



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

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→ THE EUROPEAN SPACE AGENCY



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

Satellites

Heritage	Operational	Developing	Preparing	Total
04	14	41	22	81

Timeline of Satellites:

- 2010:** ERS-1, ERS-2, Envisat, Proba-1, GOCE, SMOS, CryoSat, Swarm, Proba-V, MetOp-A, Meteosat 10 (MSG).
- 2015:** MetOp-B, Sentinel-1A, Sentinel-2A, Sentinel-3A, Sentinel-5P, Sentinel-1B, Sentinel-2B, Sentinel-3B, Sentinel-1C, Sentinel-2C, Sentinel-3C, Sentinel-6 Michael Freilich, MTG-I1, Sentinel-4A MTG-S1, CO2M-A, CO2M-B, CO2M-C, Sentinel-2D, Sentinel-3D, Sentinel-6B, Sentinel-2E, Sentinel-3E, Sentinel-4B MTG-S2, CRISTAL-A, CRISTAL-B, CIMR-A, CIMR-B, ROSE-L-A, ROSE-L-B, CHIME-A, CHIME-B, LSTM-A, LSTM-B, FLEX, ALTUS, FORUM, Harmony, TRUTHS, MAGIC, Earth Explorer-11.
- 2020:** MetOp-C, Sentinel-1D, Sentinel-2F, Sentinel-3F, Sentinel-4C MTG-S3, Sentinel-5B MetOp-SG-A2, Sentinel-6C, Sentinel-7, Sentinel-8, Sentinel-9, Sentinel-10, Sentinel-11, Sentinel-12, Sentinel-13, Sentinel-14, Sentinel-15, Sentinel-16, Sentinel-17, Sentinel-18, Sentinel-19, Sentinel-20, Sentinel-21, Sentinel-22, Sentinel-23, Sentinel-24, Sentinel-25, Sentinel-26, Sentinel-27, Sentinel-28, Sentinel-29, Sentinel-30, Sentinel-31, Sentinel-32, Sentinel-33, Sentinel-34, Sentinel-35, Sentinel-36, Sentinel-37, Sentinel-38, Sentinel-39, Sentinel-40, Sentinel-41, Sentinel-42, Sentinel-43, Sentinel-44, Sentinel-45, Sentinel-46, Sentinel-47, Sentinel-48, Sentinel-49, Sentinel-50, Sentinel-51, Sentinel-52, Sentinel-53, Sentinel-54, Sentinel-55, Sentinel-56, Sentinel-57, Sentinel-58, Sentinel-59, Sentinel-60, Sentinel-61, Sentinel-62, Sentinel-63, Sentinel-64, Sentinel-65, Sentinel-66, Sentinel-67, Sentinel-68, Sentinel-69, Sentinel-70, Sentinel-71, Sentinel-72, Sentinel-73, Sentinel-74, Sentinel-75, Sentinel-76, Sentinel-77, Sentinel-78, Sentinel-79, Sentinel-80, Sentinel-81.
- 2025:** Sentinel-1E, Sentinel-2G, Sentinel-3G, Sentinel-4D MTG-S4, Sentinel-5C MetOp-SG-B1, Sentinel-6D, Sentinel-7A, Sentinel-8A, Sentinel-9A, Sentinel-10A, Sentinel-11A, Sentinel-12A, Sentinel-13A, Sentinel-14A, Sentinel-15A, Sentinel-16A, Sentinel-17A, Sentinel-18A, Sentinel-19A, Sentinel-20A, Sentinel-21A, Sentinel-22A, Sentinel-23A, Sentinel-24A, Sentinel-25A, Sentinel-26A, Sentinel-27A, Sentinel-28A, Sentinel-29A, Sentinel-30A, Sentinel-31A, Sentinel-32A, Sentinel-33A, Sentinel-34A, Sentinel-35A, Sentinel-36A, Sentinel-37A, Sentinel-38A, Sentinel-39A, Sentinel-40A, Sentinel-41A, Sentinel-42A, Sentinel-43A, Sentinel-44A, Sentinel-45A, Sentinel-46A, Sentinel-47A, Sentinel-48A, Sentinel-49A, Sentinel-50A, Sentinel-51A, Sentinel-52A, Sentinel-53A, Sentinel-54A, Sentinel-55A, Sentinel-56A, Sentinel-57A, Sentinel-58A, Sentinel-59A, Sentinel-60A, Sentinel-61A, Sentinel-62A, Sentinel-63A, Sentinel-64A, Sentinel-65A, Sentinel-66A, Sentinel-67A, Sentinel-68A, Sentinel-69A, Sentinel-70A, Sentinel-71A, Sentinel-72A, Sentinel-73A, Sentinel-74A, Sentinel-75A, Sentinel-76A, Sentinel-77A, Sentinel-78A, Sentinel-79A, Sentinel-80A, Sentinel-81A.
- 2030:** Sentinel-1F, Sentinel-2H, Sentinel-3H, Sentinel-4E MTG-S5, Sentinel-5D MetOp-SG-B2, Sentinel-6E, Sentinel-7B, Sentinel-8B, Sentinel-9B, Sentinel-10B, Sentinel-11B, Sentinel-12B, Sentinel-13B, Sentinel-14B, Sentinel-15B, Sentinel-16B, Sentinel-17B, Sentinel-18B, Sentinel-19B, Sentinel-20B, Sentinel-21B, Sentinel-22B, Sentinel-23B, Sentinel-24B, Sentinel-25B, Sentinel-26B, Sentinel-27B, Sentinel-28B, Sentinel-29B, Sentinel-30B, Sentinel-31B, Sentinel-32B, Sentinel-33B, Sentinel-34B, Sentinel-35B, Sentinel-36B, Sentinel-37B, Sentinel-38B, Sentinel-39B, Sentinel-40B, Sentinel-41B, Sentinel-42B, Sentinel-43B, Sentinel-44B, Sentinel-45B, Sentinel-46B, Sentinel-47B, Sentinel-48B, Sentinel-49B, Sentinel-50B, Sentinel-51B, Sentinel-52B, Sentinel-53B, Sentinel-54B, Sentinel-55B, Sentinel-56B, Sentinel-57B, Sentinel-58B, Sentinel-59B, Sentinel-60B, Sentinel-61B, Sentinel-62B, Sentinel-63B, Sentinel-64B, Sentinel-65B, Sentinel-66B, Sentinel-67B, Sentinel-68B, Sentinel-69B, Sentinel-70B, Sentinel-71B, Sentinel-72B, Sentinel-73B, Sentinel-74B, Sentinel-75B, Sentinel-76B, Sentinel-77B, Sentinel-78B, Sentinel-79B, Sentinel-80B, Sentinel-81B.

Sentinel Next Generation Missions: Sentinel-1, Sentinel-2, Sentinel-3, Sentinel-6

Satellites

Heritage	04
Operational	14
Developing	41
Preparing	22
Total	81



European Union



Earth Observation Activities at **ESRIN** **ESTEC** **ECSA** T



ESTEC



Satellite Design
& Development

Missions
Management



ESRIN

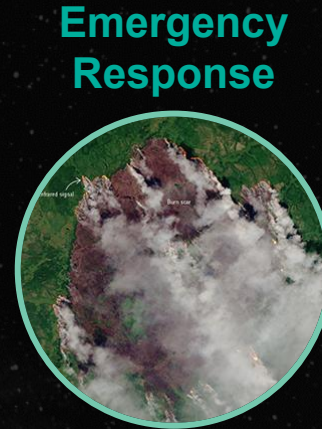


Cal/Val & Data
Distribution

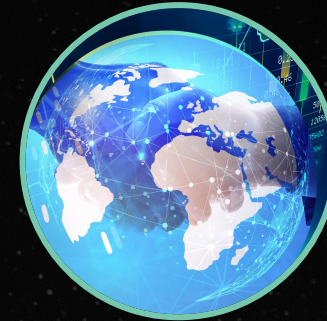
Applying the data for Earth Action



Earth
System
Science



Emergency
Response



Digital
Twins



Climate Change

Innovation

Commercialisation

**Future systems &
Instruments
activities**

Accelerate the future
of EO with cutting
edge research

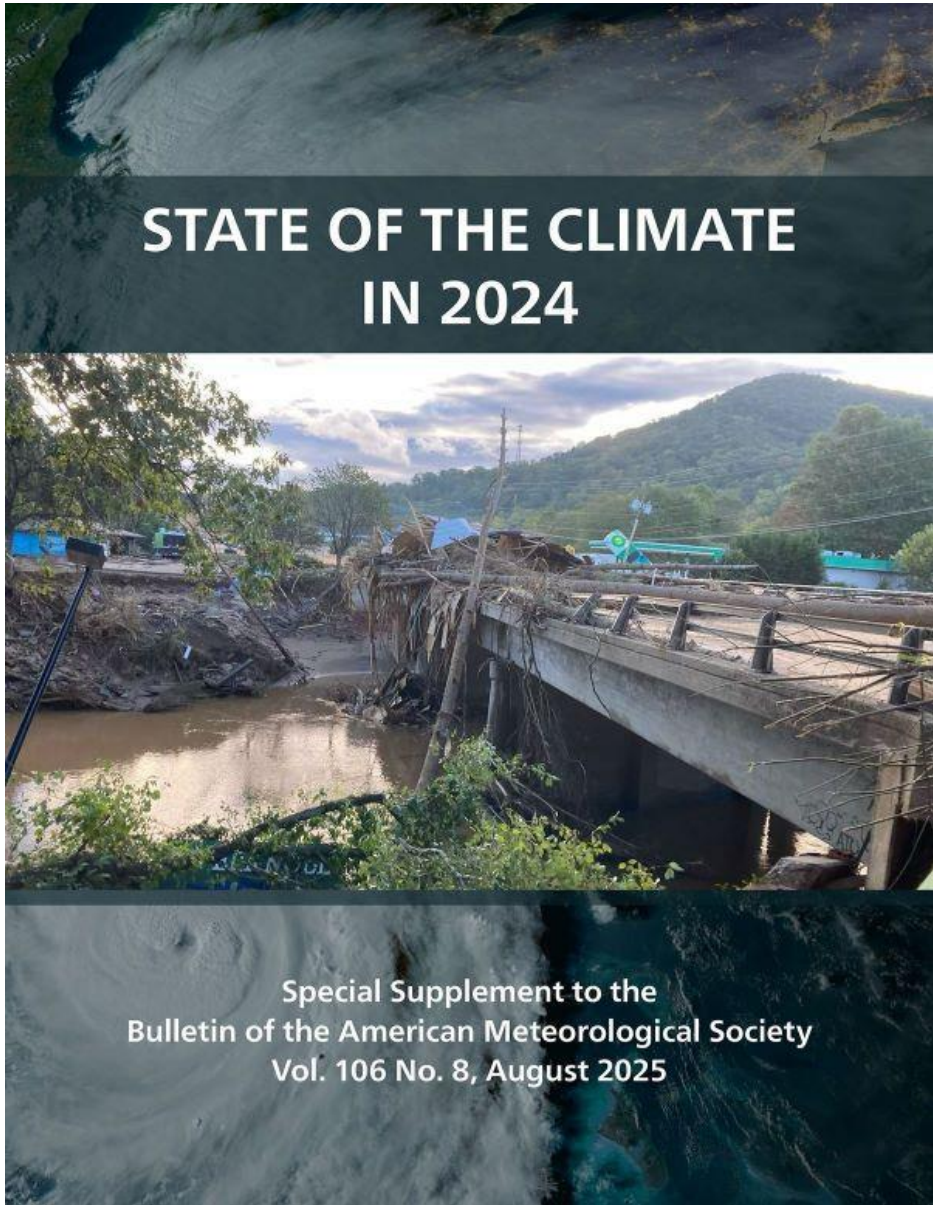
Φ-lab

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

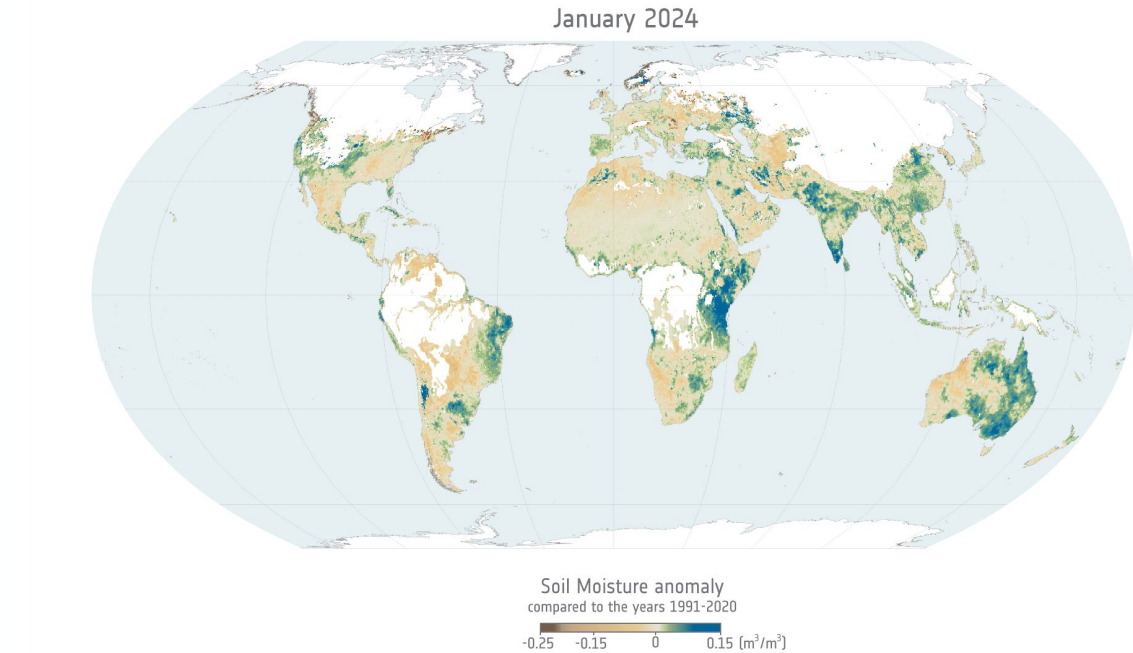
InCubed







State of the Climate - American Meteorological Society



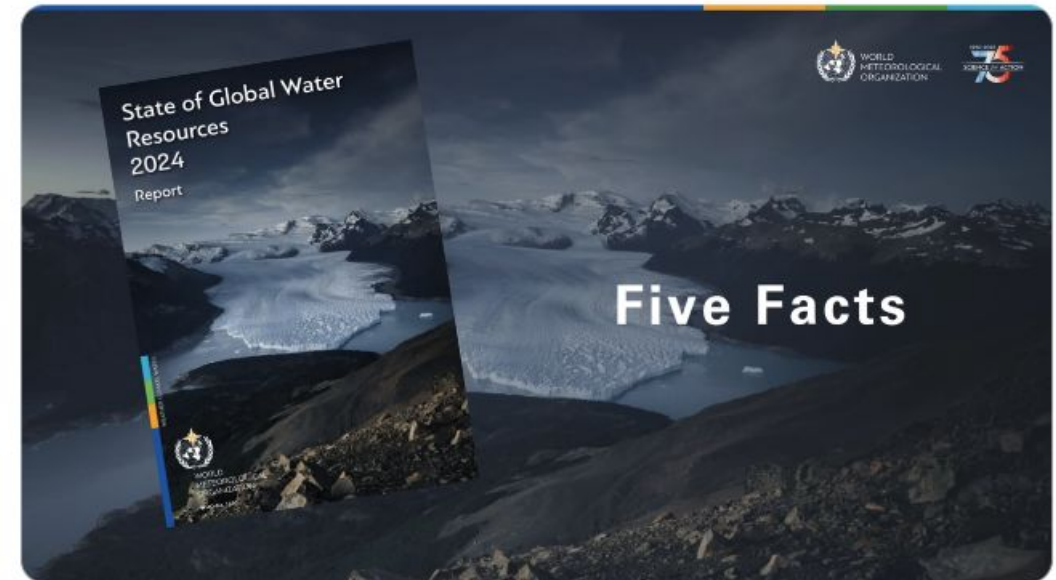
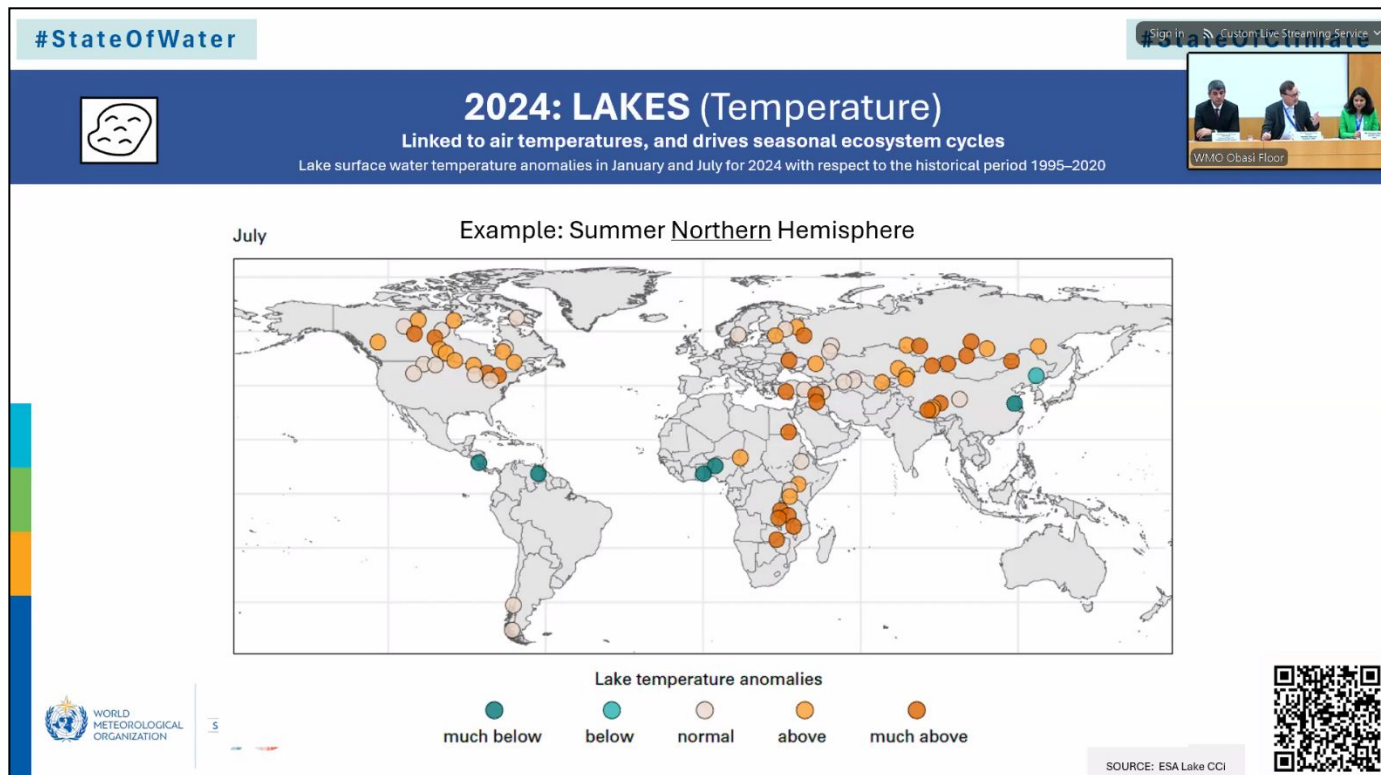
ESA's CCI provides critical satellite evidence to support the findings in the BAMS 2024 report. Insights include 'super-extreme hotspots' with land surface temperatures exceeding 50–60 °C, the highest recorded global lake surface temperature anomalies (with over half of observed lakes above +0.5 °C versus 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

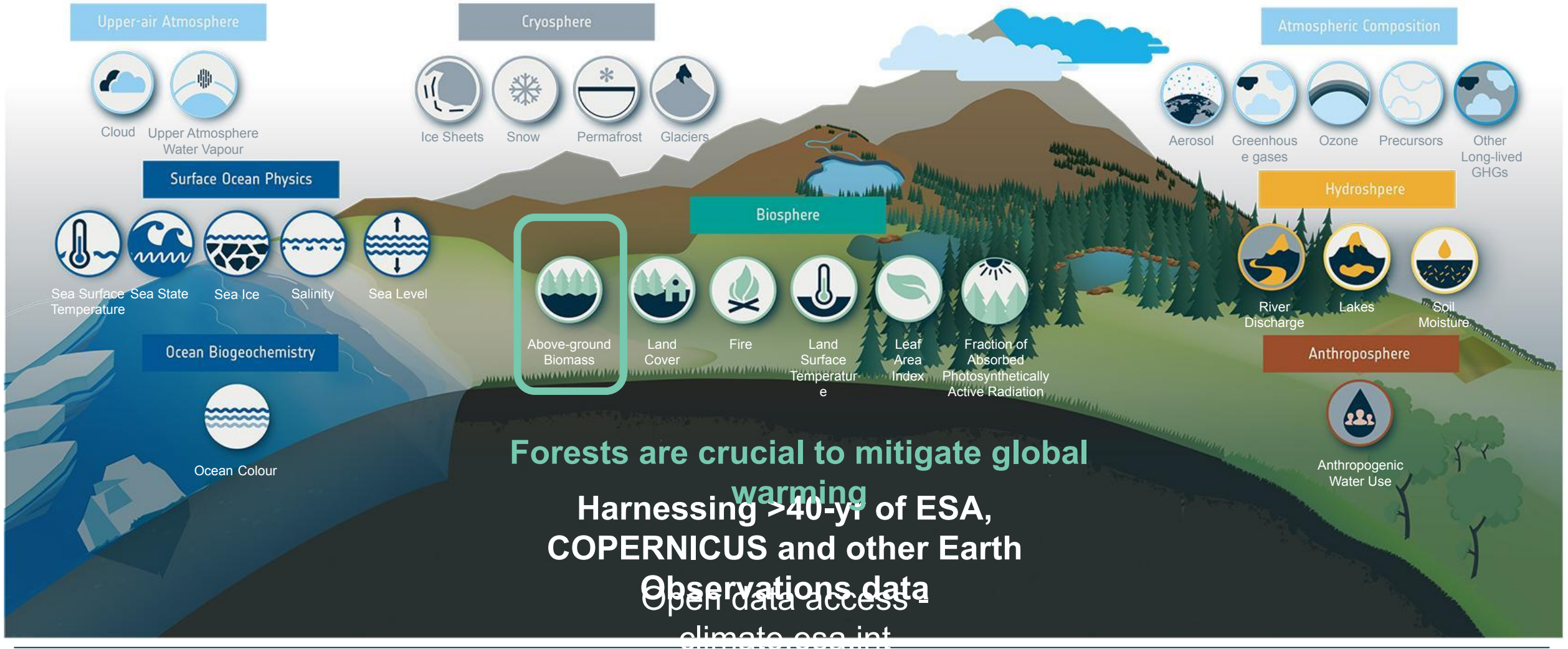


https://www.youtube.com/watch?v=IFvrvw6_73Dc&embeds_referring_e_uri=https%3A%2F%2Fclimate.esa.int%2F&source_ve_path=OTY3MTQ

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



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)

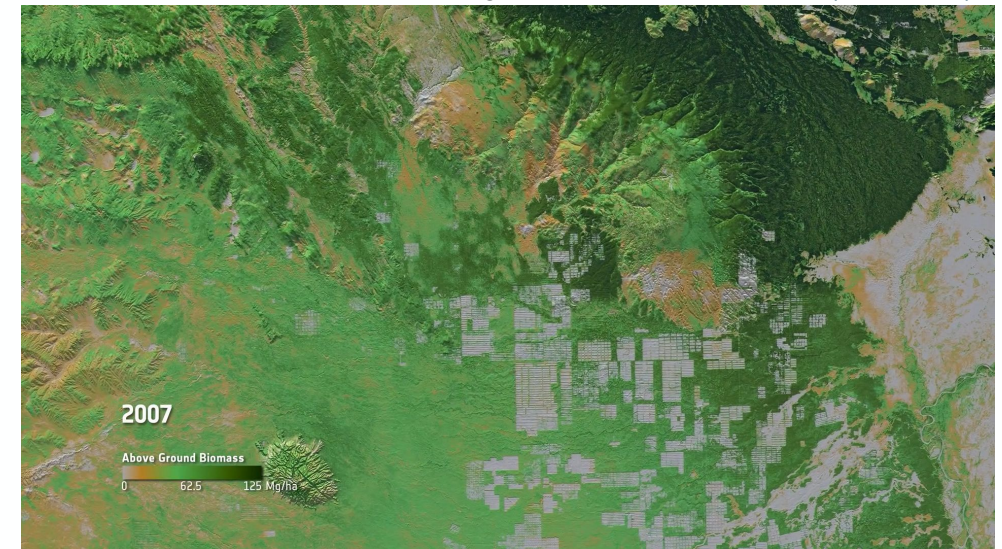
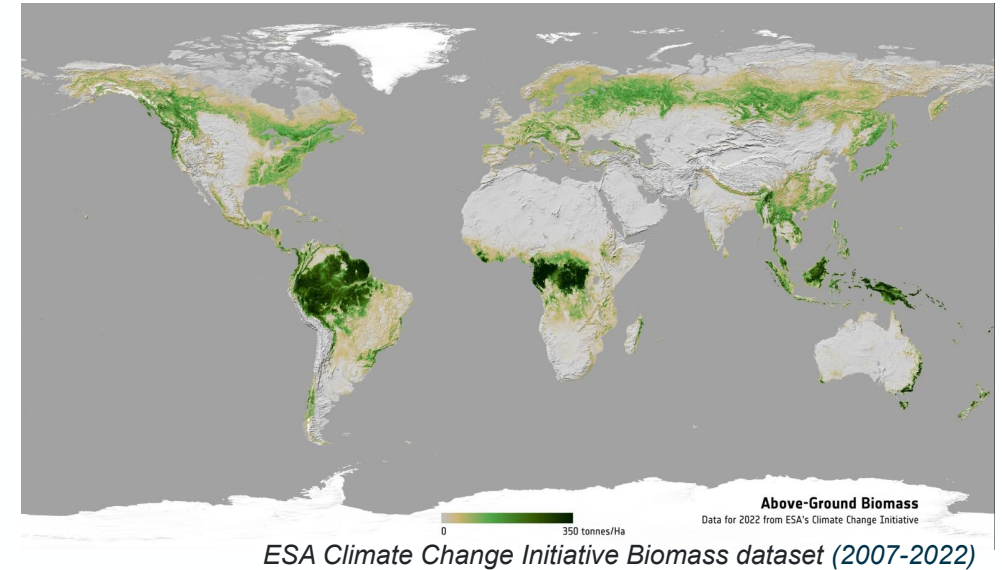
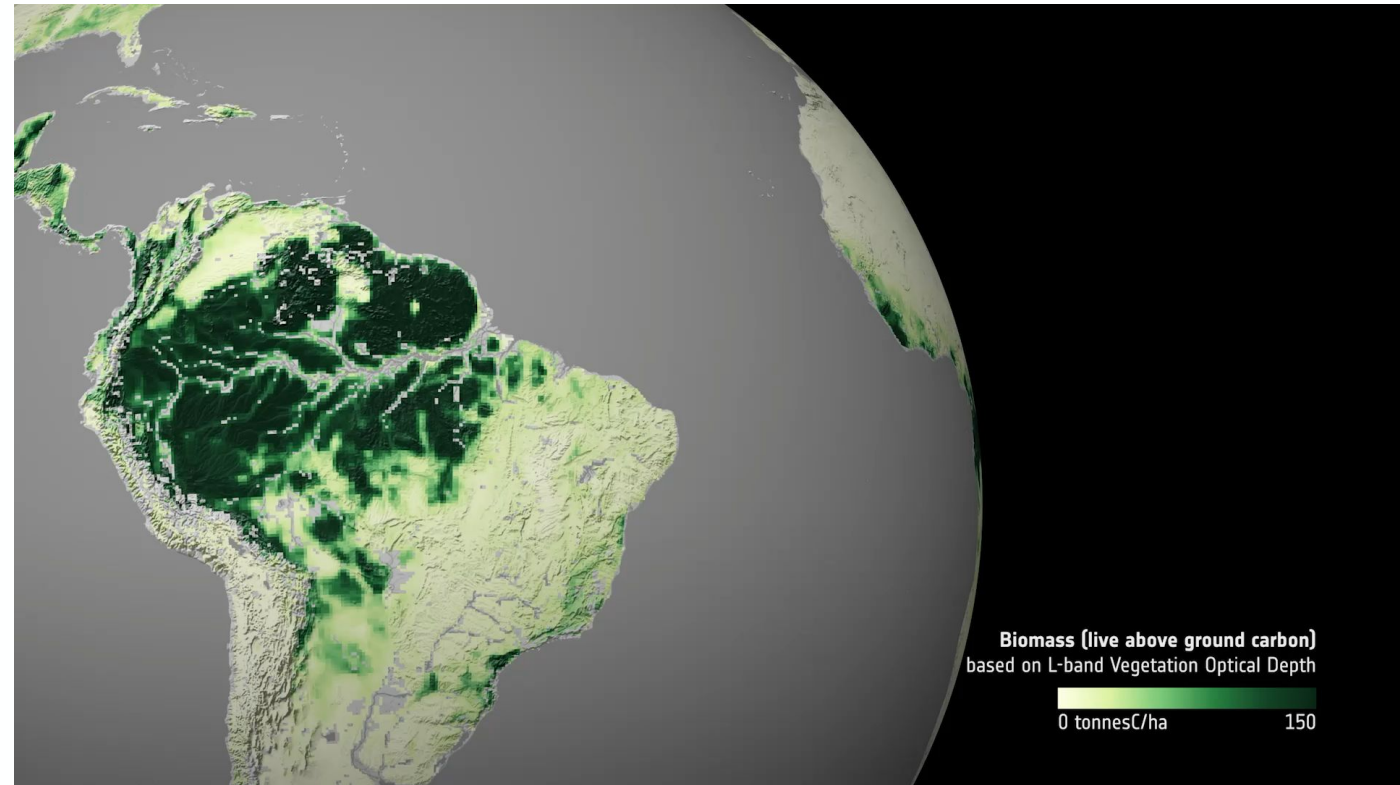


Illustration of above ground biomass change (ESA CCI (2007-2022)) ⁸

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

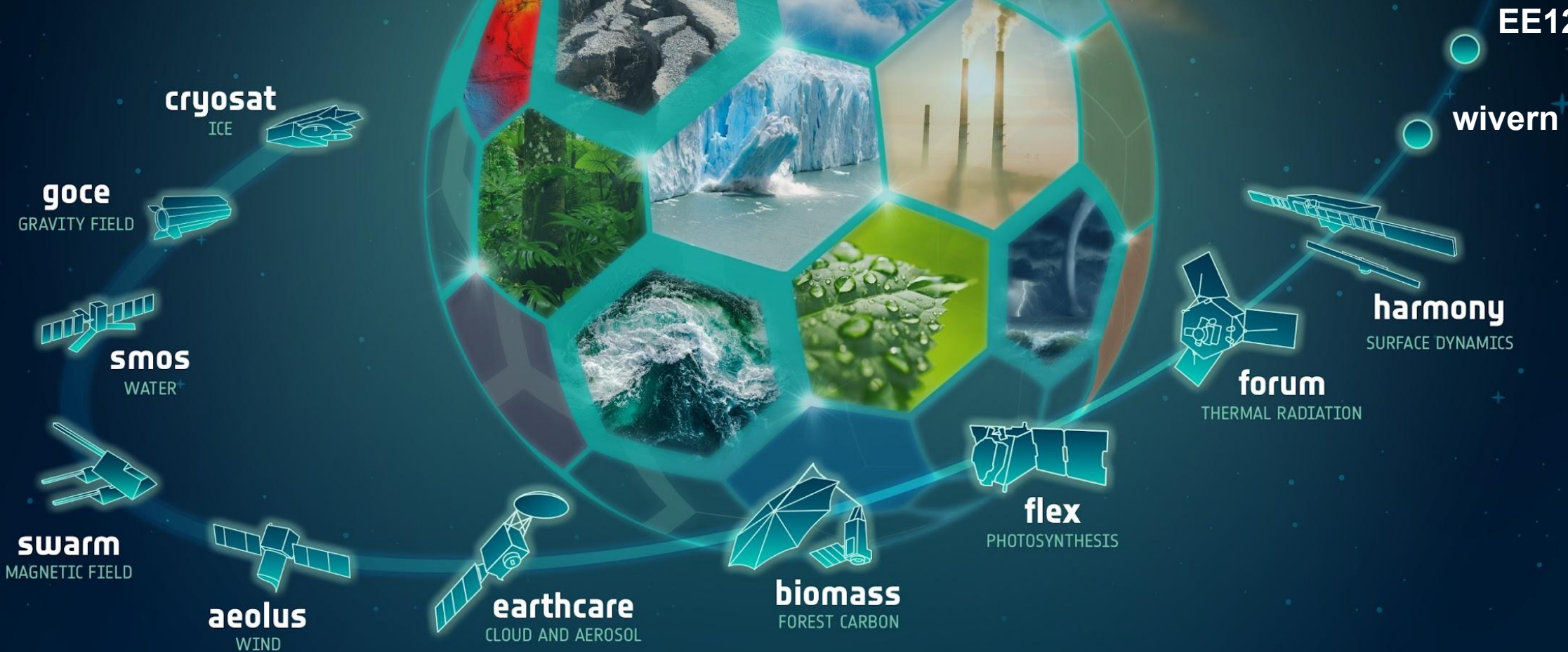
Amazon

- 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



Earth Explorers

Pioneering Scientific and Technical Excellence



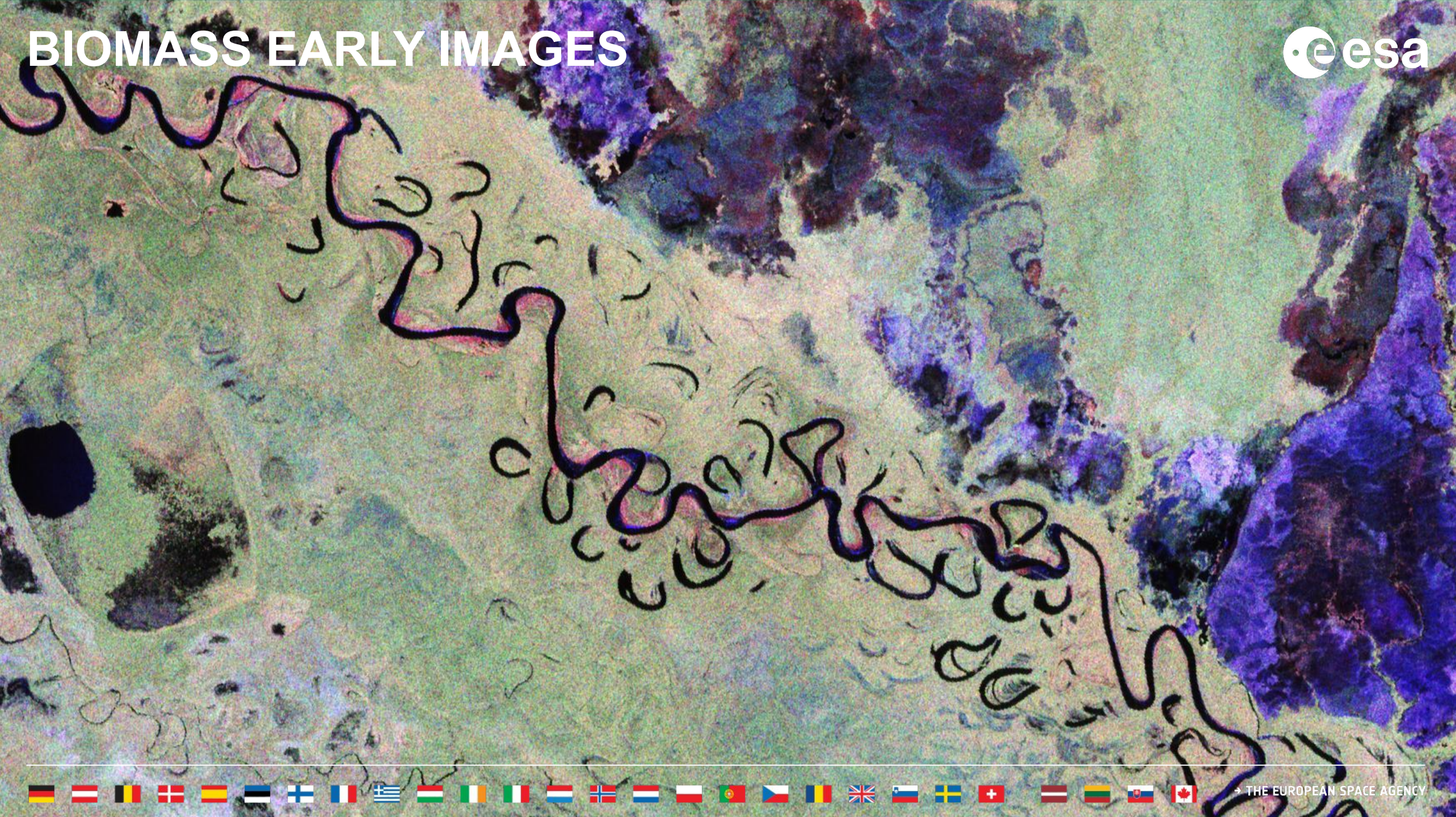
Biomass Observing the World's Forests



- Launched 29 April 2025
- Novel P-band SAR

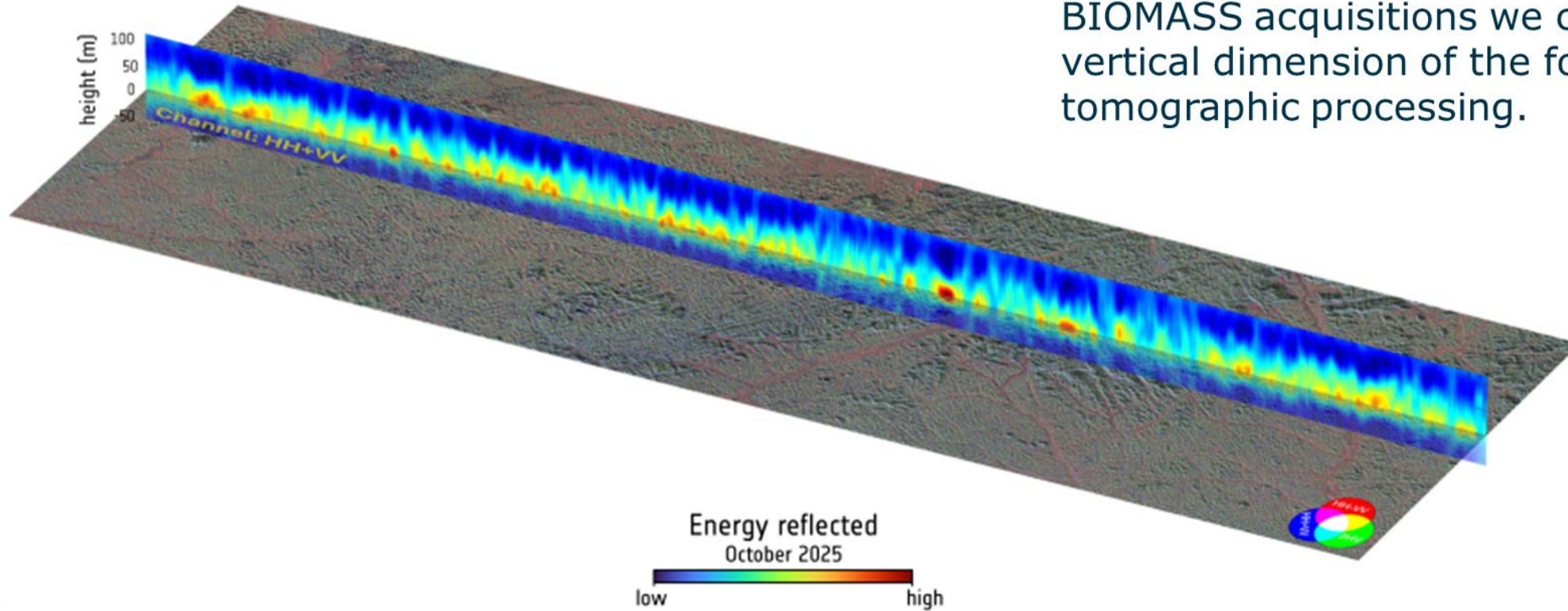


BIOMASS EARLY IMAGES



Tumucumaque Mountains National Park Pauli image + Vertical section

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 transect 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



Pleased to report that the Brazilian Air Force team are extremely happy with what they have seen over the past day or so. Their feedback was very positive - they wish us all the best with the campaign.

We are 'cleared to fly' 👍

18:38



Excellent work everyone 👍

18:38



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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