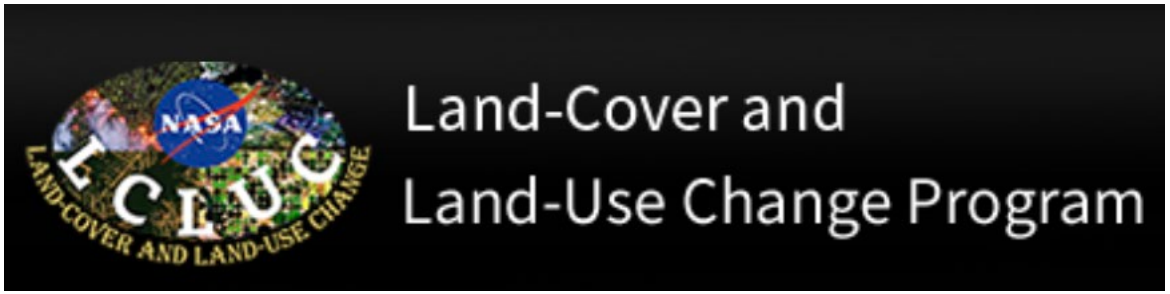
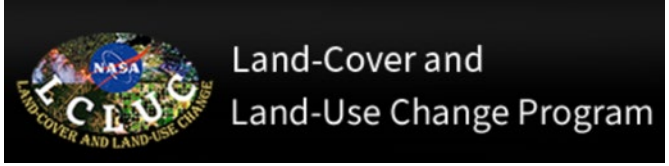


NASA LCLUC Activities in Southeast Asia

Garik Gutman,
LCLUC Program Manager
NASA HQ, Washington DC



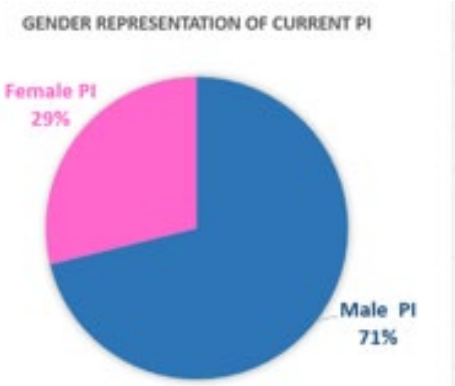
- LCLUC is a <u>global program</u> supported through regional partnerships to enhance
  - Regional scientists' access to NASA assets
  - NASA scientists' access to national data and facilitate field data collection

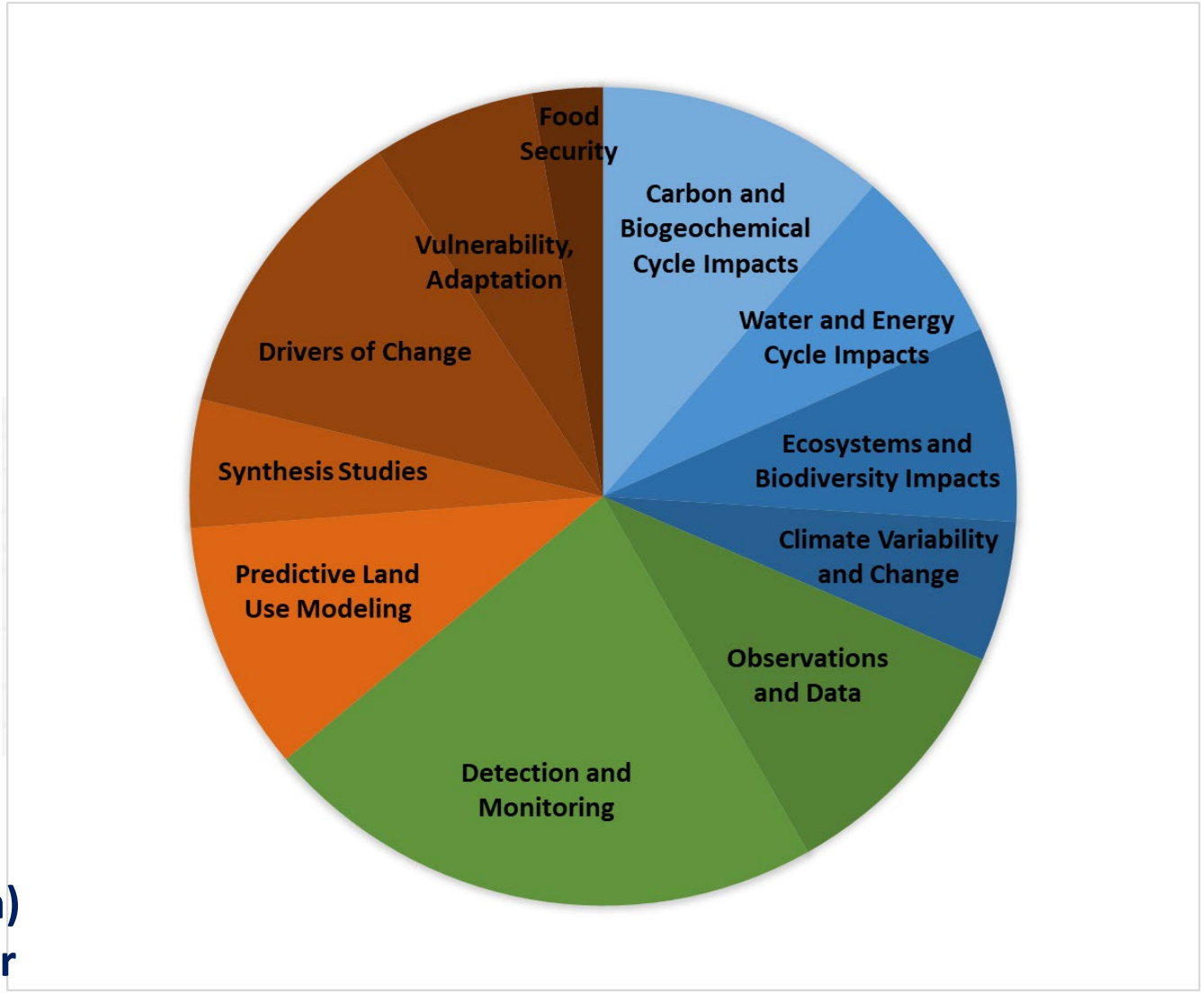
- LCLUC is a <u>catalyst for regional science initiatives</u> through
  - Networks by leveraging national/local knowledge and resources and strengthening NASA research projects
  - Workshops focused on societal priorities and policy-relevant land-use science

- LCLUC is a <u>promoter of regional capacity building</u> through
  - NASA data-use training
  - International data sharing

Program Stats and Components To Date

Program stats since its inception:
>350 projects
~40 ongoing
>940 researchers
>40 post-docs
>80 grads
>1100 publications

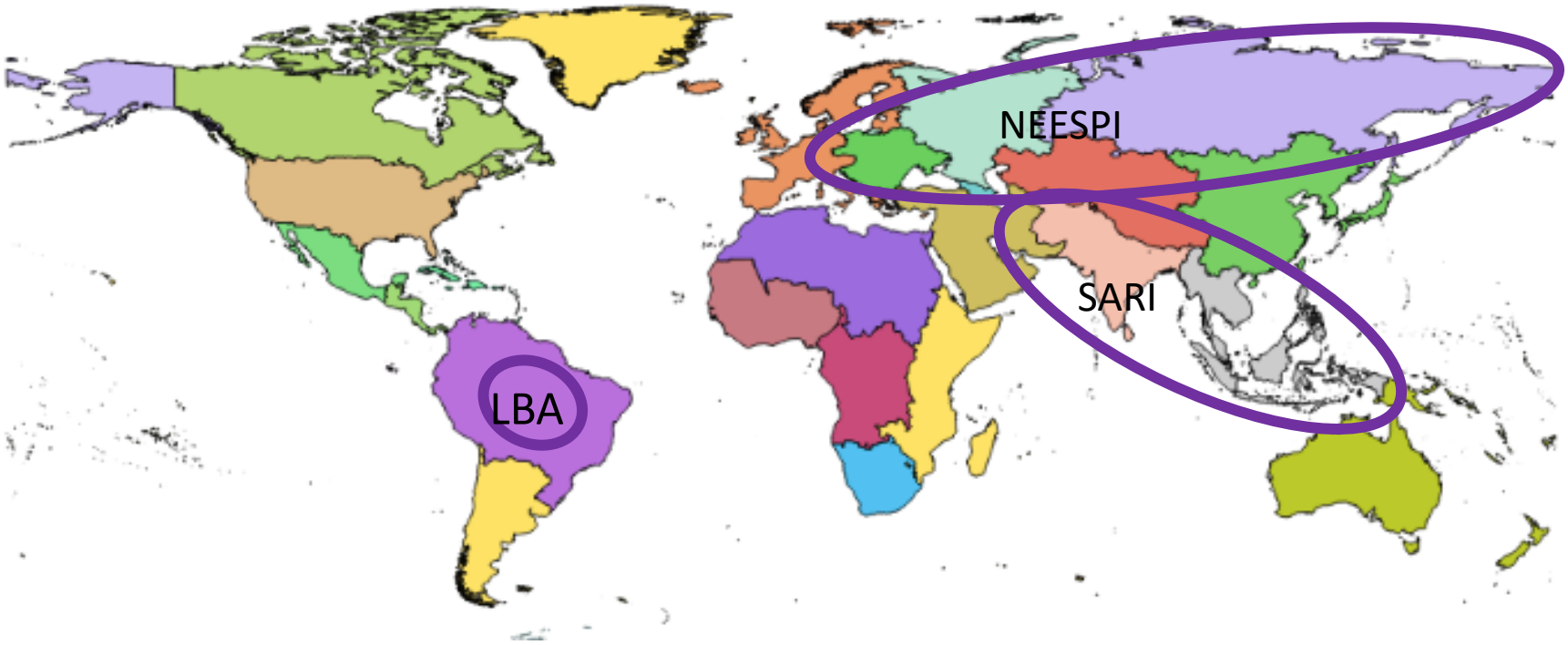




Impacts - 1/3 (blue)
Monitoring - 1/3 (green)
Drivers, synthesis, other - 1/3 (brown)

http://lcluc.umd.edu

LCLUC Regional Initiatives



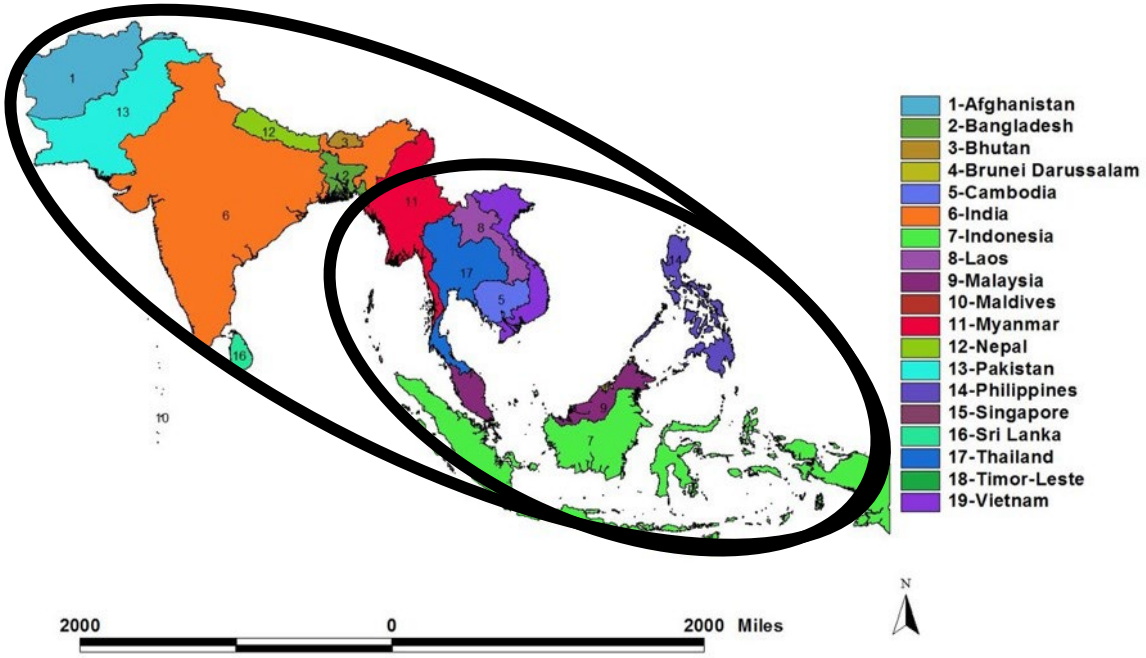
LBA – Large Scale Biosphere-Atmosphere Experiment
NEESPI – Northern Eurasia Earth Partnership Initiative
SARI – South/Southeast Asia Research Initiative

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/Southeast Asia

For Southeast Asia:

- >40 Projects since 1997
- 2 ongoing Synthesis projects
- Series of regional SARI workshops and trainings



Project Scientist
NASA-SARI
Krishna Vadrevu,
NASA, MSFC

The Inventory of SE Asia Projects 1997-Present

Principal Investigator	Project Name	Start Date	End Date
Peilei Fan	Decoding Land Transitions Across the Urban-Rural Continuums (URC): A Synthesis Study of Patterns, Drivers, and Socio-Environmental Impacts in Southeast Asia	07/31/2023	07/30/2026
Son Nghiem	Synthesis Study of Land Cover, Land Use, and Demographic Change Under MultiDimensional Developments and Climate Pressures in Southeast Asia	05/24/2023	05/23/2026
Lin Yan	Drivers and constraints of land cover land use change in Asian aquaculture hotspots	01/01/2023	12/31/2025
Josh M Gray	Toward near real-time monitoring of forest disturbance in Myanmar using multi-source imagery	09/01/2020	08/30/2023
Peilei Fan	Divergent Local Responses to Globalization: Urbanization, Land Transition, and Environmental Changes in Southeast Asia	03/23/2020	03/22/2023
Mark Cochrane	Land-Use Transitions in Indonesian Peatlands	01/01/2020	01/01/2023
Peter Potapov	Shifting Cultivation at a Crossroad: Drivers and Outcomes of Recent Land-Use Changes in Laos PDR	01/01/2020	12/31/2022
Lin Yan	Forced and Truncated Agrarian Transitions in Asia Through the Lens of Field Size Change	01/01/2020	12/31/2022
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	06/15/2018	06/14/2022
Varaprasad Bandaru	Agricultural Land Use Change in Central and Northeast Thailand: Effects on Biomass Emissions, Soil Quality, and Rural Livelihoods	05/01/2018	04/02/2022
Jefferson Fox	The Agrarian Transition in Mainland Southeast Asia: Changes in Rice Farming - 1995 to 2018	05/01/2018	12/31/2021
Son Nghiem	Land Use Status, Change and Impacts in Vietnam, Cambodia and Laos	05/01/2018	12/31/2021
Marc Simard	Mapping and Monitoring Mangrove Forests in Southeast Asia	08/13/2019	04/16/2020
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
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
Laixiang Sun	Forest Change and Oil Palm Expansion in Southeast Asia: Historical Patterns, Socioeconomic Drivers, and Future Projection	05/01/2018	05/01/2021
Naiara Pinto	Prototyping an Oil Palm Plantation MuSLI from Landsat and Dual-Wavelength Synthetic Aperture Radar	01/01/2018	01/01/2021
Peter Leimgruber	Complex Forest Landscapes and Sociopolitical Drivers of Deforestation - The Interplay of Land-use Policies, Armed Conflict, and Human Displacement in Myanmar	05/01/2017	05/01/2020
Tatiana Loboda	Understanding the Role of Land Cover/Land Use Nexus in Malaria Transmission Under Changing Socio-Economic Climate in Myanmar	05/01/2017	03/01/2020
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	01/31/2019
Xiangming Xiao	Mapping Industrial Forest Plantations in Tropical Monsoon Asia Through Integration of Landsat and PALSAR Imagery	04/01/2014	03/31/2020
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
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
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
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	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
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
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
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	Simulating of Land Use Dynamics in Southeast Asia: A Cellular Automation Approach	01/01/2001	01/01/2004
Lisa Curran	Influence of Humans, Climate, and Fire on Forest Ecosystems and Carbon Dynamics in Indonesian Borneo	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, banana, dragon fruit) → loss of shifting cultivation
- Expansion of aquaculture, roads, dams, and mines → loss of wetlands and other natural habitat

Impacts

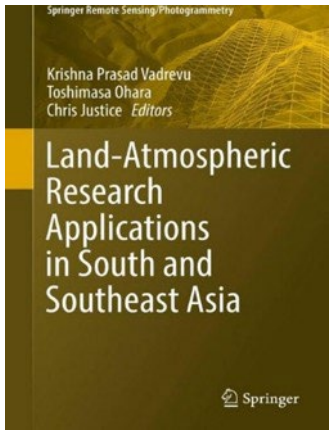
- Large-scale land-cover conversion for agriculture → changes in the carbon cycle
- Slash & Burn Ag → degraded air quality & increased emissions
- Urban and peri-urban expansion → soil compaction + paving → less absorbed rain → increased flooding; increased air pollution and waste productions
- Urbanization and expansion of large-scale plantations → decreased food production → Increased vulnerability to potential food shocks

NASA-SARI Science

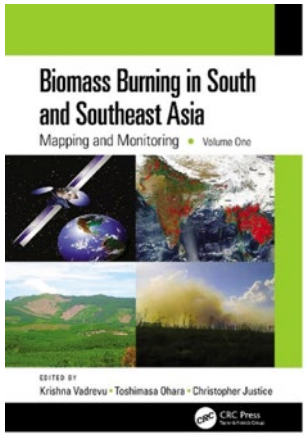
- pre-SARI studies and synthesis projects
- LCLUC-2015: South Asia
- LCLUC-2016: Southeast Asia
- LCLUC-2018: All Asia
- LCLUC-2021, -2022: Synthesis

- > 250 scientists
- >150 institutions
- 15 countries
- > 25 projects
- >250 papers
- 12 special issues

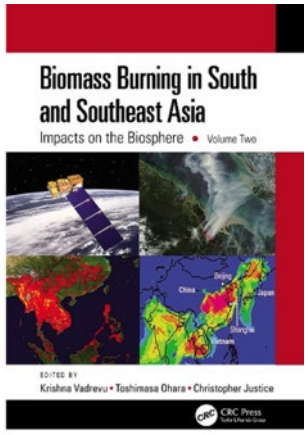
Krishna Inc. Publishing House:



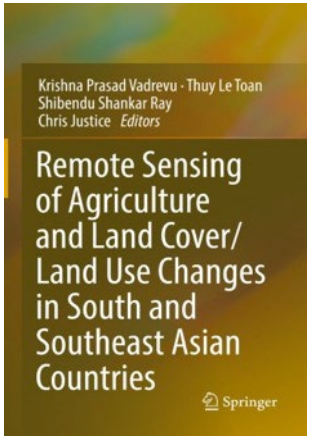
Springer
2018



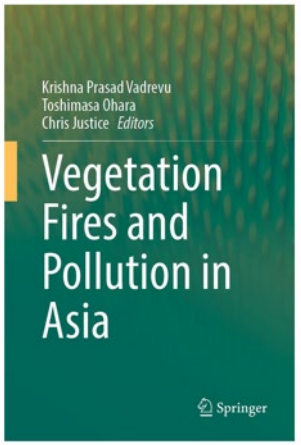
CRC Press
2021



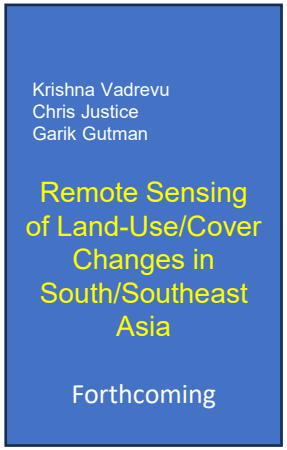
CRC Press
2021



Springer
2022



Springer
2023



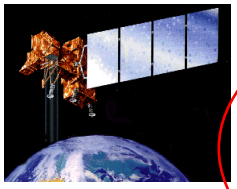
CRC in Press
2024

NASA Land Surface-Relevant Missions

Systematic Missions - Observation of Key Earth System Interactions

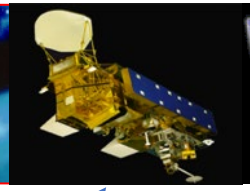
coarse resolution

moderate-→ high resolution

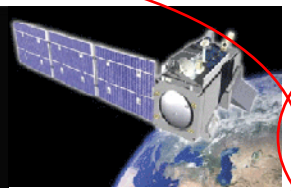


Landsat 5 & 7
3/1/84 & 4/15/99

Terra
12/18/99
ASTER ***MODIS***



Aqua
5/3/02



Suomi-NPP
10/28/11
VIIRS

Landsat 8
2/11/13

Landsat 9
9/27/21

Landsat Next
Nov 2030

International Space Station (ISS)

ECOSTRESS (thermal IR, 2018)
GEDI (Lidar, 2018)
EMIT (Hyperspectral, 2022)

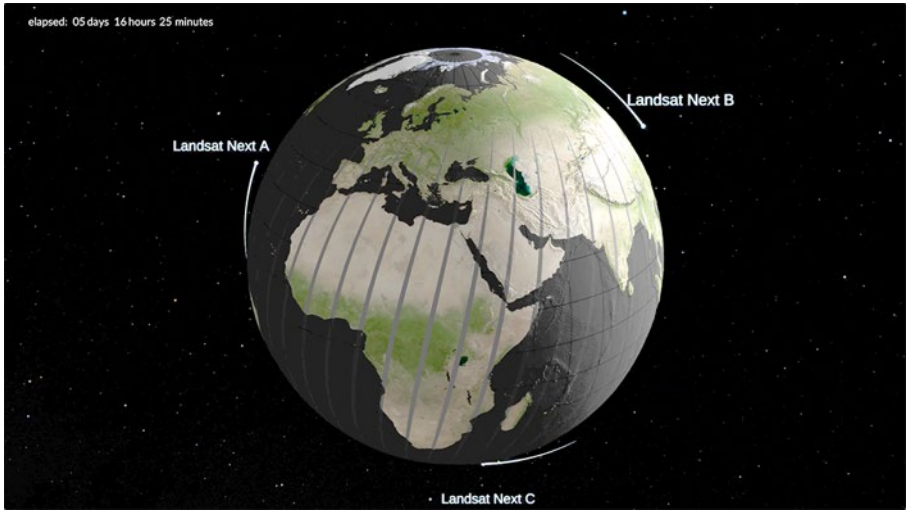
radars

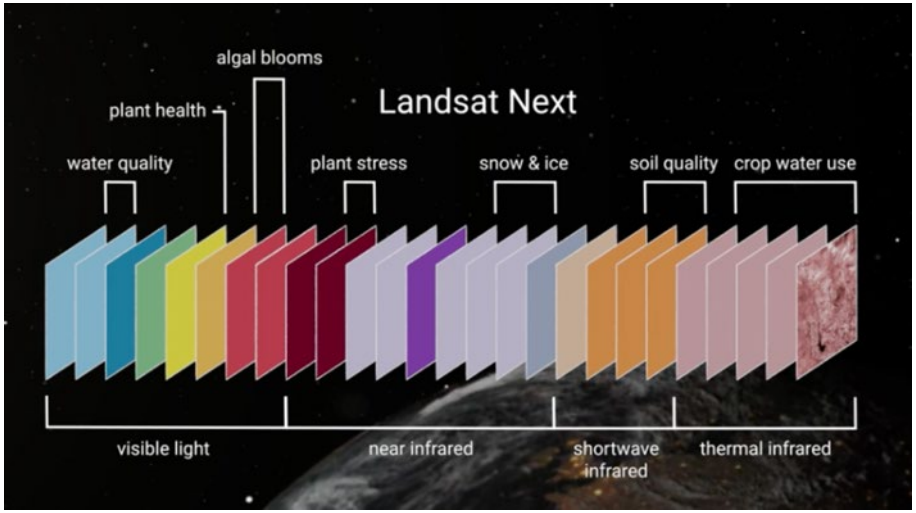
SWOT (Ka radar)
Dec 2022

NISAR (L & S radars)
2024

Landsat Next

- Constellation of 3 small satellites
- 26 wavelengths bands
- More frequent and finer resolution
- Launch: **late 2030**



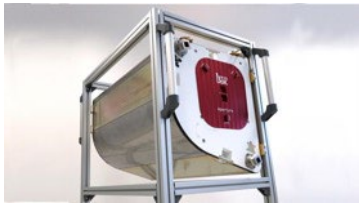


Landsat Next constellation of three spacecraft will provide finer spatial resolution (10-20m) and expanded spectral (26 band) imaging capabilities every six days (at the equator)

Data from New Sensors on the International Space Station for LCLUC Studies

- ECOSTRESS: ECOsystem Spaceborne Thermal Radiometer Experiment on ISS
  - Prototype HyspIRI **Thermal Infrared** Radiometer (PHyTIR)
  - 5 spectral bands in the 8-12.5 µm range+1.6 µm (69m x 38m)

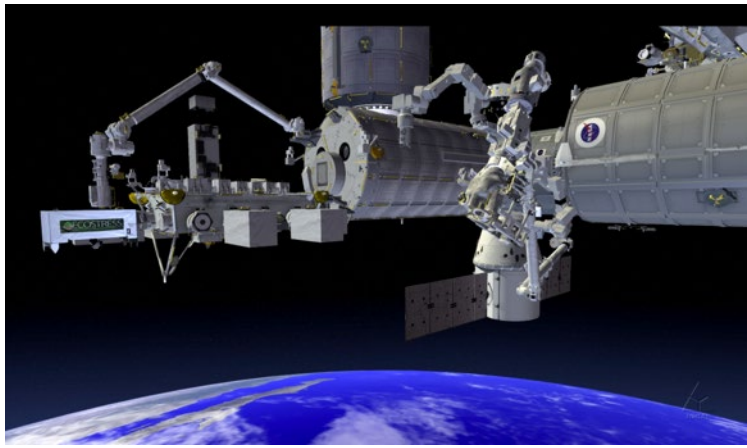
- EMIT**:** Earth Surface Mineral Dust Source Investigation - **Hyperspectral**
  - 235 spectral channels with ground res. 30m



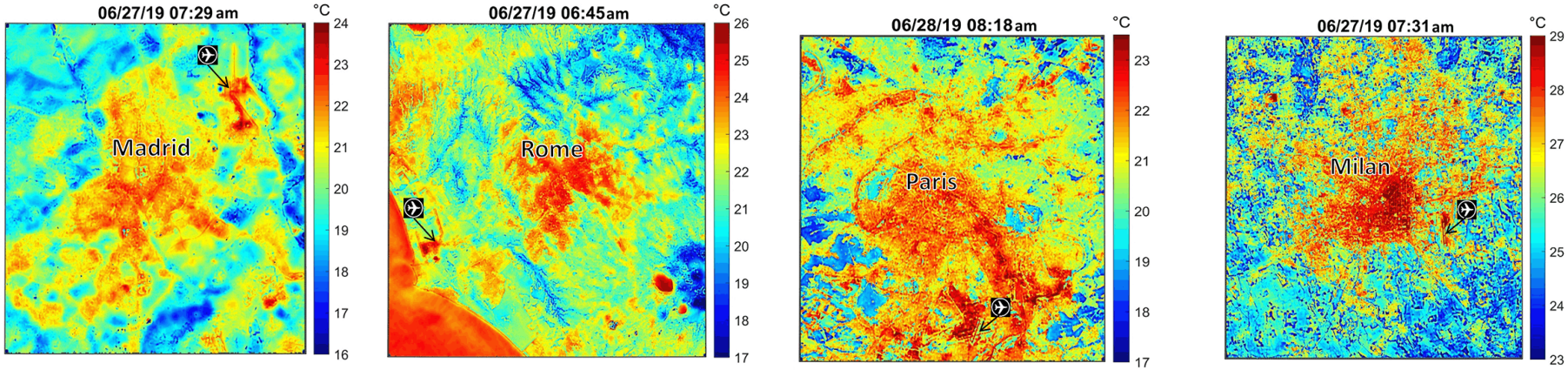
- GEDI: Global Ecosystem Dynamics Investigation - **LIDAR**
  - high resolution laser ranging observations of 3D structures
  - three lasers produce eight parallel tracks of observations
  - each laser fires 242 times per second and illuminates a 25 m spot (a footprint) on the surface over which 3D structure is measured

ECOSTRESS: NASA Instrument on ISS

ECOsystem Spaceborne Thermal Radiometer Experiment on the International Space Station (ISS)



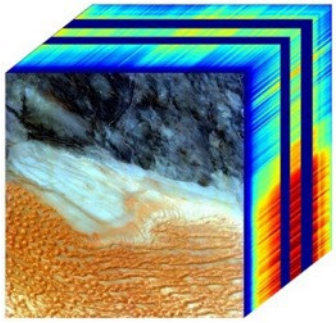
- Prototype HyspIRI **Thermal Infrared** Radiometer
  - Launched June 29, 2018
  - 5 spectral bands in the 8-12.5 µm range +1.6 µm
  - Spatial resolution ~70 m
  - **Advantage** over ASTER (on TERRA) – more frequent revisit
- Science objectives
  - Identify critical thresholds of water use and water stress in key biomes (e.g., tropical/dry transition forests, boreal forests)
  - Detect the timing, location, and predictive factors leading to plant water uptake decline and cessation over the diurnal cycle
  - Measure agricultural water consumptive use over CONUS at spatiotemporal scales applicable to improving drought estimation accuracy



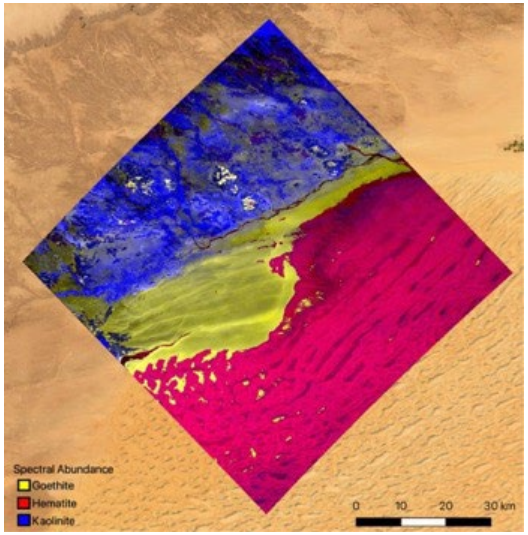
EMIT on ISS

Earth Surface Mineral Dust Source Investigation

- Launched in July 2022
- Advanced imaging spectrometer: 285 spectral bands with the range 380-2500 nm
- Spatial resolution 60 meters
- **Primary applications: mineral dust, its heating and cooling effects in the atmosphere**
- **Potential applications**
  - **natural hazards (** flood extent, ecosystem impacts, and surface water sediment load)
  - **environmental pollution (**oil spills, ocean plastics, acid mine drainage, etc.)
  - **coastal waters and harmful algal blooms (**ocean phytoplankton, harmful algal bloom biomass and composition, coral presence and bleaching events, and the health of coastal ecosystems)



the true-color view over southwestern Libya



Credit: JPL

EMIT first light: The mineral map in southwestern Libya in the Sahara Desert

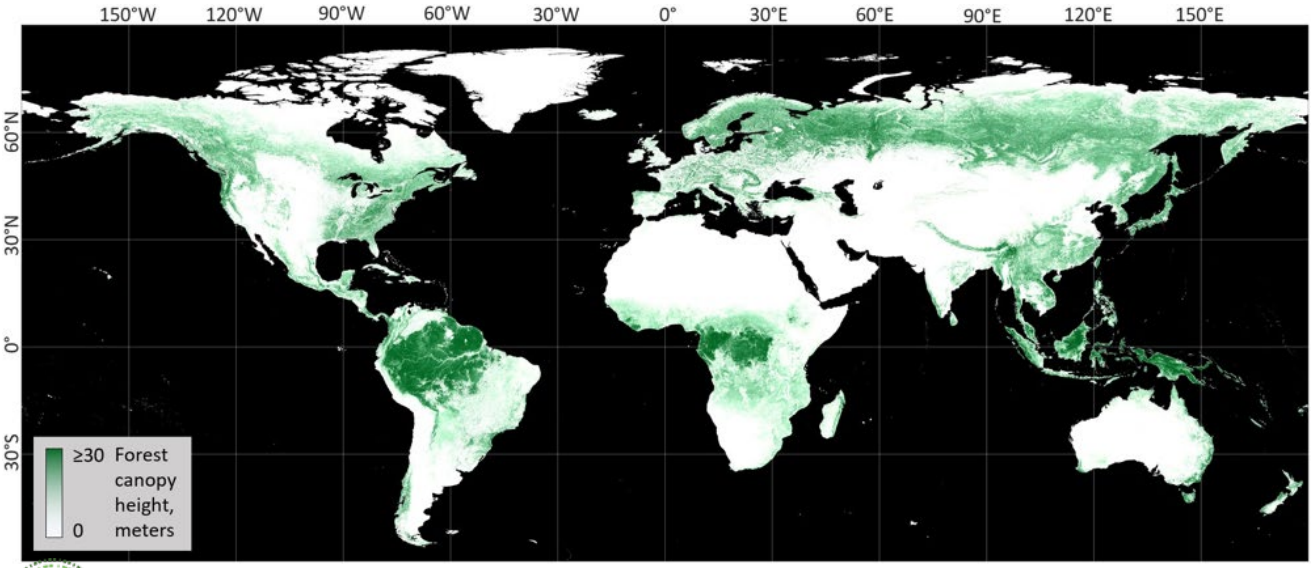
GEDI

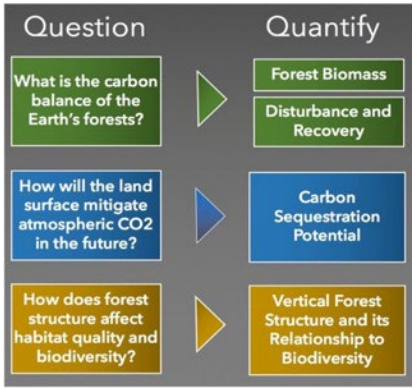
NASA Global Ecosystem Dynamics Investigation mission on ISS

- **High resolution laser ranging observations**
  - **three lasers produce eight parallel tracks of observations**
  - **each laser fires 242 times per second and illuminates a 25 m spot (a footprint) on the surface**

Credit: NASA/JPL-Caltech

Global Forest Canopy Height: 2019





Global Land Analysis & Discovery

An Exemplary Passive+Active (Lidar) RS Data Synergy

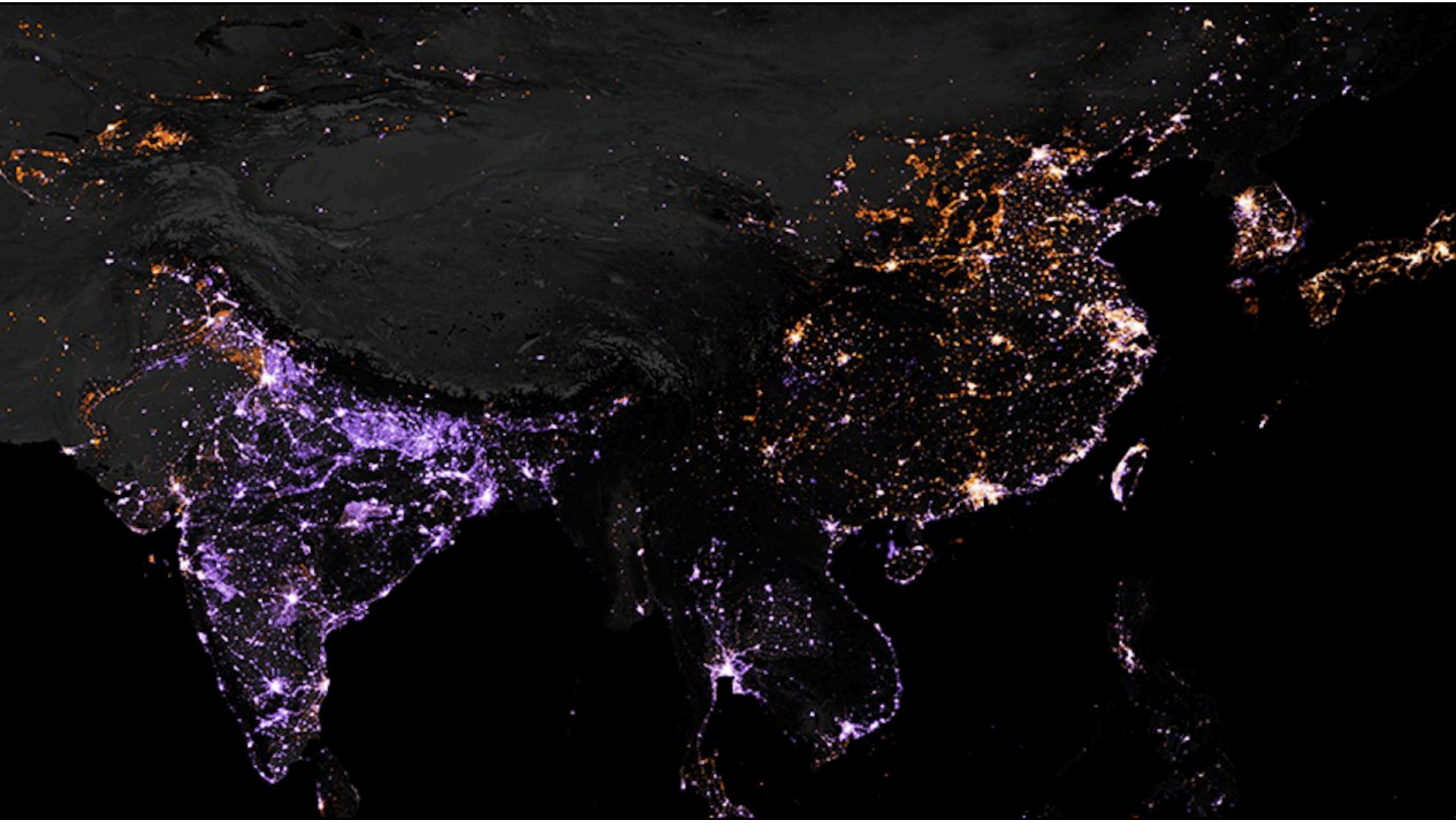
Integration of the GEDI lidar forest structure measurements and Landsat analysis-ready data time-series

Potapov et al. 2020, RSE

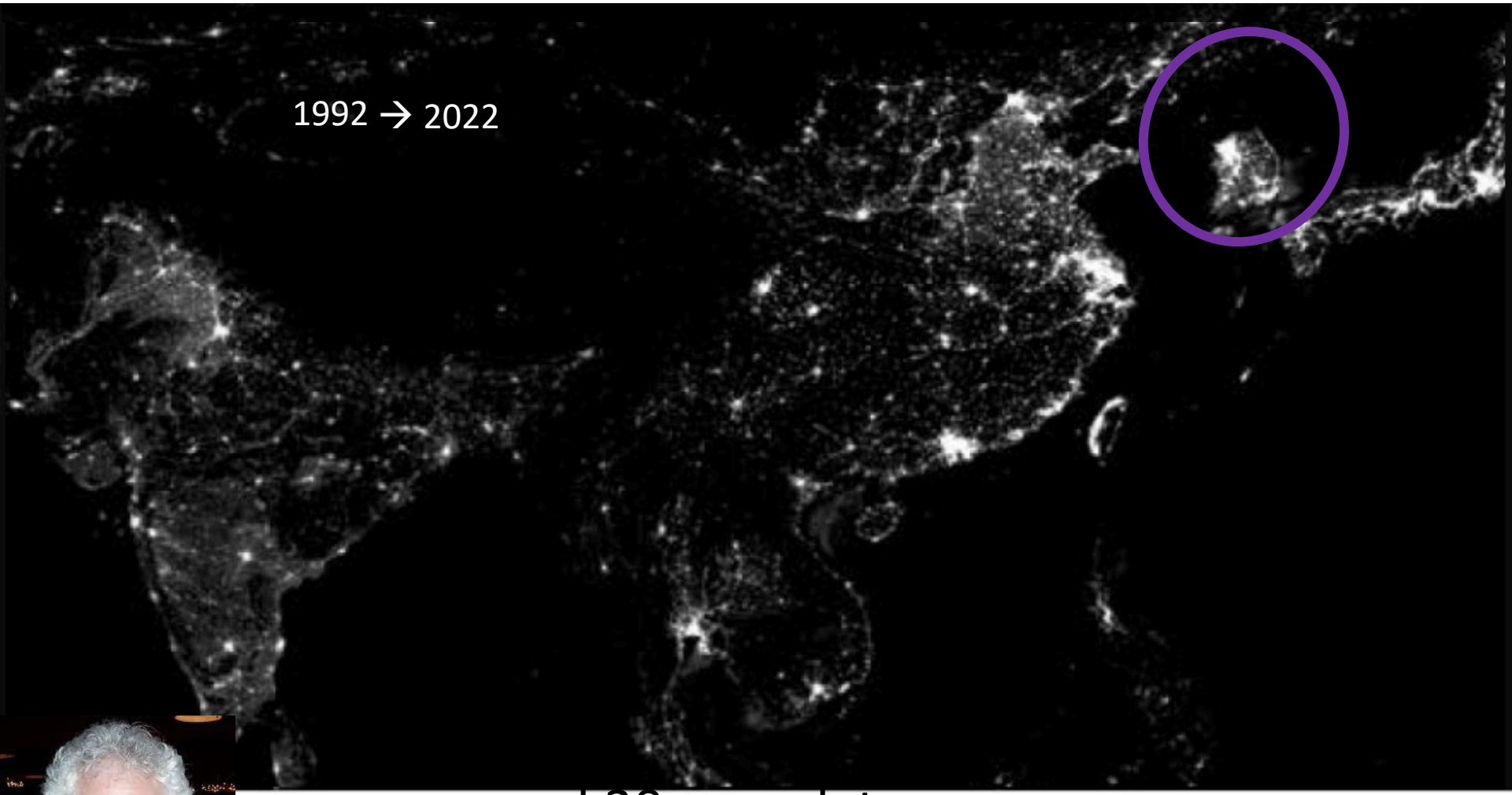
Global Night Lights from VIIRS/Suomi-NPP

The Night Lights composite: Suomi National Polar-orbiting Partnership (Suomi-NPP) satellite nine days in April 2012 and thirteen days in October 2012.

Suomi-NPP VIIRS Night Lights: 2012 → 2016



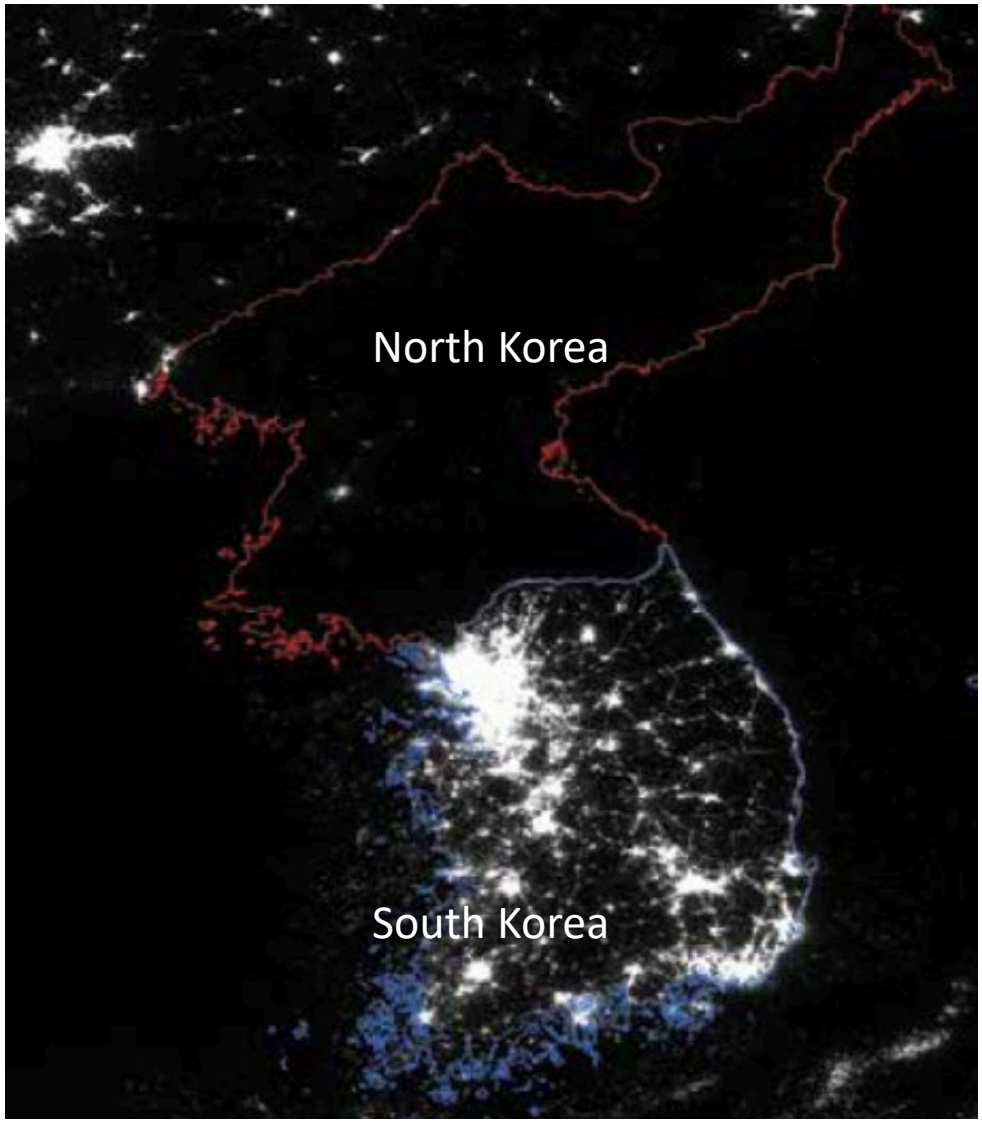
Using DMSP OLS Time Series: The Asian Economies Leap

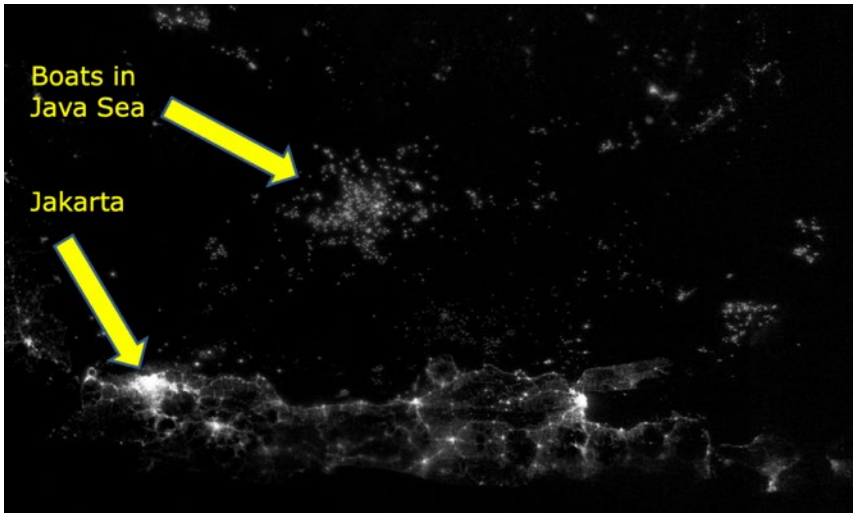


…and 20 years later

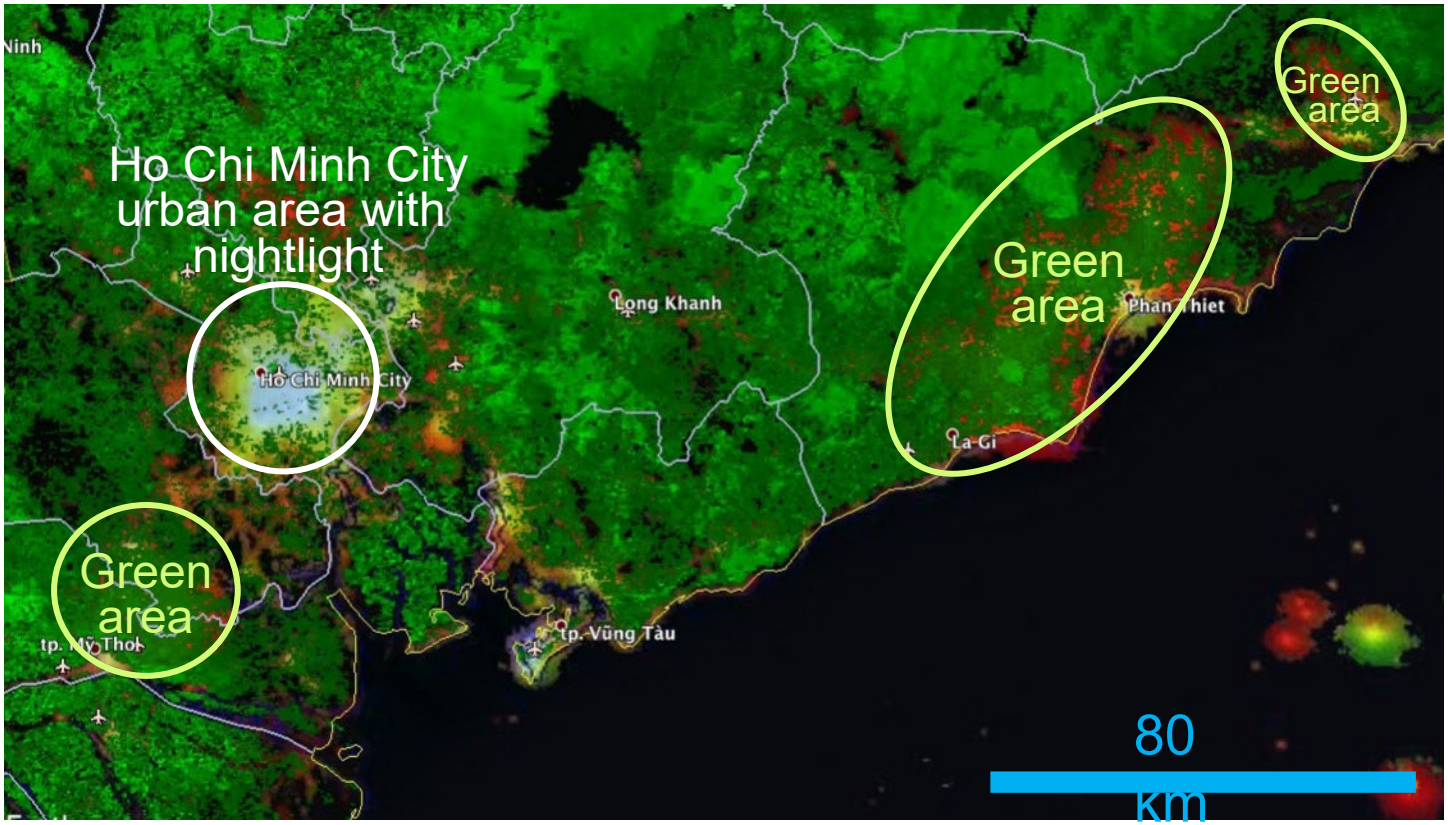
Credit: Chris Elvidge
NOAA → Colorado School of Mines

Every Picture Tells a Story



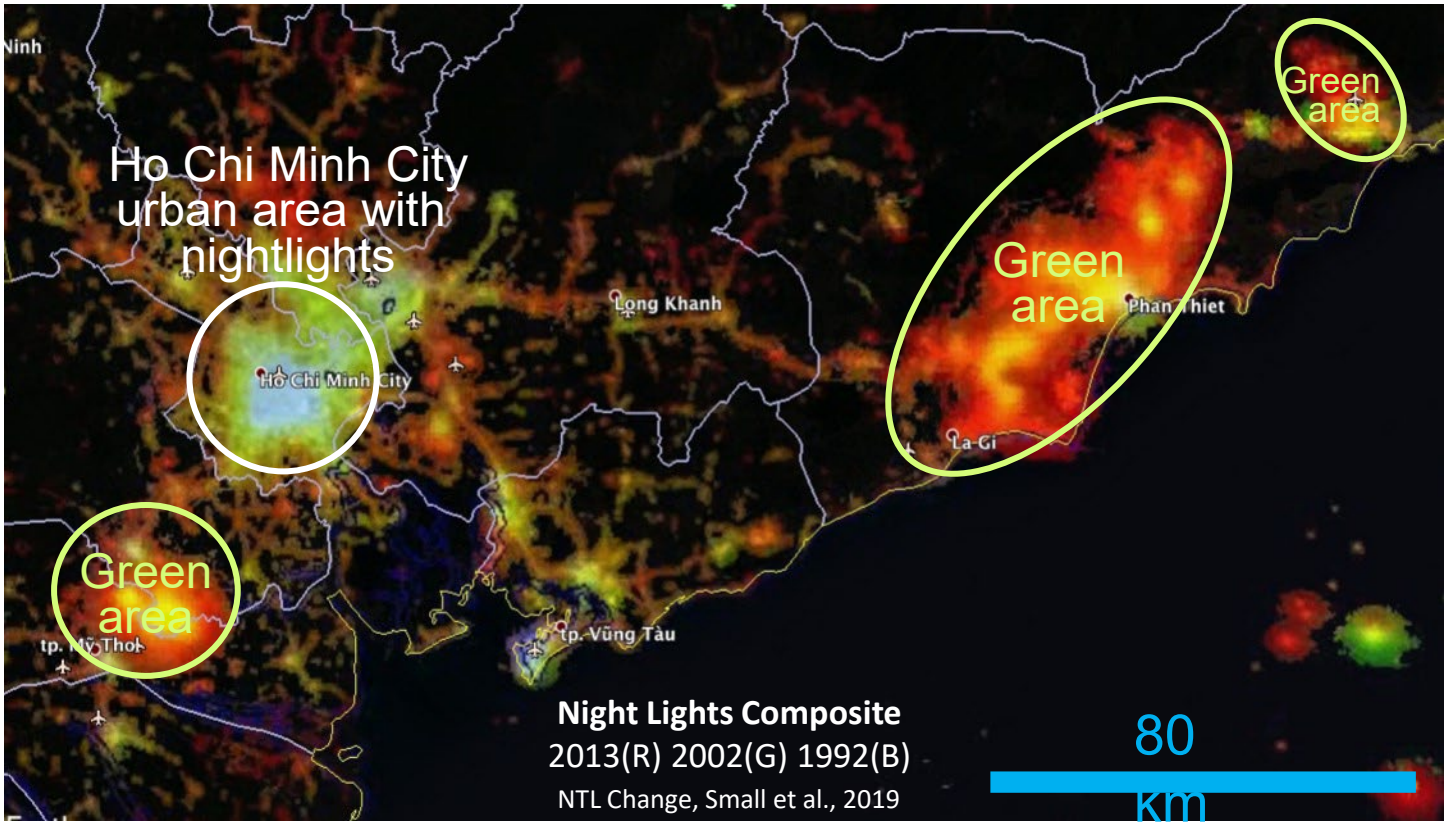


Enhanced Vegetation Index From MODIS Terra



Courtesy: Son Nghiem, JPL

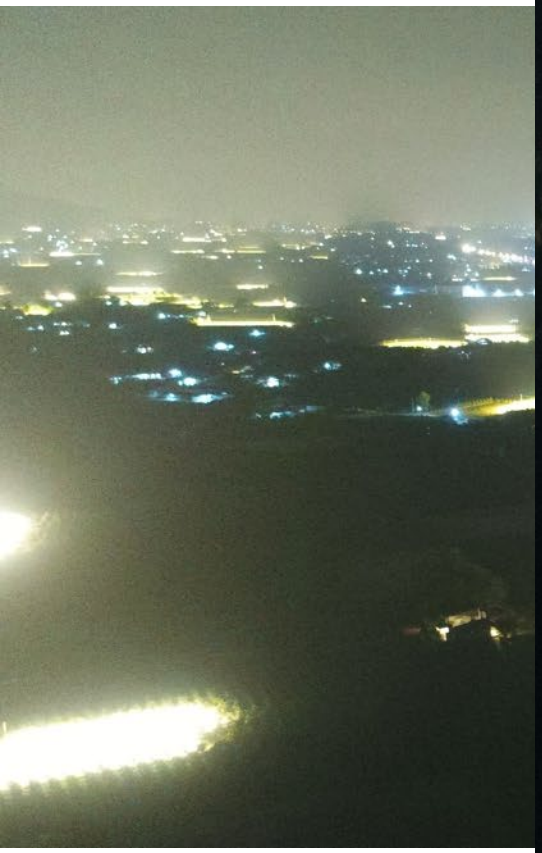
Night Lights from OLS in NASA VIIRS mask



Courtesy: Son Nghiem, JPL

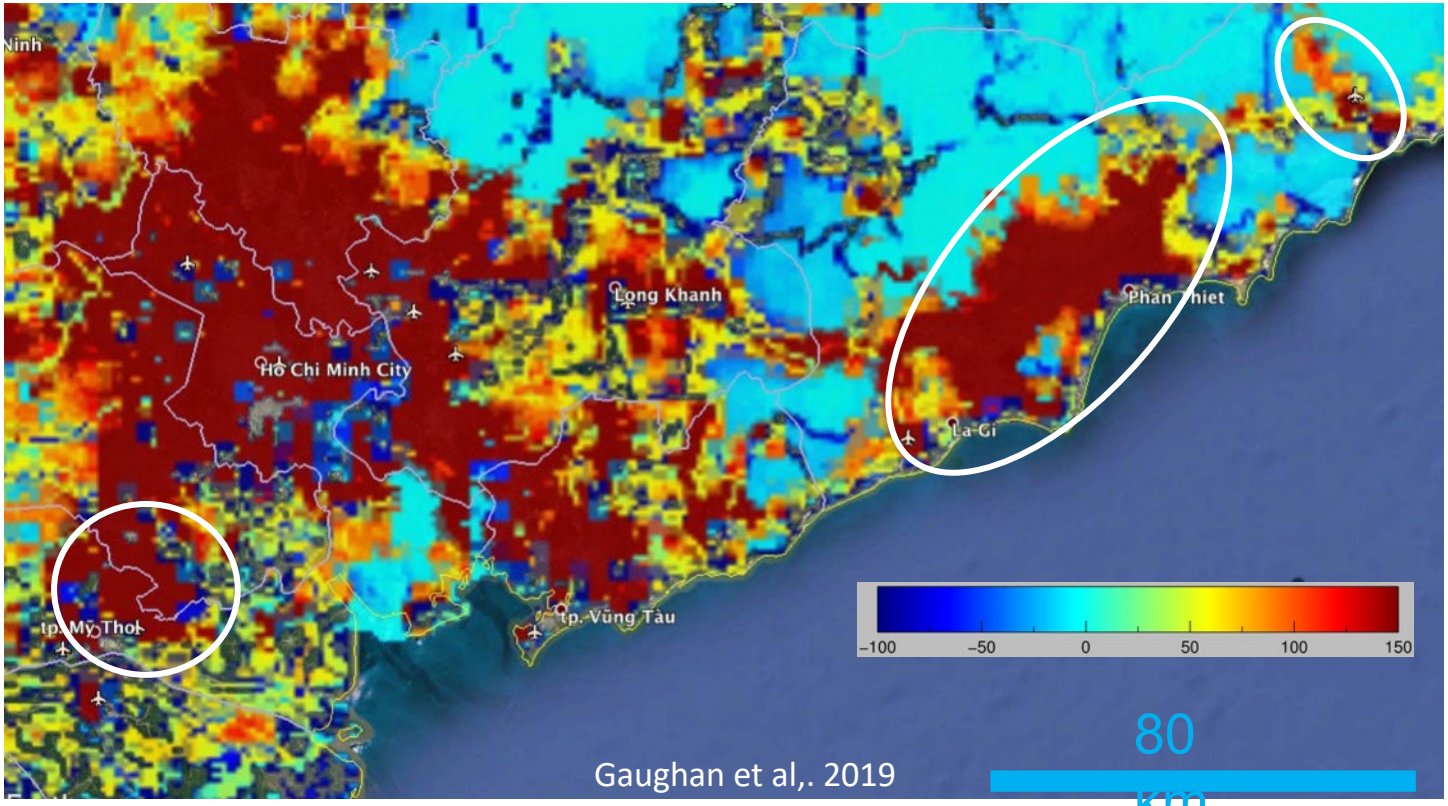
Let There Be Light
Long An and Binh Thuan Provinces

Courtesy: Son Nghiem, JPL




NASA

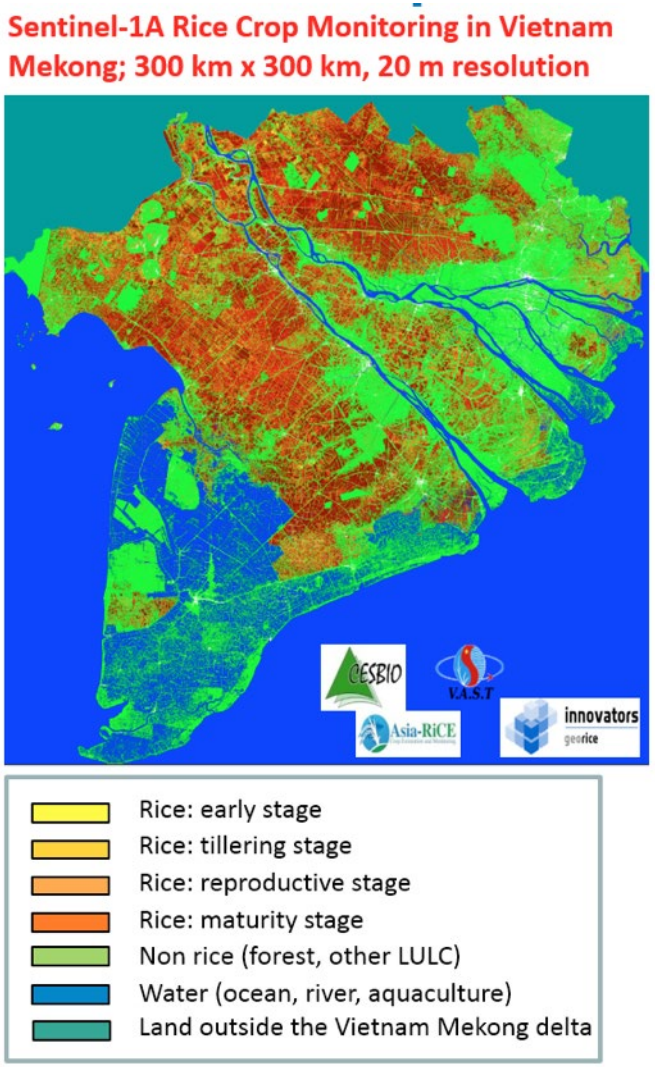
Fossil Fuel CO_2 Emission with Night Lights ⇒ Overestimation



Gaughan et al,. 2019

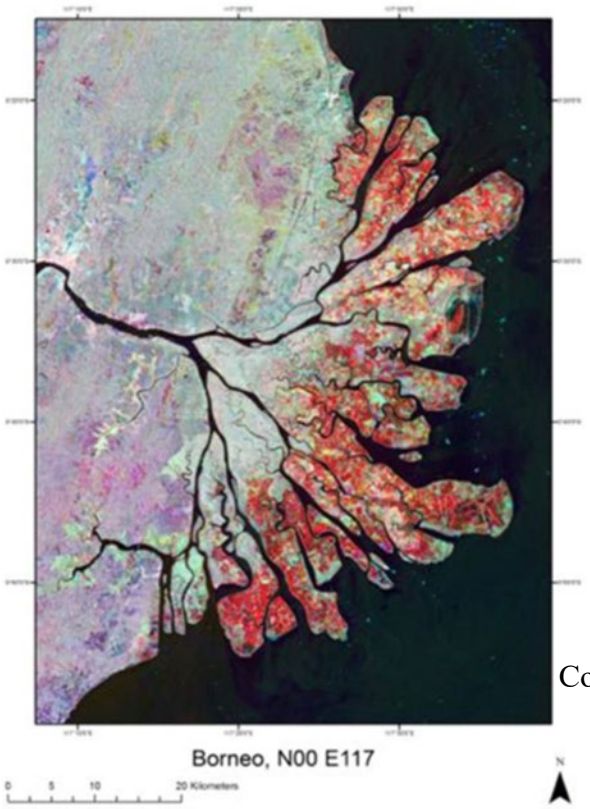
ESA Sentinel Program

- Optical
  - Sentinel-2a: launched Jun 2015
  - Sentinel-2b: launched Mar 2017
- Radars
  - Sentinel-1a: launched Apr 2014
  - Sentinel-1b: launched Apr 2016



JAXA Advance Land Observing Satellite (ALOS) Program

- ALOS
  - 2006-2011
  - PALSAR
  - AVNIR-2
- ALOS-2
  - Launched 24 May 2014
  - PALSAR-2



JERS-1 (1996) and ALOS PALSAR (2007, 2010) color composite of East Kalimantan (R:1996, B:2007, G:2010).

The red areas have largely changed from mangrove forest in 1996 to aquaculture by 2007

Courtesy of JAXA

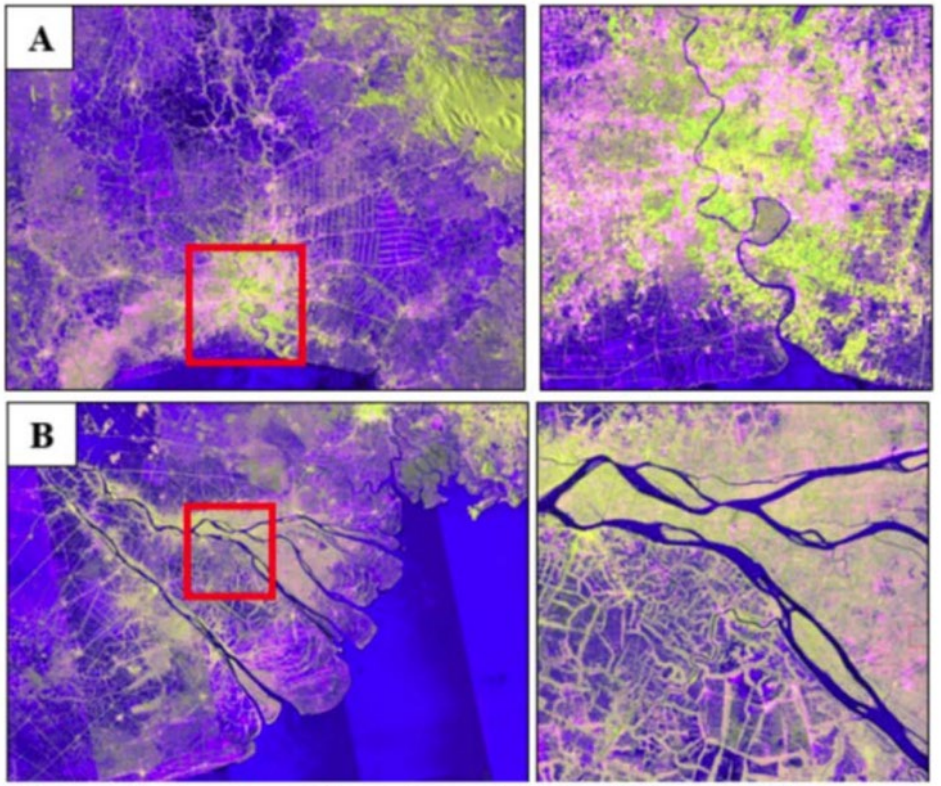


Figure 3: Land surface inundation state (purple: inundated, green: dry) observed by ALOS PALSAR fine beam mosaic, RGB: HH, HV, HH/HV observed over (A) Chao Phraya Delta, (B) Mekong Delta, Summer 2009, at 90m Resolution.

Courtesy of Zach Tessler, CUNY

ISRO (ResourceSat)

- ResourceSat-1/IRS-P6 Data: 2004 – 2013
  - Linear Imaging Self Scanning (LISS)-III 20m
- ResourceSat-2 Data: 2011 – present
- ResourceSat-2a
- Data are available after project proposal acceptance
- ESA is offering **free of charge** for scientific research and application development, access **archive** and **new acquisitions** data

One of the first images taken by the Resourcesat-2 satellite and presented to India's Prime Minister Manmohan Singh shows New Delhi and surrounding areas. Credit: ISRO satellite image

Non-US high/Mid-Resolution Observations

Spot Asia Partners

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

ISRO (ResourceSat)
ESA Sentinel-1 and -2
JAXA AVNIR, PALSAR-2

Vietnam (LotusSat-1)
planned for Dec 2024-Feb 2025
Thailand (THEOS-1, -2)
Th-2 was launched Oct 2023

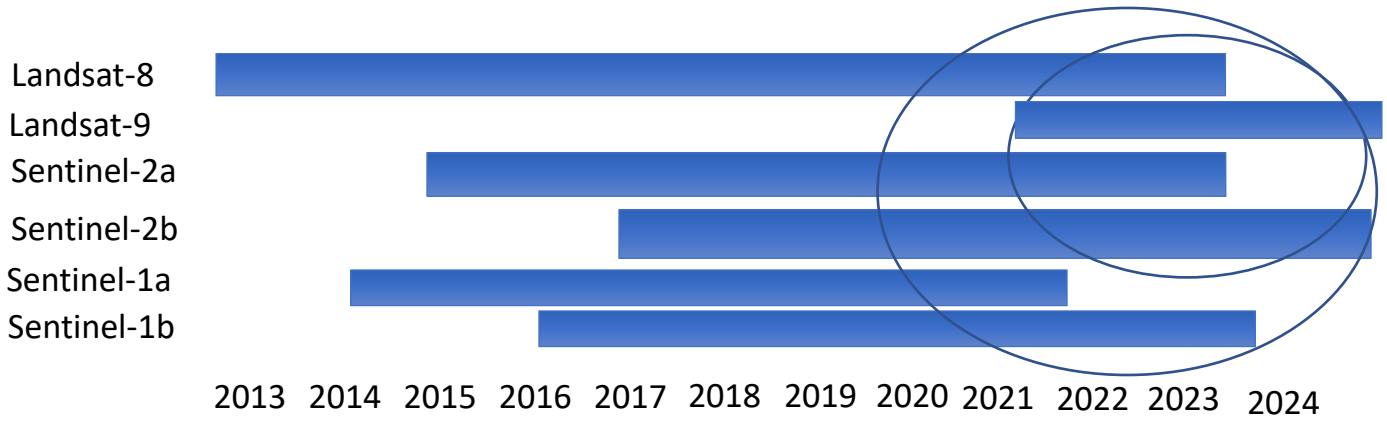
Multi-Source Land Imaging (MuSLI)

Combining optical and microwave Data: Landsat + Sentinel2 + Sentinel1

- Sentinel-2a: 2015 - present
- Sentinel-2b: 2017 - present
- Sentinel-1a: 2014 - 2024
- Sentinel-1b: 2016 - 2022
- Sentinel-1c: 2024 – 2031
- Sentinel-1d: 2025 - 2032
- Landsat-7: 1999 – lowered to "storage orbit) awaiting OSAM-1 satellite rendezvous and refueling (est. 2026)
- Landsat-8: 2013 – present
- Landsat-9: 2021 - present

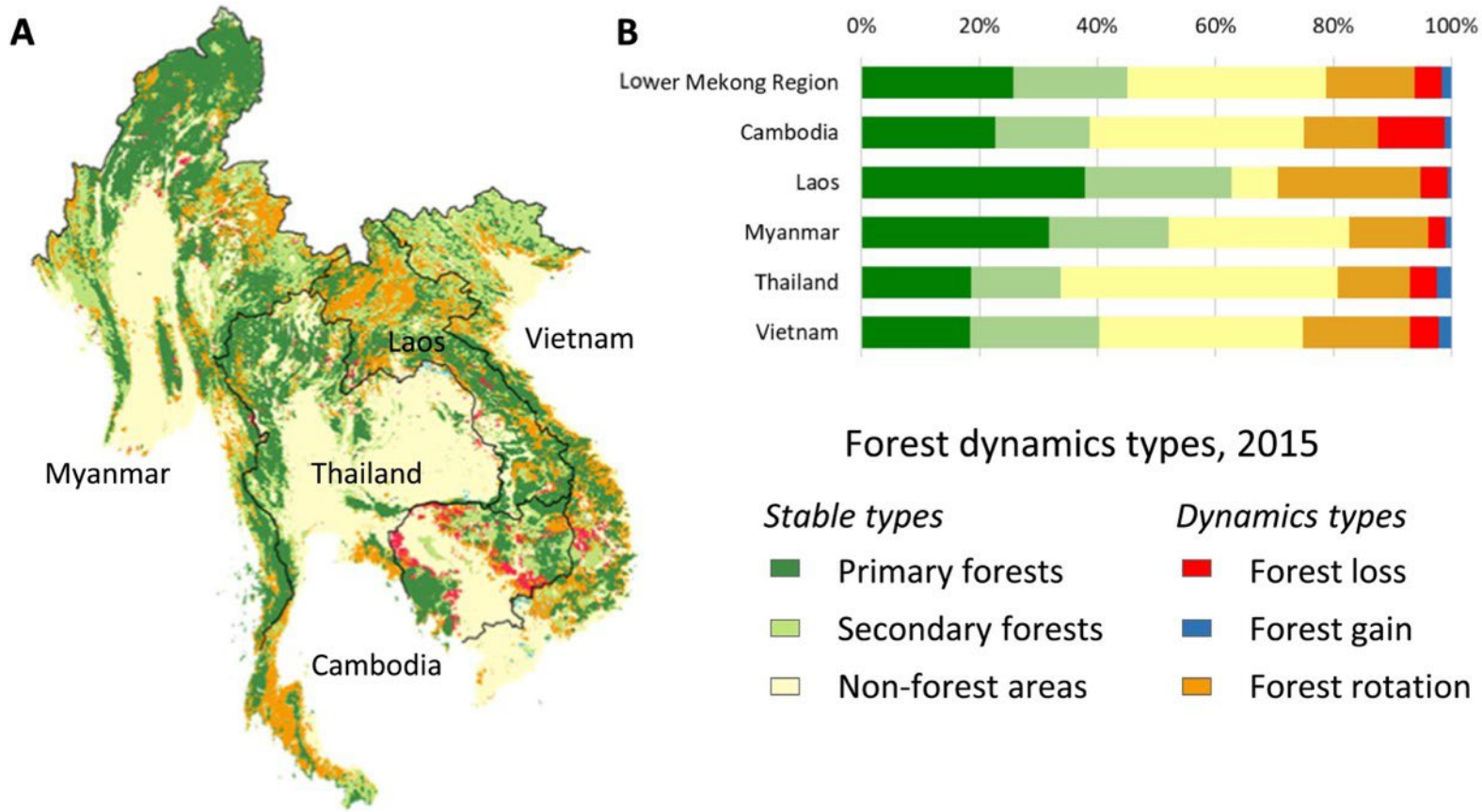
Merging Sentinel-2 and Landsat data streams could provide < 5-day coverage required for Ag monitoring

- Both sensors have 10-30m coverage in VNIR-SWIR
- Satellite orbits complementary
  - Landsat-8 & -9. 8 days out of phase
  - Sentinel-2a & 2b 5 days out of phase
- Global ~3 day
- Merging in Sentinel-1 radar data provides all-weather microwave observations



Forest Dynamics 2000-2015 in Low Mekong Region

Potapov and team (U.Maryland + World Resources Institute)



A – The dominant forest dynamics type for each 3 × 3 km grid cell.

B – Proportion of forest dynamics types from the total land area

Landsat time series

Lidar Tree height

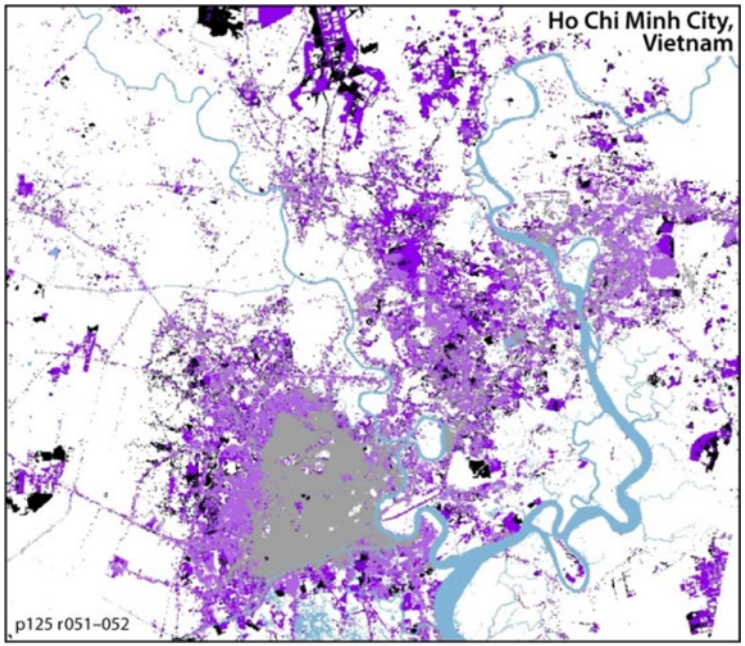
https://www.sciencedirect.com/science/article/pii/S0034425719302974

Potapov et al. 2019. https://doi.org/10.1016/j.rse.2019.111278

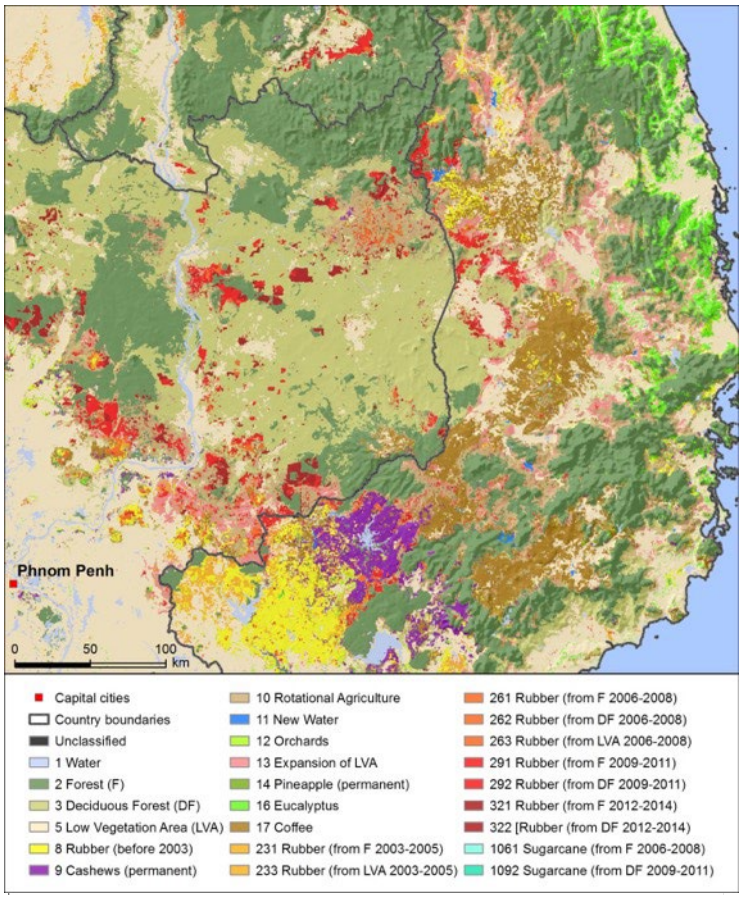
Forest, Agricultural, and Urban Transitions in Mainland Southeast Asia

Jefferson Fox (East West Center, Hawaii) and team

- Synthesized existing approaches for mapping the expansion of upland-boom crops and the growth of urban areas
- Enhanced the conceptual underpinnings of land-change science by linking it to local, national/international drivers
- Mapped urban areas and upland-tree plantations using time-series Landsat data and Google Earth images



Land-Cover Change Classification



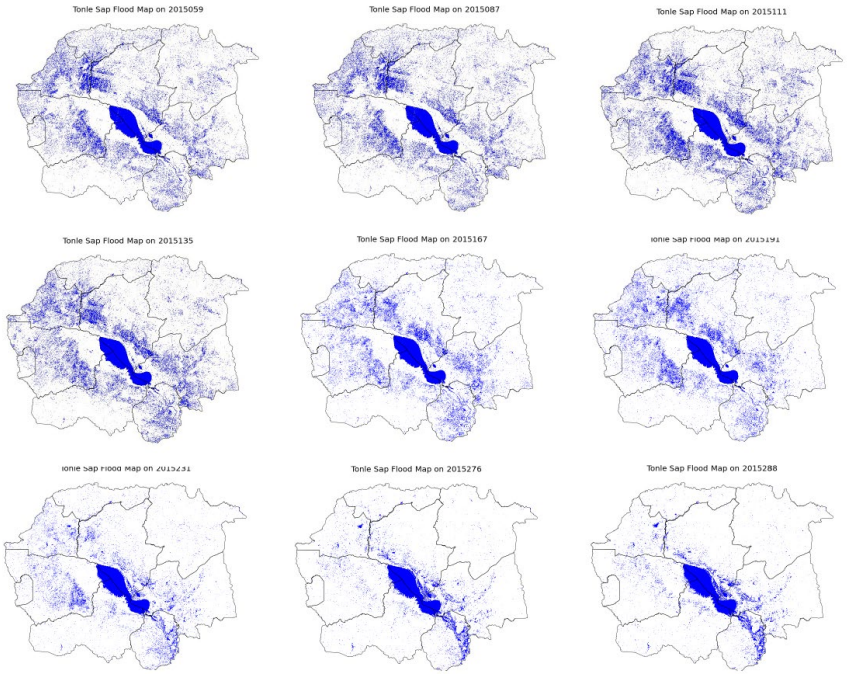
- **Cambodia and Laos**: mainly new rubber
- **Vietnam**: old and new **rubber as well as cashew, coffee, and new eucalyptus plantations**

Near Real-Time Mapping of Rice Extent and Crop Growth Stage

PI: W. Salas and Nathan Torbick (Applied GeosolutionS)

- Fuse microwave and optical data for mapping agricultural conditions
- SAR: Sentinel-1, PALSAR-2, Radarsat-2
- Optical: Landsat-8, Sentinel-2
- Coordination with ESA, regional partners (AsiaRice, IRRI, VAST, SERVIR, Ministries)
- Irrigated rice paddies are inundated prior to emergence of the crop -> low backscatter response
- Rice crops grow and gain in biomass → increase in backscatter response
- After ripening and near harvest, paddies are usually drained if still flooded or decrease in saturation and moisture -> leveling off or decline in backscatter

Tonle Sap, **Cambodia** Sentinel-1A Rice Inundation Dynamics

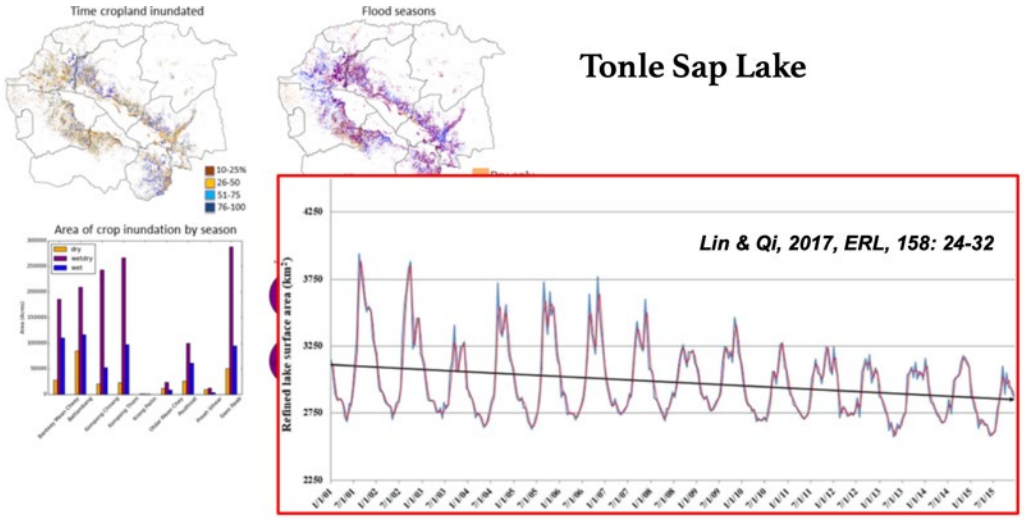


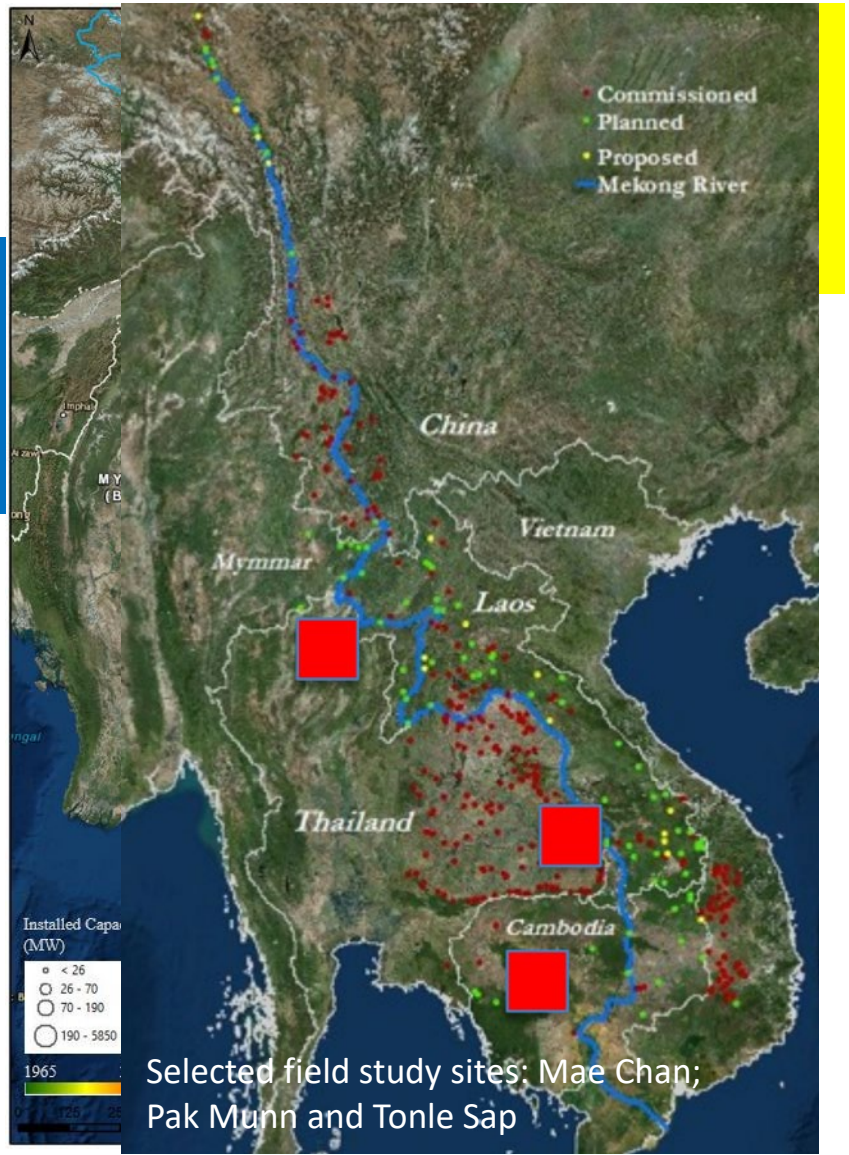
Water-Energy-Food Nexus:
Impacts of Dams in Mekong Region

Qi, Michigan State U. and team

- **Integrated satellite and ground-based obs with hydro- and eco- and socio-economic models to better understand the impacts of hydro-dams on the livelihoods of local communities**

- **Irrigated agricultural lands expanded (more crop production) and less vulnerable to droughts and floods**
- **Hydropower electricity generated does not generally benefit local communities, it is sold to other countries or cities.**

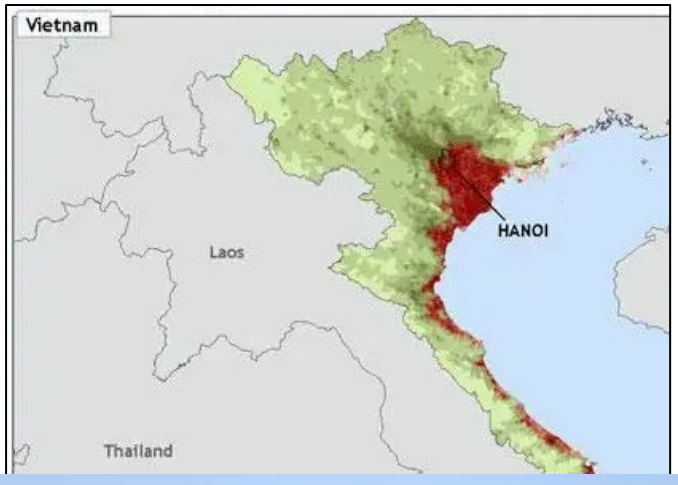




Selected field study sites: Mae Chan; Pak Munn and Tonle Sap

Coastal Zone Issues

- Overfishing
- Unmanaged tourism
- Shipping impacts, e.g. fuel spillage
- Mangroves destruction
- Pollution => declining water quality
- Non-degradable waste (e.g. plastic)



Source: the Wall Street Journal (2010, selected countries)

Water pollution in Vietnam: DOI 10.1088/1755-1315/442/1/012014

Mangroves

- Various anthropogenic influences of Urbanization
  - Discharge of pollutants from factories
  - construction of barriers along the coast
  - cutting of mangroves for firewood

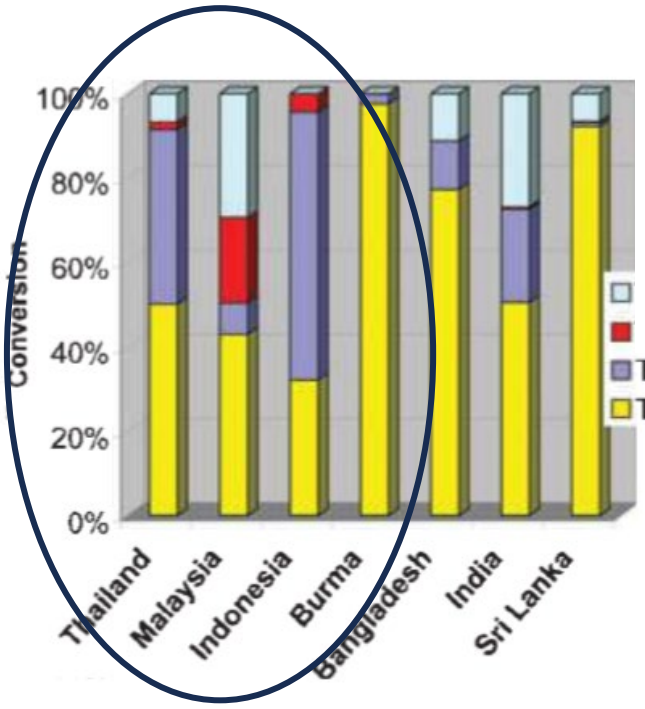
A Vietnamese woman gathers shells in a coastal forest littered with plastic waste stuck in branches after it was washed up by rising coastal tide in Thanh Hoa province, 2018.

Mangroves in southern Malaysia

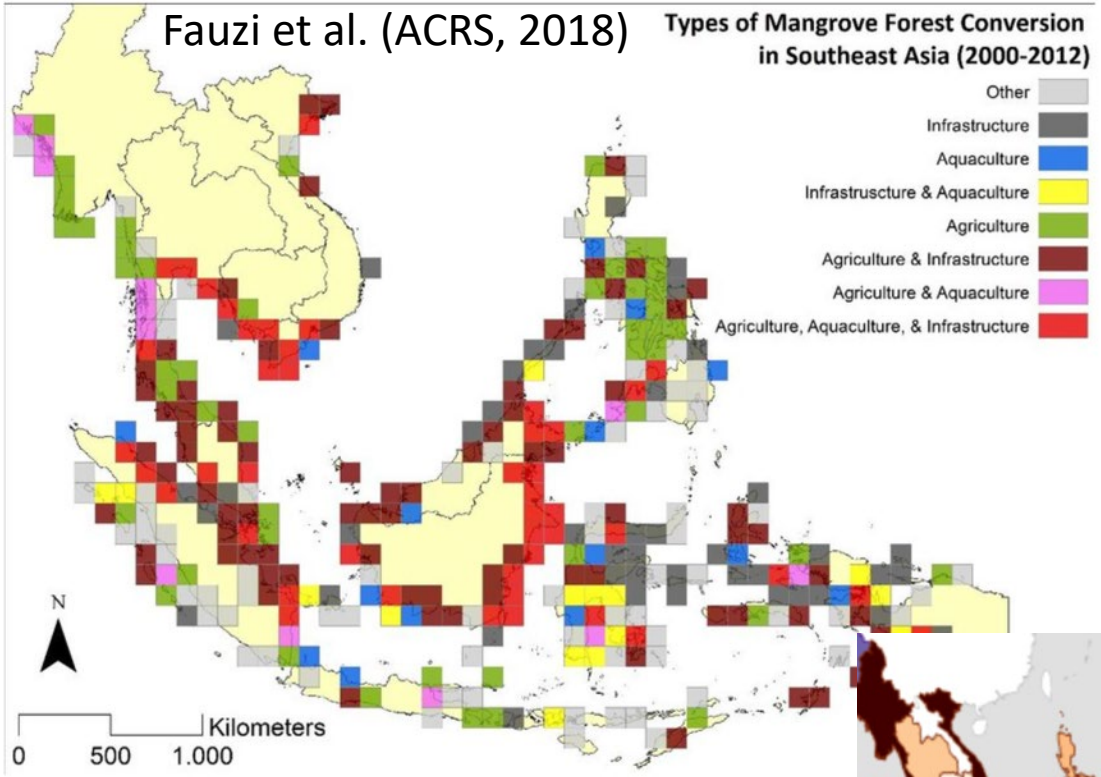
Mangroves in Southeast Asia Mapped from Landsat Observations

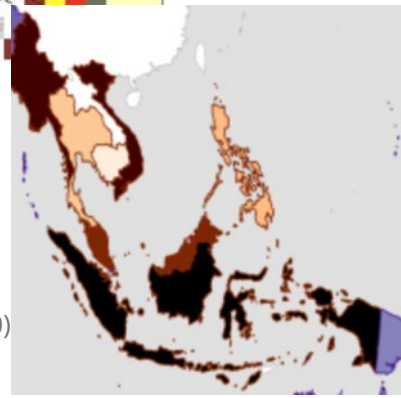
Courtesy of Chandra Giri, EPA (mapped at USGS)

Major Causes of Mangrove Destruction in Southeast Asia

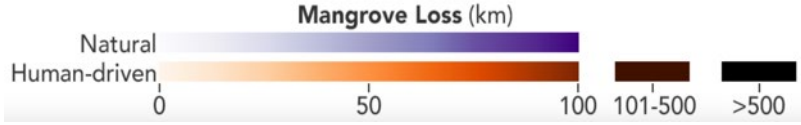


Fauzi et al. (ACRS, 2018)

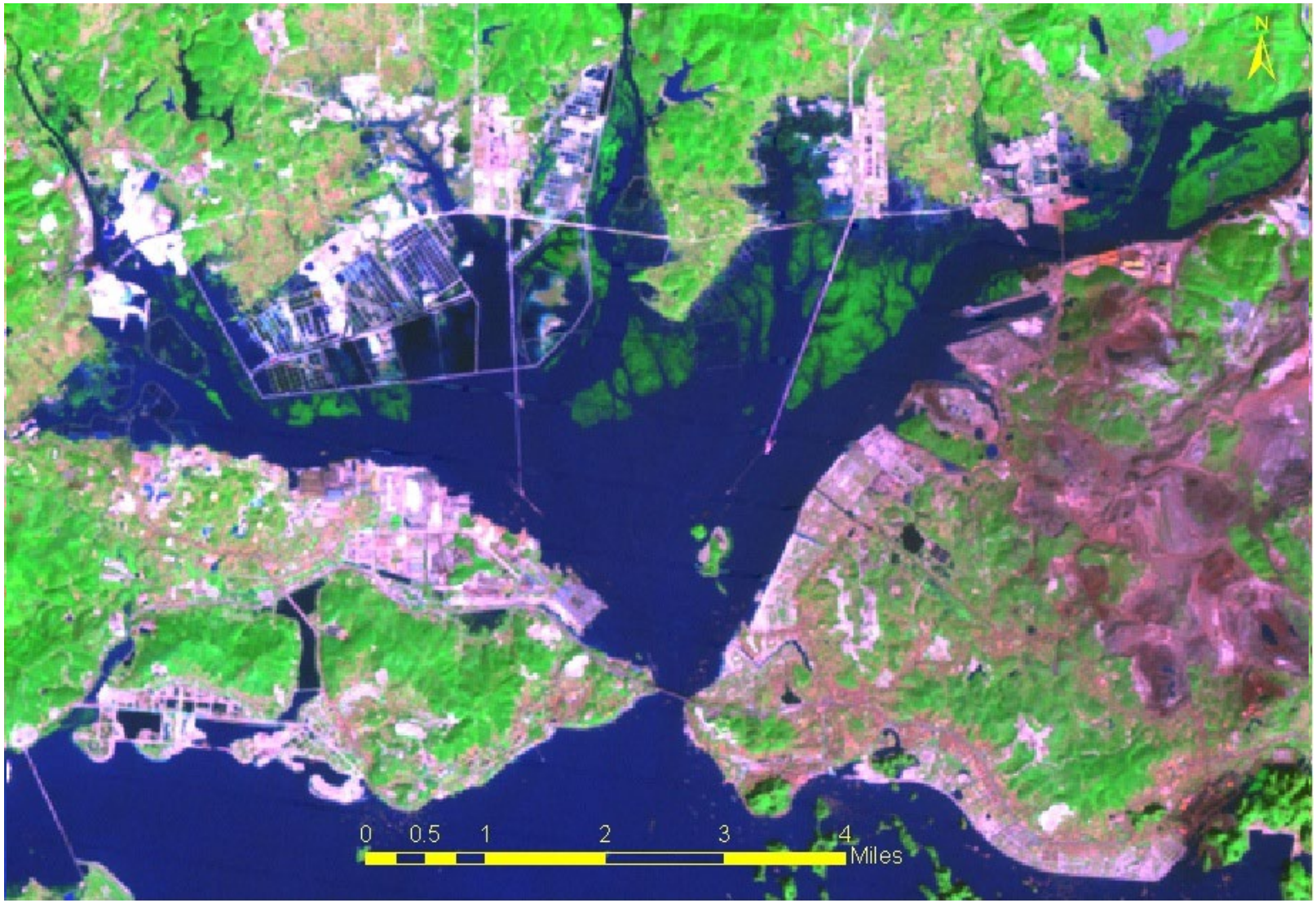




https://doi.org/10.1111/gcb.15275
Goldberg et al. (Global Change Biology, 2020)



Ha Long Bay: 1990->2001->2009



Courtesy of Chandra Giri (USGS-> EPA)

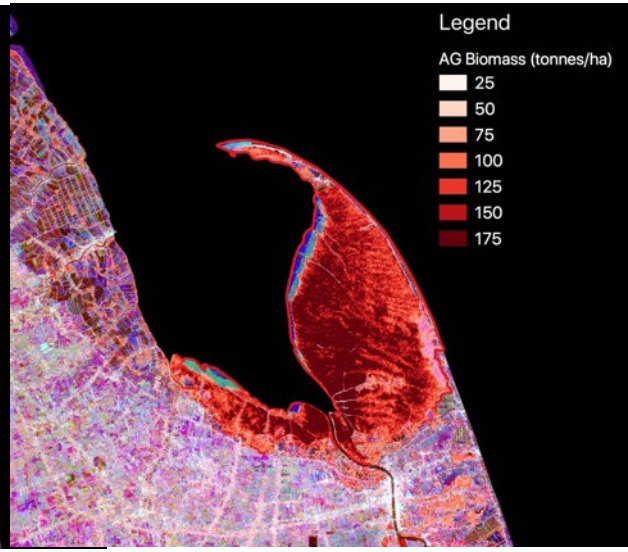
"It seems that shrimp farming and road construction changed the mangroves in this area"

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.

NASA 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.

Urbanization and Sustainability Under Global Change and Transitional Economies

PI: Peilei Fan (Michigan State U., now at Tufts U.)

webpage: senacgc.org

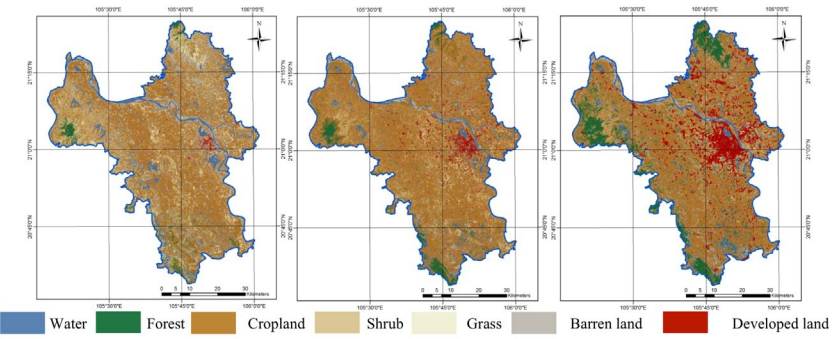
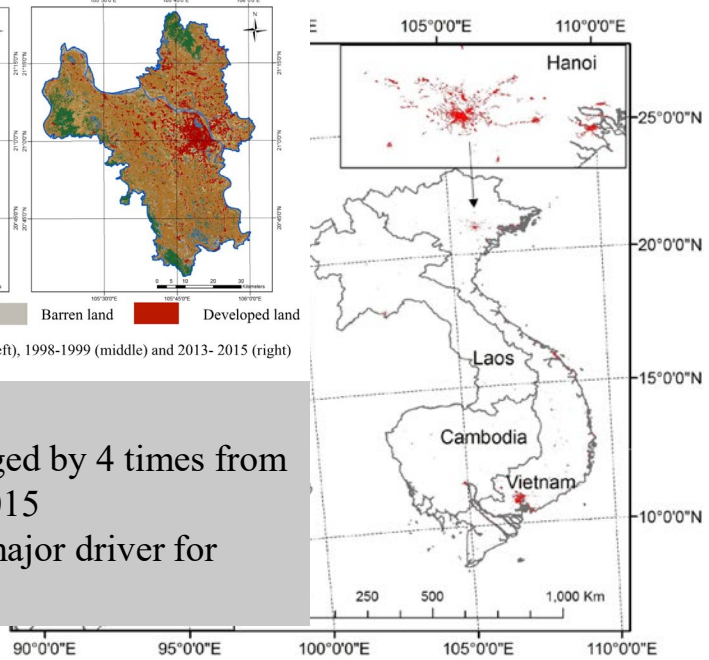


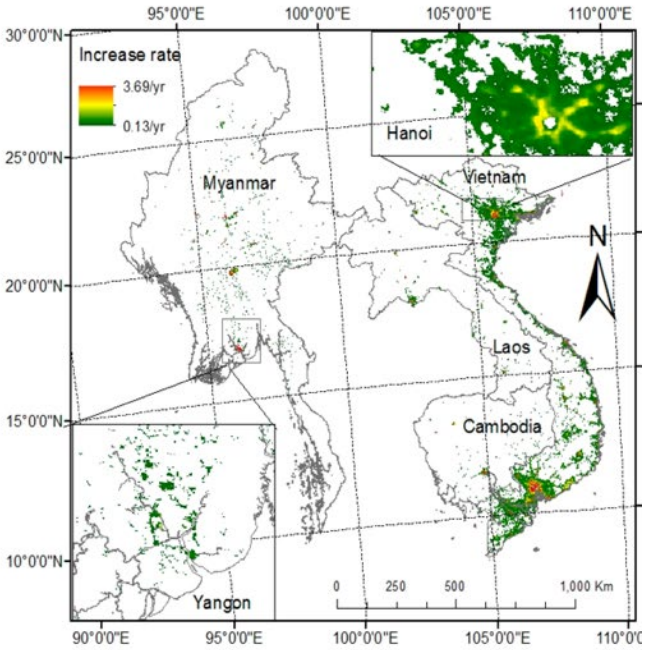
Figure 2a: Spatio-temporal pattern of urban development in Hanoi in 1988-1989 (left), 1998-1999 (middle) and 2013- 2015 (right)

Hanoi as an example

- Developed land of Hanoi enlarged by 4 times from 1989-1999, and by 11 times -2015
- Economic development is the major driver for urbanization in Hanoi



Urban built-up land in Vietnam, Cambodia, Laos, in 2010 from Landsat



Increasing trends of Night Lights in 1992-2010 from DMSP/OLS

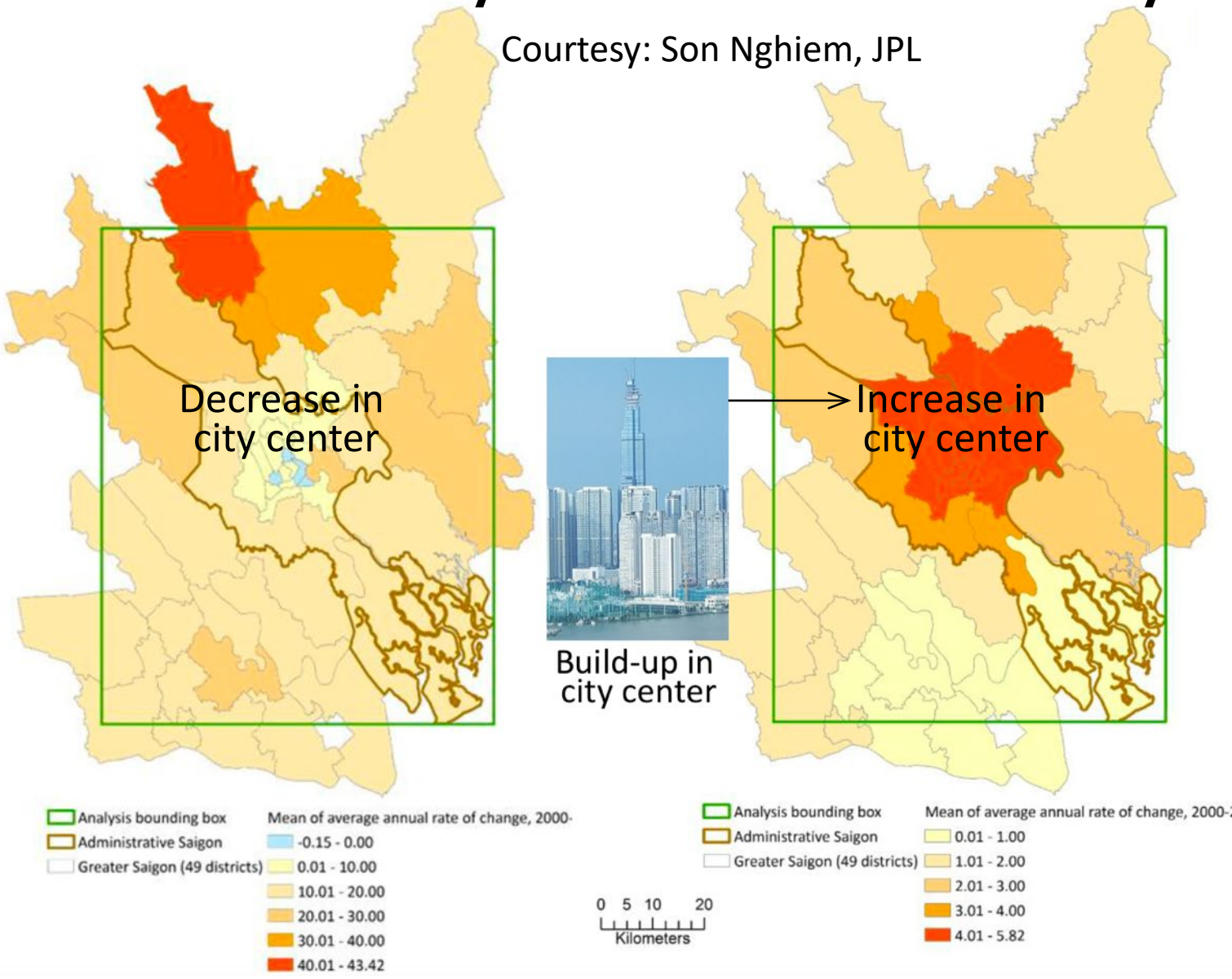
- Vietnam had the highest proportion of urban built-up area and fastest in new built-up (increased ~8.8-times during the 18-year study period)

Saigon: Before and Now
Rapid Build-up of High-Rise Structures: 3D is Important!

GHSL 2D rate of change misrepresents urbanization of Ho Chi Minh City

DSM 3D rate of change captures urbanization of Ho Chi Minh City

Courtesy: Son Nghiem, JPL

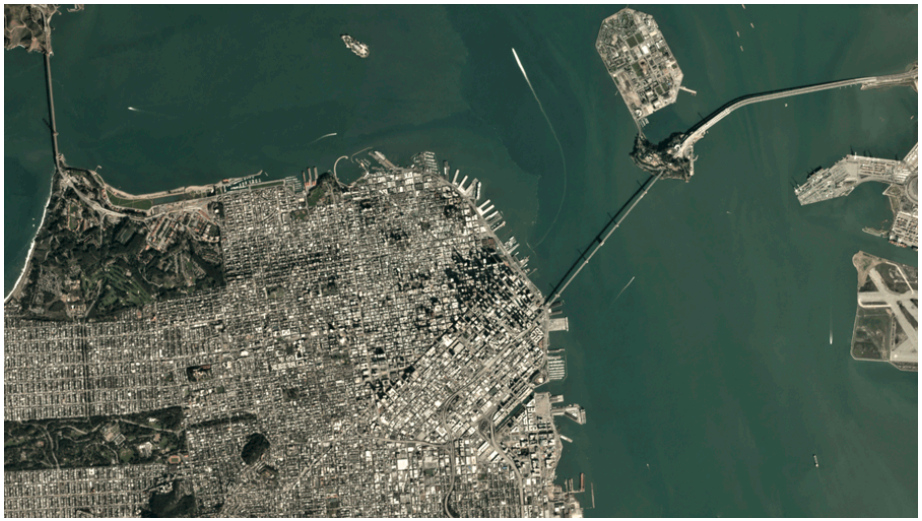


D. L Balk, S. V. Nghiem, B. Jones, Z. Liu, and G. Dunn, https://doi.org/10.1016/j.landurbplan.2018.07.009, 2019

Zooming-in:
Very High Resolution (VHR) Observations

Commercial satellites offer images at fine spatial scale and high temporal resolution

- The first NASA Data Buy 2003 –Ikonos
- Planet Labs constellation (>200 sats) acquire daily images of the Earth with 3-m resolution
- Maxar (Digital Globe, WorldView) with 1m resolution



- NASA Commercial Smallsat Data Acquisition (CSDA)
- Limited Planet datasets available for free at Universities
- Wall-to-wall VHR data over tropics purchased by the government of Norway (to tackle tropical deforestation)
  - Norway's International Climate and Forest Initiative **(NICFI) and the Bezos Earth Fund announced a new partnership to continue providing** the world with free access to high-resolution satellite data
- Special Issue in Remote Sensing (2020) on applications of VHR data in LCLUC studies (7 projects in NASA LCLUC Program)

Courtesy of DigitalGlobe: HCMC, WorldView-2, May 18, 2013

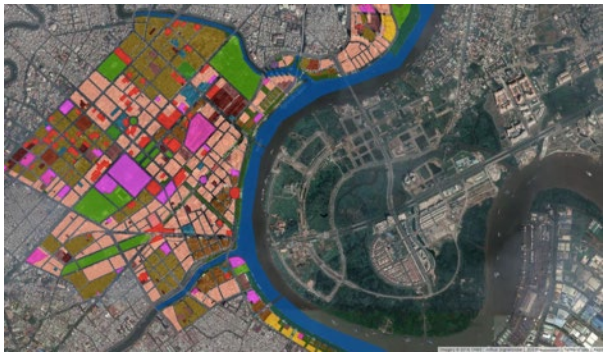
Using Very High Resolution and Machine Learning in HCMC

- In late 2017, HCMC launched a website and mobile app that allows the public to view the cadastral map and the designated planning/zoning in the city

- Complex approach
  - Very High Resolution satellite data (0.3-3m) or UAV
  - machine learning
  - cloud based platforms

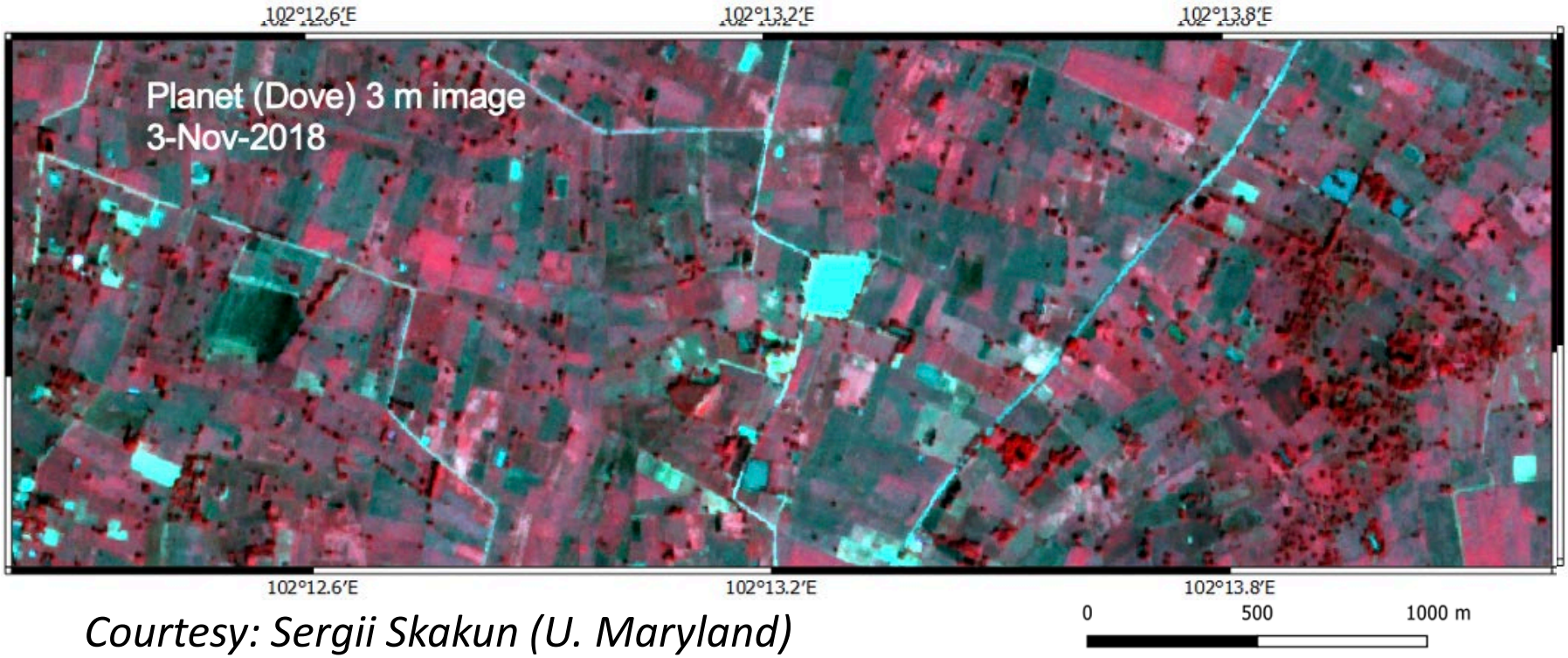
- Bird's eye view of ground processes, e.g. capture construction sites or zoning violations

Courtesy: Ran Goldblatt, New Light Technologies/ UC San Diego



Supervised machine learning algorithms "teach" computers to automatically detect and classify different types of land cover and land use across space and time, and then generate, analytics and visualizations.

Effect of Spatial Resolution on Field Boundaries: Thailand



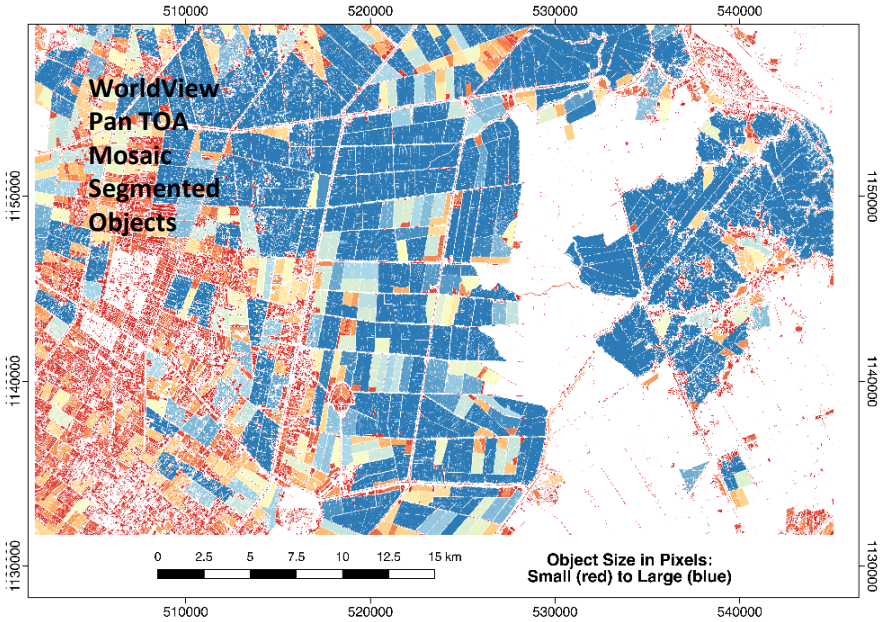
Courtesy: Sergii Skakun (U. Maryland)

Agricultural fields (mostly sugarcane) in the Chaiyaphum province, Thailand

The small agricultural fields in Thailand can only be resolved with VHR data

VHR for Agriculture Land-Use Change Studies in the Mekong River Delta

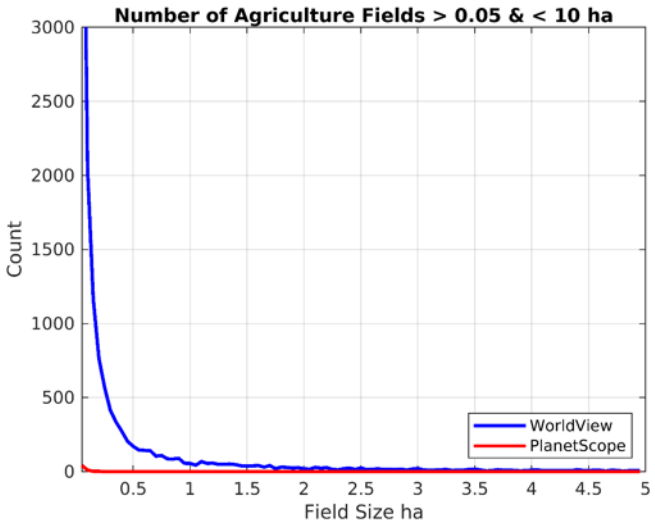
PI: Jessica McCarty (Miami University, Ohio)
Co-I: Chris Neigh (NASA/GSFC), Co-I: Carroll (NASA/GSFC), Thomas (NASA-GSFC/USRA)



Study Areas:

I. Vietnam, Mekong River Delta
II. Đồng Tháp Province and Long Xuyên, An Giang Province

- Digital Globe WorldView 1-m data ability to discriminate small fields as compared to 3-m Planet Dove data
- Field boundaries **have to be resolved near the sub meter scale** to segment individual fields into distinct objects

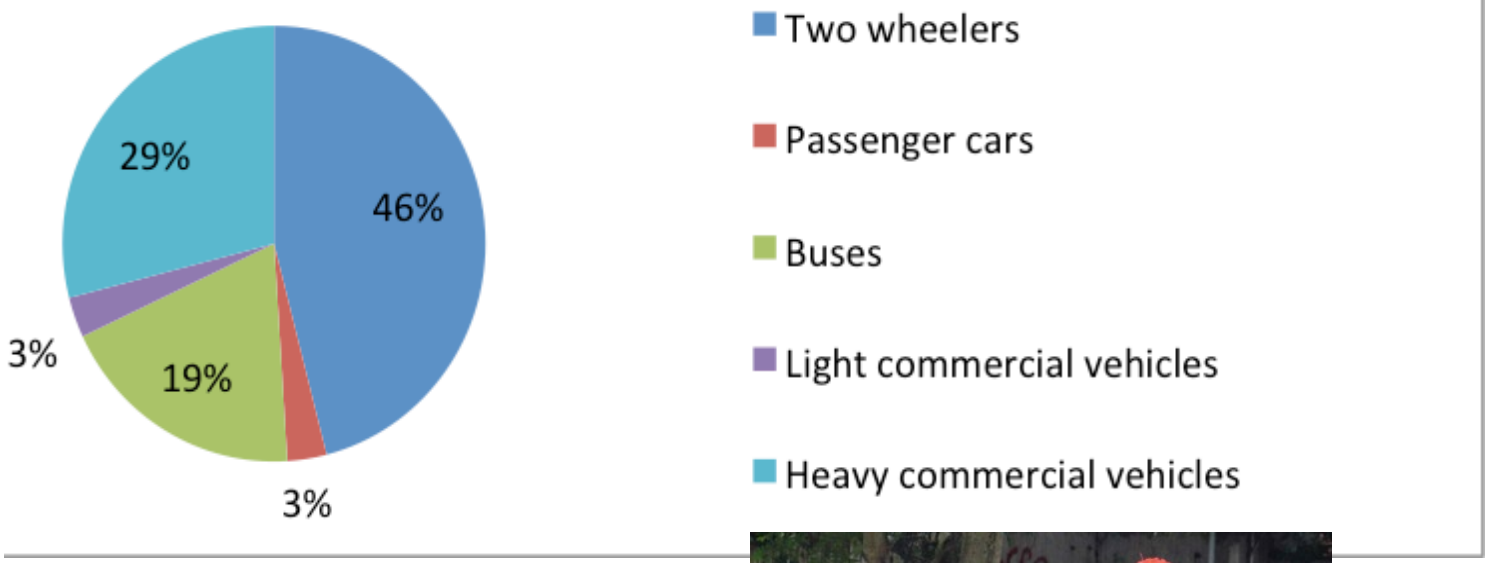


- Derived objects are more robust when combined with Sentinel-1 SAR to estimate cropping intensity
- Due to persistent clouds the temporal advantage of PlanetScope is severely limited for mapping cropping intensity

Emissions!

Viet Nam's road transport CO_2 emissions by vehicle type in 2010

Source: Clean Air Asia, 2012.



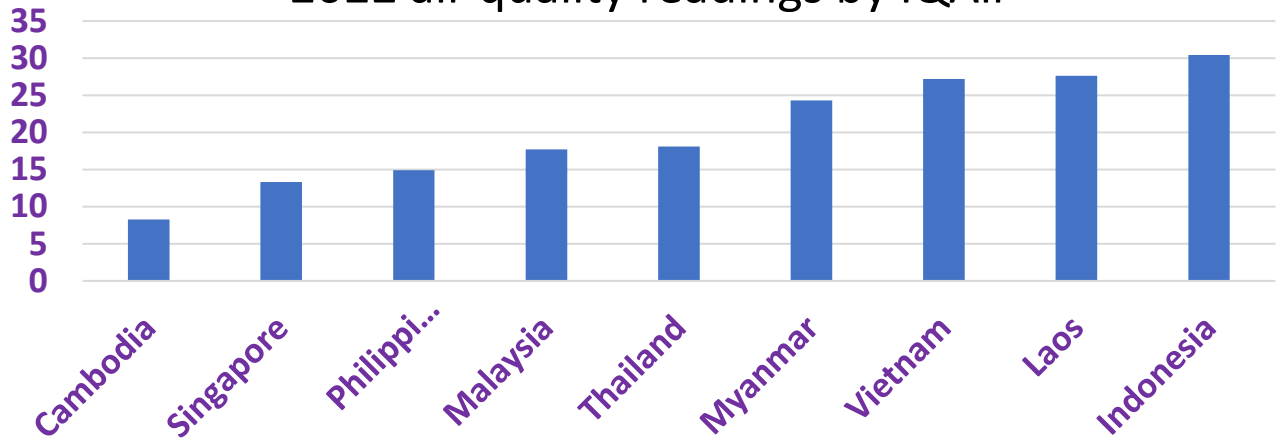
In 2012 **only 6%** of motorcycles were equipped with catalyst exhaust control devices and about 35% did not comply with any European environmental standards.

MOTORCYCLES IN VIETNAM

Nov 2011

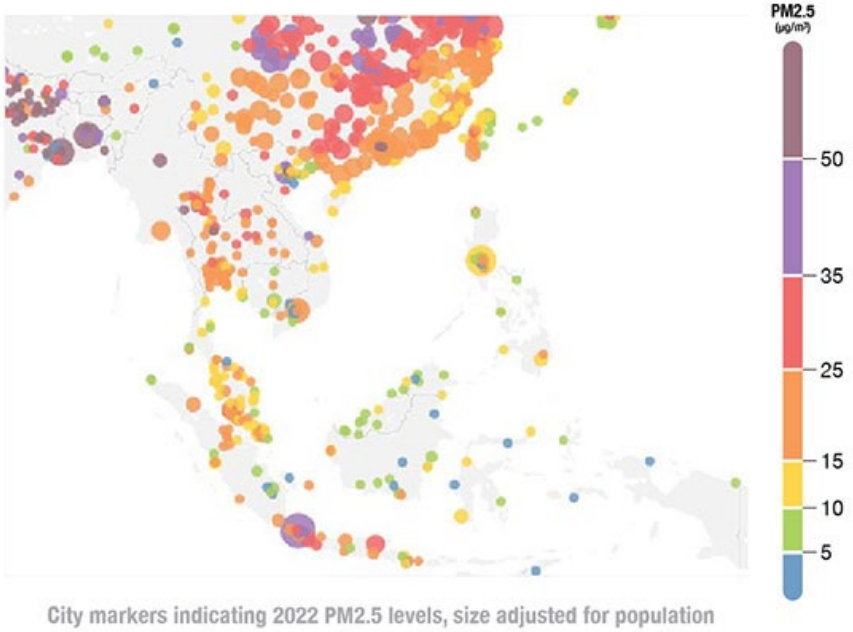
SE Asia Air Quality (µg/m3)

2022 air quality readings by IQAir



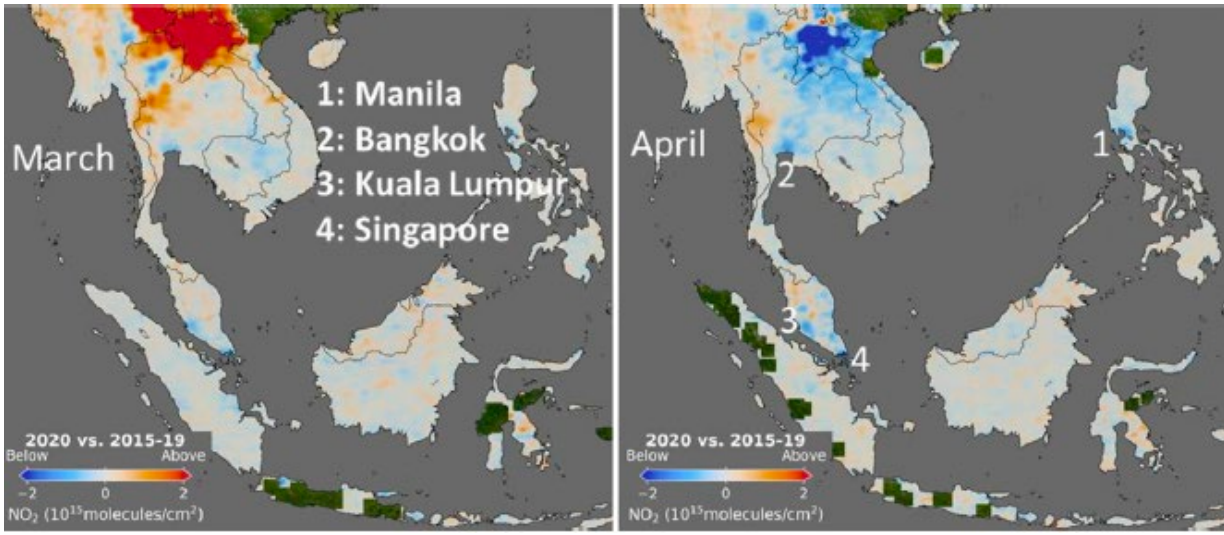
Source: AirVisual Data (Swiss-based IQAir Group)

- **Laos and Vietnam** recorded **higher** annual **averages versus 2021**
- **Indonesia** ended 2022 and 2021 with the **worst air** in the region.
- **Cambodia** showed a remarkable **58%** pollution **decrease** compared with 2021



Impact of Lockdown on Aerosols and Pollutants over Southeast Asia

- Over urban centers in Southeast Asia:
  - Reduction by about 1/3 of tropospheric NO_2
- In urban Malaysia reductions:
  - about 1/3 in PM_{10}, $PM_{2.5}$, and CO
  - Up to 20% in SO_2
  - **over 60% in NO_2**
- Data
  - NASA Aura/OMI for NO_2 concentrations
  - Jaxa Himawari-8 AOD (aerosol optical depth)



COVID-19's impact on the atmospheric environment in the Southeast Asia region. **Kanniah et al. 2020** *Science of the Total Environment 736*

Courtesy: Prof. Kasturi Kanniah, UTM

LCLUC Regional Workshops and Trainings in Southeast Asia

- Jan 2009 Kohn Kaen,Thailand
- Nov 2011 Hanoi, Vietnam
- Aug 2015 Bogor, Indonesia
- Jan 2016 Yangon, Burma
- Oct 2016 Bangkok, Thailand
- Jul 2017 Chiang Mai, Thailand
- Mar 2018 Bangkok, Thailand
- May 2018 Manila, Philippines
- Aug 2018 Vientiane, Laos
- July 2019 Johor Bahru, Malaysia
- Dec 2019 Phuket, Thailand

2020, 2021 skipped

- Aug 2022 Phnom Penh, Cambodia
- Feb 2023 Hanoi, Vietnam

To reap a return in ten years – plant trees.
To reap a return in 100 – cultivate the people.

Ho Chi Minh

All wrong-doing arises because of mind.
If mind is transformed can wrong-doing remain?

Buddah

Thank you

Thanks go to

- Krishna V. (NASA)
- VNSC: Vu Anh Tuan, Linh Phan,
- NIES co-sponsor

Source: Anton Balazh, Shutterstock