The Arctic Ocean: Water Masses and Energy Exchanges

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Introduction

A formulation of the earth's heat balance was assembled by Oort and Vonder Haar (1976) using radiation data from earth-orbiting satellites, atmospheric observations from radiosonde balloons in the northern hemisphere, and long-term oceanographic temperature observations. They found the mean northward flux of energy of $0.5 \times 10^{13}$ W, advected by atmospheric movement past the 80°N parallel of latitude, to be balanced primarily by the net outflow of radiation from the top of the atmosphere into space. Oceanic energy fluxes through 80°N played a secondary role. The radiation balance at high latitudes is dominated by the presence or absence of snow and ice which will usually alter the albedo (controlling the amount of radiation reflected from the surface back into the atmosphere) at least six-fold. Thus any oceanic or other factors, albeit energetically minor, that materially affect the snow and ice cover in polar regions will affect the final disposition of the sun's energy over the earth's surface, and hence our climate.

The ice cover, ocean, and atmosphere exchange energy in most complex ways, both negative and positive feedback mechanisms being involved. For example, an increase in heat loss from the ocean produces more ice growth: heat loss is then reduced as the insulating ice cover grows thicker. Looked at from the other side, as the area of ice cover increases, the amount of radiation reflected also increases, causing a drop in air temperature and hence a further extension of the ice cover.

During recent years weather in the northern hemisphere has apparently had a number of extreme values. Although the data are too sparse to warrant firm conclusions, they are causing meteorologists and oceanographers to look at Arctic regions with ever-increasing interest in an attempt to understand the mechanisms that control energy exchange between ocean and atmosphere at high latitudes. When it is realised that the topmost 2.5 m of the ocean has the same heat storage capacity as the complete superincumbent atmosphere, the importance of these exchanges will be understood.

With the exception of large changes in flow from the Siberian rivers, present possible man-made changes are thought to be negligible in terms of natural variations in ice cover seen between years. Extensive irrigation schemes,
possibly involving ever-increasing diversions of these rivers, extend into the next century and may be capable of producing significant climatic changes (Gribbin, 1979).

At an immediate practical level, plans for offshore production from oil and gas wells in Arctic regions and the ensuing transportation of these products to southern markets by icebreaking tankers will require prediction of ice conditions on many different time scales. ‘Good’ and ‘bad’ ice years will be interpretable in terms of the Arctic ocean heat budget and its fluctuations; prediction will require a major extension in our existing knowledge.

Water Masses of the Arctic Ocean

Figure 2.1 shows the main bathymetric features of the Arctic Ocean. It is separated into the Canadian and Eurasian basins by the Lomonosov ridge and has its main connection to southern oceans through the Fram Strait, which is...