Geophysical Research Abstracts,
Vol. 11, EGU2009-6582, 2009
EGU General Assembly 2009

The new ice-ocean drag parameterization and its impact on the Arctic Ocean ice evolution simulation

N. Yakovlev
Institute of Numerical Mathematics RAS, Moscow, Russian Federation (iakovlev@inm.ras.ru, +7 (495) 938-1821)

Recent sea ice evolution, which was not predicted by the climate models, gives a hint that there may be the lack of some physical mechanisms, responsible for the destabilization of the Arctic climate system. Tides are one of the physical mechanisms with unclear affect on the climate system of the Arctic Ocean. Tides are responsible for extra open water production, for extra heat transport from the warm Atlantic water layer, and for additional ice ridging. The quantitative estimates of these somewhat contradictory processes are still not accurate.

The coupled ice-ocean model FEMAO was applied to the simulation of the Arctic Ocean state during the period 1948-2007 in the frame of the DAMOCLES project. Forcing and basic parameterizations were according to the Arctic Ocean Model Intercomparison Project (AOMIP) protocol.

The analysis on the role of the M2 tide on the sea ice state formation was carried out. It was shown, that ocean-ice coupling in the assumption of the "levitated" ice leads to unsatisfactory results. The explicit tide leads to reduction of the mean sea ice thickness about 50cm during summer, as well as the shrinking of ice covered area. This artifact was due to increased relative velocity of ice and, thus, enhanced heat flux from the ocean. To evaluate the utility of the more sophisticated model formulations with the thick floating ice, the set of experiments with ice-ocean quadratic drag with coefficients 10 and 1000 times the standard one 0.0055 were carried out. The model appeared to be sensitive to the drag coefficient in the range 0.0055-0.055. Model results with the coefficient 1000 times the standard one gives results close to the results with coefficient 10 times the standard one. Large drag coefficients usage leads to up to 100cm thicker ice in the Central Arctic. This change happens regardless the relatively small tidal velocities about 1-3 cm/s. Thus the problem of the explicit implementation of tides into the climate model was detected partly as the problem of the ice-ocean dynamical coupling.

Simple theoretical considerations show that large drag is typical for summer, when the strong stratification exists. On the other hand during winter the deep mixed layer exists and drag is lower. Thus, one has to use variable drag coefficient. Laboratory experiments and Large-Eddy Simulation models reveals the fact, that ice-ocean drag is a complicated nonlinear function of relative velocity, even in a case of single ice keel of simple form and constant relative flow velocity. On the basis of used early for Weather Forecast and climate atmosphere models mountain drag parameterization, which takes into account gravity wave drag, blocked flow drag and ordinary skin drag, the new ice-ocean drag approximation is developed. This parameterization takes into account upper ocean layer stratification, mean ice-floe diameter of each ice thickness gradation, and distribution of ice over ice thickness gradations. The parameterization is especially suitable for the ocean model with rescaled vertical coordinate "z-star", when the large-scale drag may be estimated explicitly.

The new parameterization is used to reproduce the Arctic Ocean evolution during the 1948-2007 under the AOMIP protocol. Results of model runs with the new parameterization are presented and compared with other parameterizations of ice-ocean drag.

The utility of this parameterization for the large-scale ocean models is discussed. The problems of the parameterization development in a case of nonlinear interaction between boundary layer and gravity waves, induced by ensemble of keels are also under short discussion.