WAVE CLIMATE VARIABILITY AND RELATED CLIMATE INDICES

Nobuhito Mori, Kyoto University, mori@oceanwave.jp
Risako Kishimoto, Shimizu Corporation, odaiwokudasai@gmail.com
Tomoya Shimura, Kyoto University, shimura.tomoya.2v@kyoto-u.ac.jp

INTRODUCTION

Climate change is highly expected to give significant impact on coastal hazards and environment. The future projections of wave climate under global warming scenarios have been carried out and shows changes in wave heights depending on the regions (e.g., Hemer et al., 2013). Beside the long-term trends of wave climate, annual to decadal changes are also important to understand variability. For example, the North Atlantic Oscillation (NAO) is highly correlated to monthly mean wave height along the western European coast. However, variability of wave climate is not well understood over the globe, quantitatively. Additionally, the standard coastal engineers regard stationary process for wave environment for solving coastal problems.

This study analyzes global wave climate variability for the last half century based on principal component analysis of atmospheric forcing (sea surface winds U_{10} and sea level pressure P) and wave hindcast.

METHODS

The target of wave climate is monthly mean significant wave height H_s. The numerical analysis was conducted to understand long-term changes and variability of wave climate. First the 55 years wave hindcast (Δx=60km) was conducted by WaveWatchIII v4.18 (denotes WW3) forced by JRA-55 reanalysis over the globe.

Second, statistical analysis was conducted to estimate contribution of U_{10} and P for H_s. The linear multivariate regression model for H_s combining local grid based atmospheric information U_{10} and P, and the global scale principal component analysis (PCA) for pressure field P was constructed and calibrated by the dynamic wave hindcast results by WW3.

$$\mathrm{Hs} = \mathrm{a} + \mathrm{b}_1 \mathrm{U}_{10}^2 + \mathrm{b}_2 \mathrm{P} + \mathrm{b}_3 \Delta\mathrm{P} + \sum_{\mathrm{j}}^{\mathrm{n}} \mathrm{c}_\mathrm{j}\, \mathrm{PC}_\mathrm{j} \qquad (1)$$

where $\Delta\mathrm{P}$ the spatial gradient of P, $\mathrm{PC_j}$ the j-th mode principal component (PC) of P, c_j the its amplitude, n the total number of PC modes, and a and b_i, are empirical coefficients, respectively. The PC modes for P are considered to introduce the large scale atmospheric patterns to each grid information.

RESULTS AND DISCUSSION

The global wave climate characteristics was analyzed in detail. Fig. 1 shows the correlation coefficient of Eq.(1) and the 55yrs wave hindcast. The global mean correlation coefficients of monthly mean wave heights between Eq.(1) and the hindcast were improved from 0.84 to 0.94 in comparison without PC modes in Eq.(1). The contribution of large scale PC modes to H_s is significant. The PC modes effects can be regarded remotely generated swells. The analysis combining wave hindcast and its statistical decomposition by Eq.(1) gives variability of wave climate depends on local (wind sea) and large scale atmospheric disturbances (swells).

The effects of swells on H_s are discussed over the globe. The swells give dominative roles for H_s more than half of annual variation but related PC modes are different in the regions. For example, Figure 2 shows the individual contributions of each terms in Eq.(1) to H_s at typical three locations. Although the local point information of U_{10} and P is important for H_s, the use of 1-10 PC modes give significant improvement to estimate H_s by Eq.(1). For example, the PC mode 1 has 25% contribution to describe H_s at WNP location in Figure 2 (blue). The PC mode 1 corresponds to North Pacific Index (NP) which relates to inter-annual to decadal variations in the atmospheric circulation in the Pacific. The NP show more than 20% impact on the large regions in the middle latitude as shown in Figure 2. The similar contribution of large scale climate patterns to H_s can be seen by Atlantic Oscillations (AO), NAO and others.

The regional wave hindcast (Δx=7km) were also conducted targeted the WNP by nesting from the global simulation and were analyzed the same way. The contributions of PC modes show fine scale O(100km) regional dependence on H_s due to sheltering and diffraction of waves by regional bathymetry effects.

CONCLUSION

The dynamic and statistical wave climate analysis were conducted based on 55yrs wave hindcast. The large scale atmospheric information is estimated by the PCA for pressure fields. The statistical analysis based on PC modes, inter-annual to decadal variations are important understand variability of H_s both global and regional scale.

REFERENCES

Hemer, Fan, Mori, Semedo and Wang (2013) *Nature Climate Change*, 6p., doi:10.1038/nclimate1791.

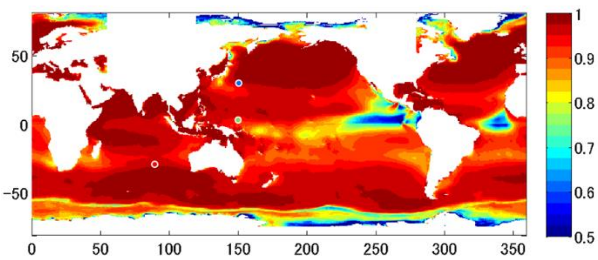

Figure 1 - Correlation coefficient of Hs between Eq.(1) and 55yrs wave hindcast.

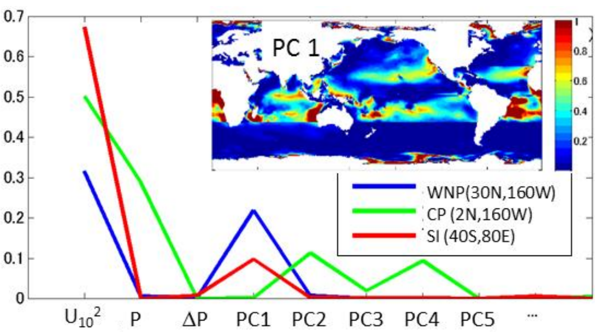

Figure 2 - Contribution of each terms in Eq.(1) to H_s at typical three locations (WNP: western North Pacific, CP: central Pacific, SI: South Indian; denoted by circles in Figure 1). The contour indicates contribution of PC1 for H_s.