AFOLU from Space – The Earth Observation Perspective

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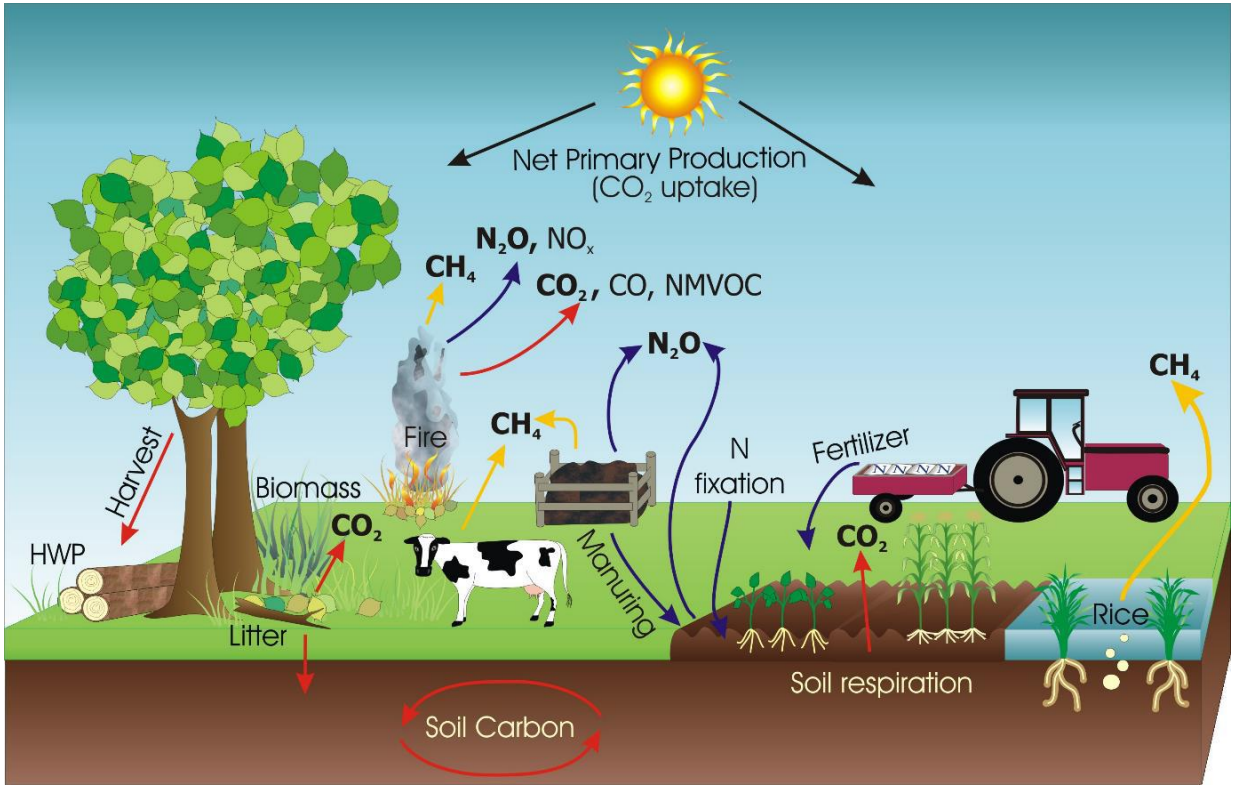
Main GHG Emissions/Removals from AFOLU



The key greenhouse gases of concern are CO2, N2O and CH4.

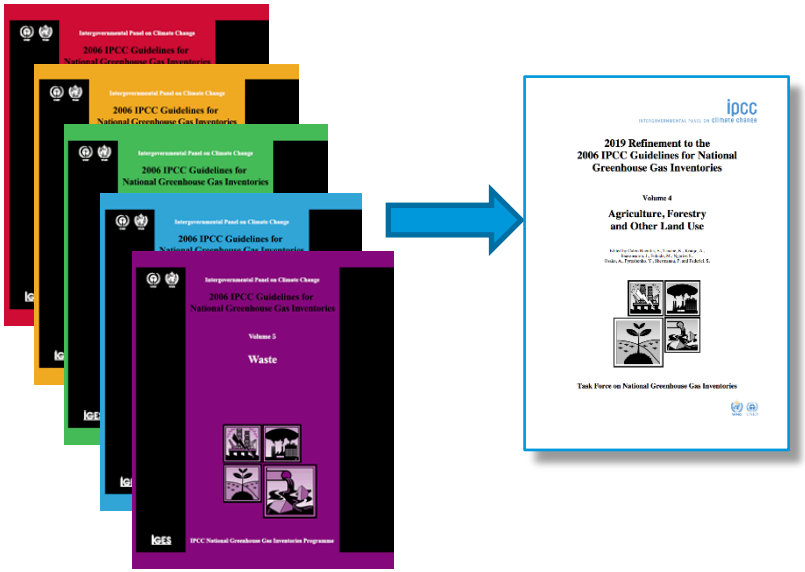
From the 2019 Refinement to the 2006 IPCC Guidelines for National GHG Inventories

IPCC Guidelines

Overall, the 2019 Refinement of the 2006 IPCC Guidelines builds on the objective of providing updates and new guidance to the 2006 IPCC Guidelines for chapters 1 to 12.

The main changes the 2019 refinement for the AFOLU sector are related to the following:

- Provision of New Guidance
- Provision of updated default emission factors
- Provision of new default emission factors
- Better and more complete coverage of sections



CARBON POOLS USED IN AFOLU

TABLE 1.1 (UPDATED)
DEFINITIONS FOR CARBON POOLS USED IN AFOLU FOR EACH LAND-USE CATEGORY

Pool		Description
Biomass	Above-ground biomass	All biomass of living vegetation, both woody and herbaceous, above the soil including stems, stumps, branches, bark, seeds, and foliage. Note: In cases where forest understory is a relatively small component of the above-ground biomass carbon pool, it is acceptable for the methodologies and associated data used in some tiers to exclude it, provided the tiers are used in a consistent manner throughout the inventory time series.
	Below-ground biomass	All biomass of live roots. Fine roots of less than (suggested) 2mm diameter are often excluded because these often cannot be distinguished empirically from soil organic matter or litter.
Dead organic matter	Dead wood	Includes all non-living woody biomass not contained in the litter, either standing, lying on the ground, or in the soil. Dead wood includes wood lying on the surface, dead roots, and stumps, larger than or equal to 10 cm in diameter (or the diameter specified by the country).
	Litter	Includes all non-living biomass with a size greater than the limit for soil organic matter (suggested 2 mm) and less than the minimum diameter chosen for dead wood (e.g. 10 cm), lying dead, in various states of decomposition above or within the mineral or organic soil. This includes the litter layer as usually defined in soil typologies. Live fine roots above the mineral or organic soil (of less than the minimum diameter limit chosen for below-ground biomass) are included in litter where they cannot be distinguished from it empirically.
Soils	Soil organic matter[1]	Includes organic carbon in mineral soils to a specified depth chosen by the country and applied consistently through the time series[2,3]. Live and dead fine roots and DOM within the soil that are less than the minimum diameter limit (suggested 2 mm) for roots and DOM, are included with soil organic matter where they cannot be distinguished from it empirically. The default for soil depth is 30 cm and guidance on determining country-specific depths is given in Chapter 2.3.3.1.

AGB can be estimated from space

From the 2019 Refinement to the 2006 IPCC Guidelines for National GHG Inventories

Use of Satellite Observation in 2019 Refinement

Volume 4: Agriculture, Forestry and Other Land Use (AFOLU)

Chapter 2: Generic Methodologies Applicable to Multiple Land-use Categories

Biomass Density Map for Biomass Estimation

- Biomass density maps are wall-to-wall, polygon- or pixel-based predictions of above-ground biomass for woody plants and trees.
- Biomass density maps are constructed by combining remotely sensed data and field observations.
- An example from Brazilian Amazon is introduced to explain how such a biomass density map can be used for estimation of GHG emissions/removals.

Use of Satellite Observation in 2019 Refinement

Volume 4: Agriculture, Forestry and Other Land Use (AFOLU)

Chapter 3: Consistent Representation of Lands

Development of land cover datasets

- In recent decades, satellite remote sensing has become the primary source of data for developing for global estimates of land cover.

TABLE 3A.1.1 (UPDATED)
EXAMPLES OF GLOBAL LAND COVER DATASETS IN 2017

	(A)	(B)	(C)	(D)
Dataset name	ESA Climate Change Initiative – Global Land Cover Products (CCI – LC)	Global Forest Change Global Forest Watch	MODIS Land Cover Type Product (MCD12Q1)	Global PALSAR-2/PALSAR/JERS-1 Forest/Non-Forest Map
Author	European Space Agency (ESA)	University of Maryland (UMD) World Resources Institute (WRI)	NASA / US Geological Survey	Japan Aerospace Exploration Agency (JAXA)

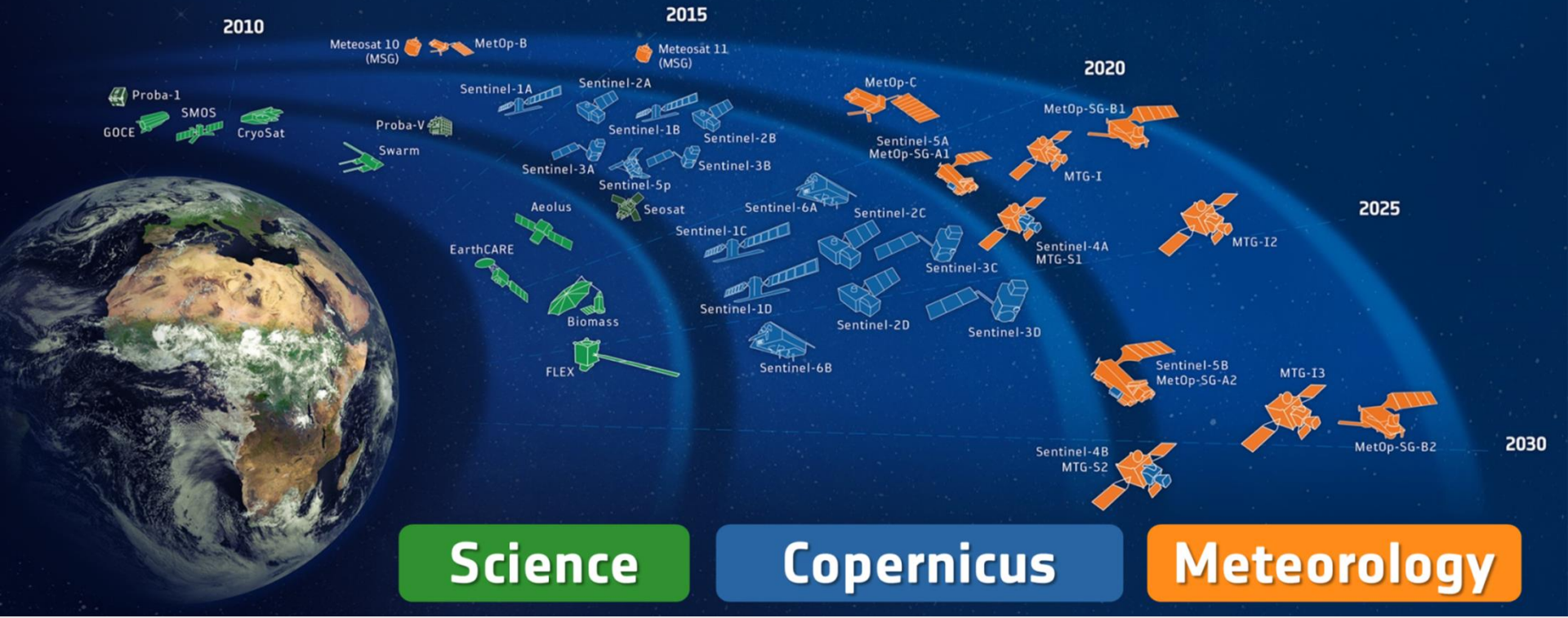
IPCC 2019 Refinement and Space

- National GHG inventories are essential to successful enhancement of transparency framework and Global Stocktake under the Paris Agreement.
- Guidance on use of satellite observation in national GHG inventories has been enhanced in the 2019 Refinement.
  - For QA/QC and verification through comparison of GHG emission estimates with atmospheric measurement using inverse models (Vol.1)
  - For estimation of GHG emissions/removals from land, through biomass density map for biomass estimation and land cover datasets for identification of human induced land-use change (Vol.4)
- Better use of satellite observation is expected to improve the quality of national GHG inventories and contribute to successful implementation of the Paris Agreement.

ESA Earth Observation

“Taking the Pulse of our Planet”

ESA-DEVELOPED EARTH OBSERVATION MISSIONS



Sentinel Launches

S-1

Radar

- A — 3 Apr. 2014
- B — 25 Apr. 2016
- C — 2022/23
- D — > 2022/23

S-2

High Resolution Optical

- A — 23 Jun. 2015
- B — 6 Mar. 2017
- C — 2022/23
- D — > 2022/23

S-3

Medium Resolution Optical & Altimetry

- A — 16 Feb. 2016
- B — 25 Apr. 2018
- C — 2023
- D — > 2023

S-4

Atmospheric Chemistry (GEO)

- A — 2021
- B — 2027

S-5P

Atmospheric Chemistry (LEO)

- A — 13 Oct. 2017

S-5

Atmospheric Chemistry (LEO)

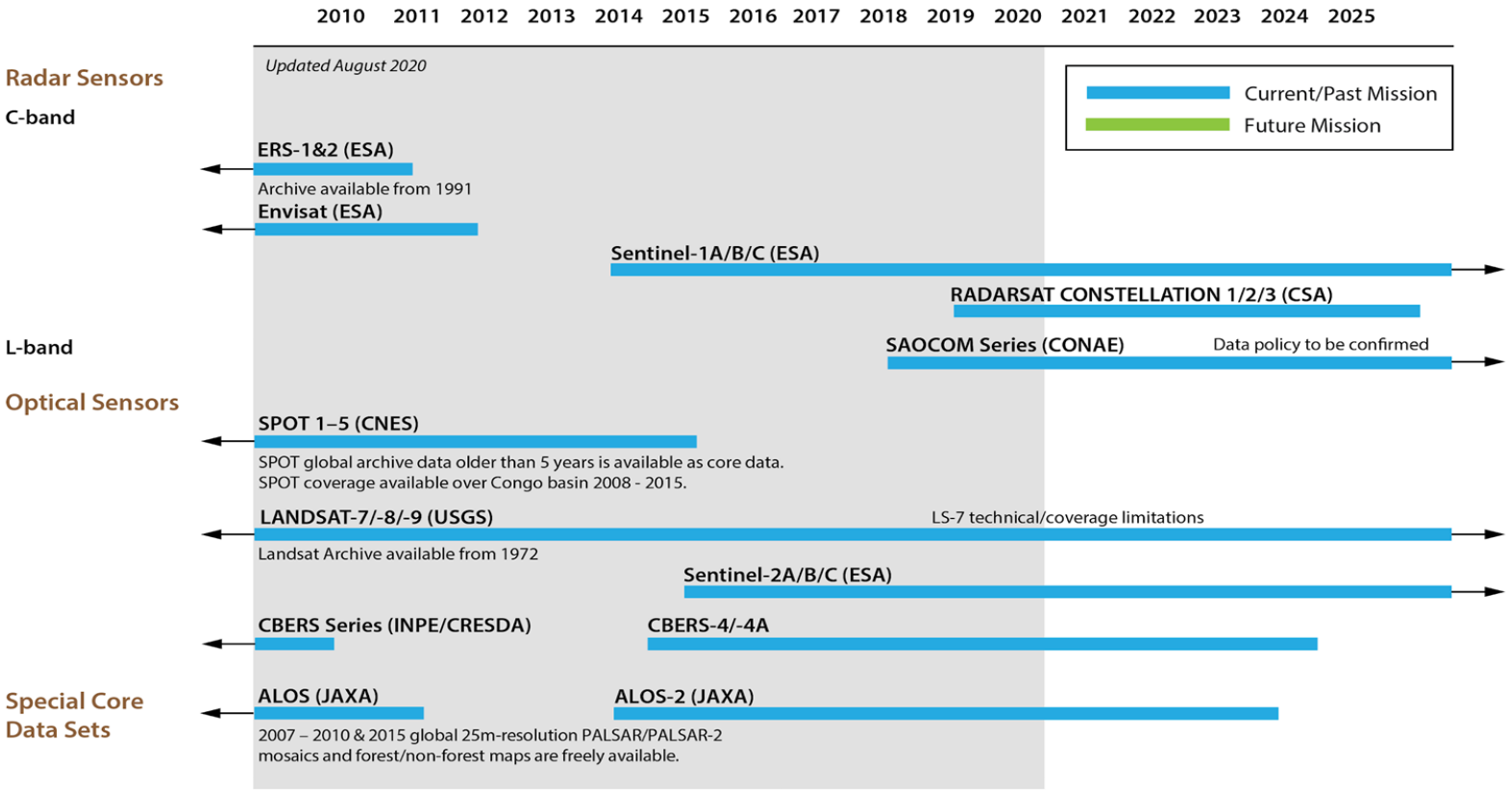
- A — 2021
- B — 2027
- C — > 2027

S-6

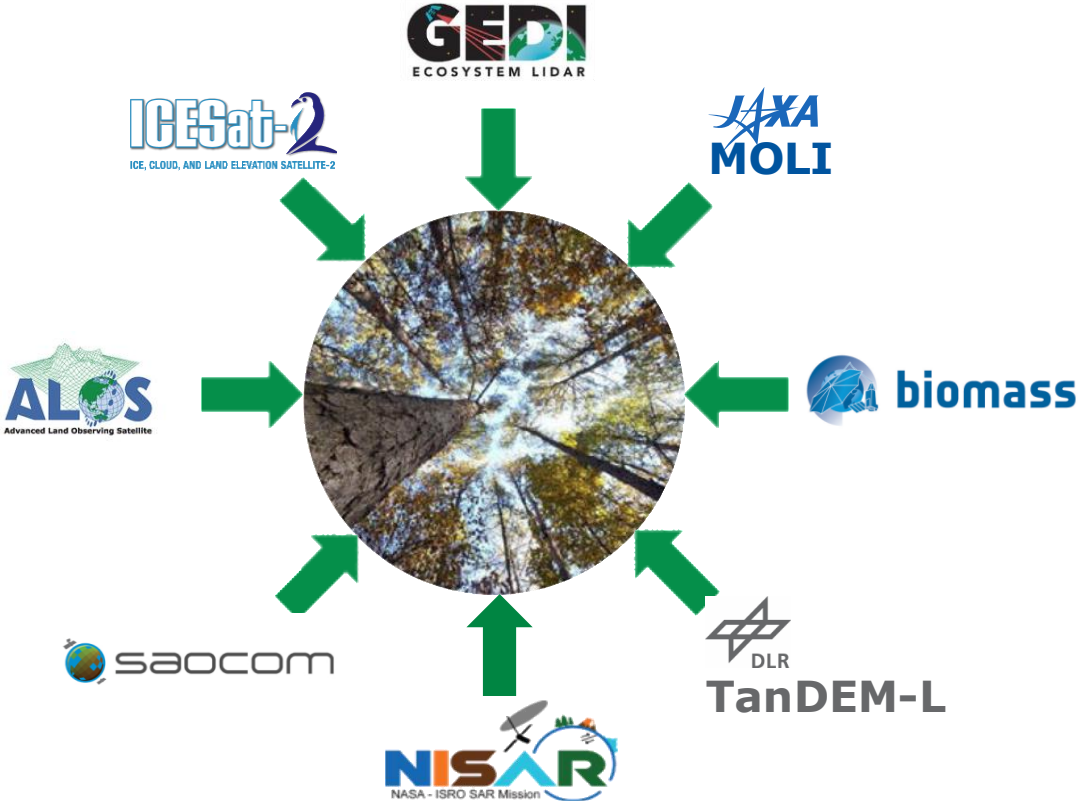
Altimetry

- A — 21 Nov 2020
- B — 2025

Key Space Missions for AFOLU



The “Golden Age” of Biomass Missions



Key Data Set for Land Cover and Agriculture

Dataset Definition	Agriculture Relevant Classes	Owner	Date of Coverage	Currently Active?	Refresh	Spatial Resolution - minimum pixel size (m)	Target Applications	Availability
Climate Change Initiative (CCI) Land Cover The CCI-LC team produced and released 3-epoch series of global land cover maps. These maps were produced using a multi-year and multi-sensor strategy in order to make use of all suitable data and maximize product consistency (ESA 2014).	**Legend** (based on the LCCS): • 10 Cropland, rainfed • 11 Herbaceous cover • 12 Tree or shrub cover • 20 Cropland, irrigated or post-flooding • 30 Mosaic cropland (>50%) / natural vegetation (tree, shrub, herbaceous cover) (<50%) • 40 Mosaic natural vegetation (tree, shrub, herbaceous cover) (>50%) / cropland (<50%) • 130 Grassland	**ESA, 2010**. https://www.esa-landcover-cci.org/?q=overview	**2008-2012, 2003-2007, 1998-2002**	**No**	3-epoch series of global land cover maps where each epoch covers a 5-year period	**300**	Intended to match the needs of key users' belonging to the climate change community	**Open** http://maps.elie.ucl.ac.be/CCI/viewer/download.php
GlobCover (ESA, 2009) . Land cover map of global extent	**Legend:** (22 class LC) • 11 Post-flooding or irrigated croplands • 14 Rainfed croplands • 20 Mosaic Cropland (50-70%) / Vegetation (grassland, shrubland, forest) (20-50%) • 30 Mosaic Vegetation (grassland, shrubland, forest) (50-70%) / Cropland (20-50%) • 110 Mosaic Forest/Shrubland (50-70%) / Grassland (20-50%) • 120 Mosaic Grassland (50-70%) / Forest/Shrubland (20-50%) • 130 Grassland • 140 Closed to open (>15%) grassland	**ESA, 2009**. http://due.esrin.esa.int/page_globcover.php	**2004 to 2006, and 2009**	**No**	Original coverage 2004-06, with opne refresh in 2009	**300**	The state of global land cover for two time periods	**Open** http://due.esrin.esa.int/page_globcover.php
Copernicus CGLS Dynamic Land Cover A global land cover product updated annually. Global change product 2016-19 to be released in 2020 (Africa available now). Data from PROBA-V 100m time series 2016-2019, Sentinel missions to be used from 2020 o	**Legend** (23 class LC): Shrubland, herbacious, cropland	**Copernicus, 2015**. https://land.copernicus.eu/global/products/lc	**2016**	**Yes**	**Annual, plus global 5 year change products** 2016-19	**100**	Land cover state and change	**Open DOI:** 10.5281/zenodo.3243509

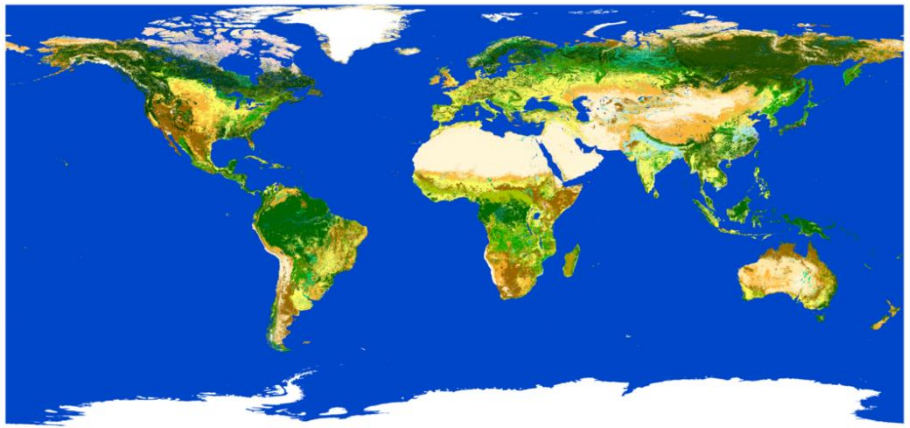
In Development

Dataset Definition	Agriculture Relevant Classes	Owner	Date of Coverage	Currently Active?	Refresh	Spatial Resolution - minimum pixel size (m)	Target Applications	Availability
WorldCover								
WorldCereal								

CCI Land Cover and continuity in C3S

CCI Land Cover project produced global LC maps for the 2000, 2005 and 2010 epochs (300 m resolution)

Annual global land cover mapping at 300m from 1992 to present



- Cropland rainfed
- Cropland irrigated or post-flooding
- Mosaic cropland (>50%) / natural vegetation (<50%)
- Mosaic natural vegetation (>50%) / cropland (<50%)
- Tree cover broadleaved evergreen (>15%)
- Tree cover broadleaved deciduous (>15%)
- Tree cover needleleaved evergreen (>15%)
- Tree cover needleleaved deciduous (>15%)
- Tree cover mixed leaf type (broadleaved and needleleaved)
- Mosaic tree and shrub (>50%) / herbaceous cover (<50%)
- Mosaic herbaceous cover (>50%) / tree and shrub (<50%)
- Shrubland
- Grassland
- Lichens and mosses
- Sparse vegetation (<15%)
- Tree cover flooded fresh/brakish water
- Tree cover flooded saline water
- Shrub or herbaceous cover flooded
- Urban areas
- Bare areas
- Water bodies
- Permanent snow and ice

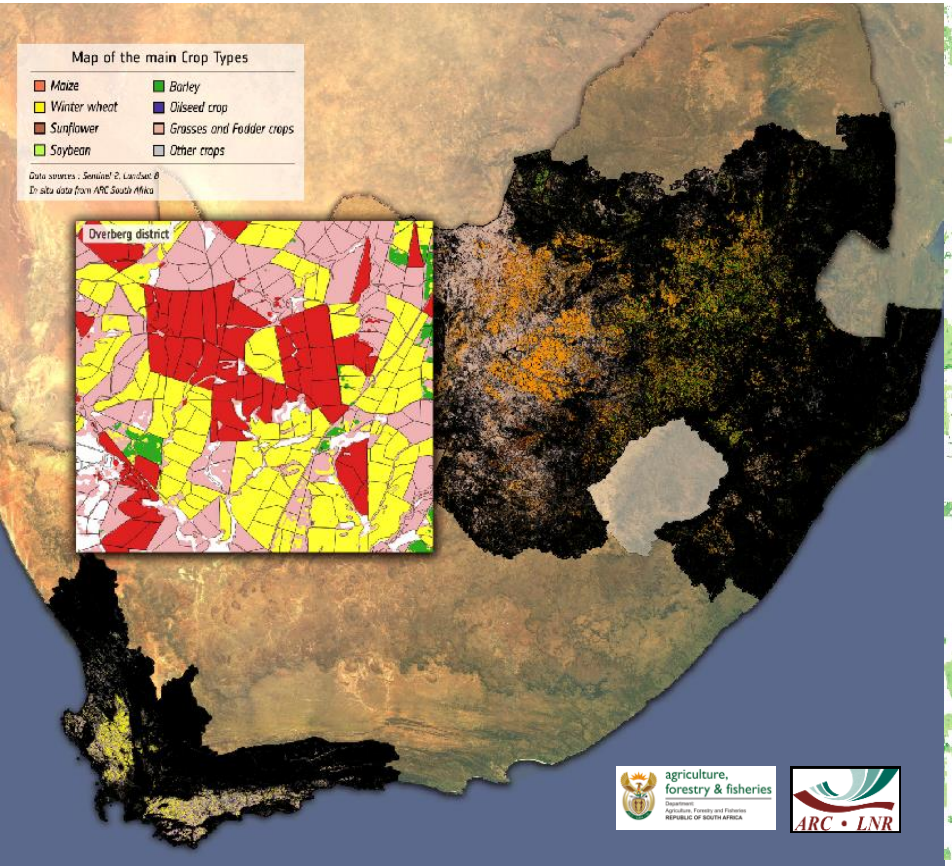
Continuity in C3S from 2015-2019 with 100 m res.

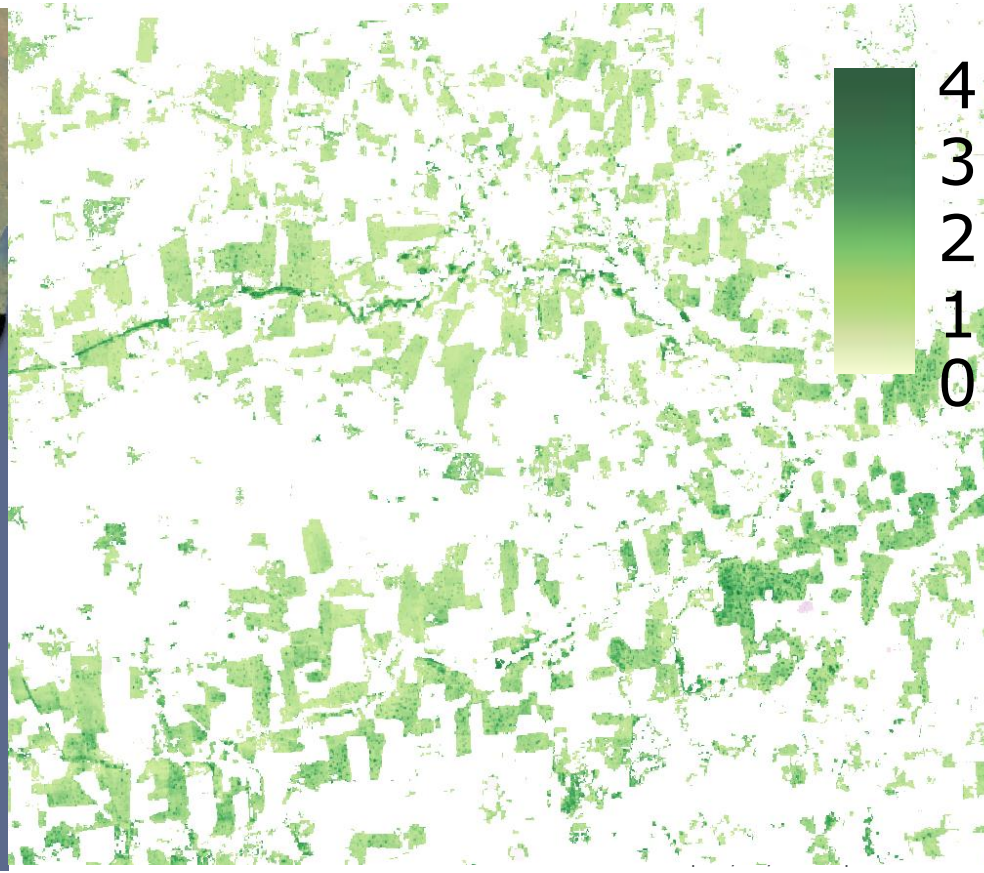
sentinel-2

→ AGRICULTURE

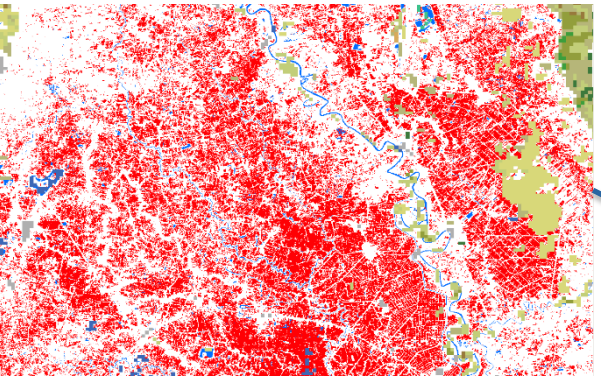
National Agriculture Monitoring

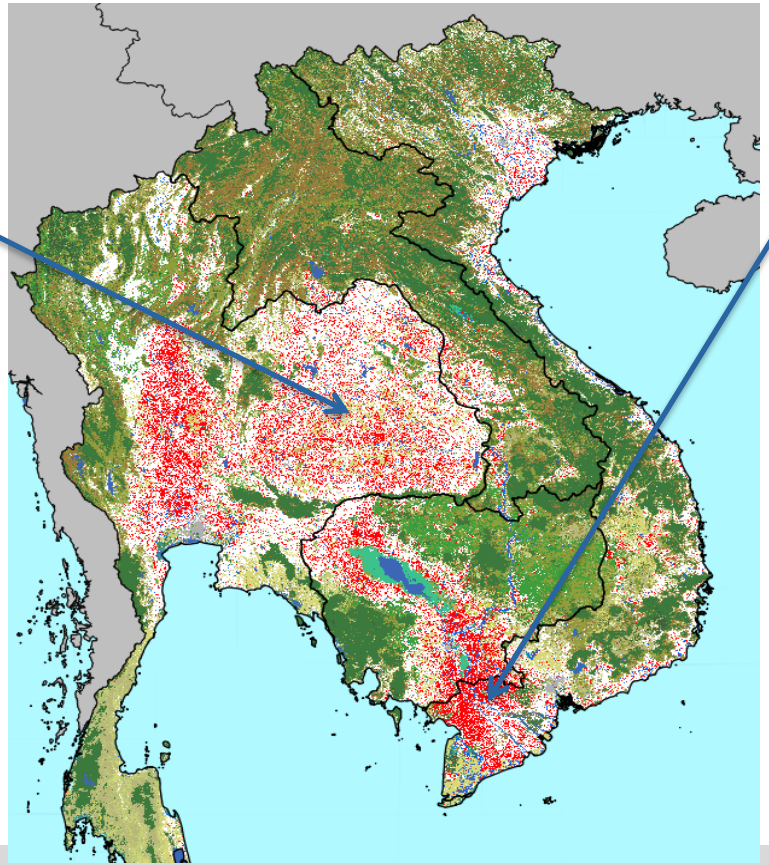
esa

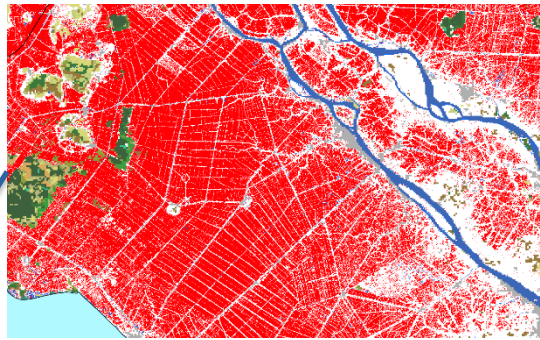




Regional Rice Monitoring in SE Asia - 2020





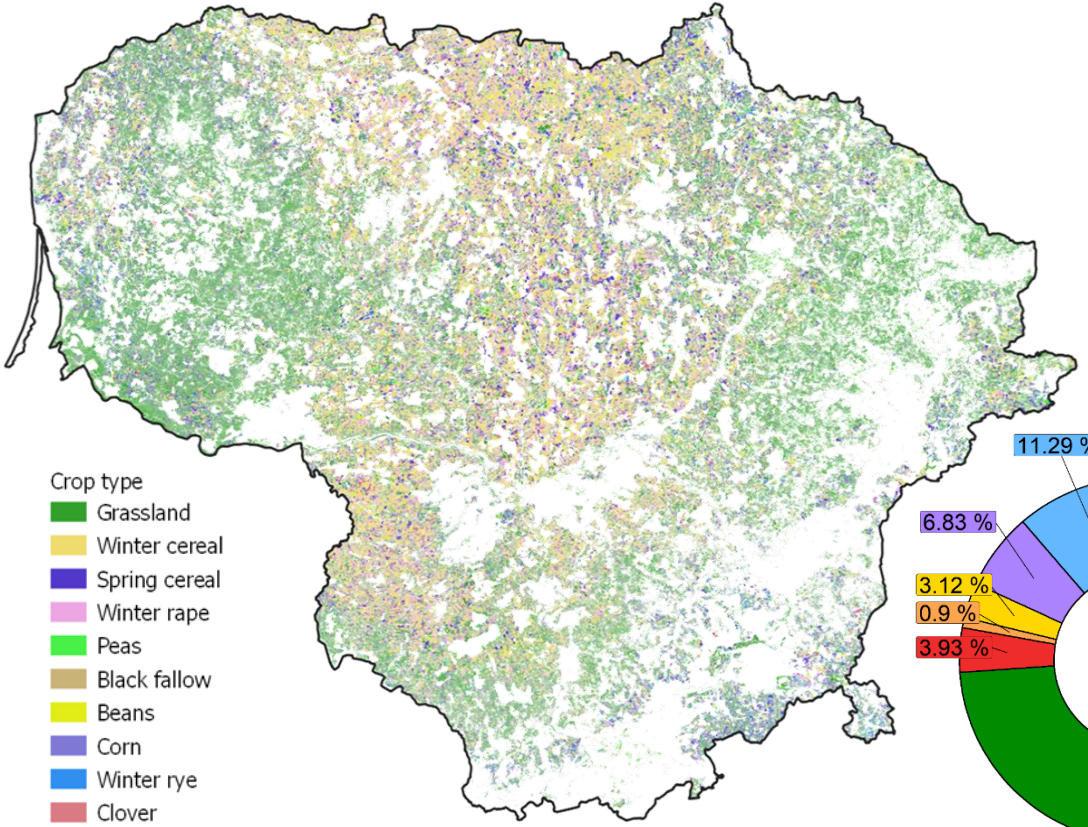


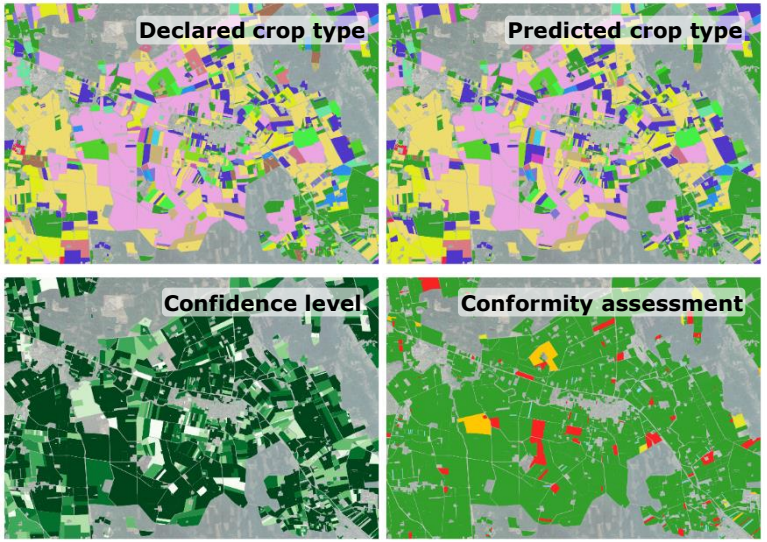
- Rice
- Tree cover evergreen
- Tree cover Deciduous
- Mosaic tree schrubland
- Schrubland
- Cropland, herbaceous or schrub cover
- Flooded
- Inland water
- Urban/bare areas

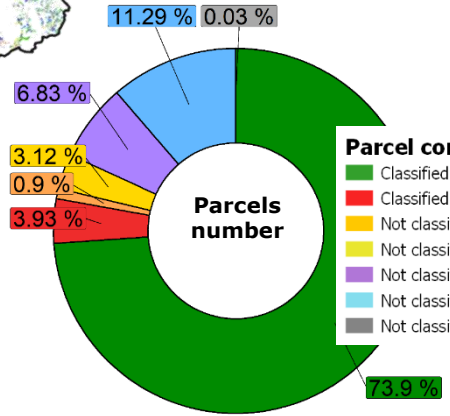
innovators
georice

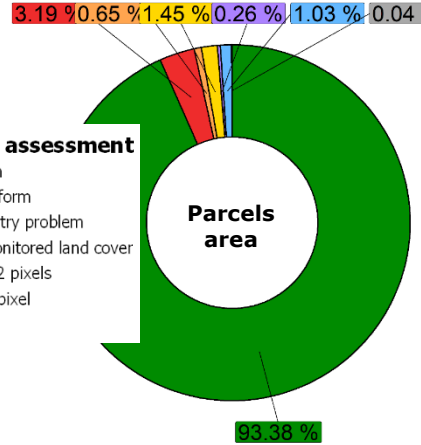
2019 National crop type map

E.g. Lithuania (Jan-Aug), > 50 crop types









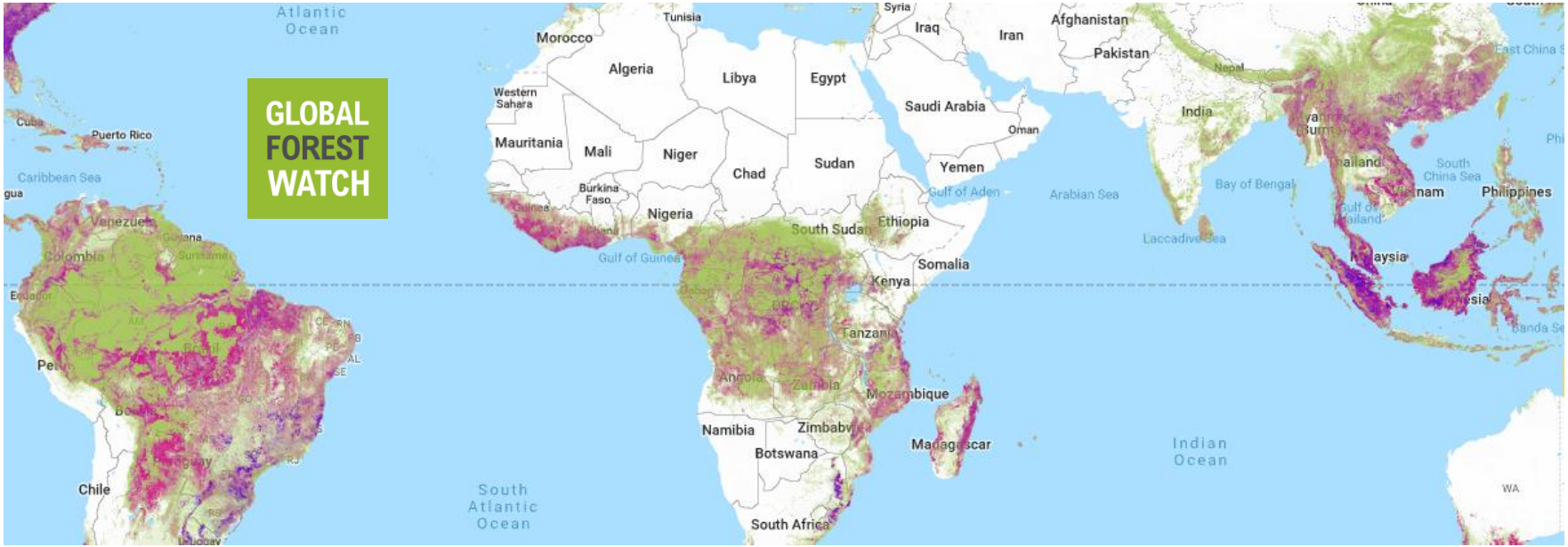
Parcel conformity assessment
- Classified and conform
- Classified and not conform
- Not classified - geometry problem
- Not classified - not monitored land cover
- Not classified - < 3 S2 pixels
- Not classified - no S1 pixel
- Not classified - other

Key Data Set for Forestry

Dataset name	AFOLU relevant area	Description	Sensors	Temporal coverage/ frequency	Spatial resolution	Reference
Treecover2010 (Global Tree Cover dataset by Univ. Maryland GLAD - Global Land Analysis & Discovery)	Forest (cover)	Pixel estimates of circa 2010 percent maximum (peak of growing season) tree canopy cover derived from cloud-free annual growing season composite of Landsat 7 ETM+ data.	Landsat 7	Circa 2010	30 m	https://glad.umd.edu/dataset/global-2010-tree-cover-30-m. Hansen, M. C., at al., 2013.
GLAD Primary Humid Tropical Forests (Primary forests in the tropics, dataset by Univ. Maryland GLAD - Global Land Analysis & Discovery)	Forest (cover)	Extent in global pan-tropical regions 2001.	Landsat	2001	30 m	https://glad.umd.edu/dataset/primary-forest-humid-tropics Turubanova, S. et al, 2018
Intact Forest Landscapes (dataset by Univ. Maryland GLAD - Global Land Analysis & Discovery)	Forest (cover)	Identifies World's remaining unfragmented forest landscapes, large enough to retain all native biodiversity and showing no signs of human alteration as of 2016. Shows reduction in IFL from 2000 to 2016.	Landsat	2016	30 m	https://glad.umd.edu/dataset/intact-forest/overview Potapov, P., at al. 2017.
Global Forest Watch	Forest (cover and change)	Pixel estimates of forest cover loss	Landsat	Current	30 m	https://www.globalforestwatch.org
Global Forest Canopy Height, 2019	Forest (cover and biomass)	Global Landsat analysis-ready data were used to extrapolate GEDI footprint-level forest canopy height measurements, creating a 30m spatial resolution global forest canopy height map for the year 2019.	GEDI and Landsat	2019	30 m	https://glad.umd.edu/dataset/gedi/ P. Potapov, et al., 2020 (*in review)* Preprint: doi.org/10.5281/zenodo.4008406
Global Mangrove Watch	Forest (cover)	Global extent of mangrove forests. Global Mangrove Watch (GMW) is an online platform that provides the remote sensing data and tools for monitoring	JERS-1 SAR ALOS PALSAR & Landsat ALOS-2 PALSAR-2	1996 2007-2010 Annually from 2015	25 m	https://www.globalmangrovewatch.org Bunting et al. 2019

Forestry – Global Forest Watch

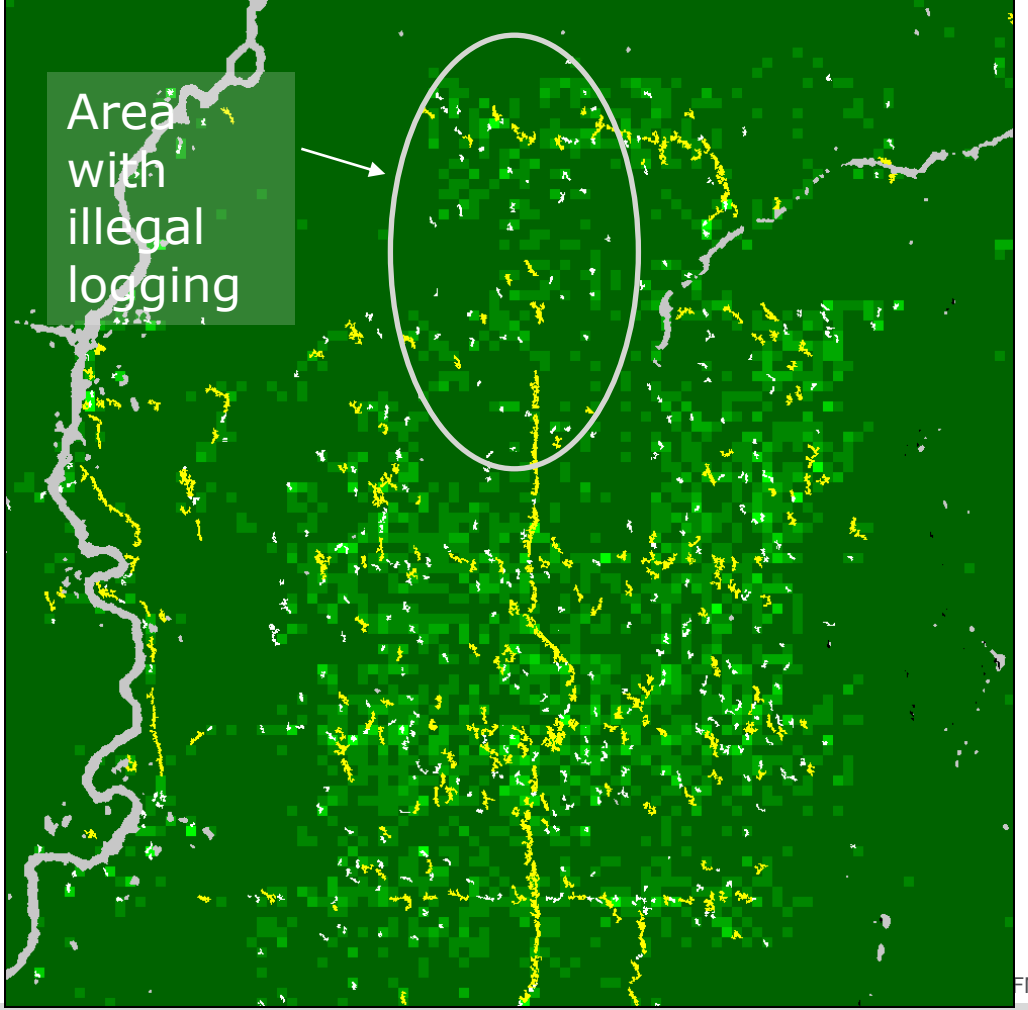
An online platform that provides data and tools for monitoring forests.



WORLD RESOURCES INSTITUTE

Area in
Northern Sumatra

SarVision
Near Real Time
Forest Monitoring
System



Yellow:
Road development

Green blocks:
Degradation

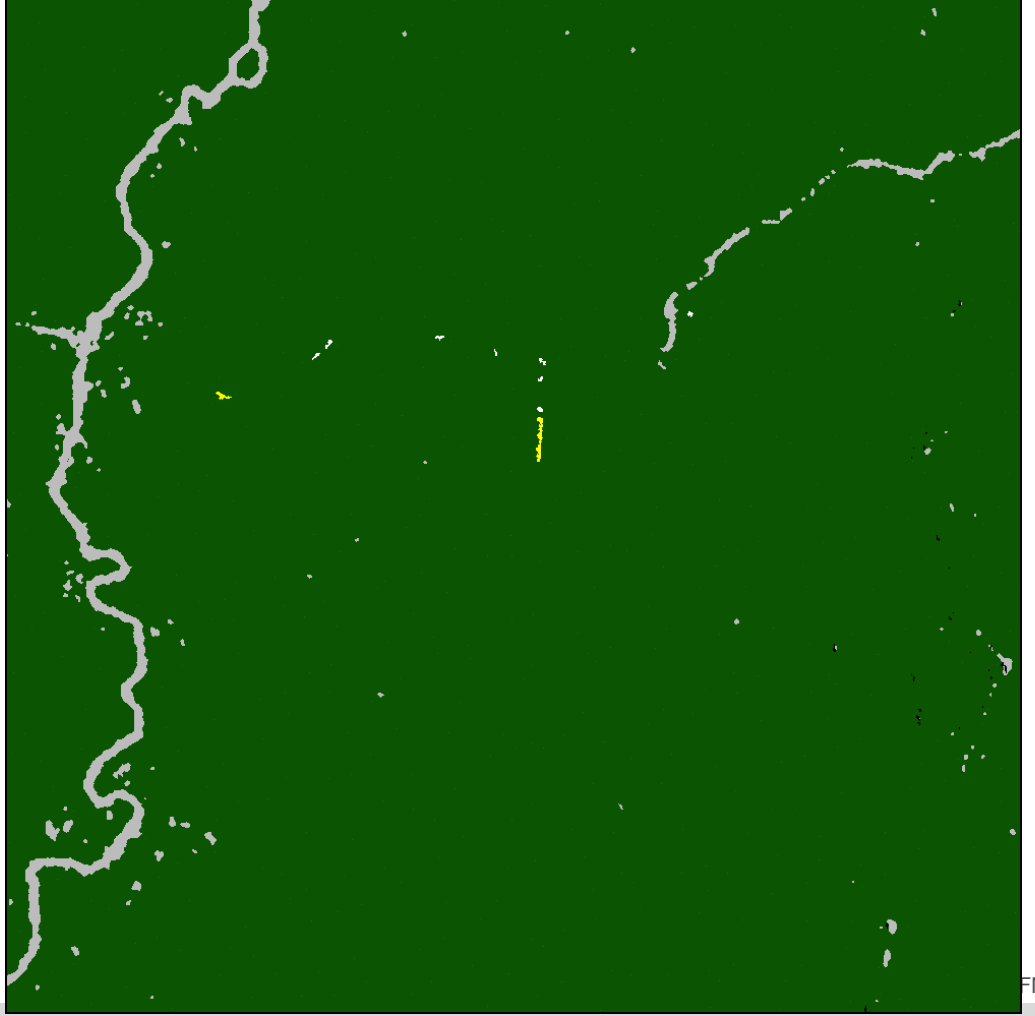
Value	*Class*	*Colour*
0	Background	0,0,0
1	Forest	0,100,0
2	Non-forest	200,200,200
3	Small segments	255,255,255
4	Large segments	255,255,0
5	Degrad 1	0,135,0
6	Degrad 2	0,170,0
7	Degrad 3	0,210,0
8	Degrad 4	0,255,0

Area in
Northern Sumatra

SarVision
Near Real Time
Forest Monitoring
System

Period:
12 Dec 2016
up to
12 July 2020

Frequency:
Every 12 days



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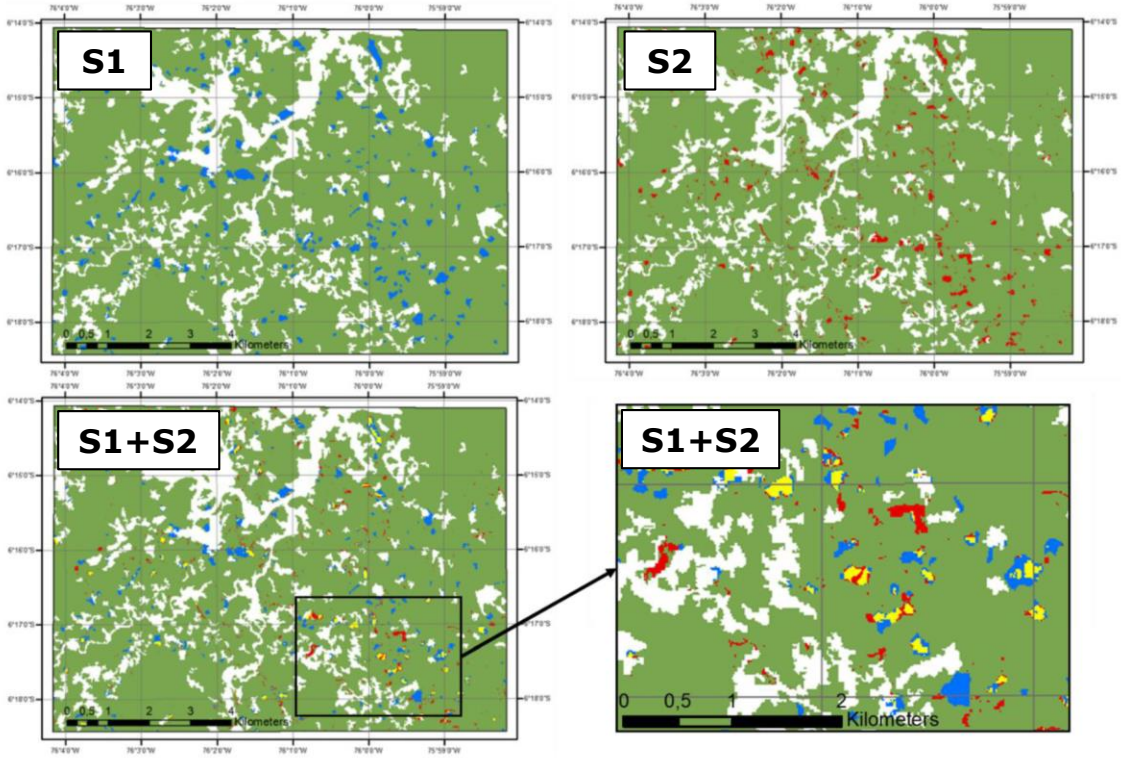
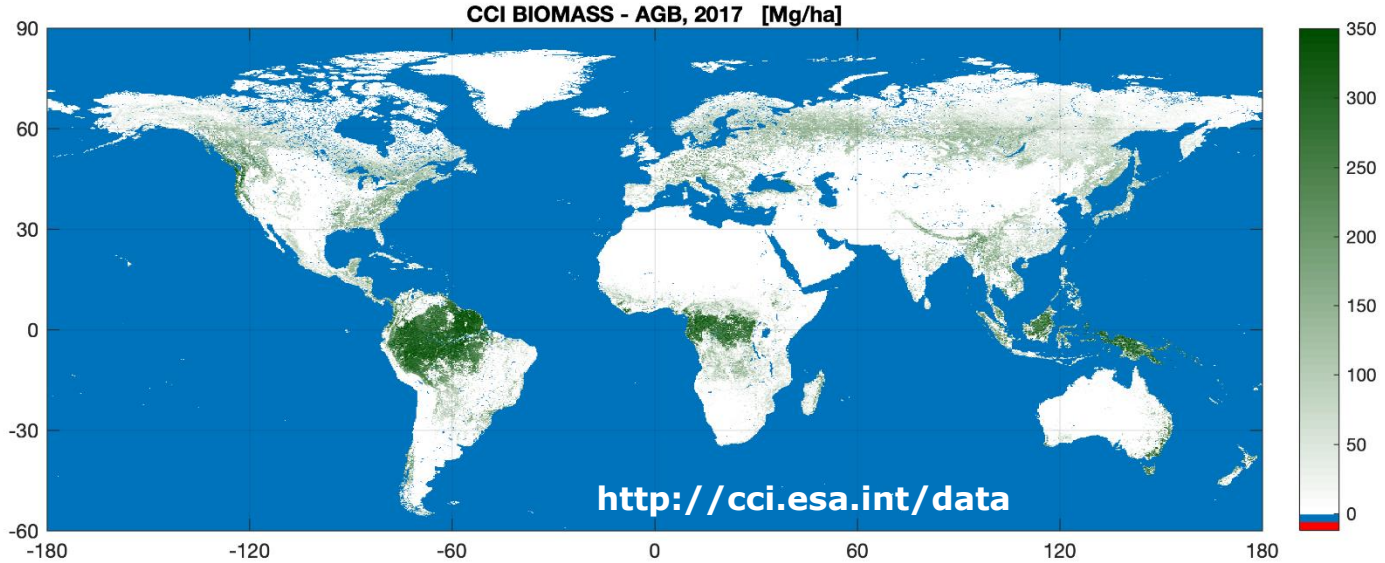
Synergy of Sentinel-1 and Sentinel-2 based forest loss detection methods in Peru



The individual optical and SAR based forest loss detections are highly complementary, and their combination improves all accuracy measures. The overall accuracies increase by about 3% in both areas, producer accuracies of the disturbed forest class increase by up to 25% when compared to only using one sensor type.

Quantifying Above Ground Biomass



- New global **series of maps to quantify the change in forest biomass** over time (2010, 2017 and 2018) combines the widest range of satellite data - **radar, optical and lidar** - to construct a high (1 hectare) resolution product
- Data to inform the **Global Stocktake** for the Paris Agreement commitments and **REDD+** for national purpose.

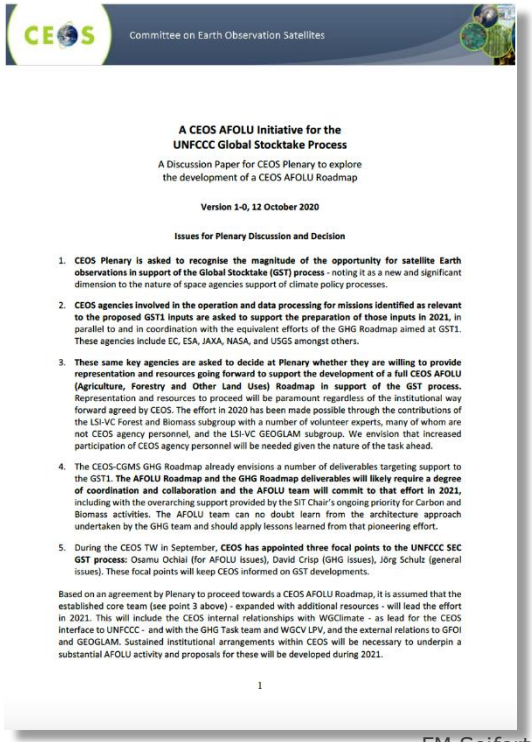
The CEOS AFOLU Roadmap

A CEOS AFOLU Initiative for the UNFCCC Global Stocktake Process

A Discussion Paper for CEOS Plenary to explore the development of a CEOS AFOLU Roadmap

Context:

1. Introduction
2. Opportunity of the Global Stocktake
3. EO Capabilities in support of AFOLU
4. Deployment of Capabilities
5. Potential Roadmap Actions
6. Summary and Next Steps
7. References



CEOS Committee on Earth Observation Satellites

A CEOS AFOLU Initiative for the UNFCCC Global Stocktake Process

A Discussion Paper for CEOS Plenary to explore the development of a CEOS AFOLU Roadmap

Version 1-0, 12 October 2020

Issues for Plenary Discussion and Decision

1. **CEOS Plenary is asked to recognise the magnitude of the opportunity for satellite Earth observations in support of the Global Stocktake (GST) process** - noting it as a new and significant dimension to the nature of space agencies support of climate policy processes.
2. **CEOS agencies involved in the operation and data processing for missions identified as relevant to the proposed GST1 inputs are asked to support the preparation of those inputs in 2021,** in parallel to and in coordination with the equivalent efforts of the GHG Roadmap aimed at GST1. These agencies include EC, ESA, JAXA, NASA, and USGS amongst others.
3. **These same key agencies are asked to decide at Plenary whether they are willing to provide representation and resources going forward to support the development of a full CEOS AFOLU (Agriculture, Forestry and Other Land Uses) Roadmap in support of the GST process.** Representation and resources to proceed will be paramount regardless of the institutional way forward agreed by CEOS. The effort in 2020 has been made possible through the contributions of the LSI-VC Forest and Biomass subgroup with a number of volunteer experts, many of whom are not CEOS agency personnel, and the LSI-VC GEOGLAM subgroup. We envision that increased participation of CEOS agency personnel will be needed given the nature of the task ahead.
4. The CEOS-CGMS GHG Roadmap already envisions a number of deliverables targeting support to the GST1. **The AFOLU Roadmap and the GHG Roadmap deliverables will likely require a degree of coordination and collaboration and the AFOLU team will commit to that effort in 2021,** including with the overarching support provided by the SIT Chair's ongoing priority for Carbon and Biomass activities. The AFOLU team can no doubt learn from the architecture approach undertaken by the GHG team and should apply lessons learned from that pioneering effort.
5. During the CEOS TW in September, **CEOS has appointed three focal points to the UNFCCC SEC GST process:** Osamu Ochiai (for AFOLU issues), David Crisp (GHG issues), Jörg Schulz (general issues). These focal points will keep CEOS informed on GST developments.

Based on an agreement by Plenary to proceed towards a CEOS AFOLU Roadmap, it is assumed that the established core team (see point 3 above) - expanded with additional resources - will lead the effort in 2021. This will include the CEOS internal relationships with WGClimate - as lead for the CEOS interface to UNFCCC - and with the GHG Task team and WGCV LPV, and the external relations to GFOI and GEOGLAM. Sustained institutional arrangements within CEOS will be necessary to underpin a substantial AFOLU activity and proposals for these will be developed during 2021.

1

Agreement at CEOS Plenary

Decision 34-08	It was agreed that it is important for a CEOS AFOLU Roadmap to proceed, noting the need for a long-term vision, but also the urgency of clearly understanding and defining targets for the first Global Stocktake (including the AFOLU products needed for modelling within the GHG monitoring system). Coordination of the AFOLU Roadmap team with the WGClimate and its GHG Task Team was recognised as essential.

Milestones towards first GST

Agriculture (in cooperation with GEOGLAM):

- **Global crop productivity** maps for reference years
- **Country cases** for agricultural land use and change, agriculture management practices and agricultural biomass burning supporting reporting of NDCs

Forestry:

- **Global forest cover and tree density** maps (in cooperation with GFW and UMD)

Biomass:

- **Global above ground biomass maps** in GST1 reference year 2021 with 2020 as backup and historical datasets from previous years (Contributions of CCI biomass with inputs from GEDI and IceSat-2 missions and WGCV LPV team)
- **Country cases of carbon stock** in forests supporting reporting of NDCs (in cooperation with GFOI)

Other Land Use: (TBD)

Conclusion

- With the **European Green Deal and** the **Paris Agreement** we have clear **policy frameworks** and with PA's **Global Stocktake** a unique opportunity to link to;
- The 2019 refinement of **IPCC Guidelines** for national GHG inventories provide an increasing role of Earth Observation data from satellites;
- Landsat and Copernicus follow a **free and open data policy;**
- We are in a **data rich period**, a good basis for **high quality products**, with clear **uncertainty** levels and **consistence** over time;
- We need to think holistically about the **integration** of EO contributions to **GHG and AFOLU**
- The **CEOS AFOLU roadmap** is an umbrella for international cooperation, please contact me if you want to join this effort.

Thank you!

Frank.Martin.Seifert@esa.int