

COMMONWEALTH SCIENTIFIC AND INDUSTRIAL RESEARCH ORGANIZATION

SECTION OF METEOROLOGICAL PHYSICS

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A N N U A L R E P O R T

FOR THE YEAR

1953-54

SECTION OF METEOROLOGICAL PHYSICS

ANNUAL REPORT FOR THE YEAR 1953-4

I GENERAL

Aside from the details of the research programme, which follow, and their bearing on national needs and problems, the international aspects of meteorological research are given constant attention. This is effected through the National Committee on Meteorology, of which the Officer-in-charge is Secretary, which reports to the International Meteorological Association; and through membership of the Standing Committee for Meteorology of the Pacific Science Association, a meeting of which in November was attended by an officer of the Section. During the current year a visit was received from the delegates to the South-West Pacific Regional Commission of the World Meteorological Organization. The Officer-in-charge is also a member of the Working Group on Micro-climatology of the W.M.O. 140

The Section moved to its new headquarters at Aspendale, Victoria, in November 1953.

II GENERAL CIRCULATION

To reach a better understanding of seasonal abnormalities and the causes and controls of climate it becomes necessary to study the mechanism of the general circulation of the atmosphere. This involves evaluation of the large-scale transport of heat, water vapour, and momentum from world-wide measurements from balloons ascending to 50,000 feet and higher. 120

This is an international problem and only relatively slow progress can be expected. During the year a paper has been published summarizing the results of Australian work to date. Apart from the detailed results there emerges a clear indication of the need for greater effort to obtain more regular high-reaching measurements at existing world stations, particularly on occasion of strong upper ('jet-stream') winds.

III DYNAMIC METEOROLOGY

(a) Large Scale Systems

The study of the dry-monsoonal circulation which predominates over the West and North-West of Australia has been continued, and extended to include relations between the large-scale distribution of pressure and rainfall over the continent and in the trade wind belt. The basic object of this work is to assess the effect of continental heating on the circulation in the region. Data covering ten years observations have been extracted and are being collated, with promise of interesting results. In particular some of the large-scale features, seen repeatedly in the surface pressure charts, appear due to the action of topography on easterly winds. This will be tested further. Some qualitative rules useful for short-term forecasting may also emerge from this work.

Sea breezes are examples of diurnal wind variations arising from differential heating at a coastline, but diurnal wind variations to considerable heights have been detected in regions far inland. A survey of upper winds has shown the continent-wide extent of these influences. Their share in sustaining the seasonal surface circulation is being explored.

A detailed analysis of upper winds from Kalgoorlie and Cloncurry indicates that the diurnal oscillation in these regions is largely due to a vertical momentum transfer varying with the intensity of convection and thus with time of day. A quantitative dynamical study of this effect should soon be completed.

Examinations are being made of discontinuities in temperature, moisture and wind associated with cold fronts in Southern Australia. One investigation is based on radio soundings for four winter seasons at Perth and Kalgoorlie, and a tentative classification of fronts in this region has been evolved. It is planned to explore its relation to the subsequent history of the fronts and to the large-scale flow patterns.

Synoptic aspects of the processes accompanying abrupt falls of temperature in summer, known as 'cool changes', form another part of

this programme. Assistance has been given by the Commonwealth Meteorological Branch and a number of Victorian State authorities in obtaining special observations required for the more detailed study of such changes affecting Victoria and southern New South Wales. Following a trial last summer it is planned to resume the co-operative part of the work next spring.

(b) Convection

Theoretical work has led to the identification of five modes (three principal, two transitional) of convective motion, depending on the temperature condition of the environment and the size of the convective element. In particular, large upward velocities can be developed only when the air is statically unstable and the 'bubble' exceeds a certain critical size. Given the rate of mixing, the temperature and velocity of the bubble can be calculated in any known environment.

This problem is of importance in vertical heat transfer in the atmosphere and in rain and cloud physics. Substantial rain requires substantial rates of uplift for its initiation and continuance, and the main limiting factor in rainfall is most probably the extent of vertical motion within the individual cloud.

Theoretical and experimental studies have been begun on continuing convection from artificial sources, which has bearings on frost protection and atmospheric pollution.

IV MICROMETEOROLOGY

The major effort in micrometeorology has continued to be an intensive investigation of the transfer of heat and water vapour from the ground surface to the atmosphere and also of the frictional influence of the ground on the wind. These fundamental studies have been framed, not only to give much needed knowledge of the processes by which atmospheric air-masses undergo modification in travelling over land and sea but also to provide means for a more thorough study of evaporation from natural land surfaces and from crops than has been possible with previous largely empirical methods.

The specially developed equipment in use at the Edithvale experimental station provides the observational material for these

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measurements of turbulent transport, and also yields a wealth of data for studies of the structure of atmospheric turbulent motion - studies of importance in relation to the diffusion of matter (smoke, factory chimney effluents, pollen etc.) in the lower atmosphere. The equipment has been extended and improved in the last year and now gives synchronous records of the turbulent structure of wind, temperature and humidity at two separate points.

Analysis of the records obtained this year and last has been pressed forward to the full capacity of the special machine analyser built for this work and a number of papers on the considerable body of results now available have just been completed. It is found that these techniques enable evaporation to be measured over short periods of time (10-20 minutes) with an accuracy far beyond that which seems feasible with the gravimetric methods under development elsewhere. A further important advantage is that no disturbance of a crop bearing surface is entailed. It has also been established beyond doubt that heat is conveyed to the atmosphere by a distinctly different mechanism than operates for momentum or water vapour, a hitherto very controversial matter and one having important implications in the study of evaporation.

A supplementary study of the very fine structure of atmospheric turbulence using cathode-ray oscillograph techniques is well advanced.

For any wide practical application of the above technique to specific agricultural evaporation problems it is desired to devise an instrument to give direct readings of evaporation and so eliminate the formidable amount of computation work at present required. Preliminary designs for such an instrument are well on the way but, although the principle is clear, a considerable amount of electronic engineering work remains to be done and it will be some time before an instrument suitable for operators who are not trained physicists is available. An extension of this method should also facilitate investigation of heating and frictional effects.

An observational study of wind gusts in the lowest 500 feet has been completed and briefly reported to P.M.G.'s Department which

requires the information in connection with the design of tall radio masts. An account for publication is in preparation.

Apparatus has been designed and built in this Section for several agricultural research workers, mainly for fine structure recording of temperature and humidity in connection with such problems as

- (i) Micro-environment studies of growing pasture plants and also of crops under trial in Northern Territory, cotton, peanuts etc.
- (ii) Humidity structure studies in connection with mildew diseases of grapevines.
- (iii) Ponding of cold air in valleys in relation to the tree-line.
- (iv) Temperature inversion survey in Queensland pine-apple district in relation to the frost problem. 650
- (v) Temperature influence on life-cycle of intestinal parasites of sheep.

Radiation equipment has been repaired and recalibrated for several research stations and advice and assistance given with observational programmes there and elsewhere.

On the theoretical side, the energy changes involved in mixing an inversion layer have been investigated with reference to frost prevention and it is found that the energy required to maintain mixing in 100 foot layer is only a small fraction of that supplied by the usual design of frost fan. Considerable improvement in frost fan performance is therefore not excluded.

V FROST PREVENTION

During the winter of 1953, frost prevention trials in citrus were continued at Griffith, using the 12ft. diameter airscrew on the low-powered wind machine. Trials were conducted at increasing angles of tilt of the blades until they were nearly vertical. The best performance was obtained with the air blast directed at about 15 degrees below the horizontal. Data collected by the Irrigation Research Station in trials with an experimental American-type machine were analysed, and also showed optimum performance at about the same tilt. An operational

test was made of a small number of return-stack orchard heaters, now manufactured in Melbourne, in conjunction with the small wind machine.

Further experiments, in co-operation with the Queensland Department of Agriculture, were conducted on the Pineapple Research Farm of the Committee of Direction of Fruit Marketing. The disappointing performance of the small wind machine, suggested in earlier trials, was confirmed, but the reason is now believed to lie, not in anomalous meteorological conditions, but in the requirement of an open-type crop for a type of air blast different from that best suited to citrus. Considerable data were also collected with various concentrations of small lard-pail type oil heaters spread over one acre, both on their own and reinforced by the wind machine.

A wind machine is now available commercially. A preliminary test in a vineyard in South Australia in the spring was encouraging, and more detailed trials are planned for the coming winter. 330

Comprehensive reports on the whole of this work are in preparation. Brief interim reports on special aspects have been made to co-operating bodies and to others requiring specific information.

Continuing laboratory work on frost alarms to improve reliability has led to modification and field trials of two commercial thermostats. A study is now being undertaken of the temperature differences under various conditions between the instruments, foliage, fruit, etc., and the air. Bad siting and exposure can result in mis-timed warnings from an otherwise reliable instrument.

VI RADIO METEOROLOGY

The Section of Meteorological Physics has done no work in this field during the current year. 20

VII OTHER WORK

Ozone Investigation

World-wide measurements of the ozone content of the atmosphere have been made for some years, under international auspices, but very few observations have so far been made in Australia. Three instruments for this purpose are now being adjusted and a measuring network

will be set up in Southern Australia. The measurements should provide information on the general circulation and an index of developments at high levels of possible value in routine analysis and forecasting.

Sea Surface Temperature Measurement

A test of the accuracy of the accepted dip bucket technique for measuring the true surface temperature at sea has been completed. Temperatures measured by bucket in Port Phillip Bay, on clear days of light wind when discrepancies might be expected, average about $\frac{1}{4}^{\circ}\text{C}$ higher than surface temperatures derived from simultaneous measurements of emitted radiation.

Maximum Rate of Rainfall

Knowledge of upper limits to the rainfall within a stated period are required for various purposes of water use, conservation, and flood control. Since rainfall is not normally measured for periods between one and twenty-four hours, the limits in this range have to be interpolated. An examination of world wide data, including one Australian station, has given evidence of one or two breaks in the intensity-duration relationship in this range. The attention of hydrologists has been drawn to this result and its implications.

Rainfall and Meteoric Dust

An appraisal was made of the influence of meteoric dust on rainfall, with the conclusion that on present knowledge any significant influence was improbable.

STAFF LIST

Officer-in-Charge	-	C.H.B. Priestley, M.A., Sc.D.
Principal Research Officer	-	W.C. Swinbank, B.Sc.
Principal Research Officer	-	E.L. Deacon, B.Sc.
Principal Research Officer	-	F.A. Berson, Ph.D.
Senior Research Officer	-	R.J. Taylor, B.Sc.
Research Officer	-	I.C. McIlroy, B.Sc.
Research Officer	-	E.K. Webb, B.A., B.Sc.
Research Officer	-	F.K. Ball, B.Sc.
Research Officer	-	C.F. Barrett, M.Sc.
Research Officer	-	W.W. Moriarty, M.Sc.
Technical Officer	-	I.S. Groodin, Dip. Mat.
Technical Officer	-	D.E. Angus, B.Sc.
Technical Officer	-	A.J. Troup, B.Sc.

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- Priestley, C.H.B. (1953) - Buoyant motion in a turbulent environment. Aust. J. Phys. 6, No.3, 279-290.
- Priestley, C.H.B. (1954) - Convection from a large horizontal surface. Aust. J. Phys. 7, No.1, 176-201.
- Priestley, C.H.B. (1954) - Vertical heat transfer from impressed temperature fluctuations. Aust. J. Phys. 7, No.1, 202-209.
- Priestley, C.H.B. (1954) - Buoyant motions and the open parcel. Met. Magazine. 83, No.983.
- Priestley, C.H.B. and Troup, A.J. (1954) - Physical interactions between tropical and temperate latitudes. Section of Met. Physics, Technical Paper No.1.
- Swinbank, W.C. (1954) - The influence of meteoric dust on rainfall. Aust. J. Phys. 7, No.2.