Future Climate Change Impact Assessment on Extreme Low Wind Events for Offshore Wind Turbines within the UK Exclusive Economic Zone

Sara Abdelaziz, Sarah N. Sparrow, David Wallom

Abstract

Wind energy has been seen as a promising renewable resource to meet the 2-degree Paris agreement target. Climate change should be considered in the offshore wind turbine (OWT) planning stage, as it will lead to more frequent and intense extreme weather events. Extreme Low Windspeed Events (LWE) must be addressed to achieve dependable and affordable wind energy. This research aims to ensure wind power reliability in the future by investigating the increase of LWE intensity in two future periods (2021-2040) and (2061-2080) using RCP8.5 compared to the historical period (1981-2000). The research uses the 2.2km UKCP18 daily mean wind speed. The analysis in this research has investigated the return time for 4m/s, 5m/s, and 6m/s cut-in wind speed thresholds in East, South, West, and North regions inspired by the shipping forecast areas [1] in the UK exclusive economic zone (EEZ), see Fig 1.

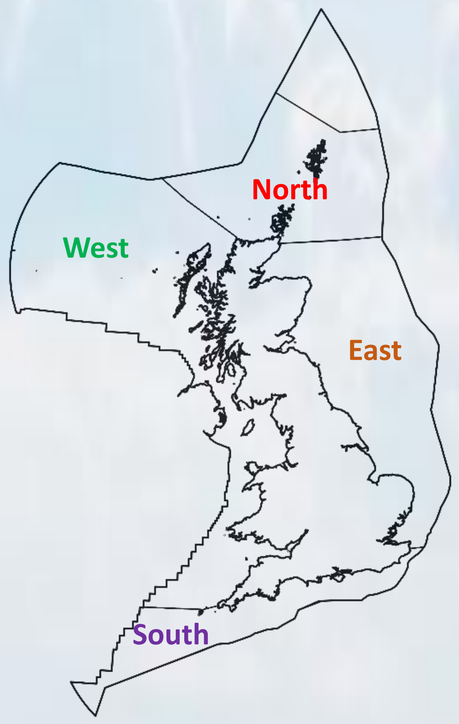

Fig1. East, South, West, and North regions.

Risk Ratio

The risk ratio (RR) is used to determine the ratio between the likelihood of the event occurring in 2021-2040 and 2061-2080 compared to the occurrence likelihood in the historical period.

$$RR = (F_i / F) / (H_i / H)$$

Where RR is the risk ratio. H_i and F_i are the numbers of data less than the cut-in wind speed threshold in the historical and future periods, respectively. H and F are the total numbers of data available in the historical and future periods, respectively.

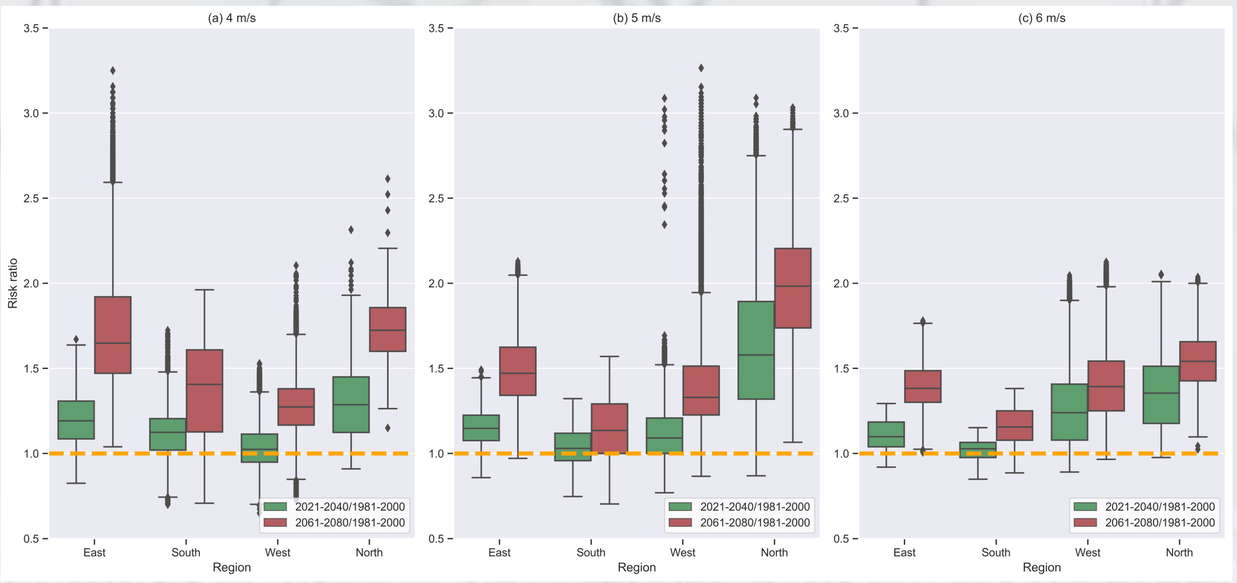

Fig 2. RR for 2021-2040 relative to 1981-2000 and 2061-2080 relative to 1981-2000 calculated for (a) 4m/s, (b) 5m/s, and (c) 6m/s thresholds using five days running mean.

Low wind event return period

- The likelihood of 4m/s, 5m/s, and 6m/s thresholds to reoccur (return year) is calculated spatially using the running mean of the daily wind speed time series for five consecutive days, see Fig 3.
- Using mean absolute error, root mean square error, and Kolmogorov-Smirnov test, beta distribution has been chosen to calculate the return year for events of magnitude equal to or less than a threshold.
- In Fig 4. The increase in the risk of LWE (reflected by a decrease in return time) is concentrated in areas near the coast compared to open sea areas.

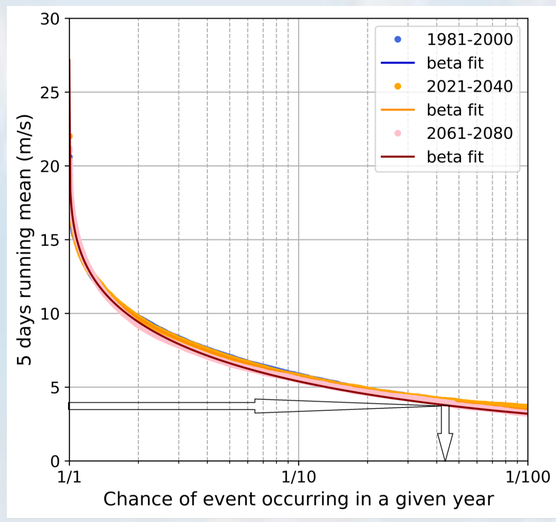

Fig 3. Return using beta distribution in a single cell grid.

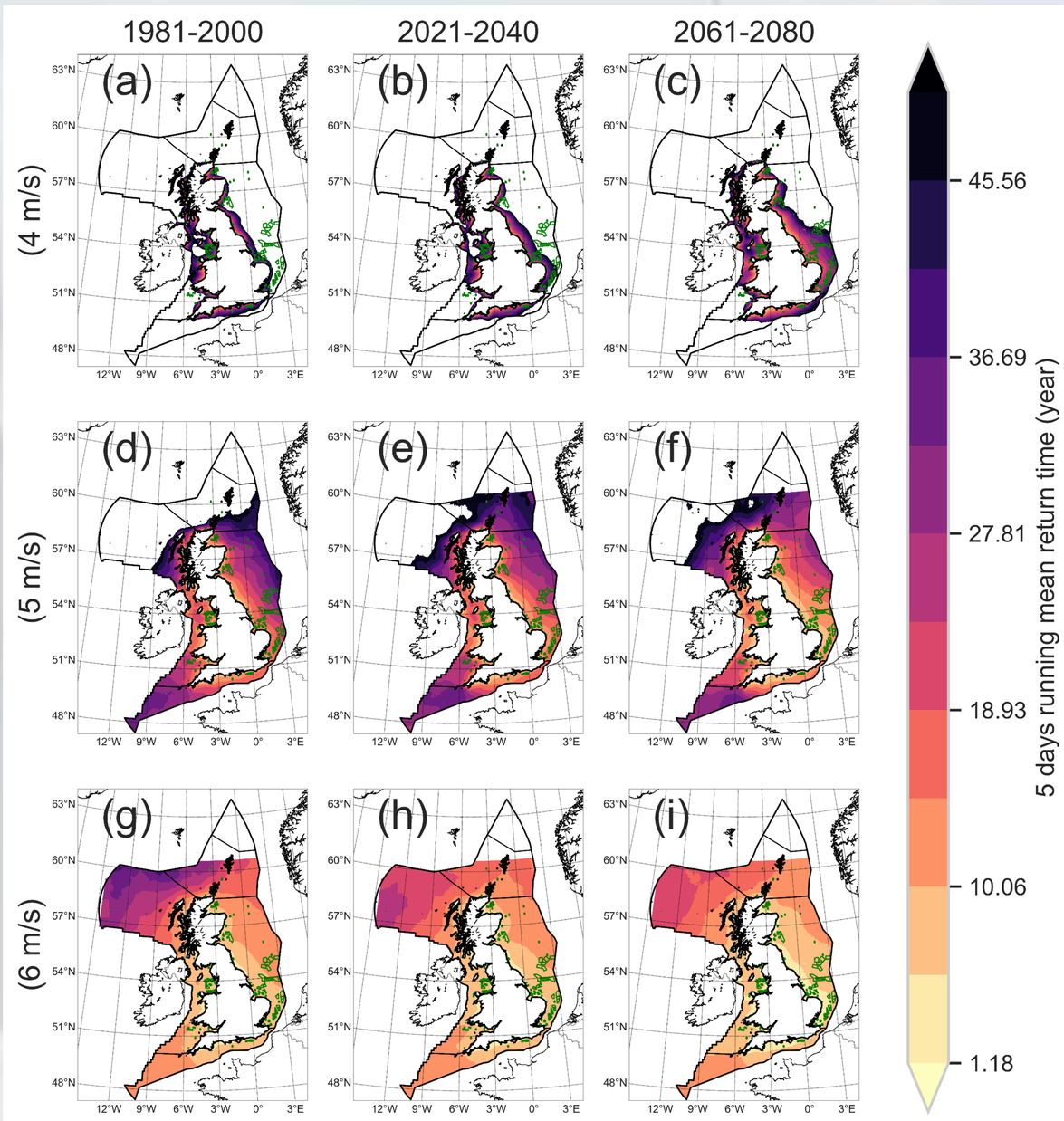

Fig 4. Return time for three different thresholds for five days running.

Findings

Emphasizing the importance to consider future planning of wind turbines with cut-in wind speed < 4m/s in locations near to the coastline.

In the period 2061-2080, the four regions show a increasing RR with rising temperatures under 4m/s, 5m/s, and 6m/s thresholds.

In the period 2021-2040, the median RR value for the 4m/s threshold in the West region and for the 5m/s and 6m/s thresholds in the South region indicate a lower risk of LWE events compared to other regions.

The return year and RR region median recommend the South for OWF installation in 2021-2040 compared to historical period using 5m/s and 6m/s thresholds and recommend the West region for 4m/s investigation in 6-, 7-, and 8-days in the same future time period.

OWT with a 6m/s cut-in wind speed, will be at risk of frequent extreme LWE in most of the EEZ in the future.

Reference:

[1] N. M. Library, "Fact sheet 8 - The Shipping Forecast National Meteorological Library and Archive."

- Background figure (Dogger Bank wind farm). Source: https://www.azocleantech.com/article.aspx?ArticleID=1072

Acknowledgment:

- Funding: The Schlumberger Foundation Faculty for the Future program partially supported this research work.
- The research used the University of Oxford Advanced Research Computing (ARC).