

ESA Climate Change Initiative

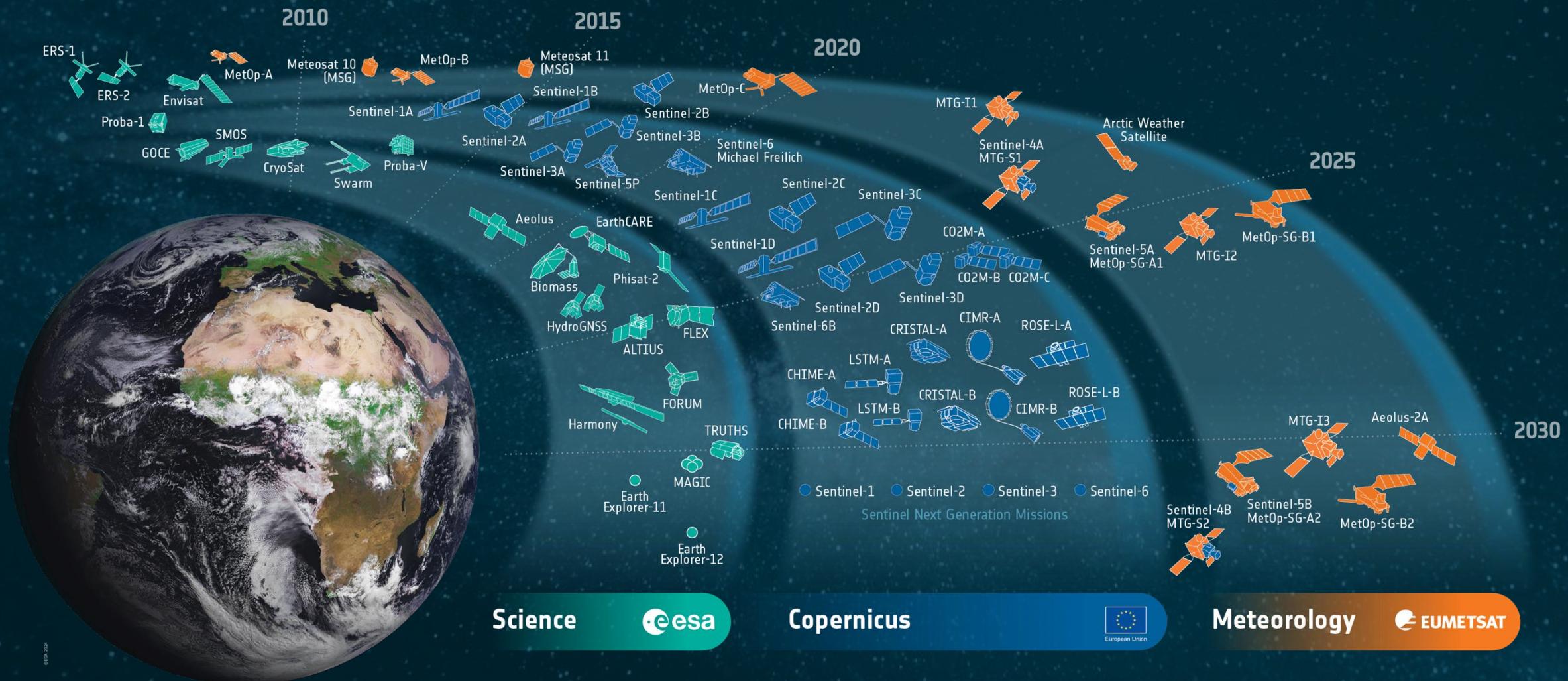
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Harwell, UK

LOLIPOP, 18 Nov 2025

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→ THE EUROPEAN SPACE AGENCY



ESA Earth Watch programme element first funded at the 2008 Ministerial Council

Objective:

“To realize the full potential of the long-term global Earth Observation archives that ESA together with its Member States have established over the last thirty years, as a significant and timely contribution to the Essential Climate Variable (ECV) databases required by United Nations Framework Convention on Climate Change (UNFCCC).”

- ➔ *Development of multi-decadal multi-satellite global Climate Data Records to support climate science (according to requirements for ECVs collected by the UN’s GCOS).*
- ➔ *Transfer mature ECVs to sustained production in an operational environment (e.g. C3S, Eumetsat SAF, ...)*

Essential Climate Variables (ECVs)



GCOS



GCOS defined 55 Essential Climate Variables:

- A physical, chemical or biological variable that critically contributes to the characterization of Earth's climate (gcos.wmo.int)
- ... provides the empirical evidence needed to understand and predict the evolution of climate, to guide mitigation and adaptation measures, to assess risks and enable attribution of climate events to underlying causes, and to underpin climate services
- ... required to support the work of the UNFCCC and the IPCC
- ... observable at global scale
- ... feasible using scientifically proven methods

Essential Climate Variables

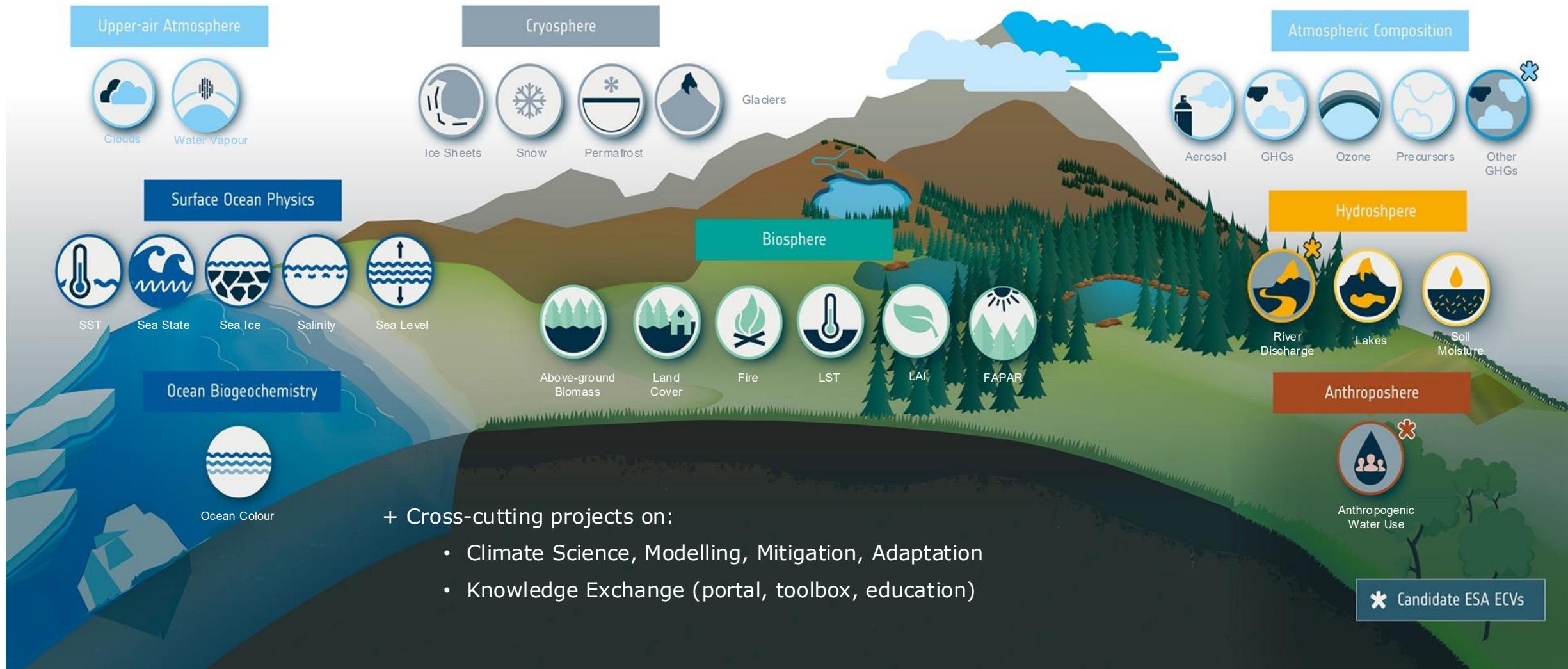
[What are Essential Climate Variables \(ECVs\)?](#)

Atmosphere	Land	Ocean
Surface	Hydrology	Physical
Precipitation	Groundwater	Ocean Surface Heat Flux
Surface Pressure	Lakes	Sea Ice
Surface Radiation Budget	River Discharge	Sea Level
Surface Temperature	Terrestrial Water Storage (TWS)	Sea State
Surface Water Vapour	Evaporation from Land	Surface Currents
Surface Wind Speed and Direction	Soil Moisture	Sea Surface Salinity
Upper-air Temperature		Surface Stress
		Sea Surface Temperature
Upper Atmosphere	Cryosphere	
Earth Radiation Budget	Glaciers	
Lightning	Ice Sheets and Ice Shelves	
Upper-air Water Vapour	Permafrost	
Upper-air Wind Speed and Direction	Snow	
		Subsurface Temperature
		Biogeochemical
	Biology	
	Above-ground Biomass	Inorganic Carbon
	Albedo	Nitrous Oxide
	Fire	Nutrients
	Fraction of Absorbed Photosynthetically Active...	Ocean Colour
	Land Cover	Oxygen
	Land Surface Temperature	Transient Tracers
	Leaf Area Index	
	Soil Carbon	
	Human Use of Natural Resources	
	Anthropogenic Greenhouse Gas Emissions	Marine Habitats
	Anthropogenic Water Use	Plankton

ESA Climate Change Initiative (CCI)



GCOS defined **55** Essential Climate Variables | **36** benefit from space observations | **27** generated by ESA Climate Change Initiative



Anatomy of a CCI ECV project

CCI projects develop and deliver global climate data records of ECVs that are observable by satellites

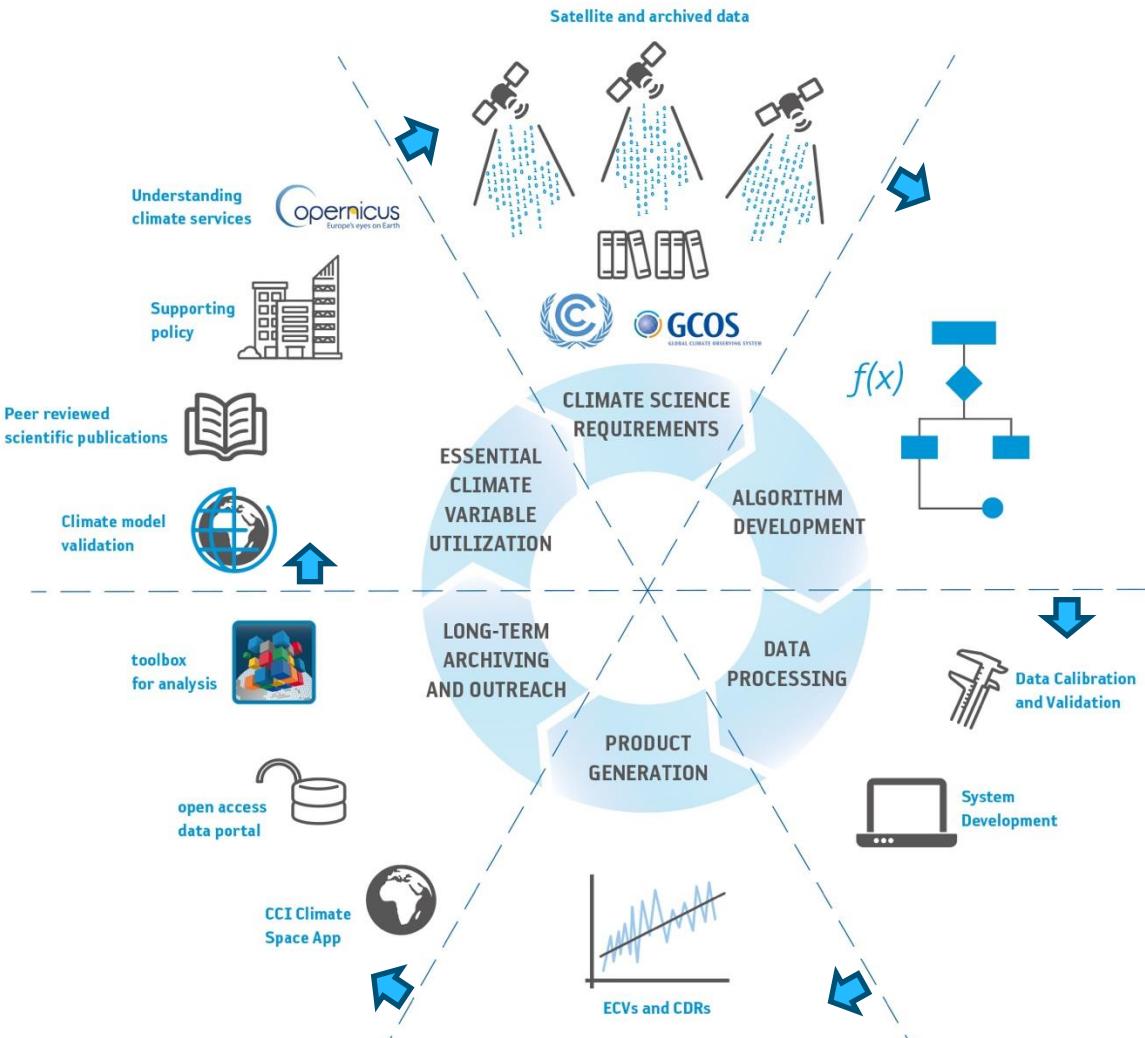
Start with ECV requirements defined by GCOS ...

- Requirements clarification
- Develop/improve retrieval algorithms
- Develop/improve processing systems
- Process global climate data records
- Validate against independent reference data
- Archive and provide open access
- Demonstrate fitness-for-purpose in climate science applications



Transfer to sustained production

(e.g. C3S, Eumetsat SAFs, national met services, ...)

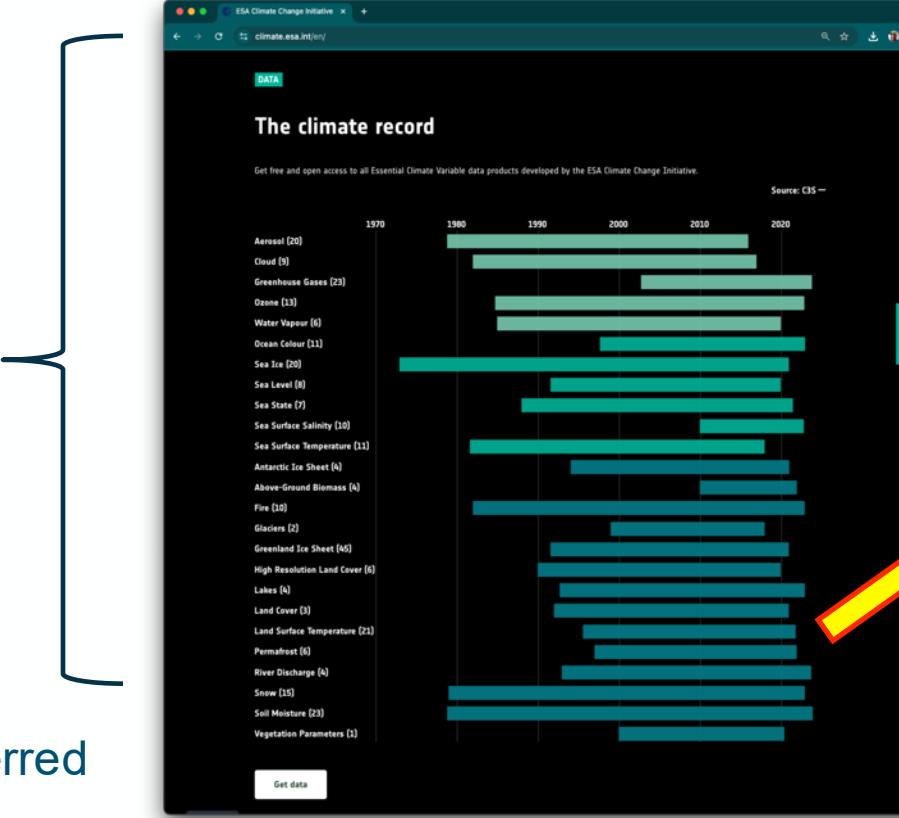


Data Access

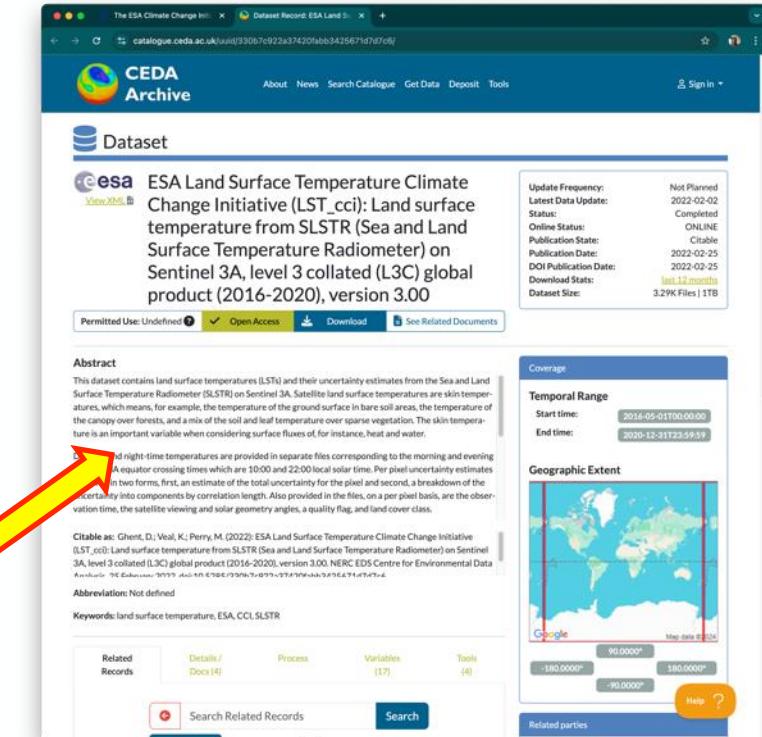


CCI ECV data sets available from climate.esa.int

Many CCI ECVs have been transferred to operational production by the Copernicus Climate Change Service: climate.copernicus.eu



CCI Web site



CCI data on CEDA archive

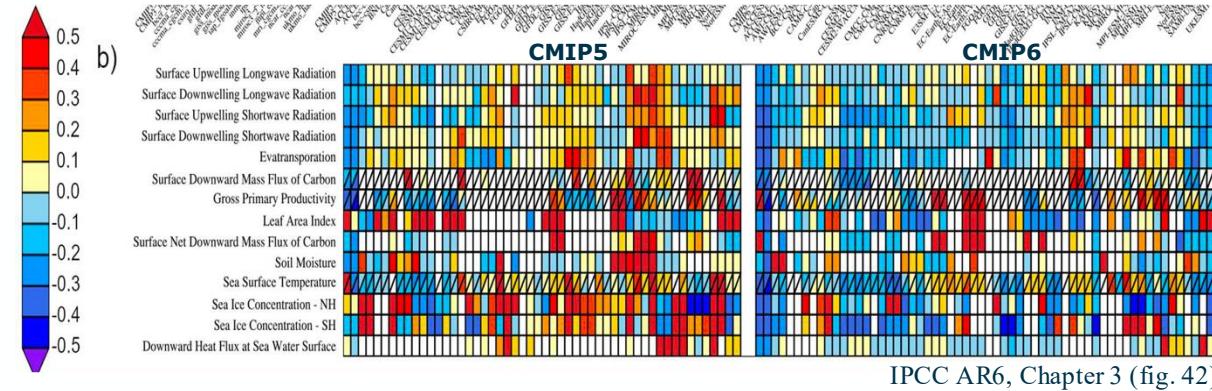


ECV Exploitation in Climate Science

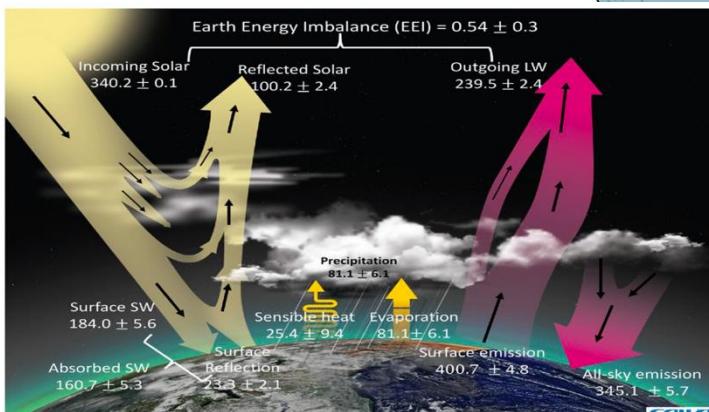
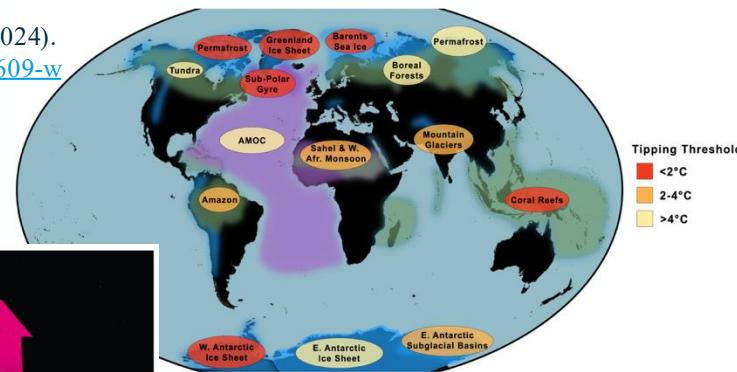


Climate Science:

- Projects demonstrating the use of CCI ECVs in climate model initialization, assimilation, reanalysis, benchmarking, calibration and parameterization (CMUG, PISCO, CAMP, COMET, ESO4Clima, PIRAMID)
- CCI hosts the WCRP's CMIP International Project Office at ESA in Harwell, UK 
- Developing CMIP7 Forcing data sets (input4MIPs) using CCI ECVs
- Climate Tipping Points (TIME, TiPSOO, CryoTipping, PREDICT, SIRENE, RESETLakes)
- Cross-ECV applications (Xfires, ArcFresh, Motecusoma, SATACI, Karakoram, GLANCE)



Lenton *et al.* (2024).
[doi: 10.1038/s41467-023-44609-w](https://doi.org/10.1038/s41467-023-44609-w)



WCRP
GEWEX

Supporting the UNFCCC Paris Agreement



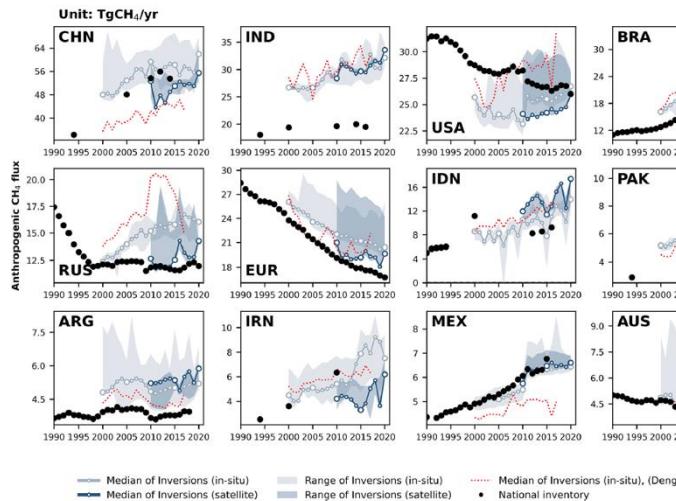
United Nations
Climate Change



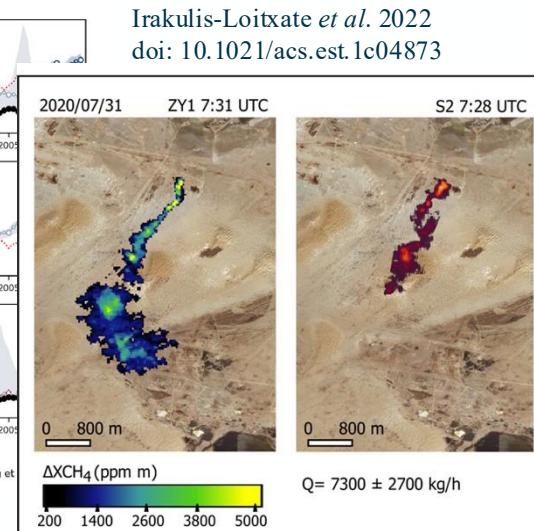
Mitigation of GHG emissions

- RECCAP – Regional carbon emissions (TD + BU)
- MEDUSA – Quality assessment of facility-scale methane emission products

Deng *et al.*, 2025, doi: 10.5194/essd-17-1121-2025

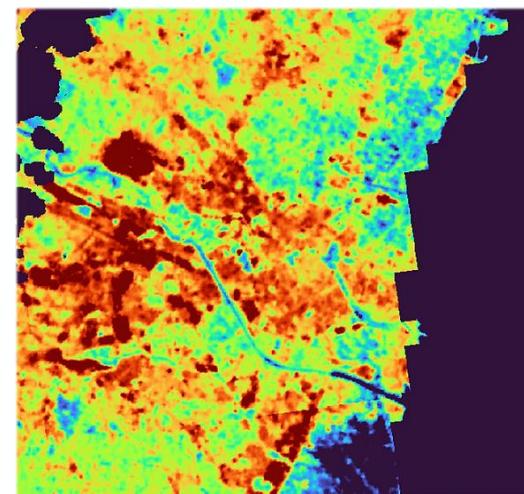


Irakulis-Loitxate *et al.* 2022
doi: 10.1021/acs.est.1c04873

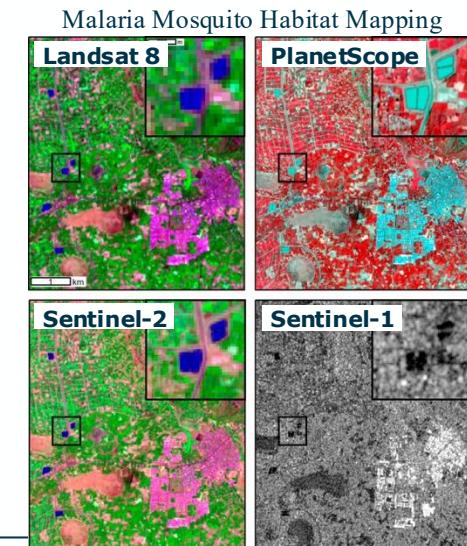


Climate Adaptation & Resilience Building

- Cities: supporting IPCC Special Report (2026)
- Health: extreme weather and infectious disease
- Biodiversity: climate regulation and ecosystem function
- Adaptation: use of satellite ECVs to inform NAPs



Urban Heat Islands, U. Valencia/CityCLIM
www.cityclim.eu



Wimberly *et al.*, 2021
doi: 10.1016/j.jpt.2021.03.003

ESA Climate Change Initiative:

- Develops and delivers global satellite-based Essential Climate Variable (ECV) data sets
- Develops and promotes the use of satellite ECVs in climate science supporting IPCC scientific assessments, the UNFCCC Paris Agreement and in climate services.

Future:

- Continuation of CCI to end 2029 is being proposed to ESA Member States in Nov 2025.

climate.esa.int

Thanks for your attention

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