Scientists Ask Why World Climate Is Changing; Major Cooling May Be Ahead

By WALTER SULLIVAN

The world's climate is changing. Of that scientists are firmly convinced. But in what direction and why are subjects of deepening debate.

There are specialists who say that a new ice age is on the way—the inevitable consequence of a natural cyclic process, or as a result of man-made pollution of the atmosphere. And there are those who say that such pollution may actually head off an ice age.

Sooner or later a major cooling of the climate is widely considered inevitable. Hints that it may already have begun are evident. The drop in mean temperatures since 1950 in the Northern Hemisphere has been sufficient, for example, to shorten Britain's growing season for crops by two weeks.

As noted in a recent report of the National Academy of Sciences, "The global patterns of food production and population that have evolved are implicitly dependent on the climate of the present century."

Vulnerability to climate change, it says, is "all the more serious when we recognize that our present climate is in fact highly abnormal, and that we may already be producing climatic changes as a result of our own activities."

The first half of this century has apparently been the warmest period since the "hot spell" between 5,000 and 7,000 years ago immediately following the last ice age. That the climate, at least in the Northern Hemisphere, has been getting cooler since about 1950, is well established—if one ignores the last two winters.

It had been forecast by some specialists that last winter would be exceptionally cold, but as all ice skaters know, it was unusually mild in the New York area. In Boston it was the warmest in 22 years and in Moscow it was the second warmest in 230 years.

A major problem in seeking to assess the trend is to distinguish year-to-year fluctuations from those spread over decades, centuries and thousands of years.

Lack of agreement as to the factors that control climate change make it particularly difficult to assess current trends. Of major importance, therefore, is the debate as to the cause of such changes and the role of human activity in bringing them about. Among the major hypotheses are the following:

1. Solar Energy Variations

The amount of solar energy reaching the earth's surface at any one place and time of year varies because of changes in the earth's orbit and the tilt of its spin axis (The extent of that tilt determines the extent of seasonal changes).

There are also slight variations in the amount of energy radiated by the sun. They follow the 11-year sunspot cycle and relate chiefly to solar ultraviolet radiation.

Dr. Walter Orr Roberts, former head of the National Center for Atmospheric Research in Boulder, Colo., believes he has found a correlation between this cycle and weather phenomena such as jetstream behavior and droughts in the high plains east of the Rocky Mountains.

The droughts, he believes, tend to occur either in step with the 11-year cycle or with one of 20 to 22 years.

Such links are doubted by Dr. J. Murray Mitchell Jr., climatologist at the National Oceanic and Atmospheric Administration's Environmental Data Service. He sees no plausible explanation of how such slight variations in solar energy could affect the massive weather phenomena responsible for droughts and floods.

Tree-ring data from Nebraska and South Dakota, according to Dr. Mitchell, show that the pattern to which Dr. Roberts refers applies only to the last century, Whereas earlier—as far back as the 16th century—a major droughts occurred at irregular intervals generally longer than 20 years.

Triggering of the ice ages by cyclic changes of the earth's spin axis and orbit was proposed as early as the nineteen twenties by a Yugoslav, Milutin Milankovitch. Because of tugging by the gravity of other planets, the orbit of the earth changes shape. Sometimes it is virtually circular. At other periods the earth's distance from the sun varies during each year by several million miles.

At present, 6 per cent more solar radiation reaches the earth on Jan. 14 than it does six months earlier or later, tempering northern winters. This variation in the shape of the orbit occurs in a cycle of about 93,000 years.

The tilt of the spin axis with respect to the earth's orbit around the sun varies from 22.0 to 24.5 degrees over a period of some 41,000 years. The aim of the axis with respect to the stars also rotates once every 26,000 years, causing precession of the equinoxes.

For many years the combined effects of these variations seemed too subtle to account for the ice ages, but recent discoveries have won converts for modernized versions of the Milankovitch thesis.

From the chemical composition of Pacific sediments, from studies of soil types in Central Europe and from fossil plankton that lived in the Caribbean it has been shown that in the last million years there have been considerably more ice ages than previously supposed.

According to the classic timetable, four great ice ages occurred. However, the new records of global climate show seven extraordinarily abrupt changes in the last million years. As noted in the academy report, they represent transition, in a few centuries, "from full glacial to full interglacial conditions."

Many scientists now consider it established that expansions of glaciers in the Southern Hemisphere coincided with the northern ice ages. Land areas, however, are meager in southern latitudes comparable to those that were heavily glaciated in the north.

Dr. George J. Kukla of Columbia University's Lamont-Doherty Geological Observatory has proposed a way in which small variations in solar energy falling on the middle latitudes—as in the Milankovitch concept—could affect the climate.

It is the extent to which northern seas and land areas become covered with snow and ice in the fall. When such cover is extensive, as in the fall of 1971, the white surface reflects sunlight back into space and there is a reduction in heating of the atmosphere.

This prolongs the northern winter and cools the globe. In 1971, according to images from earth satellites, autumn snow and ice cover increased by 1.5 million square miles.

The following year was one of freak weather throughout much of the world. The winter was exceptionally cold in North America, the Mediterranean and other areas. Severe drought struck many parts of Asia and Europe.

The implication was that a change in solar input that was slight, but sufficient to increase autumn snow and ice cover substantially, could eventually lead to a major climate change.

From a reworking of the Milankovitch calculations Dr. Kukla has found that solar energy falling on the atmosphere in the autumn hit a minimum 17,000 years ago, at the height of the last ice age. It reached a maximum some 6,000 years ago, when the world became warmest since the last ice age.

While the theory is, as yet, far from being a full explanation for climate changes it suggests, he said, that a trend toward cooling will continue for the next 4,000 years even though, since 1973, autumn snow cover has diminished somewhat.

2. Pendulum Swings

Some scientists believe that the ice ages are a product of cyclic phenomena affecting the flow of heat from the tropics to the polar regions through the sea and air.

Most of the solar energy that enters the oceans and drives the winds is received in the tropics and carried poleward. The polar regions radiate more energy into space than they receive from the sun, but ocean currents and winds bring in enough heat—or almost enough—to make up the deficit.

Until a few years ago some

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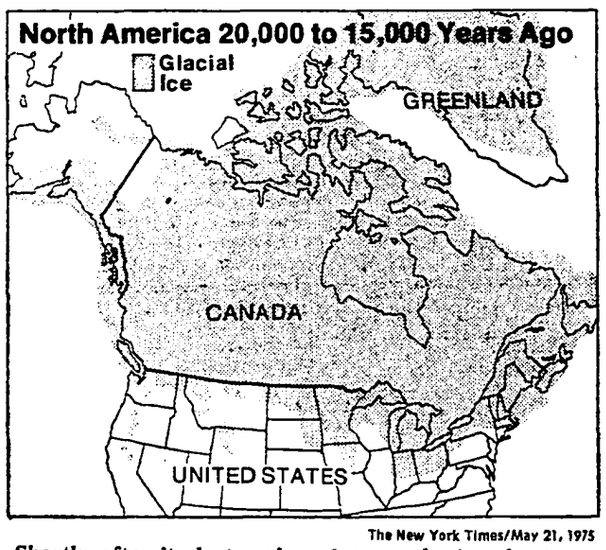
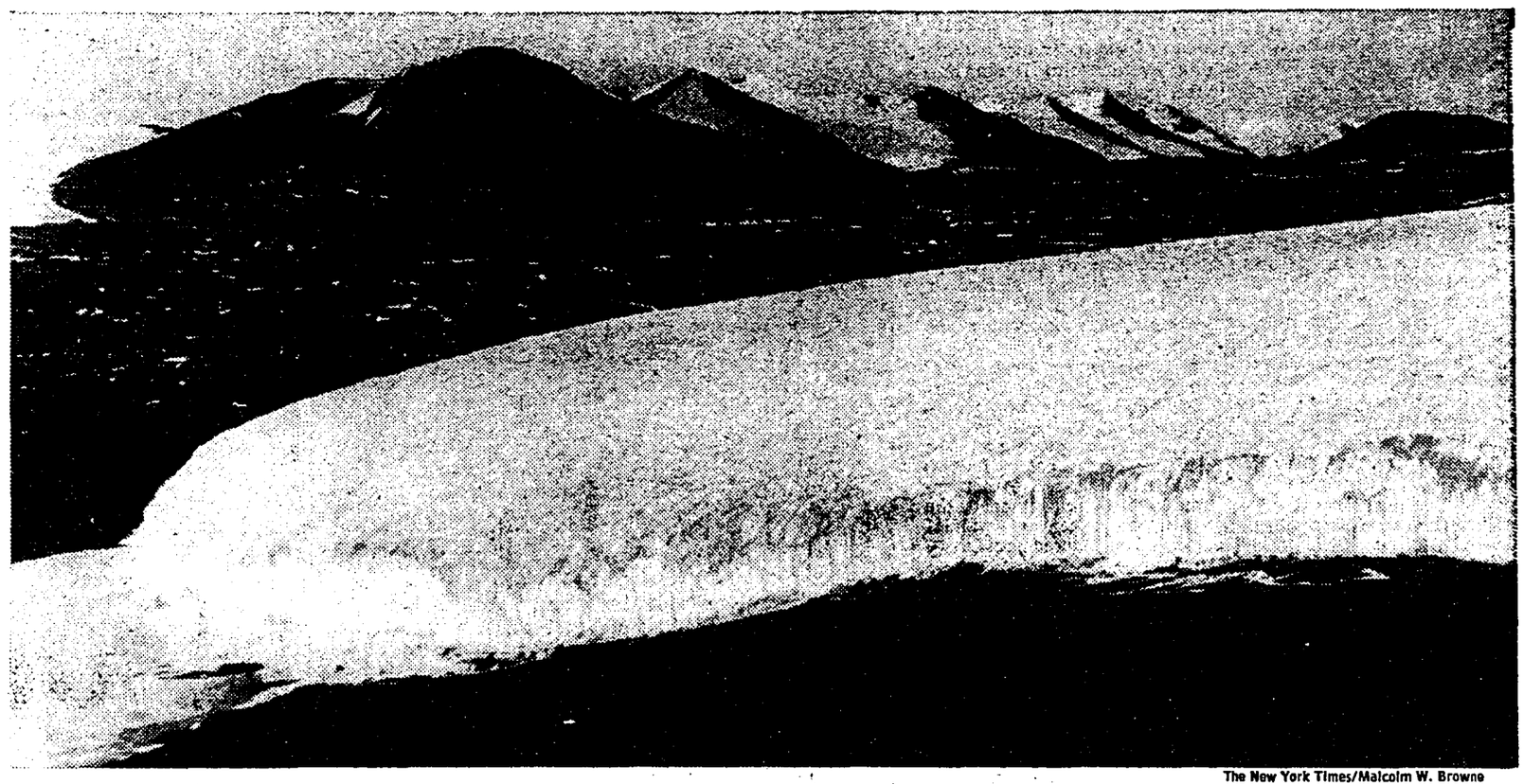


The New York Times/May 21, 1975

Shortly after its last major advance, the ice sheet covered almost all of Canada and much of the northern United States. Some scientists now believe, on the basis of recent findings, that ice resting on the sea floor extended far off the shore. The map is adapted from "The Earth and Its History" by R.F. Flint.



The New York Times/Malcolm W. Browne

Tongue of Antarctic ice sheet that invades valleys west of McMurdo Sound. If scientists wish to see how last ice age looked, they visit the continent.

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persons suspected that the presence or absence of pack ice covering the Arctic Ocean might play a key role in this delicately balanced process. An absence of pack ice, when ocean currents were carrying considerable heat into that ocean, would allow evaporation and the resulting moist winds would shed the snows of an ice age. Periodic freezing of the ocean would end the glaciation.

Recently, however, sediment samples extracted from the floor of the Arctic Ocean have shown that it was apparently never free of ice between the ice ages, even though before they began that ocean does appear to have been open.

In fact, according to Dr. F. Kenneth Hare, professor of geography at the University of Toronto, fossils from the Arctic islands of Canada, the Soviet Union and from Greenland all indicate an ice-free ocean with "luxuriant" forests along its shores.

Another proposal regarding built-in pendulum swings of climate is that of Dr. Reginald E. Newell, professor of meteorology at the Massachusetts Institute of Technology. He believes ice ages are initiated when energy losses at high latitudes exceed energy gains in the tropics—a state that may exist at present.

An ice age ends, in this concept, when enough of the ocean becomes ice covered to curtail the escape of heat being carried poleward by ocean currents. At the present stage of such a cycle, he said in a recent article, surface water in polar seas would be growing cooler, "in the slow process that will lead to the next ice age."

In a recent issue of the British journal Nature, Drs. Reid A. Bryson and E. W. Wahl of the Center for Climate Research at the University of Wisconsin cite records from nine North Atlantic weather ships indicating that from 1951 to the 1968-1972 period surface water temperatures dropped steadily.

The fall was comparable, they reported, to a return to the "Little Ice Age" that existed from 1430 to 1850. It was early in this period that pack ice apparently isolated the Norse colony in Greenland and led to its extinction. The temperature drop in the North Atlantic carried it one sixth of the way to the level of a full-fledged ice age, according to Drs. Bryson and Wahl.

Unfortunately, they said, several of these weather stations are being discontinued so that monitoring future trends will be difficult. Dr. Bryson attributes recent droughts in Africa and elsewhere to a southward displacement of the rain-bearing monsoons.

A similar change occurred in about 1600 B.C., he believes. The monsoon rains no longer reached northwest India. Fresh water lakes that had been there for 7,000 years dried into salt beds and the Indus Empire that had spread over the region for 1,500 years was destroyed.

3. Man-Made Influence

There is general agreement that introducing large amounts of smoke particles or carbon dioxide into the atmosphere can alter climate. The same would be true of generating industrial heat comparable to a substantial fraction of solar energy falling on the earth. The debate centers on the precise roles of these effects and the levels of pollution that would cause serious changes.

Carbon dioxide in the air acts like glass in a greenhouse. It permits solar energy to reach the earth as visible light, but it impedes the escape of that energy into space in the form of heat radiation (at infrared wave lengths).

Dr. Mitchell has pointed out that a variety of factors determine the role of carbon dioxide on earth. For example, the extent to which that gas, introduced into the atmosphere by smokestacks and exhaust pipes, is absorbed by the oceans depends on the temperature of surface waters.

This, in turn, is affected by climate, leading to so-called feedback effects. Plants consume carbon dioxide at rates that depend on temperature and the abundance of that gas in the air, complicating predictions of their role.

The observatory atop Mauna Loa, the great Hawaiian volcano, has recorded a steady rise in the annual mean level of carbon dioxide in the atmosphere, amounting to 4 per cent between 1958 and 1972. That, however, was a period of global cooling—not the reverse, as one would expect from a greenhouse effect.

The Mauna Loa observatory has also recorded a steady rise in atmospheric turbidity—the extent to which particles overhead dim the brightness of the sun. The academy study finds that human activity over the last 120 years has contributed more to this atmospheric dust than have volcanic eruptions.

However, it says, the present atmospheric load of man-made dust is perhaps only one fifth what was thrown into the stratosphere by the volcanic explosion of Krakatoa in 1883. The role of of atmospheric dust is complex, for it cuts off sunlight from the earth, but is itself heated by that light, warming levels of atmosphere in which it resides.

Until recently the idea that ice ages are initiated by intense volcanic activity was unpopular for lack of evidence for such activity. The hypothesis has gained more credence from the analysis of sediment cores extracted from the ocean floors by the drill ship Glomar Challenger.

According to University of Rhode Island scientists, ash was far more common in layers laid down in the last two million years than in the previous 18 million years.

If worldwide energy consumption continues to increase at its present rates, catastrophic climate changes have been projected by M. I. Budyko, a leading Soviet specialist. He says that the critical level will probably be reached within a century.

This, he has written, will lead to "a complete destruction of polar ice covers." Not only would sea levels rise but, with the Arctic Ocean free of ice, the entire weather system of the Northern Hemisphere would be altered.

However, Dr. Mitchell has suggested, warming of the climate due to pollution might be enough to head off an ice age "quite inadvertently."

CAN THE TRUTH BE LEARNED?

More precise knowledge of the past is certain to aid in choosing between various explanations for long-term climate changes. The Greenland Ice Sheet Program, with American, Danish and Swiss participants, is drilling a series of holes into the crest of the Greenland ice in the hope, ultimately, of reconstructing a year-by-year record of climate for the last 100,000 years.

So far the ice has been penetrated 1,325 feet, extending the record back 1,420 years. The yearly layers can be counted, like tree rings, in terms of summer and winter variation in the relative abundance of two forms of oxygen (oxygen 16 and oxygen 18). Their ratio indicates temperature at the time when the snow fell to form that layer of the ice sheet.

The isotopes also reflect the long-term climate changes. A remarkable finding, reported in the May 1 issue of Nature, is that the trends in Greenland for the period 850 to 1700 A.D., closely match the British record for 1100 to 1950. California tree rings show a climate record similar to the one in Britain.

The implication is a lag of 250 years between climate variations in Greenland and those in regions east and west of the Atlantic.

If, in fact, the climatic cycles of Greenland precede those of Europe and North America by 250 years, a powerful means of prediction would be available. However, as noted in the Nature article, it is by no means certain that the effect is persistent.

The Academy of Sciences report notes that any assessment of climate trends is crippled by a lack of knowledge: "Not only are the basic scientific questions largely unanswered, but in many cases we do not yet know enough to pose the key questions."

The oceans clearly play an important—and little understood—role. Not only are they the chief source of water in the atmosphere but they harbor a vast reservoir of thermal energy. "When the dynamics of the ocean-atmosphere interaction are better known, according to the report, "we may find that the ocean plays a more important role than the atmosphere in climate changes."

The report, including a wide range of proposals for national and international programs of research, was prepared by the academy's Committee for the Global Atmospheric Research Program, headed by Dr. Verner E. Suomi of the University of Wisconsin.

In his preface Dr. Suomi notes that, by the end of this decade, space vehicles will be able, on a global scale to observe the sun's output, energy reflected from the earth, distributions of clouds, snow and ice, as well as ocean temperatures. With these and other inputs a better understanding of how and why the climate is changing should become possible.