DESTINATION EARTH

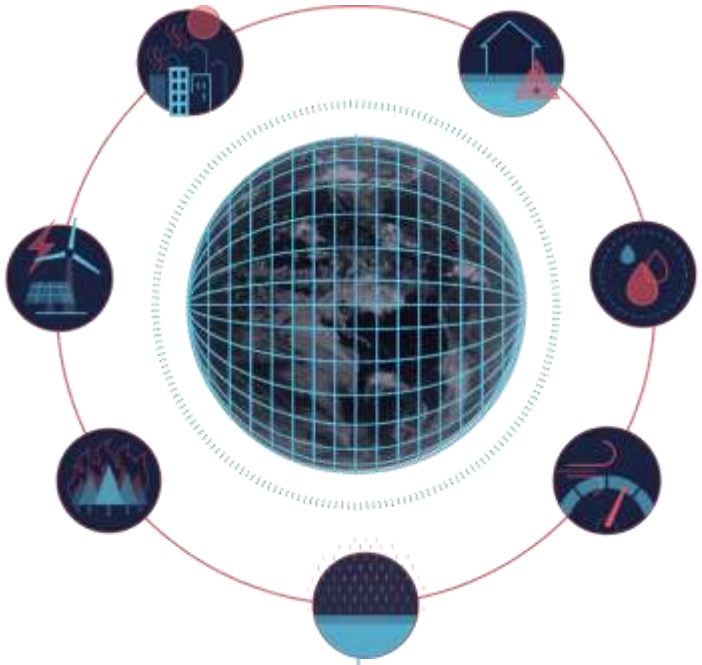
DIGITAL TWINS AND DIGITAL TWIN ENGINE

Irina Sandu, on behalf of ECMWF and its many partners

Funded by the European Union
Destination Earth implemented by ECMWF esa EUMETSAT

THE DIGITAL TWINS: UNIQUE BESPOKE SIMULATION CAPABILITY

To assess the impact of certain events or scenarios on climate and extreme events, and provide global information at scales where these impacts are observed



LUMI

MN5

Leonardo

MeluXina

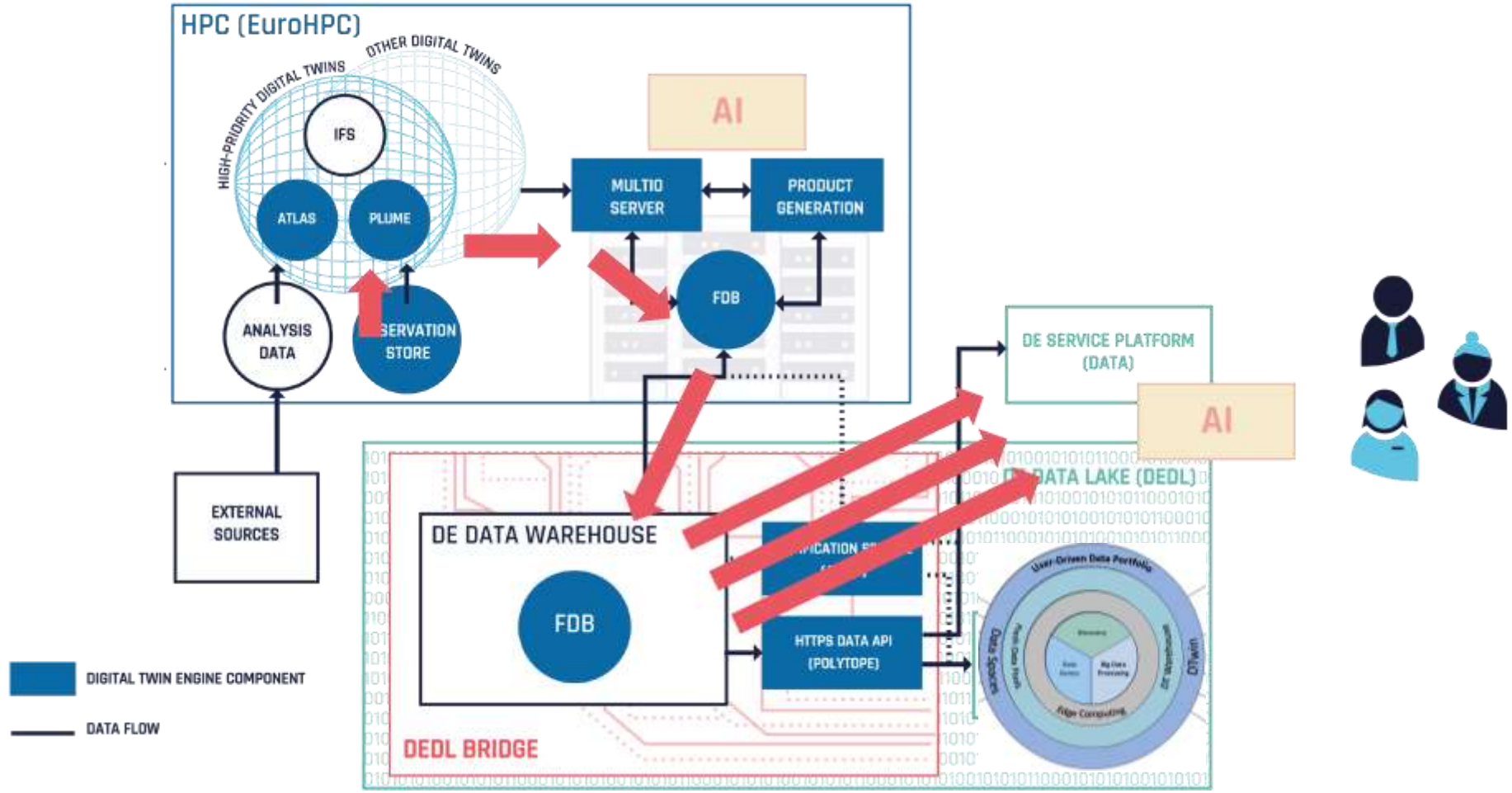
EuroHPC

THE DIGITAL TWINS: UNIQUE BESPOKE SIMULATION CAPABILITY

To assess the impact of certain events or scenarios on climate and extreme events, and provide global information at scales where these impacts are observed

DIGITAL TWIN ENGINE: AI-ENABLED SOFTWARE INFRASTRUCTURE

To operate complex Earth-system and impact-sector workflows on EuroHPC, and provide software solutions and services for accessing, handling and interacting with the digital twins and their data



CLIMATE DT: 1ST OPERATIONAL CAPABILITY FOR CLIMATE PROJECTIONS

Current climate projections

- ✓ Limited resolution (~100 km)
- ✓ Small-scale processes not represented
- ✓ Run through research efforts
- ✓ Updated in 7-10 year cycles
- ✓ Separation of Earth System Models and impact sector models

Climate DT

- ✓ 5-10 km resolution; allowing to explore the weather of the future
- ✓ Global information with local granularity
- ✓ Flexible on-demand operational production
- ✓ Regular operational production
- ✓ Bringing Earth System Models and impact sector models within the same workflow

CSC

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, Instituto 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

CLIMATE DT: 1ST OPERATIONAL CAPABILITY FOR CLIMATE PROJECTIONS

3 global climate models at ~5km

IFS-NEMO
IFS-FESOM
ICON

CSC
next GEMS

See Tracy's talk

Monitoring & evaluation framework

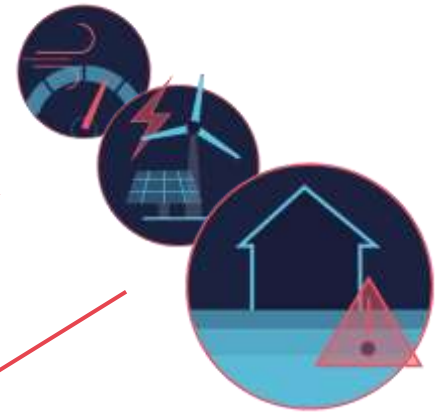
AQUA

Common format & data governance

Computing statistics

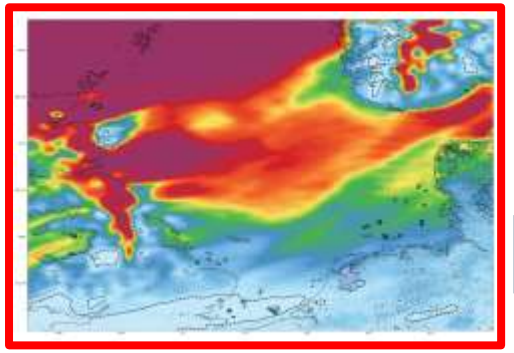
GSV

One-pass algorithm



Impact-sector models

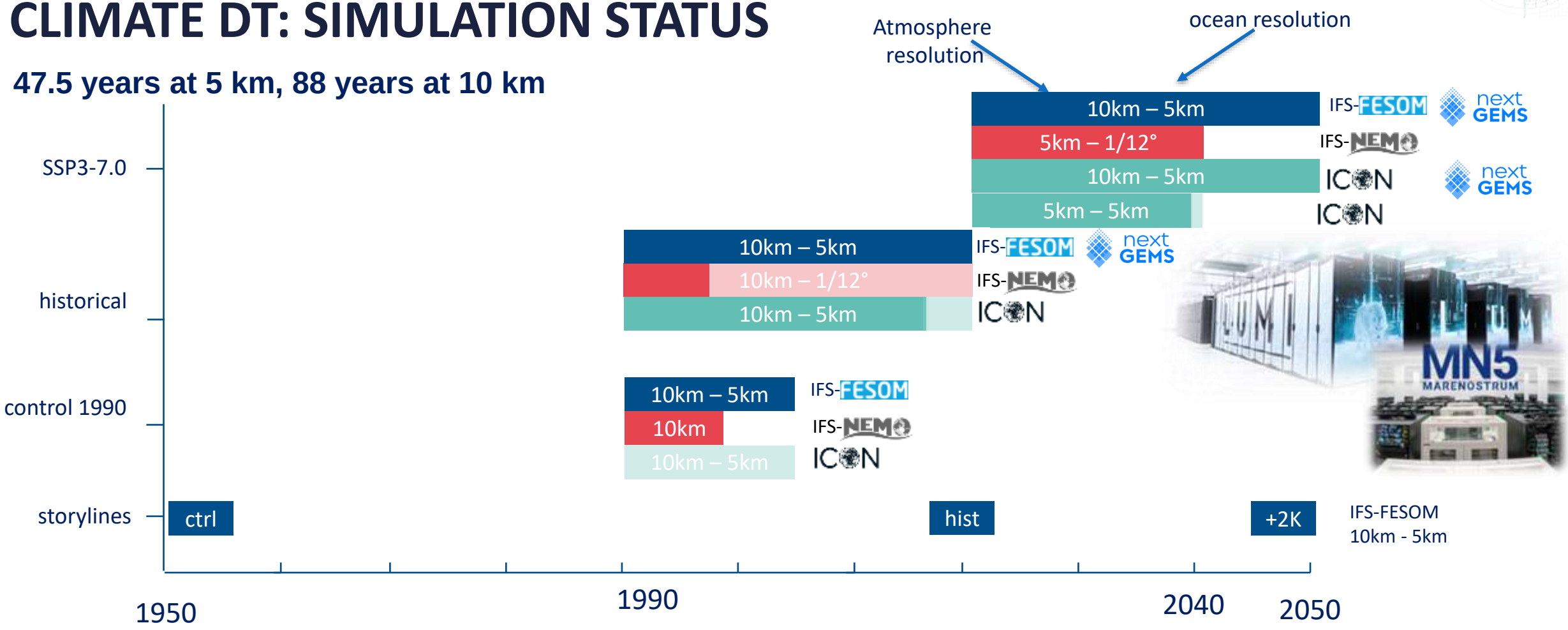
e.g Tailored information for wind energy



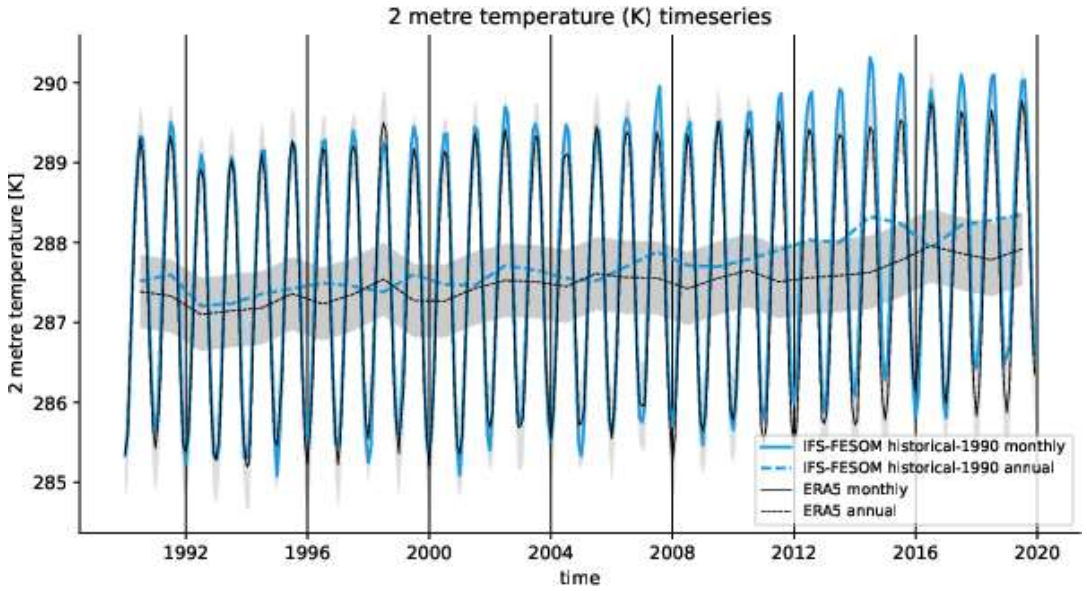
See Francesc's talk

CLIMATE DT: SIMULATION STATUS

47.5 years at 5 km, 88 years at 10 km

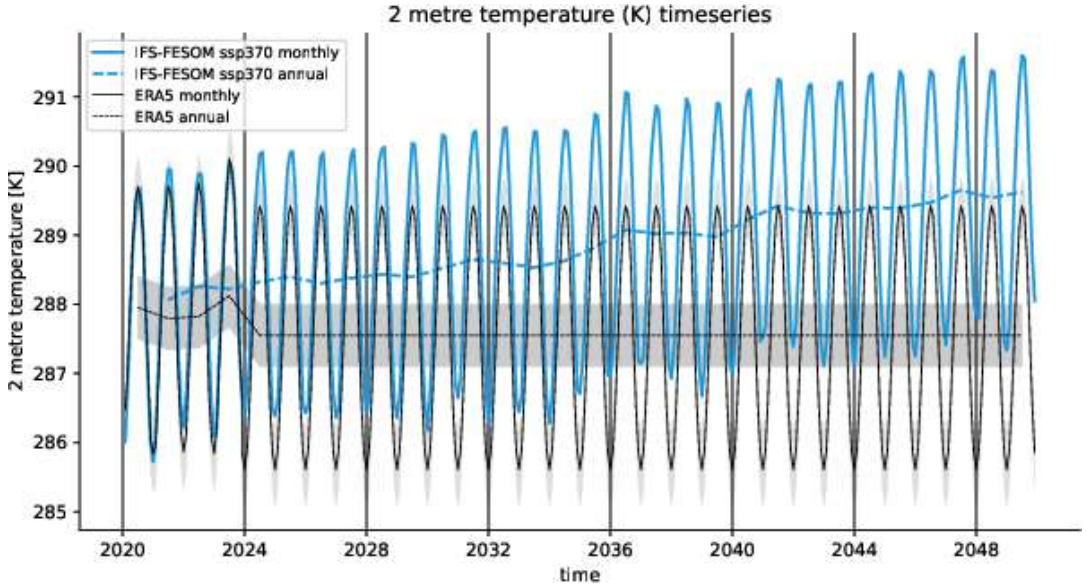


CLIMATE SIMULATIONS



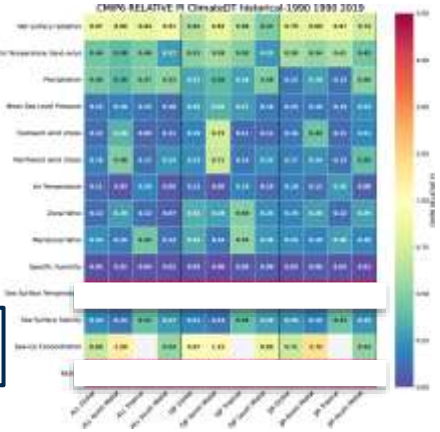
historical

Model in good agreement with historical temperature change



climate projection

~1.5 °C warming from 2020 to 2050

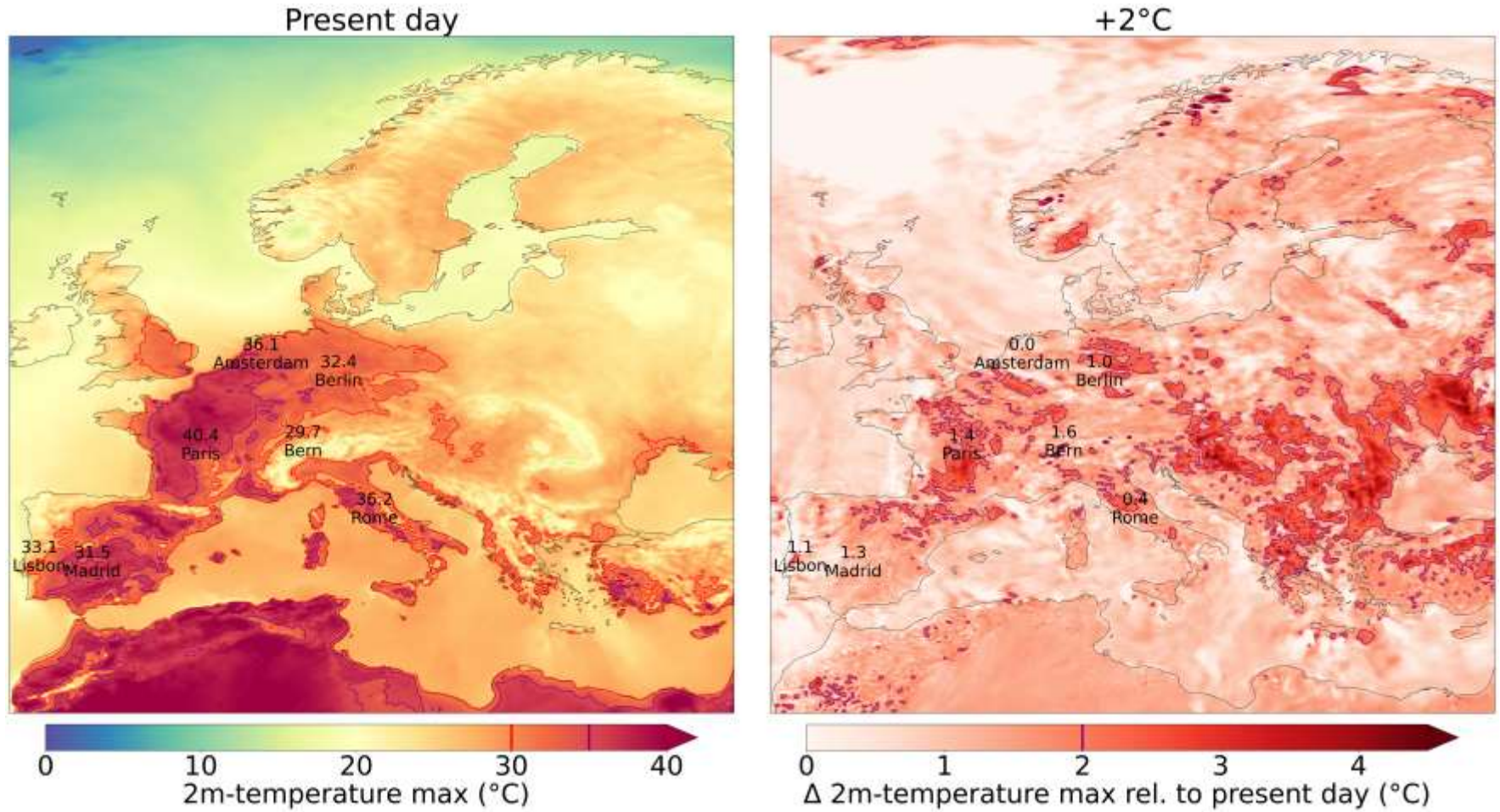


See Paolo's talk

CLIMATE DT: STORYLINES OF EXTREME EVENTS

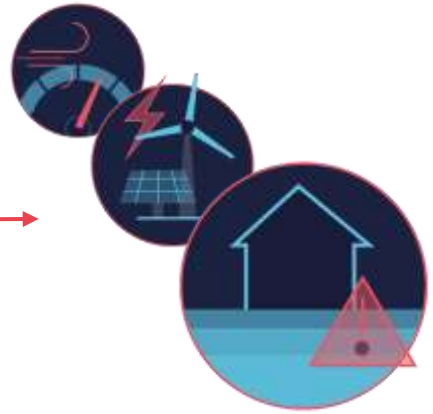
See Amal's talk

IFS-FESOM with large-scale nudged towards ERA5 (2018-2023)



EXTREMES DT : A MAGNIFYING GLASS ON EXTREME WEATHER EVENTS

DETECTION/ TRIGGERING



Global and **daily** simulations of extreme weather
4 days ahead at **4.4km**

On-Demand regional simulations
2 days ahead at **750m** to **500m**

Impact-sector models:
user-relevant information for societal impacts

IFS-NEMO

ECMWF

Arome
Harmonie-Arome
Alaro

METEO FRANCE

EXTREMES DT : A MAGNIFYING GLASS ON EXTREME WEATHER EVENTS

Current weather forecasts

- ✓ Still limited resolution (~10 km global, 2.5km regional)
- ✓ Operational production of daily forecasts
- ✓ Fixed configurations, domains, outputs
- ✓ Separation of Earth System Models and impact sector models

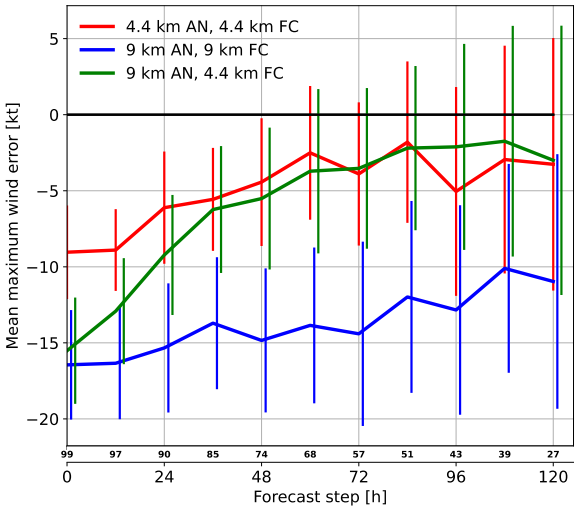
Extremes DT

- ✓ 4.5 km resolution globally; 500 - 750 m regional
- ✓ Operational capability to run simulations both regularly and on-demand for past, present and future extreme events
- ✓ Flexible configurations, domain, outputs allowing to respond to evolving extreme events by triggering tailored simulations
- ✓ Bringing Earth System Models and impact sector models within the same workflow

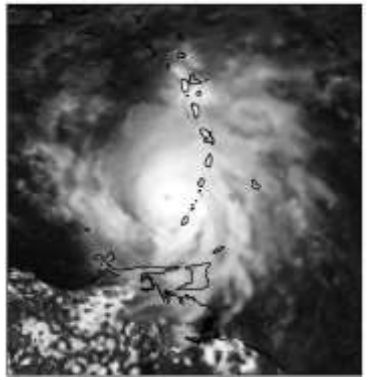
EXTREMES DT

See Extremes DT session

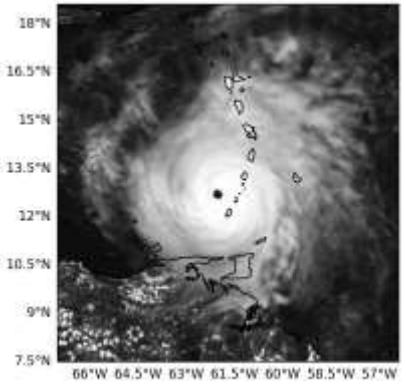
Global



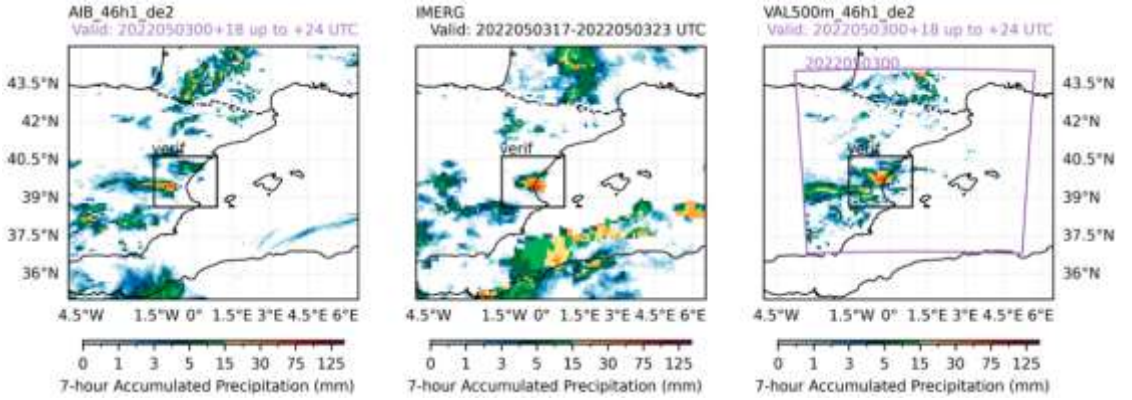
9 km



4.5 km



On-demand



2.5 km | obs | 500 m

DTS AND DTE: PHASE 1 DELIVERY

- ✓ Set up Digital Twins workflows on EuroHPC platforms
- ✓ Demonstrated DTs initial capabilities, data access and handling

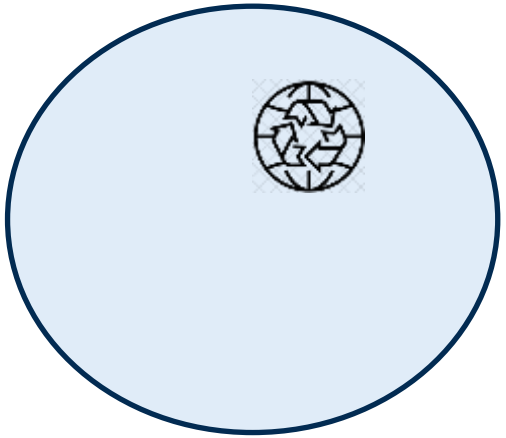
WHAT'S NEXT?

- ✓ Towards operationalisation of digital twins and digital twin engine
- ✓ Models, workflows, data handling upgrades
- ✓ AI models and AI software-layer

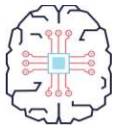
BUILDING AN AI EARTH SYSTEM MODEL

EXPANDING TOWARDS AN EARTH-SYSTEM AI MODEL WITH DESTINE

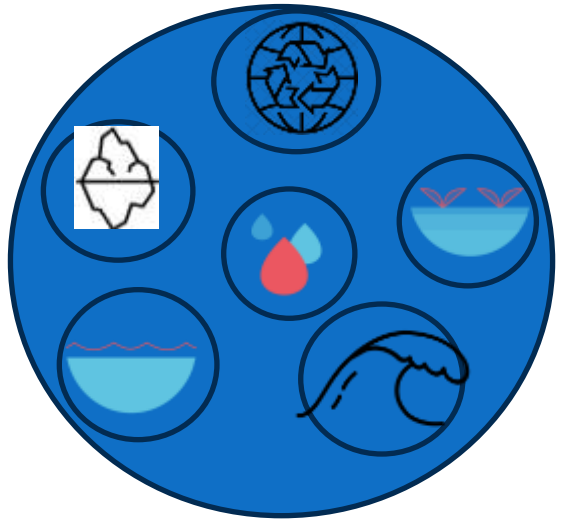
Atmospheric component



Forecasting the weather (ECMWF's AIFS)

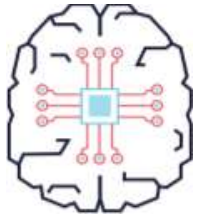


Adding land, wave, ocean, sea-ice, hydrology

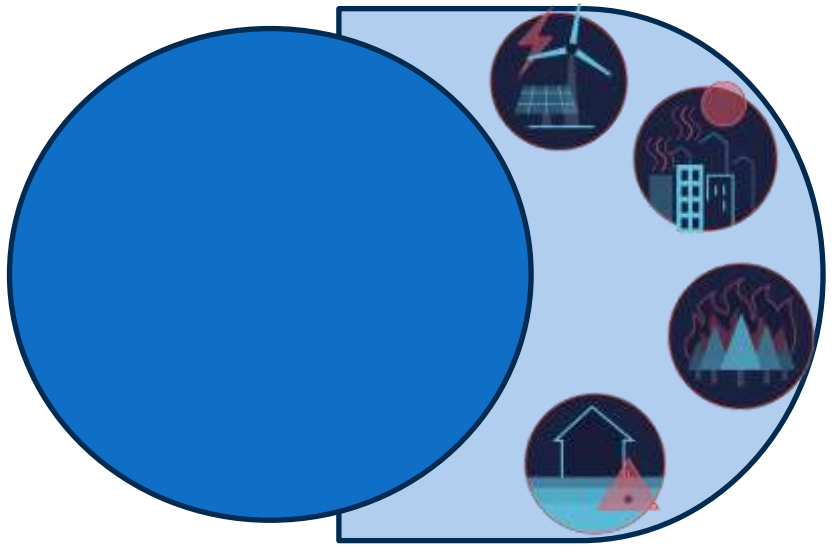


For weather extremes

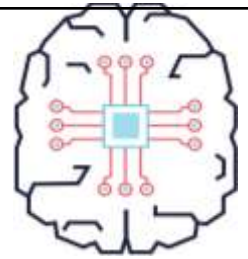
For Climate projections



Adding impact sectors

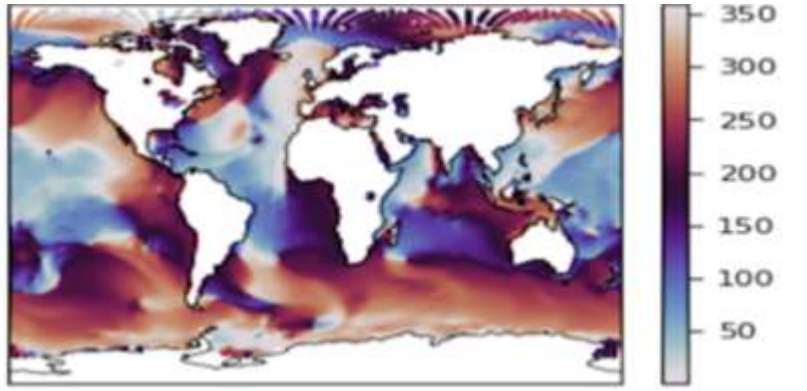


Demonstrators for impact sectors.

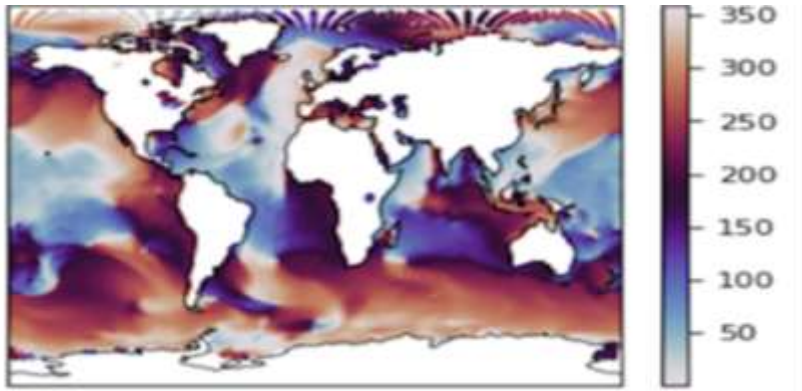


FIRST EXCITING RESULTS

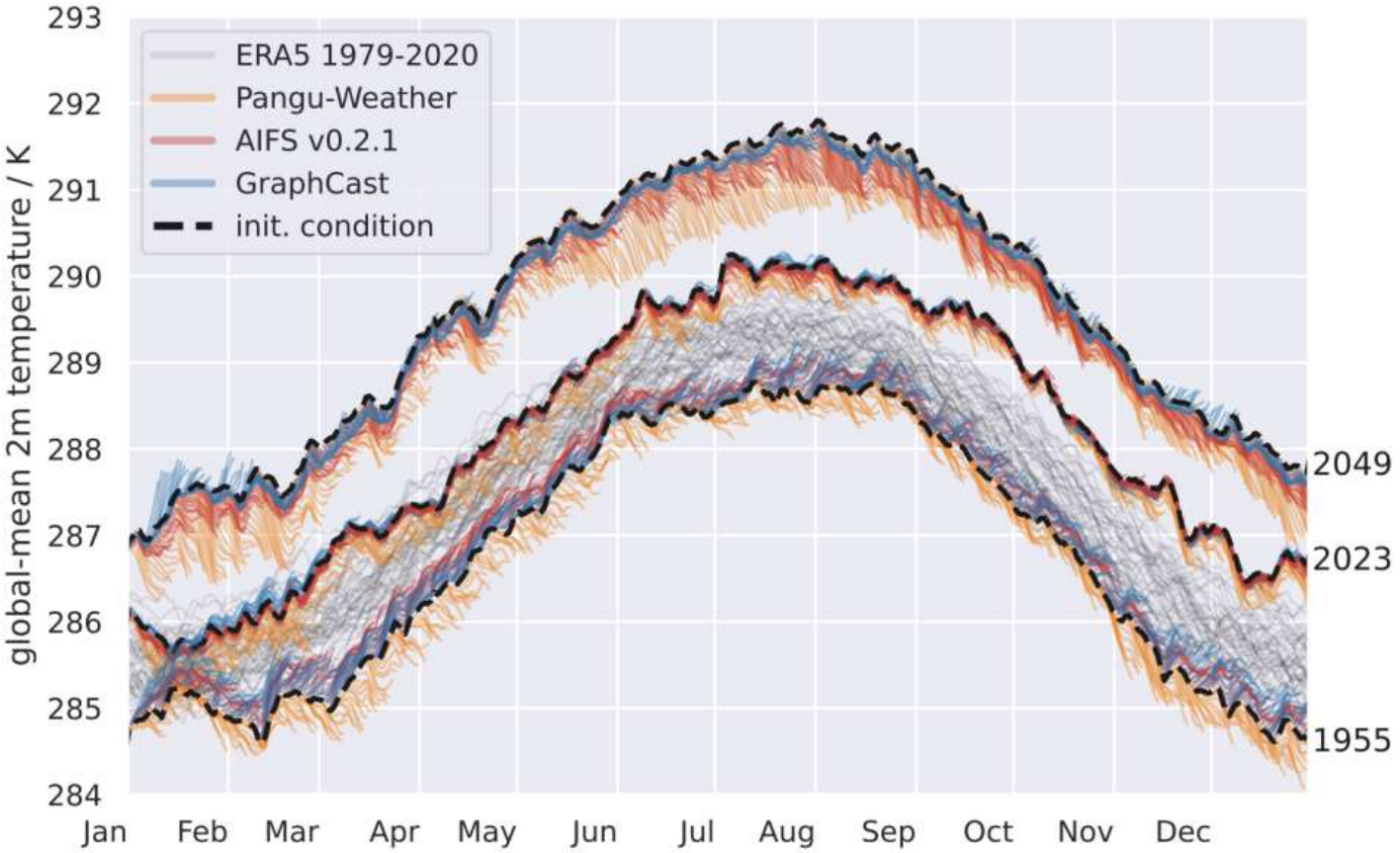
Physical wave model



Prototype ML wave model

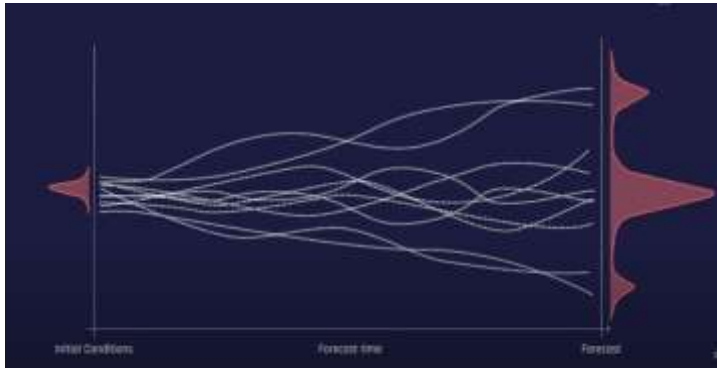


AI forecasts in a warmer world



EXPLOTING AI IN DESTINE

Quantify uncertainty



Around DestinE simulations and overcome high computational costs.

Forecast in a box

To augment DestinE's interactive features.

LLM - Chatbots

To enhance the access to complex information.

DESTINE DIGITAL TWINS AND DIGITAL TWIN ENGINE

- ✓ Offer a capability to test scenarios and what-if questions
- ✓ Provide detailed earth-system and impact-sector relevant information regularly and on-demand
- ✓ Provide the software solutions and services to access, handle and tailor the digital twin data
- ✓ The digital twin data feeds the next generation of AI models and applications
- ✓ Enable easy exploitation of this data through its AI-enabled software layer