

FUTURE PROJECTION OF WAVE ENERGY IN INDIAN OCEAN BASED ON HIGH RESOLUTION MRI-AGCM3.2S PROJECTION

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SUMMARY: Sustainability assessment of wave energy resources is vital in terms of both short-term variations and long-term changes due to the climate change. In this study, wave power was estimated in the Indian Ocean based on high resolution MRI-AGCM3.2S wind data as forcing for numerical modeling using SWAN. The modeling was carried out in both historical and future periods and the results were compared to investigate the future projections under the impact of climate change as well as short-term fluctuations. The results indicated that the southern Indian Ocean contains higher wave power potential with lower short-term variations. The northern Indian Ocean will experience lower potential of wave power with higher monthly variability which tends unstable conditions in terms of short-term variation, with the future projections of lower absolute change comparing to the southern Indian Ocean.

Keywords: renewable energy, climate change, wave energy, SWAN, Indian Ocean

INTRODUCTION

As a marine source of renewable energy with a highest density among the others [1] wave energy resources has been the topic interest of many researches in recent years. There are studies conducted the wave energy assessment in various locations in the world to investigate the potential use of it. However, in recent years, uncertainty assessment of the wave energy resources due to short-term variations and long-term changes has been considered as an important issue in order to ensure the sustainability of available resources [e.g. 2].

As a promising source of the wave energy for supplying the coastal demand, Indian Ocean has been less studied due to the scarcity of measured data. There are some researches focused on wave energy potential investigation mostly in nearshore areas of the northern parts including the Gulf of Oman [2] and Arabian Sea [3]. However, lack of information on the projection of available resources in the future due to the climate change accompanies the conducted researches with the uncertainties.

In this study, high resolution wave energy assessment is carried out in the whole Indian Ocean based on the results of numerical wave modeling using high resolution GCM projection. Based on the wave power calculated from the time series on long-term wave data, spatio-temporal distribution of the wave power will be obtained. Hotspots in the domain will be specified to evaluate the available resources considering the short-term variations and long-term change will be investigated to indicate the potential areas for further researches and providing detailed information for decision-makers.

MATERIALS AND METHOD

Wave characteristics were obtained using SWAN (Simulating WAVes Nearshore) numerical model [4] for both historical and future conditions. Each period of wave modeling consists of 25 yearly

performance (1979-2003 for historical and 2075-2099 for future condition). MRI-AGCM3.2S wind field [5] was used as the source of wind data with spatial and temporal resolutions of 20 km and 1 hr, respectively. Global bathymetry information was also obtained from GEBCO with 30 arc-sec spatial resolution. The spatial and temporal resolutions of the computational domain are $0.5^{\circ} \times 0.5^{\circ}$ and 30 min, respectively, while the outputs were generated with spatial and temporal resolutions of $0.5^{\circ} \times 0.5^{\circ}$ and 6 hourly. The modeled significant wave height were compared and verified with near-real-time merged gridded satellite data from the multi-mission product of Aviso (<http://www.aviso.oceanobs.com/>) with spatial and temporal resolutions of 1 degree and daily, respectively.

Validated SWAN model was performed for two 25-yearly periods (historical and future) and wave power was calculated based on the deep water equation: $P=0.49 \times H_s^2 \times T_e$ in which, P , H_s and T_e demonstrate wave power, significant wave height and energy period (m_1/m_0), respectively (e.g., [2]). In order to investigate the sustainability of available resources, Monthly Variability Index (MVI) of wave power was obtained for both historical and future wave data. MVI is calculated as the ratio of the difference between highest and lowest monthly mean wave power and mean annual wave power. The lower values of MVI imply lower variation in monthly values and more sustainability of the estimated resources.

RESULTS AND DISCUSSION

The wave power was obtained from the results of the numerical wave modeling in the Indian Ocean, and climate change impact was assessed by comparing the data for historical and future periods. Fig. 1 shows the annual wave power in the whole domain calculated from 25-yearly historical and future periods, as well as absolute and relative changes of the future wave power comparing to the

historical one. According to this figure, the hotspots are located in the southern Indian Ocean in both periods with the highest wave power reaching the mean value of around 120 kW/m. The mean wave power in the northern Indian Ocean and mid-latitudes around the equator indicate values of about 20 kW/m as an average. The absolute change shows a maximum future increase of mean wave power around 12 kW/m (corresponding to 10% relative change) in the southern Indian Ocean, while most of other parts of the domain experience no significant change in the future except for Arabian Sea in the west of India and parts of southern Indian Ocean which indicate a spatially smooth decrease (around 3%) in wave power values. The relative change reaches the highest values in areas with lower mean wave power such as the Red Sea, western Arabian Sea and west of Madagascar.

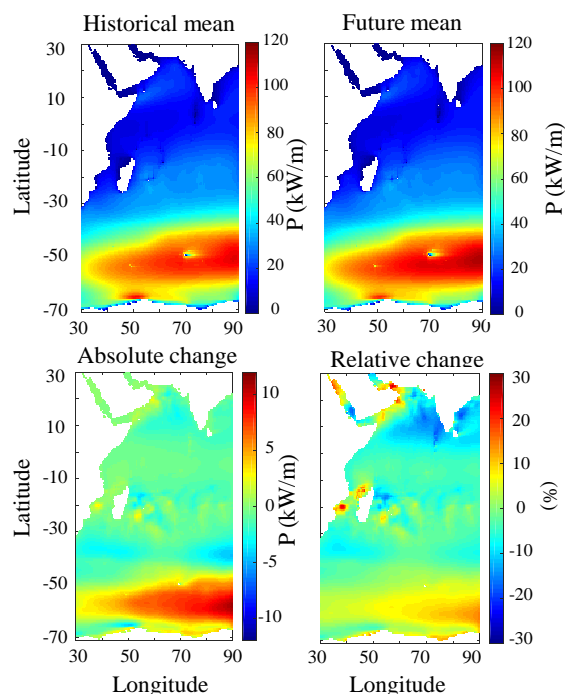


Figure 1. Annual mean wave power for historical and future periods and absolute and relative changes

In order to investigate the sustainability of available resources, MVI was calculated for the whole periods shown in Fig. 2. This figure indicates that however, the southern Indian Ocean contains higher wave power, the monthly variation is less than the northern Indian Ocean for both historical and future periods which implies a relatively stable condition in the south. The highest MVI in the southern Indian Ocean reaches about 2.5 while it is about 3.5 and 4 in the northern Indian Ocean for historical and future periods, respectively. Despite having a low annual mean wave power, Northern Indian Ocean experiences larger variations.

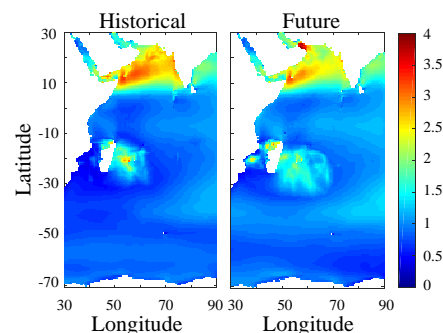


Figure 2. MVI values for historical and future periods

SUMMARY AND CONCLUSION

The wave power characteristics such as mean annual values and monthly variability indices were obtained in the Indian Ocean for historical and future conditions. The results showed that the southern Indian Ocean consists of much higher wave power values with more stability in terms of short-term (monthly) variations. However, the long-term projections show higher changes in wave mean annual power values in the southern Indian Ocean in the future. The northern Indian Ocean contains lower mean annual wave power but higher variability in terms of short-term (monthly) variations and lower change in future projection. As a conclusion, considering the higher wave power potential and lower monthly variation and relative future change, southern Indian Ocean is more appropriate for further assessment and downscaling in order to investigate the optimum locations for wave energy extractions.

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