Dansgaard–Oeschger signal[10].

Growth of the Laurentide Ice Sheet in Hudson Bay through several Dansgaard–Oeschger oscillations would have trapped geothermal heat near the bed. Sufficient warming could have caused basal melting of the ice sheet and triggered an ice surge, flooding the North Atlantic with ice-rafted debris and melt water. The resulting Heinrich event would have initiated or strengthened a super-Dansgaard–Oeschger ocean cooling[11]. The slow cooling and rapid warming of the Bond cycle may reflect the downwind effects of the slow growth, then rapid shrinkage of the ice sheet. Six or seven Heinrich layers over the most recent 100,000-year glacial cycle, most of which have strong connections with Hudson Bay[5–8], may then record the repeated build-up and collapse of the great ice sheet there.

This is one point of view. However, the idea that changes at high latitudes can affect widespread regions extending across the Equator is unpopular with many workers who do not believe that the small, energy-starved polar 'tail' can wag the large, energy-rich tropical 'dog'. In this regard, Bond and Lotti[12] found that ice-rafted debris from diverse sources around the North Atlantic increased in sediment cores during each Dansgaard–Oeschger cooling, not just during the Heinrich events. They argued that a near-synchronous response of many ice masses is inconsistent with any stochastic model in which ice-sheet dynamics force climate change. Rather, they suggested that all of these ice masses were responding to some external signal, possibly from beyond the North Atlantic region, and that the Heinrich events are special only because something in the Laurentide Ice Sheet occasionally magnified the response.

McCabe and Clark[3] now present data which suggest that the ice-rafted-debris signal of the youngest Heinrich event, called H1 and occurring about 17,000 years ago, is more consistent with a complex and varied response to a surge of the Laurentide Ice Sheet than with a common response of ice masses to an external forcing. With considerable (though not unequivocal) confidence, they show that the small British Ice Sheet advanced shortly after, and probably in response to, the cooling associated with Heinrich event H1. Cooling causes most small ice masses to advance because of reduced surface melt, often within years or decades[13], so any cooling would be expected to increase the supply of ice-rafted debris to the North Atlantic from various sources. Further, an increase in ice-rafted debris may result from a glacial retreat if an iceberg-calving margin suddenly collapses. Collapse could have occurred in response to a rise in sea level caused by a Laurentide surge, as McCabe and Clark argue happened with the ice sheets of the Barents Sea and Fennoscandia. (These results may not exclude a more complex model, in which a Dansgaard–Oeschger-type cooling triggered a Heinrich event which triggered other responses[1,14].)

Correlations between Antarctic and Greenland ice cores, produced by Sowers and Bender[15], show that warming of the Southern Hemisphere beyond the band of ice-age variability occurred while near-glacial cold conditions still prevailed in the north. This would be a major upset for the polar-forcing view of ice-age cycles, in which changes at high northern latitudes including the North Atlantic are transmitted to the south through the ocean and atmosphere[16]. But Sowers and Bender equally show that the first northern warming from the coldest conditions of the ice age led the first warming in the south. As McCabe and Clark emphasize, the anomalies then are the interruptions of northern warming, especially by Heinrich event H1 and again by the cold Younger Dryas interval of about 12,000 years ago (which has many characteristics of a Heinrich event and can be classed with them[6]), both plausibly linked to North Atlantic processes.

So, by building from an interesting new data set, McCabe and Clark refocus two of the important debates about deglaciation — the meaning of ice-rafted-debris deposits, and the interpretation of the north–south phasing of deglaciation. The tremendous rate of discovery on this topic almost guarantees that more exciting results will emerge soon, but McCabe and Clark have demonstrated that ice-sheet forcing of widespread climate change remains at least a viable model, and perhaps the preferred one. □

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Daedalus

Crookes flies high

The atmospheric mesophere, between about 50 km and 100 km altitude, is too high for aircraft or balloons but too low for satellites. It borders the ionized layers which reflect radio waves, and generate aurorae. Daedalus now wants to explore it.

He has been inspired by the Crookes radiometer, that little windmill in a glass flask which spins in sunlight. Each vane is bright on one side but black on the other. The sunlight warms the blackened side of each vane, so that gas molecules hitting it rebound with extra momentum. This thermal transpiration exerts thrust on the vane. The effect peaks at around 5 pascals or so, just about the atmospheric pressure at 70 km altitude. So Daedalus is designing a big Crookes radiometer in the form of a helicopter rotor. Each angled aerofoil blade will be black on its upper surface, but reflective underneath. The blades will be angled so that sunlight shining down on them will drive them in that rotational sense that generates lift.

This huge frail craft, designed for tenuous high-altitude air, will have to be self-stabilizing. To keep its rotor horizontal, it will have a payload slung axially beneath its central hub. It will have enough lift to stabilize above its height of maximum efficiency. If it descends a little, it will then gain power and climb back up again. Oblique sunlight will not merely power it, but will urge it sideways, away from the Sun.

Thus, in the Northern Hemisphere, it will be pushed west and north during the morning, and east and north during the afternoon. At sunset it will lose lift; during the night it will spin lazily downwards like a sycamore seed. With luck it will still be within its operating altitude when the Sun rises next day; it will climb again, and start another leg of its zig-zag progress north. In summer, its odyssey will ultimately bring it into permanent polar sunlight, where it will orbit the pole steadily. When the changing seasons replace this cheerful buoyant radiance by winter darkness, it will fall to Earth and be lost.

Daedalus's altoradiometer will be a cheap, simple, long-lived research tool for polar aerospace. A balloon could just about lift it high enough for it to climb the rest of the way under its own power. Its solar-powered instrument package would then sample and transmit radiation fluxes, ion densities and magnetic data, for months on end. Astronomers could even observe stellar occultations through its fast-spinning blades.

David Jones