Funded by the European Union

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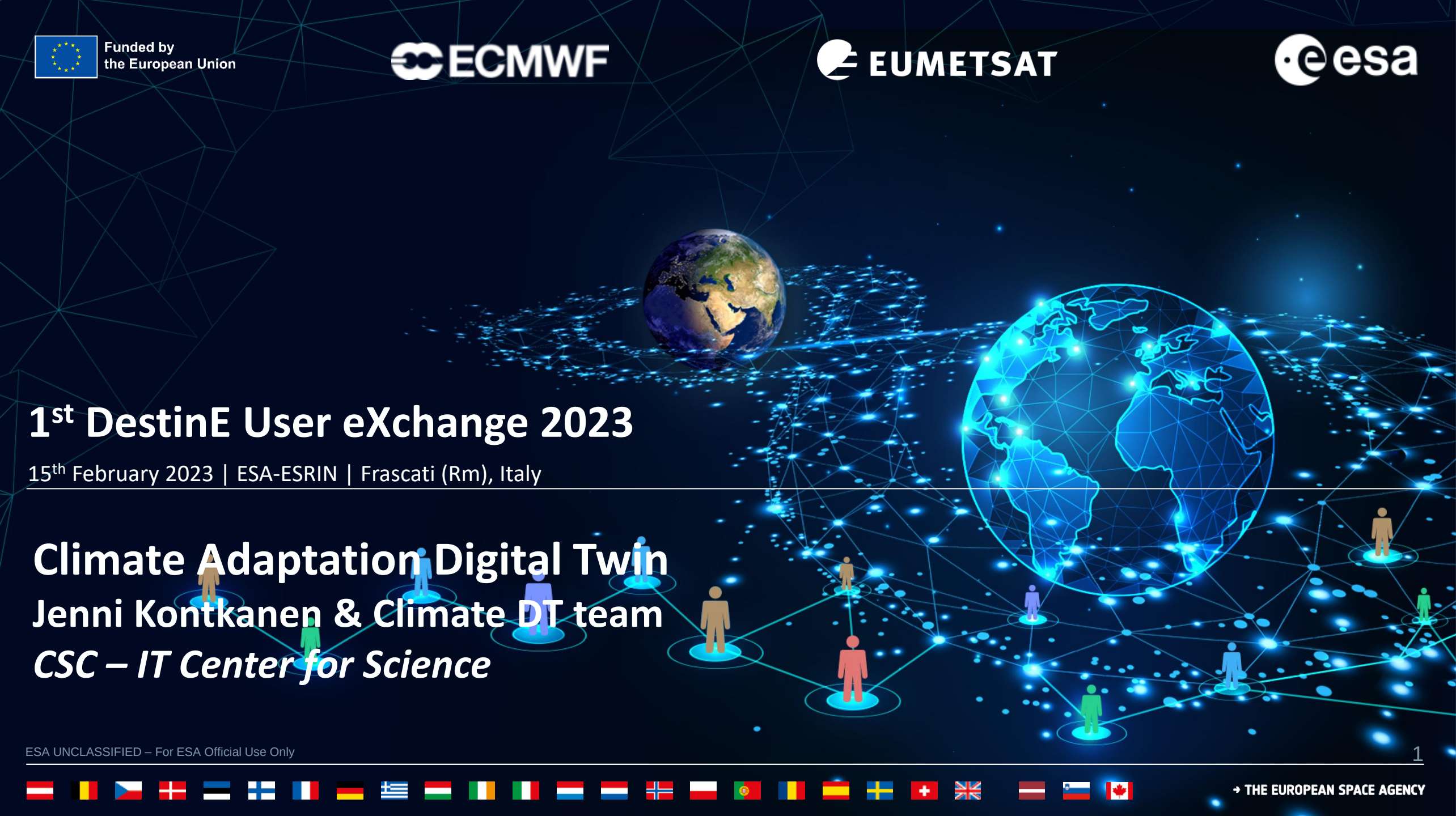


1st DestinE User eXchange 2023

15th February 2023 | ESA-ESRIN | Frascati (Rm), Italy

Climate Adaptation Digital Twin

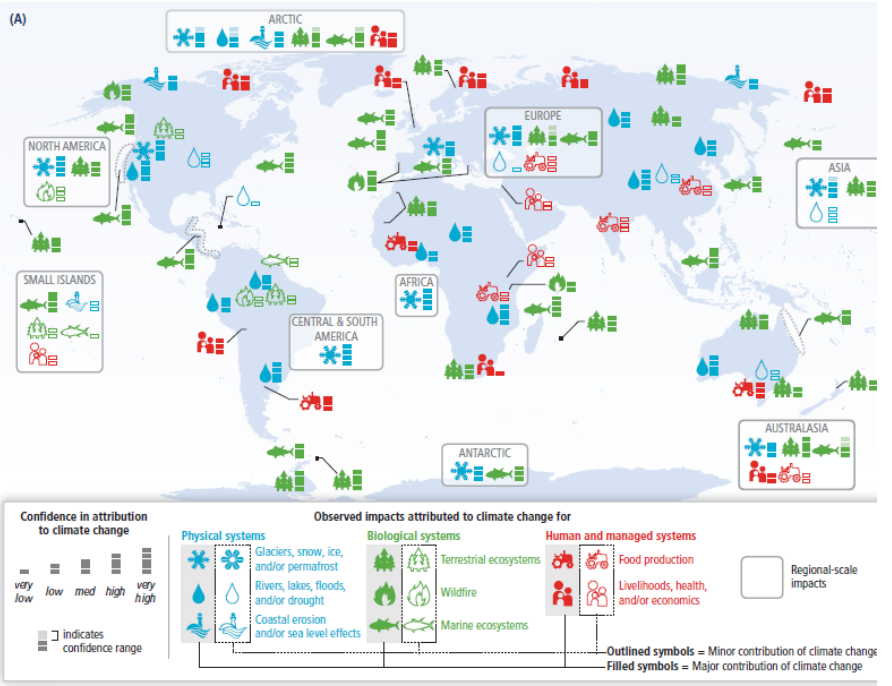
Jenni Kontkanen & Climate DT team

CSC – IT Center for Science

Climate change adaptation – need for new solutions

- Climate change will have severe impacts on human and natural systems - regional and local effects uncertain
- Current climate modelling activities have limitations regarding climate change adaptation
  - low horizontal resolution of the global models
  - slow process with no interactivity with the users

New solutions needed to **inform climate change adaptation efforts** and **to assess risks of failed mitigation actions.**



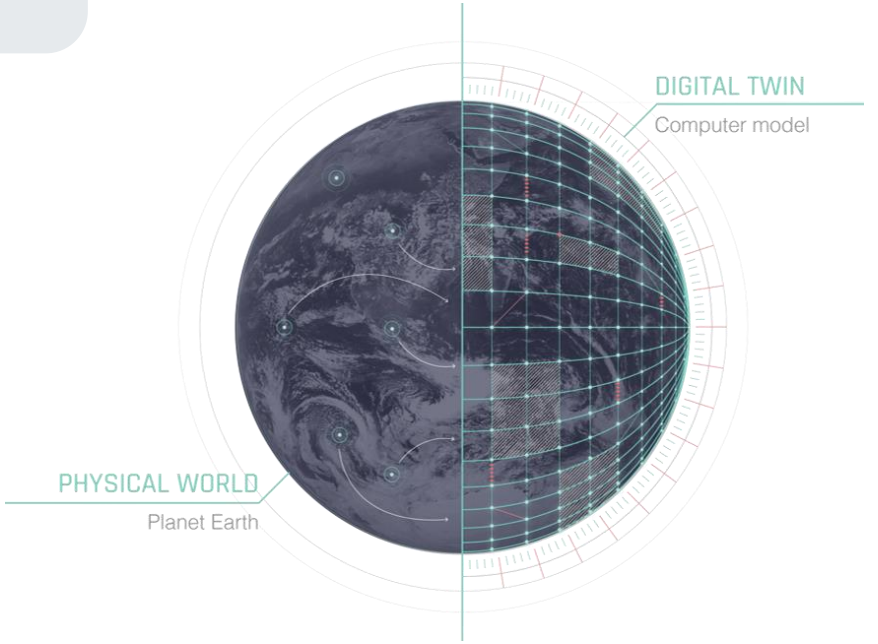
Observed climate change impacts on physical, biological and human systems. (*IPCC, AR5, WGII, 2014*).

Climate Adaptation Digital Twin (Climate DT)

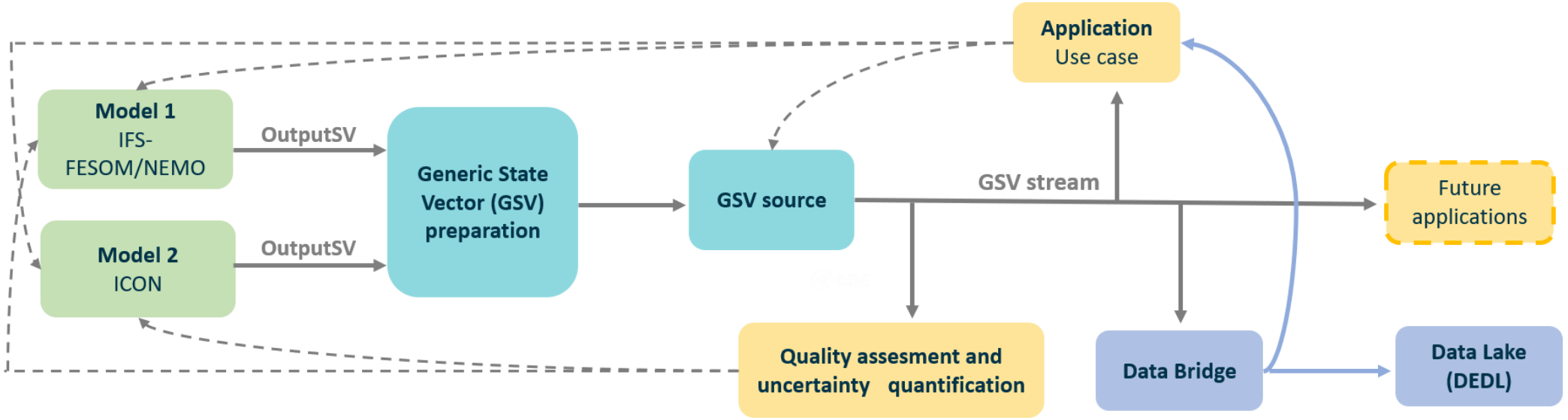
Climate DT is a new type of climate information system that can be used **to assess impacts of climate change and different adaptation strategies** at local and regional levels over multiple decades**.**

Climate DT will encompass:

- **Global climate simulations** at an unprecedented horizontal resolution
- Novel approach with **streaming of climate model output to impact models**
- **Quality assessment and uncertainty quantification** based on observations
- Deployment on **two European pre-exascale supercomputers**



Climate simulation workflow rethought



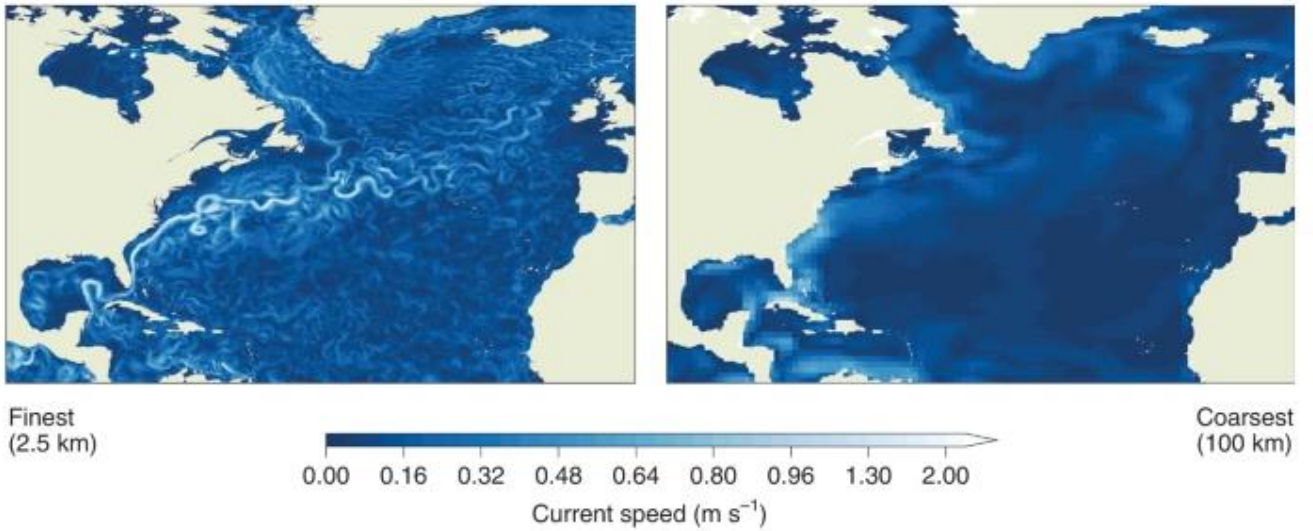
Streaming of climate model output in standardized form enables

- **users to access the full model state** as soon as it is available
- **interactivity** – users may request simulations based on their needs
- **scalability** – new applications can be added

Next-generation Earth system models

- Climate DT will utilize **two Earth system models**: ICON and IFS-NEMO/FESOM - only European models able to simulate at 5 km and finer resolution
- During the 1st phase, **multi-decadal simulations on 5 km global mesh**, work towards finer scales

- High-resolution simulations enable:
  - **smaller-scale processes** described with physics → higher fidelity
  - **local information** relevant for users
  - easier **comparison with observations**



Ocean currents in Northern Atlantic simulated at different resolutions with ICON within NextGEMS project.
(*Hewitt et al., 2016, Nat. Clim. Change*).

Observation-based model validation

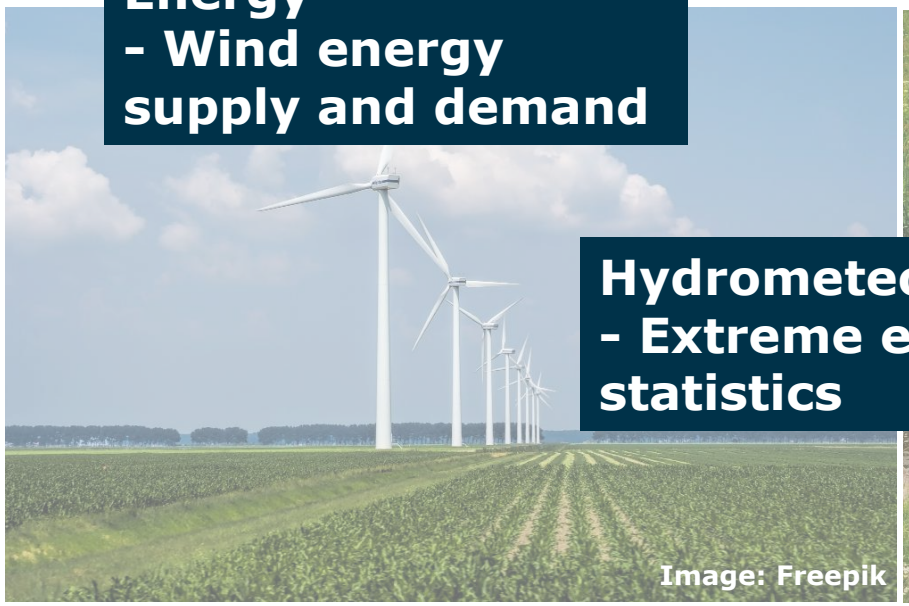
- **Quality assesment and uncertainty quantification** based on streamed climate simulation data.
- Simulations will be evaluated using **a selected set of metrics**.
- **Observational operators** will be implemented enabling
  - direct comparison of simulations to observations (remote sensing & in-situ)
  - real-time monitoring of simulations

Image: Argonne National Laboratory

Climate DT use cases – impact assessments on different sectors

- Use cases will assess **climate change impacts on different topics** based on the streamed climate simulation data.

Energy
- Wind energy supply and demand



Hydrometeorology
- Extreme event statistics

Hydrology
- Fresh water availability

Urban
- Human heat stress

Fire and carbon
- Wild fire risk and emissions

More information will be presented by Sami Niemelä

Computing platforms – LUMI and MareNostrum 5

- Climate DT simulations require **extreme computing power and data handling capacities**
  → effective use of Europe's fastest supercomputers needed.
- Climate DT utilizes **two EuroHPC pre-exascale supercomputers**: LUMI that is in operation in Finland and MareNostrum 5 that will become available in Spain during 2023.
- Computing resources are provided by EuroHPC JU.

EuroHPC Joint Undertaking

Climate DT team – 13 European organizations with expertise in climate modelling, impact assessments & high performance computing

Name	Organisation	Country
CSC	**CSC – IT Center for Science**	**FI**
BSC	Barcelona Supercomputing Center/Centro Nacional de Supercomputación	ES
MPI - M	Max Planck Institute for Meteorology	DE
UH	University of Helsinki	FI
AWI	Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research	DE
CNR-ISAC	Consiglio Nazionale delle Ricerche, Istituto di Scienze dell'Atmosfera e del Clima	IT
POLITO	Politecnico di Torino	IT
FMI	Finnish Meteorological Institute	FI
DWD	National Meteorological Service of Germany	DE
UFZ	Helmholtz Centre for Environmental Research	DE
UCLouvain	Université catholique de Louvain	BE
DKRZ	German Climate Computing Centre	DE
HPE	Hewlett Packard Enterprise	FR

Conclusions – Climate Adaptation Digital Twin

- **A new type of climate information system** based on high-resolution climate simulations, impact modeling and high-performance computing.
- **Will enable users to access** climate information in a new way.
- **Can be used to support decision making** on impacts of climate change and different adaptation strategies.
- **First version will be developed by April 2024** but the system will be made available to a wider range of users later.