Simulation of the coastal seas around Japan using a nested 2-km resolution model 2: Reproducibility of coastal water level variation

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The Japan Meteorological Agency has built a monitoring and forecasting system for the Seto Inland Sea and started its test operation in 2016. Currently, we have been developing an ocean model, MRI.COM-JPN, that extends the area to the entire coast of Japan with basic specifications of the Seto Inland Sea model such as horizontal resolution of 2 km, for the next system. Following a report about its outline at the 2016 Fall Meeting of the Oceanographic Society of Japan, we show verification of the water level using coastal tide gauge data.
The new model is based on the Meteorological Research Institute Community Ocean Model (MRI.COM) ver.4, and comprises three sub models, a global model, a North Pacific model and a 2-km resolution coastal model, which are coupled using a two-way nesting scheme. From the Seto Inland Sea model, we have implemented processes that cause water level variations such as tides and depressing and suction of sea level pressure. After spinning up the North Pacific model for 30 years using atmospheric forcings of the JRA-55 calibration data (JRA55-do), we ran the coastal model from January 1, 2008, and used the experimental results for 2009. Though this experiment is a so-called free-run experiment that does not use data assimilation, basic sea conditions such as the seasonal development of the sea surface temperature field are well reproduced. To verify the water level, hourly tide gauge data at 186 sites are used. Although this contains only the water level as a physical quantity, it is a stationary high-sampling observation covering the whole coasts of Japan, which is valuable for validation of coastal models.
First, harmonic analysis of the model water level was carried out to investigate the reproducibility of tides, which are the largest factor of coastal water level variation. As a result, distribution of amplitude and phase for main tidal constituents coincided well with tidal analysis data (FES 2014). In the comparison with the tide gauge data, the root mean square error (RMSE) of the M2 tidal amplitude is 10.4 cm, and less than 24% with respect to the amplitude itself of 44 cm. The phase error is also as small as 8.7 degrees on the average. It can be said that sea level variation due to tides was realistically reproduced despite using only the theoretical equilibrium tidal potential in the model. Next, we verified the daily average water level to evaluate the reproducibility of variations other than tides. In the result, the model water level well followed the time series of the tide gauge data. For the quantitative indices, the RMSE was 7.3 cm and the correlation coefficient was 0.86. In addition, the capture ratio showing how much of the overall variation was reproduced was 70%, and the F value showing the ratio of the time when the error was less than 15 cm was 95%. As far as the indicators used to verify coastal models are concerned, good results were obtained in the free-run experiment. We also performed an analysis run with data assimilation for this model, where these scores are further improved with the RMSE of 4.4 cm, the correlation coefficient of 0.94, the capture ratio of 89% and the F value of 99%. In addition to the overall indicators described above, some remarkable cases of water level variation are also investigated. For example, we executed an experiment on the San'in Coast in September 2012, when the water level rose by more than 50 cm after several days from typhoon passage, and succeeded in reproducing the timing and amplitude of the water level rise. In this experiment, it was also found that reproducibility is obviously improved by using wind and sea level pressure data with resolution of 5 km, instead of the JRA-55 calibration data with resolution of about 1.25 degrees. In the presentation, we will quantitatively show the influence of the resolution of wind and sea level pressure data on water level reproducibility.

Keywords: coastal model, tide gauge data, sea level variation, tide, barometric response, abnormally high tide

