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THE GLOBAL ATMOSPHERE: A MEMORIAL TO H. C. RUSSELL

C.H.B. Priestley

When introducing the speaker, Dr W.J. Gibbs recalled Dr Priestley's contributions to meteorology both nationally and internationally, from the establishment of the CSIRO Division of Meteorological Physics under his leadership twenty-five years ago to his recent appointment as Chairman of the CSIRO Environmental Physics Research Laboratories.

Dr Priestley dedicated his talk to the memory of Henry Chamberlain Russell whom he described as the most important figure in meteorology in Australia and a pioneer of the global approach in meteorology. In 1870, Russell, a graduate of the University of Sydney, was appointed in his early thirties as Government Astronomer for the colony of New South Wales. He was the first Australian graduate to be elected to the Royal Society, and became President of the Australasian Association for the Advancement of Science on the occasion of its first meeting in 1888. His greatest contribution to meteorology was a paper published by the Royal Meteorological Society in 1893, radically suggesting that, unlike their behaviour in the Northern Hemisphere, the movement of anticyclones in the Australian region was a hemispheric phenomenon. Later, E. Kidson used 34 years of charts to obtain mean tracks of anticyclone centres in the Australian region as a function of season. These tracks led to the understanding of the physical basis of Australian climate.

Little progress was achieved between the years 1925 and 1958 mainly due to lack of data in the Southern Hemisphere; however, during and following the International Geophysical Year, rapid development took place. In 1959, the International Antarctic Analysis Centre (IAAC), under the leadership of H.R. Phillpot, was formed with its primary objective initially being to provide an operational service to support Antarctic activities. In 1965, the World Meteorological Organisation (WMO) established the World Weather Watch with three World Weather Centres (WWCs) providing regular analysis and forecast services. The WWC at Melbourne took over the routine commitment of the IAAC, which then, under a new title, expanded its research activity until its dissolution in 1969.

Meanwhile a new school of thought had developed in meteorology. Attempts were made by L.F. Richardson in 1922 to integrate numerically the equations of motion and thermodynamics but the lack of success or even of promise caused his ideas to be abandoned until 1949 when J.G. Charney demonstrated that Richardson's problems could be overcome; this fired a tremendous burst of activity in the numerical approach to analysis and forecasting. Numerical methods were first applied to the Australian region by U. Radok and D. Jenssen and by R. Maine. In 1965, R.H. Clarke working in J. Smagorinsky's laboratory attempted the first numerical predictions for the whole of the Southern Hemisphere. His success gave high promise for the future.

In 1969 the Commonwealth Meteorology Research Centre (CMRC) was formed through a collaborative arrangement between the Bureau of Meteorology and the CSIRO Division of Meteorological Physics, with a view to ensuring that the benefits of numerical forecasting should accrue to Australia with the minimum of delay. Although initial emphasis was directed towards developing a simple numerical model for use at the Melbourne WWC, research on general circulation models is active in the CMRC and a milestone in Southern Hemisphere meteorology was reached late in 1969 when a series of operational hemispheric forecasts was made on a real-time operational basis using a model adapted by D. J. Gauntlett from Smagorinsky's primitive equation model. The forecasts showed skill for up to four days and there was successful prediction of new developments within that forecast period.

A significant development in international meteorology was the decision in 1967 by WMO and the International Council of Scientific Unions to enter into full cooperation in sponsoring a Global Atmospheric Research Program (GARP), partly to take advantage of new techniques in improving the observational network for regular analysis and forecasting, but also to test specific theoretical developments and to answer specific questions. The First GARP Global Experiment, scheduled for 1976-77, aims to use global data to provide the first full test of the potential of the numerical dynamics and to compare systems; whilst the tropics, which are governed by less well understood dynamics and which contain vital links in the global energy chain will be intensely observed during the GARP Atlantic Tropical Experiment during 1974.

At this stage, Dr Priestley showed a time lapse film of digital mosaic satellite cloud photographs over the Southern Hemisphere. Sequences covered mean cloudiness over 30-day, 15-day and 5-day periods as well as daily coverage; the latter graphically illustrated the correctness of Russell's suggestions regarding the migratory nature of Southern Hemisphere anticyclones.

Dr Priestley then briefly mentioned the contributions by Australian researchers in the fields of air-surface interactions and ozone studies and their roles in supporting the development of the new meteorology before moving on to discuss the major problems which present day meteorologists must face. These centre around the trends which are occurring or may occur in the concentrations of minor constituents of the atmosphere, natural or man made, and how these will influence the global weather and climate.

Our climate has always been changing and man has adapted himself to major but slow climatic changes. Only if drastic changes take place rapidly - as would occur if positive feedback processes produce, in decades, changes that would naturally take place in centuries or millenia - would resulting stresses on man's societies and practices become explosive.

An insight into this very complex meteorological problem is provided by considering the increase in atmospheric CO_2 and its effects on our climate. It appears that the absorption of CO_2 by vegetation and the oceans grows as the concentration grows but not fast enough for a really effective brake. Even if we could estimate the amount of full combustion, ability to predict the CO_2 content of the atmosphere, implies a knowledge of the detailed air-surface interaction and of deep ocean overturning processes which we do not yet possess. On the other hand the effects on our climate due to the substantial increase of CO_2 which may well have taken place are far from clear. Estimates made in the early 1950s were that the CO_2 increase would result in an average surface temperature increase of about $0.5^{\circ}C$; but these calculations were based solely on the known radiative properties of CO_2 and on the basis that as it increases, nothing else changes except surface temperature. According to F. Möller however, secondary effects such as 1 percent increase in cloudiness must also be considered. Changes of that order of magnitude are too small to be observed accurately for the moment; perhaps they may be detected after many years of satellite cloud data.

The variability of cloud amount and type, its interaction with the radiation and with the field of motion on all scales, present the global numerical modellers with a most challenging set of problems at the present time.

Just as with CO_2, so in different ways with aerosols, vapour discharge from SSTs and with other possible pollutants, the primary influence is likely to prove a totally inadequate guide to the ultimate climatic effect. It seems clear that the problem can only be solved by the development of global numerical models which incorporate the radiative properties of pollutants, their primary influence on the temperature field, the motions set up on all scales by the resulting changes of density, the consequent redistribution of the pollutants, and so on in a re-entrant chain of highly interactive processes.

In conclusion, Dr Priestley stressed that what we face is a competition between two time factors - one the rate at which climate may be inadvertently modulated by man's interference with nature, the other the rate at which we can gain the insights to tell us in detail what these changes are. It is a race of man's science against his technology, and the scientific community's most urgent and most difficult problem.

Professor P. Schwerdtfeger Department of Environmental Sciences, Flinders University, Adelaide, moved the vote of thanks to Dr Priestley.

P. G. P.
F. A. L.