Fig.6. Snowline extent in the southern hemisphere as generated by the model.

land mass near the South Pole was too large to permit snow to remain on the ground for the entire year.

Shifting continentatl distributions must surely have been accompanied by changes in the circulation of the ocean, and, therefore, changes in the poleward advection of heat (Kvasov and Verbitsky 1981). In its present form, our model cannot account for this. It is certainly an important effect, and we are now modifying our model in such a way that we can include it. It seems clear that one result of including an increased poleward advective heat flux by the oceans, as suggested by Frakes and Kemp (1973), will be to increase the annual average temperature on the continent near the South Pole. This is consistent with the belief that polar climates were warmer during the Cretaceous.

Finally, we emphasize our main point. While a

land mass must be close to a pole in order for an ice sheet to form (Watts and Hayder 1983, in press, Oerlemans in press) it seems possible for the land mass to be too large. (This is probably why the North American ice sheet formed before the Scandinavian ice sheet during the Quaternary ice age.) We conclude that a realistic model with which to study the initial formation of the Antarctic ice sheet 30 to 50 Ma BP should contain a land-sea distribution and a seasonal cycle, as well as realistic poleward advection by ocean currents.

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A GLOBAL PALEOCLIMATIC DATABASE FOR 6 AND 9 ka BP

(Abstract)

by

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A Cooperative Holocene Mapping Project (COHMAP) has assembled a database of Holocene paleoclimatic data from 1 000 locations with ^{14}C dates (Table I). The data are stored on computer tapes at Brown University and will be available for verification of computer simulations of Holocene climates. Pollen, lake-level, and marine plankton data are the main sources of paleoclimatic information (Webb in press). Multivariate statistical techniques (Imbrie and Kipp 1971, Webb and Bryson 1972) and energy-budget models (Kutzbach 1980) exist that can transform each of these types of data into quantitative estimates of past temperature and precipitation.

Sites with pollen data are the most numerous (750 sites) within the database (Table I), and dense networks of pollen sites exist in eastern North America (Bernabo and Webb 1977), Europe (Huntley and Birks 1983), the Soviet Union (Peterson unpublished) and Alaska (Anderson unpublished). Pollen data from New Zealand, Africa, and South America are also being assembled. Work is now in progress to gain climatic estimates from this pollen information, and Webb (in press) has presented maps of past temperatures and precipitation in the midwestern United States.

Lake-level data are the next most numerous source of Holocene paleoclimatic data (200 sites). Dense networks of sites exist in western North America, Africa and Australia (Street and Grove 1979). The changing lake levels directly record variations in the local water budget from which energy-budget and hydrological models can estimate past changes in precipitation (Kutzbach 1980). Water levels were

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TABLE I. DISTRIBUTION OF TERRESTRIAL AND MARINE SITES WITH RADIOCARBON-DATED POLLEN, LAKE-LEVEL, AND PLANKTON DATA IN THE COHMAP DATABASE

Region	Pollen	Lakes
North America	400	42
South America	20	12
Europe	250	1
USSR	35	5
Asia	15	30
Africa	10	90
Australia, New Zealand, Oceania	20	20
Total	750	200
Atlantic Ocean	25	
Pacific Ocean	8	
Indian Ocean	10	
Southern Ocean	4	
Marginal seas	3	
Total	50	

high in many African and north-west Indian lakes at 9 and 6 ka BP, and the model calculations indicate that the rainfall in Chad and north-west India was about 200 mm higher at 6 ka BP than at present (Kutzbach 1980, Swain and others 1983).

Marine plankton data are mainly available from the Atlantic and western Indian oceans (Ruddiman and McIntyre 1981, Prell in press). For most of the ocean regions, sedimentation rates are too low for deep-sea cores to resolve differences within the Holocene. Isolated samples from the Southern Ocean, from the margins of the Pacific Ocean, and from several marginal seas fill out the network of marine data. Patterns are evident in the maps of ocean-surface temperatures estimated from these data for 6 ka BP, but most temperatures are similar to those for today.

Recent climate-model simulations have shown how important Milankovitch factors are in influencing the global climatic patters at 9 ka BP (Kutzbach 1981). The model simulations for rainfall in the subtropics agree well with the paleoclimatic data for high lake levels in this region at 9 ka BP (Street and Grove 1979, Prell in press). The presence of the Laurentide ice sheet also affects the simulated climatic patterns at 9 ka BP (Kutzbach and Otto-Bliesner 1982). At 6 ka BP the extent of terrestrial ice sheets is approximately similar to the ice extent today, but summer insolation in the northern hemisphere was about 5% larger than it is today. The patterns of pollen-derived temperature estimates for eastern North America and Europe agree well with initial model results for July temperatures at 6 ka BP. These comparisons between model results and the paleoclimatic data will be a continuing focus for COHMAP research.

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