The water balance of the Oceans

M.I. Budyko
(text, vol. 1, p. 24)

Intervention of H.L. PENMAN:

In calculating evaporation from the radiation balance, what are the effects of:
(i) Heat stored in the ocean?
(ii) Heat carried away in ocean currents?

Reply:
Exchange of heat in ocean and transport of heat by oceanic currents are important factors of evaporation. Their influence on evaporation can be studied using the existing formulae for determination of evaporation.

Intervention of M.A. KOHLER:

I was interested in Prof. Budyko's statement concerning the comparisons between observed and computed net radiation. I believe it was said that the correlation coefficient was found to be greater than 0.95. I would like to know the time and space elements of the data used in the correlation analysis and the specific method of obtaining the computed value of radiation.

Reply:
The data of radiation balance observations are obtained for the greater part of the surface of the world ocean between lattitudes 50° N and 50° S. They were mainly collected for the last ten years. The method of calculation of radiation balance is described in the "Atlas of heat balance of the Globe" (1963).

The hydrological cycle of Greenland and Antarctica

Svenn Orvig
(text, vol. 1, p. 41)

Intervention of Prof. I. BUDYKO:

Is it possible to explain the negative balance of ice in Antarctic if level of the world ocean is increasing?

Reply:
Recent studies of the Antarctic ice budget seem to indicate that the ice budget is slightly positive at present, with an annual gain of perhaps a little less than 600 km^3 water. Greenland has, probably, a small net annual loss of a little less than 100 km^3 water.

The net result should be a lowering of the sea level of approximately 1.5 mm/year. It should be remembered that Antarctic information is very recent—since the I.G.Y. in 1957-58. Recent times have seen a relatively stable sea level—a rise of about 20 cm for the fifty years ending in 1940, but a decrease to about half of this rate of rise since then. Perhaps the various figures would be comparable if data were compared for the last 10 years. It does seem that the great ice caps are now more or less in equilibrium.

Comment of H. FLOHN:

The simultaneous occurrence of a positive mass budget of Antarctica together with a rise of the world ocean level can be easily interpreted by an increase of ocean temperature (as observed at least in the upper 100 m). The corresponding decrease of density and increase of volume is in the right order of magnitude.

Intervention of V. YEVJEVICH:

It is often customery among geophysicists to attempt immediately a physical justification as soon as a random variable shows a small change (trend) upwards or downwards. If the mean temperature of the ocean along a route of ships shows a small increase in temperature (warming-up) or a small decrease (cooling-off), the current approach is to call it "the climatic change" and to search for its explanation. Similar approach is used in the case of "an advancement or a retreat of glaciers", or in the change in biological cover, and for the other geophysical changes.

As the processes in atmosphere are periodic stochastic processes, with the random components heavily represented, all above geophysical variables are random processes also. By the sampling theory, the average values of the year or the other time intervals, must show upward-downward movements. For the annual temperatures to stay very close to the long-range mean for a long period, the probability is close to zero. Therefore, the physical explanation of these changes by a small and limited number of other variables is not usually feasible in stochastic processes, except in case of functions of random variables, when the dependent variable (temperature, volume of water in glaciers, etc.) is simply related to a small number of other random variables. A distinction should be made between the climatic changes (change of the long-term mean) and the sampling variation of the short-range mean of random variables.

Reply:

Of course, a distinction must be made between changes of the long-term mean and the sampling variation of short-range means of random variables. It is not the annual values that are usually examined and compared when discussing climate fluctuations, nor the short-period conditions when discussing various evidences for the longer-term, climate variations.

The question of how heavily the random components are represented in atmospheric processes is not answered yet, I think. It is true that heat balance studies indicate that the various terms are interdependent to a remarkable degree.

However, neglecting to attempt to seek a physical explanation for simultaneous and similar, hemispheric changes in many variables, over fairly long period, would seem to be to abandon geophysics as science and let it deteriorate to a mathematical exercise. We do not have a good theory yet for explaining climate change, although we do know that it has taken place in the past. This means that meteorologists are not in the habit of using past trends to forecast future conditions. With our present knowledge, such forecasting is doomed to failure.