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Photo: Kristine Gjesdal, MET Norway

Evaluation of different methods for reducing wind at oil platforms to 10 m reference height

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21.01.2020

Background for this study:

- Assimilation of measurements is a key part of modern Numerical Weather Prediction (NWP).
- Wind measurements at oil platforms are presently reduced to 10 m above sea level (a.s.l) before assimilated in MET's NWP-model.
- In this study we want to assess and improve current methods for wind speed reduction to 10 m a.s.l. and thereby increase the accuracy of the weather predictions.
- The results are applicable both to offshore wind resource assessment and short term wind energy forecasting.

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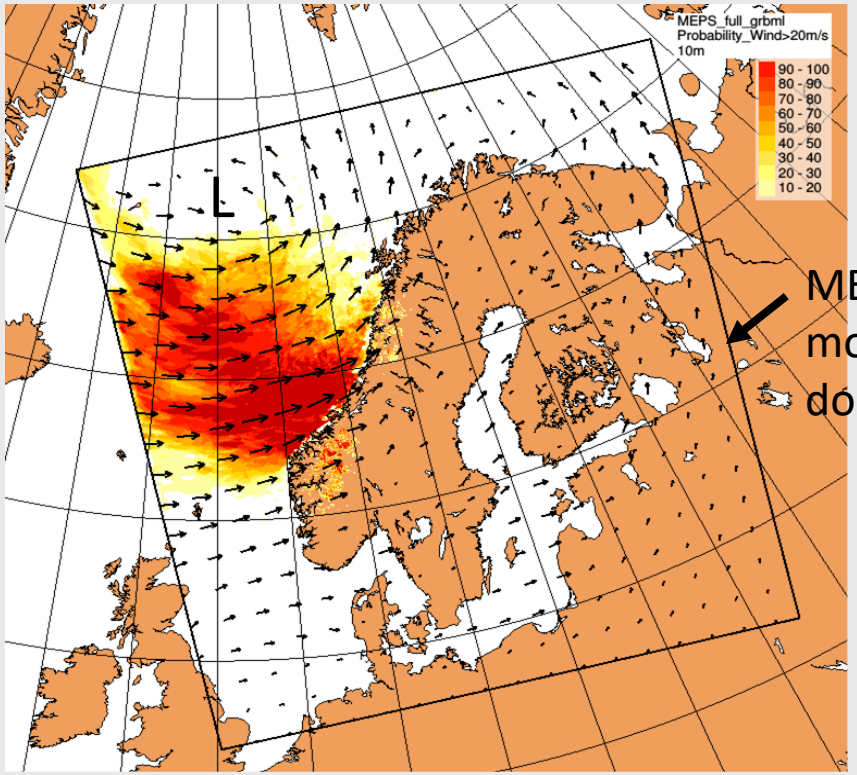
MEPS NWP-model at MET:

- MEPS
  - M-MetCoOp operational cooperation with Sweden and Finland
  - EPS-Ensemble Prediction System
- 10 ensemble members are run every 6-hour. From 4 Feb. 2020 a continuous production will provide 30 new ensemble members within a 6-hour window
- MEPS gives probability forecasts of for example wind speed (see figure)
- Data available at https://thredds.met.no

Probability of exceeding 20 m/s at 10 m a.s.l., 18 UTC 08.01.2020 given by MEPS



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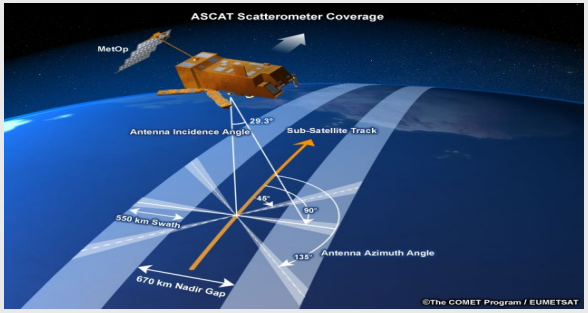
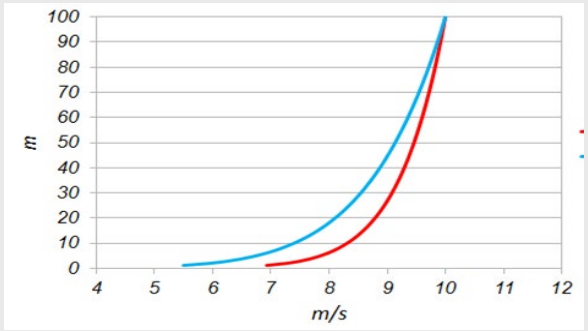
Data and methodology:

- Hourly platform observations of wind
- Screening of the quality of the wind observations and selection of the dataseries.
- Advanced Scatterometer (ASCAT) satellite data at 10 m a.s.l. for validation
- Evaluating six different wind profiles to calculate 10 m a.s.l. wind speed.





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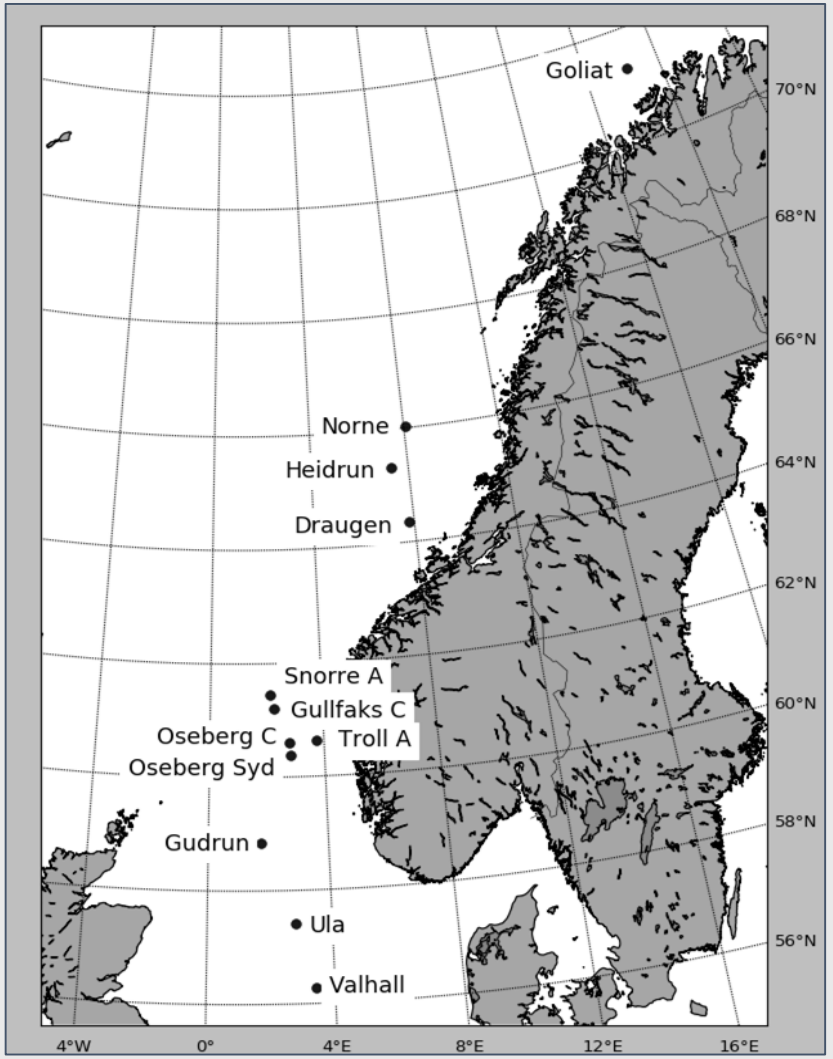
Selected platform observations:

- 12 out of 26 observations selected for this study
- Cover North Sea, Norwegian Sea, Barents Sea
- Sensor heights: 47-140 m a.s.l.

Platform	Height above sea level [m]
Draugen	78
Goliat	71
Gudrun	84
Gullfaks C	140
Heidrun	131
Norne	47
Oseberg C	120
Oseberg Syd	126
Snorre A	115
Troll A	94
Ula	111
Valhall	120



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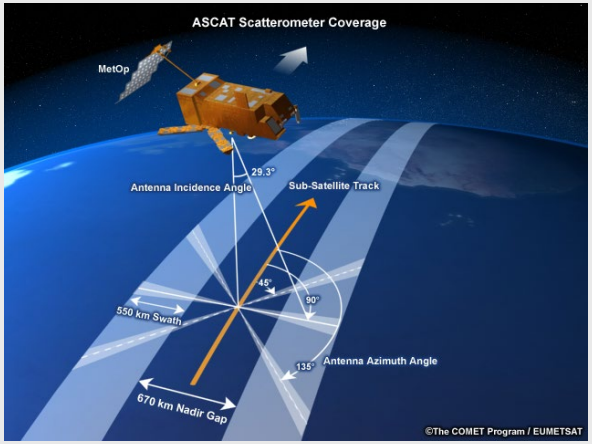
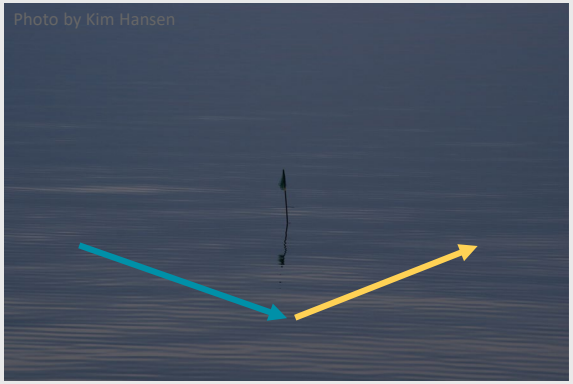
Advanced Scatterometer (ASCAT):

- Microwave radar onboard polar-orbiting satellites
- Wind speed and direction can be retrieved from the backscattered signal
- The Ocean and Sea Ice Satellite Application Facility (OSI SAF) of EUMETSAT processes the wind products from the calibrated backscatter



< 1 m/s



15 m/s

Fan beam scatterometer METOP-ASCAT

Frequency:	5.3 GHz (C-band)
Wavelength:	5 cm
Limitations:	higher wind range >30 m/s
Sampling:	12.5 - 25 km
Geometry:	static
Swath :	double (about 550 km each)

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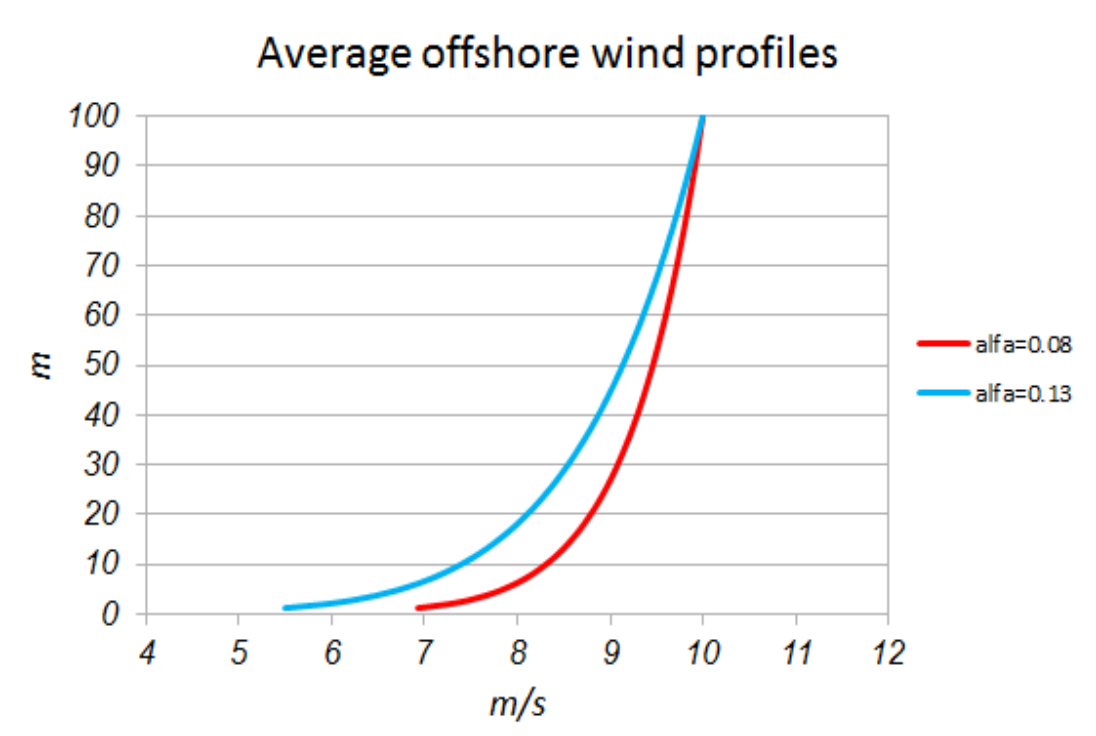
Wind profiles:

- **Power Law:**

$$U_s = U_{10}\left(\frac{h}{10}\right)^p$$

U_s - wind speed at sensor level h
U_{10} - wind speed at 10 meter height



4 different profile methods are tested:

- p = 0.13 (present method)
- p = 0.08 (typical value for neutral stability and wind speeds of 8-10 m/s).
- p dependent on stability
- p dependent on stability and wind speed

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Wind profiles continued:

- **NORSOK wind profile (Standards Norway, 2007)**. Based on the near offshore measurements at the island of Frøya.

$$U_s = U_{10}\left[1 + C\, ln\left(\frac{h}{10}\right)\right]$$
$$\text{where } C = 5.73 \times 10^{-2}\left[1 + 0.15 \times U_{10}\right]^{1/2}$$

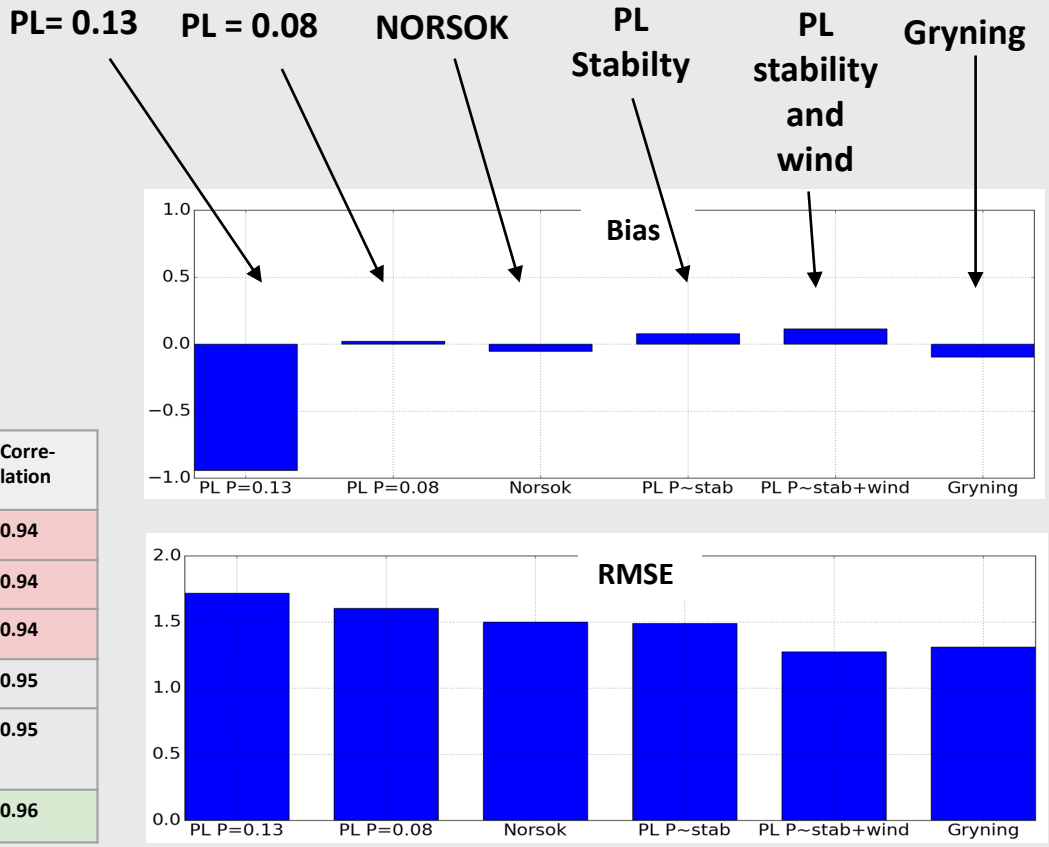
- **Gryning et al. (2007) wind profile.** Vertical wind profile method for which three length scales L_{SL}(surface), L_{MBL} (middle boundary layer) and L_{UBL} (upper boundary layer) are calculated for neutral, stable and unstable conditions.
- In addition to atmospheric stability, friction velocity, sensible heat flux and boundary layer heights are important input parameters to the scheme.
- All parameters for the Gryning method are obtained from the MEPS NWP-model.

Summary of results from all 12 platforms:

PL - Power Law

Bias - Mean Error
RMSE - Root Mean Square Error

	Bias	RMSE	MAE	Corre-lation
Power law P=0.13	-0.94	1.72	1.4	0.94
Power law P=0.08	0.02	1.60	1.22	0.94
Norsok	-0.05	1.50	1.22	0.94
Power law (P varies with stability)	0.08	1.49	1.12	0.95
Power law (P varies with stability and wind speed)	0.11	1.28	0.95	0.95
Gryning	-0.10	1.31	0.98	0.96



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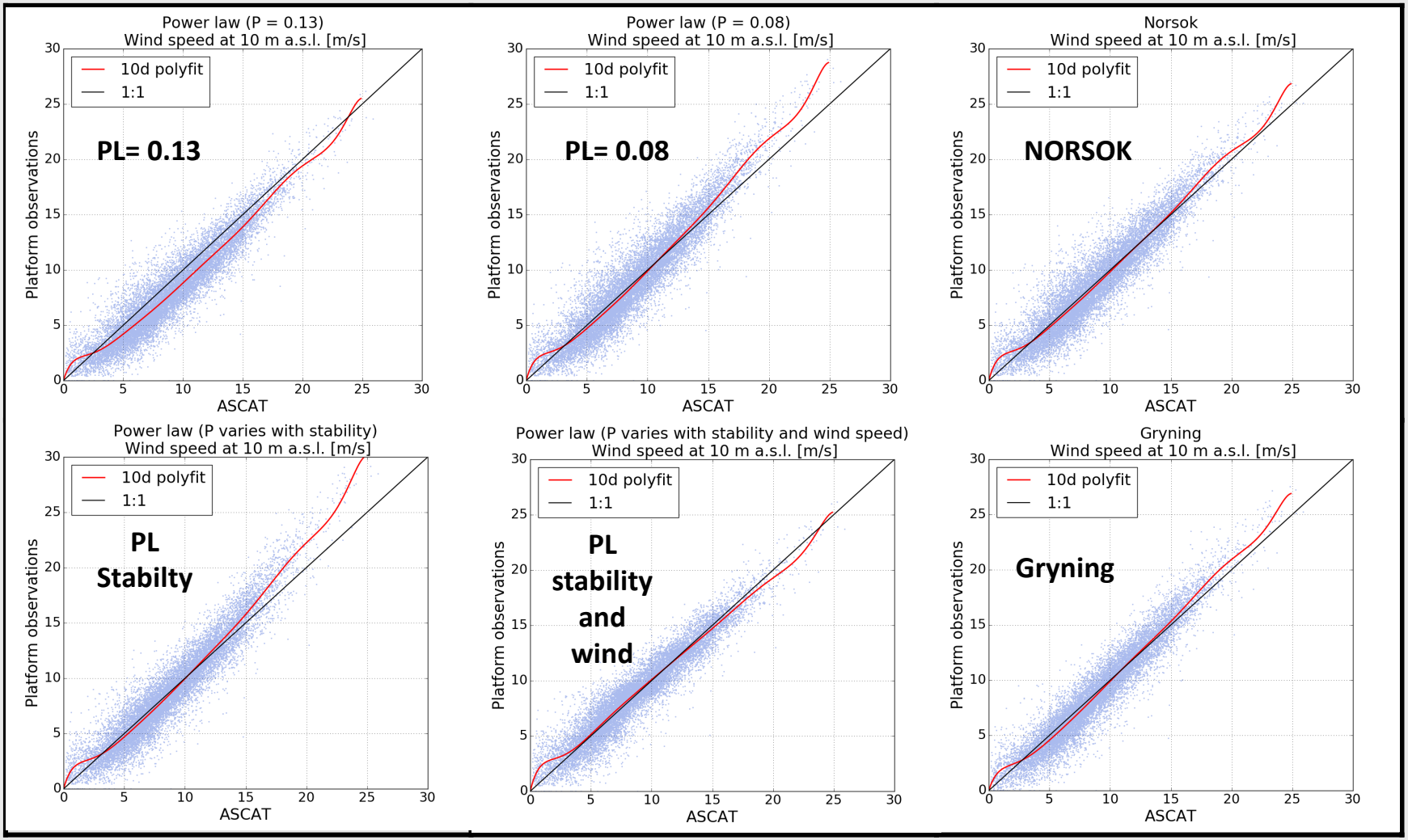
Scatter plots – all platforms:



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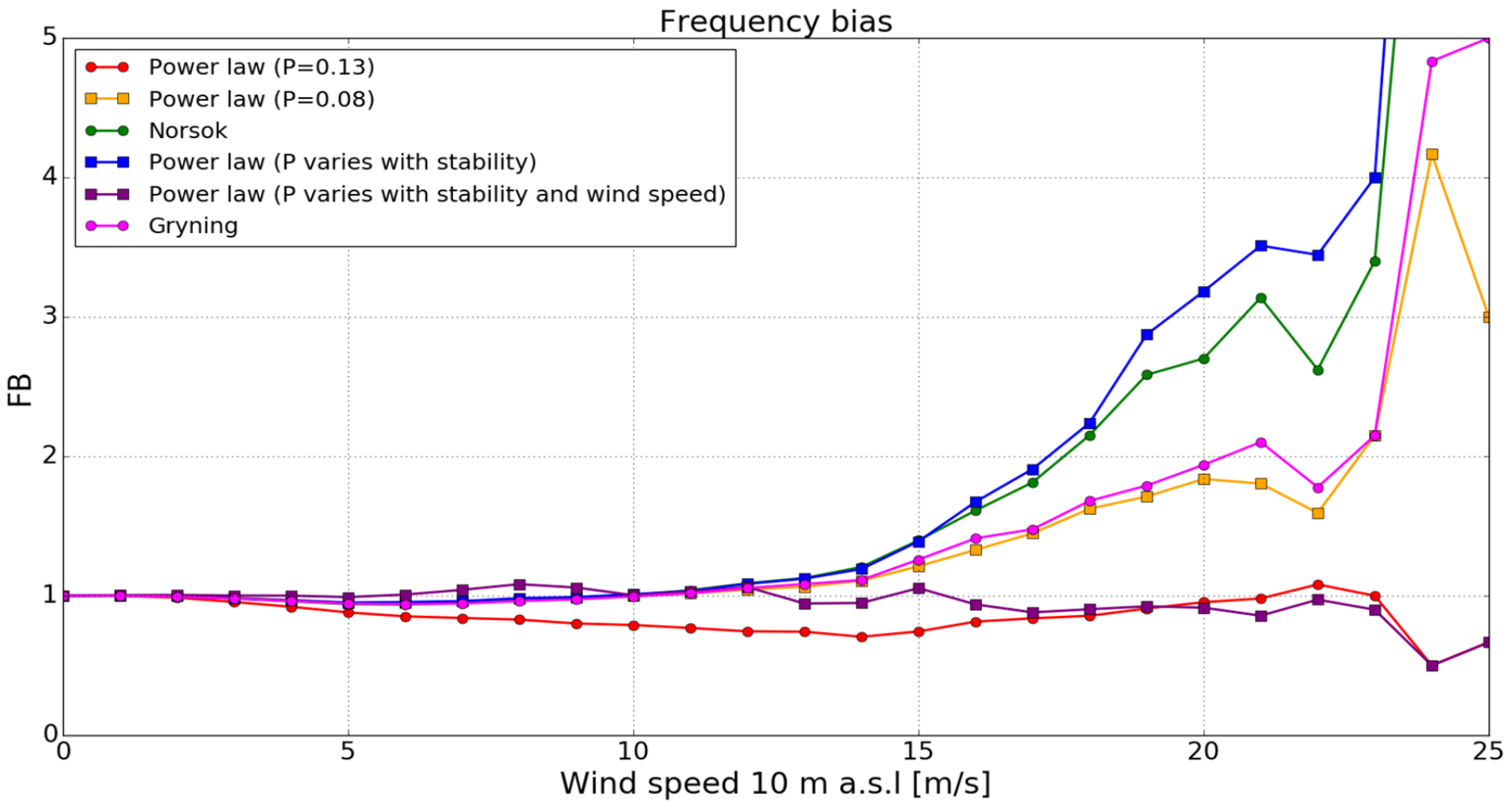
Frequency bias (FB) all platforms:

- FB > 1 occurrence overpredicted, FB < 1 occurrence underpredicted



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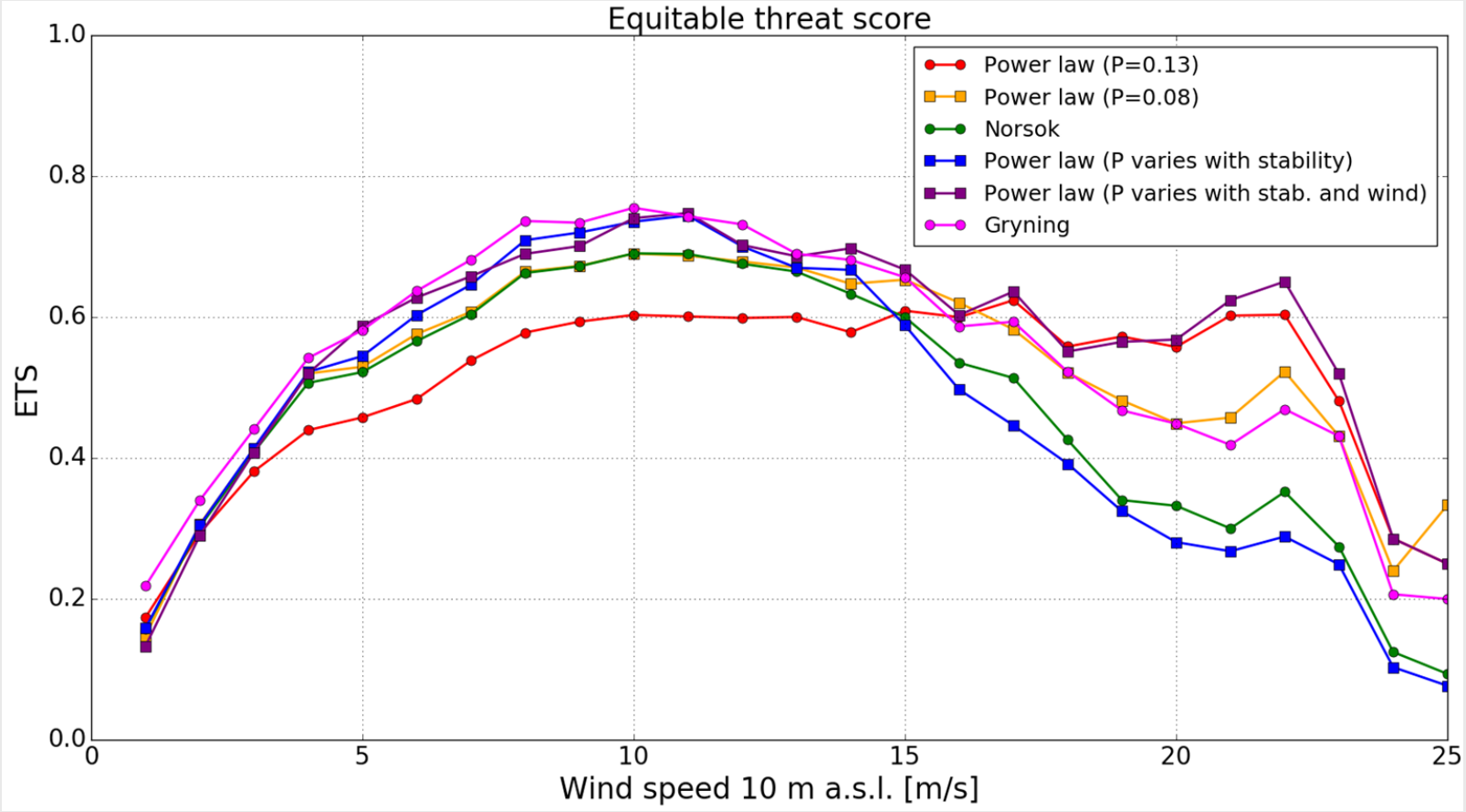
Equitable threat score (ETS) – all platforms:

- ETS = 1 perfect prediction, ETS=0 no prediction skill

Improved agreement



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Summary:

- Present wind speed reductions at Norwegian oil platforms underestimate wind speed at 10 m height. An exception is during very high wind speeds.
- An empirical derived method applying the power law with a dependence on stability and wind speed (PL-stability and wind) yields the best wind speed reduction among the 6 methods compared in this study.
- The Gryning et al. (2007) method also gives good agreement, but PL-stability and wind shows better results for wind speeds above ca. 15 m/s
- Inaccuracies in the platform observations and uncertainties in the ASCAT data may have influenced the results

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Summary :

- For offshore wind energy analysis: It is recommended to test the PL-stability and wind method further with offshore wind profile measurements from Lidars and/or offshore masts.
- For assimilation in NWP-models: It is recommended (1) to test assimilations of the 10 m level data after applying the PL-stability and wind method, and (2) to test assimilation of the measurements at the observations level.