



Forest Carbon Monitoring

Mapping Forest Change using Planet's Nanosatellite Constellation



Christopher Anderson, PhD., Lead Scientist

Aboveground Carbon (3m) | Putamayo River, Brazil | Spring 2024



Product Overview

Layers Included

Canopy Cover

Canopy Height

Aboveground
Live Carbon

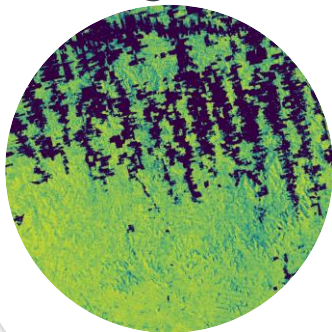
Each includes pixel-level:

- Uncertainty
- QA flag
- Day of year

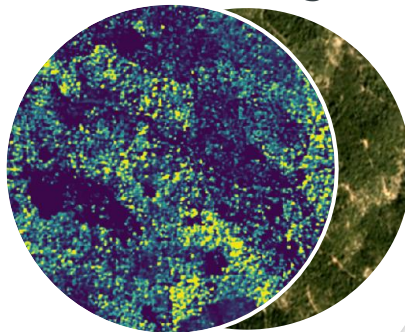
(Diligence only)

Products

Diligence

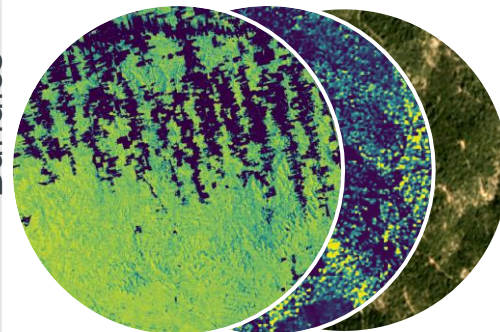


Monitoring



Bundles

All Access



Spatial resolution	30m	3m
Temporal frequency	Annual	Quarterly
Archive	2013-2023	From subscription onward
Includes	1-year delay	Quarterly visual PlanetScope Basemap
Launch Date	October 2023	September 2024

- Diligence + Monitoring
- Unlimited area

Enterprise & Platform

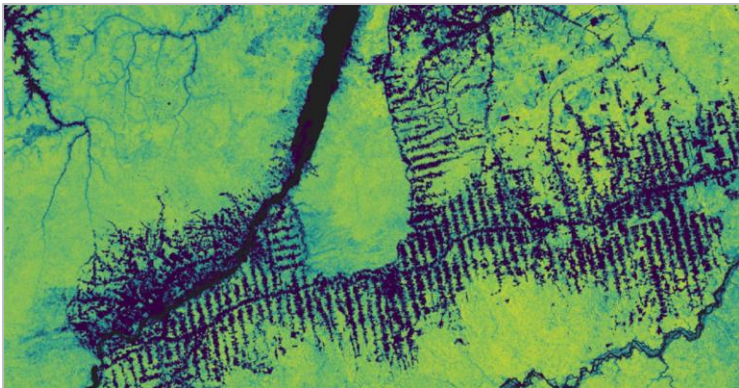
Small

Large

Custom

Custom





PLANET FOREST CARBON DILIGENCE TECHNICAL SPECIFICATION

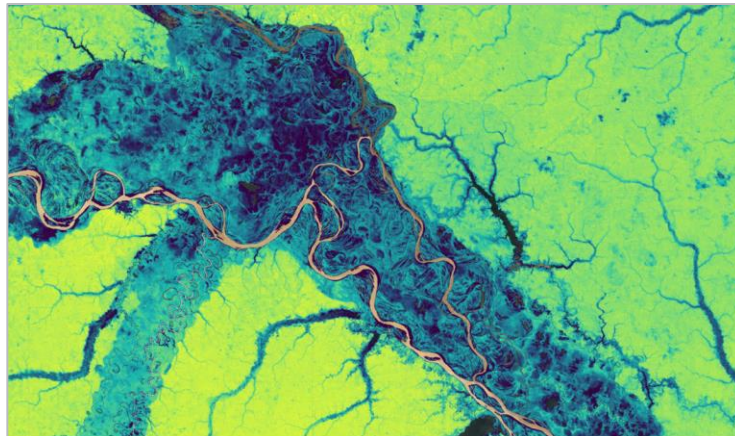
Version 1.1, April 2024

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PLANET FOREST CARBON DILIGENCE VALIDATION AND INTERCOMPARISON REPORT

Version 1.1 April 2024

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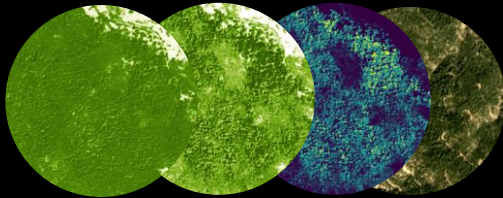
Tel. +1 (415) 419-2194

<https://www.planet.com/pulse/forest-carbon-diligence-breaking-down-the-validation-and-intercomparison-report/>



+ Forest Carbon Monitoring

Global, 3m resolution, quarterly, archive to 2021



Canopy
Cover

Canopy
Height

Aboveground
Carbon Density

Planetscope
+ Streaming
Basemaps

Target Markets

VOLUNTARY
CARBON MARKET
(VCM)

SUPPLY CHAIN &
CLIMATE RISK
MONITORING

JURISDICTIONAL
CARBON
MONITORING

Product Summary

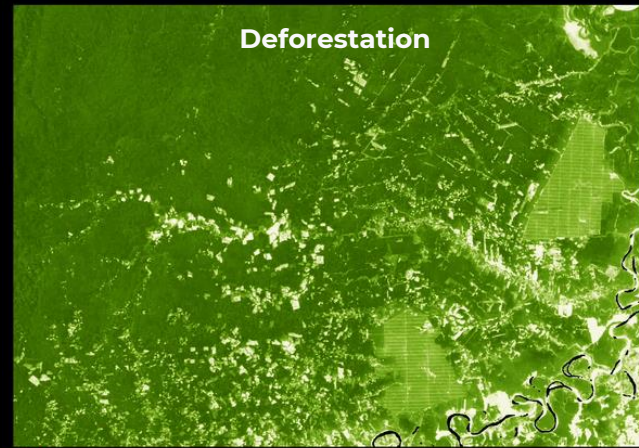
Canopy cover (%) and canopy height (m) track high resolution forest change

Aboveground carbon density provides a downscaled, GEDI-like forest carbon product with wall-to-wall spatial coverage

Quarterly updates from Q1 2021 to present

Global terrestrial land mass coverage

Statistically calibrated prediction intervals quantify pixel-level uncertainty



2021

2022

2023

2024



2021

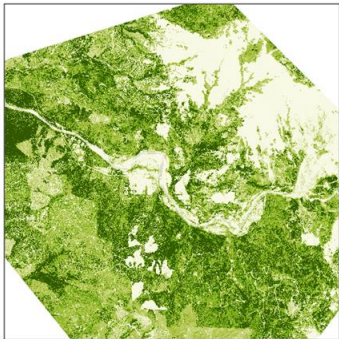
2022

2023

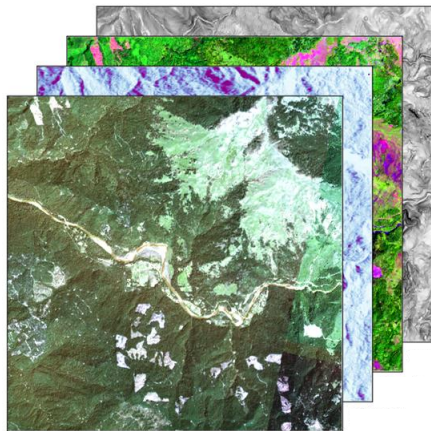
2024



Canopy Height (m)
0 30



Training data (LiDAR)

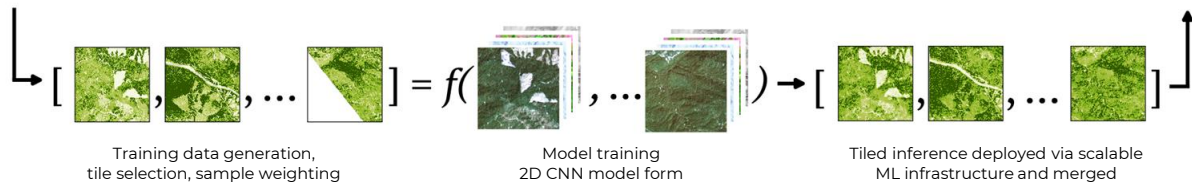
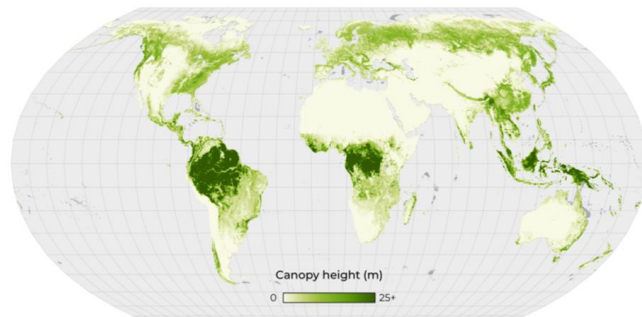
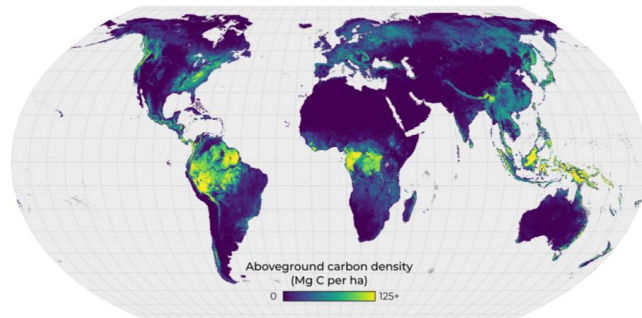
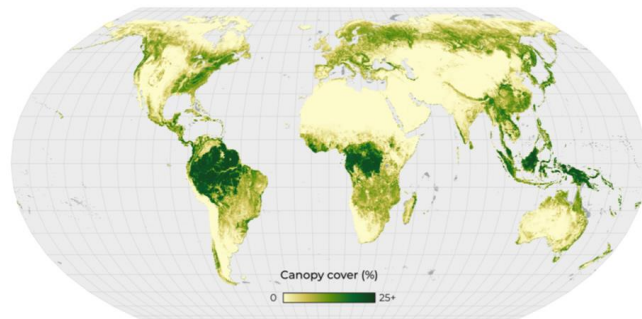
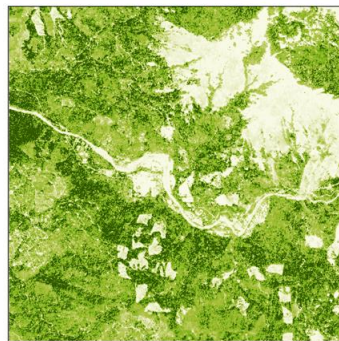
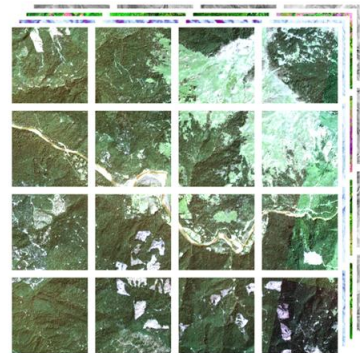
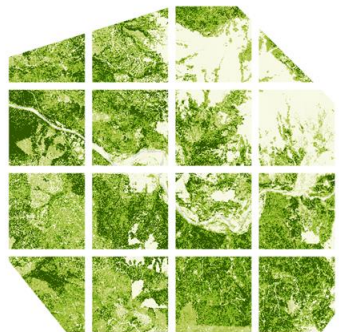


Covariate data (multiple satellites)


**Global forest
monitoring
at-scale with AI and
multi-sensor fusion**



Global model predictions



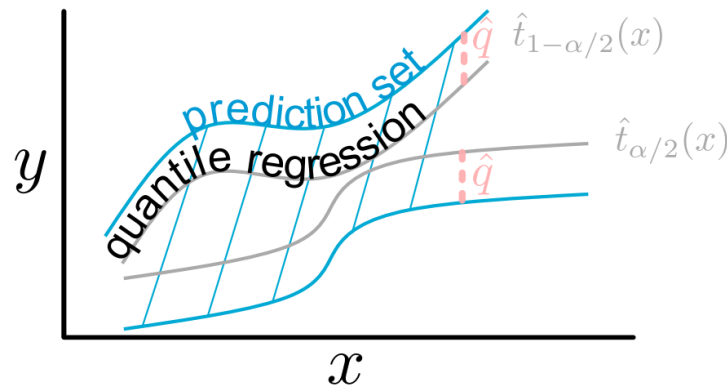


Pixel-level uncertainty quantification

Distribution-free & model agnostic uncertainty quantification via conformalized quantile regression

A calibration dataset is used to estimate the width of the interval to achieve 90% coverage.

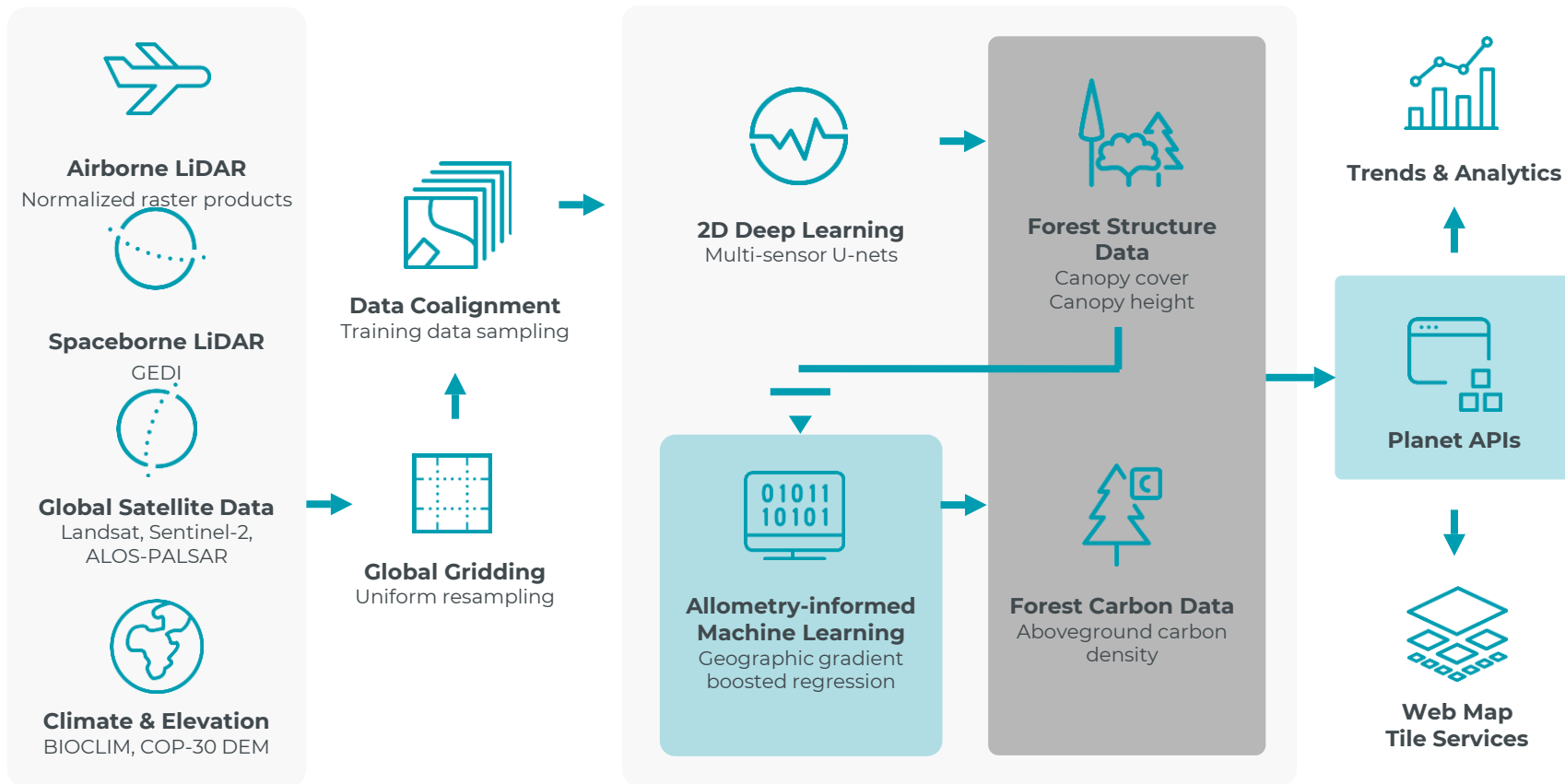
1. Model lower and upper quantiles
1. Assess coverage on calibration data
1. Adjust intervals to hit target coverage



Angelopoulos, Anastasios N., and Stephen Bates. "Conformal prediction: A gentle introduction." *Foundations and Trends® in Machine Learning* 16.4 (2023): 494-591.



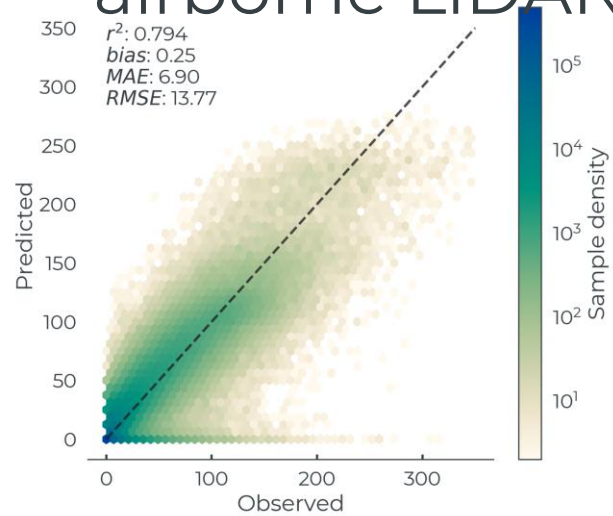
Forest Carbon Diligence (30m)



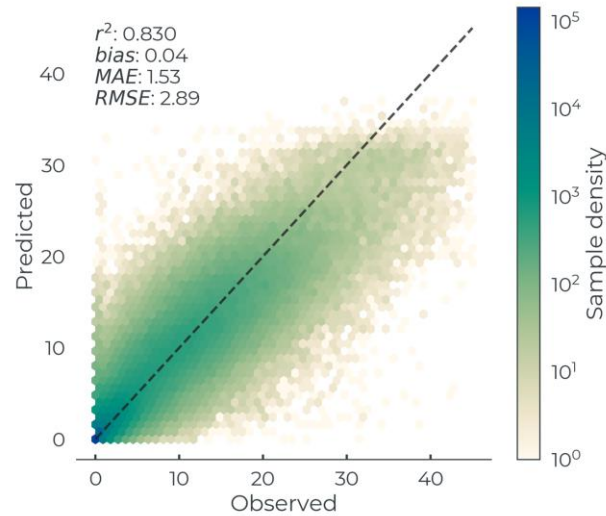


Training data performance

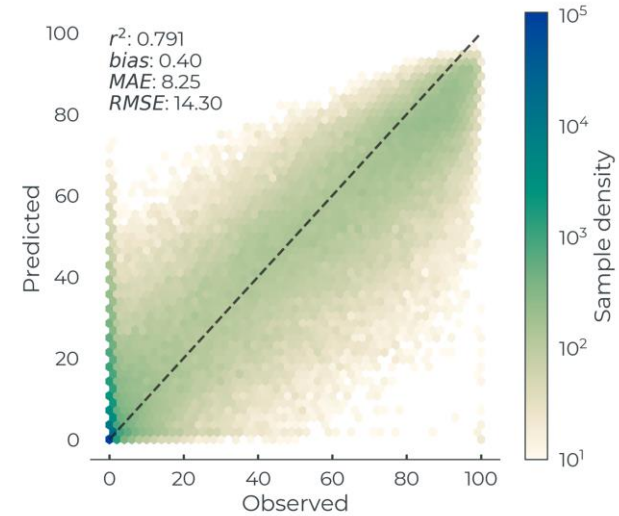
Global evaluation on 1km GEDI L4B 30m airborne LiDAR



Aboveground Carbon Density (Mg C ha^{-1})
1 km L4B



Canopy Height (m)



Canopy Cover (%)

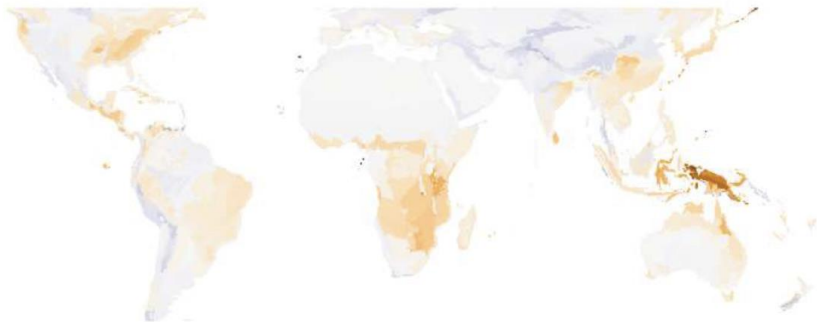


Mid-latitude intercomparison

Ecoregion scale
GEDI vs Diligence, CCI Biomass

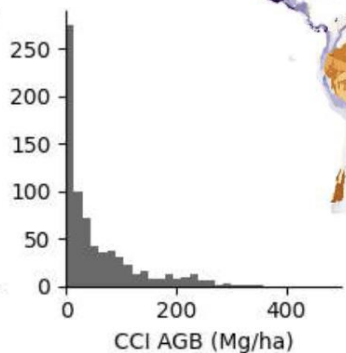
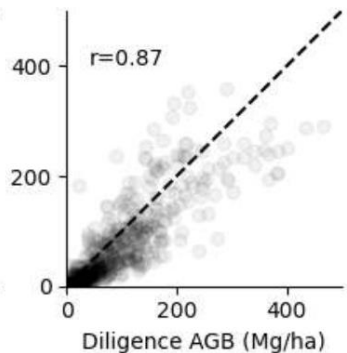
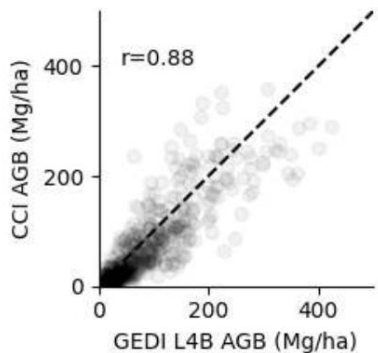
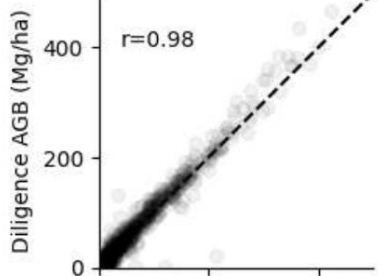
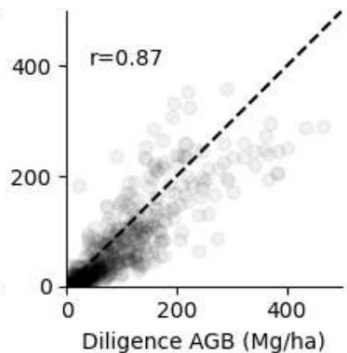
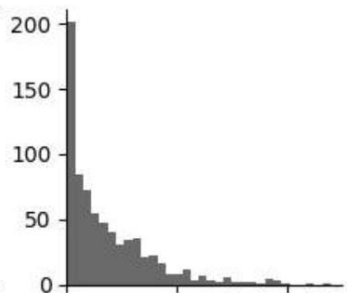
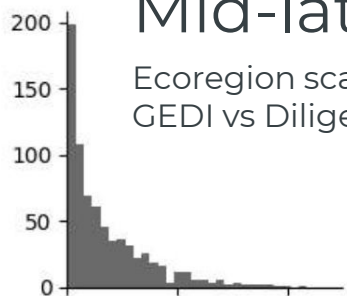
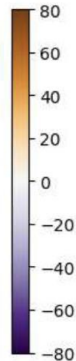
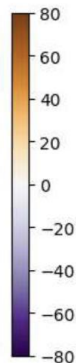
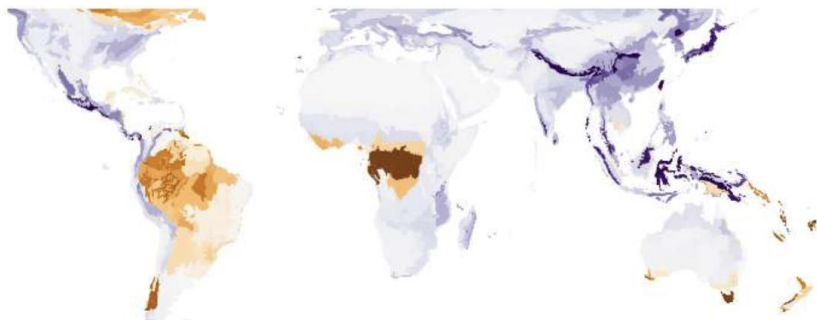
A

Diligence - GEDI L4B AGB (Mg/ha)



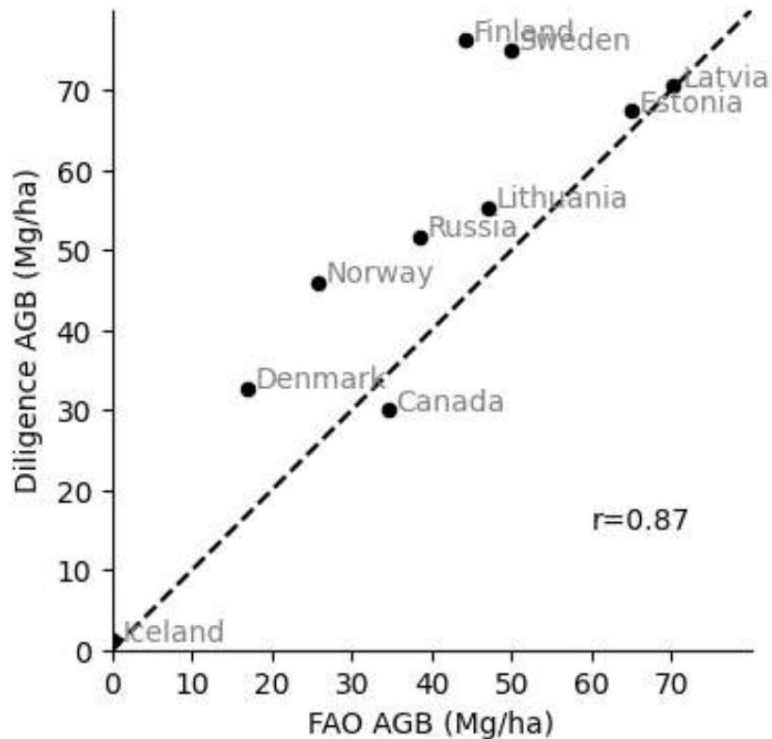
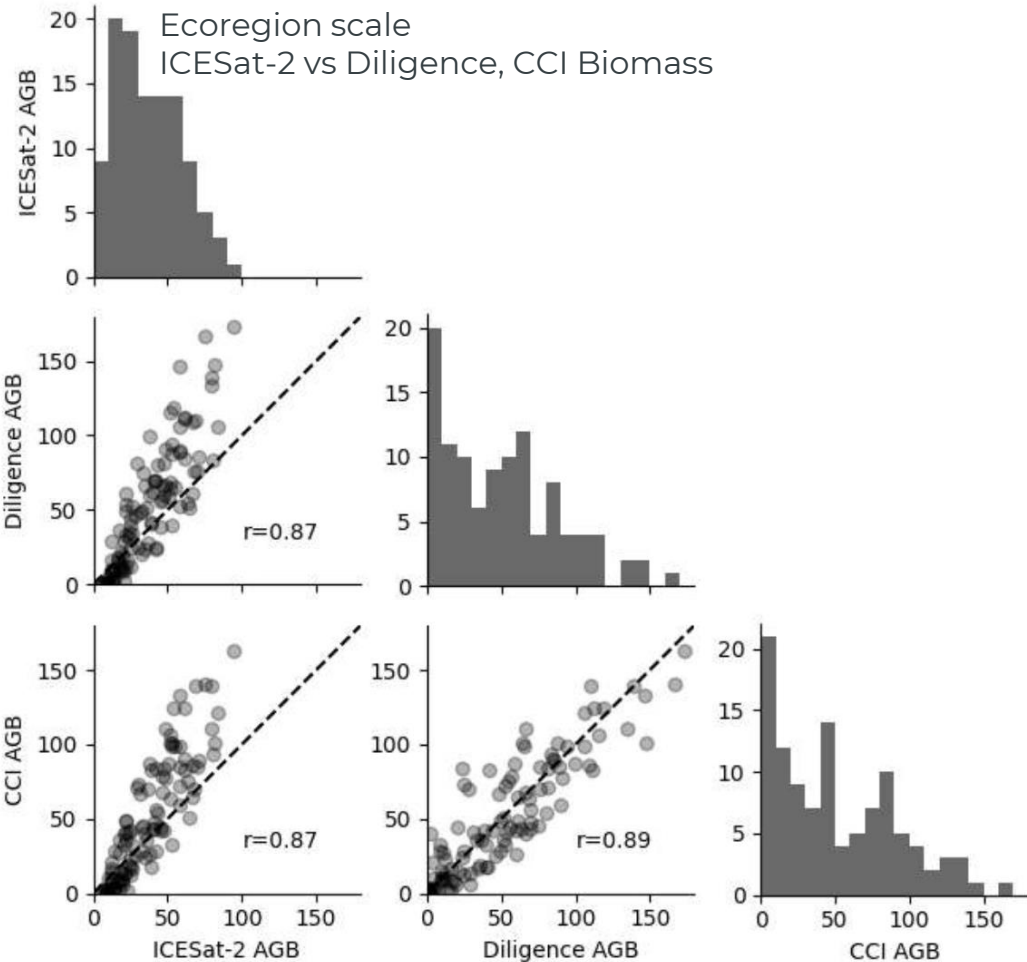
B

CCI - GEDI L4B AGB (Mg/ha)



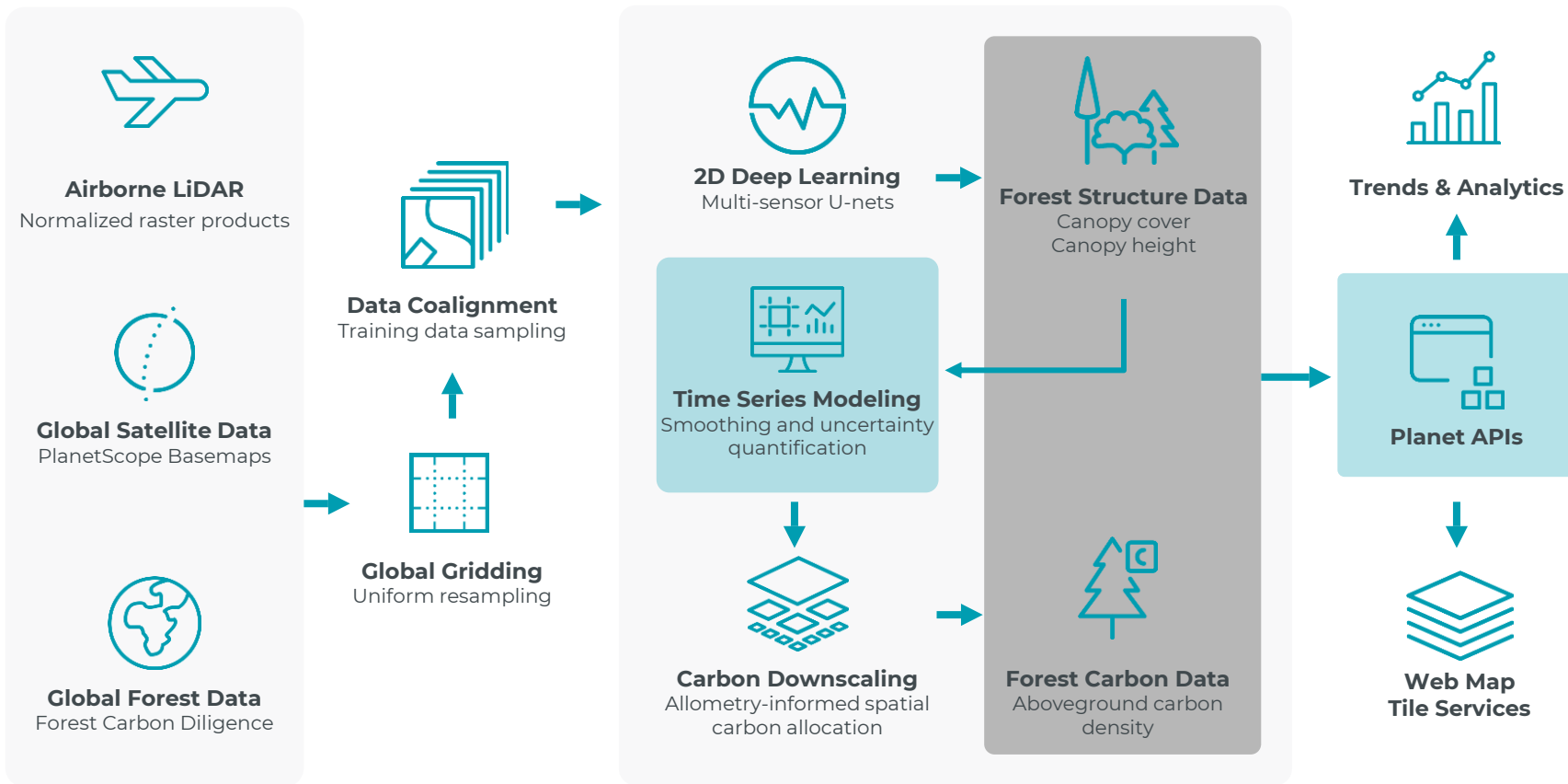
+ High latitude intercomparison

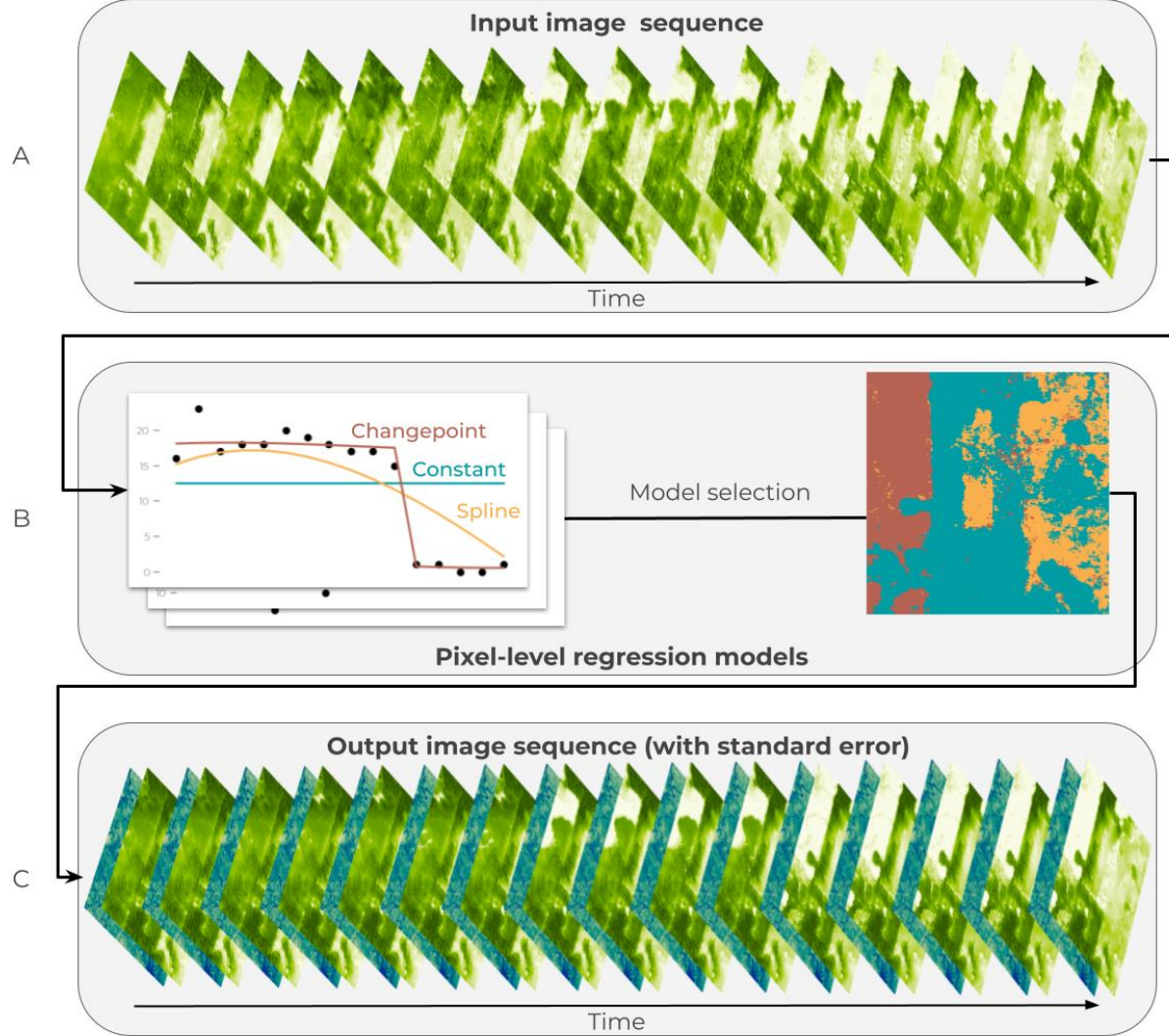
Ecoregion scale
ICESat-2 vs Diligence, CCI Biomass





Forest Carbon Monitoring (3m)







Test data performance

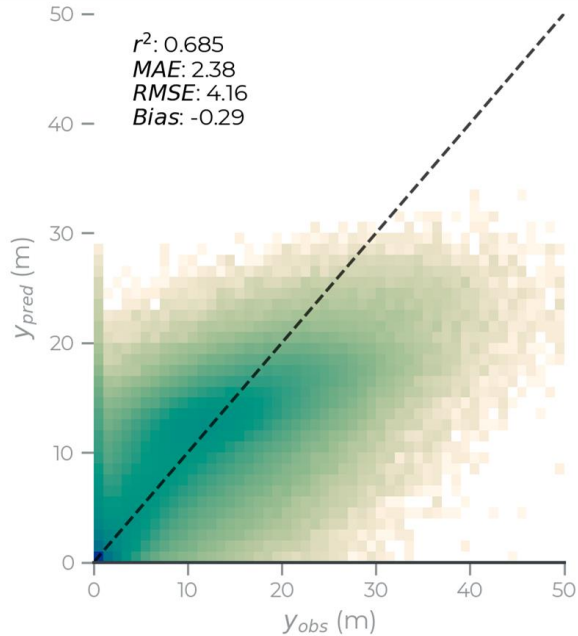
Canopy cover R2

3m: 0.68

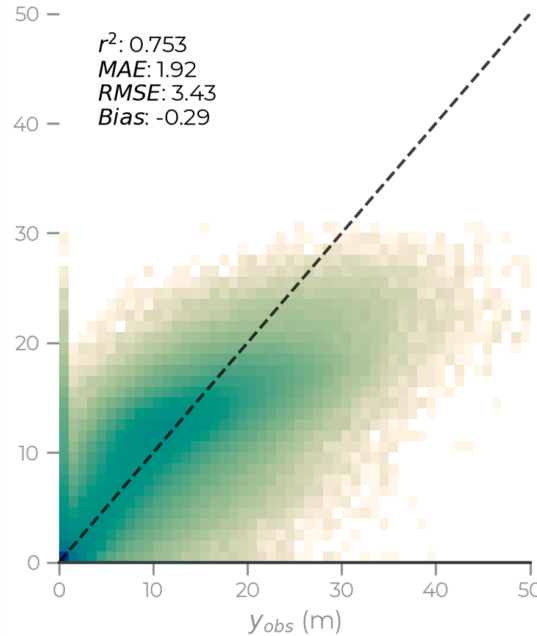
10m: 0.77

30m: 0.85

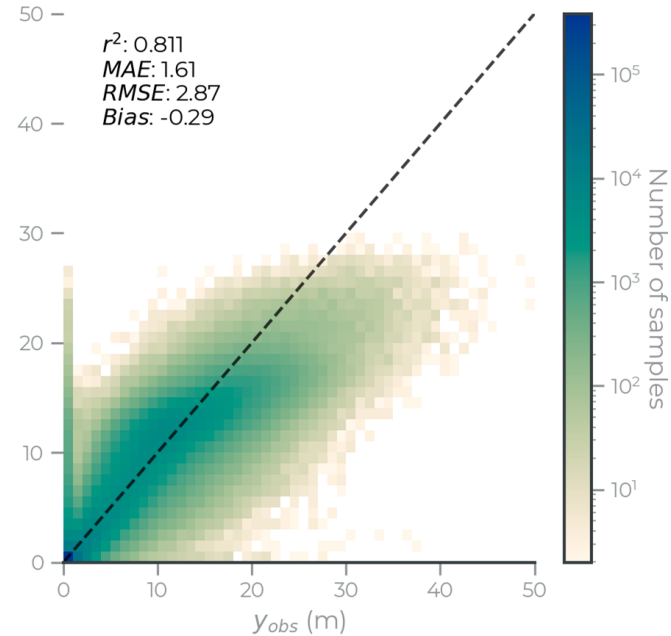
Canopy height (3 m)

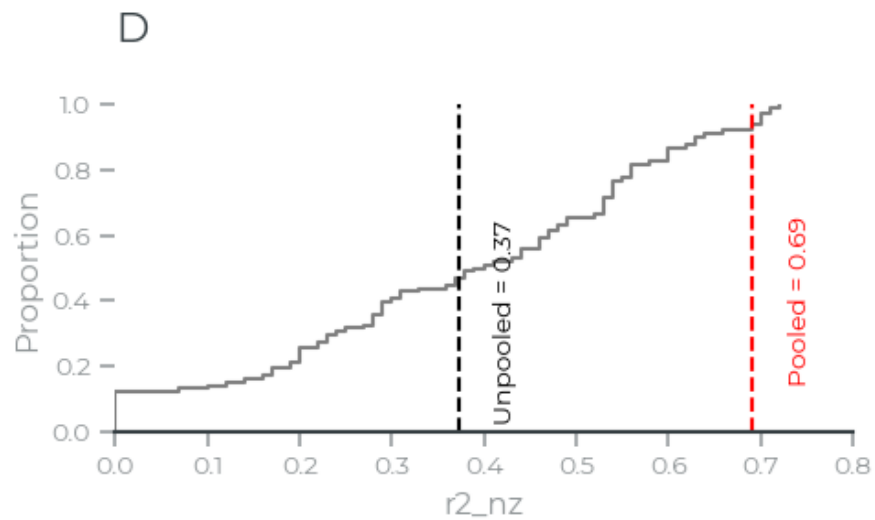
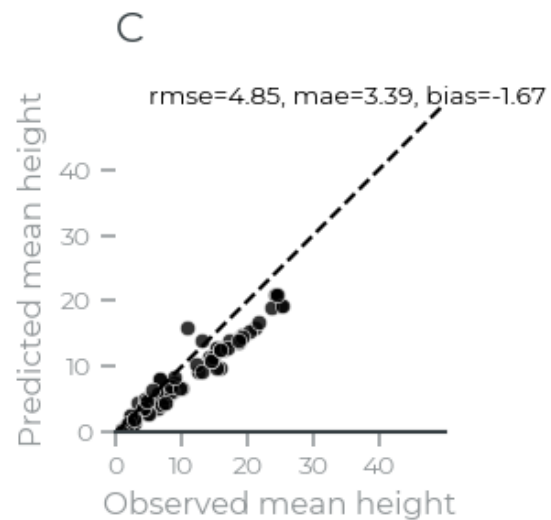
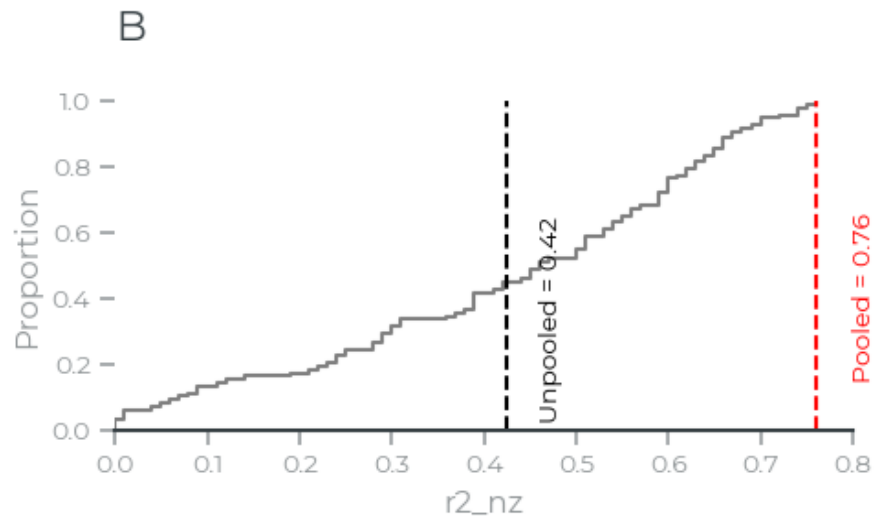
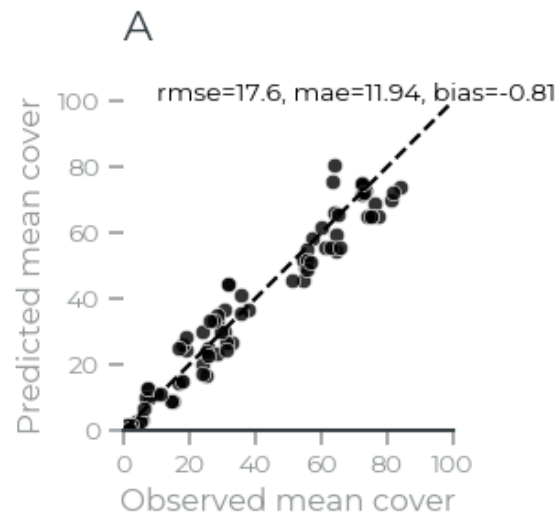


Canopy height (10 m)



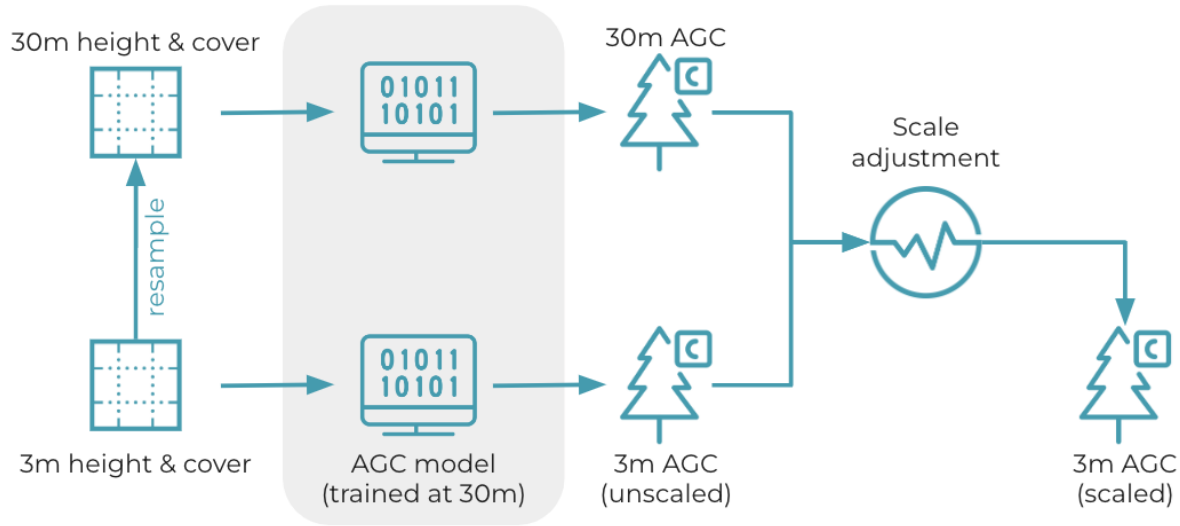
Canopy height (30 m)





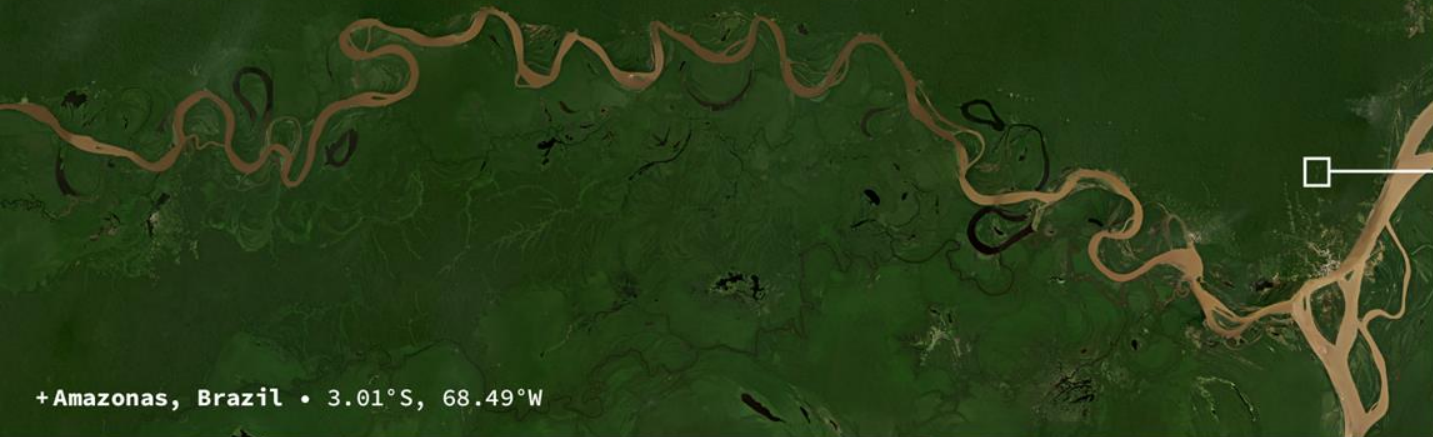


Carbon downscaling approach



- Area-based, not tree-based carbon model
- Model calibrated and evaluated at 30m, but provided as downscaled 3m product
- This supports simple, area-based aggregations, ensuring equivalence when aggregated back to 30m
- This should be the *minimum* scale of aggregation for retrieving carbon estimates

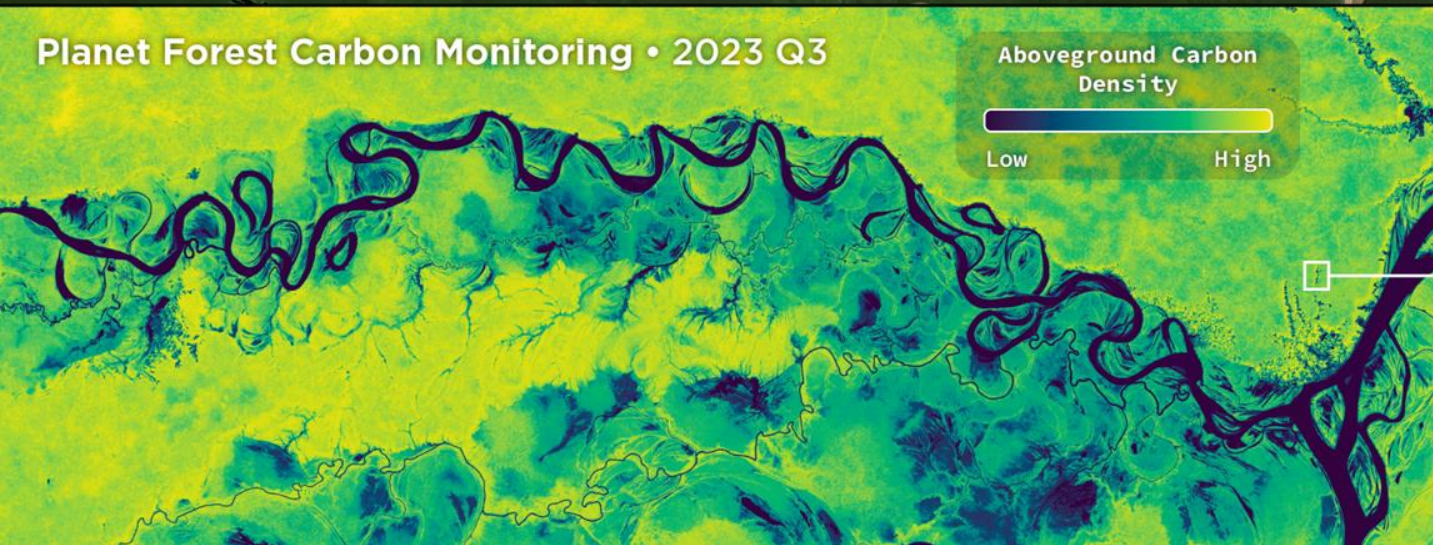
PlanetScope True Color Basemap • 2023 Q3



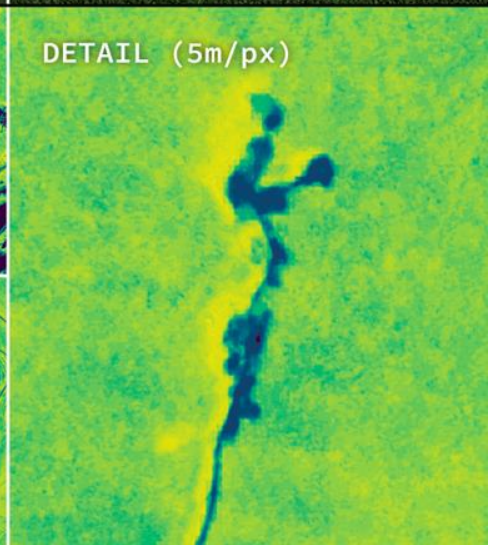
DETAIL (5m/px)



Planet Forest Carbon Monitoring • 2023 Q3

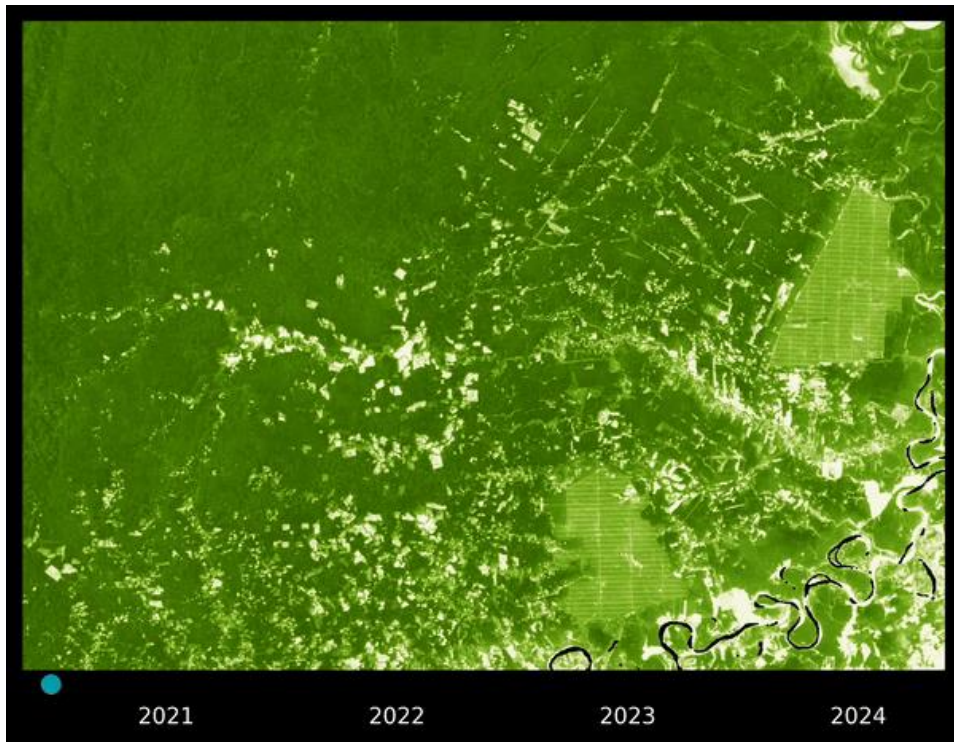


DETAIL (5m/px)





Why not provide the data at 30 m by default?



- We don't impose a 30m grid a priori. This allows users to aggregate pixels over irregularly-shaped areas—over a stand of harvested trees, or within a carbon project boundary, for example—to estimate changes in carbon density.
- So aggregation can be applied at the right scale for each use case. Aggregation to 1 ha minimizes uncertainty and is recommended by CEOS and others (Mascaro et al. 2011, Chen et al. 2016)
- High resolution data are critical for visual evaluation of carbon projects, ratings, and conservation monitoring, particularly for understanding fine-scale changes that occur as the result of a disturbance or land management activity.



Thoughts on uncertainty

- High levels of uncertainty at fine scales are expected, and should not preclude the use of high res data.
- Prediction skill and uncertainty decrease with aggregation, and nearly all use cases will require some form of aggregation.
- Model-based approaches should be preferred over design-based approaches to support comparisons across multiple quantification methods.
- Uncertainty quantification standards should minimize assumptions but reward rigor.
- Conformal inference is promising, estimating distribution-free prediction intervals in model-agnostic fashion.
- Key need is setting effective benchmarks for quantifying and comparing uncertainty across methods.

