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Interactive comment on "Hybrid improved EMD-BPNN model for the prediction of sea surface temperature" *by* Zhiyuan Wu et al.

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Response to comments of Reviewers

Interactive comment on "Hybrid improved EMD-BPNN model for the prediction of sea surface temperature" by Zhiyuan Wu et al.

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Dr. Huang knows the topic very well and his/her comments are indeed helpful in improving the quality of this MS. We are grateful to Dr. Huang for a careful checking and comments on the MS. All comments are addressed point by point, each starting with an original comment and followed by a response in italic, as follows.

This paper proposed a hybrid EMD-BPNN model for SST prediction. The research work is very interesting and important. However, in my opinion, the paper needs minor revision before acceptance. You can find my questions and suggestions bellow. Response: Thank you for these comments. The positive comments in our solid professional skills are good encouragement to us.

1. Why the simple EMD algorithm is not compared to the EEMD and CEEMD? I suggest the authors to provide comparison results of the EMD-BPNN. Response: Thank you for the professional comment. Empirical Mode Decomposition (EMD) is a state-of-the-art signal processing method proposed by Huang et al. This method can decompose the signal data of different frequencies step by step according to the characteristics of the data and obtain several periodic and trending signals orthogonal to each other, the method can decompose the stronger nonlinear and non-stationary signals into weaker nonlinear and non-stationary signals. The variation of SST is a deterministic non-linear dynamic system and a non-stationary time series data with intermittent signals. Once the intermittent signal is present in the actual signal, the frequency aliasing phenomenon occurs in the decomposition method of EMD, also called Mode Mixing Problem. The specific manifestation of this problem is that there are multiple scale components in one IMF component, or one scale component exists in multiple IMF components. Therefore, we carry out this research based on EEMD and CEEMD methods.

2. Mode mixing is the motivation that the authors applied the EEMD technique in the hybrid SST prediction model. Therefore, it is very important to demonstrate the mode mixing problem in decomposing the studied SST time series. But this is not given in this paper. I suggest the authors to provide discussions on the mode mixing problem in the present study. Response: Thank you for your suggestion, and it is indeed a very important issue. We added the following statement to the revised manuscript. The variation of SST is a deterministic non-linear dynamic system and a non-stationary time series data with intermittent signals. Empirical Mode Decom-

position (EMD) method can decompose the signal data of different frequencies step by step according to the characteristics of the data and obtain several periodic and trending signals orthogonal to each other, the method can decompose the stronger nonlinear and non-stationary signals into weaker nonlinear and non-stationary signals. However, we know that once an intermittent signal appears in the actual signal, the EMD decomposition method will produce a Mode Mixing Problem. The Mode Mixing Problem causes the essential modal function to lose its physical meaning. In addition, the Mode Mixing Problem will also make the algorithm of Empirical Mode Decomposition unstable, and any disturbance may generate a new intrinsic mode function. In order to solve this problem, scholars have proposed the use of noise-assisted processing methods, Ensemble empirical mode decomposition (EEMD) and Complementary Ensemble Empirical Mode Decomposition (CEEMD). The white noise has been added to the original signal to change the extreme point distribution of the signal in the EEMD method, while in the CEEMD method, a set of noise signals have been added to the original signal to change the extreme point distribution of the signal.

3. Line 55, “Consequently, parameters such as mean and variance also do not change over time.” In this sentence, I think it will be better to revise “parameters” as “statistical parameters”. Response: Thank you for your comment. It has been modified in the revised manuscript.

4. Lines 59-62, “This method can decompose the signal data of different frequencies step by step according to the characteristics of the data and obtain several periodic and trending signals orthogonal to each other, which can decompose the stronger nonlinear and non-stationary signals into weaker nonlinear and non-stationary signals”. This sentence needs to make some corrections. As we know, the IMFs are orthogonal components, but the trending component is not orthogonal to any IMF component. Therefore, the above descriptions are not accurate. Besides, the sentence of “which can decompose the stronger nonlinear and non-stationary signals into weaker nonlinear and non-stationary signals” is ambiguous and makes no sense. Accurately, the EMD tech-

nique decomposes a non-stationary time series into several stationary subcomponent and a trend. But it is not easy to say the nonlinearity becomes weaker. So, I suggest the authors to make the sentence more accurate. Response: Thank you for the valuable criticism. We modified these sentences in the revised manuscript. “This method can decompose the signal data of different frequencies step by step according to the characteristics of the data and obtain several periodic and trending signals orthogonal to each other, which can decompose the stronger nonlinear and non-stationary signals. The EMD method is powerful and adaptive in analyzing nonlinear and non-stationary data sets. It provides an effective approach for decomposing a signal into a collection of so-called intrinsic mode functions (IMFs), which can be treated as empirical basis functions (Duan et al., 2016).”

5. Lines 117-119, “The purpose of this study is to combine the EEMD algorithm and the CEEMD decomposition algorithm respectively with the BP neural network algorithm to establish a new prediction model, an improved hybrid EMD-BPNN model.” Accurately, the models of EEMD-BPNN and CEEMD-BPNN themselves are not new. Various works about this models in different problems have already carried out in the last ten years. Therefore, I suggest the authors not to over emphasis “new” or “improved” here. Just simply descript them as “hybrid models”. Response: Thank you for the suggestion. We modified these statements in the revised manuscript. “The purpose of this study is to combine the EEMD algorithm and the CEEMD decomposition algorithm respectively with the BP neural network algorithm to establish a prediction model, a hybrid EMD-BPNN model.”

6. Lines 294-295, “This paper presents a novel SST predicting method based on the hybrid improved EMD algorithms and BP neural network method to process the SST data with strong nonlinearity and non-stationarity.” I suggest the authors to delete the word of “novel” here (and the same in the highlight part). Becomes the hybrid models have already explored extensively in various prediction problems. Besides, the authors argue that “the SST data with strong nonlinearity and non-stationarity.”, what is the

standard of weak or strong nonlinearity and non-stationarity? Therefore, this sentence need to be corrected. Response: Thank you for the suggestion. We modified these statements in the revised manuscript. “This paper presents an SST predicting method based on the hybrid EMD algorithms and BP neural network method to process the SST data with nonlinearity and non-stationarity.”

ReferencesïijŽ Wu Z, Schneider E K, Kirtman B P, et al. The modulated annual cycle: an alternative reference frame for climate anomalies[J]. Climate Dynamics, 2008, 31(7-8): 823-841. Wu Z, Huang N E. Ensemble empirical mode decomposition: a noise-assisted data analysis method[J]. Advances in adaptive data analysis, 2009, 1(01): 1-41. Duan W, Huang L, Han Y, et al. A hybrid EMD-AR model for nonlinear and non-stationary wave forecasting[J]. Journal of Zhejiang University-SCIENCE A, 2016, 17(2): 115-129.

Please also note the supplement to this comment:
https://www.ocean-sci-discuss.net/os-2018-101/os-2018-101-AC1-supplement.pdf

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