NASA LCLUC ACTIVITIES IN MEKONG REGION

Garik Gutman,

LCLUC Program Manager

NASA HQ, Washington DC

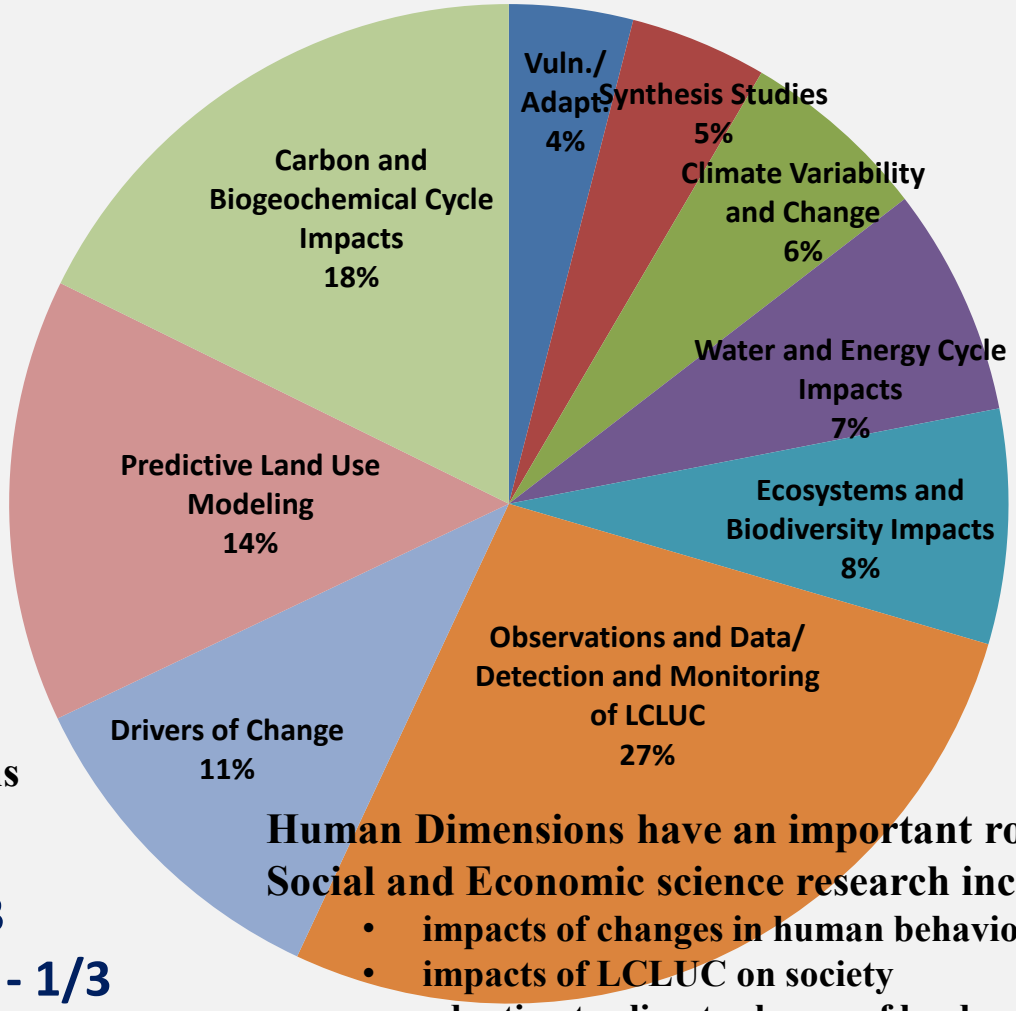
Land-Cover/Land-Use Change Program

LCLUC is an interdisciplinary scientific theme within NASA's Earth Science program. The ultimate vision of this program is ***to develop the capability for periodic global inventories of land use and land cover from space, to develop the scientific understanding and models necessary to simulate the processes taking place, and to evaluate the consequences of observed and predicted changes***

- Characterizing Land Cover
- Quantifying LC Change
- Drivers of LCLUC
  - Natural Drivers
  - Anthropogenic Drivers
    - Socio-Economic Drivers
    - Political Drivers
    - Landscape Modification
- Impacts of LCLUC
  - Carbon Cycle
  - Surface Hydrology
  - Atmosphere
  - Social Systems
  - Food, Energy, Water
- Scenarios of Future Change

LCLUC Program History and Content

- 1994: IGBP/IHDP Land Use/Cover Change (LUCC) program launched
- 1996: First NASA LCLUC program round of proposals
- 1997: 1st LCLUC Science Team



25-yr Program stats:

- >300 projects
- >800 researchers
- >1000 publications

Impacts - 1/3
Monitoring - 1/3
Synthesis, other - 1/3

Human Dimensions have an important role in LCLUC
Social and Economic science research includes

- impacts of changes in human behavior on LCLUC
- impacts of LCLUC on society
- adaption to climate change of land-use systems

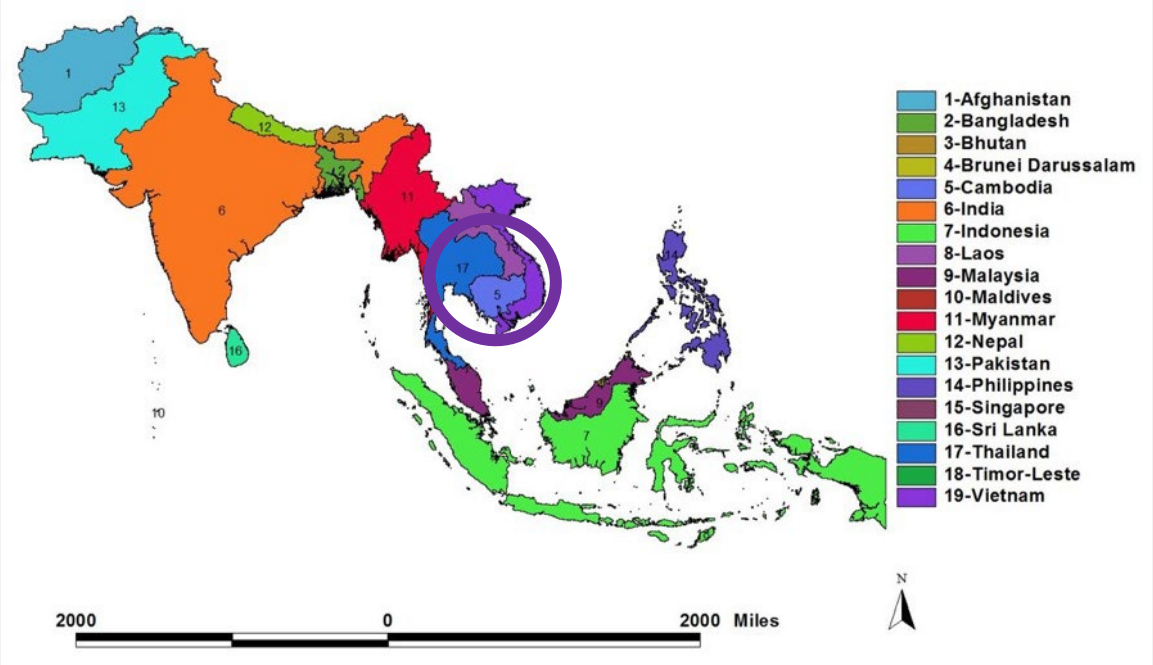
http://lcluc.hq.nasa.gov

- 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/Southeast Asia

- 25 ongoing projects on SARI region(13 **in SE Asia)**
- Interactions with two SERVIR hubs:
  - Mekong and Himalaya
- Series of regional SARI workshops and trainings



THE INVENTORY OF SE ASIA PROJECTS

Principal Investigator	Project Name	Start Date	End Date
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

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

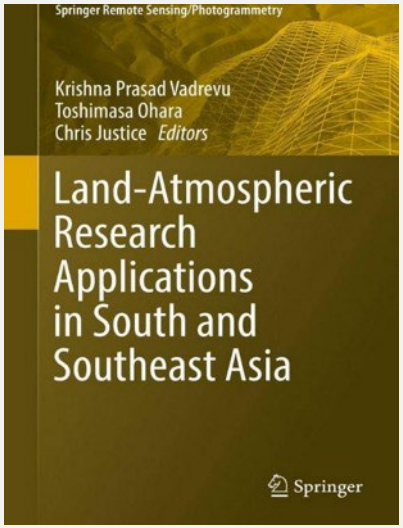
Impacts

- 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)

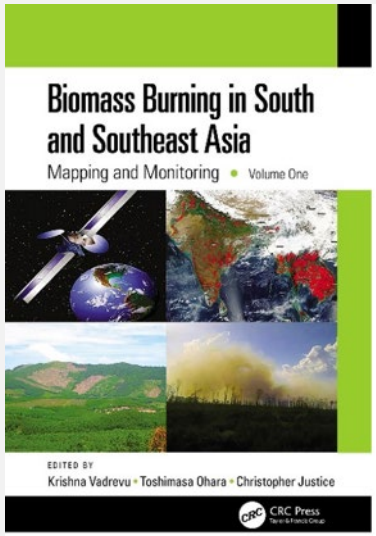
NASA-SARI SCIENCE

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

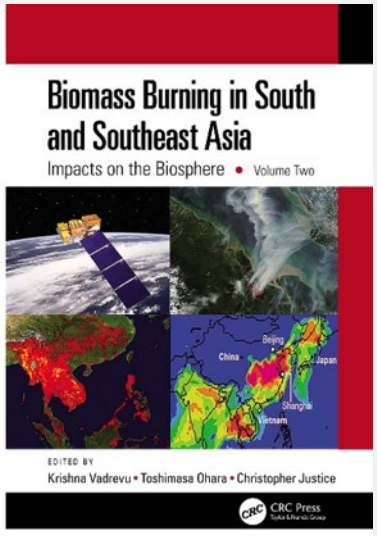
- > 250 scientists
- >150 institutions
- 15 countries
- > 25 projects
- >250 papers
- 12 special issues



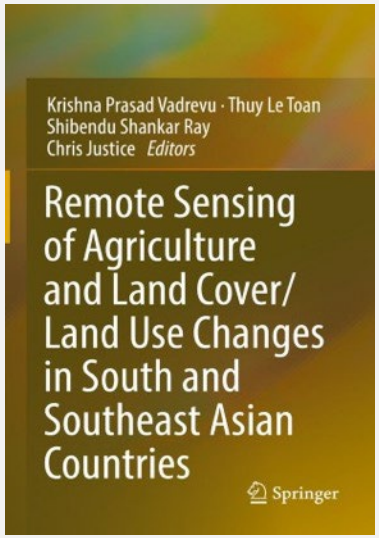
Springer 2018



CRC Press, 2021



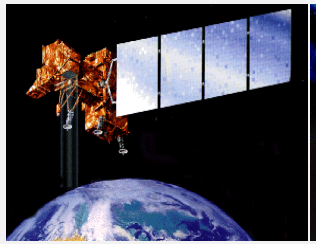
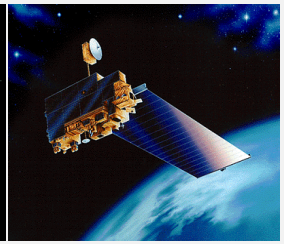
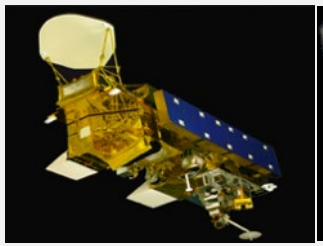
CRC Press, 2021

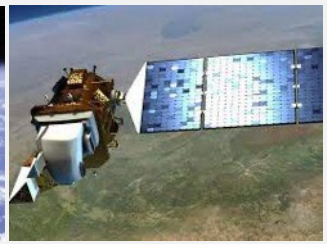


Springer 2022

NASA LCLUC-Relevant Missions

Systematic Missions - Observation of Key Earth System Interactions

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

Terra 12/18/99 — *ASTER MODIS*

Aqua 5/3/02 — *MODIS*

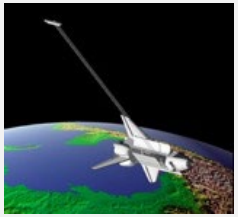
Suomi-NPP 10/28/11 — *VIIRS*

Landsat 8 2/11/13

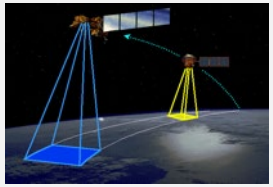
Landsat 9 9/27/21

Exploratory Missions – Exploration of Specific Earth System Processes and Demonstration of Technologies

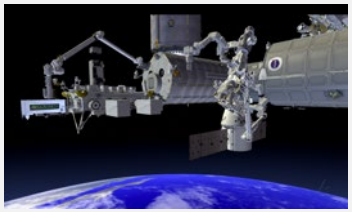
International Space Station (ISS)



ShuttleRadar Topography Mission
2/11/02-2/22/02
Space Shuttle Endeavour

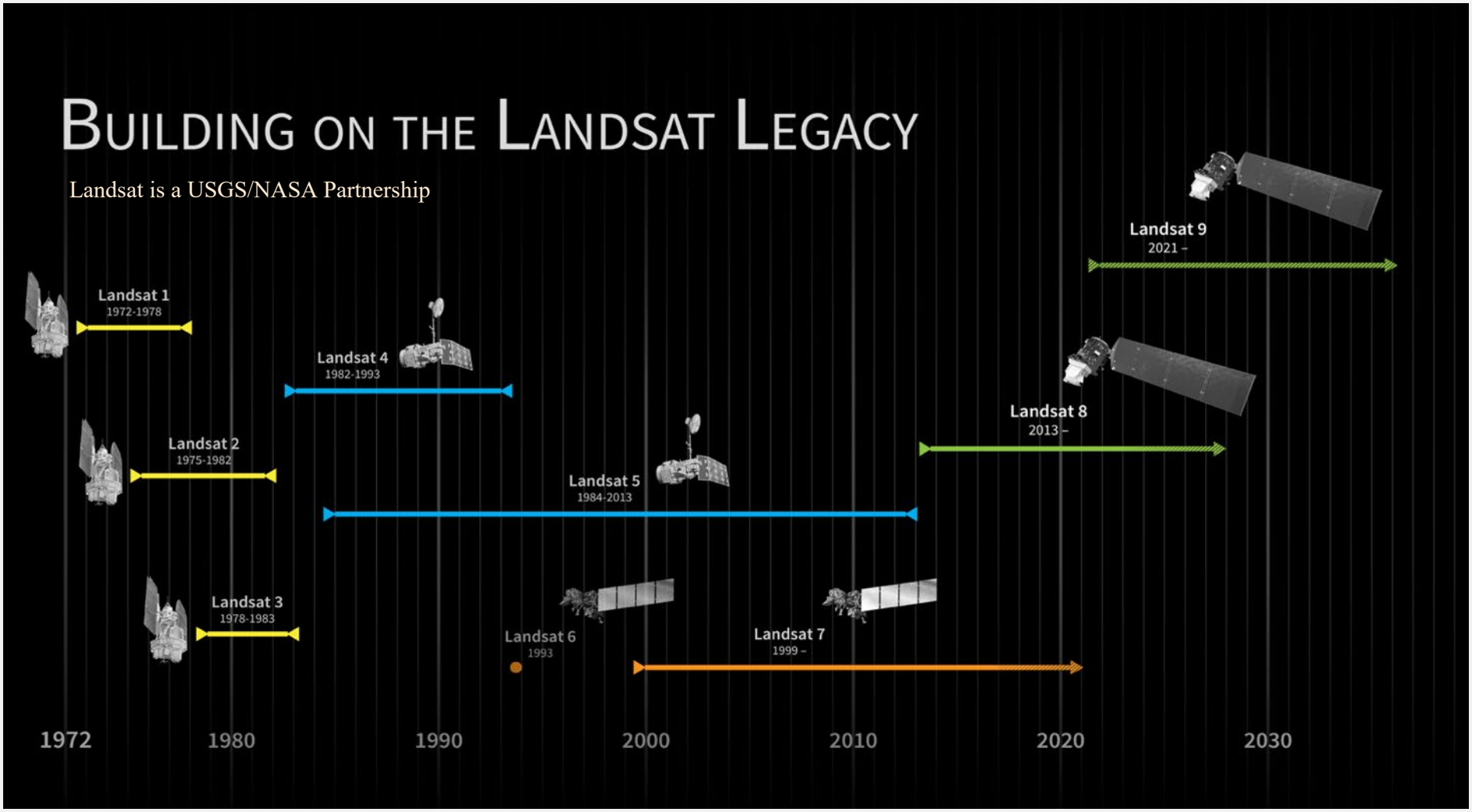


Earth Observing EO-1
ALI (predecessor of Landsat-8)
Hyperion – first hyperspectral in space
11/21/00-3/30/2017



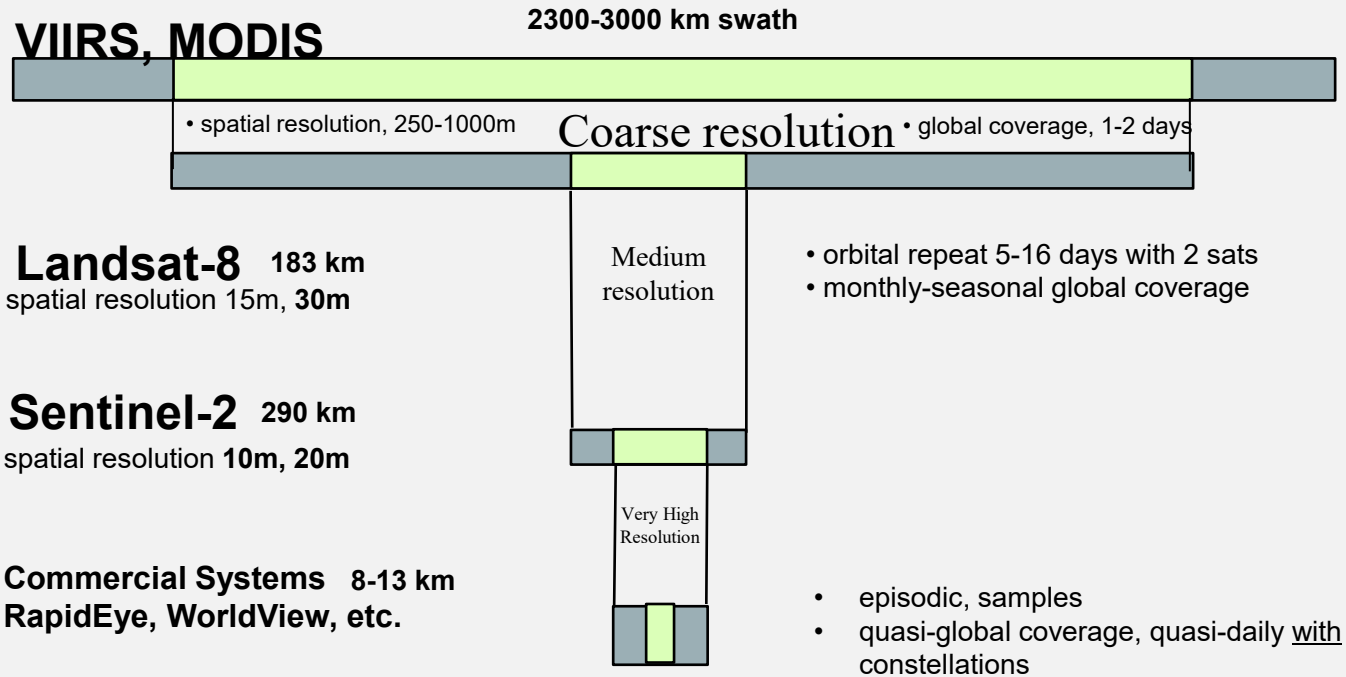
ECOSTRESS (thermal IR)
GEDI (Lidar)
DESIS (Hyperspectral)

NASA-USGS Landsat Program: 50 Years in Space



Landsat has been the workhorse of the LCLUC Program
Good (landscape) spatial resolution for Land-Cover/Use and Change studies
Insufficient frequency of observations for monitoring fast processes (e.g., Agriculture)

Synergistic Use of Optical Remote Sensing



Landsat-8 **183 km**
- spatial resolution 15m, **30m**

Sentinel-2 **290 km**
- spatial resolution **10m, 20m**

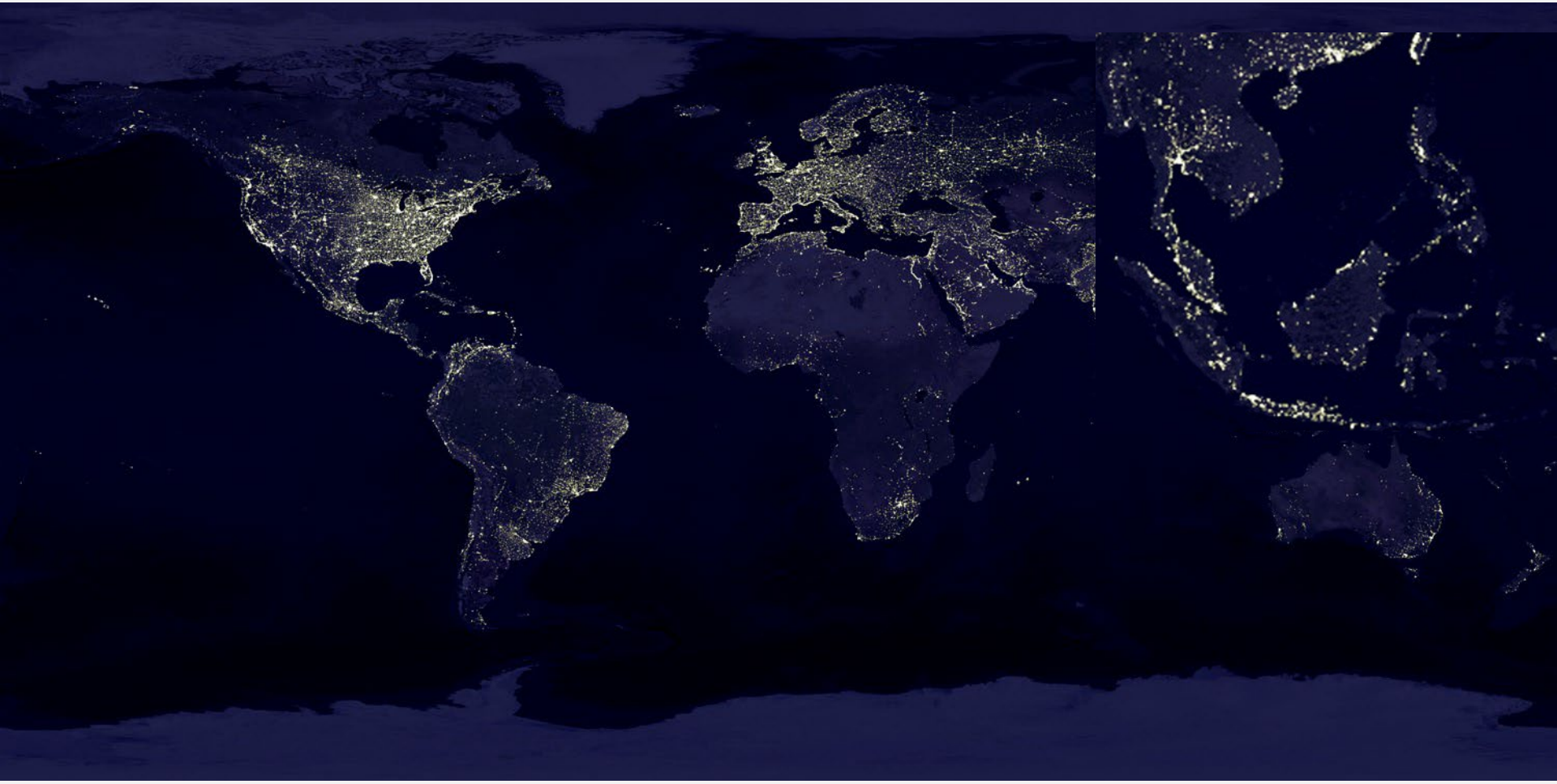
Commercial Systems **8-13 km**
RapidEye, WorldView, etc.

- spatial resolution < 5m spectral
- spatial resolution < 0.5 m panchromatic

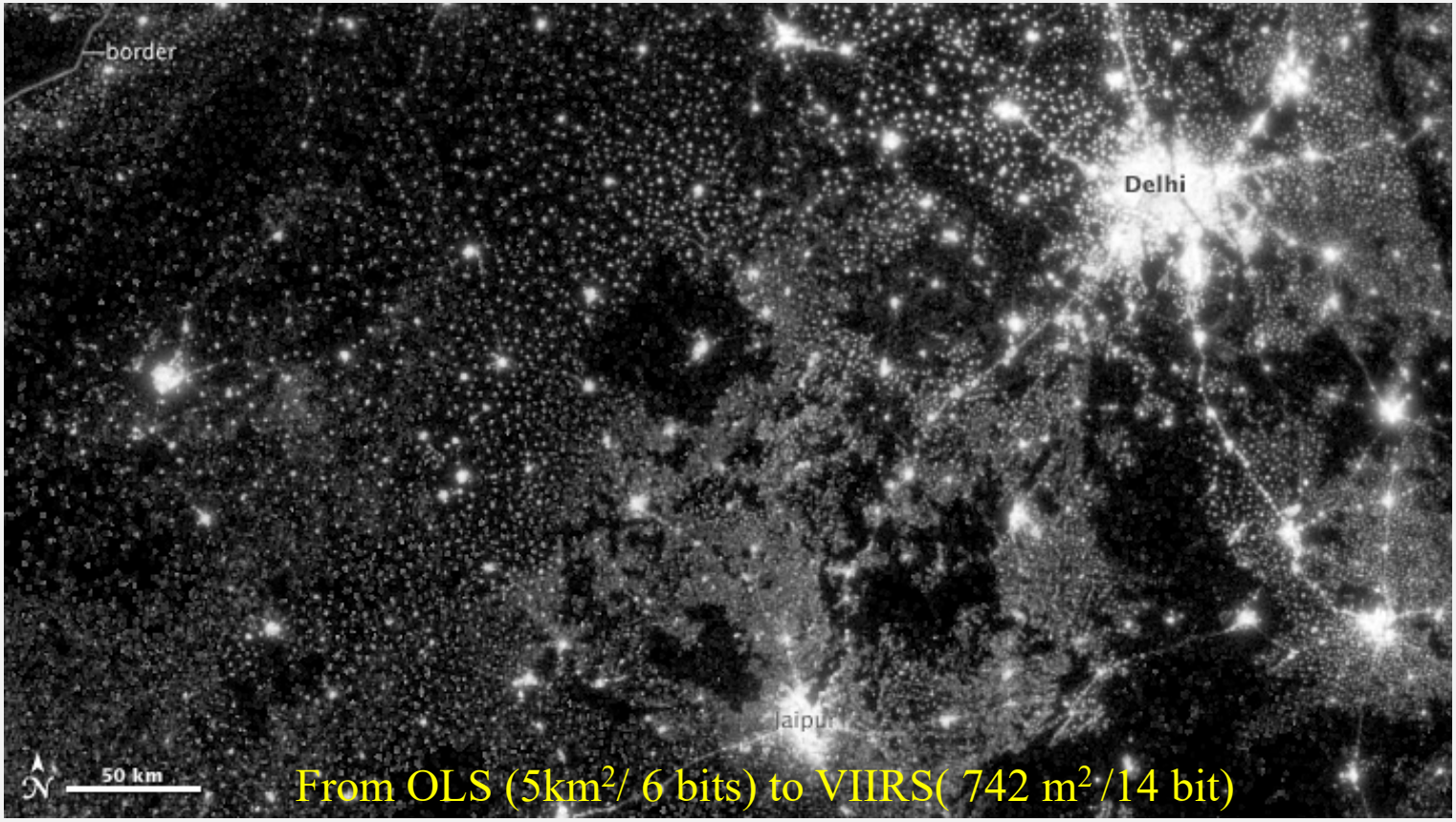
- orbital repeat 5-16 days with 2 sats
- monthly-seasonal global coverage

- episodic, samples
- quasi-global coverage, quasi-daily with constellations

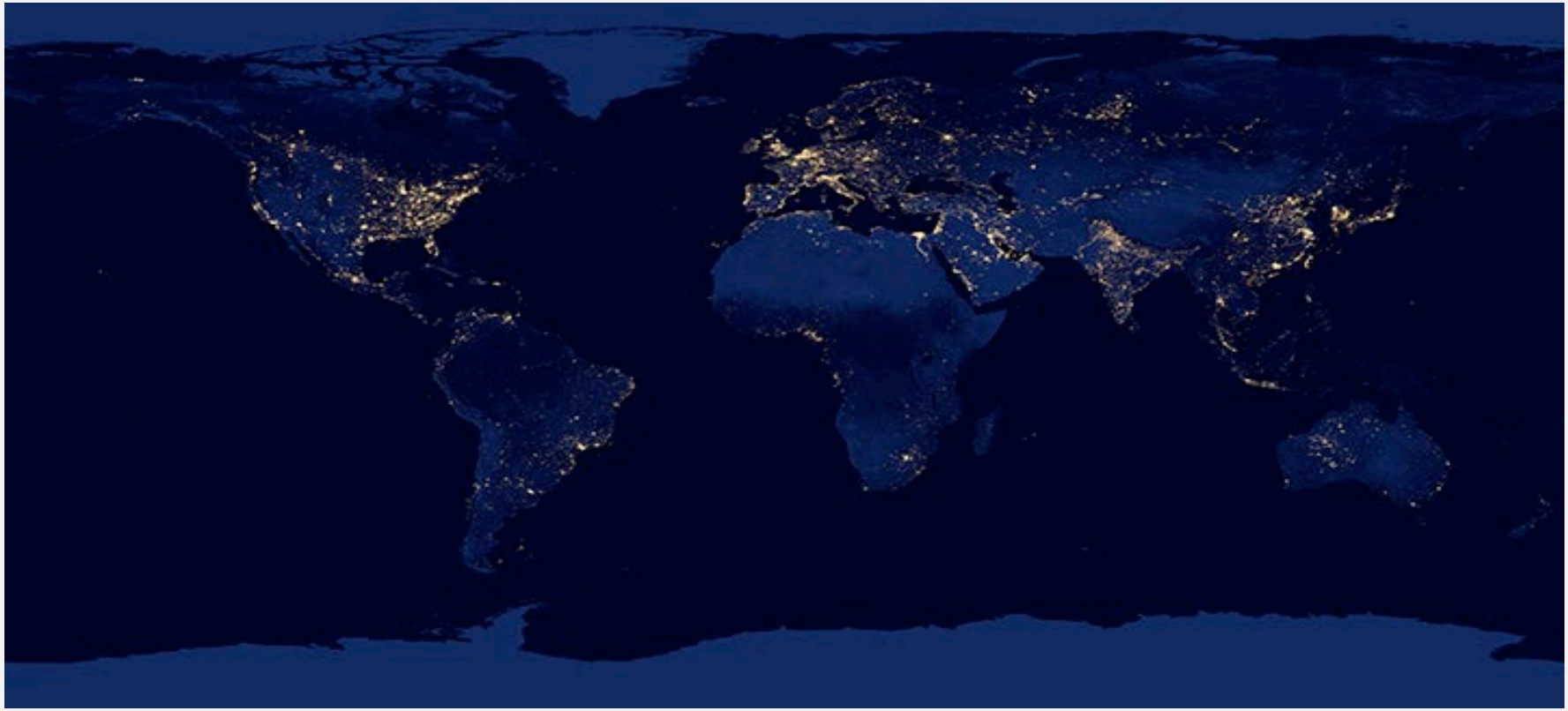
Non-NASA Mission: Earth **Night Lights** Observed by DMSP/OLS



NPP/VIIRS versus DMSP/OLS



GLOBAL NIGHT LIGHTS: DMSP/OLS→ VIIRS/SUOMI-NPP



From OLS (5km^2/ 6 bits) to VIIRS(742 m^2 /14 bit)

The Night Lights composite assembled from data acquired by the Suomi National Polar-orbiting Partnership (Suomi NPP) satellite over nine days in April 2012 and thirteen days in October 2012.

URBANIZATION AND SUSTAINABILITY UNDER GLOBAL CHANGE AND TRANSITIONAL ECONOMIES

PI: PEILEI FAN (MICHIGAN STATE UNIVERSITY)

webpage: senacgc.org

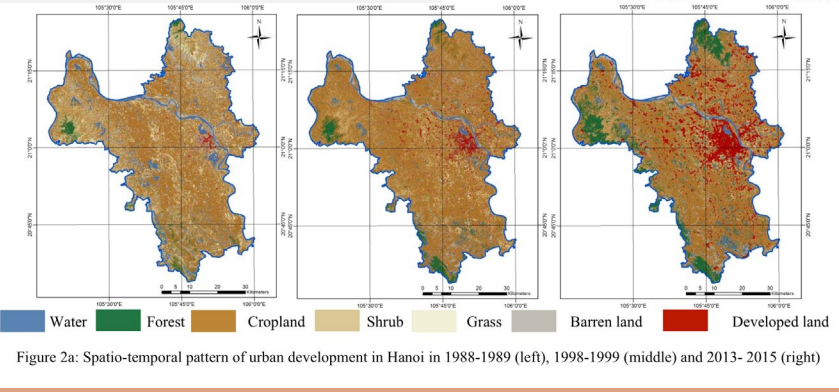
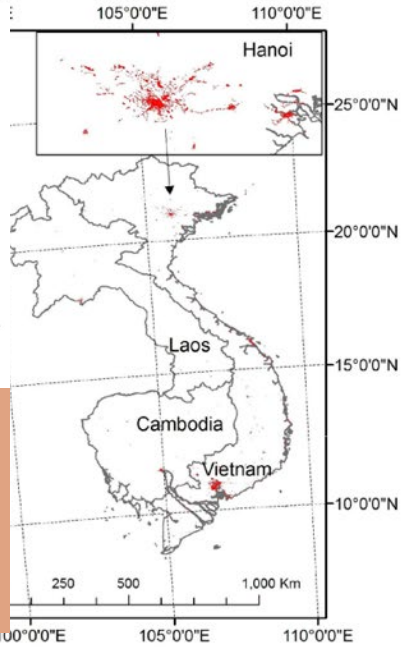


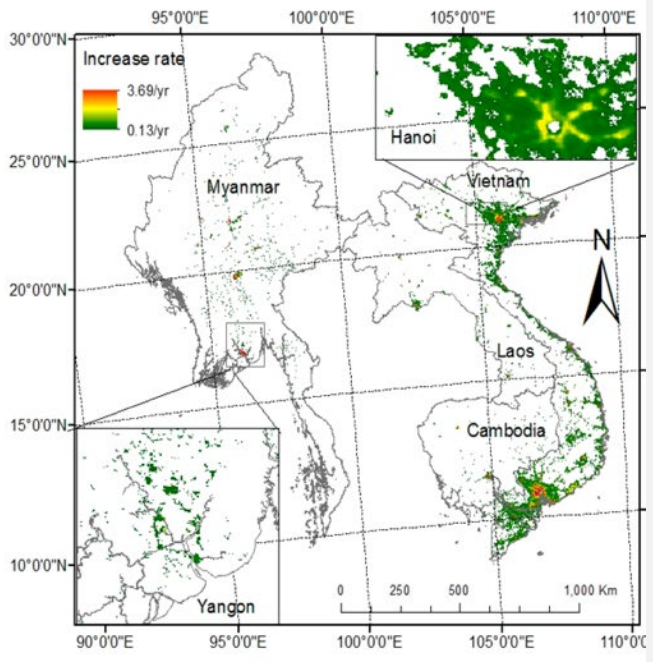
Figure 2a: Spatio-temporal pattern of urban development in Hanoi in 1988-1989 (left), 1998-1999 (middle) and 2013- 2015 (right)

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

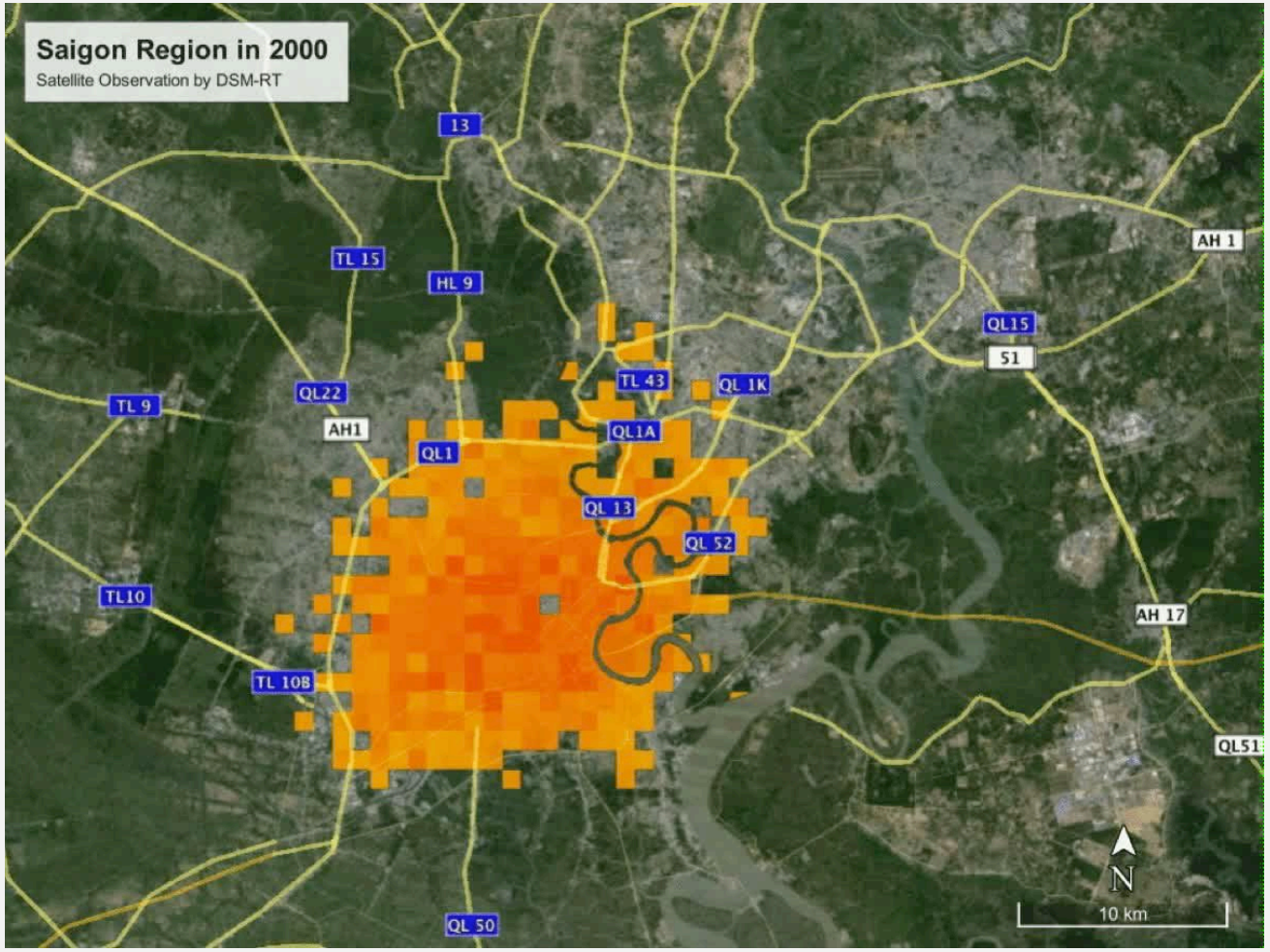


Increasing trends of Night Lights in 1992-2010 from DMSP/OLS

- 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)

URBAN EXPANSION DERIVED FROM **RADAR** OBSERVATIONS: SAIGON, VIETNAM 2000-2009

Son Nghiem, JPL



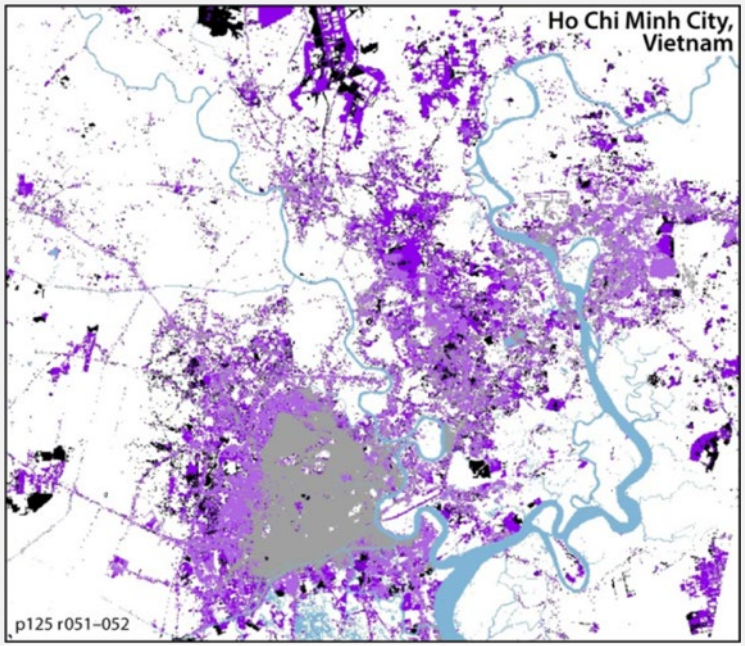
Derived from scatterometer onboard QuikSCAT satellite using DSM-RT method with **radar** backscatter observations

RAPID BUILD-UP OF HIGH-RISE STRUCTURES IN SAIGON: 3-D IS IMPORTANT!

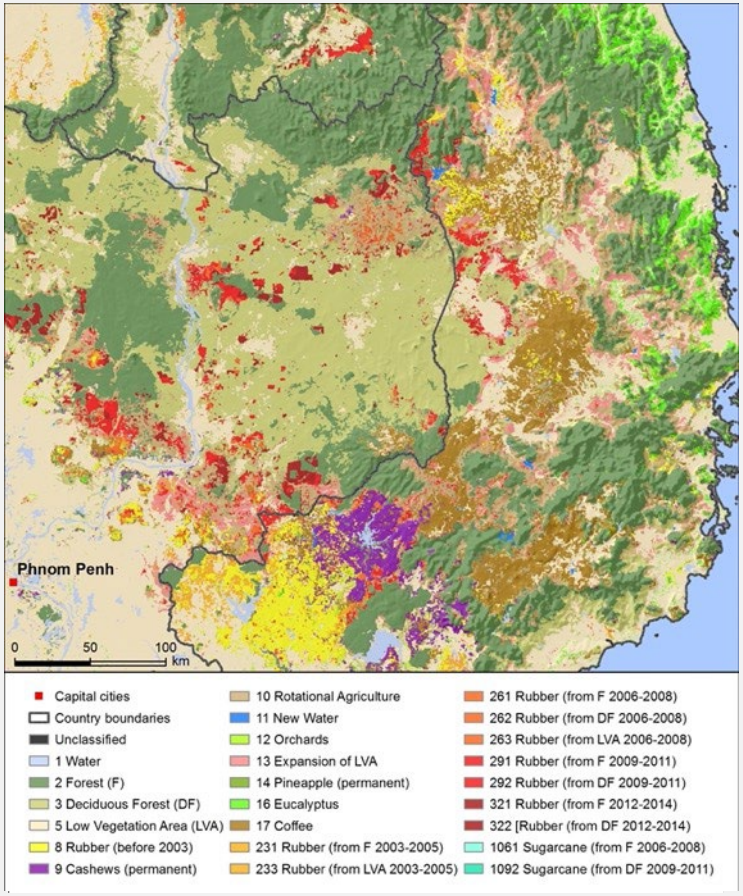
FOREST, AGRICULTURAL, AND URBAN TRANSITIONS IN MAINLAND SOUTHEAST ASIA: SYNTHESIS

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



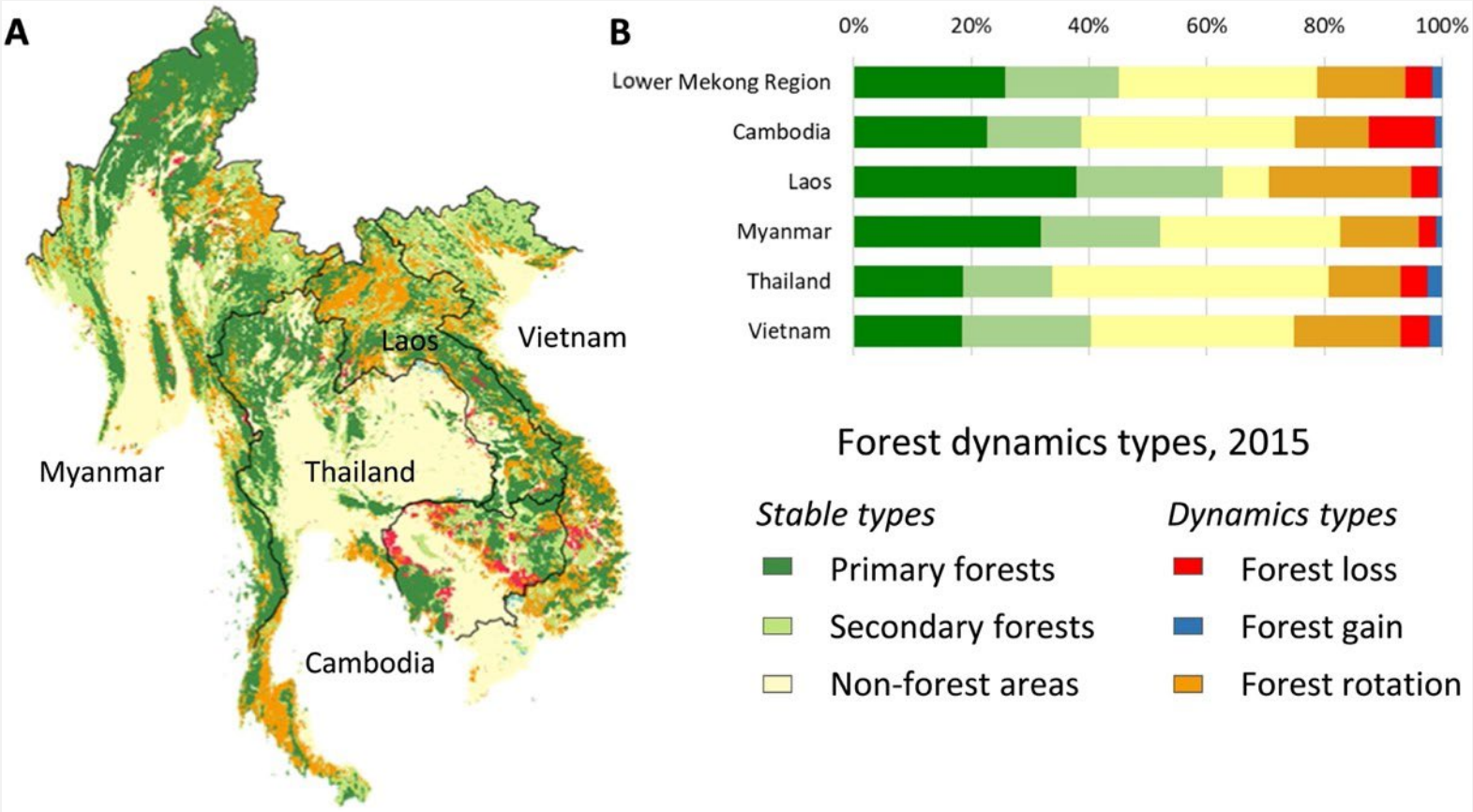
land-cover change classification



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

FOREST DYNAMICS 2000-2015 IN LOW MEKONG REGION

PETER POTAPOV AND TEAM (UMD+WRI)



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

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

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

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

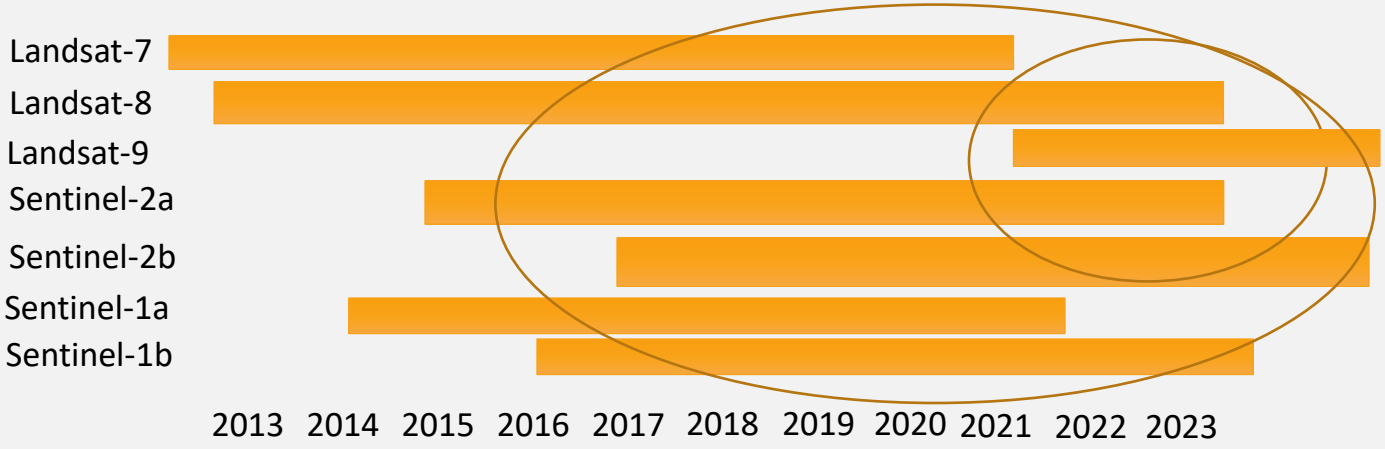
Multi-Source Land Imaging (MuSLI)

COMBINING OPTICAL AND MICROWAVE DATA: LANDSAT + SENTINEL2 + SENTINEL1

- Sentinel-2a: launched in Jun 2015
- Sentinel-2b: launched in Mar 2017
- Sentinel-1a: launched in Apr 2014
- Sentinel-1b: launched in Apr 2016
- Sentinel-1b: set for launch in 2023
- Landsat-7: launched in Apr 1999
- Landsat-8: launched in Feb 2013
- Landsat-9: launched in Sep 2021

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

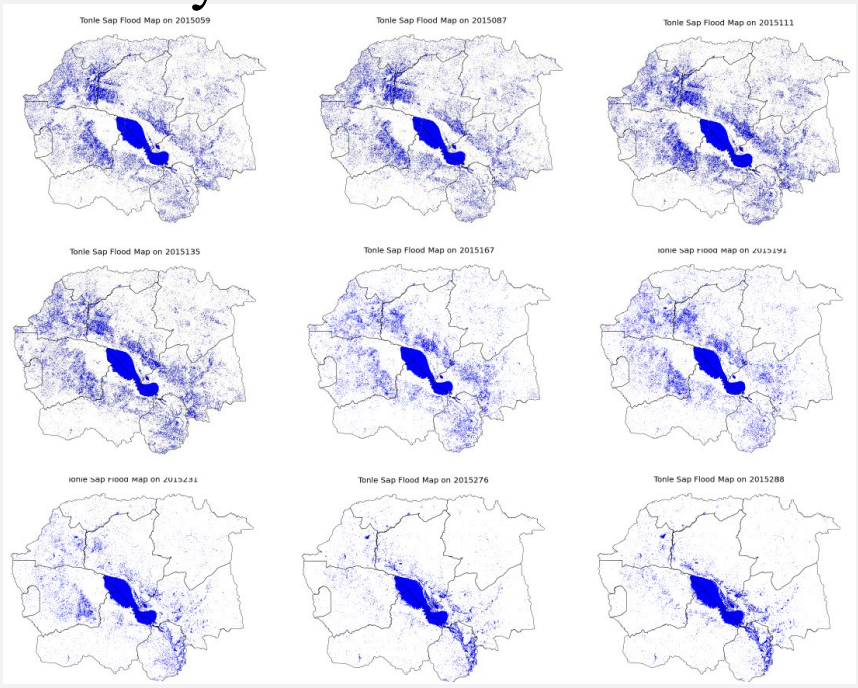


MUSLI IN CAMBODIA: NEAR REAL TIME MAPS OF RICE EXTENT AND CROP GROWTH STAGE

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

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

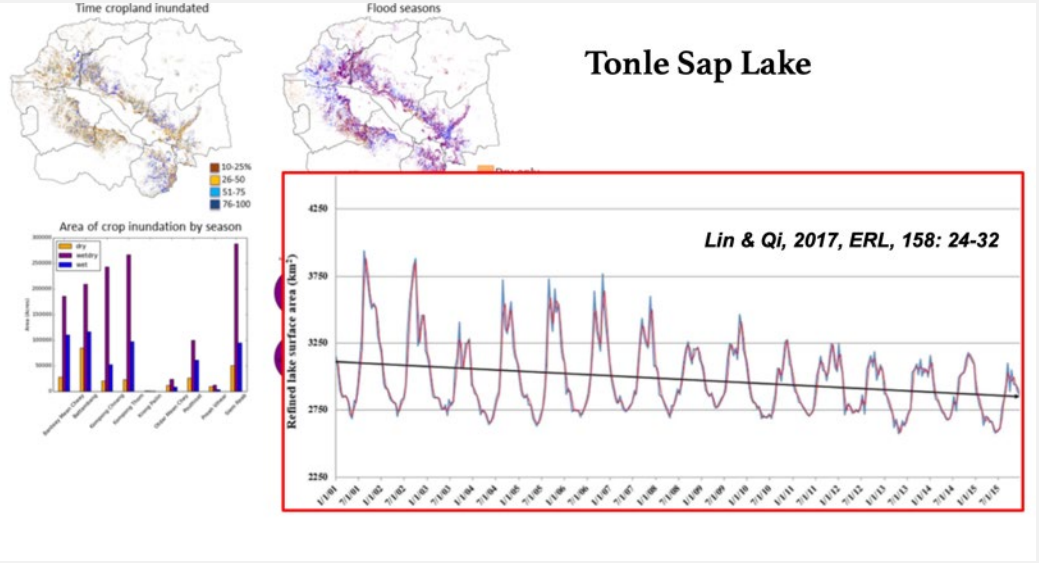


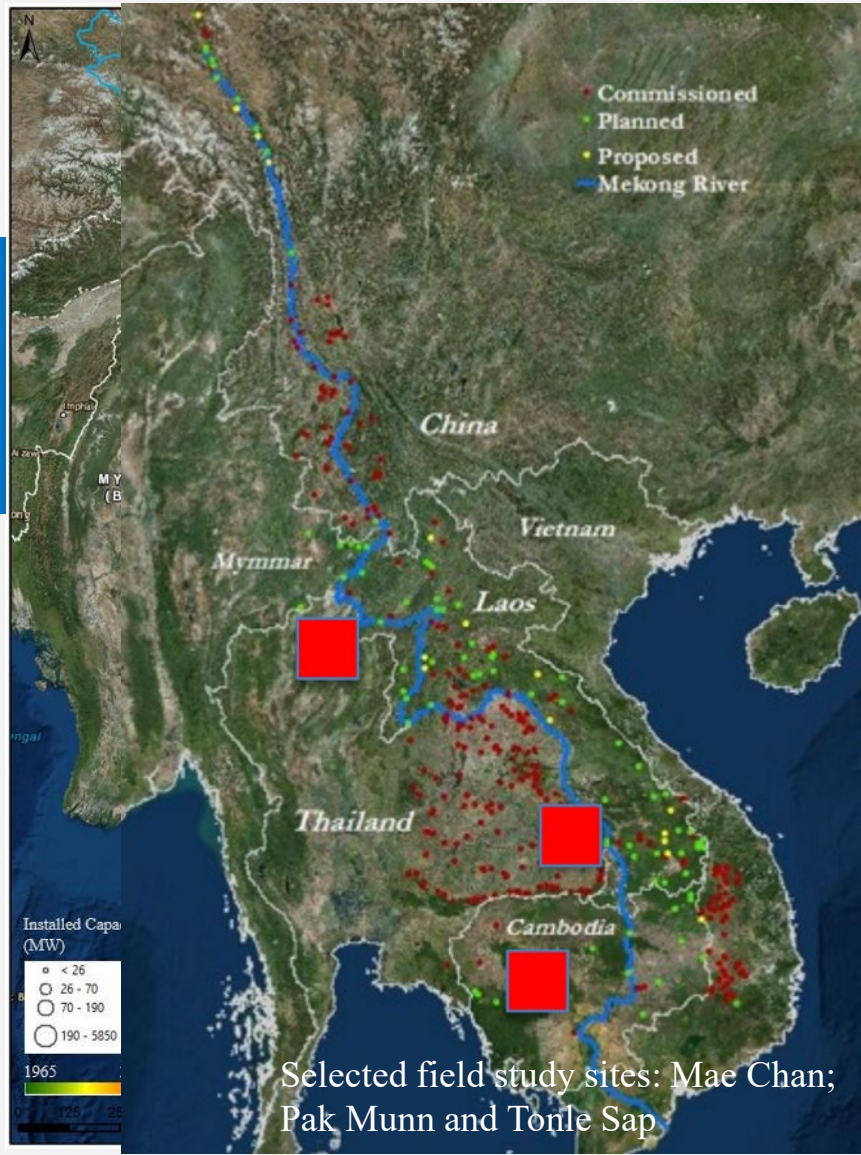
WATER-ENERGY-FOOD NEXUS: IMPACTS OF DAMS IN MEKONG REGION

QI, MICHIGAN STATE U.+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.**

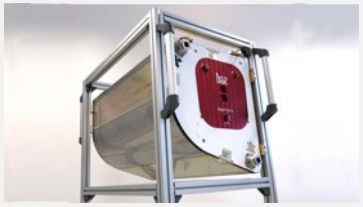




Selected field study sites: Mae Chan; Pak Munn and Tonle Sap

DATA FROM NEW SENSORS ON THE INTERNATIONAL SPACE STATION FOR LCLUC STUDIES

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



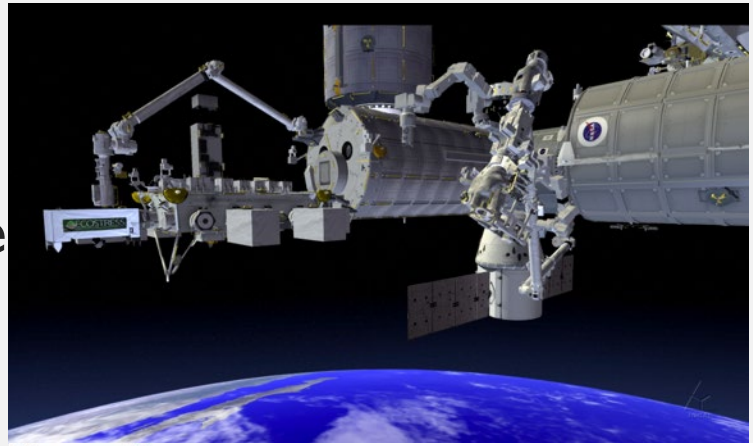
- DESIS**:** DLR Earth Sensing Imaging Spectrometer - **Hyperspectral**
  - 235 spectral channels with ground res. 30m

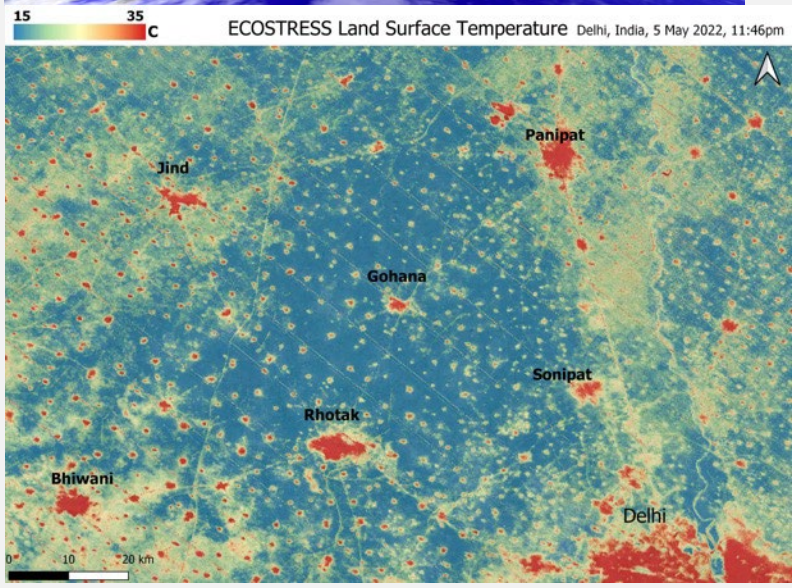
- GEDI: Global Ecosystem Dynamics Investigation - **LIDAR**
  - high resolution laser ranging observations of 3D structures
  - three lasers produce eight parallel tracks of observations
  - each laser fires 242 times per second and illuminates a 25 m spot (a footprint) on the surface over which 3D structure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

ECOSTRESS

ECOSYSTEM SPACEBORNE THERMAL RADIOMETER EXPERIMENT ON THE INTERNATIONAL SPACE STATION

- Prototype HysplRI **Thermal Infrared** Radiometer (PHyTIR)
- 5 spectral bands in the 8-12.5 μm range +1.6 μm
- Spatial resolution ~70 m





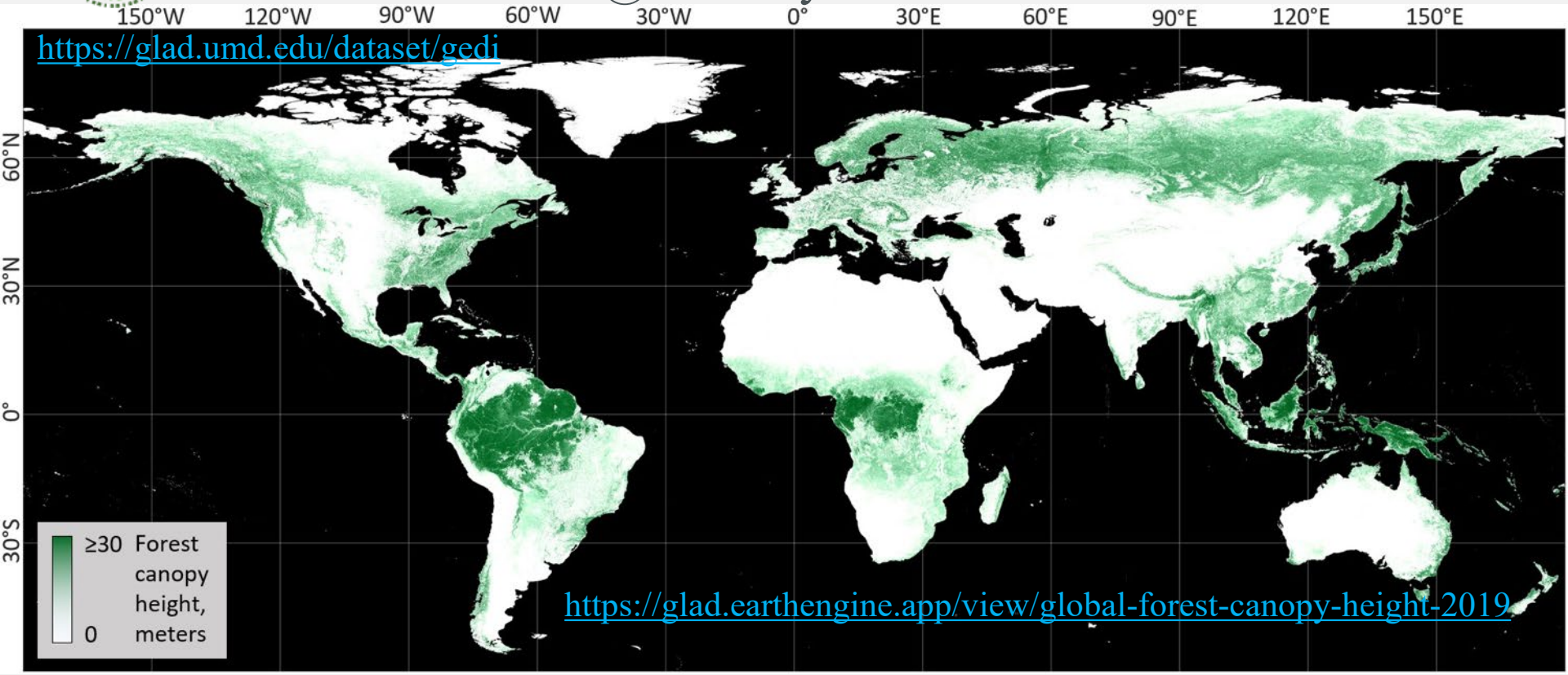
Heatwave over India: August 2022

Urban heat islands around Delhi: Over 35°C while surrounding fields are cool at 15°C

Midnight image May 5
Credit: NASA/JPL-Calthech

GEDI: GLOBAL ECOSYSTEM DYNAMICS INVESTIGATION
GLOBAL FOREST CANOPY HEIGHT, 2019

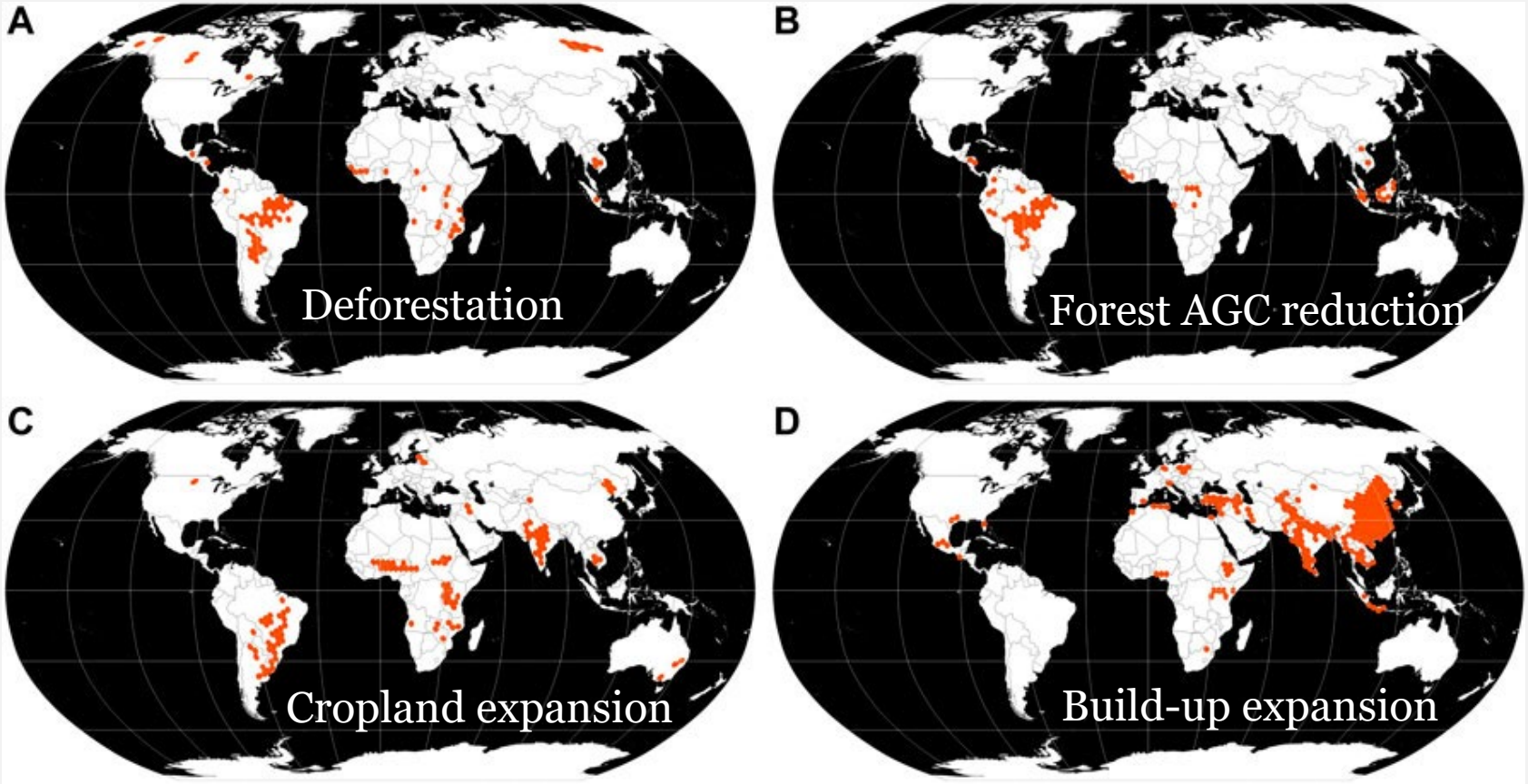
Global Land Analysis & Discovery @U. Maryland



P. Potapov, X. Li, A. Hernandez-Serna, A. Tyukavina, M.C. Hansen, A. Kommareddy, A. Pickens, S. Turubanova, H. Tang, C.E. Silva, J. Armston, R. Dubayah, J. B. Blair, M. Hofton (2020) Mapping and monitoring global forest canopy height through integration of GEDI and Landsat data. *Remote Sensing of Environment,* 112165. https://doi.org/10.1016/j.rse.2020.112165

Integration of the Global Ecosystem Dynamics Investigation **(GEDI) lidar** forest structure measurements and **Landsat** analysis-ready data time-series

GLOBAL 2000–2020 LCLUC HOTSPOTS
PETER POTAPOV AND TEAM (UMD+WRI)

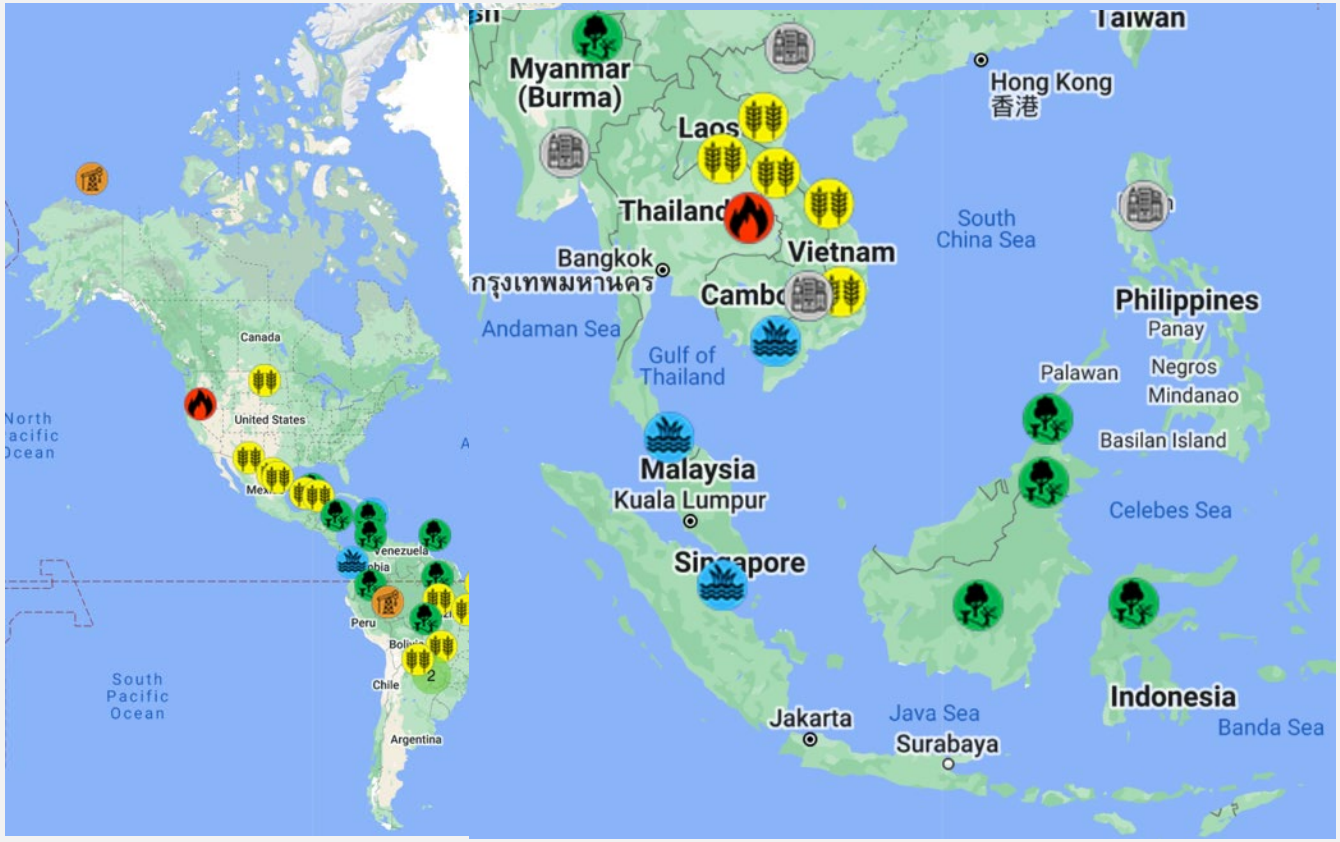


Hotspots defined as the grid cells (70,000 km² in area) that include 50% of the thematic quantity of the global total AGC – above ground (biomass) carbon

https://www.frontiersin.org/articles/10.3389/frsen.2022.856903/full

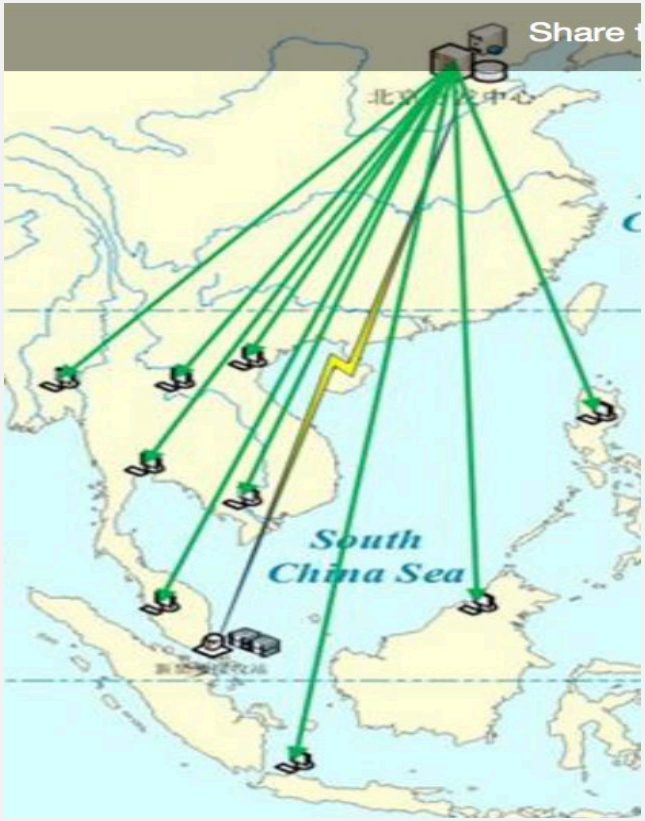
Potapov et al. 2022

HOTSPOTS FROM RECENT LCLUC PROJECTS



NON-US HIGH/MID-RESOLUTION OBSERVATIONS

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



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

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

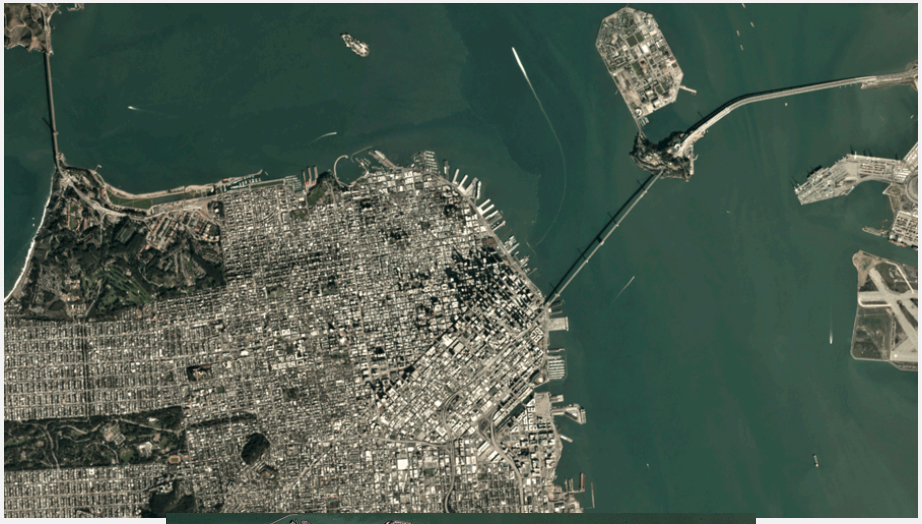
http://www.intelligence-airbusds.com/en/4239-spot-asia-partners

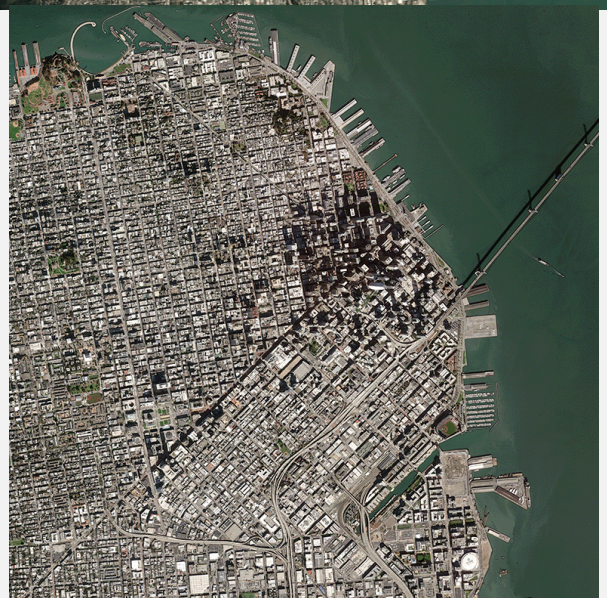
ESA Sentinel-1 and -2
JAXA AVNIR, PALSAR-2

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)
- Special Issue in Remote Sensing (2020) on applications of VHR data in LCLUC studies

EFFECT OF SPATIAL RESOLUTION ON FIELD BOUNDARIES: THAILAND

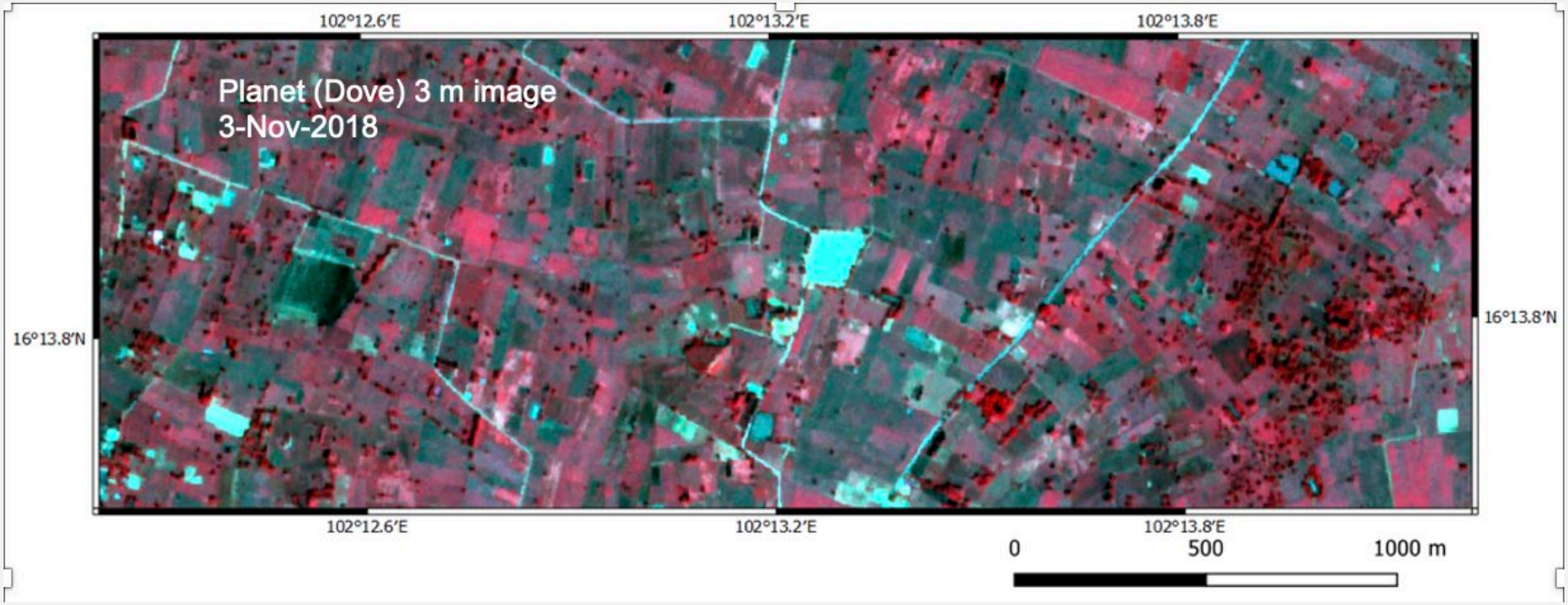
Courtesy: Sergii Skakun (U. Maryland)

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

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

EFFECT OF SPATIAL RESOLUTION ON FIELD BOUNDARIES: THAILAND

Courtesy: Sergii Skakun (U. Maryland)

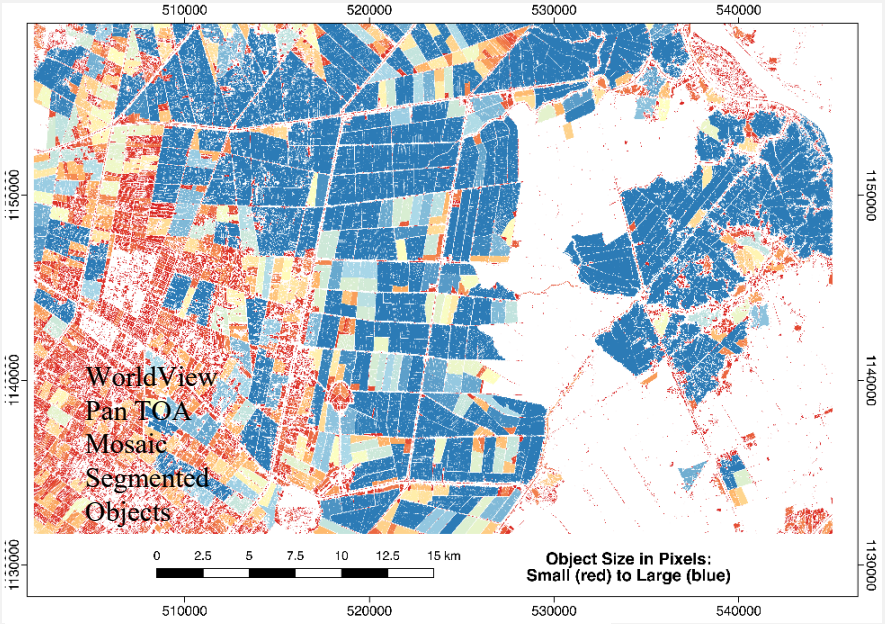


Agricultural fields (mostly sugarcane) in the Chaiyaphum province, Thailand

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

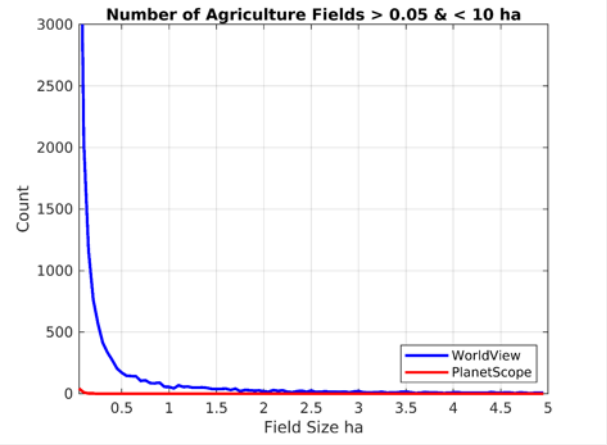
PI: Jessica McCarty (Miami University, Ohio)
Co-I: Chris Neigh (NASA/GSFC), Co-I: Carroll (NASA/GSFC), Thomas (NASA-GSFC/USRA)



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 **<u>have to be resolved near the sub meter scale</u>** to segment individual fields into distinct objects

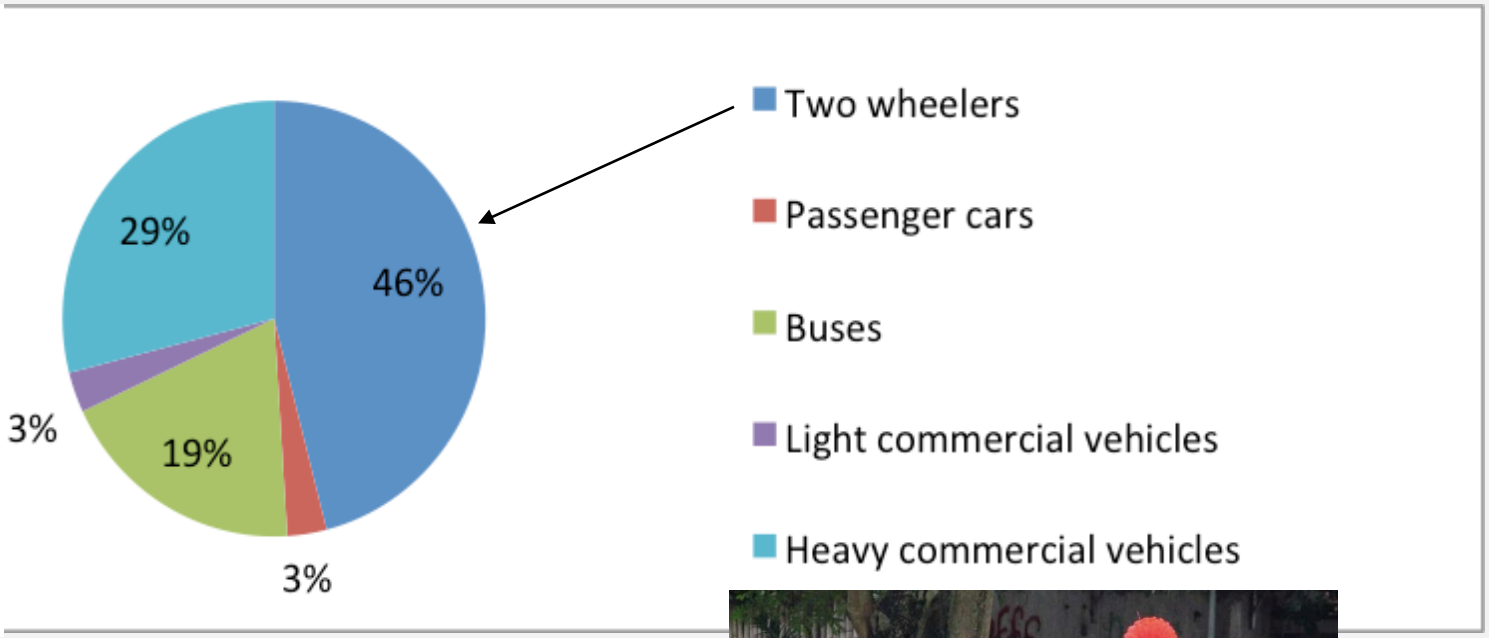


- Derived objects are more robust <u>when combined with Sentinel-1 SAR</u> to estimate cropping intensity
- Due to persistent clouds the temporal advantage of PlanetScope is severely limited for mapping cropping intensity

Emissions!

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

Source: Clean Air Asia, 2012.



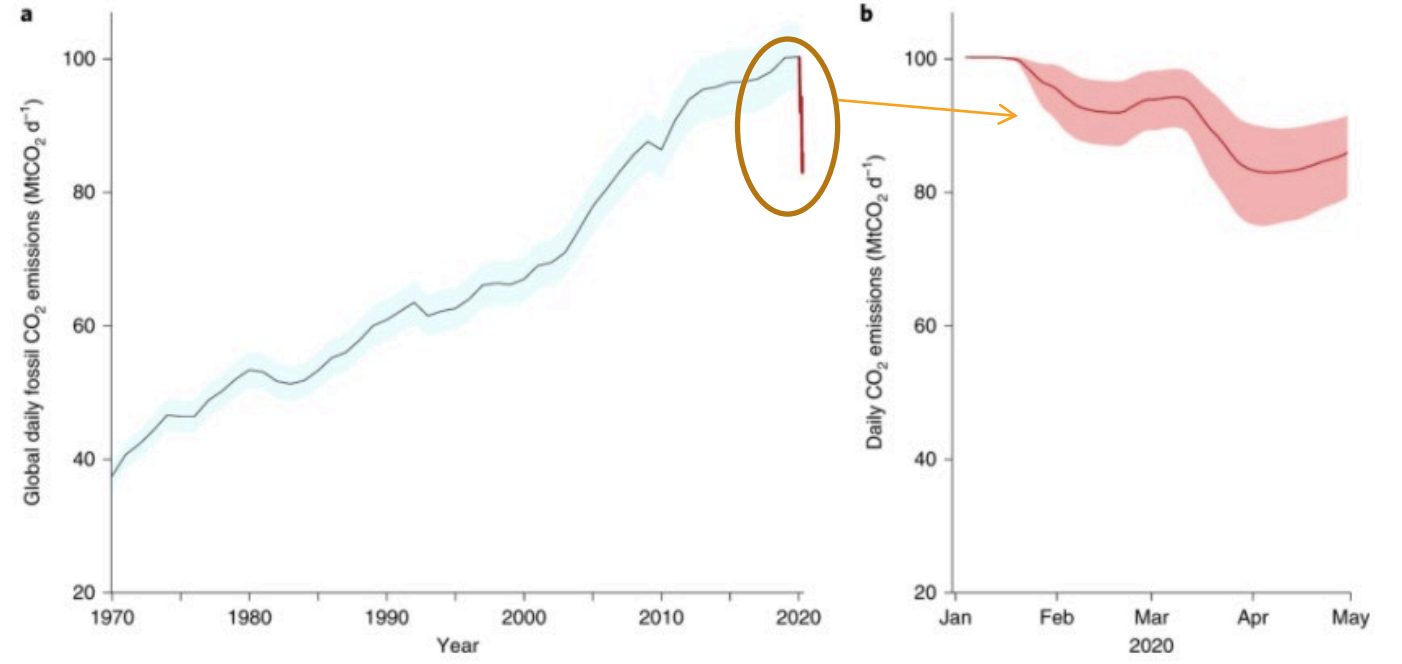
In 2012: **only 6%** of motorcycles were equipped with catalyst exhaust control devices and about 35% did not comply with any European environmental standards.

MOTORCYCLES IN VIETNAM

COVID-19 IMPACT ON CO_2 EMISSIONS DATA FROM GLOBAL CARBON PROJECT

Fig. 3: Global daily fossil CO_2 emissions ($MtCO_2\ d^{-1}$).

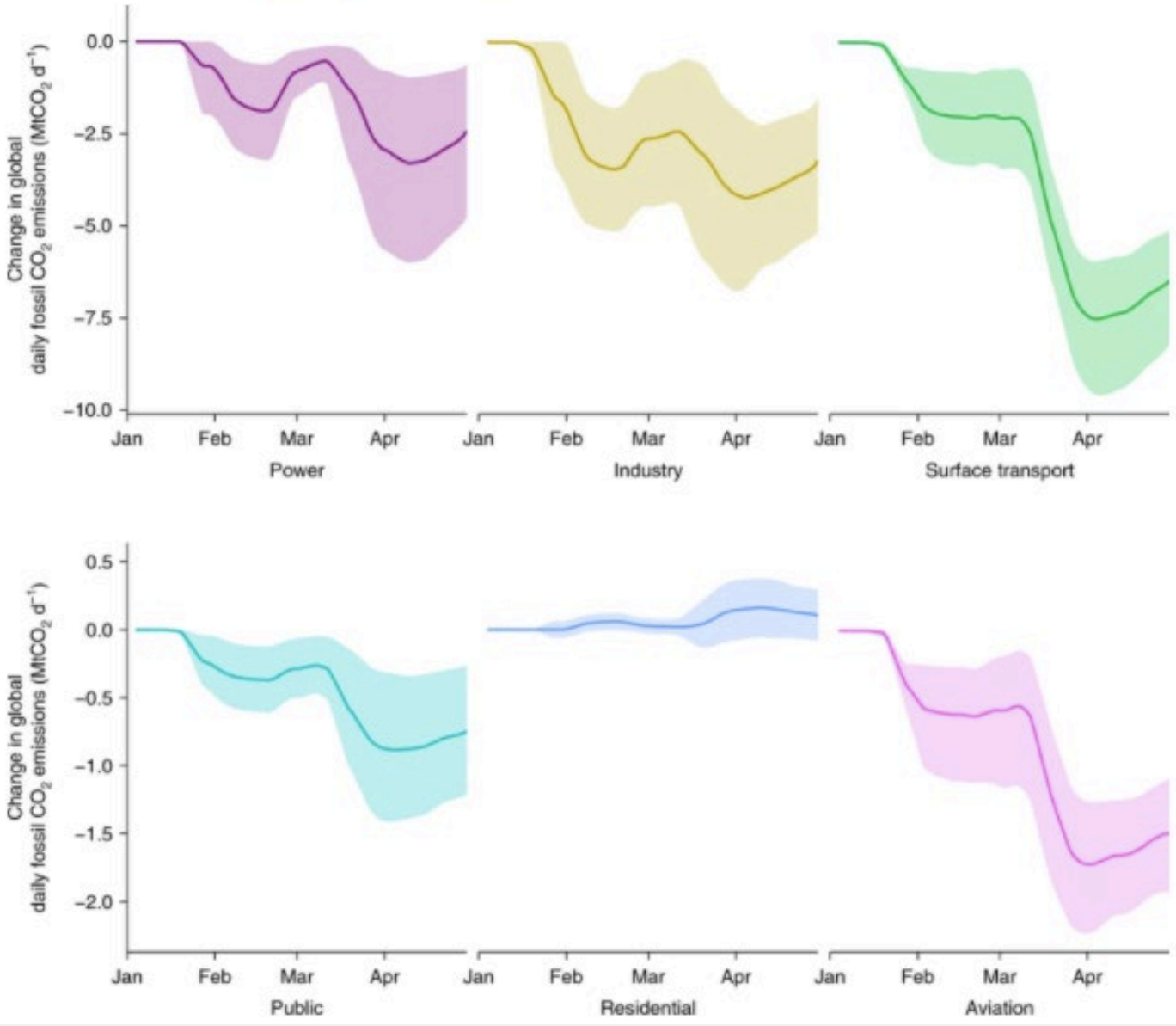
From: Temporary reduction in daily global CO_2 emissions during the COVID-19 forced confinement



Le Quéré, C., Jackson, R.B., Jones, M.W. *et al.* Temporary reduction in daily global CO_2 emissions during the COVID-19 forced confinement. *Nat. Clim. Chang.* **10,** 647–653 (2020).

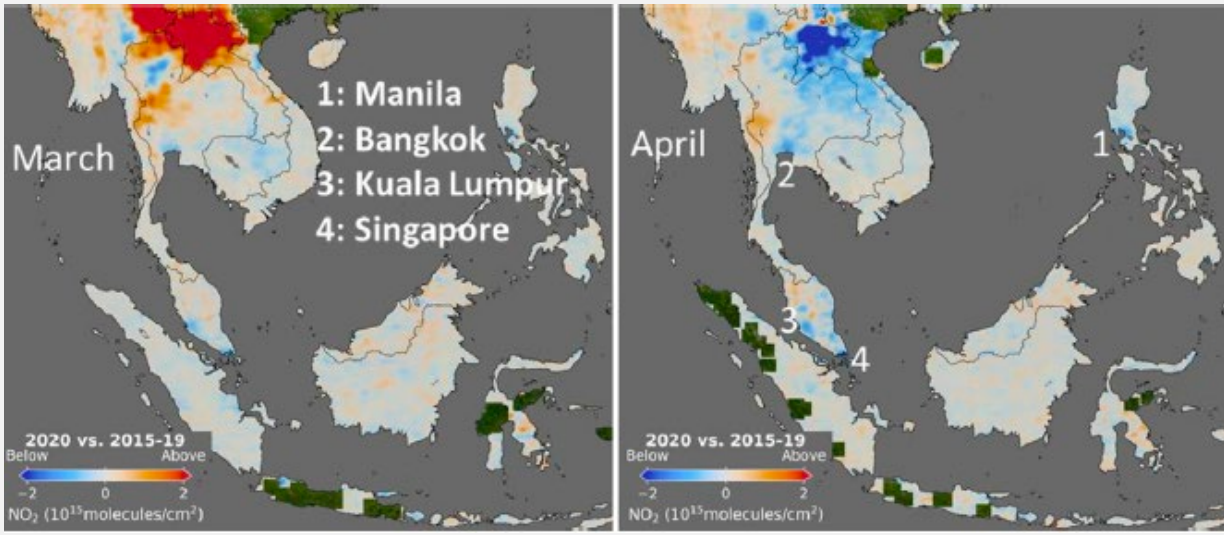
Fig. 4: Change in global daily fossil CO_2 emissions by sector ($MtCO2\ d^{-1}$).

From: Temporary reduction in daily global CO_2 emissions during the COVID-19 forced confinement



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

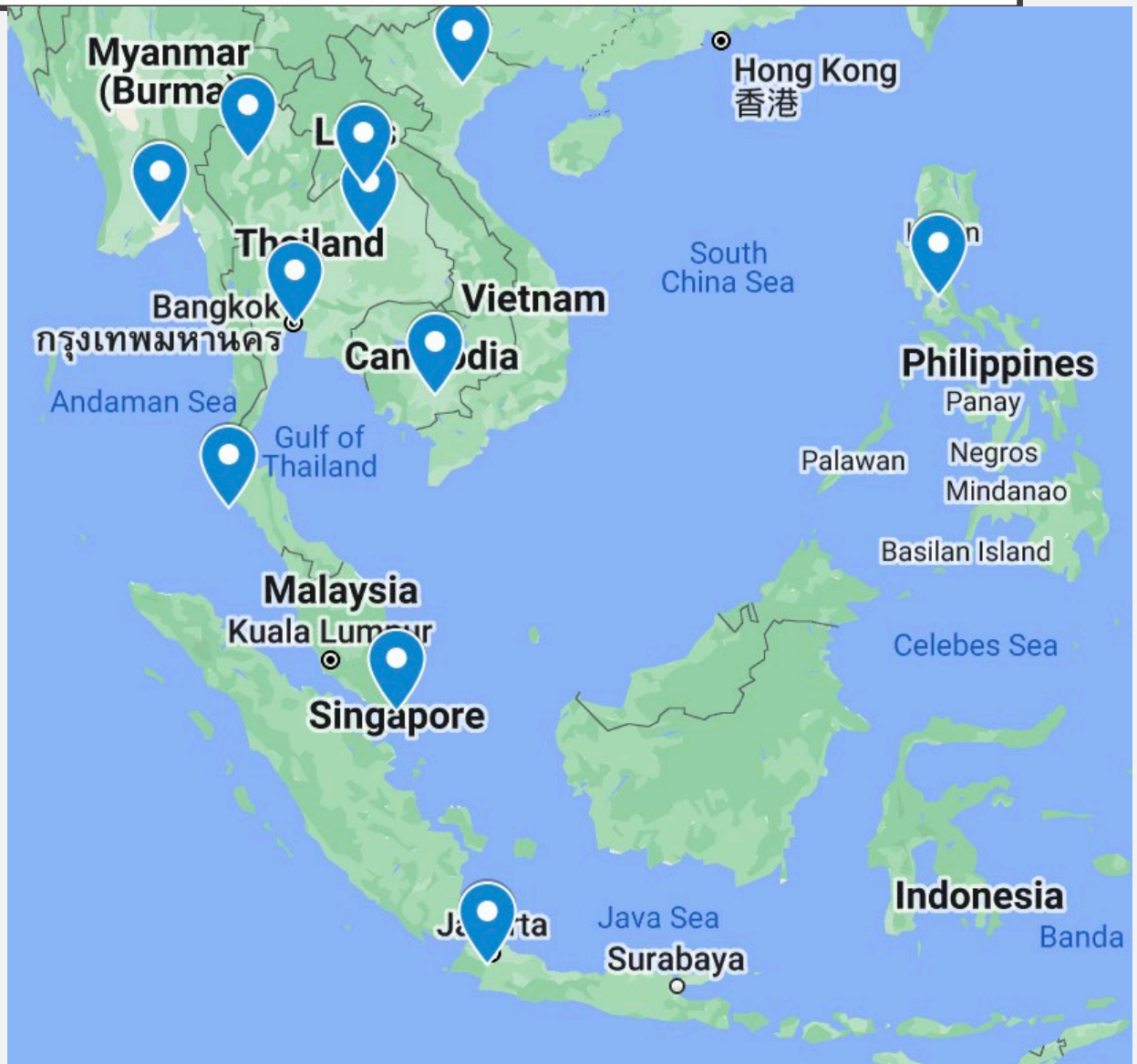
LCLUC REGIONAL WORKSHOPS AND TRAININGS IN SOUTHEAST ASIA

- 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

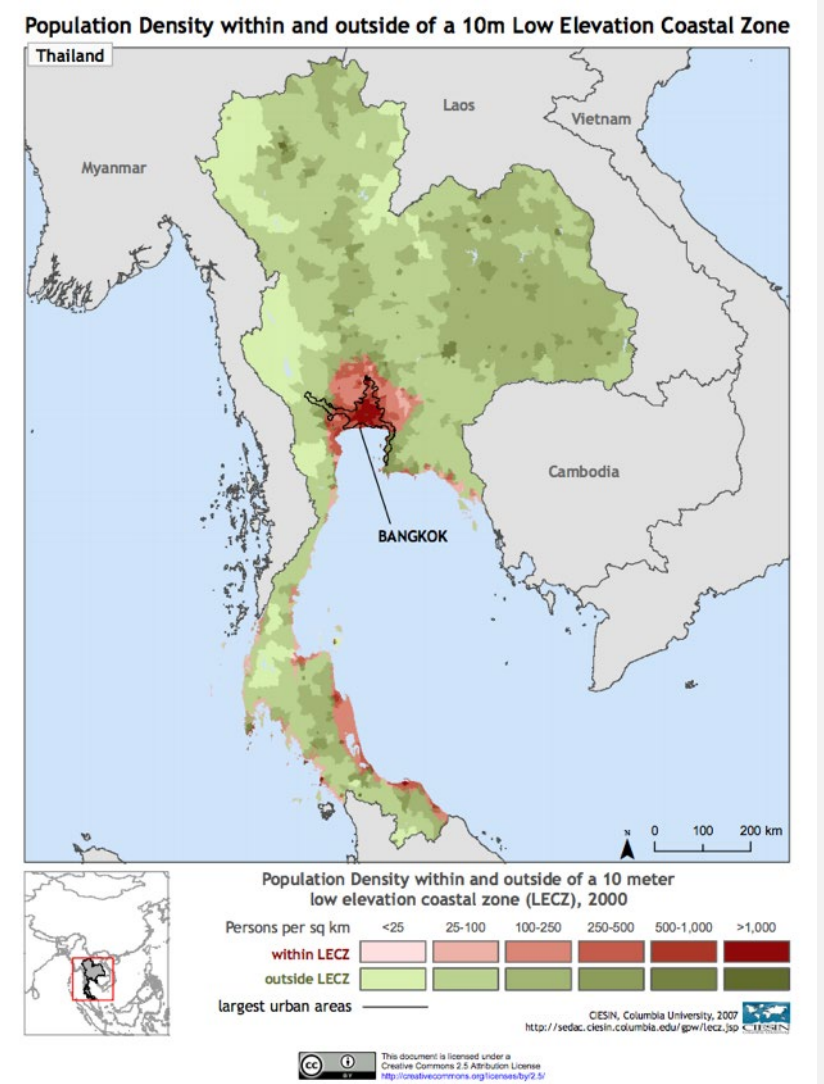
Aug 2022 Phnom Penh, Cambodia

- *Feb 2023 Sri Lanka?*



COASTAL ZONE ISSUES

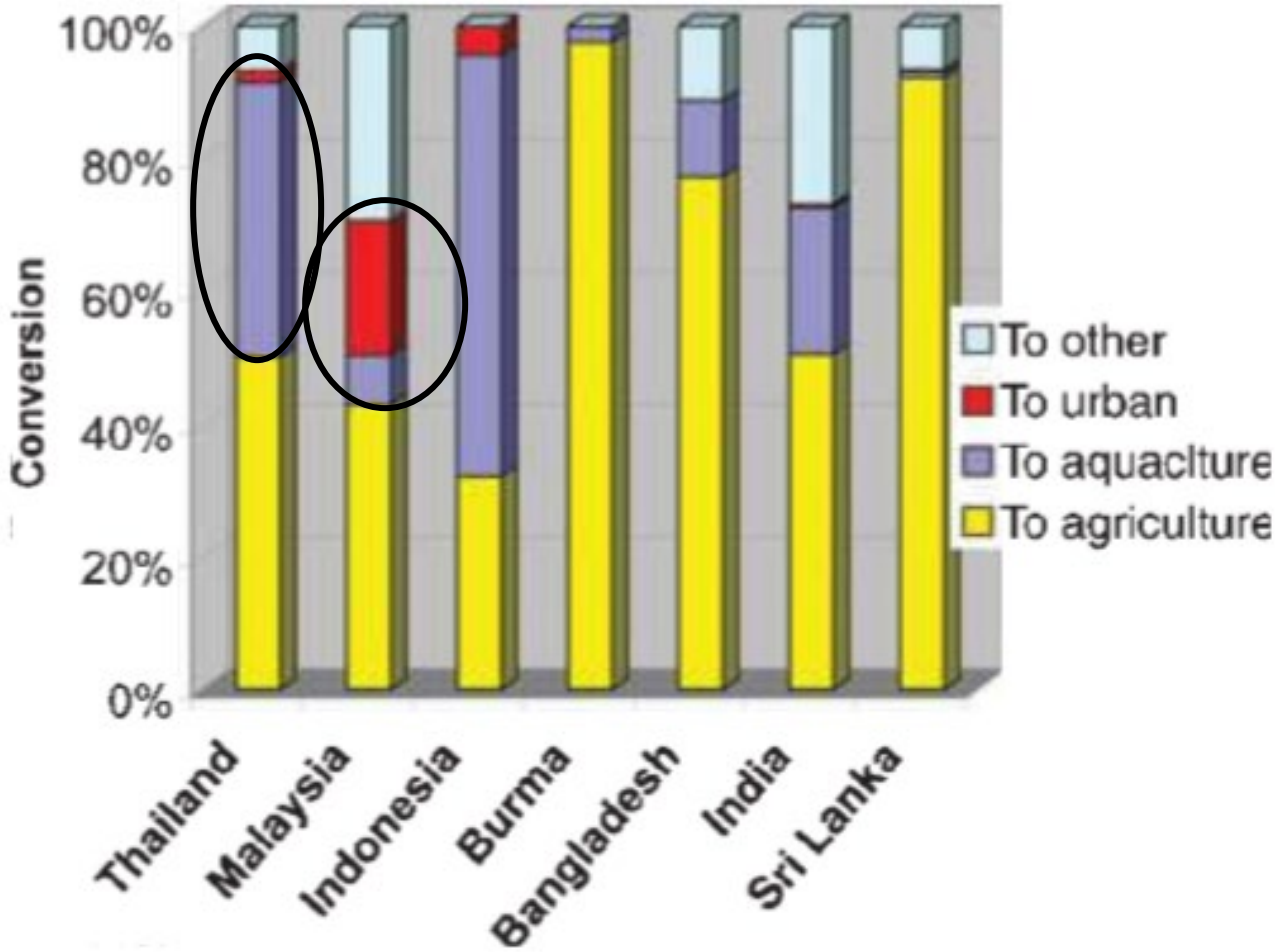
- Presently about 40% of the world's population lives within 100 kilometers of the coast
- As population density and economic activity in the coastal zone increases, pressures on coastal ecosystems increase
- Pollution => declining water quality
- Overfishing
- Unmanaged tourism/vessel traffic
- Indirect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



MANGROVES IN SOUTHEAST ASIA DERIVED FROM LANDSAT DATA

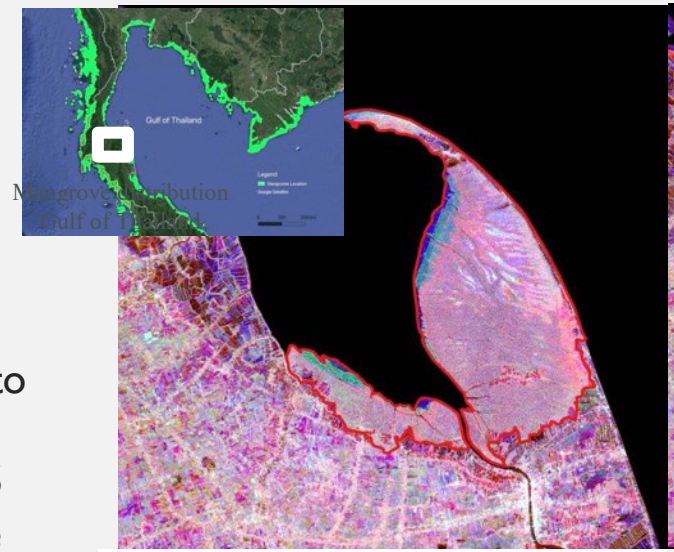
Courtesy of Chandra Giri, EPA (mapped while at USGS)

MAJOR CAUSES OF MANGROVE DESTRUCTION IN SELECT COUNTRIES

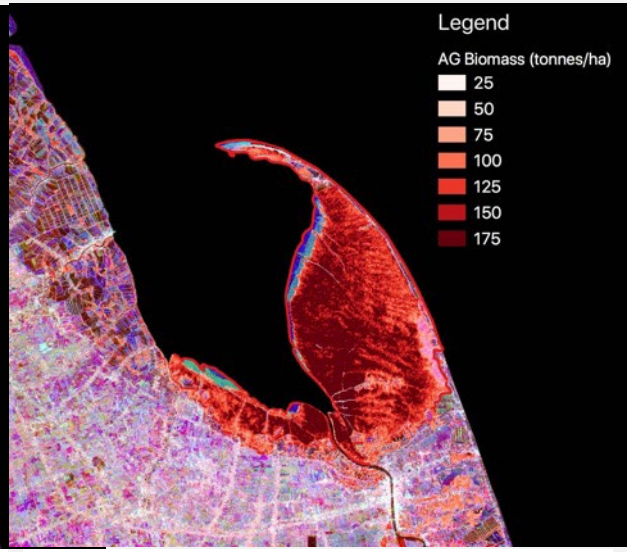


GLOBAL MANGROVE MONITORING WITH RADAR

- 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 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.

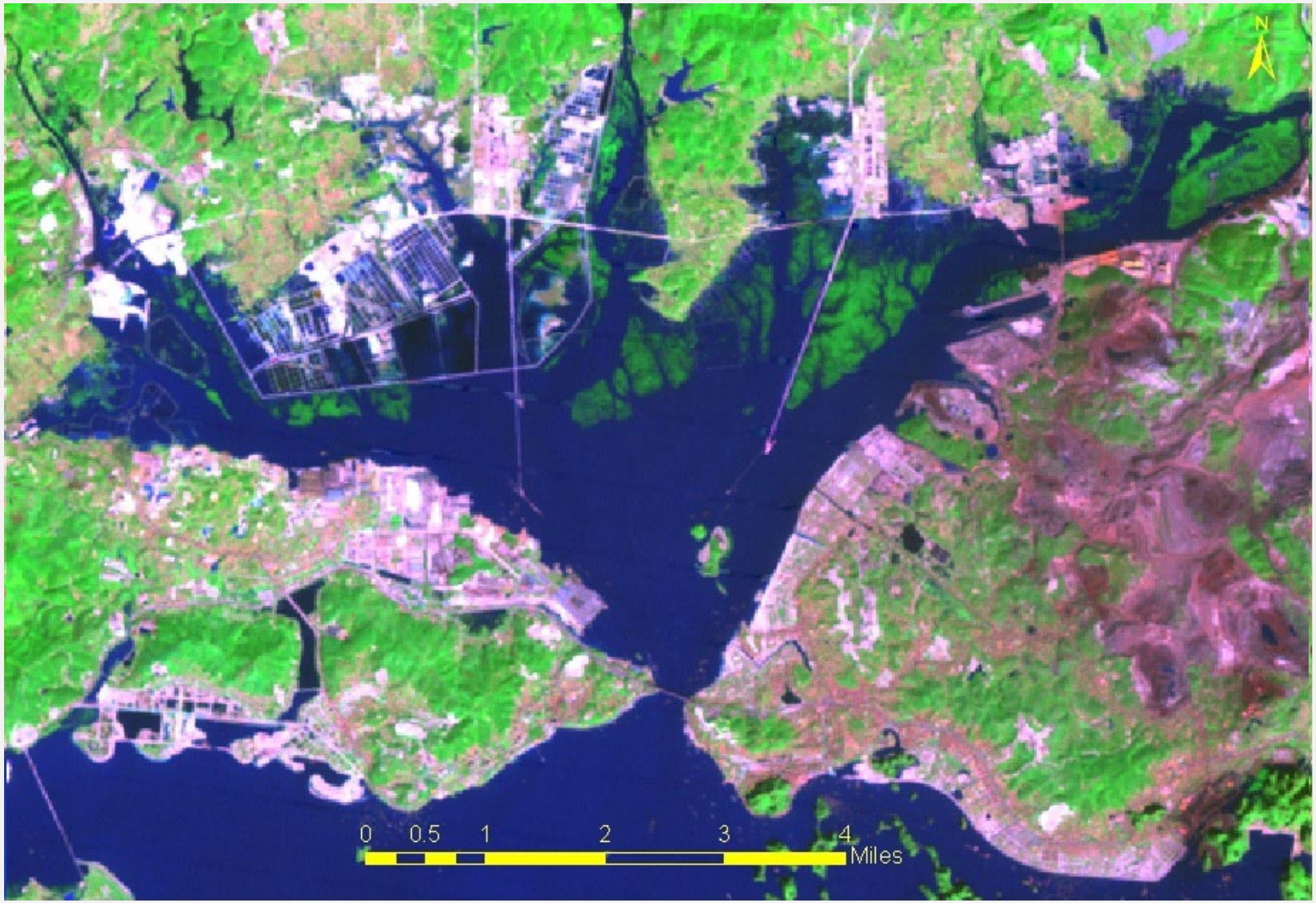


Aboveground biomass measured in 2000 is overlaid on change image.

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.



1990->2001->2009 Courtesy of Chandra Giri (USGS-> EPA)

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

HYACINTH PLANTS AND PLASTIC TRAPPED IN WATER

The invasive plants, which grow at exponential rates, obstruct waterways, clog hydropower plants, and block sunlight from penetrating much below the water's surface.

Good news: water hyacinths can also play an important role in cleaning polluted water. Calculating the amount of nutrients absorbed by the plants in twelve reservoirs, researchers found that the plants soaked up much of the excess nutrients that had polluted the water

Water hyacinths cover many waterways, including the Tonle Sap River in Cambodia, and they also **trap plastics**.

arkoun

Thank you

Special thanks to

- NIES Satellite Observation Center – co-sponsorship
- Royal University of Agriculture, Cambodia - host