

$$\frac{\partial u}{\partial z} = u_* / kz$$

where u_* is an auxiliary reference velocity called the friction velocity and k is von Karman's constant.

The Monin Obukhov universal functions ϕ_H , ϕ_M , ϕ_W were then introduced in an attempt to determine their variation with the stability parameter z/L where L is the Monin Obukhov constant. A suitable framework for analysis of the flux profile relationship is then provided in the Monin Obukhov form

$$\frac{\partial \theta}{\partial z} = -H(\rho C_p k u_* z)^{-1} \phi_H \left(\frac{z}{L} \right).$$

In order to evaluate ϕ_H , ϕ_M , ϕ_W , the potential temperature gradient $\frac{\partial \theta}{\partial z}$ was assumed to be equal to $\Delta\theta/\Delta z$ for adjacent heights and taken as applicable at the geometric mean height for z between 1 and 2 metres. In order to evaluate u_* , near neutral conditions were assumed near the surface where ϕ was taken as equal to unity. A series of slides was shown with plots of the universal functions ϕ_H , ϕ_W and ϕ_M against $-z/L$. In the case of ϕ_H and ϕ_M points representing results from different heights for overlapping regions of z/L meshed nicely and approximated a curve approaching unity for small values of z/L . Such curves can be looked upon as empirical solutions to the problem and it was possible to equate the transfer coefficients for heat and water vapour, writing

$$\phi_H, \phi_W = \left(1 - 15 \frac{z}{L} \right)^{-0.55}$$

Thus the transfer coefficients K_H and K_W have been successfully evaluated. Whilst the attempt to value K_M is not completely successful at present, the desired solution seems to be in sight.

During question time the opportunity was taken to seek further advice from Dr. Dyer on certain aspects of his work. The major discussion that ensued can be summarised by the following selection of questions. Mr. Hounam queried the justification of the assumption $\phi = 1$ with adiabatic conditions and neutral stability during very hot weather with surface temperature above 100°F.

Dr. Radok asked if u_* could be evaluated directly from a measurement of stress rather than the use of the assumption $\phi = 1$ near the surface. Mr. Spillane asked if it was consistent to use filters to exclude certain wavelengths when using the Fluxatron while no filters were used in measurements of temperature gradients.

Dr. Radok commented on an interesting parallel in the problem of the general circulation of the atmosphere and expressed the opinion that it can be dangerous to be too selective in an investigation of this type.

F.A.P.

20 July 1967

SATELLITE STUDIES OF CYCLONIC DEVELOPMENTS OVER THE SOUTHERN OCEAN

By D.W. Martin

Mr. David Martin, from the University of Wisconsin, presented the results of his year's work at the International Antarctic Meteorological Research Centre, (Melbourne). He opened his talk by pointing out the tremendous potential of meteorological satellites, particularly when applied to meteorological problems in the southern hemisphere. Many thousands of cloud photographs have already been received on an operational basis, but as yet we have hardly

begun to tap the enormous quantities of useful data that they contain. In particular, his work had shown that they may often contain enough information for the inference of tropospheric profiles of temperature, humidity and wind.

Mr. Martin then described his technique (based upon the earlier work of Taljaard and Van Loon) for obtaining tropospheric profiles from cloud photographs. Using radiosonde observations from Macquarie, Campbell and Marion Islands for June, July and August 1966, mean profiles of temperature, humidity and wind were worked out for each of 21 different synoptic categories. Each sounding was placed in one of these categories using the concurrent MSL analysis prepared by SHAC (Southern Hemisphere Analysis Centre). Over half of the soundings fell into one of five categories - "ridge", "west side of ridge", "warm sector", "post-cold-frontal" and "east side of ridge". Each of these types displayed essentially the same pattern of behaviour at the different stations, and there was a consistent sequential pattern of structure.

The success of this approach encouraged an attempt to classify soundings according to significant cloud patterns as viewed in satellite photographs. Mr. Martin described the main features of his cloud classification scheme, which, for convenience, is based upon scale size - the three scales of organisation considered being synoptic (500 to 2000 km), meso (50 to 500 km) and meso-micro (10 to 50 km). The final classification included 45 meso-microscale types. The soundings for Macquarie and Campbell Islands were classified using this scheme (in each case allowance was made for the time-lag between the soundings and the photographs). This provided sufficient data to allow mean profiles to be constructed for 24 of the meso-microscale types.

The homogeneity of atmospheric conditions between 40°S and 60°S suggests that these results (obtained using data from Macquarie and Campbell Islands) might be applied whenever the significant cloud-pattern types are observed in this latitude belt. The accuracy of the temperature profile inferred in this way will of course be increased if a local surface temperature is available to fix the lower end of the profile - alternatively local sea-surface temperatures could be used.

By comparing cloud-derived with circulation-derived profiles, it was possible to associate the more striking cloud patterns with particular wind and pressure patterns - this in turn made it possible to construct a mean cross-section through a typical synoptic-scale system. This cross-section showed an eastward-tilted cold dome lying directly below a warm core in the lower stratosphere, and bounded by baroclinic zones to both east and west. The eastern ("cold-frontal") zone was the more intense of the two, while both baroclinic zones became weak near the surface, and were most intense at levels between 850 and 700 mb.

Mr. Martin concluded his talk by presenting a case-study covering the period 29 July to 4 August 1966. During this period two systems passed across Macquarie Island in less than 24 hours. Using the satellite photograph coverage, autographic records and the individual Macquarie observations, it was possible to construct a fairly detailed analysis of the structure of both systems - which in each case showed a striking similarity to the classical Norwegian "frontal wave" model. The case study provided a convincing demonstration of the practical applicability of Mr. Martin's analysis scheme.

At the conclusion of the talk the meeting was shown a short time-lapse film made up from a series of photographs taken at regular intervals by the earth-synchronous satellite ATS-1. This film proved to be of great interest, as the development of synoptic-scale systems over the Pacific was clearly revealed.

In the discussion which followed, Mr. K. Morley noted that the analyses presented had conformed well to the traditional frontal model, and asked whether Mr. Martin's work had produced any evidence to support the idea of a tropospheric polar front which was continuous around the hemisphere. Dr. Tucker commented that this was probably not a profitable concept. Mr. Martin agreed, and said that the frontal model, while useful for explaining transient phenomena, is of no real use from a climatological point of view.

Mrs. J. Hopwood asked how much the mean profiles corresponding to different cloud pattern types differed from each other. Mr. Martin replied that many of the mean profiles were quite similar; however, there was a marked dissimilarity between profiles corresponding to convective cloud and those corresponding to stratiform cloud. It had been found that the overall shape of the profile and the value of the 1000 - 500 mb thickness could be estimated quite well from the cloud pattern alone. Dr. Tucker then asked him what type of variation had been observed

about the mean profiles, and what errors might be expected in applying this approach quantitatively in numerical analysis. Mr. Martin said that, on the basis of the comparison between the cloud pattern types and the synoptic types, he would expect the errors to be small, but due to the small size of the samples so far considered, no estimates of error magnitudes had been made.

Mr. K. Spillane asked whether the cloud edge coincided with the boundary of the cold air both for cold fronts and for occlusions, to which Mr. Martin replied that the errors involved in gridding the satellite photographs made it impossible to arrive at definite conclusions on a very small scale. Mr. Spillane then enquired whether it had been possible to recognise areas of precipitating cloud through albedo variations, and Mr. Martin said that this had not been attempted - however, a good correlation had been found between precipitation type and cloud type.

Dr. Tucker made some comments on differences between the two hemispheres, observing that the horizontal dimensions of extra-tropical cyclones appeared somewhat smaller in the southern hemisphere, and that they may also move a little more slowly. If these observations are valid, they have interesting implications concerning the conversion of potential to kinetic energy by the cyclones, and also their predictability in numerical experiments. If it were necessary to reduce the grid-length in numerical prediction there would be a corresponding reduction in the period of effective forecasting. Mr. R. Maine noted that the Bureau was in fact using a grid-length approximately two-thirds the size of that normally used in the northern hemisphere. Mr. Martin commented that the systems he had studied often moved quite rapidly - occasionally with speeds of forty knots.

Mr. C. Wallington stated that it would be better now to forget the old "polar front" concept - in the modern view, a front may be regarded as a baroclinic zone which (after a possible initial formative stage) is self-sustaining. It is necessary to look upon fronts as essentially mesoscale, rather than planetary scale features. This has the advantage of freeing the analyst from the use of preconceived models. Mr. W.J. Gibbs said that he had noticed that, following the introduction of satellite photographs on an operational basis, both CAO (Central Analysis Office) and SHAC were using more "trailing fronts" than previously. He was unsure whether to attribute this to the influence of the satellite photographs, or to the influence of Mr. J.C. Langford (SHAC). Mr. Martin is preparing a fuller account of this work to be published in the IAMRC Technical Report Series.

T.T.G.

31 August 1967

THE HEAT ENERGY TRANSFER THROUGH A FOUR-LAYER SYSTEM: AIR/SNOW/SEA-ICE/SEA-WATER

By G.E. Weller

Mr. Weller of the Meteorology Department, University of Melbourne, was the speaker. It is observed that the northward extension of the Antarctic pack-ice during the southern winter leads to an effective doubling of the area of the Antarctic "continent". That this has a profound effect on meteorological processes over a large part of the Southern Hemisphere has been widely accepted but the nature of the effect has remained imperfectly understood. The results of the micrometeorological research undertaken by Mr. Weller at Mawson, an Australian Antarctic base, in 1965 are contributing significantly to such an understanding. A selection of these results was presented to the Colloquium and provided the basis for a lively discussion.

Mr. Weller opened his talk with some general remarks on ocean-atmosphere energy exchange processes, their magnitude and their significance. In suggesting the important role played by the Antarctic ice pack, he illustrated pictorially and diagrammatically its appearance, structure, thickness and mean seasonal extent.

Moving from the broadscale approach to the micrometeorology of the problem, Mr. Weller discussed the structure of the sea-ice in terms of such parameters as density and salinity, and then outlined the nature of the physical processes (conduction and radiation) which effect energy transfer through such a medium. The meteorological and glacio-meteorological instrumentation employed in the 1965 experiment on a sea-ice surface 400 metres offshore from Mawson was described. This included a capability for measurement of temperature and wind profiles above the ice, temperature profiles and heat flux in the ice, sub-surface and supra-surface radiation measurements and a novel device for the automatic measurement of sea-ice thickness.