Validation and Sensitivity Experiments Comparing the Physical Parameterization of Numerical Wave Model

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Abstract— The Korean Peninsula is surrounded by the sea on three sides except for the northern part, In order to simulate sea state, Korea Meteorological Administration (KMA) has been operating WAVEWATCHIII (WW3) since 2008, which is numerical wave model it was constructed in operational wave forecasting system. Recently, new version of WW3, version 4.18, was officially released and construction of new operational wave forecasting system is performed for upgrading the previous system that is version 2.22. Therefore, the objective of this study is to conduct a comparison of energy input and dissipation source term of WAM4 for comparison and verification of WAM4 with Tolman and Chalikov (TCL) option. In conclusion, the more bias was decrease as wind-wave energy growth term increase. And the more bias was decrease as the more wind-wave energy growth term was increase. The verification results of physical option during two seasons shown negative bias both option WAM4 and TCL. The negative bias was improved in winter, but summer season was shown an opposite result. Also, forecasting performance was better result in summer, but performance was deteriorated after 36 forecast hour.

Keywords— wave model, physical parameterization, WAVEWATCHIII, verification, sensitivity experiment

I. INTRODUCTION

The sea wave forecast is offered by the Korea Meteorological Administration(KMA). It builds on WAVEWATCHIII which is numerical model of third generation wave and operates in the field at present. Also it is building and operating Global WAVEWATCHIII(GWW3) with regard to global marine, Regional WAVEWATCHIII (RWW3) applied at sea of Northeast Asia and Coastal WAVEWATCHIII(CWW3) which built the Korean peninsula's coast for a detailed prediction. Operational wave forecast system of KMA is operating by WAVEWATCHIII version 2.22. The major feature of this version is possibility of application to various platforms by changing source code to FORTRAN 90 and modularization of program code structure. After version 2.22, revision and development of model are carrying out gradually. Recently version 4.18(Tolman, 2014) is officially released. New version 4.18 can separate sea wave and swell of wave as model output data and adds physical option and measure of parameterization of origin function which is related wind-wave interaction. Therefore in this study, we are conducted a sensitivity experiment by parameter adjustment related energy increment between atmosphere that is applied WAM cycle 4 which is newly added as energy input and dissipation method. Also, we performed intercomparison verification of Tolman and Chalikov(TCL) and WAM4, TCL was used in Operational Regional wave forecast system.

II. DATAS AND METHODS

By upgrading WAVEWATCHIII, as compared with version 2.22, version 4.18 is improved to separate expansion of new physical option and measure from sea wave and swell. In the case of physical option, WAM cycle 4 was added as energy input and dissipation method, and it is parameterized theory of surface wave creation by Jassen(1991). The theory of Abadalla and Vidlot(2002) is reflected to consider gustiness meteorological input by unstable atmosphere. Disappearance process of surface wave by friction and breaking wave process is based in Ardhuim(2008)'s theory. It needs to compare to Tolman and chalikove method(1996) that is using in operating system. Furthermore breaking waves at bottom scattering and surf zone are added and WRT package, the physical option concerning interaction of nonlinear component wave, is upgraded to version 5. Newly added sea wave and swell algorithm determines a boundary line of spectrum or component by applying watershed algorithm devised by Vinvent and Soile(1991) to wave energy spectrum have direction. Every wave from spectrum gets together and then is classified as code 0. The rest of component are defined as swell. Separate wave component is segregated into one independent model by applying Hanson and Pjilips(2001)'s measure.

In this study area is longitude 115° E~150° E and latitude 20° N~50° N, there is Regional operating system area.

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Spatial resolution of model is 1/12° and resolution spectrum has 25 wavenumber from minimum frequency 0.418Hz to 0.4114 and wave direction resolution set an interval of 10. Wind input data was used 10m wind fields of RDAPS data, integration area model of the KMA. In an experiment 1(EXP1), we conducted a sensitivity experiment win atmosphere-wave energy. We used Betamax as wind-wave parameter and conducted a sensitivity experiment in the case of betamax value 1.6, 1.7 and 1.8. In the experiment 2, we conducted TCL and WAM4 forecast result because TCL by Tolman and Chalikov(1996) is using as energy input and dissipation method in case of RWW3. In this study, analysis period of two experiments is three months in winter season(12, 1, 2) and three months in summer season(6, 7, 8). Comparison verification method compares forecast data with observational data at an interval of 12 hours specified 00, 12, 24, 36, 48, 60 and 72 hours. Verification was conducted using BIAS and RMSE which is statistical verification method, and 6 buoy data of KMA are used for observation data.

III. RESULTS

A. Experiment 1

As a result of performing adjustment of Betamax which is wind-wave growth parameter, as the Betamax increase, BIAS and RMSE are better result except two buoy stations(Deokjeikdo(22101) and Chilbaldo(22102)). It appears to two buoy stations are located at low depth, so wave growth about wind are bigger work(Fig. 1). BIAS and RMSE were averaged to general forecast performance of all buoy station. So Betamax are increase, underestimated BIAS was improvement, but RMSE was similar(Fig. 3).

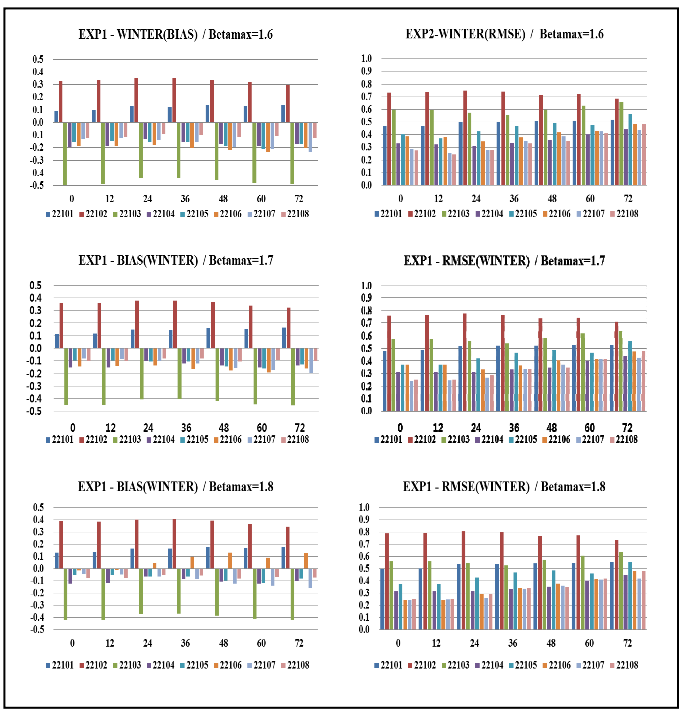

Fig. 1. BIAS and RMSE of significant wave height of experiment 1 during winter(2013.12~2014.02). Left panels represent BIAS and right panels represent RMSE.

In summer season, the more Betamax increase, the better result of BIAS and RMSE at all buoy stations. But forecast time was increase, underestimated BIAS are turn into overestimated(Fig. 2). The result of average BIAS and RMSE in all buoy stations, as the Betamax are increase, difference of model and observation are decrease like winter season. RMSE was shown more good result than winter, but RMSE was increase after 36 hour forecast time(Fig. 3).

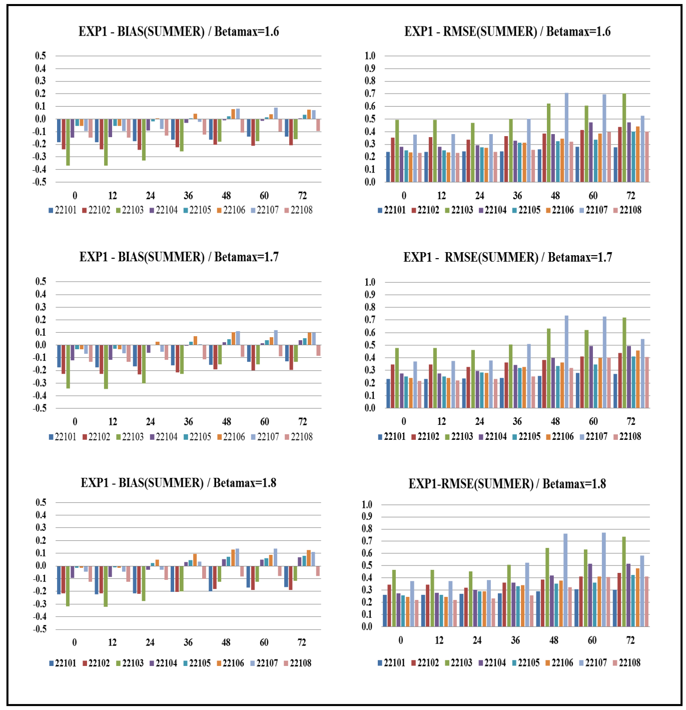

Fig. 2. Same as Fig. 2, but for summer(2014.06~08)

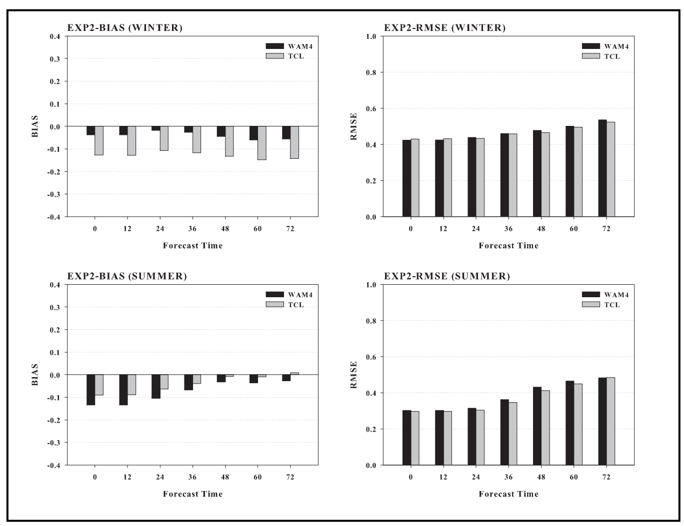

Fig. 3. BIAS and RMSE of significant wave height of experiment 1 during winter(2013.12~2014.02, upper) and summer(2014.06~08), bottom). Left panels represent BIAS and right panels represent RMSE.

B. Experiment 2

AS a result of performing BIAS and RMSE for two seasons each 3months in summer and winter, in case of TCL, every data has negative BIAS except Deokjeokdo(22101) buoy. Whereas in case of WAM4, positive BIAS is shown in east sea at four buoy stations(Chilbaldo(22102), Geomundo(22103), Donghae(22105), Pohang(22106)). So it shows a tendency to overestimate more than TCL. Although there is difference by buoy stations, we generally can verify forecast efficiency of WAM4 is more improved than TCL. The result of RMSE, it has difference of forecast value by areas, butut it shows improved forecast value in south sea at two buoy stations(Geomundo(22103), Geojedo(22104))and Oeyeondo bouy and low verification result in the rest areas. Averaged BIAS and RMSE about all buoy stations were shown both WAM4 and TCL are underestimated, and WAM4 are more good result than TCL in BIAS. RMSE shown WAM4 was good result by 24 hours forecast time approximately 2 % forecast performance improvement, but RCL was more good result after 36 hour forecast time approximately 2 %(Fig. 3).

During three months in summer, verification result of BIAS and RMSE about TCL and WAM4 is that TCL shows a tendency to underestimate in west sea and south sea area and to overestimate in Jejudo areas during 3 months in summer. The longer forecast time, the less BIAS two versions show. Verification result of RMSE is that it has bigger value than TCL in Geojedo(22104) and Oeyeondo buoy, but the rest area has improved result. Averaged BIAS and RMSE about all buoy stations were shown both WAM4 and TCL are underestimate like winter season, but TCL more good result than WAM4 about BIAS and RMSE(Fig. 4).

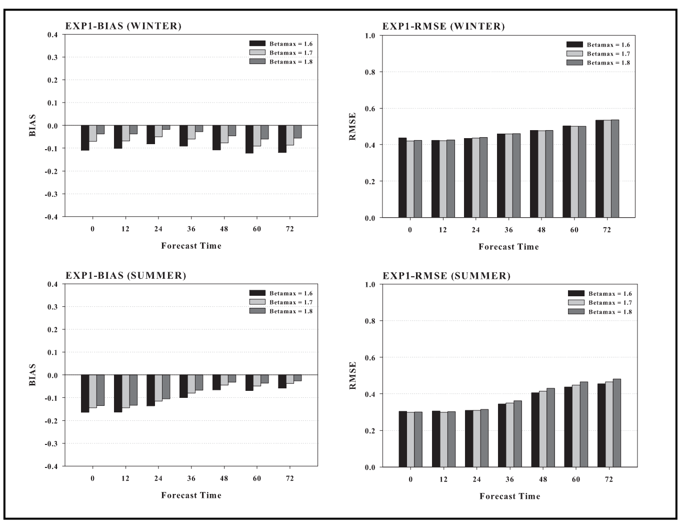

Fig. 4. Same as Fig. 3, but for experiments 2.

IV. DISCUSSION

WAVEWATCHⅢ that is numerical model of operational wave forecast system in KMA is officially released as version 4.18 and added parameterization of origin function associated wind-wave interaction physical option and parameter. We accomplish quantitative verification in two seasons of summer and winter 2014 for operational regional wave forecast system area to compare sensitivity experiment by regularized coefficient on new physical parameterization with currently use option. Consequently, as the wind-wave growth coefficient increases, difference of model and observation appears to decrease. Also as a result of the Verification of seasonality by physical option, WAM4 and TCL have generally negative deviation compared with observation. So they show the tendency to underestimate. AS the estimated time increase, difference of model and observation with observed value increase in the winter, but decrease in summer. And forecasting capability in summer is better than winter. But forecasting capability decreased since 36 hours. As the result of verification, there exists difference in each buoy area. So, from now on sensitivity experiment in each area should be conducted by physical parameterization like parameter adjustment. Furthermore WAVEWATCHⅢ version 4.18 needs additional study to choose physical factor optimized for season.

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