

climate change initiative

→ LAND SURFACE TEMPERATURE

ESA's Climate Change Initiative

Simon Pinnock, ESA Climate Office, Harwell, UK

simon.pinnock@esa.int

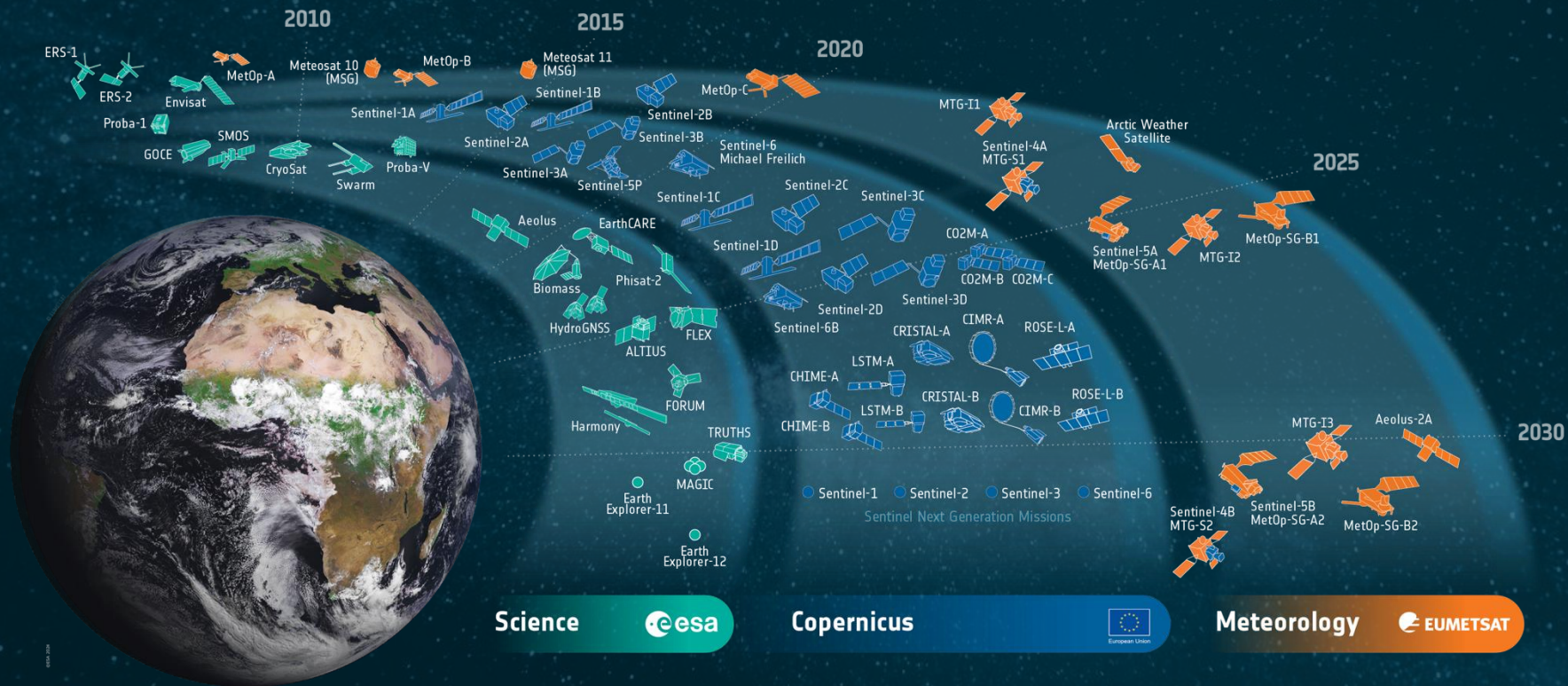


land surface
temperature
cci

05/12/2024

ESA UNCLASSIFIED – Releasable to the public

ESA-developed Earth observation missions





Objective:

- *To support the needs of the UNFCCC and its Paris Agreement for systematic observations of the Earth's climate system*

CCI activities:

- *Development of global Climate Data Records according to **GCOS ECV** requirements (multi-decadal, multi-satellite)*
- *Develop the use of ECVs in **Climate Science** (IPCC Assessments), **GHG Mitigation** and **Climate Adaptation** applications*
- *Transfer mature ECVs to an operational entity (CCI is only an R&D programme)*

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)
- ... 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)?

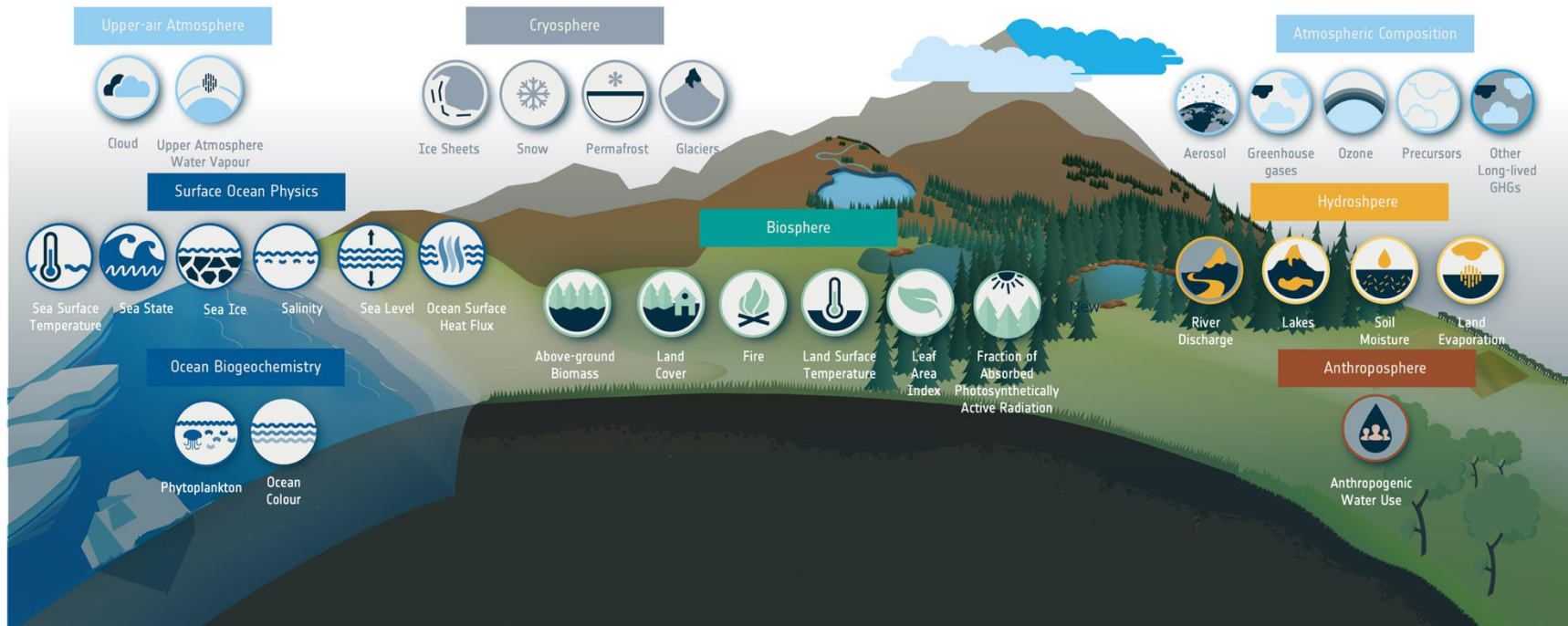
Atmosphere	Land	Ocean
Surface - Precipitation - Surface Pressure - Surface Radiation Budget - Surface Temperature - Surface Water Vapour - Surface Wind Speed and Direction - Upper-air Temperature	Hydrology - Groundwater - Lakes - River Discharge - Terrestrial Water Storage (TWS) - Evaporation from Land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



ESA Climate Change Initiative (CCI)



GCOS defined **55** Essential Climate Variables | **36** can benefit from space observations | **30** addressed by ESA's Climate Change Initiative



Anatomy of a CCI ECV project

(e.g. LST_cci)

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

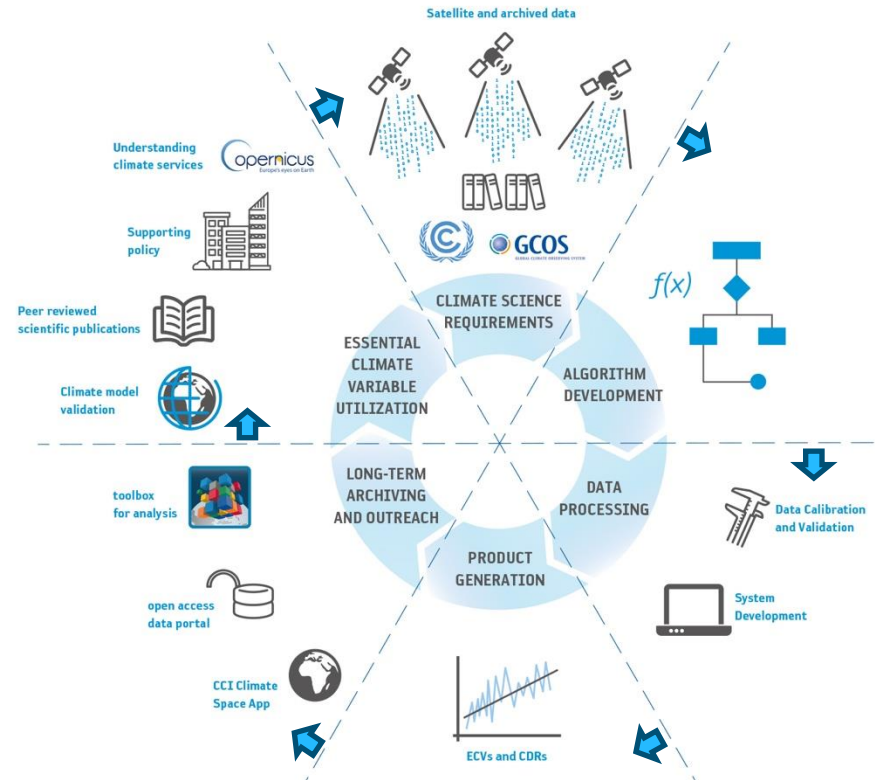
Start with ECV requirements defined by GCOS ...

- 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 mature ECVs to sustainable production

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



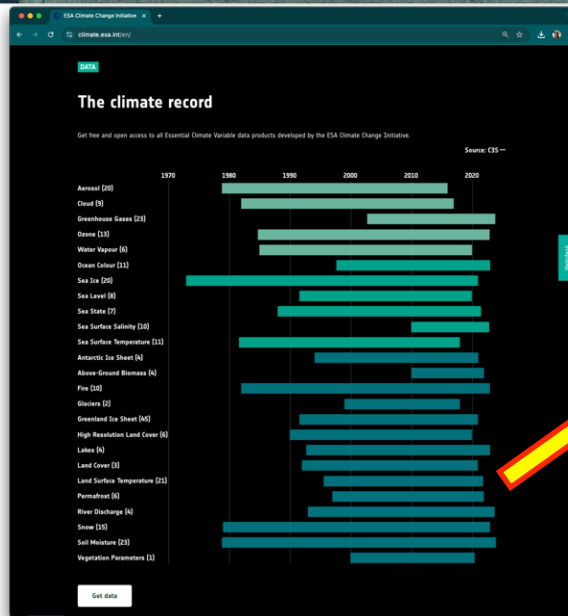


CCI Data Access

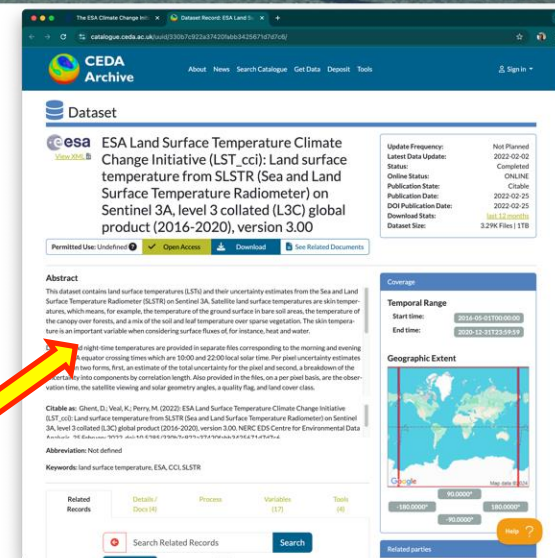


CCI ECV products (data sets)
available from:
climate.esa.int

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



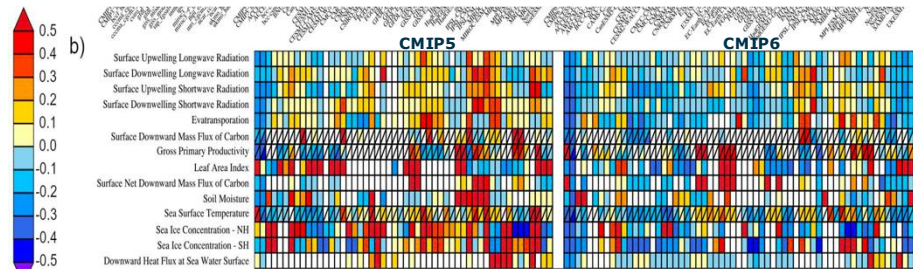
CCI Web site



CCI data on CEDA archive

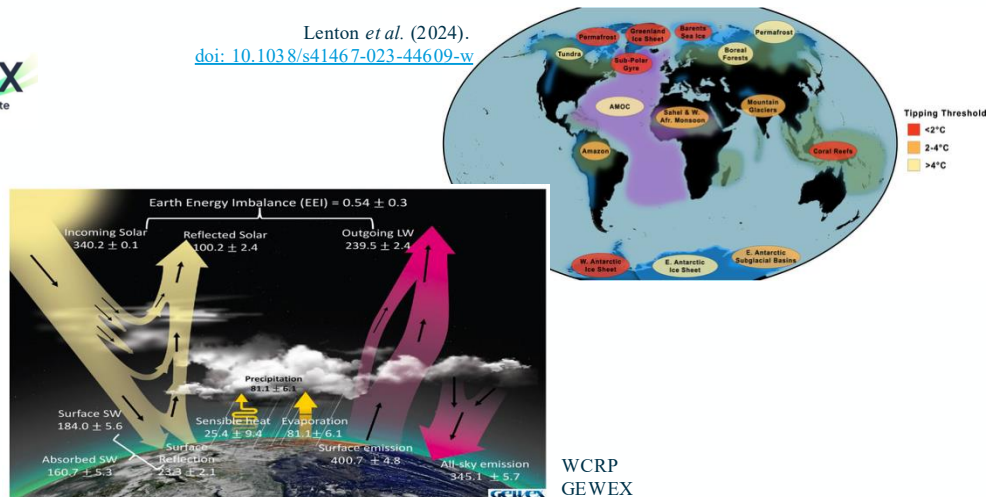
Climate Science:

- 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 and CORDEX International Project Offices 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)
- Research fellowships



IPCC AR6, Chapter 3 (fig. 4.2)

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



WCRP
GEWEX

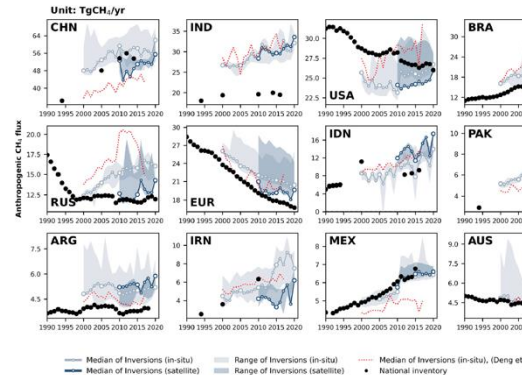
Mitigation of GHG emissions

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

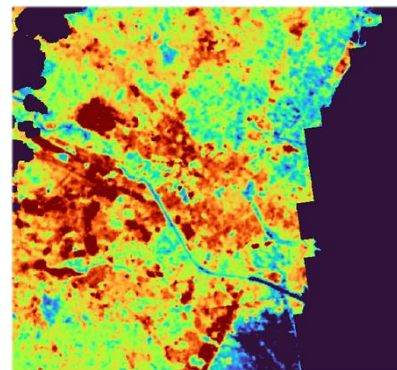
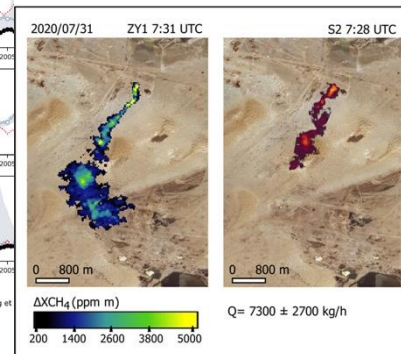
Climate Adaptation & Resilience Building

- 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

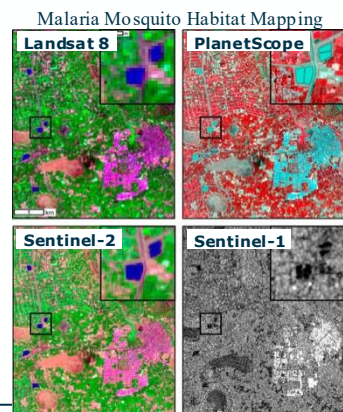
Deng *et al.*, 2025, doi: 10.5194/essd-17-1121-2025



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



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



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



Applications of LST in CCI



Lots of applications of LST data across the CCI programme, particularly in combination with other ECVs:

- Land cover
- Fire
- Soil Moisture
- Vegetation parameters
- Snow
- ...

Climate Science

- Climate and land-surface model development/evaluation (ESMValTool)
- Process understanding
- Earth Energy Imbalance and climate sensitivity
- Methane emissions
- Permafrost mapping
- Ice sheet surface mass balance

Climate Impacts

- Agricultural productivity
- Wildfire risk
- Desertification
- Vegetation state/drought monitoring
- Ecosystem change monitoring
- Extreme heat
- Urban heat island and urban environmental change
- Human and livestock disease vector risk mapping



Conclusions



- ESA's Climate Change Initiative is producing a suite of **climate data records** for many GCOS ECVs, including Land Surface Temperature
- LST is extremely valuable, particularly in combination with other ECVs, for model evaluation and development, for characterizing Earth system processes, and for characterizing the state of the environment.
- All CCI climate data records are made publicly available, either from climate.esa.int or directly from the projects.

ESA Climate Change Initiative

