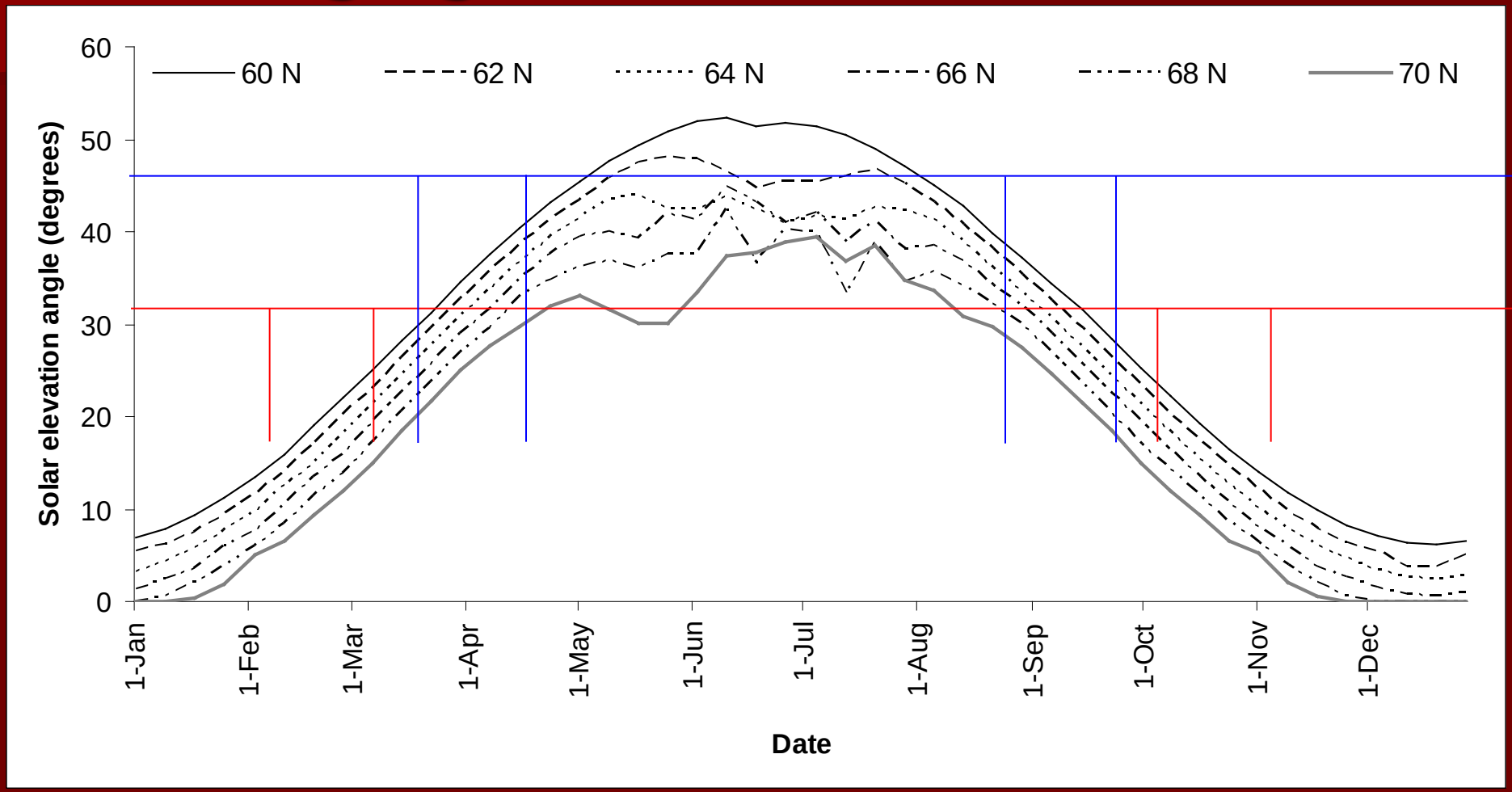
The intercept is -0.005 and the r2 is 0.746



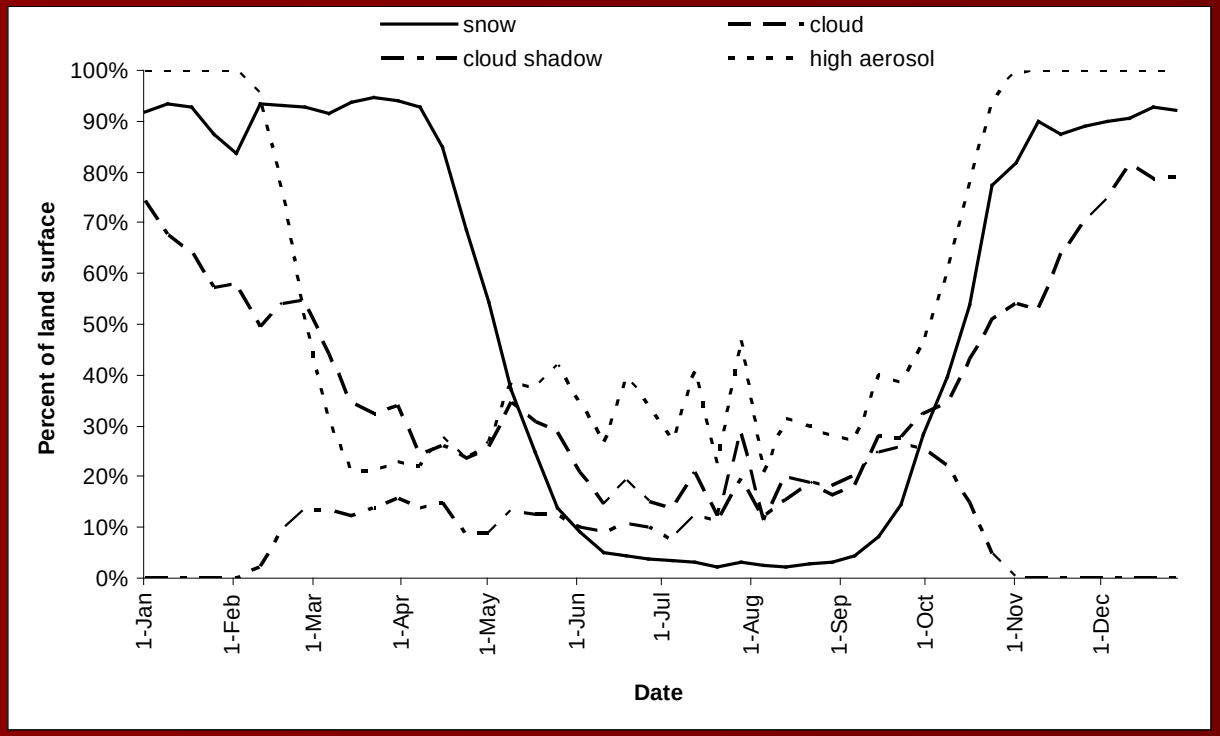
Specialized regional product development

- Best results in spatial and inventory accuracy
- Factors in regional specifics
  - Fire occurrence
  - Land surface imaging

Regional specifics of land surface imaging: Alaska solar elevation

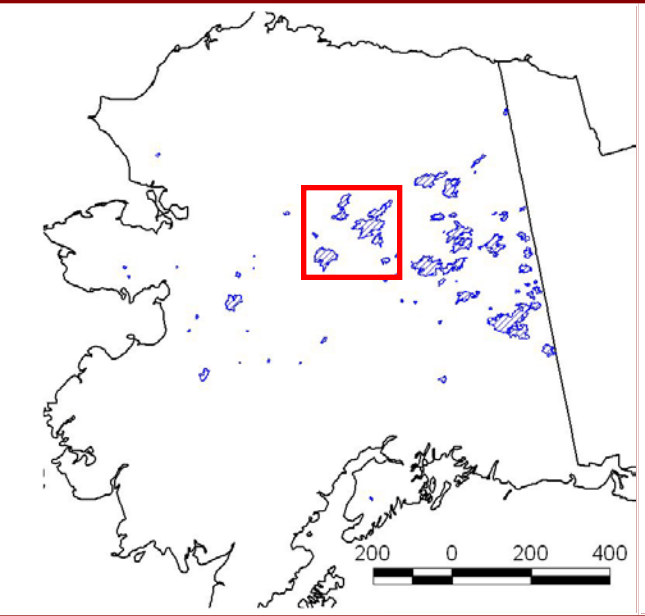


Regional specifics of land surface imaging: Alaska – clear sruface

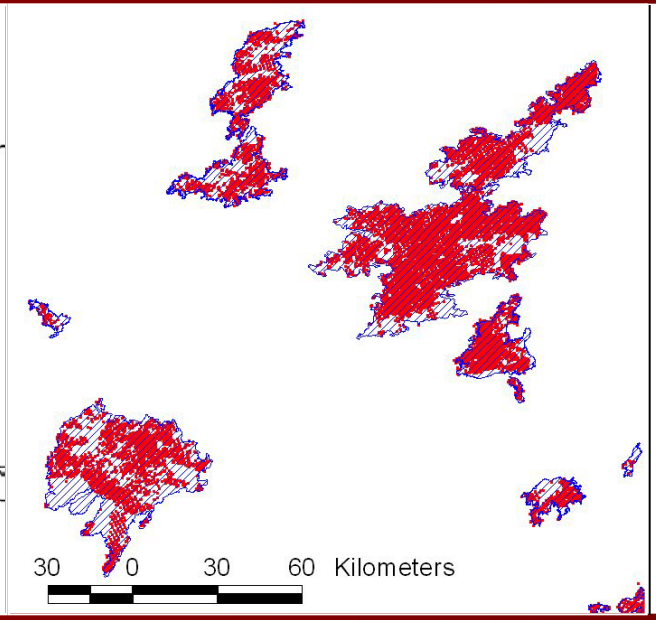


MODIS-based algorithms used to estimate burned area in Alaska

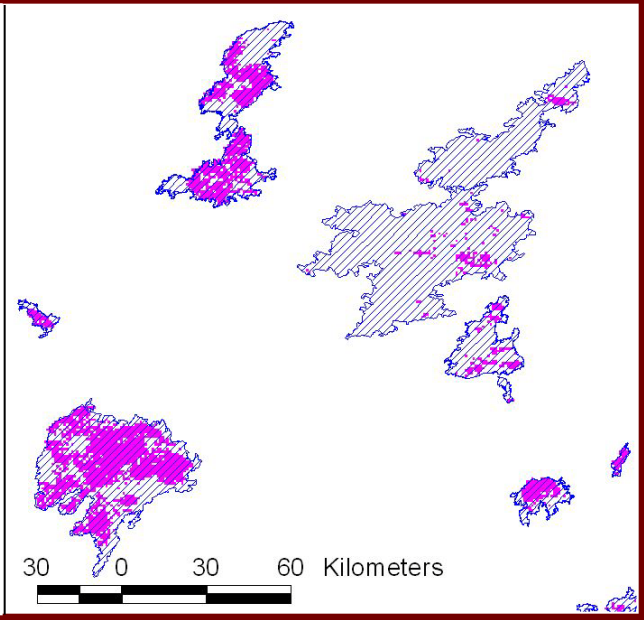
MTBS



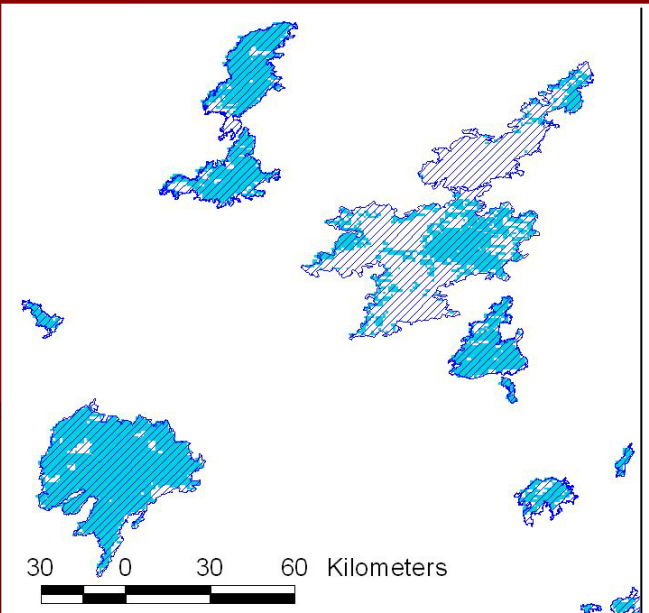
MODIS active fires



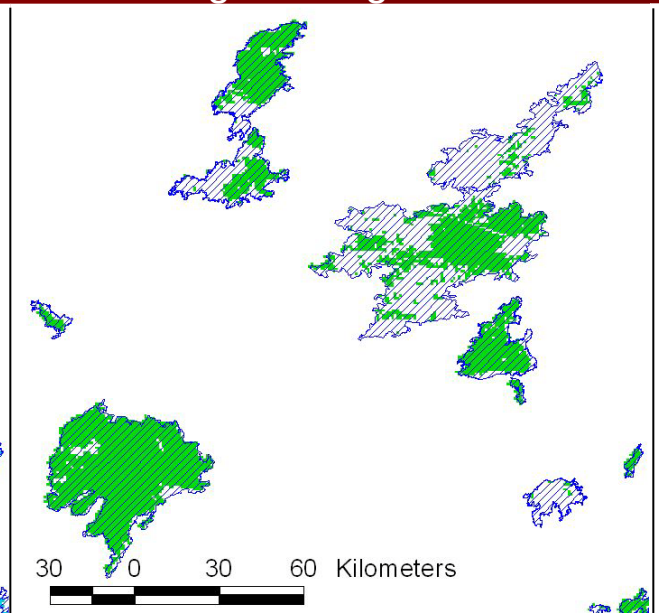
Provisional burned area product



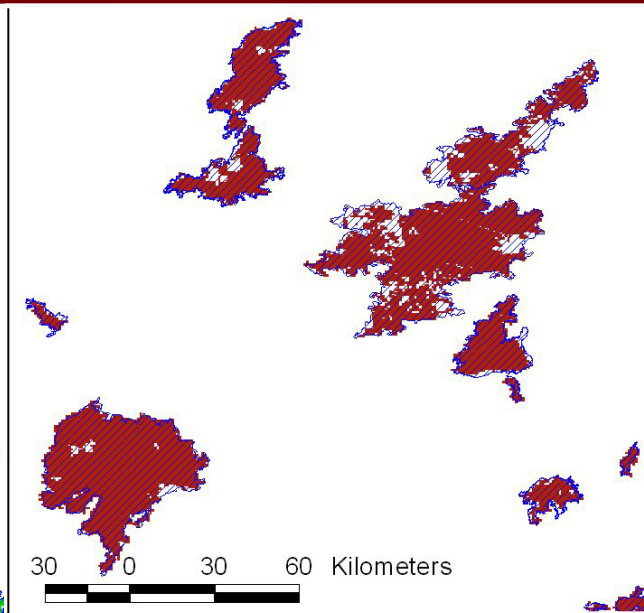
Direct Broadcast algorithm



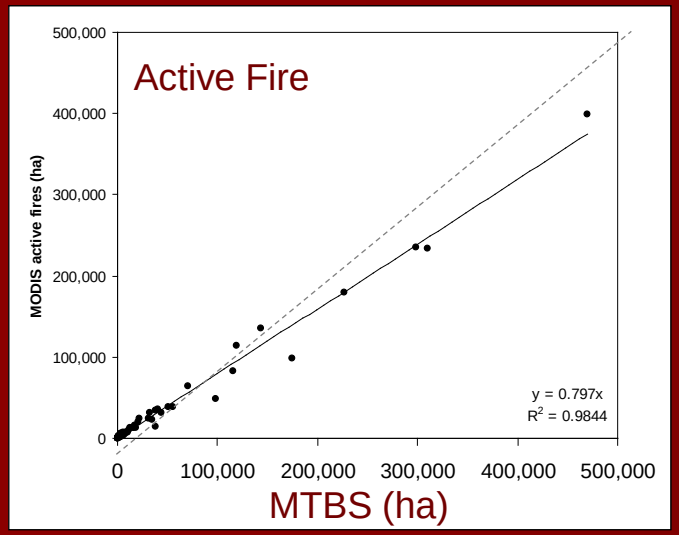
Regional algorithm

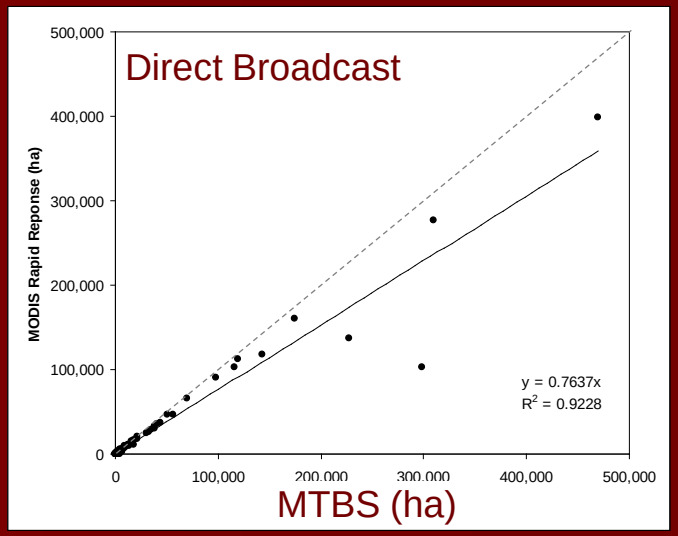


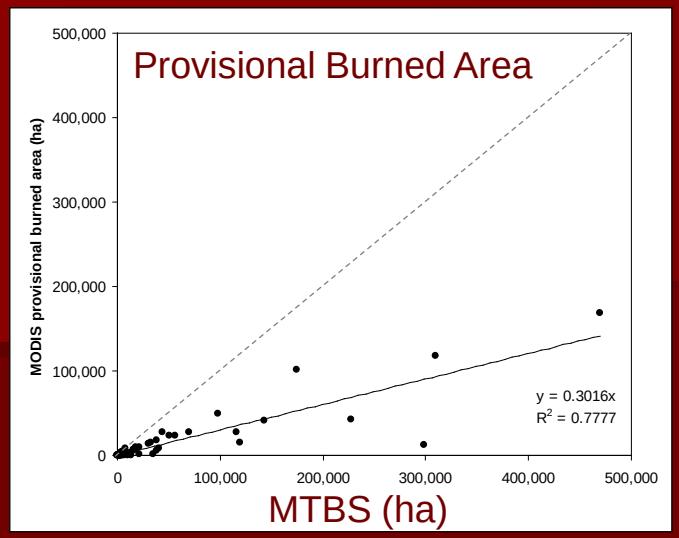
Regional algorithm (adjusted)

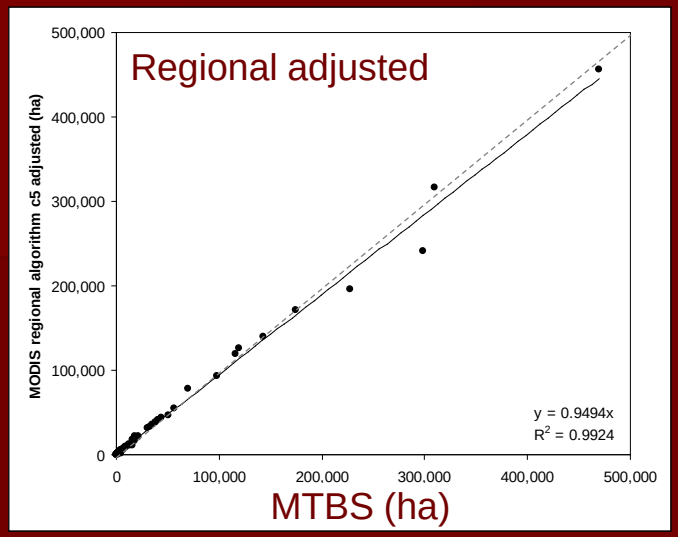


Comparison of burned area estimates from various MODIS–based algorithms during 2004 fire season in Alaska against MTBS scars (n = 67)









MODIS in Giovanni: online visualization

http://gdata1.sci.gsfc.nasa.gov/daac-bin/G3/gui.cgi?instance_id=neespi

National Aeronautics and Space Administration

Search DISC + GO + Advanced Search

Giovanni - The Bridge Between Data and Science

+ ABOUT GIOVANNI | + NEWS | + INSTANCES | + FEEDBACK | + RELEASE NOTES | + HELP

Operations Notification

September 10, 2009: Giovanni Users - the annual NASA data center user satisfaction survey is underway! Using Giovanni does not require submission of an email address to the GES DISC, so if you would like to help us improve Giovanni and our other data services, click here for instructions on how to receive an invitation to take the survey.

Northern Eurasia Earth Science Partnership Initiative

Monthly Products

Home | Remove All

This instance focuses on monthly atmospheric, land surface and cryospheric products for supporting Northern Eurasia Earth Science Partnership Initiative (NEESPI) project. Information of the NEESPI project can be found at the supporting website. For help on how to use this Giovanni instance, please see the NEESPI help page.

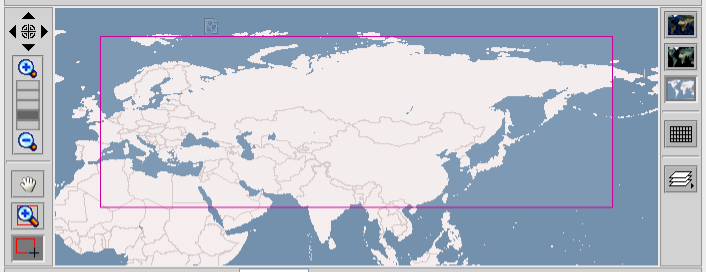
Other NEESPI products are available in Giovanni: Daily data.

ACKNOWLEDGMENT: The NASA NEESPI Data and Services Center project is supported by NASA HQ through ROSES 2005 NNH05ZDA001N-ACCESS.

Select:

Spatial

Cursor Coordinates: 0.00000, 0.00000



Area of Interest: West: 0 North: 80 South: 20 East: 180 Update Select...

Parameters

Display: ☑ Data Product Info ☐ Climatology Info ☐ Units ☐ Only Parameters with Climatology

Analysis Options: ◉ Parameter ○ Climatology ○ Anomaly Show Notes...

Atmospheric Measurement

☐ MODIS-Terra (1x1 degree) (2000/02/01 - 2009/08/01)

Parameter	Data Product Info		
☐ Aerosol Optical Depth at 550 nm	MOD08_M3.005	MODIS-Terra Ver. 5	2000/02 - 2009/08
☐ Aerosol Small Mode Fraction	MOD08_M3.005	MODIS-Terra Ver. 5	2000/02 - 2009/08
☐ Cloud Fraction (Day and Night)	MOD08_M3.005	MODIS-Terra Ver. 5	2000/02 - 2009/08
☐ Cloud Fraction (Day only)	MOD08_M3.005	MODIS-Terra Ver. 5	2000/02 - 2009/08
☐ Cloud Fraction (Night only)	MOD08_M3.005	MODIS-Terra Ver. 5	2000/02 - 2009/08
☐ Cloud Optical Depth_Ice (QA >=)	MOD08_M3.005	MODIS-Terra Ver. 5	2000/02 - 2009/08

MODIS in Giovanni: online visualization

http://gdata1.sci.gsfc.nasa.gov/daac-bin/G3/gui.cgi?instance_id=neespi_daily

National Aeronautics and Space Administration

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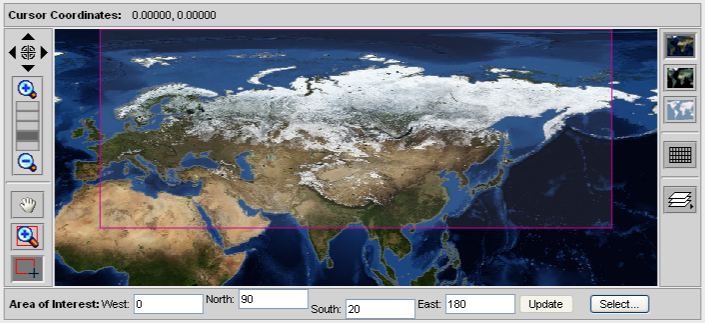
Select:

Spatial



Parameters

Display: Data Product Info Units

Atmospheric Measurement

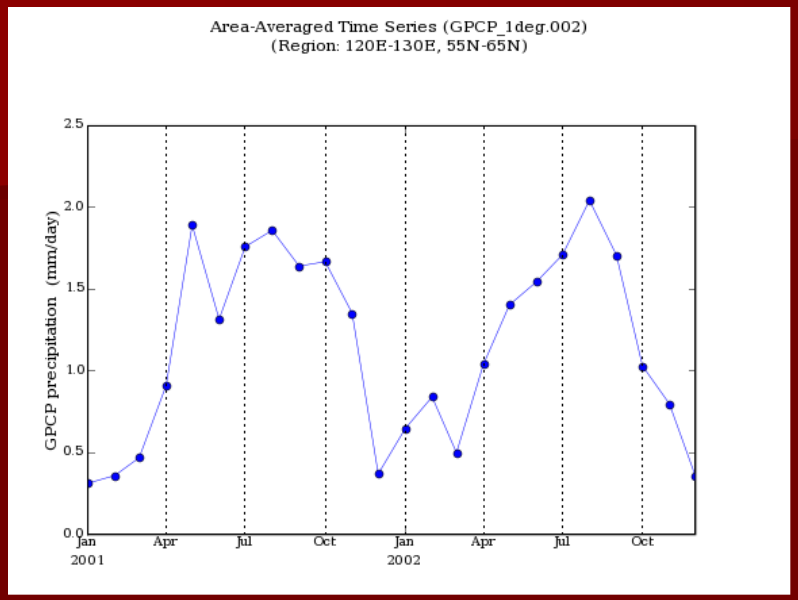
MODIS-Terra (1x1 degree)(2000/02/24 - 2009/09/06)

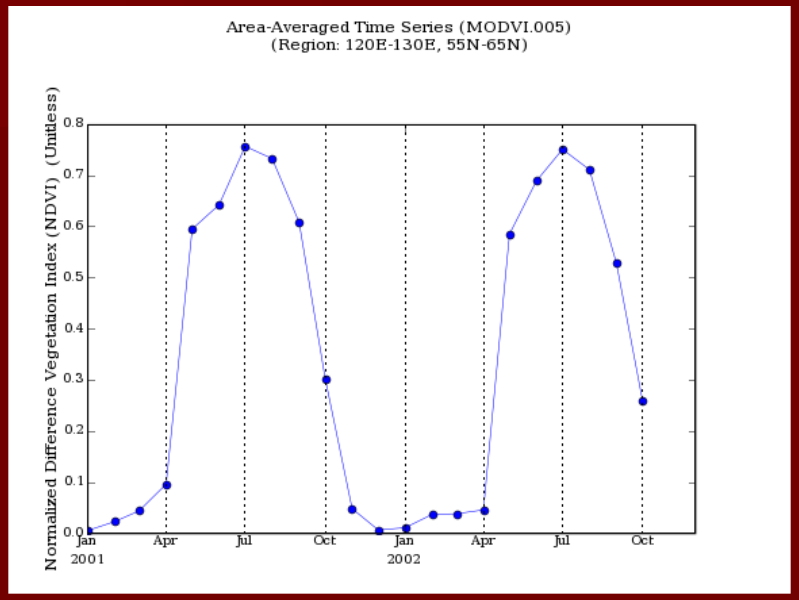
Parameter	Data Product Info		
Aerosol Optical Depth at 550 nm	MOD08_D3.005	MODIS-Terra Ver. 5	2000/02/24 - 2009/09/06
Aerosol Small Mode Fraction	MOD08_D3.005	MODIS-Terra Ver. 5	2000/02/24 - 2009/09/06
Cloud Fraction (Day and Night)	MOD08_D3.005	MODIS-Terra Ver. 5	2000/02/24 - 2009/09/06
Cloud Fraction (Day only)	MOD08_D3.005	MODIS-Terra Ver. 5	2000/02/24 - 2009/09/06
Cloud Fraction (Night only)	MOD08_D3.005	MODIS-Terra Ver. 5	2000/02/24 - 2009/09/06

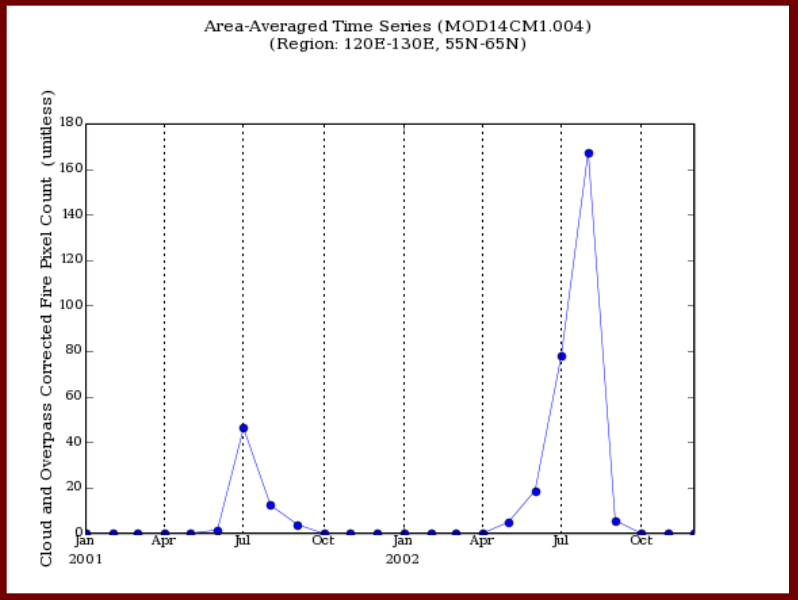
MODIS-Aqua (1x1 degree) (2002/07/04 - 2009/09/08)

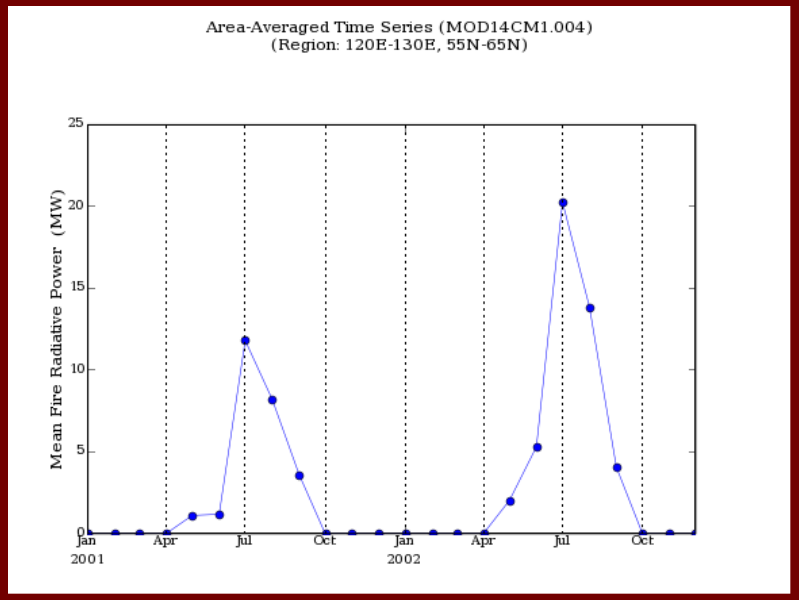
Parameter	Data Product Info		
Aerosol Optical Depth at 550 nm	MYD08_D3.051	MODIS-Aqua Ver. 5.1	2002/07/04 - 2009/09/08
Aerosol Small Mode Fraction	MYD08_D3.051	MODIS-Aqua Ver. 5.1	2002/07/04 - 2009/09/08
Cloud Fraction (Day and Night)	MYD08_D3.051	MODIS-Aqua Ver. 5.1	2002/07/04 - 2009/09/08

Relationship between precipitation and fire occurrence in boreal forests

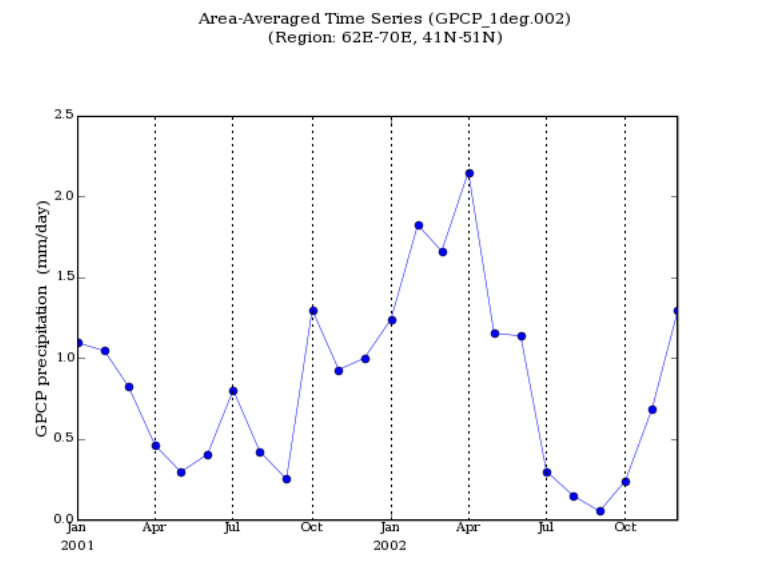


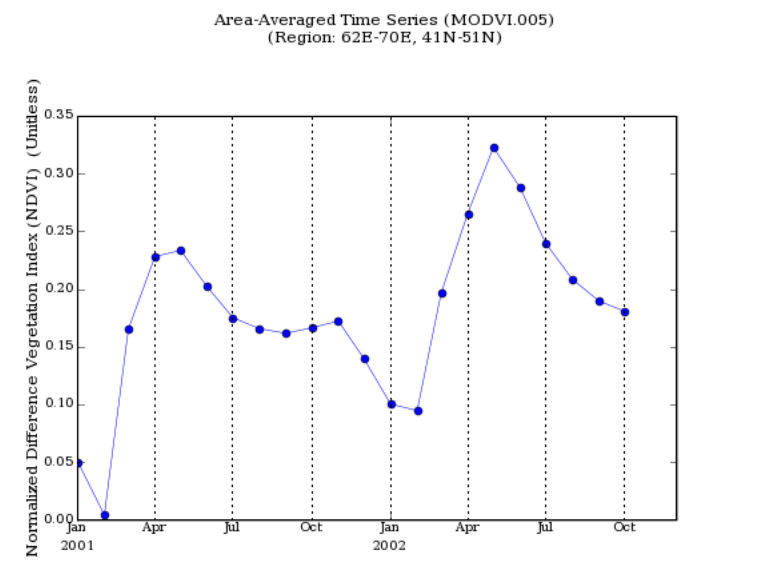


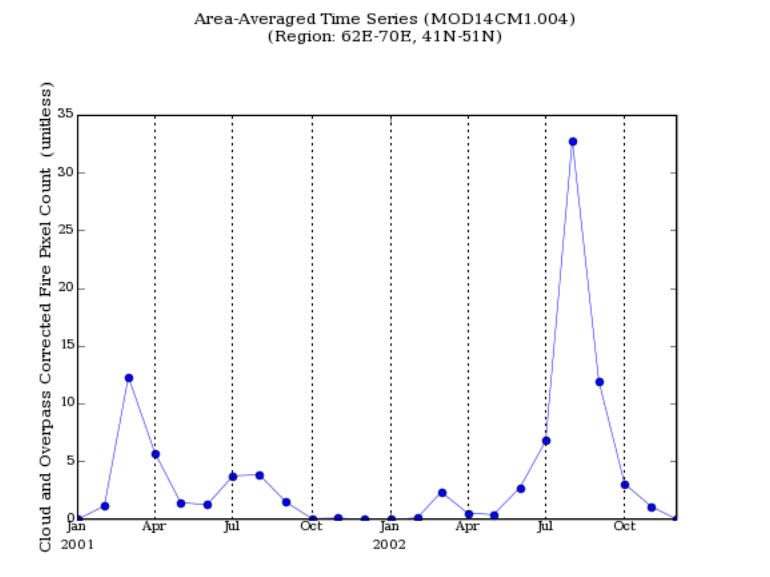


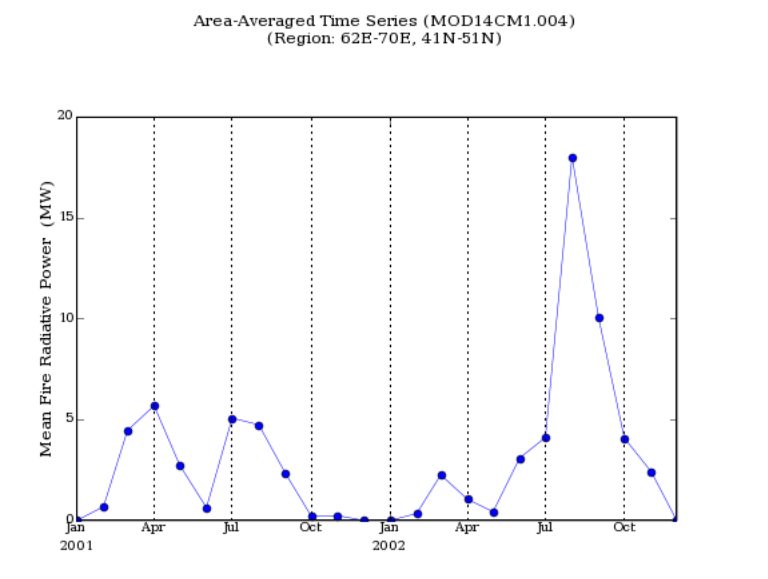


Relationship between precipitation and fire occurrence in dry lands









Conclusion

- MODIS fire products are
  - Standard
  - publicly available
  - Free of charge
- We need community help to improve algorithm performance through joint validation efforts