International Workshop on
Vegetation Lidar and Application from Space
May 26, 2017

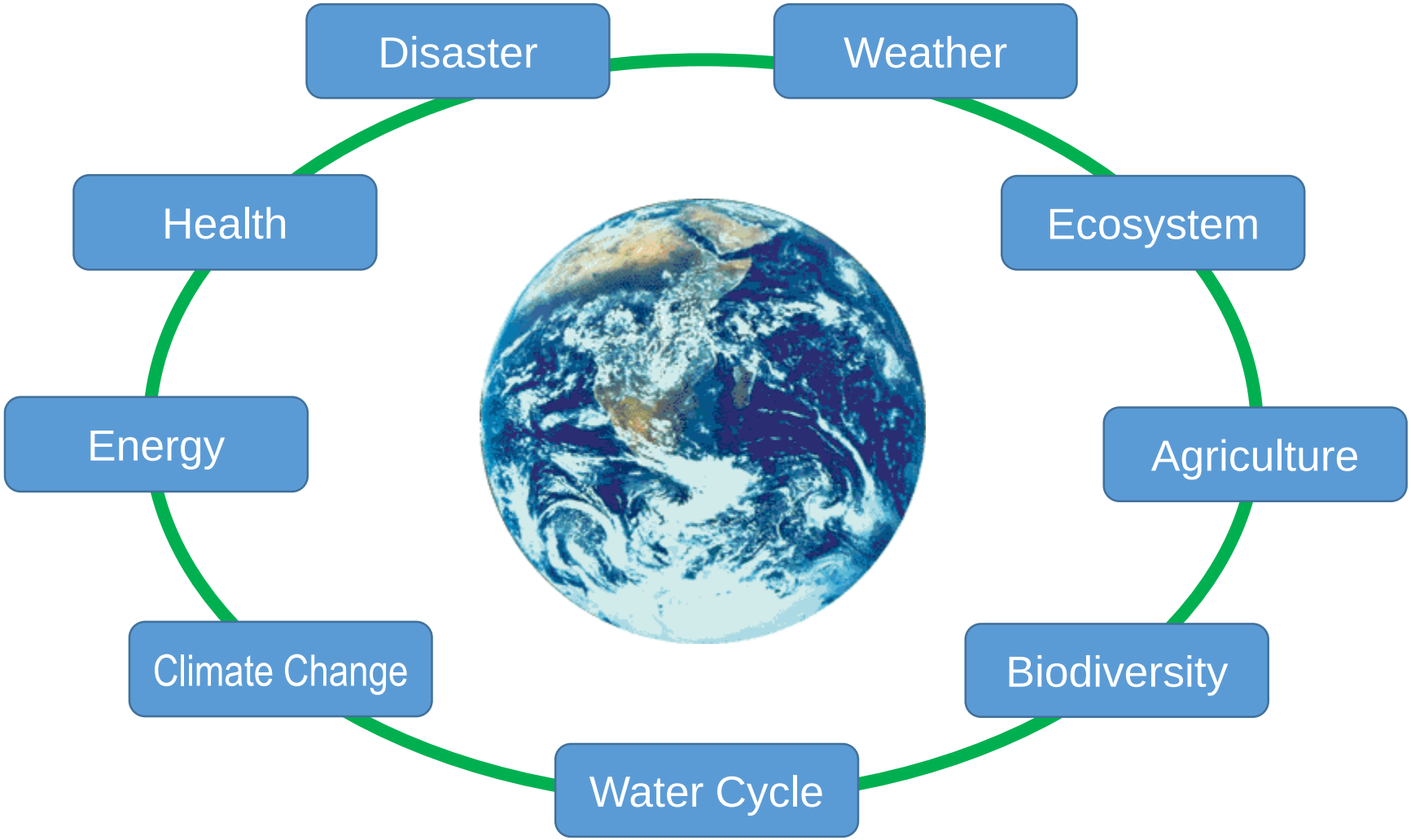
MOLI Science Plan

Forestry and Forest Products Research Institute

Yasumasa Hirata

Current Global Issues

Contributions to Global Issues through GEOSS

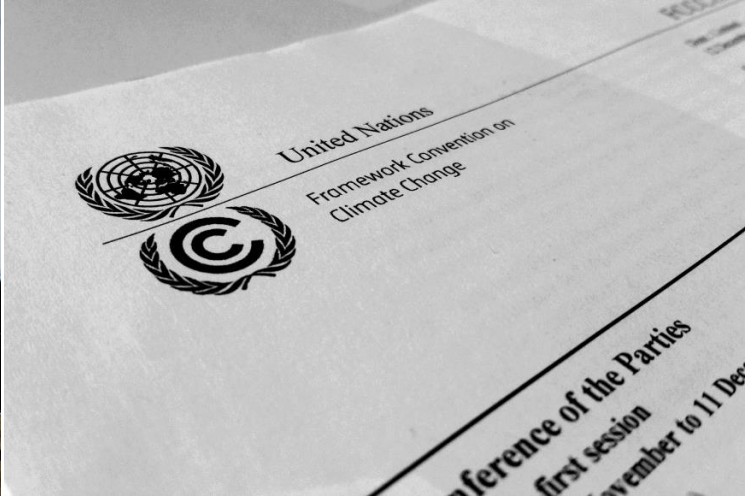


Climate Change

TOKYO 2020

TOKYO 2020
PARALYMPIC GAMES

2020



2020

PARIS2015
UN CLIMATE CHANGE CONFERENCE
COP21·CMP11

UNCED

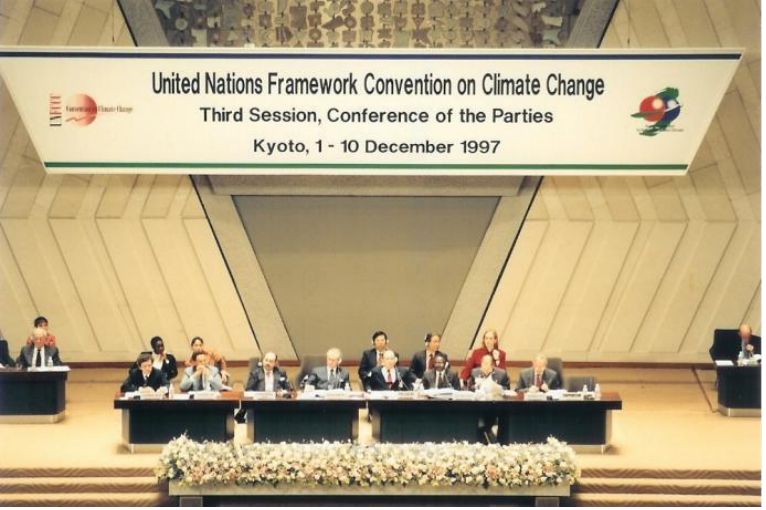
Agenda 21

森林原則声明

1992

UNFCCC

CBD



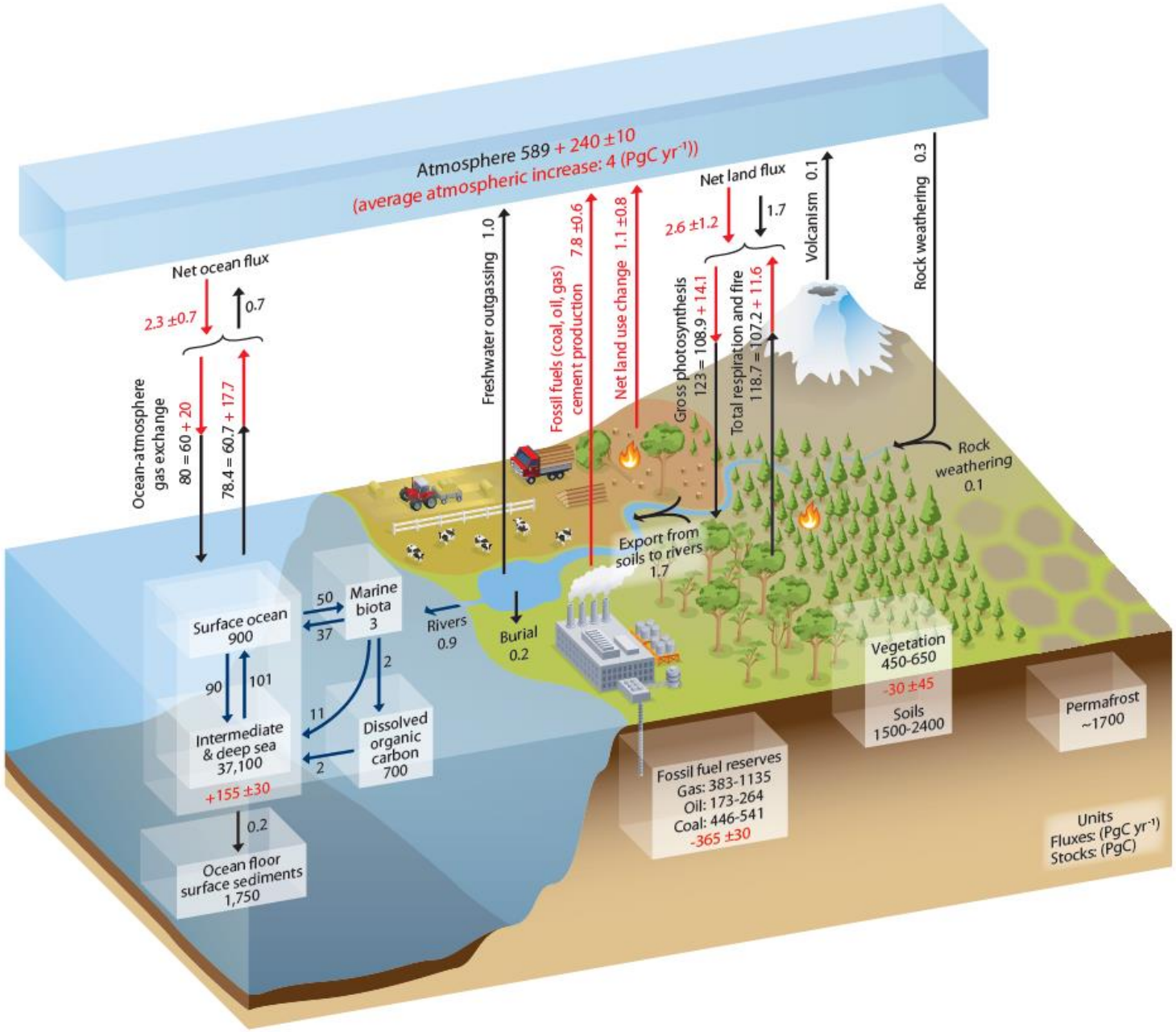
COP 3 in UNFCCC

Kyoto Protocol

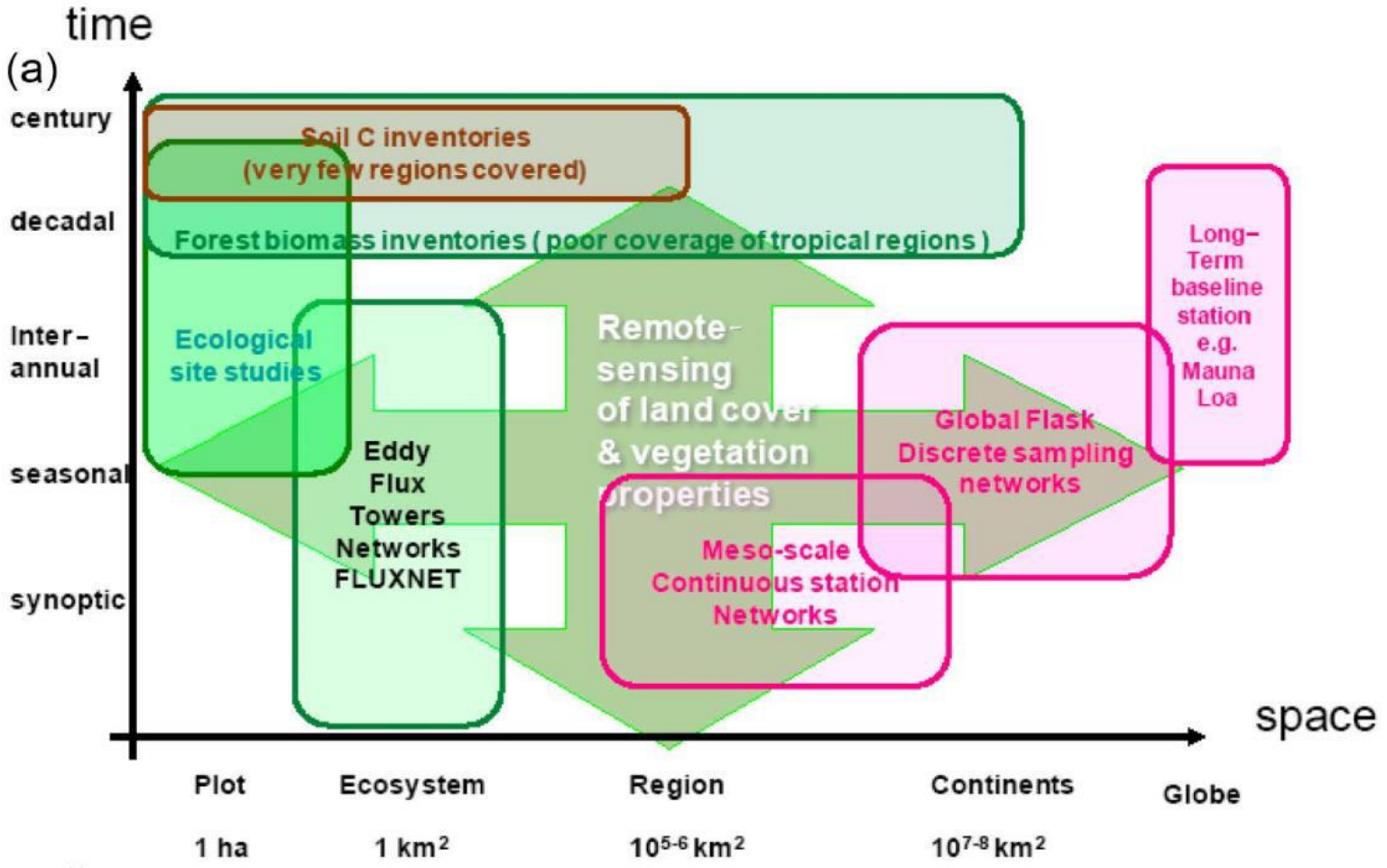
1997

- Reduce their GHG emissions by 5.2% on average for the period 2008-2012, relative to their annual emissions in a base year, usually 1990
- Rate of Emission reduction: EU – 8%, USA – 7%, Japan – 6 %

Carbon Cycle

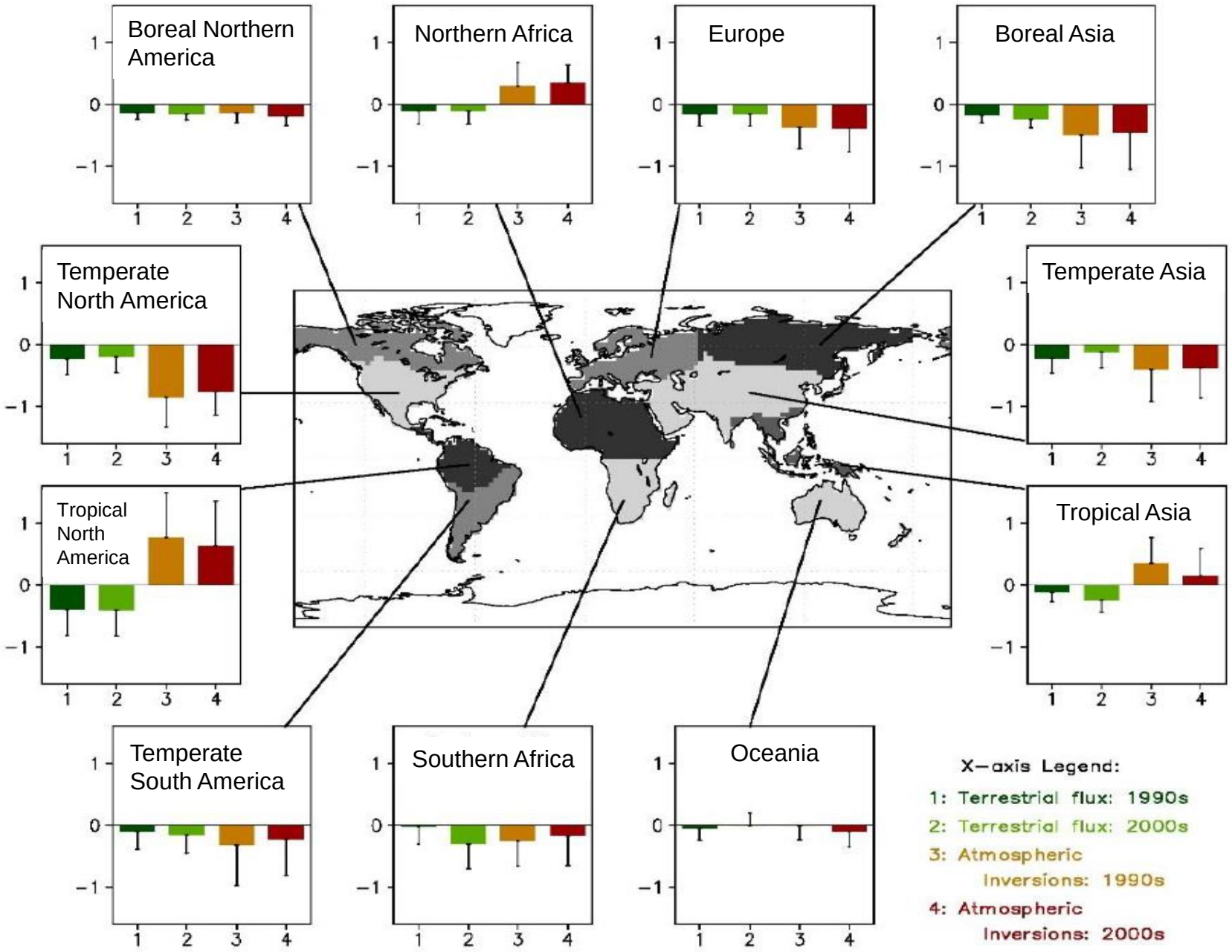

Atmosphere 589 + 240 ±10
(average atmospheric increase: 4 (PgC yr-1))
Net ocean flux
2.3 ±0.7
0.7
Ocean-atmosphere gas exchange
80 = 60 + 20
78.4 = 60.7 + 17.7
Freshwater outgassing 1.0
Fossil fuels (coal, oil, gas) cement production 7.8 ±0.6
Net land use change 1.1 ±0.8
Net land flux
2.6 ±1.2
1.7
Gross photosynthesis 123 = 108.9 + 14.1
Total respiration and fire 118.7 = 107.2 + 11.6
Volcanism 0.1
Rock weathering 0.3
Rock weathering 0.1
Export from soils to rivers 1.7
Surface ocean 900
50
37
Marine biota 3
Rivers 0.9
Burial 0.2
90
101
2
11
2
Intermediate & deep sea 37,100
+155 ±30
Dissolved organic carbon 700
0.2
Ocean floor surface sediments 1,750
Vegetation 450-650
-30 ±45
Soils 1500-2400
Permafrost ~1700
Fossil fuel reserves
Gas: 383-1135
Oil: 173-264
Coal: 446-541
-365 ±30
Units
Fluxes: (PgC yr-1)
Stocks: (PgC)

Techniques and Networks of Global Carbon Cycle Observation at Various Time and Spatial Scales

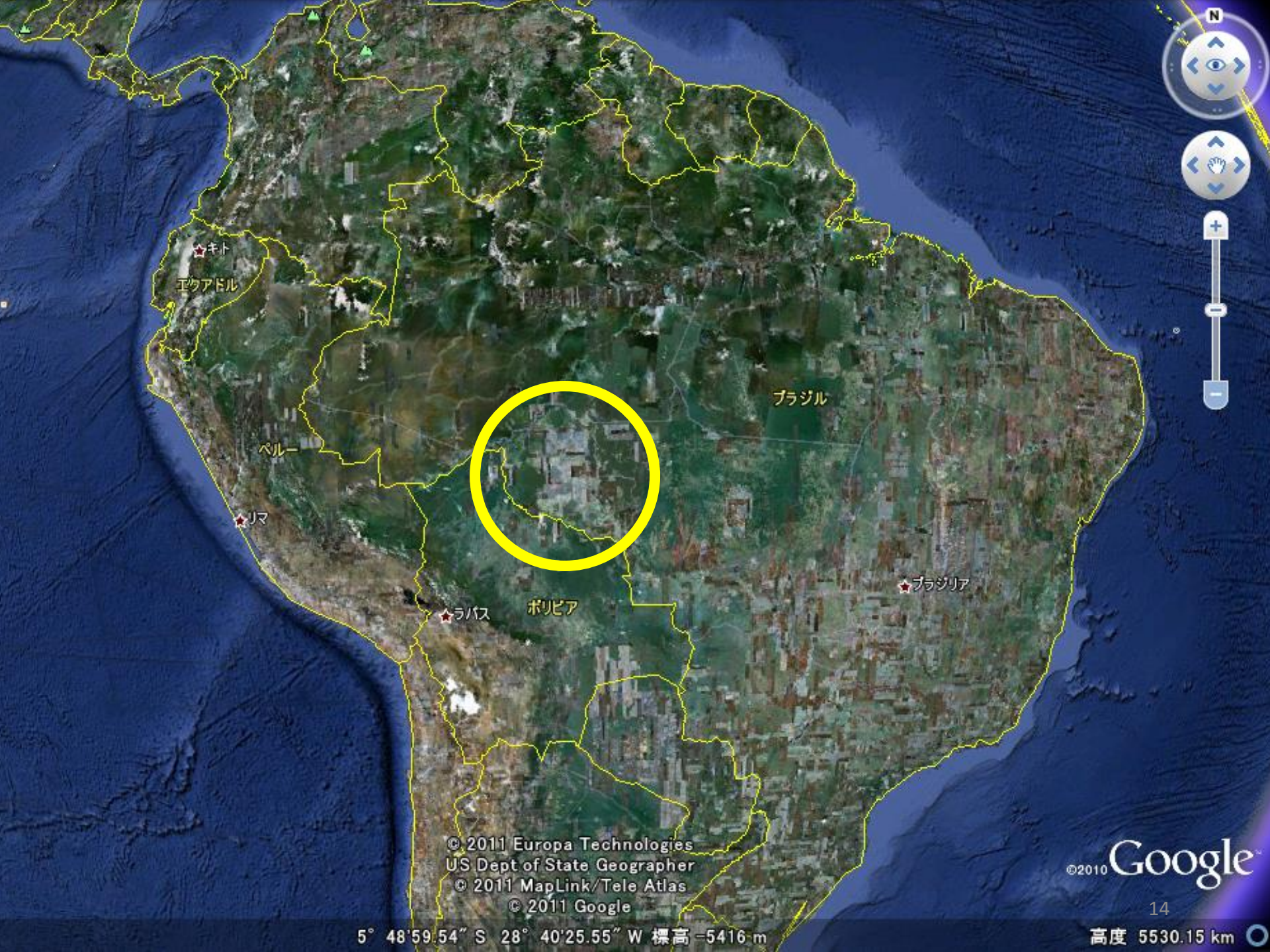


Ciais et al.,2014

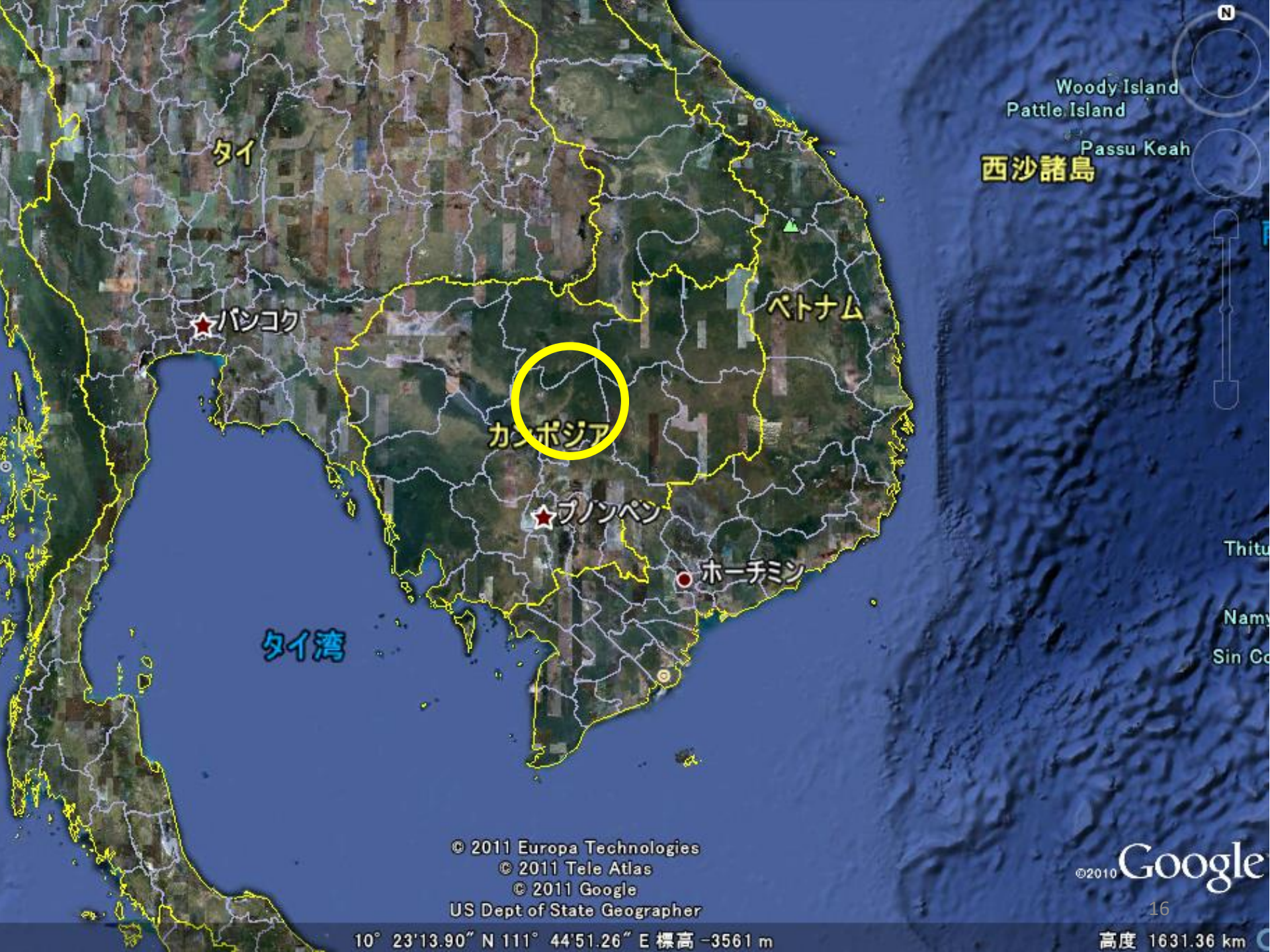
Land-to-atmosphere CO_2 Flux

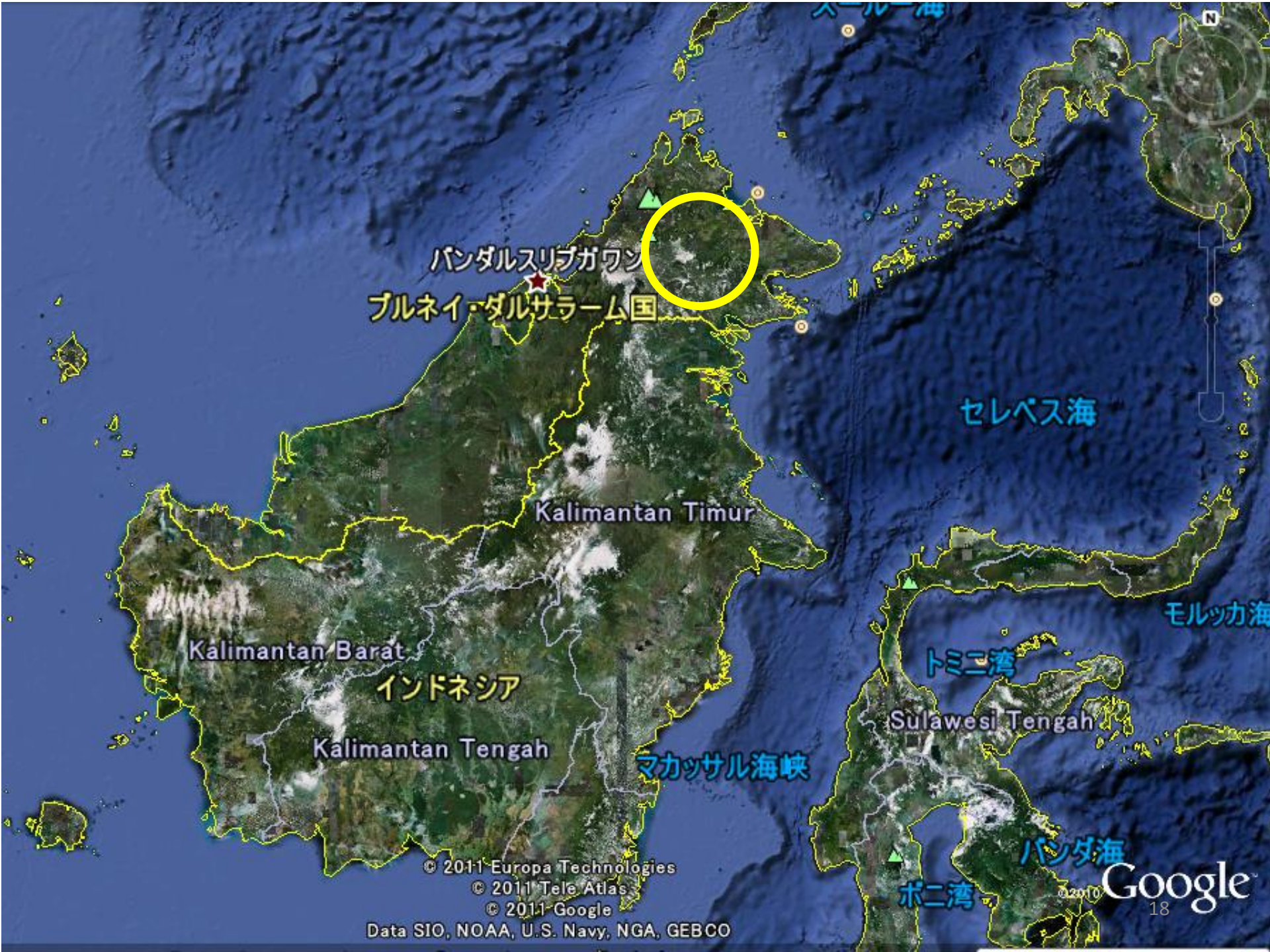


REDD-plus


キト
エクアドル
ペルー
リマ
ブラジル
ブラジリア
ボリビア
ラパス
© 2011 Europa Technologies
US Dept of State Geographer
© 2011 MapLink/Tele Atlas
© 2011 Google
©2010 Google
5° 48'59.54" S 28° 40'25.55" W 標高 -5416 m
高度 5530.15 km





タイ
バンコク
カンボジア
ベトナム
プノンペン
ホーチミン
タイ湾
西沙諸島
Woody Island
Pattle Island
Passu Keah
© 2011 Europa Technologies
© 2011 Tele Atlas
© 2011 Google
US Dept of State Geographer
©2010 Google
10° 23'13.90" N 111° 44'51.26" E 標高 -3561 m
高度 1631.36 km


バンダルスリブガワン
ブルネイ・ダルサラーム国
セレベス海
Kalimantan Timur
Kalimantan Barat
インドネシア
Kalimantan Tengah
マカッサル海峡
トミニ湾
Sulawesi Tengah
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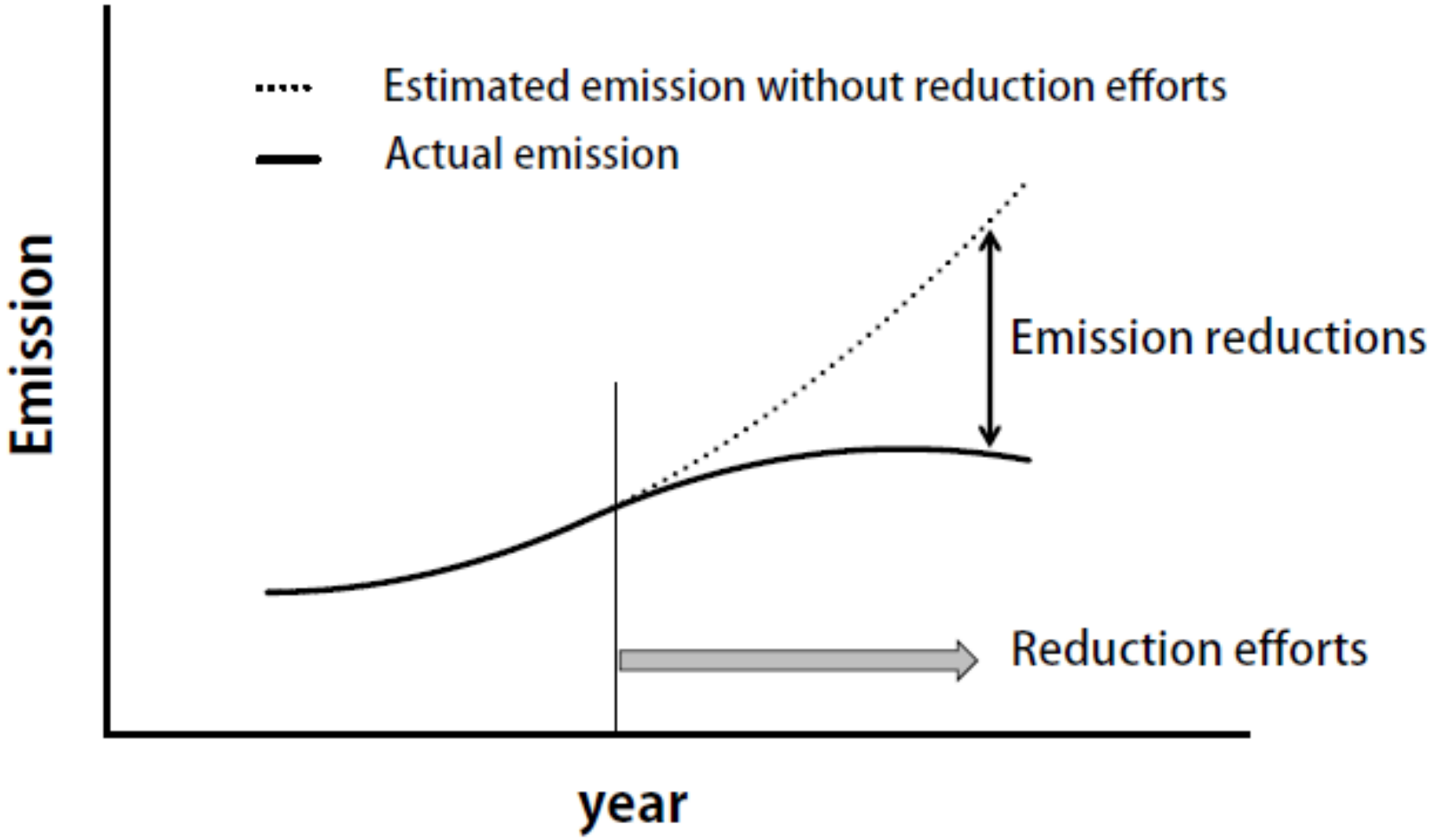
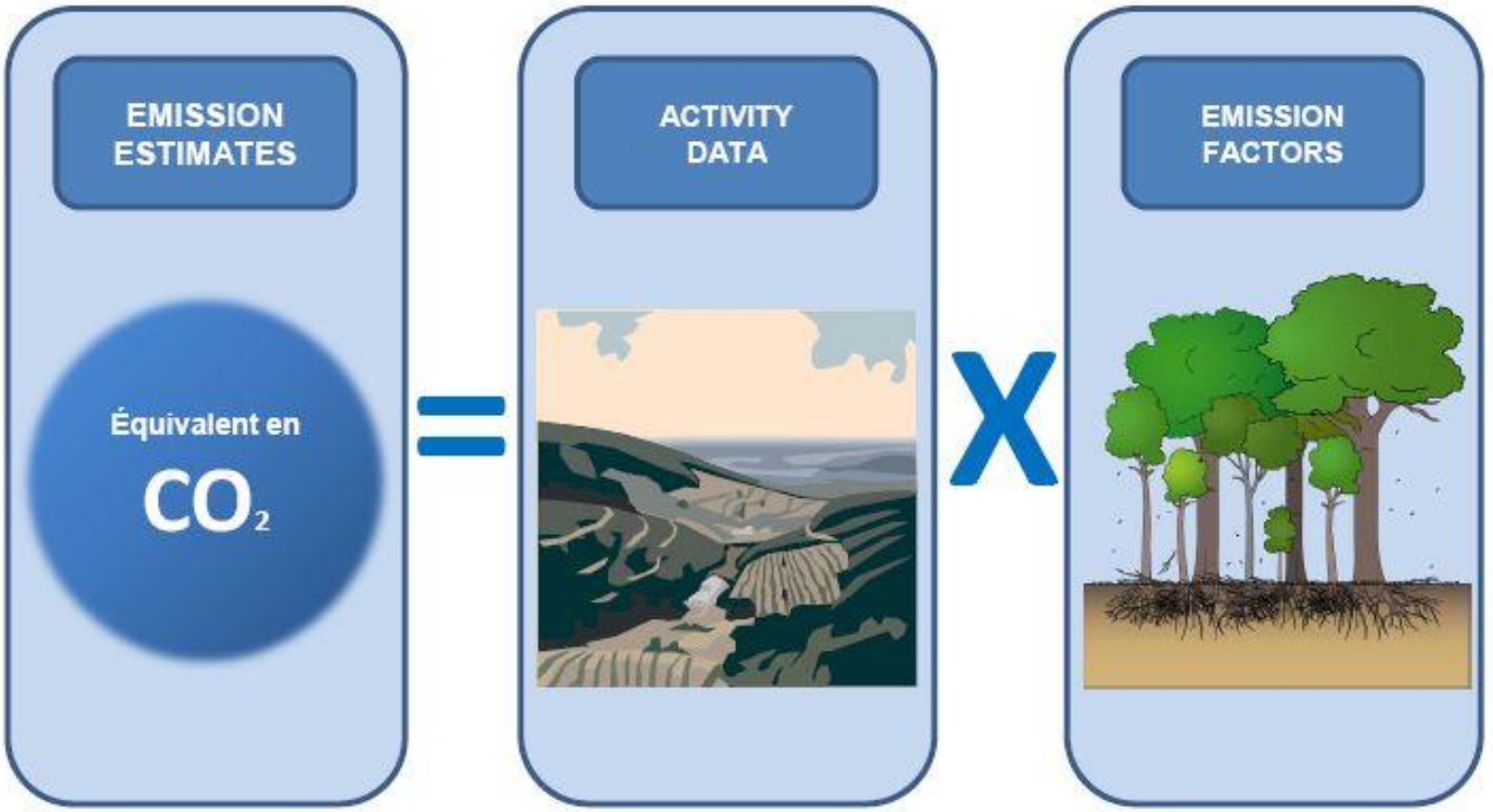
Google

Concept of Emission Reduction in REDD+

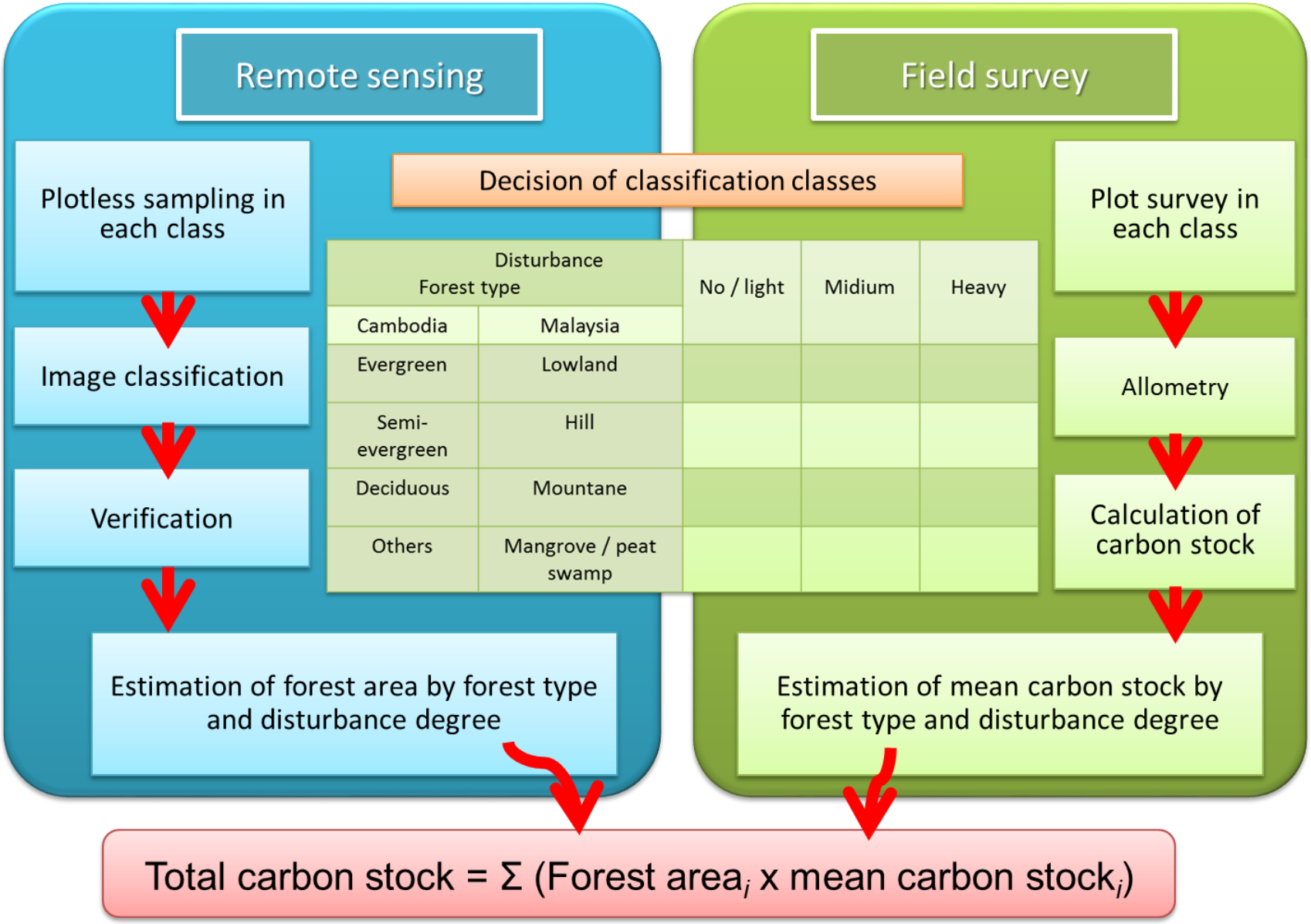


IPCC basic equation to estimate GHG emissions from activities related with LULUCF sector

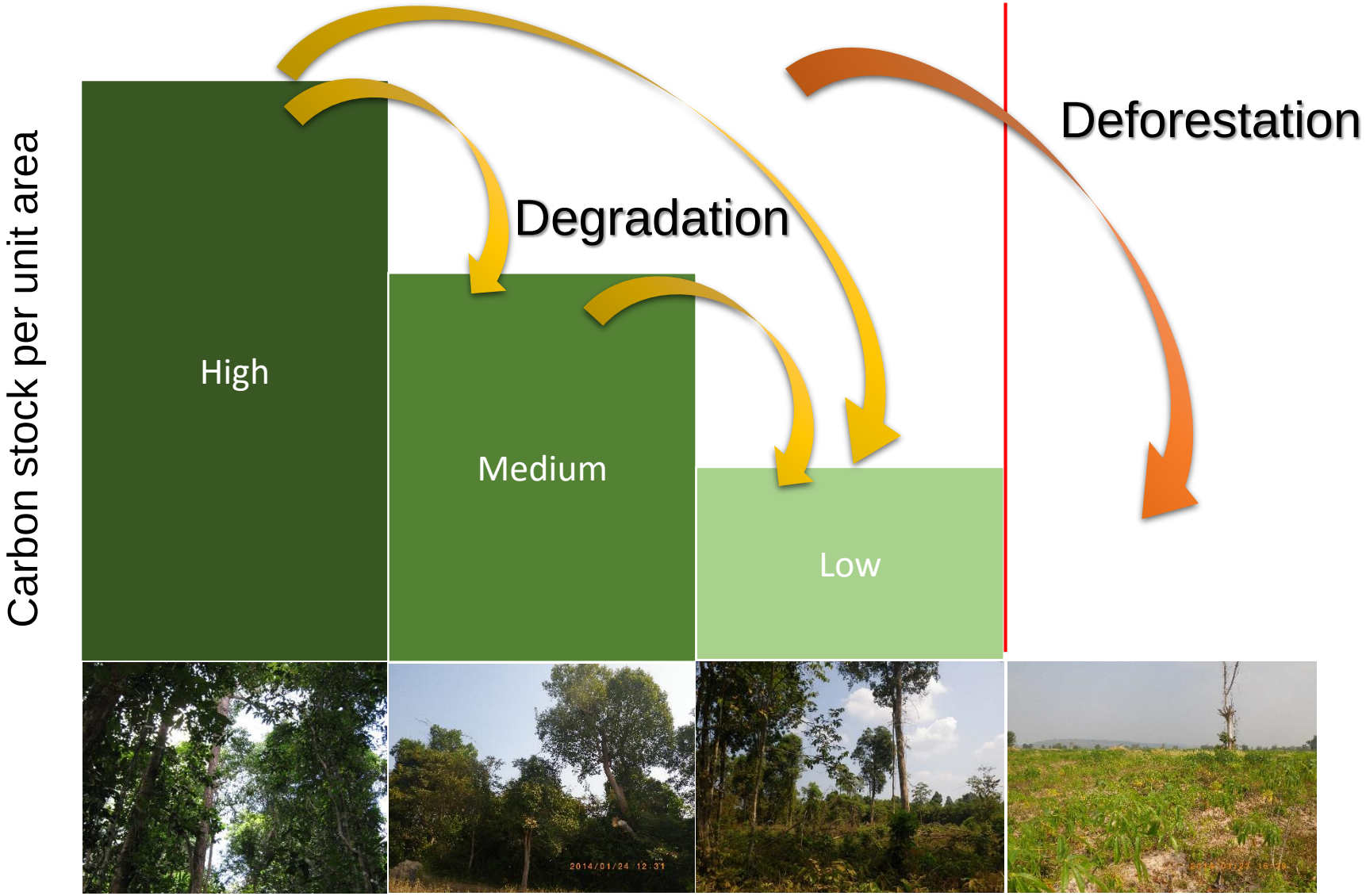


Danilo Mollicone, FAO

Forest Carbon Stock using Remote Sensing and Field Survey



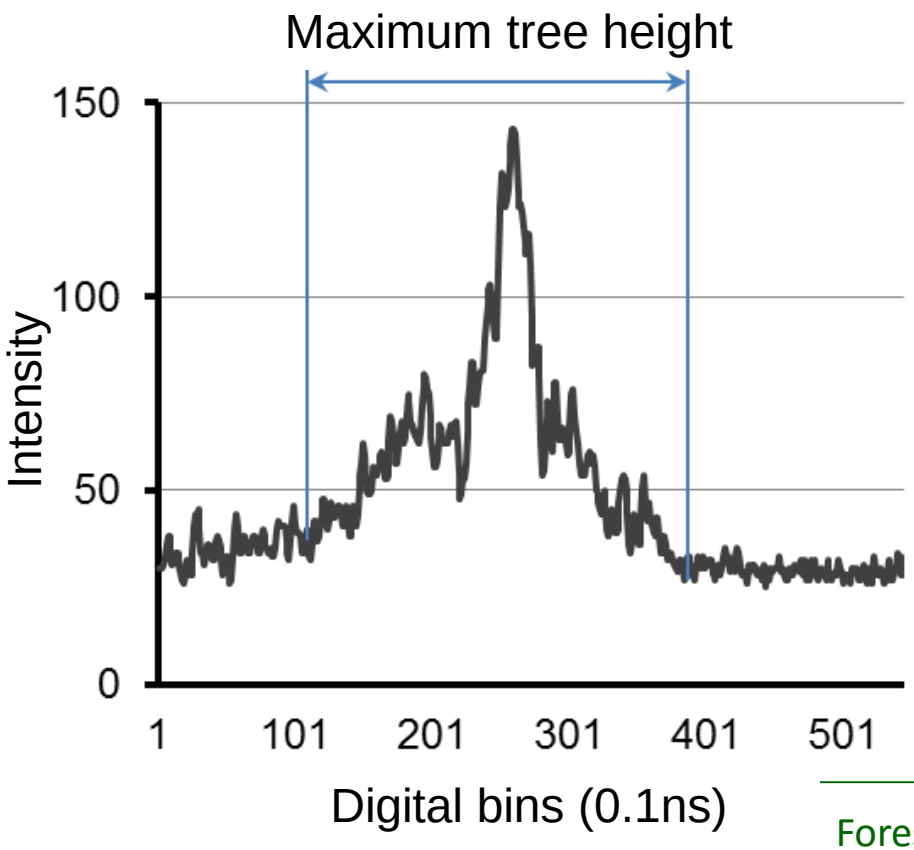
Idea of Forest Degradation



Lesson and Learn from GLAS Mission

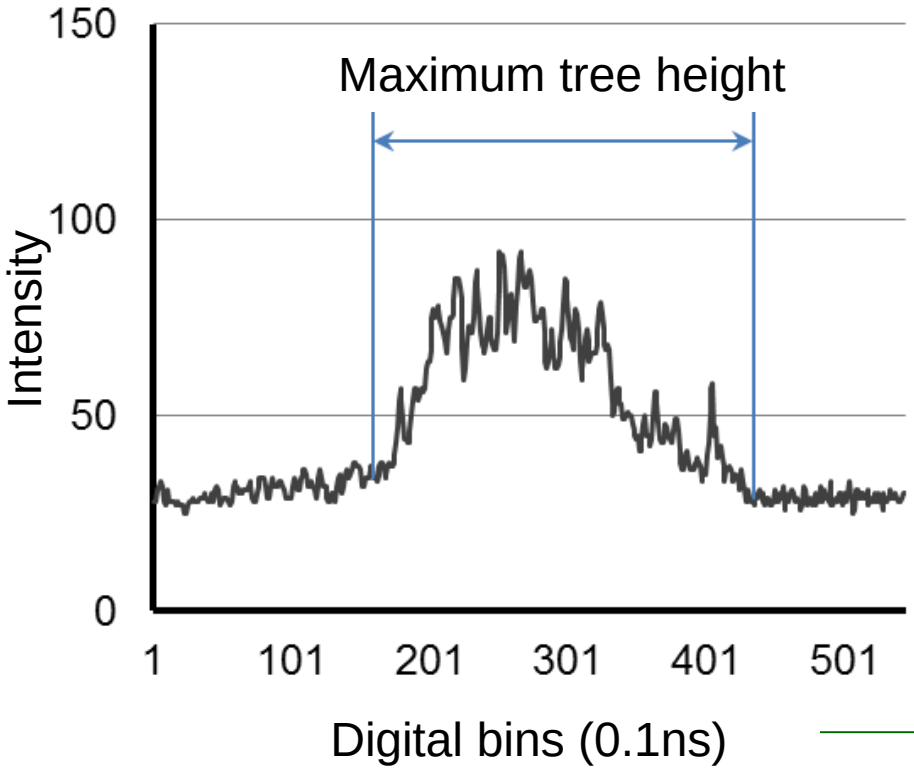
Waveform of LiDAR data in a mature forest

- Maximum tree height derived from LiDAR data was about 43 m.
- Intensity has a peak around 23m height and it means canopy layer.

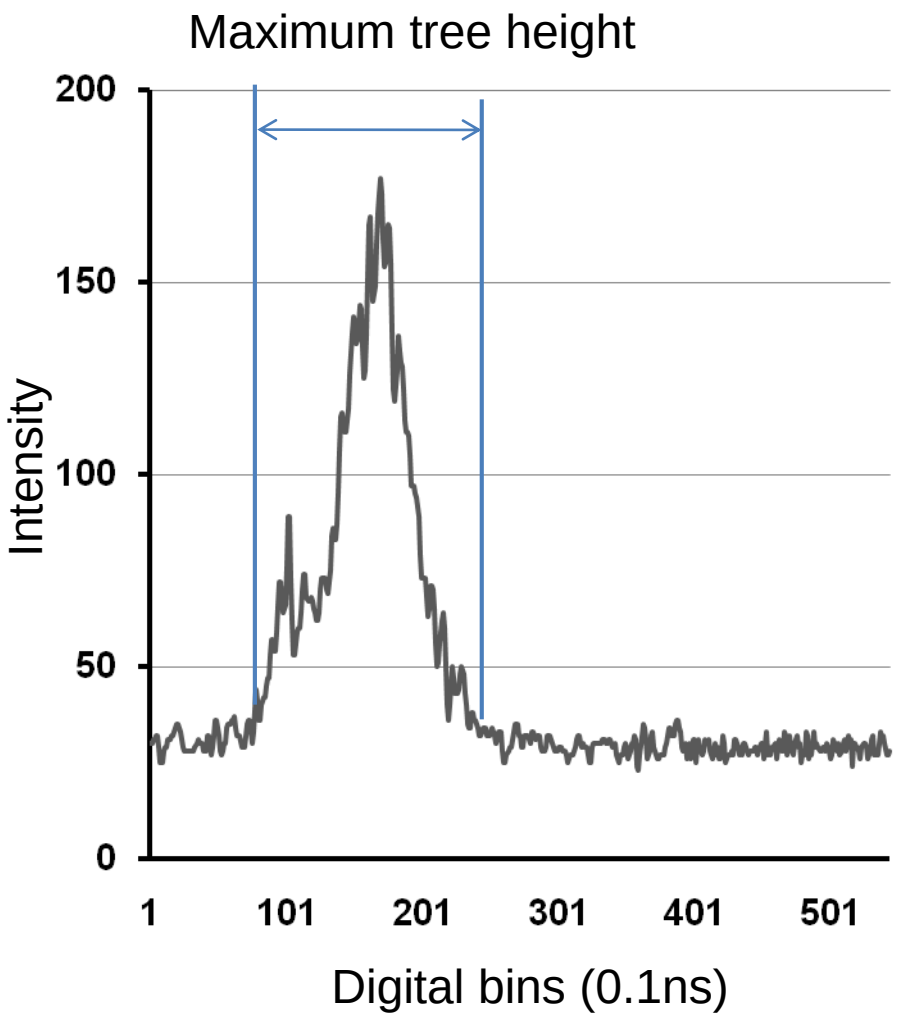


Waveform of LiDAR data in a degraded forest

- Maximum tree height derived from LiDAR data was about 42 m.
- Intensity was relayively weak through all layers.

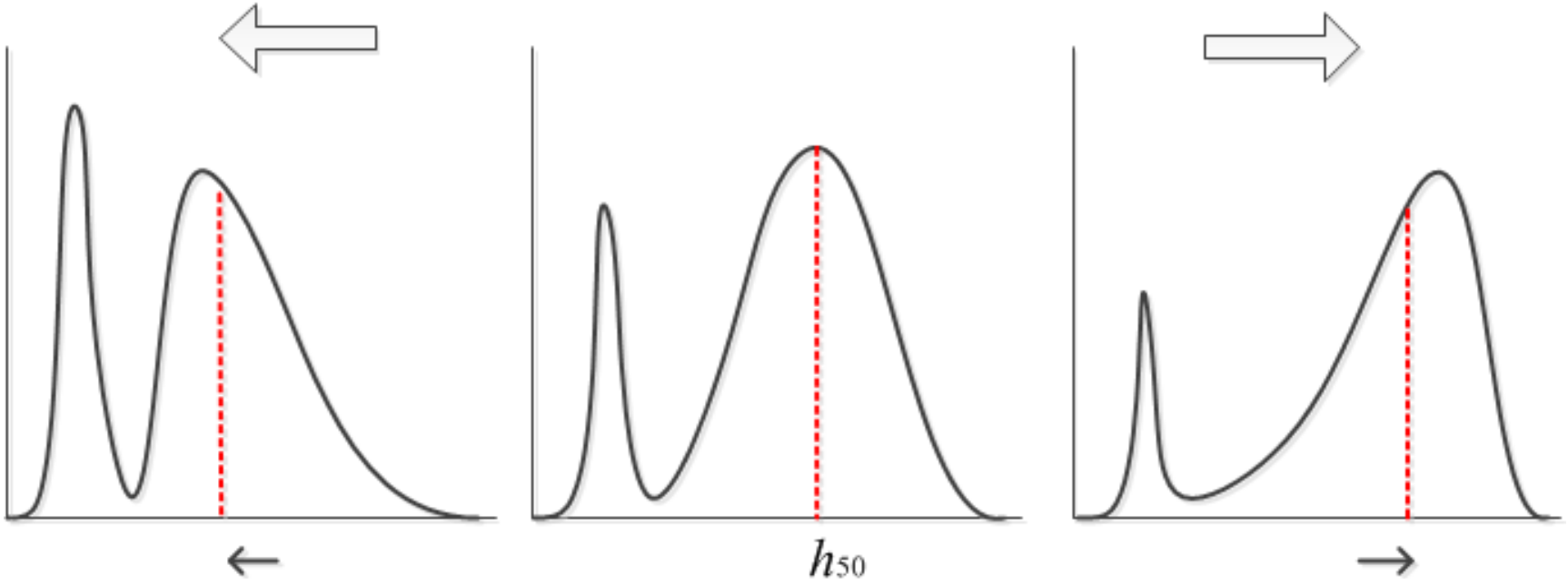


Waveform of LiDAR data in a rubber plantation

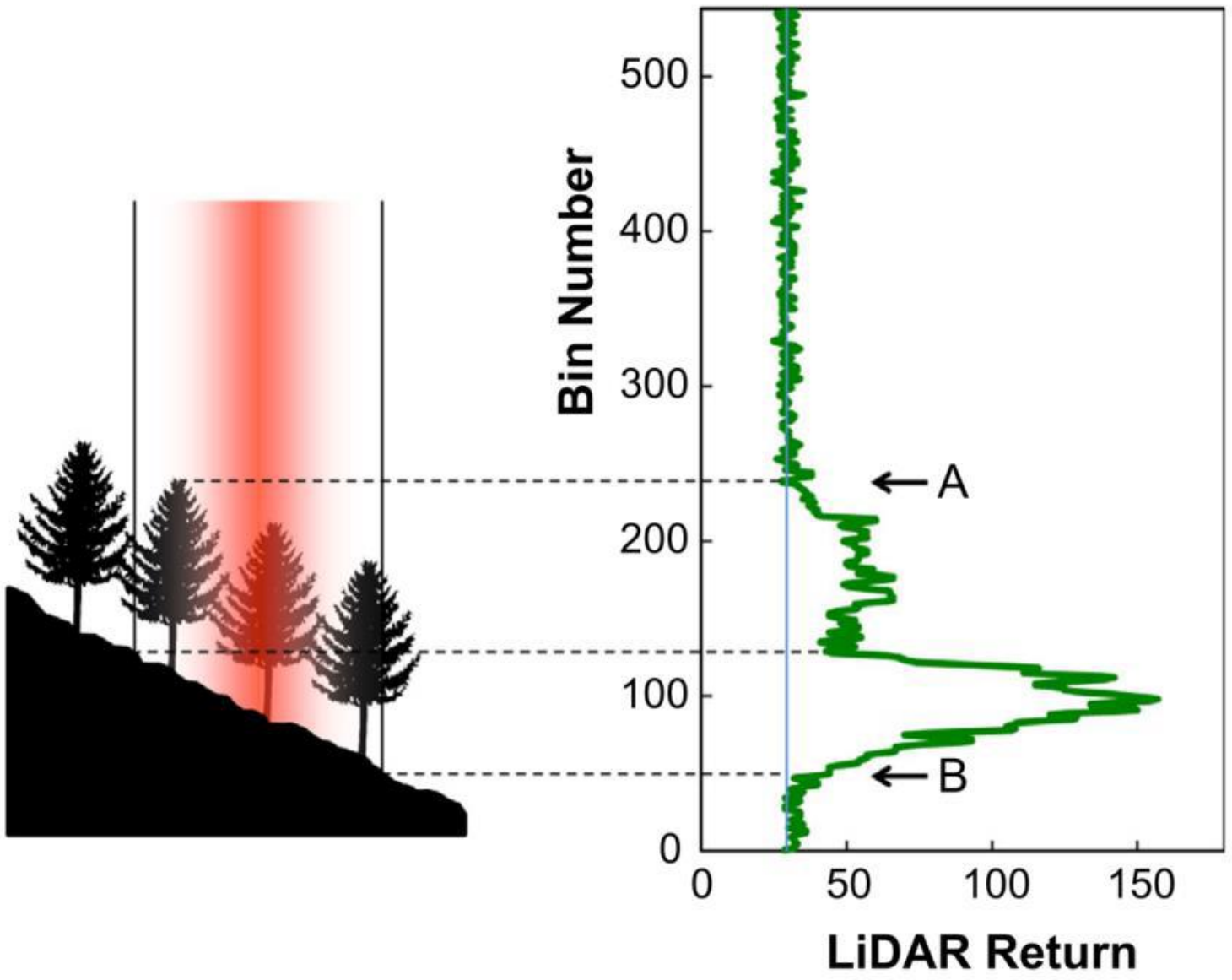


- Maximum tree height derived from LiDAR data was about 23 m.
- Intensity has a peak around 15m height and it means canopy layer.

Growth and Degradation of Forest from Waveform changes

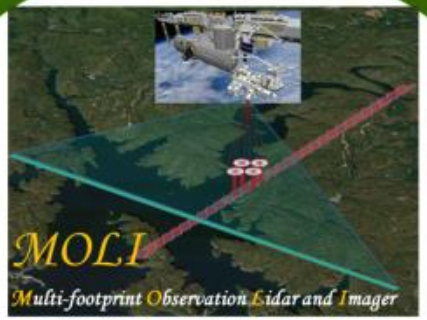


Issue of Observation using Large footprint on a slope



Objectives and Products of MOLI

Response prediction of terrestrial ecosystems due to climate change



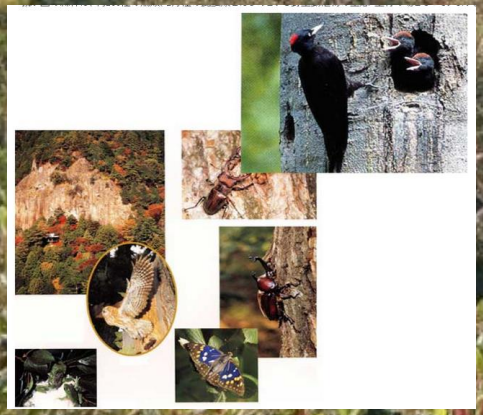
- Canopy height
- Above Ground Biomass
- Forest structure
- DEM
- Imager product

Carbon cycle

Biodiversity

Forestry

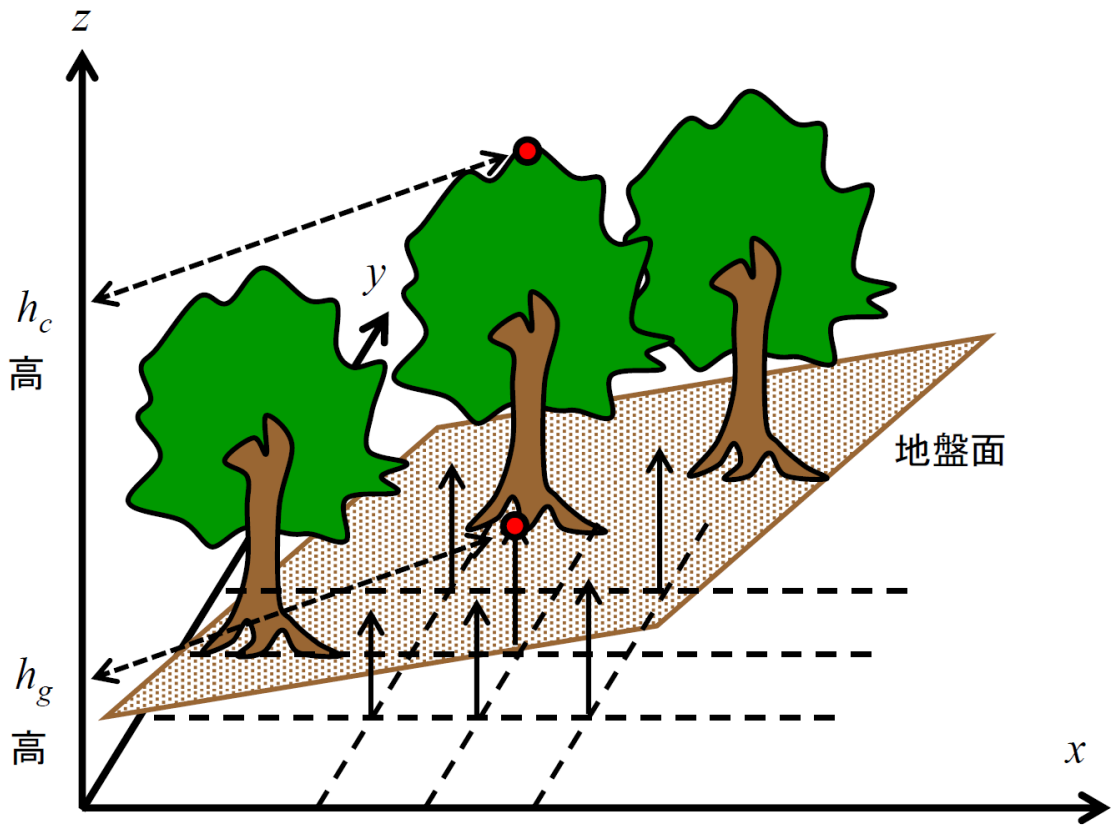
REDD+



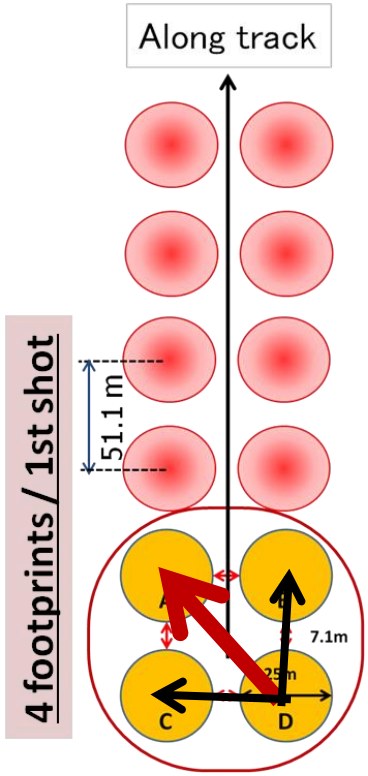
The number of footprints of GLAS after screening

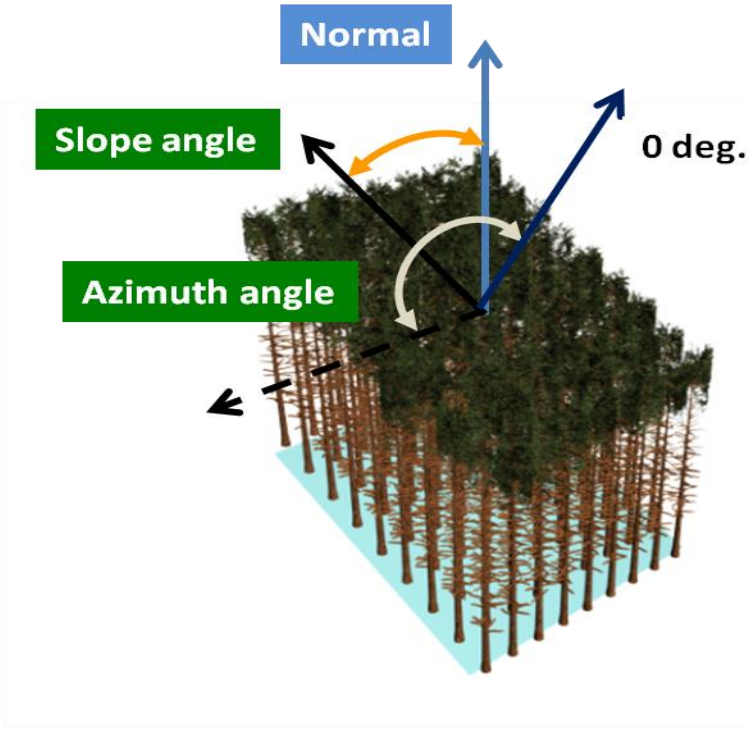
Samples (million)	Tropical America	Tropical Africa	Tropical Asia	Total
Available	13.2	18.2	11.8	43.2
After screening	2.3	2.5	0.7	5.5
Percent % used	17.4	13.8	5.9	12.7

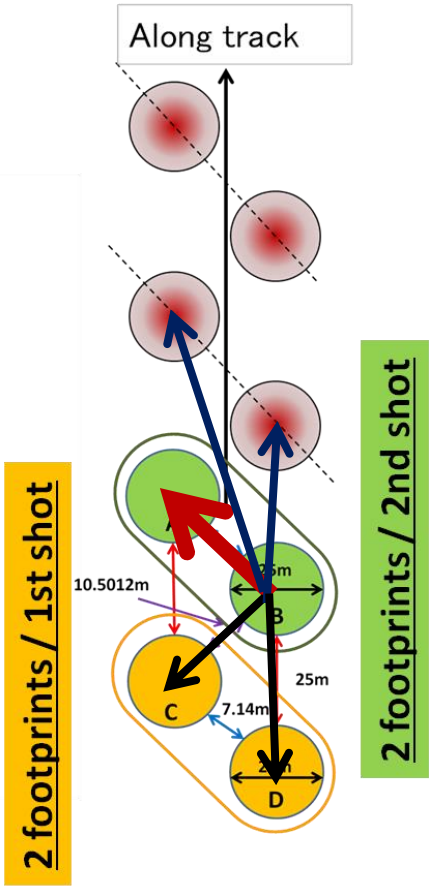
Reduction of Topographic Effect



Principle of determination for slope & azimuth angle using multi-footprint



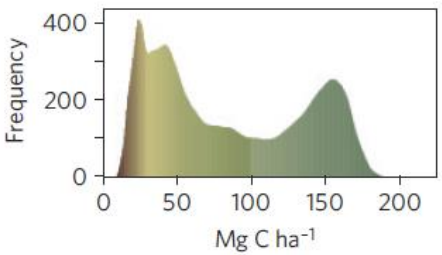


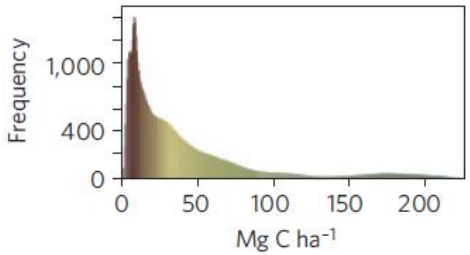


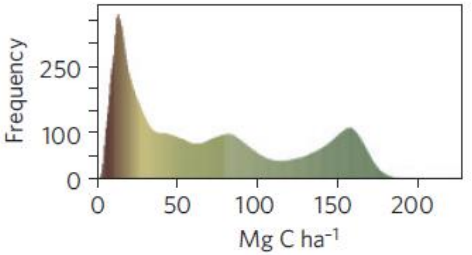
	True value	Number of footprints /one pulse	
		4	2
Azimuth angle	135.00 deg.	135.33 deg.	135.00 deg.
Slope angle	30.00 deg.	30.03 deg.	29.80 deg.

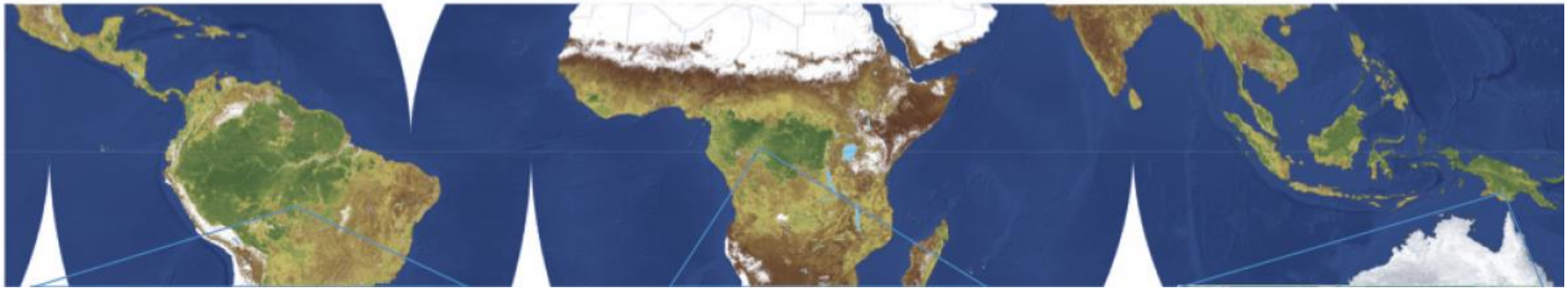
Saturation for large biomass in SAR observation

from A.Baccini et.al,NATURE CLIMATE CHANGE(2012), 2

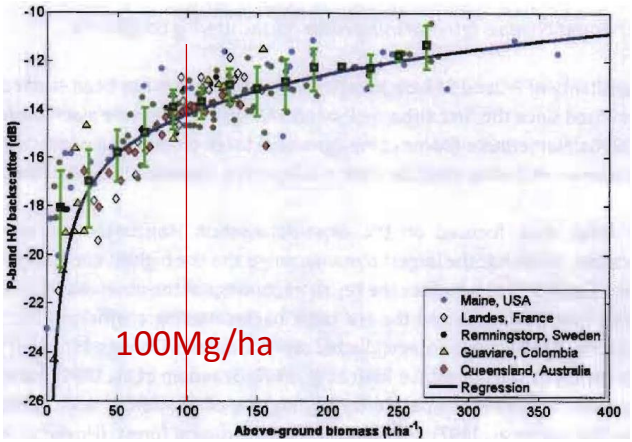






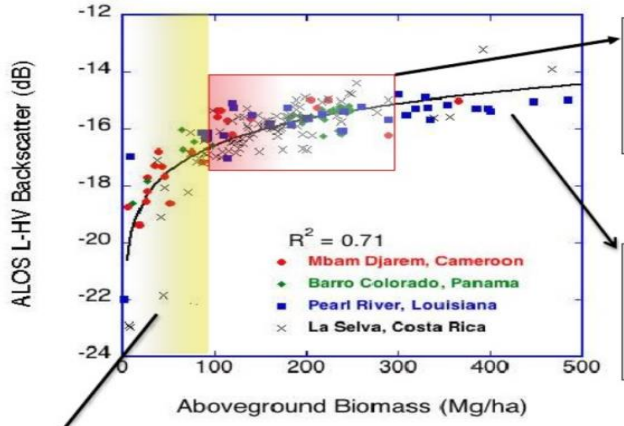


P-band,HV



from ESA report assessment"BIOMASS",2008

ALOS L-band,HV



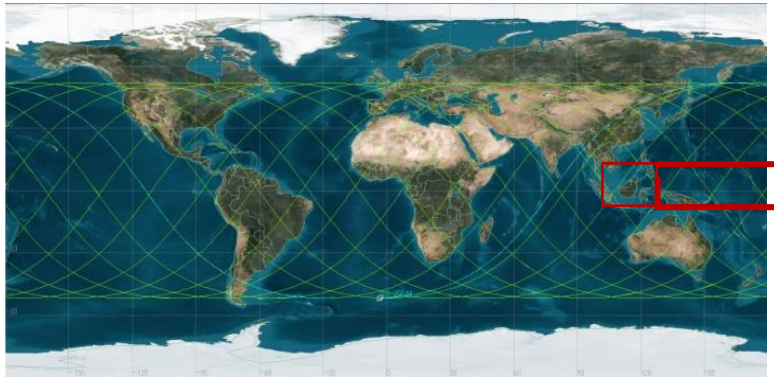
Low or no sensitivity above 100 Mg/ha Fusion with lidar samples may extend this range

Highest biomass areas estimated using dense grid of lidar samples alone at coarser resolutions

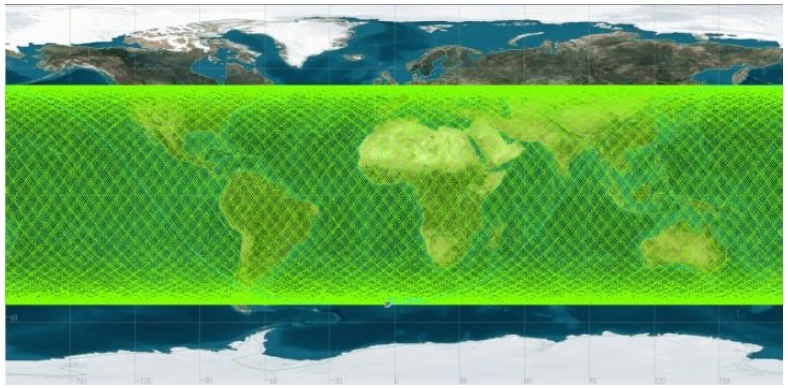
Many different studies achieved 10-20% accuracy for biomass below < 100 Mg/ha

from R.Dubaya et.al,GRSSIEEE2010

ISS ground tracks

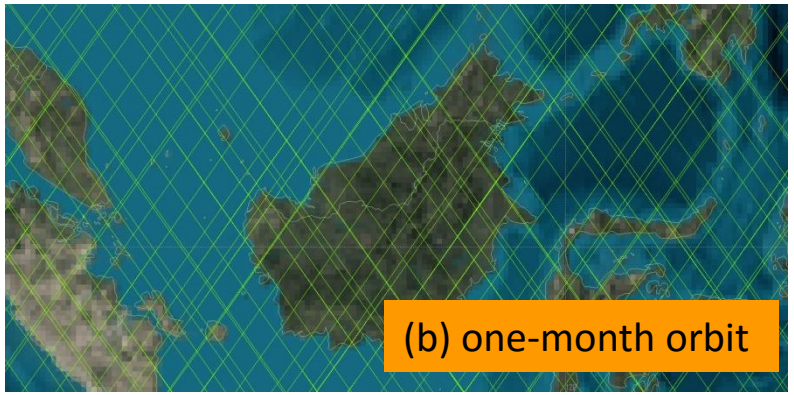


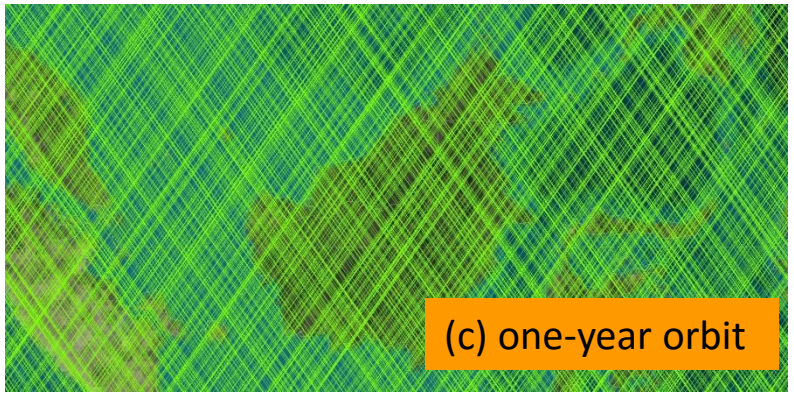
(a) one-day orbit



(b) one-month orbit

A chain of islands including Borneo and Celebes and Java and Sumatra in Southeast Asia





Estimation of Aboveground Biomass(AGB) by Lidar

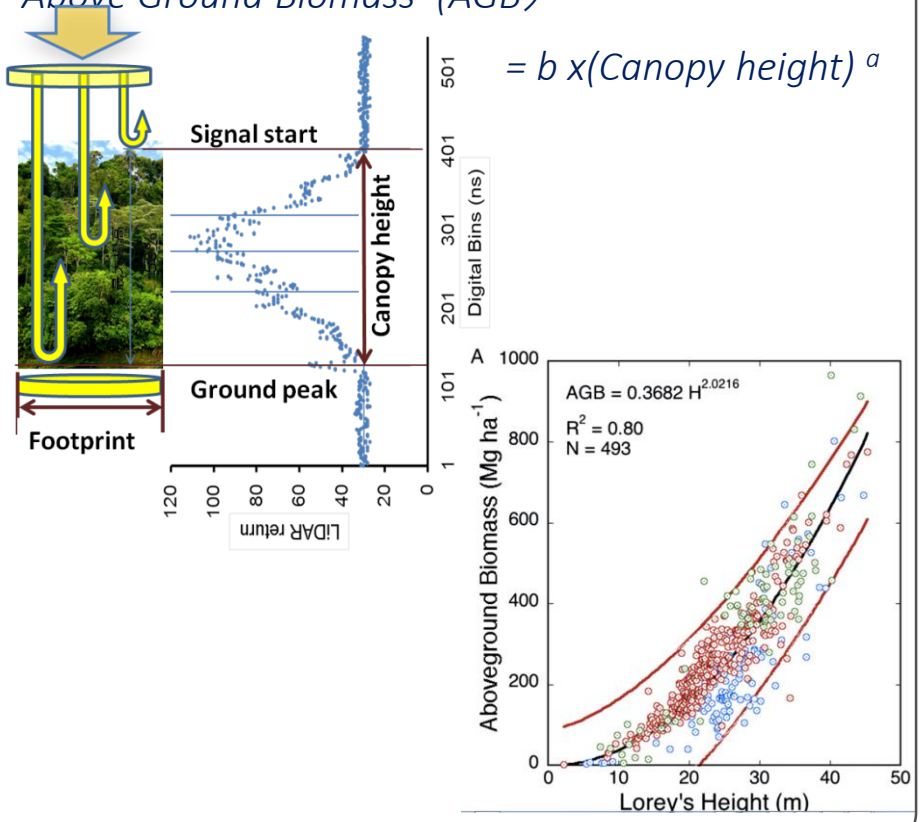
Forest height to biomass allometry

Canopy Height $= a_1 x$ *[Waveform Extent]*

$- a_2 x$ *[Elevation Difference in Footprint]*

Above Ground Biomass (AGB)

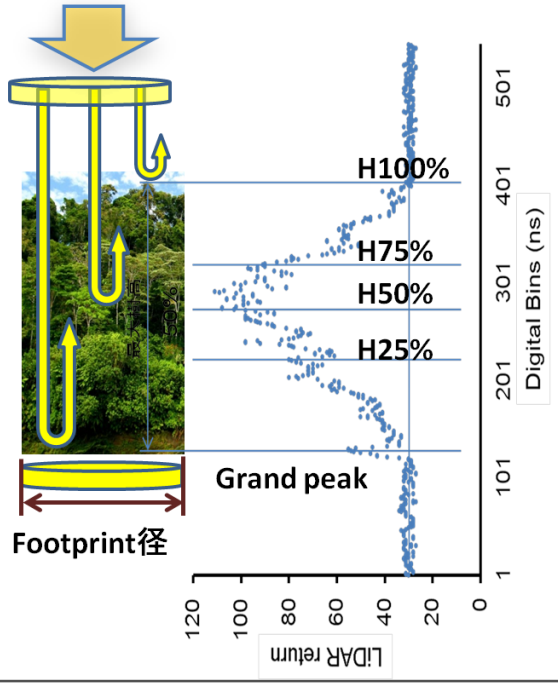
$= b \times (\text{Canopy height})^{a}$



AGB regression model (e.g. in Sabah , Malaysia)

$$\text{AGB} = 3.75 h_{10}^{0.742} h_{25}^{-2.864} h_{50}^{3.406} h_{75}^{-3.364} h_{90}^{-0.170}$$

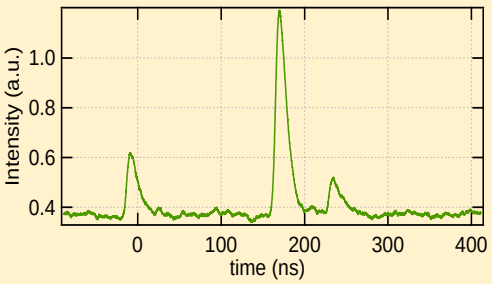
, where h_{10}, h_{25}, h_{50}, h_{75}, h_{90} are corresponding to the point (height) in the waveform at which the given energy percentile is reached.

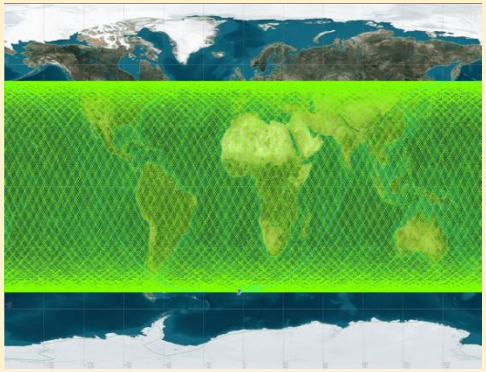


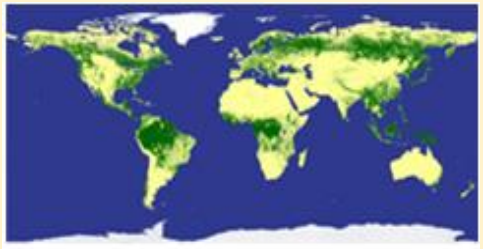
Requirement of Observation Parameters and accuracies

Parameters	Coverage	Uncertainties	Remarks
Forest height	Global	1m-3m, or 10%-20%	For biomass estimation
	Regional	1m-3m, or 10%-20%	For forest inventory
	Local	~10%	Site quality estimation
Forest structure	Global	Three layers ~5m-10m	Contribution to biomass, Forest monitoring
	Regional	Three layers ~5m-10m	Disturbance, Monitoring, REDD++
Forest biomass	Global	~20t/ha	Carbon stock
	Regional		Forest inventory
Topography	Global	<2m	DEM

Plan for product development







Level 0

Level 1 : Full-waveform product

Full-waveform product will be generated from Level 0 data. This product will include full-waveform data and information about location, attitude of platform, and, time.

Level 2 : Tree height product (ISS nadir only)

Tree height will be estimated by analysis of full-waveform product. This product will include tree height data and information about location, attitude of platform, and, time.

High level product : Global tree height map/Global biomass map

High level product will be generated by fusion use of tree height product and other satellite data such as imager and SAR.

Assumed User

- Waveform analyst
- Tree height map maker
- Elevation map maker

- Carbon cycle modeler
- Forest monitor
- Tree height map maker

- Carbon cycle modeler
- Forest monitor

- **Policymaking and contribution to society**

2020

Thank you for your attention!