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NUMERICAL SIMULATIONS OF SEA ICE WITH DIFFERENT ADVECTION SCHEMES*

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Abstract: Numerical simulations are carried out for sea ice with four different advection schemes to study their effects on the simulation results. The sea ice model employed here is the Sea Ice Simulator (SIS) of the Geophysical Fluid Dynamics Laboratory (GFDL) Modular Ocean Model version 4b (MOM4b) and the four advection schemes are, the upwind scheme originally used in the SIS, the Multi-Dimensional Positive Advection (MDPA) scheme, the Incremental Remapping Scheme (IRS) and the Two Step Shape Preserving (TSSP) scheme. The latter three schemes are newly introduced. To consider the interactions between sea ice and ocean, a mixed layer ocean model is introduced and coupled to the SIS. The coupled model uses a tri-polar coordinate with 120×65 grids, covering the whole earth globe, in the horizontal plane. Simulation results in the northern high latitudes are analyzed. In all simulations, the model reproduces the seasonal variation of sea ice in the northern high latitudes well. Compared with the results from the observation, the sea ice model produces some extra sea ice coverage in the Greenland Sea and Barents Sea in winter due to the exclusion of ocean current effects and the smaller simulated sea ice thickness in the Arctic basin. There are similar features among the results obtained with the introduced three advection schemes. The simulated sea ice thickness with the three newly introduced schemes are all smaller than that of the upwind scheme and the simulated sea ice velocities of movement are all smaller than that of the upwind scheme. There are more similarities shared in the results obtained with the MPDA and TSSP schemes.

Key words: advection scheme, sea ice, simulation

Introduction

As an important component of cryosphere, the sea ice plays an important role in the global climate system through ocean-sea ice-atmosphere interactions. In the simulation of a climate system, an accurate representation of the sea ice has an important impact on the overall results. It was found that the simulation results of climate in high latitudes are strongly influenced by the disposition of the sea ice[1,2]. Particularly, in the simulation with an ocean-atmosphere coupled model, the behavior of the sea ice seems to be critical to the results[3]. So, it is a challenge to represent the sea ice appropriately for the development of climate models. It is also shown from numerical experiments that the processes related with the sea ice dynamics play an important role in climate. For example, in a long period simulation experiment, the wind-driven changes in the sea-ice area are about twice as large as those due to thermodynamic (i.e., radiative) forcing[4]. Hence, the sensibility of a sea ice model to the variation of the thermal forcing is larger if only the thermodynamic forcing is considered than if both thermodynamic forcing and sea ice dynamics are considered. Similarly, when the dynamical variation of the sea ice is included in the coupled climate system modeling, the sensitivity of an atmospheric general circulation model to the global warming effect due to the doubling of CO_2 is decreased[5]. Based on the results from a comparison of the simulated sea ice volume with the observed data by submarine in the

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