Modelling the Impact of Offshore Wind Subsea Structures on Ocean Stratification

William R. Macdonald[1], Rory O' Hara Murray[1], Michela De Dominicis[2]

1. Scottish Government: Marine Directorate, Aberdeen, UK 2. National Oceanography Centre, Liverpool, UK

Scottish Government
Riaghaltas na h-Alba
gov.scot
marine directorate
ECOWind PELAgIO

Reduction in Stratification

Offshore wind turbines generate turbulent mixing in the water column through interactions with their subsea structures [1]. Given the rapid expansion of offshore wind energy, it is crucial to promptly and accurately assess these effects to support informed policy decisions.

This study is part of the Ecowind project, PELAgIO, which combines lower-resolution regional modeling and fieldwork to evaluate the impacts of offshore wind on physical and ecosystem processes. Here, we present preliminary findings from a high-resolution model focused on an existing wind farm.

The model incorporates a parameterisation for subsea structures associated with offshore wind farms. Comparisons are conducted between baseline physical models and those that include wind farm structures, highlighting the potential impact of offshore wind development on ocean stratification.

This work shows a significant reduction in stratification from the presence of offshore windfarms (Fig 1).

Temperature profiles (Fig 2.) show how including offshore windfarm parameterisation in our model changes the vertical water column structure.

Within the windfarm the profile shifts from stratified to well mixed and moving away from the windfarm returns to stratification present in the model with no windfarms.

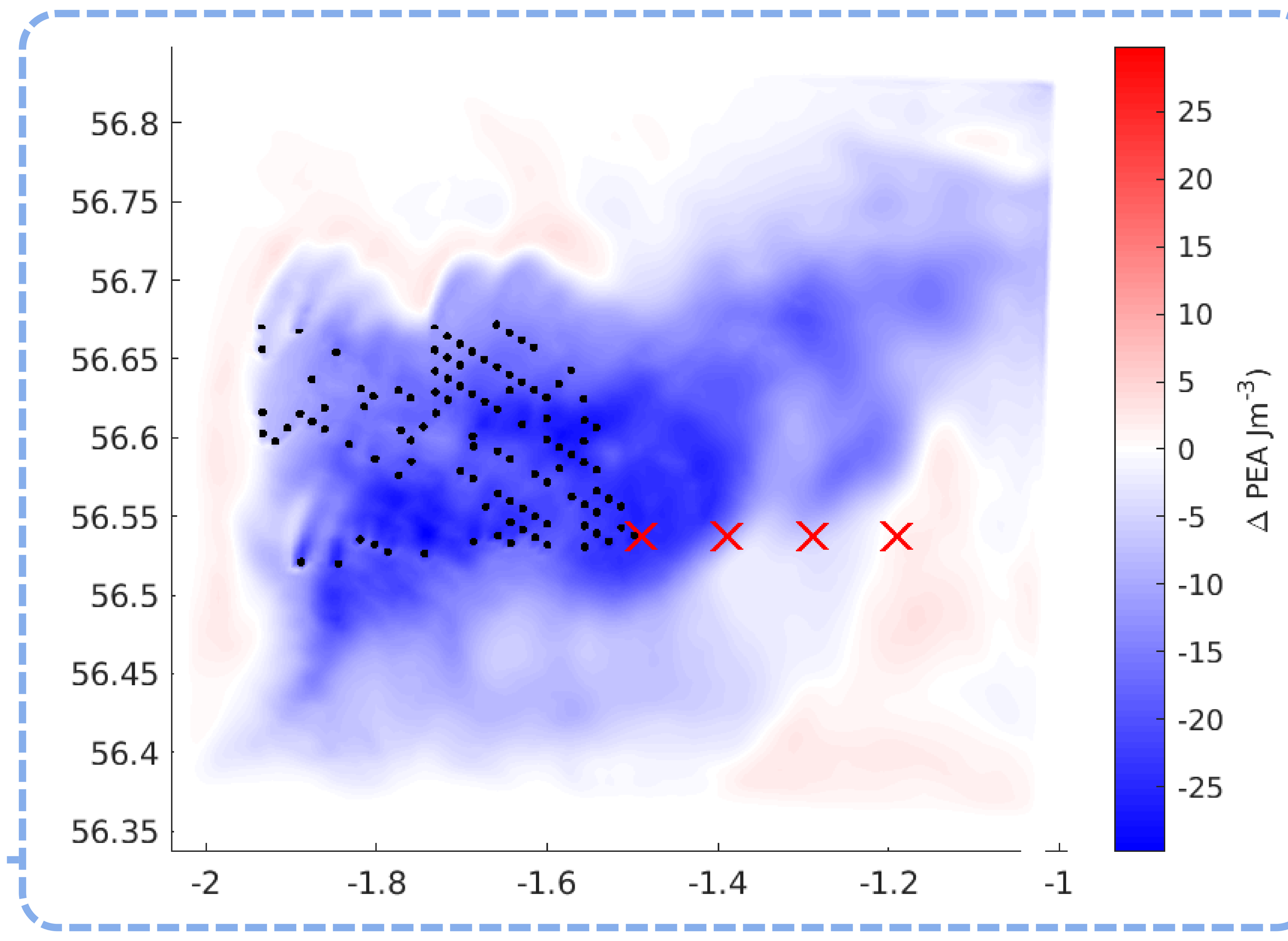

Figure. 1 Instantaneous (7th May 2023 20:00) change in Potential Energy Anomaly for simulations with and without windfarm parameterisation.

X - represents extracted water column profiles

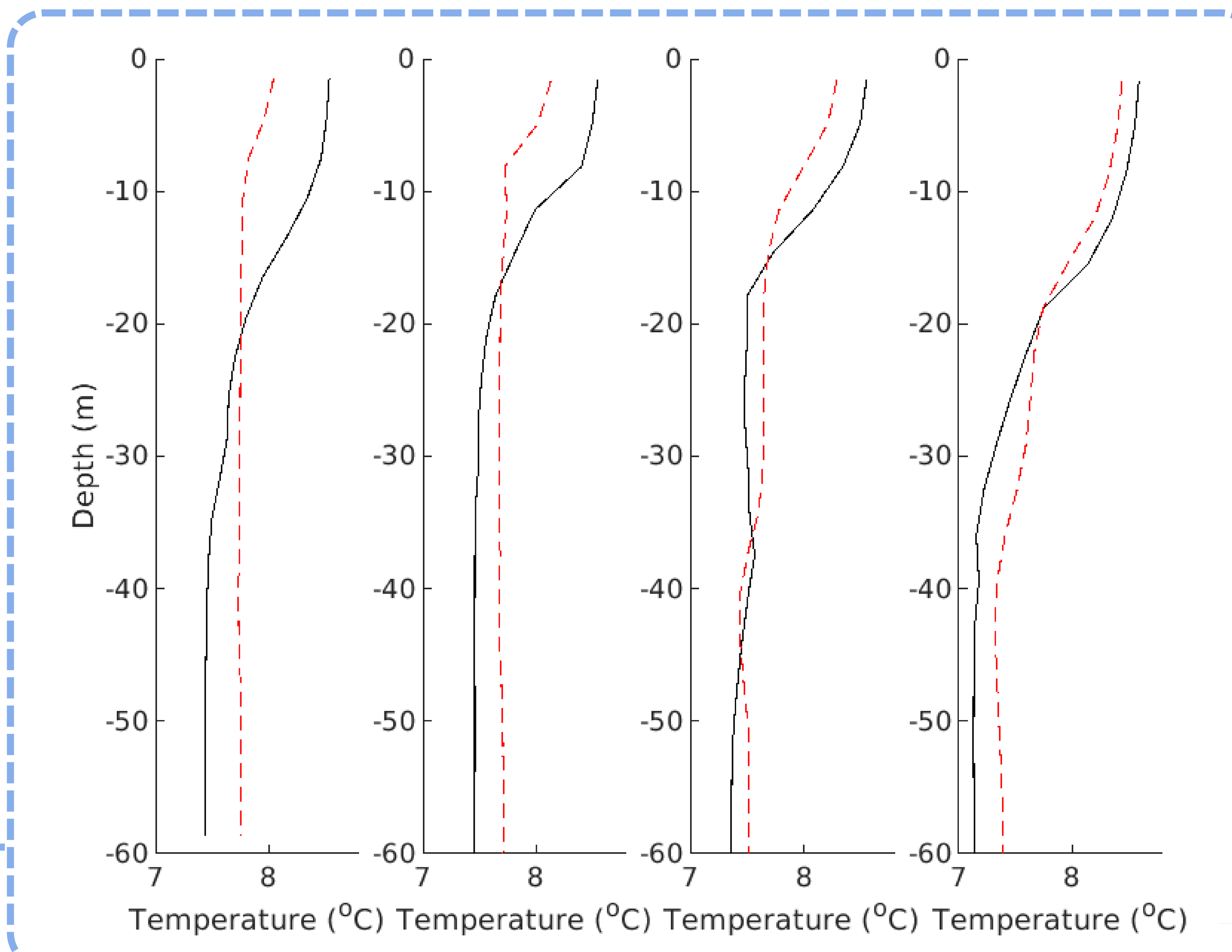

Figure. 2 Comparison of water column structure for models with and without windfarms. (7th May 2023 20:00) (A - D represents sample point from west to east respectively)

Grid Sensitivity

Work is being undertaken around parameter estimation and validation of models with data collected during PELAgIO field studies. With this in mind it is important to develop confidence in our results before applying these findings to different areas.

Sensitivity analysis of the model's windfarm parameterisation is happening in a number of ways:

- Testing sensitivity to environmental and oceanic conditions
- Exploring how the model changes with grid size
- Identifying which parameters are most influential within the model

An example of this sensitivity work is shown here.

There is a qualitative sensitivity to grid size discovered when modelling the impact of windfarms on stratification (Fig 3).

Quantitative analysis (Fig. 4) reveals this sensitivity is created by the ocean physics model (FVCOM) rather than the additional OWF model.

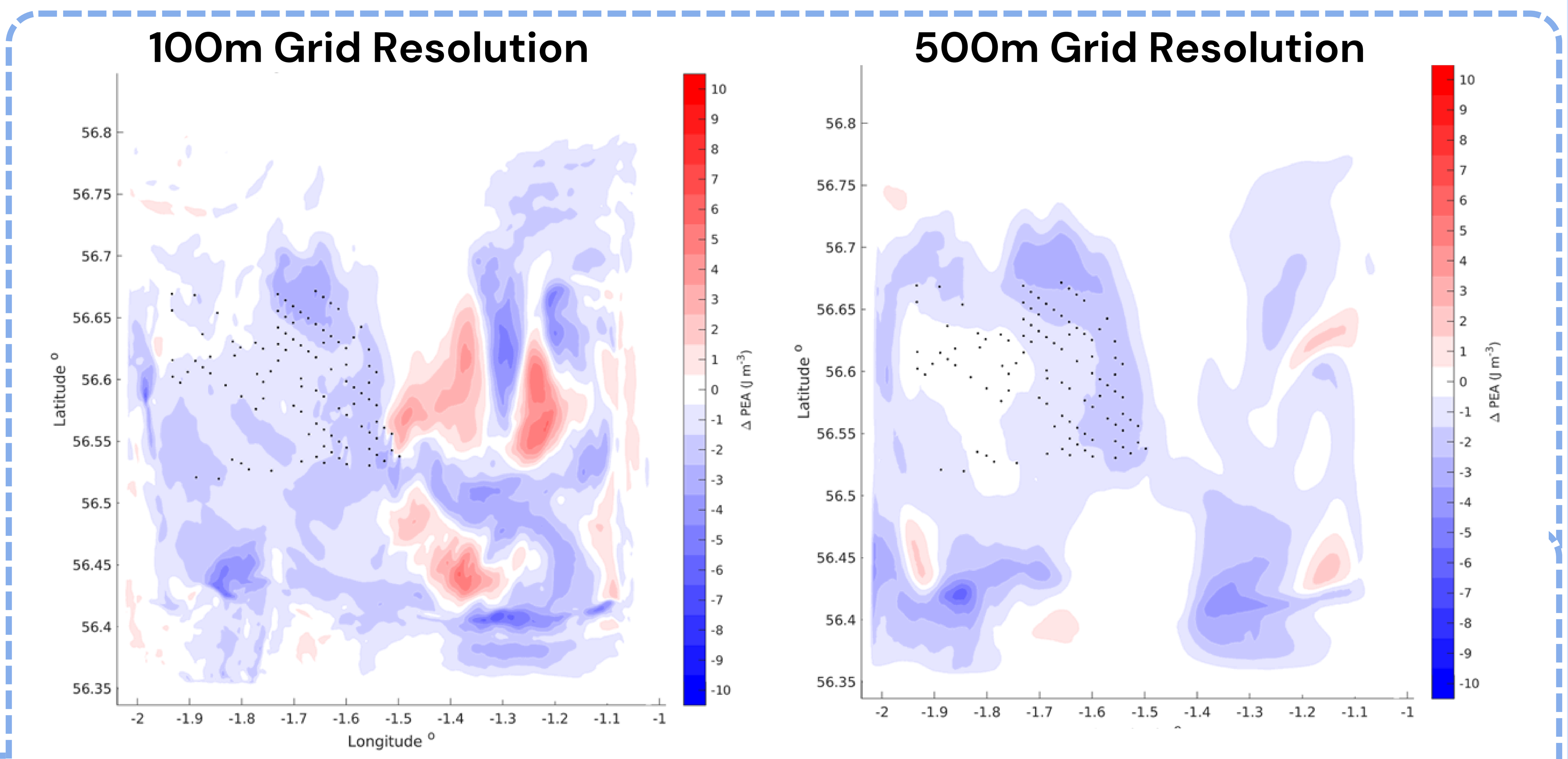

Figure 3 Weekly Averaged (1st April - 8th April 2003) change in Potential Energy Anomaly between a model including offshore windfarms and physics only. This shows a comparison of two grids using an average node spacing of 100m and 500m.

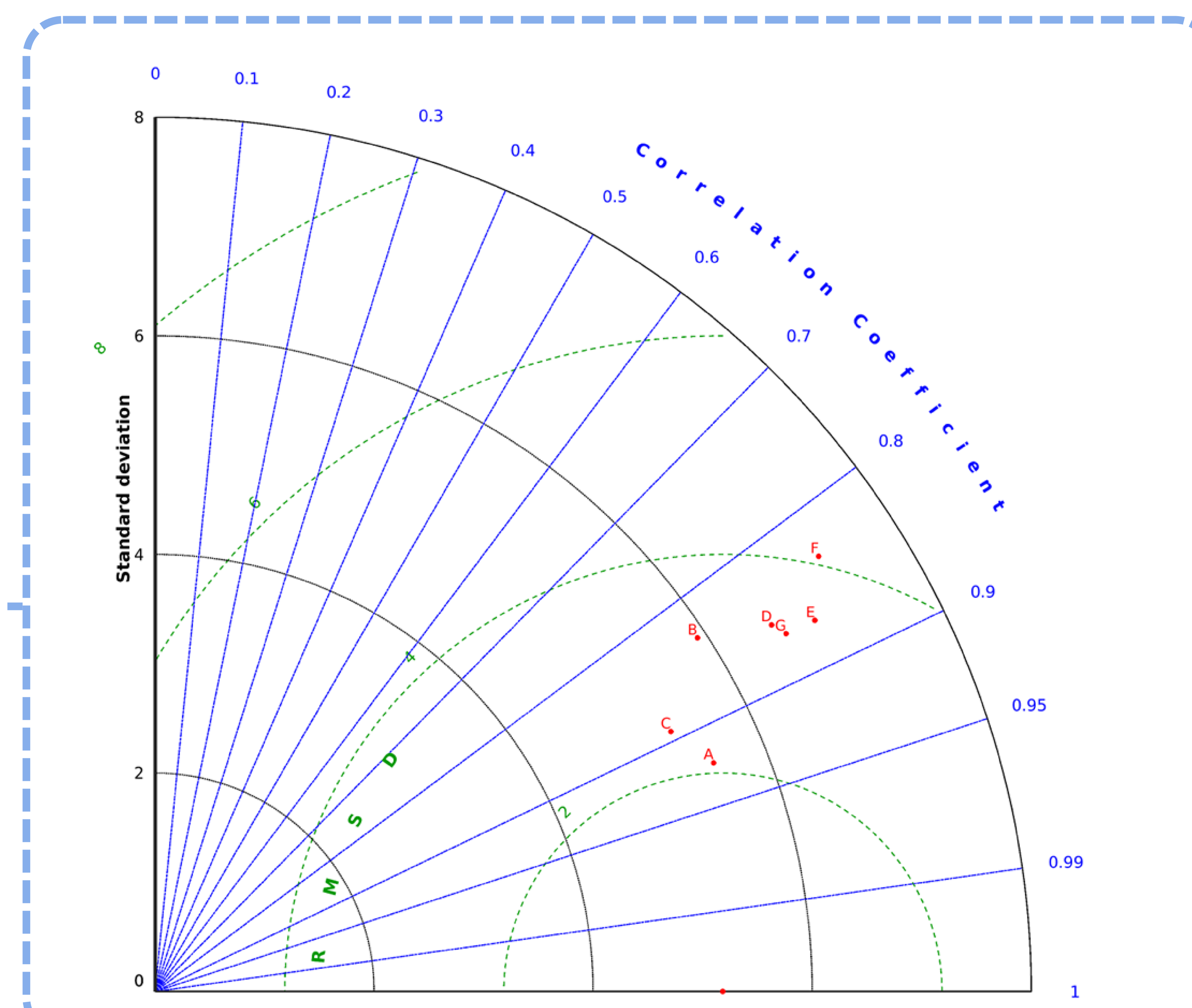

Figure 4 Taylor diagram of the variation of Potential Energy Anomaly for final timestep of one month model run (June 2016).
(Reference Grid: 500m physics only, A: 250m physics only ,B: 100m physics only ,C: 50m physics only ,D: 500m windfarms included ,E: 250m windfarms included ,F: 100m windfarms included ,G: 50m windfarms included)
All results are averaged to the 1000m grid before comparison.

References:
[1] Dorrell, R.M. et al. (2022) 'Anthropogenic mixing in seasonally stratified shelf seas by offshore wind farm infrastructure', Frontiers in Marine Science, 9. doi:10.3389/fmars.2022.830927.

For further information email: william.macdonald@gov.scot