

EO for Monitoring, Reporting, and Verification of Carbon Removals  
Copenhagen, 8-11 October 2024

Session 4 - Opening and linkages between the EU Carbon Removals and  
Carbon Farming Certification (CRCF) Regulation and the LULUCF regulation

## EO Missions and solutions relevant to carbon monitoring

**Giuseppe Ottavianelli**

Head of Applications Section

Climate Action, Sustainability And Science Department (EOP-S)

Directorate of Earth Observation Programmes





# EO for Carbon Markets Forum October 2023

- **150 participants onsite** (plus additional online participation)
- bringing together **policy making entities, certification bodies, public agencies, finance and insurance entities, carbon project operators, operators in different industry sectors, EO industry, NGOs and academia.**
- Key recommendations - EO shall be integrated to:
  - improve quality and transparency,
  - provide global solutions,
  - increase trust

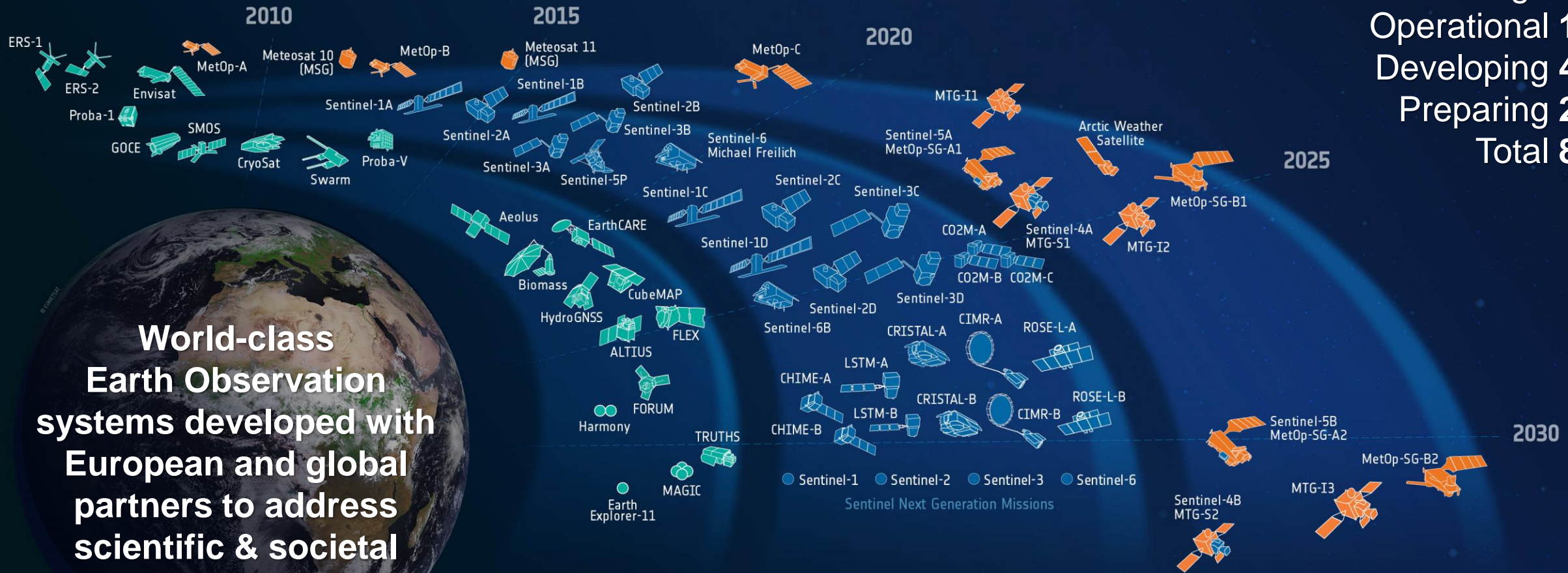
in both Compliance and Voluntary markets, which is an essential contribution to stimulate climate change mitigation and the implementation of the Paris Agreement Article 6 towards net zero.



# ESA's Earth Observation Missions



**Satellites**  
 Heritage 04  
 Operational 15  
 Developing 41  
 Preparing 22  
**Total 82**



**World-class Earth Observation systems developed with European and global partners to address scientific & societal challenges**

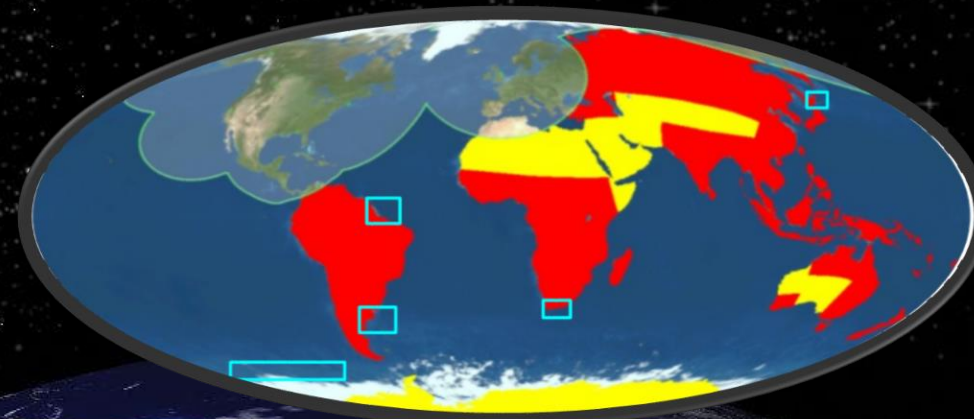
Science 
Copernicus 
Meteorology 



# Biomass

P-band global measurements of forest biomass and carbon cycle

Observation targets



Providing maps of forest biomass stocks, disturbance and growth,

Using PolSAR backscatter, PolInSAR coherence and multi-baseline PolSAR (TomoSAR)

- Forest Height, res: 200m
- Forest Disturbance: res: 50m
- Above Ground Biomass: res: 200m

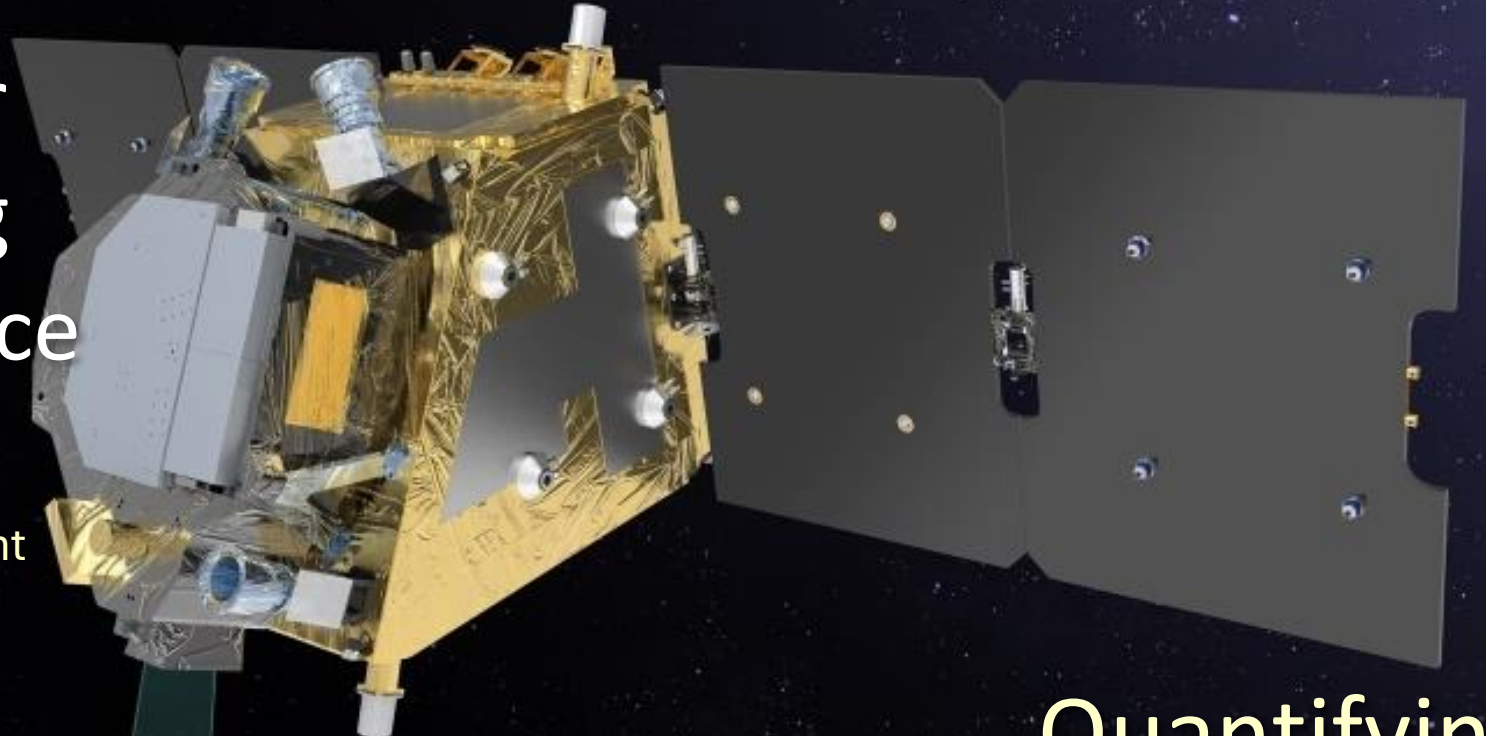
**Expected launch March/April 2025**



# FLEX in tandem with Sentinel-3

## Imaging spectrometer mission for measuring vegetation fluorescence

Understanding the conversion of atmospheric carbon dioxide and sunlight into energy-rich carbohydrates through photosynthesis.  
FLORIS Spatial resolution of 300m.



## Quantifying photosynthetic activity and plant stress on a global scale

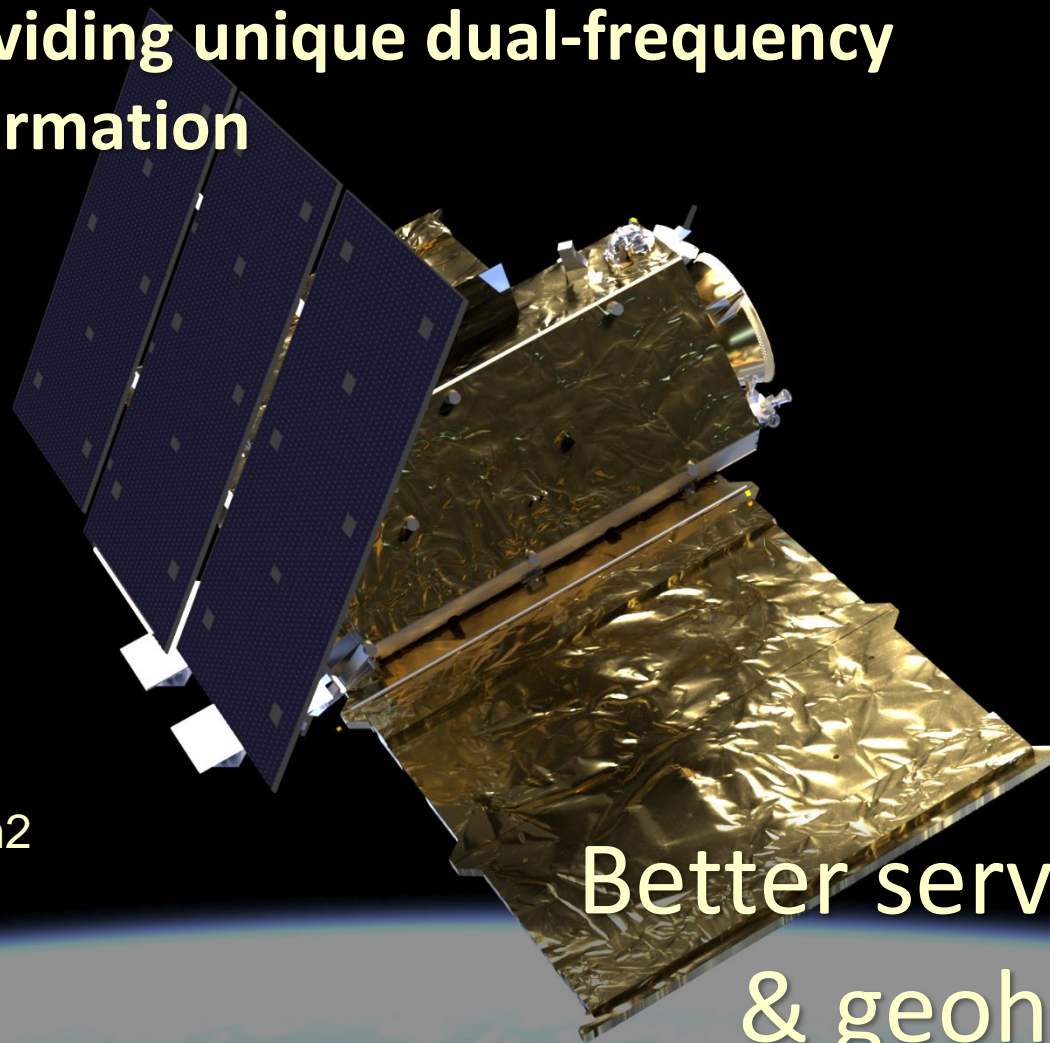
Expected launch 2026



# ROSE-L

L-band SAR  
system for  
Europe

as a system of systems with Sentinel-1,  
providing unique dual-frequency  
information



Dual-polarization mode <math>< 50\text{m}^2</math>  
Quad-polarization mode <math>< 100\text{m}^2</math>

Better services for disasters  
& geohazards, forests &  
agriculture management

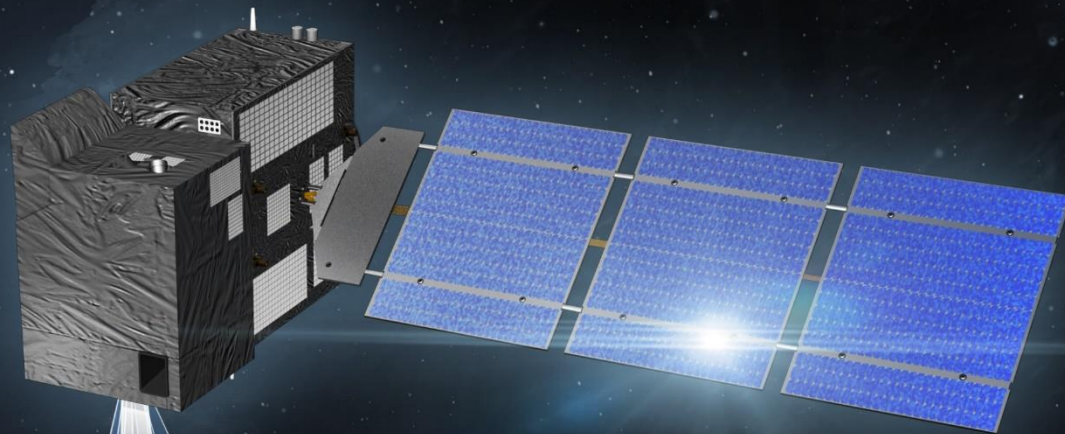
Expected launch A 2028 / B 2030



# CO2M

## Anthropogenic CO<sub>2</sub> Monitoring Mission

Inverse modelling for verification of bottom-up inventories and better measure anthropogenic CO<sub>2</sub> emissions and annual budgets and trends reporting, with dense spatial sampling (4Km<sup>2</sup>) of CO<sub>2</sub> observations, complemented by NO<sub>2</sub>, aerosol and cloud observations.

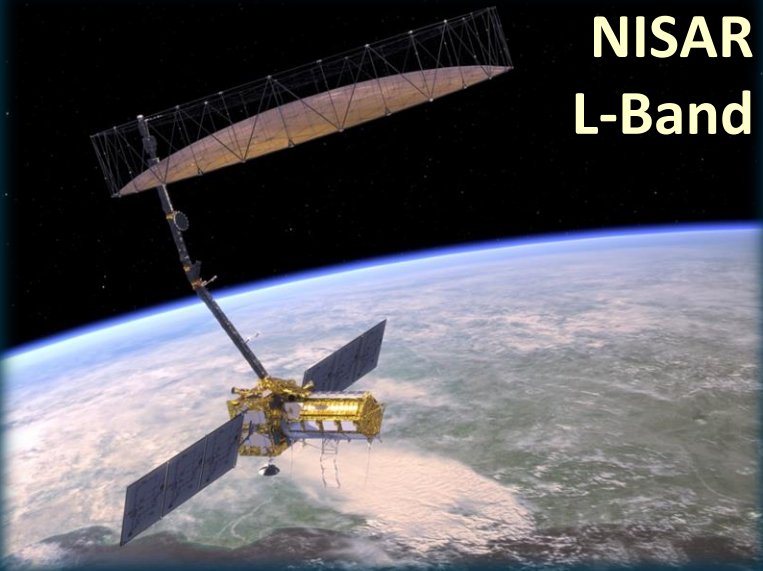


Analyse CO<sub>2</sub> emissions and overall budget at country and regional/megacity scales

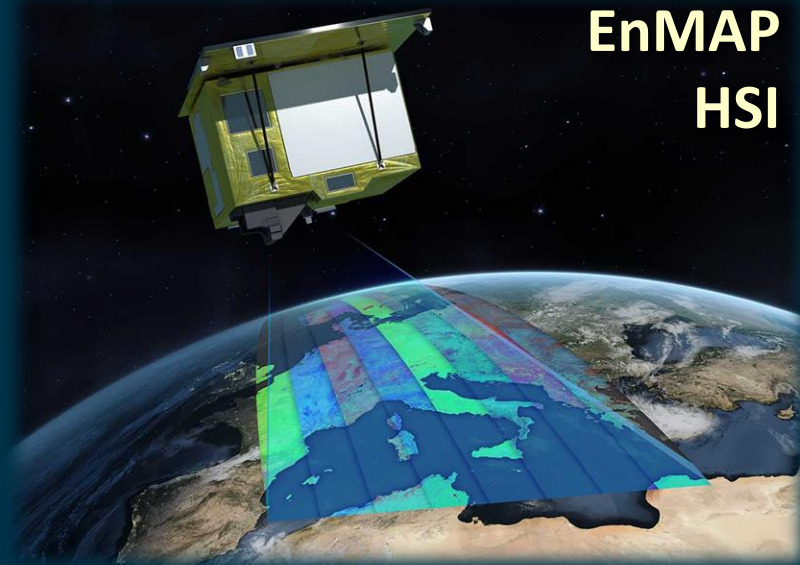
Expected launch A/B 2026 – C 2027



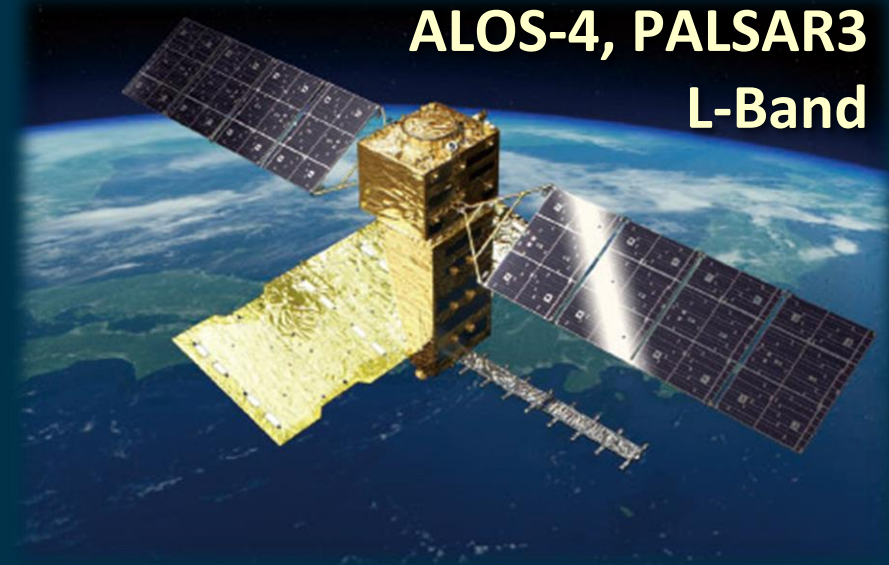
# International Missions



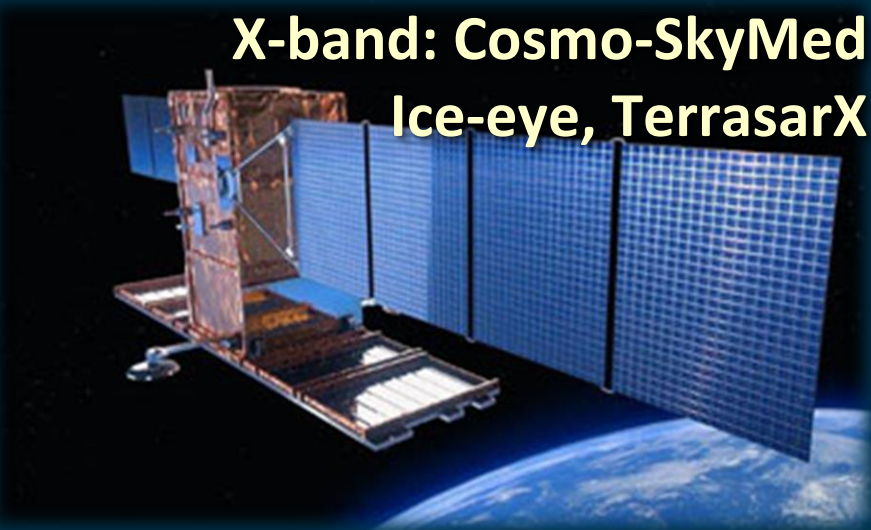
**NISAR**  
L-Band



**EnMAP**  
HSI



**ALOS-4, PALSAR3**  
L-Band



**X-band: Cosmo-SkyMed**  
Ice-eye, TerrasarX



**GEDI**  
LiDAR



**PRISMA**  
HSI

**FROM MISSIONS...**

**...TO SOLUTIONS**



# Mapping Forest Degradation in Detail (Example Amazon)



Rondonia, Brazil  
Sentinel-2  
29 June 2022



# Recovering Forests (Study within CCI RECCAP2 led by INPE & Uni. Bristol)



3 km

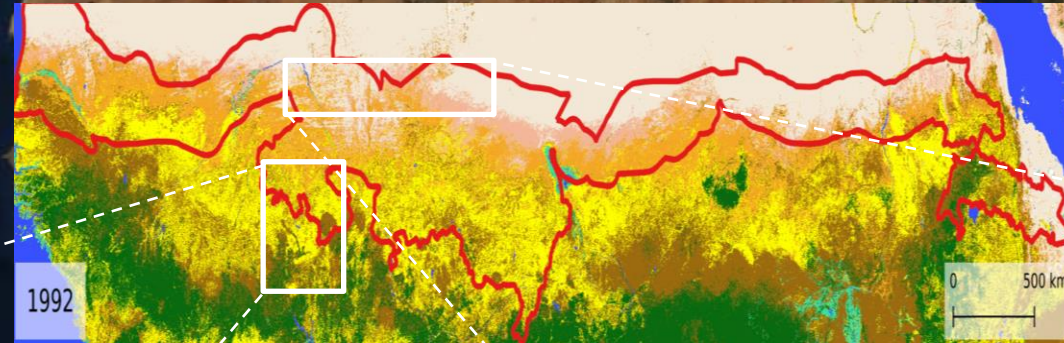


1985 12

# The Great Green Wall Initiative - Chronology



Started in 2007, the 8000-kilometre-long Great Green Wall is an African-led initiative, spanning 11 countries, to combat land degradation, desertification and drought.

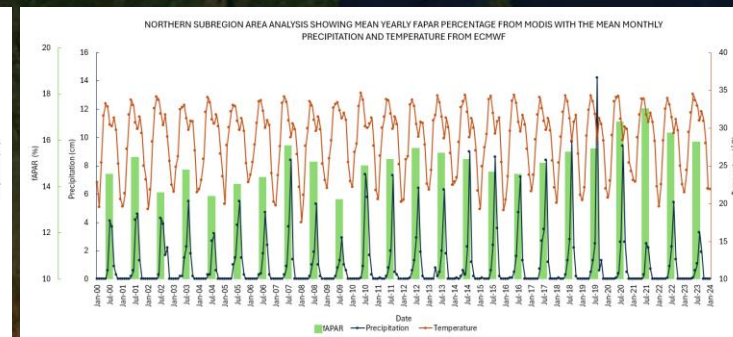
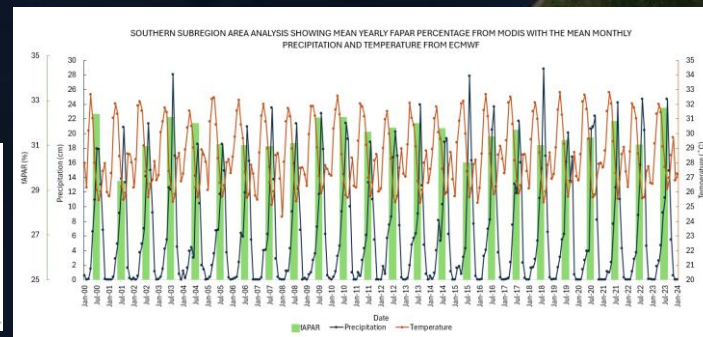
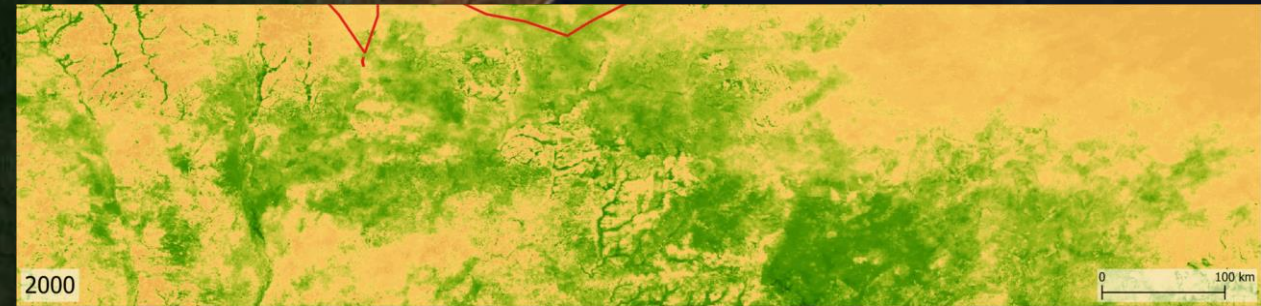


- Bare
- Sparse Vegetation
- Cropland
- Grassland
- Shrubland
- Tree Cover
- Urban
- Flooded Vegetation
- Water

Investigating correlation across CCI Landcover data, fAPAR, ERA5 precipitation and LST, showing in some regions vegetation is advancing into arid areas, in others it is retreating



Detected recession (left) and advancement (right) from pre-GGW to now



EO FAST TRACK APPS – EXPRO+



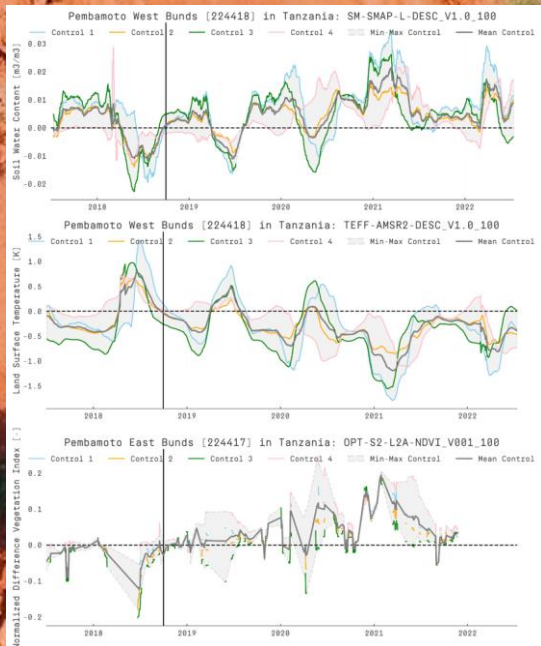
# Ecosystem Restoration and Conservation.



## An example.

### LANDSCAPE RESTORATION

Using simple techniques to bring back vegetation.



### BUNDS DIGGING

By capturing rainwater with the help of bunds, rainwater has more time to enter the soil and restore the water balance. The seeds in the soil get the chance to sprout, and eventually allow the area to grow green, lush and cool.

JUNE 2019

JUNE 2020

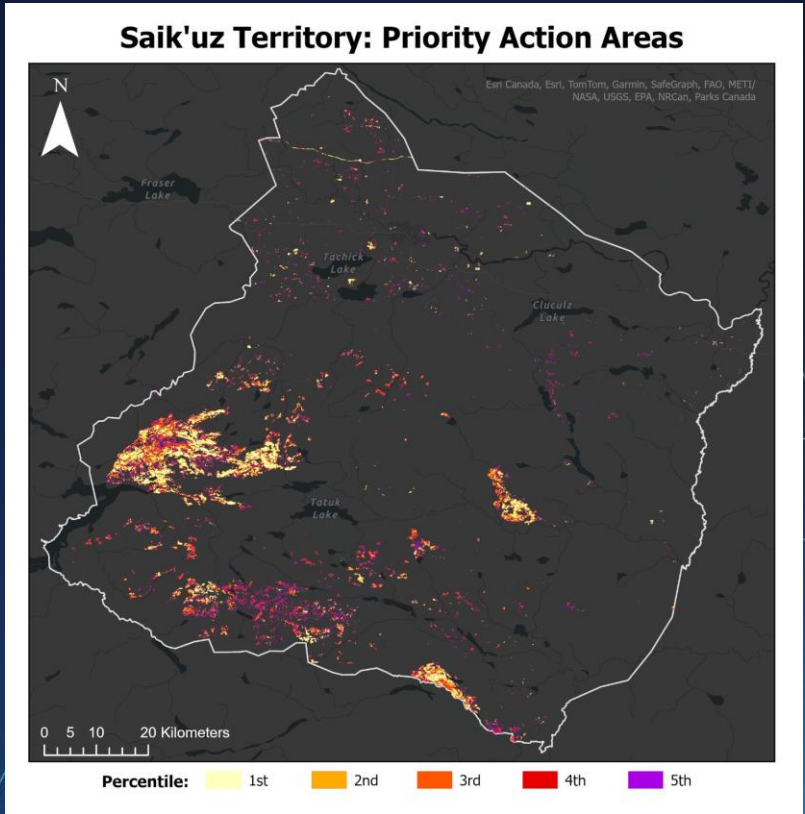
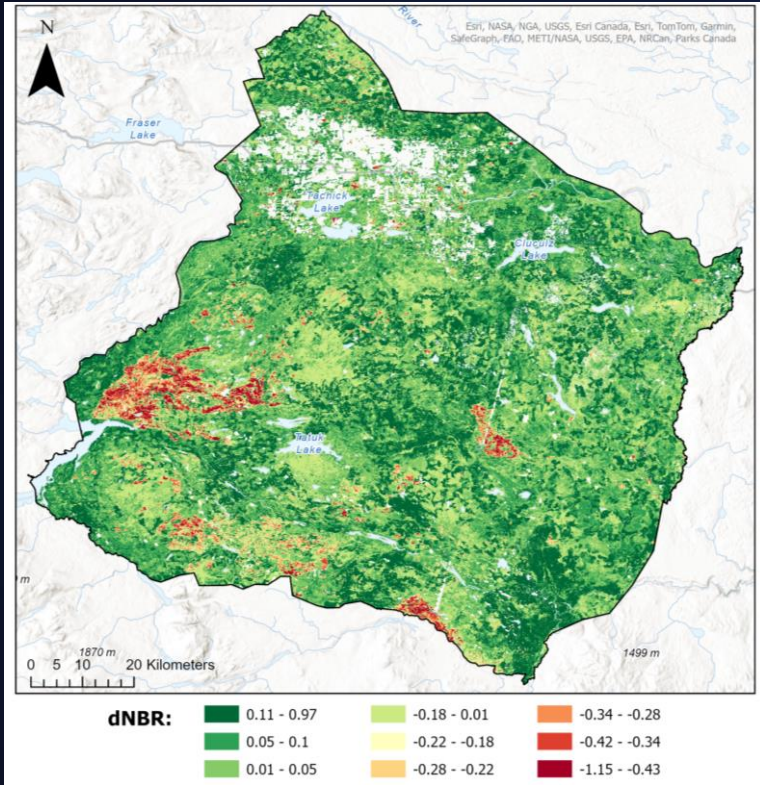
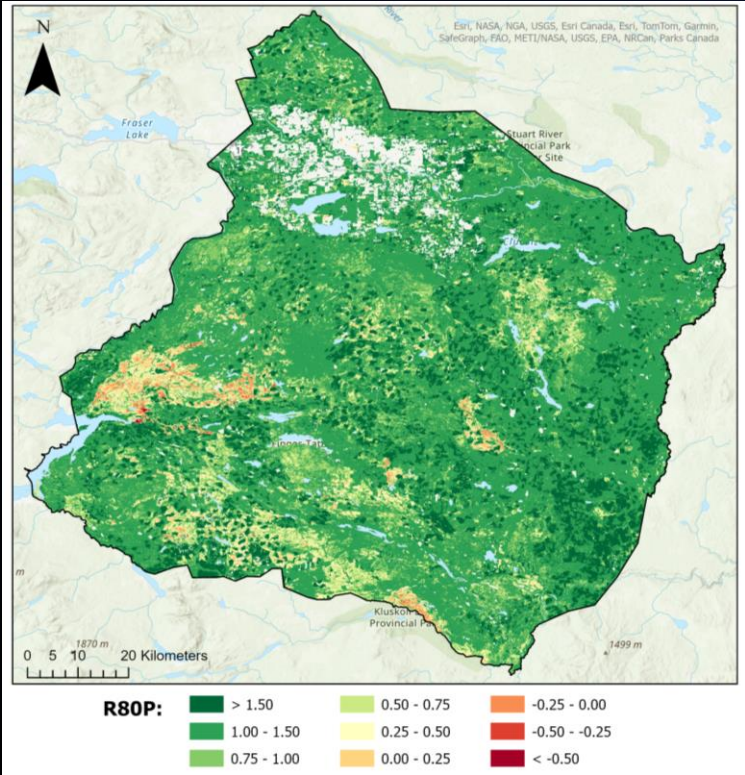
JUNE 2022

IF WE CAN WARM UP THE EARTH,  
WE CAN ALSO COOL IT DOWN

# Burned Area Restoration in Canada



Normalized Burn Ratio (NBR) across the landscape



# Estimating Carbon Loss Using Sentinel-1

“Sentinel-1 for Science: Amazonas” is an exploratory scientific project, funded by the European Space Agency (ESA), looking to assess how Sentinel-1 imagery can be used to **estimate forest carbon losses associated with land use and land cover changes in the entire Amazon basin.**

The Sentinel-1 for Science: Amazonas project presents a simple and transparent approach to **using Sentinel-1 satellite radar imagery to estimate forest loss.** The project uses a space-time data cube design (also known as StatCubes), where statistical information relevant to identify deforestation is extracted at each point in the radar time-series.

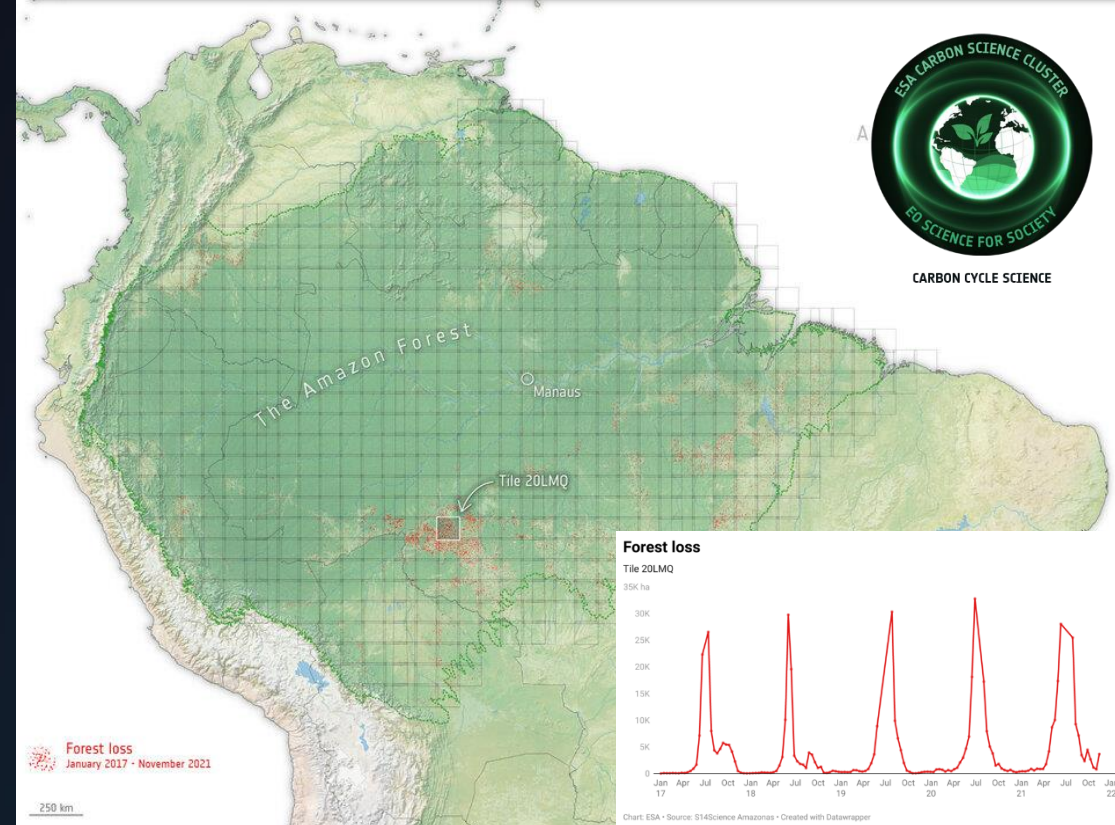
<https://sen4ama.gisat.cz/>

*The team were able to detect forest loss of over 5.2 million hectares from 2017 to 2021, which is roughly the size of Costa Rica.*



Amazon basin dynamic deforestation product, from Sentinel-1 time series

- Estimate Carbon loss from LULC (mainly forest loss)
- 5 years of data: 2017-2021
- Continental scale processing on CREODIAS (1 run in 48h)
- Sentinel-1 Forest loss Estimation
- **20 m scale, Openly available product**
- Time series of forest loss evolution
- Confidence layer (0-100%) for the detection of loss



# Biomass from Space



- Version 5 with global AGB from 2010, and annually from 2015 to 2021 in cooperation with



Maps are provided at 100m spatial resolution together with their standard deviation.

Consistency: a decade of change



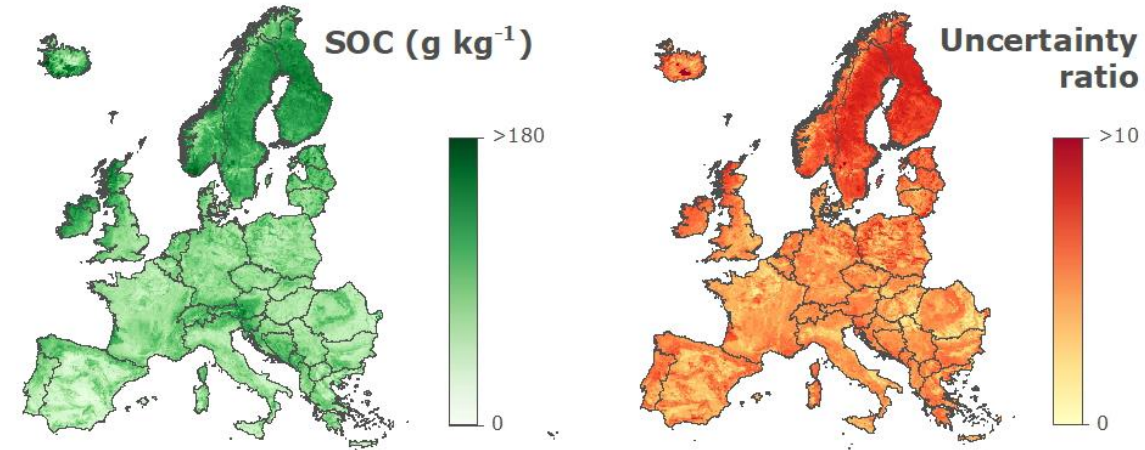
# WORLDISOILS – A SOC PREDICTION SYSTEM

Data visualization and download  
<https://gui.world-soils.com/>

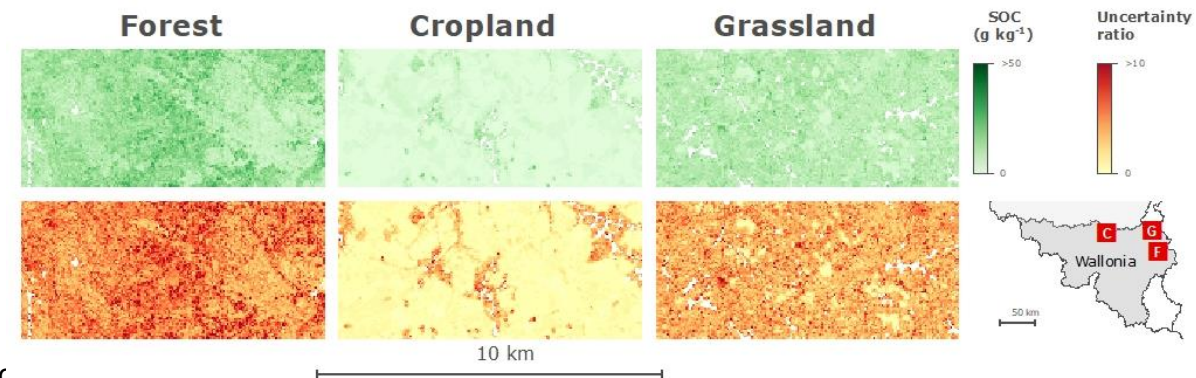


- **Validation with National Reporting Centers data sets**
  - **Wallonia:** very high accuracy ( $\geq 90\%$ )
  - **Czech Republic:** tendency to overpredict SOC values
  - **Macedonia:** mosaiced crops difficult SOC pixel assignation

## European Topsoil SOC



## Regional Topsoil SOC



# Blue Carbon and Ocean Carbon Cycle

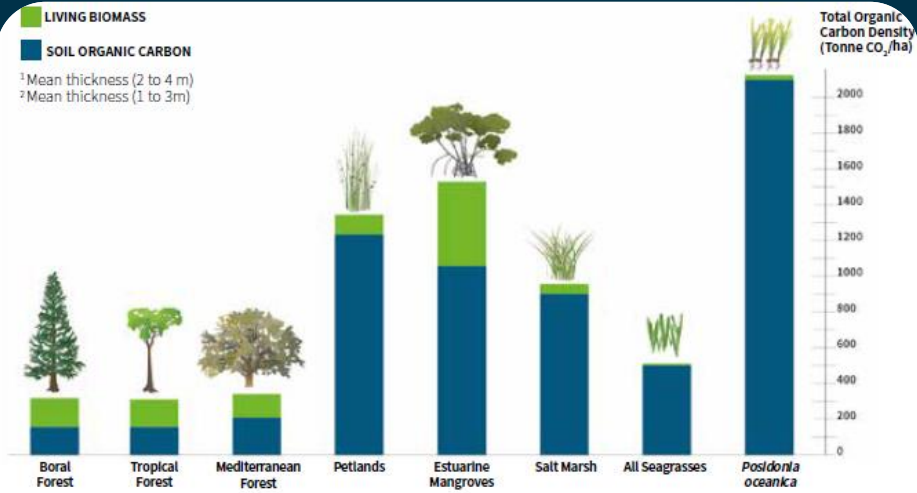
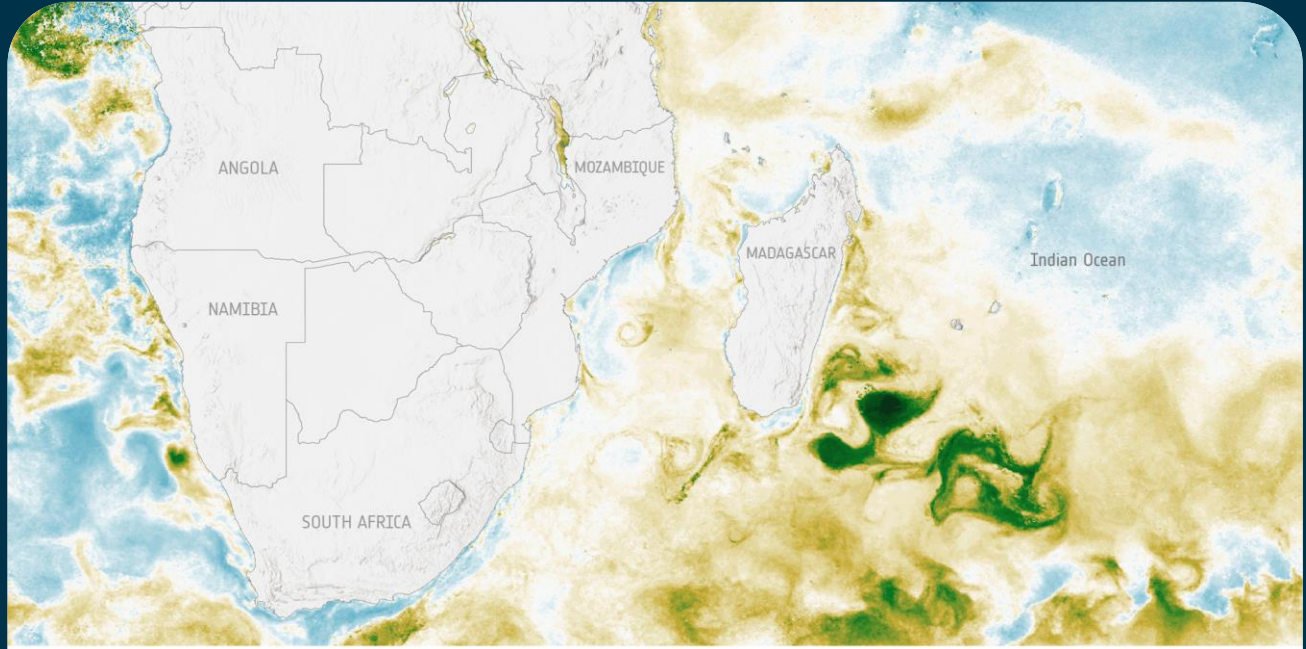


Figure 5: Comparison of soil C<sub>org</sub> storage in the top metre of the soil with total ecosystem C<sub>org</sub> storage for major ecosystem types. Here, the seagrass *Posidonia oceanica* is a unique seagrass in terms of the quantity of organic carbon that can be stored in its sediments and mat. Soil Data: Top meter sediment [12, 111, 112, 113].

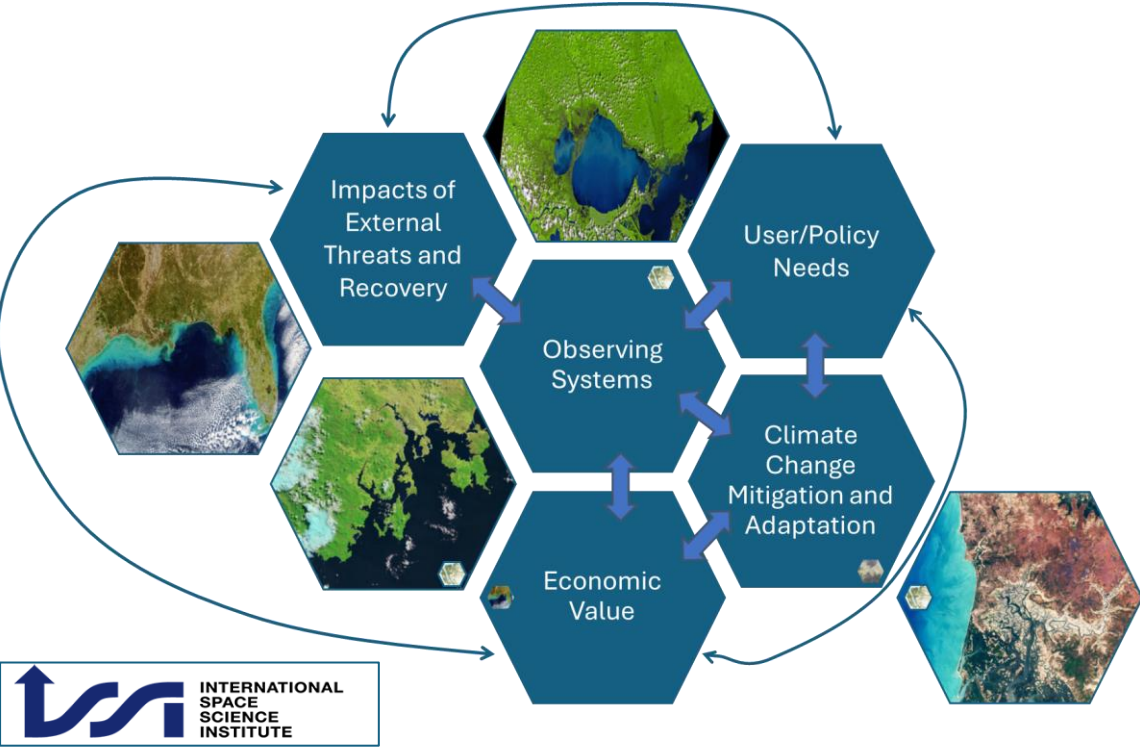


Chlorophyll-a monthly anomaly (%)  
 -200 0 600  
 November 2018



Seagrass cover (02 May 2018)  
 0 50 100 %  
 500 m

Organized jointly by **ESA** and **NASA** with the support of the **International Space Science Institute (ISSI)**, the Blue Carbon From Space Forum gathered **24 participants from 14 different countries** across six continents with diverse and complementary expertise in the realm of blue carbon including remote sensing and in-situ observations experts, blue carbon ecosystems and climate change ecologists, marine biologists, and representatives of international organizations and NGOs (IPCC, UNESCO, Wetland Internationals, Conservation International, the Nature Conservancy, GRID-ARENDAL).

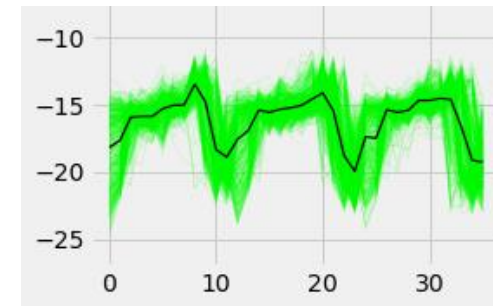


- Status, gaps and opportunities of EO capabilities to **map blue carbon ecosystem extent, carbon stock and change** were reviewed.
- Discussions focused on how satellite data can support **policy and user needs**, contribute to **carbon credits and voluntary carbon markets**, support **Monitoring, Reporting and Verification** strategies, the **monitoring and prediction of external driver effects on carbon stocks/sequestration potentials** and the quantification of the **impact of blue carbon ecosystem conservation and restoration** on their climate change mitigation capabilities.
- A forum summary is under preparation together with a perspective paper on the **role for improved Earth Observations to boost blue carbon ambition**.

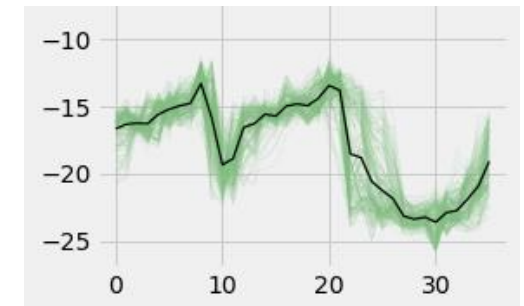
# Wetland Ecosystem Restoration in Vietnam

- Re-naturalize a large area within Vietnam's upper Mekong Delta and transition away from a third annual rice crop into nature-based solutions of flood-based agriculture
- High dikes constructed to prevent deep flooding and enable third rice crop
- Ecosystem degradation – loss of wetland functions
- Dynamic Time Warping (DTW) on Sentinel-1 time series was calculated between individual time series and reference temporal profiles that represent triple rice and double rice → overall accuracy of 86%.
- **Comparison between the classification of 2019 and 2022 suggest ~20% decline in triple rice areas**

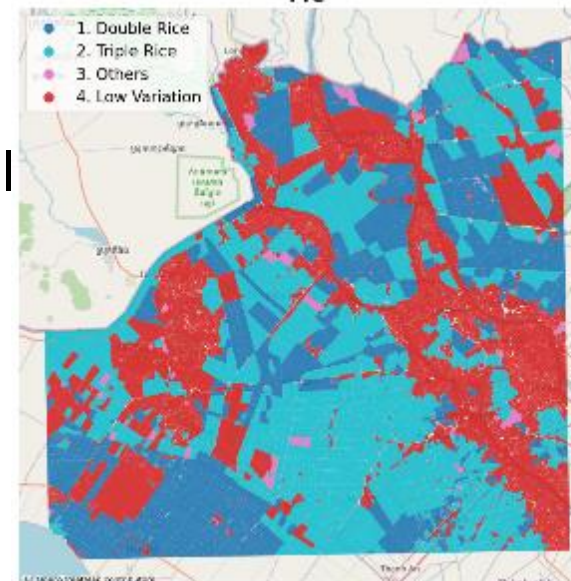
Isolated from floodplain



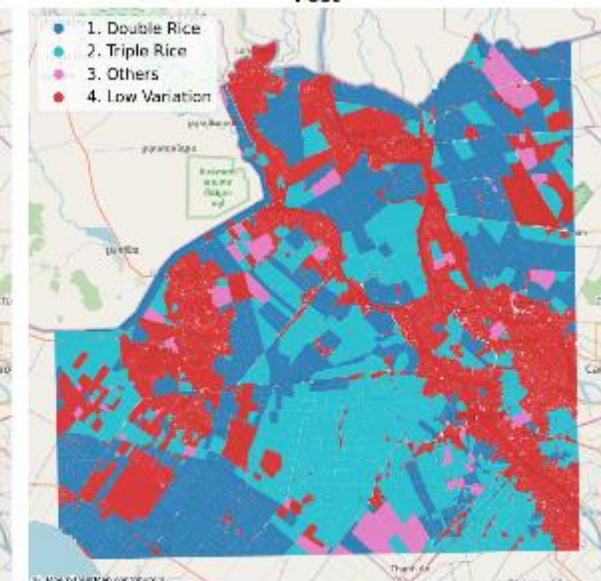
Connection to floodplain

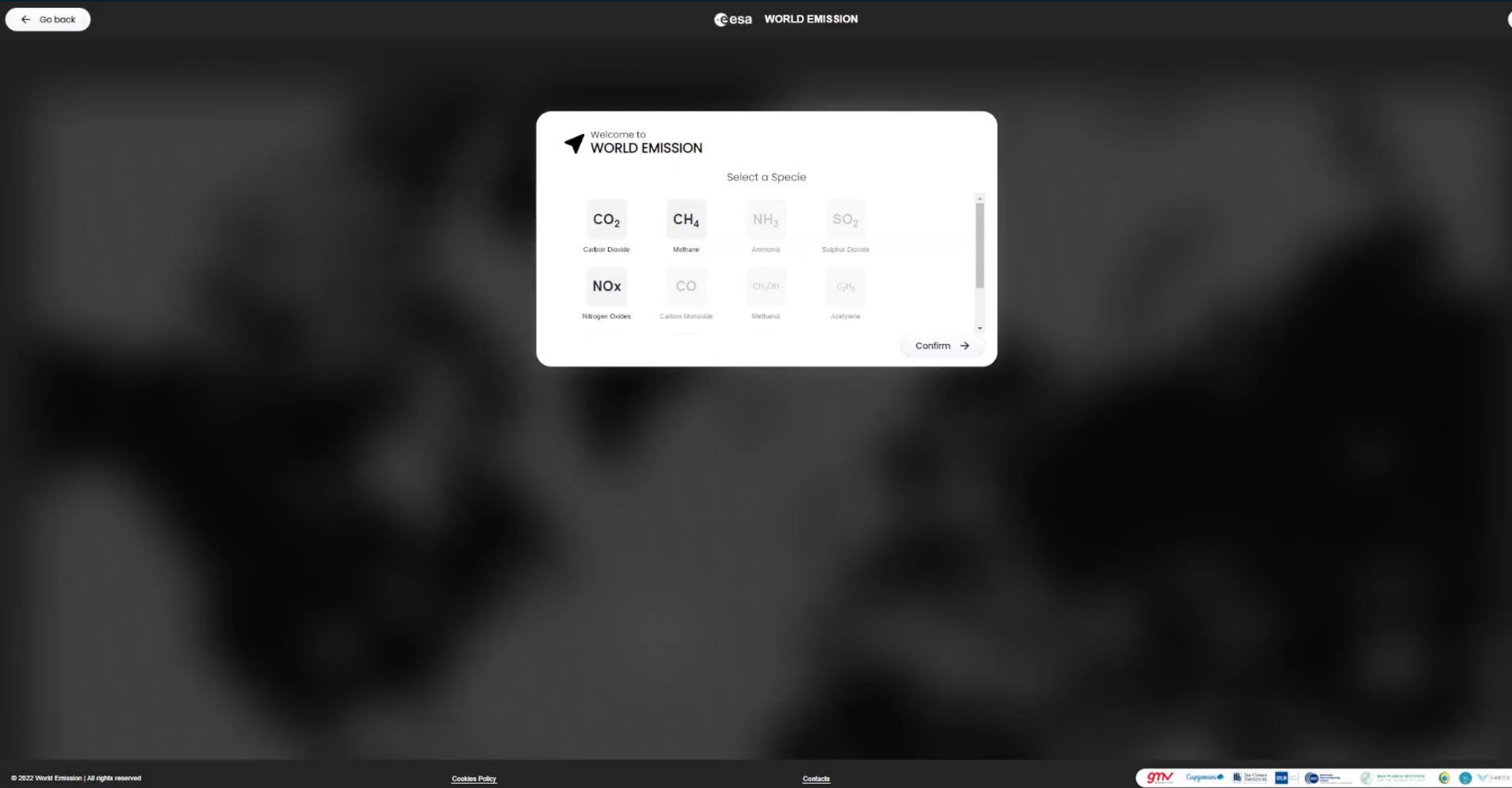


Pre



Post





Anthropogenic emissions from space, from regional emissions fluxes to individual plumes from polluting industries.

Private constellations are also rising and fill the need of VHR imagery of GHG plumes

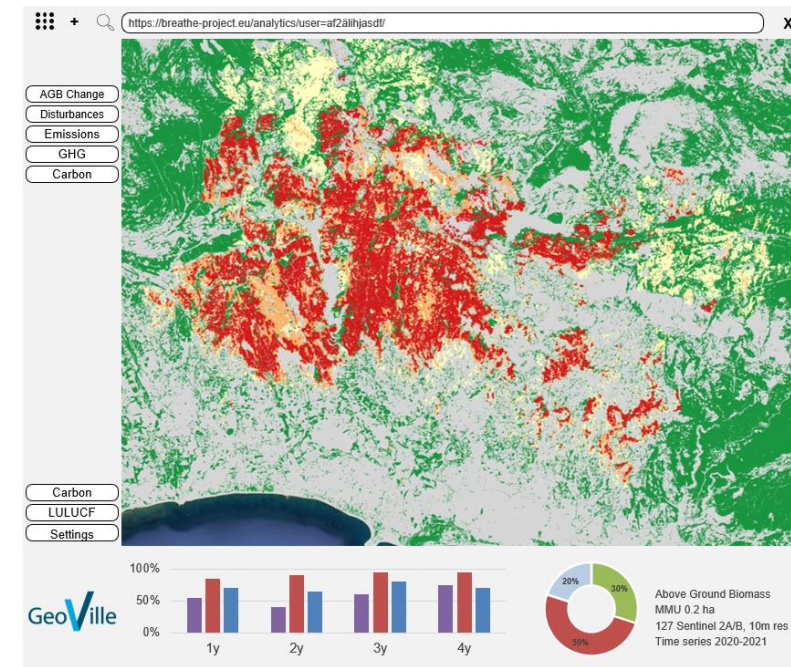
# EO Services Contribution to MRV

## Monitoring Reporting and Verification System of greenhouse gas anthropogenic emissions

- **Users:** The Environment Agency Austria, The Turkish Ministry of Agriculture/Directorate General of Forestry, The European Environment Agency
- **Challenge:** Enhancement and Verification of LULUCF reporting by Member States for the compliance market (EC, UNFCCC)
- **Initiative:** FFG ASAP, EC EUREKA
- **Results:** Earth-Observation-integrated Monitoring Reporting and Verification System for LULUCF and carbon emissions by sources and removals by sinks from Above-Ground-Biomass
- **Service provider:** GeoVille

**GeoVille is committed to developing Europe's first EO-based carbon and GHG MRV system!**

**GeoVille**



<https://breathe-project.eu/>



<https://ghg-kit.at/>

# ESA Forestry Applications roadmap



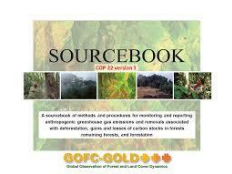
1997

DUP Kyoto Inventory

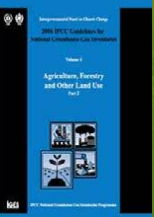
2000



2005



2009



2020



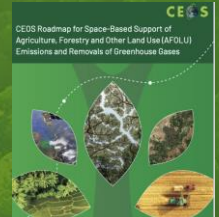
2013



2023



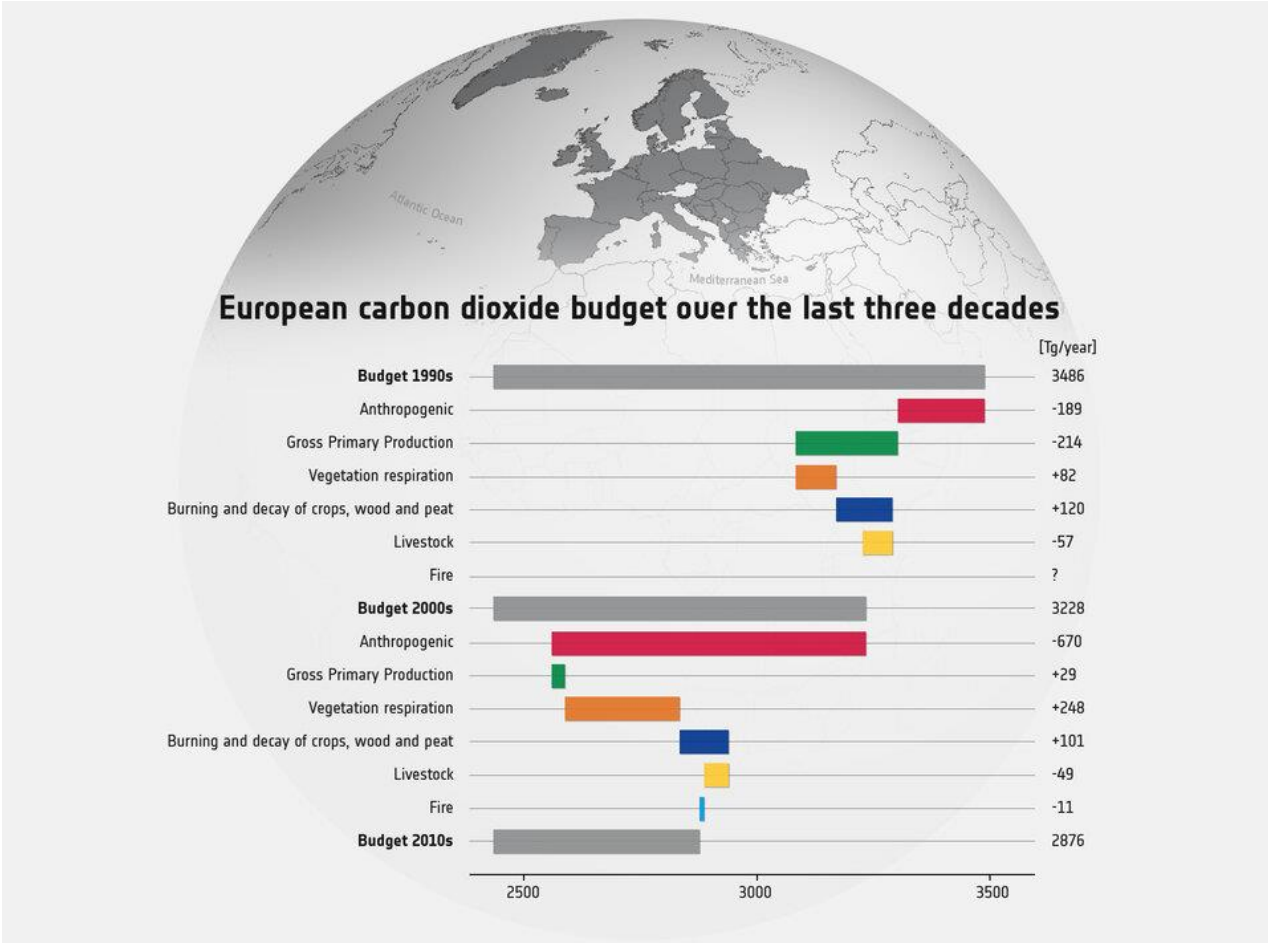
2015



2025

# The Big Picture

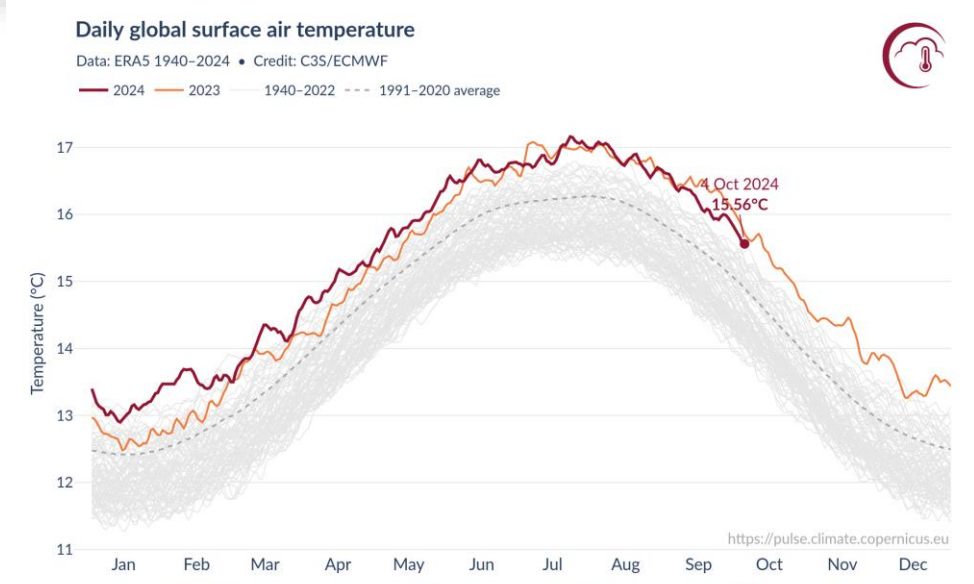
## European greenhouse gas emissions decline but land stores weaken



ENVIRONMENT • CLIMATE CHANGE

### Land carbon sinks collapsed in 2023, a stark warning of climate changes to come

Forests and soils only absorbed between 1.5 and 2.6 billion metric tons of CO<sub>2</sub> in 2023, far behind the 9.5 billion in 2022, mainly due to drought in the Amazon and fires in Canada and Siberia.



# New Integrated Policy Expert Scheme (IPES)

<https://eo4society.esa.int/integrated-policy-expert-scheme-ipes/>

The policy expert is seamlessly integrated into the ESA team, fostering collaboration and leveraging unique insights to accelerate the implementation of effective strategies addressing the global climate and environmental crisis.

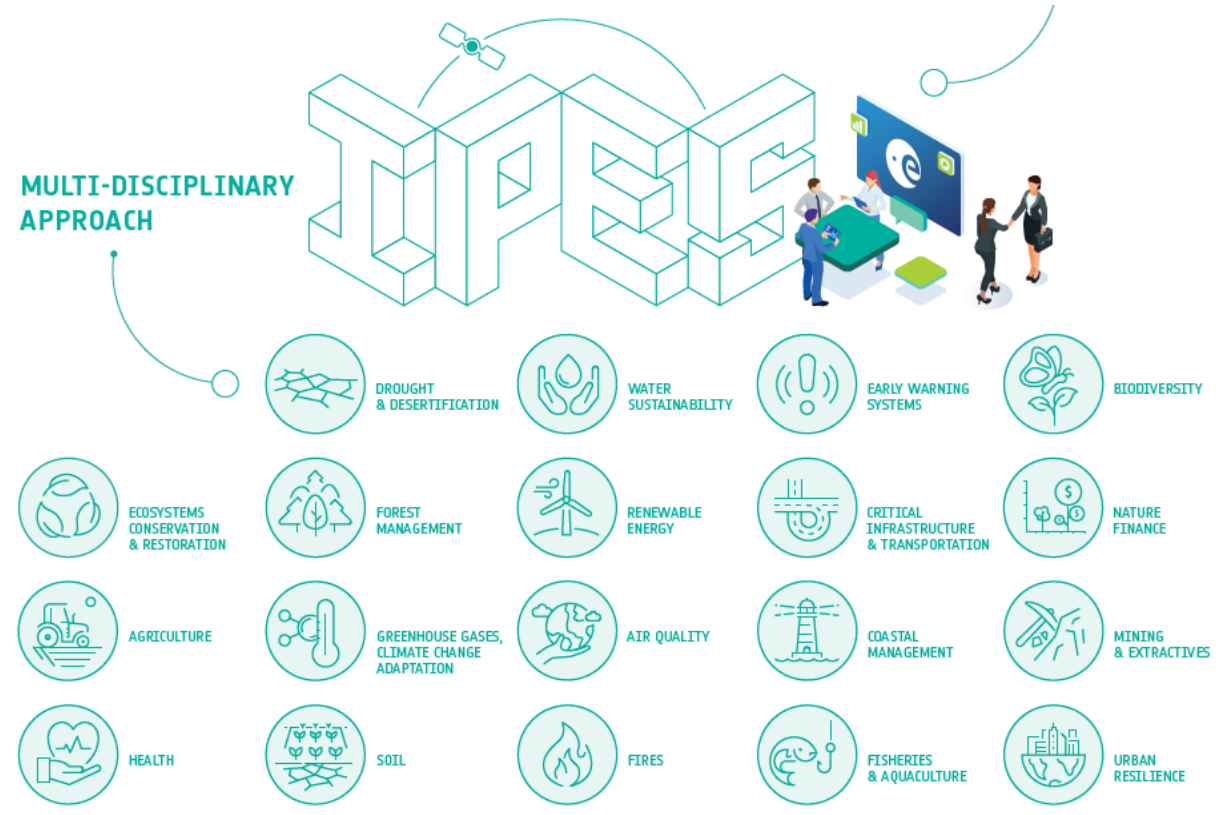
The scheme duration spans from 3 months to 1 year, with the possibility of renewable to a maximum of 2 years. While actively engaged in ESA projects, the experts maintain their employment with their original organization. ESA assumes responsibility for covering some specific additional costs.

**Launching in 2024/5.**

**Get in touch with ESA via the dedicated [ipes@esa.int](mailto:ipes@esa.int) e-mail address.**

## INTEGRATED POLICY EXPERTS FROM

- INTERNATIONAL AND EUROPEAN ORGANIZATIONS
- NATIONAL / REGIONAL / LOCAL ENTITIES
- MULTILATERAL CONVENTIONS
- CIVIL SOCIETY ORGANIZATIONS
- INDIGENOUS SOCIETIES



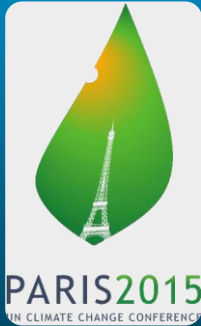
## MUTUAL BENEFITS

- SYNERGISTIC ACTIONS AND RESOURCE MOBILIZATION
- POLICY ALIGNMENT
- ENHANCED DECISION-MAKING
- INTERDISCIPLINARY HOLISTIC SOLUTIONS DEVELOPMENT
- STAKEHOLDERS AND END-USERS EMPOWERMENT
- EFFECTIVE INTEGRATION INTO POLICY FRAMEWORKS
- FOSTER OPERATIONAL UTILIZATION
- ENABLE ACTION FOR A SUSTAINABLE GREEN TRANSITION TOWARDS A CARBON-NEUTRAL, RESOURCE-EFFICIENT AND RESILIENT SOCIETY

# EO to enable International and European Policy Frameworks



## UN Resolutions, Treaties & Int. Conventions



	Reduce	Increase
7 GLOBAL TARGETS	<b>Mortality/</b> global population 2020-2030 Average << 2005-2015 Average	Countries with national & local DRR strategies 2020 Value >> 2015 Value
	<b>Affected people/</b> global population 2020-2030 Average << 2005-2015 Average	<b>International cooperation</b> to developing countries 2030 Value >> 2015 Value
	<b>Economic loss/</b> global GDP 2030 Ratio << 2015 Ratio	<b>Availability and access</b> to multi-hazard early warning systems & disaster risk information and assessments 2030 Values >> 2015 Values
	<b>Damage to critical infrastructure &amp; disruption of basic services</b> 2030 Values << 2015 Values	



## European Regulations, Directive and Strategies



**EO for Monitoring, Reporting, and  
Verification of Carbon Removals**  
Copenhagen, 8-11 October 2024

**Thanks**

