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Koninklijk Meteorologisch Instituut

Institut Royal Météorologique

Königliches Meteorologisches Institut

Royal Meteorological Institute

Improving wind power forecasts in the Belgian North Sea

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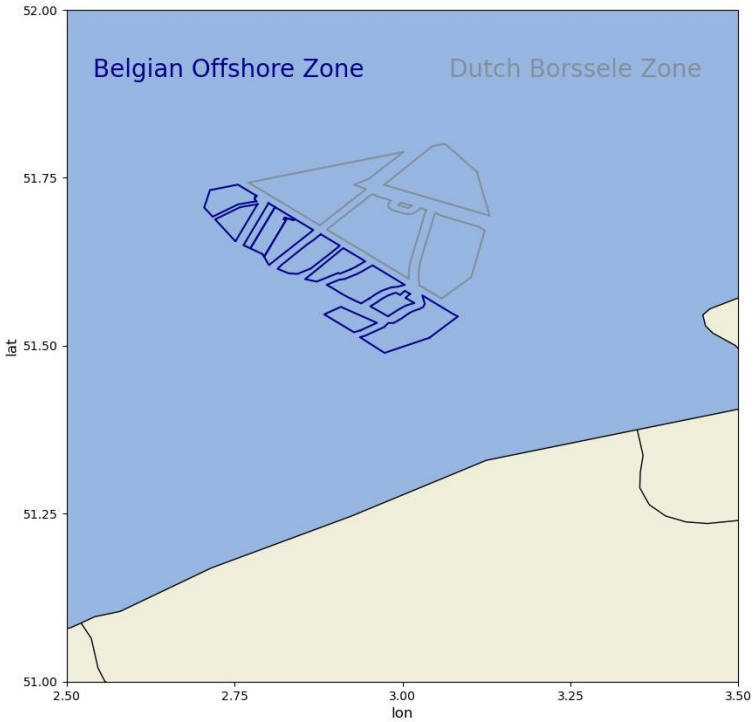
Offshore wind energy in Belgian North Sea



Belgian Offshore Zone (BOZ)

- Installed capacity of 2.3 GW
- On average 8 TWh/year
- 10% of total Belgian electricity demand

Princess Elizabeth Zone

- Planned capacity of 3.5 GW by 2030

RMI has various activities on wind power forecasting

- Elia Storm Forecast Tool

  Operational service to the Transmission System Operator of the Belgian high voltage electricity grid
- BeFORECAST

  www.beforecast.eu
- E-TREND

  www.belspo.be/belspo/brain2-be/projects/E-TREND_N.pdf
- DE_330_MF WP8

  meetingorganizer.copernicus.org/EGU23/EGU23-6122.html

  The-On-Demand-Extremes-DT-and-wind-energy.pdf

The BeFORECAST project

BeFORECAST

economie
FOD Economie, K.M.O., Middenstand en Energie

von KARMAN INSTITUTE FOR FLUID DYNAMICS

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SABCA

- Investigates the forecasting of offshore wind power in the Belgian North Sea including the **effect of** wind turbine and wind farm **wakes**.
- Advanced data handling and the assimilation of measurements in now- and forecasting tools using machine learning on data from offshore SCADA, RADARS, LIDARS, and “fly-for-weather” drones.

The BeFORECAST project

BeFORECAST

economie
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RMI researches the improvement of wind power forecasts by:

- Correcting wind to power conversion through physical wake models as well as data driven AI models.
- **Including a wind farm parametrization (WFP) in its NWP models**
- Postprocessing using both statistical and machine learning techniques.

Fitch Wind Farm Parametrization

Wind turbine: sink of momentum, source of turbulence

$$M\frac{\partial \vec{V}}{\partial t} = -\frac{\rho}{2}C_{\mathrm{T}}|\vec{V}|\vec{V}A_{\mathrm{rotor}}$$

$$\frac{\partial\,\mathrm{TKE}}{\partial t} = \frac{\rho}{2}\left(C_{\mathrm{T}}-C_{\mathrm{P}}\right)|\vec{V}|^{3}A_{\mathrm{rotor}}$$

Include effect as physics parametrization in NWP model: WFP

Implemented in WRF
Fitch et al., Monthly Weather Review, (2012)

Implemented in HARMONIE-AROME by KNMI
van Stratum et al., Journal of Advances in Modeling Earth Systems, (2022)

We have ported the KNMI code to **ALARO** (and AROME).

Fitch WFP in ALARO (cy43)

1) SU0PHYS ← SUWINDFARM ← wind_turbine_*.tab

Turbine characteristics are loaded and collected per gridpoint.

KNMI
HARMONIE-AROME

2) APLPAR ← WINDFARM

Windfarm routine takes U,V and returns change in U-, V- and TKE-tendencies due to turbines, per gridpoint and vertical level. (TENDWF U/V/PTKE)

Specific to ALARO: after call to WINDFARM

a) U,V tendencies converted to fluxes by vertical integration

b) TTE is updated: TTE=TTE+TENDWFPTKE*Δt

c) Tendency/fluxes updated with contribution from wind turbines

(U,V, PTKE updated later in code through tendency/fluxes, as usual)

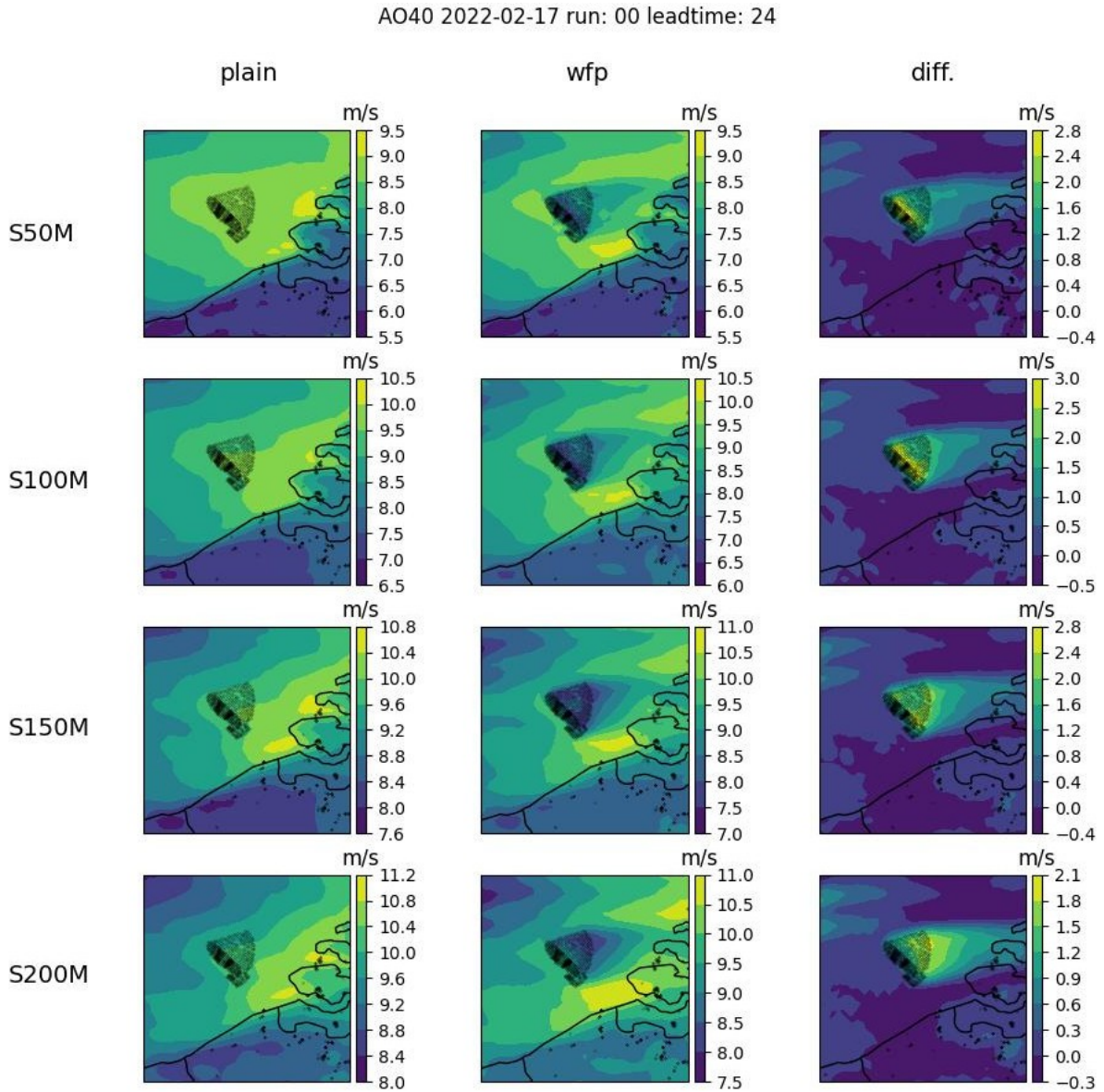
Validation (first results)

ALARO 4.0km & 1.3km

with and without WFP

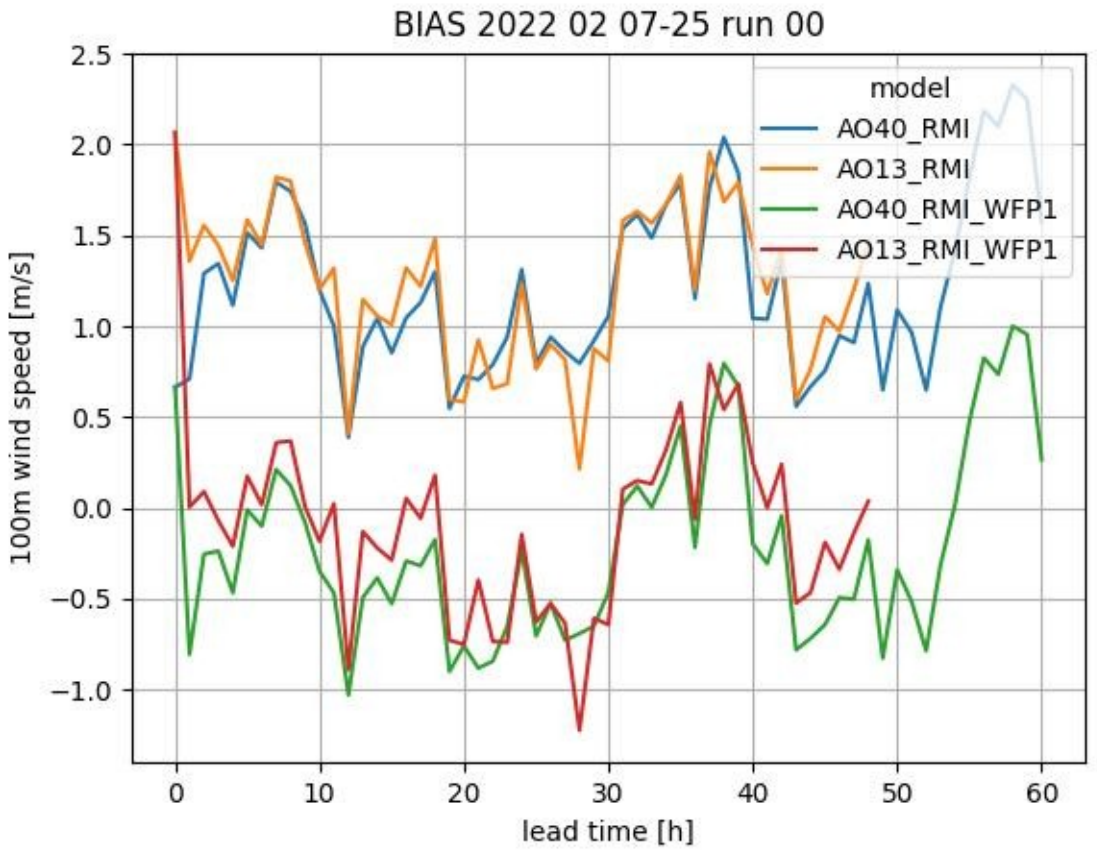
Validation period
2022 02 07-25

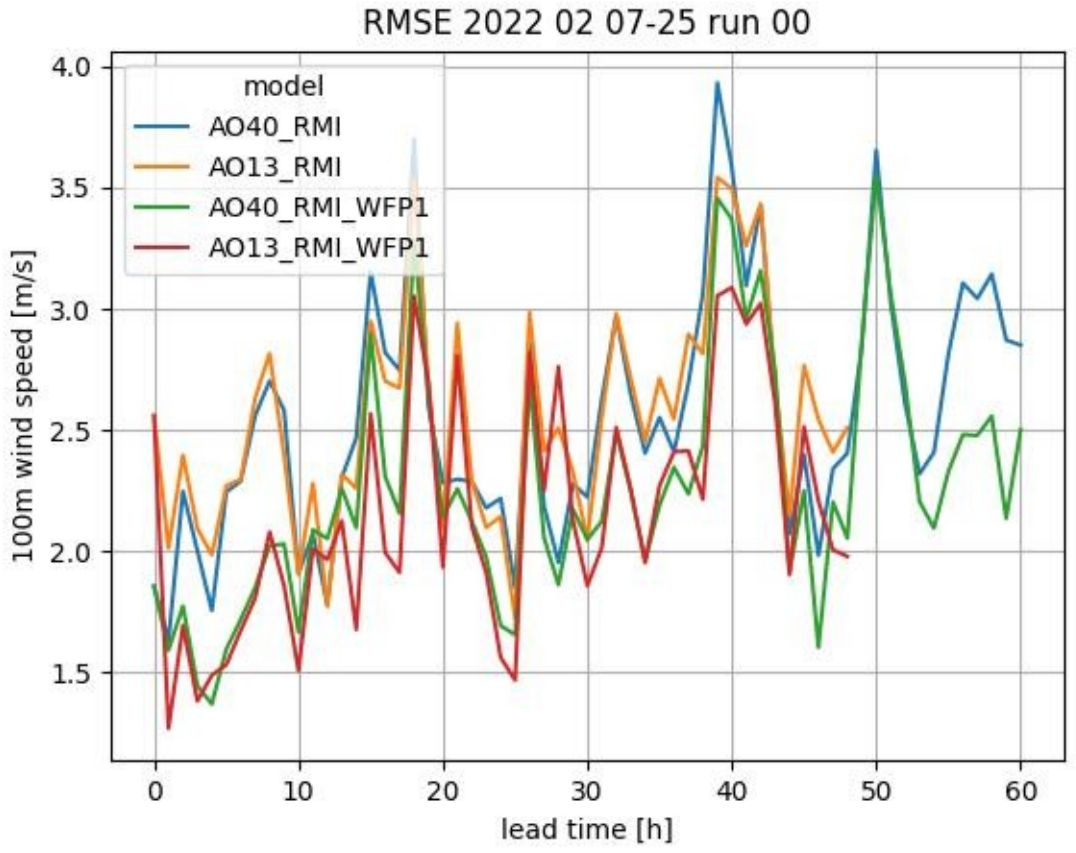
includes storm Eunice



Validation (first results)

100m wind speed as measured by two Lidars @ Borssele and Belgian wind farm

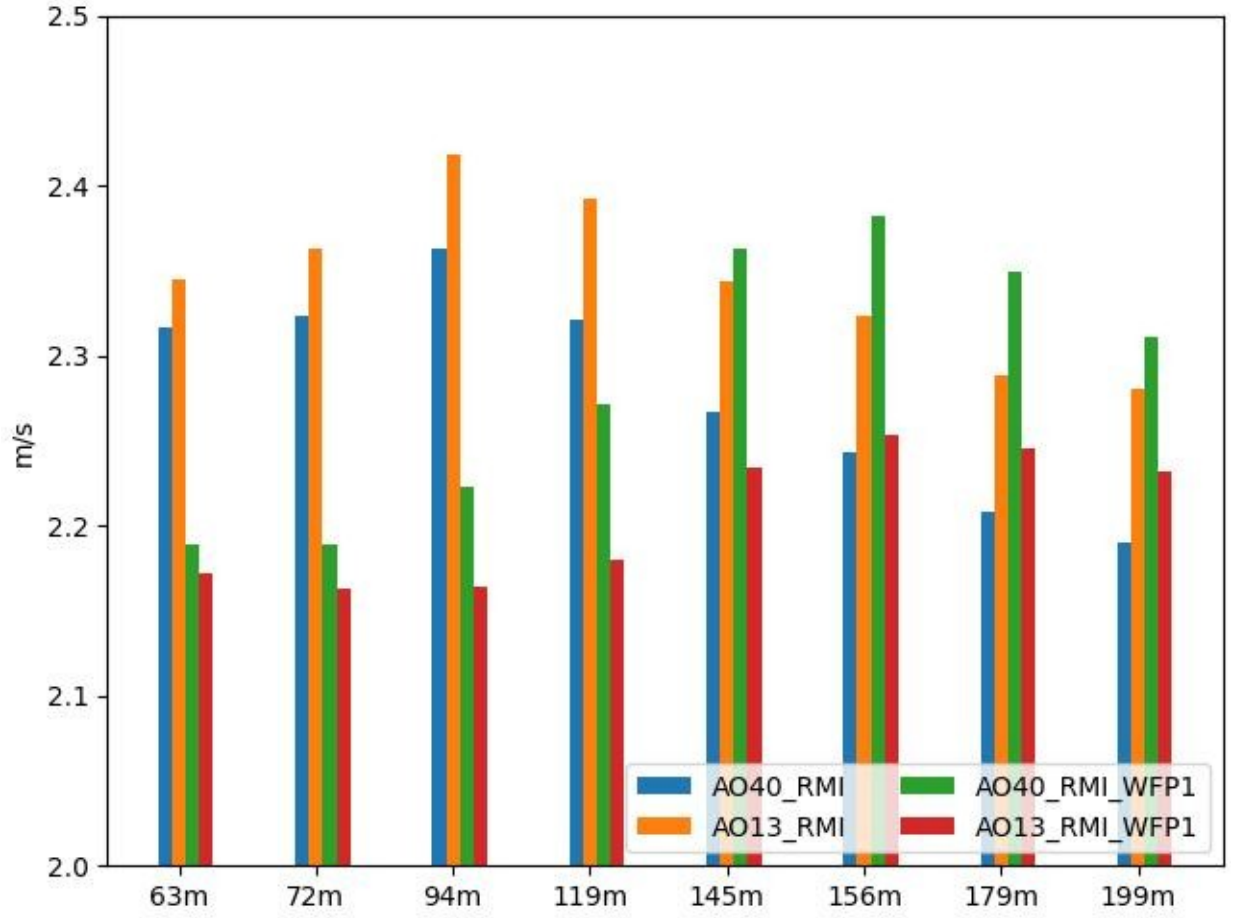




Validation (first results)

RMSE of wind speed forecast per height for Borssele Lidar

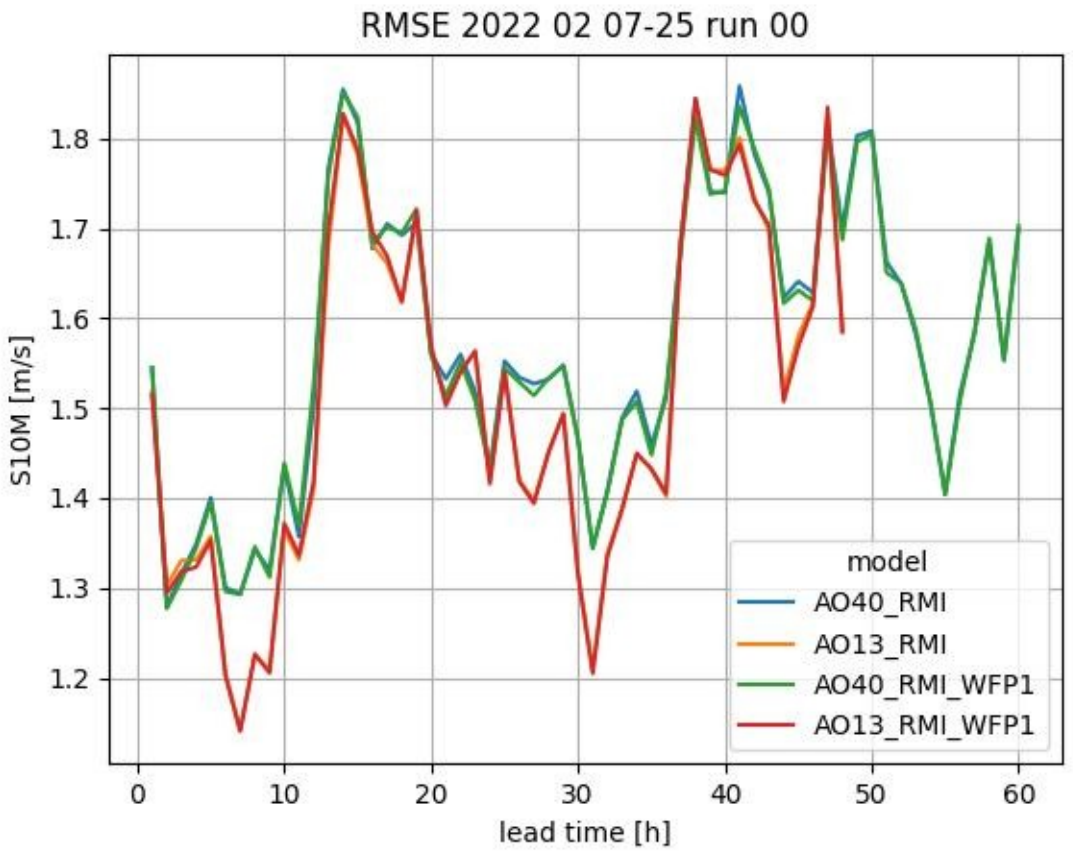
(00 run averaged over 48h lead times and whole verification period)

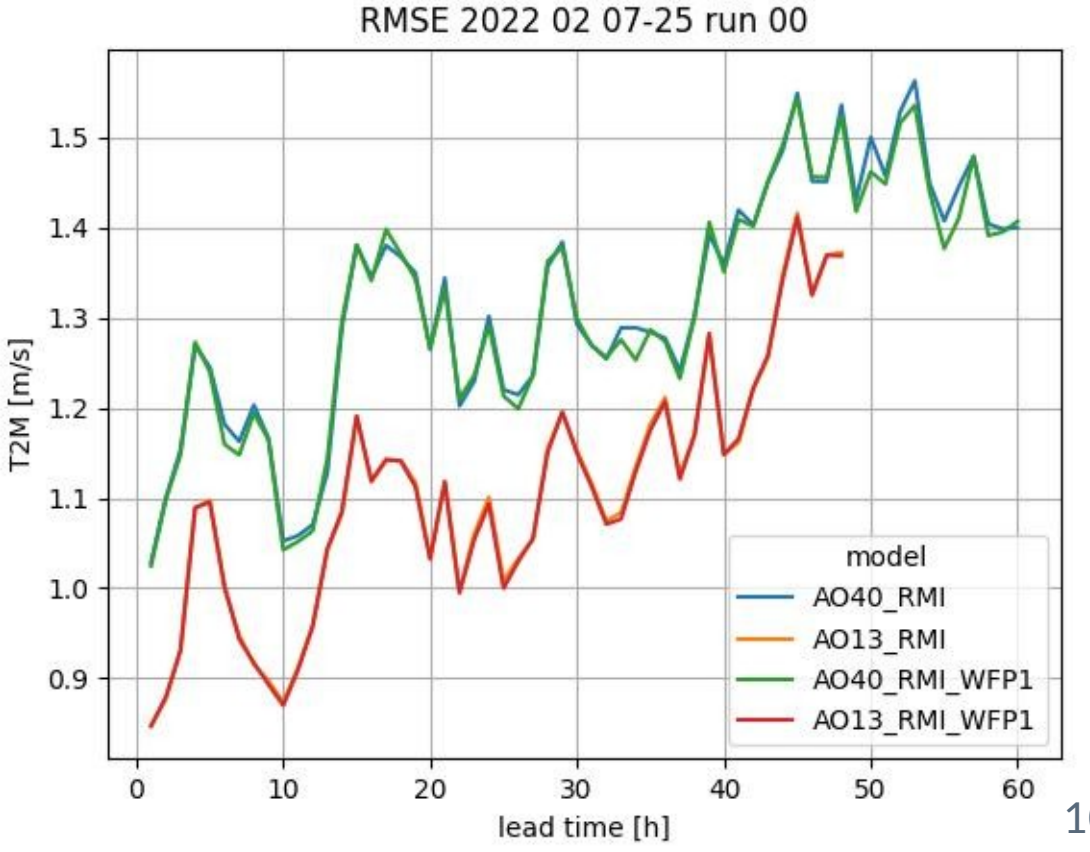


Validation (first results)

Away from wind farms WFP effects almost indistinguishable, keeping performance intact

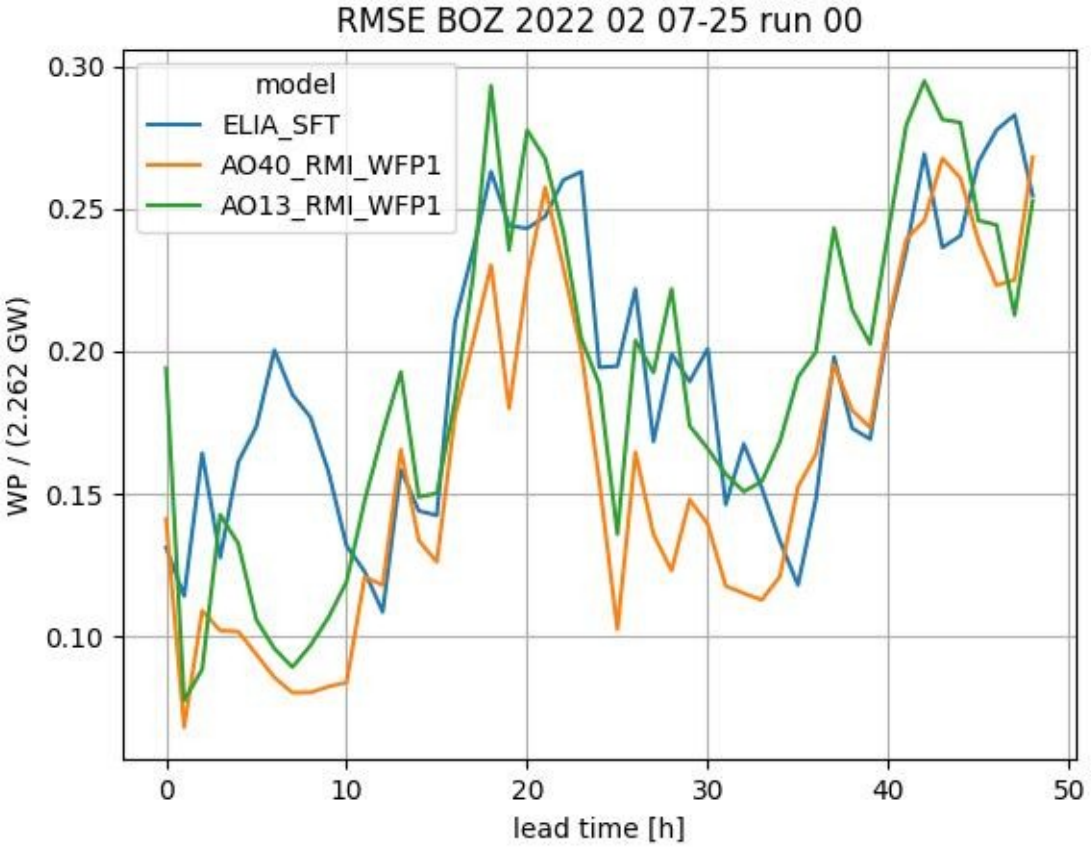
RMSE of forecast against 9 Belgian SYNOP stations

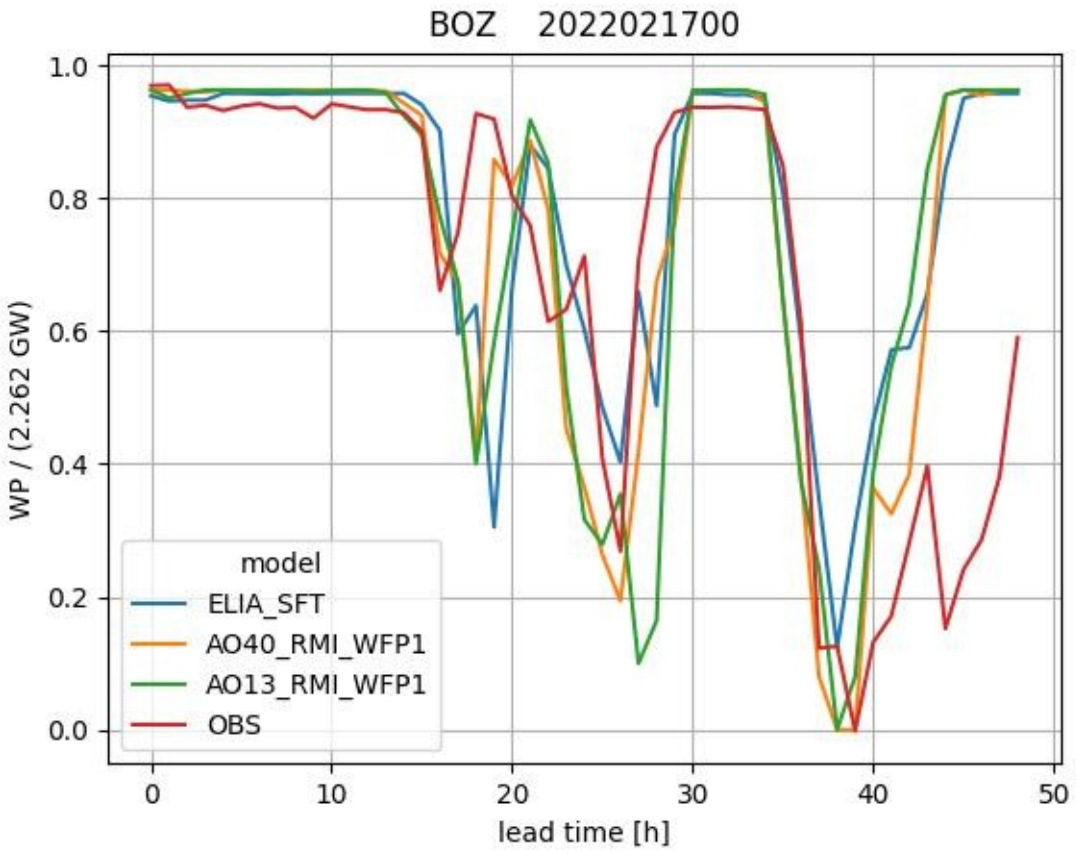




Wind power forecasts (first results)

Comparison to our operational forecasts





Remark:
1.3km model is punished since speed to power conversion still tuned to 4km model

Slight impact on timing of cutout?

Conclusions and Outlook

Successfully implemented Fitch WFP into ALARO (and AROME) [cy43]

First results appear promising:

- Moderate improvement in wind speed and power forecasting near wind farms
- No negative effects away from wind farms

To be done:

- Extended validation:

  longer period, multiple runtimes, 15min output, further Lidars/SCADA, TKE vs TI
- Analysis of wind direction dependence
- Combination with other methods (AI power conversion, postprocessing)
- Adoption in operational model (?)

THANK YOU

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