



Climate Change

Copernicus Climate Change Service (C3S): A quick introduction

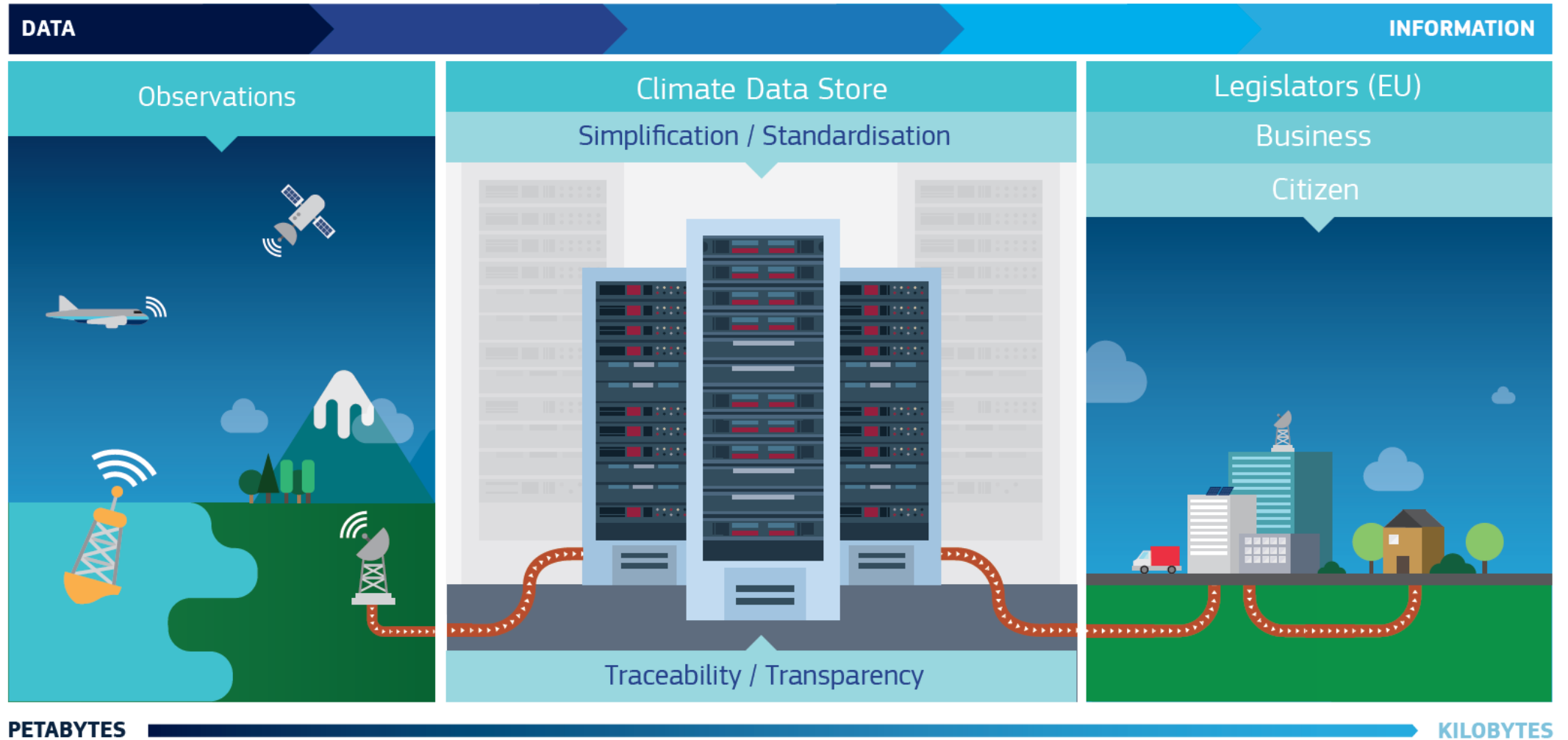
Samuel Almond / Chiara Cagnazzo - ECMWF





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More Than Climate Data..... Climate Information



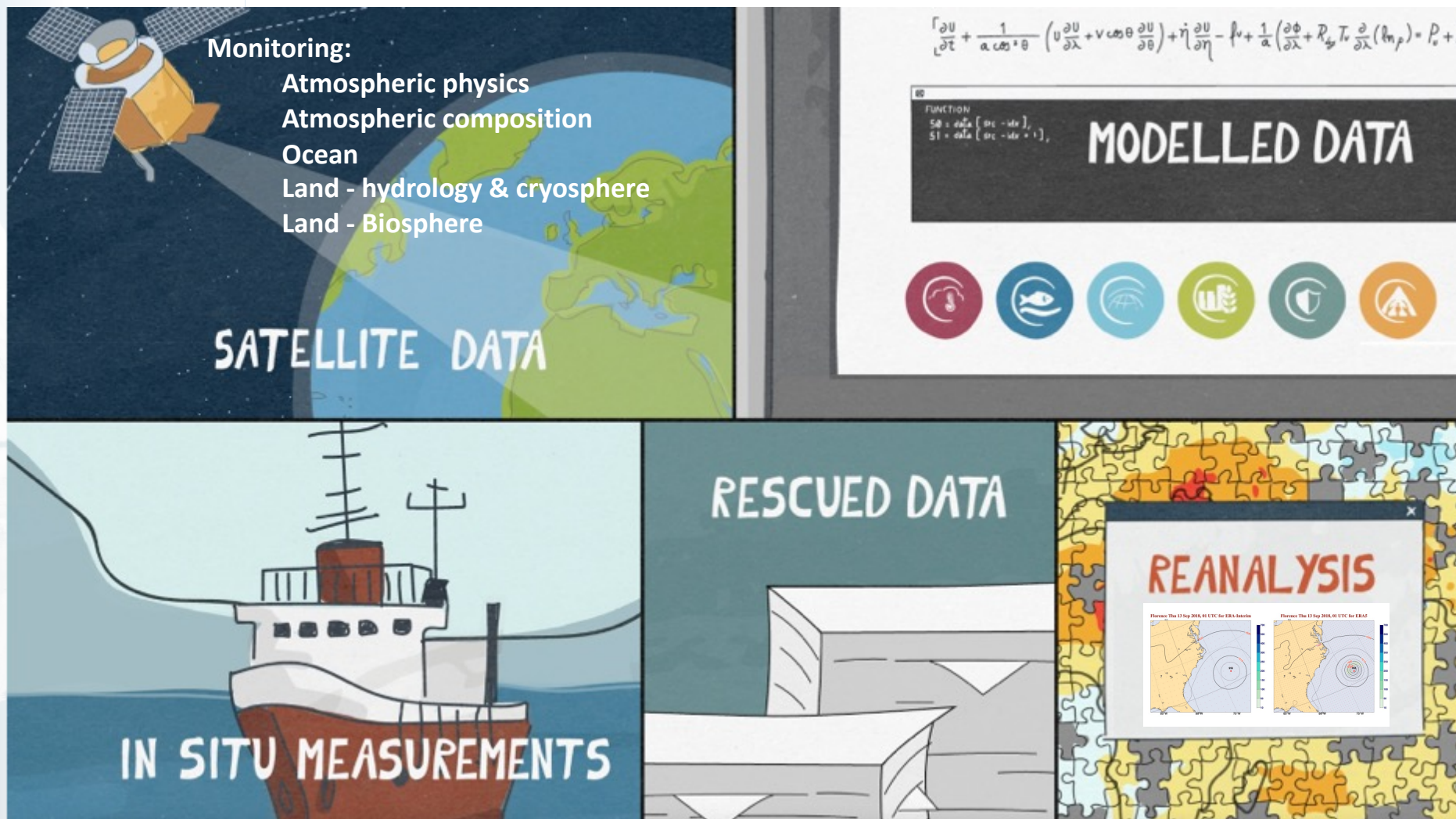
Typical download: **70 TB /day**

200,000 + users



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

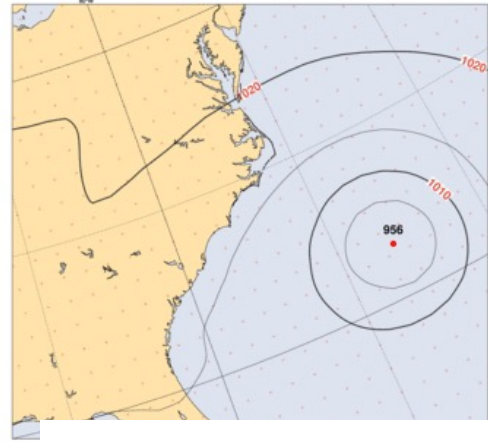




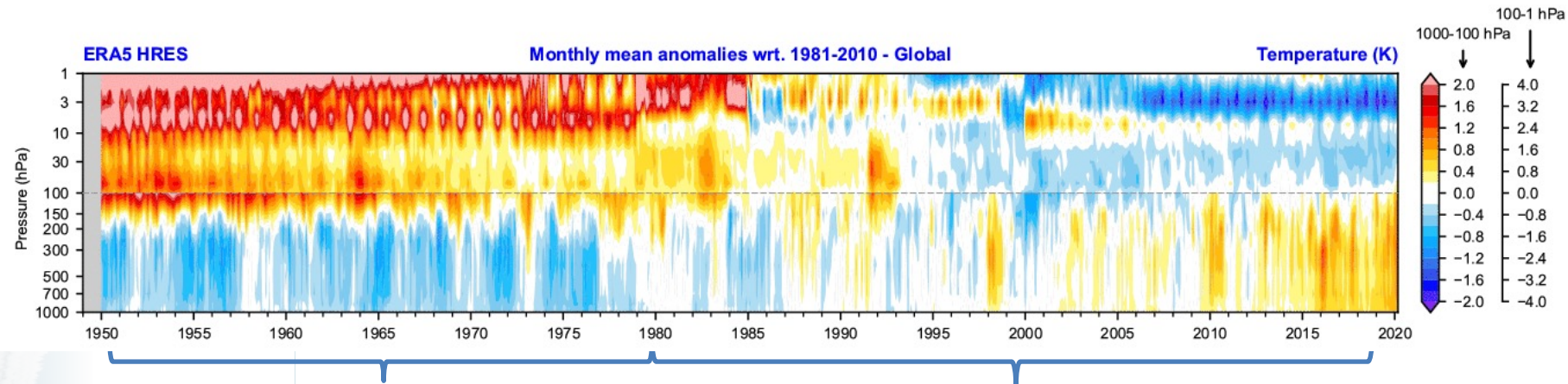
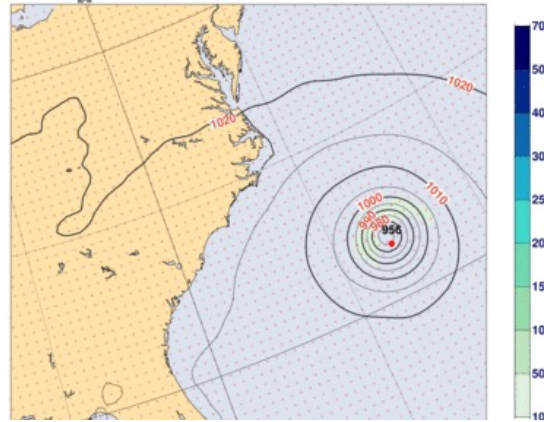
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The past weather without gaps: global atmospheric reanalysis ERA5

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



Florence Thu 13 Sep 2018, 01 UTC for ERA5



1950 – 1979

Published end 2021

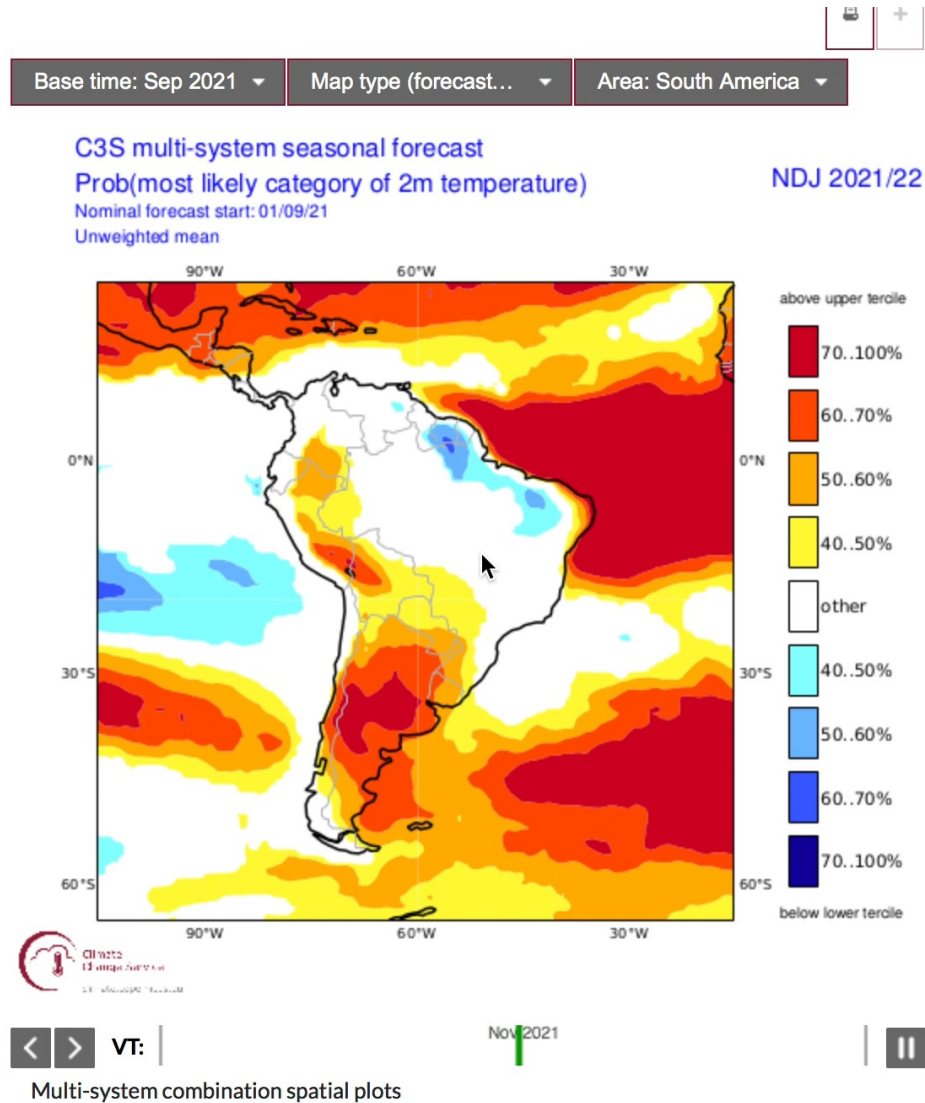
1979 – present

Complete. NRT stream runs RT – 1 day



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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

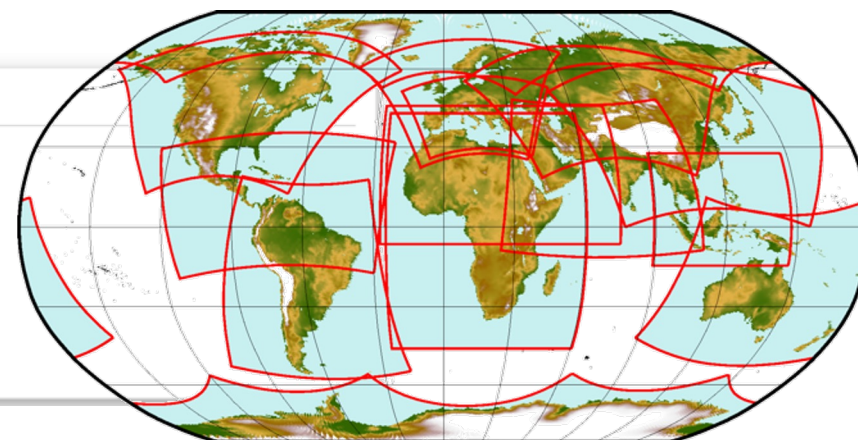
Domain ?

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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Evaluation & Quality Control framework



Home / News

1st October 2020



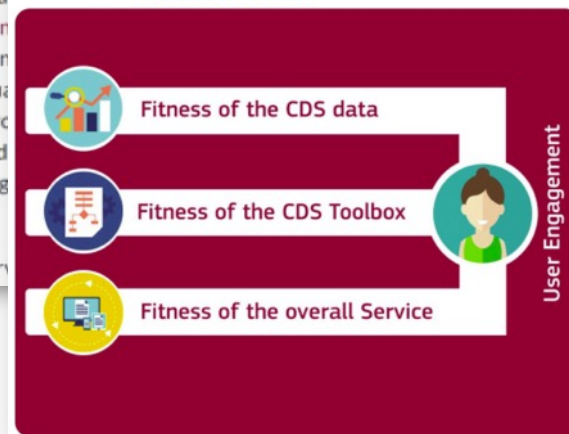
Data quality has always been important for C3S*, and now a new quality assurance framework is becoming operational. At a time when C3S is a trusted source, delivering quality data that are traceable and representative, the new quality assurance features that will play an important role in ensuring data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

*One of the issues around climate services



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



ERA5 monthly averaged data on pressure levels from 1979 to present

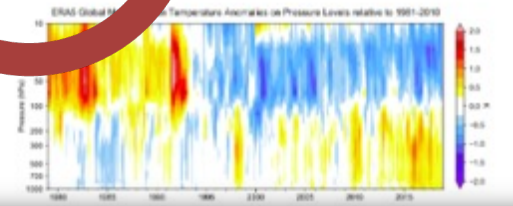
Overview

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



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



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C3S Scope

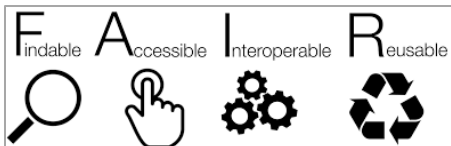
- **Standard Metadata & Services.**
- **Harmonized Data Access interfaces.**
- **Simplicity and consistency** are key
- **User Profiles** and Management
- **Terms of use** linked to datasets
- **Quality Control (EQC)** function
- **24/7 – User Support**
- **Expert tools** to interact with Data

Discover Data in the Catalogue

Request (catalogue or API)

Retrieve

Interact



```
# Create a c3s client
import c3sapi
c = c3sapi.Client()

# Retrieve data
c.retrieve("dataset-short-name",
          "... sub-selection request ...",
          "target=file")
```





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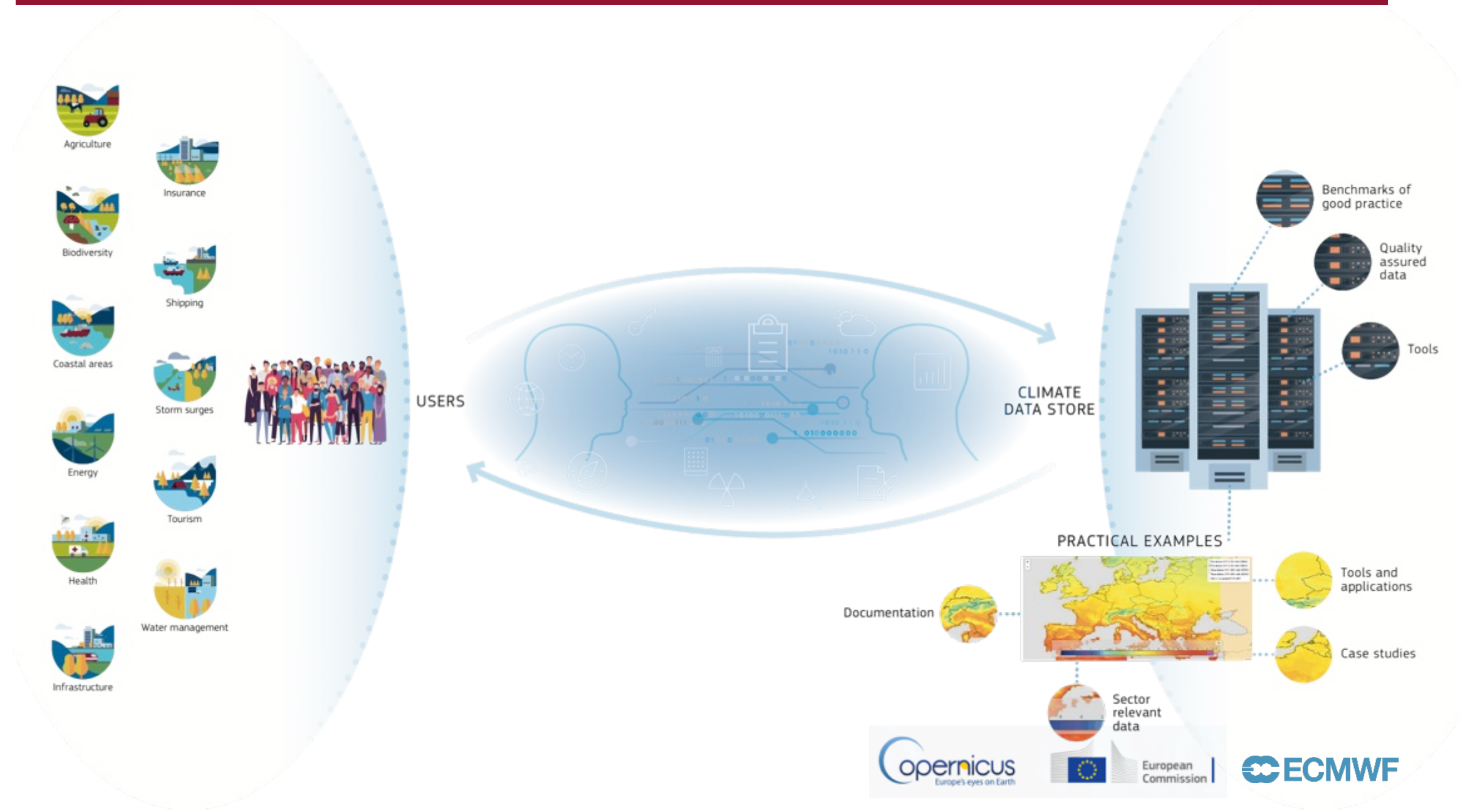
An Introduction to the Sectoral Information System





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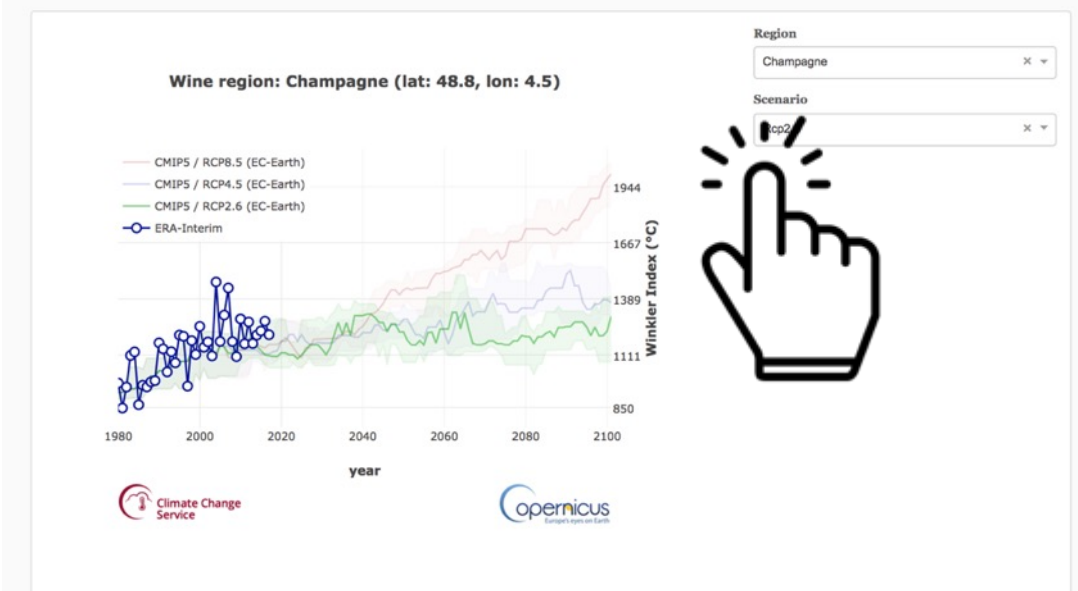
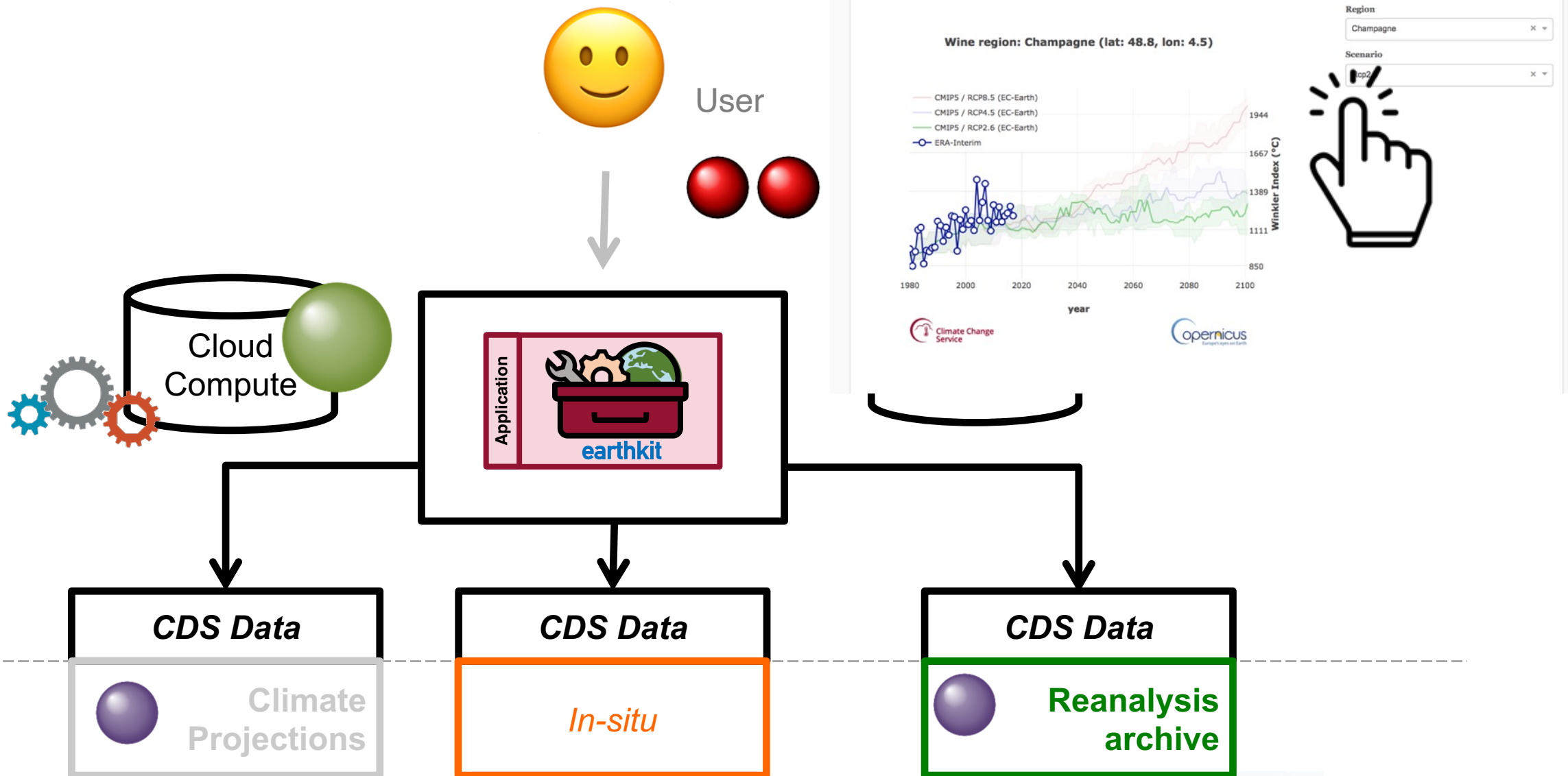
Creating Climate Information & Applications for Users Across Sectors





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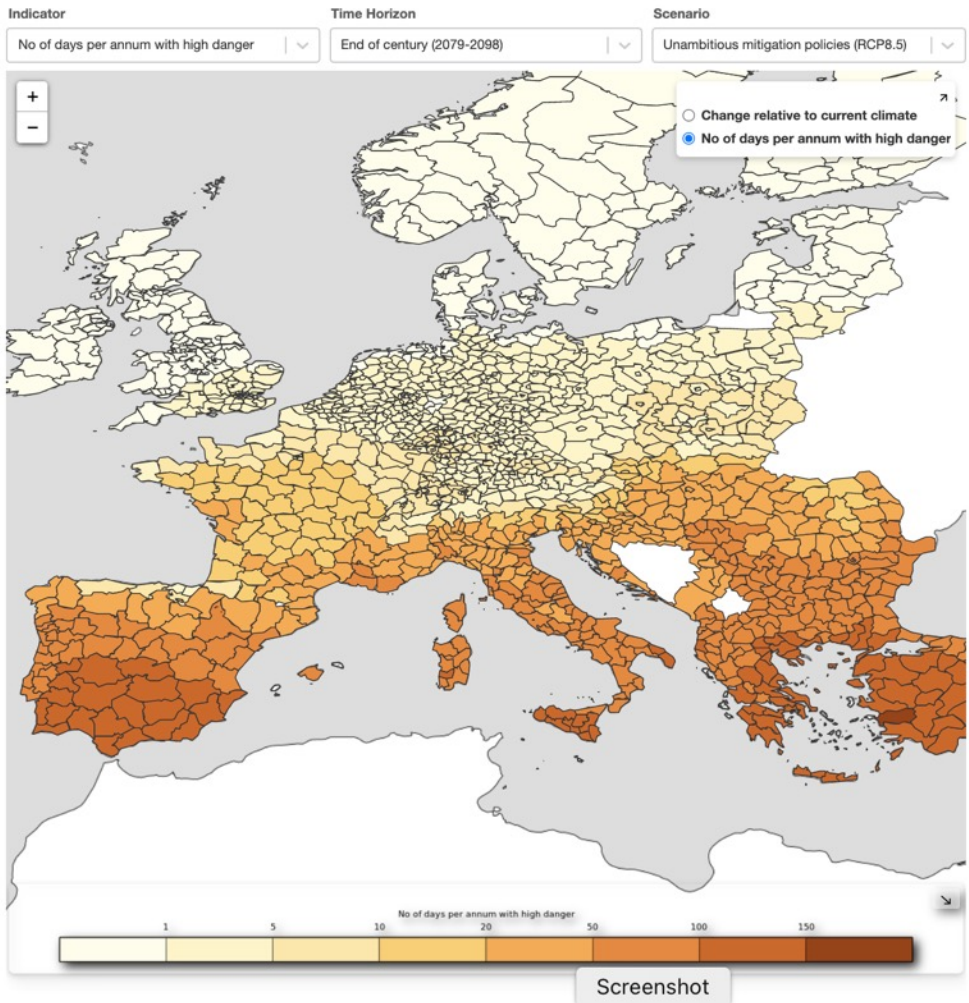
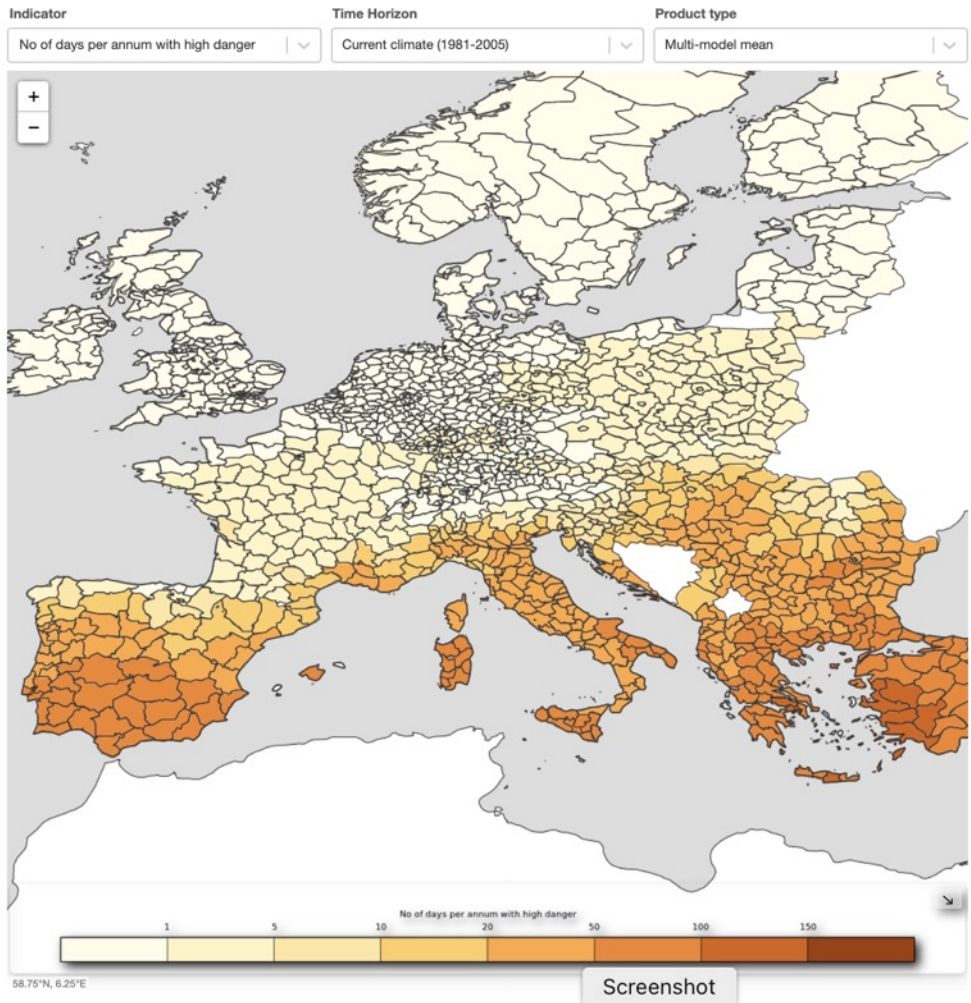
The C3S Applications Strategy





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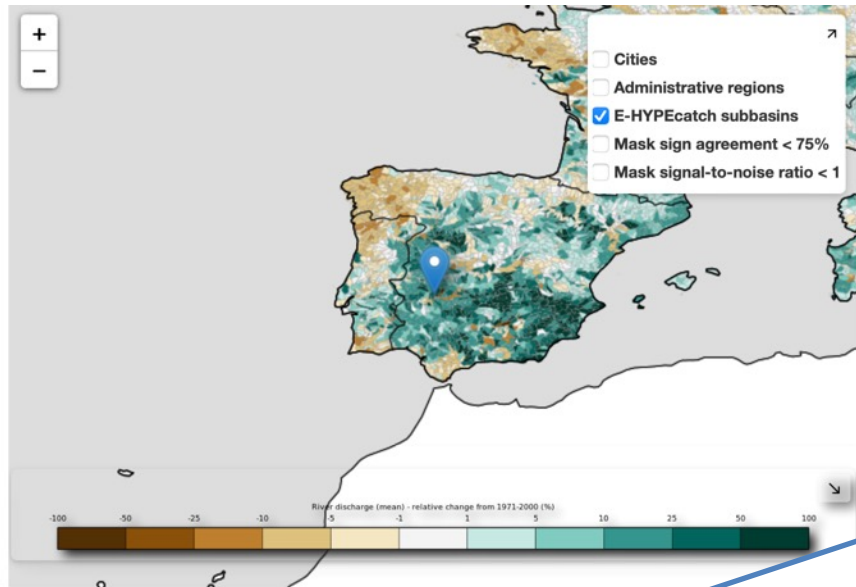
Example Application 1 – Europe’s Evolving Fire Risk



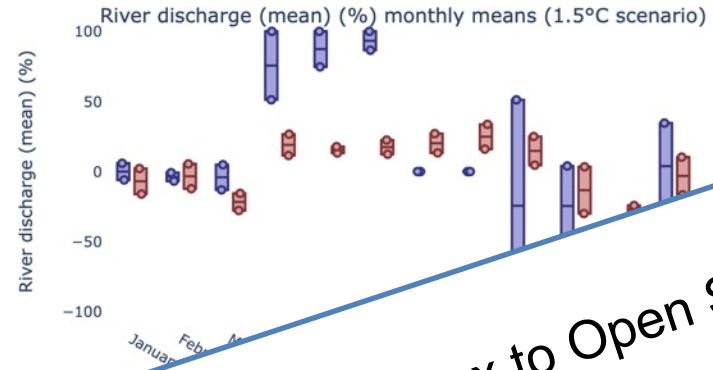


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Example Application 2 – Hydrology in a 3.0 degree world!

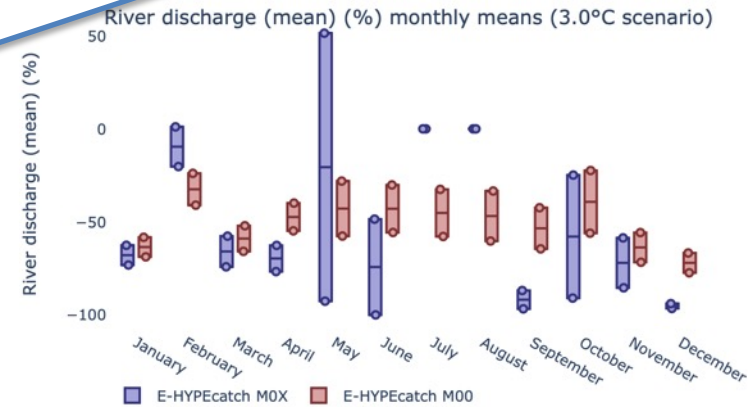
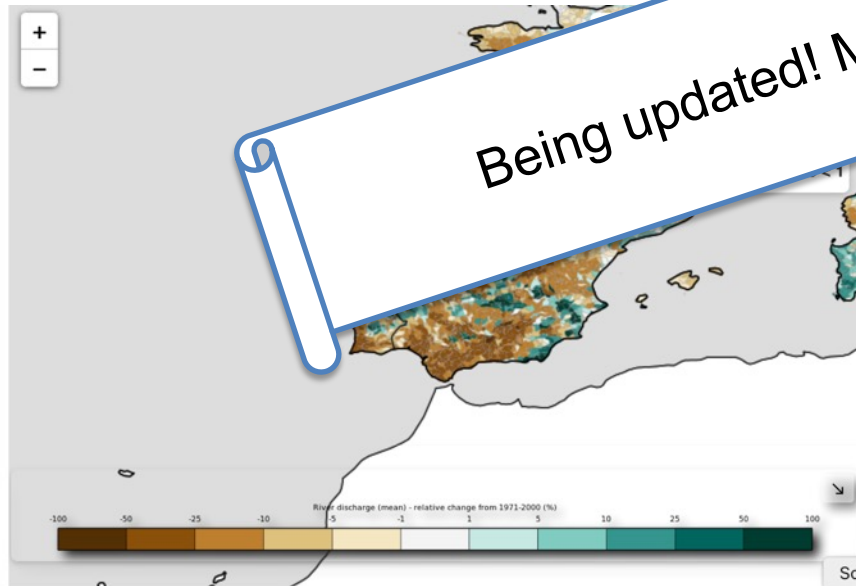


Position: 39.1°N, 5.93°W



Water quantity indicators
Water quality indicators
Bias adjusted climatic indicators

Being updated! Move from CDS Toolbox to Open Source



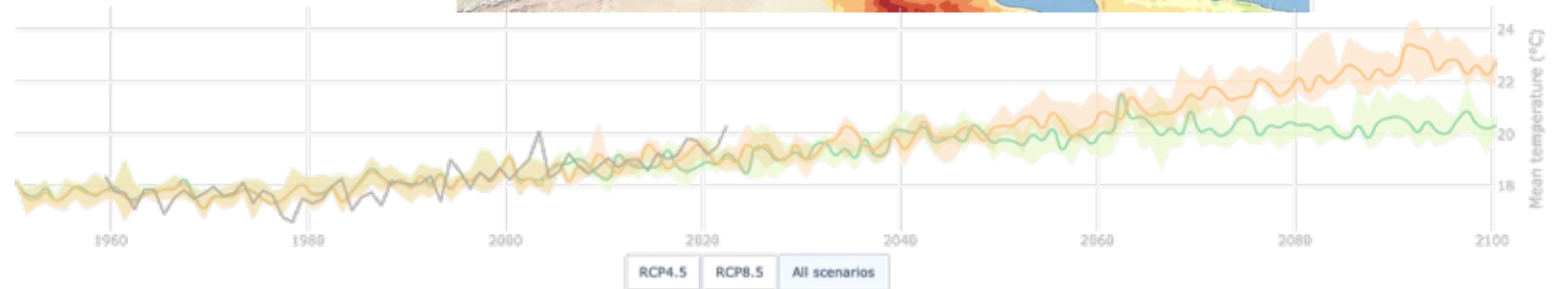
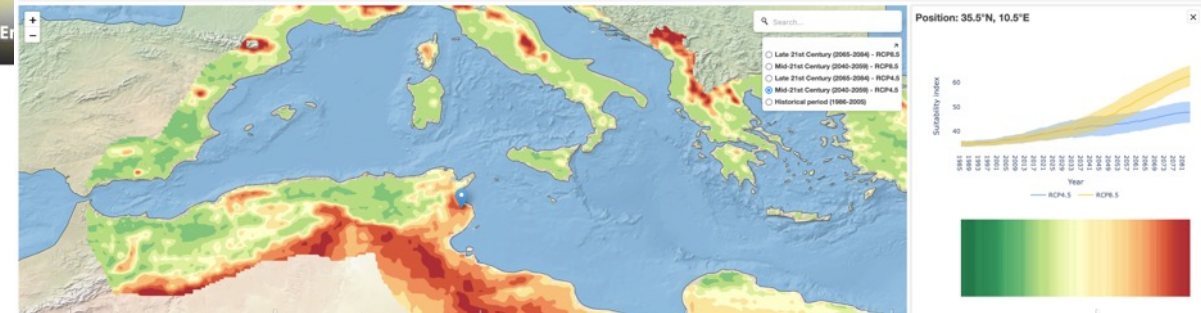
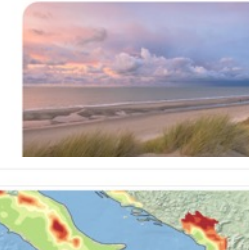
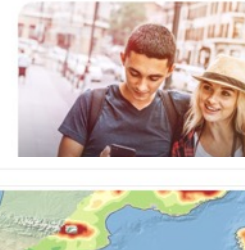
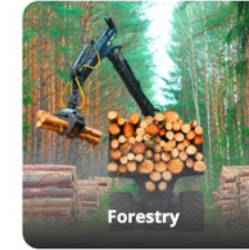
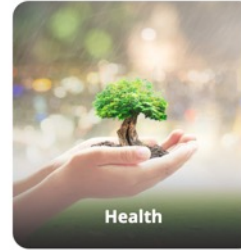
Screenshot

User Engagement: Institutional services / users

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

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

European Climate Data Explorer

[Help](#)
[Overview list of all indices](#)




Climate Change

An overview of other C3S Services





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State of the Climate & Climate Bulletins



Temperature



Lake and Sea
Temperatures



Wildfires



Precipitation



Soil moisture



River
discharge



Land
cryosphere



Atmospheric
circulation

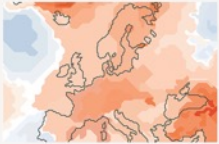


Clouds and
sunshine
duration



Wind and solar
energy
resources

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

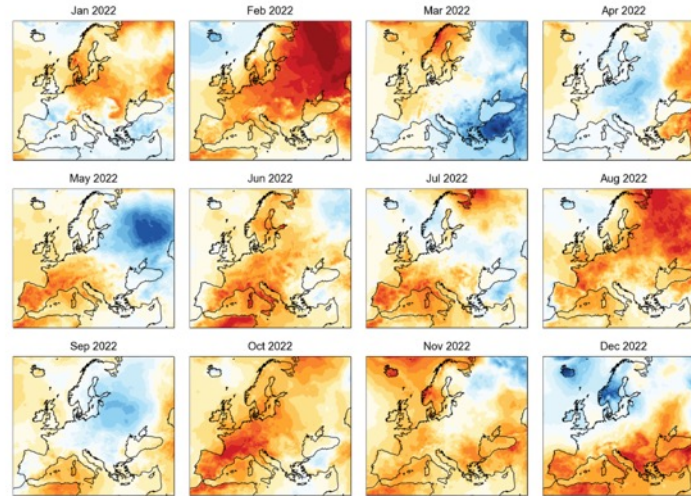


The ESOTC provides a detailed analysis of the past calendar year, with descriptions of climate conditions and events, and explores associated variations in key climate variables across the Earth system.

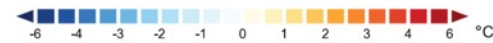
[View ESOTC >](#)

[Back to top ^](#)

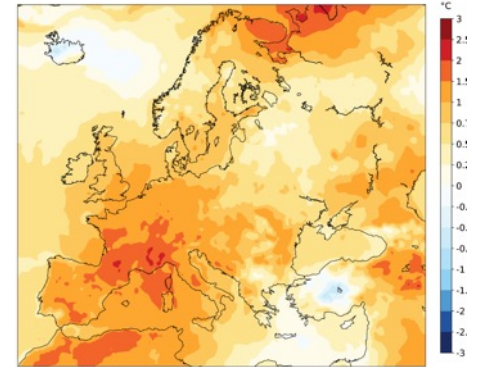
Monthly surface air temperature anomalies in 2022



Data: ERA5
Reference period: 1991-2020
Credit: C3S/ECMWF



2022 mean temperature anomaly



Reference period: 1991-2020. Data source: ERA5. Credit: C3S/ECMWF
Copernicus Climate Change Service
European State of the Climate (2022)
Copernicus
ECMWF

- Globe
- Europe
- Arctic



Copernicus
Europe's eyes on Earth

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Copernicus
Europe's eyes on Earth



European
Commission

ECMWF



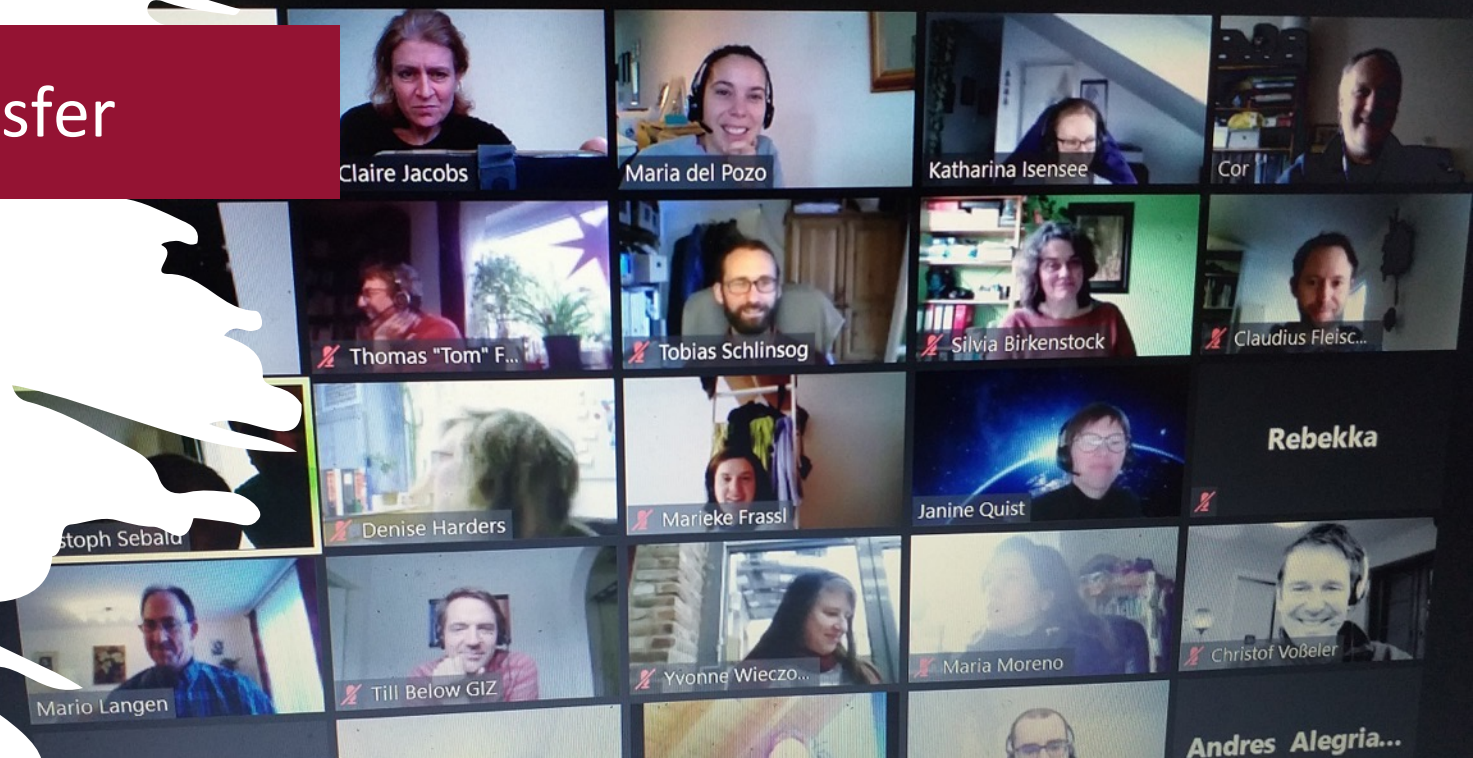
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Training & Knowledge Transfer

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!



Climate
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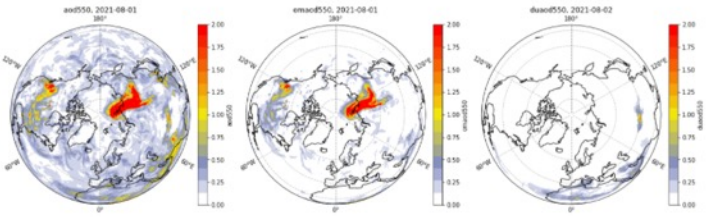
C3S User Learning Services
Training of Future Trainers

Jupyter Notebook Viewer

nbviewer.org/gi...

JUPYTER FAQ </> [Icons]

```
In [10]: variables[0], variables[1] = variables[1], variables[0]
In [11]: variables
Out[11]: ['aod550', 'omaod550', 'duaod550']
In [12]: fig, axs = plt.subplots(3, 1, figsize=(12, 10), subplot_kw={'projection': 'cylindrical'})
for i in range(3):
    da = ds[variables[i]]
    axs[i].gridlines(color='gray', alpha=0.5)
    axs[i].set_title(f'{variables[i]} (2012-08-01 to 2012-08-02)')
    im = axs[i].pcolormesh(da, transform=ccrs.PlateCarree(), cmap=camscmp, vmin=-0.5, vmax=2.0)
    axs[i].coastlines(color='black') # Add coastlines
    cbar = fig.colorbar(im, ax=axs[i], fraction=0.046, pad=0.04) # Specify the colorbar label
    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)

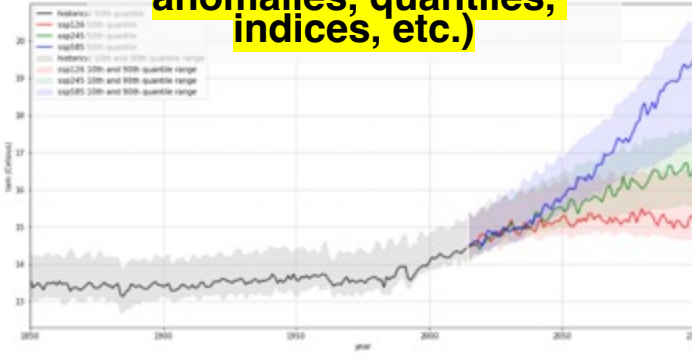
Jupyter Notebook Viewer

nbviewer.org/gi...

JUPYTER FAQ </> [Icons]

```
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 range')

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



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.

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

Jupyter Notebook Viewer

nbviewer.org/gi...

JUPYTER FAQ </> [Icons]

training / C3S_heatwave-analysis.ipynb

PROGRAMME OF THE EUROPEAN UNION Copernicus ECMWF

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 for example experienced its hottest day in September 2020 since 1950. This event was analyzed using data from the Copernicus Climate Change Service (C3S).

The tutorial comprises:

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

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

Focus on technical users!

E-learning modules

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The screenshot shows the Copernicus E-learning resources homepage. The browser address bar displays `climate.copernicus.eu/e-learn...`. The page features a grid of modules, each with a thumbnail image, a title, a 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 Copernicus E-learning module titled 'Question 2'. The question is: 'Which SSPs can lead to a radiative forcing of 8.5 W/m2 by the end of the century (and are therefore...)'.

The options are:

- ☐ SSP1
- ☐ SSP2
- ☐ SSP3
- ☐ SSP4
- ☒ SSP5

The correct answer is indicated by a green checkmark and the text 'Correct'.

The feedback text says: '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.'

A 'Continue' button is visible at the bottom right of the question box.

Thank you for your attention



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