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(ECMWF)

Climate Change

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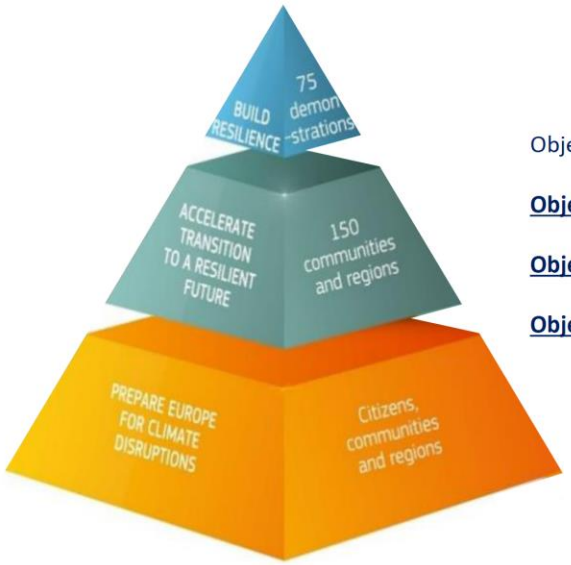
@carlo_tuitter

A rapidly changing landscape

World Economic Forum 2022: Global Risks Report: “most severe risks on a global scale over the next 10 years”

There are more climate related disasters now than ever before. Improving our ability to describe then and predict them would equip our society to better manage them.



Objectives:

Objective 1: Preparing and planning for climate resilience

Objective 2: Accelerating transformations to climate resilience

Objective 3: Demonstrating systemic transformations to climate resilience

The European Green Deal

ACER
European Union Agency for the Cooperation of Energy Regulators

European Investment Bank
The EU bank

European Climate and Health Observatory

ecdc
EUROPEAN CENTRE FOR DISEASE PREVENTION AND CONTROL

entsoe

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European Commission

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Too complex (big) to handle

- In 1995, ECMWF archive was growing annually by 14 TB
- In 2012, the archive was growing daily by 28 TB
- In early 2018, the daily growth was 200 TB

http://htor.inf.ethz.ch/publications/img/schulthess-exascale-climate.pdf

At the end of 2015, the archive held about 140 PB of data

The current figure is about

400 PB* and growing

A simple example
ERA-I 0.1 Pb
ERA5 12 Pb
ERA6 <80+ Pb

*If it were music, it could provide a staggering 1.000.000 years of streaming more than our life on the planet as homo sapiens
https://iammdnor.com/2015/08/15/infographic-hpw-large-is-150-petabytes/

Image from:
https://twitter.com/GCWeniger/status/1363822745834967043?s=20&t=3izmNInjv_FMKnvgbn-RvA

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C3S: operational support to climate adaptation

https://cds.climate.copernicus.eu

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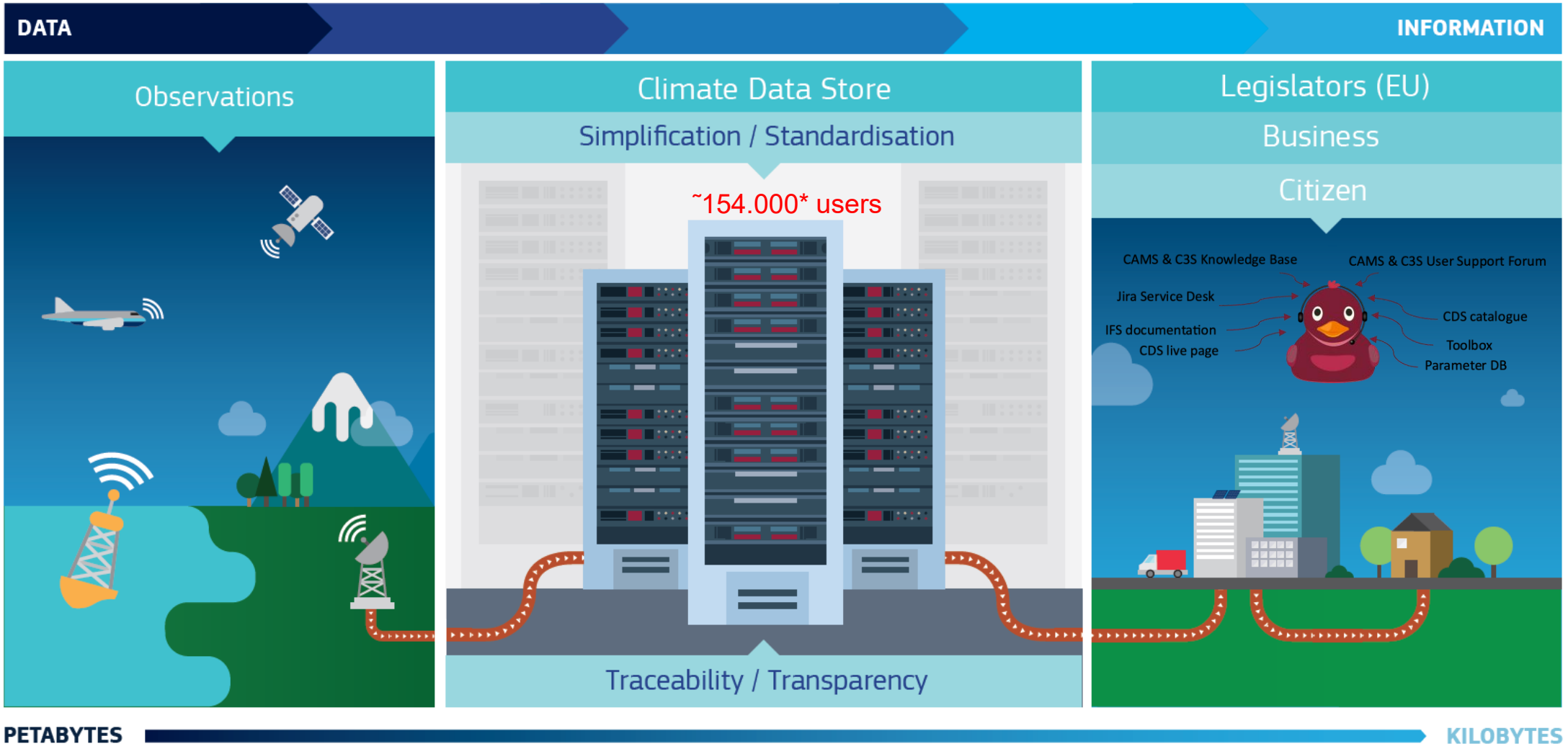

Typical download: ~100 TB /day

Typical number of requests: 500k/day

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Smart data for smart decisions

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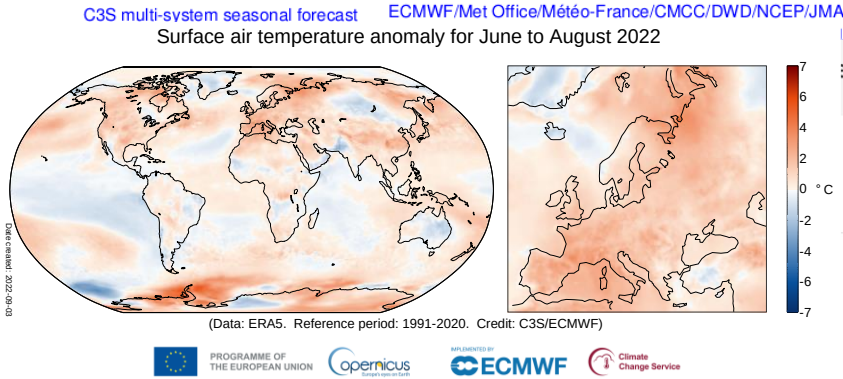

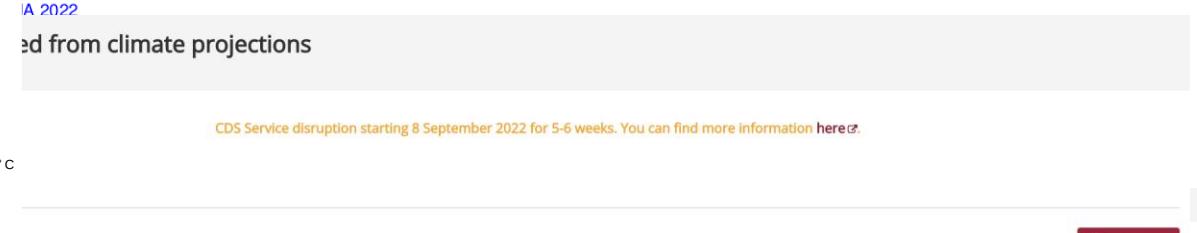

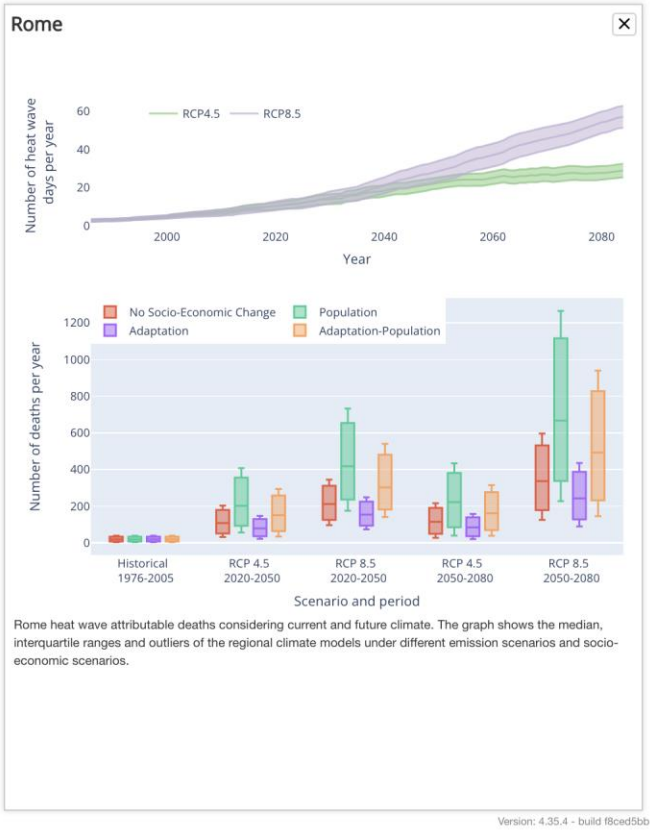

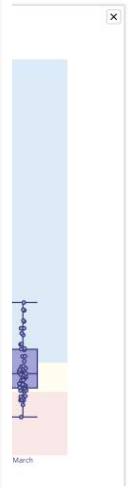

Version: 4.35.4 - build f8ced5bb

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Observations and data rescue (see H. Hersbach talk)

New in-situ products available:

- Temperature, RH and wind profiles - GRUAN reference network
- In situ total column ozone and ozone soundings from the World Ozone and Ultraviolet Radiation Data Centre.
- Integrated Global Radiosounding Archive
- Global Land & Marine Observations Database: surface atmospheric variables from comprehensive in-situ observations
- E-OBS: 8 gridded, daily variables from 1950 to the present, derived from European station observations
- Regional networks:
  - NGCD: Nordic gridded, daily temperature and precipitation data from 1971 to present derived from in-situ observations.
  - LAPrec: gridded, monthly precipitation from 1871 and 1901, from Alpine stations.

In situ temperature, relative humidity and wind profiles from 2006 to March 2020 from the GRUAN reference network

In situ total column ozone and ozone soundings from 1924 to present from the World Ozone and Ultraviolet Radiation Data Centre

In situ observations of meteorological variables from the Integrated Global Radiosounding Archive and the Radiosounding Harmonization dataset from 1978 onward

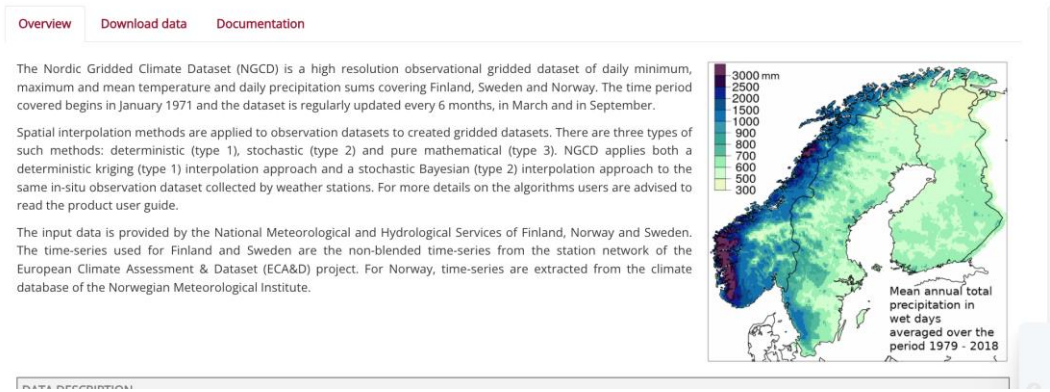
Global land surface atmospheric variables from 1755 to 2020 from comprehensive in-situ observations

Global marine surface meteorological variables from 1851 to 2010 from comprehensive in-situ observations

E-OBS daily gridded meteorological data for Europe from 1950 to present derived from in-situ observations

Alpine gridded monthly precipitation data since 1871 derived from in-situ observations

Nordic gridded temperature and precipitation data from 1971 to present derived from in-situ observations



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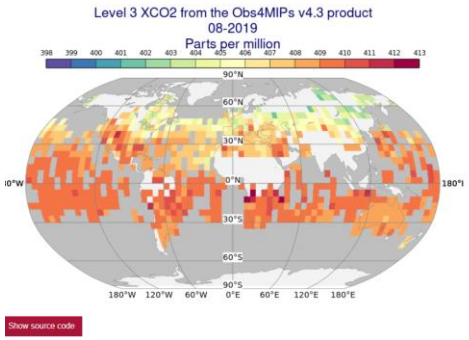
Operationalising ECV provision (see J. Muñoz Sabater's talk)

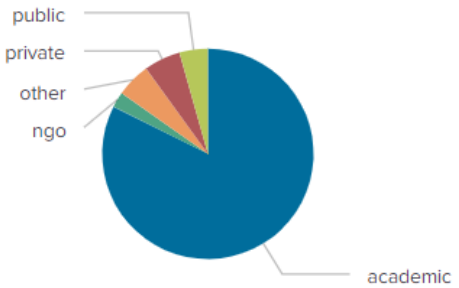
- **5 thematic ECV hubs:**
  - Atmospheric physics
  - Atmospheric composition
  - Ocean
  - Hydrology & Cryosphere
  - Land Biosphere
- **37 ECV products**
- **2 new products by end of 2022**
  - Ice Surface Temperature
  - Sea Ice Drift

- > **300 user-oriented documents**
- 9 tutorials
- 4 published data viewers
- **4 published toolbox applications + 25 new applications/use cases under analysis**
- **Jupiter notebooks under preparation**

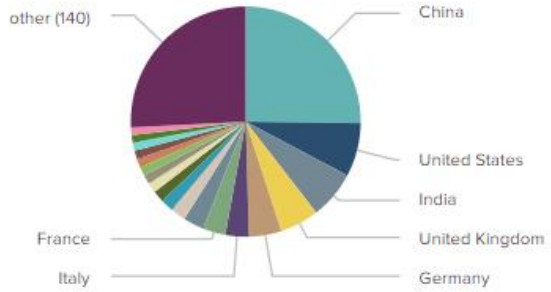


Total number users	Total volume downloaded (in GB)	Total number requests
22,966	307,201	712,407

Distribution per sector



Distribution per country

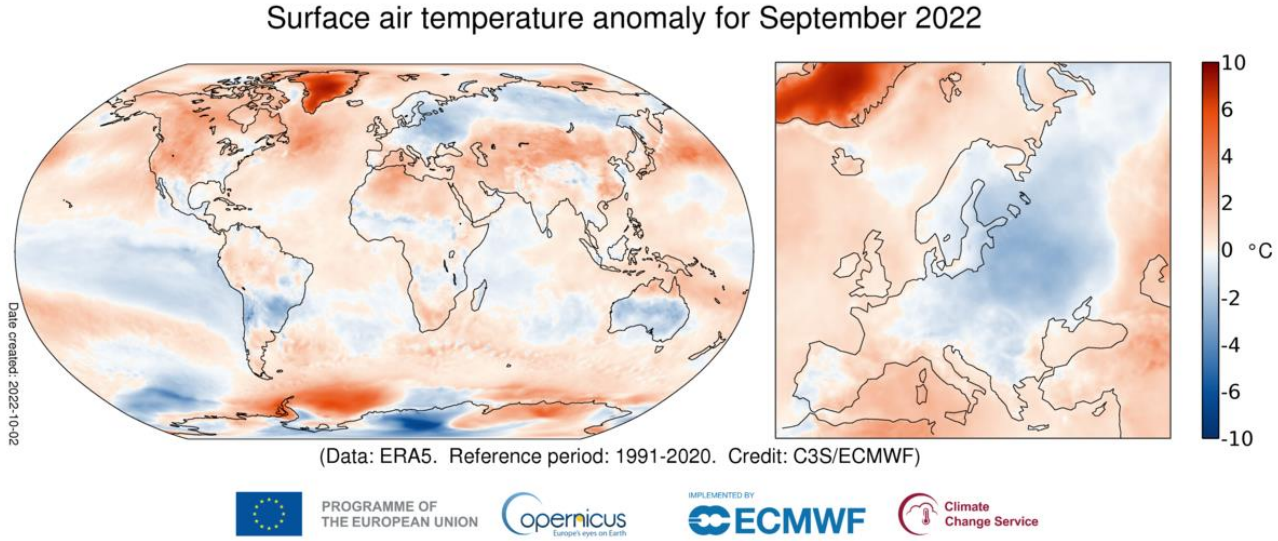


And much more…

- Full list of citations & acknowledgments per ECV product,
- Licenses for all products,
- Generation of DOI per catalogue entry
- Expert user support
- Independent and full quality control assessment per variable
- Products generated for the European State of the Climate

The dataset: ERA5 Reanalysis

ERA5: A full-observing-system global reanalysis for the atmosphere, land and



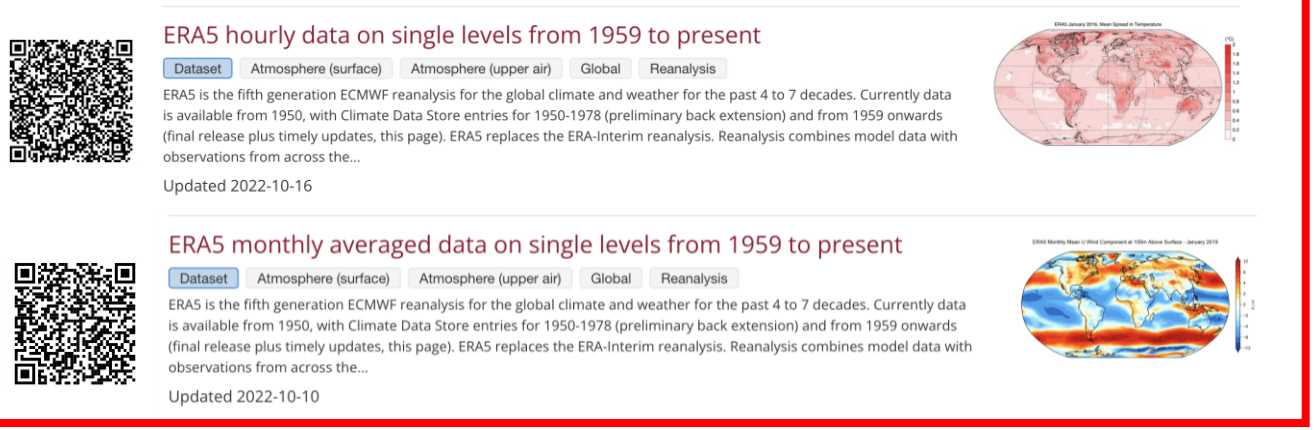
- Most popular dataset in the CDS (92 K Users)
- Available from 1959 onwards
- Daily updates 5 days behind real time
- Production of additional decades (1940-1958) available soon

Hersbach et al., 2020 (QJRMS)
https://doi.org/10.1002/qj.3803

Why ERA5 for this application ?

No gaps in space / time
Quality controlled
Key in climate monitoring activities & many other applications
Updated in NRT

ENTRY CATALOGUE DATA USED FOR THE APPLICATION



EVALUATION AND QUALITY CONTROL (EQC): QUALITY CONTROLLED, RELIABLE DATA

INDEPENDENT **FULLY TRACEABLE**

TRANSPARENT TO THE USERS **REPLICABLE**

BASIC CHECK

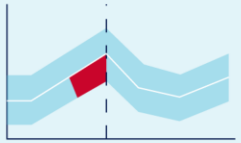
- → Independent check on resolution
- → Dataset Completeness

DATASET MATURITY

- → Independent maturity assessment
- → Implement and adapt
- → Quality functions and methods

FITNESS-FOR-PURPOSE

- → Through state-of-the-art scientific use cases
- → Means and variability
- → Trend detection
- → Cross-comparison observations, models and reanalysis
- → Extreme events (selected)



SUMMARY

- → Summary for the User
- → User Guidance
- → (Application Matrix): Closeness of Datasets to User

OPEN SOURCE SOFTWARE FOR REPRODUCIBILITY & VERSIONING

Chain of services and products and feedback loops

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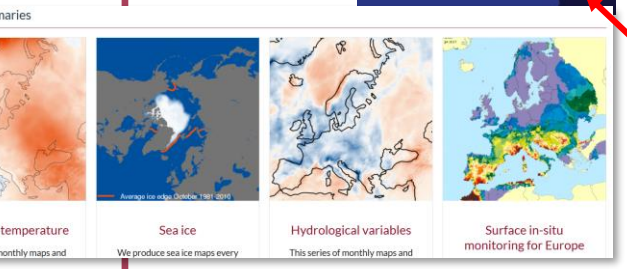

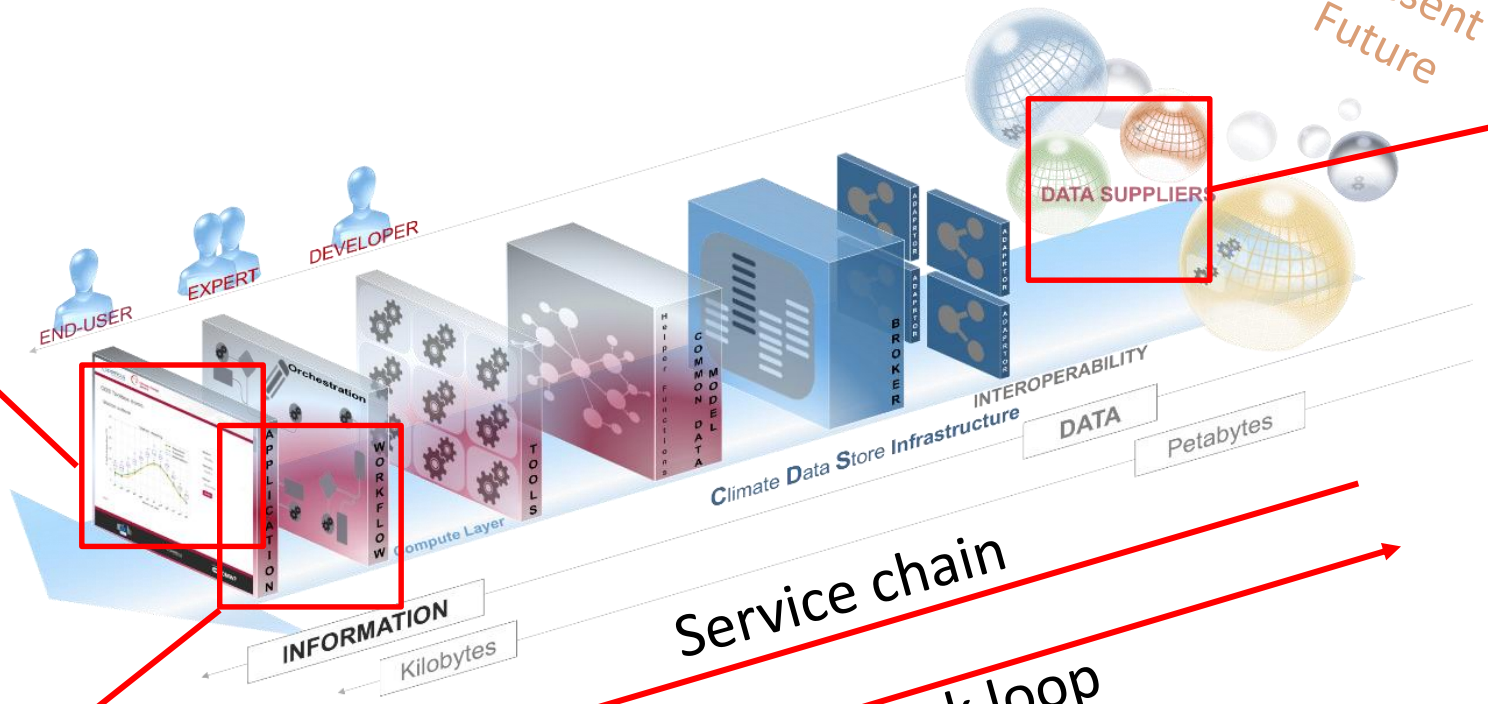

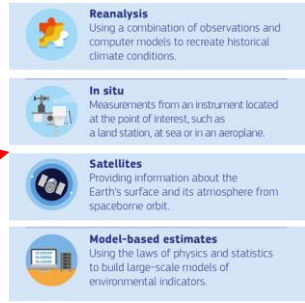

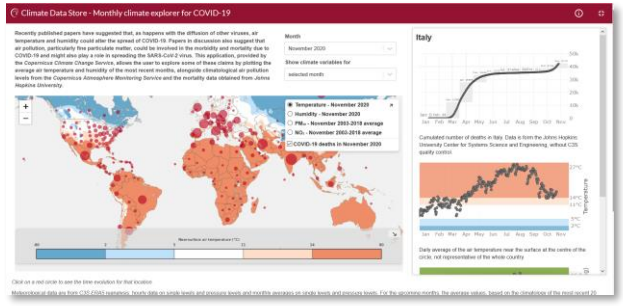

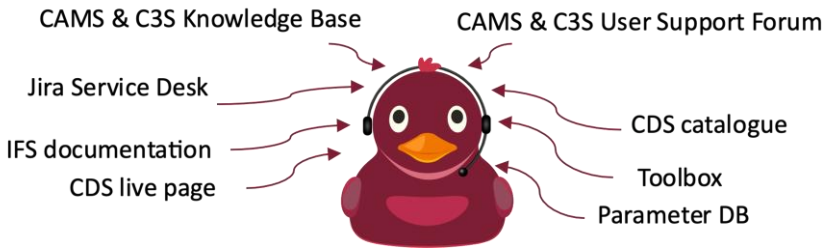

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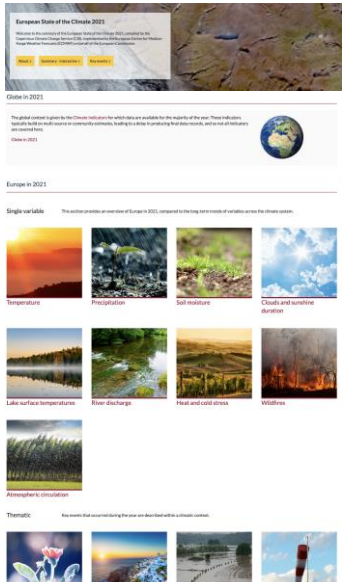
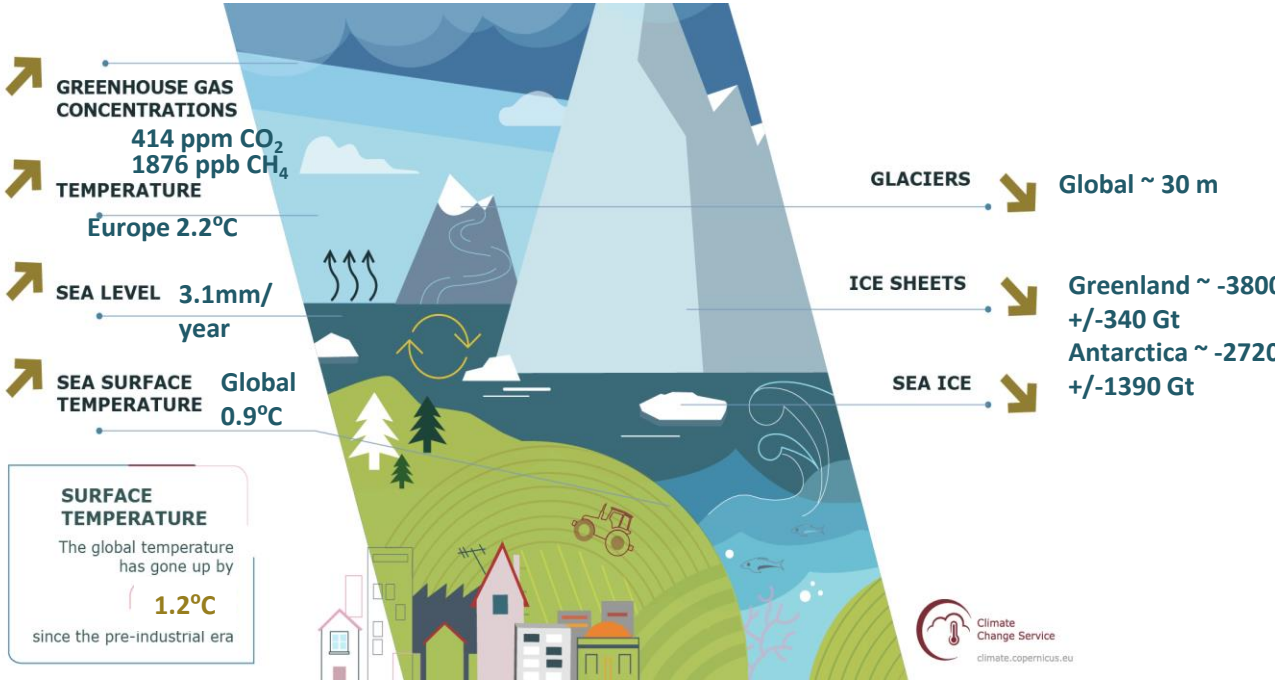
European State of the Climate 2021 – 5th edition of annual report





- https://climate.copernicus.eu/esotc/2021
- https://climate.copernicus.eu/climate-indicators

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What is an application?

Overview | Application | Documentation | Source code

Copy to clipboard

Application source code

```
import calendar
import datetime

import cdstoolbox as ct

TODAY = datetime.date.today()
CURRENT_YEAR = TODAY.year
CURRENT_MONTH = TODAY.month
CURRENT_DAY = TODAY.day

SWITCH_MONTH_DAY = 9
if CURRENT_DAY >= SWITCH_MONTH_DAY:
    DEFAULT_MONTH = (CURRENT_MONTH - 2) % 12 + 1  # prior month
else:
    DEFAULT_MONTH = (CURRENT_MONTH - 3) % 12 + 1  # two months ago

DEFAULT_YEAR = CURRENT_YEAR - 1 if CURRENT_MONTH < DEFAULT_MONTH else CURRENT_YEAR

LIMIT_TEMPERATURE = 1.5
LIMIT_TIME = '2061-01'

DESCRIPTION = (
    '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.**'
)

EXPLANATION = (
    'In this application:\n\n'
    '* "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;\n'
    '* "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;\n'
    '* "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.\n\n'
    '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).'
)

CLAIM_TIME = '1971-02'
CLAIM = (
    'Global warming reached an estimated <b>{current_temperature:.2f}°C</b> '
    'in <b>{year_month_name}</b>.<br>If the 30-year warming trend leading up '
    'to then continued,<br>global warming would reach '
    '<b style="color: {WINE_RED}">{LIMIT_TEMPERATURE}˚C</b> by '
    '<b style="color: {WINE_RED}">{latest_fit_date}</b>.'
)
FOOTER = f"Generated using Copernicus Climate Change Service information {DEFAULT_YEAR}."

WINE_RED = 'rgb(142, 14, 53)'
DEEP_YELLOW = "rgb(249, 241, 232)"
ORANGE = "rgb(249, 191, 124)"
DARK_GRAY = 'rgb(91, 91, 91)'
```

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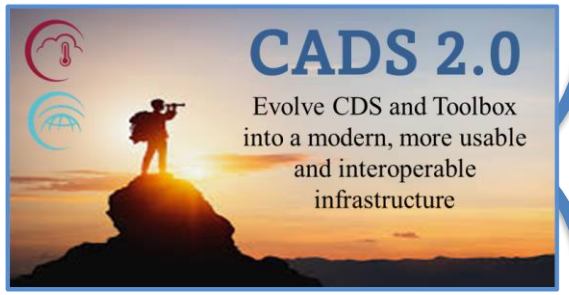
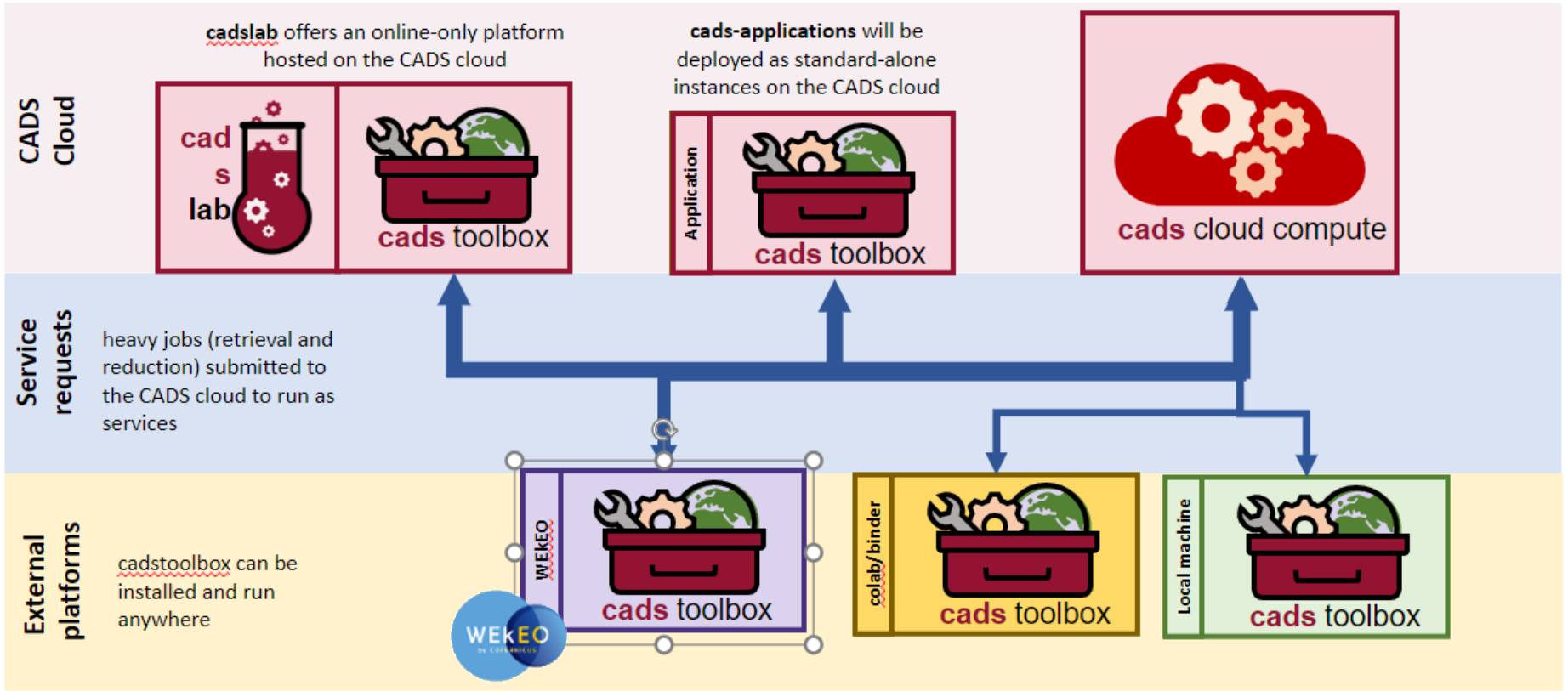
CADS Toolbox Blueprint

```
[user@macbook] $ pip install cadstoolbox
```

```
# import the package into your python session
import cadstoolbox as cads
```





Whilst the new system is being developed, providers can create informative Jupyter notebooks which can be used as training material

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Final GCOS slide

What are the bottlenecks in today's observation system you encountered in terms of transforming climate data into information relevant for decision making (Topic 3) and accessing, archiving, and processing climate data? (Topic 5)

- The direct use of observational records is perceived hard by non-academic users. The dataset are often complex, non-standard, non(always)-timely produced …

Which are the most urgent yet feasible actions for improving the situation?

- Standardise, standardise, standardise!
- Data and metadata structure need to be extremely uniform across data sources so that a set of universal tools can be developed and operate seamlessly across them.

Your vision for the future: By 2050, I imagine GCOS to:

- GCOS won't exist anymore as all the issues we face now will be fully tackled by then. And it is always a good sign to factor-in our own obsolescence.

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