

# C3S: El Servicio de Cambio Climático de Copernicus



Climate Change

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

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



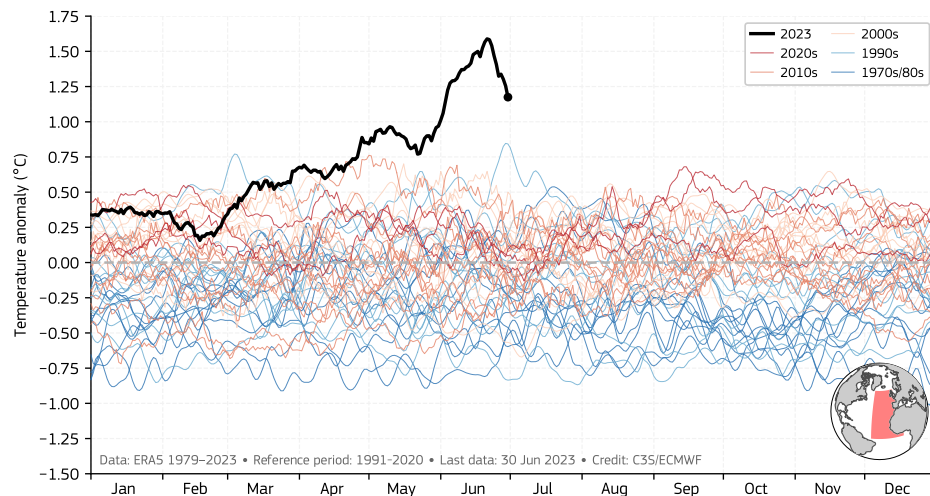


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# Leaving on uncharted territories

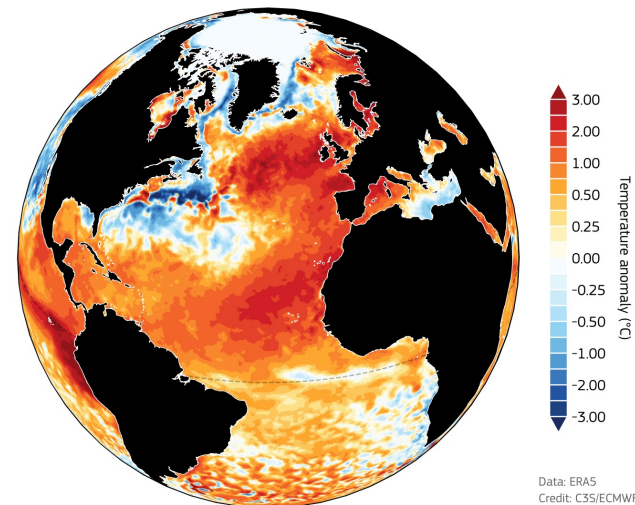
## DAILY SEA SURFACE TEMPERATURE ANOMALY

Northeastern Atlantic (40°W–0°E, Eq.–60°N)



## SEA SURFACE TEMPERATURE ANOMALY • JUNE 2023

relative to June average for 1991–2020



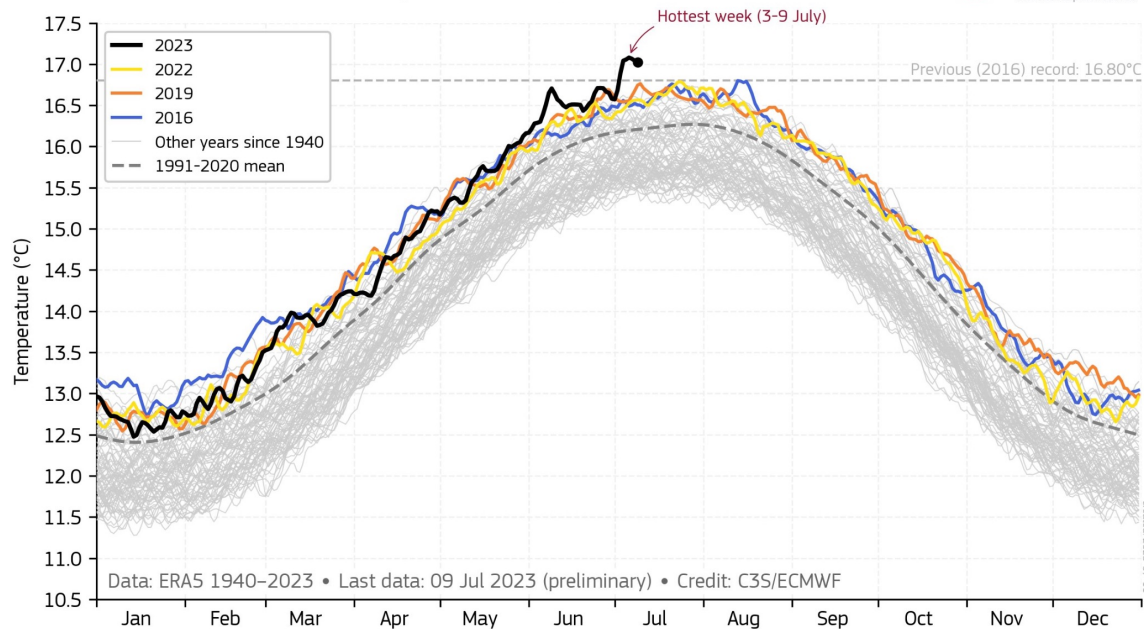


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# Living on uncharted territories

## DAILY SURFACE AIR TEMPERATURE

Global domain (0–360°E, 90°S–90°N)



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THE EUROPEAN UNION



European  
Commission





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# Outline

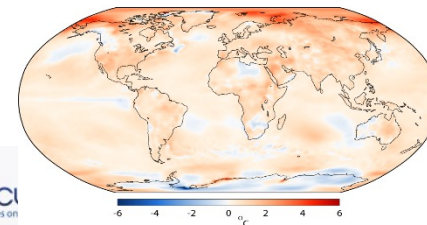
¿ Qué es el Servicio Europeo de Cambio Climático (C3S) ?

¿ 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 ?




Abierto, completo, gratuito



Sentinels



opernicus



CLIMATE CHANGE

MARINE MONITORING



ATMOSPHERE MONITORING




LAND MONITORING



SECURITY



EMERGENCY MANAGEMENT



1st MFF (2014-2020): ~ 4300 M€

2nd MFF (2021-2027): ~ 5420 M€

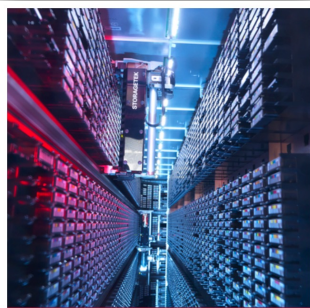


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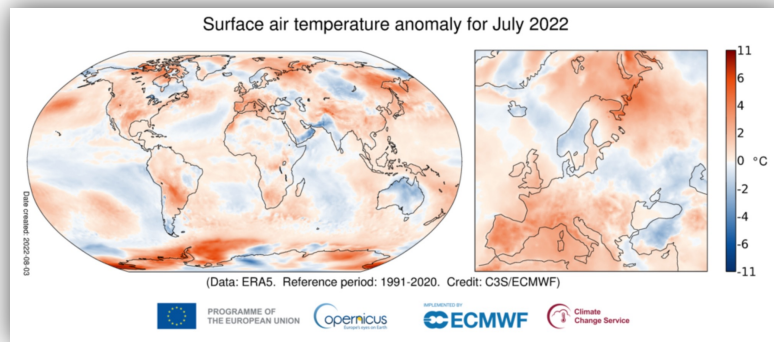
# What is the Copernicus Climate Change Service (C3S)?

<p><b>Water management</b></p> <p>We provide our users with the data and tools they need to prepare for climate variability and change in the water sector. For example, our data services provide information on changes in river discharge, droughts and floods.</p>	<p><b>Agriculture and forestry</b></p> <p>We use climate data to help the agricultural sector predict the climate-dependent variations in annual crop yields in the regions to farm. Our data have been used to assess how long-term variations in the climate may affect investment decisions for woody crops and forests.</p>	<p><b>Insurance</b></p> <p>We use climate data to help the insurance sector with data that identifies the historical occurrence of some specific extreme weather events, such as windstorms.</p>	<p><b>Energy</b></p> <p>We support the energy sector, which is increasingly relying on renewable energy production, by providing climate-related information, such as forecasts of air temperature, atmospheric transparency, wind strength, and projections of wave size and frequency.</p>
<p><b>Infrastructure, Transport and Associated Standards</b></p> <p>We provide climate indicators that can be used to help build resilient cities able to mitigate the challenges that climate change pose to infrastructure.</p>	<p><b>Health</b></p> <p>We provide access to high-resolution maps of temperature and heat-wave frequency for major urban centres across Europe. We also provide forecasts of the distribution of pollen and vector-borne diseases.</p>	<p><b>Coastal areas</b></p> <p>Fisheries are an important part of the European economy. We provide information on the future distribution of key ocean variables and their impacts on the aquatic ecosystem, including species distribution and possible changes in fish stocks.</p>	<p><b>Disaster risk reduction</b></p> <p>We provide climate information to support policies related to disaster risk reduction, as well as practices to address weather-emergencies.</p>
<p><b>Shipping</b></p> <p>We use seasonal indicators and climate projections to inform shipping companies of new opportunities and threats using up-to-date climatologies and future trends in key climate variables such as winds, wave cycle forecasts.</p>	<p><b>Tourism</b></p> <p>The warming climate has the potential to significantly affect the appeal of tourist destinations. Working with experts we provide indicators able to inform personal and business decisions on seasonal and multi-year forecasts.</p>	<p><b>Biodiversity</b></p> <p>Climate change puts high pressure on global biodiversity and is likely to become one of the most significant drivers of biodiversity loss in the 21st century.</p>	<p><b>Global Users</b></p> <p>We aim to facilitate climate adaptation workbooks and offer an interactive web application with refined data, guidance and practical proposals.</p>

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



Climate Data Store





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# Estructura de C3S

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..

Climate Data Store



Sistemas de Información Sectorial



ENERGY



WATER  
MANAGEMENT



INSURANCE



AGRICULTURE  
& FORESTRY



INFRASTRUCTURE

Usuarios & stakeholders



Divulgación & difusión



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# Outline

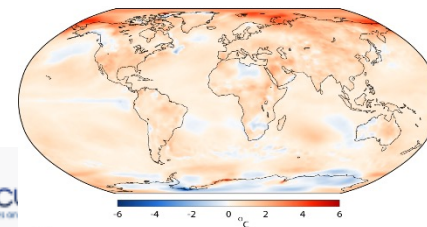
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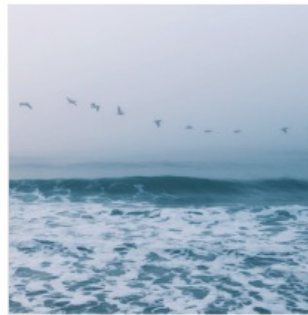






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# The Climate Data Store – ‘A one stop shop for climate data’

 <h3>Observations</h3> <p>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.</p> <p><a href="#">Read more &gt;</a></p>	 <h3>Climate reanalyses</h3> <p>Climate reanalyses combine past observations with models to generate consistent time series for a large set of climate variables. Reanalyses are among the re-used data products in physical sciences.</p> <p><a href="#">Read more &gt;</a></p> <p><a href="#">Reanalysis data on the CDS &gt;</a></p>	 <h3>Seasonal forecasts</h3> <p>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.</p> <p><a href="#">Read more &gt;</a></p> <p><a href="#">Seasonal forecast data on the CDS &gt;</a></p>	 <h3>Climate projections</h3> <p>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.</p> <p><a href="#">Read more &gt;</a></p> <p><a href="#">Climate projection data on the CDS &gt;</a></p>
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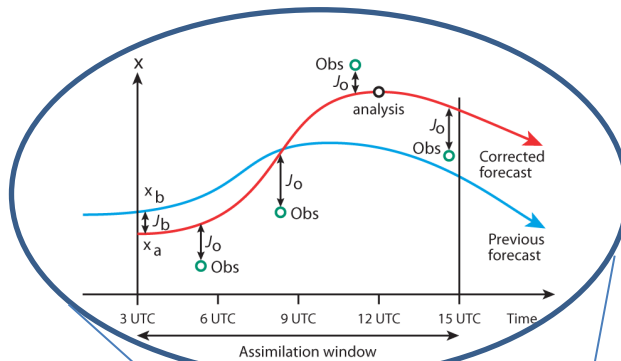
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# What is the reanalysis?

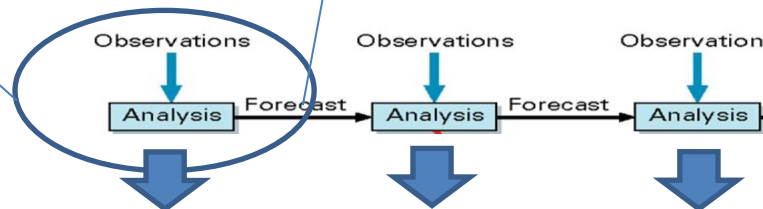
## MODELING



## 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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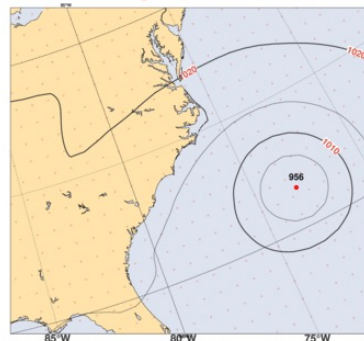
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# Maps without gaps: global atmospheric reanalysis ERA5

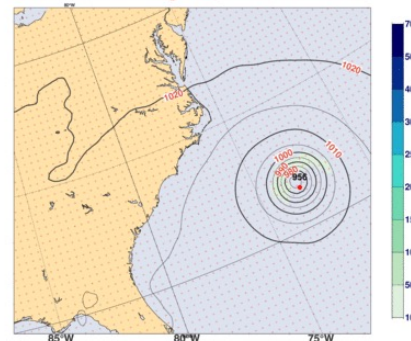
## ERA5:

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

Florence Thu 13 Sep 2018, 01 UTC for ERA-Interim



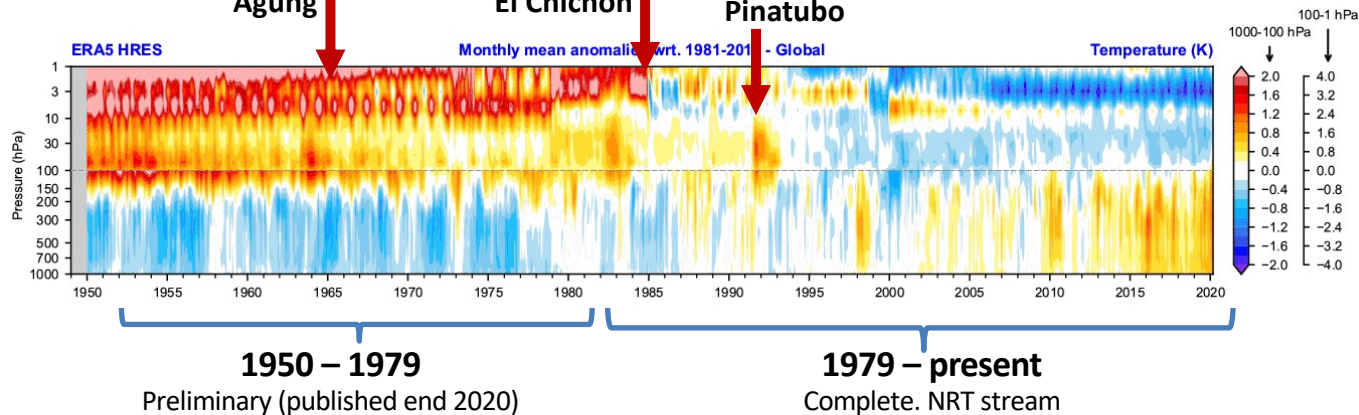
Florence Thu 13 Sep 2018, 01 UTC for ERA5



Agung

El Chichón

Pinatubo



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

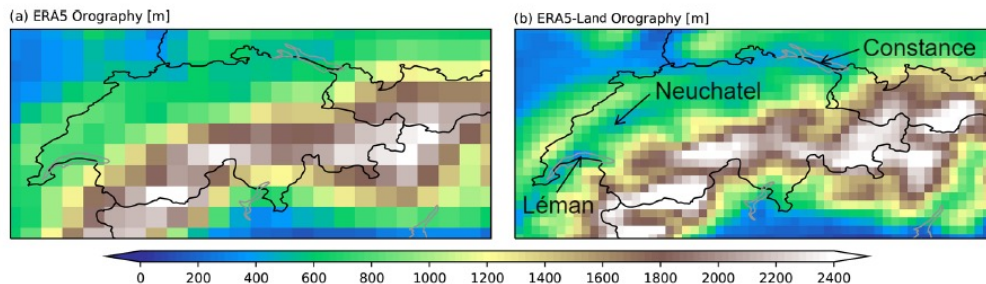




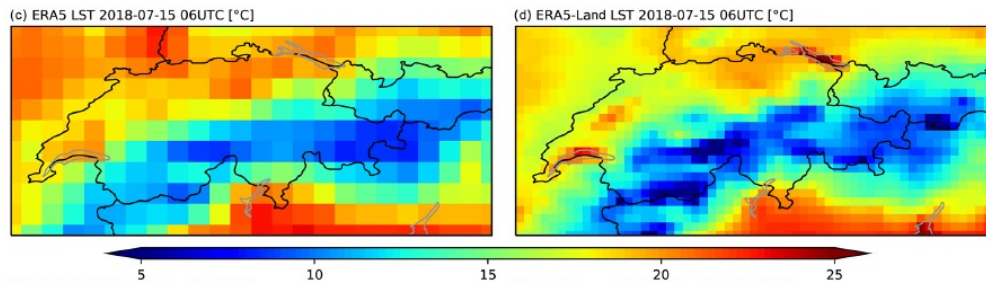
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# High-resolution and consistency for the land evolution: ERA5-Land (1950-present)

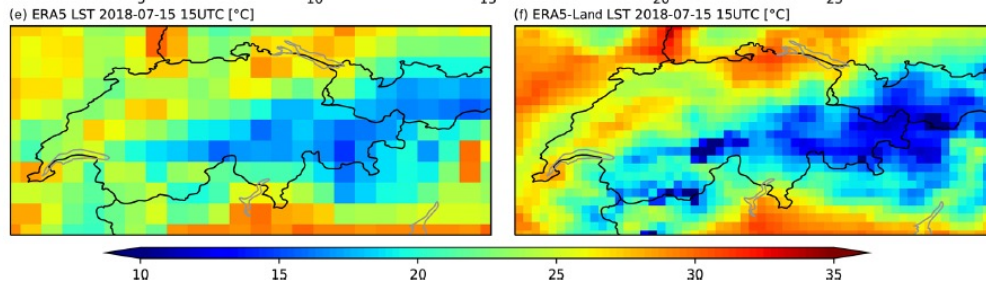
orography



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

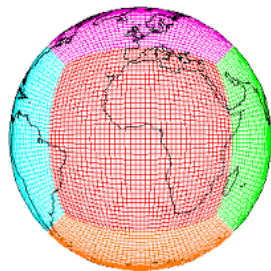
Muñoz-Sabater et al., 2021 (Earth Syst. Sc. Data),  
<https://doi.org/10.5194/essd-13-4349-2021>





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# Regional reanalyses - Why do we need them?



Global reanalyses



Station		Date		Time		Temperature		Humidity		Wind		Pressure		Clouds		Precipitation		Sunshine		Other	
No.	Name	Year	Month	Day	Hour	Max	Min	Max	Min	Max	Min	Max	Min	Max	Max	Min	Max	Min	Max	Min	Max
1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...

local observations

## Regional models at higher horizontal resolution

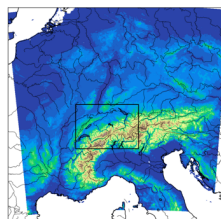
- 2.5 km in the Arctic or 5.5 km for Europe
- Wind field better account for to the local orography
- More detailed description of extreme events.

## Additional (local) observations

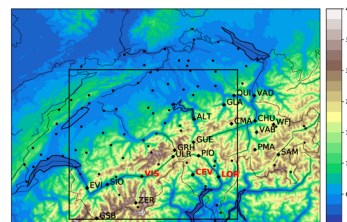
- Local surface observations and slightly different treatment of satellite data where possible

## 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



(a)



(b)

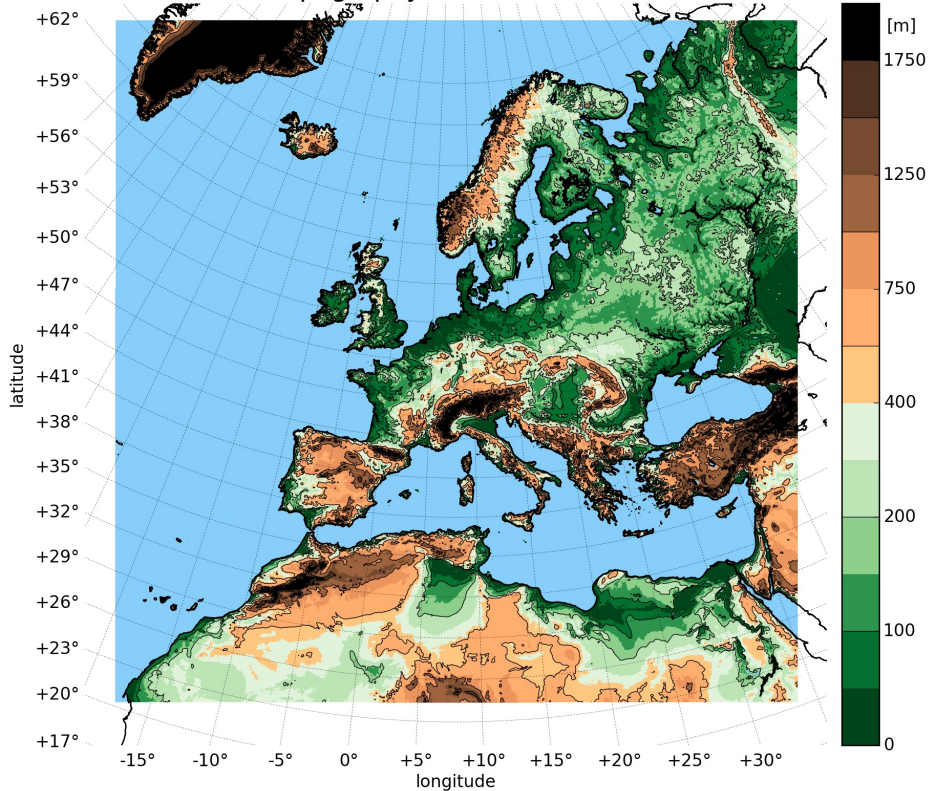


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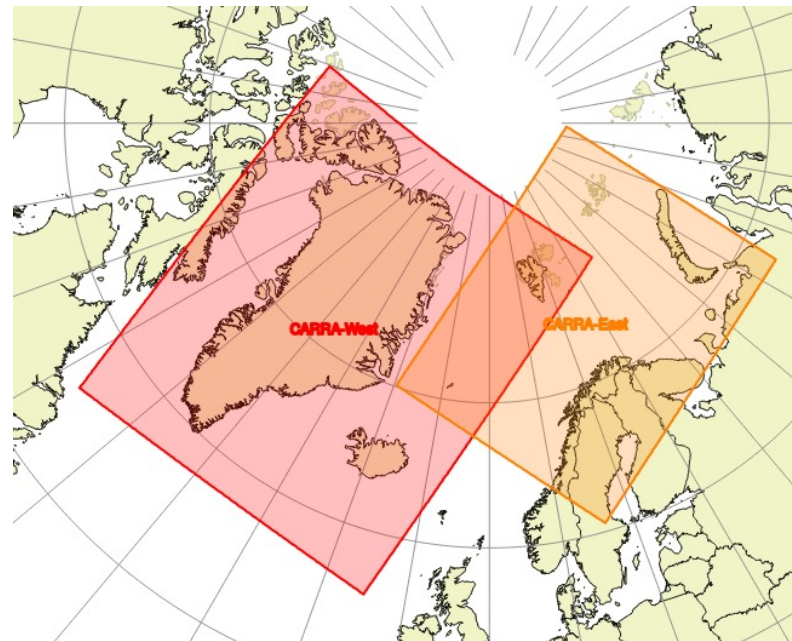
# C3S regional reanalyses: domains (left: Europe, right: European part of the Arctic)

## UERRA

Topography and ocean mask



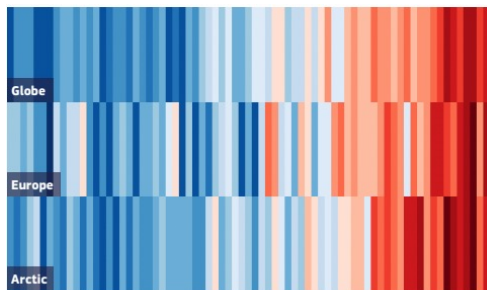
## CARRA



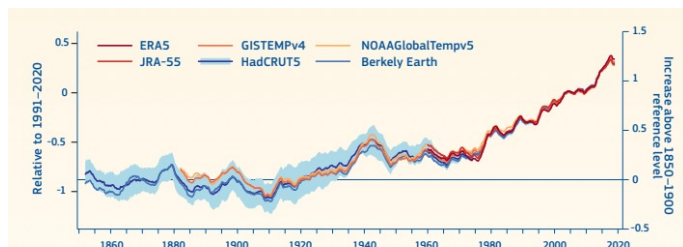


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# Reanalysis; a tool for outreach ESOTC 2022



Climate stripes from ERA5, 1950-2022



Global six-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** ↗

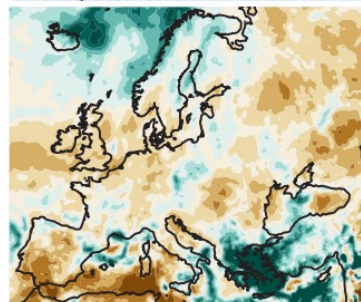
**Europe**  
**+2.2°C** ↗

**Arctic**  
**+3°C** ↗



**Precipitation**

A lack of precipitation contributed to widespread drought conditions.

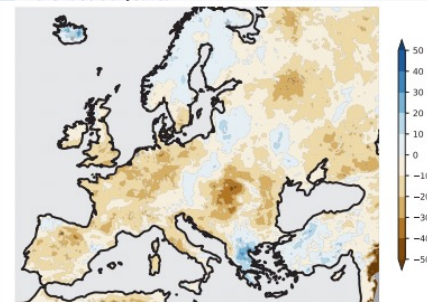


Precipitation anomalies (%) for summer (JJA) 2022, expressed as a percentage of the seasonal average for the 1991–2020 reference period. Data source: ERA5. Credit: C3S/ECMWF.



**Soil moisture**

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

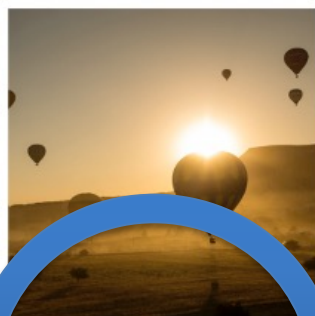


Soil moisture anomalies (%) in the top soil layer for summer (JJA) 2022, expressed as a percentage of the seasonal average for the 1991–2020 reference period. Data source: ERA5-Land. Credit: C3S/ECMWF.



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



## Observations

Observations are key to understanding the climate system. CDS users can access a vast variety of instrumental data records ranging from historic weather measurements to the most recent 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 >](#)

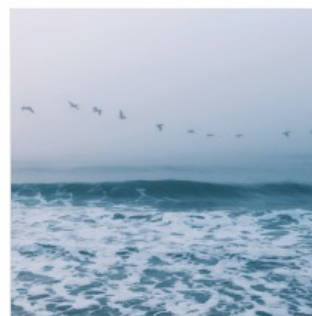


## Seasonal forecasts

CDS 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 scenarios for concentrations of greenhouse gases and aerosols, based on outputs from multiple global and regional climate models.

[Read more >](#)

[Climate projection data on the CDS >](#)





Climate Change

# What is the climate system?

## CRYOSPHERE



Snow



Ice Sheets and Ice Shelves



Glaciers



Permafrost

## 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

Available now

Satellite ECVs

ECVs from reanalysis

Ambition

## 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

## ANTHROSPHERE



Anthropogenic Water Use



Anthropogenic Greenhouse Gas Fluxes

## BIOSPHERE



Soil Carbon



Albedo



Fire



FAPAR\*



Leaf Area Index (LAI)



Land Surface Temperature



Above-ground Biomass



Land Cover

\*Fraction of Absorbed Photosynthetically Active Radiation

Focus on users

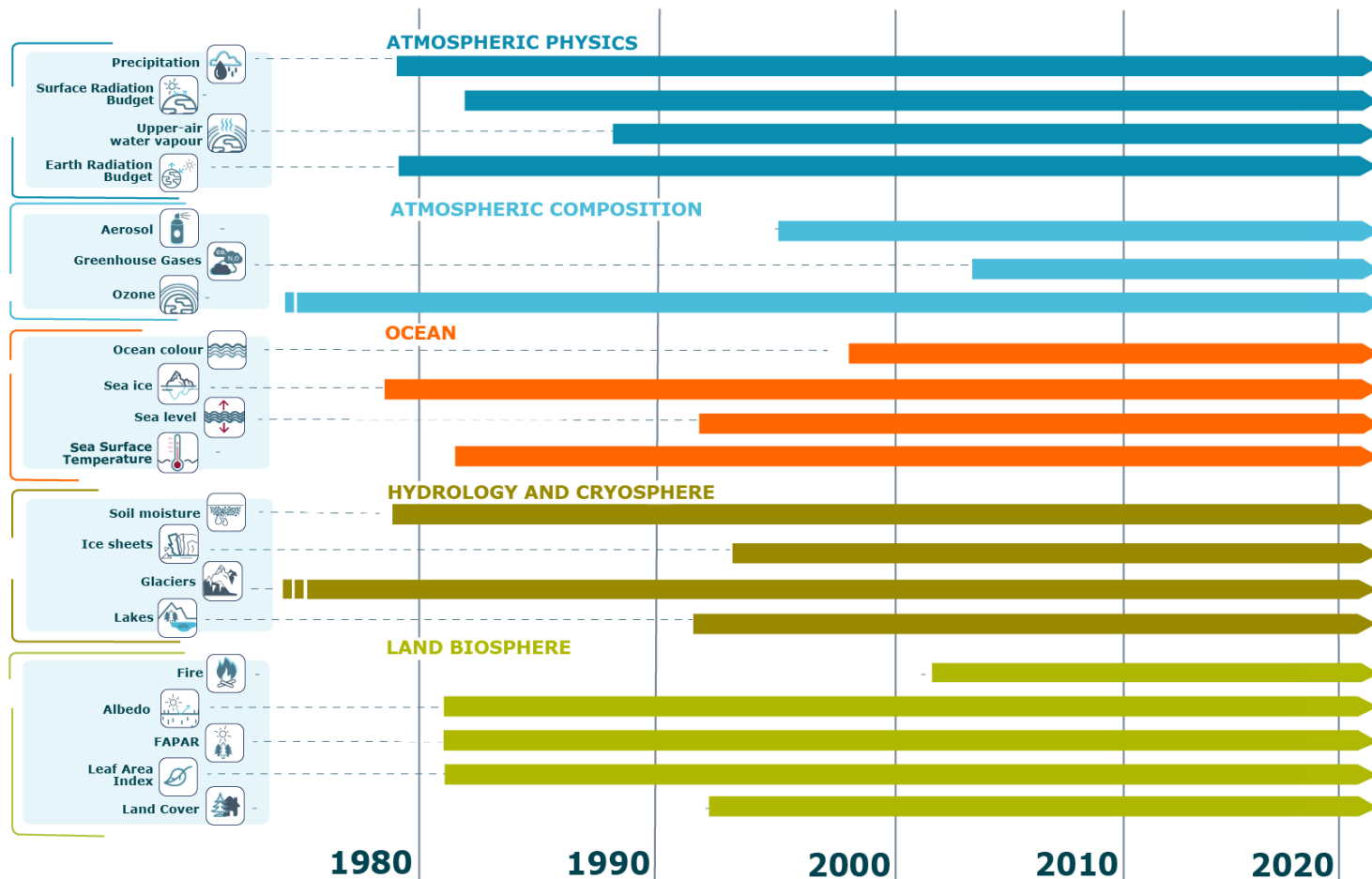
Enhanced collaboration with ESA & EUMETSAT

Exploit synergies with other Copernicus Services



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# Satellite ECV data records



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



Mainly use Sentinel-3 data

Future use of other Sentinel data

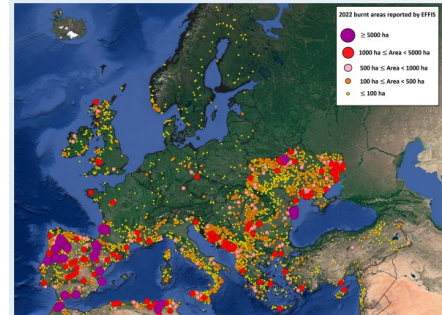


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# Climate information and indicators based on satellite ECV data records

## Wildfires

1991–2020 Second largest burnt area on record across the EU countries.



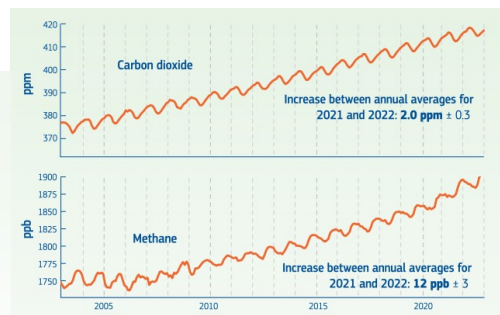
Distribution and extent of burnt areas across Europe and the Mediterranean in 2022. Data source: European Forest Fire Information System (EFFIS). Credit: EFFIS/Copernicus EMS.

In 2022, the annual average concentrations of greenhouse gases were

**CO<sub>2</sub>**  
**+417 ppm** ↗

**CH<sub>4</sub>**  
**+1894 ppb** ↗

Concentrations (column-averaged mixing ratios) for CO<sub>2</sub> and CH<sub>4</sub> covering 2003–2022.



Monthly averaged atmospheric concentrations of carbon dioxide (CO<sub>2</sub>) and methane (CH<sub>4</sub>). Data are derived from satellite measurements and averaged over the whole atmospheric column and for 60°S–60°N. Data source: CS5/Obs4MIPs (v4.4) consolidated (2003–2021) and CAMS preliminary near real-time data (2022) records. Credit: CS5/CAMS/ECMWF/University of Bremen/SRON.

### 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.

5.4 times the height of the Eiffel Tower

## RECORD LOSS OF GLACIER ICE IN EUROPEAN ALPS IN 2022

more than **5 km<sup>3</sup>**

Glacier ice loss

Global **>8600 km<sup>3</sup>** since 1997 ↘

Europe **>960 km<sup>3</sup>** (excluding Greenland) since 1997 ↘

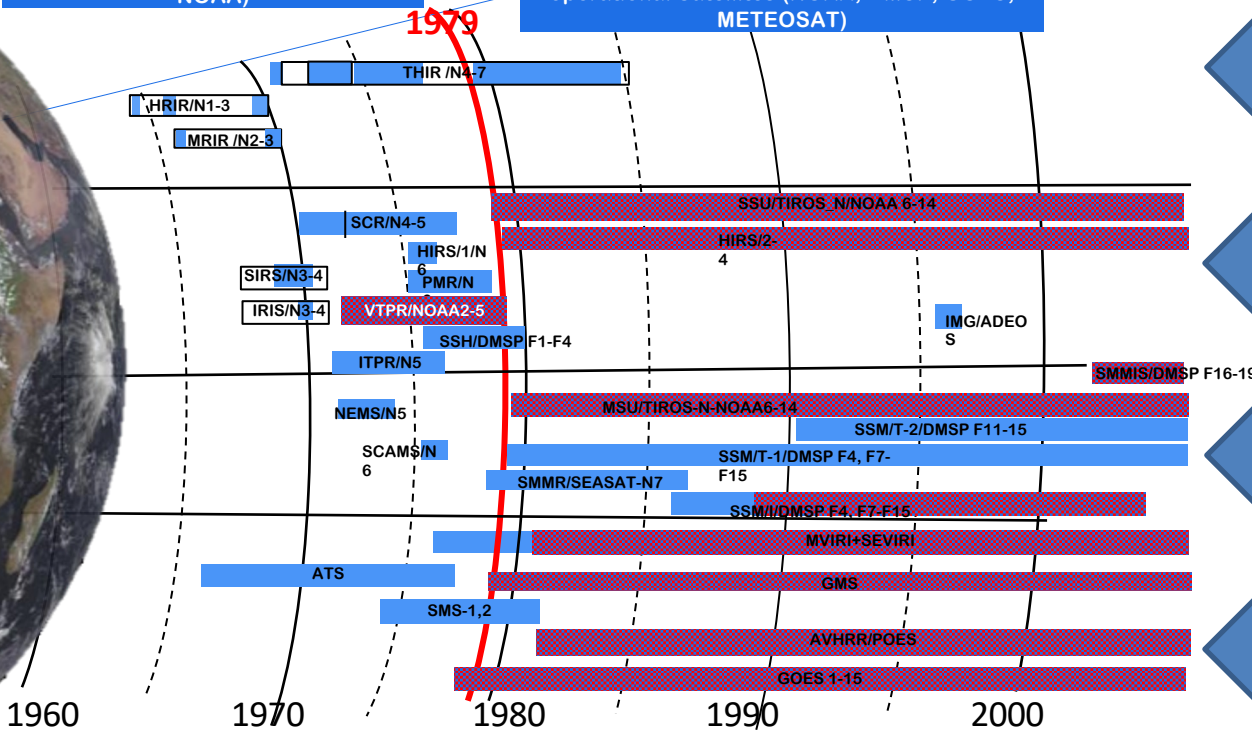
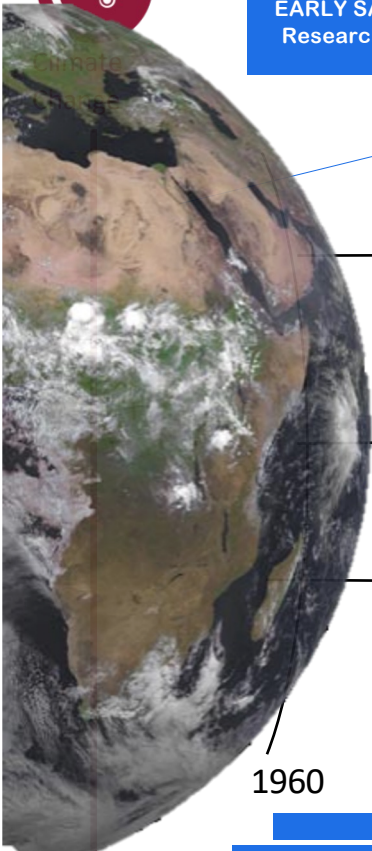
# Satellite data rescue

**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



Infrared Imagers

Infrared Sounders

Microwave Sounders/Imagers

Geostationary + Atmospheric Motion Vectors

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

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



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implemented by **ECMWF**



Climate Change

# Importance of data rescue



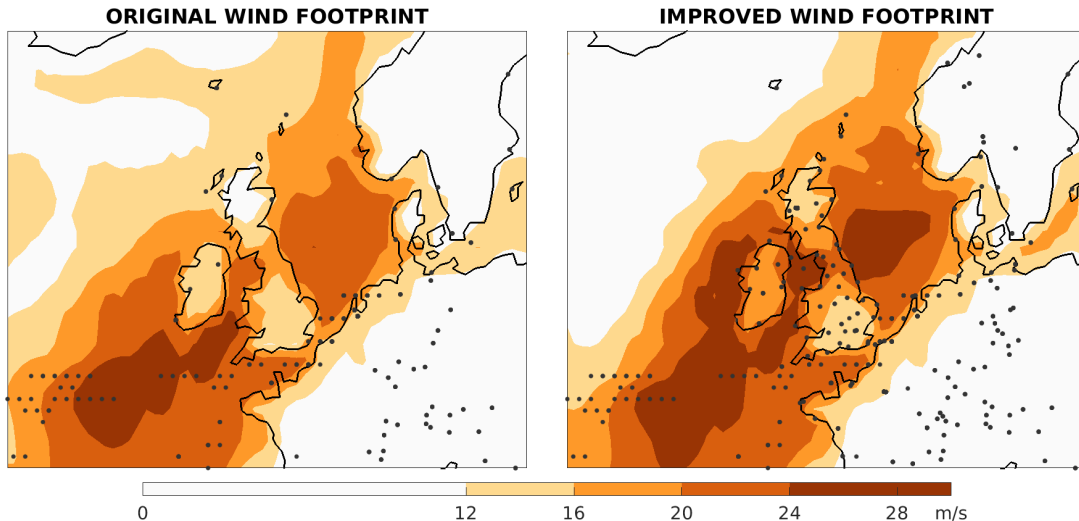
GREAT STORM, FEBRUARY 27, 1903.  
Phoenix Park—2,048 Trees blown down (1,242 Forest Trees, 1,706 Thorns).

**DAILY WEATHER REPORT**  
for 8 a.m. on Friday, 27<sup>th</sup> February, 1903.  
Issued by the METEOROLOGICAL OFFICE, 68, Victoria Street, London. W. N. SHAW, Secretary.

STATIONS.	VELOCITY SYSTEM (See note on last page)				THIS MORNING (See note on last page)							PART M. RECORD			
	Beauf.	Temp.	Wind.	Weather.	At top of Mast.	Close to Mast.	At surface.	Change from 1000 ft.	Direction.	Force in Miles.	Force in Kts.	Max.	Min.	Sea.	State of Sky.
Hagstranda ...	27 47	27	W	0	29.35	29.32	29.31	0.03	W	2	0	—	—	0	1/2
Herringönd ...	27 50	26	W	2	29.36	29.33	29.32	0.04	W	2	0	—	—	0	0/2
Stockholm ...	27 50	26	W	2	29.36	29.33	29.32	0.04	W	2	0	—	—	0	0/2
Widby ...	27 50	26	W	2	29.36	29.33	29.32	0.04	W	2	0	—	—	0	0/2
Karlbad ...	27 47	27	W	0	29.35	29.32	29.31	0.04	W	2	0	—	—	0	0/2
Färder (Swedish)	27 47	27	W	0	29.35	29.32	29.31	0.04	W	2	0	—	—	0	0/2
Bodo ...	27 42	27	W	0	29.34	29.31	29.30	0.04	W	2	0	—	—	0	0/2
Christiansund ...	27 33	27	W	0	29.33	29.30	29.29	0.04	W	2	0	—	—	0	0/2
Skudenesnes ...	27 41	26	W	0	29.33	29.30	29.29	0.04	W	2	0	—	—	0	0/2
Samburgh Head ...	27 28	27	W	0	29.32	29.29	29.28	0.04	W	2	0	—	—	0	0/2
Stormöy ...	27 26	27	W	0	29.32	29.29	29.28	0.04	W	2	0	—	—	0	0/2
Main Head ...	27 27	27	W	0	29.32	29.29	29.28	0.04	W	2	0	—	—	0	0/2
Blackhead Pt. ...	27 25	27	W	0	29.31	29.28	29.27	0.04	W	2	0	—	—	0	0/2
Valerick ...	27 25	27	W	0	29.31	29.28	29.27	0.04	W	2	0	—	—	0	0/2
Roche's Point ...	27 22	27	W	0	29.30	29.27	29.26	0.04	W	2	0	—	—	0	0/2
Parsonstown ...	27 20	27	W	0	29.29	29.26	29.25	0.04	W	2	0	—	—	0	0/2
Dunshallow ...	27 19	27	W	0	29.28	29.25	29.24	0.04	W	2	0	—	—	0	0/2
Liverpool Obay ...	27 18	27	W	0	29.27	29.24	29.23	0.04	W	2	0	—	—	0	0/2
Holyhead ...	27 17	27	W	0	29.26	29.23	29.22	0.04	W	2	0	—	—	0	0/2
Penrhynde (on Sea) ...	27 15	27	W	0	29.25	29.22	29.21	0.04	W	2	0	—	—	0	0/2
Castle (on Sea) ...	27 14	27	W	0	29.24	29.21	29.20	0.04	W	2	0	—	—	0	0/2

'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.



PROGRAMME OF THE EUROPEAN UNION







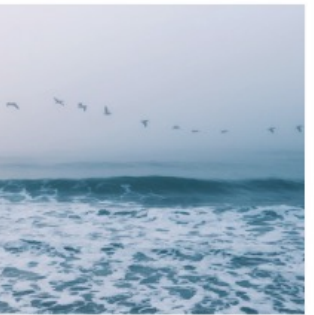
implemented by ECMWF



Climate  
Change

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



			
<h3>Observations</h3> <p>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.</p> <p><a href="#">Read more &gt;</a></p>	<h3>Climate reanalyses</h3> <p>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.</p> <p><a href="#">Read more &gt;</a></p> <p><a href="#">Reanalysis data on the CDS &gt;</a></p>	<h3>Seasonal forecasts</h3> <p>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 published monthly on the climate data store.</p> <p><a href="#">Read more &gt;</a></p> <p><a href="#">Seasonal forecast data on the CDS &gt;</a></p>	<h3>Climate projections</h3> <p>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.</p> <p><a href="#">Read more &gt;</a></p> <p><a href="#">Climate projection data on the CDS &gt;</a></p>



# C3S seasonal prediction: components

Climate Change



## DATA PRODUCTS

[cds.climate.copernicus.eu](https://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 6<sup>th</sup> (ECMWF) and 10<sup>th</sup> day of month (the rest)



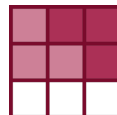
```

import cdsapi
c = cdsapi.Client()

c.retrieve(
    'seasonal-forecast-single-level',
    {'format': 'grib',
     'originating_centre': 'meteo',
     'variable': 'total_precip',
     'product_type': ['ensemble_mean', 'hindcast'],
     'year': '2018',
     'month': '09',
     'leadtime_month': ['1', '2', '3', '4', '5', '6']},
    'cds_seasonal_output.grib')
  
```

CDS API

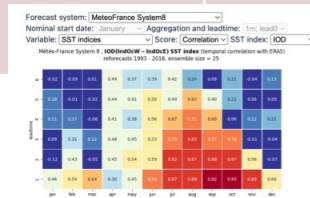
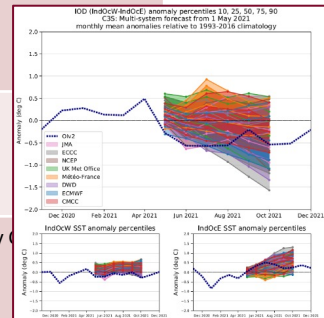
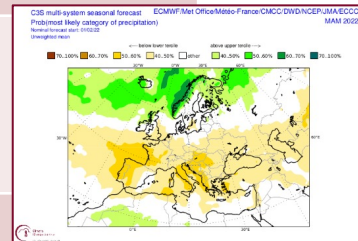
CDS Toolbox



## GRAPHICAL PRODUCTS

[climate.copernicus.eu/charts/packages/c3s\\_seasonal/](https://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



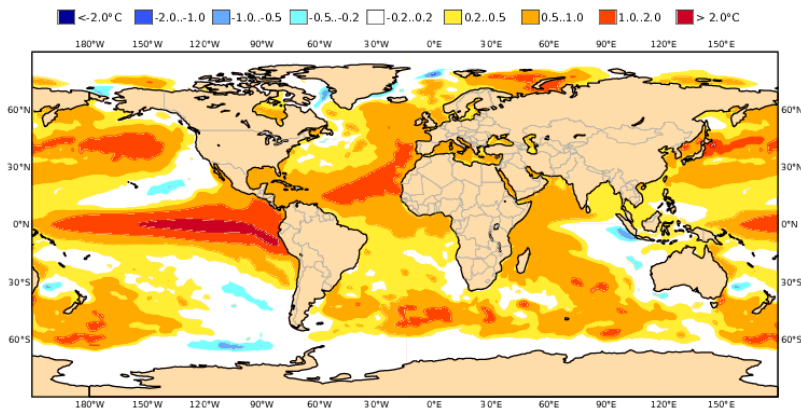


Climate  
Change

# Climate Predictions – Seasonal Forecasts

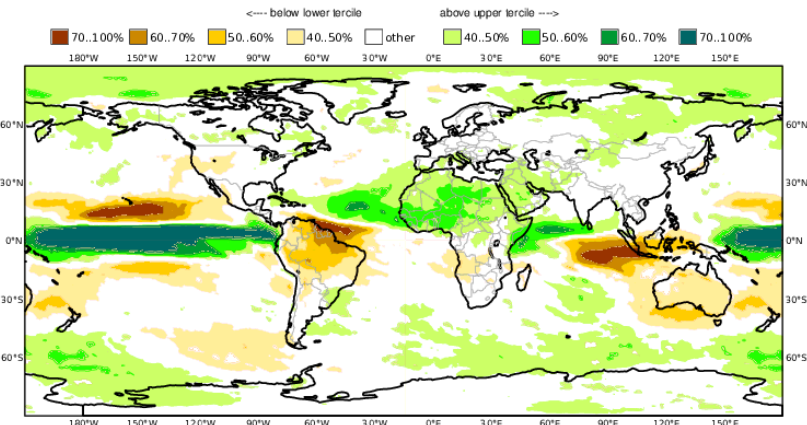
C3S multi-system seasonal forecast    ECMWF/Met Office/Météo-France/CMCC/DWD/NCEP/JMA/ECCC  
Mean forecast SST anomaly    OCT 2023

Nominal forecast start: 01/07/23  
Variance-standardized mean



C3S multi-system seasonal forecast    ECMWF/Met Office/Météo-France/CMCC/DWD/NCEP/JMA/ECCC  
Prob(most likely category of precipitation)    OCT 2023

Nominal forecast start: 01/07/23  
Unweighted mean

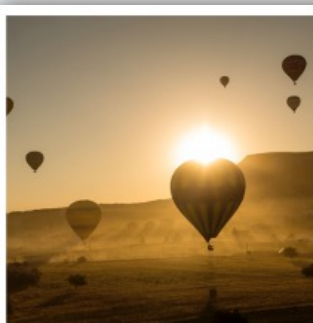






Climate  
Change

# 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 >](#)

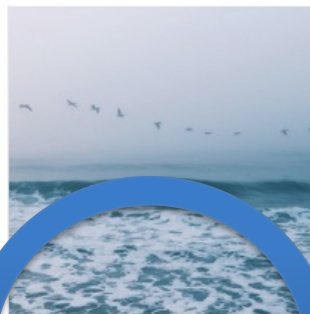


## Seasonal forecasts

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 scenarios for concentrations of greenhouse gases and aerosols, based on multiple global and regional models.

[Read more >](#)

[Climate projection data on the CDS >](#)



Climate  
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# Global climate projections

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

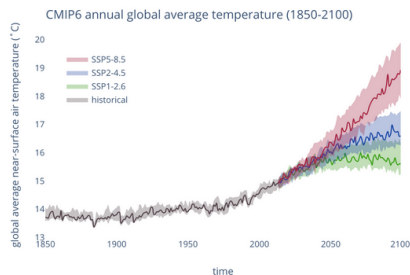
Download data

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](mailto:copernicus-support@ecmwf.int)

## Licence

[CMIP6 - Data Access - Terms of Use](#)

## Publication date

2021-03-23

## References

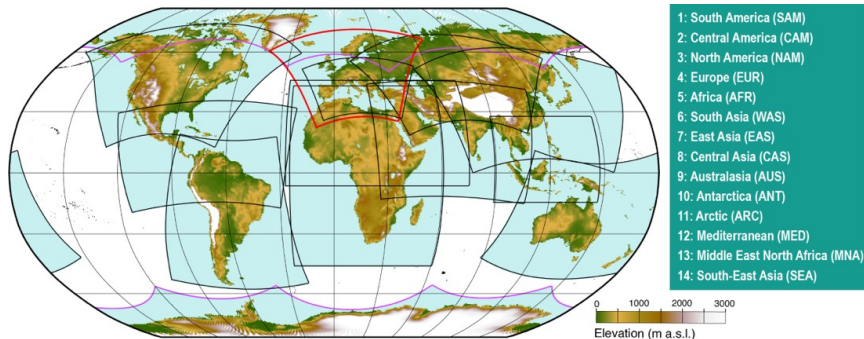
DOI: [10.24381/cds.d7eaec3d](https://doi.org/10.24381/cds.d7eaec3d)



Climate Change



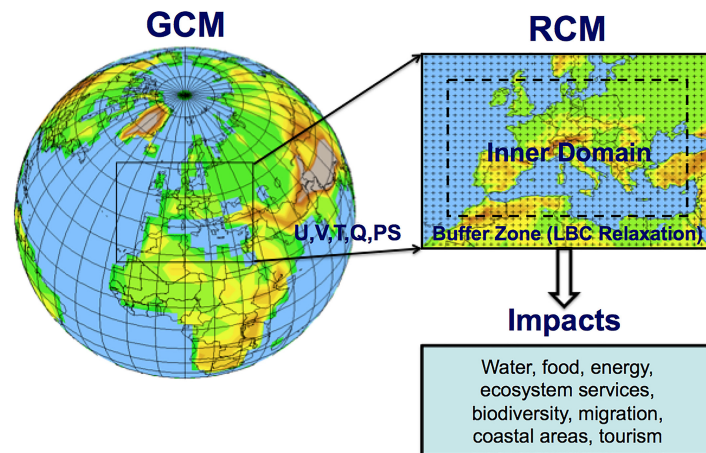
# Regional climate projections: Europe and beyond



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)

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





Climate  
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# Outline

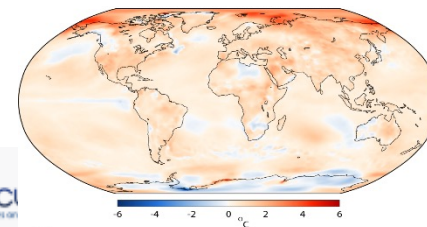
¿ Qué es el Servicio Europeo de Cambio Climático (C3S) ?

¿ 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) ?

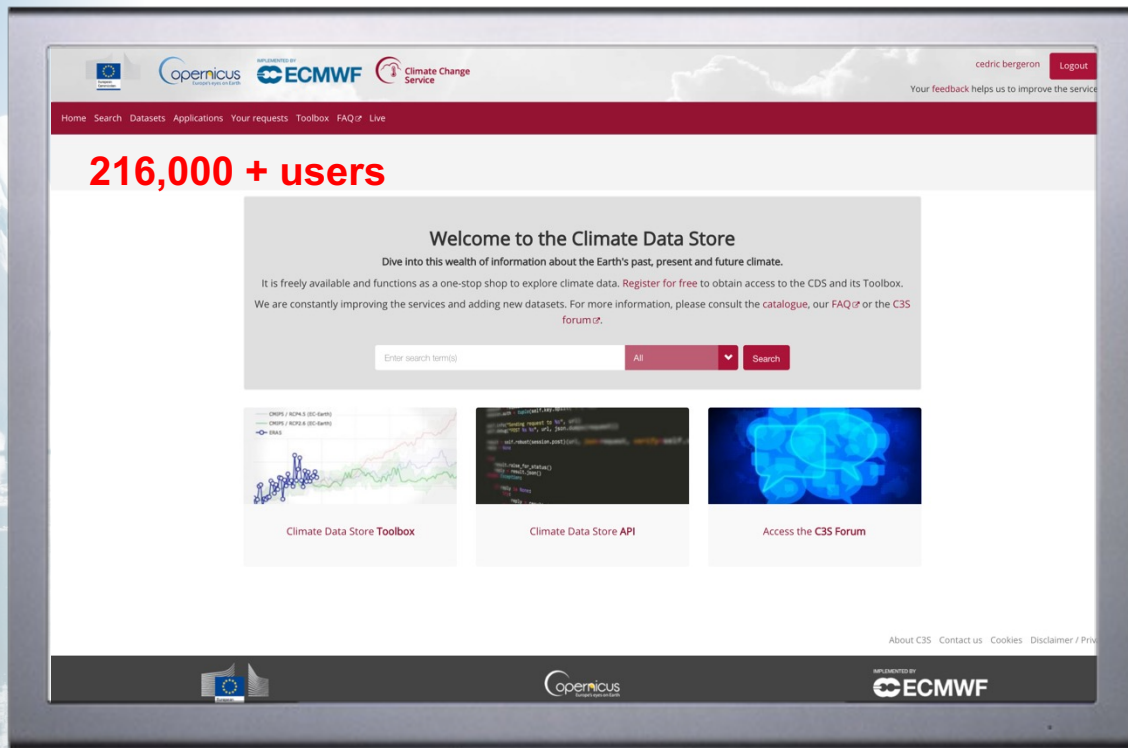
¿ Algún otro componente en C3S ?





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...

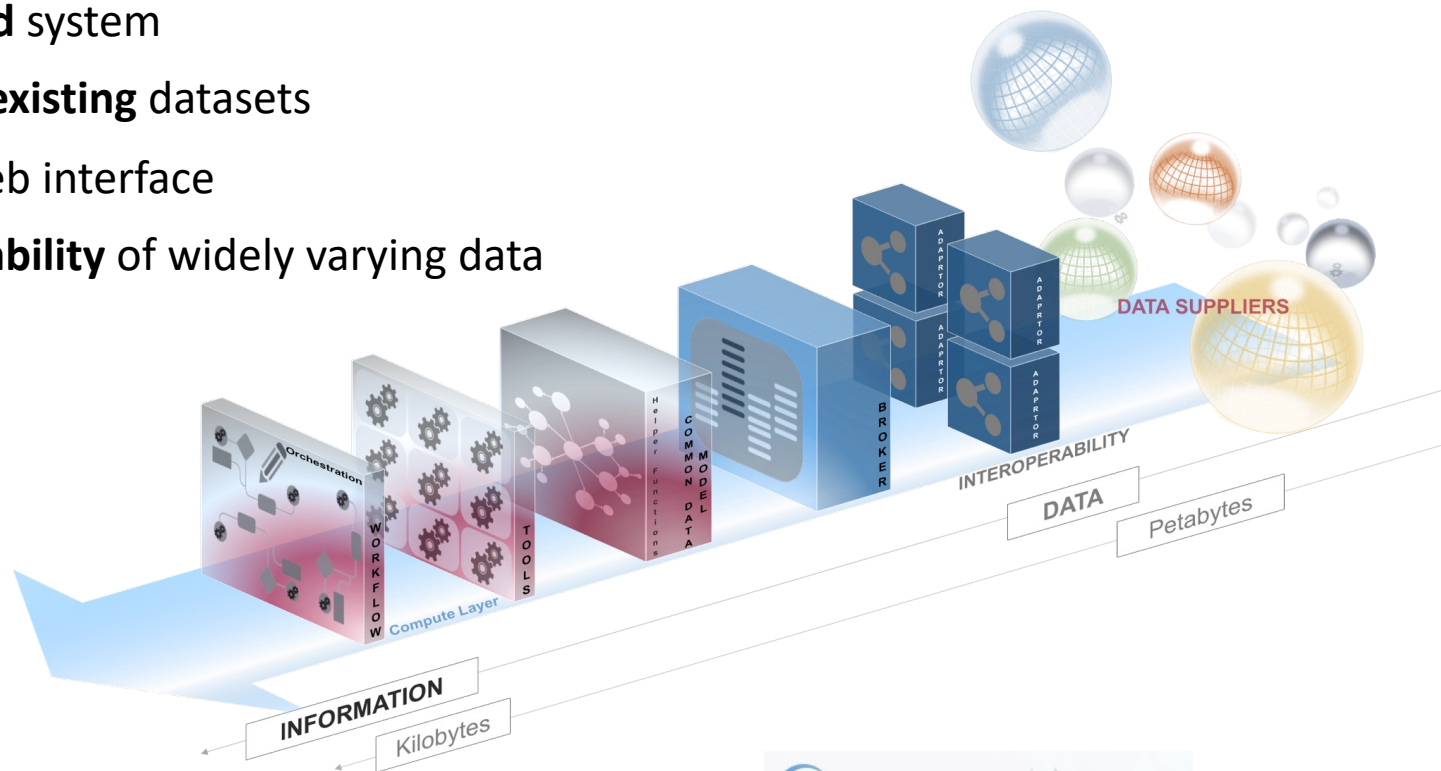
... It allows users to build their own applications, maps and graphs



Climate  
Change

# The Climate Data Store

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





Climate  
Change

# The Climate Data Store

The screenshot shows the search results for 'ERAS hourly single levels'. The top navigation bar includes logos for the European Union, Copernicus, ECMWF, and Climate Change Service, along with the user name 'James Varndell' and a 'Logout' button. The search bar contains the query 'ERAS hourly single levels' and shows 'All' filters. The results are sorted by 'Relevancy'. The first result is 'ERAS hourly data on single levels from 1959 to present', which is highlighted with a red box. This result includes a 'Dataset' tag, category filters for 'Atmosphere (surface)', 'Atmosphere (upper air)', 'Global', and 'Reanalysis', a brief description of the dataset, and a world map. The second result is 'ERAS hourly data on single levels from 1950 to 1978 (preliminary version)', which also includes a 'Dataset' tag, category filters, a description, and a world map.



The screenshot shows the documentation page for the ERAS data. The navigation tabs are 'Overview', 'Download data', 'Quality assessment', and 'Documentation'. The 'Documentation' tab is active. The page contains a list of links and descriptions:

- [ERAS data documentation](#) Detailed information relating to the ERAS data archive can be found in the web link above.
- [The ERAS global reanalysis: Preliminary extension to 1950](#) Journal article describing the ERAS preliminary extension.
- [The ERAS global reanalysis](#) Journal article describing ERAS.
- [Renamed variable: form ocean waves 10m wind to ocean surface stress equivalent 10m neutral wind](#) The reason for the change was a parameter name clash between variables in ERAS wind and ERAS ocean waves.

**Simplicity and consistency are key**



# The Climate Data Store

Climate

Seasonal forecast monthly statistics on single levels

Overview Download data Quality assessment Documentation

Originating centre

ECMWF CMCC UK Met Office NCEP Météo France JMA

System

1 2 3 4 7 8 12 13 21 35 60 601

Variable

- 10m u-component of wind
- 10m wind gust since previous post-processing
- 2m dewpoint temperature
- East-west surface stress rate of accumulation
- Maximum 2m temperature in the last 24 hours
- Mean sub-surface runoff rate
- Minimum 2m temperature in the last 24 hours
- Sea-ice cover
- Snow depth
- Soil temperature level 1
- Surface latent heat flux
- Surface solar radiation
- Surface thermal radiation
- Top solar radiation
- Total cloud cover
- 10m v-component of wind
- 10m wind speed
- 2m temperature
- Evaporation
- Mean sea level pressure
- Mean surface runoff
- North-south surface stress rate of accumulation
- Sea surface temperature
- Snowfall
- Solar insolation rate of surface
- Surface sensible heat flux
- Surface solar radiation
- Surface thermal radiation
- Top thermal radiation
- Total precipitation

Select all Clear all

## Surface radiation budget from 1982 to present derived from satellite observations

Overview Download data Quality assessment Documentation View

Product family

At least one selection must be made

- CLARA (Cloud, Albedo and Radiation)
- CCI (Climate Change Initiative)

Origin

At least one selection must be made

- CES (Copernicus Climate Change Service)
- EUMETSAT (European Organisation for the Exploitation of Meteorological Satellites)
- ESA (European Space Agency)

Variable

At least one selection must be made

- Surface upwelling shortwave flux
- Surface upwelling longwave flux
- Surface downwelling shortwave flux
- Surface downwelling longwave flux
- Surface net downward shortwave flux
- Surface net downward longwave flux
- Surface net downward radiative flux
- All variables (CCI product family)

Select all Clear all

## Climate and energy indicators for Europe from 2005 to 2100 derived from climate projections

Overview Download data Documentation

Variable

Meteorology

- Electricity demand
- Hydro power generation rivers
- Wind power generation offshore
- Hydro power generation reservoirs
- Solar photovoltaic power generation
- Wind power generation onshore

Spatial aggregation

- Country level
- Maritime country level
- Original grid
- Sub-country level
- Maritime sub-country level

Energy product type

- Capacity factor ratio
- Energy
- Power

Temporal aggregation

- 3 Hourly
- Monthly
- Annual
- Daily
- Seasonal

## CMIP6 climate projections

Overview Download data Documentation

Temporal resolution

- Monthly
- Daily
- Fixed (no temporal resolution)

Experiment

- Historical
- SSP4-6.0
- SSP1-1.9
- SSP3-7.0
- SSP5-2.6
- SSP5-8.5
- SSP4-3.4
- SSP5-3.4OS
- SSP2-4.5

Level

- Single levels
- 1 hPa
- 5 hPa
- 10 hPa
- 20 hPa
- 30 hPa
- 50 hPa
- 70 hPa
- 100 hPa
- 150 hPa
- 200 hPa
- 250 hPa
- 300 hPa
- 400 hPa
- 600 hPa
- 850 hPa
- 925 hPa
- 1000 hPa

Variable

- Air temperature
- Daily maximum near-surface air temperature
- Eastward near-surface wind
- Evaporation including sublimation and transpiration
- Grid-cell area for atmospheric grid variables
- Land ice area percentage
- Near-surface air temperature
- Daily minimum near-surface air temperature
- Eastward wind
- Geopotential height
- Grid-cell area for ocean variables
- Moisture in upper portion of soil column
- Near-surface relative humidity
- Capacity of soil to store water

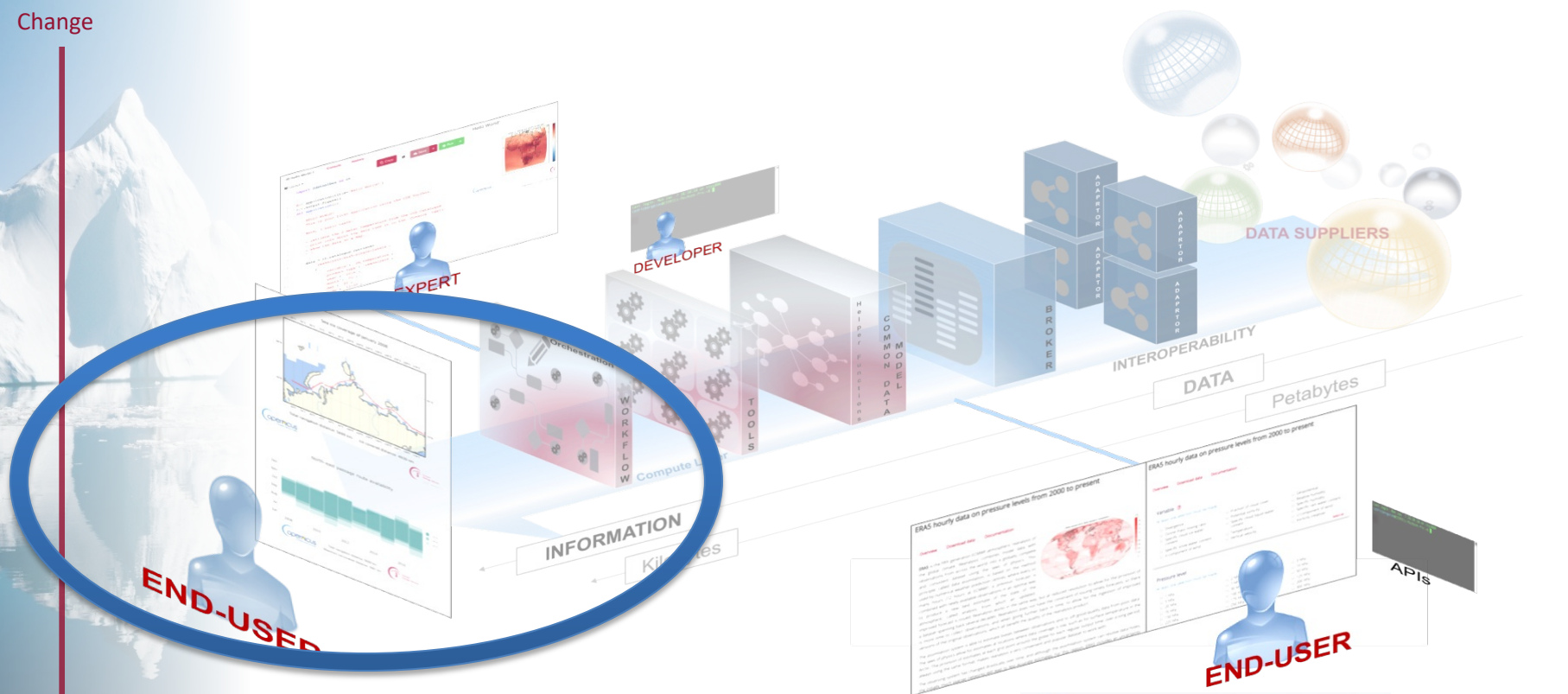
Simplicity and consistency are key





Climate  
Change

# The Climate Data Store





Climate  
Change

# The Climate Data Store

The screenshot displays the Climate Data Store's web interface. At the top, there are logos for the European Union, Copernicus, and ECMWF, along with the text 'Climate Change Service' and a 'Logout' button. Below the navigation bar, the 'Toolbox Editor' is open, showing a Python script for 'climate-strips'. The script imports 'calendar' and 'cdstoolbox as ct', defines 'YEARS' and 'REFERENCE' variables, and uses 'ct.Layout' to create a form with input fields for 'city' and 'month', and an output field for 'output-1'. It also includes a 'LiveFigure' component that retrieves data from the 'reanalysis-era5-single-levels-monthly-means' dataset and generates a 'warming\_strips' chart. The dataset catalogue on the left lists various climate data products, including 'climatology\_mean', 'climatology\_percentile', 'climatology\_std', 'compute\_climatology\_bias', 'compute\_extreme\_index', 'daily\_max', 'daily\_mean', 'daily\_min', 'daily\_std', 'monthly\_mean', 'monthly\_std', 'normalize\_to\_climatology', 'relative\_anomaly', 'season\_select', 'climexp', 'cube', 'eurostat', 'geo', 'livemap', 'map', 'math', 'observation', 'operator', 'sectoral', 'shapes', and 'stats'. On the right, the visualization shows a form for 'Climate stripes for Bonn (DE)' with a 'Month' dropdown set to 'January', a 'City' dropdown set to 'Bonn (DE)', and input fields for 'Latitude' (50.73438) and 'Longitude' (7.09549). Below the form is a 'Climate stripes for Bonn (DE)' visualization showing a series of vertical bars representing monthly temperature anomalies.

share applications

simple Python editor  
in your web browser

configurable GUI  
elements

dataset catalogue API  
no downloads needed

interactive  
visualisations

wide range of tools

backend caching

help and support



Climate  
Change

# The Climate Data Store

The screenshot displays the Climate Data Store (CDS) interface. At the top, there are logos for the European Commission, Copernicus, and ECMWF, along with the text "IMPLEMENTED BY" and "Climate Change Service". A user profile for "James Varndell" and a "Logout" button are visible in the top right. Below the navigation bar, the notebook interface shows a terminal window with the following Python code:

```
1 import cdstoolbox as ct
2
3
4 YEARS = [str(year) for year in range(1991, 2021)]
5
6
7 @ct.application(title='Hello World!')
8 @ct.output.livemap()
9 def application():
10
11     data = ct.catalogue.retrieve(
12         "reanalysis-era5-single-levels",
13         {
14             'variable': '2m_temperature',
15             'product_type': 'reanalysis',
16             'year': YEARS,
17             'month': '08',
18             'day': '25',
19             'time': [f"{hour:02d}:00" for hour in range(24)],
20         }
21     )
22     mean = ct.cube.average(data, dim="time")
23
24     regions = ct.shapes.catalogue.states_provinces(country="Italy")
25     layers = [mean, regions]
26     livemap = ct.livemap.plot(layers, crs="EPSG3035")
27
28     return livemap
29
```

On the right side of the notebook, the output is a map titled "Hello World!" showing a temperature distribution over Italy. The map uses a color scale from blue (cooler) to red (warmer). A scale bar at the bottom of the map indicates "2 metre".

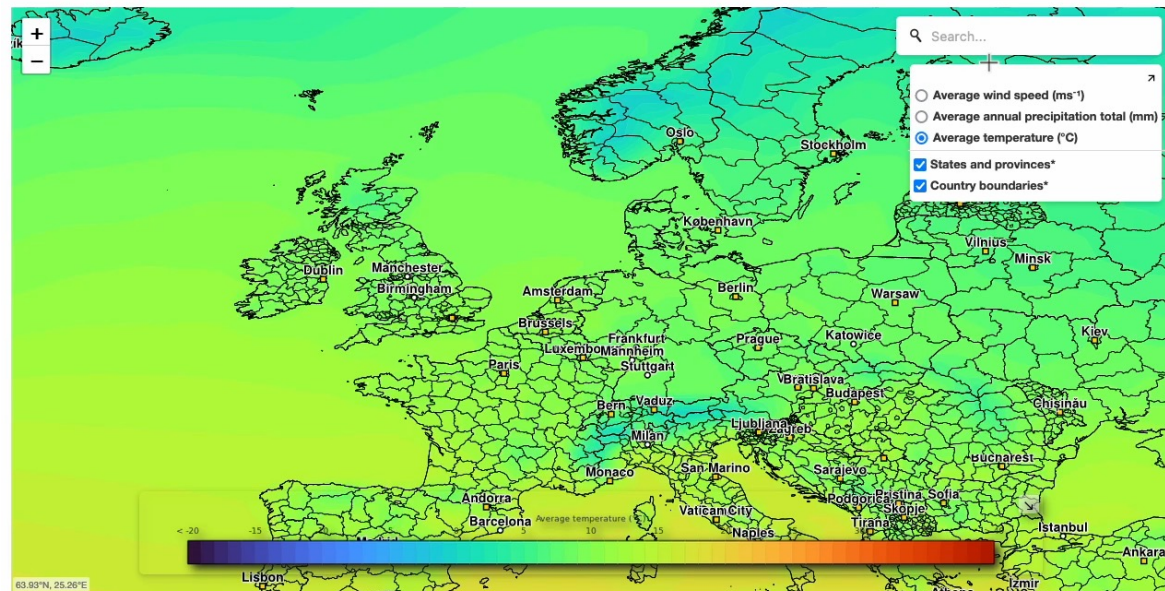


Climate  
Change

# The Climate Data Store

Click anywhere on the map or search for a city to discover a range of local climate statistics for the period 1979-2020.

This application is driven by [ERA5](#), the fifth generation ECMWF atmospheric reanalysis of the global climate. Inspired by [Lobelia's Past Climate Explorer](#).



\*The designations employed and the presentation of material on the map do not imply the expression of any opinion whatsoever on the part of the European Union concerning the legal status of any country, territory or area or of its authorities, or concerning the delimitation of its frontiers or boundaries.

Version: 4.35.4 - build f8ced5bb



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



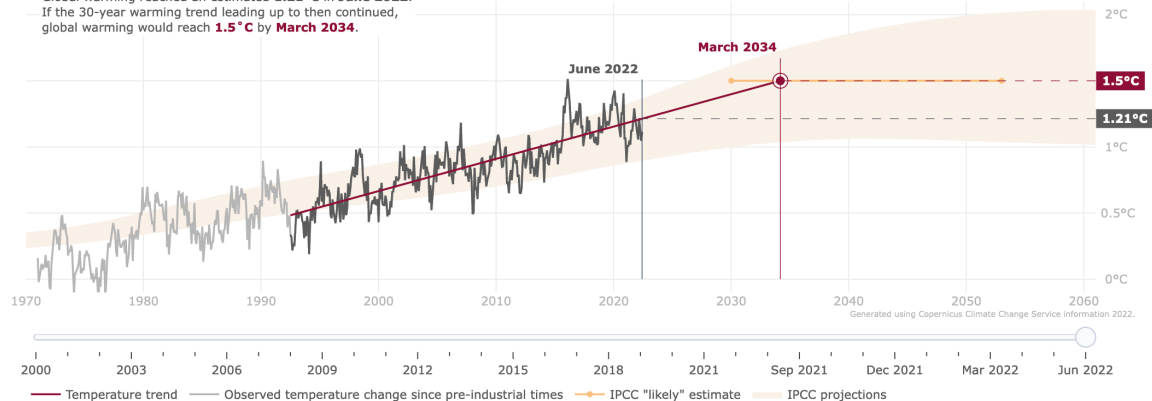
Climate  
Change

# The Climate Data Store

## 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.**

Global warming reached an estimated **1.21°C in June 2022**.  
If the 30-year warming trend leading up to then continued,  
global warming would reach **1.5°C by March 2034**.



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>



Climate  
Change

# Outline

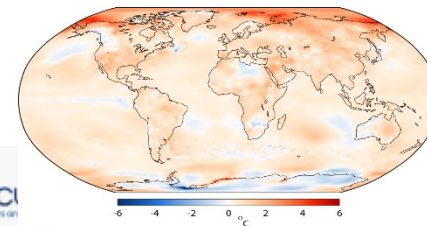
¿ Qué es el Servicio Europeo de Cambio Climático (C3S) ?

¿ 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 ?





Climate Change

# What is the SIS and how it works



Agriculture



Insurance



Biodiversity



Shipping



Coastal areas



Storm surges



Energy



Tourism



Health



Water management



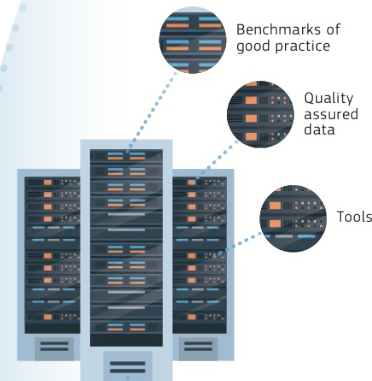
Infrastructure



USERS



CLIMATE DATA STORE



PRACTICAL EXAMPLES

Documentation



Tools and applications



Case studies



Sector relevant data









Climate Change

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

**JANUARY 2021**  
Climate cl  
The Danish M  
Denmark.

**FEBRUARY 2021**  
SCO FLAude: Understanding extreme hvdrometeorological events in Aude and Occit:

**DECEMBER 2020**  
By analy  
propose  
Usin  
deliv  
WECTOU, climate and environmental information customised for the tourism sector

**OCTOBER 2020**  
CLIMTAG, the CLimate InforMation Tool for AGriculture

**JUNE 2020**  
Climate-smart risk management for ports

**OCTOBER 2020**  
Climate data for sustainable infrastructure

**NOVEMBER 2020**  
ESOX from Lautec – using climate data to simulate offshore wind power operations

**DECEMBER 2020**  
The impact of climate change on the cotton industry

EOXPLORE and Terranea are using data and tools from the C3S Climate Data Store (CDS) to develop novel information sources to help the cotton industry understand and adapt to changes in the environment and climate.



CLIMATE ADAPTATION INFORMATION ACROSS EUROPE

Search Climate-ADAPT Database items

- ABOUT -
- EU POLICY -
- COUNTRIES, TRANSNATIONAL REGIONS, CITIES -
- KNOWLEDGE -
- NETWORKS

Home » Knowledge » European Climate Data Explorer

## European Climate Data Explorer

Help Overview list of all Indices



PROGRAMME OF THE EUROPEAN UNION



implemented by ECMWF



Climate  
Change

# Outline

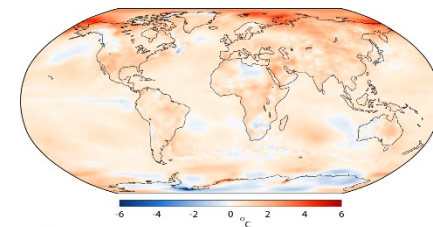
¿ Qué es el Servicio Europeo de Cambio Climático (C3S) ?

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

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¿ Algún otro componente en C3S ?



PROGRAMME OF  
THE EUROPEAN UNION



WF



Climate  
Change

In summary....



## Climate Change

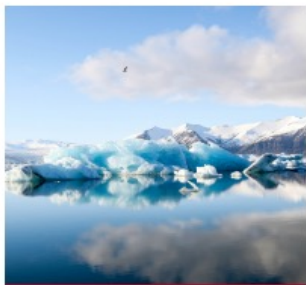
We provide authoritative information about the past, present and future climate, as well as enable climate change mitigation and adaptation strategies by policy makers and business.

<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



Climate  
Change

## Biodiversity sector

# 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.



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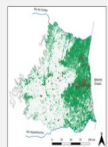
## Biodiversity sector

### Climate data from C3S for Global Biodiversity

- Historical data: ERA5-Land reanalysis dataset
- Future data: 6 GCMs of CMIP5 database
- Set of 4 relevant climatic indicators
- Emission scenarios: RCP 4.5 and RCP 8.5

### Occurrence data

- 76 presence records from field surveys



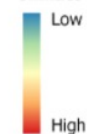
Ecological Niche Modelling tools

Future climate suitability for GHLT in 2040, 2060 & 2080

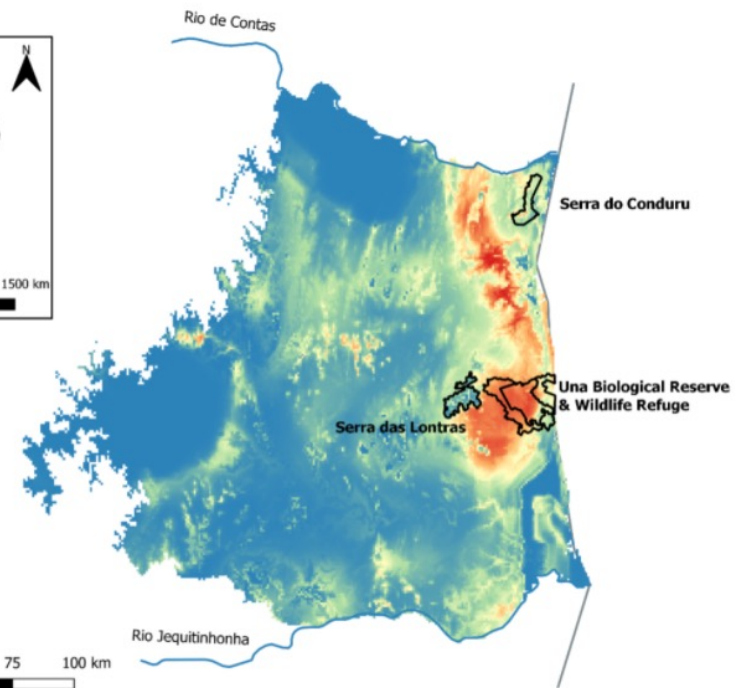


— Major rivers  
□ Protected\_areas

### Climate suitability



0 25 50 75 100 km

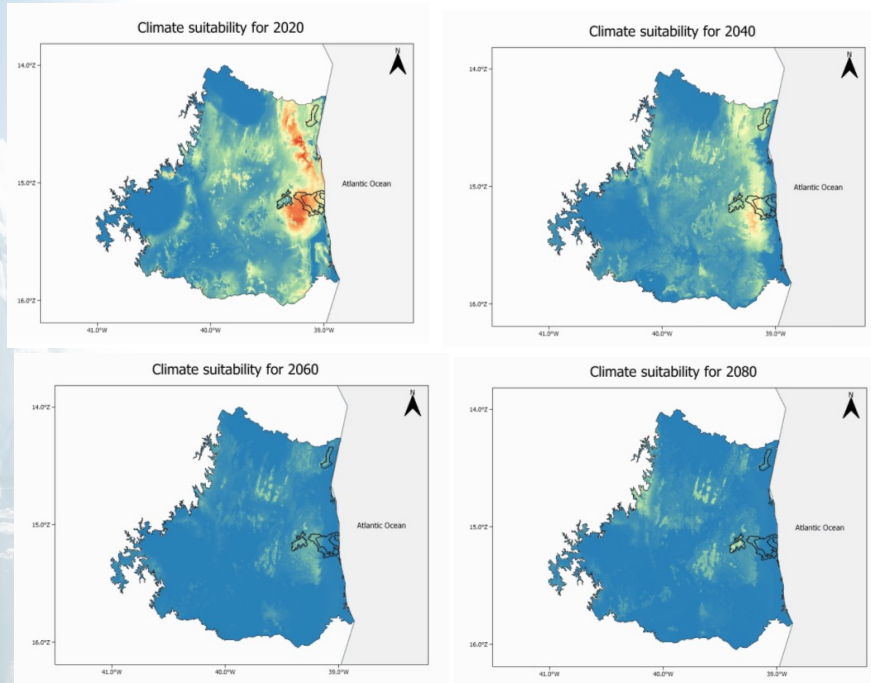


Current climate suitability of the study area in Bahia forest for the golden-headed lion tamarins. Protected areas are indicated in black. Warmer colours represent areas with a high climate suitability while cooler colours represent areas with low climatic suitability.



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## Biodiversity sector



### Outcomes:

- 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

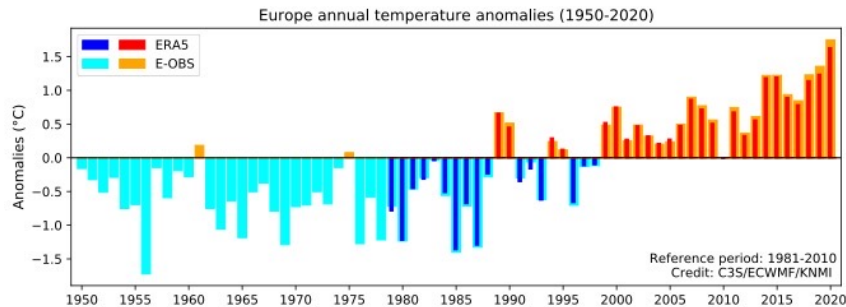
→ If we do not succeed in keeping global average temperature rise well below 2°C, the golden-headed lion tamarin and many other species could face extinction by the end of the century.





Climate Change

# 2020: an exceptional year for Europe and the Arctic

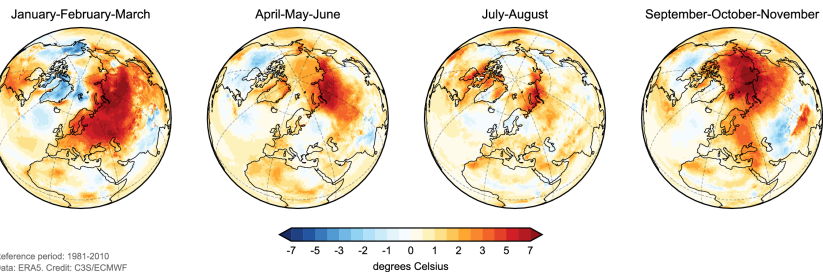


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## Multi-month average surface temperature anomalies in 2020



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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

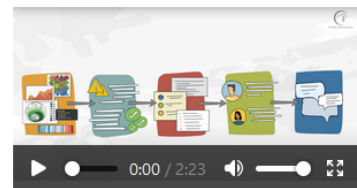
For users of the C3S services  
Become part of the community, work together and support each other.

## Contact us

Can't find the answer you're looking for? Get in touch!  
Login to the **C3S Enquiry Portal**

[ECMWF SUPPORT GUIDELINES >](#)

FINDING YOUR WAY TO THE RIGHT DATA:



## 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.