Satellite Observations of Land Cover Change, Biomass Burning and Transboundary Haze Pollution in Insular Southeast Asia

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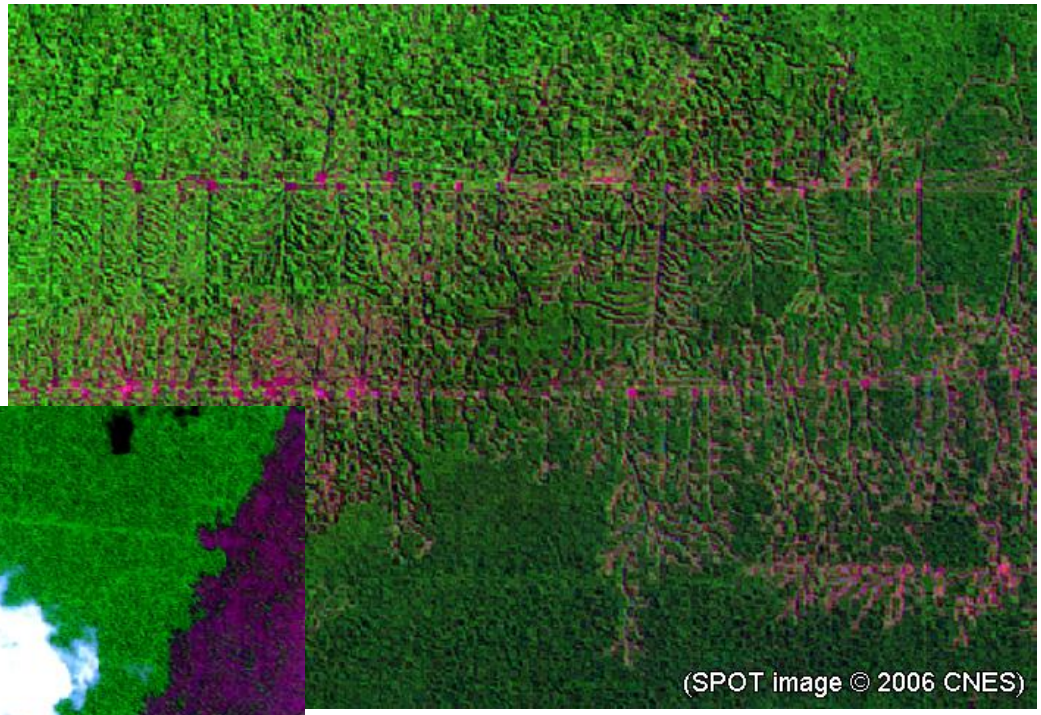
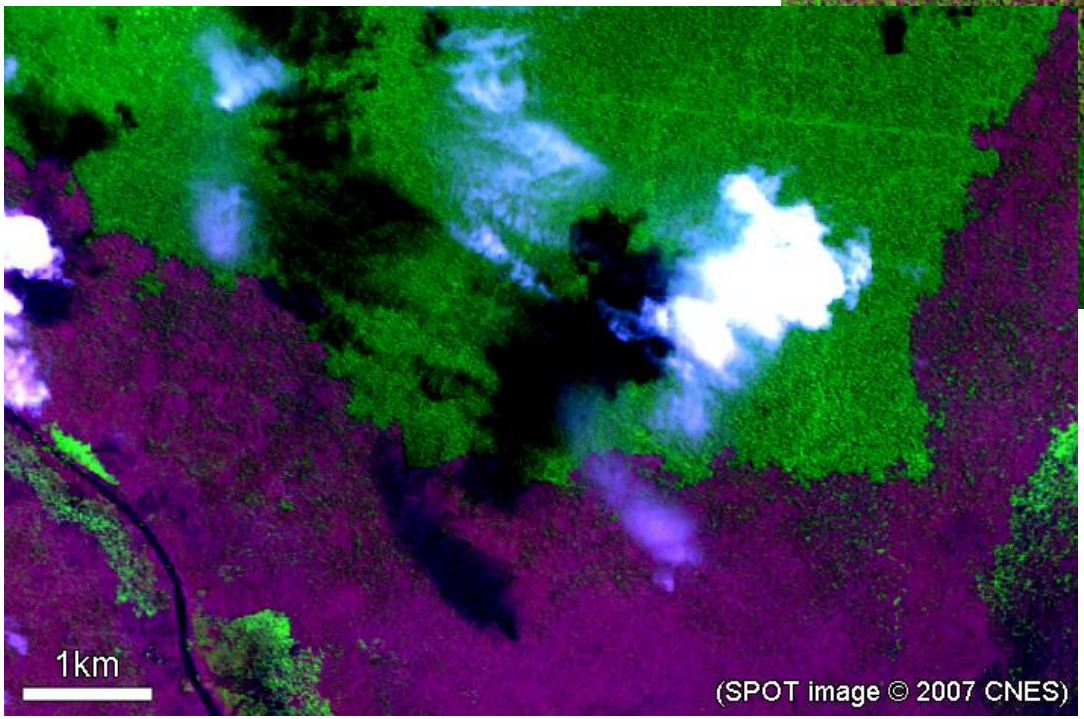
Land cover change in insular Southeast Asia

Degradation of forest





Deforestation…

Land cover change in insular Southeast Asia

Draining peatlands

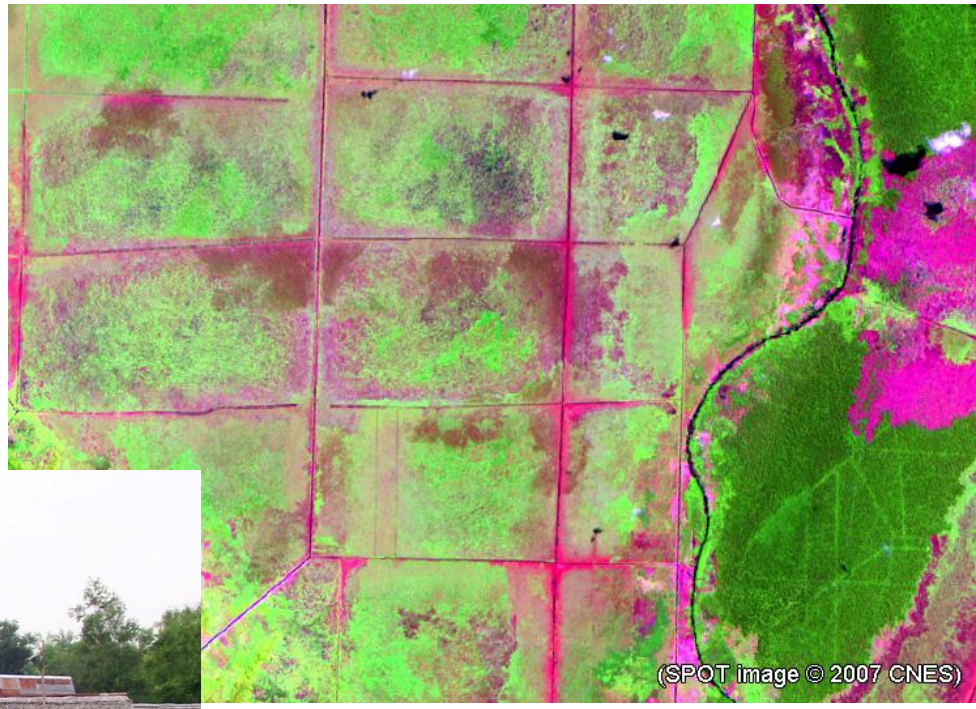
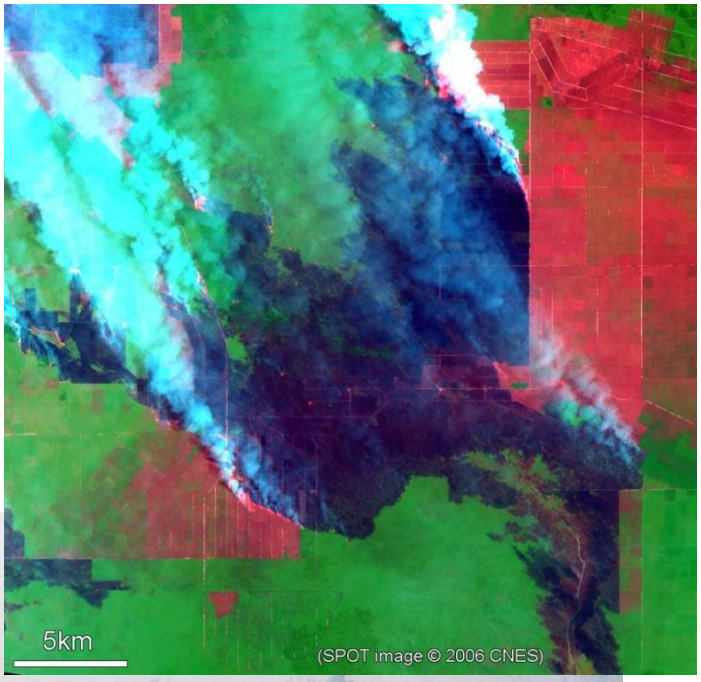


photo © Jukka Miettinen 2006-2007

Land cover change in insular Southeast Asia

Fires…



photos © Jukka Miettinen 2006-2007

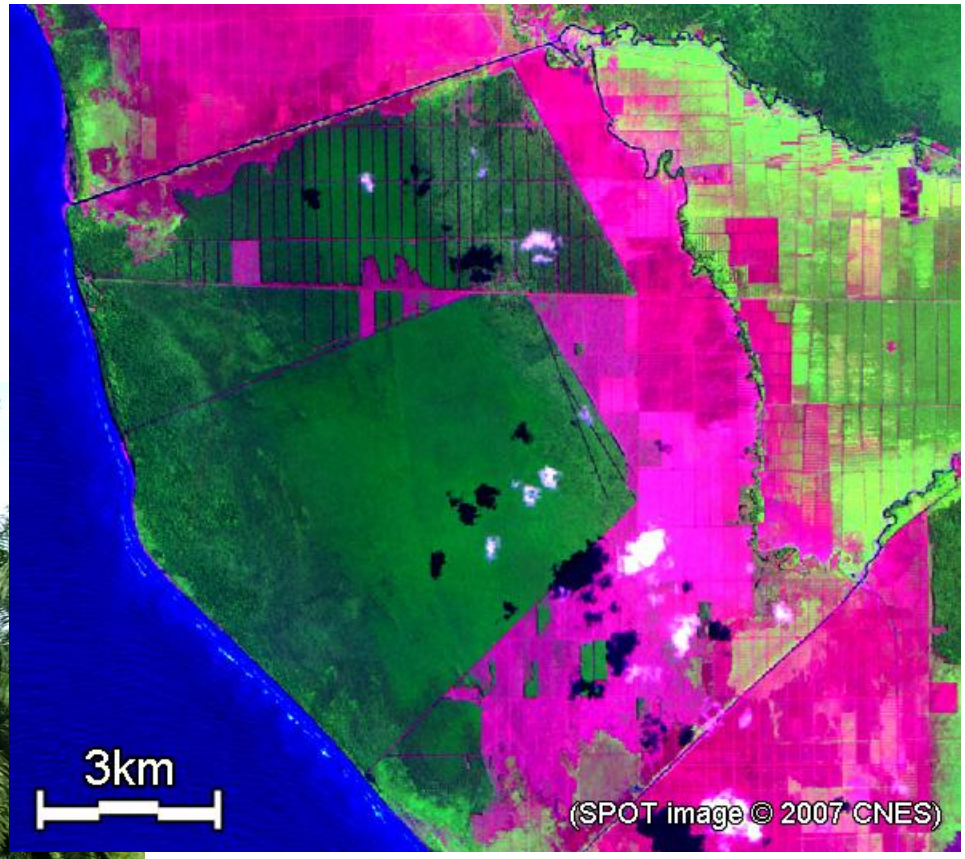
Land cover change in insular Southeast Asia

Transboundary haze …

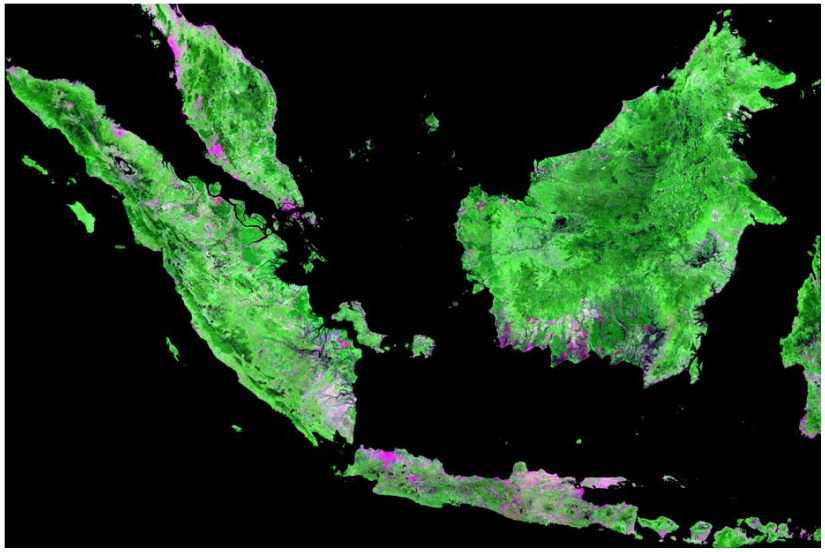
Land cover change in insular Southeast Asia

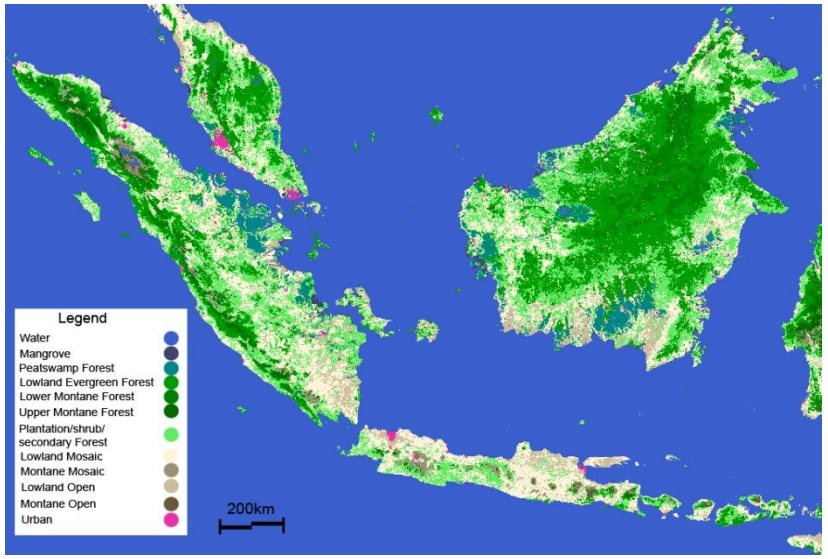
Plantation Development

photo © Jukka Miettinen 2006-2007



Regional land cover classification





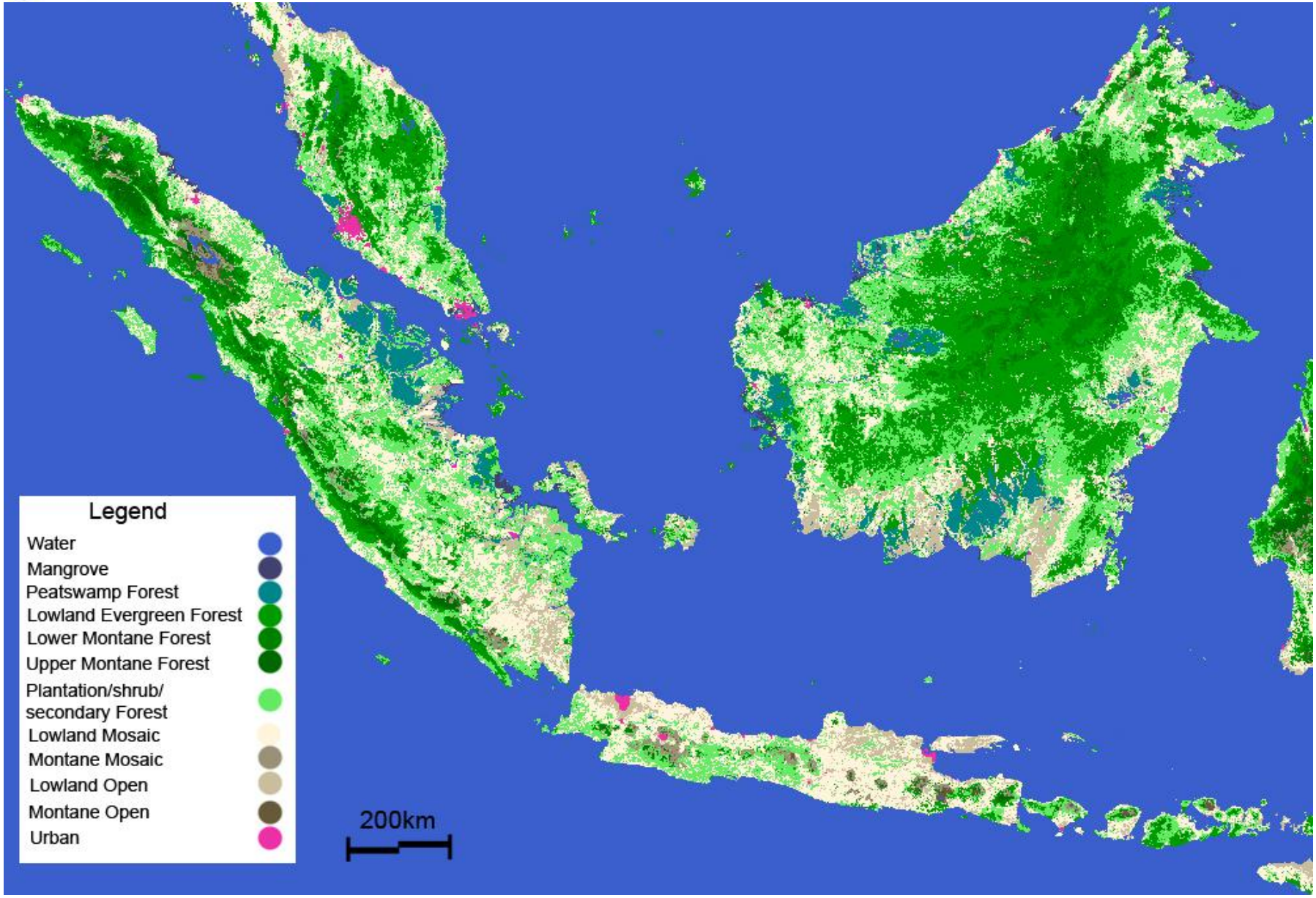
500m resolution MODIS mosaic

500m resolution land cover map

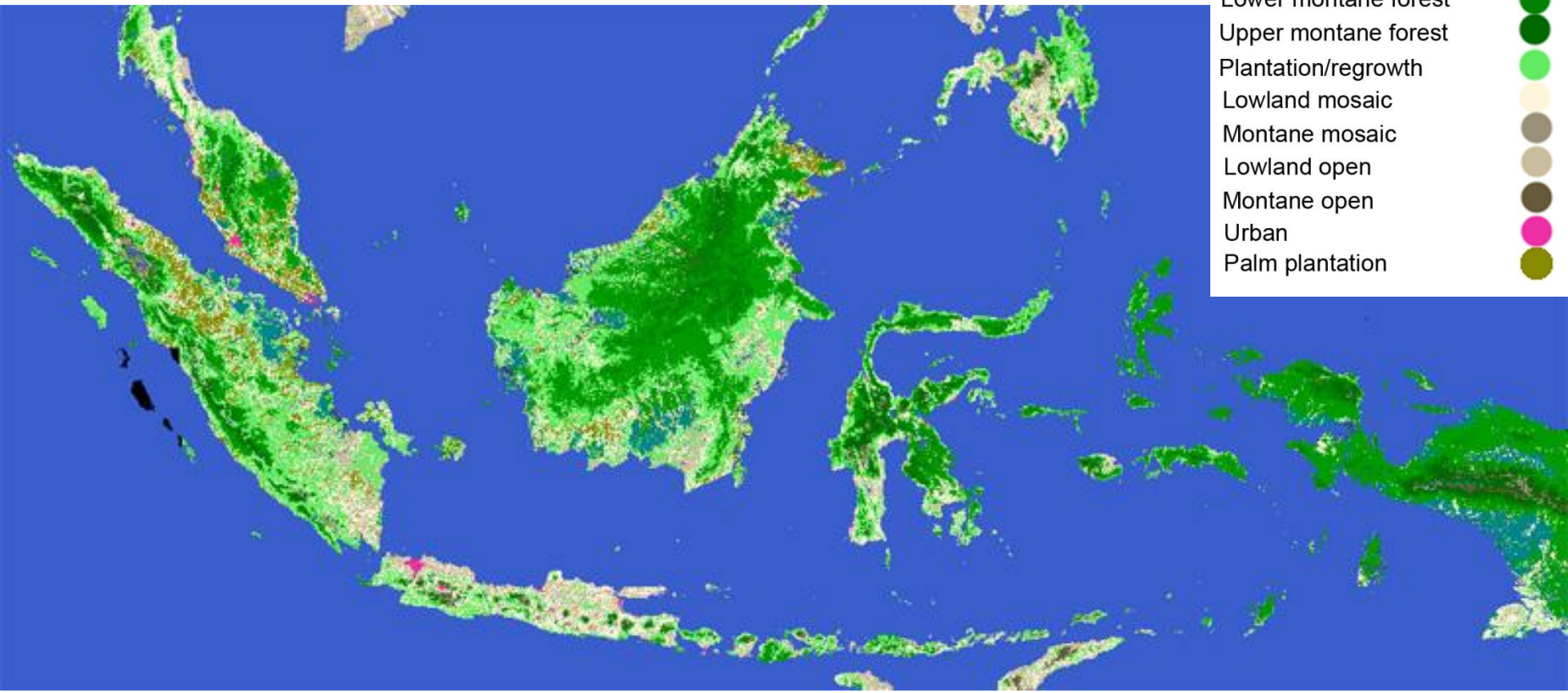
Miettinen, J., Wong C.M and Liew S.C. (2008). New 500m spatial resolution land cover map of the western insular Southeast Asia region. *International Journal of Remote Sensing* 29: 6075-6081.

2007 land cover map (500m resolution)

Available at: http://www.eorc.jaxa.jp/SAFE/LC_MAP/



2010 land cover map (250m resolution)



Results – deforestation rates by forest type

	Forest cover (2000)		Forest cover (2010)		Change 2000-2010		
	Kha	%	kha	%	kha	%	%/year
Mangrove	2706	1.2	2367	1.1	-339	-12.5	-1.3
Peat swamp forest	13970	6.4	11214	5.1	-2756	-19.7	-2.2
Lowland evergreen f.	70889	32.2	63020	28.7	-7869	-11.1	-1.2
Lower montane forest	18397	8.4	18019	8.2	-378	-2.1	-0.2
Upper montane forest	6574	3.0	6814	3.1	240	3.6	0.4
Total forest area	112536	51.2	101434	46.1	-11102	-9.9	-1.0

From Miettinen, Shi and Liew, Global Change Biology (2011).

- Note the clearly highest deforestation rate in peat swamp forests.

- Estimates for the 1990's vary between 0.8%/a (Achard *et al.* 2002) for 1990-1997 and 1.5-1.7% for the entire decade (FAO 2006, Hansen *et al.* 2009).

Results – deforestation rates by sub-region

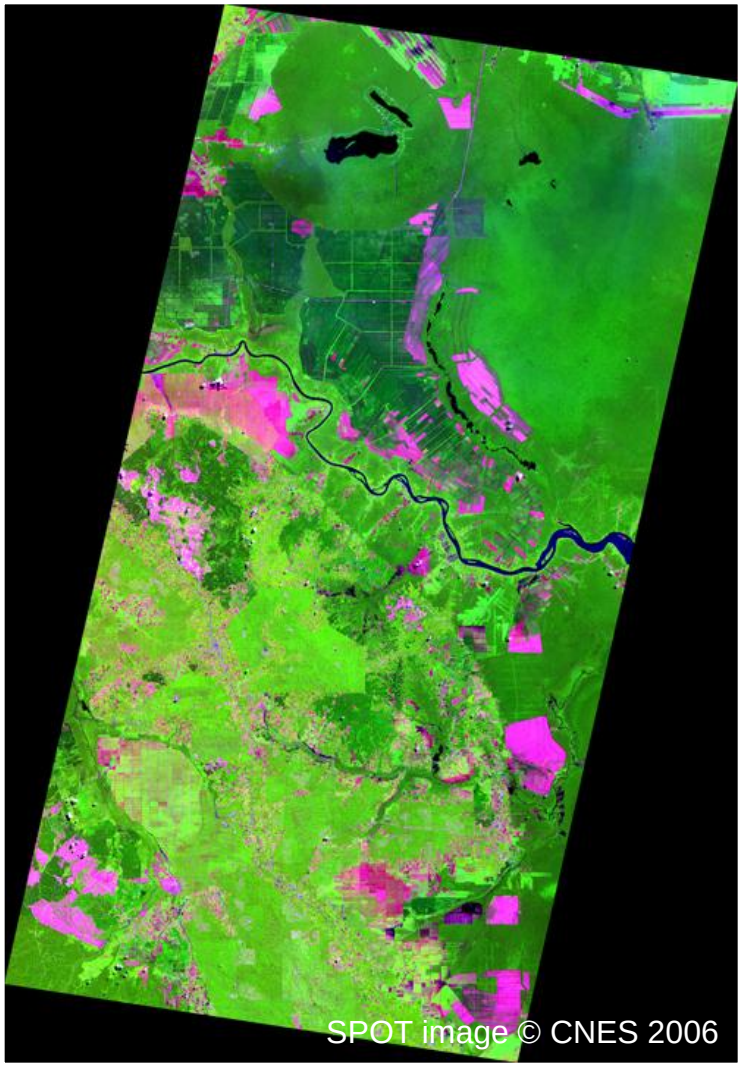
	Forest cover (2000)		Forest cover (2010)		Change 2000-2010		
	kha	%	kha	%	kha	%	%/year
Peninsular Malaysia	5388	41.1	4947	37.7	-441	-8.2	-0.9
	287	*2.2*	*235*	*1.8*	*-52*	*-18.0*	*-2.0*
Sumatra	14555	33.5	11104	25.5	**-3451**	-23.7	**-2.7**
	3131	*7.2*	*1839*	*4.2*	***-1292***	*-41.3*	***-5.2***
Borneo	41688	56.6	36688	49.8	**-5000**	-12.0	-1.3
	4182	*5.7*	*3144*	*4.3*	***-1038***	*-24.8*	***-2.8***
Java	866	6.8	902	7.1	37	4.2	0.4
	0.0	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*
Sulawesi	8959	53.0	7993	47.1	-966	-10.8	-1.1
	0.0	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*
New Guinea	31625	84.8	30859	82.7	-767	-2.4	-0.2
	6336	*17.0*	*5970*	*16.0*	*-366*	*-5.8*	*-0.6*
Indonesia	94867	51.3	86039	46.5	-8828	-9.3	-1.0
	12740	*6.9*	*10541*	*5.7*	*-2199*	*-17.3*	*-1.9*
Malaysia	17242	52.4	14962	45.4	-2281	-13.2	-1.4
	1230	*3.7*	*673*	*2.0*	*-557*	*-45.3*	***-5.9***

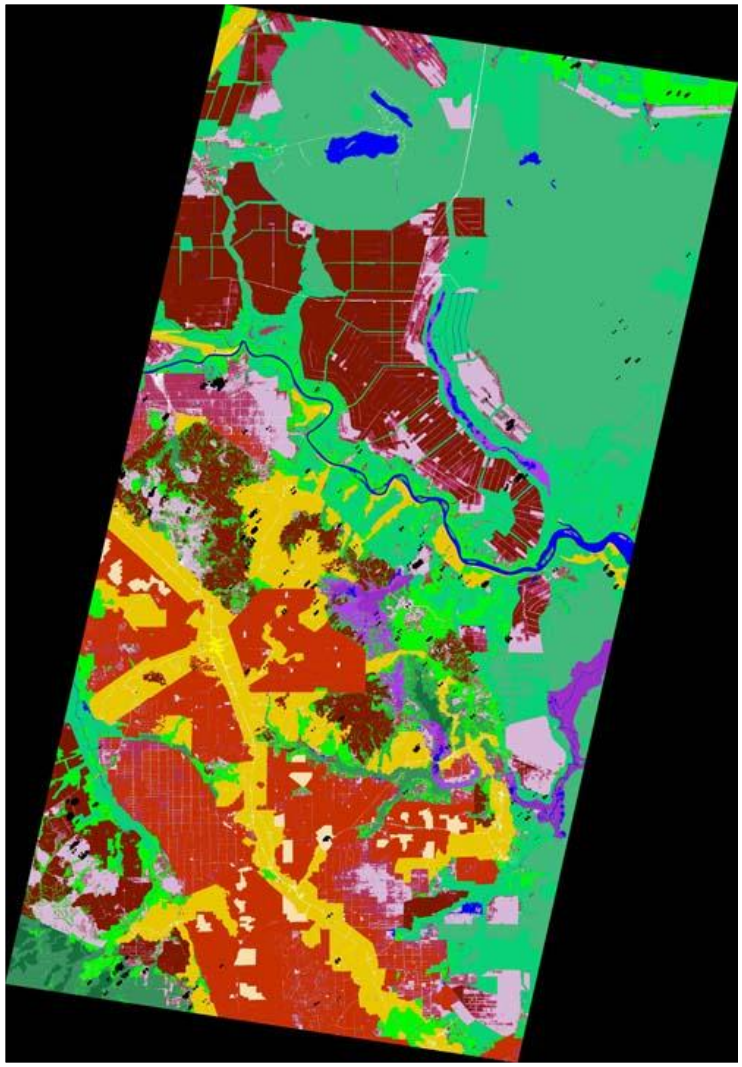
Note: The second row in each cell refers to forest cover on peatland only.

From Miettinen, Shi and Liew, Global Change Biology (2011).

Land cover classification
High resolution satellite data

SPOT satellite image → **Land cover classification map**

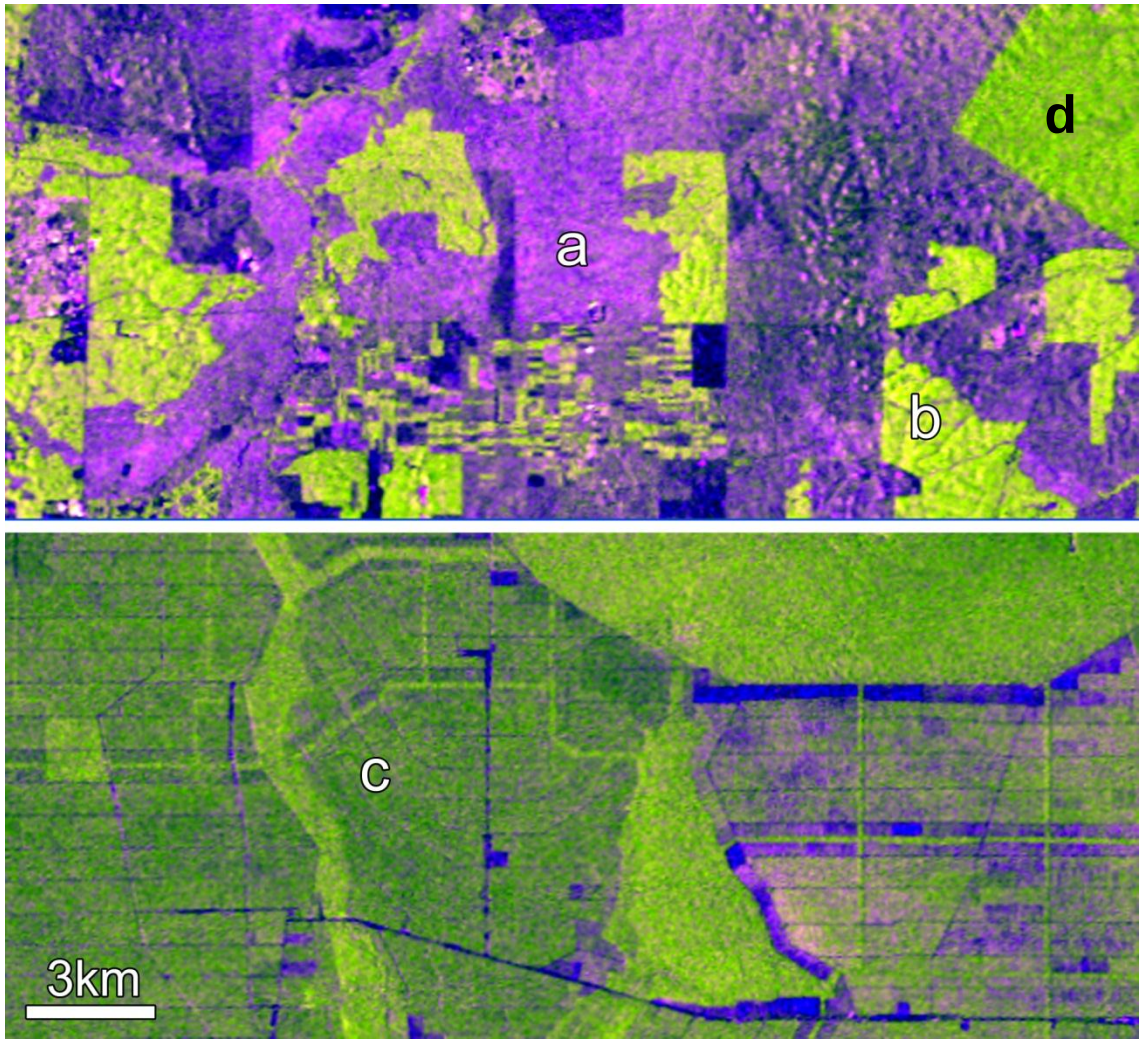




Legend

- Unclassified
- Primary forest (ph1) and Lowland f. (ph 2 &3)
- Secondary forest/ plantation (ph 1) and Secondary forest/ Small-holder pl. (ph 2&3)
- Shrub
- Clearance
- Paved/Constructed
- Water
- Acacia plantation
- Oil-palm plantation
- Degraded lowland forest
- Peatswamp forest
- Degraded peatswamp f.
- Swamp vegetation
- Degraded swamp veg.
- Settlement
- Major town
- Small-holder dominated area

ALOS PALSAR for detecting oil palm plantations



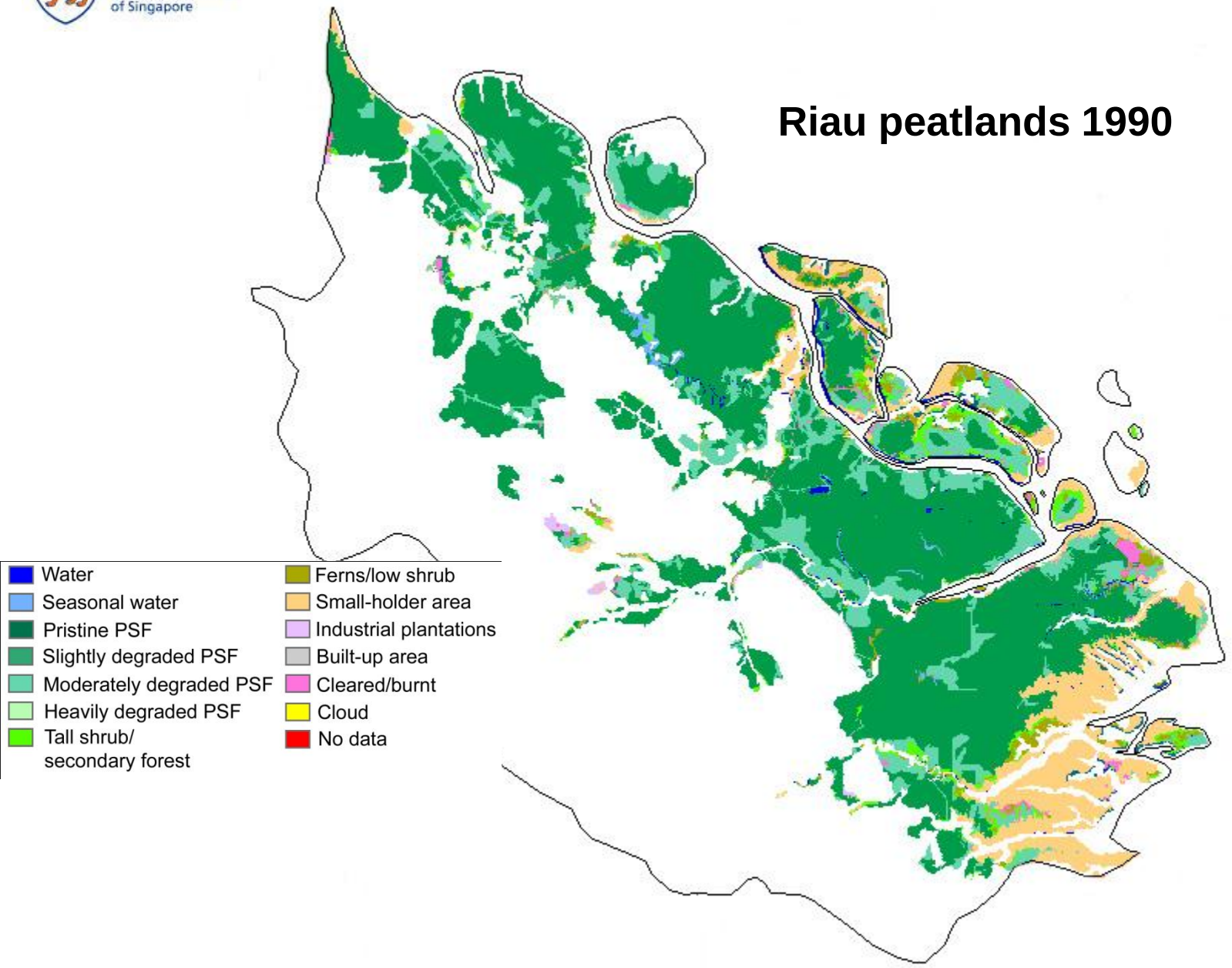
ALOS PALSAR
RGB:HH,HV,HH-HV

a. **Oil Palm**
b. **Rubber**
c. **Acacia**
d. **Forest**

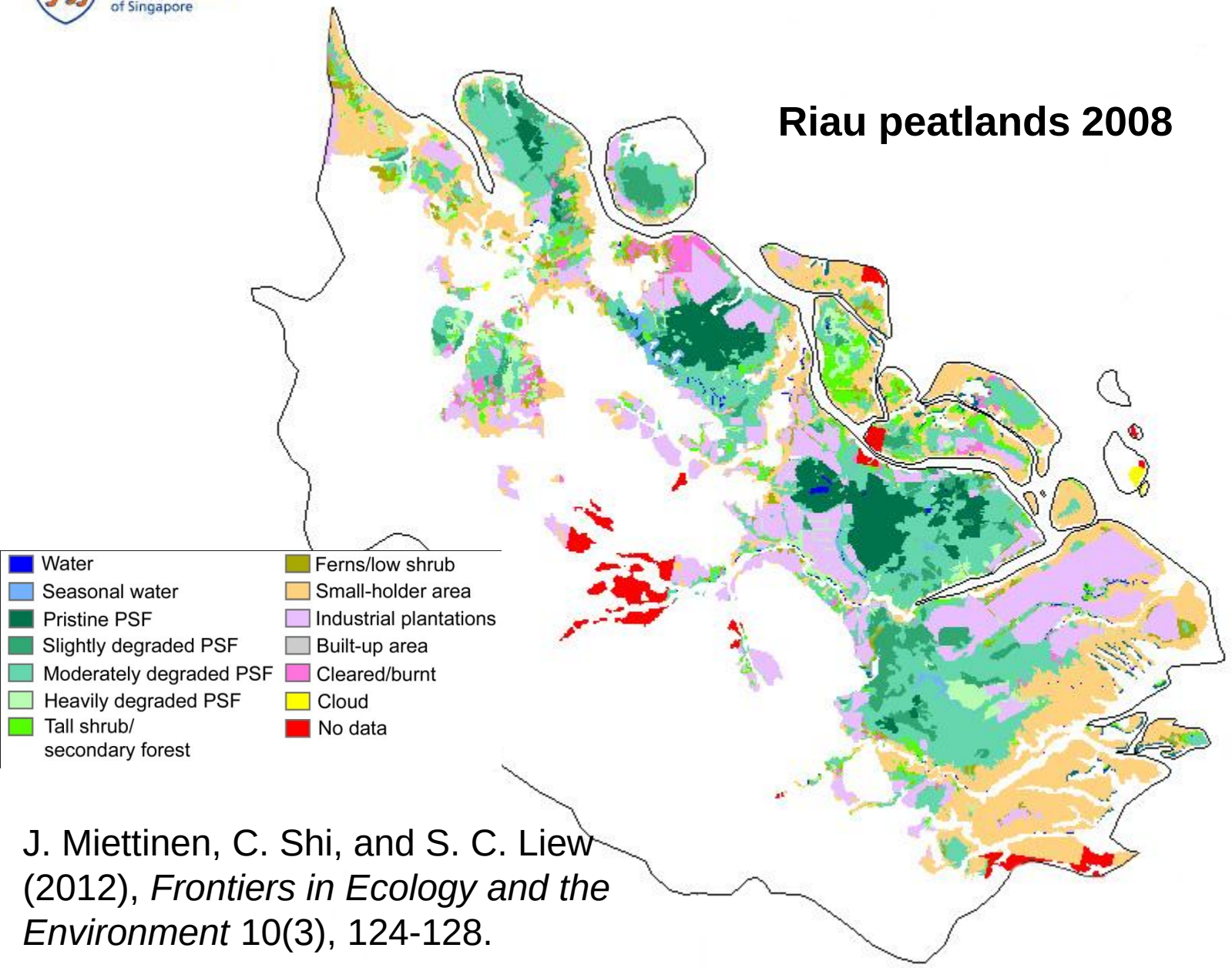
Note that oil palm can be mistakened as bare land in PALSAR images but can be easily detected as vegetation in optical images.

Miettinen and Liew (2011), Remote Sensing Letters 2(4), 299-307.

Landcover Change in Riau Peatlands, 1990 - 2008

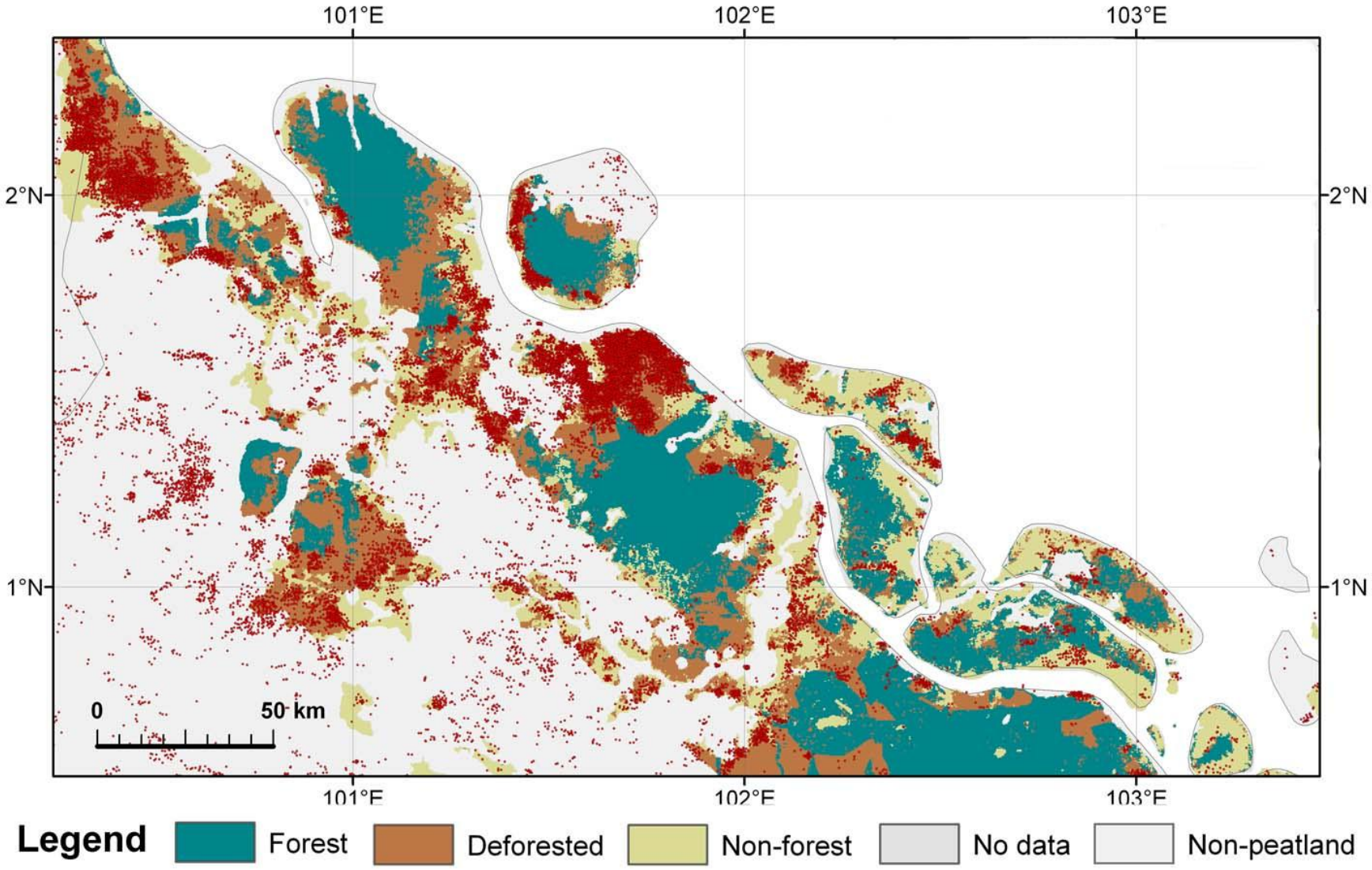


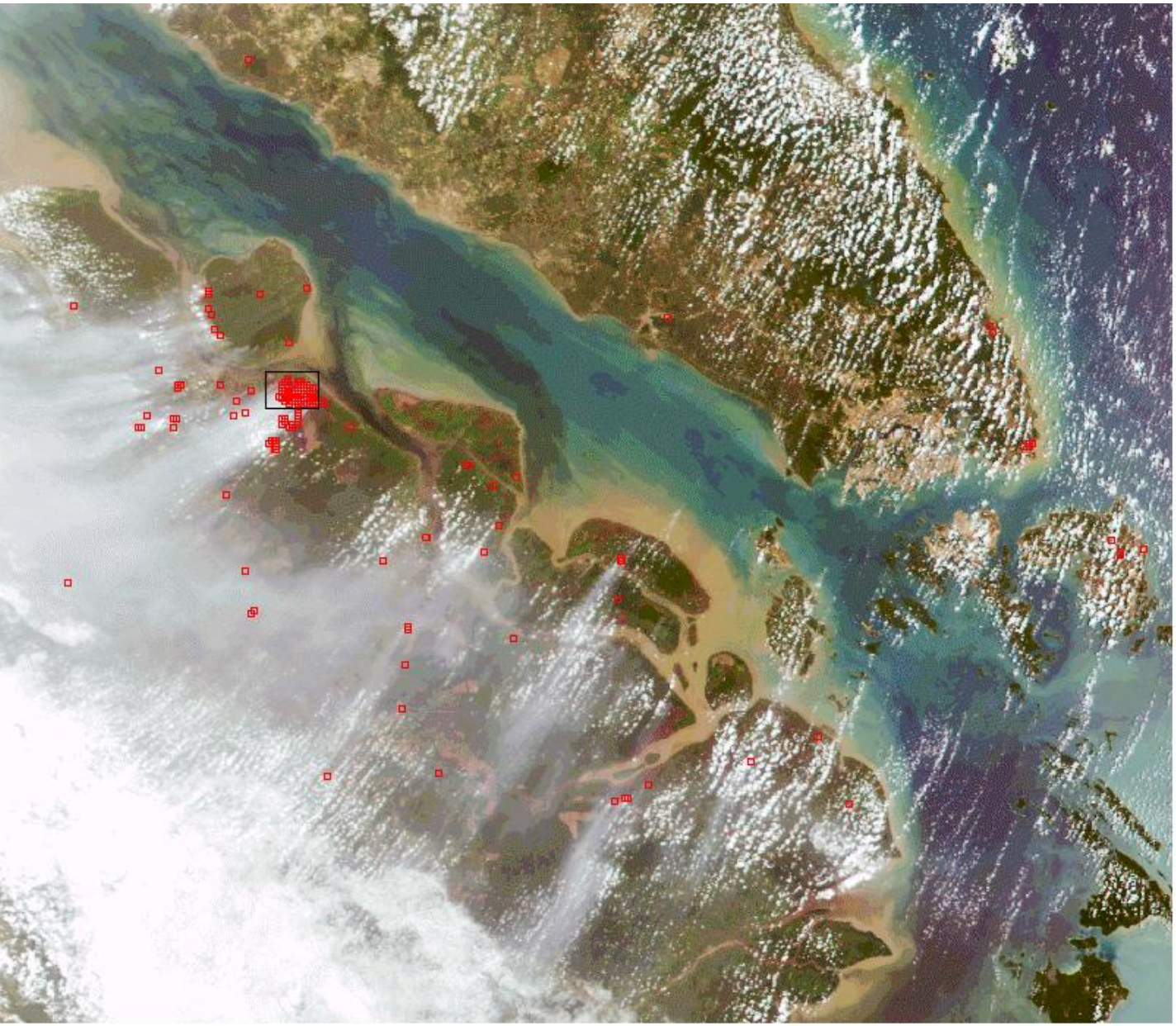
Landcover Change in Riau Peatlands, 1990 - 2008



J. Miettinen, C. Shi, and S. C. Liew (2012), *Frontiers in Ecology and the Environment* 10(3), 124-128.

decadal land cover change 2000-2010 in northern Riau with fire activity (red dots) overlaid





CRISP
National University of Singapore

Terra MODIS Fire Hotspots overlaid on 250m true color image

09 March 2005, UTC 03:27

CRISP
National University of Singapore

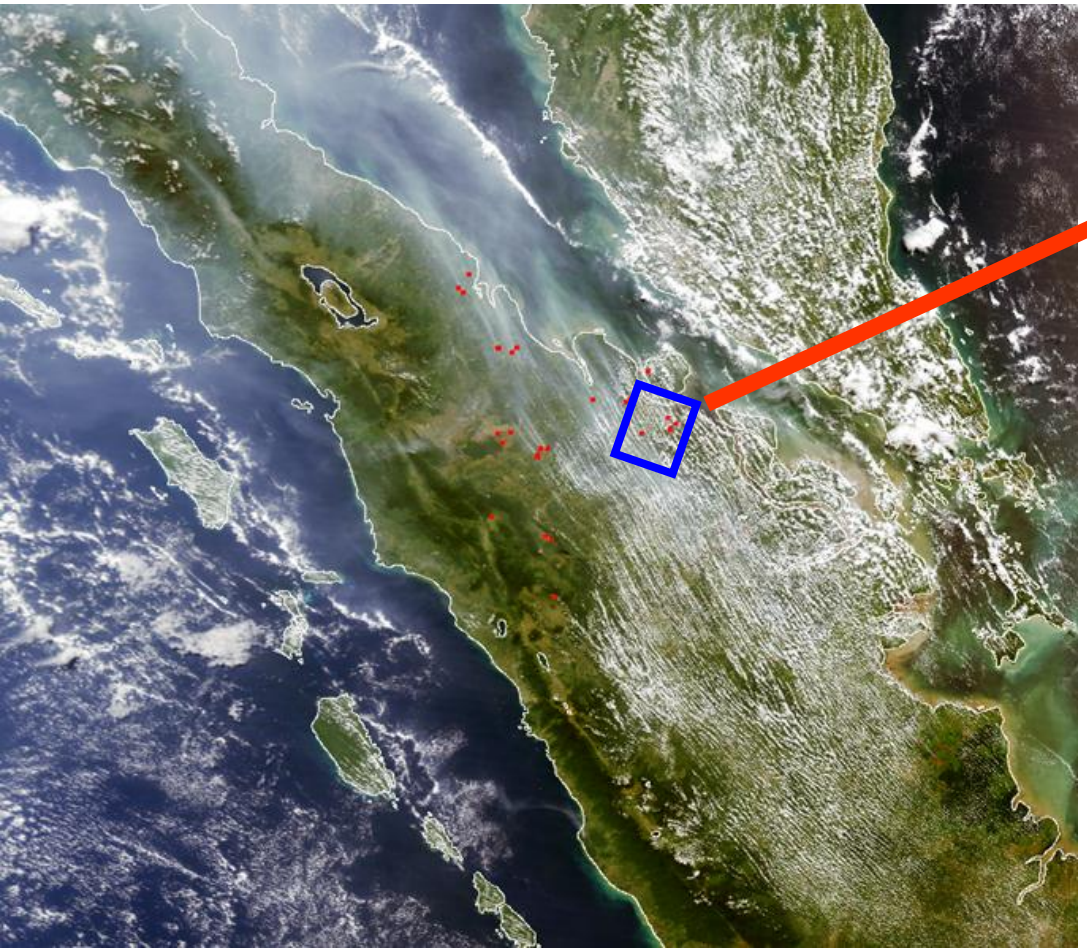
MODIS

Fire hot spots and smoke plumes - Riau, Sumatra

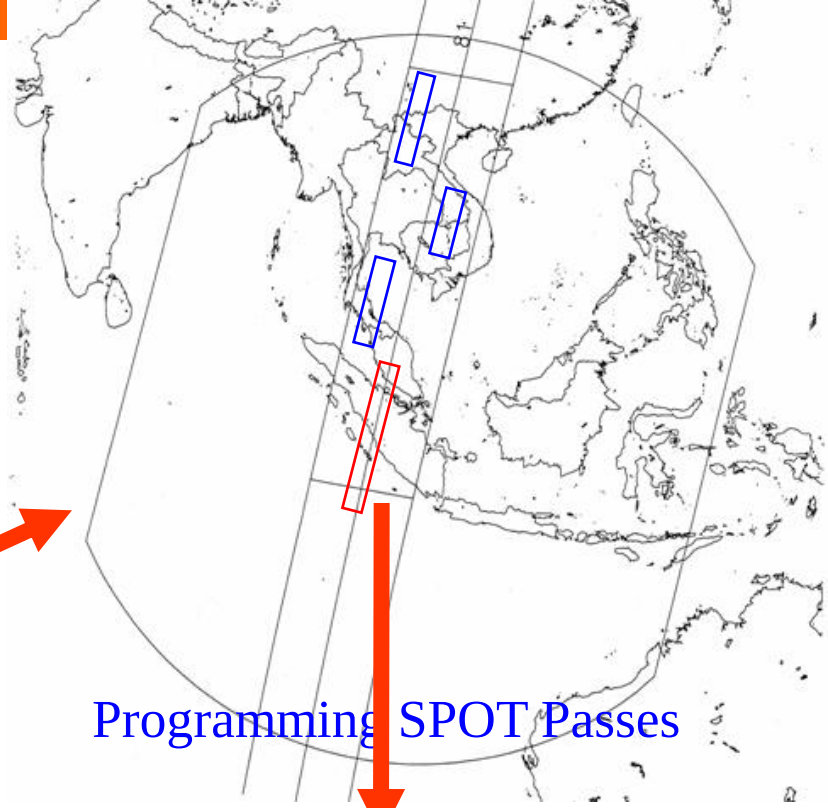
2005/06/25 03:55 UTC

CRISP
National University of Singapore

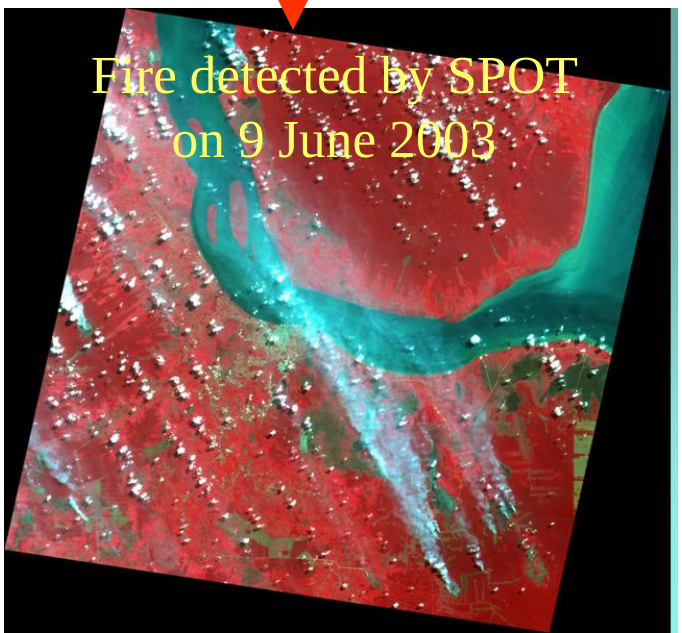
Regional fire monitoring operation

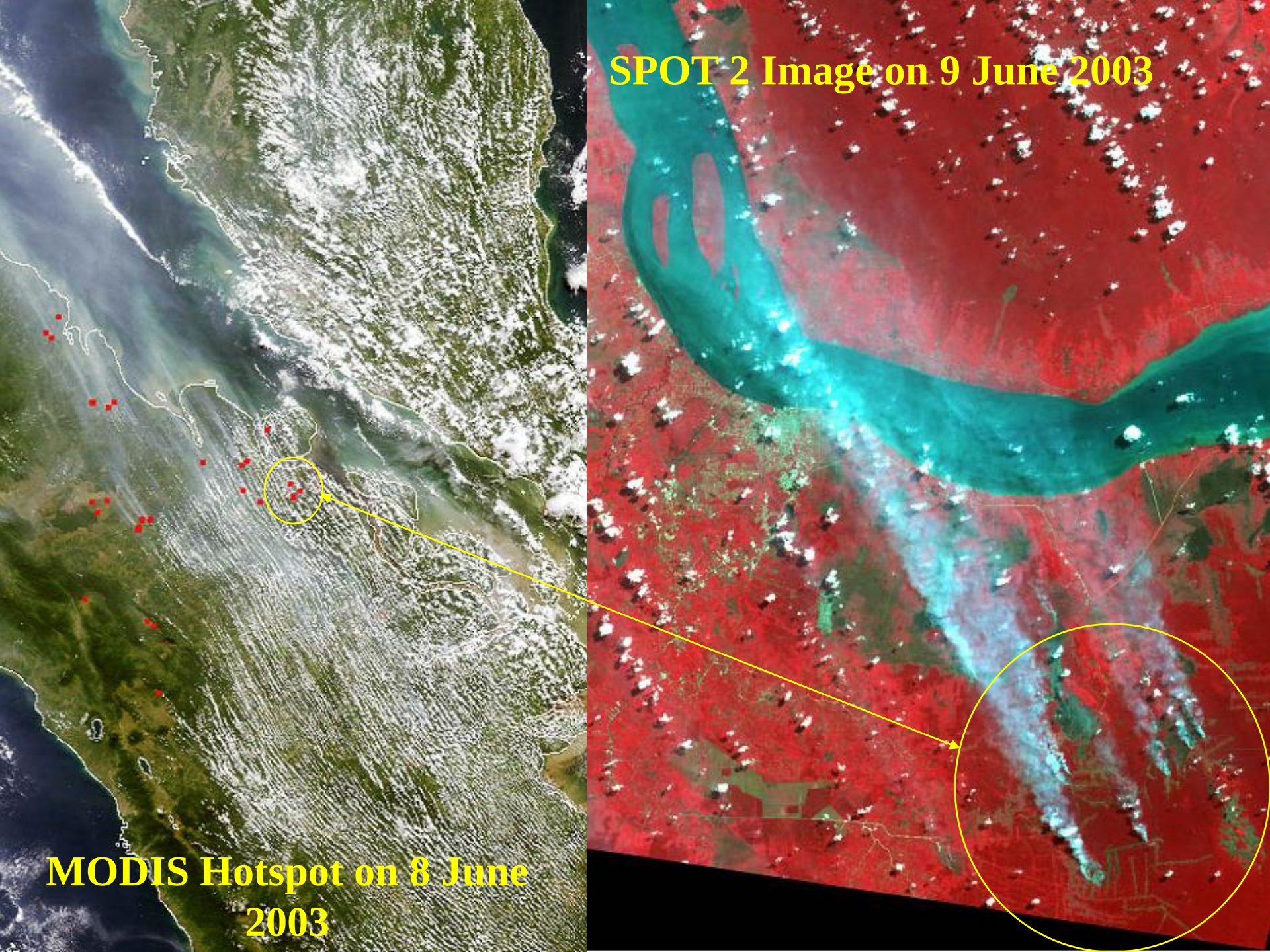


MODIS detected hotspots on 8 June 2003



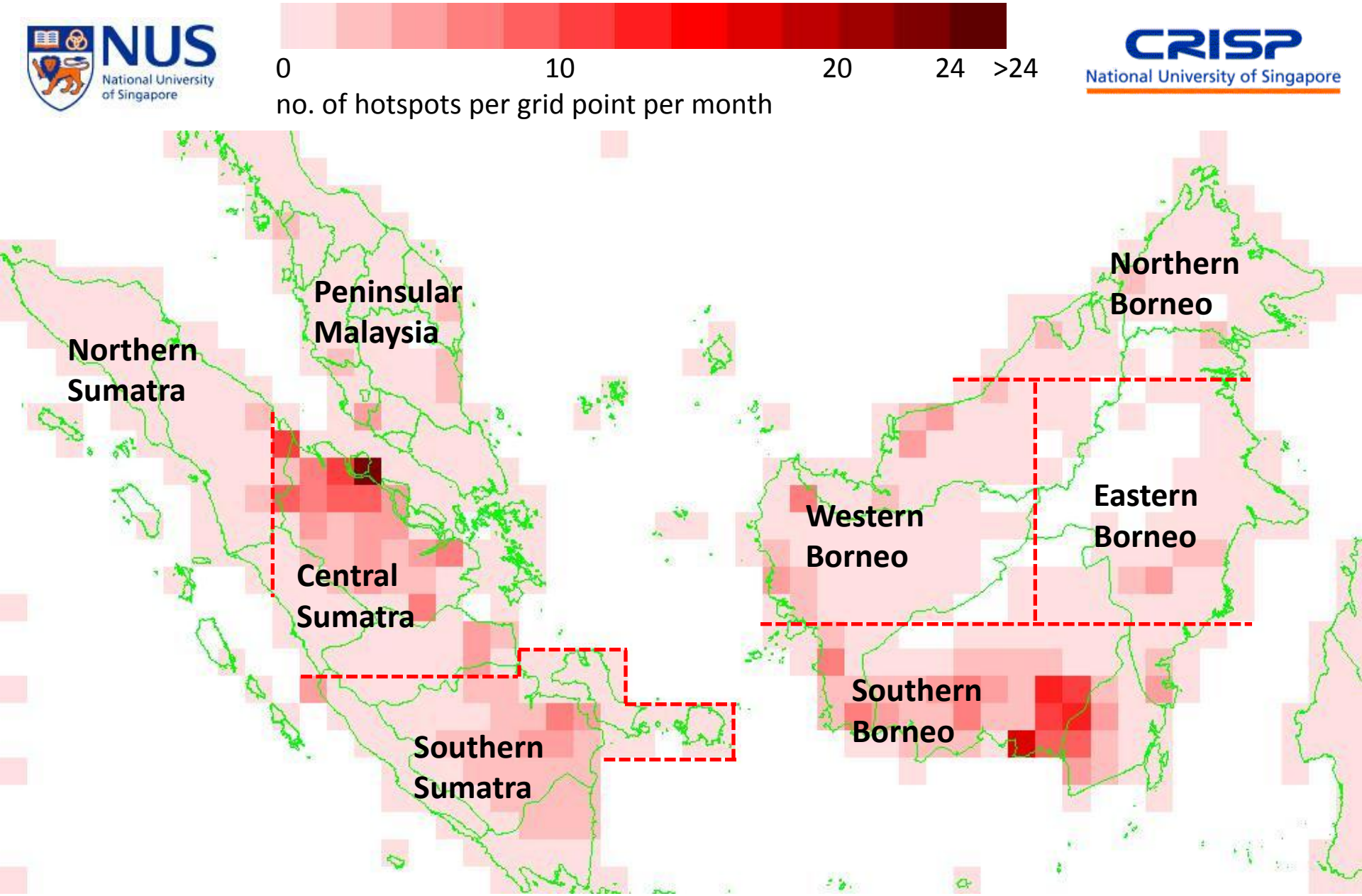
Programming SPOT Passes




SPOT 2 Image on 9 June 2003
MODIS Hotspot on 8 June 2003

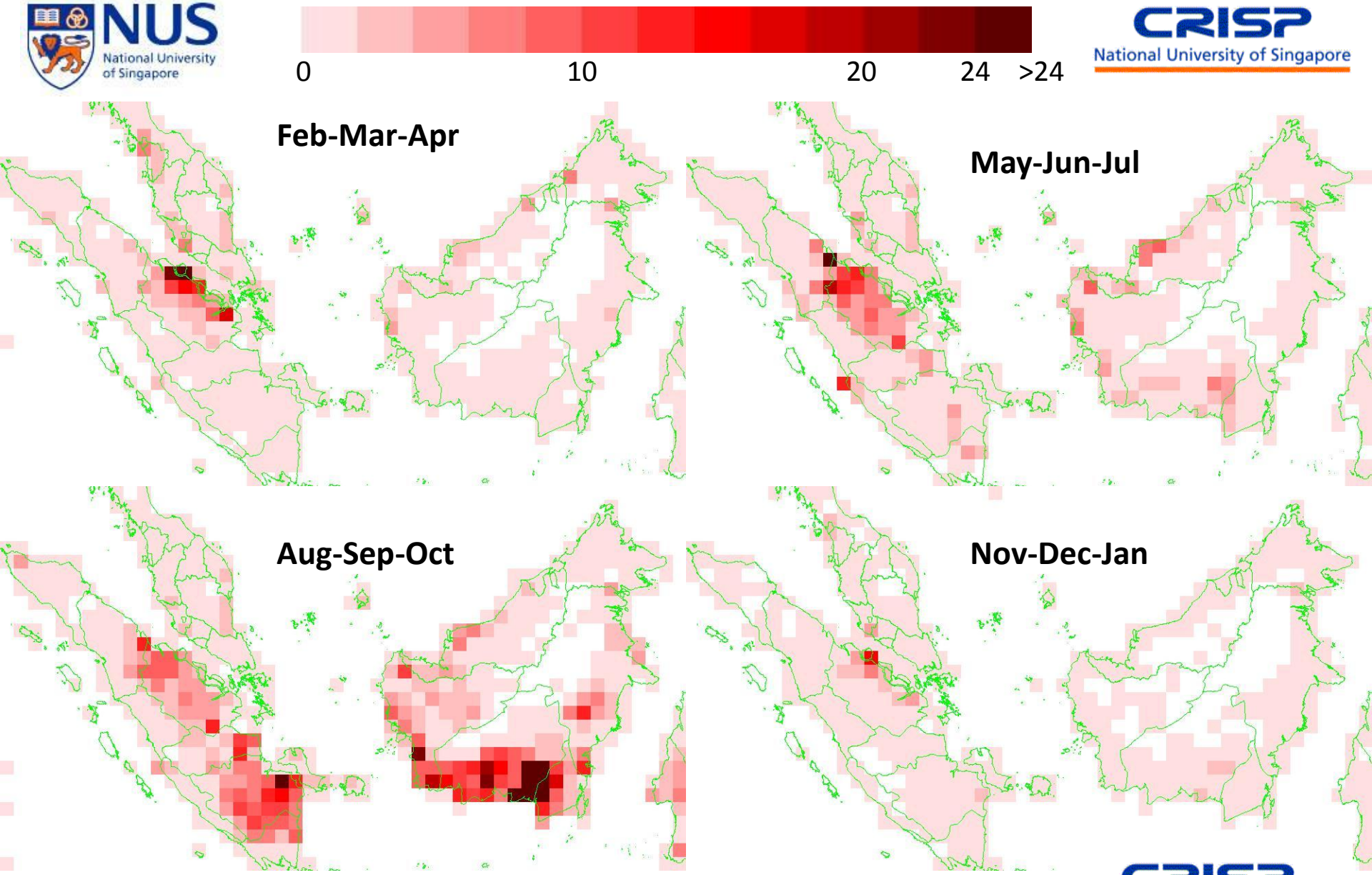
Factors influencing fires

- Human Activities
  - Land clearings by small holders, shifting cultivators
  - Extensive land use change (typical pattern: Forest → degraded forest → plantation)
- Climate
  - Rainfall is one single most important factor that has high correlation with fires in the southeast Asia region
  - More land clearing activities during dry weather
  - Fires run out of control in extreme dry weather (e.g. during El-Nino)

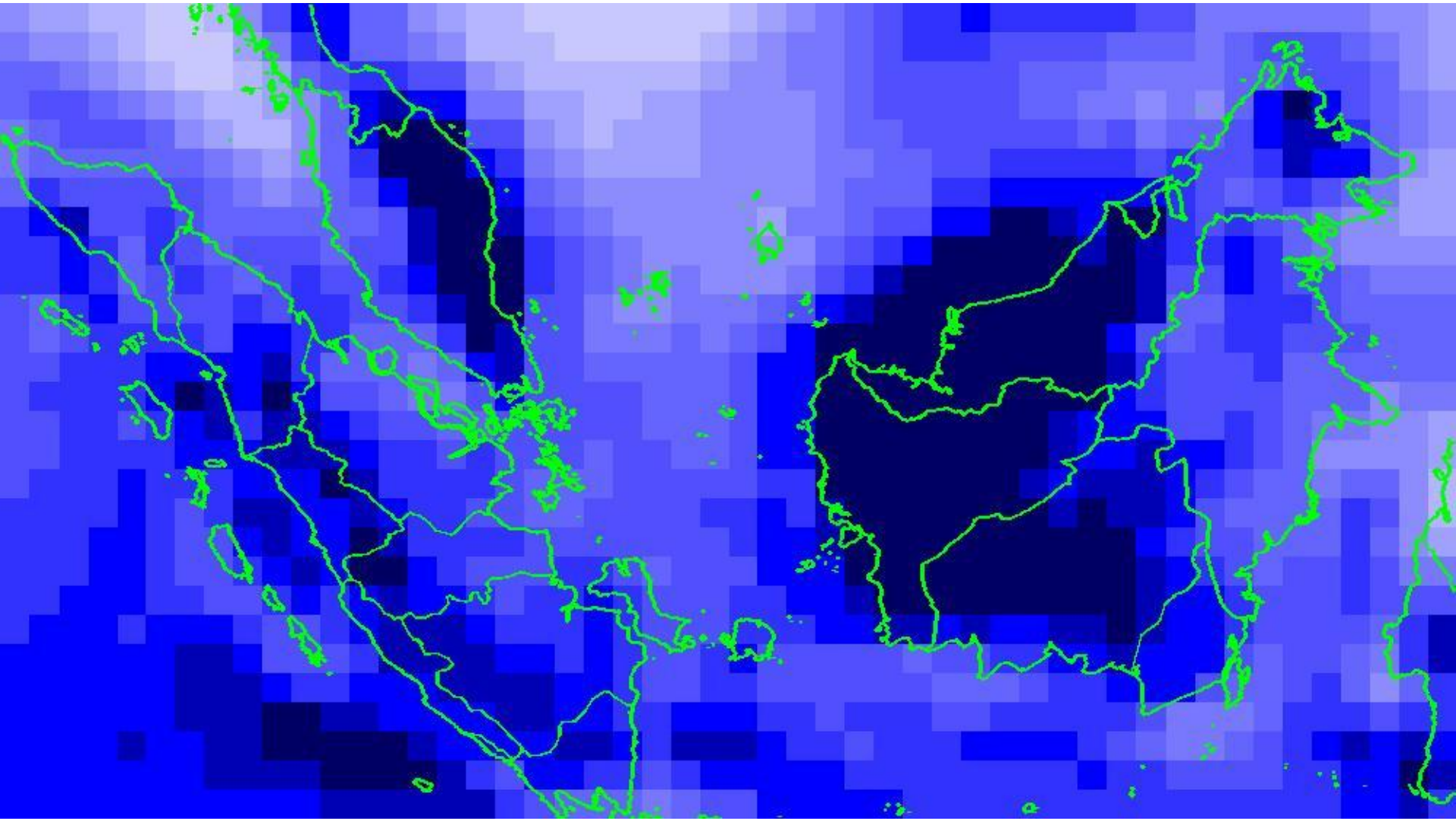


Terra MODIS (morning passes) mean hotspots count per month, 2001 – 2010.

Each grid point occupies an area 0.5 deg x 0.5 deg

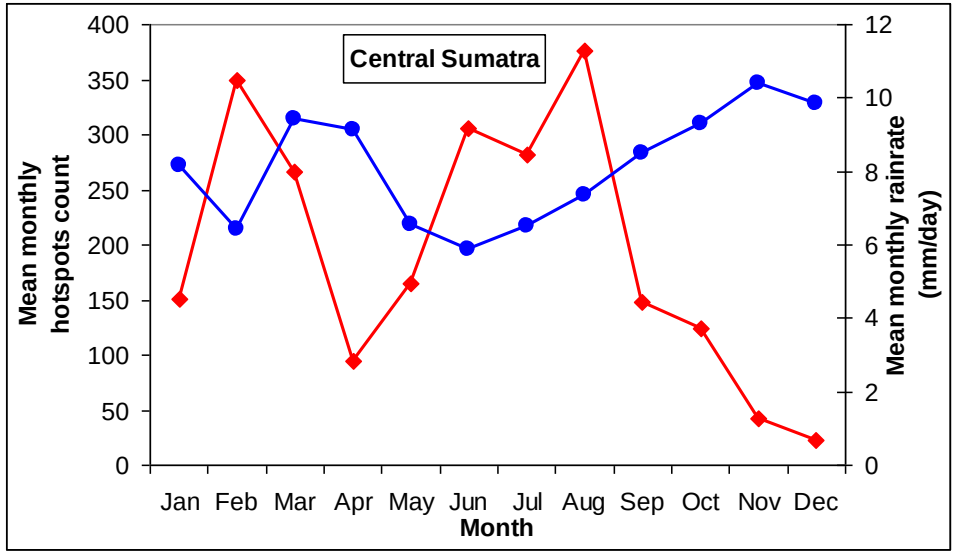


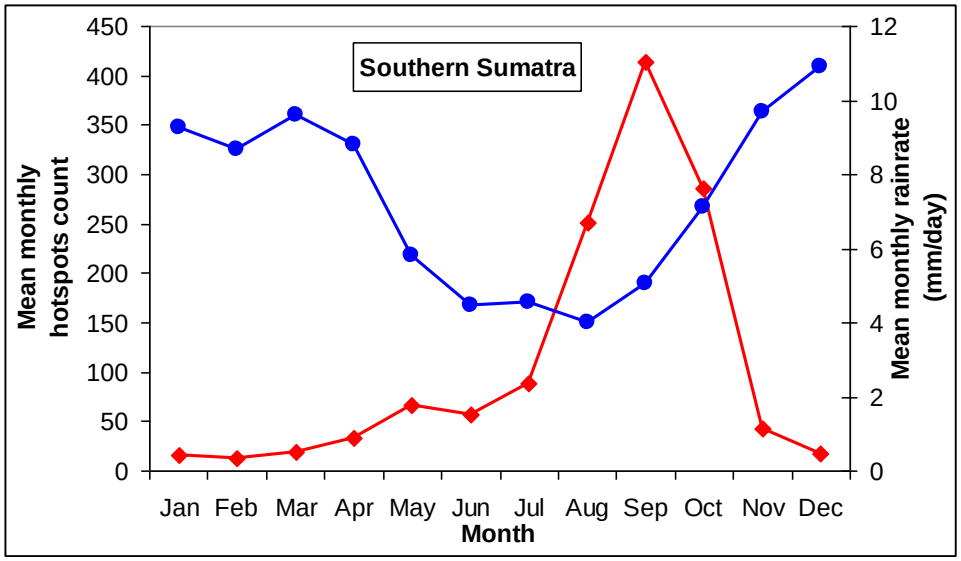
Terra MODIS (morning passes) seasonal mean hotspots count per month

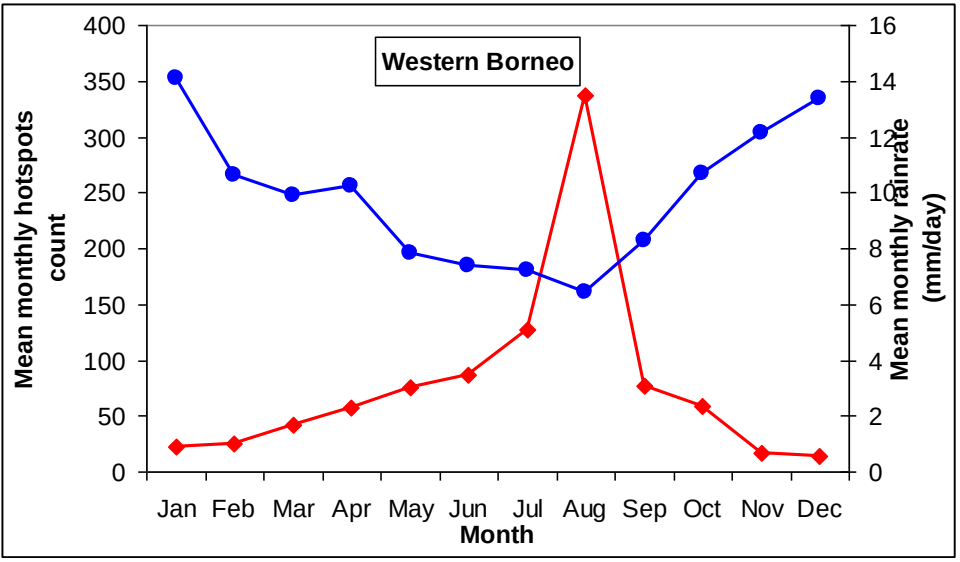


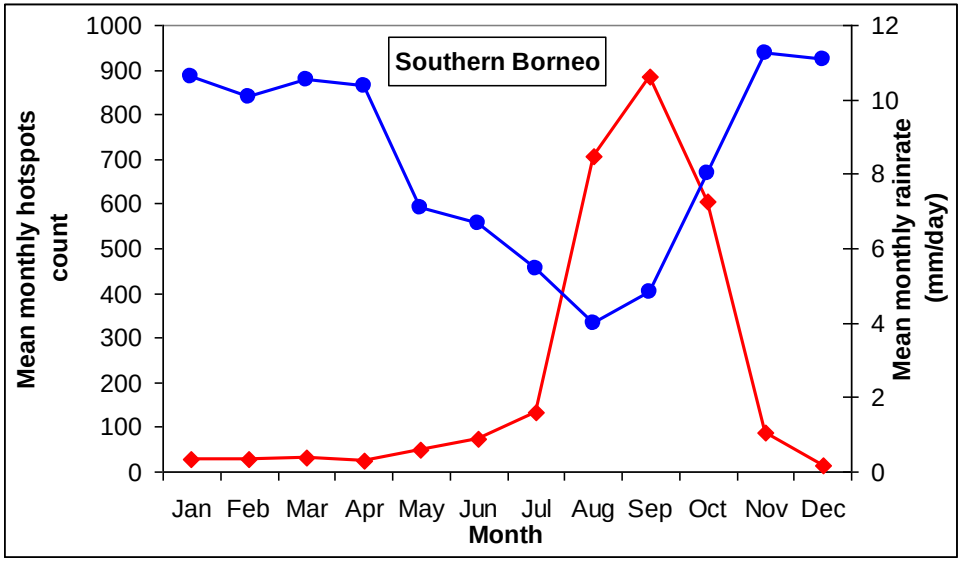
TRMM 3B43 seasonal mean rainrate (mm/day)

"Climatological" monthly hotspots count and monthly rainrate (2001 to 2010)

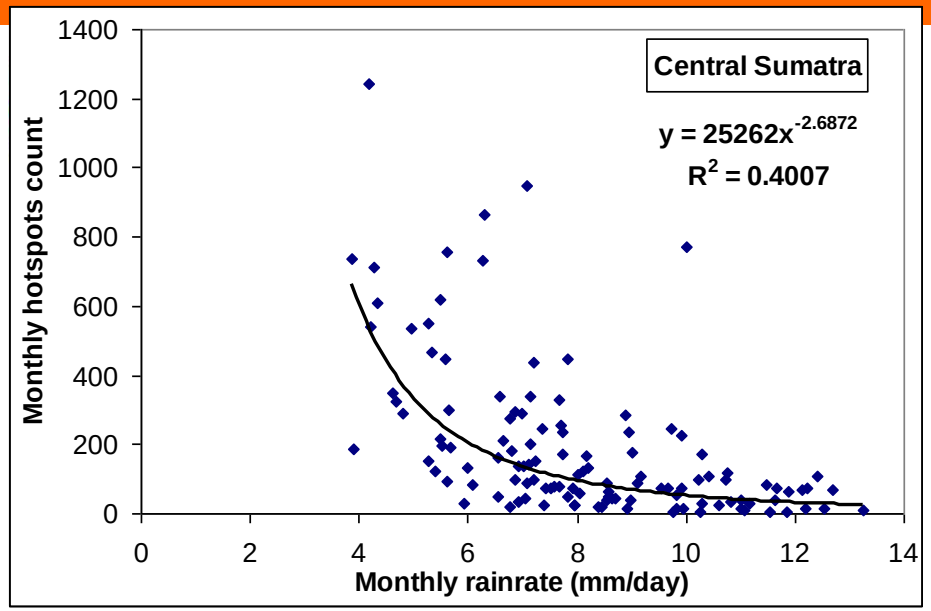


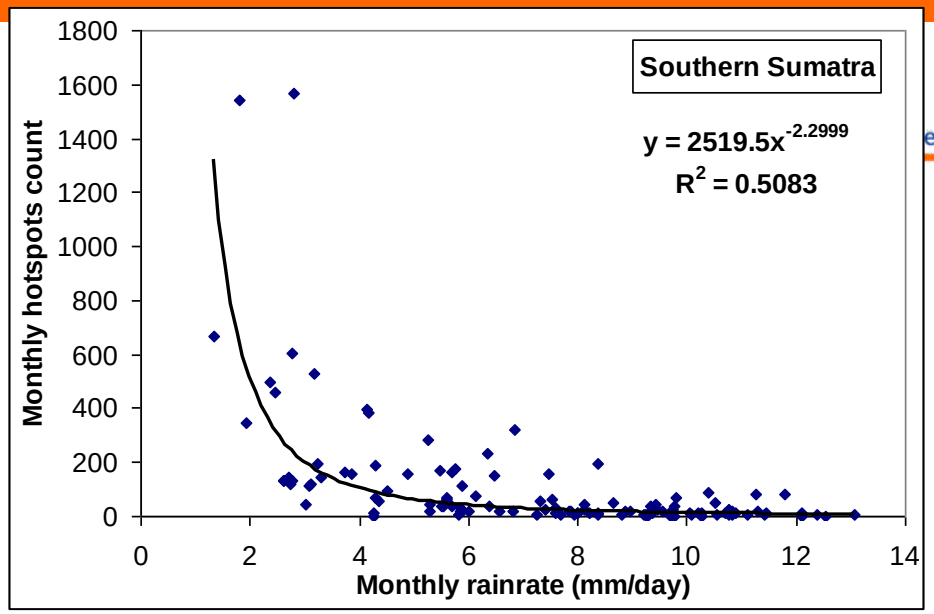


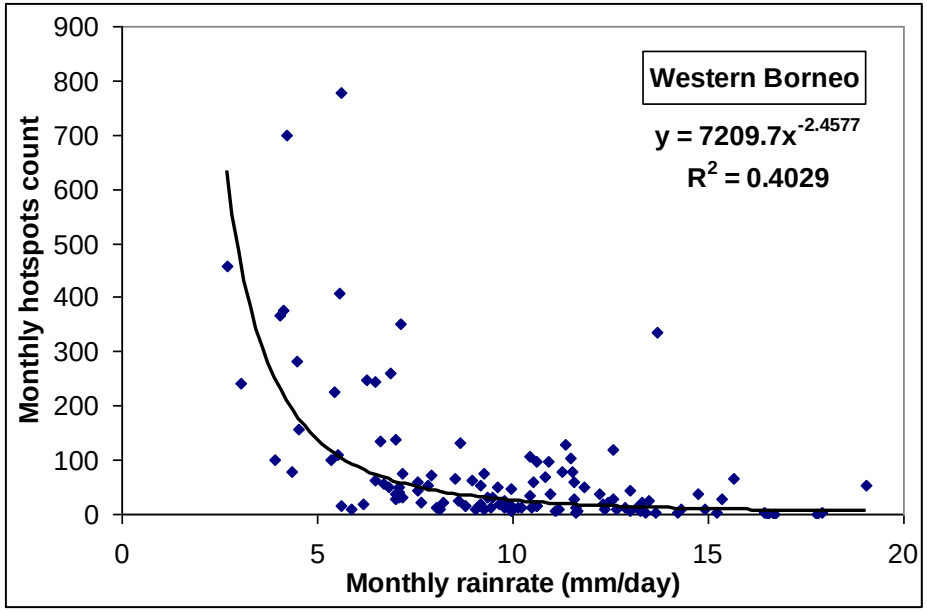


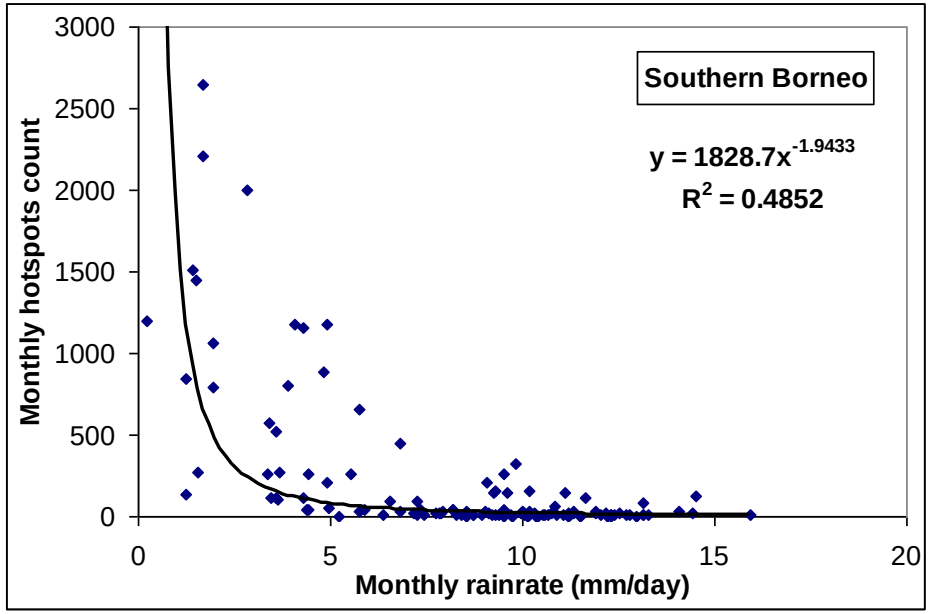


Blue: rainrate; Red: hotspots count

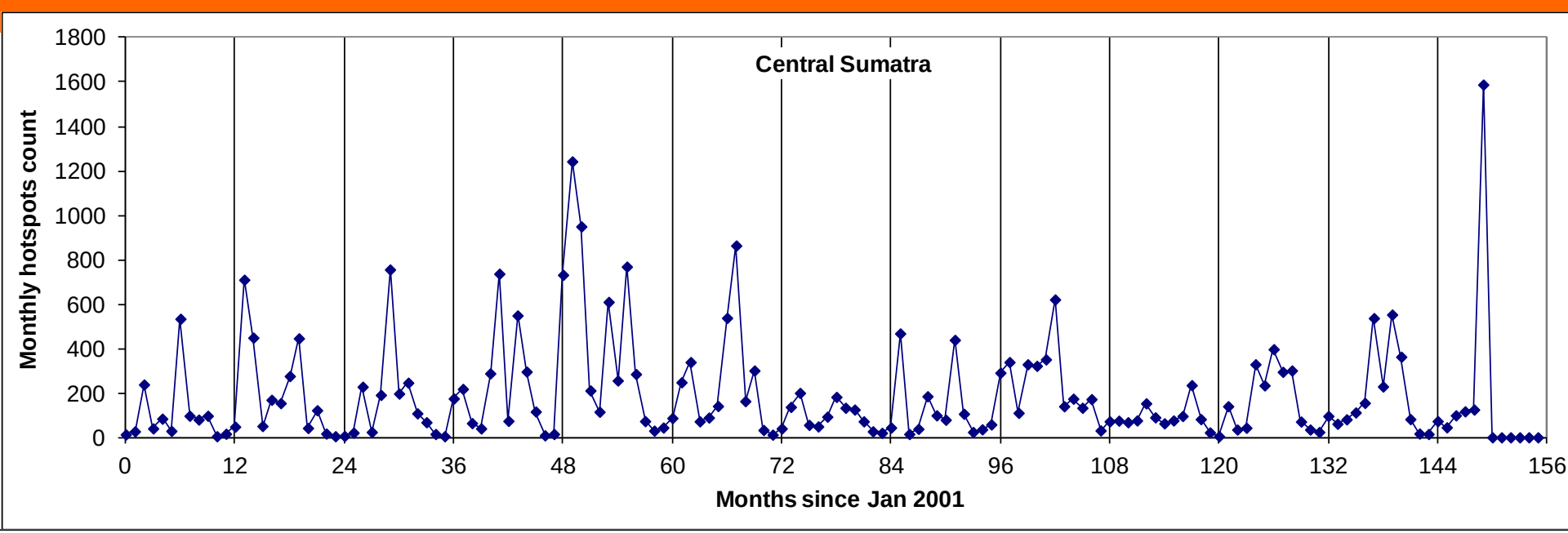


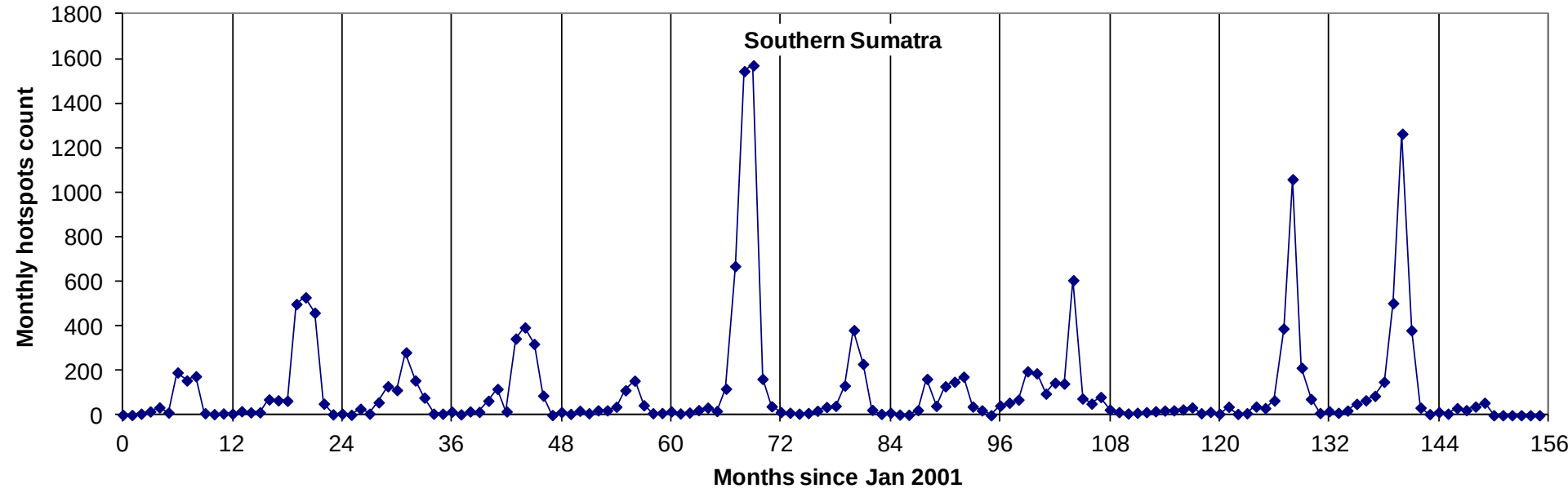




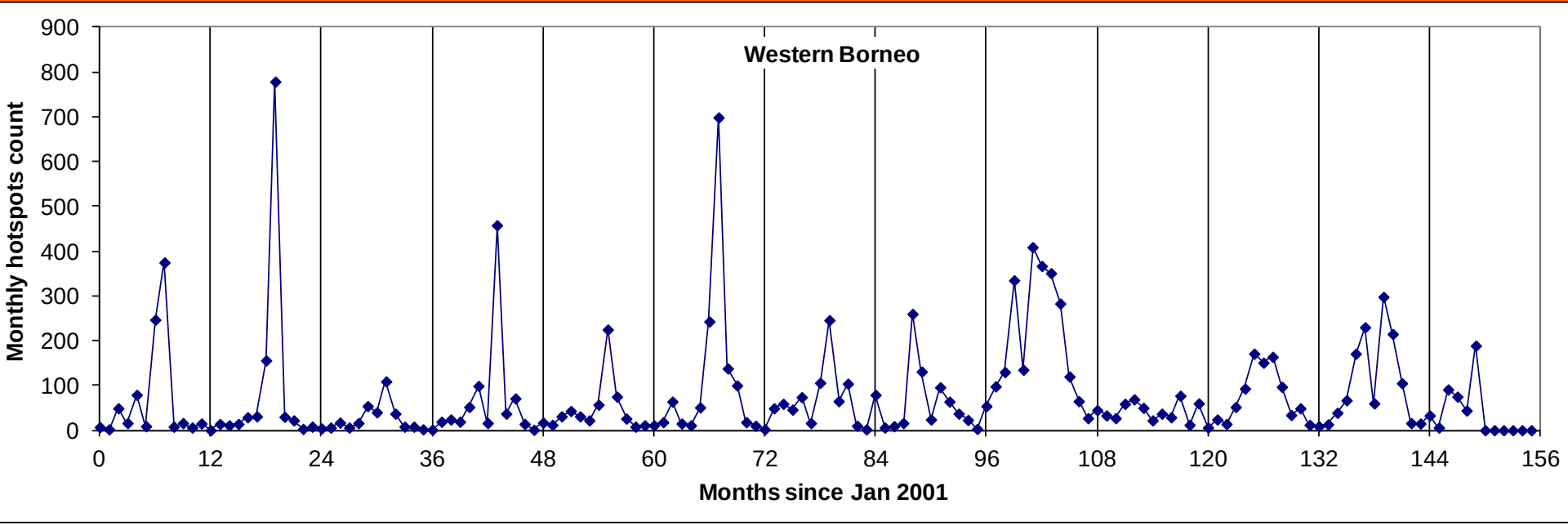


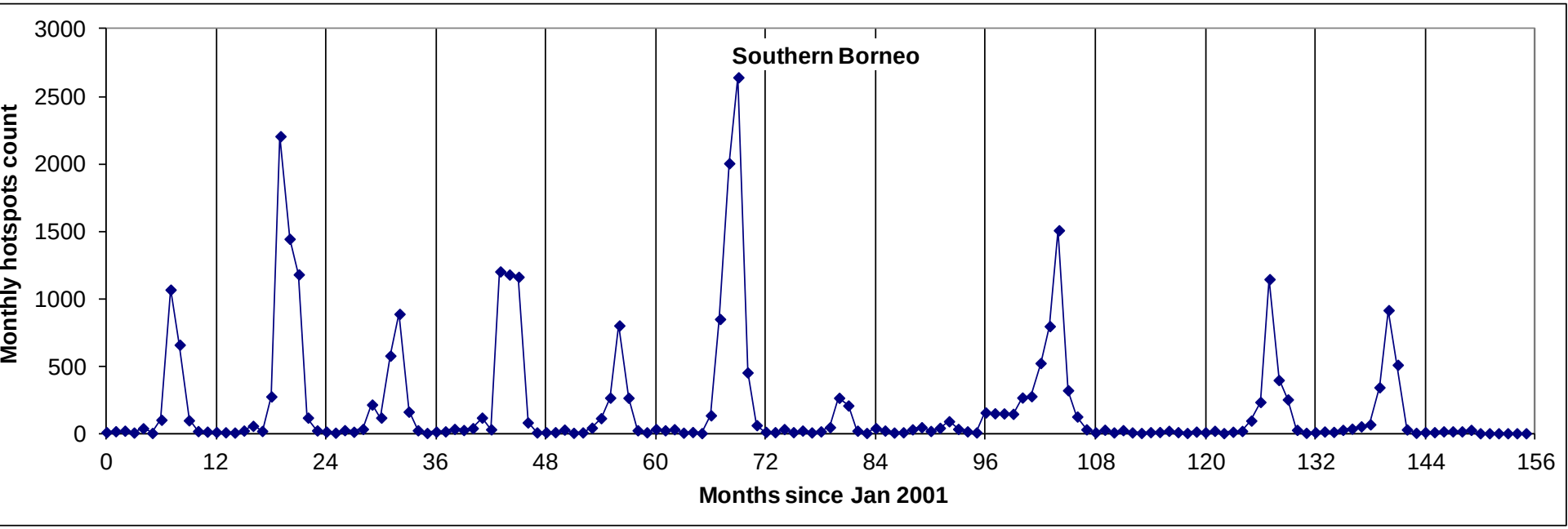
Regression relation (inverse power law) between MODIS monthly hotspots count and monthly rainrate. About 40% to 50% of the variance in the hotspots count can be explained by rainfall.



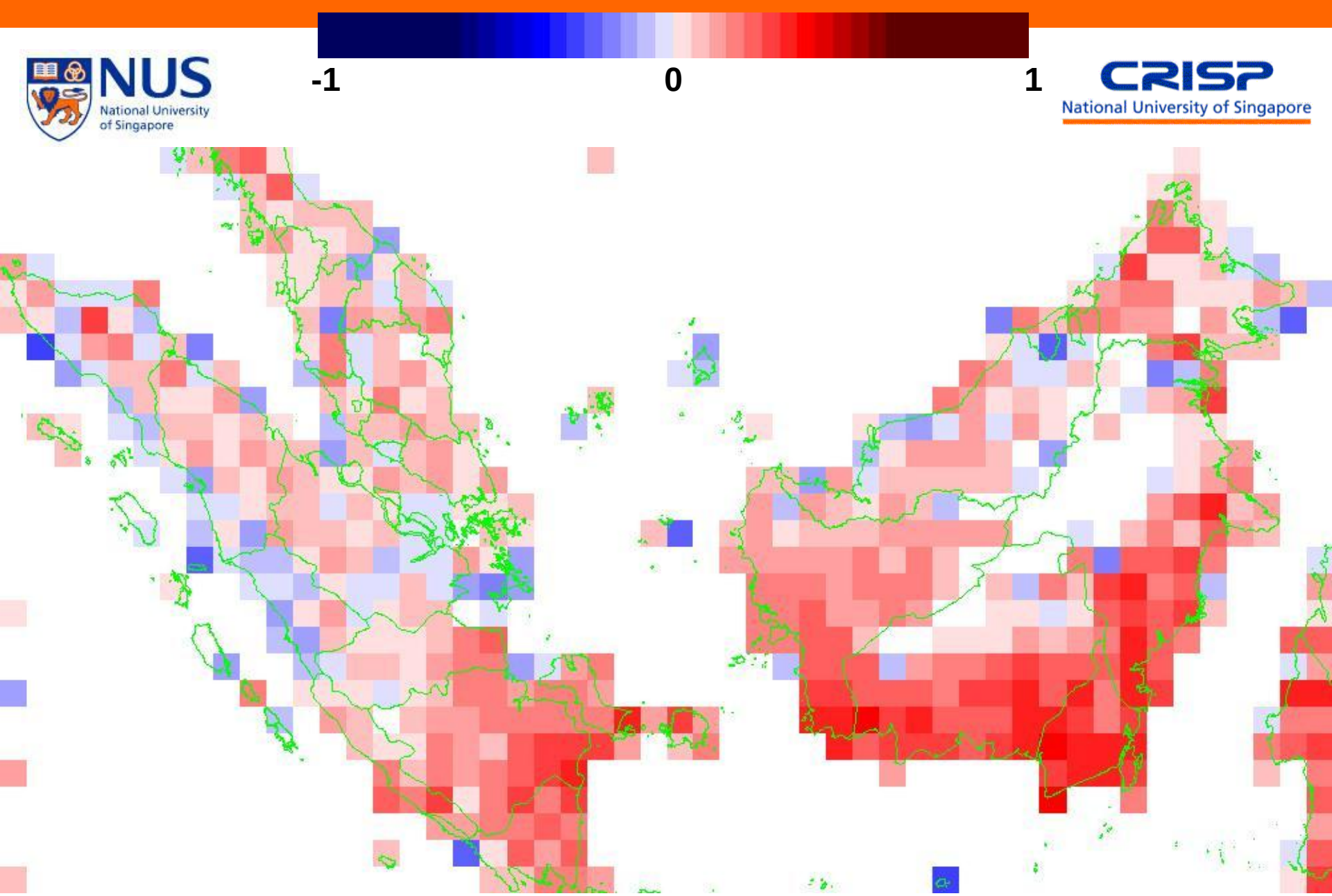


MODIS monthly hotspots count, 2001 to 2010: Central Sumatra and Southern Sumatra



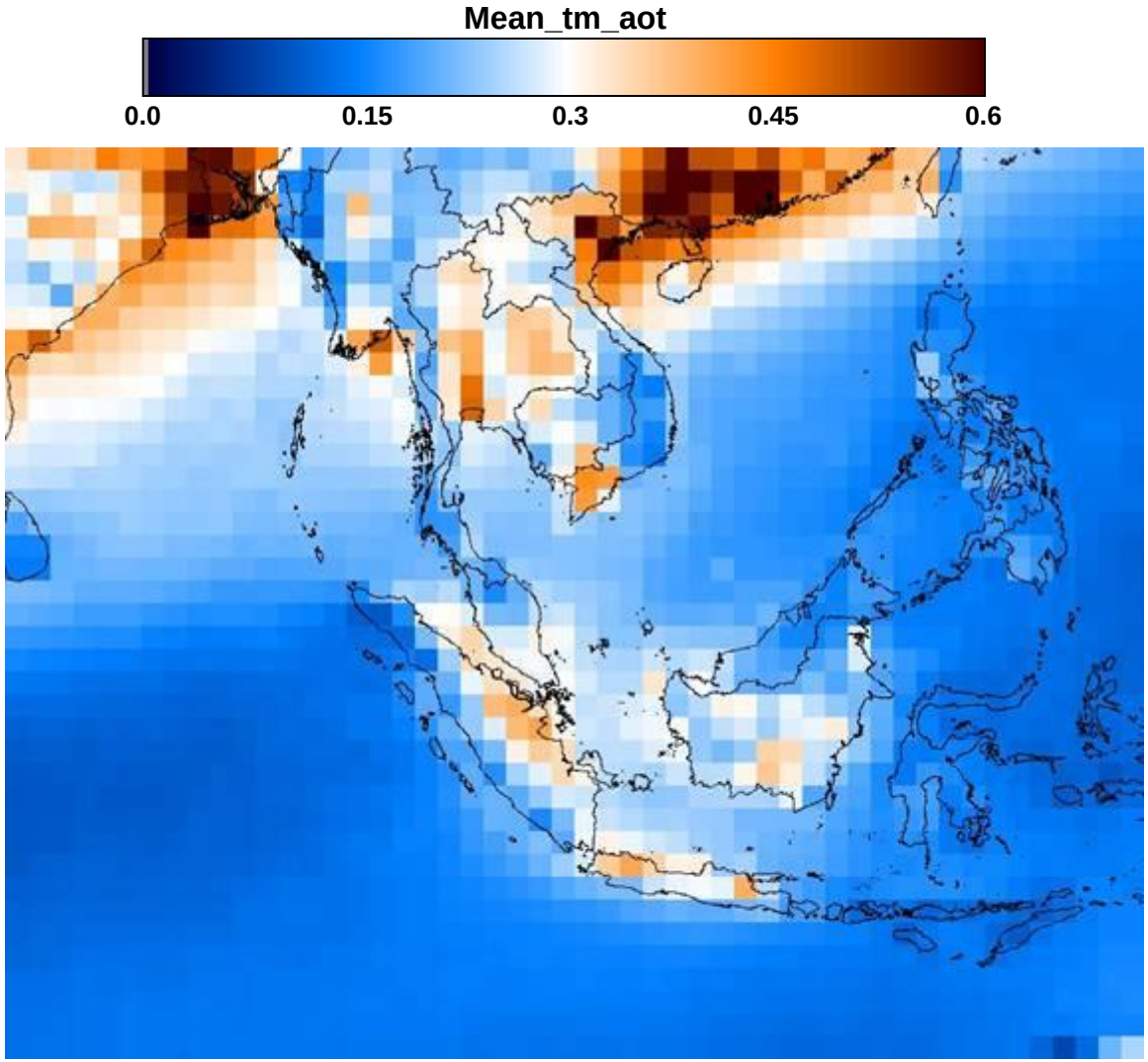


MODIS monthly hotspots count 2001 to 2010, Western Borneo and Southern Borneo

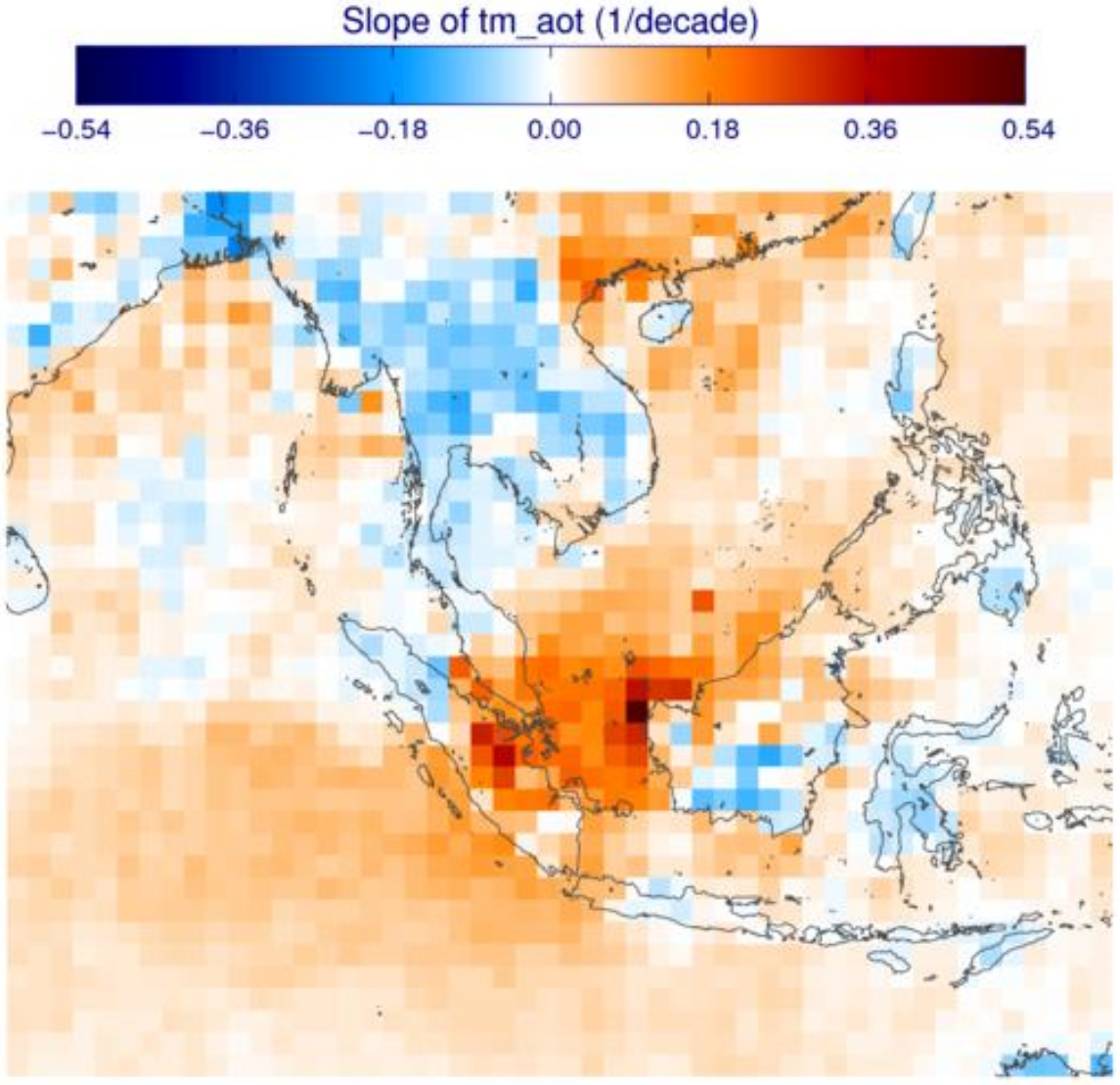


Pearson's correlation coefficient, MODIS monthly hotspots count vs. monthly mean ocean nino index. High correlation in S Borneo, S Sumatra, but low in Riau, Sarawak

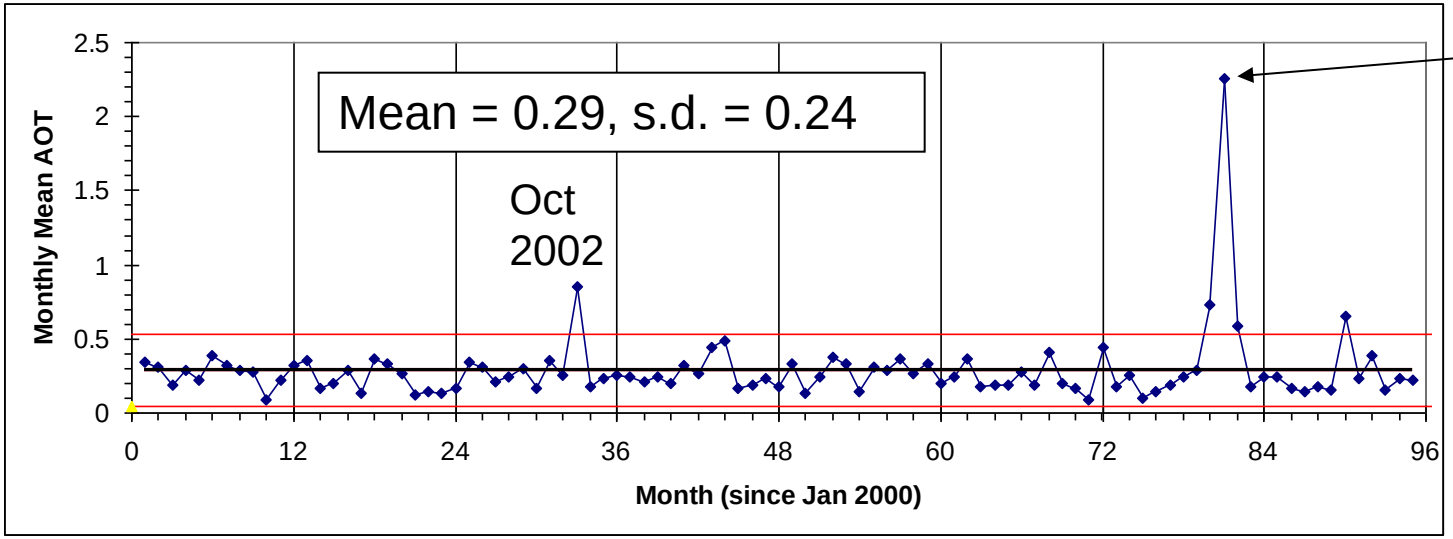
Mean MODIS Aerosol Optical Thickness, 1998 to 2007



Average rate of change of Aerosol Optical Thickness (per decade) 1998 to 2007

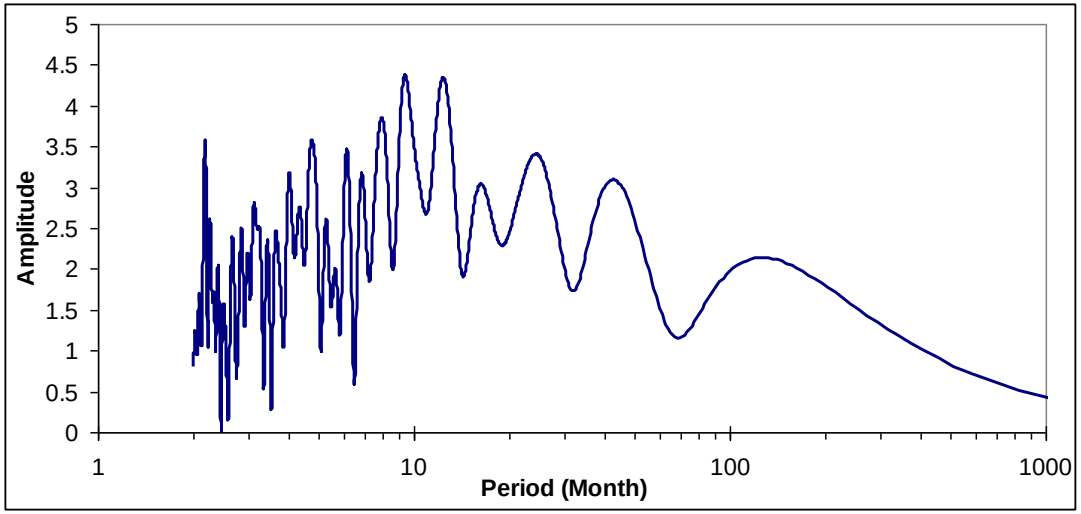


Mean monthly MODIS AOT over a 1 deg x 1 deg grid point centred at Singapore

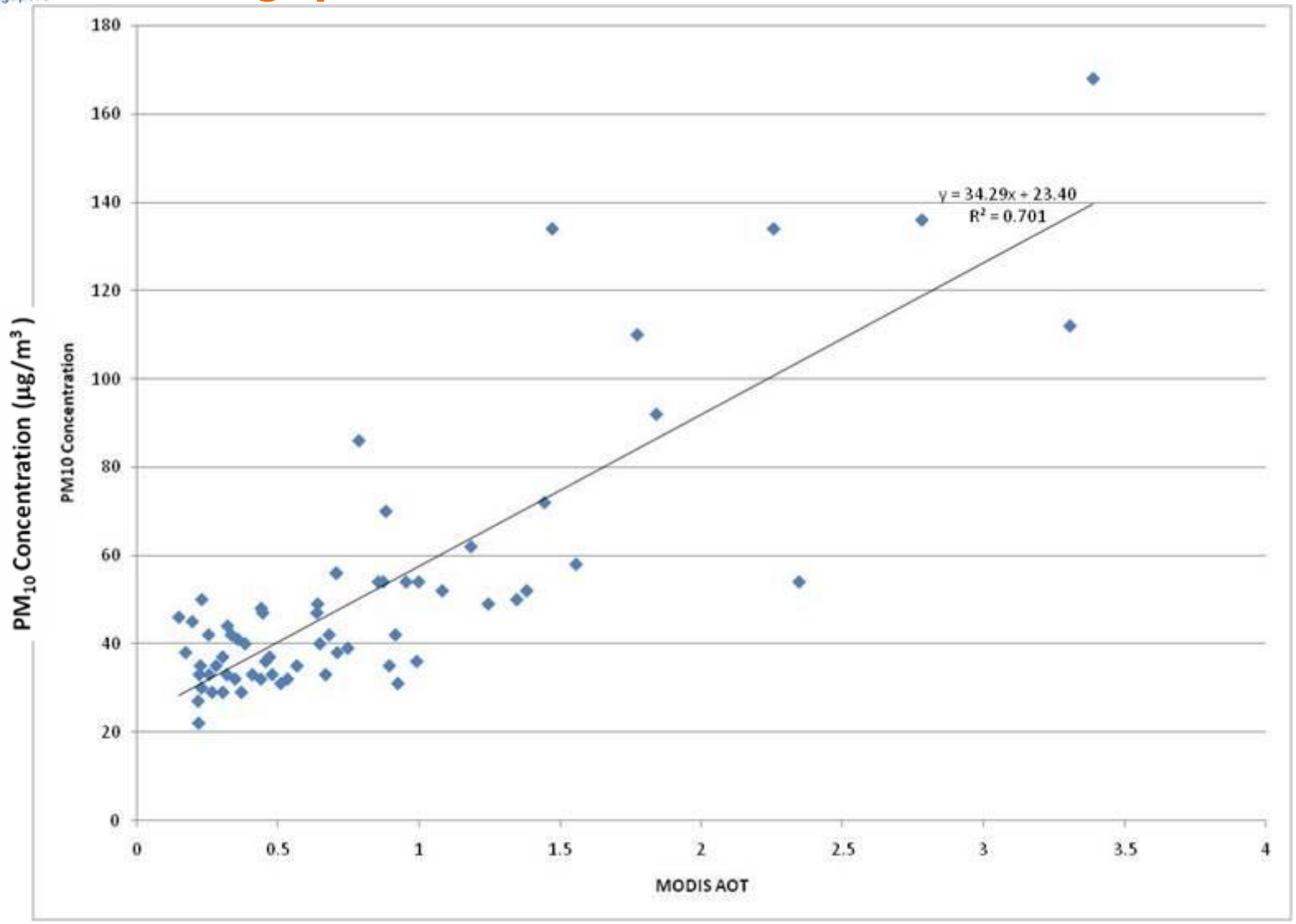


Mean = 0.27, s.d. = 0.13 if extreme point of Oct 2006 (AOT = 2.26) is omitted.

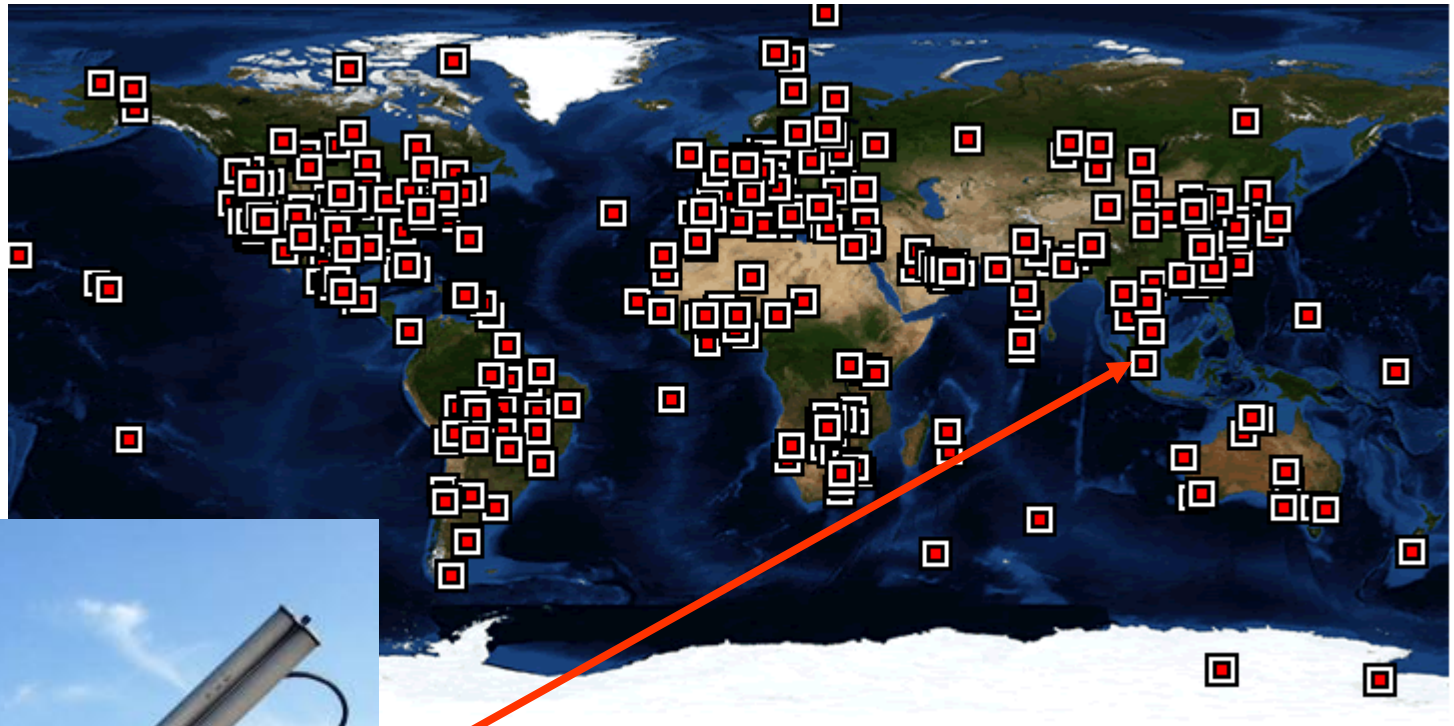
No dominant periodic components.



Correlation of PM10 with MODIS AOT, Singapore, Jun – Oct 2006



AERONET Singapore Station



Seven South East Asian Studies (7 SEAS)

Goal: Isolate the impacts of aerosol particles on *weather, cliamte and the environment through partnership with regional universities.*

Seven research areas:

- Tropical and subtropical meteorology including air-sea and land interaction
- Clouds and precipitation
- Radiative transfer
- Biomass burning and pollution
- Natural aerosol chemistry
- Satellite and model calibration/validation
- Seasonal forecasting and climate


CIMEL Sunphotometer
(AERONET site)


Multi-Filter Rotating
Shadowband Radiometer


Thermo Andersen $PM_{2.5}$
Samplers


Broadband Radiometers

Broadband Radiometers on Solar Tracker

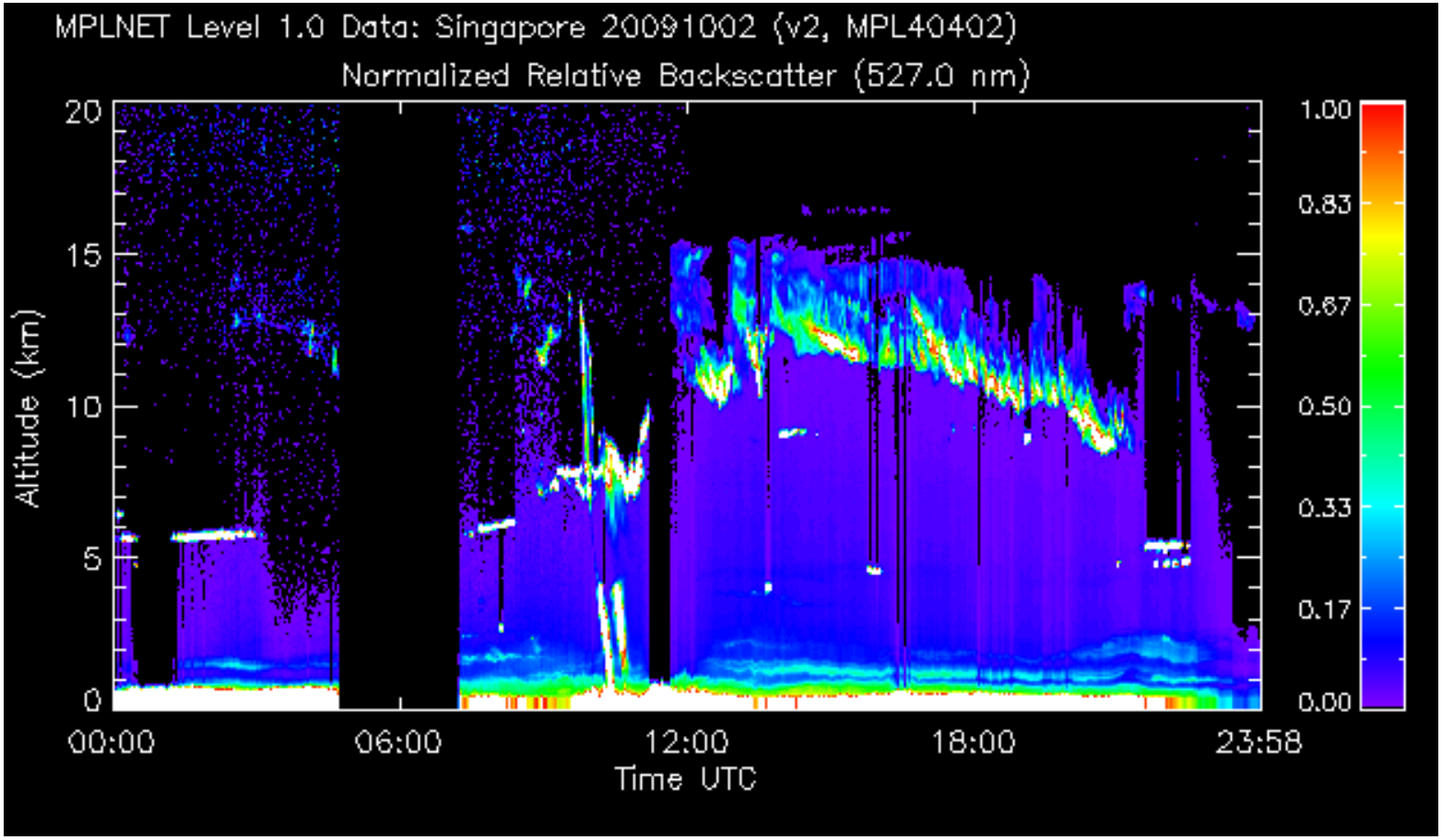
Total Sky Imager

MPL

MPL Environmental Enclosure

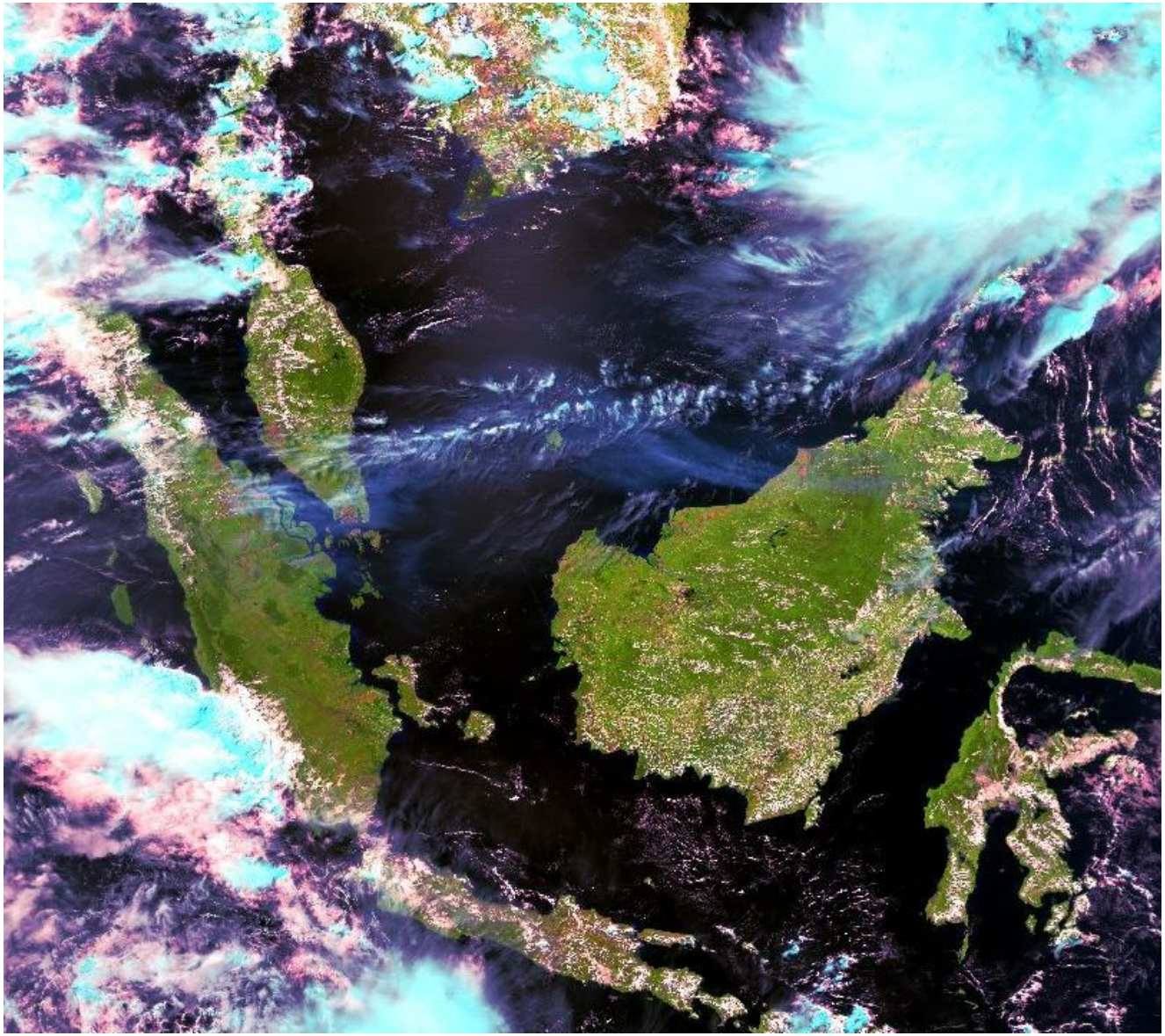
Micro-Pulse Lidar

MPL Relative backscatter 2009-10-02



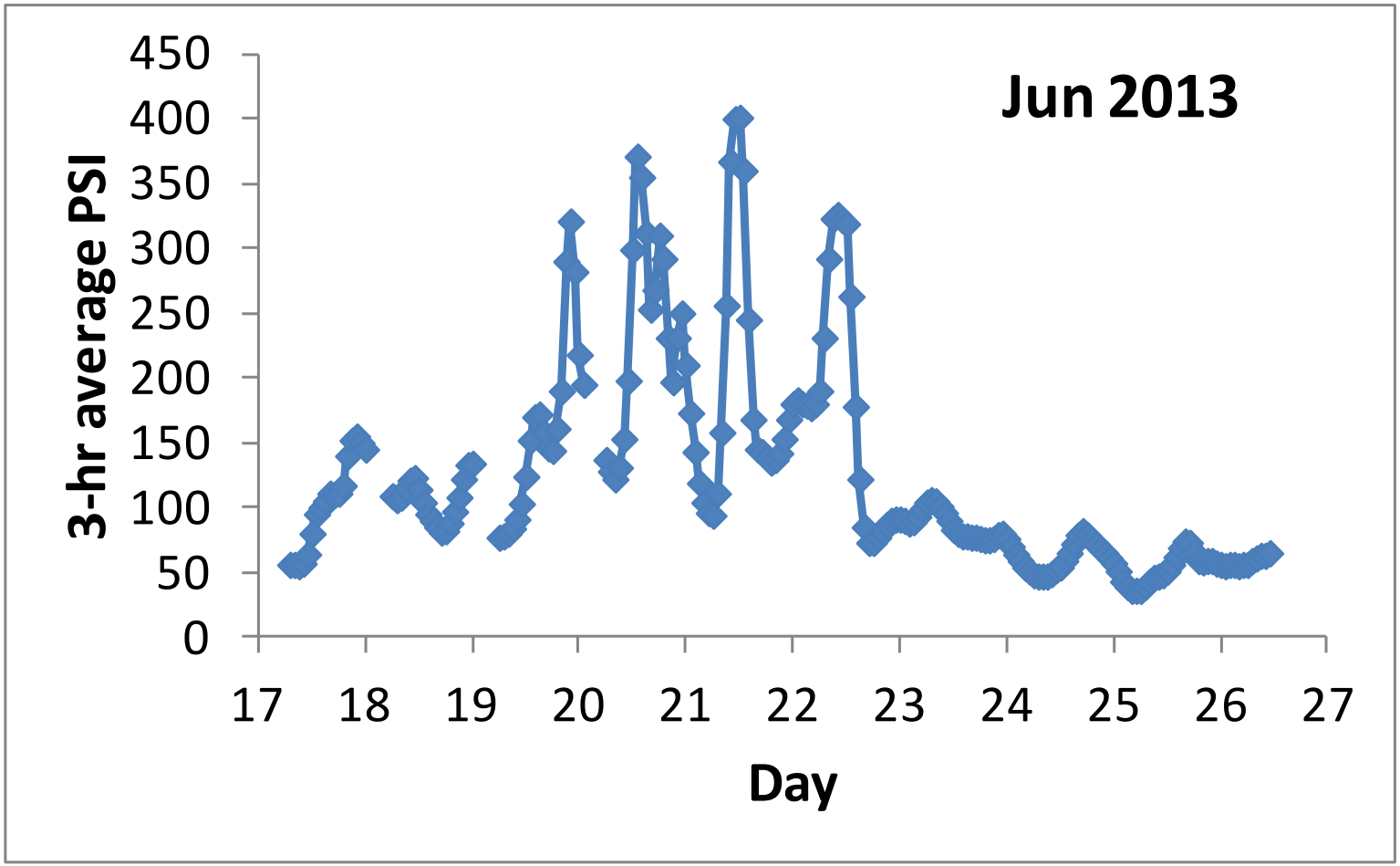
PSI : 55; 24-hourly PM10: 60 μg/m3

Suomi NPP
2013-06-19

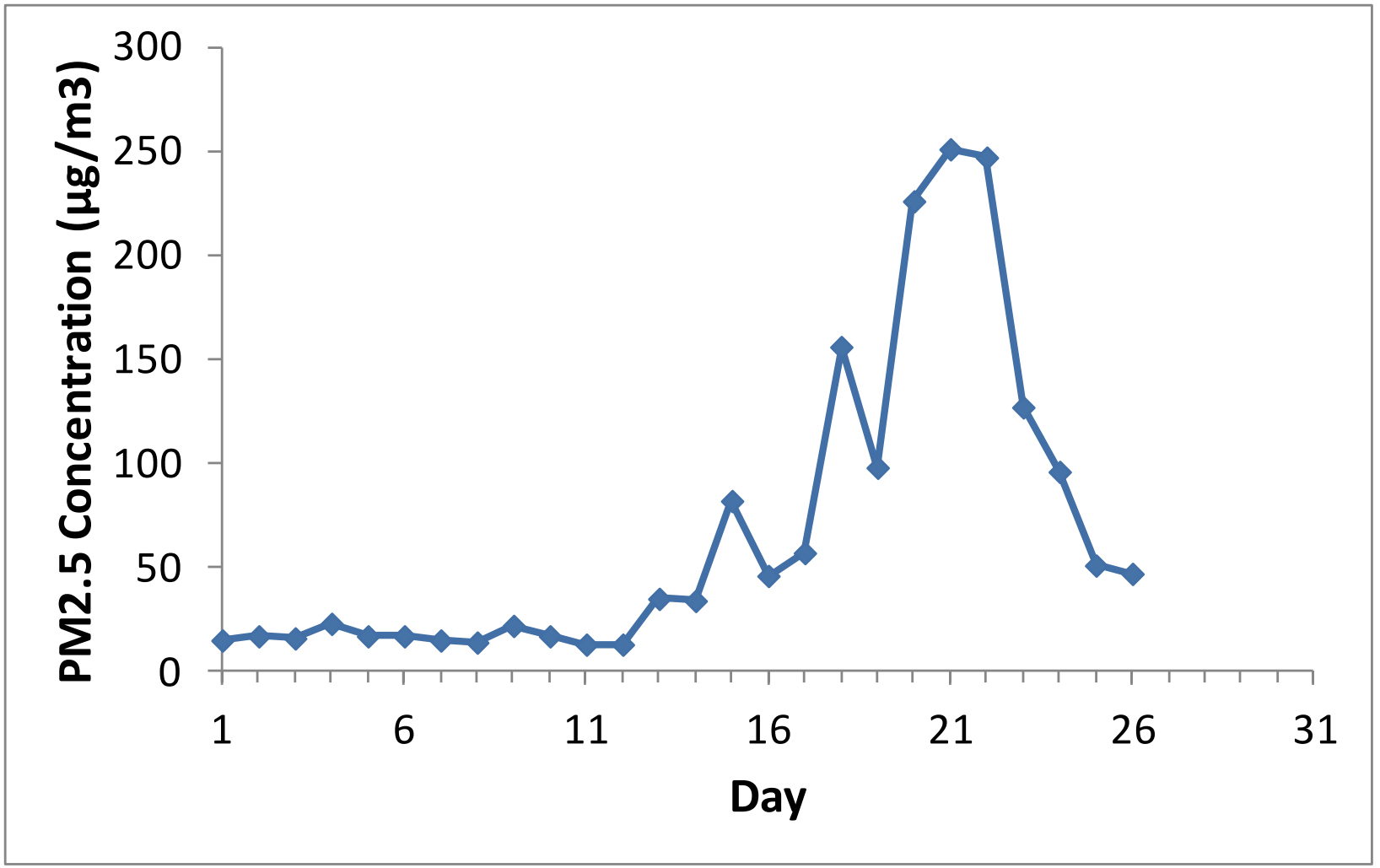


Suomi NPP
2013-06-19

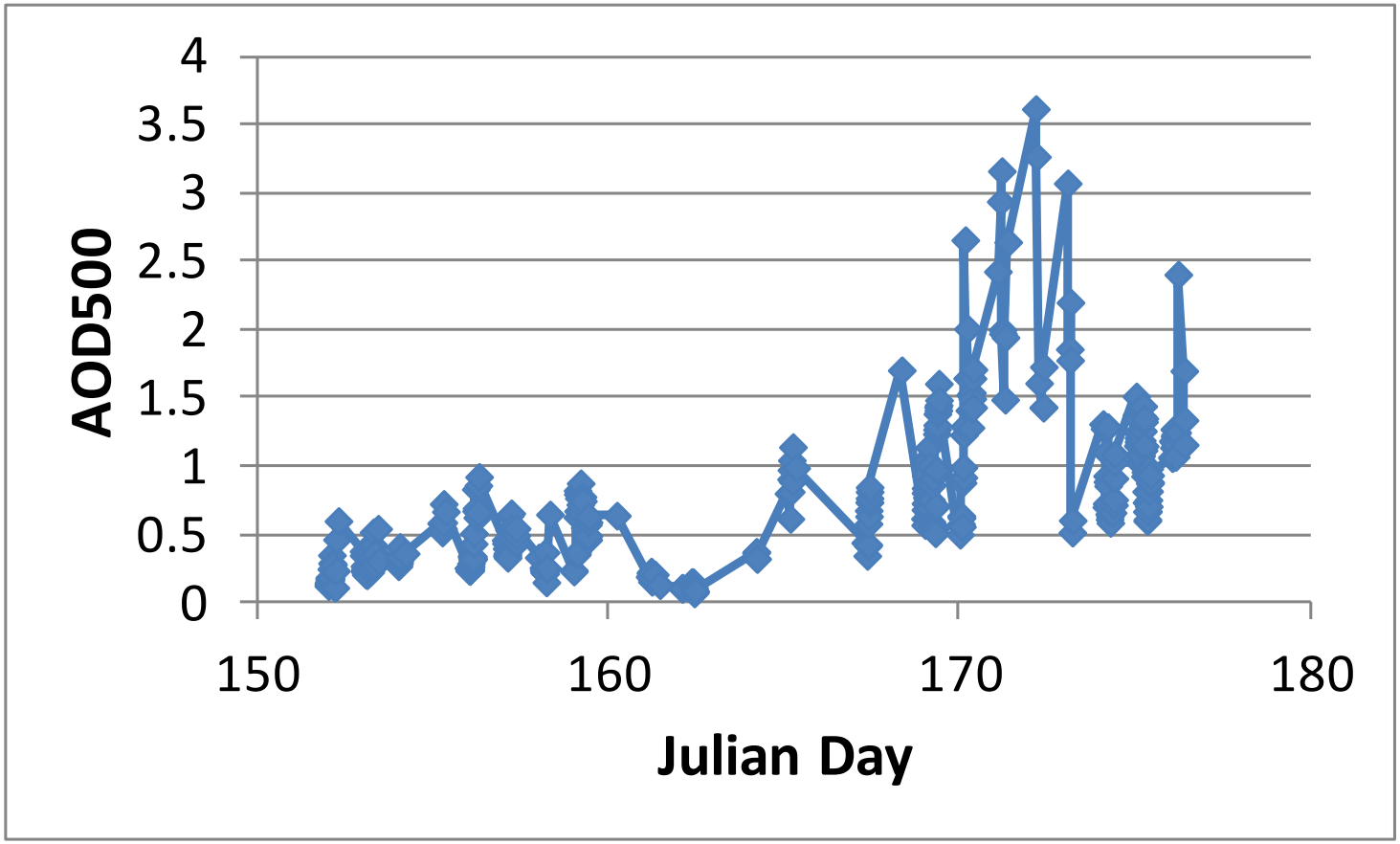
Singapore PSI
June 2013



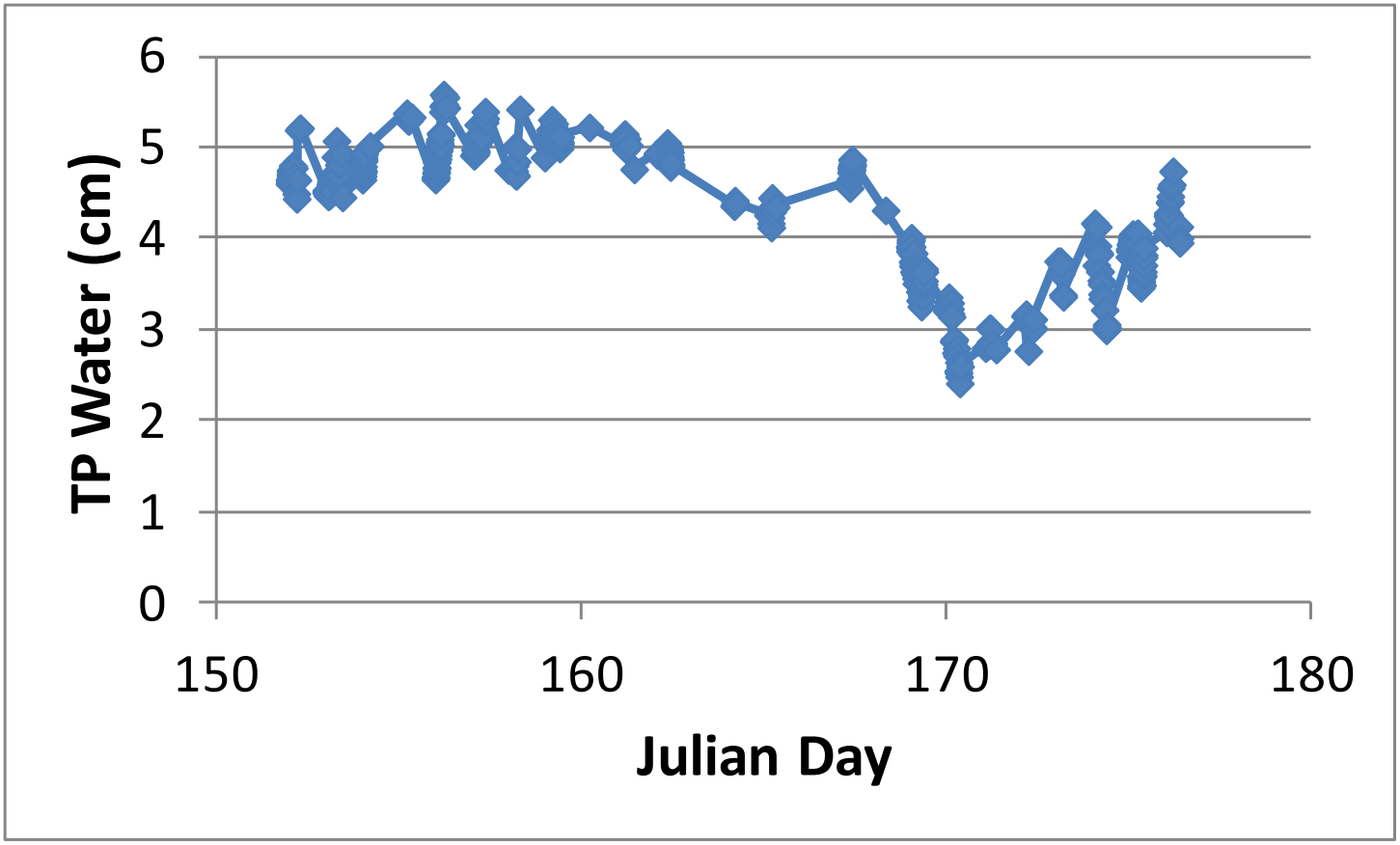
Singapore
24 hr avg PM2.5 at 8 am



Singapore AERONET AOD500 (AE>1)



Singapore AERONET TP Water



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2013-06-21