

Support to climate policy needs: UNFCCC Paris Agreement

Philippe Ciais

CCI programmatic review - Dec 9 - 2024



INRAE

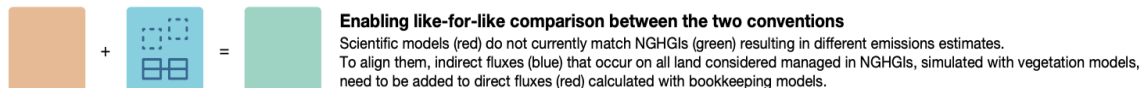
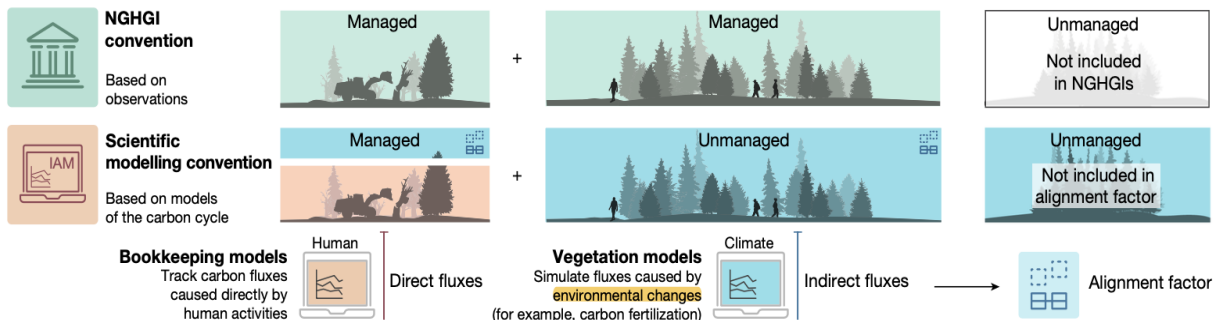


Aligning Scientific Modelling with countries reports



Misalignment between NGHGs and scientific models

Differences stem from definitions of managed land and the carbon fluxes that are included



Aligning Scientific modelling conventions with countries reports – Can we also do it with EO-based models ?

This is the main focus of RECCAP2



Global CO₂ budget
Global CH₄ budget
Global N₂O budget



Climate Space

RECCAP-3

2025-
Global Stock Stake 2028



'Cross ECVs
Six regional case studies
high resolution estimates

RECCAP-2
2019-Ongoing



CCI-phase 2

'Attribution
National scale
CO₂ & CH₄
2 global datasets'

Top down / Bottom up
CO₂ & CH₄
New regional EO products
Pre-operational system
Hands on work with inventory agencies

RECCAP-1
< 2019



Pre-CCI Project ECV
'Fluxes mean and variability
CO₂ only'



CCI-phase 1

'Top-down / bottom up
Stock change / fluxes



Key scientific achievements : 15 Nature family papers More in the pipeline ...

nature geoscience

Article <https://doi.org/10.1038/s41561-023-01274-4>

Global increase in biomass carbon stock dominated by growth of northern young forests over past decade

communications
earth & environment

ARTICLE
Synthesis of the land carbon fluxes of the Amazon region between 2010 and 2020

Thais M. Rosan¹, Stephen Sitch¹, Michael O'Sullivan¹, Luana S. Basso^{2,3}, Chris Wilson^{4,5}, Camilla Silva^{6,7,8}, Emanuel Gloor⁹, Dominic Fawcett¹⁰, Viola Heinrich¹¹, Jefferson G. Souza¹², Francisco Gilroy Silva Bezerra¹³, Celso von Randow¹⁴, Lina M. Mercado¹⁵, Luciana Gatti¹⁶, Andy Wilbrows¹⁷, Pierre Friedlingstein¹⁸, Julia Pongratz¹⁹, Clement Scheuinghacker²⁰, Matthew Williams²¹, Luke Snudman²², Jürgen Knauer²³, Vivek Arora²⁴, Daniel Kennedy²⁵, Hengui Tian²⁶, Wenping Yuan²⁷, Abul K. Jain²⁸, Stefanie Falk²⁹, Benjamin Poulter³⁰, Almut Arneth³¹, Qing Sun³², Shrike Zehe³³, Anthony P. Walker³⁴, Etsuko Kato³⁵, Xu Yue³⁶, Ana Bastos³⁷, Philippe Ciais³⁸, Jean-Pierre Wigneron³⁹, Clement Albergel⁴⁰ & Luiz E. O. C. Aragão⁴¹

nature geoscience

Article <https://doi.org/10.1038/s41561-022-01087-6>

Siberian carbon sink reduced by forest disturbances

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Check for updates
Lei Fan¹, Jean-Pierre Wigneron^{1,2}, Philippe Ciais³, Jerome Chave⁴, Martin Brandt⁵, Stephen Sitch⁶, Chao Yue⁷, Ana Bastos⁸, Xin Li⁹, Yuemei Qin¹⁰, Wensheng Yuan¹¹, Dmitry Schepaschenko^{12,13}, Ludmila Mukhorova¹⁴, Xiaojun Li¹⁵, Xiangshuo Liu¹⁶, Mengjia Wang¹⁷, Frédéric Frappart¹⁸, Xiangming Xiao¹⁹, Jingming Chen²⁰, Mingqiao Ma²¹, Jiangang Wei²², Xuzhi Chen²³, Hul Yang²⁴, Geze van Wees²⁵ & Ramona Fernandes²⁶

PNAS

RESEARCH ARTICLE ENVIRONMENTAL SCIENCES



Climatic and biotic factors influencing regional declines and recovery of tropical forest biomass from the 2015/16 El Niño

Hul Yang¹, Philippe Ciais², Jean-Pierre Wigneron³, Jérôme Chave⁴, Oliver Cartus⁵, Xuzhi Chen⁶, Lei Fan⁷, Julia K. Green⁸, Yuanyuan Huang⁹, Emile Joetjzer¹⁰, Heather Kay¹¹, David Malowski¹², Fabienne Maignan¹³, Maurizio Santoro¹⁴, Shengli Tao¹⁵, Uyang Liu¹⁶, and Yitong Yao¹⁷

ARTICLE

<https://doi.org/10.1038/s41561-022-02050-1>

OPEN



Large carbon sink potential of secondary forests in the Brazilian Amazon to mitigate climate change

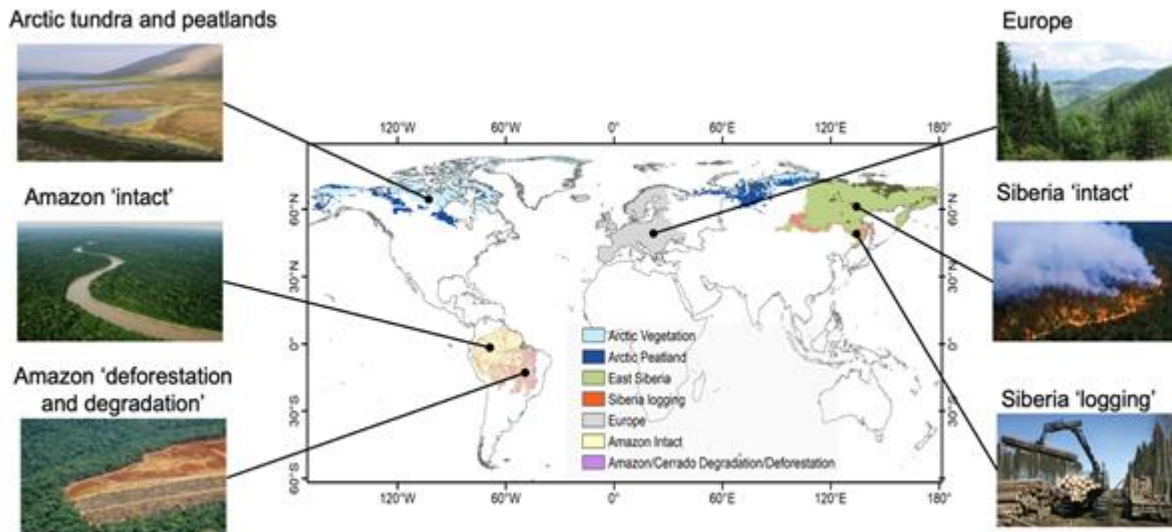
Viola H. A. Heinrich^{1,2}, Ricardo Dalagnol³, Henrique L. G. Cassol⁴, Thais M. Rosan⁵, Catherine Torres de Almeida⁶, Celso H. L. Silva Junior⁷, Wesley A. Campanharo⁸, Joanna I. House^{1,4}, Stephen Sitch⁹, Tristram C. Hales⁵, Marcos Adams⁶, Liana O. Anderson⁷ & Luiz E. O. C. Aragão^{2,3}

nature sustainability
ANALYSIS
Doubling of annual forest carbon loss over tropics during the early twenty-first century

Key contribution to GCP RECCAP-2 protocols and synthesis
Inversions for the 2023 global stock-stake : Deng et al. , Byrne et al. 2022
New datasets : L-VOD processing, inundated areas
New methodologies : loss and recovery C budgeting models
Exchange with IPCC task force on national GHG inventories (workshops in 2023 and 2024)

Main Objectives of RECCAP-2 Climate Space (2024-2027)

- Assessment of GHG gross and net fluxes for six case study regions
- Top down and bottom-up estimates using EO will be compared and reconciled with inventories.
- These regional case studies are completed by the collection and analysis of global ECVs aiming to reduce the uncertainty on the global biomass carbon change and methane budgets
- **This project integrates across CCI ECVs**



Integration and synthesis

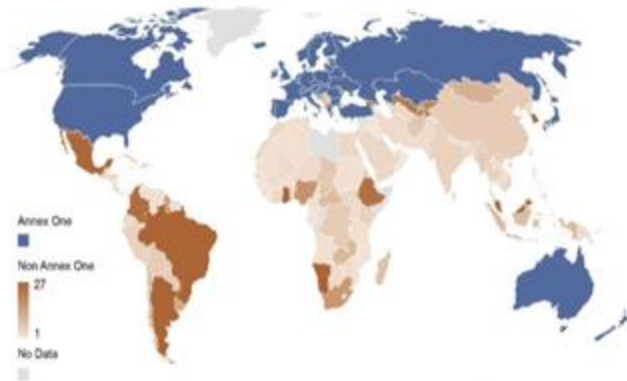


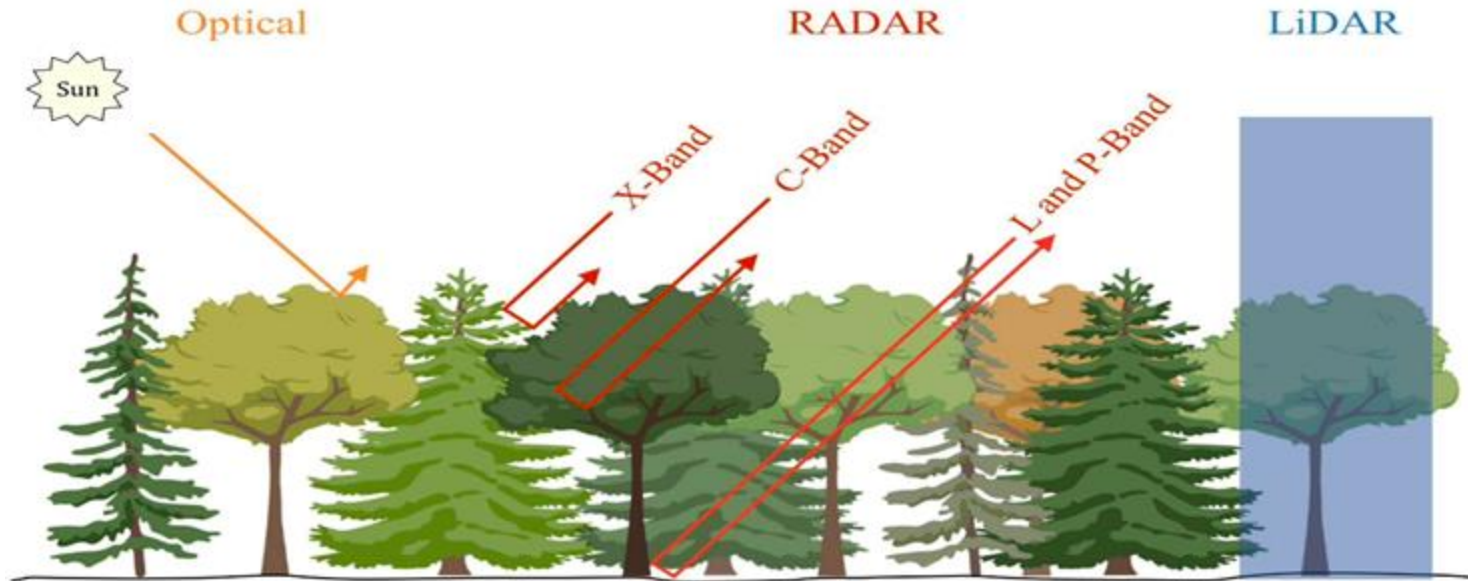
Fig 8. Number of years covered by NGHGIC reports (National communications + Biennial Update Reports) in each country (as of March 6, 2023)

Deng et al. 2022, 2024 part of CCI RECCAP2

- **Partnership with CITEPA, CMCC. Collaboration with UKDES and INPE**
- **Make system boundaries & definitions as close as possible between EO data and IPCC Guidelines used for NGHGIs**
- **Data cube for data homogenization and visualisation (Brockmann)**
- **Scientific publication to track progress of national mitigation efforts (LSCE)**
- **National Agency engagement and contribution to the Global Stocktake (U Leipzig)**

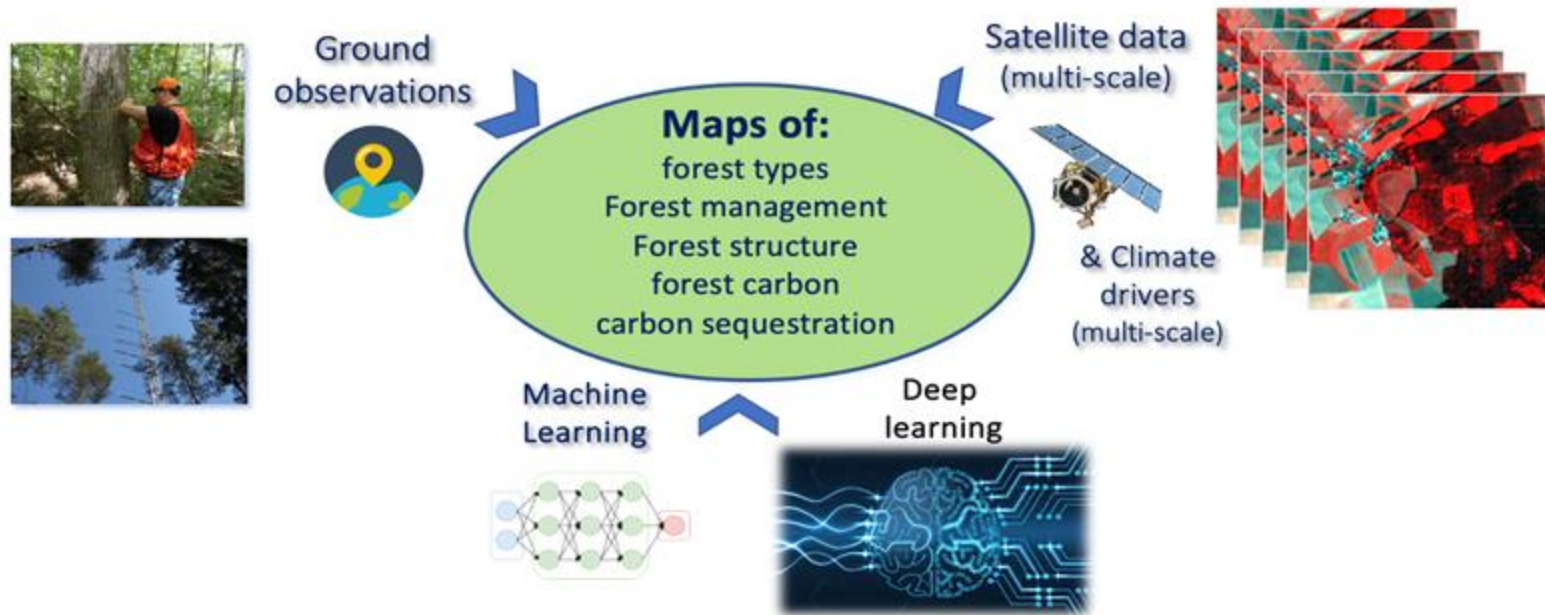
Can we reconcile Country Reports with EO-based estimates of GHG budgets ?

Deluge of EO data to map forest attributes



Can we reconcile Country Reports with EO-based estimates of GHG budgets ?

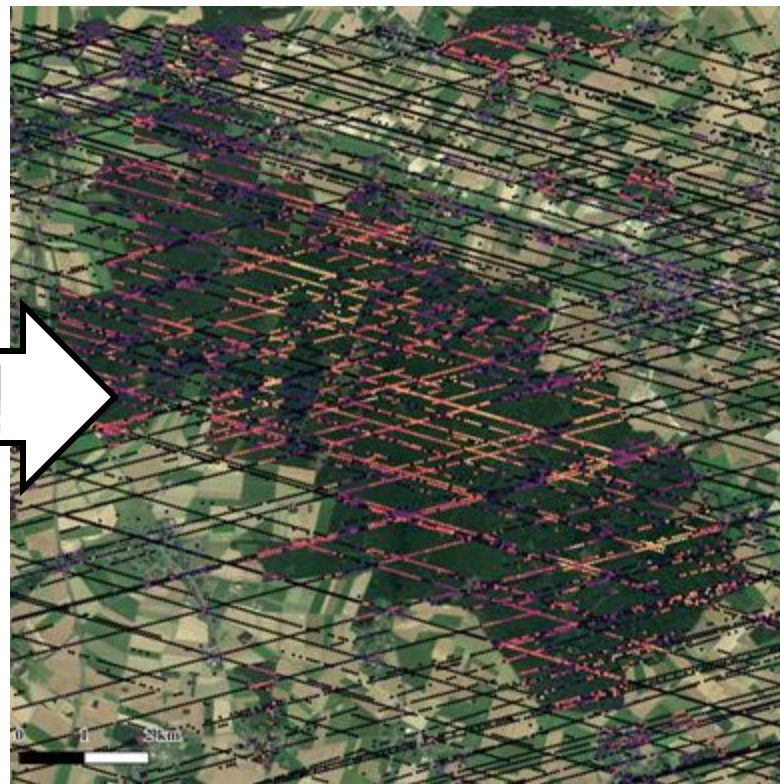
Artificial intelligence can be used for the fusion of satellite imagery and ground data



Crecy Forest, Somme, © Google Maps



GEDi height measurements



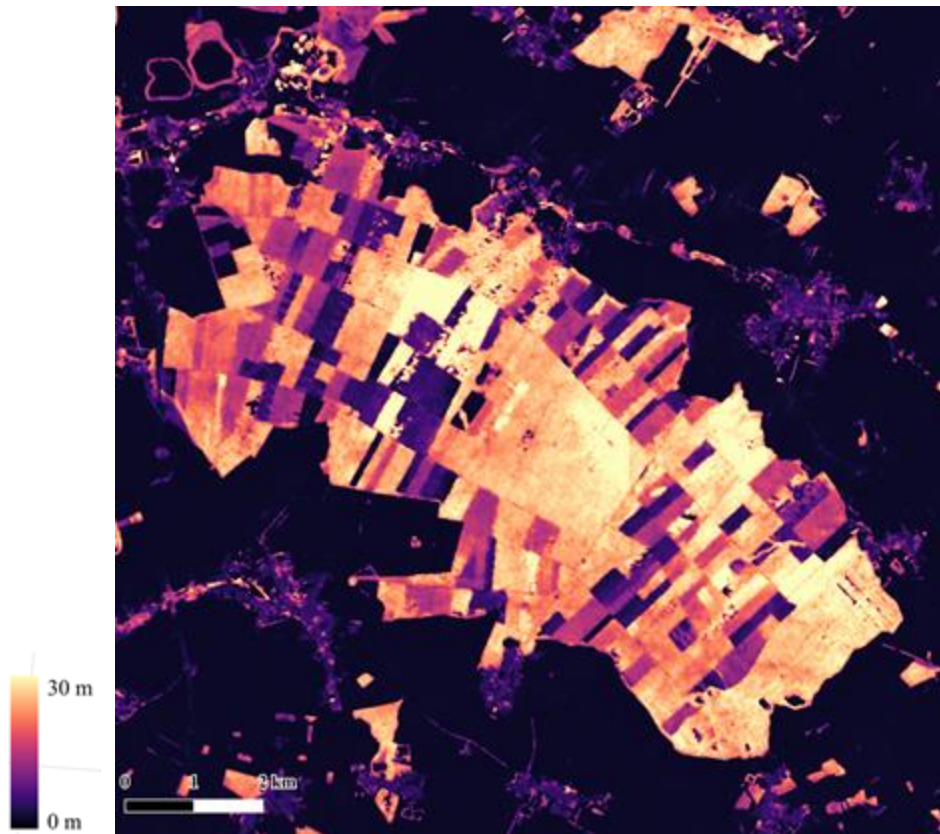
FORMS-H: Canopy height map

Google Maps, Forêt de Crécy (France)



GED
ECOSYSTEM LIDAR

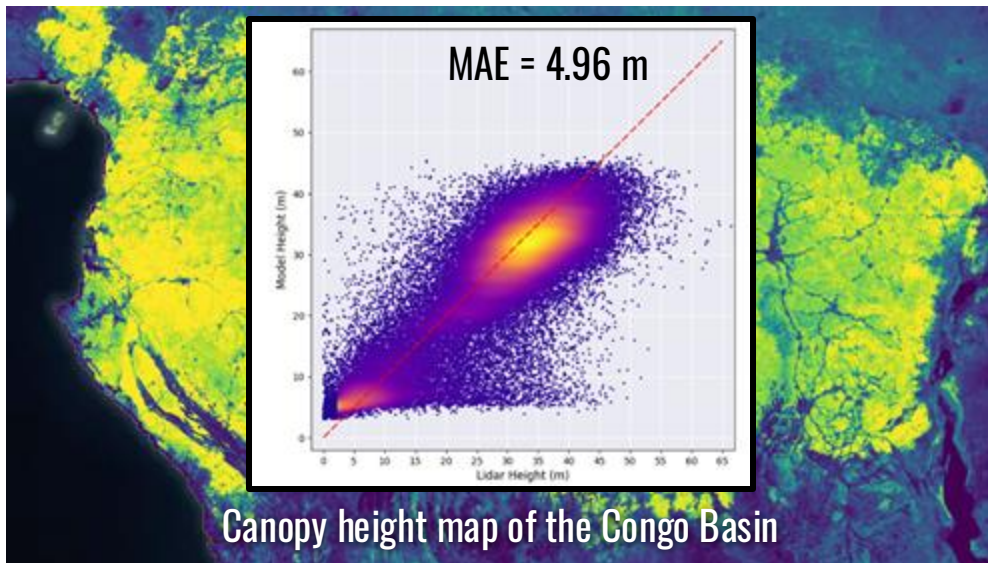
FORMS-H (our model)





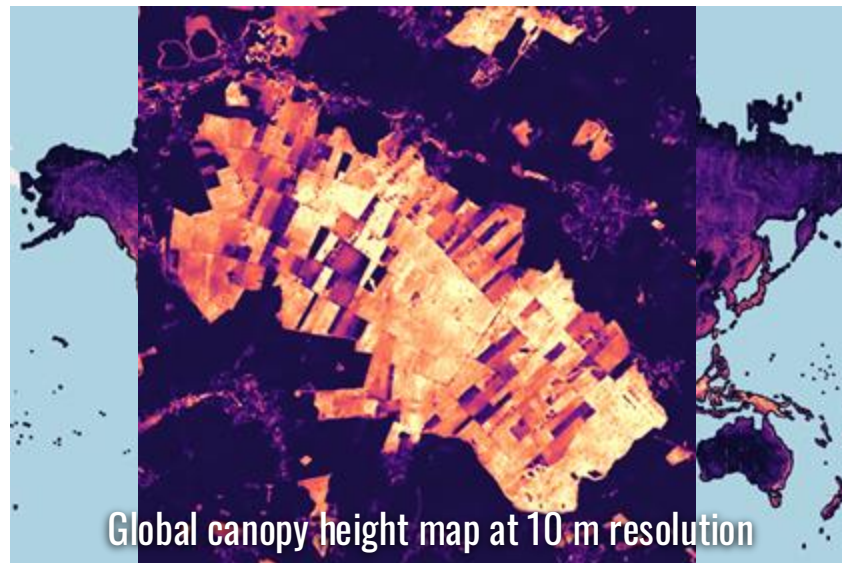
African forest height change map ✓

African biomass change map ✗



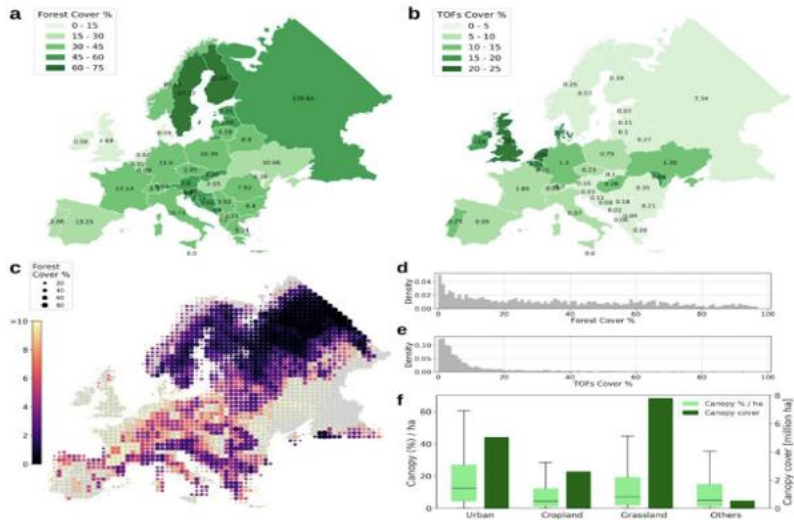
Global height map ✓

Global biomass map ✗

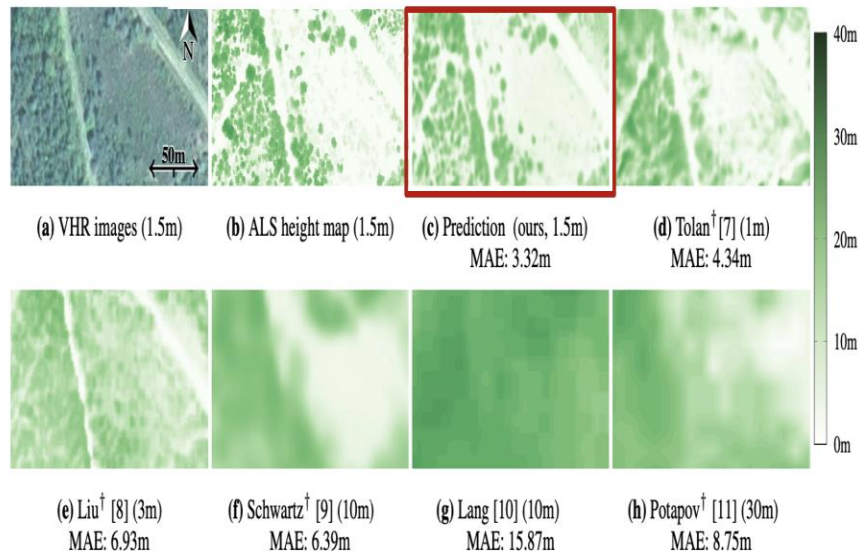


Making visible of trees outside forest

Making visible tree level mortality

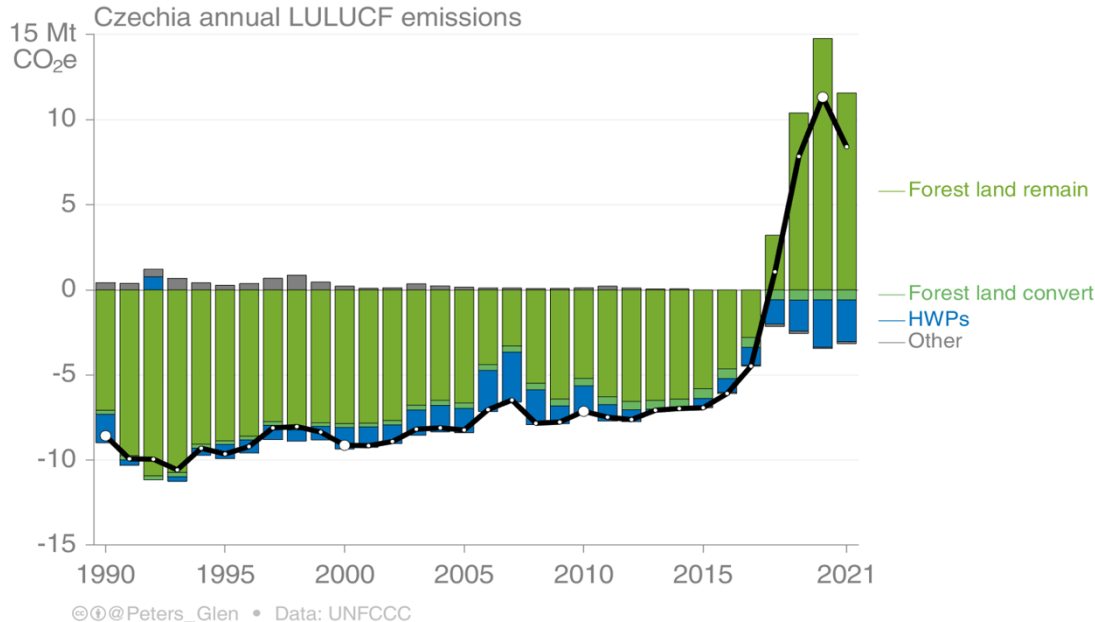


Planet scope tree cover maps 2019 – Europe 3 m
Liu et al. 2023 Science Advances



SPOT tree height map 2013-23 – France 1.5 m
Vogel et al. 2024

European forests on the brink of change



Some countries became net carbon sources

What about France ?

● European Commitment in 2030

- Exposure to climate risk has increased over the last 40 years
- Tree mortality dramatically increased after 2010
- The EU commitment of a carbon sink of 400 MtCO₂ y⁻¹ in the land use sector will be challenging to reach

Is there a risk that carbon sinks become unstable ?





reccap-2
cci

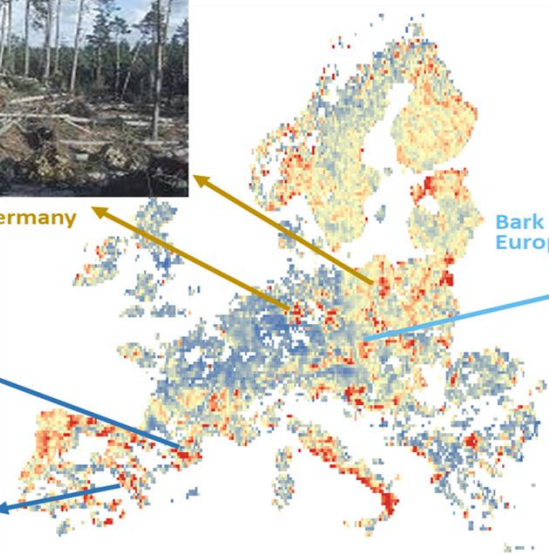
European forests on the brink of change Mapping carbon loss and regrowth gain from disturbances



Processionary moth in Spain



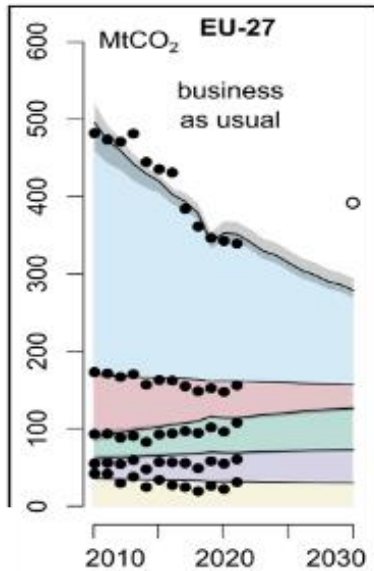
Windthrow in Germany and Poland



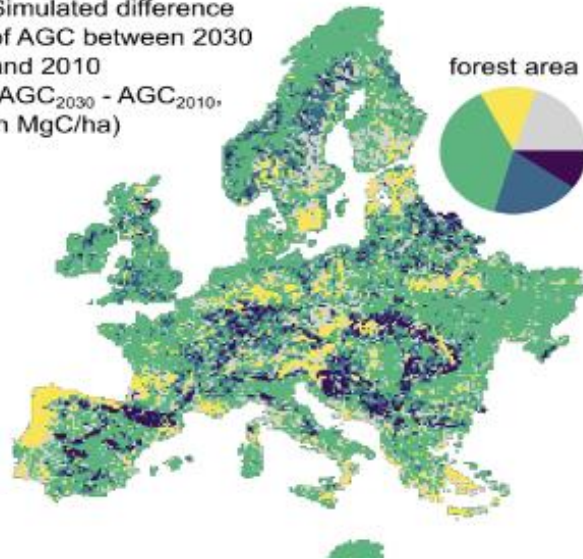
Bark Beetle in Central Europe



Predicting the EU carbon sink in 2030 from EO-data ?



Simulated difference
of AGC between 2030
and 2010
(AGC₂₀₃₀ - AGC₂₀₁₀,
in MgC/ha)



Will EU be on target ?
NO, there will be a gap of
100 MtCO₂ y⁻¹

Can EU be back on target ?
YES, but it would imply
accepting a 26% reduction of
harvest

Does planting 3 B trees fill the gap ?
NO, it will merely sequester 10 Mt
MtCO₂ y⁻¹

Conclusions – forward looking

- A clear framework has been established to reconcile scientific models estimates of national GHG budgets with national inventories
- We have extended this framework to reconcile EO-based atmospheric inversions estimates of CO₂ and CH₄ fluxes with national inventories
- A new approach is needed to integrate diverse EO-based estimations of carbon stock changes and GHG fluxes into comprehensive budgets consistent with national reports
 - **Top down inversions and bottom-up methods offer the opportunity to achieve verification**
 - **Focus on missing components : dead wood, soil C changes, lakes and rivers CH₄ emissions**
 - **Attribution of forest disturbances to human vs natural events on managed land**
 - **Estimation of carbon losses during extreme events**
- Exploit and evaluate existing and new AI-based maps of above ground-biomass changes
- Extend the reconstruction of forest C changes to the past 40 years using Landsat
- RECCAP2-CS will focus on addressing these research gaps for 6 regions by developing new synergies between EO-based products and national inventory agencies