Climatic Change

In spite of man's remarkable advances in technology, ultimately he is still dependent on the Earth's climatic system for food and fresh water. The recent occurrences in certain regions of the world of climatic extremes such as excessive rain or droughts and unseasonably high or low temperatures have led to speculation that a major climatic change is occurring on a global scale. Some point to the recent drop in temperatures in the northern hemisphere as an indication that the Earth is entering a new ice age. Others see a global warming trend that may be due to a build-up of carbon dioxide in the atmosphere. An authoritative report on the subject has been prepared by a World Meteorological Organization Panel of Experts on Climatic Change. Excerpts from the report are given below.

For about the past 8 000 years, the Earth has been in a comparatively warm interglacial phase of an ice-age sequence, with less ice (most of it in the Greenland and Antarctic ice sheets) than at any time in the past 100 000 years. Mid-latitude temperatures are today 5 to 8°C warmer, and sea levels 80 to 100 meters higher than those typical of extreme glacial stages.

Since the recovery of the Earth from the last glacial stage, about 8 000 to 10 000 years ago, the global climate has been found from a variety of paleoclimatic indicators to have fluctuated within much narrower limits. In part the post-glacial climate changes have involved expansions and retreats of polar ice and mountain glaciations, at intervals of approximately 2 000 to 3 000 years, in what is described as a "neo-glacial cycle". The "Little Ice Age", a period of temperatures 1 or 2°C lower than today and stormy conditions in the North Atlantic, lasting from about 1550 to 1850 A.D., was a part of the neo-glacial cycle.

Since the time of the Little Ice Age, the world has generally warmed about 1°C, but the rate of warming has been irregular and it is not certain whether the Little Ice Age has yet run its full course. This warming was especially pronounced during the first half of the 20th century, with temperatures rising most rapidly (several degrees C in 50 years) in the Atlantic sector of the Arctic. Events in the southern hemisphere are less clearly documented.

The climatic trends characteristic of the first half of the 20th century appear, generally speaking, to have reversed direction since then, at least in the northern hemisphere. Temperatures have fallen especially in the Arctic and the Atlantic Sub-Arctic (by several degrees C in some areas) where the extent of sea ice has again been increasing. The atmospheric circulation of the northern hemisphere appears to have reverted to a pattern resembling that of the last part of the 19th century, with a tendency towards greater variability of weather conditions in many areas. These changes may have begun to falter, if not actually to reverse yet again, in the last few years.

Recent years have also witnessed severe drought, as in the Sahelian zone of Africa, shifts of the monsoon belt of the tropics, and other extreme events elsewhere in the world. To what extent such developments are related to one another, as manifestations of a globally coherent and systematic fluctuation of climate, is not clear.

Severe drought in Upper Volta, a country in the Sahelian Zone on the southern edge of the Sahara desert. A nomad picks leaves to eat from one of the few green trees left at the waterhole. Photo: UN/FAO.

One illustration of the kind of interaction that probably contributes significant variability to the climatic system is that between snow cover, reflection of solar radiation, and air temperature. If a small decrease of temperature occurs which favours the development of a snow cover, the greater reflection of solar radiation from the snow will locally reduce solar heating of the Earth's surface and atmosphere. The reduced heating will then lower air temperature still further, preserving the snow and perhaps favouring additional snowfall over a wider area. A similar, but opposite, chain of events is involved if the starting point is a small increase of temperature. The end effect is both to amplify small climatic disturbances, and to prolong them.

Effects of man's activities on climate

Many scientists have suggested that man's activities may be responsible in various ways for changes of climate occurring now or in the future. On a local scale, as in urban areas, human effects on climate are a demonstrable reality. The relative warmth of large cities, known as the "urban heat island effect", is a well documented example of such local effects. On larger geographical scales, human effects are generally thought to be small, at the present time, in relation to the magnitude of natural climatic variability. They are, nevertheless, to be recognized as of potentially great importance in altering the natural evolution of large-scale climate over the next century or two.

A build-up of carbon dioxide in the global atmosphere, already clearly evident in observations around the world and which thus far amounts to at least ten per cent since the last part of the 19th century, is reliably traceable to the combustion of fossil fuels. If most known reserves of such fuels are consumed in the next century or two, as it now seems they may be, atmospheric carbon dioxide concentrations would be likely to increase several fold above present levels. The best information now available indicates that such a large carbon dioxide increase would result in a very significant warming of global climate, by several degrees C and that, because of the slow pace of removal mechanisms, this warming would persist for many centuries after the fossil fuel reserves have been substantially depleted. Further climatic effects, as yet difficult to foresee in specific detail, would also be likely.

The heat released to the environment by the generation and use of energy, whether fossil or nuclear, may also produce a significant warming, although this would be unlikely to be a cause for concern unless or until the societal demand for energy increases by a factor of ten or more, which could take place within the next century.

Further effects of man, for example those attributable to increasing pollution of the atmosphere by particulate materials, and alterations of the upper atmosphere through the effects of contamination by nitrogen oxides or chlorine compounds (such as chloro-fluoromethanes), are as yet of relatively uncertain importance to future climate. These matters deserve further investigation.

Other than on a local scale, there is no unequivocal observational evidence that human influences of any kind have yet been the origin of unusual climatic behaviour anywhere in the world. This is not altogether surprising in view of the high natural variability of climate which makes detection of human impacts difficult. Nevertheless there is no justification on these grounds for complacency about the potentially serious effects that man's activities could have in the future.

Knowledge of past climates suggests that the interglacial warmth of the past 8 000 years or so will eventually change to a colder, more glacial regime. The onset of that change may be a number of millennia or centuries away; conceivably it may already have begun. It seems likely that this transition will be sufficiently gradual so that in the next 100 to 200 years it would be almost imperceptible amid the ubiquitous variability of climate. There is however a very small yet finite probability that a much more rapid cooling of climate will occur in the same time period.

It must be recognized that such assessments would be invalid if, as now considered probable, the addition of carbon dioxide to the atmosphere, and other effects of human activities during the next 200 years, contribute to a general warming of global climate. This would probably result in a considerable reduction of the floating sea-ice in the Arctic regions. It is pertinent to note that when the sea-ice retreated during the so-called climatic optimum, about 5 000 years ago, there were important shifts of climatic belts in lower latitudes. The general warming could conceivably culminate in the total disappearance of the Arctic sea-ice, an extreme situation believed to be without precedent in the past million years.

Present ecosystems and many of the complex, interdependent systems developed by modern man are fairly well adopted to the climatic conditions that prevailed in the past, and are therefore quite sensitive to changes in climate. For example, the present systems used for food and fibre production are predicated on average climatic conditions and even a modest

change in climate would have serious social and economic repercussions. A cooling of the Earth by as little as 1°C could result in a shorter growing season and a shift of the boundary of major wheat production regions, and decrease fish catch and timber production in middle and higher latitudes; in lower latitudes, however, such a change could be beneficial. Similarly, warmer global temperature could result in improved productions in some latitudes and reduced yield in others.

Future action

On the base of existing knowledge, *monitoring* of the natural and anthropogenic processes causing climatic variability is of vital importance, especially for the early assessment of possible risks. Such monitoring is now in preparation within the GEMS Programme. Among the parameters to be monitored, the following should be mentioned:

(a) Carbon dioxide;

(b) Nature and transmissivity of aerosol particles of volcanic origin in the stratosphere especially in polar regions;

(c) Amount of trace gases (e.g. nitrogen oxide, sulphur dioxide, chlorofluorocarbons) and low-tropospheric aerosols;

(d) Extent and albedo of snow and ice at the surface;

(e) Changes in surface albedo over both land and sea especially with respect to land use patterns, vegetation changes, pollution and biological productivity of the oceans.

Special stress must be given to the need to monitor possible small changes of the extraterrestrial solar radiation, mainly in the visible and near ultra-violet range.

Research is also needed for a better adaptation of man's activities to climatic variability and change. This is especially true regarding the need for increasing agricultural production and regarding the impact of energy use on local, regional and global climatic conditions.

The Executive Committee of the World Meteorological Organization has approved the following statements on climatic change and its study:

- Although in the long-term, a major *natural* change to a different climatic regime must be expected, it is unlikely that any trend towards such a change would be perceptible in the short-term, as it would be obscured by the large shorter-term climatic variability;
- The shorter-term natural or possible man-made changes in climate are of immediate concern, because of their important impact on human welfare and economic development;
- An improved ability is needed to predict short-term natural changes in climate to enable governments to consider appropriate action;
- Improved understanding of and improved ability to predict the impact of man's activities on the global climate is needed in view of their possible consequences;
- Existing knowledge of natural short-term climatic variability, although limited, should be used more effectively in planning economic and social development.