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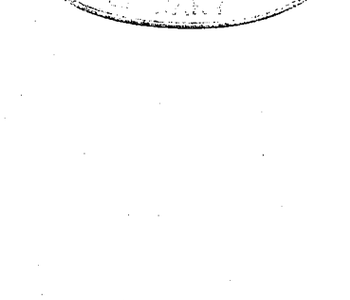
COMMONWEALTH SCIENTIFIC AND INDUSTRIAL RESEARCH ORGANIZATION

SECTION OF METEOROLOGICAL PHYSICS



ANNUAL REPORT

FOR THE YEAR

1952-53

SECTION OF METEOROLOGICAL PHYSICS

ANNUAL REPORT FOR THE YEAR 1952-3

I GENERAL

The Section of Meteorological Physics has a programme of study whose main object is to attain a more fundamental understanding of the weather and of the physical processes which control it. Meteorology is a public utility on which almost every phase of community life depends in some way. Whereas meteorology already provides a wide range of services to the country, these can only prosper and improve against a background of basic research into the many problems as yet unsolved. Thus while some of the fields under investigation in the Section are capable of application to the immediate benefit of the community, the main task is to consolidate the foundations of the subject, to strengthen it against the continually growing demands for meteorological information and advice which are made by aviation and other transport services, by primary and secondary industry, and by the individual in his private life.

II GENERAL CIRCULATION

Work has continued on the study of the large scale transport of heat, water, and momentum by the variable air currents extending through the atmosphere from the surface to about 50,000 feet. These transports are major factors in determining the average pattern of wind, temperature and rain over the whole earth, and the study may continue for many years so that not only the pattern and its variation with season, but also its variation from year to year, may be better understood.

The research involves the working-up of Northern as well as Southern Hemisphere data, since the number of good observing points in the Southern Hemisphere is not sufficient to allow the problems to be tackled on the basis of this data alone. Parallel work is proceeding in many countries, much of it following the lines pioneered in

Australia; the work is an example of international collaboration on an international scientific problem.

An exploratory study has been completed and published of another aspect of large scale weather - the trends in temperature, rainfall etc. which occur during periods of the order of a century. This has shown that concurrent with the well established and marked changes which have taken place in the Northern Hemisphere, particularly since about 1900, changes have also occurred over most of the south-east part of the Australian continent. Inland summer temperatures have declined appreciably and summer rainfall in S.Australia and Victoria has increased by amounts of the order of 20-50%. The pattern of these and also of the atmospheric pressure changes is consistent with a movement in mean position of the high pressure belt which, in these latitudes, is the marked feature of the general circulation. What evidence has so far been found suggests that these changes, together with the Northern Hemisphere trends, may well fit into a consistent picture of global change.

III DYNAMIC METEOROLOGY

(a) Large Scale Systems.

The dynamic meteorology of the large scale systems is concerned with the patterns of motion and pressure which individually control the day-to-day variations in weather and collectively determine the climate of a locality or region.

The study of climatic features in Australia is largely concerned with the distribution of temperature and rainfall especially with regard to position relative to the coast and the Eastern Mountain Ranges, and to latitude. The very marked changes in climatic conditions from place to place are broadly understood, although much work has still to be done in this field. Less is known concerning the occurrence of extraordinarily marked variations from year to year in some regions. These variations are shown up particularly in the areas subject to monsoonal seasons where a normally regular phenomenon may occur unduly late or even fail to appear, and their study calls for a physical

approach rather than for the statistical methods normally used in climatology. A preliminary programme of research into three of the basic processes affecting these changes in Australia was set up early this year.

Most of the West and North-West of Australia in summer is dominated by a dry-monsoonal circulation, apparent as a surface low pressure area subject to diurnal oscillations. The intensity, position, and structure of this system are being investigated statistically. Relations to the large scale features of the region, and in particular to the trade winds and to the Northern wet-monsoonal circulation, are under examination.

Variations in the effective solar heating may be associated with the climatic anomalies in the region. A formula has been developed which allows the heat input to be calculated from suitably analysed charts, and the results are being studied on a continent-wide basis. Computations on similar thermally impressed patterns in other parts of the world are being made simultaneously. This part of the programme is progressing very slowly due to the labour of working up the aerological data. Preliminary results are promising.

A theoretical study of the initiation of large scale disturbances in the west-wind regions of the Southern hemisphere indicated that frictional effects might be more important than previously thought, but has been put aside pending the resolution of mathematical difficulties. Particular attention is now being given to the mutual dependence of the slow moving or nearly stationary large deformations and the smaller, more rapidly moving, disturbances which account for the typical weather sequences of Australia. The study is handicapped by the paucity of observational data over the Oceans, and the progress of the investigation will depend on the rate at which data become available. Some aspects are being treated in collaboration with the Meteorological School at the University of Melbourne.

(b) Convection.

Work in recent years on the physics of rain has concentrated on the physical behaviour of cloud particles and drops, with

relatively little research into the dynamical process of upward air movement or convection which provides the condition under which the drops can grow, and without which little rain can occur. A theory has now been developed for the motion and thermal behaviour of an element of air, of any size, moving under buoyancy in a turbulent environment. According to the condition of the environment, three types of behaviour can result; velocity and temperature differences may be rapidly damped out, they may oscillate, or they may grow rapidly. The solutions obtained appear capable of explaining the essentials of the different types of motion observed with convective clouds. In particular they provide the explanation for the vertical oscillation of large cloud tops observed in stable layers. This process is often associated with heavy rain.

IV MICROMETEOROLOGY

Micrometeorology is that branch of the subject concerned with the study of the physical processes that occur in the layer of air close to the ground. The three variables which control these processes are temperature, water vapour content and wind structure, and measurement of these quantities with suitable instruments reveals in each case two outstanding features -

a) a pronounced fluctuation in space and time. Instruments of the highest resolving power used to date fail to reveal a lower limit either to the period or dimension of these fluctuations, and the upper limit appears to be reached only at the scale of the largest weather systems.

b) a marked stratification in the mean value of each quantity so that each may change rapidly with height in the lowest few feet. In general the nature of the change depends on the time of day, becoming reversed at night in the case of temperature and humidity, and its intensity depends on such factors as weather and type and condition of the soil and vegetation.

This complex structure has a profound influence on a wide range of superficially unlike phenomena such as the warming of the

atmosphere, the evaporation of water from land and sea, the frictional interaction between atmosphere and earth, the transport of light seeds the dispersal of smoke from factories, etc. In particular the factors mentioned above determine the nature of the climate in and around crops which, being subject to greater extremes, may be substantially different from that revealed by standard climatic data which refers to conditions at a height of four feet above a short grass surface.

From the meteorological aspect the importance of studying these processes lies in the fact that it is in this region that the exchanges of heat, water vapour and momentum between the atmosphere and the underlying surface are effected. The energy of wind, rain and heat in the atmosphere derive originally from these interactions.

The micrometeorological work so far carried out in the Section has been mainly of a fundamental nature, though the knowledge so gained has already found useful application in other connections, for example in the problem of frost prevention in orchards. The instrumentation designed for this investigation comprises apparatus of sufficiently rapid response to record the fine structure of temperature, humidity and wind, and a mechanical analyser which, by providing correlations between the variables, yields values of the fluxes of heat, water vapour and momentum. The fine structure apparatus has recently been improved by the development of a hot wire anemometer linear over the lower range of wind speed. So that account may be taken of all factors in the heat balance at the ground surface, instruments have also been designed to measure the net incoming radiation and heat flow into the ground.

During the past year the field work at the experimental station at Edithvale has mainly been an extension and consolidation of that of the previous year. It is now possible to take synchronous records of wind structure and temperature of humiditity at two heights, and thus to obtain valuable information on the variation with height of the flux of heat, water vapour and momentum. But analysis of the data remains a bottle-neck and attention is being given to the development of apparatus which will yield flux values in the field. The

40 or more feet above ground where the temperature on frosty nights is from 5 to 10°F warmer than near the surface. The object of the work is to determine the most efficient design of fan of a size likely to be suited to Australian requirements.

Work in previous winters with 12 H.P. fans of 21 ft. diameter in a citrus orchard showed that a fan with its axis tilted 60° to the vertical was from 2-3 times more effective than when the axis was vertical.

The 1952 trials in citrus at Griffith were made using a 12 ft. diameter airscrew of good aerodynamic design in place of the cruder 21 ft. rotor. The 12 ft. fan was found to give, at 60° tilt, performance equal to that of the larger fan, the power consumption being the same in each case. The smaller fans have the advantage of being cheaper and more robust than the large types.

The effect of power variation over the range 5 to 15 H.P. was also investigated and work continued on the extent of the beneficial influence of air velocity on fruit temperature.

A set of 60 electrical thermometers was provided and a programme of observational work undertaken in connection with a frost-fan installed in a pineapple field in Queensland. The pineapple industry in Queensland suffers, in some winters, losses due to frost damage of up to £500,000 and, owing to the high value per acre of this crop, some method of frost protection may well be economically sound.

The results obtained with the fan were, however, distinctly disappointing in comparison with those obtained in citrus at Griffith with an exactly similar machine. This was found largely to be a result of the smaller increase of air temperature with height at the Queensland site than at Griffith on clear calm nights. To ascertain whether or not this is a result of the local topography, apparatus to record the temperature at various heights has now been installed at three pineapple plantations some miles apart.

Work has recommenced this season at the Queensland site, in co-operation with the Department of Agriculture and Stock, Queensland on a series of trials comparing the effect of the frost fan with that

of a layout of oil-burning orchard heaters of the type used in the Mildura district to protect vines. Some trials will also be made on a combination of the fan and a small number of heaters, a system now much favoured in California.

In addition to the work on frost fans, a large number of observations of the rate of loss of heat from the ground by radiation and of other factors bearing on the incidence of frost were made at Griffith with the object of providing improved aids to forecasting frost in this irrigation area.

There will remain a need in fruit-growing districts for some reliable system to signal an alarm when frost threatens. The most usual instrument for this purpose is a mercury in glass thermometer operating a relay through inset contacts when the air temperature falls to within some two degrees of the freezing point. But complaints have been received from the Research Station, Merbein, that all makes of this type of instrument used in that district have at some time or other failed. Accordingly some consideration has been given to the suitability of other types and tests with a simple bimetallic type of instrument have given promising results. The tests will be continued. Elaborate research on this problem is not proposed, however. Beyond a certain point, the demand for immunity from breakdowns of the alarm system can be met more economically by duplication of moderately reliable instruments than by development of a single instrument of exceedingly high reliability.

VI RADIO METEOROLOGY

Some relationship might be expected between variations in conditions in the troposphere and in the ionosphere since both are due ultimately to solar influence, though the nature of the two influences are quite different. Correlations which appear to have definite prognostic value to the meteorologists have been claimed to exist in different parts of the world and similar relationships, particularly between parameters of the tropopause and the F-layer critical frequency, have been sought in an investigation undertaken in the Section.

Australian data has been limited to Canberra, where surface pressure was used in the absence of tropopause data. A more extensive examination was made of data from S.E. England. In the former case, though correlation between critical frequency and sea level pressure appeared to exist this occurred only at certain times and nothing was found to provide a criterion for the occurrence of such periods. In S.E. England, again for certain periods only, there was evidence of correlation of F-Layer height with tropopause temperature, and of critical frequency with tropopause height; there was some indication that the occurrence of the former was connected with wind conditions near the tropopause. A report is in preparation.

VII OTHER WORK

Ozone Investigation.

Measurements of the total concentration and vertical distribution of ozone in the upper atmosphere have now been made for many years at a number of stations in other countries, chiefly in the Northern hemisphere. The absorption of radiation by ozone plays an important part in the radiative equilibrium of the atmosphere. Besides this, ozone variations appear to be closely associated with the synoptic situation and to provide an index of dynamic development in the upper atmosphere; their study is therefore of potential value to the synoptic meteorologist.

It is proposed to make ozone studies in Australia with three ozone spectrophotometers which have been in the country for several years and have now been made available to the Section. The setting of the instruments has been disturbed and their reconditioning and recalibration is a major task which is being carried out in collaboration with the Division of Industrial Chemistry. The Observational programme will then be started.

Sea Surfact Temperature Measurement.

The standard method of measurement of sea surface temperature is by dip bucket. For certain uses, however, the temperature at the

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