Proceedings of the Seventeenth (2007) International Offshore and Polar Engineering Conference
Lisbon, Portugal, July 1-6, 2007

ISBN 978-1-880653-68-5; ISBN 1-880653-68-0(Set); ISSN 1098-6189 (Set)

Discussion on the Error of Wave Forecast by Markov Chain Theory

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ABSTRACT

By adopting the transition probability matrix of Markov chain method, this paper attempts to predict the short-term wave height information. This study presents the discussion on the error of wave forecast by Markov chain theory, so as to understand the capability of this theory for wave forecast. The wave forecast results are obtained from wave height transition probability matrix; it shows the mean errors of the prediction of wave height within 3 days forecast are all less than 30 cm respectively. For the sake of the decrease of the error of wave forecast, the joint probability of transition matrix of Markov chain which based on the observed wind speed and wave height data is applied in this study. It shows the method of joint probability of transition matrix of Markov chain is suitable for wave forecast in the Beaufort scale 1~6 grades. Various wave forecasts result in different seasons are also discussed here; the accuracies of the forecast wave height are relatively high in winter. There might be a great error of wave forecast during typhoon duration due to its non-stationary characteristics, which influences the accuracy of transition probability matrix of Markov chain.

KEY WORDS: Markov chain theory; error of wave forecast.

INTRODUCTION

Ocean waves are extremely random and are influenced by meteorological, hydrological, oceanographic and topographical factors. The information of Ocean waves is required for various applications, such as marine tourism, disaster prevention, coastal engineering, environment protection, port operations, and rescue. Wave forecast information is significant and essential for the purposes of marine tourism and disaster prevention. Accurate wave forecast information can decrease the damage of marine disaster and the risk of sea acivitives effectively. Hence, wave forecast is important in marine science.

Generally speaking, the method for forecasting ocean waves can be classified as numerical and statistical models. Tsai et al. (2002) applied neural network in wave forecasting. It is shown the possibility of wave forecasting by applying statistical methods.

Markov chain theory is capable to describe the relationship between two connected states (Dynkin, 1965). This theory has been applied in analyzing ocean waves characteristics, such as grouping waves and extreme waves (Stansell et al., 2002) (Liu et al., 1998). Doong et al. (2002) applied this theory to find out the connection between two neighbor sea areas and receive good results in wave height. It has been proofed the possibility of estimating waves by Markov Chain Theory. It should be practicable to establish the relationship of sea states between the present and the future time.

The aim of this study is to discuss the error of wave forecast by applying Markov chain theory, so as to understand the capability of this theory in wave forecast. The way to establish Markov chain transition probability matrix for forecast wave height of the future time by using in-situ data is presented in this study, and the estimating errors by this method on wave forecast in different kinds of cases are also discussed here. By the establishment of this statistical model, short-term and frequent wave forecast results could be predicted easily and quickly.

METHODOLOGY

The theory of Markov Chain is described as follows. For continuous time series data, the state can be described by Markov chain. The state may be changed from one state to another; the changes of state are called transitions. A Markov process is a stochastic process that has the Markov property, where it means the conditional probability distribution of the state in the future depends on its current state.

Probability is a mathematical phenomenon which is characterized by randomness and uncertainty. Probability is used for modeling situations for occurrence at the same catageories,. Assume a sequence of variables $S_1, S_2,.., S_n,..$ which are depended on each other. A state j is accessible from state i if there is a non-zero transition probability. The relationship between state i and state j can be presented as Eq. 1.

$$P_{ij} = \frac{f_{i,j}}{\sum_{j=1}^{m}\sum_{i=1}^{n} f_{i,j}} \qquad (1)$$