

equations with four unknown variables. Apart from great simplicity, both in derivation and in application, the hypothesis has the added virtue of relatively few constraints.

There is no reference to stability, no requirement for constant pressure gradients in time, and accelerations are permitted in the flow.

Dr. Sargeant complimented Mr. Swinbank on the amazing simplicity of his treatment. He pointed out the absence of stability as a factor and asked whether its effect was implicit in the theory. Mr. Swinbank held that stability will be reflected in the variation of wind direction.

Dr. Tucker questioned the validity of deducing shearing stresses from the model and using them to test it. Mr. Swinbank re-affirmed that the shearing stresses used in validation were obtained by quadrature of the geostrophic departure.

Dr. Priestley summed up the discussion by repeating the previous comment "amazing" and drew the attention of the meeting to the two theoretical innovations in the treatment, (i) postulating the problem from the top of the boundary layer downwards, and (ii) assuming the shearing stress operates in the direction of the wind. He personally and intuitively would have preferred that the stress operated in the direction of the wind shear, and raised the possibility that this amendment could be tested by computer experiments.

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K. T. M.

26 June 1968

INDIRECT OBSERVATIONS OF THE ATMOSPHERE USING MICROWAVES

By D.H. Sargeant

Dr. Sargeant, of the Departments of Meteorology and Electrical Engineering, University of Wisconsin, Madison, (currently working at the International Antarctic Meteorological Research Centre) pointed out that the modern development of numerical forecasting methods has created a need for observations, particularly of the mass field, on a global scale. The "microwave occultation technique" which has been proposed, was first used to estimate surface pressure and atmospheric scale height on Mars and Venus by examining changes in the tracking signal of the Mariner probes as they passed behind those planets and the signal was gradually affected by the planetary atmospheres. For meteorological purposes, more information than surface pressure and scale height is needed and a system would be used which includes a master and one or more slave satellites, the latter returning to the master the signal transmitted by it so that phase comparison could be made and the change in optical path length due to bending and retardation could be determined.

Results of typical calculations were presented, using both model and observed atmospheres, from which it appears that the maximum change in optical path when the height of closest approach of the signal beam is very near zero is about 200 metres and a resolution equal to the wavelength used (perhaps 1 cm) should be possible. The sensitivity to change of the optical path is about 1 m per N-unit (N is equal to 10^0 (refractive index -1)) and this, near the surface, corresponds to about $\frac{1}{2}\%$ in density. The resolution along the beam is of the order of 300 to 500 km, though features down to 100 km or less in size should be detectable.

Given an atmosphere and the profile of refractive index in it, the calculation of change in optical path is straight-forward, but the problems of the reverse to deduce the profile from the optical path change are likely to be considerable. Moreover, serious difficulties of interpretation of the radio measurements are likely due to the strong effect of water vapour on refractive index, which is thus not a function of density alone, and due to imprecise knowledge of satellite position, since the distance between master and slave satellites must be known to an accuracy equal to the resolution desired in measuring optical path changes.

Dr. Sargeant then described measurements made by the University of Wisconsin on propagation of microwaves by tropospheric forward scattering over a total path of some 200 km. The dependence of the Doppler shift of frequency on antenna azimuth angle (measured from the great circle joining the two stations) was demonstrated, and the relationship between this frequency shift and the lateral component of the velocity of the scatterers was discussed. A correlation technique was described, which also makes it possible to determine the height of the scatterers so that a vertical profile of the lateral velocity component can be constructed.

R. J. T.

31 July 1968

RESULTS OF A SOUTHERN HEMISPHERE FORECAST WITH A NINE-LEVEL MATHEMATICAL MODEL

By R. H. Clarke.

Mr. Clarke of CSIRO Division of Meteorological Physics, Aspendale, Victoria has recently returned from the United States, where he was attached to Dr. J. Smagorinsky's group at the Geophysical Fluid Dynamics Laboratory of ESSA in Washington.

Using the nine-level primitive equation model developed by Smagorinsky (1965), forecasts for the Southern Hemisphere for a period of 14 days from 1 March 1965 have been produced. Before presenting the results of these forecasts, the speaker devoted considerable discussion to the problems associated with the preparation of suitable initial data for such forecasts. The initial data required were manual (vertically consistent) analyses of the mass, temperature and moisture fields for all standard pressure levels from 1000 mb to 10 mb for five days; the climatological, latitudinal distributions of cloud, water vapour, carbon dioxide and ozone for use in radiation computations; and a suitable smoothed field of orography. It is further required that the initial data be interpolated to the grid system required by the existing prediction model. Finally, the balance equation and the omega equation are employed to produce dynamically conditioned initial horizontal and vertical wind fields.

The experimental results presented included correlation coefficients between predicted and manually analysed height changes at 500 mb, R.M.S. errors between predicted and observed heights, and selected individual forecast days for various levels and particular geographical areas. Certain diagnostic results were also presented - for example, the meridional profiles of temperature, zonal wind and zonal kinetic energy.