

Probabilistic storm forecasts for wind farms in the North Sea

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Outline

1. Elia storm forecast tool
2. Past winter test periods
3. Summer updates
4. Future model improvements

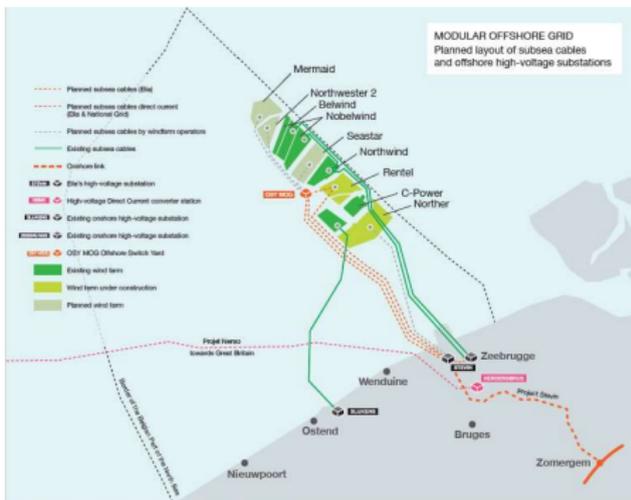
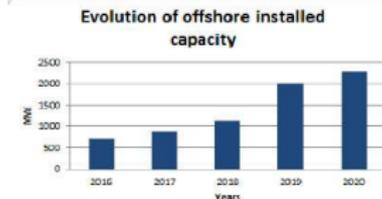


Figure: Belgian offshore wind farms (source: Elia)

Belgian offshore wind energy capacity (source: Elia)

Windfarm	Capacity (MW)	# Turbines
C-Power	325	54
Rentel	294	42
Belwind	171	56
Northwind	216	72
Nobelwind	165	50



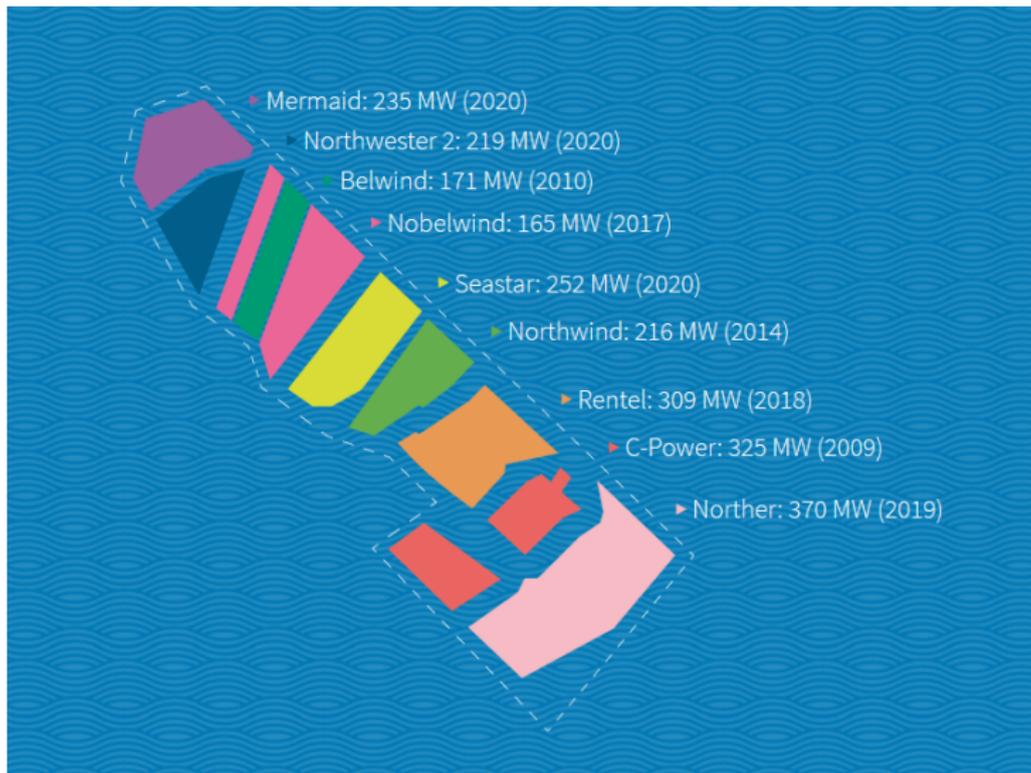


Figure: Belgian Offshore Platform (BOP)

Some facts from BOP website

- ▶ Currently **6 operational wind farms** with **1.5 GW** total installed capacity.
 - Norther became operational this summer.
- ▶ Estimated by **2020: 2.2GW** total capacity which will produce an average 8 TWh annually
 - electricity consumption of 2 million families,
 - 10 % of Belgian electricity consumption.
- ▶ Operational lifetime: 20 years.
- ▶ Possible to increase to at least **4 GW** capacity **after 2020.**

Numerical weather models at the RMI

- ▶ ECMWF (9km, operational, 2 runs per day)
- ▶ ALARO (4km, operational, 4 runs per day)
- ▶ ALARO (1.3km, experimental, 4 runs per day)
- ▶ ECMWF EPS (18km, operational, 2 runs per day)
- ▶ RMI-EPS (2.5km, experimental, 2 runs per day)

⇒ operational products based on combination of
ECMWF EPS and ALARO 4km

⋮

NOTE: in addition our forecasters also look at other models (GFS, UKMO, AROME-MF,...)

Probabilistic storm forecasts

- ▶ Wind farms in the North Sea
- ▶ Cut-out events (25 m/s and 30 m/s) for transmission system operator Elia
- ▶ ALARO (4km) wind speed (15min) at turbine height
- ▶ ECMWF EPS (18km) wind speed (1h) at 100m
NOTE: only 3-hourly data before 23 Nov 2016.

Wind power model

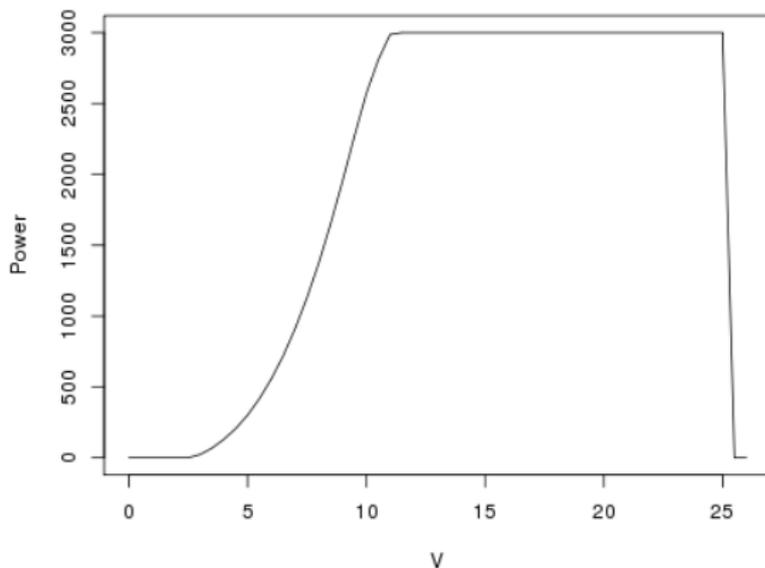


Figure: Wind power curve: a typical example

Wind power model

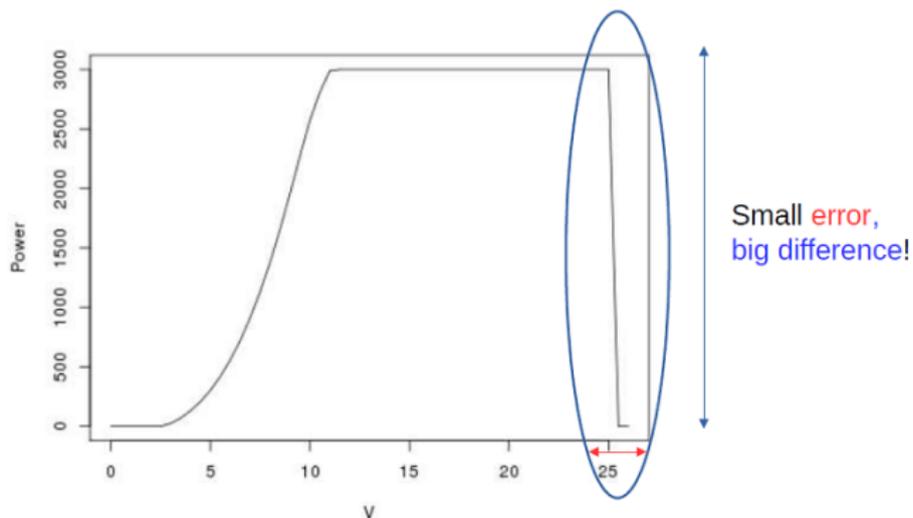
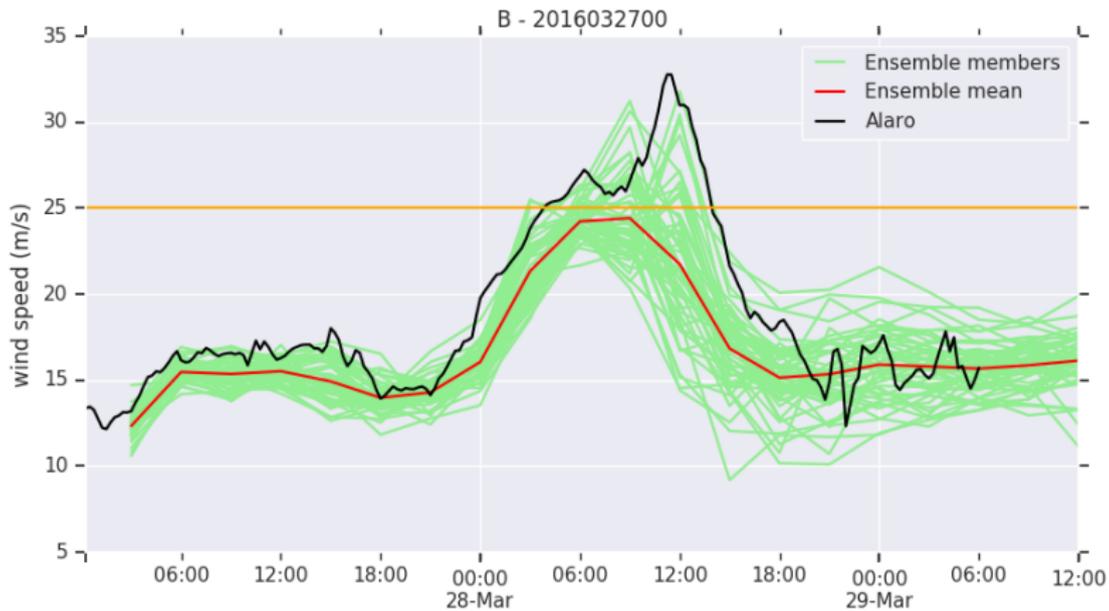
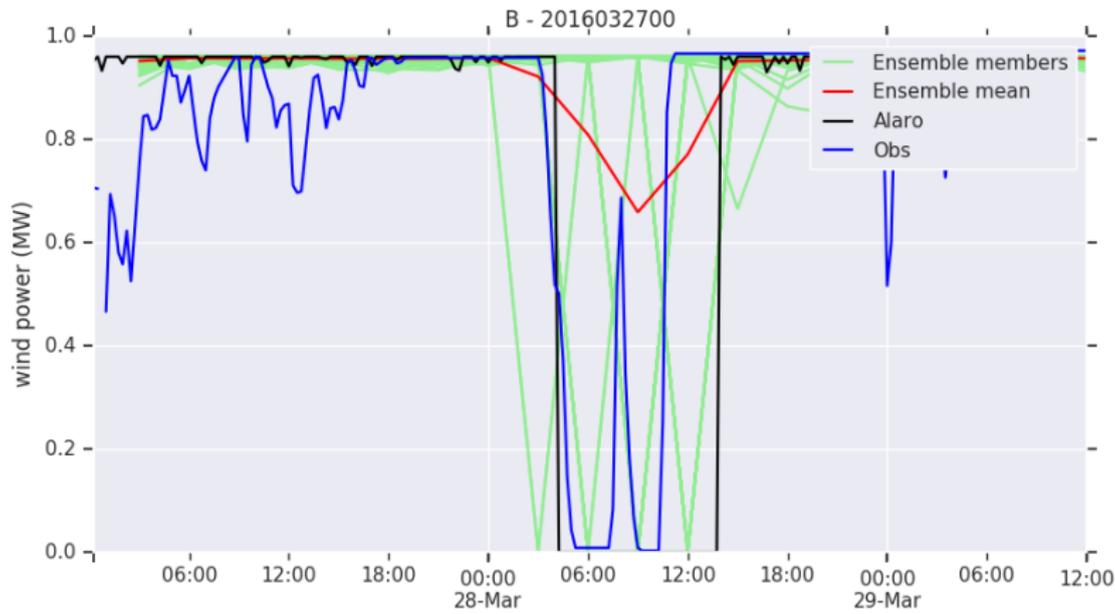


Figure: Wind power curve: a typical example

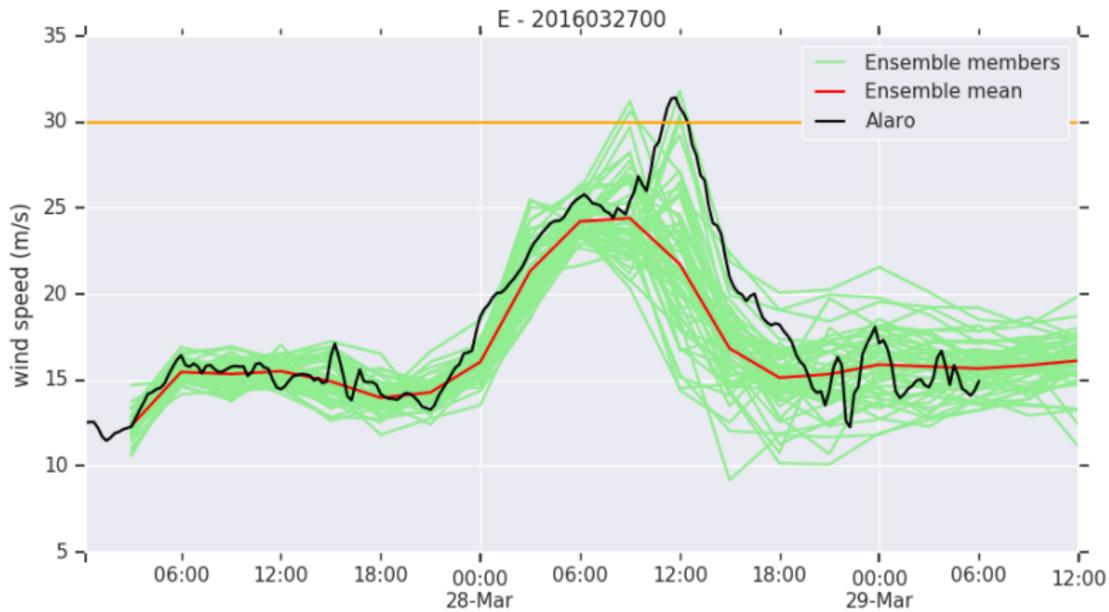
Cut-out event of 28 March 2016



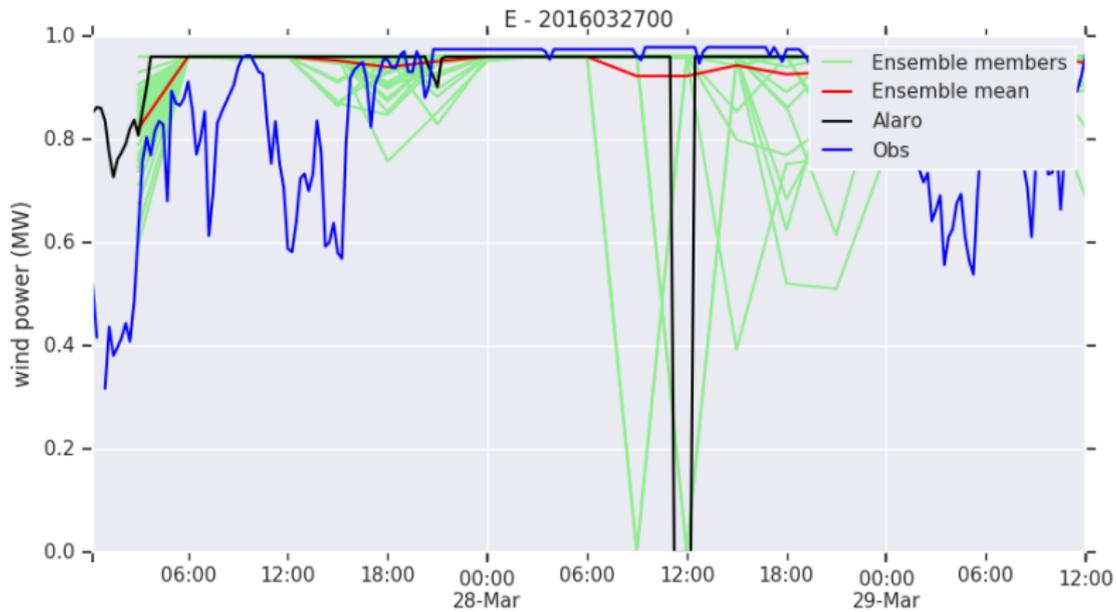
Cut-out event of 28 March 2016



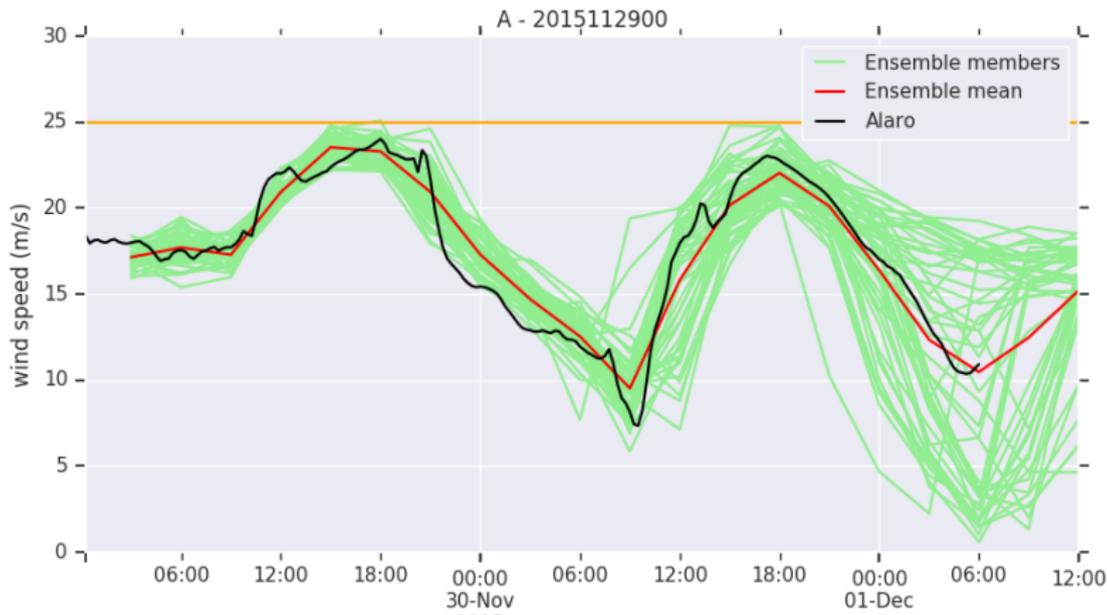
False alarm for 28 March 2016



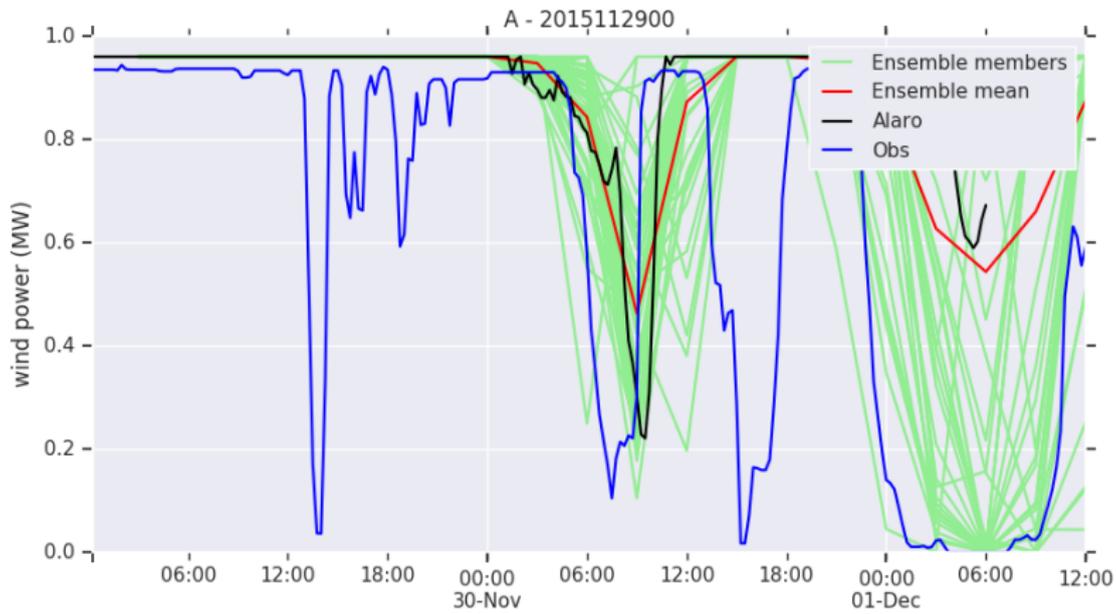
False alarm for 28 March 2016



Near misses for 29-30 November 2015



Near misses for 29-30 November 2015



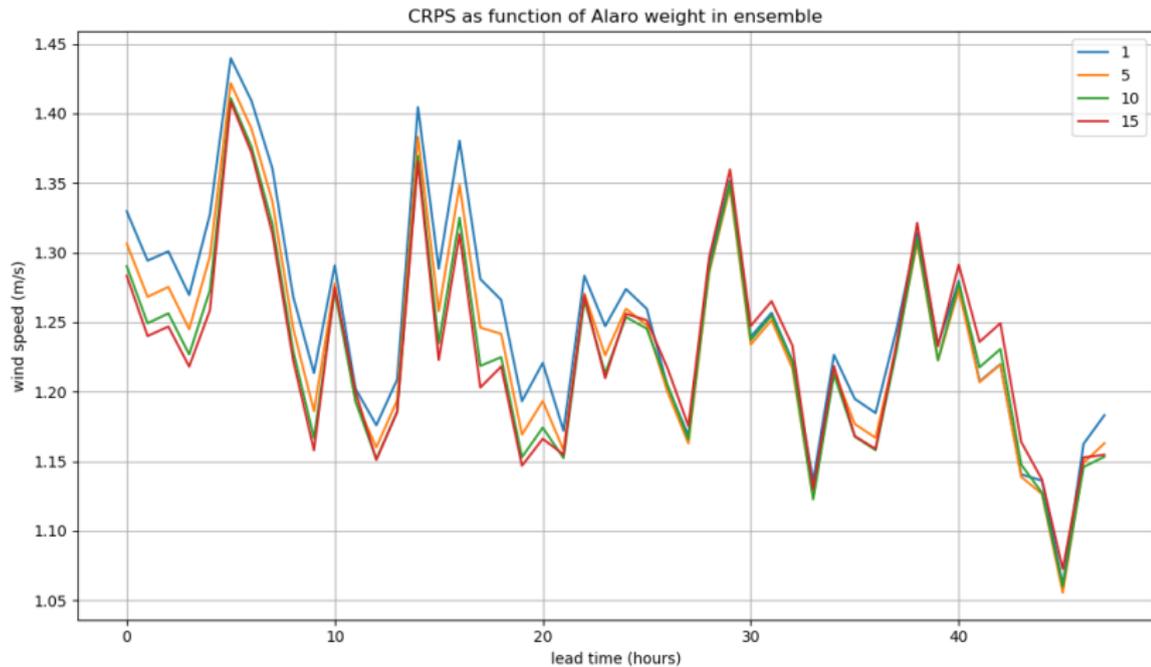
Verification: hits, misses and false alarms

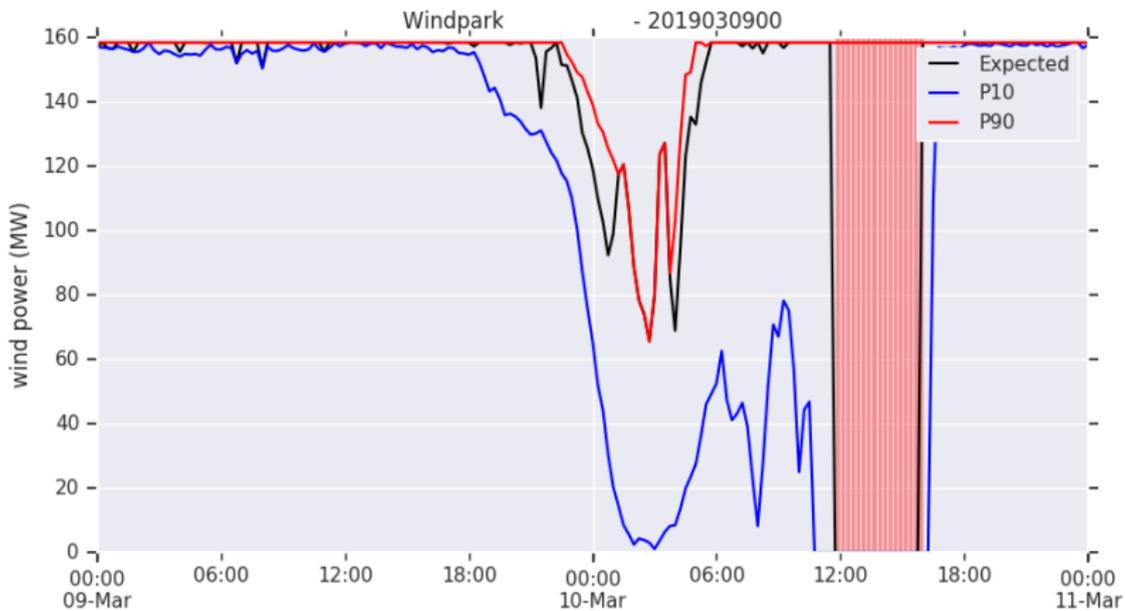
- ▶ For moderate and extreme storms, leading to cut-out events.
- ▶ 1 September 2015 - 31 March 2016
 - reruns for 7 month historical period
 - 5 hits, 3 misses, 0 false alarms
- ▶ 1 November 2018 - 14 March 2019
 - real time forecasts in test period
 - 1 hit, 0 misses, 2 false alarms

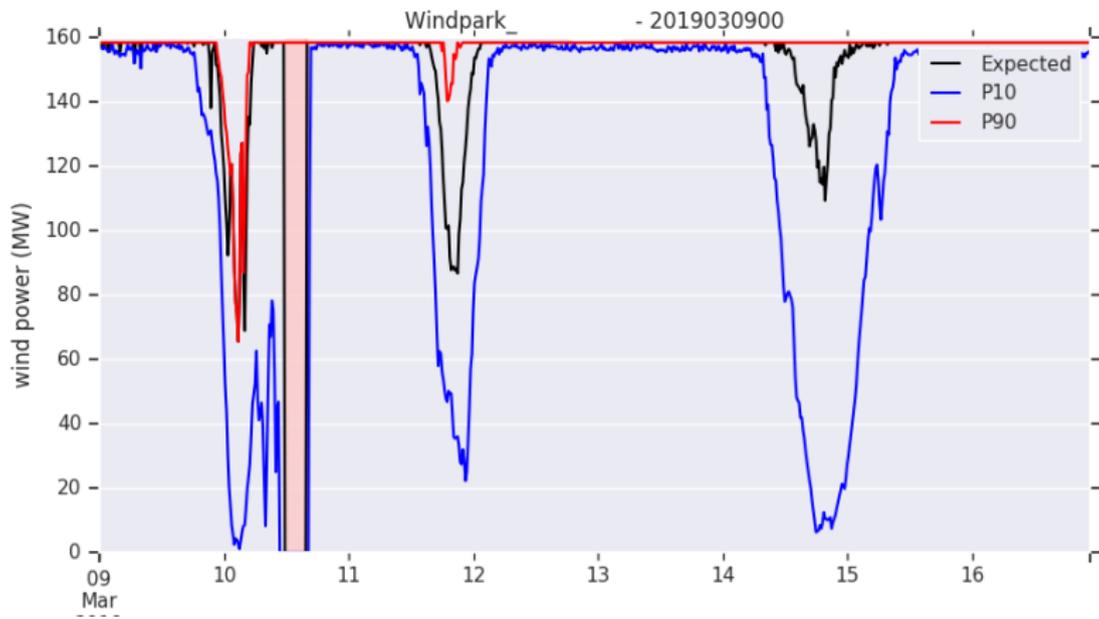
Summer updates

Elia storm forecast tool

- ▶ Forecasts up to 7 days
- ▶ P10-P90: adding ALARO to ECMWF ensemble
 - ALARO ‘worth’ about 15 ensemble members (first 24h)
- ▶ Expected forecast: ALARO in first 48h
 - ECEPS median after 60h
 - Weighted average of ALARO and ECEPS median in between







Future model improvements

Short-term

- ▶ Retuning wind power curves with historical wind power (and speed) observations
- ▶ Calibration wind speed forecasts with historical wind speed observations

Calibration with historical wind speed

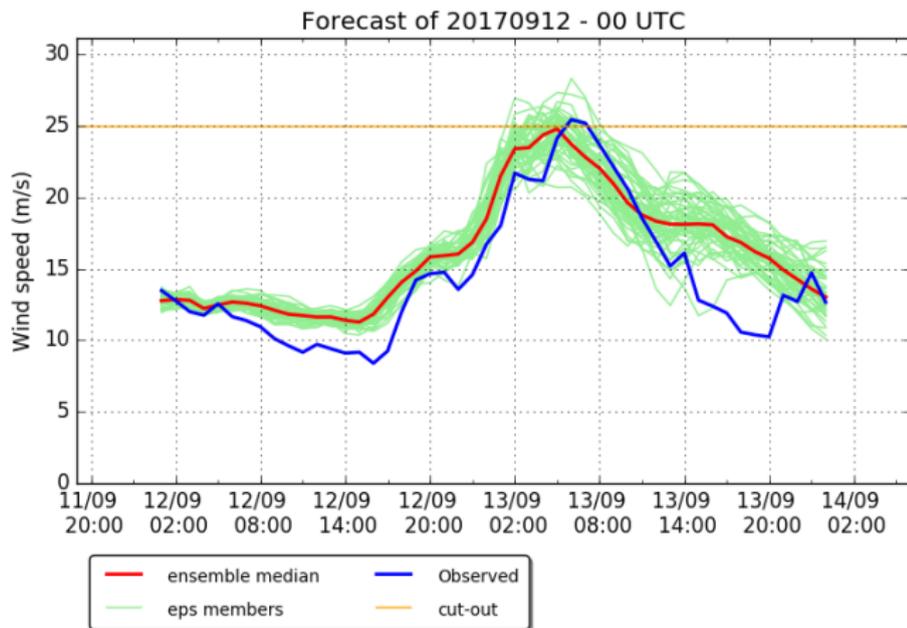


Figure: Raw ensemble forecast

Calibration with historical wind speed

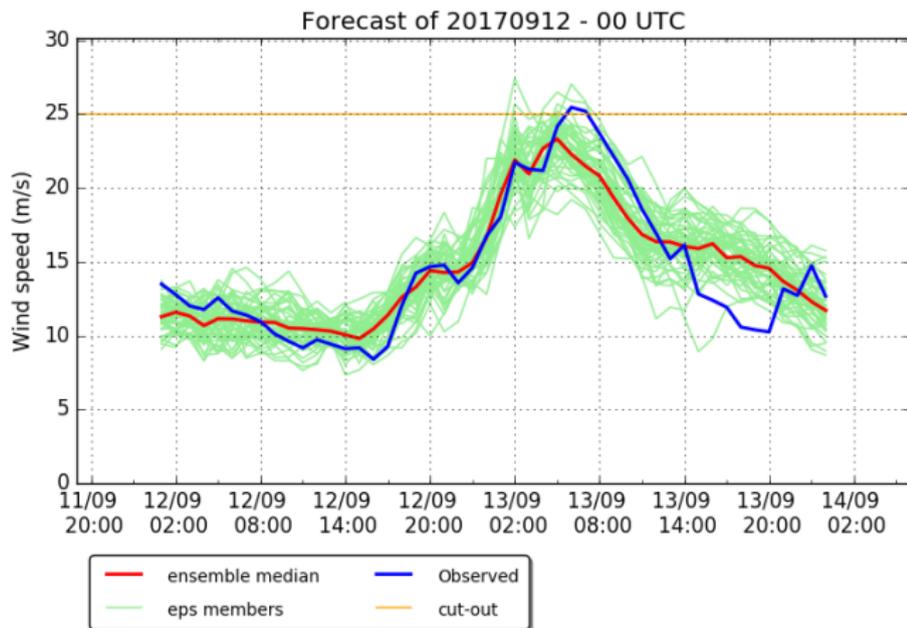


Figure: Calibrated ensemble forecast

Calibration with historical wind speed

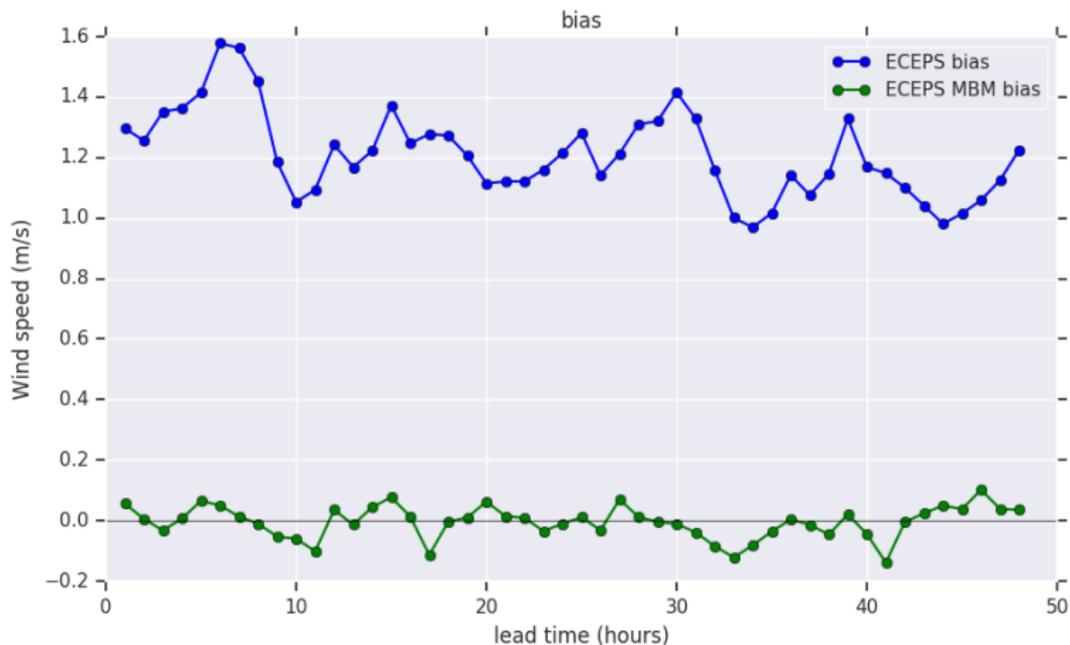


Figure: Bias of raw and calibrated ensemble

Calibration with historical wind speed

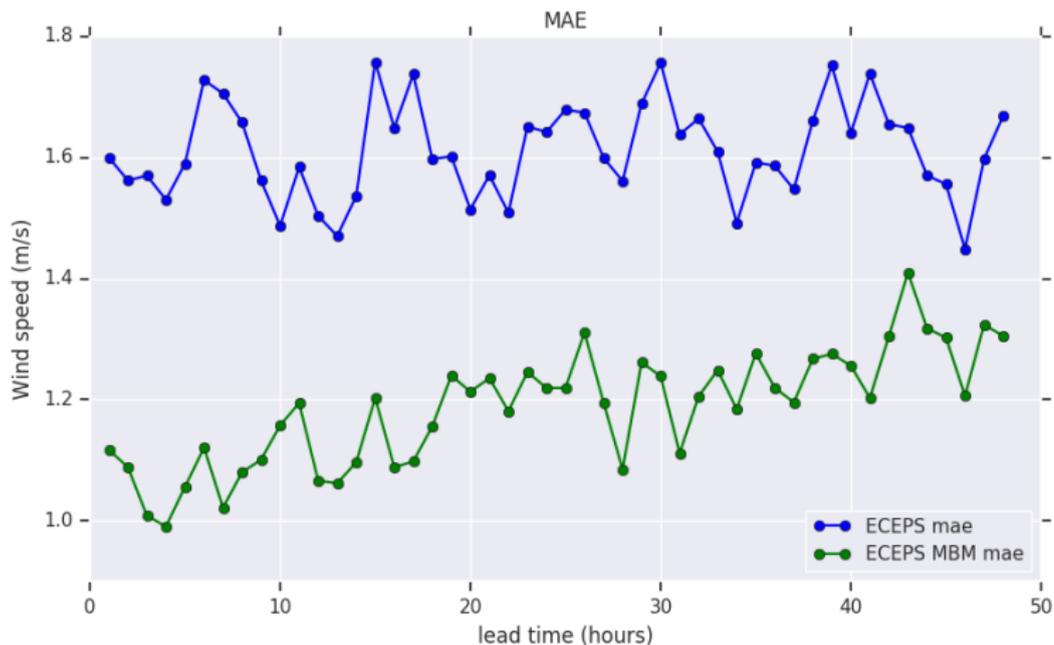


Figure: MAE of raw and calibrated ensemble

Calibration with historical wind speed

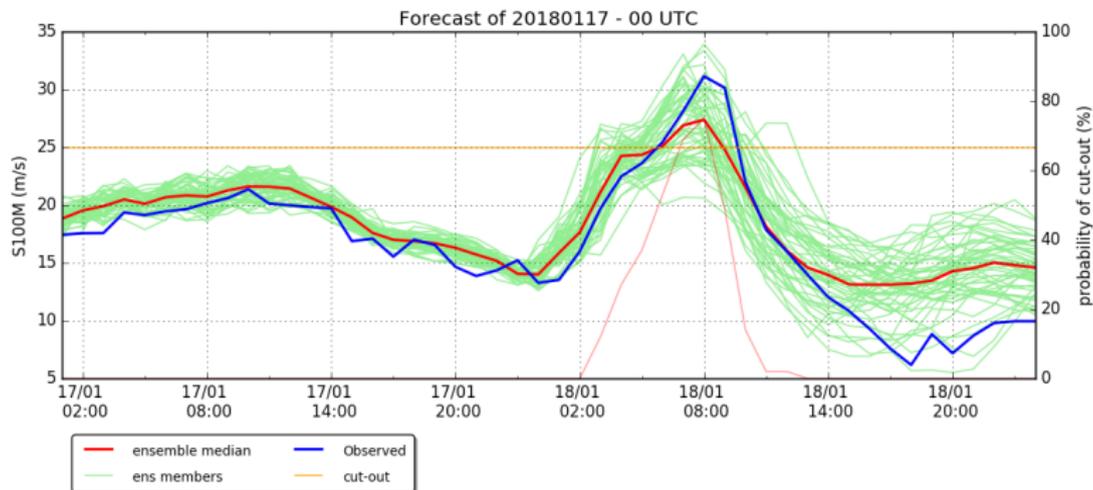


Figure: Cut-out event: raw ensemble forecast

Calibration with historical wind speed

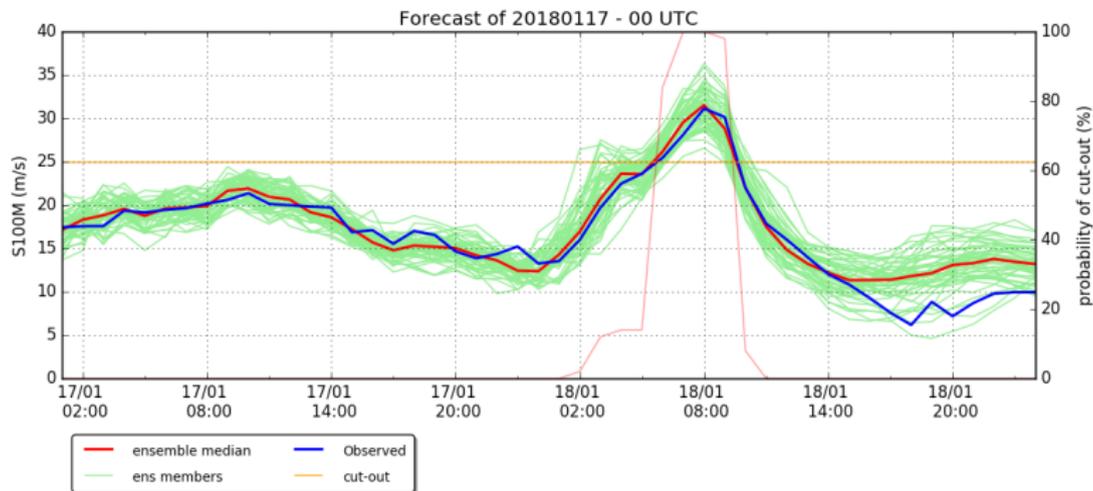


Figure: Cut-out event: calibrated ensemble forecast

Future model improvements

Long-term

- ▶ Use of wind direction?
- ▶ (Maybe also wind gusts?)
- ▶ More detailed spatial modeling of the wind farms?
- ▶ Wake effects? Influence of other turbines and wind farms.

THANK YOU