Abstract View

Volume 9, Issue 4 (July 1979)

Journal of Physical Oceanography
Article: pp. 815–846 | Abstract | PDF (2.21M)

A Dynamic Thermodynamic Sea Ice Model

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(Manuscript received May 1, 1978, in final form December 13, 1978)

DOI: 10.1175/1520-0485(1979)009<0815:ADTSIM>2.0.CO;2

ABSTRACT

A numerical model for the simulation of sea ice circulation and thickness over a seasonal cycle is presented. This model is used to investigate the effects of ice dynamics on Arctic ice thickness and air-sea heat flux characteristics by carrying out several numerical simulations over the entire Arctic Ocean region. The essential idea in the model is to couple the dynamics to the ice thickness characteristics by allowing the ice interaction to become stronger as the ice becomes thicker and/or contains a lower areas percentage of thin ice. The dynamics in turn causes high oceanic heat losses in regions of ice divergence and reduced heat losses in regions of convergence. TO model these effects consistently the ice is considered to interact in a plastic manner with the plastic strength chosen to depend on the ice thickness and concentration. The thickness and concentration, in turn, evolve according to continuity equations which include changes in ice mass and percent of open water due to advection, ice deformation and thermodynamic effects.

For the standard experiment an integration of eight years in length is performed at one day timesteps and 125 km resolution in order to obtain a cyclic equilibrium. A zero ice strength condition is used at the Greenland-Spitsbergen passage to allow natural outflow or inflow. Several other shorter experiments, including a case without open water effects, are also run for comparison. Input fields consist of observed time varying geostrophic winds over a one year period, fixed geostrophic ocean currents, and geographically invariant ice growth rates dependent on ice thickness and season.

Many of the observed features of the circulation and thickness of the Arctic ice cover are reproduced by the model. The average annual drift shows the classic anticyclonic ice flow in the Beaufort Sea together with a transpolar drift of ice from the Siberian coast toward the Greenland Sea. In addition, the nonlinear plastic rheology allows the formation of a shear zone (velocity discontinuity) from time to time off the North Slope of Alaska. The average rate of ice export out of the basin is ~ 0.1 Sv in reasonable agreement with observational estimates. Geographical ice thickness contours show ice in excess of 6 m along the Canadian Archipelago with thicknesses decreasing to 2 m near the Siberian coast. The form of these contours is in good agreement with that estimated from submarine sonar data and aerial ridge surveys. In summer a low compactness region of up to 50% open water builds up off the Alaskan and

Siberian coasts, in general agreement with satellite-derived ice concentration charts. Further from shore, smaller, but still significant, amounts (~ 10%) of open water also form in summer. An important, less verifiable characteristic is that the annual net ice production is dominated by the North Slope and Siberian nearshore regions where, on the average, offshore advection creates open water and thinner ice. Overall the simulation results suggest that lateral heat transport due to ice motion is of the same order of magnitude as vertical air-sea heat fluxes.

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