



Climate Change

EQC function of the Copernicus Climate Data Store

ESIP IQC monthly telco

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European
Commission





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COPERNICUS CLIMATE CHANGE SERVICE (C3S)



Copernicus is the European Union's Earth observation programme coordinated and managed by the European Commission

Copernicus provides a unified system through which vast amounts of data are fed into a range of **thematic information services**, designed to benefit the environment, the way we live, humanitarian needs and support effective policy-making for a more sustainable future



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Copernicus provides a unified system through which vast amounts of data are fed into a range of **thematic information services**, designed to benefit the environment, the way we live, humanitarian needs and support effective policy-making for a more sustainable future

One of the thematic services, namely the **Copernicus Climate Change service (C3S)**, aims at providing comprehensive information about past, present and future climate to a wide range of users

Target users are policy makers, scientists and business to achieve a more sustainable future

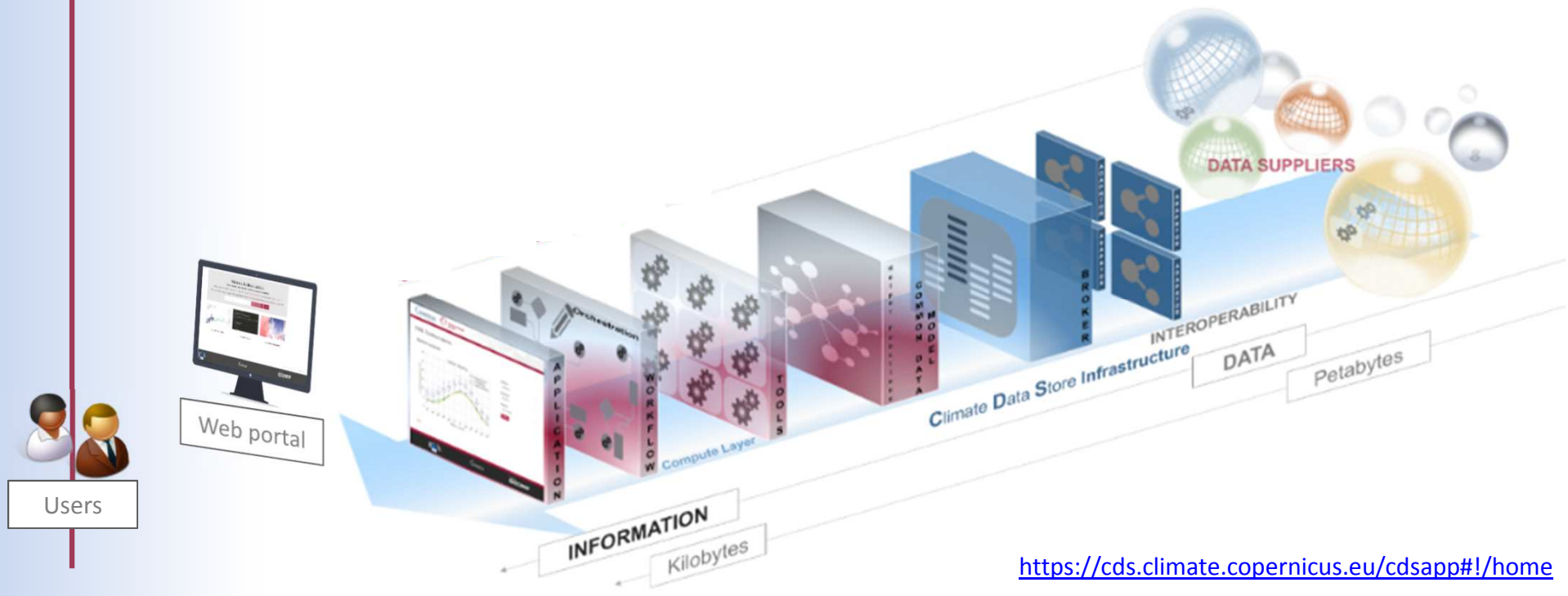
All this information is collected and made available in the **Climate Data Store (CDS)**, the cornerstone of the C3S



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CLIMATE DATA STORE (CDS)

At the heart of the **C3S** infrastructure is the cloud-based **Climate Data Store (CDS)**. It provides a single point of access to a wide range of climate datasets, namely satellite and in-situ observations, reanalyses, seasonal forecasts and climate projections



<https://cds.climate.copernicus.eu/cdsapp#!/home>

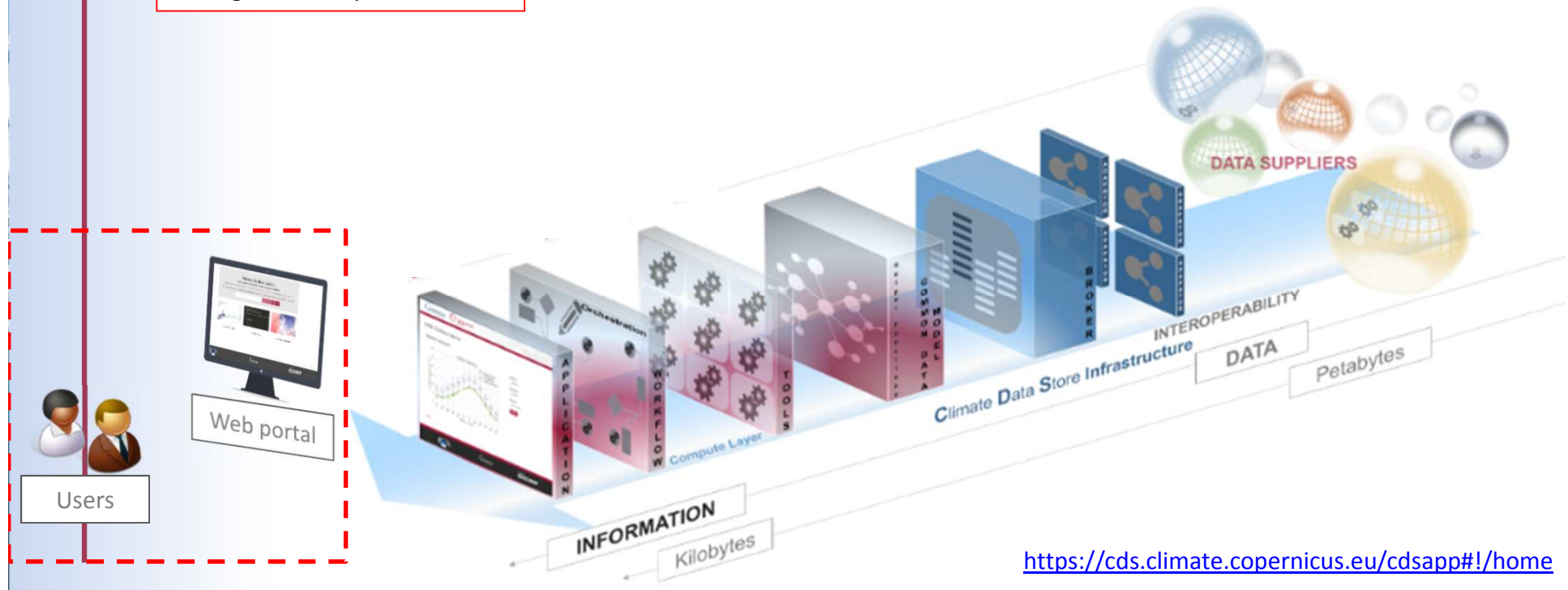


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CLIMATE DATA STORE (CDS)

The **Climate Data Store (CDS) of the C3S** provides a single point of access to a wide range of climate datasets, namely satellite and in-situ observations, reanalyses, seasonal forecasts and climate projections

Users can explore the CDS data through the web portal



<https://cds.climate.copernicus.eu/cdsapp#!/home>

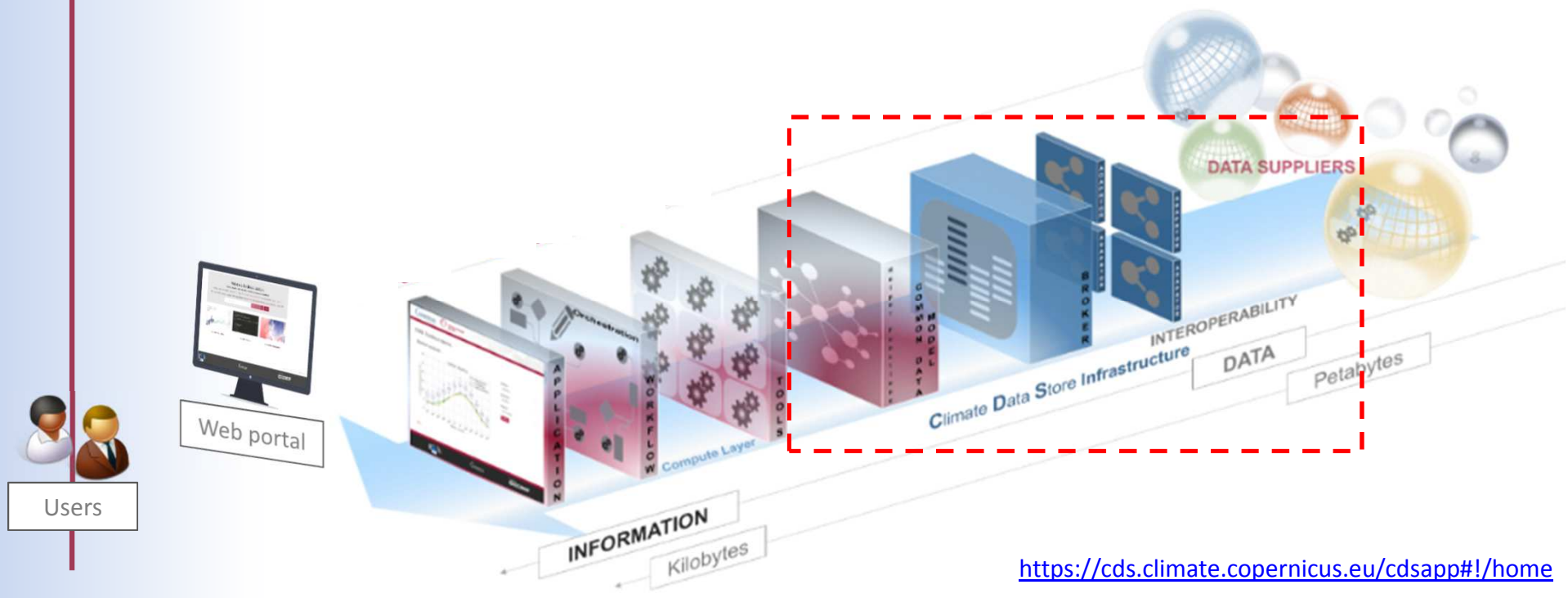


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CLIMATE DATA STORE (CDS)

The **Climate Data Store (CDS)** of the **C3S** provides a single point of access to a wide range of climate datasets, namely satellite and in-situ observations, reanalyses, seasonal forecasts and climate projections

Data can be downloaded



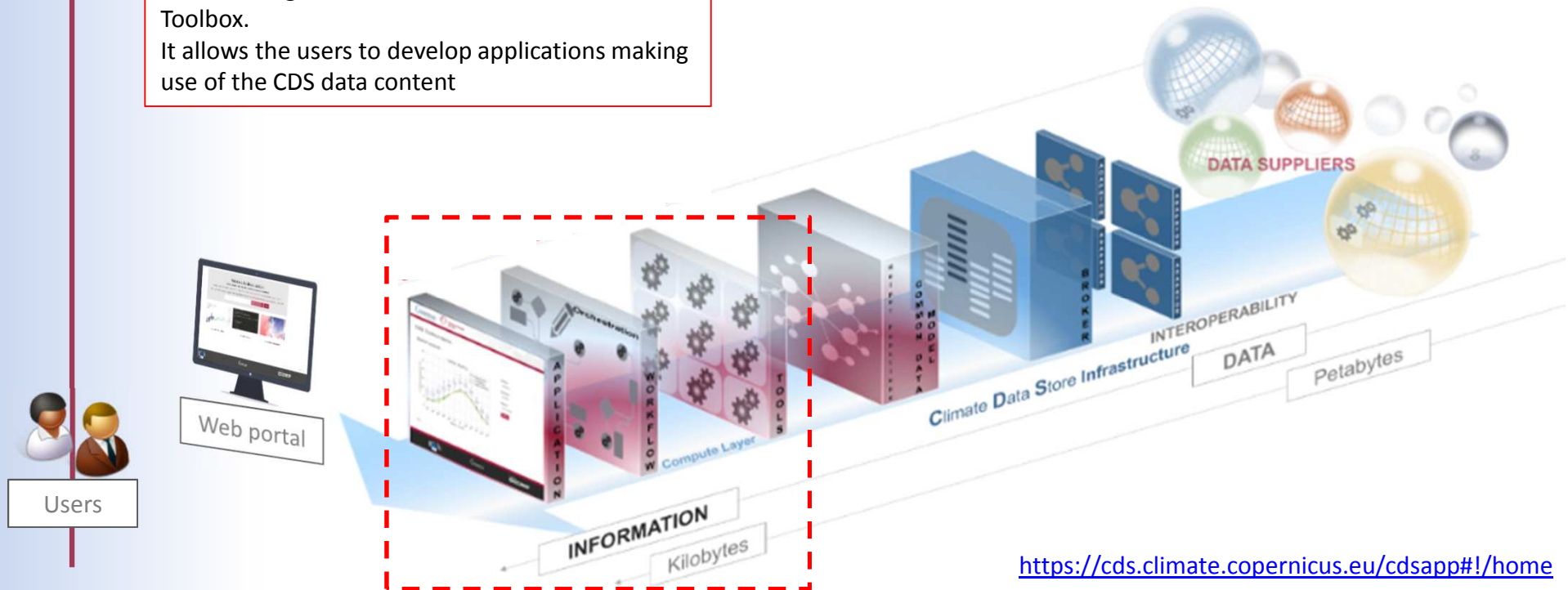


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CLIMATE DATA STORE (CDS)

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Data can be explored (e.g. visualized, subsetting) on-line using a suite of software tools, i.e. the Toolbox.
It allows the users to develop applications making use of the CDS data content



<https://cds.climate.copernicus.eu/cdsapp#!/home>



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EVALUATION & QUALITY CONTROL OF THE CDS

Such a complex infrastructure requires an ***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



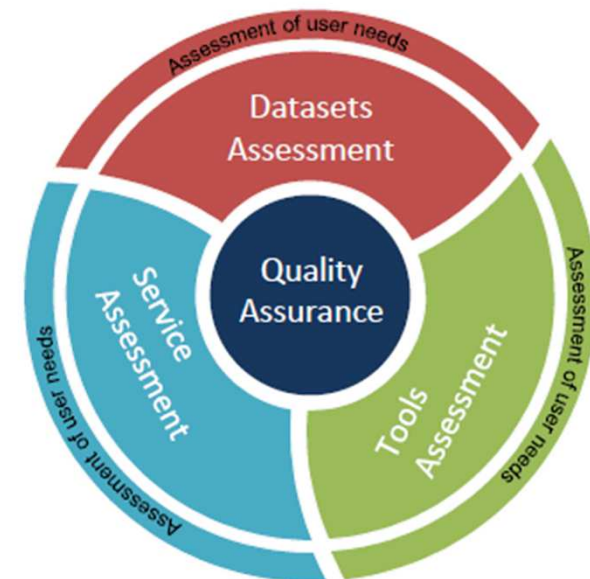
CDS Toolbox: assessment of maturity and fitness for purpose of the software provided to explore the datasets



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



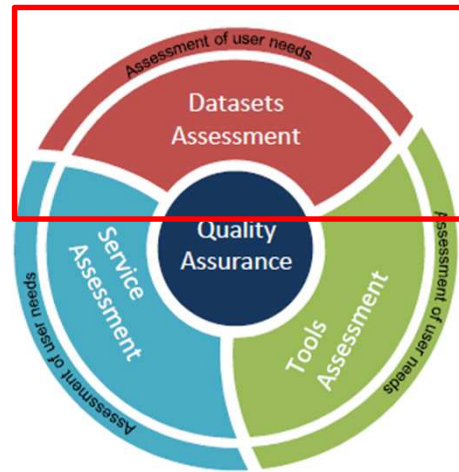
CDS users: user requirement assessment to measure users' satisfaction with the CDS. Map evolving user needs into viable user requirements to ensure a user-oriented evolution of the CDS





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EQC OF THE CDS DATASETS

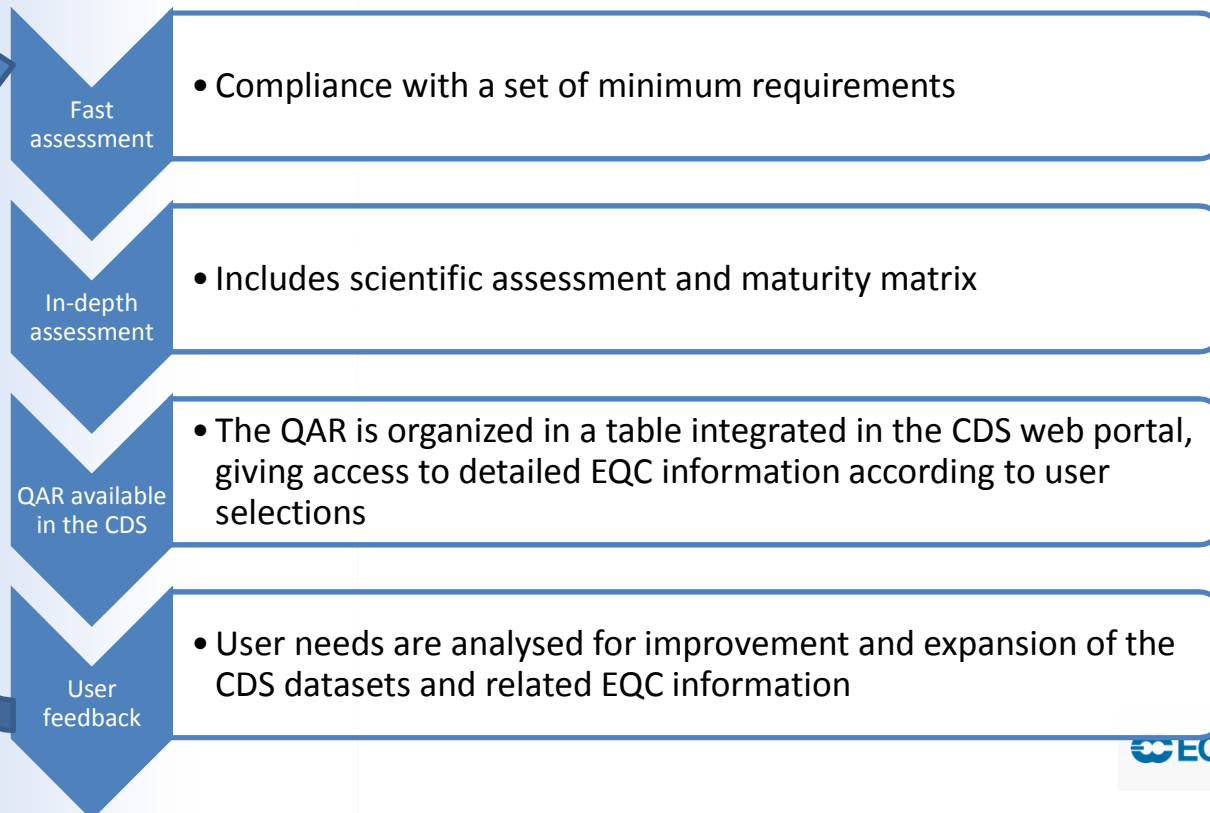




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EQC OF THE CDS DATASETS

The EQC function builds a workflow to assess the quality of the CDS datasets, leading to the publication of Quality Assurance Reports (QARs)





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EQC OF THE CDS DATASETS

The EQC information is made by dataset documentation according to provider indications and reviewed during the EQC process + an independent assessment conducted by the EQC team

Fast
assessment

- Compliance with a set of minimum requirements



- ☐ Documentation: e.g. quantity name, units, format, resolution, provider, version, description of processing, uncertainty characterization
- ☐ Data checker: e.g. space/time completeness of data and metadata, physical ranges of plausibility

In-depth
assessment

- Includes scientific assessment and maturity matrix



- ☐ Documentation: e.g. quality flags, cloud masking, product traceability chain, validation report, inter-comparison activities
- ☐ Independent assessment: e.g. compliance with international standards, maturity matrix (whether best practises have been followed), fitness for purpose of identified use cases (dataset is robust and sufficient for the user's specific application), performance metrics



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EQC OF THE CDS DATASETS

QAR available
in the CDS

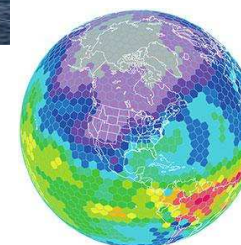
- The QAR is organized in a table integrated in the CDS web portal, giving access to detailed EQC information according to user selections

A challenge: the CDS datasets encompass a wide variety of data types:

- ☐ Satellite observations
- ☐ In-situ observations
- ☐ Reanalysis
- ☐ Seasonal forecasts
- ☐ Global and regional climate projections

This poses challenges to provide a ***seamless and homogeneous EQC information*** for the whole CDS datasets

To overcome this issue a ***synthesis table*** is integrated in the CDS web portal





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CDS PORTAL

Overview Download data Documentation

EQC

Processing level ?



Level 3



Level 4

Variable ?



Ozone mole content



Ozone concentration



All ozone variables from nadir sensors



Ozone mixing ratio



Ozone concentration anomaly

Vertical aggregation ?



Total column



Vertical profiles from limb sensors



Tropospheric column



Vertical profiles from nadir sensors

Sensor



Combination of MIPAS, GOMOS, SCIAMACHY and OSIRIS sensors



Combination of 15 sensors using gap-filling assimilation methods



ACE (Atmospheric Chemistry Experiment)



GOME (Global Ozone Monitoring Experiment-I)



GOME2A (Global Ozone Monitoring Experiment-II onboard METOP-A)

Show EQC information



- User selects the dataset and variable of interest
- The user has then the option to consult the related EQC information, clicking on the appropriate tab
- A set of information is presented through a web page displaying a synthesis table, the webpage is created dynamically



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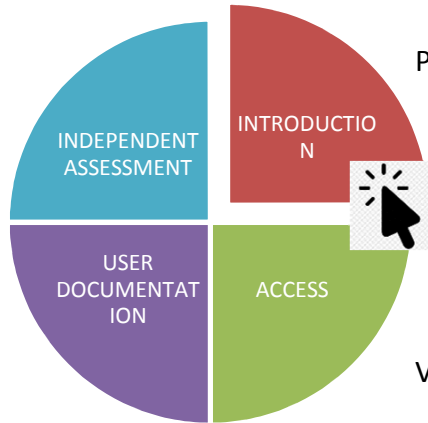
CDS PORTAL

Overview

Download data

Documentation

EQC



PRODUCT NAME: *Ozone monthly gridded data from 1970 to present*

VARIABLE: *Ozone concentration*

PROCESSING LEVEL: *Level 3*

SENSOR: *ace (atmospheric chemistry experiment)*

VERTICAL AGGREGATION: *vertical profiles from limb sensors*

INTRODUCTION

Dataset overview

Temporal and spatial
coverage and resolution

Providers

Dataset version

Record update

EQC last update: 28/05/2019

- The EQC information is organized and homogenized across all datasets
- The layout is agnostic of the product type selected
- The user clicks on the box of interest and will be directed to another web page (also created dynamically) displaying the specific EQC information



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EQC OF THE CDS DATASETS

Overview

Download data

Documentation

EQC

Dataset overview

Temporal and
spatial

Providers

Dataset version

Record update

INTRODUCTION

ECV: Earth radiation budget

Physical Quantity Name: Active Fire Maps

Version number: v1.0

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

Organisation(s): My organisation

Processing Level of product:
Level 2

Timeliness

Primi igitur omnium statuuntur Epigonus et Eusebius ob nominum gentilitatem oppressi praediximus enim Mortium sub ipso vivendi termino his vocabulis appellatos fabricarum cupasse tribunos ut adminicula futurae molitioni pollicitos.

Point of contact

Name
John Doe

Email
john@gd.com

Product status: Completed

Date product last updated
Fri, 05/11/2016 - 12:00

Date product made available
Tue, 04/17/2016 - 12:00

Description of any further updates to the product
Yes

Point of contact

Name

Email

Product status

Date product last updated

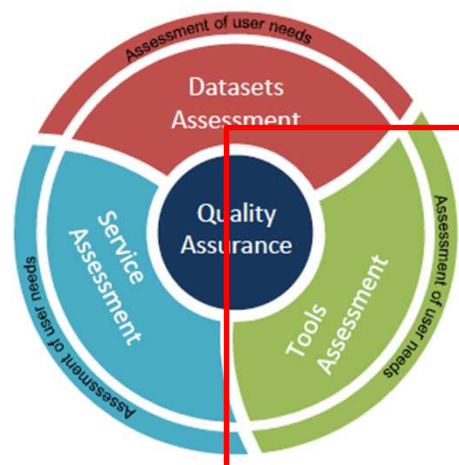
Date product made available

- A web page is built dynamically, showing the information stored and managed by the Content Management System (CMS).
- The user selections form the query to interrogate the SQL database managed by the CMS.



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EQC OF THE CDS TOOLBOX





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CDS TOOLBOX

The Toolbox is a suite of software tools, which allows the users to explore (e.g. subsetting, averaging, visualizing) the CDS products and develop their own applications based on the CDS data content

Workspace and editor

Execution status and Results

Toolbox editor

Applications Data Documentation

Search for app or example:

- your workspace

- 51 Calculate zonal means
 - 11 Calculate time mean and standard deviation
 - 21 Calculate regional mean and anomalies
 - 03 Extract time series and plot graph
 - 01 Retrieve data - Training
 - 02 Plot map-1
 - 02 Plot map
 - 00 Hello World
- #### - 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

52 Format maps to allow visual comparison

Console

Layout

Copy

Run

```
import cds toolbox as ct

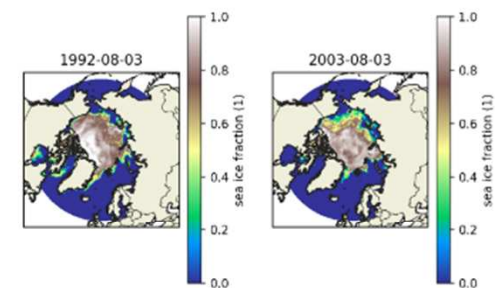
@ct.application(title='Format maps to allow visual comparison')
@ct.output.figure()
def ice():
    """
    Application main steps:
    - retrieve a sample dataset (sea ice area fraction)
    - compare sea ice area fraction in August 1992 and August 2003 on two different maps.
    """

    sic = ct.catalogue.sample('OSTIA', 'sic', 'day')
    time_92 = '1992-08-03'
    time_03 = '2003-08-03'
    sic_1992 = ct.cube.select(sic, timestep_92)
    sic_2003 = ct.cube.select(sic, timestep_03)

    projection = ct.cdsplot.crs.LambertAzimuthalEqualArea(central_latitude=90)
    fig = ct.cdsplot.figure(figsize=(10, 10), subplot_kw={'projection': projection}, adjust_kwards={'wspace': .4})
    ct.cdsplot.geomap(
        ct.cube.select(sic_1992, lat=(55., 90.)), fig=fig, figcol=0,
        title=time_92, pcolormesh_kwards={'cmap': 'terrain'})
    ct.cdsplot.geomap(
        ct.cube.select(sic_2003, lat=(55., 90.)), fig=fig, figcol=1,
        title=time_03, pcolormesh_kwards={'cmap': 'terrain'})

    return fig
```

Format maps to allow visual comparison



Copernicus
European Space Agency

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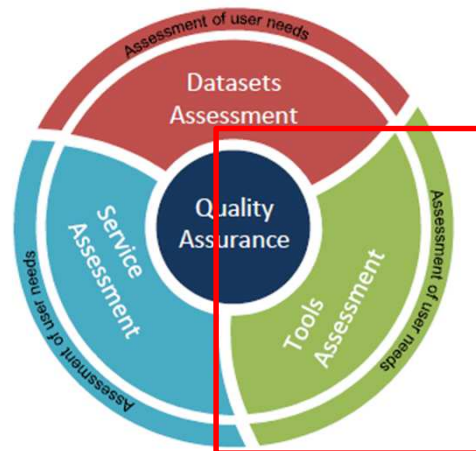
Version: 3.5.12 - build 3a14702



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EQC OF THE CDS TOOLBOX

The EQC function assesses the quality of the CDS Toolbox from multiple angles: tools, workflows, Common Data Model (CDM), application editor, provenance tracking system. Here we focus on the tools only



In particular, the EQC framework of the Toolbox aims to:

- ❑ Assess the maturity of the software tools: robust in terms of code versioning and testing and well documented
- ❑ Evaluate the fitness-for-purpose of the software through use cases identified together with the users, that checks the applicability of the Toolbox to specific operations.

Software quality assessment is based on the internationally-recognized standard ISO/IEC 9126 and extensions (e.g. ISO/IEC 25010:2011)





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EQC OF THE CDS TOOLBOX

```
variables = link(2m_temperature = 3, mean_sea_level_pressure = 4,
values=['2m_temperature', 'mean_sea_level_pressure'])
)
@ct.input.dropdown('frequency1', when=1, values=['dayofyear', 'weekofyear', 'month'])
@ct.input.dropdown('frequency1', when=2, values=['dayofyear', 'month'])
@ct.input.dropdown('frequency2', when=3, values=['dayofyear', 'weekofyear', 'month'])
@ct.input.dropdown('frequency2', when=4, values=['dayofyear', 'month'])
@ct.output.livefigure()
def workflow(variable1, variable2, frequency1, frequency2):
    'Here goes the workflow.'
```

`cdstoolbox.input.checkbox(name, values, default=None, type=<class 'str'>, label=None, link=False, when=None, description="", help=") → Callable` [\[source\]](#)

Insert a dropdown menu as input widget for the workflow. It must be used as a decorator to the main function of the workflow.

- Parameters:
- **name** – String. Name of the variable that will be set to selected value or default value.
 - **values** – List of values selectable.
 - **default** – Default value if no selection is made.
 - **type** – Data type to be set for value.
 - **label** – String for the widget title.
 - **description** – Add a description of the input widget.
 - **help** – Add an helper tooltip of the input widget.

Show EQC
information



`cdstoolbox.input.constant(name, value, type=<class 'str'>, label=None, link=False, when=None, description="", help=") → Callable` [\[source\]](#)

Insert a constant text field as input widget for the workflow. It must be used as a decorator to the main function of the workflow.

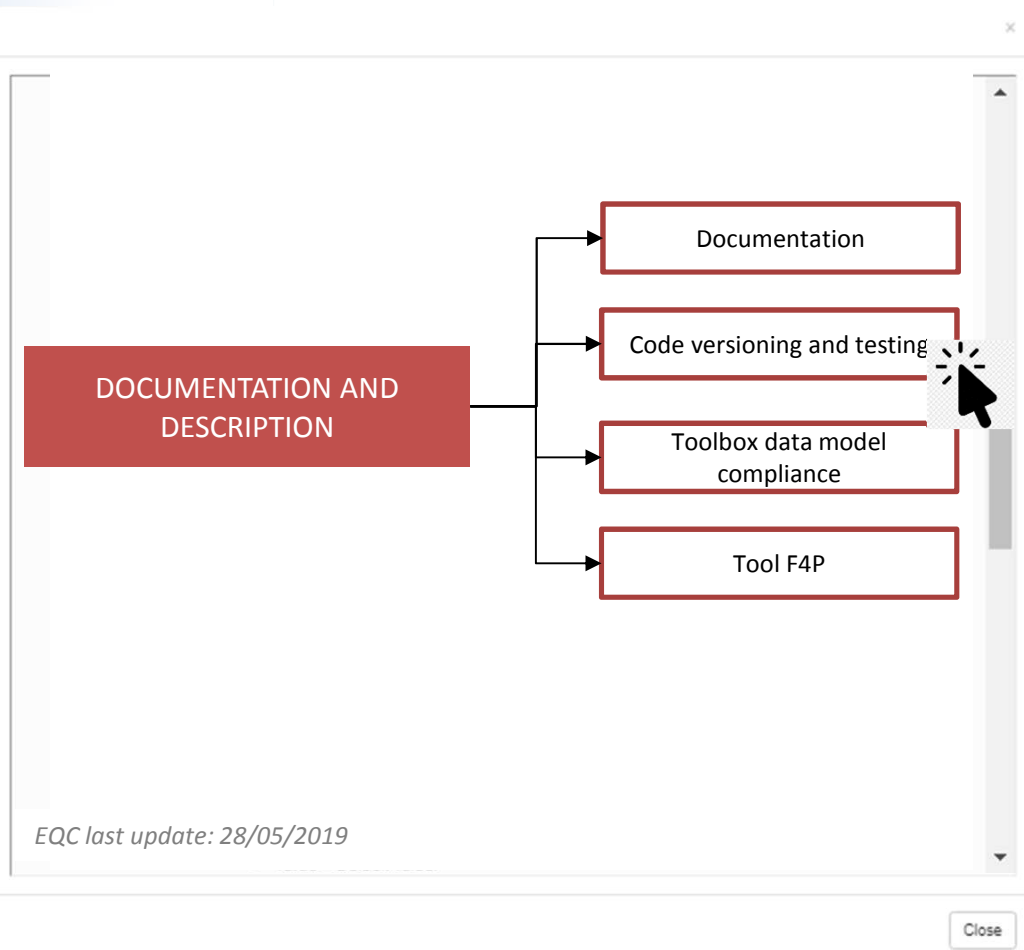
- Parameters:
- **name** – String. Name of the variable that will be set.
 - **value** – Default value.

- The user clicks one of the tools, a web-page opens describing briefly the tool function
- The user is offered the possibility to access the details of the related EQC information



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EQC OF THE CDS TOOLBOX



- A web page is built dynamically, showing the EQC information organized and homogenized in a synthesis table
- The user clicks on the box of interest and will be directed to another web page (also created dynamically) displaying the specific EQC information



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EQC OF THE CDS TOOLBOX

Documentation

Code versioning
and testing

Toolbox data
model
compliance

Tool F4P

DOCUMENTATION AND DESCRIPTION

Is the tool container-
based?

Yes

Accessibility of the
source code

The source ...

Source code

Github.com/ES/...

Independent Evaluation on Code Versioning and Testing and

Description of code testing with
maturity matrix

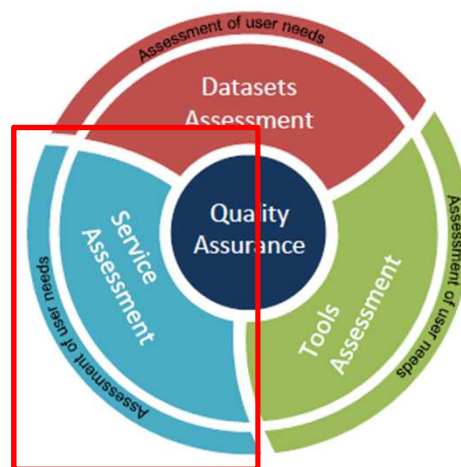
Code	Basic Check	Functionality (Suitability) unit testing and integration testing	Performance through standardized tests
Information Availability (a)			
Information Appropriateness (b) (if script based)			
Information Appropriateness (c) (if container based)			
Functionality 1 (d)			
Functionality N (d)			

- A web page is built dynamically, showing the information stored and managed by the Content Management System (CMS).
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EQC OF THE CDS SERVICE

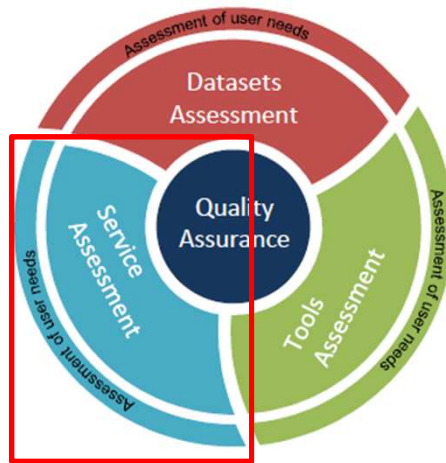




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EQC OF THE CDS SERVICE

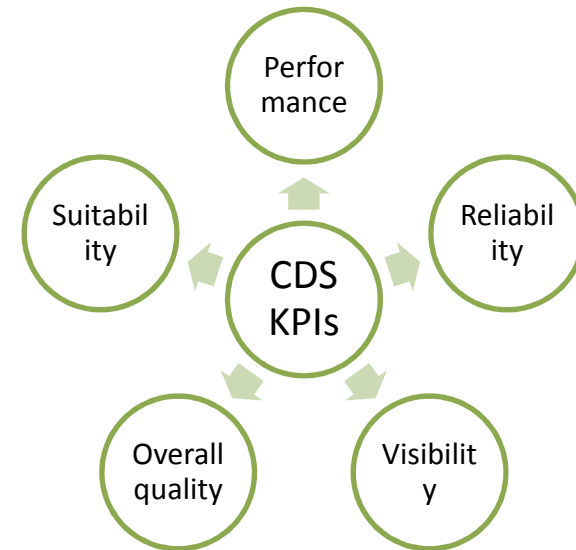
The EQC function measures and reports the technical quality of the CDS service (e.g. system availability, response time)



In particular, monitoring of the CDS infrastructure is based on:

- ❑ A set of Key Performance Indicators (KPIs)
- ❑ On-line rating widgets to monitor user satisfaction
- ❑ Development of a web dashboard hosting the KPIs and widgets statistics

The KPIs have been inspired by the internationally-recognized standard ISO/IEC 25010 and 25011

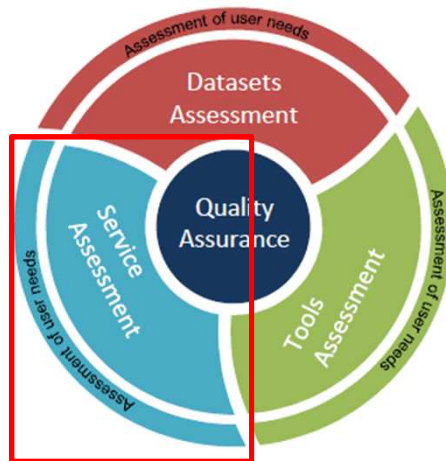




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EQC OF THE CDS SERVICE

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Performance

Rate the speed of the Toolbox

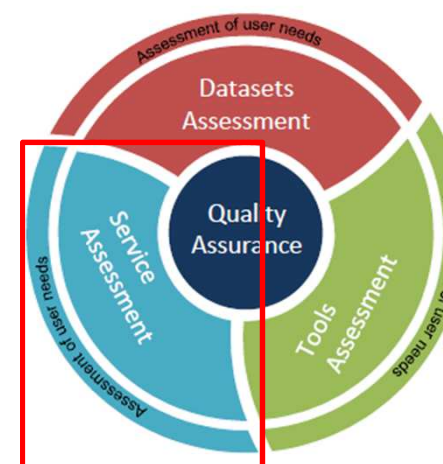
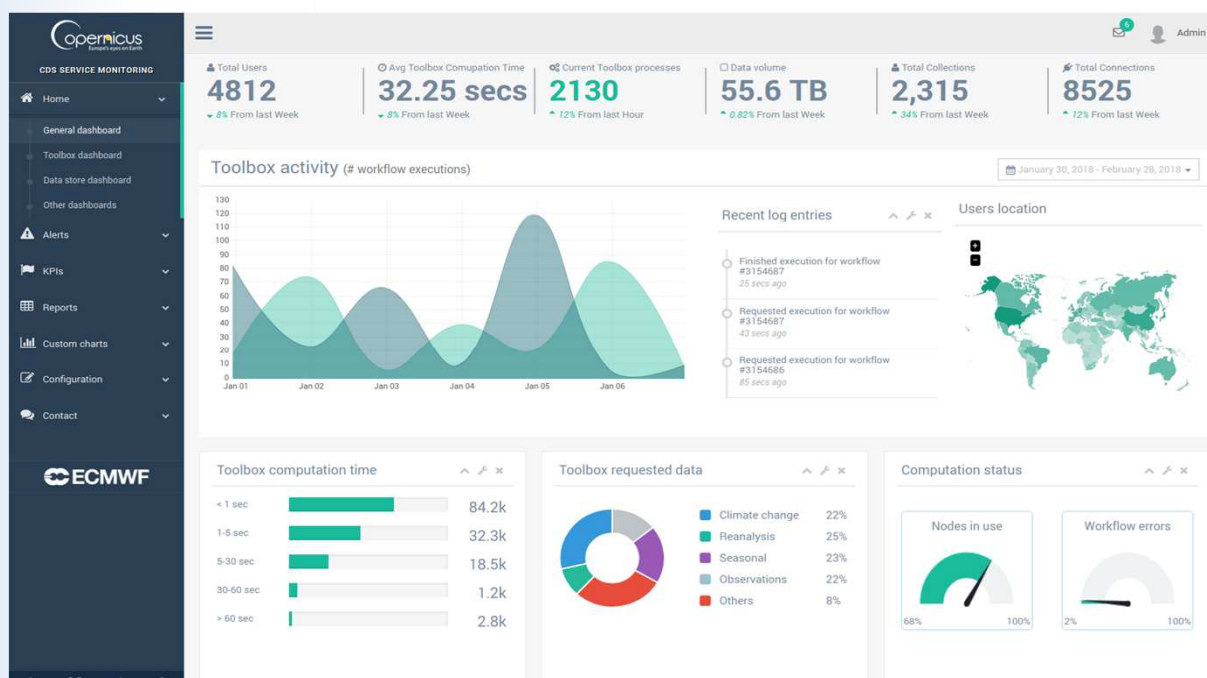
RATING SCORE	1	2	3	4	5
USER MOOD	Very unsatisfied	Unsatisfied	Neutral	Satisfied	Very Satisfied



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EQC OF THE CDS SERVICE

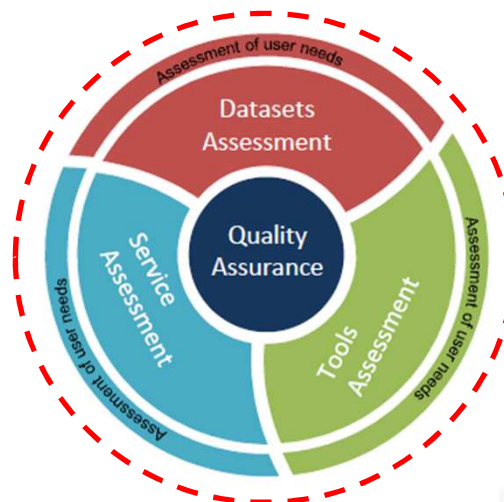
Preliminary version of the dashboard hosting the KPIs and widgets statistics





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USER NEEDS

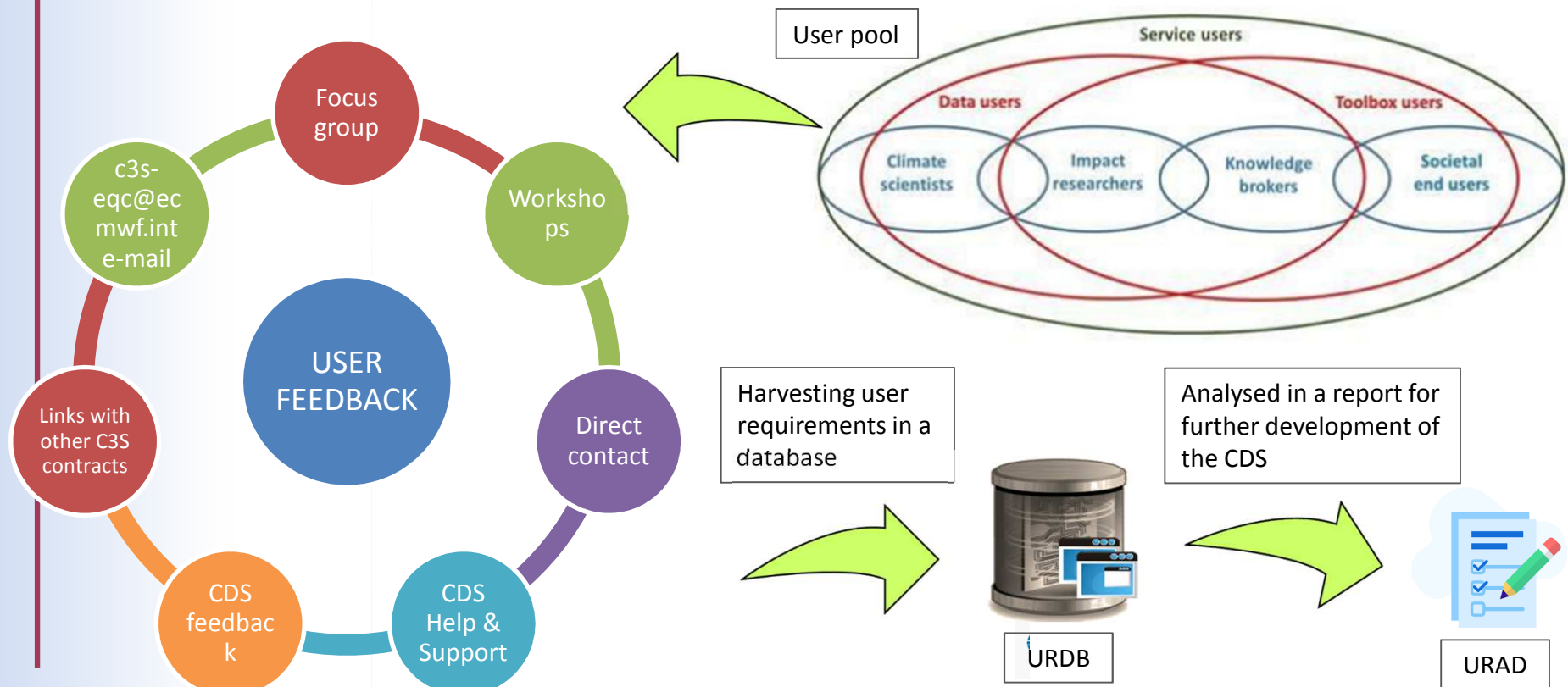




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USER NEEDS

As the C3S is a user-driven climate service, user feedback is central to develop recommendations for improvement and expansion of the CDS data, Toolbox and service

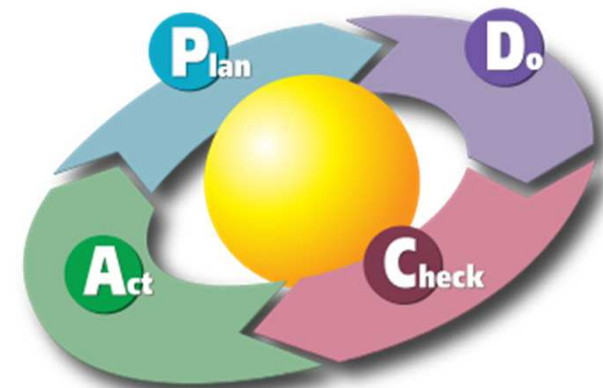




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M A N Y C O M M O N A L I T I E S W I T H E S I P I Q C

- ☐ Bring together different communities to assess aspects of quality of Earth science data
- ☐ Establish baseline of standards for data quality for adoption by data providers
- ☐ Promoting data management standards and best practices for ensuring high quality datasets for use in climate policy and services
- ☐ Data quality harmonization
- ☐ Users guidance and data conventions are fundamental to the development of the CDS
- ☐ Presenting quality information to users: meet user's needs and avoid data are misused.
- ☐ Maturity matrix and promotion of an holistic approach
- ☐ Sharing experience and lessons learnt about long-term management, preservation and curation of Earth system data



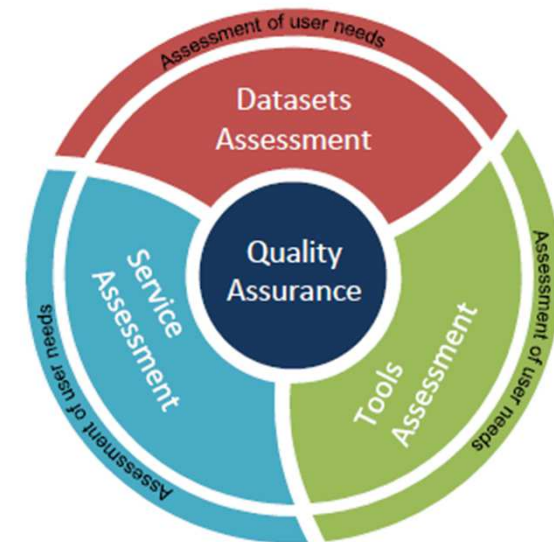
*Deming cycle as suggested in
Peng et al. (2018)*



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CONCLUSIONS

- ❑ The EQC function of the CDS provides an **overarching quality assurance service for the whole CDS**: dataset, Toolbox, infrastructure, users
- ❑ The CDS contains a **wide variety of datasets**: satellite and in-situ observation, reanalysis, seasonal forecasts, global and regional climate projections
- ❑ A suite of software tools is available to explore and visualize datasets (**Toolbox**)
- ❑ Users can fully understand status and purpose of data product, with **all relevant information in one place**, based on the matters the user deems most important
- ❑ The **homogenization of the EQC information** across all datasets allows to directly compare several different products
- ❑ The EQC function provides **guidance to data producers** on the information they need to deliver and to be compliant
- ❑ **Users are central** for the development and expansion of the CDS
- ❑ **ESIP IQC** seems an appropriate place for the discussions on EQC aspects.





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SOME OPEN QUESTIONS ...

- ☐ What type of information of the datasets are the users interested in?
- ☐ Missing a list of minimum requirements to assure a minimum quality of the datasets.
- ☐ What is the level of granularity expected by users?
- ☐ What is the frequency of updating EQC information? What can be automatized?
- ☐ How to devise a scoring system informing about the level of dataset information available?
- ☐ Lack of ISO standards for climate data and metadata quality standards.
- ☐ Are there any maturity levels defined for an EQC process?
- ☐ Are there maturity matrix for modelling output datasets?
- ☐ Are there international standards similar to GCOS that could be applied to modelling datasets?
- ☐ Gaps in standardisation of terminology, processes and practices due to a lack of an appropriate regulatory framework





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THANK YOU

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ECMWF

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European
Commission





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ACKNOWLEDGMENTS

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