DIVISION OF

METEOROLOGICAL PHYSICS

ANNUAL REPORT

1970-71

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Division of Meteorological Physics

Commonwealth Scientific and Industrial

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I INTRODUCTION

Since its inception in 1946 the broad aim of the Division has been a fuller understanding of the fundamental physical processes which underly weather and climate. A major field of study has been micrometeorology, i.e. the relatively small-scale processes which transfer heat, water vapour and momentum between the earth's surface and the air layers immediately above it, and which, together with radiation control the climate. Large-scale atmospheric dynamics has also been well to the fore as this is at the heart of the weather process. Agricultural meteorology - essentially a sub-division of micro-meteorology dealing with the interaction of plant and environment and including evaporation (the latter of particular interest in Australia) has an obvious place in the Division's program, as also has atmospheric and terrestrial radiation since solar radiation is of course the ultimate source of energy for the weather process.

For the first decade or so the period was one of initial growth and consolidation: little was it then realised how much of an impact on meteorology the coming satellites and high speed computers were to have. Indeed, it is solely a result of the latter that numerical models of the atmosphere became a practical reality.

In the mid-1960's a 5 year plan for a modest expansion in the Division's strength was initiated whilst later in 1969 the Commonwealth Meteorology Research Centre came into existence. The latter, with its own offices in Melbourne, is jointly operated by the Commonwealth Bureau of Meteorology

and this Division, and is concerned largely with the development of numerical models of the atmosphere on a global scale.

This development in its turn has re-focused attention on certain areas of atmospheric physics which are essential to a proper numerical modelling of the general circulation but need to be incorporated in more quantitative terms than present knowledge permits. Two such areas which now call for increased experimental effort are atmospheric radiation, particularly radiation properties of clouds, and air-sea interaction. The Division, with its expertise in micrometeorological experiments over land, is well poised to step up its work on the latter. One of the practical difficulties is a stable platform from which to work.

A further development during the year is the initiation of laboratory model work in density-stratified fluid tanks simulating a variety of atmospheric and also oceanic phenomena.

As a result of organisational changes, this Division has, from July 1, 1971, been re-named the "Division of Atmospheric Physics".

II DYNAMICAL AND SYNOPTIC METEOROLOGY

The Boundary Layer

The atmospheric boundary layer continues to present a variety of challenging problems in fluid dynamics, radiation, and convective energy transfer. Here, in a relatively shallow layer 1 Km thick, a variety of processes such as surface heating and cooling, radiation balance, varieties in wind speed and direction and temperature (in the horizontal and vertical), mechanical effects of surface irregularities (waves and trees) go to control the weather and climate. Such studies even contribute, to a major degree, to a better overall understanding

of atmospheric processes on the global scale, as well as to more local problems of accummulation and dispersal of pollutants in industrial areas.

Results from the 1967 Wangara expedition to Hay, N.S.W., have confirmed that present theories enable us to model the behaviour of the boundary layer over land with considerable success. The nocturnal wind maximum occurring about midnight, the diurnal variation in wind direction, changes in surface stress, exchange of heat and water vapour with the surface are all reproduced - though with some discrepancies. There is, for instance, a tendency for the model to lead the real atmosphere by 1-3 hours in the diurnal cycle and, in general, to provide insufficient turning of the wind with height. Although, for many purposes the differences involved are acceptably small, it is expected that further work will reveal the reasons for them.

A valuable approach to boundary layer problems is a spectral analysis of the three components of wind flow and temperature. With the use of Wangara data it has been found that in the so-called 'meso-scale' range (periods between 2 and 24 hours), the energy of the horizontal components of wind speed (F_u, F_v) varies with frequency (n) according to

$$\left.\begin{matrix} F_u \\ F_v \end{matrix}\right\} \alpha \; n^{-2.4}$$

It is also deduced that the vertical component of the wind, which is much smaller, probably follows a similar law.

The analysis also supports the idea of a spectral gap, at periods of 1-2 hours in which turbulent energy is at a minimum. One of the implications of this work is, that the meso-scale turbulence up to a height of about 1 Km does not obey simple laws such as 2 or 3 dimensional isotropy or symmetry about a vertical axis.

In order to achieve computational stability in numerical models of the atmosphere it is necessary to incorporate a means of extracting energy from the smaller scales of motion. Using Wangara data, we are attempting - for what appears to be the first time - to estimate three dimensional stresses and thus removal of energy from the real atmosphere, on scales too small to be resolved by present numerical models.

Another aspect of the spectra is a pronounced increase in energy at a period of about 21 hours (the inertial period for Hay) arising from the earth's rotation. The northward velocity maximum is observed to follow the eastward by about a quarter of this period, as would be expected from simple inertial considerations. The vertical velocity, on the other hand, has a diurnal component, with a maximum tending to occur in the middle of the day.

Eddies with periods extending from about one day to 2 weeks convey eastward and southward momentum upwards, while the meso-scales contribute very little to momentum transfer. Above the lowest 100 metres or so, the micro-scale contribution (periods less than 2 hours) was also found to be rather small.

The implication, if these conclusions are of general validity, is that a large scale vertical circulation (the Ferrel cell) must exist to transfer momentum downward in the west wind belts. It is indirect (i.e. it takes kinetic energy out of the atmosphere), and in such a sense that mean ascent occurs at about latitude 60 degrees, and descent at about latitude 30 degrees.

Laboratory Atmospheric Models

In February 1971, work was started on the development of facilities for the dynamical simulation of atmospheric phenomena in the laboratory. The medium used is water, with common salt added to provide the density variations created thermally in the atmosphere.

Equipment has been built for the preparation of large quantities of water with controlled salinity; 100 gallons or more of linear or exponential stratification being produced automatically within an hour or two. A miniature thermistor probe has been developed for the accurate measurement of velocities down to 2 mm/sec.

Specific problems now being tackled relate to the transfer of momentum and energy within fluids of varying stratification, including explanations for their observed microstructure. Interconnected studies of the behaviour of broad-based plumes (of relevance to the dynamics of cumulous clouds) are planned to run in parallel.

Internal Wave Breaking. There are distinctive differences between the behaviour of waves on surfaces separating fluids of different densities, and 'internal' waves within a medium the potential temperature of which increases continuously with height. Most of the atmosphere is stably stratified, and uniformly distributed mixing would make the temperature variation within it continuous. Internal waves are transmitted upwards from ground features or regions of local convection. Their role in the large scale transfer of momentum and the distribution of energy (and hence the form of the stratification itself), as well as in smaller scale phenomena such as clear air turbulence, is recognized as important but is far from being completely understood.

The present program is to examine the details of transfer processes by creating in the laboratory, wave fields well described by theoretical analysis. When experimental conditions leading to accelerated energy dissipation and 'mixing' are attained, the kinematical parameters defining these conditions may then be accurately estimated.

In the first stage of the investigation simple standing waves are forced continuously within a linearly stratified salt solution in a rectangular tank. Visible distortion of the field

was found to be initiated by the growth of pairs of free wave modes in resonant interaction with the forced wave. Conditions of frequency amplitude and viscosity for this degeneration process to occur were found to be in excellent agreement with theoretical prediction. Such interactive instability is believed to be an ubiquitous feature in internal wave fields. Work is continuing to verify theoretically predicted evolution and limit states of the energy exchange process.

With a view to simplifying the kinematic field description, a study was made of the region of interaction of two internal wave beams radiating from discrete sources of different frequencies. It appears that irreversible distortion is accomplished when constant density surfaces experience rotations greater than 90^{o} from the horizontal. Interaction between a pair of waves produces a profound non-linear effect, so that traumatic conditions may be attained though the waves individually are weak. For each of the above cases, the Richardson number (the conventional parameter for stability of stratified motions) is not critical.

A stepped profile of temperature is frequently observed in the atmosphere. In the laboratory such a profile can be produced by creating a stratification using two solutes, one of which is unstably stratified. Preliminary investigations have shown that internal wave energy dissipation is greatly increased in such media. Work is continuing to verify theoretical estimates of the increase.

Large-Scale Prediction Experiments

In the Southern Hemisphere forecasting the weather is made even more difficult than elsewhere by the lack of conventional soundings of the atmosphere - which number only 1/6th of those in the northern half of the globe. However, encouraging results have been obtained from a collaborative venture between ourselves and the Geophysical Fluid Dynamics Laboratory, Princeton, N.J. A numerical

model, set up on a computer has been used to predict the movement of weather map systems (in the form of surface pressure changes) over periods of 24 and 48 hours with correlations of 89% and 78% respectively. Predicting rainfall amount, recognized as being much more difficult, was less successful but still achieved a 60% correlation over a 24-hour period. These figures auger well for the future of the Commonwealth Meteorology Research Centre, where much more extensive work of this kind is being carried out.

Again in collaboration with the Princeton laboratory, an evaluation has been made of the effect of an increasingly sophisticated treatment of the boundary layer on such models. The results show that the differences between the least and most complex models were almost insignificant up to about 7 days but became large after 10 days. In other words, for longer-term forecasting a good knowledge of the boundary layer is important.

Radar Meteorology

Radar has long been a useful tool for studying certain types of atmospheric phenomena - usually the hydrometeors associated with convection activity (precipitating cloud systems). However, the last few years have seen the use of 10 cm radar to investigate the so-called 'anomalous' echoes from visually clear skies. Dry cool changes with which such echoes are often associated, have been so examined in the Melbourne area and the echoes attributed to atmospheric inhomogeneities of water vapour and temperature. The work is to be extended using a 3 cm radar (instead of the 10 cm) which will permit the phenomenon to be looked at in greater detail.

Ice crystal fall-out from cumulo nimbus anvils, referred to last year, has again been the subject of an expedition. Based on Brisbane, Queensland, and in co-operation with the C.S.I.R.O. Division of Radio Physics and the Commonwealth Bureau of Meteorology, an aircraft was used to collect samples of ice crystals, the

observations being timed to coincide with those being made from a nearby 10 cm radar. Interest in such work stems from the possibility of ice crystals being an important source of condensation nucleii for adjacent developing storms.

General

Local storms of tornado severity, though rare, occur in parts of Australia and New Zealand with a frequency apparently surpassed only by those of the U. S. A. The origin of the tornado vortex is not yet fully understood, but it may lie in the electrical processes of the thunderstorm which it accompanies. A study is being made of the formation of a vortex sink generated by ohmic heating in certain types of lightning discharge. This electrical heating hypothesis, put forward by other workers, is being extended to allow for the effects of both the self-induced and geomagnetic fields. A rigorous theoretical treatment is still awaited and it is hoped that an explanation of the association between global features of tornado frequency and the geomagnetic field will emerge.

The weather of a large part of the Australian coastline, especially in Summer, is dominated by sea-breeze effects which can be important in the generation of thunderstorms and the dispersion of pollutants. Since the sea-breeze is largely a boundary layer phenomenon, the fairly successful methods which have been developed for treating this layer in dynamical studies, open up the possibility of modelling sea-breezes in some detail. This is now being done, particular attention being paid to topographical effects and the inland penetration of coastal wind regimes. A simplified version of this model has also been used to take a closer look at the circumstances concerning nocturnal radiation reversal - when more radiation is received from cloud or fog than is emitted from the earth's surface. It is shown that even if the cloud is quite high (up to 3 Km), reversal can occur when a strong pressure gradient advects warm dry air over a moist surface.

Workers on numerical modelling of the atmosphere need to know the rates at which heat and water vapour are supplied at the Earth's surface. Over the land, on a scale of some hundreds of kilometres, (though not over the oceans) the total of these two is very strongly controlled by the local net radiation. Since net radiation measurements are becoming more common, it is of particular interest to know how the energy thus supplied is divided between sensible and latent heat fluxes into the atmosphere. Work in this context, referred to last year has been carried a stage further with the analysis of three more sets of independent data. All the evidence points to the fact that, ignoring advection, (which is usually justified on the scale mentioned above) the evaporation (E) from a saturated surface is directly related to the net radiation (R_N) by

$$E = \alpha R_N ,$$

where α depends solely on surface temperature. This result of course, is also of value to those engaged in evaporation studies in relation to agriculture or hydrology. Some progress has also been made with the problem of estimating the reduced rate of evaporation as the surface dries out.

In Section VI, 'The Upper Atmosphere', a reference is made to a correlation between the mean seasonal latitude of the high pressure belt (L) off the east coast of Australia and ozone amount. Also related to L is the rainfall in certain parts of the area. Significant negative correlations have been found along the southern coast of Australia and in Tasmania and equally significant positive ones down the east coast of Australia. These relationships are not localised: e.g. they hold also in the Chile region. Such associations could play a useful part in the design and evaluation of local weather modification experiments and also in climatic changes such as might be induced by large scale atmospheric pollution. This work is being extended

to include different longitudes and individual stations.

The collection of statistics on shower activity in southern Victoria continues: the object is to relate radio-sonde and wind data to areal frequency of rain echoes and their height.

Two members of the Division recently assisted the Division of Entomology in a field expedition connected with locust infestation. They gave help in the maintenance and operation of a mobile 3cm radar and in meteorological observations, particularly the measurement of upper winds. Although the main purpose of the radar was to track locusts, many of the patterns displayed on the radar screen were of considerable meteorological interest. For instance, distinct cellular patterns were seen by day, and moving line echoes by night, the latter suggestive of propagating hydraulic jumps.

III RADIATION - ATMOSPHERIC & TERRESTRIAL

At one time the radiation reaching the earth's surface was generally observed merely as hours of sunshine obtained by reference to a burnt trace on a piece of cardboard. Since then, the years have seen increasing requirement for pyranometers providing a measure of the energy of the radiation and more recently, a further sophistication, in the sub-division of the energy into wavelength bands, e.g. the ultra-violet (connected with skin cancer and the weathering of materials) and the photosynthetic wavelengths (related to plant growth). With increasing emphasis on atmospheric quality and the presence of trace gases etc., which absorb selectively, a further elaboration of this trend in the future is certain.

As solar radiation is the source of energy for the whole weather process, much more detailed knowledge of radiative budgets is needed, not only for the surface, but for upper atmospheric levels as

well. To enable numerical forecasting to extend its range beyond two or three days, it is particularly important that radiative processes should be incorporated in the mathematical models in the form of suitably simple approximate formulations which accordingly need to be developed in the light of further observational and theoretical studies.

Governed by these sorts of considerations the radiation section has developed into two groups: one devoted to the routine measurement of the main radiation quantities at ground level, together with improvement of calibration techniques and standards, and the other to fundamental research orientated towards current problems involving the atmosphere in depth.

Emissivity of Clouds:

There has been another joint program with the Physics Department of the University of Adelaide: observations of cirrus clouds were made simultaneously with the University's pulsed laser (Lidar) and our radiation thermometer. A great diversity of cirrus was investigated and numerous measurements of thickness, density and infra-red emissivity of the clouds obtained. As found earlier there was considerable variation in cirrus density but notably less in thickness. The emissivity of the clouds was found to correlate quite well with the total scattered radiation returned to the laser receiver. In the case of alto-cumulus at middle levels the emissivity/backscatter ratio was very different - indicating a different cloud micro-structure. Work is continuing on the interpretation of these results.

The average zenith emissivity of cirrus was found to be 0.28 and that of alto-cumulus 0.50. These emissivities lie within the range of values obtained in two American studies. One set of results from Barbados indicated highly emissive clouds whilst the other (from flights over the U.S.A.) indicated lower emissivity. Our values are

generally closer to the U.S.A. results - with one exception. On one particular day, immediately after the passage of a front, our cirrus emissivity agreed with the Barbados figure. Since the properties of a cloud will obviously depend on its height, temperature, available water content and origin the question then arises, what is the importance of these variables separately to cirrus development? As a start it is proposed to examine the infra-red data in both the 11.5μm (window) and 6.7 μm (water vapour) bands as given by the Nimbus 4 satellite and attempt to relate the origins of the cirrus observed at Adelaide with synoptic features.

Radiative Properties of Cloud

As part of an overall investigation of the radiative properties of cloud a 3-week airborne expedition was made to Cairns. A D.C.3 aircraft was fitted with instruments to measure both the upward and downward fluxes of 'short-wave' (0.2 - 2μm) and 'long-wave' (2 - 200μm) radiation, as well as the upward infra-red radiation at 11μm. The latter wave-length is of great significance in remote sensing of the atmosphere since it is not absorbed by atmospheric water vapour and so can be used, for instance, to measure cloud and surface temperature from satellites.

The work yielded a body of data on the radiative characteristics of trade-wind strato-cumulus. It was found that such cloud was not nearly so absorptive (black) to long-wave radiation as previously assumed. Further, it appears likely that their blackness can be related, with sufficient accuracy to either their thickness, or visible reflectivity.

Water Vapour Absorption Under Clear Skies: At 10-12μm absorption of water vapour in a clear atmosphere has been found to be greater than previously thought - at times twice as great. This is thought to be due to an interaction between water vapour molecules at high water vapour pressures. In fact, the measured water vapour coefficient did

correlate with water vapour pressure: however, it was also correlated with temperature and due to the strong vapour pressure - temperature correlation, the separate dependencies were hard to unravel. Measurements of clear sky emission in the zenith have also been made over the last year. Water vapour absorption coefficients derived from this data agree well with the Cairns values.

These results have been used to make better corrections to satellite surface temperature measurements. In most tropical atmospheres, for example, the correction should be considerably greater than the currently accepted value. It is planned shortly to examine sea surface temperatures obtained by satellite (from 11.5μm measurements) with the normal ship's bucket values.

Large-Scale Surface Albedo

It has been discovered that the surface albedo (reflection coefficient) of most of the east coast of Australia can be defined, with quite good accuracy, by only two curves of albedo versus solar elevation. That is, the short wave albedo of most of the surface can be equated to that of either dry grassland or eucalypt forest. This is a most useful simplification and of great help in broad scale modelling of the radiation climate of Australia.

Observatory, Calibration and Standards

In organising meteorology on a worldwide scale the World Meteorological Organisation (W.M.O.) divides the globe up into six regions. Australia falls into Region V (the S-W Pacific) and within this region Aspendale is the radiation centre. In this context, and apart from the research aspects - which are referred to earlier in this section - we are principally concerned with the maintenance of a comprehensive Radiation Observatory and the operation of a nationally recognised radiation calibration facility. Every five years, the W.M.O. organises an International Comparison of Regional

Working Standard Pyrheliometers; and this year, the third such occasion, a member of the staff took one of the Division's Ångström pyrheliometers (Å578) to Davos for the comparison. This instrument is the newer of our two Ångström pyrheliometers, both of which represent the 1956 International Pyrheliometric Scale in Region V. To simplify operation, the instrument was used with a specially constructed conductance box which measured and controlled the current. As a result of the comparisons, the calibration constant for Å578 (which had not previously been subjected to an inter-regional check) has been tentatively set at a figure about 1.9% lower than the manufacturer's value and in agreement with that obtained when using our other Ångström (Å502) as a standard.

At the Davos comparisons two different absolute black body radiometers newly developed in U.S.A. were used, in addition to the Ångström and Silver Disc Pyrheliometers. When the results are published it is anticipated that the International Pyrheliometric Scale which is the present standard of short wave radiation will be more firmly based than hitherto.

Routine measurement continued at Aspendale of the six main radiation quantities viz. global, diffuse, net, direct, ultra violet and duration of sunshine, records being maintained in the form of hourly integrated totals.

An improved instrument for measuring global ultra-violet radiation has been developed. This uses a thick (8 mm) hemispherical glass filter and the incoming radiation is 'chopped' at 1 cycle per minute to eliminate spurious signals due to filter heating.

General

A brief account of atmospheric turbidity measurements employing radiation techniques appears under Section V "Quality of the Environment".

Assistance is being given to the University of Melbourne's School of Forestry in the development of a narrow beam short-wave radiometer. The instrument will be used to calibrate areal photographs so that a relationship can be established between reflected solar energy and vegetative type. Later, the equipment will be used at Aspendale for investigating diffuse sky radiation.

An improved form of the magnesium oxide 8.13μm pyrgeometer mentioned in last year's Report has been developed - and shown to work successfully under field trials.

The number of radiometers submitted for calibration during the year was about 390, of which the major proportion were new net pyrradiometers manufactured by the three local licensees of the C.S.I.R.O. patented radiometer. The calibrating facilities are being re-arranged so that all calibration work can be concentrated in one laboratory.

Equipment was lent to the Australian Road Research Board to measure solar radiation as affecting the photo-oxidation of bitumen used in road making.

Assistance has been rendered to the State Electricity Commission by the loan of instruments to study the radiation climate around Westernport Bay and to measure radiation in glasshouses.

The enquiries received during the year were again varied, but the preponderance of those concerning ultra violet radiation and its effects on materials, was even more marked than last year.

IV MICRO-METEOROLOGY

Air-sea Interaction

Until recently, a considerable effort in the

Division has gone into evaluating energy fluxes over the land but less into similar work over the ocean. However the success achieved by fairly simple numerical models of the atmosphere, the economic value of good weather forecasts, the necessity for improved general circulation models and better understanding of climatic trends and changes, are all demanding information on exchange processes over the sea. The Division's experience in flux measurement over the land should ease somewhat the much more difficult problem over the sea.

The 1969 experiment in Bass Strait, in which use was made of the 'Marlin' natural gas platform to measure eddy fluxes of momentum and sensible heat, was successful. Not only did the program verify the feasibility of using our equipment to measure the low heat fluxes which must be expected over the ocean, but it permitted also the evaluation of such parameters as the surface drag coefficient and the bulk transfer coefficient for sensible heat. These are two of the coefficients required to evaluate fluxes from measurements of such quantities as sea surface temperature, air temperature and humidity, and wind speed. As described in the previous Annual Report, the drag coefficients measured at Marlin showed a gradual increase with wind speed.

Following the international comparisons in Russia (described on page 19), equipment was taken to the U.S.A. where, in co-operation with Argonne National Laboratory, a series of measurements were made from the Laboratory's fixed tower in Lake Michigan. The results obtained confirm the general picture derived from the Bass Strait exercise, even though the two situations differ greatly in conditions of fetch and depth, and hence of surface wave structure.

The quality of the data obtained is most reassuring and plans are to continue putting considerable effort into this aspect of our work. Emphasis however will be given to those areas which have so far received insufficient attention, i.e.

conditions of unusually high atmospheric stability and very high wind speeds. The second of these is of great practical importance, since much of the momentum loss of the atmosphere takes place when and where wind speeds are extremely high; for example, in the Roaring Forties belt south of Australia.

A survey of the literature regarding air-sea interaction shows that many workers have relied upon profile information in order to deduce the fluxes. A critical study of this technique shows that large consistent errors can result if conditions are not sufficiently near neutral. For this reason the Division's policy will be to concentrate on the more direct measurement of the eddy fluxes themselves over water surfaces and thus to avoid these sources of possible errors.

Diffusive Adjustment

Often, in practical applications, micro-meteorological measurements must be made with only a limited fetch, e.g. over a lake or irrigated land. In such cases it is desirable and perhaps sometimes essential, to know to what degree the basic flux-profile relationships for a diffusing quantity, e.g. heat or water vapour or a pollutant, fall short of complete adjustment to the underlying surface.

A theoretical treatment of this problem referred to in last year's report, takes account of the important effect of purely molecular (non-turbulent) diffusion in a thin layer adjacent to the surface. At present the treatment is restricted to conditions of near neutral thermal stability.

The solutions contain an integral which converges so slowly that even a computer does not provide numerical values within practical time limits. However, by employing continued fractions, numerical solutions for a wide selection of fetches and heights have now been evaluated.

The theory is concerned with specified changes in the surface value of either, concentration (temperature in the case of heat transfer) or flux. It can be applied to the situation where dry air passes over irrigated land, assuming the sum of the sensible and latent heat fluxes at the surface to remain approximately constant (depending on the net radiation received). When the specified change is in concentration, the flux at the surface is initially very large, decreasing at first rapidly and then more gradually with increasing fetch. Despite the basic difference between this and the case of specified flux, the degree of adjustment becomes roughly the same - that is, at a given fetch, the relative change of flux up to a given height is about the same for the two cases.

The results again emphasize the large fetch/height ratio which is needed to secure close adjustment of flux or gradient to the surface change. For example, over grassland, a fetch/height ratio of 300 gives about 90 percent adjustment, 100 gives about 80 percent, 30 gives about 50 percent. The theoretical results make it possible to estimate the correction to a measured flux to compensate for lack of adjustment, provided only that a supplementary measurement of the flux at a location upwind of the surface change is also available.

An International Comparison

An international field comparison between equipment used for measuring fluxes and gradients in the lower atmosphere was held at Tsimlyansk in Russia during 1970. Those taking part came from the U.S.A., Canada, and Australia; equipment ranged from the relatively simple propeller anemometers and thermistor thermometers favoured by the Australian contingent to relatively recent and more complex sonic apparatus.

Data were evaluated at the site by a spectrum analyser which produced variance and co-variance spectra shortly after the completion of

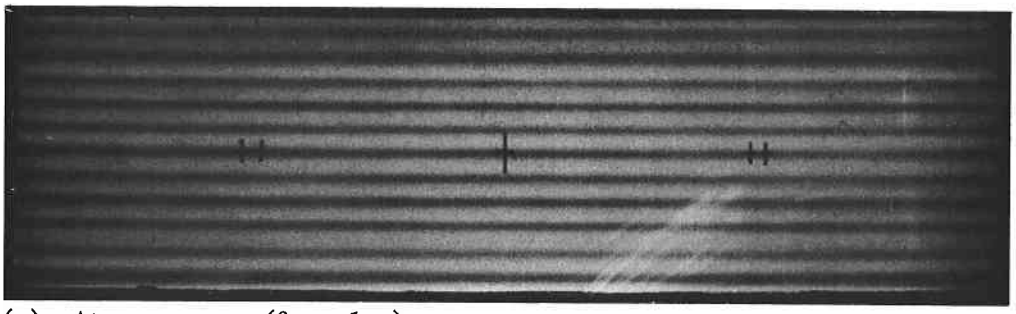
chosen runs. This allowed relatively rapid comparison between the performance characteristics of the various sensors employed. In general, and as must be expected, the mechanical sensors showed a slower speed of response than the sonic equipment.

The eddy fluxes as determined from the mechanical sensors were accordingly lower, but it must be remembered that this type of sensor was not designed to explore the high frequency region of atmospheric turbulence but rather provide the non-specialist with an acceptable and simple means of measuring eddy fluxes. In addition, the flux-carrying spectrum at Tsimlyansk extended more into the high frequency region than had previously been found elsewhere, and it is not yet known whether this is a feature of atmospheric turbulence generally, or is site-dependent.

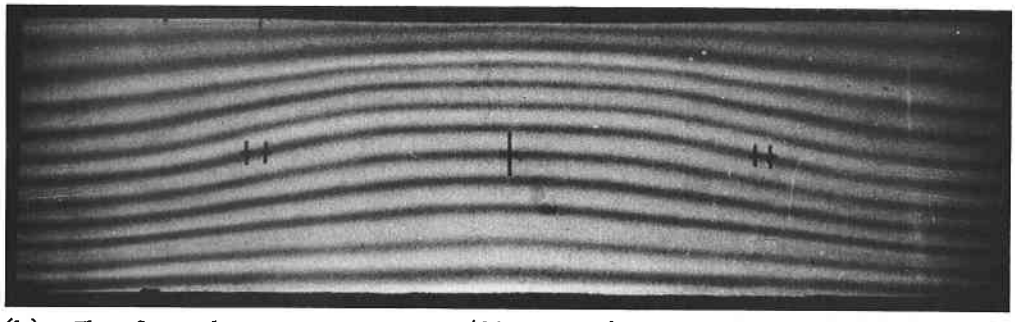
While at Tsimlyansk, the Australian equipment (using two identical instruments) was able to provide a large body of excellent data demonstrating the constancy of the various fluxes both in the vertical and horizontal.

Thermal Convection

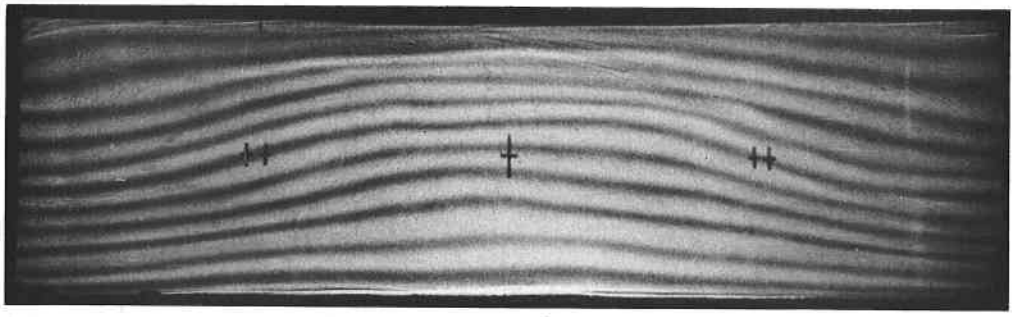
Through thermal convection, vast quantities of heat and water vapour are transported upwards from the earth's surface into the atmosphere. Last year's Report mentioned a series of measurements made in 1970, over flat terrain at Hay, N.S.W., to extend our knowledge of convection; particularly to investigate the nature of the coupling between the surface layer (heights up to 30m or so) and the larger-scale thermals which rise to heights of hundreds or thousands of metres. Quantities recorded include turbulent fluctuations of velocity components, the temperature at several heights up to 32m, and the pattern of surface flow measured by a cross-wind array of seven wind-speed/direction instruments at 100m intervals; the tracks of



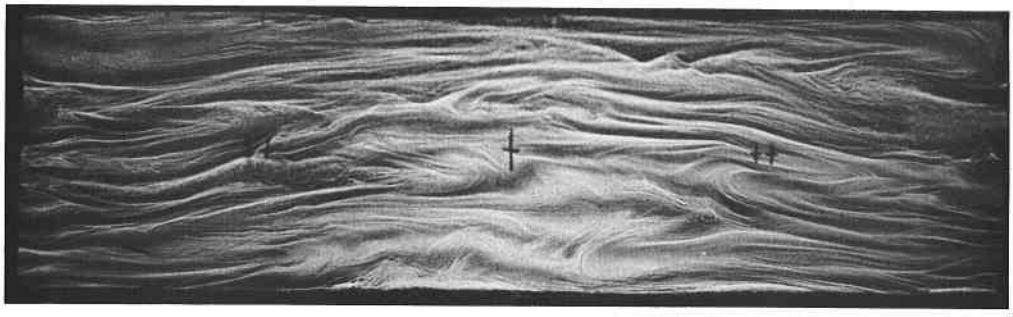
(a) At rest. (0 cycles)



(b) The forced wave grows. (20 cycles)



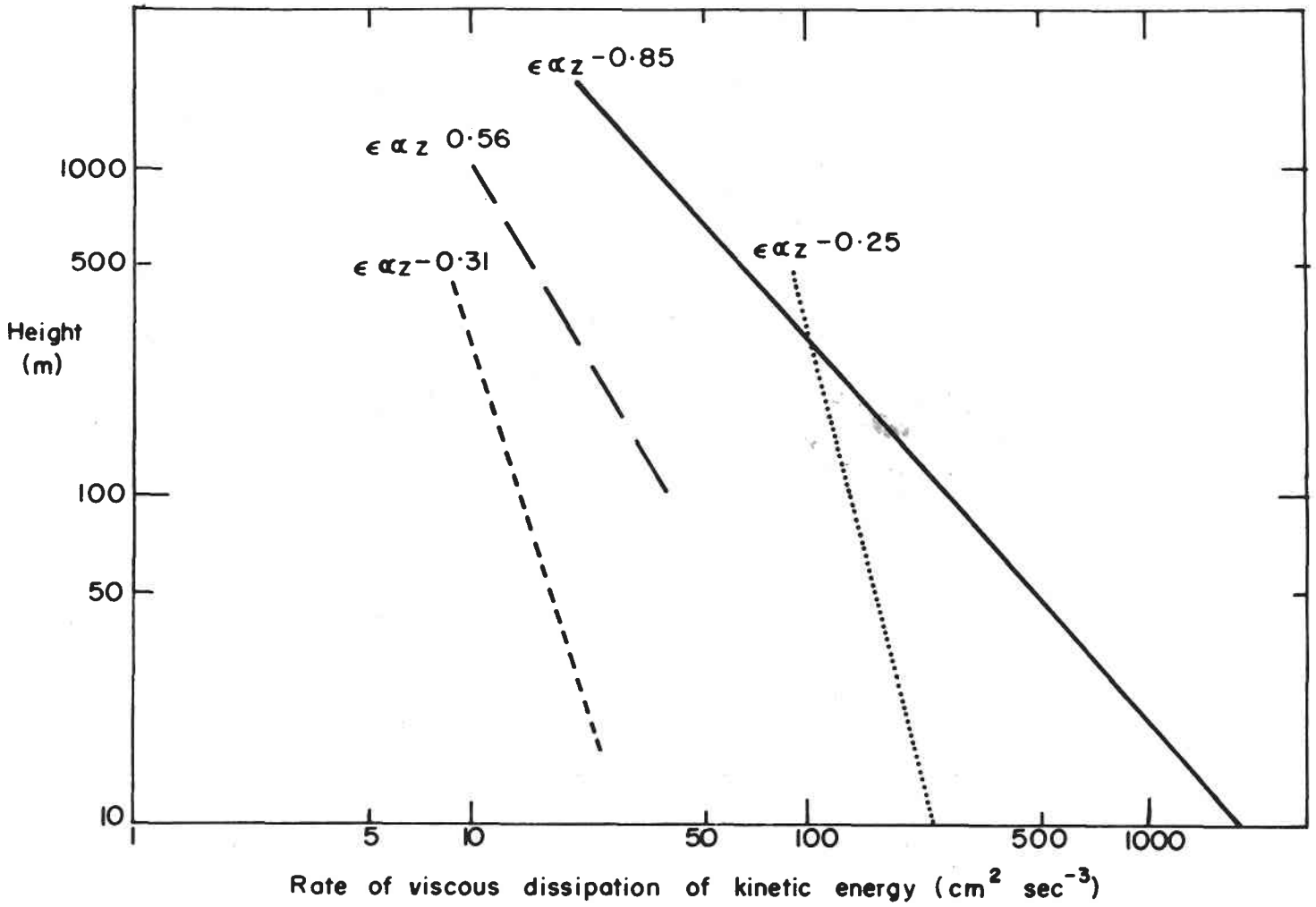
(c) Becomes modulated by interacting waves. (45 cycles)



(d) Till conditions are reached when the stratification is intensified in layers, leading ultimately to turbulence. (65 cycles)

INTERNAL WAVE BREAKING

A standing wave is forced at resonance in a tank filled with linearly stratified salt solution. Dye has been injected in layers during filling. The number of cycles of forcing oscillation are given.


$\epsilon \propto z^{-0.85}$
$\epsilon \propto z^{0.56}$
$\epsilon \propto z^{-0.31}$
$\epsilon \propto z^{-0.25}$
1000
500
100
50
10
Height (m)
5
10
50
100
500
1000
Rate of viscous dissipation of kinetic energy (cm^2 sec^{-3})

thermals were followed using gliders circling at heights of 1000 to 3000 feet.

Extraction of the background data has now been completed. This provides synoptic information, mean wind and temperature profiles, and aircraft temperature soundings (the latter showing inversion heights ranging from 4,500 to 7,500 feet on different days).

Two previously observed peculiarities of strong convection were again often in evidence. One is the sporadic vanishing of the mean potential temperature gradient over heights 16 to 32M for periods of up to several minutes; the other is the intermittent "flat base" behaviour, with the temperature dropping, for intervals of up to a minute or more, to a minimum value quite devoid of the usual fluctuations. The relationship of those and other characteristics, including the pattern of surface flow, to the passage of thermals will be investigated in a detailed analysis now under way.

Structure of Turbulence

The role of turbulence in many atmospheric processes has been emphasised here and in previous annual reports. A useful way of looking at the intensity and structure of turbulence is by means of the viscous dissipation of the (turbulent) kinetic energy. The latter has been evaluated from spectra of vertical velocity measurements made from an aeroplane flying at heights up to 5,000 ft. The analysis, started last year, is now complete, the results appearing graphically opposite page 21. The values obtained agree well with those obtained by other workers except that where dissipation rates are derived from diffusion experiments (as distinct from spectral ones as described above), it appears that the former method may lead to a serious under-estimation of the true value.

Instruments

In numerous past reports there have been

references to the Fluxatron and its use to determine evaporation from natural surfaces as well as drag coefficients at the surface of the sea. The instrument is still an invaluable tool on many expeditions and improvements to it are still being made, particularly in respect of the response time of the sensors themselves, e.g. the vane-mounted propellor is now being replaced by a light-weight anemometer.

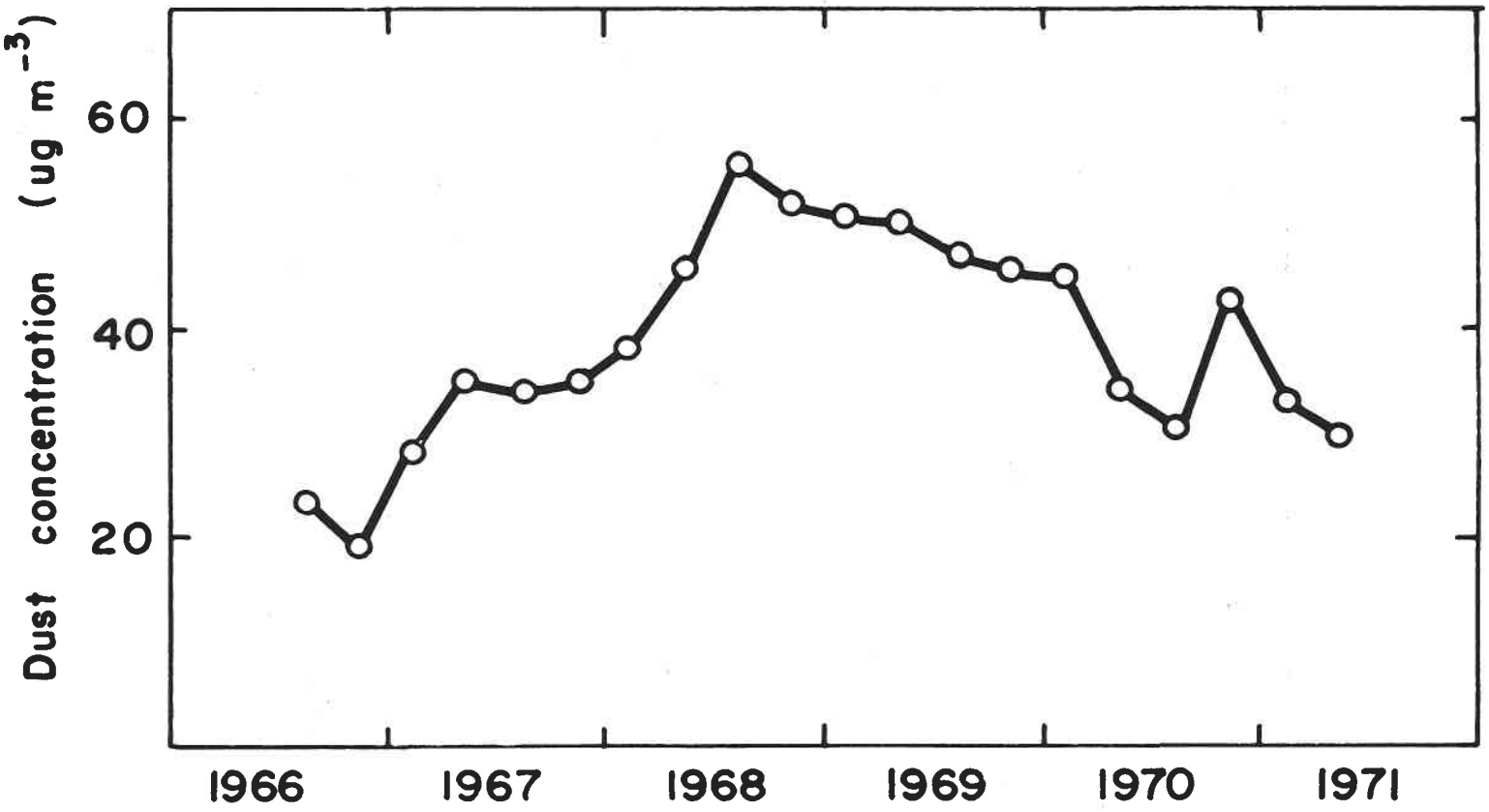
It has long been appreciated that cup anemometers over-run in fluctuating winds, indicating a higher mean wind speed than actually occurs. Few estimates of the amount of overrun are available. An investigation into this effect was conducted, using the cup anemometers which had been used on major field trips in the past. Wind tunnel experiments established the acceleration characteristics of this type of anemometer and, using data from the spectrum of atmospheric turbulence, the percentage overrun in the real atmosphere was calculated to be about 1%.

V QUALITY OF THE ENVIRONMENT

Carbon Dioxide Transfer Between Ocean & Atmosphere

If all the carbon dioxide released into the atmosphere as the result of the burning of fossil fuels remained there, the CO_2 content of the atmosphere would be increasing during the present decade by between 0.2 and 0.3 percent per annum. However American and Swedish monitoring programs are tending to show that only some third of the output is accumulating in the atmosphere, the remainder being taken up by the oceans and probably to a lesser degree by the land biosphere. CO_2 has a strong absorption band in the infra-red region of the spectrum, and an increasing amount in the atmosphere could have important effects on world climate which we cannot yet estimate in full detail. It seems possible that by the end of the century there will be some 30 percent more CO_2 in the atmosphere than in the pre-industrial era. There is

DUST CONCENTRATION IN SURFACE AIR, ASPENDALE



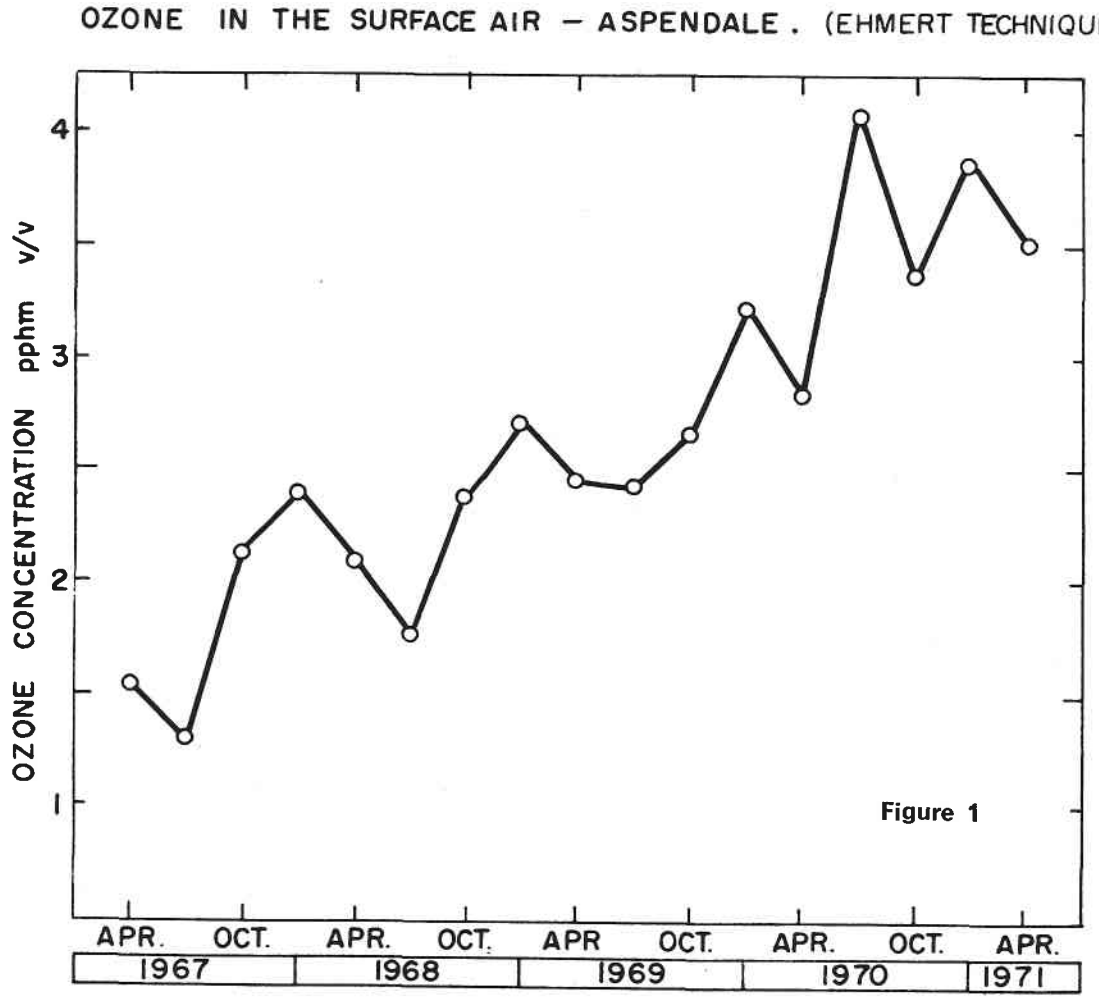

OZONE IN THE SURFACE AIR – ASPENDALE. (EHMERT TECHNIQUE)
OZONE CONCENTRATION pphm v/v
4
3
2
1
APR.
OCT.
APR.
OCT.
APR
OCT.
APR.
OCT.
APR.
1967
1968
1969
1970
1971

Figure 1

a widespread concern to promote more intensive studies of the CO_2 budget of the atmosphere and its detailed effect on global climate.

In recent years the difference in CO_2 partial pressure between the atmosphere and the ocean has been observed during extensive oceanographical voyages of some American and Japanese ships. But hitherto there has been no way of relating these differences to actual fluxes of CO_2 between sea and air in other than a qualitative fashion. A relationship has now been developed which should be applicable to the ocean for light to moderate wind speeds. Strong winds and rough seas present difficulties, as is the case for all air/sea transfer problems.

The treatment developed should also be useful in the study of the transfer of ozone and other gases between air and sea.

Near-Surface Ozone

Tropospheric ozone, particularly ozone in the surface air near urban regions, has two sources. Normally, ozone is produced by the action of ultra-violet light on atmospheric oxygen in the upper stratosphere. It passes from there to the troposphere where it is destroyed principally at the earth's surface. However it can be produced by the action of sunlight on high concentrations of nitrogen oxides and hydrocarbons, themselves products of combustion processes. Three-monthly mean values of surface ozone, observed since 1967 at Aspendale, are shown in Fig. 1. Surface ozone is increasing steadily. As this increase is not associated with middle tropospheric ozone observed by sondes, it is thought to be due to increased levels of pollutants. Ozone sensors flown beneath balloons launched near Aspendale, have shown ozone rich layers of air near the earth's surface which are most probably the result of local ozone production. These occurrences have been detected more frequently in recent years.

The surface ozone observations made at Darwin during October to December 1970, show a high variability, with individual daily maximum concentrations varying between 0 and 6 pphm v/v. Some contamination from SO_2 was suspected and a filter has now been fitted. As most ozone enters the troposphere at middle and high latitudes the observations at Darwin will aid the study of exchange processes between the tropical and higher latitudes as well as the inter-hemispheric exchange of air in the troposphere.

Atmospheric Dust

The air sampling program which has been described in earlier reports has continued. We now have some five years of weekly measurements of concentrations of solid particulate matter (upwards of 0.2μ in size) in near-surface air. During this same period the area around the Division has changed from a lightly populated bayside suburb to a fairly typical residential zone.

From 1966 to 1968 dust concentrations increased from about 20μg m^{-3} to about 50μg m^{-3} but since this it has been decreasing until now it stands at about 35μg m^{-3}. Various plausible reasons can be put forward for explaining either increases or decreases in concentration and the situation is still far from clear. One might expect to find an annual cycle in the dust records: in fact no such cycle can be found.

The Aspendale site is located close to Port Phillip Bay and in some respects therefore, not well suited to studies of near surface contaminants. However, dust concentration is related to certain meteorological variables. For instance, concentrations tend to be highest at times of low wind speed coupled with high temperature. Rain seems to have no effect. Understandably, when the wind blows from the north, where the industrial areas are, dust concentrations are again high.

A re-analysis of the data comparing daily dust concentrations with coincident measurements of ozone concentration and natural atmospheric radio-activity has been undertaken. Previously it was reported that the sources which gave rise to low-level atmospheric radio-activity also contributed to the atmosphere dust loading and to the ozone concentration. Although this may be partly so, a probably more realistic view is that the meteorological conditions which give rise to high concentrations are the same for radio-activity, ozone and dust. Whilst the problem remains a complex one, the work has illustrated the benefits of employing more than one tracer in investigations of this nature.

Stratospheric Water Vapour

Water vapour in the stratosphere, its concentration and the possible effects of an increase in its concentration by high flying aircraft, have aroused considerable interest, both public and scientific, in the past year or so. Because of its association with pollution and its potential use as a tracer, a program is being mounted to measure the water vapour content of the stratosphere at an altitude of about 15 km. The instrumentation which is nearing completion, measures the attenuation of the solar beam in the 6.3μ water vapour absorption band. Through the good offices of the R.A.A.F., a Canberra aircraft is being made available for the purpose.

Atmospheric Turbidity

Determinations of Ångström's turbidity coefficient 'β' have continued, mainly from the data produced by the automatic spectral pyrheliometer referred to in last year's Report. A similar instrument is being constructed for installation at Rutherglen, (some 280 miles N.E. of Melbourne) a site which is remote from major sources of industrial pollution.

At the request of the U.S. Government

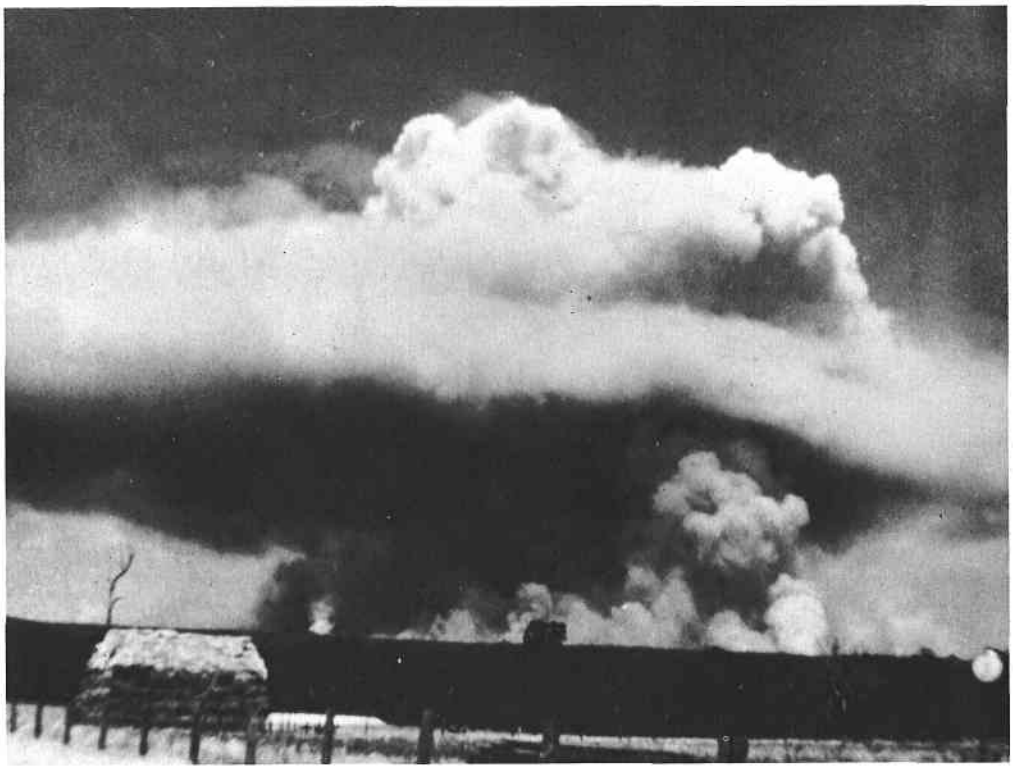
Environmental Protection Agency, two Volz Sun Photometers for measuring atmospheric turbidity are being set up, as part of a global system to monitor any long term changes. Negotiations are in hand to establish one station in Mawson, Antarctica. The second will be maintained at Aspendale for a sufficient period to compare with results from one spectral pyrheliometer and may subsequently be transferred to a location more remote from local pollution sources.

VI UPPER ATMOSPHERE

Ozone

The measurement of ozone both at the surface and in the upper atmosphere has continued as part of the Division's observing program. Currently our upper air network comprises stations at Aspendale, Darwin, Brisbane, Hobart, Perth, and Macquarie Island, in collaboration with the Commonwealth Bureau of Meteorology and the Antarctic Division of the Department of Supply. Each station measures total ozone using a Dobson Spectrophotometer. At Aspendale, the vertical distribution of ozone is also measured, indirectly by the Umkehr method, and directly by balloon-borne sondes of the Mast Brewer type. The measurement of surface ozone initiated at Aspendale in 1965, now extends to Darwin and Macquarie Island. A report of this aspect of the work can be found in Section V under 'Quality of Environment'.

Aspendale has a good record for longstanding, regular measurements of total ozone and its vertical distribution. We are therefore, well placed to look at long-term trends in ozone amount as related to changes in atmospheric global circulation - such as might be associated with solar cycles or climatic change (natural or man-made). An examination of total ozone amounts for Darwin (1965 onwards) shows a definite upward trend and, to a smaller extent, for Brisbane and Aspendale (1960 onwards). There is a barely discernible upward trend for Macquarie



Intense forest fire, reaching 14,500 ft., showing inflow at lower levels and outflow above. Note billows of convective cloud above.

(By courtesy of the Division of Applied Chemistry)

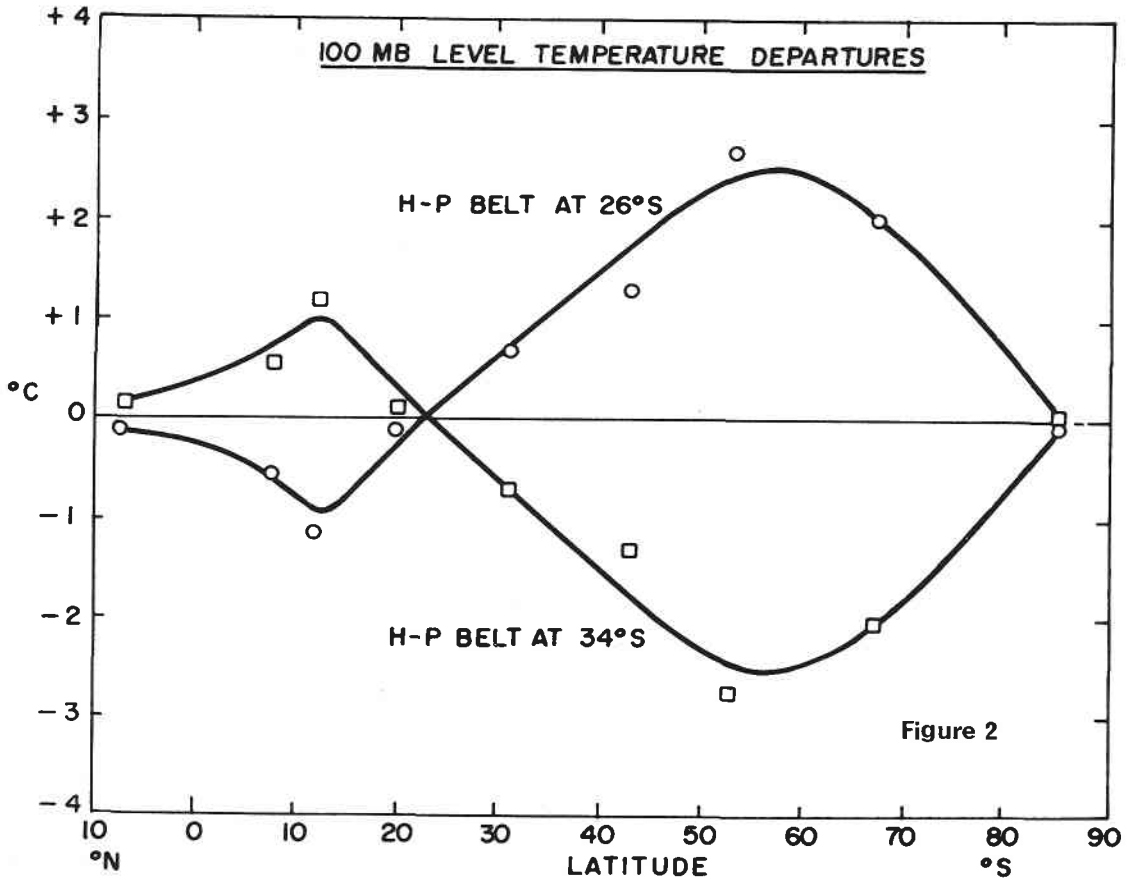


Figure 2

100 mb level temperature departures, for displacement of surface high pressure belt relative to 30° S, for Aug.–Sep.–Oct., from regression lines.

Island. The statistical significance of these changes are being worked out.

The must discussed biennial oscillation in ozone, stratospheric winds and temperature which disappeared in 1963, seems to have returned in 1967, but with a smaller amplitude and longer periodicity. One is tempted to connect this with sunspots, since, between 1956 and 1963, an all-time maximum in sunspot activity coincided with a similar maximum in the amplitude of the biennial oscillation. This feature is much more in evidence in the Southern Hemisphere than in the Northern.

When attempting to make measurements at altitudes beyond the reach of balloons it is sometimes possible to achieve results by using indirect means such as radio probes or airglow techniques. The latter approach has been used at Deniliquin, N.S.W.

At lower altitudes, a significant correlation between the mean seasonal latitude of the high pressure belt (L) off the east coast of Australia and the seasonal mean of total ozone in the Australian region has been obtained. The period of observation - from 1956 to the present - includes most of the time when the biennial cycles of both parameters were in evidence. The suggestion is that the nearer the high pressure belt is to the equator, the greater the meridional transport of ozone towards the sub-polar stratosphere. Similar associations have also been found between L and stratospheric temperatures and winds. An illustration of the temperature case is shown in Fig. 2.

A report of the work on near surface ozone can be found in Section V "Quality of the Environment".

Radioactive Tracers

The Division's interest in radioactivity is oriented towards elucidation of the details of the global circulation, particularly at stratospheric

levels, and employs radioactive materials as tracers. By selecting appropriate tracers such as C_s-137 (of predominantly equatorial origin) and B_e-7 (polar origin), it is possible to infer certain characteristics of the motion within the stratosphere. Although in this type of investigation, statistical significance is of prime importance, the figures so far available do suggest a poleward drift within the stratosphere at certain times of the year. Verification and amplification of this await the accumulation of further data.

At present two types of routine radio activity measurements are made at Aspendale. The first, initiated in 1958 concerns the gross radioactivity deposited at the surface, mainly by rain. The second is a more recent program and involves the measurement at the surface of several radionuclides in air. From the 13 years of records available for Aspendale, 5 years of negligible input (by atomic weapons tests) have been selected to obtain an estimate of the annual cycle. It is found that the cycle peaks in about October with a minimum about May, i.e. 1 or 2 months behind the stratospheric ozone oscillation. The lag is attributed to the transport mechanisms governing the downward transfer of radioactive material from the stratosphere. An annual cycle is also found in near-surface air concentrations of radioactivity.

NOTE: A forthcoming experiment using water vapour as a stratospheric tracer is described in Section V, 'Quality of the Environment'.

VII AGRICULTURAL METEOROLOGY

The exchange of heat, water vapour and CO_2 between the atmosphere and vegetated surfaces (both natural and man-made), particularly in terms of plant evaporation and growth, are the main concern of the agriculture Meteorology team; although others, such as those engaged in numerical modelling

or the more general aspects of surface energy balance, are also concerned.

In the past much of the team's activity has been connected with the Aspendale lysimeter installation, but with the deteriorating exposure of the area, due to encroaching residential buildings, this side of the work is being tapered off. From now on, this type of work will be confined to shorter-term experiments at more suitable sites, e.g. as exemplified by projects at Rutherglen and Derrimut.

Plans have been made and some initial work started on heat and mass transfer from individual plant leaves, with emphasis at first on the role of forced convection. When modelling plant growth and water loss, this work should permit greater accuracy in predicting the sensible and latent heat terms in leaf energy balance equations. Another aspect of the work is the effect of leaf size on heat, water and CO_2 transfer rates; the outcome hopefully, being a general (i.e. world-wide) relationship between leaf size and climate.

A Mathematical Plant Model

Many kinds of theoretical plant model have been proposed from time to time but most of them rely on empirical relationships obtained from field experiments. Whilst the resultant models can be quite useful they can also have severe limitations - which arise, for instance, when the physical or chemical basis of the empiricism is not properly understood. The last few years have seen the development in the Division of a model which overcomes the more serious deficiencies and which, from measurements made above the plant canopy, generates its own microclimate within the crop.

This year, in co-operation with the State Agricultural Department a large field experiment has been initiated at Rutherglen, northern Victoria. The object is to check certain aspects of the model, e.g. its prediction capability of the in-crop

environment and overall growth rate and water use. Some 50 meteorological variables as well as a number of biological ones are being monitored, the former on a continuous basis throughout the crop's life, the latter at frequent regular intervals. Two members of the Division's staff have been transferred to Rutherglen to maintain the equipment and attend to the day-to-day running of the experiment. Every attempt is being made to make the project really comprehensive and since it is anticipated that the data will be of interest to other workers, including those with more specific agriculturally-orientated problems, the data are being assembled in a readily accessible form.

Evaporation - Measurement and Estimation

When planting row crops, the agriculturalist does not often give much attention to the orientation of the rows with respect to the prevailing wind. Yet some recent work in a vineyard has suggested that it might be economically sound to consider wind direction when planting grape vines. Started about a year ago, and using the Fluxatron, measurements of the turbulent fluxes of heat, water vapour and momentum made over grape vines have continued. The most recent expedition was to Griffith, N.S.W., and was a co-operative venture with the John Curtin School of Biological Sciences, Australian National University. When analysis of the data is complete, it is hoped to be able to relate evaporation and crop damage (from high winds) to the prevailing wind direction for a row crop.

In collating the overall results from the Division's lysimeter installation, over the past years, the following are the more interesting points to emerge:

(a) Despite continued generous watering there has been a slow decrease in pasture evaporation over the past decade. This appears to be due to changes in species composition - mainly an invasion of the original grass-clover mixture

by Kikuyu - and is an indication of how grass species, and presumably others, can differ, both in their potential evaporation rates, and in their physiological constraints on water loss under conditions of even slight water stress.

(b) The changing geometry of a grass and potato crop appear to significantly affect evaporation from both the plants and the soil between.

(c) Evaporation from bare soil and water filled lysimeters varies strongly both with changes in immediate surroundings (small-scale advection or 'clothes line' effects); and the more distant surroundings, such as have occurred around the Aspendale site where a once grass area has been built up.

These, and other findings illustrate how important it is when using predictive formulae based on simple meteorological data, to take account of the crop geometry and stomatal behaviour, as well as the nature of the surroundings, both immediate and local. The latter factors must also enter into the proper siting of lysimeters or other evaporation devices.

Earlier reports have referred to the 'combination' formula used to estimate potential evaporation from standard meteorological measurements. Further success with the formula has been achieved this year, both as a means of determining evaporation, as well as explaining how it varies with weather, type of surface, and so on. However, there is still a need to evaluate a factor - based on readily measurable soil and plant parameters - to convert potential evaporation to actual evaporation when the water supply is limiting.

Of the parameters examined so far, soil moisture content and relative water content of leaves seem the best. Using the latter approach,

for example, estimates of day-time potato crop evaporation have generally been well within 10% of lysimeter values. On the few occasions when there were large discrepancies, the evaporation rate was low (less than 4mm/day) and therefore of little practical importance.

Instrumentation

Field trials of the Energy Partition Evaporation Recorder have continued successfully. This instrument is essentially a portable device which continuously solves a modified version of the well-known Bowen ratio formula using measured values of net radiation, together with wet and dry bulb temperature differences. The unit survived a searching test on a recent field experiment when it was used to measure evaporation at well below the potential rate, from a sparse natural grass cover. Good agreement was found when the results were compared with those from a nearby precision weighed lysimeter.

Neutron Moisture Meter: For many purposes a neutron moisture meter is the ideal way to measure soil moisture content. Unfortunately, its price is too high for a large number of would-be users. Just completed in the Division is a neutron moisture meter working along recognized lines, but incorporating unit construction, simplicity and relatively low-cost. A tubular container (1½ metres long and just under 4 centimetres in diameter) carries a radioactive source and counter at one end; the other being capped by a small box containing printed-circuit amplifiers, power supplies, ratemeter etc. There are no external leads or plugs to be connected. To operate, the unit is lowered into a standard polythene access tube, switched on, and a single reading taken on the ratemeter. The instrument is light and easy to handle and therefore can be moved around without difficulty. Preliminary trials in the field have been very encouraging and it is now undergoing more extensive and rigorous field tests at Rutherglen.

Combination Atmometer: Although instruments for accurate measurement of evaporation from natural surfaces are constantly being improved and simplified there is still room, and will be for some time to come, for more straight-forward devices which will provide at least a good estimate of potential evaporation. Into the latter category comes the Combination Atmometer. This consists basically of two small water containers mounted alongside each other, one carrying an opaque sunshield, the other a dimensionally similar but transparent shield. Water losses from the two containers will differ because of the unequal radiation reaching them. Combining readings from the two units in one particular way provides a figure surprisingly close to the potential evaporation from the underlying surface. (This, of course, entails an initial calibration with a nearby lysimeter or other means of accurately measuring evaporation).

Combining the readings in another manner yields a good approximation to net radiation. Although only preliminary tests have so far been made, over an improved pasture surface, using atmometers of cheap construction, results have been excellent. When the actual evaporation is much less than potential, a factor similar to that described earlier for the combination formula must be applied.

Lysimetry

The special balance designed to measure evaporation from a snow surface, and described in earlier reports, has undergone further tests during the past winter at Falls Creek, N.S.W. It has proved rugged enough to withstand the climate but the sensitivity needs improving, and the unit has been returned to Aspendale for further development.

The need for simple but reliable and precise lysimeters suitable for operation by agricultural and hydrological authorities remains as great as ever, and development has continued.

Assistance has been given to two other C.S.I.R.O. Divisions in the installation of monolith weighing lysimeters with precision balances of the type used at Aspendale.

VIII COMMONWEALTH METEOROLOGY RESEARCH CENTRE

In collaboration with the Bureau of Meteorology, the Division now operates the Commonwealth Meteorology Research Centre. The work of the Centre has two principal objectives; a better understanding of the fundamental process of meteorology, in particular the large-scale behaviour of the earth's atmosphere, and the application of this knowledge towards improvements in the accuracy and time-scale of predicting the atmosphere's behaviour. In the first years of its existence the Centre's activities are being directed strongly towards the second of these objectives, i.e. emphasis is being placed on work designed to aid the Bureau of Meteorology's operational activities in the fields of weather analysis and prognosis. However, it is expected that in the course of time the full scope of activities envisaged for the Centre will be developed.

Within the broad objectives stated above the research program is kept under review by a committee comprising the Chief of the Division, the Director of Meteorology, and the Officer-in-Charge of the Centre (Dr. G. B. Tucker). The Centre's Annual Report is published separately.

IX MISCELLANEOUS

Forest Fires

Every year in Australia sees great damage done by grass and forest fires, many of which are so intense that they cannot be contained. The problem is one of determining the response of a

fire to a given weather situation so that dangerous developments can be predicted. Last year's Report referred to a collaborative venture between ourselves and the Division of Applied Chemistry, when detailed information on turbulence and wind structure was obtained from three large (40 to 50Km^2) intense forest fires. In two cases the resulting smoke reached to 3,000 m and in the third, to 4,500 m. Analysis of the work is now complete and tentative rules have been established for predicting the height to which convection will penetrate, given:

(1) the amount of fuel available (litter on the forest floor and, in the case of really severe wild fires, the standing timber also).

(2) surface humidity, and

(3) air temperature from the surface to as great a height as possible. (In operational practice, these would normally be obtained as forecasts from the national weather service).

The height of the smoke column is both a gauge of the intensity of the fire, and, in conjunction with the wind speed, an indication of the rate at which burning embers, carried on the wind, will cause fresh 'spot' fires. It is hoped to test these rules on another intense fire during the coming spring.

Towards the end of 1970 and again working with the Division of Applied Chemistry, a number of milder fires were started, this time to investigate the diffusion rate of smoke into the atmosphere. We hope to report some of these findings next year.

Instrument Development

As will be seen from remarks made elsewhere in this Report, our efforts to make use of certain radioactive materials as tracers have been very successful. As a result of this, a surface air sampling unit driven by a ½ h.p. 240 V motor, has

been designed to operate outdoors, on a continuous basis. A meter records the actual running time, a thermal overload device protects the motor and a manometer connected to the outlet indicates the airflow (and a clogged filter). The filter, which is normally changed every week is easily removable and can be fitted with a simple protective wrapper for transmission through the post. Five sampling units have been made and have been thoroughly tested at Aspendale prior to installation in various parts of Australia.

More often than not when making measurements amongst crops, plants adjacent to the path giving access to the crop are irrepairably damaged thus destroying the homogeneity of the vegetative cover. To overcome this, an extensible 'walk-way' has been designed which will swing out over the crop and provide access to instruments installed amongst the plants, up to a distance of 20 ft. away.

Current design work includes a remotely activated, transmitting digital barometer, and a feasibility study on a proposed platform to be erected on the sea-bed of Port Phillip Bay.

General

N.A.T.A. (National Association of Testing Authorities) is an organization established to maintain and improve standards of testing and calibration within Australia. The actual work is carried out in suitably equipped and approved laboratories (both government and private) selected by the Association. This Division is one such laboratory in the fields of low-speed anemometory and atmospheric and terrestrial radiation instruments. In both cases the number of instruments received for calibration continue to rise steadily. Current figures (per annum) are: radiometers - 390; anemometers - 214.

The small data processing and computation group has continued to provide assistance in terms of program preparation for various research

projects. The building up of the analogue to digital conversation system continues and it is anticipated that it will be completed within the next 12 months.

The original aluminium building comprising offices and laboratories, and which served as the Division's first permanent accommodation, has finally succumbed to the salt air and has been replaced by a brick building of slightly larger floor area.

X ACTIVITIES AND PERSONALIA

It is with great regret and a real sense of loss that we have to record the retirement of Dr. K. Ball, on medical grounds following a serious car accident in the U.K. Dr. Ball joined the Division in 1950 and was responsible for significant contributions in the field of geophysical fluid dynamics.

Dr. Dyer and Mr. Hicks have been awarded the David Syme Research Prize for 1971. This Award is made each year by the University of Melbourne for the most distinguished contribution in Australia to Biology, Chemistry, Geology or Physics during the preceding two years.

Mr. I.E. Galbally was this year awarded an M.Sc. by Melbourne University for his work entitled: "Vertical Flux of Atmospheric Ozone".

From London University Mr. P. Hyson received a M. Phil. for his thesis entitled: "Measurement of Winds and Temperatures in the Upper Atmosphere".

Mr. F.K. Tighe has been awarded a B.A. from Melbourne University.

Overseas Visits

In January, 1971 Dr. C.H.B. Priestley left for Bombay where he attended a meeting of the Joint

Organising Committee of the Global Atmospheric Research Programme (G.A.R.P.).

An International Field Comparison of Flux Measuring Equipment was held at Tsimlyansk, U.S.S.R. in the early part of the year. Dr. A.J. Dyer and Mr. B.B. Hicks both took part using the Division's Fluxatron*. Dr. Dyer returned to Aspendale via Japan and India, where he visited various laboratories, whilst Mr. Hicks went on to the U.S.A. taking in meteorological centres in the U.K. and Canada. Whilst in America Mr. Hicks was attached to the Argonne National Laboratory for some 8 months and worked on heat and water losses, including surface stress, over Lake Michigan.

The Third International Comparison of Regional Working Standard Pyrheliometers, sponsored by W.M.O. was held at Davos, Switzerland in September and October, 1970. Mr. B.G. Collins, representing Australia and the W.M.O. Region V, took with him the Division's two Ångström pyrheliometers. Advantage of the trip was taken to visit other meteorological establishments in the U.K., Canada and in the U.S.A. Some results from the comparisons can be found on page 14 under 'Observatory, Calibration and Standards'.

Dr. A.D. McEwan, who recently joined the Division to work on the dynamic simulation of atmospheric phenomena by means of laboratory models, spent two months visiting meteorological centres in the U.S.A., Canada, U.K., Japan and Sweden. The purpose of his trip was to make contacts and to see at first-hand the most recent progress in this field.

Visitors from Overseas

Dr. C.G. Little, Director of the Wave Propagation Laboratories, N.O.A.A., Boulder, Colorado, arrived late in December to spend an eight months sabbatical with the Division. Dr. Little's

*Further details of this exercise can be found on page 17 under "Micro-Meteorology".

work is concerned with the application of electromagnetic and accoustic techniques to remotely observe and interpret atmospheric processes.

Because of the relative scarcity of suitable training establishments or courses and the need to increase food production in certain parts of the world, increasing numbers of requests are being received by the Division to train Colombo Plan Fellows, or others sponsored by the U.N. or W.M.O., in agro-meteorology. This year the following have spent time in the Division:-

Mr. N.O. Itoralba - Colombo Plan Fellow and Senior Meteorologist from Manila.

Mr. E.U. Ahmed - Also Colombo Plan Fellow from the Pakistan Meteorological Service.

Mr. C. Malibiran - W.M.O. Special Fund Fellow, from the Philippines Weather Bureau.

All were concerned with agrometeorological methods and instrumentation.

XI PUBLICATIONS

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