Wave Climate Assessment in the Indian Ocean

〇Bahareh KAMRANZAD, Nobuhito MORI

Introduction

Long-term wave data are required for a promising wave climate assessment. Since the wave measurements are generally gathered in limited spatio-temporal coverages, numerical wave modeling can be utilized to generate the time series of wave characteristics in desired spatial and temporal resolutions. Indian Ocean has been a topic of interest for wave climate assessment due to the complexity of wave climate under the influence of phenomenon like monsoon. However, due to the scarcity of high resolution data with a full coverage of the domain, the previous researches have focused on continental shelves or coastal regions. Wave climate in the Northern Indian Ocean has been studied by Kamranzad et al. (2017) using spectral wave model forced by JRA-55 wind field considering different approaches for wave hindcasting indicating how the quality of input winds and downscaling approach influence the quality of the wave characteristics. In this study, wave climate assessment are carried out using higher resolution input wind field and extending the domain to the whole Indian Ocean. In addition, the future wave climate using the high resolution wind field will be generated in order to investigate the impact of climate change on wave characteristics in the study area.

Methodology

High resolution MRI-AGCM3.2S wind field was used to force SWAN (Simulating WAves Nearshore) (Booij, 1999) numerical model in order to generate the wave climate in the Indian Ocean. MRI-AGCM3.2S contains the historical and future wind field with spatial and temporal resolutions of 20 km and 1 hr, respectively. Global bathymetry information of GEBCO with 30 arc-sec spatial resolution was used to provide the bottom conditions for SWAN. The computational domain covers the longitudes between 20° E and 90° E and latitudes between 71° S and 30° N with a spatial resolution of 0.5°×0.5°. A sensitivity analysis was carried out for a typhoon event in order to assess the reliability of the model performance in simulating the typhoon condition with the intended computational time step and computational time step was considered as 30 min. The model was performed for two 25-yearly periods including historical (1979-2003) and future (2075-2099) periods. Time series of the wave characteristics were obtained in the domain with 0.5°×0.5° and 6-hourly spatial and temporal resolutions, respectively.

Results

In order to evaluate the model performance, the modeled H_s was compared to near-real-time merged gridded data from the multi-mission product of Aviso (http://www.aviso.oceanobs.com/) for 8 years and the results showed consistency between the simulated monthly mean H_s and satellite measurements. Wave characteristics such as significant wave height (H_s), mean wave period (T_{m01}), energy period (T_e) and wave power (P) were obtained for two 25-yearly periods of historical and future runs, and were compared in terms of spatio-temporal variation and long-term change. P is calculated by the formula $P= 0.49\times H_s^2\times T_e$ for deep water condition, while T_e is defined by m_{-1}/m_0 (e.g., Abbaspour and Rahimi, 2011). Fig. 1 shows the annual averages of the wave parameters and the percentage of change in the future comparing to the historical data were compared. According to Fig. 1, H_s, T_{m01}, T_e and P values are generally higher in the southern Indian Ocean comparing to the northern parts in both historical and future periods. The maximum future increase of H_s and T_e in the southern Indian Ocean is about 8% and 2% which has led to a maximum increase of about 15% in wave power (P) near the Antarctic.

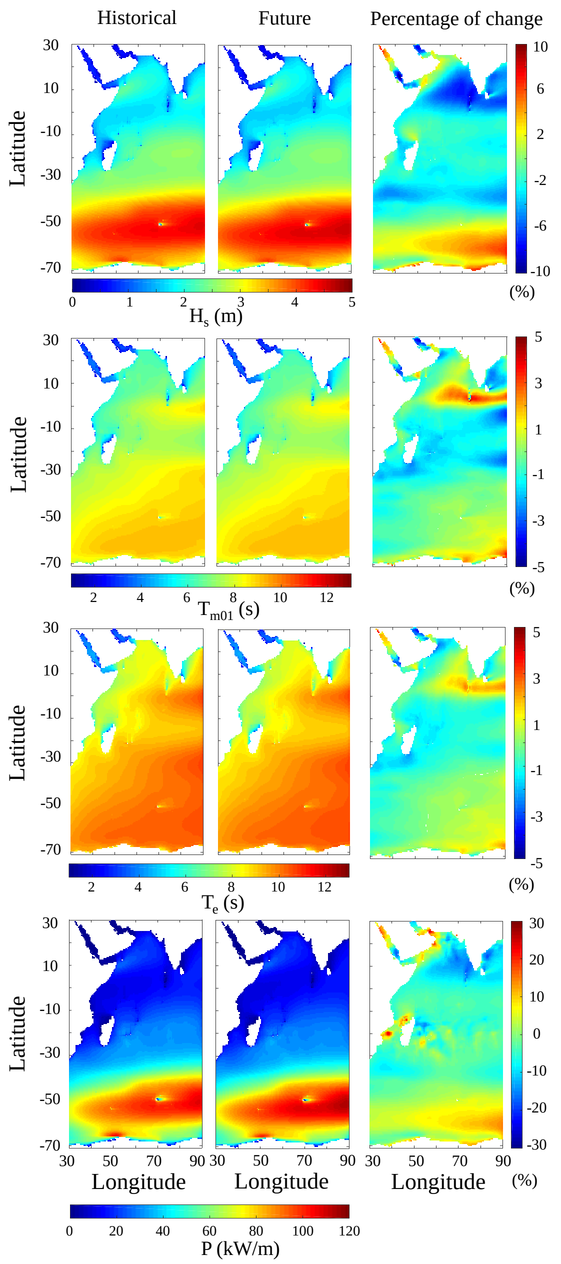

Fig. 1 Annual average of wave parameters and percentage of change

In the Northern Indian Ocean, H_s shows a maximum future decrease of about 10%, while the T_{M01} and T_e show maximum future increase of about 4% and 3%, respectively, in the same area (i.e., west of India), which has resulted in a consequent decrease of around 15% in future P. Comparison of the results around the equator illustrates that however the wave periods will increase in the future especially in the western parts, wave power will decrease due to the decrease in future H_s.

Conclusion

Long-term wave data simulation was performed by SWAN using high resolution MRI-AGCM3.2S wind field for the historical and future periods. The results of numerical modeling were evaluated by comparing to the satellite measurements and spatio-temporal variation of the wave climate and the future projections was investigated. The results showed that the significant wave height will decrease in the future in the northern Indian Ocean, while it will increase in the lower latitudes near the Antarctic. In the annual scale, the wave period will have an increase in the northern Indian Ocean and will not change significantly in the southern parts. Since the change of wave power is mostly dependent on the change of significant wave height, the wave power change in the future follows the significant wave height change pattern in the Indian Ocean.

References

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