COMMONWEALTH SCIENTIFIC AND INDUSTRIAL RESEARCH ORGANISATION

DIVISION OF METEOROLOGICAL PHYSICS

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

FOR THE YEAR

1957-8.

DIVISION OF METEOROLOGICAL PHYSICS

ANNUAL REPORT FOR THE YEAR 1956-7

I GENERAL

The work of the Division of Meteorological Physics is directed towards a better understanding of the behaviour of the atmosphere with a view not only to improving the prediction of its effects but also to using these to the greatest advantage. Australia is the driest of all the continents and lacks adequate water supplies over wide areas. The Organization as a whole is concerned with many aspects of water, the manner in which it becomes available, its use and conservation, and the Division is involved in many of these projects in either an active or advisory way. Much of its own work contributes to this end through the problem of evaporation. Aside from water, such diverse interests as aviation, agriculture, and the everyday life of the community make growing demands on our knowledge of the weather and its processes.

Meteorology requires organisation and much critical review work at the international level, and the World Meteorological Organization has established working groups to meet some of these needs, Mr. Deacon is a member of that on Short-wave Radio Propogation and Dr. Priestley the Chairman of that on Atmospheric Diffusion. The International Union of Geodesy and Geophysics held its triennial General Assembly at Toronto during the year; this was attended and three papers representing various aspects of the Division's work were presented. Dr. Priestley continues as a member of the Executive Committee of the International Meteorological Association, a constituent of U.G.G.I., and Mr. Swinbank as a member of the Ozone Commission. A paper on the generation of turbulence in the free atmosphere was read at the O.S.T.I.V. (gliding) Conference (Lezno) and one on the direct measurement of natural evaporation at the Ninth Pacific Science Congress (Bangkok).

Dr. Priestley, Chief of the Division, returned in November 1957 after leave of absence working in the Department of Meteorology of the University of Chicago. Other meteorological institutions in the U.S.A., Canada, Britain, Sweden, and India were visited en route and lectures given on the work of the Division.

Dr. R. B. Montgomery, Associate Professor of Oceanography at

Johns Hopkins University, arrived in March 1958 to spend nine months in Australia as a Fulbright Research Scholar. Dr. Montgomery will work mainly at Aspendale and is lecturing on oceanography at the University of Melbourne.

Members of the Division are giving a course of lectures on micrometeorology in the Department of Agriculture, University of Melbourne, in June and July.

II DYNAMIC METEOROLOGY

There is a pressing need in meteorology to know the effects of heating on flow patterns and many so far unexplained phenomena on the largest scale, such as monsoons and the details of seasonal behaviour, depend on these effects. The distribution over the Southern hemisphere of the summer heating of the air below 10,000 feet is being mapped, as the first step in assessing the influence of the Australian continent on the whole flow.

Strongly stratified air is common over Australia and gives rise to a variety of associated problems. It is strongly affected by orography, and the structure of lee waves, which can become a flying hazard, is under experimental investigation in collaboration with the University of Melbourne and the R.A.A.F. The theory of Antarctic katabatic (downslope) winds, developed in 1956, has been recently tested and the sudden onset and cessation of wind shown to be similar to the hydraulic jump in an open channel. Another analogy, between the large scale horizontal flow of the mid-troposphere and the vertical perturbations of a stratified fluid, has been found theoretically and opens up prospects of new line of attack on the large scale problem.

A study of jet streams in collaboration with the University of Melbourne revealed areas of negative absolute vorticity associated with strong horizontal and vertical wind shear. A year's statistics were built up on the distribution of the jet axis in Eastern Australia in space and time.

As an aid towards quantitative rainfall prediction, statistical relationships were derived between frontal passages, upper winds, stability, humidity and daily rainfall for Melbourne in spring. The two most

promising indices were stability and humidity, but much residual variance remained.

Studies of the mechanism of cool changes have continued and a second paper on this work has been completed. Especially for changes occurring in two stages it is necessary to supplement the simple model of the Southern Ocean front. The differential heating between land and sea carries evidence for the formation of a 'coastal front' south of the continent, which influences the weather sequence associated with the change, while the cooling of warm air over water should help to explain the frequently unexpected early arrival of the front. The time of arrival is urgent in connection with bushfire control. Special wind measurements are disclosing unsuspected features in the shape of the wedge of undercutting cold air and further work with improved observing equipment is planned. A marked advance in the theory of fronts has followed from recognition of the effect of surface friction and it may be possible to classify into deep and shallow fronts, and into upsliding or downsliding conditions (the critical factor with regard to rainfall), according to the exact pattern of surface isobars.

A factual study of the incidence of Australian tornadoes and the wind speeds associated with them is nearing completion.

III MICROMETEOROLOGY

Radiation from the sun becomes available for atmospheric processes, in the main, only after absorption at the earth's surface. This energy is passed into the atmosphere by radiative and turbulent transfer of heat, and by evaporation. The exchange of mechanical energy between the atmosphere and the earth is achieved almost entirely by friction at the surface. Weather phenomena on all scales depend ultimately on these exchanges, which in turn are governed by physical processes occurring in the layer of air immediately above the surface. This is therefore a region calling for special study, and a major part of the Division's activity is directed to this purpose.

The principal aim has been, through observations of the fine structure of temperature, water vapour and air motion to elucidate the laws governing the exchange of heat, water vapour and momentum. Specially responsive equipment has had to be developed. The most recent work has

defined the response requirements with some precision, with wind speed, height of observation, and stability the main determining factors, and serves to calibrate the results from earlier measurements.

The study of temperature profiles under conditions of strong convection has been extended to include wind profiles. Simultaneous records of temperature fluctuations at different heights up to 100 feet outline the pattern of motion and deep penetration of the convective elements. The structure of the turbulence is also being examined in respect of velocity and temperature correlations over distances of 50 to 100 feet. These are fundamental background studies with many applications, the transfer problems above, seed and spore dispersal and atmospheric pollution, wind stresses on aircraft and fixed structures.

A mechanical harmonic analyser, designed and built in the Division is now in operation and is being used to examine the spectra of atmosphere turbulence. It has been used in an analysis of gusts likely to be experienced by the radio-telescope structure presently being designed for the Division of Radiophysics.

The instrument developed to provide an accurate, automatic measure of natural evaporation has undergone further extensive trials with satisfactory results. This has encouraged development of a Mark II model which is now well advanced in the design stage. It will embody compactness and comparative simplicity and economy in operation and should go far to meet a pressing need in a wide variety of activities involving a knowledge of the water balance. These, ranging from the purely meteorological to studies in agricultural research, include requirements met in irrigation and water conservation practices.

Investigations directed to evaluating the exchange of energy and the frictional stress between atmosphere and ocean have been continued, the F.R.V. "Derwent Hunter" again having been loaned by the Division of Fisheries for this purpose for three weeks in May 1958. Such studies are essential to a proper understanding of both atmospheric and oceanic behaviour, as is evident from the large sea-to-land ratio over the earth. A body of observations was secured in a wide range of wind speeds which will supplement the results of previous trials. These have shown, inter alia, that the stress exerted by light winds is rather less than had been

thought previously.

IV AGRICULTURAL METEOROLOGY

The instrumentation developed for studying atmospheric turbulence, and the knowledge so gained, find application in a variety of agricultural problems. A small section has been formed to follow up these aspects, with major emphasis on evaporation from growing crops under varying conditions.

Four of the battery of twelve large soil containers (diameter 5'3", depth 4') are now in operation, and measurements are being made of evaporation loss from different bare soils under conditions of plentiful moisture supply. During the coming year it is hoped to complete the installation and include measurement of crop evaporation. Concurrently instrumentation is being set up to provide the micro-meteorological observations necessary to a proper interpretation of the performance of these lysimeters.

Full exploitation of the lysimeters (the first installation of its kind in Australia) will not be possible until each container is provided with its own weighing equipment. The necessary accuracy (one part in fourteen thousand) makes heavy demands on design and accuracy of fabrication. A prototype instrument has been designed and built within the Division's workshop. This machine, a development of one built in England at the National Institute of Agricultural Engineering, is now ready for trial.

Advice and assistance with meteorological aspects of their work have again been given to a number of primary Divisions. For the Division of Plant Industry special equipment has been constructed and a new procedure for measuring evaporation is under test in water balance studies in parts of the upper Snowy Mountains; while a theoretical analysis of the meteorological aspects of the infestation of tobacco leaf by blue mold has been carried out. This has stimulated a new observational programme which extends to the related problem of dew formation.

V RADIATION

To assist researches in progress (e.g. the evaporation investiagation) and also for their intrinsic value, radiation studies have been given more attention.

Continuous recordings have been started of:

1. Total insolation received by a horizontal surface.
2. The sky contribution to 1.
3. The long wave (infra-red) radiation from the atmosphere.
4. The net radiation income of a grass surface.

A new weatherproof radiometer of high sensitivity is under development for radiation balance measurement and is to be employed in a study of the variation of radiative flux with height in the lowest 100 feet at night - a matter of interest in problems of frost prevention, fog formation, etc.

Radiometers have been calibrated for outside bodies and equipment was prepared and calibrated for measurements at Mawson. Battery-operated apparatus for field recording and integration of solar and net radiation has been developed and supplied to the Division of Land Research at Alice Springs.

VI OZONE INVESTIGATIONS

Measurements by the Dobson spectrophotometer of the ozone amount at 20-50 km. height have continued through the year. This investigation is under international auspices. Australian observations are taken at Brisbane by the Bureau of Meteorology, by the Antartic Division (Department of External Affairs) at MacQuarie Island where good results have been obtained in the face of difficult conditions, and at Aspendale by this Division, who are responsible for the co-ordination and interpretation of results. The locations were chosen with the requirements of the International Geophysical Year in mind. Local variations may be related to the weather situation while, more generally, the results are of significance in the radiation balance and indirectly for health reasons, while their evidence on the general circulation at high levels assumes a new importance from the question of global distribution of the radioactivity from nuclear explosions.

VII MISCELLANEOUS

As a further contribution to the International Geophysical Year, the amount of radioactivity in precipitation is being determined in Melbourne and environs. Chief interest lies in the activity from long lived isotopes and monthly samples are being collected from four stations.

A calibration service for anemometers is provided for outside

bodies and the laboratory is now registered with the National Association of Testing Authorities for such work. Among other physical apparatus designed for research in the Primary Divisions, work is on hand on a single pen recorder for recording water levels, rainfall, temperature, or humidity for up to twelve months unattended. The instrument is intended to be comparatively inexpensive and of low installation cost for operation in remote areas.

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