The effect of future climate-related variabilities of tropical monsoons in the Indian Ocean on wave energy resource around Sri Lanka

*Bahareh Kamranzad[1], Pravin Maduwantha[3], Harsha Rathnasooriya[3], Kasun De Silva[3], Harshinie Karunarathna[2]

1. The Hakubi Center for Advanced Research/Graduate School of Advanced Integrated Studies in Human Survivability, Kyoto University, 2. Zienkiewicz Centre for Computational Engineering, College of Engineering, Bay Campus, Swansea University, 3. Department of Civil Engineering, University of Moratuwa

The direct swell wave approach and relatively narrow continental shelf make more favorable conditions for wave energy harvesting in Sri Lankan coastal region. West and south coasts consist of relatively strong waves comparing to the north and east coasts providing the potential for wave energy harvesting. However, the wave climate in the south and west coasts is highly modulated by the tropical monsoon systems in the Indian Ocean. Southwest monsoon season normally occurs from June to September when winds blow from the southwest, the Indian Ocean and the Arabian Sea, and generate energetic waves in the west and south coasts of Sri Lanka. The northeast monsoon, which falls between December and February, generates high sea waves in the north and east coasts. Although, climate change may alter the regular seasonal cycle. Therefore, it is essential to examine the climate change impacts on available wave energy resource in long term aspects.

Present and future ocean wave climate around Sri Lanka was simulated using numerical wave modeling. The waves have been simulated using wind outputs from the super high-resolution Atmospheric Global Climate Model of the Japan Meteorological Agency, MRI-AGCM3.2S. The future climate scenario of Representative Concentration Pathway (RCP 8.5), as defined by representing trajectories of increasing global radiative forcing reaching + 8.5 W m^{-2}, by the year 2100 compared to pre-industrial conditions, was used. These outputs were first used to develop an Indian Ocean wave model (KU_IO) using SWAN spectral wave model and downscaled up to Sri Lankan Regional model (KU_SLK) (5°-11°N, 79.5°-83.5°E). Based on the generated wave characteristics, the total average wave power distribution under the present climate (total average power from 1979 to 2003) and future climate (total average power from 2075 to 2099) for the Sri Lankan domain were calculated. The results indicate that even though the west and south coasts of Sri Lanka have the highest available wave power, under the future wave climate, 2 to 3 kW/m wave power reduction can be observed in these regions. In addition, no noticeable change can be seen in the north and east coasts. Future reduction in the available wave power around Sri Lanka can be either due to change in swell conditions of the southern Indian Ocean or due to potential changes to the south-west tropical monsoon. However, these changes may be attributed to wave climate variations in southwest monsoon season since it highly modulates the wave conditions in the south and the west coasts. Therefore, the distribution of total average wave power reduction (total average wave power in the future –total average wave power in the present) was separated into two time periods as southwest monsoon and non-south-west monsoon period. Even in the southwest monsoon season, the highest wave power reduction (2-2.5 kW/m) can be observed along the west to the south coast of Sri Lanka. In this region, the wave power reduction in the future during the non-monsoon period is relatively low (0.4 - 0.6 kW/m). The wave power reduction may cause by the variations of either wave height or wave period. However, the results reveal that according to the model simulations, the future reduction of wave power may be attributed to the change in the southwest tropical monsoon generated wave heights as a result of global climate change.

Acknowledgement:

Financial support provided by Swansea University through the Global Challenge Research Fund project ‘Wave energy resource characterisation for Sri Lanka in a changing ocean climate’ to conduct the research presented in this paper is greatly acknowledged. Japan Meteorological Agency is acknowledged for sharing atmospheric model data. Bahareh Kamranzad is supported by the Hakubi Center for Advanced Research at Kyoto University and JSPS Grants-in-Aid for Scientific Research (KAKENHI), the Ministry of Education, Culture, Sports, Science, and Technology-Japan (MEXT).

Keywords: Climate change, Wave power, Wave projections, Sri Lanka