Reanalysis within Europe's Copernicus Initiative

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Climate Change

European Centre for Medium-Range Weather Forecasts

Overview

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- Rationale behind reanalysis
- The Copernicus Climate Change Service (C3S)
- C3S global reanalysis
- C3S regional reanalysis for Europe
- Concluding remarks

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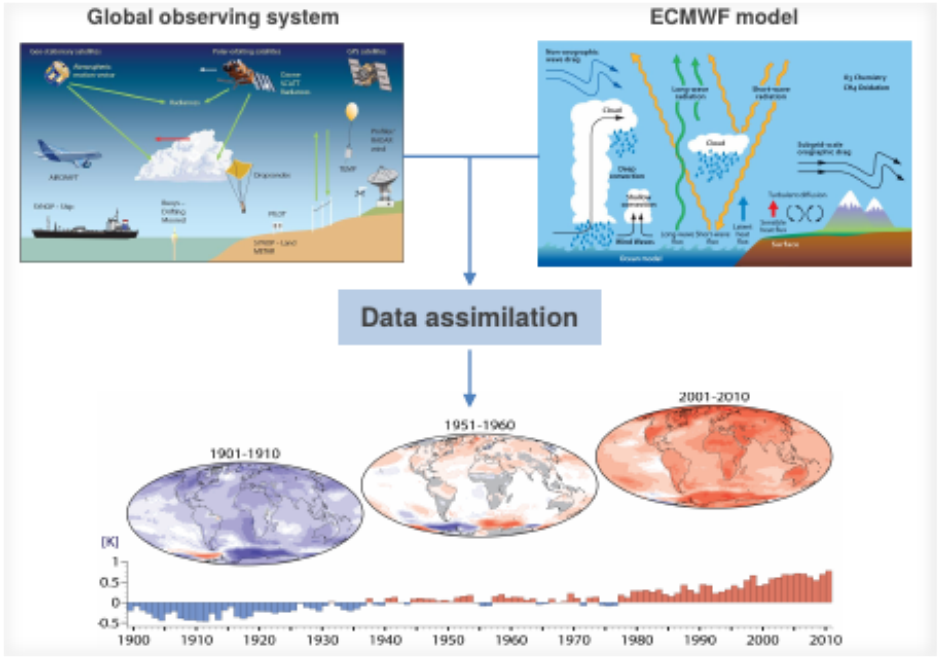
Why Reanalysis?

Reanalysis offers a detailed overview of the past atmosphere (and other components)

- Complete: combining vast amounts of observations into (global) fields
- Consistent: use the same physical model and DA system throughout
- State-of-the-art: use the best available observations and model at highest feasible resolution
- *Reanalysis allows for a close monitoring of the Earth's climate system also where direct observations are sparse (e.g. rising Arctic surface temperature)*



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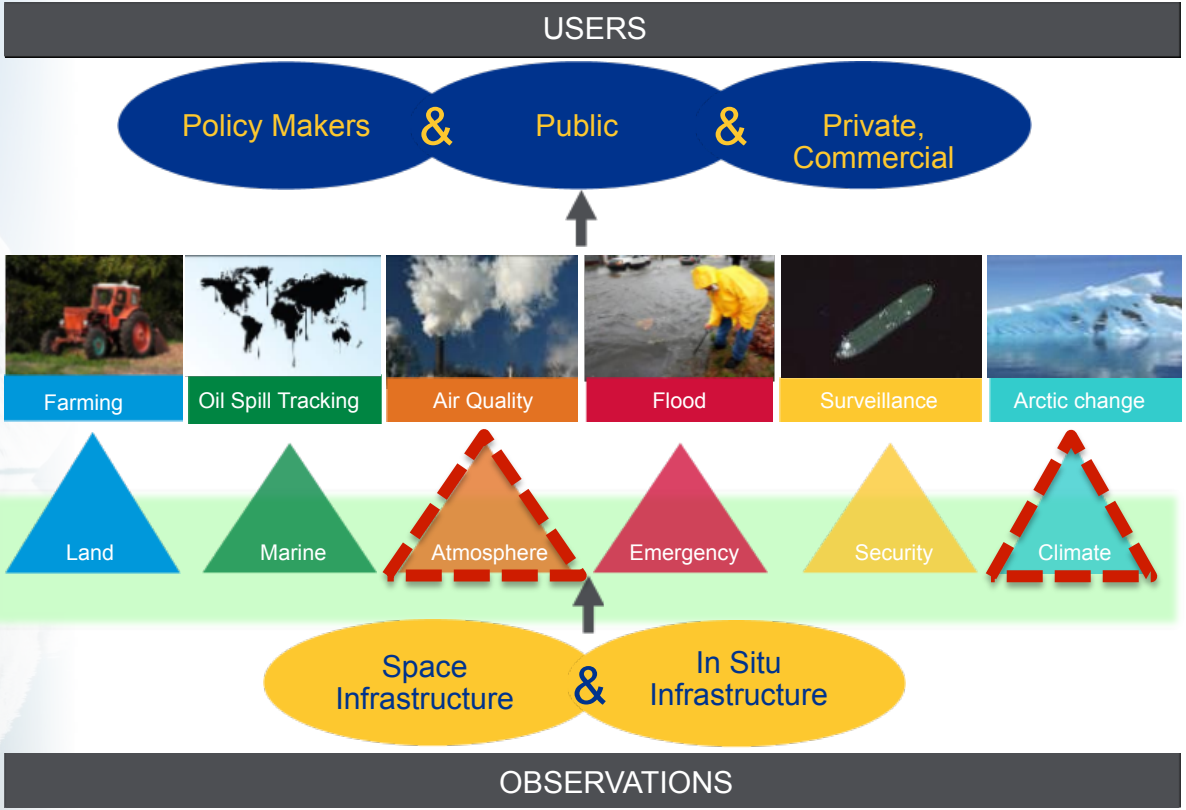
Copernicus Services



Different Needs

Examples of areas covered

6 Information Services

Sustainable observation capabilities

ECMWF operates the Copernicus Climate Change Service (C3S) and Copernicus Atmosphere Monitoring Service (CAMS) on behalf of the European Commission.

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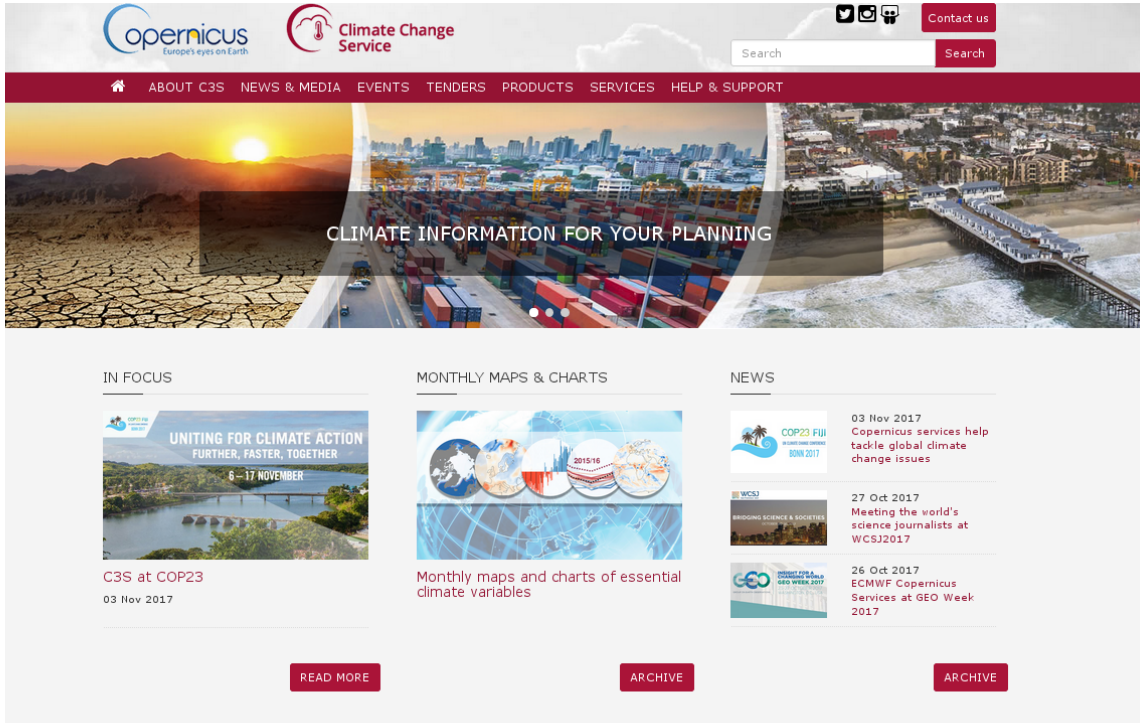
https://climate.copernicus.eu/



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Entities contributing to C3S

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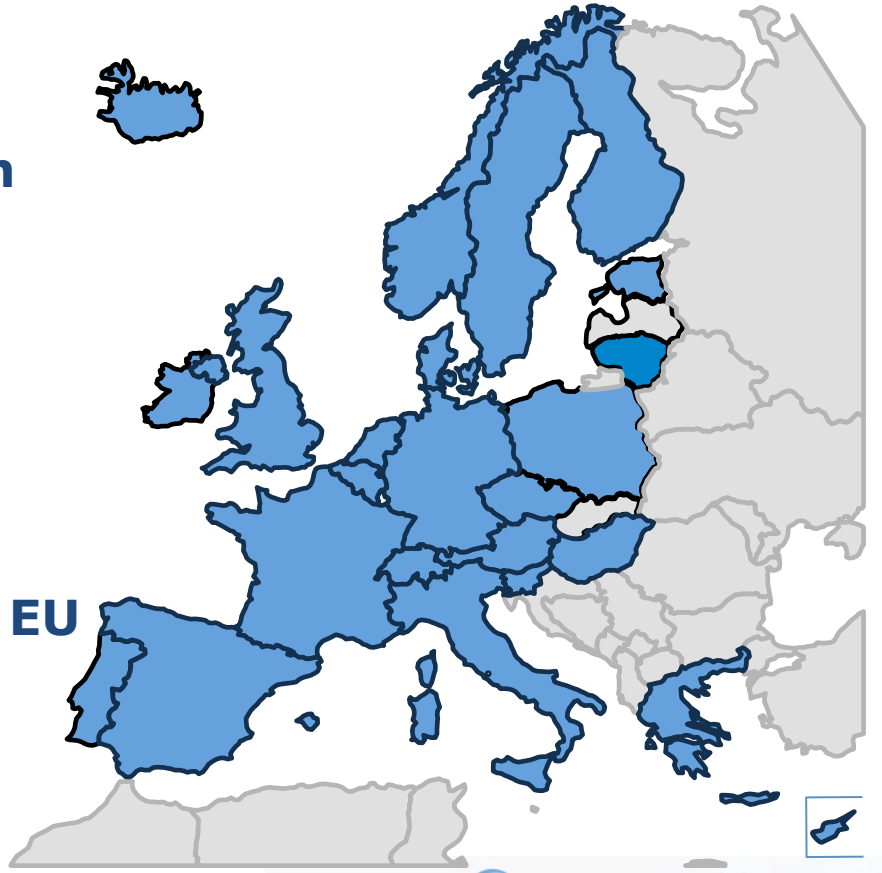
C3S

Builds upon massive European investments in science and technology

A truly European effort

175 different entities from 24 EU and ECMWF Member States

+ International Organisations



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Climate Change Service: Solutions

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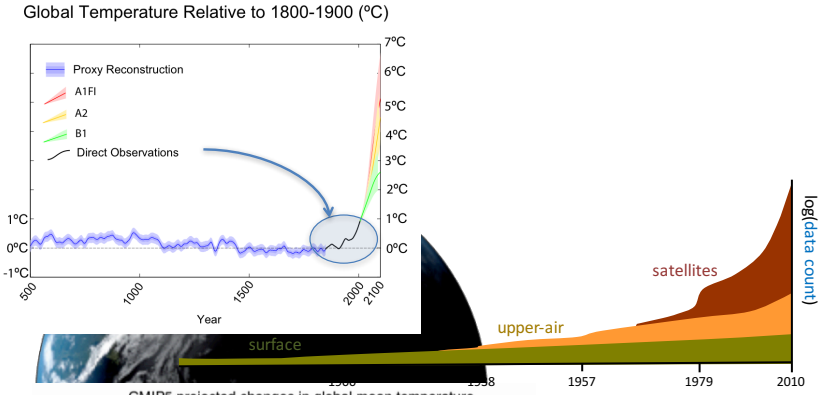

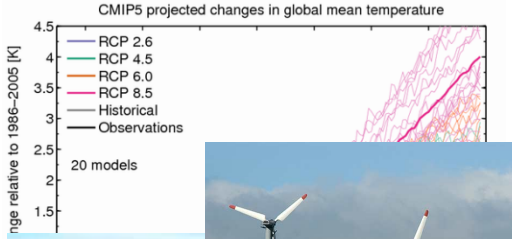

- **How is climate changing?**
  - Earth observations
  - Reanalyses
- **Will climate change continue/accelerate?**
  - Predictions
  - Projections
- **What are the societal impacts?**
  - Climate indicators
  - Sectoral information

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C3S climate data store and toolbox

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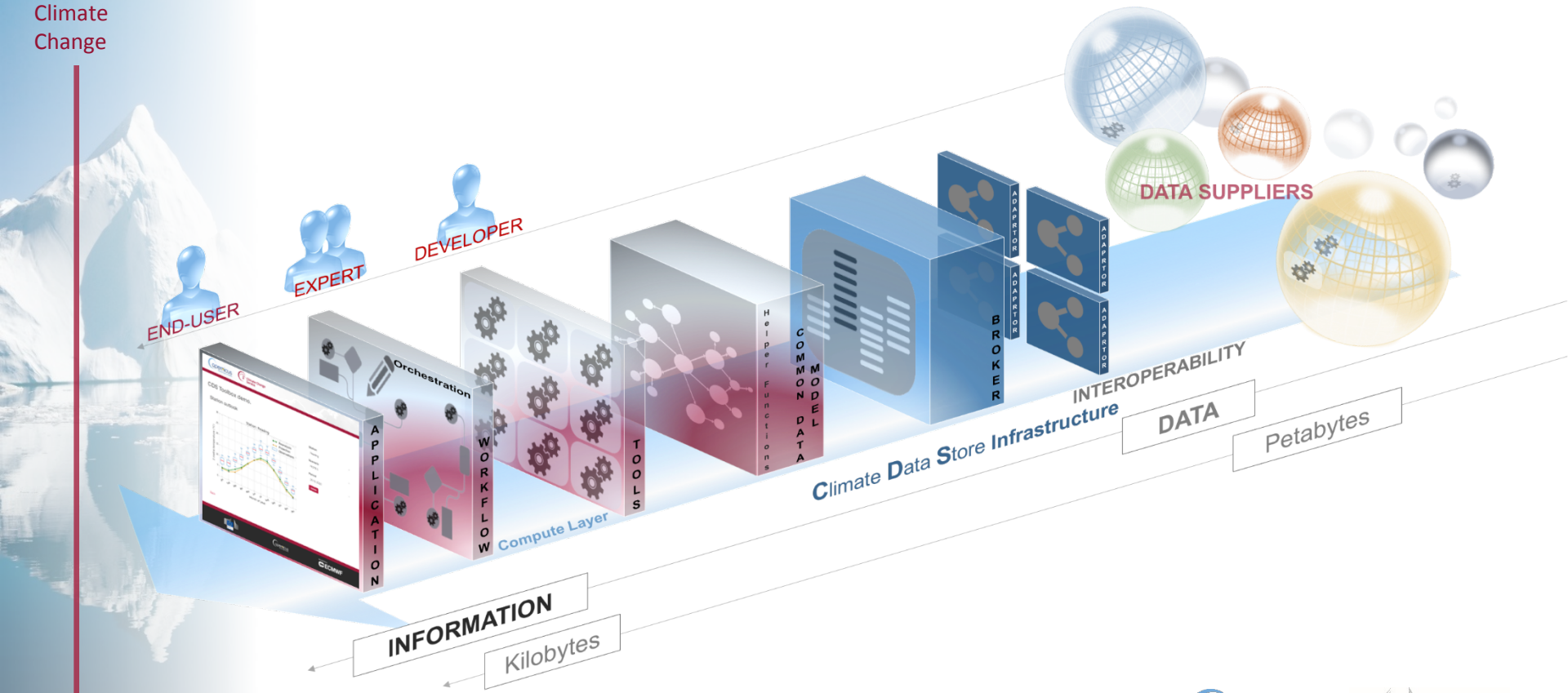

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Climate Data Store content (December 2017)

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Scientific basis:

- Essential Climate Variables as defined by GCOS
- GCOS Status Report and Implementation Plan
- IPCC, CMIP

Action engaged

In progress

Not started

Observations	Global estimates of ECVs from satellite and in-situ observations	Reprocessed CDRs, reference observations	Support for data rescue, climate data collections	Climate Indicators
Climate reanalysis	Global atmosphere, ocean, land	Regional reanalysis for Europe	Coupled climate reanalysis for 100 years (*)	
Model output	Multi-model seasonal forecast products	Access to CMIP data and products (global and regional)	Reference set of climate projections for Europe	

(*): CERA_20C accessible via the CDS

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C3S global reanalysis

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C3S global reanalysis: status & outlook

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User requirements:

- 'Climate quality'
- High resolution
- As far back as possible
- Uncertainties
- Additional products
- Latest model developments
- Timely delivery
- Easy access
- Great user support

2006 - 2018: **ERA-Interim from 1979**

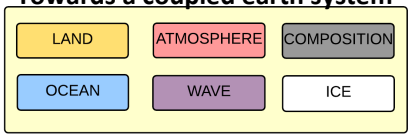
2016 - 2019: **ERA5 from 1950**

- Aided by R&D from FP7 ERA CLIM
- ERA5T: preliminary data at short delay (<7 days)
- ERA5L: 9km global land products

Future Productions

- coupled, aided by R&D from FP7 ERA CLIM 2 (CERA-SAT)
- joint CAMS/C3S reanalysis
- Centennial reanalysis

Towards a coupled earth system



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ERA-Interim users world wide

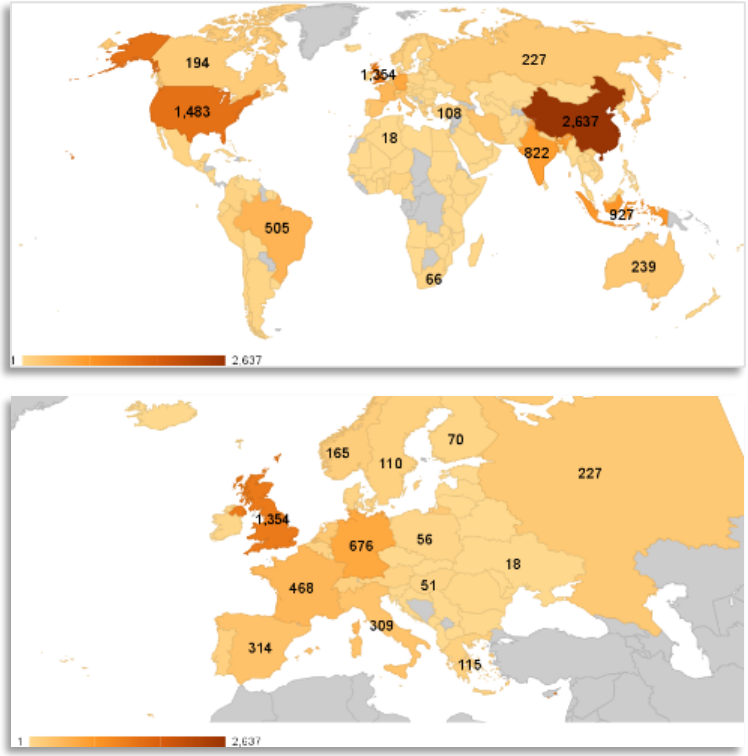
ERA-Interim had more than 20,000 unique users in 2015-2016 alone.

Users and stakeholders:

- Climate monitoring & provision of climatologies
- ECMWF member states
- Research and education, over 7,000 citations
- Public sector
- Space agencies
- Commercial applications

ERA-Interim is being replaced by ERA5

Unique registered users in 2016



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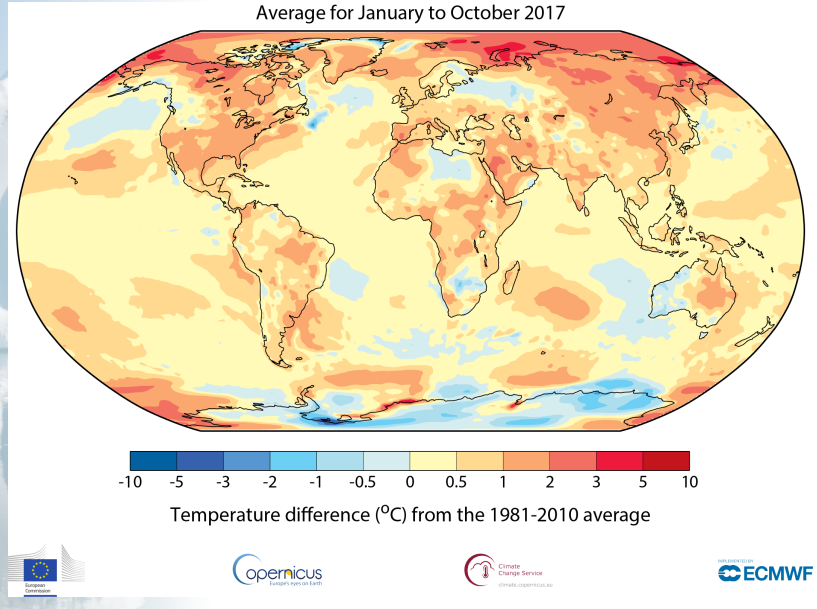
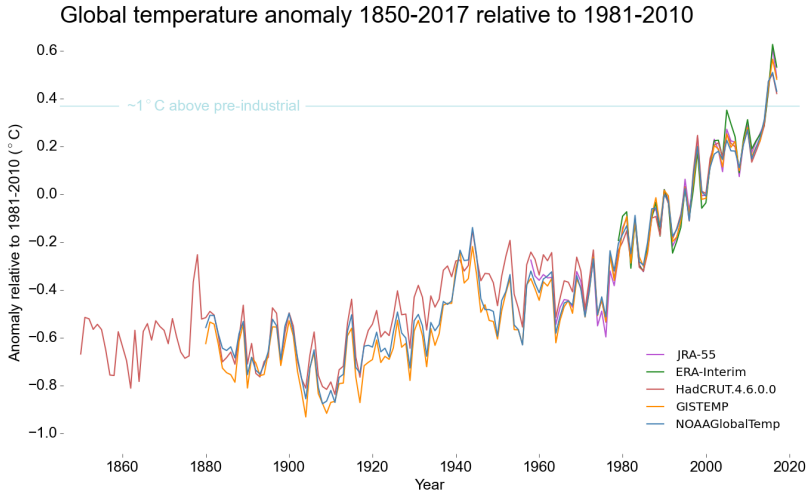
WORLD METEOROLOGICAL ORGANISATION

WMO preliminary State Of Climate at COP23:

2017 is set to be in the three hottest years, with record-breaking extreme weather





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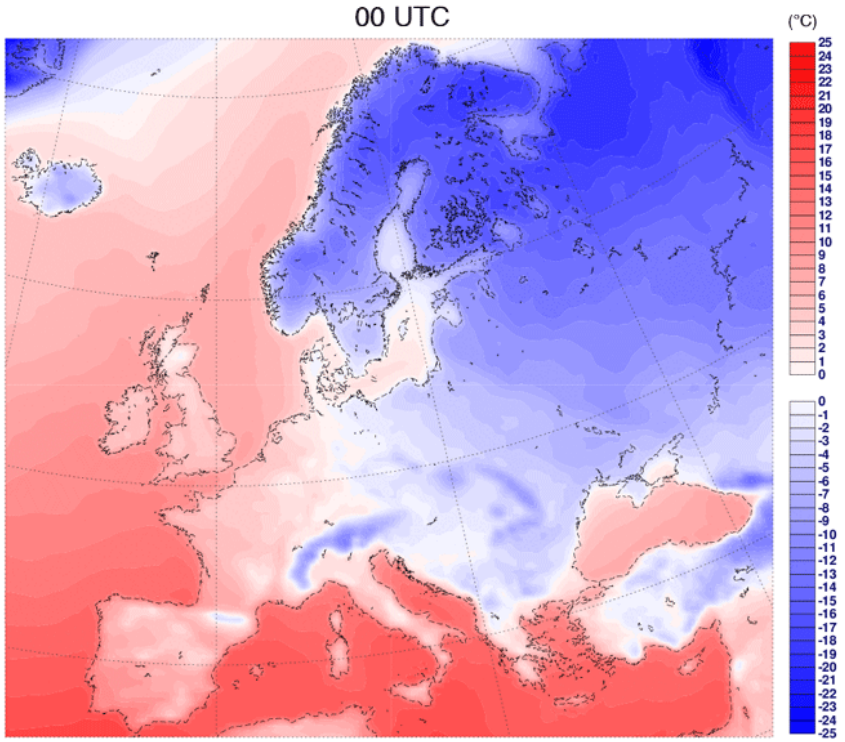
ERA5, the follow-up of ERA-Interim

- Atmosphere/land/wave parameters
- 31 km global resolution, 137 levels
- Hourly output from initially 1979 onward
- Updated close to real time
- To extended back to 1950
- Forcing appropriate for climate

- Using 2016 ECMWF forecast system
- Using improved input observations
- Provide uncertainty estimates

To date 2010 - 2016 is publicly available

- https://climate.copernicus.eu/climate-reanalysis



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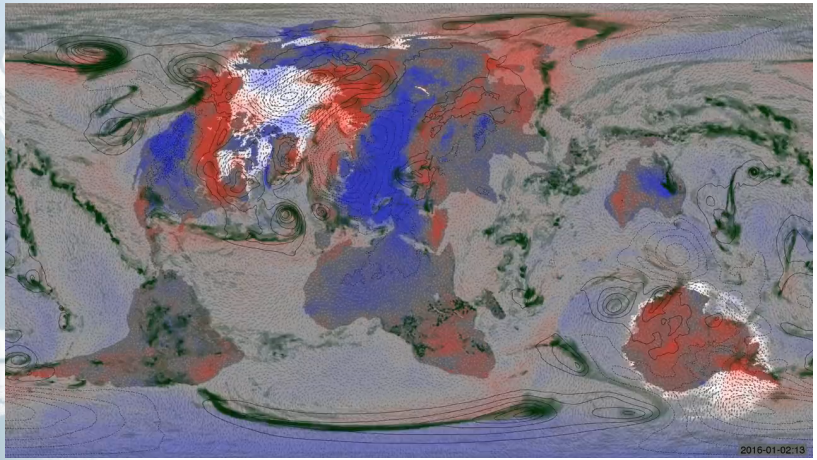
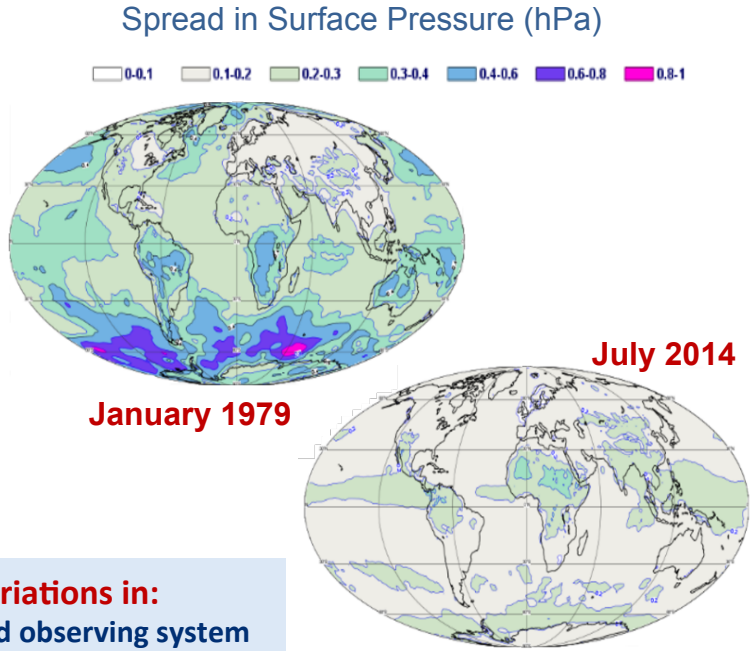
What is new in ERA5?

Hourly data and more parameters



Courtesy: Philip Brohan

Uncertainty estimate



Reflects variations in:

- ingested observing system
- flow-dependent sensitivity

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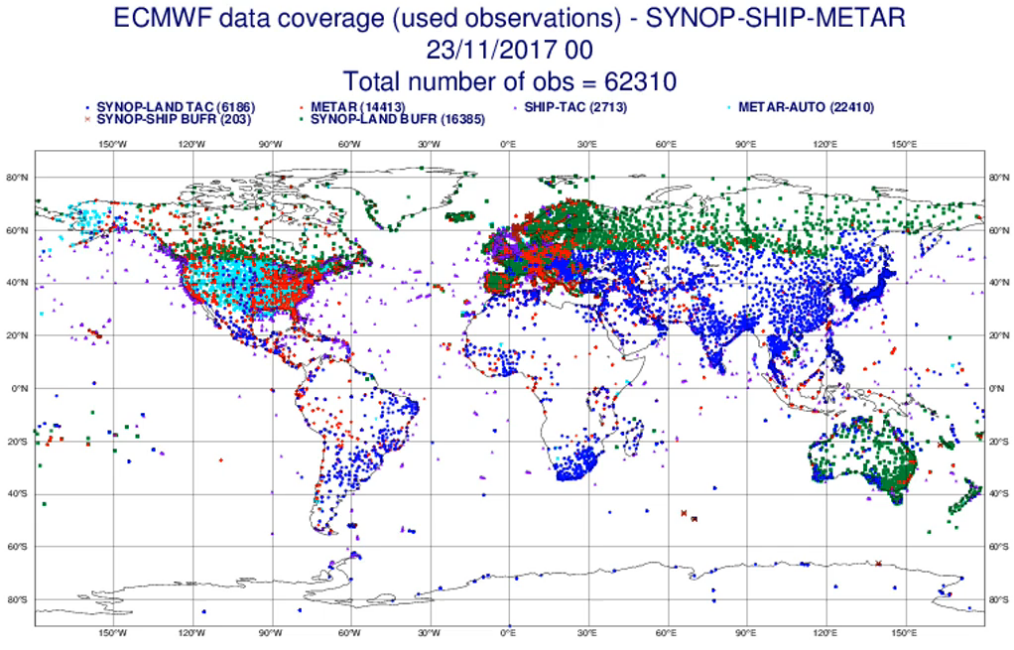
Current-day data usage in ERA5



Data sources:

In situ, conventional, satellite

Global and as resilient as possible

Pressure, wind, temperature, humidity, wind, ozone, .. brightness temperature, bending angles, …

Multivariate assimilation method:

variables work together to form a consistent view

Observation counts in ERA5:

Increasing over time

Use about 50 Million observations per day

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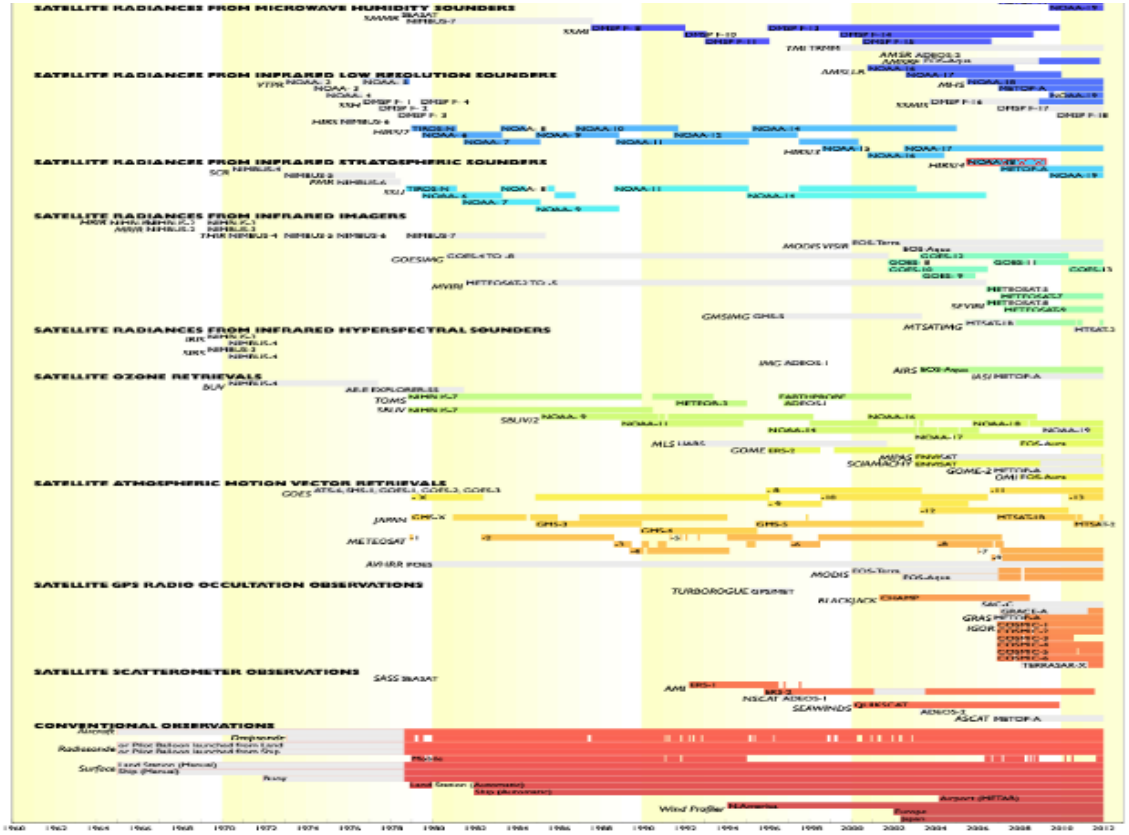
Evolution of the observing system



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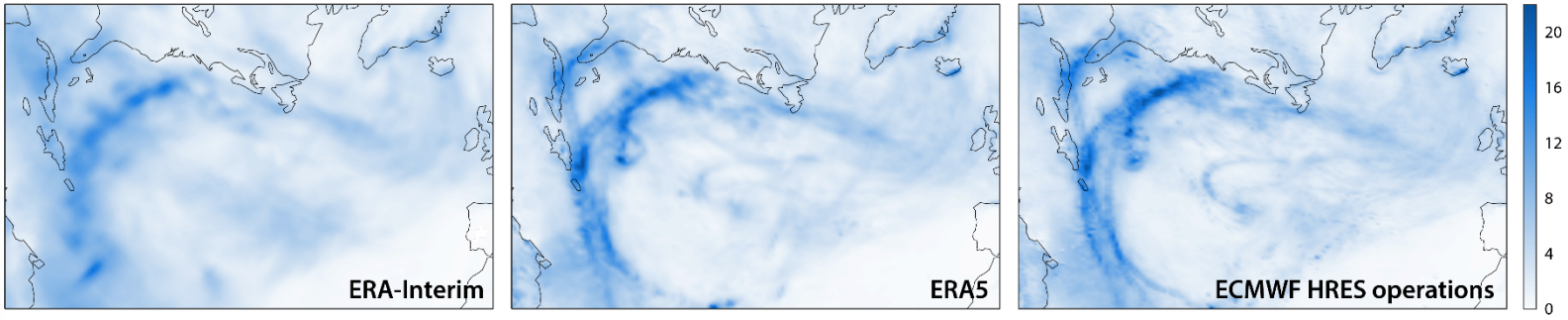
Horizontal resolution and depiction of tropical cyclones

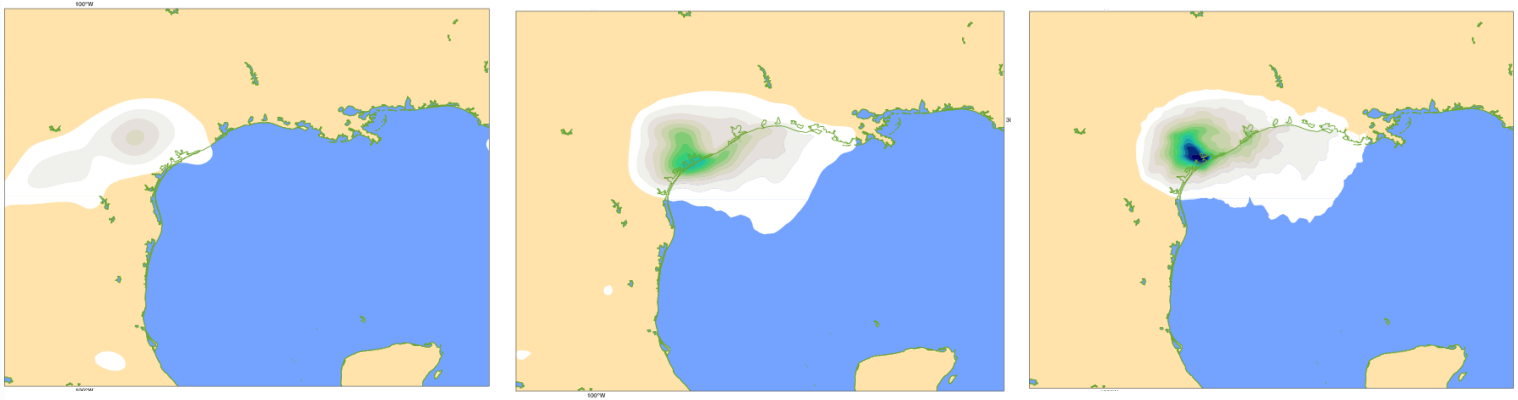
Mean precipitation rate (mm/day) for September 2017



Horizontal resolutions: **~80km** **~30km** **~10km**

Courtesy: Adrian Simmons

5-day precipitation for Harvey



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C3S regional reanalysis for Europe

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C3S Regional Reanalysis

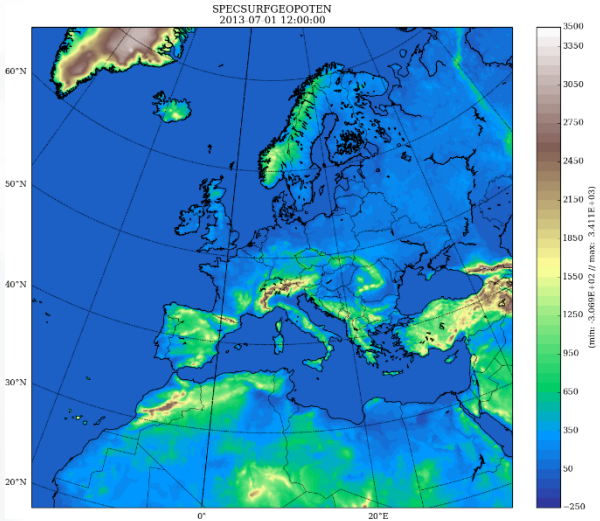
SMHI · Norwegian Meteorological Institute · METEO FRANCE · DMI Vejr, klima og hav · ILMATIETEEN LAITO · Veðurstofa Íslands

- Warming in the Arctic roughly twice as high as global average
- Need for understanding and management of change processes
- Increased economic activity in the region

Two 4-year tendered contracts have started recently

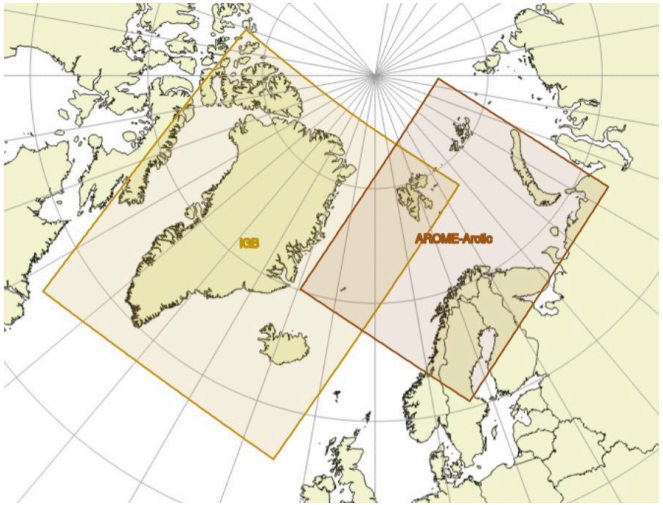
European domain, SMHI lead contractor

- 5.5 km resolution
- uncertainty estimate (11km)
- From early 1980s
- R&D, demonstration from FP7 UERRA project



Arctic domain, NMI lead contractor

- 2.5 km resolution, two domains
- Uncertainty estimate
- Special emphasis on handling of "*cold surfaces*": Snow, sea ice, glaciers
- July 1997 – June 2021



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Concluding remarks

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Summary and Final remarks

C3S is one of the Copernicus Services. Vision:

- Authoritative source of climate information for Europe
- Build upon massive European investments in science and technology

The C3S Climate Data Store (plus toolbox) will provide access to many ECV products

- observations, **reanalysis**, model output

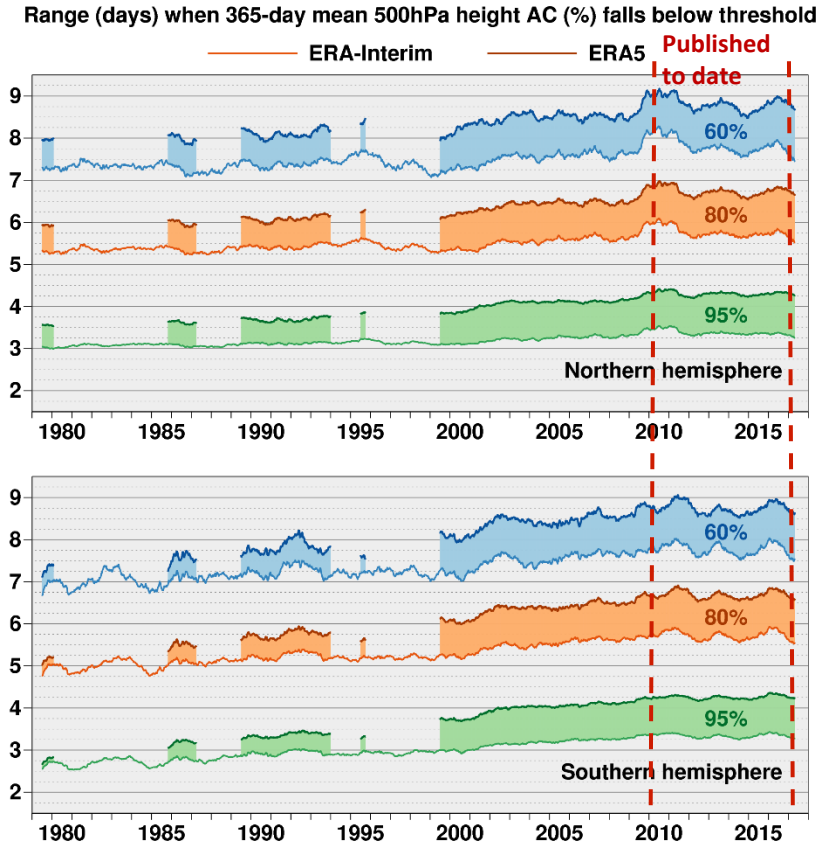
Reanalysis has numerous users and is increasingly recognized as an important source for climate monitoring

Both C3S global and regional reanalysis benefit from R&D (FP7) projects funded by the European Commission

The production of ERA5 is well underway:

- 31km global resolution, from 1950, hourly output, uncertainty estimate.
- To date ERA5 2010-2016 is publicly available
- Release of other periods will be done in stages.
- C3S User service Desk, Knowledge Base, FAQ's, user support

ERA5 is freely available and a timely product will be available one week behind real time



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