ECMWF
The strength
of a common goal

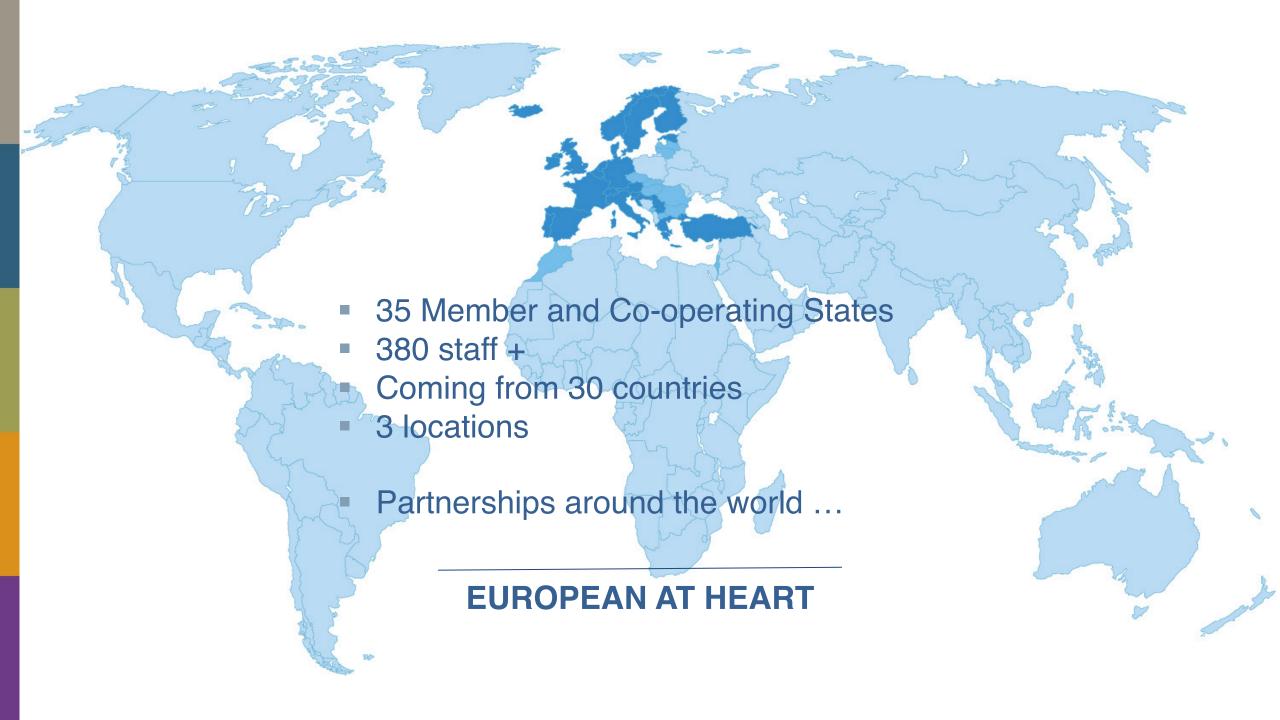ECMWF | EUROPEAN CENTRE FOR MEDIUM-RANGE WEATHER FORECASTS

Conferenza GARR 2022
Matteo Dell'Acqua

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

- 35 Member and Co-operating States
- 380 staff +
- Coming from 30 countries
- 3 locations

- Partnerships around the world …

EUROPEAN AT HEART

Three sites: one unique role

Reading

Bonn

Bologna

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

ECMWF

ECMWF new
Data Centre in Bologna

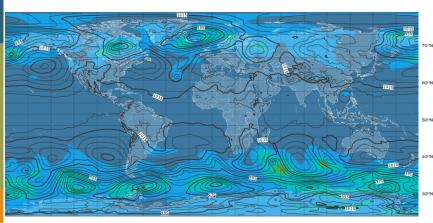# Emboldening **global collaboration**

What do we do?

European co-operation at its best: **deliverables**

- Global numerical weather forecasts
- Supercomputing & data archiving
- Education & training programme

- EU activities: *Operating the Copernicus Climate and Atmosphere Services, contributing EFAS and FIRE to the Copernicus Emergency Management Service, entrusted entities of DestinE*
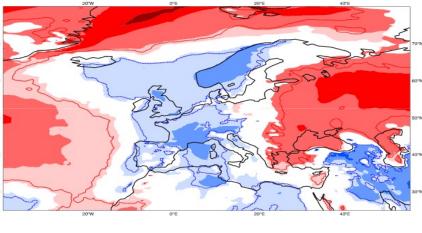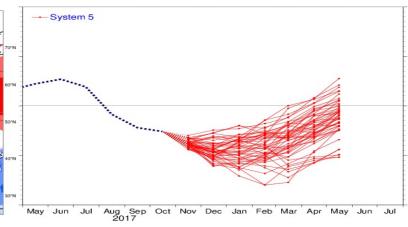
Deliverables: Global NWP at all ranges

Medium-range prediction

High-resolution mean sea level pressure and ensemble spread

Monthly forecast plumes
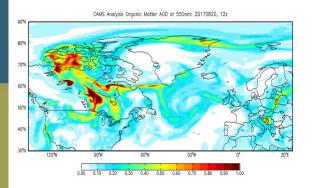
Weekly anomaly – 2m temperature over Europe

Long-range prediction
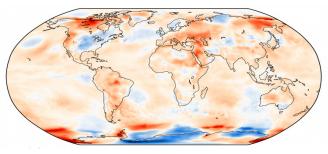

El Nino SST anomaly plume

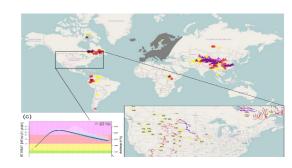# **Working with the EU**: Environmental information
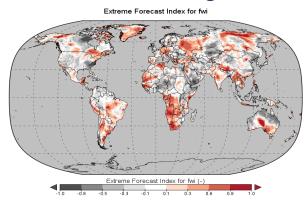
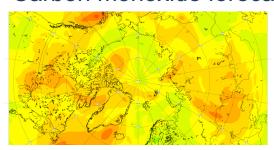## Atmosphere Monitoring

Climate Change

Flood forecasting

Fire forecasting

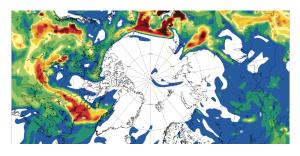## Carbon monoxide forecast

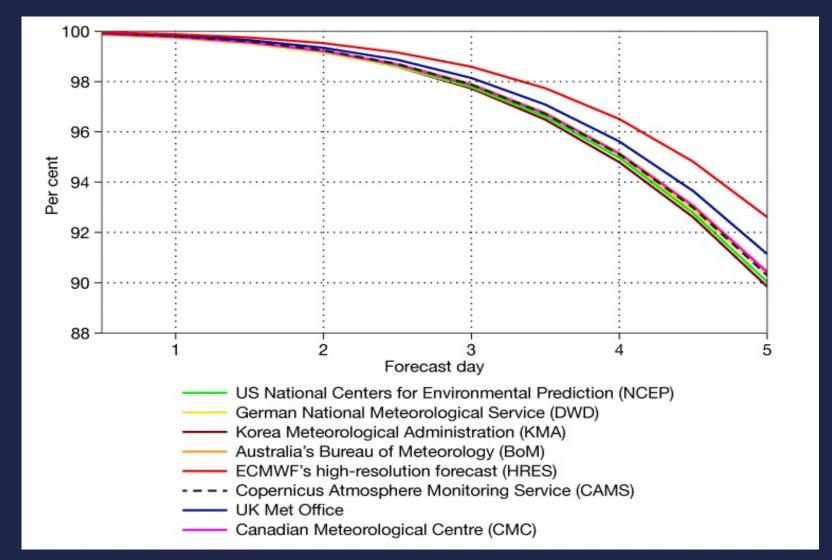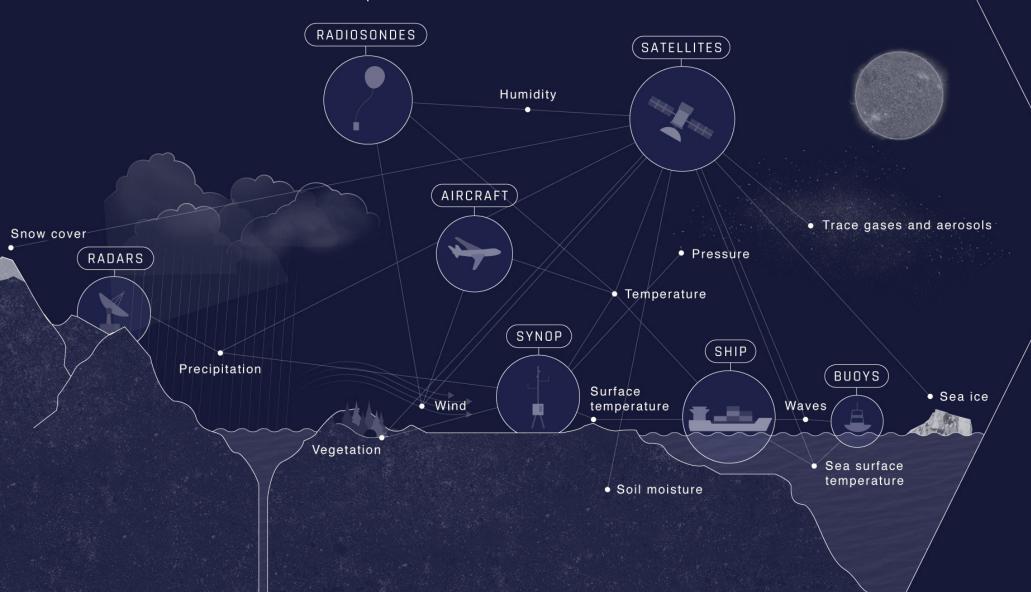## Ozone forecast

Model performance: WMO comparison

How do we do it?

ECMWF EARTH SYSTEM APPROACH

SUN

ATMOSPHERE

Turbulence

Solar radiation

Sea-ice atmosphere coupling

Sea-ice ocean coupling

OCEAN

Wind stress

Terrestrial radiation

Trace gases and aerosols

Evaporation

Human influences

Heat exchange

Precipitation

LAND

Land-atmosphere coupling

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CAPTURING THE WEATHER

To predict the future, we observe the present. Every day, we absorb 800 million observations to create a detailed snapshot of Earth's weather.

RADIOSONDES

SATELLITES

Humidity

AIRCRAFT

Snow cover

RADARS

Trace gases and aerosols

Pressure

Temperature

Precipitation

SYNOP

SHIP

BUOYS

Surface temperature

Waves

Sea ice

Wind

Vegetation
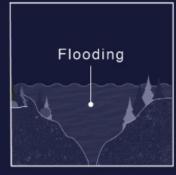
Sea surface temperature

Soil moisture

800M DAILY OBSERVATIONS

BEYOND THE WEATHER FORECAST

ECMWF's forecasting system is now giving us even more vital predictions about Earth's environmental developments. These forecasts can protect infrastructure, promote economic development and save lives.

POSSIBLE OUTPUTS

Wild fires

Flooding

Weather

Climate change

CO2 emissions

Air quality

ECMWF ENSEMBLE PREDICTION

Initial conditions

Ensemble members illustrating the possible scenarios

Distribution of ensemble members

Confidence level of predicted forecasts

Low High

3D view of model predictions
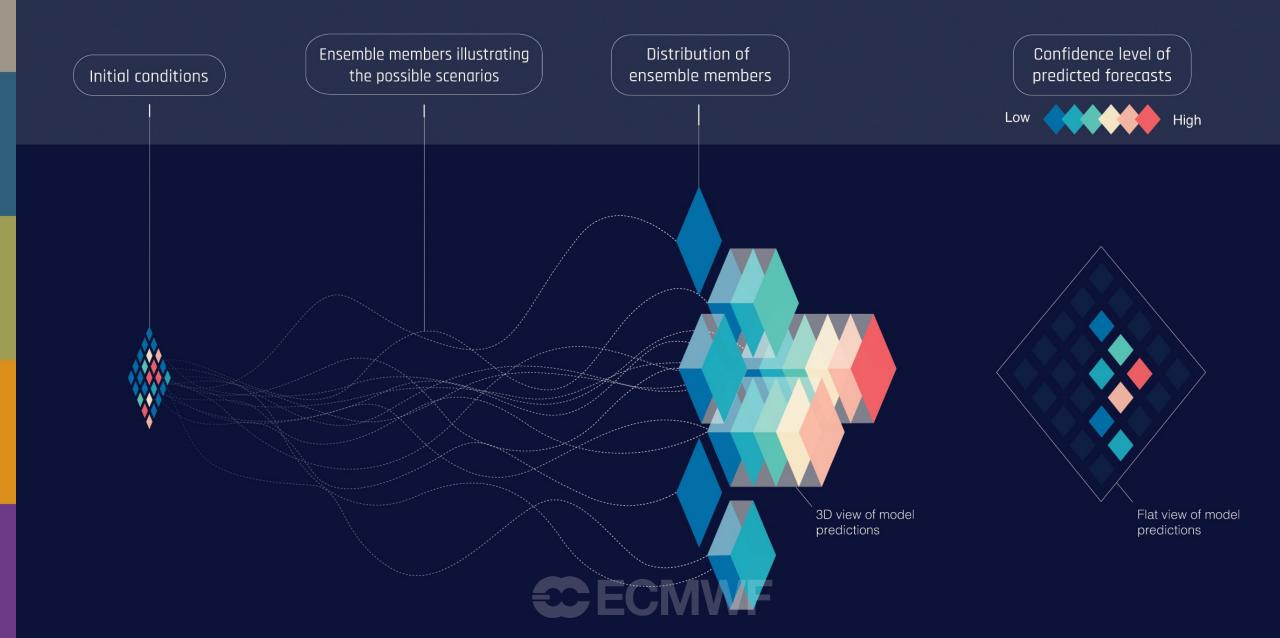
Flat view of model predictions
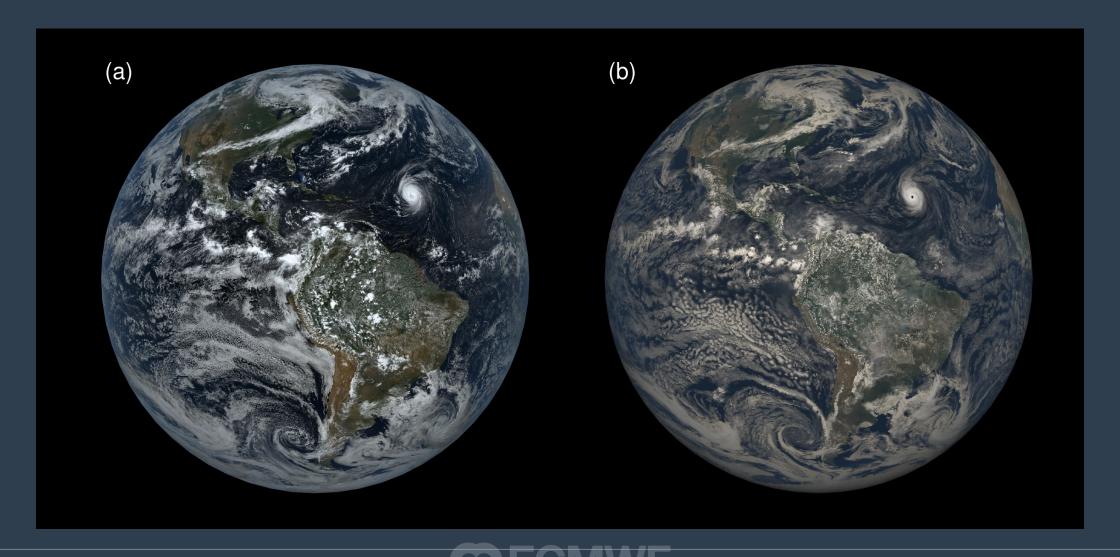
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Increase realism in model

(a) (b)

Machine Learning has been part of ECMWF forecasts for many years

Obs

η

Obs

η

Obs

η

Obs

6 UTC   9 UTC   12 UTC   15
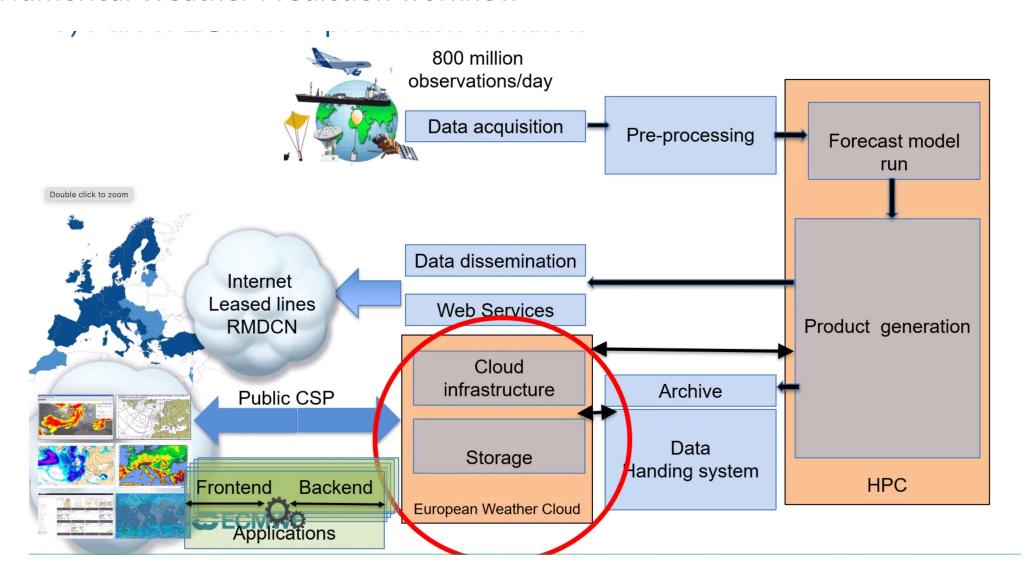
Assimilation window

Analysis trajectory

First-guess trajectory

ECMWF

And now planning to revolutionize the full NWP workflow…

Computing & Scalability
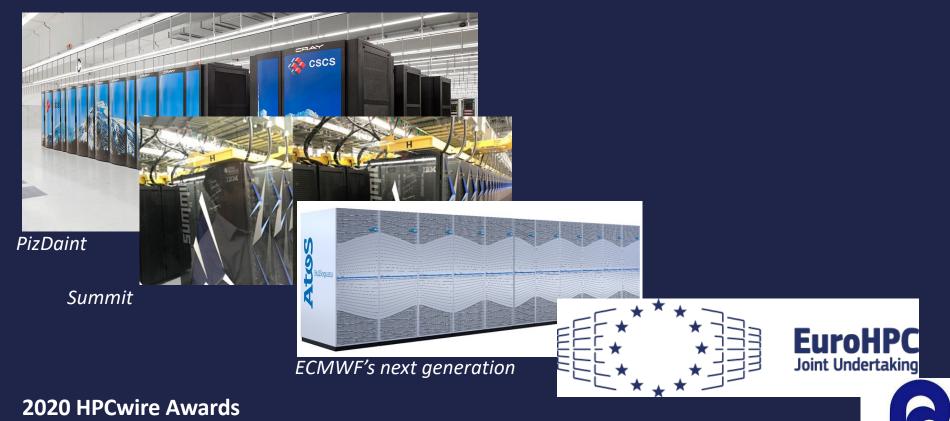
Numerical Weather Prediction workflow

800 million observations/day

Data acquisition → Pre-processing → Forecast model run

Data dissemination

Web Services

Internet Leased lines RMDCN

Double click to zoom

Public CSP

Cloud infrastructure

Storage

European Weather Cloud

Archive

Data Handing system

Product generation

HPC

Frontend   Backend

Applications
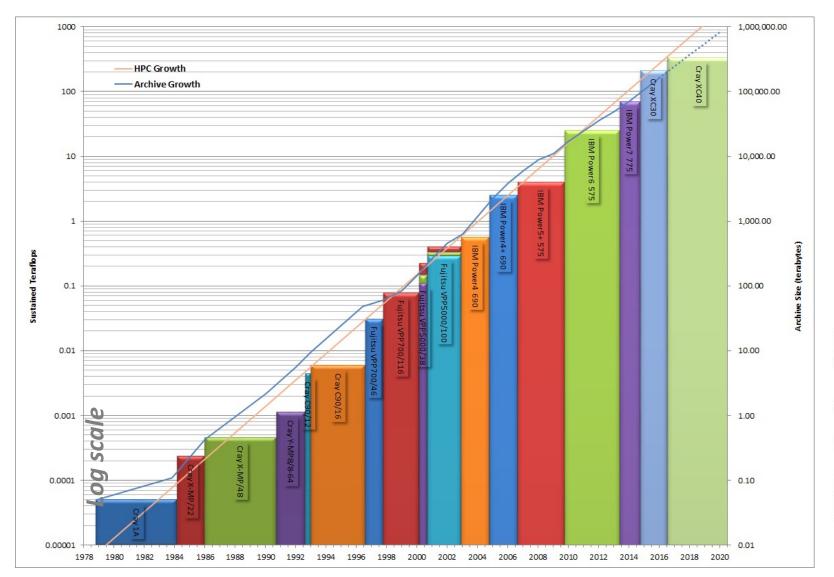
HPC use of some of the largest supercomputers

PizDaint

Summit

ECMWF's next generation

2020 HPCwire Awards
Readers' Best Use of HPC in Physical Sciences –
ECMWF & ORNL
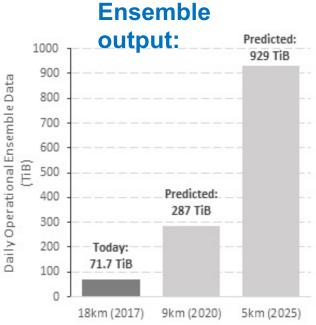
Wedi et al, 2020

Largest meteorological archive in the world

Total volume in archive:

350 PB

Ensemble output:
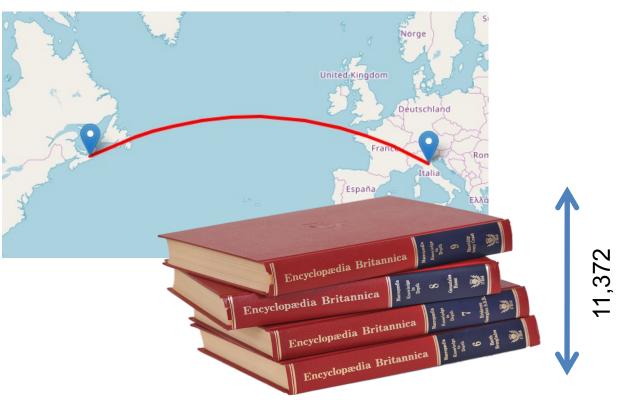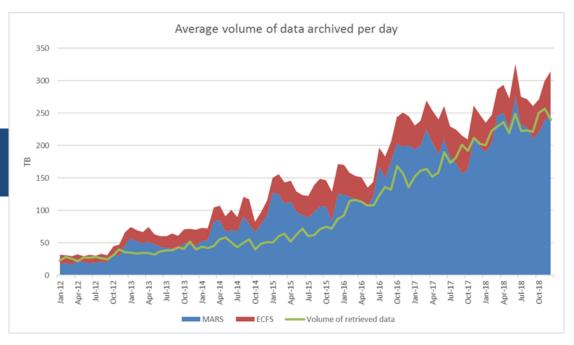
The ECMWF data Archive

Every day the archive grows more than 250TB.
This is approximately 1.75 Petabytes (PB) every week

Average volume of data archived per day

11,372
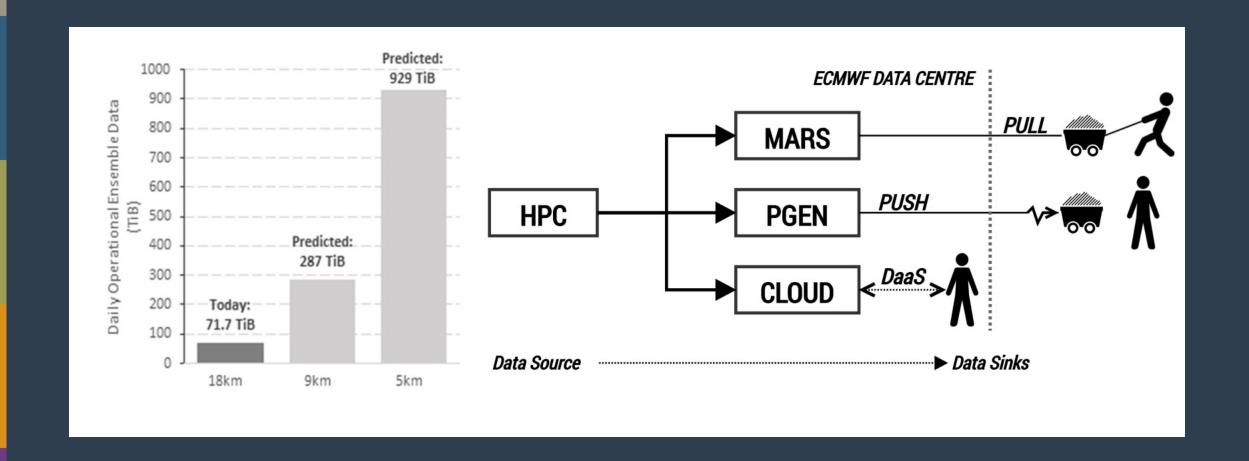
If this data was printed, the books produced could be put in a 11,372 km long row. This is about the distance travelling from Bologna to Nova Scotia, Canada and back again!

Data consumption scenarios

Data Dissemination

- A total of 1374 Destinations with 2121 Hosts across 79 countries:
  - Dissemination: 611 Destinations across 78 countries
  - Acquisition: 694 Destinations across 34 countries
  - Data Portal: 69 Destinations (mostly CAMS and MACC)

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EUROPEAN WEATHER CLOUD

CLOUD COMPUTING-BASED INFRASTRUCTURE, FOCUSED ON THE NEEDS OF THE METEOROLOGICAL COMMUNITY

- 3-year pilot project started in January 2019 until 2021

- Currently in Continued Pilot Usage and Preparation for Operations phase

- Use Case workshops every 6 months, currently 30 use cases
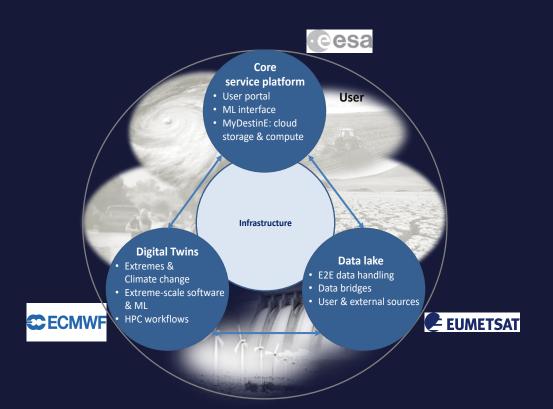
- Operationalisation in 2022

The European Weather Cloud aims to become the **cloud-based collaboration platform for meteorological application development & operations in Europe** *and contributes to the digital transformation of the European Meteorological Infrastructure*

"a **community** *cloud"*

Destination Earth
digital twins of the Earth system

UNDERSTAND THE PAST, PREDICT THE FUTURE
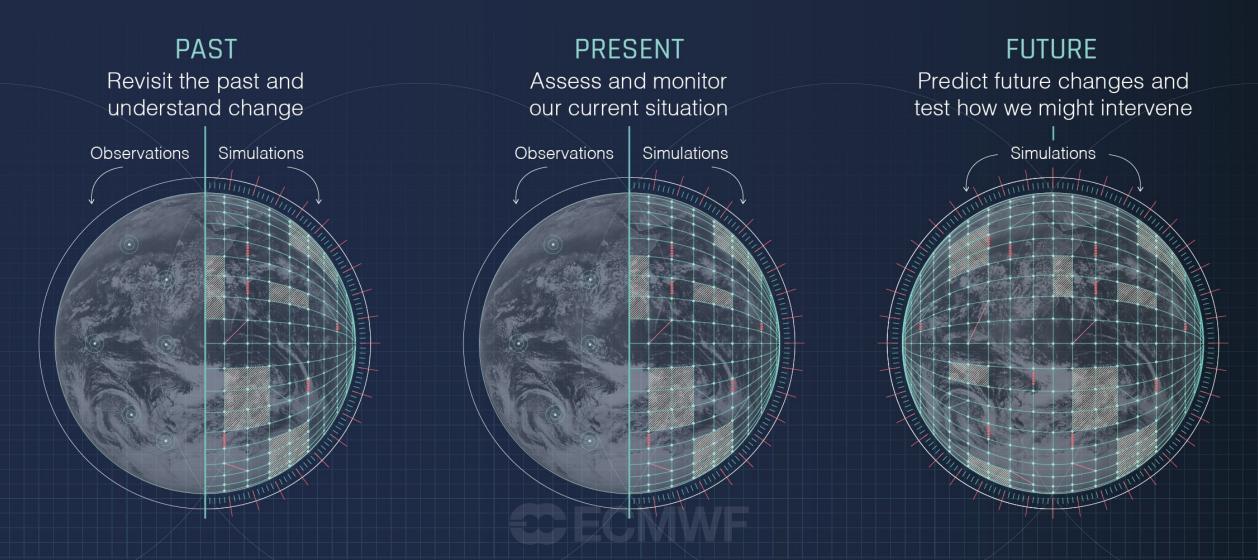
Fed by real-world observations, these digital twins let us understand
what has happened on Earth – and what will happen in the decades ahead.

PAST
Revisit the past and
understand change

Observations | Simulations

PRESENT
Assess and monitor
our current situation

Observations | Simulations

FUTURE
Predict future changes and
test how we might intervene

Simulations

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DIGITAL TWIN, REAL IMPACT

Giving us new insights on days or entire decades,
Earth's digital twin can provide huge benefits to many sectors.

CITIES

Smart cities can harness the digital twin for everything from traffic management to construction planning

FARMING

The digital twin can aid agriculture's key functions (irrigation, fertilisation, harvest) and its response to extreme weather

ENERGY

We will have new knowledge to enable ambitious projects like harvesting Earth's inner heat, converting this geothermal energy and storing it
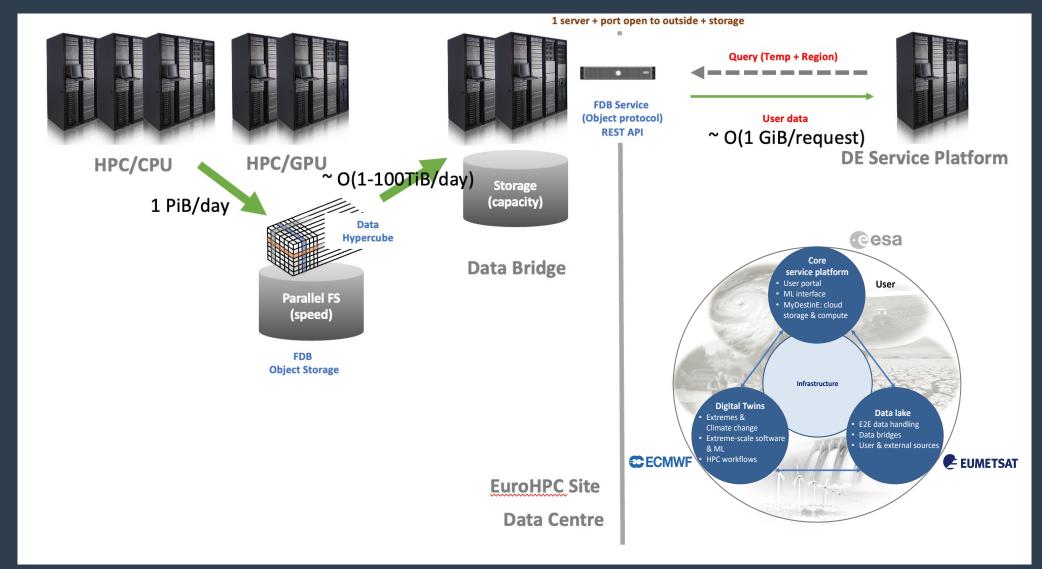
CLIMATE CHANGE

The digital twin's unique insights will help drive Europe's efforts to become the world's first climate-neutral continent by 2050

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How to manage the dataflow

1 server + port open to outside + storage

HPC/CPU · HPC/GPU

1 PiB/day

~ O(1-100TiB/day)

Data Hypercube

Parallel FS (speed)

FDB Object Storage

Storage (capacity)

Data Bridge

FDB Service (Object protocol) REST API

Query (Temp + Region)

User data

~ O(1 GiB/request)

DE Service Platform

EuroHPC Site

Data Centre

esa

Core service platform
- User portal
- ML interface
- MyDestinE: cloud storage & compute

User

Infrastructure

Digital Twins
- Extremes & Climate change
- Extreme-scale software & ML
- HPC workflows

Data lake
- E2E data handling
- Data bridges
- User & external sources

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EUMETSAT

#OneECMWF