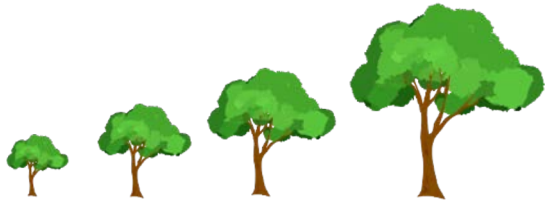
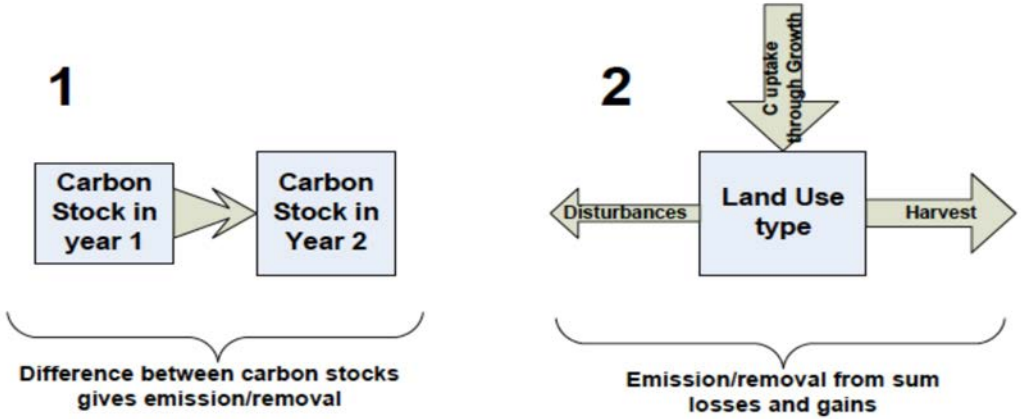
Combining satellite biomass and disturbances observations to monitor current sinks and project the future

P Ciais





From S Saatchi

(a) Stock change method

(b) Gain loss method

Stock change Method 1

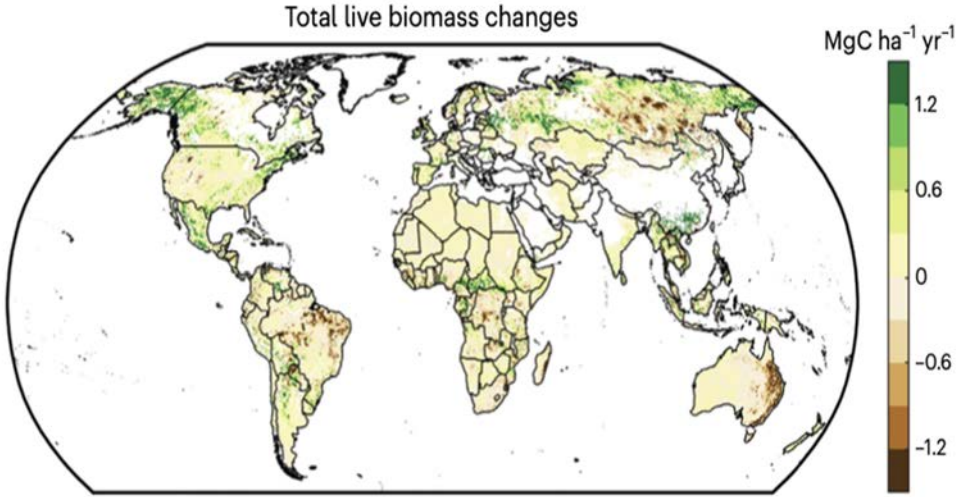
- Coarse resolution annual AGB change maps
- High resolution downscaling of AGB change
- Deep learning AGB change from GEDI and Sentinel 1-2

Gain loss Method 2

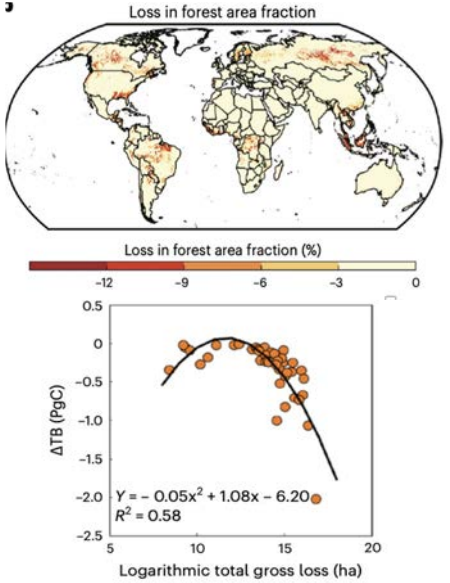
- High resolution recovery curves and explainable AI
- Secondary forests C budget for boreal and tropical forests

Method 1 –stock change
Global annual biomass change from VOD

- Daily microwave data from SMOS and SMAP at 25 km resolution
- Annual maps of biomass and biomass change since 2010 calibrated using ESA CCI Biomass maps
- We found a **net carbon loss in tropical forests**, due to deforestation and degradation
- Unlike in IPCC and GCP models, **most of the carbon sink is in young temperate and boreal**

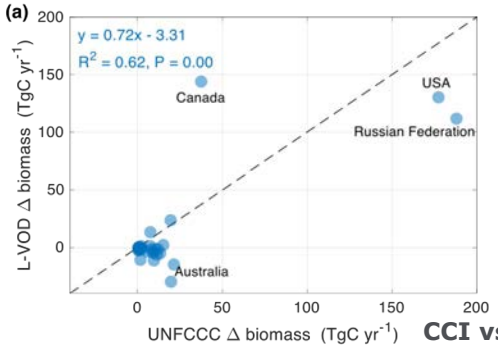


Yang et al. Nature Geosciences

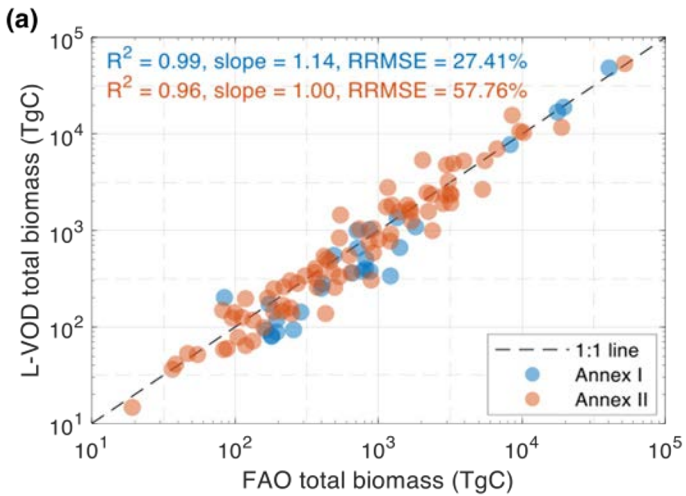


Comparison of biomass and biomass change

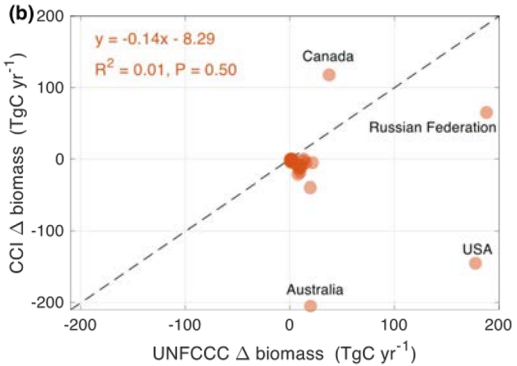
Biomass change
VOD vs UNFCCC



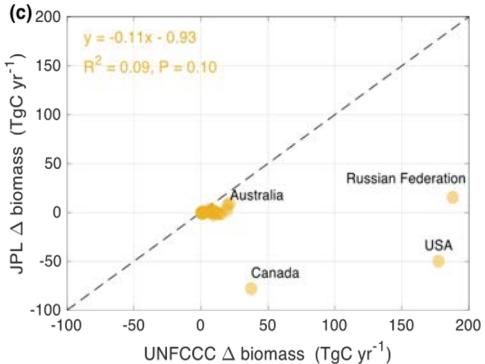
Mean biomass



CCI vs UNFCCC



JPL C-TREES vs UNFCCC

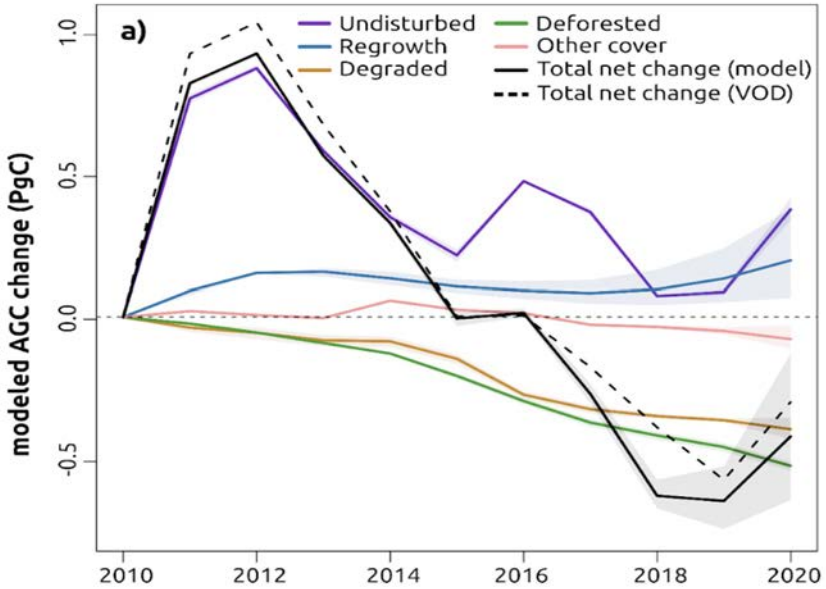


Downscaling L-VOD biomass to 100 m resolution data

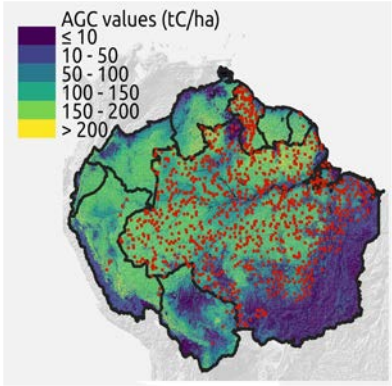
Statistical non parametric downscaling method

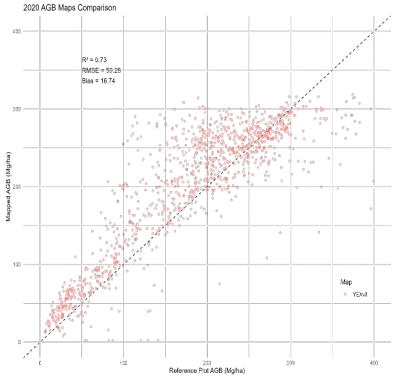
Input data : high resolution forest area loss, degradation, fires, climate, and Biomass CCI ESA

100 m maps of AGB change over the Amazon



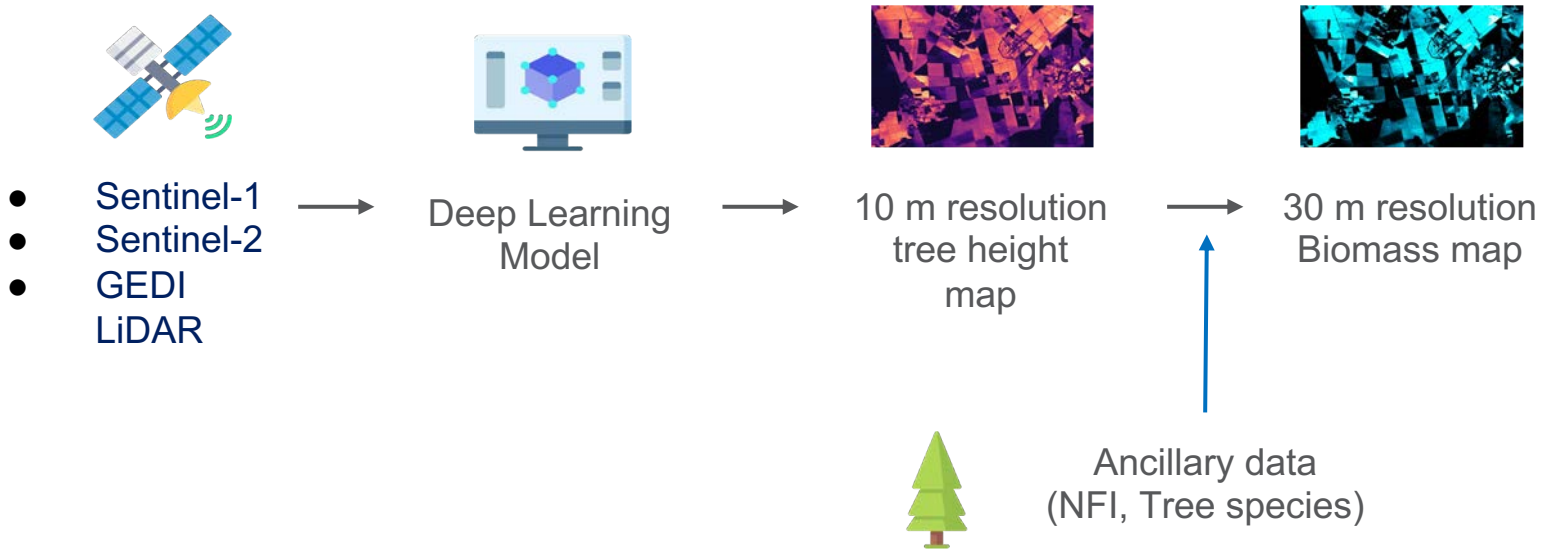
Validation against plot data





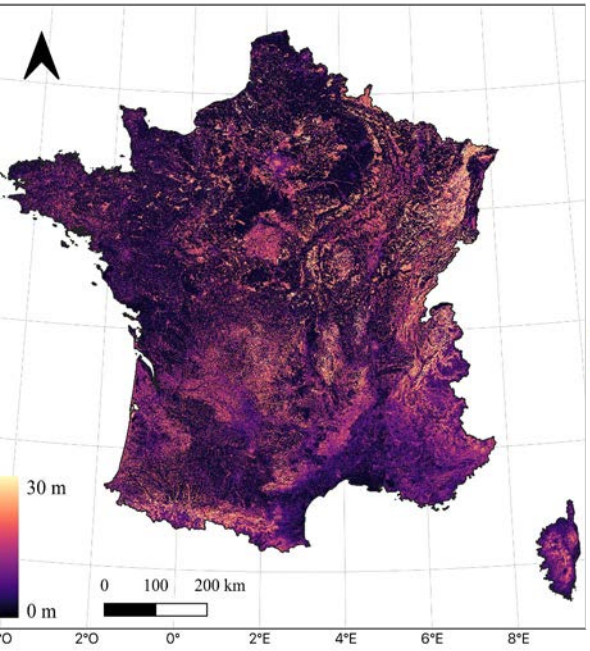
Mapping height and biomass at high resolution

A novel approach based on deep learning with Sentinel-1, Sentinel-2 and GEDI sensors

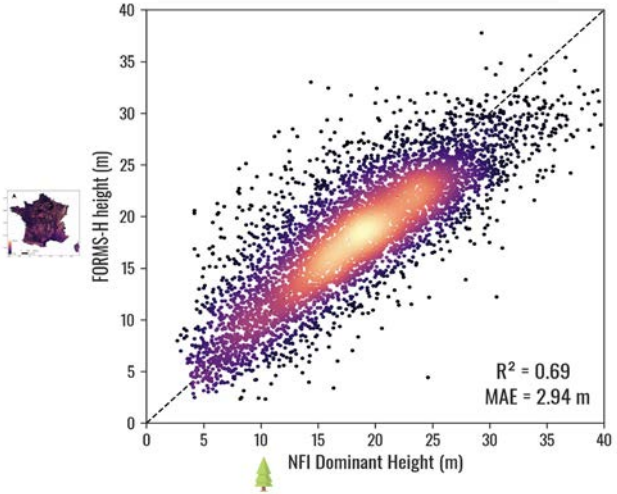


FORMS-H: **FOR**est **M**ultiple **S**atellite - **H**eight

Height at 10 m resolution

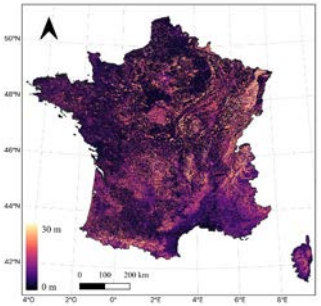


Comparison to Forest Plot data (5 475 plots)
French National Forest Inventory 2020, IGN



Biomass at 30 m resolution

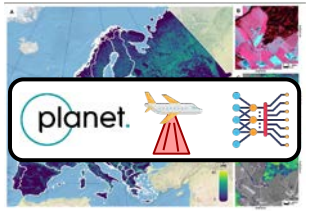
How does it compare to other models ?



FORMS-H
Schwartz et al. (2023)

Potapov et al. (2021)

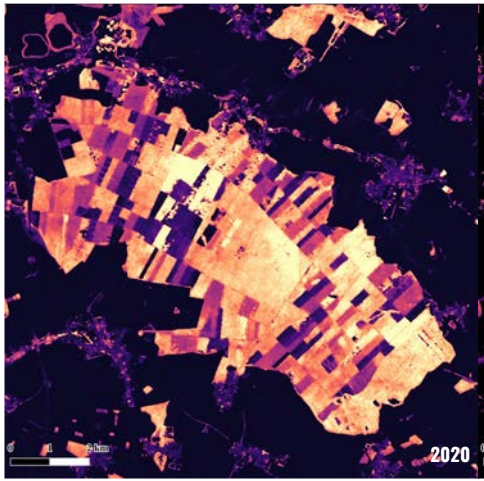
Lang et al. (2023)



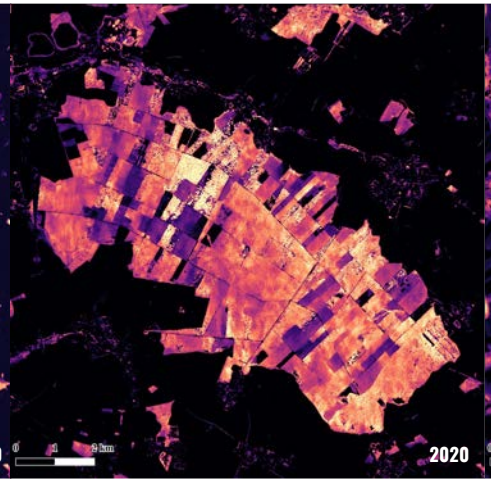
Liu et al. (2023)

Comparison with other models: Visual

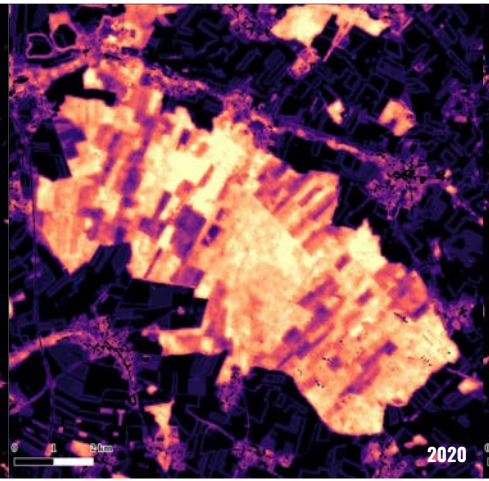
FORMS-H (Schwartz et al., 2023)



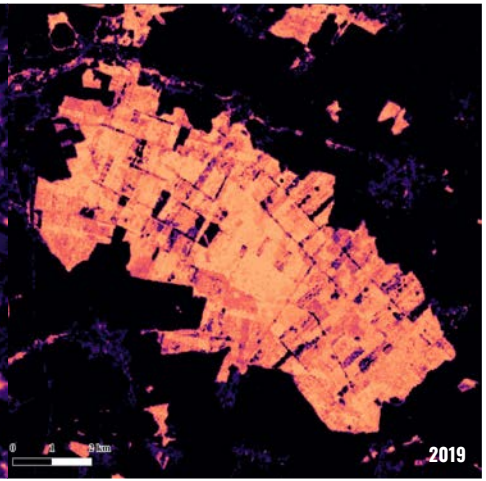
Liu et al. (2023)



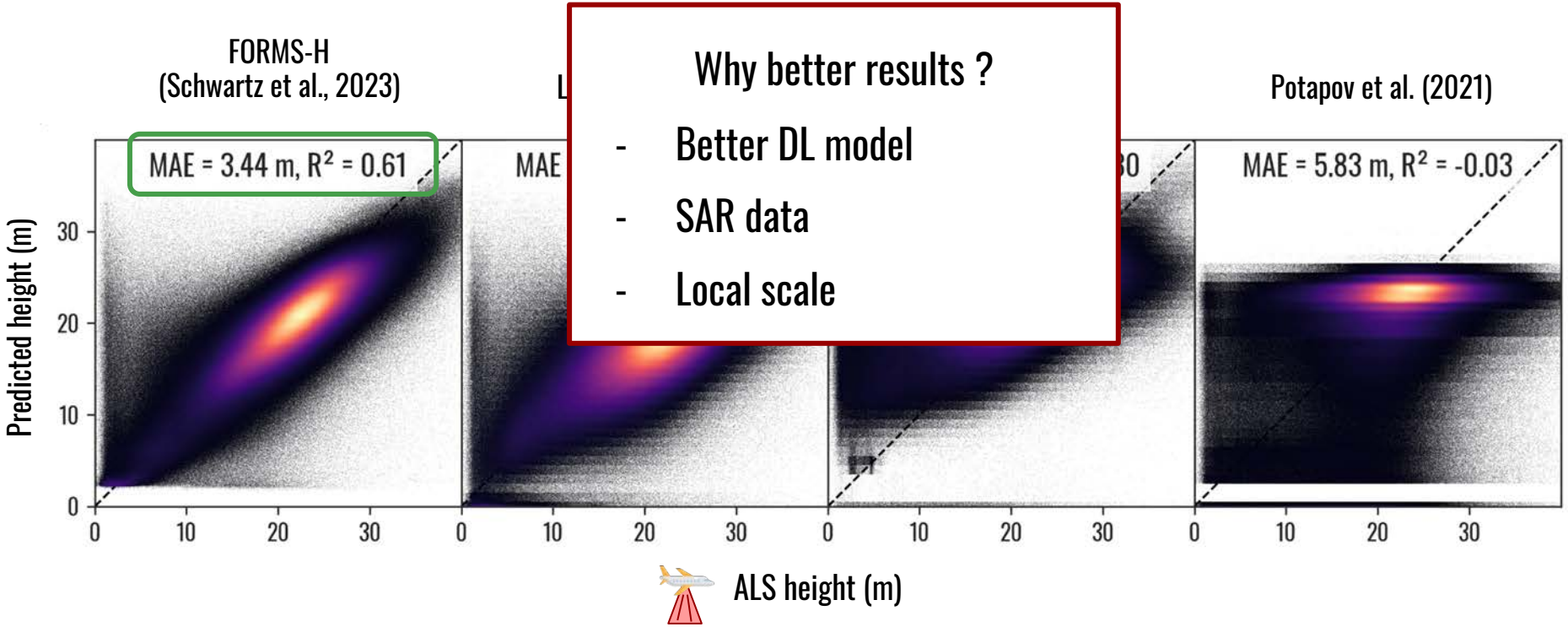
Lang et al. (2023)



Potapov et al. (2021)



Comparison with other models: Quantitative



Why better results ?

- Better DL model
- SAR data
- Local scale

Now Global !

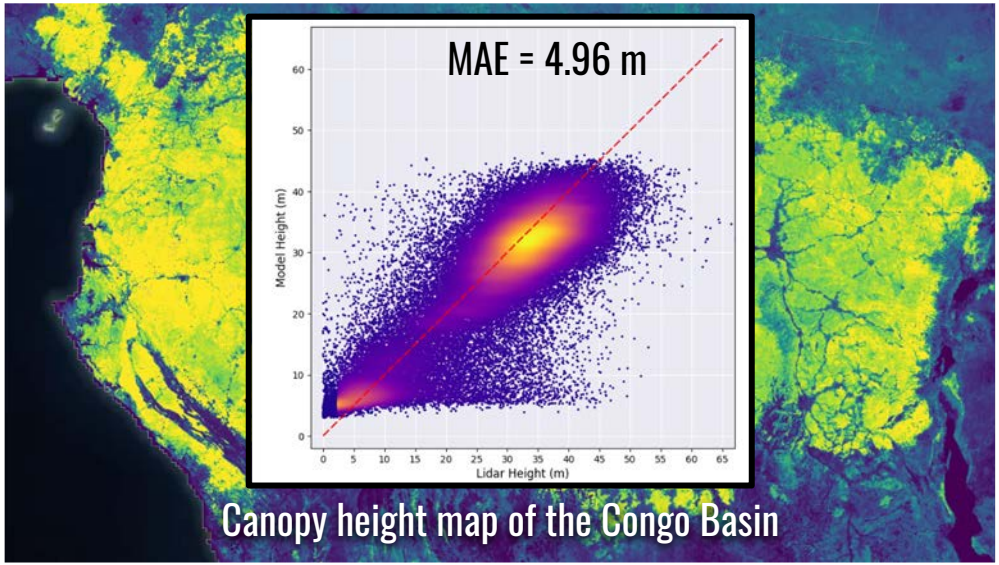
global maps can have same the quality than local maps

Pauls et al. 2024

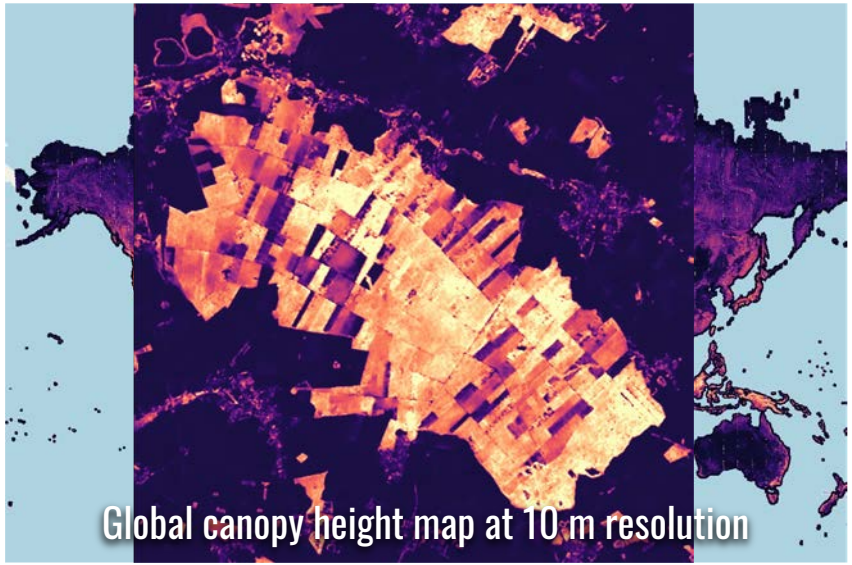
Congo basin : One Forest Vision Initiative & Kayrros

Universität Münster

Collaboration with Jan Pauls & Fabian Gieseke Global height map



Canopy height map of the Congo Basin



Global canopy height map at 10 m resolution

Can we do change ?

Year agnostic deep learning model

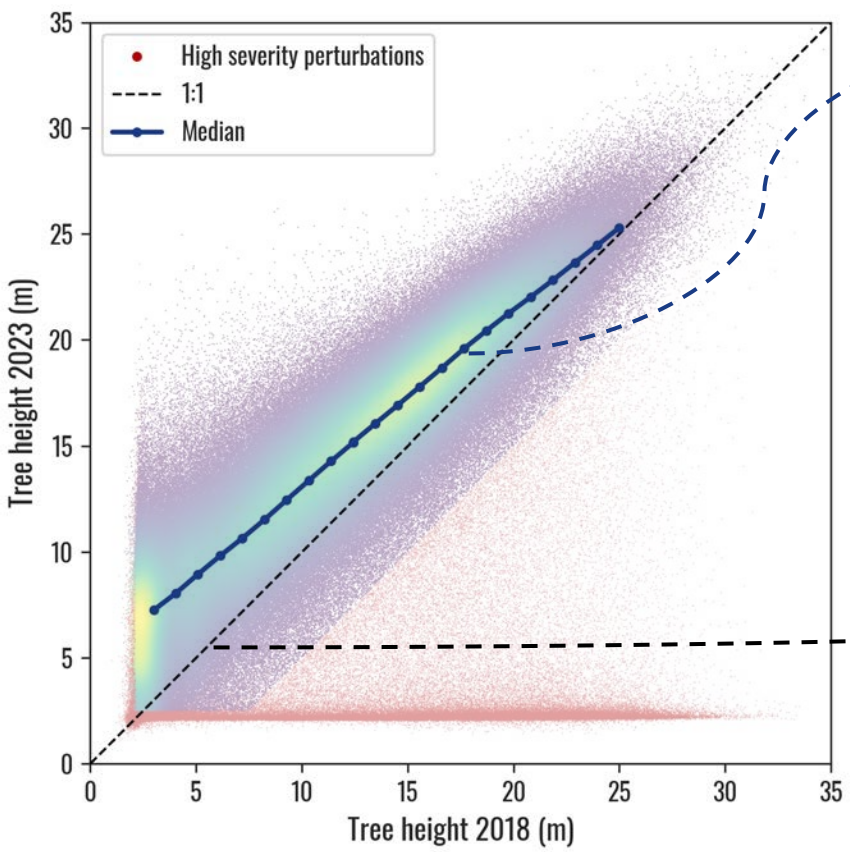
Visual results

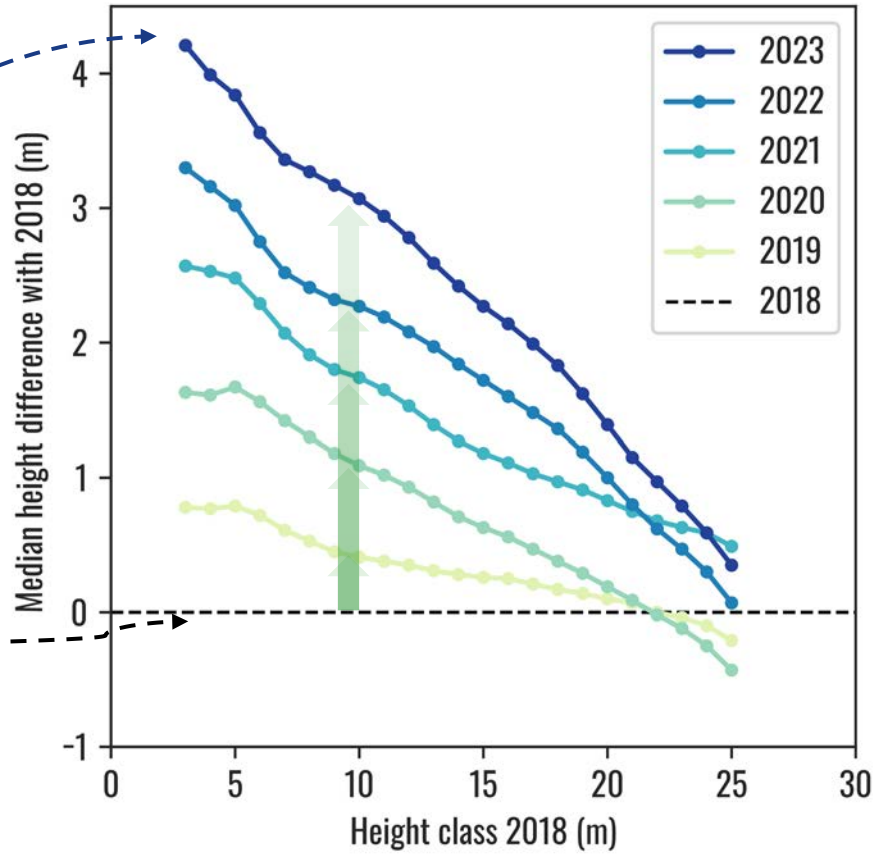
Maritimes Pine Plantation, Les Landes

Evolution of height 2018 → 2023

Height difference 2023 - 2018

Height change at high resolution:
Average growth rate (Landes forest) seem realistic



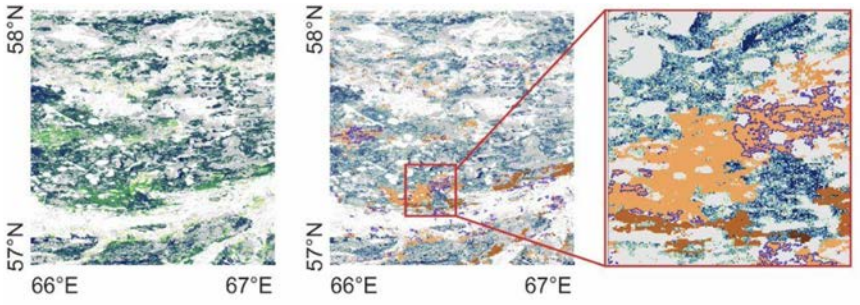


Flux analysis system : C losses and gains

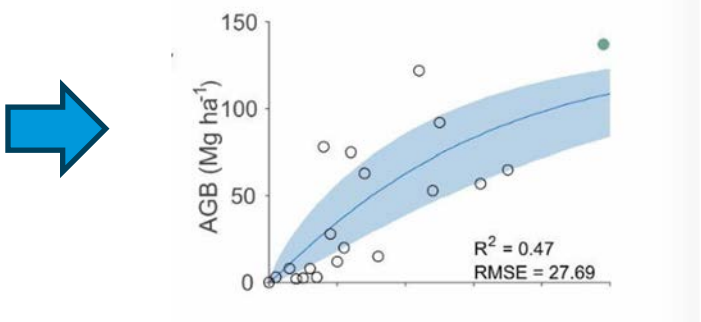
Framework
High resolution biomass maps CCI + CTREES
Disturbance history since 1984

- Divide boreal region into small areas with disturbances 50 x 50 km
- **Post disturbance loss**
- **Local post disturbance recovery curves** + uncertainties
- Evaluation against in-situ data
- Dead wood decay functions
- Soil C loss and recovery from in-situ chrono-sequences studies
- Analyzed growth curves changes over time

High res biomass map + disturbance history



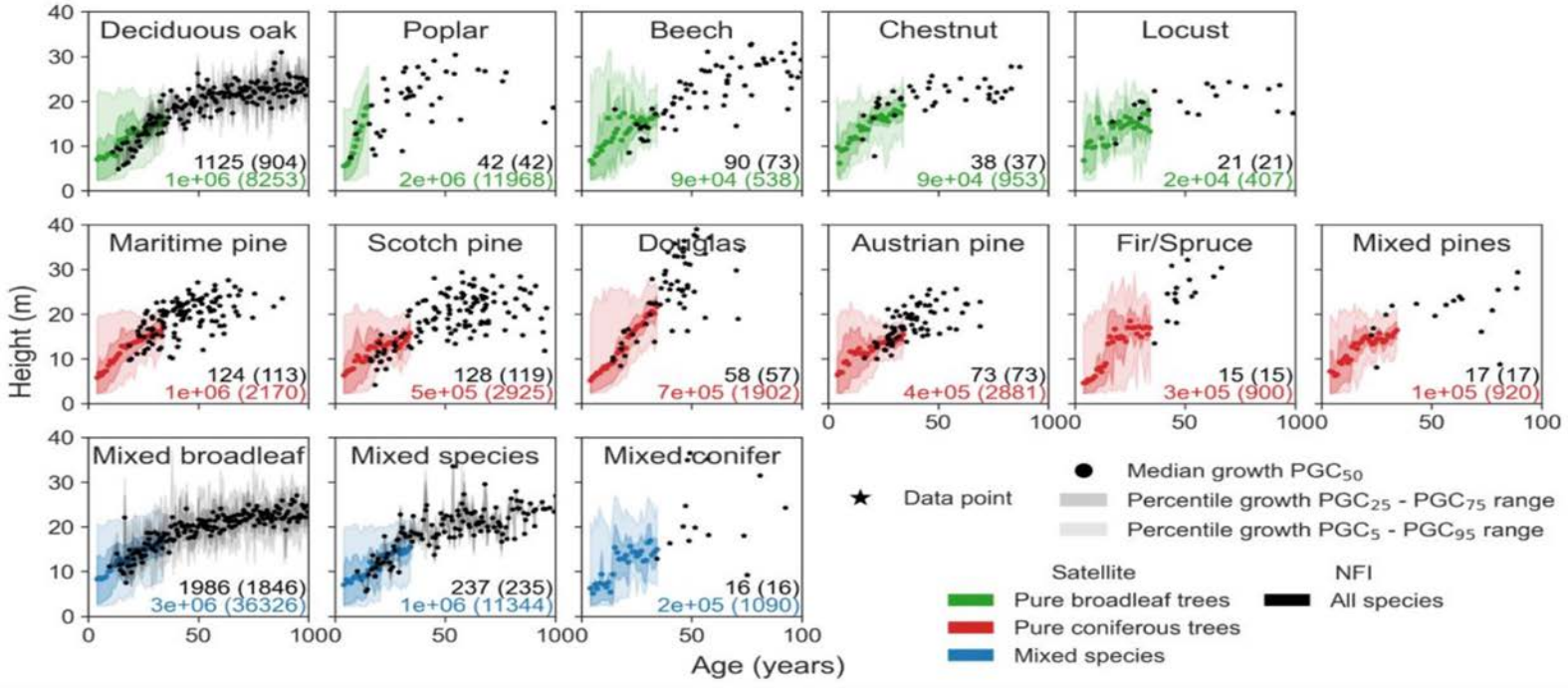
Local recovery curve
(compares very well with ground data)



Yidi Xu et al. Nature in review

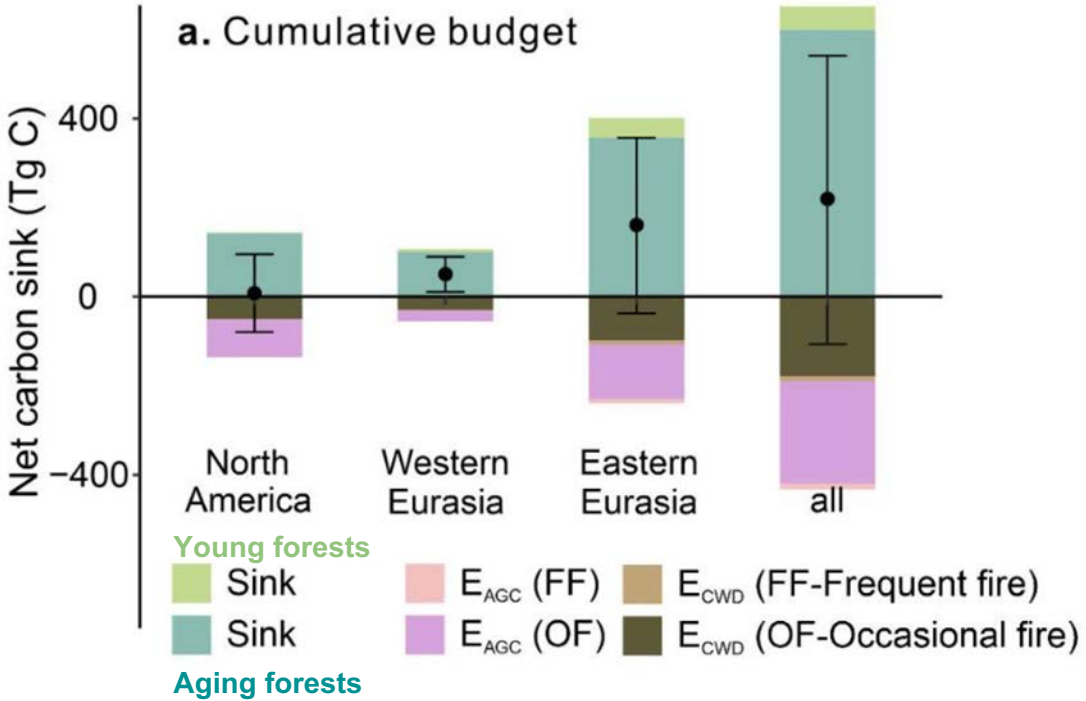
Recovery curves at high resolution

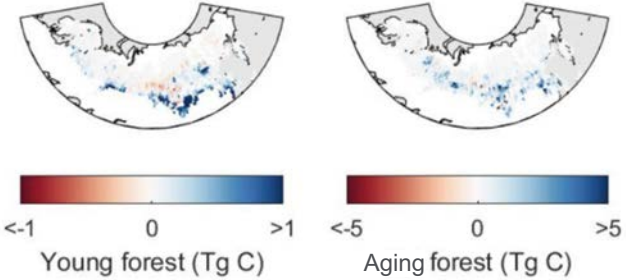
- Explainable ML to explain the drivers of regional regrowth



Application - C budget of boreal secondary forests

Aging boreal forests > 30 years make most of the C sink in boreal regions





'Landsat forests'
< 40 yrs

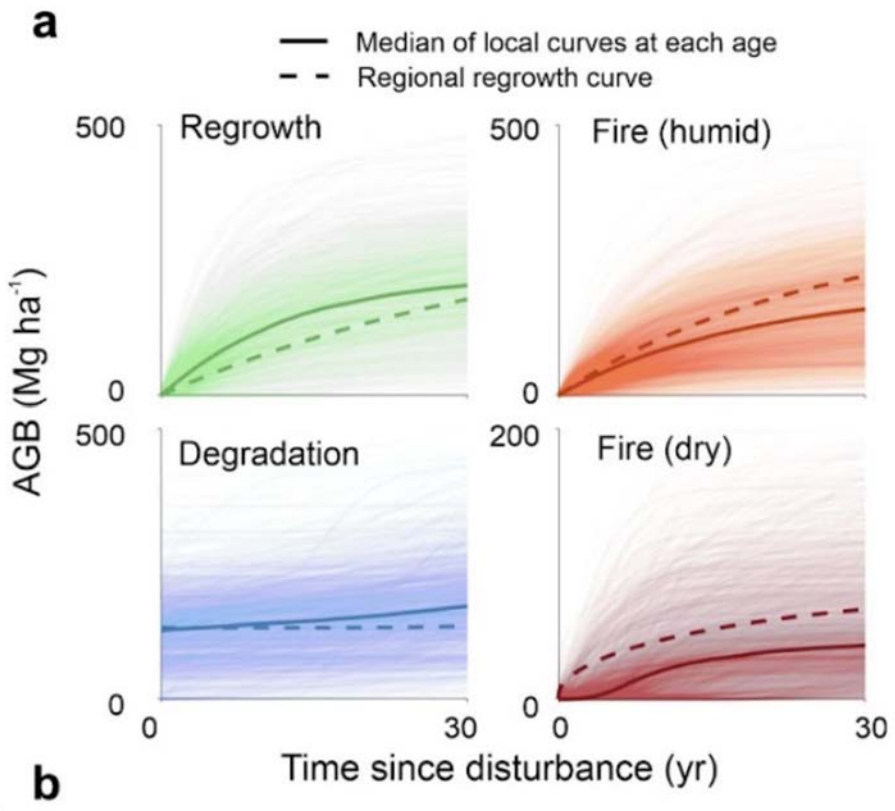
'Pre Landsat forests'
> 40 yrs

Moving to the Tropics : high resolution C accounting models

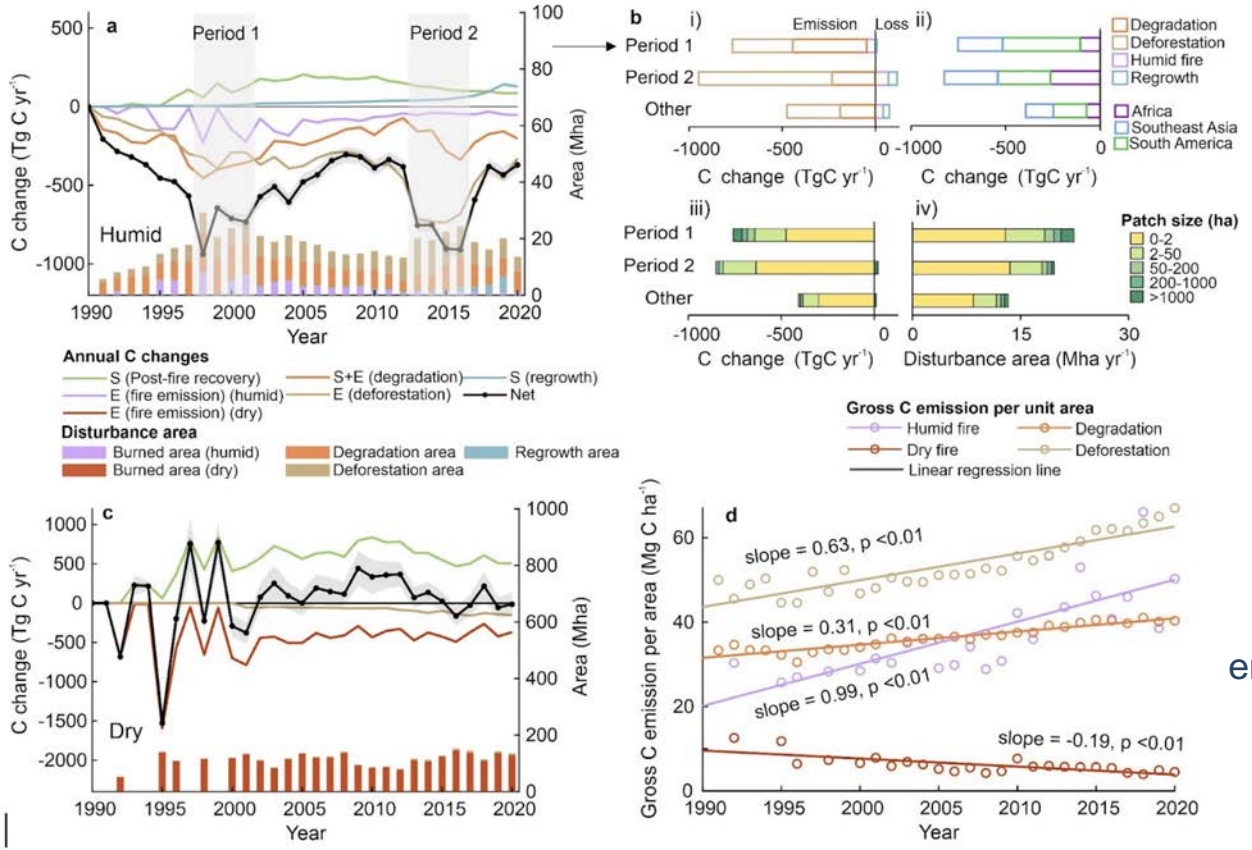
Quantify recovery gains From different disturbance agents

Humid forest: slower recovery after fires compared to non-fire disturbances

Dry forests lower fire intensity shows a quick recovery and higher C accumulation potential compared with forests with higher fire intensity.



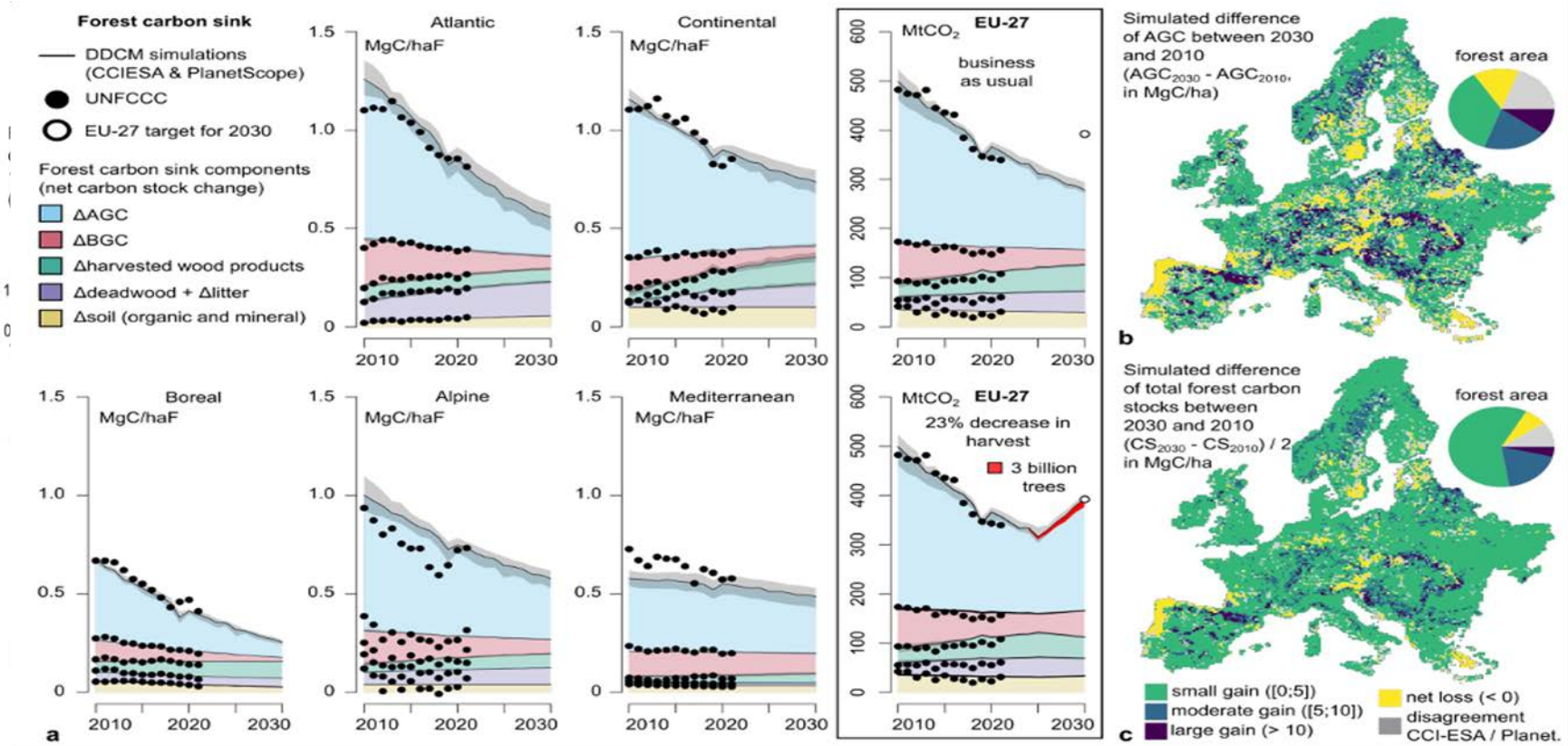
Small-scale disturbances dominate biomass carbon losses from tropical forests over the last 30 years



Disturbance losses encroaching in C rich forests

Application - European forest C sink projection to 2030

Alarming decline in the carbon sink of European forests driven by disturbances



Going global

Full C budget of global secondary forests from EO data using disturbance loss and recovery curves

- Boreal (in review)
- Europe (in review)
- Pan-tropical (submitted)
- China (in prep)
- Australia (in prep)

Top down - bottom up budgets

see Deng et al. poster on inversions