Climate Change

Copernicus Climate Change Service

Climate Change and the Urban Environment

Copernicus Europe's eyes on Earth

European Commission

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Outline

1. The Copernicus Climate Change Service (C3S)
   - What is it?
   - Products and Services
   - Applications

2. Climate Change and the Urban Environment
   - Urban Sectorial Information System (SIS) Demonstrator Project

Copernicus Climate Change Service (C3S)

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The C3S mission

To support European adaptation and mitigation policies by:

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

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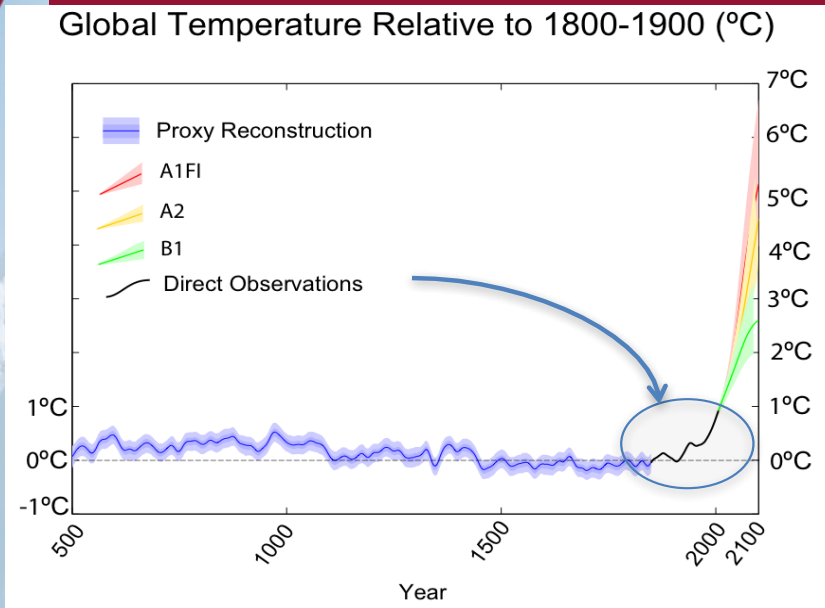
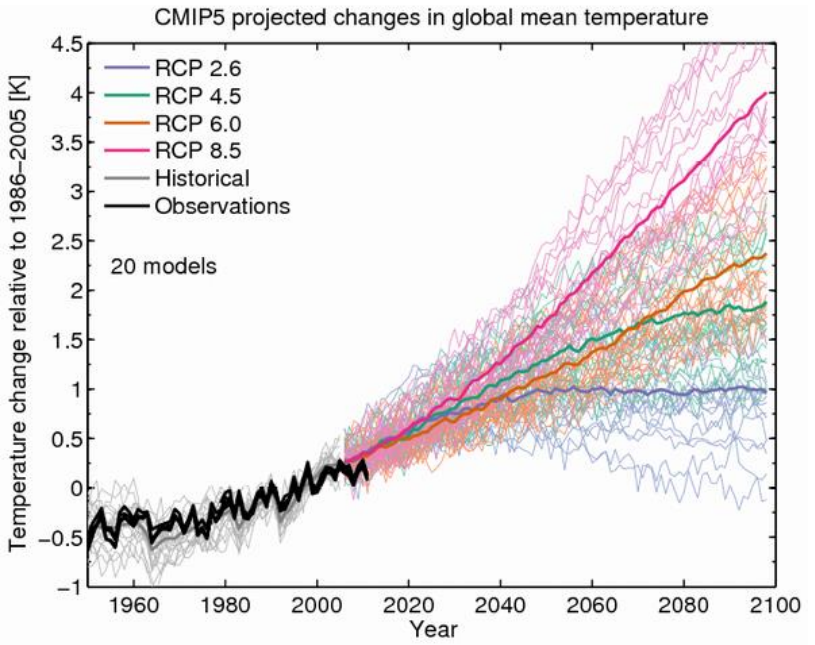
Climate Change Service: Solutions





- How is the climate changing?
- How will it change in future?
- How will it impact society?

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Past, present and future climate information

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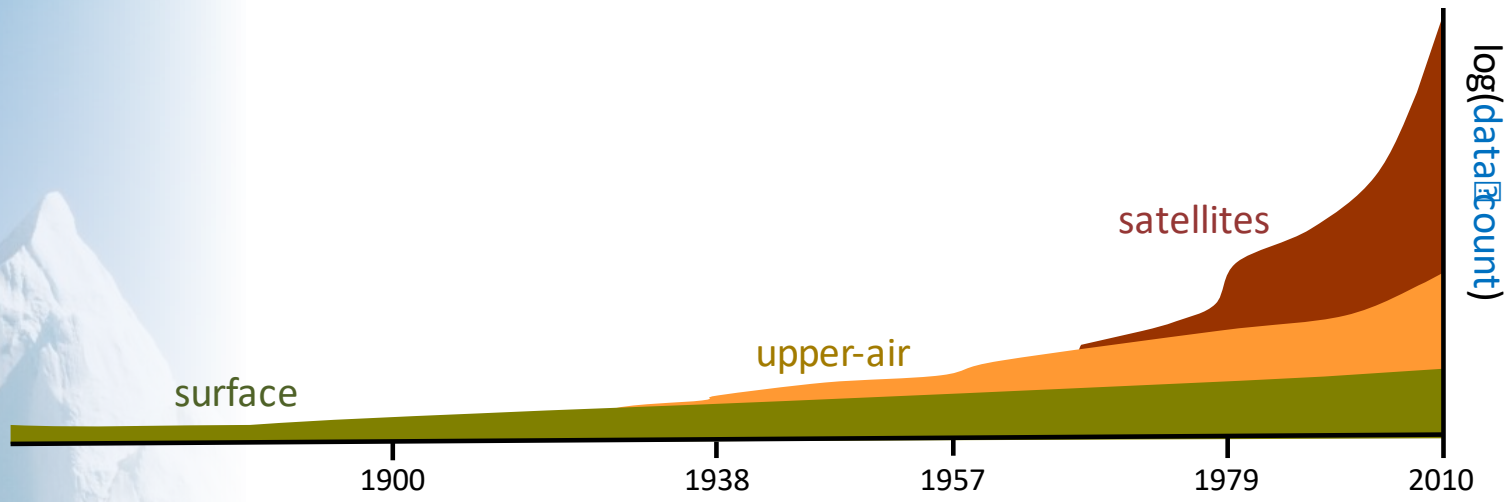
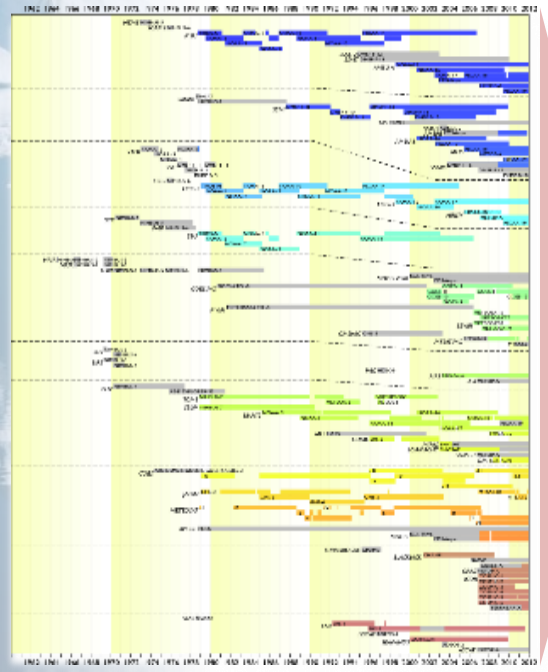
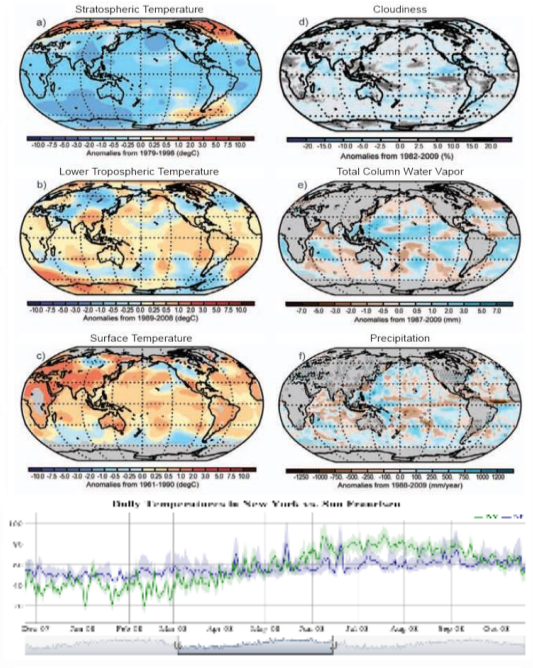


Past Observations

- Exponential increase
- EO data since 1979





Climate Reanalysis

e.g. ERA-5.

Many observation data feed into physical Earth System Models to produce multidimensional data sets.

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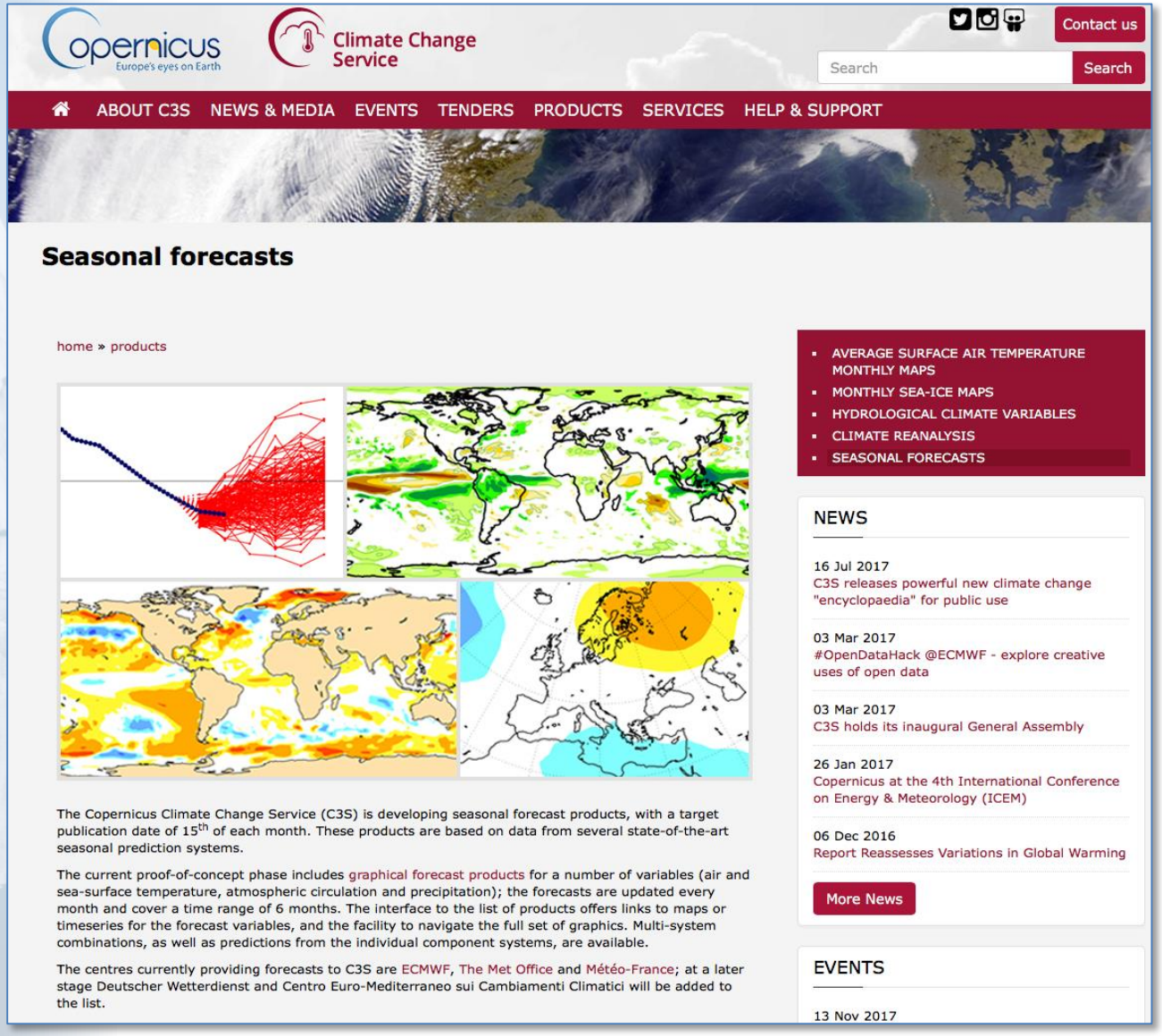
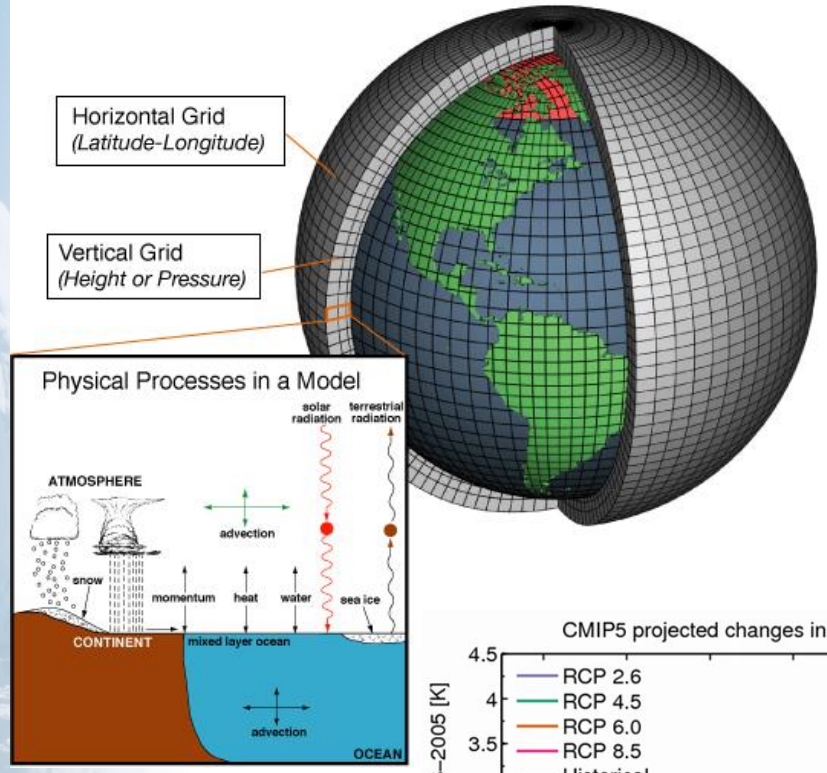
Past, **present** and future climate information

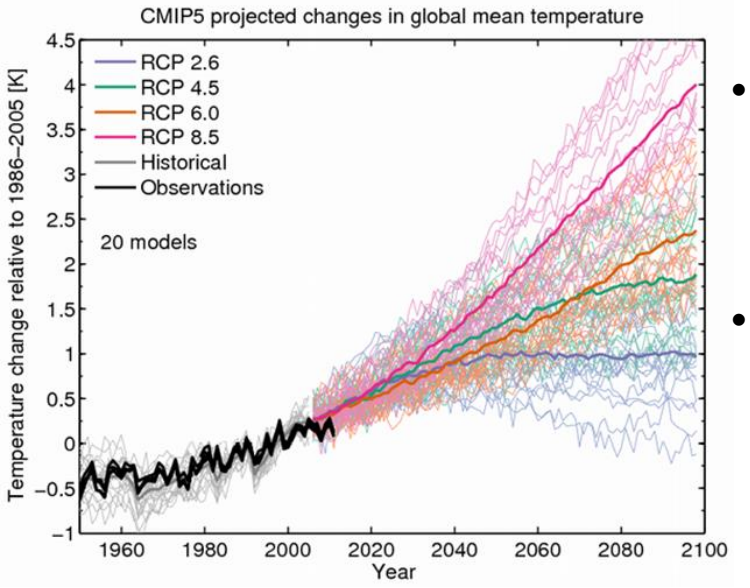


Seasonal Forecasts

- C3S regularly publishes seasonal forecast products
- Updated every month – currently on the 13th day at 12 UTC
- Cover a time range of six months.
- Includes data as well as graphical products
- Based on data from several state-of-the-art seasonal prediction systems.

Past, present and **future** climate information





Climate Projections

- Simulations of Earth's climate in future decades, typically until 2100
- From numerical models of Earth system physics, assuming various 'scenarios' (RCP) for the concentrations of greenhouse gases, aerosols, and other atmospheric constituents that affect the planet's radiative balance.
- Global Climate Models (GCMs) – also known as General Circulation Models – from the Coupled Model Intercomparison Project phase 5 (CMIP5).
- Regional Climate Models (RCMs) from the Coordinated Regional Climate Downscaling Experiment (CORDEX).

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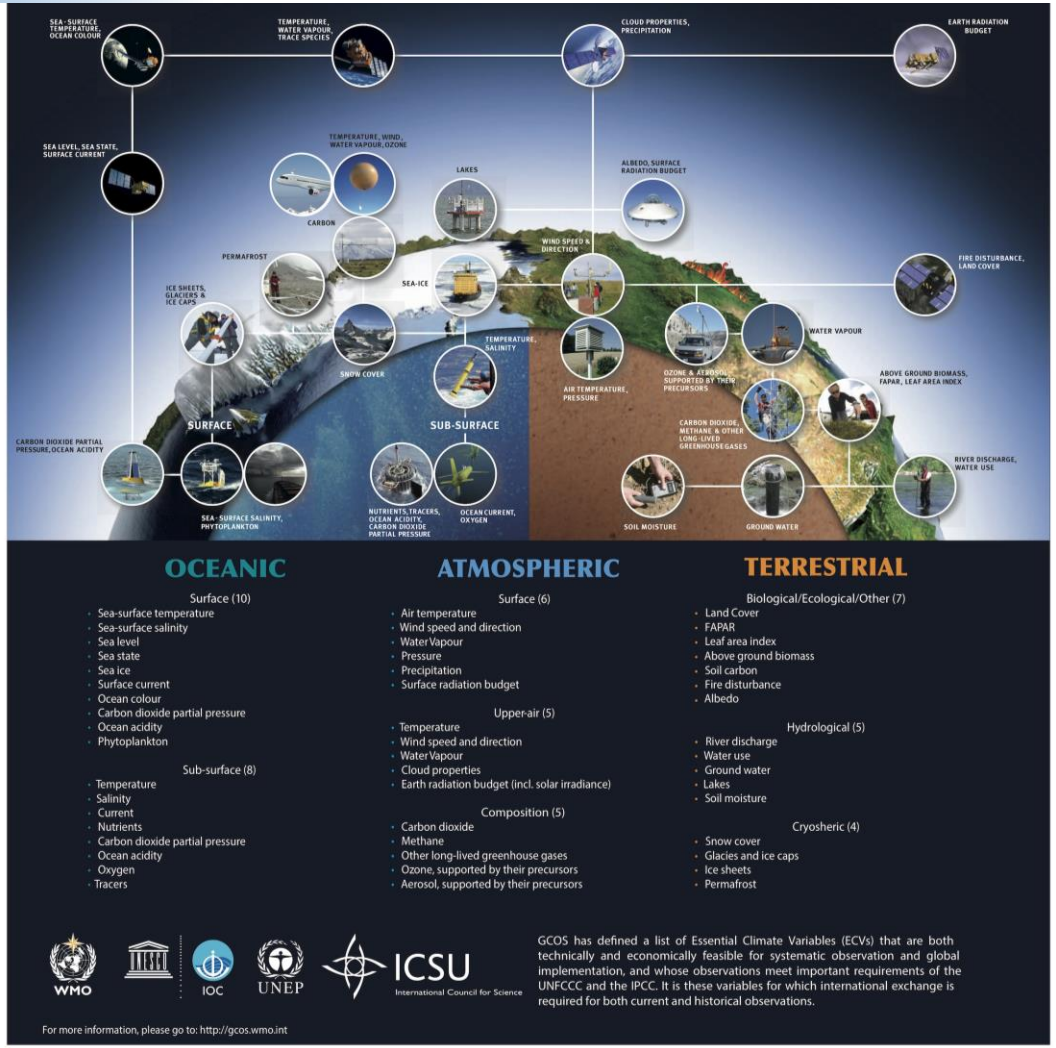
Essential Climate Variables

Global Climate Observing System (GCOS) list of Essential Climate Variables (ECV)



ECVs supported by C3S contracts

			C3S_312a				
				C3S_312b			
		GCOS	2017	2018	2019	2020	2021
Atmospheric physics							
	Precipitation	4.3.5		Lot 1			
	Surface Radiation Budget	4.3.6					
	Water Vapour	4.5.3					
	Cloud Properties	4.5.4					
	Earth Radiation Budget	4.5.5					
Atmospheric composition							
	Carbon Dioxide	4.7.1	Lot 6	Lot 2			
	Methane	4.7.2	Lot 6				
	Ozone	4.7.4	Lot 4				
	Aerosol	4.7.5	Lot 5				
Ocean							
	Sea Surface Temperature	5.3.1	Lot 3	Lot 3			
	Sea Level	5.3.3	Lot 2				
	Sea ice	5.3.5	Lot 1				
	Ocean Colour	5.3.7					
Land hydrology & cryosphere							
	Lakes	6.3.4		Lot 4			
	Glaciers	6.3.6	Lot 8				
	Ice sheets and ice shelves	6.3.7					
	Soil moisture	6.3.16	Lot 7				
Land biosphere							
	Albedo	6.3.9	Lot 9	Lot 5			
	Land Cover	6.3.10					
	Fraction of Absorbed Photosyntheti	6.3.11	Lot 9				
	Leaf Area Index	6.3.12	Lot 9				
	Fire	6.3.15					
			2017	2018	2019	2020	2021

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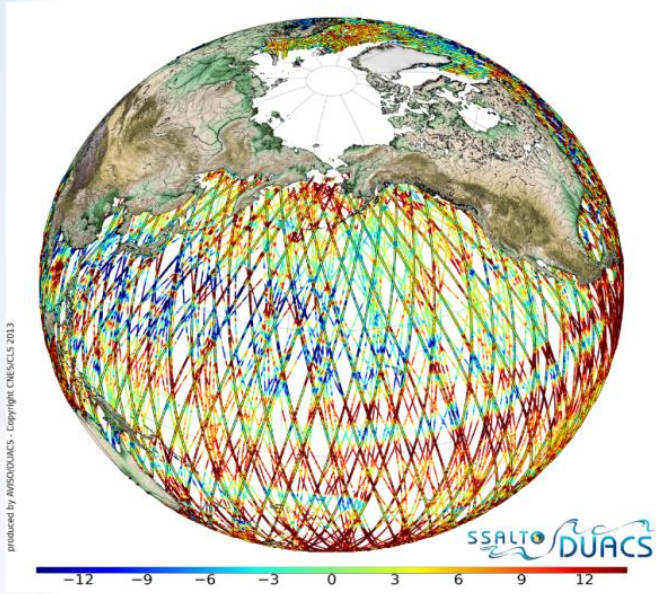
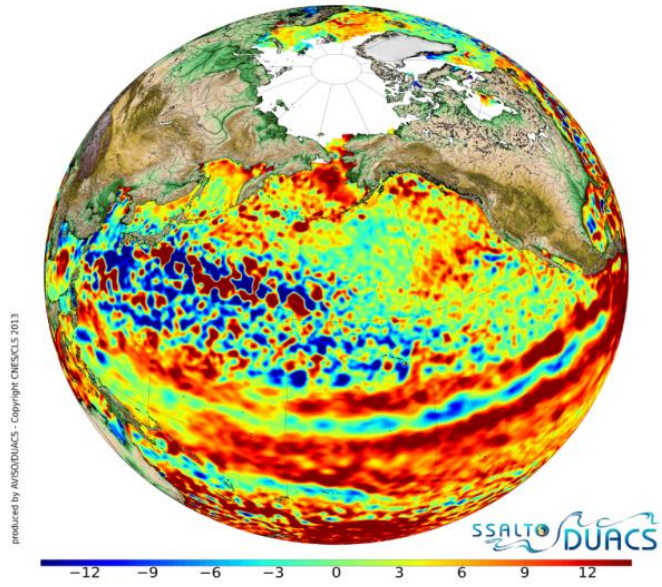
Example: Sea Level ECV production service

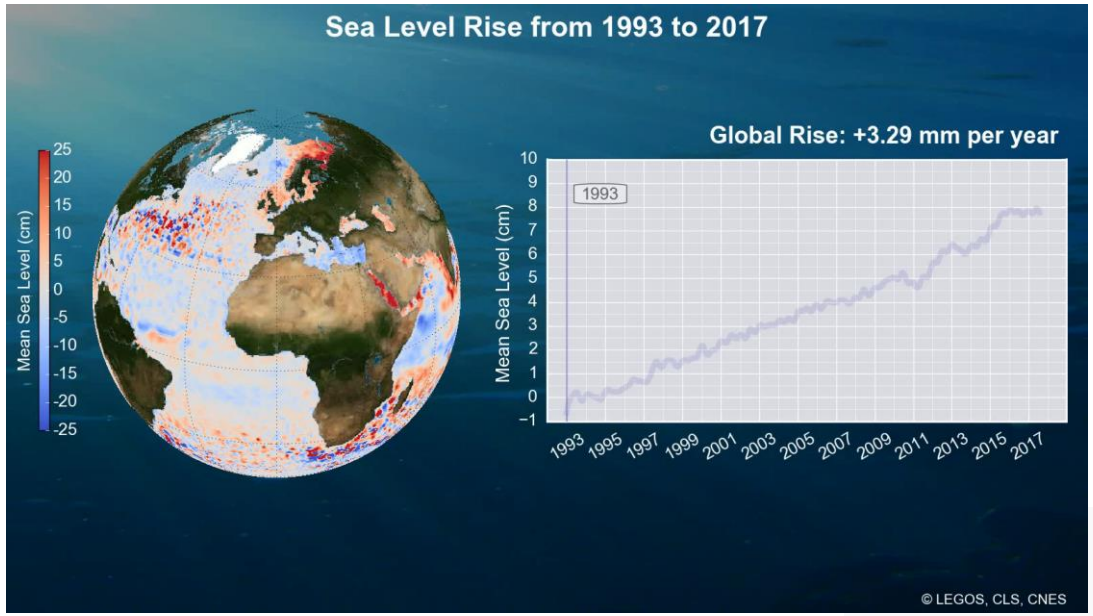


From satellite along-track altimetry measurements…

… to sea level gridded maps…



… to derive Ocean Monitoring Indicators



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C3S and UNFCCC Sustainable Development Goals

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	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.
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.

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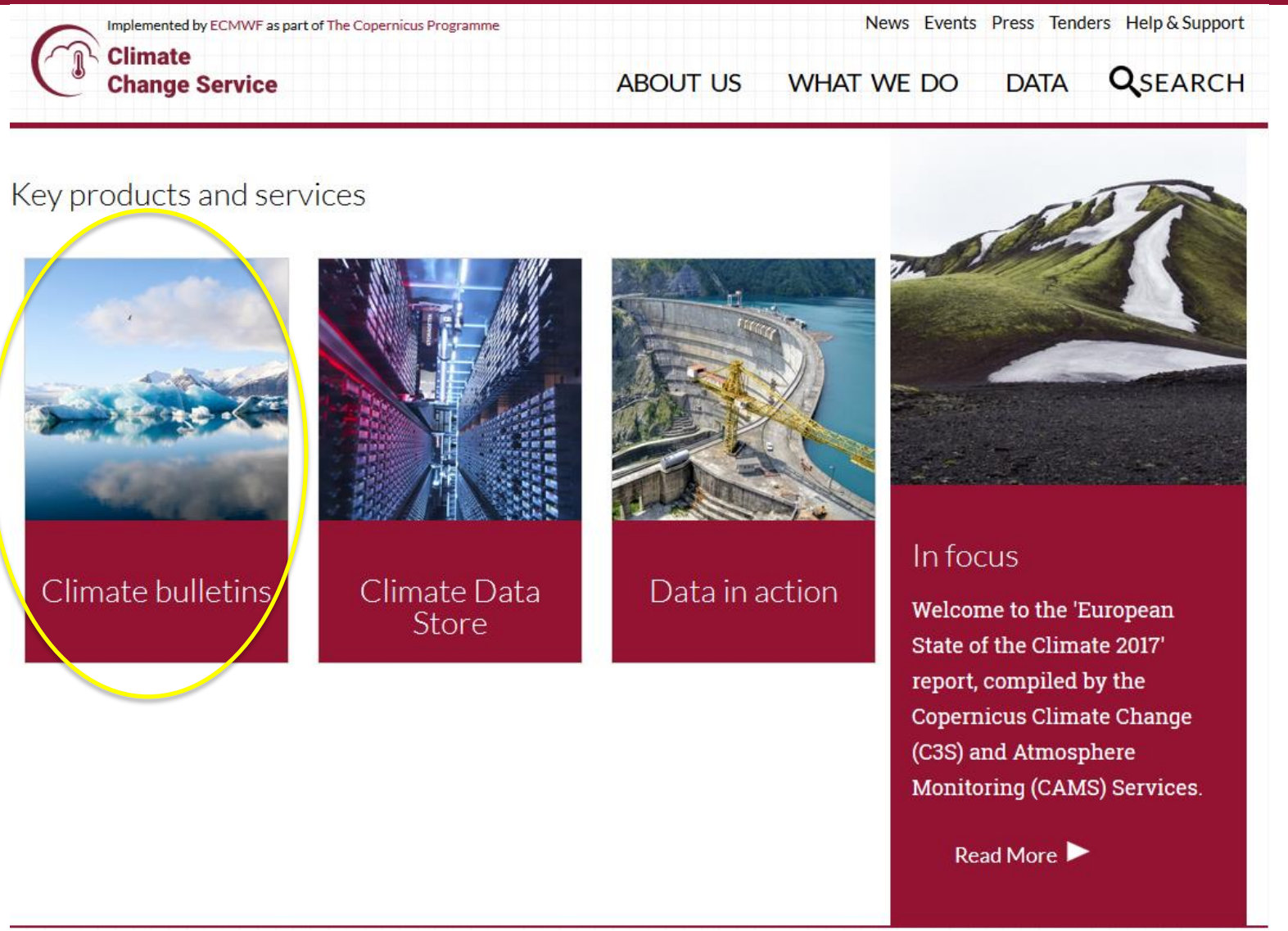

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Monthly Climate Bulletin

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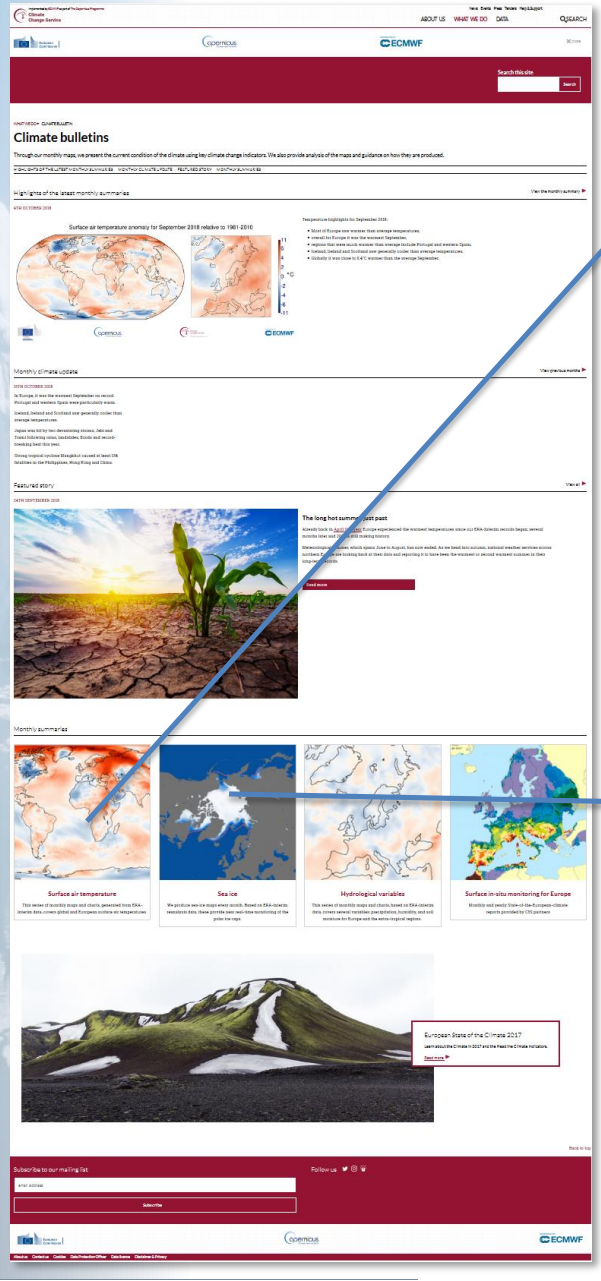
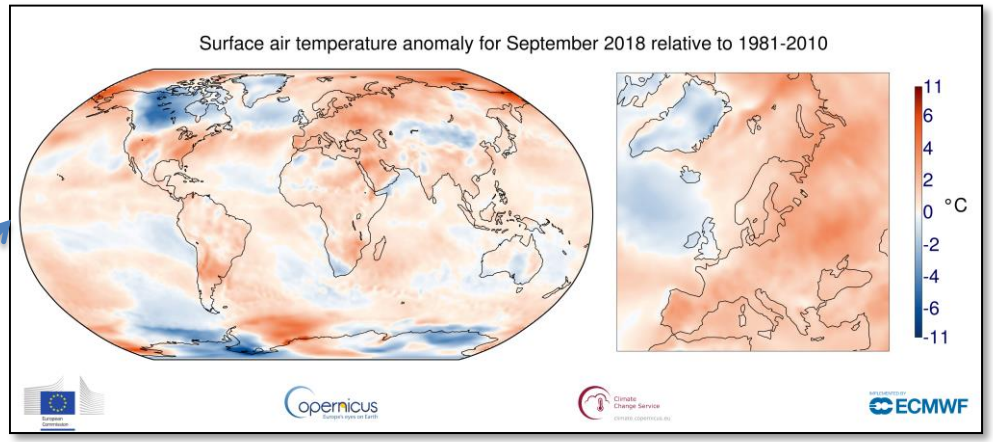
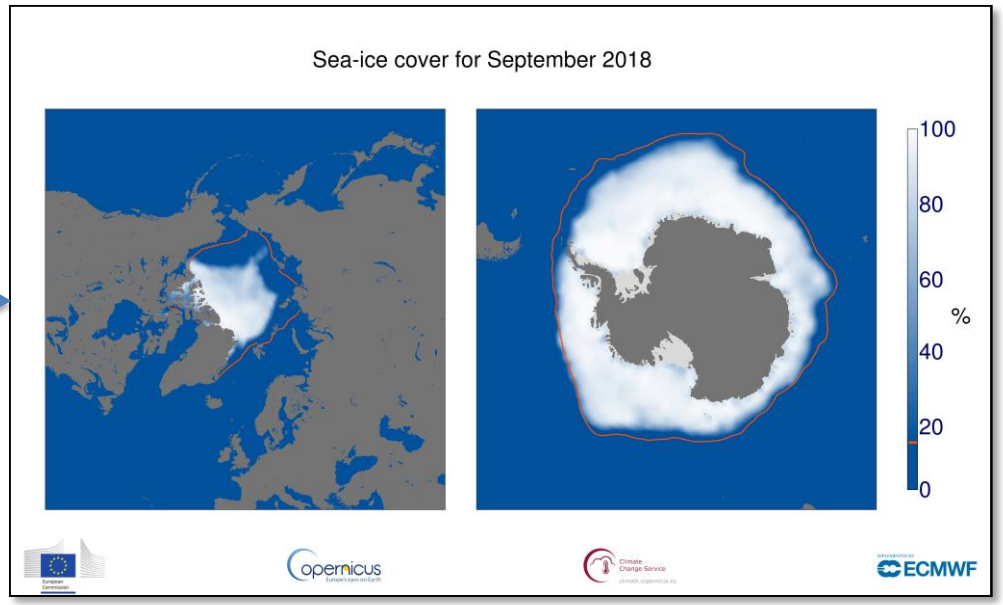




- Globally it was close to 0.4°C warmer than the average September.
- Overall for Europe it was the warmest September.
- Scotland saw generally cooler than average temperatures.



- The pink line denotes the climatological ice edge for September for the period 1981-2010.
- Arctic sea-ice extended much less to the south than is normal for September.

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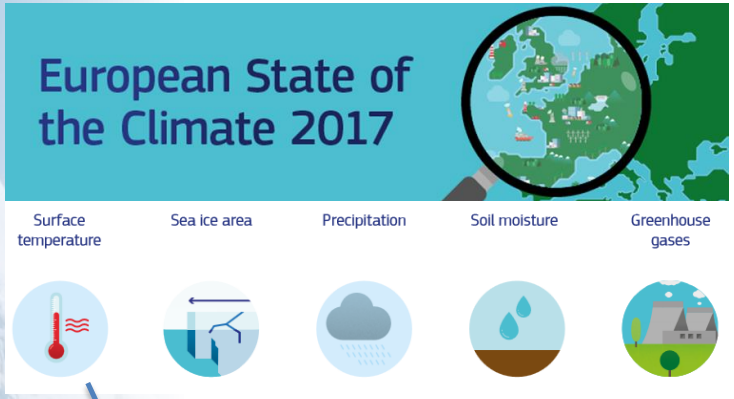
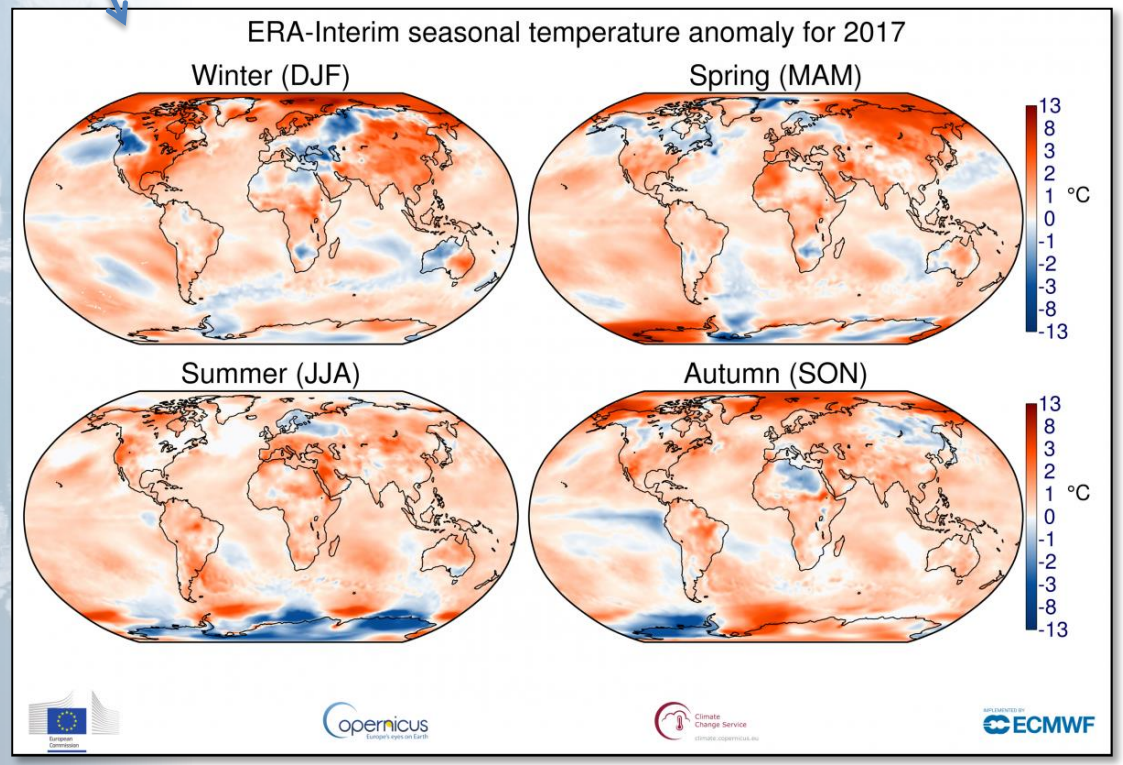
Annual Climate Bulletin



The European State of the Climate 2017 covers two main themes

- The Climate in 2017 and
- Headline Climate Indicators.



- Surface air temperatures for 2017 were higher than the average for 1981-2010 over most areas of land and ocean.
- They were most above the 1981-2010 average in the Arctic but were also well above average over much of North America, south-western Europe, the Middle East, north-western and central Africa, eastern and southern Asia, and offshore of West Antarctica.

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Climate Indicators

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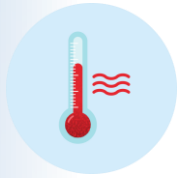


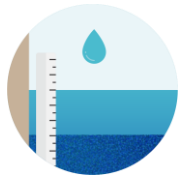
Surface Air Temperature

Greenhouse Gases

Rain

Sea Ice

Glaciers



Sea Level

Soil Moisture

Examples of user uptake by media

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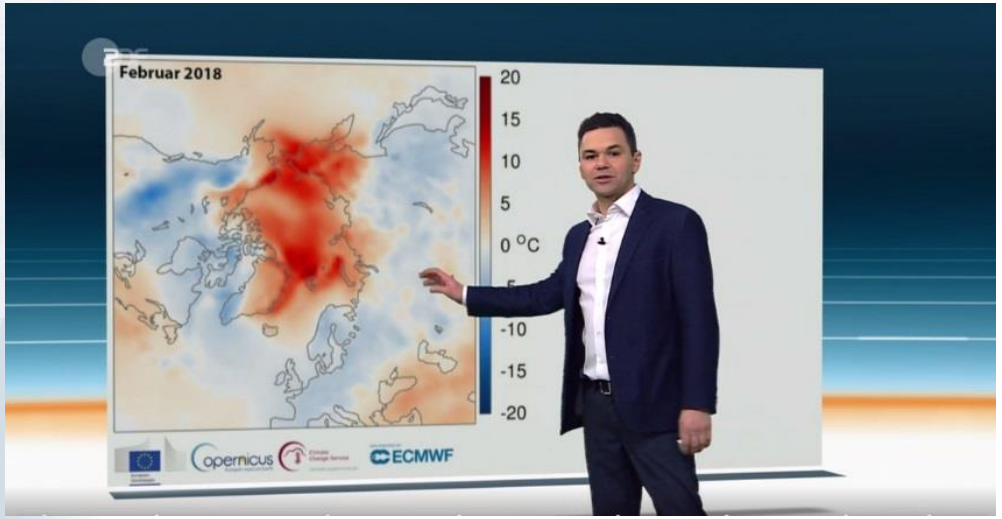
- Standard C3S monthly products
- “Bespoke” C3S products



Credit: ZDF, Özden Terli, C3S

BBC, July 2018

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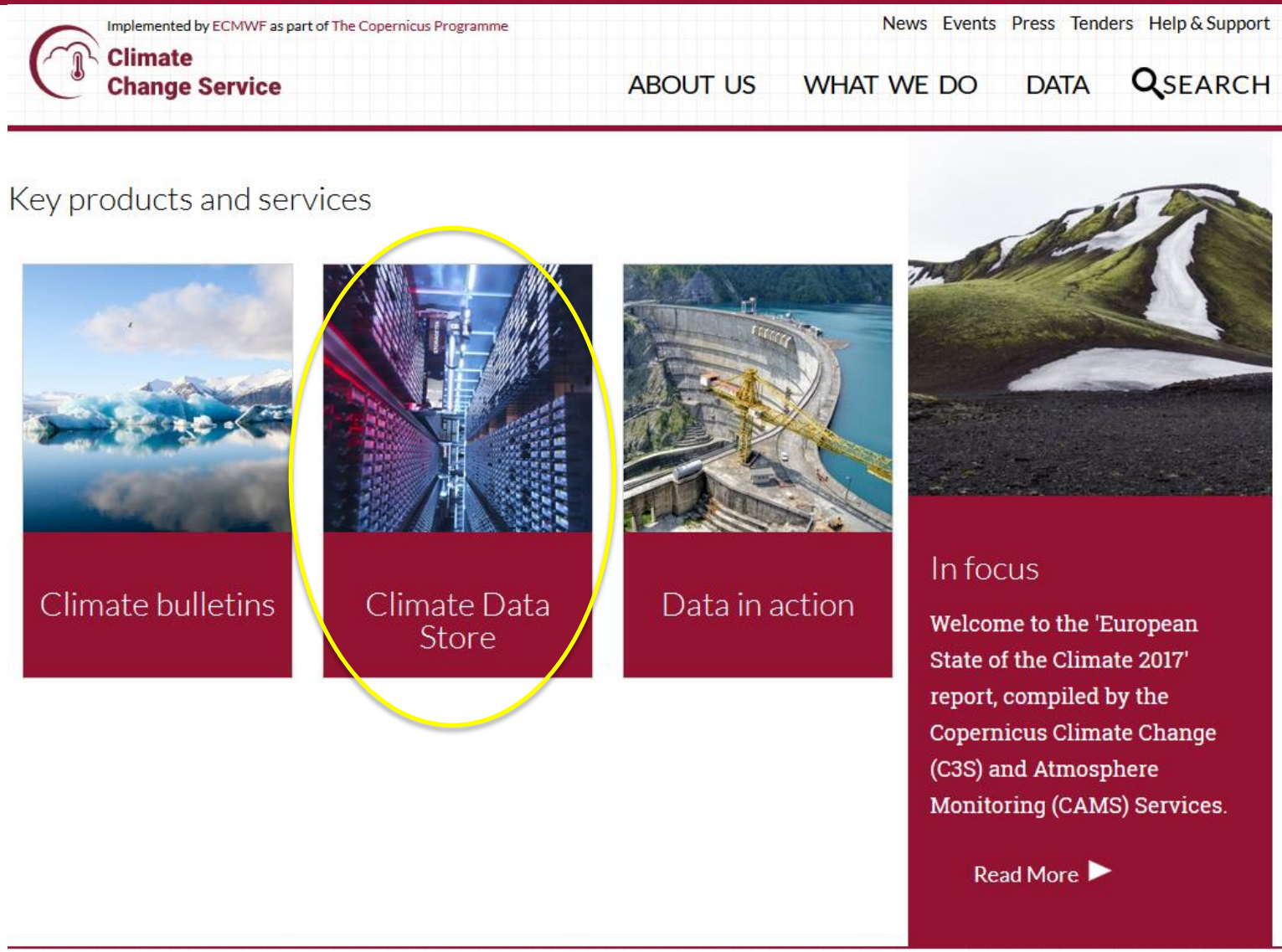

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Climate Data Store

- We have built a store
- The door opened to customers in June 2018
- We continuously put products on the shelves
- Open and free data

cds.climate.copernicus.eu

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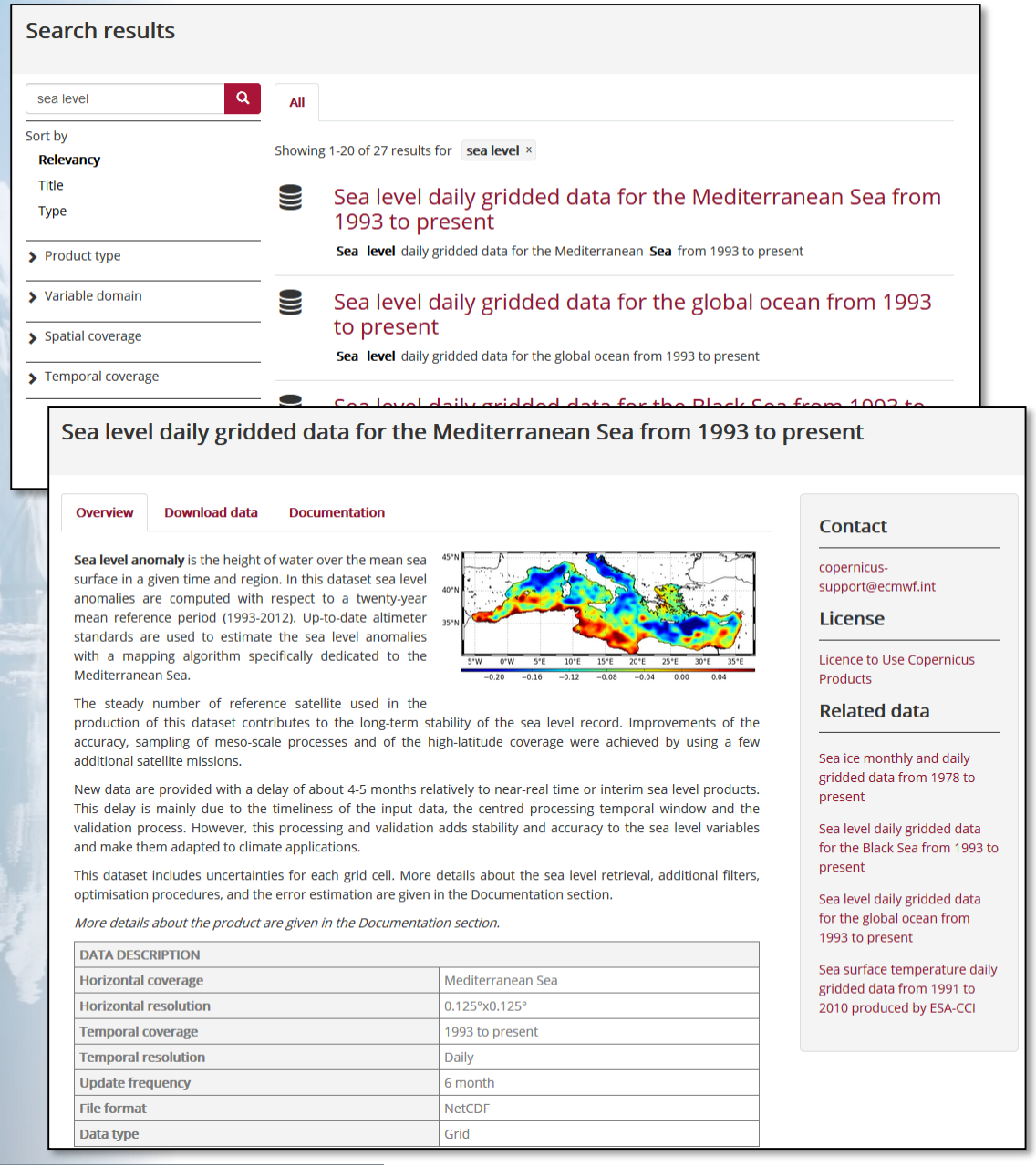
Climate Data Store



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- Search on Keywords
- Filter on Facets
- Data Products and Applications
- Browse Overview
- Access Full Documentation
- Accept Licence
- Download Data

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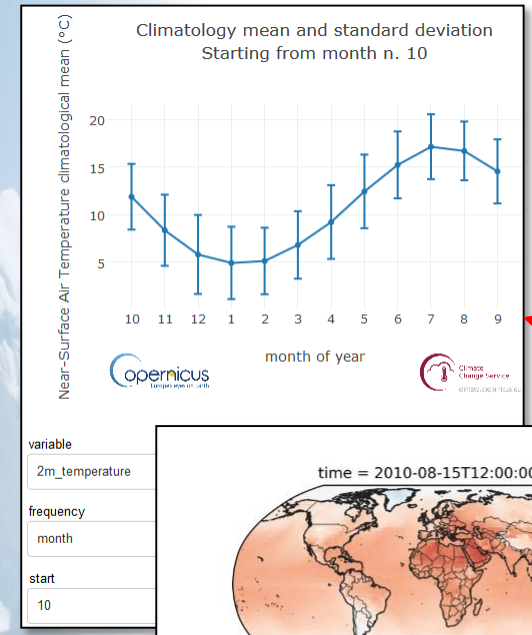
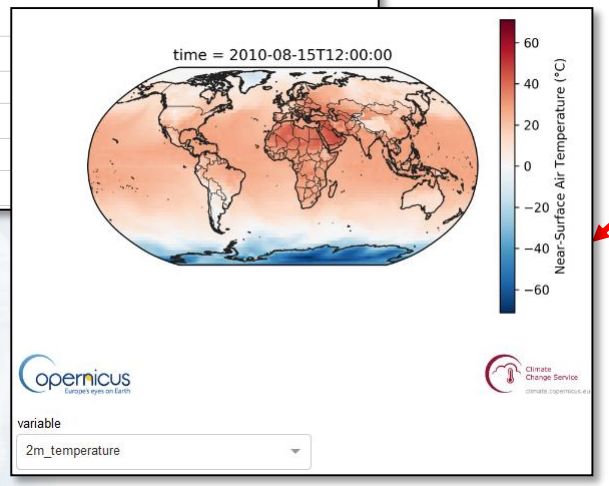
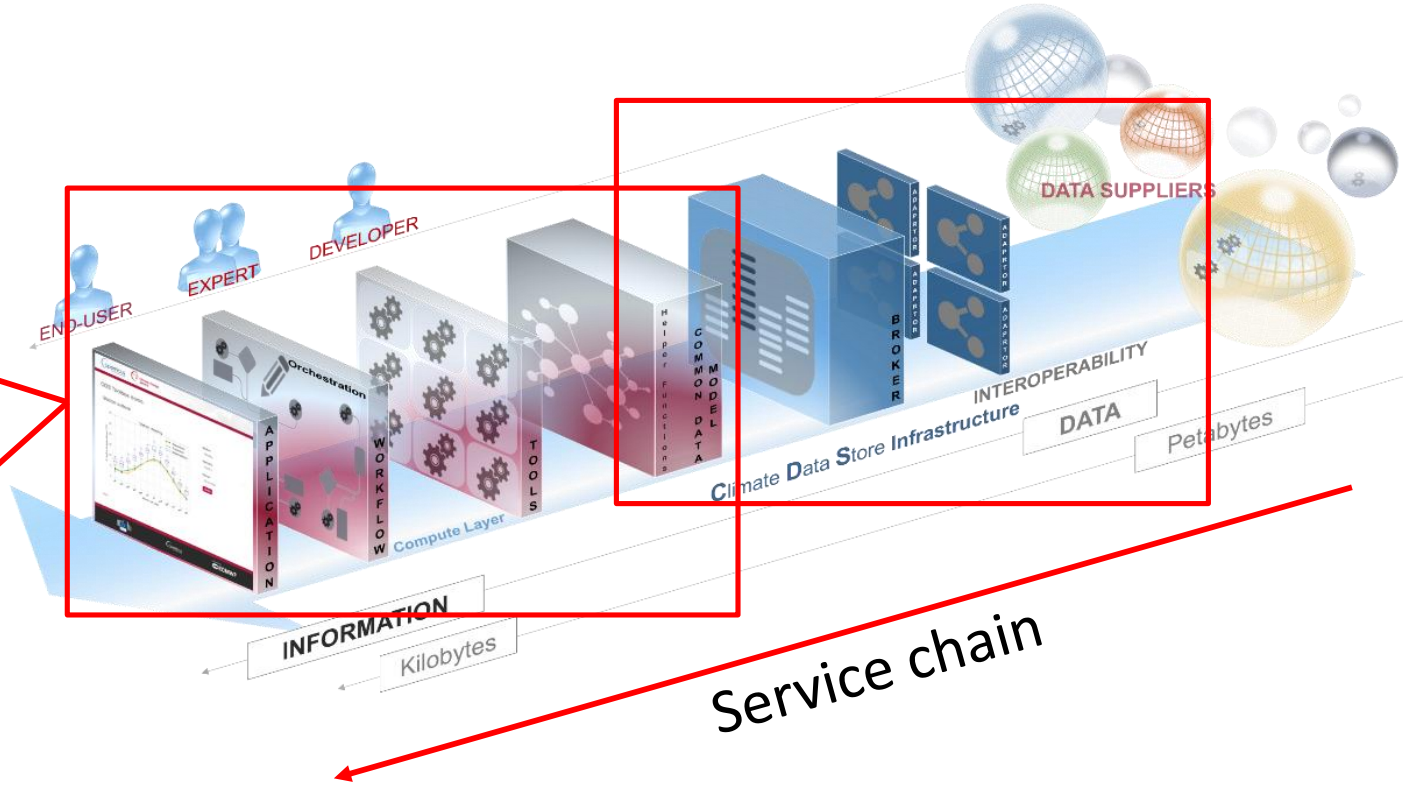
Data, tools, workflows and applications







Quality Assured information and tools for users ranging from scientists to practitioners and policy makers.

One-stop shop for data from multiple suppliers, all harmonised to a common data model and interoperable.

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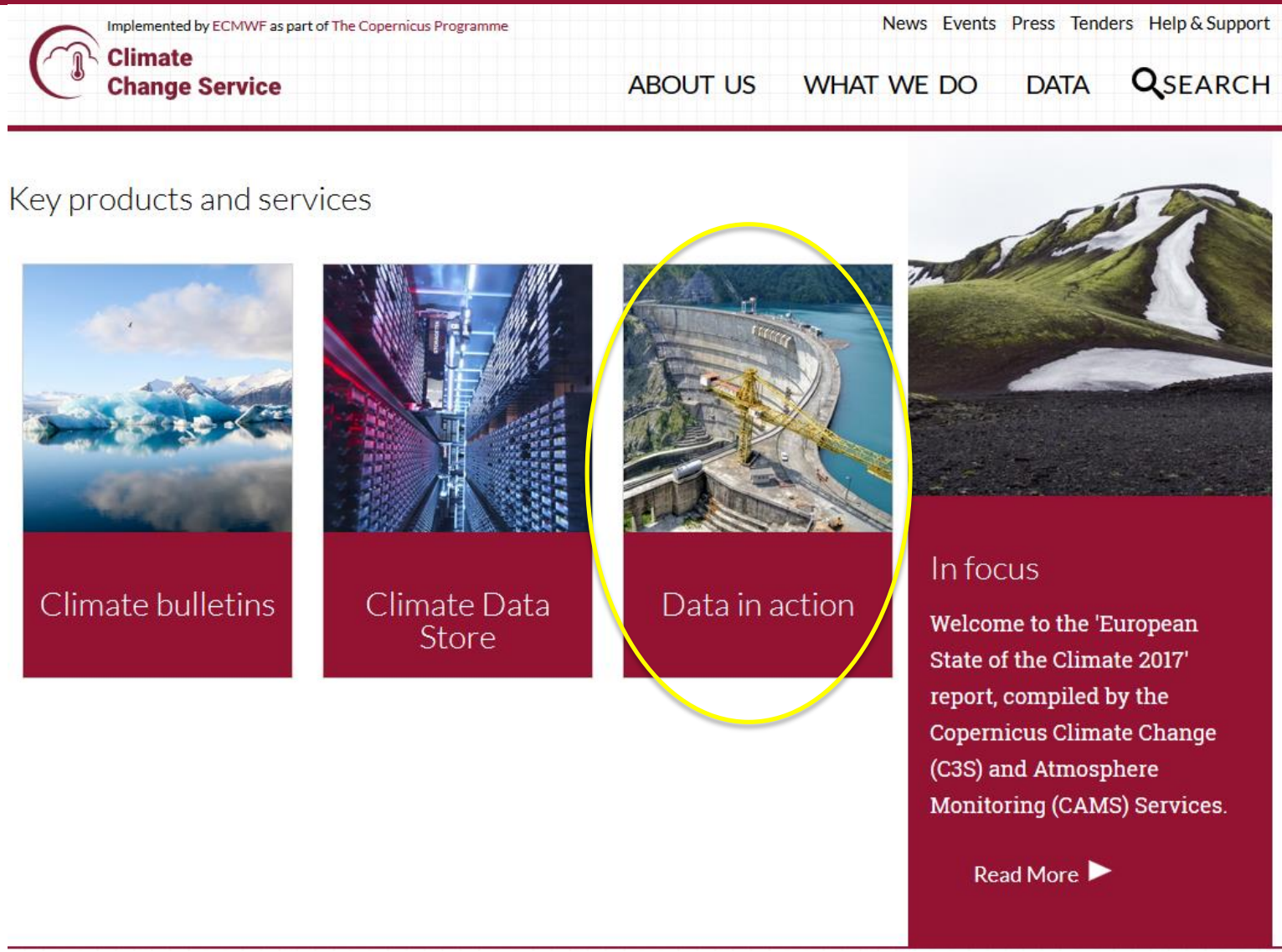

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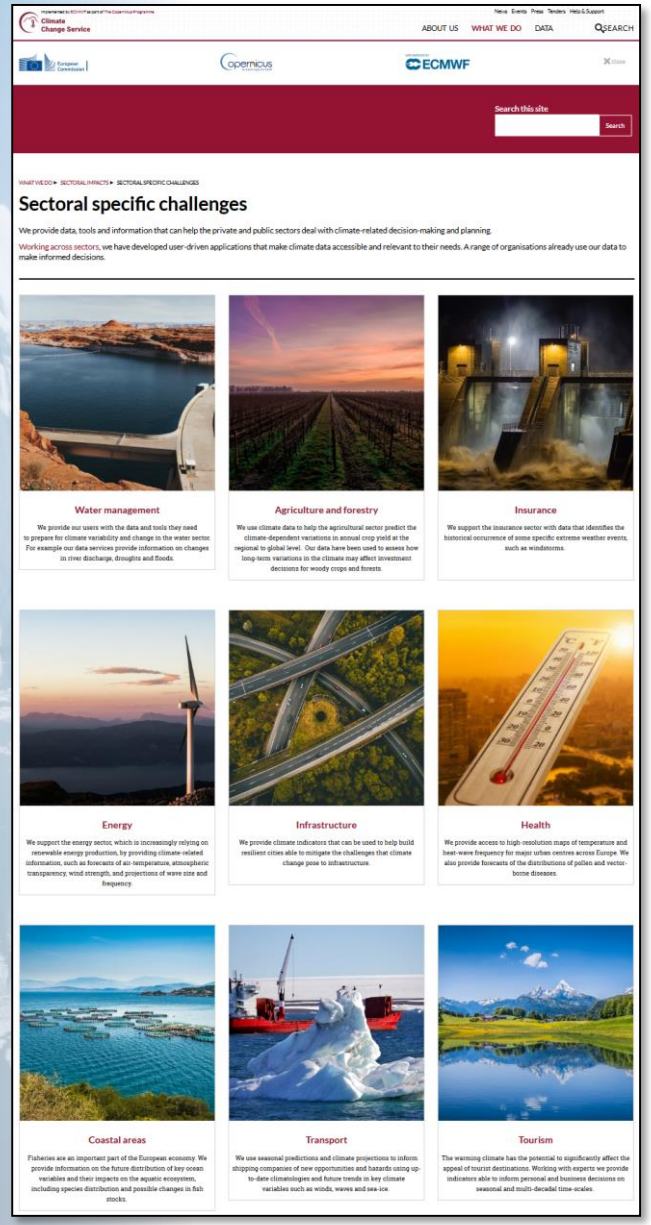
Sectorial Impacts



C3S has developed a number of case studies and applications – known as Sectorial Information Systems (SIS).

These demonstrate how climate data can be accessed, transformed and made relevant to address specific contexts.

- Water management
- Agriculture and forestry
- Insurance
- Energy
- Infrastructure
- Health
- Coastal areas
- Transport
- Tourism

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Examples: Climate indicators related to Shipping

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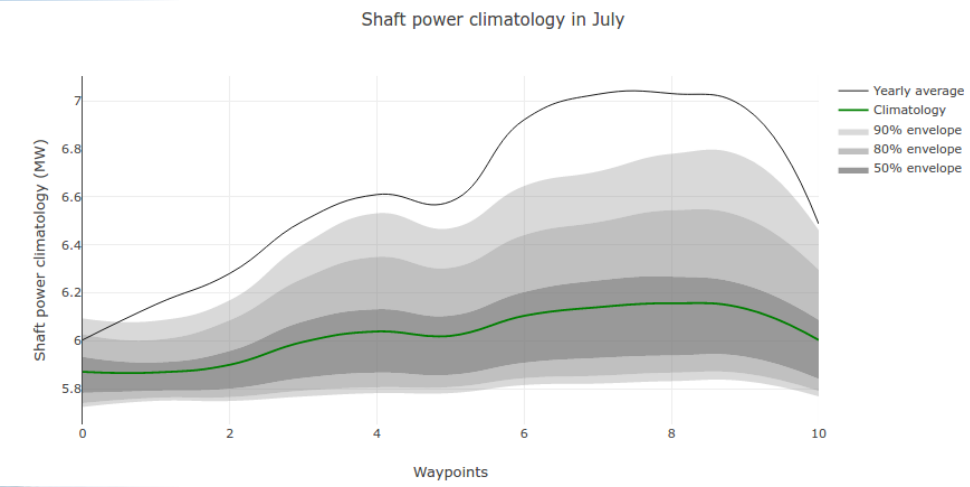
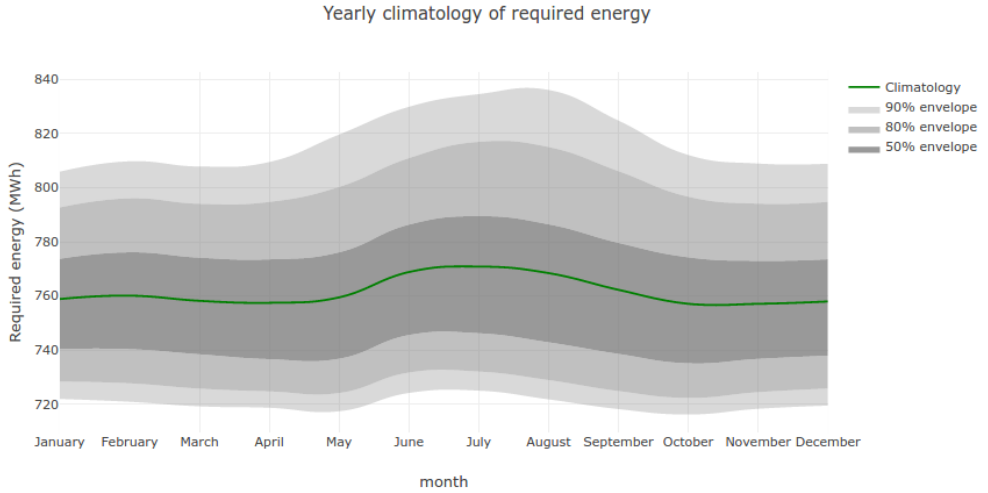
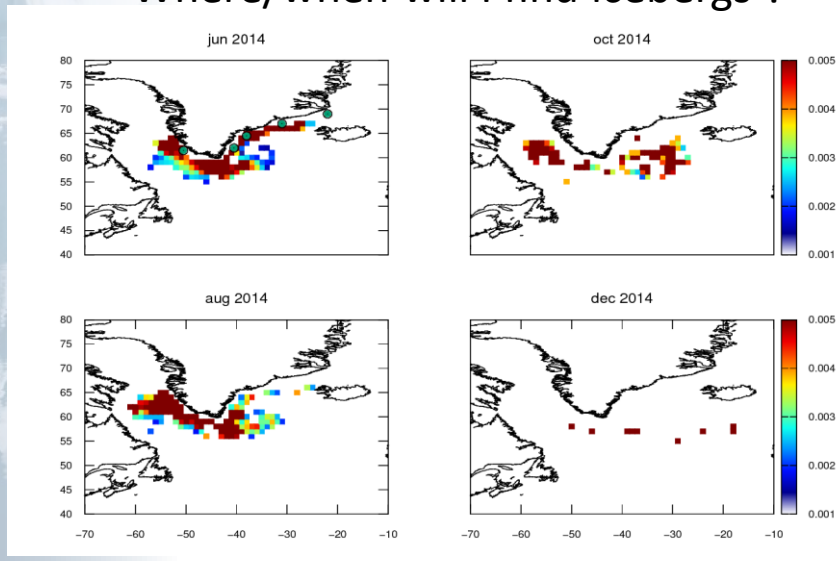
Which part of the route/season is most likely to lead to overconsumption ?

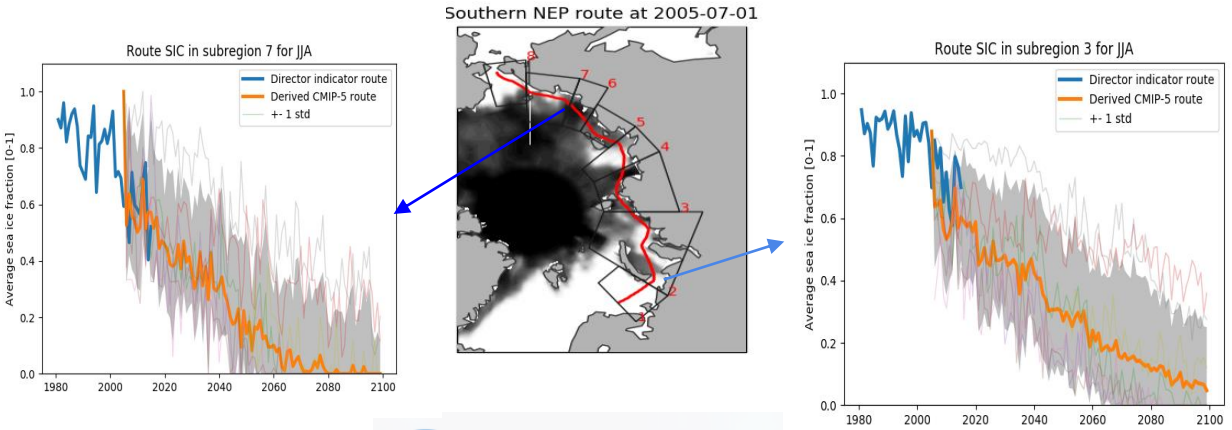




Where/when will I find icebergs ?



When will the Arctic route become commercially viable?



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Case Study: Viticulture in Buzet, SW France

The case study considered 4 key stages in grape vine phenology:

1. Bud Break
2. Flowering
3. Veraison
4. Maturity

Using data from historical observations, a mathematical model was developed to correlate the Day of Year (DOY) reaching each stage, with the accumulated temperature, measured in Growing Degree Days. Then, using simulated future daily weather from climate projections, it was possible to predict how the DOY of each stage might change in future.

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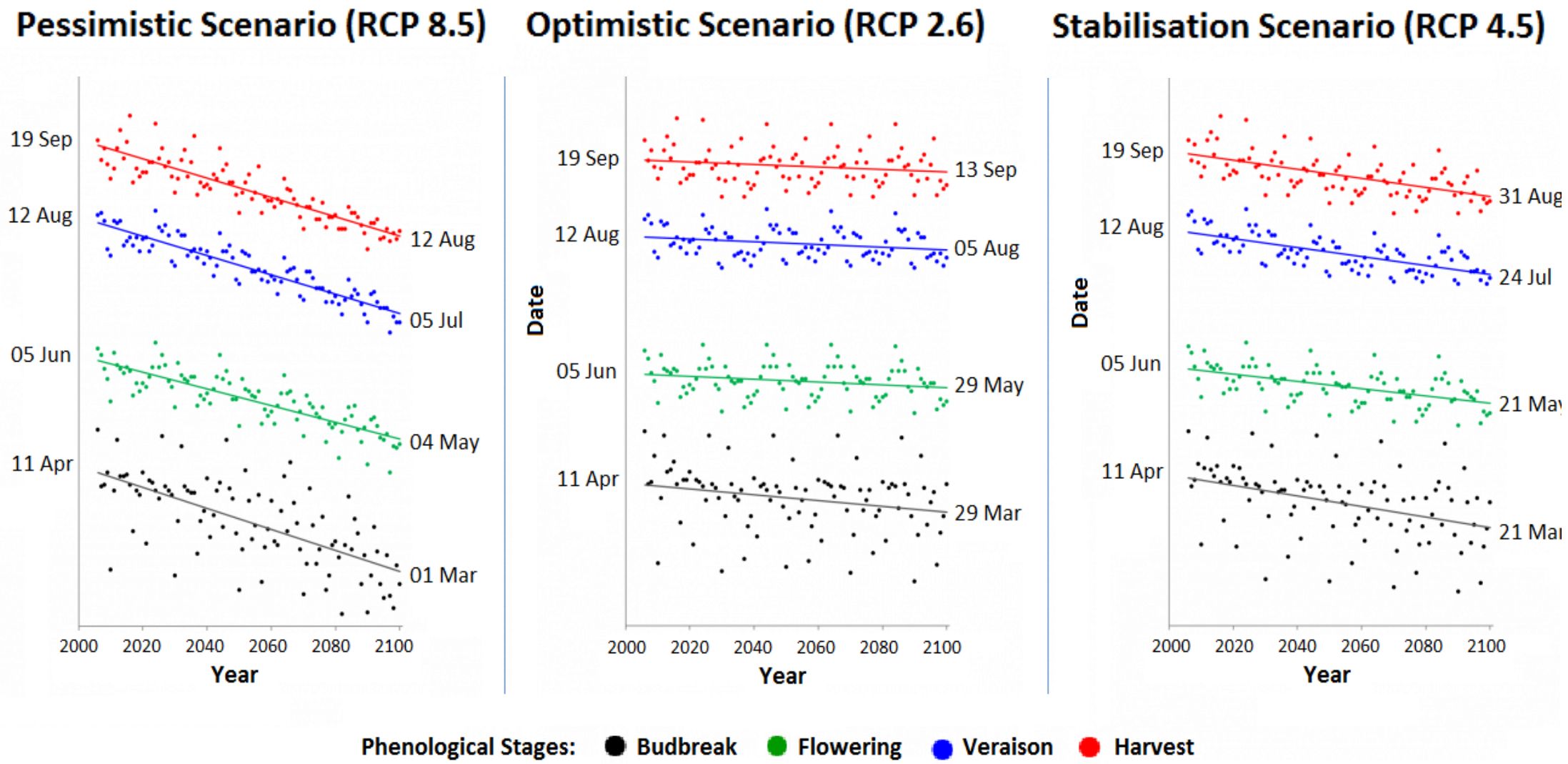
Case Study: Viticulture in Buzet, SW France



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Example: Huglin Index for Grape Varieties

Huglin-Index H	Selected varieties of grapevine which are worth cultivating
H < 1500	Not recommended for cultivation
1500 < H < 1600	Müller-Thurgau
1600 < H < 1700	Pinot blanc, Gamay noir
1700 < H < 1800	Riesling, Chardonnay, Sylvaner, Sauvignon blanc, Pinot noir
1800 < H < 1900	Cabernet franc
1900 < H < 2000	Chinon blanc, Cabernet sauvignon, Merlot
2000 < H < 2100	Ugni blanc
2100 < H < 2200	Grenache, Syrah
2200 < H < 2300	Carignan
2300 < H < 2400	Aramon

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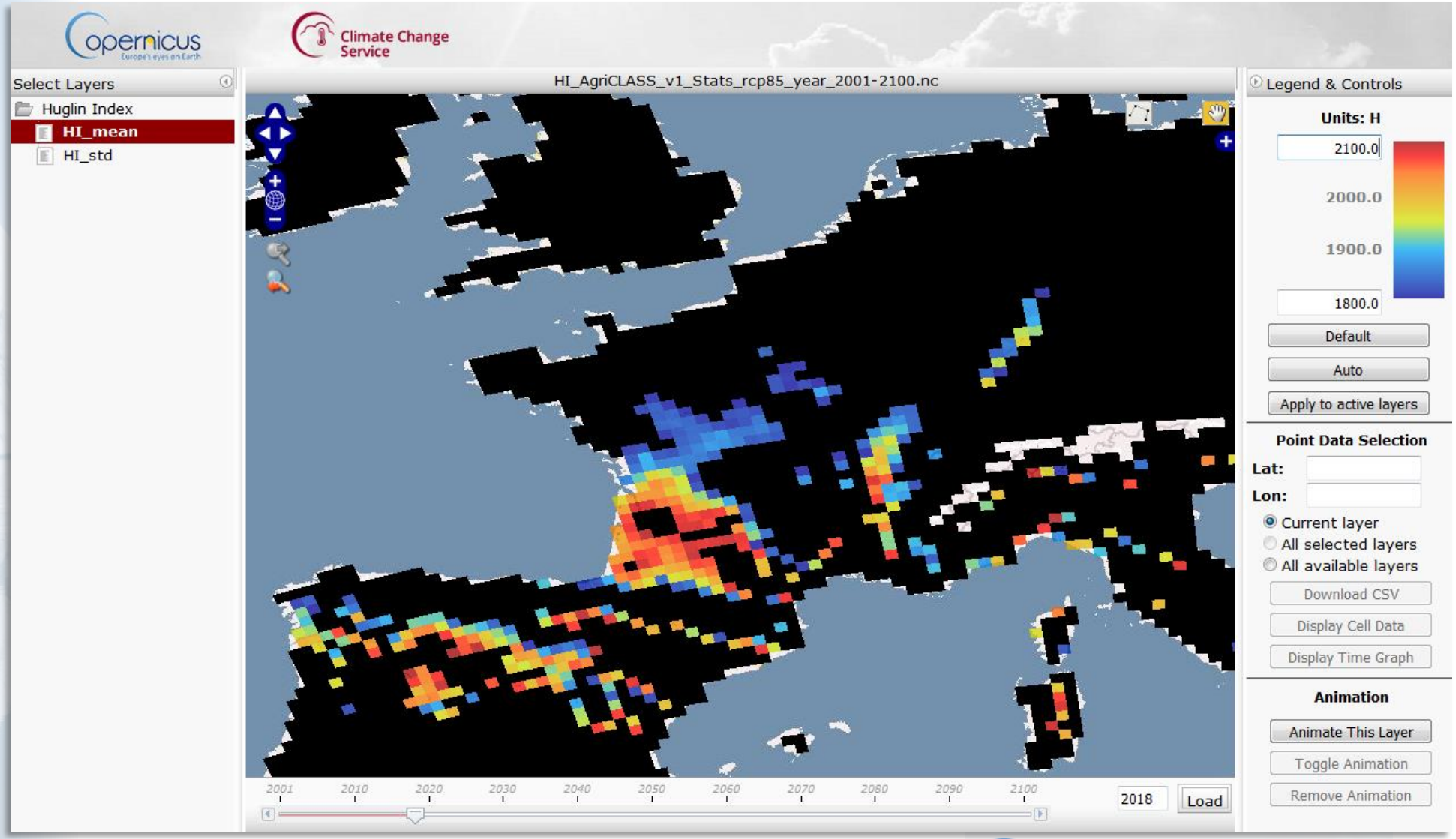
Example: Huglin Index for Grape Varieties (2018)



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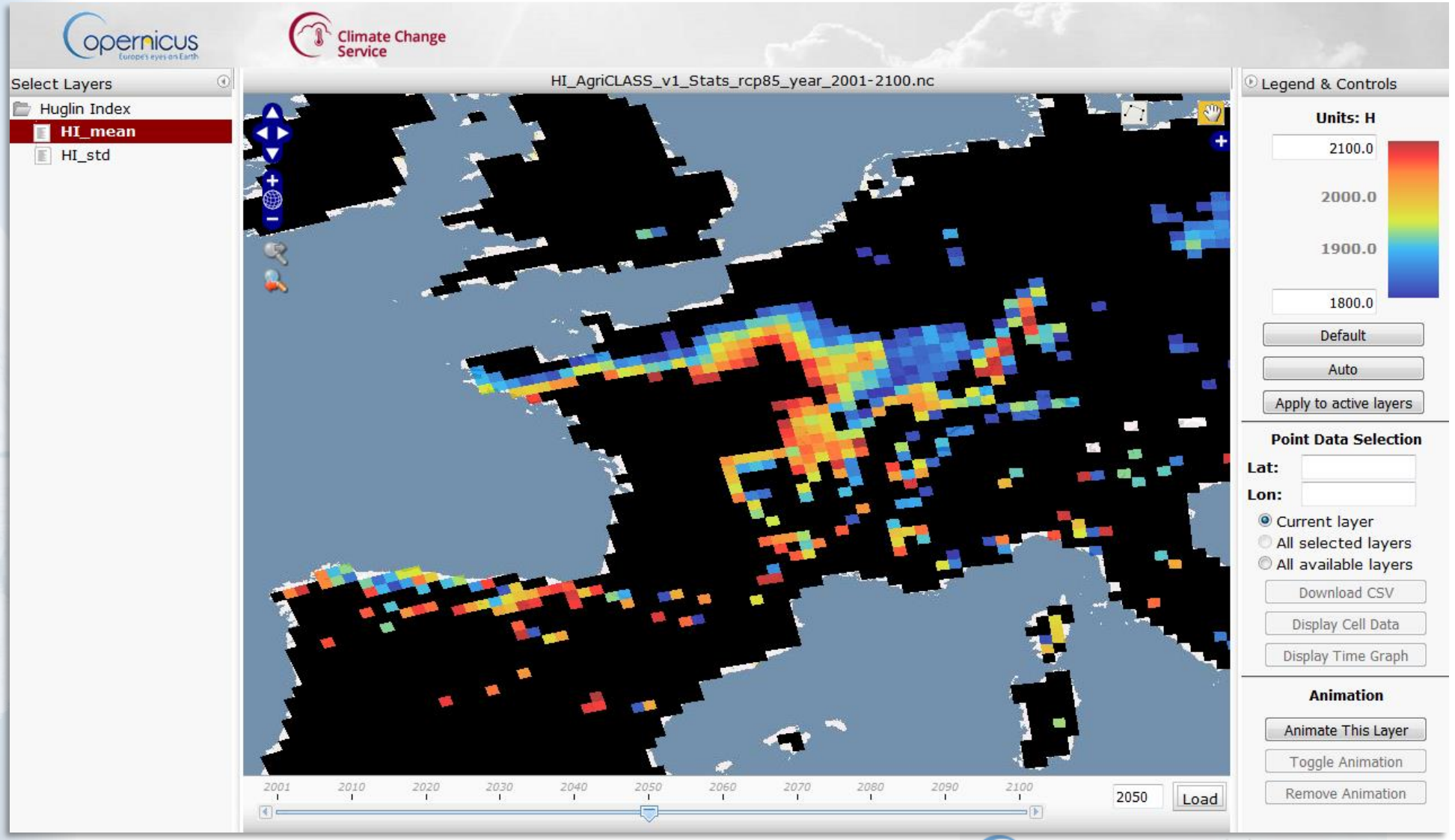
Example: Huglin Index for Grape Varieties (2050, RCP8.5)



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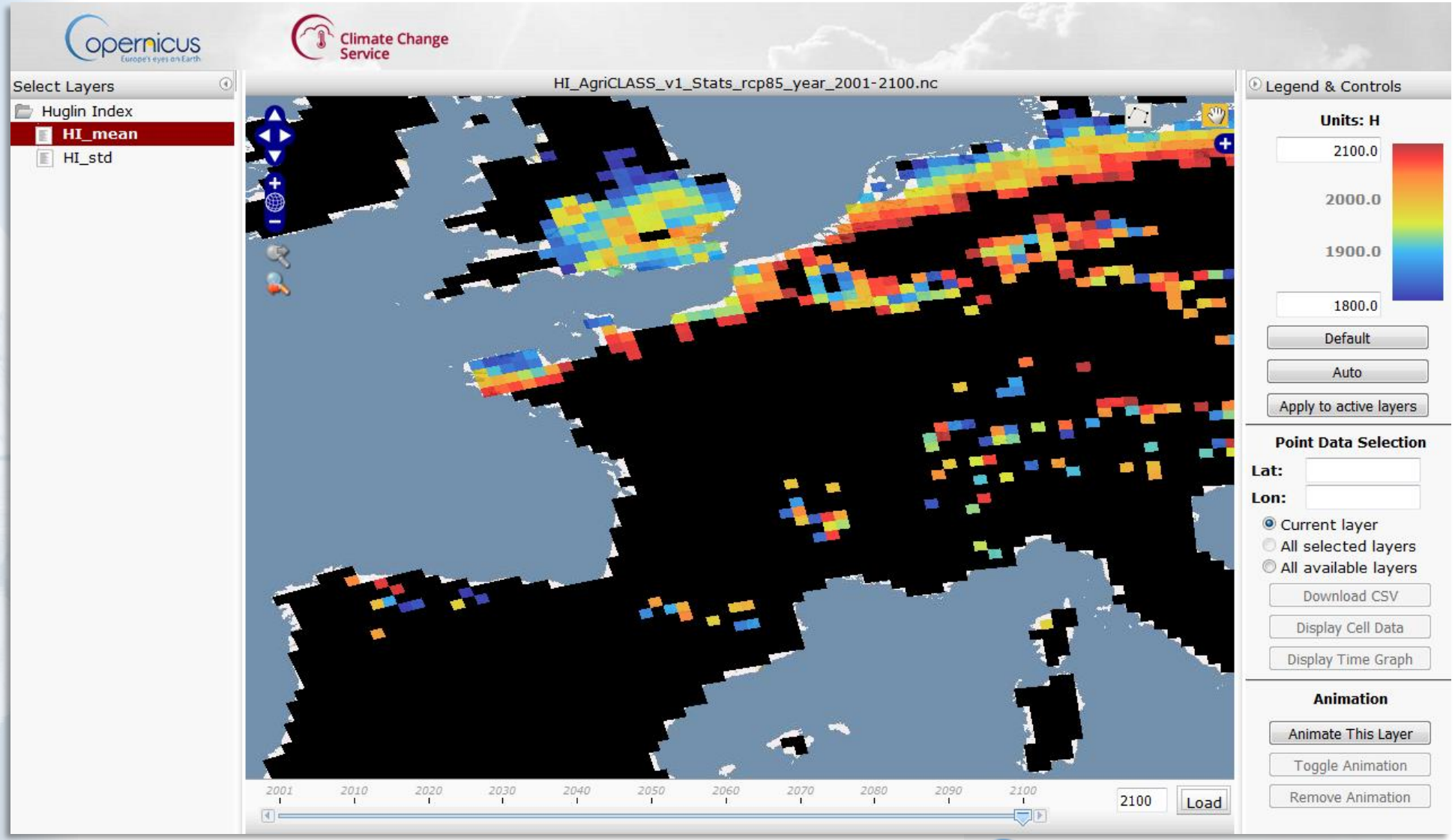
Example: Huglin Index for Grape Varieties (2100, RCP8.5)



Evaluation and Quality Control (EQC)

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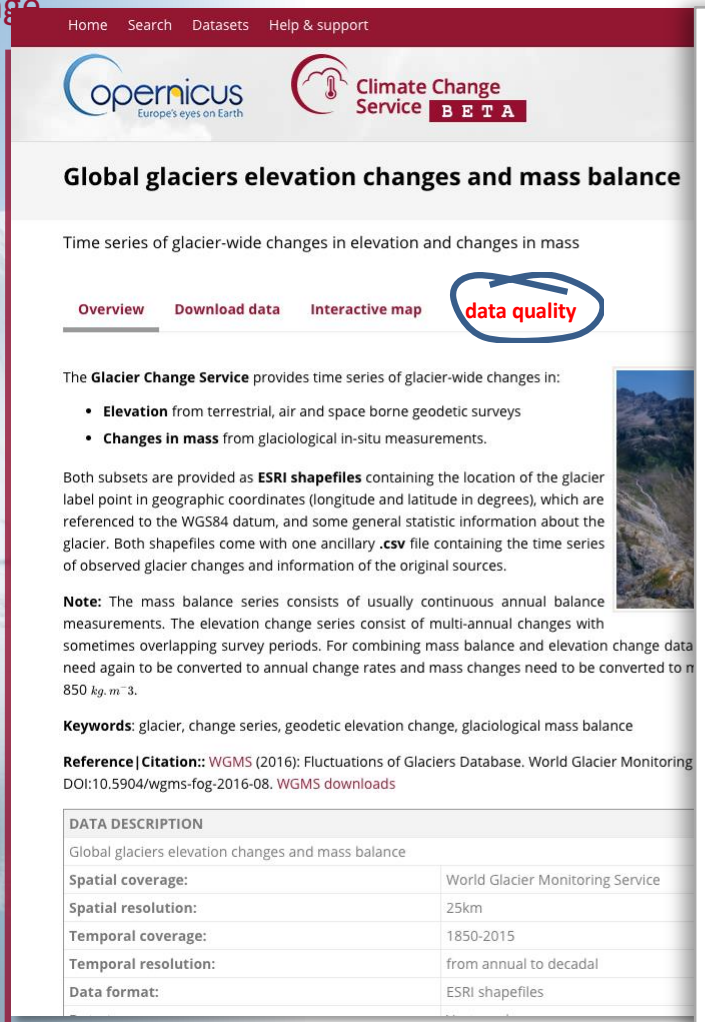

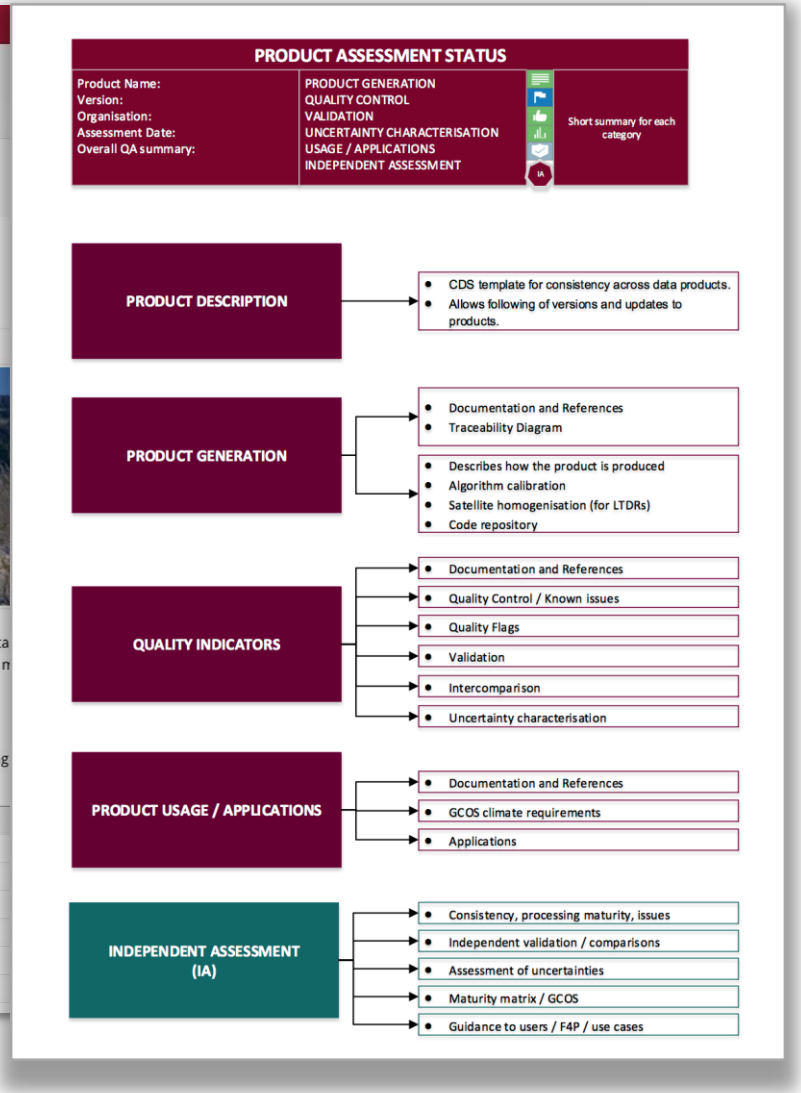

Quality of data

- 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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C3S and the ecosystem

Climate Change

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etc…

Drias les futurs du climat

National Climate Services
- Value chain at local level, governments, etc.
- Provision of pan-European dimension for national businesses

EEA (Climate Adapt):
- State of Climate for Europe
- Climate Indicators
- CDS toolbox
- CC IV report

DG-Clima

GFCS:
- Global products (ECVs, reanalyses, seasonal forecasts and projections)
- WIS compliance
- Training and outreach
- Global SIS
- Liaison with RCCs

H2020/ERA4CS/JPI/KIC/etc.:
- CDS as a data resource
- Liaison with RD projects
- Underpinning science

Coordination with DG-DEvCO

GEO & UNFCCC:
- C3S discoverable through GEOSS portal
- Contribution to many SDGs

GCOS GLOBAL CLIMATE OBSERVING SYSTEM

WMO & GCOS:
- C3S ECVs and global indicators
- WMO State of the Climate

NOAA:
- Coordination on observations and CDR issues with NCEI
- In-kind contribution of NCEP seasonal forecasts

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Conclusions

- C3S is still young and has recently entered its operational phase
- The service provides monthly and annual bulletins and occasional bespoke products
- Climate Data Store (CDS) is state-of-the-art cloud infrastructure for users to freely access an unprecedented range of quality-controlled climate data and information.
- CDS provides a compute layer allowing users to create and run their own applications / workflows on the cloud without downloading huge volumes of data.
- C3S includes a series of exemplar applications to show how the infrastructure can be used to address specific user needs: SIS (Europe, Global), Use Cases, Demonstrators, Downstream Services
- The Quality Assurance process within C3S is unique and absolutely critical
- C3S serves a wide range of European and worldwide users and bodies: EU DGs, WMO, GCOS, GFCS, EEA, etc.

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Climate Change and the Urban Environment

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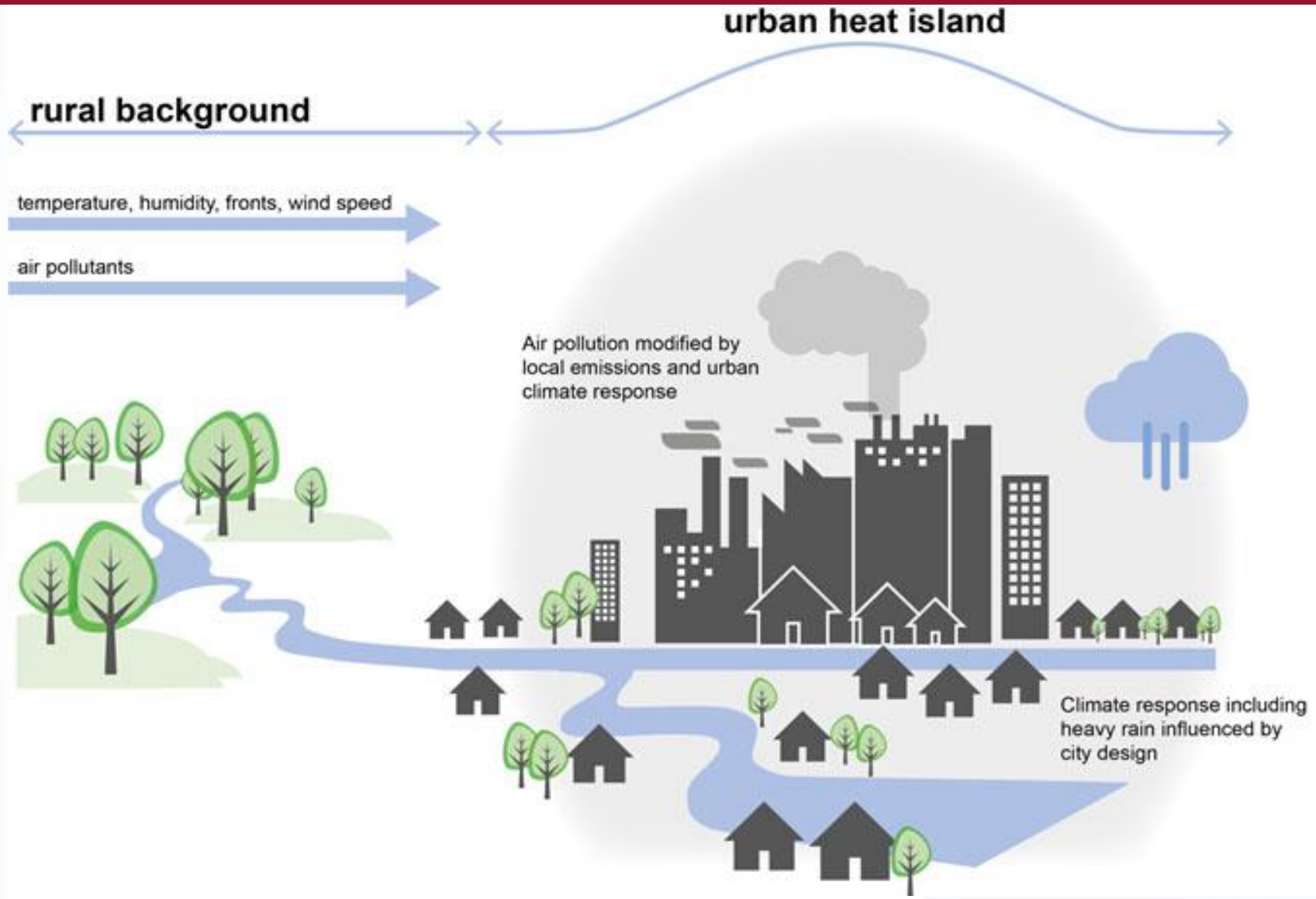
Climate Impacts



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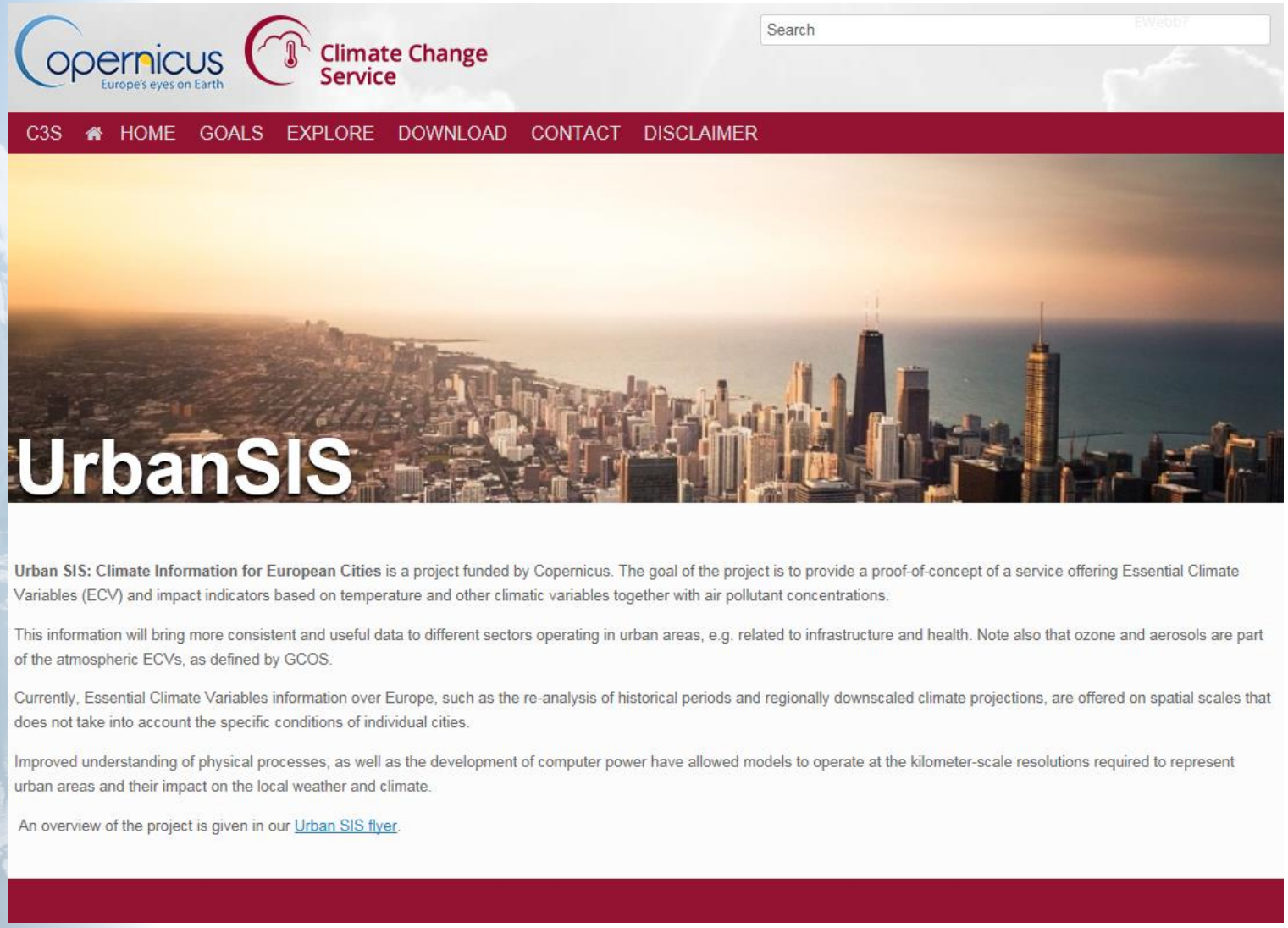
Urban SIS Project



Urban Sectorial Information System (Urban SIS)

A demonstrator project from the proof of concept phase of the C3S programme

Active: Oct 2015 – Dec 2017

Project Partners

- Swedish Meteorological and Hydrological Institute (SMHI)
- University of Reading,
- University of Umea, SE
- ARPA
- University of Bologna
- WSP
- Veryday

http://urbansis.climate.copernicus.eu/

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Target Users

Advanced end users (consultants, urban engineers, modellers):

- improved input data to run local impact models
- consistent ECV variables, dynamically downscaled
- both historical periods and future climate projections (climate adaptation required also today!)
- generation of city-specific impact indicators
- possibility for an extended commercial market of local assessments

Urban planners in general:

- the spatial perspective (maps) allow identification of “hot spots”
- possibility to compare and prioritize different climate-related threats to a specific city and a specific sector
- possibility to compare impact indicators from one city to another
- possibility to discuss problems and solutions across different sectors (different indicators based on the same ECVs)

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Aims

- Provide **city-specific** climate data and impact indicators to support the infrastructure and health sectors operating in cities.
- Develop, demonstrate and test a method to **downscale** climate and impact indicators to the urban scale (~1x1km^2)
- Deliver the information in such **format** that it is directly useful for consultants and urban engineers/scientists as input to specific/local models or dimensional calculations
- Concerning in particular the following urban **hazards**:
  - Intense rainfall
  - Heat waves
  - Extreme air pollution levels

HEALTH

INFRASTRUCTURE

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Sectorial Indicators

Health Sector

Heat Stress
- Number of hot days
- Heat wave duration
- Heat induced mortality

Discomfort
- Thom Discomfort Index
- Universal Thermal Climate Index
- Frequency of tropical nights

Air Quality
- EU limit values: concentration
- EU limit values: concentration
- Mortality long-term exposure
- Mortality short-term exposure

Infrastructure Sector

Flooding
- Short duration extreme precipitation
- Short duration extreme precipitation intensity/duration

Green infrastructure
- Growing season length

Transport infrastructure
- Frost days
- Ice days
- Zero-crossings

Energy Sector

Energy consumption
- Heating degree days
- Cooling degree days

Solar energy
- Shortwave solar insolation

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Essential Climate Variables (ECV)

Temperature
- Air temperature
- Urban air temperature
- Nature air temperature
- Higher layer air temperature

Precipitation
- Precipitation
- Snowfall

Other meteorological variables
- Wind
- Boundary layer height
- Total Cloud Cover
- Relative Humidity
- Global Radiation
- Direct shortwave radiation
- Diffuse shortwave radiation

Hydrology
- Discharge
- Runoff
- Surface runoff
- Soil moisture
- Evapotranspiration
- Snow cover

Air quality
- NO2
- O3
- PM10
- PM2.5

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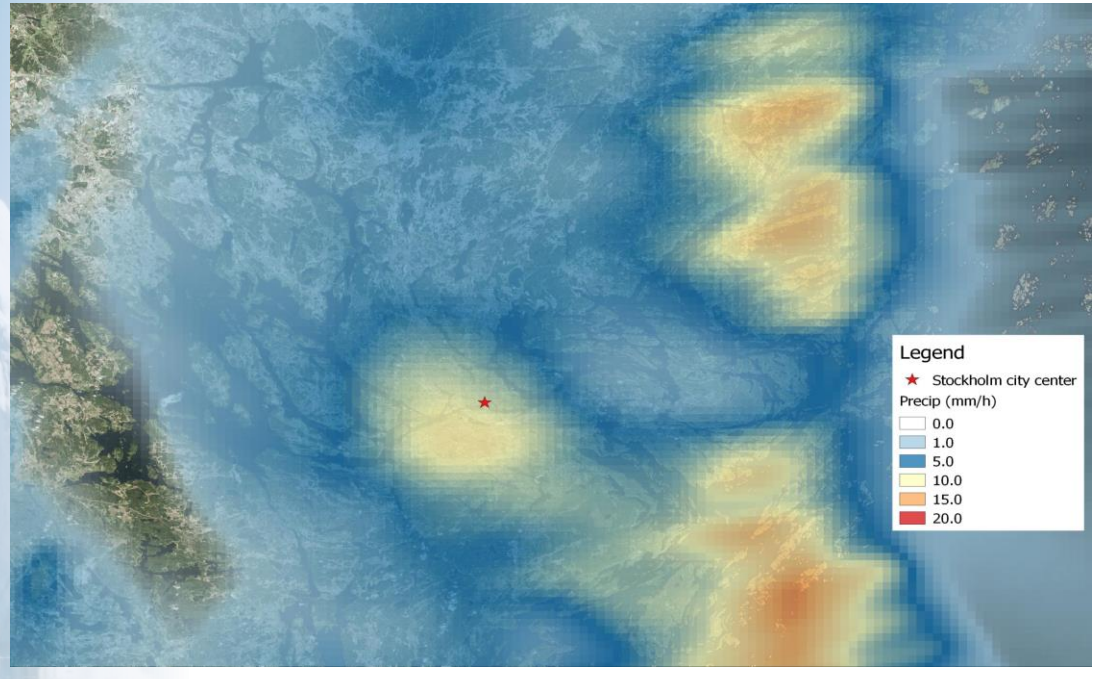
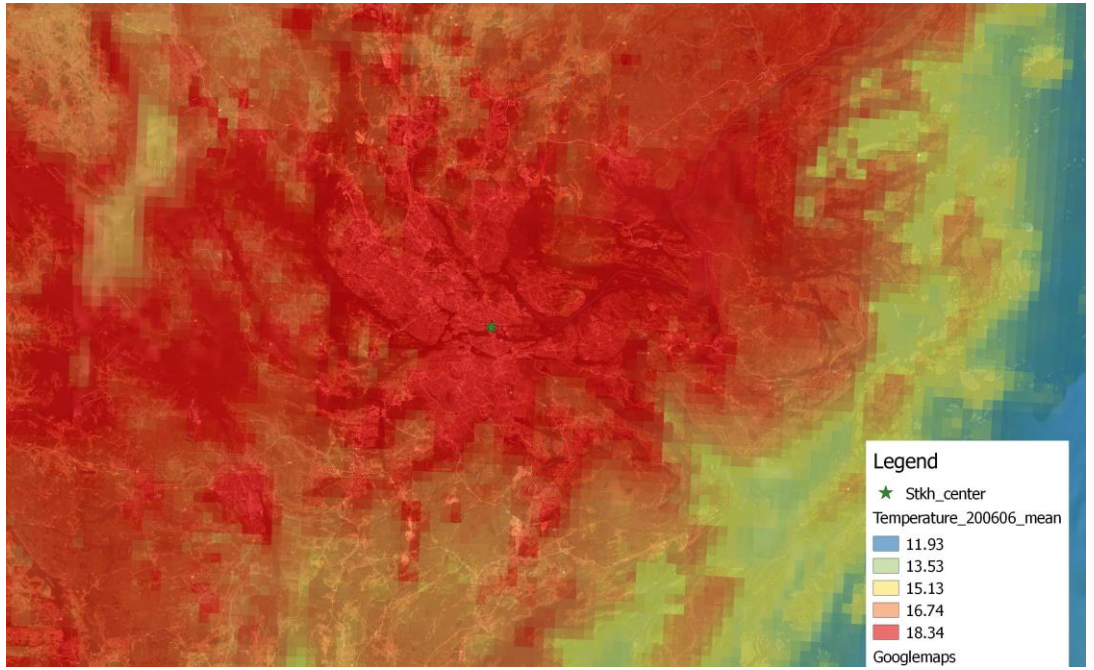
Spatial and Temporal Resolution



Stockholm: Intense Rainfall



Stockholm: Urban Heat island

Climate datasets are available over Europe, but these are currently at low spatial resolution, suitable for regional scale analysis, but less informative for individual cities.

Higher resolution (km) datasets are required to represent urban areas and understand their impact on local weather and climate.

This project aims to downscale Essential Climate Variables (ECVs) and impact indicators to the urban scale (1km2)

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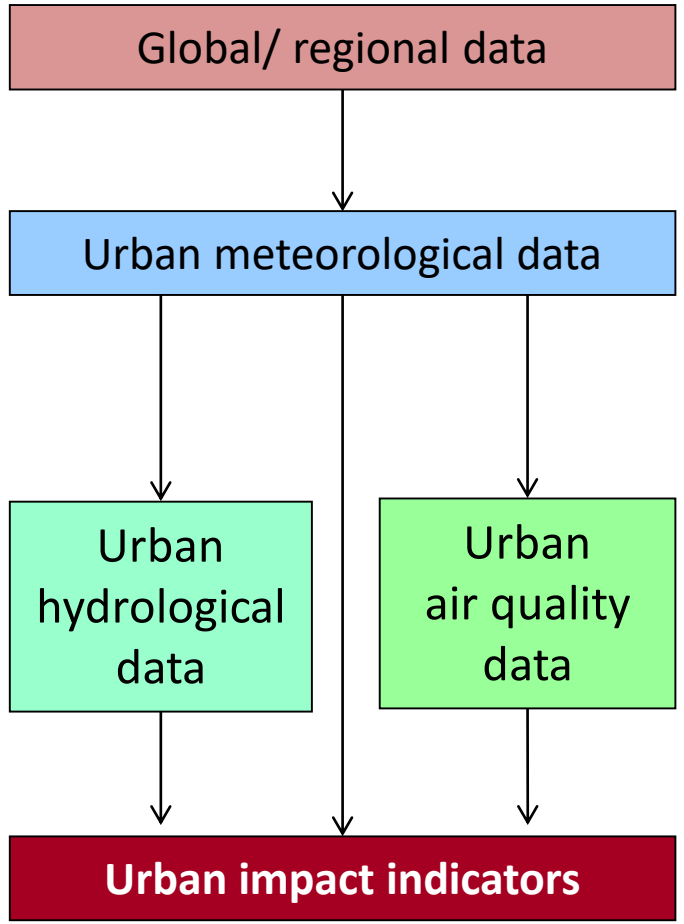
Data Production

- ECV data downscaled over cities (150 - 200km2)
- Climate data and local data combined with climate scenarios and advanced models
- Output data as hourly 1 x 1km grids, for 5 - 10 year windows, for past, present and future conditions
- Downscaled ECVs validated with historical datasets
- Statistical processing of ECVs to generate city-specific Urban Impact Indicators to show the impact of climate change on urban sectors
- Indicators tailored to meet requirements from modellers and end-users
- Urban Impact Indicators have been chosen based on their relevance to urban areas, through workshops and interviews with stakeholders.



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Pilot Studies

Three pilot studies were run to assess the usefulness of project datasets on a local scale:

- Stockholm
  Use case: urban flooding

- Bologna
  Use cases: urban flooding; urban heat; urban air quality

- Amsterdam-Rotterdam
  No formal use case. Validation of downscaled ECVs and Impact Indicators, to demonstrate the scalability of datasets

This project could be extended in the future to cover additional European cities.

Technical Reports are available to download at
http://urbansis.climate.copernicus.eu/goals/

Urban SIS Data Portal

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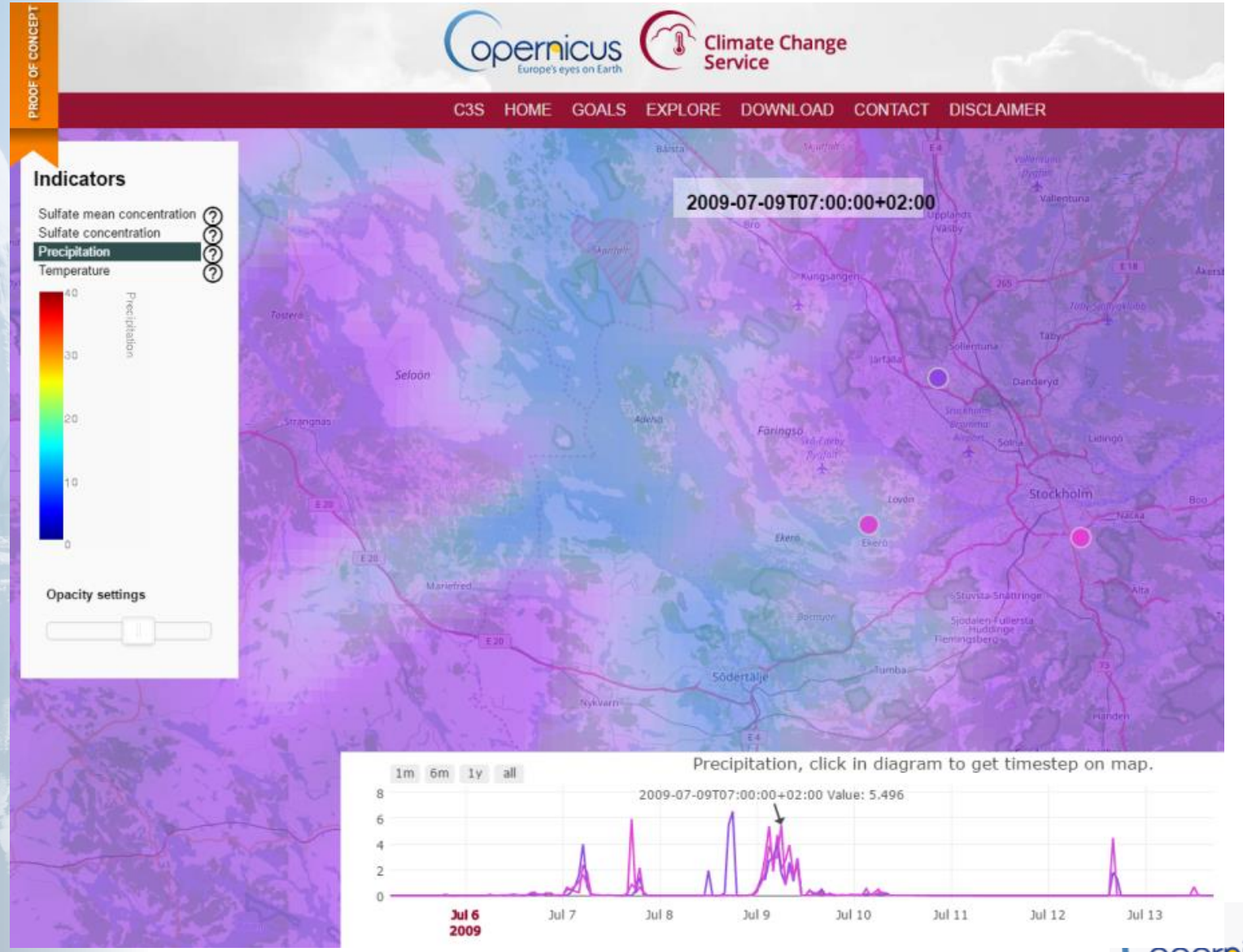

The interactive data portal tool allows you to select, visualise and download the Urban Impact Indicators from the case study sites.

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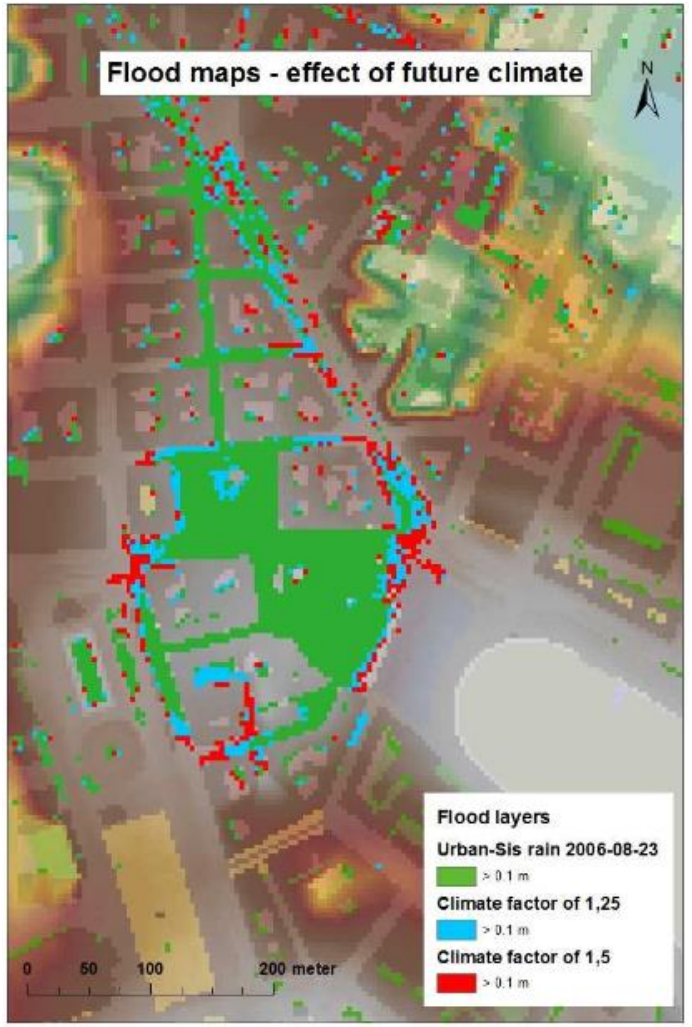
Pilot Study: Urban Flooding (Stockholm)

- Built-up urban areas are vulnerable to pluvial flooding especially in low point areas
- Hourly gridded ECV data used to assess historical, present & future risk of intense rainfalls
- HARMONIE meteorological model run for historical (UERRA) and future climate scenarios (RCP8.5) with detailed land-use characteristics from EEA Urban Atlas
- HYPE hydrological model used to simulate surface runoff per subcatchment and per different land uses (impervious, green etc).
- Impact indicators for heavy rainfall analysed in comparison with simulations made with other input data



Urban flooding effects in parts of the Berzelii Park using the Urban SIS rain event of August 23rd 2006 (green) and climate factors of 1,25 (blue) and 1,5 (red) respectively.

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Pilot Study: Urban Flooding (Bologna)

- Built-up urban areas are vulnerable to flooding (storms and fluvial)
- Hourly gridded ECV data used to assess historical, present & future risk of flash flooding after storms
- HARMONIE meteorological model run for historical (UERRA) and future climate scenarios (RCP8.5) with detailed land-use characteristics
- HYPE hydrological model used to simulate river discharge (Ravone & Reno), local runoff etc.
- Impact indicators for heavy rainfall analysed in comparison to large infrastructure projects

Bologna (en.wikipedia.org)

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Pilot Study: Urban Heat (Bologna)

- Extreme heat can present risks to human health
- Impact indicators derived to assess the impact of local climate changes on health sector, e.g.
  - Heat wave duration
  - Thom Discomfort Index (measure of human discomfort based on temperature & humidity)
- C3S climate data used as input to microclimate ENVIMET model
- Used to assess how specific buildings – existing and planned – respond to heat waves and heat island phenomena in the city

02/07/2015 (www.stirimeteo.com)

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Pilot Study: Urban Air Quality (Bologna)

- The Po Valley is heavily industrialised and densely populated
- In winter: particulate matter and NO2 concentrations are particularly high
- In summer: O3 concentration exceeds limits
- MATCH air quality model run with local emissions to obtain urban air pollution levels
- Study aims to assess the effectiveness of the multi-annual plan for air quality improvement (PAIR), when climate change and long-range pollution are taken into account

The Po Valley (research.metoffice.gov.uk)

Turin, Northern Italy (www.thelocal.it)

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Summary

- It is important to assess climate change impacts on urban areas to ensure sustainability in the future
- Existing climate data is available at a regional scale but less suitable to smaller scale urban studies
- C3S 'Proof of Concept' demonstrates the downscaling of ECVs to the city-scale (1km^2) for 5 - 10 year windows for past, present & future conditions
- Modelling used to generate city-specific urban impact indicators
- Data provided in an easily accessible format for use by modellers, engineers and urban planners
- Demonstrates a potential service to bring climate experts and stakeholders together to discuss how best to tackle the challenges of climate change

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Thank You

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