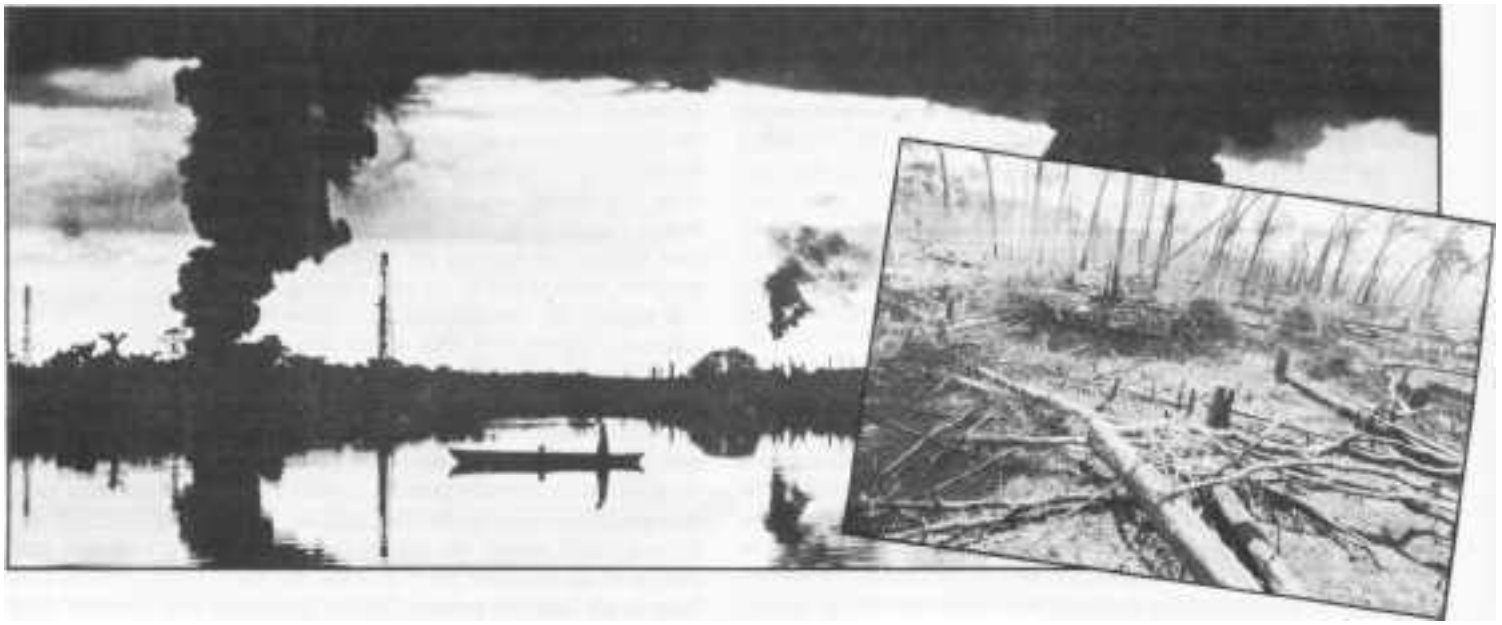
**The winter was bad: though it didn't signal the start of a new Ice Age. But is our climate going through a fundamental change?**

Mick Kelly and Jean Palutikof

# Facing up to the weather



Few can have been unaffected by the severe weather of the present winter, yet both the Government and the environmental lobby appear unconcerned about what many scientists consider one of the major environmental issues facing society today.

Underlying the mild hysteria with which the popular press greeted the bad weather this winter is a major environmental problem that must transcend the barriers that exist between the scientist and the layperson. The 'Arctic Hell syndrome', the tendency of the media to treat every cold snap as the forerunner of the next ice age, inevitably results in reluctance on the part of scientists to risk their reputation in the hands of Fleet Street. Many academics and scientists are, of course, notoriously reluctant to talk in intelligible terms to the public, preferring to use academic language to hide their fear of confronting social issues.The standard of treatment of scientific issues by the media provides the final validation of their ivory tower retreat.

Yet we may soon have to face the fact that we have, by polluting the atmosphere with carbon dioxide and cutting down forests, brought about a climatic change on a scale not seen for 10,000 years, a climatic change that could have catastrophic social consequences. This will occur on a timescale that is slow in terms of the lifetime of most governments. The measures that must be taken to avert the worst consequences will be seen as unpleasant by many, inexpedient by politicians. They will have to be taken without the obvious stimulus of heavy snowfall or drought, before an irreversible change has occurred. If scientists' warnings concerning the problem of future climatic change are not taken seriously, are relegated to the 'Arctic Hell' or 'Phew, it's another scorcher' level, we could in a couple of decades face a world radically different from today — in environment, climate, and possibly socio-economic structure.

A science fiction scenario? Or yet another funding pitch by scientists faced with spending cuts? Informed public debate of these issues is imperative. It is tragic that the environmental lobby in this country has yet to add the carbon dioxide issue to its agenda. It is in this area that society's lack of sensitivity to environment problems, particularly concerning the rational use of the Earth's limited resources, is most clear. And it is in this area that we may soon be taught a very unpleasant lesson. In this article, we discuss the weather of the present winter, the impact of such climatic extremes on society and place these events in the wider context of the carbon dioxide issue.

## The winter of 1981-2

The weather of December 1981 and January 1982 in the United Kingdom ranks amongst the coldest and snowiest this century. The winter has been particularly severe, though no more so than in the average Scandinavian winter. A period of severe weather such as this is known as a climatic extreme. They occur from time to time, and are a characteristic of our climate. Sometimes they occur apparently at random, sometimes as part of a slower change in climate. For example, during the late 1960s and early 1970s, the UK experienced a sequence of mild winters. This short term climatic fluctuation possibly led to complacency about our winter climate and, in a period of spending cuts, provided an easy rationale for reducing emergency provisions in case of severe weather. Local authorities estimate that their bill for the winter of 1981/82 will amount to close to £100 million — not all would have been saved if they had been better prepared but the cost would certainly not have been so great. The cost in terms of human suffering and death is less easy to estimate. Could the winter have been predicted?

We wish to thank Susan Boland, Brigid Cherry, Niger Huckster, Liz Kelly and Ruth Pearson for their assistance and acknowledge permission to reproduce material from *Climate Monitor*, the bulletin of the Climatic Research Unit, University of East Anglia.

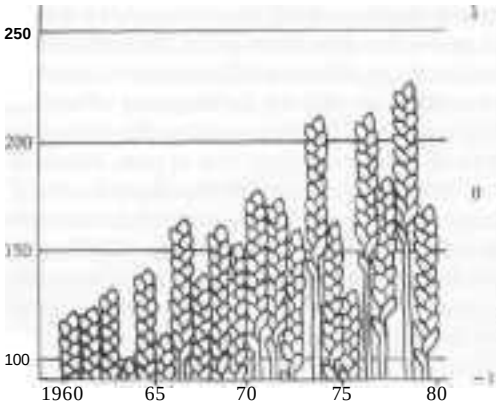



Fig **1. USSR Grain Production** (MMT)

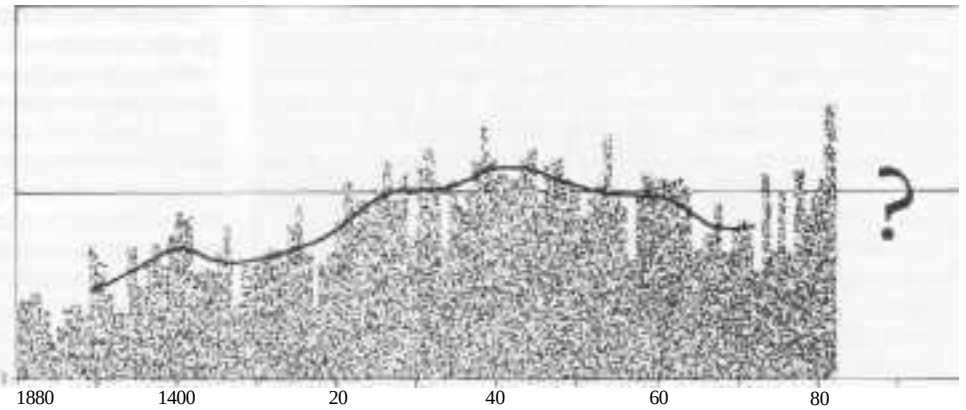



Fig **2. Northern Hemisphere Temperature Change** (degrees Celsius)

The immediate cause of the bad weather lay in a disruption of the wind patterns (the atmospheric circulation) that shape our climate. The UK is usually situated beneath the zone of westerly winds that meander round middle latitudes. These westerly winds steer depressions (areas of low pressure) and anticyclones (areas of high pressure) across the country, usually from the west but occasionally, when the meanders are large, from other directions. These westerly winds mark a transition zone between warm southern air masses and cold polar air, and it is the conflict between these air masses that give rise to the depressions and fronts which dominate our weather maps. Sometimes the meanders grow in size and lock into place and the westerly winds are diverted away from their usual track, giving rise to prolonged periods of abnormal weather in certain locations. When the westerly flow is diverted north of the UK, as occurred during the drought of 1975/76, we tend to be affected by southern air masses and the subtropical anticyclone resulting in hot, dry and settled weather. When the westerly flow is diverted south, we tend to be affected by cold northerly air masses, sometimes accompanied by changeable, adverse weather, at other times by cold, settled weather. The winter of 1981/82 falls into the latter category. A marked advance of cold polar air into middle latitudes over the North Atlantic sector resulted in the stimulation of the mid-latitude depressions which brought the snow, and the sub-zero temperatures which prevented the snow melting. The impact was worsened by the fact that when melting occurred it was rapid, resulting in widespread Hooding in many areas.

Why the atmospheric circulation occasionally locks into place giving rise to climatic extremes is not well understood. Some climatologists favour explanations rooted in the climate system (the oceans, atmosphere and ice masses of the Earth); others prefer external mechanisms, such as solar or volcanic activity; a few see these events as essentially random and unpredictable. Theories abound, but none is as yet sufficiently well-founded to be used in forecasting. This admission of ignorance reflects the current state of the science of climate change.

**Impact on society**

Events such as the winter of 1981-82 have an obvious impact on everyday life and no one would deny the effects of climatic extremes in the Third World. The tragic famines in the Sahel and elsewhere in Africa during the 1970s were a graphic example of how a society can be made more vulnerable to climate by socio-economic change. The impact of the current winter on a personal level can be clearly seen in the rise of mortality rates and sickness in the elderly, work lost in the construction industry and elsewhere, and increased financial pressure on the unemployed and low wage earners.

The weather can cause widespread disruption of virtually every facet of our economy, both in terms of costs and losses. A single snowstorm, lasting only a few hours, can incur costs for road-clearing and emergency and relief services. People fail to arrive at work, and the flow of materials to and from factories is brought to a halt. At the other end of the scale, a major drought persisting over several months can lead to severe crop losses. The drought of 1976 in England and Wales caused a shortfall in cereal production on such a scale that imports to the value of £80 million were necessary to replace losses.

Although we recognise that such disruptions occur, we know surprisingly little about their precise magnitude, nor about how they compare with impacts from other sources. Analysis of recent periods of severe weather, the winter of 1962-3 and the drought of 1975-6, shows that industrial production can be significantly affected[1]. The impact in both cases was comparable to that of the three-day working week of early 1974. During the winter of 1962-3, mining and quarrying, shipbuilding, brick and timber industries were badly affected. During the drought of 1975-6, the iron and steel industries and the utilities were most affected, both requiring large quantities of water. And the cost of climate-induced failure in the economic sector is passed on in price rises and job losses.

Climatic change is rarely taken into account in long term planning. For example, despite the fact that day-to-day energy demand is largely determined by the weather, little account is taken of future climatic change in planning energy strategy. The mild winters of the early 70s may well have substantially reduced the effects of the oil crisis of that time.

We have so far only considered climate and climatic impact in the UK. But a period of bad weather in one country can have worldwide effects, given the inter-linking of national economies and the global distribution of resources. This is nowhere more clear than in the fluctuations in world food supplies. During the 1950s and 1960s, world grain production rose steadily (about 3% per year during the 1960s) despite crop failures in various regions associated with climatic extremes. The rapid development of new agricultural lands and techniques made global food supplies quite resilient to local harvest failures until the 1970s.

In the 1970s, however this rise was arrested by a series of climate-induced crop failures, most notably in 1972-3 and 1974-5. In 1960, world reserves of grain, which account for about 70 per cent of world food consumption, stood at a 95-day supply. By 1976, these reserves had dropped to around a 19-day supply. Much of this depletion occurred following a 12% shortfall in the Soviet grain harvest in

[1] JP Palutikof *The Incidence and Impact of Climatic Extremes*. Report on Department of Environment Contract No DGR/480/579, 1981, Climatic Research Unit, Norwich.

1972 and a similar deficit in 1975 (figure 1). One quarter of the United States wheat crop was sold to the USSR following the 1972 harvest failure and, in the same year, the Indian harvest failed owing to a poor monsoon season. Even though these local harvest failures only resulted in a drop in world production of around 1%, such was the vulnerability of world food supplies at that time that the world price of wheat more than doubled as panic buying triggered a period of price inflation.

As world food supplies become more limited and more vulnerable, the need to take climate into account becomes inceasingly important — and the responsibility that society must accept for future climate change becomes greater. What of the future?

In planning the rational use and distribution of the world's limited resources, reliable forecasts of climate, one year, ten yearsfand more ahead, would be of obvious value. But this requires a degree of understanding of climatic change which is not yet available. For much of the present century, climatology, and particularly the study of climatic change, has been neglected in favour of the development of a reliable system of day-to-day weather prediction. Although this neglect was largely due to the more immediate gain resulting from accurate weather forecasts, it was compounded by the fact that the period of rapid advance in the understanding of the atmosphere coincided with a time of climatic improvement in many regions —for example the marked warming of the Northern Hemisphere land masses during the early 20th century (Figure 2). While climatic deterioration is soon registeed and scientific interest and research as a result stimulated, this climatic improvement passed relatively unnoticed. Although commented on by a handful of scientists, the major climatic shift of the late 19th century and early 20th century was not widely accepted until the 1950s. By that time, the warming had ended and climatic deterioration soon affected many regions.

The problem of climatic change was not taken seriously by atmospheric scientists until recent decades. Advances in computing then enabled the analysis of the large collection of instrumental weather data collected over the centuries and the development of sophisticated numerical climate models. The former led to the realisation that climate changed on all timescales, from year to year, decade to decade, and century to century; the latter led to a climatic change becoming a topic of interest to theoreticians — it provided an elegant test of their numerical models. So climatic change is a relatively new science, at the stage of data collection, analysis and grand speculation rather than forecasting using accepted scientific laws. Nevertheless, advances have been made and climatologists are gradually approaching a consensus concerning one possible course of future climate.

In the early 1970s, the World Meteorological Organisation reported on some two dozen forecasts of climatic developments over the coming thirty years. There appeared to be a surprising degree of agreement. Most of the forecasts favoured continued cooling (see Figure 2), a shift away from the warmer and largely beneficial climatic conditions of the early 20th century. The fundamental basis of these predictions, whether explicit or not, was the observation that the climatic epoch experienced during the 20th century was unique in the context of the last 100 years. It was not, therefore, likely to continue for much longer.

That set of predictions was based on the past record of so-called 'natural' climatic fluctuations: those occurring during the period when society's activities probably did not affect climate to a significant degree. Since then, awareness of our potential to alter climate has increased. It is now obvious that this factor must be incorporated in any attempt at a long-range climate prediction. In a report published in 1978, the National Defense University, Washington DC,



sampled the opinions of leading climatologists concerning future climatic changes. The consensus reached was the opposite of that of the forecasts reviewed by the World Meteorological Organisation only a few years earlier. On balance they predicted warming due to carbon dioxide pollution of the atmosphere.

**The carbon dioxide issue**

By polluting the atmosphere through burning fossil fuels and deforestation, we are increasing the amount of atmospheric carbon dioxide — by the year 2050, it is predicted, it will have doubled. There are uncertainties in this prediction, it is of necessity based on forecasts of future energy strategy, but there is no doubt that carbon dioxide levels are rising at an unparalleled rate. The global carbon balance is being dramatically upset as we return to the atmosphere carbon which has been stored underground for millions of years. And carbon dioxide in the atmosphere plays an important role in the Earth's energy balance — the so-called 'greenhouse' effect.

Carbon dioxide allows the energy from the sun to pass through to heat the Earth's surface, so providing the driving force behind the atmospheric circulation, the world's weather patterns, and hence climate. However, it traps energy trying to escape from the Earth. A rise in atmospheric carbon dioxide levels leads to a rise in temperature; the same amount of energy reaches the Earth's surface, but less energy escapes. Numerical models predict that a doubling of carbon dioxide levels will lead to a global rise in temperature of 2 to 3° C. This is greater in magnitude and speed than any climatic change experienced since the last ice age and, if it occurs, will inevitably have grave social consequences — it will affect food supplies, economic development and possibly societal stability.

The predicted rise in temperature of 2 to 3° C is averaged over the world. Some regions will warm much more than this, others may cool slightly. The geographical patterns of climatic change can be complicated. For example, the severe cold of this winter was restricted to an area around the North Atlantic Ocean. Elsewhere, conditions were remarkably warm. While the UK was freezing, it was the warmest December in the 100-year record over the hemisphere as a whole! As the weather patterns change, some regions will get drier and some will get wetter, affecting agricultural production. The Earth's climate system will adjust rapidly — society may not be able to adapt so quickly. The first changes could be noticeable this decade.

The scientific uncertainties are, however, great and scientists are careful to express their predictions in terms of scenarios, or possibilities, rather than firm forecasts. Assessment of the precise societal impact is also problematic, being affected by the scientific uncertainties as well as ignorance of past effects of climate on society. It is in this context that climatologists have to face up to their responsibility to society and that society has to decide what it requires of science. The intent of this article has been to provide background information, but we end by listing some of the issues that we, as scientists, face and that we all may soon have to confront.

If action is to be taken to avert the potential consequences of increased carbon dioxide levels, for example, by pollution control or alternative energy strategies, decisions have to be taken soon. There is already evidence that the Earth is warming again (see Figure 2, 1981 was the warmest year on record) and lag effects mean that reducing carbon dioxide production now will not have an appreciable effect on atmospheric carbon dioxide levels for some ten years. Decisions concerning energy strategy will have to be international, will affect the Third World hardest (where the potential and need for increased usage of fossil fuel is greatest), and will almost certainly lead to a drop in the standard of living of many people. Given the nature of global politics, it is difficult to see any international action being taken. Will any politician act when their self-interest is threatened? It will be too easy to delay 'until the scientific uncertainties are resolved", by which time it may be too late.

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Society's planning time scale is too short to permit anything beyond coping with immediate problems (with immediate being generally defined as before the next election). Perhaps a problem which originates in the present but has consequences some ten years in the future is, for all practical purposes, insoluble. A depressing prospect — perhaps the role of the scientist is simply to say 'I told you so' when the worst has happened.

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*Further reading:*

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