



Climate Change

Copernicus Climate Change Service: How user requirements influenced ERA5 products

18th May 2022

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Copernicus Climate Change Service (C3S)

DATA

Observations

Core

Standardisation

INFORMATION

(EU)

Business

Citizen

Traceability / Tra

PETABYTES

KILOBYTES

<http://climate.copernicus.eu>





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HEART OF C3S: CLIMATE DATA STORE (CDS)

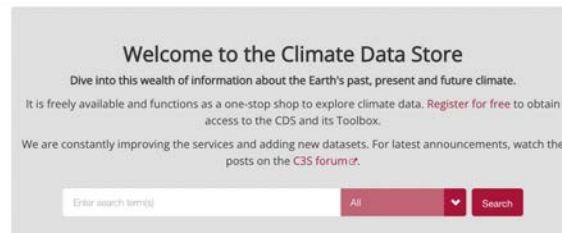
A '**one-stop-shop**' access to quality assured climate information, tools and good practices.

Distributing system offering access to over 130 datasets including ECVs, climate analyses, reanalyses, projections and indicators.

Over 130,000 users of which 80,000 are users of Reanalyses.

76TB/day downloaded (web/API)

Data comes hand in hand with a Toolbox, User Support service and an Evaluation and Quality Control (EQC) service.



<https://cds.climate.copernicus.eu>





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The ERA5 global reanalysis

ERA5 is in production at ECMWF for C3S

Atmosphere, land, ocean waves

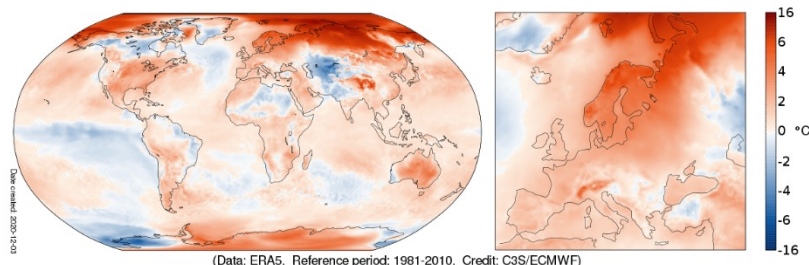
ERA5 has replaced ERA-Interim

(ERA-I was stopped end August 2019)

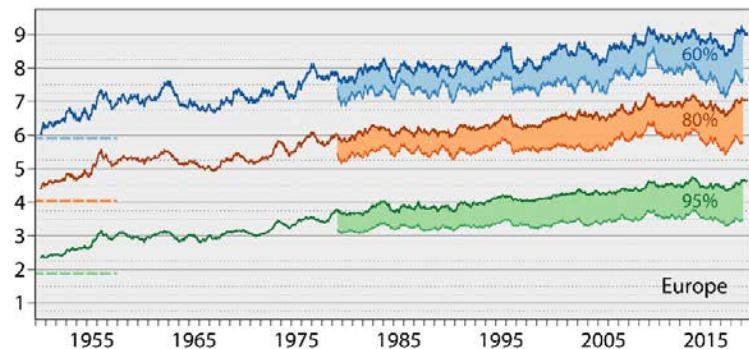
Improvements compared to ERA-Interim:

- Benefit from additional 10 years R&D development
- Much higher resolution; **31km** versus 80km
- More and better input data
- **Hourly output**
- 10-member EDA-based **uncertainty estimate** (at 63km)
- Continued close to real time; latency of 5 days
- Reaches further back in time (1950 versus 1979)
(highest quality over data rich areas)

Surface air temperature anomaly for November 2020



(Data: ERA5. Reference period: 1981-2010. Credit: C3S/ECMWF)



Forecasts from ERA5 have higher skill than those from ERA-Interim



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Thanks to Chiara Cagnazzo



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ERA5 in CDS – Most popular dataset!

ERA5 documentation, Quality assessment,
Guidelines on how to download data, etc

CDS web download form:
simply tick the boxes!

Home Search Datasets Applications Toolbox Support Live

ERA5 hourly data on single levels from 1979 to present

NOTIFICATION 2021-12-03: please be aware that the September 2021 final release of ERA5 differs from the timely updates (ERA5T), and it will be for the months October-December 2021 as well. See the online ERA5 documentation for more information.

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 1950, split into Climate Core entries for 1950-1978 (preliminary back extension) and from 1979 onwards (final release plus timely updates, this page). ERA5 replaces the previous reanalysis.

Reanalysis combines model data with observations from across the world into a globally complete and consistent dataset using the laws of physics. This principle, called data assimilation, is based on the method used by numerical weather prediction centres, where every 12 hours (12 hours at ECMWF) a previous forecast is combined with newly available observations in an optimal way to produce a new best estimate of the state of the atmosphere, called analysis. This analysis is then used to forecast the state of the atmosphere for the next 12 hours. Reanalysis works in the same way, but at reduced resolution to allow for the provision of a dataset spanning several decades. Reanalysis does not have the constraint of issuing timely forecasts, so there is more time to collect observations, and when going back in time, to allow for the ingestion of improved versions of the original observations, which all benefit the quality of the reanalysis product.

ERA5 provides hourly estimates for a large number of atmospheric, oceanic and land surface variables. The reanalysis is sampled by an underlying 10-member ensemble at three-hourly intervals. Ensemble mean and spread have been pre-computed for convenience. Such uncertainty estimates are a key feature of the reanalysis system which has evolved considerably over time. They also indicate flow-dependent sensitive areas. To facilitate many climate applications, monthly-mean averages have been pre-calculated too, using ensemble mean and spread.

ERA5 is updated daily with a latency of about 5 days. In case that serious flaws are detected in this early release (called ERA5T), this data could be different from the final release 2 to 3 months later. In case that this occurs users are notified.

The data set presented here is a regridded subset of the full ERA5 data set on native resolution. It is online on spinning disk, which should ensure fast and easy access. It should satisfy the requirements for most common applications.

An overview of all ERA5 datasets can be found in this article: Information on access to ERA5 data on native resolution is provided in these guidelines.

Data has been regridded to a regular lat lon grid of 0.25 degrees for the reanalysis and 0.5 degrees for the uncertainty estimate (0.5 and 1 degree respectively for ocean waves). There are four main sub sets: hourly and monthly products, both on pressure levels (upper air fields) and single levels (atmosphere, ocean wave and land surface quantities).

The present entry is "ERA5 hourly data on single levels from 1979 to present".

| DATA DESCRIPTION | |
|-----------------------|------------------------------------------------------------------------------------------------------------------------------------------------|
| Data type | Gridded |
| Projection | Regular latitude-longitude grid |
| Horizontal coverage | Global |
| Horizontal resolution | Reanalysis: 0.25° x 0.25° (atmosphere), 0.5° x 0.5° (ocean waves) Mean, spread and members: 0.5° x 0.5° (atmosphere), 1° x 1° (ocean waves) |
| Temporal coverage | 1979 to present |
| Temporal resolution | Hourly |
| File format | GRIB |
| Update frequency | Daily |

Overview Download data Quality assessment Documentation

Product type

☒ Reanalysis ☐ Ensemble members ☐ Ensemble mean ☐ Ensemble spread [Select all](#) [Clear all](#)

Variable [?](#)

At least one selection must be made

Popular

☐ 10m u-component of wind ☐ 10m v-component of wind
☐ 2m dewpoint temperature ☐ 2m temperature
☐ Mean sea level pressure ☐ Mean wave direction
☐ Mean wave period ☐ Sea surface temperature
☐ Significant height of combined wind waves and swell ☐ Surface pressure
☐ Total precipitation [Select all](#)

Temperature and pressure
Wind
Mean rates
Radiation and heat
Lakes
Evaporation and runoff
Precipitation and rain
Snow
Soil
Vertical integrals
Vegetation
Ocean waves
Other [Select all](#)

Year

At least one selection must be made

☐ 1979 ☐ 1980 ☐ 1981 ☐ 1982 ☐ 1983 ☐ 1984
☐ 1985 ☐ 1986 ☐ 1987 ☐ 1988 ☐ 1989 ☐ 1990
☐ 1991 ☐ 1992 ☐ 1993 ☐ 1994 ☐ 1995 ☐ 1996
☐ 1997 ☐ 1998 ☐ 1999 ☐ 2000 ☐ 2001 ☐ 2002
☐ 2003 ☐ 2004 ☐ 2005 ☐ 2006 ☐ 2007 ☐ 2008
☐ None ☐ None ☐ None ☐ None ☐ None ☐ None



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ERA5 simplified data presentation

- **ERA-Interim:**
 - Specify: an or fc, date, time, step
 - Accumulations: from start of fc
- **ERA5 CDS:**
 - Specify: date, time (hourly)
 - Accumulations: last hour
 - Mean fluxes: last hour

Year

At least one selection must be made

| | | | | | |
|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|
| <input type="checkbox"/> 1979 | <input type="checkbox"/> 1980 | <input type="checkbox"/> 1981 | <input type="checkbox"/> 1982 | <input type="checkbox"/> 1983 | <input type="checkbox"/> 1984 |
| <input type="checkbox"/> 1985 | <input type="checkbox"/> 1986 | <input type="checkbox"/> 1987 | <input type="checkbox"/> 1988 | <input type="checkbox"/> 1989 | <input type="checkbox"/> 1990 |
| <input type="checkbox"/> 1991 | <input type="checkbox"/> 1992 | <input type="checkbox"/> 1993 | <input type="checkbox"/> 1994 | <input type="checkbox"/> 1995 | <input type="checkbox"/> 1996 |
| <input type="checkbox"/> 1997 | <input type="checkbox"/> 1998 | <input type="checkbox"/> 1999 | <input type="checkbox"/> 2000 | <input type="checkbox"/> 2001 | <input type="checkbox"/> 2002 |
| <input type="checkbox"/> 2003 | <input type="checkbox"/> 2004 | <input type="checkbox"/> 2005 | <input type="checkbox"/> 2006 | <input type="checkbox"/> 2007 | <input type="checkbox"/> 2008 |
| <input type="checkbox"/> 2009 | <input type="checkbox"/> 2010 | <input type="checkbox"/> 2011 | <input type="checkbox"/> 2012 | <input type="checkbox"/> 2013 | <input type="checkbox"/> 2014 |
| <input type="checkbox"/> 2015 | <input type="checkbox"/> 2016 | <input type="checkbox"/> 2017 | <input type="checkbox"/> 2018 | <input type="checkbox"/> 2019 | <input type="checkbox"/> 2020 |
| <input type="checkbox"/> 2021 | <input type="checkbox"/> 2022 | | | | |

Select all

Month

At least one selection must be made

| | | | | | |
|----------------------------------|-----------------------------------|------------------------------------|----------------------------------|-----------------------------------|-----------------------------------|
| <input type="checkbox"/> January | <input type="checkbox"/> February | <input type="checkbox"/> March | <input type="checkbox"/> April | <input type="checkbox"/> May | <input type="checkbox"/> June |
| <input type="checkbox"/> July | <input type="checkbox"/> August | <input type="checkbox"/> September | <input type="checkbox"/> October | <input type="checkbox"/> November | <input type="checkbox"/> December |

Select all

Day

At least one selection must be made

| | | | | | |
|-----------------------------|-----------------------------|-----------------------------|-----------------------------|-----------------------------|-----------------------------|
| <input type="checkbox"/> 01 | <input type="checkbox"/> 02 | <input type="checkbox"/> 03 | <input type="checkbox"/> 04 | <input type="checkbox"/> 05 | <input type="checkbox"/> 06 |
| <input type="checkbox"/> 07 | <input type="checkbox"/> 08 | <input type="checkbox"/> 09 | <input type="checkbox"/> 10 | <input type="checkbox"/> 11 | <input type="checkbox"/> 12 |
| <input type="checkbox"/> 13 | <input type="checkbox"/> 14 | <input type="checkbox"/> 15 | <input type="checkbox"/> 16 | <input type="checkbox"/> 17 | <input type="checkbox"/> 18 |
| <input type="checkbox"/> 19 | <input type="checkbox"/> 20 | <input type="checkbox"/> 21 | <input type="checkbox"/> 22 | <input type="checkbox"/> 23 | <input type="checkbox"/> 24 |
| <input type="checkbox"/> 25 | <input type="checkbox"/> 26 | <input type="checkbox"/> 27 | <input type="checkbox"/> 28 | <input type="checkbox"/> 29 | <input type="checkbox"/> 30 |
| <input type="checkbox"/> 31 | | | | | |

Select all

Time

At least one selection must be made

| | | | | | |
|--------------------------------|--------------------------------|--------------------------------|--------------------------------|--------------------------------|--------------------------------|
| <input type="checkbox"/> 00:00 | <input type="checkbox"/> 01:00 | <input type="checkbox"/> 02:00 | <input type="checkbox"/> 03:00 | <input type="checkbox"/> 04:00 | <input type="checkbox"/> 05:00 |
| <input type="checkbox"/> 06:00 | <input type="checkbox"/> 07:00 | <input type="checkbox"/> 08:00 | <input type="checkbox"/> 09:00 | <input type="checkbox"/> 10:00 | <input type="checkbox"/> 11:00 |
| <input type="checkbox"/> 12:00 | <input type="checkbox"/> 13:00 | <input type="checkbox"/> 14:00 | <input type="checkbox"/> 15:00 | <input type="checkbox"/> 16:00 | <input type="checkbox"/> 17:00 |
| <input type="checkbox"/> 18:00 | <input type="checkbox"/> 19:00 | <input type="checkbox"/> 20:00 | <input type="checkbox"/> 21:00 | <input type="checkbox"/> 22:00 | <input type="checkbox"/> 23:00 |



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USER SUPPORT – TURNTABLE

Label/Producers



Record/Data

Arm/Support



Spectators/Users



User Support team is in a prime position to collect feedback/issues from users and turn to the reanalysis team for follow-up and more.

Image source: bhphotovideo.com



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USER SUPPORT – TURN TABLE

- ✓ Broad knowledge of ERA5, C3S products and more widely ECMWF activities
- ✓ Extensive experience with handling user enquiries and problem resolution
- ✓ Close working relationships with technical teams e.g. Reanalysis team

User Support => Fast-track channel from users' needs to technical teams

With the potential of influencing data products => Users needs satisfied



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ERA5 timely updates

Many users asked for timely updates in addition to a consistent long climate record:

- However, we cannot guarantee good quality control

Solution: ERA5T, 5 days behind real time

- each day one day is added to the CDS
- 3 months later, one month of the final product is made available
 - allows for correction if required

This service was introduced in December 2019

- Since then, each month ERA5 final = ERA5T.

Until October 2021, when an erroneous wet blob of soil moisture was found north of the Caspian.

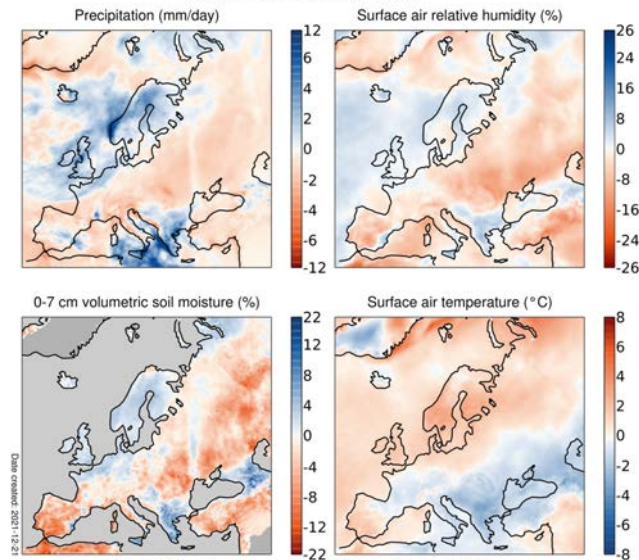
Appeared to be related to the assimilation of poor snow observations
It was decided to withhold the station (and a few others) and to rerun.

Such that the final ERA5 product was corrected in time.

Later, general QC for snow observations was improved in ERA5T

Thanks to Hans Hersbach

Anomalies for October 2021





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EQC function at C3S

Evaluation and Quality Control (EQC) function providing an overarching quality assurance service for the whole CDS:



CDS datasets: provide information about the technical and scientific quality and fitness-for-purpose, along with independent assessment of the datasets



CDS Toolbox: assessment of maturity and fitness for purpose of the software provided to explore the datasets



CDS service: performance assessment of the CDS infrastructure (e.g. speed, responsiveness, system availability)



CDS users: user requirement assessment to measure users' satisfaction with the CDS. Map evolving user needs into viable user requirements to ensure a user-oriented evolution of the CDS

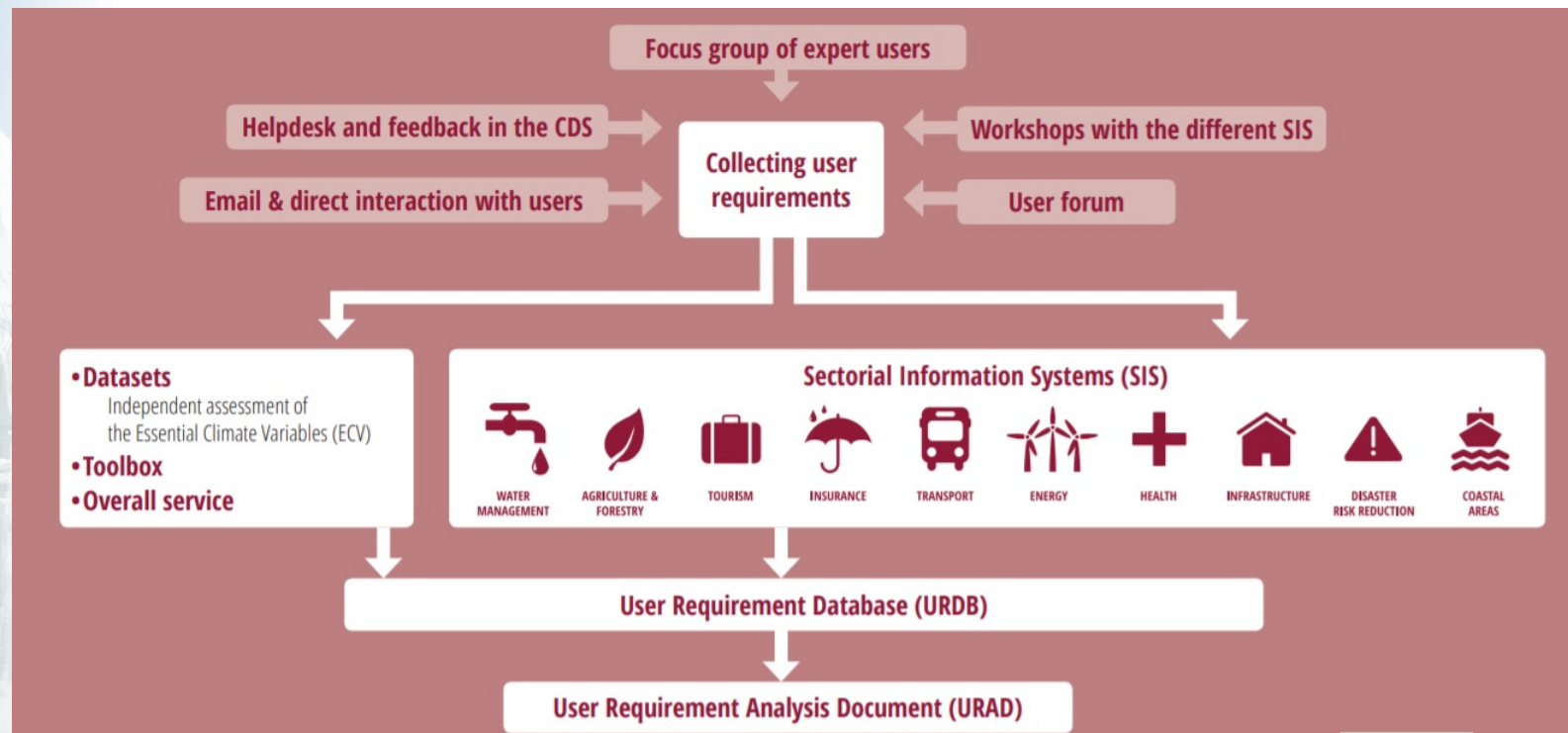
Source: C3S_512





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Collecting user requirements



→ Clustered user requirements

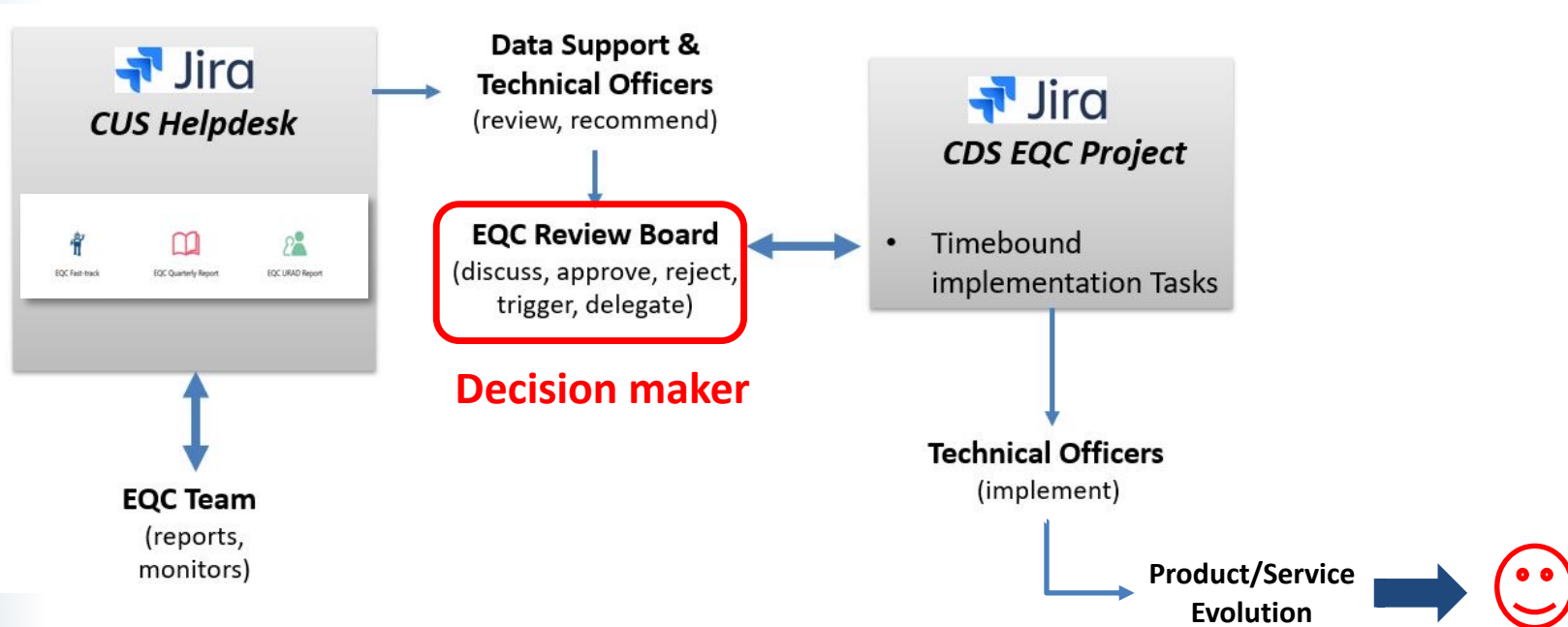
→ Actionable recommendations



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EQC Process – Outline

C3S Teams collaboration at its best!



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Daily statistics calculated from ERA5 data

- Hourly and Monthly Reanalysis
- Too big of a gap – users want daily!
- Proposed solution: Use the CDS toolbox to generate the daily data on demand
- A tool for users to obtain ERA5 data aggregated at daily frequency without having to download the original sub-daily resolution data.

⇒ User demand satisfied
⇒ Potential of CDS Toolbox exposed
⇒ Source code available

Climate Data Store - Application Preview

Daily statistics calculated from ERA5 data

This application allows users to compute and download selected daily statistics in local time (via the Time zone widget) of variables from a number of hourly ERA5 reanalysis datasets. Before computing the daily statistics the ERA5 hourly data can be subsampled in time (using the Frequency widget) and space (using the Grid and Area widget). Further details can be found in the application [Overview](#) and [Documentation](#).

| | | | |
|--------------------------------------------------------------------------------|----------------------|-------------------|-----------|
| Dataset | | Product type | |
| ERA5 hourly data on single levels from 1950 to 2022 (including back extension) | | Reanalysis | |
| Variable | Pressure level (hPa) | Statistic | |
| 2m temperature | | Daily mean | |
| Year | Month | Time zone | Frequency |
| 2022 | January | UTC-07:00 | 1-hourly |
| Grid (DD) | | Geographical area | |
| 0.25/0.25 | | N: 41 | W: -106 |
| | | S: -39 | E: -104 |
| Download 5134e82e-4372-4dd9-bc21-d28d289a5751.nc | | Run | |

Version: 4.35.1 - build 22ac52f





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Under consideration for ERA6 (Wishlist)

- Include surface photosynthetically available radiation (PAR)
- AOD 2D fields
- Few variables in ERA5 only available for one temporal aggregation (i.e., monthly mean but not hourly, or vice versa) e.g. Few variables in ERA5 are available only for one temporal aggregation (i.e., hourly but not monthly mean or vice versa e.g.
 - 10m_wind_gust_since_previous_post_processing
 - maximum_2m_temperature_since_previous_post_processing
 - maximum_total_precipitation_rate_since_previous_post_processing
 - minimum_2m_temperature_since_previous_post_processing
 - minimum_total_precipitation_rate_since_previous_post_processing
 - 10m wind speed is available for the monthly means, but not in the hourly entry



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Let's recap!

Copernicus Climate Change Service (C3S): **User-driven #FreeData for #SmartDecisions**



ECMWF Support for C3S: **Turntable** from the users' world to scientific and technical teams and back!



Technical & Scientific teams:
Data producers!

Climate Data Store (CDS): **One-Stop-Shop access** to quality assured climate information, tools and good practices.



Evaluation and Quality Control (EQC): C3S function providing an overarching quality assurance service for the whole CDS.





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Connecting the dots is key to our success

Recipe to C3S success in driving the evolution of reanalysis products:

- **Ingredients:** Focus on users + operational nature of C3S
- **Method:** Governed collaboration (User Support + EQC Process + Production teams)

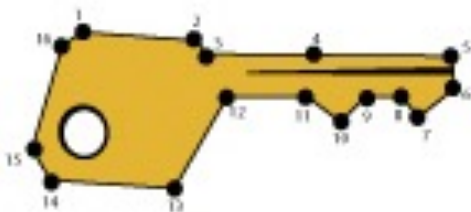


Image source: bforball.com



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Thank you for your attention

