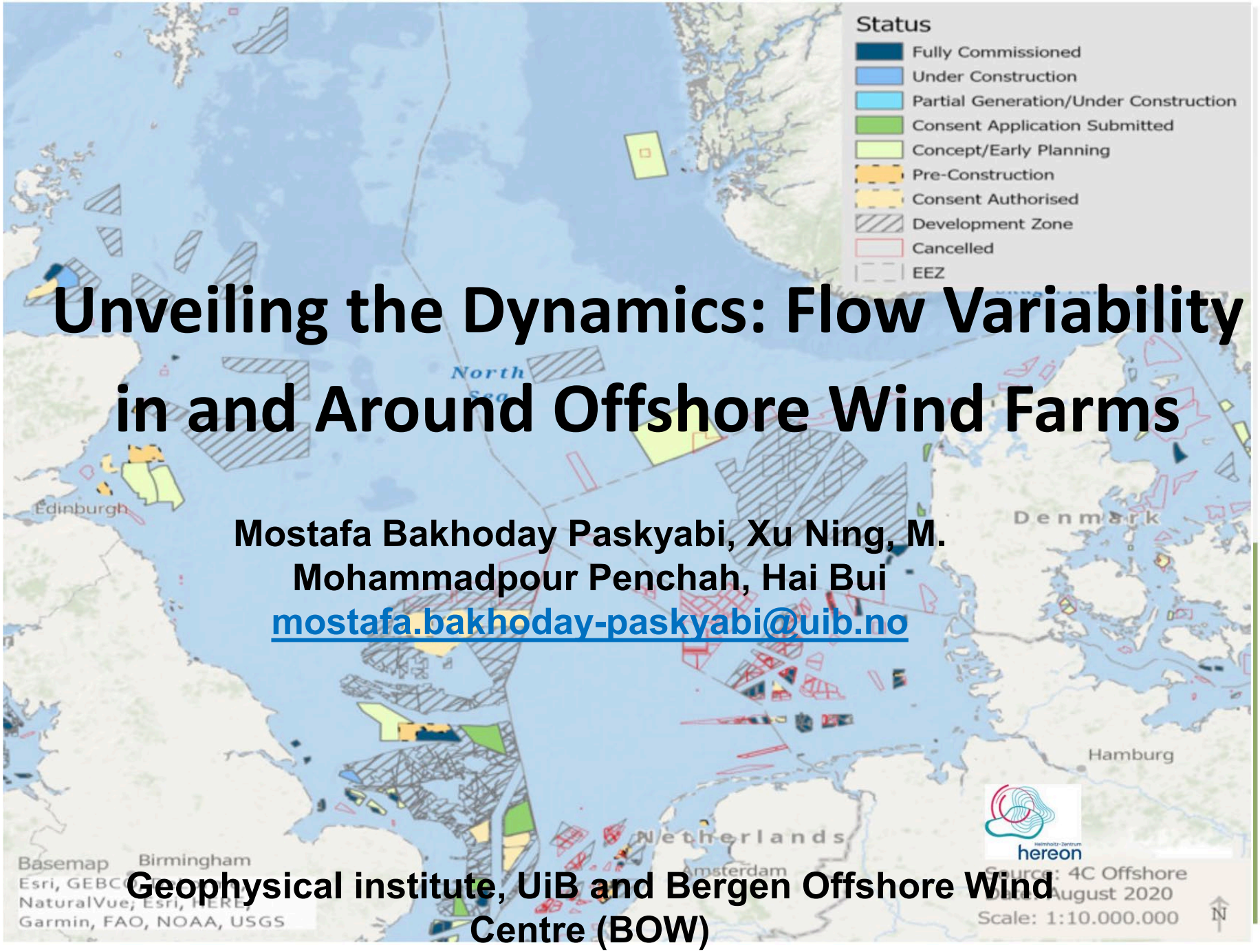

Unveiling the Dynamics: Flow Variability in and Around Offshore Wind Farms

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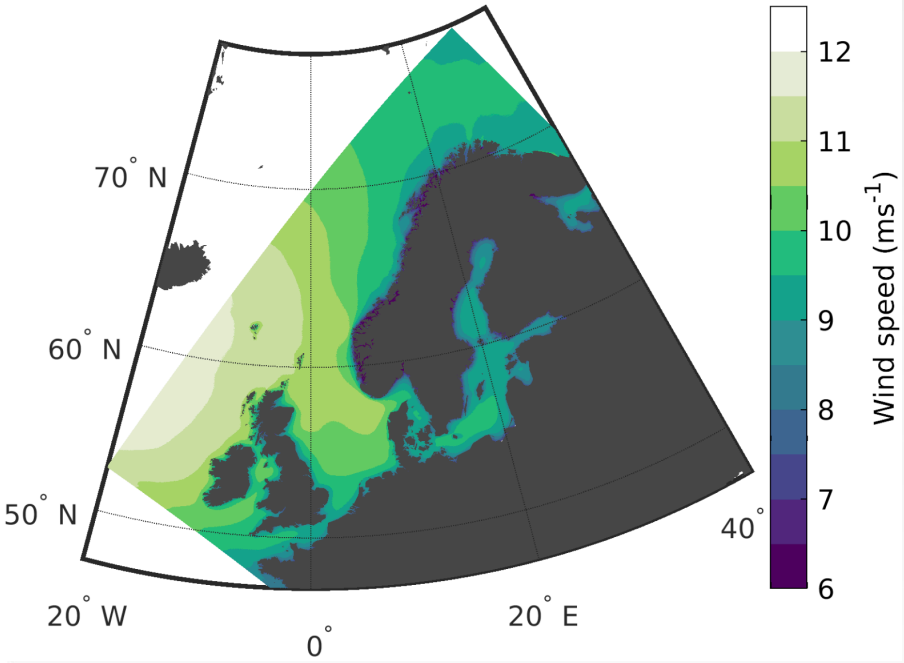
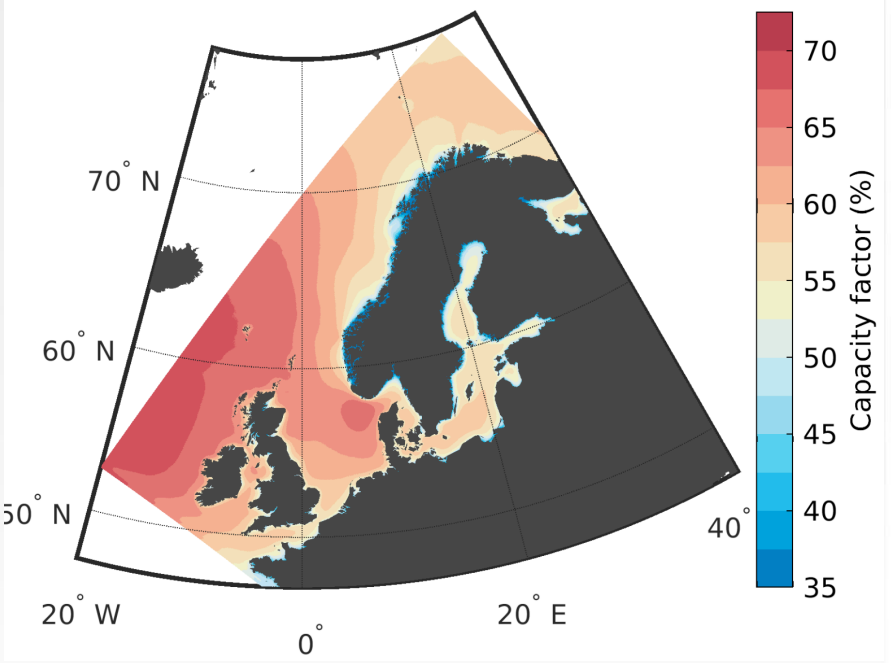
Wind resource assesment

Wind resource assessment is crucial in the design of offshore wind parks as it provides key information for **energy production estimation**, **turbine siting**, **technology selection**, **financial analysis**, **risk assessment**, and **environmental impact assessment**.



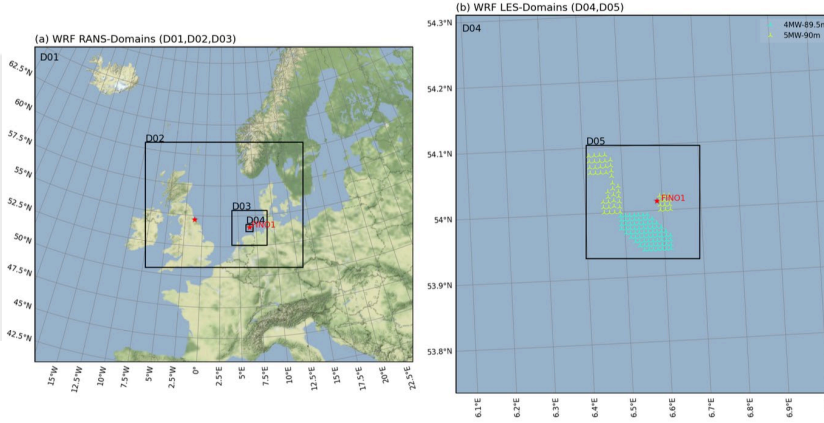
The average offshore wind speed at 150m above the mean sea level for the period 1996-2019 from NORA3 3km reanalysis



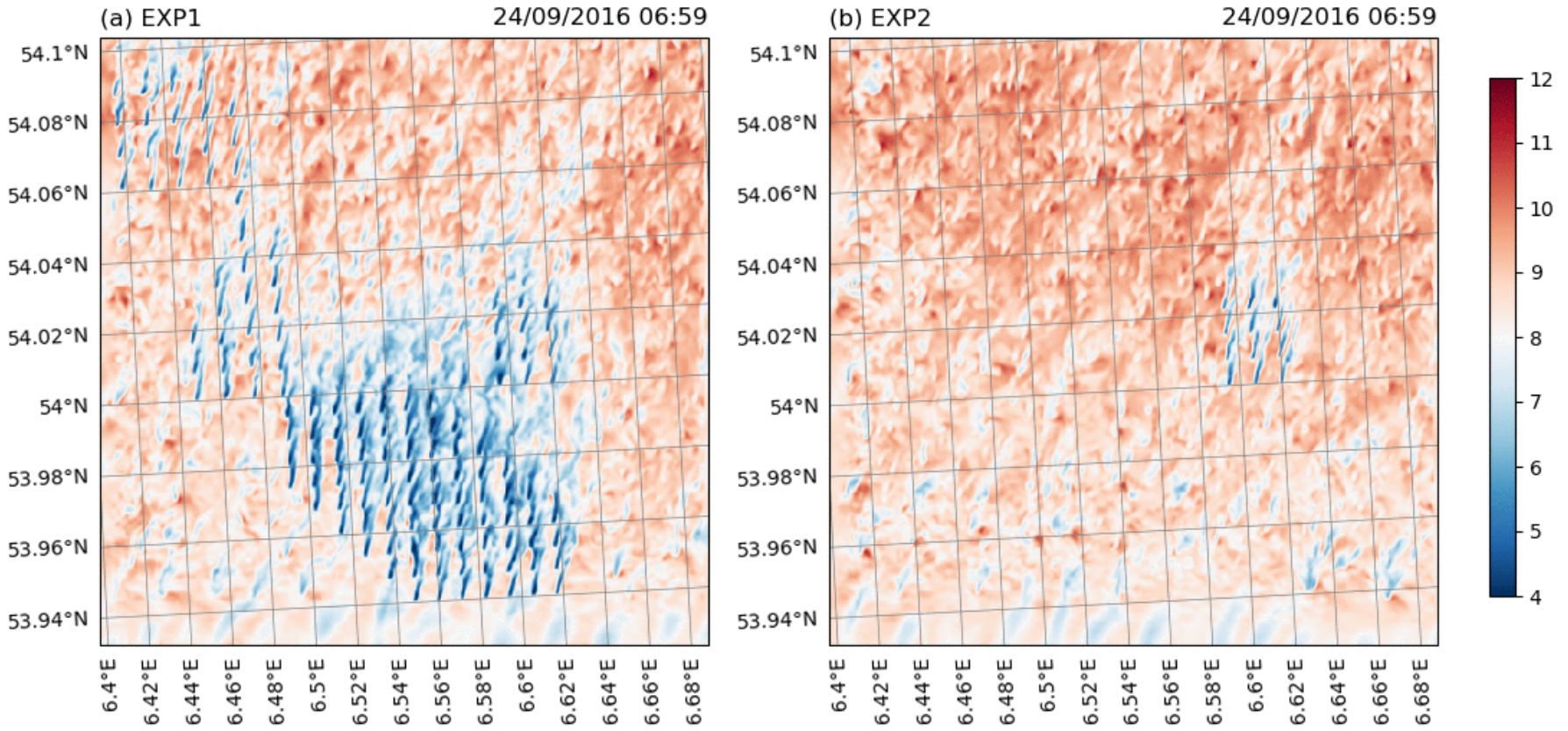
The average offshore monthly capacity factors (CF) for the period 1996-2019 from NORA3 3km reanalysis

Solbrekke and Sorteberg, 2022
Hoskins and Hodges, 2019

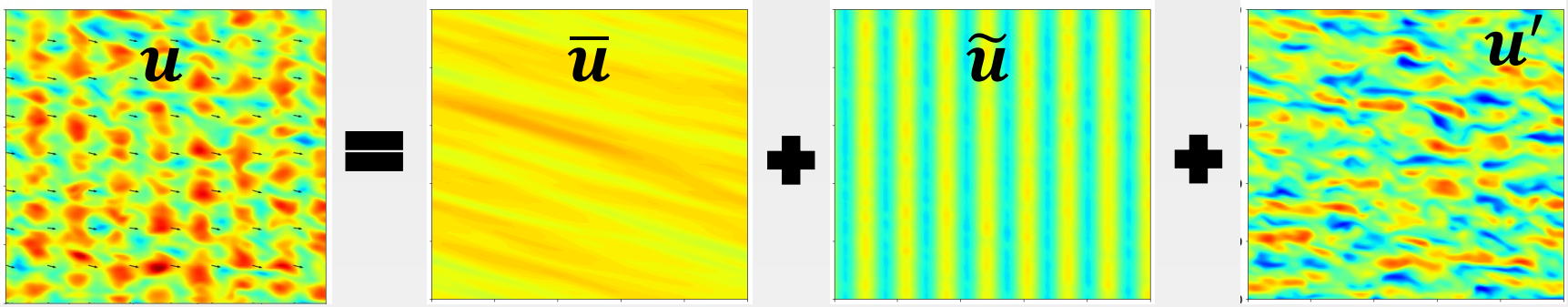
Multiscale framework SADLES

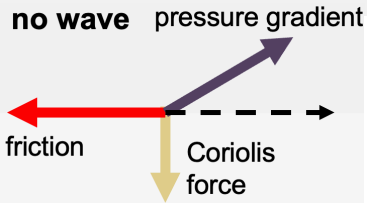


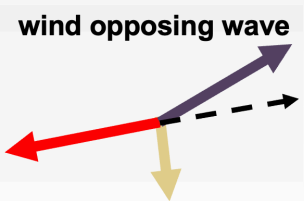
Reduction in wind speed at Alpha Ventus by 14%
And power generation by 35%. [3]

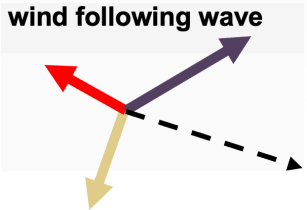


Wind wave interaction: Impacts on mean and turbulent flows

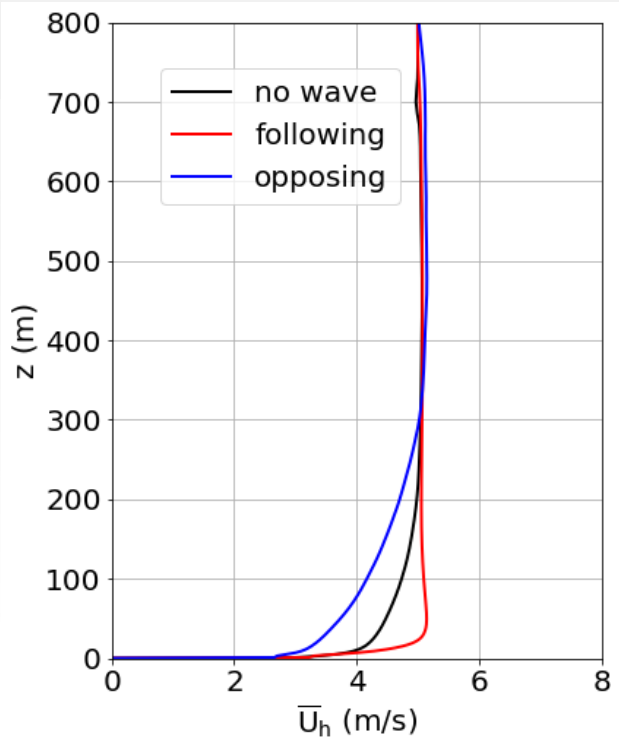




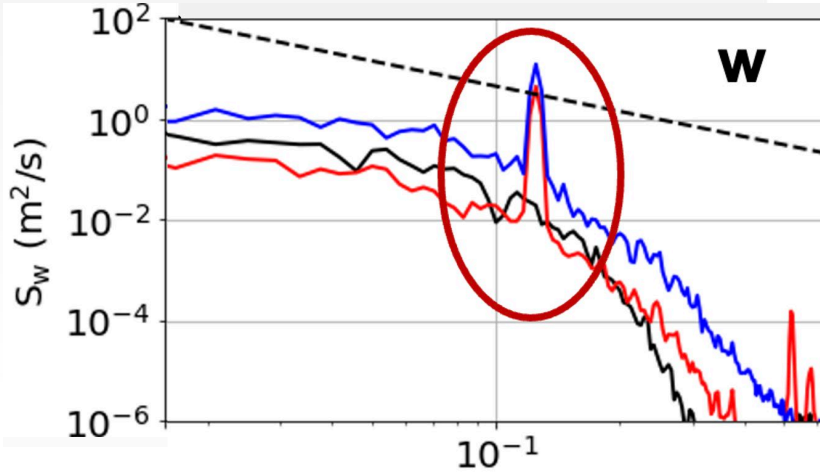




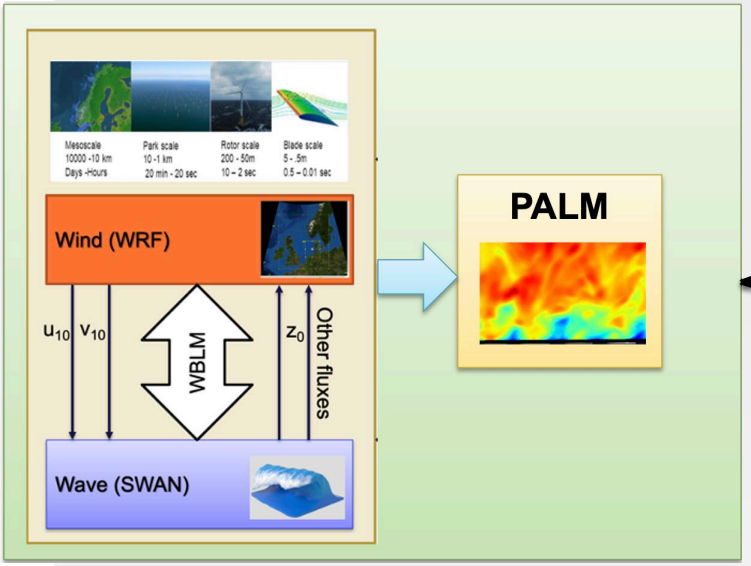
Profiles of the mean wind



Power spectral density curves at 20m height

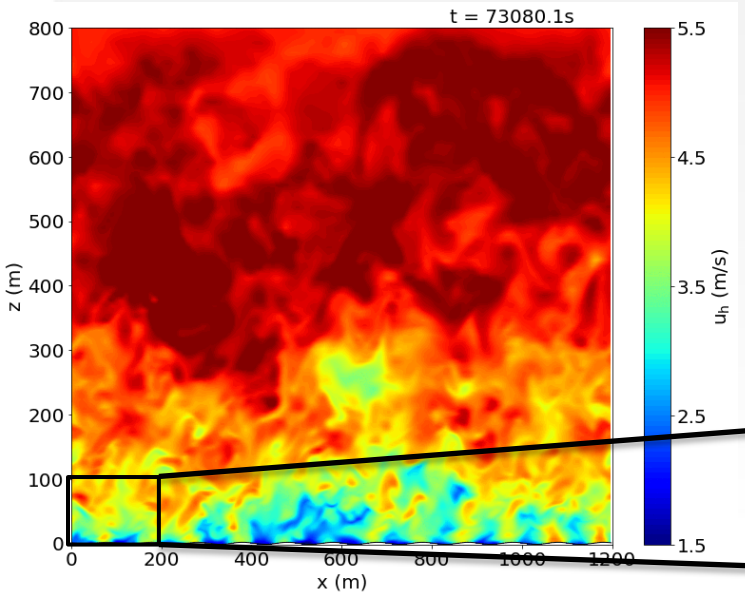


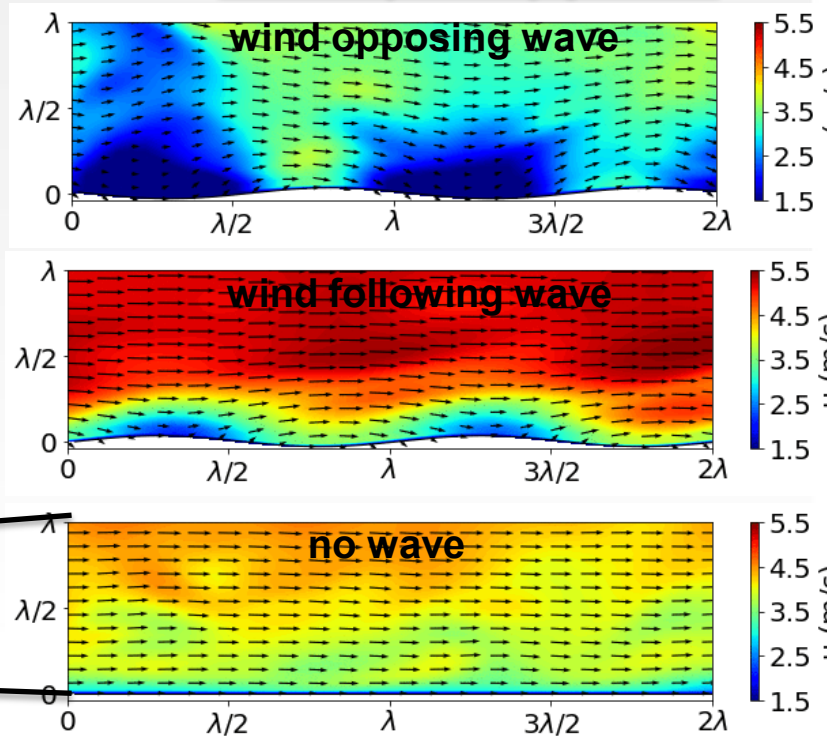
Multiscale modelling framework



- Roughness length parameterization [1]
- Wave induced momentum (energy) distribution functions [2,3]
- Applying curvilinear wave-dependent system [4]

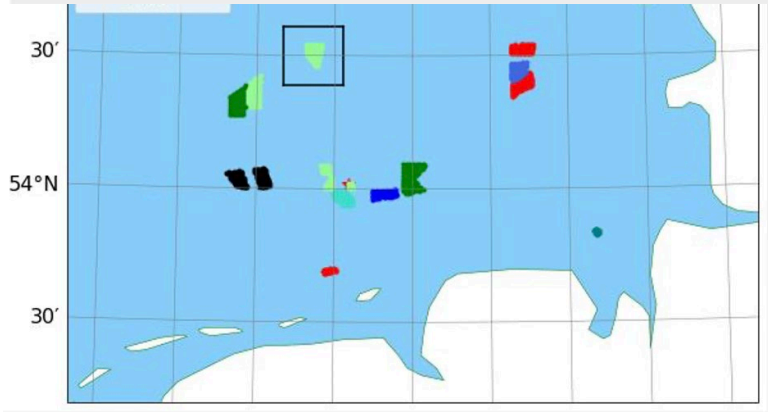
Fluctuation of horizontal velocity at *x*-*z* plane





Farm and wind wave interaction

Southern North Sea



Ning and Bakhoday Paskyabi, 2024

Mean horizontal wind speed at the hub height plane with streamlines

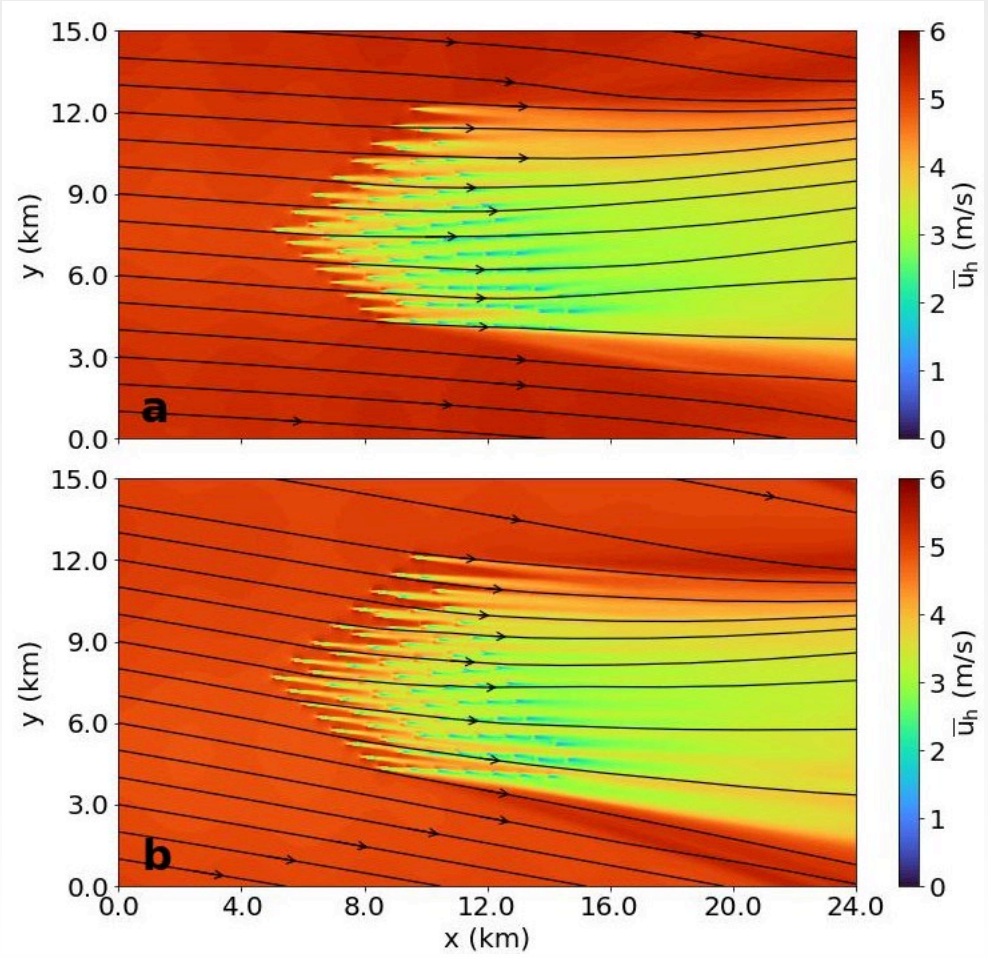
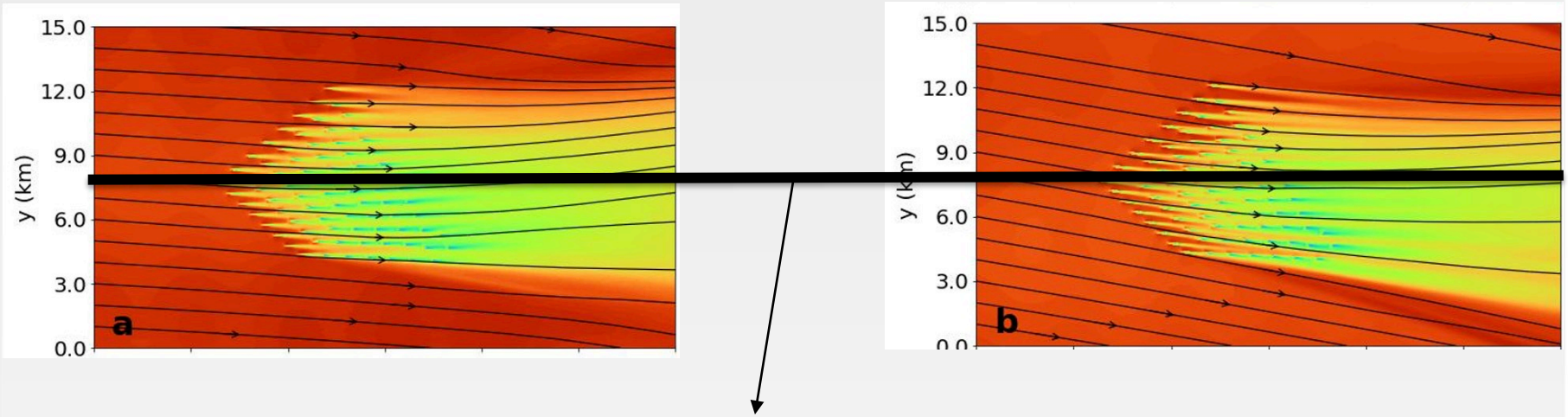
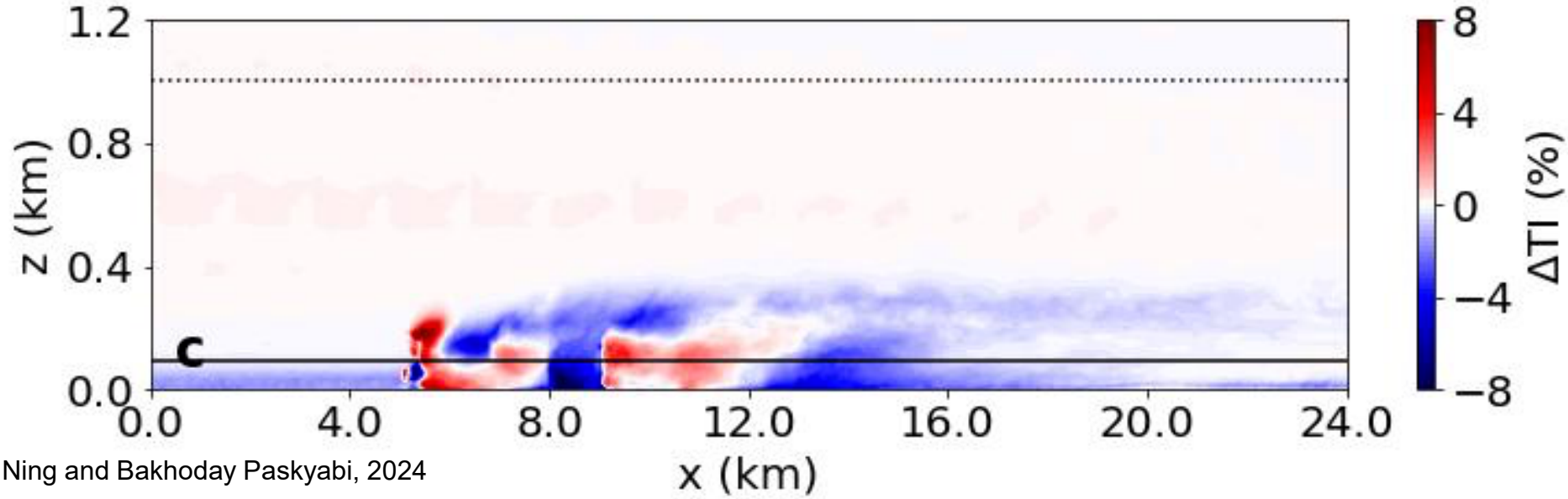


Figure a is control run with wind direction of 315 deg degree without wave effect and figure b we have the peak wave speed is 12.0 m/s and the wave direction is 337.5 deg.

Farm and wind wave interaction



$$TI_{difference} = TI_{of(b)} - TI_{of case\ (a)}$$



Ning and Bakhoday Paskyabi, 2024

Summary

- Wind assessment and wake modelling are crucial in turbine positioning in a park.
- Wake modelling along with sophesticated control strategies contribute in reducing the wake losses.
- Multiscale frame work enables us to design more efficient layout design.

References

[1] Ning, Xu; and **Bakhoday Paskyabi, Mostafa**, Evaluation of sea surface roughness parameterization in meso-to-micro-scale simulation of the offshore wind field, *Atmospheric Research*, reply to reviewers' comments, 2022.

[2] Mohammadpour Penchah, Mohammadreza; **Bakhoday Paskyabi, Mostafa;** and Bui, Hai**,** Considering the effects of sea waves on offshore wind simulations in the Weather Research and Forecasting model, *Wind Energy*, under review, 2024.

[3] Bui, Hai; **Bakhoday Paskyabi, Mostafa;** and Mohammadpour Penchah, Mohammadreza, Implementation of a Simple Actuator Disc for Large Eddy Simulation (SADLES-V1.0) in the Weather Research and Forecasting Model (V4.3.1) for Wind Turbine Wake Simulation, *Geoscientific Model Development (GMD)*, under review 2023.

[4] Bakhoday Paskyabi, Mostafa, Impact of swell waves on atmospheric surface turbulence: A wave-turbulence decomposition method, *Wind Energy Science*, under reviewer, 2024.

[5] **Bakhoday Paskyabi, Mostafa**; Zieger, S; Jenkins, Alastair David; Babanin, A. V.; Chalikov, D. Sea surface gravity wave - wind interaction in the marine atmospheric boundary layer. *Energy Procedia* 2014 :Volum 53. s. 184-192NORCE UiB