buoyancy effects (Budd and others 1979) modifies the evolution of the ice sheet. An attempt will then be made to simulate the Holocene retreat of the Antarctic ice sheet.

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SOUTHERN OCEAN SEA-ICE RESPONSE TO ATMOSPHERIC WARMING

(Abstract)

by

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The response of Antarctic sea ice to hypothetical atmospheric temperature increases has been simulated with a thermodynamic/dynamic sea-ice model having horizontal resolution of approximately 200 km. The model was run, as a standard case, with mean-monthly climatological air temperatures and dew points, followed by four subsequent simulations with all temperatures and dew points uniformly increased by -1, +1, +3, and +5 K. A temperature increase of 3 K suffices to eliminate the mid-summer ice around all of East Antarctica, with ice remaining only in the Amundsen and western Weddell seas. A temperature increase of 5 K suffices to eliminate the summer ice cover almost entirely, a small amount of ice remaining only off the Thwaites Glacier region in the Amundsen Sea. In winter, the hemispheric average of the calculated ice-edge retreat rates is 1.4° latitude for each 1 K increase in atmospheric temperature. These retreat rates are nonlinear with respect to temperature change, the sensitivity of the position of the ice edge decreasing as temperatures are further increased. This nonlinearity in the response of the ice edge occurs in the response of other ice variables as well, including the total ice area and total ice volume at maximum ice extent. These maximum areas and volumes decrease by roughly half with an atmospheric temperature increase of 5 K. Among the other simulation results of increasing the atmospheric temperatures is an increase in the temporal asymmetry in the annual cycle of ice cover, showing longer, slower periods of ice growth and shorter, faster periods of ice decay.

The results of this study are described in full in a paper to appear in: Hansen J, Takahashi T (*eds*) *Climate processes: sensitivity to solar irradiance and CO_2*. Washington, DC, American Geophysical Union (M Ewing Series 4).

PAST ACCUMULATION RATES AT CAMP CENTURY AND DEVON ISLAND, DEDUCED FROM ICE-CORE MEASUREMENTS

(Abstract)

by

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Measurements of oxygen-isotope ratio in cores from polar ice sheets have provided detailed long-term records of past fluctuations in temperature. Cores in which annual layers can be identified also contain a record of past precipitation rates provided that one can calculate the total vertical strain to which each layer has been subjected since it was deposited at the surface. Because this is difficult, few such records have been published so far.

Nye (1963) proposed a method based on the assumption that the vertical strain-rate along any vertical line in the ice was uniform at any instant and that there was no basal melting. The first assumption is invalid and the method gives implausible results in the cases in which we have used it. Reeh and others (1978) obtained continuous records of precipitation, extending back to 600 AD in one case, from three cores in Greenland. They also assumed that the vertical strain-rate did not vary with depth, but only

down to the maximum depth of measurement. Because this was less than one-quarter of the ice thickness, their assumption is probably satisfactory. They also assumed that the strain-rate had not changed over the period of their records; this is also reasonable.

Hammer and others (1978) have measured annual layer thicknesses at about 35 points in the core from Camp Century, Greenland, and Koerner (unpublished) has made similar measurements on a core from the Devon Island ice cap. Because these measurements extend to within 100 m of bedrock at Camp Century and 15 m at Devon Island, an assumption of uniform strain-rate is certainly incorrect. We assumed that the horizontal velocity at Camp Century was given by the usual formula for laminar flow and obtained the vertical strain-rate from the condition of incompressibility. On the assumptions of (1) steady-state and (2) no change in accumulation rate and ice thickness for about 35 km upstream, the total vertical strain at any depth was obtained by integrating the strain-rate from the surface to that depth. Because the Devon Island bore hole is within three ice thicknesses of the ice divide, we used a finite element model, developed from a model of Raymond (in press), to calculate total vertical strain as a function of depth.

The Camp Century record can be divided into four parts, according to date:

(i) 0-3000 BP. Accumulation rate approximately equal to its present value. None of the ten individual measurements differs by more than 5% from the present value.

(ii) 3000-4000 BP. Accumulation rate about 10% greater than at present.

(iii) 4000-6000 BP. Mean accumulation rate about same as at present but larger variations than in the first period.

(iv) 7000-8500 BP. Accumulation about 10% less than at present.

Because ice thickness and velocity at Camp Century during the last glaciation are unknown, the total vertical strain cannot be calculated. So we have not used the measurements of Hammer and others (1978) in the ice-age ice.

For Devon Island, comparison of measured layer thicknesses with those calculated from the steady-state model suggests that (a) the accumulation rate has not changed significantly for the past 1 500 a and (b) it was greater than it is at present for the 3 500 a before that.

Imbrie (1972) and Dansgaard and others (1982) have dated the Camp Century core by comparing features of the oxygen isotope record with corresponding features in the climatic record in ocean cores, while Mörner (1972) made a similar comparison with the glacial geological record in North America and northwest Europe. The authors of these three studies then calculated variations in accumulation rate during the last glaciation from the relative lengths of core sections between horizons of known age. This method is unreliable because it takes no account of ice deformation. Moreover, there is little correlation between the results of these studies.

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A SPECTRAL MODEL OF THE ICE-AGE CYCLE WITH GLACIAL ISOSTATIC ADJUSTMENT

(Abstract)

by

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A new theory of glacial isostasy has been constructed which provides, for the first time, a coherent explanation of all the phenomena associated with glacial isostatic adjustment. These include the complete set of globally-distributed and radiocarbon-controlled relative sea-level data covering the time interval from the present to 20 ka BP, the free-air gravity anomalies associated with continental regions which were once ice-covered, the astronomically-observed non-tidal component of the acceleration of planetary rotation, and the true polar wander evident in the International Latitude Service (ILS) record of polar motion based on photo zenith-tube data taken since 1900. Taken together, these data constrain very accurately the radial variation of viscosity in the Earth's mantle from the surface to the boundary with the molten iron core. This model of glacial isostasy, which has no free parameters, has been successfully coupled to a zonally-averaged climate model in which an active cryosphere is directly forced, through an appropriate accumulation function, by fluctuations in effective solar insolation produced by variations in the Earth's orbit. Milankovitch experiments completed with this model show that the isostatic adjustment component is crucial in supporting long time-scale oscillations on the 10^5 a period which have been found in $^{18}O/^{16}O$ data in sedimentary cores taken from deep ocean basins.