

SECTION OF METEOROLOGICAL PHYSICS

ANNUAL REPORT FOR THE YEAR 1951-2.

I GENERAL

The Section of Meteorological Physics is concerned with the study of the physical processes underlying and controlling the weather and climate. Though not responsible for the provision of forecasts, its studies contribute to the understanding on the basis of which forecasts must be made. The demand for meteorological information and prediction, notably from aviation and agriculture, continues to grow and expand in scope, and emphasizes the need for basic long-term research.

There are in addition many fields of application of meteorological knowledge which are not related to forecasting. The most effective use of natural resources in primary production depends on a detailed examination of the very variable conditions in the lowest layers of the atmosphere and a study of the relations between the living unit and its environment. The design and ventilation of buildings, the weathering of materials, the siting and protection of crops likewise require the best understanding and exploitation of the meteorology of these layers. The possibilities of some measure of control of weather, e.g. of frost and rain, involve fundamental research into the mechanisms of the various processes at work.

Apart from pursuance of its own research programme the Section has continued to give advice on meteorological matters to a wide range of interests including primary industry, building, radio-communication, and aviation. During a recent overseas tour the Officer-in-Charge gave lectures on micro-meteorology and general circulation to meteorological institutions, and groups of the U.S. Army and Air Force.

II GENERAL CIRCULATION

It is generally recognised that a better understanding of the longer period changes in weather and abnormality of seasons can only come from a study of the physical processes controlling the general circulation of the atmosphere. Scientists in all countries are working on this problem and, since advance can only come about by international collaboration, contributions to this field must be regarded from the international viewpoint. Parallel work to that on the global heat, moisture, and momentum transport, referred to in previous Annual Reports, is being intensively pursued in the U.S.A. and in some European countries.

Pioneer work in Australia has been accepted as offering one of the most promising lines of research in this field. The method involves the special analysis of widespread upper air measurements but, as these have been available for only a relatively few years, progress must be slow. Studies are continuing, based on data from both hemispheres, of the interactions between the tropical and temperate circulations in the form of the large-scale transports of energy and momentum.

III DYNAMIC METEOROLOGY

Dynamic meteorology deals with some of the basic processes underlying day-to-day changes in the weather. These include the factors governing the formation, maintenance, and decay of the weather-producing systems (anticyclones, depressions, waves in the pressure pattern). Progress has been noted in previous reports, and although staff changes have prevented concentration on these matters over the last year, it is planned to return to them. Problems of immediate concern to the sequences of weather in Australia comprise the formation of disturbances in easterly flow patterns, the distortion of flow patterns by mountains and land-sea boundaries, and the double structure of frontal disturbances affecting the Southern half of the continent. The phenomena of tropical and temperate latitudes are in many respects quite distinct, and Australia in

experiencing both régimes is faced with a wider range of problems than most countries.

IV TURBULENCE AND MICROMETEOROLOGY

Micrometeorology is that branch of the subject concerned with the detailed structure of wind, temperature, humidity, etc., and turbulence with the behaviour of these elements in the layer of air just above the ground.

The structure of all these elements reveals, among other complexities, a marked layering in that the wind, temperature and humidity change very rapidly with height in the first few feet. The change depends strongly on time of day, becoming reversed at night, and also on such other factors as weather and type and condition of soil. These factors determine the nature of the climate in and around crops which therefore differs greatly from that revealed by standard climatic data (which refers to 4 feet over a grass surface). The practical aim of micrometeorology is to examine these effects and turn them to best use for primary industry and other applications.

The turbulent structure and associated stratification are of great significance to meteorology in a more fundamental sense, since virtually the whole energy of the atmosphere is derived from processes occurring in, and measurable in, these layers which thereby exert a profound influence on the atmosphere as a whole. But many of the details are imperfectly understood. It has therefore been desirable first to concentrate on the fundamental aspects of these processes. This policy has also been necessary in view of the lack in Australia of trained meteorologists with knowledge in this field, and the consequent need to combine research with training.

During the past year measurements of fine structure of wind (turbulence), temperature and humidity have been made on a number of clear days and nights, at the field station at Edithvale. The basic instrument records all these elements simultaneously and so allows transport of heat, water vapour and

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directly, and the method developed is in principle the only one which can be applied to evaporation from any type of surface. One ultimate aim is the ability to assess the natural evaporative water loss from any region at any time. If the method proves too elaborate for this fully extensive use - its operation requires a trained physicist - its rôle may be that of a standard; from it, attempts will be made to develop working formulae, expressed in terms of more easily measured and recorded quantities, and to check such formulae as have been previously advanced.

momentum to be measured. This instrument has been duplicated and synchronous sets of values at two levels are yielding important new information on the laws of transfer. To give greater range into light wind conditions a photo-electric wind azimuth recorder has been incorporated, and the sensitive thermocouples are being replaced by fine platinum resistance elements to give improved reliability in the vapour pressure record.

A symposium on "Atmospheric Turbulence in the Boundary Layer" in Boston, U.S.A., was sponsored by the U.S. Air Force and the Massachusetts Institute of Technology, and two officers of the Section were invited to attend. An account was given of the techniques developed and certain of the information already obtained.

Among important natural processes controlled in this manner is the evaporation from soil or natural surfaces. The work at Edithvale represents the first successful attempt to measure this quantity directly. It is hoped that the instrument developed will be adopted more widely for similar measurements elsewhere, for the method is the only one which is applicable to measurements over any type of surface. The technique is, however, difficult and elaborate and attempts will be made to relate the measurements to other, more easily observed, quantities: more reliable estimates may thence be obtained for evaporative water loss from other regions than has previously been possible, and the question of regional and continental water balance of soil be placed on a surer scientific foundation.

The problem of heat balance is closely analogous to water balance and is being investigated concurrently. An instrument developed to record the net incoming radiation (long and short wave combined) is in operation. Measurements of heat flow into the ground are also made.

This work has special importance to semi-arid regions, where both heat balance and water balance are critical. This was recognised when a member of the Section was appointed to represent the International Meteorological Association on the

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UNESCO Joint Commission for the Arid Zone.

Opportunity has been taken to study the micro-structure of the larger scale disturbances: the passage of one cold front and one sea breeze discontinuity have so far been bracketed within the period of observations. With the former the fall of temperature was as rapid as 10°F in 8 seconds.

Information on the variation of wind velocity with height near the ground over different types of terrain has been used by the R.A.A.F. Research and Development Unit in the accurate assessment of the take-off performance of new types of aircraft. Similar information and advice has been given to the P.M.G.'s Department in connection with the design of high radio masts. The variation with height of storm gust velocity (the significant factor in the latter case) is not so well known, and suitable anemometers are being developed to enable the problem to be investigated more thoroughly.

V FROST PREVENTION

Experiments have continued on the protection of fruit from frost by means of fans. This method makes use of the fact that, in Australian fruit-growing districts, the very large majority of frosts occur on relatively clear still nights when the air some 50-100 feet above ground level is appreciably warmer and may be artificially brought down to the level of the fruit.

As stated in previous reports the practical feasibility of this method has already been demonstrated, and the chief objective is to determine the most efficient design of fan and arrangement of fans for orchards of a given size. This may vary to some extent from one crop or site to another, and meteorological advice on operation will always be desirable. Earlier trials provided an assessment of the degree of protection afforded by small (10 h.p.) fans with axis vertical. Later trials have indicated, as suspected, that the area protected is considerably increased when the axis is inclined up to 60° from the

vertical and revolves slowly about the vertical: protection is then extended to some 2 to 3 times the original area. The main trials have been carried out in orange orchards at Griffith.

Comparison of the results achieved there with the latest published work from the United States suggests that under comparable meteorological conditions the design is considerably more efficient than the American type which has a nearly horizontal axis. It is proposed to examine whether any further degree of protection is to be gained by using a more efficient type of airscrew.

The criterion above is entirely in terms of rise in air temperature. Additional benefit is gained from the artificial movement of air, since transfer of heat from the air to the fruit is thereby enhanced. More attention is now being paid to measurement of air movement and simultaneous measurement of fruit and air temperature.

The Section has advised and assisted with similar work at other places, by providing the thermometric equipment and undertaking responsibility for the observational work. Preparations are nearly complete for similar work in the pineapple fields in Queensland where heavy losses due to frost have been suffered in recent years.

VI RADIO METEOROLOGY

The structure of the troposphere and that layer of the upper atmosphere known as the ionosphere are both due ultimately to solar influence. For this reason, and perhaps more immediate dynamical ones, it might be expected that there would be some relationship between the behaviour of the two layers, though the mechanism of the connection is not clear. Correlations between certain characteristics pertaining to the two layers have been reported from different parts of the world, some of which appear to have definite prognostic value. Similar relationships have been sought in an investigation undertaken by the Section. For the Australian region (Canberra) the study

has tended to confirm the existence of marked correlation over short periods (a week or so) between ionospheric F_2 critical frequency and mean sea level pressure. But the investigation has failed to reveal any connection between such periods of correlation and the synoptic situation.

An officer of the Section has continued to serve on a sub-committee formed to consider means of investigating the possibility of establishing radiotelephone links between capital cities. The efficiency and economic installation of such links depends on the meteorological and micrometeorological conditions.

VII OTHER WORK

Evaporation Survey.

Surveys of water resources and of climate, particularly with a view to assessing the potential of under-developed areas, involve evaporation as a central element. Previous surveys have been based on measurements from water tanks, but these are recognised as being limited in application, and a field method of measurement of evaporation from natural surfaces is required. The use of grass covered pots, under study in the Section, promised well but has been found to present one grave difficulty, the maintenance of the surface in dry conditions without artificial watering.

Wind Tunnel.

A wind tunnel designed for meteorological work with working section 2 ft 6 inches square has been completed during the year, and is available for the calibration of airflow instruments and an examination of airflow round model structures. The projected design of the Oceanographic Research Ship, which will also be used for meteorological measurements at sea, has been tested for the distortion of airflow round its bows and found satisfactory. Airmeters have been calibrated for the Department of Mines and Mineral Resources.

Radiation Problems.

Assistance and advice on miscellaneous problems

involving atmospheric radiation have been given to the State Electricity Commission of Victoria and to the Victorian State Railways.

STAFF LIST.

Officer-in-Charge	-	C. H. B. Priestley, M. A.
Principal Research Officer	-	W. G. Swinbank, B. Sc.
Principal Research Officer	-	E. L. Deacon, B. Sc.
Research Officer	-	I. G. McIlroy, B. Sc.
Research Officer	-	R. J. Taylor, B. Sc.
Research Officer	-	E. K. Webb, B.A., B. Sc.
Research Officer	-	F. K. Ball, B. Sc.
Research Officer	-	G. 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.
Technical Officer	-	D. R. Samuel, Dip. App. Sc.

LISTS OF COMMITTEES.

The Meteorological Research Consultative Committee remains as before save that Mr. H. N. Warren is deceased. Presumably his place is occupied ex officio by the Acting Director (Mr. E. W. Timcke) until a new Director is appointed.

PUBLICATIONS.

- Angus, D. E. (1951). — Inclined axis frost fan trials in citrus orchards. Section. Met. Physics Reports Nos. 1 and 2.
- Deacon, E. L. (1951) — Climatic change in Australia, 1880-1940. Res. d. Comm. U.C.G.I.; Brussels: 22-23.
- James, R. W. (1951) — The structure of steady-state anticyclones. Aust. J. Sci. Res. A, 4 : 329-343.
- Priestley, C. H. B. (1951) — A survey of the stress between ocean and atmosphere. Aust. J. Sci. Res. A, 4 : 315 - 328.
- Swinbank, W. G. (1951) — The measurement of vertical transfer of heat and water vapour by eddies in the lower atmosphere. J. of Met. 8 : 135 -145.
- Swinbank, W. G. (1951) — The measurement of the vertical transfer of heat, water vapour and momentum by eddies in the lower atmosphere. Res. d. Comm. U.C.G.I., Brussels : 24-26
- Taylor, R. J. (1952) — The dissipation of kinetic energy in the lowest layers of the atmosphere. Quart. J. Roy. Met. Soc. 78, 179-185.