A one-year comparison of new wind atlases over the North Sea

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What is the presentation about?

(Climatological) Wind atlas:

Database containing wind speed and direction at specific height(s) over a long period (e.g. 30 years) in a given region.

Examples:

- ERA5 Reanalysis: 31 km horizontal resolution, 1-h time resolution, World
- NEWA: 3 km horizontal resolution , 30-min time resolution, Europe
- NORA3: 3 km horizontal resolution , 1-h time resolution, northern Europe

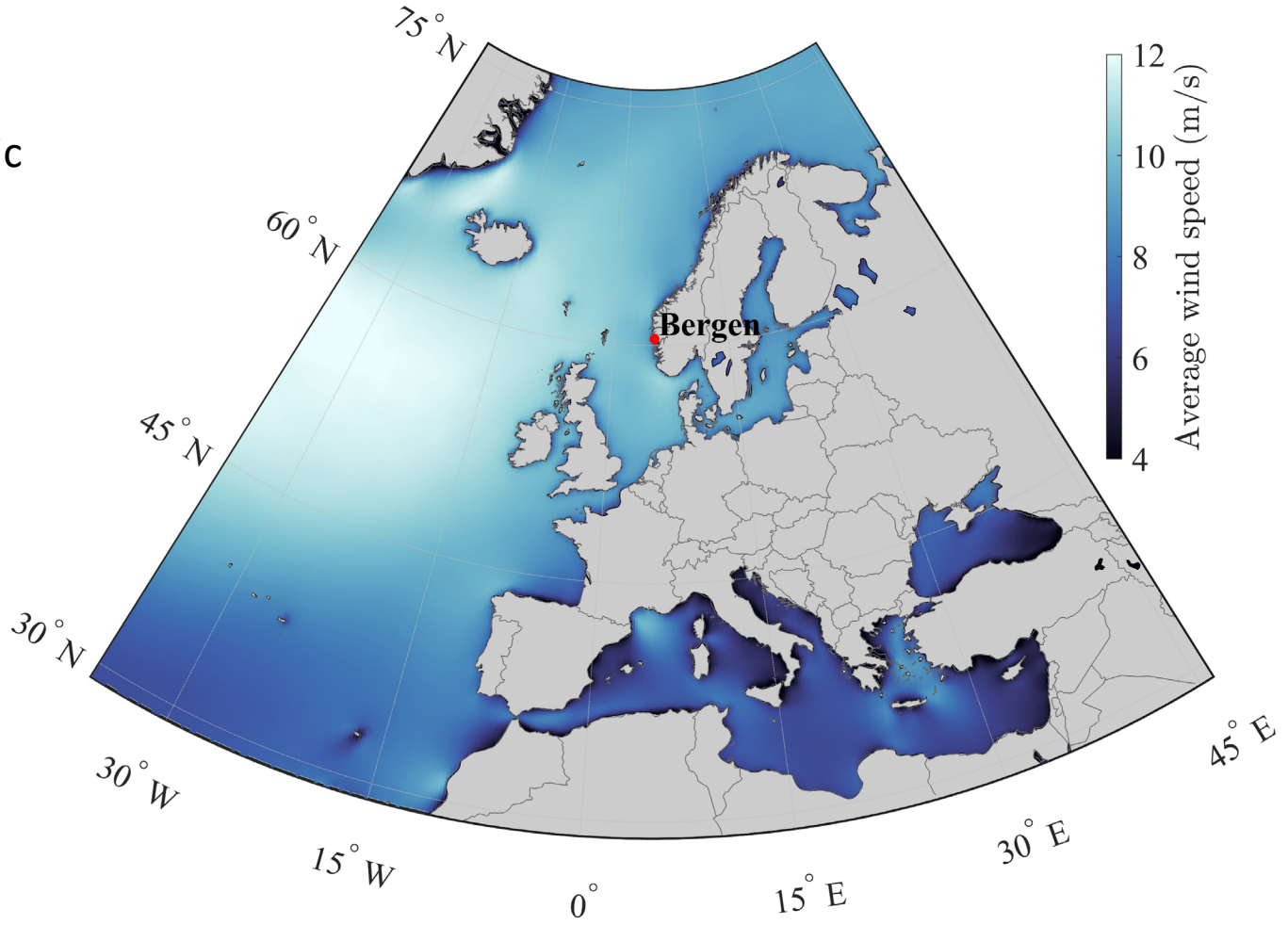


Figure: Hourly mean wind speed at 100 m above sea level (asl) from ERA5, between 2010 and 2020

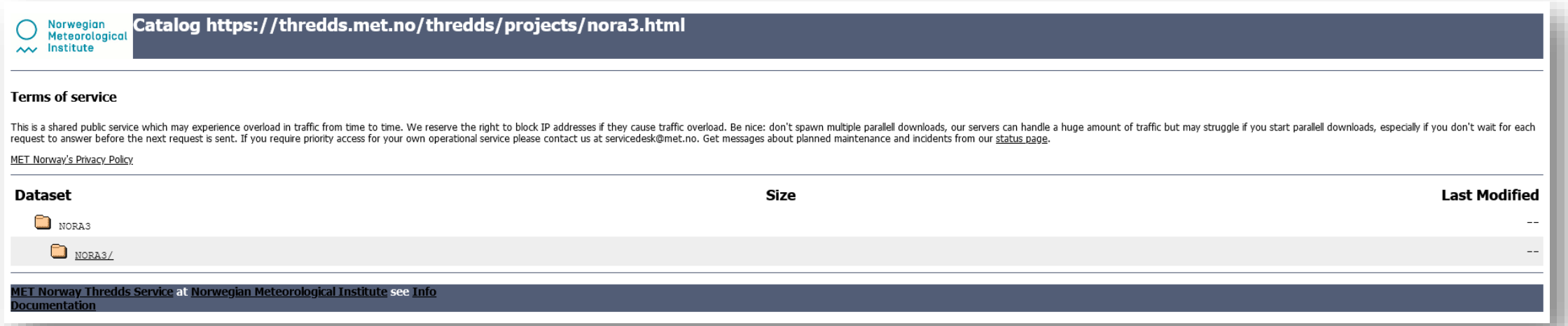
Objective

To assess the performances of NORA3 and NEWA
in a case study (FINO1 in 2009)

Impact & applications

Wind Resource assessment
+
Wind turbine design

NORA3 & NEWA databases are open-access



Norwegian Meteorological Institute

Catalog https://thredds.met.no/thredds/projects/nora3.html

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Dataset	Size	Last Modified
NORA3		--
NORA3/		--

MET Norway Thredds Service at Norwegian Meteorological Institute see Info
Documentation

OPeNDAP

Contents of /newa/

Name	Last Modified	Size	DAP Response Links	Dataset Viewers
NEWA_MESOSCALE_ATLAS/	2019-07-03T10:37:46GMT	-	- - - - - - -	

THREDDS Catalog XML

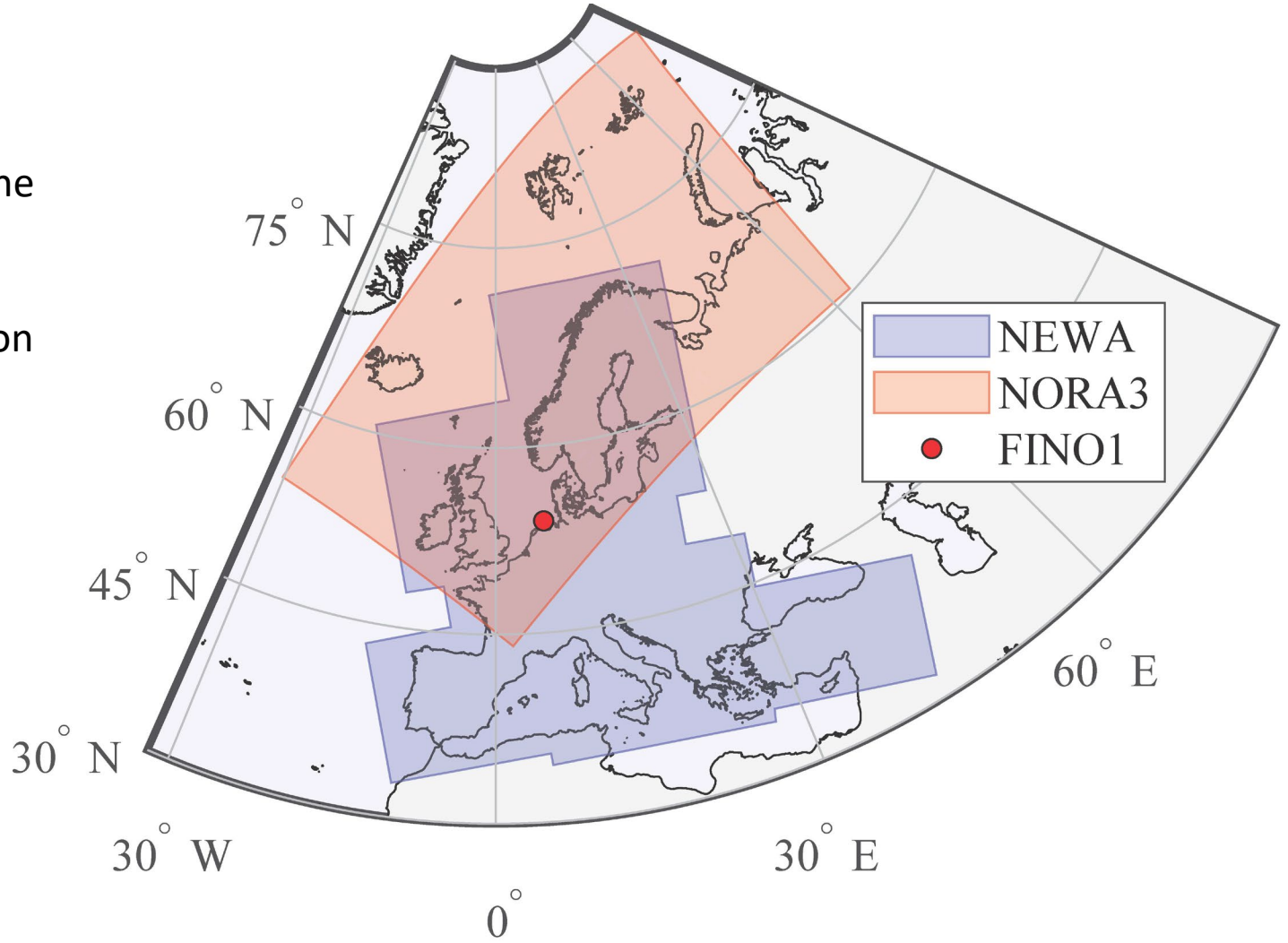
Hyrax development sponsored by NSF , NASA , and NOAA

OPeNDAP Hyrax (1.16.0)
Documentation

Questions? Contact Support

NORA3 & NEWA in details

- **Both** are derived from ERA5 reanalysis.
- **The New European Wind atlas (NEWA)** relies on the WRF model (no data assimilation) [1,2].
- **The NORwegian hindcast Archive (NORA3)** relies on HARMONIE-AROME (data assimilation of 2 m temperature and relative humidity [3].



[1] Hahmann, A. N., Sīle, T., Witha, B., Davis, N. N., Dörenkämper, M., Ezber, Y., ... & Söderberg, S. (2020). The making of the new european wind atlas–part 1: Model sensitivity. *Geoscientific model development*, *13*(10), 5053-5078.

[2] Dörenkämper, M., Olsen, B. T., Witha, B., Hahmann, A. N., Davis, N. N., Barcons, J., ... & Mann, J. (2020). The making of the new european wind atlas–part 2: Production and evaluation. *Geoscientific model development*, *13*(10), 5079-5102.

[3] Haakenstad, H., Breivik, Ø., Furevik, B. R., Reistad, M., Bohlinger, P., & Aarnes, O. J. (2021). NORA3: A Nonhydrostatic High-Resolution Hindcast of the North Sea, the Norwegian Sea, and the Barents Sea. *Journal of Applied Meteorology and Climatology*, *60*(10), 1443-1464.

Reference data from the offshore platform FINO1

Sensors selected:

Cup anemometer at 101 m

Wind vane at 91 m

Thermometer at 101 m

Year selected:

2009 (>8000 samples of 1h duration)

Metrics used to compare the datasets

Pearson correlation coefficient R^2 → Measures the linear correlation

Bias → Measures the systematic error

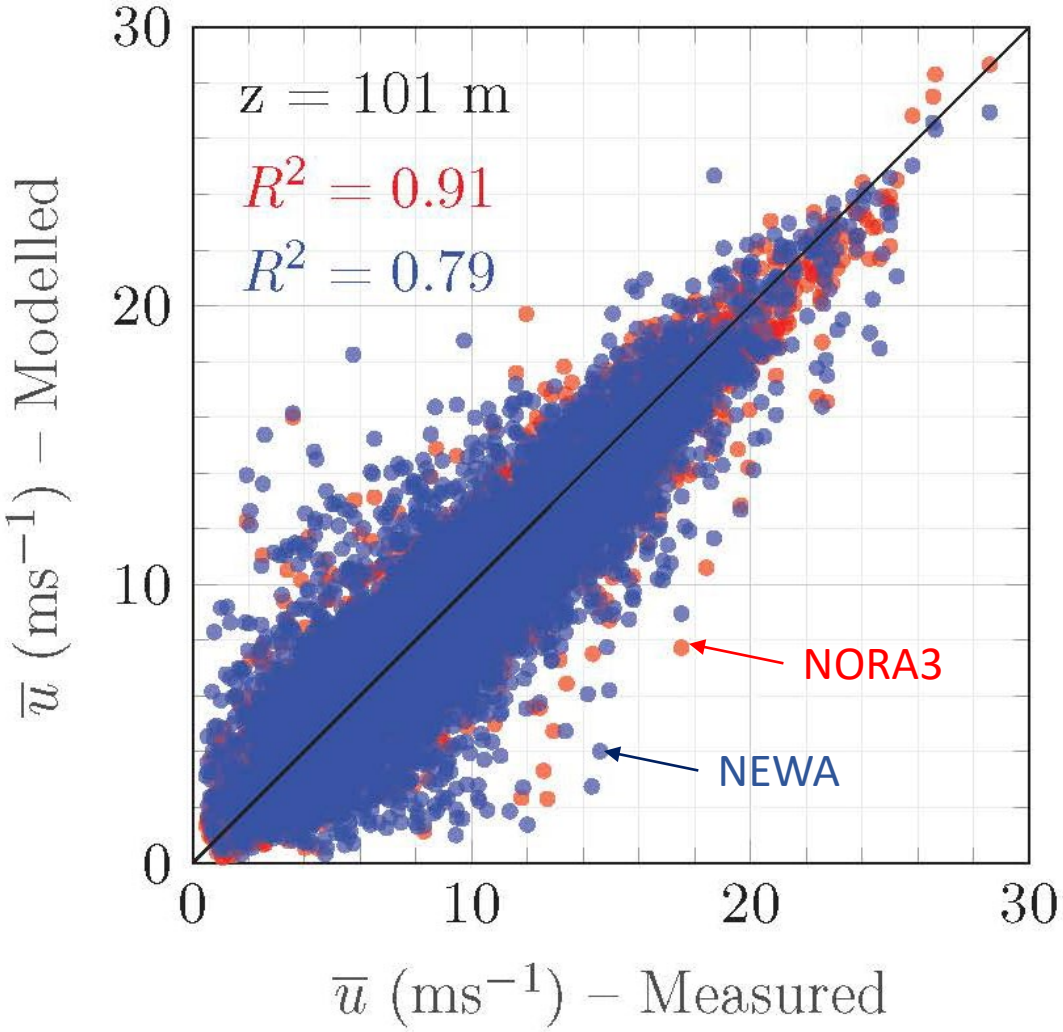
Root-mean square error (RMSE) → Measures the dispersion

They complement each other

Earth's mover distance (EMD) → Measures the distance between two probability density functions (pdfs)

Circular EMD (CEMD) → Same as EMD but for circular distributions

Mean wind speed comparison



Bias

NORA3: -0.11 ms^{-1}
NEWA: -0.31 ms^{-1}

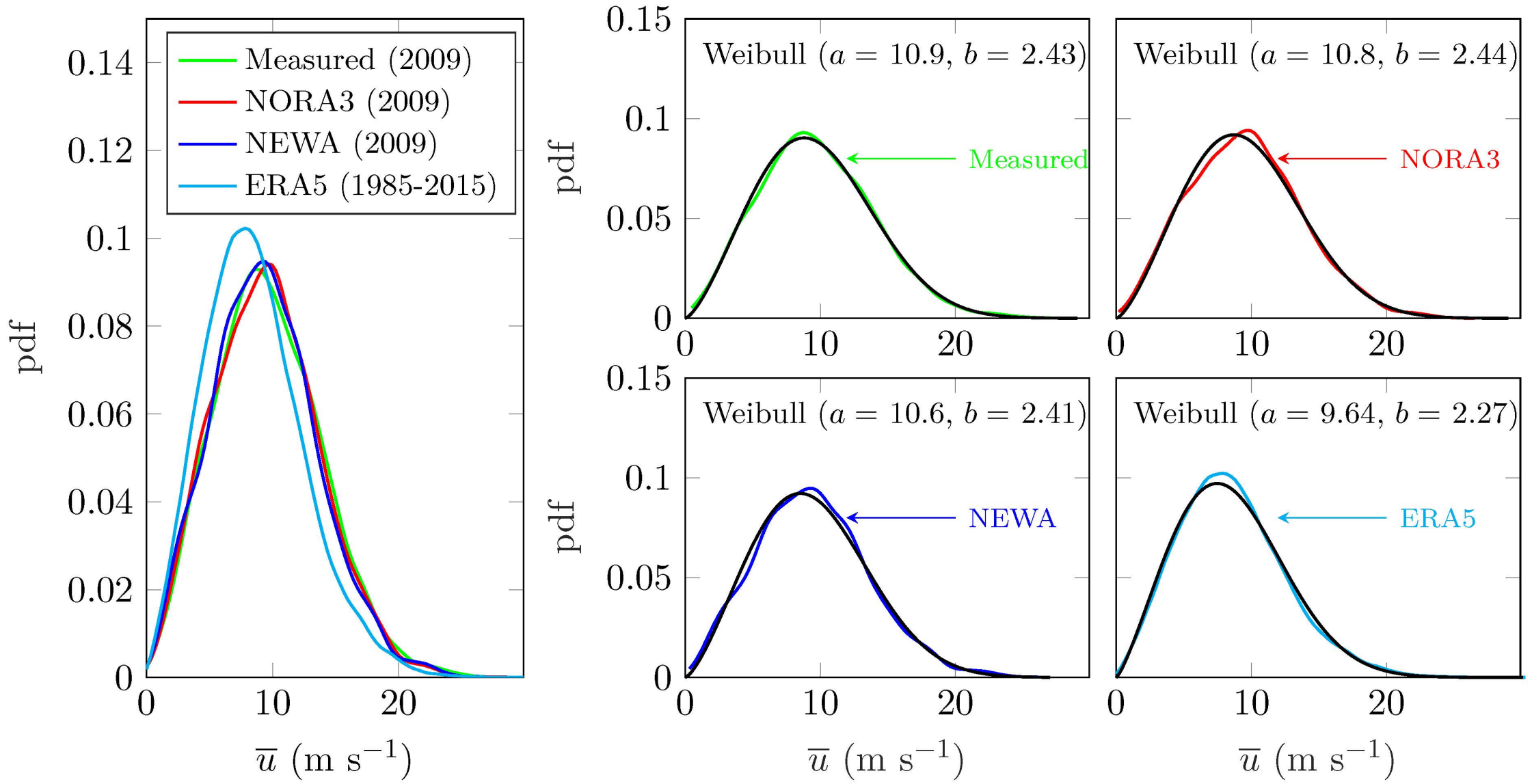
Root-mean square error (RMSE)

NORA3: 1.3 ms^{-1}
NEWA: 2.0 ms^{-1}

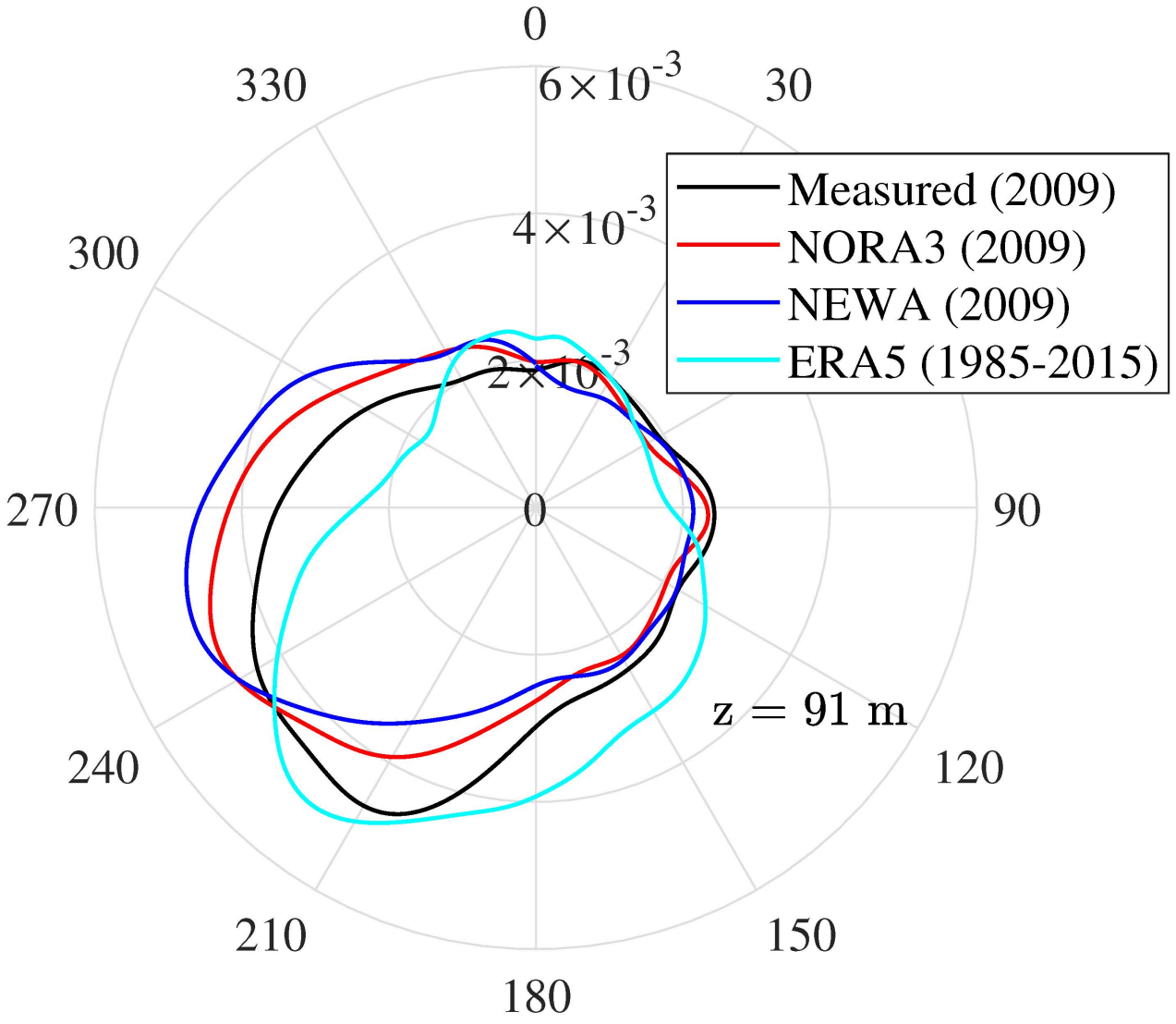
Earth's mover distance (EMD)

NORA3: 0.13 ms^{-1}
NEWA: 0.26 ms^{-1}

Mean wind speed distributions



Mean wind direction distributions

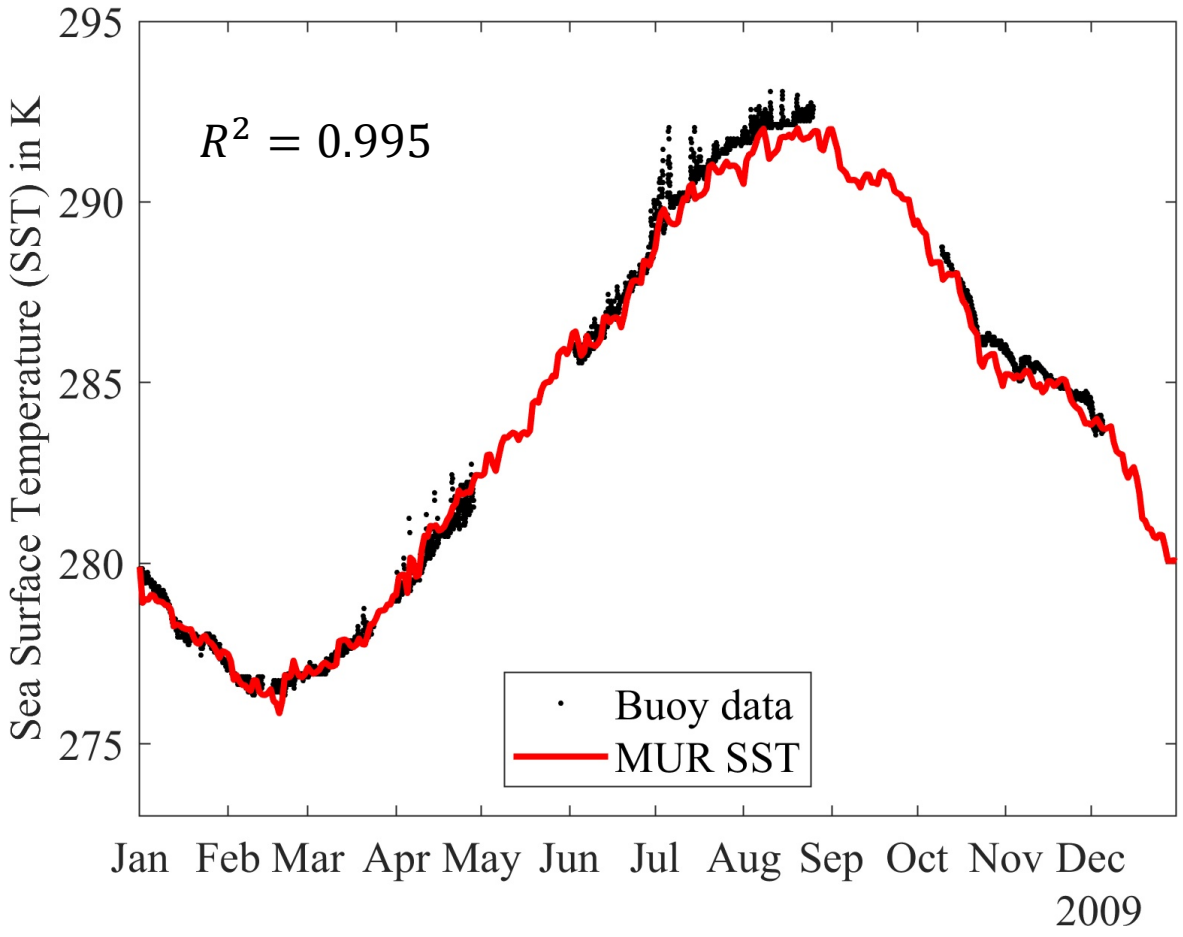


Circular earth's mover distance (CEMD)

NORA3: 5.8°
NEWA: 7.0°

Larger-than-expected deviations due to calibration bias in the wind-vane data?

Sea surface temperature (SST)

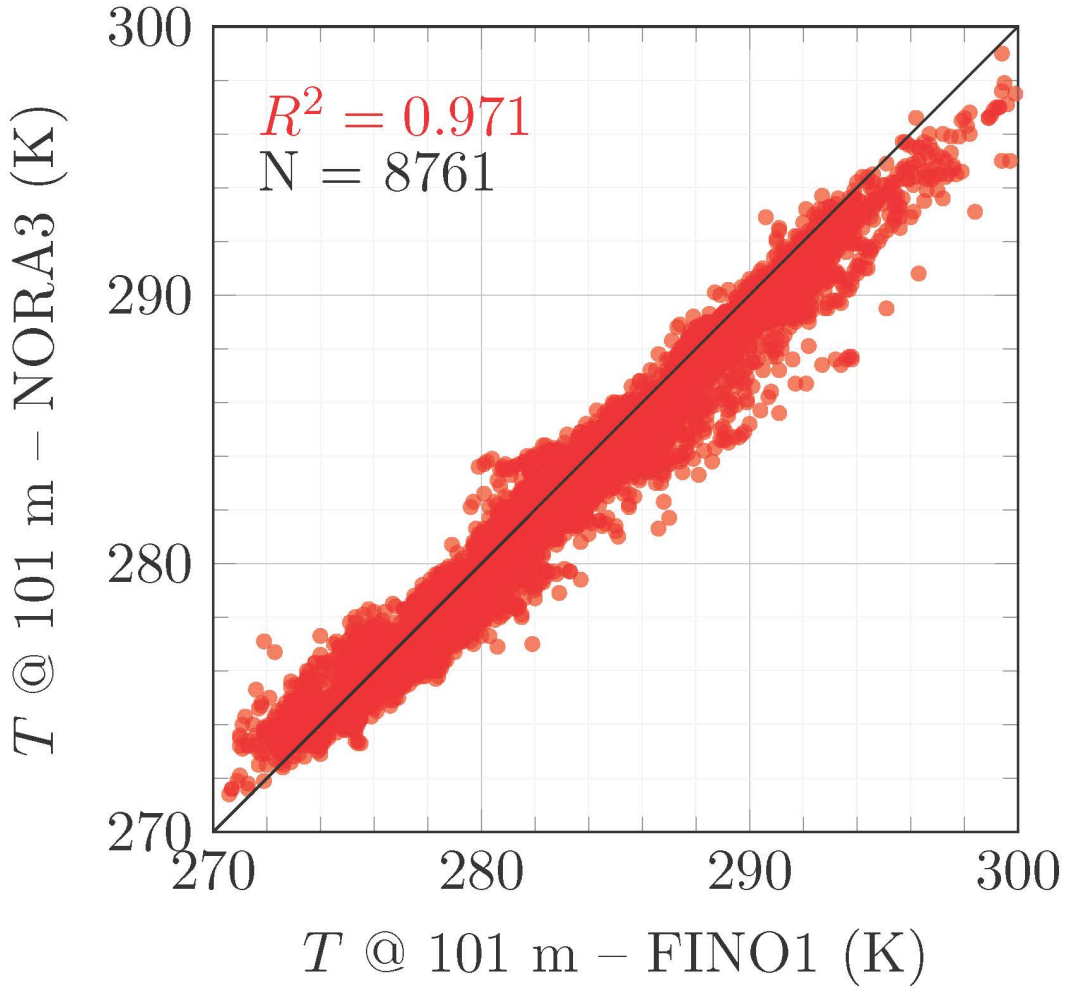


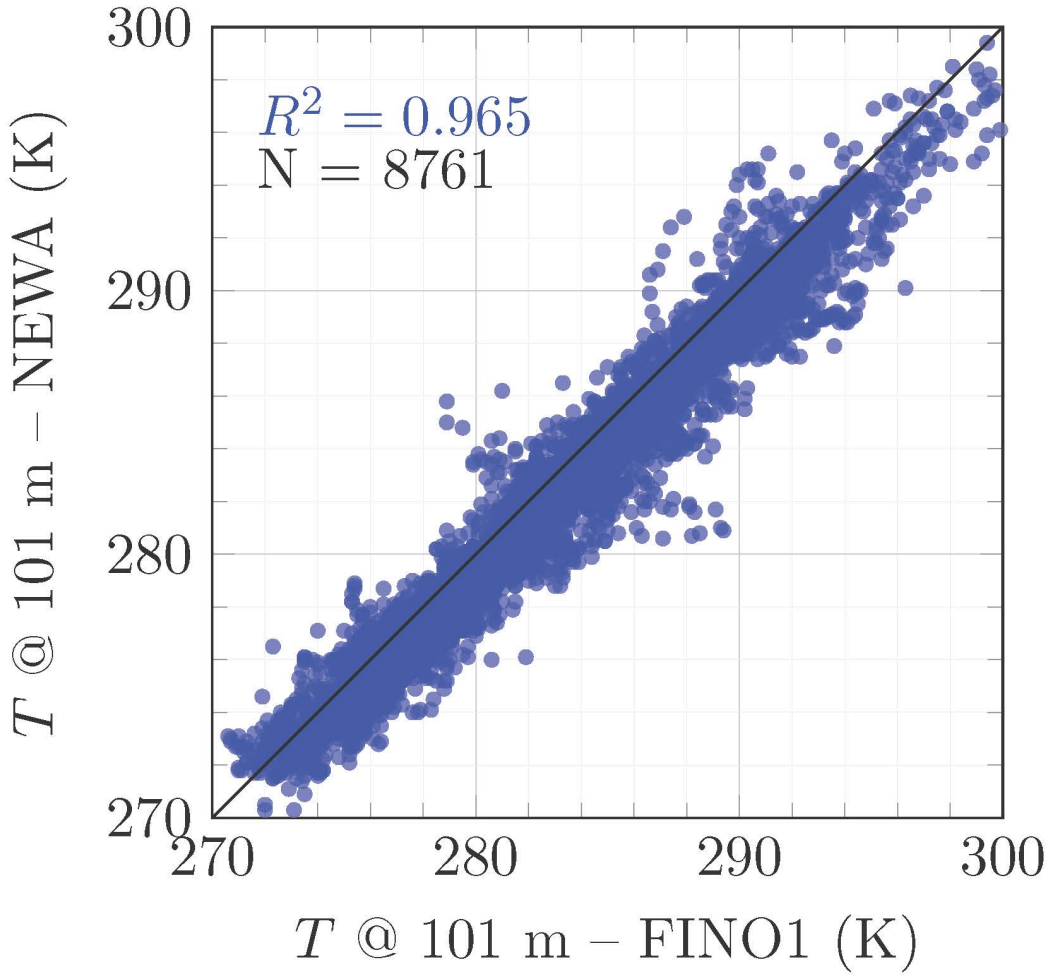
MUR SST database collected from satellite data analysis [4]. Data available since 2002.

The buoy data were collected a few hundreds meters from the FINO1 platform (limited data availability).

[4] JPL MUR MEaSUREs Project. 2015. GHRSST Level 4 MUR Global Foundation Sea Surface Temperature Analysis. Ver. 4.1. PO.DAAC, CA, USA.

Air temperature



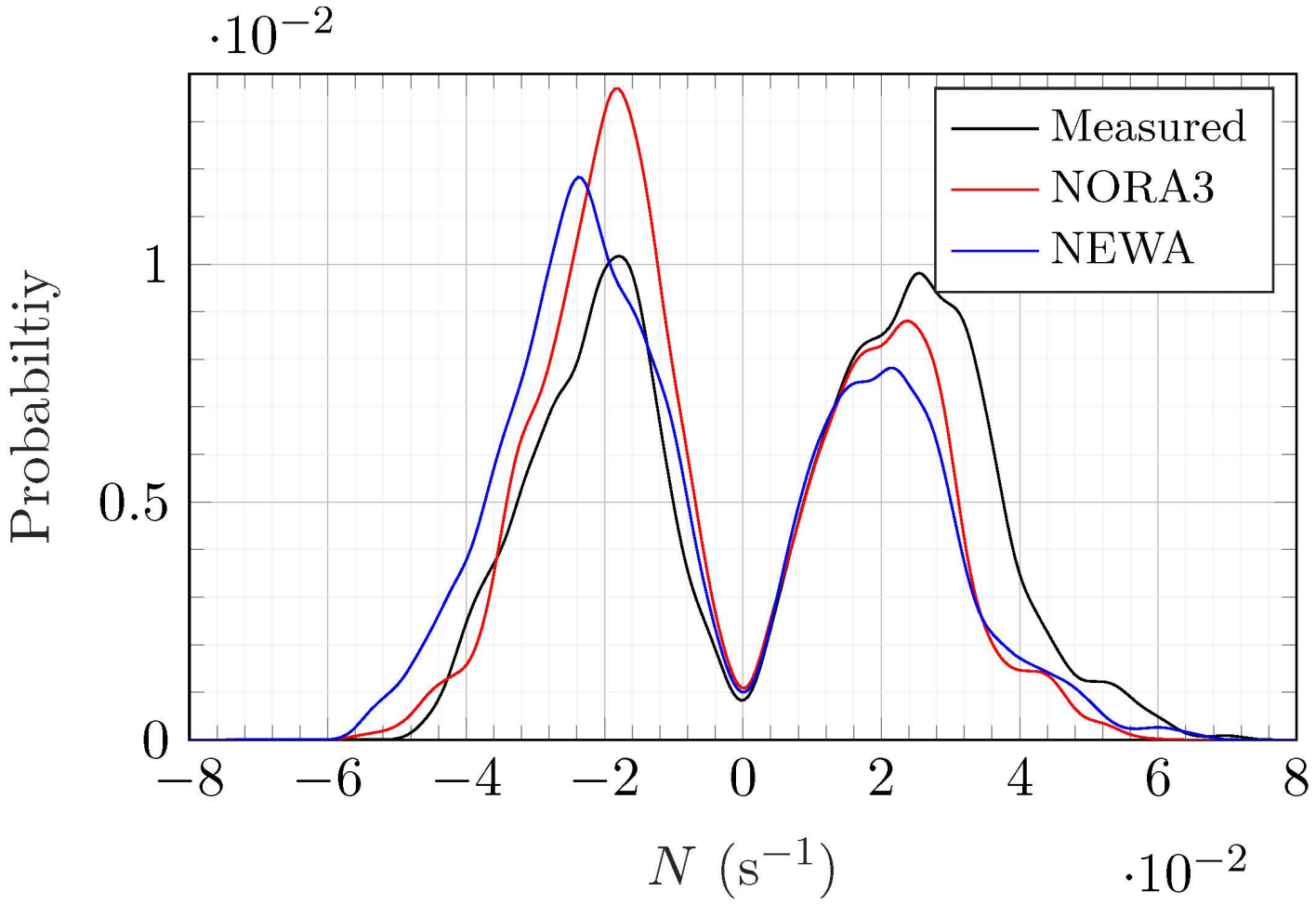


Static stability (Brunt–Väisälä frequency, N)

$$N^2 = \frac{2\,g[\theta(z_1) - \theta(z_2)]}{[\theta(z_1) + \theta(z_2)](z_1 - z_2)}$$

Here:
g = 9.81 ms^{-2}
$z_1 = 100$ m
$z_2 = 0$ m
θ(z): potential temperature at height z

Improved agreement with measured data compared to a previous study [5]



[5] Barstad, I. (2016). Offshore validation of a 3 km ERA-Interim downscaling—WRF model's performance on static stability. *Wind Energy*, *19*(3), 515-526.

Conclusions

Both NEWA and NORA3 show good performances to describe the distribution of mean wind speed and mean wind direction at FINO1 in 2009.

NORA3 slightly outperforms NEWA in terms of RMSE, bias, EMD, R^2 and CEMD

Both NEWA and NORA3 show encouraging results to characterize the static stability

Additional validation of the NORA3 database is ongoing.

See the poster Offshore wind validation of the new NORA3 hindcast data with Lidar measurements, by J.M. Diezel (UiB)

Thank you

Acknowledgments:

The Federal Maritime and Hydrographic Agency of Germany (BSH) is acknowledged for providing the FINO1 data, available at http://fino.bsh.de/. We are grateful to Dr Andrea Hahmann and Dr Bjarke Tobias Olsen for their help regarding the implementation of the circular EMD function.

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