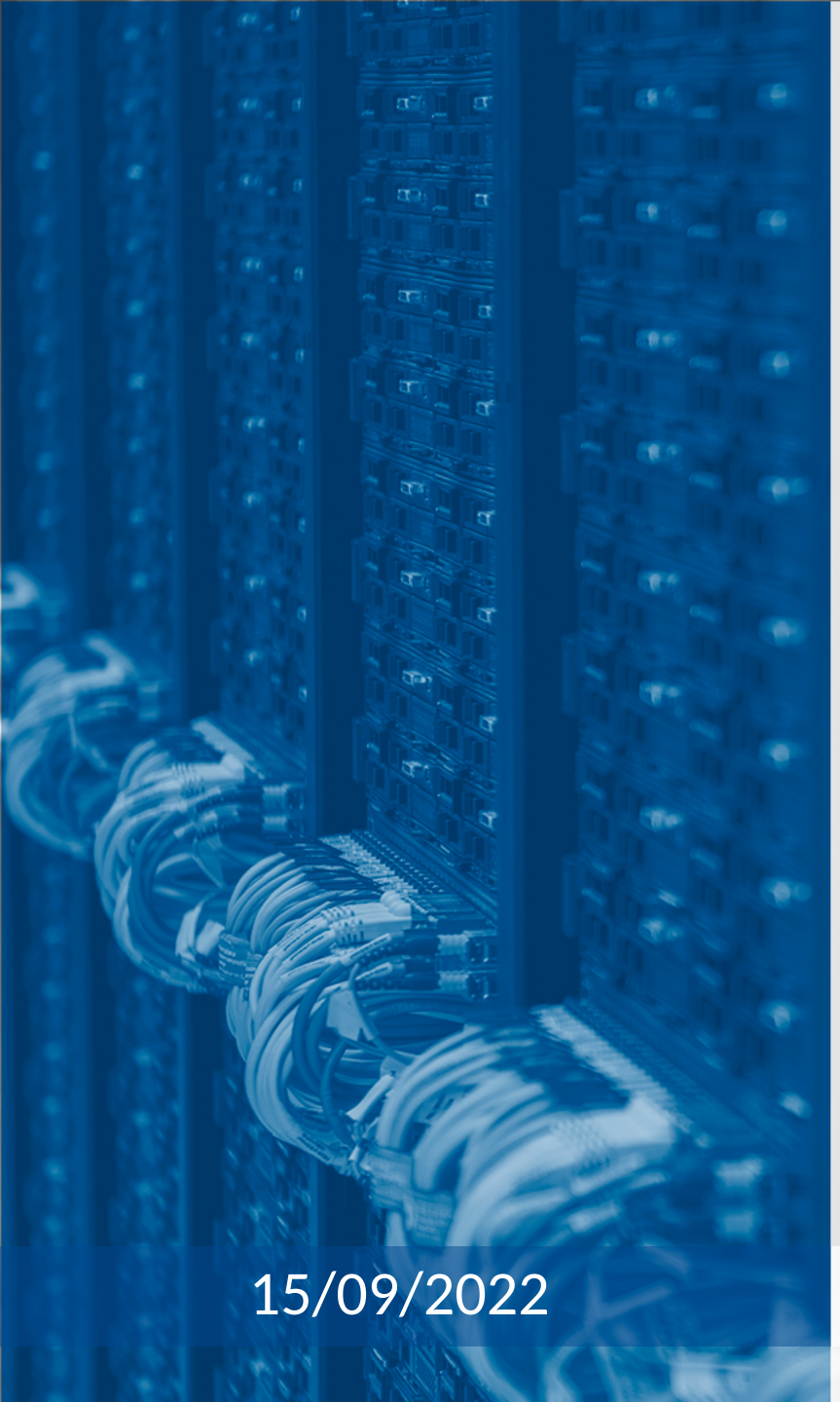

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Destination Earth project: implementation of Earth Digital Twins at BSC

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15/09/2022

16th USERS CONFERENCE - RES

Outline

- BSC Earth Sciences
- Destination Earth program
- Digital Twins
- Implementation at BSC

Earth Sciences

Environmental modelling and forecasting, with a particular focus on weather, climate and air quality

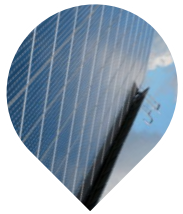
Modeling
air quality and
Sand and Dust Storms
Processes from urban to Global and the impacts on weather, health and ecosystems

Research and Forecasts

Climate
predictions system from subseasonal-to-decadal forecasts

Service Users Sectors

Infrastructures



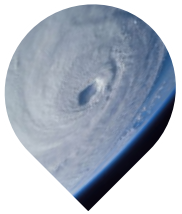
Solar Energy

Urban development

Transport

Wind Energy

Agriculture



Insurance

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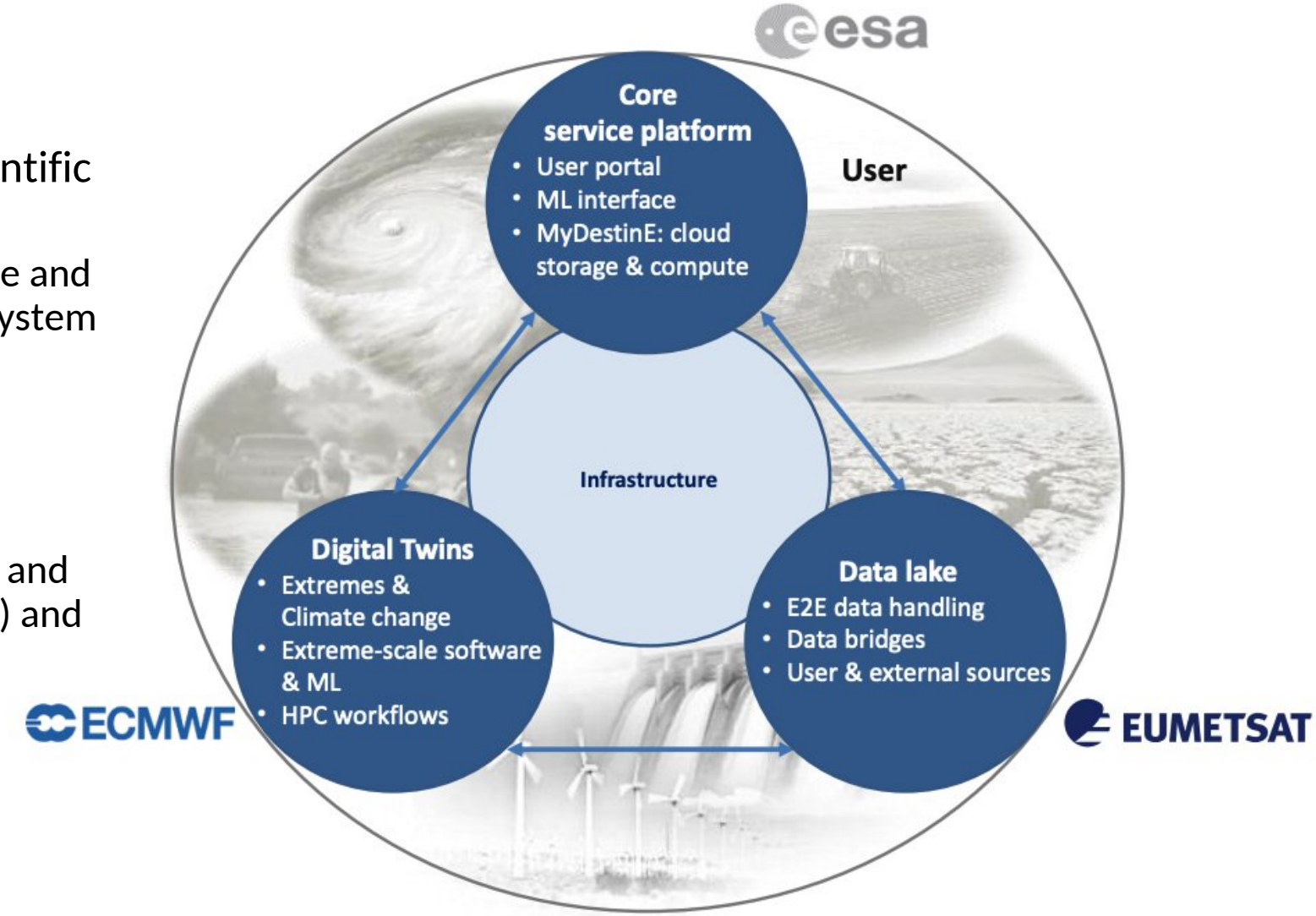
Destination Earth

- Destination Earth is user-centred
- Users of DestinE, including non-scientific experts, will be able to:
  - Perform highly accurate, interactive and dynamic simulations of the Earth system
  - Improve prediction capabilities to maximize impact
  - Support EU policy-making and implementation
  - Exploit the potential of distributed and high performance computing (HPC) and data handling at extreme scale



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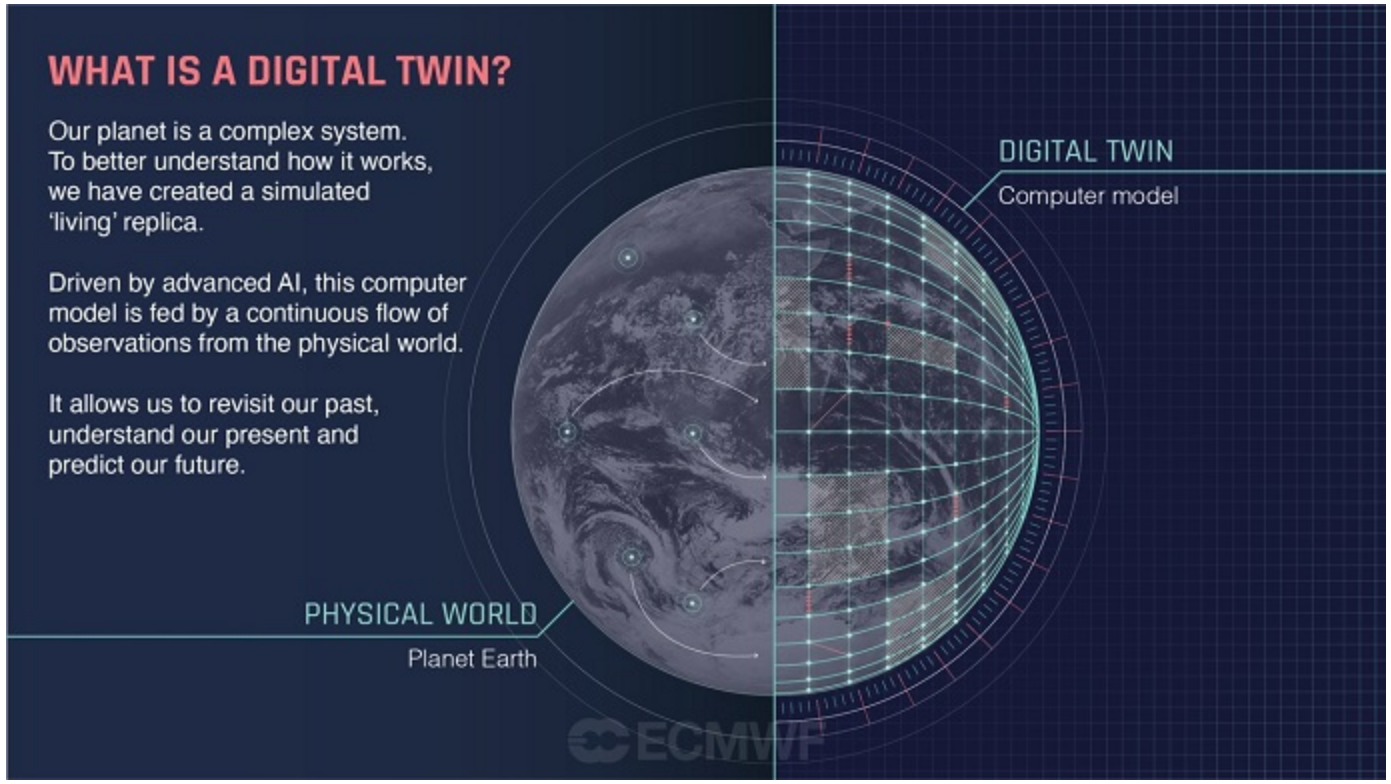
https://digital-strategy.ec.europa.eu/en/policies/destination-earth

Digital Twins



- BSC is involved in two digital twins:
  - CATS: Climate Adaptation Digital Twins
  - DEODE: Destination Earth On-Demand Extremes
- Schedule
  - Started 1st September
  - 20 months

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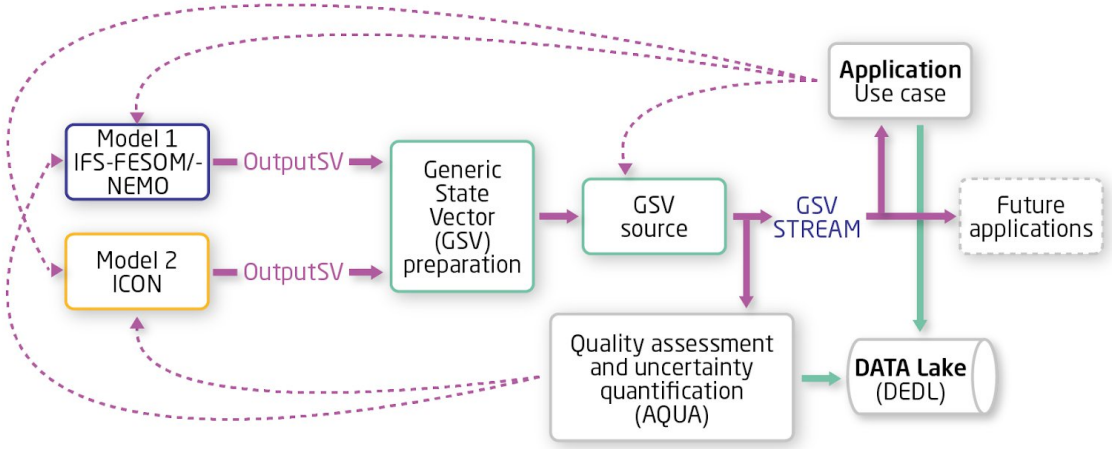
CATS (Climate DE)

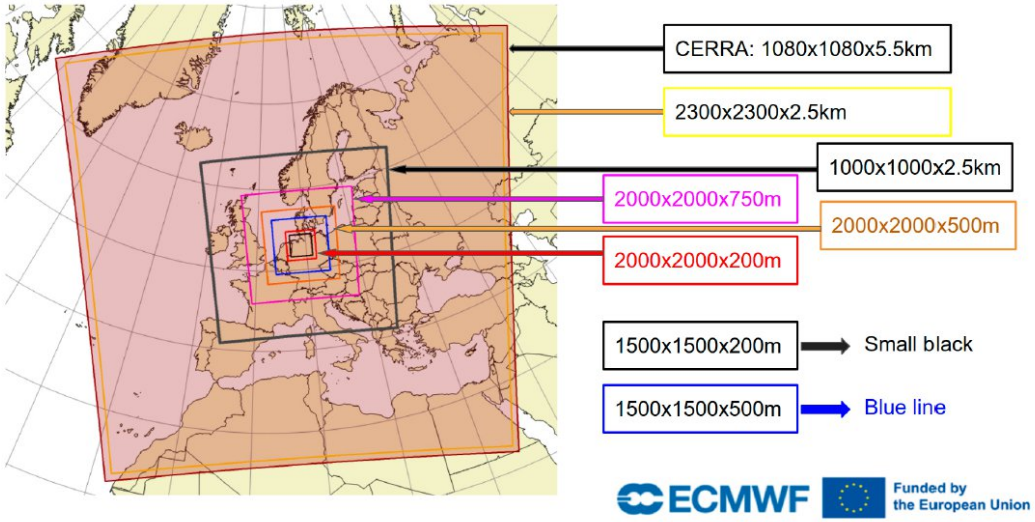
- Led by CSC (Finland) but strong BSC involvement
- Create a climate information system that, enabling kilometre-scale models, effectively guides climate change adaptation measures
- Models will run in EuroHPC machines
- Focus on workflows data streaming is central to the envisioned solution, delivering data needed by applications



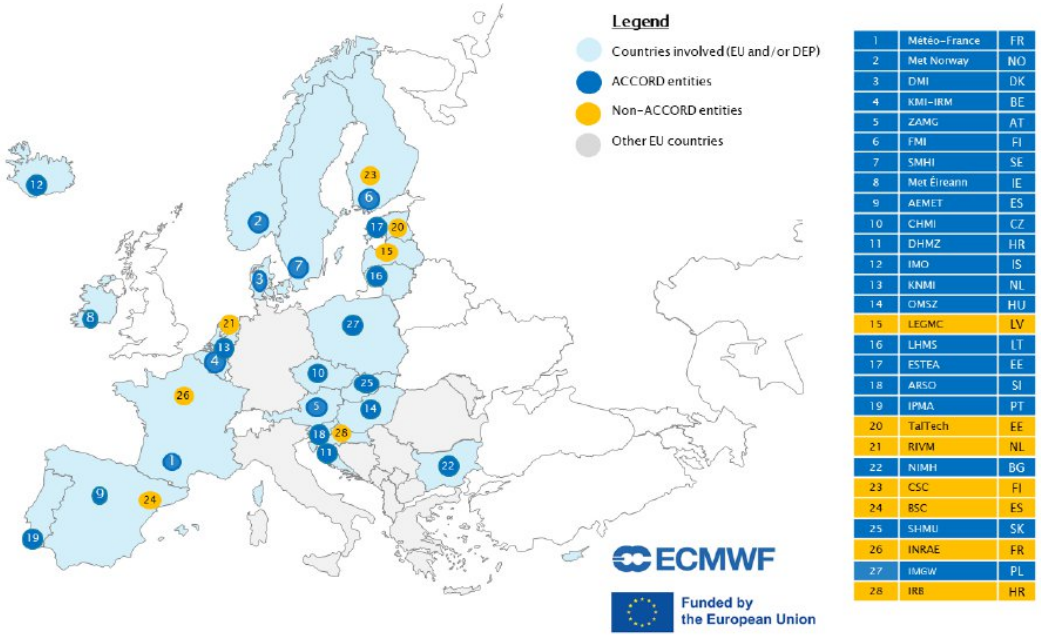
DestinE CATs simplified concept

DEODE (Extremes DT)

- Led by Meteo France with BSC technical involvement
- Solution for making on-demand configurable digital twin engines for forecasting of environmental extremes at the sub-km scale
- The model will run in LUMI
- Based on the ACCORD existing consortium and meteorological model
- Most of the meteorological services in Europe



Example of DEODE digital twin model domains



Map of entities involved in the DEODE project

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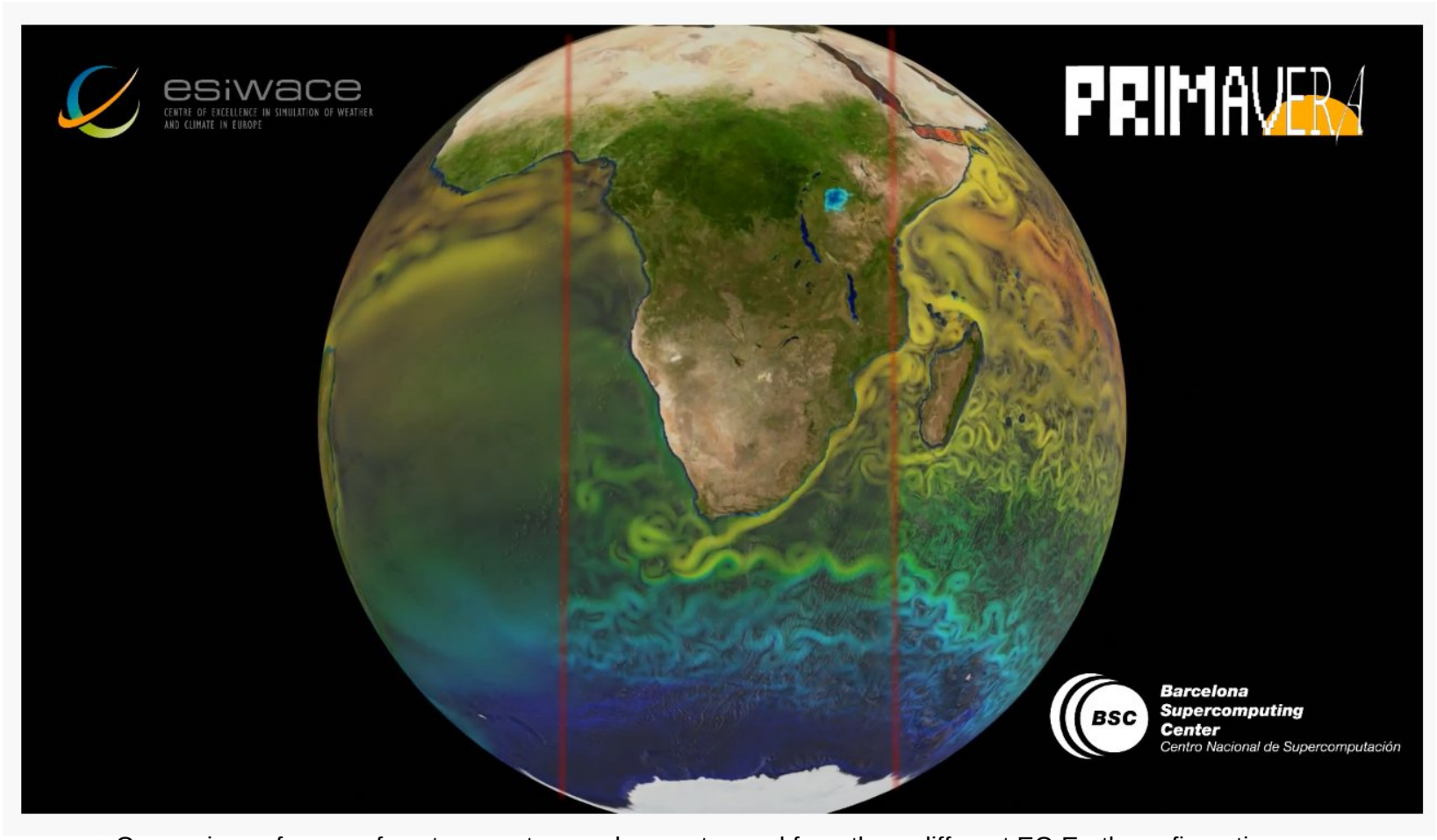
Unprecedented space and time resolution

- Up to 2.5km of horizontal resolution in climate models **and hourly resolution (at least).**

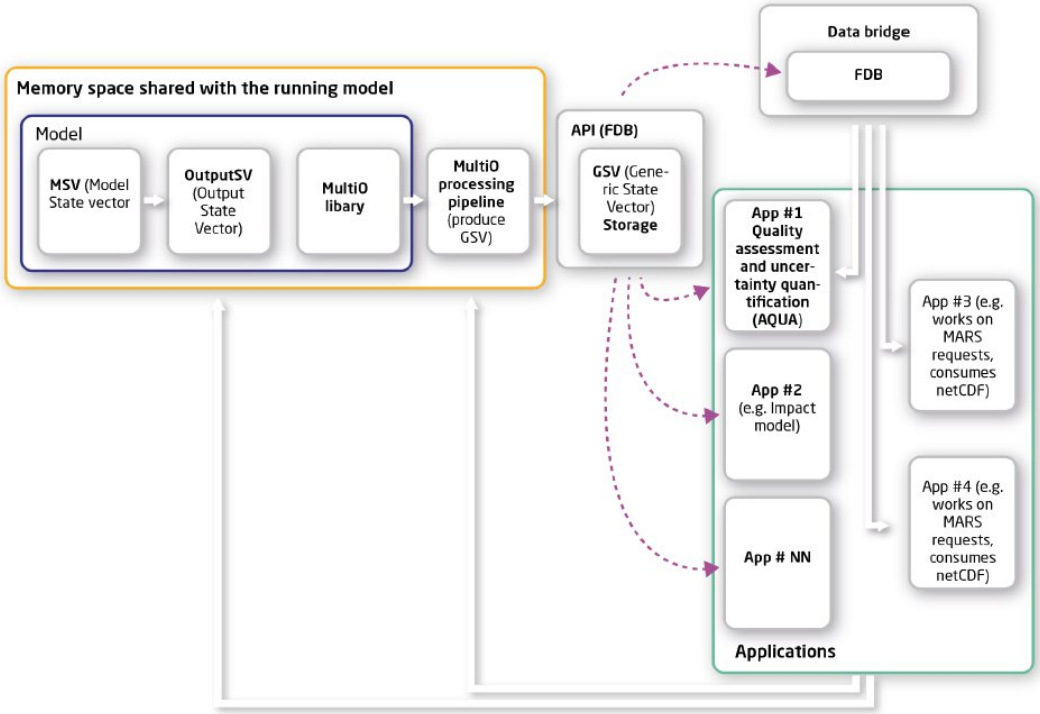


Comparison of sea-surface temperature and current speed from three different EC-Earth configurations (ORCA1º, ORCA1/4º and ORCA1/12º).

https://www.youtube.com/watch?v=xmE9t0WYhsA

Output management

- Digital Twins will produce unprecedented data volume traditional approach based on files is no longer valid
- DTs will store reduce and store data in Fields DataBases (FDB)
  - FDB is a domain-specific object store for meteorological objects (GRIB) developed by ECMWF (https://github.com/ecmwf/fdb)



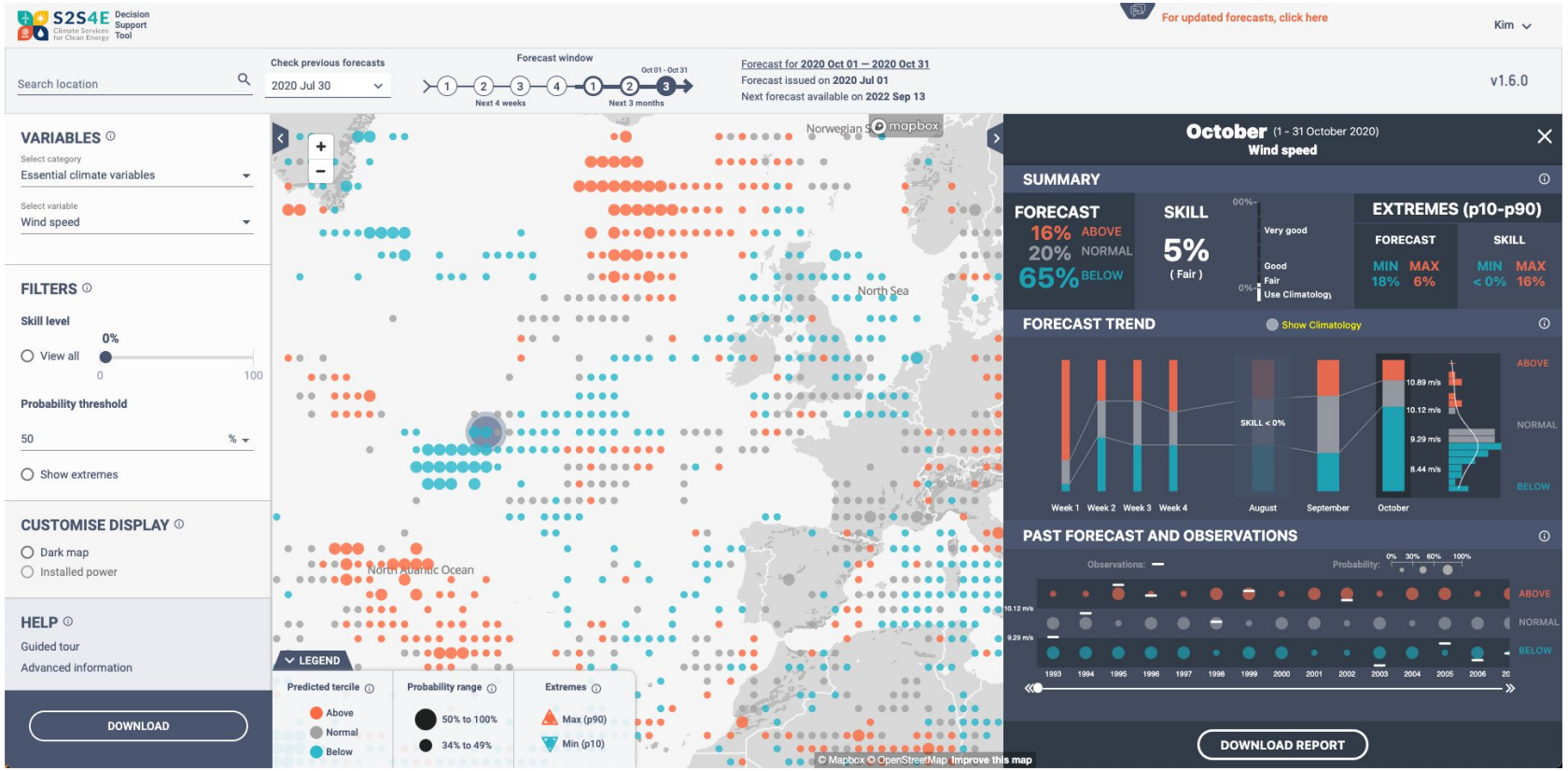
DestinE climate DT simplified concept

DE Uses Cases

- Both DT will offer uses cases to show the potential application of the digital twins
- Those uses cases should open the door to other applications (from end users)

- Climate
  - Energy
  - Wildfires
  - Hydrology (river flows)
  - Hydro Meteorological Ind.
  - Urban Environments

- Extremes
  - Hydrology
  - Air quality
  - Renewable energy



S2S4E Decision support tool

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EuroHPC and pre-exascale machines

- DTs will run in LUMI, Mare Nostrum 5 and Leonardo
- Codes need to be modified to leverage the full potential of accelerators
- With different models, different GPU porting strategies are considered
  - OpenACC
  - Source-to-source translators and DSLs (Loki, Psyclone, GPUFort, …)
  - CUDA

- Strong involvement of model developers, performance engineers and system administrators to be successful

- Further develop AI methods applied to Earth Sciences needs

Multidisciplinary and Interdepartamental

- DestinE is an ambitious project and will requirement a wide range of expertise and knowledge to tackle the objectives

- Within BSC
  - Earth Sciences
    - Computational Earth Sciences (performance analysis, porting, workflow design, post-processing tools, …)
    - Climate Variability and Change (model development, climate sciences, …)
    - Earth System Services (climate services, outreach, liason with users and stakeholders, …)
  - Computer Sciences (performance tools, co-design, …)
  - Operations (HPC operation, deployment of solutions, …)

- Not many research institutions have this diverse knowledge in-house. The BSC role is key because few other institutions offer software engineers, natural scientists and social scientists under the same roof and sharing the same vision.

- The technological solutions that will facilitate a new way of interacting with decision makers in DestinE require a significant investment in multidisciplinary groups such as those at BSC

Impact of DE in Spanish Ecosystem

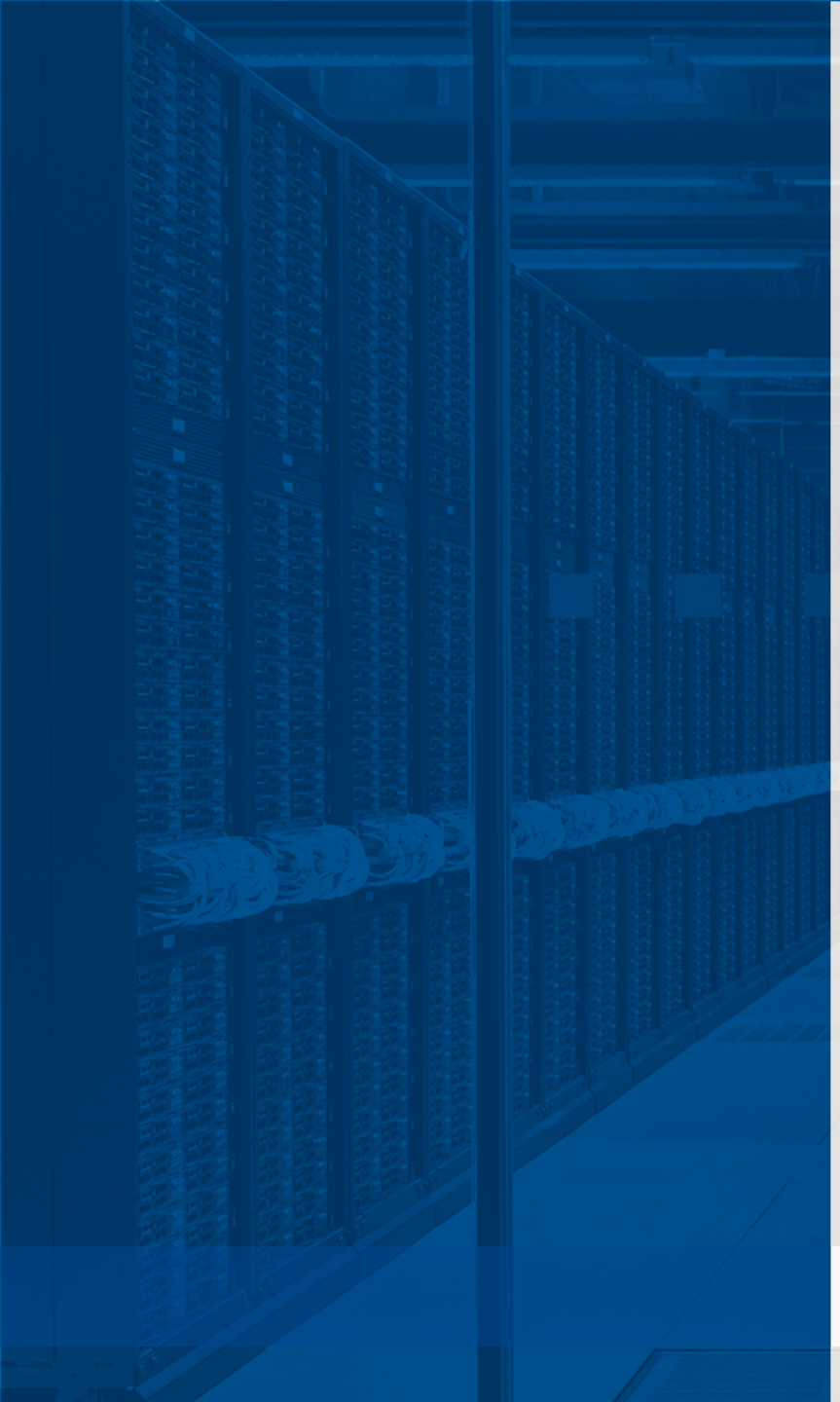
- Mare Nostrum 5 will run Destination Earth simulations
- National expertise in models development and operation and data
- Spanish meteorology and climate community (and HPC ecosystem associated) should take advantage of such a position
- Stay tuned for the next dissemination activities (stakeholders meetings, data hackathons, …)

Destination Earth next phases

- Phase 1 (2021-2024):
  - Delivery of 1st digital twin generation
  - Demonstration of new capabilities at scale
- Phase 2+ (2024-):
  - Extend to new applications
  - Fully integrate components
  - Widen DTE scope (more DTs to come…)
- By 2027
  - Further enhancement of the Destination Earth system and integration of additional digital twins and related services.
- By 2030
  - A ‘full’ digital replica of the Earth

Destination Earth as a game changer

- Long-term vision:
  - CATS: revolutionize climate adaptation putting user requirements at the centre and making the best use of the technology (models and machines)
  - DEODE: on-demand workflow of unprecedented, high-resolution forecasts extreme weather events combined with decision making support for impact sectors
- DestinE will provide unprecedented environmental information in terms of quality, interactivity and relevance, ready to be consumed by applications through dedicated data lakes and a service platform



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Thank you

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