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COMMONWEALTH SCIENTIFIC AND INDUSTRIAL RESEARCH ORGANIZATION

DIVISION OF METEOROLOGICAL PHYSICS

ANNUAL REPORT

FOR THE YEAR

1959-60

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I GENERAL

It is hard to think of any phase of human activity which is not in some way dependent on weather and climate. Meteorology as a public utility provides an increasing number and variety of services, and their increasing effectiveness is built on a foundation of basic research into many physical processes which still await clarification and solution. The work of the Division is directed towards a better understanding of the behaviour of the atmosphere, embracing selected problems ranging from the largest scale, which underlies the seasonal and world-wide variations in weather, to the smallest, or micro-meteorological, scale wherein lie many avenues for research affecting the growth and health of plants and animals.

The wider implications of the work outside the normal boundaries of meteorology are reflected in the representation of the Division on the National Committees for Oceanography, Hydrology, Antarctic, and Space Research. In the international sphere there has been work associated with the activities of the World Meteorological Organization, the International Association of Meteorology and Atmospheric Physics, the International Ozone Commission, and the International Antarctic Analysis Centre, and also UNESCO and FAO.

Nearly all meteorological research is of a long-term nature so that the pattern of study changes and matures only rather slowly. There have been no major changes in the main areas of investigation or of staff during the year reported herein. The construction of the radar tower is now completed at Aspendale and the installation of the electronic units has begun.

II DYNAMIC METEOROLOGY

The general circulation of the atmosphere is maintained by sources and sinks of energy located mainly in the tropics and the polar regions. Australia's geographical position requires a thorough understanding of, and is well suited for exploring, the dynamic

influences of both the Antarctic sink and the tropical source regions. Availability of observational, especially IGY, data, has been awaited in order to continue the earlier work on the nature of interactions in the general circulation as reported in three papers at the Symposium of Antarctic Meteorology in 1959 and elsewhere.

Meanwhile an assessment of the input of the several forms of energy in the layer from the ground to 10,000 feet has been completed for the Southern Hemisphere north of 65° lat. in January, as a preliminary to an attempted evaluation of effects on large scale motions, especially that of the heating due to the Australian continent.

Anomalies due to heating and cooling of the Australian and Asian continents, respectively, affect markedly the monsoons in the eastern hemisphere during Southern summer. An assessment has been made of angular momentum balance for the equatorial trough zone, from a consideration of frictional torque of the monsoonal westerlies, zonal and meridional stresses. This study is a prerequisite to exploring causes of variations in the onset of monsoon rain regimes, its abruptness and subsequent pulsations. Vertical and horizontal distribution of easterly winds in the upper troposphere at low latitudes is found to be a decisive factor in the mean and eddy transfers of angular momentum (vorticity) and thereby in changes of the monsoonal circulation.

Alongside these physical investigations, some empirical studies of long-period changes have continued, stimulated in particular by discoveries concerning effects of solar particles on various geophysical and astronomical phenomena. It has been known, for instance, that tropical surface temperature responds to the eleven year solar cycle; it is now found that this response has undergone slow change, most marked around 1920, presumably due to secular changes of the tropical circulation.

On a smaller scale of phenomena, heating and turbulence, especially by their diurnal variations, strongly influence the behaviour of sea breezes and synoptic scale cold fronts. Observations on frontal structure from the Renmark expedition in January 1959 have demonstrated,

near the forward portions of such fronts, oscillations and circulations of considerable magnitude and of a period corresponding to that of the multiple disturbances often noticed at the ground. This sheds new light on the development of squall lines and pressure jumps. Resumed field work employing an aircraft and quick response equipment for measuring temperature and wind components should consolidate these studies and provide new information on the transfers of heat and momentum between the warm and cold air.

The broad features of the fronts studied so far agree well with the theoretical predictions from a consideration of frontal shapes in relation to surface stress (ground friction). This theory has been extended to take account of mass transfer through the front. Solutions were obtained representing damped oscillations and a series of gusts accompanied by pressure jumps.

Attempts are being made to assess eddy shearing stress by means of serial balloon flights simultaneously with micro-meteorological measurement of surface stress under conditions of strong wind.

An instrument consisting of a modified radiosonde attached to a kite is being developed for measuring the detailed profiles of temperature and wind up to 2000 feet. A first model is at present on trial at Mawson by personnel of the Commonwealth Bureau of Meteorology, and improved equipment is being constructed for use in 1961. It is hoped to obtain information on the structure of the katabatic winds during these trials.

Following a request from the R.A.A.F., estimates were made of the average relationship between surface winds and winds at 1500, 3000 and 5000 feet, over the oceans within 1000 miles of the continent. This was required for estimation of surface winds from aircraft, to correct drifts observed by Doppler radar navigation.

III MICROMETEOROLOGY

Micrometeorology is the study of conditions in the air layers close to the ground, as determined largely by turbulence and radiation processes. Its scientific significance and practical importance to Australia through impact on agricultural science have been described in previous annual reports. The process of evaporation in

particular becomes an economic problem wherever restricted supply demands efficient water usage.

Specialised equipment to measure and record the evaporation from natural surfaces has been developed (the 'Evapotron'). This instrument comprises a suitably sensitive anemometer and hygrometer, the outputs from which are combined electronically on the eddy-flux principle to yield the evaporation as a dial reading on a meter. The present year has seen the successful completion of the proving field tests of the prototype instrument, short-period evaporation over open grassland being directly measured to an accuracy of a few per cent. A transistorised version, which is simpler and portable, has been constructed and is due to begin field trials. It is hoped that this model will provide the basis for ultimate commercial production of the 'Evapotron'.

Though designed specially for evaporation measurement, the instrument is readily modified to provide values of heat and water vapour flux for more fundamental studies of the mechanism of turbulent transfer. It has been so used during the past summer, with concurrent measurements of the detailed profiles of the relevant meteorological elements. This large body of data is now undergoing analysis.

Studies of temperature and wind profiles under varying degrees of atmospheric stability have continued. An analysis of the magnitude of temperature fluctuations as a function of height, wind speed, and stability has been completed.

In this Division and elsewhere a new approach has been developed to the problem of the estimation of the turbulent transfer of heat, water vapour and momentum. This is by way of structure functions, and preliminary assessment of the transfers by such methods show satisfactory results. The new technique promises to be much more suited to shipboard use than others now available.

The investigation on evaluation of evaporation from Lake Eucumbene has been brought to a satisfactory conclusion with the completion of the full analysis of the experimental data. Considerable confidence in the bulk aerodynamic method, recommended for routine use, is provided by the concordant results obtained from two independent methods, based on the heat budget and profiles respectively.

The construction of equipment for transferring turbulence records or other data in analogue form to digital form on punched paper tape is now almost complete. Special studies of turbulence and gust structure have been carried through for the Army Design Establishment and Weapons Research Establishment.

IV METEOROLOGY FOR AGRICULTURE

This year has seen the installation of the last two of the battery of twelve lysimeters which has been set up to study the evaporation from different crops and soils under varying atmospheric and water supply conditions. Each lysimeter, a large concrete pot containing soil or water, sunk flush with the ground, weighs approximately six tons, and the water loss is to be measured by automatic balances. These balances have been designed and are being built in the Division's workshop. Four such instruments, which are capable of detecting a loss of 0.001 inch of water, have now been completed and tested.

Early results from balances already in use have demonstrated the need for corrections to the values of evaporation obtained from the common lysimetric technique (water input minus drainage) on which many previous conclusions have been based. Such errors may be significant for monthly and dominant for weekly periods, but the results from weighings and improved techniques of working up the data can overcome them. The analysis of the first full year of observations allows values to be tentatively assigned to the relative evaporation rates from water, bare soil, and short grass. A reasonably satisfactory degree of uniformity of 'evaporative power' (including wind speed, temperature, and humidity) is being indicated from a continuing survey over the lysimeter site.

The investigation into the meteorological conditions associated with the infestation of tobacco crops by blue mould has been continued at Ovens, Victoria and at Mareeba, Queensland in cooperation with the Victorian Department of Agriculture and C.S.I.R.O. Division of Plant Industry respectively. The results are consistent with the indications of the previous season's work, that the incidence of

conditions critical for the sporulation of the mould are related to atmospheric conditions around the crop. The study of the onset of dew deposition on a freely exposed lamina, a related problem, has been continued. A grant received from the Central Tobacco Advisory Committee for use in 1960-61 will provide for improvement in instrumentation during the next season.

During the summer an investigation into the relationship of water loss from drying hay with meteorological conditions was undertaken in collaboration with the Fodder Conservation Section. Analysis of the observations is still in progress.

Irrigation is an accepted method of alleviating or preventing frost damage, but little quantitative work has previously been done on the effect. Comparative trials using various intensities of irrigation and measuring the response in air temperature were conducted in vineyards in the Merbein area in cooperation with the Commonwealth Research Station, Merbein, and the State Rivers and Water Supply Commission. The investigation will continue next spring.

A portable instrument to measure the amount of dew on natural grass is under development.

Construction of equipment, and general assistance and advice in micro-meteorological problems have been provided to other bodies, in particular to the Divisions of Plant Industry and Land Research and Regional Survey, C.S.I.R.O., and the Horticultural Research Farm, Scoresby, Victoria.

V RADIATION

The net radiometer previously reported, and now in commercial production, has been employed in further studies of the night cooling under clear skies of the first few metres of air above the ground. The investigation emphasises the importance of radiative cooling of the air in the early stages of the formation of the nocturnal inversion, with application to the development of fogs and frost. It has revealed appreciable errors in standard radiation charts, due probably to under-estimation of the absorptivities of water vapour used in their construction.

The recording of net, global and diffuse radiation has been continued at Aspendale, and at Deniliquin and Alice Springs in cooperation with the Divisions of Plant Industry and Land Research and Regional Survey respectively. These measurements have shown that Budyko's Atlas of Heat Balance substantially under-estimates net and global radiation in the Southern Australian region. Observations have been continued at Mawson in collaboration with A.N.A.R.E. and the Bureau of Meteorology.

A sensitive and simple electro-mechanical integrator has been developed and will be manufactured under licence. This instrument, though designed specifically for use with the net radiometer, is suitable for the integration of signals in the mV range from other types of equipment.

VI OZONE

Ozone measurements for collation in the global network inaugurated for the IGY have been continued at Aspendale, and in collaboration with the Commonwealth Meteorological Bureau at Brisbane. The instrument lost by fire at Macquarie Island will be replaced during the coming year, but its location remains to be decided.

A new absolute method has been developed for calibrating the wedges of the Dobson ozone spectrophotometer. Besides being quick and easy to apply, this new technique is more accurate than that formerly used.

VII MISCELLANEOUS

A strip chart recorder for long period operation has been designed and a prototype instrument has successfully completed 15 months of field trials. This instrument is capable of operating unattended for periods up to 12 months and is intended for use in remote areas where it can provide records of river level, rainfall, temperature etc. according to the type of sensing element coupled to it. A considerable amount of interest has been evoked by its possibilities, particularly amongst water supply authorities. The results of the preliminary trials indicate

that the recorder represents a major improvement over existing instruments in low cost installation while at the same time competing favourably in simplicity of design, ease of servicing by unit replacement in the field, linear scale with straight time ordinates, accurate time check of chart rate and freedom from undesirable characteristics such as ambient temperature effects. The recorder has been patented and commercial production of a limited number (12) is nearly complete. These are being purchased by interested authorities who have agreed to cooperate in a period of further operational testing and assessment before unrestricted commercial manufacture is approved.

Measurements of the radio-activity of rain water have been continued at Aspendale. They have provided particularly valuable information on the world-wide problem as to how the debris, projected into the stratosphere at the explosion site, travels and spreads before finally falling to earth. The radio-active stratospheric clouds suffer only limited dispersion and retain their identity for several months. Evidence has been obtained of a poleward drift at stratospheric heights of order 1 m/sec.

Instruments embodying the transistor operated cup anemometer referred to in the last report have now been supplied to the Division of Plant Industry, the Tobacco Research Institute, and the State Electricity Commission.

An instrument to measure temperatures in ice boreholes is being developed for the Antarctic Division and the Meteorology Department, University of Melbourne; this will allow assessment of temperature gradients and the associated heat flows, important to the ice balance of the Antarctic continent.

Some special radiation and climatic studies were made for Mt. Stromlo observatory to aid the search for new observatory sites.

Calibration services for anemometers and radiation instruments were maintained for outside users.

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