From ground to orbit: Combining in-situ and satellite monitoring of water and forest resources for adaptation to climate change

Clement Albergel
Head of ESA's Actionable Climate Information section
Monday 10th November, 18:30-20:00 - Blue Zone, Side-Event Room 9

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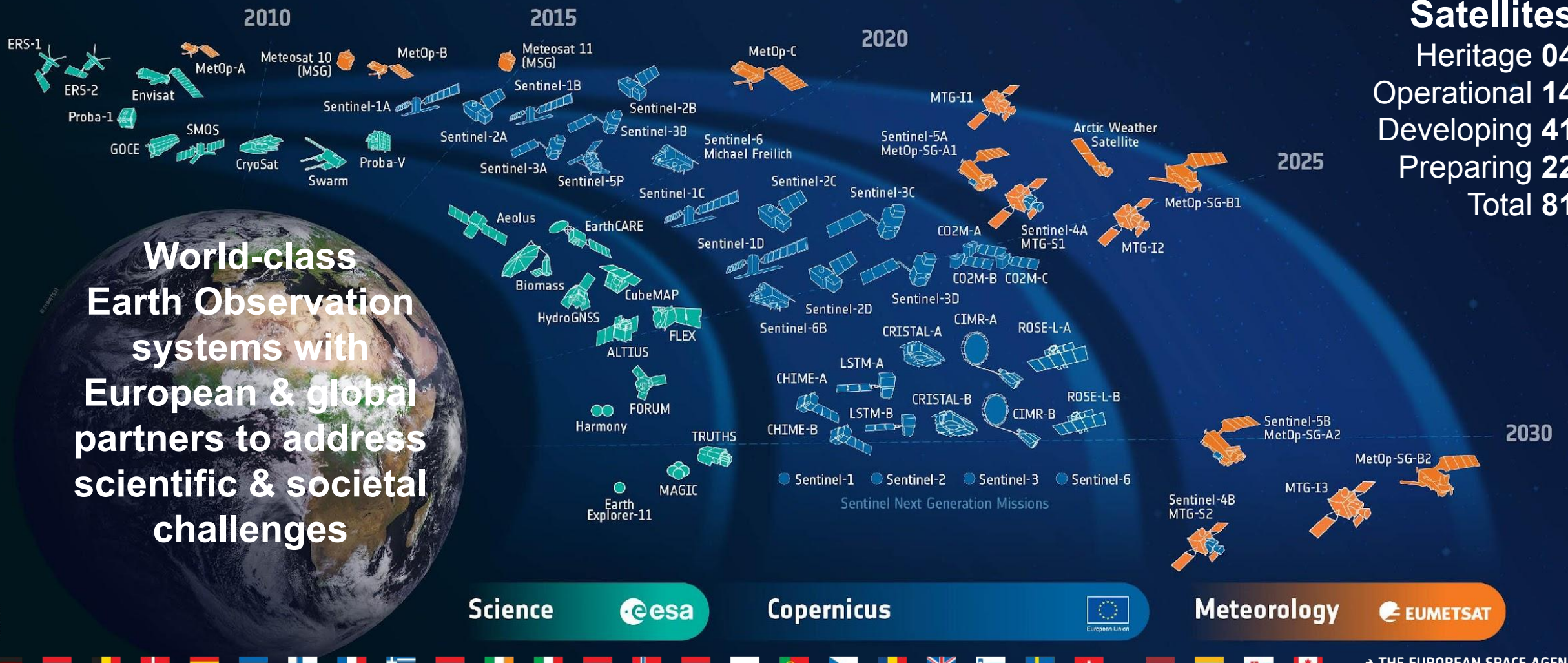
10/11/2025

ESA's Earth Observation Mission



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

Satellites

Heritage **04**
Operational **14**
Developing **41**
Preparing **22**
Total **81**

Science esa Copernicus European Union Meteorology EUMETSAT

Earth Observation Activities at ESRIN ESTEC ECSAT

ESTEC

Satellite Design & Development

Missions Management

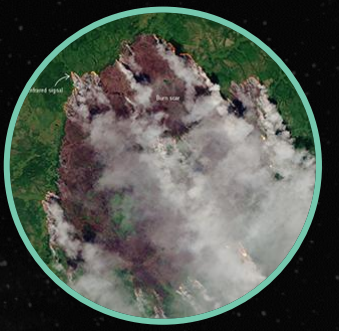
ESRIN

Cal/Val & Data Distribution

Applying the data for Earth Action

Earth System Science

Emergency Response



Digital Twins

Climate Change

Innovation

Future systems & Instruments activities

Accelerate the future of EO with cutting edge research

Φ-lab

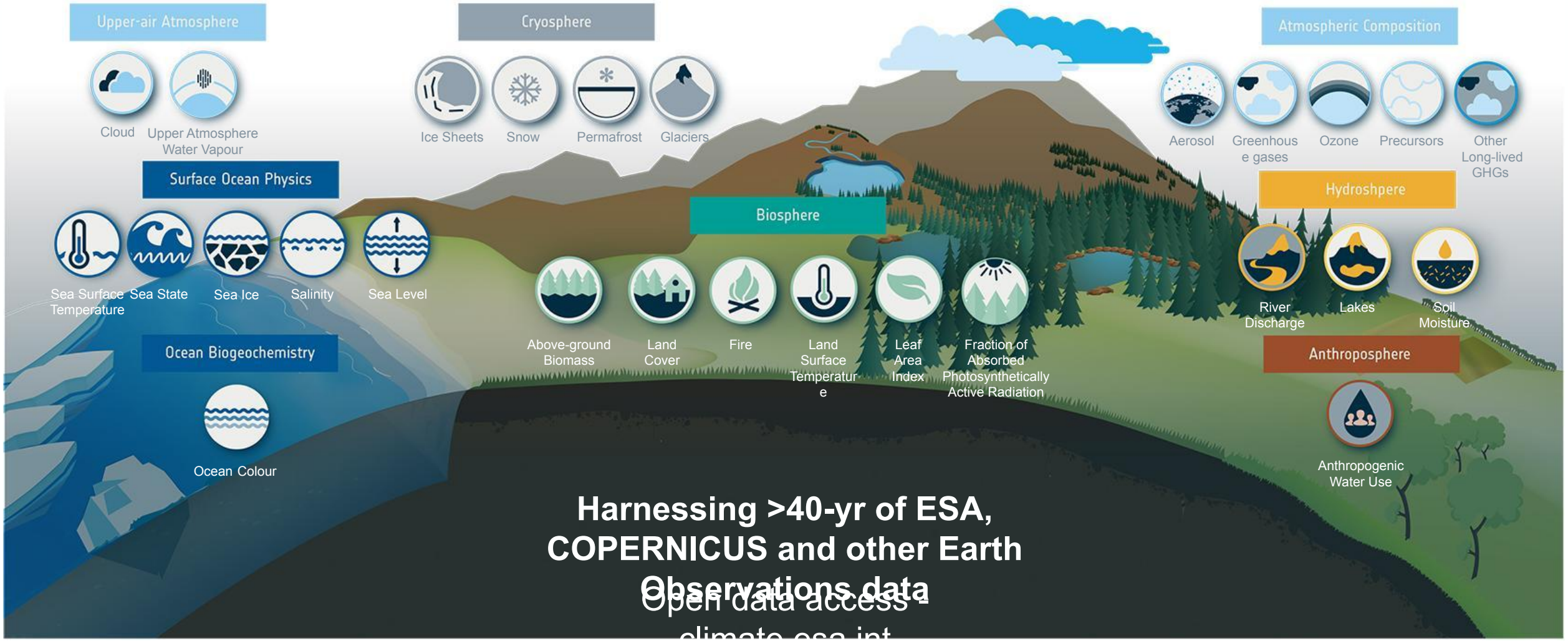
Accelerate the future of EO via transformative innovation & com-mercialisation actions

Commercialisation

InCubed

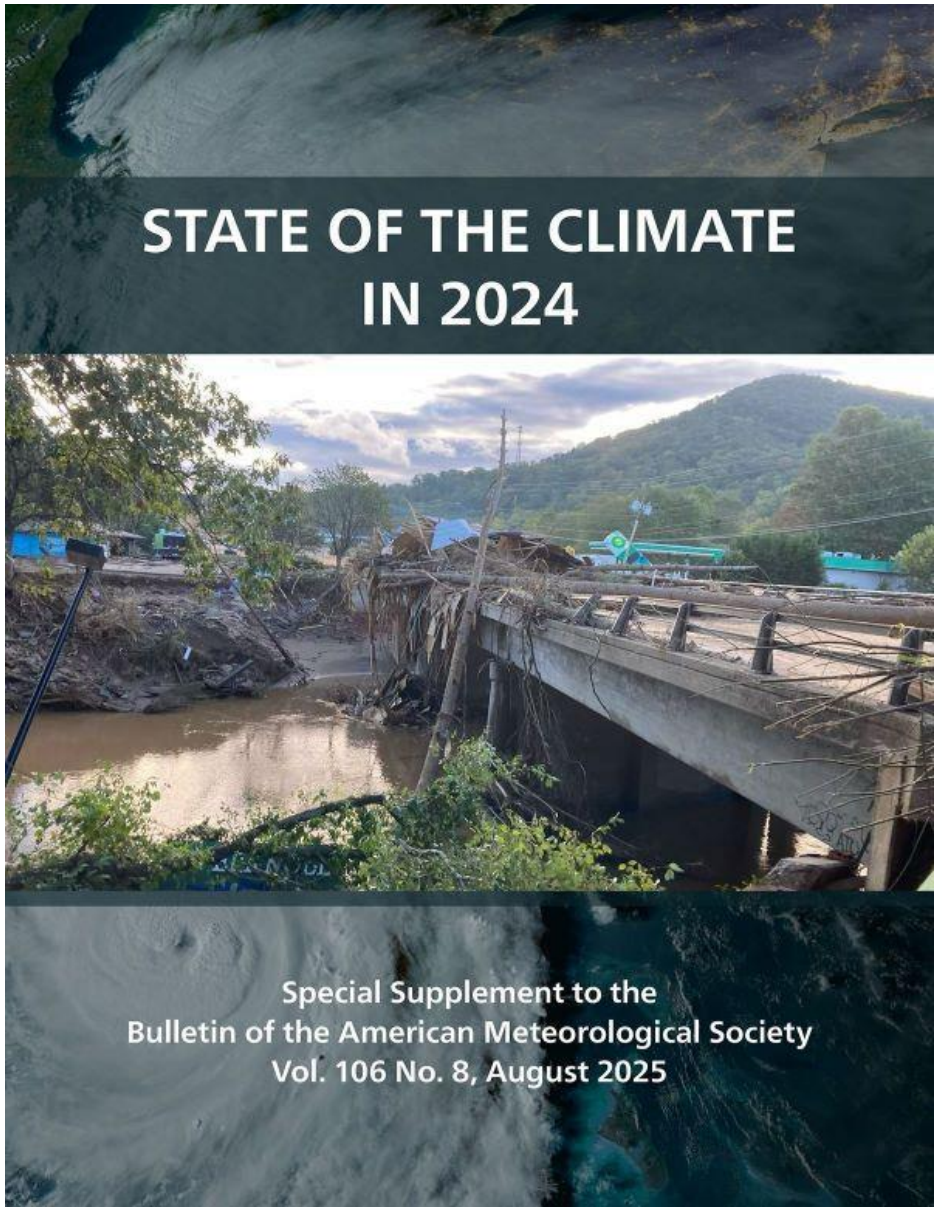
ESA's Climate Change Initiative (CCI):

The climate-quality datasets produced by CCI are a major contribution to the evidence base used to understand climate change, which drives international action

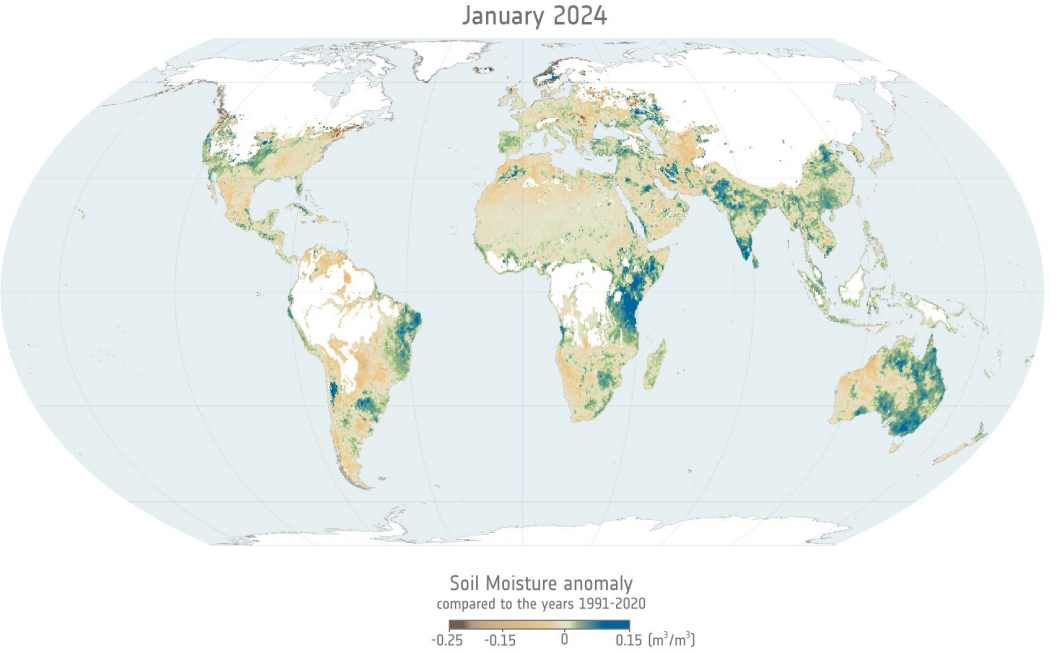


Harnessing >40-yr of ESA, COPERNICUS and other Earth Observations data

Open data access - climate.esa.int



State of the Climate - American Meteorological Society



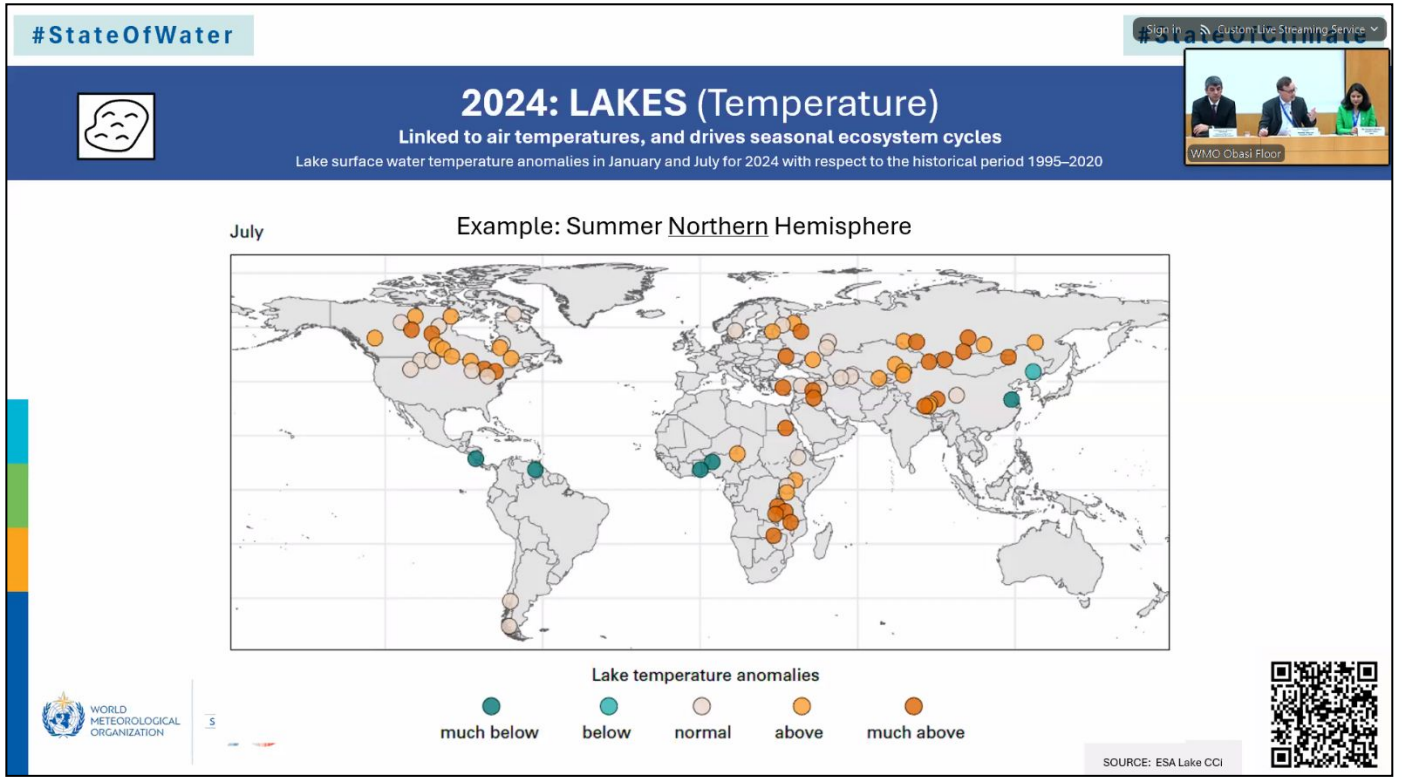
ESA's CCI provides critical satellite evidence to support the findings in the BAMS 2024 report. Insights include 'super-extreme hotspots' with land surface temperatures exceeding 50–60 °C, the highest recorded global lake surface temperature anomalies (with over half of observed lakes above +0.5 °C versus 1995–2020), sharp contrasts in soil moisture from a water-swollen Sahel to drought across the United States and accelerating rock glacier movement as permafrost thaws. At the same time, stratospheric ozone experienced a positive year, with levels in the Northern Hemisphere the highest since satellite monitoring began.

ESA - ESA data records help underpin climate change report

WMO State of Global Water Resources 2024 & Climate Space

World's lakes show severe climate fingerprint as the global water crisis deepens

European satellite data reveal how space-based monitoring supports critical water resource assessments
In nearly all the 75 monitored lakes, temperatures were well above historical norms in July 2024, affecting water quality



https://www.youtube.com/watch?v=IFvrw6_73Dc&embeds_referring_euri=https%3A%2F%2Fclimate.esa.int%2F&source_ve_path=OTY3MTQ

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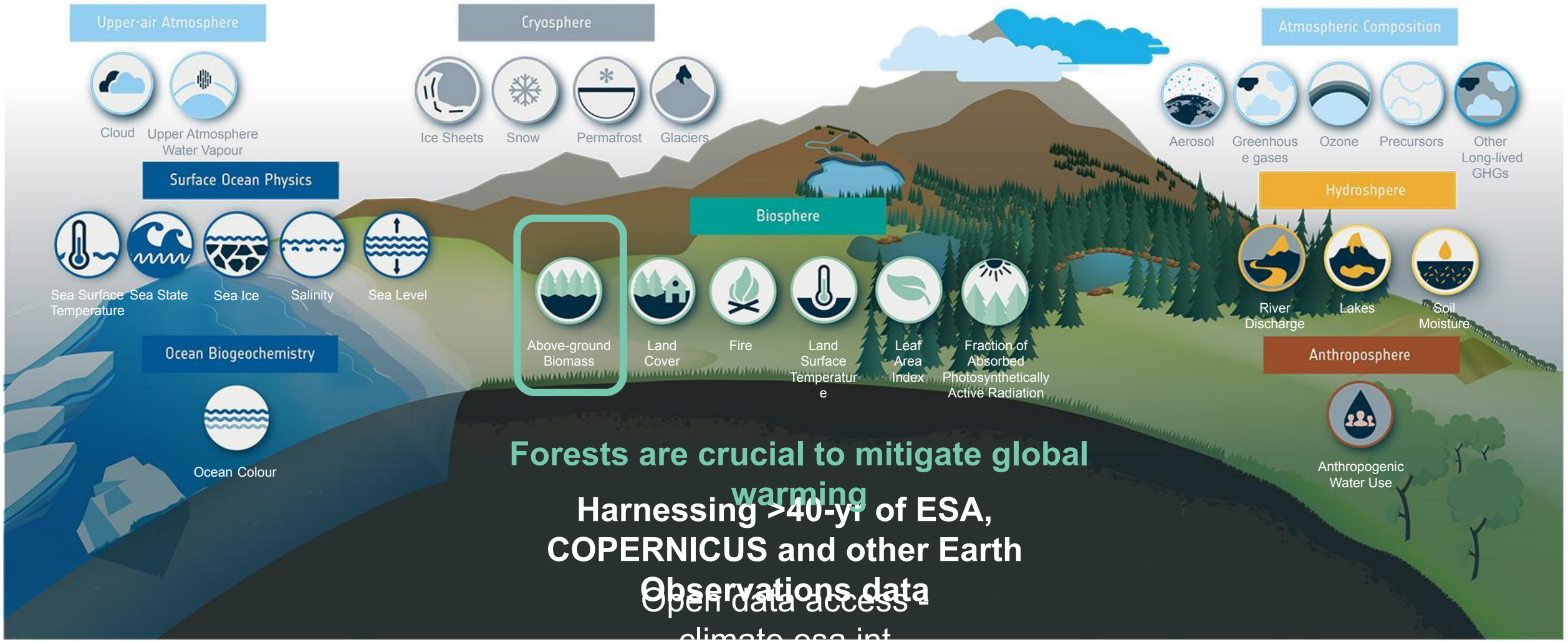


Forests are crucial to mitigate global warming

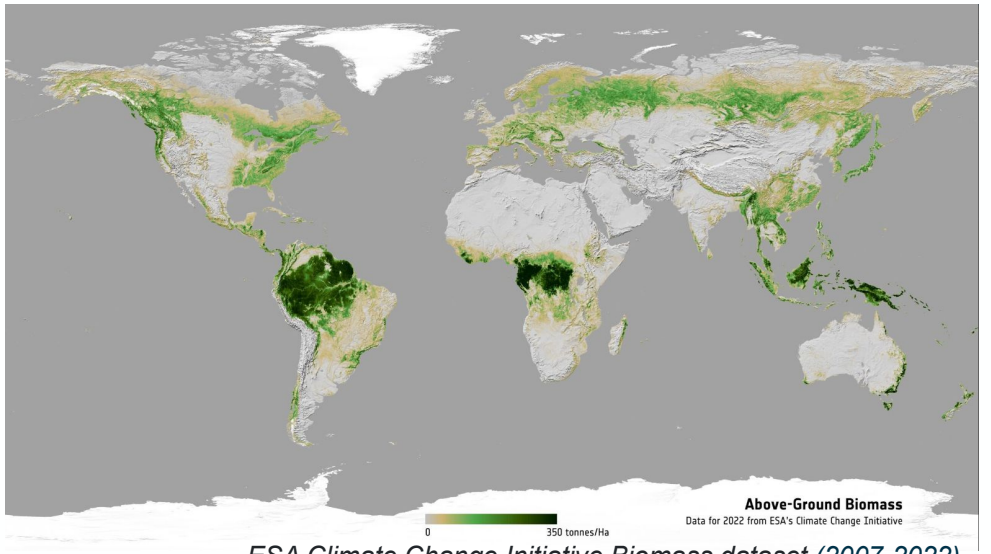
Harnessing >40-yr of ESA, COPERNICUS and other Earth Observations data

Open data access - climate.esa.int

Above-ground forest biomass record (2007-2022)

- Dataset development led by **Aberystwyth & Sheffield** Universities as part of ESA Climate Change Initiative
- Quantifies global forest biomass & change over time
- Dataset combines data from multiple missions *inc. ESA Envisat; Copernicus Sentinel-1; JAXA's ALOS-1 & -2; & NASA's ICESat & GEDI*

- **Applications:**
  - Climate & carbon model development
  - Forest conservation (UN Reducing Emissions from Deforestation and Forest Degradation, REDD+, programme)
  - Improved national GHG reporting (Paris Agreement)



ESA Climate Change Initiative Biomass dataset (2007-2022)

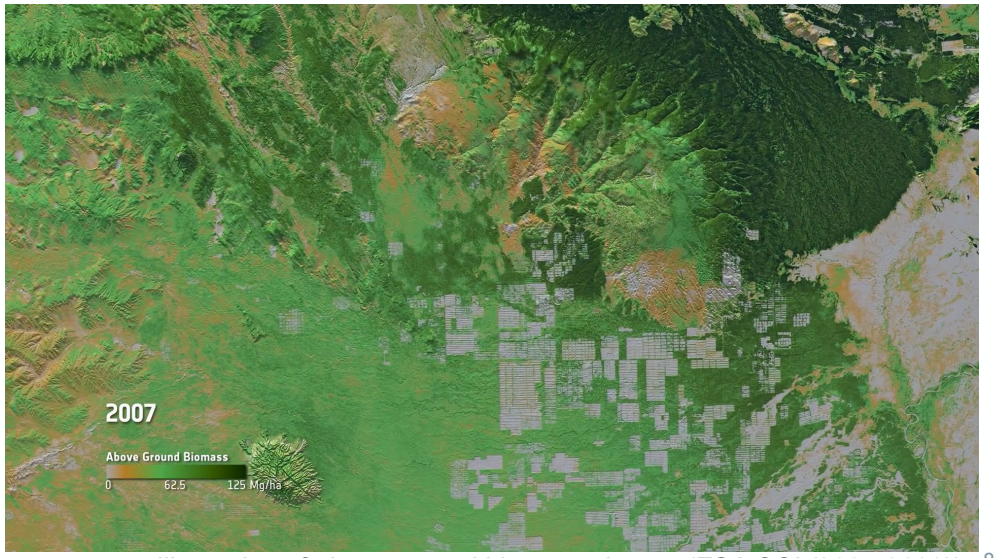


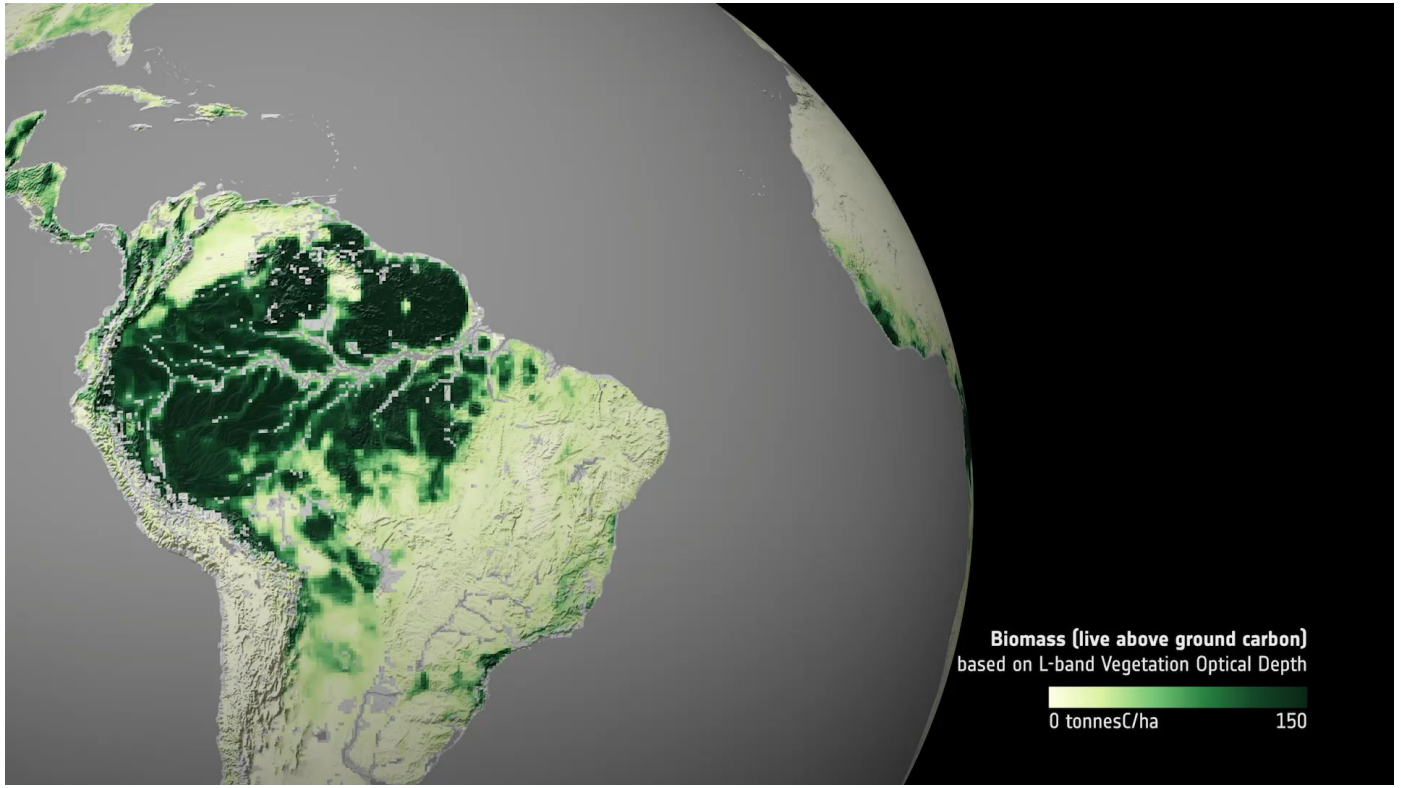
Illustration of above ground biomass change (ESA CCI (2007-2022))

Observations for Carbon Stock

The L-band microwave radiometer on the ESA SMOS satellite is sensitive to annual changes in vegetation, including forests

- These observations are combined with ground data and computer models to map global land carbon stocks
- The Amazon region lost 370 million tonnes of carbon 2010-2020 decade. The south-eastern area is now a net source
- Carbon absorption by growing forest has been outweighed by deforestation, degradation and agricultural use

Amazon



Earth Explorers

Pioneering Scientific and Technical Excellence

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PHOTOSYNTHESIS

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THERMAL RADIATION

harmony
SURFACE DYNAMICS

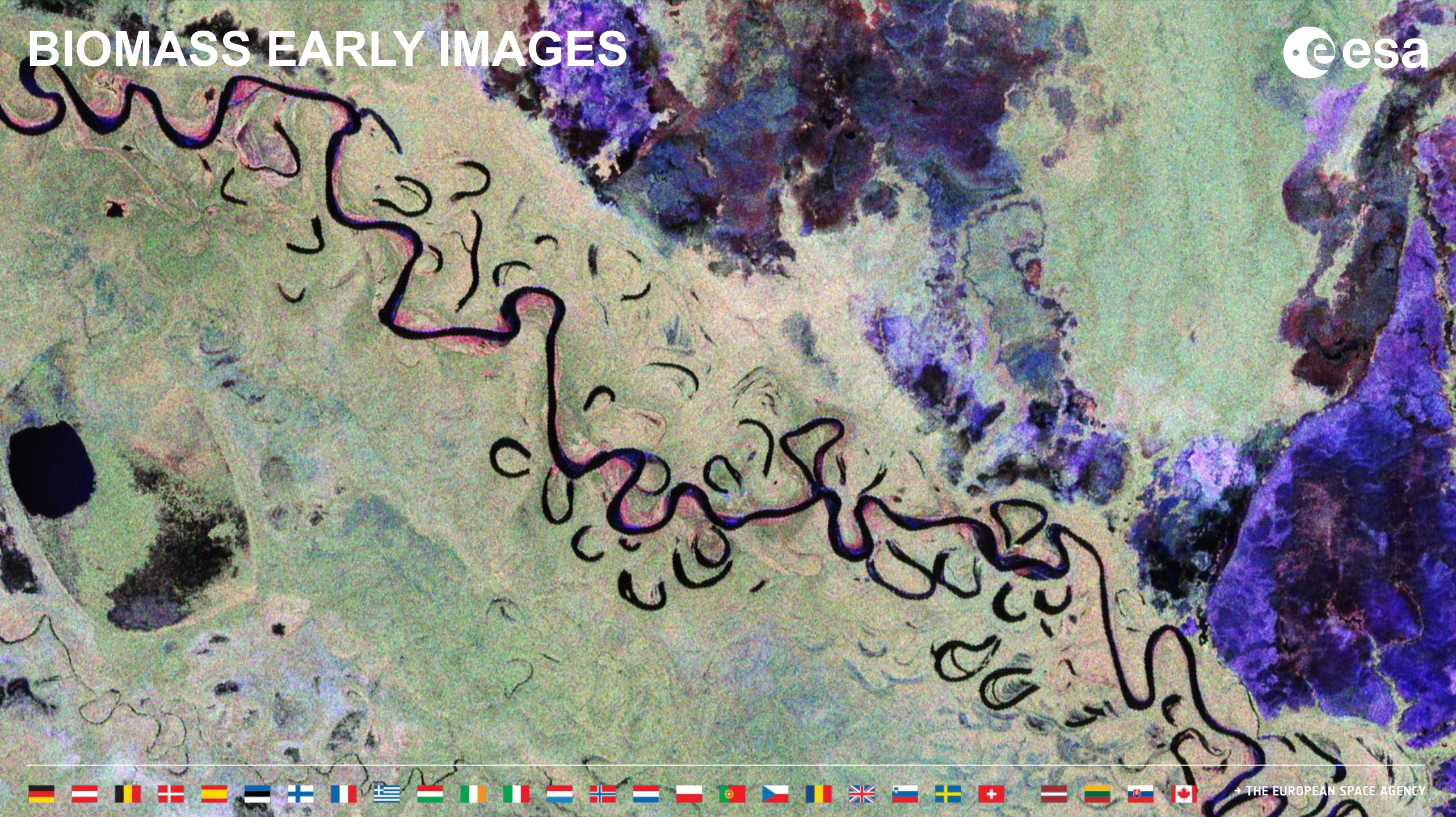
wivern

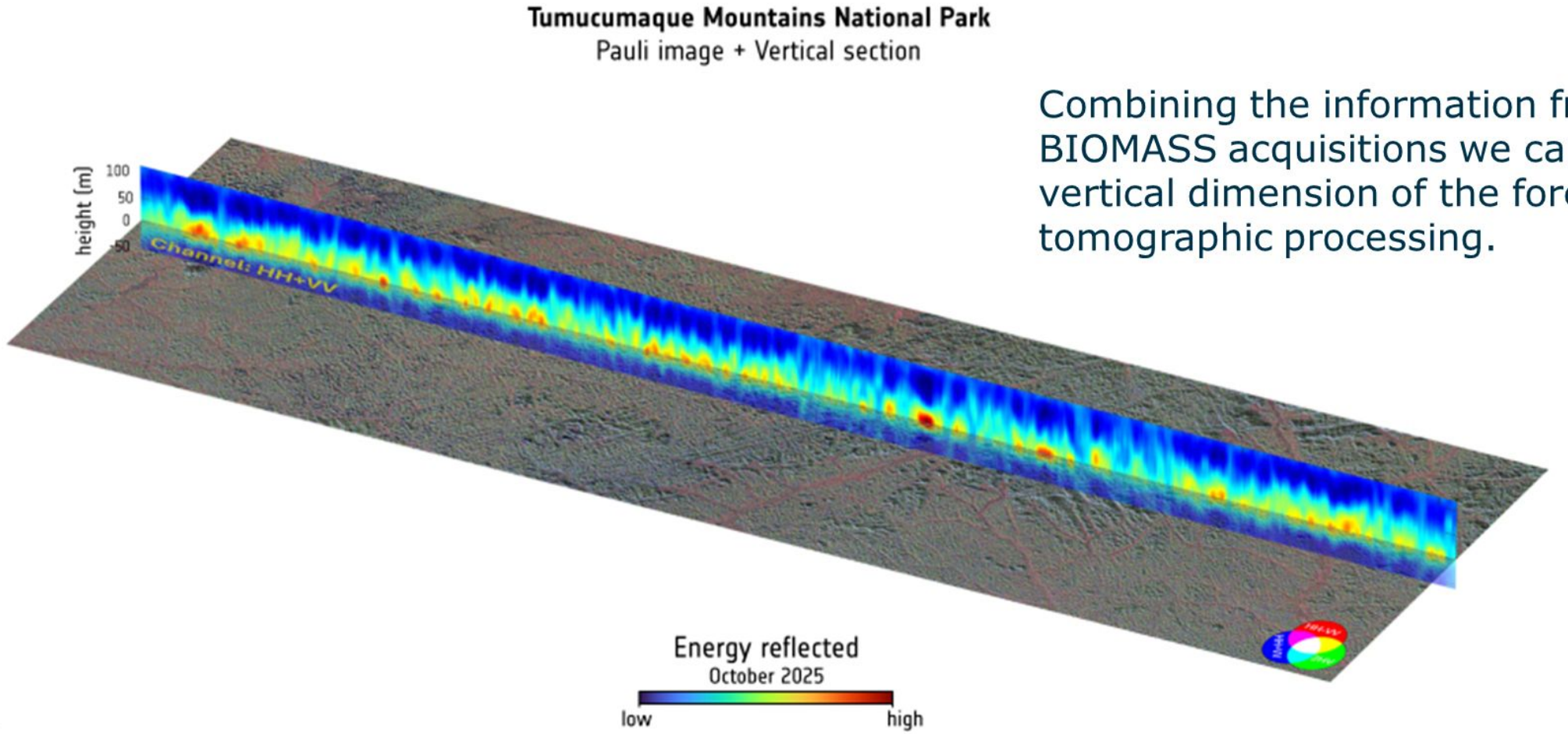
EE12

Biomass Observing the World's Forests

- Launched 29 April 2025
- Novel P-band SAR

BIOMASS EARLY IMAGES





Combining the information from several BIOMASS acquisitions we can resolve the vertical dimension of the forest using SAR tomographic processing.

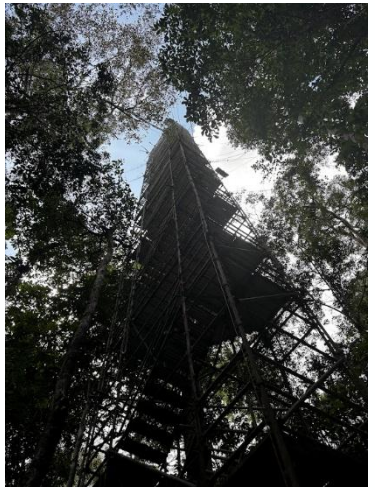
The image above shows a tomographic transact through the scene. The colours show the energy reflected per vertical layer. Red is high energy; blue is low energy.

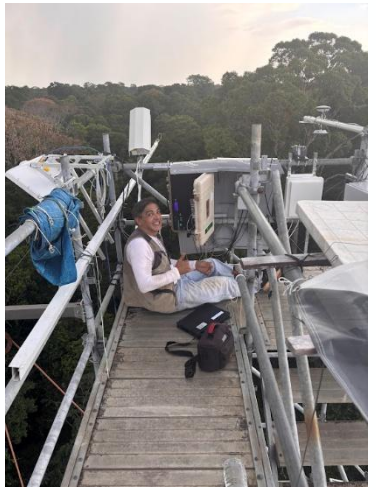
Observations for GHG inventories and reporting

Improving emissions factors: ESA/INPE/UFOPA airborne campaign

The Amazon is a potential near-future tipping point of terrestrial carbon emissions. Despite this, significant uncertainty remains regarding the region's current and projected GHG emissions

A large-scale field experiment (Pará State, Brazil) is providing new and detailed observations to better understand the carbon dynamics (stock & fluxes) associated with different land cover types and fire





LBA KM67 flux tower in the Tapajos protected forest (left to right) from the ground, the top, and from the hyperspectral system onboard the aircraft

climate.esa.int/carbonara

ESA-INPE CarbonARA Research Activity

climate.esa.int/CarbonARA/

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ESA RECCAP-2

Amazon Rainforest experiment
ESA/INPE/UFOPA

Questions

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