oceanic circulation are capable of leading to substantial changes in the heat exchange with the atmosphere.

The area of ice and snow cover in the polar regions decreased between 1900 and 1930, then began to increase in the late 1950s. One school of thought attributes the increase to the lower direct heat input since about 1945, but the decline in the Atlantic winter circulation in the last two to three decades could perhaps have produced the same effect. There is even some evidence that a further change occurred about 1970. The area of sea ice was less for the four years 1971–74 than for the preceding four years. Again there has been a change in the Atlantic winter circulation but it is noteworthy that Budyko in an updating in 1973 of his direct radiation index shows an increase setting in during the late 1960s.

Other atmospheric variation

Changes in precipitation have also received attention—local changes as well as regional distribution—and various claims have been made for periodic fluctuations. The supporting evidence has not however been strong enough to lead to a consensus of opinion. For example the 22 years of the double sunspot cycle is claimed (and widely accepted) to be related to the incidence of droughts over the plains of the American Middle West but data for the steppe and forested zones of the Soviet Union do not show the same pattern.

Fluctuations in the strength of the general wind circulation in the Northern Hemisphere broadly parallel the temperature behaviour though there is an indication of a lead of about 10 years—the peak in the hemispheric westerlies for the latitude band 35–55°N being reached by 1930. The North Atlantic winter circulation which displays these changes to a marked degree certainly declined after 1930 whatever latitude band is examined. It is difficult to relate these or the smaller scale variations in a sensible way with changes in the temperature gradient between the tropics and the pole or suspected changes of the meridional heat flux. Only a small fraction of the internal energy of the atmosphere is converted to kinetic energy and so there is no reason to expect a simple relation between energy input and circulation energy.

The reality of strictly periodic fluctuations in the Earth's climate being to some extent in doubt and trends in various parameters being either doubtful (as for example turbidity) or not yet distinguishable from random fluctuations, satisfactory predictions for the next few decades cannot be made. Perhaps all that is justified are estimates of the range of possible future fluctuations based on past climatic data together with assessments of the influence of human activity on the surface of the Earth and the composition of its atmosphere.

Protecting damaged plant life of Galapagos

from Peter D. Moore

THE impact of man and his domesticated animals upon the unique flora and fauna of the Galapagos Islands has been the source of considerable concern in recent years. Schofield (*Biol. Cons.*, **5**, 48; 1973) considered that many endemic trees and shrubs, such as *Scalesia pedunculata* and *Miconia robinsoniana*, were threatened both as a

New climatologists begin here

ON March 10, Dr Peter Wright (University of East Anglia) spoke at the University of Bristol about climatic change to an audience of mixed physical scientists. He emphasised that climate is always changing, on many timescales, and that these changes occur globally. A disturbance of climate in one part of the world will affect the whole system, with possibly drastic repercussions on the other side of the globe. But man's direct influence on climate, through heating of cities, for example, seems insufficient to disturb the global machinery. The kind of disturbance cited by Wright as important would be about 1,000 km across and persistent—paving over the interior of Brazil, say; or smaller and more energetic, but persistent—exploding a nuclear device in the same spot every day for ten years. So it is still the study of 'natural' climatic fluctuations which is of key importance.

Wright dismissed most of the proposed natural causes of change as minor contributors. Solar variations (over the sunspot or longer cycles) could play a part, but are unlikely to dominate to the extent of causing ice ages; the Milankovitch theory that changes in the Earth's orbit and inclination affect insolation enough to cause ice ages seems more tenable (especially now that the geological record has been reinterpreted to give a better guide to the variations of glaciation over the past few million years); dust in the atmosphere from volcanoes or blown away from eroded and desert areas is a good candidate for irregular effects, but is difficult to reconcile with cyclic changes in climate (if, that is, you believe that climatic changes are cyclic, which Wright does not); geomagnetic fluctuations could, says Wright, 'just conceivably' play a small part (others might argue that by varying the flux of cosmic rays reaching the atmosphere such changes in magnetism could be of greater importance); and man's influences have certainly not been important as yet.

All of these processes are forcing effects; Wright, however, believes that, although such variations may make conditions more suitable for, say, icier conditions, it is feedback that maintains any climatic regime.

For example if a patch of ocean in the northern hemisphere becomes warmer than average, the effect will tend to be to shift the circumhemispherical wind streams so that instead of blowing from west to east across the warm patch they swing up from the south-west, pass around the north of the warm patch and swing away to the south-east. The effect is to bring warmer air over the 'anomaly', tending to maintain its warmer state.

A more realistic example of a feedback system is the "Southern Oscillation", in which a patch of ocean along the equator just west of the Americas fluctuates between a colder and less cold state (the difference is no more than 3 °C) with associated changes in the pattern of trade winds. Each state seems stable, and each is maintained by feedback between wind and ocean systems. Why should the situation ever change? Clearly there are external factors involved, even in the rest of the air–ocean system, and computer modelling is far from the stage of sophistication where all these effects are included.

As Wright pointed out, climatology today is still to a great extent in the data gathering stage; but already many data are available for analysis and more physical ideas are needed for testing both in the real world and in the models—and this is where there seems to be scope for new talent. Outsiders with experience in fluid mechanics, thermodynamics, statistical interpretation of noisy data and so on could play a vital part in the interpretation of the data as they are collected.