

The ratio of volume to volume flux also yielded time. The volume of the ocean,  $1369 \times 10^6 \text{ km}^3$ , divided by the estimated evaporation from the ocean,  $40 \text{ km}^3/\text{hr}$  (Dietrich, 1957, Abb. 71), gave 3900 yr as a residence time for water in the ocean. The exchange of water across the equator in the Atlantic Ocean was stated (Sverdrup et al, 1942, table 76) to be  $32 \text{ km}^3/\text{hr}$  in each direction; the resulting residence time for water in the North Atlantic Ocean was some 600 yr. For the Arctic and Greenland-Norwegian seas (volume  $17 \times 10^6 \text{ km}^3$ ) the exchange of  $13 \text{ km}^3/\text{hr}$  (Sverdrup et al., p. 655) gave a residence time of 150 yr. For the Mediterranean and Black seas ( $4.2 \times 10^6 \text{ km}^3$ ) the Gibraltar Surface Current of  $6 \text{ km}^3/\text{hr}$  (Sverdrup et al., table 78) gave a residence time of 80 yr. For the Black Sea alone the residence time estimated in this way was 2500 yr (Sverdrup et al., p. 651).

Professor Montgomery stated that he had prepared a short paper on "Salinity and the residence time of subtropical oceanic surface water" for the Rossby Memorial Volume. It had been found that in each of the six oceans there was a subtropical surface lens of water of high salinity. The thickness of the lenses was about 200 m, and the salinity reached some 36.5 per mille in contrast with the prevailing salinity of 34.7 per mille. Hence, the salt lenses represented a water deficit of about 10 m. This water deficit, at a rate of 1 m/yr for the subtropical excess of evaporation over precipitation, would accumulate in 10 yr. This result represented an estimate of the residence time of the water within each subtropical surface lens of high salinity.

26 June, 1958

The vorticity theorem, and its application

in dynamic meteorology

by S. Karelsky

Mr. Karelsky of the Bureau of Meteorology discussed the vorticity theorem for the atmosphere as it applied to the spherical rotating earth under the following headings:

- (a) The general vorticity theorem for a rotating atmosphere in vector form.

- (b) The complete system of equations for a barotropic non-divergent atmosphere in the spherical and Cartesian co-ordinate systems.
- (c) The validity of some simplifying assumptions in both systems.
- (d) The general integrals obtained for both spherical and Cartesian systems.

From his treatment of the vorticity theorem and discussion of resulting equations, Mr. Karelsky concluded

- (a) that motion of a barotropic non-divergent atmosphere without the vertical component of the wind and without the horizontal components of vorticity was impossible on the spherical rotating earth,
- (b) that motion of a barotropic non-divergent atmosphere on the XOY plane tangent to the surface of the rotating earth without the Z component of the wind and with only the Z component of vorticity was possible if  $V_x$  is independent of X and Y in the whole XOY plane and  $V_y$  was a function of x only. In this case Helmholtz's vorticity theorem was valid for a motion of the fluid on a plane rotating with an angular velocity  $\Omega = \text{constant}$  around an axis inclined to the plane.

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Dr. C.H.B. Priestley, Chief of the Division of Meteorological Physics, C.S.I.R.O. was the speaker. He gave an account of his investigations while on attachment for a five months period during 1957 as Visiting Research Meteorologist, to the staff of the Department of Meteorology, University of Chicago. His investigations were in the field of turbulence, and in particular, were concerned with the assessment as far as possible in terms of synoptically available quantities, of the energy gained by the atmosphere through contact with the ground. Dr. Priestley pointed out the significance of this assessment in relation to the numerical prediction project at present being conducted at Chicago under the leadership of Professor Petterssen. He discussed in particular the problem of a cold outbreak, and showed how the rate of adjustment of air temperature was dominated by the nature and condition of the underlying surface.

In the second part of his talk, Dr. Priestley gave his general impressions on the current trends and prospects in overseas research, in the United States and also in England, where he had spent a few weeks at

meteorological establishments. His impressions were, broadly, that in the fields of investigation of cloud and rain physics, numerical prediction, the general circulation and chemical meteorology, the initial surge of advance had ceased and the present period was rather one of consolidation. He described in some detail the problems confronting workers in numerical prediction investigations and indicated differences in the lines of approach and application in this field in the two countries. As regards the prospects in meteorology, Dr. Priestley's impression was that there were no outstanding new fields of investigation developing, although in the United States, much emphasis was being devoted to meso-meteorology, a field between the micro and synoptic scale.