Seasonal Simulations of a Coupled Ice-ocean Model in the Bohai Sea and North Yellow Sea since the Winter of 1997/1998

Yu Liu1,2 Qinzeng Liu1 Jie Su1 Maoning Tang2 Shan Bai2

(1) College of Physical and Environmental Oceanography, Ocean University of China, Qingdao, China
(2) Key Laboratory of Research on Marine Hazards Forecasting, National Marine Environmental Forecasting Center, Beijing, China

ABSTRACT

A fine-resolution coupled ice-ocean model configured for the Bohai Sea and North Yellow Sea is presented. A horizontal grid spacing of 3.7km×2.8km was used in this coupled model. Seasonal simulations were made from the winters of 1997/1998 to 2008/2009. By comparing the simulation results and the remote sensing images, the ice-ocean coupled model reasonably reproduces the seasonal variations of the sea ice conditions in the Bohai Sea and North Yellow Sea. The predicted ice-freezing date, ice-ending date and ice periods are in fairly good agreement with observations, and some are even identical to measurements. Moreover, the simulation of maximum sea ice extent date matches well. Normally, the sea ice thickness of the west part in Liaodong bay is less than that of the east part, which can be reproduced well by the ice-ocean coupled model. However, during the melting period, simulated sea ice melts much faster than observations, and the model loses accuracy in simulation of specific ice thickness distribution.

KEY WORDS: Coupled Ice-ocean Model; the Bohai Sea and North Yellow Sea; Sea Ice Concentration; Sea Ice Extent; Sea Ice Period; Sea Ice Thickness; Seasonal Variations.

INTRODUCTION

The Bohai Sea and North Yellow Sea are the only regions with sea ice in China Seas, and are almost the lowest-latitude regions (37°–41°N, 117.5°–127°E, see Fig.1) which ice can naturally form in the world. Every winter, sea ice in these areas imposes different impacts on shipping, offshore oil and gas exploration, with oil platform collapsed, ships damaged, shipping stopped during severe ice conditions in history. The heaviest sea ice disaster took place in the winter of 1969, one of the three oil platforms was pushed down by drifting ice and another was damaged severely in the Bohai Sea. There were 8 ships stranded, 19 ships frozen on the sea and 5 huge ships of a million ton were broken by pack ice (Zhang, 1986; Bai et al., 1998). Even during the years of mild ice condition, there are also disasters at parts of the Bohai Sea, such as in the 2007 winter (Zhang, 2007). Therefore, sea ice is one major factor to be considered for marine engineering design, shipping and exploration for the ocean environment in the Bohai Sea and North Yellow Sea. Since 1980s’, by using field observation and experimentation, data analysis and numerical simulation, a series of studies on sea ice dynamics and thermodynamics have been carried out in China. The air-ice and air-sea heat budgets were calculated by using observed data at platforms and other field data (Wang et al., 1982). Sea ice thermodynamic processes were discussed, including solar radiation penetration through ice, the “thermal reservoir” effect of brine pocket and the processes which determine sea ice formation and growth, such as heat conduction among ice and thermal forces of atmosphere and ocean (Wu et al., 1992). Based on research of these sea ice thermal processes, parameterizations of sea ice thermal processes were proposed to determine the sea ice thermal growth function (Wu, 1991; Wang et al., 1994). According to non-uniformity caused by ice breaking and ice ridging, deformation functions was introduced, sea ice dynamic models was developed, and numerical experiments of ice drift was taken in the Bohai Sea (Wang, et al., 1984; 1994, Wu, et al., 1995; 1998). By using the open water, level ice and ridged ice to depict sea ice distribution within one grid, a dynamic-thermodynamic sea ice model was developed in the Bohai Sea, and has been applied to operational ice numerical forecast in NMEFC (National Marine Environmental Forecasting Center), China (Yang et al., 1991 and Bai et al., 1998).

Based on research of the interactions between atmosphere, ice and ocean, the ice–ocean coupled model has both scientific significance and practical value in terms of long-term study of sea ice or even climate change in this area. The establishment of global and North Pacific ocean-atmosphere coupled climate system has been used for short-term climate prediction (Zhang et al., 2000; Liu et al., 2000, 2004). Over the past years, the numerical sea ice model research focused on the sea ice simulation and forecasting application in the Bohai Sea in China. Gradually, the regional ice-ocean coupled model has been developed. An ice-ocean coupled model was developed by using POM and a viscous - plastic thermodynamic-dynamic sea ice model in the Bohai Sea, and continuous sea ice simulations for two representative winters were taken, which got encouraging results(Su et al., 2004; 2005).

All the previous calculation domains of regional sea ice models or ice-ocean coupled models were limited to the Bohai Sea in China. However, the Bohai Sea and the Yellow Sea are closely linked, and the sea ice occurrence and disappearance in North Yellow Sea is closely related to the marine environment of the Bohai Sea, thus may in some way affect