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On the sophisticated ice-ocean drag parameterization and its utility for the Arctic Ocean climate modelling

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

During the last several years the analysis of the role of the M2 tide on the sea ice and ocean state formation was carried out. For this study the finite-element coupled ice-ocean model FEMAO by the author of this presentation was applied to simulate the Arctic Ocean state during the period 1948-2007 in the frame of the DAMOCLES project. It was shown that model with the explicit M2 tide is sensitive to the drag coefficient variation in the range 0.0055-0.055 regardless the relatively small tidal velocities – the ice thickness in the central Arctic is up to 1 m greater in the case of a large drag coefficient. 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.

Up to now there are two main parameterizations used for climate ocean modelling – the traditional "levitated ice" with the skin drag and "embedded ice" by Hibler under the assumption of the strong ice drift and ocean flow velocity correlation.

The new parameterization was developed to take into account some additional physical mechanisms, such as gravity wave drag, blocked flow drag with the wake effect, and the wind waves radiation pressure, which represents the force exerted on ice floes by reflected and diffracted surface waves. This parameterization takes into account upper ocean layer stratification, mean ice-floe diameter in each ice thickness gradation, and distribution of ice mass over ice thickness gradations. The main idea is that ice-ocean drag is different for summer and for winter seasons and may vary significantly in the marginal ice zones due to the wave conditions.

The utility of this parameterization for the large-scale Arctic Ocean modeling is demonstrated by the 1948-2007 period realistic simulations. It was shown, that the new drag parameterization causes accelerates ice cover shrinking during the last decade.

Some problems of the parameterization implementation are discussed: the non-uniform vertical stratification, non-constant ocean flow velocity, interaction with the upper mixed layer.