

<https://destination-earth.eu/>

# DESTINATION EARTH

## DESTINATION EARTH - DIGITAL TWINS AND INNOVATIVE USE OF HPC

Nils Wedi



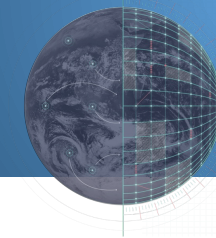
Funded by  
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**Destination Earth**

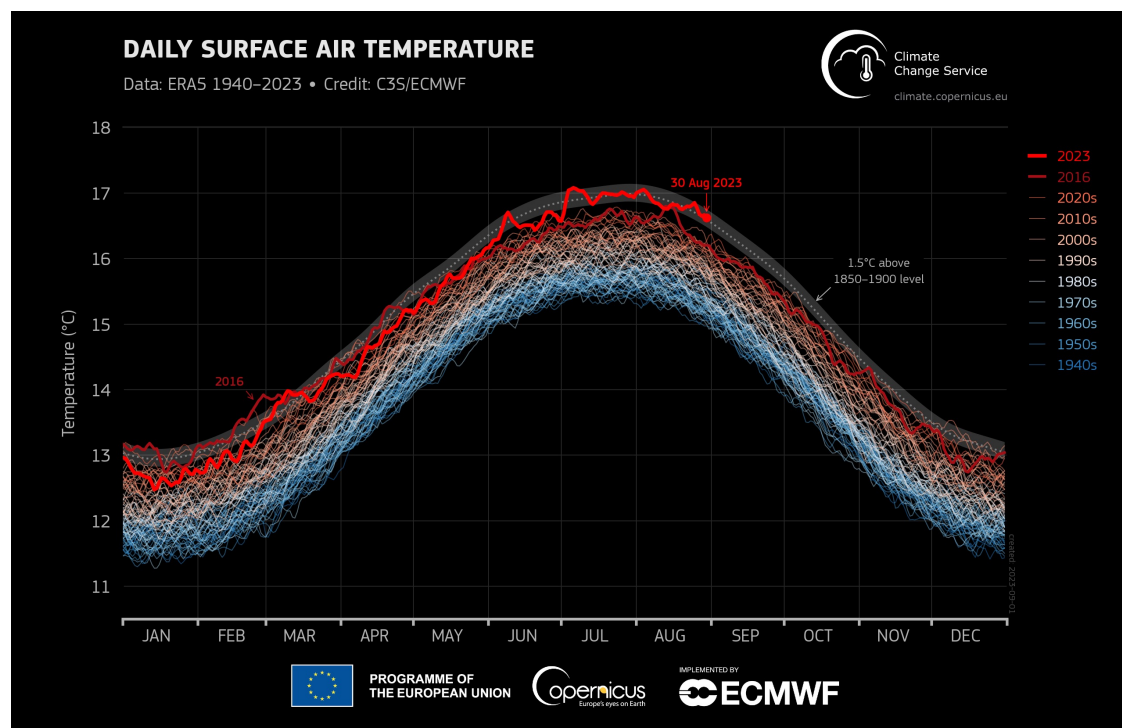
implemented by



PSNC GridLab workshop 21.12.2023



# CLIMATE CHANGE AND INCREASE OF EXTREME EVENTS

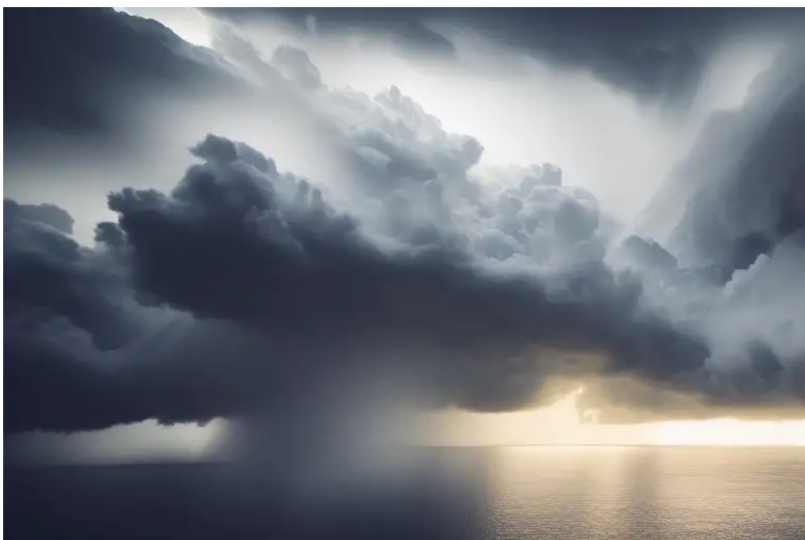




## The landscape ...

<https://community.wmo.int/en/news/exploring-possibilities-artificial-intelligence-areas-water-weather-and-climate>

### DeepMind & Google's ML-Based GraphCast Outperforms the World's Best Medium-Range Weather Forecasting System



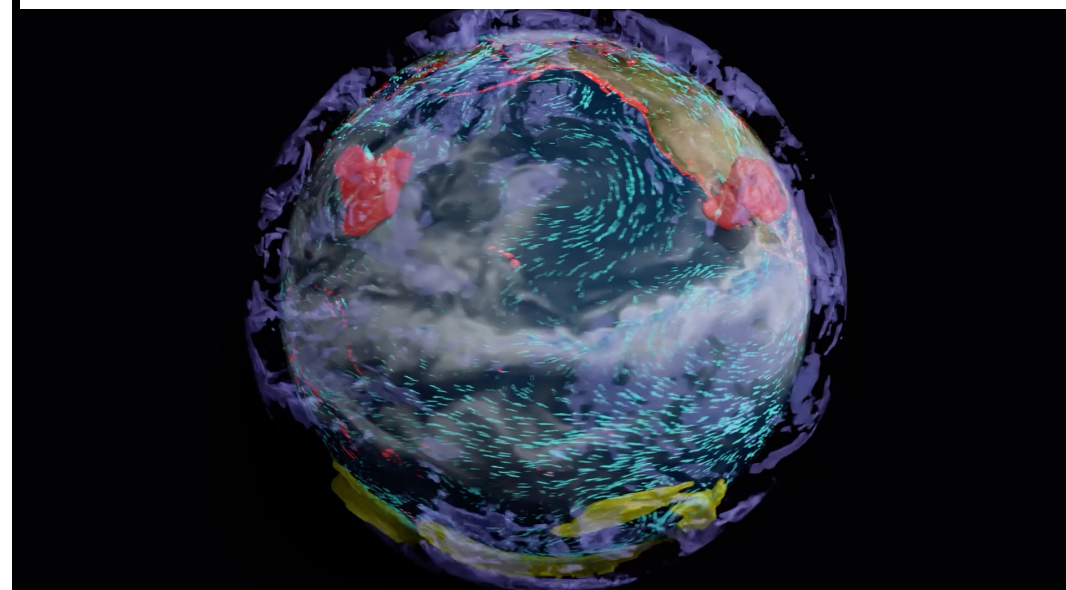
<https://arxiv.org/abs/2212.12794>

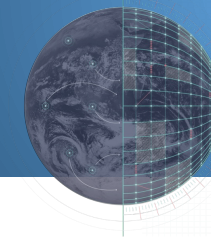


*Natural language translation*

## NVIDIA to Build Earth-2 Supercomputer to See Our Future

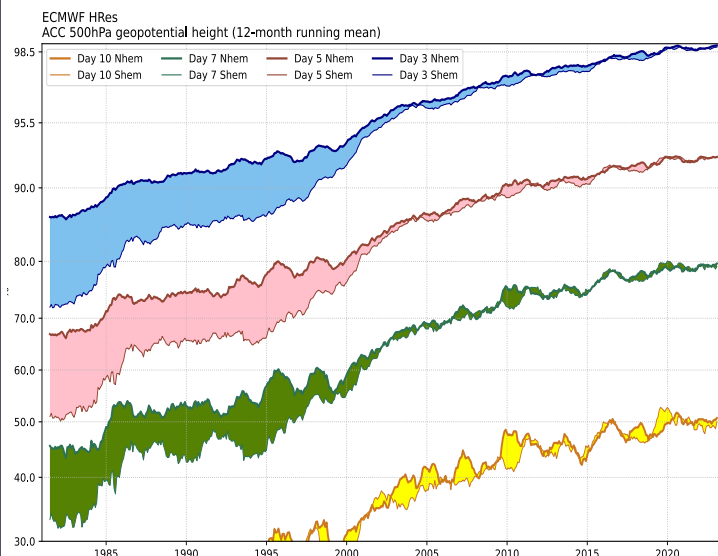
November 12, 2021 by JENSEN HUANG



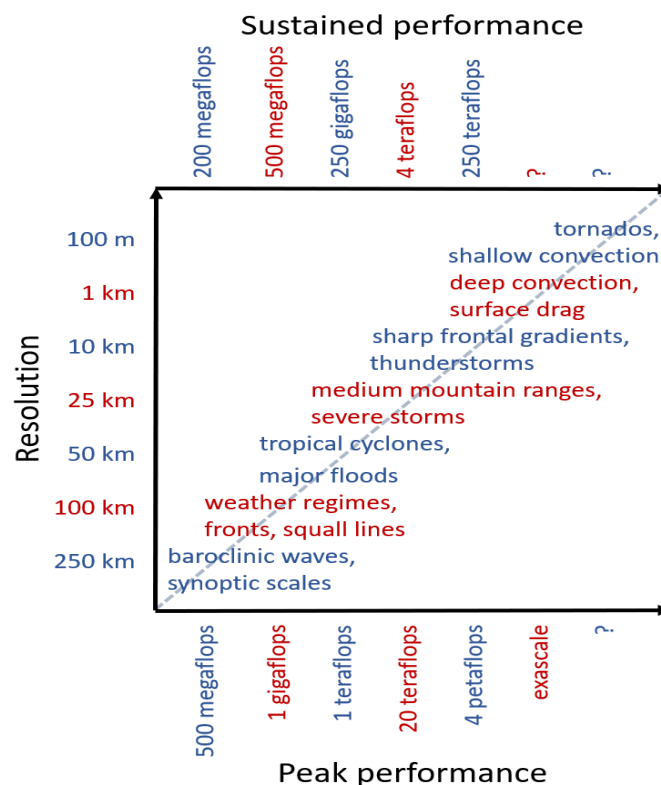


# EXPLOITING INVESTMENTS IN SCIENCE, TECHNOLOGY, AI

## The quiet NWP revolution (1980 - today)



## The digital revolution (2020 – today)



## The machine learning revolution (2022 – today)

arXiv > physics > arXiv:2307.10128

Physics > Atmospheric and Oceanic Physics

[Submitted on 19 Jul 2023]

### The rise of data-driven weather forecasting

ECMWF unveils alpha version of new ML model

13 October 2023  
The AIFS team

ECMWF is today launching a newborn companion to the IFS (Integrated Forecasting System), the AIFS, our Artificial Intelligence/Integrated Forecasting System (one "I" covering both Intelligence and Integrated).

The AIFS is barely a few months old and proudly entering its alpha version. Its arrival signals the strengthening of ECMWF's efforts in the field of machine learning (ML), which we have been navigating for a few years now. The AIFS forms one of three components of our new ML project, which began in summer 2023 and aims to expand our applications of machine learning to Earth system modelling.

Recent posts

ECMWF unveils alpha version of new ML model



**Destination Earth** is a **flagship initiative of the European Commission** to develop highly accurate digital models of the Earth (i.e., **Digital Twins of the Earth system**) to **deliver bespoke simulation capabilities** that model, monitor and simulate natural phenomena, hazards and related human activities, assisting users in designing and communicating accurate and **actionable adaptation strategies and mitigation measures**.

Harnessing **world-leading supercomputing capacities of the European High Performance Computing Joint Undertaking**, by **pushing the limits of computing, ML/AI and climate sciences**, and leveraging the “*path to the digital decade*” with **hundreds of European research and computational scientists** from industry, academia, many national as well as European international institutions,

DestinE represents an essential pillar of the European Commission’s effort towards both the **Green Deal** and the **Digital Strategy**.

Three entities **ECMWF, ESA, EUMETSAT** are working together with the European Commission **DG-CNECT** and the **JU**



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European Union



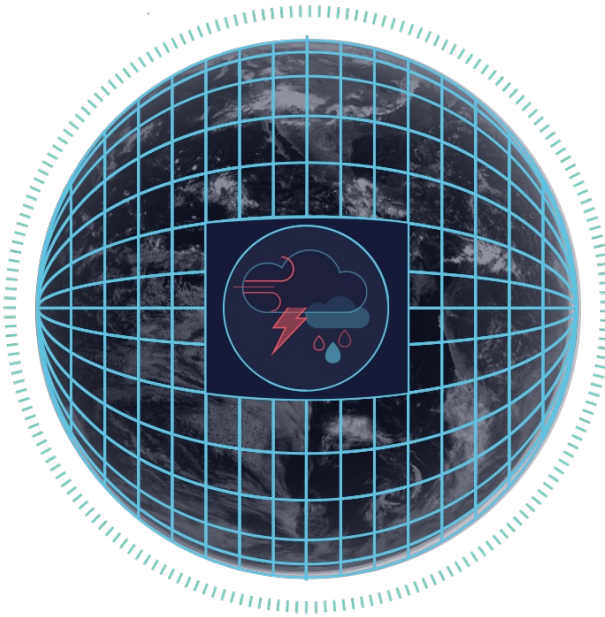
# Two high-priority Digital Twins

To support decision making for  
real-time response to extreme events

To support the efforts of defining and  
planning activities linked to climate  
change adaptation

Timescale of 2-5  
days ahead  
(1h to sub-hourly  
output)

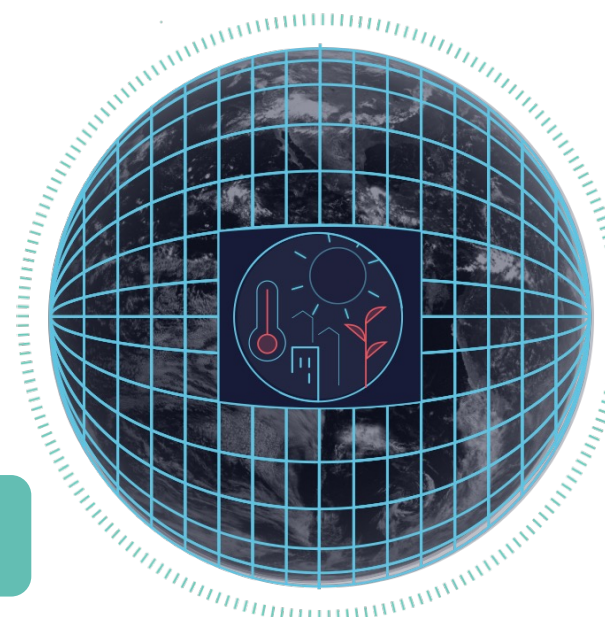
Km-scale resolution  
1-4 km globally,  
500-750m regionally



**Weather-induced extremes**

Run regularly &  
on demand &  
configurable

Decision-driven data  
analytics



**Climate change adaptation**

Multi-decadal timescales  
(2020 to ~2050)  
(1h to 6 hours output)

Global multi-decadal  
projections operationalised

Km-scale resolution  
globally (5km)



# ECMWF's role in EU's DestinE initiative

## Towards a Digital Twin Earth



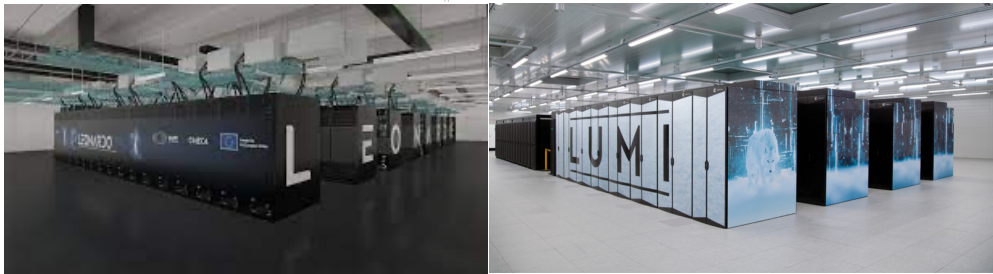
Weather-induced and Geophysical\* **Extremes Digital Twin**:

- capabilities and services for the assessment and prediction of **environmental extremes**

*ECMWF will develop the global component of the Extremes DT*

*“The French Meteorological Service **Météo-France** and partners from **22 European countries** will develop a **configurable capability for an interactive European monitoring and prediction framework.**”*

\*not in phase 1



# ECMWF's role in EU's DestinE initiative

## Towards a Digital Twin Earth



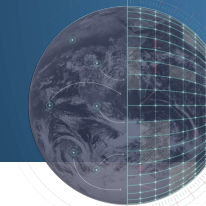
### Climate Change Adaptation Digital Twin

- capabilities and services in support of climate change **adaptation policies and mitigation scenario testing**

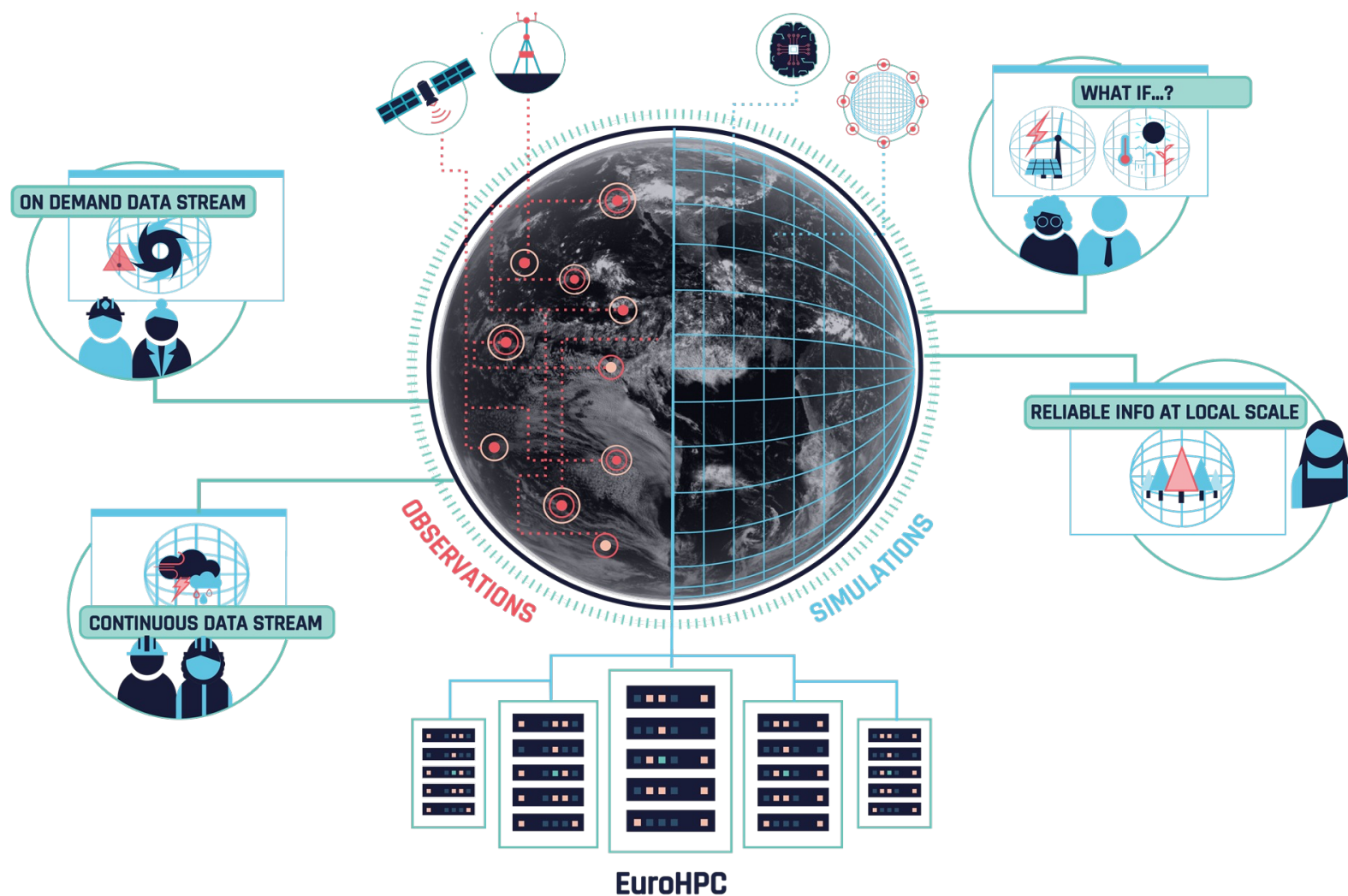
*“CSC – IT Center for Science leads a European partnership to deliver the Climate Change Adaptation Digital Twin – with a global multi-decadal storm & eddy resolving simulation capability”*

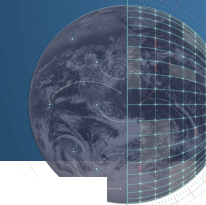




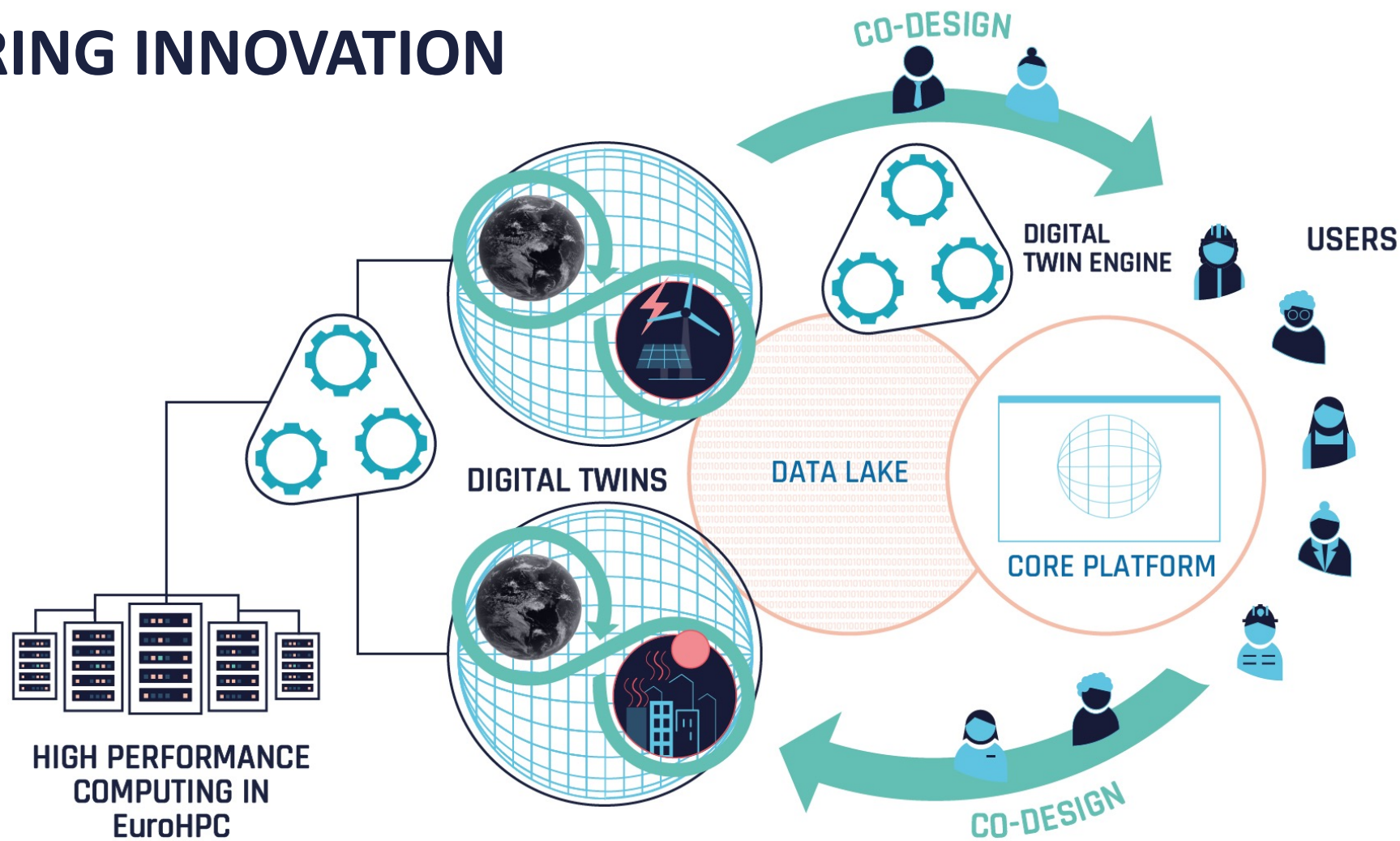


# A NOVEL INFORMATION SYSTEM

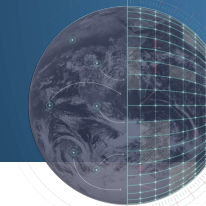




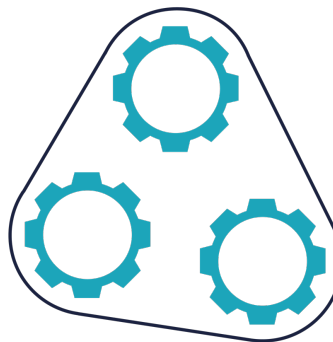
# FOSTERING INNOVATION







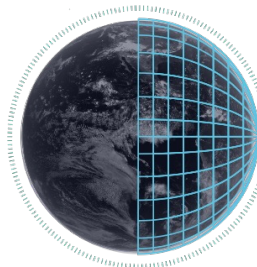
# THE DIGITAL TWIN ENGINE



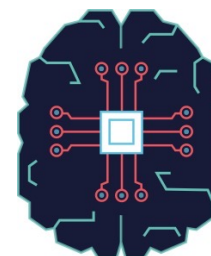
## Software environment



Ensuring complex simulations are run efficiently on EuroHPC



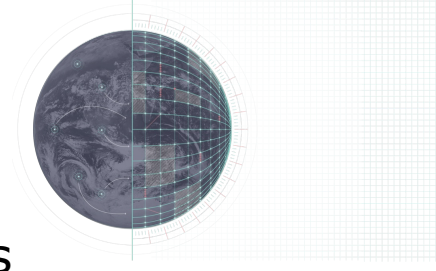
Running the digital twins and managing distributed big data



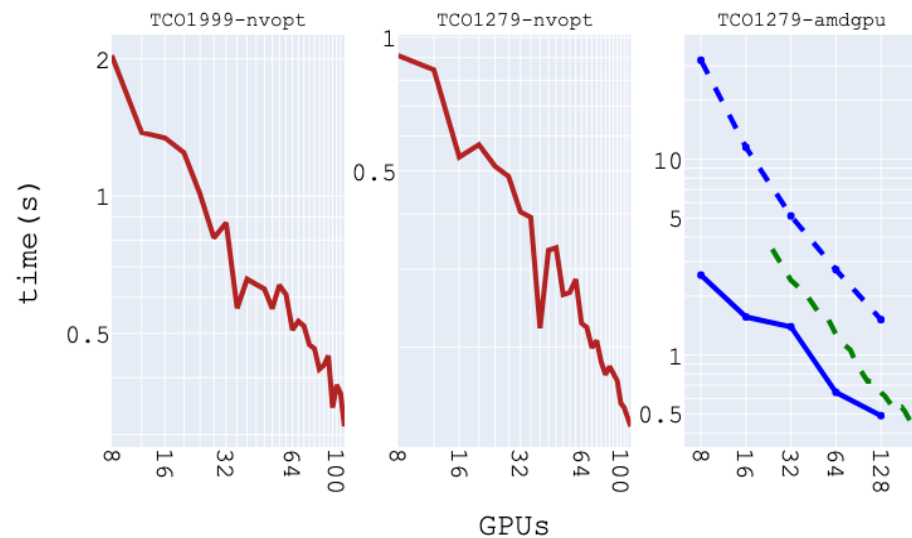
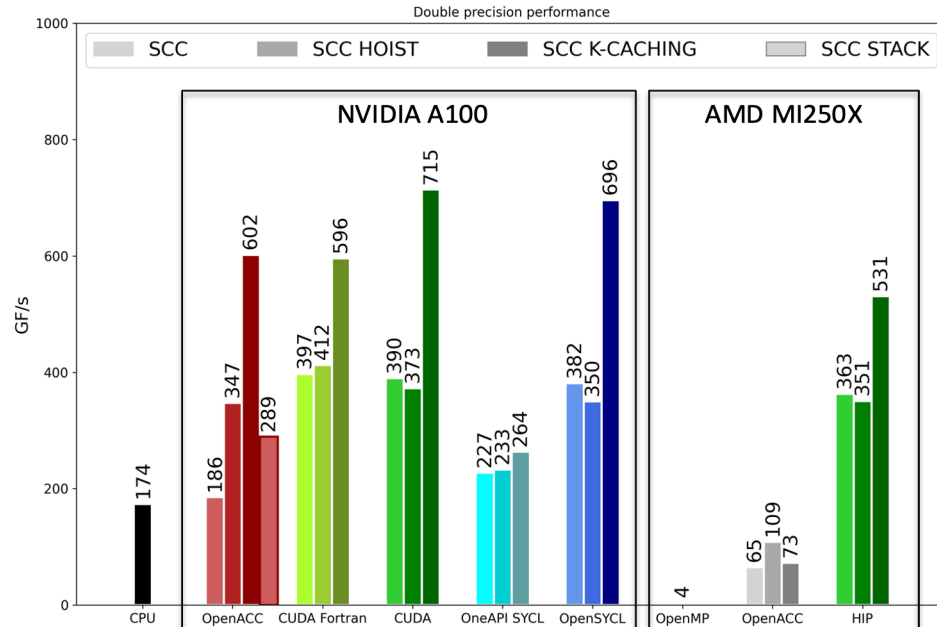
Using ML/AI to increase the efficiency of the digital twins and estimate uncertainty



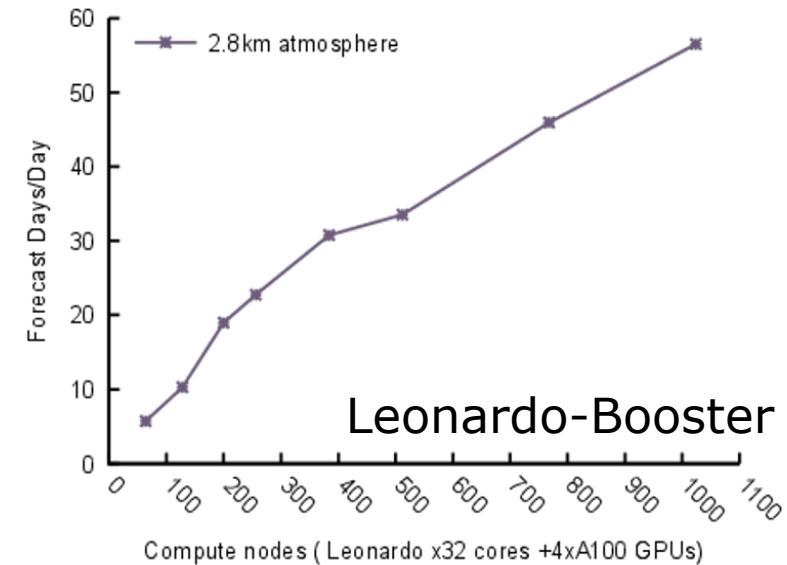
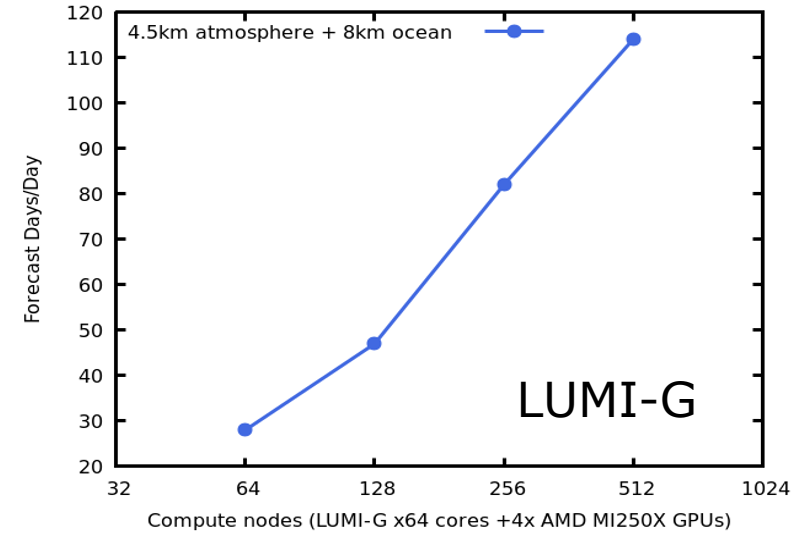
Tailoring information to user's needs and interactivity



# HIGH PERFORMANCE COMPUTING



## Optimising DTs





# Partnering with use cases



- Resource adequacy
- Grid planning
- Validation



Renewables  
Grid Initiative



- High-res regional AQ
- Coupled to DT Extremes
- Interactive emissions



- Five regional/local hydro models
- Disaster risk and climate scales

**Deltares**

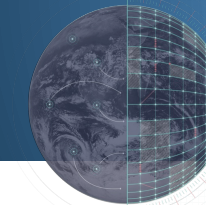


- Coupled urban climate model
- Simulate heat stress/health impact



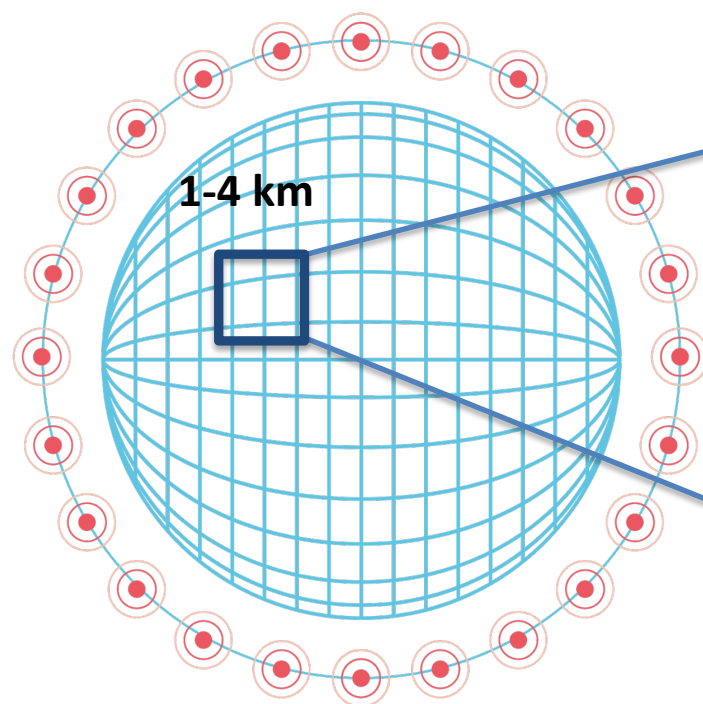
- Wind damage risk predictions
- Harvesting conditions under climate scenarios



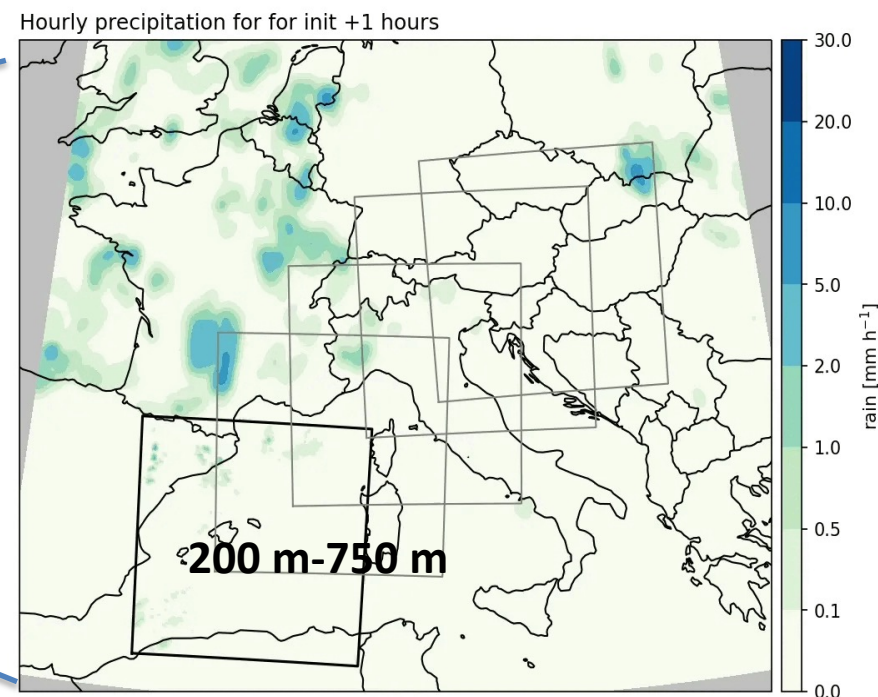


# EXTREMES DT: ON-DEMAND SIMULATION CAPABILITIES

Continuous global component



On-demand regional component

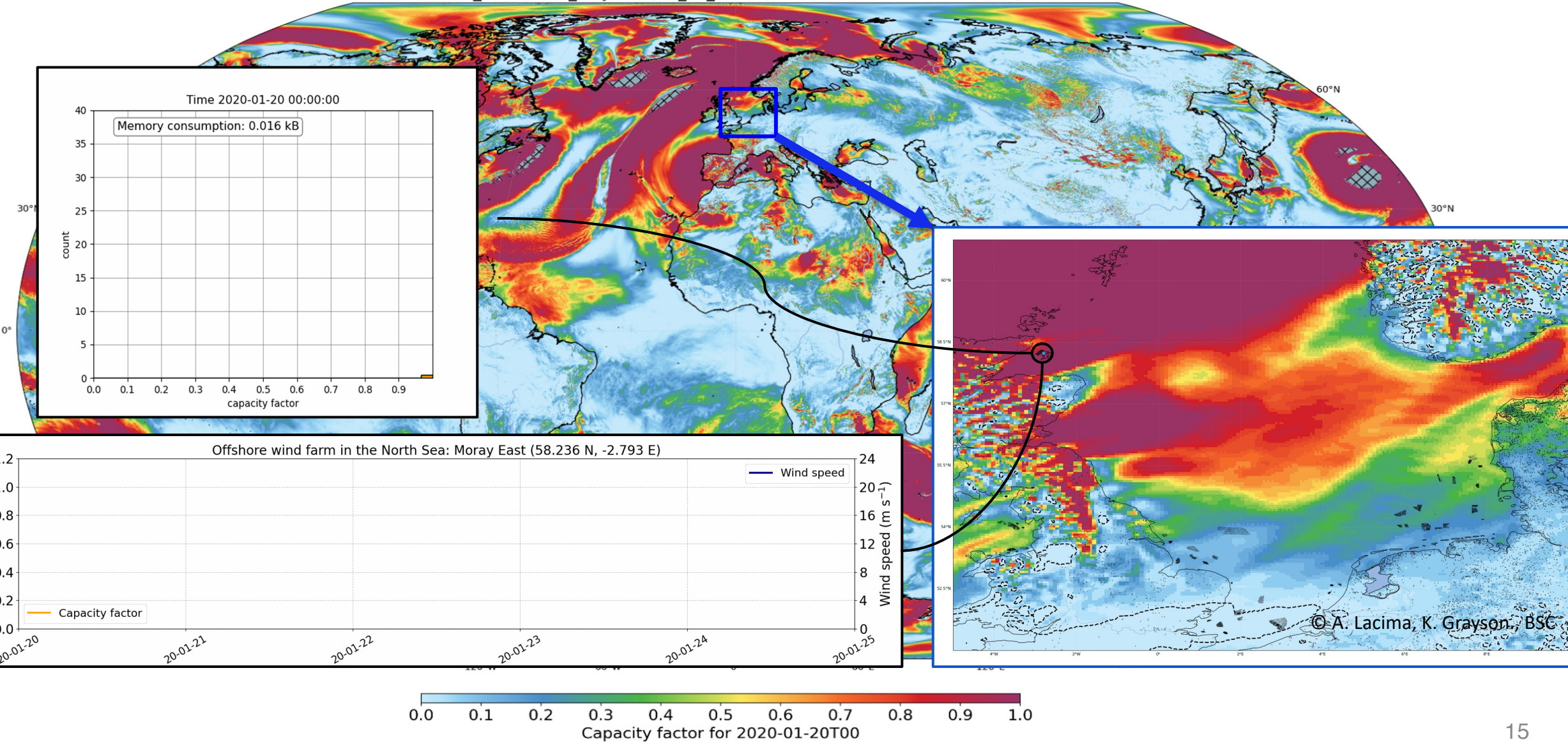


Crisis management in Extreme situations and urgent computing is manifested in the regulation but requires refining the access policies and system availability to make this a reality.

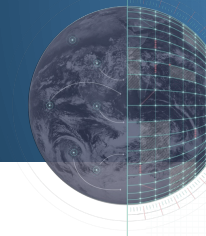


# Tailoring the information to user needs

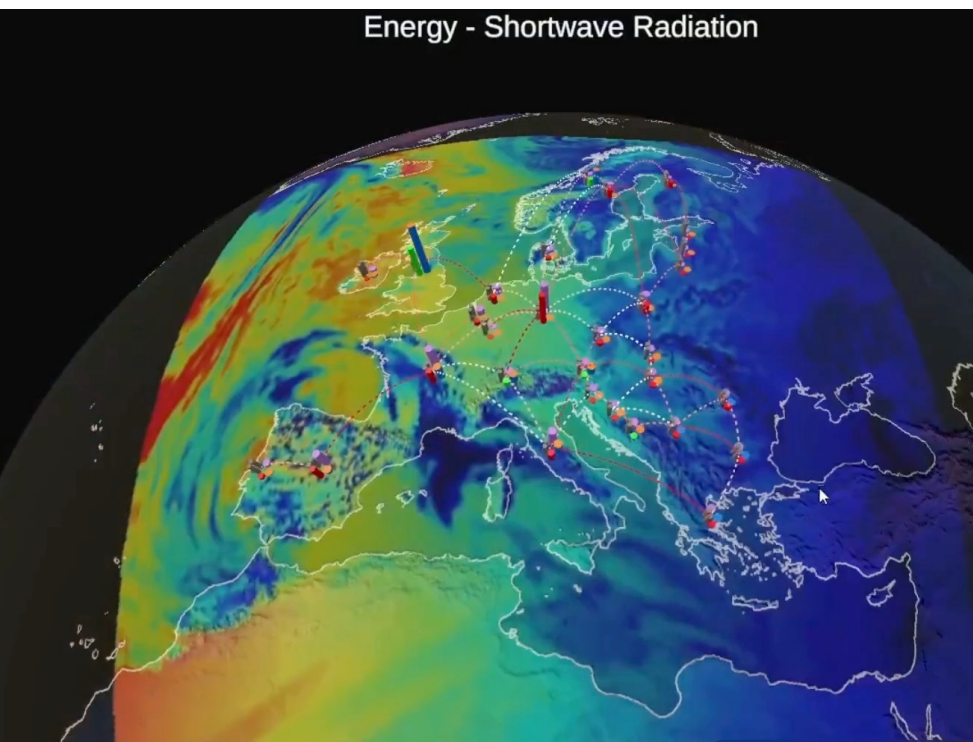
IFS\_4.4-FESOM\_5-cycle3 (2D\_1h\_native) - Class S (Vestas V164/9.5MW)





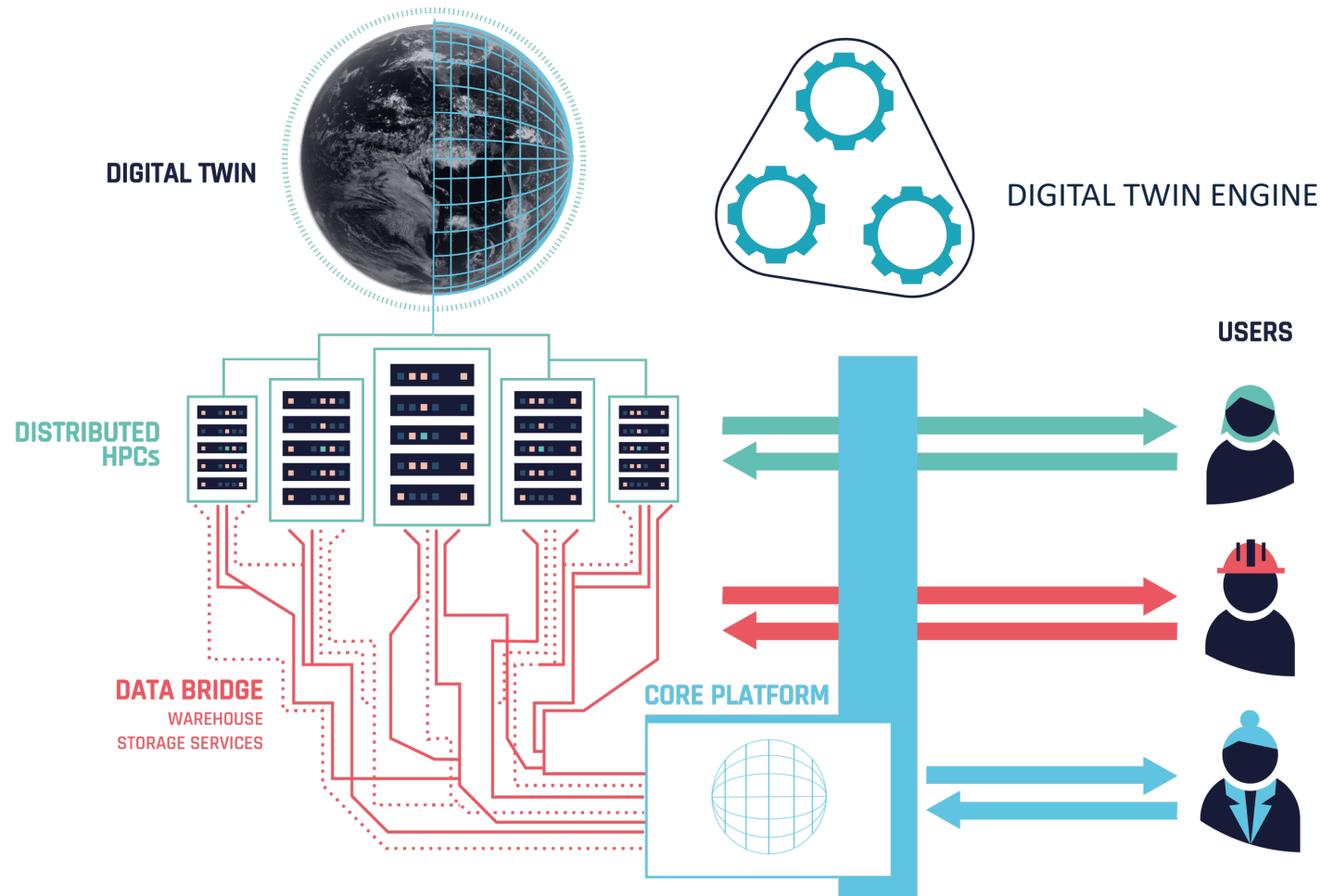


## DTE: INTERACTIVITY

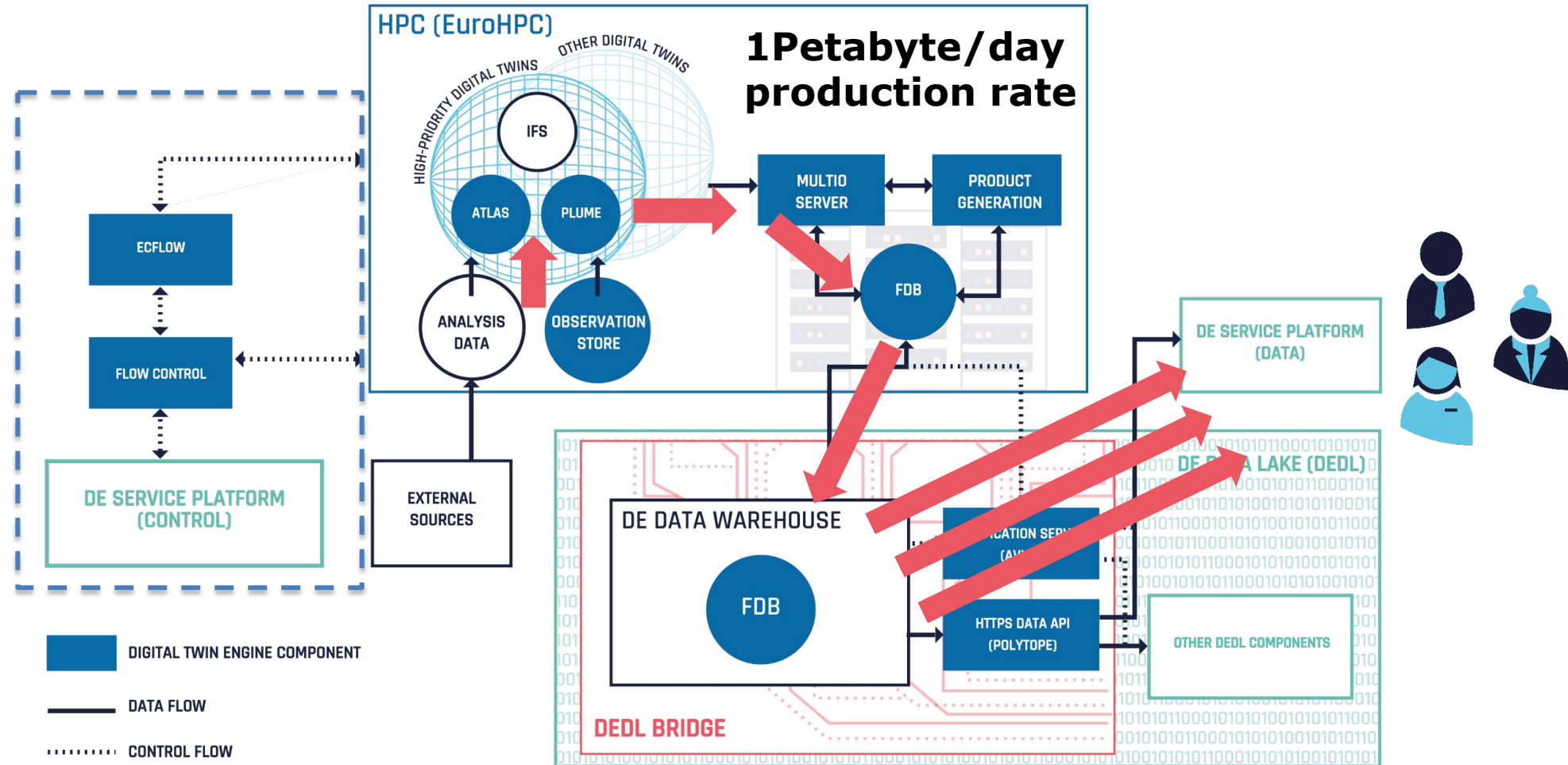


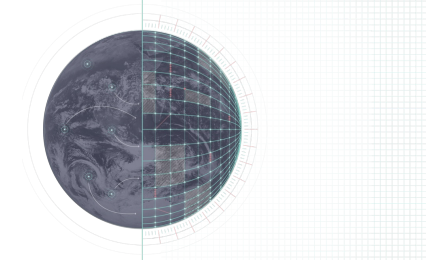
Exprivia/CMCC/DLR

Renewable energy online  
supply/demand/redistribution  
in a changing climate



# Running DTs & Managing Big Data

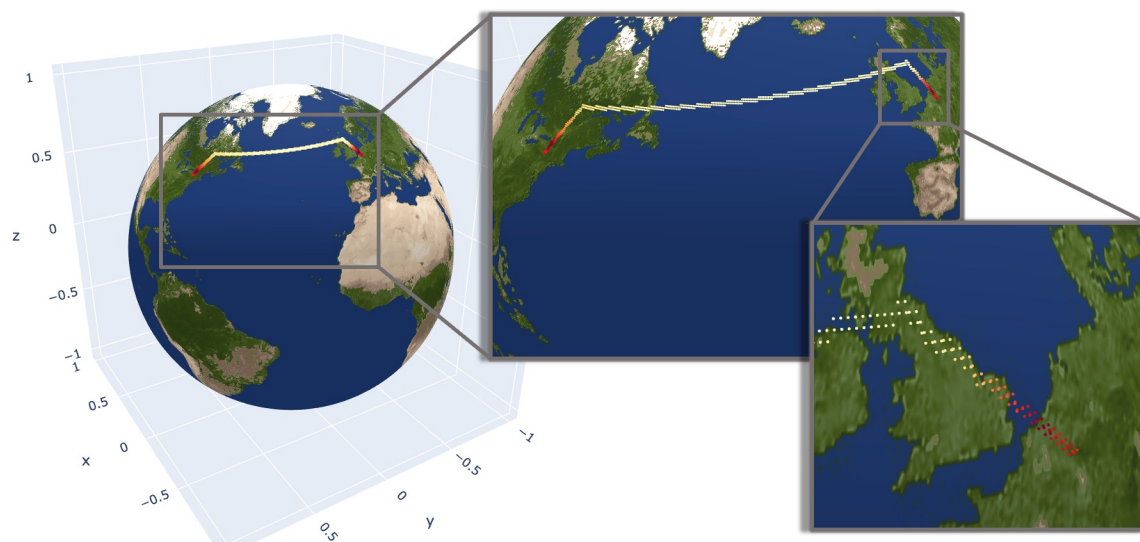




# REST-API POLYTOPE FEATURE EXTRACTION

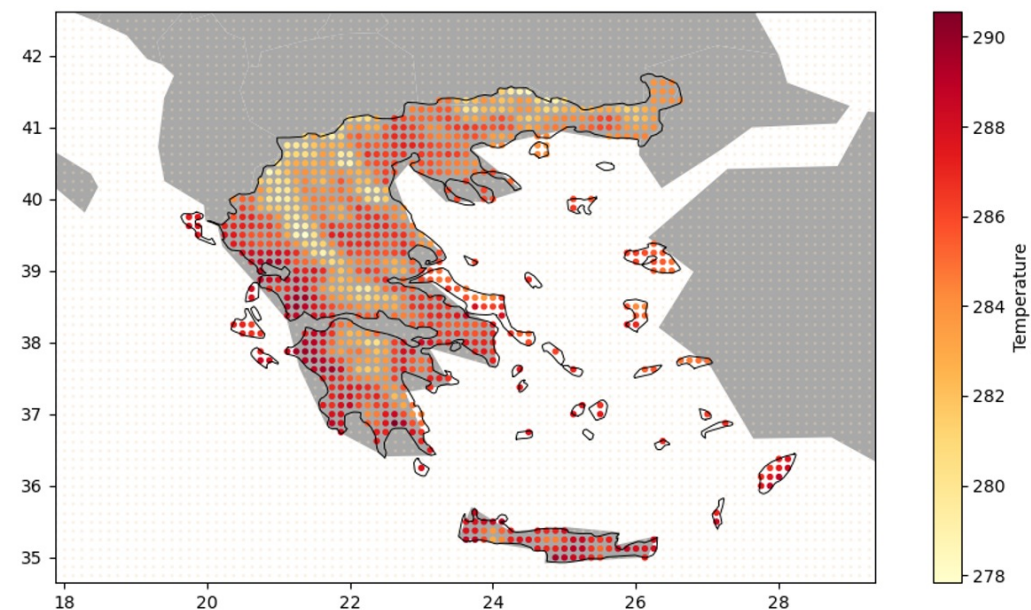
OGC compliant, supporting new WMO data governance and data distribution standards

FLIGHT PATH



**99.99% I/O reduction vs 4D (x, y, z, t) bounding-box**

SHAPE EXTRACTION



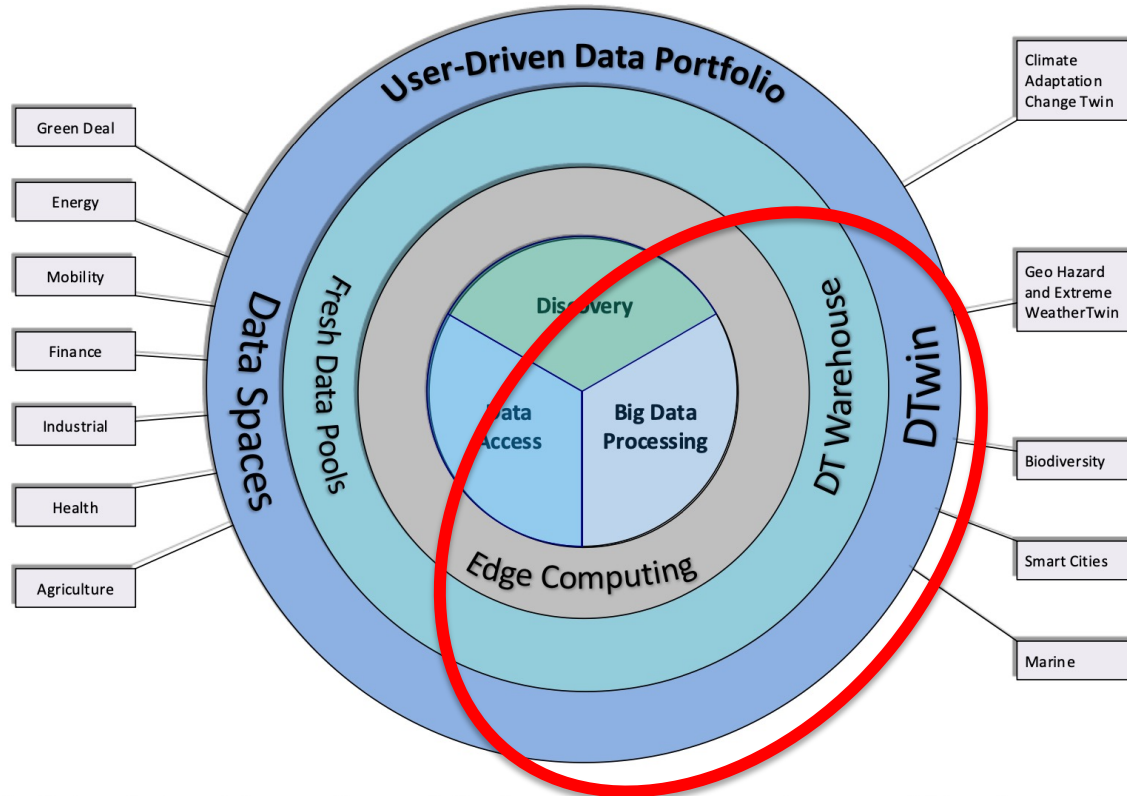
**Coloured points are directly addressed and extracted from within the DestinE data warehouse(s).**



# Digital Twin data governance, provenance & federation



## Destination Earth Data Lake – physical & digital twin data



### Destination Earth



Key Points: fusion of data, on-Demand, distributed processing near data, extendable reference Architecture, suitable for AI/ML, workflows

EUM/DSA/TEN/23/1348307, v1, 15 February 2023

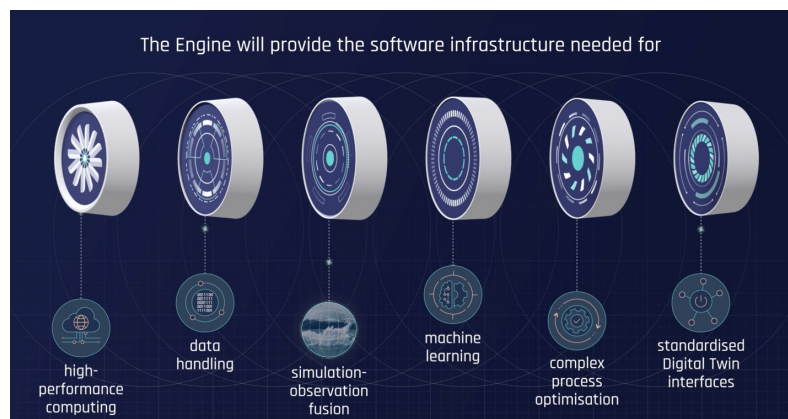
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Destination Earth

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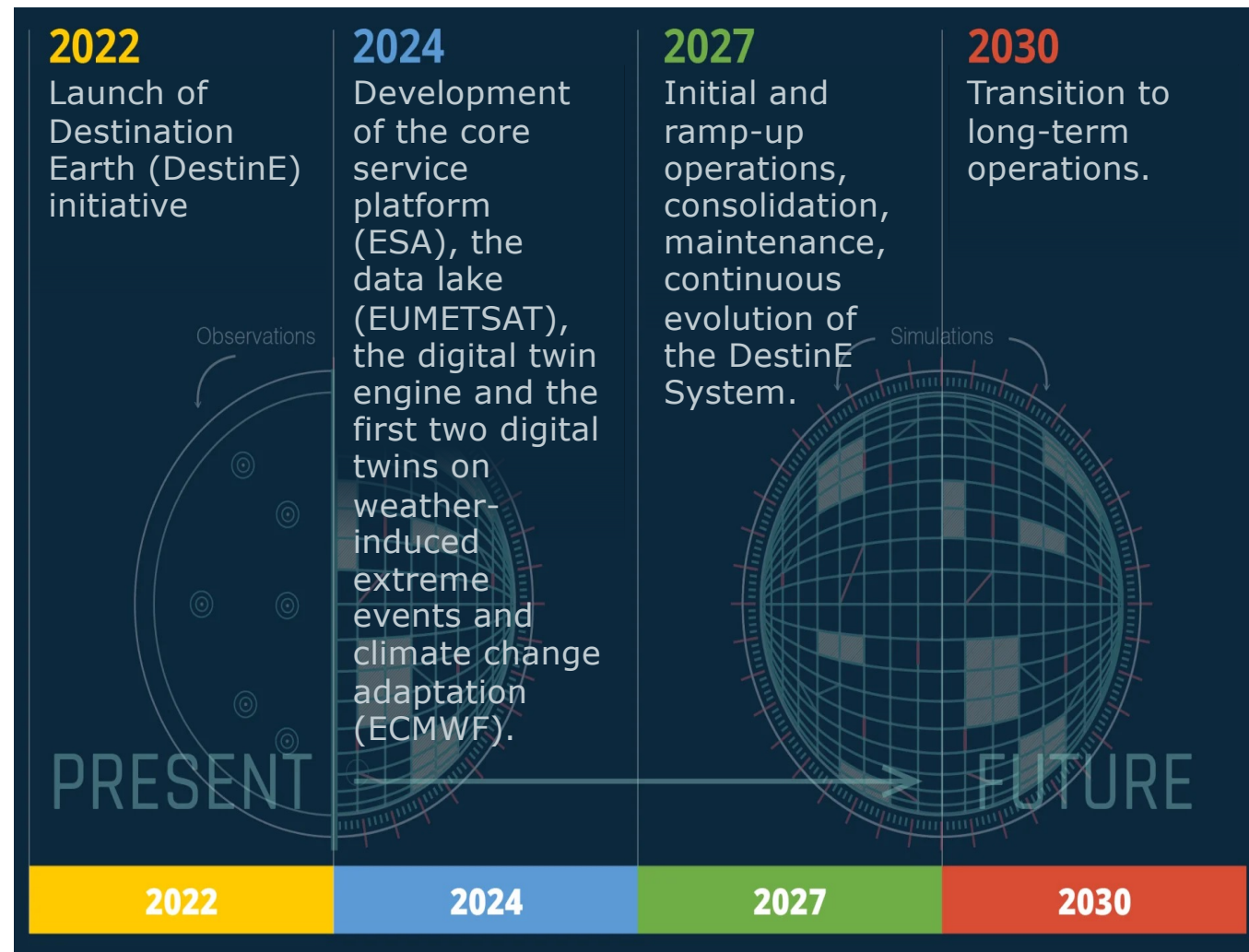


# Implementation: Phasing

- Novel investment in infrastructure & technology
- Embed Earth-system information into the wider digital environment to enable creation of new information



**EuroHPC**  
Joint Undertaking



Funded by the  
European Union

