Perspectives of remote sensing for the monitoring of forest resources

Alessandro Cescatti, Giacomo Grassi
Joint Research Centre, Ispra

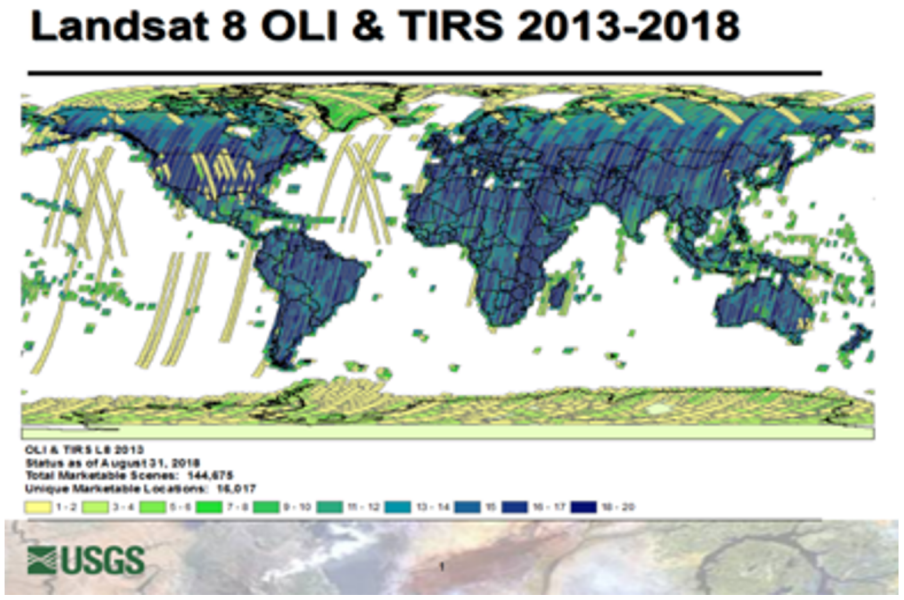
JRC LULUCF workshop, 8 June 2021

Potentials of satellite remote sensing for forest monitoring

Integrate ground-based forest statistics with satellite records in order to:

- Apply a **uniform methodology** across the entire EU
- Obtain **spatially explicit information** on forest resources to support implementation of multiple **forest-related strategies and policies**
- Achieve **frequent and timely update** on the state of EU forest resources

High-resolution satellite retrievals



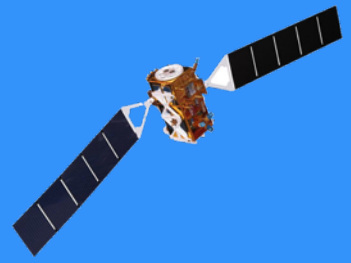
Cloud-Computing

Google Earth Engine

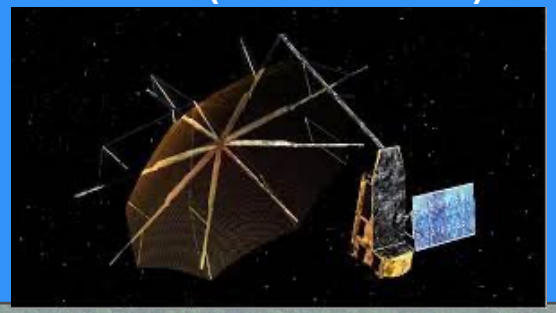
Increasing constellation of sensors

Sentinel 2 (optical data)

Sentinel 1 (radar)



Biomass (PBAND SAR)

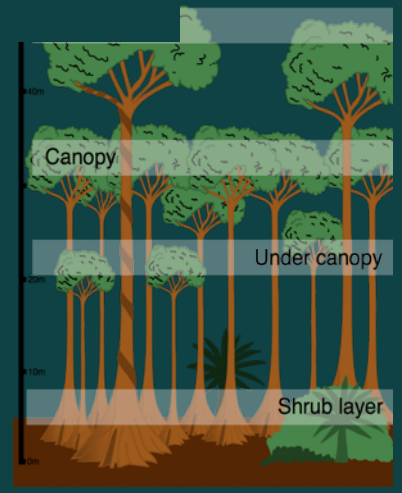


GEDI (LIDAR)

- forest cover
- patch size, fragmentation
- diveristy metrics
- disturbances
- drought detection

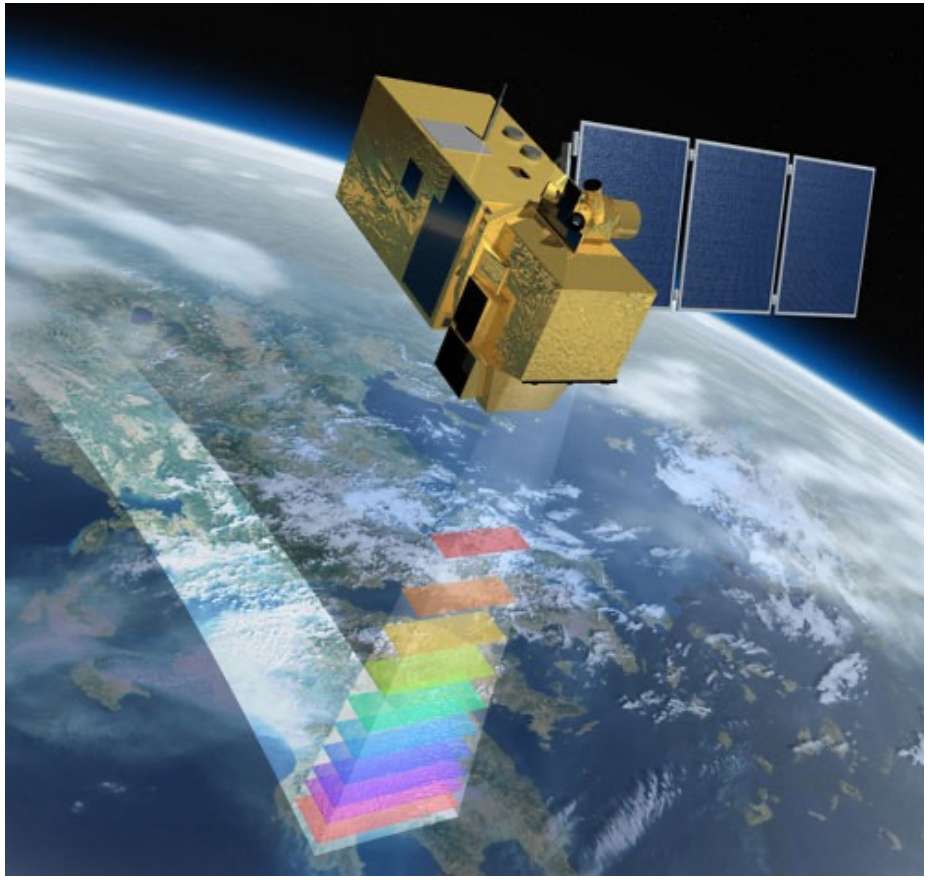
Tree cover and structural information can be combined to produce forest metrics

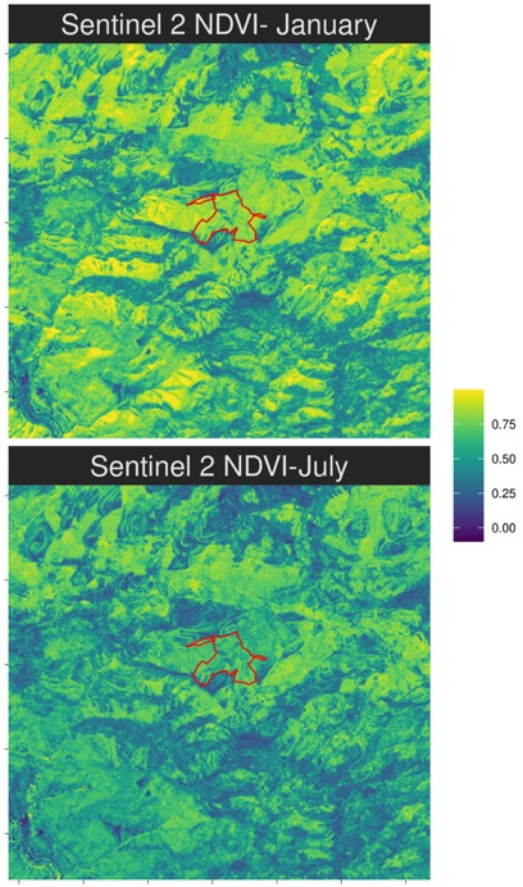
Forest structure
Tree height
Biomass

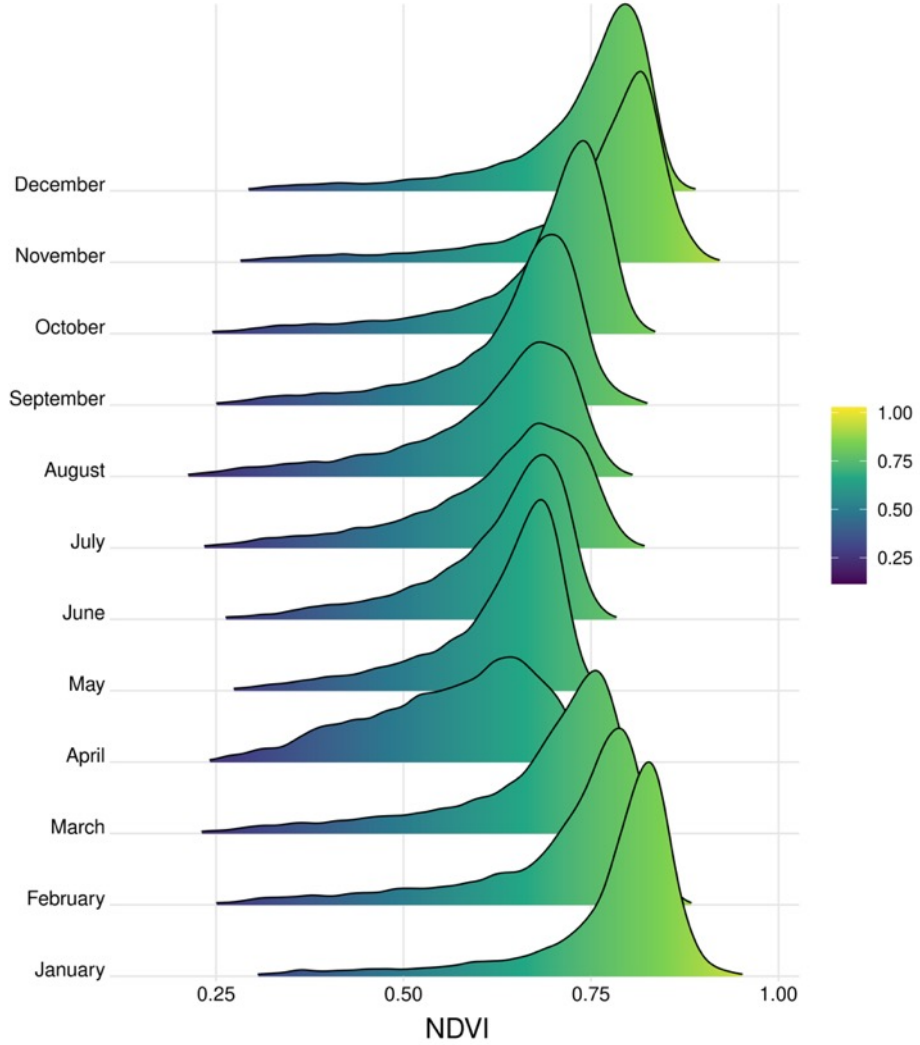


GCU ES0124: seasonal and spatial distribution of NDVI

Copernicus: Sentinel 2, 10m resolution



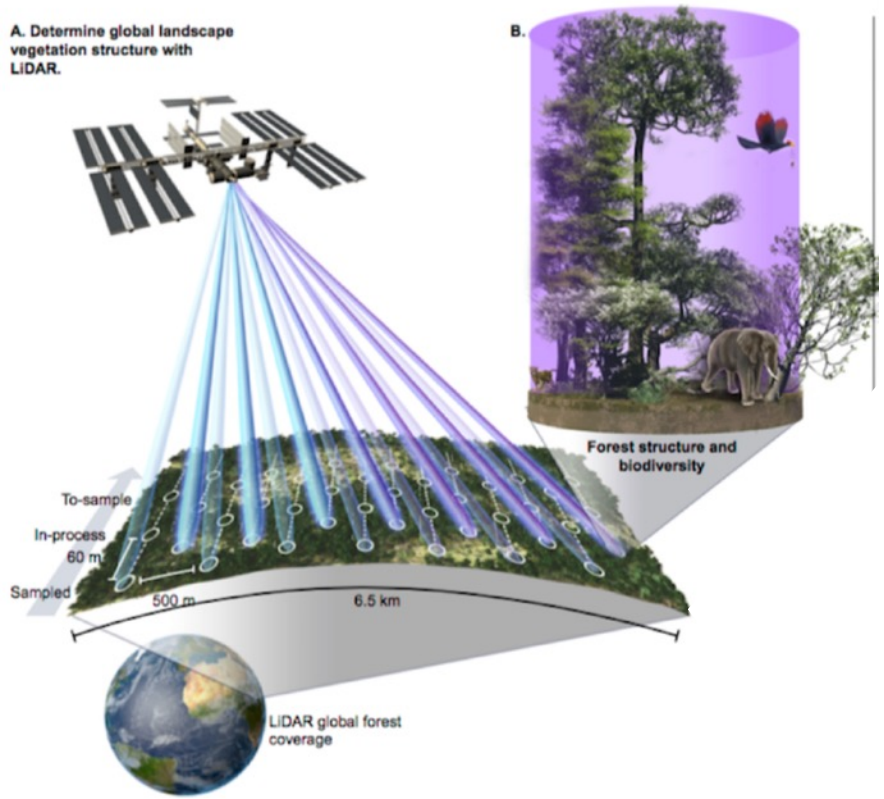


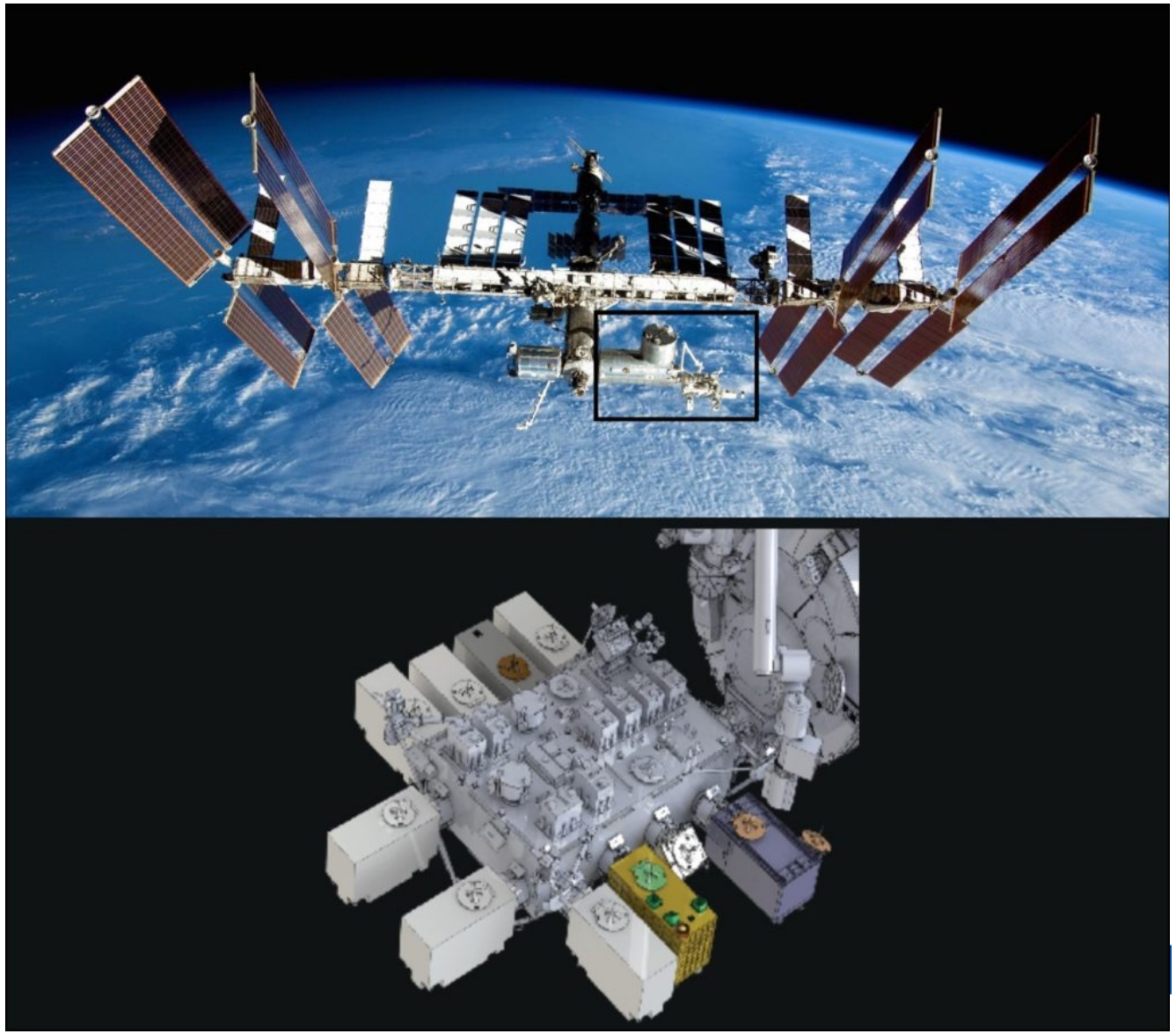


GEDI: Lidar profiles of canopy height

GEDI
ECOSYSTEM LIDAR

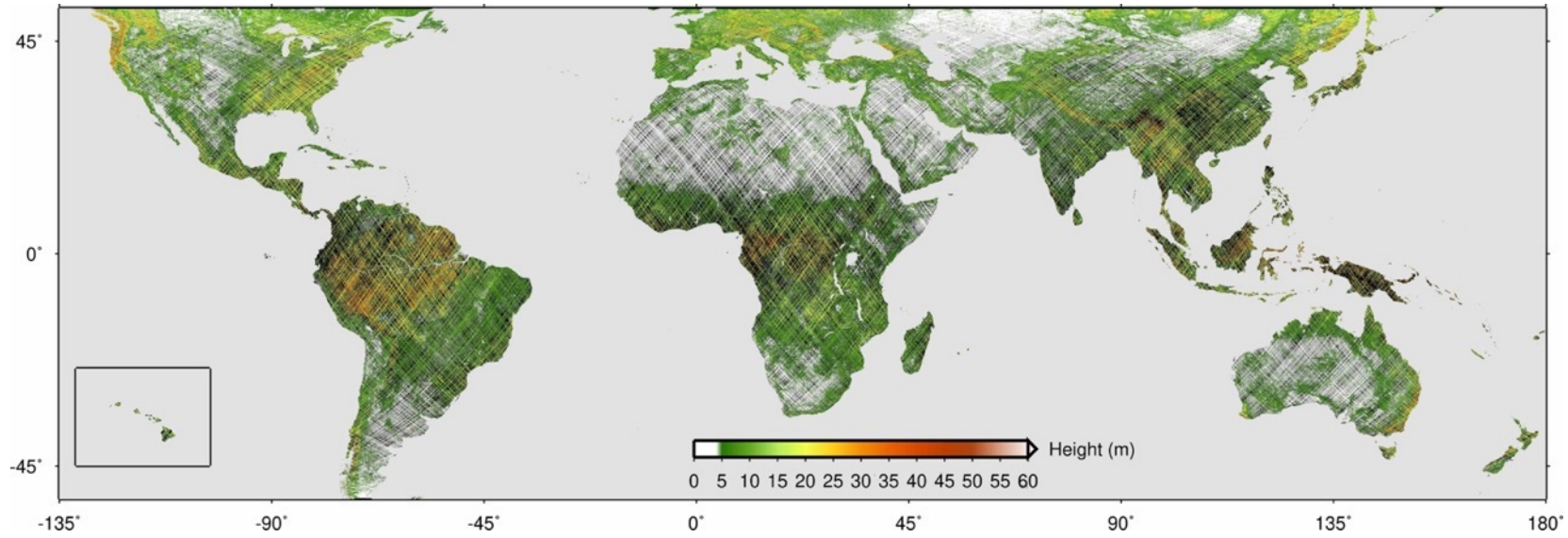
Earth in the Third Dimension:
First GEDI Data Available

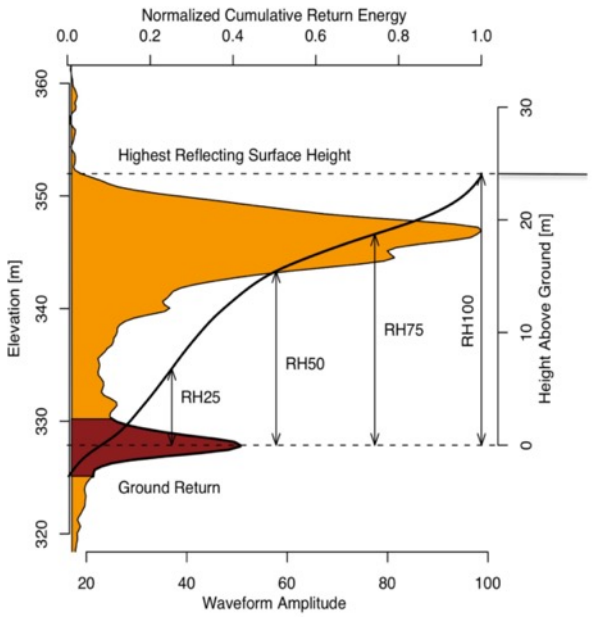


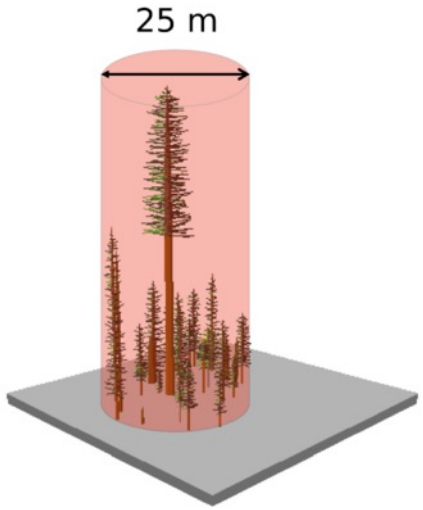


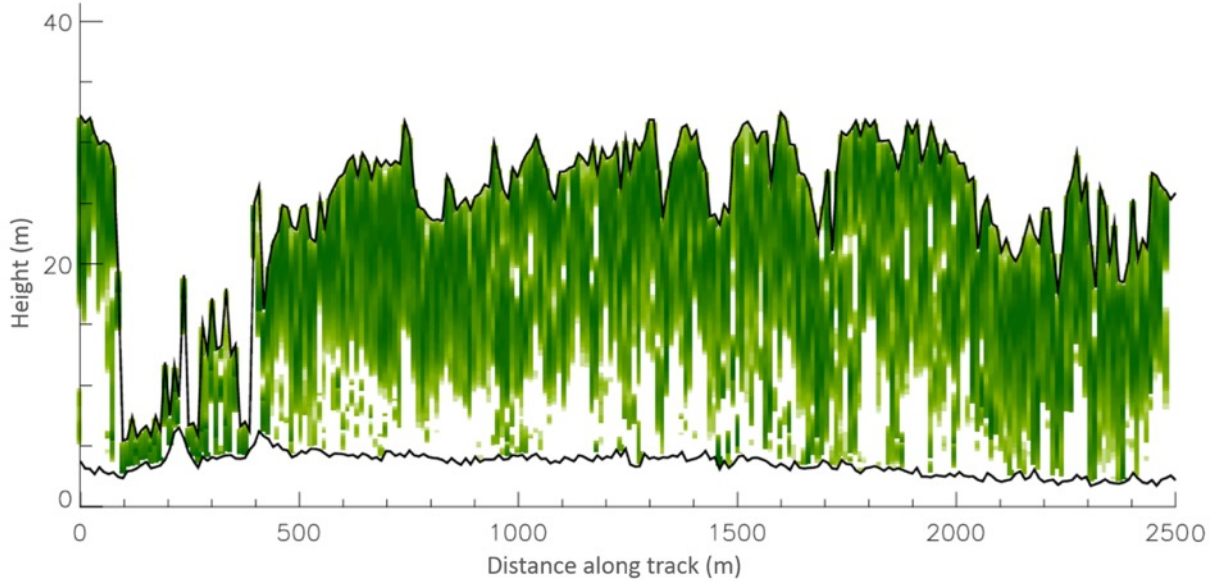
GEDI: Lidar profiles of canopy height

Mapping
- Tree height
- Biomass
- Canopy structure







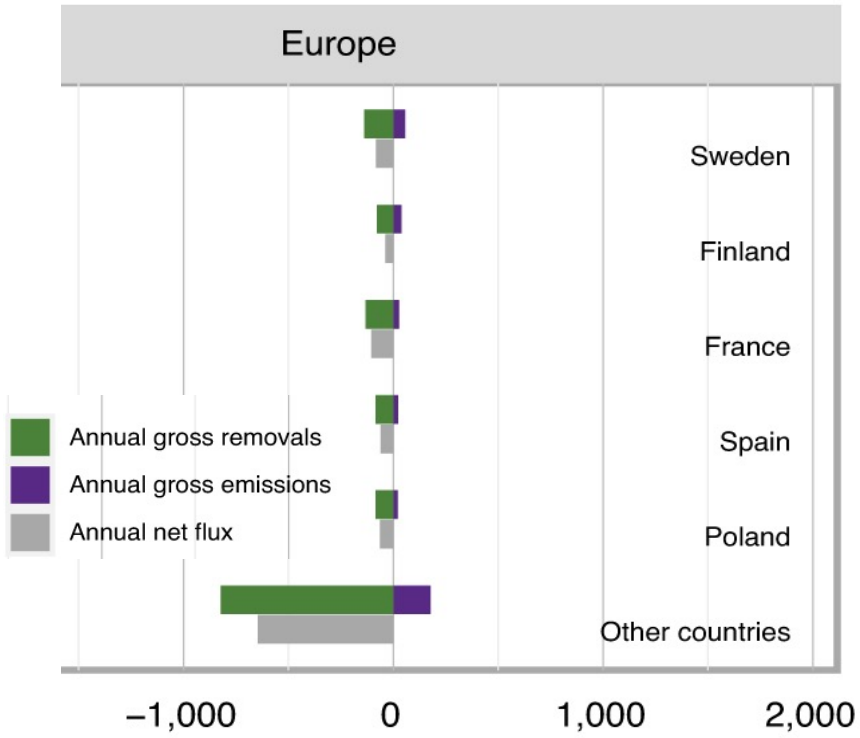


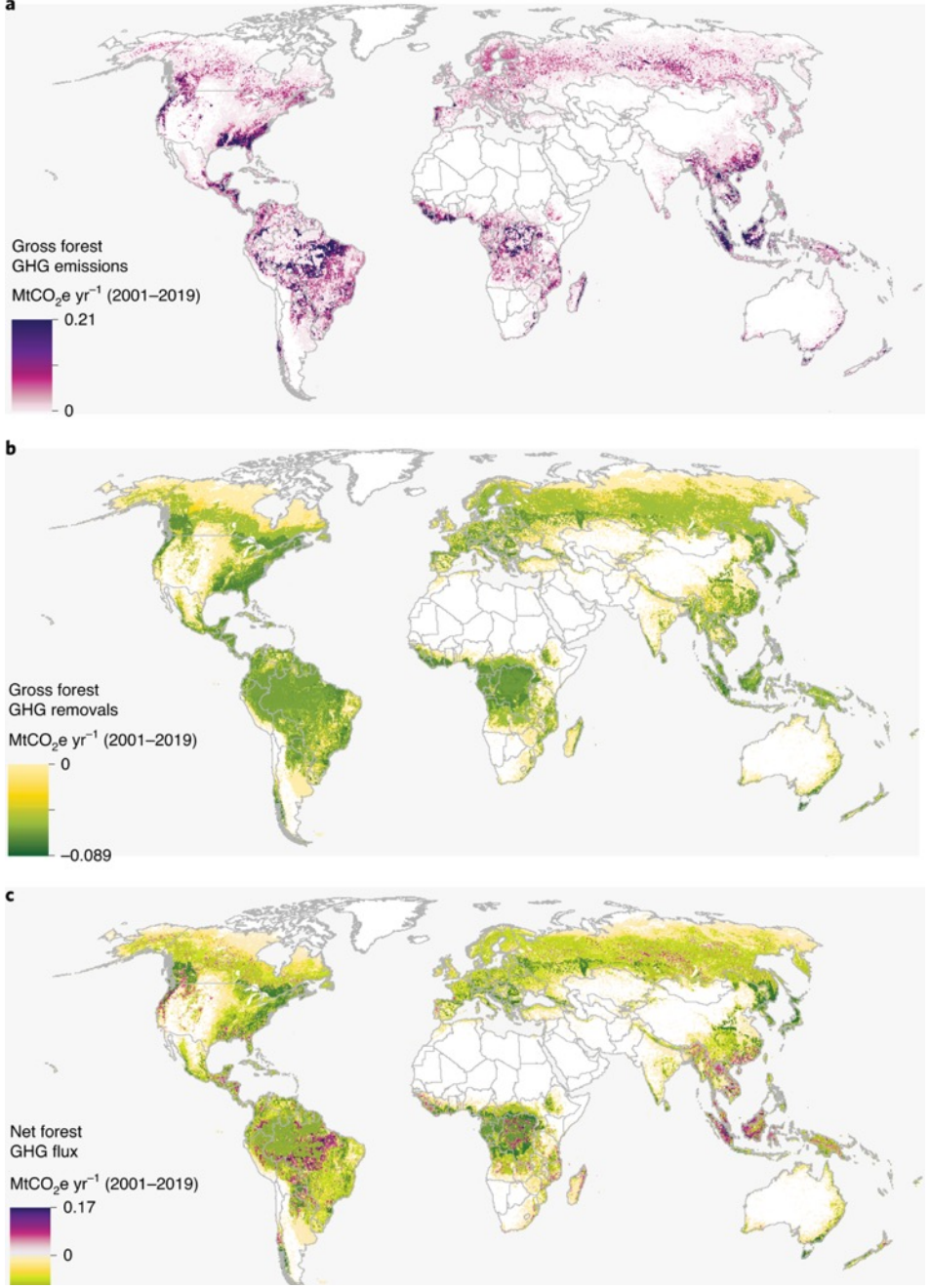
Assessment of gross and net GHG fluxes from forests From Earth Observations (annual average, 2001–2019)

Article | Published: 21 January 2021

Global maps of twenty-first century forest carbon fluxes

Nancy L. Harris ✉, David A. Gibbs, Alessandro Baccini, Richard A.





a, Gross annual GHG emissions. **b**, Gross annual GHG removals. **c**, Net annual GHG flux.

Spatially-explicit annual estimates of harvested forest area

AREA

Forest Area: FAOSTAT 2015

Tree cover change: Global Forest Cover (200 present), used in many publications
https://www.globalforestwatch.org/

- High spatial (30x30 m) resolution
- Annual updates

BIOMASS

Above Ground Biomass:
Globbiomass ESA - 2010

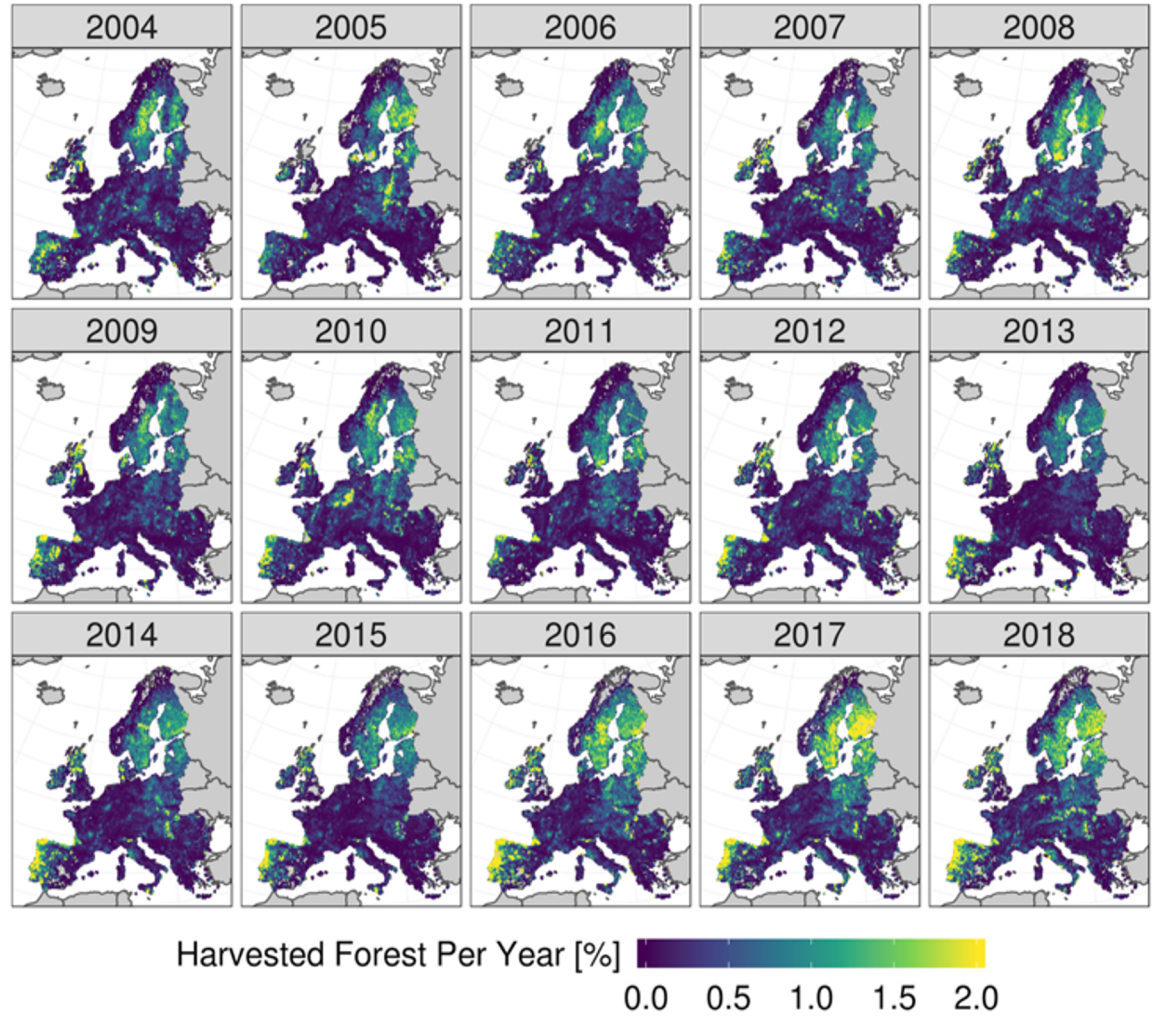
Forest Growth:
State of Europe's Forests 2015 Report

nature

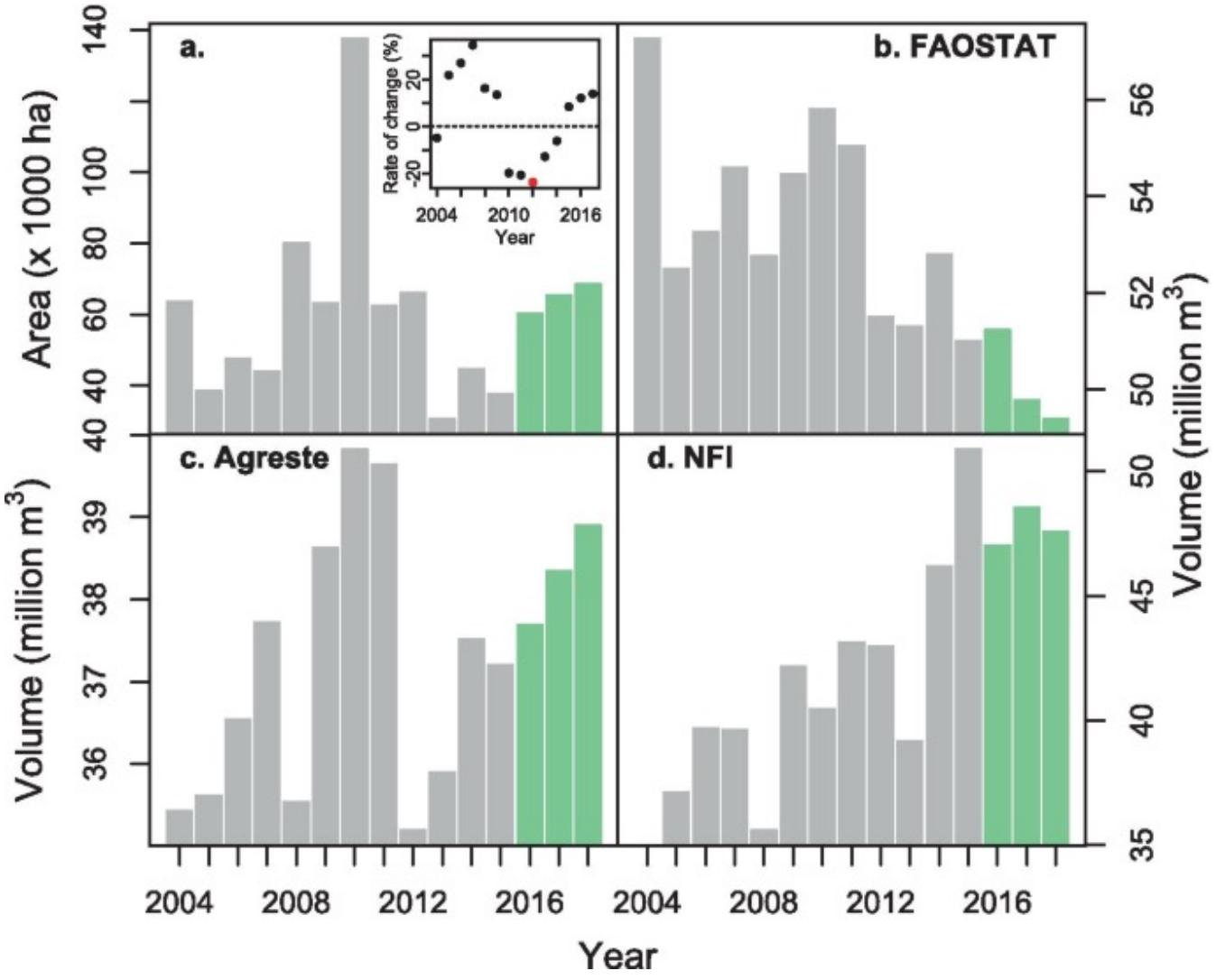
Abrupt increase in harvested forest area over Europe after 2015

https://doi.org/10.1038/s41586-020-2438-y
Received: 17 May 2019

Guido Ceccherini[1], Gregory Duveiller[1], Giacomo Grassi[1], Guido Lemoine[2], Valerio Avitabile[1], Roberto Pilli[1] & Alessandro Cescatti[1]



Monitoring the harvest rate in EU



Temporal changes across 2004–2018 in harvested forest area:
a data from Ceccherini et al.
b FAOSTAT
c Agreste (survey logging companies and sawmills)
d National Forest Inventory.

Conclusion

The discrepancy between Ceccherini et al.'s data and other data on harvested volumes **points out the difficulty of reconciling different approaches to estimate wood harvest at a country level**

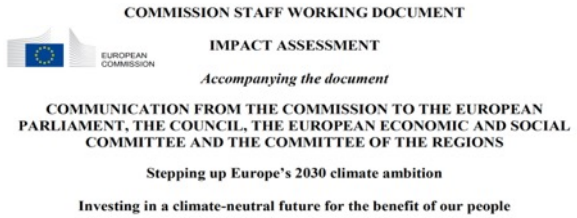
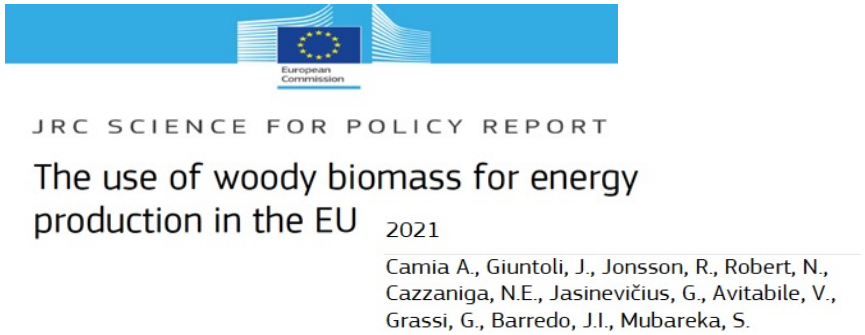
Picard et al. 2021. ASF

European Commission

Are these approaches sufficiently robust?

How should the results from Ceccherini be interpreted?

Premise: a scientific paper is not a direct input to EU policies

	TYPE of document	Example	Typical Disclaimer
Direct input to EU policies	IMPACT ASSESSMENT (Editor: EC)	 COMMISSION STAFF WORKING DOCUMENT IMPACT ASSESSMENT *Accompanying the document* COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS Stepping up Europe's 2030 climate ambition Investing in a climate-neutral future for the benefit of our people	NO disclaimer
	JRC SCIENCE FOR POLICY REPORT (Editor: EC)	 European Commission JRC SCIENCE FOR POLICY REPORT The use of woody biomass for energy production in the EU 2021 Camia A., Giuntoli, J., Jonsson, R., Robert, N., Cazzaniga, N.E., Jasinevičius, G., Avitabile, V., Grassi, G., Barredo, J.I., Mubareka, S.	This reports aims to provide evidence-based scientific support to the European policymaking process. The scientific output expressed does not imply a policy position of the European Commission.
NO direct input to EU policies	SCIENTIFIC PUBLICATION (Editor: Scientific Journal)	 nature Abrupt increase in harvested forest area over Europe after 2015 https://doi.org/10.1038/s41586-020-2438-y Received: 17 May 2019 Guido Ceccherini, Gregory Duveiller, Giacomo Grassi, Guido Lemoine, Valerio Avitabile, Roberto Pilli & Alessandro Cescatti	The views expressed are purely those of the writers and may not in any circumstances be regarded as stating an official position of the European Commission

Does Ceccherini et al. contradict country statistics? Are results “impossible”?

From Palahi et al.:

How could harvest go up from 470 Mm3/y to 790 Mm3 (= 69% increase) in just a few years ? There is no harvesting capacity or personnel to do that.

Ceccherini et al. (Nature 2020) measured clear-cuts, not total harvest

While this was *unfortunately* not clear in the abstract, it was explained *five* times in the text

We note that the GFC data-set is sensitive to clear-cuts instead of the actual wood harvest, which can be complemented by thinning operations that may not be seen by the satellite—such as when the change in crown cover is not large

Our approach has limitations in the detection of small-scale silvicultural practices.

Although the GFC clearly does not require full clear-cuts to detect forest-cover loss, it is not able to reliably capture partial removal of trees caused by forest thinning, selective logging,

addition, most changes occurring below the canopy cannot be detected by optical instruments, potentially leading further to an underestima-tion of actual harvest wood.

30 m. Small-scale silvicultural practices such as thinning or selective logging—which are relevant in some EU countries—could therefore not be fully detected.

The Suppl Info quantified the share of clear cut (final felling) for each country, e.g.:

Member State	Share of final cut on the managed area (or volume in case of CBM)
Sweden	≈ 37%, as total area

Sweden. The lack of correlation between the GFC data and harvest-removal data is probably due to: (1) when large disturbance

Sweden); and (3) for this country, final felling covered (in terms of area) about 37% of the area annually affected by fellings between 2000 and 2015[56]. This area is not statistically correlated with the total amount

At EU level, ~ 40-50% of harvest is from clear-cuts

EU SCIENCE HUB

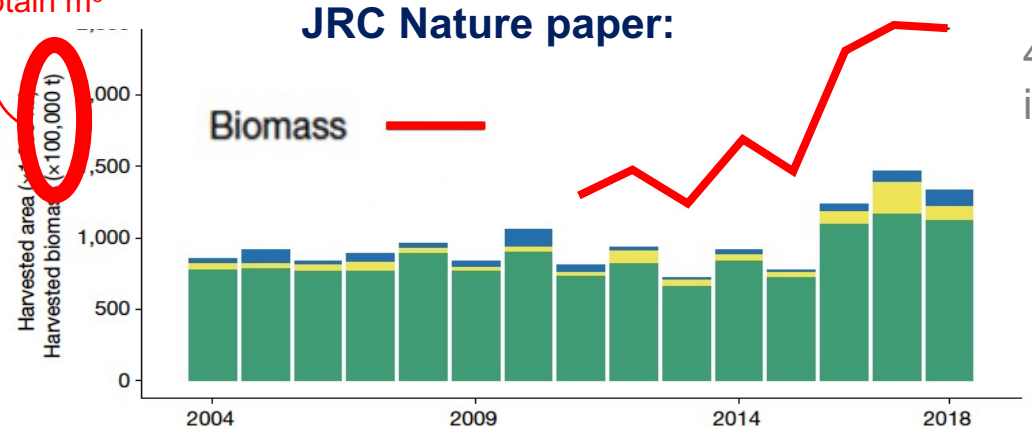
Recent surge in EU forest harvesting, according to JRC study

JUL 02 2020

The total area of forests 'clear-cut' harvested in the EU in 2016-2018 was 49% higher than in 2011-2015, according to a JRC study published in Nature.

Resolving misunderstandings in comparing Ceccherini et al. with country statistics

Multiply by ~ 2 to obtain m^3

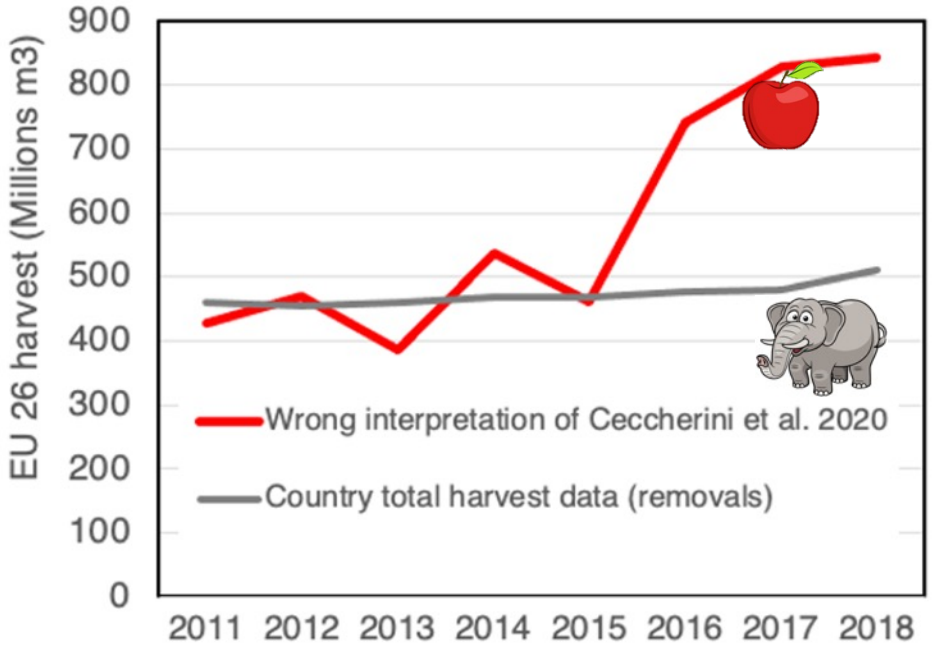


"How could harvest go up from 470 Mm3/y to 790 Mm3 (+69%) in just a few years?"

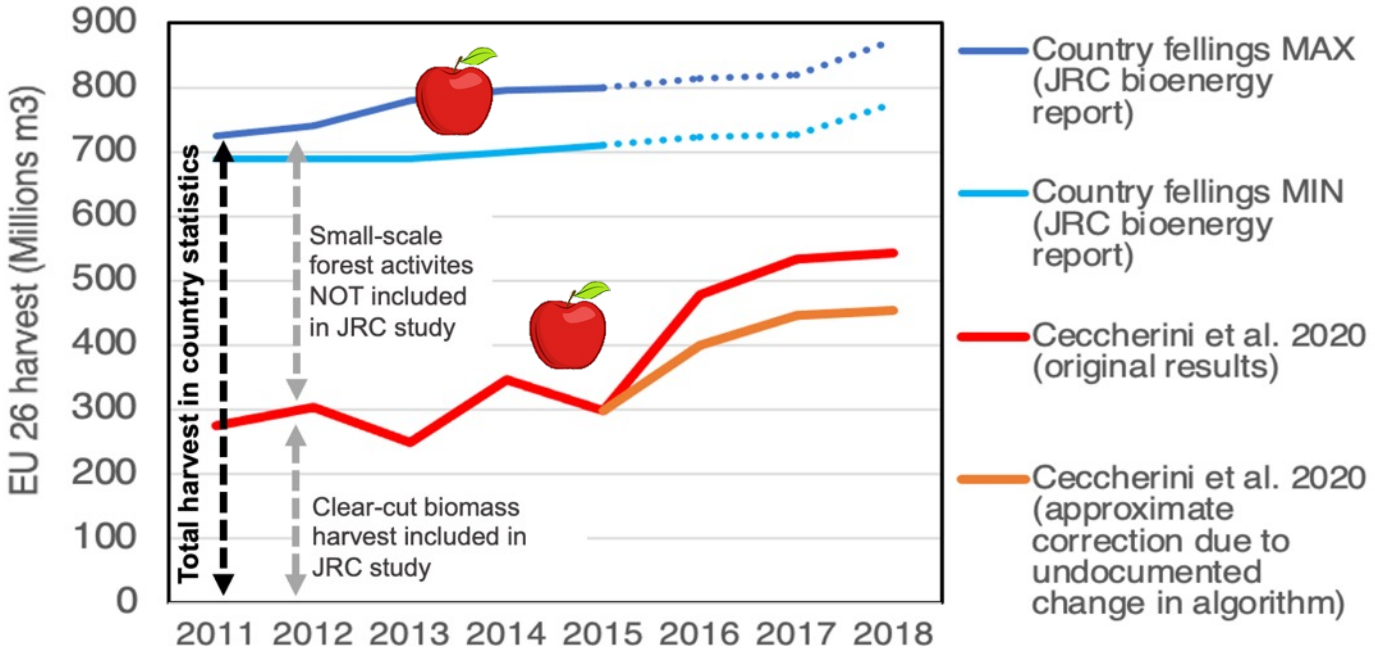
Tonnes of clear-cut fellings overbark (JRC study) *cannot be compared with* m3 of total removals underbark (country statistics)

When latest and more realistic statistics are used, ***Ceccherini results are well below country statistics***

Incorrect comparison JRC vs countries



Correct comparison JRC study vs. country statistics



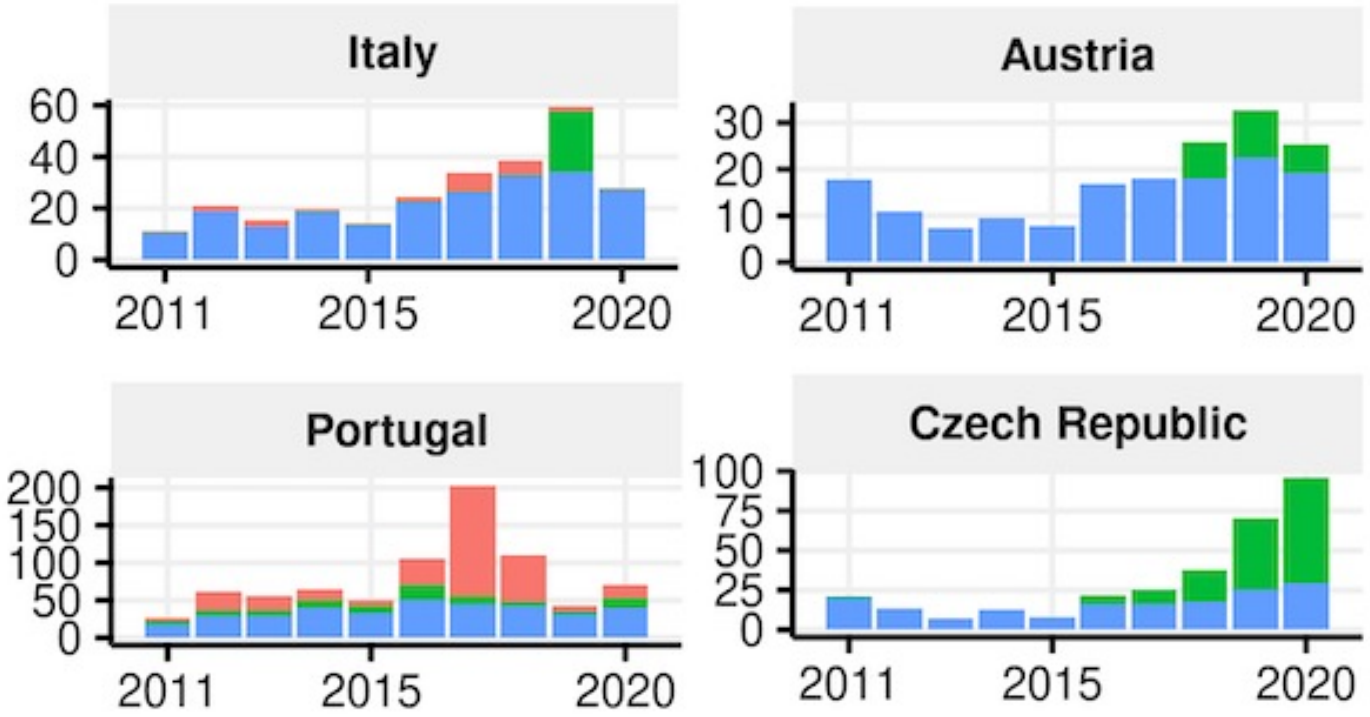
Science advances through progressive improvements. We support open discussions and argumentative exchanges as long as they are exhaustive and unbiased.

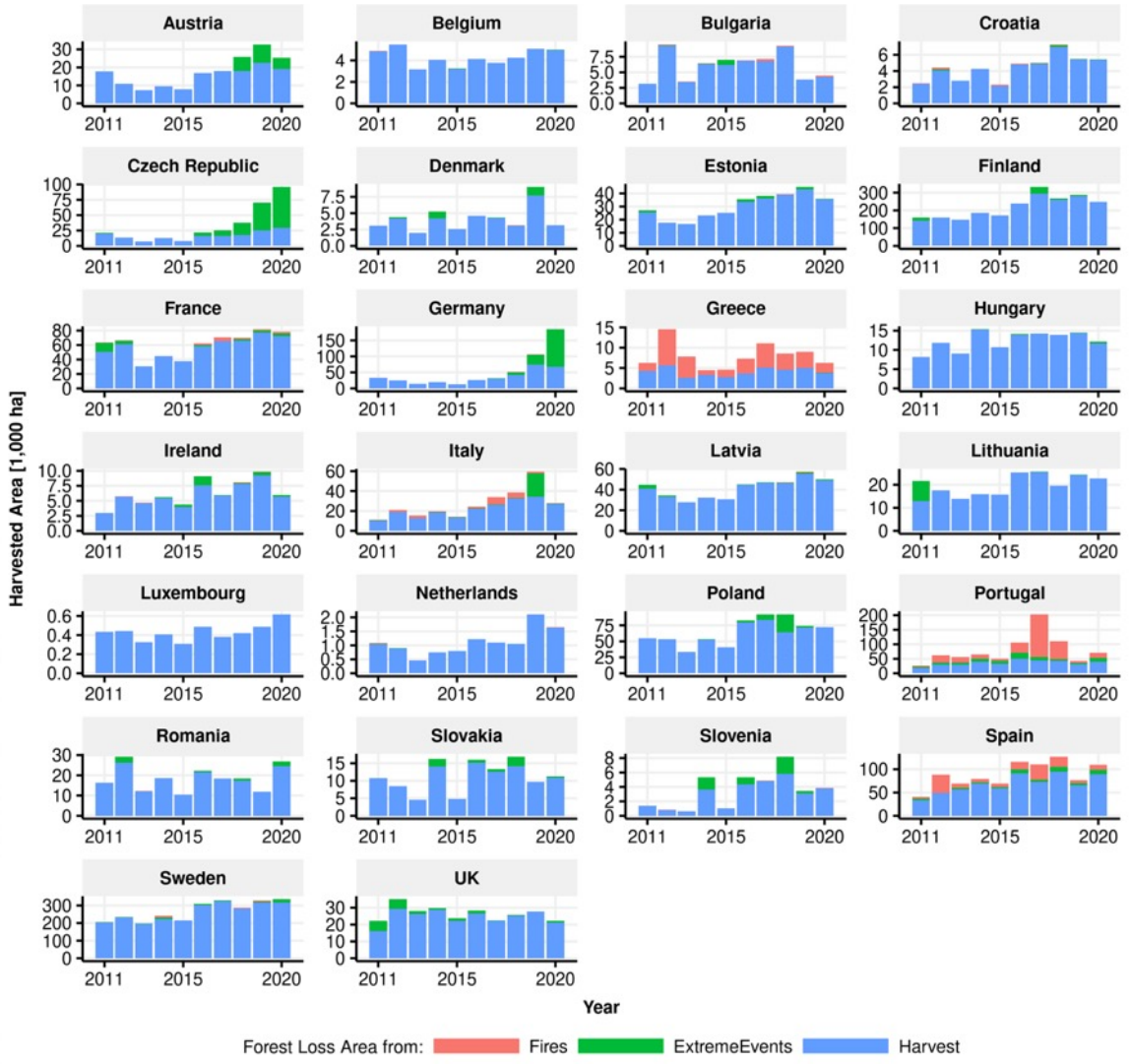
If you want to know more, *read the full story*, i.e.:

- Original JRC study (Ceccherini et al. 2020) https://www.nature.com/articles/s41586-020-2438-y
- Critic 1 (Wernick et al. 2021) https://www.nature.com/articles/s41586-021-03293-w
- Critic 2 (Palahi et al. 2021) https://www.nature.com/articles/s41586-021-03292-x
- Point-by-point rebuttal (Ceccherini et al. 2021) https://www.nature.com/articles/s41586-021-03294-9
- Additional clarification (Grassi et al. 2021, https://iforest.sisef.org/abstract/?id=ifor0059-014), including:
  - Factual mistake in the documentation of the *original dataset* (Global Forest Change) – the JRC study used in a scientifically correct way the best information available, and rectified results when *new* information became available.
  - The results the original study should be interpreted as a warning on a recent increase in clear-cuts observed by satellites, not necessarily as a contradicting country statistics.
  - The study offered a vision for integrating satellite data into the monitoring of forest resources, key to implement LULUCF Reg. Follow up discussions and collaborations should focus on this.

Detection of forest disturbances

- Extreme events based on anomaly in harvest rate
- Detect major ongoing events
- To improve the method we need georeferenced data



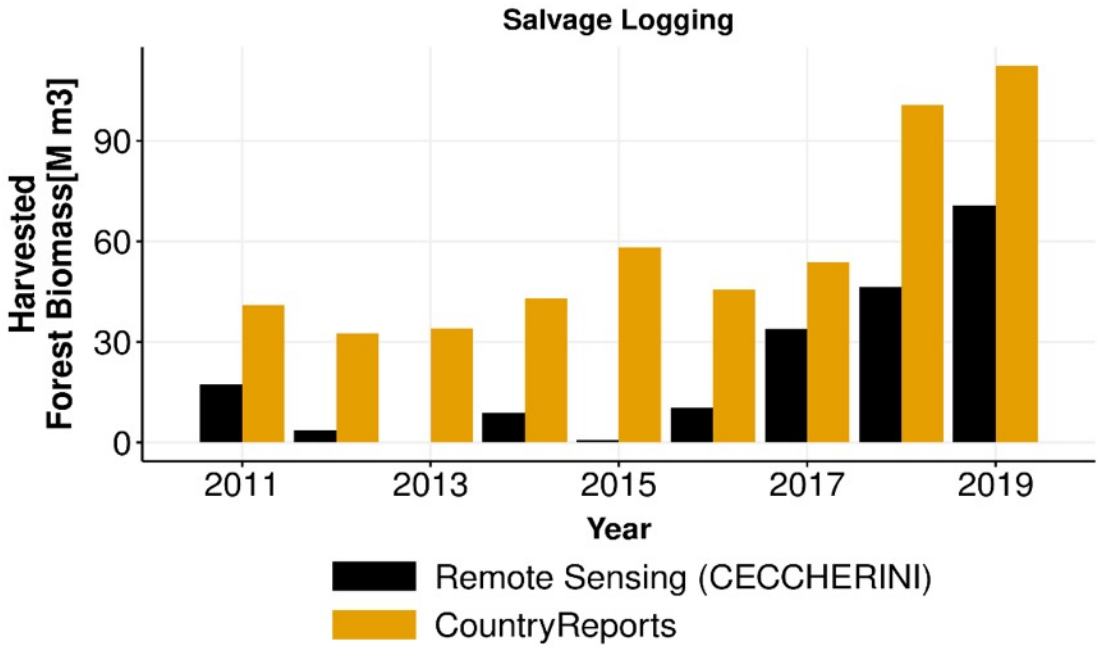


- Early warning system to detect anomalies in disturbance rate.
- The method can become operational at continental and global scale (annual update).

Detection natural disturbances from satellite records

- Our method detects anomalies in forest cover losses, therefore **major events** but not the "background" level of natural disturbances.
- While our approach is an approximation, no better data for the EU is currently available.
- Recent country-based evidence suggests that **our study understimated the absolute level of natural disturbances, but captured well the trend**

https://www.globalwoodmarketsinfo.com/

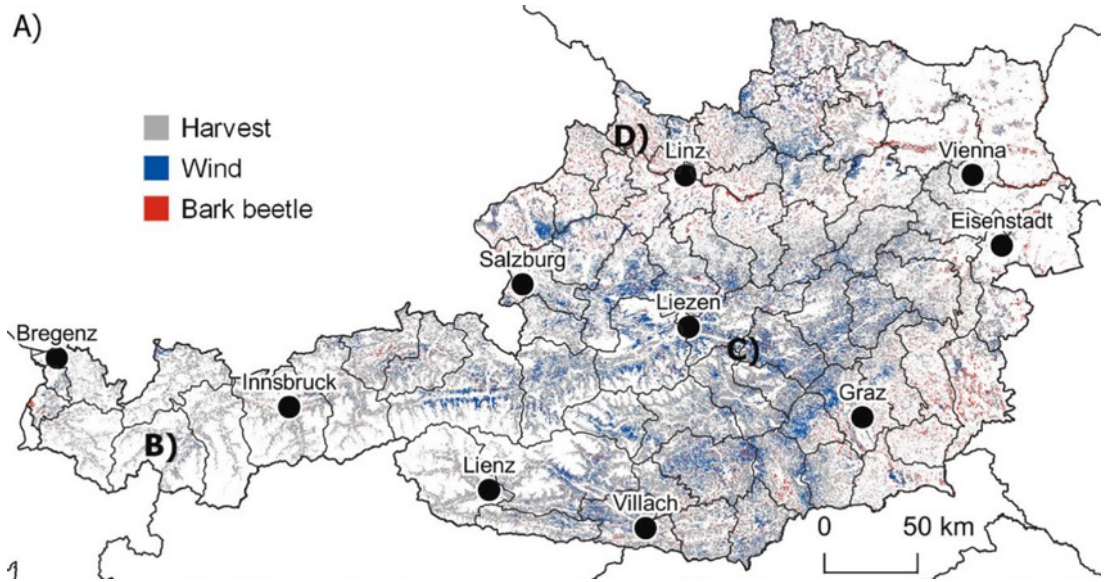


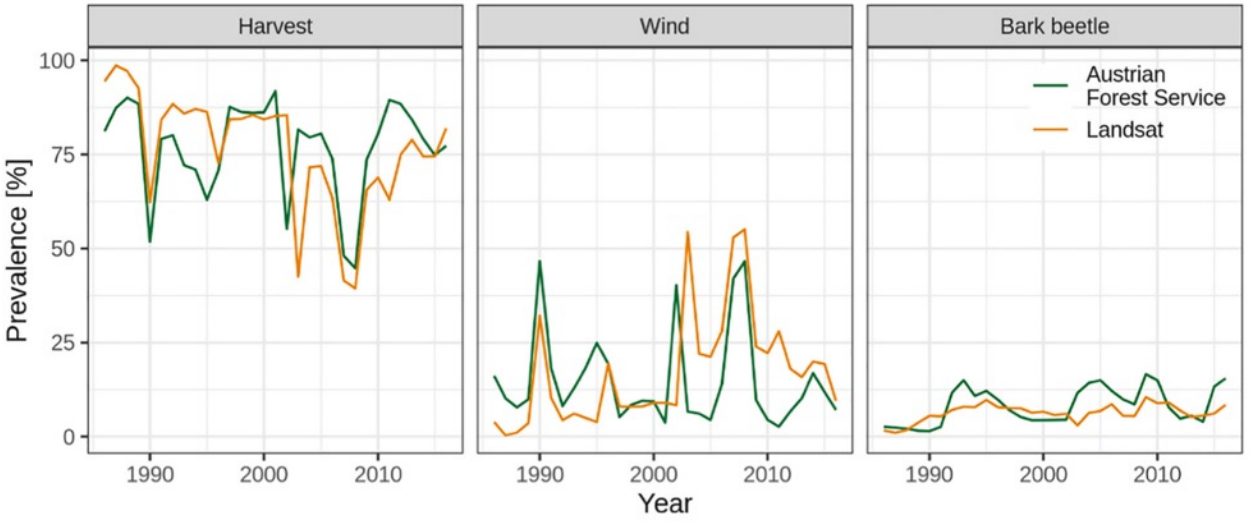
Reports on harvested biomass from salvage logging from 14 MSs: Austria, Bulgaria, Croatia, Czechia, Estonia, Finland, France, Germany, Hungary, Lithuania, Poland, Slovakia, Slovenia, Sweden

Satellite retrievals and machine learning for the attribution of disturbance agents

Sebalt et al. presented a novel approach for the causal attribution of forest disturbance agents in Austria for the period 1986–2016:

- 1.01 million disturbance patches mapped with Landsat
- Surface data at 2620 disturbance patches for training
- RF Machine learning algorithm





Sebald, J., et al., Remote Sens. Environ.2021.

European Commission

The critical role of surface data for the production and validation of remote sensing products

- National Forest Inventory. Extraordinary valuable source of detailed surface data, still largely unexploited because:
  - Different methodologies and time frequency between countries
  - Limited availability of data, in particular the accurate plot coordinates
  - Variables report often stand and not plot properties

- Collection of data on natural disturbances (WindFor, DEFID2)

Earth Syst. Sci. Data, 12, 257–276, 2020
https://doi.org/10.5194/essd-12-257-2020

Open Access Earth System Science Data

A spatially explicit database of wind disturbances in European forests over the period 2000–2018

CONCLUSIONS

- There is great demand for robust, spatially explicit and timely forest data
  - Data on forest biomass, C budgets and harvest rates are relevant for a multitude of ecosystem services (i.e. climate mitigation, biodiversity, biomass supply) and are likely affected by the rapid increase in natural disturbances.
  - EU policies and strategies need timely and spatially-resolved datasets.

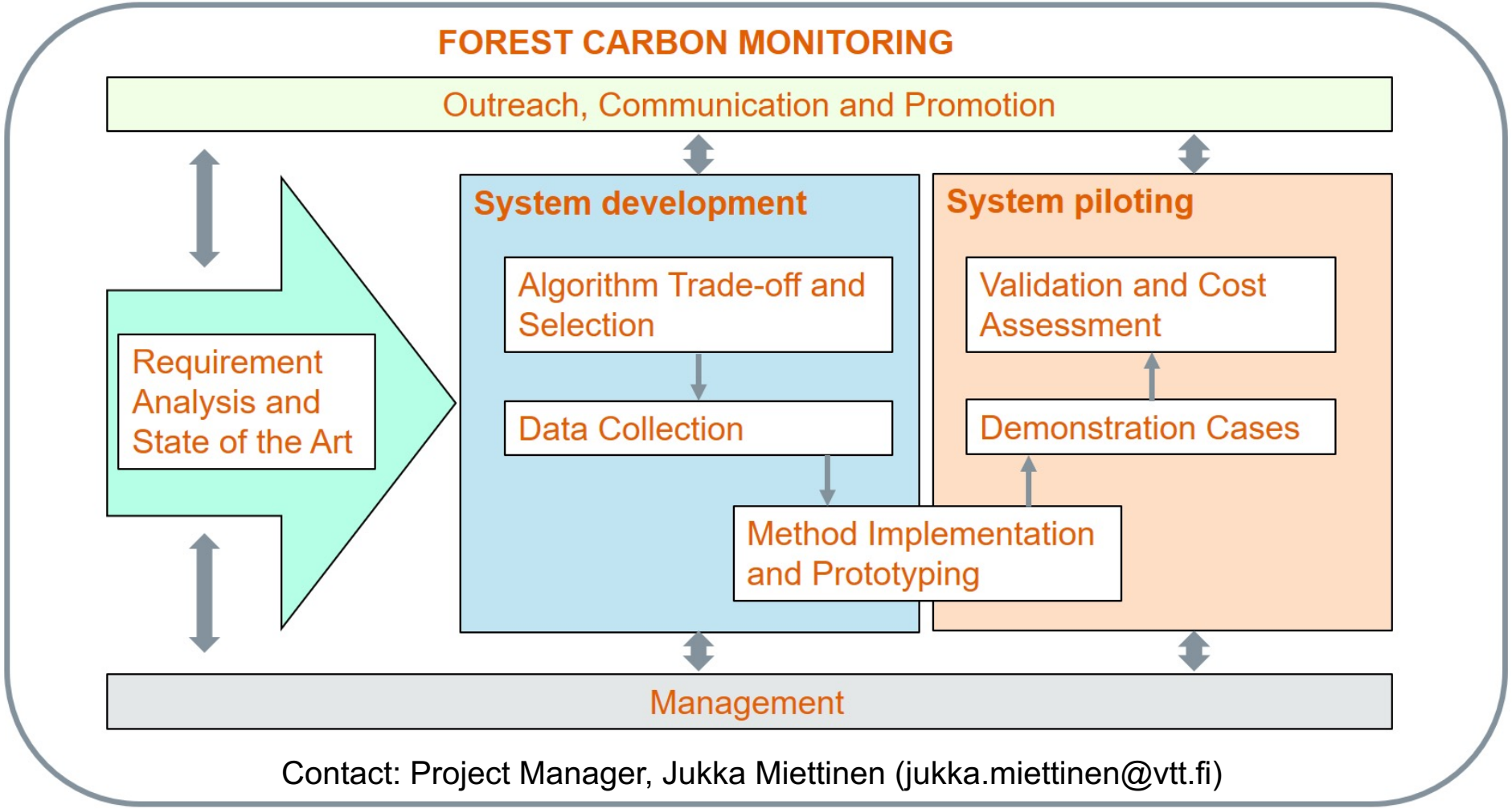
- Sample-based approaches in isolation cannot become the operation way to meet this high demand
  - Ground samples are of exceptional value to build and validate hybrid products based on Earth Observations. To do so, ground surveys should be designed from the beginning for the integration with satellite RS.

We are approaching a revolution for the integration of Earth Observation.

The success of this integration, depends not only and the combination of ground surveys and satellite retrieval, but also on the cooperation among the scientific communities involved, the National Forest Agencies and the EU institutions.

ESA Forest Carbon Monitoring project (2 year: Jul 2021 – Jun 2023)

The objective of the project is to **develop a prototype of a reliable monitoring and accounting platform for forest carbon stock** which maximizes the synergetic use of Earth Observation data and responds to policy needs with direct added-value for user organizations.



Contact: Project Manager, Jukka Miettinen (jukka.miettinen@vtt.fi)

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