

50 years of ECMWF: Where Next?



 ECMWF | 50

The strength of a common goal

European co-operation at its best: **pooling resources**





THIS BUILDING WAS OPENED
BY
H.R.H. THE PRINCE OF WALES K.G.L.F.
AND
PRESENTED ON BEHALF OF HER MAJESTY'S GOVT
BY
PRESIDENT OF THE COUNCIL PROF. LA VUORE
EUROPEAN CENTRE FOR MEDIUM RANGE WEATH
ON 11 JUNE 1979

Three sites: one unique role

23 Member States
12 Cooperating States
~500 staff

ECMWF's role is to address the critical and most difficult research problems in medium-range NWP that no one country could tackle on its own.



Change to new HQ planned for 2027

Reading

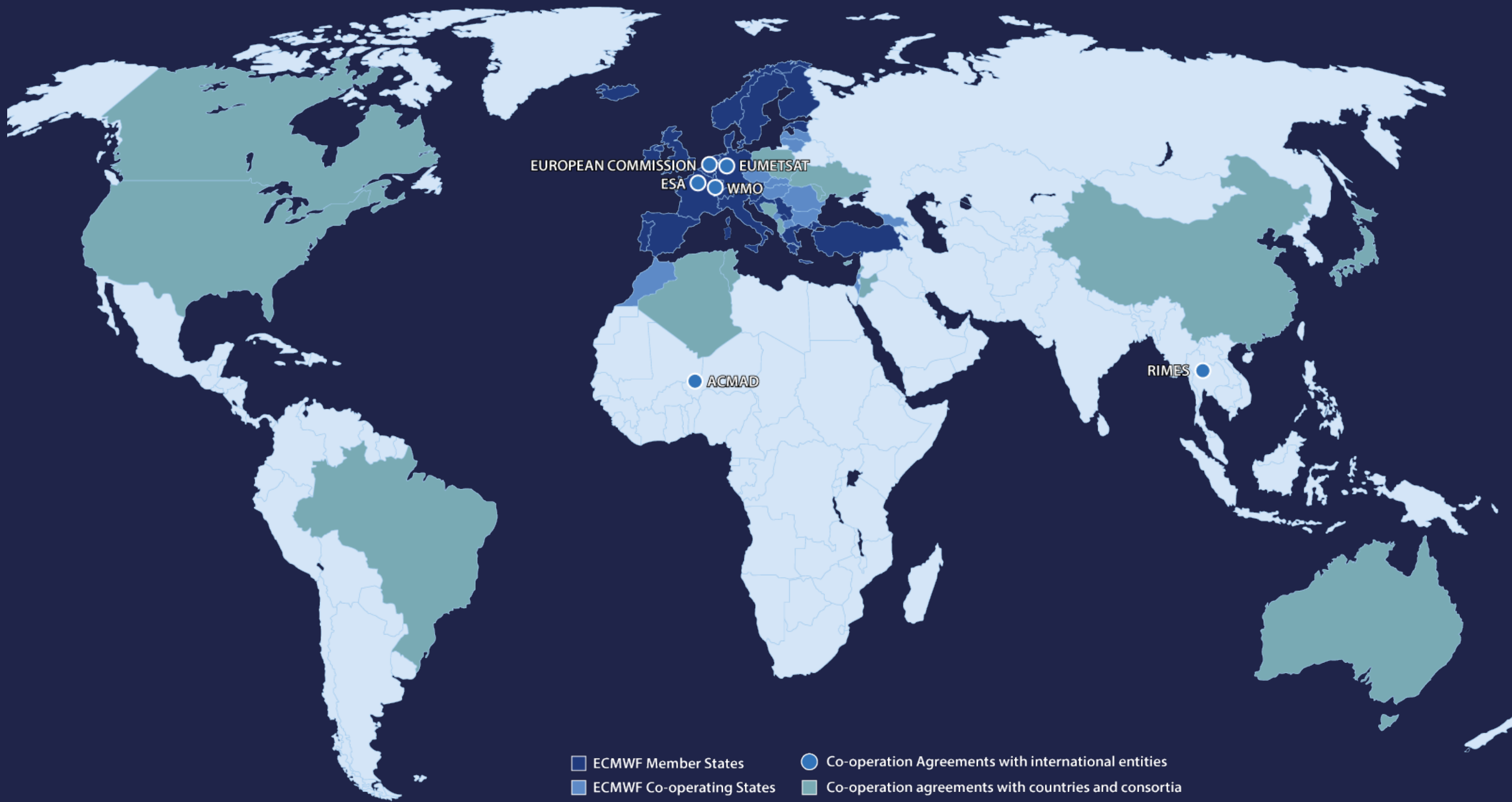
Bonn

Bologna

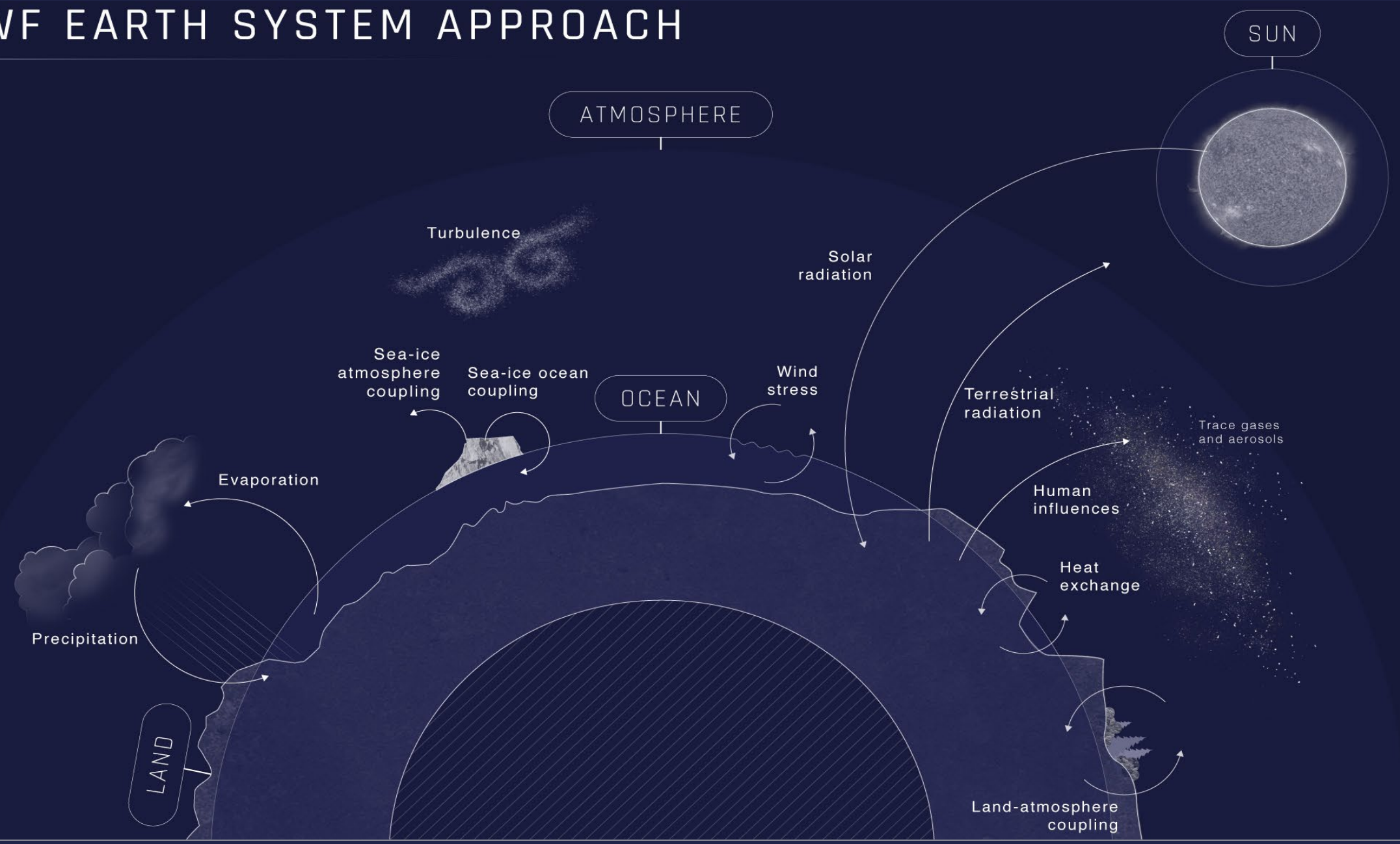


Change to new building planned for 2027

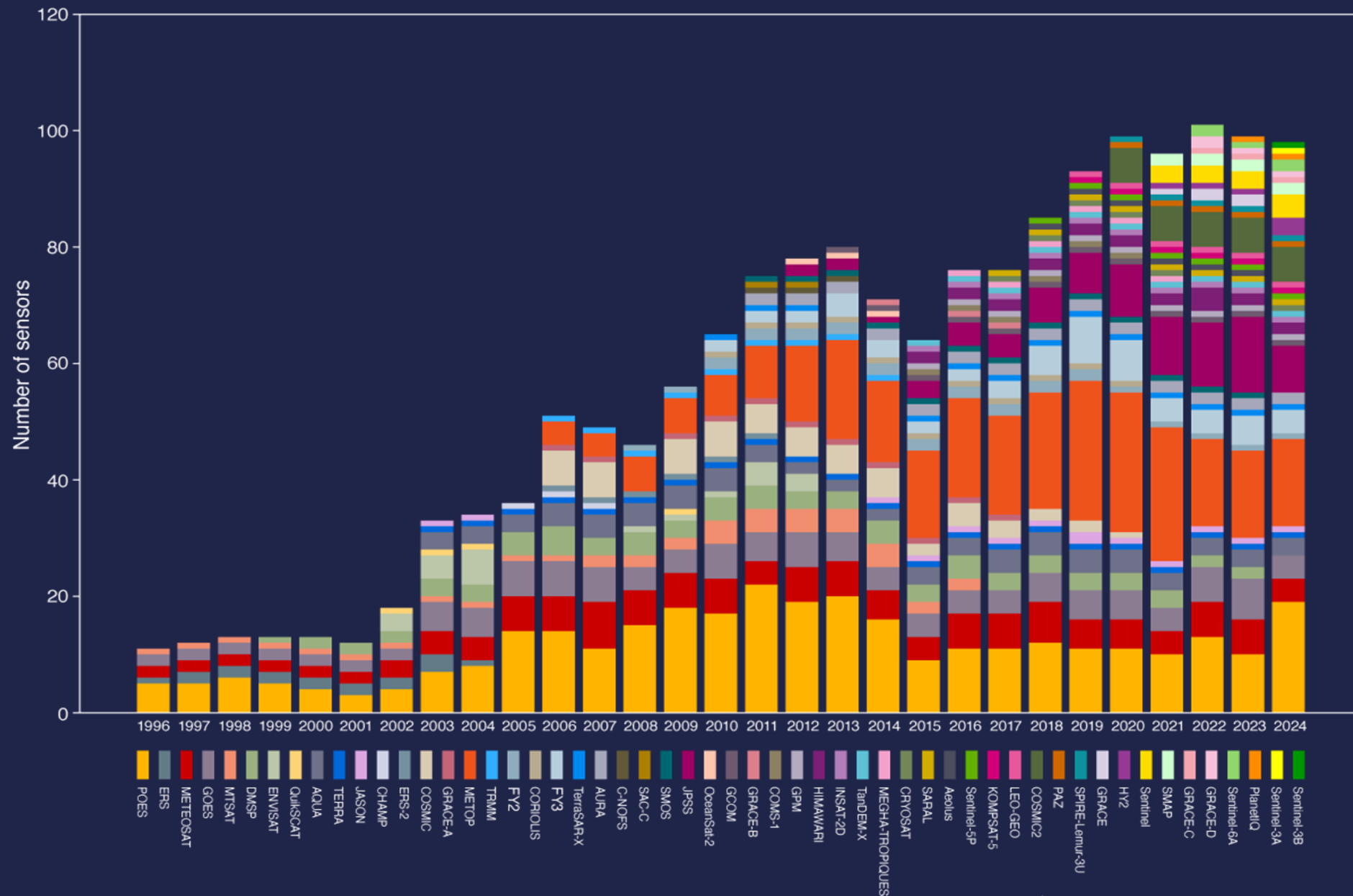




ECMWF EARTH SYSTEM APPROACH



NUMBER OF SATELLITE INSTRUMENTS PROCESSED AND USED OPERATIONALLY AT ECMWF

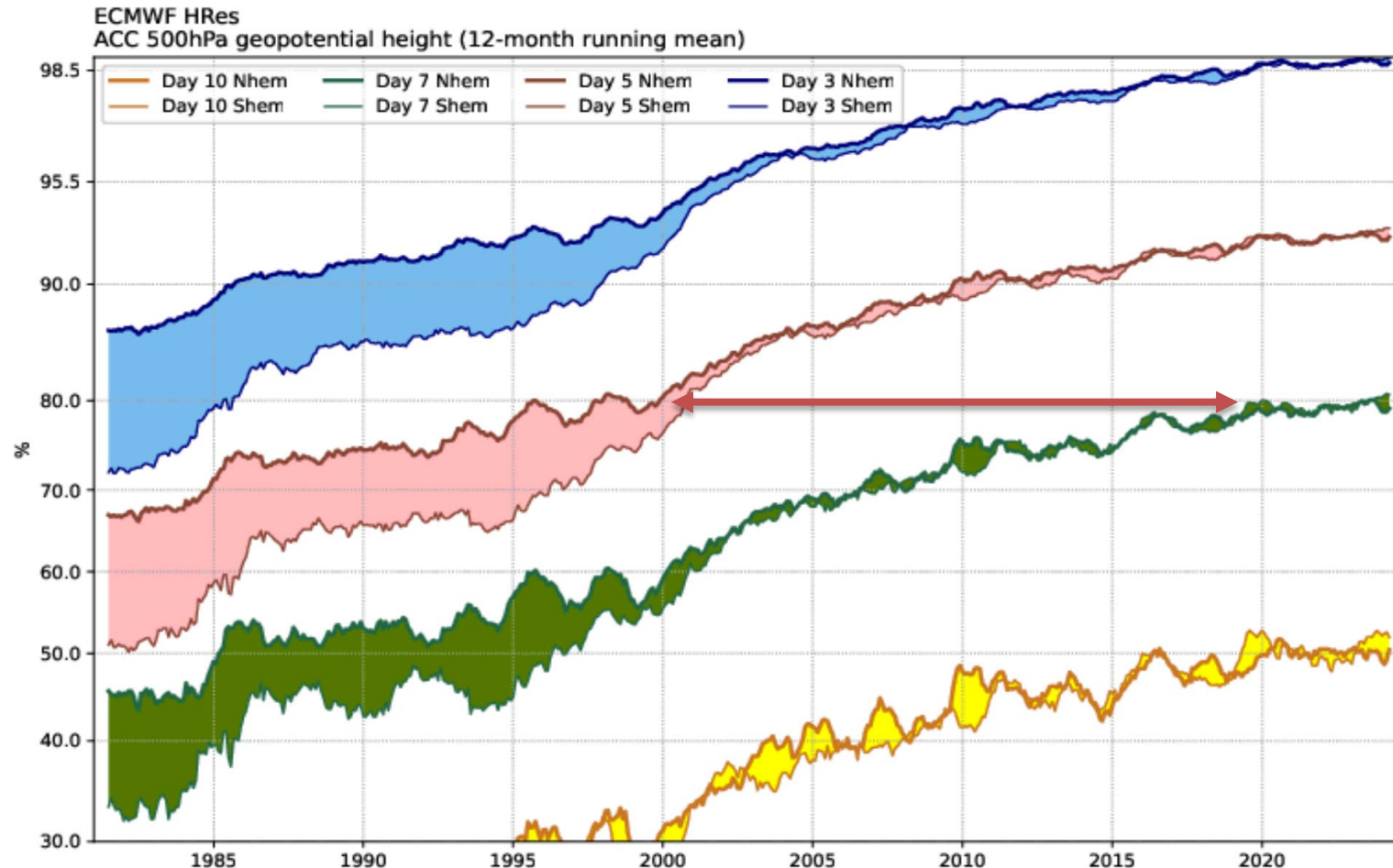


From the Cray1 to hybrid architectures, large increase in computing power



PROGRESS: ONE DAY PER DECADE AND BOTH HEMISPHERES EQUALLY PREDICTABLE

Lead time of anomaly correlation coefficient (ACC) reaching multiple thresholds (High resolution (HRES) 500 hPa height forecasts)



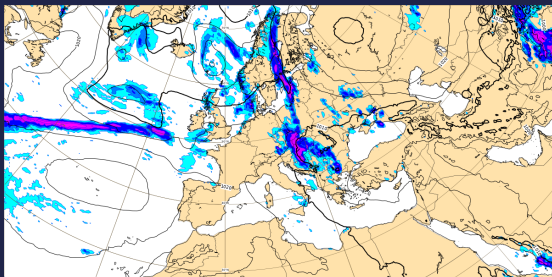
Same quality

day 7 forecast in 2020

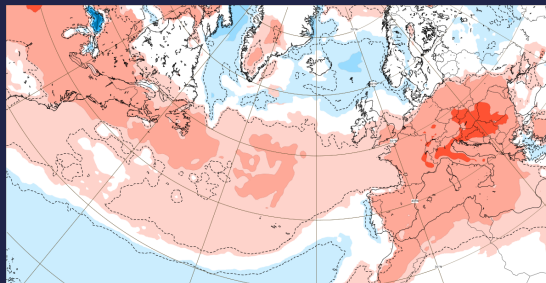
day 5 forecast in 2000

Some operational products

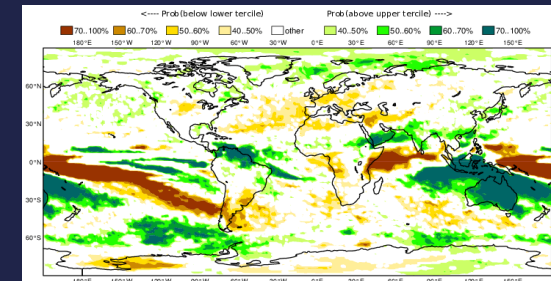
Medium range: up to 2 weeks



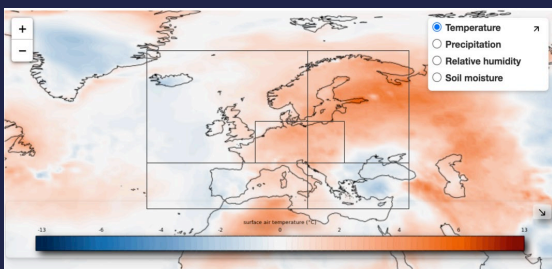
Sub-seasonal range: up to 6 weeks



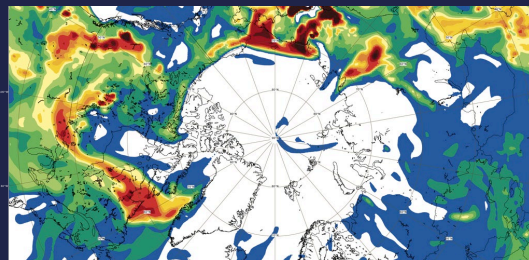
Seasonal range: up to a year



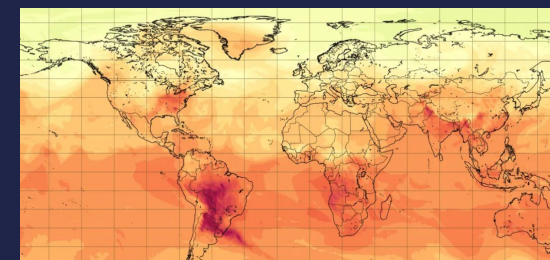
Climate monitoring



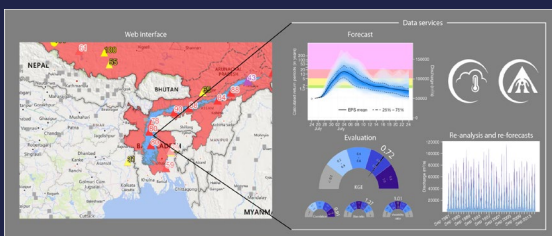
Air quality forecasts



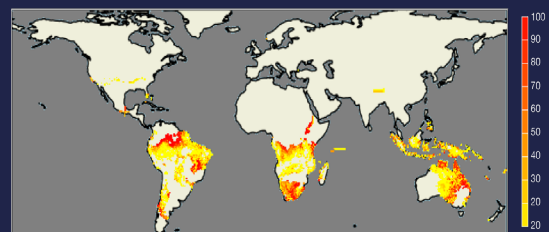
Greenhouse gas forecasts



Hydrological forecasts



Wildfires: probability of ignition by lightning



Anomalies in monthly average river flow in 2023

Data: EFAS • Reference period: 1991–2020 • Credit: CEMS/C3S/ECMWF

Exceptionally low Notably low Below average Average Above average Notably high Exceptionally high

January **February** **March**

April **May** **June**

July **August** **September**

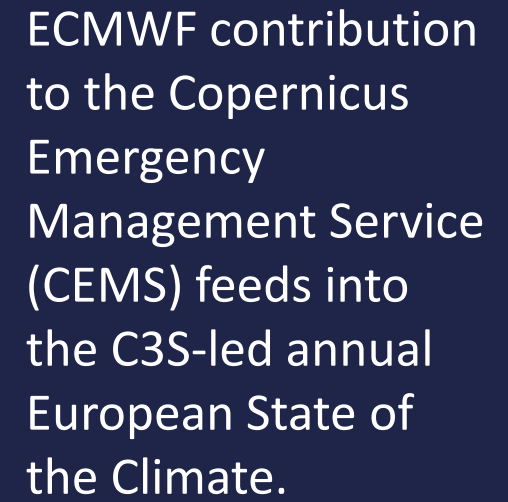
October **November** **December**

Legend:

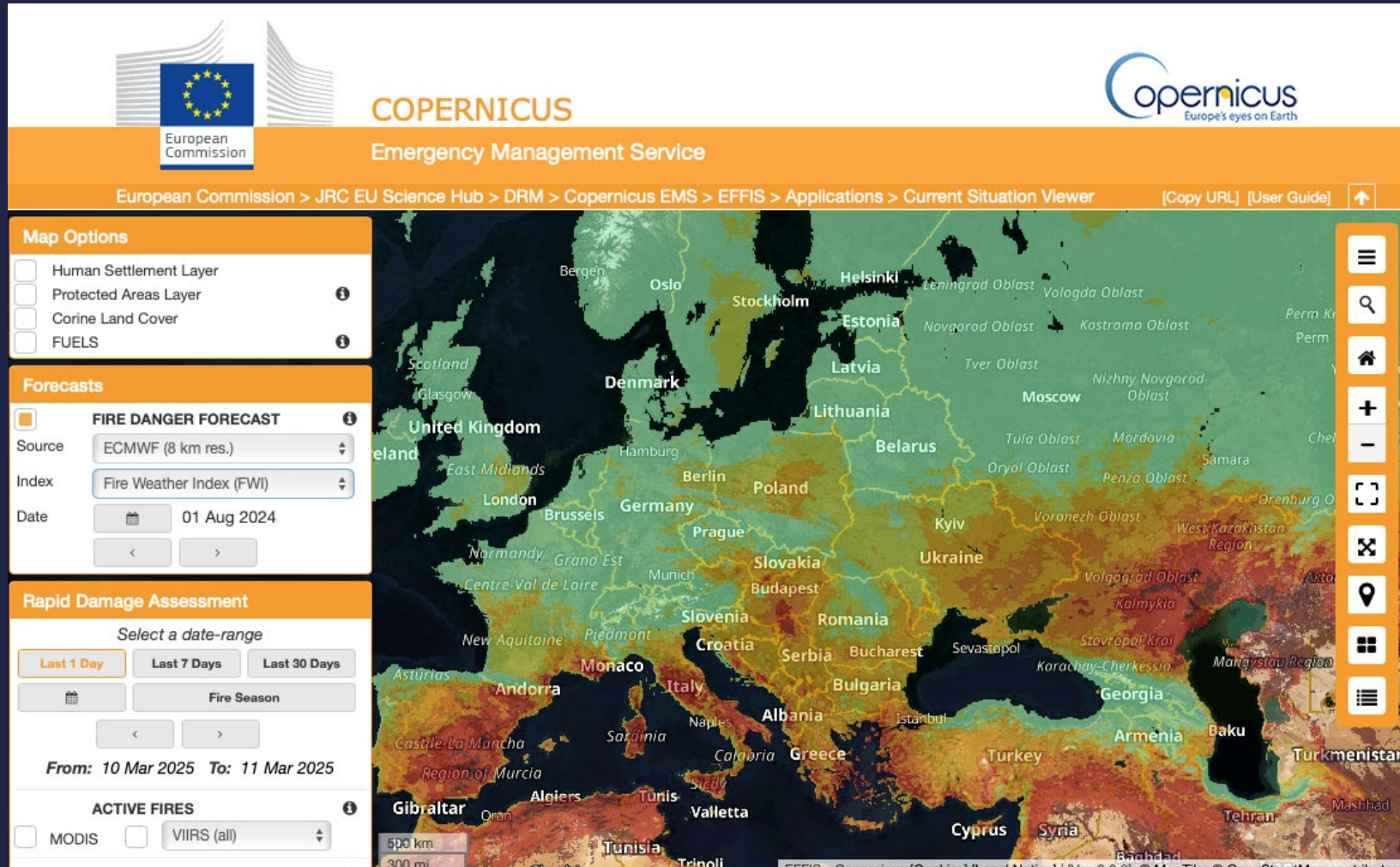
- Exceptionally low
- Notably low
- Below average
- Average
- Above average
- Notably high
- Exceptionally high

Logos:

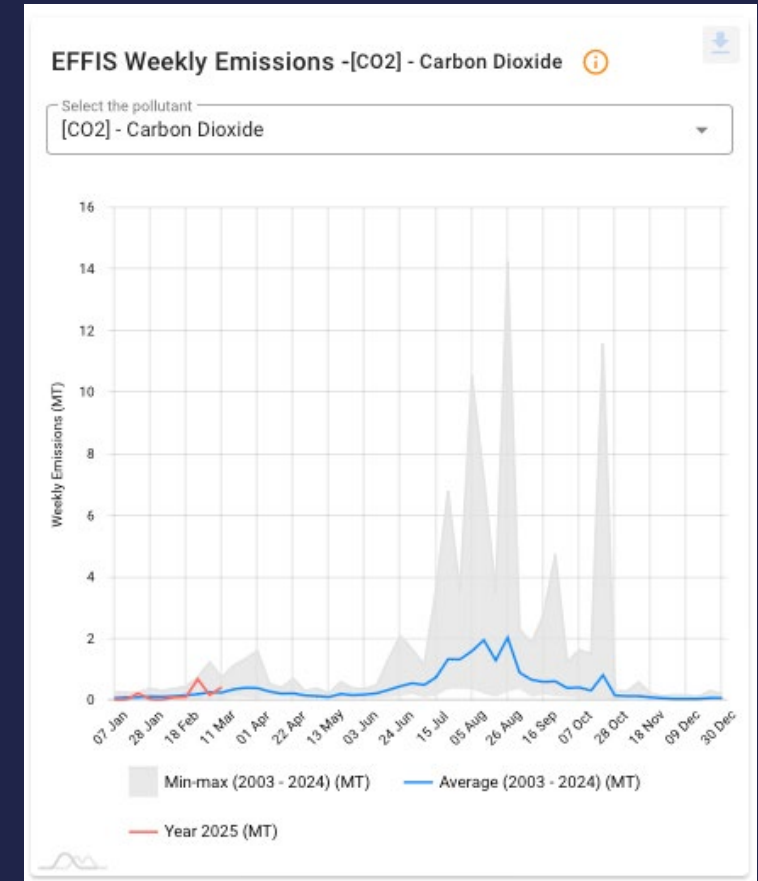
- Copernicus Climate Change Service European State of the Climate | 2023
- PROGRAMME OF THE EUROPEAN UNION
- Copernicus
- ECMWF
- Emergency Management



Example: Fire danger forecasts and fire emissions



ECMWF powers the European Forest Fires Information System of CEMS providing in particular daily-updated fire danger forecast information (here for 01 August 2024).



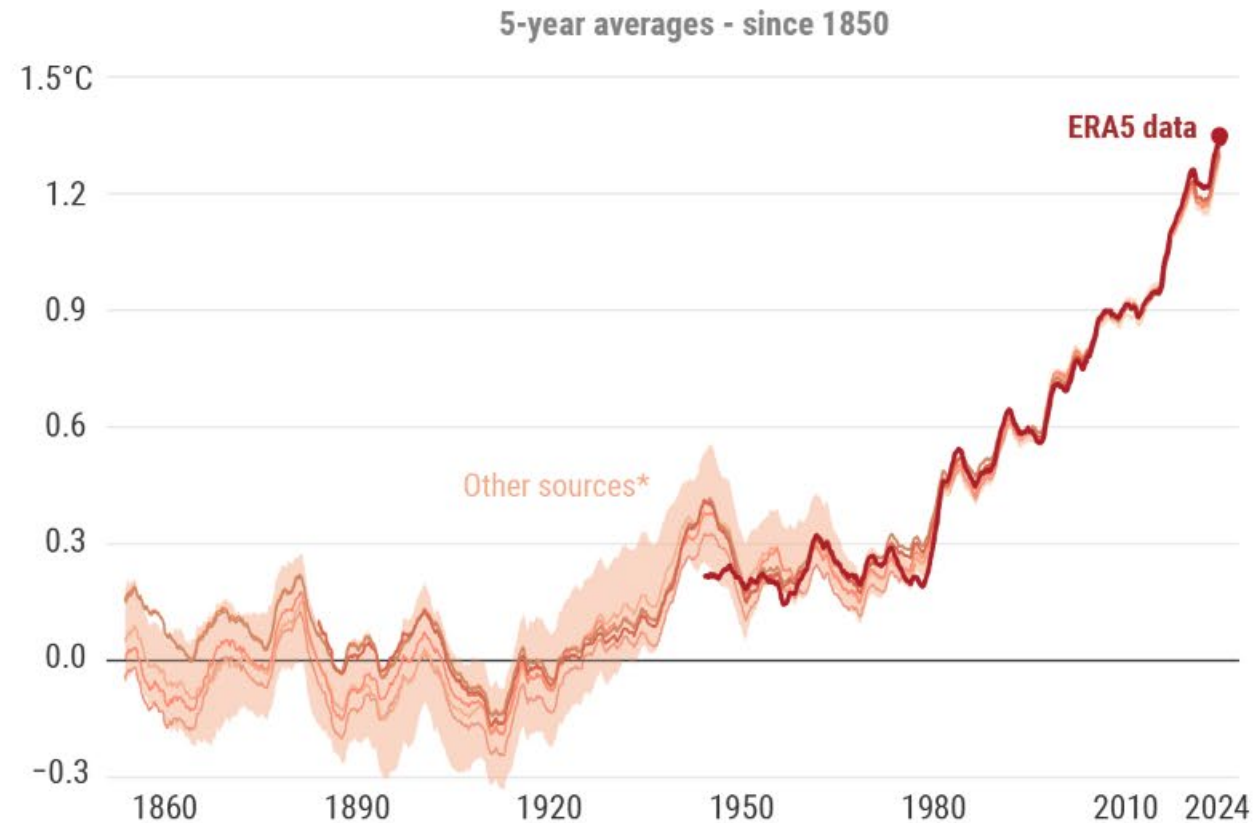
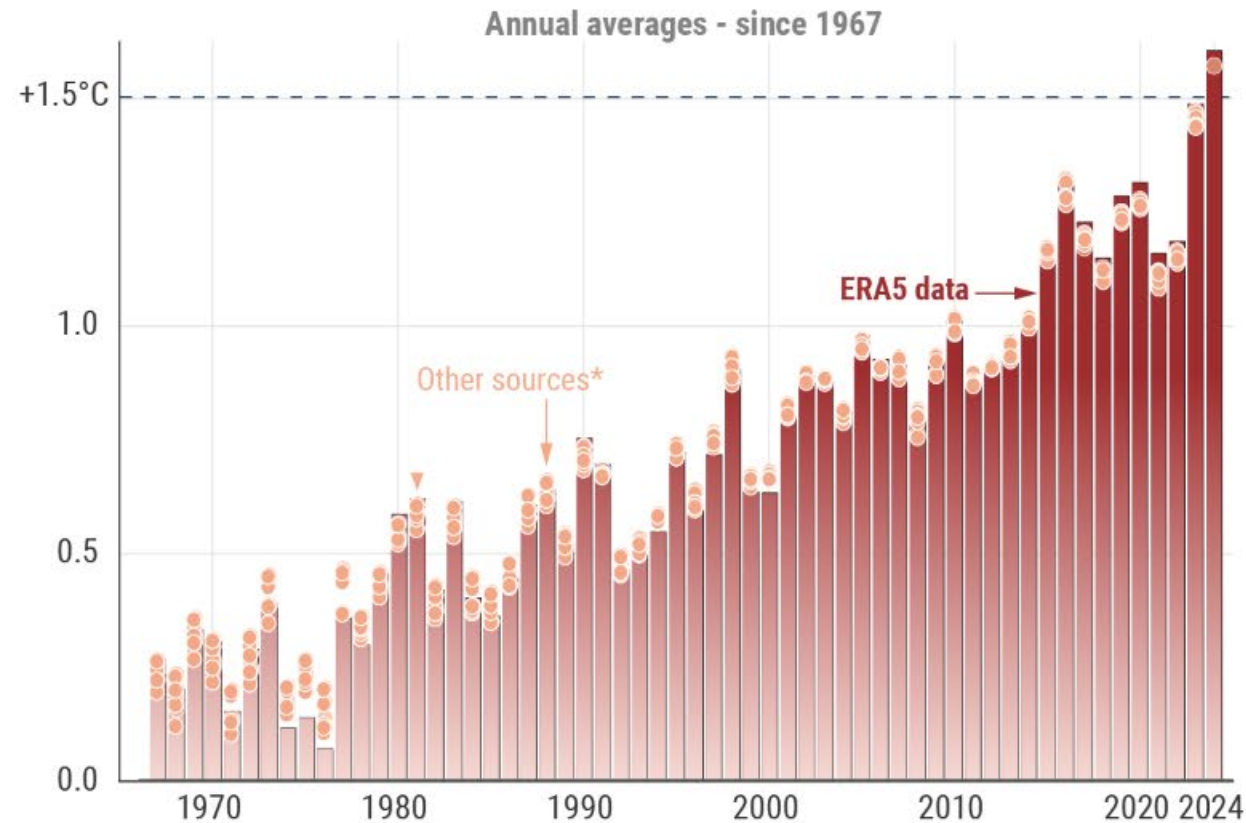
ECMWF also provides NRT information on pollutants and greenhouse gas emissions from wildfires (produced as part of CAMS).

GLOBAL REANALYSIS (ERA5) : A TOOL FOR CLIMATE MONITORING AND FOR MACHINE LEARNING



Global surface temperature increase above pre-industrial

Reference period: pre-industrial (1850–1900) • Credit: C3S/ECMWF



*Other sources include JRA-3Q, GISTEMPv4, NOAA GlobalTempv6, Berkeley Earth and the HadCRUT5 ensemble mean. Shading shows the range of the HadCRUT5 ensemble.

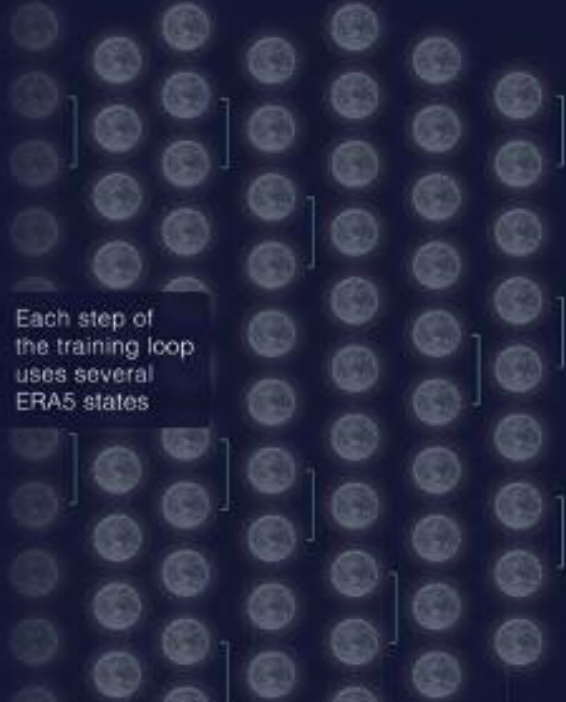
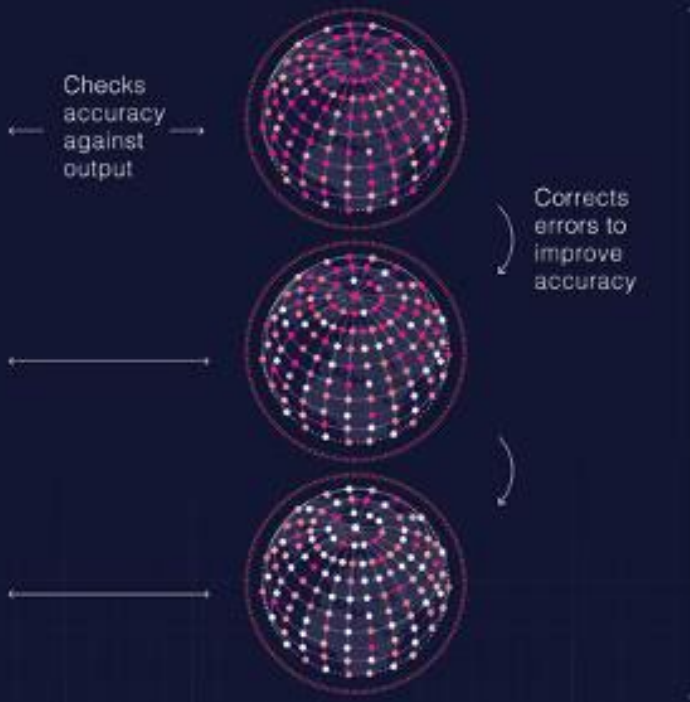


PROGRAMME OF
THE EUROPEAN UNION



TRAINING THE AIFS MACHINE LEARNING (ML) MODEL

The model is highly accurate due to **ERA5**, a dataset of hourly physical states of Earth since 1940.

Sets of training data from ERA5	Example of training loop	ML model
 Each step of the training loop uses several ERA5 states	 Checks accuracy against output Corrects errors to improve accuracy	 Predicts weather based on physical state of Earth after learning from ERA5

The future: impact of AI/ML

ARTIFICIAL INTELLIGENCE FORECASTING SYSTEM (AIFS)



1. Observe

Every day, we collect **800 million** observations of Earth's atmosphere, wind, temperature and beyond

2. Absorb

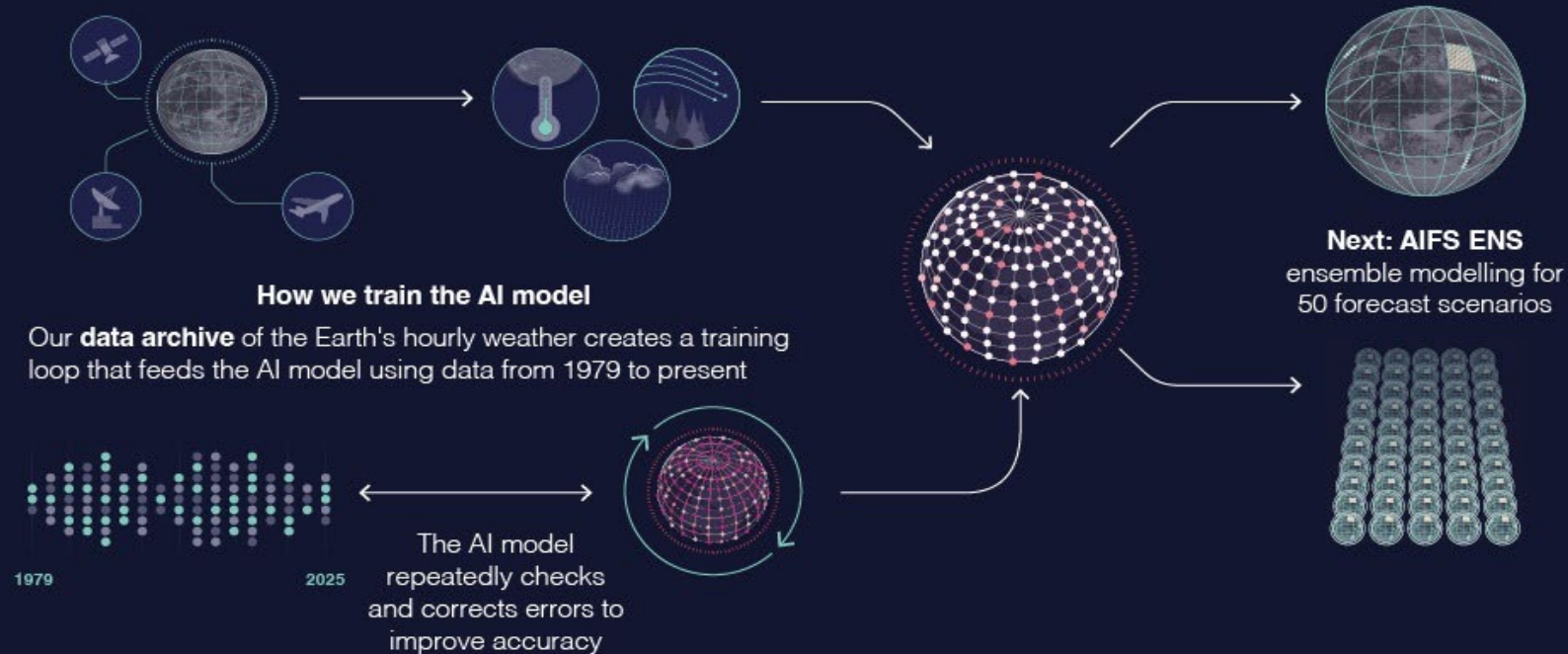
60 million quality-controlled observations are absorbed by our physics-based Integrated Forecasting System

3. Model

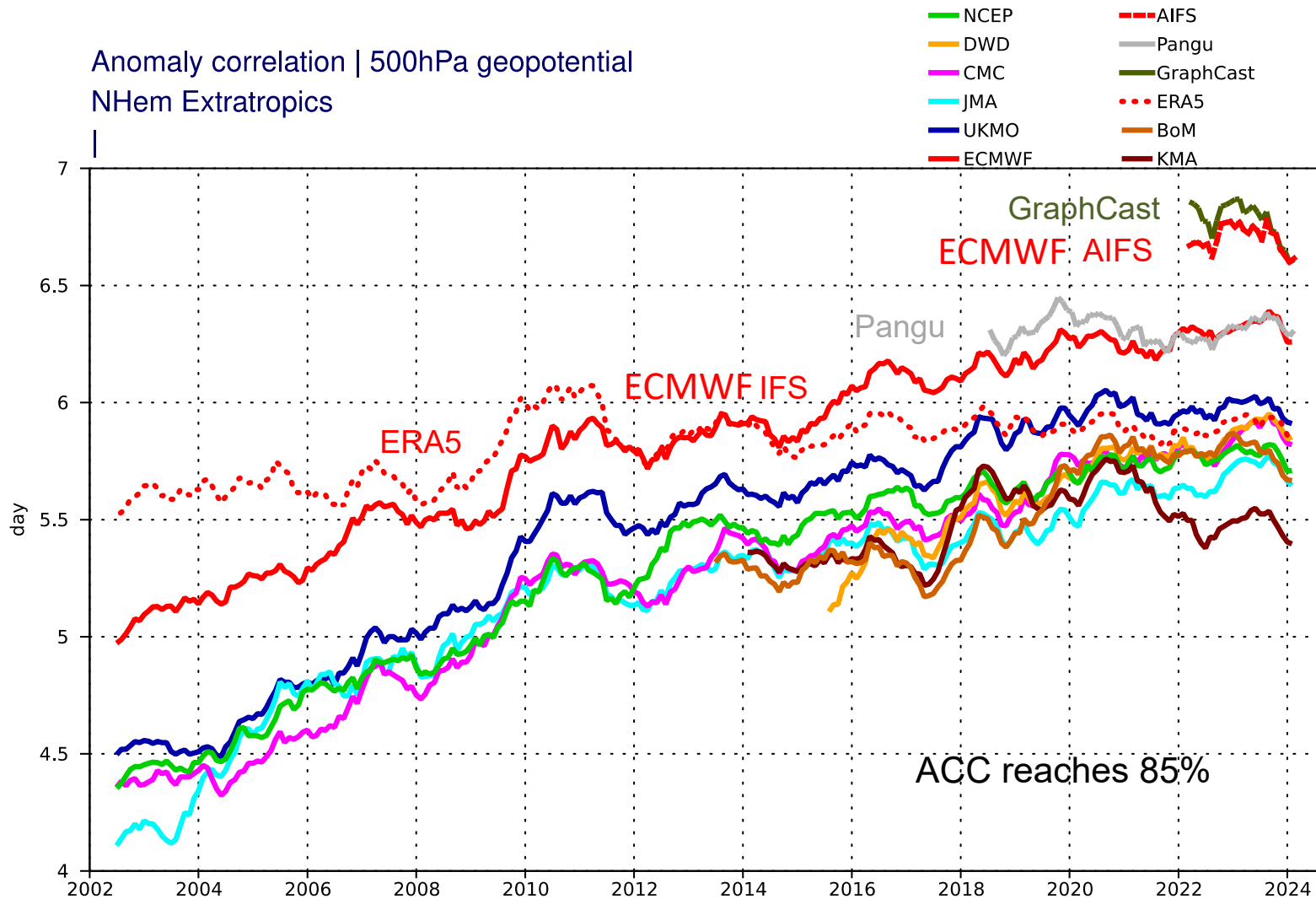
They feed the **AIFS'** new AI model, which predicts Earth's weather for the coming days

4. Predict

Now: AIFS Single one forecast at a time



Model performance

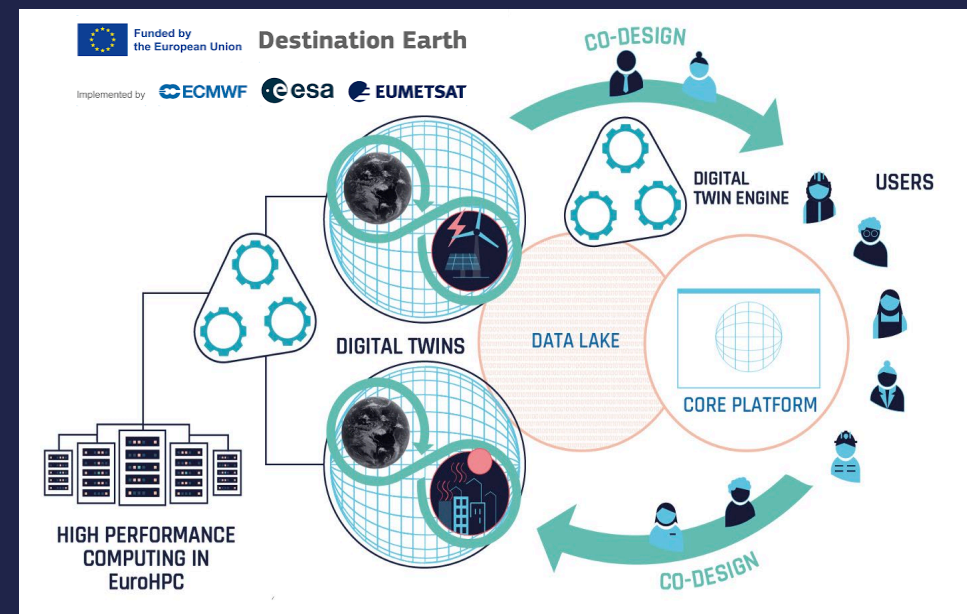


Data-driven (ML) models

Physics-based models



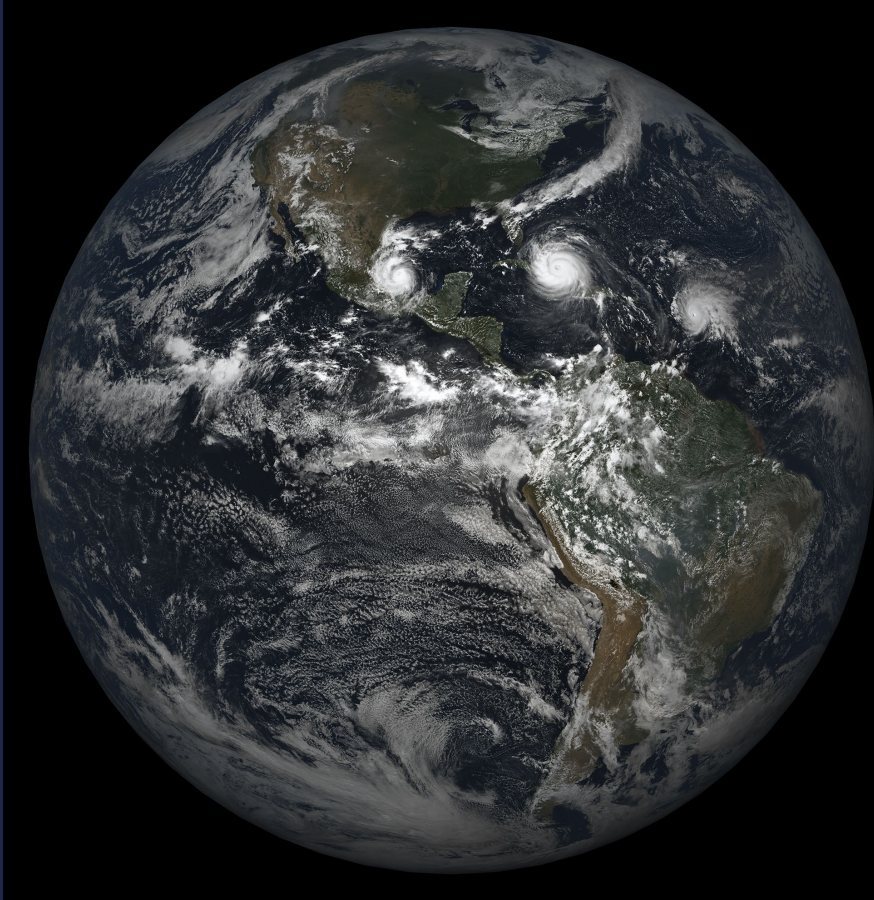
- **Since 1990s**, ECMWF has been involved in EU Research and Innovation programmes
- **Since 2014**, ECMWF implements the Copernicus Atmosphere Monitoring Service (CAMS) and the Copernicus Climate Change Service (C3S) as Entrusted Entity of the EC / DG DEFIS, and is contractor for the Copernicus Emergency Management Service (CEMS)
- **Since 2021**, ECMWF implements Destination Earth together with ESA and Eumetsat as Entrusted Entities of the EC / DG CNECT
- **Since 2025**, ECMWF also works with ESA and Eumetsat on a project of the EC / DG INTPA on Space for Early Warnings in Africa (SEWA).



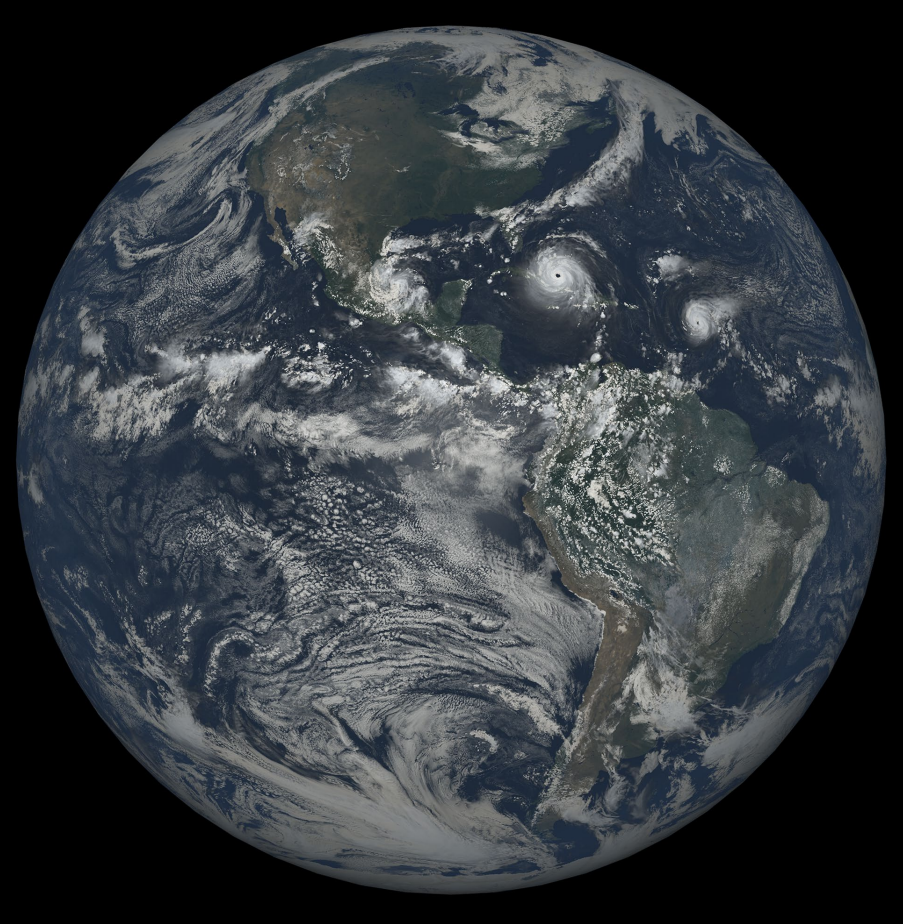
(CAMS and C3S will be presented this afternoon)

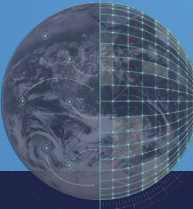
Towards digital twins of the earth system

Planet Earth as observed by satellites



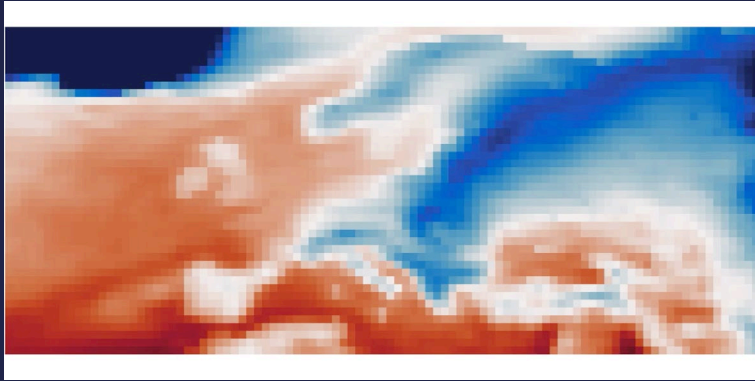
**Planet Earth as
modelled by
ECMWF's IFS for
Destination Earth
(2.8 km)**



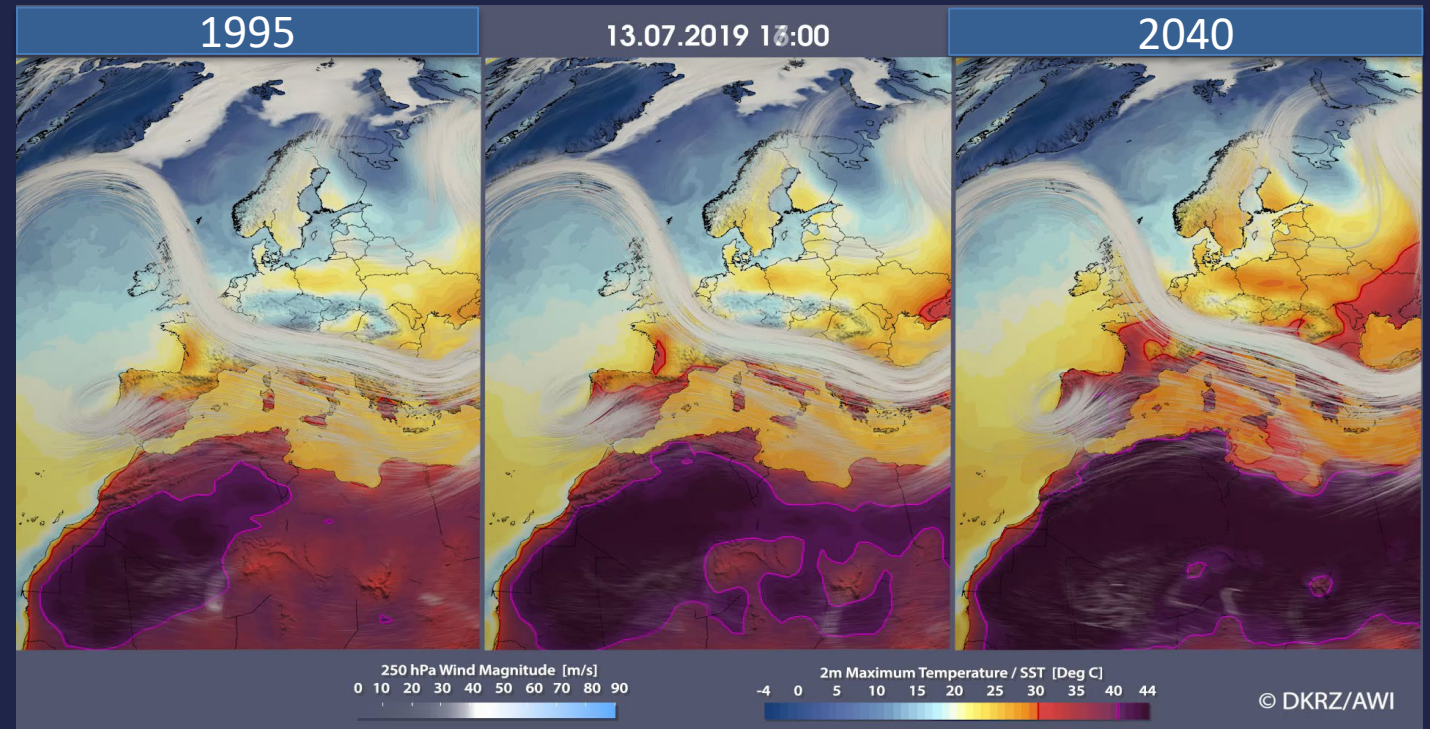
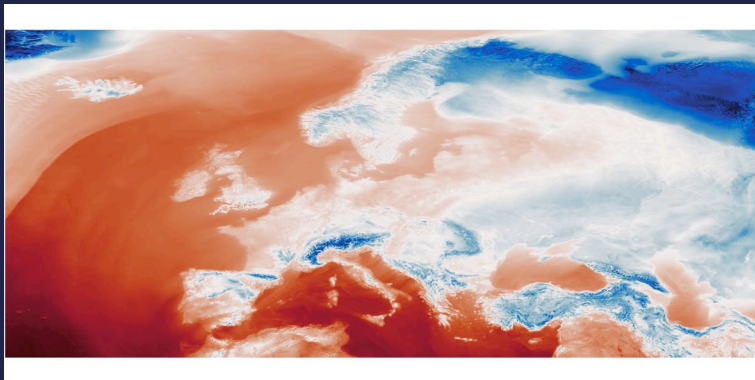


Pushing the boundaries of climate projections / Climate-DT

IPCC AR6 (2021), 100km



Digital Twin, 5km





THE STRENGTH OF A COMMON GOAL



Our Vision:

World-leading monitoring and predictions of the Earth system enabled by cutting-edge physical, computational and data science, resulting from a close collaboration between ECMWF and the members of the European Meteorological Infrastructure, will contribute to a safe and thriving society

ECMWF in 2035:

- Innovating at the cutting edge of physical, computational and data science for environmental monitoring and prediction
- Delivering forecast tools and products of unprecedented quality, exploiting data-driven methods anchored on physics-based modelling
- Integrated in and collaborating with the wider European meteorological community to deliver maximum value to society

Our Mission: Deliver global numerical weather predictions focusing on the medium-range and monitoring of the Earth system to and with our Member States

Strategic Pillars and Actions:

Science & Technology

Improve use of observations & Earth system data assimilation

Improve seamless Earth system models

Exploit high-performance computing, technology & computational science for numerical weather prediction

Harness artificial intelligence/machine learning for data-driven forecasting

Optimise system design & enhance flow from research to operations & vice versa

Impact

Meet users' needs & deliver world-leading quality products

Optimise provision & sharing of data, tools & resources

Enhance partnerships, training & communications

Organisation & People

Increase organisational performance, resilience & effectiveness

Enable a thriving multi-site environment with an emphasis on sustainability



Collaboration essential to achieve this vision!





 **ECMWF | 50**
The strength of a common goal