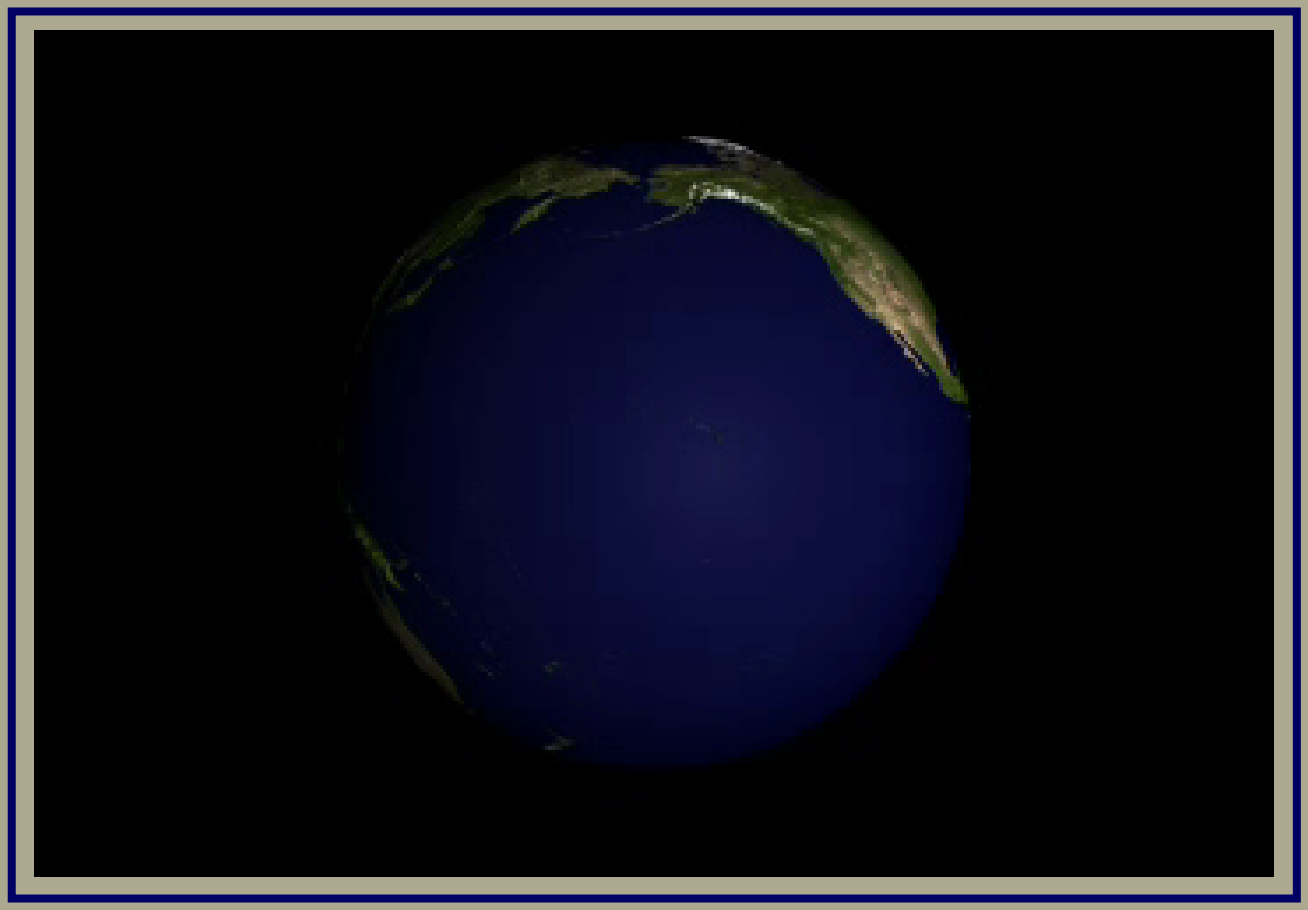


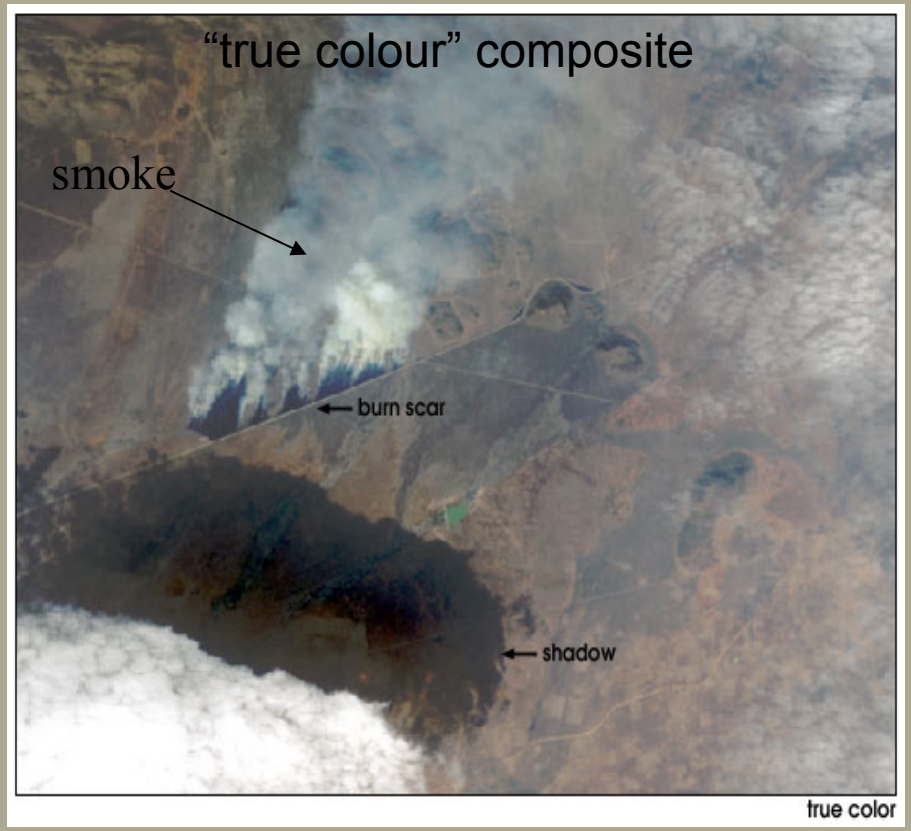
Active Fire Observations

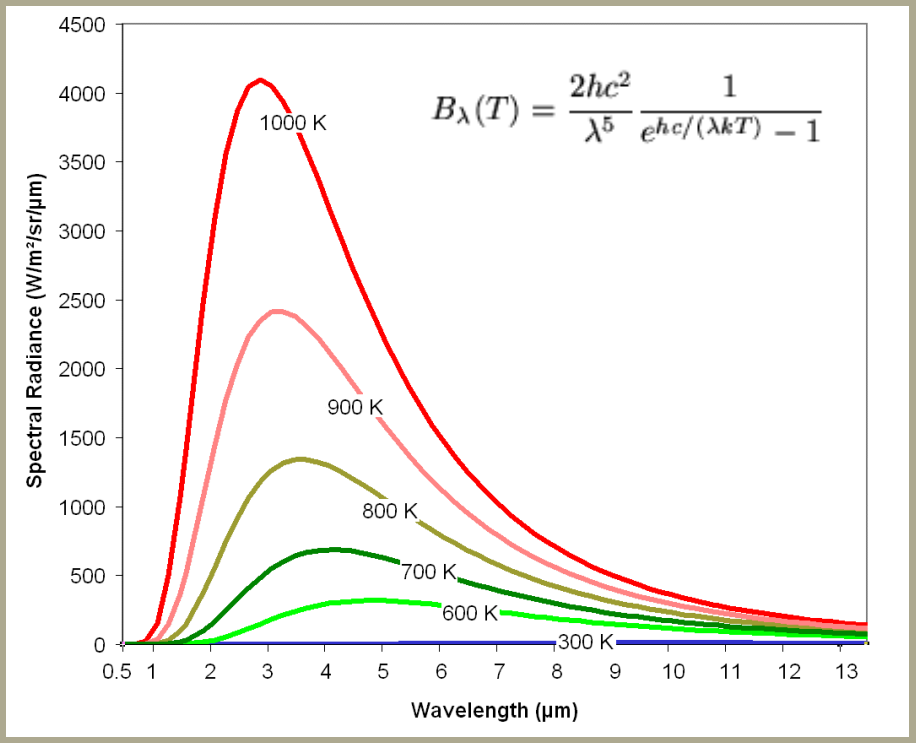
Presenter: Martin Wooster, King's College London (KCL)
G. Roberts, W. Xu, P. Freeborn, A. Lattanzio, Y. Govaerts, J. Kaiser, M.Schultz, EUMETSAT LandSAF

European Science Foundation Exploratory Workshop

Farnham Castle, UK, 14-16 September 2009

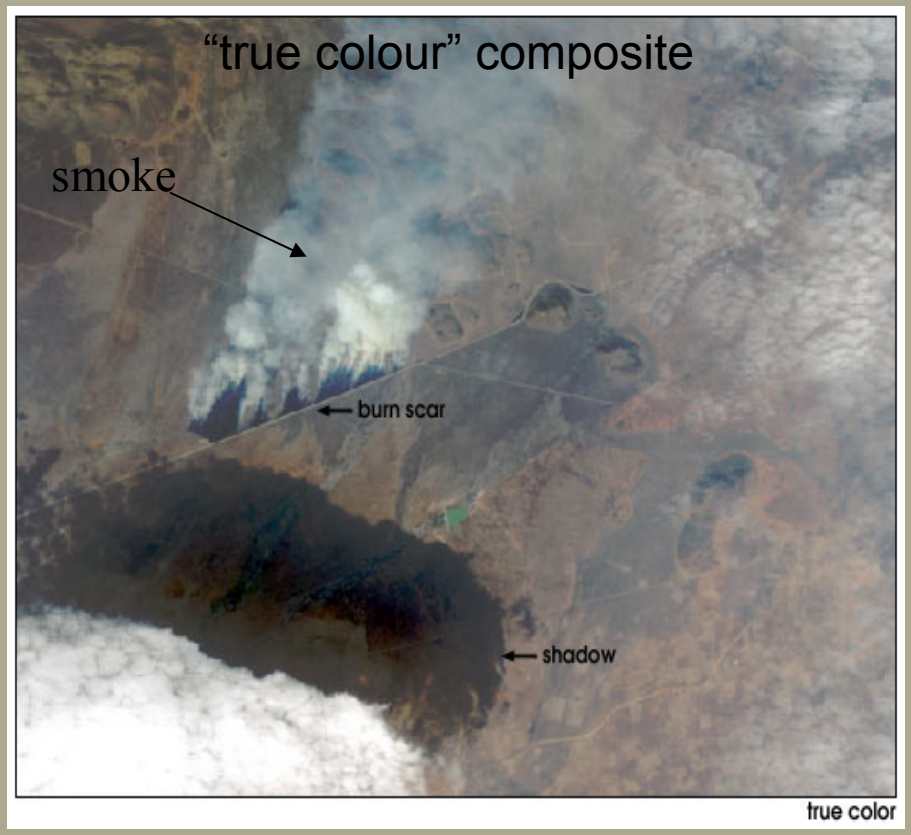
Active Fire Detections - Theory

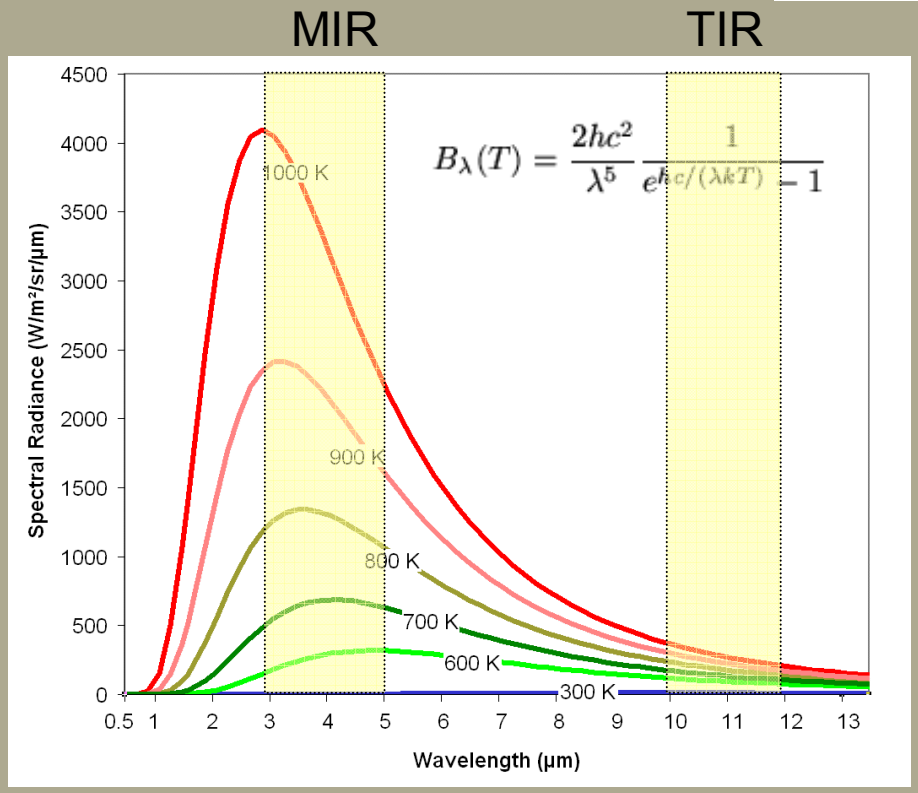




- Fires have very high temperatures (> 600 K) compared to their ambient surroundings

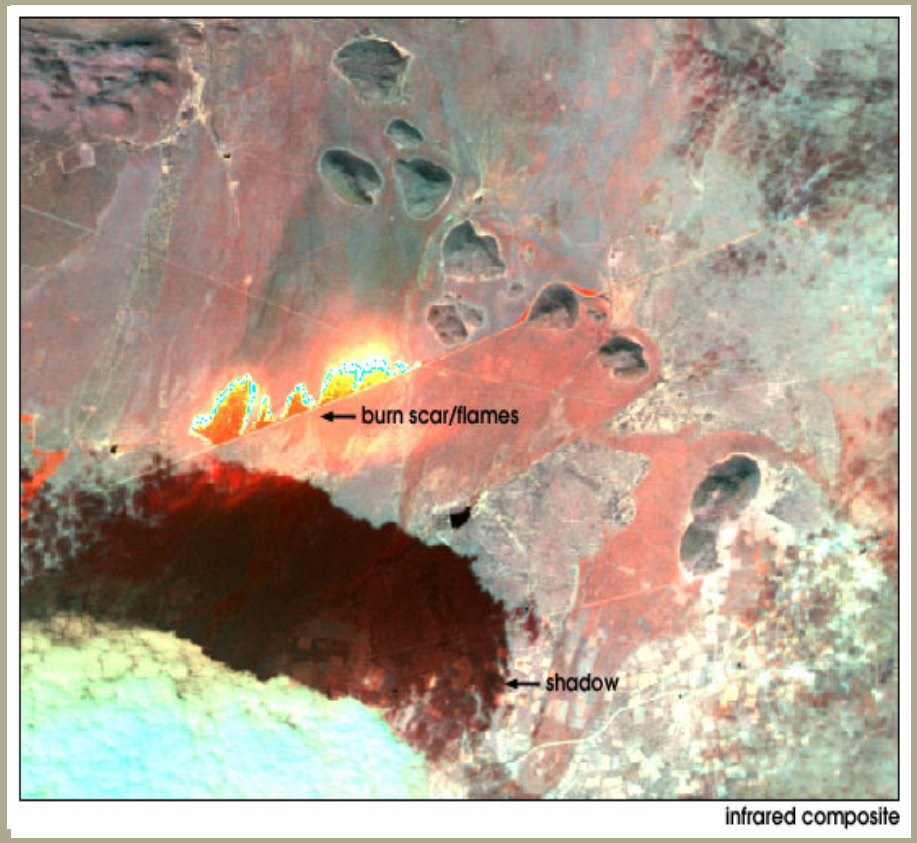
Active Fire Detections – Theory

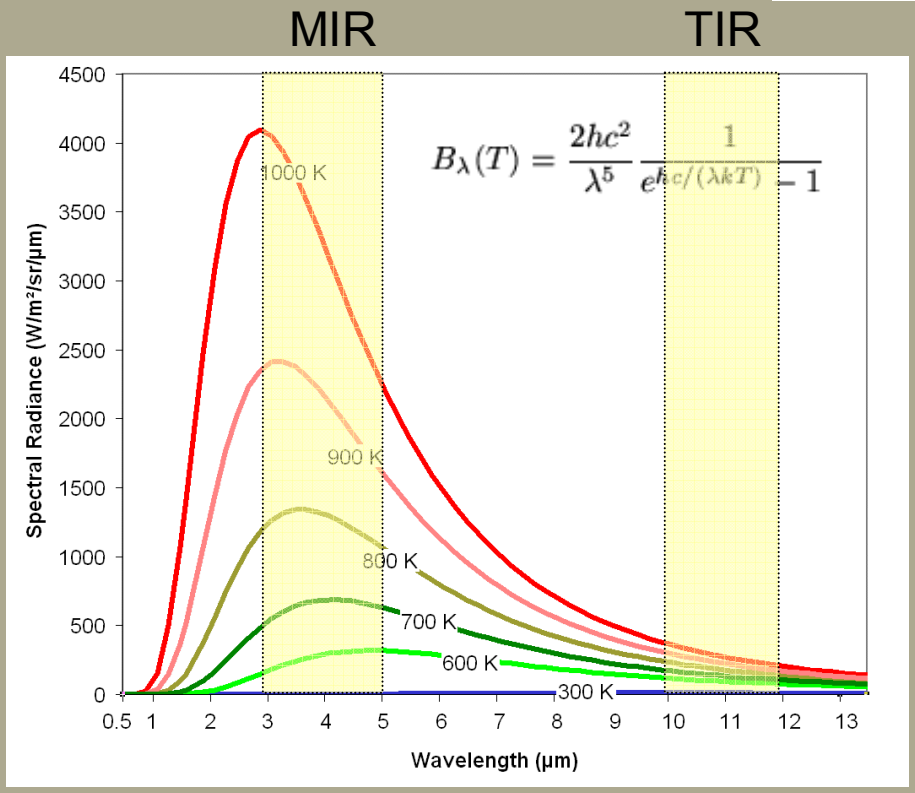




- Fires have very high temperatures (> 600 K) compared to their ambient surroundings
- The high temperatures result in intense IR radiant energy emissions, more so in MIR (3-5 µm) than TIR region.

Active Fire Detections – Theory





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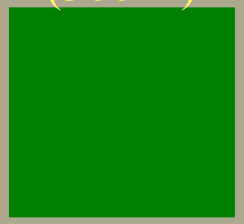
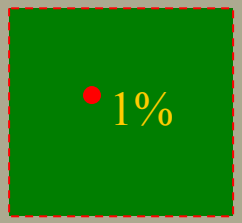
- The high temperatures result in intense IR radiant energy emissions, more so in MIR (3-5 μm) than TIR region.

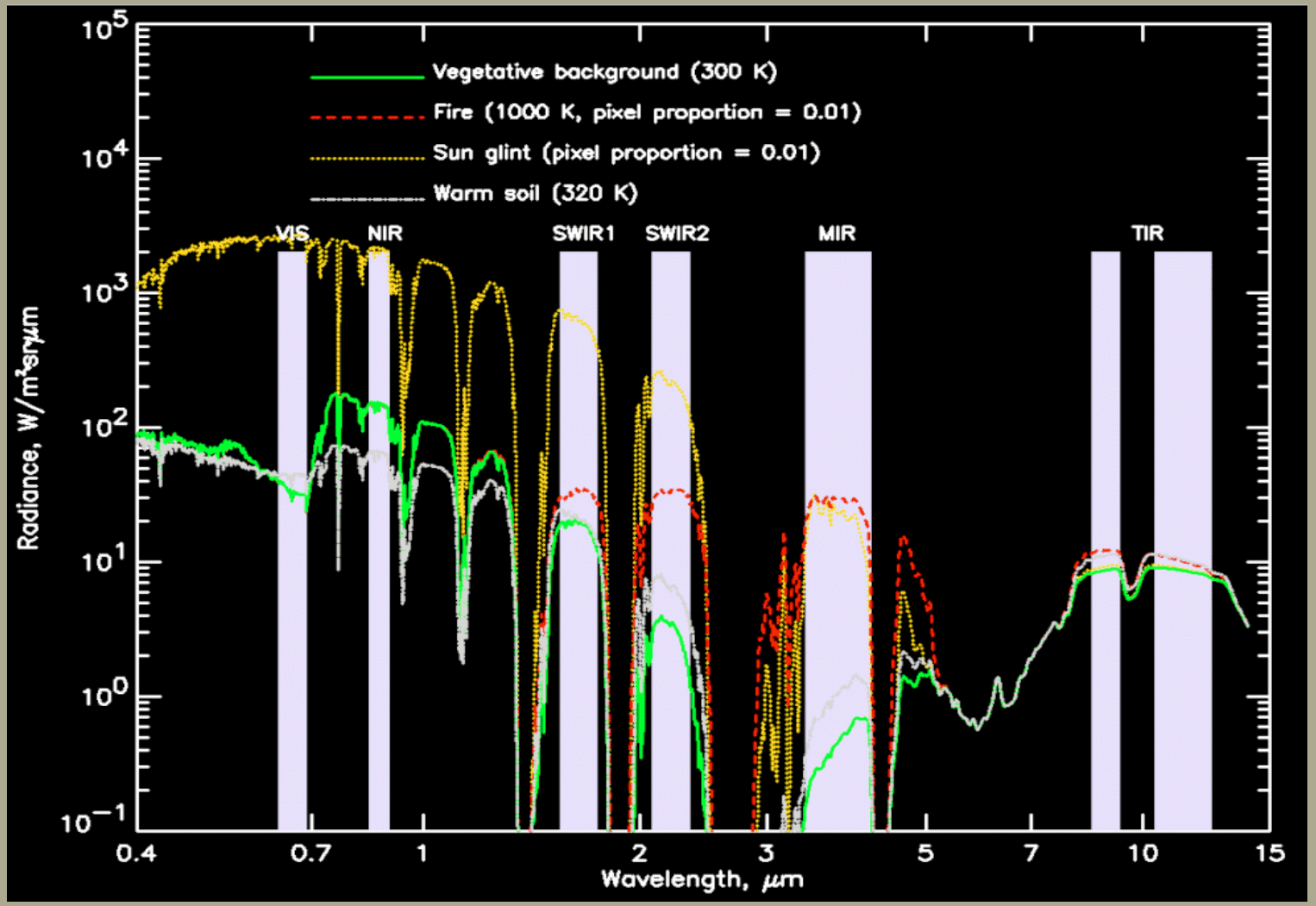
Sub-Pixel Spaceborne Fire Detection

Veg Only (300 K)





Veg + 1% Fire



Zhukov *et al.* (2006)

Sub-Pixel Spaceborne Fire Detection

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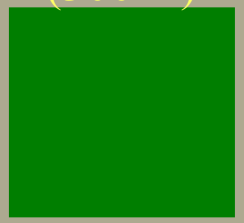
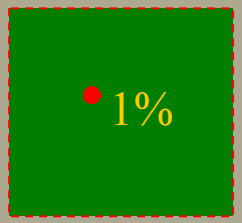
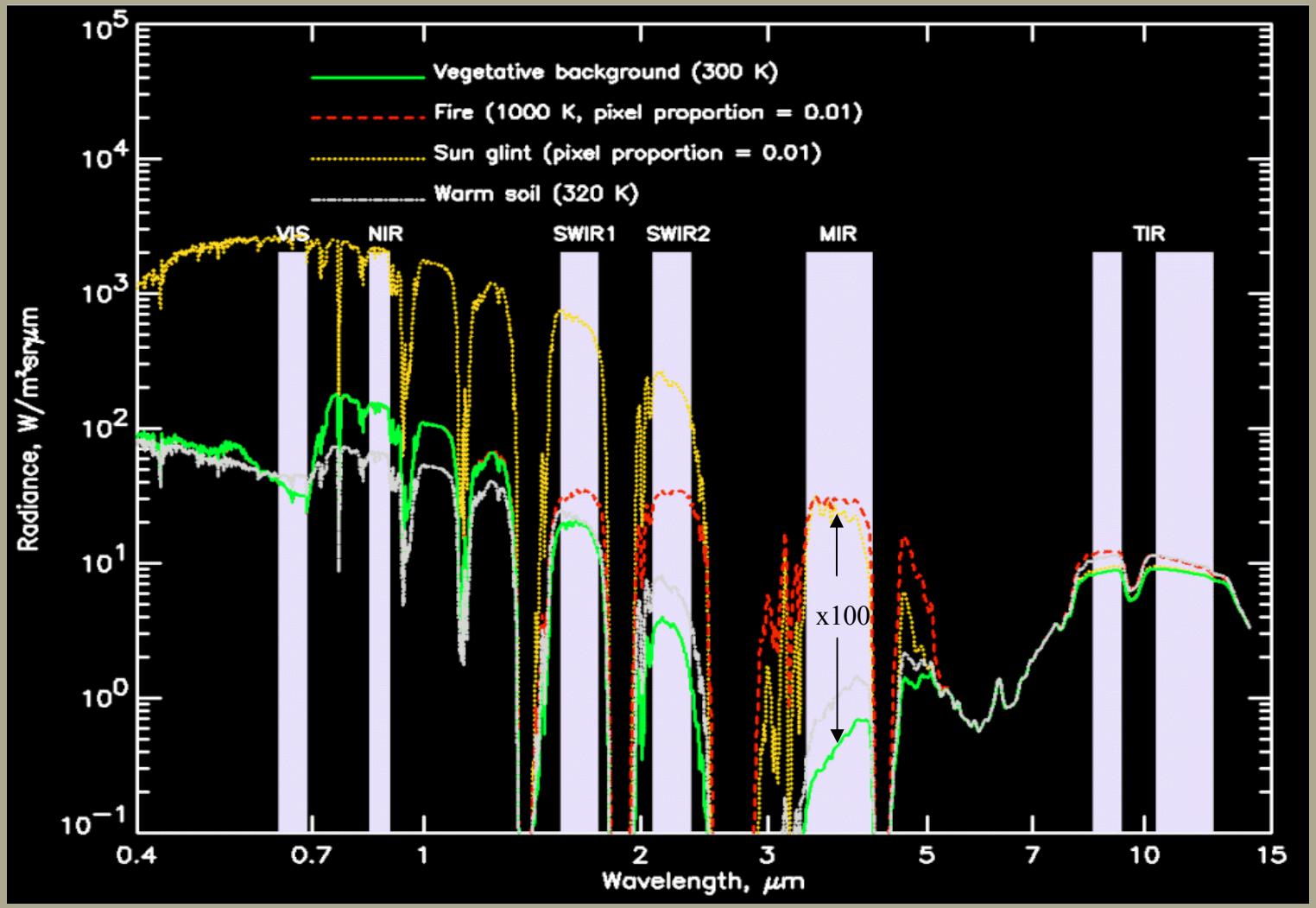
University of London

Veg Only (300 K)





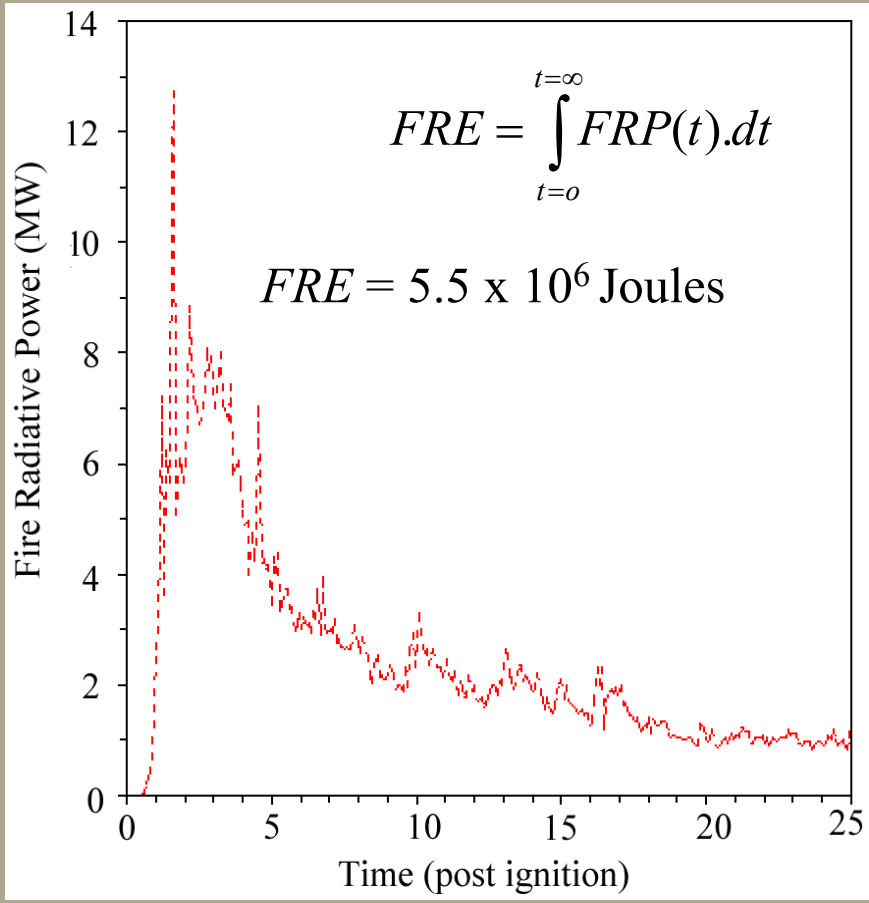
Veg + 1% Fire



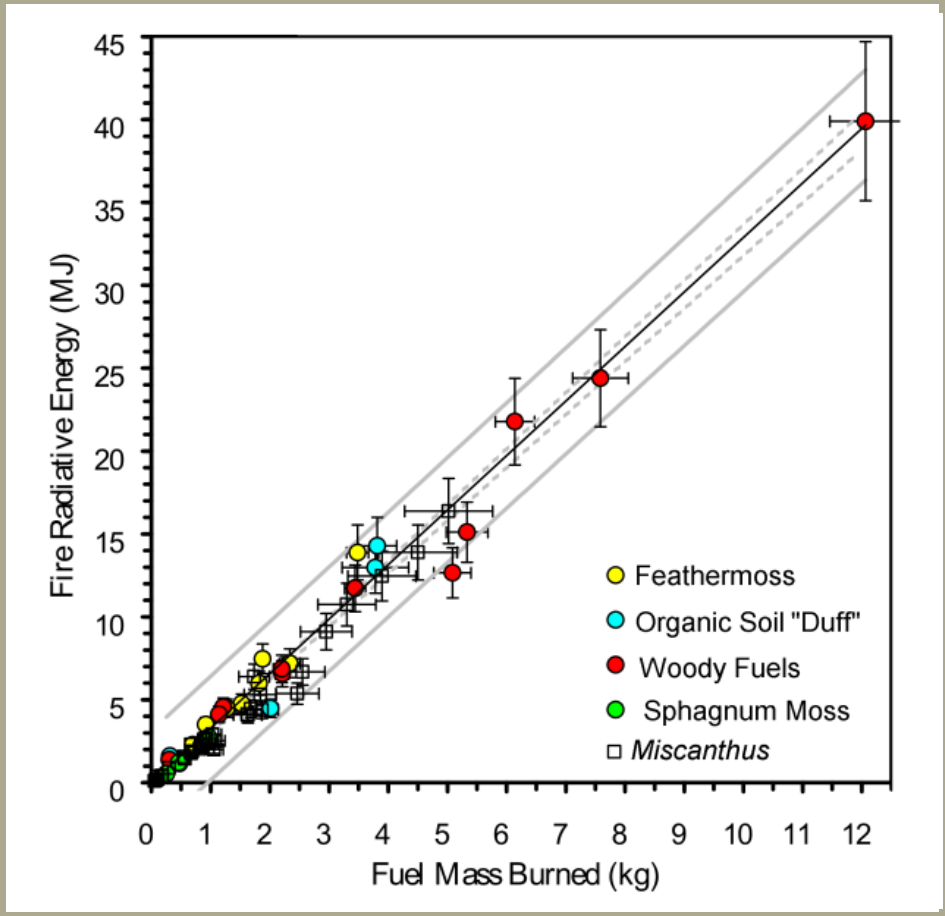
Possible to detect active fires covering < 1000th of pixel!

Fire Radiative Power & Energy

Fire Radiative Power Record (1 fire)



Total Fuel Consumed *vs.* FRE (many fires)

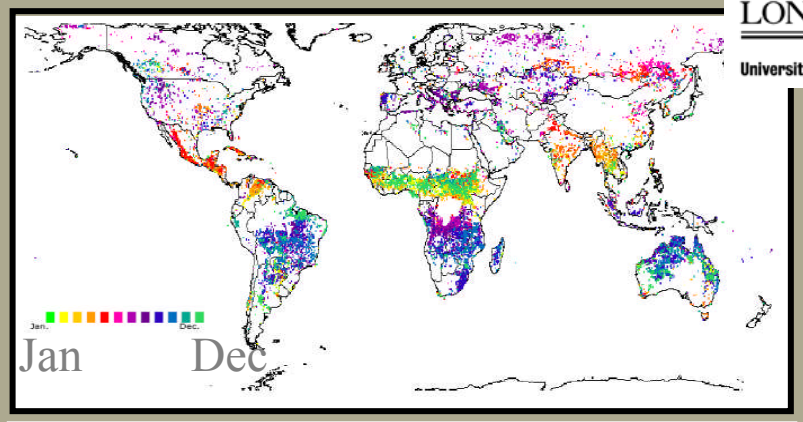


Example LEO Fire Data

ATSR (World Fire Atlas)

http://dup.esrin.esa.it/ionia/wfa/index.asp

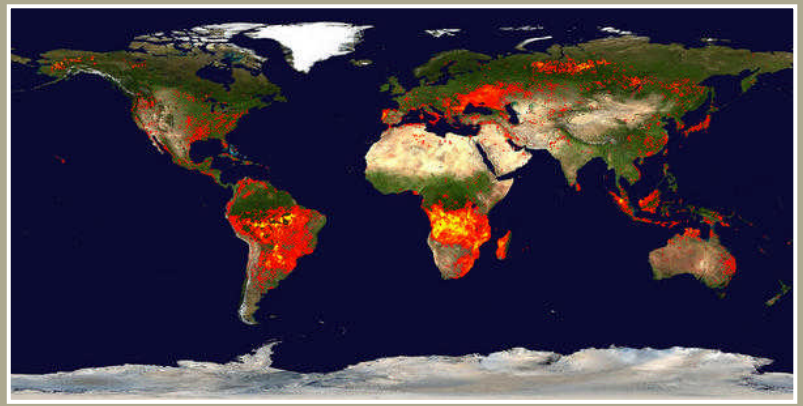
Long-term (since ’95) but only night.



MODIS Active Fires

http://rapidfire.sci.gsfc.nasa.gov/

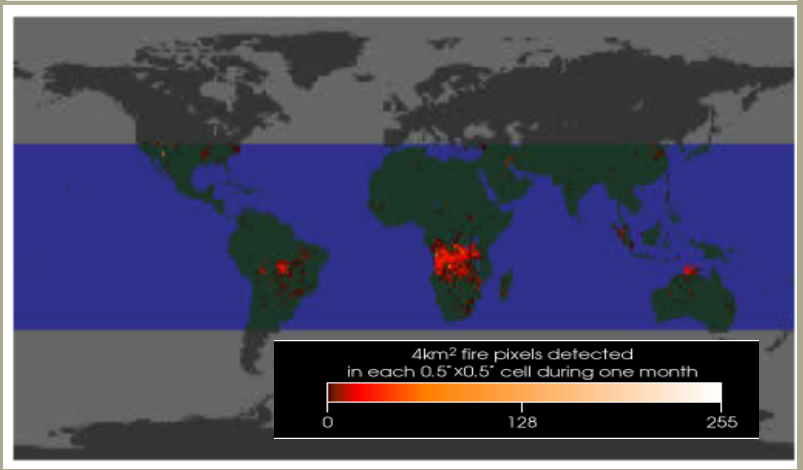
Every 6 hrs global since 2002.



TRMM Global Fires

ftp://ftp-tsdis.gsfc.nasa.gov/pub/yji/DAILY//
http://eobglossary.gsfc.nasa.gov/Observatory/Datasets/fires.trmm.html

~ Monthly diurnal sampling, but only tropics



Russian Active Fires (MODIS)

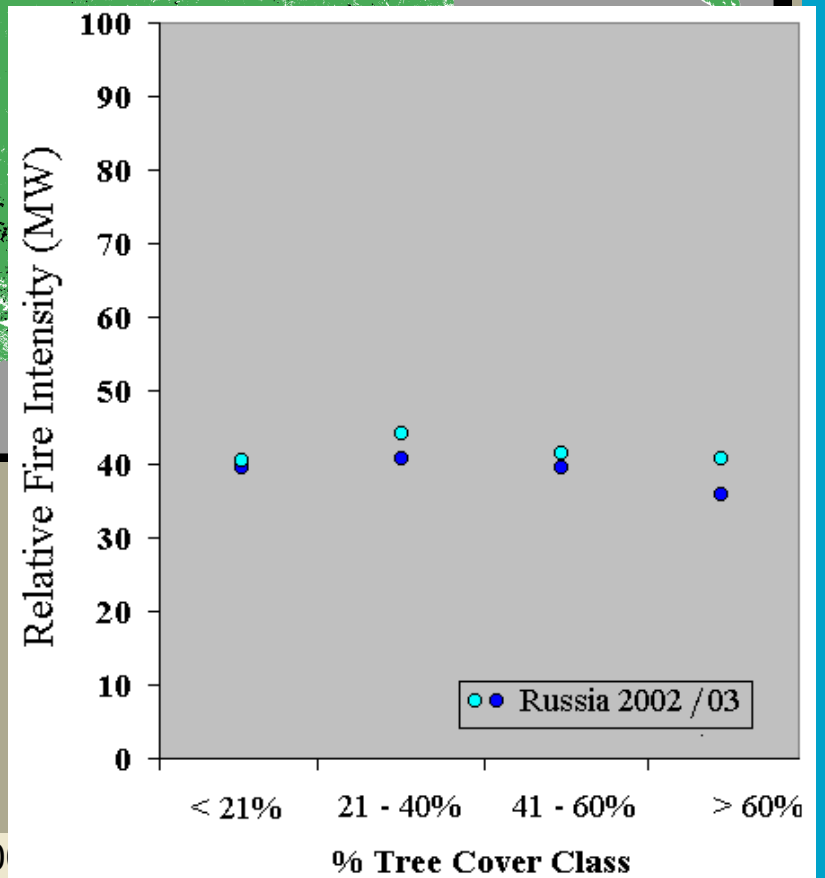
Terra/Aqua – Jun/Jul/Aug 2003)

EO-derived fire intensity measured used to investigate a long-standing and oft-mentioned but unproven hypothesis, important for carbon flux modelling and potentially Kyoto reporting from 2008 onwards:

'Boreal forest fires burn less intensely in Russia than in North America, due to a much lower incidence of crown fire activity' (Kasichke, 1999)

Russian Active Fires (MODIS)

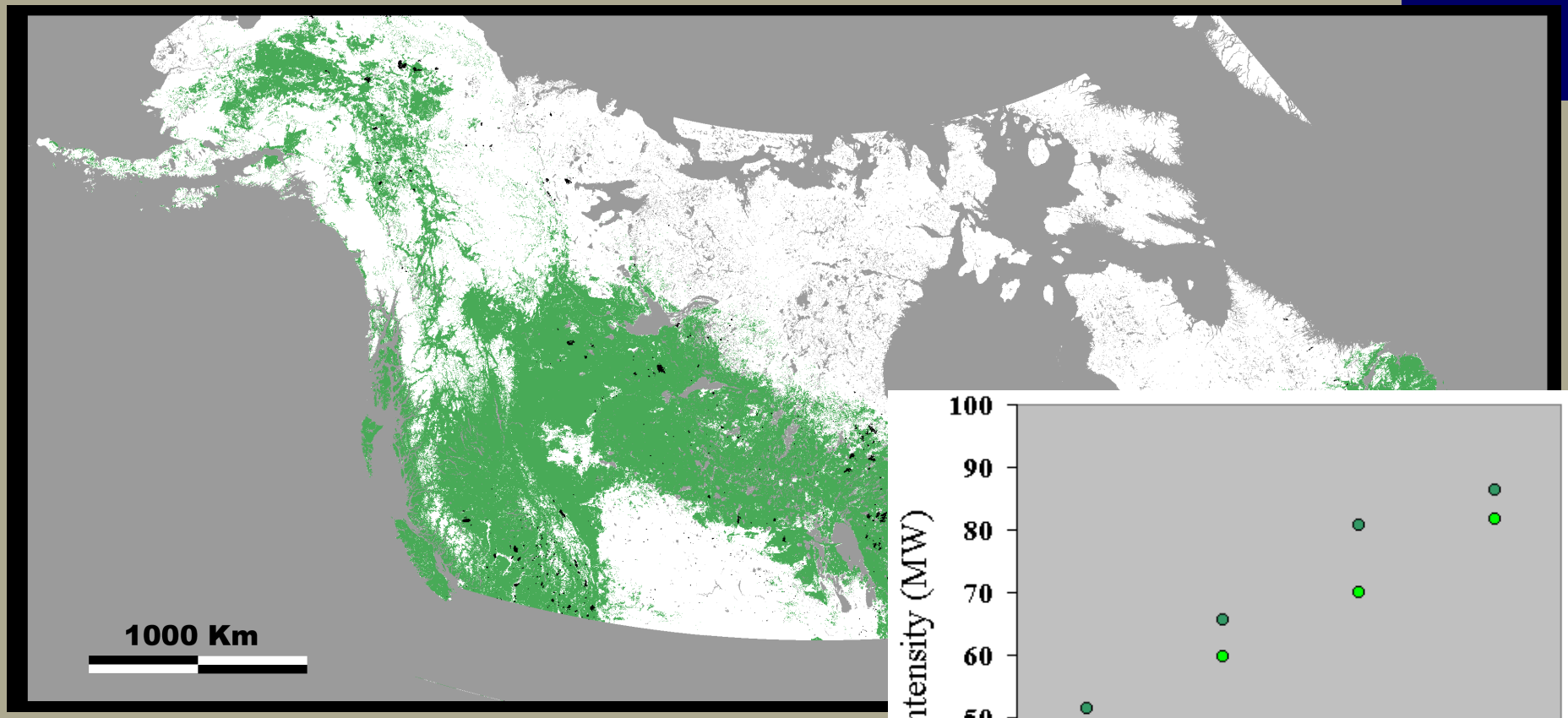
Terra/Aqua – Jun/Jul/Aug 2003)



Russian Boreal Forest Fires

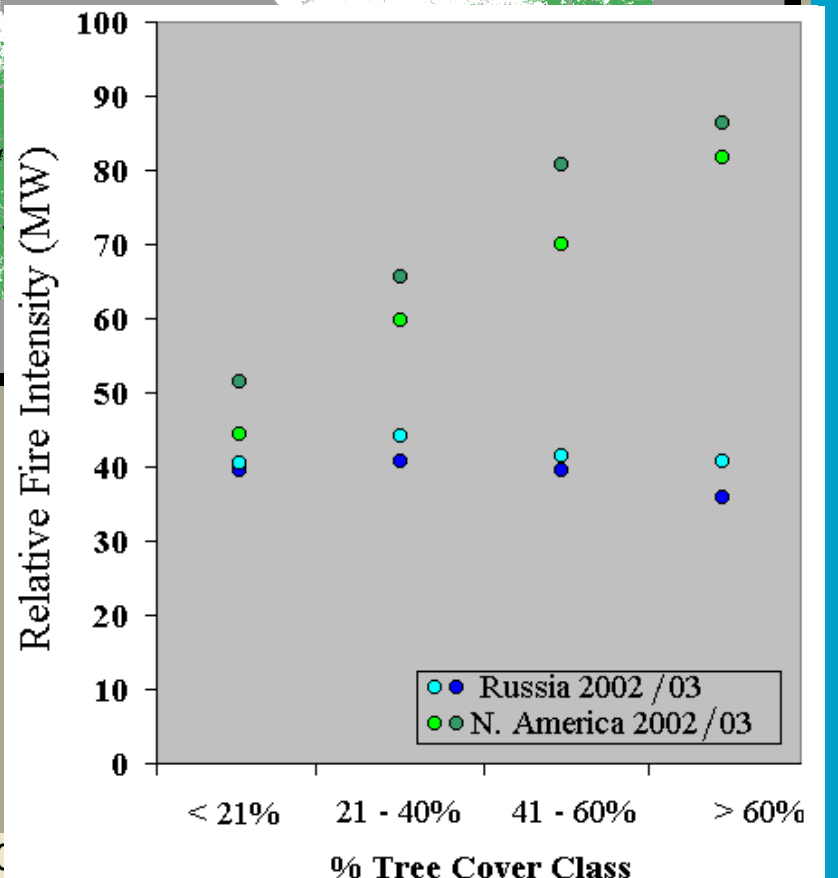
- Fire intensity mean ~ 42 MW/fire pixel
- No relationship with % tree cover

North American Active Fires



North American Boreal Forest Fires

- Fire intensity mean ~ 70 MW/fire pixel
- Increasing in proportion to % tree cover

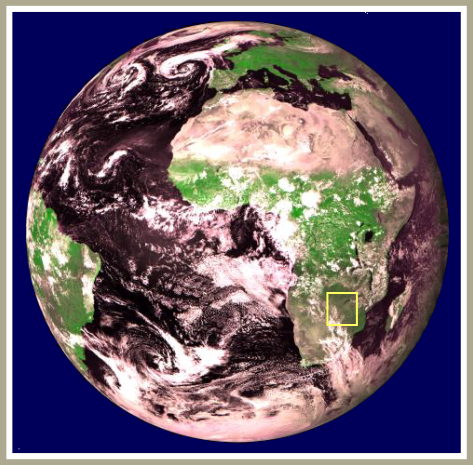


Wooster, M.J and Zhang, Y.-H., Boreal Forest Fires Burn Less Intensely in Russia than in North America (2004) *Geophysical Research Letters*, 31, doi:10.1029/2004GL020805

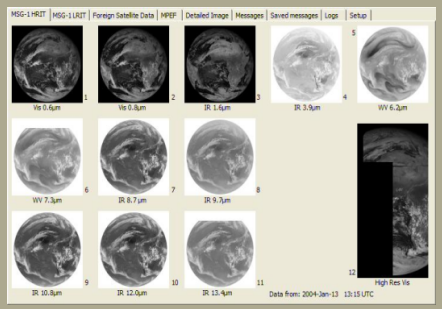
Geostationary Fire Detection Methods Based on Polar Orbiting Approaches

KING'S College LONDON
University of London

MSG SEVIRI

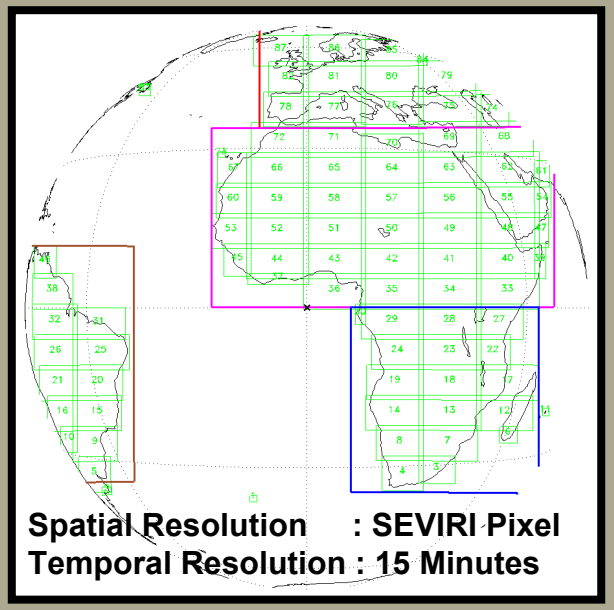


15 min imaging freq.



12 channel imager

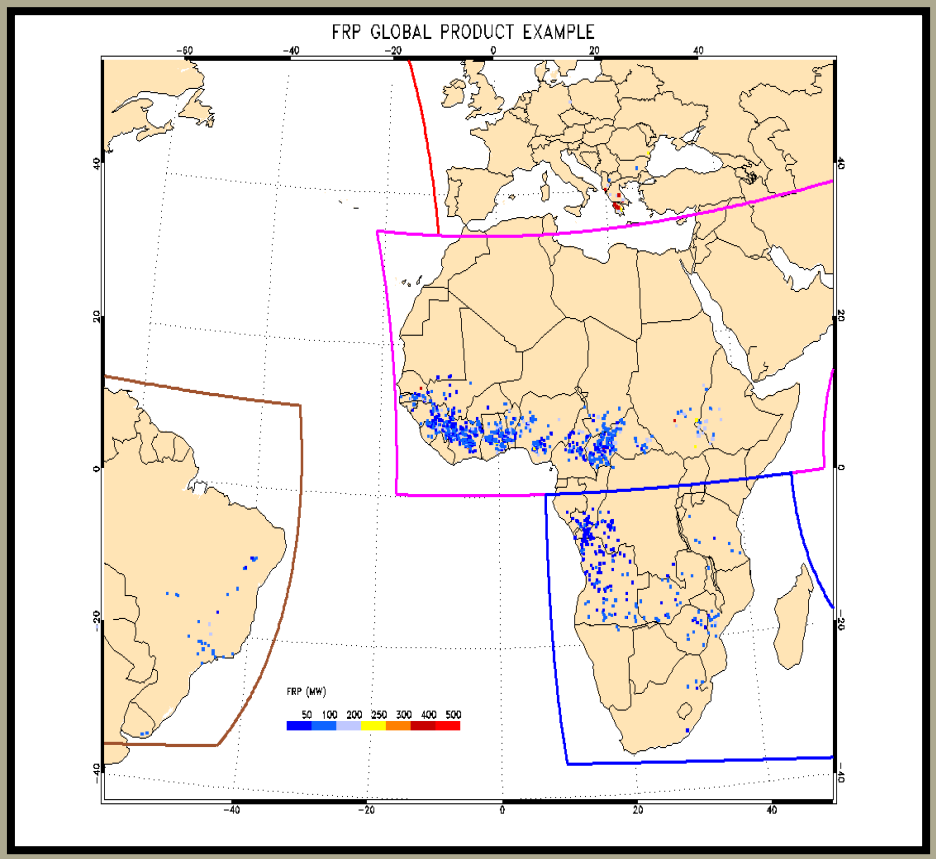
SEVIRI Fire Radiative Power (FRP) Product (http://landsaf.meteo.pt/)



Spatial Resolution : SEVIRI Pixel
Temporal Resolution : 15 Minutes

FRP Pixel product generated for four regions:

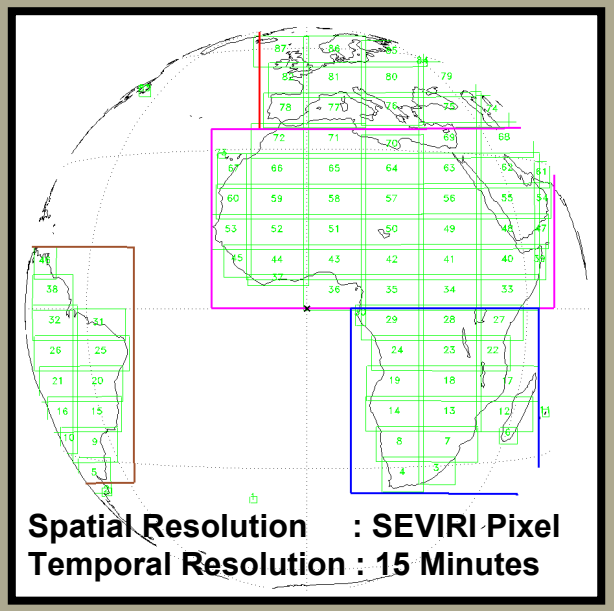
- **Euro (Europa): Red**
- **NAfr (Northern Africa): Magenta**
- **SAfr (Southern Africa): Blue**
- **SAme (Southern America): Brown**



SEVIRI FRP Pixel Product

Simulated "Global product" generated from FRP pixel derived for different dates only (as a visual example; normally relatively few fires are burning in North and South Africa on the same date)

SEVIRI Fire Radiative Power (FRP) Product (http://landsaf.meteo.pt/)



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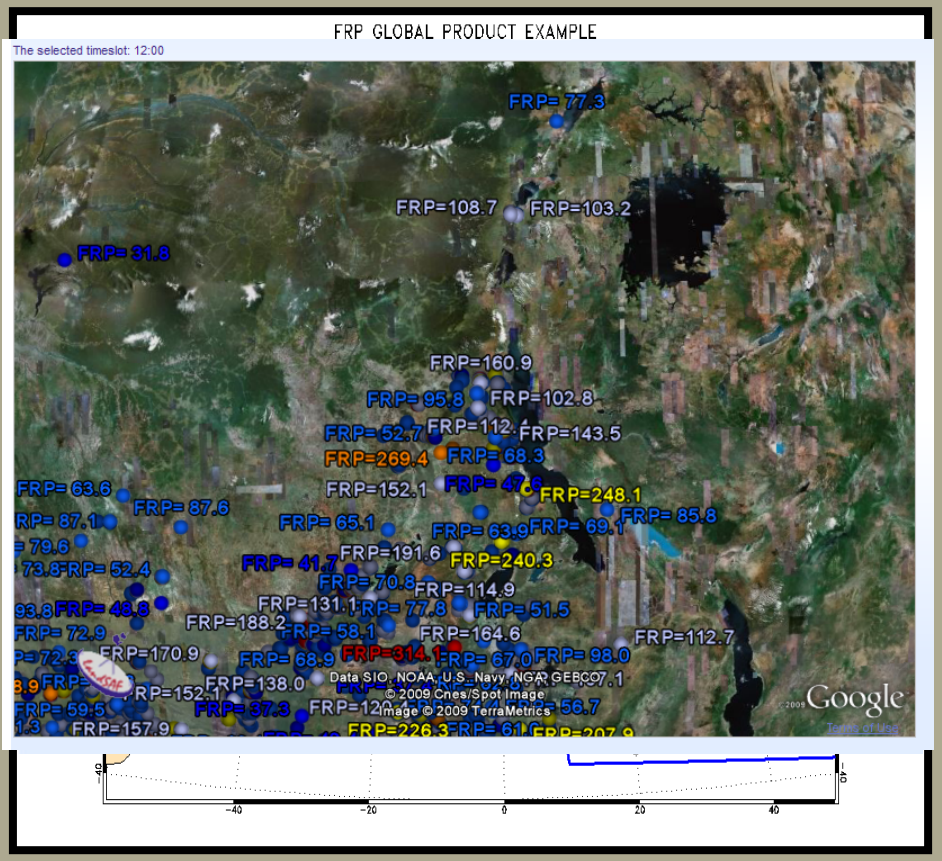
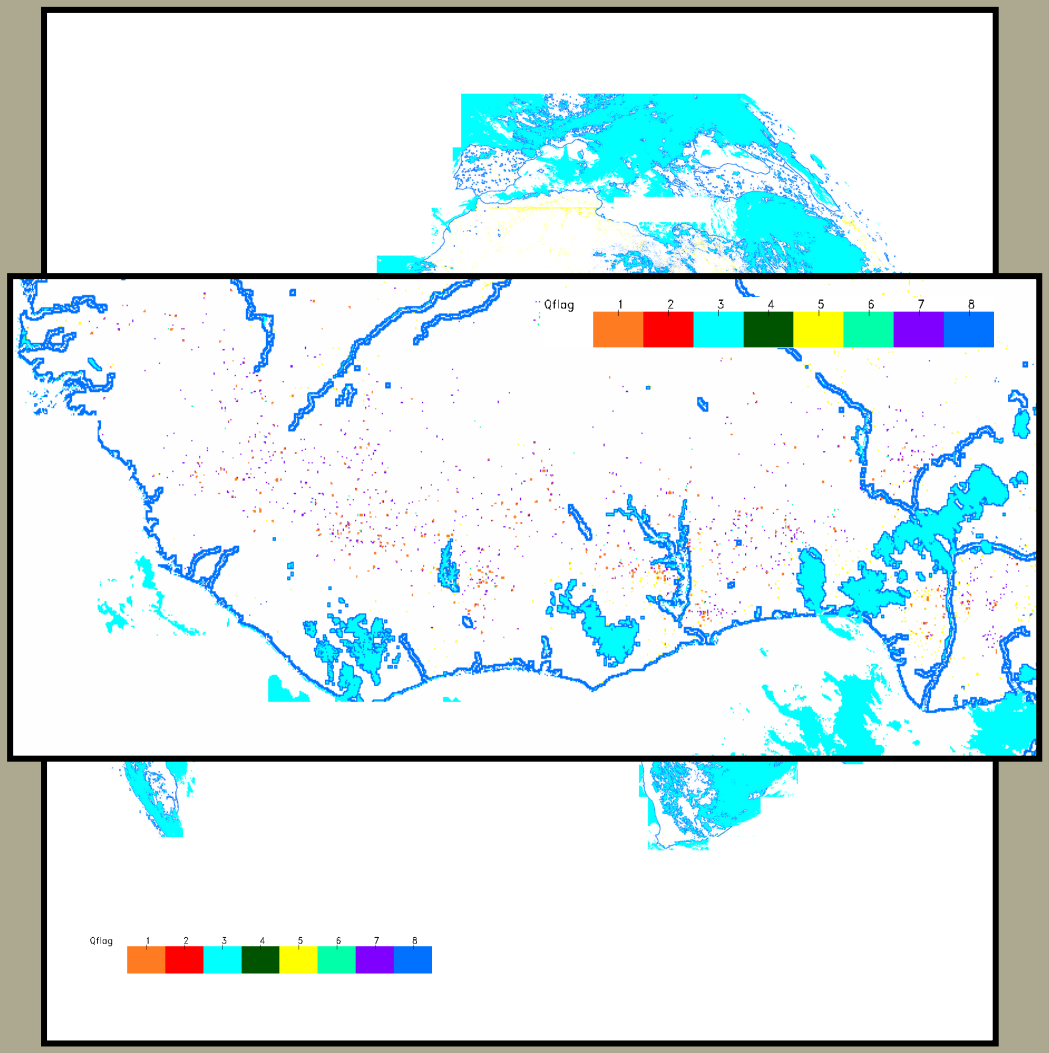


SEVIRI FRP Pixel Product

Simulated "Global product" generated from FRP pixel derived for different dates only (as a visual example; normally relatively few fires are burning in North and South Africa on the same date)

METEOSAT SEVIRI FRP – "Quality Product" Dataset

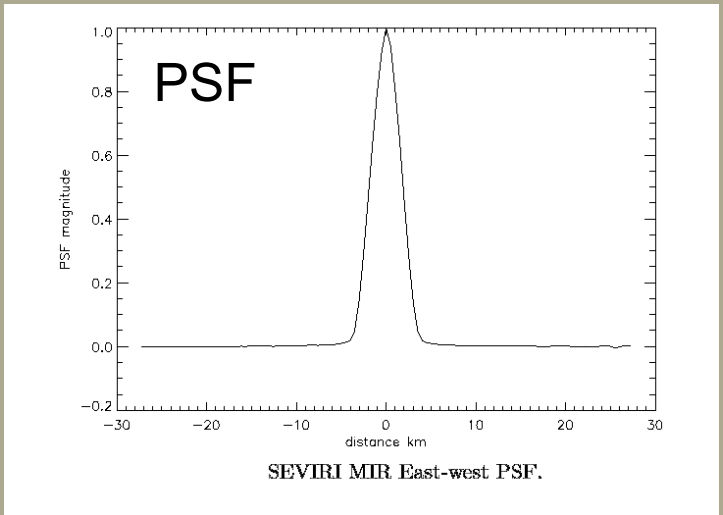


VALUE	MEANING
0	NOT POT FIRE
1	FRP OK
2	FRP SAT
3	CLOUDY
4	SUN GLINT
5	SUN GLINT RATIO
6	NO BCK
7	BAD BCK
8	CLOUD EDGE
254	NOT PROCESSED

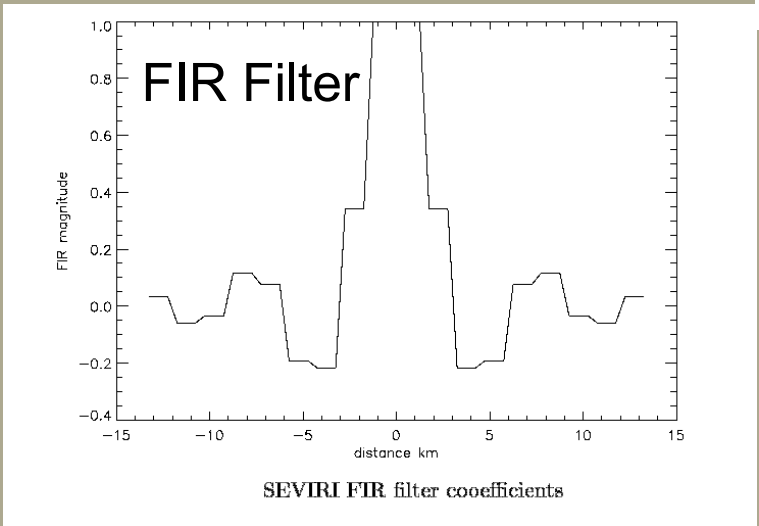
"Quality Product" reports the processing status of each pixel – Fire Detected & FRP measured, cloud-covered, etc.

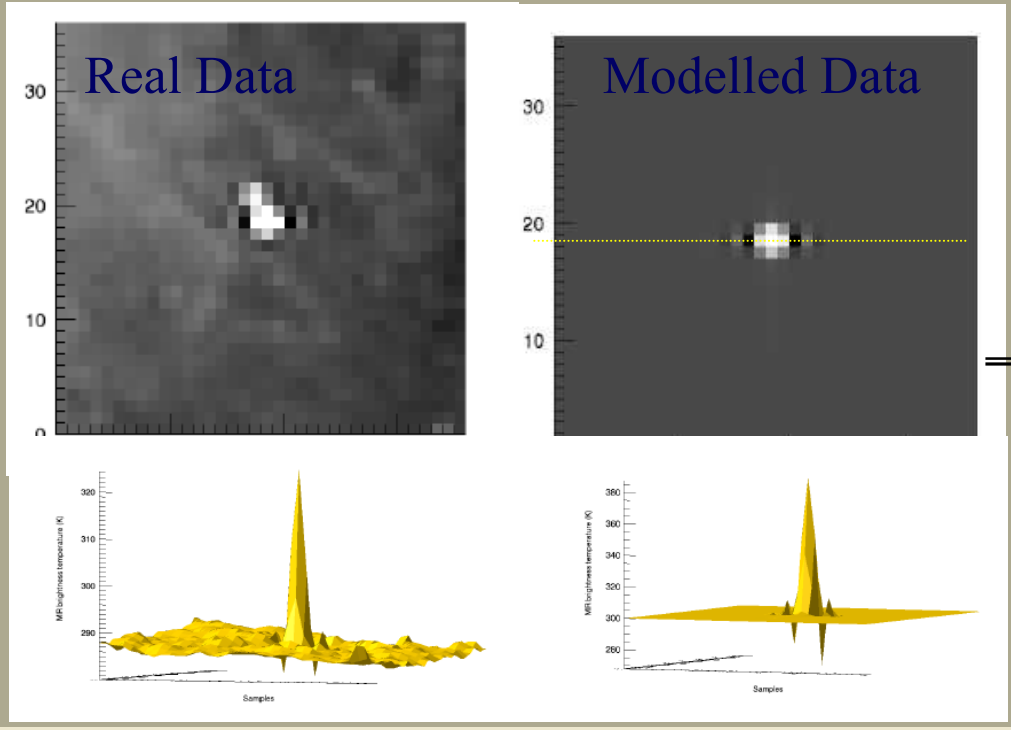
Comparison to MODIS indicates a false fire detection rate of 6 - 8 %.

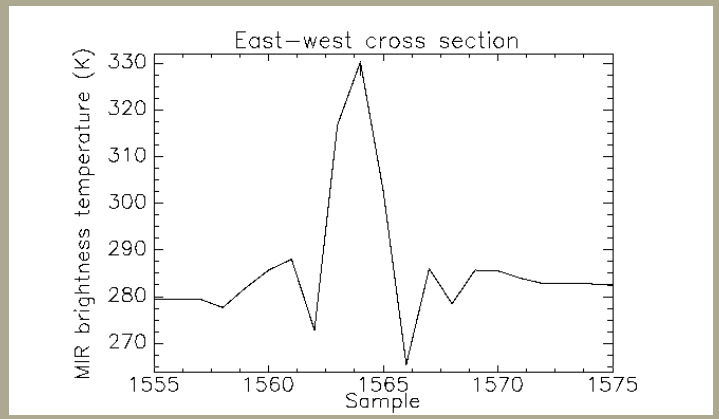
Modelling SEVIRI Observations



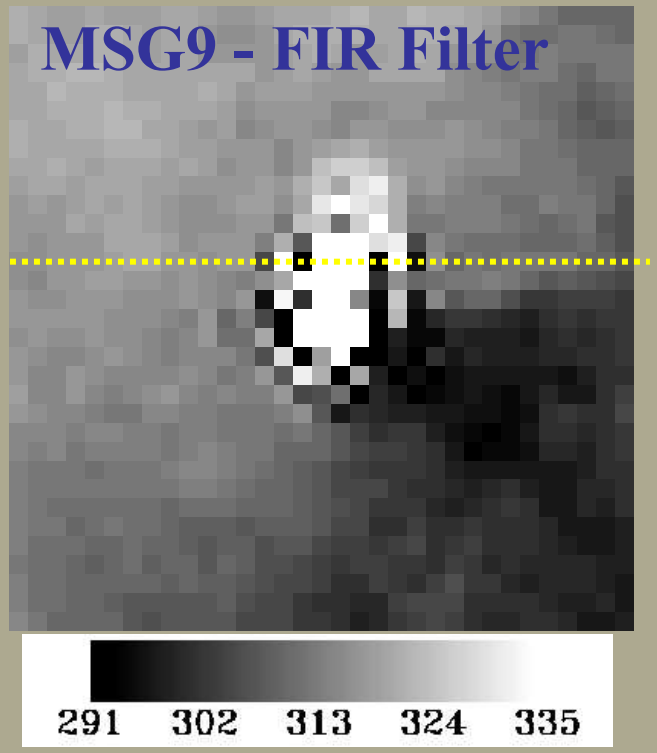
+

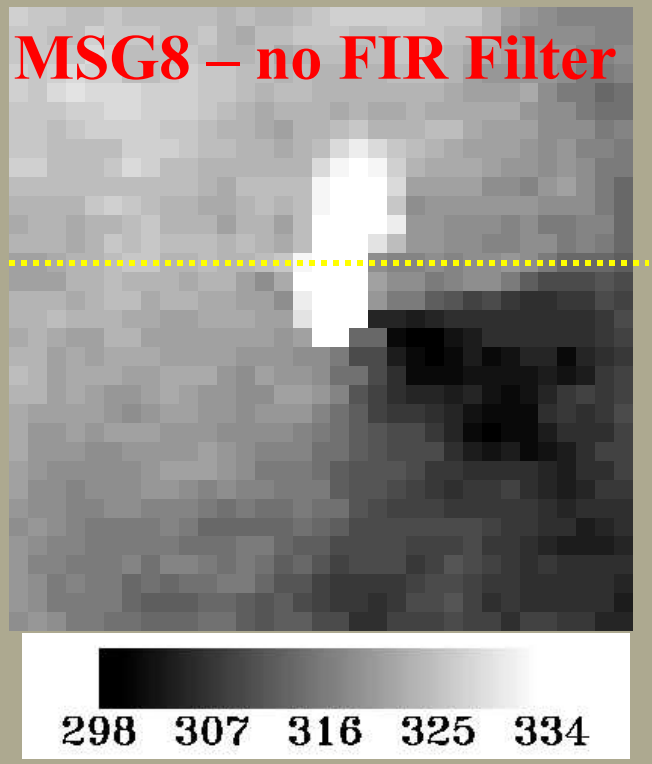


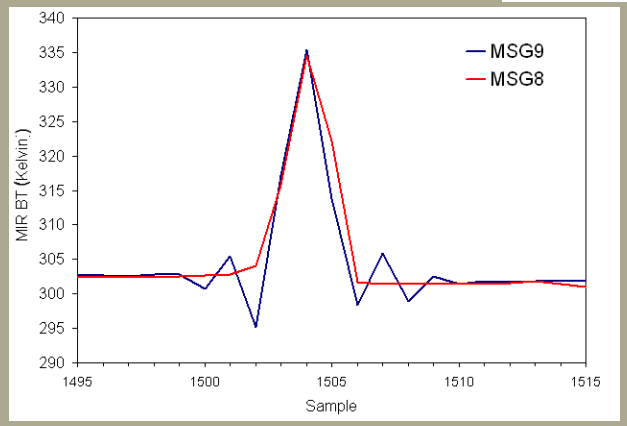




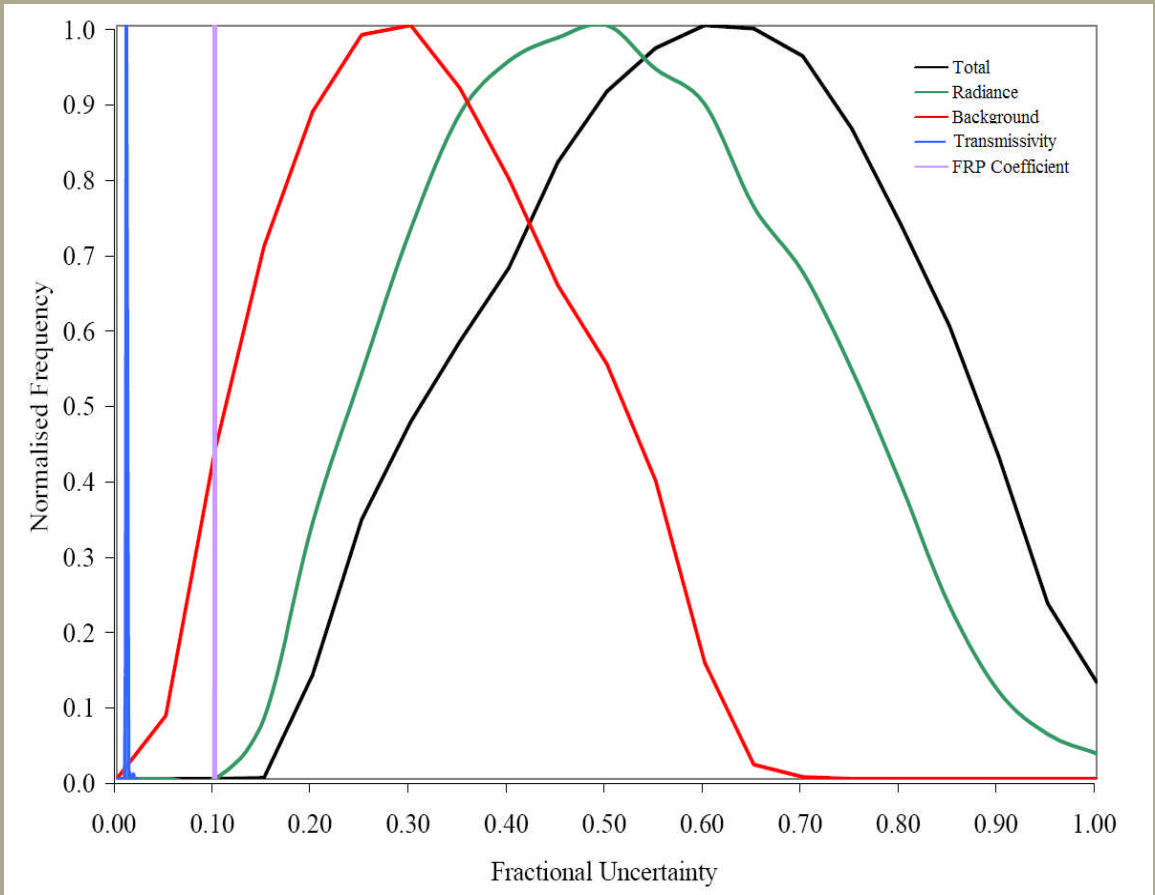
Analysis of real data – FIR filter removed on MSG8





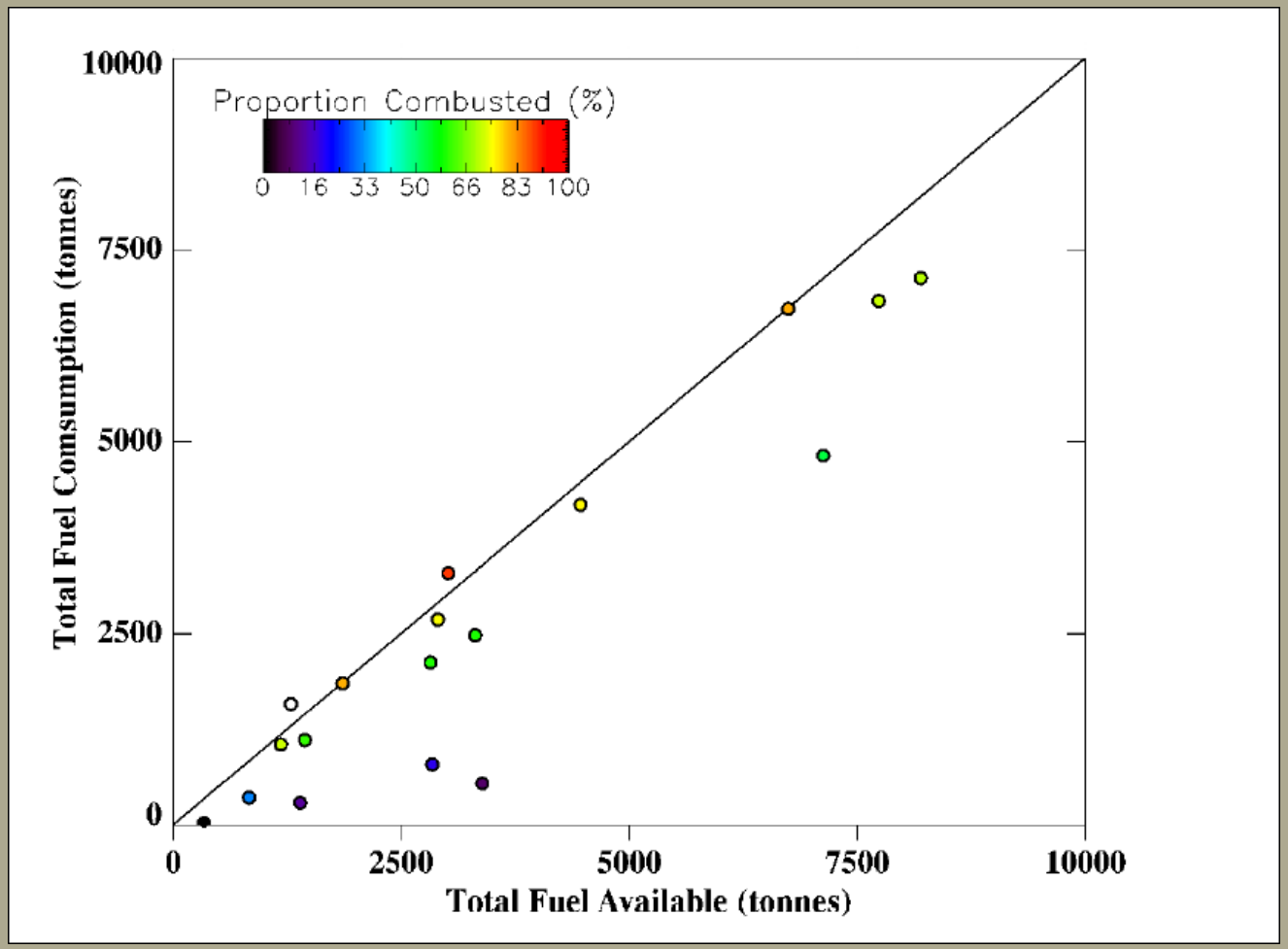


FRP Per-Pixel Error Budget

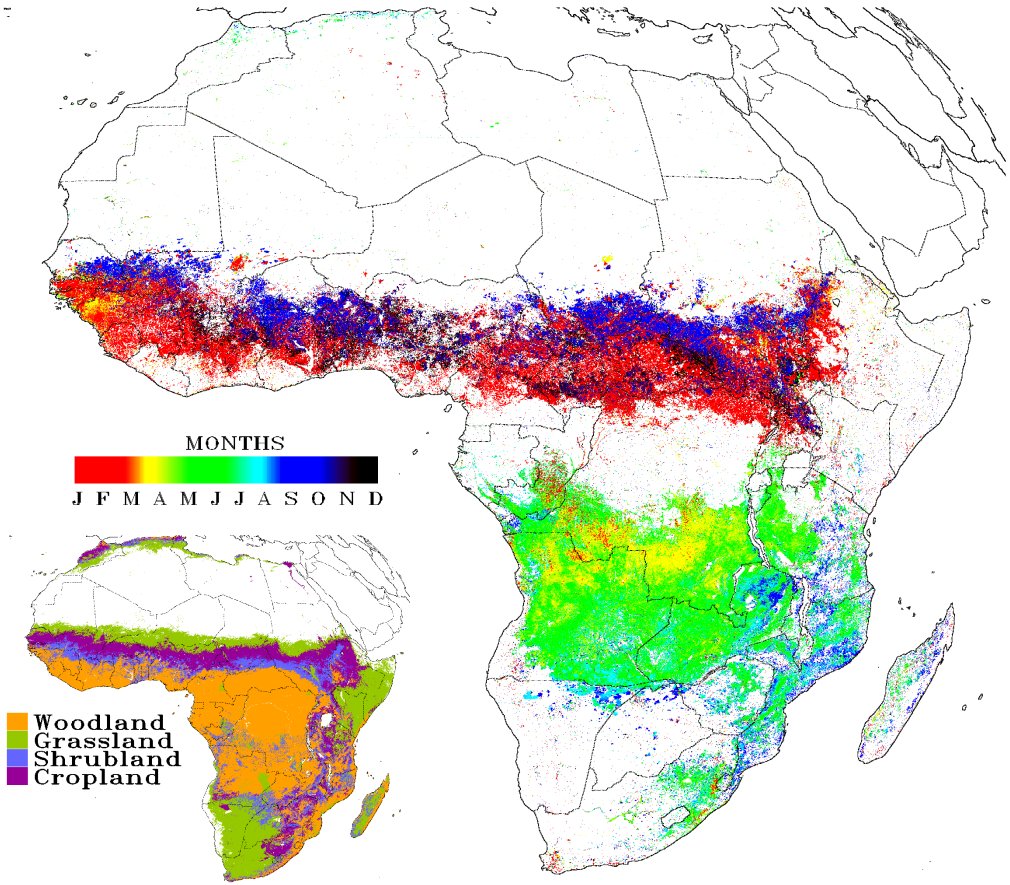


Radiance = Uncertainty in Fire Pixel Radiance Measure
Background = Variation in Pixel Background Window Radiance
Transmissivity = Uncertainty in Atmospheric Transmission
FRP Coefficient = Uncertainty derived from Planck Function Approximation

FRE-Derived Fuel Consumption vs Fuel Load

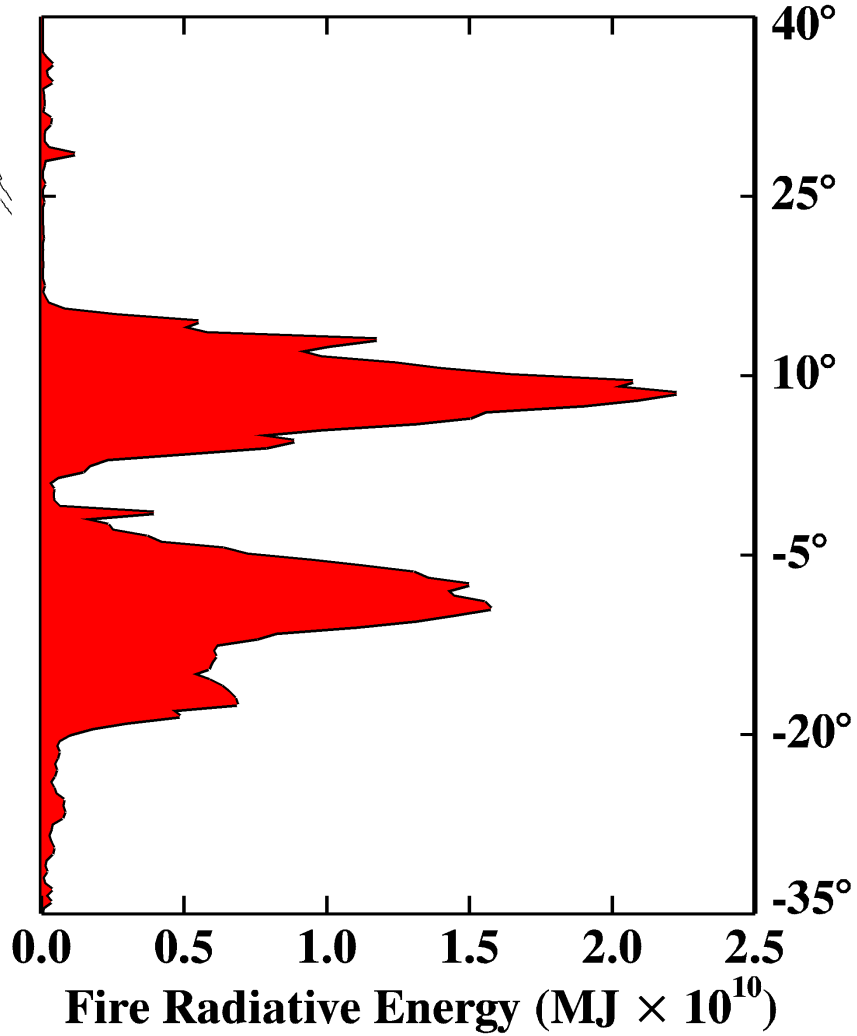


Fire Seasonality and Location

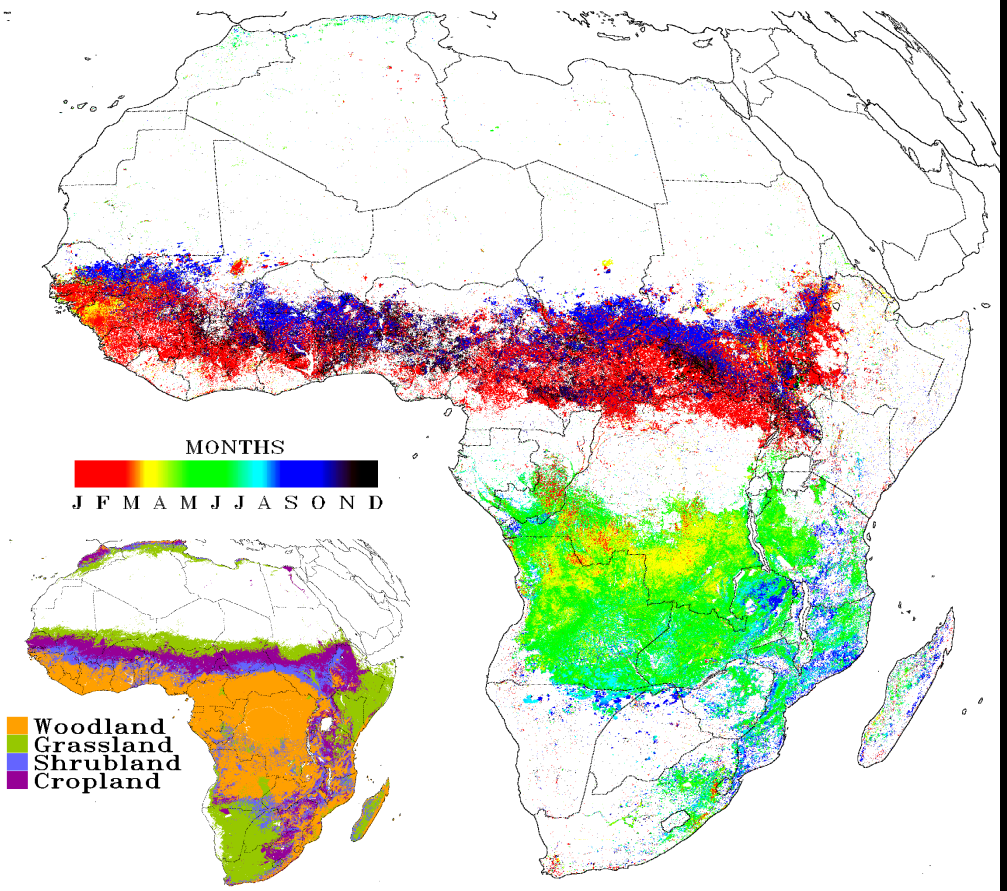


[Very strong seasonal cycle]

Latitudinal Emissions Variation

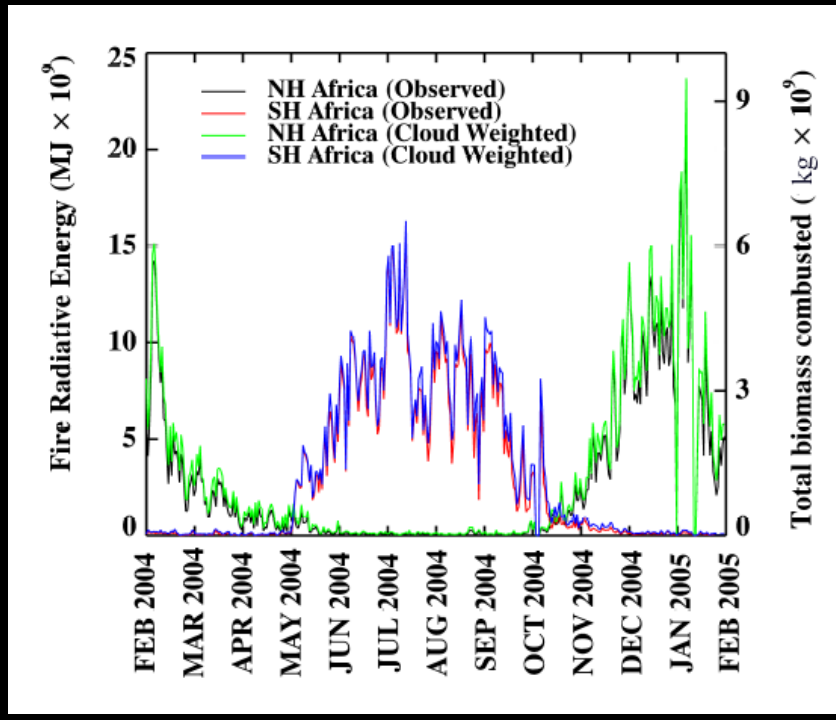


Fire Seasonality and Location



[Very strong seasonal cycle]

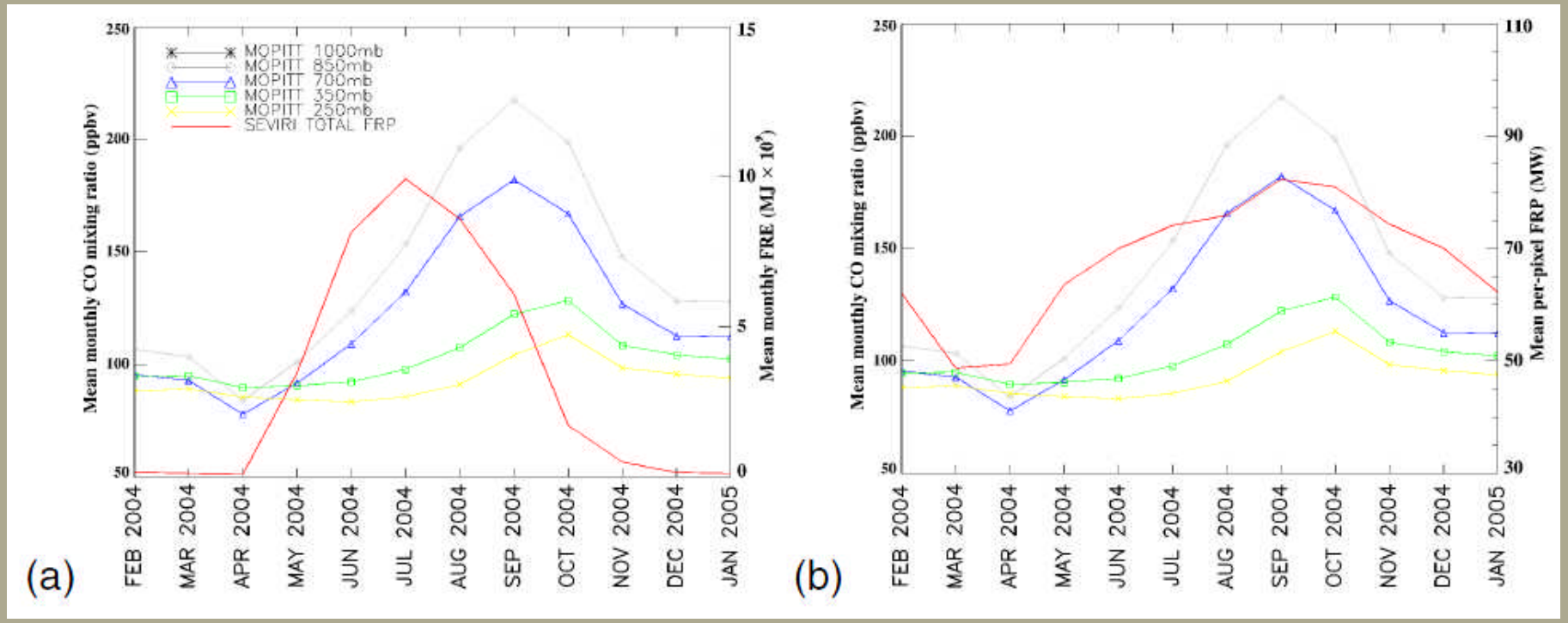
Temporal Emissions Variation



→ *NH Africa 362 - 414 Tg*

→ *SH Africa 402 - 440 Tg*

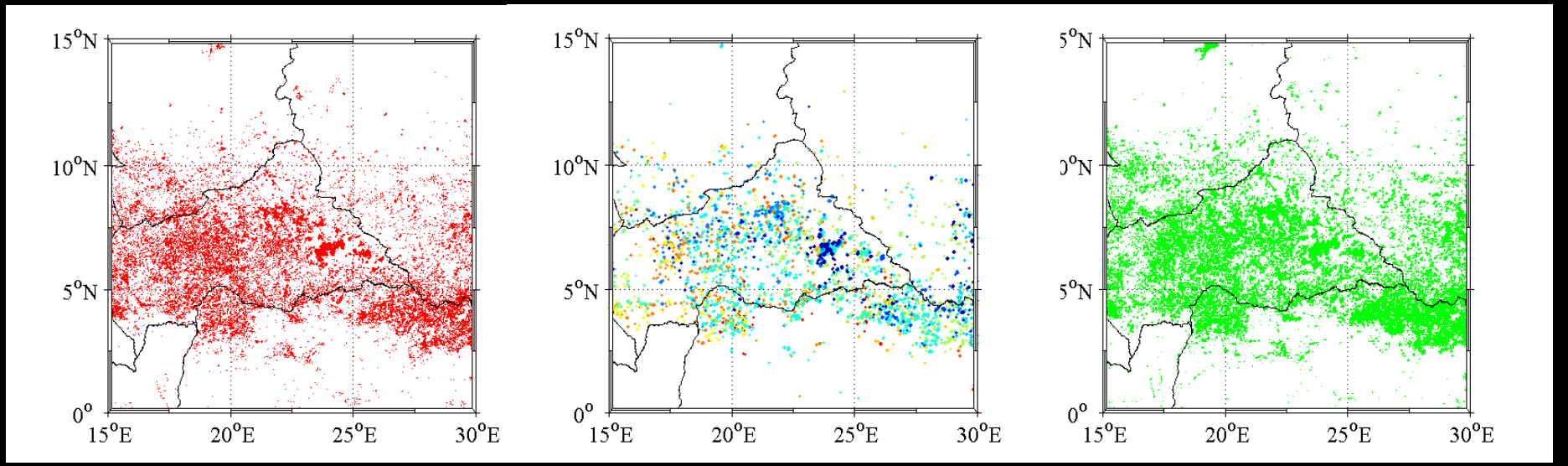
SEVIRI FRP vs MOPITT CO



Total FRP over southern Africa

Mean Per-Pixel FRP over southern Africa

MODIS & SEVIRI Fire Detection Comparison

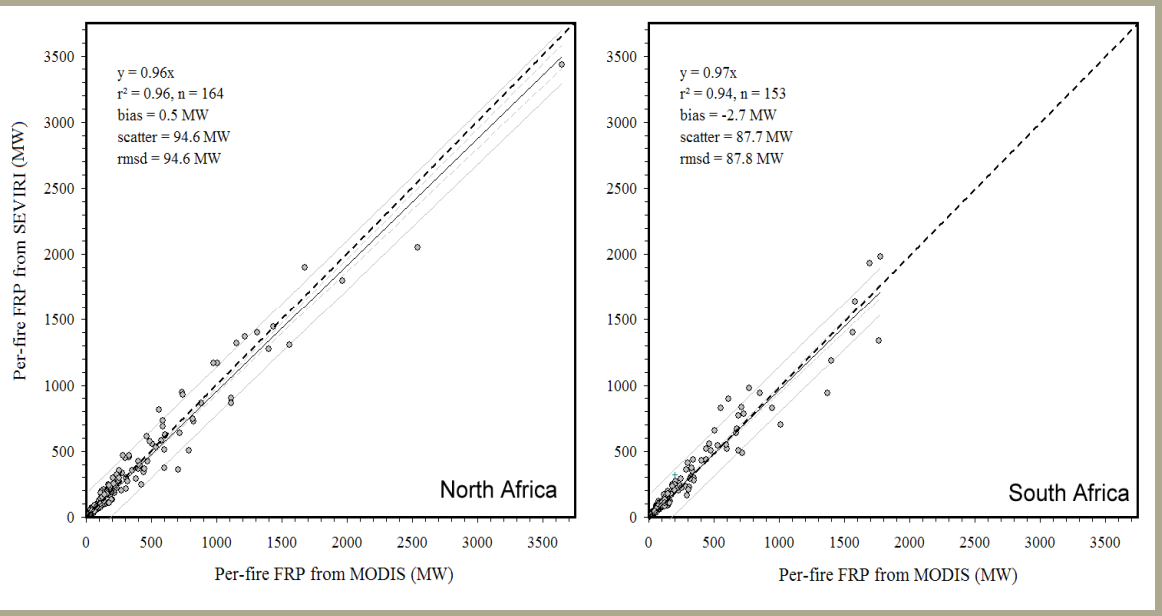


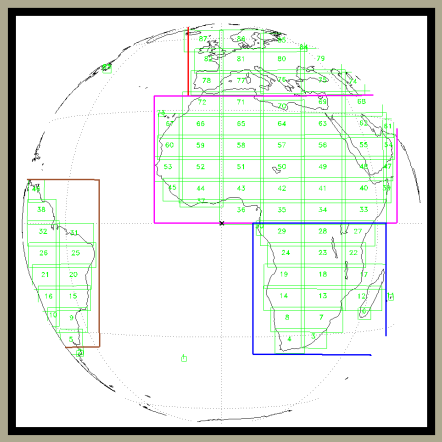
All MODIS detections
01 – 14 Feb 2004

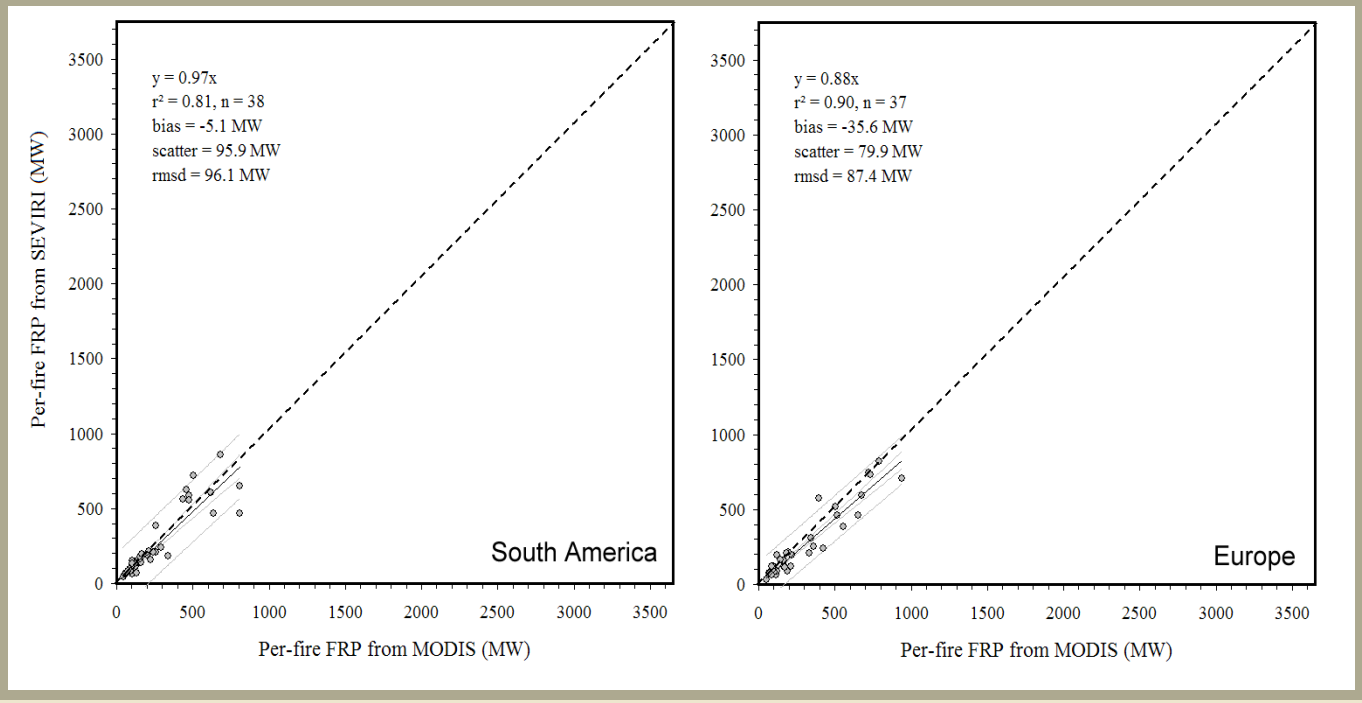
SEVIRI detections at MODIS overpass times only (± 6 minutes)
01 – 14 Feb 2004

All SEVIRI detections for all SEVIRI timeslots
01 – 14 Feb 2004

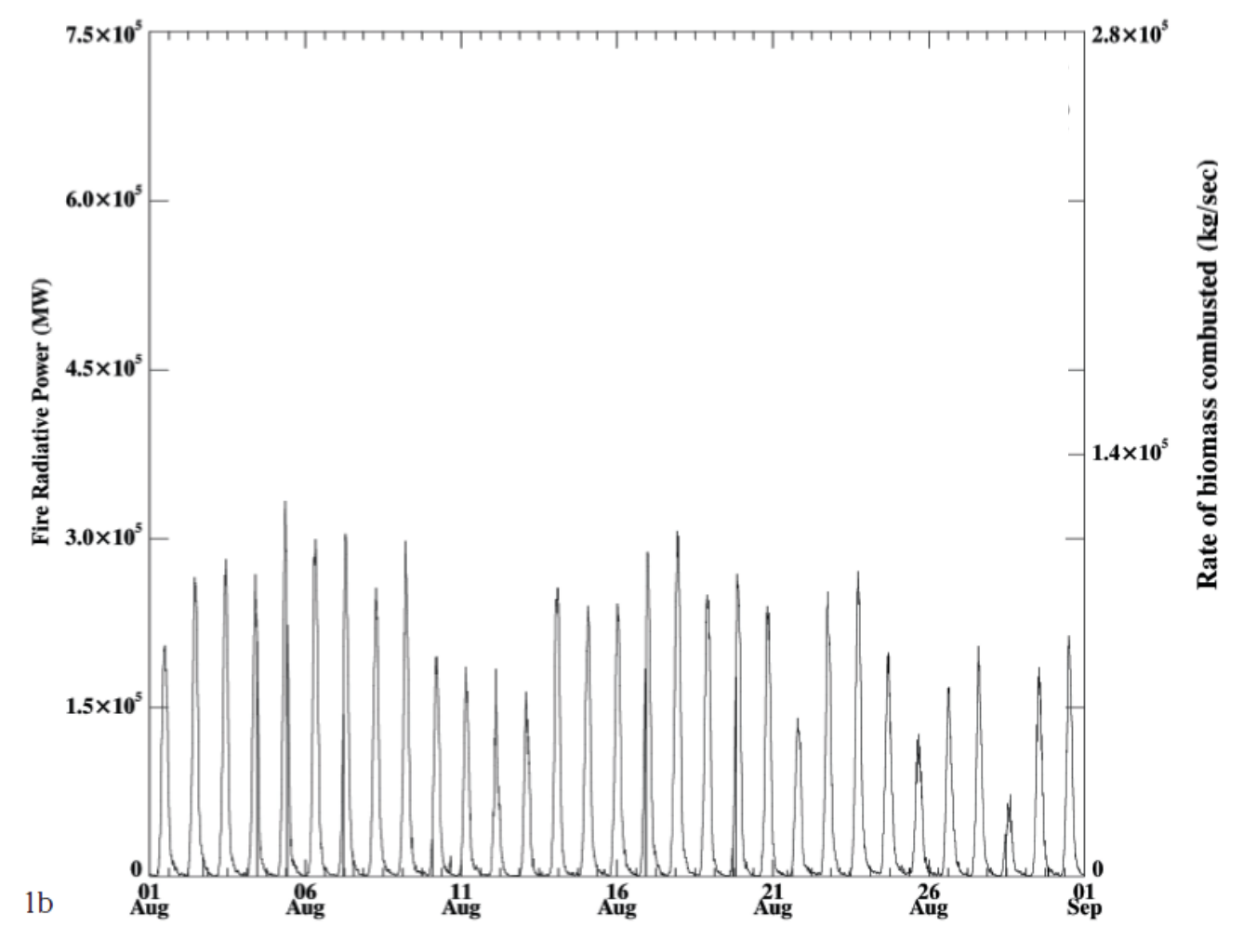
SEVIRI vs MODIS FRP Intercomparison



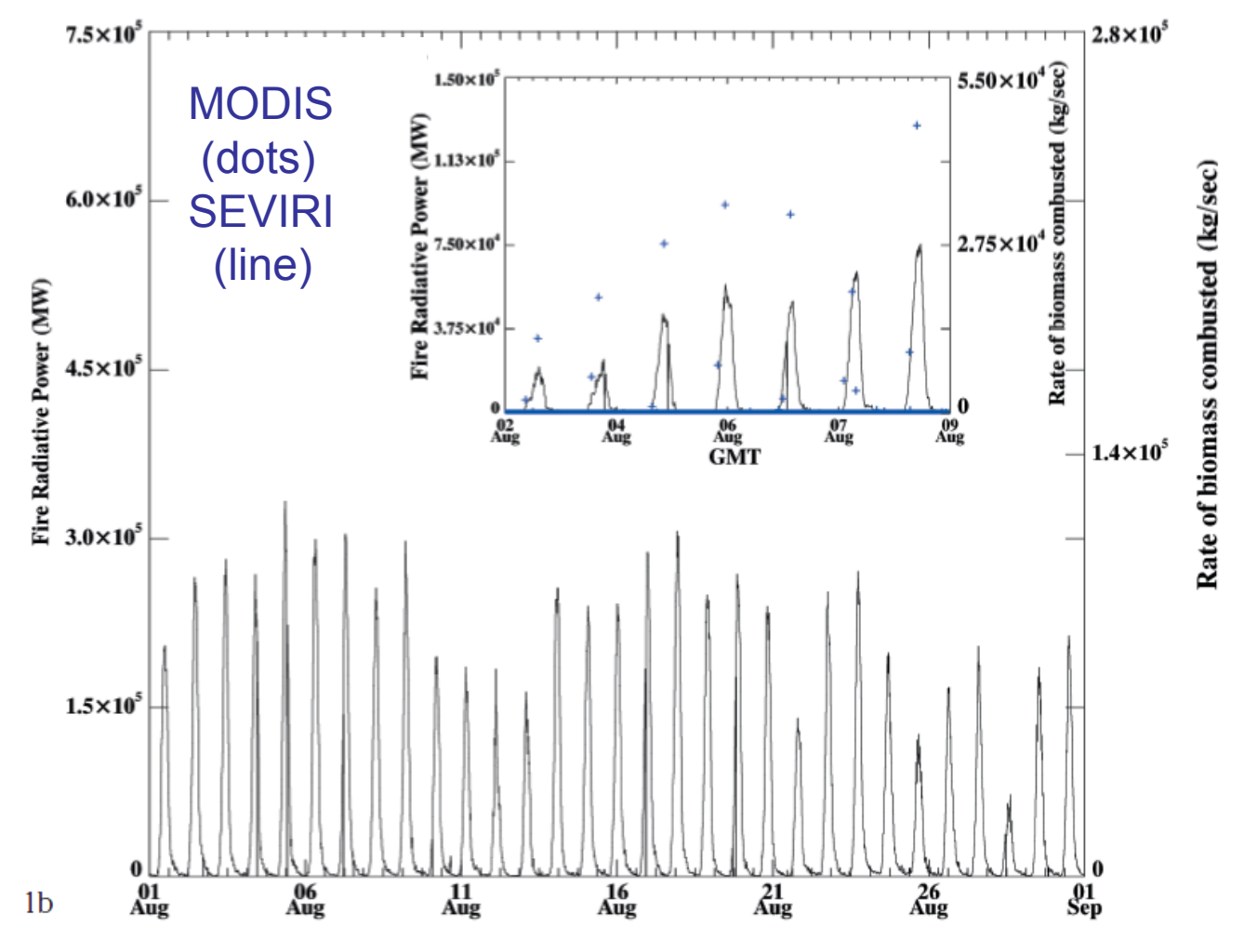




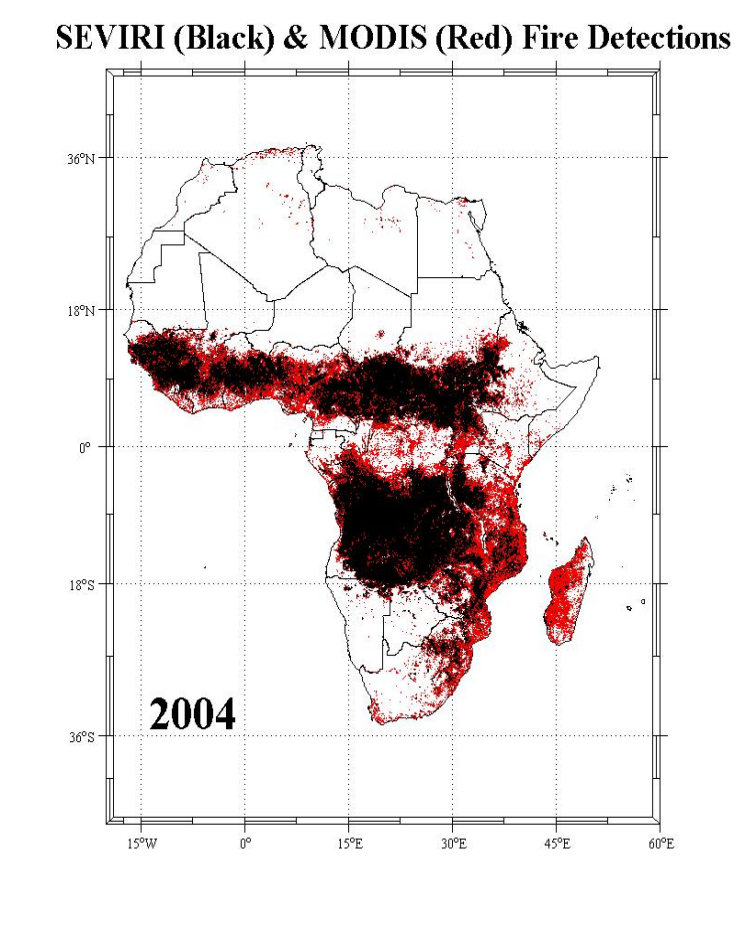
Comparing MODIS and SEVIRI Record

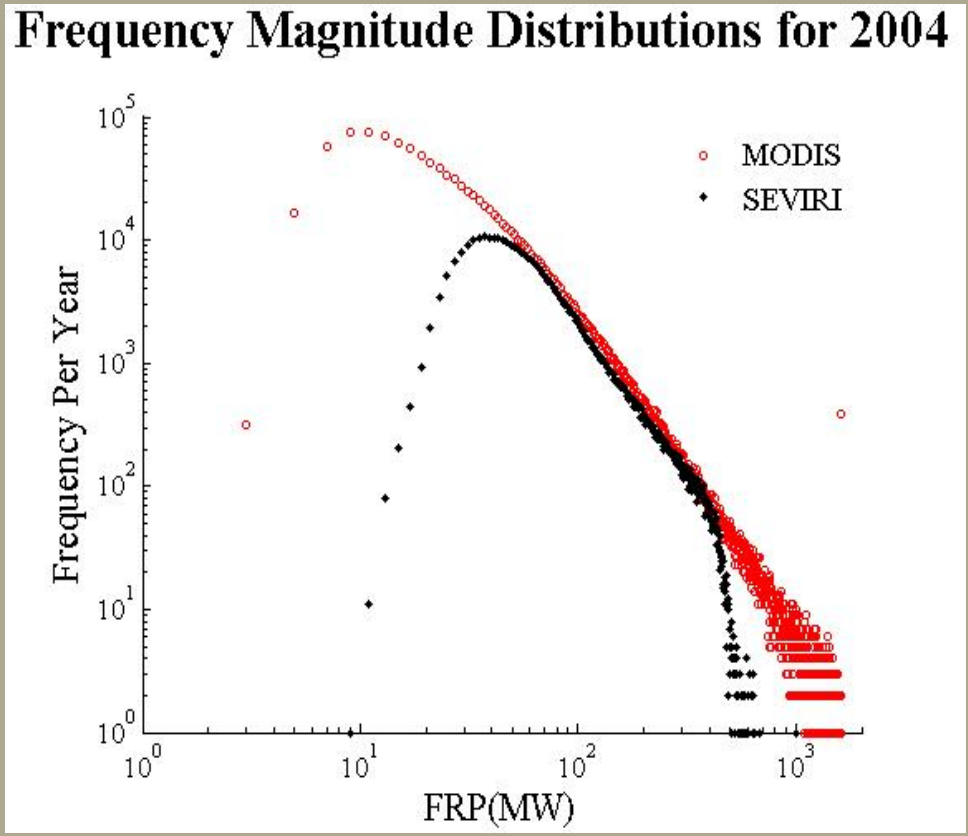


Comparing MODIS and SEVIRI Record

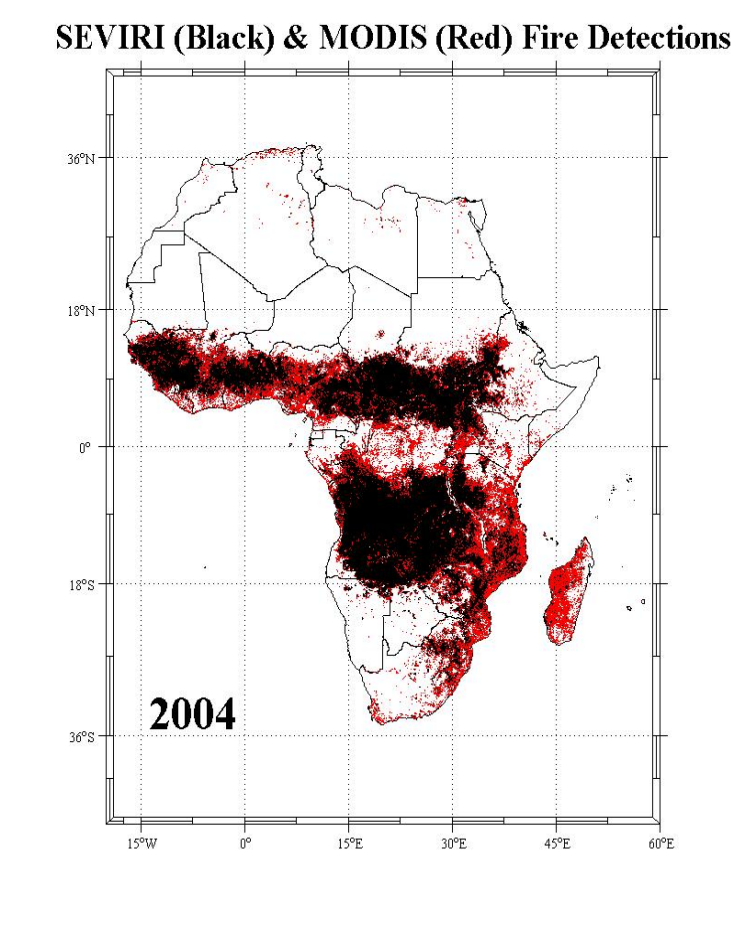


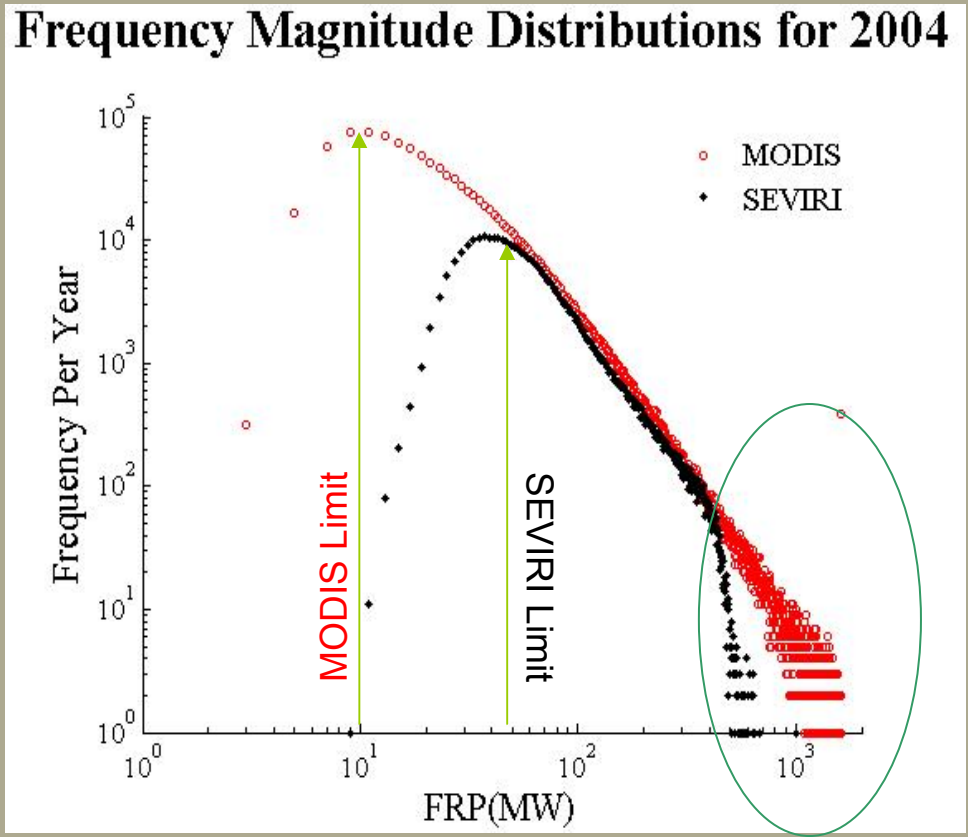
FRP Statistical Distributions SEVIRI *vs* MODIS





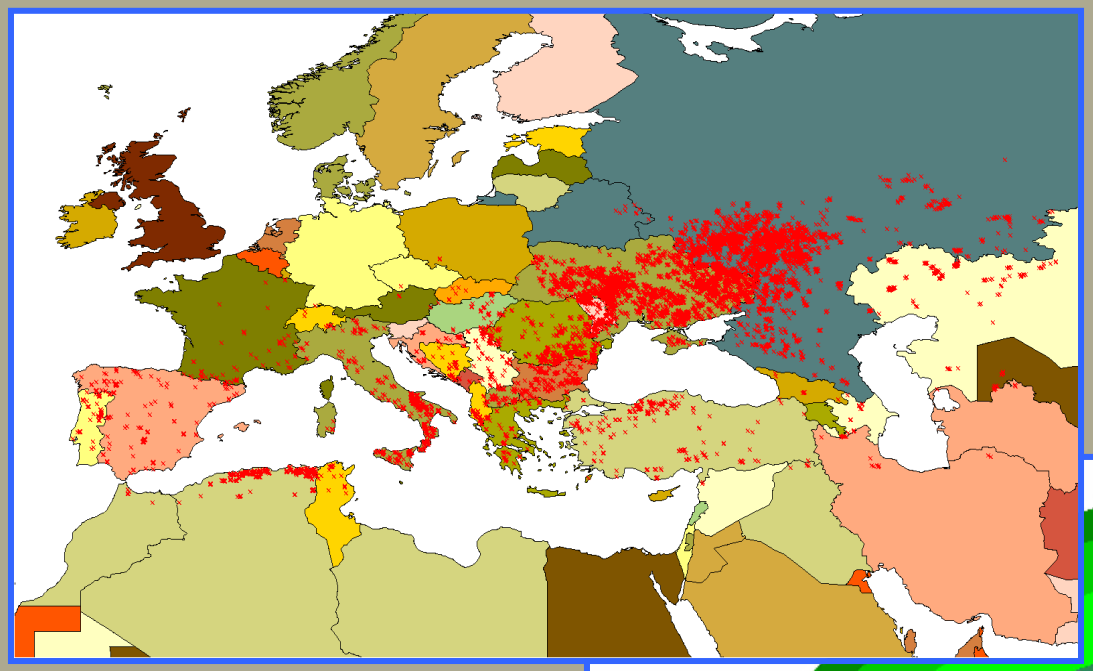
FRP Statistical Distributions SEVIRI *vs* MODIS



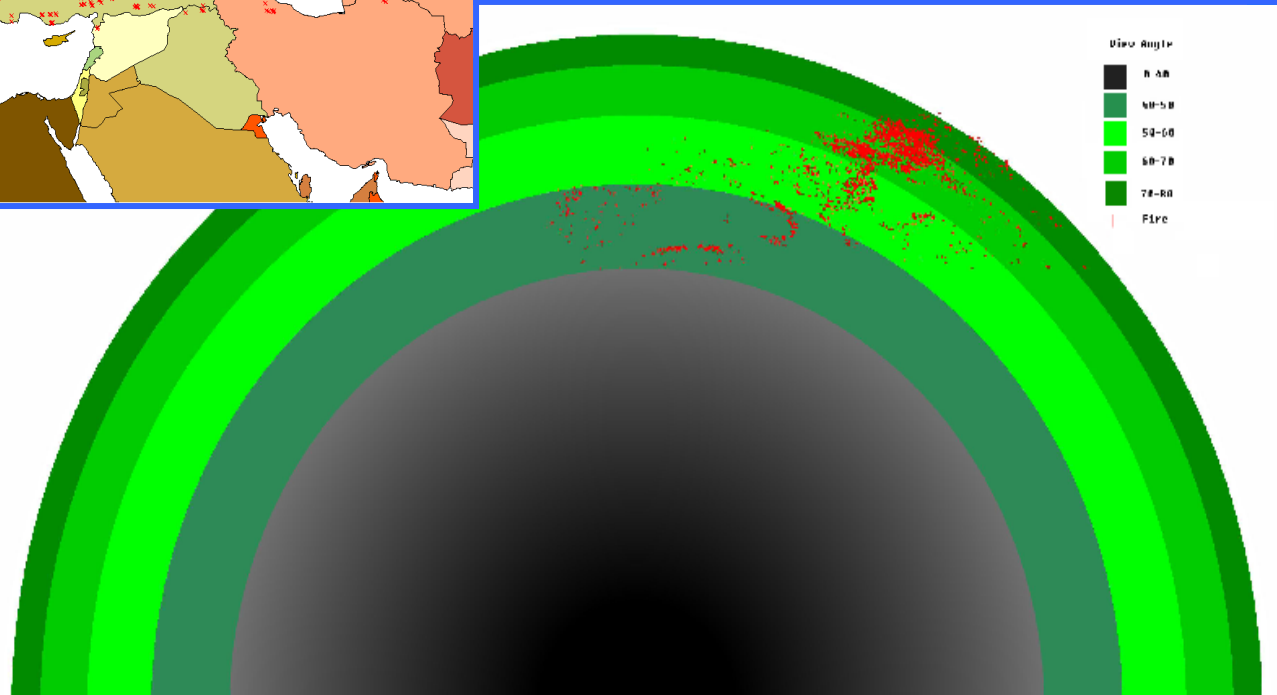


sensor saturation

View Worsens at High Zenith Angles



Europe LSA SAF
Region 9 – 17 Aug 08

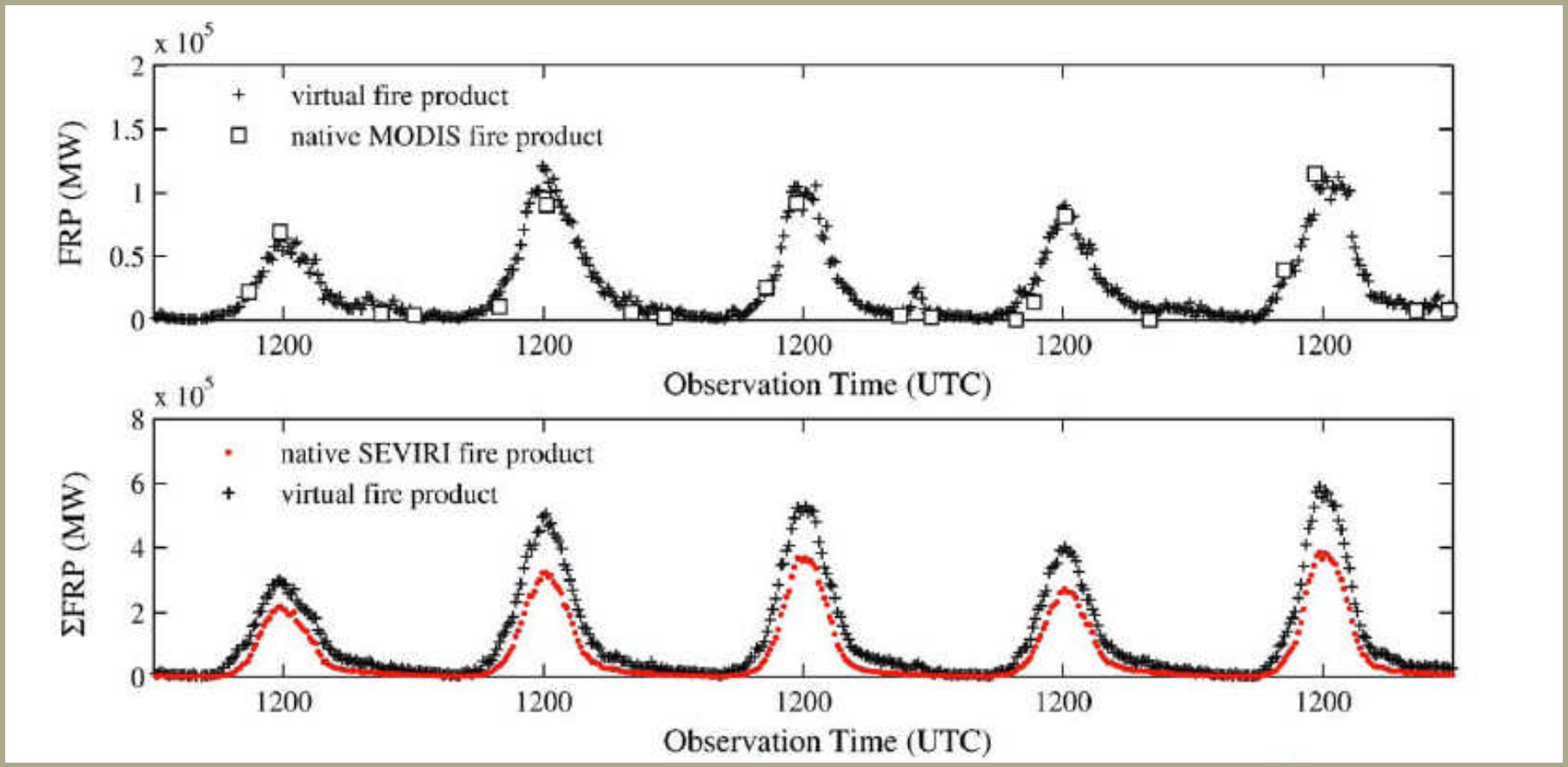


In Europe most fires are in East and have have SEVIRI view zenith angle > 60°

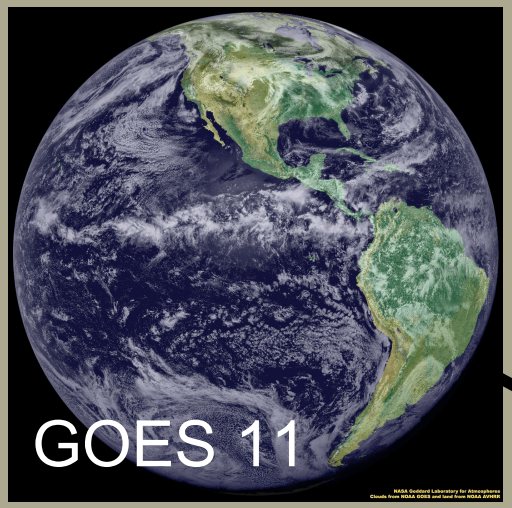
FRP_PIXEL per-area comparison to MODIS

	Image Dates (2008)	Fire Detection Omission Error (%)	Fire Detection Comission Error (%)	Slope of linear best fit between SEVIRI-to-MODIS per-fire FRP	Slope of linear best fit between SEVIRI-to-MODIS per-area FRP
North Africa	1 - 8 Dec	62%	8%	0.96	0.91
South Africa	19 - 24 Aug	71%	6%	0.97	0.80
South America	14 - 24 Aug	85%	9%	0.97	0.30
Europe	9 - 17 Aug	95%	1%	0.88	0.13

Combining Polar and Geostationary Data to Synthesize Improved Product

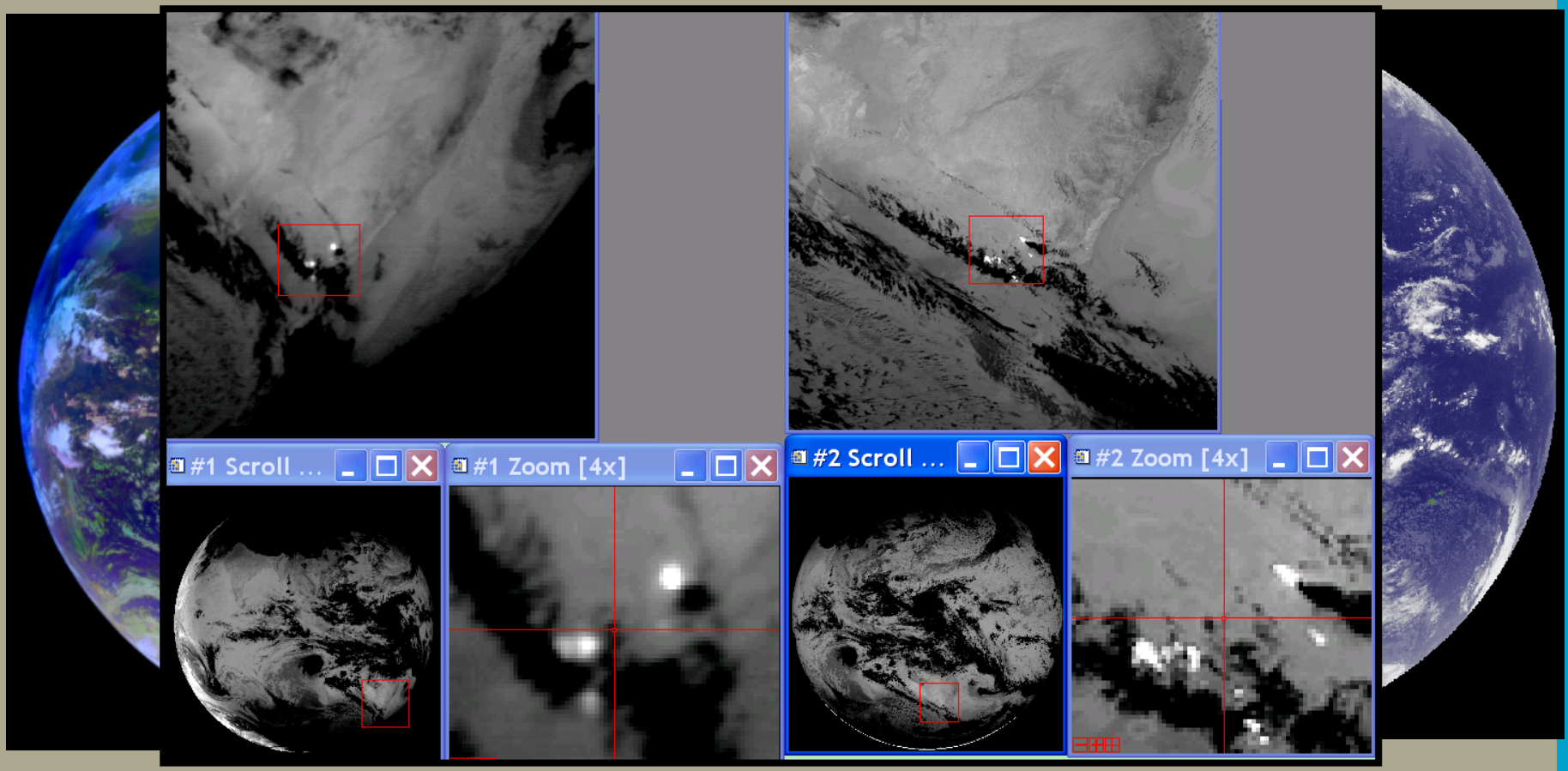


GOES FRP System Prototype



GOES-detected fires (red)
Superimposed on landcover map

Asian Geostationary Systems



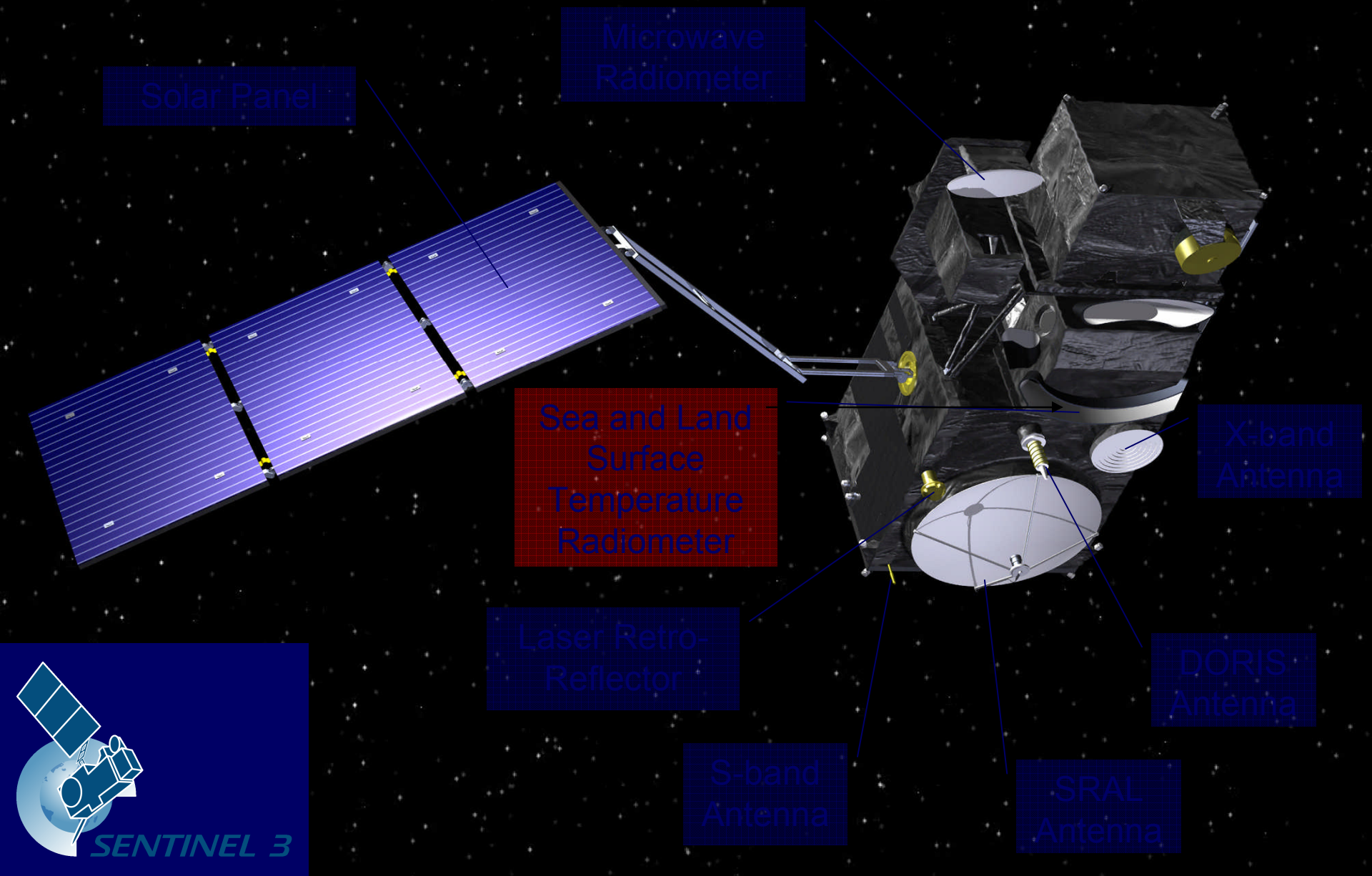
105° E

140° E

FY2C (China)

MTSAT (Japan)

Sentinel-3 Spacecraft



Sea & Land Surface Bands

- absolute rad. accuracy (S1-S6) : <5% (EOL) <2% (BOL)
- absolute rad. accuracy (S7/8/9) : 0.2 K
- polarisation sensitivity < 0.07 (S1-S6) or < 0.10 (S7/8/9)
- stability (S1-S6): <0.1%
- stability (S7/8/9): <0.08K

Band	λcenter [μm]	Δλ [μm]	SNR [-] / NeΔT [mK]	SSD [km]
S1	0.555	0.02	20	0.5
S2	0.659	0.02	20	0.5
S3	0.865	0.02	20	0.5
S4	1.375	0.015	20	0.5
S5	1.61	0.06	20	0.5
S6	2.25	0.05	20	0.5
S7	3.74	0.38	80 mK	1.0
S8	10.95	0.9	80 mK	1.0
S9	12	1.0	80 mK	1.0

AATSR heritage

SLSTR new bands

Active Fire Bands

Band	λcenter [μm]	Δλ [μm]	Tmax [K]	SSD [km]
F1	3.74	0.38	500	1.0
F2	10.95	0.9	400	1.0

SLSTR Channels

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Sea & Land Surface Bands

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AATSR heritage

SLSTR new bands

Do We Require Further Information on Small-Fires Component of the Fire Regime?

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- *Fire regime component with FRP < 10 MW is sampled by no sensor, but there are many fires in this region → thus they may release significant emissions.*

- ***Higher spatial resolution*** *data can tell us.*

- *May allow* ***site-specific emissions*** *factors (P_{flame}).*

- *In global fire record from BIRD hi-res data ~ 98% of total FRP comes from fires capable of being seen by MODIS.*

- *93% by fires capable of being seen by SEVIRI.*

- *But likely to be strongly biased….*