Fast Generation of Ensemble Typhoon Wind Field and Its Application

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ABSTRACT

This paper presents an efficient method to fast generate the ensemble typhoon wind field by using the forecast wind data obtained from several operational weather forecast centers. The weighted bias-removed ensemble mean (WEM) method is utilized to generate the characteristic parameters, i.e., typhoon track and maximum wind speed, for the control typhoon. Based on the error analysis of typhoon forecasts during the training period, 15 ensemble typhoon members are then generated by combination of 5 different typhoon tracks and 3 different maximum wind speeds from those of the control typhoon. Finally, 15 ensemble wind fields are generated by applying the Jelsnianski typhoon model on each ensemble member. The generated ensemble wind fields are used in the forecast of storm surge for Typhoon Haikui (1211) and the results show that the ensemble forecast method can effectively increase the reliability and accuracy of the storm surge forecast.

KEY WORDS: Typhoon, wind field, numerical forecast, multimodel ensemble, storm surge

INTRODUCTION

The eastern and southern coastal areas of China are frequently affected by the typhoon events because those areas directly face to the Northern West Pacific Ocean, which is one of the most frequent typhoon-affected regions in the world. As the typhoon-induced storm surge may cause serious damage to the coastal cities/towns, it is necessary to conduct numerical forecast of storm surge to improve our disaster prevention and mitigation capacity.

As it is well known, the accuracy of storm surge forecast depends on the accuracy of typhoon forecast. However, small perturbations in the initial conditions, physical/numerical parameters and physical processes may cause significant errors in the typhoon prediction, which makes the typhoon forecast with large uncertainties.

In order to solve the uncertainty problem, the ensemble forecast method was put forward (Epstein, 1969; Leith, 1974). The ensemble method of Singular Vector and Breeding Growing Mode was first proposed by generating the initial perturbations for the meteorological forecast model. Nevertheless, it did not consider the uncertainties from the model itself. Krishnamurti et al (1999) proposed a multi-model ensemble method which utilizes different model forecast results from several weather forecast centers as an ensemble forecast. Subsequent studies have shown that it is an effective technique to overcome the systematic errors generated by the individual forecast centers (Krishnamurti et al, 2007; Mutemi et al, 2007). Georss (2000) found that a simple ensemble average coming from a combination of several weather models was more precise, on average, than the forecast results from the individual models. The equal weighted average of the results from each model was first proposed and it was improved by using the weighted factors based on the least squares minimization principle (Kumar et al, 2003). It could remove the bias of each model and give a more consensus forecast (Mutemi et al, 2006). Zhi et al (2011) and Wang et al (2012) proposed a weighted scheme to reduce the function of poor model forecasts, and the results showed a promising advance. Referring to previous studies, this study adopts the weighted bias-removed ensemble mean method to generate the ensemble typhoon. The ensemble wind fields are applied for the ensemble forecast of storm surge along the East China Sea.

METEOROLOGICAL DATA

The 24h, 48h and 72h forecasts of typhoon tracks and intensities (maximum wind speed) over the Northern West Pacific (10° ~ 50° N, 100° ~ 150° E) are obtained from China Meteorological Administration (CMA), Japan Meteorological Agency (JMA), Joint Typhoon Warning Center (JTWC) of USA and Taiwan Meteorological Center (TMC). The observed data are obtained from Fujian Province Water Conservancy Information Network (http://www.fjwater.gov.cn). The time length of forecast and observed data covers the whole typhoon active seasons in 2012, i.e., the period from 1 June until 31 October 2012. The typhoon forecast data is 6 hourly based, i.e. 4 times per day, at 02 BJT, 08 BJT, 14 BJT and 20 BJT, respectively. The observed data are used to justify the quality of typhoon forecasts.

FAST GENERATION OF ENSEMBLE WIND FIELD

Control Typhoon

As mentioned above, the control typhoon is generated by using the weighted bias-removed ensemble mean (WEM) method (Zhi et al, 2011; Wang et al, 2012), which is one of multi-model ensemble (or called as super-ensemble) methods. According to this method, the whole typhoon seasons can be divided into two periods, i.e., training period and forecast period. Based on the quantitative analysis of forecast errors in the training period, the weighted factor for each center is able to be determined. Those weighted factors will be used in the ensemble forecast of storm surge in the forecast period.