Earth observation for improving LULUCF GHG inventories in Europe

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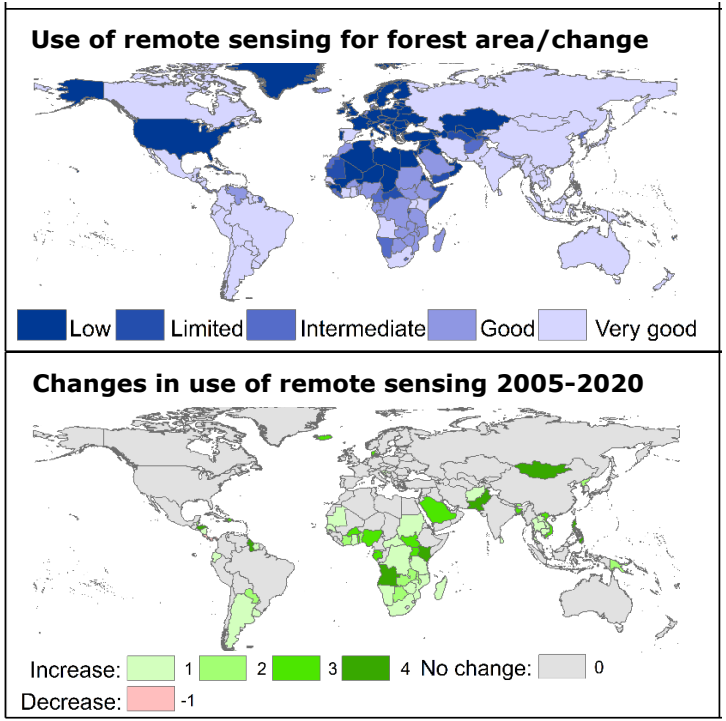
With contributions by many …

GFZ Helmholtz-Zentrum Potsdam

WAGENINGEN UNIVERSITY & RESEARCH

Country forest monitoring data (FAO FRA 2020)



Nesha et al., 2021. An assessment of data sources, data quality and changes in national forest monitoring capacities in the Global Forest Resources Assessment 2005–2020, ERL

- Continuous improvement in the use of remote sensing for forest area and change estimation (in tropical countries Africa)
- Impact of international capacity development initiatives (i.e. FAO, GFOI, GFOI Methods and Guidance Document)
- Most European countries use multi-date NFIs

Recent and upcoming EU policies

- **Refined LULUCF regulation**
- **New EU Forest Strategy for 2030**
- **Nature Restoration Law (proposal)**
- **Climate Law**
- **Sustainable Carbon Cycles**
- **Envisaged legal proposal on EU forest monitoring**
- **Regulation on deforestation-free products**

-> increasing role of satellite forest monitoring becoming essential for current and new policy making, compliance monitoring, transparency and enforcement of EU policies

New LULUCF regulation and implications for EO monitoring

1. Geographically-explicit land use conversion data:
   - IPCC approaches 2 and 3 and more transparency
2. Geographically-explicit information to identify priority areas that have the potential to contribute to climate action:
   - Spatial information for climate policy purposes
3. Improved monitoring of natural disturbances:
   - Identification (location, type, period) and potential compensation for losses
4. Moving towards Tier 2 as minimum requirement from 2028 onwards:
   - Tier 3 in specific areas (i.e. high carbon stocks, high climate risk)
5. Increasing timeliness:
   - Annual inventories, compliance checks, closer ties to policies and actions

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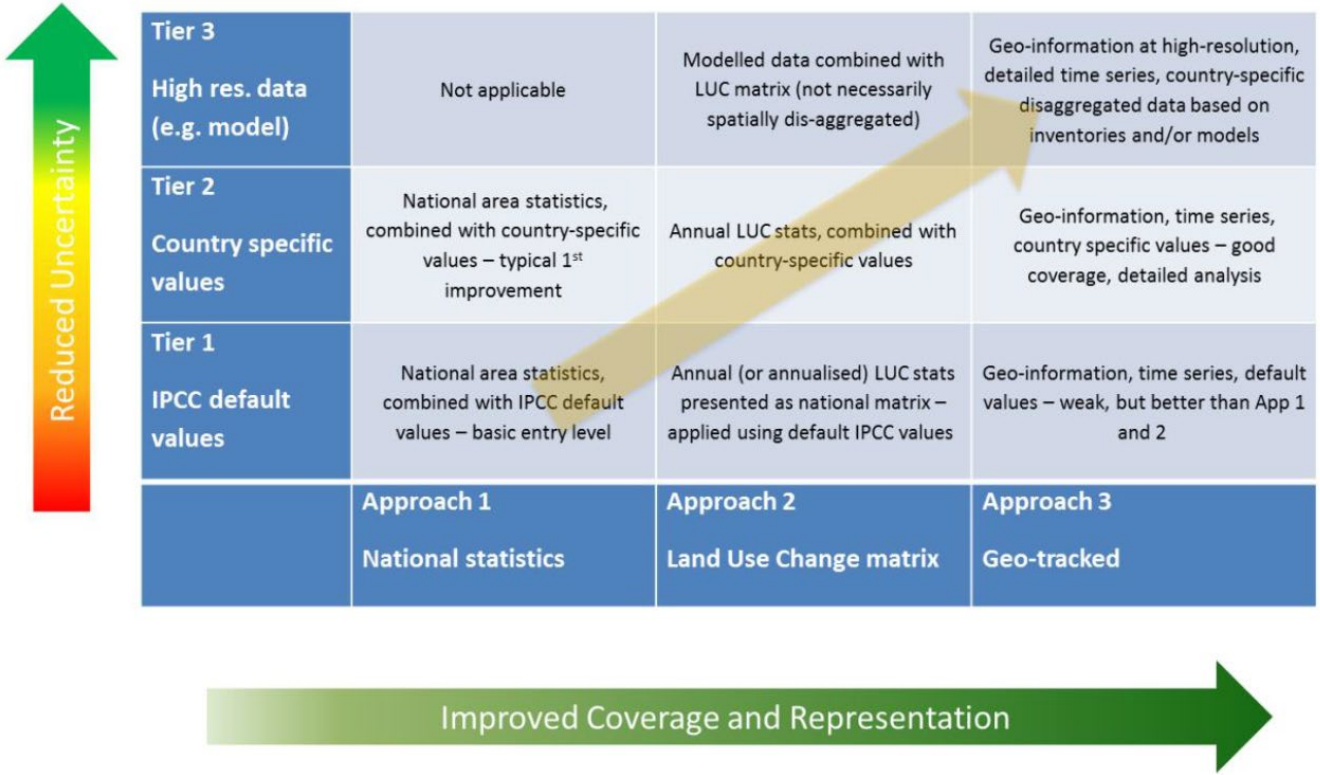
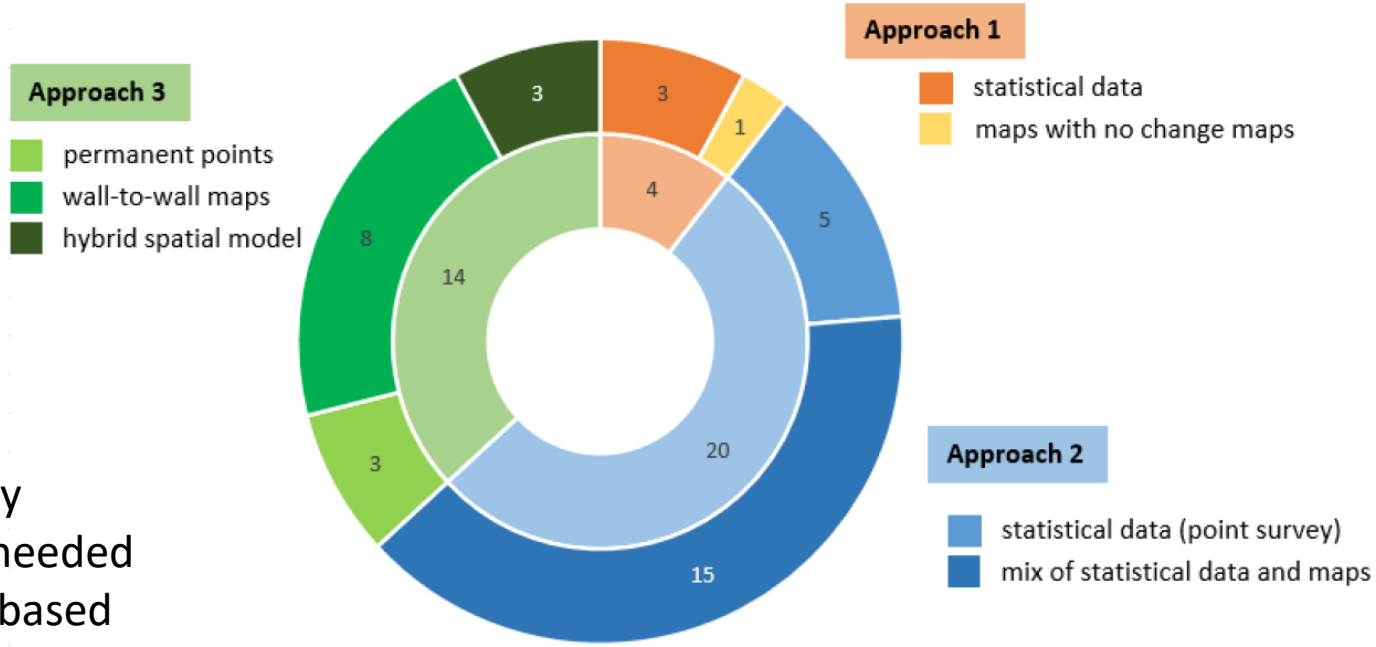
Geographically-explicit land use conversion data



Land representation approaches applied in EU MS



Some issues:

- Land use definitions
- Temporal consistency
- Additional capacity needed moving towards EO-based approaches

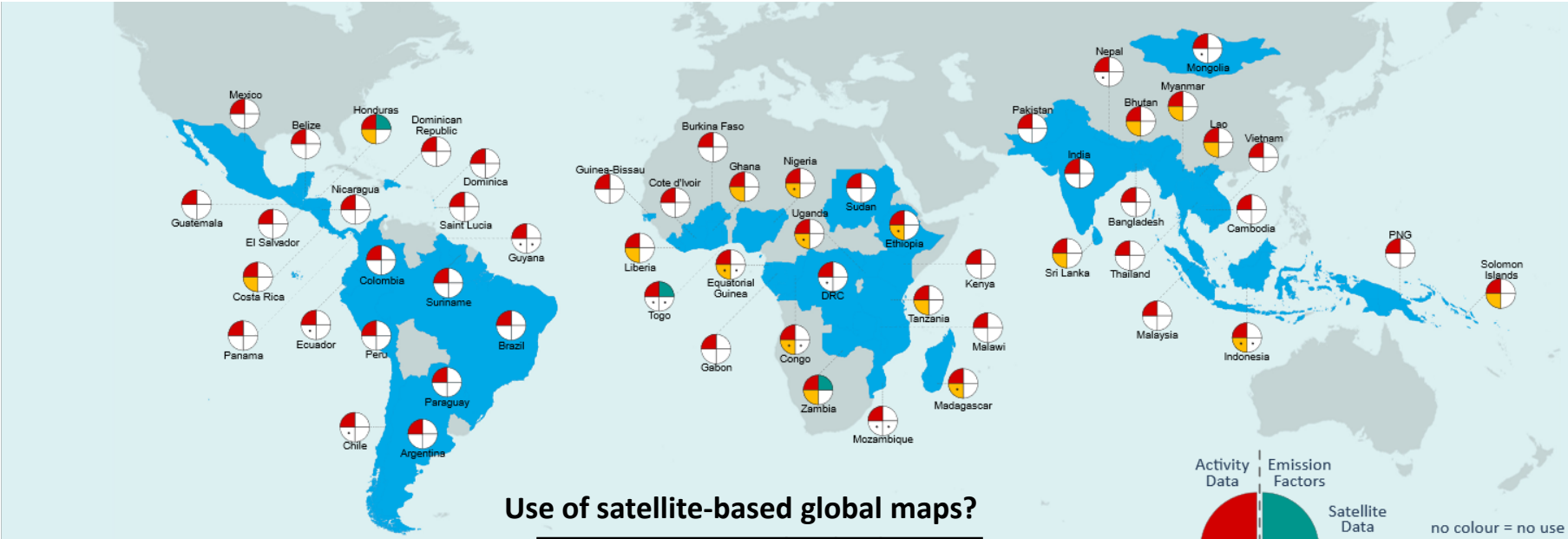
Source: EEA report

Note: some countries use different approaches for different periods

Earth Observations for land change monitoring

1. Approaches for forest, land cover (use), area and changes are developed
   - Landsat satellite archive (30x30 m) since 1984
   - Sentinel 2 (and Sentinel 1, 10x10 m) since 2015
2. Series of (operational) large-area products and services:
   - EEA's CORINE land cover
   - JRC's tropical moist forest dataset (1990-2019, 30 m)
   - UMD/WRI Hansen tree cover, land cover change (2000-20, 30 m)
   - Copernicus EU high resolution layers and global land monitoring service (Global: 2015-19, 100 m)
   - Future Copernicus global land cover/forest monitoring service (tender open)
3. Free, open and transparent data and information

Use of satellite data in forest reference emission levels

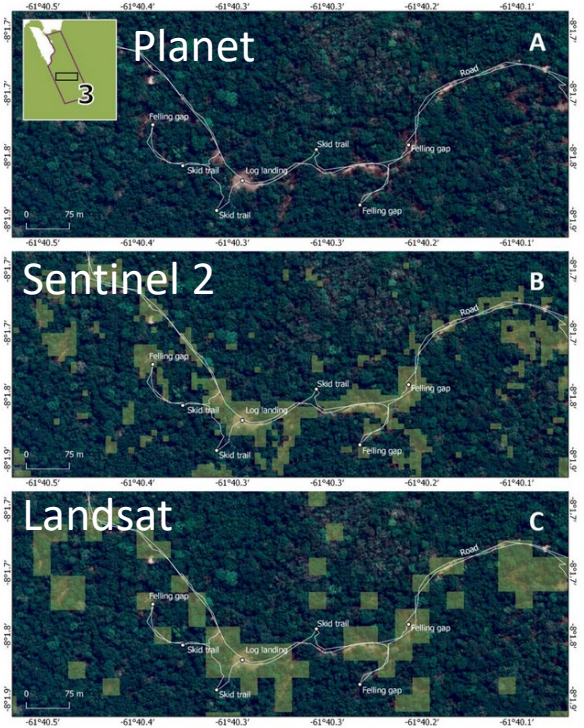


Use of satellite-based global maps?

Global product	AD	EF	Indirectly
Global forest change (GFC)	16	-	14
MODIS Fire (BA, AF)	2	-	1
Saatchi et al (2011)	-	-	3
Baccini et al (2012)	-	-	2

Source: Melo et al., 2023 ERL

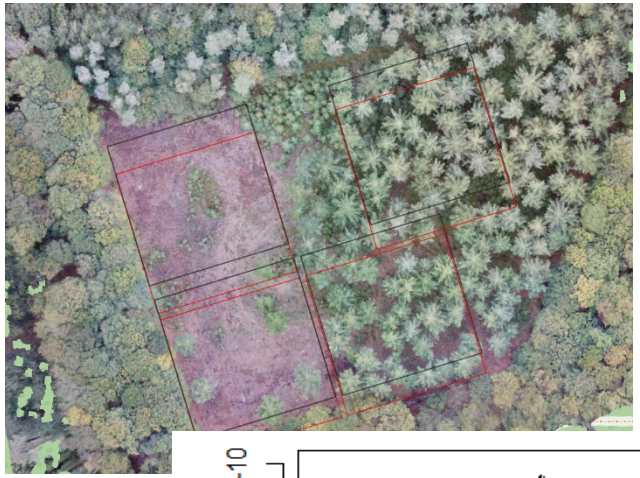
Increasing spatial detail in disturbance monitoring and characterization



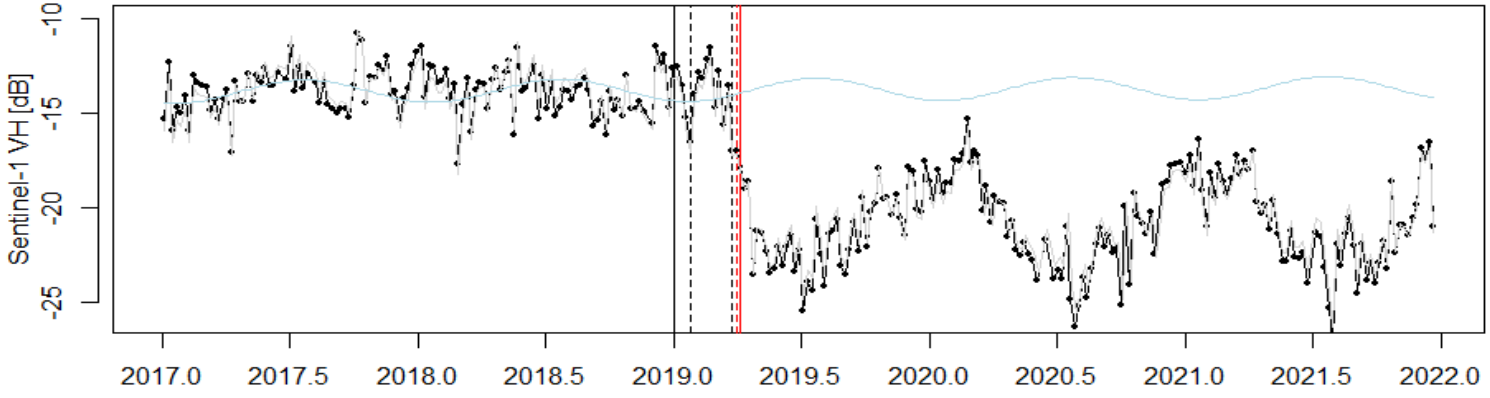
[Forest disturbance detection S2 versus Landsat
Almeida Lima et al., 2019]

1. Moving from Landsat (30x30m) to Sentinel-based (10x10m) monitoring for large areas
2. Sentinel data availability from 2015 onwards
3. Both optical (S2) and Radar (S1) dense time series data
4. Increasing detail and quality for small-scale disturbances – i.e. selective logging

Increasing temporal detail in disturbance monitoring and characterization



- Importance of dense time series data for tracking changes and dynamics (S1 2-3 days repeat for most of Europe)
- Potential for rapid detection of changes



Credit: F. Sterk and S. vd Woude (WUR)

Refining land use conversion data using EO

1. Long-term consistency is key but not necessarily in "methods" but for (robust) statistical estimates that can be compared
   - Different methods can be applied over time (if robust and without/little bias)
   - Confidence will increase over time with better data and approaches
2. New regulation – focus on 2030 target and period after 2015
   - Not downgrading today's approaches with "weakest" method in the past
3. Concept of methodological adjustment to neutralize effects of the changes in methodology
   - Opportunity to introduce new approaches
4. Minimum option in absence of available national data: use Landsat historical archive (since 1980's) and Sentinel archive starting 2015
   - New EU LULUCF regulation – higher quality IPCC GPG approaches
   - If better estimates can be provided now, some "downgrading" could be done to comply with IPCC also for historical periods (i.e. 1990's)

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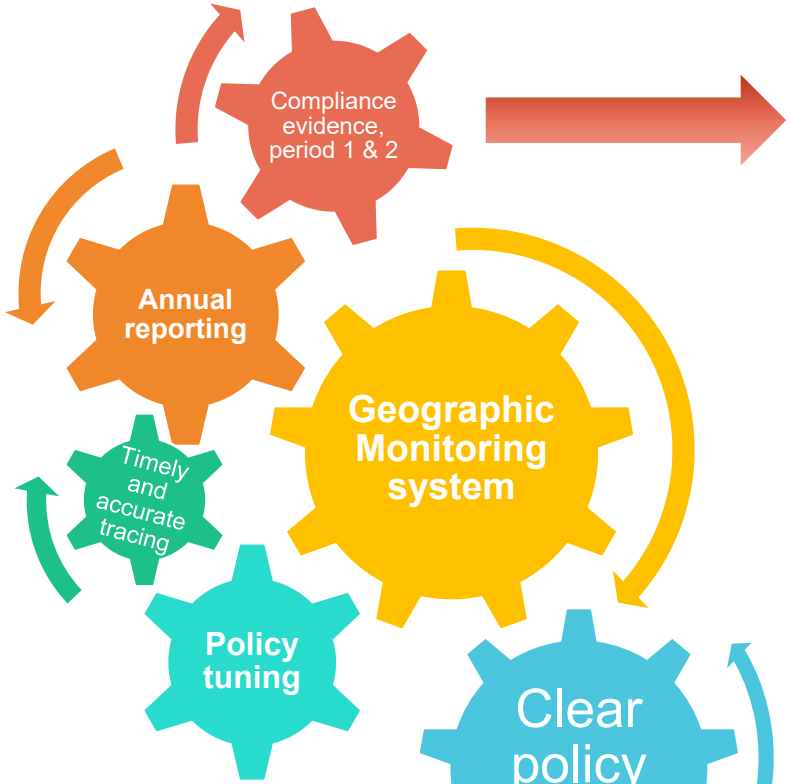
Differentiated LULUCF observation needs along the policy cycle

- **Awareness/problem definitions:**
  - Land use change and GHGs emissions
  - IPCC assessment reports etc.
- **Policy options/selection (national):**
  - EU/national policies development (NDCs)
  - Scope activities: where, why, how
- **Implementation (local):**
  - Local data supporting land management
  - Strategic land use planning
  - Regular progress tracking, transparency
- **Evaluation/performance assessment:**
  - Incentive systems
  - National: GHG inventories and reporting
  - UNFCCC global stocktake

Monitoring - the key to policy implementation

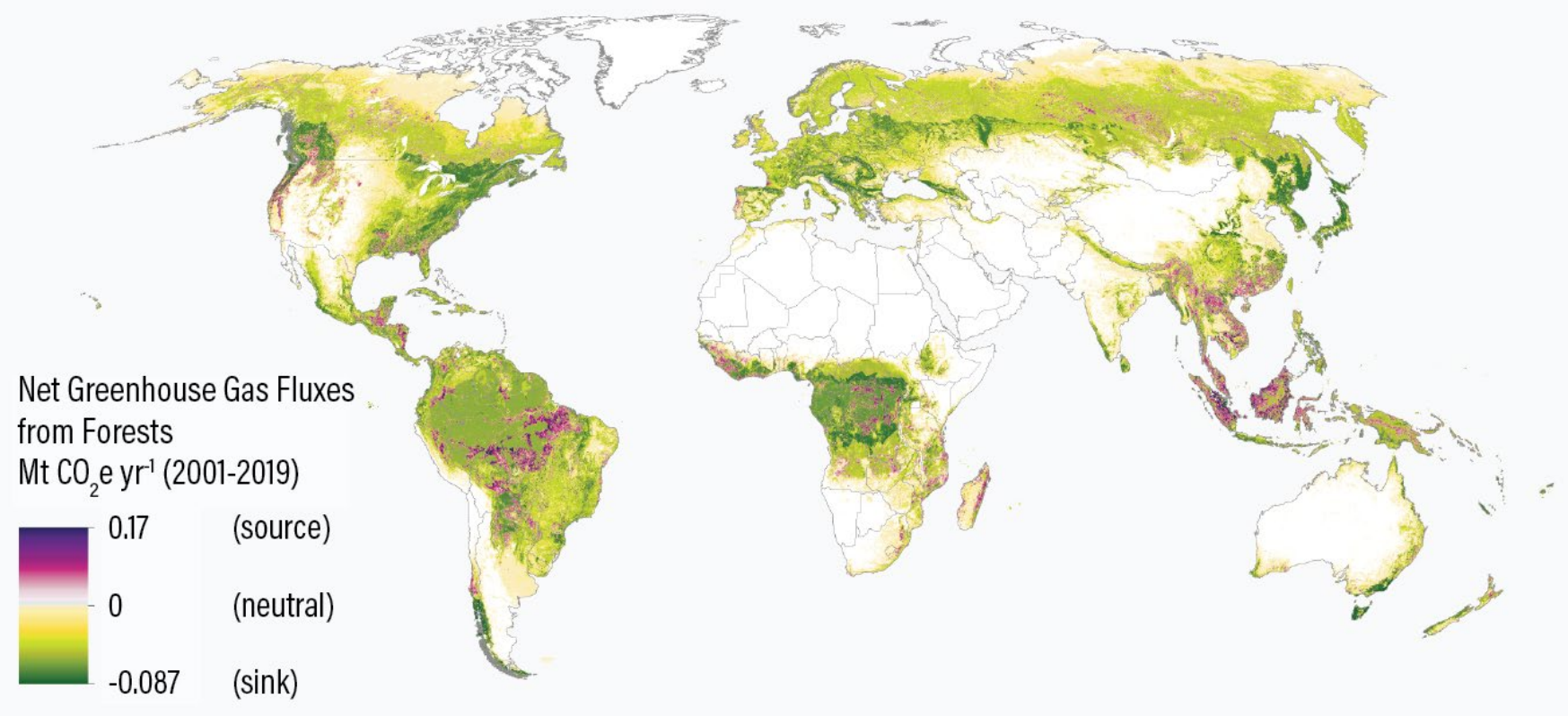


Compliance **check** with target, 2027 & 2032

Transparent, simplified targets

European Commission

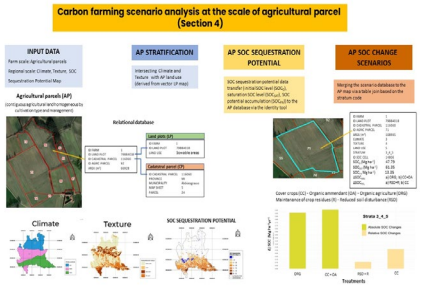
Ongoing research: Earth Observation-based forest carbon stock change estimations



Paper: Harris et al., 2021, Nature Climate Change
Data: https://gfw.global/315sv5h

GIS FARMs

www.c-farms.eu



- **Decision support system (DSS)**
- **Repository of monitoring information**
- **Knowledge hub**
- **Registry/verification tool**

Functions | *End users*

Selection and simulation of the effects of the CF practices at farm level

Upload monitoring and measurement data

Farmers

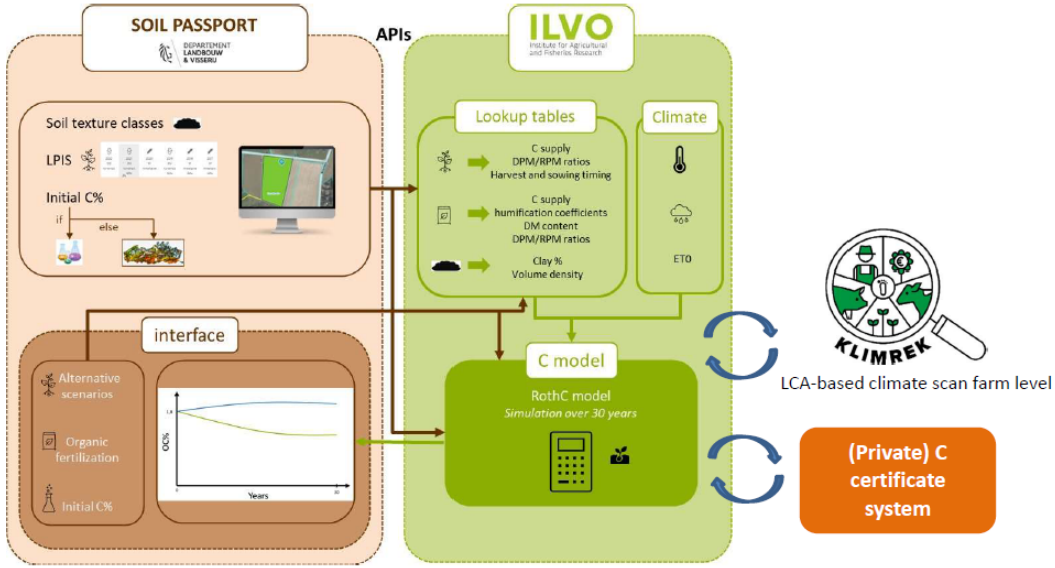
Validation, storage, registry, link with LPIS system, **Link with GHG inventory agency**

Scheme owner/payment operators

Selection and simulation of the effects of the CF practices at landscape level

Policy makers

Case soil carbon



⇒ **Interoperability**
⇒ **Harmonised MRV knowledge base**
⇒ **Allowing for improvements upon new scientific evidence/insights**
⇒ **Connecting with EU research (a.o. EJP SOIL)**

LIFE CarbonCounts:
Enabling carbon farming in Flanders by establishing a geospatial information System

Contact:
Greet.Ruysschaert@ilvo.vlaanderen.be

ILVO

Spatial/timely information for climate policy and actions

- Evolve GHG-I towards policy tools
  - Consider NDC and national climate action plans (consistency)
- Where to implement certain climate actions and why?
  - Distribution of stocks, sinks and sources can be an important baseline
- Support the implementation (i.e. improved land management) with specific data and information on land use and GHG impacts
  - How to keep track of progress and provide transparency on the climate actions and their impacts (and link to incentive systems)
- Tracking activities and progress:
  - As for Nature restauration law for example
  - Need to regularly check and adjust polices (if needed)

Time for Q&A

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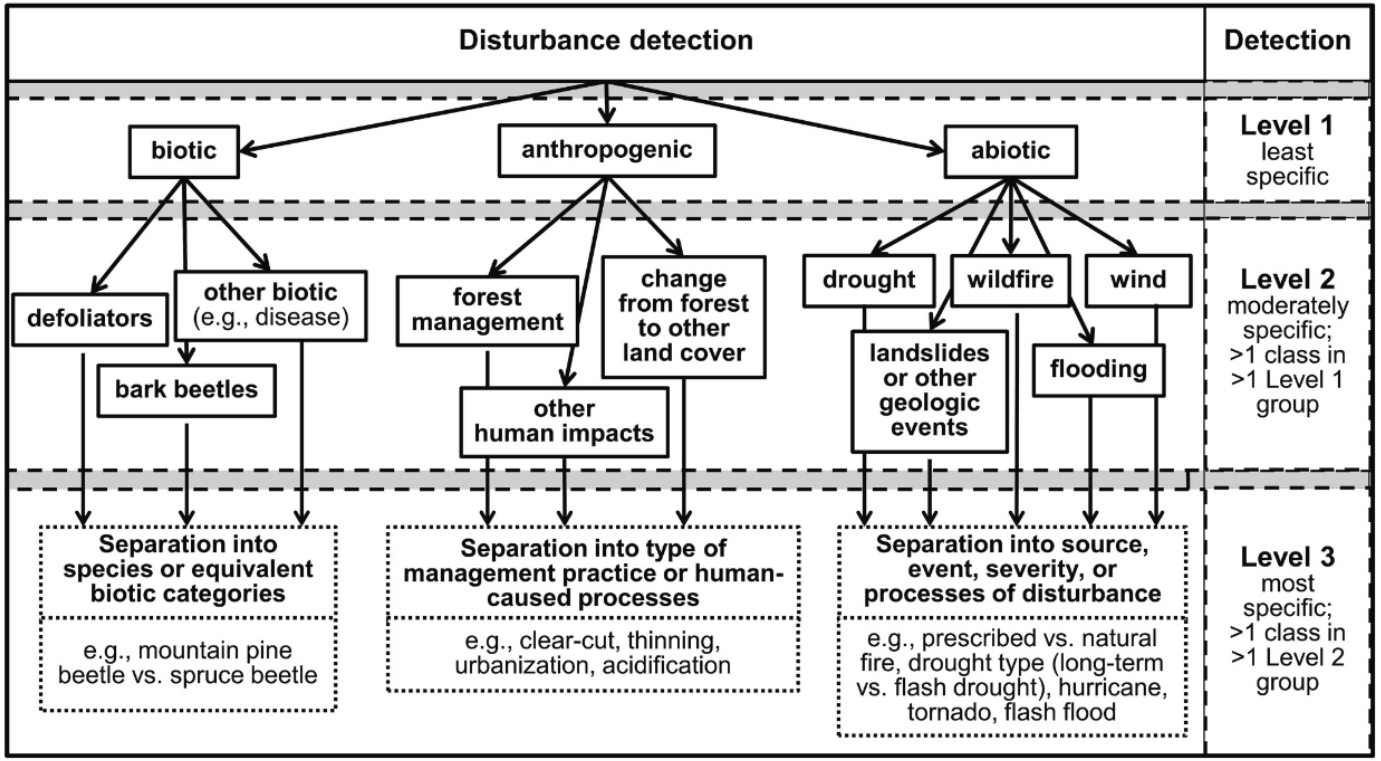
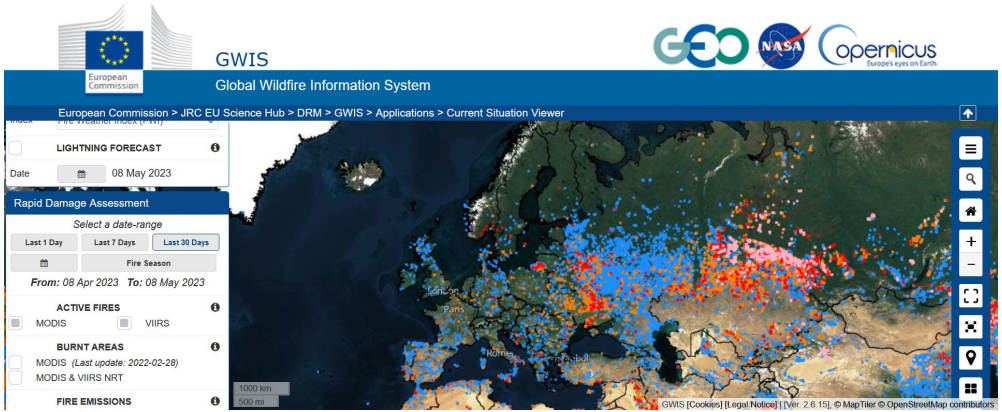
Forest disturbances: definitions, types and characteristics



Stahl et al., 2023, RSE

Some tools and approaches exist



JRC Fire Information System:
https://effis.jrc.ec.europa.eu/

JRC: drought observatory
https://edo.jrc.ec.europa.eu/

Improved monitoring of natural disturbances

- Important to consider for GHG-I and for potential compensation
- Monitoring and attribution of natural disturbances:
  - "Identification of all land areas affected by natural disturbances in that particular year, including their geographical location, the period and types of natural disturbances"
  - Some tools are already available (i.e. EFIS) and for tracking forest disturbances
  - For others, approaches still need to be developed
- With good baseline spatial data of terrestrial carbon stocks (biomass, soils) any impact of natural disturbances can be assessed more easily

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Moving towards higher Tiers as minimum requirement

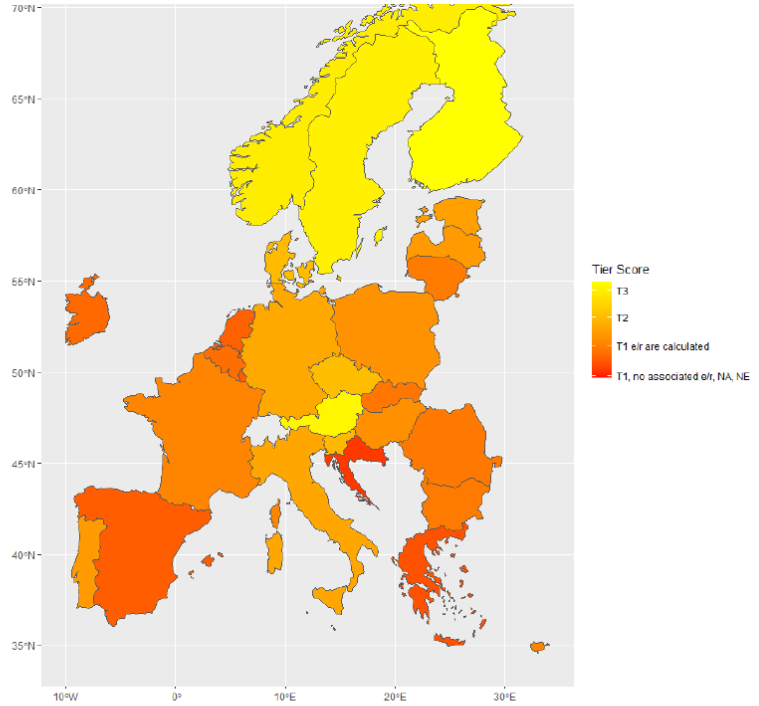
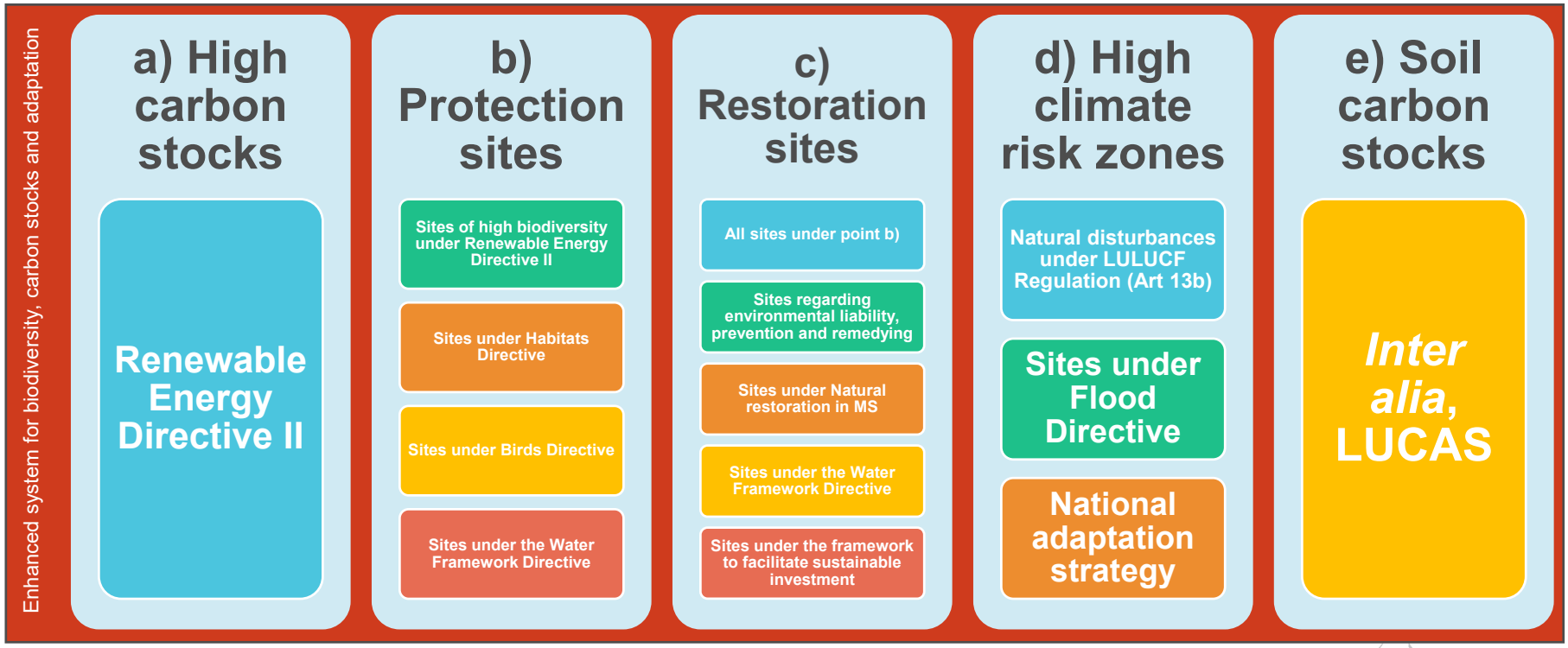


Figure 20 Weighted average of Tier reporting by country by land area in all carbon pools the land use categories (4A – 4F)

- Member States shall use at least Tier 2 methodologies (for 2030 reporting) and Tier 3 in specific areas
- Improve the quality for estimation
- Supporting climate action (assessment)

Source: EEA report

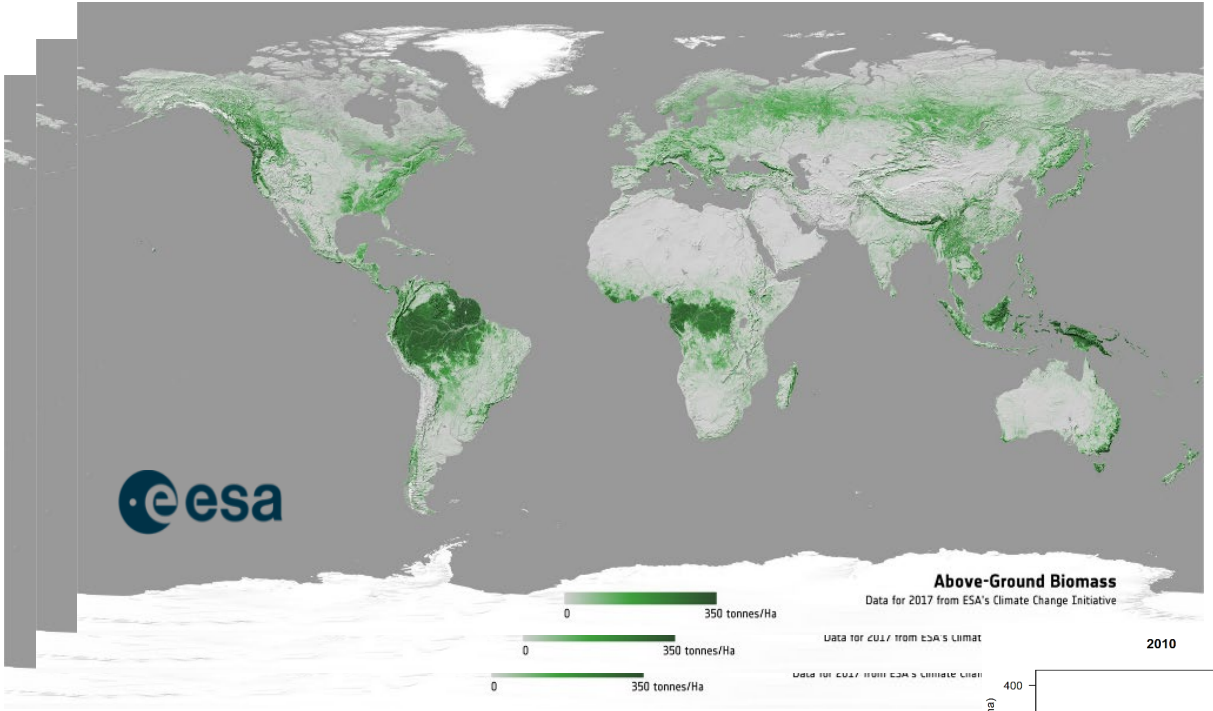
Enhanced LULUCF monitoring (higher Tiers)



Biodiversity Strategy, Nature Restoration Law

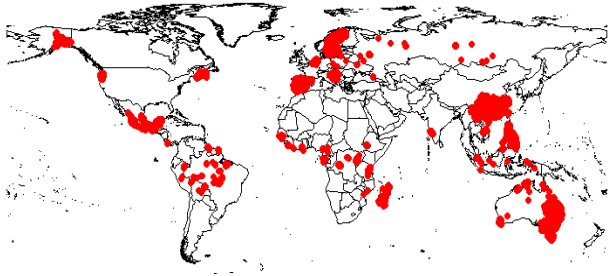
European Commission

Aboveground biomass estimation using satellite data

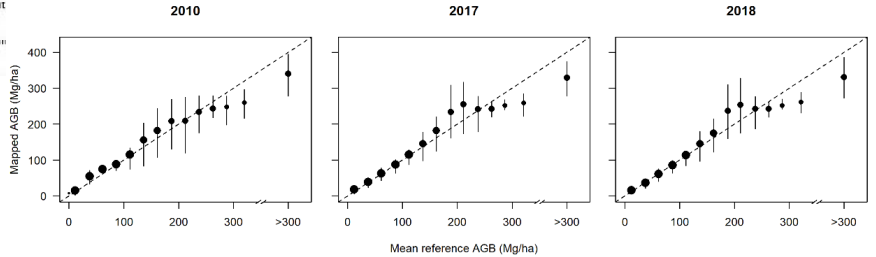


ESA Global aboveground biomass for 2010, 2017, 2018, 2020 at 100m spatial resolution, http://cci.esa.int/biomass
Santoro et al., 2021, ESSD

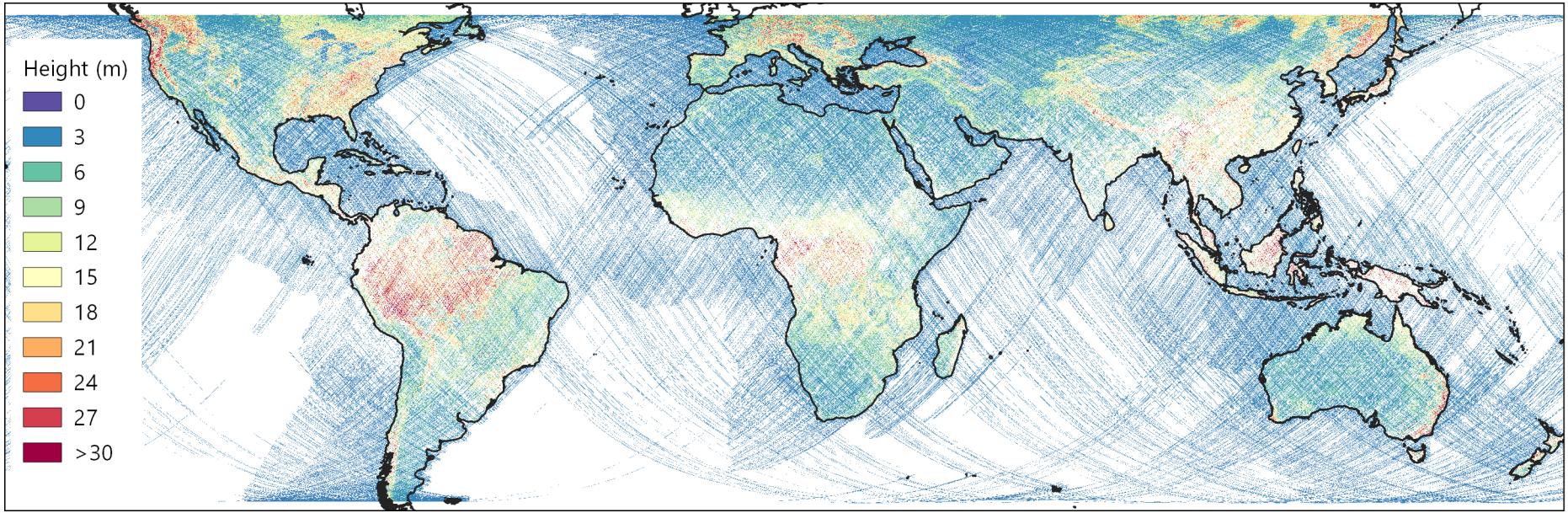
Global reference database (~109.000 plots)



Biomass harmonization for Global Stocktake UNFCCC COP 26 dashboard:
https://ceos.org/gst/
https://earthdata.nasa.gov/maap-biomass



ISS-GEDI samples (first 6 months)



Canopy top height measurements of GEDI LiDAR, resampled at 1 km spatial resolution, for the first 6 months of data available for 2019

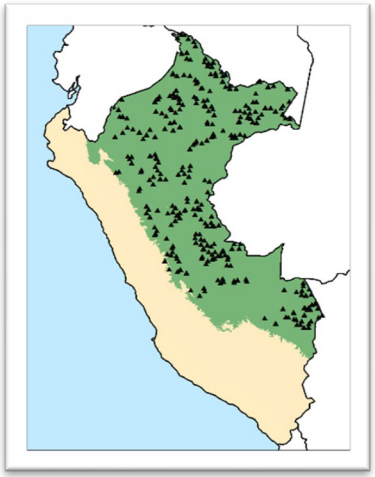
Enhancing country level estimation using space-based biomass estimates

- Some countries are already using/producing biomass density maps (airborne LIDAR data very useful)
- National GHG estimation and reporting (see also IPCC GPG 2019 refined guidance):
  - Assess carbon stocks to produce emissions estimates, incl. to increase data density in under-sampled or inaccessible areas
  - Integration with activity data to produce wall-to-wall estimations
  - Direct estimation of biomass change (i.e. for IPCC Tier 3)
  - Verification and comparison purposes
  - Provide additional spatial information to the GHG-inventory
- Statistical appraoches for combining national forest inventory data with satellite-based biomass estimations

Peruvian Amazonia: Assess the gain of *precision* in AGB estimates from the use of the global biomass maps through 4 different scenarios

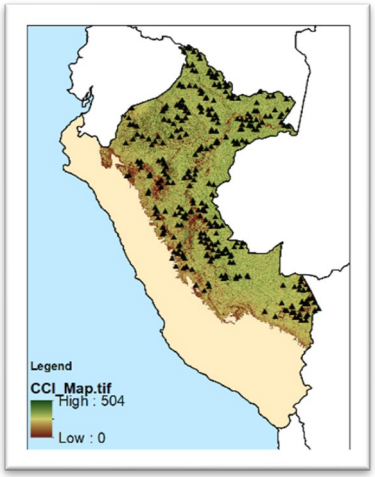
Scenario A

Baseline scenario



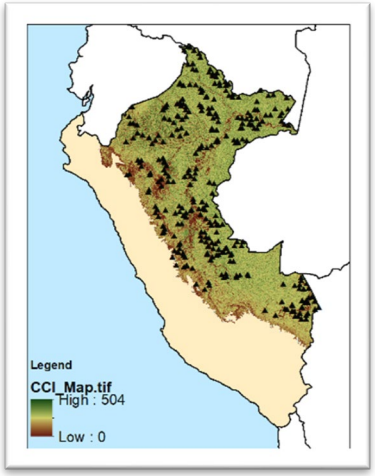
Scenario B

Using the uncalibrated biomass map



Scenario C

Using the locally calibrated biomass map



[Accounting for uncertainties]

Scenario D

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Increasing timeliness of GHG estimation

- Temporal frequency: need for annual inventories
- Regular reporting and assessments: Compliance check every 5 years (but based on annual/recent estimates)
- Up to date data and estimates: closer ties of GHG-I to policies and corrective actions
- EO as a source of data help to tracks the “fast” changes:
  - Land use changes and various types of disturbances
- Combined use of ground measurements and inventories with EO approaches is possible

http://radd-alert.wur.nl

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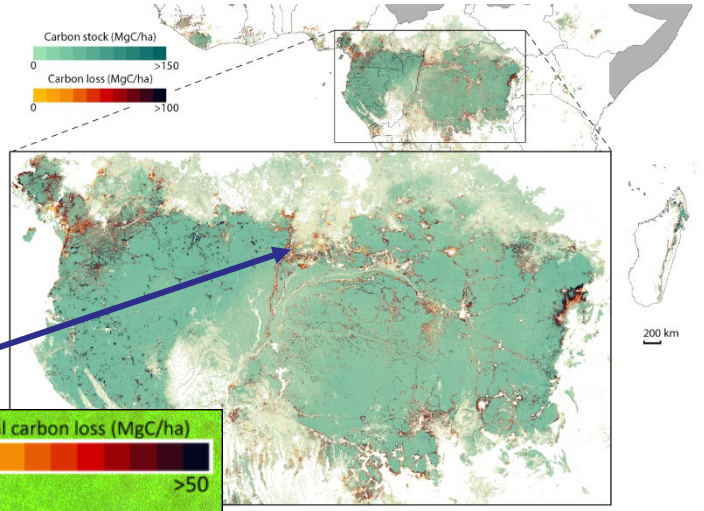
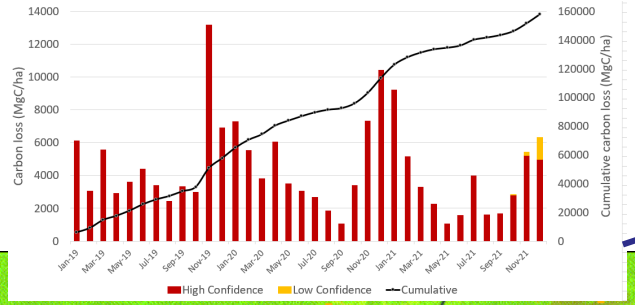
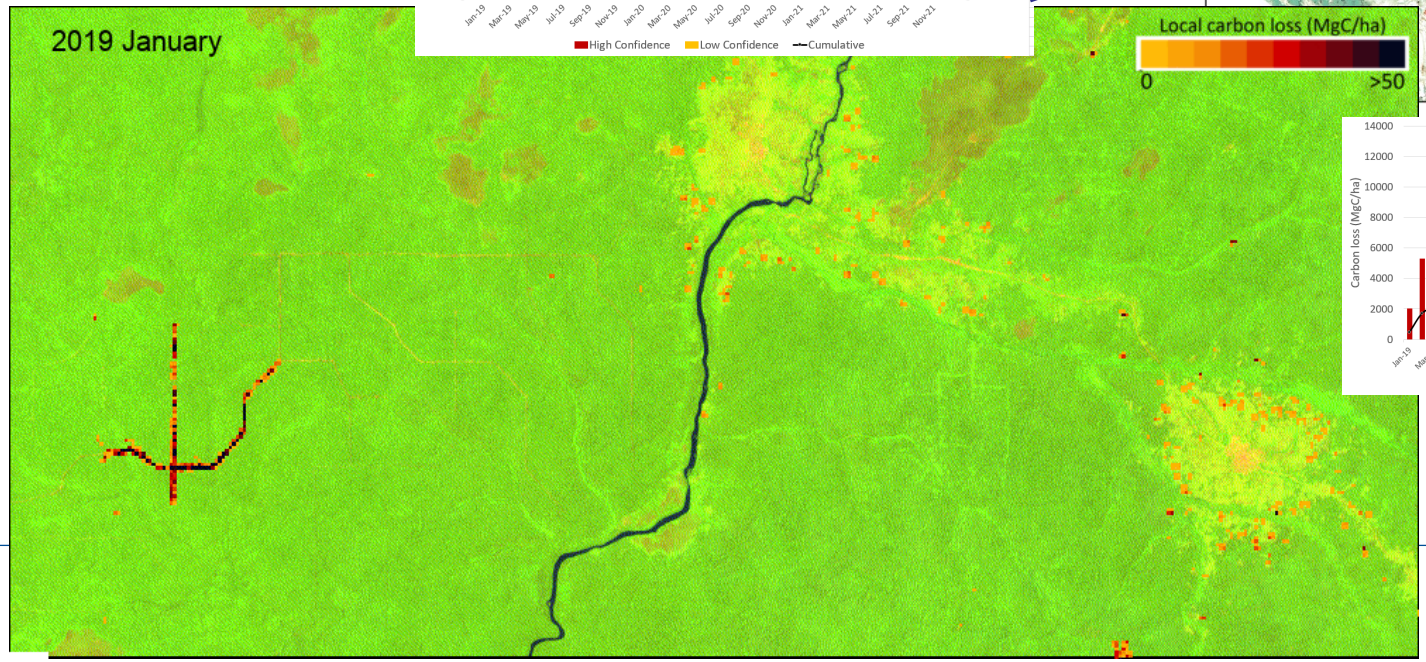
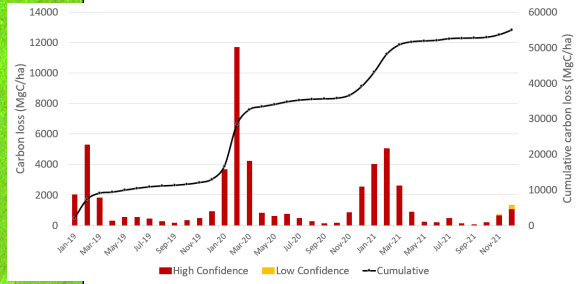
Selective tree logging
(Central African Republic)

Using Sentinels for higher frequency/near-real time forest monitoring for enforcement and adaptation









[Csillik et al. 2022. Nature Coms.EE]

https://gena.users.earthengine.app/view/raddalert

HELMHOLTZ

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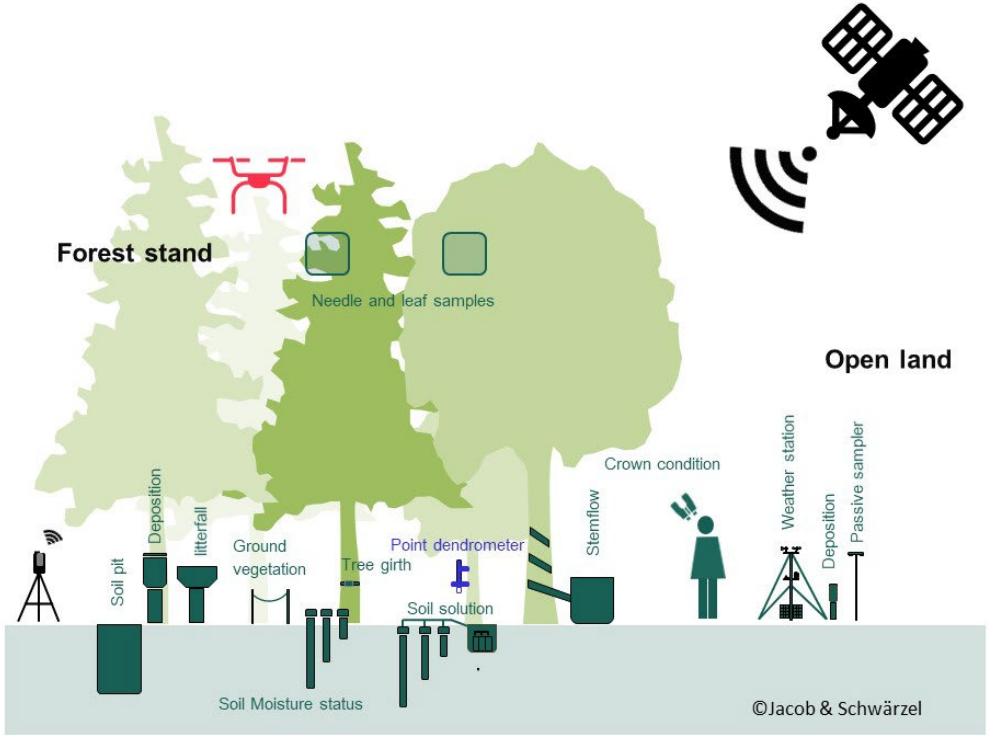
The European commission is investing in R&D

Project Acronym	Cordis link	Project information
SPACETWIN	https://cordis.europa.eu/project/id/101039795	https://spacetwin.ugent.be/
SWIFTT	https://cordis.europa.eu/project/id/101082732	https://swiftt.eu/
FORWARDS	https://cordis.europa.eu/project/id/101084481	https://www.icons.it/news/forwards-project-kicks-off-in-umea/
ForestPaths	https://cordis.europa.eu/project/id/101056755	https://forestpaths.eu/
ForestNavigator	https://cordis.europa.eu/project/id/101056875	https://www.forestnavigator.eu/
ForExD	https://cordis.europa.eu/project/id/101039567	https://www.bgc-jena.mpg.de/en/bgi/forexd
RESDINET	https://cordis.europa.eu/project/id/101078970	https://ife.sk/news/project-resdinet-has-been-launched/
PathFinder	https://cordis.europa.eu/project/id/101056907	https://www.nibio.no/en/news/a-novel-eu-project-provides-forest-information-for-europes-roadmap-towards-climate-neutrality
EVOLAND	https://cordis.europa.eu/project/id/101082130	https://www.sinergise.com/en/news/start-evoland-project
Open Earth Monitor Cyberinfrastructure	https://cordis.europa.eu/project/id/101059548/	https://earthmonitor.org/
DIGIFOREST	https://cordis.europa.eu/project/id/101070405	https://digiforest.eu/

Link with in-situ monitoring and near-sensing



- Integrated on-the ground and remote sensing
- Expanding upon the ICP forest networks
- Linking disturbances with changes on the ground and related impacts and processes
- Developing complementary data streams

Credit: EC FORWARDS project super site concept

Preparing for future Copernicus capabilities

Satellite sensors	Importance for improving monitoring of forest disturbances
Hyperspectral (CHIME, ENMAP …)	Agriculture, pasture, soils, disturbance characteristics, forest species/biodiversity,
L-Band Radar (ROSE-L)	Forest structure, biomass, soil moisture, rapid monitoring
Thermal (LSTM)	Climate/drought processes and impacts

Summarizing remarks – next steps for countries

1. Assess the suitability of current country GHG-I practices in light evolving needs (new regulations, climate action plans in LULUCF etc.)
2. Provide a plan/roadmap on how gaps and shortcomings can be addressed
3. Seek help if needed: work with country experts / research partners / EC