LETTERS TO THE EDITORS

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Distribution of Wet Bulb Potential Temperature in Latitude and Altitude

IF potential temperature is denoted by θ and wet bulb potential temperature by θ′, then log θ is proportional to the entropy of dry air and log θ′ to the entropy of the mixture of air and water vapour. Because air is compressible, entropy is a guide to its motion, and Sir Napier Shaw was the first to prepare a diagram of the variation of log θ or θ with latitude and height, and to use it as a text on which to expound the stratification of the atmosphere. When, however, cloud in convection penetrates the air strata, log θ′ takes the place of log θ as an operative factor. A world picture of θ′ is required to complement that of θ.

During the War, we prepared the diagram that is reproduced here, basing it upon the upper-air humidity data then available in India, namely, those of Batavia, of Indian stations up to 1940, English and German data up to 1937, and American *radio-sondes* of 1939–41. The data therefore were not representative of a single meridian, but the requisite smoothing has, it is believed, conserved the main features of the distribution, which may be summarized as follows.

1. Around the thermal equator, where much of the heat in the lower layers is in the form of latent heat, the θ′-lines assume the shape of a fountain, in marked contrast to the θ-lines, which by themselves are more suggestive of horizontal stratification[1]. On the other hand, wherever the concentration of water vapour is small, as it is near the poles and near and in the stratosphere, the lines of θ′ and θ approximately coincide.

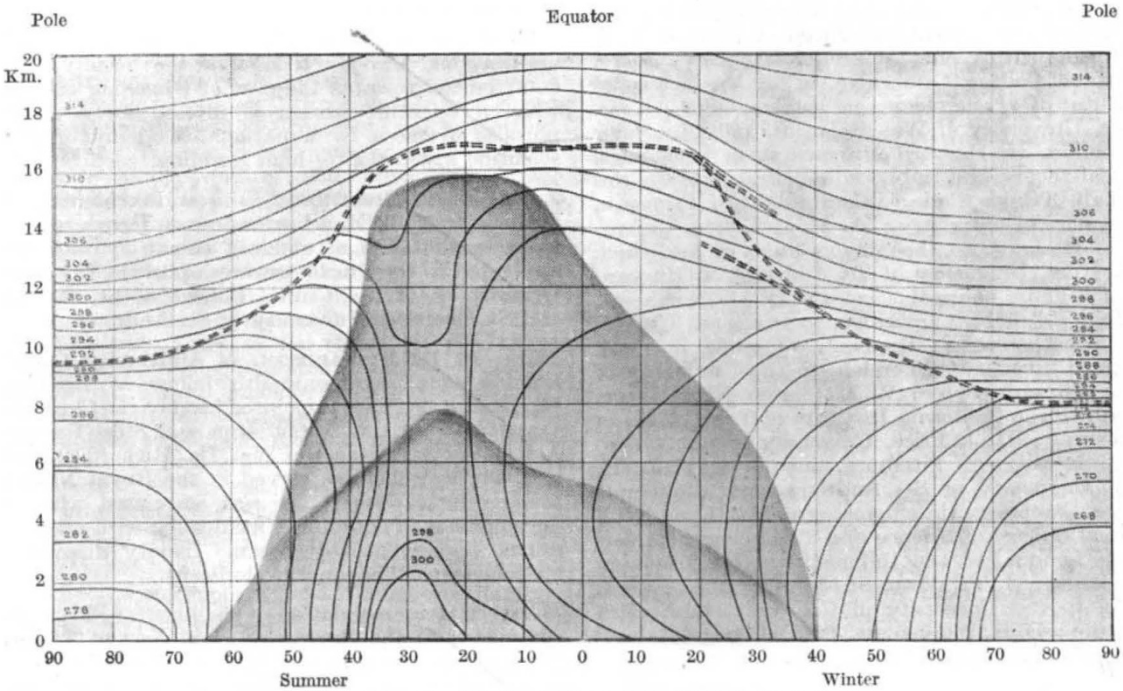
2. At all levels below 8 km., θ′ is maximum at the equator and minimum at the poles; but above 15 km. the minimum is over the equator and the maxima at the poles. Between 10 km. and 15 km. maxima occur both at the poles and near the equator, with minima between.

3. The lower shaded area around the thermal equator on the diagram marks out the region of *convective instability* within which θ′ normally diminishes with height and the lapse-rate of entropy is negative. This region appears to stretch from about lat. 40° in winter to lat. 60° in summer and to rise to a height of 6–8 km. near lat. 20° in summer.

4. The upper shaded area marks off the region in which θ′, though rising with height, is lower than the surface value θ'_0. The upper shaded boundary is drawn through the heights at which θ′ is equal to θ'_0. For example, at the equator, θ′ normally falls from a value of 295° A. at the surface to about 292° A. at 4 and 5 km., then rises slowly at higher levels and regains the surface value of 295° A. at a height of 13 km. When rising air becomes saturated, one would expect it normally to continue to rise out of the region of convective instability and to cease rising below the level at which θ′ regains the surface value. The total shaded area of the diagram may be termed the region of convective liability.

5. The shaded region nowhere extends into the stratosphere, the base of which is denoted by the broken double line. Over the thermal equator, however, the shaded area is seen to rise much higher than the polar stratosphere and almost to touch the equatorial stratosphere, thus giving support to the belief that convection is a main cause of the higher stratosphere over the equator. A critic may ask why, if this is so, the stratosphere is so much higher than the shaded convective area between lat. 10° and lat. 30° in winter; in other words, why is the convective region in this diagram so asymmetrical about the equator, whereas the height of the stratosphere is fairly symmetrical? This discrepancy is more apparent than real, at least in Indian longitudes, where the base of the stratosphere is always sharp and clear-cut and single-valued in summer, but is just one of several inversions in winter, from which the final choice is arbitrarily made by arithmetical rule rather than by any uniquely significant physical change.

It is to be noted that the tropical values in this diagram are drawn mainly from those of the Indian monsoon area, where the values of θ′ aloft are perhaps too great to be representative of all meridians. Between 1943 and 1945 the number of *radio-sonde* stations became so great that their unpublished observations may now be sufficient to show how the meridional sectional diagrams of θ and θ′ vary from one meridian to another.



Distribution of wet bulb potential temperature (θ′) with height

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June 13.

[1] See Brunt, "Physical and Dynamical Meteorology" (2nd edn.), 415.

Research on Free Animals, with Particular Reference to Fisheries

MANAGEMENT of animals that are free to wander presents man with a difficult problem. The Fisheries Research Board of Canada has been attempting for a dozen years or so to make rapid progress in solving that problem for Atlantic salmon. A certain measure of success has been attained and a pattern for treatment of the matter has gradually developed.

There have been two objectives: the first has been to make the salmon available for the best use—for angling, in which they are of high value for sport as well as for food; the second has been to increase their numbers. The problem presents two great difficulties: (1) the complexity of conditions in Nature, and (2) enumeration of animals wandering in a medium (water) foreign to man. Practice in fishery management has largely been rational, that is, based upon reasoning from the limited knowledge available. Empirical practice, based upon successful trial, has had little chance to develop, owing to difficulty or failure in assessing the results. Scientific practice, in which the result is predicted accurately, and economic practice, in which there is a proper relation between effort and result, are only for the future.

Three courses are open. (*a*) Rational practice may be continued indefinitely, as governmental fish culture has been in Canada and the United States for more than seventy years. (*b*) Scientific workers