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VARIABILITY OF THERMOHALINE CIRCULATION UNDER AN ICE SHELF

(Abstract)

by

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The production of Antarctic Bottom Water is mainly influenced by Ice Shelf Water, which is formed through the modification of shelf water masses under huge ice shelves. To simulate this modification a two-dimensional thermohaline circulation model has been developed for a section perpendicular to the ice-shelf edge. Hydrographic data from the Filchner Depression enter into the model as boundary conditions. In the outflow region they also serve as a verification of model results.

The standard solution reveals two circulation cells. The dominant one transports shelf water near the bottom toward the grounding line, where it begins to ascend along the inclined ice shelf. The contact with the ice shelf causes melting with a maximum rate of 1.5 m a^{-1} at the grounding line. Freezing and therefore the accumulation of "sea ice" at the bottom of the ice shelf occurs at the end of the melting zone at a rate on the order of 0.1 m a^{-1}. Both rates are comparable with values estimated or predicted by models concerning ice-shelf dynamics.

As one example of model sensitivity to changing boundary conditions, a higher sea-ice production in the southern Weddell Sea, as might be expected for a general climatic cooling event, is assumed. The resultant decrease/increase in temperature/salinity of the inflow (Western Shelf Water) reduces the circulation under the ice shelf and therefore the outflow of Ice Shelf Water by 40%. The maximum melting and freezing rate decreases by 0.1 m a^{-1} and 0.01 m a^{-1}, respectively. and the freezing zone shifts toward the grounding line by 100 km.

In general the intensity of the circulation cells, the characteristics of Ice Shelf Water, the distribution of melting and freezing zones and the melting and freezing rates differ from the standard results with changing boundary conditions. These are the temperature and salinity of the inflow, the surface temperature at the top, and the extension and morphology of the ice shelf.

SEASONAL ARCTIC SEA-ICE SIMULATIONS WITH A PROGNOSTIC ICE–OCEAN MODEL

(Abstract)

by

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The seasonal cycle of sea ice, especially the ice margin location in the East Greenland region, is significantly affected by ocean circulation. The ocean circulation in turn can be altered by ice dynamics which cause large amounts of ice to be transported to the ice margin to be melted, thus stratifying the ocean there. By responding to wind changes, the ice dynamics can also create rapid melting or freezing events which can destabilize the ocean.

In an earlier study, Hibler and Bryan (1987) carried out a diagnostic simulation of the Arctic ice-ocean system in which a coupled ice-ocean circulation model was integrated for about five years beginning with mean annual estimates by Levitus (1982) of the observed temperature and salinity fields. As a consequence of this short integration, the mean baroclinic circulation of the ocean deviated little from the initial fields, although seasonal and local effects due to the interactive models were simulated. One particularly interesting result of this study was the presence of fluctuations of oceanic heat flux at the ice margin, which appeared to coincide with strong wind events occurring over a few days which induced periods of freezing.

With this diagnostic model, good results for the location of the ice margin were obtained. However, a global budget analysis indicated that the net northward heat transport through the Faero–Shetland passage was not adequate to balance the heat loss to the atmosphere sustained by the ocean in the fifth year. Moreover, a 20-year simulation without diagnostic terms showed a degraduation of the baroclinic fields in the Arctic Basin possibly due to the very weak wind stress used for this particular years's wind forcing, or perhaps due to excessive damping in the ocean due to computational requirements imposed by the coarse grid.

As a first step in the development of a higher-resolution fully interactive prognostic model, we have modified this model and carried out two prognostic simulations of the Arctic ice ocean system by employing 50-year integrations. The ocean model used for this study is essentially that of Hibler and Bryan (1987). However, the

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boundary conditions, atmospheric forcing, and ice model have been changed. In particular, a much more robust wind forcing was obtained by replacing the monthly mean wind fields with a 30-year means in order to obtain a seasonal forcing closer to climatology. With regard to the ice rheology, a cavitating fluid model in spherical coordinates which fully conserves ice mass and air sea heat exchanges was employed. The idea here is to attenuate less of the stress into the ocean so that even though the circulation is somewhat sluggish due to large viscous damping, a reasonable current field for the Arctic Basin might be obtained.

Two types of prognostic circulation experiments were carried out with this model using different southern boundary conditions. In one case, a diagnostic relaxation near the boundary as used by Hibler and Bryan (1987) was employed. In this case, heat mass and salt transports through the southern boundary are essentially simulated. In the second case, the net burotropic flow through the Faero–Shetland passage and Denmark Strait were specified with the baroclinic transports partially specified by diagnostic relaxation terms. The results from both these models are analyzed with special attention to the ice edge location and the character of the baroclinic fields in the Arctic Basin.

ON THE INTERANNUAL VARIABILITY OF A DIAGNOSTIC ICE-OCEAN MODEL

(Abstract)

by

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Sea-ice drift and dynamics can significantly affect the exchanges of heat between the atmosphere and ocean and salt fluxes into the ocean. The ice drift and dynamics, in turn, can be modified by the ocean circulation. This is especially true of the ice margin location whose seasonal characteristics are largely controlled by the substantial oceanic heat flux in the Greenland Sea due to convective overturning.

A useful framework to analyze the interannual variability of ice–ocean interaction effects relevant to climatic change is the diagnostic ice–ocean model developed by Hibler and Bryan (1987). In this model, the oceanic temperature and salinity is weakly relaxed (except in the upper layer of the ocean which is essentially driven by the ice dynamic-thermodynamic sea-ice model) to climatological temperature and salinity data. This procedure allows seasonal and interannual variability to be simulated while still preventing the baroclinic characteristics of the ocean circulation from gradually drifting off into a total model defined state. However, in the work of Hibler and Bryan only the seasonal equilibrium characteristics of this model with the same forcing repeated year after year have been considered.

In order to begin to examine the interannual behavior of this model, we have carried out a three-year simulation for the Arctic Greenland and Norwegian seas over the time period 1981–83. (The geographical region is essentially the same as used by Hibler and Bryan.) This three year simulation is carried out after an initial two year spin up using the 1981 atmospheric forcing data. For comparison purposes, an ice model simulation with only a fixed depth mixed layer was also carried out over this time interval.

The results of these two simulations are analyzed with special attention to the ice margin characteristics in the Greenland and Norwegian seas to determine the role of ocean circulation on the variability there. The ice margin results are also compared to the variability in the northward transports of heat through the Faero-Shetland passage which in the fully-coupled model are calculated rather than specified.

REFERENCE

Hibler, W.D. III and K. Bryan. 1987. A diagnostic ice–ocean model. *J. Phys. Oceanogr.*, 17(7), 987-1015.