THE CLIMATIC RESPONSE OF THE ARCTIC OCEAN TO SOVIET RIVER DIVERSIONS

(Abstract)

by

Albert J. Semtner Jr.

(National Center for Atmospheric Research, P.O. Box 3000, Boulder, Colorado 80307, U.S.A.)

A numerical model is constructed to evaluate the effect of river diversions on the circulation of the Arctic Ocean, including the climatically important response of the extent of sea ice. The ocean model solves the primitive equations of motion in finite-difference form for the irregular geometry of the Arctic Ocean and the Greenland and Norwegian seas, using 110 km horizontal grid spacing and up to 13 unevenly spaced levels in the vertical. Annual-mean atmospheric conditions and river discharges are specified from observations. The presence of sea ice is diagnosed on the basis of model ocean temperature; and the effects of sea ice on the surface fluxes of momentum, heat, and salt are included in a simplified way. Lateral exchanges at the southernmost boundary are held near observed values but respond to circulation changes in the Greenland and Norwegian seas. Two equilibrium solutions are obtained by hundred-year integrations from simple initial conditions: the first with inflow from all rivers and the second with the inflow reduced by the contributions of four major rivers (the Ob', Yenisey, Dvina, and Pechora). The latter is an extreme case amounting to three times the net diversion actually envisioned by the Soviet Union over the next fifty years.

The control integration gives a good simulation of known water masses and currents. In the central Arctic, for example, the model correctly predicts a strong shallow halocline, a relatively warm intermediate layer of Atlantic origin, and a temperature jump across the deep Lomonosov Ridge. The overall pattern of surface salinity and the margin of the pack ice are also properly simulated.

When runoff into the marginal Kara and Barents seas is diverted, almost no effect on the halocline results in the central Arctic. In particular, deep convection does not develop in the Eurasian Basin, the possibility of which was suggested by Aagaard and Coachman (1975). The stable stratification within the two marginal seas is considerably eroded, but not to the point of convective instability. The surface currents in this area change to confine the water with increased salinity to the shelf region, except for outflow into the deep basins of the ice-free Greenland and Norwegian seas, where existing deep convection is slightly enhanced. As a result, there is some additional heat loss from the Atlantic layer before it enters the central Arctic. The ice extent remains nearly the same as before within the Kara and Barents seas. In fact, since modified bottom currents over the continental shelf bring in less heat from the Greenland Sea, an increased thickness of sea ice may result there, in spite of reduced vertical stability. These model responses are generally in agreement with those suggested by Soviet investigations of the effect of river diversions.

REFERENCE

Aagaard K, Coachman L K 1975 Toward an ice-free Arctic Ocean. *Eos. Transactions, American Geophysical Union* 56 (7): 484-486

https://doi.org/10.3189/S0260305500003980 Published online by Cambridge University Press