

# The Essential Climate Variables programme in the Copernicus Climate Change Service



Climate Change

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

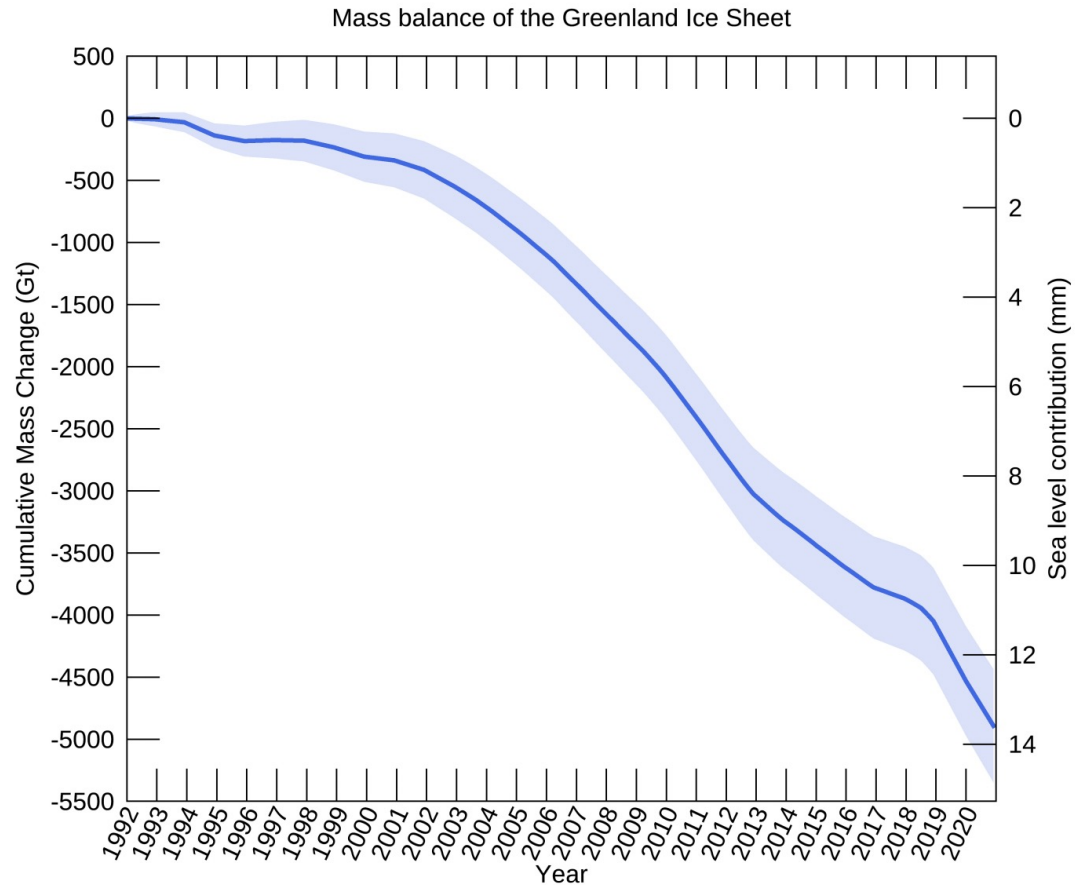
ESA Living Planet Symposium – Bonn, Germany – 23-27 May 2022





Climate  
Change

# Monitoring the climate system



Data Source: IMBIE

Credit: IMBIE/ESA/NASA



Photo: National Geographic

World Economic Forum 2022, Global Risks Report: “the most severe risk on a global scale over the next 10 years is **Climate Action failure**”



PROGRAMME OF  
THE EUROPEAN UNION

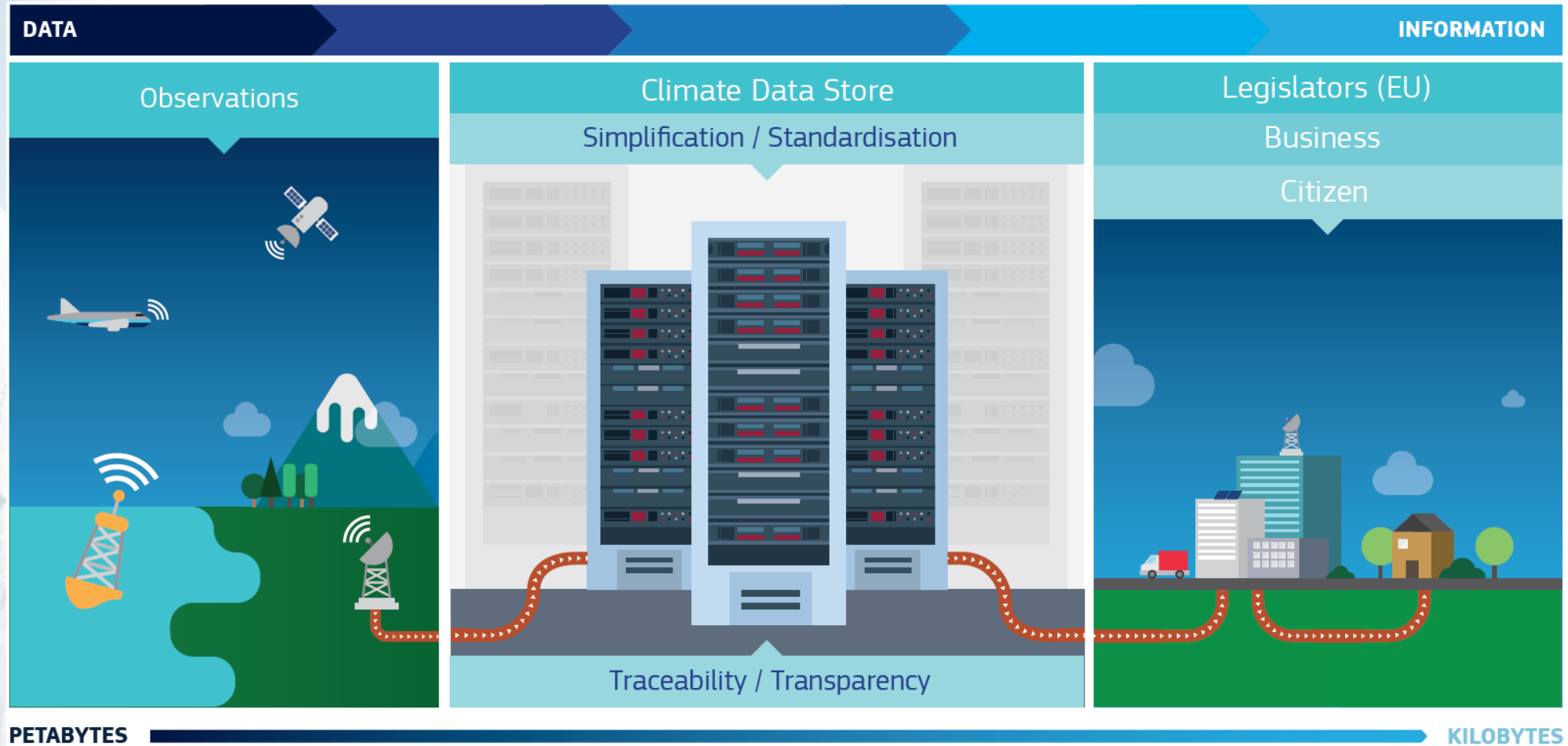


implemented by  ECMWF



Climate Change

# The Copernicus Climate Change Service (C3S)



authoritative quality-controlled data and information based on Earth Observation about the past, present and future climate;

tools to inform climate change mitigation and adaptation strategies by policy makers and businesses;

examples of best practice in the use of climate information.



PROGRAMME OF THE EUROPEAN UNION



implemented by

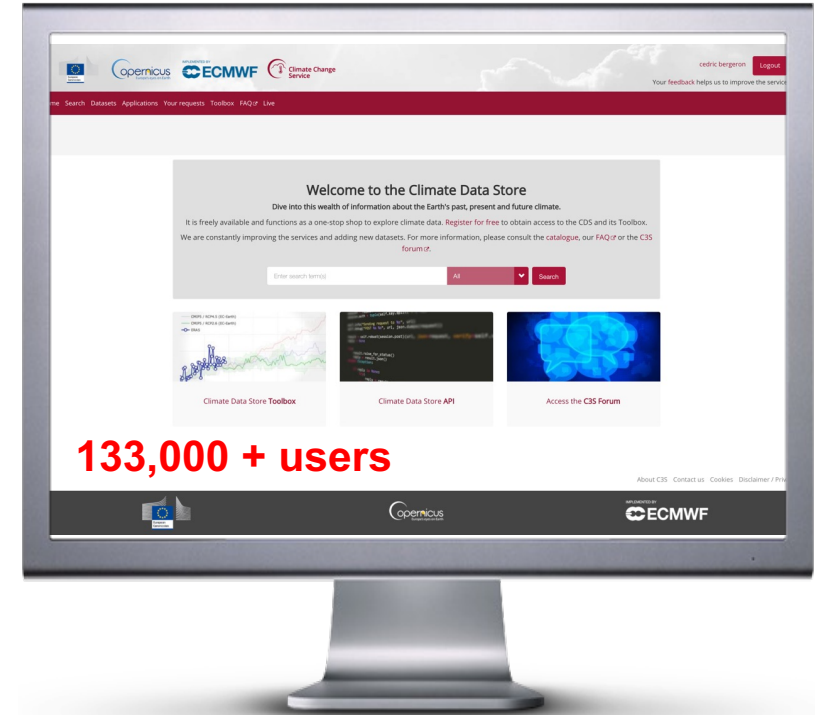






Climate Change

# The Climate Data Store – ‘A one stop shop for climate data’



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



PROGRAMME OF THE EUROPEAN UNION



implemented by ECMWF





Climate Change

# The Essential Climate Variables (ECVs)

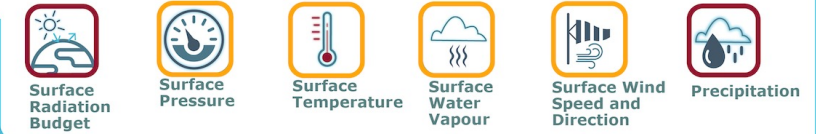
## CRYOSPHERE



### COP1

- = satellite ECVs
- = ECVs from reanalysis

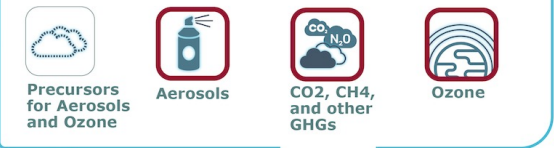
## SURFACE ATMOSPHERE



## UPPER-AIR ATMOSPHERE



## ATMOSPHERIC COMPOSITION



## SURFACE OCEAN PHYSICS



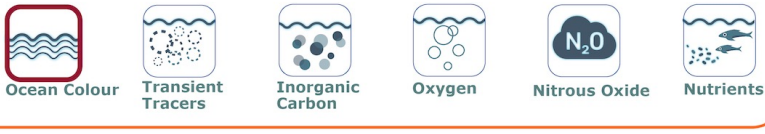
## SUBSURFACE OCEAN PHYSICS



## OCEAN BIOLOGY / ECOSYSTEMS



## OCEAN BIOGEOCHEMISTRY



## HYDROSPHERE



## ANTHROPOSPHERE



## BIOSPHERE



\*Fraction of Absorbed Photosynthetically Active Radiation



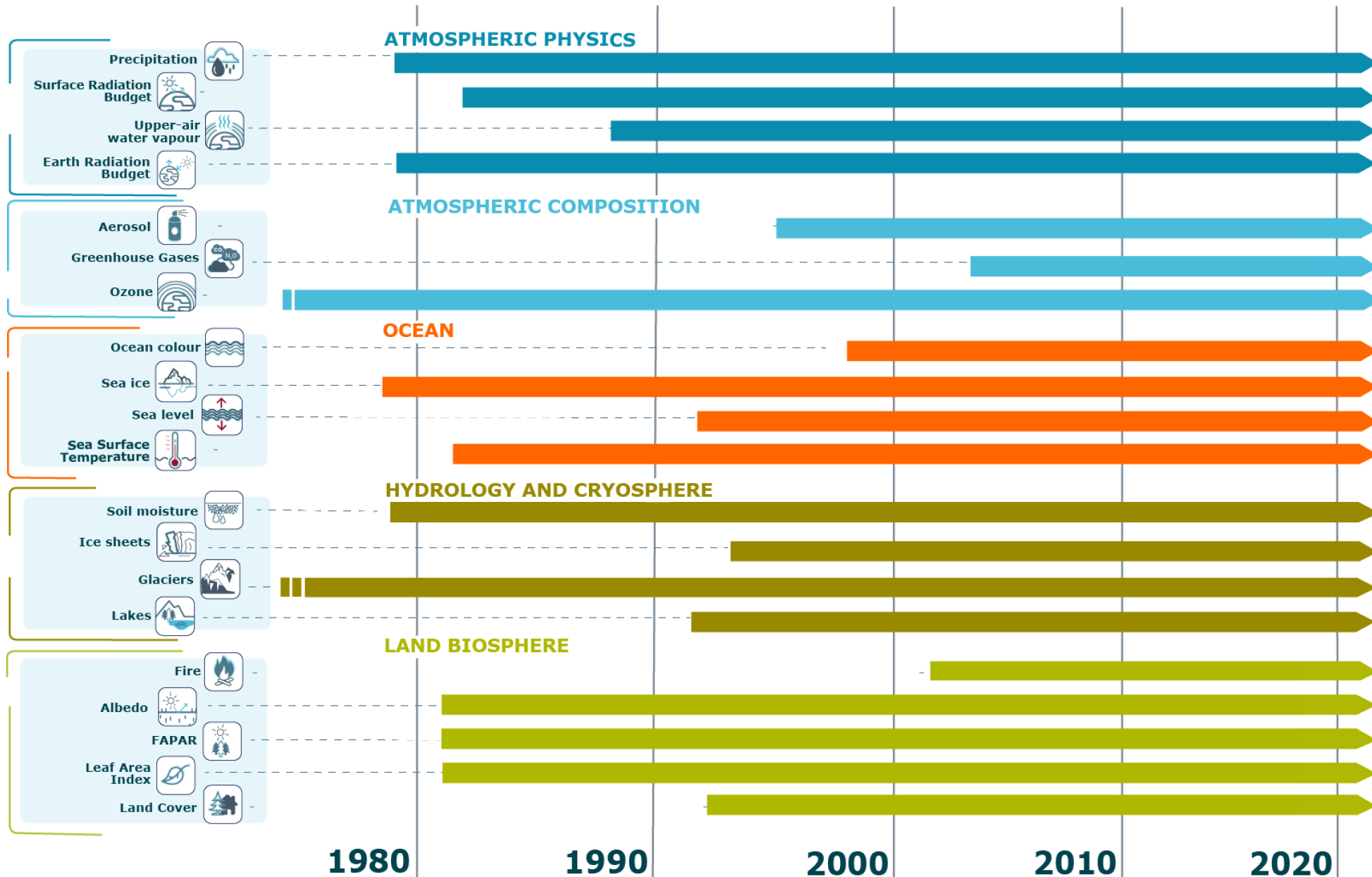
Climate Change Service

climate.copernicus.eu



Climate Change

# Satellite ECV data records



IN COLLABORATION with more than **50** organisations.



Mainly use Sentinel-3 data

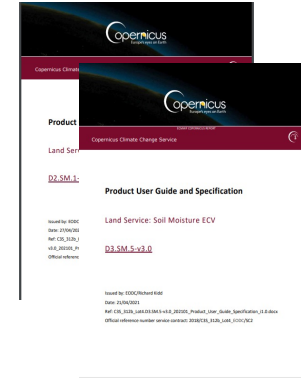
Future use of other Sentinel data



Climate Change

# ECVs in numbers

- **5 thematic ECV hubs:**
  - Atmospheric physics
  - Atmospheric composition
  - Ocean
  - Hydrology & Cryosphere
  - Land Biosphere
- **> 300 user-oriented documents**
- **9 tutorials**
- **5 published data viewers**
- **6 published toolbox applications + new applications/use cases under analysis**

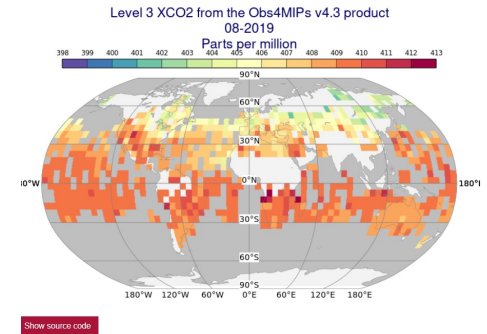


- **35 ECV products**
- **3 new products by end of 2022**
  - Cloud Properties
  - Ice Surface Temperature
  - Sea Ice Drift

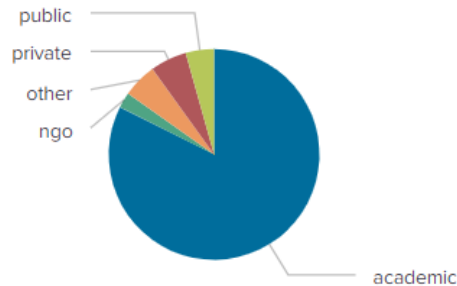
Total number users  
**19,142**

Total volume downloaded (in GB)  
**307,201**

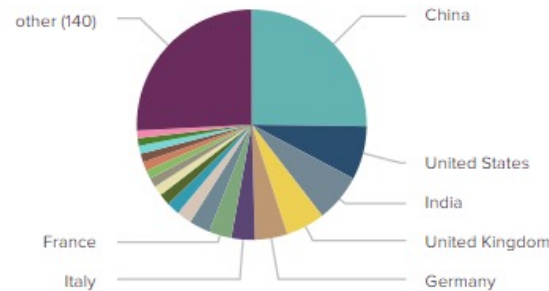
Total number requests  
**712,407**



Distribution per sector



Distribution per country



And much more...

- Full list of citations & acknowledgments per ECV product,
- Licenses for all products,
- Generation of DOI per catalogue entry
- Expert user support
- Independent and full quality control assessment per variable
- Products generated for the European State of the Climate



PROGRAMME OF THE EUROPEAN UNION



implemented by ECMWF

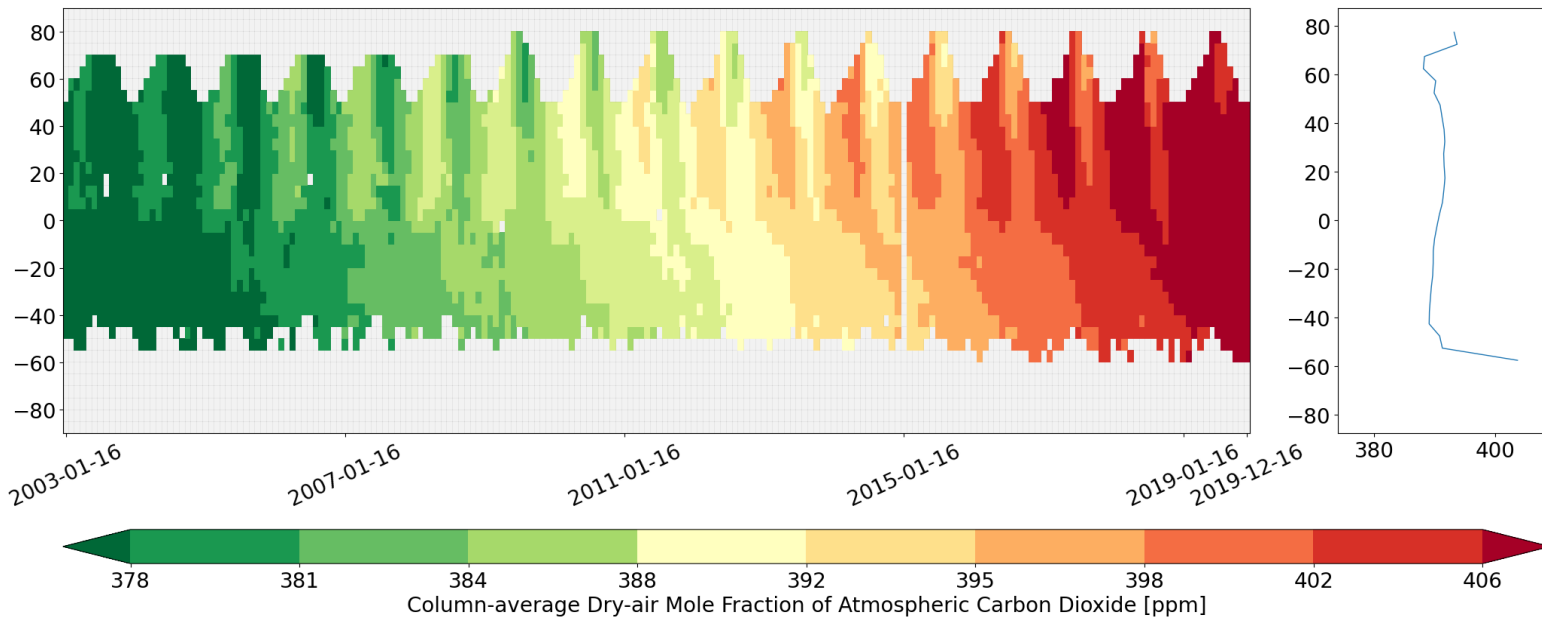




Climate Change

# 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)



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



implemented by ECMWF



Climate  
Change

## Example: EQC for Carbon Dioxide

Carbon dioxide data from 2002 to present derived from satellite observations - XCO<sub>2</sub> 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 XCO<sub>2</sub> L3 (v4.2) dataset is just barely long enough to allow for meaningful trend comparisons with ESM simulations



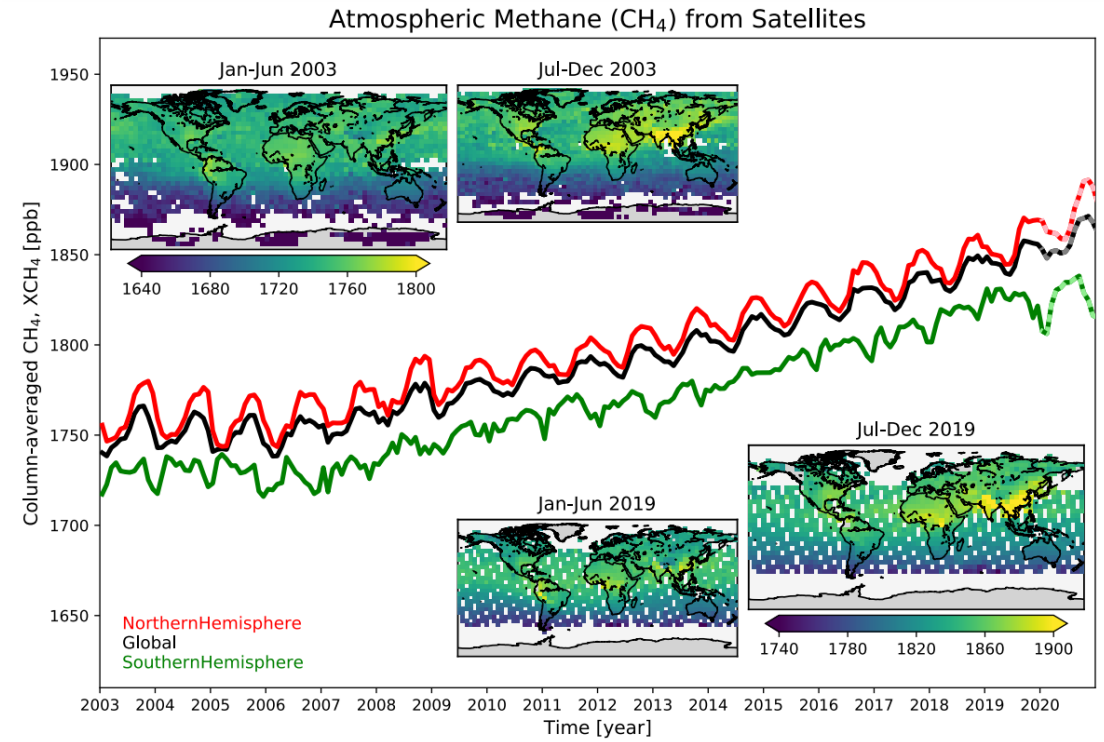
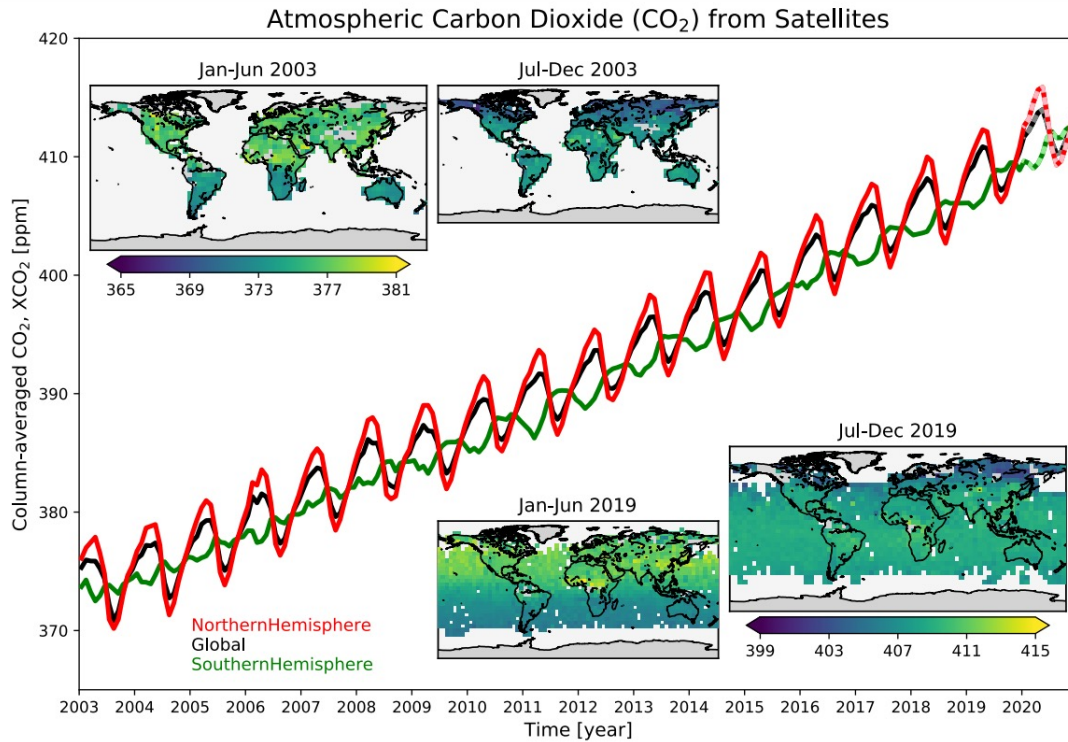
PROGRAMME OF  
THE EUROPEAN UNION



implemented by  ECMWF



# Key information for policy makers

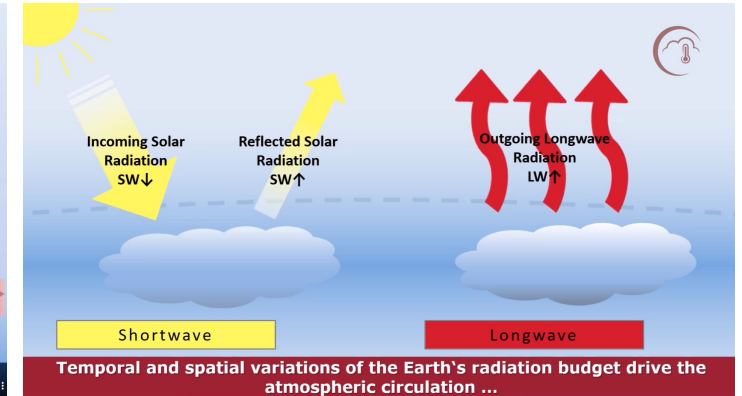
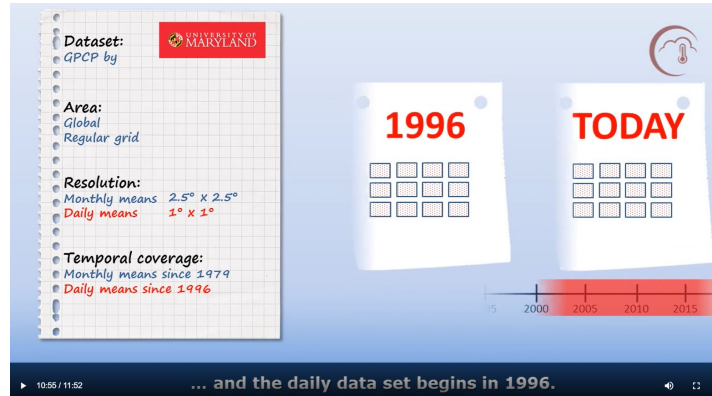
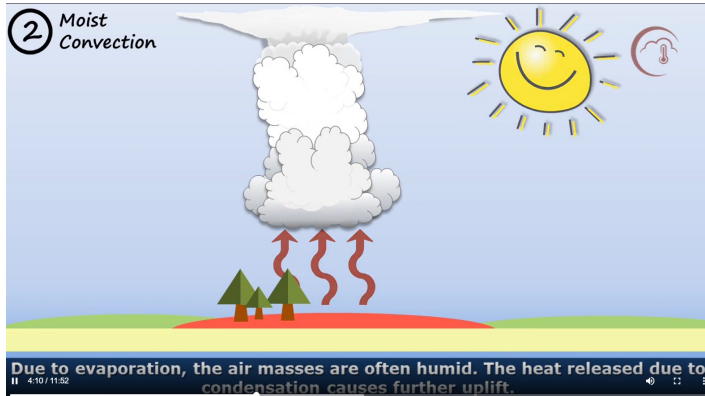




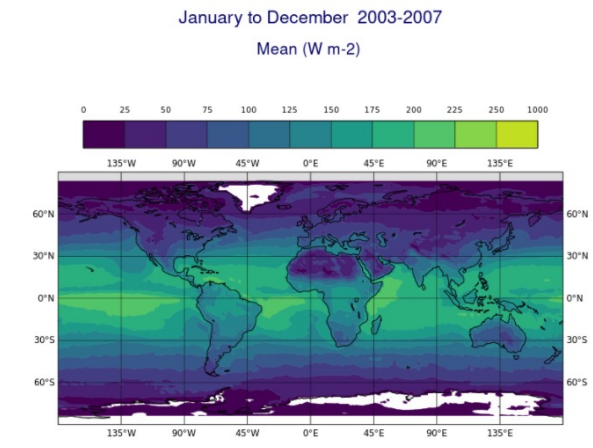


# Tutorial and toolbox applications

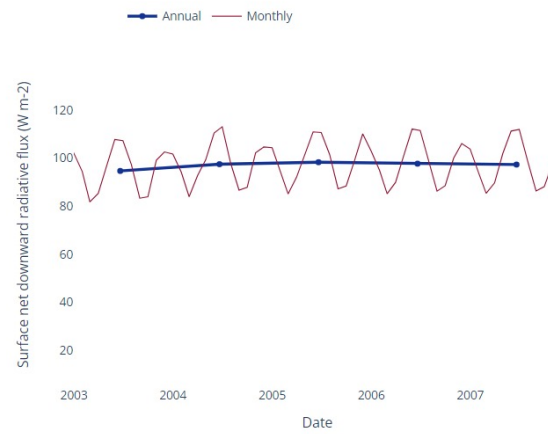
## Generation of educational Tutorials on atmospheric physics ECVs



## Published toolbox applications to provide examples of data use



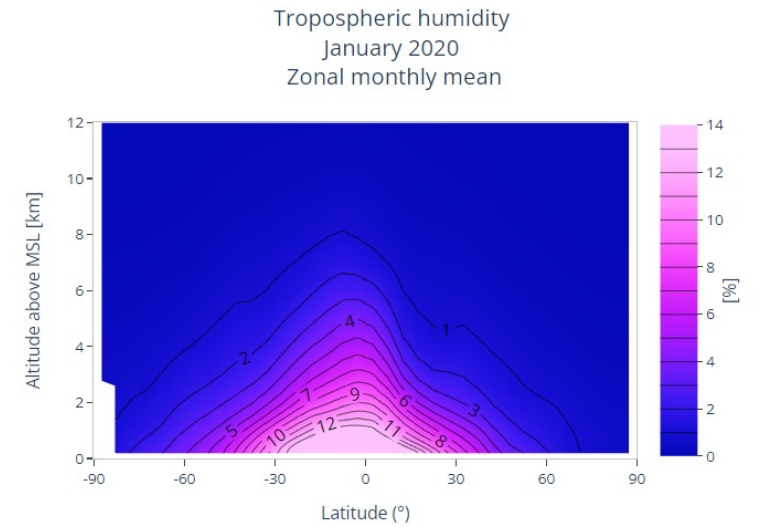
Temporal mean of the surface net downward radiative flux for the Global region. The temporal period is defined as the years 2003 to 2007 and the months January to December.



Time series of the surface net downward radiative flux mean for the Global region. Series are provided for the annual mean of the selected monthly subset (January to December) and for the complete monthly mean time-series.

Year

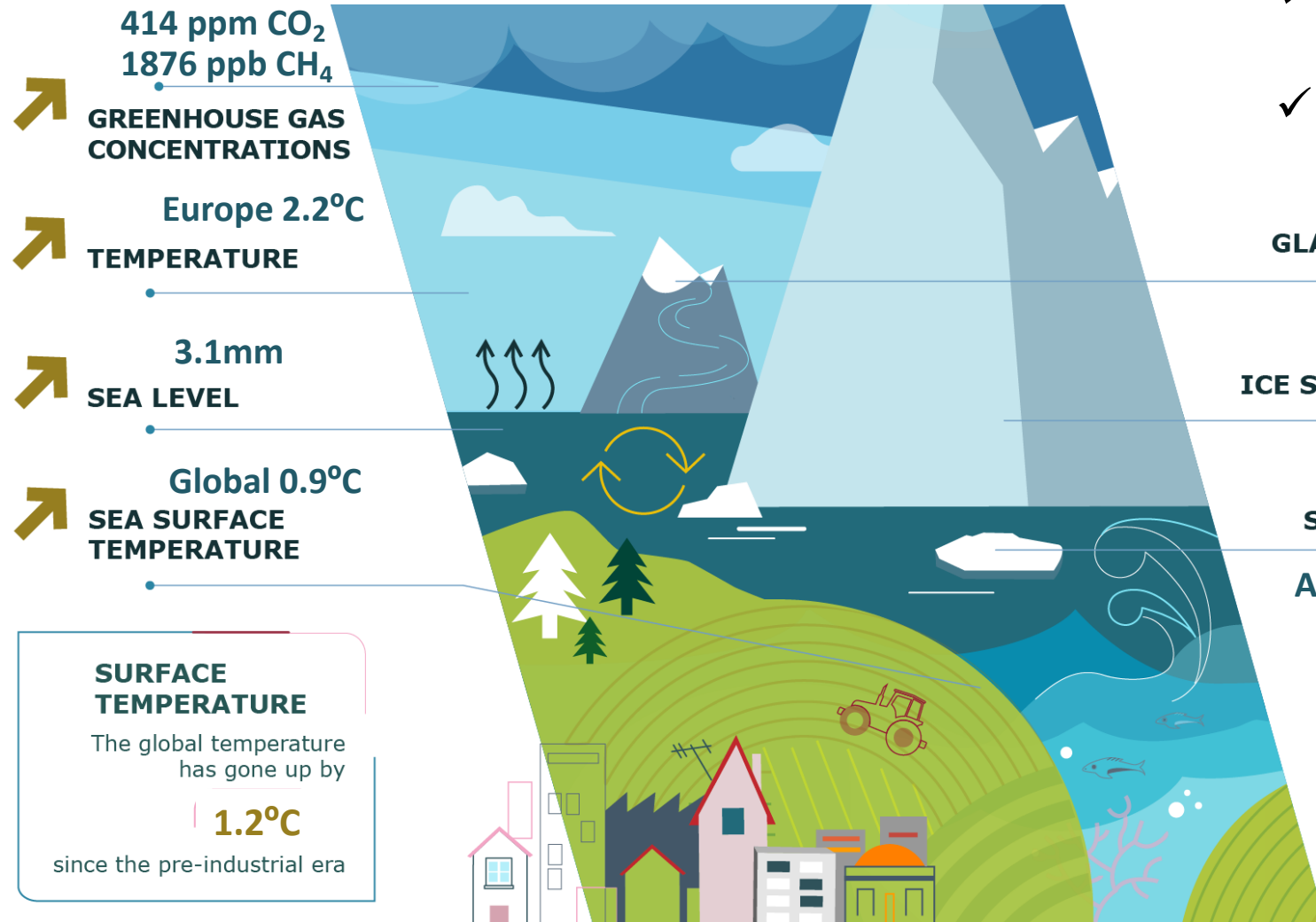
2020





Climate Change

# Climate monitoring



**SURFACE TEMPERATURE**

The global temperature has gone up by

**1.2°C**

since the pre-industrial era

## Key climate indicators

- ✓ Responding to monitoring and reporting for UNFCCC
- ✓ Capture long-term trends, but also year-to-year variability

**GLACIERS**

Global ~ 30 m

**ICE SHEETS**

Greenland ~ -3800 +/-340 Gt

Antarctica ~ -2720 +/-1390 Gt

**SEA ICE**

Arctic ~ -12.2% /y<sup>10</sup>

Published in the ESoTC-2021



PROGRAMME OF THE EUROPEAN UNION



implemented by ECMWF



Climate Change

# Improving our understanding of the Earth system

## CRYOSPHERE



Snow



Ice Sheets and Ice Shelves



Glaciers



Permafrost

### COP1

□ = satellite ECVs

□ = ECVs from reanalysis

### COP2 AMBITION

□ = 1<sup>st</sup> Priority

□ = 2<sup>nd</sup> Priority

## SURFACE ATMOSPHERE



Surface Radiation Budget



Surface Pressure



Surface Temperature



Surface Water Vapour



Surface Wind Speed and Direction



Precipitation

## UPPER-AIR ATMOSPHERE



Upper-air Temperature



Upper-air Water Vapour



Upper-air Wind Speed and Direction



Lightning



Earth Radiation Budget



Clouds

## ATMOSPHERIC COMPOSITION



Precursors for Aerosols and Ozone



Aerosols



CO<sub>2</sub>, CH<sub>4</sub>, and other GHGs



Ozone

## SURFACE OCEAN PHYSICS



Surface Currents



Surface Stress



Sea Surface Temperature



Sea Ice



Ocean Surface Heat Flux



Sea Level



Sea Surface Salinity



Sea State

## SUBSURFACE OCEAN PHYSICS



Subsurface Temperature



Subsurface Currents



Subsurface Salinity

## OCEAN BIOLOGY / ECOSYSTEMS



Plankton



Marine Habitats

## OCEAN BIOGEOCHEMISTRY



Ocean Colour



Transient Tracers



Inorganic Carbon



Oxygen



Nitrous Oxide



Nutrients



## HYDROSPHERE



Soil Moisture



Lakes



Groundwater



River Discharge



Evaporation from Land

## ANTHROSPHERE



Anthropogenic Water Use



Anthropogenic Greenhouse Gas Fluxes

## BIOSPHERE



Soil Carbon



Albedo



Fire



FAPAR\*



Leaf Area Index (LAI)



Land Surface Temperature



Above-ground Biomass



Land Cover



Climate Change Service

climate.copernicus.eu

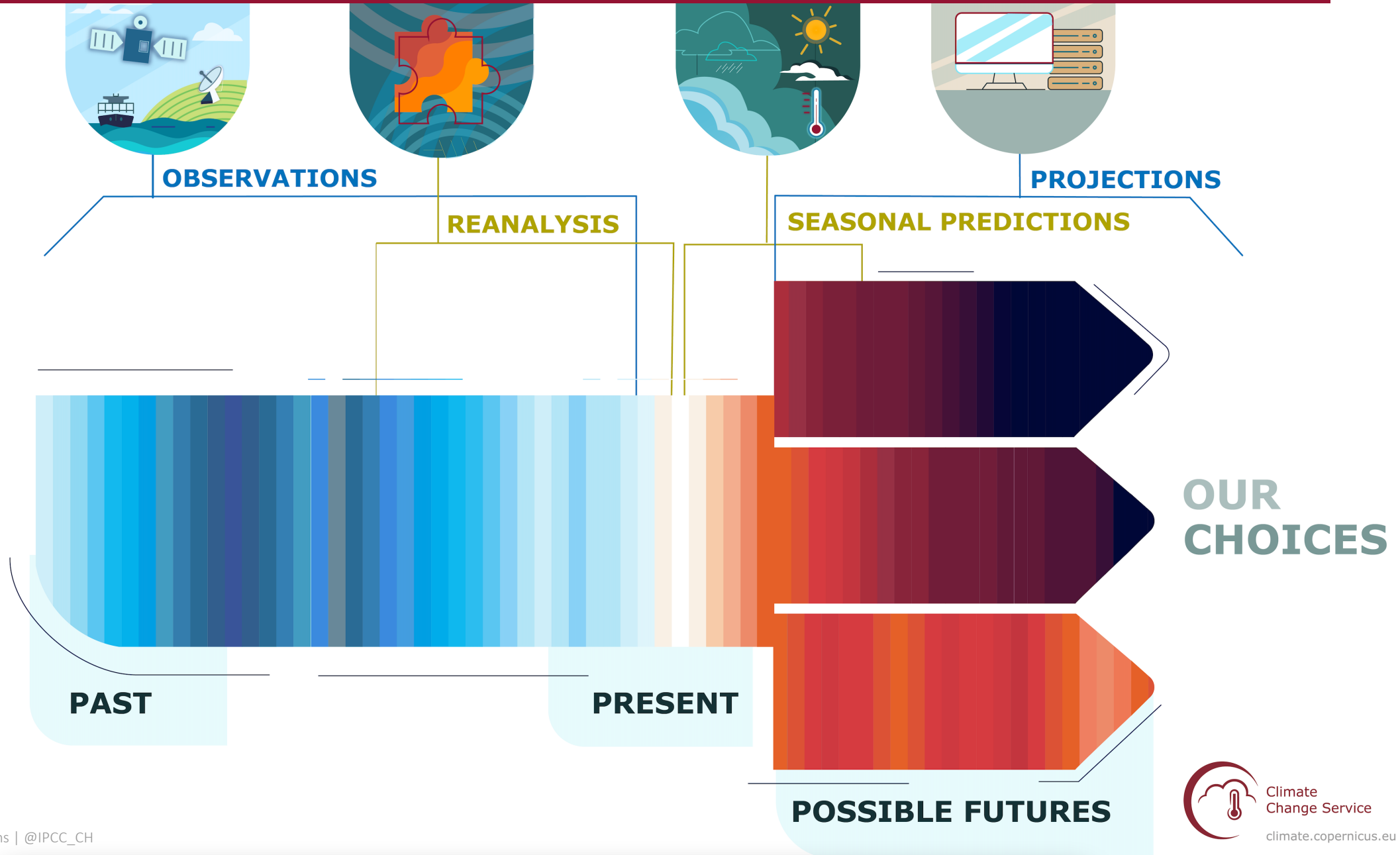
\*Fraction of Absorbed Photosynthetically Active Radiation





Climate  
Change

# Authoritative data for smart decisions





Climate  
Change

# Thank you for your attention



**Copernicus EU**



**@copernicusecmwf**



**Copernicus ECMWF**



**Copernicus EU  
Copernicus  
ECMWF**



**@CopernicusEU  
@CopernicusECMWF  
@j\_munoz\_sabater**



**www.copernicus.eu  
climate.copernicus.eu**



PROGRAMME OF  
THE EUROPEAN UNION



implemented by 