The Greenhouse Effect and Ireland

Global temperatures are increasing, a trend most scientists attribute to the greenhouse effect — the trapping of radiant heat by atmospheric gases. In the 21st century, writes *John C Sweeney*, Ireland can expect a climate similar to that of Bordeaux today. Other countries, however, can expect more serious changes.

'It's time to stop waffling so much and say the evidence is pretty strong that the greenhouse effect is here.'
(Dr James Hansen, director of the US Institute for Space Studies).

Climatologists are by their nature rather conservative individuals, chastened by their knowledge of the vagaries of past climatic conditions into seldom making radical predictions about the future course of climate. In a world where the natural rhythms of climate produce substantial aberrations, even over short time scales, they have good reason to be cautious about human induced disruption of a climatic system which is, as yet, imperfectly understood.

In little over a millennium natural fluctuations have produced occasions where, on the one hand, the Irish monk Dicuil could report in the late 8th century sailing due north for a day in ice-free seas to the north of Iceland and, on the other hand, the inhabitants of Aberdeen could record an Eskimo paddling his kayak in the River Don in the early 18th century.

Historically, the well being of humankind has been strongly influenced by whether or not a benign climate permits the all important harvest to be garnered. However, climatologists now see humans not as prisoners but as the major controllers of future climate. They are, in addition, increasingly in agreement in their assessment of the climatic future as one which will be characterised by a global warming not experienced since the beginnings of humanity, and occurring during the lifetimes of the majority of the globe's current inhabitants.

Warming Up

One of the mildest Irish winters of the century has now been followed by a dry, sunny spring and early summer. Little, however, can be inferred from one year alone concerning any climatic trend. It is when Irish temperatures are aggregated with those from elsewhere in the world that the larger picture emerges.

Figure 1 shows that global temperatures have risen by about 0.5°C this century as the world recovered from the cold decades of the 17th and 18th centuries, the so-called Little Ice Age. Indeed, after a dip around mid-century (in retrospect, possibly associated

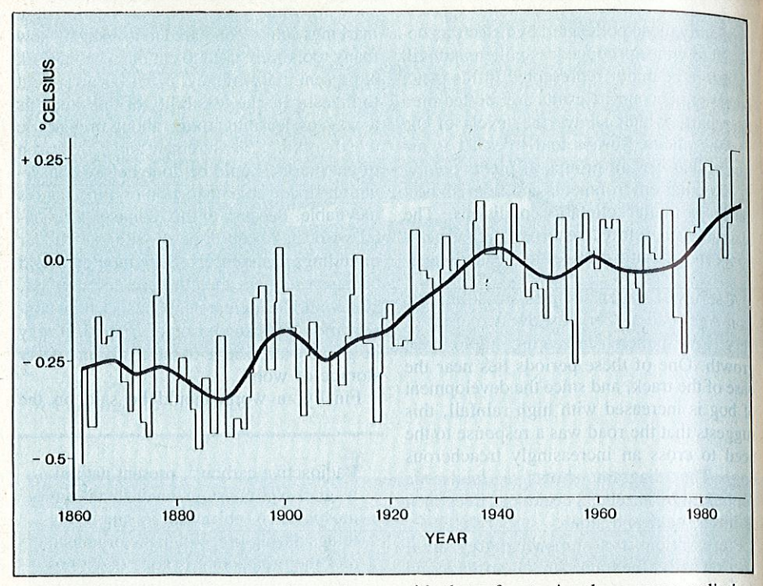


Figure 1. *Global temperatures have risen by about 0.5°C over the last 100 years.*

with increased volcanic activity), the warming trend has intensified. Remarkably, the five hottest years this century have occurred in the 1980s: in 1980, 1981, 1983, 1987 and 1988. Faced with such evidence, climatologists are increasingly of the opinion that we may be seeing the harbingers of the long predicted 'greenhouse effect'.

The single largest waste product from fossil fuel combustion is carbon dioxide (CO_2) of which an atmospheric pool of 711,000 million tonnes currently exists. About 2,500 million tonnes net is added to this reservoir each year as a consequence of fossil fuel combustion and the clearance of tropical forests. Deforestation is particularly serious since not only are the photosynthesisers which take carbon dioxide out of the atmosphere destroyed, but the trees are subsequently burned to add further to CO_2 emissions.

Accordingly, centuries old bubbles of air trapped in the Greenland ice sheets, and even air samples from as recently as the turn of the present century, suggest a 'pre-industrial' carbon dioxide concentration of around 290 parts per million. Currently, the concentration is about 350 ppm and increasing by 0.3-0.5 per cent each year, a fact which implies that doubling of pre-industrial levels is likely to occur sometime within the next 40 to 60 years.

The problem with this increased concentration lies of course in its ability to absorb radiation in the band from 13-18μm wavelength, a band which corresponds closely with that of outgoing long wave radiation from the earth's surface. This characteristic is also shared by a number of other gases, such as methane, nitrous oxide (a final decay product of nitrogen fertilisers), and the CFC family of compounds which all therefore contribute to global warming or the greenhouse effect.

Before the climatic impact of these gases can be modelled, and the regional implications for places such as Ireland identified, the rate of future emissions must be estimated in some way. This is extremely problematical, and constitutes the principal source of uncertainty regarding when and how serious a threat greenhouse warming poses.

Figure 2 shows three estimates of future energy consumption. The highest estimate allows oil and gas consumption to increase exponentially, with coal consumption increasing linearly. Though not historically unrealistic (Irish electricity demand grew at 8.5 per cent per annum in the years 1960-80), this scenario would, however, exhaust fossil fuel reserves well before the end of the next century.

The lowest estimate is, however, probably equally unattainable, showing a reduction in energy consumption based on careful energy auditing and maximising the efficiency of energy use. So close is the link between energy consumption and development that it must be considered unlikely that an absolute reduction in global energy demand is feasible in the next century.

The intermediate projection from the International Institute for Applied Systems Analysis projects energy demand to 2030 and linearly extends this value to 2100. The range of uncertainty in emissions is clearly huge

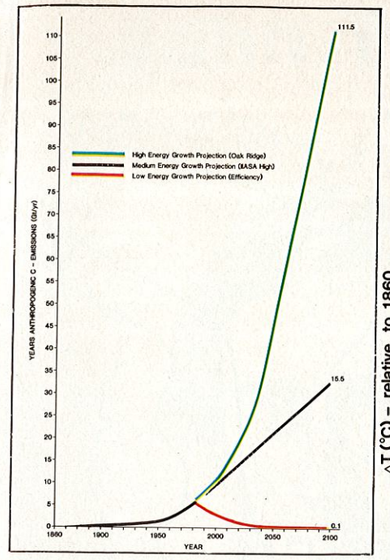


Figure 2. *Three estimates of future energy consumption.*

and thus the timing of climatic impacts is imprecise.

Global Impacts

Assessing the climatic impact of increased greenhouse gases involves understanding a number of feedback loops. For example, a warmer earth would evaporate more water. Water vapour is an even better greenhouse gas than carbon dioxide. More water vapour should therefore mean more warming.

But do more clouds mean more absorption of outgoing radiation (warming) or more reflection of incoming radiation (cooling)? And what happens to the incoming radiation budget once the bright shiny surfaces of ice at high latitudes melt and become dark? In this case, does warming produce more absorption of incoming radiation, and thus accelerate warming? How much of the extra carbon dioxide will the oceans absorb? These are the research questions of which modellers must take account.

Figure 3 shows the warming predicted for each of the three energy scenarios just discussed. A warming of between 1.5 and 4.5°C for a doubling of CO_2 is predicted or, if other greenhouse gases are included, of between 2 and 8.33°C, depending on the energy scenario chosen.

Taking the conservative IIASA estimate, it is clear that expected warming in the first decade of the next century will match the warmest times of the present post-glacial period, some 4-8,000 years ago. By mid-century the peak warmth of the last interglacial will be reached, and by the end of the next century global warming will produce

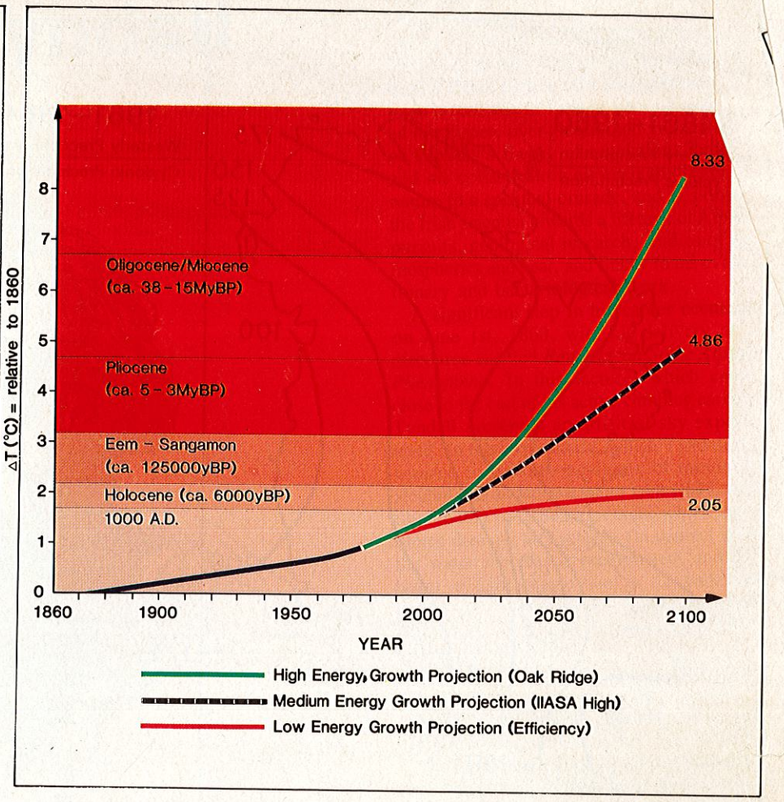


Figure 3. *The warming predicted for each of the three energy consumption scenarios shown in Figure 2.*

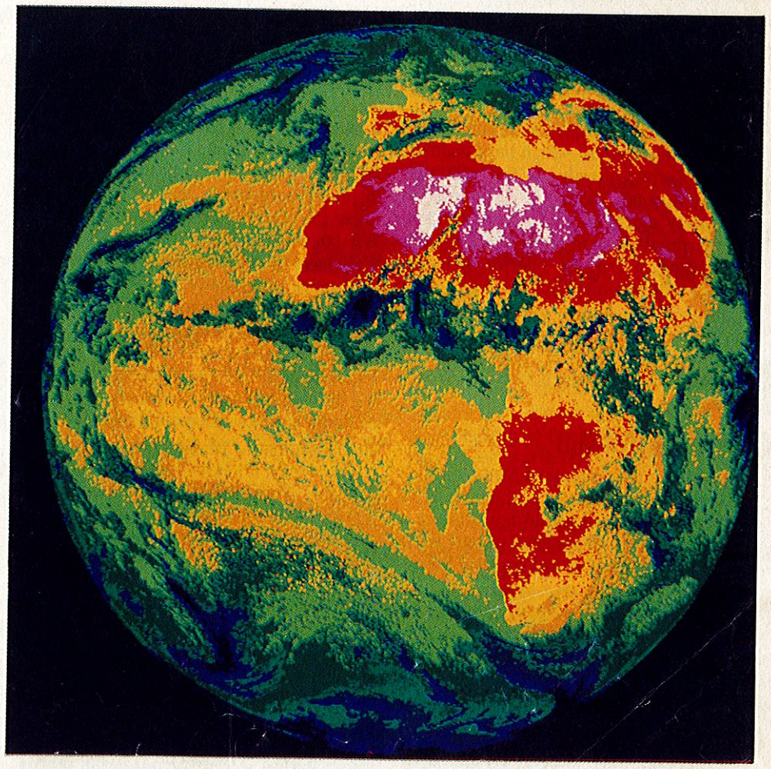
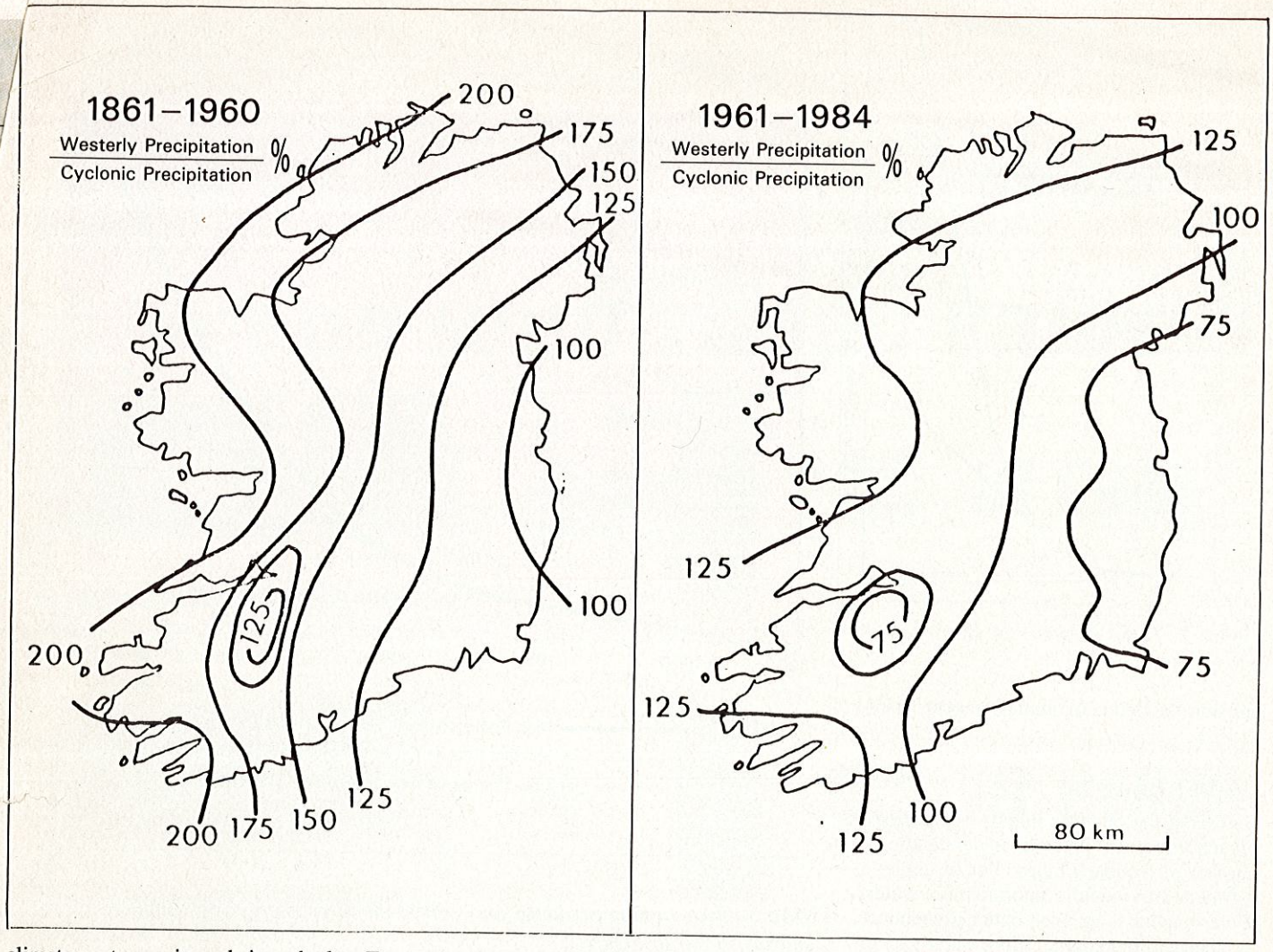


Figure 4. *Infra-red image of the world taken by Meteosat on July 4th, 1979, showing prominent climatic belts. The major red areas are the deserts of north and south Africa and the Middle East.*



climates not experienced since the late Tertiary, some 15-40 million years ago.

As computer power increases, it is possible to model the regional implications of these projections, and a fair agreement exists between various studies for this exercise. First, they show a desiccation (drying) of the semi-arid Sahel zones, which have endured much suffering already in the past two decades. Second, though a more reliable monsoon system is implied in low latitudes, a more irregular one in north-western India is suggested. Third, the interior of North America will become much drier as a consequence of the higher temperatures and lower soil moisture reserves.

The social and political consequences of these climatic changes are horrendous to contemplate.

Effects on Ireland

In contrast to the melting of land-based ice on Greenland or Antarctica, the melting of the Arctic Ocean ice would not produce a significant change in sea level. Arctic ice is presently floating and global sea level has accommodated itself to its volume. It is likely, however, that climatic belts, so prominently displayed in Figure 4, would shift polewards by about 400-800km when the Arctic Ocean ice cover melts.

A doubling of CO_2 will thus produce a mean temperature increase for Ireland of at least 4°C and a temperature régime not unlike that presently enjoyed by Bordeaux. It is with the circulation changes, however, that the principal effects of greenhouse warming on Ireland may be felt.

The westerly winds are driven by the temperature gradient between the pole and the equator. The fast flowing ribbons of westerly air aloft, the jetstreams, act as guidewires for Atlantic weather systems. The westerly jetstreams will undoubtedly be displaced northwards, leaving Ireland more under the control of continental conditions. What this means is that Ireland will increasingly have to look eastwards for its weather and, more importantly, for its rainfall.

In examining the sources of Irish rainfall from 1861-1960 it is clear from Figure 5 that most of Ireland mainly depended then on receiving rain from westerly sources. During the last 25 years this has changed, with cyclonic sources the main provider across almost the entire island.

This switch is a reflection of changing frequencies in the westerly winds, perhaps related to the greenhouse effect, and can be expected to continue as the westerlies decline further. As long as the rain arrives however, it is not too critical from where it comes, but for places almost solely dependant on rain from westerly sources the outlook is for a slight reduction over time as the greenhouse effect intensifies.

Figure 5 shows that the most sensitive Irish area in this respect is that around Co Limerick, where the surrounding topography causes it to be sheltered from all but westerly air mass trajectories. A gentle long-term downward trend may be expected in such areas.

Figure 5. *Changes in the source of Irish rainfall in recent years can be seen if westerly precipitation is taken as a percentage of total cyclonic precipitation.*

The agricultural implications of these climatic effects are not researched for Ireland as yet, but geographical changes in land use are likely. It is clear for example that maize may become a significant crop in future years in Ireland, and that grass growth may be less vigorous. Equally, implications for peatlands, forestry and soil processes may be anticipated and these require research in the near future.

Coping with the greenhouse effect requires an understanding of both social and environmental processes, a synthesis of skills not common, but probably best possessed by geographers. Ultimately, however, it presents the global community with probably its most important challenge for the 21st century.

International co-operation on the ozone layer is a relatively painless operation compared to the lifestyle sacrifices which may be required if the more extreme greenhouse impacts projected above are to be avoided.

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