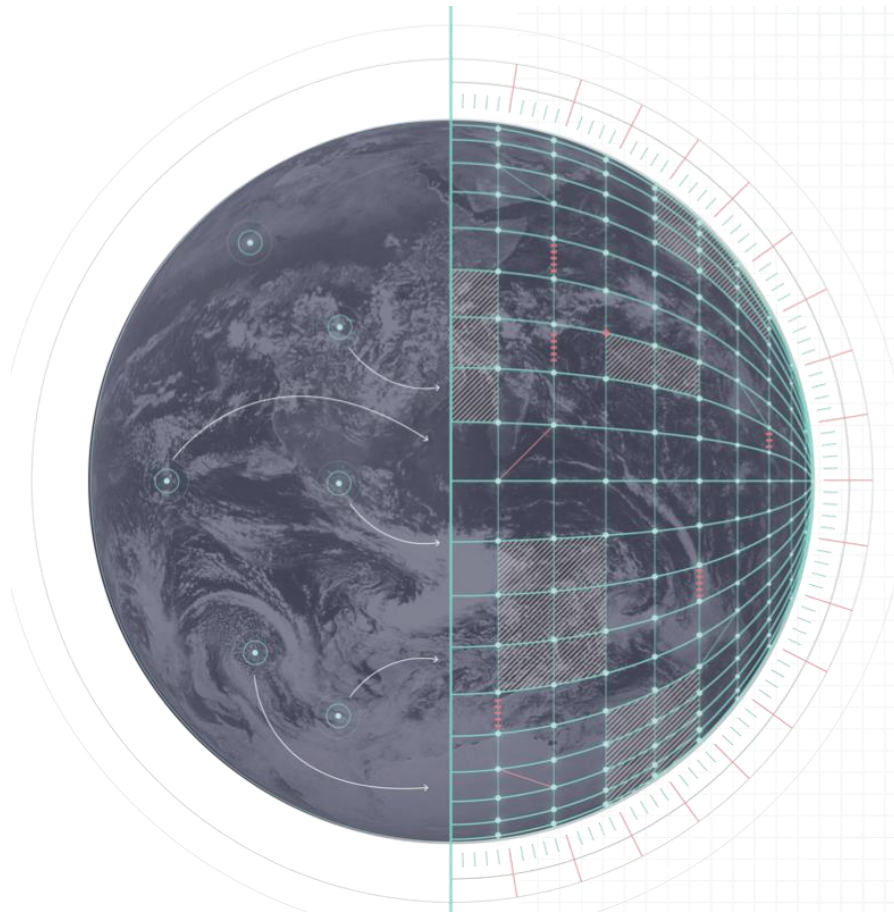


DESTINATION EARTH

The On-Demand Extremes DT and wind energy

Geert Smet, Evgeny Atlaskin, Anders Lindfors,
Florian Meier, Natalie Theeuwes,
Joris Van den Bergh



Second Destination Earth User eXchange, 13-14 November 2023, Bonn, Germany



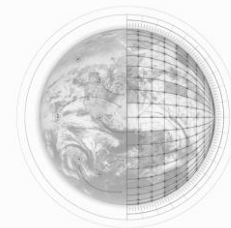
Funded by
the European Union

Destination Earth

implemented by



Outline



- Storm Forecast Tool for Elia (TSO, Belgium)
- On-Demand Extremes Digital Twin and Wind Energy
 - Added value
- Challenges and Questions

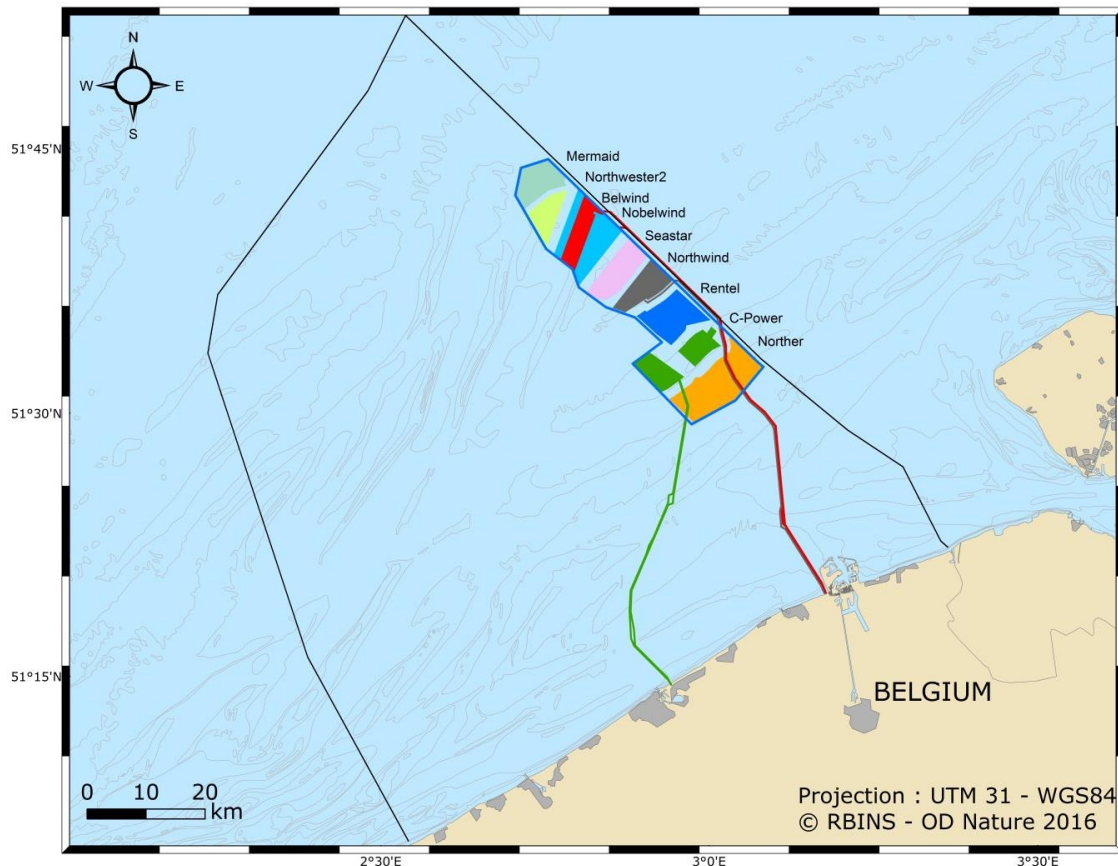
Belgian offshore wind farms
(source: MUMM)

Wind farms in all 9 domain concessions fully operational since end of 2020. Total installed capacity of 2.262 GW, which will produce an average 8 TWh annually.

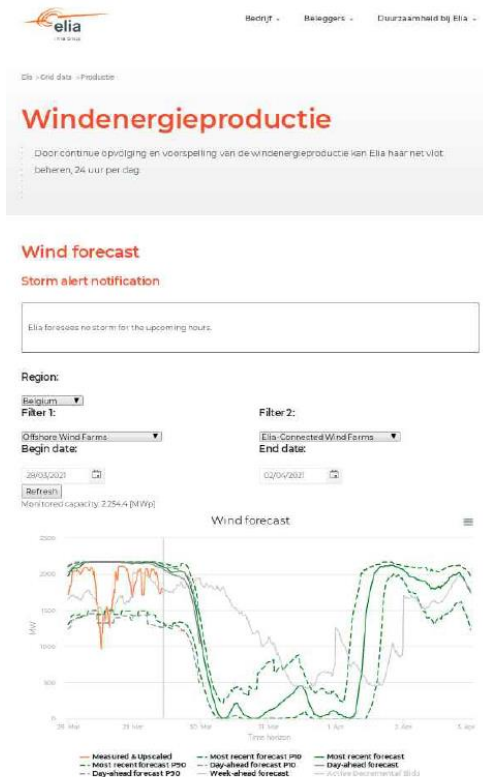
- electricity consumption of 2 million families,
- 10 % of Belgian electricity consumption.

(source: Belgian Offshore Platform)

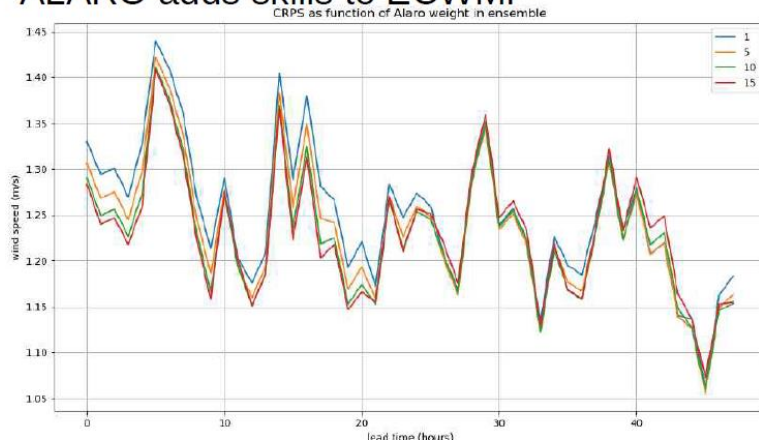
PROBLEM (for TSO): windstorms (typically occurring from September to end of March) causing cut-out(s)



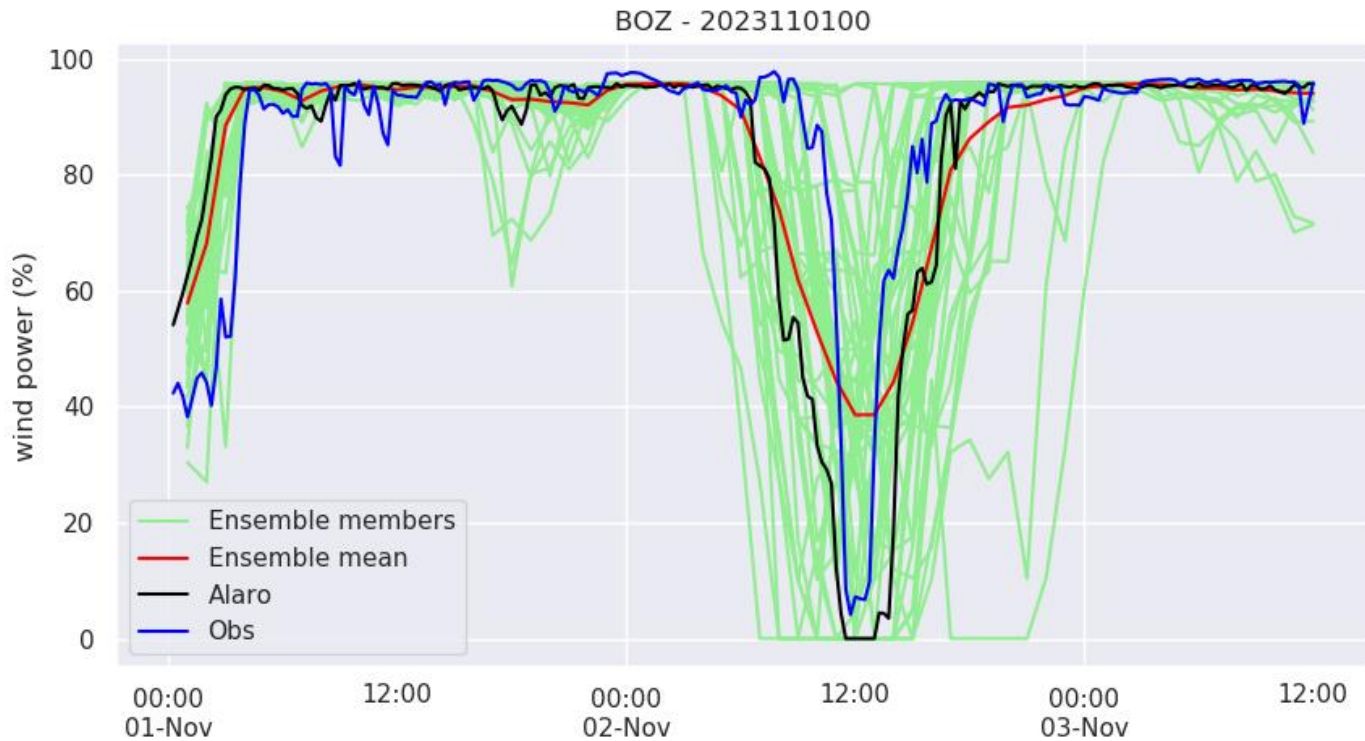
Elia Storm Forecast Tool



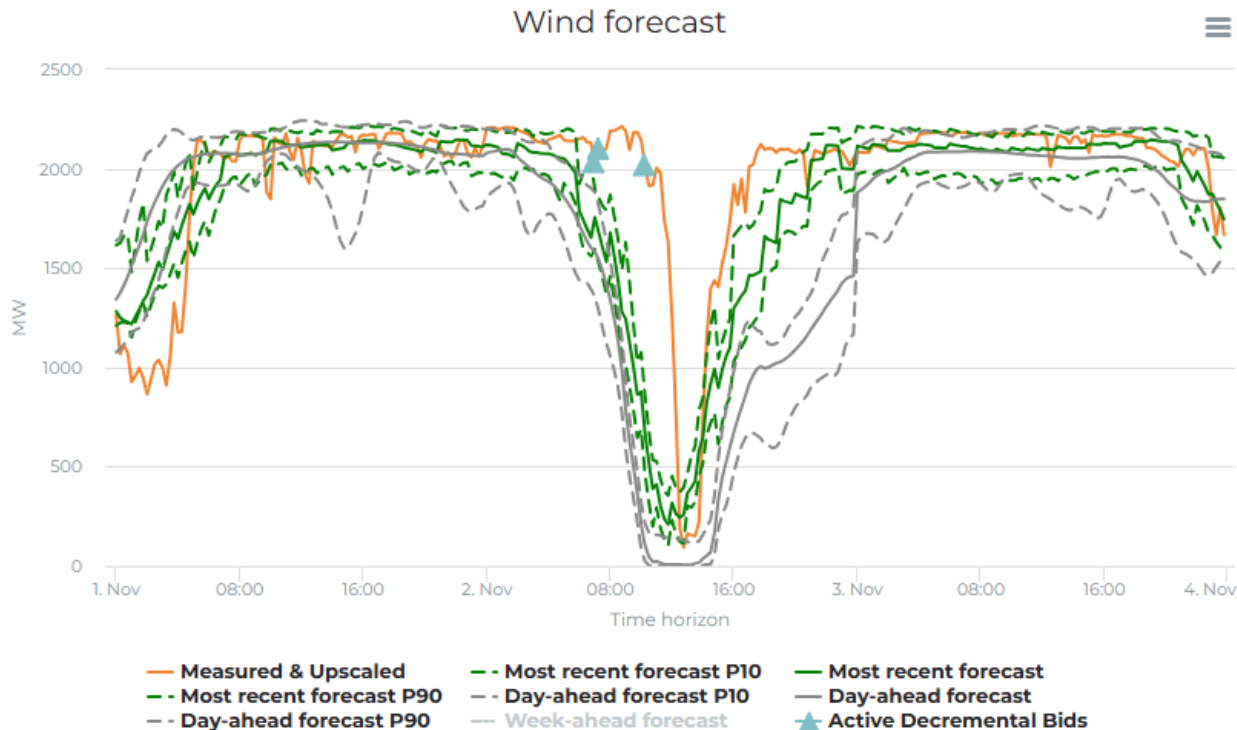
- 🕒 Production of wind farms in the North Sea
- 🕒 Predict Cut-out events (between 25 m/s and 30 m/s) transmission system operator Elia
- 🕒 ALARO (4km) wind speed (15min) at turbine height
- 🕒 ECMWF EPS (18km) wind speed (1h) at 100m
- 🕒 ALARO adds skills to ECWMF



Storm Ciarán (2 November 2023)



Storm Ciarán (2 November 2023)

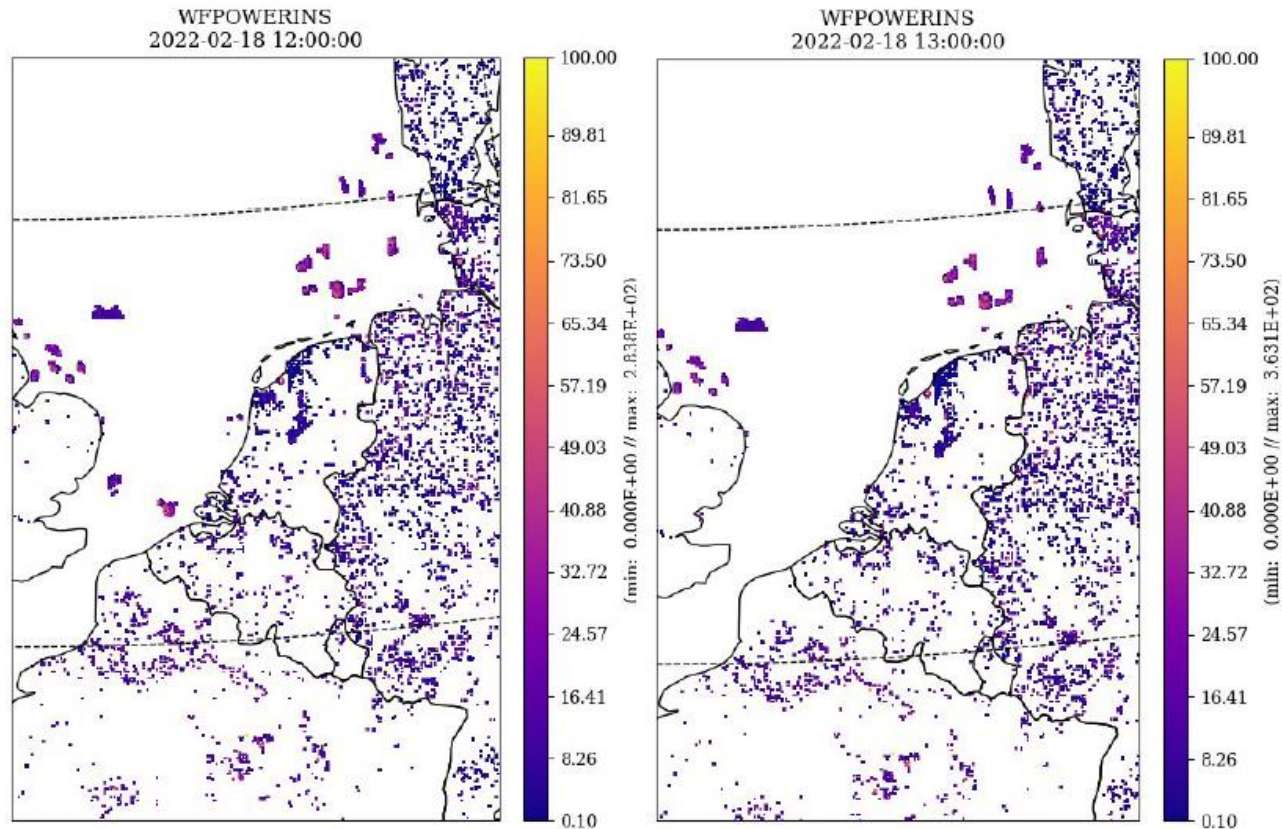


<https://www.elia.be/nl/grid-data/productie/windenergieproductie>

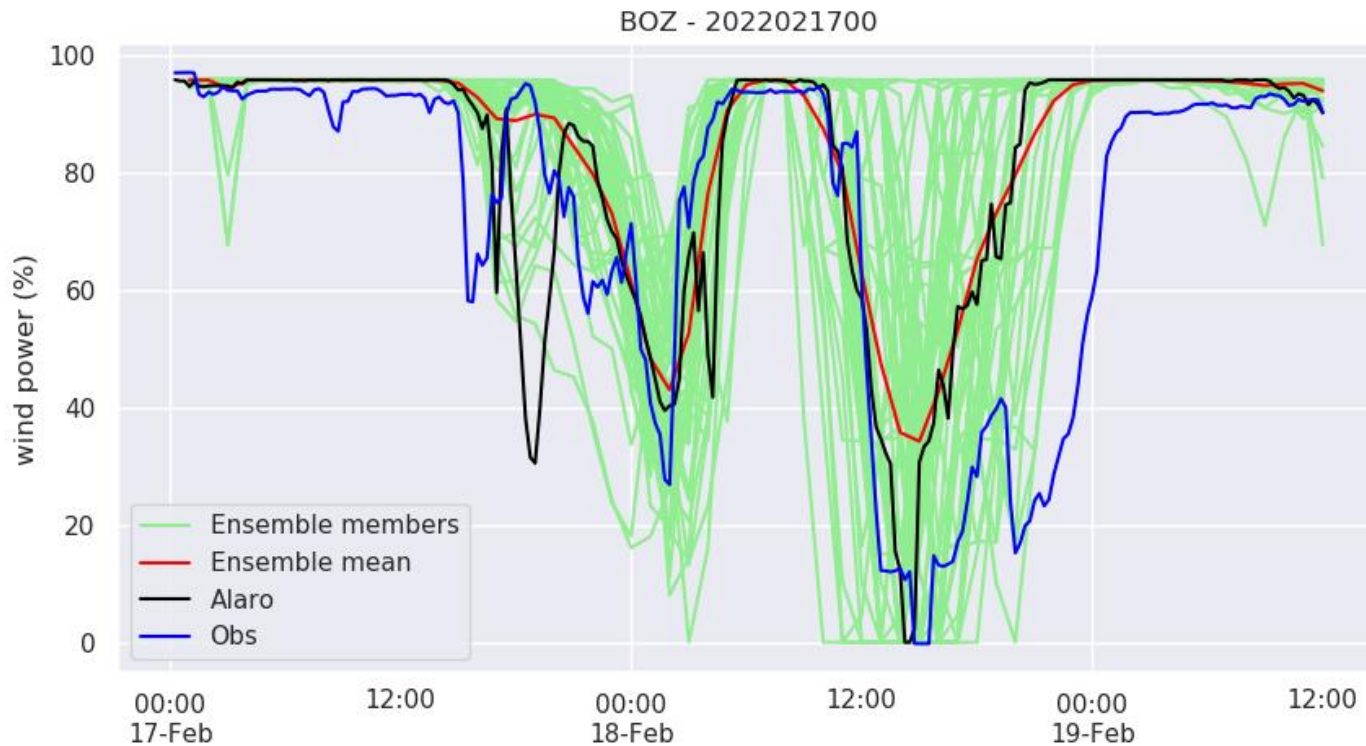
The On-Demand Extremes DT and wind energy

Reference runs at 2.5 km with HARMONIE-AROME (includes a wind farm parameterization following Fitch et al.)

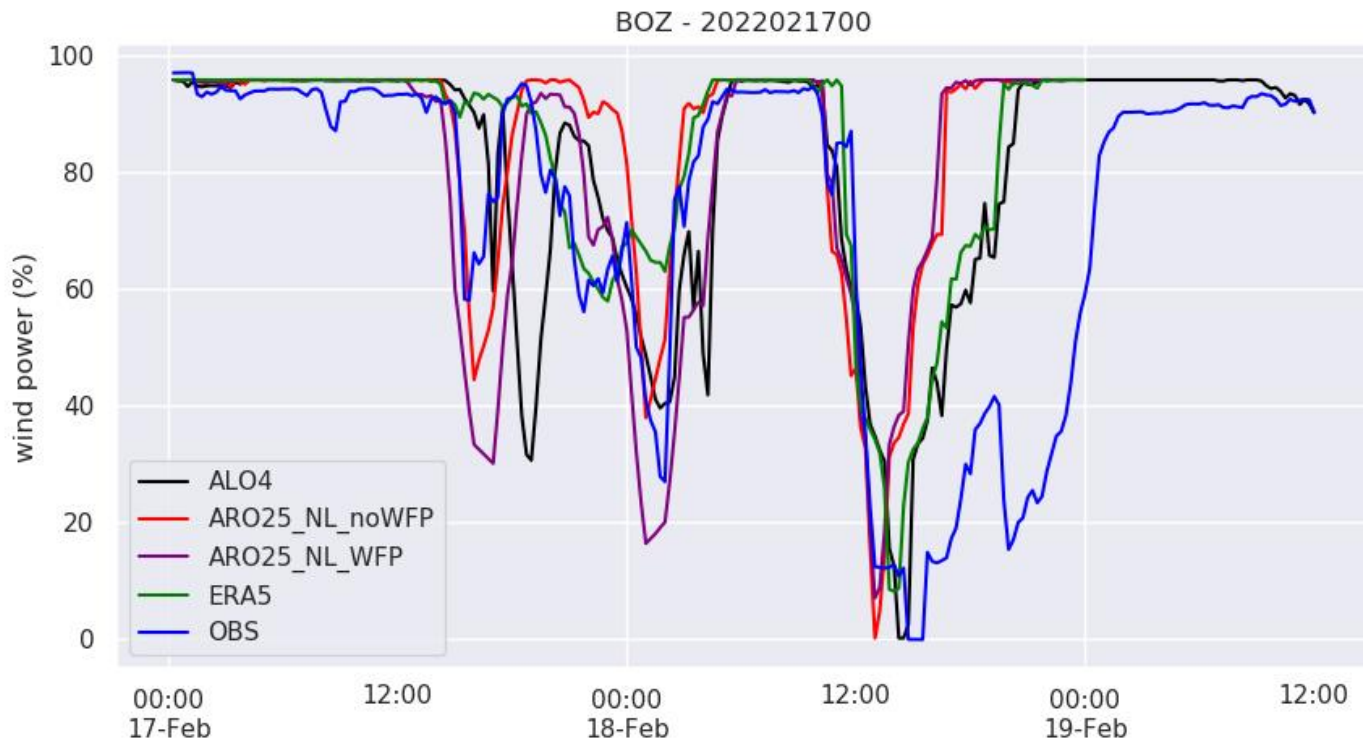
Cut-out for Belgian (and neighbouring Dutch) wind farms during Eunice Storm on 18 February 2022



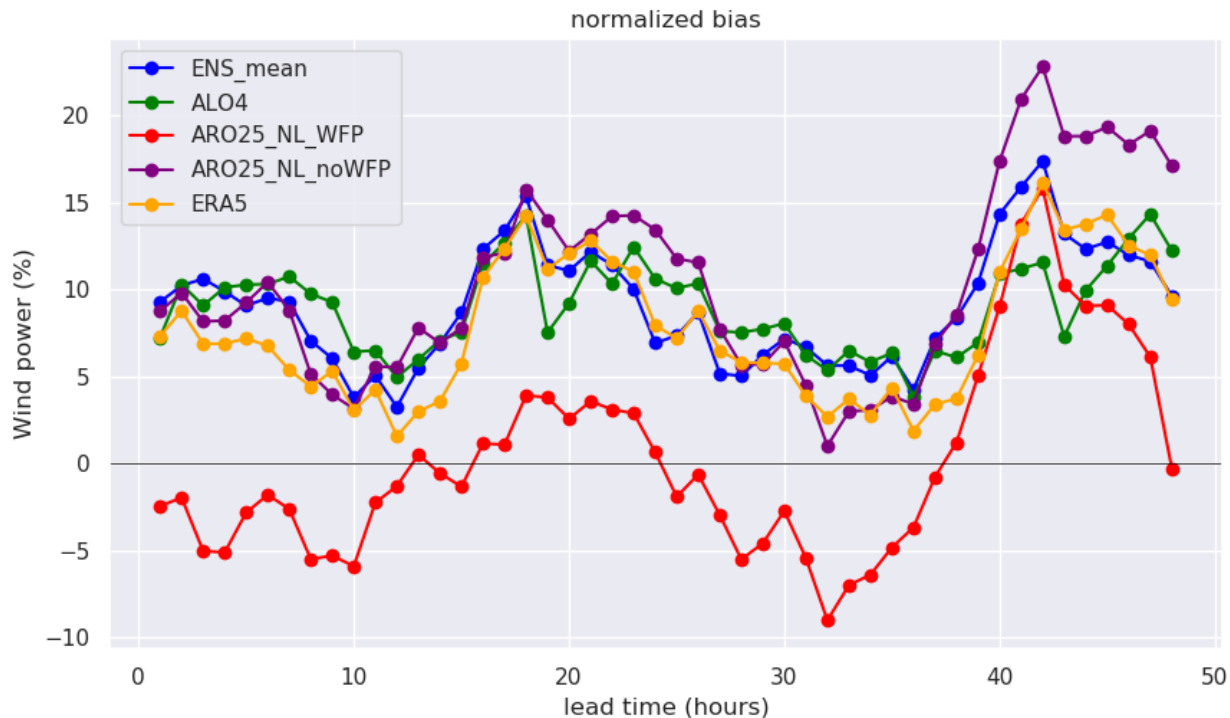
Storm Eunice (18 February 2022)



The On-Demand Extremes DT and wind energy (Storm Eunice)



The On-Demand Extremes DT and wind energy (Verification from 7 Feb 2022 until 25 Feb 2022)



The On-Demand Extremes DT and wind energy (Experiments with sub-km simulations ongoing)

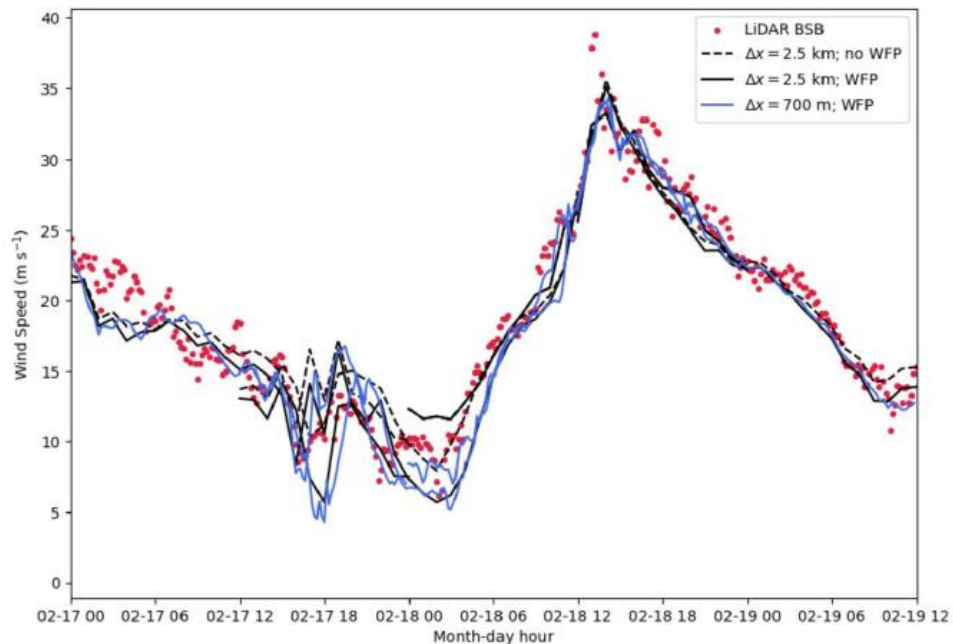


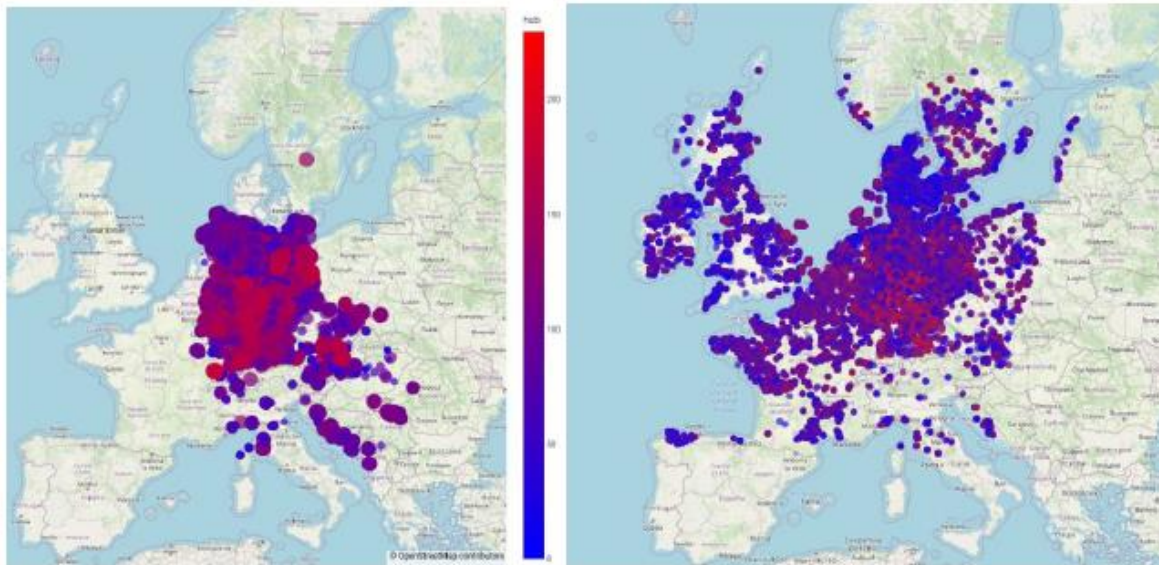
Figure : Wind speed at 100m at one of the Borssele wind lidars, the observations (red dots) and the 2.5 km NWP simulations (black), with (solid lines) and without (dashed lines) the WFP. The 750 m simulations (blue) use the wind farm parameterisation. The 24-hour forecasts initialised at 00 and 12 UTC are plotted.

The On-Demand Extremes DT and wind energy (Challenges and Questions)

Currently using two wind farm databases compiled by KNMI and GeoSphere Austria

Need turbine locations, heights, diameters, C_p and C_t curves for calculation of power production, wake effects, local impact on weather

Database at EU level?



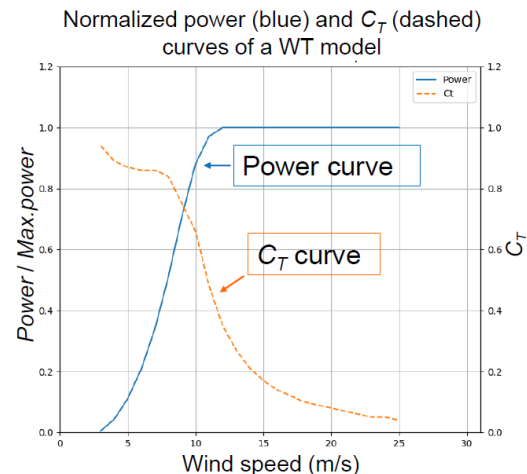
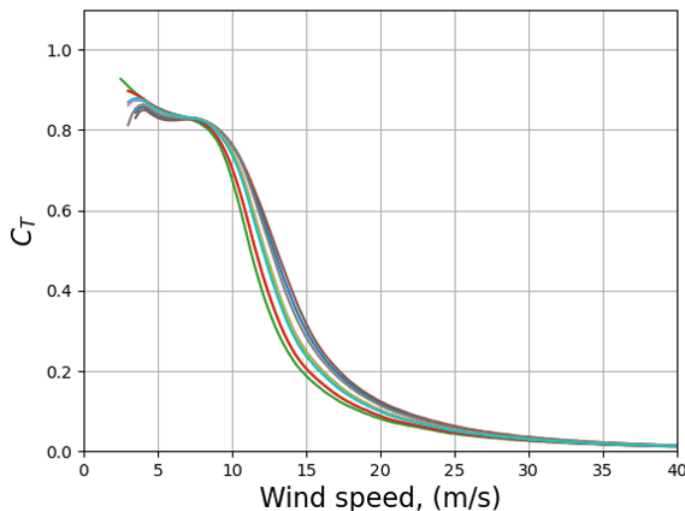
The On-Demand Extremes DT and wind energy (Challenges and Questions)

Often C_t -curves not available
(in open sources)

Approximation of C_t -curves based on a statistical model, employing general wind turbine specifications such as rotor diameter, nominal (rated) power, cut-in and cut-off wind speeds, etc., developed at FMI

The effect of storm control systems on (approximation of) C_t -curves in the Belgian Offshore Zone (BOZ) were not yet taken into account

C_T curves of wind turbines installed in BOZ

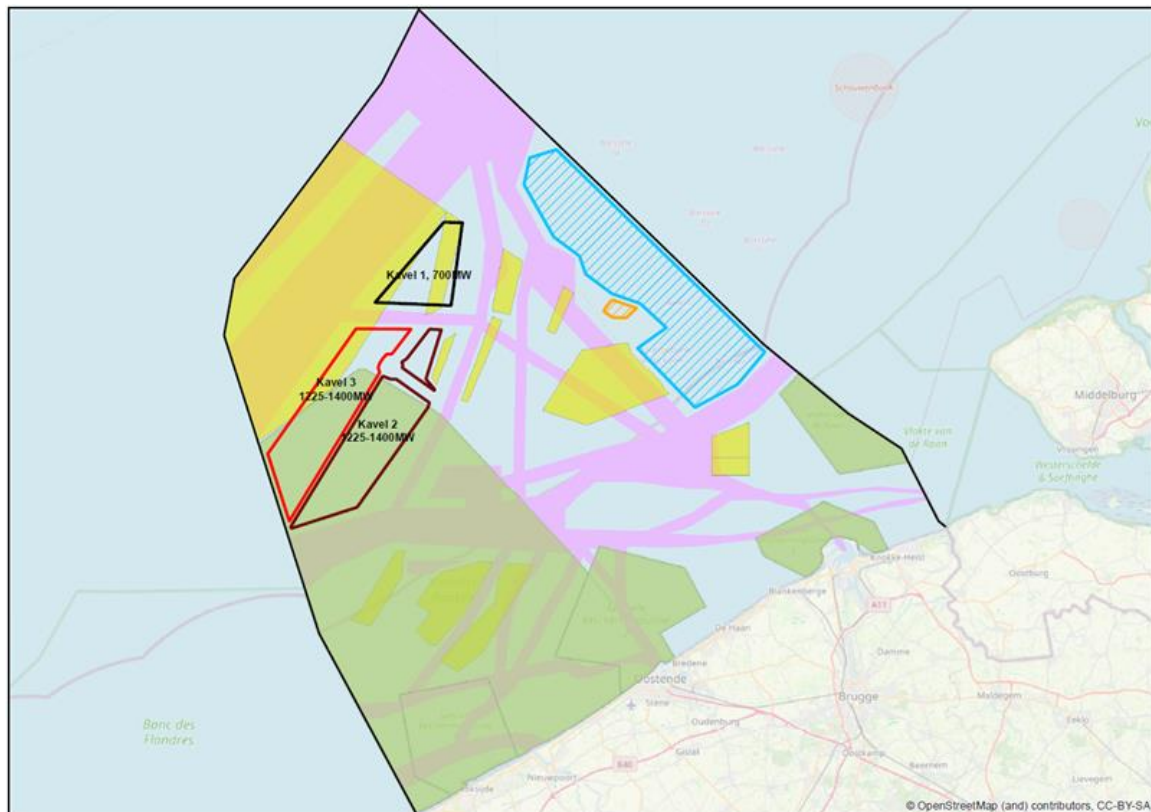


The On-Demand Extremes DT and wind energy (Challenges and Questions)

New to be developed Princess Elisabeth Zone will add up to 3.5 GW to current ~2.3 GW installed capacity (source FOD Economie):

- Kavel 1 (2024-2028): 700 MW
- Kavel 2/3 (2026-2030): 1225-1400 MW each

Forecasting and triggering (by users) for ramping events?

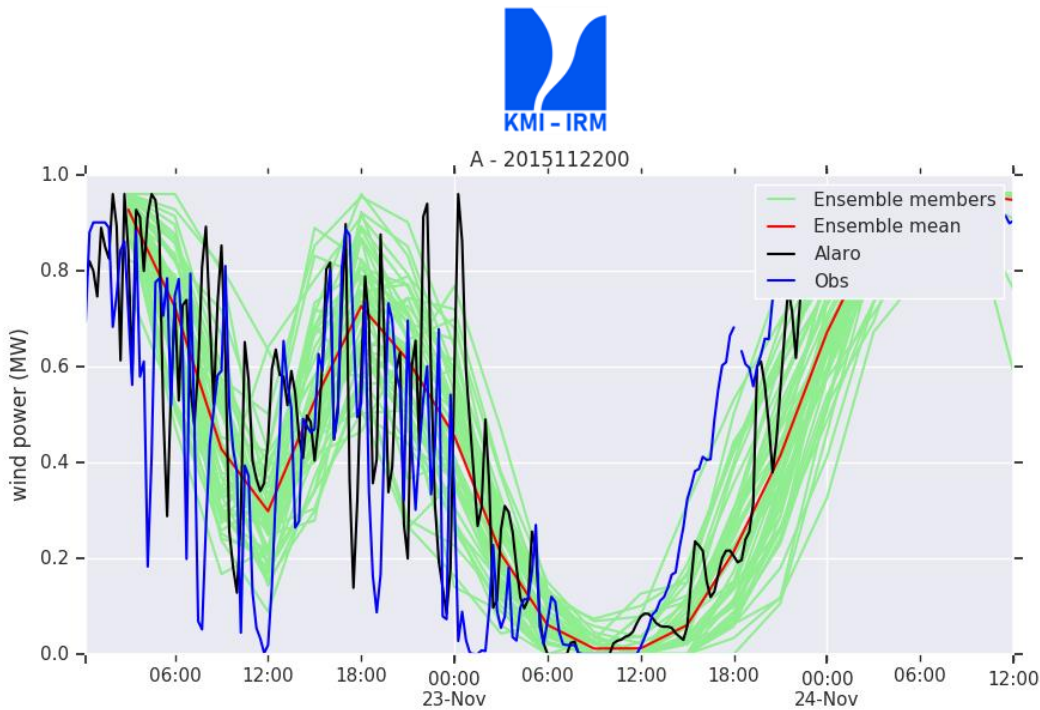


The On-Demand Extremes DT and wind energy (Challenges and Questions)

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The On-Demand Extremes DT and wind energy (Challenges and Questions)

Interested users for the On-Demand Extremes DT (and its wind energy impact model)?

- TSO, DSO, wind farm operators, electricity providers(/traders), energy service companies,...

What output variables needed?

- Wind speed and power, P10/P90, 15min/30min power gradients, cut-out probability, storm alert, ramping probability, max ramp over a certain period, ...

What output frequency needed?

- 15min?

Combining information (e.g. coming from global DT or local forecasts)?

- to calculate P10/P90, or for triggering, etc?

Need wind energy production data for

- Bias correction (or postprocessing) of power forecasts
- Uncertainty quantification (P10/P90)
- Verification