



Climate Change

Copernicus Climate Change Service (C3S): How climate data can be made user relevant and usable?

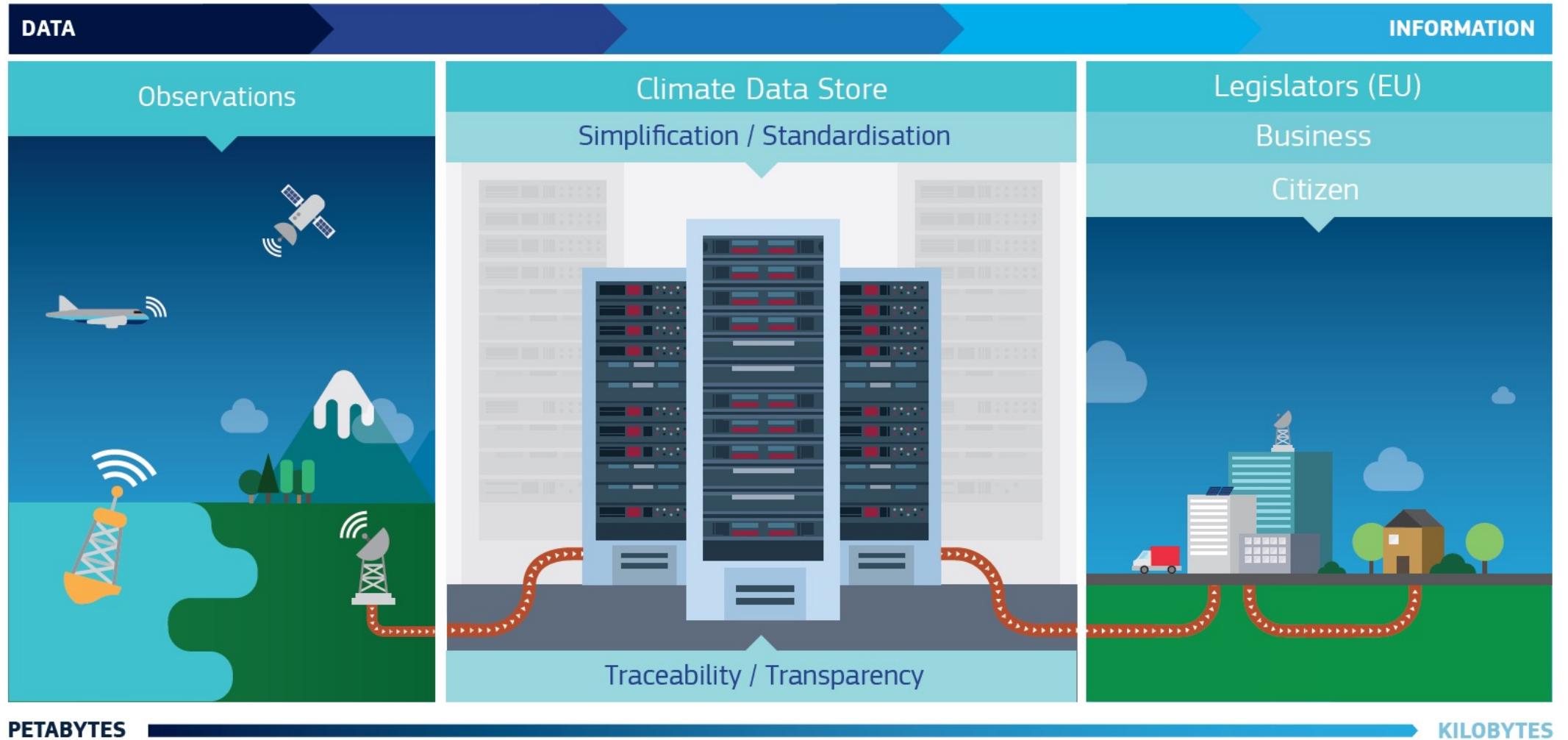
Samuel Almond - ECMWF





Climate
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More Than Climate Data..... Climate Information



Typical download: **70 TB /day**

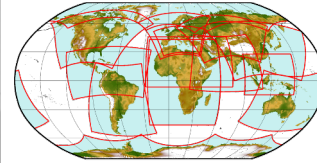
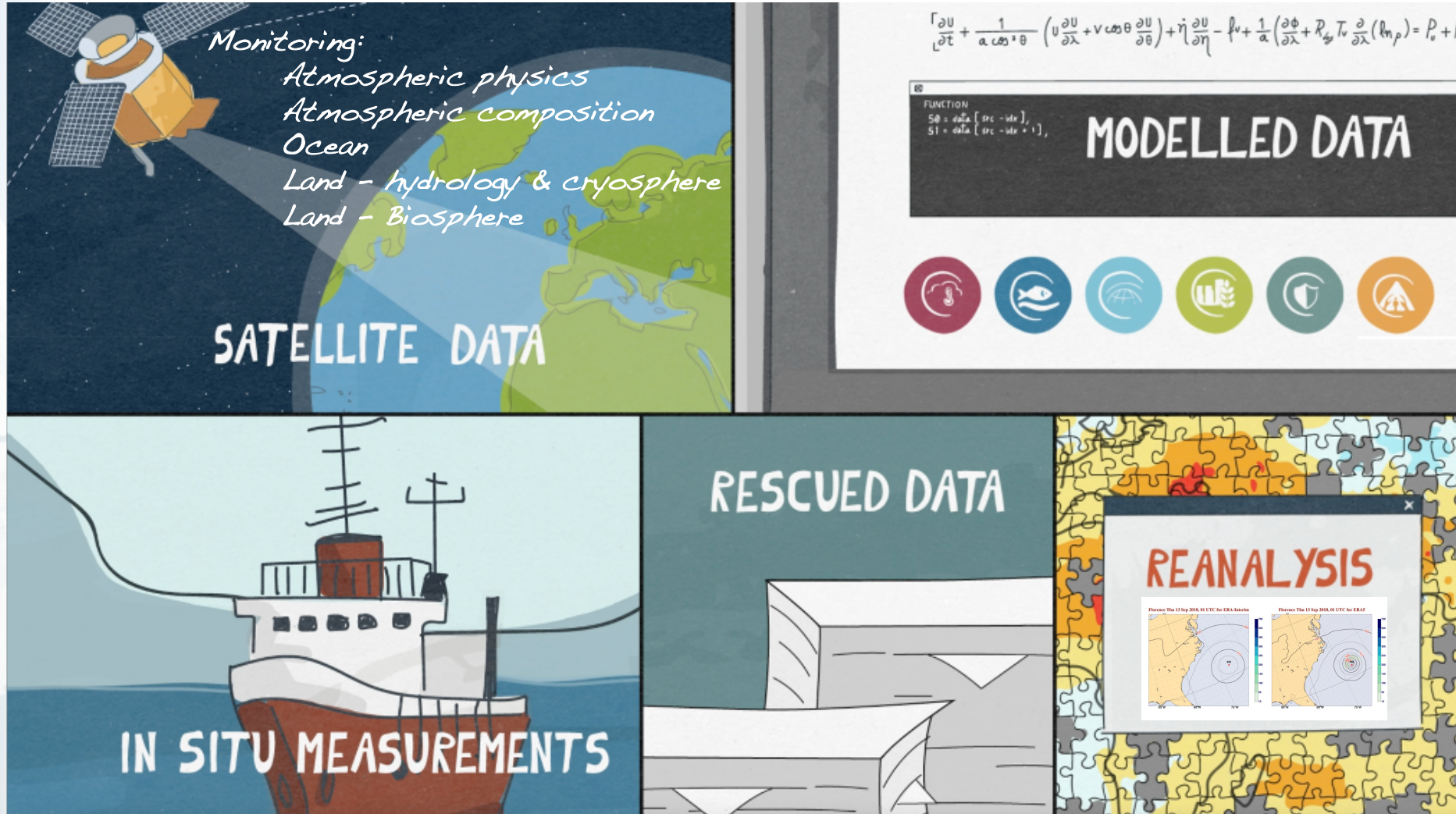
100,000 + users





Climate Change

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

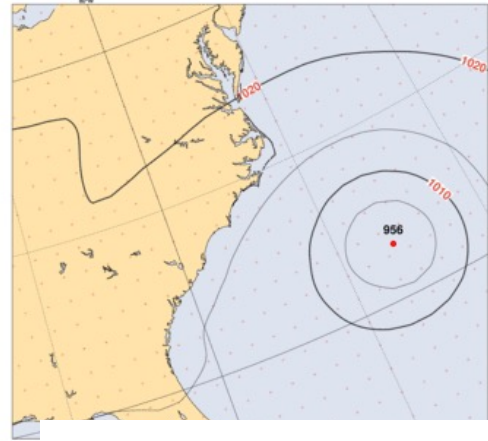




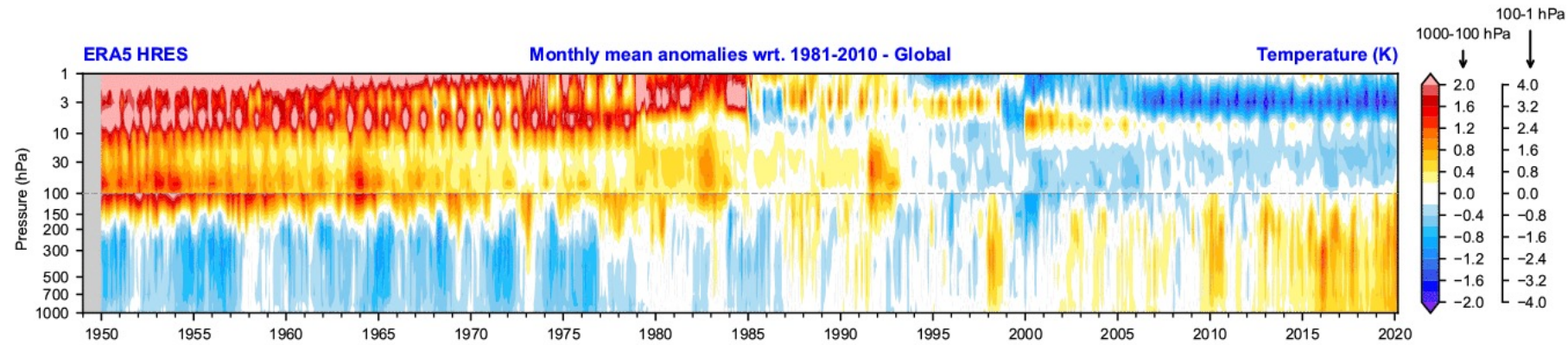
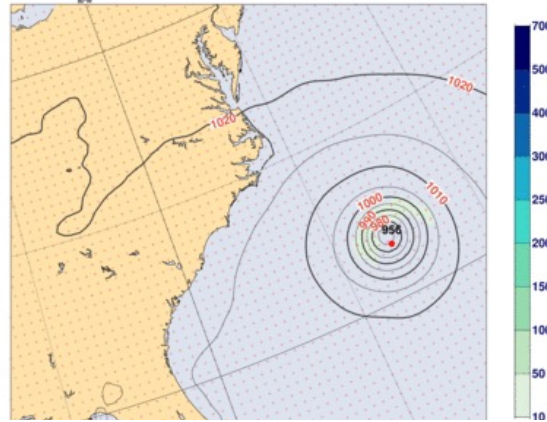
Climate
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The past weather without gaps: global atmospheric reanalysis ERA5

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



Florence Thu 13 Sep 2018, 01 UTC for ERA5



1950 – 1979

Published end 2021

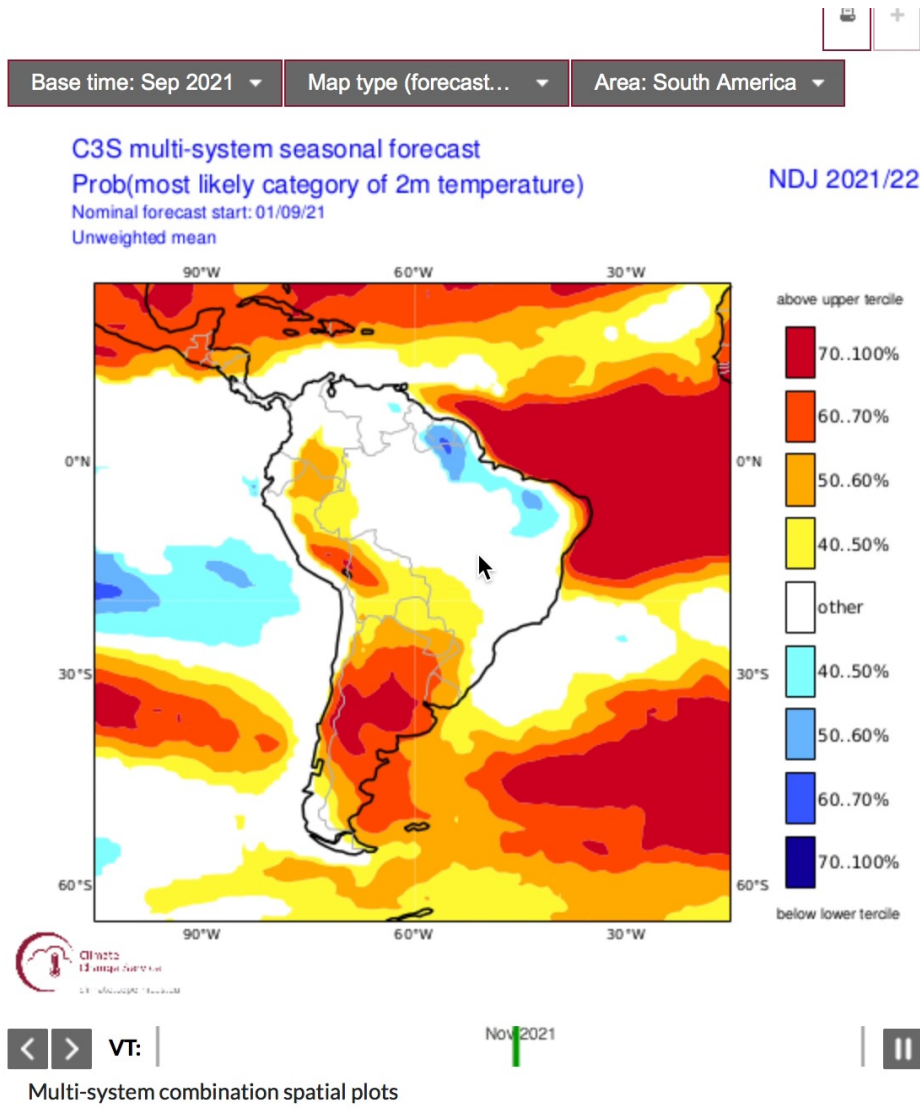
1979 – present

Complete. NRT stream runs RT – 1 day



Climate Change

Climate Predictions – Seasonal Forecasts



- Data – from world-leading producers
- Operational schedule – released monthly (12th of the month)
- Tools and computational environment

Free and open access to all these resources





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C3S Climate Projections

- **CMIP5 simulations:** in the Climate Data Store (CDS) since 2018
- **CMIP6 simulations:** published in CDS in March 2021
 - **New functionality** to improve handling of data **web-processing services**
- **World-wide CORDEX simulations:** European region in the CDS since 2019; continual update with data for other regions

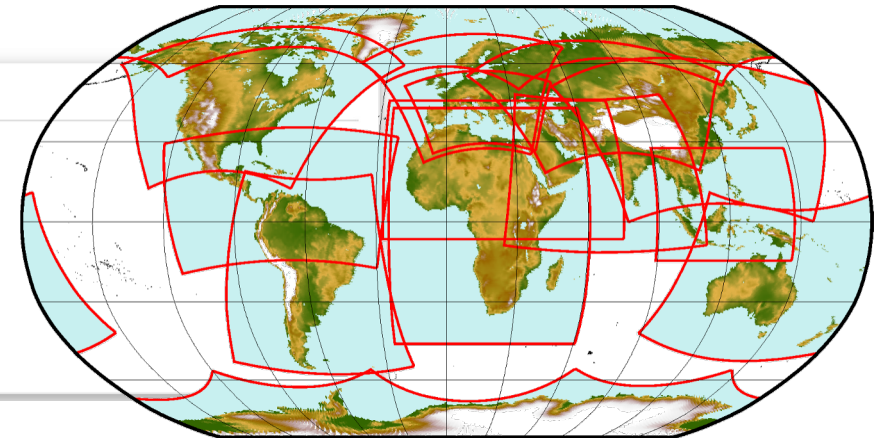
Domain

At least one selection must be made

- Africa
- Australasia
- East Asia
- Middle East and North Africa
- South-East Asia

- Antarctic
- Central America
- Europe
- North America
- South Asia

- Arctic
- Central Asia
- Mediterranean
- South America



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Climate Change

Evaluation & Quality Control framework



Ensuring a quality performance from C3S

Home / News

1st October 2020



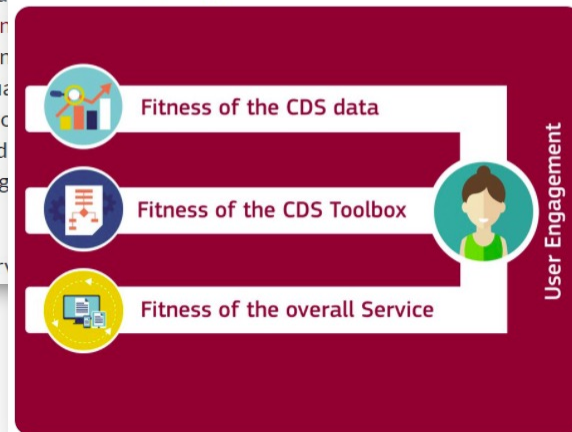
Copernicus ECMWF
@CopernicusECMWF

A new quality assurance framework for the #CopernicusClimate Change Service is now operational. The new features distinguish #C3S from other climate services & cover datasets, the service as a whole & the #CDS Toolbox.

Learn more bit.ly/3ih1kKX

Data quality has always been important for Copernicus (C3S*), and now a new quality assurance framework is becoming operational. At a time when C3S is a trusted source, delivering quality data that are traceable and reproducible, new quality assurance features that will play an important role in ensuring the service is starting to go live.

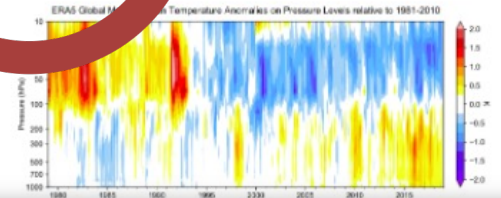
*One of the issues around climate services



ERA5 monthly averaged data on pressure levels from 1979 to present

Overview Download data **Quality assessment** Documentation

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



Finding your way to the right data

<https://climate.copernicus.eu/ensuring-quality-performance-c3s>



Climate Change

An Introduction to the Sectoral Information System: The SIS



Climate Change

Creating Climate Information & Applications for Users Across Sectors

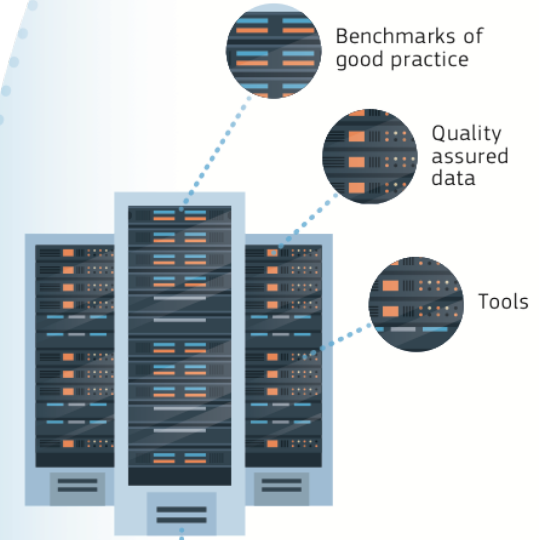
- Agriculture
- Insurance
- Biodiversity
- Shipping
- Coastal areas
- Storm surges
- Energy
- Tourism
- Health
- Water management
- Infrastructure



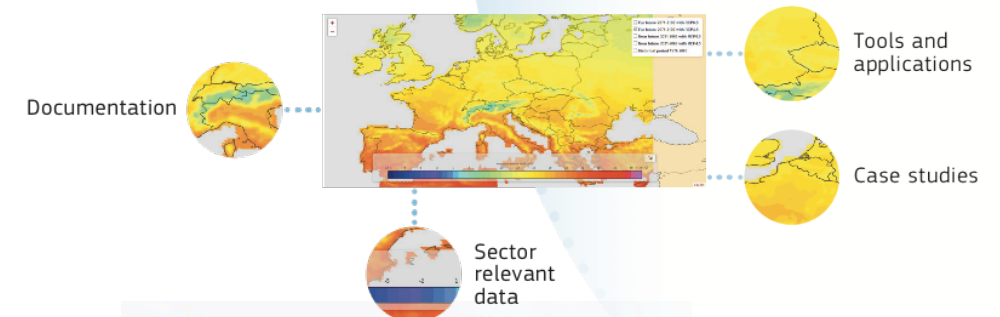
USERS



CLIMATE DATA STORE



PRACTICAL EXAMPLES





Climate
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Access to Data in The Climate Data Store



Login/register

Your [feedback](#) helps us to improve the service

[Home](#) [Search](#) [Datasets](#) [Applications](#) [Toolbox](#) [FAQ](#) [Live](#)

Welcome to the Climate Data Store

Dive into this wealth of information about the Earth's past, present and future climate.

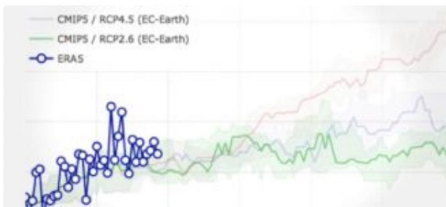
It is freely available and functions as a one-stop shop to explore climate data. [Register for free](#) to obtain access to the CDS and its Toolbox.

We are constantly improving the services and adding new datasets. For more information, please consult the [catalogue](#), our [FAQ](#) or the [C3S forum](#).

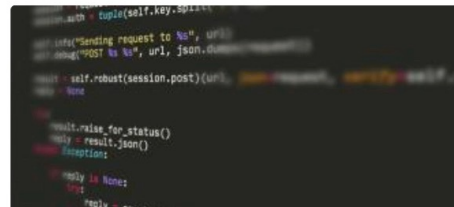
All



Search



Climate Data Store [Toolbox](#)



Climate Data Store [API](#)

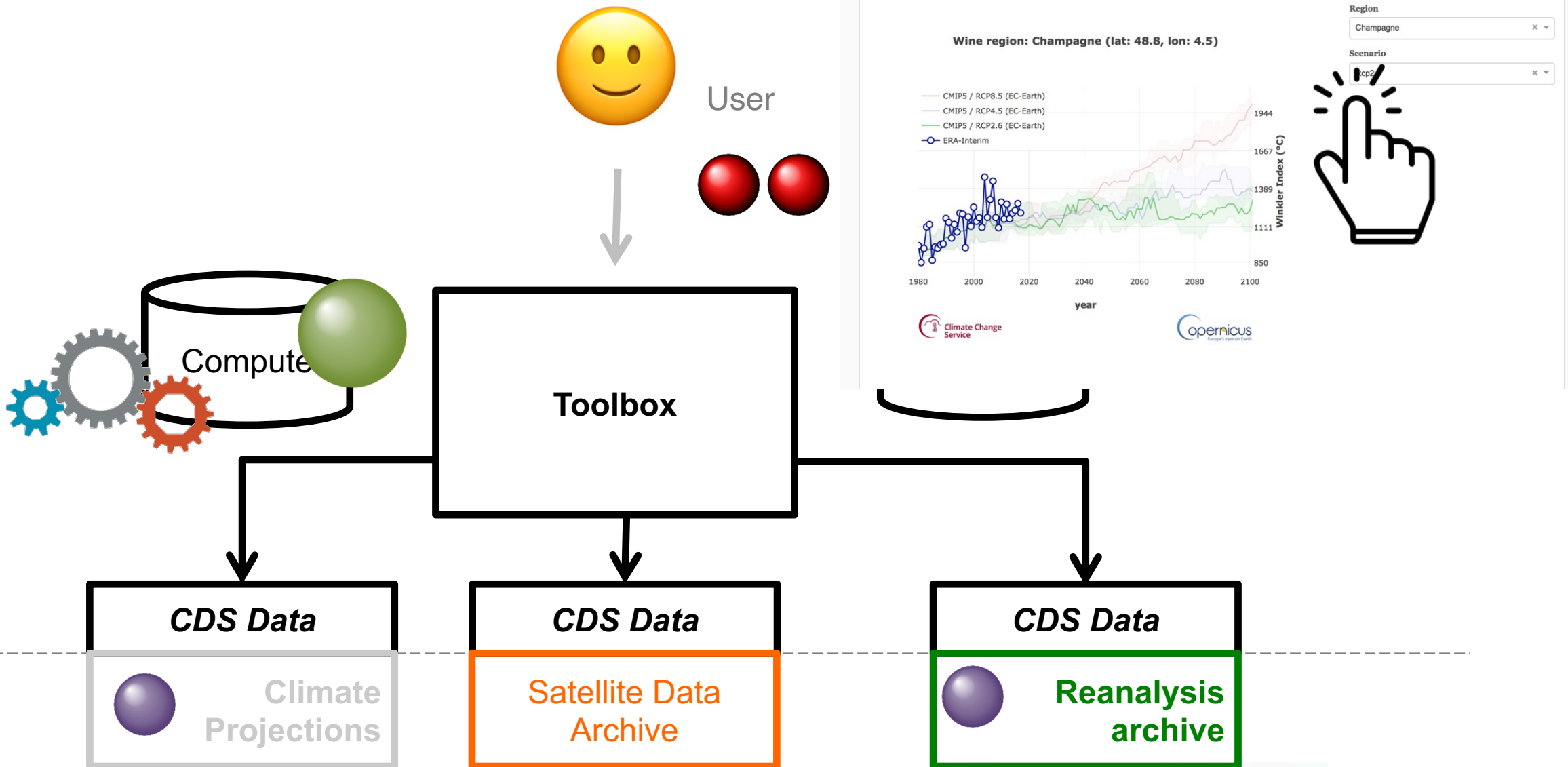


Access the [C3S Forum](#)



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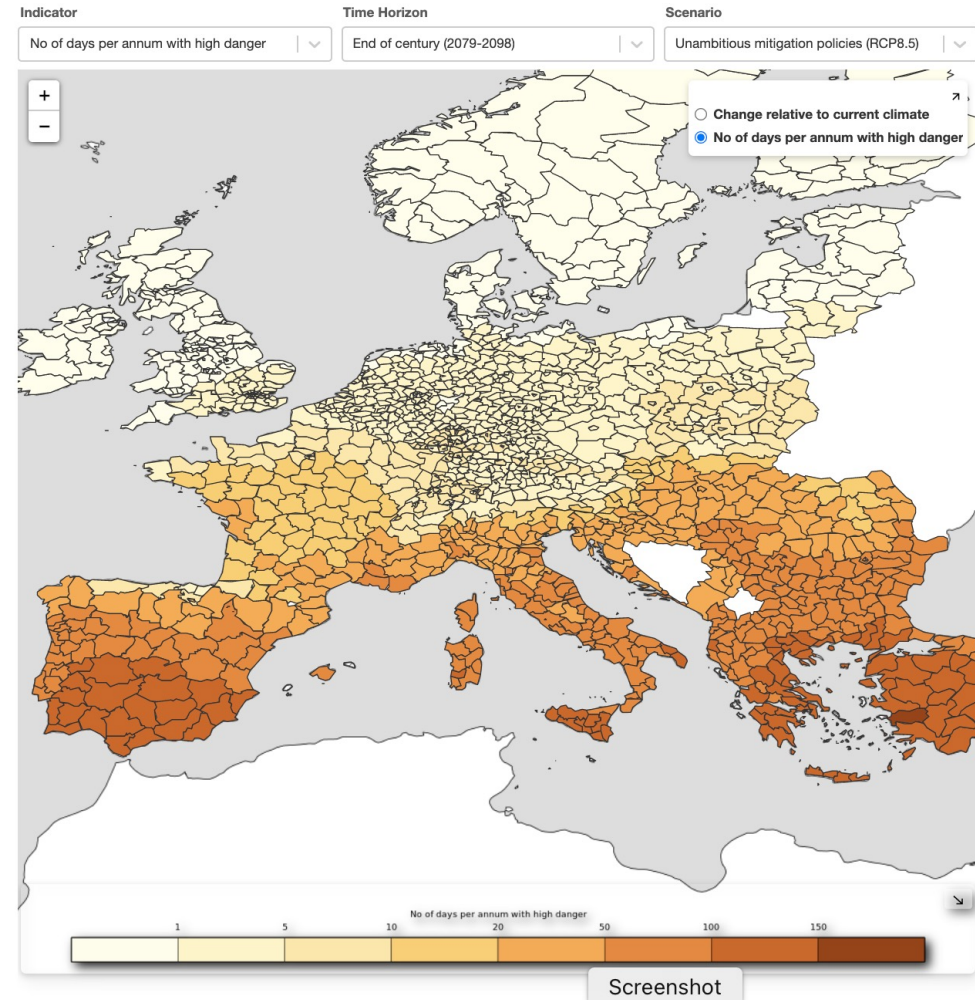
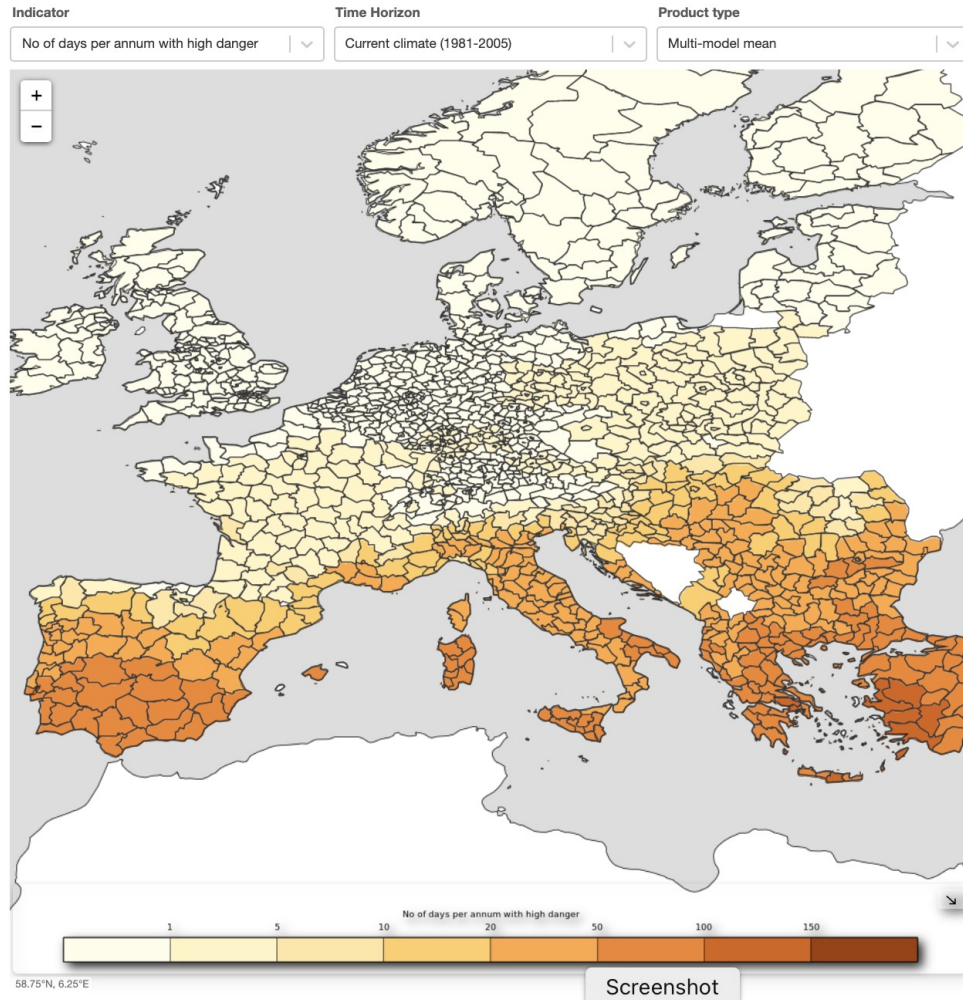
The C3S Toolbox- Concept





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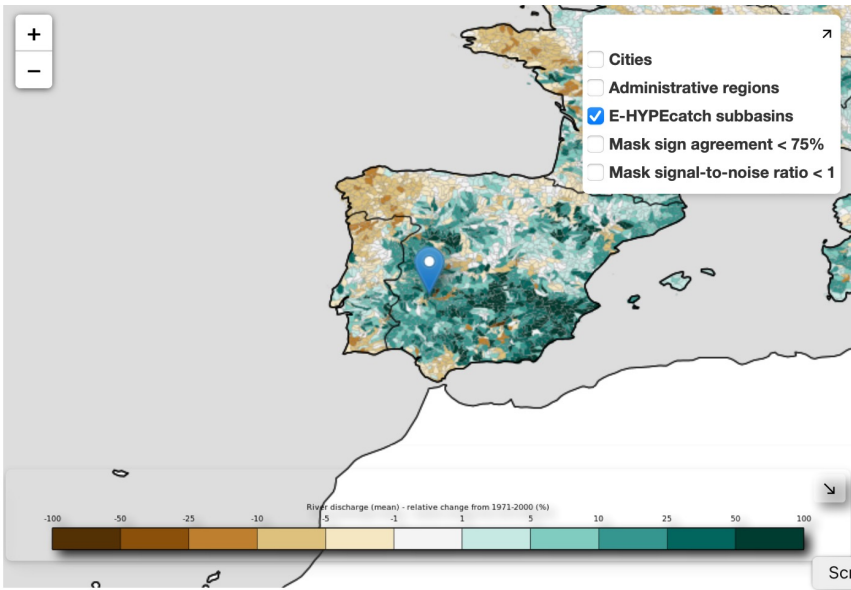
Example Application 1 – Europe's Evolving Fire Risk



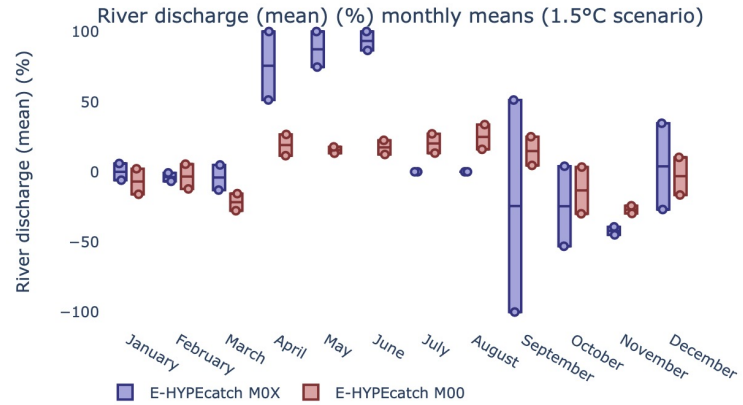


Climate Change

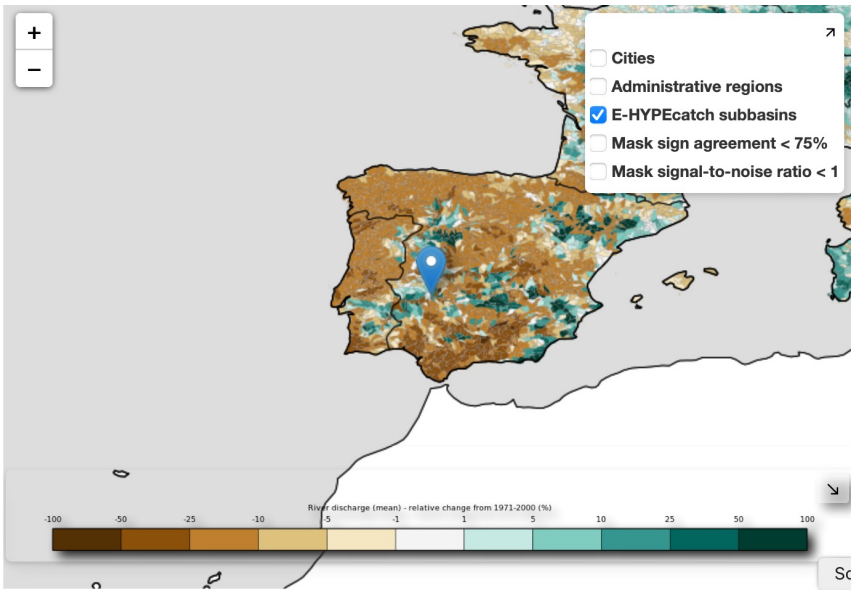
Example Application 2 – Hydrology in a 3.0 degree world!



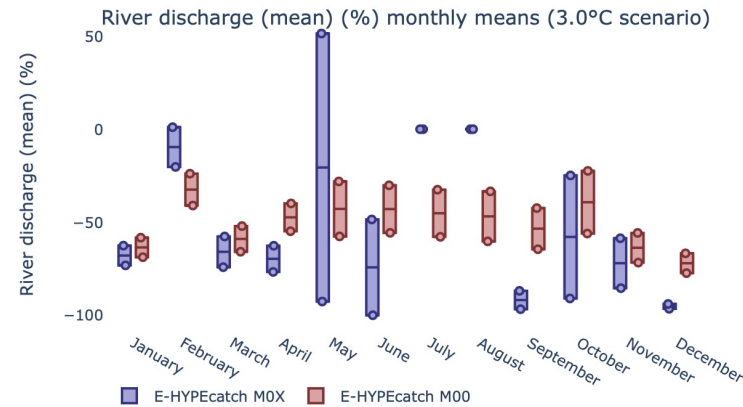
Position: 39.1°N, 5.93°W



Water quality
Water Quality
Bias adjusted climatic indicators



Position: 39.1°N, 5.93°W





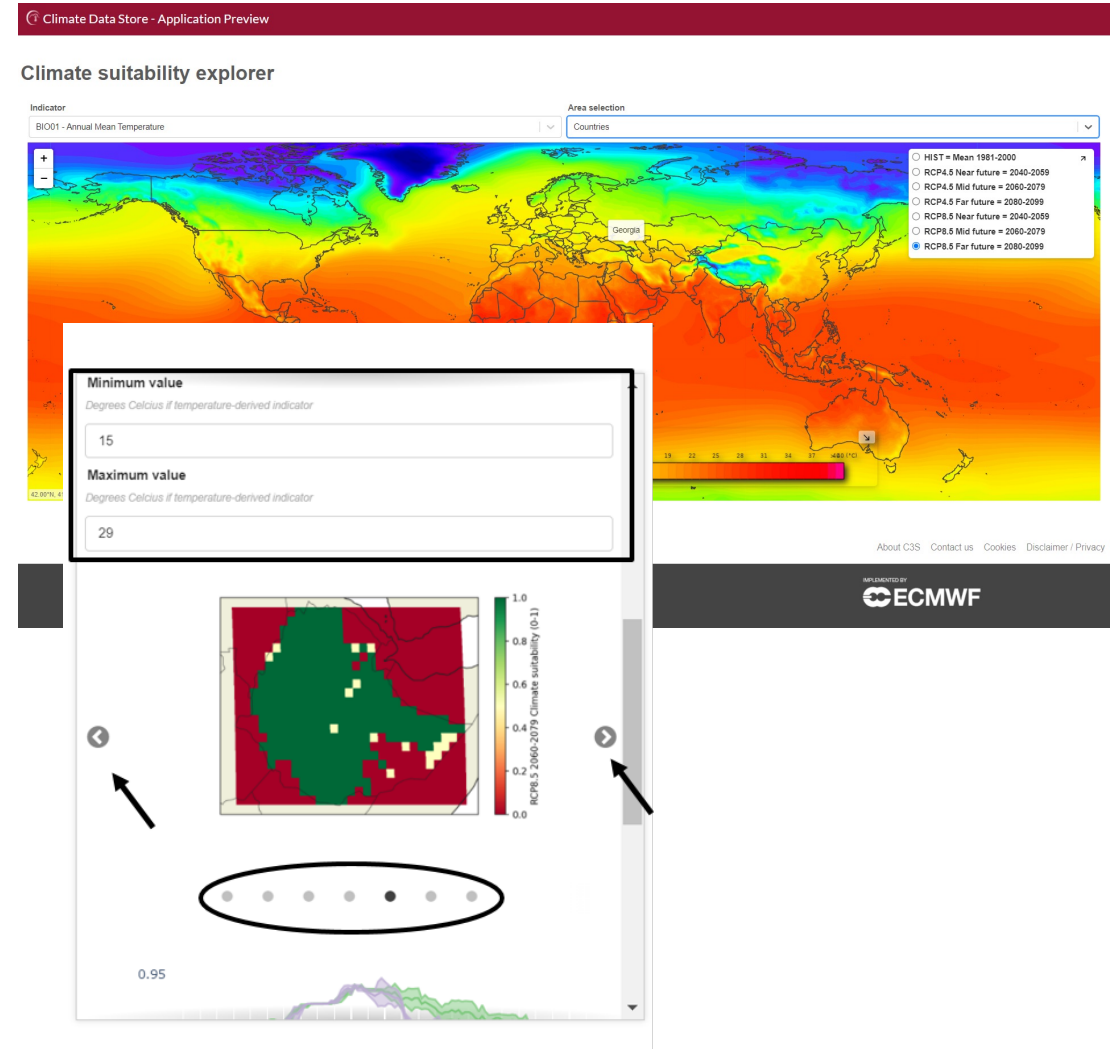
Climate
Change

Providing relevant climate information – Fisheries, Conservation and Resources



New Sectoral Applications to Support Assessment of Climatic Suitability; Biodiversity Service

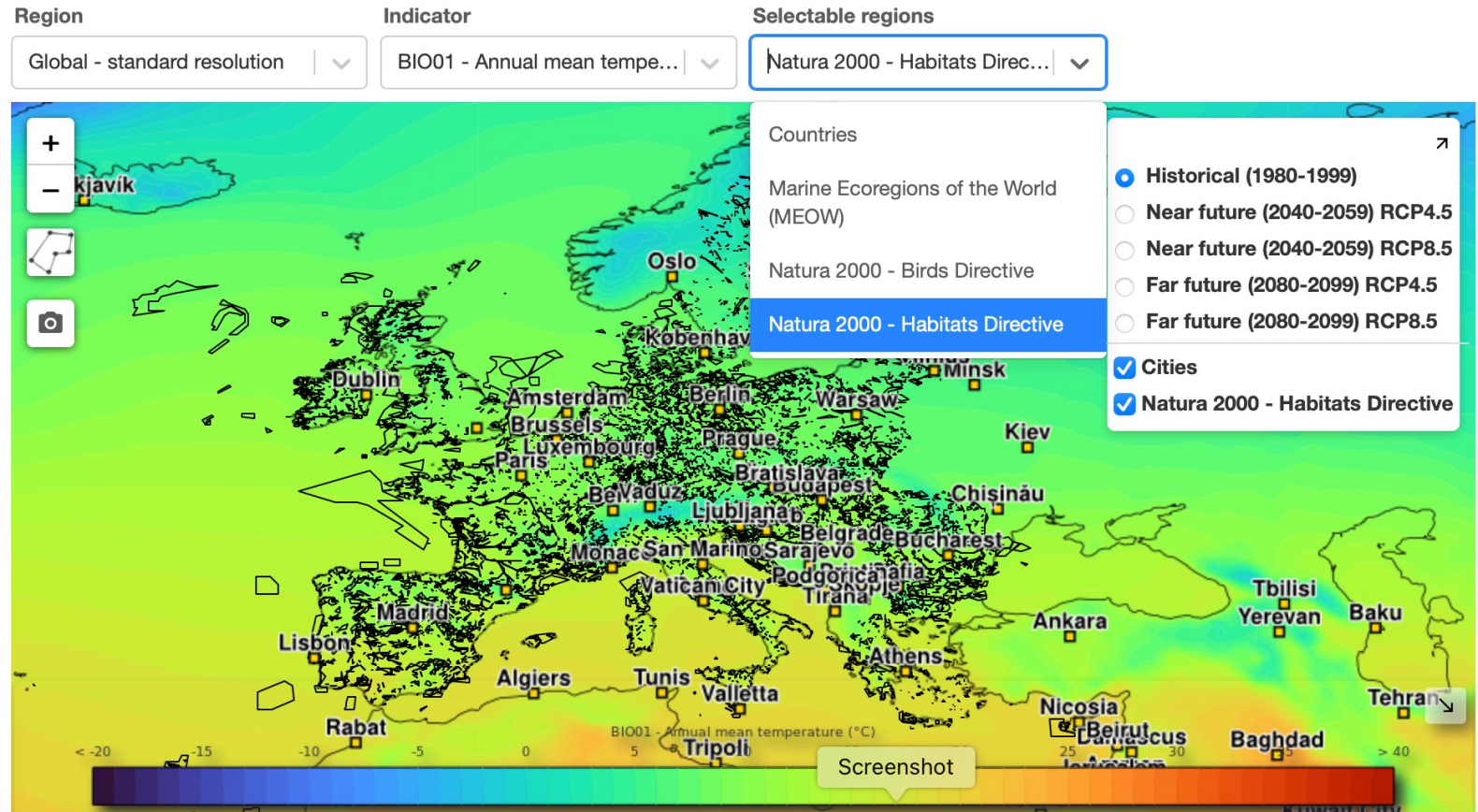
- Interactive applications to visualize and explore bioclimate indicators
- Explore per country or by Natura 2000 site
- User can use a species 'climatic envelope' to help identify if and when a species may become stressed, or impacted by climate change
- Powerful tool to assist with biodiversity assessment and ecosystem services
- Dedicated applications for European grassland and hedges - exploring the impact of climate change on European landscapes





Natura 2000 Sites

Inclusion of Shapefiles

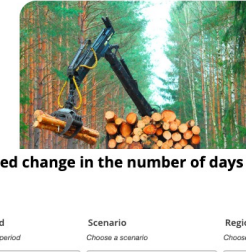
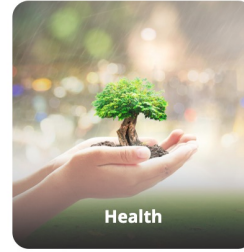


User Engagement: Institutional Interfaces

Working directly with EU institutions to provide bespoke climate information relevant to users / policy requirements

- EEA
- Union For Mediterranean (UfM)
- European Investment Bank
- ECDC

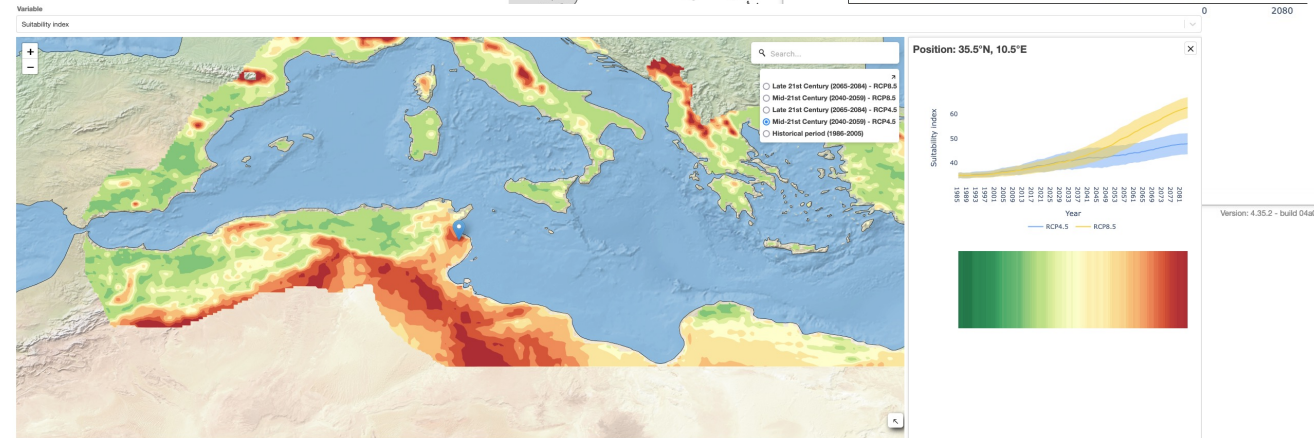
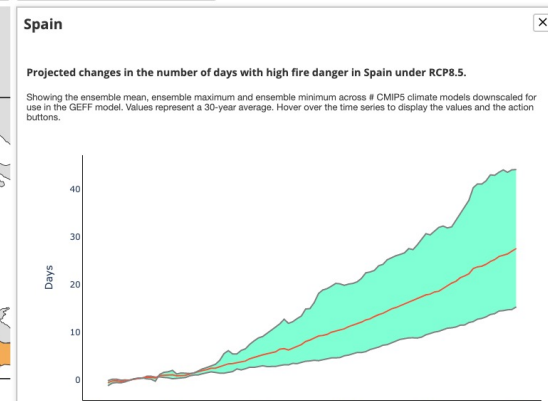
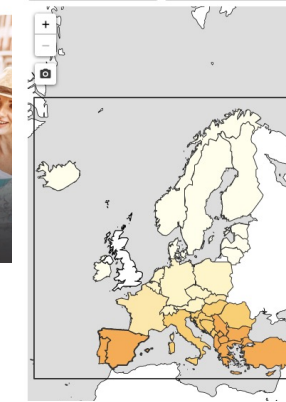
European Climate Data Explorer



Projected change in the number of days with high fire danger - Explore index

Go back

Time period: 2066-2095
 Scenario: RCP8.5
 Regional aggregation: National level (NUTS0)





Climate Change

Demonstrator Cases

The aim of the demonstrator contracts are to maximise the impact and visibility of C3S

Demonstrate the value of C3S data and infrastructure across multiple sectors.

These contracts, do not have to be underpinned by a business model, but communication potential.

Climate, weather & migrants: A story of birds facing global warming

Weather has shaped bird migration for thousands of years but now the rules have changed. Discover the respiratory variations of migratory birds in Europe.

[Learn more](#)

Climate Data Store - The impact of climate change on global cotton production

Country of interest: India

Gujarat

Climate model origin: NOAA, USA | RCP scenario: RCP 8.5 - Unambitious mitigation p... | Analysis: Precipitation

Bar chart showing the number of days (y-axis, 0-4) across months (x-axis, Jan-Dec) for three periods: 2011-2040, 2041-2070, and 2071-2099. The number of days peaks in July and August.

France Annual Air Temperature

France's highest annual air temperature between 1980-2019 was 43.8°C. A 1°C increase would lead to a 2014-2049 mean of 44.8°C.

Roadford Company: South West Water

Select a grid from the map

Year	2011	2012	2013	2014	2015	2016	2017	2018	2019
Observed annual mean	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
80% of C3S model	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
90% of C3S model	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
95% of C3S model	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
99% of C3S model	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0

Verification metrics for 2012 when looking 1 month ahead

Metric	Value	Percentage of days
Observed annual mean	10.0	45.0%
80% of C3S model	10.0	45.0%
90% of C3S model	10.0	50.0%
95% of C3S model	10.0	55.0%
99% of C3S model	10.0	60.0%

Data grid 44 selected -4,51





Climate Change

An overview of other C3S Services





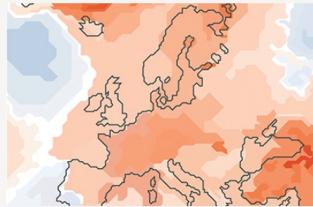
Climate Change

State of the Climate Reports



Globe
Europe
Arctic

Climate bulletin



The conditions of the past month are presented, using key climate change indicators. Analysis of the maps and guidance on how they are produced is also provided.

[View bulletin >](#)

ESOTC



The ESOTC provides a detailed analysis of the past calendar year, with descriptions of climate conditions and events, and explores associated variations in key climate variables across the Earth system.

[View ESOTC >](#)

[Back to top ^](#)



Copernicus
Europe's eyes on Earth

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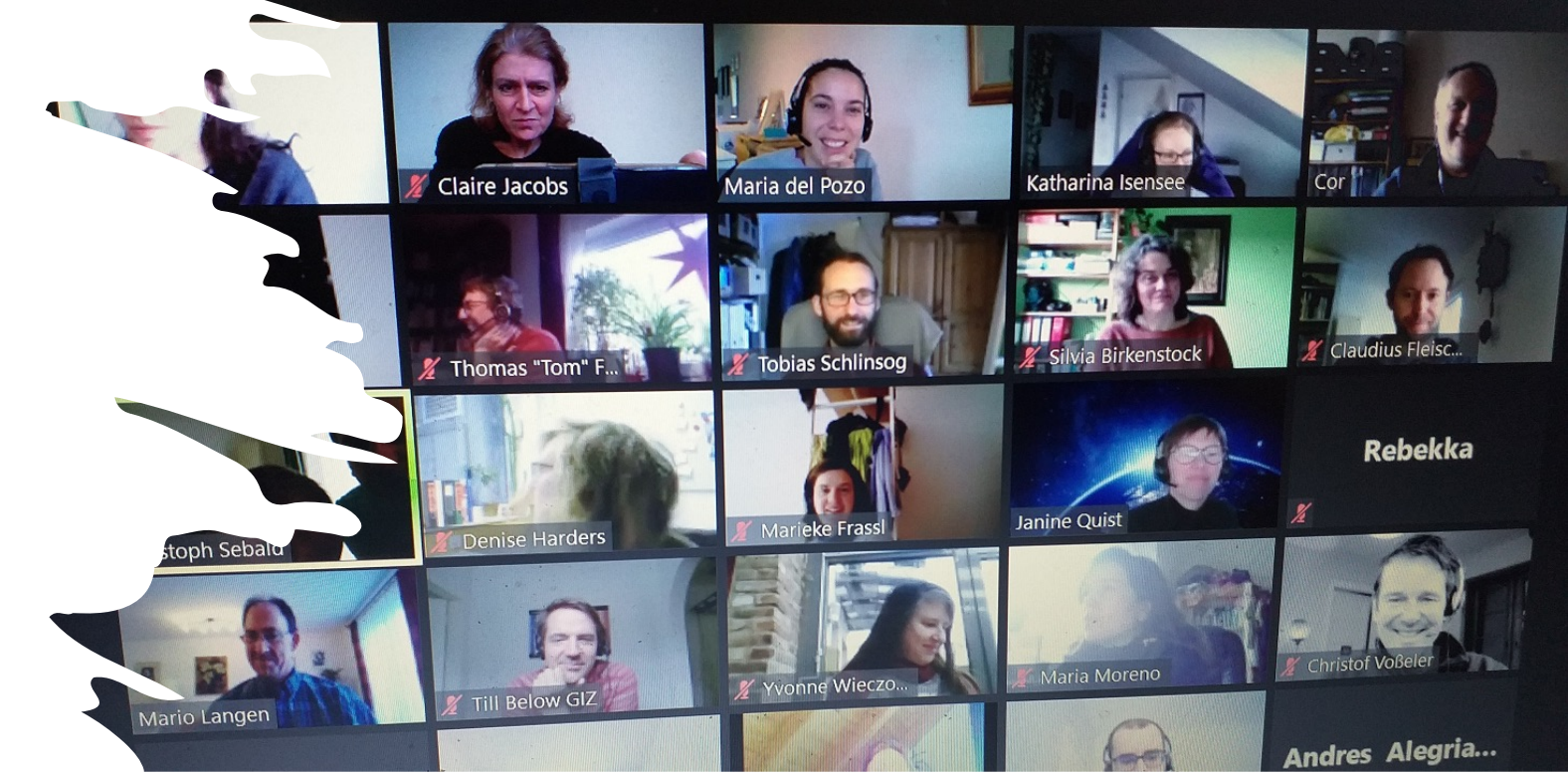


Training & Knowledge Transfer

As operational services, both the Copernicus Climate Change and Atmosphere Monitoring Services provide high quality training and knowledge transfer to facilitate use of our products

- **Free training material**
 - Data tutorials
 - E-learning resources
 - Material from training events
- **Training courses**
 - Targeting specific user communities
 - Variety of formats (online, f2f, blended)
 - Train-the-trainers approach
- **Capacity building**
 - Support to CB programmes (e.g. ClimSA)
 - Training in collaboration with regional entities

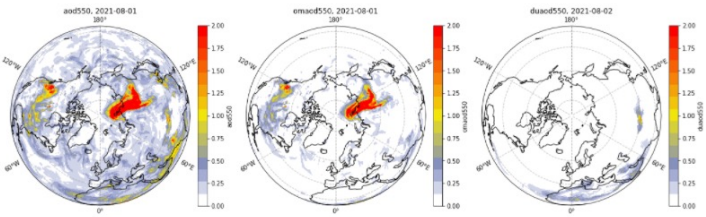
Tell us how we could best support you!



Jupyter Notebook Viewer

```
In [10]: variables[0], variables[1] = variables[1], variables[0]
In [11]: variables
Out[11]: ['aod550', 'omaod550', 'duaod550']
In [12]: fig, axs = plt.
for i in range(
da = ds[vari
axs[i].gridli
axs[i].contour
im =
transform = ccrs.PlateCarree(), cmap=camscmp, vmi
axs[i].coastlines(color='black') # Add coastlines
cbar = fig.colorbar(im, ax=axs[i], fraction=0.046, pad=0.04) # Specify th
cbar.set_label(variables[i]) # Define the colourbar label

plt.show() # Display the figure
fig.savefig(f'{DATADIR}AOD_NHem.png') # Save the figure
```



We can see that the high values of AOD seem to be mainly due to organic matter in North America and Siberia, which saw many wildfire activity in this period, while further south we can see a dust contribution.

CAMS global reanalysis (EAC4) monthly averaged fields

In this part of the tutorial we will look at another CAMS dataset, the fourth generation ECMWF

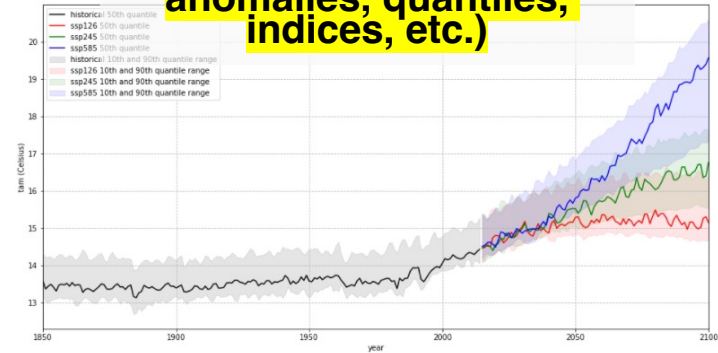
Data access & visualization (images, animations, plots)

Jupyter Notebook Viewer

```
for i in np.arange(len(experiments)):
    ax.plot(data_50.year, data_50[i,:], color=f'{colours[i]}',
            label=f'{data_50.experiment[i].values} 50th quantile')
    ax.fill_between(data_50.year, data_90[i,:], data_10[i,:], alpha=0.1, color=f'{data_50.experiment[i].values} 10th and 90th quantile ran

ax.set_xlim(1850,2100)
ax.set_title('CMIP6 annual global average temperature (1850 to 2100)')
ax.set_ylabel('tam (Celsius)')
ax.set_xlabel('year')
handles, labels = ax.get_legend_handles_labels()
ax.legend(handles, labels)
ax.grid(linestyle='--')

fig.savefig(f'{DATADIR}')
```



Processing (climate normal, anomalies, quantiles, indices, etc.)

The visualization of the CMIP6 annual global average temperature (1850 to 2100) above shows that the global average temperature was more or less stable in the pre-industrial phase, but steadily increases since the 1990s. It shows further that, depending on the SSP scenario, the course and increase of the global annual temperature differs. While for the best case SSP1-2.6 scenario, the global annual temperature could stabilize around 15 degC, in the worst case SSP5-8.5 scenario, the global annual temperature could increase to above 20 degC.

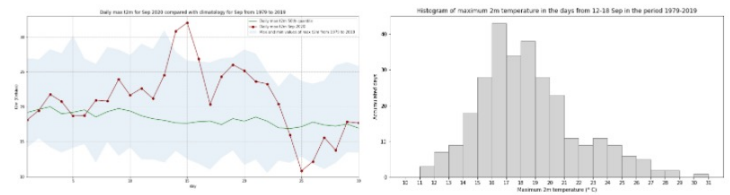
Jupyter Notebook Viewer

Analysis of the September 2020 European heatwave using data from the Copernicus Climate Change Service

In September 2020, a record-breaking heatwave occurred in large parts of western Europe, (see a description here). The heatwave in southern France was particularly intense as it was the hottest day in September 2020 since 1950. This event was analyzed using data from the Climate Data Store (CDS) and the Copernicus Climate Change Service (C3S).

Case studies (heatwaves, dust, fires, etc.)

1. Search, download and view data
2. View daily maximum 2m temperature for September 2020
3. Compare maximum temperatures with climatology



How to access the notebook

This tutorial is in the form of a **Jupyter notebook**. You will not need to install any software for the training as there are a number of free cloud-based services to create, edit, run and export Jupyter notebooks such as this. Here are some suggestions (simply click on one of the links

Focus on technical users!

E-learning modules

Climate Change

The screenshot shows a web browser with three tabs: 'User Learning Services', 'E-learning', and '13 C3S ULS'. The address bar shows 'climate.copernicus.eu/e-learn...'. The main content area displays a grid of nine e-learning modules, each with a representative image, a title, a brief description, and a 'Download PDF' button.

- Data Resources - Introduction**: This lesson provides an overview of the various types of climate data resources, and teaches what Essential Climate Variables are. It will indicate the main advantages and disadvantages of the various data sources.
- Data Resources - Observations**: This lesson provides training on observations data. The different types of measurements are explained, the types of observing systems and the measurement uncertainty are explained.
- Data Resources - Reanalyses**: This lesson teaches users the basics of climate reanalysis. The lesson explains how reanalyses are made, an overview of global reanalyses datasets, and their strengths and limitations.
- Data Resources - Climate Models**: This lesson explains how climate models work and how the quality of climate models can be evaluated. Differences between climate projections, predictions and scenarios are explained.
- Bias Correction and Downscaling**: This lesson teaches about downscaling and bias correction methods. An exercise for bias correction is included.
- Using climate models for climate scenarios**: This lesson teaches how to use climate models in the development of national climate scenarios. Examples are provided for The Netherlands, Switzerland and the U.K.

<https://climate.copernicus.eu/e-learning-resources>

- More theoretical, less practical
- No programming needed
- Interactive

The screenshot shows a web browser with three tabs: 'User Learning Services | Copernicus', 'E-learning resources | Copernicus', and '13 C3S ULS Climate models for C...'. The address bar shows 'climate.copernicus.eu/courses/13-c3s-uls-climate-models-for-climate-scenarios/'. The main content area displays a question interface for 'Question 2'.

Question 2

Which SSPs can lead to a radiative forcing of 8.5 W/m² by the end of the century (and are therefore...)

- SSP1
- SSP2
- SSP3
- SSP4
- SSP5

Correct

That's right! Only SSP5 produces a scenario with emissions high enough to yield a radiative forcing of 8.5 W/m² by the end of the century.

Continue

Thank you for your attention



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