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Prediction of Extreme Wind Speed under the Background of Climate Change

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ABSTRACT

In this paper, 64-year tropical cyclone (TC) data in the Northwest Pacific (NWP) were analyzed to predict extreme wind speed under the background of climate change. The extreme value theory is presented in order to obtain extreme wind speed with different return periods in both stationary and non-stationary processes in the NWP. Results show that the non-stationary extreme wind speed of 50-year return periods is 3.2% higher than the stationary one in the NWP. As a result, it is proposed that the non-stationary effects of long-term variation in atmospheric general circulation should be considered in the offshore engineering standard or criterion revision.

KEY WORDS: Marine environment; Tropical cyclone; Climate change; Non-stationary; Extreme wind speed; Return period.

INTRODUCTION

The NWP is the place where the most frequent and intense TCs occur among the global sea areas, and the reliability of offshore structures in this area are heavily affected by TCs, which may bring strong winds and corresponding huge destructive waves inducing great damage of social property and economic. On the other hand, with the development of the human economy, the climate change induced by greenhouse gases (e.g. CO_2 and CH_4 et.al.) emission has become an unchangeable fact. The annual report released by IPCC (Intergovernmental Panel on Climate Change) in 2007 persuasively confirmed that the global temperature has risen by 0.74℃ in the past one hundred years (1906-2005). Under the background of climate change, the extreme marine events evidently occur more often than ever. For example, when the hurricanes of Katrina which is the most destructive natural disaster in American history (Demirbilek, 2010; D.H. Levinso et al., 2010)and Rita were haunting about the Mexico gulf in 2005, the 167 offshore platforms and 183 oil pipelines were destroyed, resulting in 40 percent oil production of Gulf of Mexico interruption. In the South China Sea (SCS), a great many of offshore structures were also threatened by super strong typhoons such as Zhenzhu in 2006. Very probably the above accidents can be attributed to the underestimation of marine environment parameters under the background of climate change, for instance, the designed wind speed with different return period in the ocean engineering. So how to reasonably estimate the extreme wind speed with different return period under the background of climate change become a challenging issue we have to confront, which will exert significant effect on the criterion revision of marine engineering constructions.

Many studies have been undertaken to estimate the TC extreme wind speed in the sea areas where offshore structures located. Poisson-Gumbel compound extreme value distribution had developed by Liu and Ma (1980) to compute the design wave height and wind speed and this method proved quite reasonable. Shi and Zhou (1999) used moment estimate to estimate parameters of wind speed distribution functions, which proved good for practical purposes. In 2005, Liu et al. used the further developed extreme value theory to analyze the long-term data of hurricane speeds and simultaneous water levels of Mississippi river. It is found that the return period of hurricane Katrina is 50 years rather than 200 years based on the former prevention design criteria. By using the 3-parameter Weibull distribution model, Qi et al. (2010) calculated the extreme wind, wave and current with different return periods in the SCS deepwater areas, intending to provide primary reference for design and management of ocean engineering.

Though such works already have been done in the past, there still exist some important and critical problems: how to take the non-stationary process influence into consideration in the estimation of extreme wind speed, which is become more and more important for ocean engineering under the background of climate change. In this paper, according to the analysis of 64-year TC database in the NWP, the TC activity is considered as a non-stationary process. By establishing the non-stationary extreme value model, this paper aims at obtaining the variation of extreme wind speed with different return period both in the NWP and providing instruction for offshore engineering construction.

The 64-year (1845-2008) TC data used in this paper is collected from China Meteorological Administration and the method for revising recorded TC wind speed data is introduced by Emanuel Kerry