The Copernicus **C**limate **D**ata **S**tore

The Copernicus Climate Data Store: ECMWF's approach to provide online access to climate data and tools

Gionata BIAVATI, ECMWF gionata.biavati@ecmwf.int

Cedric BERGERON, ECMWF cedric.bergeron@ecmwf.int

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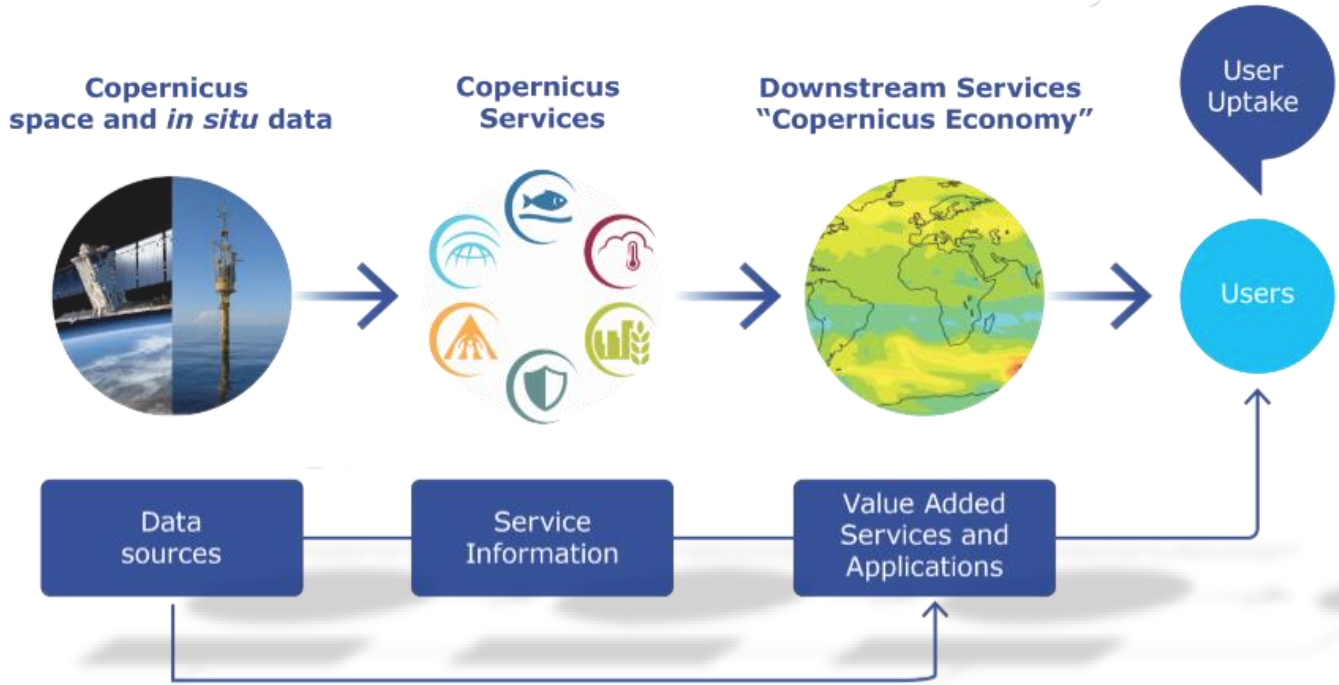
Why COPERNICUS?



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Copernicus Climate Change service - C3S

- The European Commission has entrusted **ECMWF** with the implementation of the Copernicus Climate Change Service – **C3S**

- The **Copernicus Climate Change** service will provide information to increase the knowledge base to support **adaptation** and **mitigation** policies.

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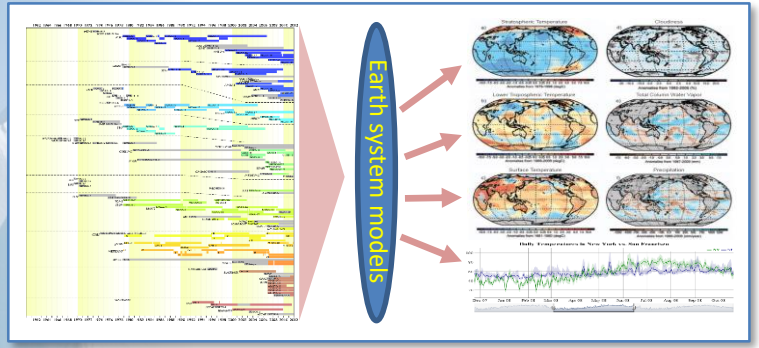
What kind of data?

Access to past, present and future climate information

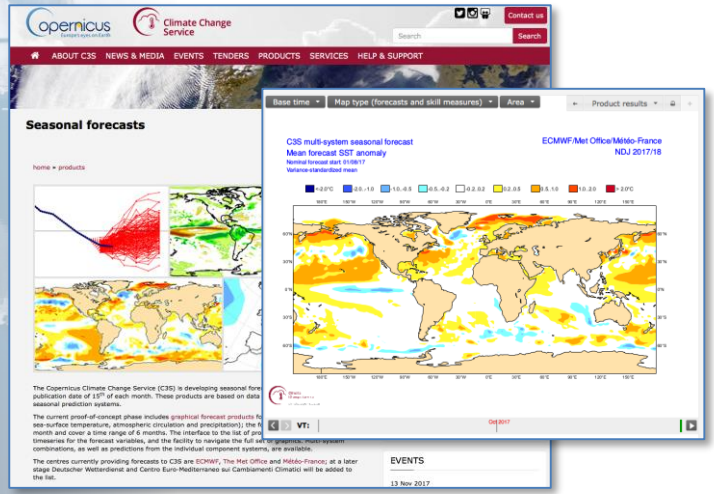


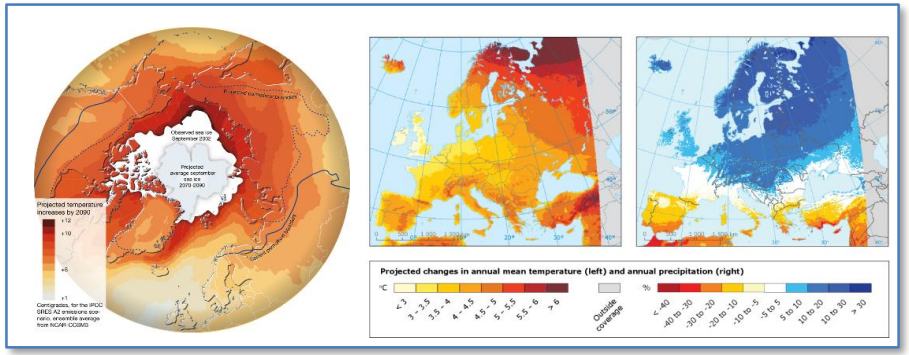
Observations and climate reanalysis

Seasonal forecast data and products

Climate model simulations

Global and pan European





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How to find, Access, and Use these Data Online?

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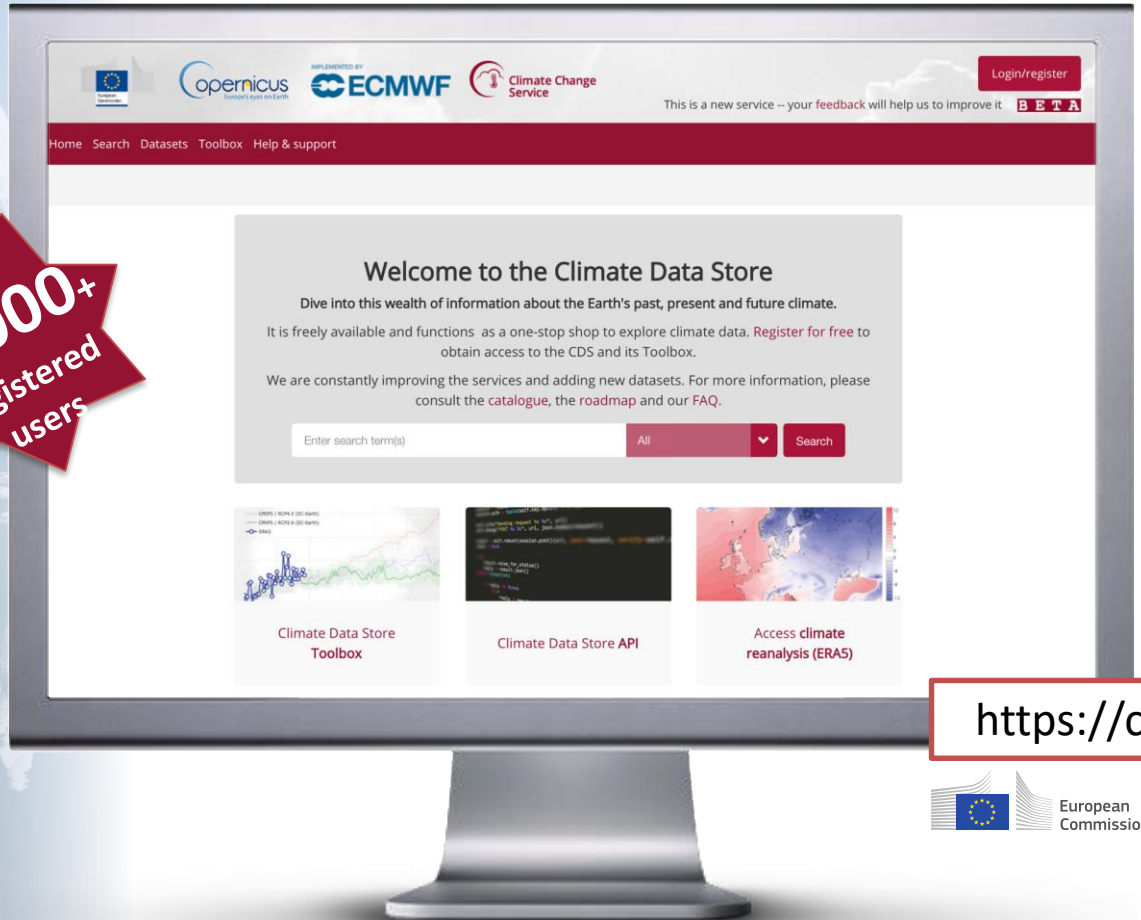

23000+ registered users

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

https://cds.climate.copernicus.eu

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What is the CDS vision?

- Make data discovery, access easy and relevant for users
- Provide scalable data access
- Provide online capabilities to process the data
- Enable reproducible research

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The CDS: An operational system

- On-Premises Private Cloud
- 72+ nodes, 4000+ CPUs, 12TB memory
- 3.9 PB usable (of which 380TB SSD)

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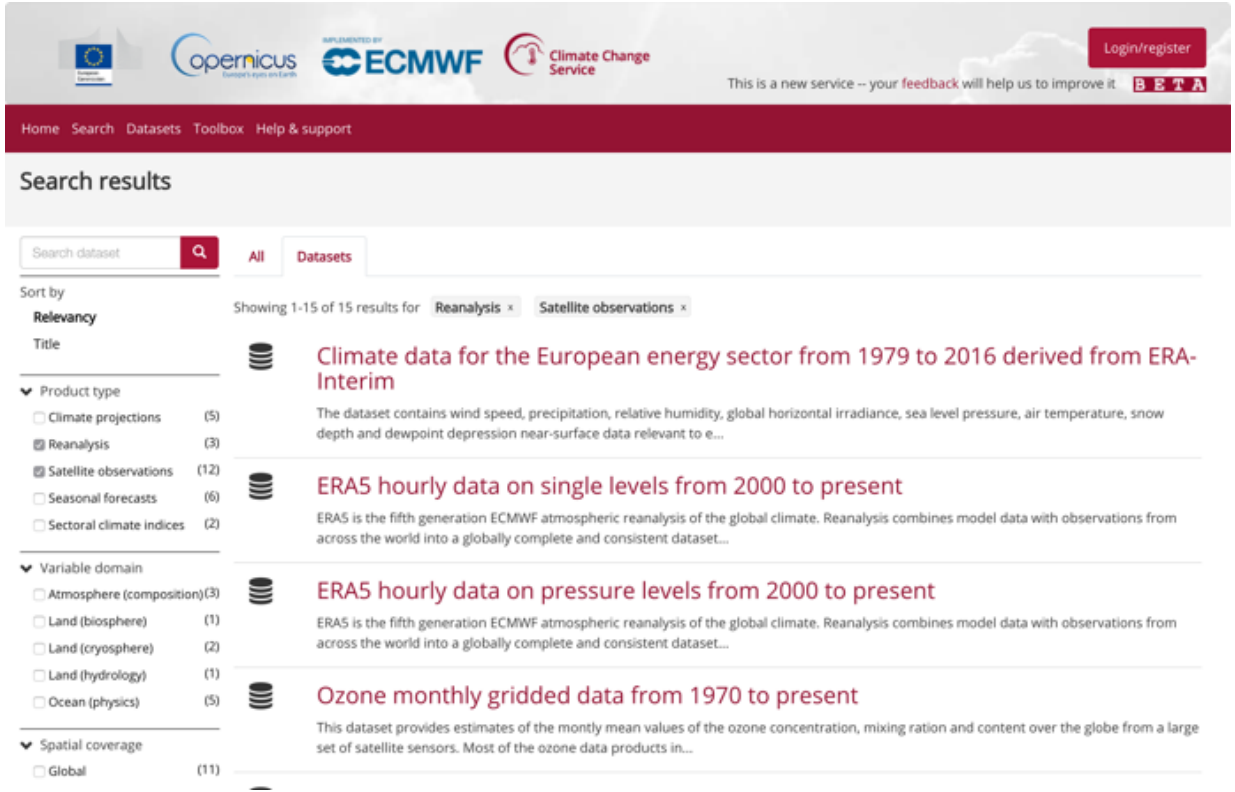
Finding datasets



Metadata ISO 19115

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Accessing datasets: Global reanalysis data

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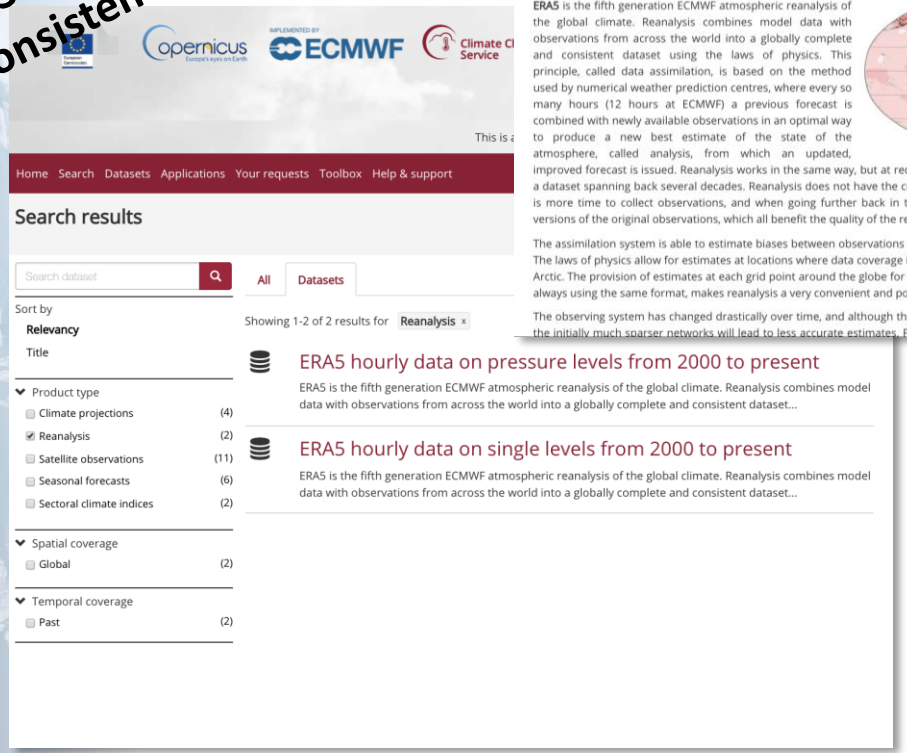
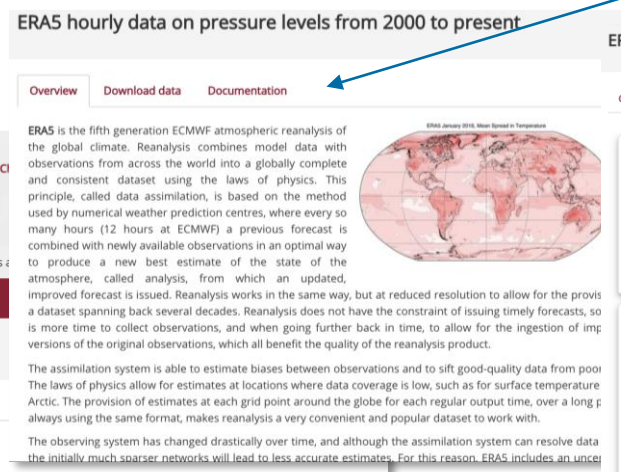
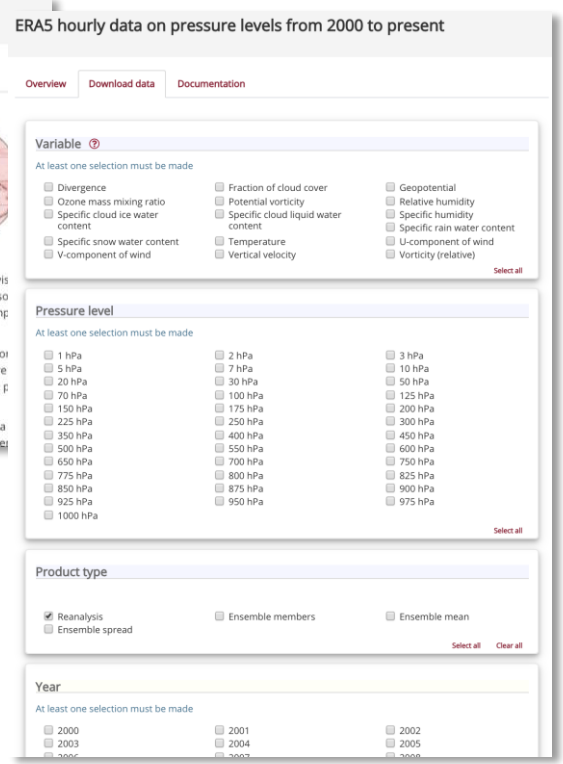
Simplicity and consistency are key

Quality Evaluation will come soon (2019)







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Accessing datasets: Multi-system seasonal forecasts

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Simplicity and consistency are key

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Home Search Datasets Applications Your requests Toolbox Help & support

Search results

Search dataset

All | Datasets

Sort by
Relevancy
Title

Product type
- Climate projections (4)
- Reanalysis (2)
- Satellite observations (11)
- Seasonal forecasts (6)
- Sectoral climate indices (2)

Spatial coverage
- Global (6)

Temporal coverage
- Future (6)
- Past (6)

Showing 1-6 of 6 results for Seasonal fo

Seasonal forecast to present
Seasonal forecasts provide a lo
or months, as a result of predic

Seasonal forecast monthly statistics on pressure levels from 2017 to present
Seasonal forecasts provide a long-range outlook of changes in the Earth system over periods of a few weeks or months, as a result of predictable changes in some of the slow-varying components of the s...

Seasonal forecast daily data on pressure levels from 2017 to present
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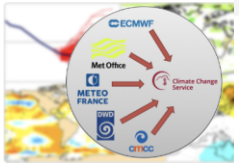
Seasonal forecast daily data on single levels from 2017 to present
Seasonal forecasts provide a long-range outlook of changes in the Earth system over periods of a few weeks or months, as a result of predictable changes in some of the slow-varying components of the s...

Seasonal forecast monthly statistics on single levels from 2017 to present

Overview | Download data | Documentation



Seasonal forecasts provide a long-range outlook of changes in the Earth system over periods of a few weeks or months, as a result of predictable changes in some of the slow-varying components of the system. For example, ocean temperatures typically vary slowly, on timescales of weeks or months; as the ocean has an impact on the overlaying atmosphere, the variability of its properties (e.g. temperature) can modify both local and remote atmospheric conditions. Such modifications of the 'usual' atmospheric conditions are the essence of all long-range (e.g. seasonal) forecasts. This is different from a weather forecast, which gives a lot more precise detail - both in time and space - of the evolution of the state of the atmosphere over a few days into the future. Beyond a the chaotic nature of the atmosphere limits the possibility to predict precise changes at local scales. This is c reasons long-range forecasts of atmospheric conditions have large uncertainties. To quantify such uncertain range forecasts use ensembles, and meaningful forecast products reflect a distributions of outcomes.

Given the complex, non-linear interactions between the individual components of the Earth system, the best long-range forecasting are climate models which include as many of the key components of the system and typically, such models include representations of the atmosphere, ocean and land surface. These models are with data describing the state of the system at the starting point of the forecast, and used to predict the ev this state in time. While uncertainties coming from imperfect knowledge of the initial conditions of the comp the Earth system can be described with the use of ensembles, uncertainty arising from approximations ma models are very much dependent on the choice of model. A convenient way to quantify the effect approximations is to combine outputs from several models, independently developed, initialised and operate

To this effect, the C3S provides a **multi-system seasonal forecast service**, where data produced by state- seasonal forecast systems developed, implemented and operated at forecast centres in several European co collected, processed and combined to enable user-relevant applications. The composition of the C3S seaso

Seasonal forecast monthly statistics on single levels from 2017 to present

Overview | Download data | Documentation

Originating centre
At least one selection must be made
- ECMWF
- UK Met Office
- Météo France

Select all

Variable
At least one selection must be made
- 10m u-component of wind
- 10m v-component of wind
- 10m wind gust since previous post-processing
- 10m wind speed
- 2m dewpoint temperature
- 2m temperature
- East-west surface stress rate of accumulation
- Evaporation
- Maximum 2m temperature in the last 24 hours
- Mean sea level pressure
- Minimum 2m temperature in the last 24 hours
- North-south surface stress rate of accumulation
- Runoff
- Sea surface temperature
- Sea-ice cover
- Snow density
- Snow depth
- Snowfall
- Soil temperature level 1
- Surface latent heat flux
- Surface sensible heat flux
- Surface solar radiation
- Surface solar radiation downwards
- Surface thermal radiation
- Surface thermal radiation downwards
- Top solar radiation
- Top thermal radiation
- Total cloud cover
- Total precipitation

Select all

Product type
At least one selection must be made
- Ensemble

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Accessing datasets: Climate model output via ESGF

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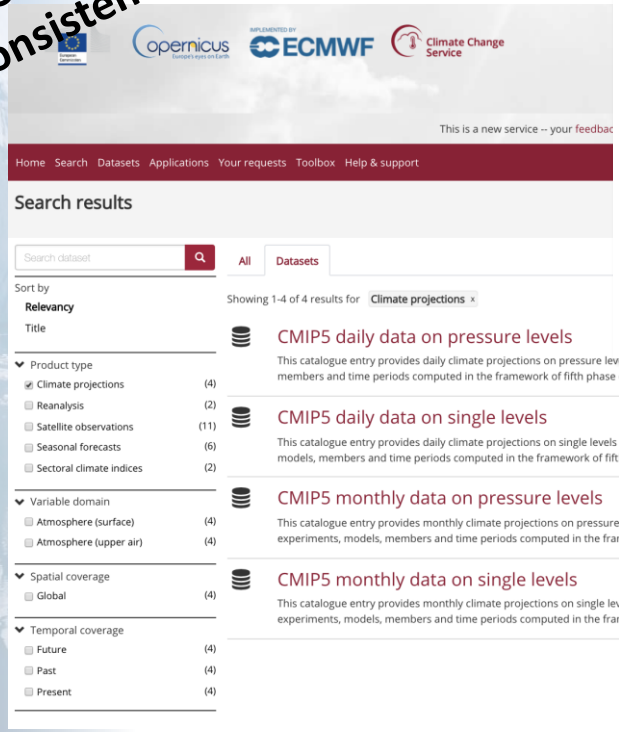
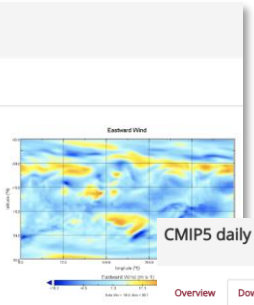
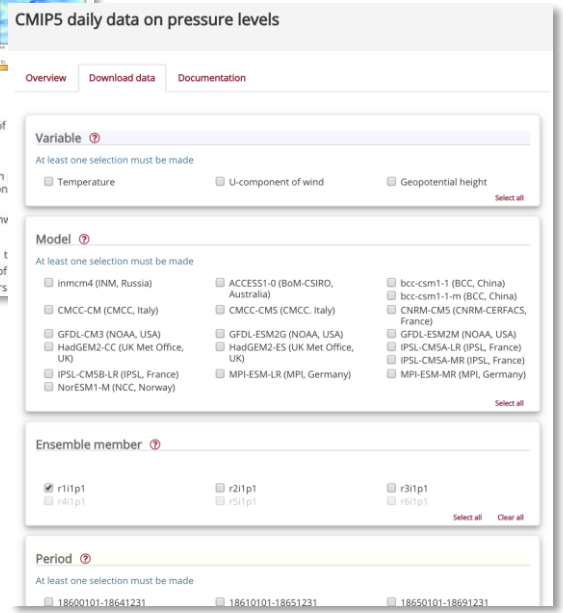
Simplicity and consistency are key







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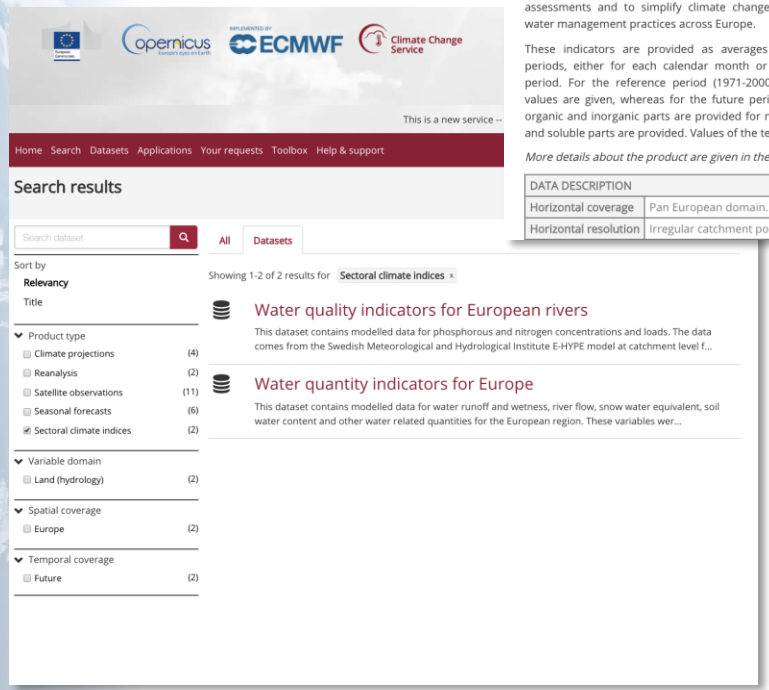
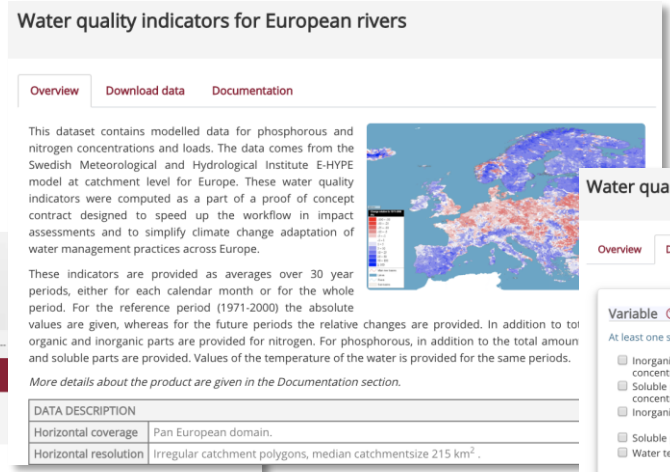
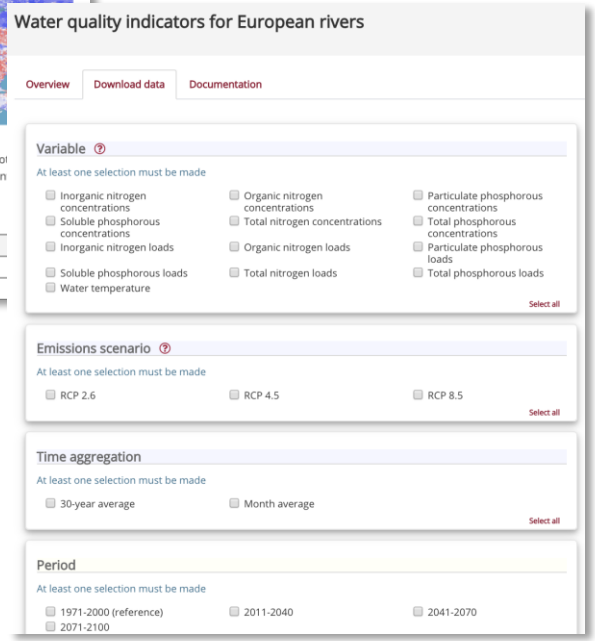
Accessing datasets: Sectoral impact indicators

Simplicity and consistency are key







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Using the data online: The CDS Toolbox Editor

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cedric bergeron Logout

Your feedback helps us to improve the service

Home Search Datasets Applications Your requests Toolbox FAQ

Toolbox editor

Applications Data Documentation

Search for app or example

your workspace

Nice demonstration

examples

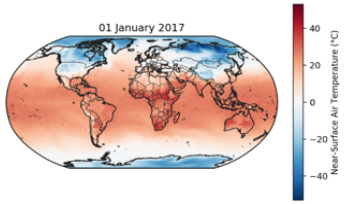
- 00 Hello World
- 01 Retrieve data
- 02 Plot map
- 03 Extract time series and plot graph
- 11 Calculate time mean and standard deviation
- 12 Calculate climatologies
- 21 Calculate regional mean and anomalies
- 31 Calculate trends
- 41 Calculate GDD
- 42 Use cdo functions
- 51 Calculate zonal means
- 52 Format maps to allow visual comparison

00 Hello World | Console | Your queue

Layout | Copy | Run

```
1  import cdstoolbox as ct
2
3
4  @ct.application(title='Hello World!')
5  @ct.output.figure()
6  def application():
7      """
8      HELLO WORLD!
9      This is your first application using the CDS Toolbox.
10
11     Here, 3 basic tasks:
12
13     - retrieve the 2 meter temperature from the CDS Catalogue
14     - print info about the data (see it in the 'Console' tab!)
15     - show the data on a map.
16     """
17
18     data = ct.catalogue.retrieve(
19         'reanalysis-era5-single-levels',
20         {
21             'variable': '2m_temperature',
22             'product_type': 'reanalysis',
23             'year': '2017',
24             'month': '01',
25             'day': '01',
26             'time': '12:00',
27             'grid': ['3', '3'],
28         }
29     )
30
31     print(data)
32
33     fig = ct.cdsplot.geomap(data, title='01 January 2017')
34
35     return fig
36
```

Hello World!



Using the data online: Building Online Applications

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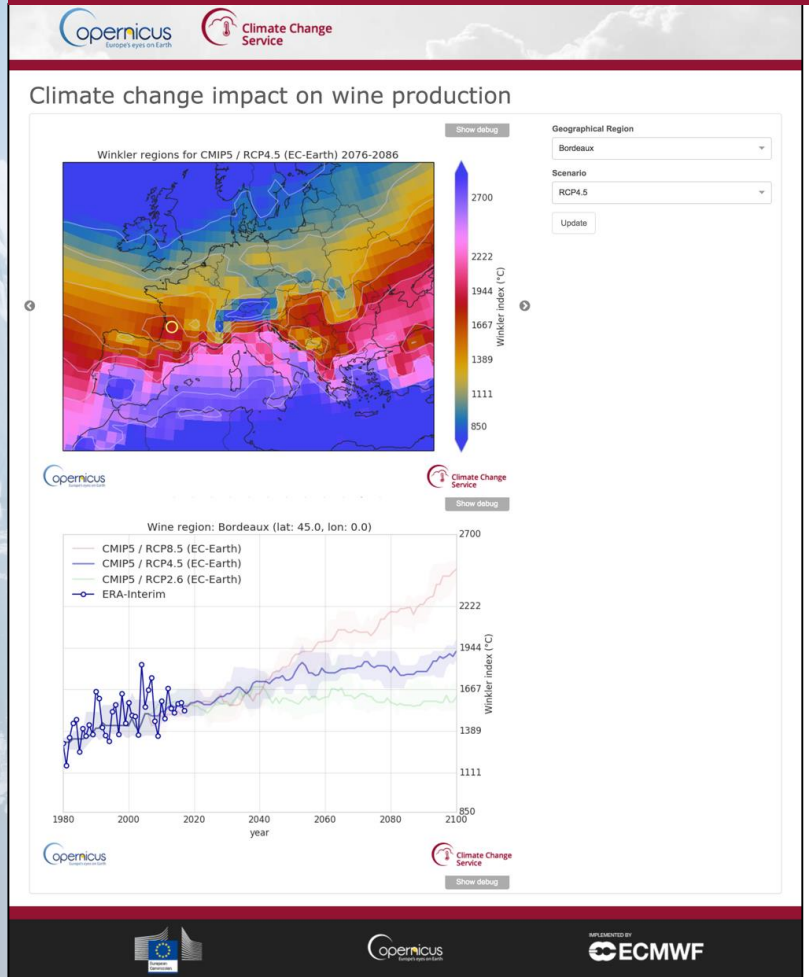

- Web page/components with possible parameterization from users
- Perform specific tasks
- Provide one or more of:
  - Data
  - Processed results
  - Plots / Maps

Using the data online: Building Online Applications

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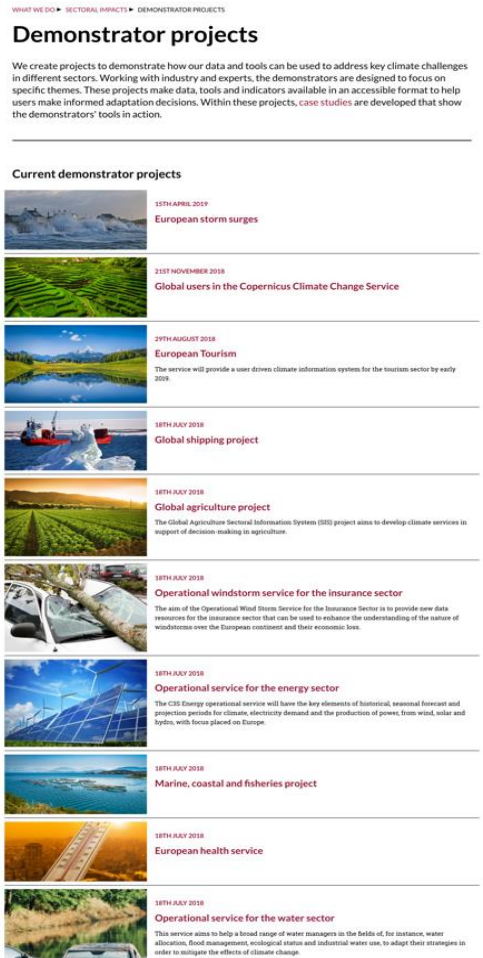

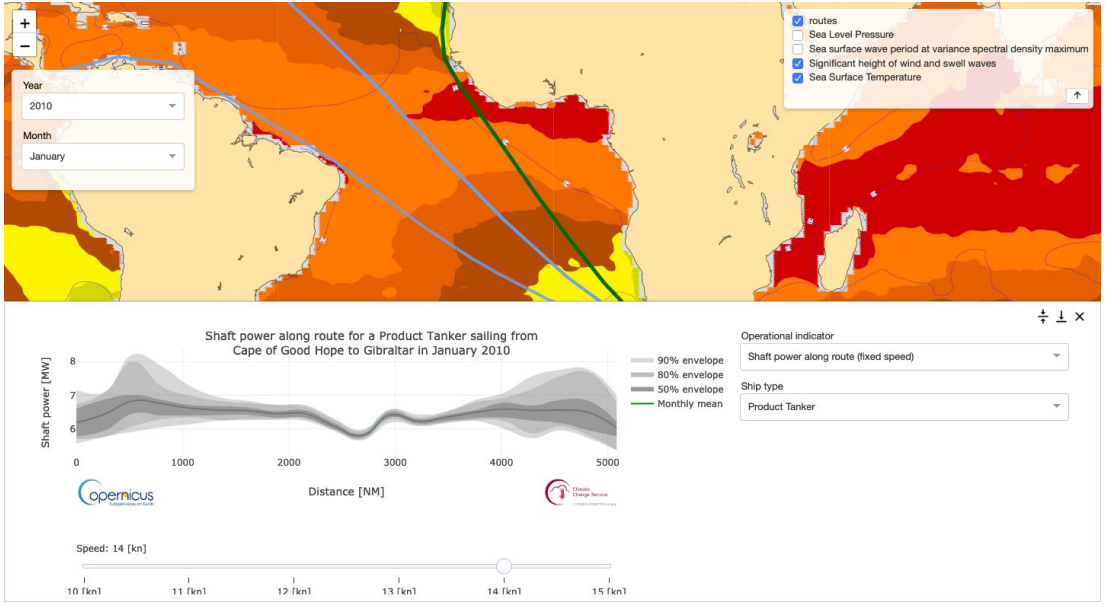

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Accessing datasets through the CDS API

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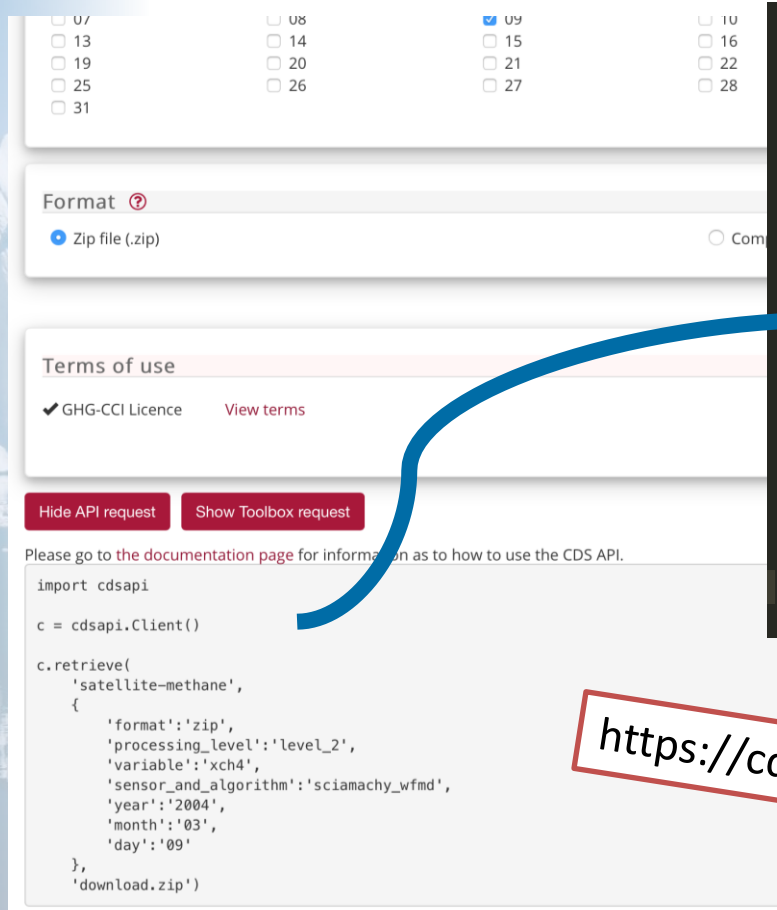


```python
import cdsapi

c = cdsapi.Client()

c.retrieve(
    'satellite-methane',
    {
        'format': 'zip',
        'processing_level': 'level_2',
        'variable': 'xch4',
        'sensor_and_algorithm': 'sciamachy_wfmd',
        'year': '2004',
        'month': '03',
        'day': '09'
    },
    'download.zip')
```

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

pip install cdsapi

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Tuning

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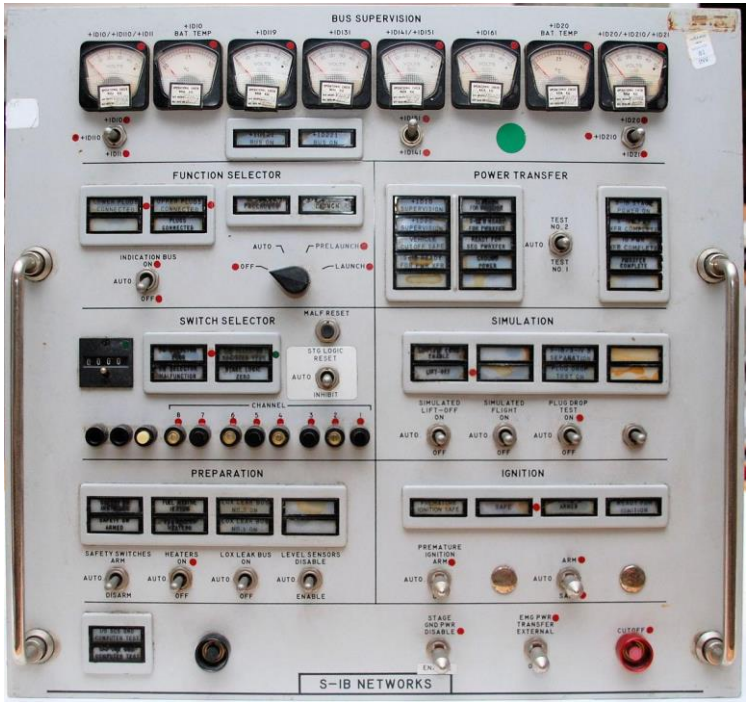
- Broker queue (“Quality of Service”)
  - Simultaneous request limits
    - Per user (current 10)
    - Per dataset (e.g. 40 for ERA5, 2 for ESA CCI, 10 for seasonal,…)
  - Priorities
    - ↑ Interactive
    - ↓ API
- Caching
  - Currently ~30 TB
  - Per type policies: PNG, NetCDF, GRIB, etc.
- A lot of tuning required



By Ilbasso -, CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=7257660

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Reproducibility

- CDS is a data store, not a data archive (we broker access to datasets maintained by third parties)
- We have an agreement with our data provider to store all data releases for up to 5 years
- When serving a datasets we assign a DOI to offer an easy way to reference the dataset.
- When there are changes in the dataset (a new version is released) we instantiate a new DOI using the DataCite API
- The CDS DOIs are easy to recognise: ***10.24381/cds.[xxxxxxxx]***

Reproducibilityand the toolbox

Reproducibility and the toolbox

The toolbox has several components:

- A user defined code called workflow
- Functions to access data stored in the CDS
- A set of tools that can perform several data processing from data reduction, statistical analysis and plotting

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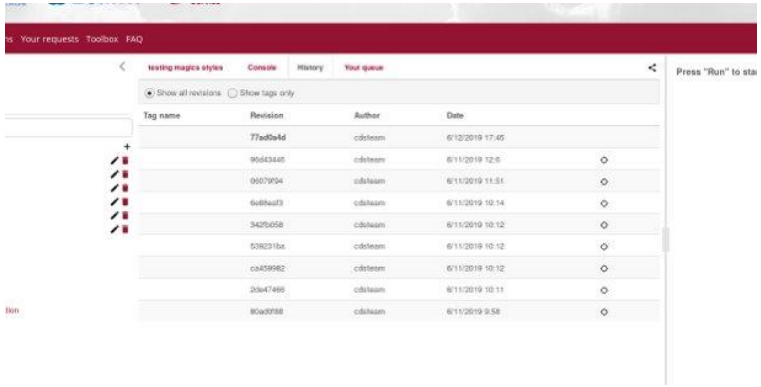
Reproducibility and the toolbox

- All workflows are tracked using git
- Sofware used by the toolbox is also tracked with git, in particular we know what version of each package is used at a certain time
- When there are major changes in the software we keep old versions for backward compatibility (a time span is not defined yet)



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Toward a more reproducible workflow

- Toolbox outputs includes different formats. Adding all necessary metadata for reproducing the steps taken to have a certain output is not trivial
- We have currently on going actions (EQC) to improve the reproducibility of workflows and tracking tools changes

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Thank you

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