C3S: El Servicio de Cambio Climático de Copernicus

Joaquín Muñoz Sabater
European Centre for Medium-Range Weather Forecasts (ECMWF)

Climate Change

Introducción a los servicios climáticos – Universidad Politécnica de Valencia, 21 July 2023

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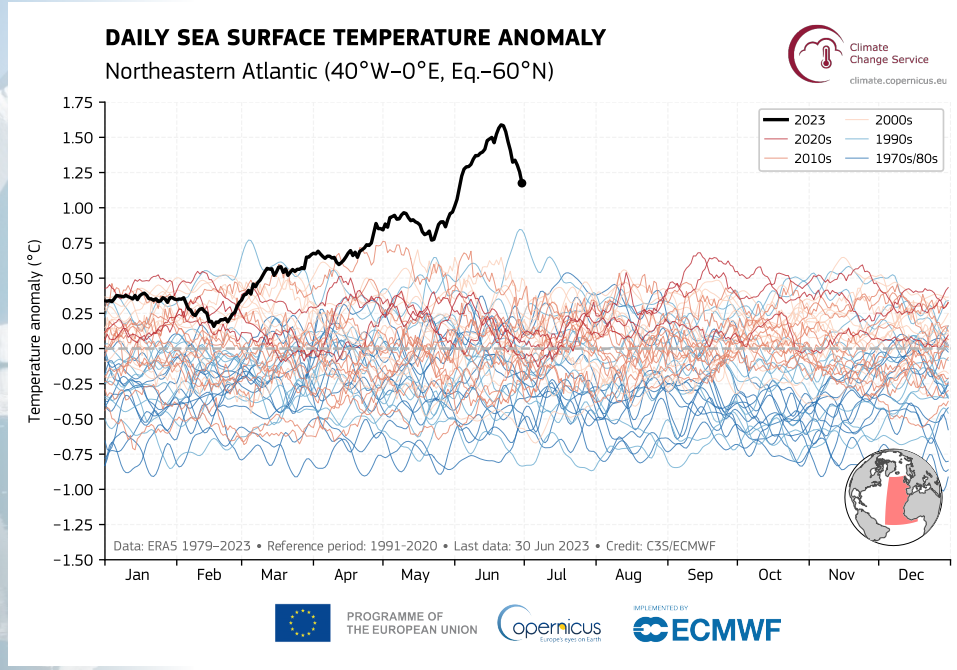
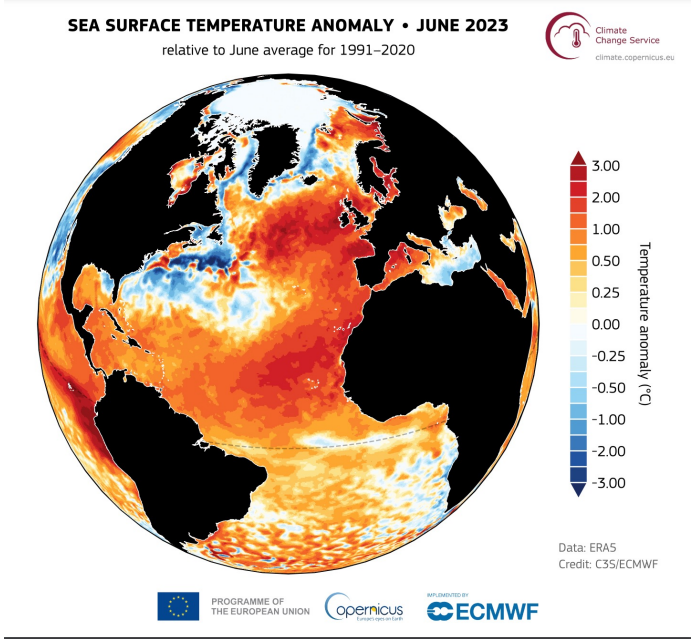
Leaving on uncharted territories

Climate Change





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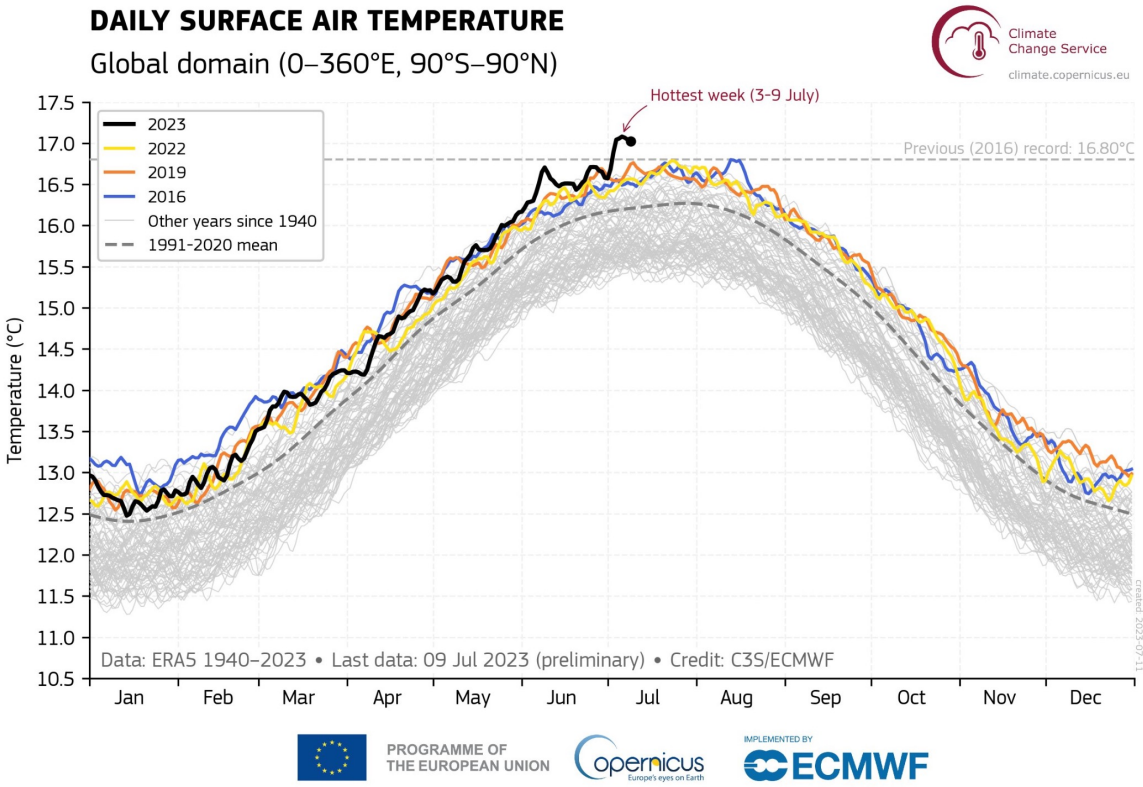
Living on uncharted territories

Climate Change



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IMPLEMENTED BY ECMWF

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Outline

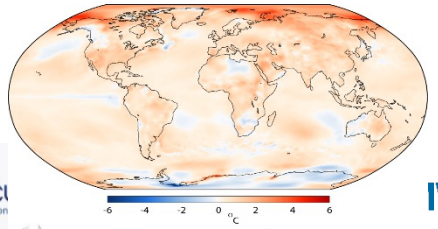
¿ Qué es el Servicio Europeo de Cambio Climático (C3S) ?

¿ Qué productos se ofrecen ?

¿Cómo acceder a los productos de C3S y qué herramientas de apoyo existen ?

¿ Para qué sirven los Sistemas de Información Sectorial (SIS) ?

¿ Algún otro componente en C3S ?



IWF

Abierto, completo, gratuito

1st MFF (2014-2020): ~ 4300 M€

2nd MFF (2021-2027): ~ 5420 M€

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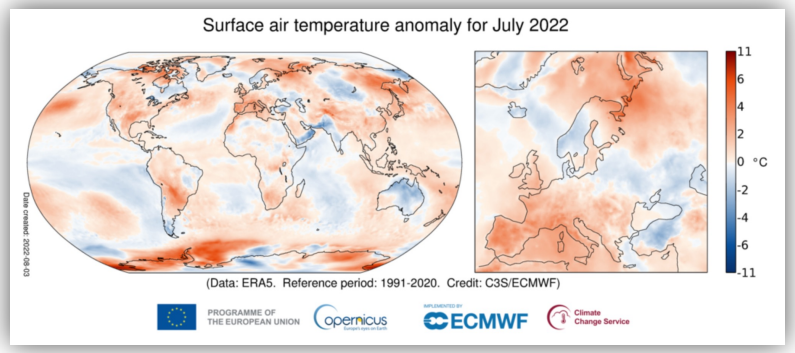
What is the Copernicus Climate Change Service (C3S)?

The **Copernicus Climate Change Service (C3S)** operationally provides information and data in support of **adaptation** decision and **mitigation** policies



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Estructura de C3S

Climate Change

Evaluación & Control Calidad

Garantía de calidad
Integridad del Servicio
Necesidades de usuarios

European commission e.g., H2020, Horizon Europe

EU estados miembros, ESA, EUMETSAT, EEA, WMO..

Divulgación & difusión

Climate Data Store

Sistemas de Información Sectorial

ENERGY · WATER MANAGEMENT · INSURANCE · AGRICULTURE & FORESTRY · INFRASTRUCTURE

Usuarios & stakeholders

Copernicus · European Commission · ECMWF

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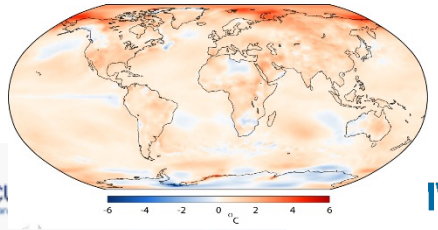

IWF

The Climate Data Store – ‘A one stop shop for climate data’

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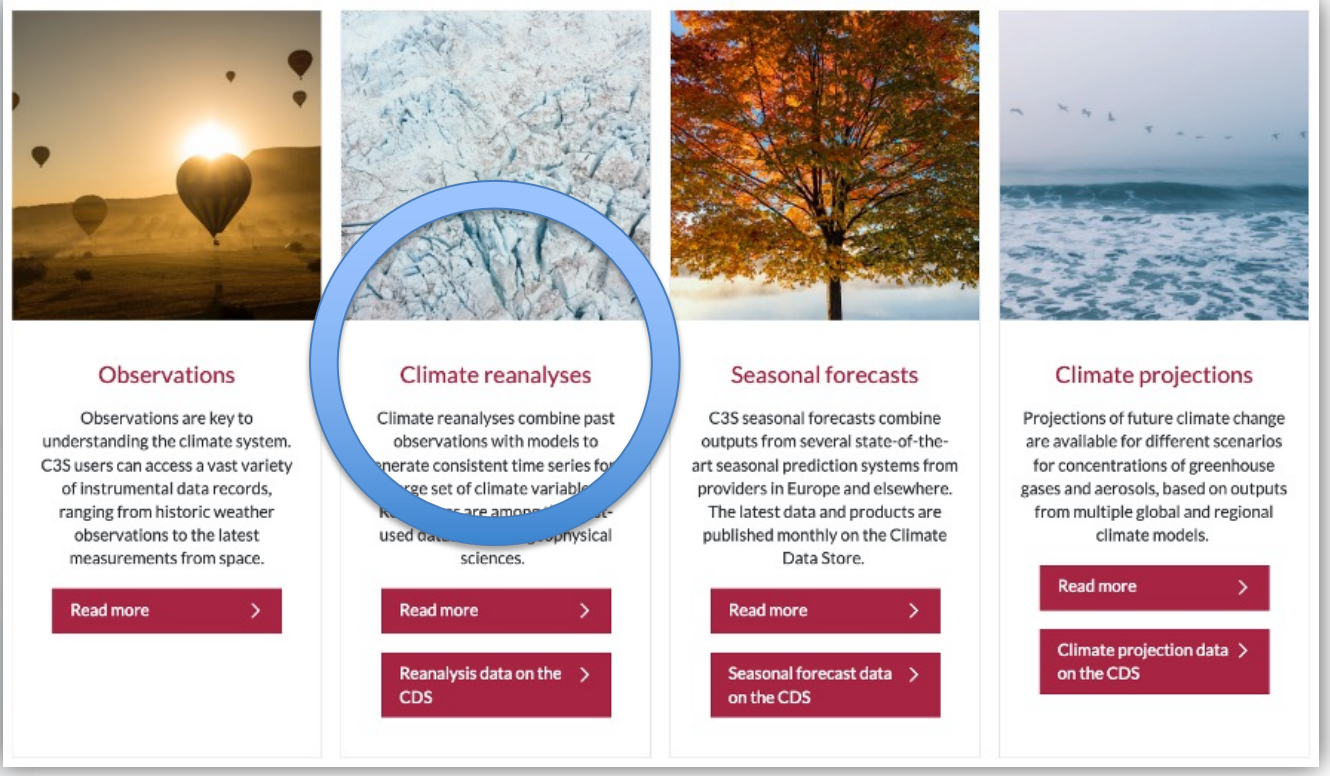

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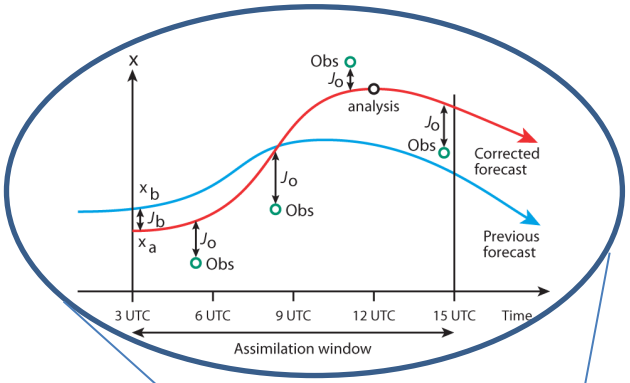
What is the reanalysis?

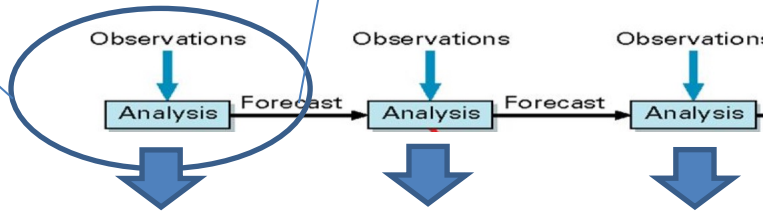
Climat
Chang

MODELING

OBSERVATIONS



Data assimilation & reanalysis
Combining information from observations and models to provide an estimate of weather and climate over multi-decadal timescales



Types: **Global (ERA5)** **Regional (CARRA & UERRA)** **Specialized (ERA5-Land)**

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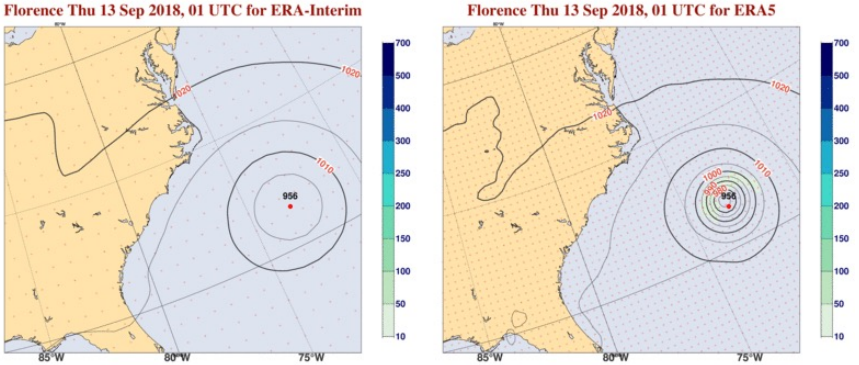
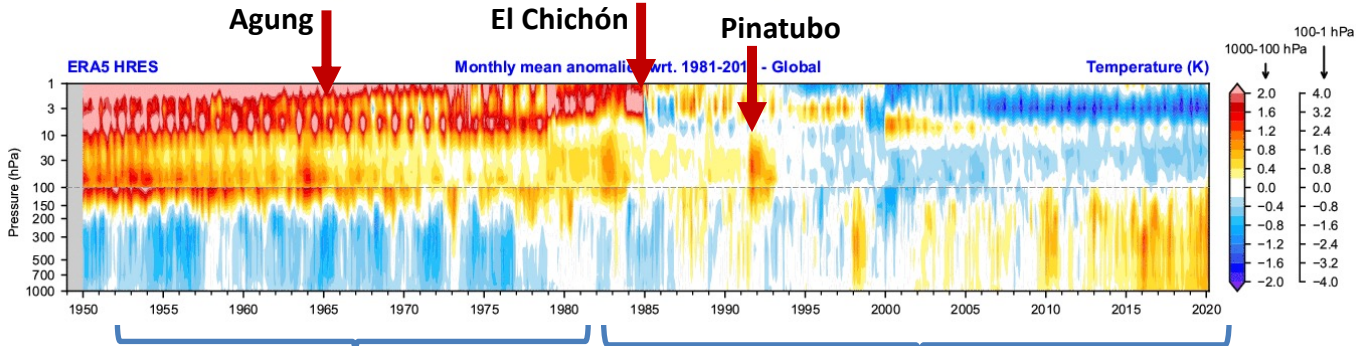
Maps without gaps: global atmospheric reanalysis ERA5

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





1950 – 1979
Preliminary (published end 2020)

1979 – present
Complete. NRT stream

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

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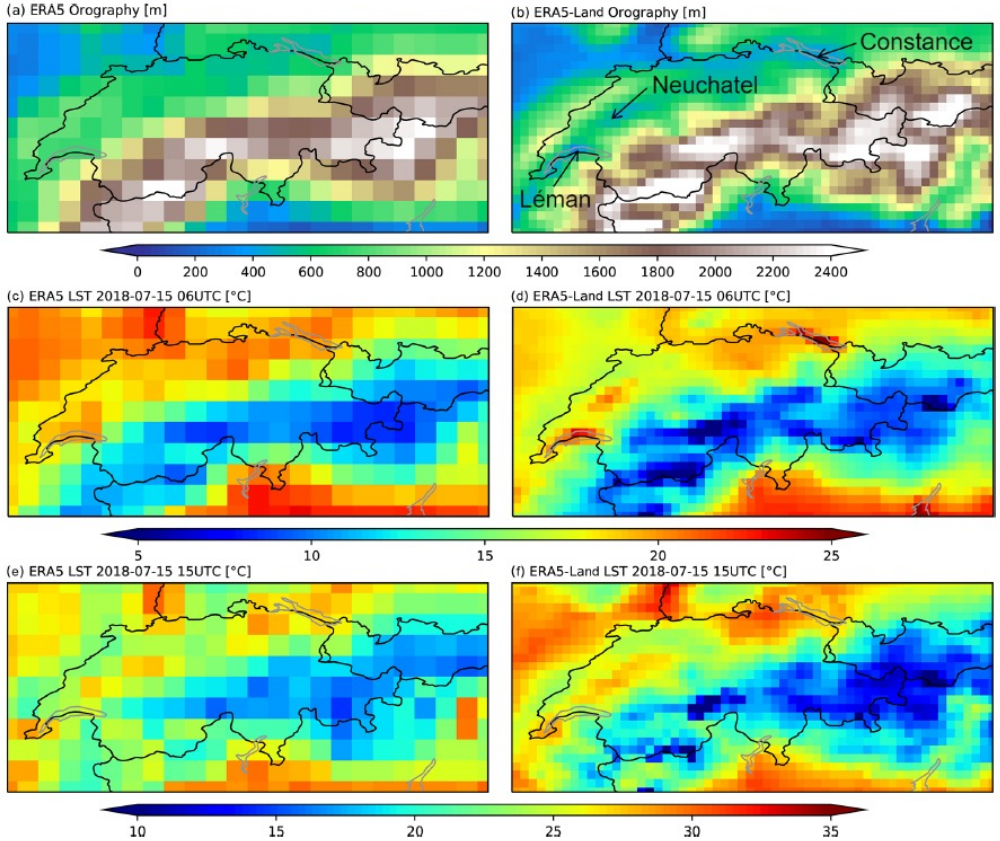
High-resolution and consistency for the land evolution: ERA5-Land (1950-present)

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
NRT stream – daily data

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

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Regional reanalyses - Why do we need them?

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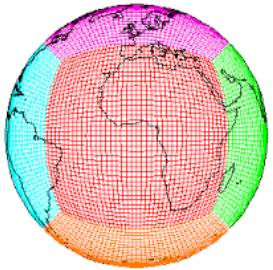
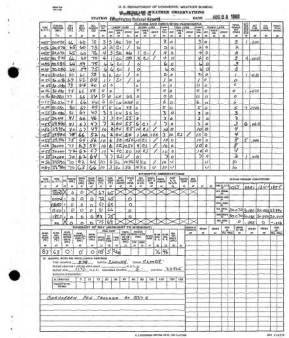


Global reanalyses

+



local observations

Regional models at higher horizontal resolution

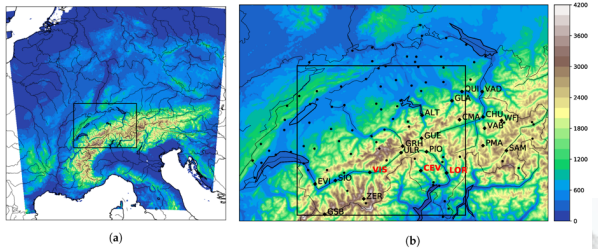
- 2.5 km in the Arctic or 5.5 km for Europe
- Wind field better account for to the local orography
- More detailed description of extreme events.

Additional (local) observations

- Local surface observations and slightly different treatment of satellite data where possible

Better description of surface characteristics

- Sea surface temperature, sea ice concentration, glacier albedo, snow cover for the Arctic
- Additionally, orography and soil information and vegetation on 1 km resolution for Europe



C3S regional reanalyses: domains (left: Europe, right: European part of the Arctic)

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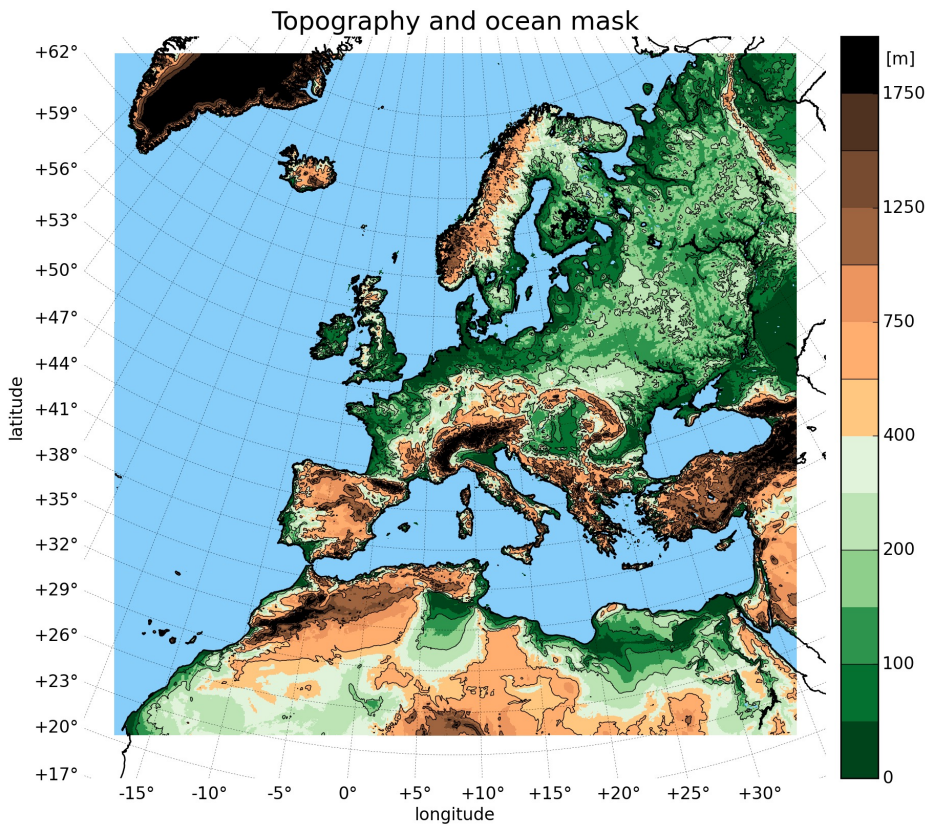
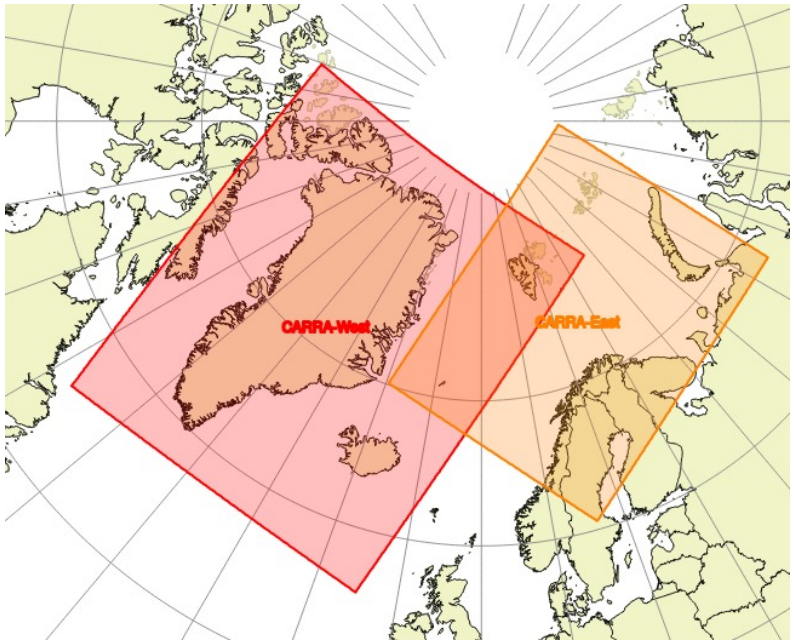
UERRA



CARRA



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Reanalysis; a tool for outreach ESOTC 2022

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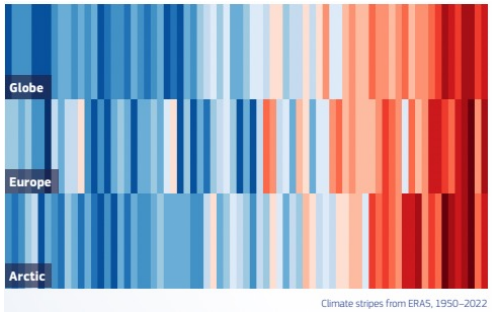
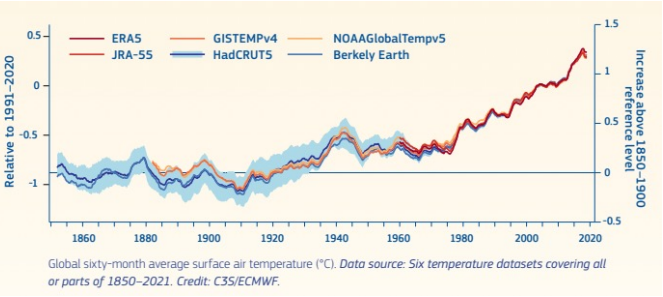


Climate stripes from ERA5, 1950–2022



Global sixty-month average surface air temperature (°C). *Data source: Six temperature datasets covering all or parts of 1850–2021. Credit: C3S/ECMWF.*

Since 1850—1900, an increase in surface air temperature of around

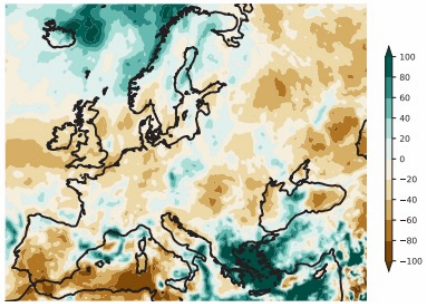
Globe
+1.2°C ↗

Europe
+2.2°C ↗

Arctic
+3°C ↗

Precipitation

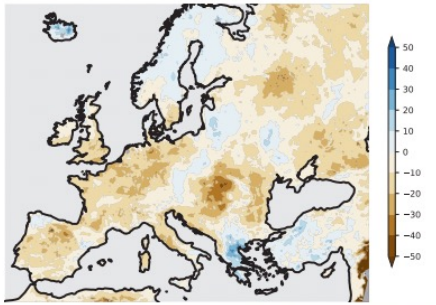
A lack of precipitation contributed to widespread drought conditions.



Precipitation anomalies (%) for summer (JJA) 2022, expressed as a percentage of the seasonal average for the 1991–2020 reference period. *Data source: ERA5. Credit: C3S/ECMWF.*

Soil moisture

Soil moisture conditions were the second lowest in the last 50 years.



Soil moisture anomalies (%) in the top soil layer for summer (JJA) 2022, expressed as a percentage of the seasonal average for the 1991–2020 reference period. *Data source: ERA5-Land. Credit: C3S/ECMWF.*

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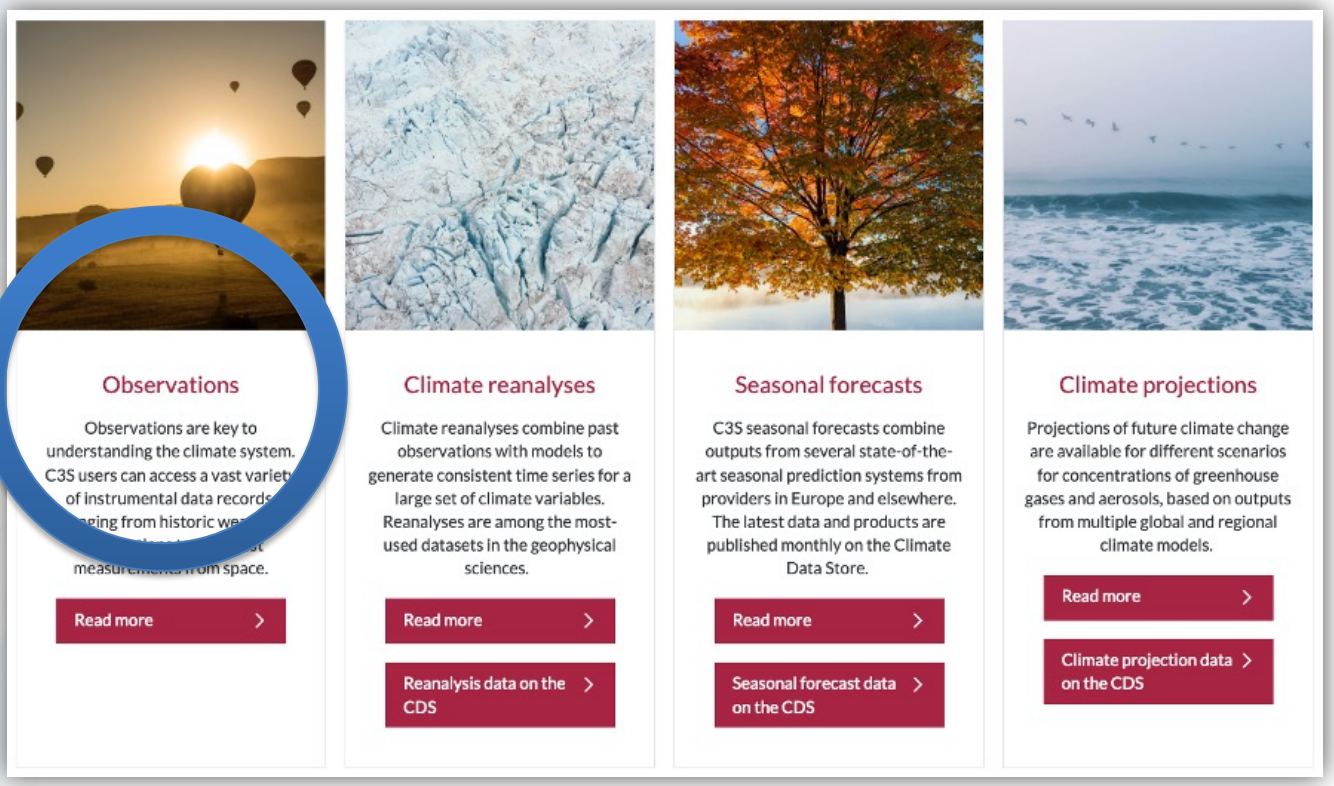
The Climate Data Store – ‘A one stop shop for climate data’



Observations

Observations are key to understanding the climate system. C3S users can access a vast variet of instrumental data records ging from historic we measur from space.

Read more

Climate reanalyses

Climate reanalyses combine past observations with models to generate consistent time series for a large set of climate variables. Reanalyses are among the most-used datasets in the geophysical sciences.

Read more

Reanalysis data on the CDS

Seasonal forecasts

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Climate projections

Projections of future climate change are available for different scenarios for concentrations of greenhouse gases and aerosols, based on outputs from multiple global and regional climate models.

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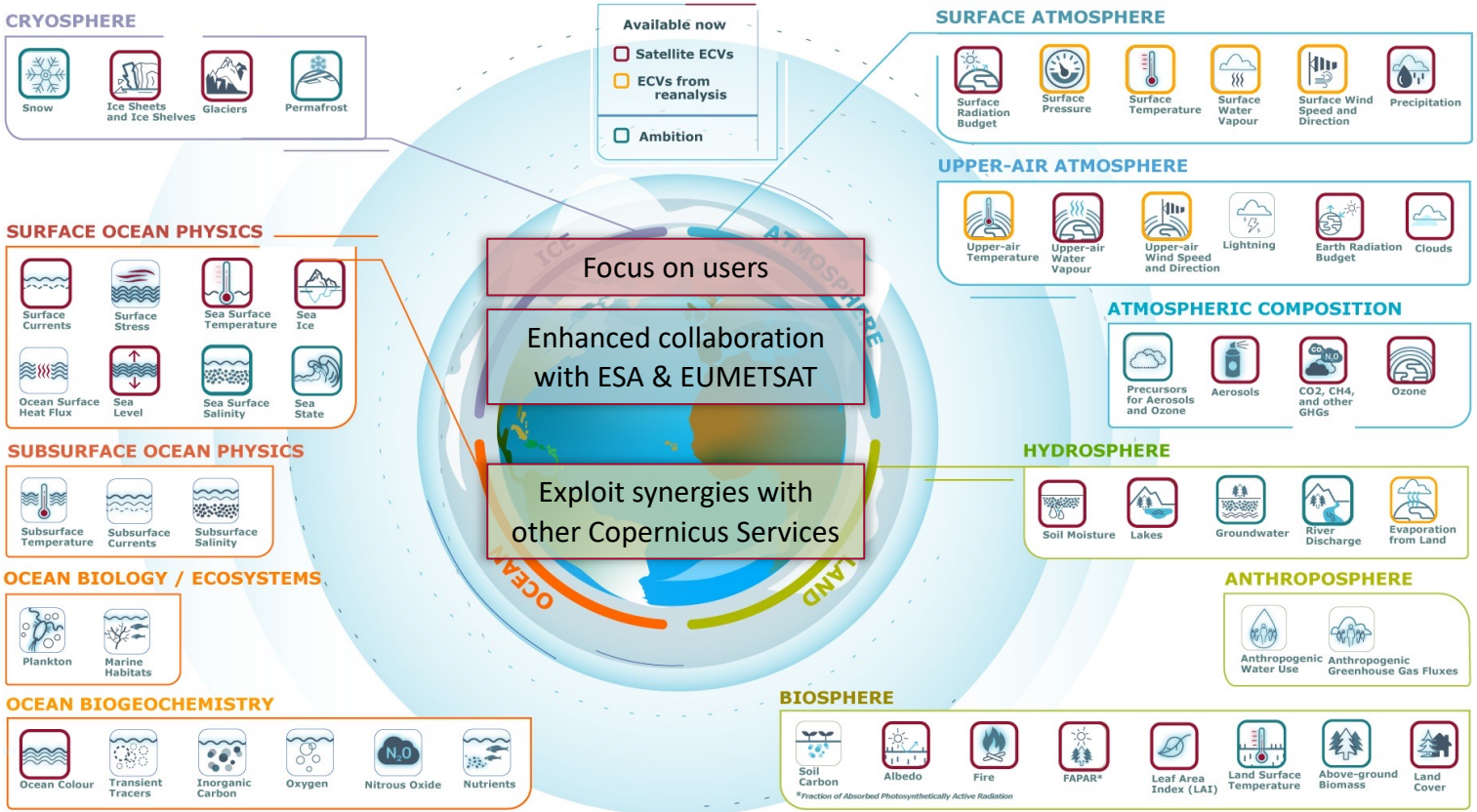
What is the climate system?



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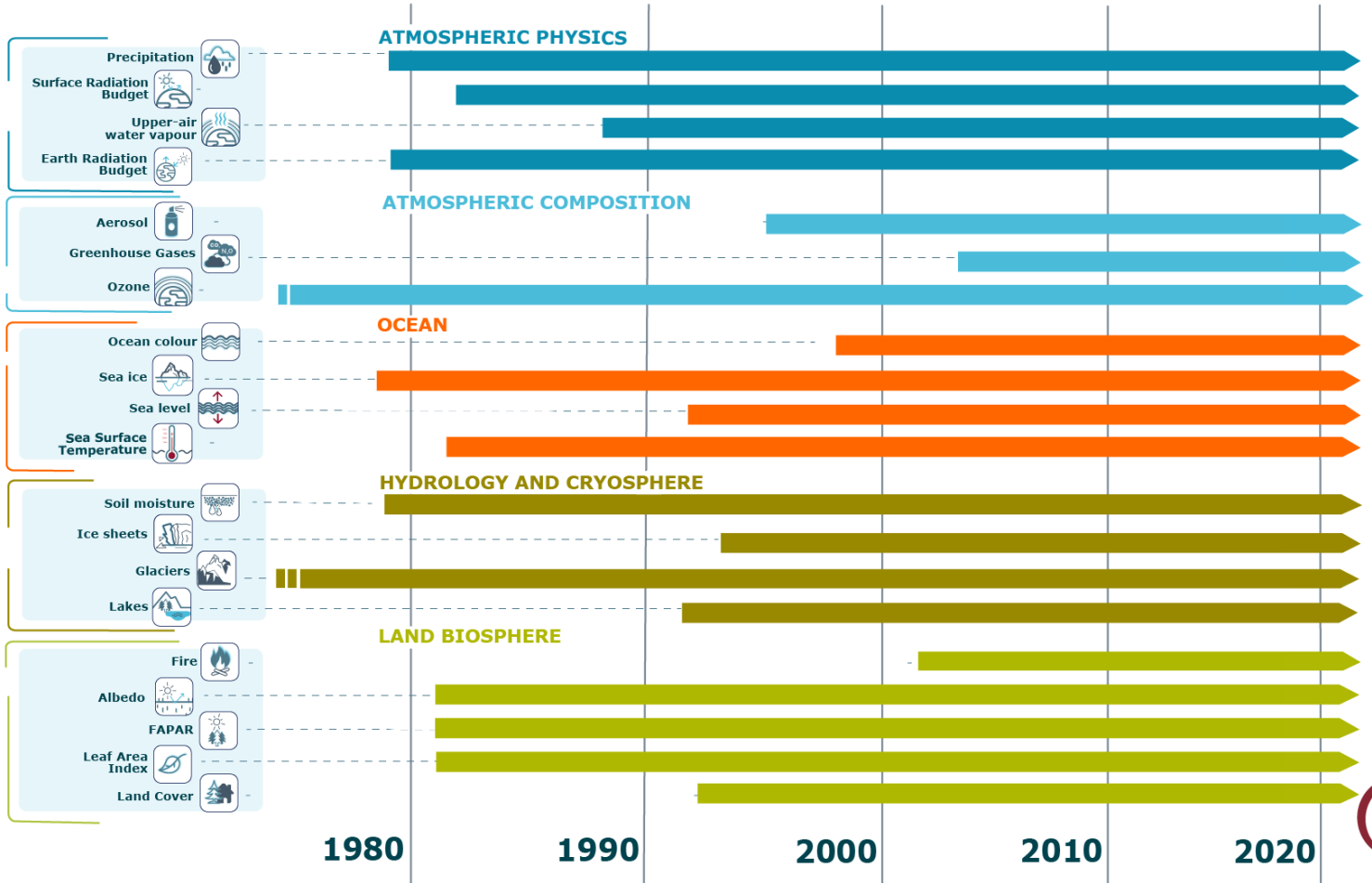
Satellite ECV data records



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

EUMETSAT

esa

Mainly use **Sentinel-3** data

Future use of other Sentinel data

Climate Change Service

climate.copernicus.eu

Climate information and indicators based on satellite ECV data records

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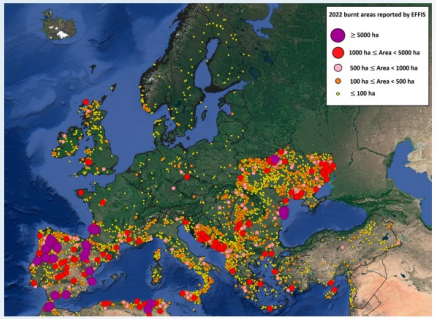
Wildfires

1991–2020

Second largest burnt area on record across the EU countries.



Distribution and extent of burnt areas across Europe and the Mediterranean in 2022. *Data source: European Forest Fire Information System (EFFIS). Credit: EFFIS/Copernicus EMS.*

Glaciers

Both globally and across Europe, glaciers, distinct from the two ice sheets in Greenland and Antarctica, have seen a substantial and prolonged loss of ice since the mid-19th Century. This loss has intensified since around the 1990s. Melting of ice from glaciers has contributed to more than 3 cm of global sea level rise.

Glacier ice loss

Global
>8600 km³ since 1997

Europe
>960 km³ (excluding Greenland) since 1997

5.4 times the height of the Eiffel Tower

RECORD LOSS OF GLACIER ICE EUROPEAN ALPS IN 2022

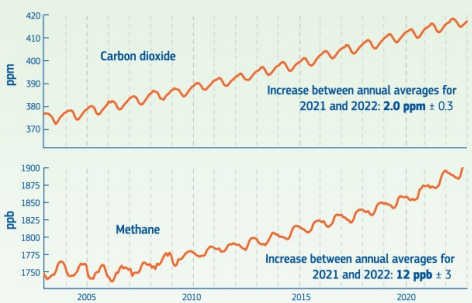
more than **5 km³**

In 2022, the annual average concentrations of greenhouse gases were

CO_2
+417 ppm

CH_4
+1894 ppb

Concentrations (column-averaged mixing ratios) for CO_2 and CH_4 covering 2003–2022.



Monthly averaged atmospheric concentrations of carbon dioxide (CO_2) and methane (CH_4). Data are derived from satellite measurements and averaged over the whole atmospheric column and for 60°S–60°N. *Data source: C3S/Obs4MIPs (v4.4) consolidated (2003–2021) and CAMS preliminary near real-time data (2022) records. Credit: C3S/CAMS/ECMWF/University of Bremen/SRON.*

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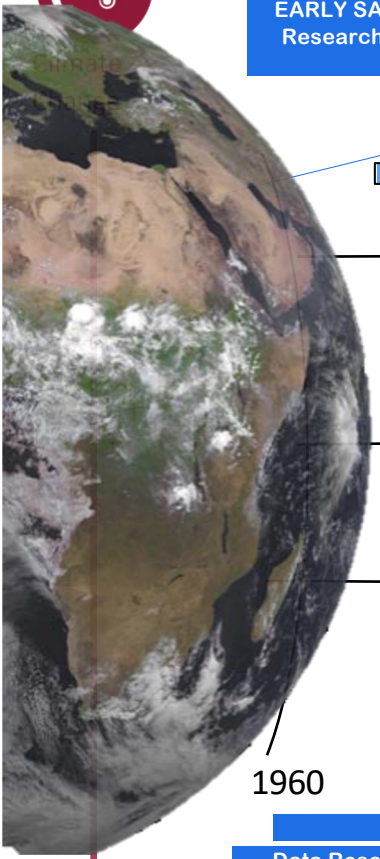
Satellite data rescue



EARLY SATELLITE ERA (pre-1979)
Research satellites (NIMBUS 1-7, NOAA)

MODERN ERA (1979-2000)
operational Satellites (NOAA, DMSP, GOES, METEOSAT)

Data not yet assimilated

Data assimilated in ERA5

1979

THIR /N4-7
HRIR/N1-3
MRIR /N2-3
SCR/N4-5
HIRS/1/N 6
SIRS/N3-4
PMR/N
IRIS/N3-4
VTPR/NOAA2-5
SSH/DMSP F1-F4
ITPR/N5
NEMS/N5
SCAMS/N 6
ATS
SMS-1,2
SSU/TIROS_N/NOAA 6-14
HIRS/2-4
IMG/ADEOS
SMMIS/DMSP F16-19
MSU/TIROS-N-NOAA6-14
SSM/T-2/DMSP F11-15
SSM/T-1/DMSP F4, F7-F15
SMMR/SEASAT-N7
SSM/I/DMSP F4, F7-F15
MVIRI+SEVIRI
GMS
AVHRR/POES
GOES 1-15

1960 1970 1980 1990 2000

Infrared Imagers

Infrared Sounders

Microwave Sounders/ Imagers

Geostationary + Atmospheric Motion Vecto

Reprocessing (recalibration, navigation, ...), quality assessment

Data Rescue: decoding original data, reformatting, archiving & QC

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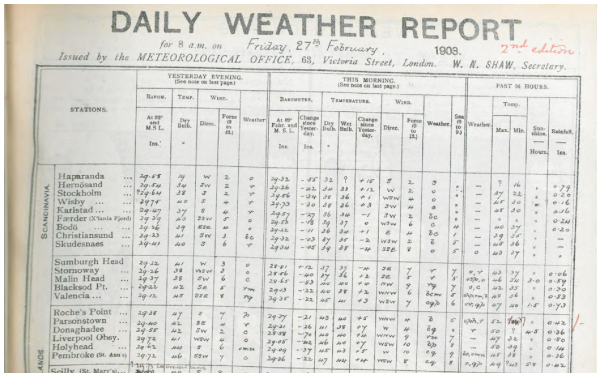
Importance of data rescue

GREAT STORM, FEBRUARY 27, 1903.
Phœnix Park—2,948 Trees blown down (1,242 Forest Trees, 1,706 Thorns).



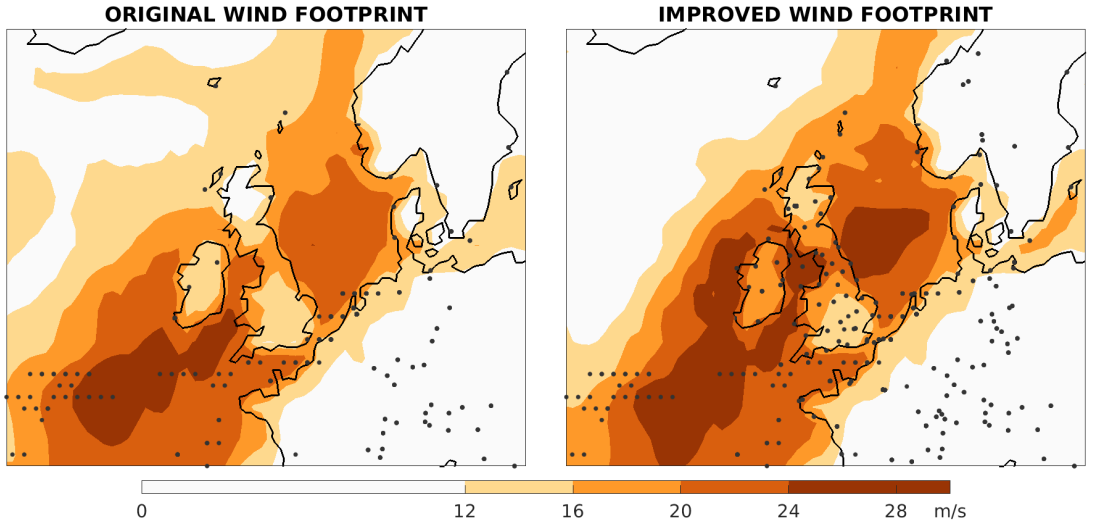
DAILY WEATHER REPORT

for 8 a.m. on Friday, 27th February, 1903. 2nd edition

Issued by the METEOROLOGICAL OFFICE, 63, Victoria Street, London. W. N. SHAW, Secretary.

'Ulysses' windstorm of February 1903, which hit Ireland and UK

- Data for many European locations rescued from paper.



- Wind footprint in a reanalysis of the event was not severe enough to cause known damage. Adding rescued data (new black dots) produced a credible reanalysis of the storm.

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C3S seasonal prediction: components

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DATA PRODUCTS

cds.climate.copernicus.eu

- Datasets available in the Climate Data Store:

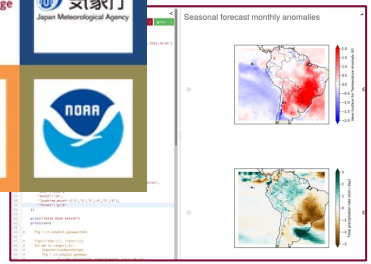
atmosphere

- daily and subdaily data (6h, 12h, 24h)
- monthly statistics (mean, max, min and 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

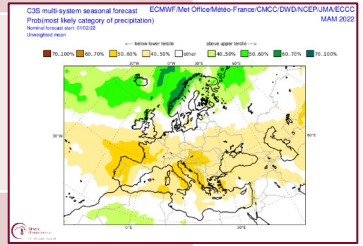


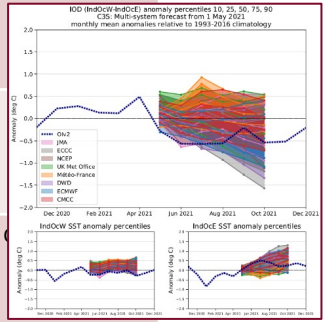
CDS Toolbox

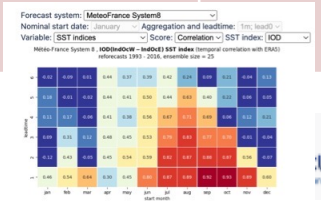
GRAPHICAL PRODUCTS

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

Source	Individual contributing systems Multi-system combination
Variables	Total precipitation Near-surface temperature Mean sea-level pressure Sea surface temperature Geopotential height at 500 hPa Temperature at 850 hPa
2D Maps - Global - Predefined regions	Ensemble mean anomaly Probabilities exceed quantiles: Median Terciles Quintiles
Time series - SST NINO regions - SST Indian Ocean - Wind at 10hPa	Ensemble members Percentiles Probabilities
Verification diagnostics	For graphical products published by C







European Commission

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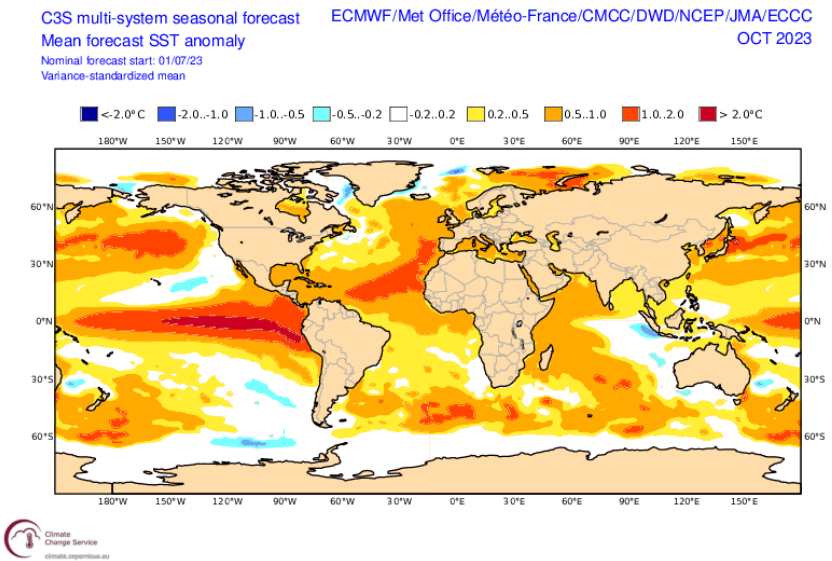
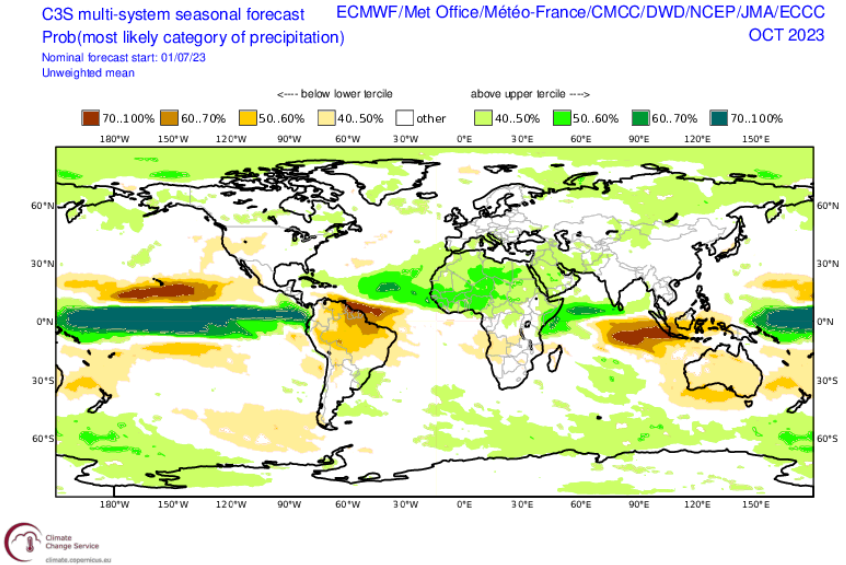
Climate Predictions – Seasonal Forecasts





Climate Change

The Climate Data Store – ‘A one stop shop for climate data’

Observations

Observations are key to understanding the climate system. C3S users can access a vast variety of instrumental data records, ranging from historic weather observations to the latest measurements from space.

Read more >

Climate reanalyses

Climate reanalyses combine past observations with models to generate consistent time series for a large set of climate variables. Reanalyses are among the most-used datasets in the geophysical sciences.

Read more >

Reanalysis data on the CDS >

Seasonal forecasts

C3S seasonal forecasts combine outputs from several state-of-the-art seasonal prediction systems from providers in Europe and elsewhere. The latest data and products are published monthly on the Climate Data Store.

Read more >

Seasonal forecast data on the CDS >

Climate projections

Projections of future climate change are available for different scenario for concentrations of greenhou and aerosols, based on ts ltiple global onal

Read more >

Climate projection data on the CDS >

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Global climate projections

Climate Change

CMIP6 projections (CMIP5 data were in the CDS since 2018) published and updated in the CDS: https://cds.climate.copernicus.eu/cdsapp#!/dataset/projections-cmip6

- **This dataset is underpinning the IPCC AR6 report**
- **Compute processes are activated like temporal and spatial (horizontal and vertical) subsetting → reduction of data volumes**
- **Soon: CMIP6 decadal predictions to be published**

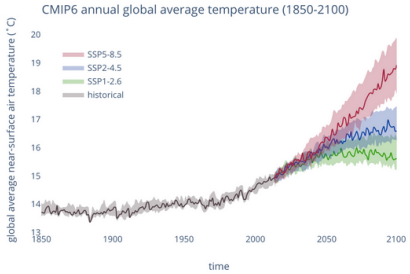
CMIP6 climate projections

Overview | Download data | Documentation

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 scientific questions that arose as part of the IPCC reporting process;
- improving the understanding of the climate system;
- providing estimates of future climate change and related uncertainties;
- providing input data for the adaptation to the climate change;
- examining climate predictability and exploring the ability of models to predict climate on decadal time scales;
- evaluating how realistic the different models are in simulating the recent past.



Contact

copernicus-support@ecmwf.int

Licence

CMIP6 - Data Access - Terms of Use

Publication date

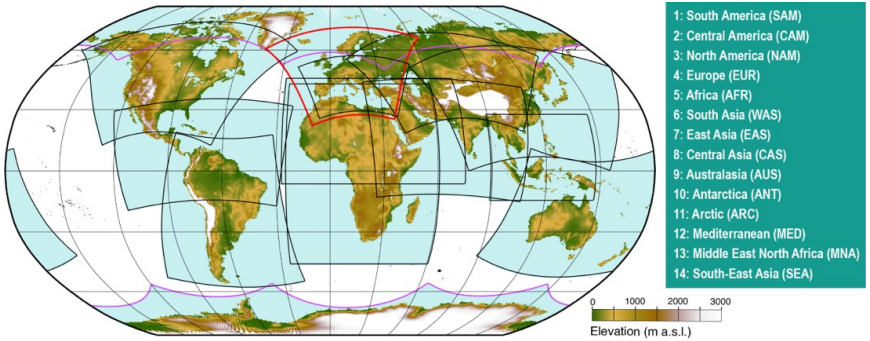
2021-03-23

References

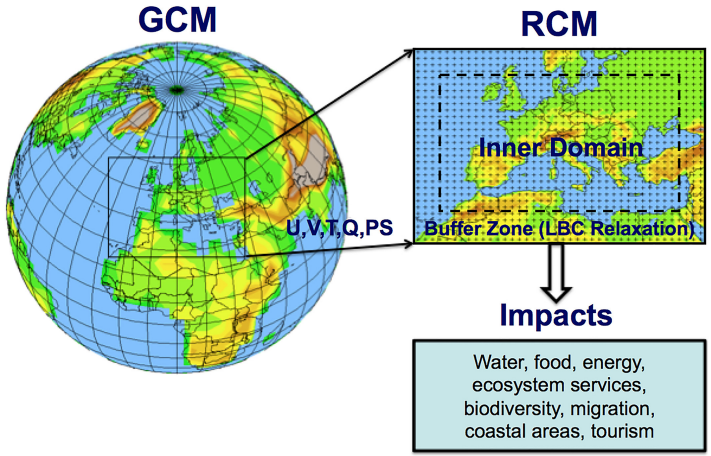
DOI: 10.24381/cds.d7eaec3d

Climate Change

Regional climate projections: Europe and beyond



New CORDEX simulations including high resolution EURO-CORDEX simulations and world-wide simulations for all 14 CORDEX domains published in the CDS



World-wide simulations: connected and aligned to the IPCC Climate Atlas.

Very large ensemble for Europe (130 simulations about half of which was funded by C3S)

Copernicus European Commission ECMWF

Climate Change

Outline

¿ Qué es el Servicio Europeo de Cambio Climático (C3S) ?

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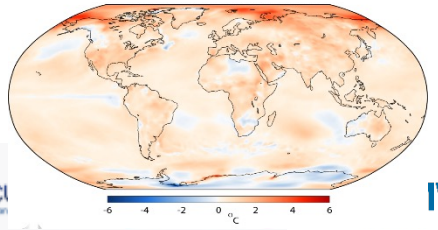
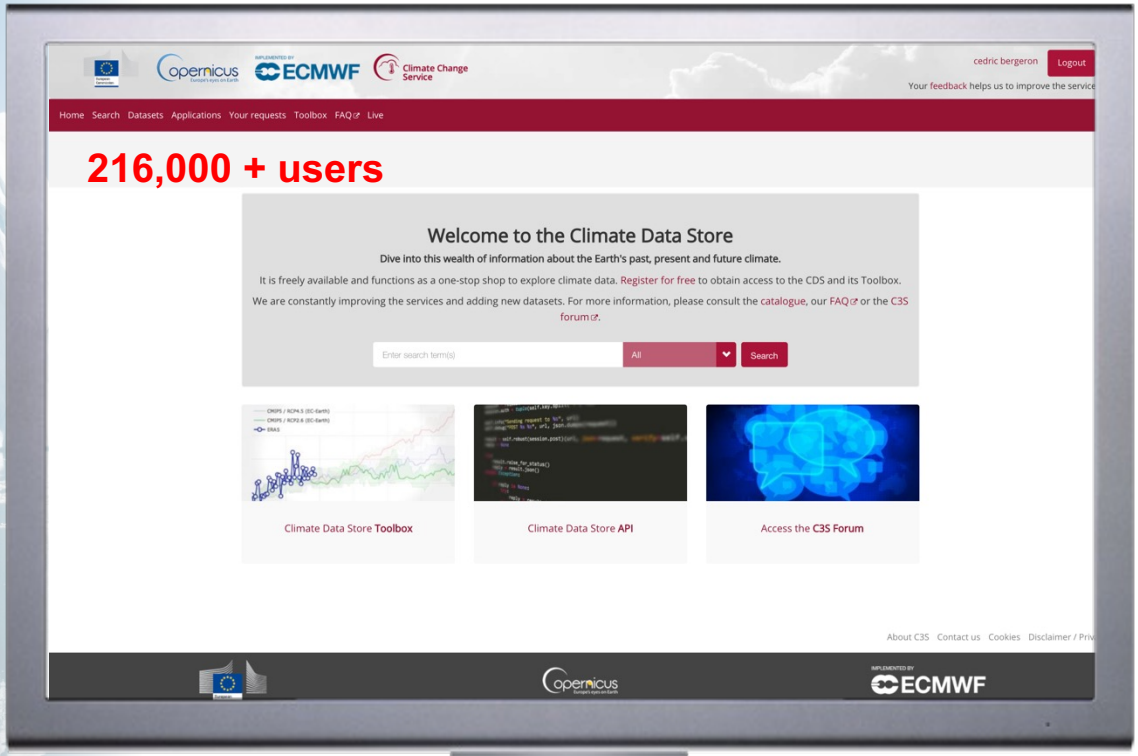


IWF

The Climate Data Store

Climate Change



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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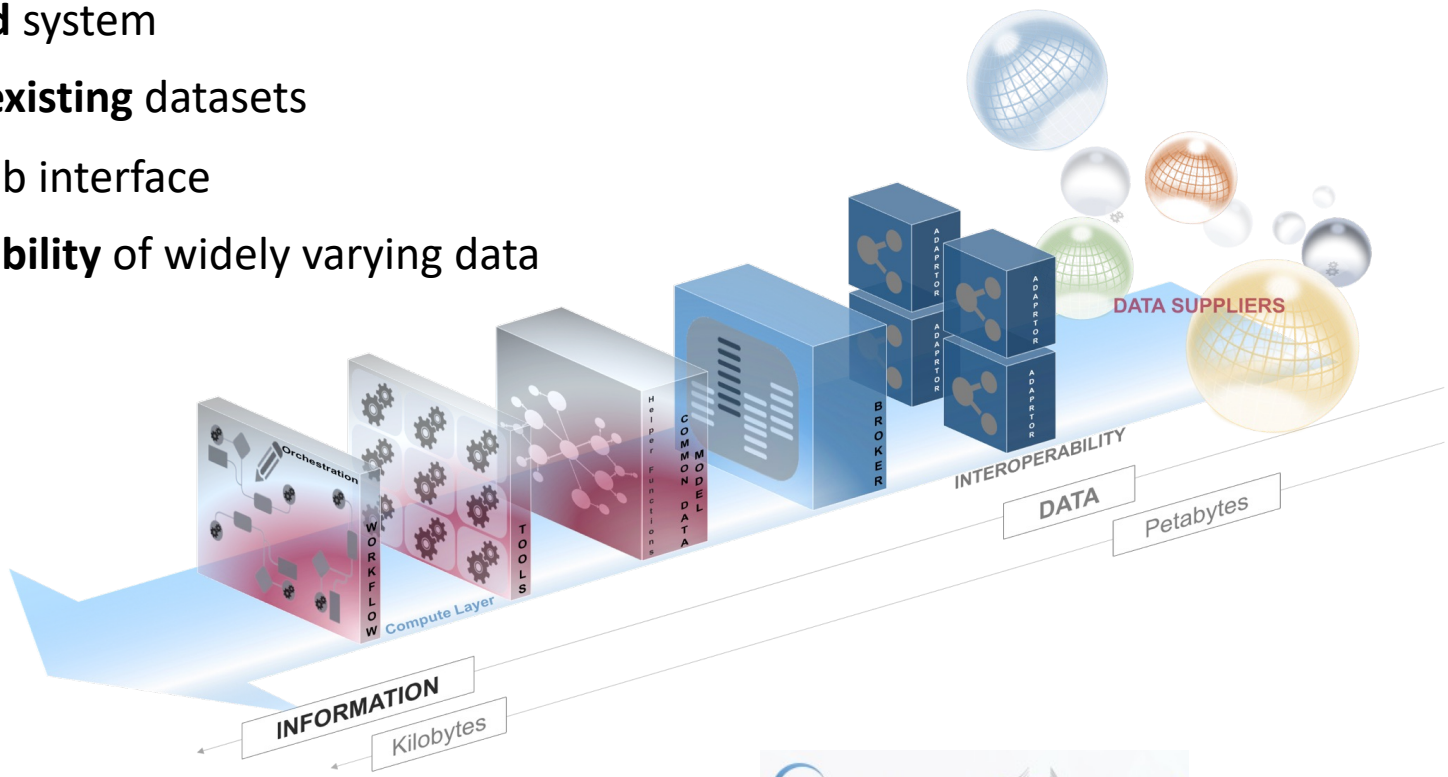
The Climate Data Store

Climate Change

- **distributed** system
- access to **existing** datasets
- **unified** web interface
- **interoperability** of widely varying data



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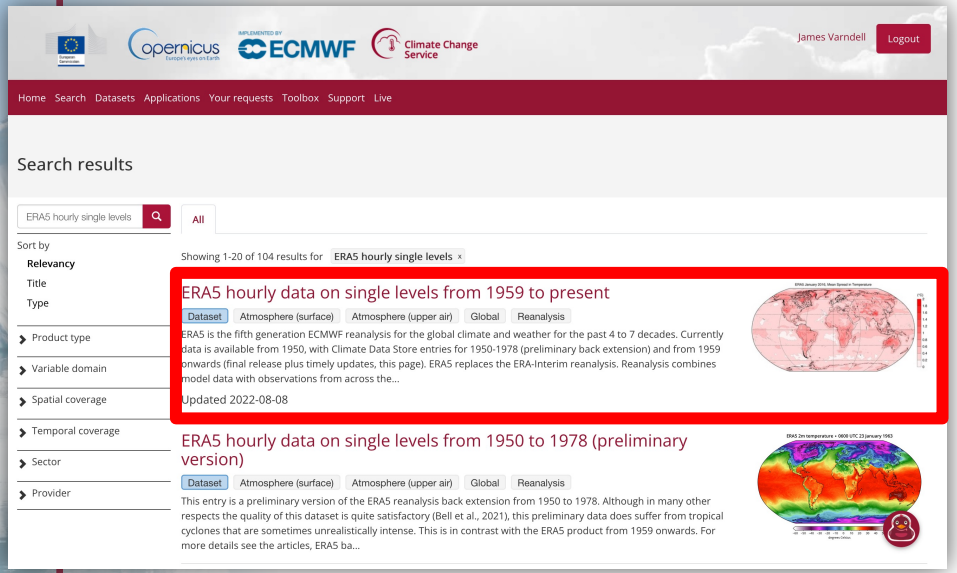
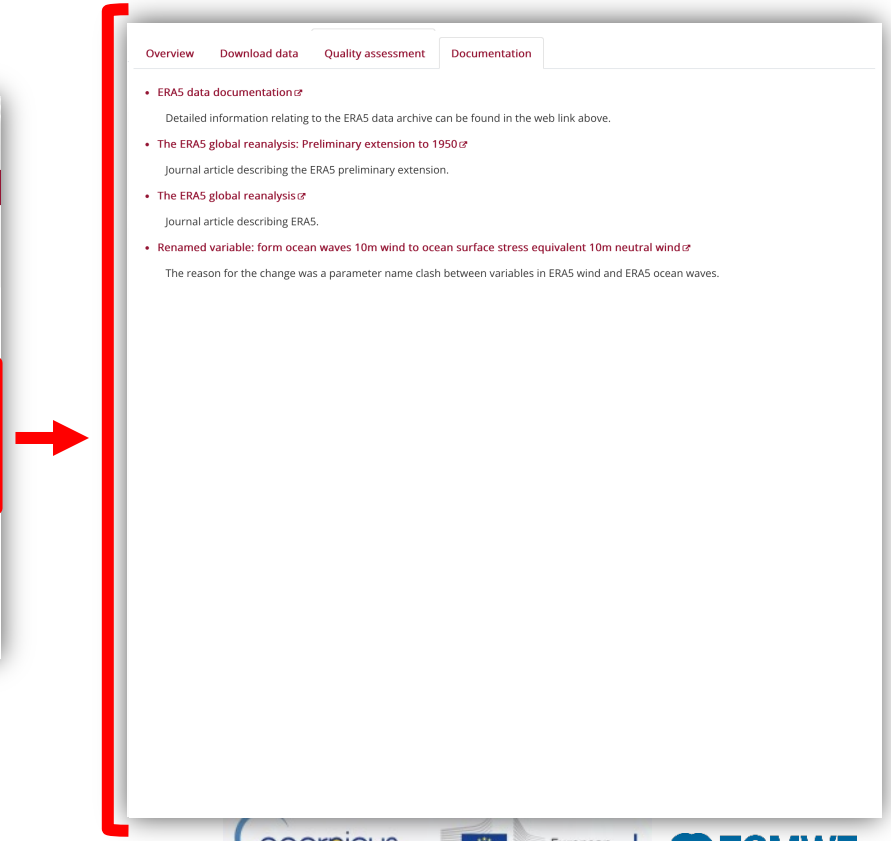
The Climate Data Store

Climate Change





Simplicity and **consistency** are key

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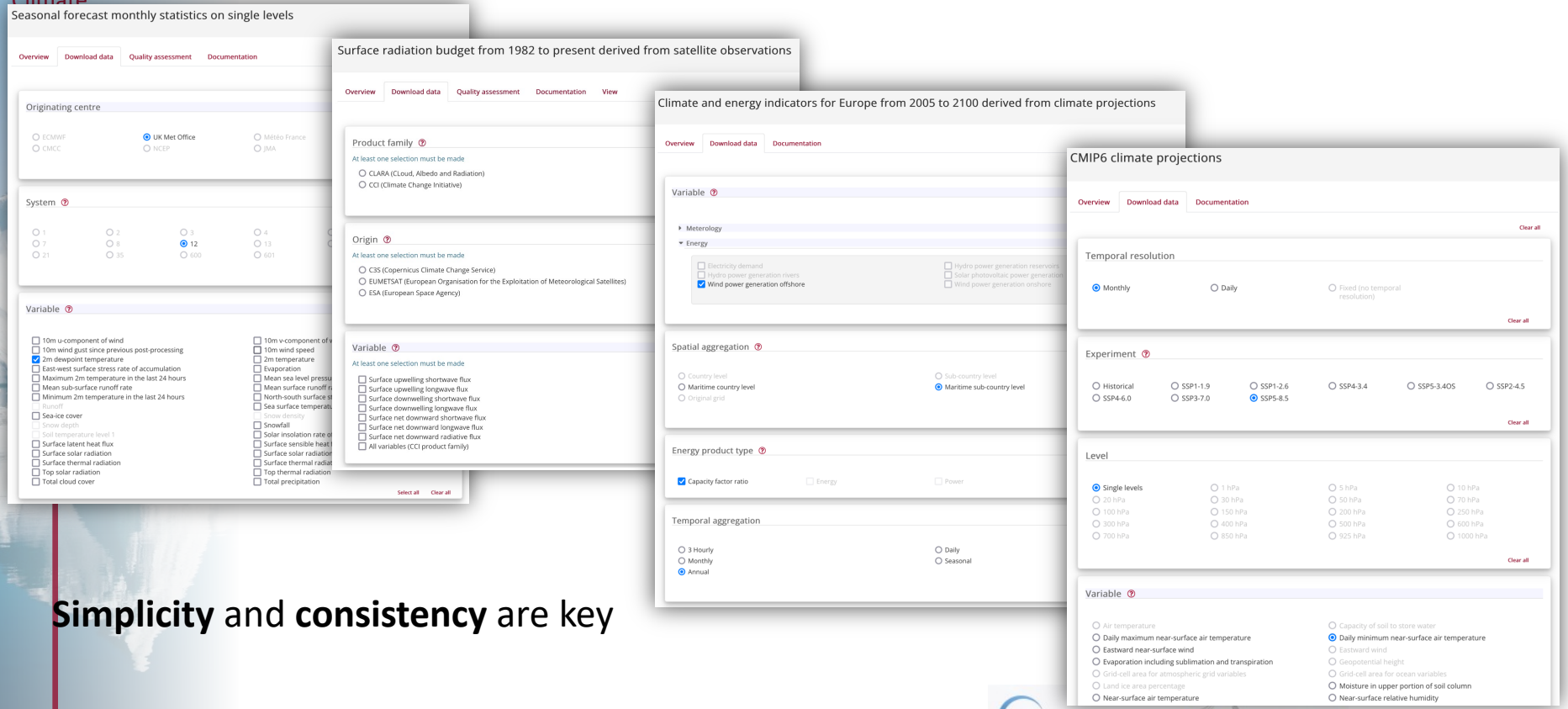
The Climate Data Store



Simplicity and **consistency** are key

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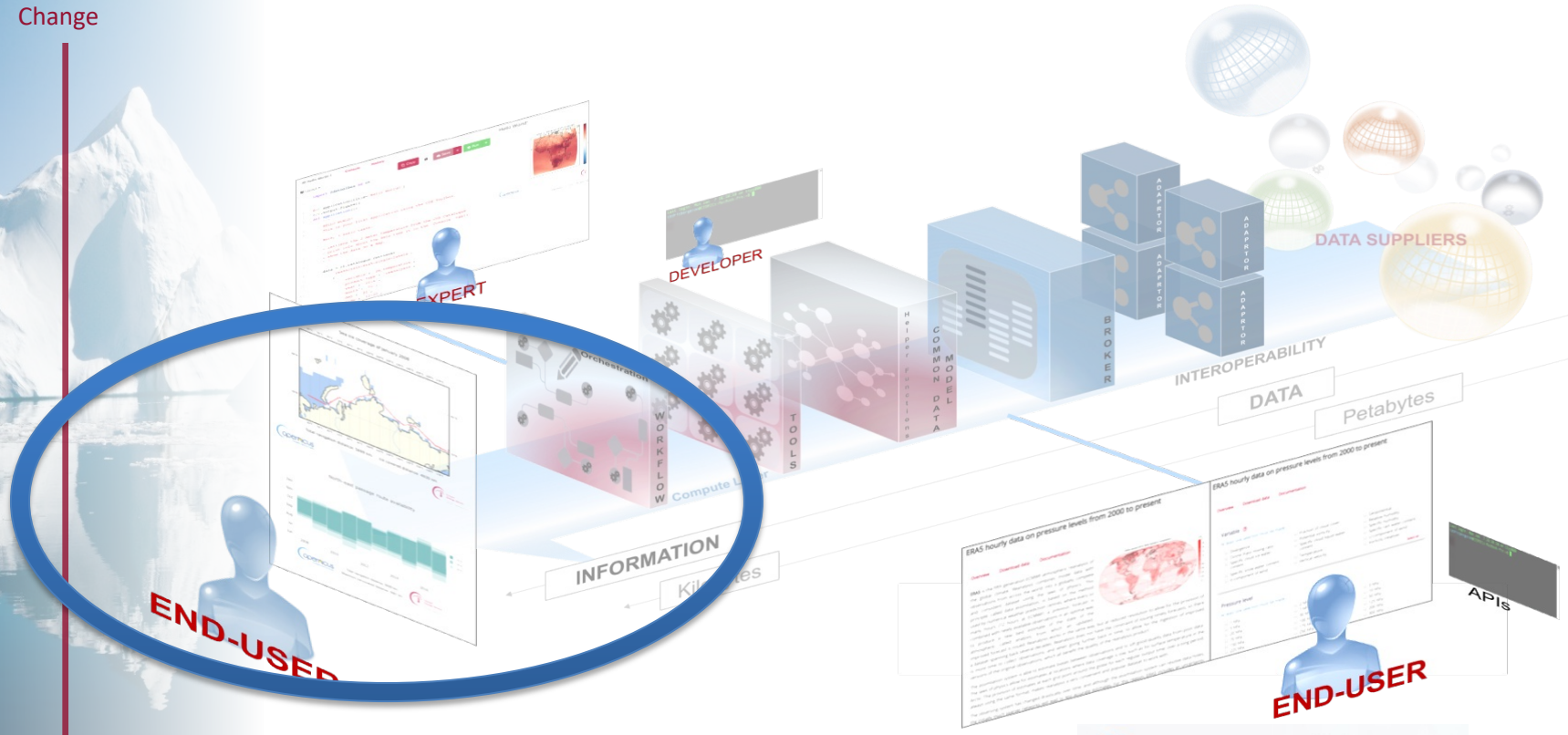
The Climate Data Store

Climate Change



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ECMWF

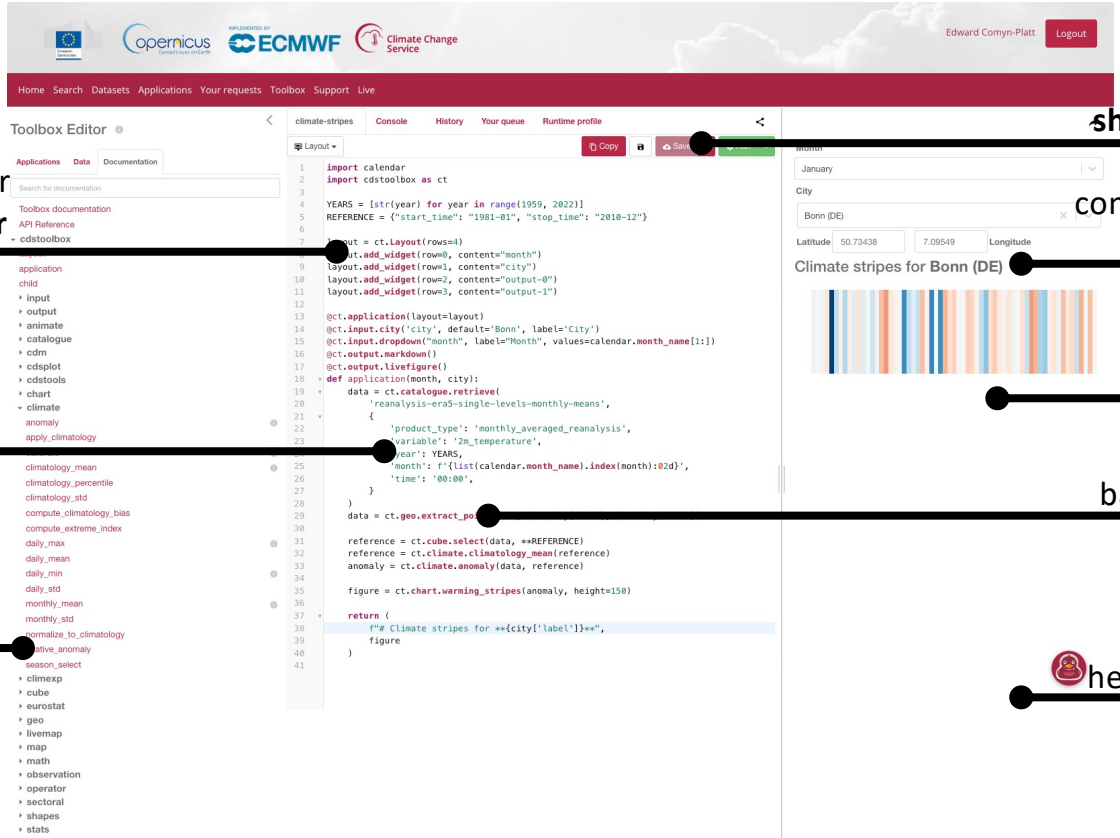
The Climate Data Store

Climate Change

simple **Python** editor in your **web browser**

dataset **catalogue** API
no **downloads** needed

wide range of **tools**



share applications

configurable **GUI elements**

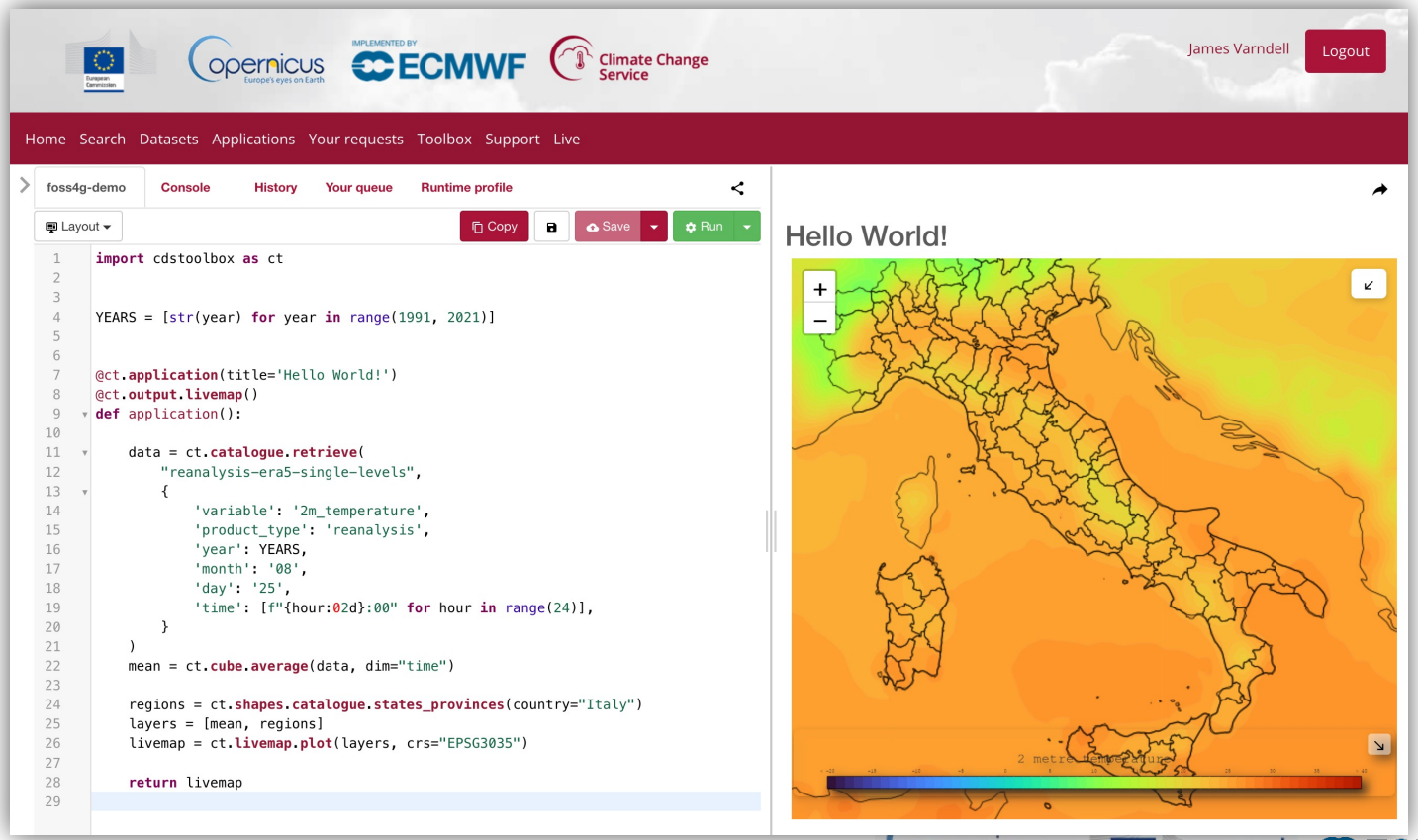
interactive visualisations

backend **caching**

help and **support**

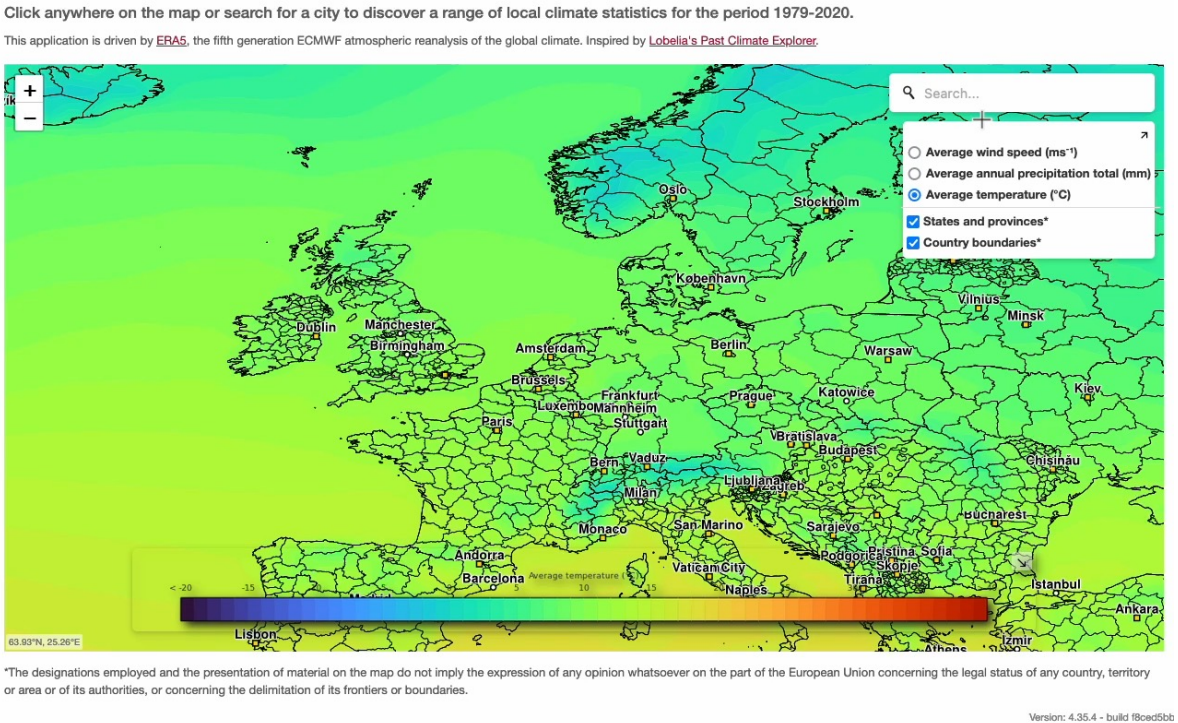
The Climate Data Store

Climate Change



The Climate Data Store

Climate Change



https://cds.climate.copernicus.eu/apps/c3s/app-era5-explorer

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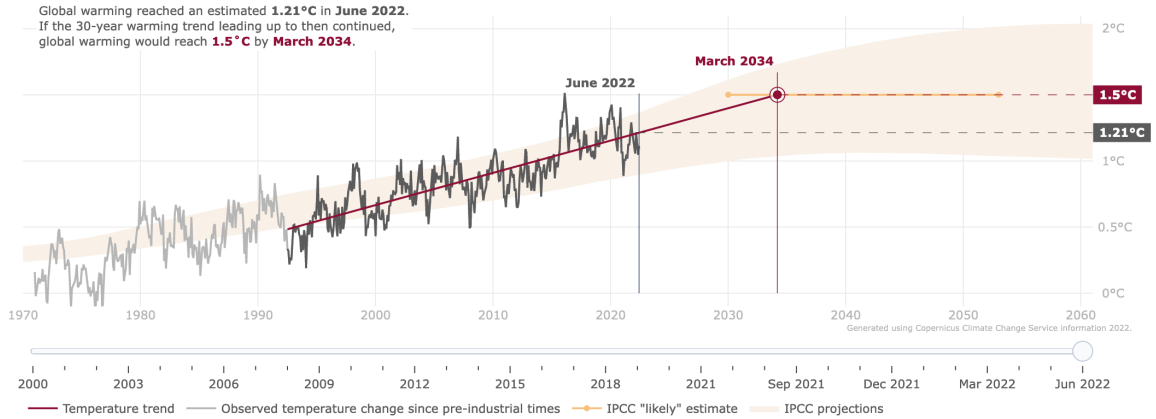
The Climate Data Store

Climate Change

How close are we to reaching a global warming of 1.5°C?

Reaching 1.5°C of global warming - a limit agreed under the Paris agreement - may feel like a very distant reality, but it might be closer than you think. Experts suggest it is likely to happen between 2030 and the early 2050s. See where we are now and how soon we would reach the limit if the warming continued at today's pace. **Use the slider to explore how the estimate changes in time.**



In this application:

- "Global warming" at a point in time refers to the increase in a 30-year average, centred on the specified time, of Earth's global surface temperature relative to the pre-industrial period;
- "Reaching the limit" refers to the moment when the central time of the 30-year average temperature equals 1.5°C above pre-industrial values;
- "Pre-industrial values" refers to the approximation of the surface air temperature of this era from the IPCC 'Global warming of 1.5°C' report.

The application is first and foremost a monitoring tool and the indicative future date is there for illustrative purposes only and should not be interpreted as a forecast (see page 13 of documentation).

https://cds.climate.copernicus.eu/cdsapp#!/software/app-c3s-global-temperature-trend-monitor

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Outline

Climate Change

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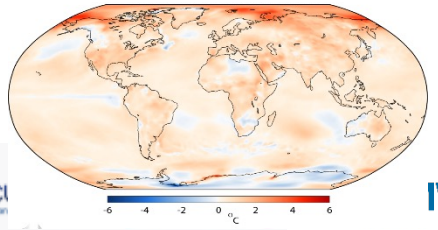


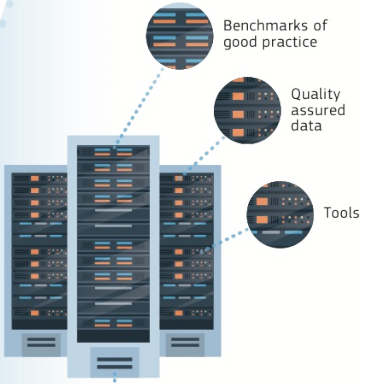
IWF

Climate Change

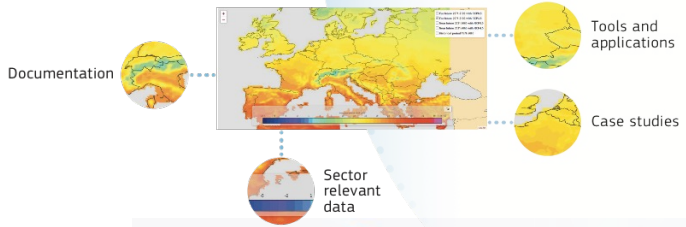
What is the SIS and how it works

USERS

CLIMATE DATA STORE



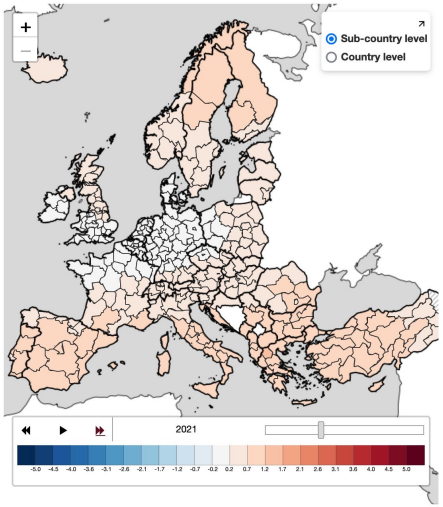
PRACTICAL EXAMPLES

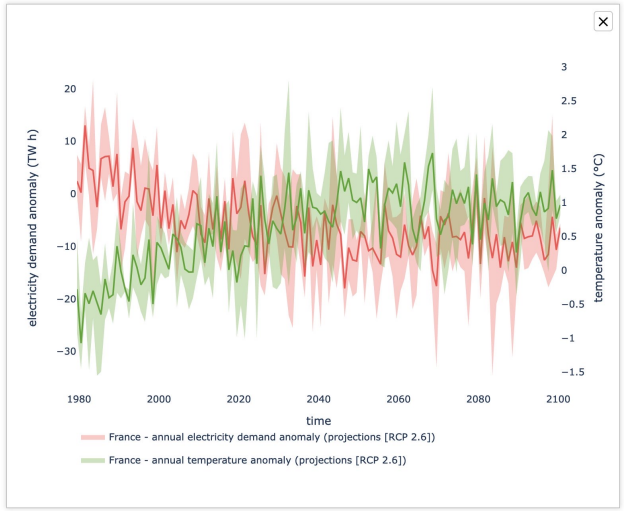


ECMWF Copernicus Europe's eyes on Earth European Commission

Climate Change

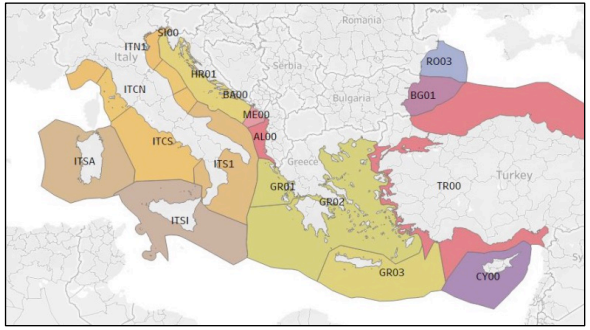
More complex sectoral applications: operational energy





What does it provide? Climate & energy variables from reanalyses, regional climate projections, and multi-model seasonal forecasts.

Who is it for? EU Agency for the Cooperation of Energy Regulators (ACER) and ENTSO-E (European network of transmission system operators for electricity).



PROGRAMME OF THE EUROPEAN UNION

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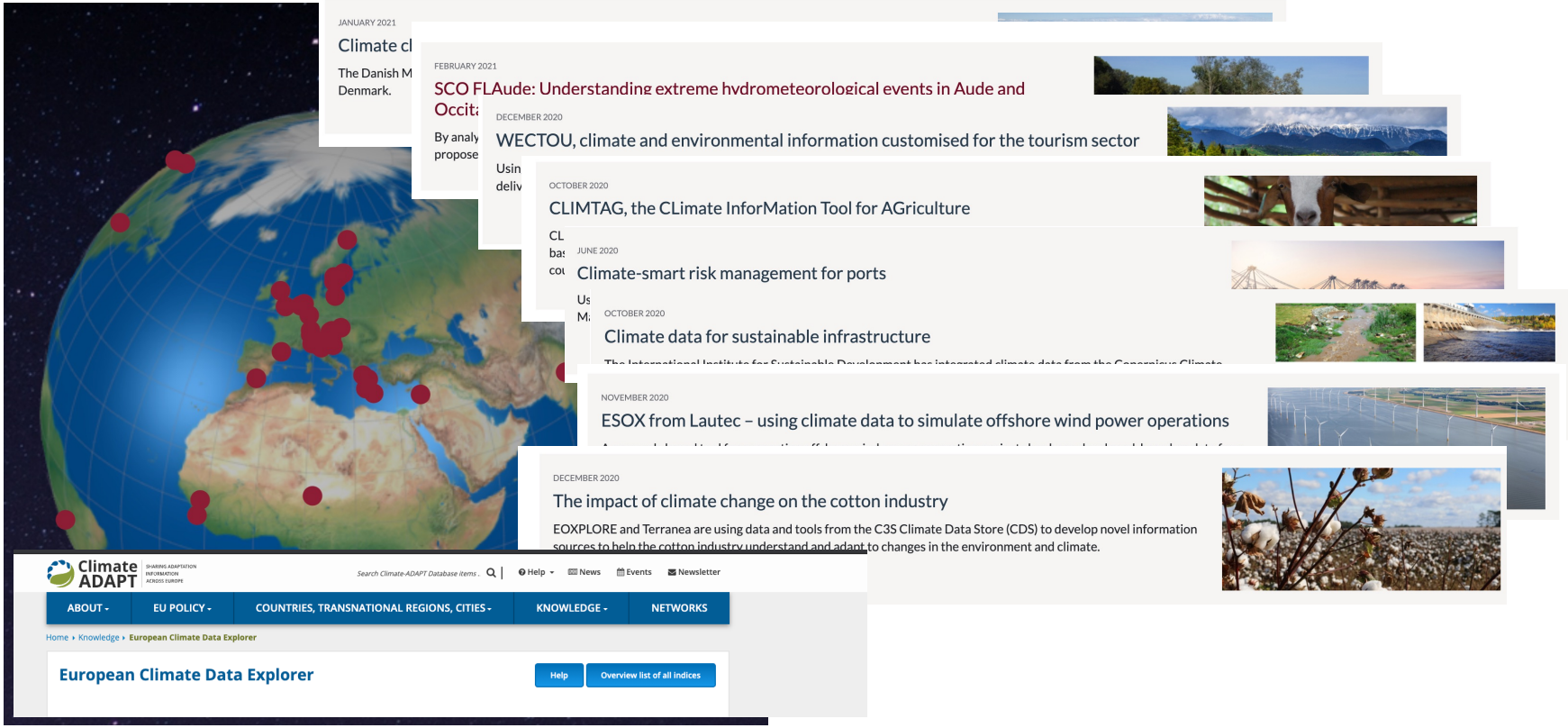
implemented by ECMWF

Climate Change

Many examples of applications (more than can possibly be shown here)



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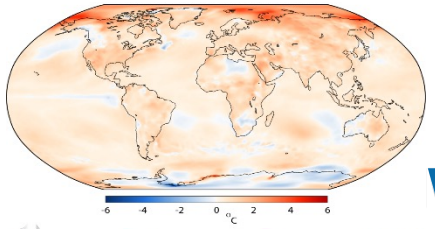

PROGRAMME OF THE EUROPEAN UNION

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In summary…..

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Copernicus Climate Change Service

About Us What we do Data

close

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Climate Change

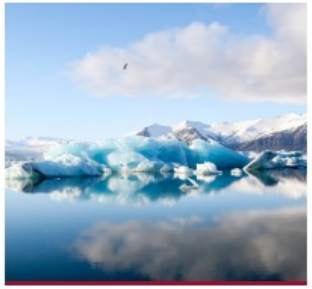
We provide authoritative information about the past, present and future climate, as w enable climate change mitigation an strategies by policy makers and busi

https://climate.copernicus.eu

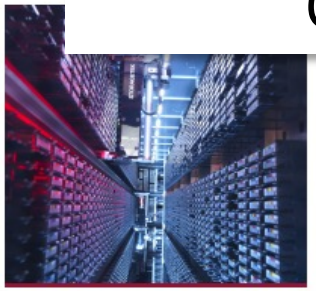
@j_munoz_sabater

@CopernicusECMWF

Key products and services



Climate bulletins



Climate Data Store

Data in action

The *European State of the Climate 2020*, an essential snapshot of the region and a useful benchmark for future assessments of the environment.

In focus

Extra material

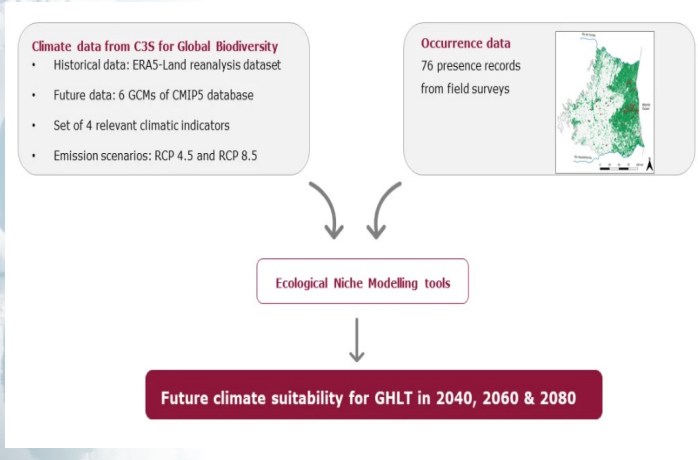
Conservation of the golden-headed lion tamarin in a changing climate

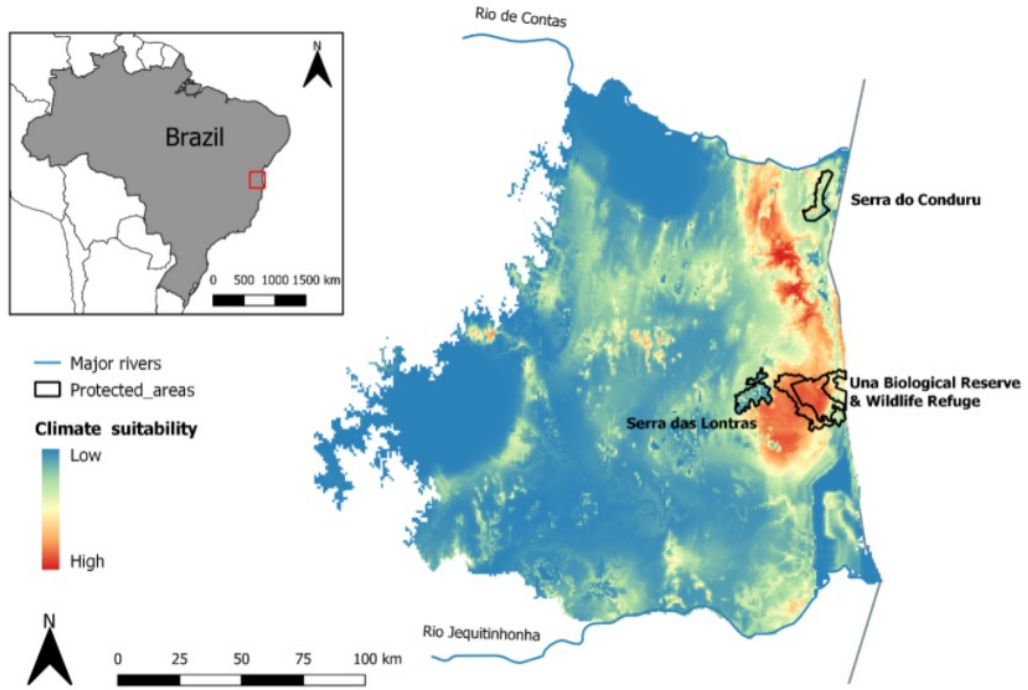
The habitat of the golden-headed lion tamarin is limited to a region south of Bahia in the Brazilian Atlantic Forest, which has been identified as an appropriate conservation study area for the species. Credit: RZSA.

The golden-headed lion tamarin plays an important role in dispersing the seeds of many fruits and air plants. This contributes to naturally regenerating coastal rainforests, making it essential to protect the species and the landscape in which it lives.

Biodiversity sector

Climate Change

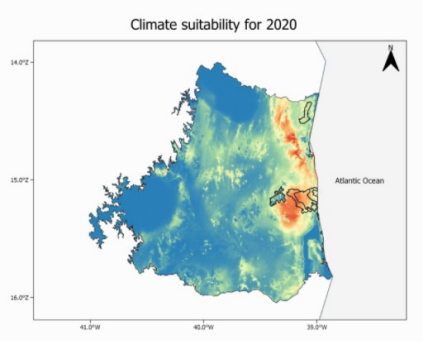


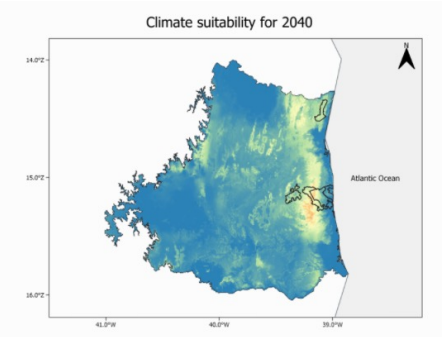


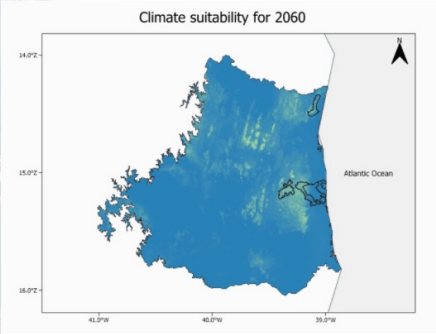
Current climate suitability of the study area in Bahia forest for the golden-headed lion tamarins. Protected areas are indicated in black. Warmer colours represent areas with a high climate suitability while cooler colours represent areas with low climatic suitability.

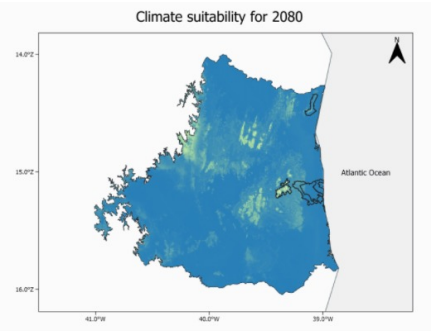
Climate Change

Biodiversity sector









<u>Outcomes</u>:

- potential effects of climate change on the distribution of this endangered tamarin;
- integrated into a strategic conservation action plan;
- support the development of conservation strategies that focus on landscape management

→ If we do not succeed in keeping global average temperature rise well below 2°C, the golden-headed lion tamarin and many other species could face extinction by the end of the century.

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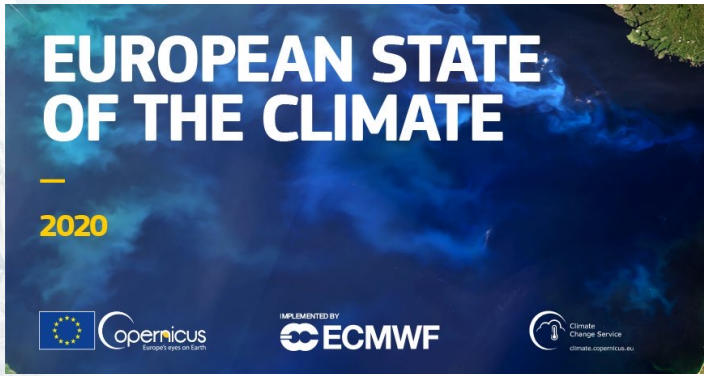
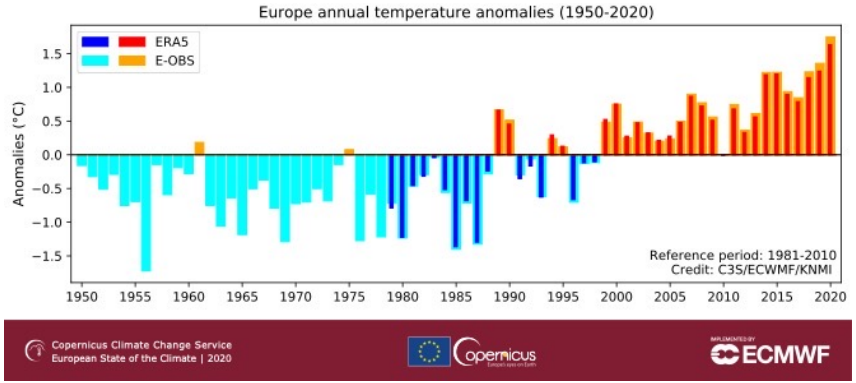
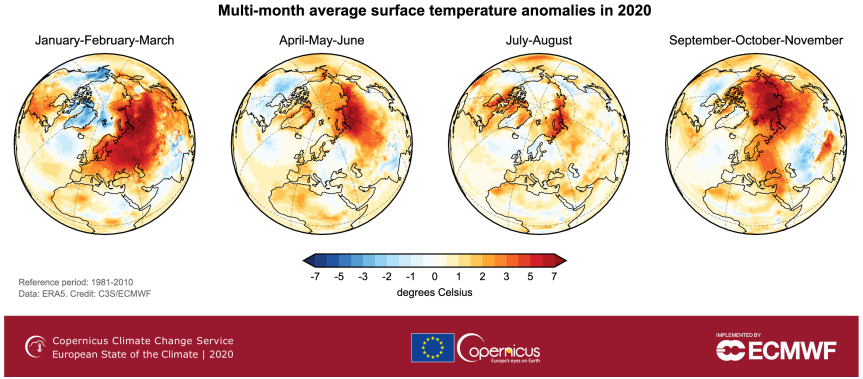
Climate Change

2020: an exceptional year for Europe and the Arctic







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Help and support

We provide a dedicated user support service to aid Climate Change Service data discovery, dissemination, understanding and use by all users. The user support service currently includes a Knowledge Base accessible 24/7 and a friendly manned helpdesk.

24/7 Knowledge Base

The Knowledge Base provides documentation and answers to frequently asked questions.

Forum

For users of the C3S services

Become part of the community, work together and support each other.

Contact us

Can't find the answer you're looking for? Get in touch!

Login to the **C3S Enquiry Portal**

User Satisfaction Surveys

We run user satisfaction surveys every year.

- 2020 Report
- 2019 Report
- 2018 Report
- 2017 Report

Your user story

We collect user stories to show the diversity and wide-range usage of our data and services. You will find here some examples. Contact us directly to share your user story with us.

User Training

C3S User Learning Services offers free training in how to use the Climate Data Store platform and its content.

ECMWF SUPPORT GUIDELINES >

FINDING YOUR WAY TO THE RIGHT DATA: