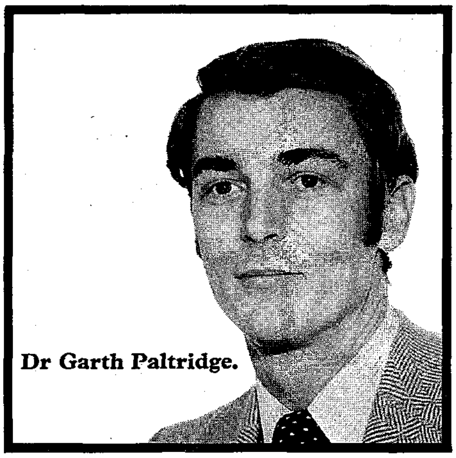
Outlook


Dr Garth Paltridge.

A key to our climate

Dr Garth Paltridge is a physicist. For the past 8 years he has been studying what happens to the energy reaching us from the sun, and how it produces our climate and supports living things. His subject of interest is huge and complicated, and one that still nobody has really begun to understand. For instance, he and his colleagues at the CSIRO Division of Atmospheric Physics at Aspendale, near Melbourne, regard with great scepticism any predictions that pollution will have such and such an effect on the world climate. As far as they are concerned we just don't yet know enough.

The modern approach for trying to predict how things like pollution will affect our climate involves feeding thousands of details of vast complicated models into great 'number-crunching' computers.

For Dr Paltridge, this goes against the grain. Like so many physicists before him, he loves simplicity. For him the computer modelling approach is like trying to work out how a jumbo jet will perform by looking at its huge number of parts with eyes that cannot see any component that is smaller than a certain size. To get an answer at all from a computer model, assumptions and approximations have to be fed in, so we can't be very confident that the final answer is right. In fact, Dr Paltridge points out, we still can't even predict the mean temperature of the earth using this approach—which we have already measured—without making assumptions which, in effect, assume the answer beforehand. So he doubts that we have much hope of correctly predicting things we don't have the answer to.

It's not that Dr Paltridge thinks that developing huge models is a waste of time and money, he just feels that we need to get much more information about the atmosphere and the sea before this approach can confidently yield true answers.

So he fell back on the classical physicist's method—he looked for a simple answer by searching for an underlying law that would govern the complicated energy transfer system that is our climate. He thinks he may have found it. So far it has stood up to all tests applied to it. If he's right, then at last it will be possible to make some confident predictions.

Earth keeps its cool

To start with, let's have a look at the world sitting out in space and the influences acting on it. The earth receives radiation from the sun, which tends to heat it up. Quite a bit of this radiation is reflected back into space, but by no means all. Yet the globe is not getting hotter, and it keeps itself in balance by radiating infra-red rays back into space.

> *. . . he looked for a simple answer by searching for an underlying law that would govern our climate.*

The earth absorbs the most radiation from the sun near its equator, and very little at the poles. But it radiates infra-red rays back into space from all latitudes. So, some process must be going on to transfer the energy absorbed at the equator towards the poles. In fact, this transfer process goes on in the atmosphere and in the oceans, and this is what produces the day-to-day weather conditions that make up our climate.

We all know that our climate consists of a large number of variable and interrelated features such as the temperature, humidity of the air around us, rainfall, and the amount of cloud cover. Clouds and the fraction of the earth's surface that they cover at any moment are what give climatologists their biggest headaches. So far no model has really been able to cope with them.

Clouds reflect the sun's radiation back into space (thus cooling the earth), and they reflect the earth's infra-red radiation back towards the ground (thus heating it). Scientists are still disputing which effect wins—whether more cloud makes the world hotter or cooler—but the present consensus is that more cloud cover would cool the earth.

But even if they knew the answer to that question, they would still be stuck, because they don't know what determines the amount of cloud covering the earth.

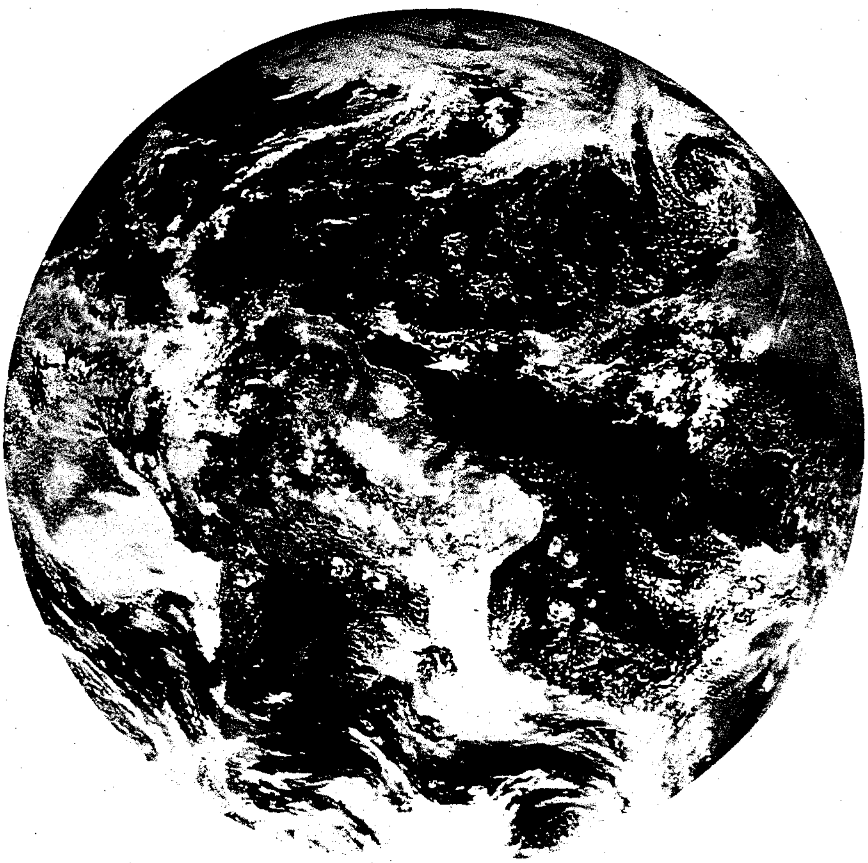
Obviously the presence of clouds is connected with such factors as the temperature and humidity, but they don't know how. To make predictions about climatic change, computer models have to assume that the cloud cover is constant or make some similar assumption that probably isn't true.

Issue ducked

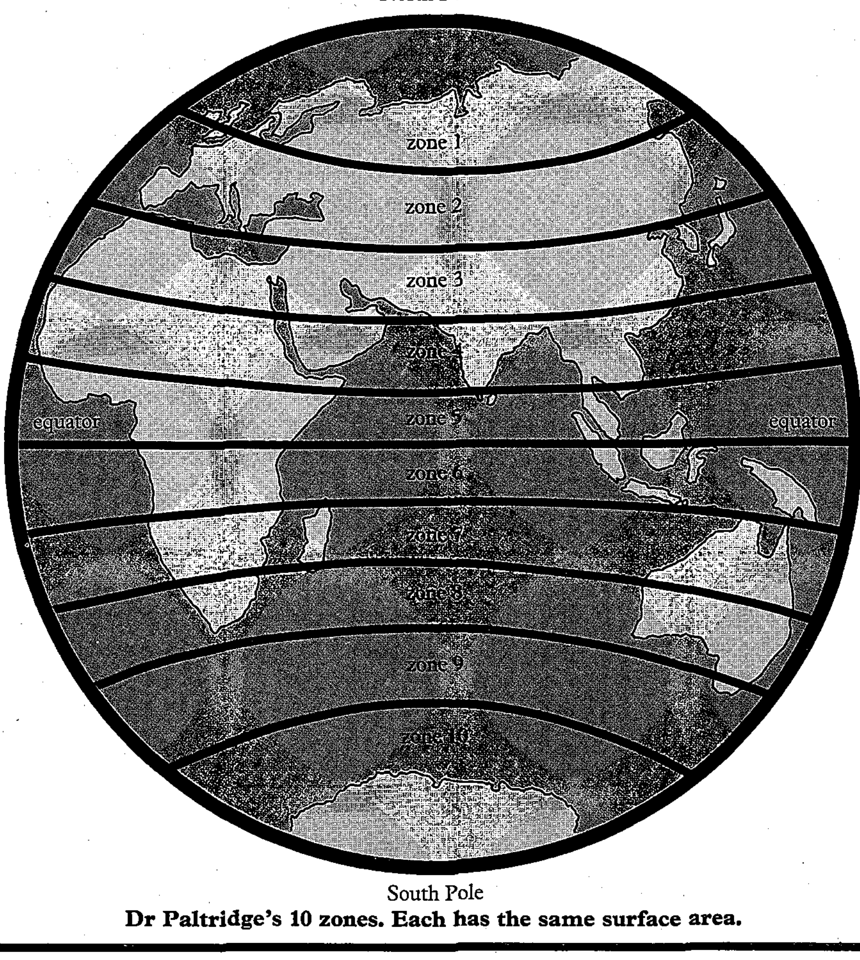
Dr Paltridge has by-passed the problem. By looking for some underlying law rather than attempting to predict what clouds should do from what we know about them, he has produced a simple mathematical equation that, among other things, shows how the world's cloud cover will alter when other climatic influences vary. In other words his equation shows *what* the clouds will do when other influences change, without saying *why*.

To find his underlying law of the climate, Dr Paltridge looked for what's known as a 'minimum principle'. Physicists often do this to solve problems. What they are doing is looking for some underlying physical factor that tends to operate at the minimum possible level. As Dr Paltridge points out, it is very rare to be able to predict the existence of such

Clouds—our planet's most prominent and enigmatic feature.



North Pole



South Pole

Dr Paltridge's 10 zones. Each has the same surface area.

factors by logic from existing knowledge; they appear by a process of luck and intuition.

His solution of how the earth absorbs the sun's radiation, transfers it towards the poles, and retransmits it as infra-red rays came by trial and error. It is based on the second law of thermodynamics.

Dr Paltridge's solution shows that the globe, as it transfers and retransmits the sun's energy, seems to operate so that the rate of production of what scientists call entropy is the lowest possible.

The consequence of this statement is that if any change occurs in such influences as the amount of the sun's radiation reaching the earth, then the world and its atmosphere will automatically rebalance themselves.

The important point about this self-balancing concept is that, if it's correct, it allows us to make predictions about the climate, some of which can be tested by observing the real world.

Acid test

First let's take the testable predictions. Atmospheric physicists know how much energy the earth receives from the sun, and how much it transmits back into space as infra-red rays. Using these known quantities, and his self-balancing concept, Dr Paltridge calculated for comparison purposes several known climatic features at various latitudes. He did this by dividing the world from north to south between the two poles into 10 zones of latitude.

His predictions and the observed facts turned out to be very close. For example, his predicted average temperatures and those observed in all zones coincided almost exactly.

Other predictions about how much of the globe should be covered in cloud were close to observed values too. The greatest difference between them occurred in the zone between 11·5° and 23·5° South. Dr Paltridge's calculations suggested that, on average, 44% of this region should be covered in cloud—5% less than the actually observed 49%. (However, scientific observations on world cloud cover probably aren't much more accurate than to the nearest 5% anyway.)

The self-balancing concept also predicts that at present the edges of the polar ice caps should be located at about 63° North and South—close to where they really are. This doesn't mean that they will necessarily remain at those latitudes for all time, or that other people's predictions about coming ice ages are wrong, but