The Copernicus Climate Change Service (C3S)

Jean-Noël Thépaut

& the C3S team at ECMWF

Climate Change

Twitter: JeanNoelThepaut

Email: jean-noel.Thepaut@ecmwf.int

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THE COPERNICUS PROGRAMME OBJECTIVES

Copernicus

The Union Earth Observation and monitoring programme

Protect people and assets

Increase general knowledge on the state of the Planet

Improve environmental policy effectiveness

Facilitate adaptation to climate change

Monitor the environment

Foster downstream applications in a number of fields

Help managing emergency and security related situations

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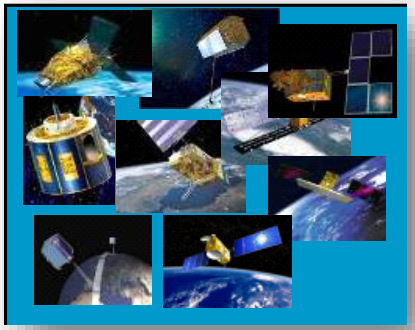
PROGRAMME ELEMENTS

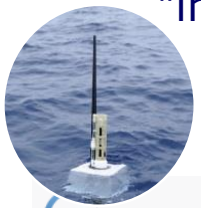
Copernicus Sentinels

6 services use Earth Observation data to deliver …



Other Satellites

"in-situ"



…added-value products

Copernicus

COPERNICUS SATELLITES

FULL, FREE AND OPEN

Sentinel Mission and Status		Key Features
 SENTINEL-1: 4-40m resolution, 3 day revisit at equator	*2 Sats in orbit*	Polar-orbiting, all-weather, day-and-night radar imaging
 SENTINEL-2: 10-60m resolution, 5 days revisit time	*2 Sats in Orbit*	Polar-orbiting, multispectral optical, high-res imaging
 SENTINEL-3: 300-1200m resolution, <2 days revisit	*2 Sats in Orbit*	Optical and altimeter mission monitoring sea and land parameters
 SENTINEL-4: 8km resolution, 60 min revisit time	*1st Launch in 2020*	Payload for atmosphere chemistry monitoring on MTG-S
 SENTINEL-5p: 7-68km resolution, 1 day revisit	*1 Sat in Orbit*	Mission to reduce data gaps between Envisat, and S-5
 SENTINEL-5: 7.5-50km resolution, 1 day revisit	*1st Launch in 2021*	Payload for atmosphere chemistry monitoring on MetOp 2nd Gen
 SENTINEL-6: 10 day revisit time	*1st Launch in 2020*	Radar altimeter to measure sea-surface height globally

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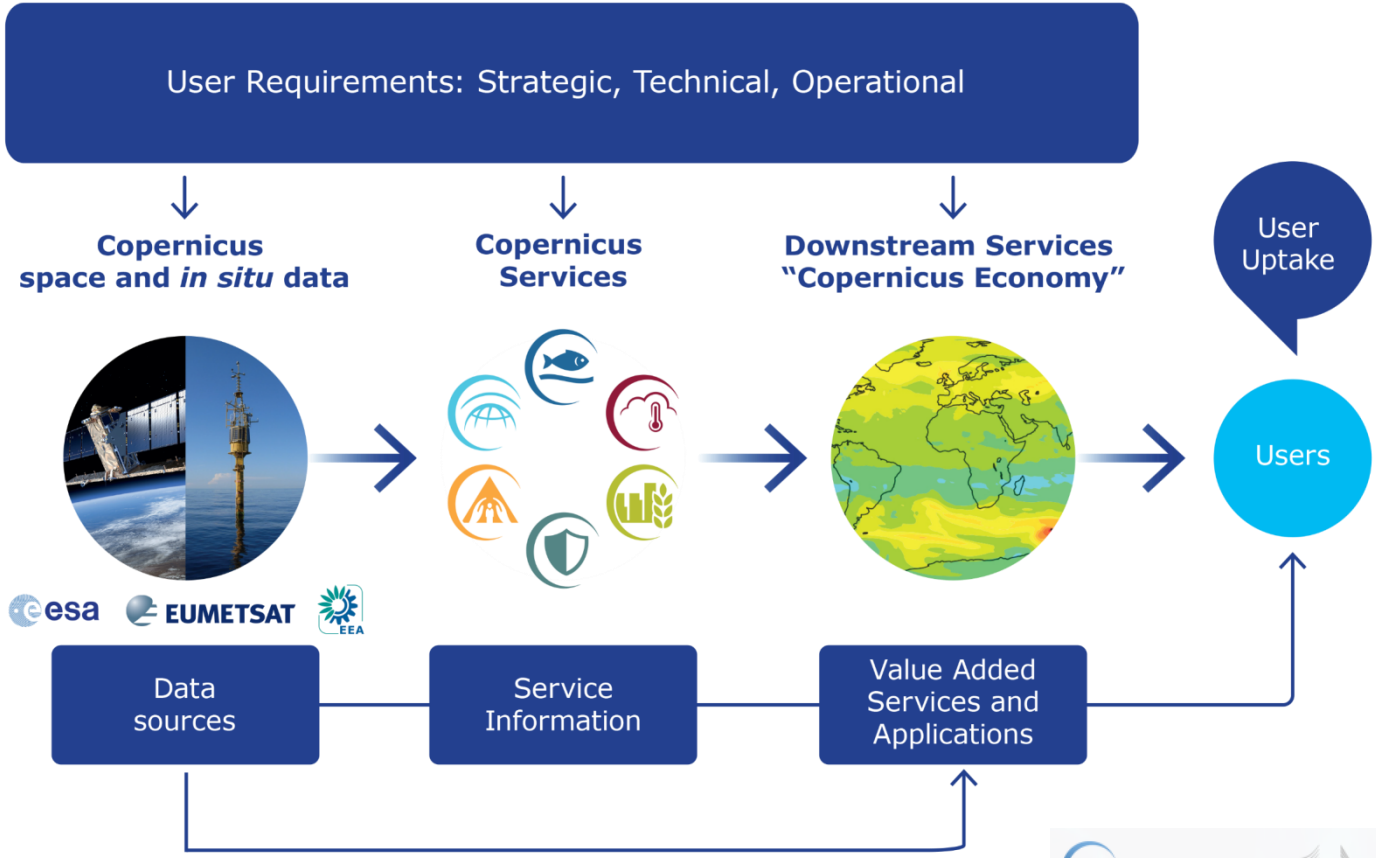
COPERNICUS IS DRIVEN BY THE USERS



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The C3S mission

To support European adaptation and mitigation policies by:

- Providing consistent and authoritative information about climate (past, present, future)
- Building on existing capabilities and infrastructures (nationally, in Europe and worldwide)
- Stimulating the market for climate services in Europe

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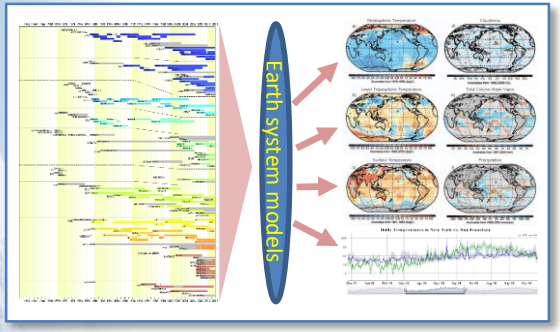
C3S: ACCESS TO PAST, PRESENT AND FUTURE CLIMATE INFORMATION

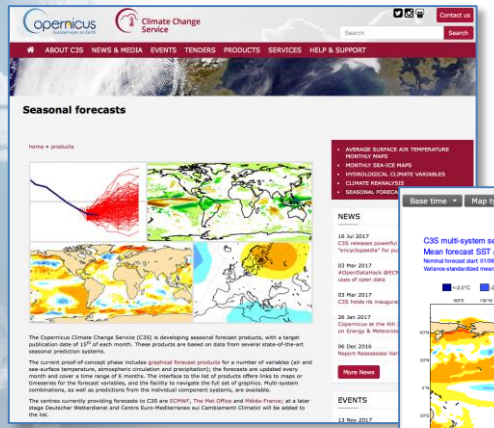


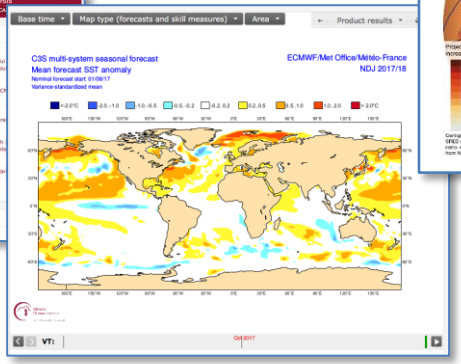
Observations and climate reanalyses

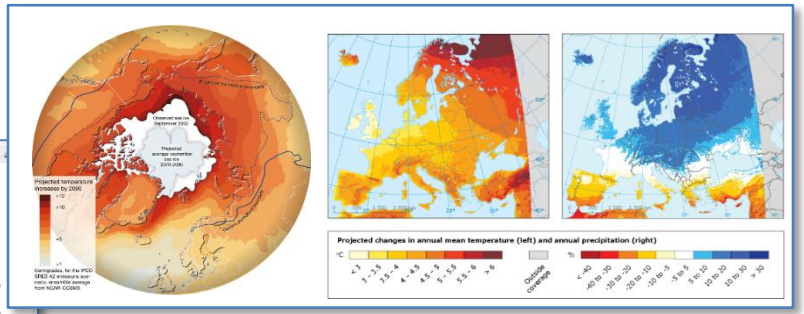
Seasonal forecast data and products

Climate model simulations

Sectoral climate impact indicators







http://climate.copernicus.eu

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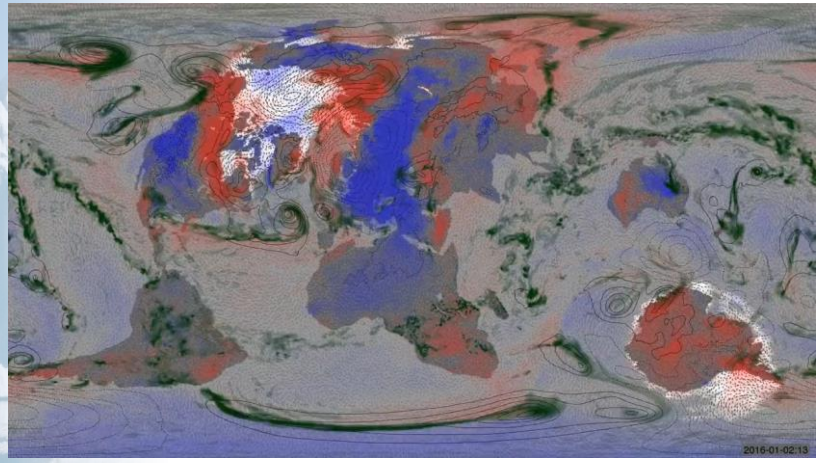
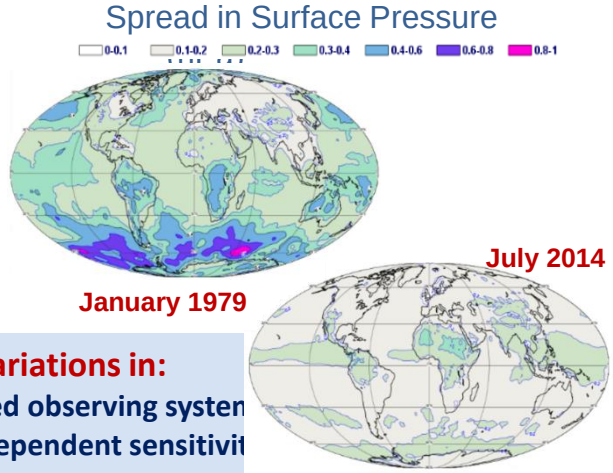
C3S: Reanalysis based Essential Climate Variables (30km global ERA5) Builds upon IFS modelling and Data Assimilation

Hourly data and increased number of parameters



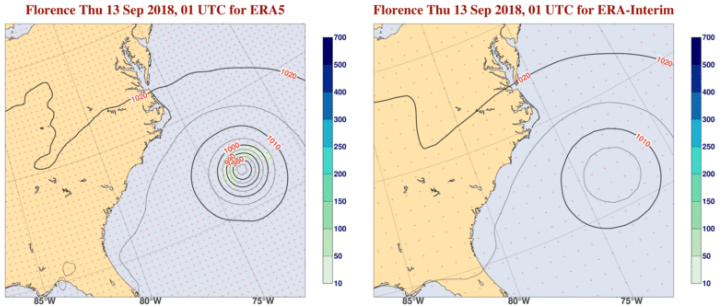
Uncertainty estimate

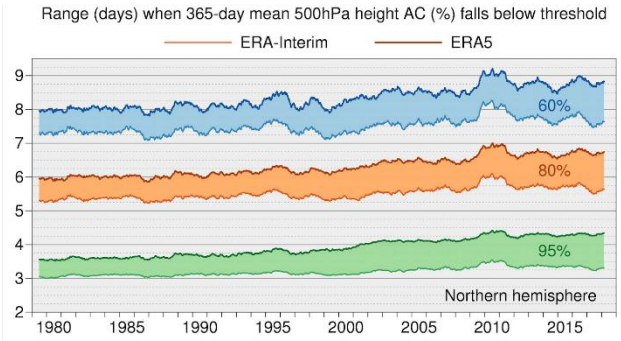


Reflects variations in:

- ingested observing systen
- flow-dependent sensitivit

Courtesy: Philip Brohan





Credit: H. Hersbach, ECMWF

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C3S: EO based Essential Climate Variables

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- Large uptake by Copernicus of Science in Europe (e.g. ESA Climate Change Initiative, EUMETSAT SAFs, etc.)
- Copernicus is a resource to WMO State of Climate, GCOS climate indicators, contributes to CEOS-CGMS Climate data records inventory

		Science		uptake	Operations
GCOS-195		CCI	CCI+		C3S
Atmospheric surface					
4.3.1	Air temperature				
4.3.2	Wind speed and direction				
4.3.5	Precipitation				■
4.3.6	Surface radiation budget				■
Atmospheric upper air					
4.5.1	Air temperature				
4.5.2	Wind speed and direction				
4.5.3	Water vapour		■		■
4.5.4	Cloud properties	■		■	■
4.5.5	Earth radiation budget				■
Atmospheric composition					
4.7.1	Carbon dioxide	■		■	■ ■
4.7.2	Methane	■		■	■ ■
4.7.3	Other long-lived greenhouse gases				
4.7.4	Ozone	■		■	■ ■
4.7.5	Aerosol	■		■	■ ■
Ocean surface					
5.3.1	Sea-surface temperature	■		■	■ ■
5.3.2	Sea-surface salinity		■		
5.3.3	Sea level	■		■	■ ■
5.3.4	Sea state		■		
5.3.5	Sea ice	■		■	■ ■
Ocean biogeochemistry					
5.3.7	Ocean colour	■		■	■
5.3.8	Carbon dioxide partial pressure				
5.3.9	Ocean surface acidity				
Ocean sub-surface					
5.4.1	Temperature				
5.4.2	Salinity				
5.4.3	Current				
Land hydrology & cryosphere					
6.3.4	Lakes		■		■
6.3.5	Snow cover		■		
6.3.6	Glaciers and ice caps	■		■	■ ■
6.3.7	Ice sheets	■		■	■
6.3.8	Permafrost		■		
6.3.16	Soil moisture	■		■	■ ■
Land biosphere					
6.3.9	Albedo	■		■	■ ■
6.3.10	Land cover (including vegetation type)		■		■
6.3.11	Fraction of absorbed photosynthetically active radiation				■ ■
6.3.12	Leaf area index				■ ■
6.3.13	Above-ground biomass		■		
6.3.15	Fire	■		■	■
6.3.17.1	Land-surface temperature		■		

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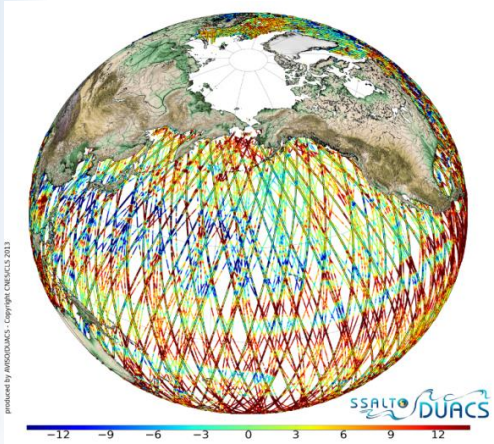
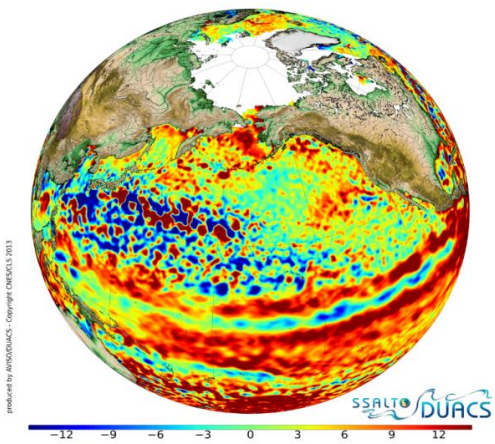
Sea Level ECV production service

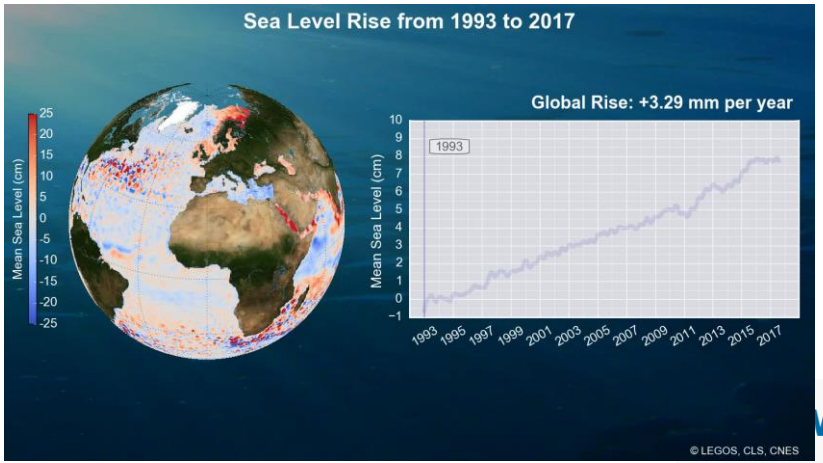


From satellite **along-track** measurements…

… to **sea level gridded maps**…



… to derive Ocean Monitoring Indicators



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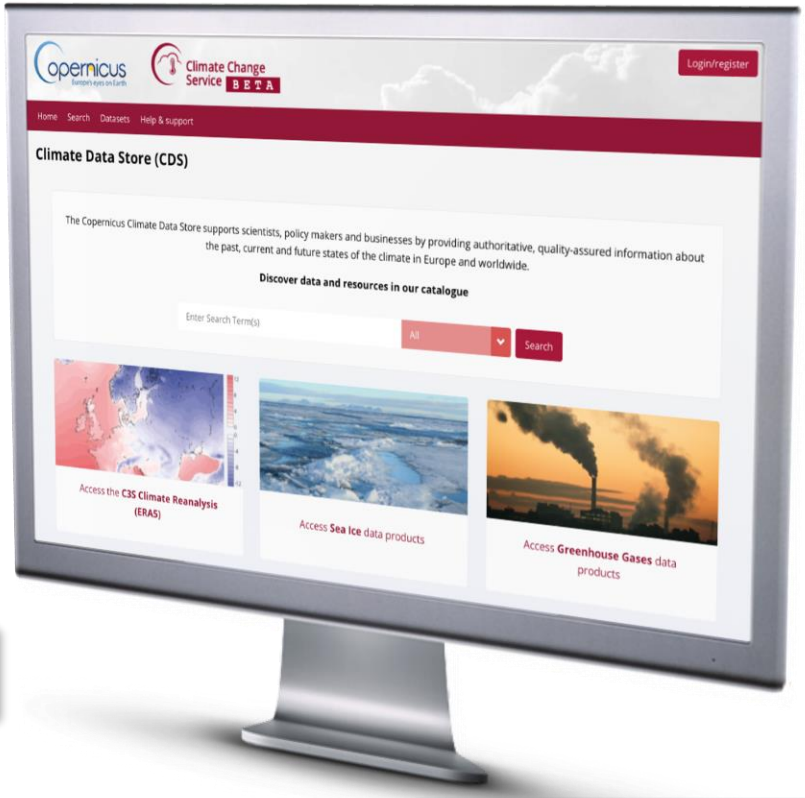
What C3S offers to its users

- Access to climate data
- Tools needed to use the data
- Information on sectoral impacts
- Quality assurance
- User support and training
- Climate change assessments
- Outreach and communication

A one-stop Climate Data Store



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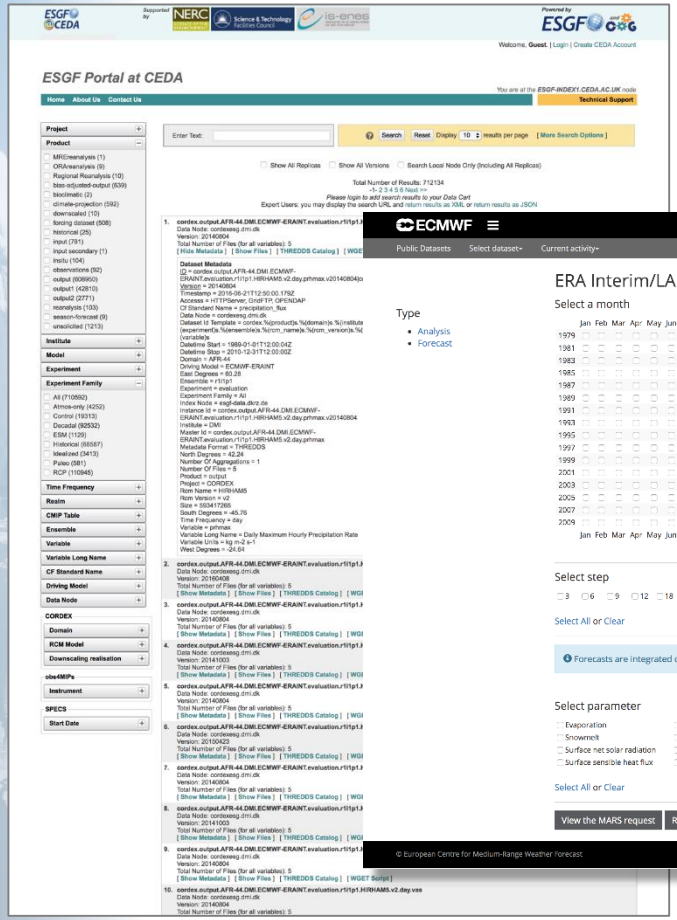
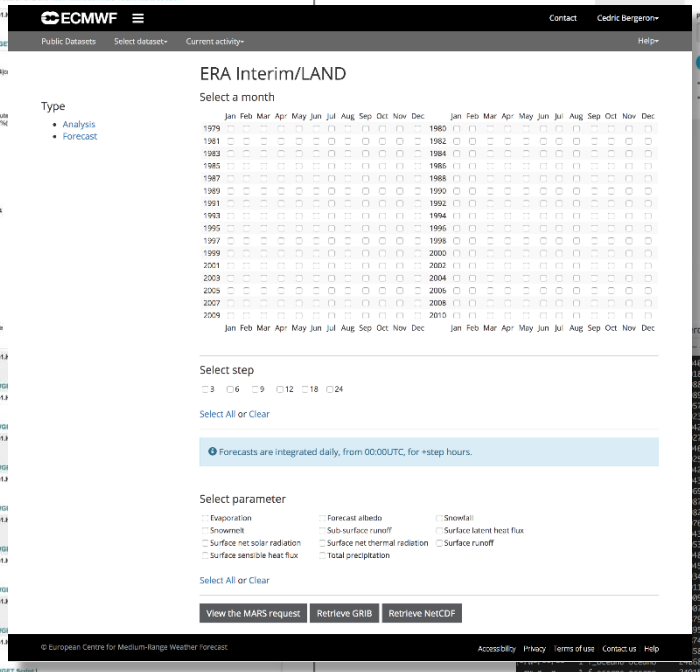
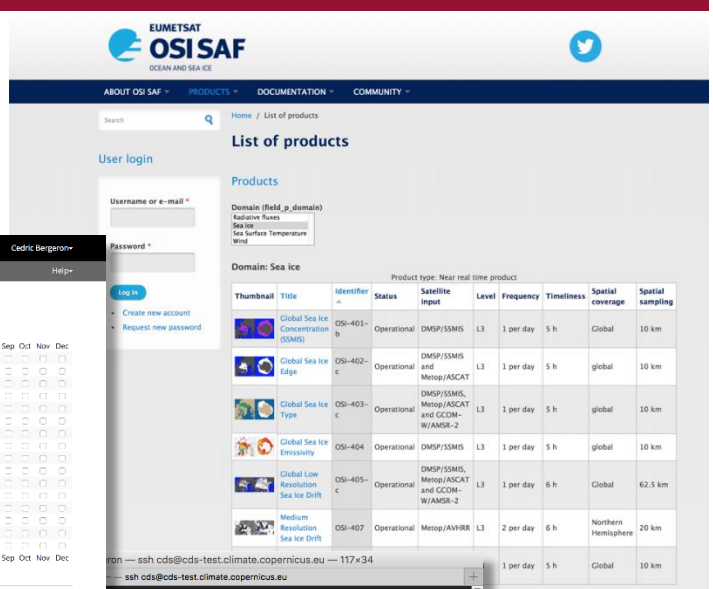
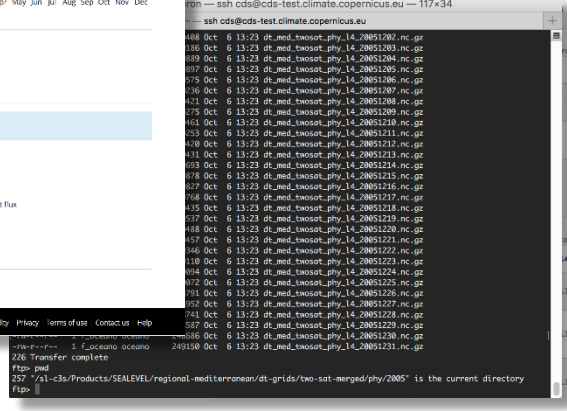
Access to climate datasets before the CDS…









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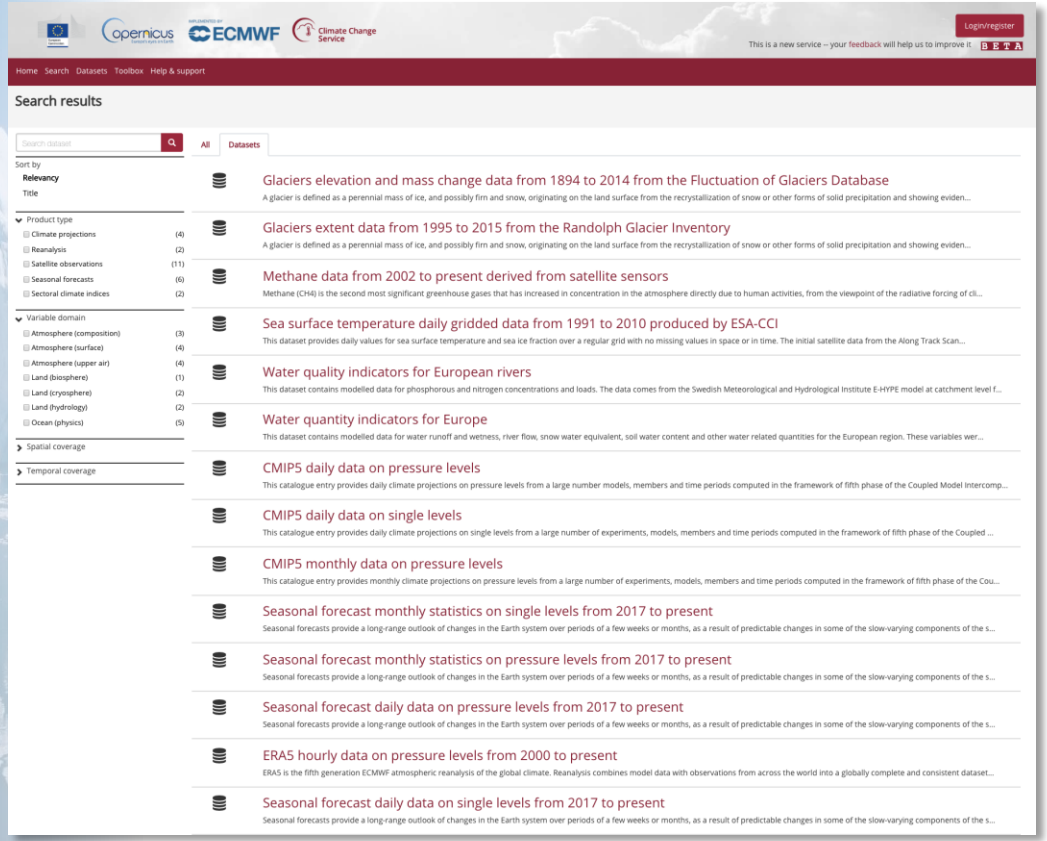
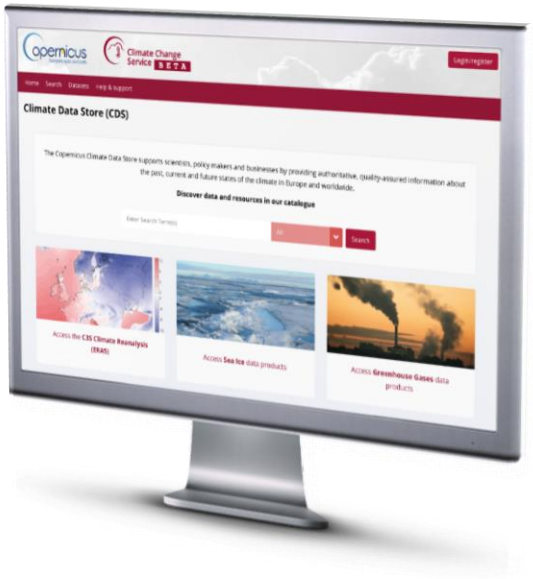
Catalogue of climate datasets





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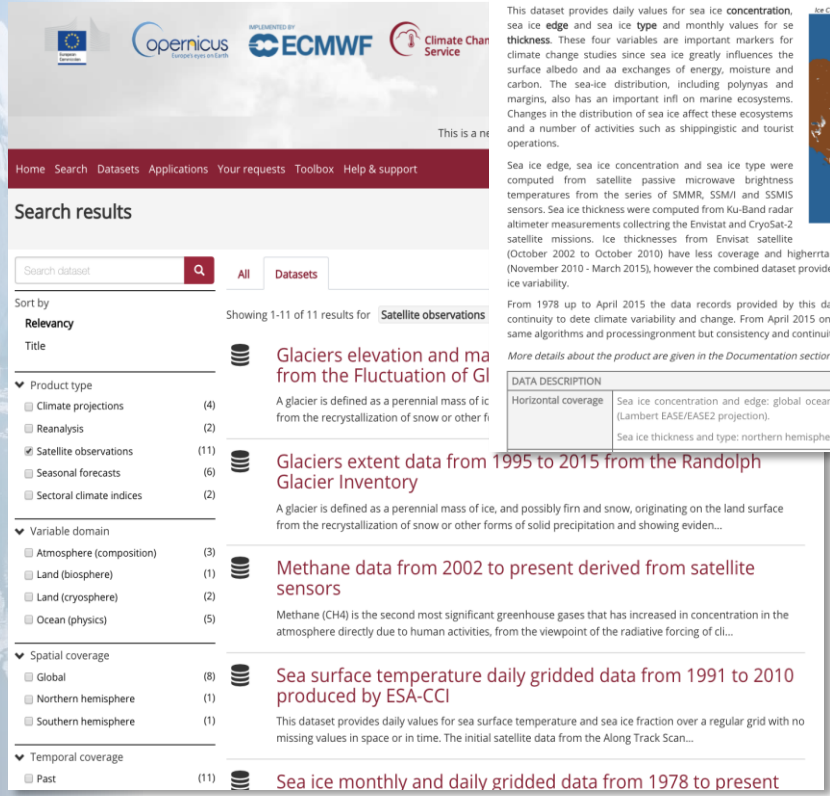
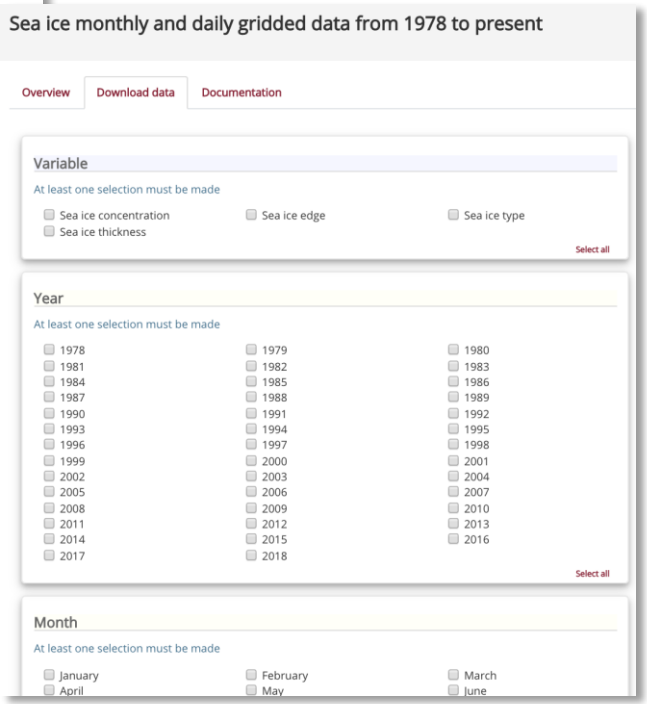
ECV products from Earth observations





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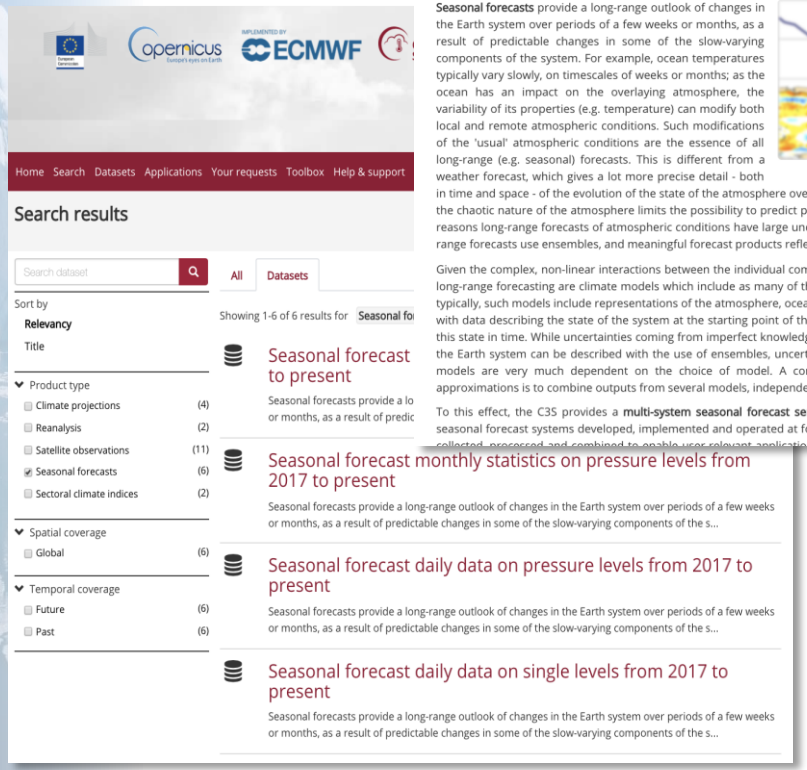
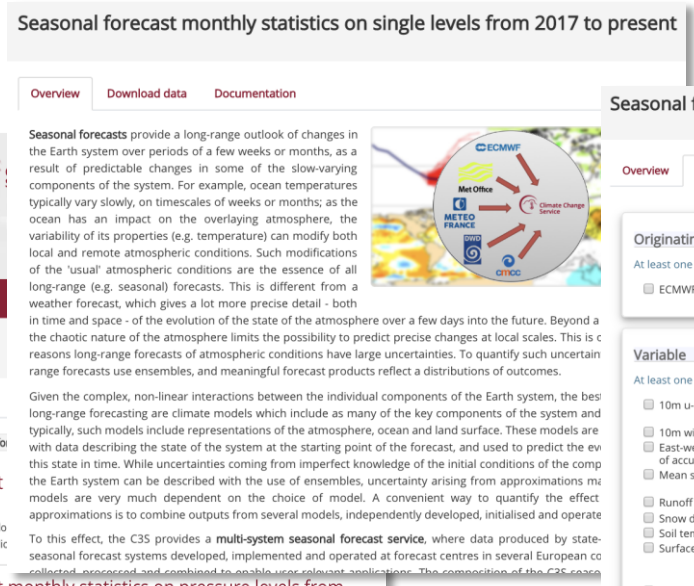
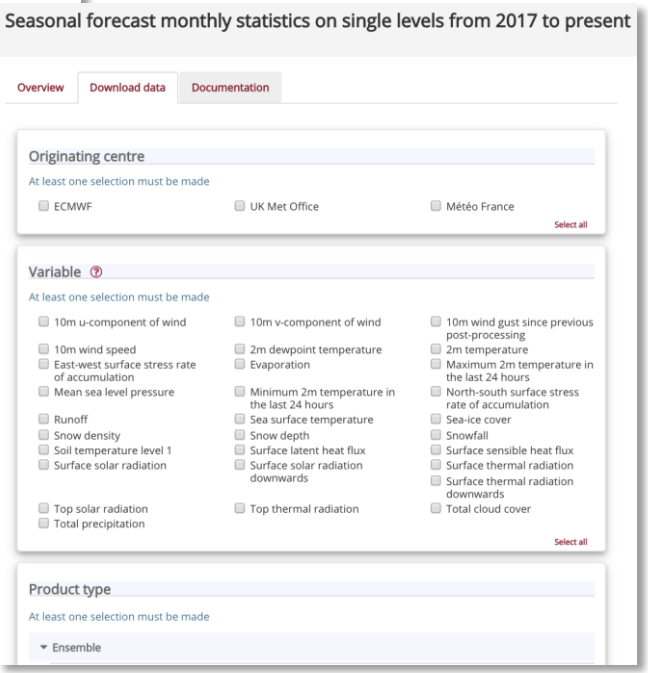
Multi-system seasonal forecasts







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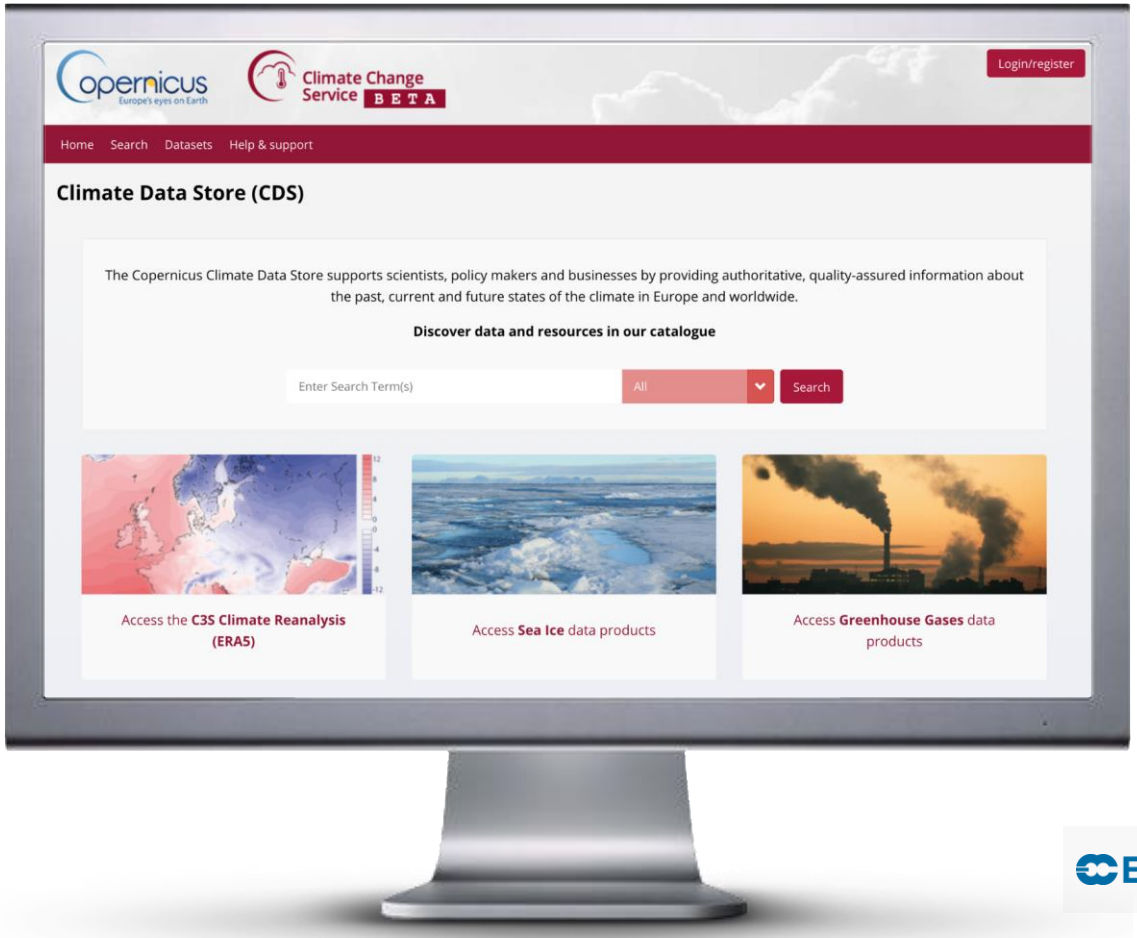
Climate Data Store – CDS



The CDS contains **observations**, global and regional **climate reanalyses**, global and regional **climate projections** and **seasonal forecasts.** It also contains generic and **sectoral climate indicators.**

The CDS is designed as a **distributed system**, providing improved access to **existing datasets** through a **unified web interface**

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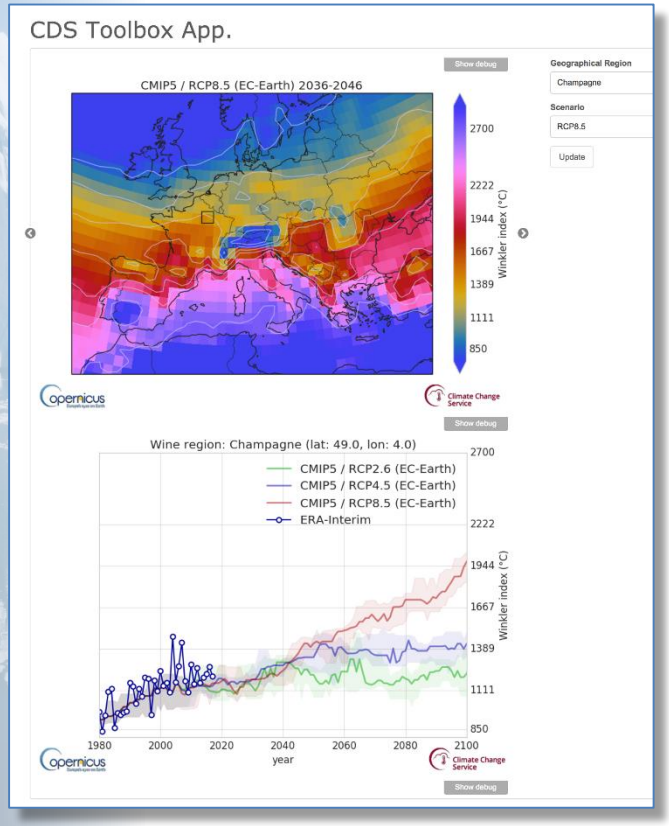
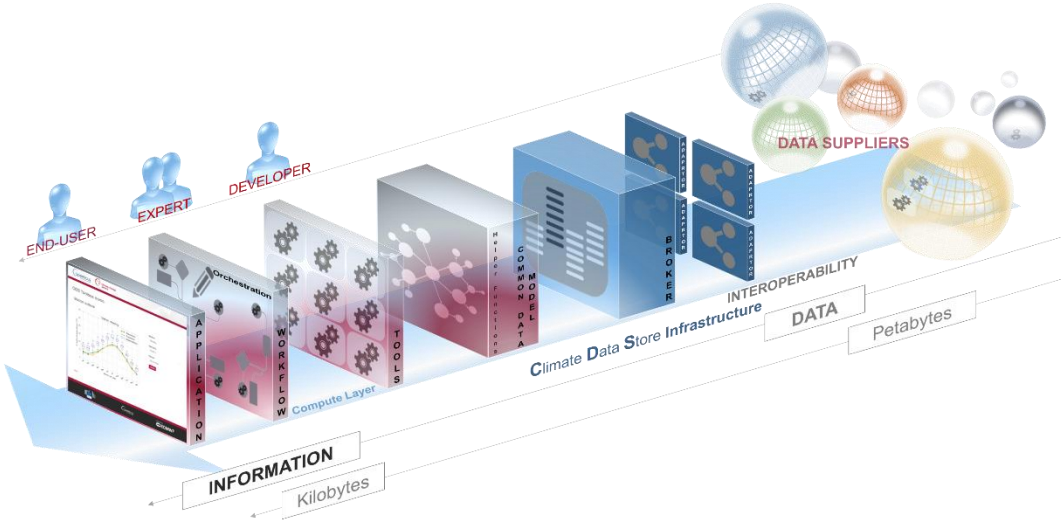
C3S infrastructure
CDS concept: Access to tools, workflows and applications





The CDS and its Tool Box allows managing and handling “climate objects” in a seamless way and within a unified environment.

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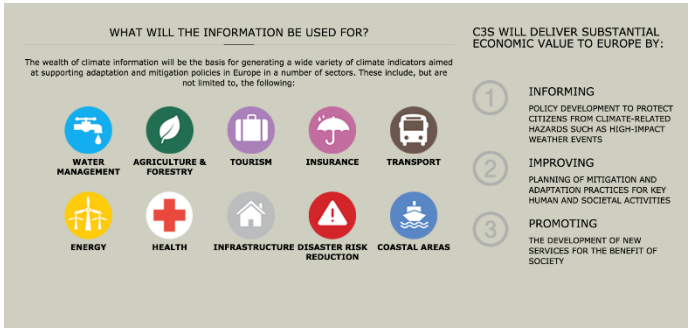
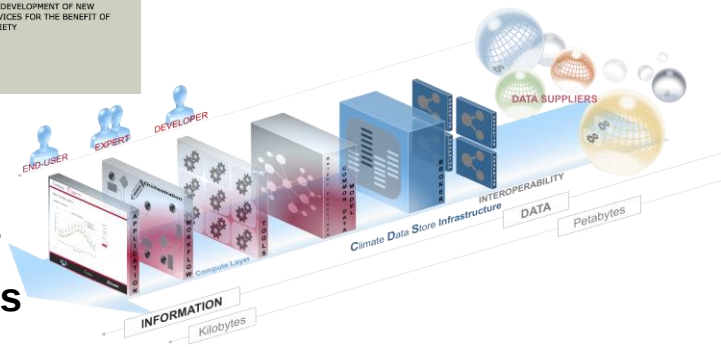
SECTORAL INFORMATION SYSTEM

Proof-of-concepts of climate services: Demonstration of the **value chain** with several end-to-end **demonstrators**



As an operational Service, **C3S** ambitions to become an **enabler** of **downstream climate services**, by providing or brokering **high quality** and sector relevant climate **data** and **indicators**, **good practices**, **tools** and by supporting compelling **use cases**.



Further down the line, Copernicus **DIAS** will provide free access to **all Copernicus data and information** in the cloud, plus a development environment for users to develop and market their own **cloud-based applications**/front offices (under cloud computing commercial terms). Other EO missions data are also expected to be available.

5 DIASs under development (4 by ESA, 1 by ECMWF/EUM/MO)

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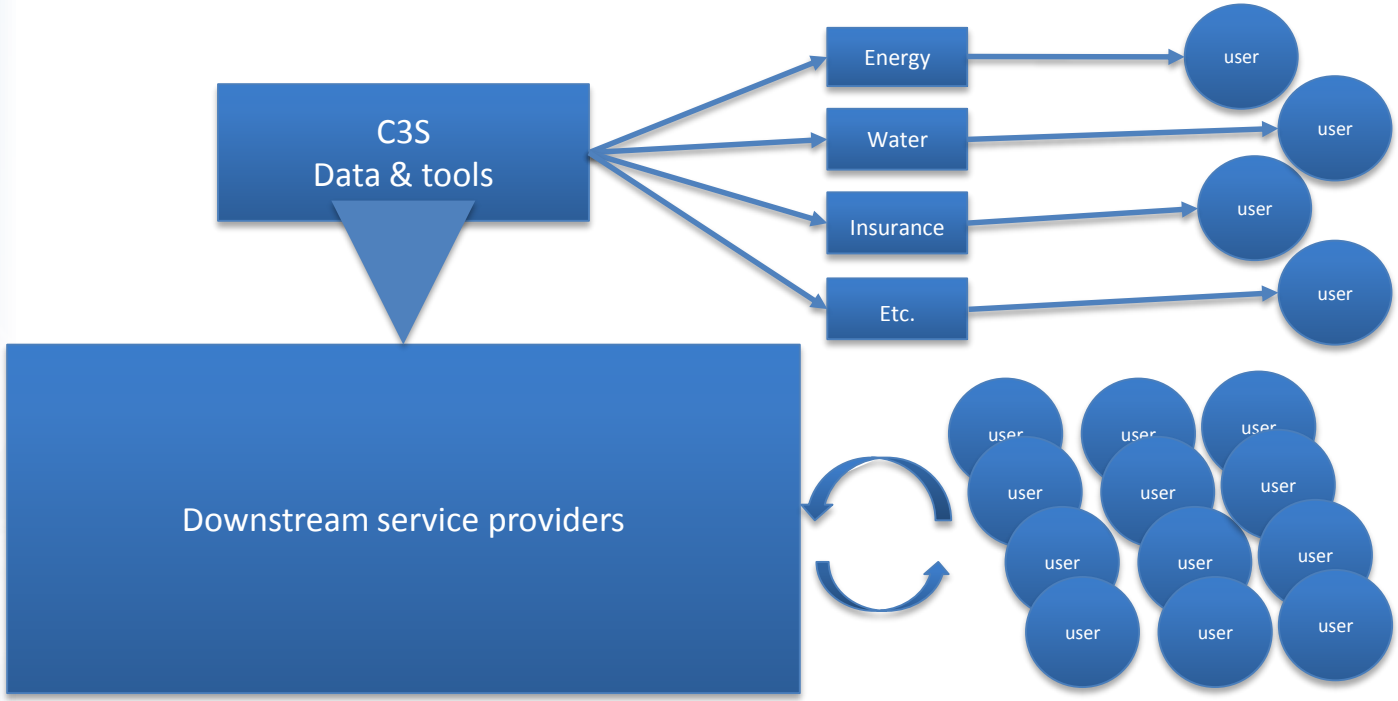
C3S: Enabler for downstream exploitation



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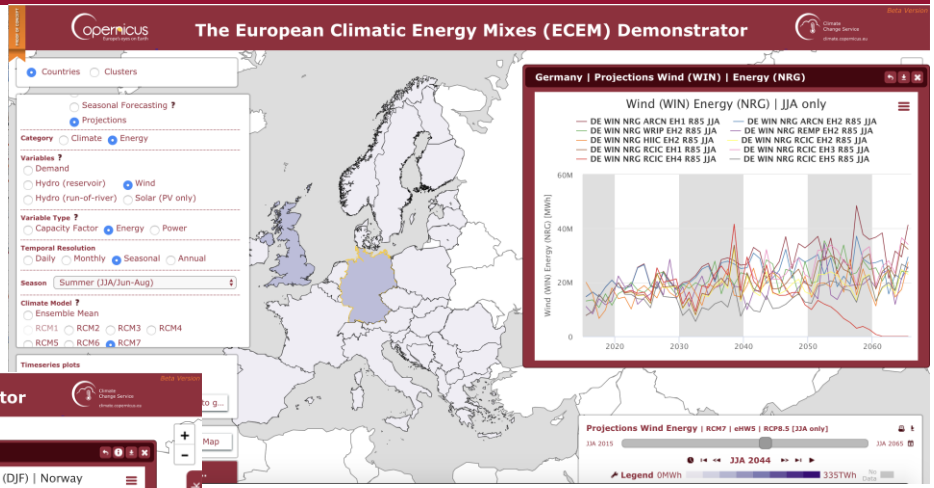
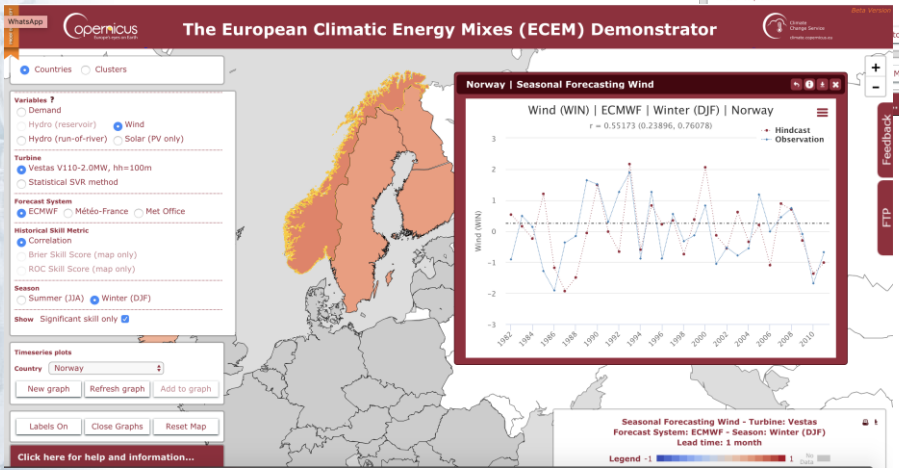
Energy

Integrating climate and energy scenarios to learn how well prepared our infrastructure is to cope with the climate of the future. Will the renewable dominated energy mix of the future able to cope with the expected change in the energy demand profile?





Using a combination of historical data, reanalysis, seasonal predictions and climate projections the SIS contracts have demonstrated how it will be possible to address some of these questions through the CDS.

Contract led by UEA

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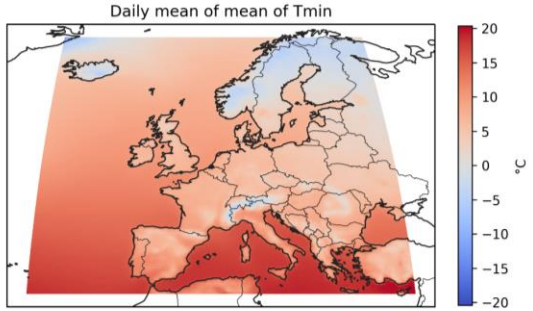
Health exposure demonstrator

Climate Change

Secure | https://cds.climate.copernicus.eu/apps/355/heat_exposure?sdk_version=2.8.1

Heat_exposure



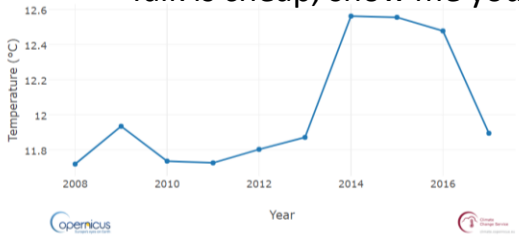
Variable: Tmin

City: Rome

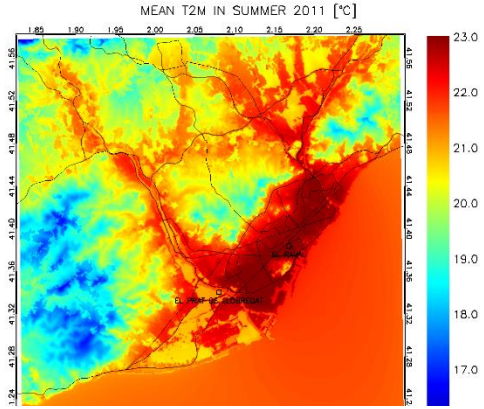
Statistic: Mean

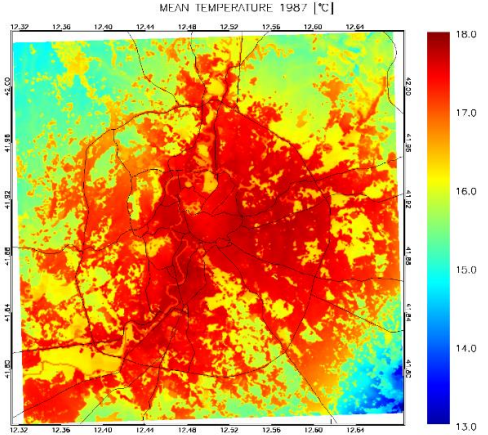
Period: Annual

Timeseries of mean of Tmin for Rome



"Talk is cheap, show me your code" *Linus Torvalds 2000-05-02*





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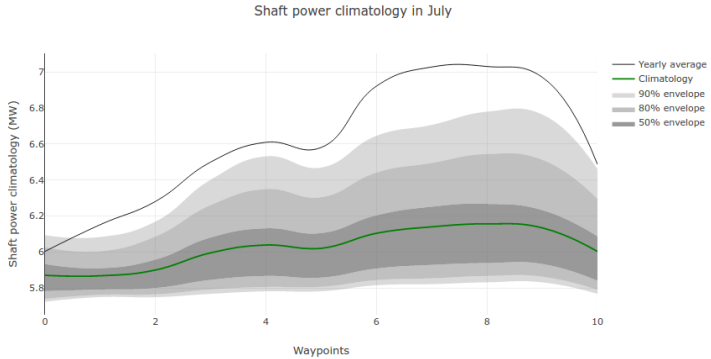
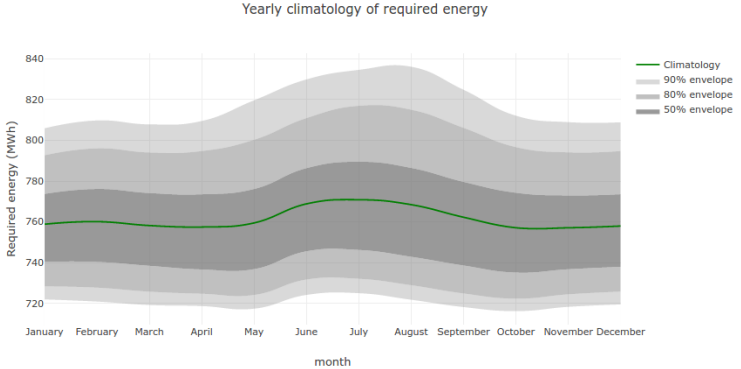
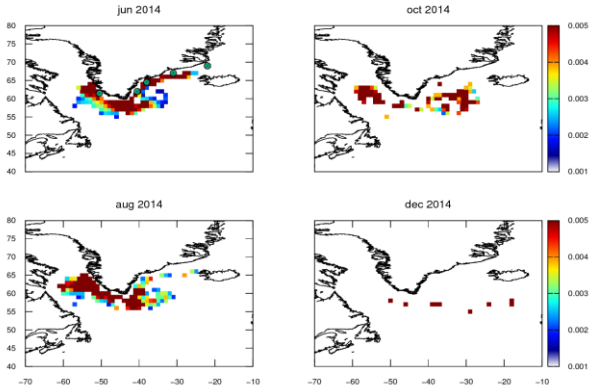
Climate indicators related to Shipping

Which part of the route/season is most likely to lead to overconsumption ?

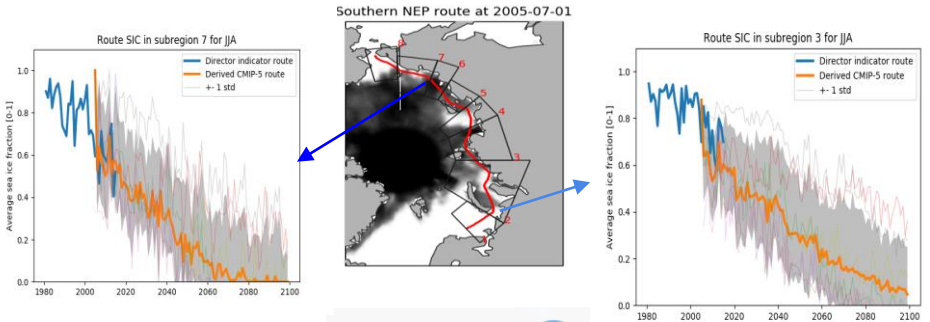




Where/when will I find icebergs ?



When will the Arctic route become commercially viable?



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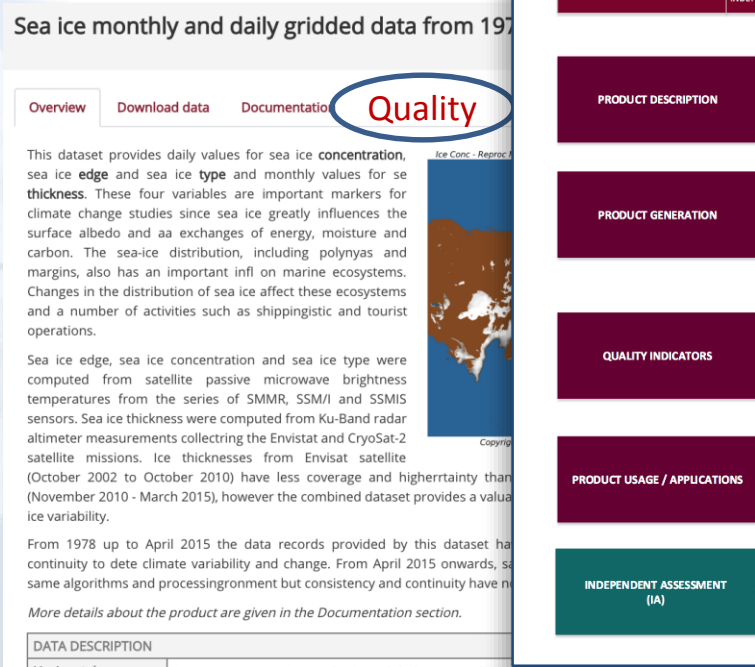
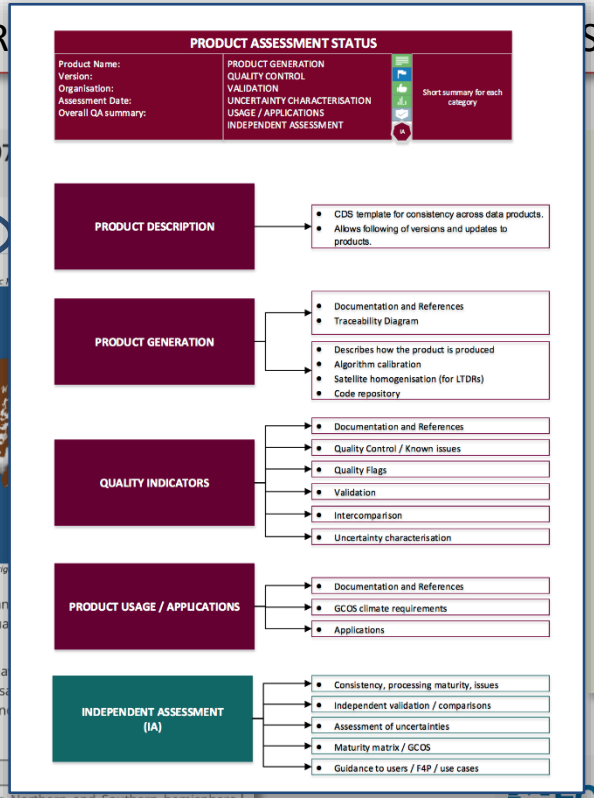
Evaluation and Quality Control (EQC)

A suitable EQC framework has been developed for quality assurance of CDS datasets

Key feature: Quality Assurance R S





Quality of data:
- assessments
- user guidance
- gaps and limitations

Quality of tools:
- fitness for purpose
- best practices

Quality of service:
- speed, responsiveness
- system availability, …

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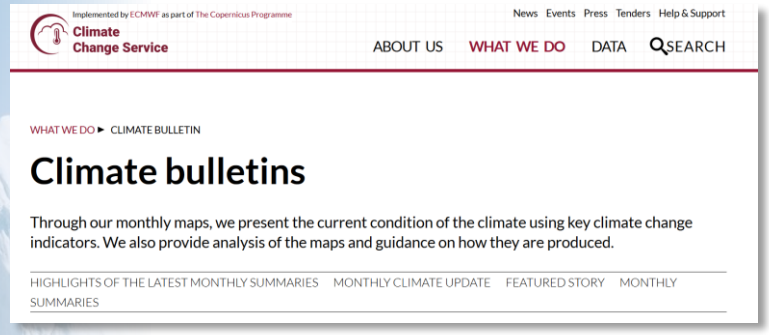
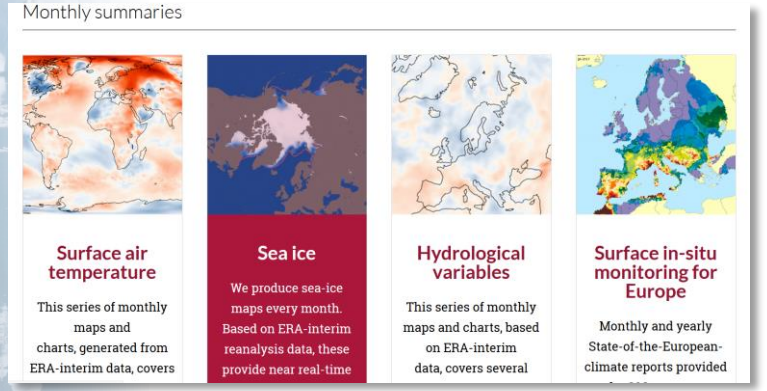
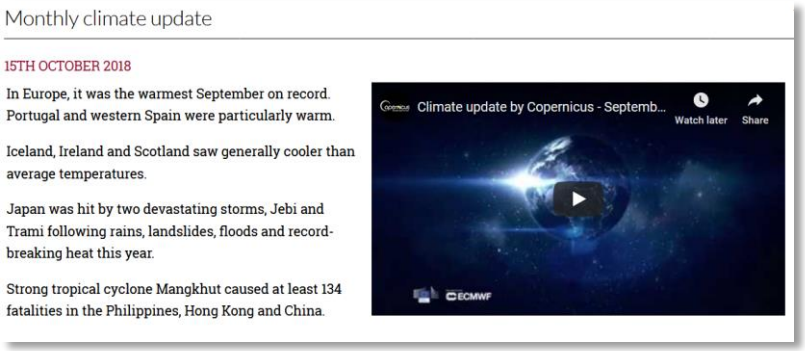
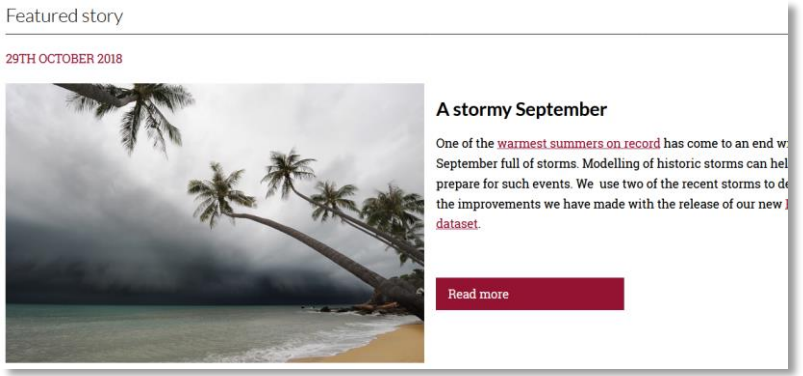
Monthly climate bulletins

Climate Change









➢ climate.copernicus.eu/climate-bulletins

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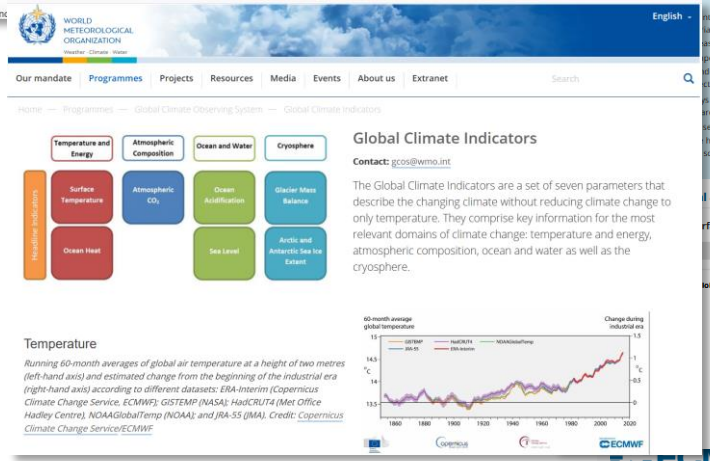
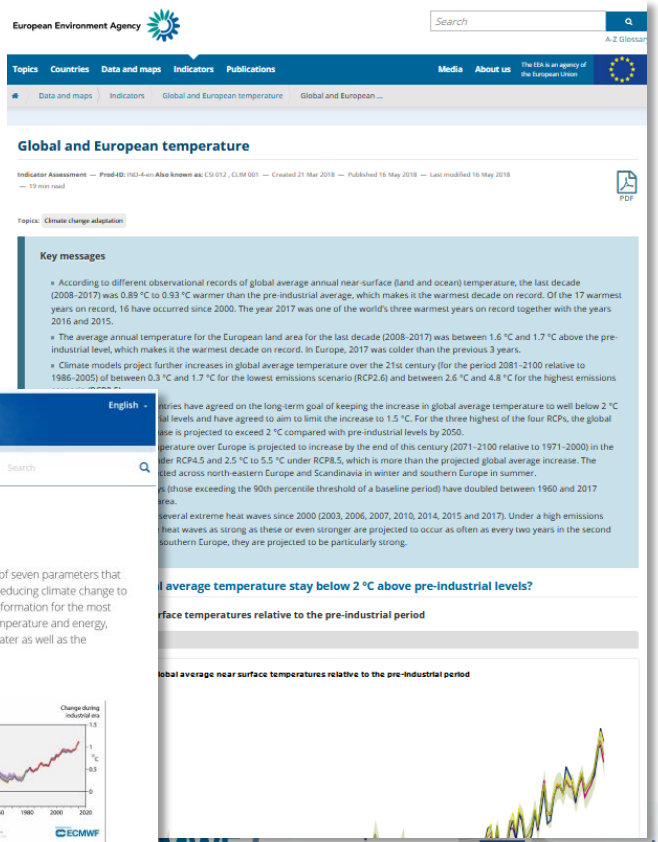
Contributing to EEA, GCOS and the WMO

Climate Change





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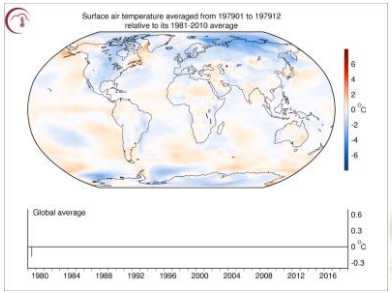
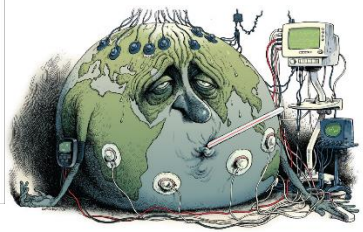
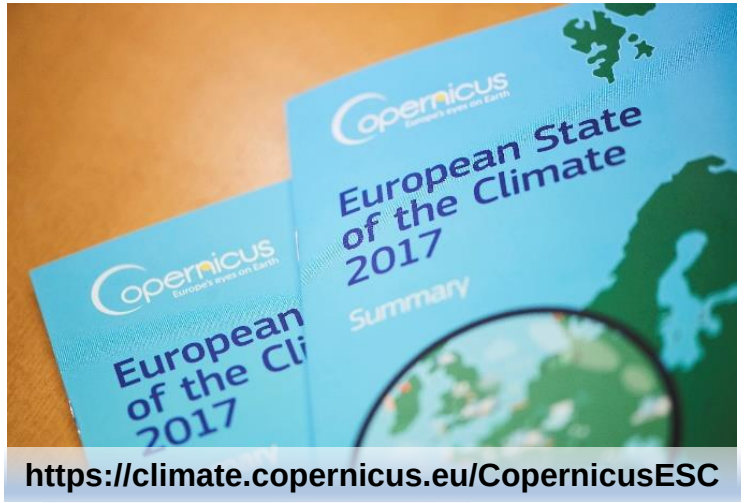
C3S: Operational production of climate indicators

Surface temperature	↑
Greenhouse gases	↑
Rain	–
Sea Ice	↓
Glaciers	↓
Sea Level	↑
Soil Moisture	↓





Credit: Victor & Kennel, Nature Climate Change, 2014.



https://climate.copernicus.eu/CopernicusESC

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C3S and UNFCCC Sustainable Development Goals

Climate

	C3S contribution to SDGs
2 ZERO HUNGER	C3S SIS addresses agriculture, and some of the global services will focus on food security
3 GOOD HEALTH AND WELL-BEING	C3S SIS addresses health, providing relevant climate change indicators
6 CLEAN WATER AND SANITATION	Two Proof-of-concept SIS projects in C3S dedicated to water management. A urban PoC SIS is also addressing this SDG at city level. Operationalisation underway
7 AFFORDABLE AND CLEAN ENERGY	Two proof-of-concept SIS projects in C3S dedicated to the Energy Sector. Reanalyses (produced by C3S) are also highly relevant.
8 DECENT WORK AND ECONOMIC GROWTH	C3S activities contribute indirectly to this SDG insofar that the energy climate impact indicators (see goal 7) are relevant.
9 INDUSTRY, INNOVATION AND INFRASTRUCTURE	C3S is working closely with the standardisation community (via DG-CLIMA) on developing climate change information required for the writing of standards in infrastructure and transport.

	C3S contribution to SDGs
11 SUSTAINABLE CITIES AND COMMUNITIES	C3S SIS related to urban aspects of climate change, as well as health and infrastructure aspects, contribute indirectly to this SDG. Reanalysis products too.
12 RESPONSIBLE CONSUMPTION AND PRODUCTION	C3S SIS products and indicators on water management are directly relevant for this goal.
13 CLIMATE ACTION	ECV products, including from reanalysis, CDRs, seasonal forecasts and climate scenarios, directly relevant for adaptation. The SIS also delivers relevant indicators in support of adaptation. Cooperation: EEA Climate ADAPT
14 LIFE BELOW WATER	Some of the ECV products generated by C3S (including reanalysis ORAS5) are ocean relevant. This is done in coordination with CMEMS.
15 LIFE ON LAND	Biodiversity is a future sectoral application of C3S. Relevant products will contribute to this goal. ECV products on soil moisture, forestry, lakes, also contribute to this goal.

Climate Change

C3S user learning services

Focus on the use of the Climate Data Store to address climate change adaptation challenges

Key elements:

- Blended training
- Online training resources freely available anywhere and anytime
- Personalized learning
- 3 main target audiences
- In-country training events in local language in more than 30 EU countries
- Train the trainers to widen the reach of the training and increase the impact

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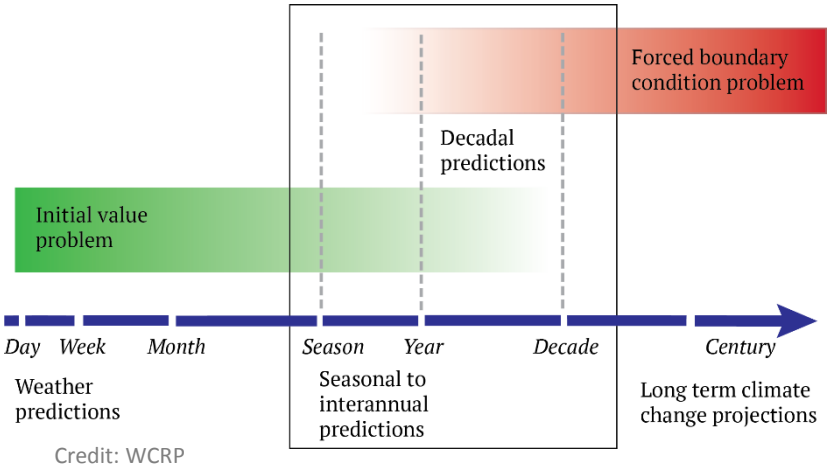
What's next: Decadal Component

Climate Change

- Rationale:
  - Current user requirements surveys and discussions with C3S stakeholders clearly indicate the need for information at decadal timescales.
    - Current gap in the Service
- Process:
  - Workshop (early 2019) involving key stakeholders, the scientific and user community
    - Take stock of the existing state-of-play
      - (WMO operational initiative, C3S climate projections roadmap recommendations, projects e.g. EUCP, etc.)
  - Assess the level of maturity of decadal prediction (including verification) science.
  - Agree and design a prototype decadal component before the end of the current Delegation Agreement



Credit: WCRP

Reference:

- C3S User Requirement study (https://climate.copernicus.eu/secteur)
- https://www.sciencedirect.com/science/article/pii/S2405880717300018
- European Roadmap for Climate Services

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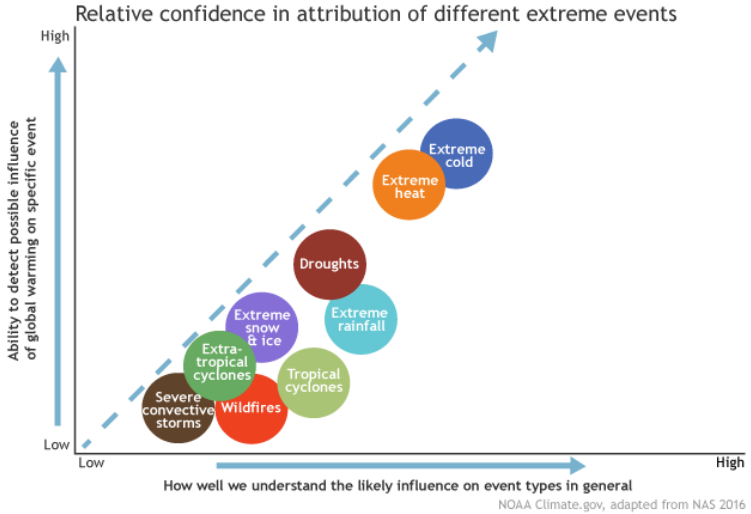
What's next: Attribution component

Climate Change

- Rationale:
  - High interest from the society (media, policy makers, planners)
  - Event attribution studies aim at providing a rigorous scientific approach to determine to what extent weather-related risks have changed due to human influences on climate.
- Process:
  - Brainstorming with key stakeholders to revisit the "attribution science" state of play (Prague workshop, 10-11 October 2017)
  - Ongoing study to define a publishable protocol for operational attribution, together with requirements on data and tools
  - Validation of this protocol by the scientific community
  - commission a "prototype" Attribution service element towards a possible operational Attribution component for C3S next generation.



Reference:

- C3S Technical Annex (page 34)
- C3S precursor project EUCLEIA https://eucleia.eu

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What's next: Broad international agenda

- "Transforming our world: the 2030 Agenda for Sustainable Development" - 17 **Sustainable Development Goals** with 169 associated targets
- Sendai Framework for **Disaster Risk Reduction** 2015–2030 with seven global targets
- **Paris Agreement** adopted by conference of parties to United Nations Framework Convention on Climate Change (COP-21)
- The **New Urban Agenda** adopted at Habitat III

Credit: WMO

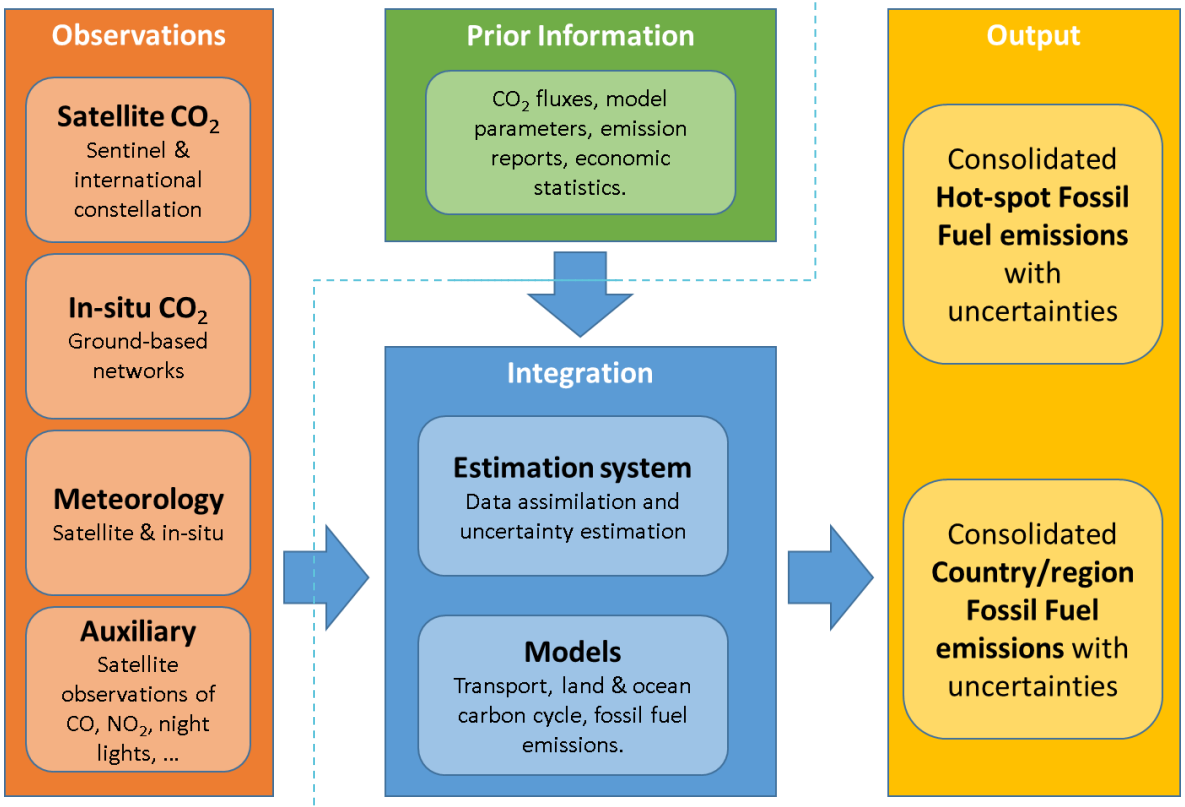
Establishment of User Needs / Requirements for Copernicus evolution

- The EC conducted in 2016-17 a wide initiative to identify long term, “user-driven” requirements for evolution of Copernicus services and space segment => user consultations, workshops, etc.
- Copernicus will continue to be a public service, driven by the needs of policy and public administrations, and fostering economic development in Europe
- Stability of the programme and long term commitment
  - (Enhanced) continuity of current data and services;
  - Continuity of full, open and free data policy
- Emerging needs
  - Climate change and sustainable development;
  - Monitoring CO2 and other greenhouse gas emissions;
  - Land use and forestry;
  - Changes in the Arctic;
  - Security and Defence: Improving the EU's capacity (border control, maritime surveillance);

Space Segment, observation requirements preliminary conclusions

- **The (enhanced) continuity of existing observation capacity is the overarching priority;**
- **Conclusions on major gaps :**
  - CO2 measurements to estimate anthropogenic emissions (highest priority)
  - High-Resolution Thermal observations
  - SAR L-band observations
  - Monitoring of sea ice and ice sheets in the polar region (various measurements and instruments)
  - Hyper-spectral measurements
- Very **ambitious plans** being put forward by the EC/ESA for the future generation of Copernicus satellites (Sentinels 1 to 6 deployment completion, Next Gen S1 to S6, and further missions)

CO_2 ANTHROPOGENIC EMISSION MONITORING SYSTEM



Approach based on CAMS and C3S, with 3 complementary components:

- ECMWF/IFS @5-10km, 100+ satellite data streams
- Regional zooms @1-2km
- Hot spots

Implemented by ECMWF as part of The Copernicus Programme

Climate Change Service

News Events Press Tenders Help & Support

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Get involved with the Copernicus Climate Change Service

Questions?

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