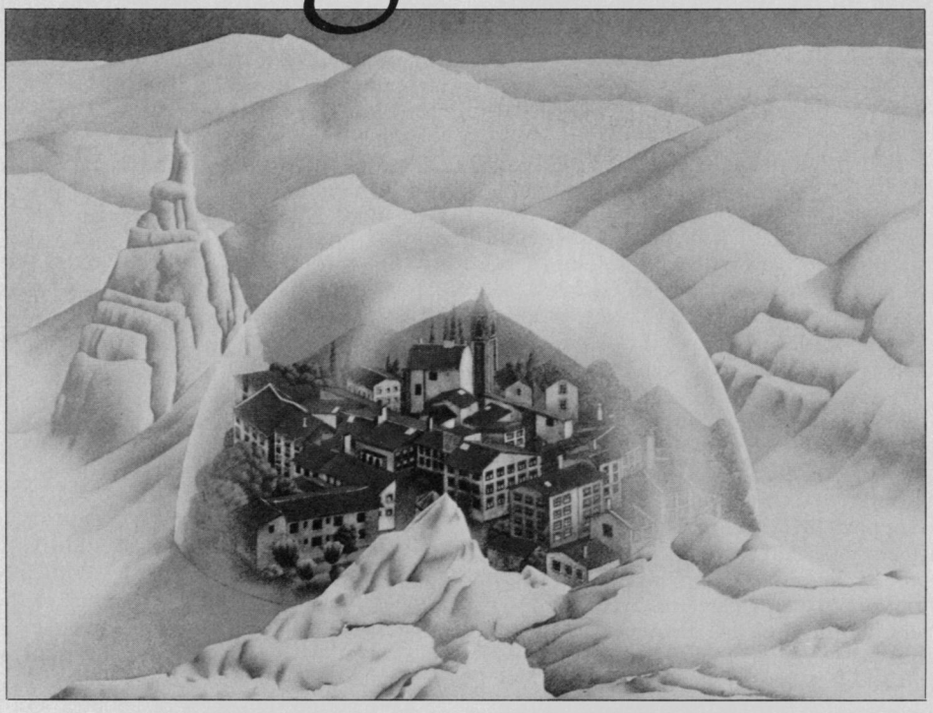
Climate Change: Chilling Possibilities



Melinda Berdelon/Courtesy Champion International Corporation

The unusually beneficial climate of the past few decades may be degenerating, facing humanity with a new challenge to survival

by John H. Douglas

The winter of 1780-81 was a particularly bitter one for the American Revolutionary forces. Washington's troops hunkered down, ill-clothed and ill-fed, around their campfires at Morristown, N.J., while a few miles away British troops enjoyed the relative luxury of an occupied New York City. But even the British had their problems, for the winter was so cold that parts of New York harbor froze for weeks at a time, blocking movement of their powerful fleet. The ice even got thick enough to allow hauling cannons from Manhattan to Staten Island.

The colonists had struggled against devastating winters ever since establishment of the earliest settlements, when one of the few holidays celebrated by the stern Puritans was that of Thanksgiving—for a harvest bountiful enough to ensure survival until spring. Though they didn't realize it, these hardy pioneers were trying to conquer a New World in the midst of some of the worst weather in over 2,000 years, a cold spell that had begun in the early 15th century and was to continue until around 1850, known to later climatologists as the "Little Ice Age."

By constrast, the weather in the first part of this century has been the warmest and best for world agriculture in over a millenium, and, partly as a result, the world's population has more than doubled. Since 1940, however, the temperature of the Northern Hemisphere has been steadily falling: Having risen about 1.1 degrees C. between 1885 and 1940, according to one estimation, the temperature has already fallen back some 0.6 degrees, and shows no signs of reversal. Specific areas, of course, may experience changes markedly different from the average. During the warming period, temperatures in parts of Norway rose five times more than the hemisphere average, and since the cooling trend began again, Iceland's temperature has dropped nearly 2.0 degrees, threatening continued existence of some crops. What will happen to the added billions of people if climatic conditions return to those prior to the turn of the century?

This question has led many scientists to call for new emphasis on the study of climate and for planning ahead to meet any eventuality. Typical of these expressions of concern is the recent National Academy of Sciences report on global climate change (SN: 1/25/75, p. 52), with its pleas for immediate action. In tones of restrained apprehension, the academy report urgently tries to dispel the indifference with which climate is usually viewed, and counters Mark Twain's observation that "everybody talks about the weather, but nobody does anything about it" with a detailed plan to study and perhaps someday to change the climate.

Climatology, however, is still an infant science, and its practitioners have faced their sudden popularity with the blinking uncertainty of squirrels roused from hibernation: Some have dashed forward with instant pronouncements

of impending doom, while others have shyly retired behind the complexities of their arcane studies, refusing even to speculate about what changes may lie ahead or what action could be taken to confront them. To gain a perspective on these divergent views, SCIENCE NEWS interviewed C. C. Wallen, chief of the Special Environmental Applications Division, World Meteorological Organization, at the WMO headquarters in Geneva.

The cooling trend observed since 1940 is real enough, he says, but not enough is known about the underlying causes to justify any sort of extrapolation. Particularly dangerous would be any attempt to generalize from even shorter-term experience, like the bad weather in 1972 and following years, to prognosticate any future weather patterns. On the other hand, the cooling since 1940 has been large enough and consistent enough that it will not soon be reversed, and we are unlikely to quickly regain the "very extraordinary period of warmth" that preceded it. Even this mild diagnosis can have "fantastic implications" for present-day humanity, Wallen says.

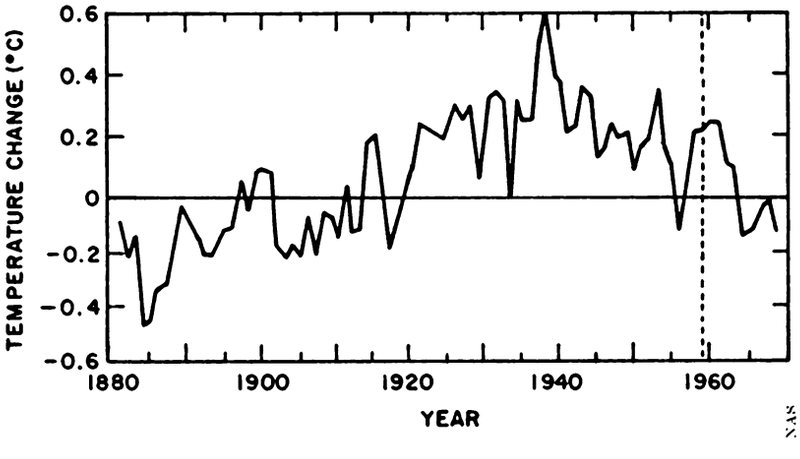
The principal weather change likely to accompany the cooling trend is increased variability—alternating extremes of temperature and precipitation in any given area—which would almost certainly lower average crop yields. The cause of this increased variability can best be seen by examining upper atmosphere wind patterns that accompany cooler climate. During warm periods a "zonal circulation" predominates, in which the prevailing westerly winds of the temperate zones are swept over long distances by a few powerful high and low pressure centers. The result is a more evenly distributed pattern of weather, varying relatively little from month to month or season to season. During cooler climatic periods, however, the high-altitude winds are broken up into irregular cells by weaker and more plentiful pressure centers, causing formation of a "meridional circulation" pattern. These small, weak cells may stagnate over vast areas for many months, bringing unseasonably cold weather on one side and unseasonably warm weather on the other. Droughts and floods become more frequent and may alternate season to season, as they did last year in India. Thus, while the hemisphere as a whole is cooler, individual areas may alternately break temperature and precipitation records at both extremes.

If global temperatures should fall even further, the effects could be considerably more drastic. According to the academy report on climate, we may be approaching the end of a major interglacial cycle, with the approach of a full-blown 10,000-year ice age, a real possibility. Again, this transition would involve only a small change of global temperature—2 or 3 degrees—but the impact on civilization would be catastrophic. Scientists once thought the onset of an ice age would be very gradual, with glaciers slowly pushing down from the North, but recent studies of cored material taken from the sea bottom and remaining glaciers indicate the transition can be rather sudden—a matter of centuries—with ice packs building up relatively quickly from local snowfall that ceases to melt from winter to winter. Major changes in vegetation can occur even more quickly, with a forest becoming a prairie in less than a century and a savannah turning into a desert in a few decades. The first step toward being able to predict these changes or planning how to cope with them is to find the underlying causes.

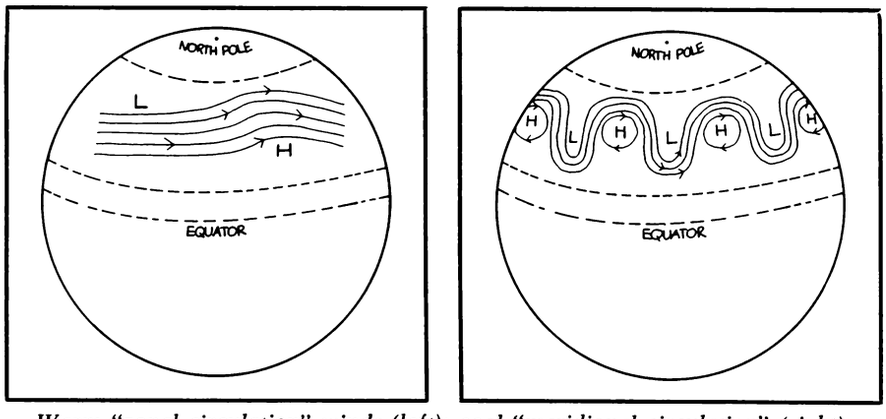
The atmosphere is essentially a heat pump, transferring warmth and humidity from the tropics to the temperate zones. As air is warmed over tropical oceans, it rises and expands toward the poles. Where it cools and descends, high pressure systems form, whose winds begin to circulate clockwise (in the Northern Hemisphere) because of angular momentum gained from the earth's spin. (To get an intuitive feeling for the process involved, stand on a merry-go-round moving counter-clockwise—like the earth seen from the North Pole—and try to swing a simple ball-and-string pendulum back and forth. You can't; it inevitably begins to take on a circular, clockwise motion like the air in a high pressure center.) As these centers interact, the great movements of wind and weather result.

The factors that can alter this basic pattern are perhaps the most complex and interrelated of any natural phenomenon scientists have ever tried to study: The chemical composition of the air controls how much sunlight is absorbed—with carbon dioxide increasing absorption and small particles either increasing or decreasing absorption depending on their composition and the underlying terrain. Oceans represent vast heat reservoirs, whose currents can deliver heat absorbed on one side to areas on distant continents, years later. The distribution of clouds and their interaction with aerosols can drastically affect the amount of light reaching the ground; growth of polar ice caps changes the proportion of light reflected back into space, and periods of extensive volcanic eruptions appear to have some yet unexplained relationship to ice ages (SN: 2/15/75, p. 100). Such remote disturbances as sunspots, wandering of the earth's poles, continental drift and changes of the earth's position relative to the sun and other planets may also have some effect on climate. Finally, to complicate matters even further, virtually limitless interactions are possible. For example, creation of dust in the Sahel resulting from decreased vegetation caused by the recent drought has increased the downwind particulate content of far-off Barbados by 300 percent—giving its previously clear air a city-like haze.

The activities of mankind are also becoming increasingly important. According to the academy report, atmospheric carbon dioxide has been rising by four percent a year since 1910, because of industrialization. Stephen H. Schneider of the National Center for Atmospheric Research says that by the turn of the century, enough carbon dioxide will have been put into the atmosphere to raise the temperature of earth half a degree. Particulate pollution is also increasing because of human activities, but the effects are much harder to predict. Under the right circumstances, such pollutants can either increase or decrease precipitation or temperature of a region. While many forms of pollution can be controlled, one kind cannot be—heat pollution. The Second Law of Thermodynamics decrees that no activity can take place without the expenditure of heat, and within a century or so the projected heat generation from human activity is likely to equal one percent of the heat earth absorbs from the sun. Under the simplest set of assumptions, this addi-



Annual mean temperature of the Northern Hemisphere.



Warm "zonal circulation" winds (left); cool "meridional circulation" (right).

tional heat would raise the global temperature about a degree Celsius, but after various corresponding changes are taken into account, the overall effect might be a temperature rise as great as 3.0 degrees.

Already man-made climate changes are clearly evident around cities. Buildings and pavement tend to store more heat than vegetation in the surrounding countryside, hence temperatures can range some 4.0 degrees higher in the summer and 2.0 degrees higher in the winter. Such "heat islands" change wind patterns including creation of vertical plumes of hot air rising some 3,000 feet over some cities. As a result, a survey of nine American cities showed increased rainfall in the vicinity ranging from 9.0 to 27.0 percent. The severity of these storms is also affected: Near Houston, Tex., hailstorms were found to increase by 430 percent. The most detailed of these studies is under way in the St. Louis area, where an urban-related 25 percent increase of thunderstorms was found to affect some 1,000 to 2,000 square miles of the surrounding area. The cumulative effect of such changes from all cities is not known, but the possible interactions increase the likelihood of severe consequences as urbanization continues.

At first glance it might appear that most human activities would tend to heat up the climate at the same time natural forces seem to be cooling it down. This has led to some speculation that the two competing trends might cancel each other out. The biggest problem with this assumption is that at present climatologists have no way of finding out; indeed, they cannot even agree whether man-made carbon dioxide or man-made particulate pollution will ultimately become more important, or whether the overall effect will be heating or cooling. Also, human activities tend to be irregularly dispersed about the globe, so for the moment they seem to serve no other function than making the whole problem more complex. The most controversial aspect of the question is whether we should try *purposely* to change the climate.

On a very small scale, scientists have been experimenting with changing local weather conditions since 1946, when Vincent Schaefer and Nobel laureate Irving Langmuir discovered that "seeding" a cloud with dry ice would, under proper conditions, cause droplets to form. There have been four to six documented, conclusively successful controlled experiments resulting in augmented snowfall or rainfall, and the National Center for Atmospheric Research is testing a cloud seeding program it hopes will reduce the more than half-billion dollars of crop damage caused each year by hail. Russian scientists have claimed an 80 to 90 percent effective hail suppression program and, while American meteorologists are skeptical of these figures, the director of the U.S. project, David Atlas, says even a 10 percent effect program would be economically desirable.

Large-scale climate modification is a different story. While climate could indeed be changed intentionally in a variety of ways, most of the changes proposed would probably involve disastrous side effects. If, for example, someone really wanted to melt the polar ice cap, spreading a layer of black, heat-absorbing soot over the North Pole should do the trick very neatly in about three years, Schneider estimates. A more likely means of achieving the same end involves a Russian project, already begun, to dam certain rivers emptying into the Arctic Ocean, in order to irrigate Siberian farmlands. A possible result would be to raise the salinity of the Arctic Ocean and melt the ice cap. In turn, the sea level around the world would rise and any number of unpredictable weather changes could result. Concludes Schneider: "There are more schemes for controlling climate now than for controlling the climate controllers."

Clearly more research is needed, especially before some ambitious engineering project sets off an irreversible climatic change. The National Academy of Sciences has proposed increasing the annual budget for climate research from the present $18 million to around $67 million, over the next five years, with particular emphasis on studying climatological records and developing computerized models to allow prediction of what effects human activities may have on climate. At the same time more attention must be given to alternative means of growing and distributing crops, since a shorter growing season in the northern temperate latitudes makes development of tropical agriculture all the more urgent. Finally, the possibility of changing climate and the certainty of variable weather lends new impetus to long-overdue political decisions on food security: In any given three-year period, according to the National Oceanic and Atmospheric Administration, the probability of a drought seriously disrupting the American Midwest wheat crop is 29 percent; as international food stocks fall and the Third World becomes more and more dependent on that crop of wheat, the potential for tragedy increases apace.

What if we *are* entering a period of degenerating weather—even a new ice age? How much would it really affect daily life? A look at the historical record is not encouraging. On the one hand, the great civilizations of Rome, Egypt and China developed during relatively warm, agriculturally beneficial climatic epochs; on the other hand, drought and famine drove the original Greeks to settle in the Hellenic Peninsula and later to band together in the great city-states that marked the height of their civilization. John Wilkinson of the Center for the Study of Democratic Institutions believes the Renaissance and Industrial Revolution may also have resulted in part as a response to the challenge of the Little Ice Age. But civilizations that were overpopulated or could not migrate or adapt were not so lucky. Failure of monsoons like those seen in the last couple of years destroyed the great Indus Empire of northwestern India in 1600 B.C. Conditions like those in the Sahel today have destroyed several past civilizations there, including the once powerful and overpopulated Mali Empire with its famed capital of Timbuktu. Some 300 million to 400 million people now live in areas undergoing monsoon retreat, according to outspoken climatologist Reid A. Bryson, and the options for such people to migrate or adapt, of course, are minimal.

Even for the most highly industrialized countries a significant change in the climate could strain all available resources, possibly leading to wars of conquest on the one hand, or extremely expensive adaptation, such as climate domes, on the other. Present-day New Yorkers would hardly consider it an advantage to be able to drive across the harbor to Staten Island. □