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Relative Humidity Gradient and the Form of Cloud Bases

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IN THE FEBRUARY, 1940, issue of the BULLETIN an abstract was given of a paper entitled as above, which was presented in full for the writer by Rev. Leo Welch, S.J., at the Washington Assembly, September 1939, of the International Union of Geodesy and Geophysics. It was understood that the complete paper was to be published in the *Proceedings* of the Assembly. Unfortunately, due to lack of funds, only a very brief abstract was published in the said *Proceedings*. The original manuscript can not now be found, and the author's carbon copy perished in the siege of Manila, February 1945. The present paper is an endeavor to reproduce the essential features of the original article.

In our explanation we found it convenient to use the Robitsch adiabatic diagrams, which are perhaps unfamiliar to Americans. We shall here employ only the left hand section of such a chart, and its construction is easily explained. The ordinates are logarithm of pressure. The full curved lines of most slant are dry adiabats numbered according to potential temperature. The dashed lines of less slant are wet adiabats. The abscissae are really lines of equal specific humidity, but, as Robitsch shows, if unit mass of damp air contains s grams of water vapor, its water vapor content is equivalent very approximately to a temperature increase of the air of $2.5s$ degrees Centigrade, where s is the specific humidity. In our discussion we shall consider the abscissae under their aspect of specific humidity, not temperature.

To obtain condensation levels on such a chart, we proceed as follows: There is first plotted a *saturation* curve using the pressures and potential temperatures obtained from the meteorograph record. We then plot a curve of the actual unsaturated conditions by retaining the same pressure ordinate but using now as abscissa the previous saturation abscissa multiplied by the relative humidity. This gives us an abscissa representing the *actual* specific humidity of the air (multiplied by 2.5). Assuming condensation at 100% relative humidity, the condensation level is now easily obtained simply by going along the dry adiabat passing through the given point on the *saturation* curve until we reach the ordinate of required specific humidity, i.e., the point directly above the plot of our fiducial point on the *non*-saturated curve.

We are now in a position to understand the diagrammatic representation of the cases enumerated in the abstract given in the BULLETIN.

I) AIR LIFTED THROUGH SURROUNDINGS HAVING DRY ADIABATIC LAPSE RATE

A) The Specific Humidity Remains Constant with Height. On our Robitsch chart the case is clearly represented. All the significant points of the saturation curve lie on the same dry adiabatic, say ABC (FIG. I). Since there is constant specific humidity, all the points on the non-saturated curve must lie on the same ordinate A′B′C′. The condensation level for all the rising air particles is clearly the level of the intersection of the two lines ABC and A′B′C′, i.e., the common point O.

This case is of special interest, since it is usually contended that in air thoroughly mixed by turbulence there will be a dry-adiabatic temperature gradient with constant specific humidity throughout the turbulent region. (*Cf.* Byers, "Synoptic & Aer. Meteorology," p. 241.) In other words, when there is thorough mixing from turbulence and enough lifting, condensation occurs for all particles of air at the same level, and the clouds will tend to have *flat bases*. It is also apparent that if there is wave motion, condensation only occurs at those points of each wave which are lifted up to and above the common condensation level. Hence we shall have cloud strips with flat bases all at the same level, or a continuous flat cloud base but shaded, with the darker parts below the higher parts of the cloud.

B) Specific Humidity Steadily Decreasing, Relative Humidity Steadily Increasing with Height. Let us now take air, still of dry

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