28 March 2025 / POWSEIDOM + DRACCAR NEMO Webinar

NEMO – New methods for turbulence measurements and models in offshore wind

FRANCE ENERGIES MARINES

Fraunhofer IWES

Outline
This presentation

- Project overview – NEMO
- Targeted research results
- Preliminary results
- Intensive measurement campaign
- Summary / outlook

Project overview

NEMO – **Ne**w **m**ethods for turbulence measurements and models in **o**ffshore wind

Two sub-projects (with own [matching] funds):

- ICON* NEMO led by Fraunhofer IWES
- DRACCAR NEMO led by France Energies Marines

Project duration

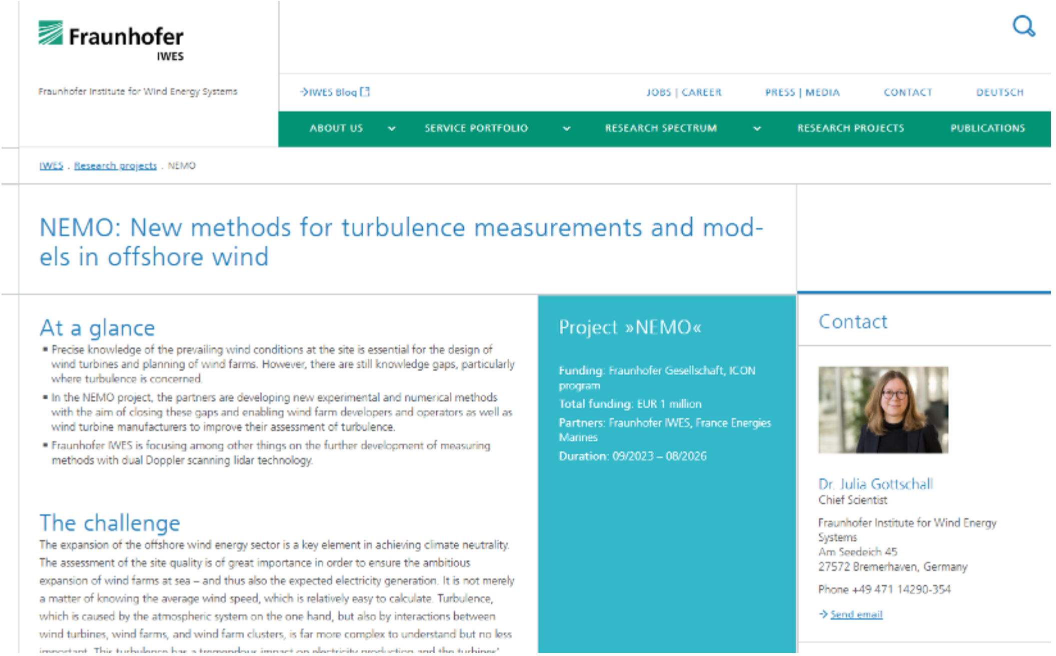
1 September 2023 – 31 August 2026 (36 months) .. for ICON NEMO

***ICON** – International Cooperation and Networking (Fraunhofer-internal programme)

Project overview

NEMO – **New methods** for turbulence measurements and models in **offshore** wind

https://www.iwes.fraunhofer.de/en/research-projects/current-projects/nemo.html



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Fraunhofer Institute for Wind Energy Systems

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IWES › Research projects › NEMO

NEMO: New methods for turbulence measurements and models in offshore wind

At a glance

- Precise knowledge of the prevailing wind conditions at the site is essential for the design of wind turbines and planning of wind farms. However, there are still knowledge gaps, particularly where turbulence is concerned.
- In the NEMO project, the partners are developing new experimental and numerical methods with the aim of closing these gaps and enabling wind farm developers and operators as well as wind turbine manufacturers to improve their assessment of turbulence.
- Fraunhofer IWES is focusing among other things on the further development of measuring methods with dual Doppler scanning lidar technology.

The challenge

The expansion of the offshore wind energy sector is a key element in achieving climate neutrality. The assessment of the site quality is of great importance in order to ensure the ambitious expansion of wind farms at sea – and thus also the expected electricity generation. It is not merely a matter of knowing the average wind speed, which is relatively easy to calculate. Turbulence, which is caused by the atmospheric system on the one hand, but also by interactions between wind turbines, wind farms, and wind farm clusters, is far more complex to understand but no less

Project »NEMO«

Funding: Fraunhofer Gesellschaft, ICON program

Total funding: EUR 1 million

Partners: Fraunhofer IWES, France Energies Marines

Duration: 09/2023 – 08/2026

Contact

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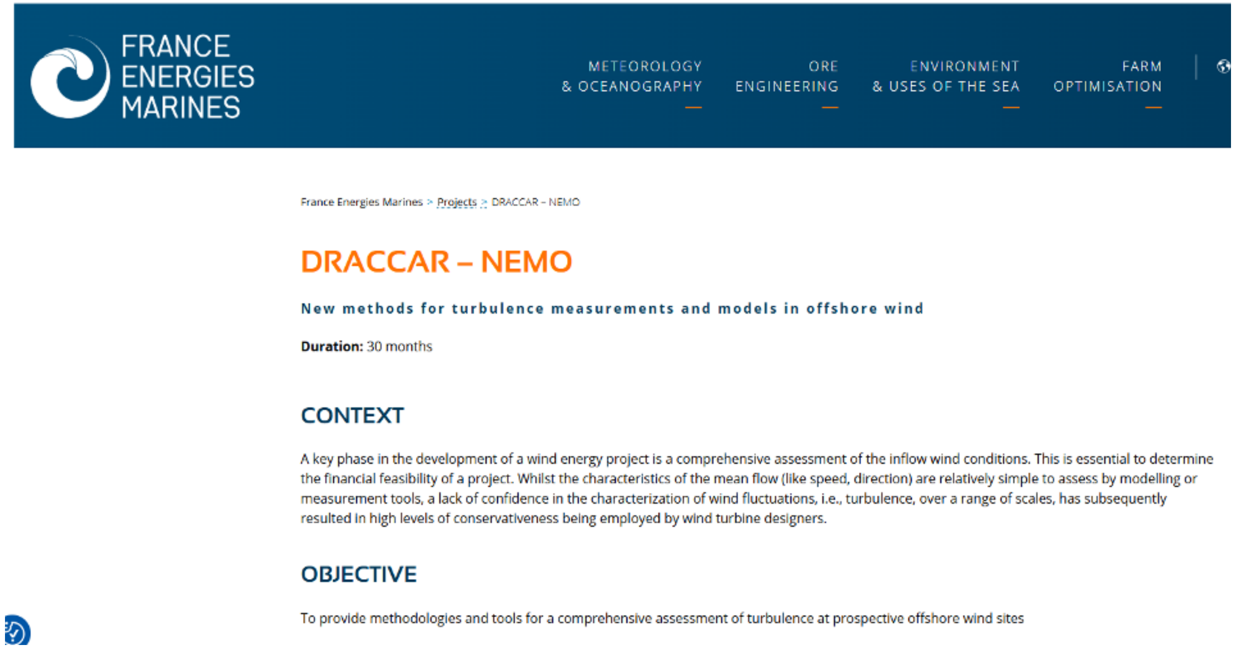
https://www.france-energies-marines.org/en/projects/draccar-nemo/



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France Energies Marines > Projects > DRACCAR – NEMO

DRACCAR – NEMO

New methods for turbulence measurements and models in offshore wind

Duration: 30 months

CONTEXT

A key phase in the development of a wind energy project is a comprehensive assessment of the inflow wind conditions. This is essential to determine the financial feasibility of a project. Whilst the characteristics of the mean flow (like speed, direction) are relatively simple to assess by modelling or measurement tools, a lack of confidence in the characterization of wind fluctuations, i.e., turbulence, over a range of scales, has subsequently resulted in high levels of conservativeness being employed by wind turbine designers.

OBJECTIVE

To provide methodologies and tools for a comprehensive assessment of turbulence at prospective offshore wind sites

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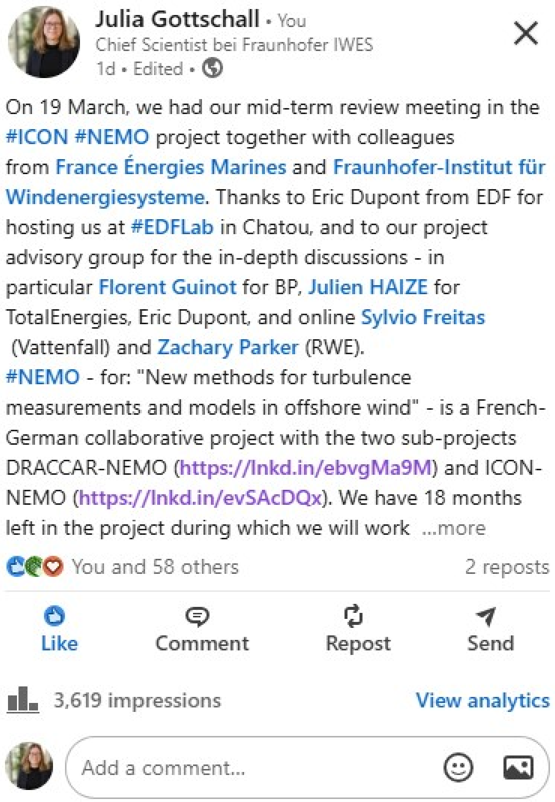
Project overview

NEMO – **Ne**w **m**ethods for turbulence measurements and models in **o**ffshore wind



Julia Gottschall • You
Chief Scientist bei Fraunhofer IWES
1d • Edited •

On 19 March, we had our mid-term review meeting in the #ICON #NEMO project together with colleagues from France Énergies Marines and Fraunhofer-Institut für Windenergiesysteme. Thanks to Eric Dupont from EDF for hosting us at #EDFLab in Chatou, and to our project advisory group for the in-depth discussions - in particular Florent Guinot for BP, Julien HAIZE for TotalEnergies, Eric Dupont, and online Sylvio Freitas (Vattenfall) and Zachary Parker (RWE).
#NEMO - for: "New methods for turbulence measurements and models in offshore wind" - is a French-German collaborative project with the two sub-projects DRACCAR-NEMO (https://lnkd.in/ebvgMa9M) and ICON-NEMO (https://lnkd.in/evSAcDQx). We have 18 months left in the project during which we will work ...more

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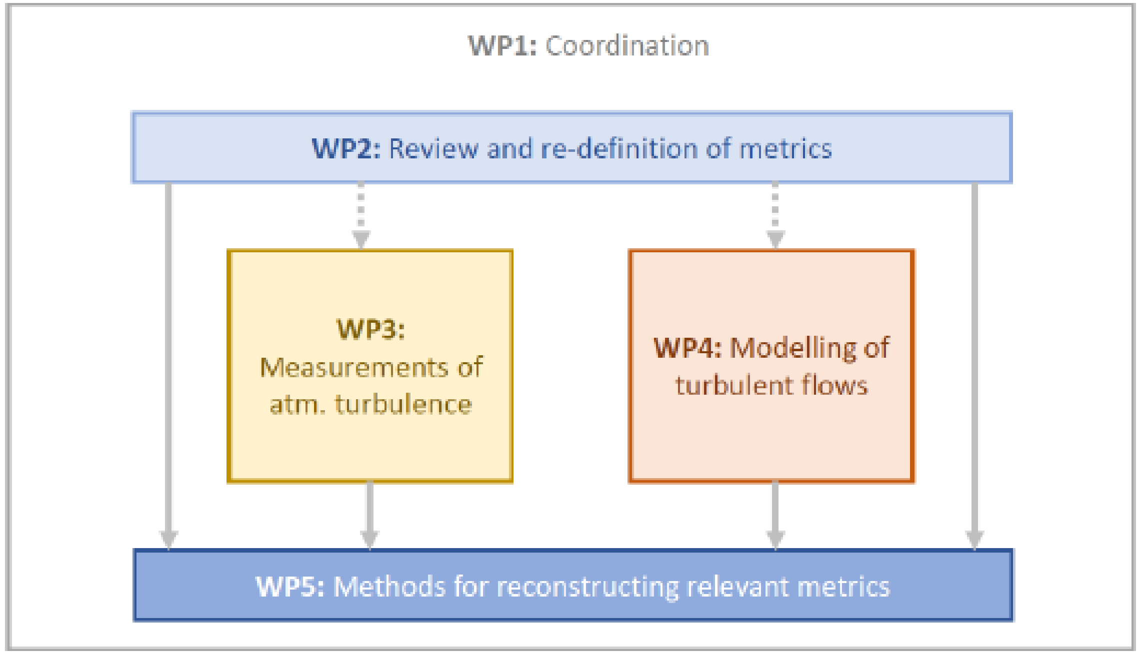
Research goals

- A new turbulence reconstruction algorithm for **floating lidar** measurements
- An advanced measurement concept and strategy to combine floating and **dual-Doppler scanning lidar** for optimal offshore turbulence measurements
- A methodology for extracting turbulence metrics from **modelling in grey-zone resolution** calibrated against high-resolution **LES** model results



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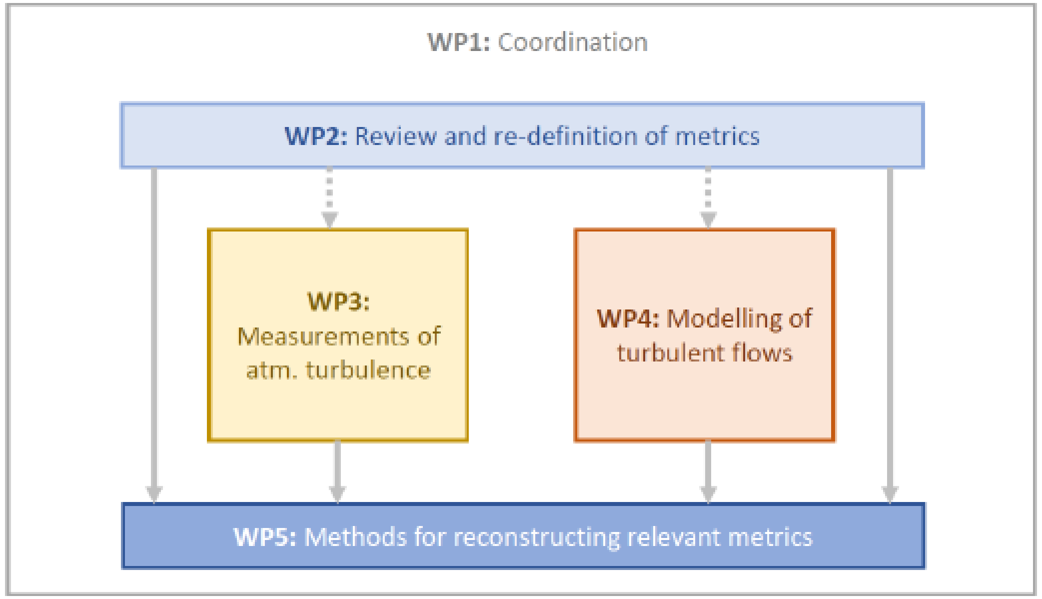
Targeted research results

Nr.	Result	Specification
1	Standardized metrics for turbulence, gusts and extreme winds	Parameters, to be reviewed and further specified during the project, shall be identified as optimal to assess turbulence and extremes in the offshore energy application. The current standards will be adjusted according to our findings in the medium to long term (i.e., 2-10 years after the end of the project).
2	Measured turbulence metrics from floating and dual-Doppler scanning lidar	The expected result is a novel and advanced procedure to derive turbulence metrics from floating lidar measurements, benchmarked against the corresponding results of dual-Doppler scanning lidar. The procedure is validated by a successful demonstration study (short term), and the inclusion in international standards used by the wind industry (mid- to long-term).
3	Industry applicable turbulence modelling (grey-zone scale)	Intended is the development and validation of an optimized setup for reliable calculation of turbulence intensity that is consistent with lidar derived turbulence parameters. The setup is planned to be immediately available after the end of the project for the calculation of site relevant turbulence parameters.
4	Calibration of grey-zone turbulence modelling with LES	Calibration of the new grey-zone turbulence parametrization with single precise high-resolution simulations that allow for estimating the accuracy of the modelling described in (3). The calibration methodology is planned to be immediately available after the end of the project.
5	Estimation of extreme winds supported by machine-learning	The development of the estimation procedure for extreme winds, is intended to be an alternative approach to those described in international standards. Its performance will be examined in benchmark studies against observational data. The improved estimation procedure may be reached on a short-term time horizon, i.e., either still within the project period or shortly after.



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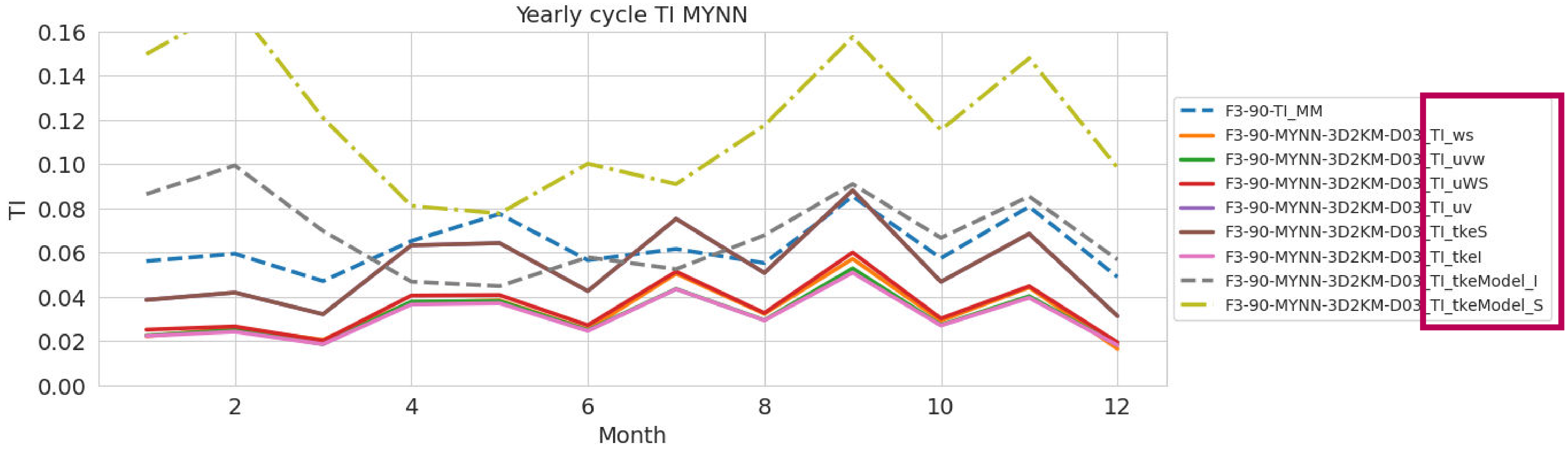
Preliminary results

- TI from mesoscale model simulations
- TI from floating lidar measurements

Preliminary results

TI from mesoscale simulations



Monthly averages of turbulence intensity calculated from WRF simulations and observations using different methods compared to met mast data from FINO-3
[Schwegmann et al. WESC 2025 Book of Abstracts]

Preliminary results

TI from floating lidar measurements

[Watson et al. "Evaluating the Impact of Motion Compensation on Turbulence Intensity Measurements from Continuous-Wave and Pulsed Floating Lidars" – submitted to Wind Energy Science / preprint should be available shortly]

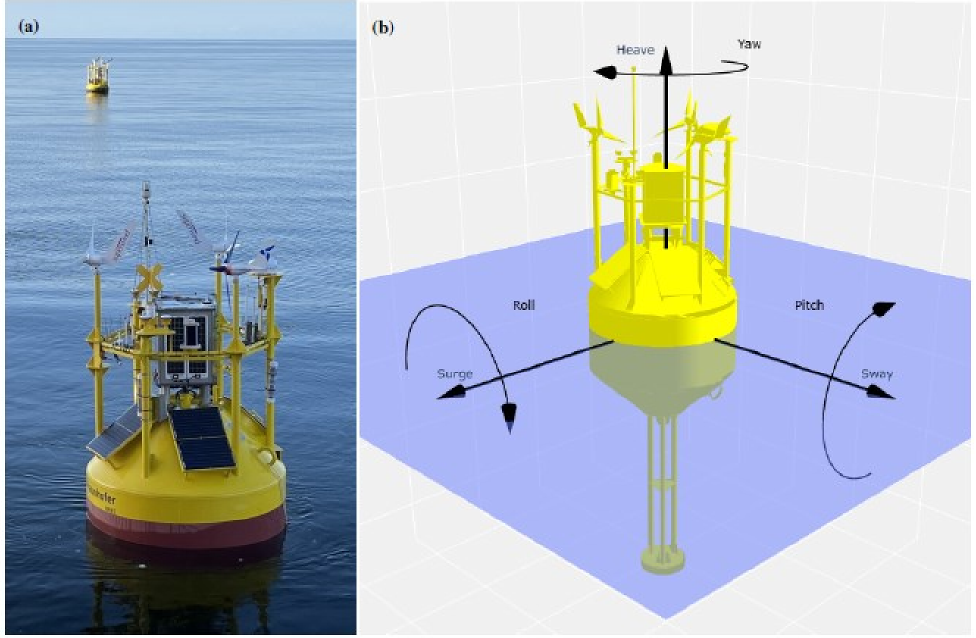


Figure 1. (a) Picture of the Fraunhofer IWES Wind Lidar Buoy (© Christian Tietjen, Fraunhofer IWES). In (b), a schematic representation of the Fraunhofer IWES Wind Lidar Buoy with a reference coordinate system and arrows denoting the 6-degrees of freedom is depicted.

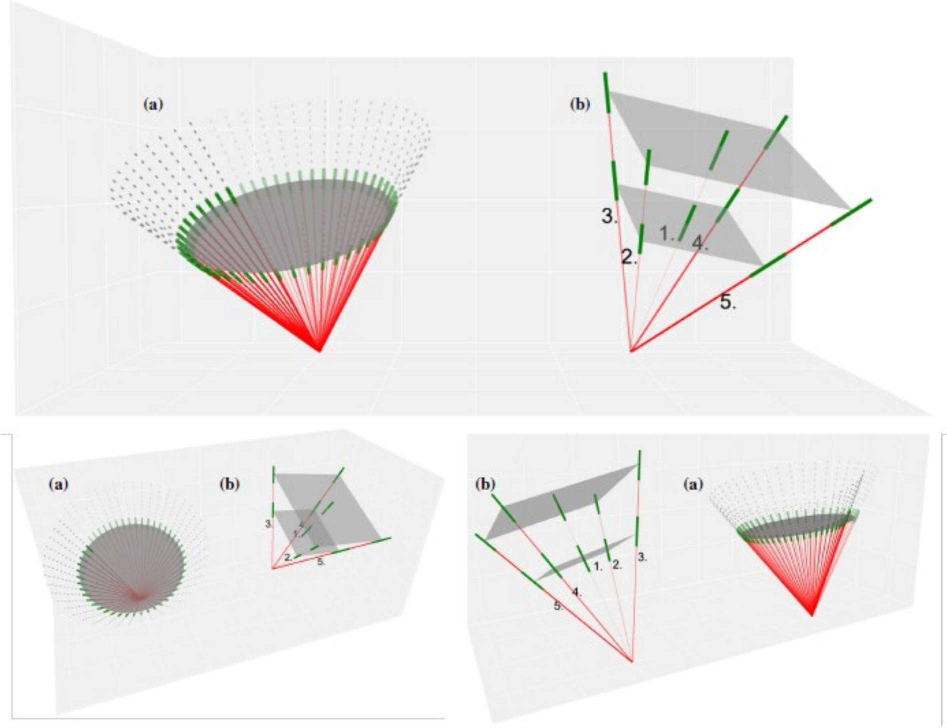


Figure 3. Simulation of tilted vertical profiling wind lidar measurement principles. (a) illustrates the scanning geometry of a cw lidar performing a conical scan at 100 m; (b) depicts the scanning geometry of a pulsed lidar, measuring at two heights simultaneously, 100 m and 150 m.

Preliminary results

TI from floating lidar measurements

[Watson et al. "Evaluating the Impact of Motion Compensation on Turbulence Intensity Measurements from Continuous-Wave and Pulsed Floating Lidars" – submitted to Wind Energy Science / preprint should be available shortly]

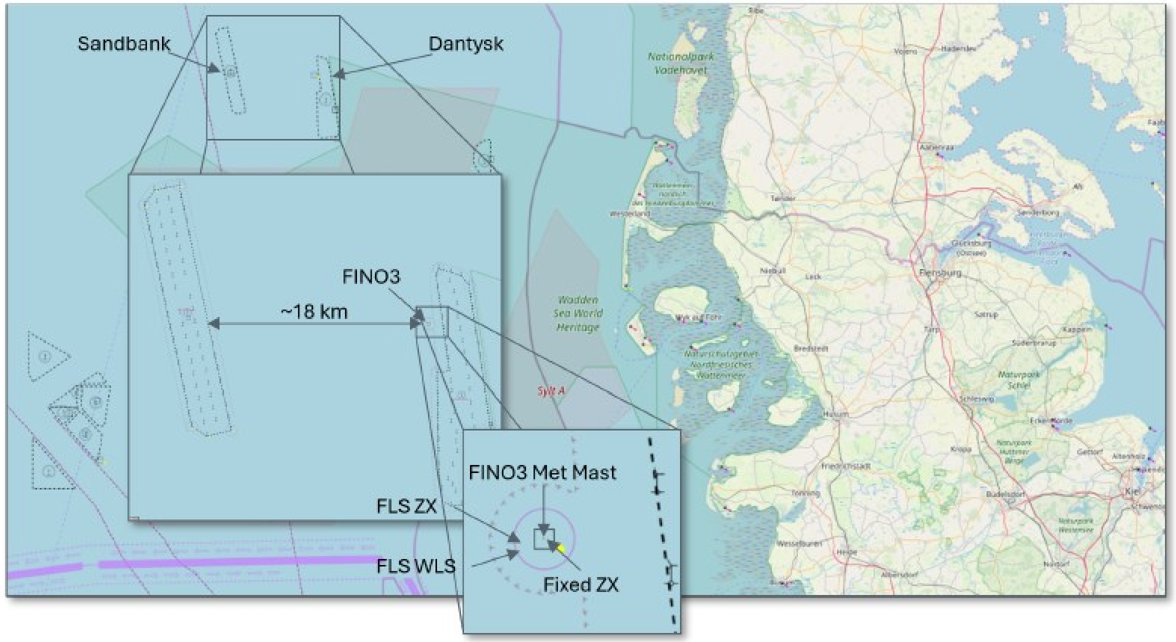
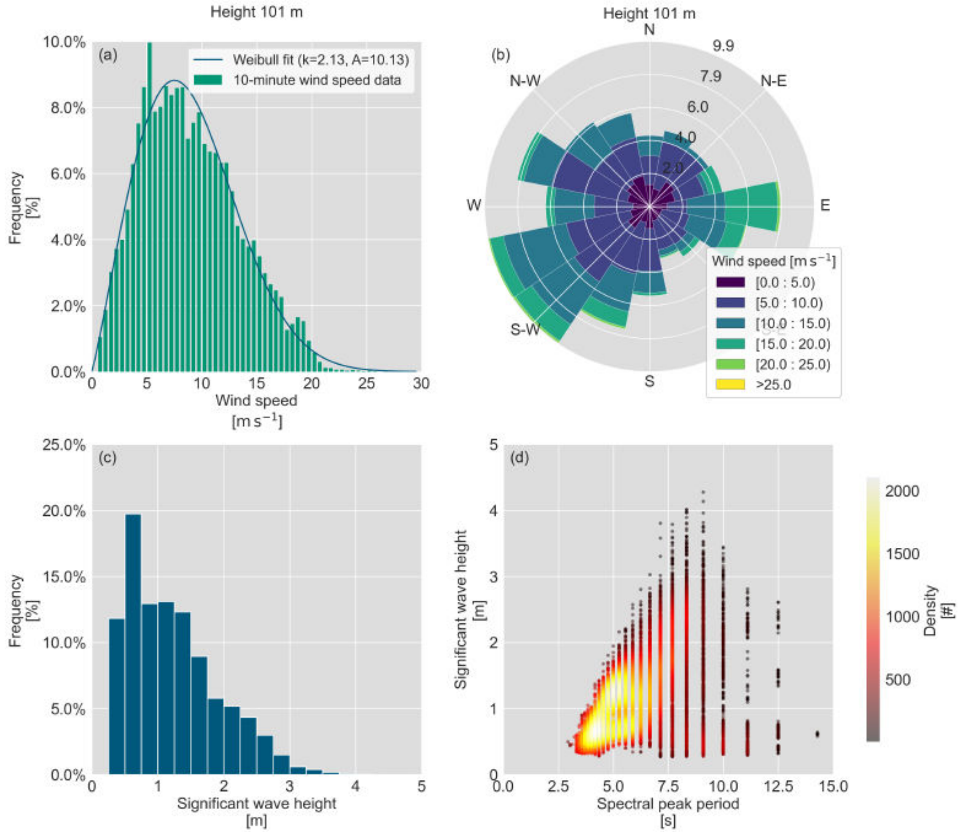


Figure 4. Measurement campaign location at FINO3 in the German North Sea.



Preliminary results

TI from floating lidar measurements

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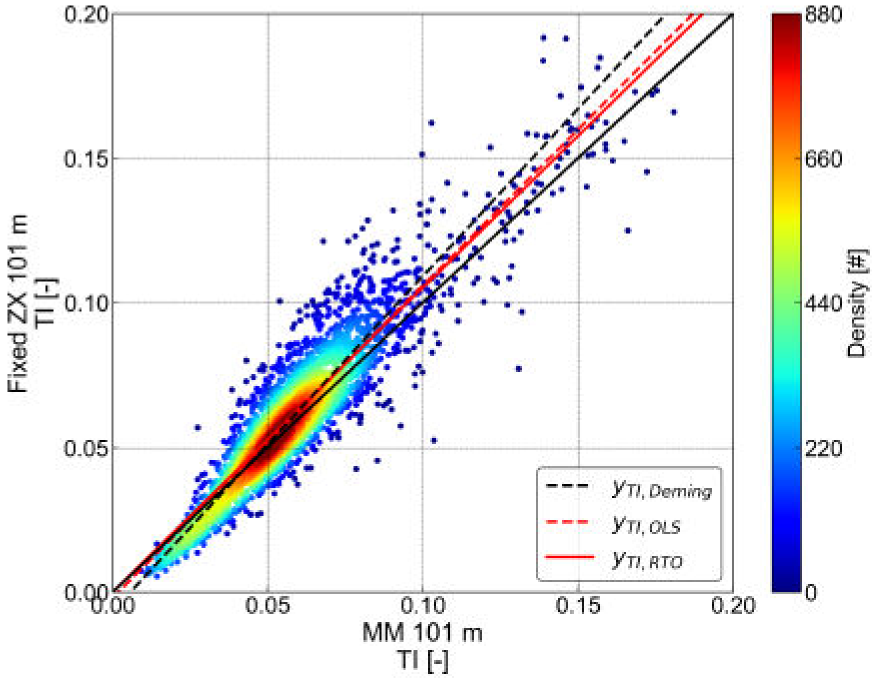

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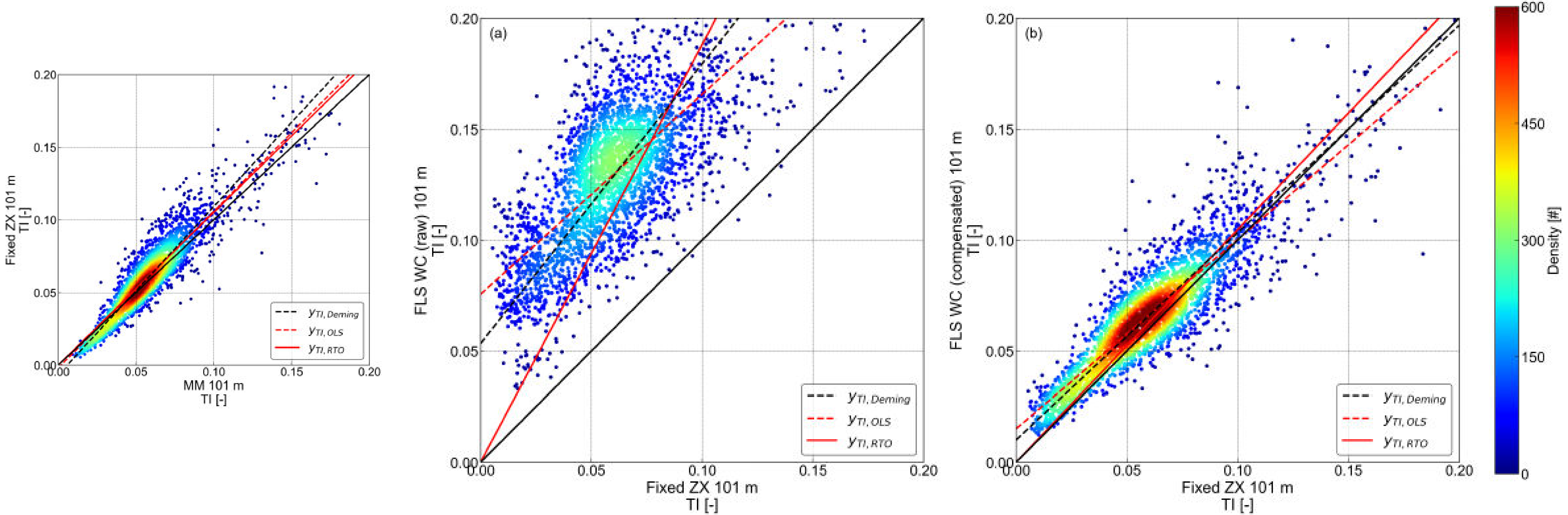

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Preliminary results

TI from floating lidar measurements

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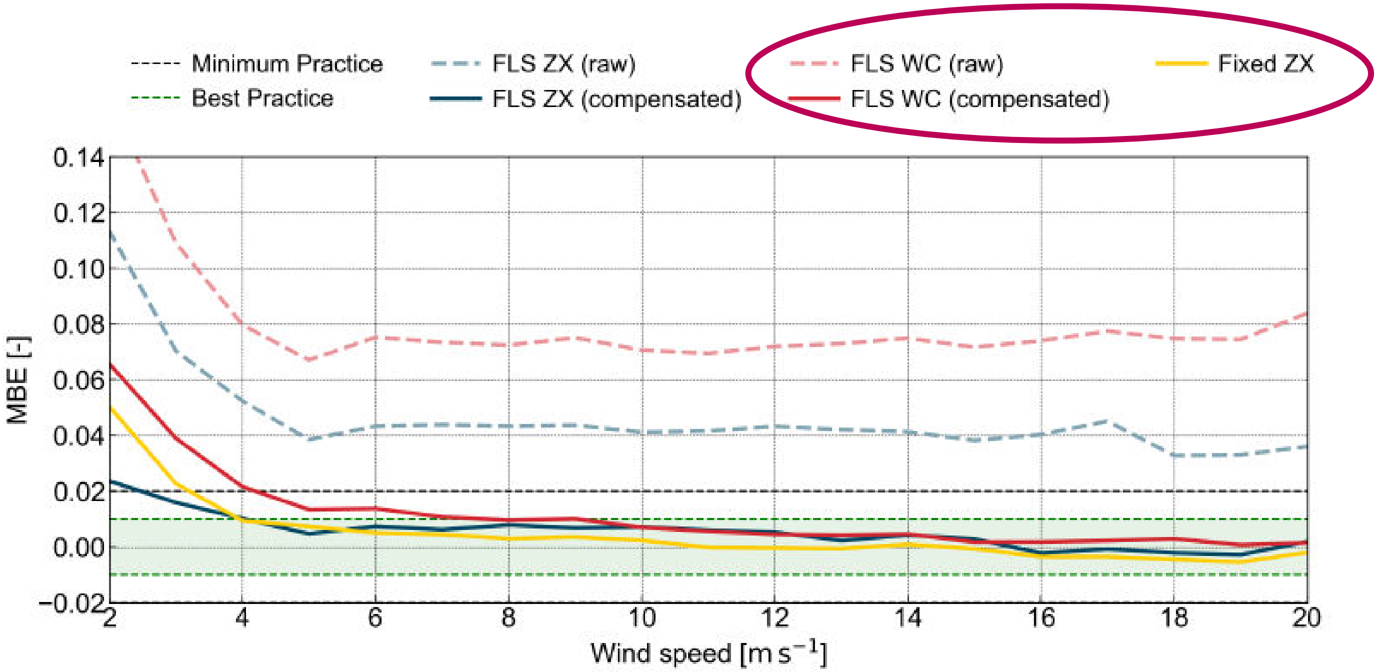

Figure 10. Binned Mean Bias Error between the MM TI and the TI of the trialed devices Fixed ZX (yellow), FLS ZX (blue lines, where the dashed line represents raw data and the solid line depicts motion-compensated data) and the FLS WC (red lines, where the dashed line represents raw data and the solid line depicts motion-compensated data) from 101 m above LAT.

Preliminary results

TI from floating lidar measurements

[Watson et al. “Evaluating the Impact of Motion Compensation on Turbulence Intensity Measurements from Continuous-Wave and Pulsed Floating Lidars” – submitted to Wind Energy Science / preprint should be available shortly]

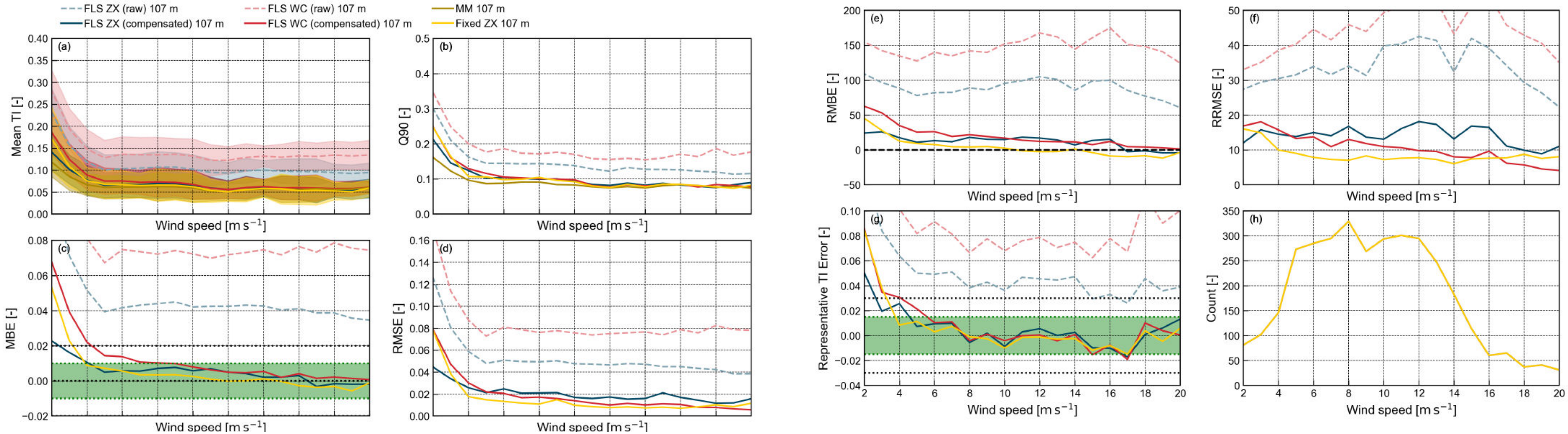

Figure A5. TI Error between the MM TI and the TI of the trialed devices Fixed ZX (yellow), FLS ZX (blue lines, where the dashed line represents raw data and the solid line depicts motion-compensated data) and the FLS WC (red lines, where the dashed line represents raw data and the solid line depicts motion-compensated data) from 107 m above LAT; (a) mean TI; (b) TI Q90; (c) TI MBE; (d) TI RMSE; (e) TI RMBE; (f) TI RRMSE; (g) Representative TI; (h) count.

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Ongoing work

- TI from mesoscale model simulations
- TI from floating lidar measurements (motion correction + correction for lidar profiler)
- TI from (dual) scanning lidar measurements
- Calibration with LES
- Gust and extreme winds .. incl. application of machine-learning methods

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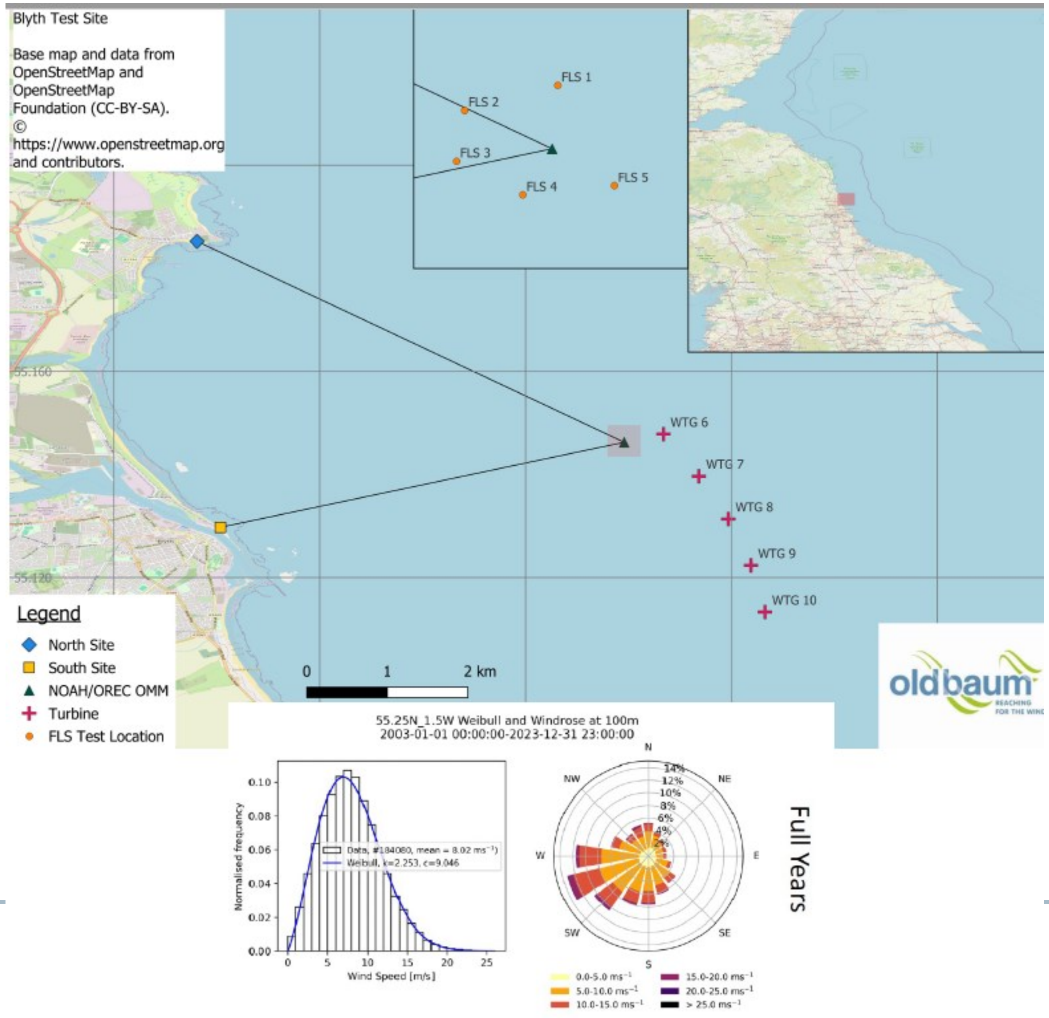
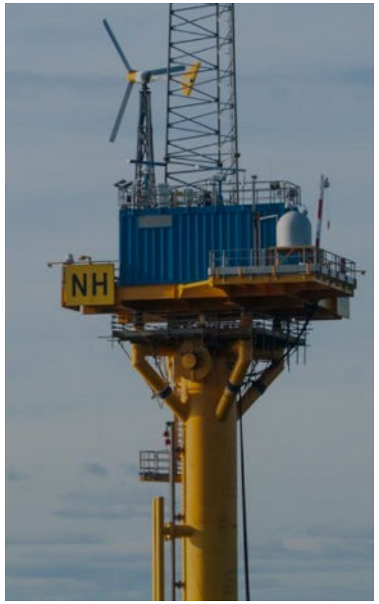
Demonstration of methods → intensive measurement campaign

C-TEST (Centre for the Testing of Environmental Sciences Technology) site





[National Offshore Anemometry Hub (NOAH) | ORE Catapult]

ICON **NEMO**

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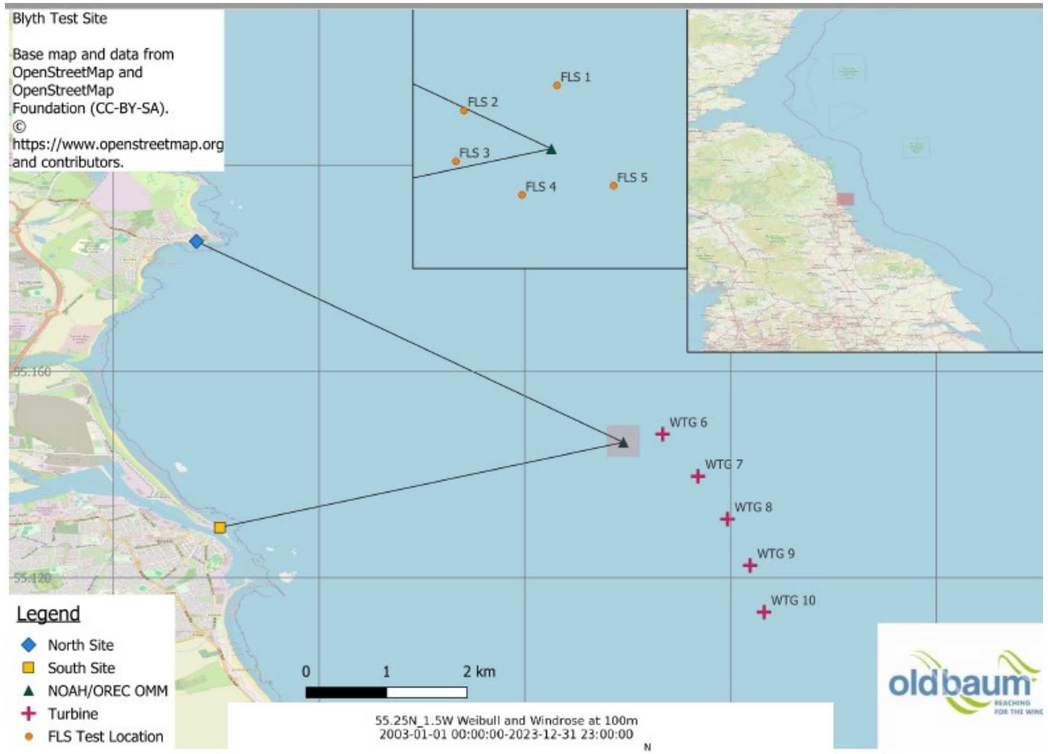

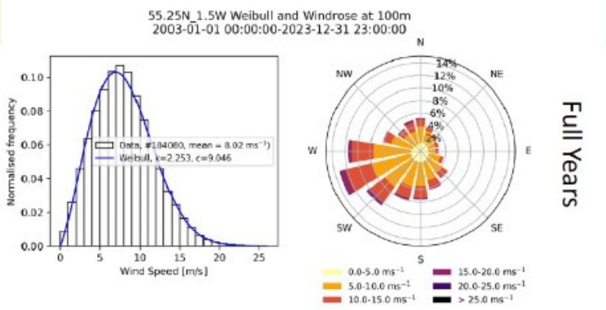

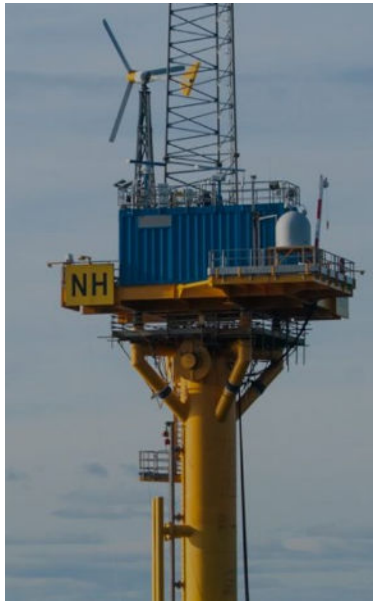

[NOAH | ORE Catapult]

ICON **NEMO**

Demonstration of methods → intensive measurement campaign

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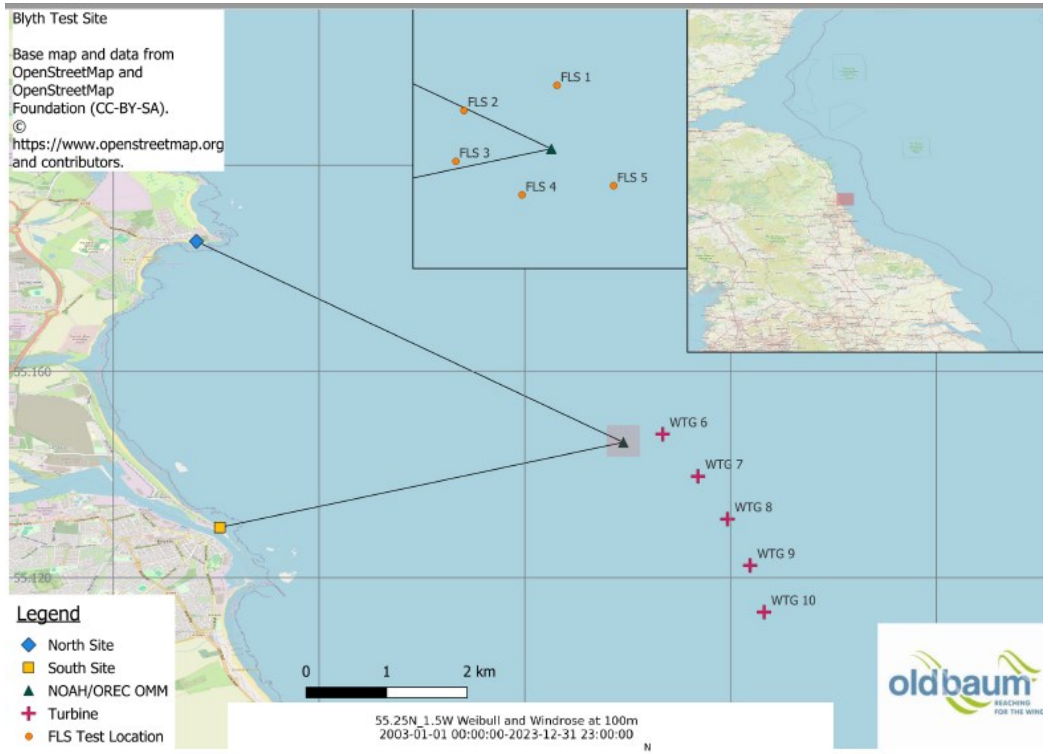
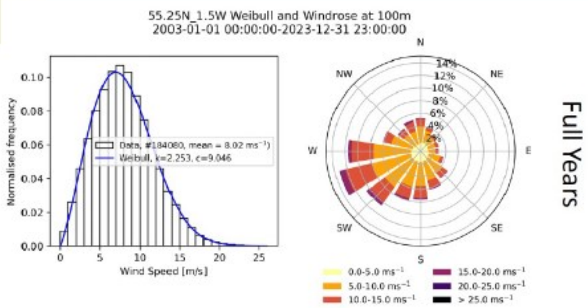
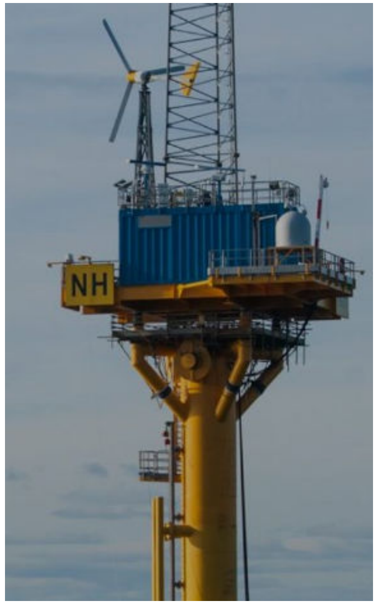






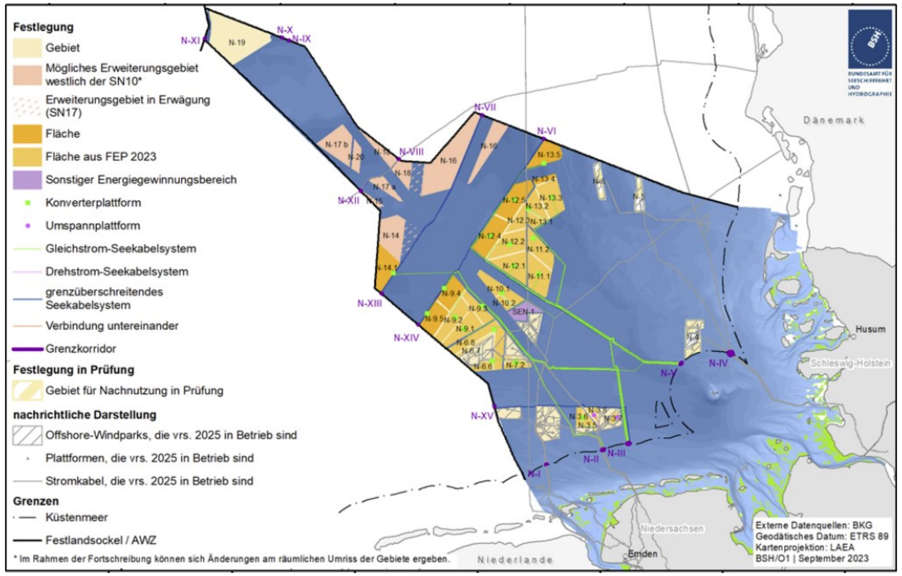
[NOAH | ORE Catapult]

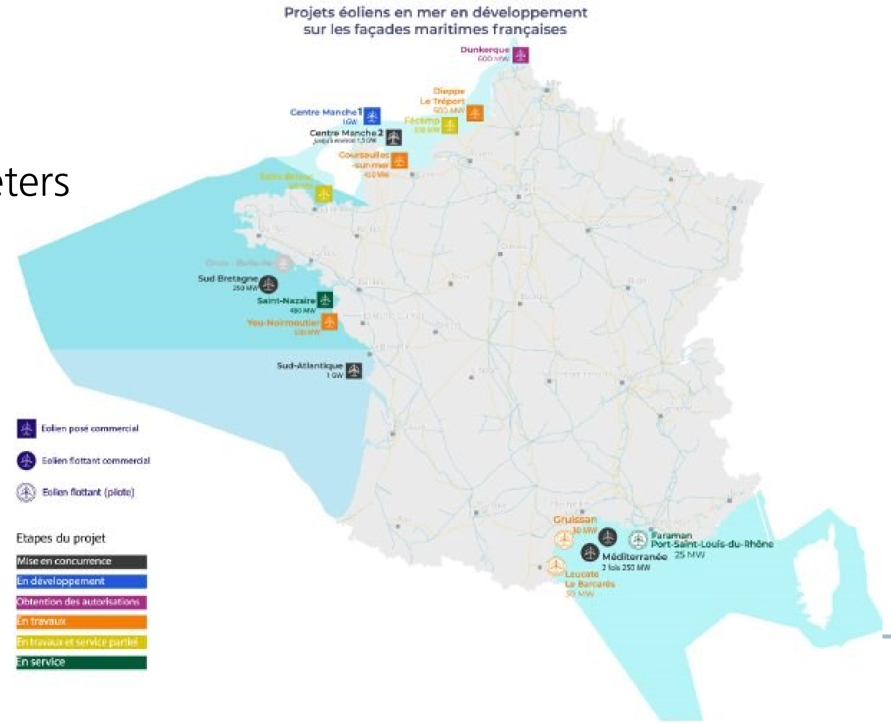
ICON **NEMO**

Summary / outlook

- Ambitient offshore wind plans both in Germany and France
- Wind resource is key but also siting conditions (incl. TI) are paramount
- .. for wind turbine and farm design (loads and also wakes)

- Key R&D questions [not just for NEMO] ..
  - where to get data from
  - which metrics to apply
  - further reconstruction procedures for additonal parameters (gusts, extreme winds)





ICON / DRACCAR **NEMO at WESC 2025**

https://wesc2025.eu/themes

WESC 2025
24 - 27 JUNE | NANTES, FR

Organisation | Themes & sessions | Submission

#01 Wind resource, metocean and extreme conditions

Topics | Mini-symposia

MS#01.1 (Dual) Doppler Wind Radar for Wind Energy Applications
B. LANGE[1], J. GOTTSCHALL[1], B. HIRTH[2], J. SCHROEDER[2]
[1] Fraunhofer IWES | [2] Texas Tech University

MS#01.3 The role of air-sea interactions in offshore wind energy applications
A. AIYER[1], S. PORCHETTA[2], K. YOUSEFI[3], J. FISCHEREIT[4], M. HOWLAND[5], X. GUO LARSÉN[4]
[1] Lehigh University | [2] TU Delft | [3] University of Texas at Dallas | [4] DTU Dept of Wind and Energy Syst

MS#01.4 Icing of wind turbine blades
T. KARLSSON[1], T. KIM[2]
[1] VTT Technical Research Centre of Finland Ltd. | [2] DTU Dept of Wind and Energy Systems

MS#01.6 Understanding the Impact of Tropical Cyclones and Winter Storms on Offshore Wi
G. DESKOS[1], X. GUO LARSÉN[2]
[1] National Renewable Energy Laboratory | [2] DTU Wind and Energy System

MS#01.7 New methods for turbulence measurements and models in offshore wind
J. GOTTSCHALL[1], F. ROUHOLAHNEJAD[1], M. THIÉBAUT[2]
[1] Fraunhofer IWES | [2] France Energies Marines

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