Copernicus Climate Change Service updates

Joaquín Muñoz Sabater & the C3S team
European Centre for Medium-Range Weather Forecasts (ECMWF)

Climate Change

13th ESA-CCI colocation meeting– Harwell, UK– 7-8 Nov 2023

Copernicus Europe's eyes on Earth | European Commission | ECMWF

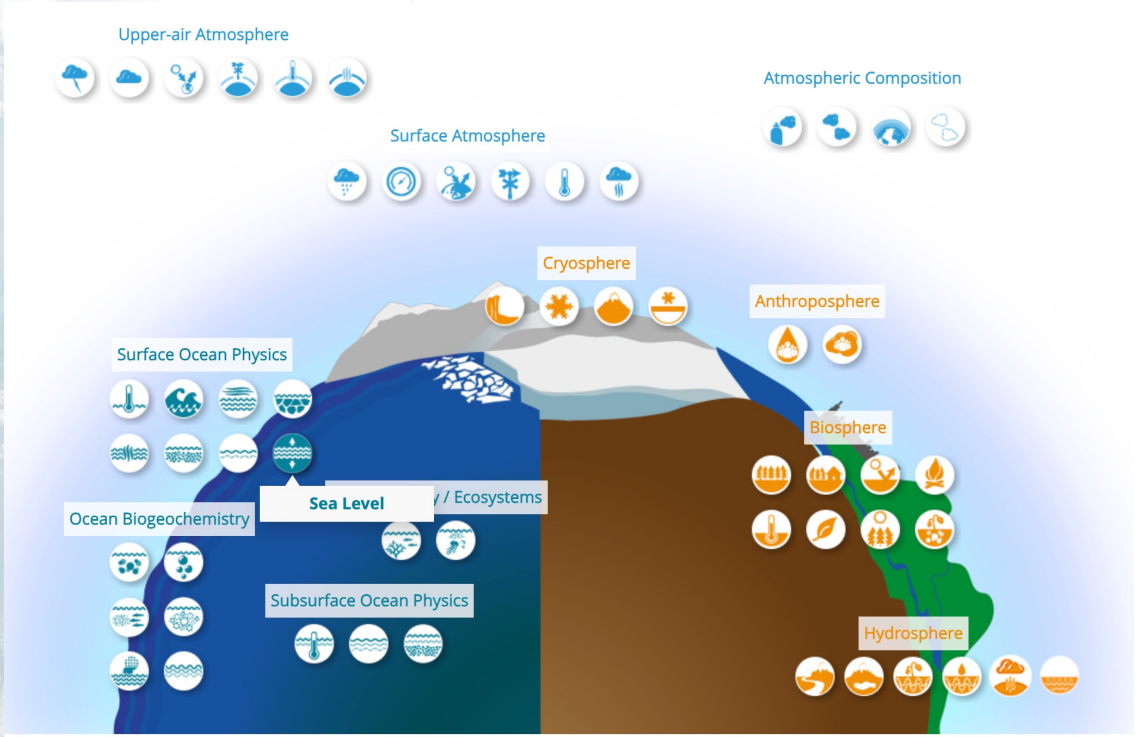
Climate Change

Outline

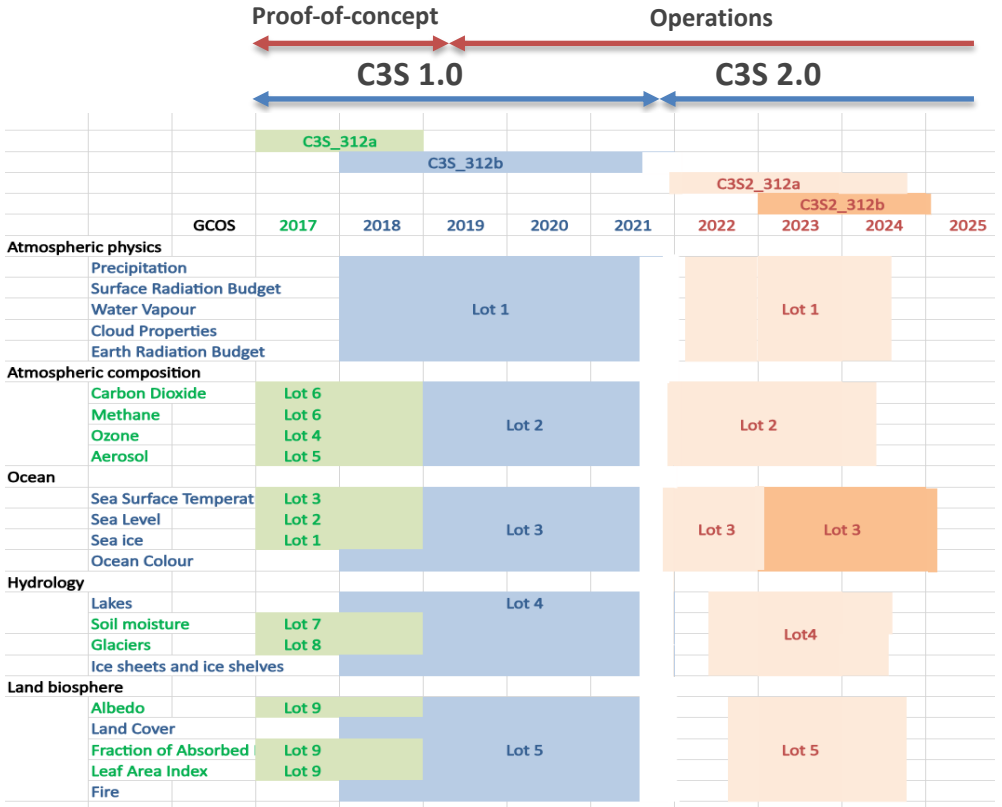
- The Copernicus Climate Change ECV Programme
- Climate Intelligence
- EQC reshuffle
- CADS 2.0
- Others

G C O S & C 3 S E C V s

- C3S responds to the GCOS implementation needs
- C3S ECV programme is based on the GCOS definition of ECVs
- C3S facilitates transitions from research to operations



- GCOS IP 2016 -



PROGRAMME OF THE EUROPEAN UNION

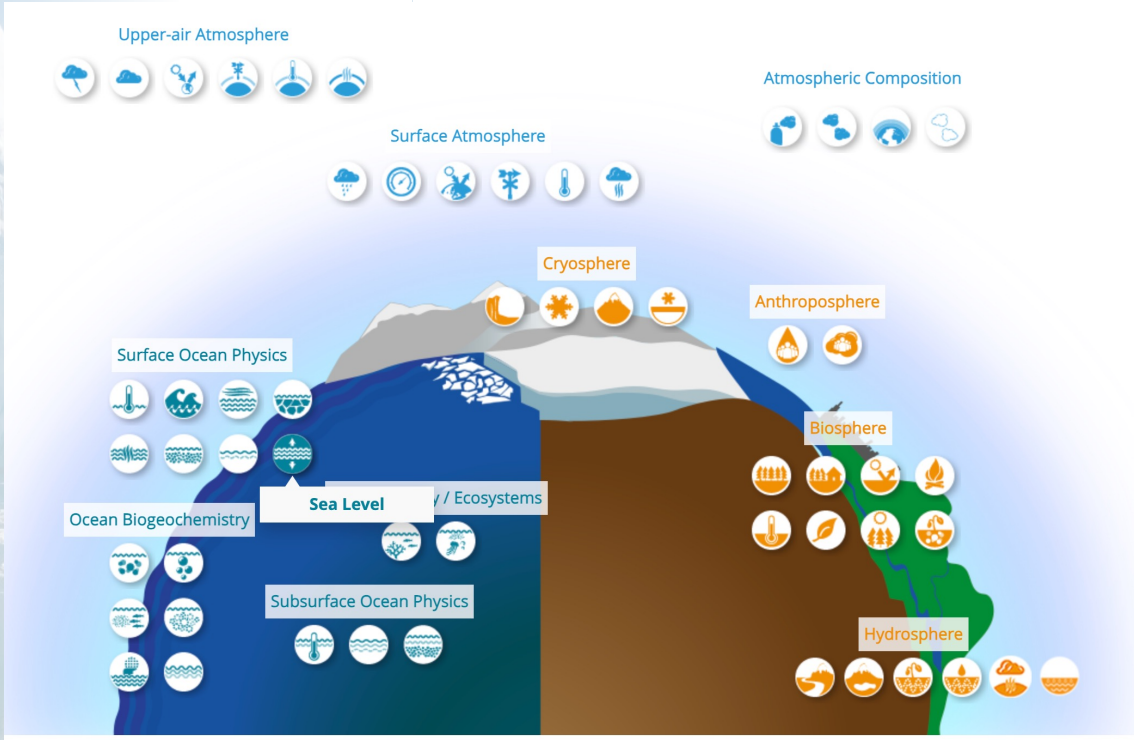
Copernicus Europe's eyes on Earth

implemented by ECMWF

Climate Change

GCOS & C3S ECVs

- GCOS IP 2016 -



- GCOS IP 2022 -

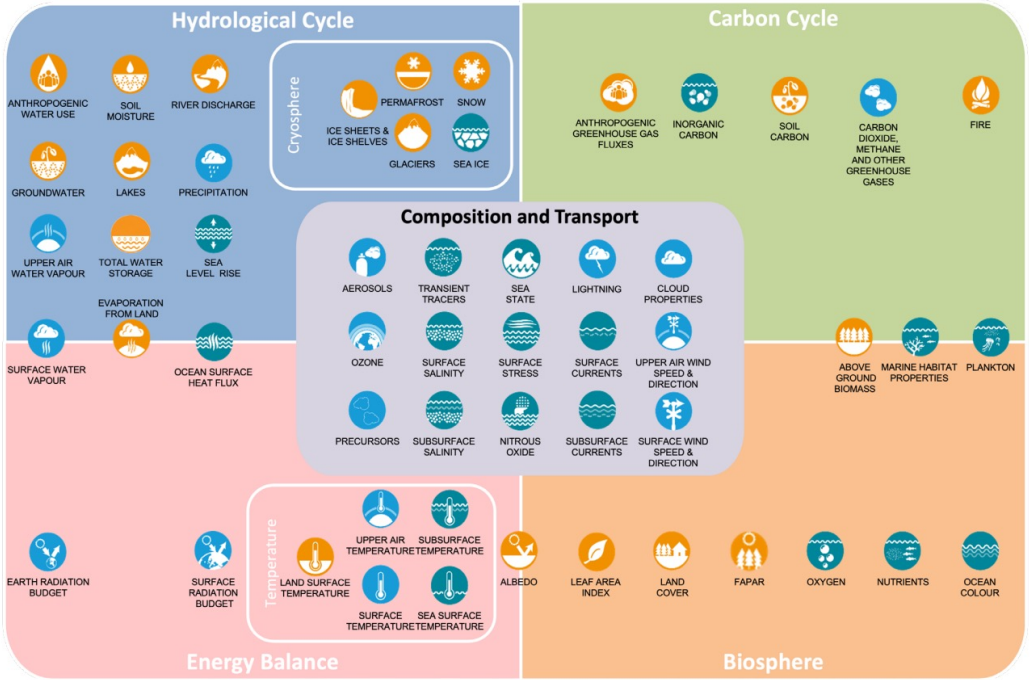


Figure 2. Essential Climate Variables and the climate cycles (See section 2.4). Many ECV contribute to understanding several different cycles – this only indicates the main links.

ECVs belong to three panel domains: ● Atmosphere ECVs (AOPC); ● Ocean ECVs (OOPC); ● Terrestrial ECVs (TOPC)

Total Water Storage is the new only ECV that has been approved by the GCOS Steering Committee

PROGRAMME OF THE EUROPEAN UNION

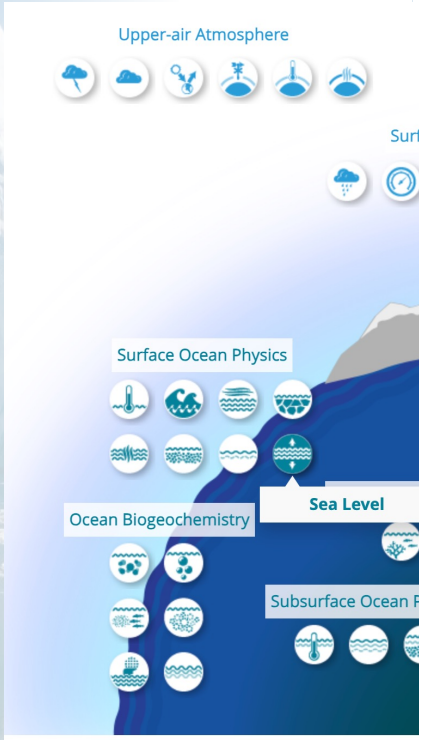
Copernicus Europe's eyes on Earth

implemented by ECMWF

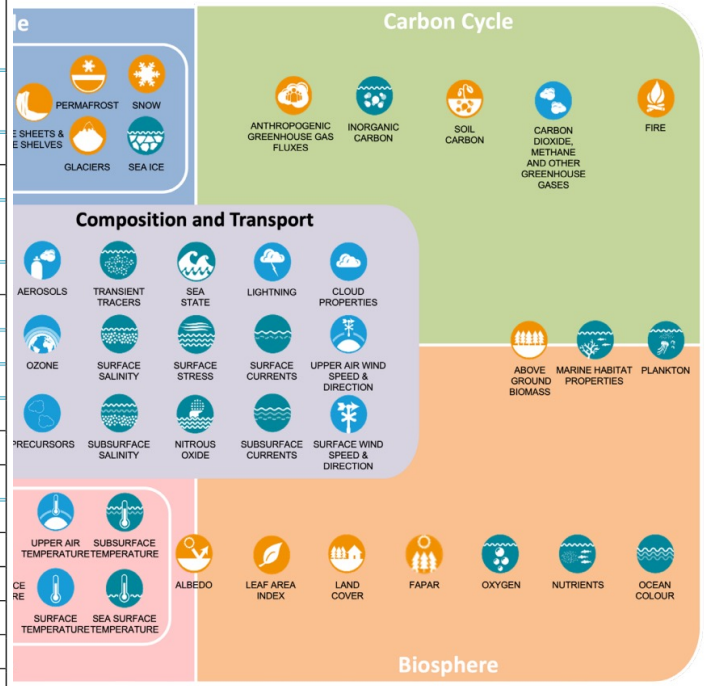
Global Climate observing System and ECVs

Climate Change

GCOS IP 2016



Ocean			
ECV	**ECV Product 2016**		**ECV Product 2022**
Sea-Surface temperature	Sea-Surface temperature		Sea-Surface temperature
Subsurface Temperature	Interior Temperature		Interior Temperature
Sea-Surface Salinity	Sea-Surface Salinity		Sea-Surface Salinity
Subsurface Salinity	Interior Salinity		Interior Salinity
Surface Currents	Surface Geostrophic Current		Surface Geostrophic Current
			Ekman Currents
Subsurface Currents	Interior Currents		Vertical Mixing
Sea Level	Regional Sea Level		Regional Mean Sea Level
	Global Mean Sea Level		Global Mean Sea Level
Sea State	Wave Height		Wave Height
Surface Stress	Surface Stress		Surface Stress
Ocean Surface Heat Flux	Radiative Heat Flux		Radiative Heat Flux
	Sensible Heat Flux		Sensible Heat Flux
	Latent Heat Flux		Latent Heat Flux
Sea Ice	Sea Ice Concentration		Sea Ice Concentration
	Sea Ice Thickness		Sea Ice Thickness
	Sea Ice Drift		Sea Ice Drift
	Sea Ice Extent/Edge		Sea Ice Age
			Sea Ice Surface Temperature (IST)
			Sea ice Surface Albedo
			Snow Depth on Sea Ice
Oxygen	Interior Ocean Oxygen Concentration		Dissolved Oxygen Concentration
Nutrients	Interior Ocean Concentrations of Silicate, Phosphate, nitrate		Silicate
			Phosphate
			Nitrate



ibles and the climate cycles (See section 2.4). Many ECV contribute to eral different cycles – this only indicates the main links.

s: ● Atmosphere ECVs (AOPC); ● Ocean ECVs (OOPC); ● Terrestrial ECVs (TOPC)

C3S responds to the GCOS im

C3S ECV programme is based

new only ECV that has been approved by the

PROGRAMME OF THE EUROPEAN UNION

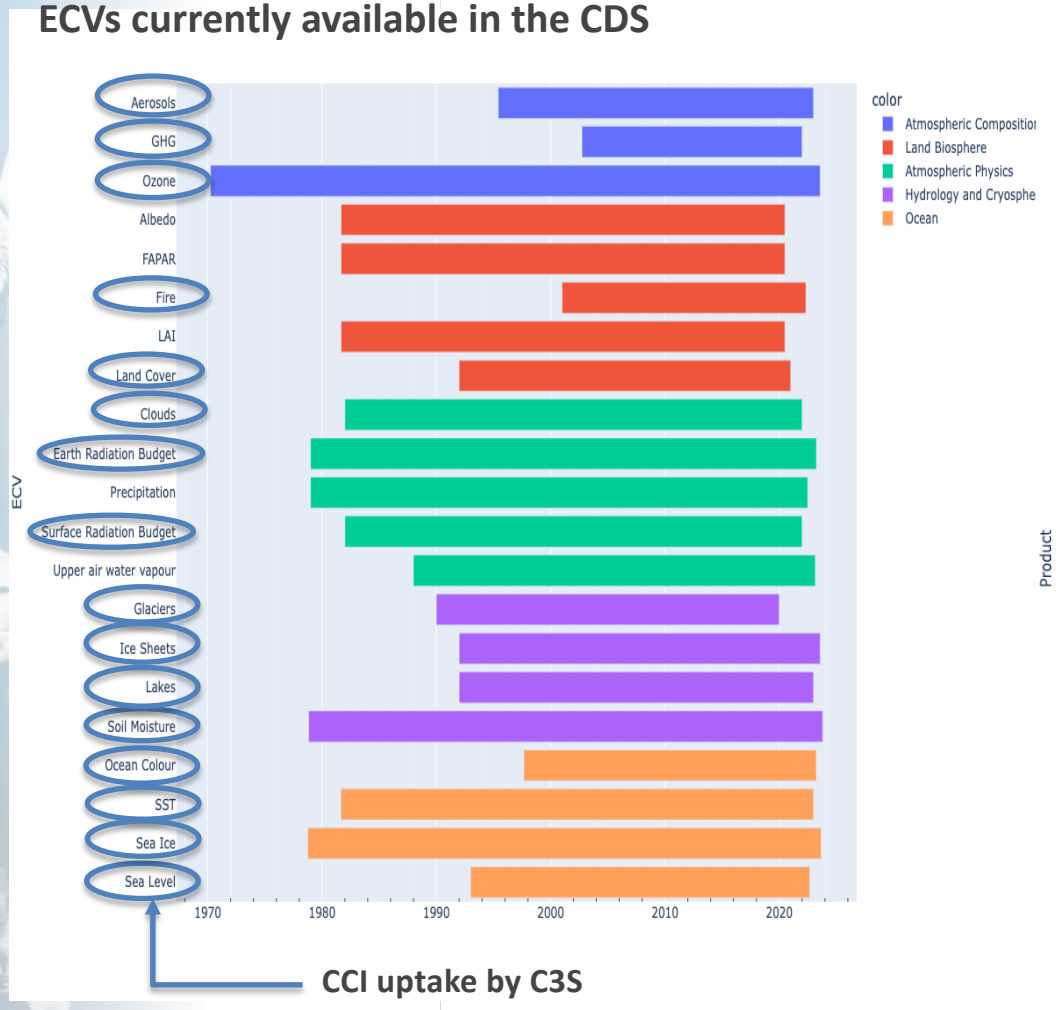
Copernicus Europe's eyes on Earth

implemented by ECMWF

Access to ECV data through the CDS

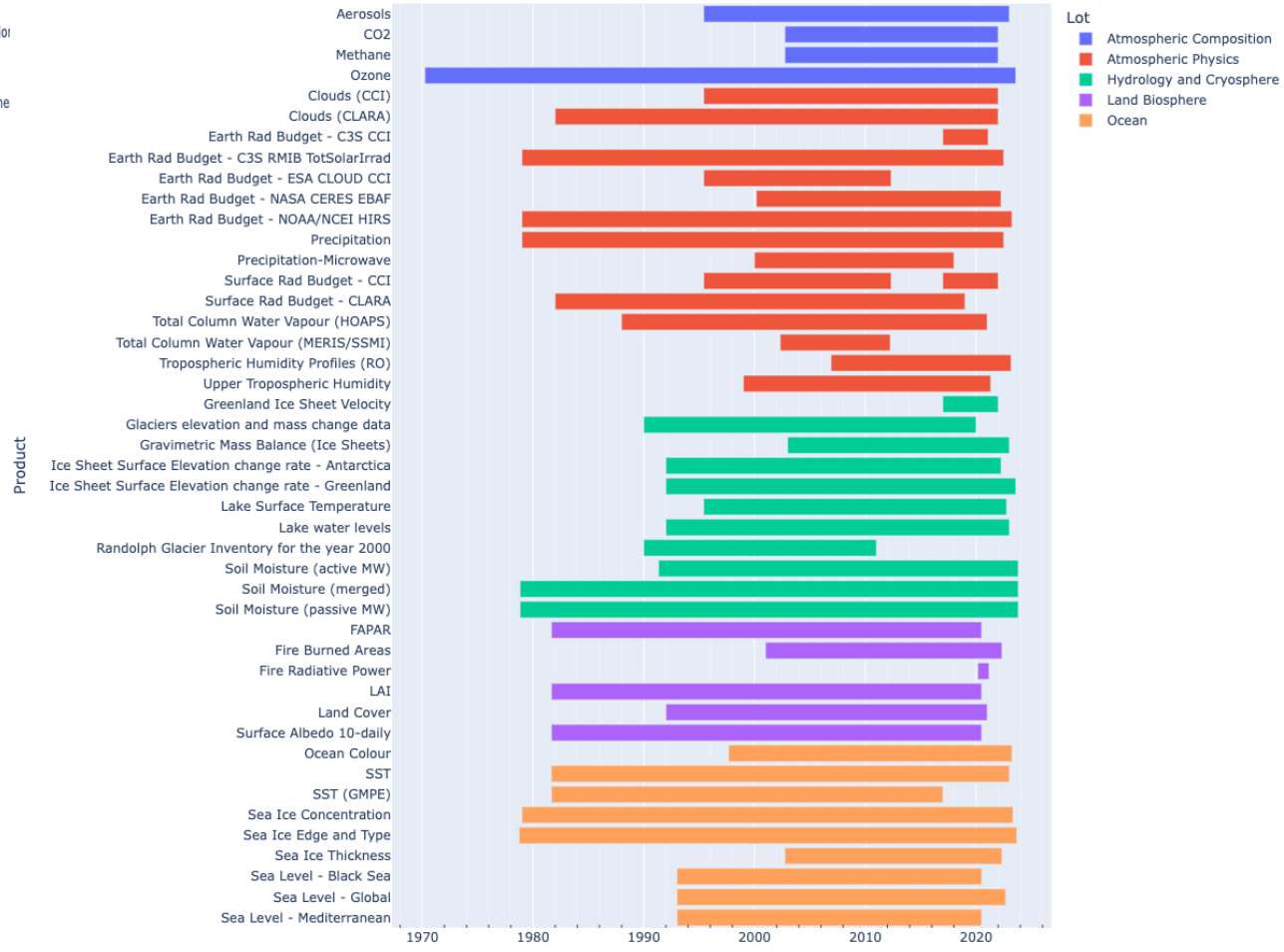
Climate Change

ECVs currently available in the CDS



CCI uptake by C3S

ECV products currently available in the CDS



Credits - Joao Martins -

PROGRAMME OF THE EUROPEAN UNION
opernicus Europe's eyes on Earth
implemented by ECMWF

Climate Change

Statistics from the CDS (01 Nov 2023)

ALL CDS

Registered users (global)

254,319

Represented countries (>=15users)

185

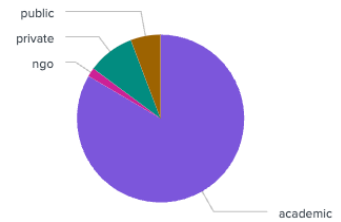
New users in the last 24h

300

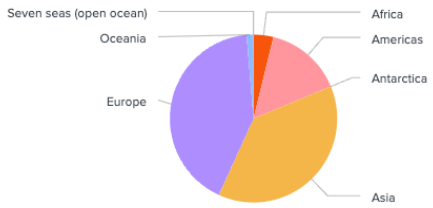
Daily registration (avg) (global)

172

Distribution by sector (global)



Users by World Region



- Current rate of downloaded data: 130 Tb/day

Top 10 users (countries)

Country	Users
China	48426
Belgium	32971
United States	17345
Indonesia	12718
United Kingdom	10622
Germany	10067
India	10053
France	8953
Italy	8596
Spain	5481

ECVs

Total number users

33,201

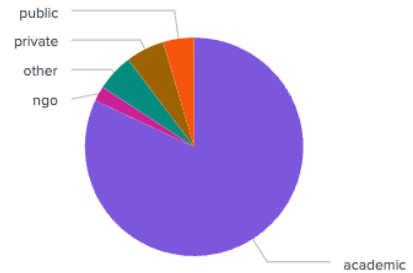
Total volume downloaded (in GB)

628,314

Total number requests

1,832,559

Distribution per sector



- Every month between 700-900 new users
- Current rate of downloaded data: 13-17 Tby/month
- After reanalysis, ECVs are the second most popular category of CDS products
- This is not the whole picture…

Top 10 users (countries)

China	7258
United States	2421
India	2011
United Kingdom	1585
Germany	1410
Italy	1069
France	1060
Indonesia	754
Unknown	704
Spain	665

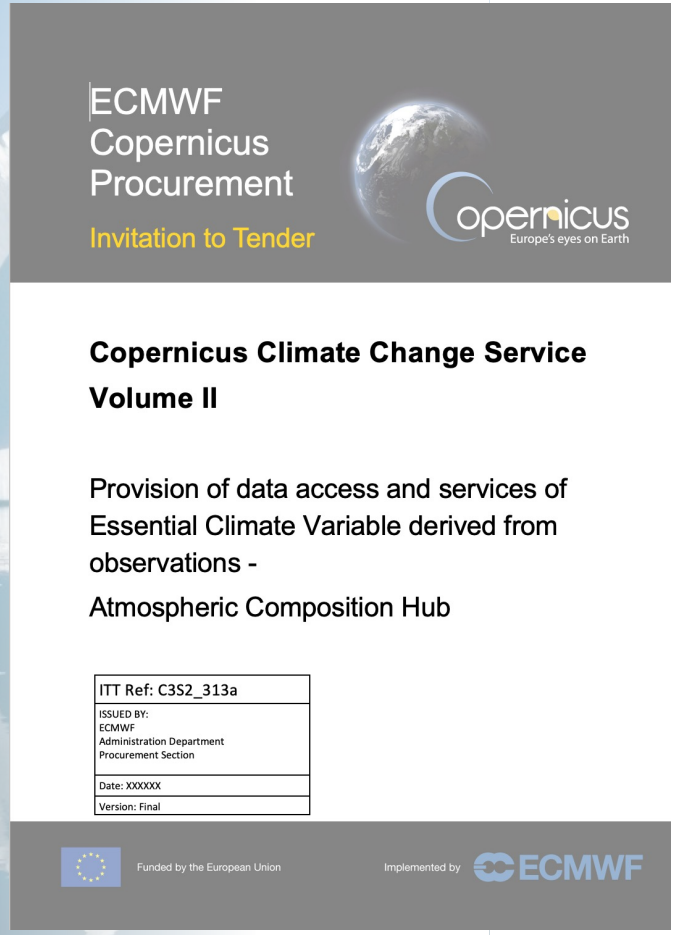
PROGRAMME OF THE EUROPEAN UNION

Copernicus Europe's eyes on Earth

ECMWF

Climate Change

New Invitation to Tender for ECVs



- **A minimum of 5 ITTS** will be released between Q4-2023 and Q1-2024, for the provision of ECV services based on satellite observations
- The **first one** will be for the **provision of atmospheric composition services**

Thematic ECV Hub	End current contract
atmospheric physics	31st July 2024
atmospheric composition	30th April 2024
ocean	1st Feb 2025
hydrosphere & cryosphere	31st July 2024
Land biosphere	30th Sept 2024

- The total **procurement process** is expected **to last between 4-6 months**, depending on the complexity of negotiations.
- Calls for **services related to new ECVs** could be anticipated.
- It is **not ruled out that** before the end of our current Framework Agreement, **services for yet new ECVS are requested**.
- **UK entities will be able to bid** once the MS ratify the contribution of UK to the Copernicus programme.

PROGRAMME OF THE EUROPEAN UNION

opernicus Europe's eyes on Earth

implemented by ECMWF

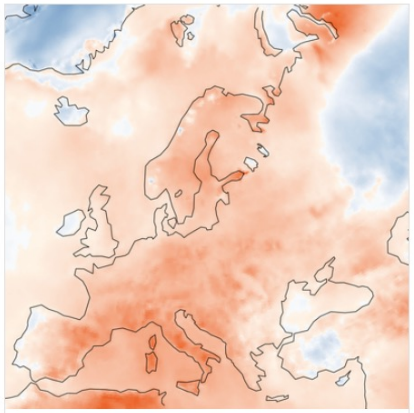
Climate Change

Climate Intelligence

The Copernicus Climate Change Service (C3S) provides climate intelligence information for a broad audience encompassing policy makers, hydrological and meteorological agencies, the press, and the general public.

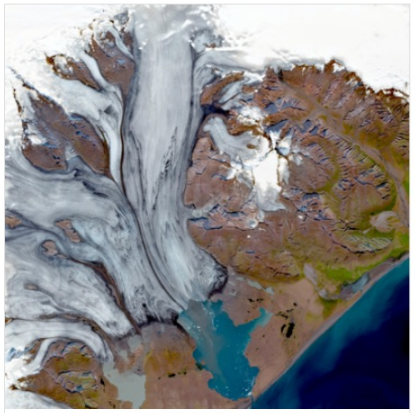
The Service's key publications include the monthly Climate Bulletins and the annual European State of the Climate report, with analyses covering the climate conditions and events of the previous calendar month and year respectively, including at a Global level as well as European and the polar regions. As a part of its climate intelligence activities, C3S also regularly updates the Climate Indicators, helping understand long term global and regional climate trends.

These products are based on a variety of climate data and differ in timing and scope and include related documentation and guidance on their production and exploitation.



Climate Bulletins

A snapshot of climate conditions of the previous month or season, based on latest data on temperature, hydrological variables and sea ice for the Globe, Europe and the Polar regions. It is typically published between the 5th and the 8th of the following month.



European State of the Climate (ESOTC)

A more in-depth publication than the monthly Climate Bulletins, the ESOTC provides information about the climate conditions of the *previous year* for Europe and the Arctic. The ESOTC is based on a wide range of climate data, including reanalysis, satellite- and in-situ observations, model estimates and on the expertise from across the C3S community, as well as other Copernicus services and external partners. It is typically published in

Climate Indicators

Several key variables showing the long-term evolution used to assess the global and regional trends of a changing climate. They are updated at least once a year, for the publication of the European State of the Climate.

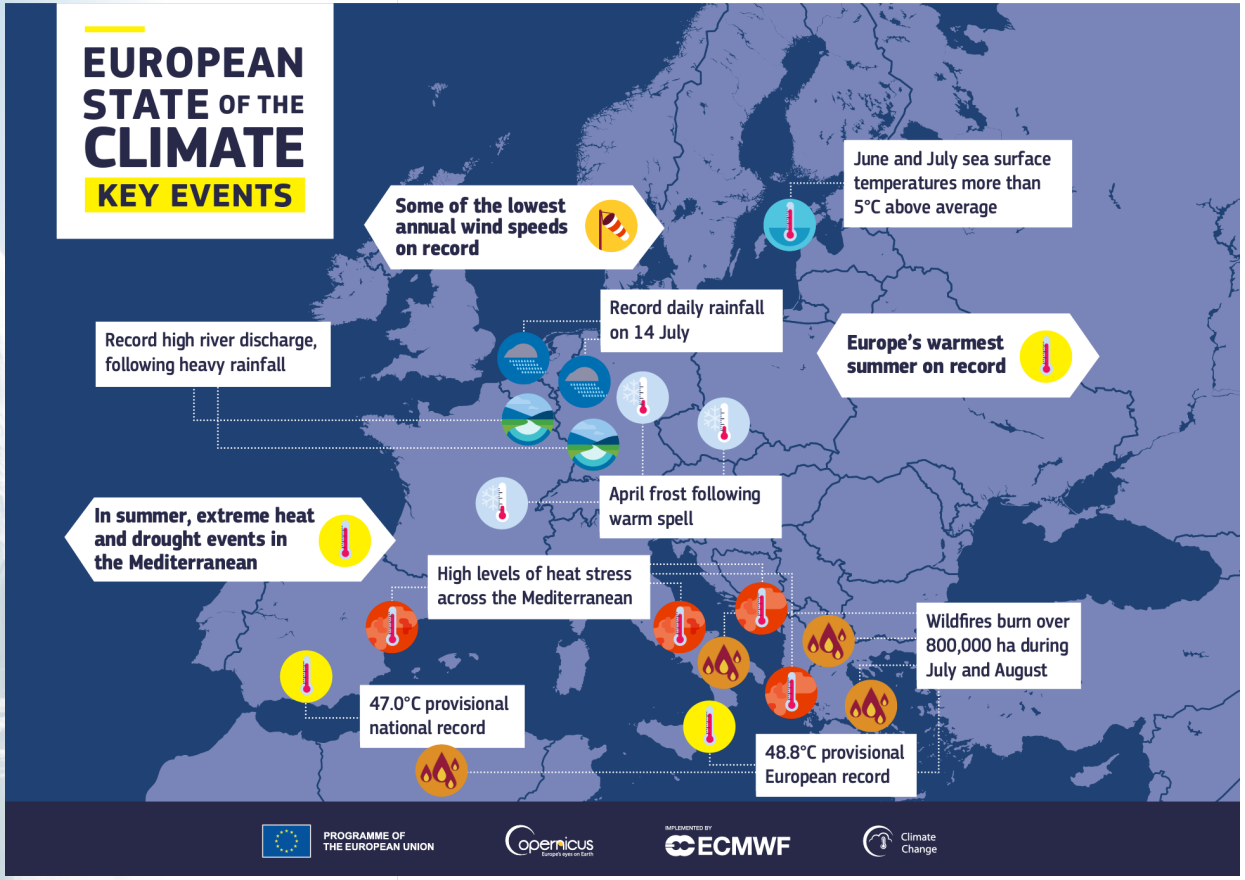
Annual Global Climate Highlights

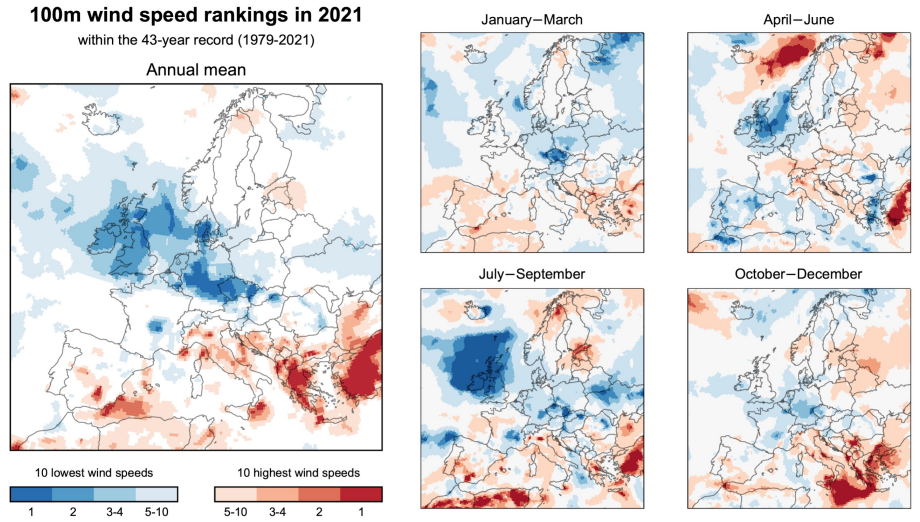
Published during the first two weeks of January, this report provides an early, concise analysis of the climate of the past year. It includes information on temperature and greenhouse gas (GHG) concentrations in the single and multi-year context and summarises noteworthy events from across the globe.

ECMWF

Climate Change

A tool for outreach ESOTC 2022





Data: ERA5 • Credit: C3S/ECMWF

Thematic

Key events that occurred during the year are described within a climatic context.

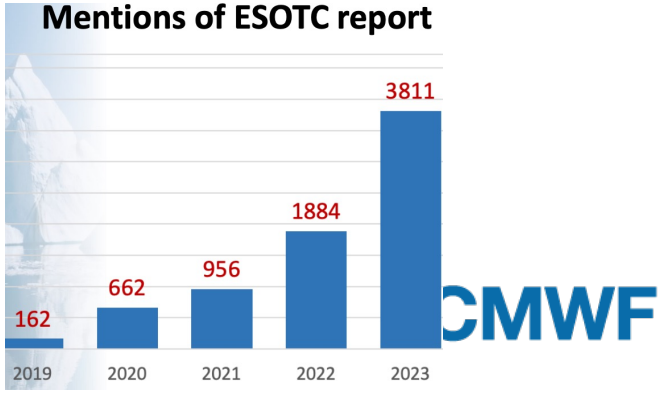

Late spring frost


Mediterranean summer extremes


Flooding in Europe

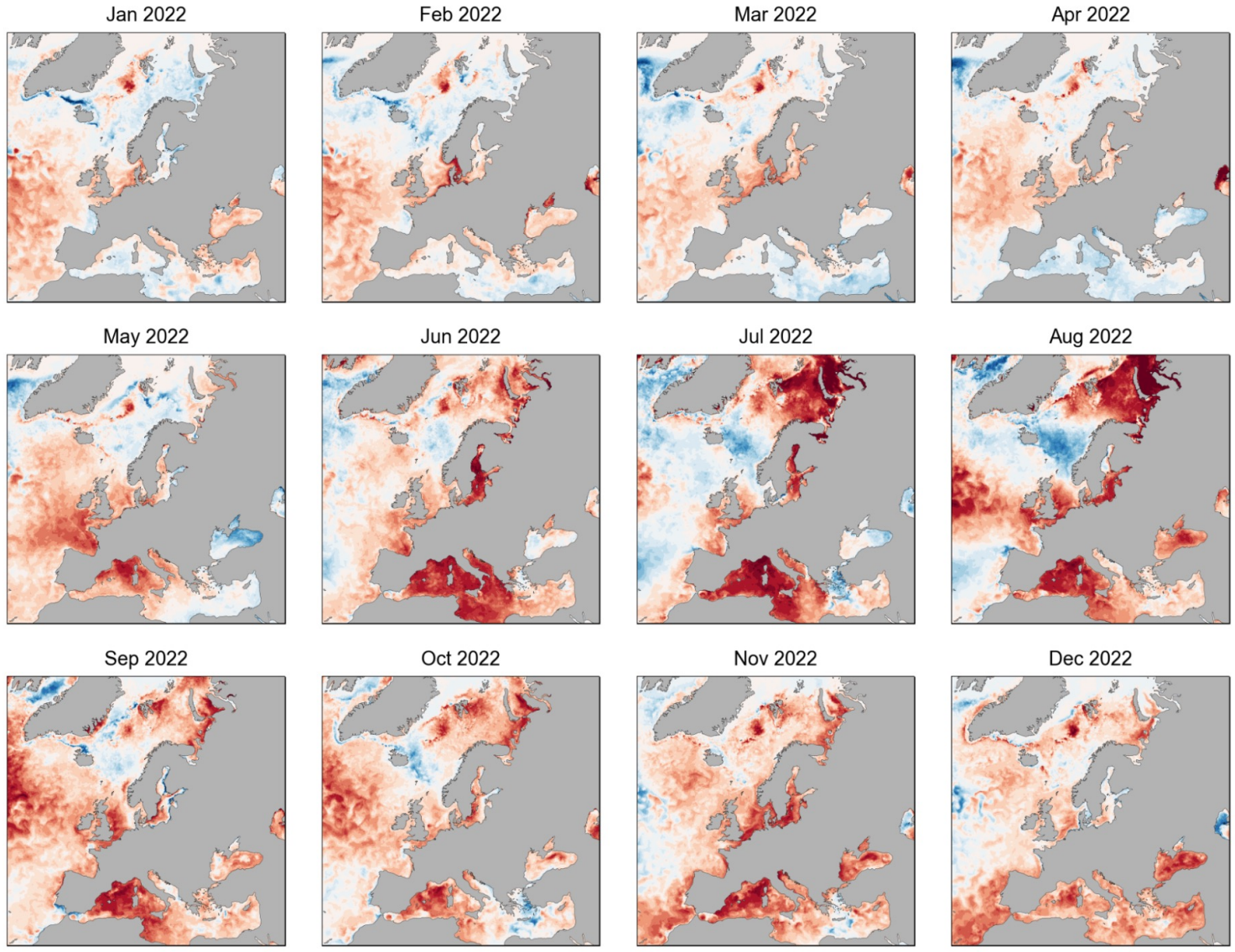

Low winds

opernicus
Europe's eyes on Earth



EUROPEAN STATE OF THE CLIMATE 2022

Warmest average SSTs on record & exceptional marine heatwaves



Reference period: 1991-2020
Data: ESA CCI/C3S SST CDR v3
Credit: C3S/ECMWF/Met Office

EUROPEAN STATE OF THE CLIMATE 2022

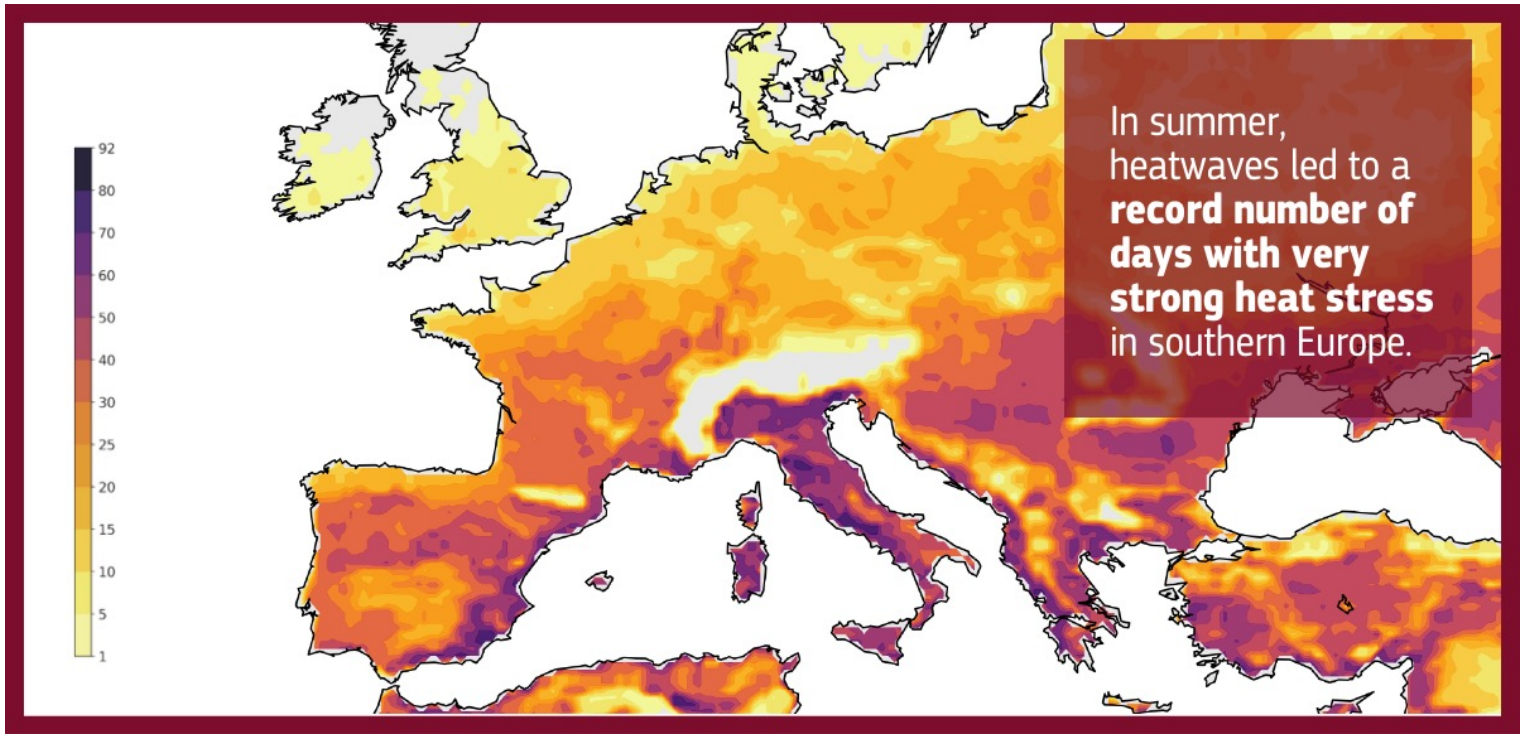
New in 2022: Land cryosphere monitoring section

Winter snow deficit & summer heatwaves' impact on Alpine glaciers

Data: World Glacier Monitoring Service

EUROPEAN STATE OF THE CLIMATE 2022

Extreme Heat in 2022

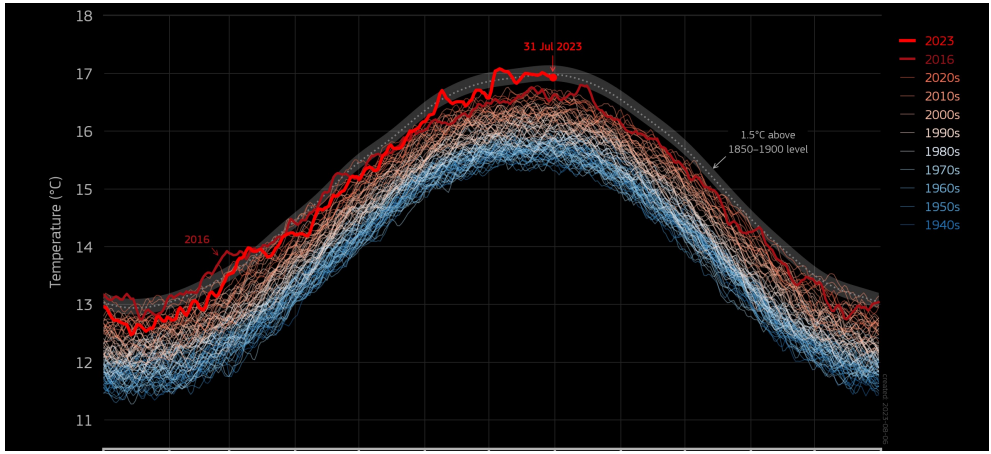


Data: E-OBS, ESA CCI/C3S SST, ERA5, ERA5-HEAT, CAMS Ozone

- Climate Bulletins: Changing from climate variable to geographic fields, + graphics and data changes
- Starting ESOTC earlier
- Adapting to the increased flexibility of EarthKit
- Working mote with the WMO – reports monitoring etc
- Navigating the increased media interest in climate


ESOTC Policy Event
Brussels
"The European State Of The Climate report of C3S is an invaluable resource for policy makers in Europe".
- Belgian Minister for Climate, Zakia Khattabi

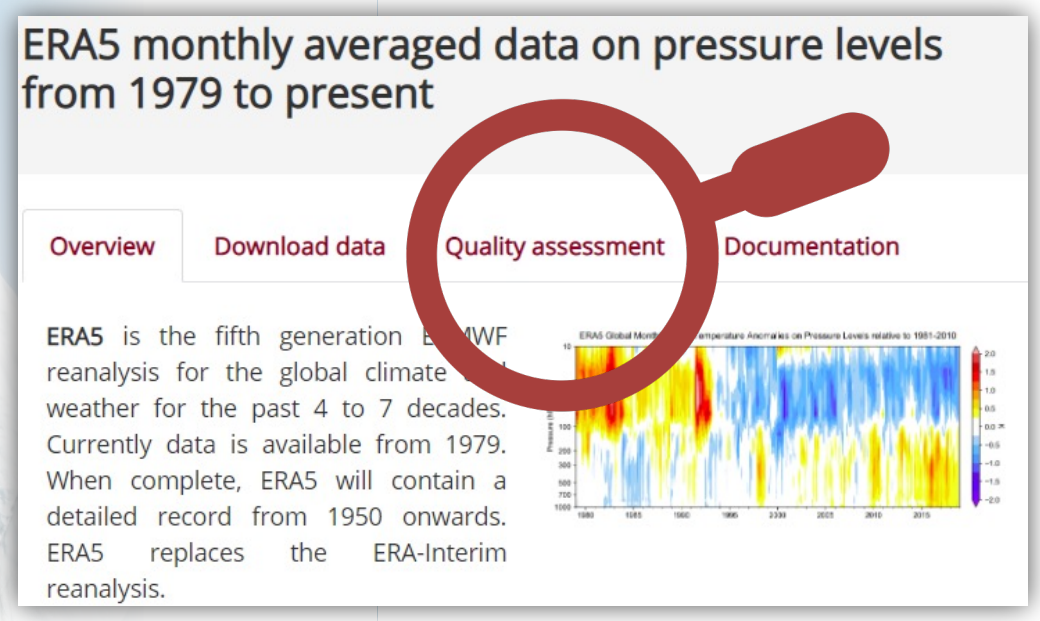

CLIMATE
Mauro Facchini
European Commission, DG DEFIS


18
17
16
15
14
13
12
11
Temperature (°C)
31 Jul 2023
2016
1.5°C above
1850–1900 level
2023
2016
2020s
2010s
2000s
1990s
1980s
1970s
1960s
1950s
1940s


023 sees multiple global temperature records

Climate Change

Evaluation and Quality Control



Quality Assurance Reports presented as Synthesis Table in the CDS

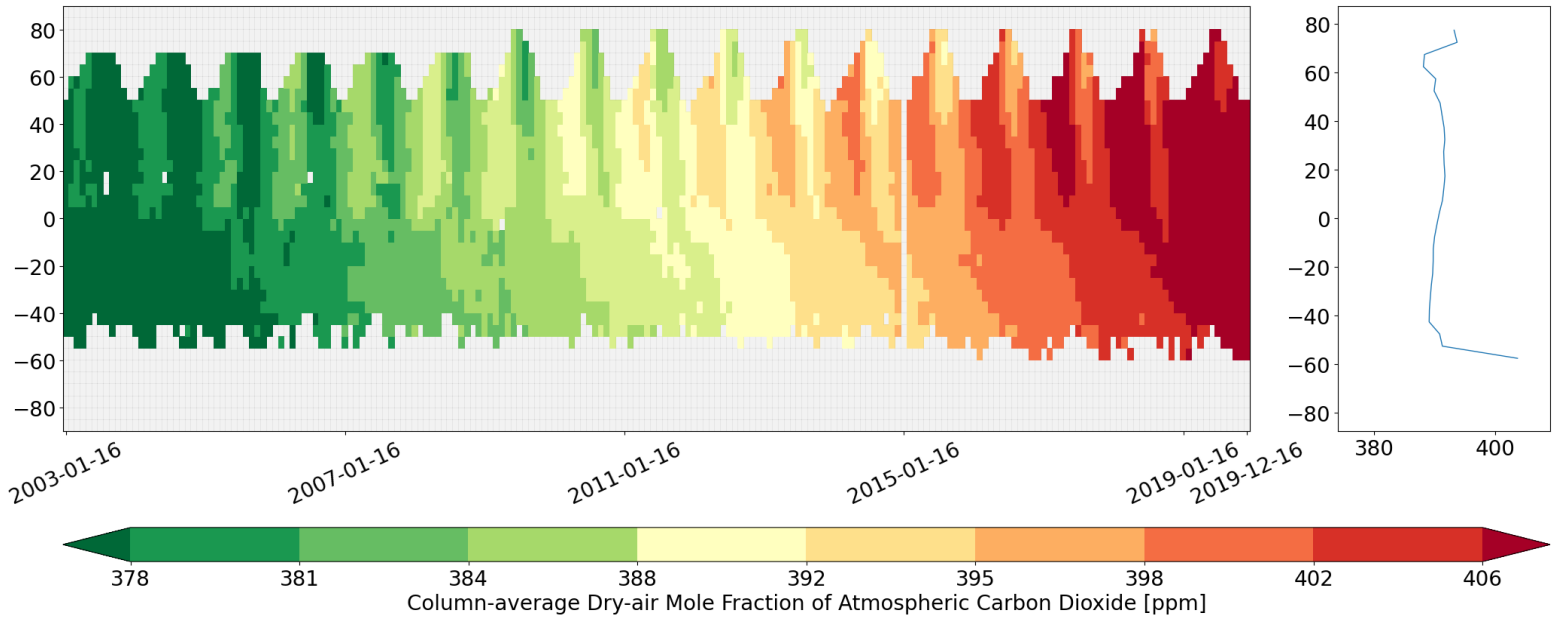
INTRODUCTION	USER DOCUMENTATION	ACCESS	INDEPENDENT ASSESSMENT
Dataset overview	User guide	Toolbox compatibility	Data check
Temporal and spatial coverage and resolution	Scientific methodology	Archive	Expert evaluation
Providers	Uncertainty quantification		Dataset maturity
Dataset version	Validation		Summary of independent assessment
Data update	Inter-comparison		

ECMWF Copernicus Europe's eyes on Earth European Commission

Climate Change

Example: EQC for Carbon Dioxide

Carbon dioxide data from 2002 to present derived from satellite observations - XCO2 Level 3 v4.2 (01/2003- 12/2019)



Maturity Matrix

Metadata	User Documentation	Uncertainty Characterisation	Public access, feedback, and update	Usage
Standards	Formal description of scientific methodology	Standards	Public Access/Archive	Research
Collection level	Formal validation report	Validation	Version	Decision support system
	Formal product user guide	Uncertainty quantification	User feedback	
		Automated quality monitoring	Updates to record	

1	2	3	4	5	6

Mean values for XCO2 as function of latitude and time (aggregated over longitude; left), and as latitudinal averages (aggregated over longitude and time; right). Grey areas represent missing values. Based on the CDS data downloaded on 28 January 2021.

PROGRAMME OF THE EUROPEAN UNION

Copernicus Europe's eyes on Earth

implemented by ECMWF

Climate Change

Example: EQC for Carbon Dioxide

Carbon dioxide data from 2002 to present derived from satellite observations - XCO2 Level 3 v4.2 (01/2003- 12/2019)

Mean/climatology 😐

Ok, but care has to be taken in specific regions (high-latitudes, Southeast Asia) and seasons when data availability might not be sufficiently high. Before mid of 2009, only observations over land available.

Variability 😐

The dataset length, spanning the period 2003-2019, is sufficient to allow some meaningful comparison of temporal variability with ESM, e.g. short-term variability like interannual and seasonal changes. Spatial variability can be assessed if the region of interest is well enough covered by the dataset

Trend 😐

With a temporal coverage of 17 years, the CDS XCO2 L3 (v4.2) dataset is just barely long enough to allow for meaningful trend comparisons with ESM simulations

Climate Change

Lessons learned

Extensive stakeholder consultation phase (Expert panel, C3S officers, Data providers, User feedback, Consultant)

- Much of current EQC is useful, but there is too much of it and the presentation to users is not effective.

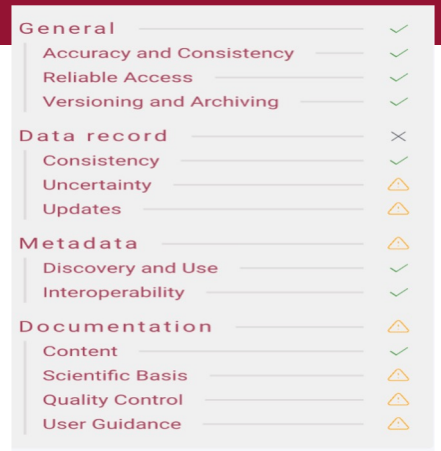
- Better distinction between various EQC aspects
- Reducing granularity by providing info at catalogue entry level
- Improving user experience by enabling better navigation
- Closer connection with actual user requirements

EQC 2.0 Content

Climate Change

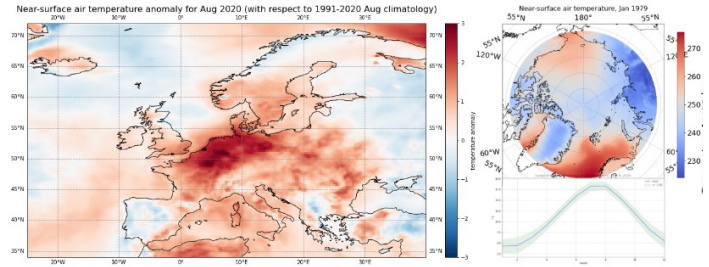
Quality assurance

Based on explicit requirements
Simple checklist with details on demand



Quality assessment

Addressing specific user questions
Providing scientific expertise



Fitness for purpose

Succinct overview with implications for best practice

"How, and how well, can I use these data for my purpose?"

→ **Deployment in the CDS scheduled in Q1-2024**

PROGRAMME OF THE EUROPEAN UNION

Copernicus Europe's eyes on Earth

IMPLEMENTED BY ECMWF

Climate & Atmospheric Data Store

- **Simple** and relevant data **discovery** and **access**
- **Online** tools for data **analysis** and **visualisation**
- Enable **reproducible research**
- Ensure users spend **less time** handling data

broad catalogue of datasets and applications…

...but years of evolution resulted in **backend work-arounds**

A **powerful broker** which could manage many types of service requests…

...but data requests and toolbox applications **competed** for resources

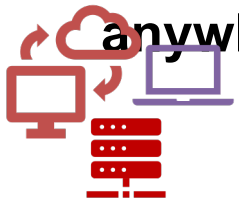
A **service-based** API facilitated powerful cloud computing…

...but the software was **bespoke** and **infrastructure dependent**

A catalogue designed with the **benefit of hindsight**

infrastructure independence for improved **scalability**

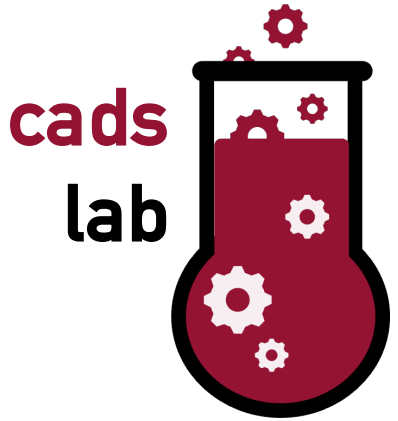
modular **open-source** code base that can be **executed anywhere**



The **Climate and Atmosphere Datastore (CADS)** project will **modernise** the CDS

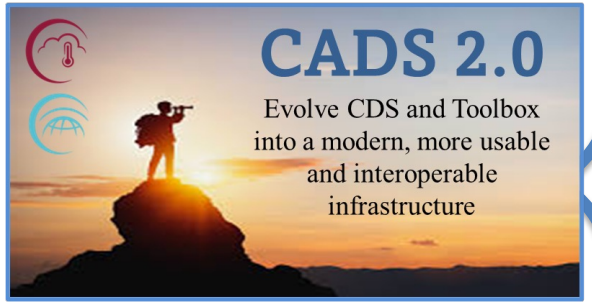
improved **interface** and **exploration** of ever-growing **catalogue** of data

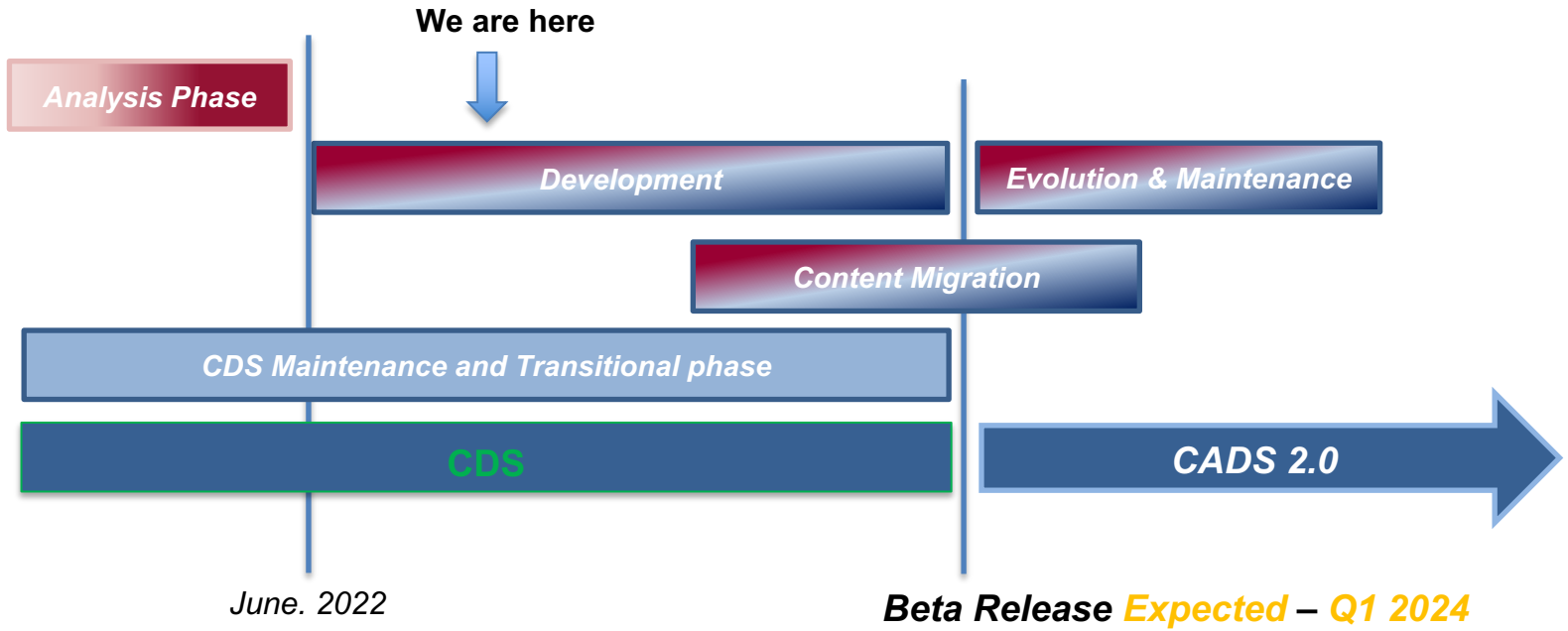
open-source Python tools for data **access**, **analysis** and **visualisation**



cloud resources and web interface underpinned by **Jupyter notebooks**

CADS 2.0 Roadmap



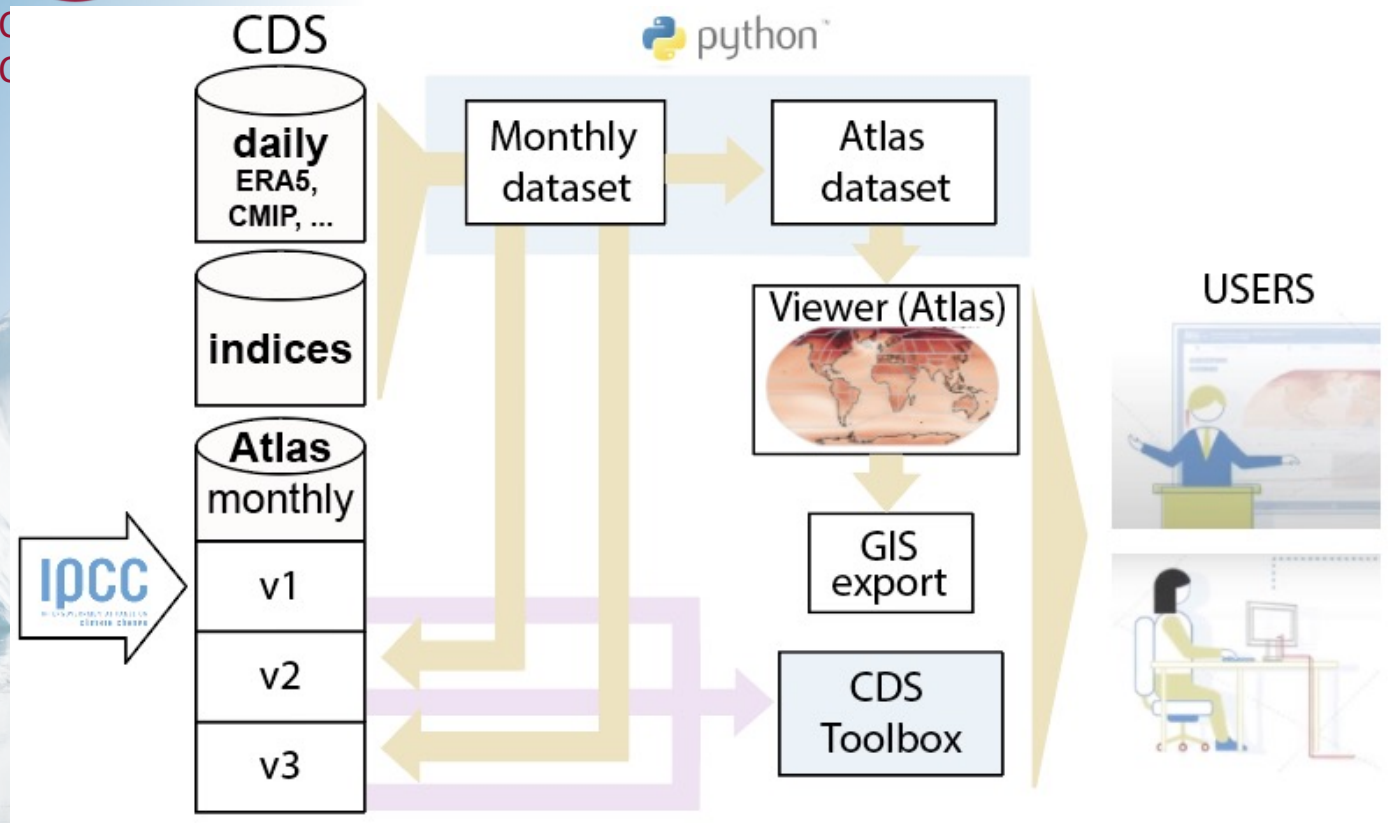


- Transition **strategy towards CADS 2.0**
- **Broader set of components** (EQC, Observations)
- Close **collaboration with other contracts and partners.**
- Inherited **automatic catalogue management** will facilitate content migration
- **Current Toolbox will not be backwards compatible**.
- Improved access to **User Support, Training Material, Documentation.**

PROGRAMME OF THE EUROPEAN UNION

IMPLEMENTED BY ECMWF

Other future work / opportunities



Contribution of Univ. Cantabria and Predictia

- Start from the frozen IPCC Interactive Atlas
- Evolution:
  - Publish IPCC-IA data in the CDS (v1) and viewer (v2)
  - Add content and functionality not available in the IPCC-IA
  - Consider C3S priorities and user requirements

- Full C3S Interactive Climate Atlas for 2025
- Possible initial point for the IPCC-IA for AR7?

- Attribution ITTs in development
- Training material based on Jupyter Notebooks
- …

Copernicus EU

@copernicusecmwf

Copernicus ECMWF

Copernicus EU
Copernicus ECMWF

@CopernicusEU
@CopernicusECMWF

www.copernicus.eu
climate.copernicus.eu

@j_munoz_sabater

Climate Change

Thank you for your attention

Copernicus Europe's eyes on Earth

European Commission

ECMWF