C3S: The Copernicus Climate Change Service

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European Centre for Medium-Range Weather Forecasts (ECMWF)

Climate Change

13 June 2024

Copernicus Europe's eyes on Earth | European Commission | ECMWF

Open, complete, free

Earth Observation component of the EU Space Programme

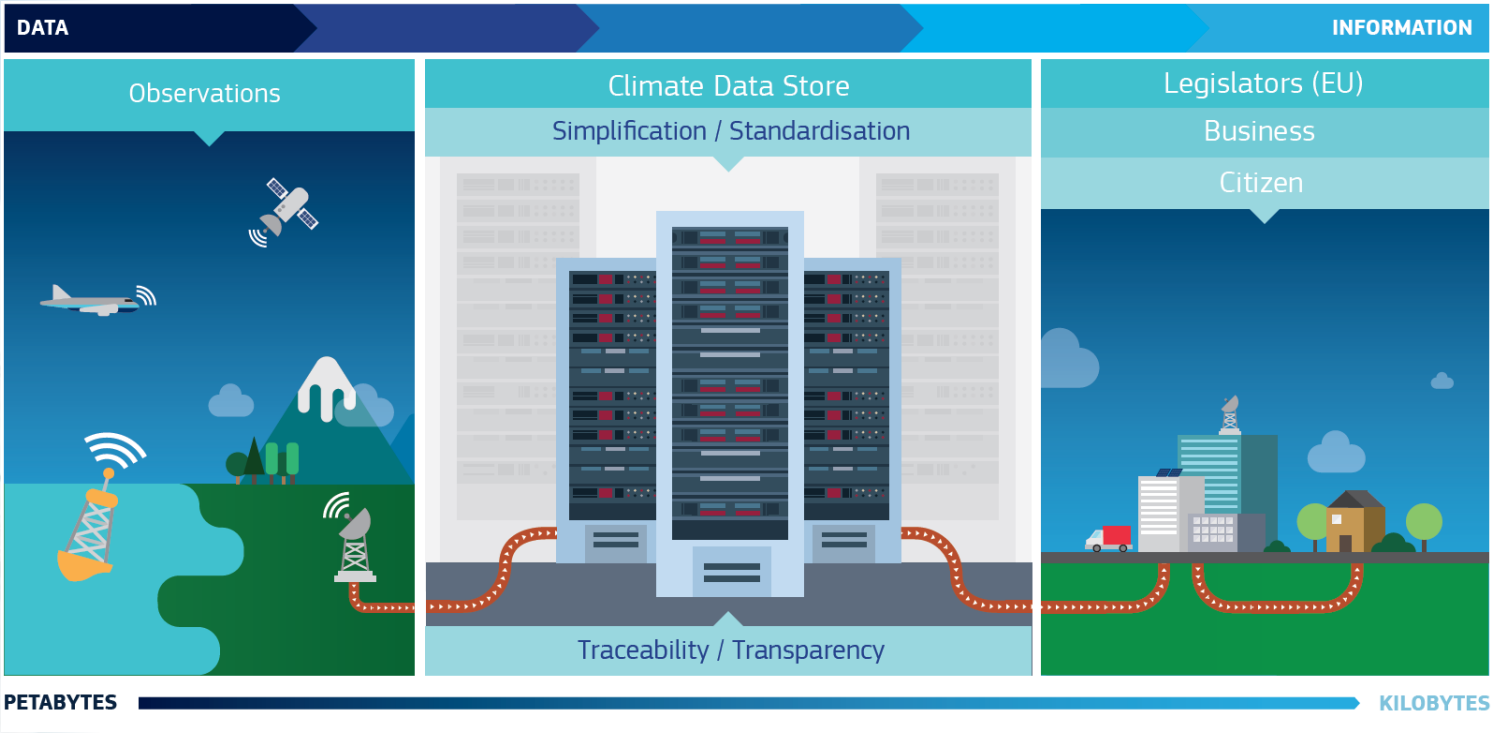
- CLIMATE CHANGE
- MARINE MONITORING
- ATMOSPHERE MONITORING
- LAND MONITORING
- SECURITY
- EMERGENCY MANAGEMENT

1st MFF (2014-2020): ~ €4.3 billions

2nd MFF (2021-2027): ~ €5.4 billions M€

Climate Change

What is the Copernicus Climate Change Service (C3S)?



authoritative quality-controlled data and information based on Earth Observation about the past, present and future climate;

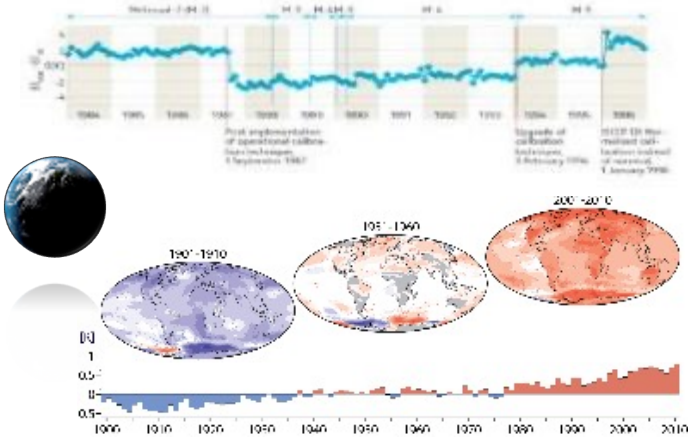
tools to inform climate change mitigation and adaptation strategies by policy makers and businesses;

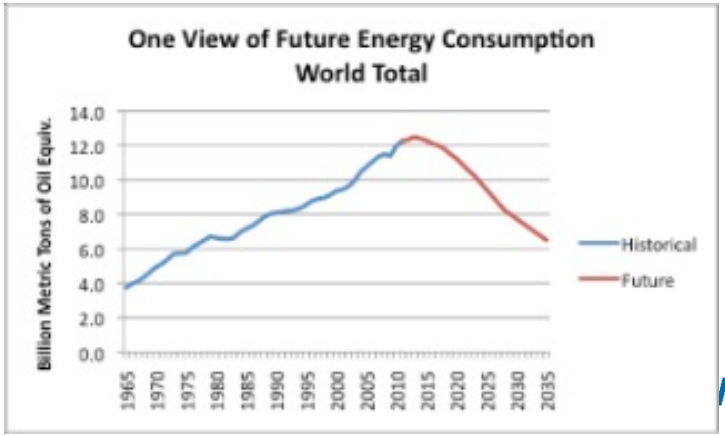
examples of best practice in the use of climate information.

Copernicus | European Commission | ECMWF

Topics addressed in this service:

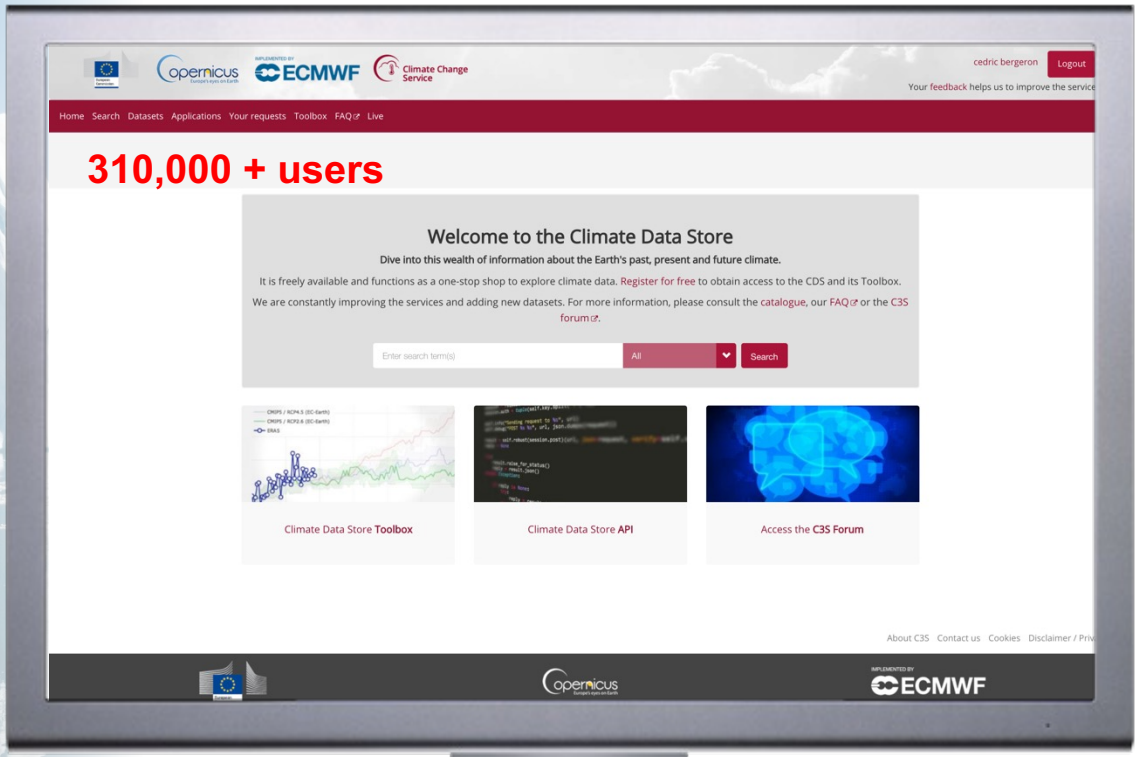
- How is the climate changing?
  - Earth Observation data
  - Reanalysis
- Will climate change continue/accelerate?
  - Predictions
  - Projections
- What are the impact in society?
  - Climate Indicators
  - Sectoral Information Systems





Climate Change

The Climate Data Store



https://cds.climate.copernicus.eu

The **Climate Data Store** also called CDS, is **an online open and free service**.

It allows users to browse and access the wide range of climate datasets via a searchable catalogue…

… It allows users to build their own applications, maps and graphs

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Climate Change

… and a consistent and simple meta(data) access

Download form

Overview

EQC Information

Documentation

Coming very soon
(still under validation)

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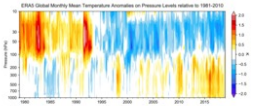
ERA5 monthly averaged data on pressure levels from 1979 to present

Overview | Download data | Quality assessment | Documentation

ERA5 is the fifth generation ECMWF reanalysis for the global climate and weather for the past 4 to 7 decades. Currently data is available from 1979. When complete, ERA5 will contain a detailed record from 1950 onwards. ERA5 replaces the ERA-Interim reanalysis.



Reanalysis combines observations into globally complete fields using the laws of physics with the method of data assimilation (4D-Var in the case of ERA5). ERA5 provides hourly estimates for a large number of atmospheric, ocean-wave and land-surface quantities. An uncertainty estimate is sampled by an underlying 10-member ensemble at three-hourly intervals. Ensemble mean and spread have been pre-computed for convenience. Such uncertainty estimates are closely related to the information content of the available observing system which has evolved dramatically over time. They also indicate flow-dependent sensitive areas.

The native resolution of the ERA5 atmosphere and land reanalysis is 31km on a reduced Gaussian grid (TI639) and 63km (TL319) for the ensemble members. Ocean-wave products are produced at 0.36 degrees and 1 degree for the ensemble. The atmospheric component consists of 137 levels in the vertical from the surface up to 1 Pa (about 80km). This spans the troposphere, stratosphere and mesosphere. There are both analysis fields and short forecast fields that link the assimilation windows used in 4D-Var. A detailed description can be found in the online ERA5 documentation. The full data set resides in the MARS tape archive.

The data presented here is a post-processed subset of the full ERA5 data set. It is online on spinning disk, which should ensure fast and easy access. It should satisfy the requirements for most common applications.

Data has been regridded to a regular lat-lon grid of 0.25 degrees for the reanalysis and 0.5 degrees for the uncertainty estimate (0.5 and 1 degree respectively for ocean waves). There are two main sub sets: data on pressure levels and data on single levels. The data on pressure levels contain 16 atmospheric quantities on 37 pressure levels from 1,000 hPa (surface) to 1 hPa (around the top of the stratosphere). Single-level data are available for a number of atmospheric, ocean-wave and land surface quantities.

Data is available on their hourly (three-hourly) resolution. To facilitate many climate applications, monthly-mean averages have been pre-calculated as well. Though, no monthly means are available for ensemble mean and spread.

Monthly mean updates are available about 3 days after the end of the month. Initial release data, i.e. data no more than three months behind real time, is called ERA5T. In the event that serious flaws are detected in ERA5T, this data could be different to the final ERA5 data. In practice, though, this will be very unlikely to occur. Based on experience with the production of ERA5 so far (and ERA-Interim in the past), our expectation is that such an event would not occur more than once every few years, if at all. In the unlikely event that such a correction is required, users will be notified as soon as possible.

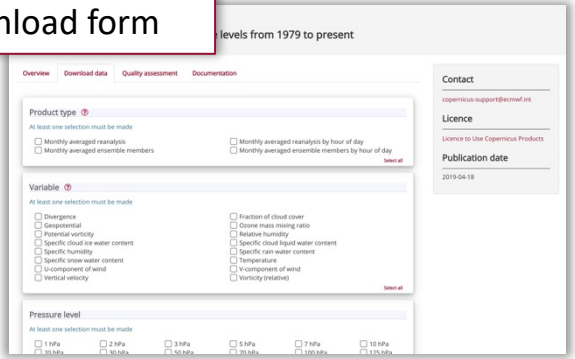
The record in this page links to the "ERA5 monthly averaged data on pressure levels".

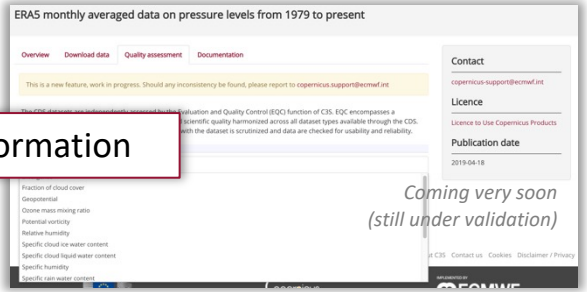
DATA DESCRIPTION	
Data type	Gridded
Horizontal coverage	Global
Horizontal resolution	Reanalysis: 0.25°x0.25° Ensemble members: 0.5°x0.5°
Vertical coverage	1000 hPa to 1 hPa
Vertical resolution	37 pressure levels
Temporal coverage	1979 to present

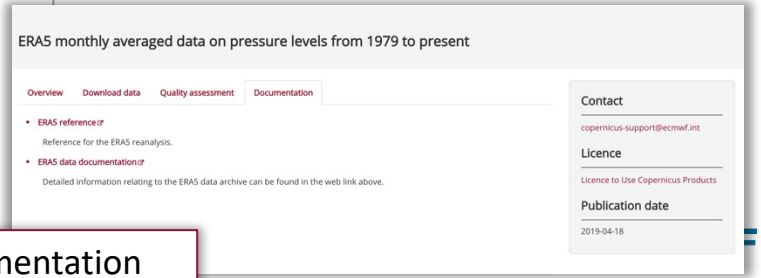
Contact
copernicus-support@ecmwf.int

Licence
Licence to Use Copernicus Products

Publication date
2019-04-18







Climate Change

… and a consistent and simple meta(data) access

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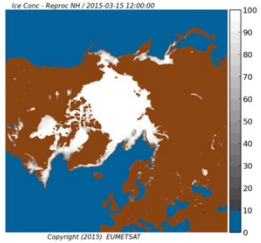
Sea ice monthly and daily gridded data from 1978 to present derived from satellite sensors

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 distribution, including polynyas and margins, also has an important influence on marine ecosystems. Changes in the distribution of sea ice affect these ecosystems and a number of activities such as shipping, logistic and tourist operations.

Sea ice edge, sea ice concentration and sea ice type were computed from satellite passive microwave brightness temperatures from the series of SMMR, SSM/I and SSMIS sensors. Sea ice thickness were computed from Ku-Band radar altimeter 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 EA projection). Sea ice thickness and type: northern hemisphere (Lambert EASE2 projection).
Horizontal resolution	Sea ice concentration and edge: 12.5 km grid resolution (true spatial resolution is about 40-50 km a respectively). Sea ice thickness and type: 25 km grid resolution (true spatial resolution is about 1-10 km and 4 respectively).
Temporal coverage	Sea ice concentration: 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: monthly (Arctic winter months from October - April).

Contact

copernicus-support@ecmwf.int

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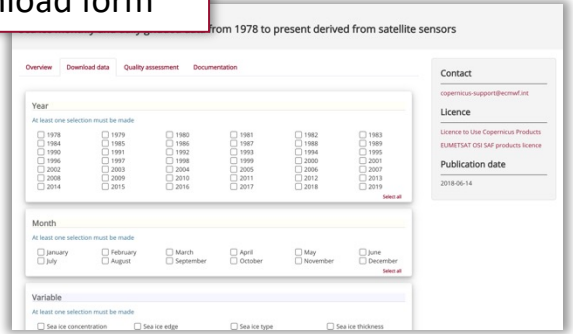
EUMETSAT OSI SAF products licence

Publication date

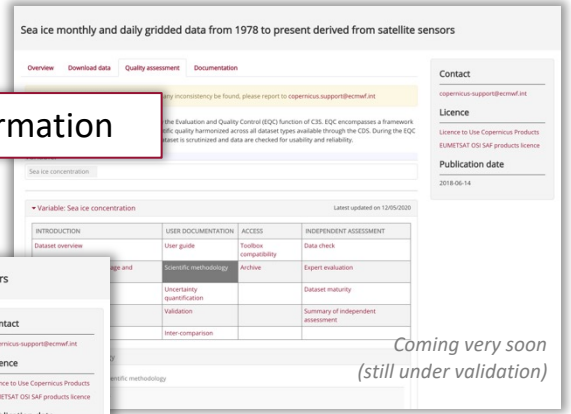
2018-06-14

Overview

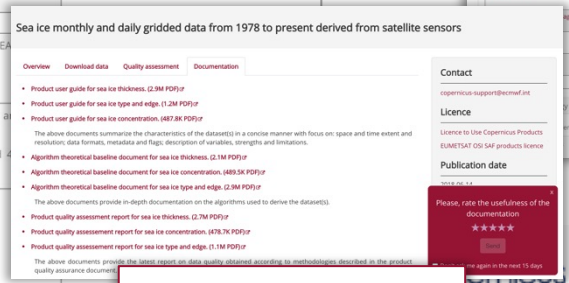
Download form



EQC Information



Coming very soon (still under validation)



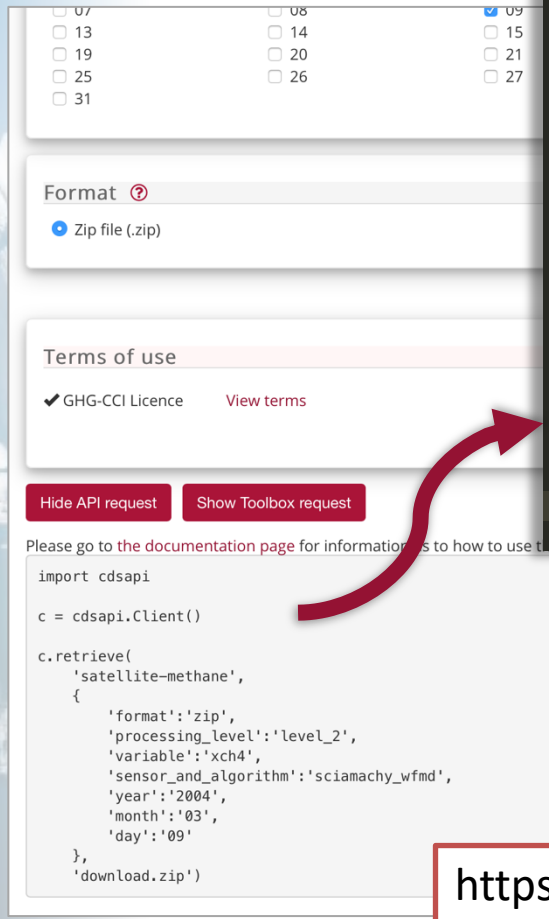
Documentation

European Commission

ECMWF

Climate Change

… with a robust CDS API access




```python
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')
```

pip install cdsapi

https://cds.climate.copernicus.eu/api-how-to

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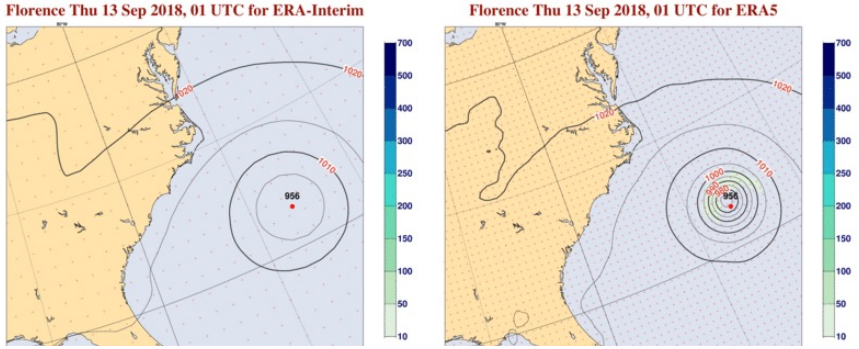
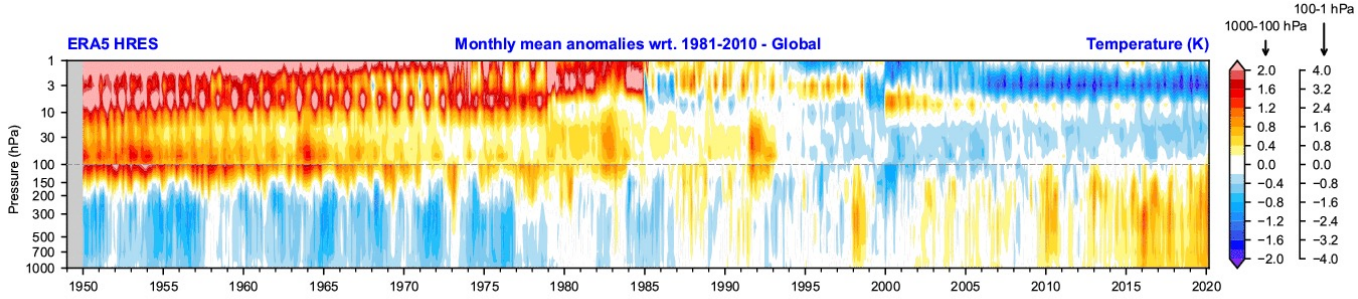
Maps without gaps: global atmospheric reanalysis ERA5

ERA5:
Spatial resolution: 31 km
Temporal resolution: hourly
Period: 1940-present





1950 – 1979
Based on preliminary data (published end 2020)

1979 – present
NRT stream runs RT – 1 day

Hersbach et al., 2020 (Quart. J. Roy. Met. Soc.),
https://doi.org/10.1002/qj.3803

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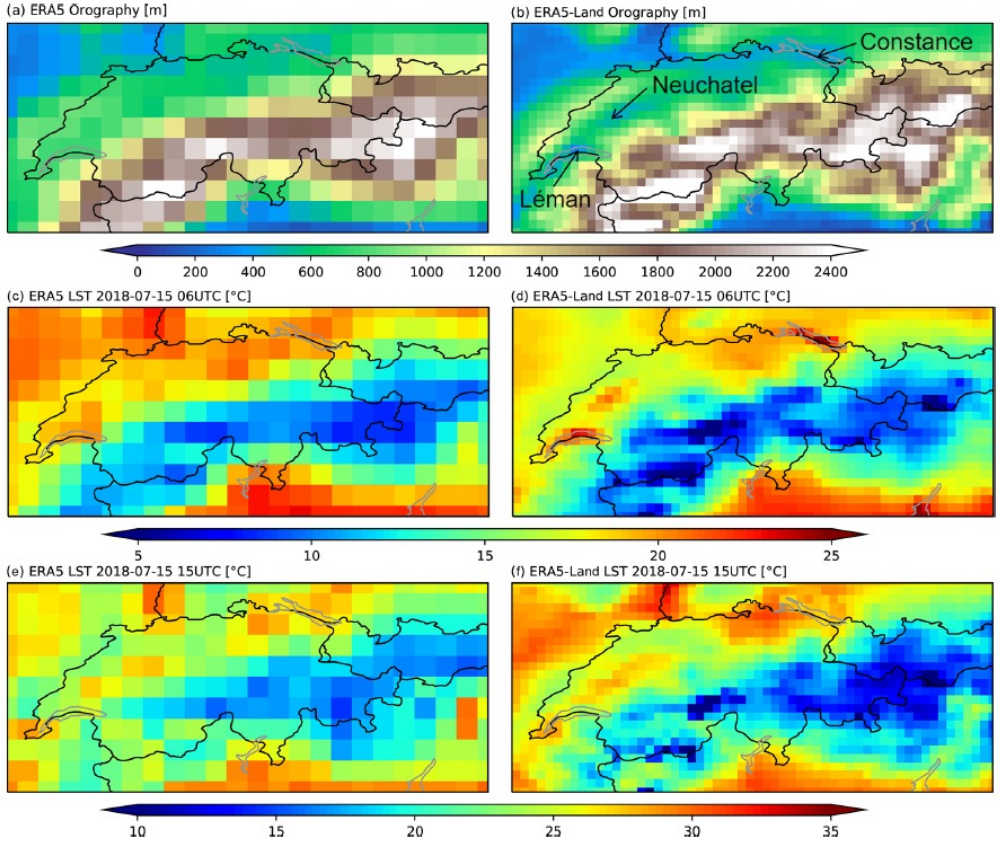
High-resolution and consistency for the land evolution: ERA5-Land (1950-present)

orography

Soil Temperature (15 July 2018 06UTC)

Soil Temperature (15 July 2018 15UTC)



ERA5-Land:
Spatial resolution: 9 km
Temporal resolution: hourly
Period: 1950-present
Land consistency

Muñoz-Sabater et al., 2021 (Earth Syst. Sc. Data), https://doi.org/10.5194/essd-13-4349-2021

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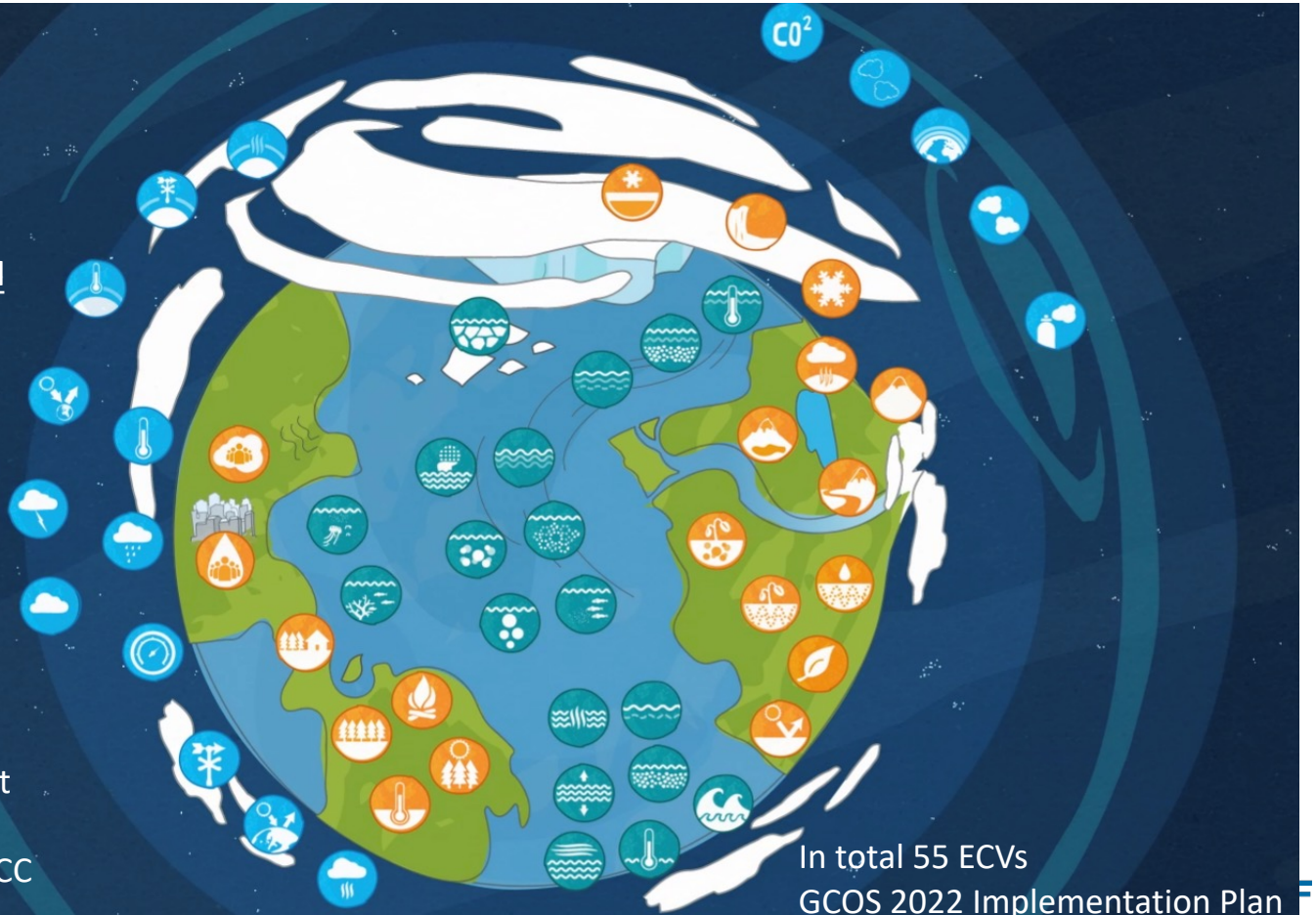
Climate Change

Essential Climate Variables

We use historical observations from in-situ and satellite sensors to build Climate Data Records of Essential Climate Variables (ECVs)



Required to support the work of the UNFCCC and the IPCC

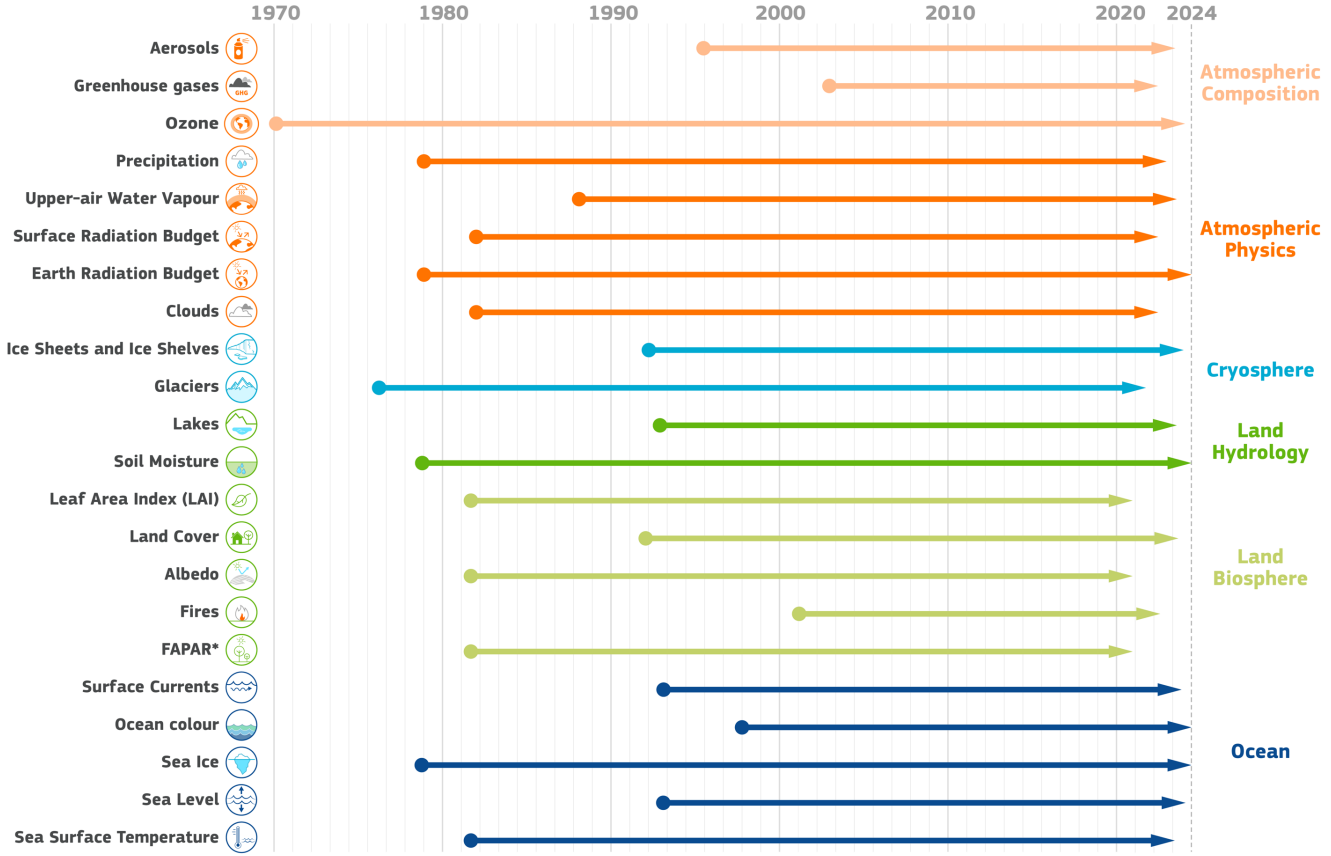
In total 55 ECVs
GCOS 2022 Implementation Plan

ECV – climate data records

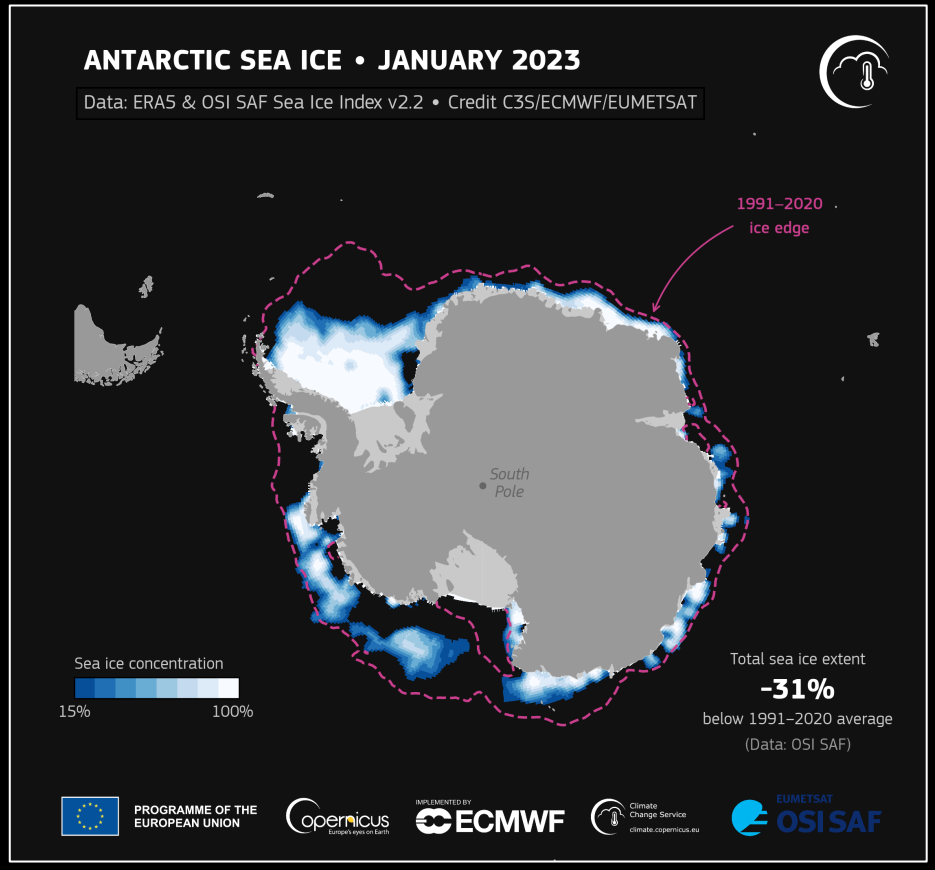
Based on satellite data, they monitor trends and variability

Involve close coordination and collaboration with major providers (ESA, EUMETSAT) and Copernicus Services

Their production require the expertise of many public and private entities in Europe



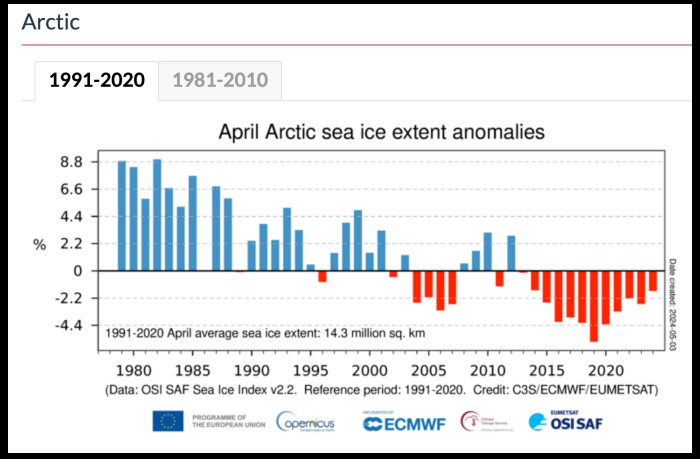
Ocean domain



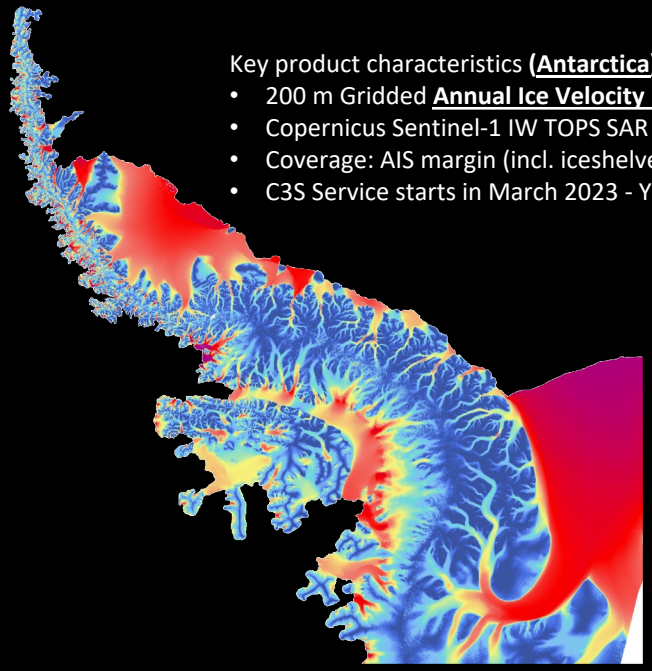
Monthly mean sea ice concentrations around Antarctica in 2023

Data: ERA5 (sea ice concentration), EUMETSAT OSI SAF Sea Ice Index v2.2 (sea ice extent anomaly).

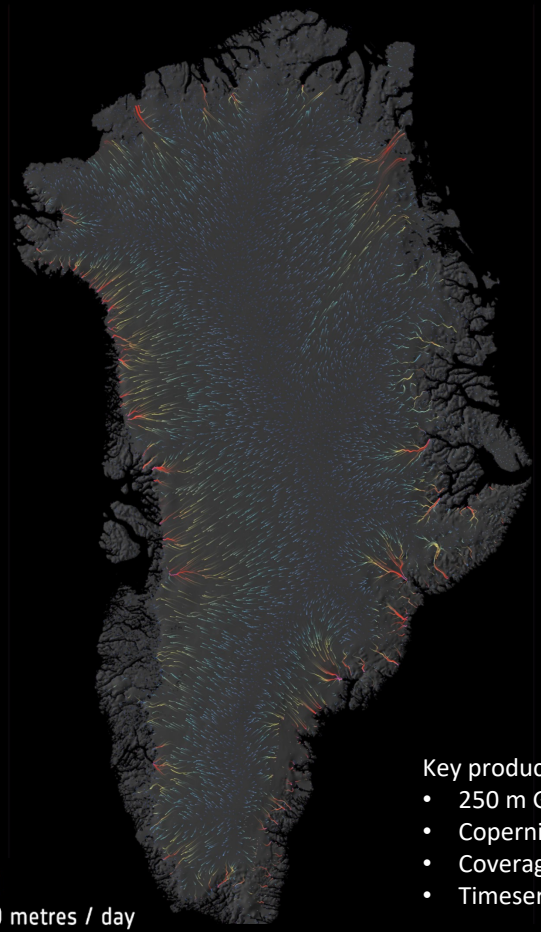
Credit: C3S/ECMWF/EUMETSAT



Cryosphere domain



Key product characteristics **(Antarctica)**
- 200 m Gridded **Annual Ice Velocity Maps**
- Copernicus Sentinel-1 IW TOPS SAR
- Coverage: AIS margin (incl. iceshelves)
- C3S Service starts in March 2023 - Yearly updates



Key product characteristics **(Greenland)**
- 250 m Gridded **Annual Ice Velocity Maps**
- Copernicus Sentinel-1 IW TOPS SAR
- Coverage: AIS margin (incl. iceshelves)
- Timeseries starts in 2014 - Yearly updates

Climate Change

C3S seasonal prediction: components

DATA PRODUCTS

cds.climate.copernicus.eu

- Datasets available in the Climate Data Store
  - Atmosphere
    - daily and subdaily data (6h, 12h, 24h)
    - monthly statistics (mean, max, min, standard deviation)
    - bias corrected data (monthly anomalies)
  - Ocean monthly means
- Multi-system retrospective forecasts and real-time forecasts, the latter published on 6th (ECMWF) and 10th day of month (the rest)

CDS API

```
import cdsapi

c = cdsapi.Client()

c.retrieve(
    'seasonal-monthly-single-levels',
    {   'format':'grib',
        'originating_centre':'meteo_france',
        'variable':'total_precipitation',
        'product_type':[
            'ensemble_mean','hindcast_climate_mean'
        ],
        'year':'2018',
        'month':'09',
        'leadtime_month':['1','2','3','4','5','6'] },
    'cds_seasonal_output.grib')
```

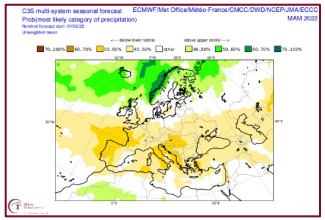
Python workflows

jupyter

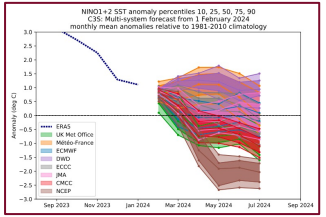
GRAPHICAL PRODUCTS

climate.copernicus.eu/charts/packages/c3s_seasonal/

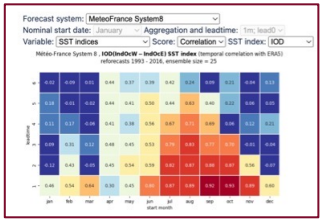
Products for individual contributing systems and multi-system combination



Total precipitation
Near-surface temperature and wind
Mean sea-level pressure
Sea surface temperature
Sea ice concentration
Geopotential height at 500 hPa
Temperature at 850 hPa



Sea surface temperature NINO regions
Sea surface temperature Indian Ocean
Zonal mean wind at 10hPa



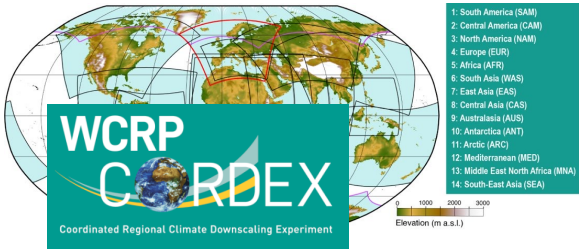
Temporal correlation
Relative Operating Characteristic (ROC) score
Ranked Probability Score (RPS)

C3S climate prediction and projection data

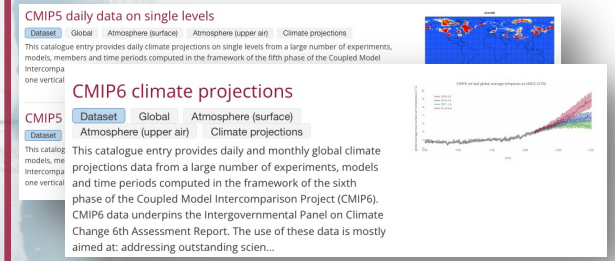
Climate Change

WCRP CMIP5 World Climate Research Programme

WCRP CMIP6 World Climate Research Programme



Global climate projections



CMIP5 daily data on single levels

Dataset | Global | Atmosphere (surface) | Atmosphere (upper air) | Climate projections

This catalogue entry provides daily climate projections on single levels from a large number of experiments, models, members and time periods computed in the framework of the fifth phase of the Coupled Model Intercompa... one vertical

CMIP6 climate projections

Dataset | Global | Atmosphere (surface) | Atmosphere (upper air) | Climate projections

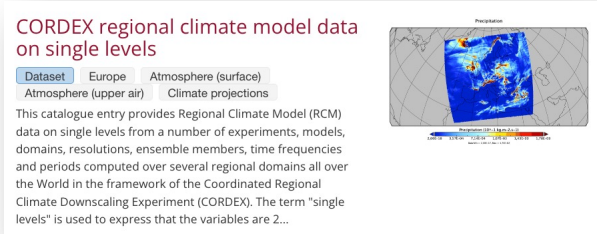
This catalogue entry provides daily and monthly global climate projections data from a large number of experiments, models and time periods computed in the framework of the sixth phase of the Coupled Model Intercomparison Project (CMIP6). CMIP6 data underpins the Intergovernmental Panel on Climate Change 6th Assessment Report. The use of these data is mostly aimed at: addressing outstanding scien...

Climate Change Service

climate.copernicus.eu

- operational data access
- quality control
- data tutorials

Regional climate projections

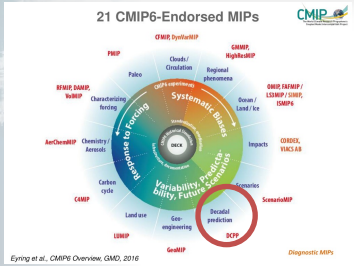


CORDEX regional climate model data on single levels

Dataset | Europe | Atmosphere (surface) | Atmosphere (upper air) | Climate projections

This catalogue entry provides Regional Climate Model (RCM) data on single levels from a number of experiments, models, domains, resolutions, ensemble members, time frequencies and periods computed over several regional domains all over the World in the framework of the Coordinated Regional Climate Downscaling Experiment (CORDEX). The term "single levels" is used to express that the variables are 2...

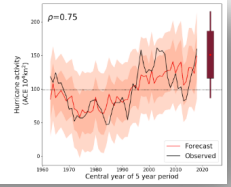
Decadal predictions



CMIP6 predictions underpinning the C3S decadal prediction prototypes

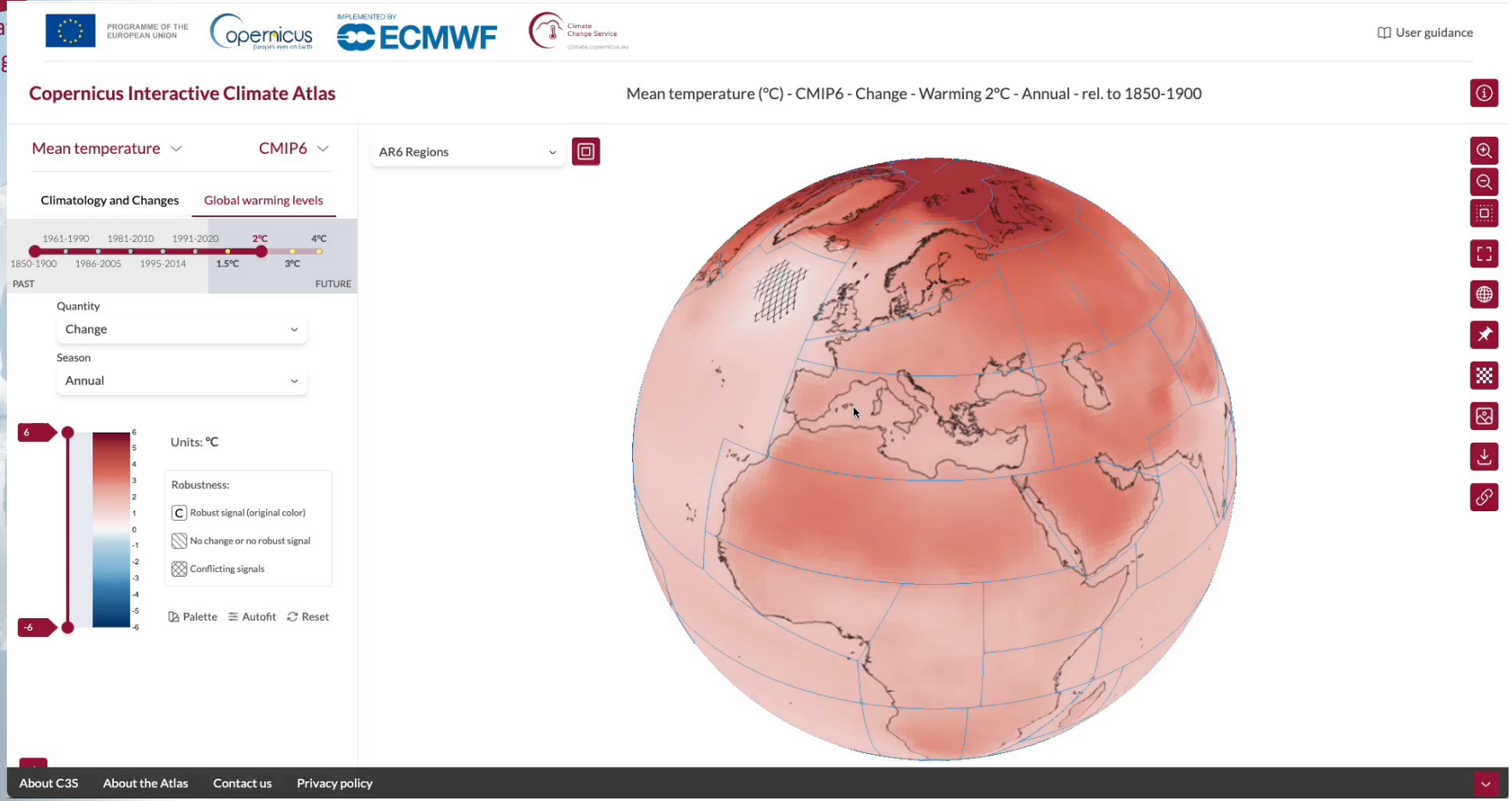
Dataset | Global | Atmosphere (surface) | Atmosphere (upper air) | Climate projections

This catalogue entry provides daily and monthly global climate model data from Decadal Climate Predictions Project (DCPP) experiments, part of the sixth phase of the Coupled Model Intercomparison Project (CMIP6). The decadal data in the Climate Data Store (CDS) are a quality-controlled subset of the full DCPP. CMIP6-DCPP data addresses the ability of the climate system to be predicted on annual, m...



ECMWF

Copernicus Interactive Climate Atlas (C3S Atlas): demo of map features

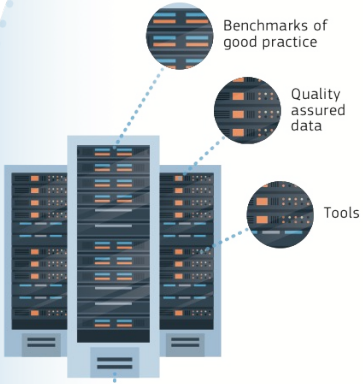


Climate Change

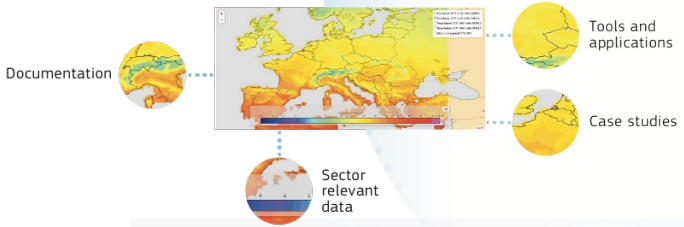
What is the SIS and how it works

USERS

CLIMATE DATA STORE



PRACTICAL EXAMPLES

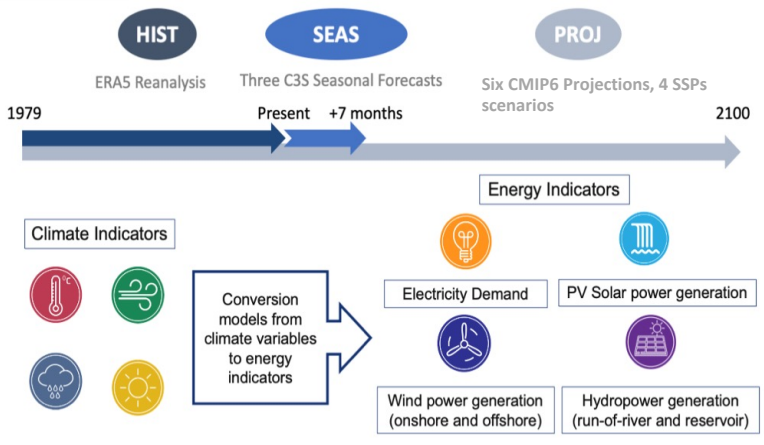


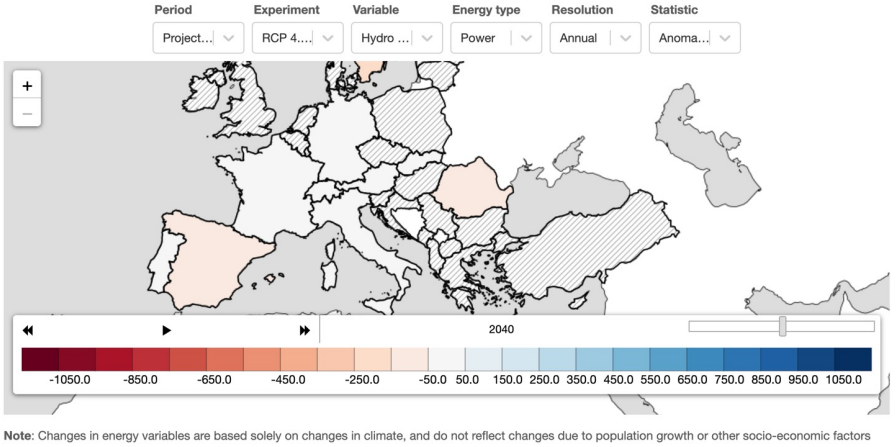
ECMWF Copernicus Europe's eyes on Earth European Commission

Climate Change

European energy and climate data explorer

This application explores climate data over Europe and the **effect of climate change on energy supply and demand**. This is beneficial in anticipating important climate-driven changes in the energy sector for either long-term planning or medium-term operational activities. The application can also be used to **investigate the role of temperature on electricity demand across Europe, as well as its affect on renewable energy generation**.





Note: Changes in energy variables are based solely on changes in climate, and do not reflect changes due to population growth or other socio-economic factors

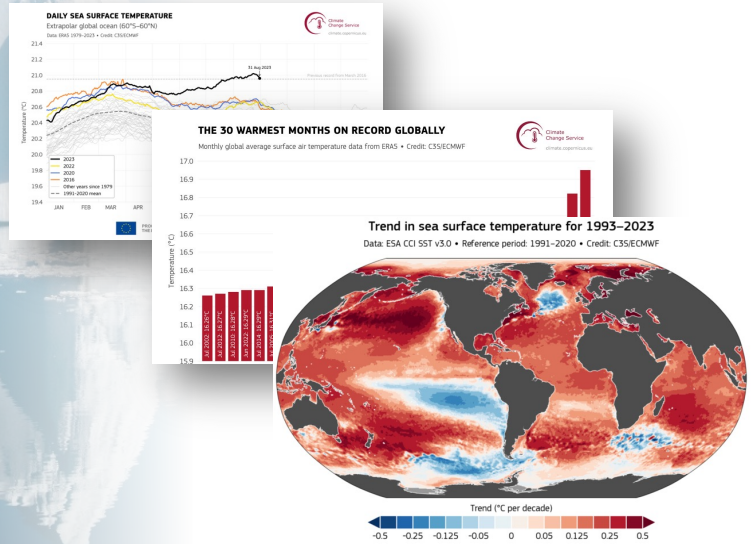
https://climate.copernicus.eu/operational-service-energy-sector

ECMWF Copernicus Europe's eyes on Earth European Commission

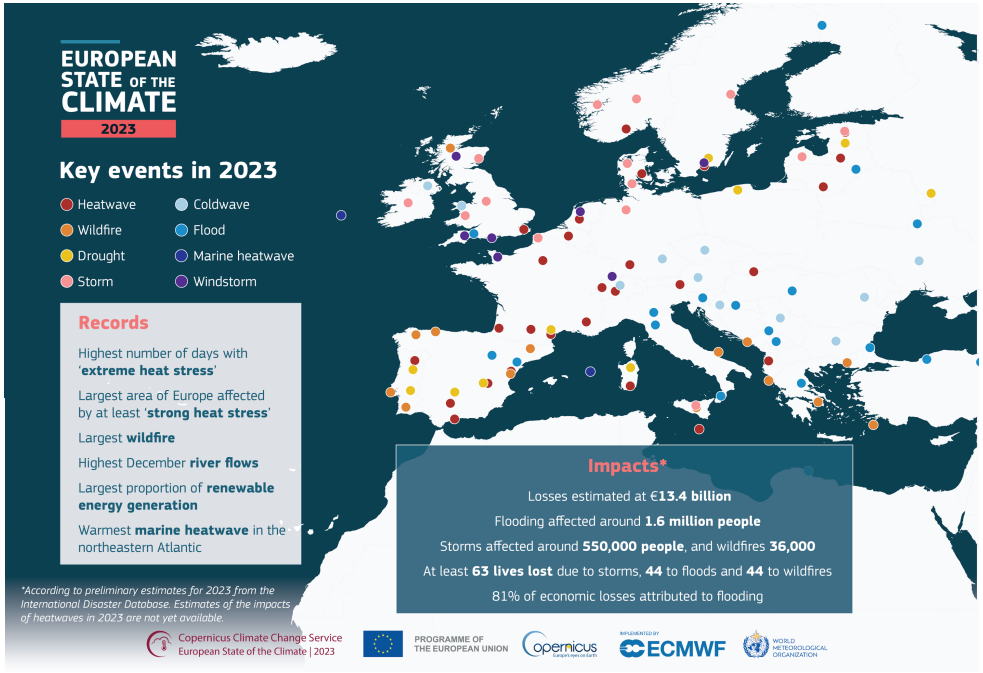
C3S Climate Intelligence component

Climate Change

C3S Climate Intelligence provides information for a broad audience: policy makers, hydrological and meteorological agencies, the press, and the general public



Annual European State of the Climate report



https://climate.copernicus.eu/esotc/2023

Monthly Climate Bulletins: *https://climate.copernicus.eu/climate-bulletins*

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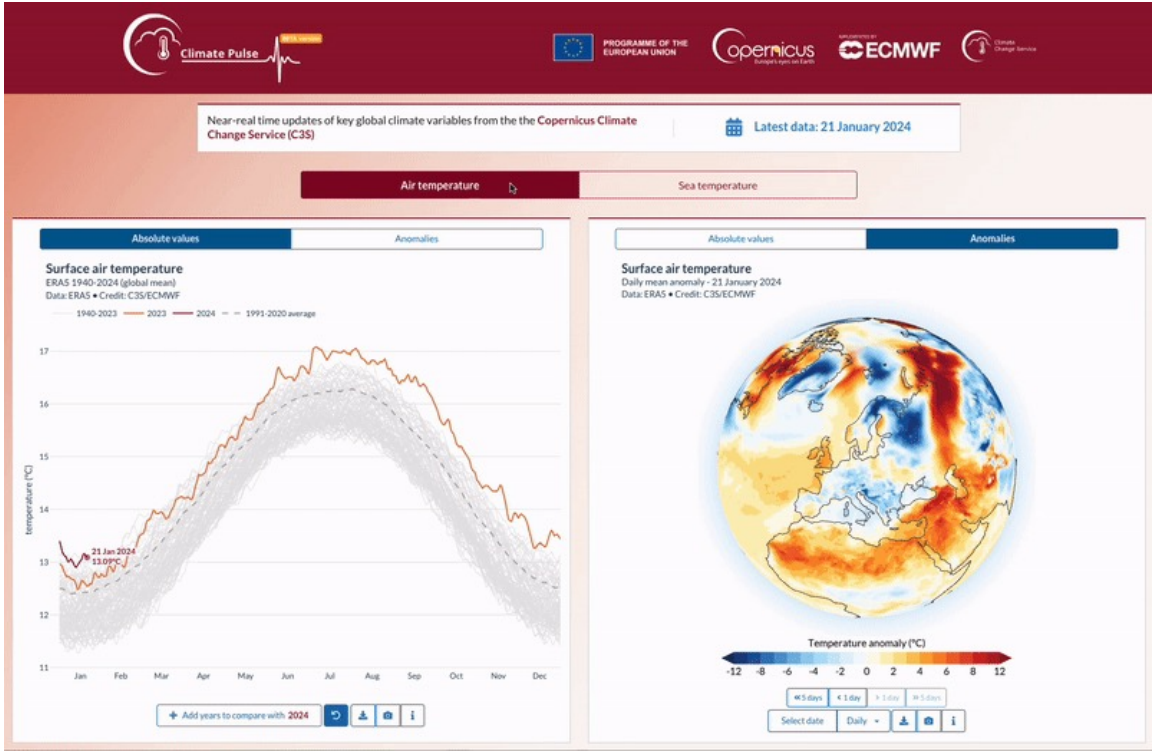
Climate Pulse – A tool for climate monitoring in NRT

Climate Change

Climate Pulse is a new interactive web application developed and maintained by the Copernicus Climate Change Service (C3S) to **make climate monitoring more accessible to a broad audience**. It provides daily charts and maps of global surface air temperature and sea surface temperature updated close to real-time, as well as an archive of past daily, monthly and annual maps.

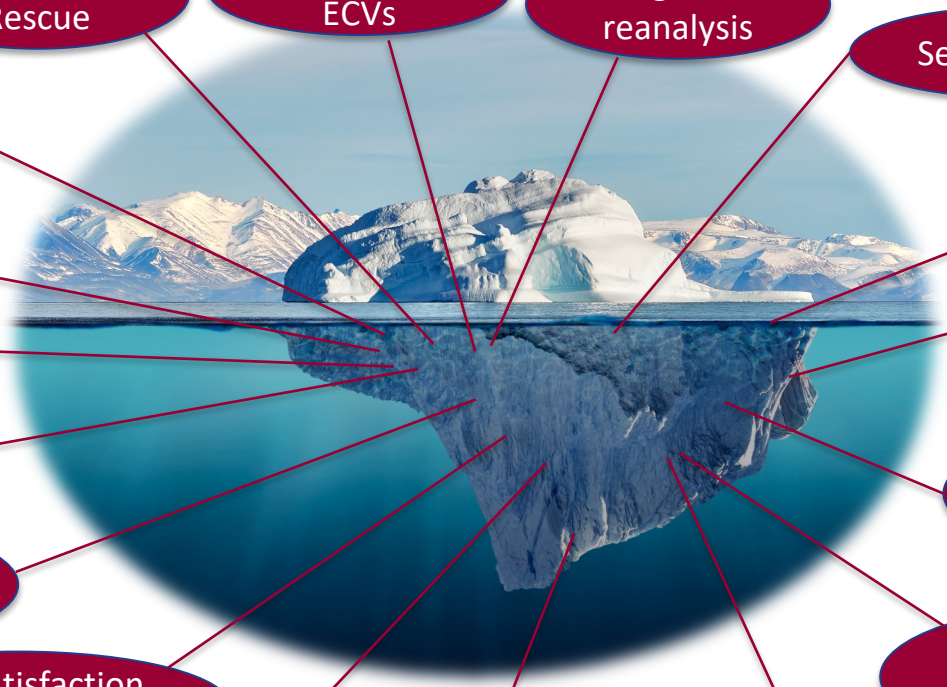


https://pulse.climate.copernicus.eu/

Copernicus Europe's eyes on Earth
European Commission
ECMWF

Climate Change

There is much more than you can see...



Data Rescue

In-situ ECVs

Regional reanalysis

Service Desk

Forum

User support

Mailing list

Knowledge Base

Contractors on support

Workshops, GA

Communications

Climate Intelligence

Engagement with other teams

User satisfaction monitoring

Evaluation & Quality Control

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Toolbox applications

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Thank you for your attention

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