

FUTURE CHANGES IN THE BLACK SEA WAVE POWER UNDER TWO CLIMATE SCENARIOS

Fulya Islek, Istanbul, Yildiz Technical University, islek.fulya@mail.com
 Yalcin Yuksel, Istanbul, Yildiz Technical University, yalcinyksl@gmail.com
 Cihan Sahin, Istanbul, Yildiz Technical University cihansahin81@gmail.com

INTRODUCTION

Climate change will have impacts on wave power resources due to changes in the spatial and temporal characteristics of wave climate. The Black Sea (BS) wind and wave climate is vulnerable to possible climate change impacts with significant rates (Islek et al. 2021, Islek et al. 2022). Therefore, determining projected changes in wave power potential is critically important not only for the construction of reliable offshore and coastal structures but also for the semi-closed basin ecology.

Although wave power assessments have been previously performed in various studies for both current and historical periods in the Black Sea, a limited number of them have evaluated future wave power potential. Moreover, few studies have been conducted on the possible impacts of climate change on BS wave power (Rusu 2019, Rusu 2020), and almost none have determined whether these changes represent a significant or not.

The main purpose of this study is to (i) determine the future wave power potential and (ii) reveal significant projected changes in the BS wave power resources for the next 80 years (2021–2100). Moreover, this study is the first attempt to detect the projected effective wave height (EWHO) and wave power occurrences using the key indicator of ‘Energy Level Occurrence’ proposed by Zheng and Li (2011) (Available Level Occurrence ALO, Moderate Level Occurrence MLO, and Rich Level Occurrence RLO). These key indicators make it possible to better understand the future availability of wave power potential.

MATERIALS AND METHODOLOGY

The present study evaluated the expected wind fields using EUR-11 provided by EURO-CORDEX. These spatially high-resolution wind fields (0.11°) are delivered by the Rossby Centre's latest regional climate model (RCA4) developed by the Swedish Meteorological and Hydrologic Institute (SMHI) (Strandberg et al., 2014).

Future and historical wave climate in the Black Sea was generated from the MIKE 21 SW (spectral wave) forced with the wind fields simulated by the RCM (namely RCA4). Modeled wave results were compared to measured wave parameters at five different stations.

The near future (NF) (2021–2060) and middle future (MF) (2061–2100) wave power potential over the Black Sea were assessed considering the RCP4.5 and RCP8.5 scenarios. To detect a pattern of future change (FC) in mean wave power, the NF and MF periods under the two RCP scenarios are compared with the historical (1970–2005) period ($FC = P_{RCP} - P_{Hist}$). The FC with statistical significance levels based on the Student's t-test (Scheer, 1986) are presented in Figure 1.

RESULTS AND DISCUSSION

In the NF period, the RCP4.5 scenario suggests higher mean wave power than the historical period, except in the western coastal region (Figure 1a, e). For the same interval under the RCP8.5 scenario, there are more remarkable increases in the mean wave power in the eastern and central BS (Figure 1c, g). The entire BS will be characterized by significant increases in the mean wave power for the NF under both RCPs.

In the MF period under the RCP4.5 scenario, the projected changes in the mean wave power concerning the historical period are not significant over almost the entire basin. However, slight changes were found in the western coastal region and a small region in the central BS (Figure 1b, f). For the same interval, the RCP8.5 scenario predicts significant reductions in the northern part of the basin, while significant increases are found only in the southeastern BS (Figure 1d, h). The analysis in the MF period reveals that the eastern BS exhibits more marked increases under the RCP8.5 scenario, which is absent under the RCP4.5 scenario.

The BS wave power will be exposed to changes in terms of increase/decrease in future periods, but these projected changes will be more severe in the eastern BS compared to other parts of the sea.

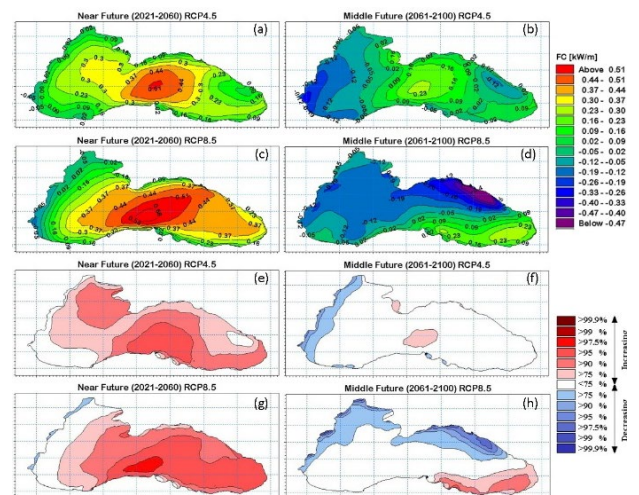


Figure 1. FC in the mean wave power under the (a, b) RCP4.5, (c, d) RCP8.5 scenarios. Significance of differences based on the Student's t-test for different confidence levels under the (e, f) RCP4.5, (g, h) RCP8.5 scenarios.

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