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On the implementation of the FEMAO (Finite Element Model of the Arctic Ocean) with tides - the dynamical ice-ocean coupling in a case of thick ice

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The Arctic sea ice manifests the high sensitivity to the observed climate change, being in its turn the trigger to positive feedbacks in the Earth climate system. Modern models are quite successful in many aspects of the sea ice simulation, but the latest event of the 2007 minimum of the Arctic ice extent revealed that some mechanisms are still out of scope. These mechanisms were negligible in the past, when the climate system was assumed to be comparatively stable, and are important in unsteady modern state.

One of the possible mechanisms responsible for the stabilizing or destabilizing the Arctic state is tides. There are two possible tidal mechanisms: more intensive vertical mixing in some regions, and more open water production due to ridging. According to the latest indirect estimates these two mechanisms act somewhat opposite with no clear effect on the ice (Holloway and Proshutinsky, 2007).

To evaluate the role of tides in the Arctic Ocean climate formation quantitatively the modification of the FEMAO model was developed. The sea ice regarded as “levitated” ice, with the quadratic drag and drag coefficient about 1.e-3. The M2 tide considered as the inclined wave from the North Atlantic (amplitude and phase of the volume transport were derived from the data by Kowalik and Proshutinsky, 1994). Numerical experiments for the period 1948-2002 were carried out according to the AOMIP protocol. With and without tides model showed pretty well representation of sea ice, with minor differences in extent and area. In both cases model with “levitated’ ice predicts unrealistic ice thickness distribution in Fram Strait during summer.

Test experiments with the drag coefficients 10 and 100 times the standard one showed that model predicts more realistic sea ice thickness distribution.

Thus, the problem was identified as the problem of the ice-ocean dynamical coupling under high frequency forcing (periods less than inertial period). Simple considerations and analogs with the ships lead to conclusion that drag coefficient should be a function of Froude number (upper ocean stratification), ice thickness and frequency of forcing.

The discussion of the problem, methods of subgrid parameterizations, modified formulation of the ice-ocean coupling and methods of numerical solution of the new version of the FEMAO with thick floating ice will be presented.