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TAKING THE PULSE OF OUR PLANET FROM SPACE

The contribution of the BIOMASS mission to carbon cycle and climate science

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date

BIOMASS Objectives and Products

BIOMASS Primary Objective: reducing the major uncertainties in the role of forests and their changes in the Earth's carbon cycle and climate.

The 5-year mission, launch due mid-2024, has three principal biophysical products:

Product	Resolution	Accuracy
Above Ground Biomass (AGB)	200 m	< 20% (or < 10 t/ha for AGB < 50 t/ha)
Forest Height	200 m	Biome-dependent, < 30% for trees higher than 10 m
Deforestation	50 m	Detection at a specified level of significance

Secondary Objectives

- sub-surface mapping in arid zones
- icesheet motion
- bare earth Digital Terrain Model
- ionospheric structure

Fate of anthropogenic CO_2 emissions (2011–2020)

Sources

9.5 ± 0.5
GtC/yr
90%

1.1 ± 0.7
GtC/yr
10%

Sinks

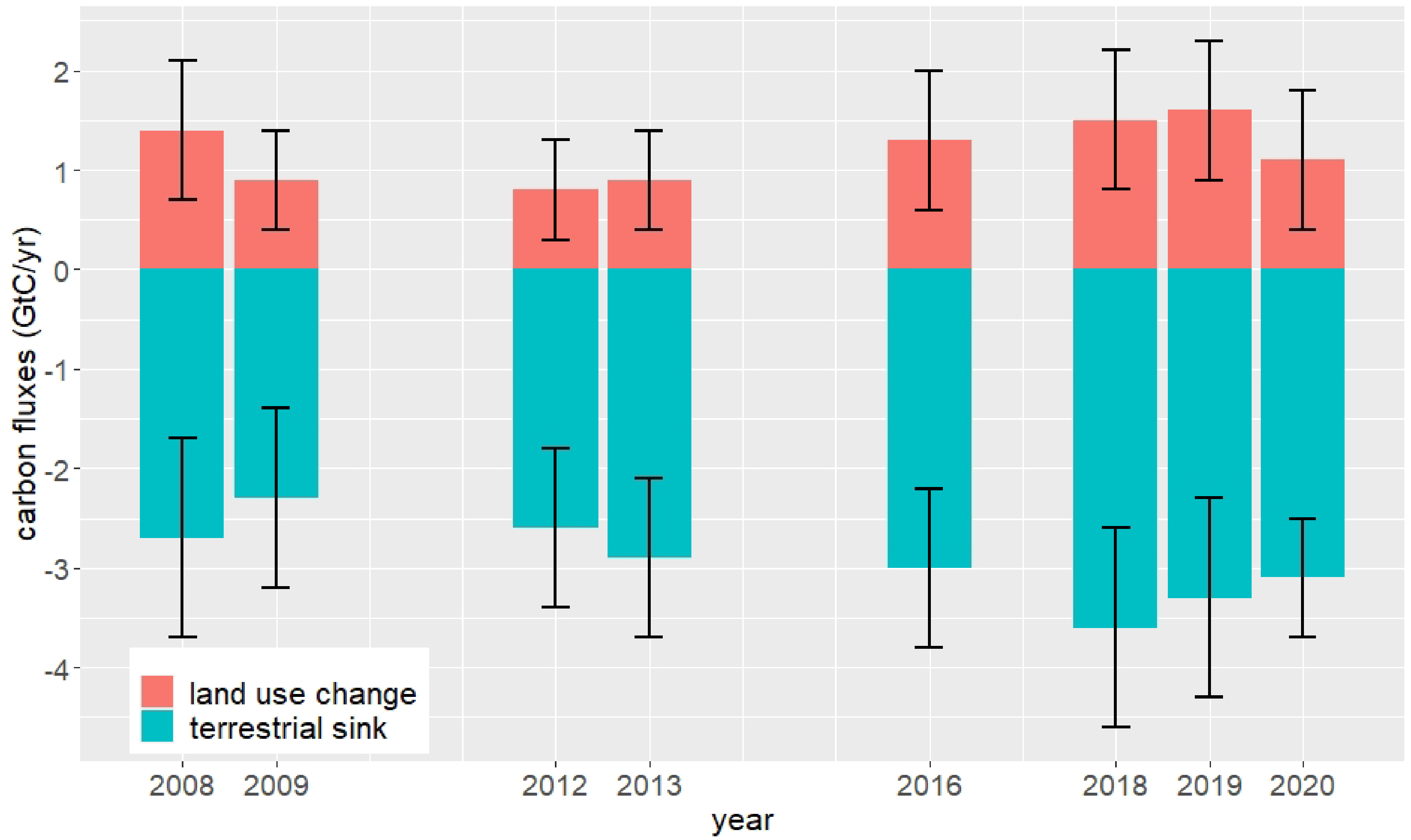
5.1 ± 0.02
GtC/yr
48%

3.1 ± 0.6
GtC/yr
29%

2.8 ± 0.4
GtC/yr
26%

Note: Sum of sources ≠ sum of sinks, indicating estimation bias in at least one of the fluxes.

Land Use Change Emissions & the Terrestrial Sink



Terrestrial sources and sinks

The land has three independent fluxes involving biomass:

1. Forest disturbance (deforestation and degradation) fluxes (predominantly tropical)
2. Forest growth (managed or occurring on abandoned agriculture/rangeland)
3. Climate-driven photosynthesis sink (CO2 fertilisation, temperature)

The Net Land Use Change Flux is (1) – (2)

LUC (GtC/y)	Loss	Uptake	Net	Other Land Uptake (model-based)
2010-2019	-4.4 ± 1.6	2.9 ± 1.2	-1.6 ± 0.7	3.4 ± 0.9
2011-2020	-3.8 ± 0.6	2.7 ± 0.4	-1.1 ± 0.7	3.1 ± 0.6

Using BIOMASS data to estimate disturbance emissions

ΔA = Activity data

Key strength of BIOMASS is in the emissions from tropical forest disturbance.

Current approach:

$$\text{Emissions} = \Delta A \times EF$$

A = forest area

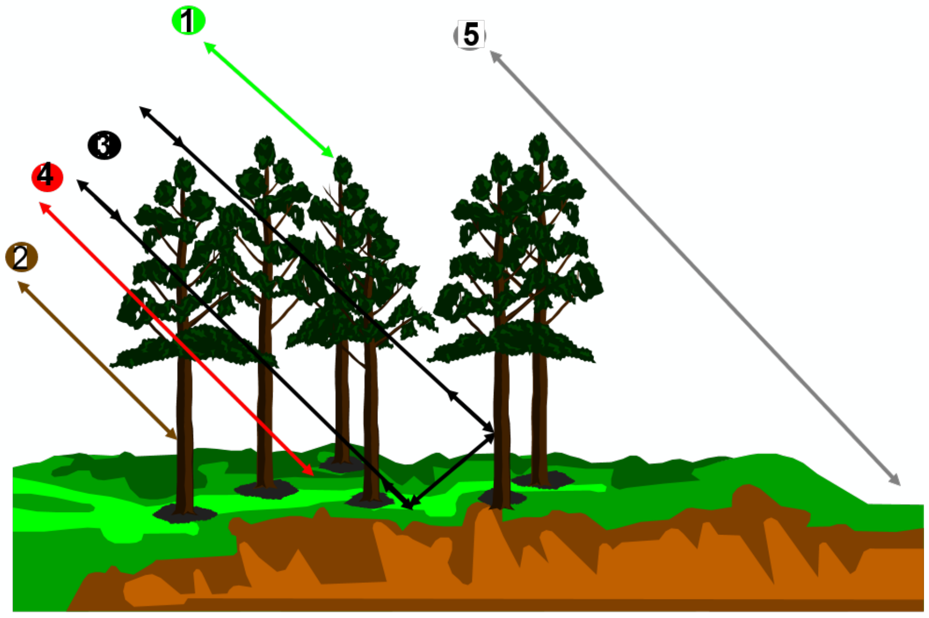
EF (efficiency factor) is typically a value for a whole region or forest type and clearly depends on AGB.

BIOMASS will measure the biomass change where forest is lost:

$$\text{Emissions} = \Delta A \times \Delta B$$

The capacity to measure loss of biomass through degradation is unclear. Expected that degradation will be detectable if at least 20-30% of AGB is lost.

Estimating the regrowth flux

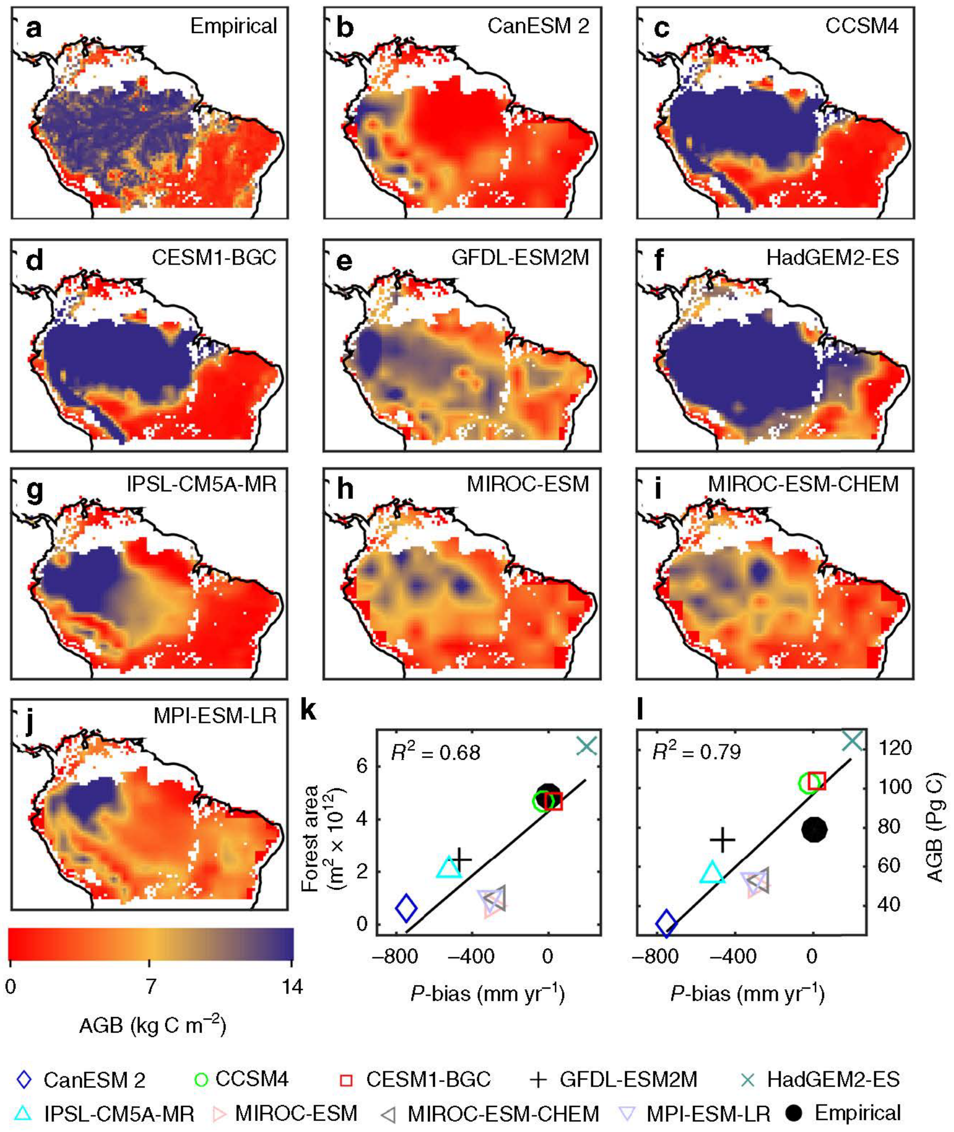


1) Direct Crown scattering
2) Trunk scattering
3) Trunk-ground & ground-trunk (double-bounce)
4) Attenuated ground
5) Direct ground

The high penetration at P-band leads to a significant soil contribution (double bounce) in the return.
In taller forests, coherent subtraction of images (from the INT or TOMO phases) allows the ground to be cancelled.

For younger, smaller forests this will not be effective.
Hence estimating the regrowth flux will require combining P- & L-band, and the full 5-year mission time will be needed.

The land sink is estimated using models: can BIOMASS test them?



Shown are Climate Model Inter-comparison Project (CMIP5) estimates of the AGB of the Amazon:

- Very different
- Highly correlated with modelled precipitation differences

Top left is AGB map from Saatchi et al. (2011) based on Icesat GLAS data.

If we could trust the Saatchi map we could identify the best-performing model.

Key question: How do assess the accuracy of space-derived AGB maps?

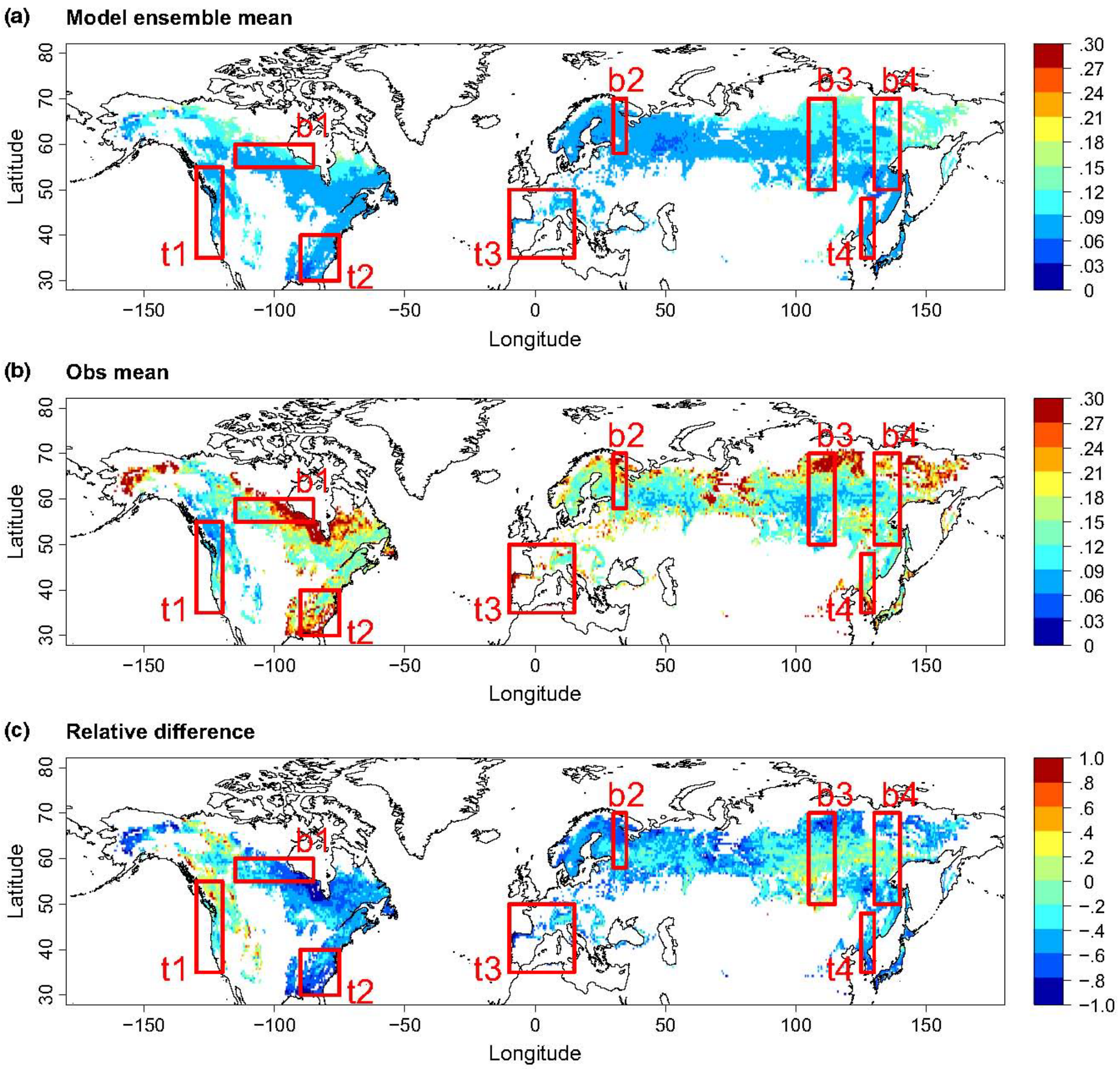
Carbon residence time (biomass/NPP) to test models

If loss rate is proportional to biomass, B, the equilibrium value of B is

$$B = \tau P,$$

where P is the Net Primary Production of biomass (NPP).

τ is the *carbon residence time*



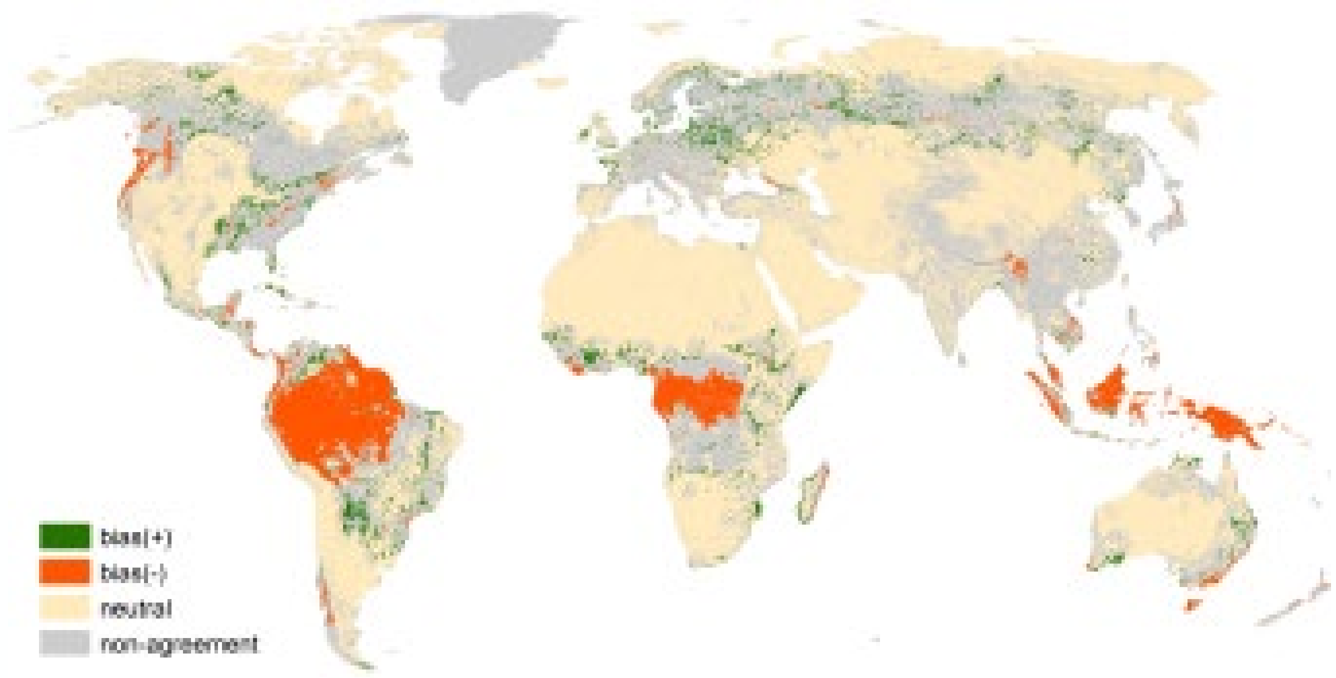
Modelled

"Observed": NPP (MODIS)/ biomass (Envisat)

Relative difference

Thurner et al. 2017

Assessing biomass map accuracy with the CCI-Biomass Plot2Map tool



Patterns of bias in 4 global AGB maps: Baccini et al. (2000), GEOCARBON (2008), GlobBiomass (2010) & CCI Biomass (2017)

Red: all 4 under-estimate

Green: all 4 over-estimate

Sand: no bias

Grey: maps disagree in bias

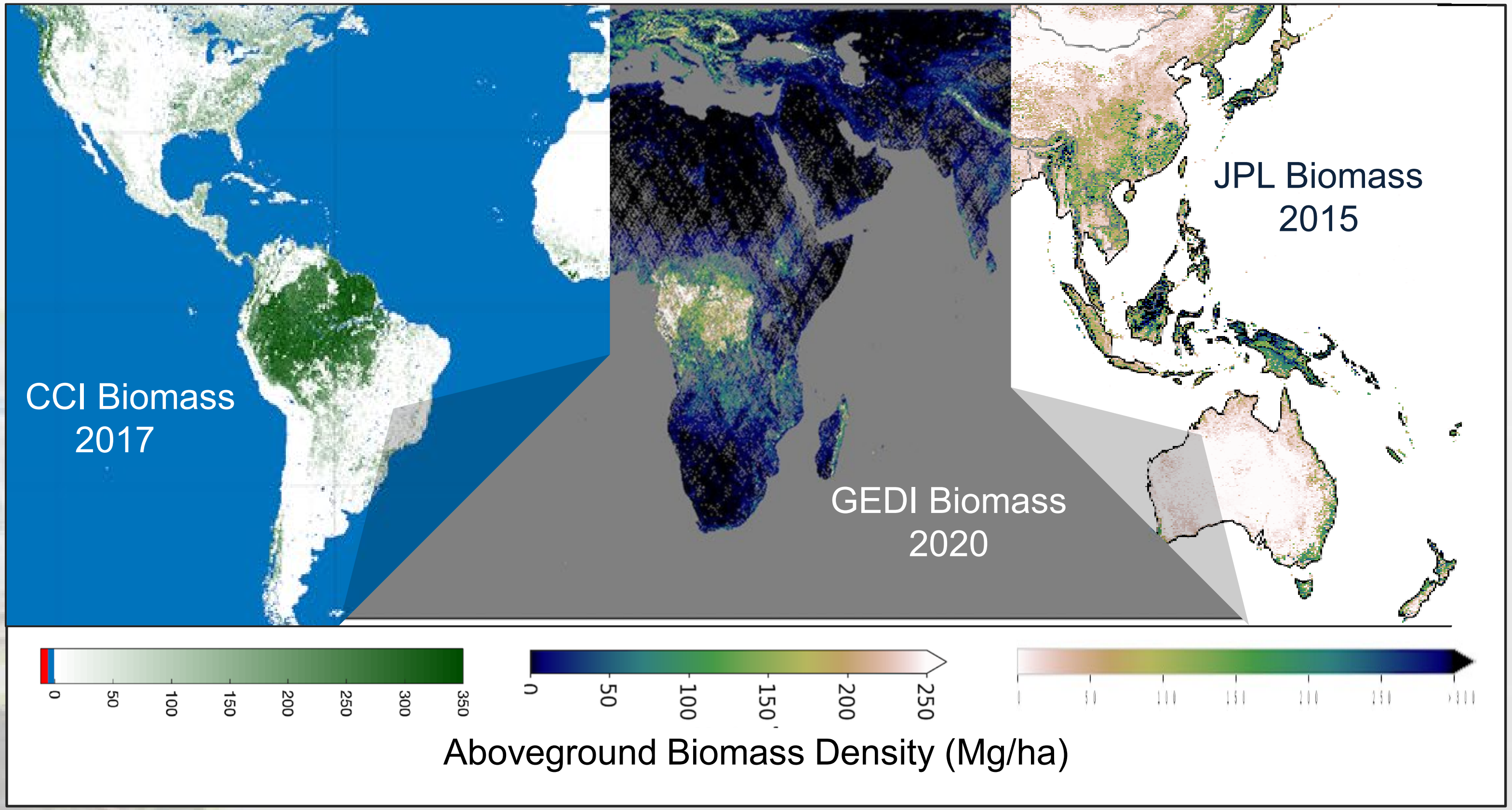
Plot2Map (Araza et al. 2021) is an outcome of CCI-Biomass that uses a global collection of in situ AGB data to estimate biases in AGB maps.

It provides a framework for:

- comparing maps
- assessing their accuracy
- bias correction

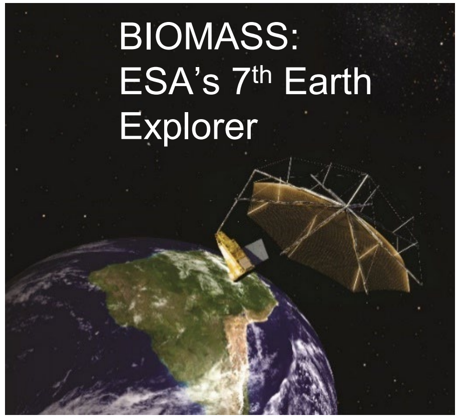
Biomass Harmonization for the Global Stocktake (GST)

- Several biomass products will be publicly available in advance of the GST (e.g. NASA's GEDI, ESA's CCI Biomass, NASA-ISRO NISAR)
- To bolster uptake of these considerable CEOS agency investments, **a harmonized approach to using these data optimally in national reporting is desirable**.

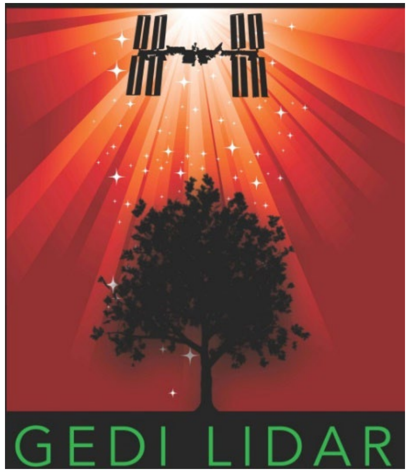


BIOMASS in a Global Carbon Observing System

Forest AGB & height (2024-2029)



Forest structure & AGB < 100 t/ha (2022-32)



Forest structure & AGB (2018-2023)

The "4th mission": in situ networks

- 3 new missions dedicated to measuring forest properties.
- Major support from ground networks: Forest Observing System, GEO-TREES
- Other L-band and C-band SAR data, L-band radiometry, IceSAT-2 lidar

The combined capability is far greater than the sum of its parts.

Final Remarks

- When it takes 20 years from proposing a mission to its launch, the world changes around it: scientific knowledge, technical capabilities, political and social priorities.
- The scientific problem which BIOMASS addresses is still as pressing as it was when the mission was proposed – the uncertainties about the role of biomass in the global carbon cycle are just as large as in 2005.
- The Paris Agreement makes accurate biomass information ever more important in international climate politics.
- The value of BIOMASS will only be realized by treating it as a crucial part of the whole system for estimating the terrestrial C cycle: sensors, models, in situ networks.
- The combination of BIOMASS, GEDI and NISAR (and other missions) offers an unprecedented opportunity to estimate biomass accurately from space. This requires tools for assessing and optimally combining these data:
    - Plot2Map
    - The ESA/NASA Mission Algorithm & Analysis Platform