Recent developments at FINO1

Juan-José Trujillo, Richard Fruehmann, Friederike Bégué, Tom Neumann
UL International GmbH, Wilhelmshaven, Germany, +49 (0) 4421 4808 839

Summary
An update on the meteorological measurements at the offshore research platform FINO1 is given. The work describes changes to the measurement setup and data validation process (normed for all three FINO platforms), transition to a new database, and observations of changes in the meteorological conditions with the increased density of wind farms in the surrounding area.

1. Changes to the measurement system

1.1 New measurements

Additional temperature measurements (sea surface via infrared and 20 m height air temperature) have been installed at FINO1. These offer improved availability for atmospheric stability estimates, important when evaluating wake lengths, energy yields, and assessing turbulent loading on turbines.

1.2 Data validation

The automated data validation tool (ValidatF) developed in the FINO-Wind project [1]. An additional visual control ensures that sensor defects and outliers not flagged by ValidatF are highlighted. A more detailed flagging system provides transparency to the user.

Faulty data are now flagged, but stay in the data set, allowing the user to make an independent decision on which data to use. ValidatF has also been applied to historic data, and hitherto unpublished data have been added to the new database, due to be online in the next months. Fig.1 shows the availability.

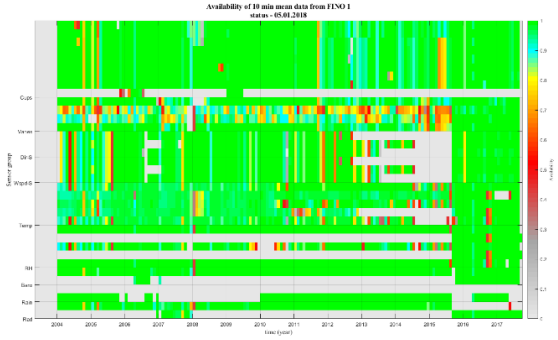

Fig. 1: Data availability in new database with flagged data

2. Changes in wind gradient and turbulence

2.1 Influence of stability on wind

The construction of the Borkum Riffgrund and Trianel wind farms has changed the wind conditions at FINO1, especially during stable atmospheric conditions. Increased mechanical mixing leads to a more homogenous wind speed profile in the lower 100 m of the atmosphere than would be expected in free stream conditions offshore.

At the same time, the turbulence intensity has increased: again the strongest effect is seen during stable conditions under which wakes propagate a long distance. This is relevant for wind turbines designed for offshore conditions under the assumption of low turbulence levels.

3. Conclusions

Percentage change in mean wind speed gradient.

Wind speed range		4 - 8	8 - 12	12 - 16	16 - 20
Stability parameter	> 2 °C	-27.66%	-38.14%	-28.92%	-20.11%
	1 : 2 °C	-19.81%	-46.49%	-28.22%	-9.70%
	0 : 1 °C	-44.23%	-48.49%	-27.33%	-12.58%
	-1 : 0 °C	-40.86%	-39.84%	-14.89%	-9.32%
	-2 : -1 °C	-0.93%	-10.86%	-4.08%	-14.88%
	< -2 °C	-12.32%	-2.16%	-7.00%	-16.38%

Percentage change in mean turbulence intensity

Wind speed range		4 - 8	8 - 12	12 - 16	16 - 20
Stability parameter	> 2 °C	29.37%	74.43%	62.11%	46.03%
	1 : 2 °C	25.70%	77.82%	56.93%	18.23%
	0 : 1 °C	12.89%	61.75%	35.10%	14.84%
	-1 : 0 °C	28.24%	39.88%	12.31%	3.95%
	-2 : -1 °C	5.33%	15.28%	9.66%	22.20%
	< -2 °C	-7.17%	3.36%	5.97%	12.68%

Fig. 2: Changes in wind speed gradient and turbulence at FINO1

FINO1 is now located in the middle of a large cluster of wind farms. For the continuation of the FINO1 measurement campaign, it is planned to further optimise the range of sensors for studying the wind conditions within a wind farm, to provide insight into the 'real life' conditions under which offshore turbines operate.

4. References

[1] Leiding et al., Standardisierung und vergleichende Analyse der meteorologischen FINO-Messdaten (FINO123), Abschlussbericht, 2016. www.dwd.de/DE/forschung/projekte/fino_wind/fino_wind_node.html