

# DESTINATION EARTH

Destination Earth - implementing digital twins of the Earth system

Nils Wedi

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

Big thank you to the many ECMWF staff and our partners in DestinE !!

# The landscape ...

Microsoft Flight simulator 3D clouds informed by real weather



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



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

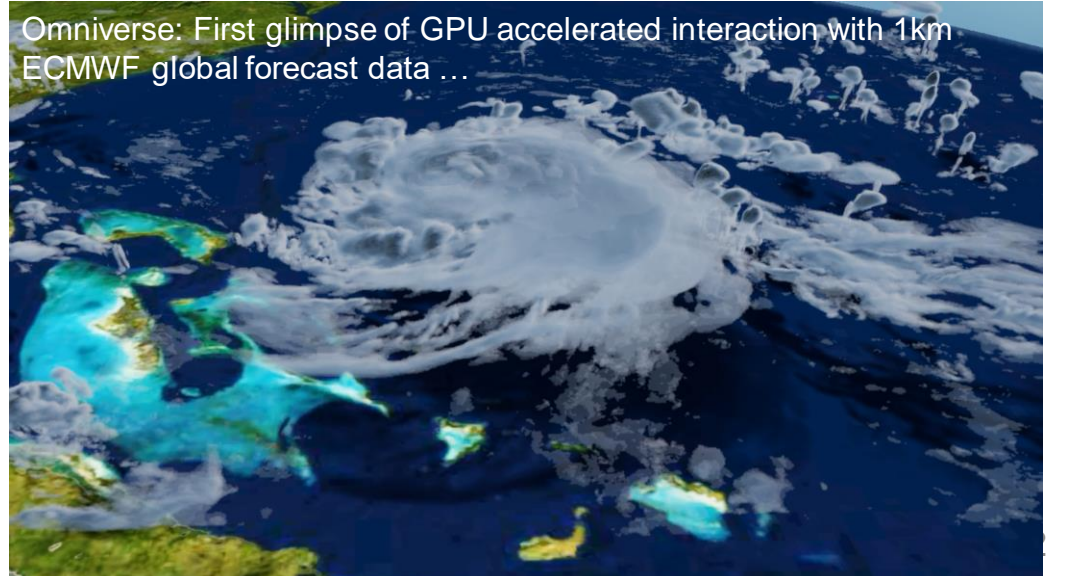
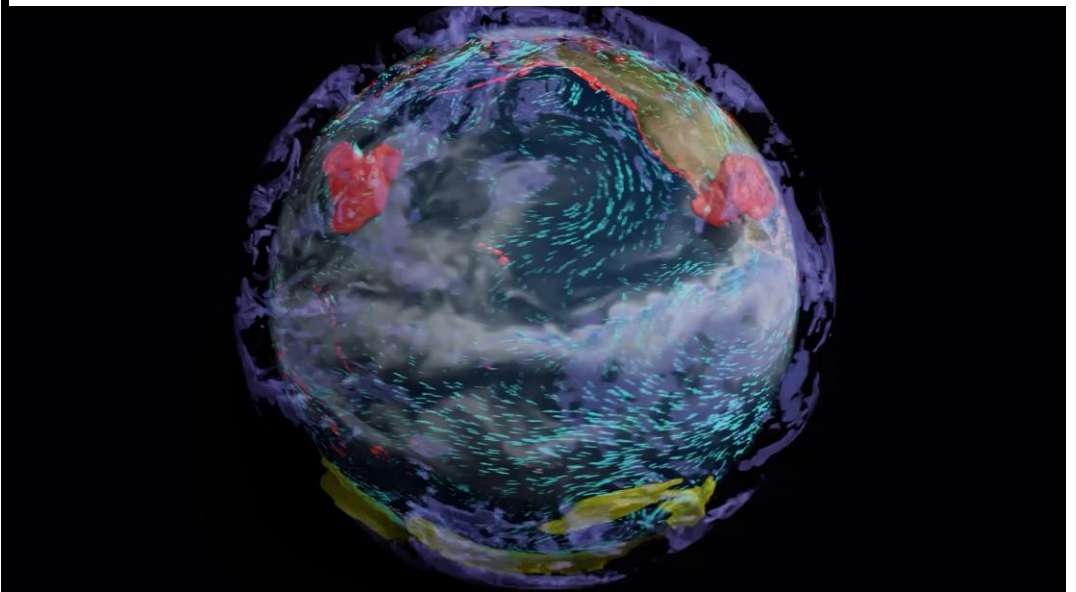


Natural language translation

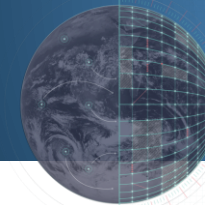


## NVIDIA to Build Earth-2 Supercomputer to See Our Future

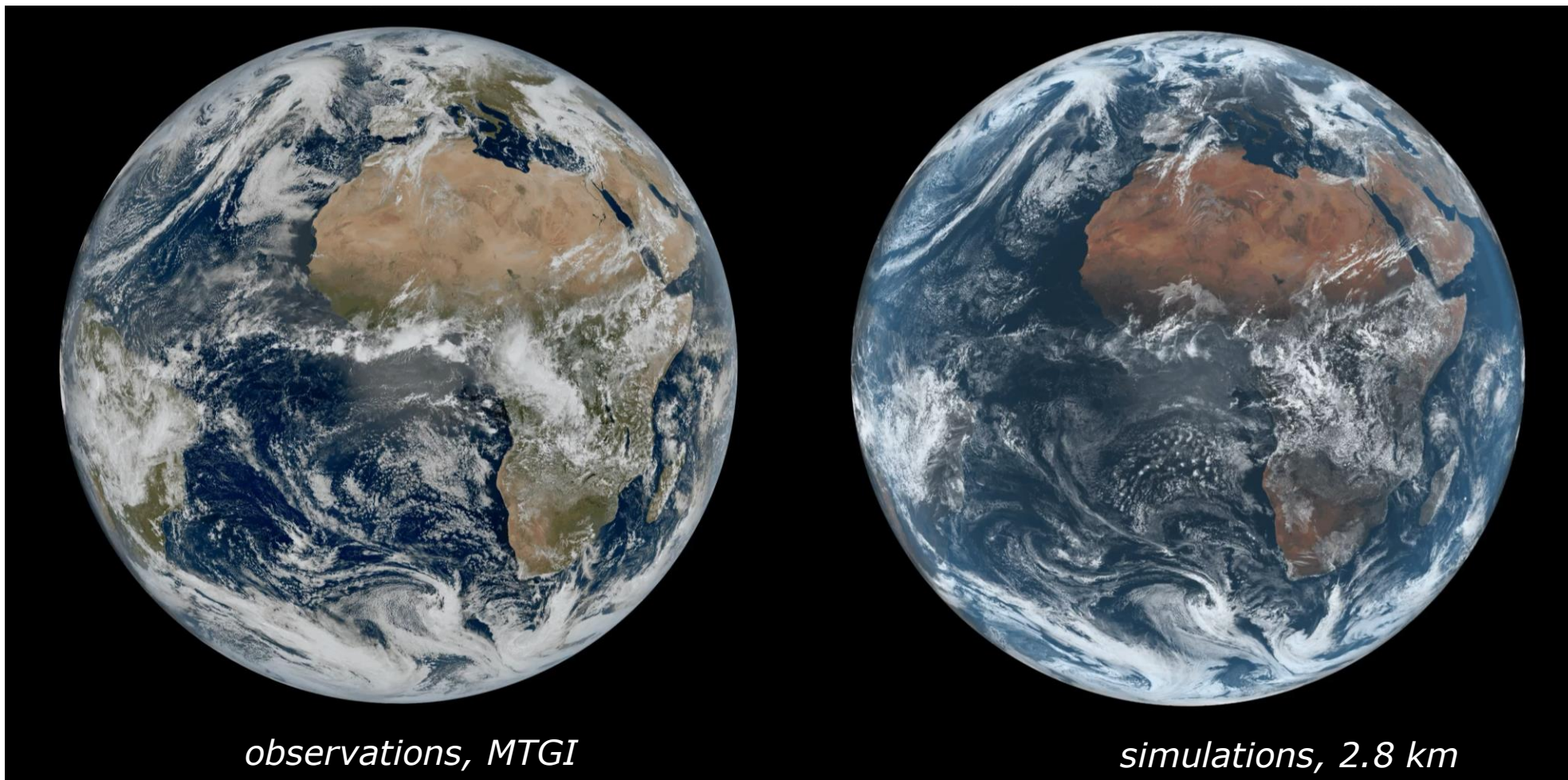
November 12, 2021 by JENSEN HUANG



Omniverse: First glimpse of GPU accelerated interaction with 1km ECMWF global forecast data ...



# QUALITY FROM GLOBAL TO LOCAL SCALE

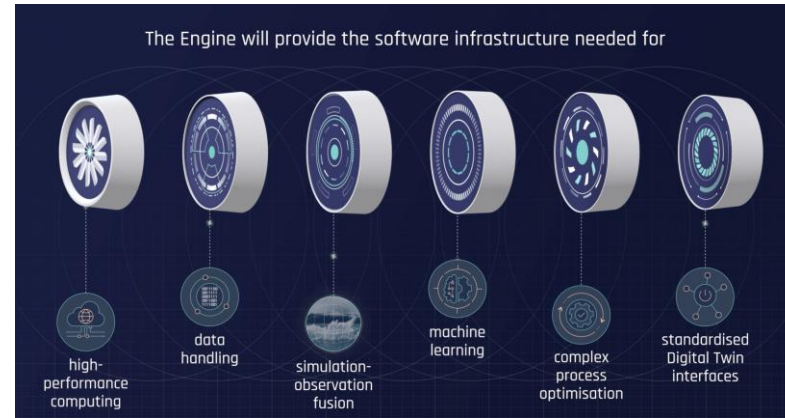
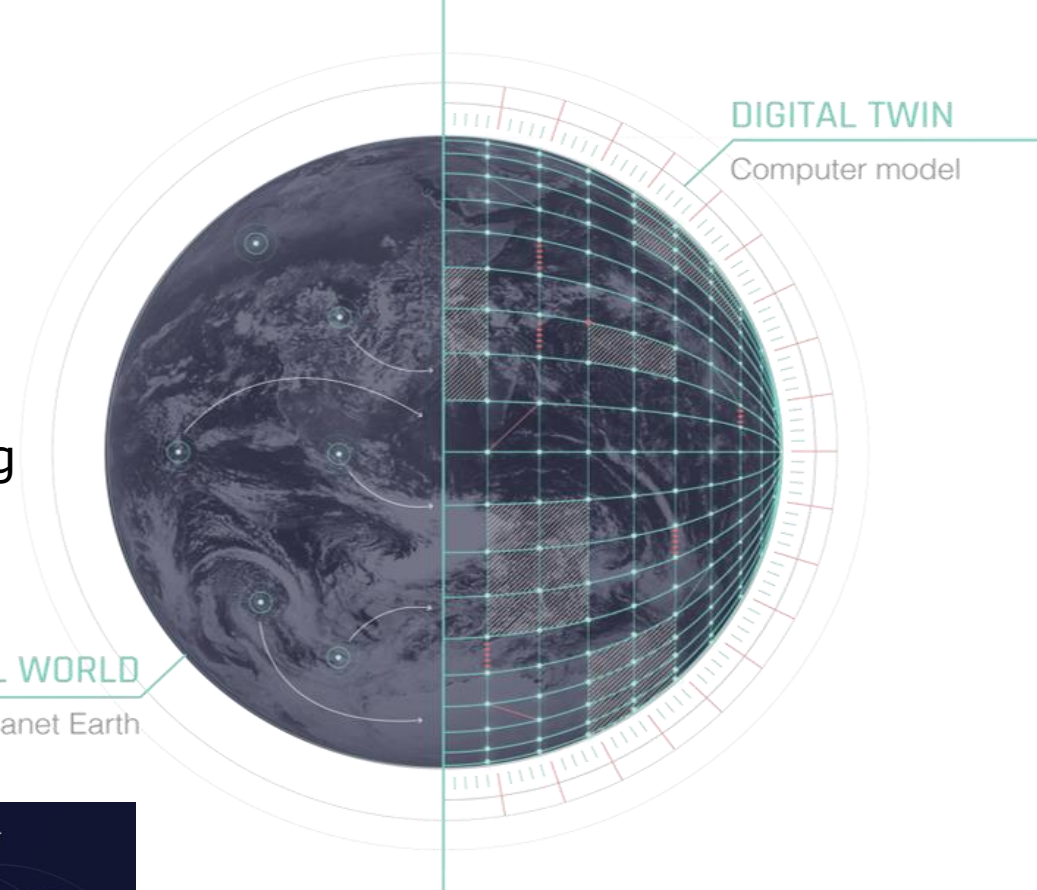
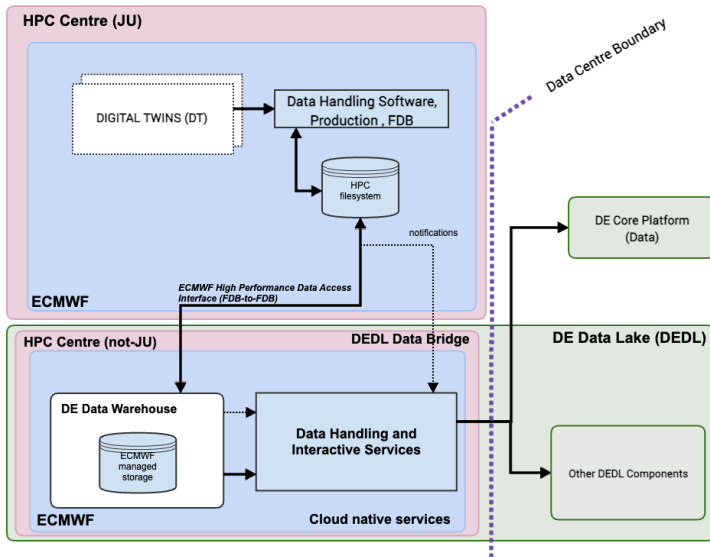


*observations, MTGI*

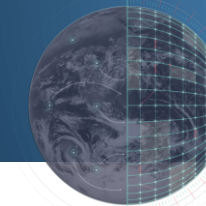
*simulations, 2.8 km*

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

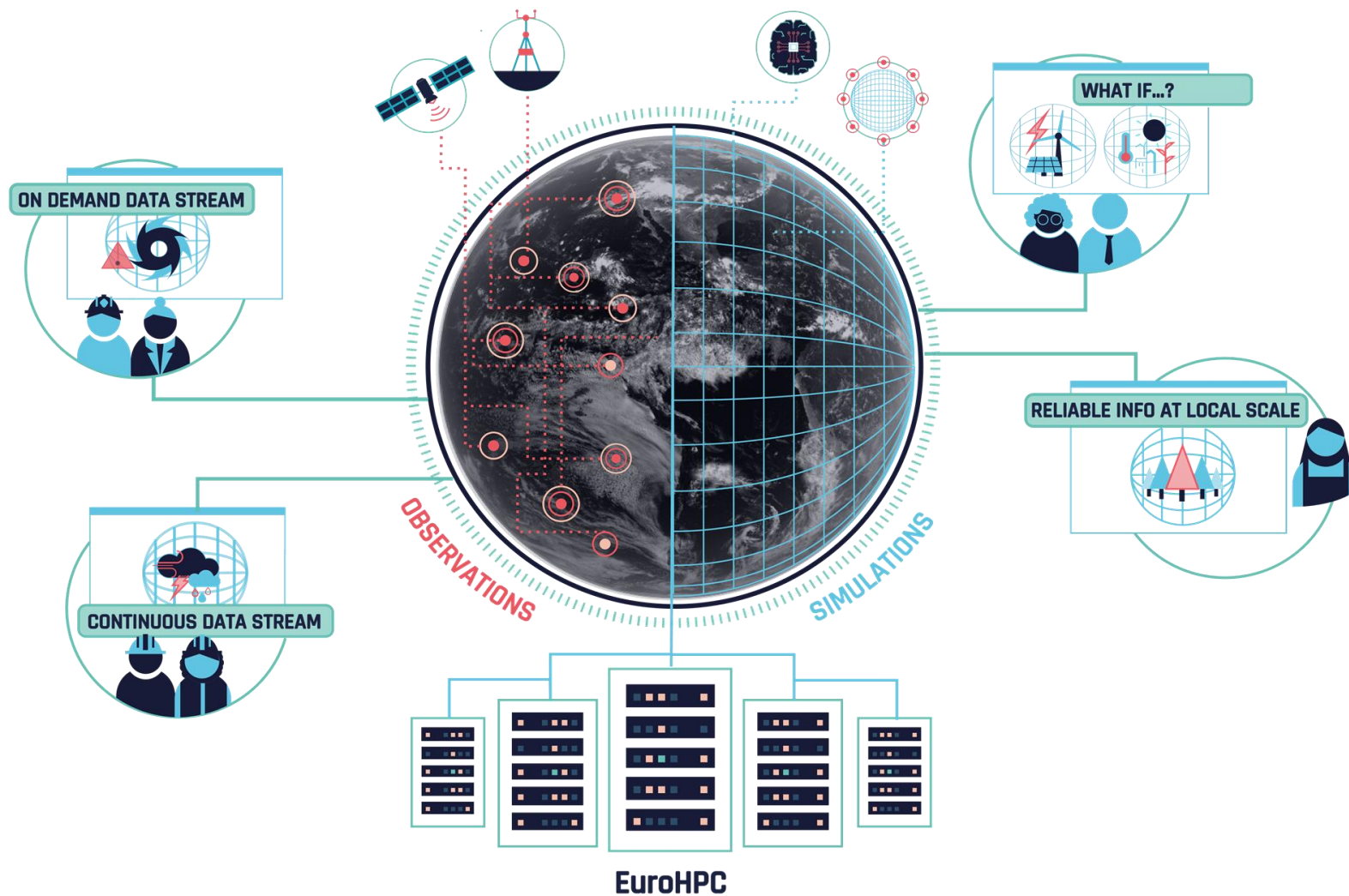
Hundreds of European research and computational scientists from industry, academia, and national institutions contributing

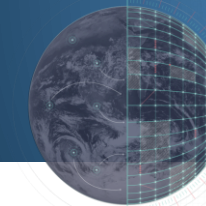


<https://destination-earth.eu/>

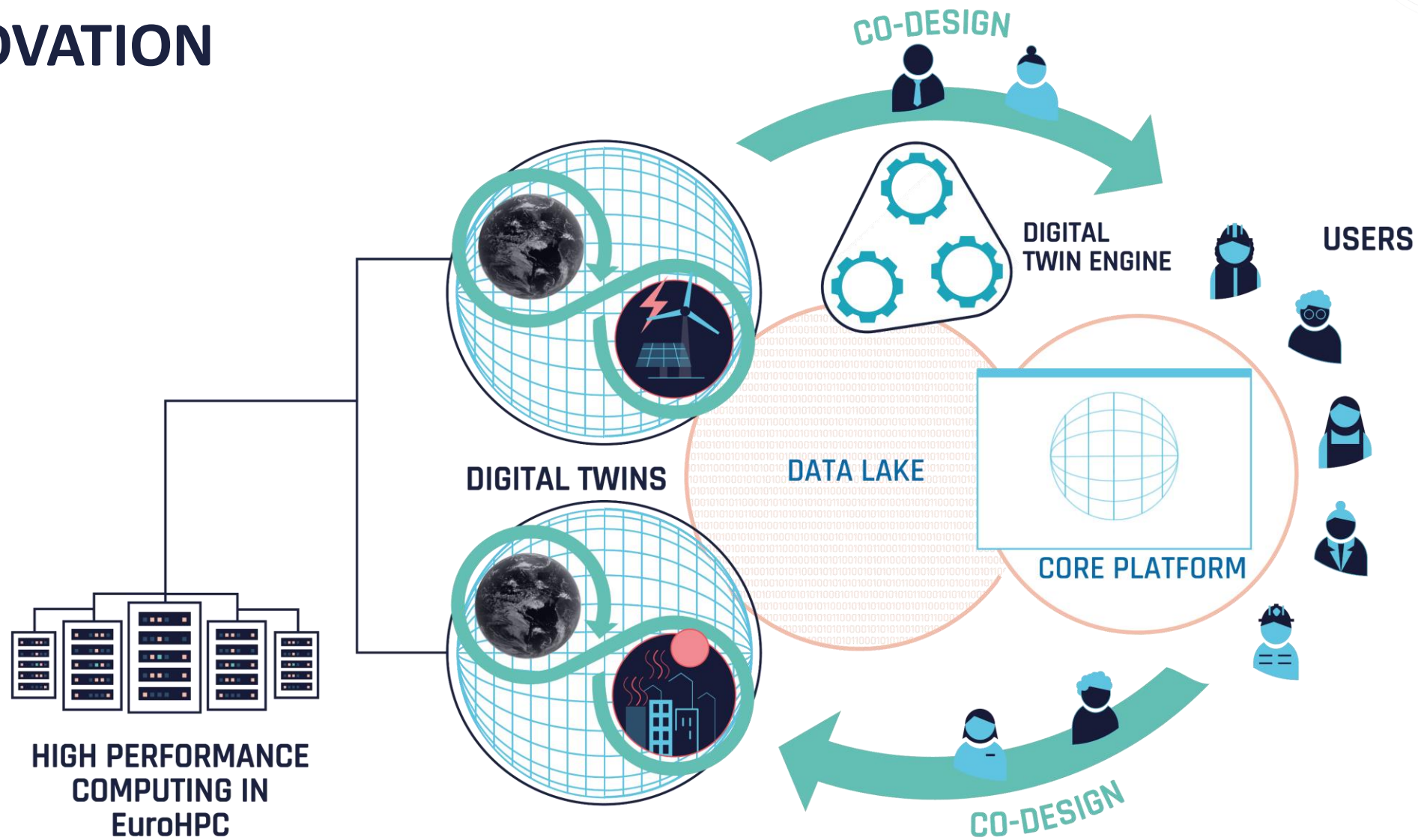


# A NOVEL INFORMATION SYSTEM





# INNOVATION



# ECMWF's Use Cases (contracts DE370)



Energy systems

- Resource adequacy
- Grid planning
- Validation



Renewables Grid Initiative



Air quality

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



Compound flood risk

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

Deltares



Urban heat

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



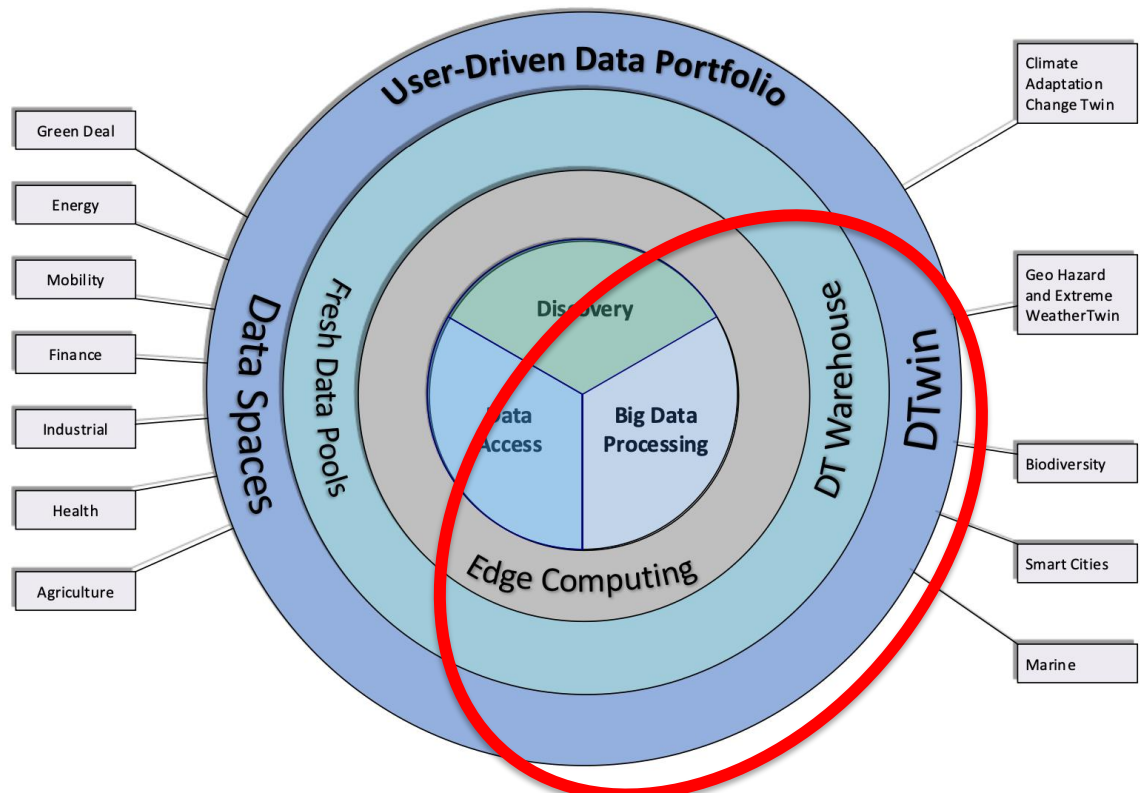
Forestry

- Wind damage risk predictions
- Harvesting conditions under climate scenarios



# Digital Twin data governance, provenance & federation

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



- Destination Earth**
- To create and test "what if" scenarios and to integrate impact sector applications for more sustainable development
  - To support near real-time decision-making at various levels (e.g. EU, national, regional, local)
  - To go beyond the current complex systems designed mainly for expert use
  - To scale up existing models and fuse simulation with observation
  - To monitor, simulate and predict natural phenomena and the impact of human activity on Earth
  - To assist in designing accurate adaptation strategies and climate change related mitigation measures
  - To accelerate the EU's green and digital transition
  - To leverage existing and new data sources and EU's advanced digital and computing infrastructure

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



# ECMWF's role in EU's DestinE initiative

## Towards a Digital Twin Earth



**ECMWF is responsible for the delivery of:**

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.**”*

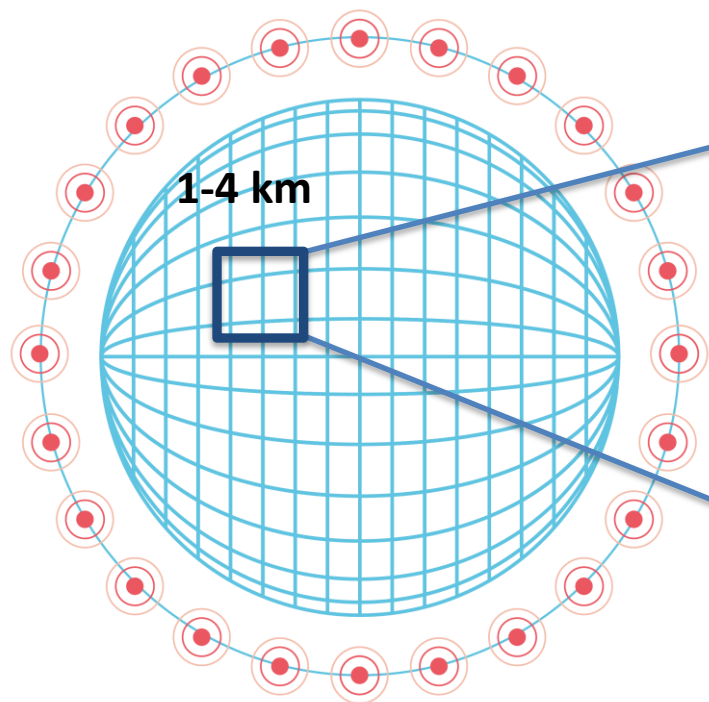
\*not in phase 1



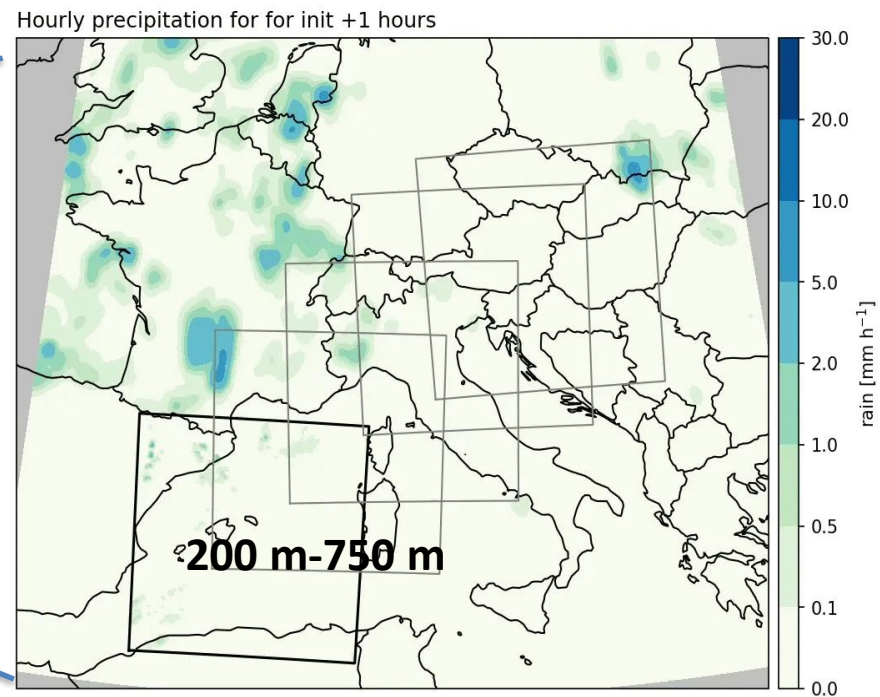


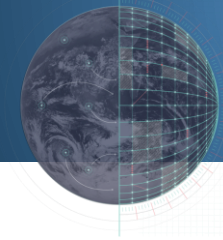
# EXTREMES DT: CONTINUOUS AND ON DEMAND

Continuous global component



On-demand regional component

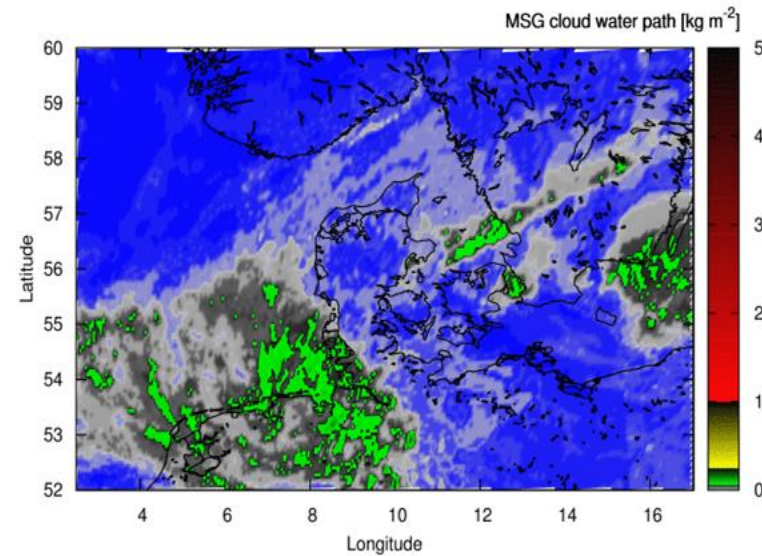




# ON-DEMAND: REDUCING ECONOMIC VULNERABILITY



2019-06-11 06:00UTC



*How can the approaching storm affect solar power yield and how will it affect energy trading?*



Unforecasted thunderstorms almost made the German electricity grid collapse on the 12<sup>th</sup> of June, 2019

# ECMWF's role in EU's DestinE initiative

## Towards a Digital Twin Earth



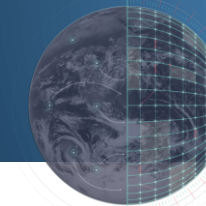
**ECMWF is responsible for the delivery of:**

**Climate Change Adaptation Digital Twin**

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

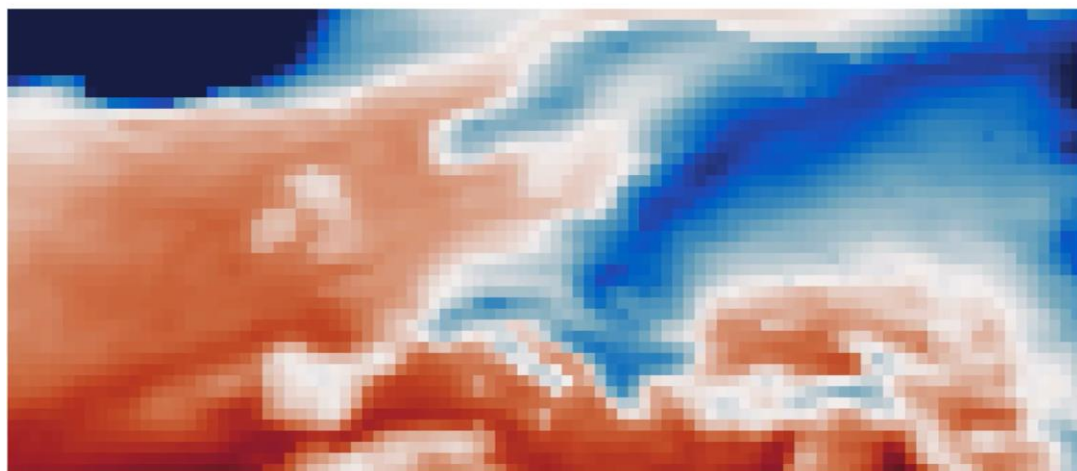
*“CSC – IT Center for Science will lead an international partnership to deliver the Climate Change Adaptation Digital Twin – a global multi-decadal storm & eddy resolving simulation capability ”*



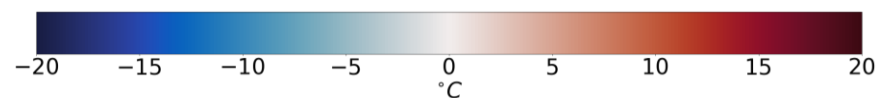
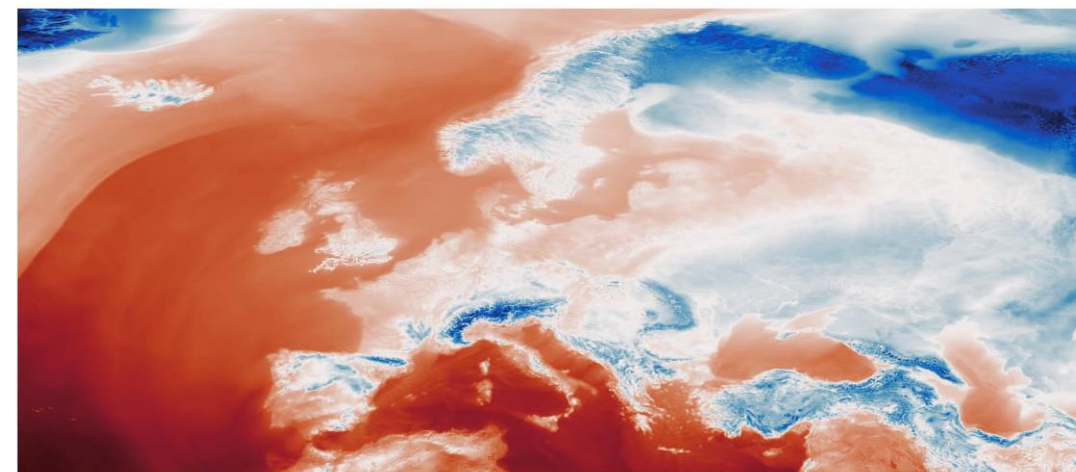


# GLOBAL INFORMATION WITH LOCAL GRANULARITY

IPCC AR6 (2021), 100km



Digital Twin, 5km





# EXPLOITING THE WORLD LEADING EUROPEAN HPC PLATFORMS

No 3 TOP500



LUMI

No 4 TOP500



LEONARDO



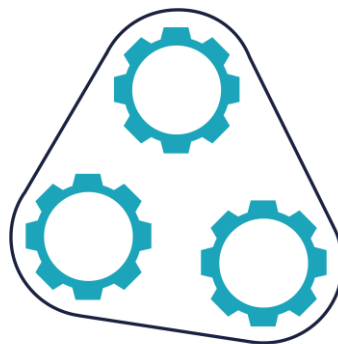
MareNostrum



**EuroHPC**  
Joint Undertaking



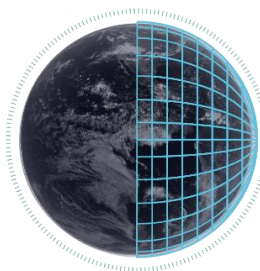
# THE DIGITAL TWIN ENGINE



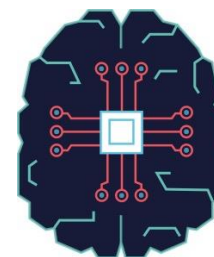
## Software environment



Ensuring complex simulations are run efficiently on EuroHPC



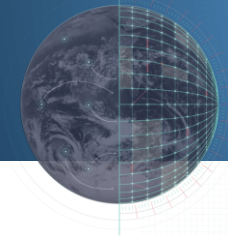
Running the digital twins and managing big data



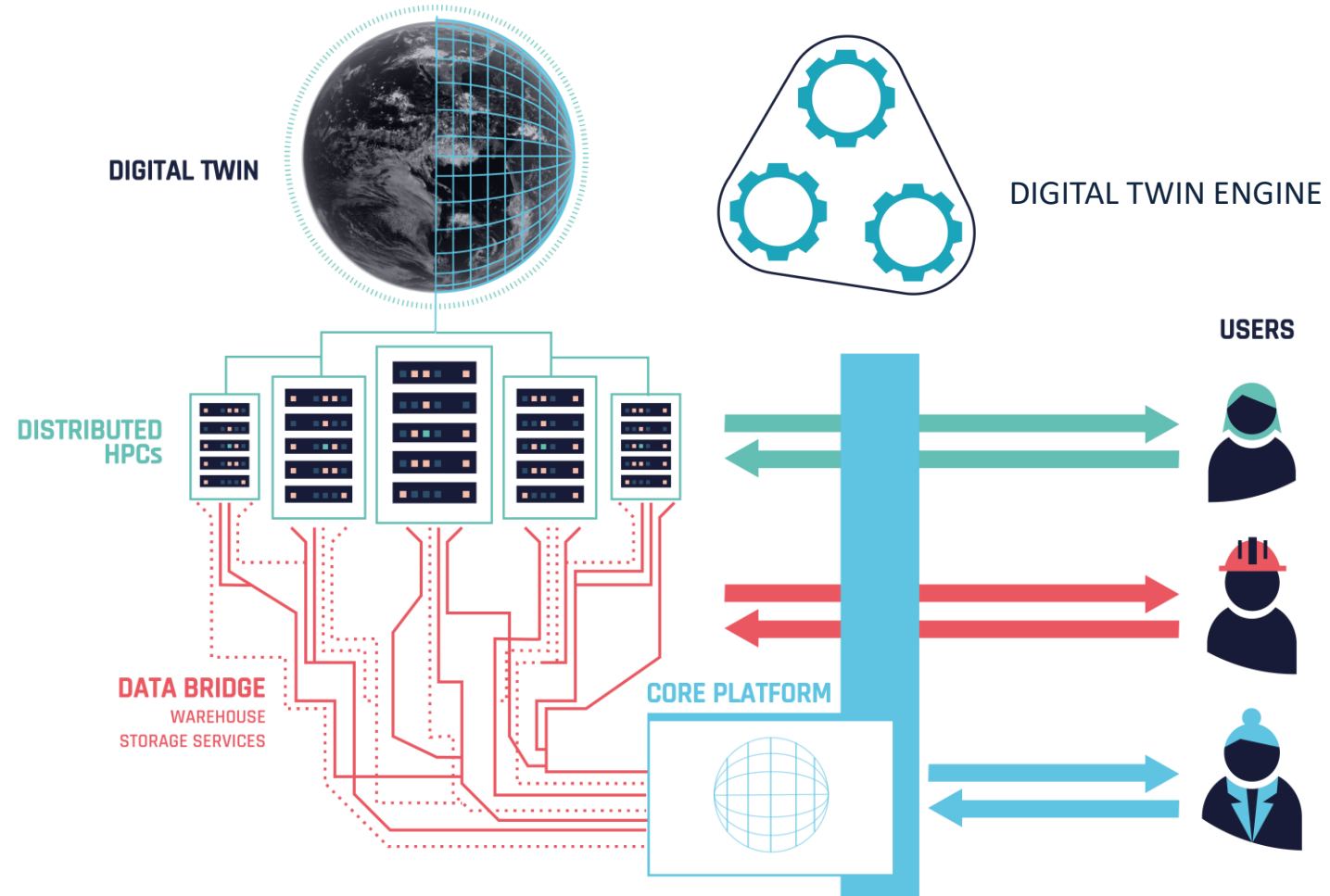
Using ML/AI to increase the efficiency of the digital twins and estimate uncertainty



Tailoring information to user's needs and interactivity

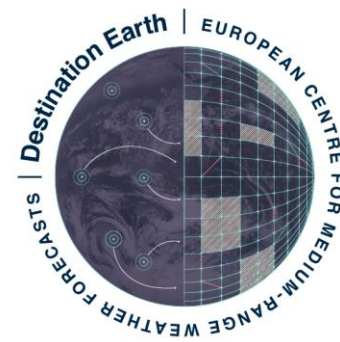


# DTE: INTERACTIVITY



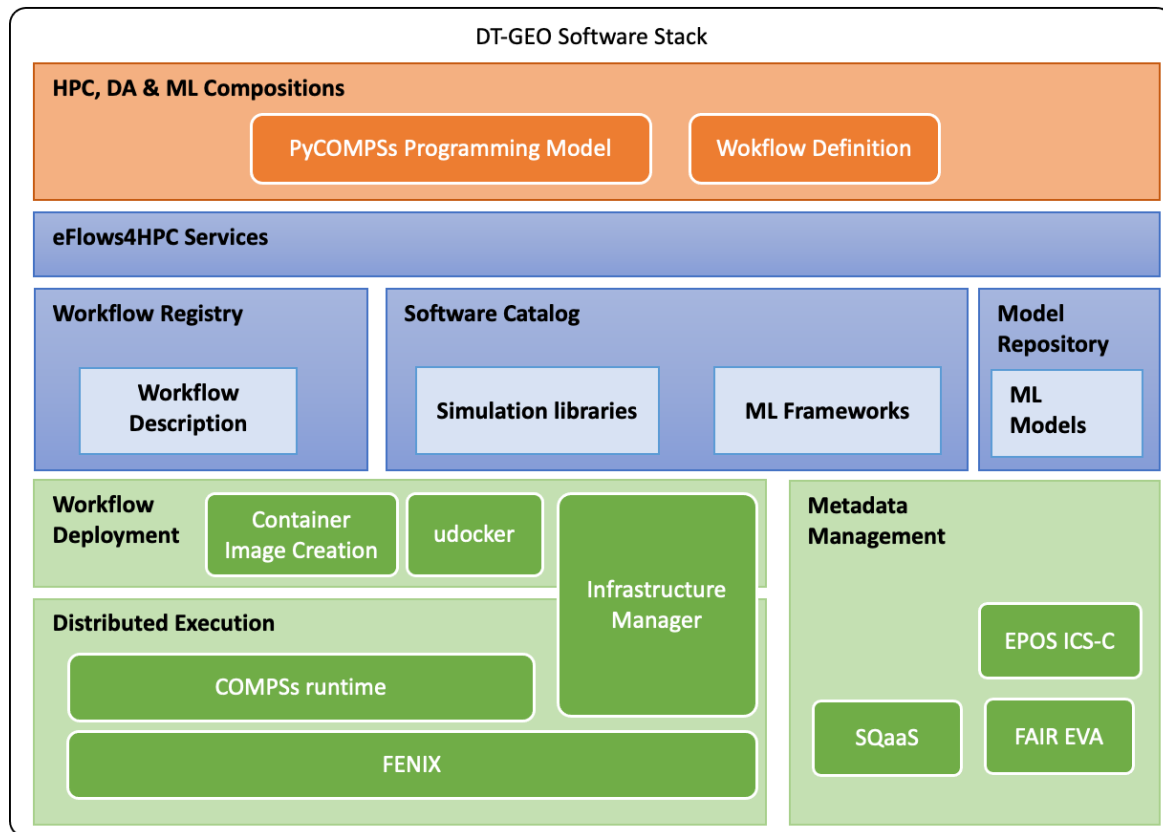


# Different types of Integration and technology transfer with other emerging digital twins

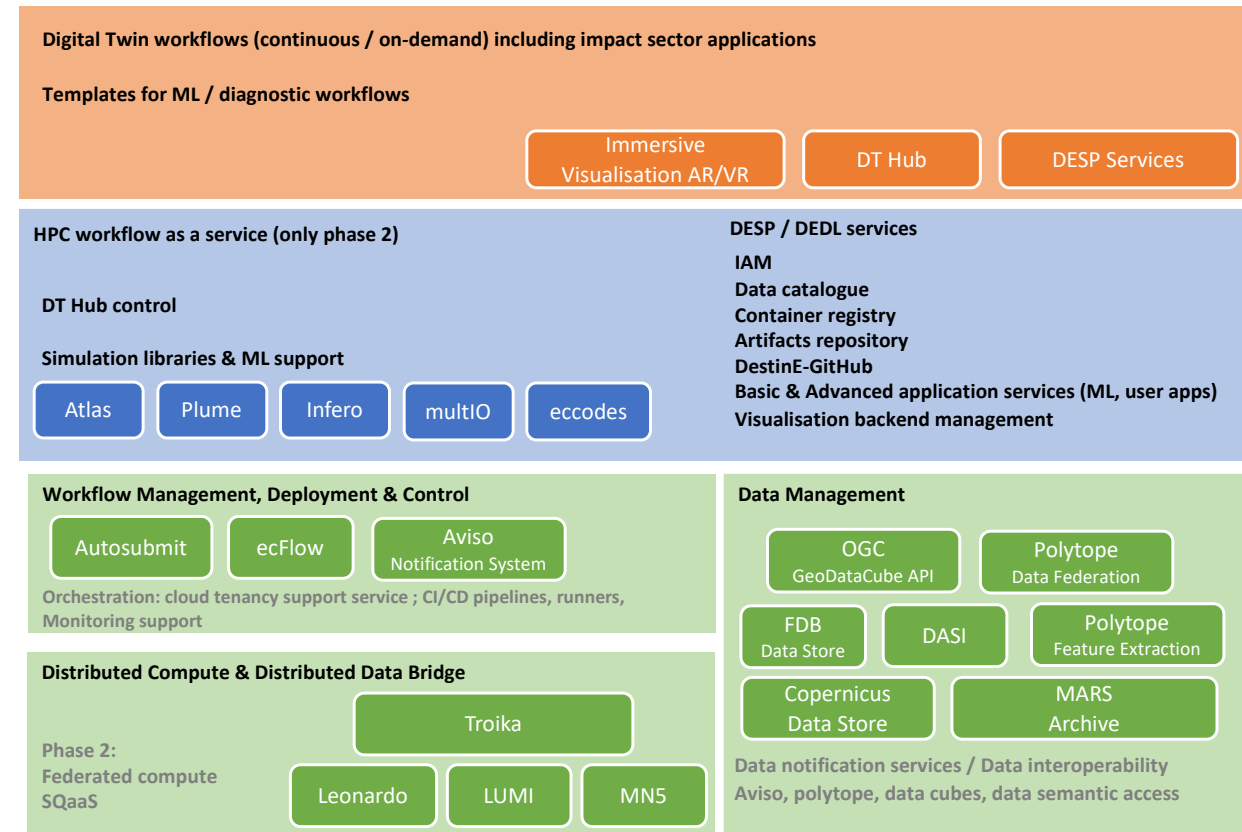


An example from DT-geo on component level

Mapping on similar concepts but **tool choice differs**

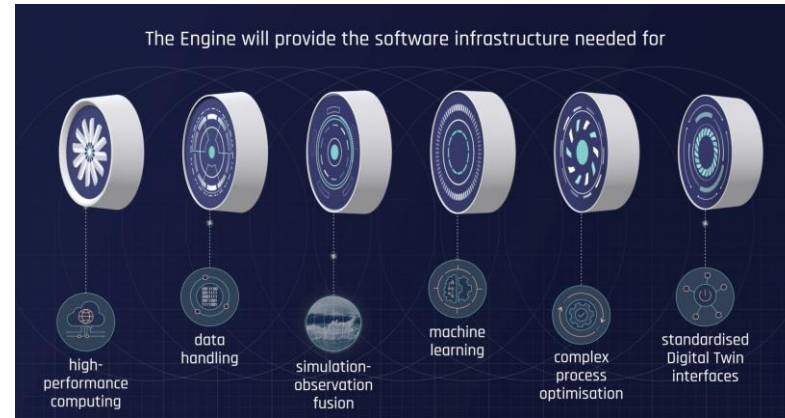
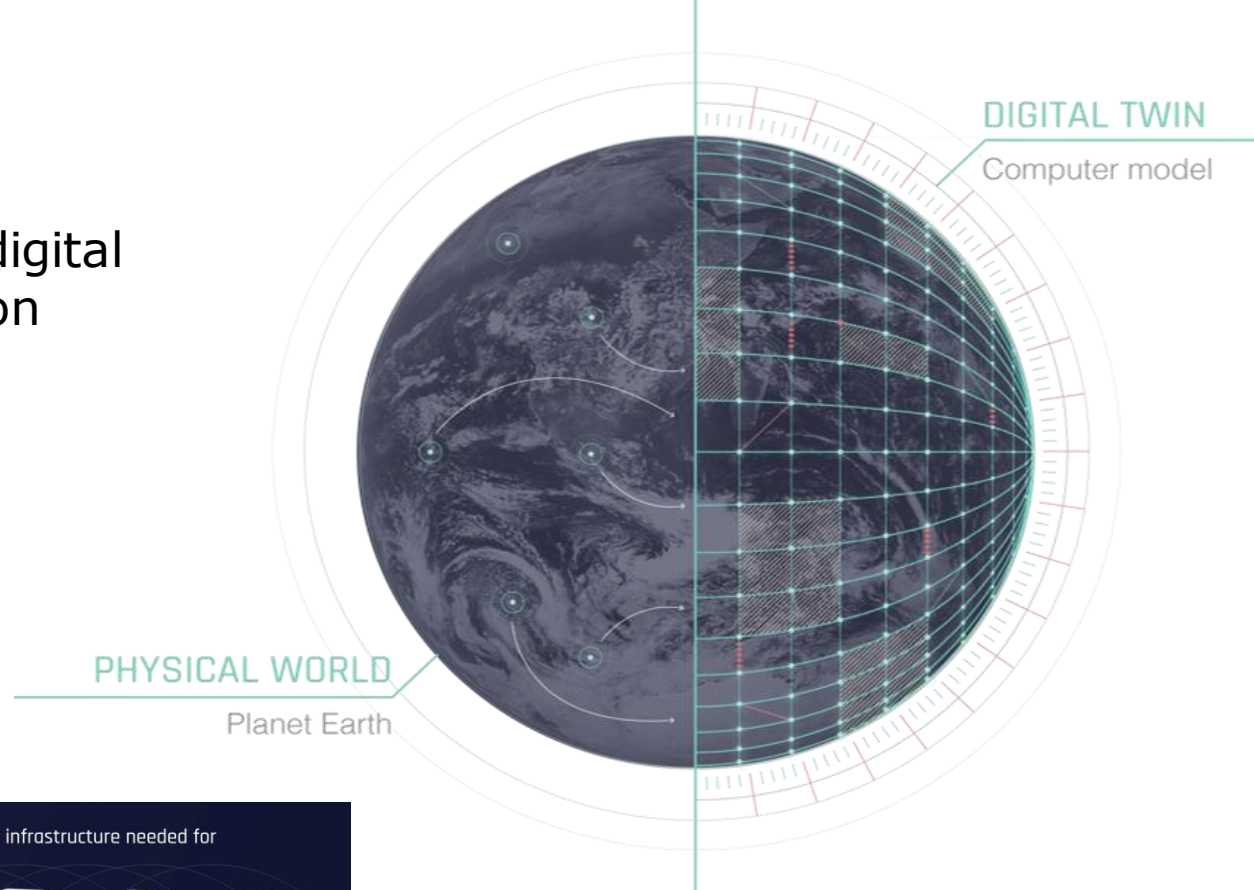
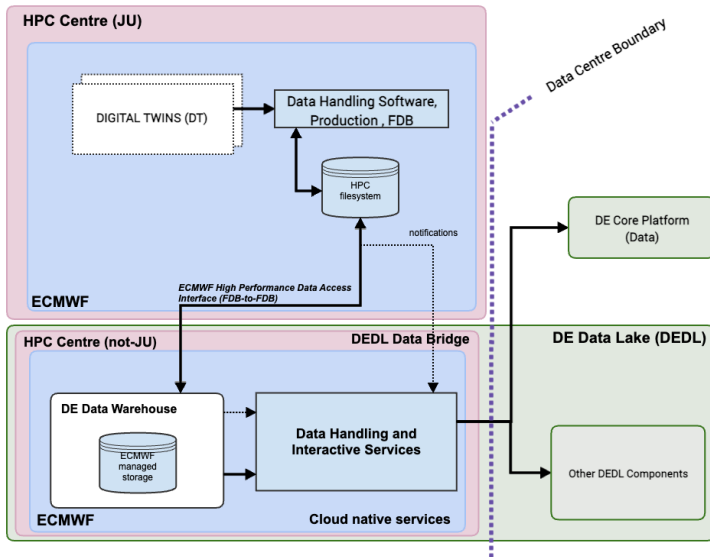


*eFlows4HPC*



# SUMMARY

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



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