The NASA Land-Cover/Land-Use Change (LCLUC) Science: Focus on South East Asia

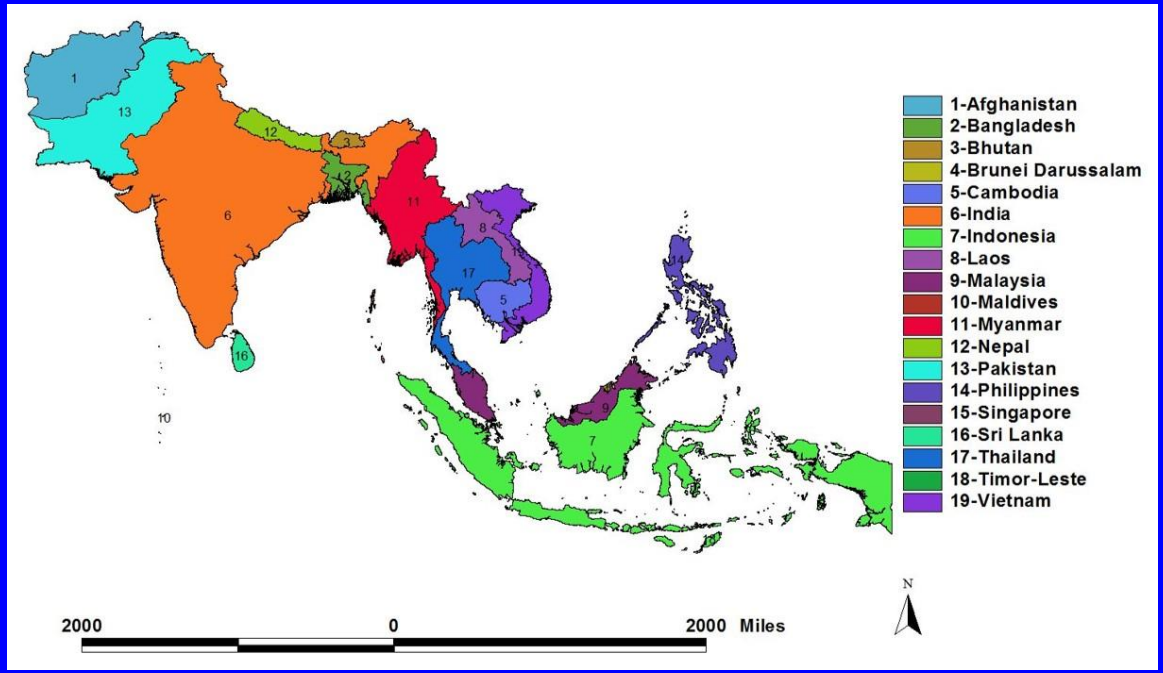
Garik Gutman,
LCLUC Program Manager
NASA Headquarters
Washington, DC

- LCLUC is a global program supported through regional partnerships to enhance
  - Regional scientists' access to NASA assets
  - NASA scientists access to national data and facilitate field data collection
- LCLUC is a catalyst for regional science initiatives through
  - Networks by leveraging national/local knowledge and resources and strengthening NASA research projects
  - Workshops focused on societal priorities and policy-relevant land-use science
- LCLUC is a promoter of regional capacity building through
  - NASA data-use training
  - International data sharing

The South/SE Asia Research Initiative (SARI)

Goal: Develop an innovative regional research, education, and capacity building program involving state-of-the-art remote sensing, natural sciences, engineering and social sciences to enrich Land Cover/Land Use Change (LCLUC) science in South/SE Asia

- 20+ ongoing projects on SARI region
- Interactions with two SERVIR hubs:
  - Mekong and Himalaya
- Series of regional SARI workshops and trainings



The Inventory of SE Asia Projects

Current Projects Southeast Asia

Displaying 1 - 10 of 10

Principal Investigator: - Any -

Search by Title

Apply Reset

Principal Investigator	Project Name	Start Date	End Date
Jiaguo Qi	Assessing the Impacts of Dams on the Dynamic Interactions Among Distant Wetlands, Land Use, and Rural Communities in the Lower Mekong River Basin	05/01/2018	05/01/2021
Matthew Hansen	A Cobra in the Forest? Quantifying the Impact of Perverse Incentives from Indonesia's Deforestation Moratorium, 2011 to 2016	05/01/2018	05/01/2021
Jefferson Fox	The Agrarian Transition in Mainland Southeast Asia: Changes in Rice Farming - 1995 to 2018	05/01/2018	05/01/2021
Varaprasad Bandaru	Agricultural Land Use Change in Central and Northeast Thailand: Effects on Biomass Emissions, Soil Quality, and Rural Livelihoods	05/01/2018	05/01/2021
Son Nghiem	Land Use Status, Change and Impacts in Vietnam, Cambodia and Laos	05/01/2018	05/01/2021
Jessica McCarty	Land-Cover/Land-Use Change in Southern Vietnam Through the Lenses of Conflict, Religion, and Politics, 1980s to Present	05/01/2018	05/01/2021

Past Projects Southeast Asia

Displaying 1 - 24 of 24

Principal Investigator	Project Name	Start Date	End Date
William Salas	Operational Algorithms and Products for Near Real Time Maps of Rice Extent and Rice Crop Growth Stage Using Multi - Source Remote Sensing	07/01/2015	07/01/2018
Peilei Fan	Urbanization and Sustainability Under Global Change and Transitional Economies:Synthesis from Southeast, East and North Asia (SENA)	05/01/2015	05/01/2018
David Skole	Monitoring and Mapping the Area, Extent and Shifting Geographies of Industrial Forests in the Tropics	04/01/2014	04/01/2017
Jefferson Fox	Forest, Agricultural, and Urban Transitions in Mainland Southeast Asia: Synthesizing Knowledge and Developing Theory	04/01/2014	04/01/2017
Yuanwei Qin	Mapping Industrial Forest Plantations in Tropical Monsoon Asia Through Integration of Landsat and PALSAR Imagery	04/01/2014	04/01/2017
Atul Jain	Land Cover and Land Use Changes and Their Effects on Carbon Dynamics in South and South East Asia: A Synthesis Study	04/01/2014	04/01/2017
Stephen Leisz	Increased Accessibility, Landscape Changes, Rural Transformations, and Urbanization: Impacts of the East-West Economic Corridor from Da Nang, Vietnam, to Khon Kaen, Thailand	01/01/2013	01/01/2016
Chandrashekhar Biradar	Quantifying Changes in Agricultural Intensification and Expansion in Monsoon Asia during 2000-2010	05/31/2011	05/30/2014
Xiangming Xiao	Quantifying Changes in Agricultural Intensification and Expansion in Monsoon Asia during 2000-2010	05/31/2011	05/30/2014
Lisa Curran	Socio-economic and Political Drivers of Oil Palm Expansion in Indonesia: Effects on Rural Livelihoods, Carbon Emissions and REDD	04/29/2011	04/28/2014
Hanqin Tian	Land Use - Ecosystem - Climate Interactions in Monsoon Asia	05/01/2008	04/30/2012
Xiangming Xiao	Developing Land Cover Classification Products in Monsoon Asia Over the Period of 2004-2007 Through Integration of Landsat and ALOS/PALSAR Images	04/23/2008	12/03/2010
Jefferson Fox	The Expansion of Rubber and its Implications for Water and Carbon Dynamics in Montane Mainland Southeast Asia	04/10/2008	04/10/2012
Atul Jain	Land Cover and Land Use Change and its Effects on Carbon Dynamics in Monsoon Asian Region	04/01/2008	03/31/2012
Darla Munroe	A Comprehensive Statistical Analysis System to Associate Local Land-Cover/Land-Use Change and Regional Aerosol Composition and Concentration	01/01/2005	01/01/2008
Jefferson Fox	The Role of Land-Cover Change in Montane Mainland Southeast Asia in Altering Regional Hydrological Processes Under a Changing Climate	01/01/2004	01/01/2007
Lisa Curran	Effects of Logging, Plantation Conversion, Biomass Burning and Regrowth on Carbon Dynamics in Bornean Peat and Dipterocarp Forests: Implications for Global Carbon Cycle	01/01/2004	01/01/2007
Ruth DeFries	Reducing Uncertainties of Carbon Emissions from Land Use-Related Fires with MODIS Data: From Local to Global Scale	01/01/2004	01/01/2007
Lisa Curran	Influence of Humans, Climate, and Fire on Forest Ecosystems and Carbon Dynamics in Indonesian Borneo	01/01/2001	01/01/2004
Matthew Hansen	Land Use Change Around Protected Areas in LCLUC Sites: Synthesis of Rates, Consequences for Biodiversity, and Monitoring Strategies	01/01/2001	01/01/2004
Ronald Rindfuss	Simulating of Land Use Dynamics in Southeast Asia: A Cellular Automation Approach	01/01/2001	01/01/2004
Andrew Hansen	Land Use Change Around Protected Areas in LCLUC Sites: Synthesis of Rates, Consequences for Biodiversity, and Monitoring Strategies	01/01/2001	01/01/2004
Ronald Rindfuss	Soils, Water, People and Pixels: A Study of Nang Rong	01/01/1997	01/01/2000
David Skole	Case Studies and Diagnostic Models of the Interannual Dynamics of Deforestation in Southeast Asia: Is the Missing Sink for Carbon in Land Cover Change	01/01/1997	01/01/2000

What We Have Learned by Now

Basic Drivers

- Population growth in Southeast Asia drives rapid urban expansion on rural and agricultural lands
- Loss of agricultural lands to urban expansion (fastest driver) → deforestation in order to clear land for new fields to meet agricultural demand
- Switch from growing rice to higher value crops (sugarcane, cassava, and banana) → loss of shifting cultivation
- Expansion of aquaculture, and roads, dams, and mines → loss of wetlands and other natural habitat

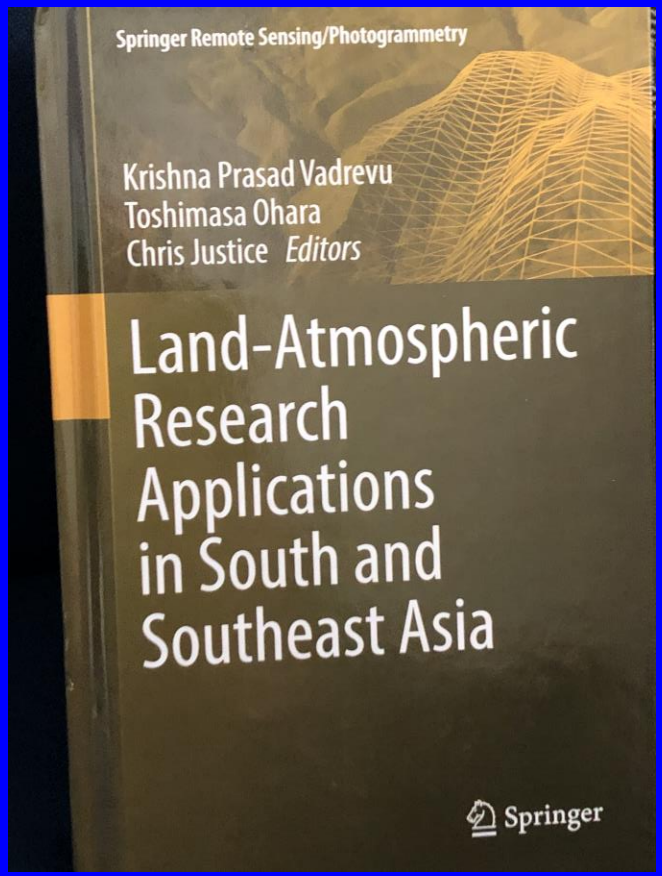
Impacts

- Large-scale land-cover conversion for agriculture → changes in the carbon cycle
- Slash & burn Ag → degraded air quality & increased emissions
- Increased field size, growth of biofeed stocks, year-round agroforestry, and livestock → ecological impacts
- Rise in the prices for rubber and palm → economic impact (reduced food production and increased food costs)

NASA-SARI Science

Based on the pre-SARI projects and ongoing projects from

- LCLUC-2015 selections for South Asia
- LCLUC-2016 selections for Southeast Asia
- LCLUC-2018 selections for Asia (to be soon announced)

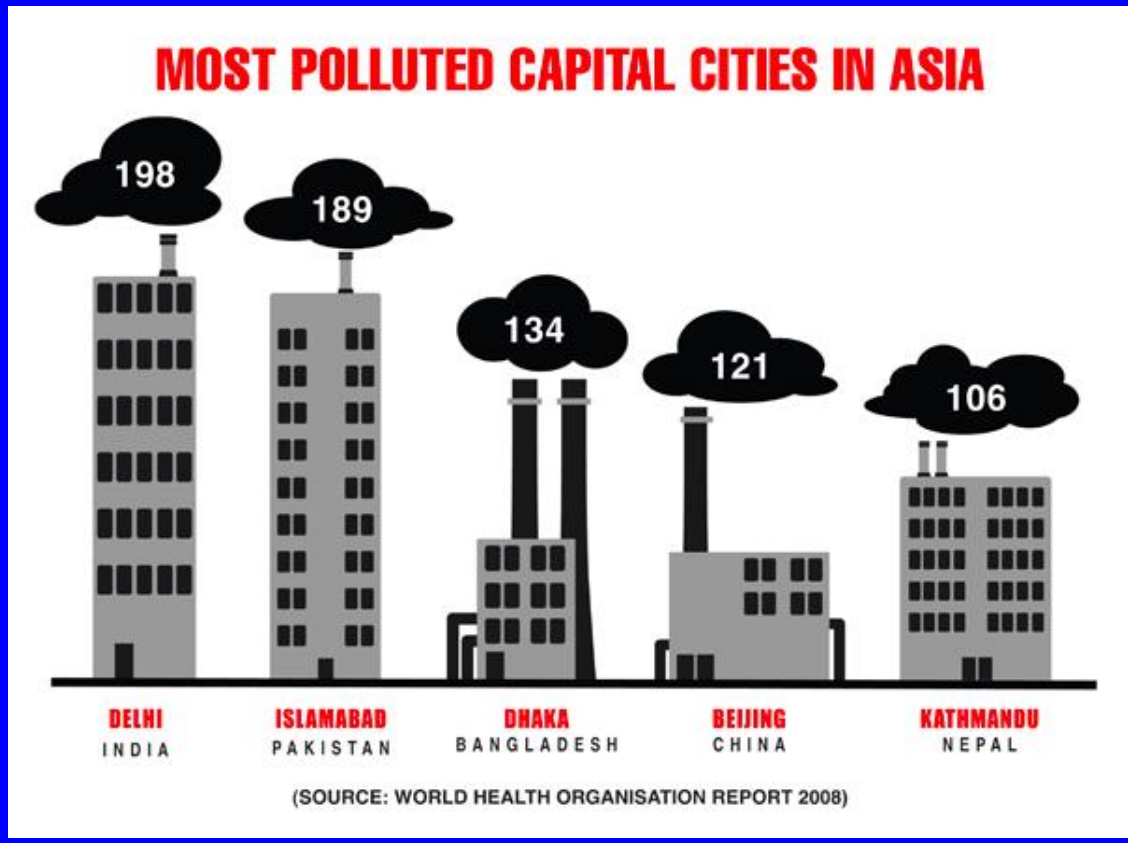


2018

Air Pollution in Asia

– Delhi	153 PM
Karachi	117
– Dhaka	8
– Beijing	56
– Colombo	28
– Jakarta	21
– Singapore	17

Air pollution in city reaches alarming level (The Jakarta Post, Jakarta | Jakarta | Mon, June 10 2013)



The WHO advises that fine particles of less than 2.5 micrometres in diameter (PM2.5) should not exceed 10 micrograms per cubic metre

Fores Fires Smoke: Transboundary haze

An aerial photo shows wildfire burning in Giam Siak Kecil Biosphere forest area, Bukit Batu, Riau, Indonesia. More than 33,300 residents of Riau have already suffered acute respiratory tract infection because of the haze. (31 March, 2014, **TEMPO.CO**, **Jakarta**)

Residents of Sampit, Indonesia, bike through smog in Sept. 2012. (Photo : Reuters)

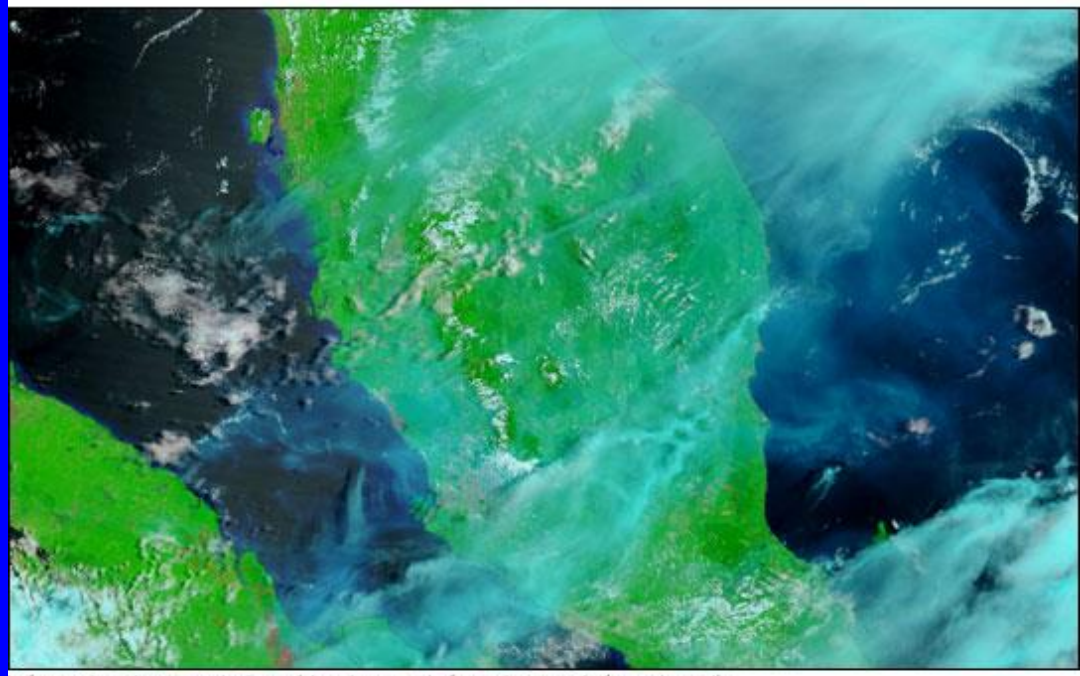
Singapore's city-state Pollutant Standards Index shot up on Monday as wild forest fires made the smog and haze sitting on the skyscrapers and landscape the worst it has been in the past seven years. Malaysia also fell prey to the choking smog that spread from the neighboring country.

The August 2005 Event

- In mid-August, several locations in mainland Malaysia declared air quality emergencies, as smoke from burning in Indonesia wafted across the Strait of Malacca and blanketed the country with haze. Many regions closed their schools and businesses, and news reports have indicated this **may be the worst air quality event the country has experienced since the terrible fire season on Sumatra during the 1997-98 El Niño**

Smoke contains many substances, including carbon dioxide, carbon monoxide, water vapor, and particulate matter.

Smoke over Malaysia, Terra MODIS, August 12, 2005


Infrared-enhanced view (shortwave infared, near infared, red)

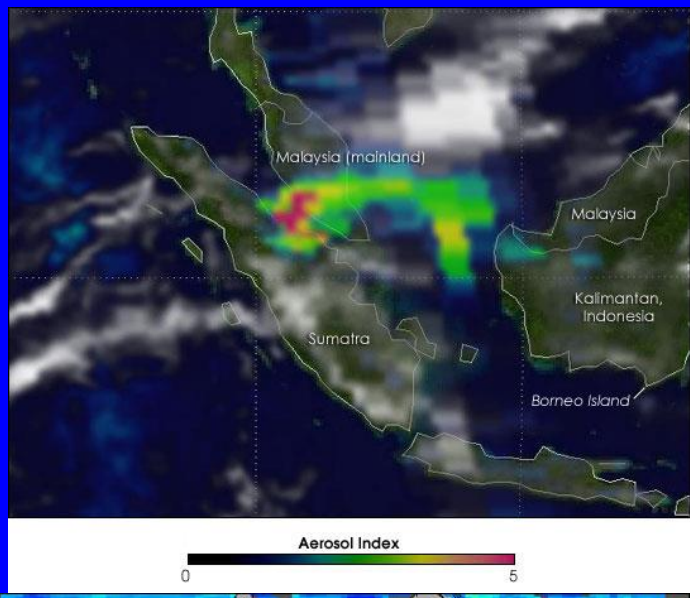
Tracking Pollution

August 2005

Ozone Monitoring Instrument (OMI) on NASA's Aura satellite

OMI measures smoke by tracking black carbon particles, or soot, that absorb ultraviolet (UV) radiation.

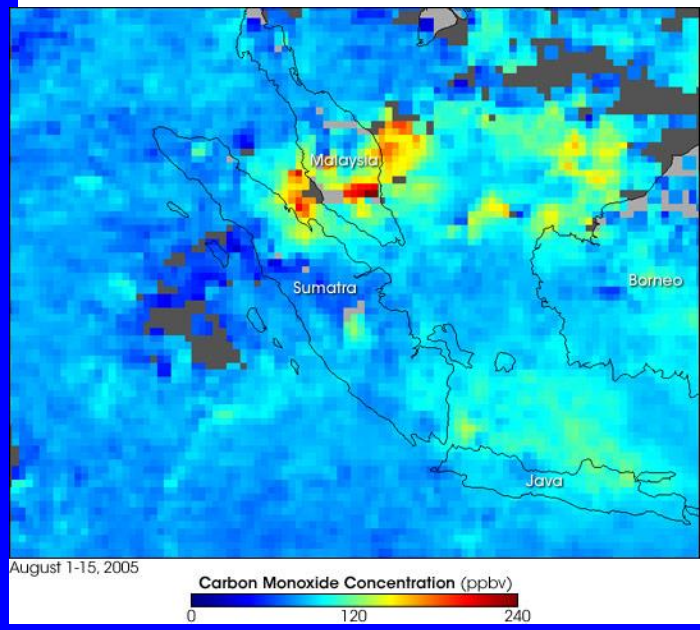
Combination of two sources of smoke—Sumatra and western Borneo—gives rise to the yellow (higher values) area between the Borneo and the mainland.



Measurements of Pollution in the Troposphere (MOPITT):

Carbon monoxide as a Tracker

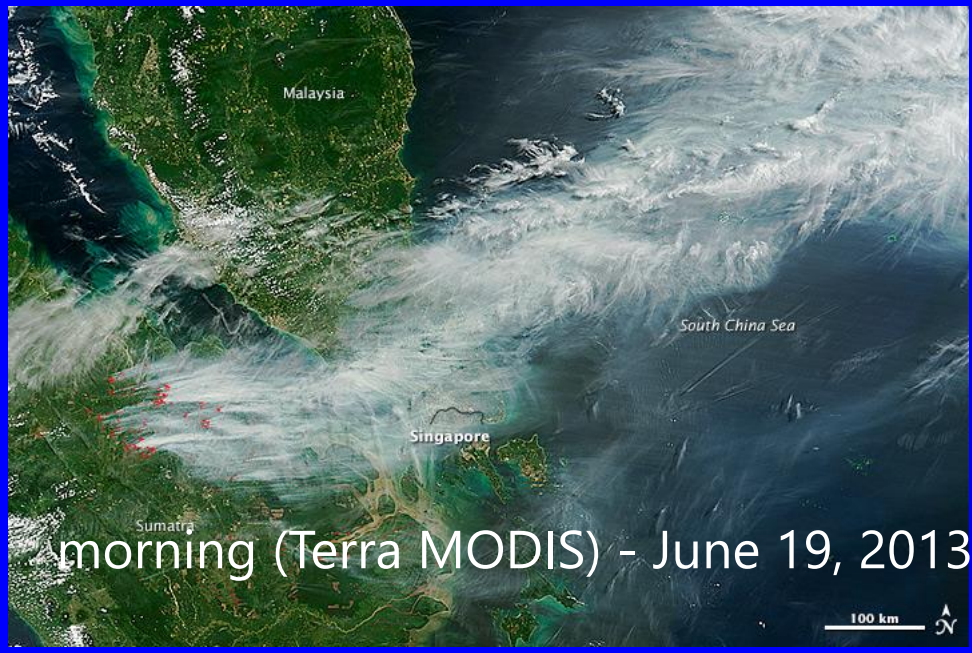
The haze was being generated by intense forest fires burning in Sumatra. Smoke began to build up over Malaysia on August 2, 2005, closing schools and businesses in the worst haze crisis since 1997-1998.



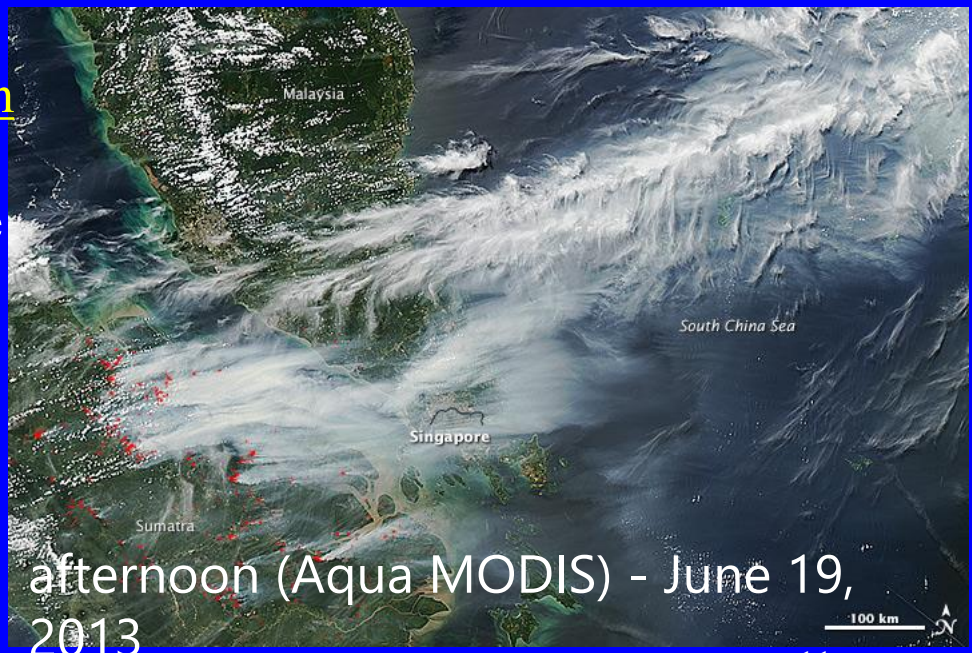
The highest concentrations, shown in red and yellow, hang over Malaysia near its capital, Kuala Lumpur. In these regions, for every billion molecules in a column of the atmosphere, 240 were carbon monoxide molecules. By contrast, regions unaffected by haze had fewer than 120 molecules per billion. High concentrations of carbon monoxide are a

The June 2013 event

Pollutant Standards Index (PSI)—similar to the Air Quality Index (AQI) used by the U.S. Environmental Protection Agency—rose to 371 on June 20, 2013, the highest level ever recorded. The previous record occurred in 1997, when the index hit 226. Health experts consider any level above 300 to be "hazardous" to human health. Levels above 200 are considered "very unhealthy."



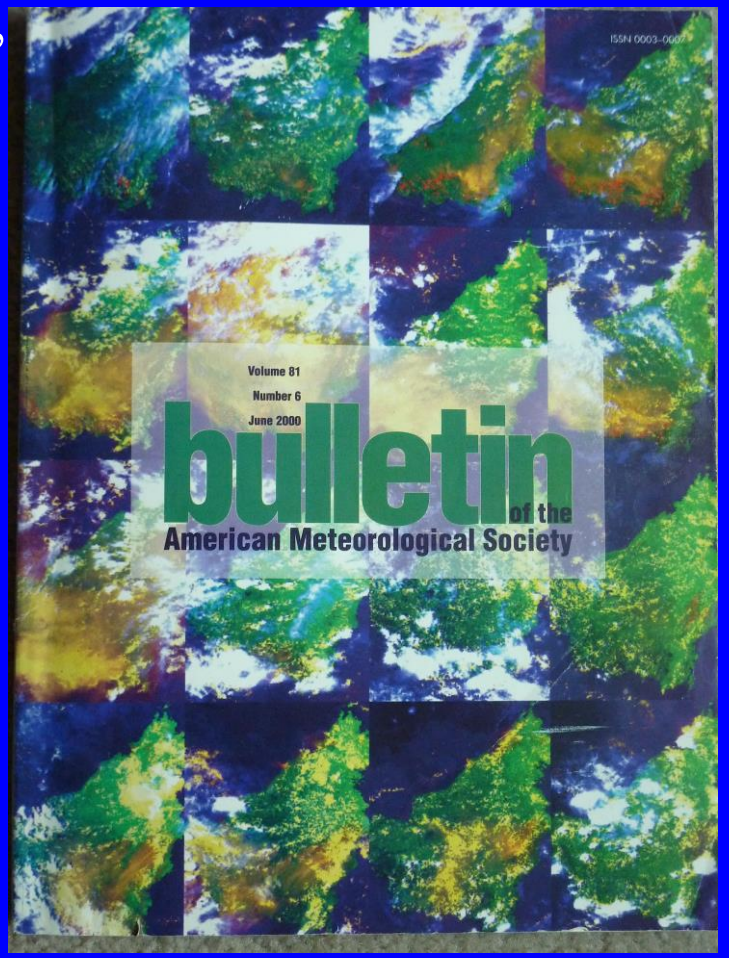
morning (Terra MODIS) - June 19, 2013



afternoon (Aqua MODIS) - June 19, 2013

Using NOAA/AVHRR Products to Monitor El Niño Impacts: Focus on Indonesia in 1997–98

- G. Gutman, I. Csiszar, and P. Romanov, 2000, Bulletin Amer. Met. Soc, 81, 1189- 1205



- AVHRR-derived variables
  - SST, LST, ALB, NDVI, Vis/NIR reflect
  - Outgoing Longwave Radiation
  - All-sky absorbed solar flux
  - Total Precipitable Water
  - Fractional Cloud Cover
  - Cloud reflectivity
  - Effective Droplet Radius
  - Fire identification

Fall 1997-Spring 1998: Consequences of El Nino event

- The fires were detected using AVHRR data with a system developed at NOAA/NESDIS based on the Justice et al. (1996) algorithm, with modifications proposed by Giglio et al. (1999) to eliminate residual false signals caused by sun glint, cloud edges, and strong thermal gradients over nonuniform land-scape
- Two phases
  - the fall of 1997
  - the spring of 1998

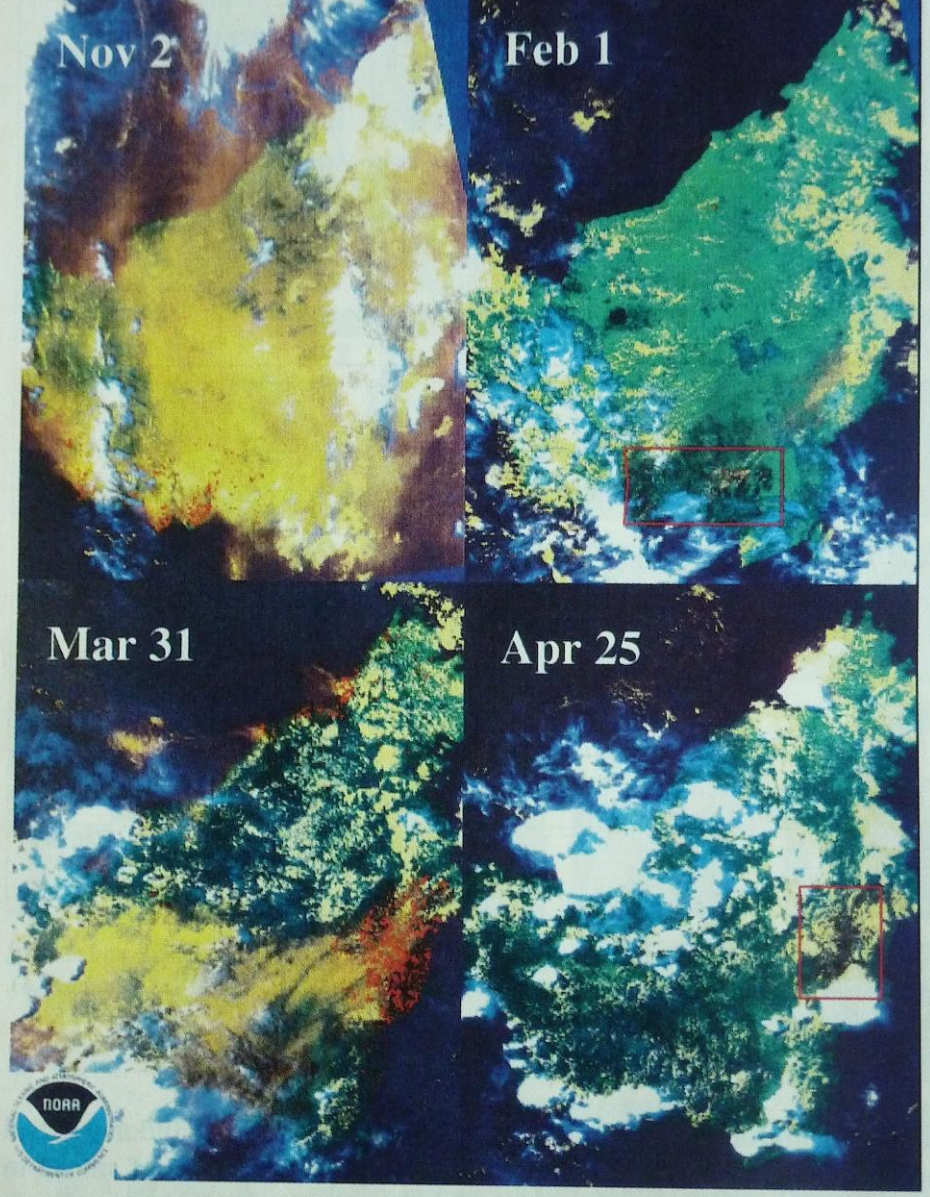


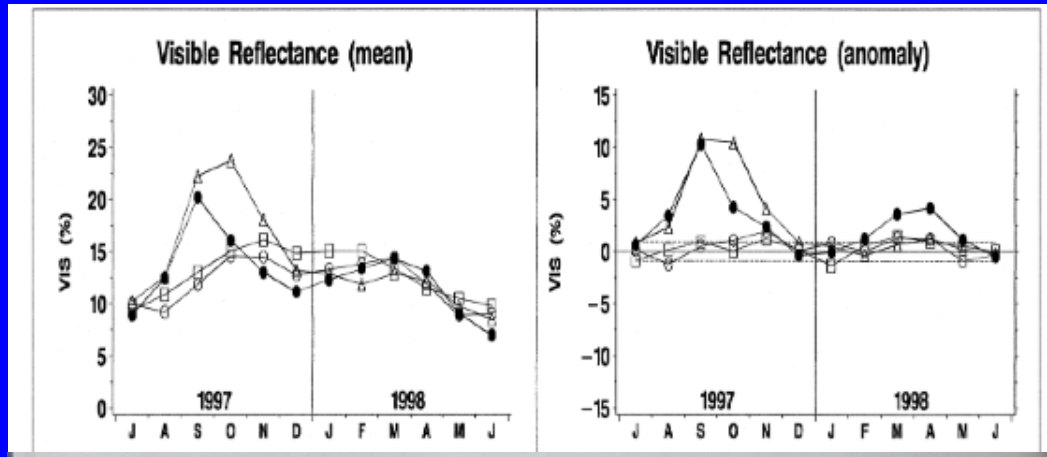
FIG. 6. AVHRR 1-km red–green–blue images over Borneo, with active fires shown as overlain red dots. Vegetation is rendered in green, smoke in yellow, clouds in white, and ocean in dark blue. The four images represent four stages of the 1997–98 event: the final phase of fires and smoke in 1997, the relatively fire-free period in the beginning of 1998, the second round of fires in 1998 and the postfire phase. The dark areas within red boxes in the southern and eastern part of the island in the 1 Feb and 25 Apr images, respectively, indicate burned areas.

Time Series of AVHRR-derived Variables: July 1997- June 1998

Land Surface Temperature (LST)

Vegetation Index (NDVI)

Visible Reflectance (LST)



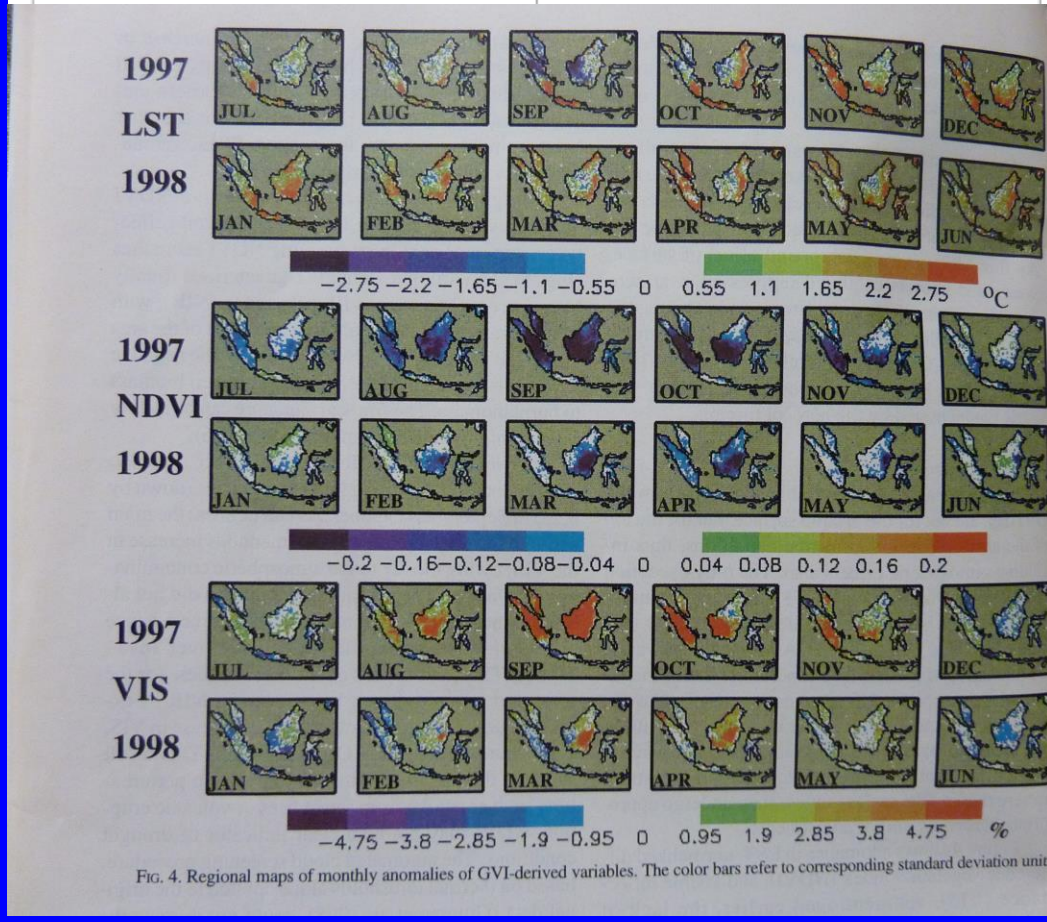
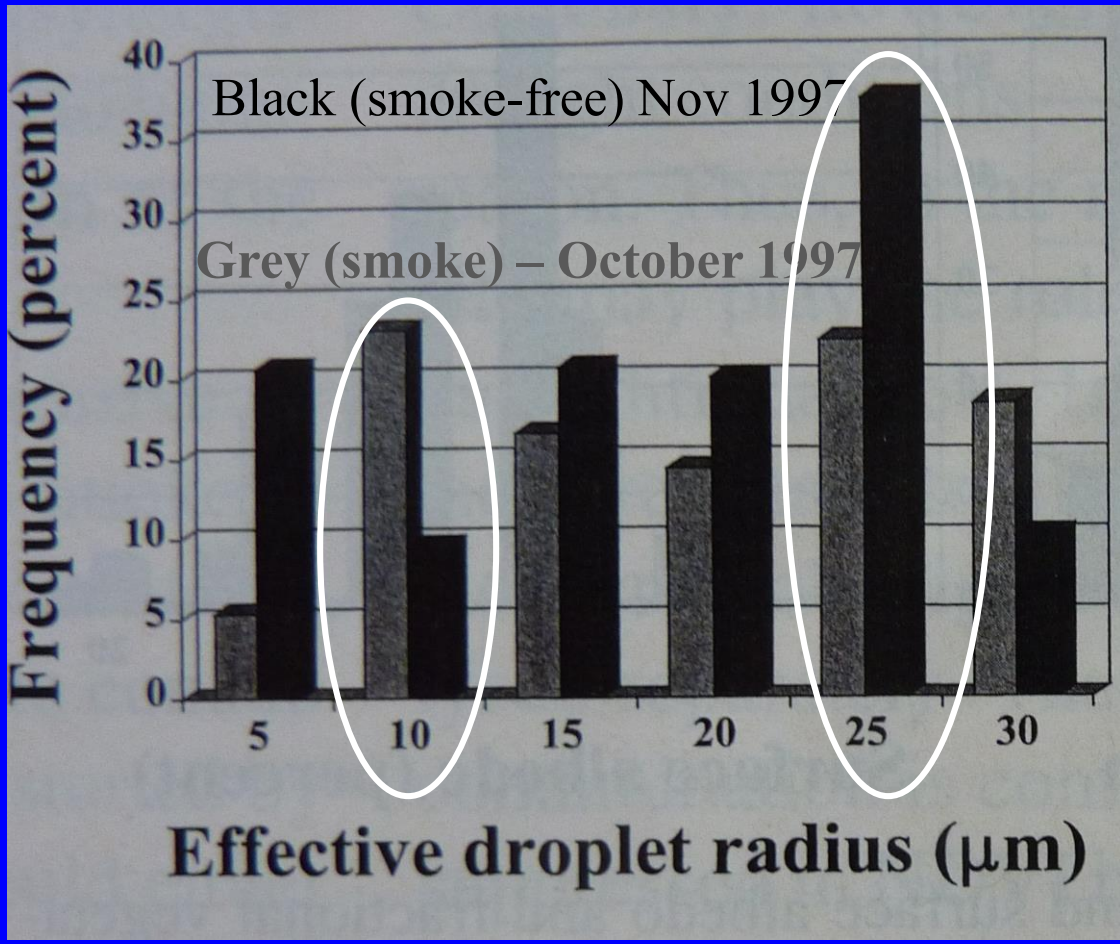


FIG. 4. Regional maps of monthly anomalies of GVI-derived variables. The color bars refer to corresponding standard deviation unit

Fire effect on cloud microphysics

Method from Rosenfeld and Gutman (1994, Atmos. Res. Journal)

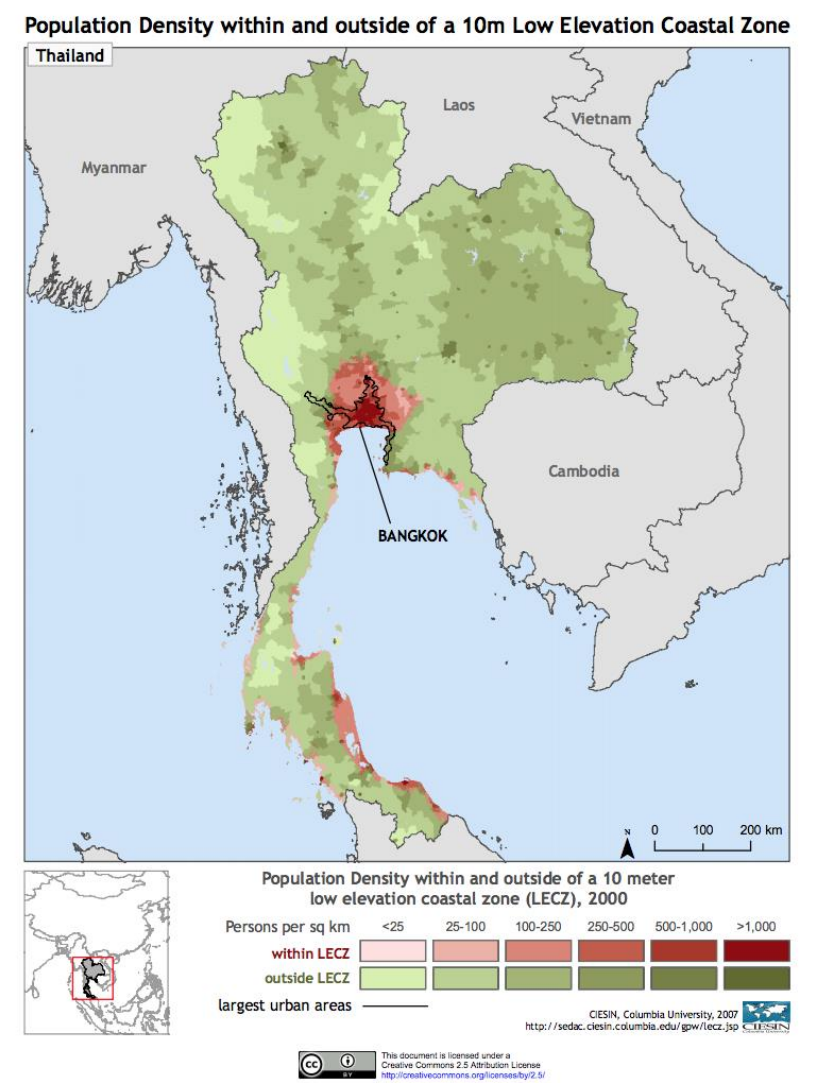
Large fires affect cloud formation processes. The maritime clouds change to a continental type with reduced rain potential, providing a positive feedback to the existing drought conditions.



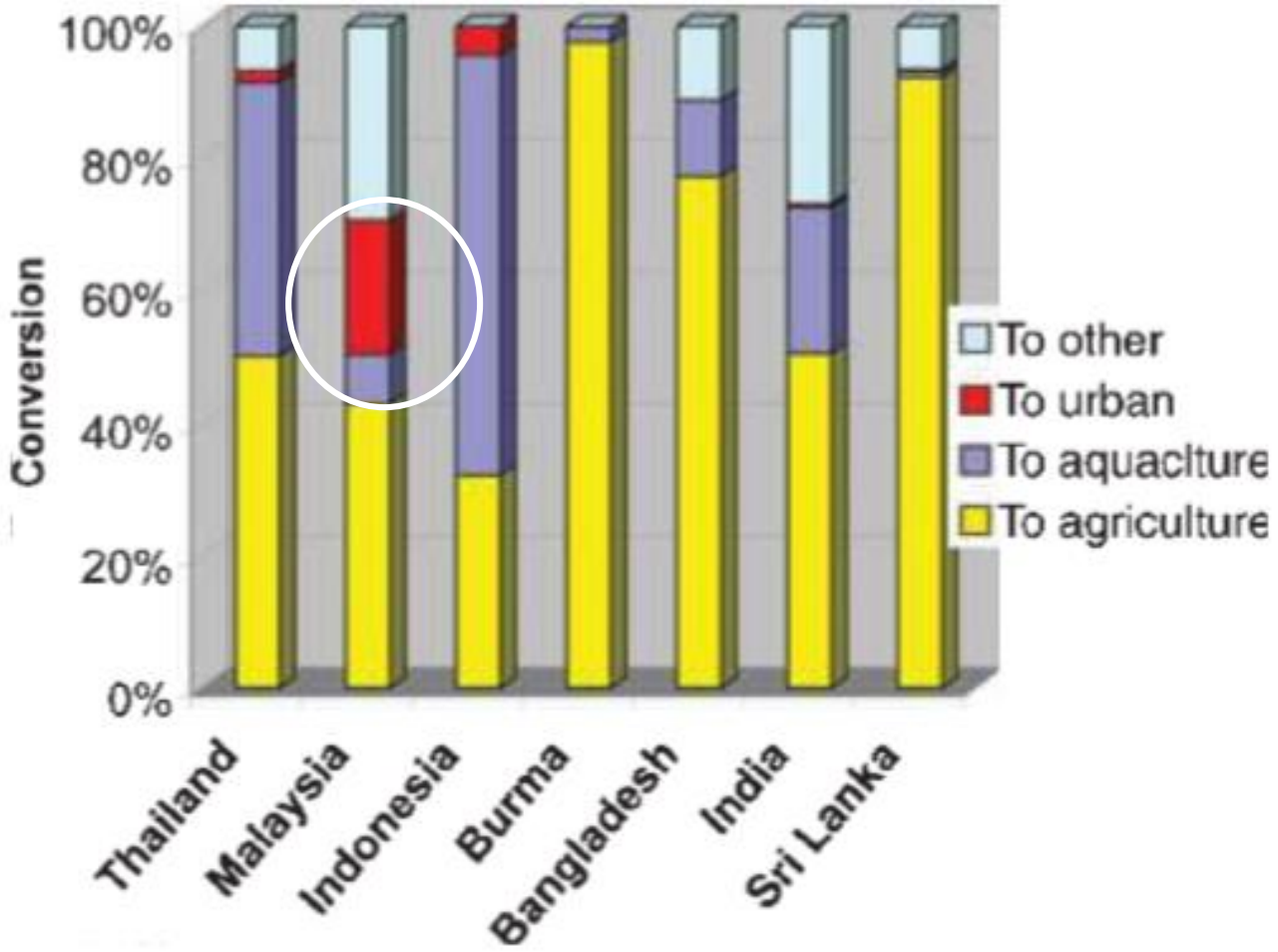
The rain systems arrived later than usual but in late November the rains put out the fires so that the end of 1997 was relatively fire- and smoke-free. As a result of fires during 1997. the total burned area over Borneo and Sumatra estimated from satellites amounted to 45 600 km2 (Levine 1999).

Coastal Zone Issues

- Presently about 40% of the world's population lives within 100 kilometers of the coast
- As population density and economic activity in the coastal zone increases, pressures on coastal ecosystems increase
- Pollution => declining water quality
- Overfishing
- Unmanaged tourism/vessel traffic
- Indirect impact of shipping
  - fuel spillage, cargo spillage, collisions
- Mangroves destruction



Major causes of mangrove destruction in select countries

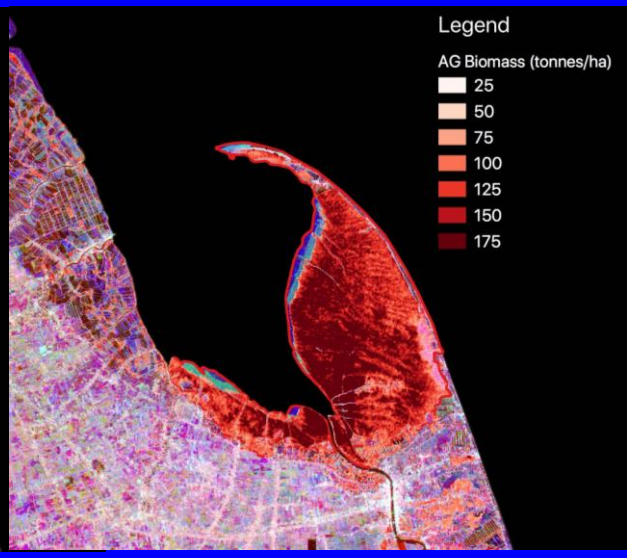


Global Mangrove Monitoring With Radar

- Loss/gain of mangrove biomass computed based on ALOS-1, ALOS-2 timeseries with 2000 baseline.
- Most mangrove loss in Thailand occurred due to shrimp farming of the 80's - 90's
- Observed gains in Thailand due to aggradation (sediment trapping) forests toward the sea from 1996 to 2017 in the shallow bay at the mouth of the Pak Phanang River, in the province of Nakhon Si Thammarat
- Mangrove distribution in Phuket, Phangna and Krabi region has NOT changed much during 2000-2015

Mangrove distribution Gulf of Thailand

Mangrove extent is shown with red polygon. RGB composition image showing aggradation (gain) of mangrove forests toward the sea from 1996 to 2017 (tones of blue at the sea edge). Light blue is gain from 2007 and 2017, and darker blue is between 2007 and 2017.



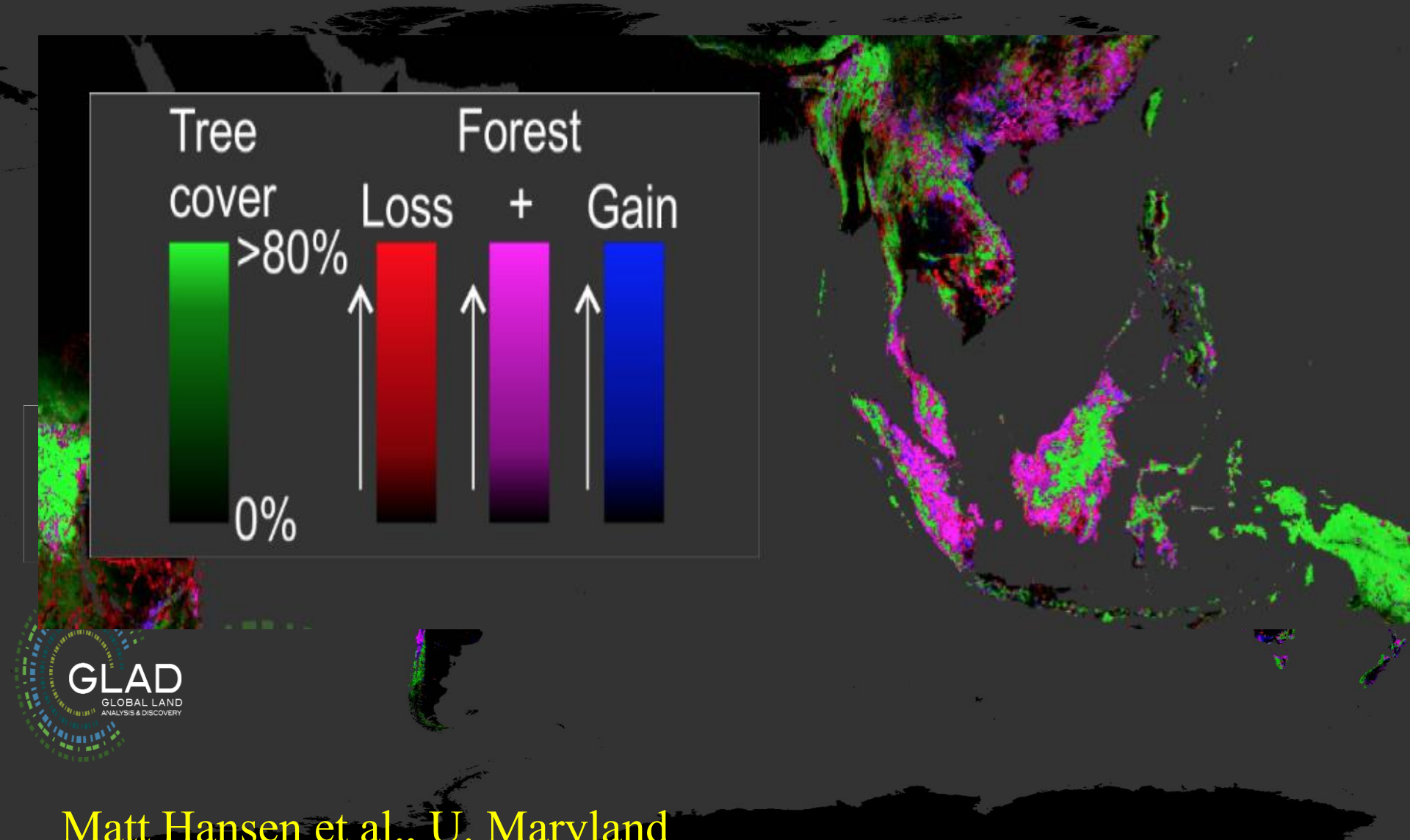
Aboveground biomass measured in 2000 is overlaid on change image.

Jet Propulsion Laboratory
California Institute of Technology

Courtesy: Marc Simard, JPL

*Thomas, N., Lucas, R., Bunting, P., Hardy, A., Rosenqvist, A. and Simard, M., 2017. Distribution and drivers of global mangrove forest change, 1996–2010. *PloS one*, *12*(6), p.e0179302.

Tree Cover Extent and Forest Loss and Gain: 2000-2014

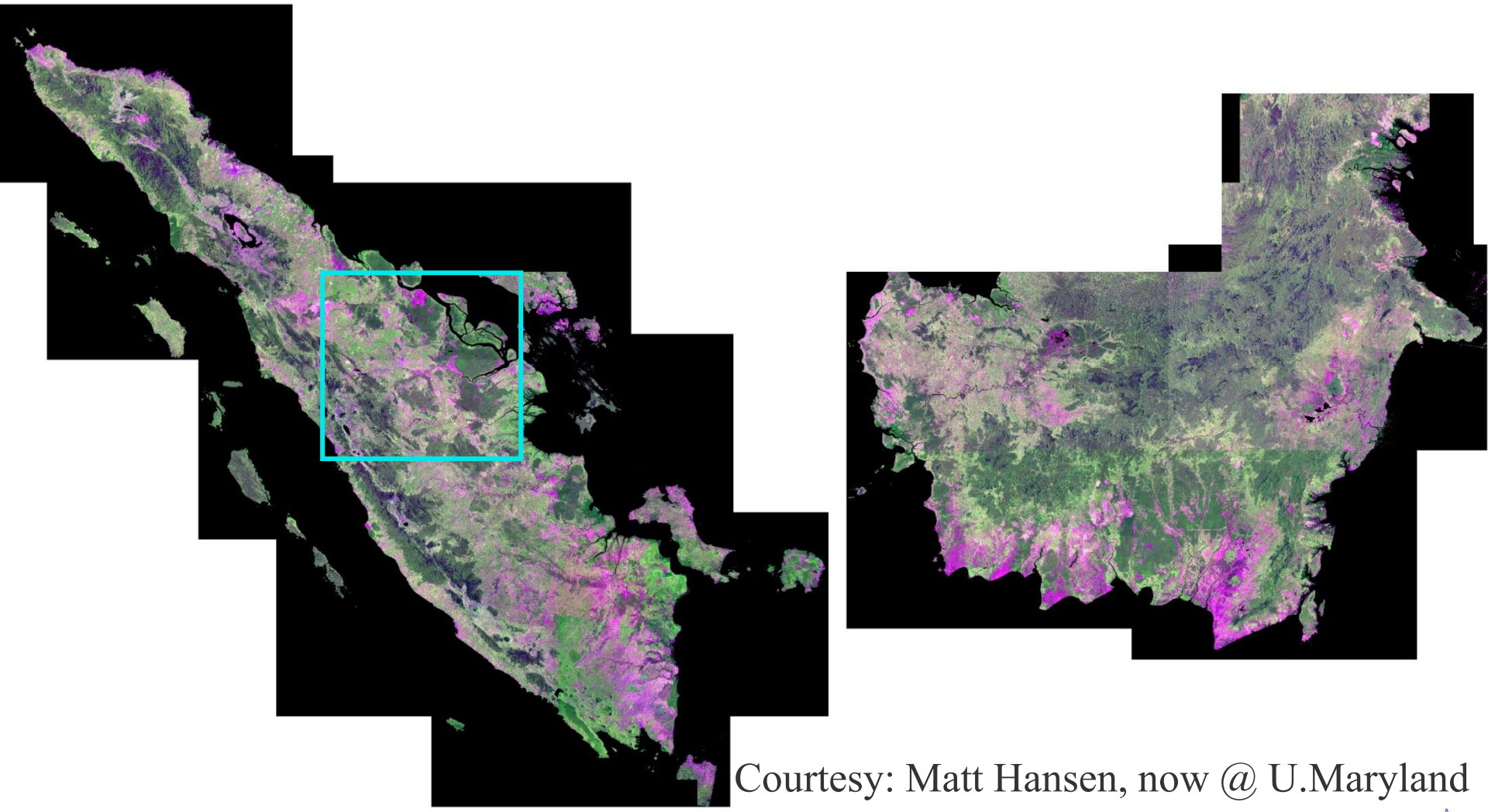


GLAD
GLOBAL LAND ANALYSIS & DISCOVERY

Matt Hansen et al., U. Maryland

Best imagery from Google
– persistent cloud cover

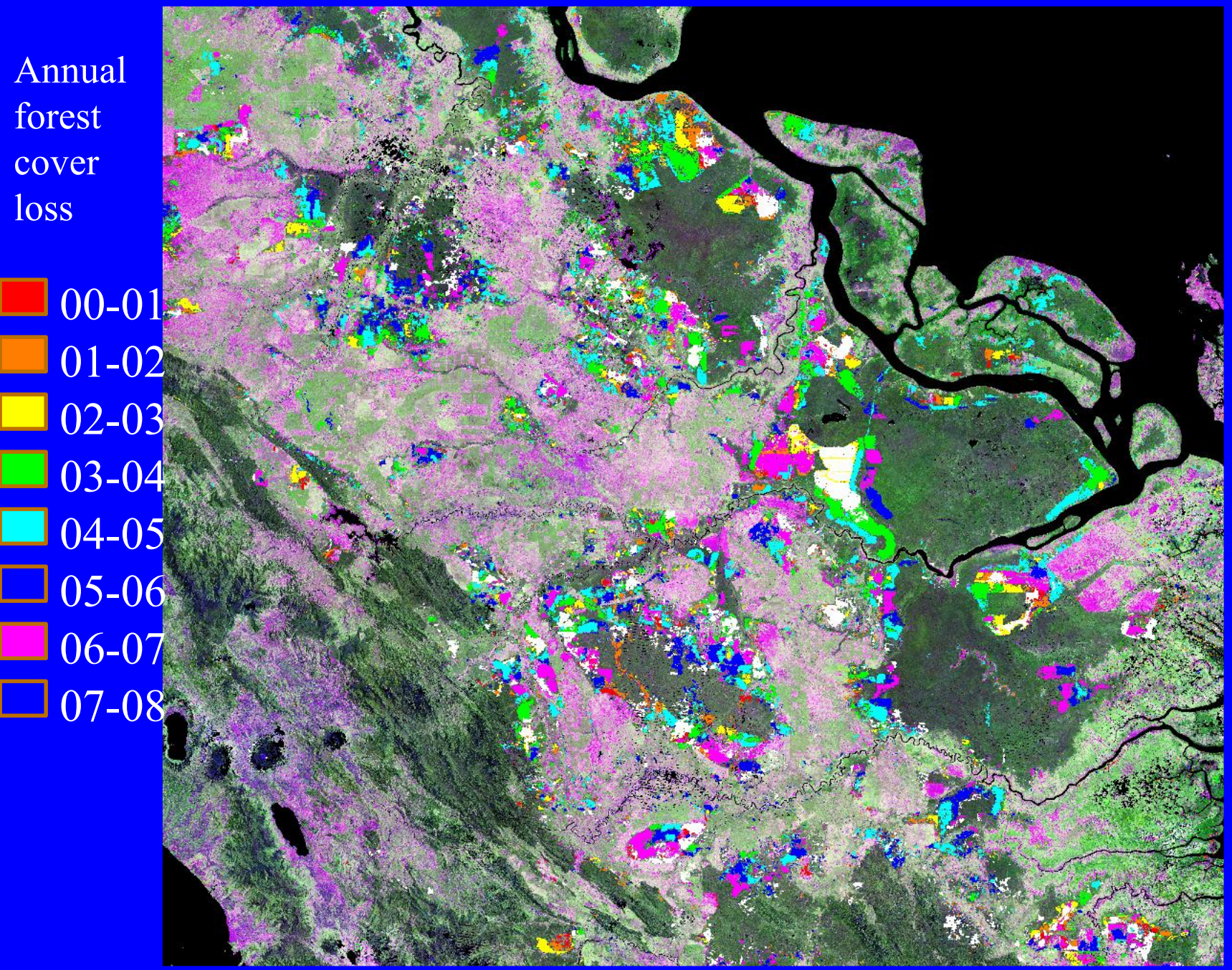
Indonesia - 6,189 images of Landsat ETM+ with 50% or less cloud cover from 1999 to 2009



Courtesy: Matt Hansen, now @ U.Maryland

Sumatra and Kalimantan

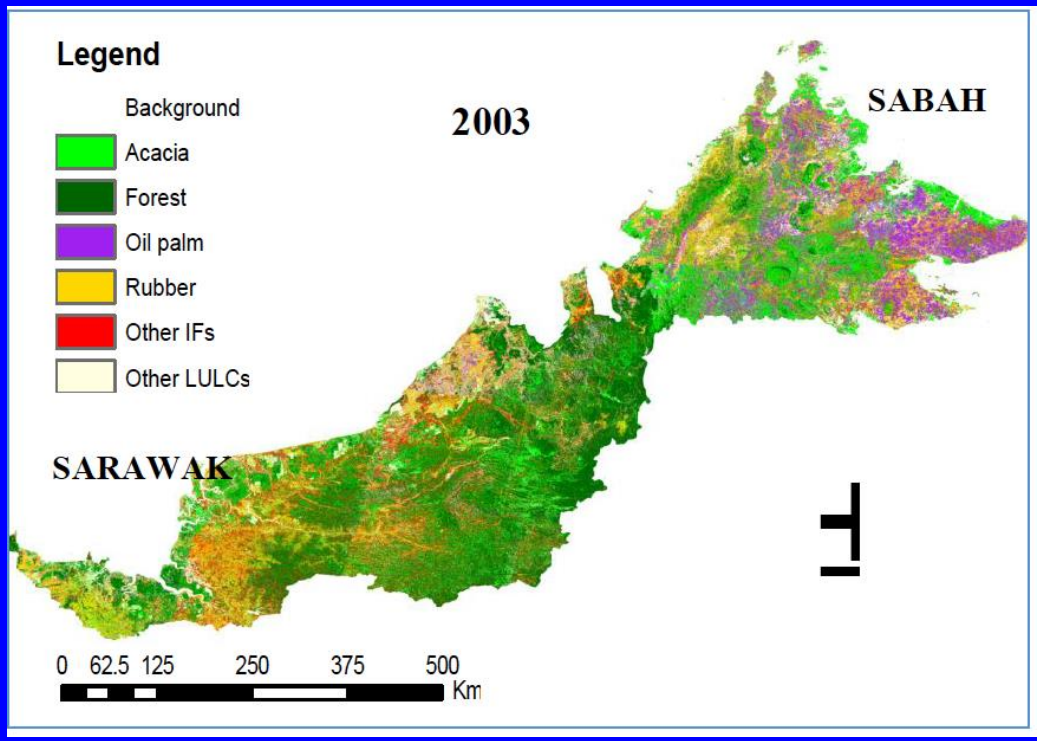
SDSU


Annual forest cover loss
00-01
01-02
02-03
03-04
04-05
05-06
06-07
07-08

MONITORING AND MAPPING THE AREA, EXTENT AND SHIFTING GEOGRAPHIES OF INDUSTRIAL FORESTS IN THE TROPICS

PI: Skole (Michigan State U.)

- VI-based industrial forest detection method
- Indices: ARVI, EVI, MSAVI*af,* NDVI*af,* SARVI and SAVI to see which index works the best for further *fC (*vegetation coverage fraction) analysis
- Methods
  - spectral analysis consisting of Principal Component Analysis (PCA), Independent Component Analysis (ICA), and Tasseled Cap Analysis (TCA)
  - textural analyses Grey Level Co-occurrence Matrix (GLCM) with textural indices consisting of Mean (MEA), Dissimilarity (DIS), and Homogeneity (HOM)



The spectral analysis-based land use/land cover map based the ***fC*** dataset in Sabah and Sarawak, Malaysia, 2003.

Non-US High/Mid-resolution

China - ASEAN Remote Sensing CBERS-4 Satellite Data Sharing Service Platform

http://www.cresda.com/EN/gjhz/jwsjld/7457.shtml

http://www.intelligence-airbusds.com/en/4239-spot-asia-partners

ISRO (ResourceSat)
Vietnam (LotusSat)
Thailand (THEOS)

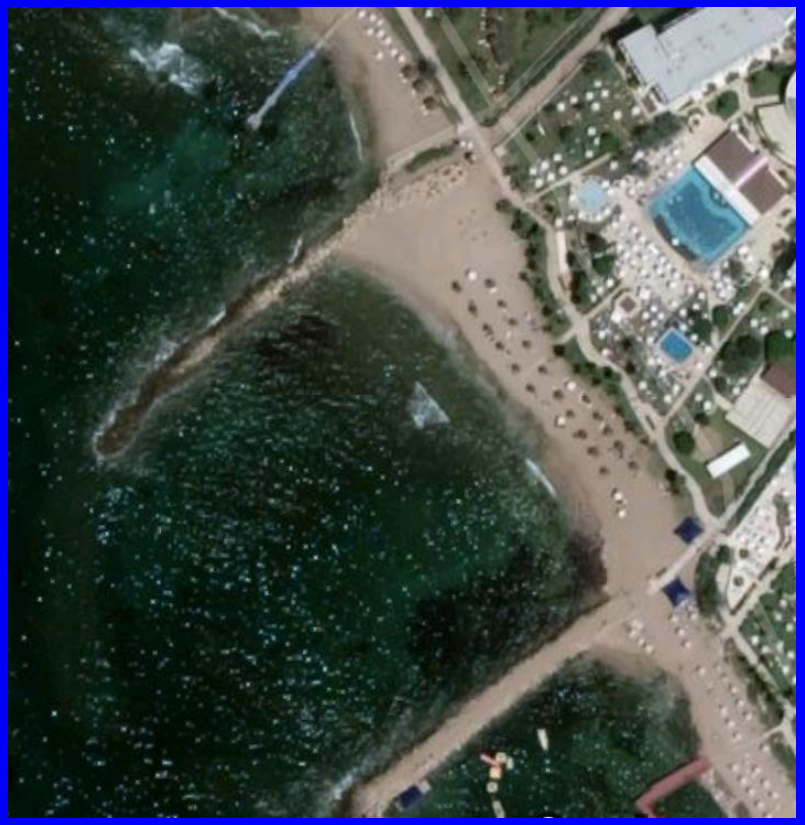
ESA Sentinel-1 and -2
JAXA AVNIR

Malaysian Remote Sensing Agency (MRSA)

- Remote sensing satellite images provided by MRSA to users are mainly acquired through Ground Receiving Station located in Temerloh, Pahang.
- Satellite images acquired by the station are from Radarsat-1, SPOT 1,2,4 & 5, NOAA, Terra and Aqua (MODIS), IRS-P4 (OCM).
- Higher resolution satellite images of QuickBird, IKONOS and Pleiades are acquired through foreign ground stations.
- **See Standard Digital Products and Pricing on http://www.remotesensing.gov.my/portal/index.php/faqs**

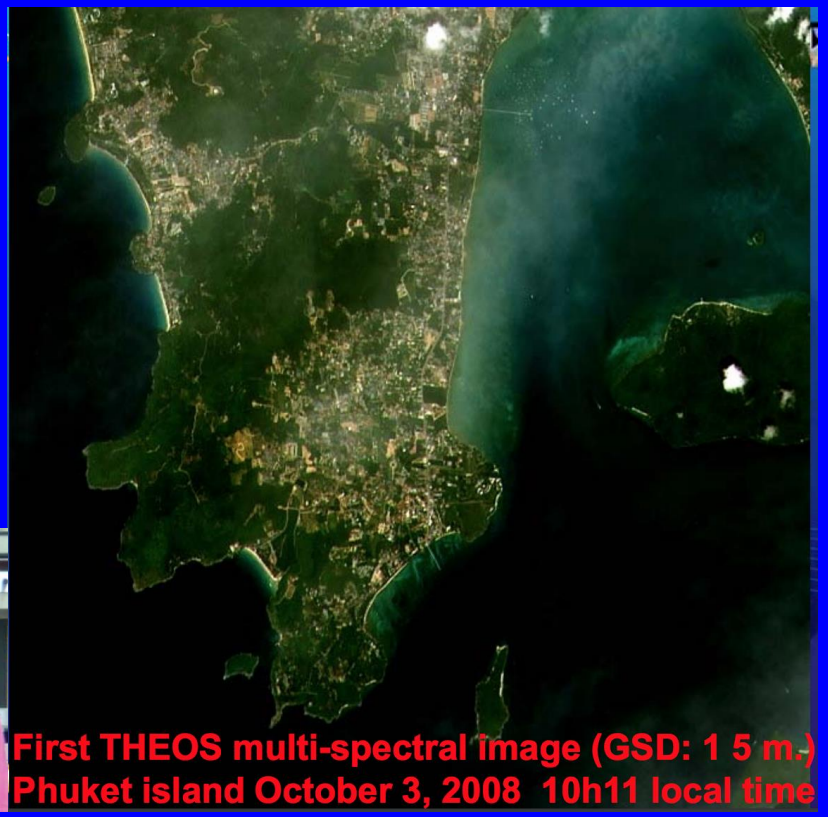
Very High Resolution Commercial Data

- It is expected that NASA-affiliated investigators will have free access to a very rich, dense high spatial resolution dataset within the next couple of years from satellite constellations of both **Planet Lab** and **Digital Globe** over land including coastal zone and cryosphere
- Limited Planet datasets are available for free already now at Universities
- Next step: fusing the DG Worldview images having higher spatial resolution but low revisit time with Planet images having lower spatial resolution but daily re-visit times



THEOS: last October - 10 years in space!

- Forest change detection
- Rice yield production
- Growth stage of rice
- Shrimp farm mapping
- Orange crop damage
- Coastal studies



THEOS first image acquisition on Oct 3, 2008

Courtesy of GISTDA

THEOS Scientific Applications

Beh Boon Chun et al., 2011: Mangrove mapping of Penang island, Malaysia by using artificial neural network. IEEE Conference Proc., Langkawi, Malaysia

2010

Educational Component: Trainings

The Data Initiative training sessions provide capacity building in support of the GOFC-GOLD Regional Networks, serving to improve access to, and use of, the remotely sensed Earth Observations around the world.

- @ Sioux Falls , SD and Boston, MA until 2012 and @ LCLUC ST meetings
- It was decided that regional trainings are preferable
- Oct 2016 - the first GOFC-GOLD Data Training hosted by GISTDA

- LCLUC SE Asia SARI Trainings
  - Jan 2016 Yangon, Burma
  - Oct 2016 Bangkok, Thailand
  - Jul 2017 Chiang Mai, Thailand
  - Mar 2018 Bangkok, Thailand
  - May 2018 Manila, Philippines
  - July 2019 Johor Bahru, Malaysia
  - *December 2019 Phuket, Thailand*


Jan 2016, Yangon, Myanmar


Jul 2017, Chiang MaiThailand

SARI Capacity Building Activities

- SERVIR
- GISTDA
- SilvaCarbon
- LCLUC
  - after/before each regional meeting

Tanita

Perry

SARI-LCLUC Regional Training, 31st May-2nd June, 2018 Philippines

terima kasih

Thank you