

# Implementation of Essential Climate Variables Services in the Copernicus Climate Change Service



Climate Change

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European Centre for Medium-Range Weather Forecasts (ECMWF)

2<sup>nd</sup> Climate Observations Conference – Darmstadt, Germany– 17-19 October 2022



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## Why Essential Climate Variables (ECVs)?

Required to support the work of the UNFCCC and the IPCC

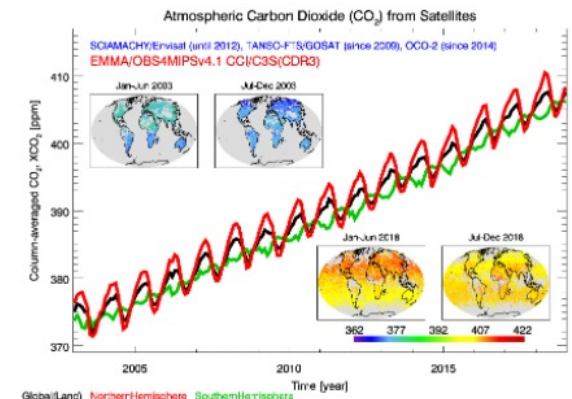
- Provide empirical evidence to understand the evolution of climate (climate indicators)
- Guide mitigation and adaptation measures (decision making)
- Assess risks and enable attribution of climate events to underlying causes
- Underpin climate services.

**Climate Data Record:** A (Thematic) Climate Data Record is a time series of measurements of sufficient length, consistency, and continuity to determine climate variability and change.

**Essential Climate Variables:** An Essential Climate Variable is a bio-physical variable (or a group of linked variables) that critically contributes to the characterization of Earth's climate.

→ Relevant, Feasible, Cost-effective

**We use historical observations from satellite sensors to build Climate Data Records of Essential Climate Variables (ECVs)**



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# The Essential Climate Variables (ECVs)

## CRYOSPHERE



Snow



Ice Sheets and Ice Shelves



Glaciers



Permafrost

### COP1

□ = satellite ECVs

□ = ECVs from reanalysis

## SURFACE ATMOSPHERE



Surface Radiation Budget



Surface Pressure



Surface Temperature



Surface Water Vapour



Surface Wind Speed and Direction



Precipitation

## UPPER-AIR ATMOSPHERE



Upper-air Temperature



Upper-air Water Vapour



Upper-air Wind Speed and Direction



Lightning



Earth Radiation Budget



Clouds

## ATMOSPHERIC COMPOSITION



Precursors for Aerosols and Ozone



Aerosols



CO<sub>2</sub>, CH<sub>4</sub>, and other GHGs



Ozone

## SURFACE OCEAN PHYSICS



Surface Currents



Surface Stress



Sea Surface Temperature



Sea Ice



Ocean Surface Heat Flux



Sea Level



Sea Surface Salinity



Sea State

## SUBSURFACE OCEAN PHYSICS



Subsurface Temperature



Subsurface Currents



Subsurface Salinity

## OCEAN BIOLOGY / ECOSYSTEMS



Plankton



Marine Habitats

## OCEAN BIOGEOCHEMISTRY



Ocean Colour



Transient Tracers



Inorganic Carbon



Oxygen



Nitrous Oxide



Nutrients

## BIOSPHERE



Soil Carbon



Albedo



Fire



FAPAR\*



Leaf Area Index (LAI)



Land Surface Temperature



Above-ground Biomass



Land Cover

## HYDROSPHERE



Soil Moisture



Lakes



Groundwater



River Discharge



Evaporation from Land

## ANTHROPOSPHERE



Anthropogenic Water Use



Anthropogenic Greenhouse Gas Fluxes



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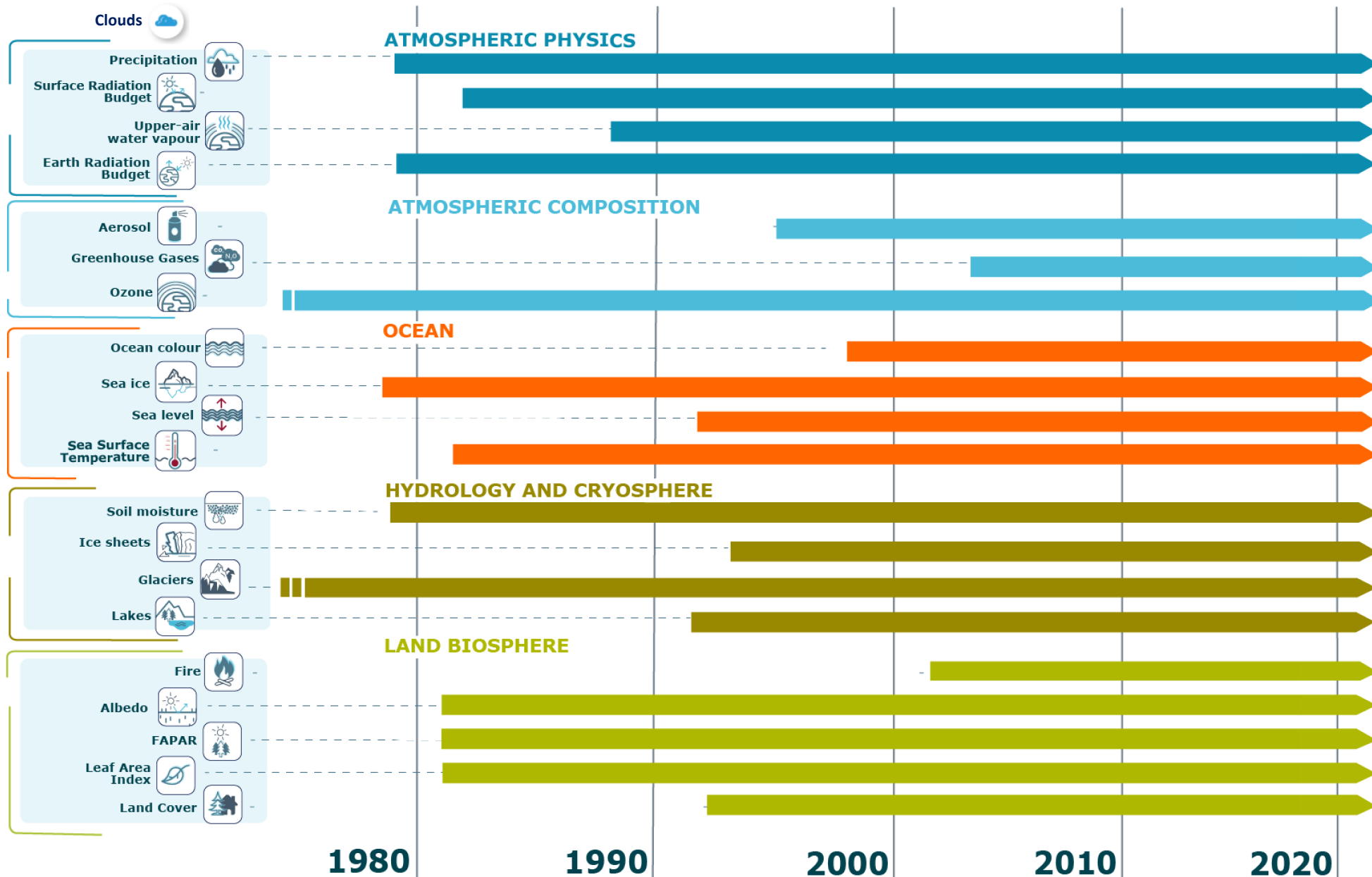
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\*Fraction of Absorbed Photosynthetically Active Radiation



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# Providing long-term, quality-assured, homogeneous and accessible global climate data records



IN COLLABORATION with more than **50** organisations.



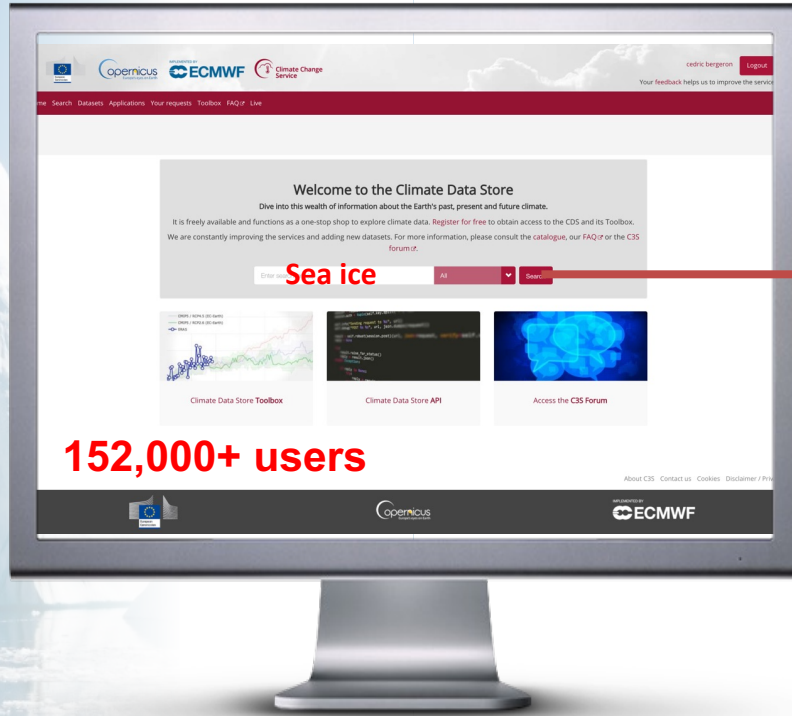
Mainly use Sentinel-3 data

Future use of other Sentinel data



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# The Climate Data Store – ‘A one stop shop for ECV data & information’



152,000+ users

<https://cds.climate.copernicus.eu>

Total number users (ECVs)

22,966

Total volume downloaded (in GB)

307,201

Total number requests

712,407



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**Landing page**

Home Search Datasets Applications Toolbox FAQ Live

Sea ice monthly and daily gridded data from 1978 to present derived from satellite sensors

Overview Download data Quality assessment Documentation

This dataset provides daily values for sea ice concentration, sea ice edge and sea ice type and monthly values for sea ice thickness. These four variables are important markers for climate change studies since sea ice greatly influences the surface albedo and exchanges of energy, moisture and carbon. The sea-ice also has an important influence on the energy balance of the Earth. The type of sea ice affect these ecosystems and the economic and logistic and tourist operations.

The sea ice type were computed from satellite measurements collected during the Envisat and CryoSat-2 satellite missions. Ice thicknesses from Envisat satellite (October 2002 to October 2010) have less coverage and higher uncertainty than thicknesses from CryoSat-2 satellite (November 2010 - March 2015), however the combined dataset provides a valuable unique observational record of sea ice variability.

From 1978 up to April 2015 the data records provided by this dataset have sufficient length, consistency, and continuity to detect climate variability and change. From April 2015 onwards, satellite data were processed using the same algorithms and processing environment but consistency and continuity have not been extensively verified.

This dataset is produced on behalf of C3S, with the exception of sea ice concentration which is produced at the EUMETSAT Satellite Application Facility on Ocean and Sea Ice (OSI SAF).

DATA DESCRIPTION	
Data type	Gridded
Horizontal coverage	Sea ice concentration and edge: global ocean split in Northern and Southern hemisphere (Lambert EASE/EASE2 projection). Sea ice thickness and type: northern hemisphere (Lambert EASE2 projection).
Temporal coverage	Sea ice concentration and edge: 12.5 km grid resolution (true spatial resolution is about 40-50 km and 15 km respectively). Sea ice thickness and type: 25 km grid resolution (true spatial resolution is about 1-10 km and 40-70 km, respectively).
Temporal resolution	Sea ice concentration, edge and type: 1978 to present. Sea ice thickness: 2002 to present. Sea ice edge: 1979 to present. Sea ice type: 1979 to present.
Temporal resolution	Sea ice concentration, edge and type: daily (every second day in the period 1978-1987). Sea ice thickness: daily (every second day in the period 1978-1987).

**Support link**  
Licenses  
Citation  
Acknowledgments  
DOI  
Related products

**Variables description**

Overview of ECV & products

Metadata

Variables description



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# Access to ECV data

Methane data from 2002 to present derived from satellite observations

**Download form**

Overview

Download data

Quality assessment

Documentation

View

Clear all

## Processing level ?

At least one selection must be made

Level 2

Level 3

## Variable ?

At least one selection must be made

- Mid-tropospheric column-averaged mixing ratios of methane (CH<sub>4</sub>) and related variables
- Column-averaged dry-air mixing ratios of methane (XCH<sub>4</sub>) and related variables

## Sensor and algorithm ?

At least one selection must be made

- IASI (Metop-A) and NLIS
- IASI (Metop-B) and NLIS
- SCIAMACHY
- TANSO-FTS and OCFP
- TANSO-FTS and OCPD
- TANSO-FTS
- MERGED and EMMA
- MERGED and OBS4MIPS

## Year

At least one selection must be made

```
import cdsapi

c = cdsapi.Client()

c.retrieve(
    'satellite-methane',
    {
        'format': 'zip',
        'processing_level': 'level_2',
        'variable': 'xch4',
        'sensor_and_algorithm': 'sciamachy_wfmd',
        'year': '2004',
        'month': '03',
        'day': '09'
    },
    'download.zip')
```



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# Comprehensive documentation & Tutorials

## Documentation

Home Search Datasets Applications Toolbox Support Live

Home

### Land cover classification gridded maps from 1992 to present derived from satellite observations

CDS Service disruption starting 8 September 2022 for 5-6 weeks. You can find more information here.

To improve our service, we need to hear from you! Please complete this very short survey. Thank you.

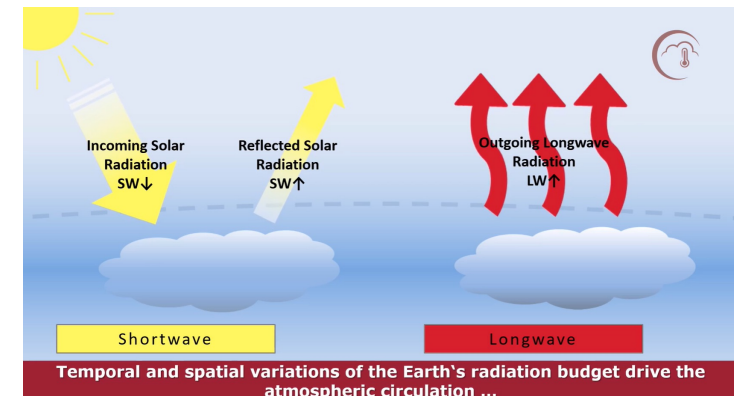
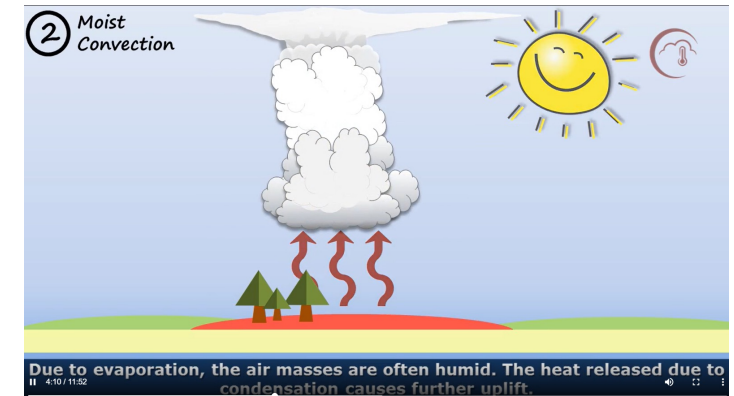
Overview Download data Quality assessment **Documentation**

► Tutorial

▼ Documentation for version 2.1

- [Product user guide \(PDF\)](#)  
The product user guide summarizes the characteristics of the dataset in a concise manner with focus on space and time extent and resolution; data formats, metadata and flags; description of variables, strengths and limitations.
- [Algorithm theoretical basis document for PROBA-V products \(PDF\)](#)  
This document provides in-depth documentation on the algorithms used to derive the dataset.
- [Algorithm theoretical basis document for Sentinel-3 products \(PDF\)](#)  
This document provides in-depth documentation on the algorithms used to derive the dataset.
- [Product quality assurance document \(PDF\)](#)  
This document describes the data quality assurance process applied by the data producer before release of the dataset.
- [Product quality assessment report \(PDF\)](#)  
Provides the latest report on data quality obtained according to methodologies described in the product quality assurance document.
- [System quality assurance document for PROBA-V products \(PDF\)](#)  
This document describes the processing chain and procedures in place at the data providers.
- [System quality assurance document for Sentinel-3 products \(PDF\)](#)  
This document describes the processing chain and procedures in place at the data providers.
- [Target Requirements and Gap Analysis Document \(PDF\)](#)  
Summarises the minimum requirements identified for the dataset and discusses identified gaps with respect to these target requirements.

► Documentation for version 2.0





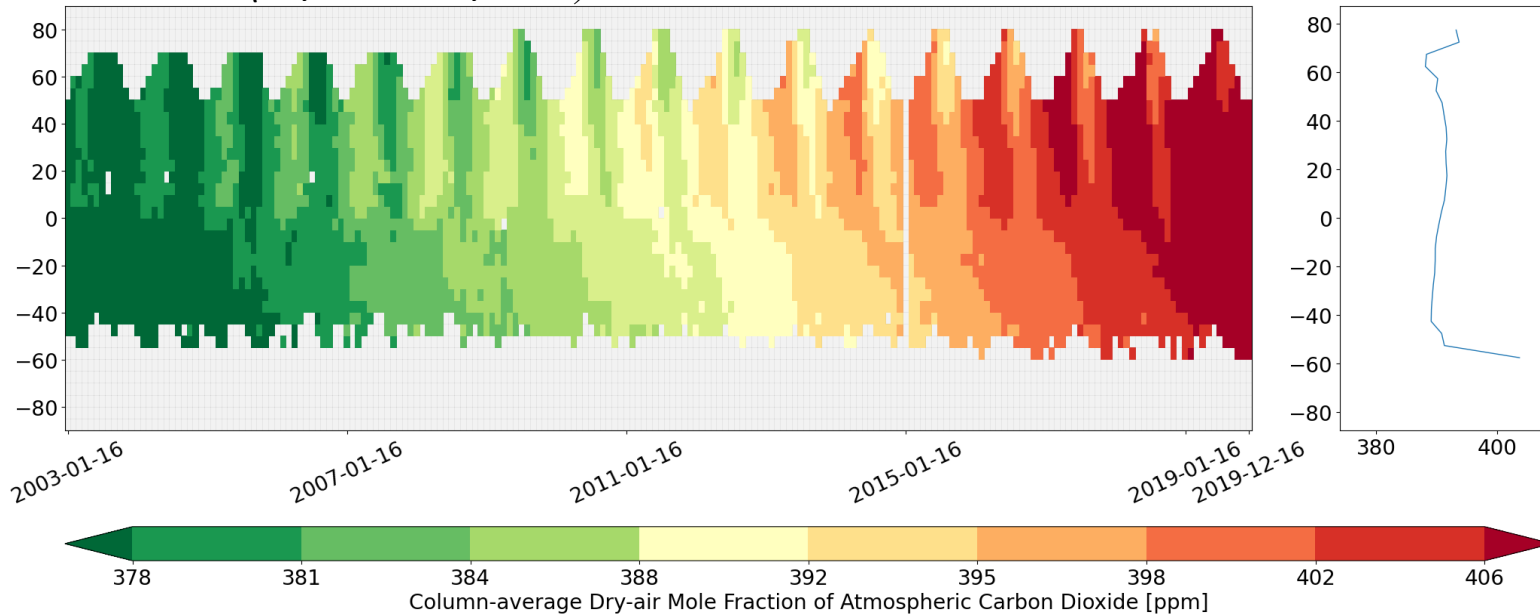
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# Quality assurance

## Three levels of quality assurance:

- Scientific validation conducted by the data provider
- C3S pre-publication review
- Service independent evaluation and quality control

Carbon dioxide data from 2002 to present derived from satellite observations - XCO2 Level 3 v4.2 (01/2003- 12/2019)



Maturity Matrix

Metadata	User Documentation	Uncertainty Characterisation	Public access, feedback, and update	Usage
Standards	Formal description of scientific methodology	Standards	Public Access/Archive	Research
Collection level	Formal validation report	Validation	Version	Decision support system
	Formal product user guide	Uncertainty quantification	User feedback	
		Automated quality monitoring	Updates to record	



Mean values for XCO2 as function of latitude and time (aggregated over longitude; left), and as latitudinal averages (aggregated over longitude and time; right). Grey areas represent missing values. Based on the CDS data downloaded on 28 January 2021.



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# Data viewers and toolbox applications

## Data viewers

Carbon dioxide data from 2002 to present

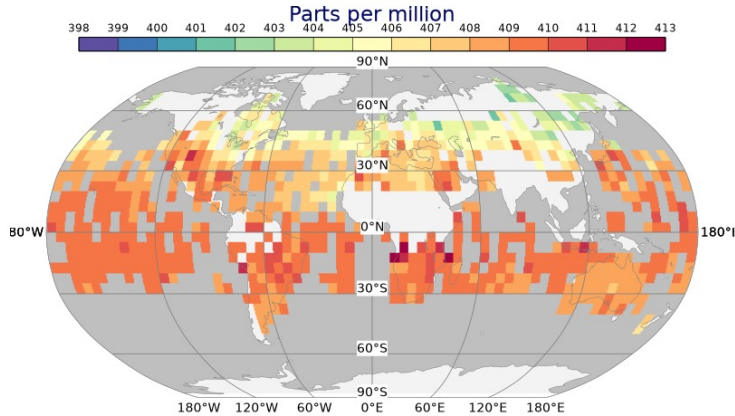
CDS Service disruption starting 8 September 2022 for 5-6 weeks. You can find more information [here](#).  
To improve our service, we need to hear from you! Please complete [this very short survey](#). Thank you.

Overview Download data Quality assessment Documentation View

This data viewer allow users to view the column-average dry-air mole fraction of atmospheric Carbon Dioxide (XCO2) from the level 3 Obs4MIPs product. Users can select the version, year and month to view. The level 3 data are gridded monthly mean values using data from a number of satellites. Users are advised to read the product user guide for more details on the satellites and algorithms used to create the data.

Version: 4.3 Year: 2019 Month: 08

### Level 3 XCO2 from the Obs4MIPs v4.3 product 08-2019



Show source code

Version: 4.35.4 - build f8ced5bb



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Global glaciers explorer

## Toolbox applications

CDS Service disruption starting 8 September 2022 for 5-6 weeks. You can find more information [here](#).  
To improve our service, we need to hear from you! Please complete [this very short survey](#). Thank you.

Overview Application Source code

Full screen

When country is set to "Global" the interactive map allows users to explore all the glaciers in the database. Clicking on a glacier (white regions) will produce a summary table and graphs of hypsometry for the glacier if such data is available for that glacier. Further clicks will append rows to the table and lines to the hypsometry graphs so that the glaciers can be compared.

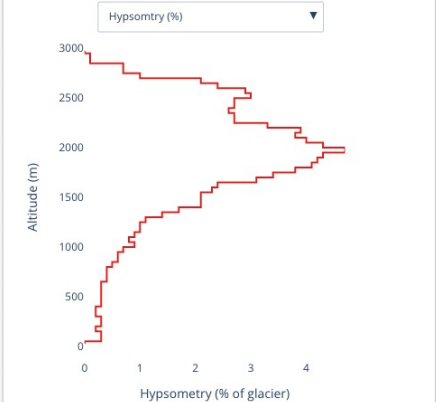
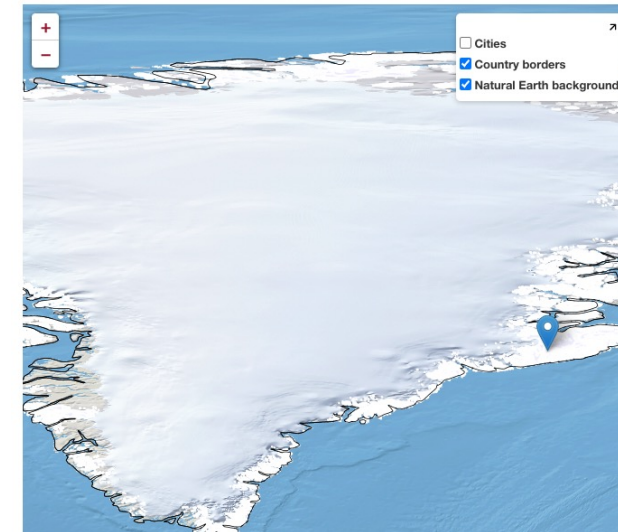
Selecting a country allows users to explore the detailed survey records of elevation and mass change. Each glacier with elevation or mass change data is indicated with a blue (elevation) or red (mass) circle on the map. Users can still explore and compare glacier extent but now with added hover information, the glacier ID and area.

Country: Global

Position: 69.03°N, 28.12°W

Glacier ID	Name	Area km <sup>2</sup>	Hypsometry curve
RGI60-05.13536	Borggraven	2219.51	Yes

The figure below displays the hypsometry for the selected glaciers where hypsometry data is available. Users can select one of four display options using the drop-down selection menu.





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# Climate monitoring

## Key climate indicators

- ✓ Responding to monitoring and reporting for UNFCCC
- ✓ Capture long-term trends, but also year-to-year variability



**EUROPEAN STATE OF THE CLIMATE**  
**SUMMARY 2021**

PROGRAMME OF THE EUROPEAN UNION | Copernicus | ECMWF | Climate Change

Report sections

**THE ARCTIC IN 2021**  
For the Arctic as a whole, 2021 saw lower temperatures than the previous five years.

**INTRODUCTION**  
Welcome to the summary of the European State of the Climate 2021 (ESOTC), from the Copernicus Climate Change Service (C3S).

**GLOBAL CONTEXT IN 2021**  
The evolution of key climate indicators provides the global context for 2021.

**EUROPE IN 2021**  
Europe saw its warmest summer on record and one of the most intense fire seasons.

**TRENDS IN CLIMATE INDICATORS**  
Climate indicators show the long-term global and regional evolution of several key variables.

**ABOUT THE REPORT**  
The ESOTC findings are based on data and expertise from across the C3S community and beyond.

**BEYOND THE ESOTC**  
C3S offers a range of products and tools to explore the impacts of climate change and variability.

**ABOUT US**  
C3S is implemented by the European Centre for Medium-Range Weather Forecasts with funding from the European Union.

**CONTACT US**

This is an interactive document  
The bottom toolbar and contents buttons allow you to navigate through the different sections of this report.

Copernicus Climate Change Service | European State of the Climate 2021  
Cover image: The Breiðamerkjúgull glacier in Iceland. Credit: European Union, Copernicus Sentinel-2 imagery.



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Copernicus Climate Change Service | European State of the Climate 2021  
Cover image: The Breiðamerkjúgull glacier in Iceland. Credit: European Union, Copernicus Sentinel-2 imagery.





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# Evolution within the current framework agreement

## CRYOSPHERE



Snow



Ice Sheets and Ice Shelves



Glaciers



Permafrost

### COP1

□ = satellite ECVs

□ = ECVs from reanalysis

### COP2 AMBITION

□ = 1<sup>st</sup> Priority

□ = 2<sup>nd</sup> Priority

## SURFACE ATMOSPHERE



Surface Radiation Budget



Surface Pressure



Surface Temperature



Surface Water Vapour



Surface Wind Speed and Direction



Precipitation

## UPPER-AIR ATMOSPHERE



Upper-air Temperature



Upper-air Water Vapour



Upper-air Wind Speed and Direction



Lightning



Earth Radiation Budget



Clouds

## ATMOSPHERIC COMPOSITION



Precursors for Aerosols and Ozone



Aerosols



CO<sub>2</sub>, CH<sub>4</sub>, and other GHGs



Ozone

## HYDROSPHERE



Soil Moisture



Lakes



Groundwater



River Discharge



Evaporation from Land

## SURFACE OCEAN PHYSICS



Surface Currents



Surface Stress



Sea Surface Temperature



Sea Ice



Ocean Surface Heat Flux



Sea Level



Sea Surface Salinity



Sea State

## SUBSURFACE OCEAN PHYSICS



Subsurface Temperature



Subsurface Currents



Subsurface Salinity

## OCEAN BIOLOGY / ECOSYSTEMS



Plankton



Marine Habitats

## OCEAN BIOGEOCHEMISTRY



Ocean Colour



Transient Tracers



Inorganic Carbon



Oxygen



Nitrous Oxide



Nutrients

Focus on users

Enhanced collaboration with ESA & EUMETSAT

Exploit synergies with other Copernicus Services

## BIOSPHERE



Soil Carbon



Albedo



Fire



FAPAR\*



Leaf Area Index (LAI)



Land Surface Temperature



Above-ground Biomass



Land Cover

## ANTHROPOSPHERE



Anthropogenic Water Use



Anthropogenic Greenhouse Gas Fluxes



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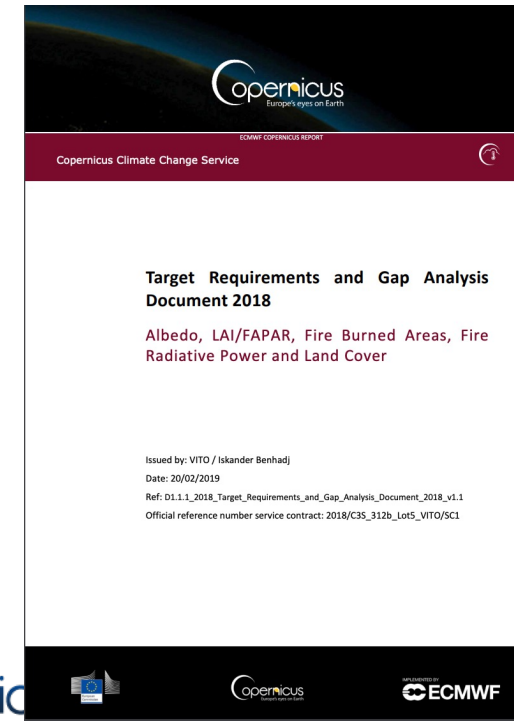
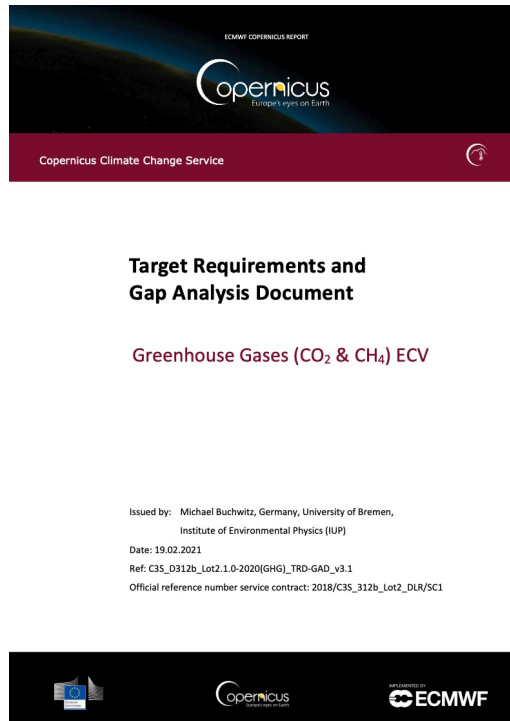


## What are the bottlenecks in today's observations system in terms of...

- meeting scientific needs in climate science (Topic 2, Cluster 1)
- building and sustaining climate data records (Topic 4)

### Partially discussed in the C3S "Target Requirement and Gap Analysis" Document.

- Define and formulate the (potentially evolving) target requirements for satellite-derived ECV products based on [C3S] user needs, such as required precision (random error, scatter) and accuracy (systematic error, bias)
- Analyses the various aspects of the retrieval methodologies that limit the fitness for purpose of the current CDRs
- Identifies the remaining activities to be carried out to fully satisfy the scientific target requirements





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# Thank you for your attention



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