An overview of GEDI satellite for forestry resource monitoring

-opportunities and challenges in SE Asia

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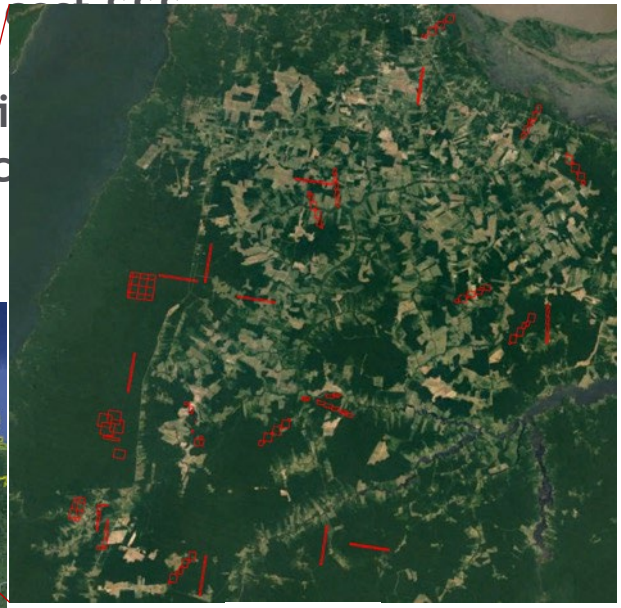
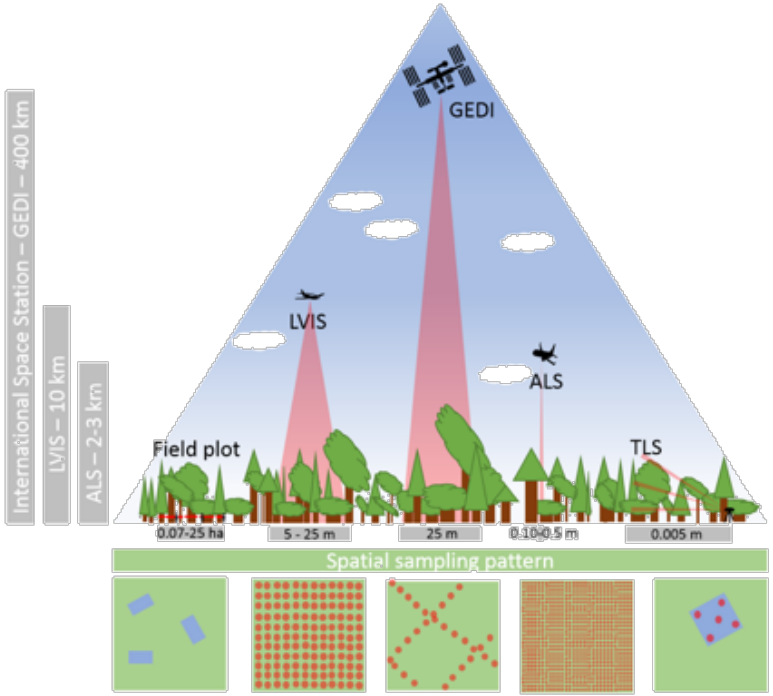
Airborne Lidar

- Prohibitively high cost $$$
  - > $100 per 1km^2
- Operation restricti
- Data access restric

Lidar over Amazon



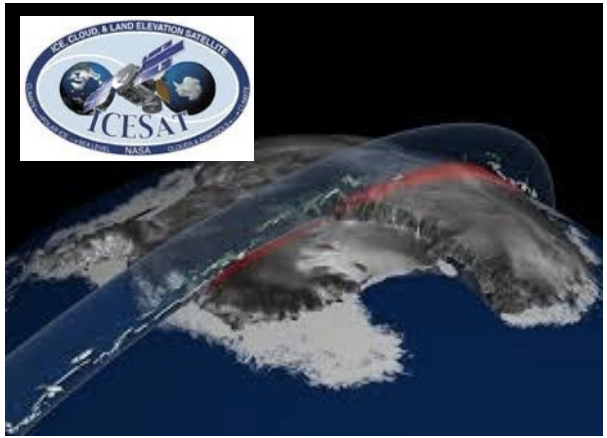
~80 km



GEDI ECOSYSTEM LIDAR

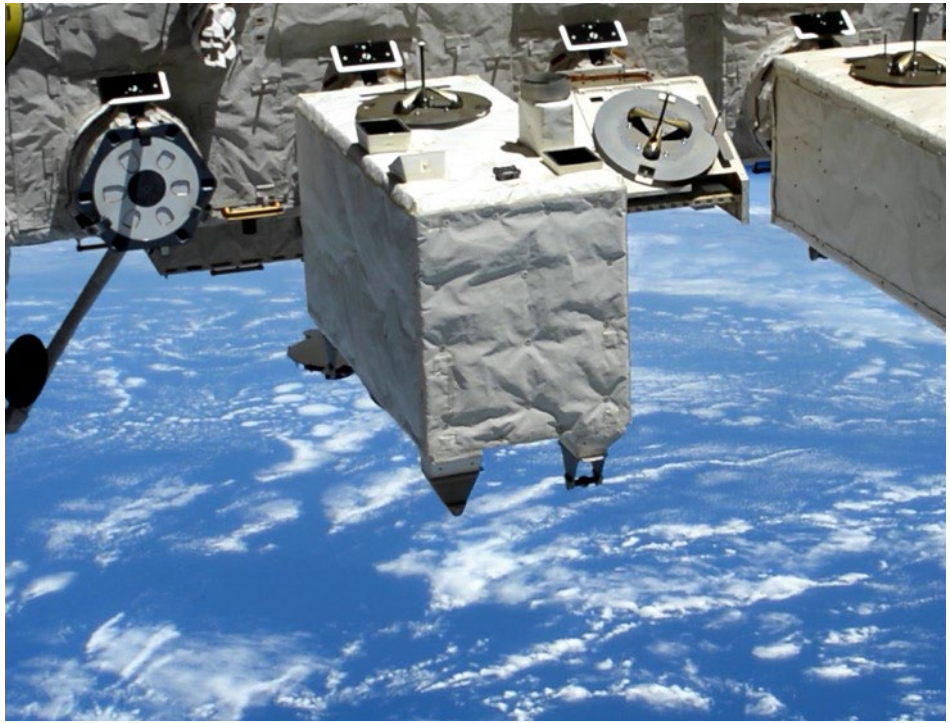
Lidar Satellites

- ICESat-1 (2003~2009) & ICESat-2 (2018~)
- GEDI (2018~) : 1st high-resolution Ecosystem Lidar

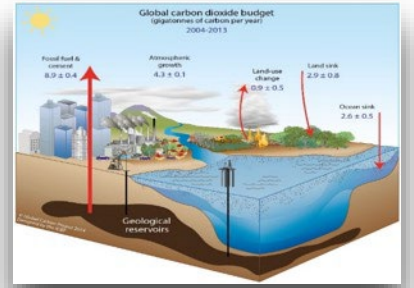


GEDI ECOSYSTEM LIDAR

GEDI: NASA Earth Ventures Instrument (EVI)



GEDI Goal: Advance our ability to characterize the effects of changing climate and land use on ecosystem structure and dynamics



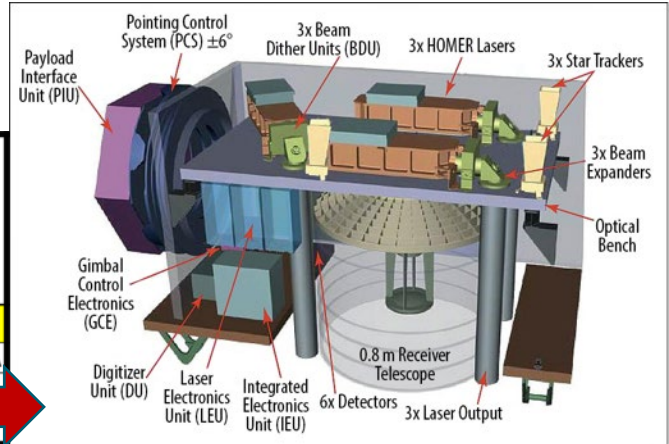
Carbon Cycle

Biodiversity

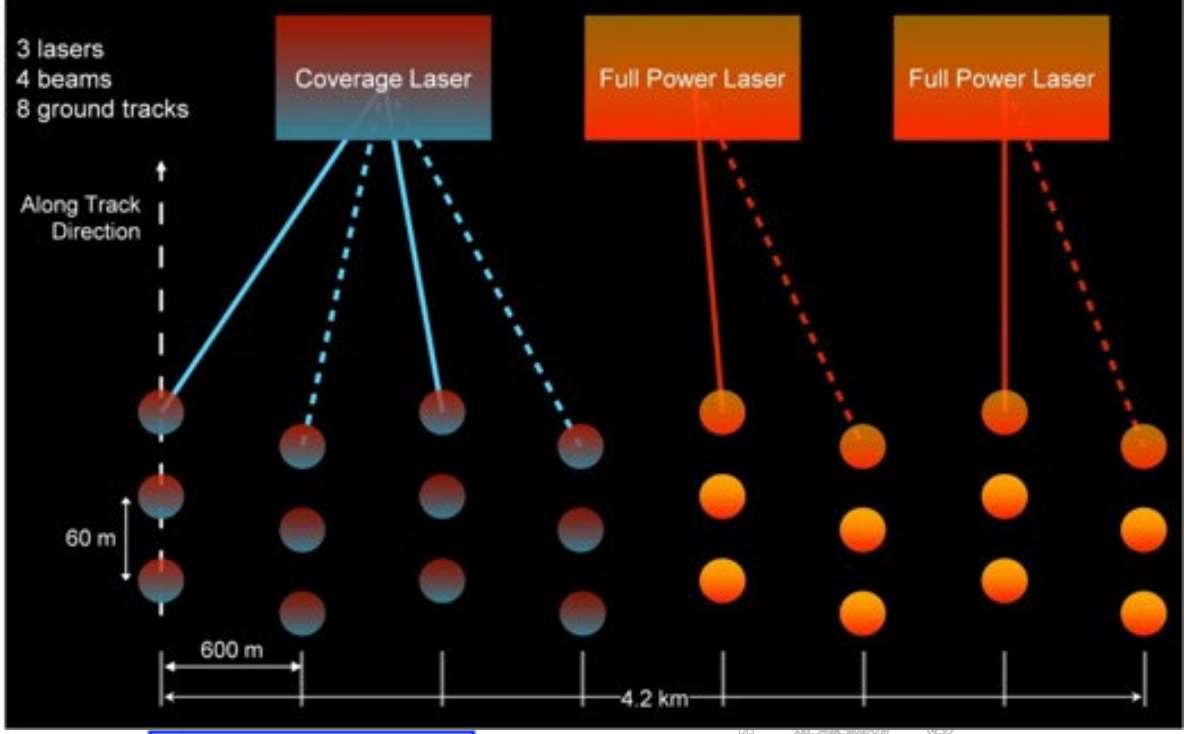
GEDI
ECOSYSTEM LIDAR

Key Mission Milestones

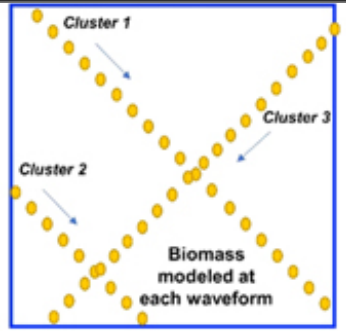
the Dragon capsule's trunk and the ISS's robotic arms



GEDI Fundamenta



Don't Expect GEDI to be "error-free"



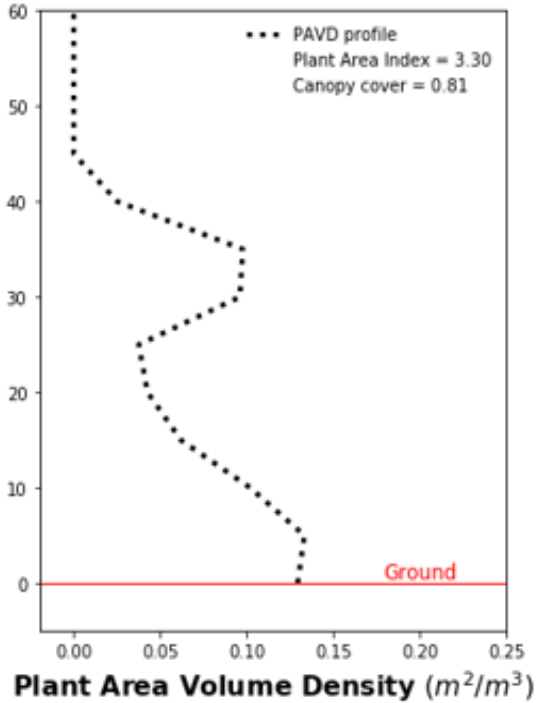
25m Plot

1km Grid

Patterson et al. 2019

GEDI Data Products

Product	Description
GEDI00_B	Level 0B: (not available)
GEDI01_A	Level 1A: (not available)
GEDI01_B	Level 1B: geolocation + waveform
GEDI02_A	Level 2A: Elevation
GEDI02_B	Level 2B: Canopy Cover + LAI
GEDI03	Level 3A: L2 Gridding
GEDI04_A	Level 4A: footprint biomass
GEDI04_B	Level 4B: 1-km biomass map



GEDI ECOSYSTEM LIDAR

GEDI L1 Mission Requirement

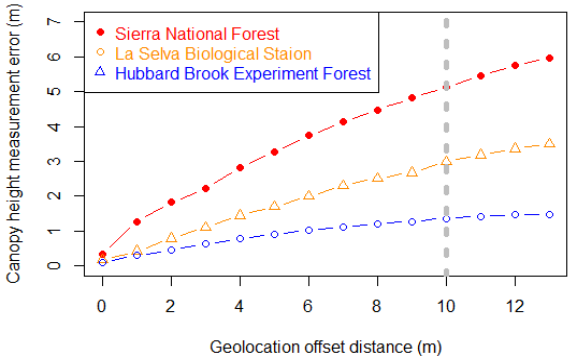
- Acquire lidar canopy vertical profile data required to estimate AGBD for the Earth's global tropical and temperate forests at ≤ 1 km resolution. At the end of a two-year mission, AGBD of at least 80% of the 1 km cells shall be estimated with a precision (standard error) of the larger of ±20 MgC/ha or 20% of the estimate

- This requirement is built upon
  - Mission operation -> data quantity and spatial distribution
  - Instantaneous acquisition and preprocessing -> input quality
  - Biomass model development

GEDI ECOSYSTEM LIDAR

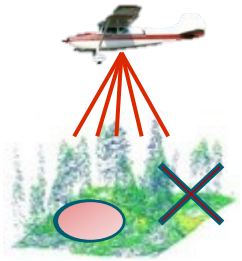
GEDI L4 Biomass Model Development

- Aboveground biomass=f(height)
- Issues
  - Geolocation error
  - Timely product delivery

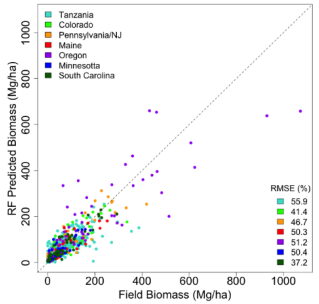


- GEDI Simulator

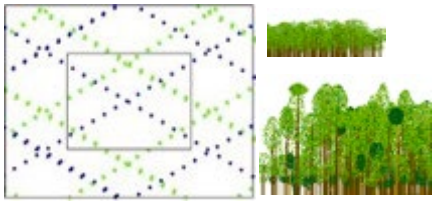
Field + airborne lidar



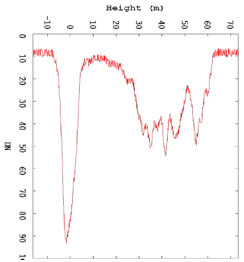
Model



Uncertainty



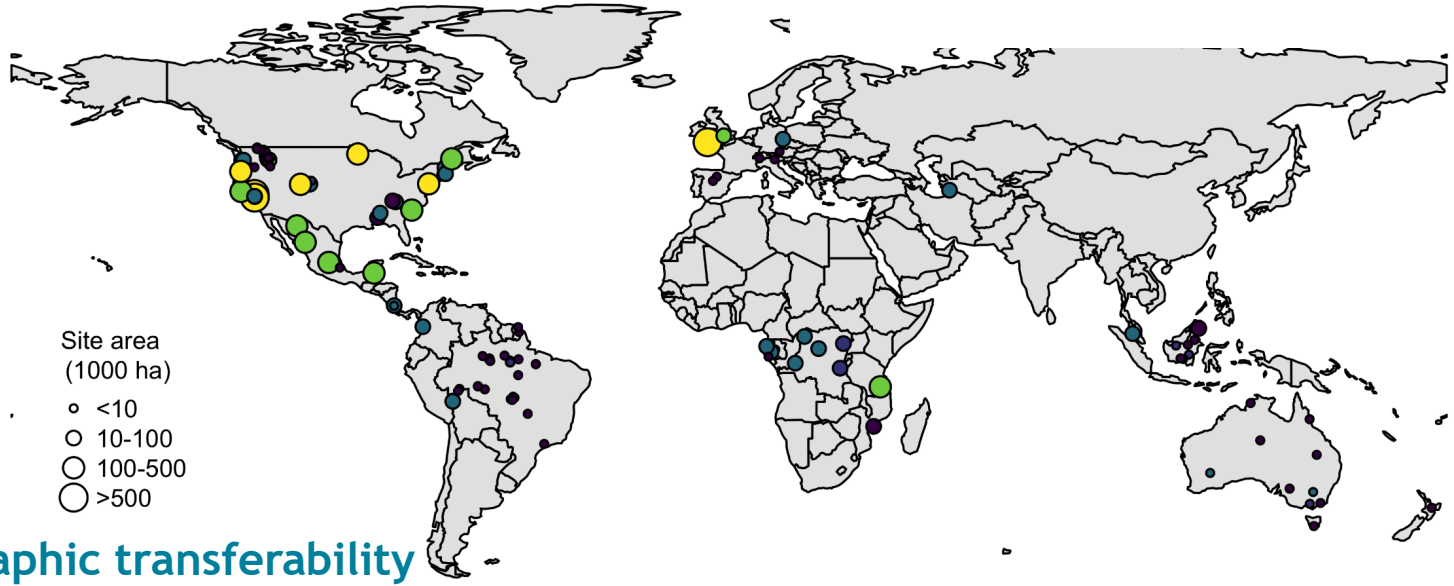
GEDI simulations



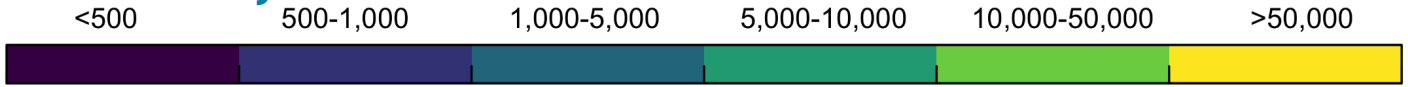
GEDI parameters

- RH Metrics
- Canopy cover
- Waveform shape
- Leading/trailing edge

GEDI Forest Structural and Biomass Database



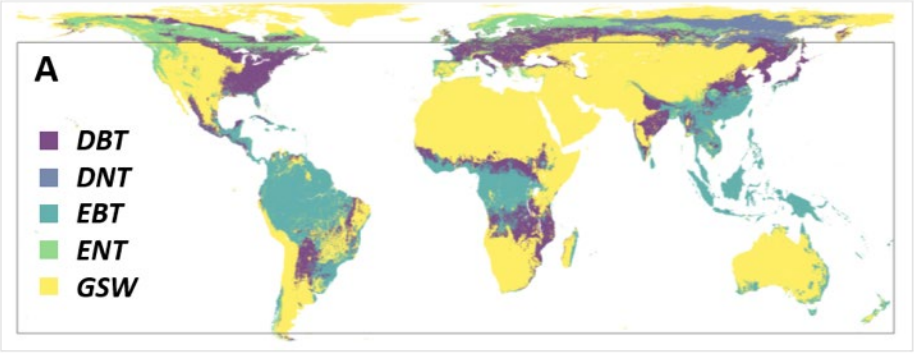
- Geographic transferability
- Model transferability

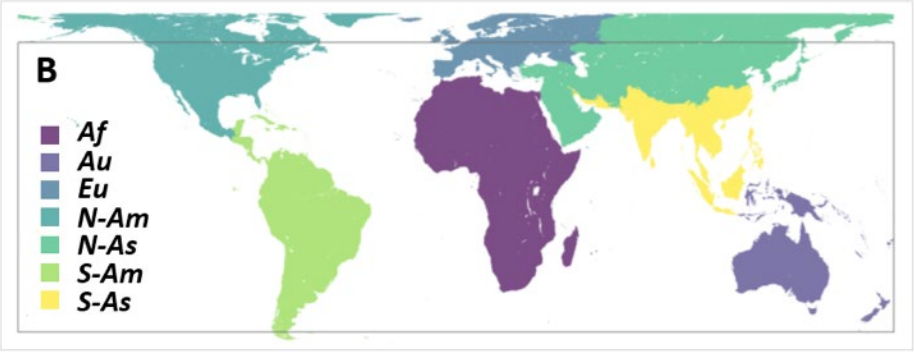


GEDI footprints have been collocated with ALS data across a wide range of conditions

GEDI ECOSYSTEM LIDAR

GEDI L4A Biomass Stratification Scheme



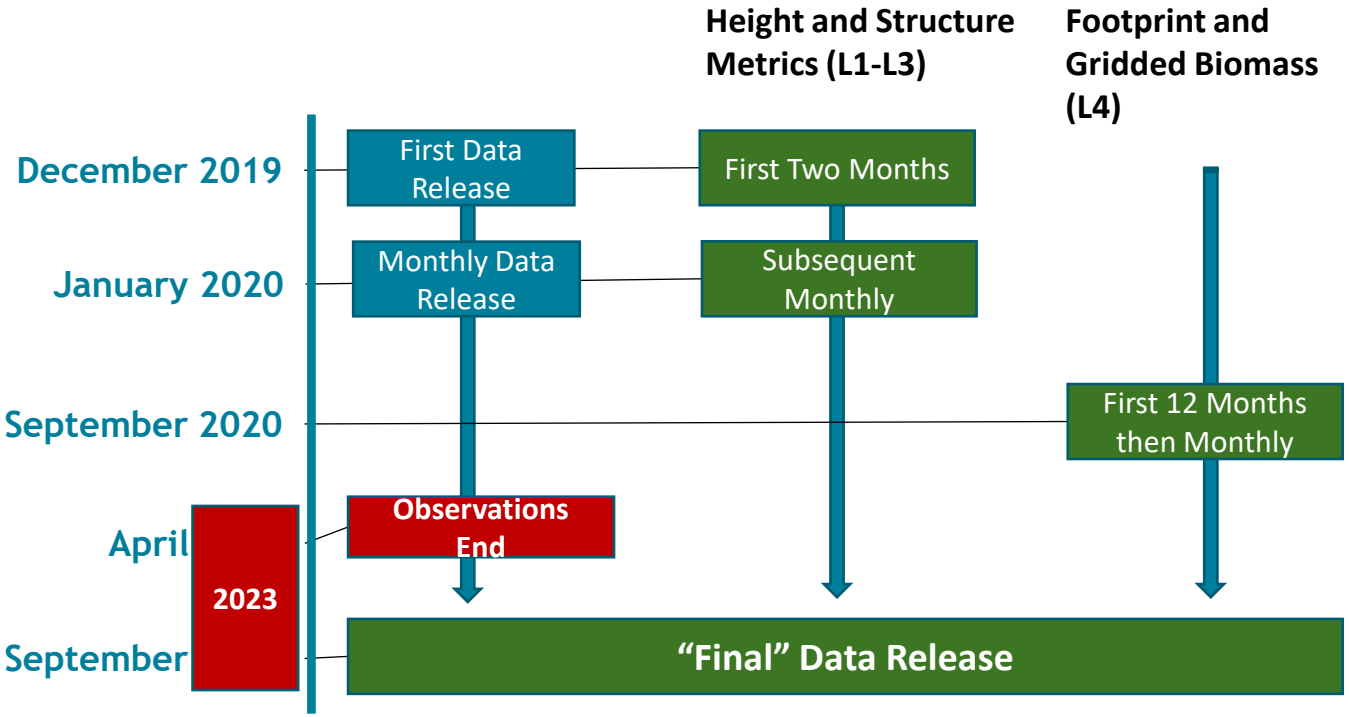


	DBT	DNT	EBT	ENT	GSW	Total
Africa	490	0	834	0	6	1,330
Australia and Oceania	0	0	213	142	65	420
Europe	333	0	0	417	0	750
North America	873	0	0	1,391	18	2,282
North Asia	2	0	0	36	0	38
South America	0	0	3,441	0	0	3,441
South Asia	0	0	326	0	0	326
Total	1,698	0	4,814	1,986	89	8,587

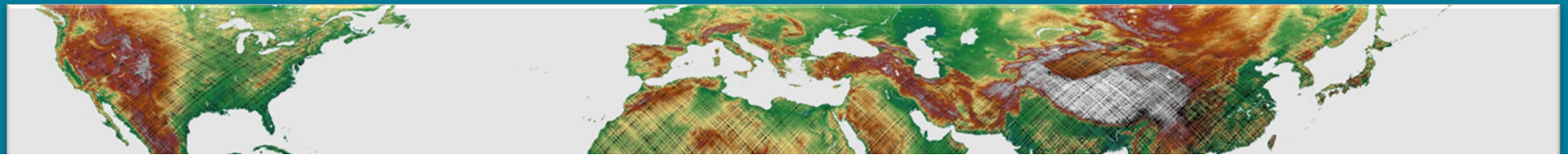
GEDI L4A Footprint Level Aboveground Biomass Density, (Version 1)
https://doi.org/10.3334/ORNLDAAC/1907
Dubayah, R.O., J. Armston, J.R. Kellner, L. Duncanson, S.P. Healey, P.L. Patterson, S. Hancock, H. Tang, M.A. Hofton, J.B. Blair, and S.B. Luthcke. 2021.

GEDI ECOSYSTEM LIDAR

GEDI Mission Timeline

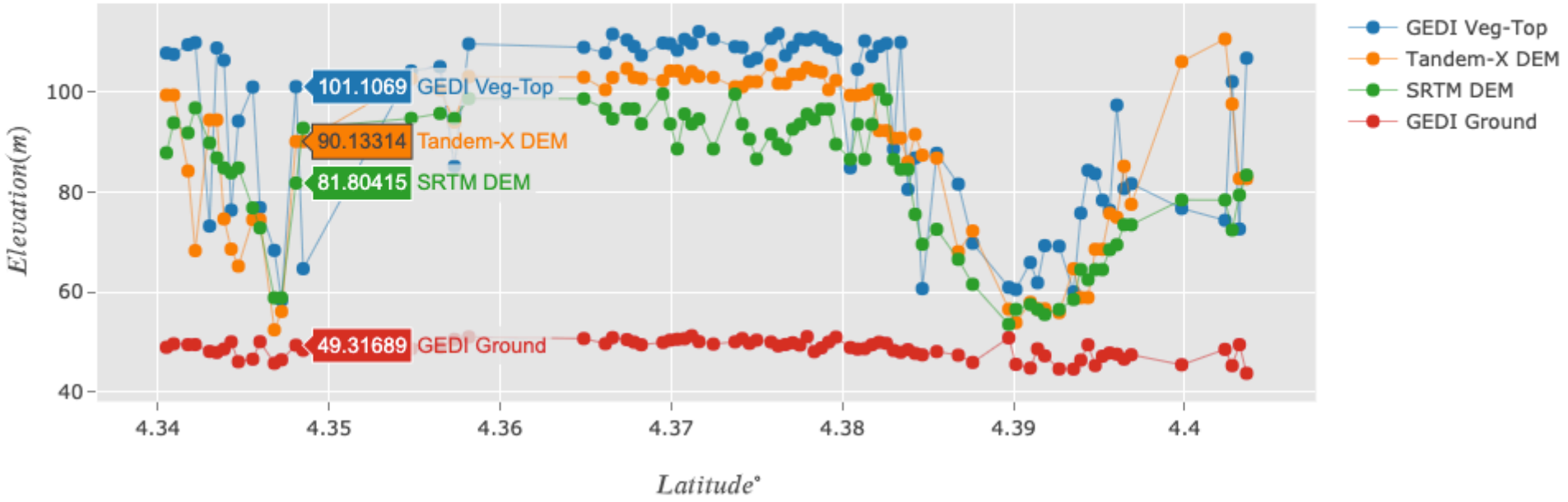


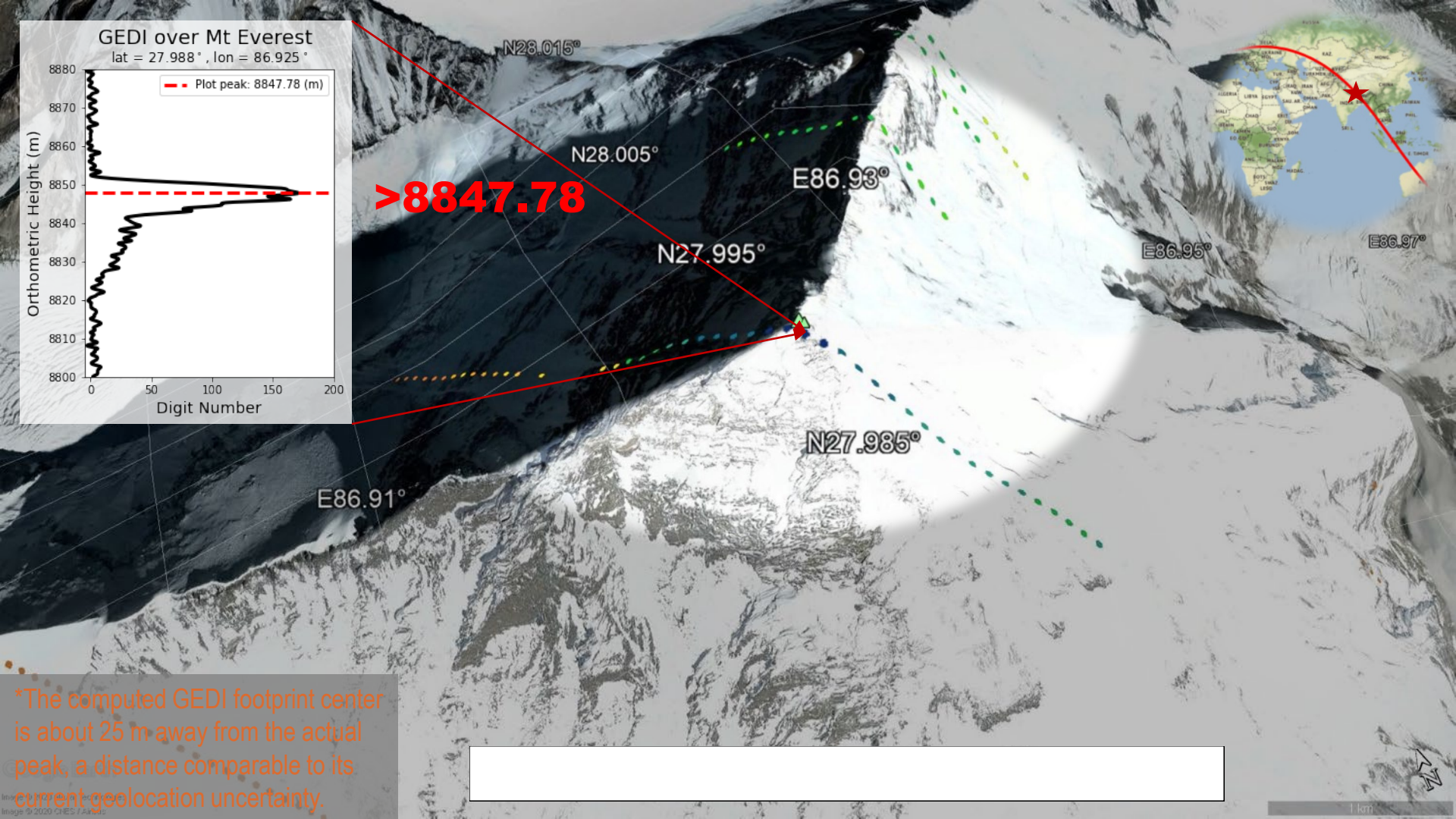
GEDI Bare Earth Elevation



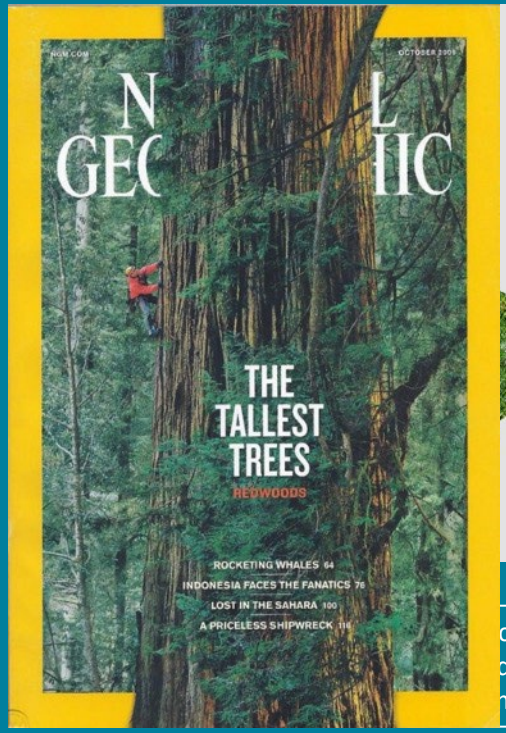
GEDI, Tandem-X, SRTM Elevation Profile (Orbit 9152; BEAM0101)

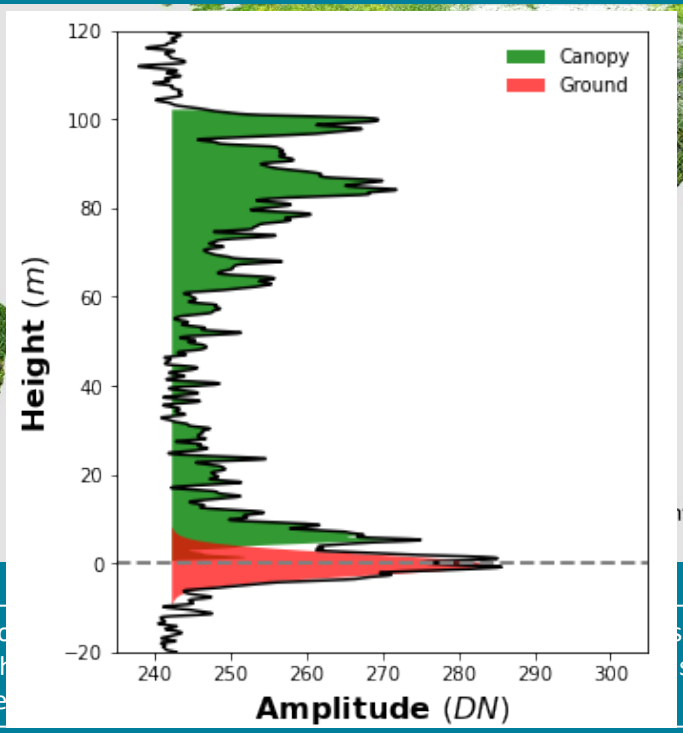
Different elevation products over a Peatland forest in Brunei

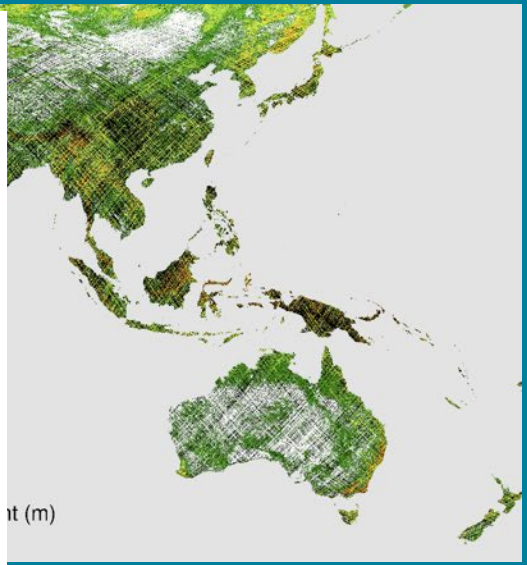



GEDI over Mt Everest
lat = 27.988°, lon = 86.925°
Plot peak: 8847.78 (m)
Orthometric Height (m)
8880
8870
8860
8850
8840
8830
8820
8810
8800
0
50
100
150
200
Digit Number
N28.015°
N28.005°
E86.93°
>8847.78
N27.995°
E86.95°
E86.97°
N27.985°
E86.91°
*The computed GEDI footprint center is about 25 m away from the actual peak, a distance comparable to its current geolocation uncertainty.

GEDI Forest Canopy Height







canc
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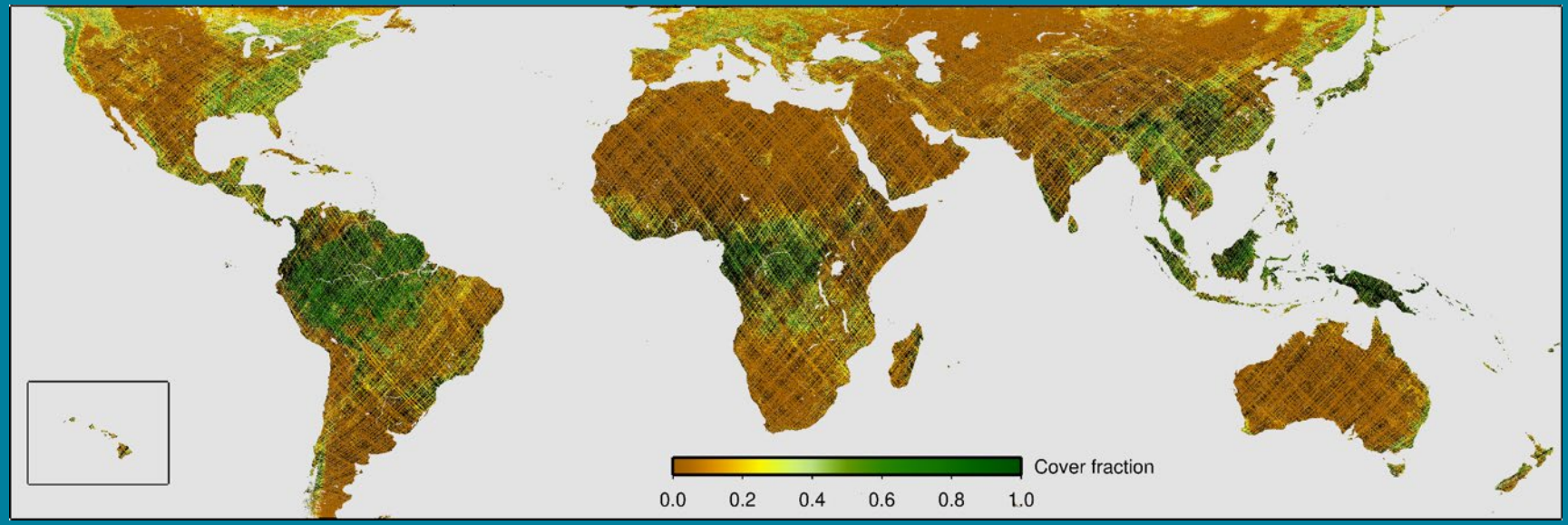
more

s from the Global Ecosystem Dynamics
structure every achieved for the pantropical

GEDI Canopy Cover



ABOUT THE MAP: This is a map of canopy cover derived from 9 months of laser altimeter measurements from the Global Ecosystem Dynamics Investigation (GEDI). Areas with high canopy cover, exceeding 90%, are key conservation targets because their forests sequester carbon dioxide from the atmosphere and provide important habitat that supports species richness and abundance. Lidar is the only technology that can accurately map these areas of high canopy cover. For more information visit GEDI at *gedi.umd.edu*

GEDI ECOSYSTEM LIDAR

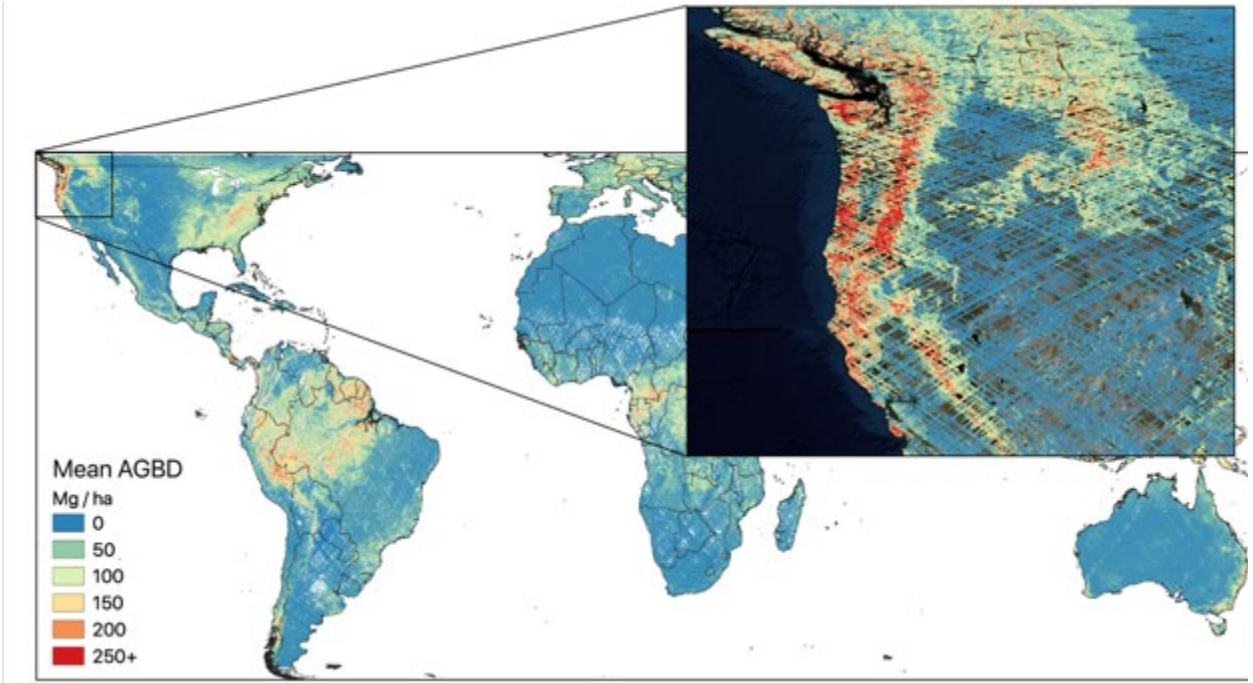
NASA

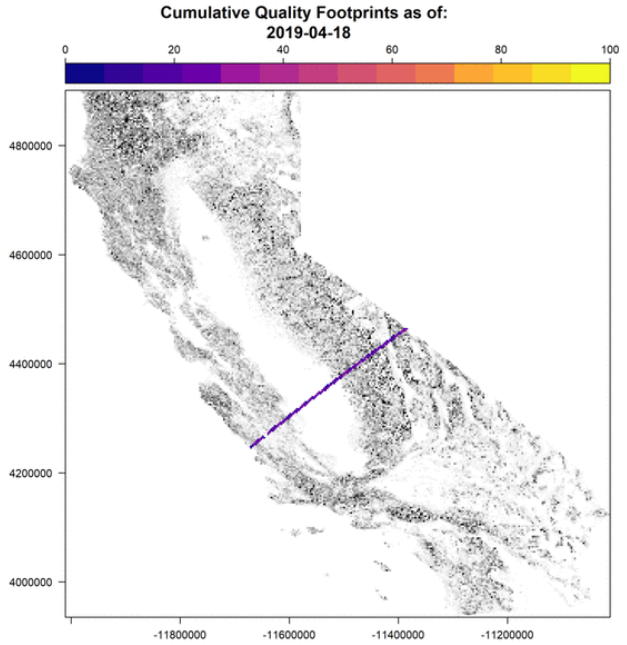
UNIVERSITY OF MARYLAND

GEDI Plant Area Volume Density (PAVD)

GEDI ECOSYSTEM LIDAR

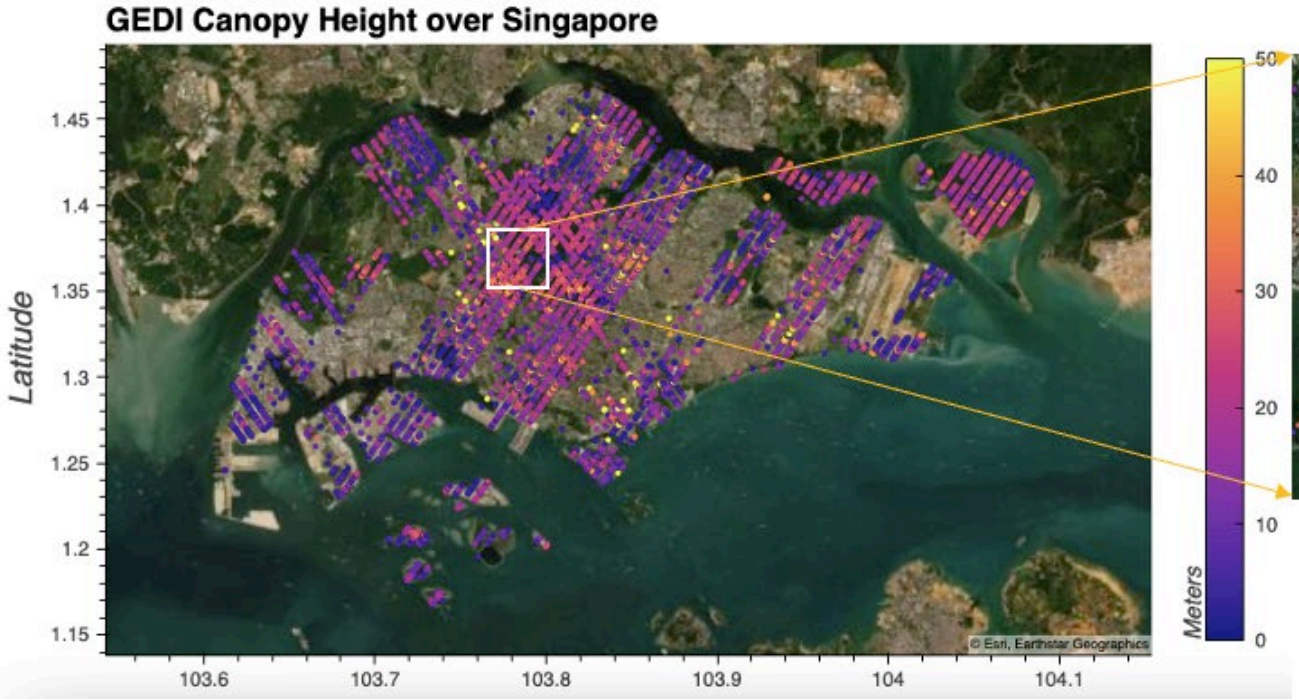
GEDI Aboveground Biomass Density





GEDI
ECOSYSTEM LIDAR

GEDI over Singapore

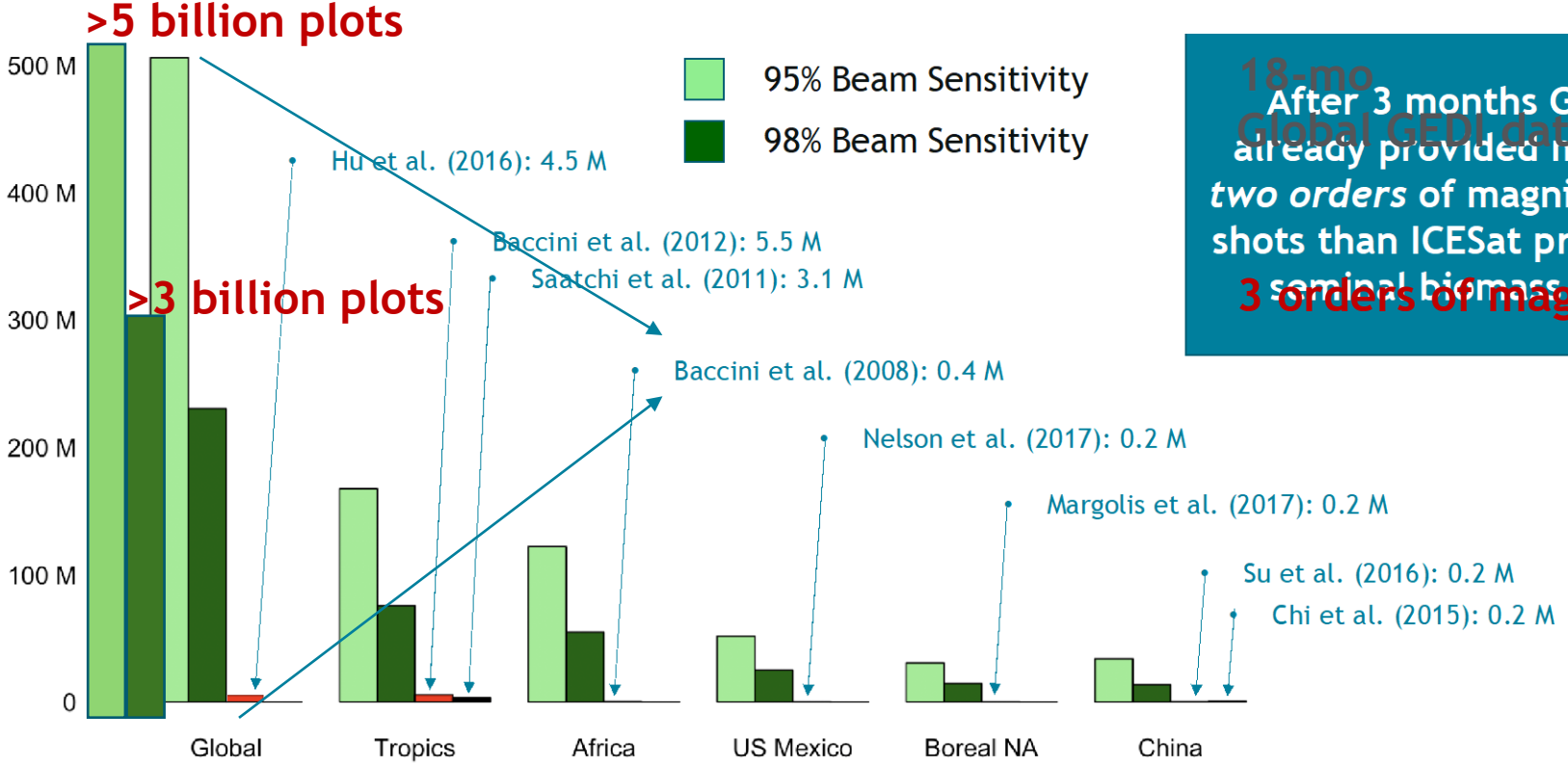


Bukit Timah nature reserve

First 18-mo of GEDI L2A

GEDI ECOSYSTEM LIDAR

GEDI Data Inventory



18-mo Global GEDI data

After 3 months GEDI has already provided more than *two orders* of magnitude more shots than ICESat provided for seminal biomass studies

3 orders of magnitude

GEDI L4A Biomass Performance (TBD)

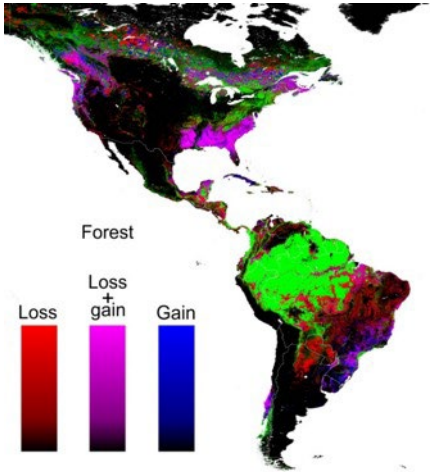
- High quality GEDI signal ≠ accurate biomass estimate
- Biomass in Asia/Southeast Asia shows the largest error in all performance metrics

Region	Plant functional type	R^2	%RMSE*	MRE (Mg/ha)†
Asia/Southeast Asia	Evergreen Broadleaf Trees	0.36	78.94	121.15
Oceania	Grasslands/Shrublands/Woodlands	0.43	44.53	8.7
Africa	Deciduous Broadleaf Trees	0.62	56.88	7.81
Africa	Evergreen Broadleaf Trees	0.64	66.89	15.32
Europe	Deciduous Broadleaf Trees	0.66	47.27	21.52
North America	Deciduous Broadleaf Trees	0.66	38.08	22.81
South America	Evergreen Broadleaf Trees	0.66	42.2	10.4
Europe	Evergreen Needleleaf Trees	0.68	35.02	14.93
North America	Evergreen Needleleaf Trees	0.68	66.44	16.71
*RMSE: Root Mean Square Error				
†MRE: Mean Residual Error				

GEDI ECOSYSTEM LIDAR

GEDI-related Prototype Products

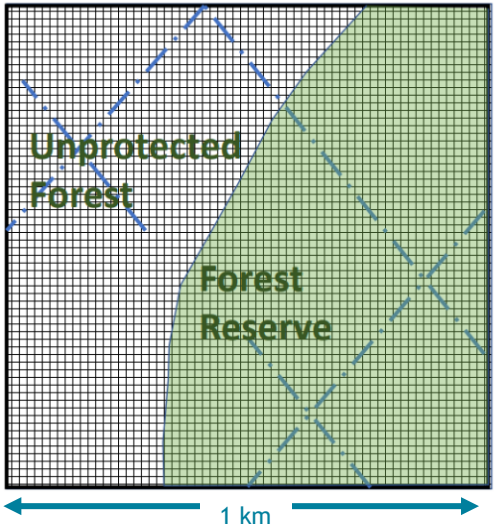
Global Land Analysis & Discovery



Discover the past change

Hansen et al. UMD

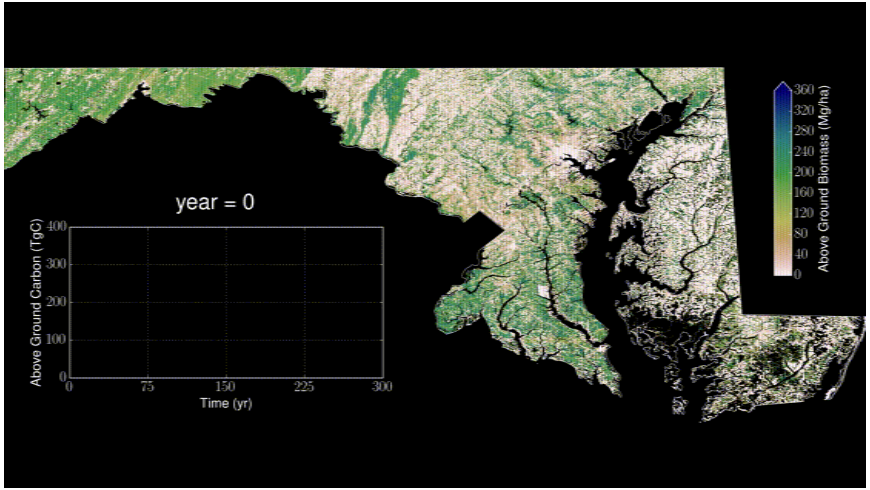
OBI-WAN
Online Biomass Inference using Waveforms And iNventory



Customize current statistical report

Healey et al. US Forest Service

Ecosystem Demography model

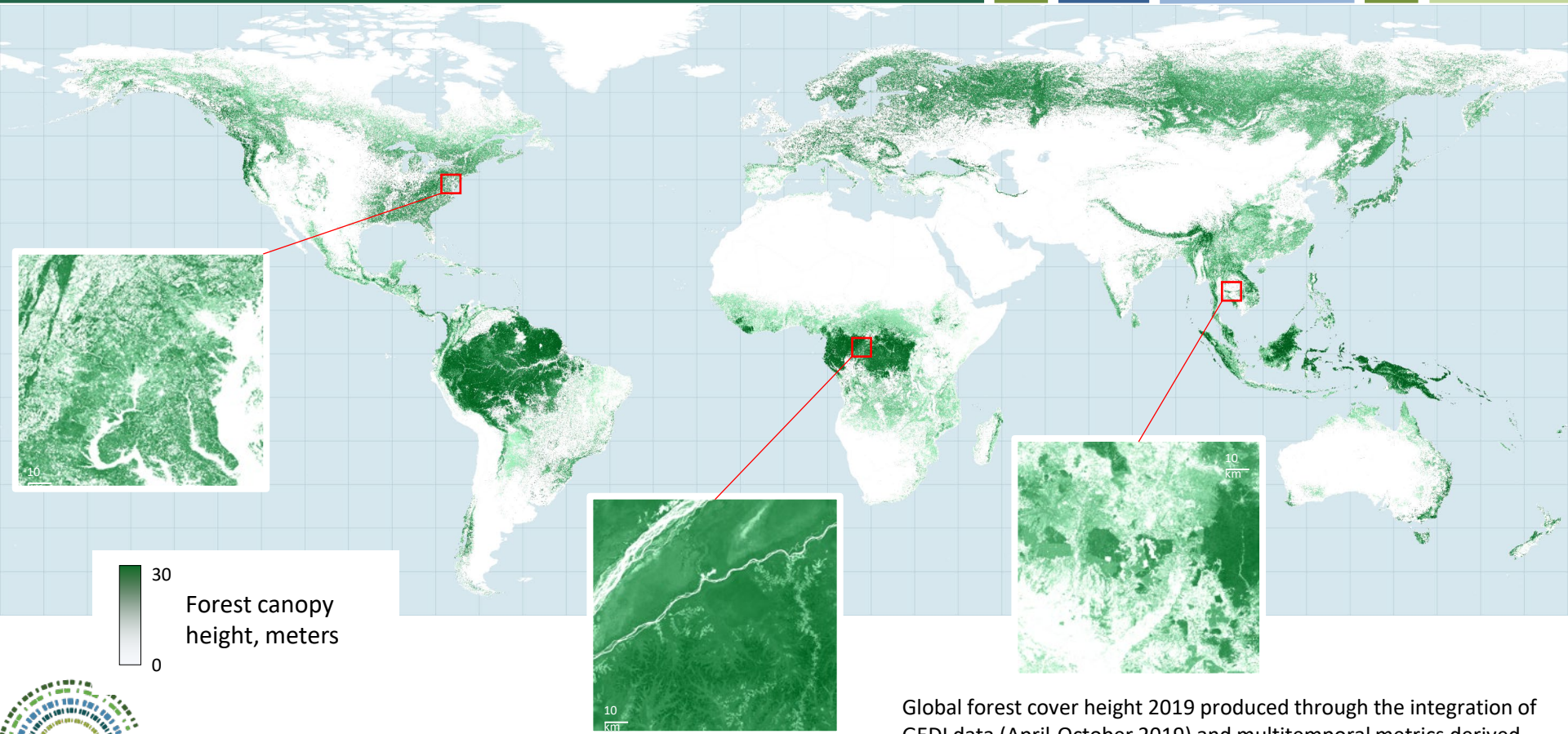


Predict future carbon sequestration

G Hurtt et al. UMD

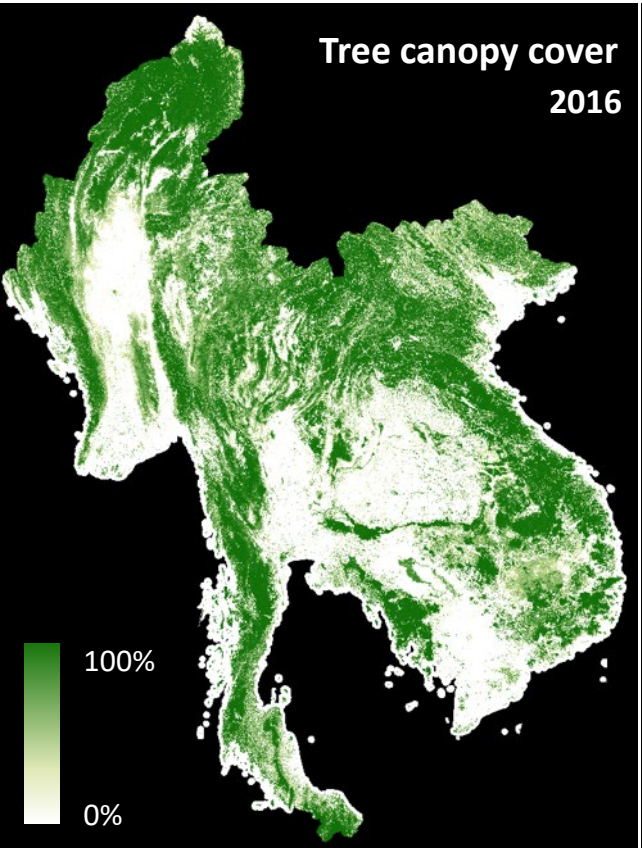
GEDI ECOSYSTEM LIDAR

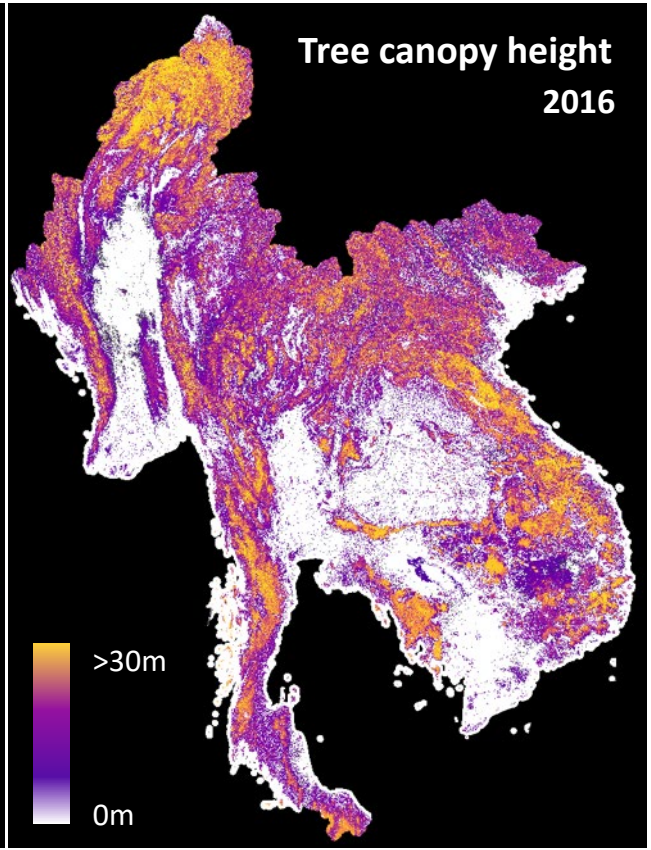
GEDI and Landsat Integration for Forest Height Mapping

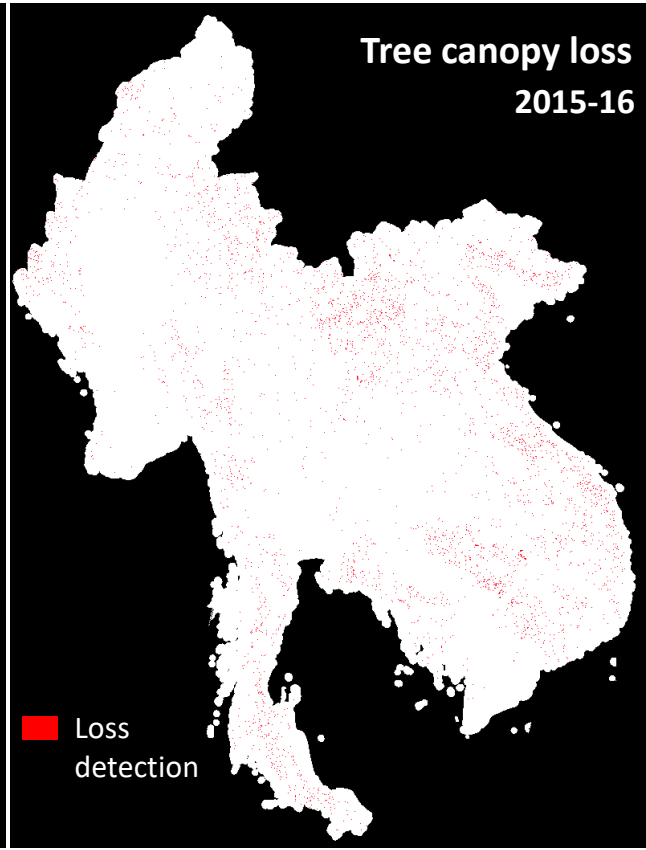


Global forest cover height 2019 produced through the integration of GEDI data (April-October 2019) and multitemporal metrics derived from Landsat GLAD ARD. *(Potapov et al., RSE, 2020)*

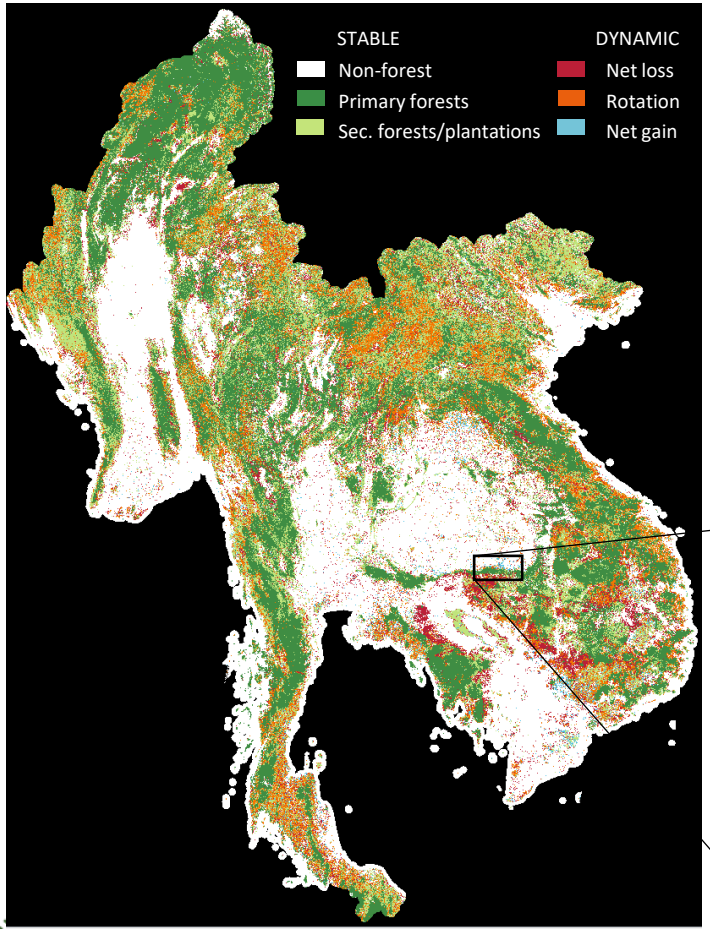
GLAD GLOBAL LAND ANALYSIS & DISCOVERY



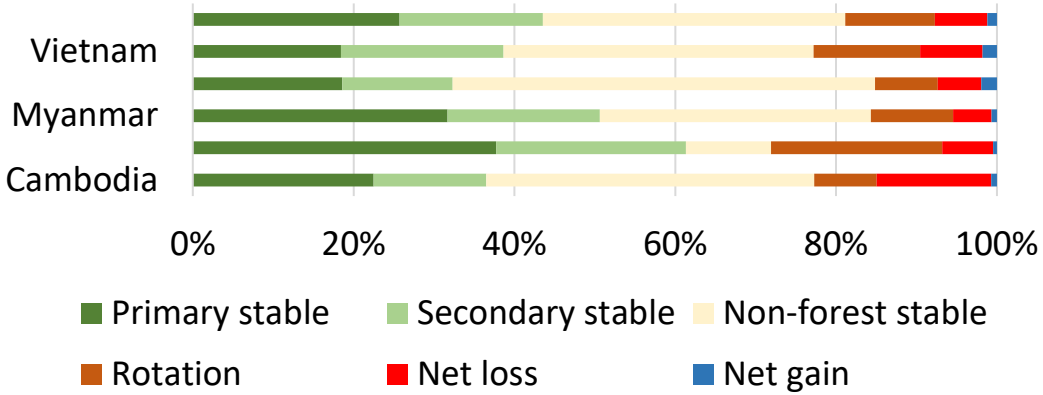


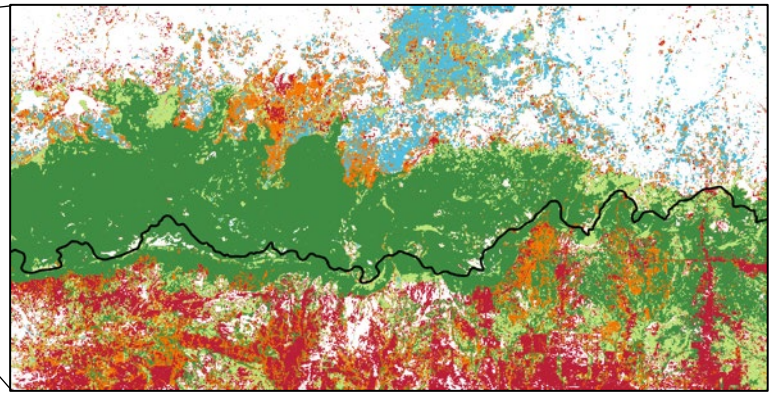


GLAD
GLOBAL LAND
ANALYSIS & DISCOVERY



Tree cover dynamic types, 2015

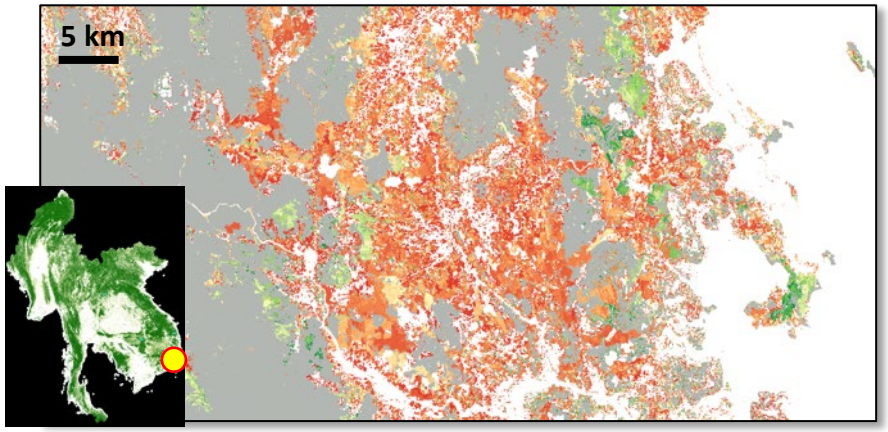




Thailand

Cambodia

GLAD
GLOBAL LAND ANALYSIS & DISCOVERY

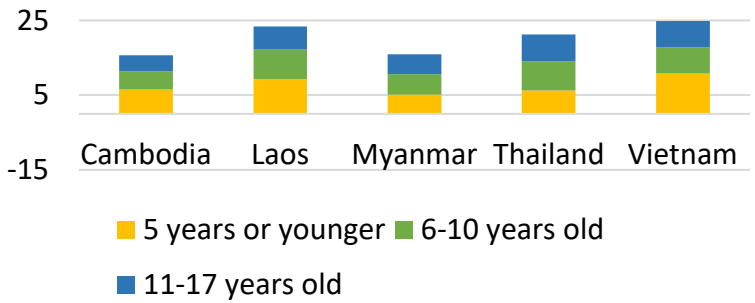


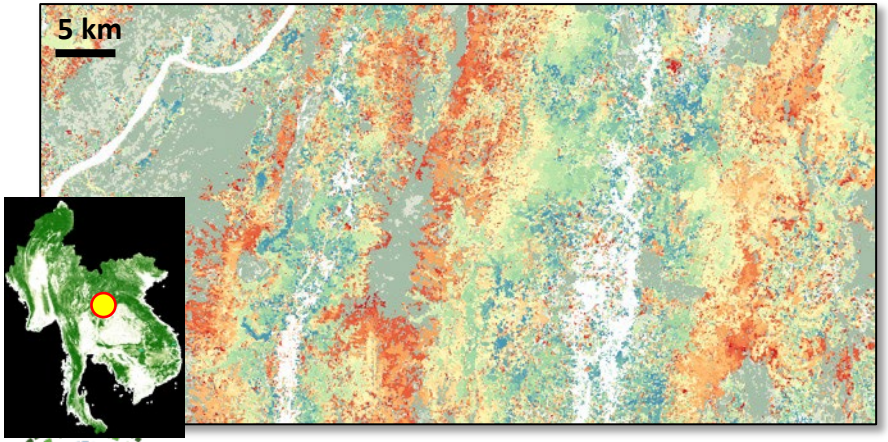
Forest age
Vietnam

1 years

17 years
>17 years

Forest* age, % of 2017 forest area
(*Forest defined as area with TCC >= 10% and TCH >= 5m)



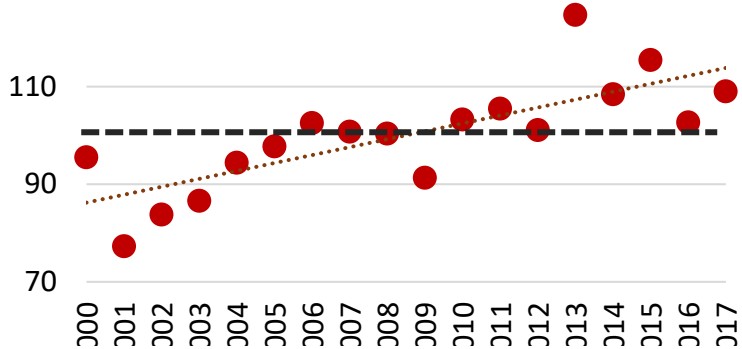


Earliest disturbance date
Laos

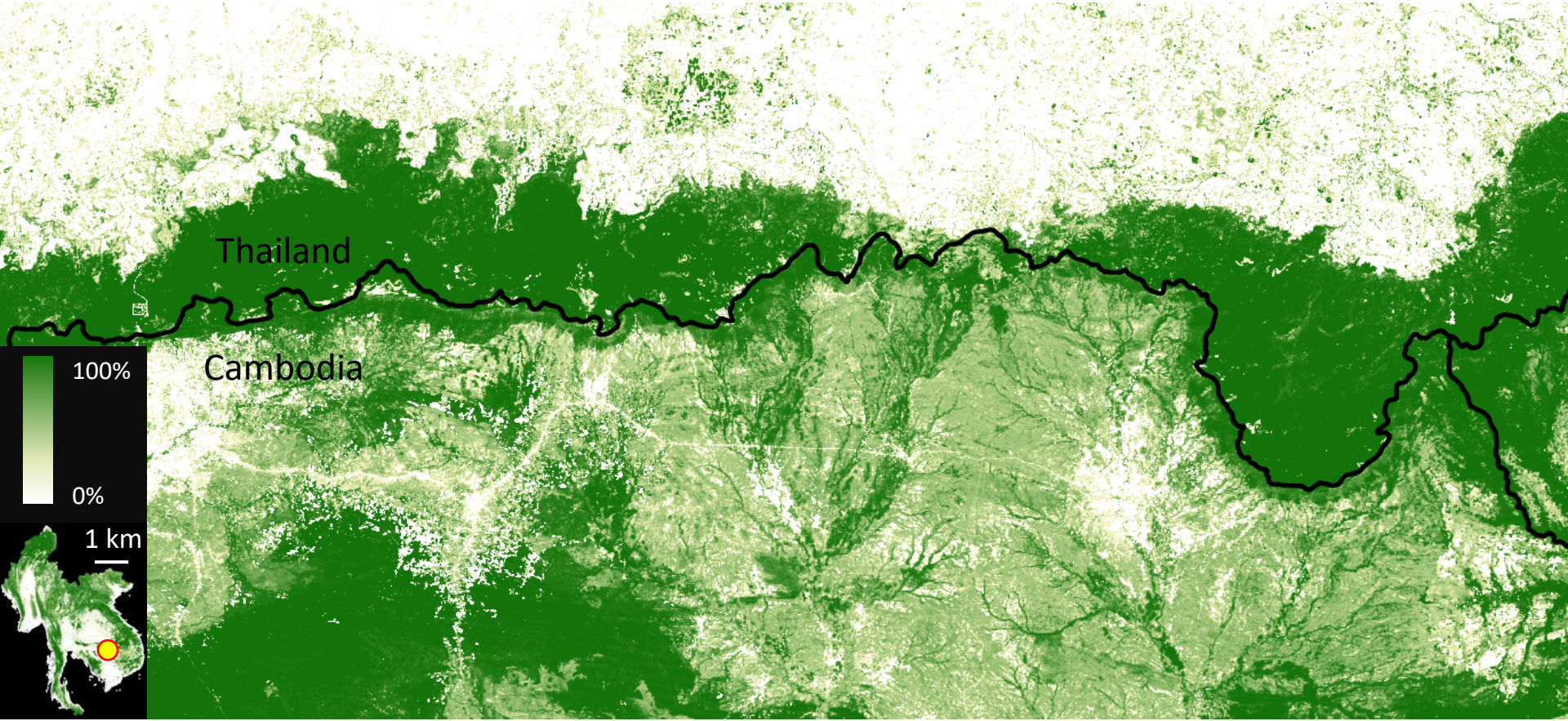
2017

2001
earlier

Annual disturbance area, % of 2000-2017 mean



GLAD
GLOBAL LAND ANALYSIS & DISCOVERY



Tree canopy cover time-series, 2000-2017

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Challenges & Opportunities

- Massive data volume and flow
  - Digital support
- Performance improvement over Asia
  - Additional field campaign
- Coordinated efforts
  - from gov, academic and industry

ATBD #	Data products	Product leads	Resolution
L1A-2A	1A: Raw waveforms, 2A: Ground elevation, canopy top height, relative height (RH) metrics	Michelle Hofton Bryan Blair	25 m (~82 ft) diameter
L1B	Geolocated waveforms	Scott Luthcke Tim Rebold Taylor Thomas Teresa Pennington	25 m (~82 ft) diameter
L2B	Canopy Cover Fraction (CCF), CCF profile, Leaf Area Index (LAI), LAI profile	Hao Tang John Armston	25 m (~82 ft) diameter
L3	Gridded Level 2 metrics	Scott Luthcke Terence Sabaka Sandra Preaux	1 km (~0.6 mi) grid
L4A	Footprint level above ground biomass	Jim Kellner Laura Duncanson John Armston	25 m (~82 ft) diameter
L4B	Gridded Above Ground Biomass Density (AGBD)	Sean Healey Paul Patterson	1 km (~0.6 mi) grid
Demonstrative products	Prognostic ecosystem model outputs	George Hurtt	Grid size: Variable
Demonstrative products	Enhanced height/biomass using fusion with TanDEM-X	Lola Fatoyinbo Seung-Kuk Lee	Grid size: Variable
Demonstrative products	Enhanced height/biomass and biomass change using fusion with Landsat	Matt Hansen Chenquan Huang	Grid size: Variable
Demonstrative products	Biodiversity/habitat model outputs	Scott Goetz Patrick Jantz Pat Burns	Grid size: Variable

GEDI ECOSYSTEM LIDAR BROWN NORTHERN ARIZONA UNIVERSITY Goddard NASA

Nature-based Carbon Credits in High Demand

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