

# ESA Climate Change Initiative

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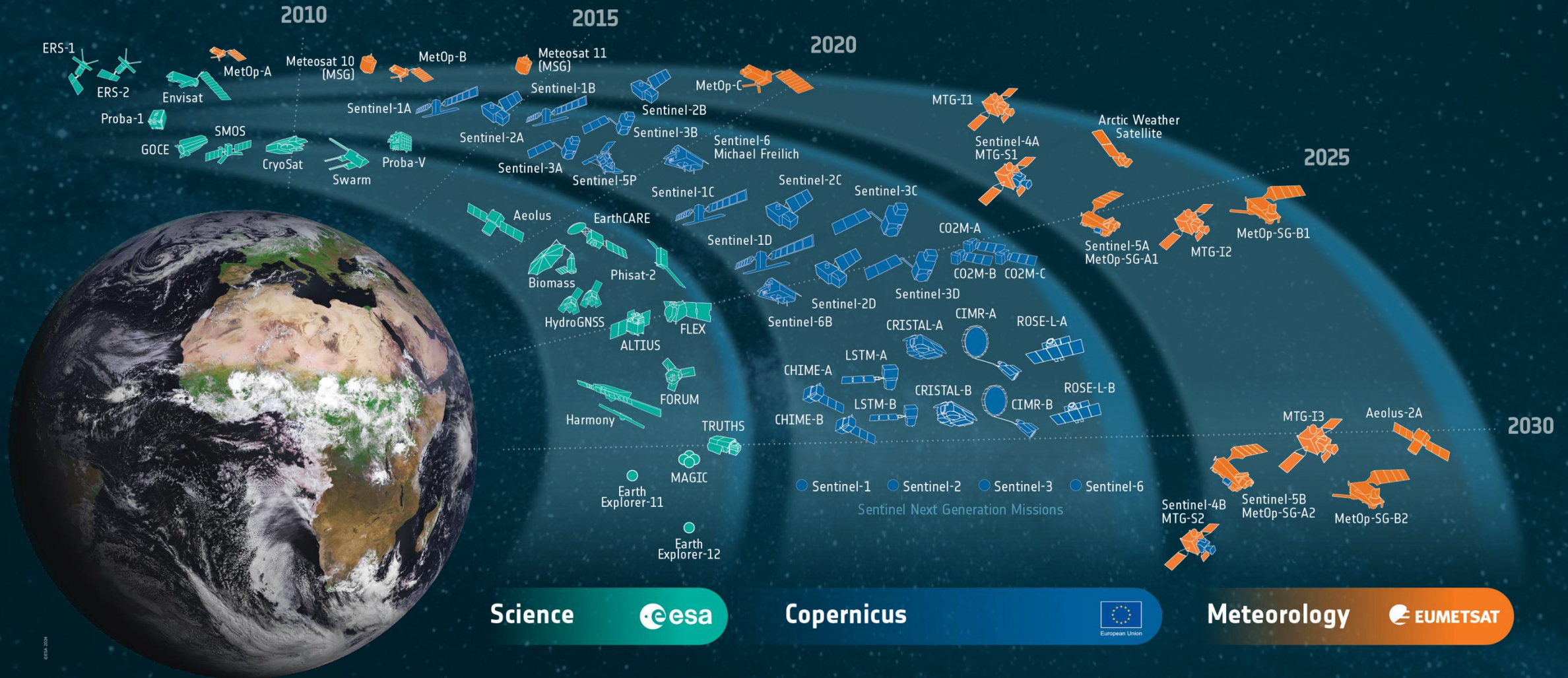
LOLIPOP, 18 Nov 2025

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→ THE EUROPEAN SPACE AGENCY

# ESA-developed Earth observation missions



Science



Copernicus



Meteorology



## Objective:

- ➔ *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 defined 55 Essential Climate Variables:

- A physical, chemical or biological variable that critically contributes to the characterization of Earth's climate ([gcos.wmo.int](https://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
<b>Surface</b> <ul style="list-style-type: none"><li>Precipitation</li><li>Surface Pressure</li><li>Surface Radiation Budget</li><li>Surface Temperature</li><li>Surface Water Vapour</li><li>Surface Wind Speed and Direction</li><li>Upper-air Temperature</li></ul> <b>Upper Atmosphere</b> <ul style="list-style-type: none"><li>Earth Radiation Budget</li><li>Lightning</li><li>Upper-air Water Vapour</li><li>Upper-air Wind Speed and Direction</li></ul> <b>Atmospheric Composition</b> <ul style="list-style-type: none"><li>Clouds</li><li>Aerosols</li><li>Carbon Dioxide, Methane &amp; Other Greenhouse Gases</li><li>Ozone</li><li>Precursors for Aerosols and Ozone</li></ul>	<b>Hydrology</b> <ul style="list-style-type: none"><li>Groundwater</li><li>Lakes</li><li>River Discharge</li><li>Terrestrial Water Storage (TWS)</li><li>Evaporation from Land</li><li>Soil Moisture</li></ul> <b>Cryosphere</b> <ul style="list-style-type: none"><li>Glaciers</li><li>Ice Sheets and Ice Shelves</li><li>Permafrost</li><li>Snow</li></ul> <b>Biology</b> <ul style="list-style-type: none"><li>Above-ground Biomass</li><li>Albedo</li><li>Fire</li><li>Fraction of Absorbed Photosynthetically Active...</li><li>Land Cover</li><li>Land Surface Temperature</li><li>Leaf Area Index</li><li>Soil Carbon</li></ul> <b>Human Use of Natural Resources</b> <ul style="list-style-type: none"><li>Anthropogenic Greenhouse Gas Emissions</li><li>Anthropogenic Water Use</li></ul>	<b>Physical</b> <ul style="list-style-type: none"><li>Ocean Surface Heat Flux</li><li>Sea Ice</li><li>Sea Level</li><li>Sea State</li><li>Surface Currents</li><li>Sea Surface Salinity</li><li>Surface Stress</li><li>Sea Surface Temperature</li><li>Subsurface Currents</li><li>Subsurface Salinity</li><li>Subsurface Temperature</li></ul> <b>Biogeochemical</b> <ul style="list-style-type: none"><li>Inorganic Carbon</li><li>Nitrous Oxide</li><li>Nutrients</li><li>Ocean Colour</li><li>Oxygen</li><li>Transient Tracers</li></ul> <b>Biological/Ecosystems</b> <ul style="list-style-type: none"><li>Marine Habitats</li><li>Plankton</li></ul>



Upper-air Atmosphere

Cryosphere

Atmospheric Composition

Surface Ocean Physics

Biosphere

Hydroshpere

Ocean Biogeochemistry

Anthroposphere

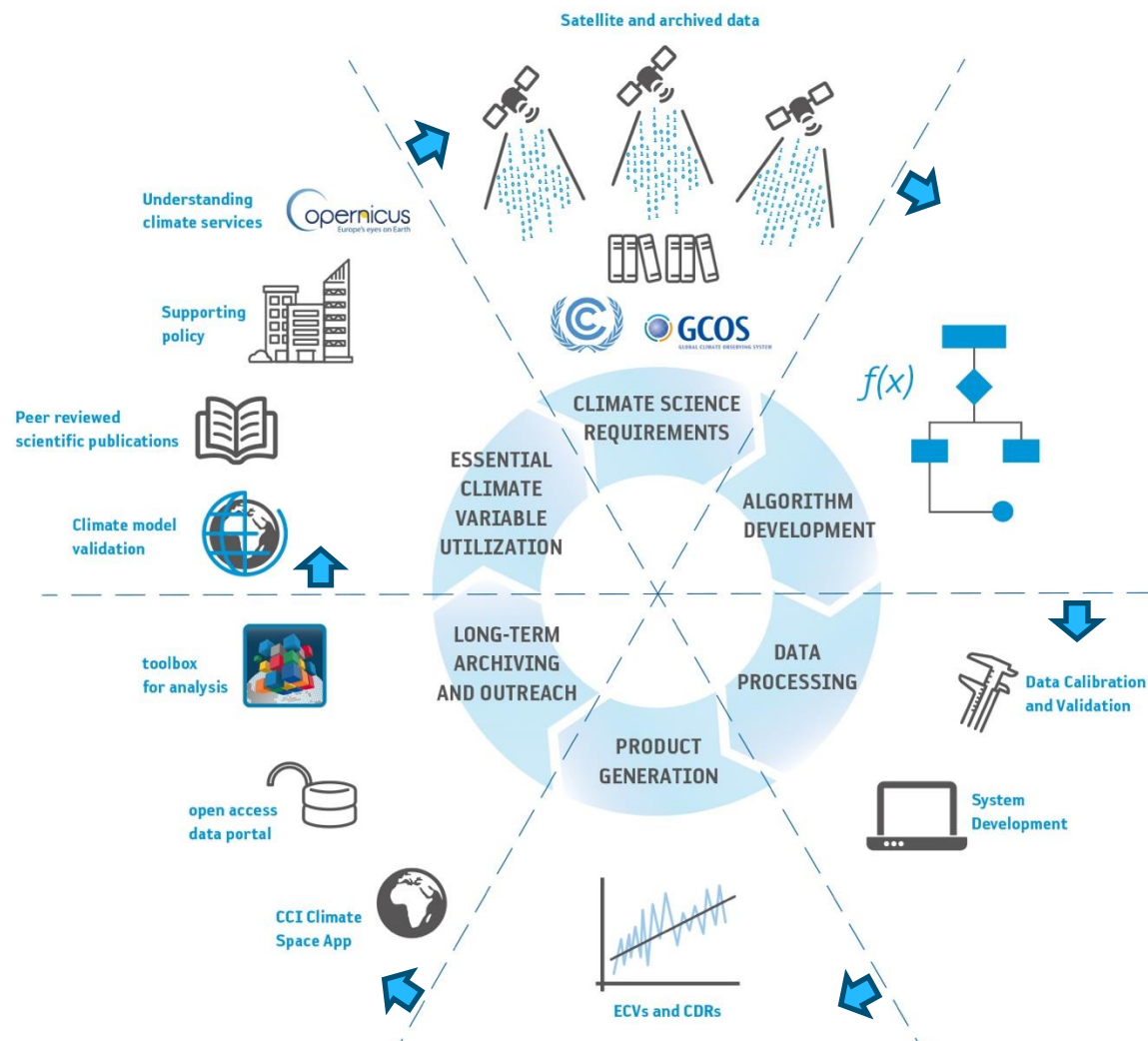
+ Cross-cutting projects on:

- Climate Science, Modelling, Mitigation, Adaptation
- Knowledge Exchange (portal, toolbox, education)

\* Candidate ESA ECVs

## 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

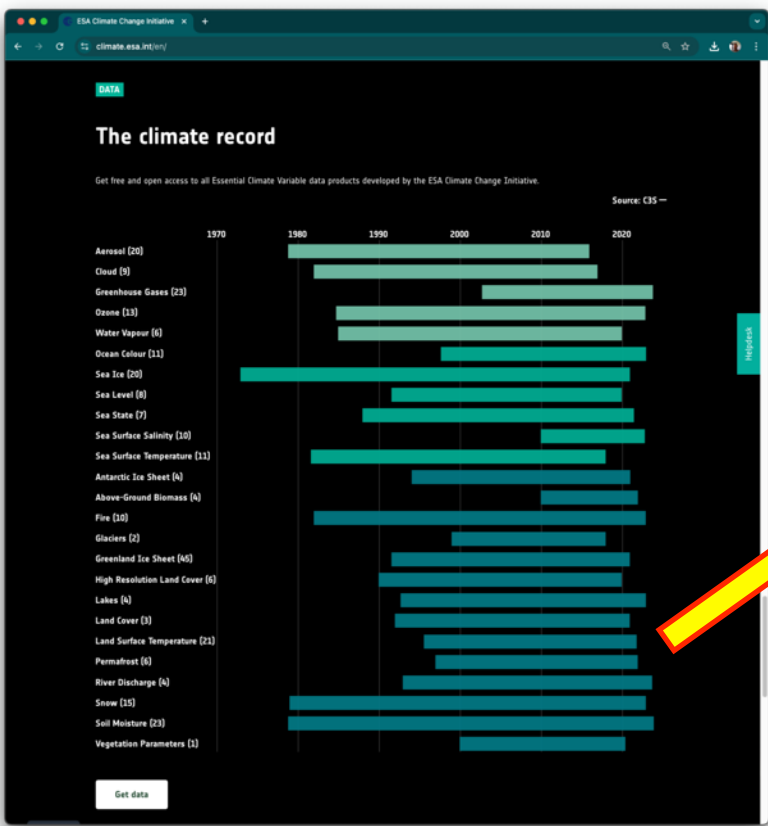


## Transfer to sustained production

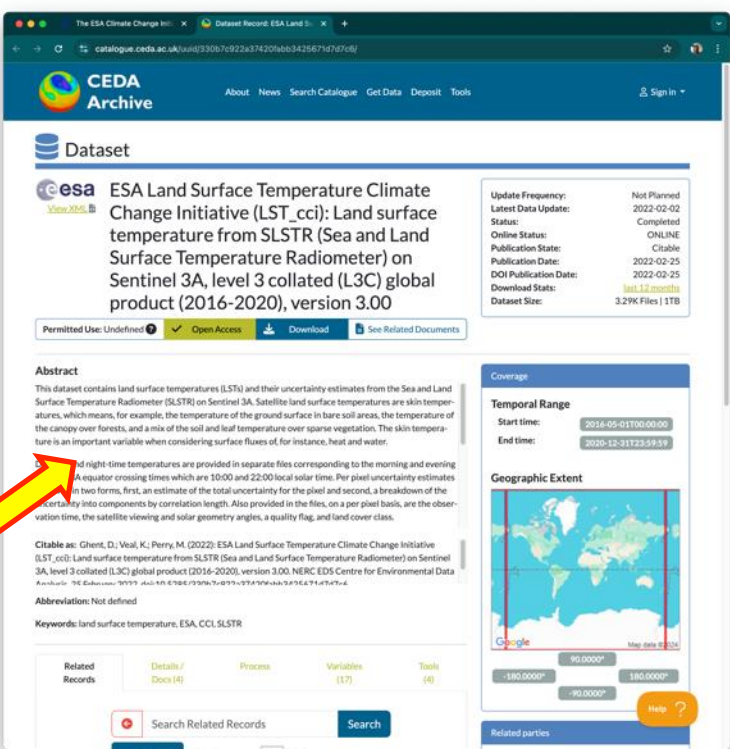
(e.g. C3S, Eumetsat SAFs, national met services, ...)

CCI ECV data sets available from [climate.esa.int](https://climate.esa.int)

Many CCI ECVs have been transferred to operational production by the Copernicus Climate Change Service: [climate.copernicus.eu](https://climate.copernicus.eu)



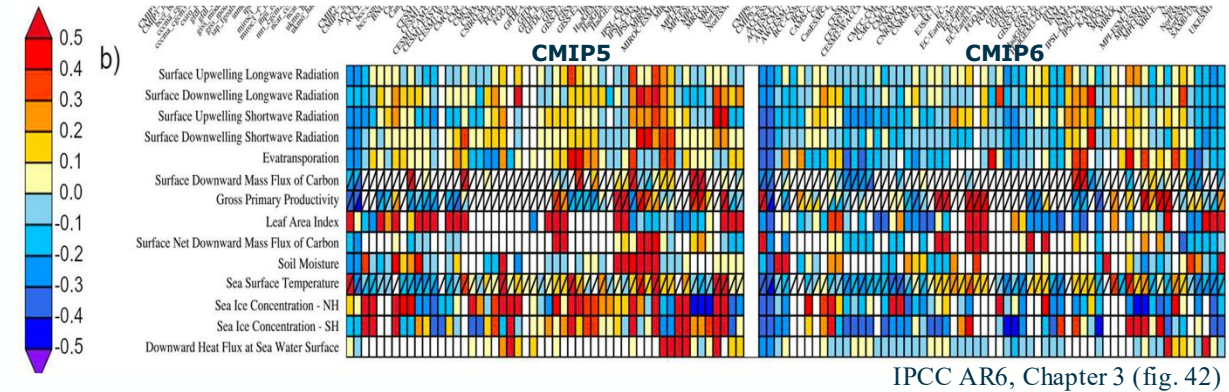
CCI Web site



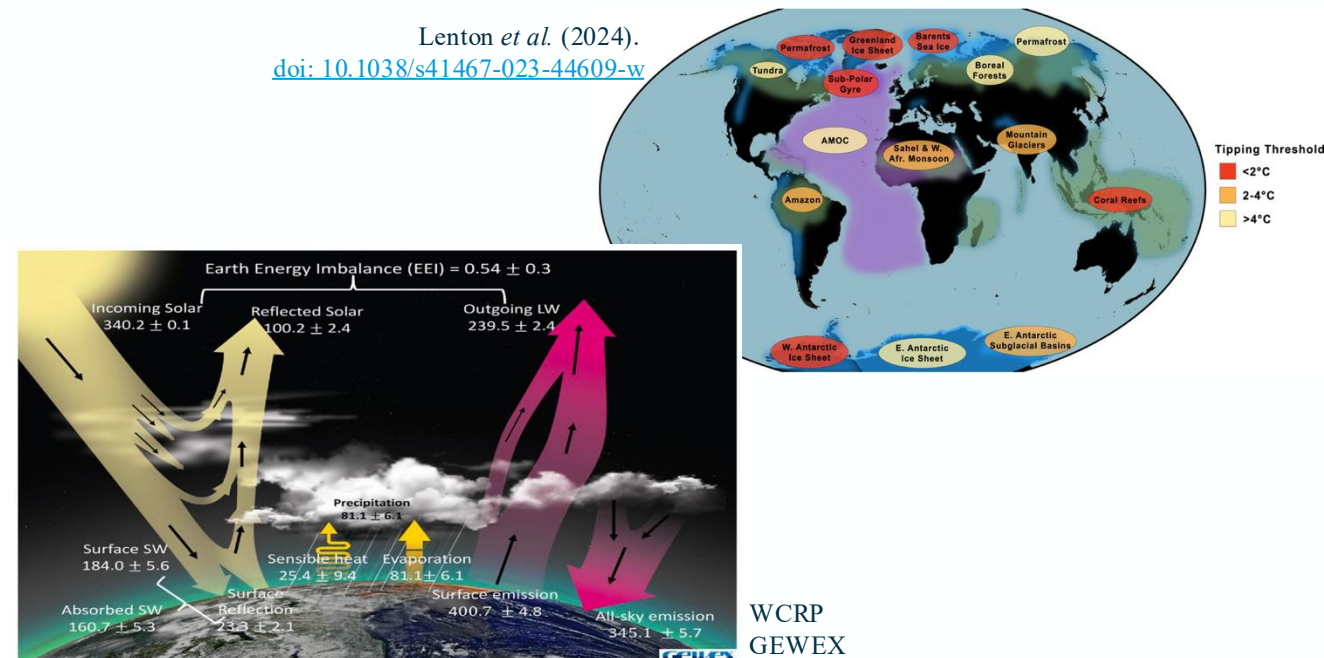
CCI data on CEDA archive

## 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



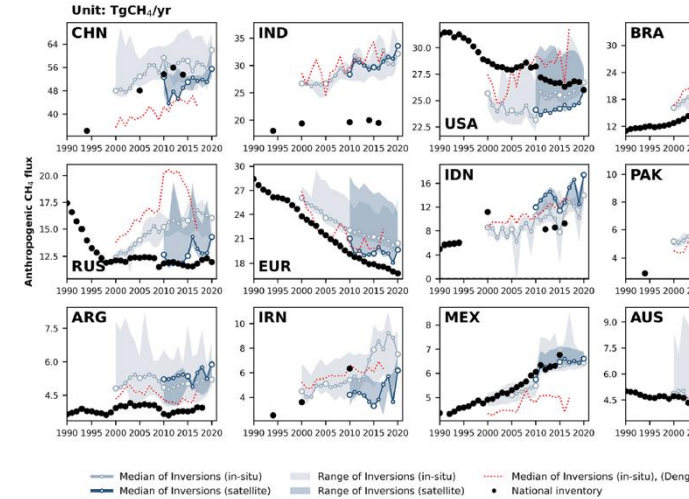
## Mitigation of GHG emissions

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

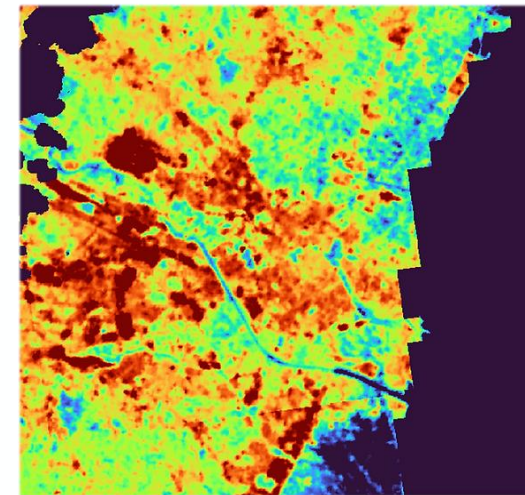
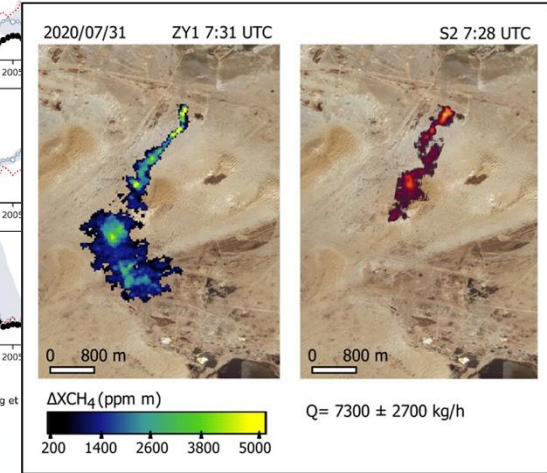
## Climate Adaptation & Resilience Building

- 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

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

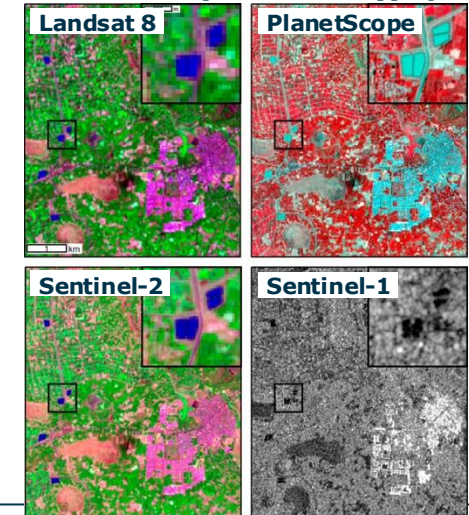


Irakulis-Loitxate *et al.* 2022  
doi: 10.1021/acs.est.1c04873



Urban Heat Islands, U. Valencia/CityCLIM  
[www.cityclim.eu](http://www.cityclim.eu)

## Malaria Mosquito Habitat Mapping



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

- 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.

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

***Thanks for your attention***

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