

Co
Ser
op
dat



Climate Change



(ECMWF)



European
Commission



@carlo_twitter

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 them and predict them would equip our society to better manage them.



ACER 
European Union Agency for the Cooperation of Energy Regulators

 European Climate and Health Observatory



Objectives:

Objective 1: Preparing and planning for climate resilience

Objective 2: Accelerating transformations to climate resilience

Objective 3: Demonstrating systemic transformations to climate resilience





Climate
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Too complex (big) to handle



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:

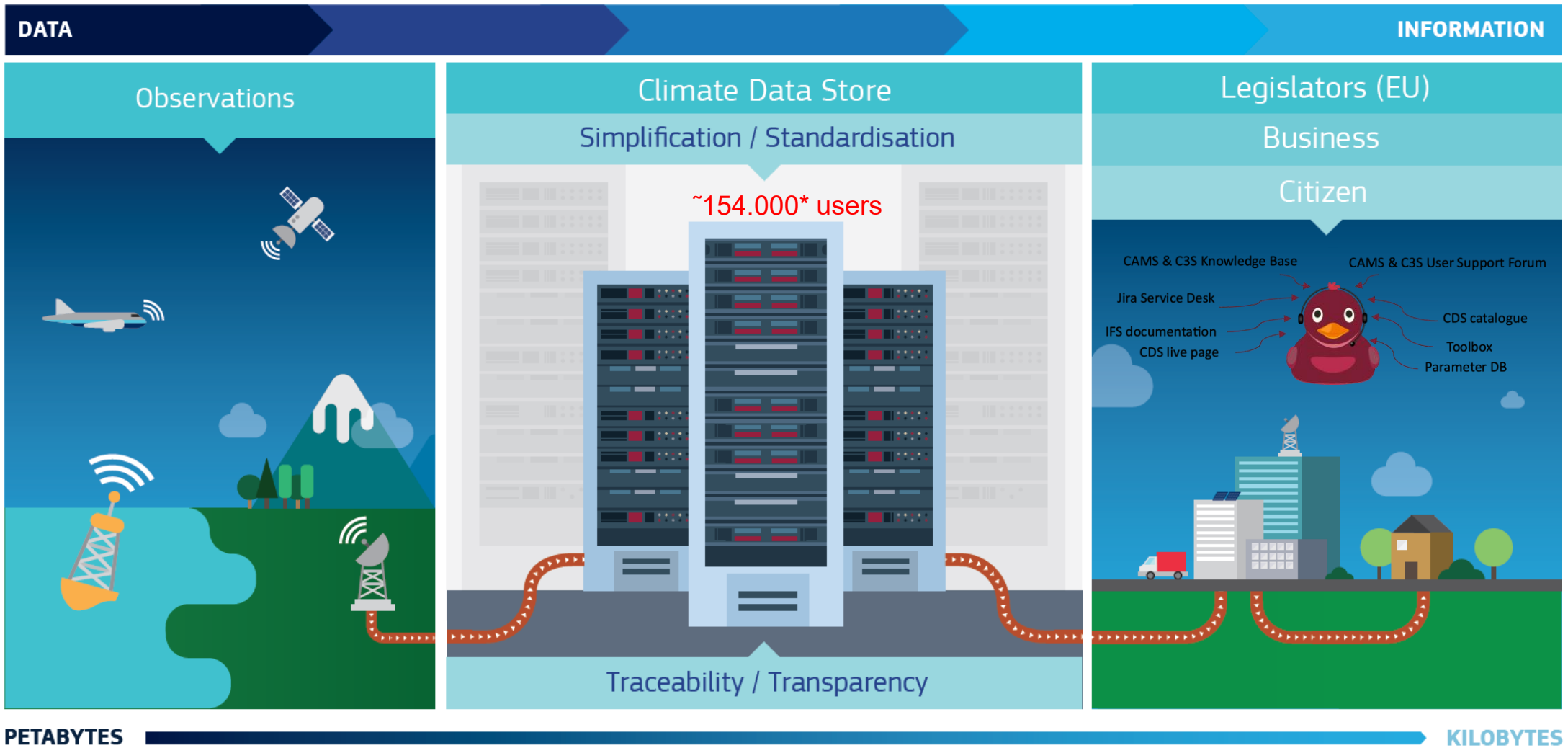
https://twitter.com/GCWeniger/status/1363822745834967043?s=20&t=3izmNinjv_FMKnvgbn-RvA

- 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>



Climate Change



Typical download: ~100 TB /day

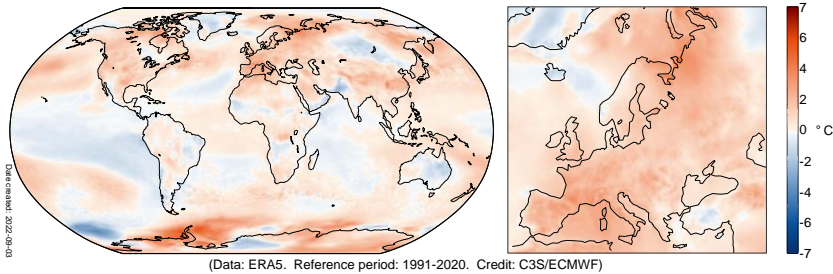
Typical number of requests: 500k/day



Climate Change

Smart data for smart decisions

C3S multi-system seasonal forecast ECMWF/Met Office/Météo-France/CMCC/DWD/NCEP/JMA/ECCC
Surface air temperature anomaly for June to August 2022



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



ed from climate projections

CDS Service disruption starting 8 September 2022 for 5-6 weeks. You can find more information [here](#).

Full screen

Le Monde

Consulter le journal

Se connecter S'abonner

ACTUALITÉS ÉCONOMIE VIDÉOS DÉBATS CULTURE M LE MAG SERVICES

PLANÈTE · CANICULE

L'été 2022 a été le plus en Europe, selon Copernicus

Europe's Brutal Sun Hottest on Record

Irish Examiner

Bloomberg

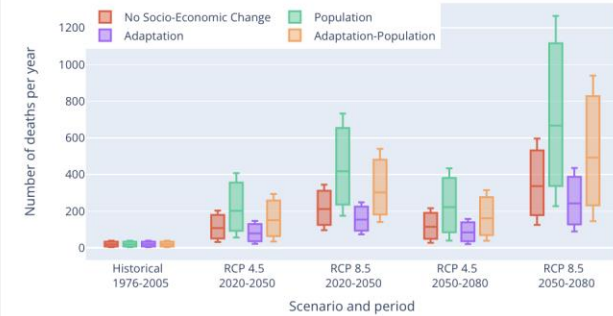
Europe's Brutal Sun Hottest on Record

Number of heat wave days per year



Rome

Number of heat wave days per year



Rome heat wave attributable deaths considering current and future climate. The graph shows the median, interquartile ranges and outliers of the regional climate models under different emission scenarios and socio-economic scenarios.

Version: 4.35.4 - build f8ced5bb

Version: 4.35.4 - build f8ced5bb

S



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

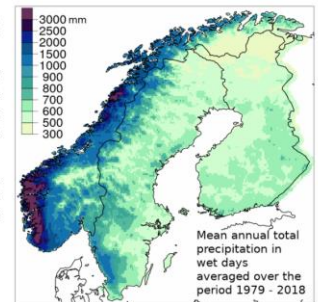
Nordic gridded temperature and precipitation data from 1971 to present derived from in-situ observations

[Overview](#) [Download data](#) [Documentation](#)

The Nordic Gridded Climate Dataset (NGCD) is a high resolution observational gridded dataset of daily minimum, maximum and mean temperature and daily precipitation sums covering Finland, Sweden and Norway. The time period covered begins in January 1971 and the dataset is regularly updated every 6 months, in March and in September.

Spatial interpolation methods are applied to observation datasets to create gridded datasets. There are three types of such methods: deterministic (type 1), stochastic (type 2) and pure mathematical (type 3). NGCD applies both a deterministic kriging (type 1) interpolation approach and a stochastic Bayesian (type 2) interpolation approach to the same in-situ observation dataset collected by weather stations. For more details on the algorithms users are advised to read the product user guide.

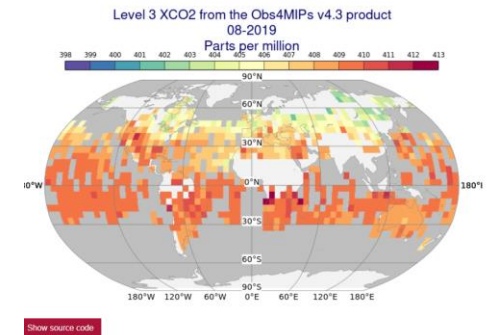
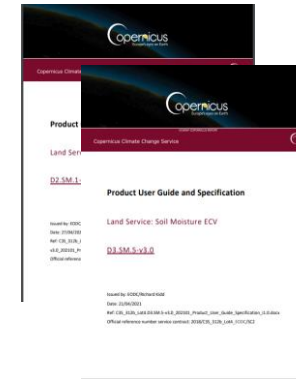
The input data is provided by the National Meteorological and Hydrological Services of Finland, Norway and Sweden. The time-series used for Finland and Sweden are the non-blended time-series from the station network of the European Climate Assessment & Dataset (ECA&D) project. For Norway, time-series are extracted from the climate database of the Norwegian Meteorological Institute.





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**

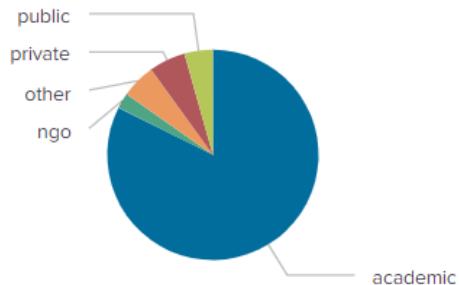


Total number users
22,966

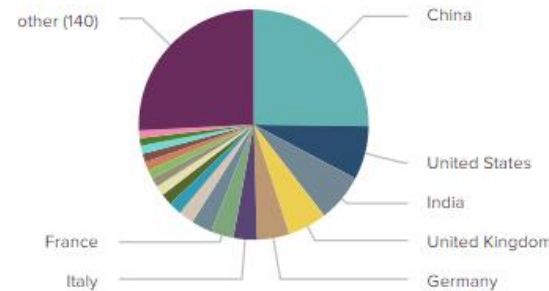
Total volume downloaded (in GB)
307,201

Total number requests
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

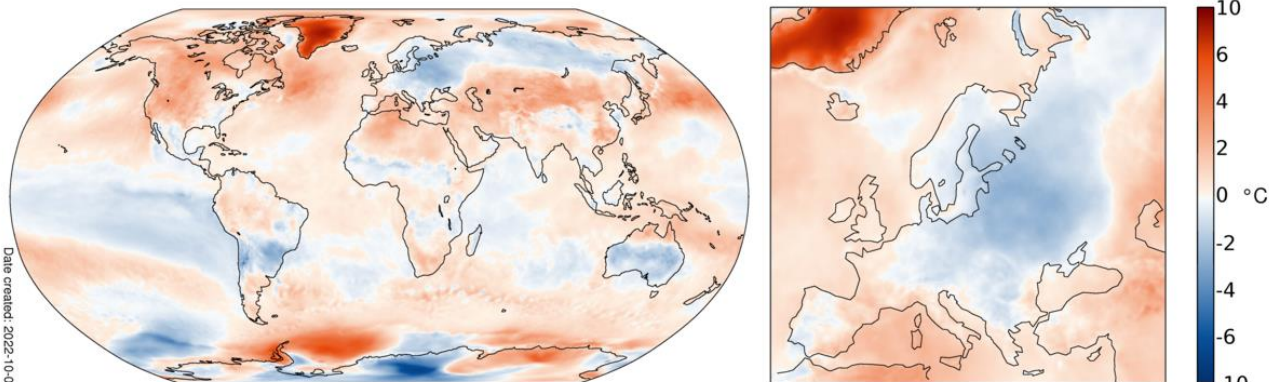


Climate Change

The dataset: ERA5 Reanalysis

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

Surface air temperature anomaly for September 2022



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

- 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>



PROGRAMME OF THE EUROPEAN UNION



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

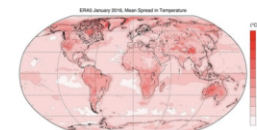


ERA5 hourly data on single levels from 1959 to present

Dataset Atmosphere (surface) Atmosphere (upper air) Global Reanalysis

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 1950, with Climate Data Store entries for 1950-1978 (preliminary back extension) and from 1959 onwards (final release plus timely updates, this page). ERA5 replaces the ERA-Interim reanalysis. Reanalysis combines model data with observations from across the...

Updated 2022-10-16

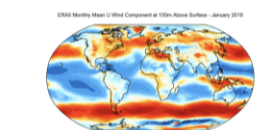


ERA5 monthly averaged data on single levels from 1959 to present

Dataset Atmosphere (surface) Atmosphere (upper air) Global Reanalysis

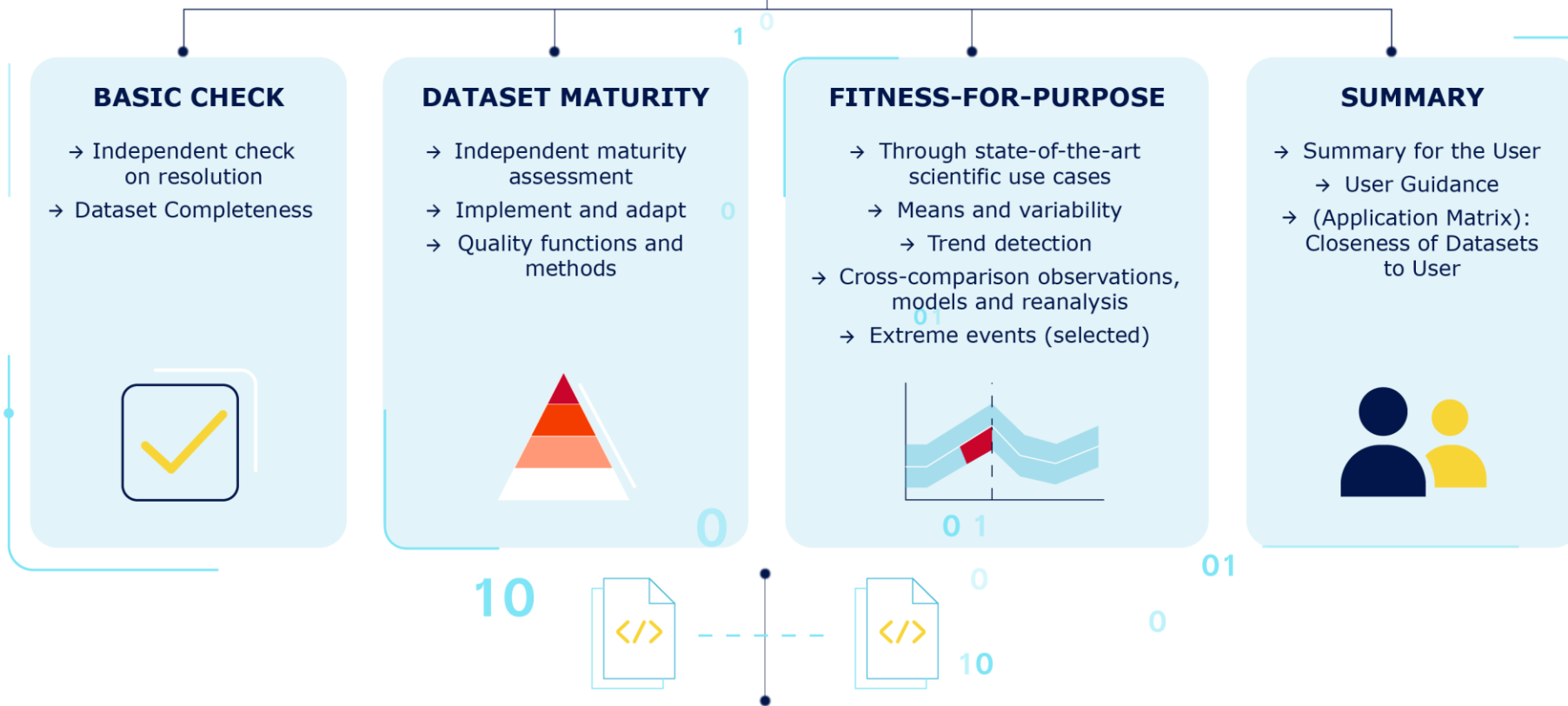
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Updated 2022-10-10



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

INDEPENDENT FULLY TRACEABLE TRANSPARENT TO THE USERS REPLICABLE

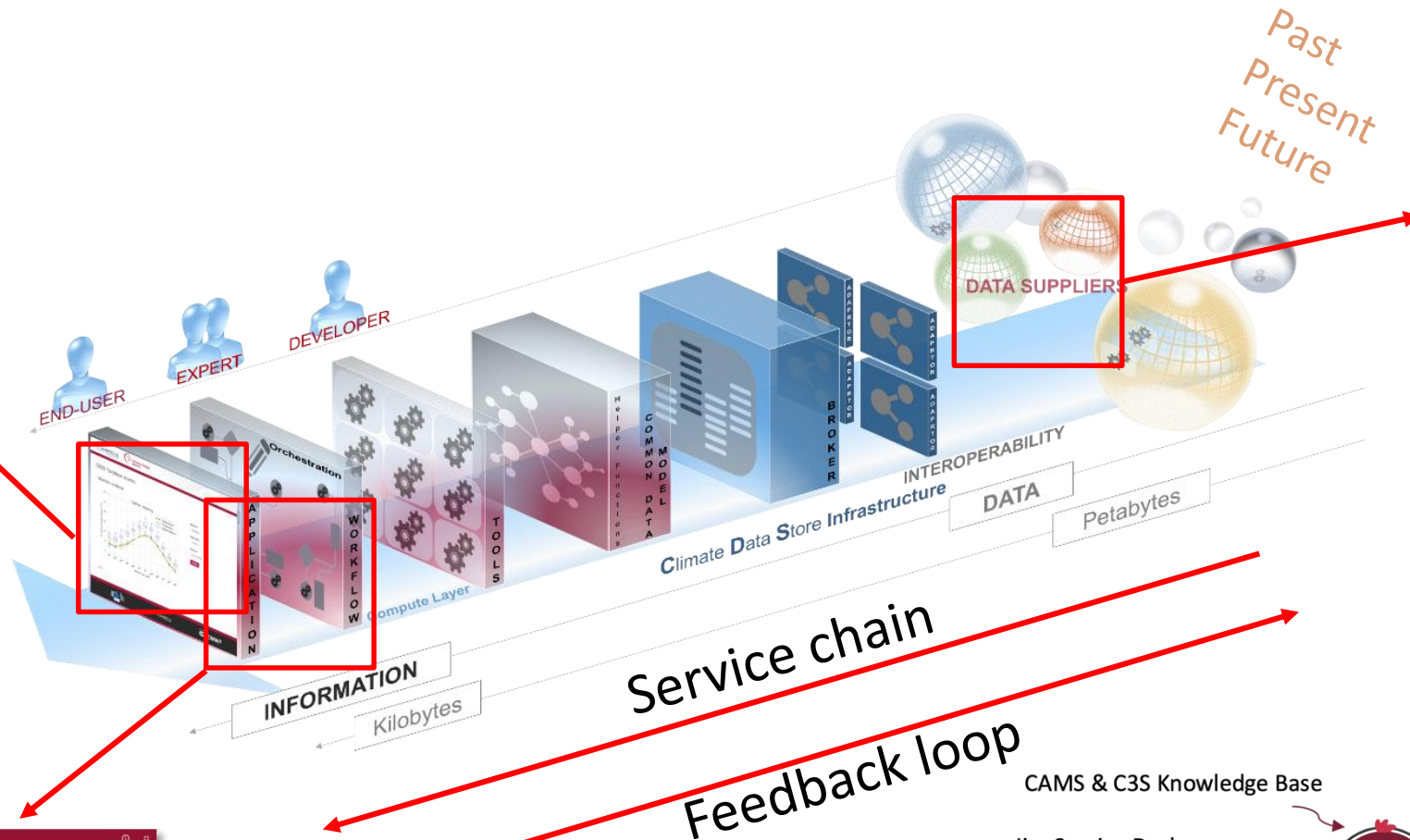
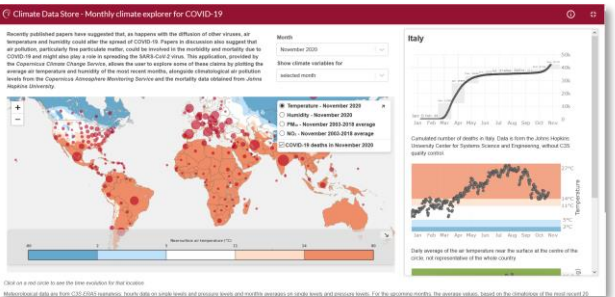
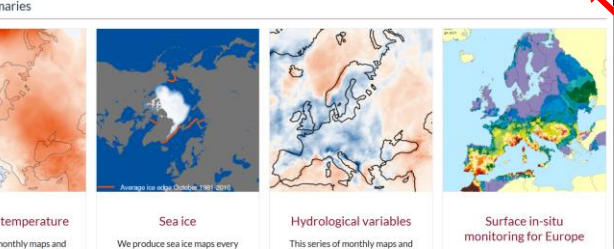


OPEN SOURCE SOFTWARE FOR REPRODUCIBILITY & VERSIONING

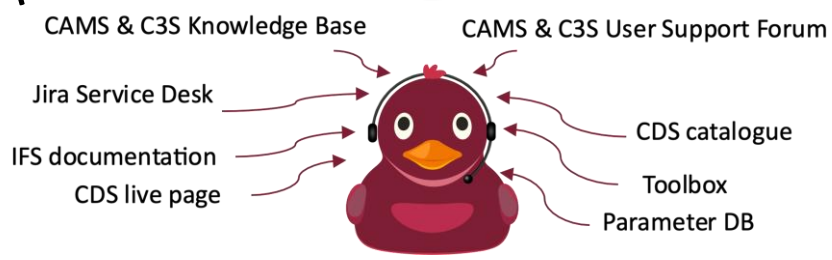


Climate Change

Chain of services and products and feedback loops



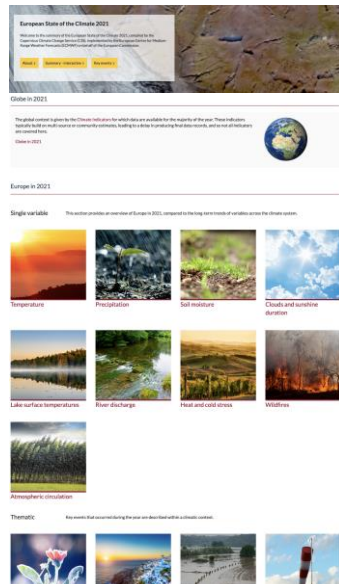
- Reanalysis**
Using a combination of observations and computer models to recreate historical climate conditions.
- In situ**
Measurements from an instrument located at the point of interest, such as a land station, at sea or in an aeroplane.
- Satellites**
Providing information about the Earth's surface and its atmosphere from spaceborne orbit.
- Model-based estimates**
Using the laws of physics and statistics to build large-scale models of environmental indicators.





Climate Change

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



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



What is an application?

Overview Application Documentation Source code

Copy to clipboard

Application source code

```
1
2 import calendar
3 import datetime
4
5 import cdstoolbox as ct
6
7 TODAY = datetime.date.today()
8 CURRENT_YEAR = TODAY.year
9 CURRENT_MONTH = TODAY.month
10 CURRENT_DAY = TODAY.day
11
12 SWITCH_MONTH_DAY = 9
13 if CURRENT_DAY >= SWITCH_MONTH_DAY:
14     DEFAULT_MONTH = (CURRENT_MONTH - 2) % 12 + 1 # prior month
15 else:
16     DEFAULT_MONTH = (CURRENT_MONTH - 3) % 12 + 1 # two months ago
17
18 DEFAULT_YEAR = CURRENT_YEAR - 1 if CURRENT_MONTH < DEFAULT_MONTH else CURRENT_YEAR
19
20 LIMIT_TEMPERATURE = 1.5
21 LIMIT_TIME = '2061-01'
22
23 DESCRIPTION = (
24     'Reaching 1.5°C of global warming - a limit agreed under the Paris '
25     'agreement - may feel like a very distant reality, but it might be '
26     'closer than you think. Experts suggest it is likely to happen between '
27     '2030 and the early 2050s. See where we are now and how soon we would '
28     'reach the limit if the warming continued at today's pace. '
29     '**Use the slider to explore how the estimate changes in time.**'
30 )
31
32 EXPLANATION = (
33     'In this application:\n\n'
34     '* "Global warming" at a point in time refers to the increase in a '
35     '30-year average, centred on the specified time, of Earth's global '
36     'surface temperature relative to the pre-industrial period;\n'
37     '* "Reaching the limit" refers to the moment when the central time of '
38     'the 30-year average temperature equals 1.5°C above pre-industrial values;\n'
39     '* "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'
40     'The application is first and foremost a monitoring tool and the indicative future '
41     'date is there for illustrative purposes only and should not be interpreted '
42     'as a forecast (see page 13 of documentation).'
43 )
44
45 CLAIM_TIME = '1971-02'
46 CLAIM = (
47     'Global warming reached an estimated <b>{current_temperature:.2f}</b>°C</b> '
48     'in <b>{year_month_name}</b>.<br><br>If the 30-year warming trend leading up '
49     'to then continued,<br>global warming would reach '
50     '<b style="color: {WINE_RED}">{LIMIT_TEMPERATURE}</b>°C</b> by '
51     '<b style="color: {WINE_RED}">{latest_fit_date}</b>.'
52 )
53 FOOTER = f'Generated using Copernicus Climate Change Service information {DEFAULT_YEAR}.'
54
55 WINE_RED = 'rgb(142, 14, 53)'
56 DEEP_YELLOW = "rgb(249, 241, 232)"
57 ORANGE = "rgb(249, 191, 124)"
58 DARK_GRAY = 'rgb(91, 91, 91)'
```




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.



Climate Change



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Thank you for your attention

