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Python in the Copernicus Climate Change Service

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CDS: A new way of serving data

Copernicus Climate Change Services (C3S)
(https://climate.copernicus.eu)
is providing the Climate Data Store (CDS)
(https://cds.climate.copernicus.eu)

The CDS provides climate relevant datasets and tools to visualize and preprocess the data

Datasets may be downloaded using web forms or a convinient API

Preprocessing occurs in the cloud and it is done using the **Toolbox**

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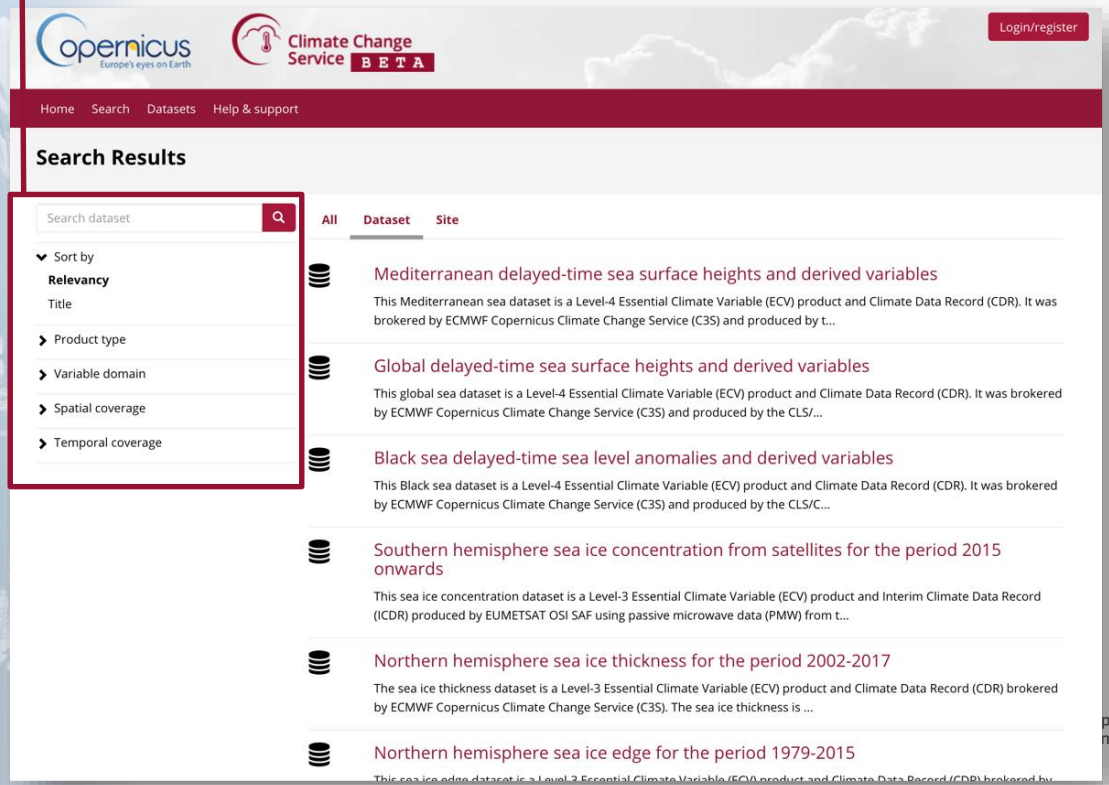
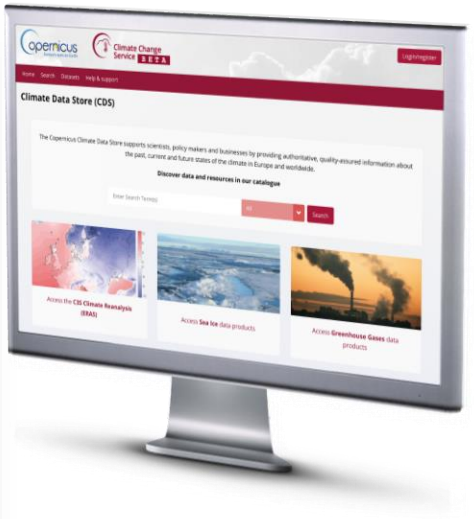
Searching and Browsing Functions





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Discovery and Retrieve Functions

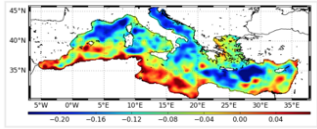
Gridded Satellite Observation Example

Login/register

Home Search Datasets Help & support

Mediterranean delayed-time sea surface heights and derived variables

Overview | Download data | Validation and verification | Documentation | Sample application

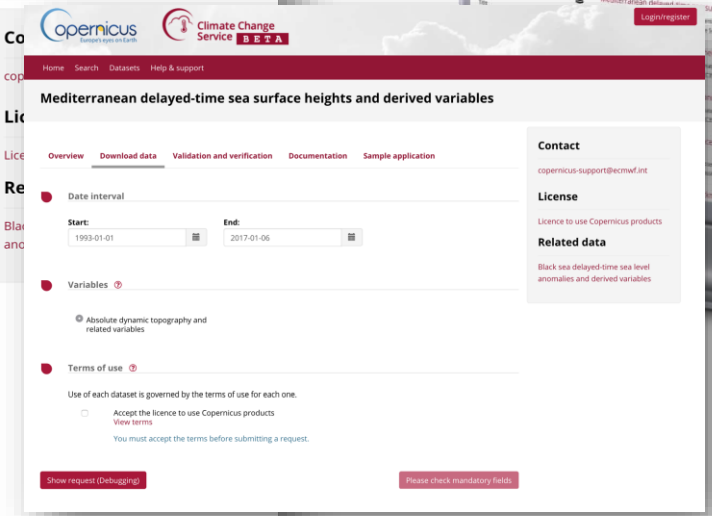


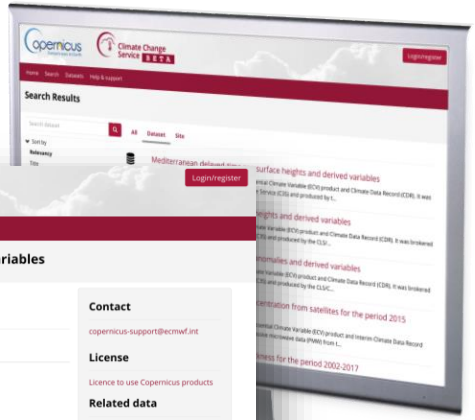
This **Mediterranean sea** dataset is a Level-4 Essential Climate Variable (ECV) product and Climate Data Record (CDR). It was brokered by ECMWF Copernicus Climate Change Service (C3S) and produced by the CLS/CNES DUACS satellite altimeter production system. Within the production process, the long-term stability and large scale changes are built upon the records from the reference missions (TOPEX-Poseidon, Jason-1, Jason-2 and Jason-3). The additional missions (ERS-1, ERS-2, Envisat, CryoSat-2, SARAL/AltiKa and Sentinel-3A) are homogenized with respect to the reference mission and contribute to improve the sampling of mesoscale processes, provide the high-latitude coverage and increase the product accuracy. The steady number of satellites used in the constellation contributes to the long-term stability of the sea level record.

Sea level anomalies and derived variables are computed with respect to a twenty-year mean reference period (1993-2012) where up-to-date altimeter standards are used to estimate the sea level anomalies with mapping algorithms dedicated to this region. Contrary to near-real time and interim sea level products, the stability and accuracy of the **delayed-time** product make it adapted to climate applications. This product is delayed about 4-5 months due to the timeliness of the input data, the centred processing temporal window and the validation process. Any modification of past input data, or of the processing chain, will provoke the issuing of a new version of the whole dataset. These products were previously distributed by AVISO+. Details on the altimeter and processing algorithms, validation results and uncertainties are available in the Algorithm Theoretical Basis Document (ATBD), the Product User Guide and Specification (PUGS) and the Product Quality Assessment Report (PQAR) in the Documentation section.

Keywords: Altimetry, Sea Level, Climate, Currents, Ocean Topography

Metadata	
Horizontal coverage:	Mediterranean sea (cartesian projection)
Horizontal resolution:	1/8 degree
Temporal coverage:	From January 1993 until present with a few months delay
Temporal resolution:	Daily
Data format:	NetCDF
Data type:	GRID





API

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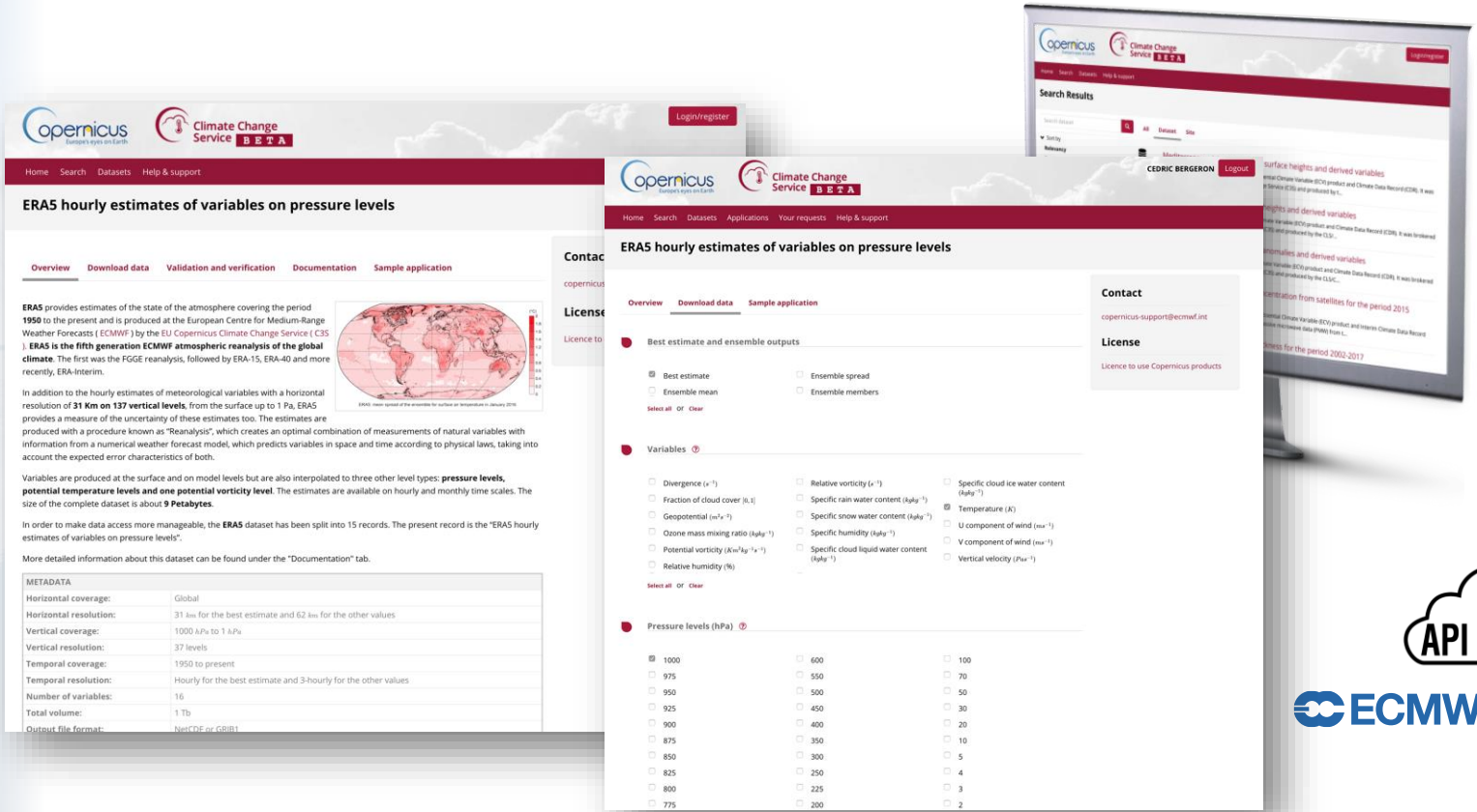
Discovery and Retrieve Functions

Reanalysis Example



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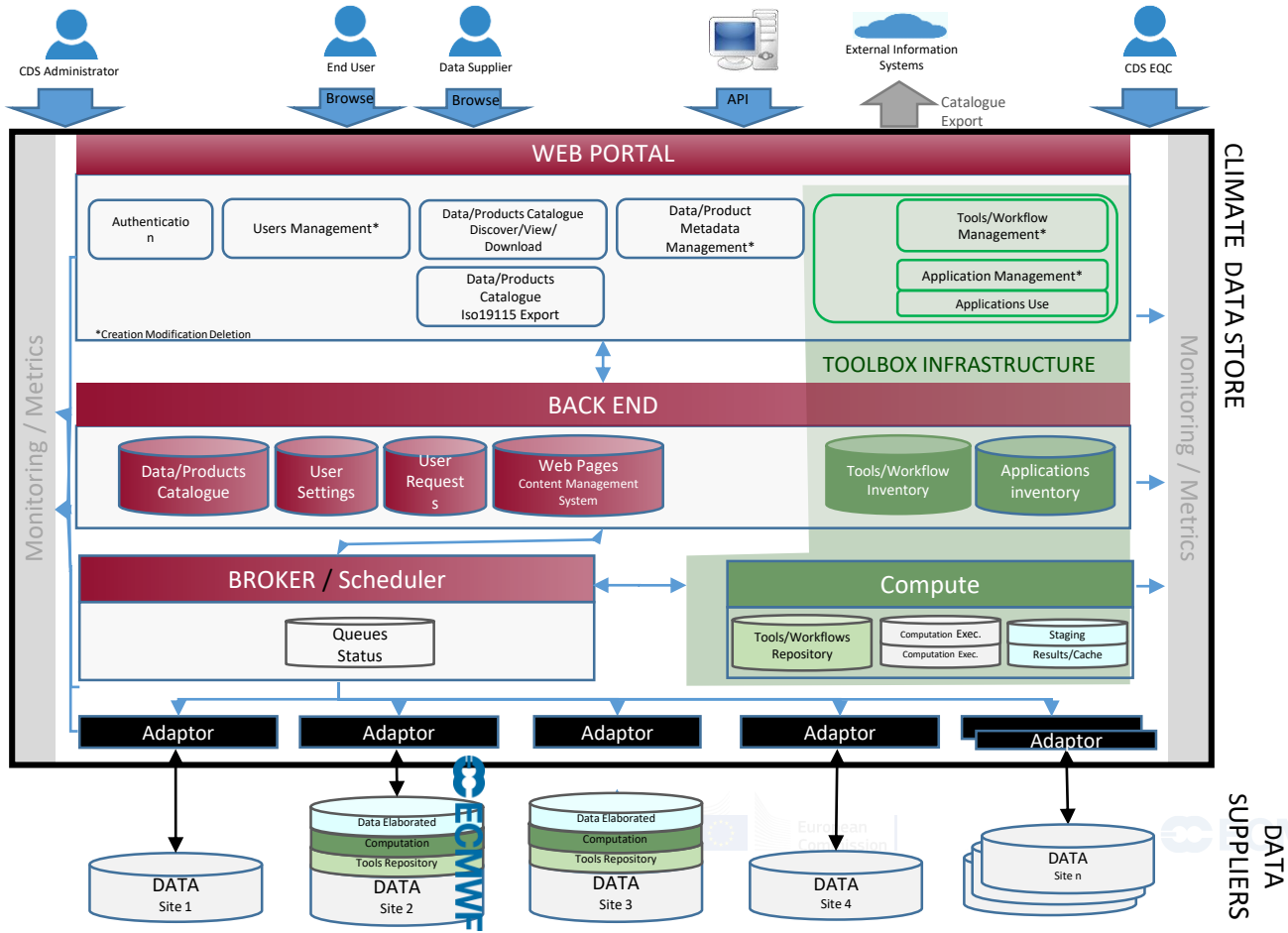
CDS – Overall technical Architecture



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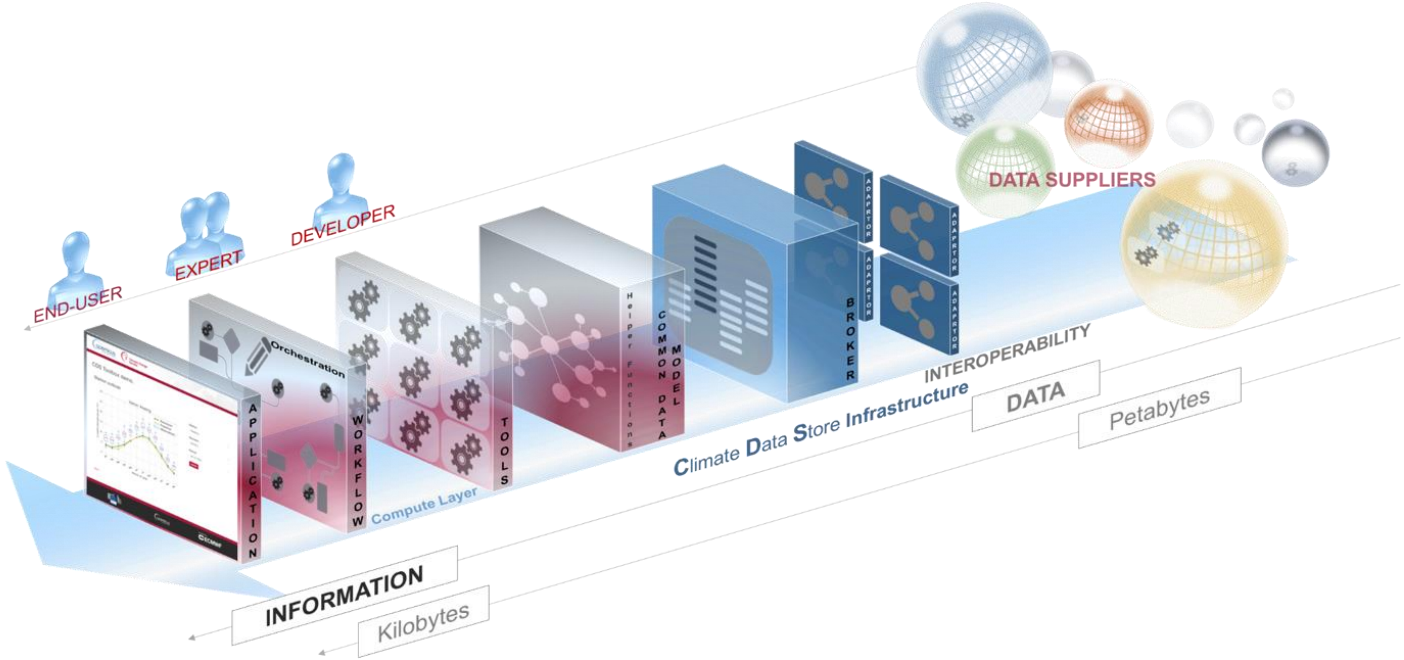
Idealized view of the toolbox



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CDS – Open-Source TECHNOLOGIES

jupyter

CDO

xarray

React

docker

python™

PostgreSQL

Java™

SciPy

Magics

Dask

openstack®

matplotlib

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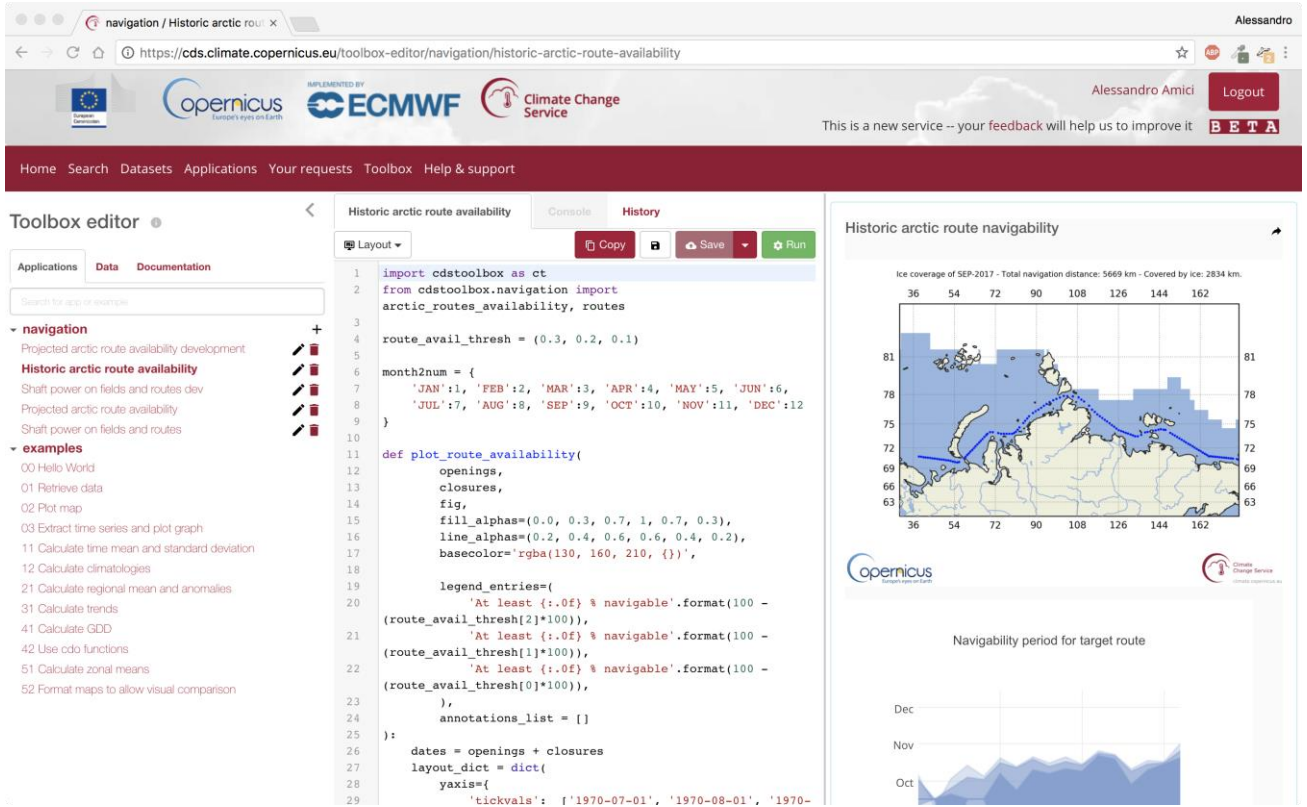
CDS Toolbox is here!



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How is the toolbox working?

The Toolbox may be seen as many things

1. A cloud infrastructure
2. A collection of services
3. A platform for developing python code
4. A platform for developing web applications

- A user submit a python script called **workflow**
- The user then can instantiate the execution of a workflow (providing inputs if defined)
- The workflow code is executed in almost perfect isolation within a docker container
- The workflow may be seen as a schedulere for a series of tasks (services or tools)
- After the execution outputs are returned as json files pointing to the urls of the results (plots or data files)

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CDS Toolbox - tools

We have five main categories of tools in the toolbox

- Application
- Catalogue
- Computation
- Graphics
- Dedicated tools

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CDS Toolbox - tools

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- Application
  - Define the web interface
  - Define input and output
- Catalogue
- Computation
- Graphics
- Dedicated tools

```
1  import cdstoolbox as ct
2
```

```
52 layout = {
53     'input_ncols': 3,
54     'output_ncols': 1,
55     'output_align': 'bottom',
56 }
57
58
59 @ct.application(title='Temperature and precipitation mothly averages over Africa', layout=layout)
60 @ct.input.dropdown('year', list(range(2000, 2019)), type=int)
61 @ct.output.carousel()
62 def application(year):
63     #
64     # Efficiency in a retrieve:
```

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CDS Toolbox - tools

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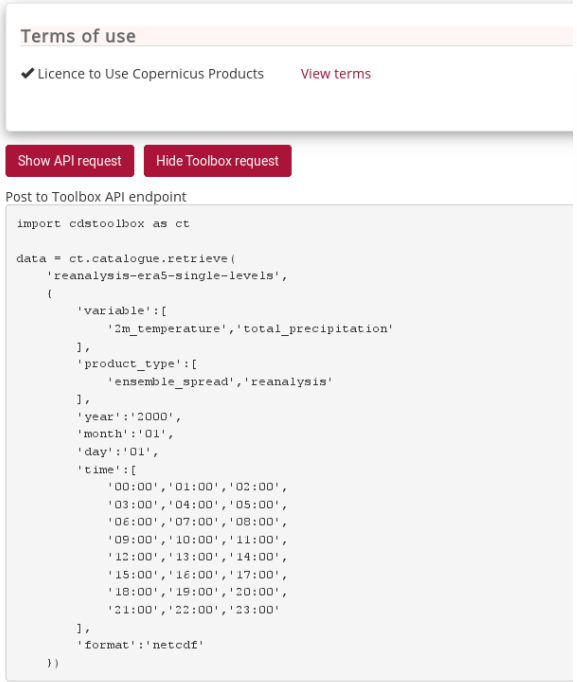
- Application
- Catalogue
  - Retrieve data from known sources
- Computation
- Graphics
- Dedicated tools



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CDS Toolbox - tools

```
35  def retrieve_full_year(year, area):
36      out = []
37      for m in ['%02d' % m for m in range(1,13)]:
38          out.append({'u': get_ea_month('100m_u_component_of_wind', year, m, area),
39                      'v': get_ea_month('100m_v_component_of_wind', year, m, area),
40                      'month': m,
41                     })
42          out[-1]['velocity'] = (out[-1]['v'] ** 2 + out[-1]['u'] ** 2) ** 0.5
43          out[-1]['velocity'] = ct.cds.services.update_attributes(out[-1]['velocity'], {'units': 'm s-1', 'long_name': '100m wind velocity'})
44      return out
```

- Application
- Catalogue
- Computation
  - Basic mathematical operations
  - Standard operators (|, ==, !=, +, -, *, /, **)
  - Data cube manipulation (average along axes, concatenation, sub-setting)
  - Max-Planck-Institut's Climate Data Operators CDO
  - Filtering on specific domains (Eurostat's nuts)
  - Statistical operations (curve fitting, detrend, extrapolation and interpolation
  - Meta data manipulation
- Graphics
- Dedicated tools

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CDS Toolbox - tools

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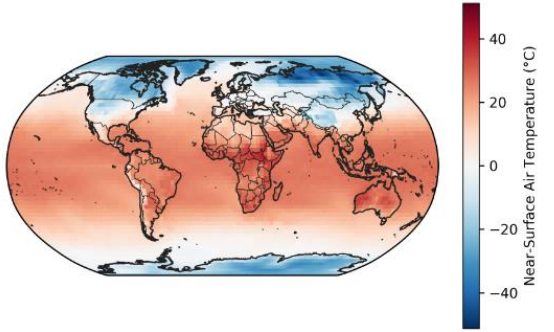
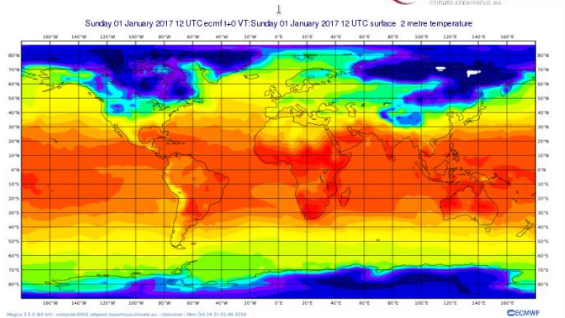
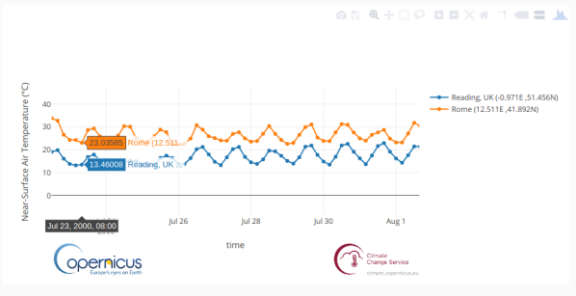
- Application
- Catalogue
- Computation
- Graphics
  - cdsplot (based on matplotlib)
  - map (based on magics)
  - chart (based on plotly for interactive plot
- Dedicated tools







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CDS Toolbox for experts

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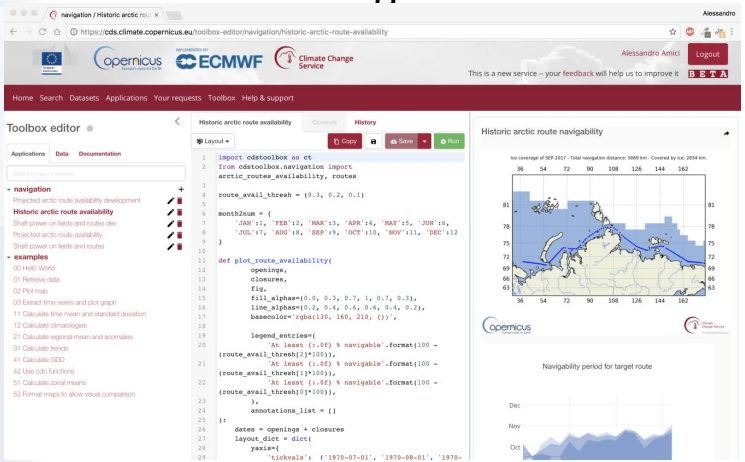
- Application
- Catalogue
- Computation
- Graphics
- Dedicated tools (for Sectoral Information System)
  - Navigation



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Features that will be implemented

- Support for observational data in form of ODB and CSV
- Support for shapefiles and other GIS formats

ODB is a data format developed at ECMWF and is used to store any type of observational data.
A C++ API is already available on the pubblic ECMWF's repositories.
A **pure python** interface is currently under testing

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Thanks

Questions ?

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