Verification of WRF wind forecasts at wind turbine height

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Introduction

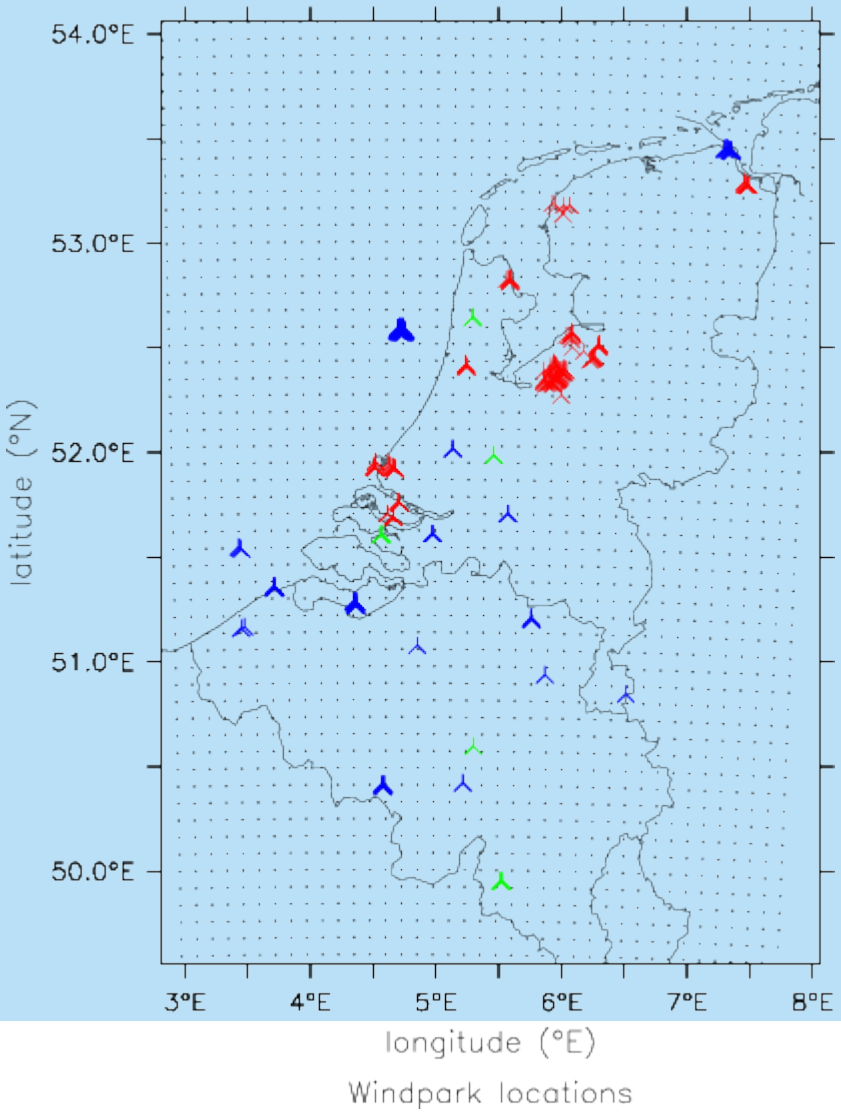
- About BMT ARGOSS
- WRF forecasts for power output forecasting
- Wind farm locations and observation stations
- Validation method and results
- Wind speed uncertainty interval
- Product examples
- Summary and conclusions

About BMT ARGOSS

- Origin in offshore information
- Metocean consultancy
- Operational wave forecasts
- Operational weather forecasts
- Tidal modelling
- Air quality modelling
- Research projects

Power output forecasts the Netherlands and Belgium

- Dutch energy provider
- Wind forecasts at turbine height (not power)
- 25 locations over the Netherlands and Belgium
- Onshore and offshore wind farms
- 4 x daily forecasts up to 120 hours
- Requirement: wind speed uncertainty interval
- 2 years of historical forecasts (!)



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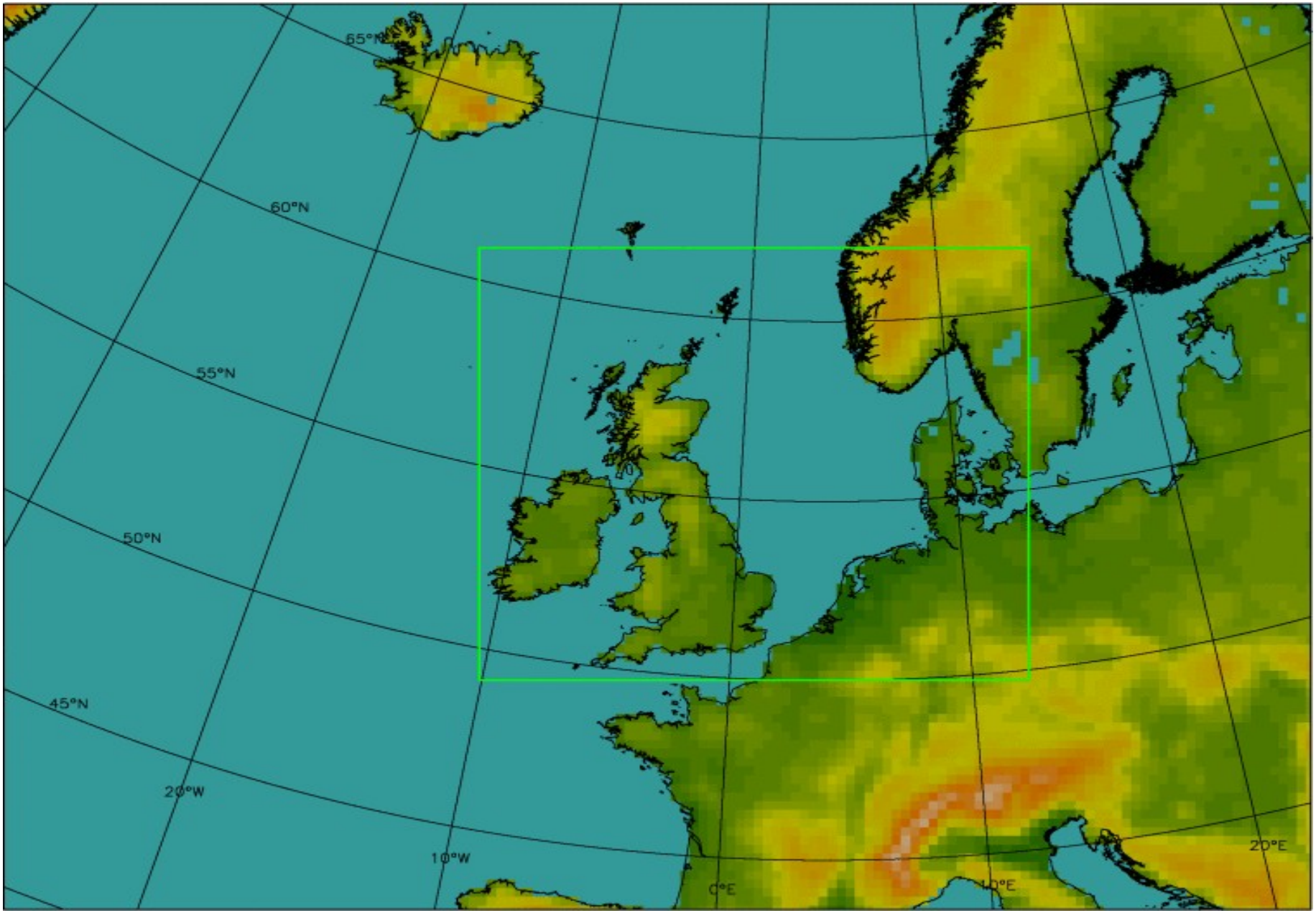

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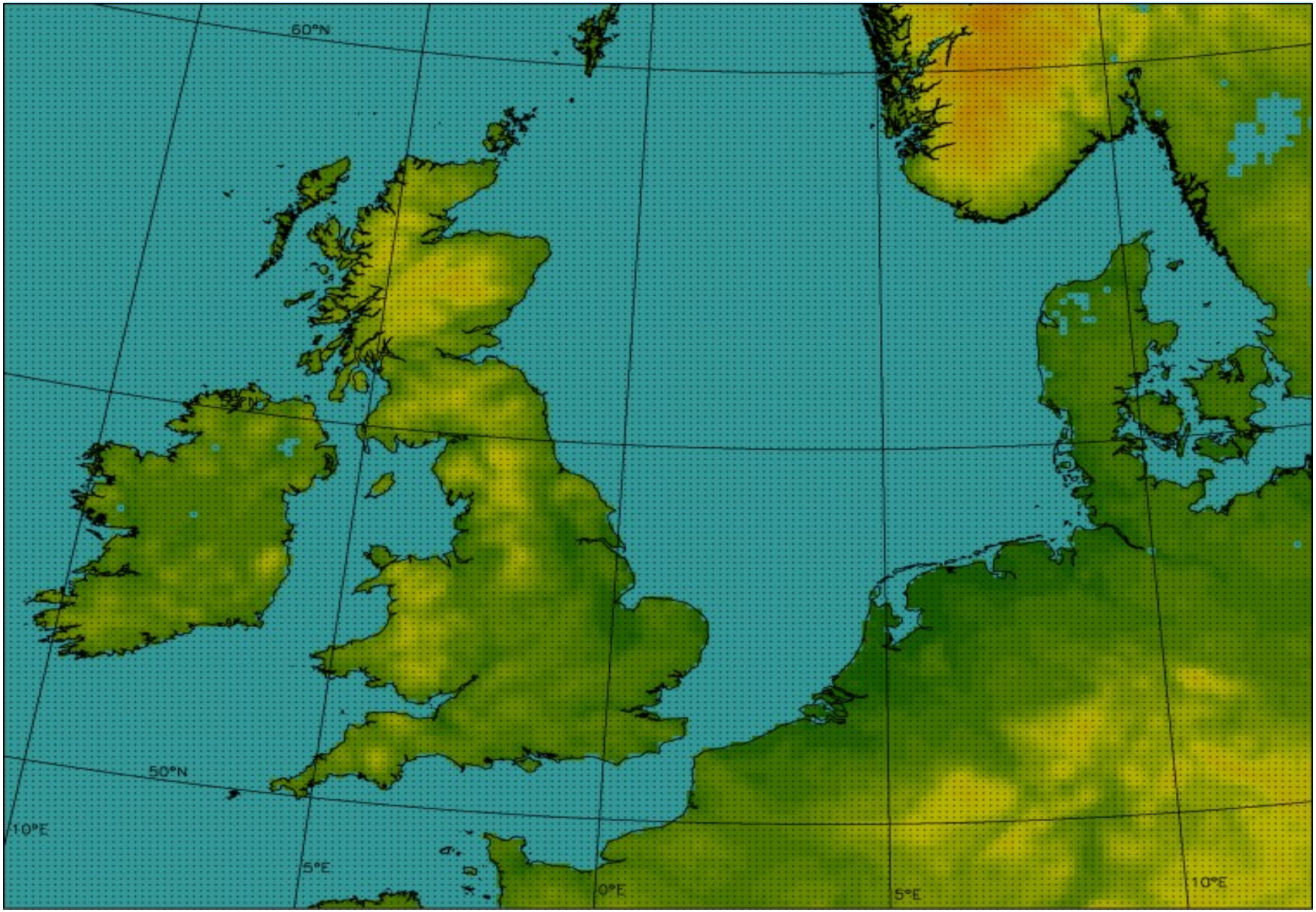

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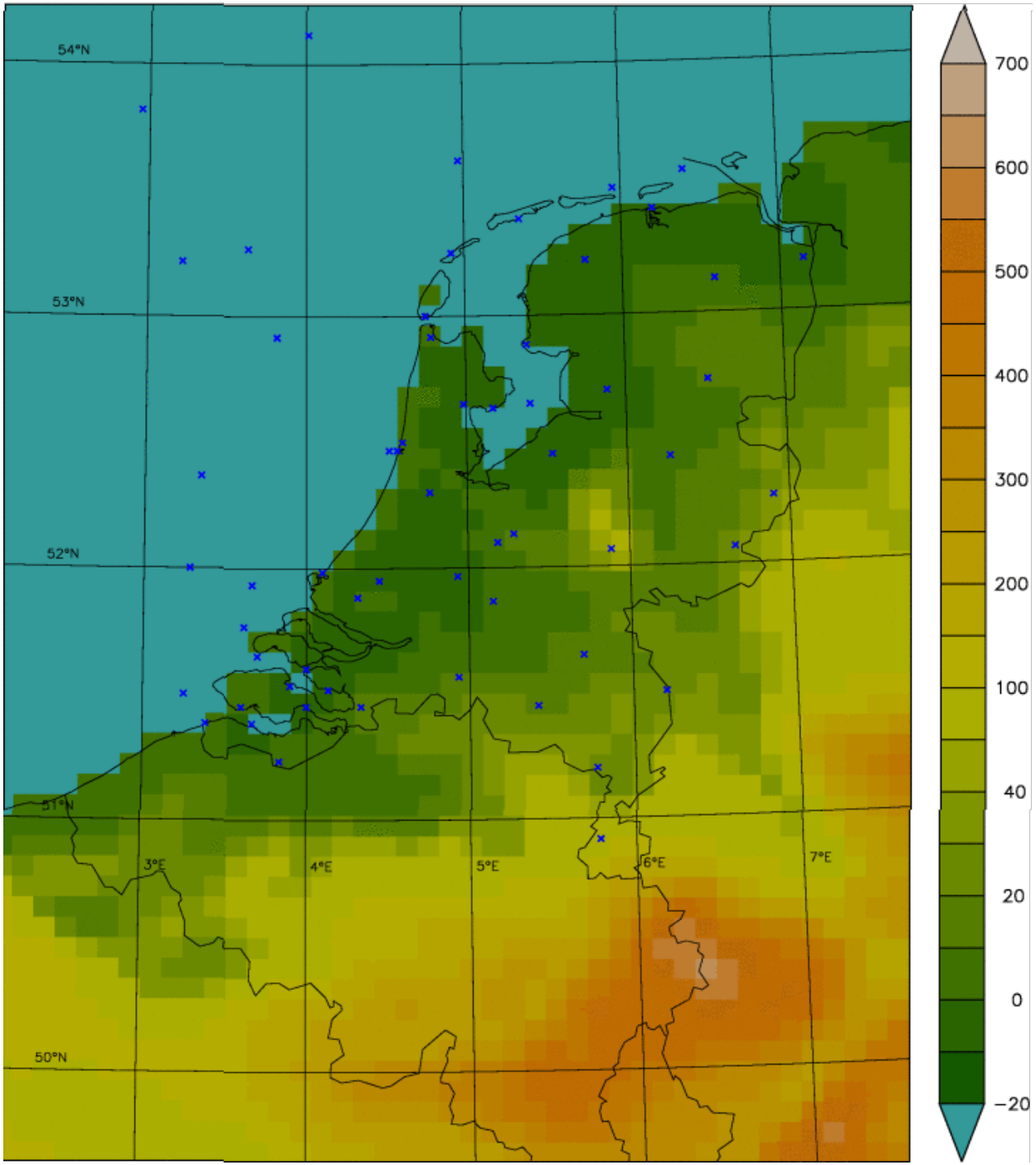
54°N
53°N
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3°E
4°E
5°E
6°E
7°E
700
600
500
400
300
200
100
40
20
0
−20

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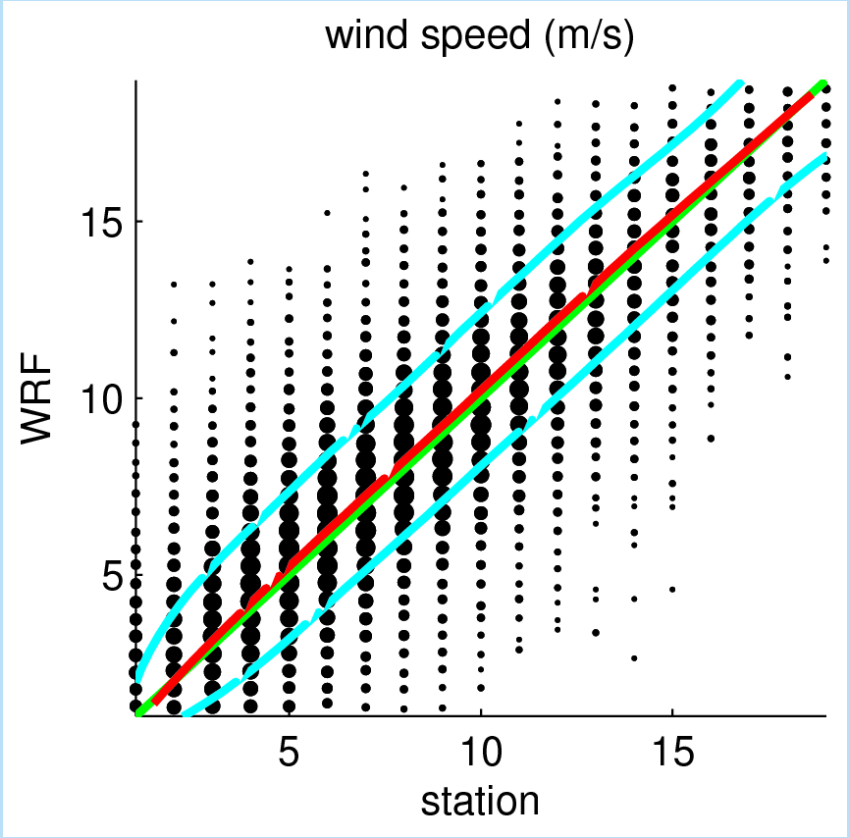
Validation: method and results

- 10 year historical database (2000 – 2009)
  GFS FNL forcing (1 degree), 48 hour simulations, 6 hour spinup
- 2 year “historical forecast” database
  GFS forcing (0.5 degree), 72 hour simulations, 3 hour spinup, twice daily
- Validated using 43 stations over the Netherlands and Belgium
- 2 validation stations at hub height (Cabauw, Egmond)
- Bias, RMSE, mean absolute error, correlation

Validation results

- Errors vary strongly per station
- Overall good quality
- 10 mwind speed bias:< 0.5 m/s
- wind speed RMSE : ~ 1.5 m/s
- Land stations perform somewhat better (after bias removal)
- Vertical profile matches well
- Hub-height wind speed good



Vlieland station (island)

Vlieland (island)

	bias	rmse	spread	correlation
Pressure	0.09 hPa	1.26 hPa	1.24 hPa	0.99
Air Temperature	-0.24 ^{0}C	2.78 °C	1.71 °C	0.89
Dew point	-0.87 ^{0}C	2.36 ^{0}C	1.40 ^{0}C	0.92
Wind speed	-0.21 ms	2.11 m/s	2.01 m/s	0.84

Lelystad (land)

	bias	rmse	spread	correlation
Pressure	0.14 hPa	1.20 hPa	1.18 hPa	0.99
Air Temperature	-0.13 ^{0}C	1.94 °C	1.90 °C	0.96
Dew point	0.83 ^{0}C	1.97 ^{0}C	1.75 ^{0}C	0.95
Wind speed	-0.57 m/s	1.68 m/s	1.55 m/s	0.81

Wind speed uncertainty interval

- 3 components:
- Model error statistics
- Variation in space
- Ensemble spread

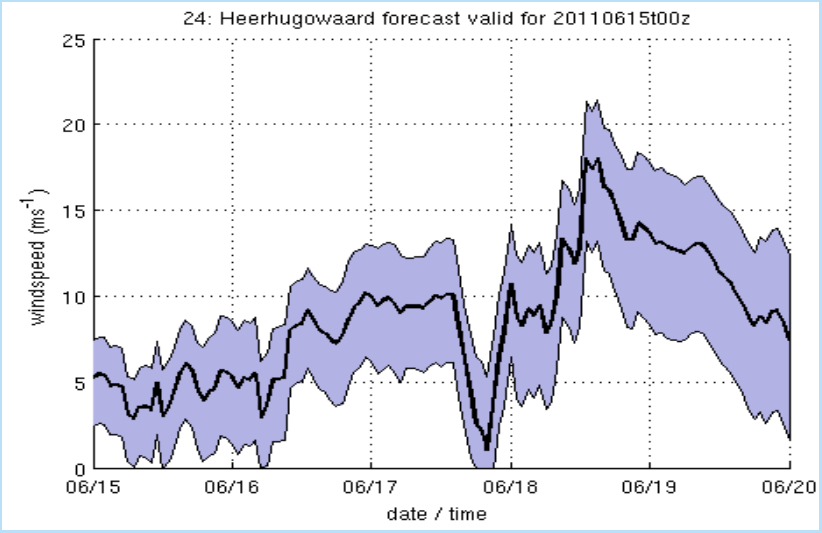
Statistical method

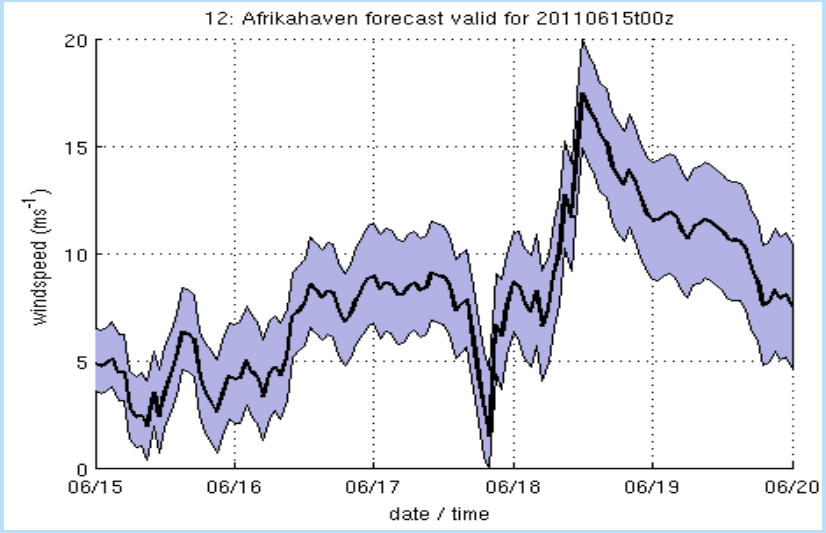
- Compute error statistics per
  - Station
  - Month (season)
  - Wind speed category
  - Forecast lead time
- Translate to hub height (?)
- Compute confidence interval (5% - 95% or 10% - 90%)
- Validation of 95% level: 95.4% of observations within interval (2009-2010)

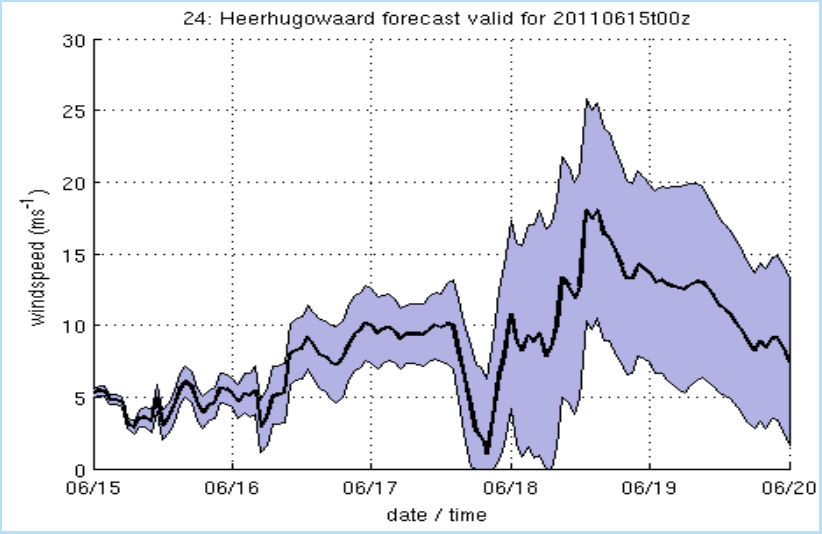
Methods that did not work?

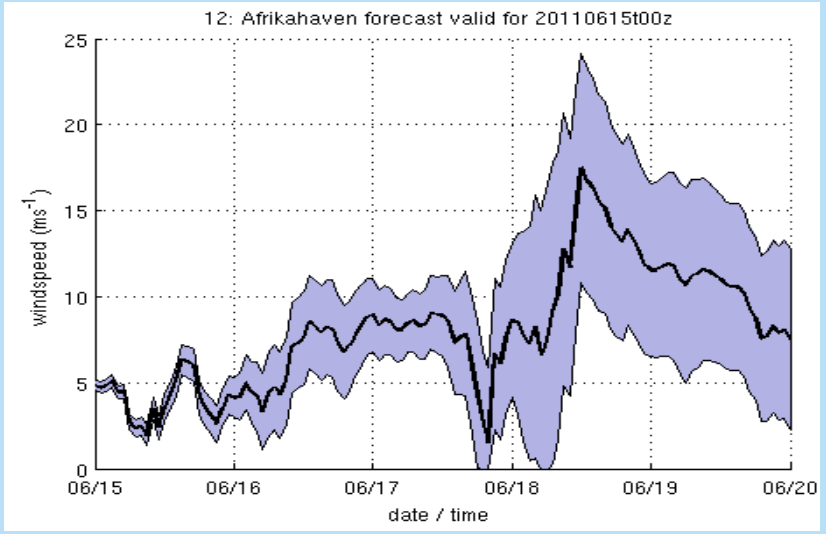
- Spatial variation
  - Wind speed variability in a radius around a wind farm
  - Expect relation between forecast error and variability
  - No gain over statistical method
- Ensemble spread
  - Expected relation between ensemble spread and forecast error (large scale variations in forcing)
  - No gain over statistical method
- Why?
  - Wind speed categories used in statistical method

Resulting products









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Summary and conclusions

- Overall good system performance
- good data quality, competitive pricing
- Reliability interval works well, but not used actively yet
- GFS + WRF cannot match ECMWF / multi model approach yet
- Data assimilation implementation ongoing
- Other improvements (up-to-date SST, land use map improvements)

Thank you for your attention!

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http://www.bmtargoss.com

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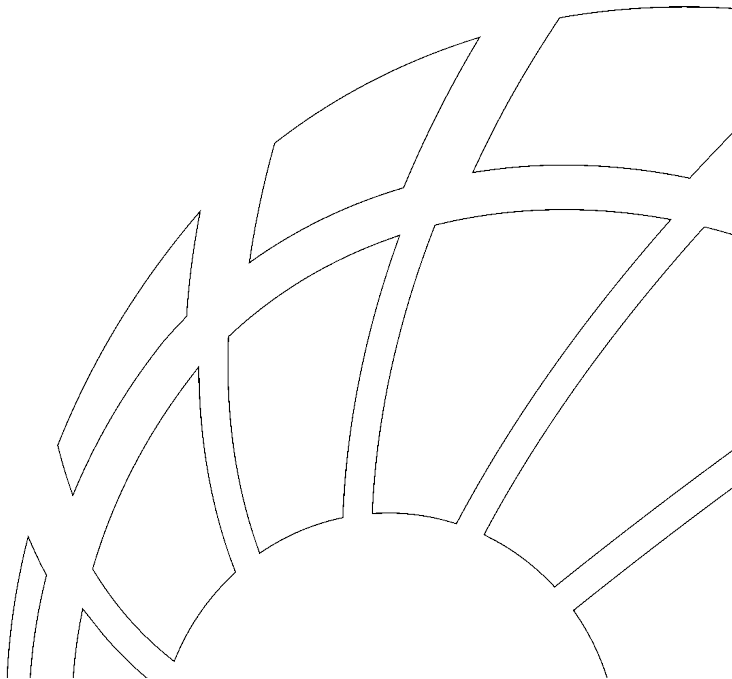
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