The NEWA Ferry Lidar Benchmark: Comparing mesoscale models with lidar measurements along a ship route

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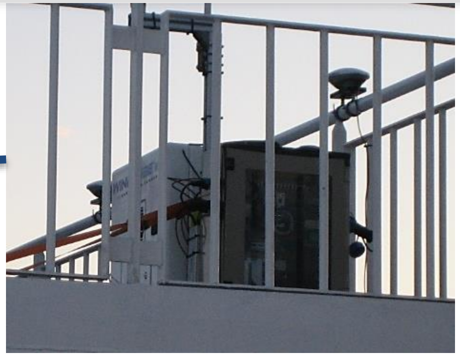
Wind Energy Science Conference 2019, Cork

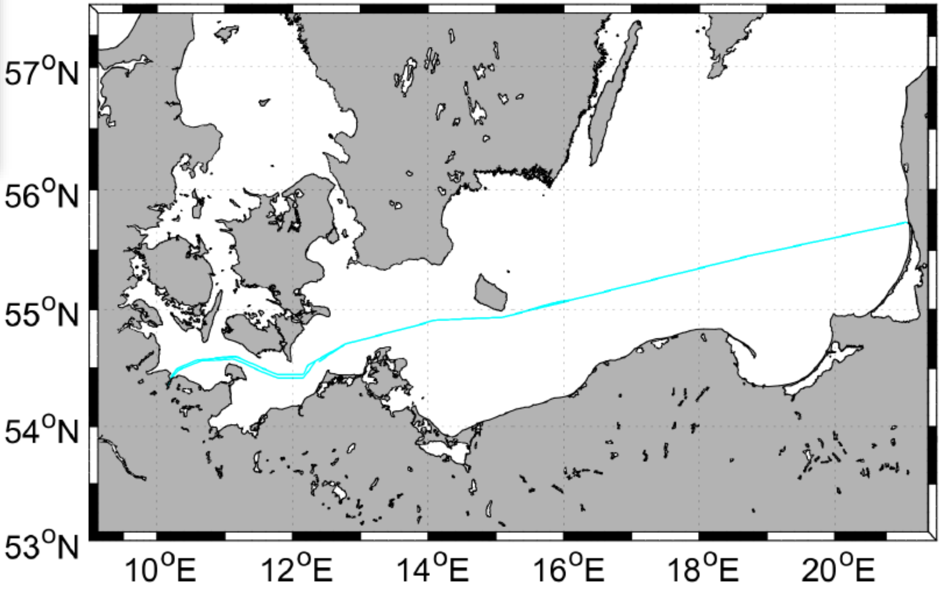
19 June 2019

NEWA Ferry LiDAR Experiment

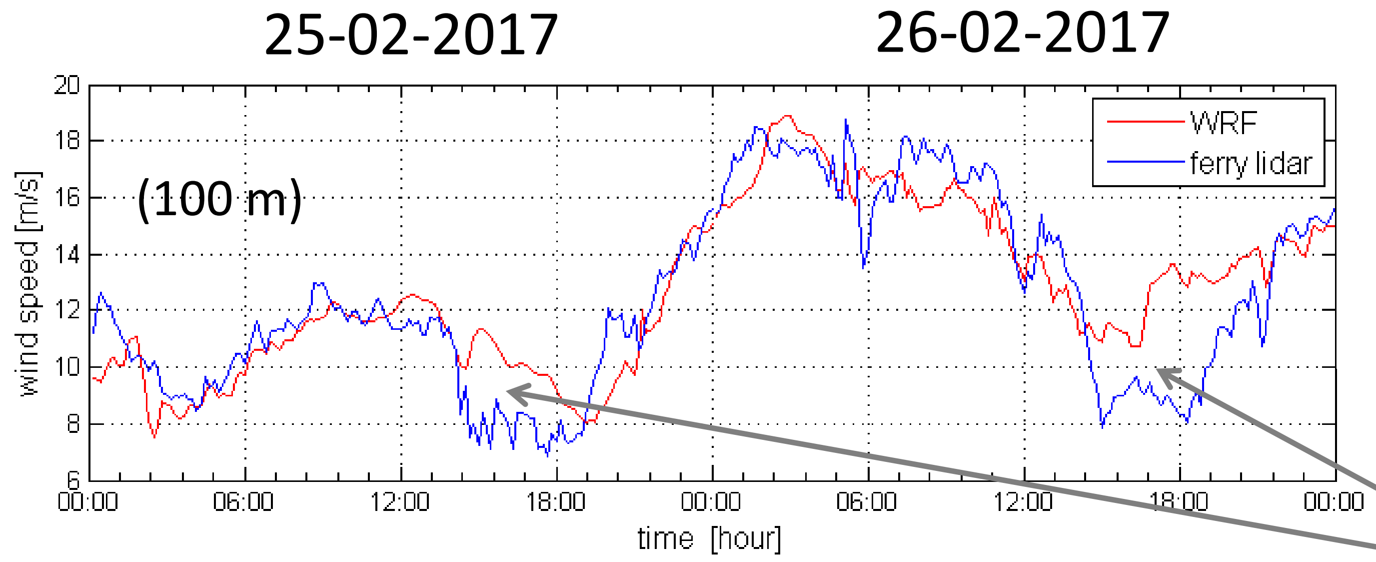
- Fraunhofer IWES Ship Lidar System installed on regular ferry travelling through the Southern Baltic Sea between Germany and Lithuania
- Measured vertical wind profiles continuously between February and June 2017

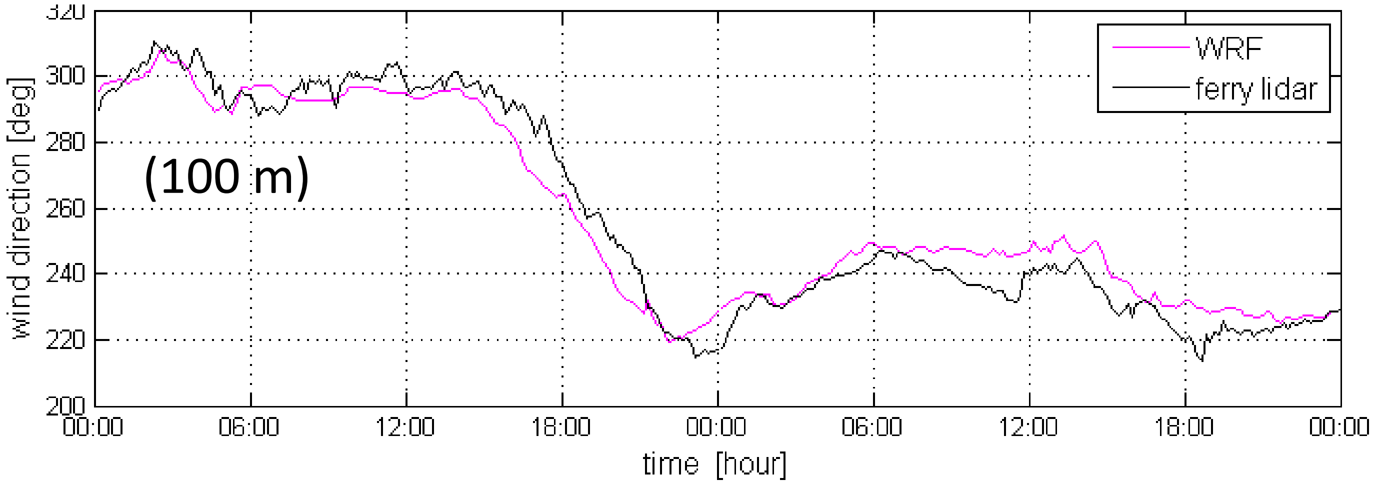
J. Gottschall et al. (2018): The NEWA Ferry Lidar Experiment: Measuring Mesoscale Winds in the Southern Baltic Sea, *Remote Sens.*, **10**, 1620

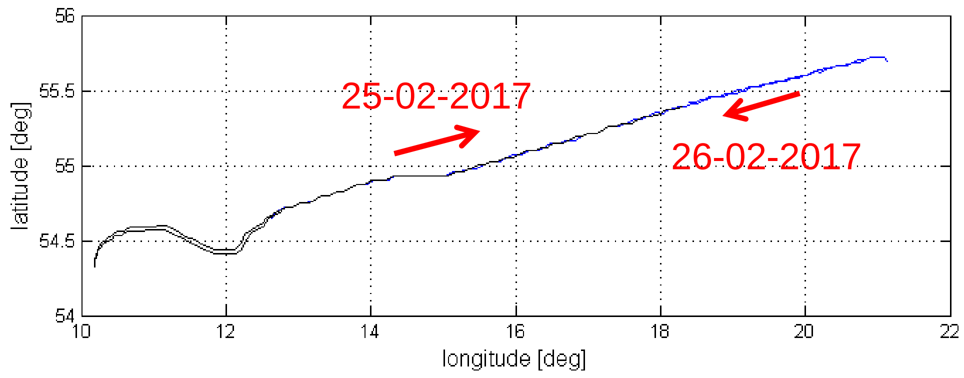




Results – initial comparison with mesoscale model data







stop in harbour
(Klaipeda, Kiel)

Ferry LiDAR Benchmark

- **Intended for mesoscale meteorological models (meso-α, meso-β scale)**
- **Objectives of the benchmark:**
  - To assess how well today's mesoscale models can reproduce the wind conditions offshore and, in particular, in the Southern Baltic Sea where quite often coastal effects are present.
  - To compare different models as well as different model setups of the same model against the measurements.
  - To gain experience with this unique kind of data (moving wind profiles) and explore its strengths and weaknesses.
- Blind test → Best practice and further setups

https://thewindvaneblog.com/the-newa-ferry-lidar-benchmark-bd79009afb26

Ferry LiDAR Benchmark

Provided data:

- Target domain (model domain can be larger):
  - South-North: 54.1°N – 56.0°N
  - West-East: 9.8°E – 21.6°E
- Minimum time period to be simulated: 6 February – 8 June 2017
- Ship path for the complete period
- Sample script for data extraction along the ship path

Output to be delivered

- Time series of wind speed, wind direction and temperature along the ship path
- Height levels: at least 100 m, if possible also: 65 m, 150 m, 200 m, 250 m
- Information about the model and the setup (model evaluation questionnaire)

Schedule

18 October 2018:	Official launch of the benchmark (Wakebench webinar)
17 December 2018:	Provided script for data extraction, final modifications
31 January 2019:	Results to be submitted
1 February 2019:	Submit abstract to WESC conference
February - April 2019:	Preliminary evaluation, discussing results with participants
30 April 2019:	Allow further submissions
May 2019:	Final evaluation, preparing WESC contribution
June 2019:	Present results at WESC
Summer/Fall 2019:	Prepare publication

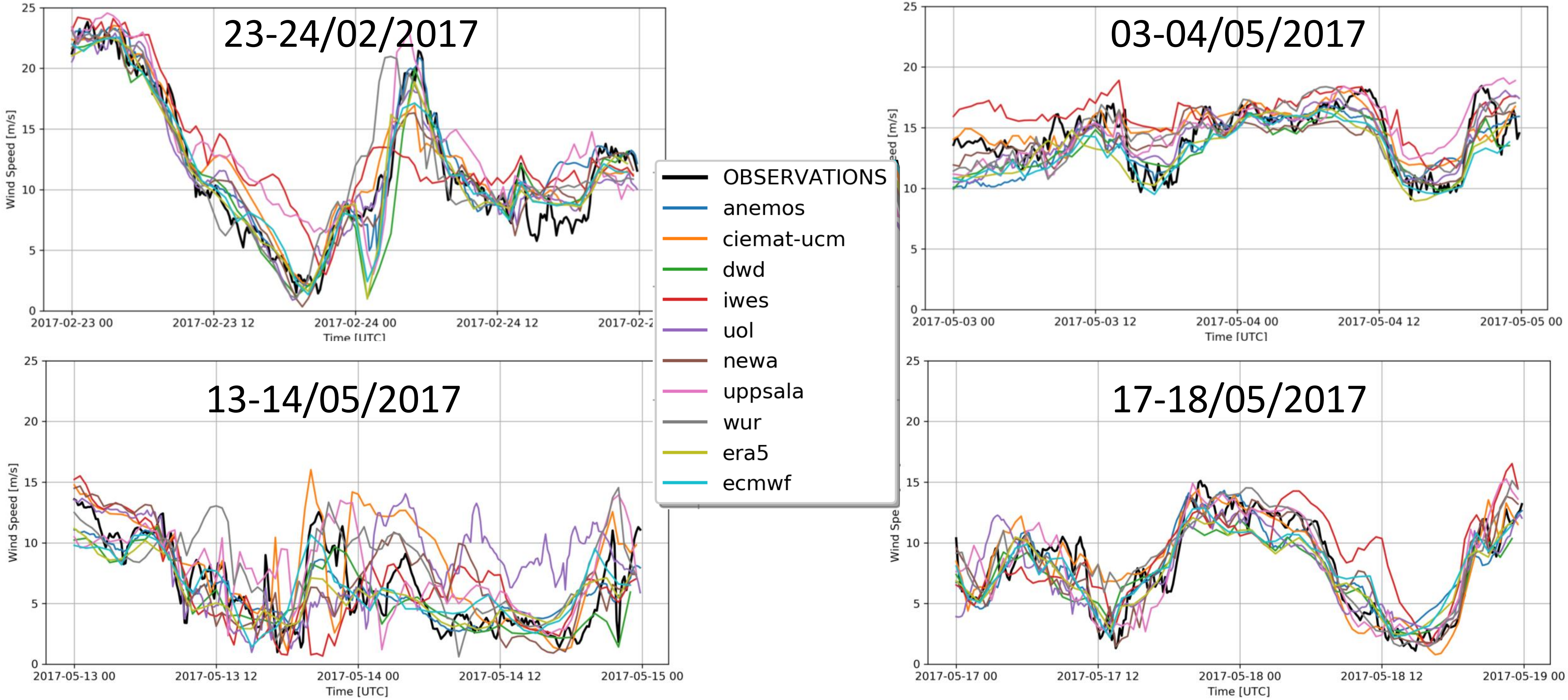
Ferry LiDAR Benchmark - participants

Anemos GmbH	Martin Schneider	D	WRF, data from 4 wind atlases	anemos
CIEMAT/UCM	Fidel González, Elena García, Jorge Navarro	E	WRF, continuous run	ciemat-ucm
DWD	Helmut Frank	D	ICON-EU forecasts, diff. lead times	dwd
Fraunhofer IWES	Martin Dörenkämper	D	WRF: offshore setup	iwes
ForWind/Uni OL	Björn Witha	D	WRF: NEWA production run	Newa
“	“	“	WRF: offshore setup	Uol
Uppsala University	Nina Svensson, Erik Sahlée	S	WRF: Baltic Sea setup	Uppsala
Wageningen University & Research	Gert-Jan Steeneveld	NL	WRF	wur
			ECMWF IFS 12 h forecast	ecmwf
			ERA5 reanalysis data	era5

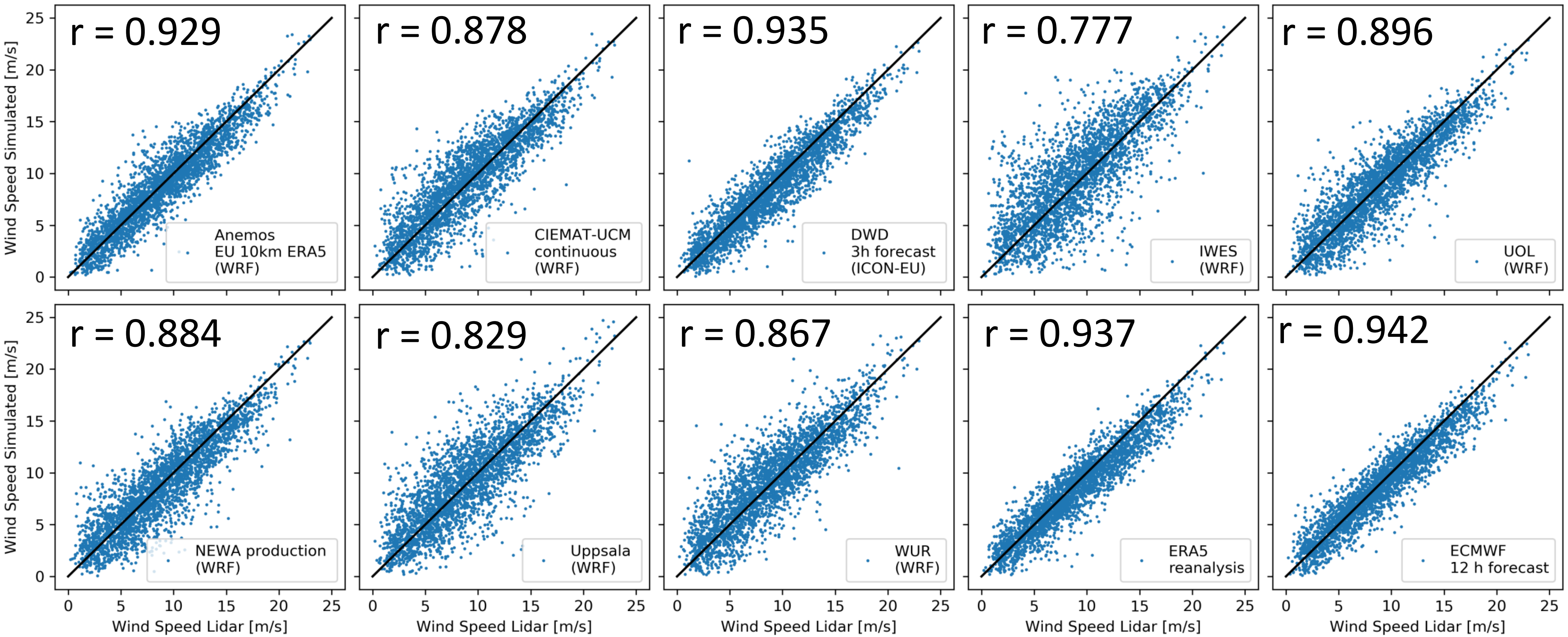
Ferry LiDAR Benchmark – model setups

participant	model (version)	resolution	dyn. forcing	SST	PBL-SL	sim. Length
anemos	WRF 3.7.1	10 km	ERA5	ERA5	YSU-MO	continuous
ciemat-ucm	WRF 3.6.1 mod.	3 km	ERA5	OSTIA	MYNN-MYNN	continuous
dwd	ICON-EU 3 h forecast	6.5 km	ICON	NCEP	Raschendorfer-Raschendorfer	3 h
iwes	WRF 3.6.1	2.1 km	MERRA2	OSTIA	MYNN2-MYNN	10 d (+24h)
newa	WRF 3.8.1 mod.	3 km	ERA5	OSTIA	MYNN-MYNN	7 d (+24h)
uol	WRF 3.8.1 mod.	3 km	ERA5	OSTIA	MYNN-MO	7 d (+24h)
uppsala	WRF 3.8.1	3 km	ERA-Interim	ERA-Interim	MYNN2-MYNN	1 d (+12h)
wur	WRF 3.9.1.1	3 km	ECMWF oper	ECMWF oper	MYNN-MYNN	1 d (+24h)
ecmwf	IFS 12 h forecast	~11 km				12 h
era5	ERA5 reanalysis	~30 km				

Wind speed time series



Wind speed, 100 m height – 1 h sample



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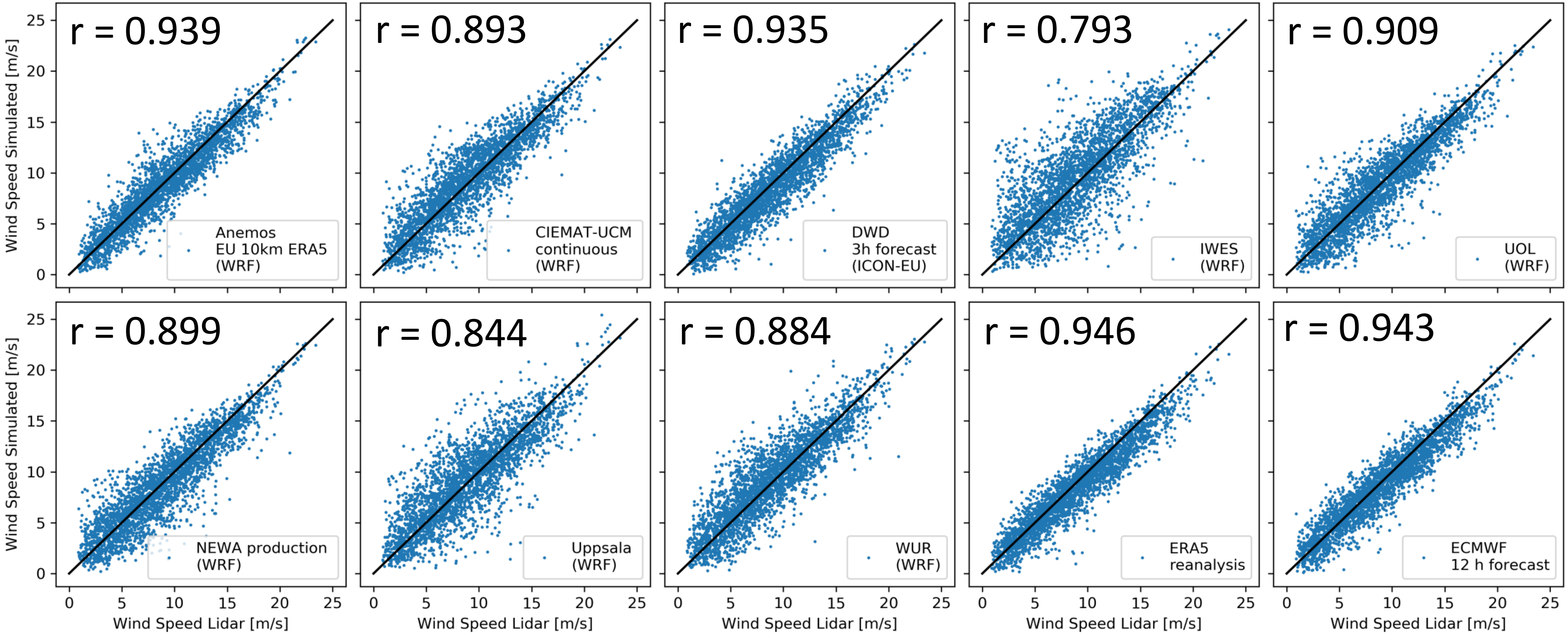
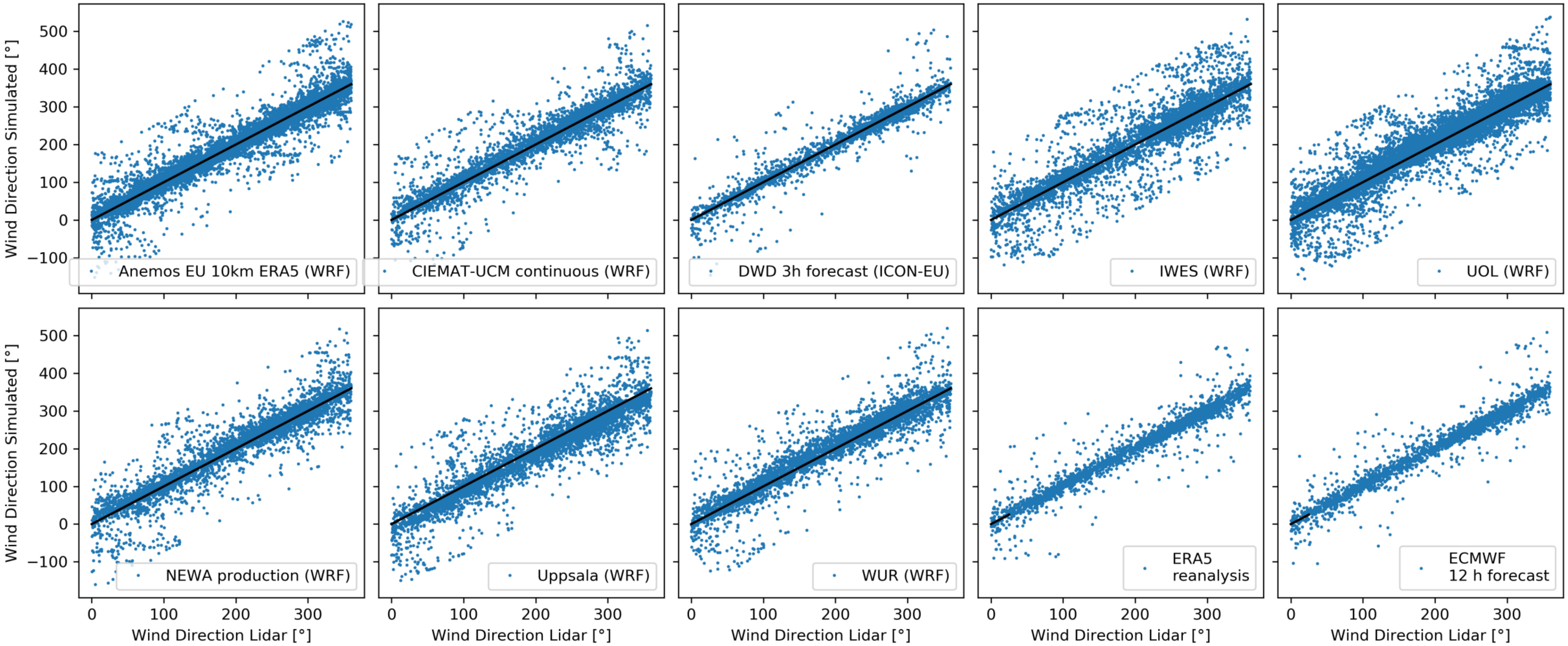
Wind speed, 100 m height – 1 h mean*



* All datasets except DWD, ERA5 and ECMWF which are hourly data

Wind direction, 100 m height



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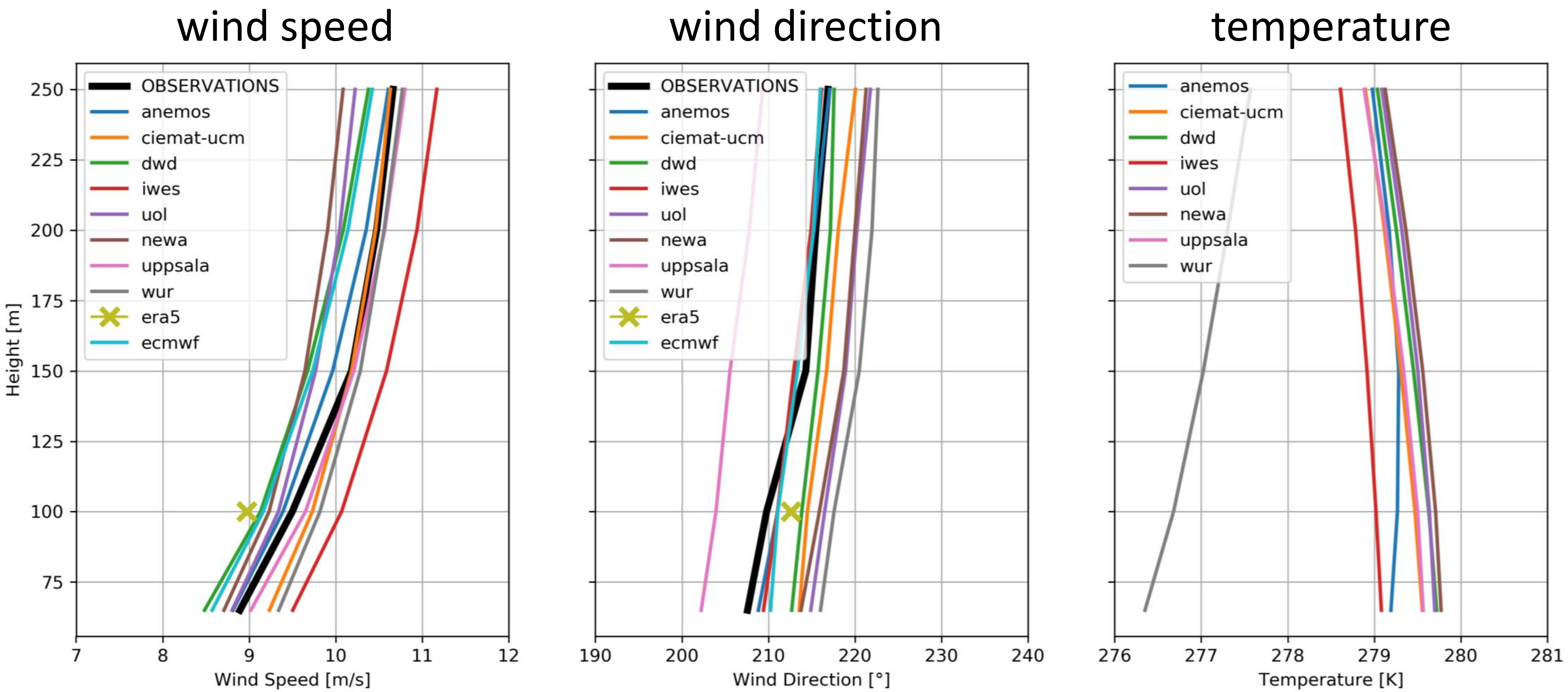
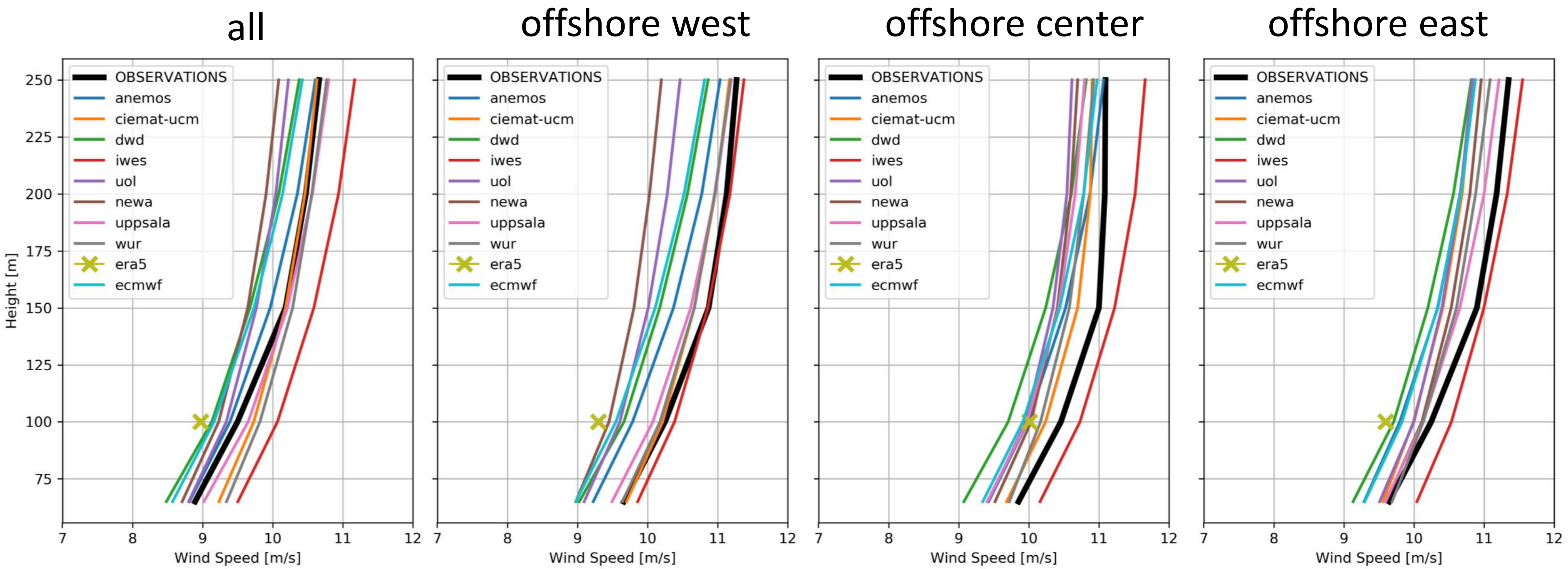
Average vertical profiles (all data)



- Average profiles are well reproduced by the models

Vertical profiles – wind speed



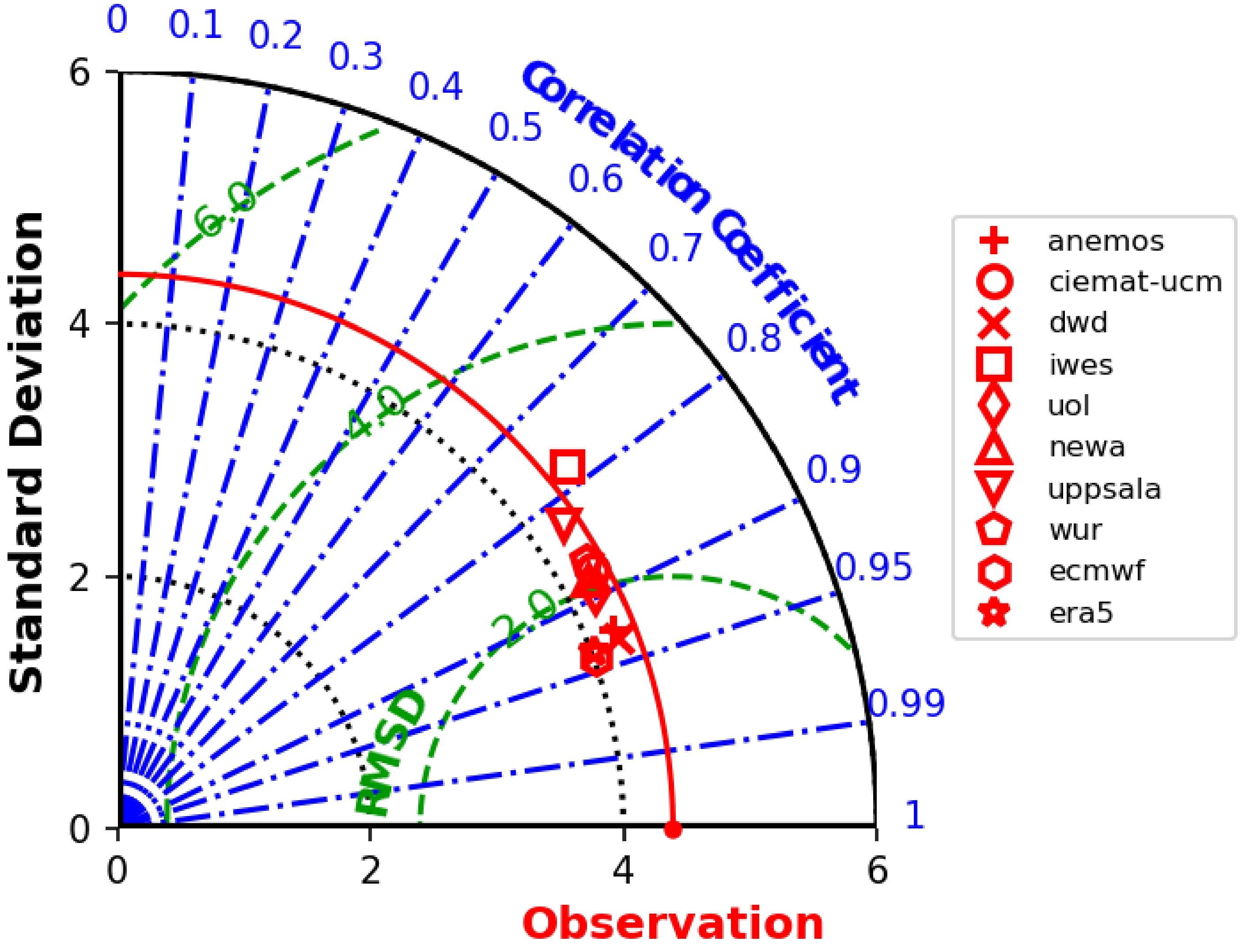
- Average profiles are well reproduced by the models – models have often less bias than ERA5
- Model spread decreases from west to east

Correlation for different parts of the ship route (ws100)

Model	Complete route	Offshore (10.3°E – 21.0°E)	West (10.3°E – 13.8°E)	Center (13.8°E – 17.5°E)	East (17.5°E – 21.0°E)
anemos	0.928	0.950	**0.951**	0.950	0.947
ciemat-ucm	0.878	0.894	**0.904**	0.880	0.897
dwd	0.935	0.945	**0.953**	0.942	0.939
iwes	0.778	0.783	0.785	0.768	**0.797**
uol	0.895	0.909	**0.917**	0.910	0.900
newa	0.883	0.892	**0.902**	0.892	0.887
uppsala	0.827	0.850	0.848	**0.884**	0.819
wur	0.868	0.894	0.890	0.893	**0.901**
ecmwf	0.941	0.949	**0.957**	0.952	0.936
era5	0.937	0.944	**0.946**	**0.946**	0.944

- Generally offshore better results and for most models in the western part
- Some models are best in the center or the eastern part

Taylor diagram



- Models and observations have a very similar standard deviation (4 – 4.5 m/s)
- Correlation mostly between 0.8 and 0.95
- RMSE between 1.5 and 3.0 m/s
- Reanalysis and forecast data superior in terms of RMSE and correlation
- WRF captures variability slightly better

Conclusions / Outlook

- NEWA Ferry Lidar Experiment has provided a valuable validation dataset for mesoscale model data offshore
- Benchmark for mesoscale models, comparison with lidar data:
  - Models perform all well, some very well
  - Regional differences (western vs. eastern part of route)
  - Reanalysis and forecasts are superior in terms of correlation and RMSE, but WRF captures variability slightly better

Further evaluation:

- Calculate wind power density for certain regions
- Filter for stability
- Evaluate statistics for certain periods or even daily, identify periods of strong/weak correlation
- Investigate Low Level Jets – statistics and case studies

→ **Paper planned**

Acknowledgements

NEW EUROPEAN WIND ATLAS
newa

We have used ERA5 data, downloaded from ECWMF and Copernicus Climate Change Service Climate Data Store (CDS)

We acknowledge PRACE for awarding us access to MareNostrum at Barcelona Supercomputing Center (BSC), Spain

Supported by:
Federal Ministry for Economic Affairs and Energy
on the basis of a decision by the German Bundestag

Part of the simulations were performed on the HPC Cluster EDDY at the University of Oldenburg, funded by the German Federal Ministry for Economic Affairs and Energy under grant number 0324005

APPENDIX

Wind speed, correlations with height

model	ws65	ws100	ws150	ws200	ws250
anemos	0.920	0.928	0.940	0.946	0.942
ciemat	0.868	0.878	0.891	0.899	0.909
dwd	0.926	0.935	0.949	0.955	0.959
iwes	0.773	0.778	0.785	0.792	0.807
uol	0.889	0.895	0.906	0.912	0.917
newa	0.878	0.883	0.892	0.896	0.902
uppsala	0.820	0.827	0.843	0.851	0.874

Limitation to offshore areas (ws100)

model	All data	Offshore only
anemos	0.928	0.950
ciemat	0.878	0.893
dwd	0.935	0.945
iwes	0.778	0.782
uol	0.895	0.910
newa	0.883	0.893
uppsala	0.827	0.852