International Journal of Offshore and Polar Engineering (ISSN 1053-5381)

Vol. 17, No. 3, September 2007, pp. 176–181

Modeling Annual Variation of Sea-ice Cover in Baffin Bay

Charles C. L. Tang and Ewa Dunlap
Bedford Institute of Oceanography, Fisheries and Oceans Canada
Dartmouth, Nova Scotia, Canada

Baffin Bay is partially covered by sea ice all year except in September. The distribution of sea ice and its annual variation are controlled mainly by the meteorological conditions and ocean currents. To model the annual variation of sea ice, a coupled ice-ocean model has been developed. The ocean model is the Princeton Ocean Model, formulated in sigma coordinates with 16 levels; it uses 2nd-order turbulence closure to parameterize vertical mixing. The ice model is based on Hibler's viscous-plastic rheology and contains multiple ice categories defined by thickness range. The heat and salt fluxes between ice and ocean are based on the formulation of Mellor and Kantha. The model domain encompasses Baffin Bay and the Labrador Sea with a grid resolution of 1/3° longitude and is variable in latitude to maintain approximately square grid cells. Forcing fields are computed from 3-hourly meteorological variables provided by the Canadian Meteorological Centre. The model is integrated from September 2004 to January 2006. The main features of the model simulations include an increasing ice cover from October to February; an approximately constant ice cover from February to May; and a decreasing ice cover from June to August. In mid-May, a polynya starts to develop in northern Baffin Bay (North Water Polynya), which is maintained through July. Ice as thick as 2.5 m appears off the coast of Baffin Island and Melville Bay in April and May. The concentration and thickness in western Baffin Bay are higher than in eastern Baffin Bay due to the influence of the warm West Greenland Current flowing into Baffin Bay. The ice velocities are relatively high in the northern straits, off the Baffin Island coast and in western Davis Strait, reflecting the seasonal wind conditions and surface circulation. The modeled ice distribution is compared with satellite data, and good agreement is obtained.

INTRODUCTION

Baffin Bay is a mediterranean sea located between the Canadian Archipelago and the Labrador Sea (Fig. 1), with 3 connections to the Arctic Ocean. The smallest is through Jones Sound with a 120-m-deep sill at Hell's Gate (the western end of Jones Sound) and a channel width of less than 30 km. The other shallow connection is to the west of Lancaster Sound at Barrow Strait, where the sill depth is about 125 m and the width about 55 km. The deepest connection is through Nares Strait with the sill in Kane Basin at a depth of about 250 m. Tang et al. (2004) have reviewed the circulation, water masses and meteorological conditions of Baffin Bay. Sea ice is present all year in Baffin Bay except in September. The onset of local freezing occurs in early fall and near complete coverage of ice exists from December to April; the ice begins to clear in the spring, starting in the North Water region (NOW in Fig. 1) and the southeastern part of the Bay.

The distribution of sea ice is strongly influenced by the relatively warm, northward-flowing West Greenland Current and a cold southward-flowing Baffin Current (Dunlap and Tang, 2006). The warm West Greenland Current delays winter freeze-up in the southeastern part of the Bay, while ice influx via the Baffin Current delays the loss of ice along the coast of Baffin Island. New ice usually starts to form in northwestern Baffin Bay during the second half of September. By mid-November the growing ice spreads southward along the Baffin Island coast as far as 61°N, and eastward from Baffin Island to cover almost all of Baffin Bay, usually reaching a maximum in March. Ice cover exceeds 50°N southward every winter and extends to nearly 46°N in some years. The spring melt and ice breakup start in southeastern Baffin Bay and extend north-northwest until they reach the North Water Polynya by about the end of July. Baffin Bay becomes ice-free in September except during cooler summers, when some floes may survive till winter, most commonly in its central part.

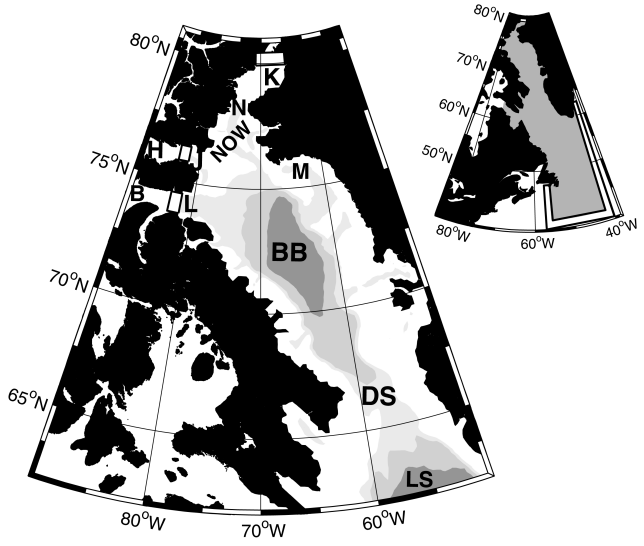

Fig. 1 Baffin Bay map and bathymetry, with model domain on map to right. Open boundaries = unfilled border lines. Depth contours: 500, 1000 and 2000 m. Map symbols: B = Barrow Strait; BB = Baffin Bay; DS = Davis Strait; H = Hell's Gate; J = Jones Sound; K = Kane Basin; L = Lancaster Sound; LS = Labrador Sea; M = Melville Bay; N = Nares Strait, NOW = North Water Polynya.

The annual variation of sea ice described above is mainly a response to meteorological forcing, which is the focus of this

Received May 1, 2007; revised manuscript received by the editors July 19, 2007. The original version (prior to the final revised manuscript) was presented at the 17th International Offshore and Polar Engineering Conference (ISOPE-2007), Lisbon, July 1–6, 2007.
KEY WORDS: Baffin Bay, sea-ice model, annual variation.