Uncovering the causes of floods and droughts

Much of eastern Australia was flood-bound again last summer, and memories of the devastating droughts of earlier years are beginning to fade. The wet spell has lasted 3 years now, and nobody can predict how long it will continue. But we can be confident of one thing: it will end some time. Australia will continue to be hit by droughts as well as floods.

Figures for long-term annual averages tell only part of the rainfall story in any portion of the country; just as important is the range of variation. That this is large everywhere shows up in the fact that average rainfall registrations in years that are wetter than normal range from 20% to more than 50% above the normal figures. Averages for drier-than-normal years are a similar distance below the averages for all years. Sometimes areas experience a succession of dry years followed by a string of wet ones.

Why? If we knew, it might be possible to forecast droughts or floods months or even years before they occur. We don't know, but mounting evidence indicates that most of the explanation lies in changes in large-scale movements in the atmosphere rather than in the types of local event that determine whether a particular day will be wet or dry. Dr Barrie Pittock of the CSIRO Division of Atmospheric Physics at Aspendale, Melbourne, has recently identified two of the most important of these processes.

One of them—for eastern Australia apparently the most important—is changes in the strength of the east–west component of the air's circulation over the Pacific Ocean and Australia. When this is stronger than usual, more warm moist air sweeps down over eastern Australia from the Coral Sea. The result is greater atmospheric instability and more rain.

This east–west movement is linked to a difference in atmospheric pressure at sea level between the eastern Pacific and the region of Indonesia and northern Australia. The pressure difference varies, and its magnitude—often set out in terms of an indicator known as the southern oscillation index—is a measure of the strength of the circulation. When this index is positive, the east–west flow is stronger than usual; when it is negative, the flow is weaker.

To test the link with rainfall, Dr Pittock obtained annual average figures for 1913 to 1974 for more than 100 rainfall districts throughout Australia. Then he looked for correlations with the oscillation index figures for the same years. Throughout eastern Australia, with the exception of southern Victoria, he found that higher-than-average rainfall nearly always coincided with a positive oscillation index and below-average rainfall with a negative one. The agreement was most striking between the latitudes of Sydney and Townsville.

Next he used statistical techniques to place the figures for rainfall variation in a series of recurring patterns. Each pattern is independent of the others, and is therefore likely to have its own separate cause.

One of the patterns that emerged accounts for more than one-third of the rainfall variation over Australia, and the parts of the country where it shows up most strongly coincide closely with the areas where the link between rainfall and the oscillation index is firmest. Dr Pittock concludes that changes in the east–west circulation component, reflected in the index, account for most of that third of the variation, and probably for considerably more than a third in eastern Australia.

The other large-scale atmospheric process that he has linked with rainfall changes is the main north–south circulation that transports heat south from the tropics. Air heated by the sun near the equator rises, travels poleward, and comes down again usually somewhere between the latitudes of Cairns and Hobart. The region of descent is the high-pressure belt; this is where the southward flow breaks down to form the highs and lows that constantly cross Australia from the west.

The high-pressure belt always lies further north in winter than in summer, but quite big changes in its average latitude also occur from year to year. Dr Pittock's analysis shows that rainfall in the southern parts of Victoria and South Australia is below average when the belt is further south than usual and above average when it is further north. In eastern areas of New South Wales and southern Queensland the effect is the opposite; when the belt is further south, more rain falls.

The explanation for this seems to be that when the high-pressure belt is further south the rain-bearing easterly trade winds blow more strongly onto the south-east coast. At the same time fronts embedded in the westerlies, which bring rain to southern areas, cross more of the Southern Ocean and less of the continent—hence the below-average rainfall over South Australia and Victoria. Statistical analysis suggests that changes in the latitude of the high-pressure belt account for nearly one-fifth of the variation in rainfall over Australia.

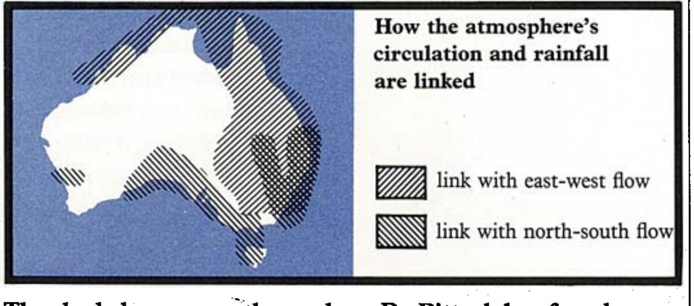
Taken together, the two processes Dr Pittock has looked at account for about half of Australia's year-to-year rainfall variations. Their effects are greatest over the main eastern and southern agricultural areas—regions where droughts and floods have their biggest impact.

If meteorologists could predict how the east–west and north–south circulations will behave from season to season or year to year, they would be well on the way to offering useful drought and flood forecasts. But they cannot do this yet. Much more needs to be learnt about the way the atmosphere works.

However, one thing that has become clear is that the pressure difference associated with the east–west air flow tends to persist at high or low values for many months and often for years. So after a switch from high to low values, for example, the circulation will probably remain weak for some time. Indications exist that the switches, when they occur, may be linked with sea surface temperature changes and variations in ocean currents as far away as the coast of Peru.

The experience of recent years bears out the influence of the east–west circulation on rainfall in eastern Australia. For example, in 1972 the pressure difference was small; it was a dry year. In 1973 and early 1974, the difference was usually much greater, and much more rain fell over eastern Australia.

Scientists in many countries are studying this circulation and the pressure differences and variations in the ocean connected with it. In Australia, researchers in the Bureau of Meteorology and the CSIRO Division of Fisheries and Oceanography are among those looking at aspects of the problem. Weather satellites with improved equipment for monitoring sea surface temperatures will be launched soon. Hopefully, these will throw more light on the subject.



The shaded areas are those where Dr Pittock has found clear links between rainfall changes and large-scale atmospheric processes.

Climatic change and the patterns of variation in Australian rainfall. A. B. Pittock. *Search*, 1975, **6**, 498–504.