Norwegian
Meteorological
Institute

Does wind power forecasting skill depend on the spatial resolution of NWP models?

John Bjørnar Bremnes (MET Norway)
Gregor Giebel (DTU)

Sites

Sites

- HyWind (2.3 MW)
- Smøla (150 MW, 68 turbines)
- Hitra (55.2 MW, 24 turbines)

Data

- Hourly energy production for each turbine
- 6 - 12 months of measurement data

NWP models

Model	Model system	Version	Data assimilation	Spatial resolution	Boundary model	Lead times
UM1	Unified Model	7.3	No	1 km	UM4	+3, +6, ..., +21h
UM4	Unified Model	7.3	No	4 km	H8	+3, +6, ..., +66h
H4	HIRLAM	7.1.3	No	4 km	H8	+3, +6, ..., +66h
H8	HIRLAM	7.1.3	Yes	8 km	EC16	+3, +6, ..., +66h
EC16	ECMWF IFS	36r1 - 37r2	Yes	16 km	-	+3, +6, ..., +66h
EC32	ECMWF IFS	36r1 - 37r2	Yes	32 km	-	+6, +12, ..., +66h

Forecasts data

- Wind speed and direction at 10 meter
- Initiated at 00 UTC
- Bilinearly interpolated to the location of each wind turbine
- Hourly averages

NWP models (2)

How are wind power forecasts made?

Physical (NWP) + statistical modelling

Historical data of

- NWP forecasts
- Wind power measurements

Statistical model

- *«What does the production tend to be when the NWP forecast is ...?»*
- Estimate relation between wind power and NWP forecasts
  - Conditional distribution of wind power given NWP forecast variable(s)
- Forecasts in terms of
  - Expected production, quantiles, probability distributions

Statistical method

Meta-Gaussian approach

- Transform each variable to standard Gaussian
- Assume multivariate Gaussian
- Derive conditional distribution
  - Wind power conditional on NWP output
- Retransform to original scale

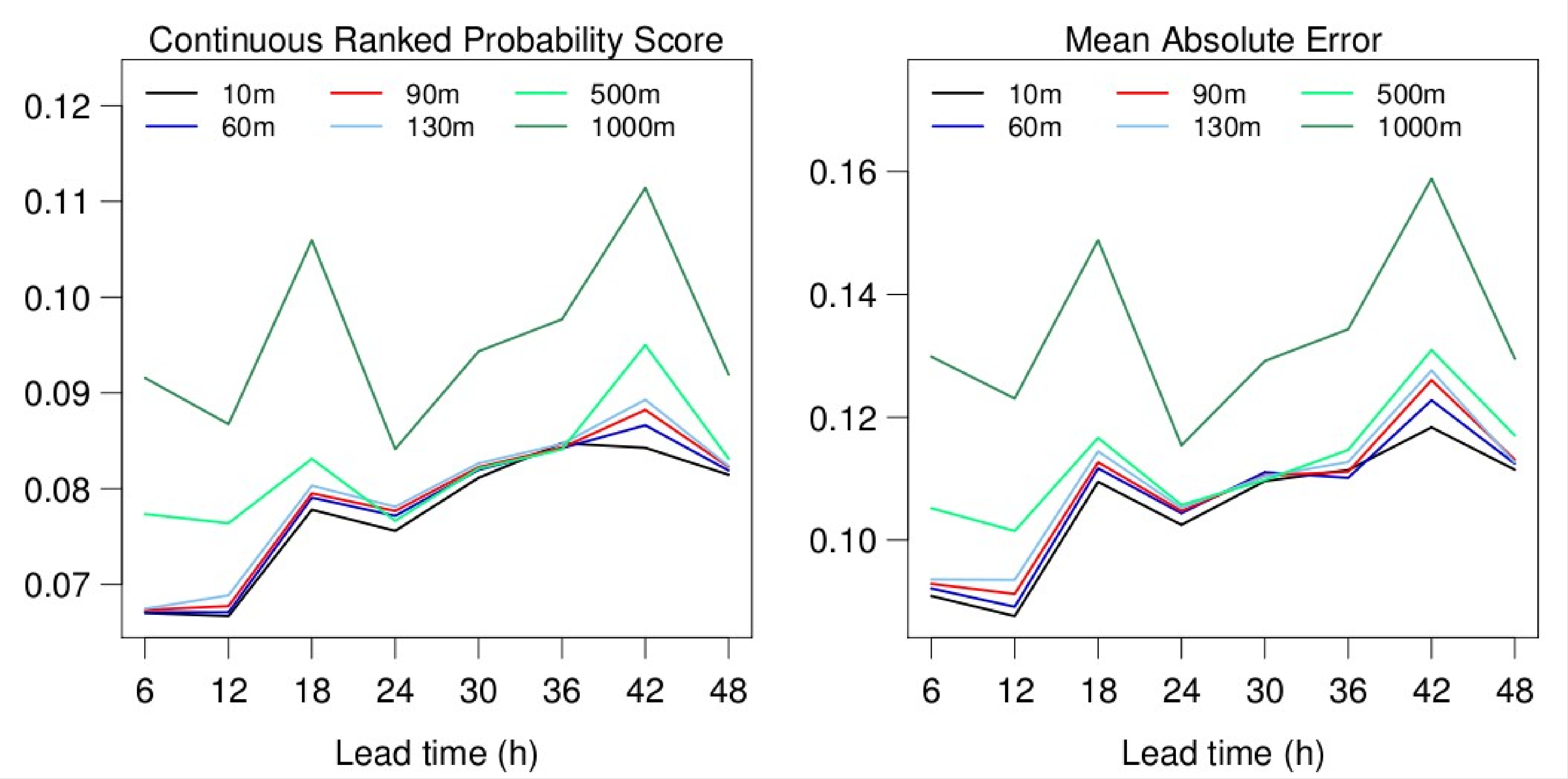
➡ Forecasts in terms of probability distributions

Wind power forecast validation

Forecast	Validation score
Probability distribution	Continuous Ranked Probability Score
50 percentile	Mean Absolute Error

Are wind forecasts at 10m appropriate?

Skill of wind power forecasts using wind
at various levels in UM 1 km at a Smøla turbine



Direct forecasting of wind farm production

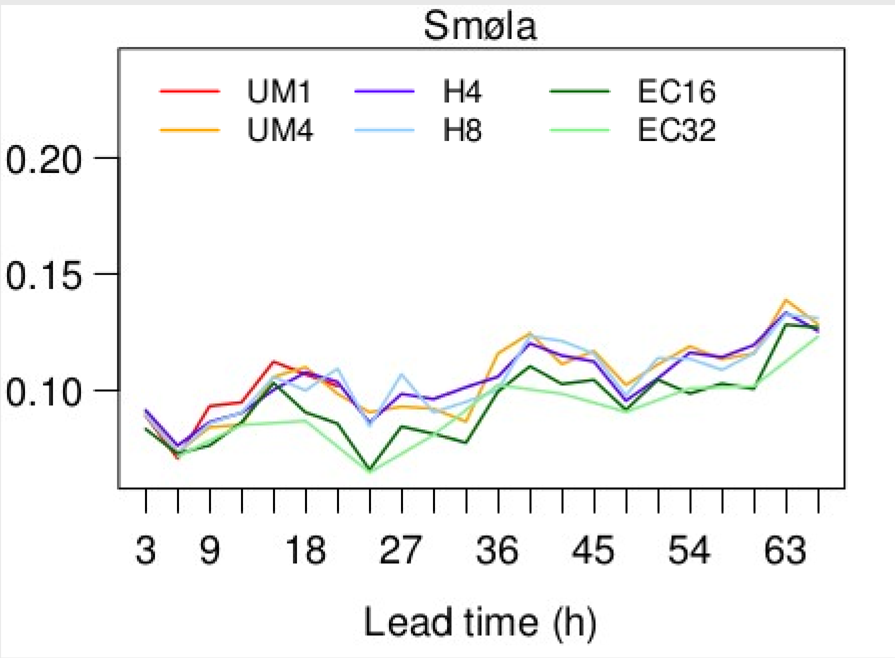
Data

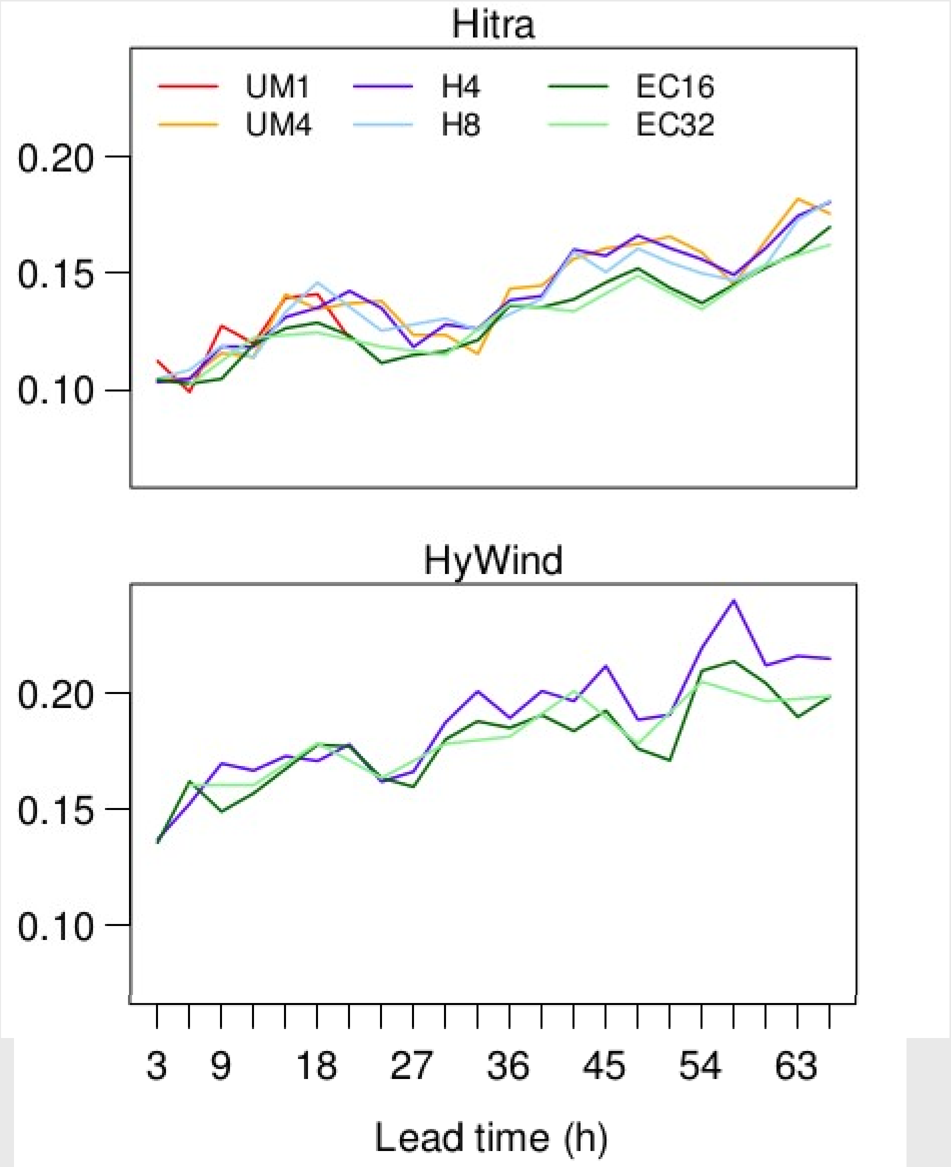
- Power production measurement averaged over turbines
- NWP wind speed forecasts also averaged
- NWP wind direction at a central turbine

Meta-Gaussian approach applied

- Separately for each lead time
- Sliding training period of 60 last days/cases
- Probabilistic and 50 percentile forecasts evaluated

MAE of 50 percentile





Similar results for CRPS

Forecasting at turbine level followed by wind farm aggregation

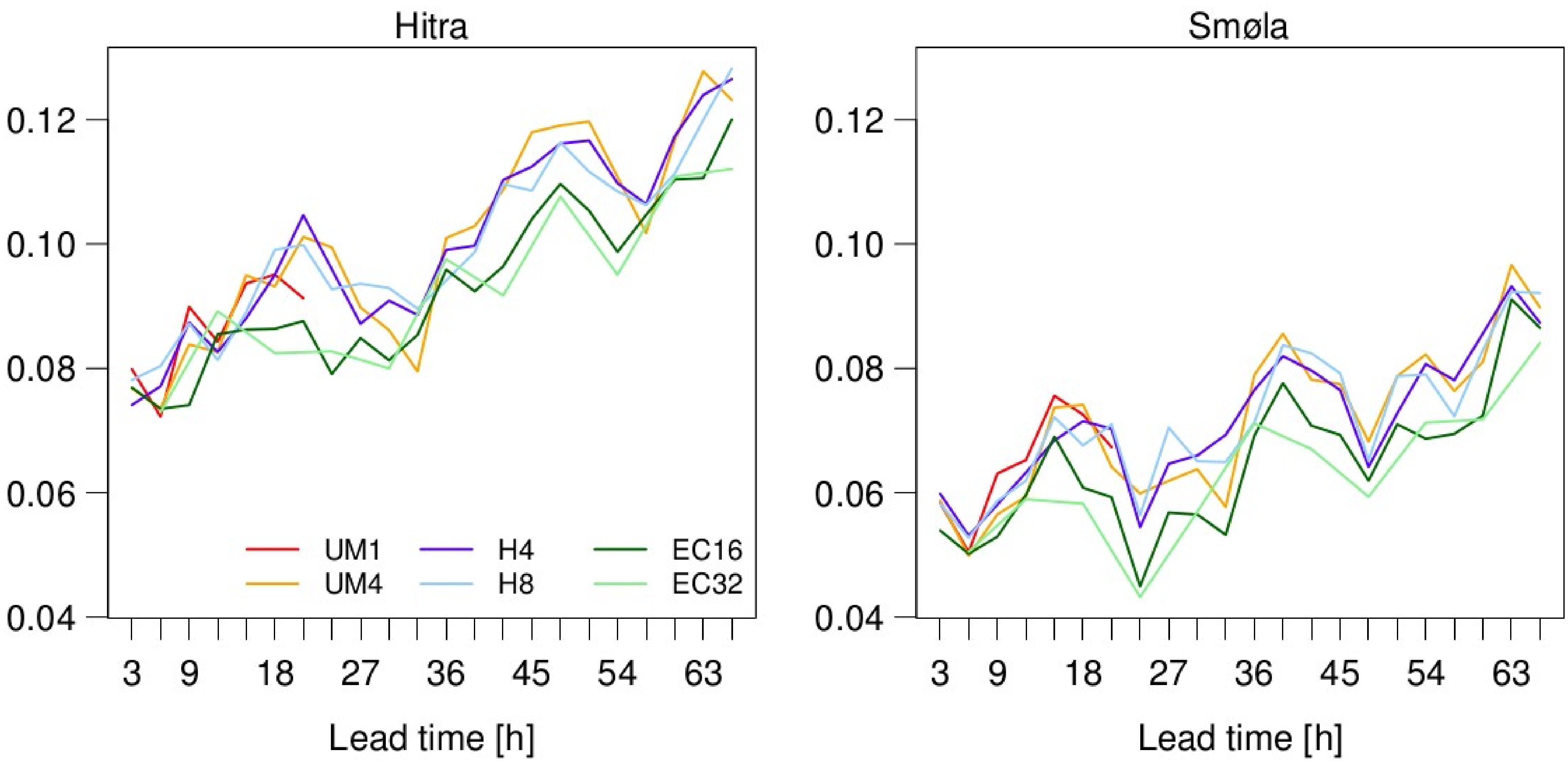
Data

- at turbine level

Meta-Gaussian approach applied

- Separately for each lead time and turbine
- Sliding training period of 60 last days/cases
- Aggregation of 50 percentiles over turbines
- Only aggregated 50 percentiles evaluated

MAE of 50 percentile



Validation of 10m wind forecasts

against nacelle measurements

Smøla			
	ME	SDE	MAE
UM4	-2.26	2.45	2.61
H4	-2.50	2.54	2.77
H8	-1.80	2.40	2.31
EC16	-0.21	2.14	1.63
EC32	-0.48	2.15	1.66

Hitra			
	ME	SDE	MAE
UM4	-2.40	2.55	2.72
H4	-2.40	2.54	2.72
H8	-2.13	2.50	2.52
EC16	-1.38	2.26	2.01
EC32	-0.99	2.26	1.86

HyWind			
	ME	SDE	MAE
H4	-0.52	2.67	2.13
EC16	-0.81	2.62	2.16
EC32	-0.78	2.65	2.17

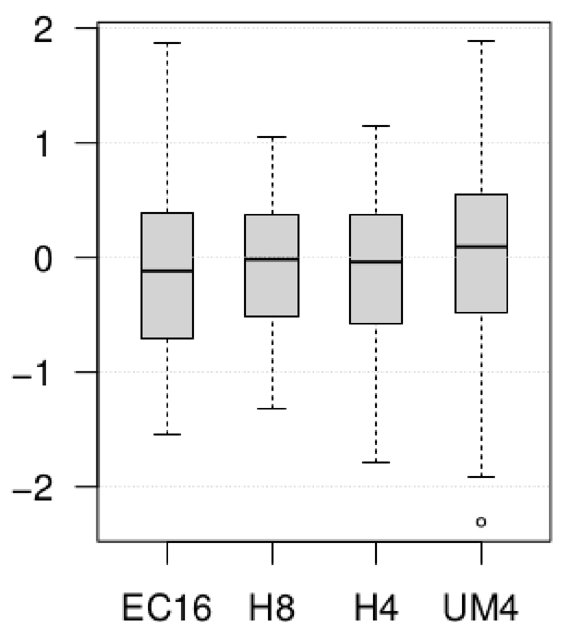
Statistics are averaged over lead times +6, +12, ..., +66h.

Validation of 10m wind speed forecasts

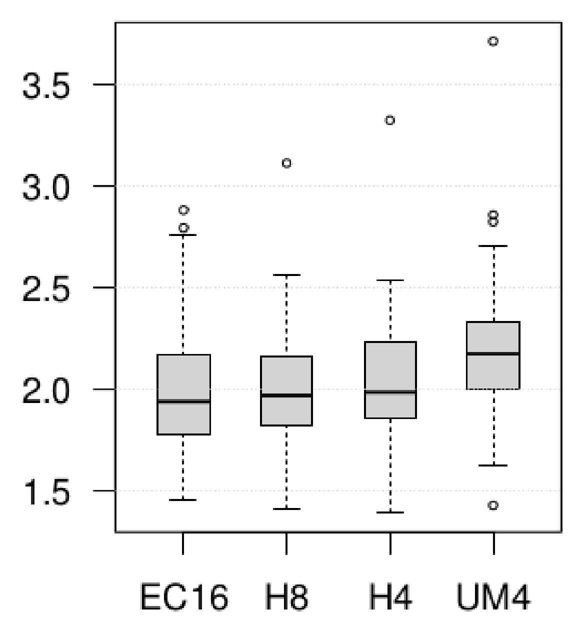
Against 31 coastal Norwegian synop stations (10m)

Feb – Sep 2011

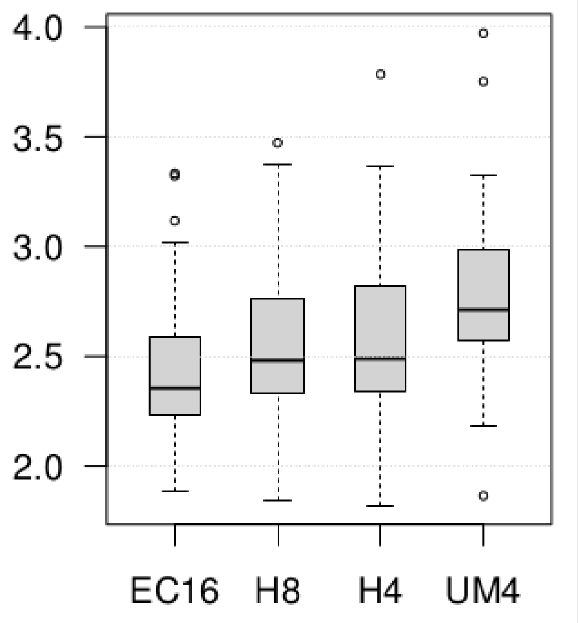
Mean Error



Mean Absolute Error



Standard Deviation of Error



Conclusions

Wind power forecasting skill seemed to

- not improve using high resolution NWPs
  - global low resolution models slightly better!
  - fine scale features of high resolution NWPs do not seem to informative
- not be sensitive to the height level of wind forecasts

Future possibilities

- Repeat the study at other locations
  - ECMWF model not that good inland; mid/northern Sweden?
- Try even more temporal and spatial averaging
  - possibly include wind forecast variation in the statistical model

Acknowledgements

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