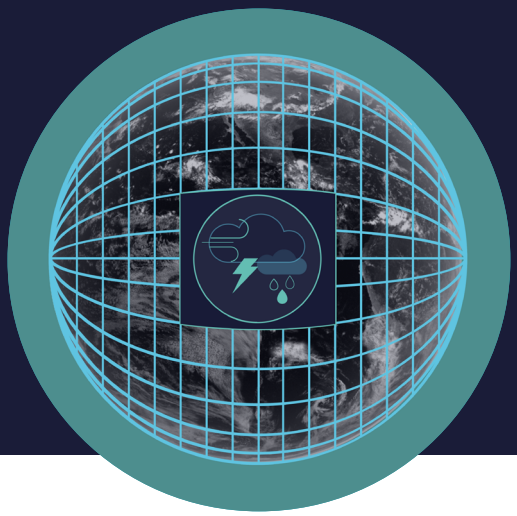
ECMWF - DestinE factsheets

DIGITAL TWIN FOR WEATHER-INDUCED EXTREMES



Sharpening our vision of extreme weather and its impacts

KEY FEATURES

Km-scale Earth system models

Uses "km-scale" models to better represent extreme weather events and deliver information at scales where their impacts are felt.

Routine production of global simulations

Produces global simulations at 4.4 km resolution for 4 days ahead to predict extreme weather events worldwide.

On-Demand refinement over Europe

Produces on-demand regional simulations at 750 to 500 m resolution for 2 days ahead to refine the representation of extreme events occurring over Europe.

From weather to impact-sector information

Integrates impact sector models in the Digital Twin workflows, to transform meteorological data into user-relevant information.

The Digital Twin for Weather-Induced Extremes (Extremes DT) supports decision-making in response to meteorological, hydrological and air quality extremes. **It has both a global component, producing simulations at resolutions of a few kilometres for four days ahead, and a regional component, producing simulations at hundreds of metres for two days ahead. Later in Phase 2, it will become possible to configure and activate on demand this regional component, providing a magnifying glass on extreme events occurring in Europe.**

INNOVATIVE DEVELOPMENTS

- Regular use of km-scale models exploiting pre-exascale EuroHPC supercomputers
- On-demand workflows for bespoke global and flexible regional simulations of past, current or future extreme events
- An automated detection and activation mechanism for selected extreme events
- AI-supported uncertainty quantification and interactivity.

Harnessing the latest developments in:

Earth System Prediction
Building on decades of expertise in operational Numerical Weather Prediction and impact modelling.

Supercomputers
Adapting to and exploiting distributed (pre-) exascale EuroHPC computing resources across Europe.

Artificial Intelligence
Exploiting recent breakthroughs in AI for weather and climate sciences.

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CONCEPTS INFO-BOX

Model Resolution

The resolution of a model refers to the size of each grid box. When increasing the resolution, the grid boxes become smaller, allowing for more detailed calculations to be performed. The high-resolution models of the Extremes DT allow for high-quality information at both global and regional levels.

Representing Small Scale Processes Explicitly

Many small-scale physical processes (smaller than one grid box) are normally "parameterized", meaning that they are not explicitly represented. With the km and sub-km scale resolutions, some key processes become explicitly represented. Improving their representation is a key element for a better prediction of expected extreme events in a changing climate.

Quantifying Uncertainty

Uncertainty in predictions arises from initial conditions and model approximations. This is addressed with "ensemble predictions", which represent different possible outcomes. This solution is computationally expensive at high resolution, so two alternative strategies are explored: using physical models for "smaller ensembles" and exploiting AI-based models.

Impact Sector Models

A set of models and indicators are integrated in the Extremes DT workflow to translate specific weather data into user-relevant indicators for key sectors such as renewable energies, water management, or agriculture.

Extreme Weather Detection/Triggering

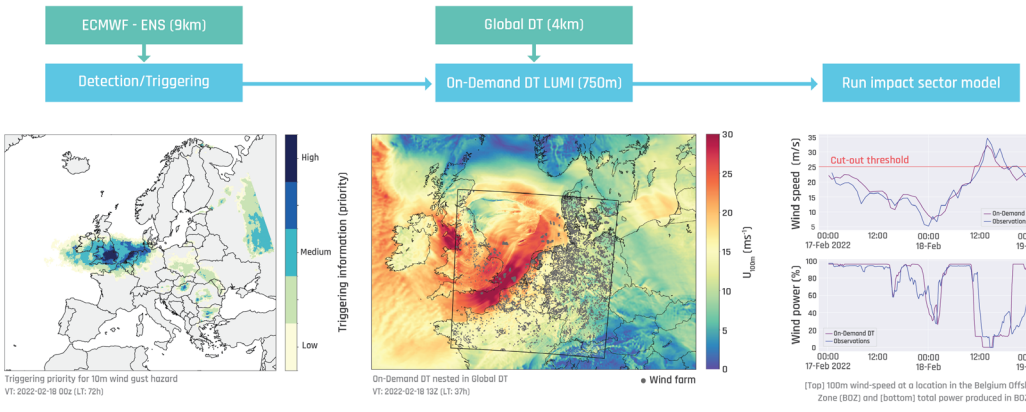
A mechanism was built to detect extreme weather events, including strong winds, heavy rain, and thunderstorms. It uses the ECMWF forecasts and the global component of the Extremes DT to evaluate the likelihood of these events. It then feeds this information into the triggering procedure that activates the regional component.

EuroHPC Supercomputers

The Extremes DT high-resolution simulations are possible thanks to the new generation of (pre-exascale) supercomputers in Europe. An agreement with the EuroHPC JU provides DestinE access to some of the most advanced supercomputers in the world.

DELIVERING SECTORAL INFORMATION FOR EXTREME WEATHER EVENTS

Hereunder an example of a workflow answering the question: **"How much wind energy production can we expect during a windstorm?"**



The extreme event detection algorithm identified a windstorm for February 18, 2022. In response, a regional model was configured with a 750-metre resolution off the coast of Belgium and driven by the global component of the Extremes DT. This model provided high-frequency wind data, which was utilized by a wind farm parameterization. The system successfully predicted a drop in energy production due to the shutdown of the wind farms, two days in advance.

EXTREMES DIGITAL TWIN CONSORTIUM

The **global component is delivered by ECMWF.** The **regional component** is delivered by a consortium of **29 partners** led by **Météo-France** through a contract procured by ECMWF.

France	Météo-France	**Latvia**	LEGMC	**Ireland**	Met Éireann	**Croatia**	DHMZ	**Belgium**	KMI-IRM	**Slovakia**	SHMU
	INRAE	**Slovenia**	ARSO	**Spain**	AEMET	**Iceland**	IMO	**Austria**	GeoSphere Austria	**Poland**	IMGW
	CNRS	**Portugal**	IPMA		BSC	**Netherlands**	KNMI	**Finland**	FMI	**Italy**	CINECA
Norway	Met Norway	**Estonia**	TalTech	**Czech**			RIVM		CSC	**Germany**	DLR
Denmark	DMI	**Bulgaria**	NIMH	**Republic**	CHMI	**Hungary**	HungaroMet	**Sweden**	SMHI	**Romania**	NMA

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