

Met-ocean Conditions at Two Norwegian Sites for Development of Offshore Wind Farms

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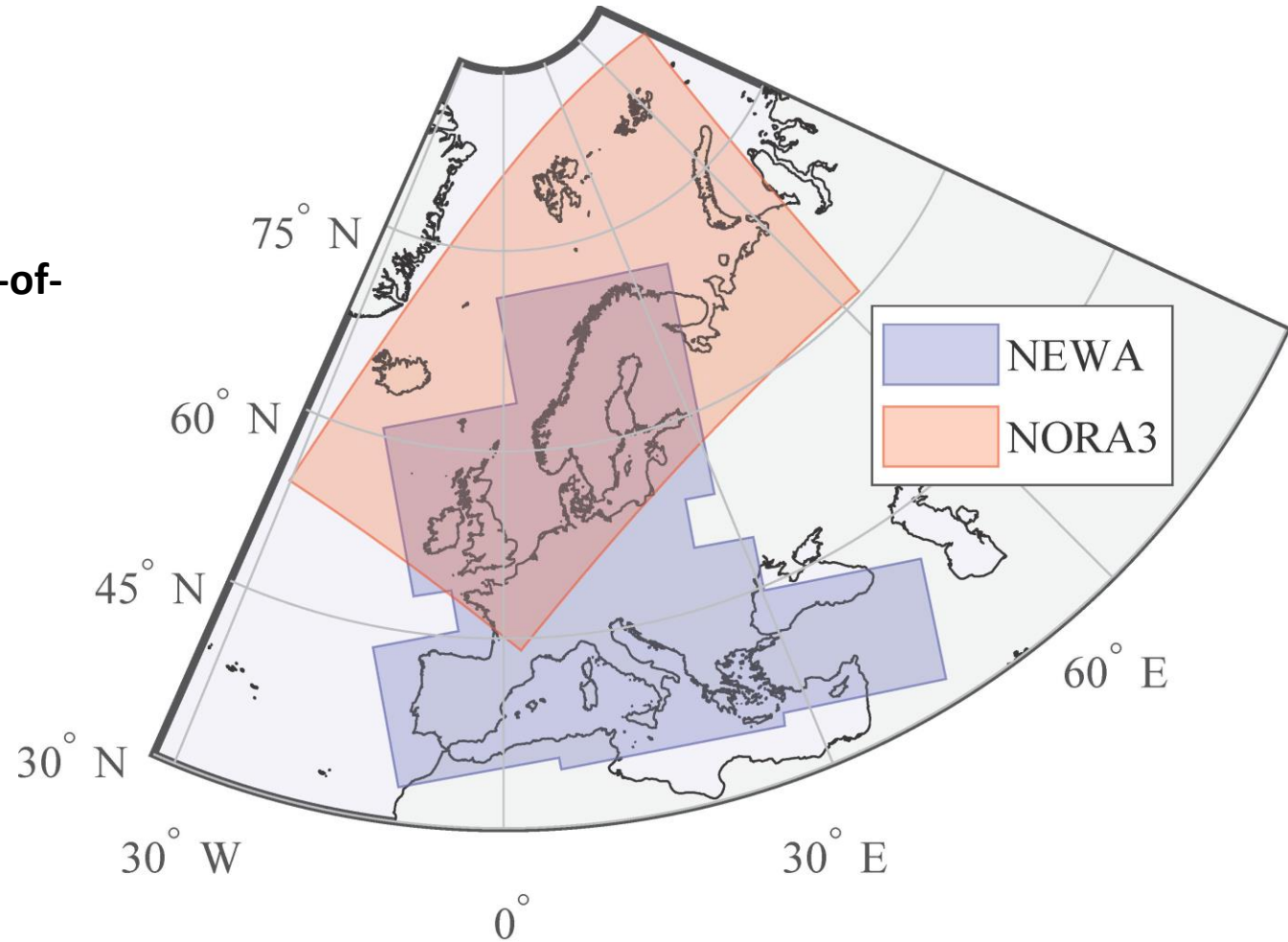
³Department of Engineering Sciences, University of Agder

The NORA3 database

The NORwegian hindcast Archive (NORA3) [1] is a **state-of-the-art wind atlas** (I oversimplify a little here)

Other wind atlases: The New European Wind atlas (NEWA) [2]

NORA3 may outperform NEWA in the North Sea [3]



[1] Haakenstad, et al. (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.

[2] Hahmann, et al.. (2020). The making of the new european wind atlas—part 1: Model sensitivity. *Geoscientific model development*, 13(10), 5053-5078.

[3] E Cheynet, I M Solbrekke, J M Diezel, J Reuder, A one-year comparison of new wind atlases over the North Sea. Accepted for publication in the *Journal of Physics: conference series*

The NORA3 database

WINDSURFER News and Events

NORA3 Wave Reanalysis now available

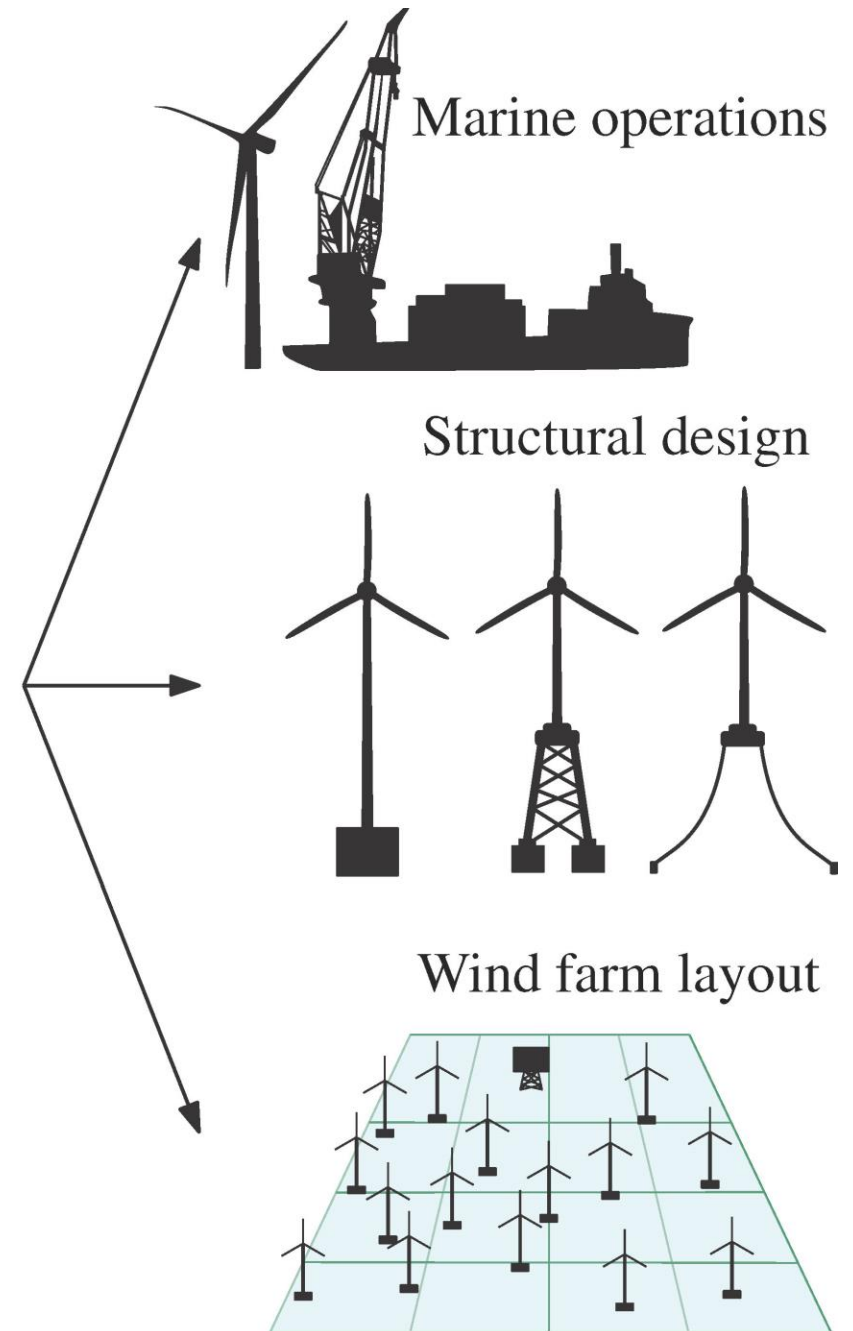
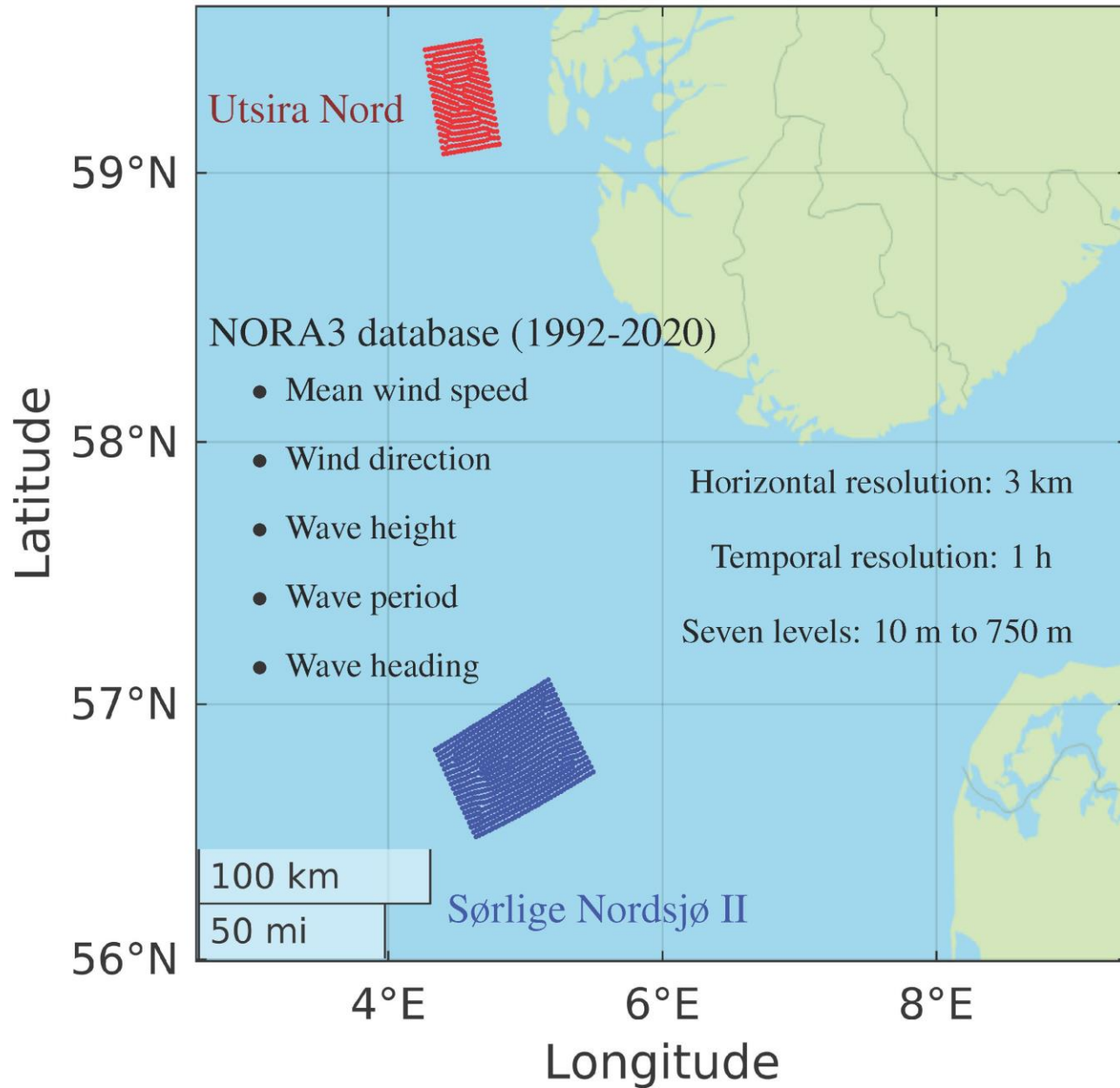
The new NORA3 wave reanalysis from Met Norway is now available at:

<https://thredds.met.no/thredds/projects/windsurfer.html>

Windsurfer project:

<https://sites.google.com/view/windsurfer/home>





Sørlige Nordsjø II(SN2)

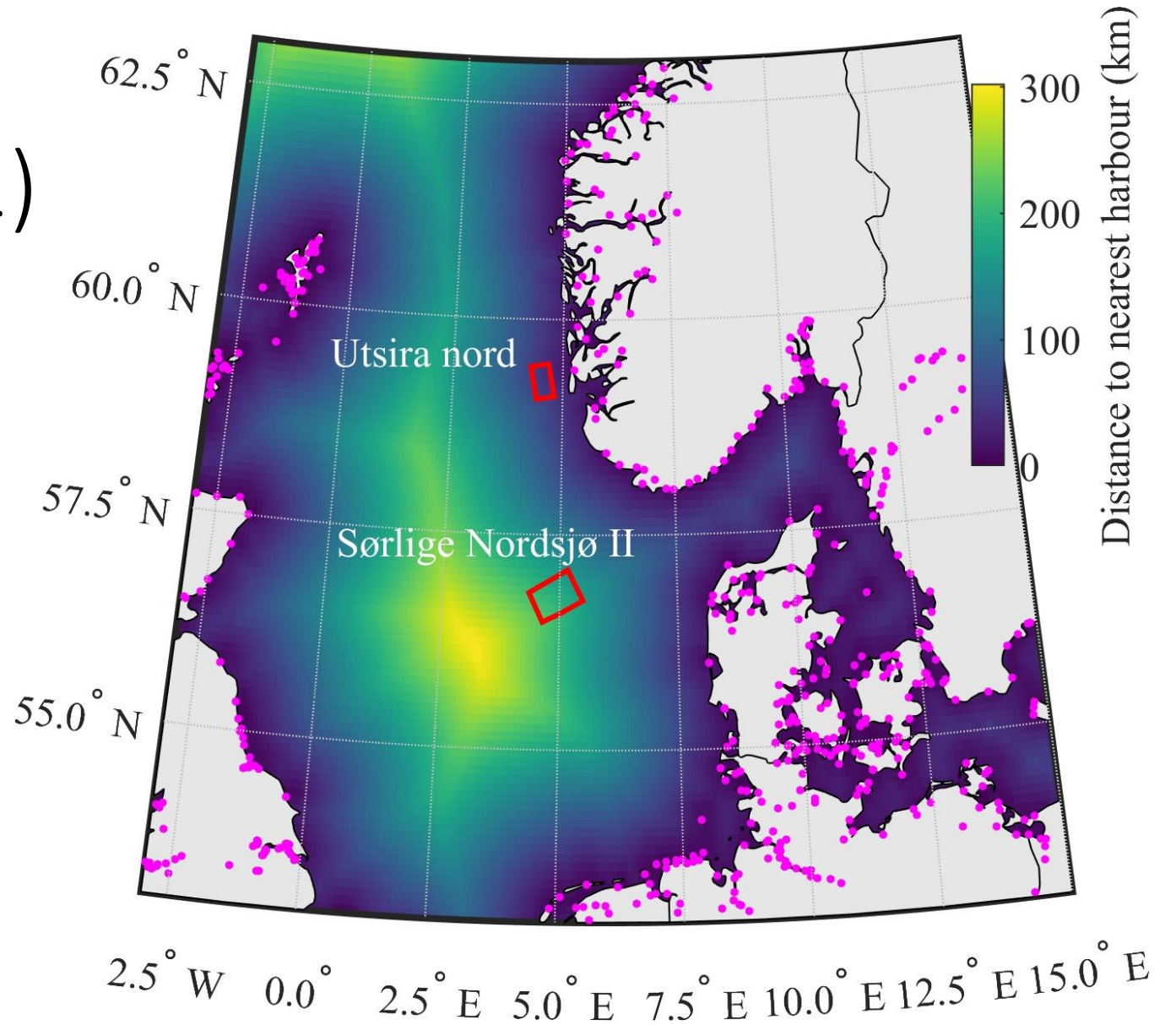
Area: 2591 km²

Water depth: intermediate (60 m)

Planned capacity: 3x 1.5 GW

Foundation types: Floating and bottom-fixed

Distance to nearest harbour: 180 km



Utsira Nord (UN)

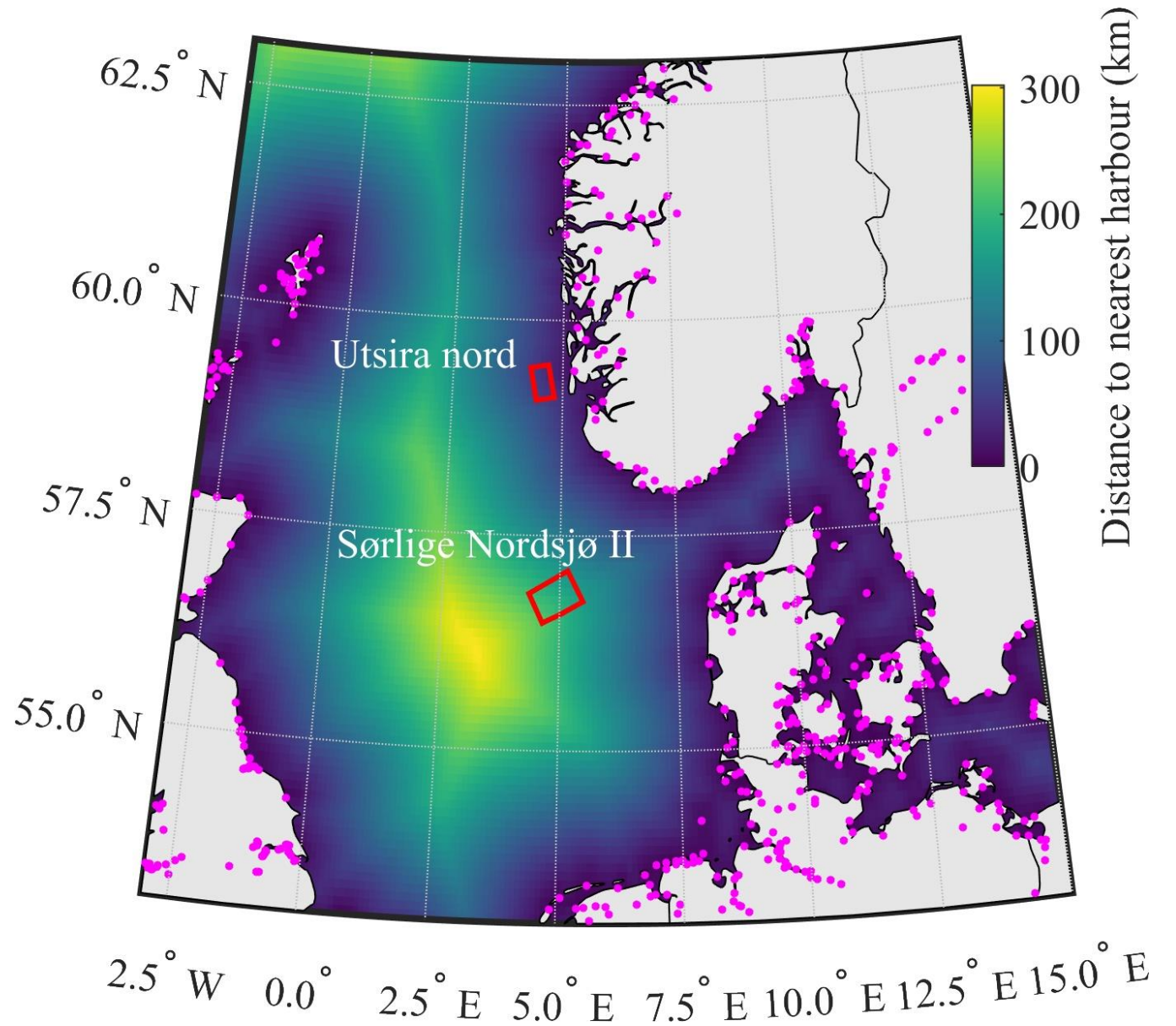
Area: 1010 km²

Water depth: Deep water (200-280 m)

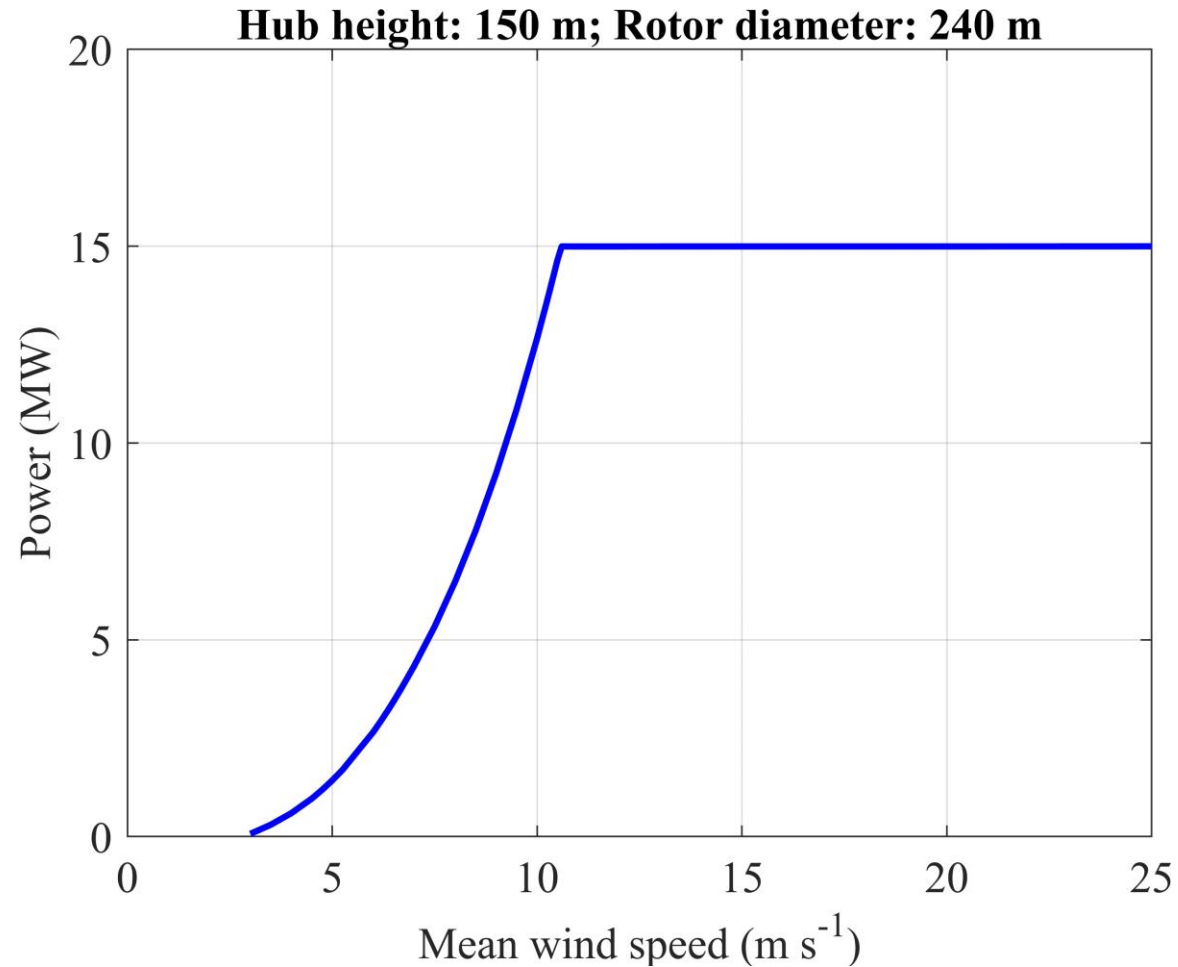
Planned capacity: 1.5 GW

Foundation types: Floating

Distance to nearest harbour: 22 km



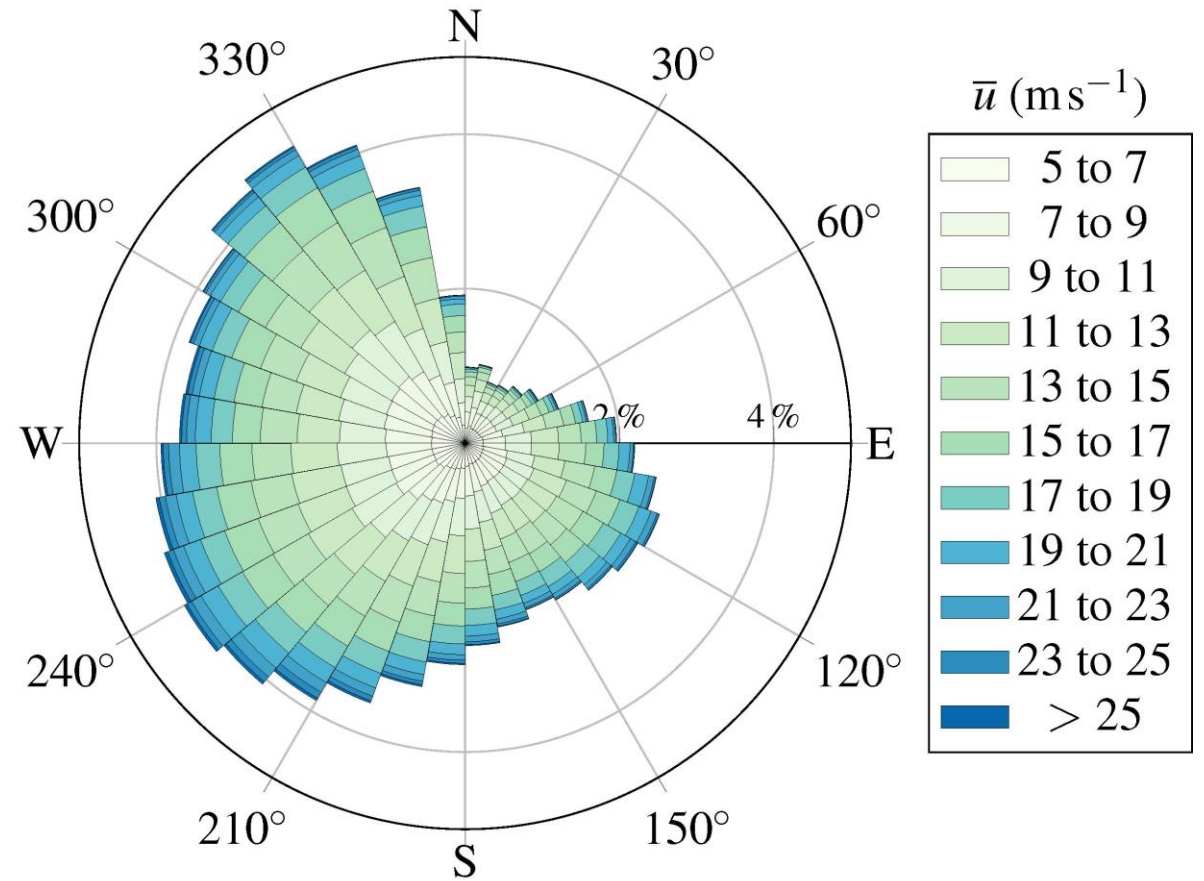
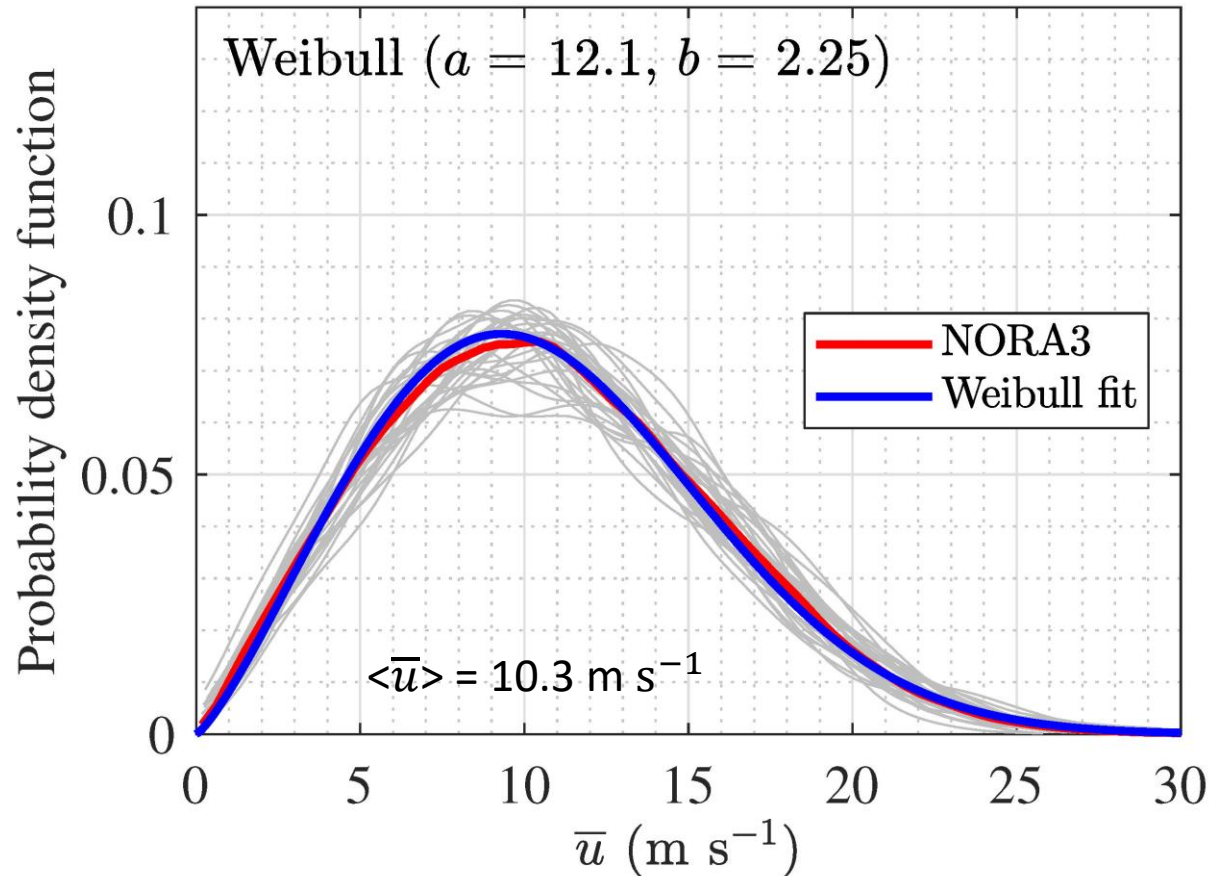
Case study: The IEA 15 MW wind turbine [1]



[1] Gaertner, E., Rinker, J., Sethuraman, L., Zahle, F., Anderson, B., Barter, G., ... & Viselli, A. (2020). Definition of the IEA 15-megawatt offshore reference wind turbine.

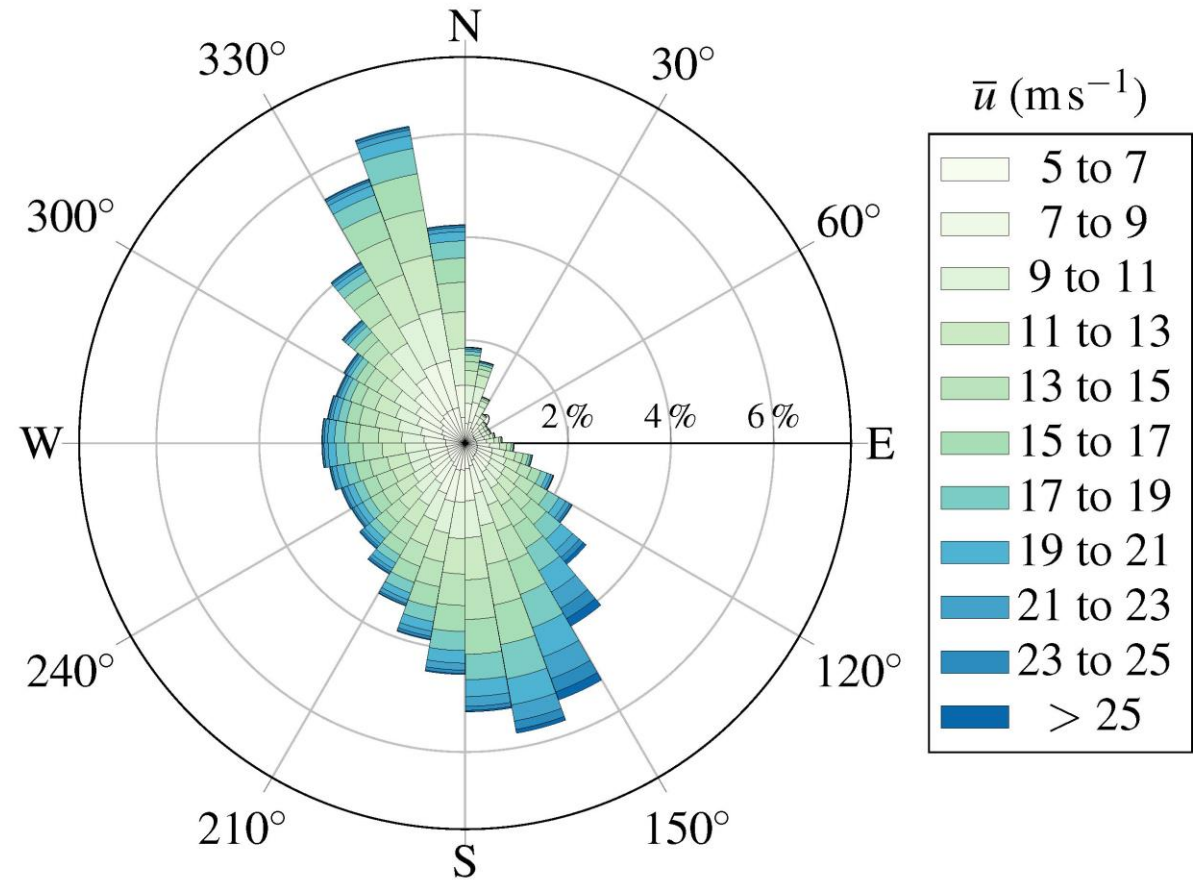
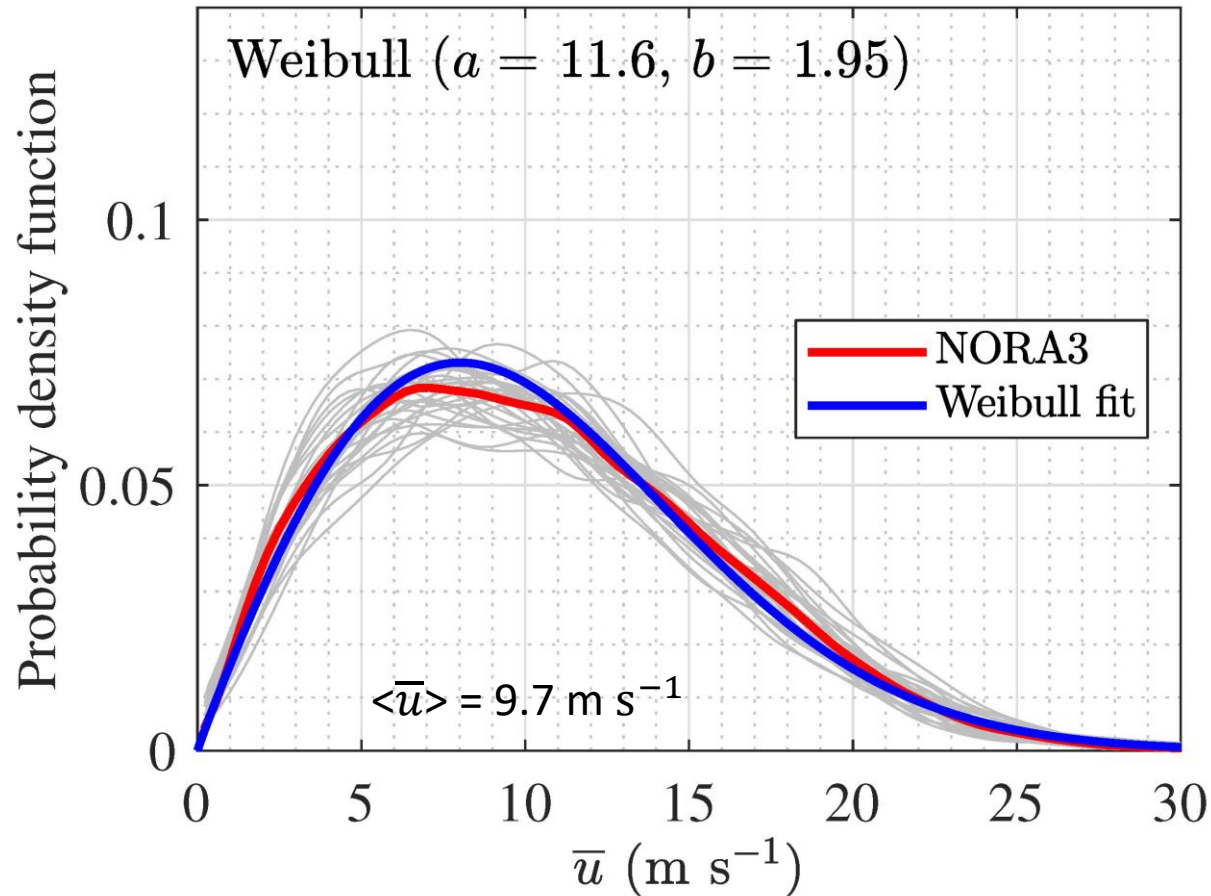
Wind conditions in Sørilige Nordsjø II

At hub height = 150 m

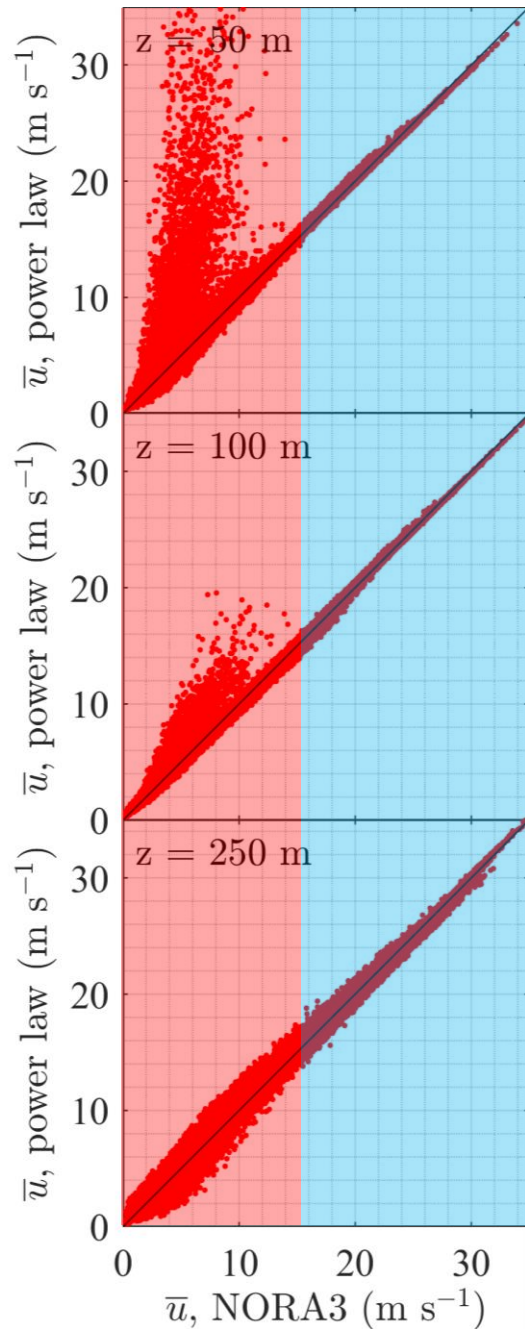


Wind conditions in Utisra Nord

At hub height = 150 m



Wind speed profiles: limits of the power law

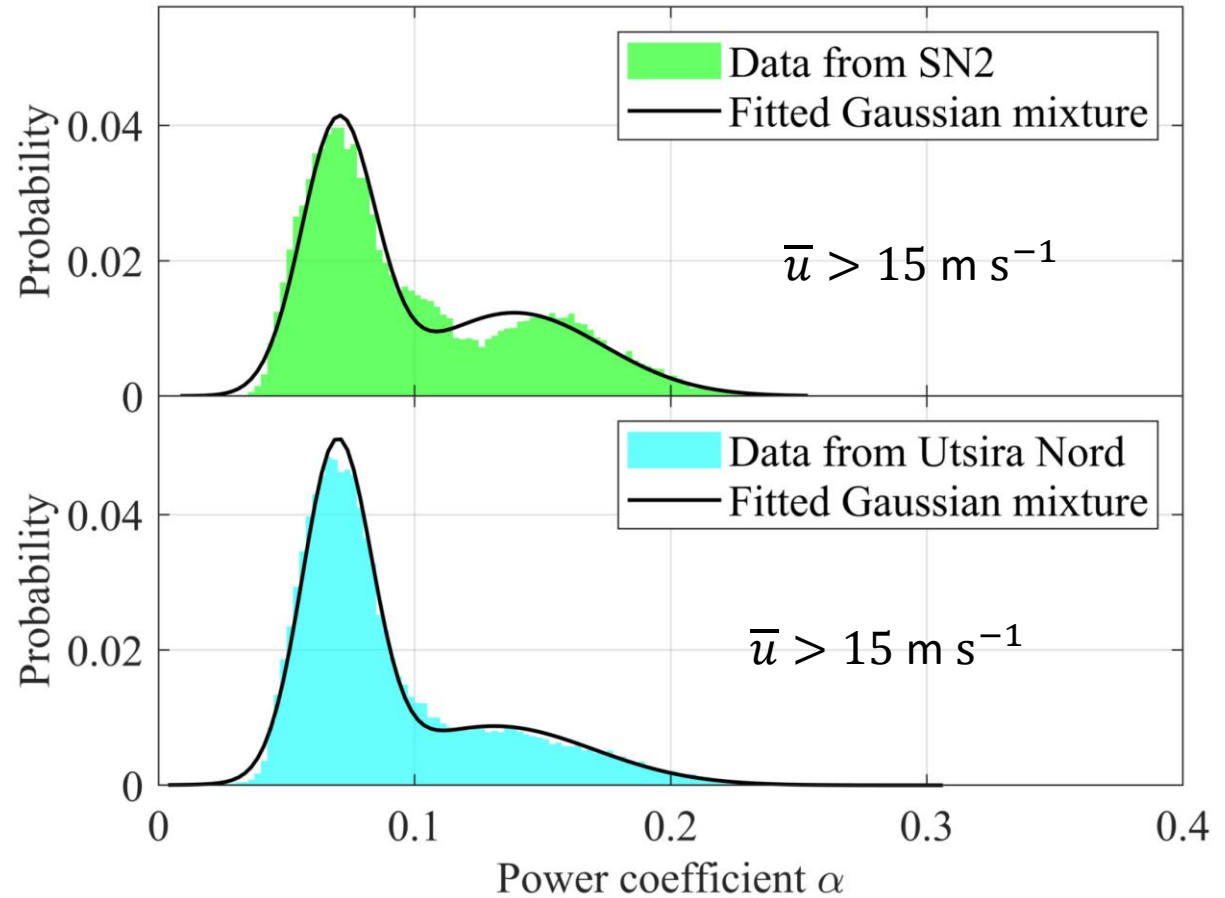
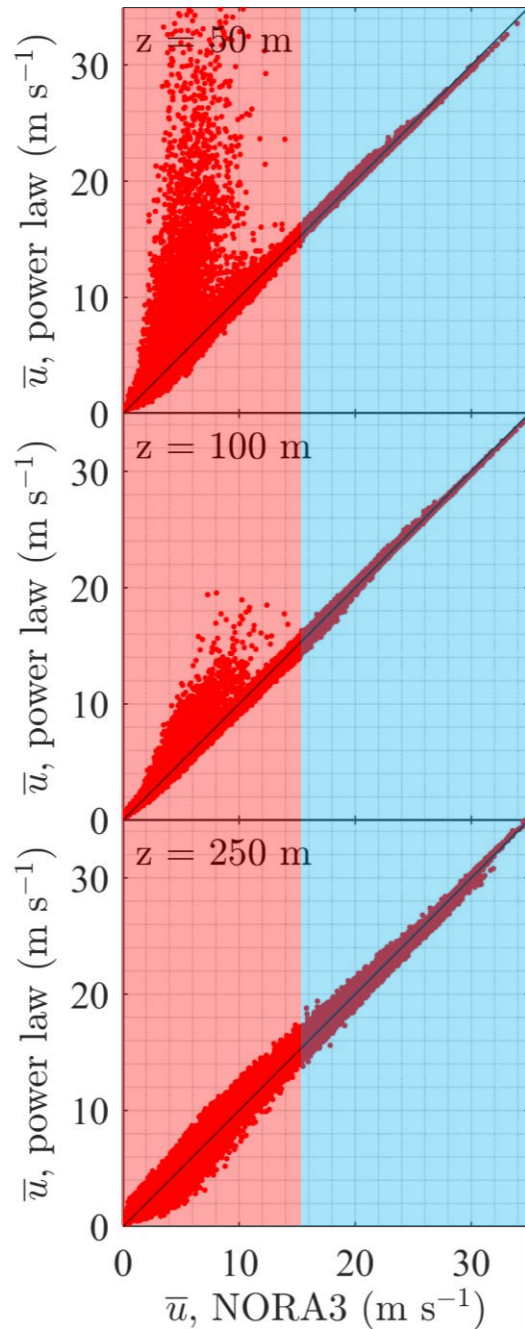


The power law is widely used in standards and codes

The power law **may be applicable** for the **ultimate limite state** design

The power law **may not be applicable** for the **fatigue limite state** design

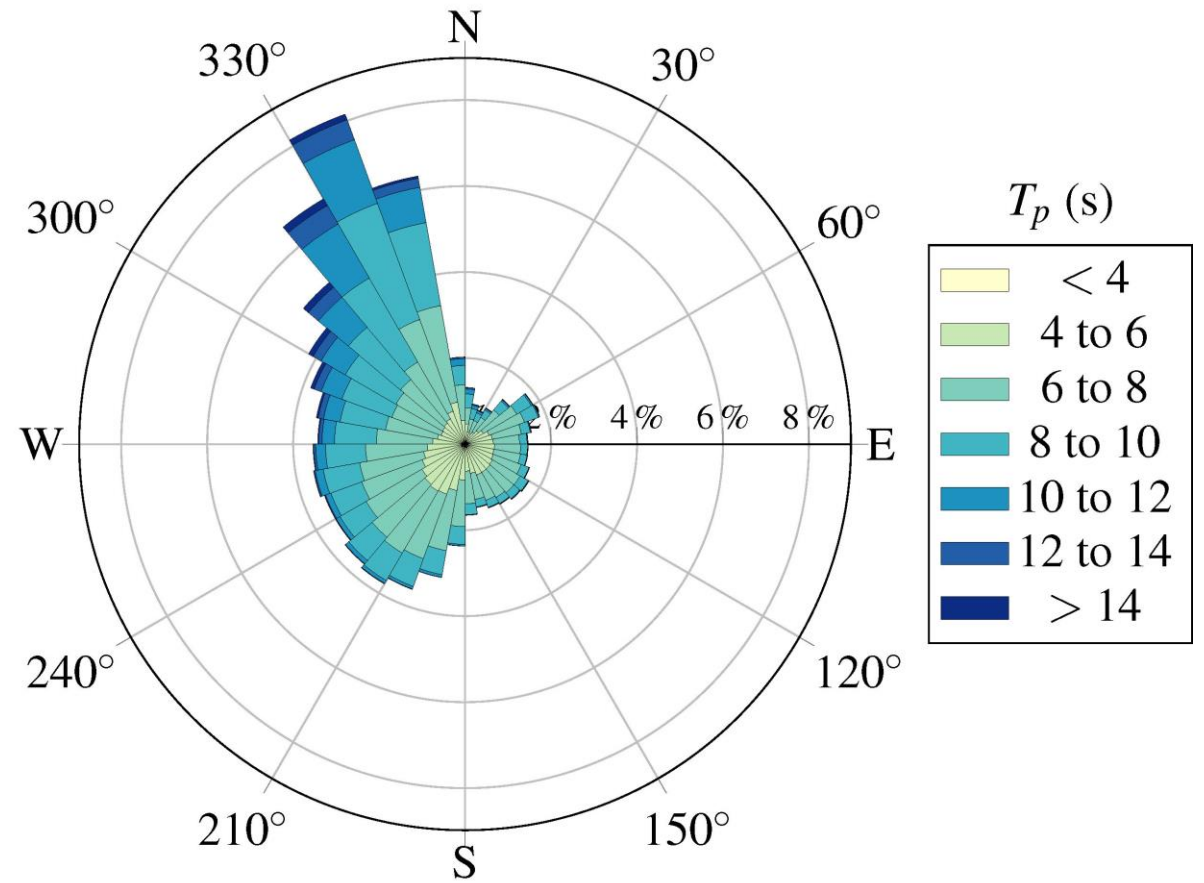
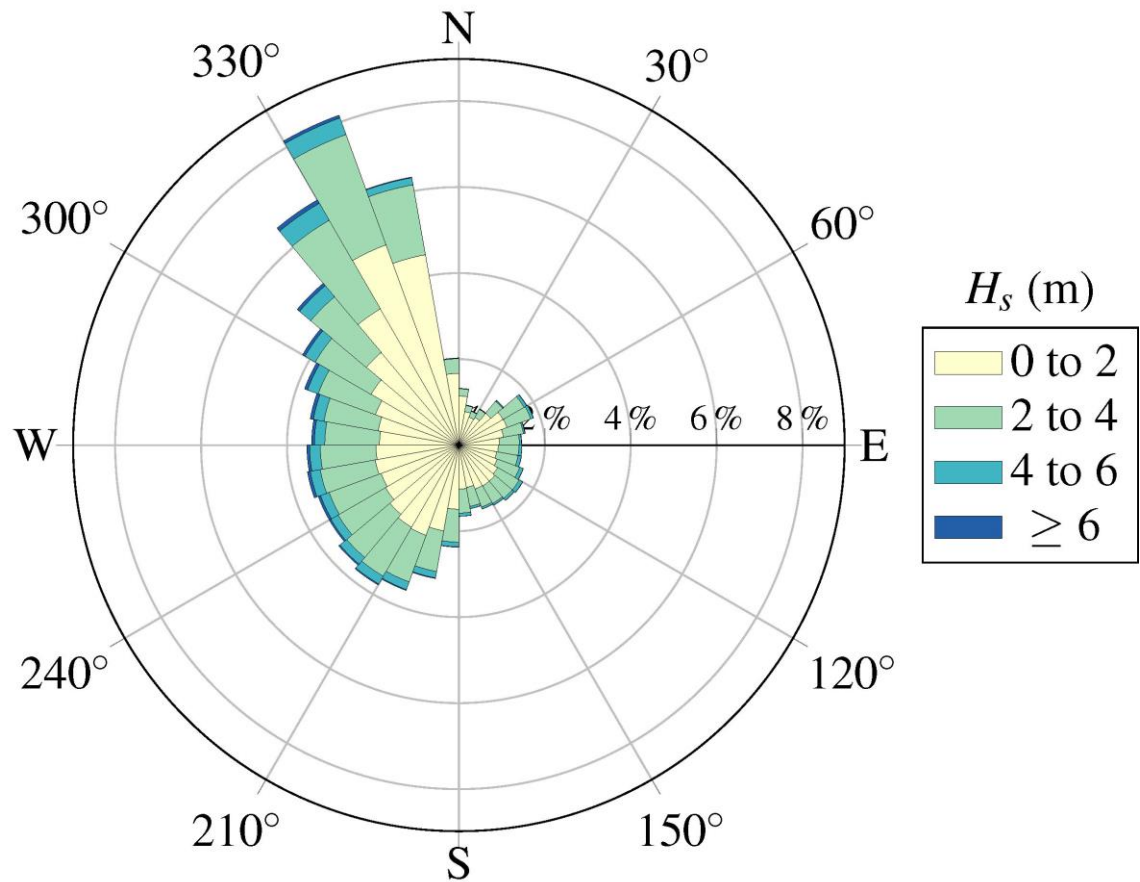
Wind speed profiles: limits of the power law



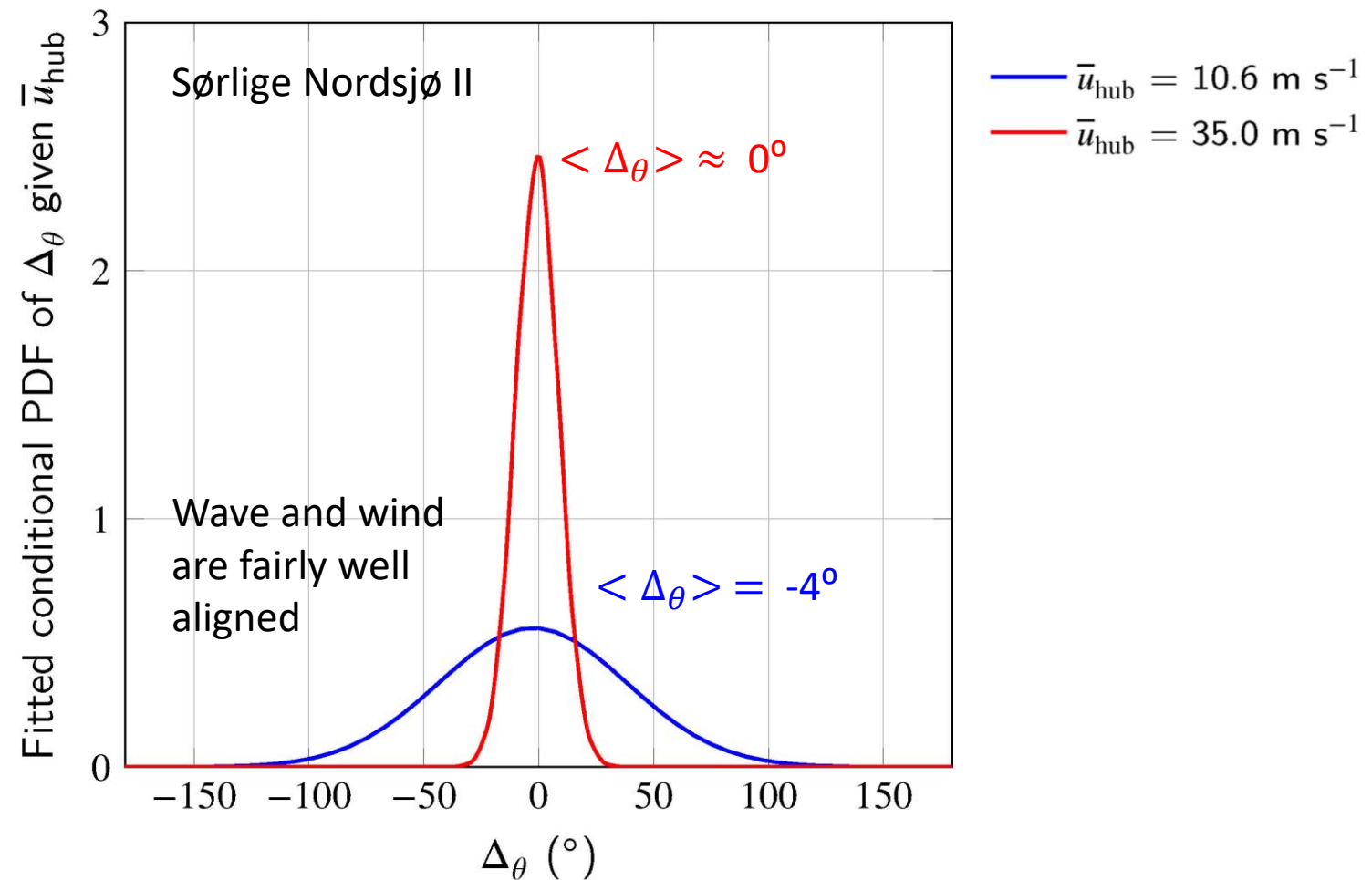
A satellite image of the ocean showing wave patterns. The image is in shades of blue, with lighter blue areas indicating wave crests and darker blue areas indicating troughs. The waves are moving from the top left towards the bottom right.

What about the
wave conditions?

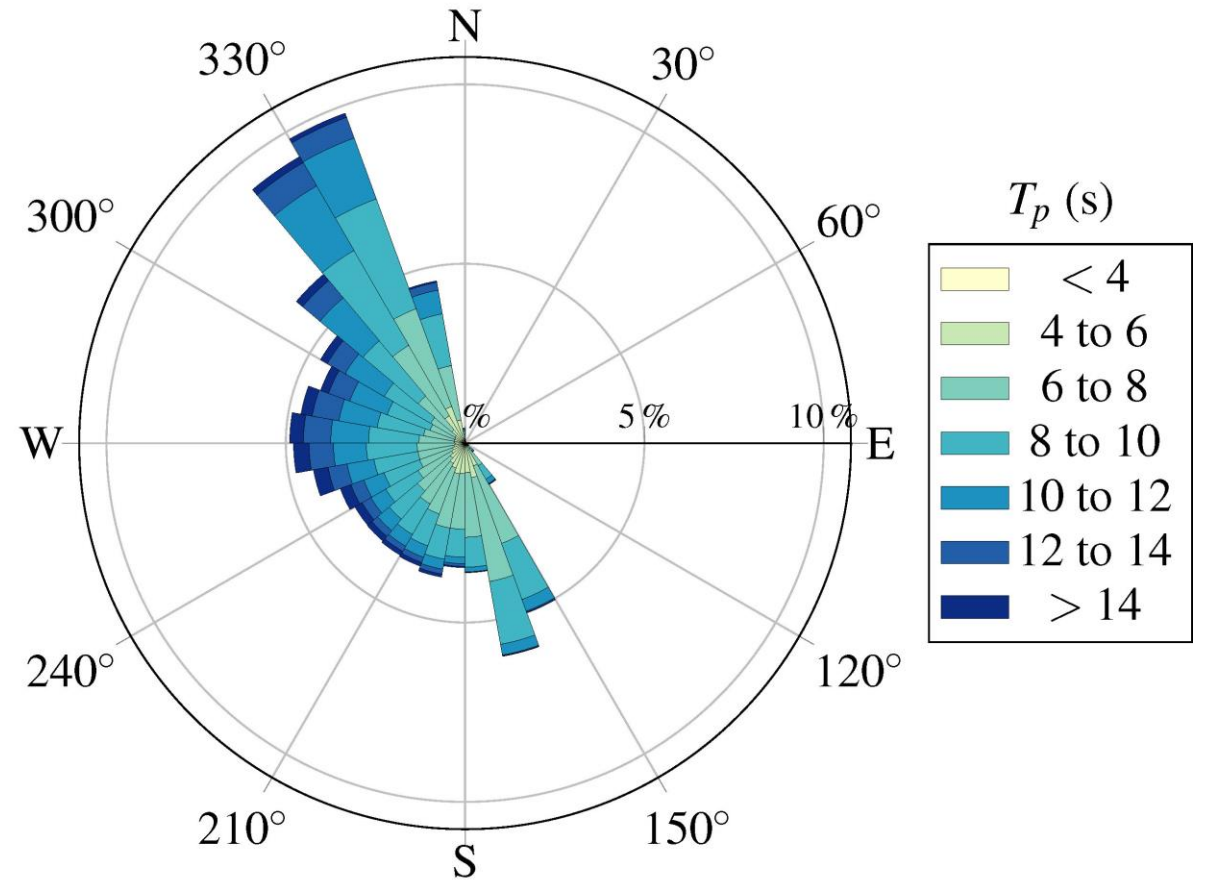
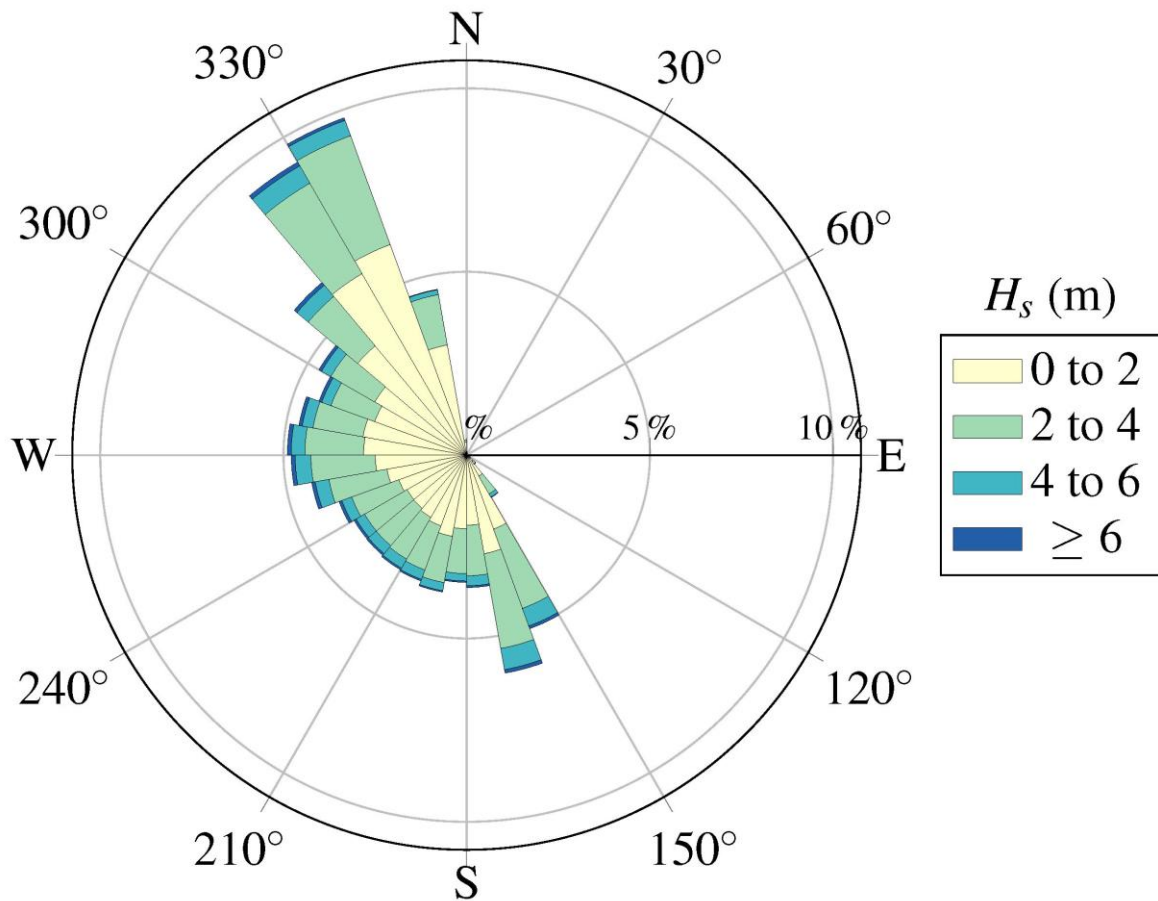
Wave conditions in Sørliche Nordsjø II



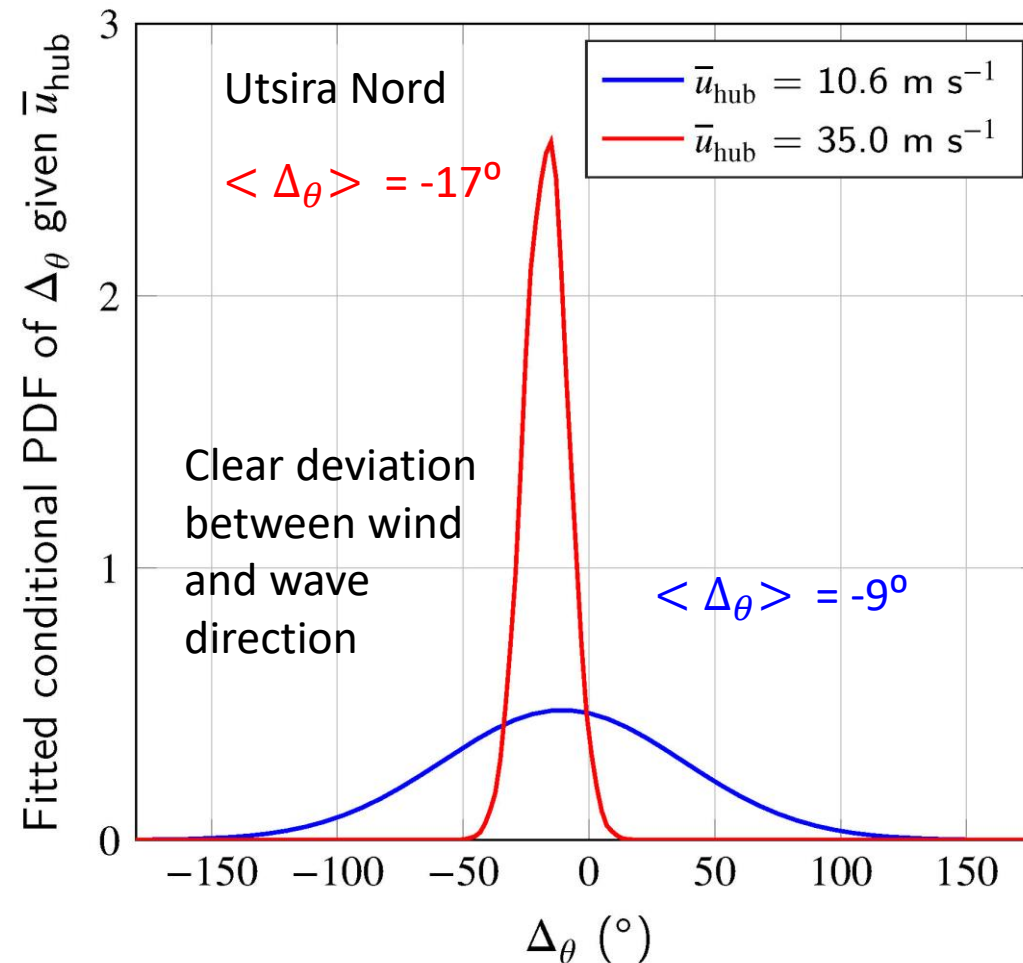
Wind-wave misalignment in Sørilige Nordsjø II



Wave conditions in Utsira Nord



Wind-wave misalignment in Utsira Nord



Extreme value analysis

50-year return period at SN2:

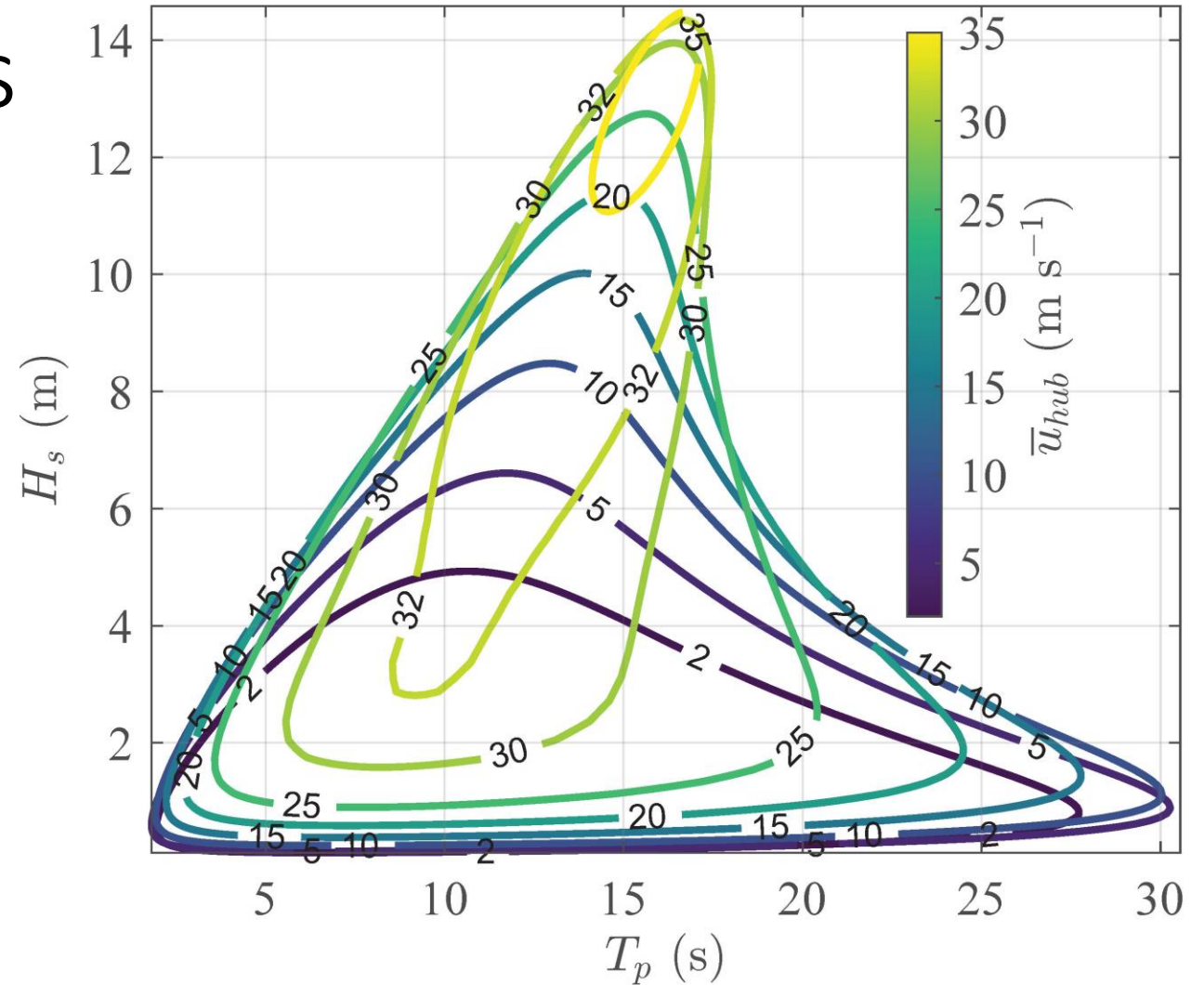
$$\bar{u}_{\text{hub}} = 37.7 \text{ m s}^{-1}$$

$$H_s = 13.4 \text{ m}$$

50-year return period at UN:

$$\bar{u}_{\text{hub}} = 42.3 \text{ m s}^{-1}$$

$$H_s = 14.6 \text{ m}$$



50-year contour surface at Utsira Nord

Conclusions

- 29 years of metocean conditions extracted at Utsira Nord and Sørliche Nordsjø II
- Approximately 0.25 milions of hourly wind speed profiles computed up to 750 m above sea level.
- Applications range: wind turbine design, marine operations and wind farm layout analysis

Thank you

