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Climatic impact of tidal and inertial variability in sea-ice deformation

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Semidiurnal oscillations in sea-ice deformation are a ubiquitous feature of the Arctic and Antarctic sea ice cover. In addition in shallower shelf and shelf break regions diurnal as well as semi-diurnal tidal ice motions are well documented from observations and estimates of their importance on the local ice mass budget suggest them to be very significant. These effects are rarely treated in ice ocean circulation models and coupled air-ice-ocean climate models. Moreover if treated they are usually parameterized in a highly unphysical manner by the use of 'levitated' ice ocean coupling. This 'levitated' coupling is used in almost all ice ocean models such as the CCSM global ice ocean model. In 'levitated' models mechanical buoyancy effects of sea ice are neglected so that convergence of ice, for example, does not affect the Ekman flux of the ocean and the driving stress on an ocean model, separate from the sea ice, is taken to be the water drag on the underside of the ice. This artificial, but widely used, formulation may be visualized by imagining an ice cover floating above rather than in the ocean; hence the term levitated. Initial comparisons of this levitated formulation with tidal forcing (Hibler et. al. 2006) show that in addition to not properly conserving the energy in the ice ocean model, the levitated coupling induces a parity dependent artifical resonance in the ice drift and deformation which can be very substantial in shallow regions leading to artifically enhanced ice deformation estimates.

Since tidal energy in ice covered oceans substantially modifies ocean mixing, a major question related to the climate is how big is the possible offsetting effect of tidal and inertial variability in sea ice deformation. To address this problem in a physically realistic way we have constructed a high resolution sea ice barotropic ice ocean model (Hibler et. al 2006) with the sea ice embedded in a relatively thin upper oceanic bound-

ary layer. With this imbedded formulation the ice is floating in the ocean and there is no artifical inertial resonance, although ice mechanics effects, even in the absence of wind forcing, can induce inertial motion in the combined ice ocean boundary layer.

In this presentation we examine results from a variety of Arctic ice-ocean seasonal simulations using this model with varying degrees of wind and tidal forcing. While comparisons with observed buoy drift and deformation and with ‘levitated’ models will be briefly discussed, the main focus of this presentation is to (1) assess degree to which combined tidal and inertial forcing modify the ice mass budget in polar regions, (2) how this modification is spatially partitioned; and finally, (3) how much known interdecadal variations of tidal forcing could be expected to insert natural variations into the sea-ice mass budget (and hence air-sea heat exchanges) quite apart from climate change due to anthropomorphic effects.