SHORTER CONTRIBUTION

GEOMETRIC DETERMINATION OF MEAN VIRTUAL TEMPERATURE OR THICKNESS ON AN AEROLOGICAL DIAGRAM

by J.N. McRAE

Central Office, Melbourne

(Manuscript received April 1957)

In the graphical (equal area) determination of heights from a radiosonde sounding errors in the estimation of the thickness of standard layers of the order of 20 geopotential ft below 500 mb and 50 geopotential ft above 500 mb are not uncommon. Such errors usually occur when a large angle is chosen between the virtual temperature line and the "equal area line". The latter line should, of course, be chosen as close as possible to the former. Where there are several changes in lapse rate through the layer the choice of the equal area line by "eye" may present some difficulty. A completely objective and accurate choice of the equal area line can be made by the following method, which can be applied to plots of virtual temperature on any aerological diagram on which - ln p is plotted against temperature.

In Fig. 1 the line ABCDE represents a plot of virtual temperature between pressures p_A and p_E in which there are changes in lapse rate of virtual temperature at pressures p_B, p_C and p_D. In the layer between pressures p_A and p_B the mean virtual temperature T_m^*, defined by

$$T_m^* \ln (p_A/p_B) = \int_{p_A}^{p_B} T^* \, d(-\ln p),$$

is obviously the temperature at the mid-point of the line AB.

To find the mean virtual temperature of the layer p_A to p_C draw the straight line QS through the mid-points of the lines AB and BC. Geometrically it can be seen that the line QS is an equal area line of the sounding A, B, C.

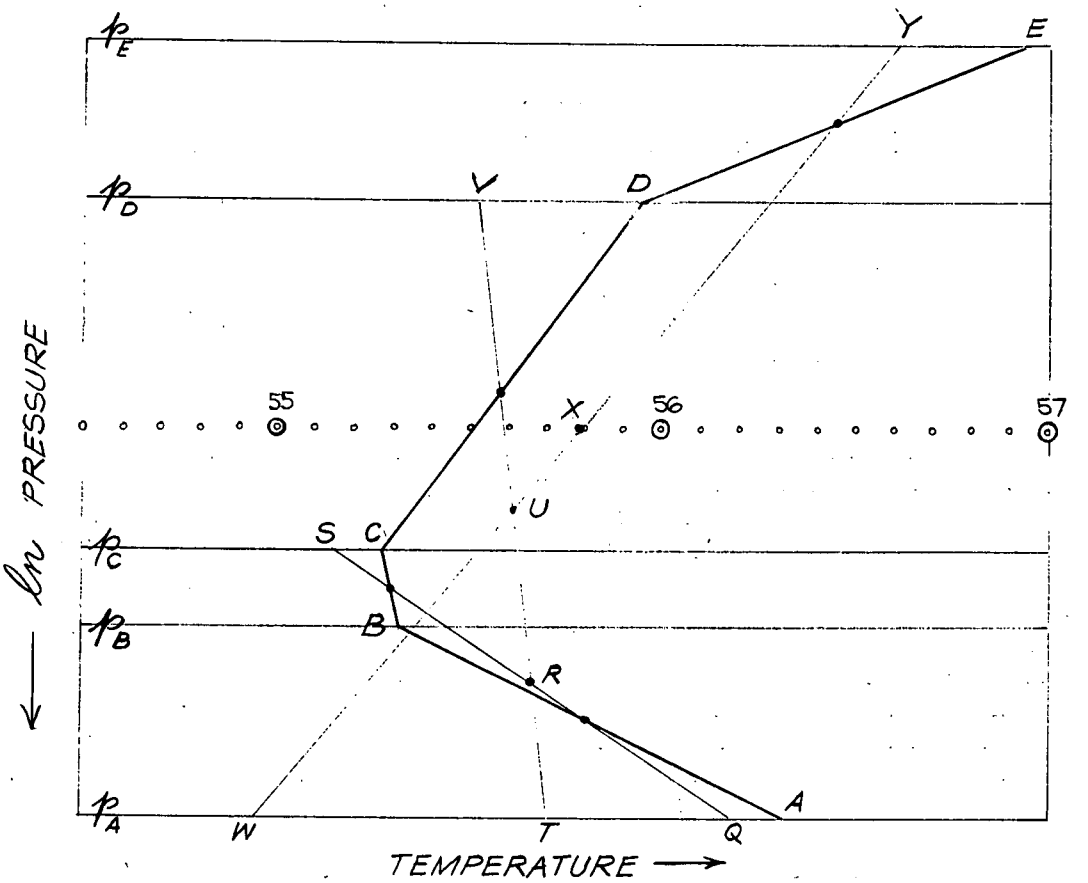

Fig. 1. Geometric determination, on a diagram of virtual temperature plotted against - ln p (isotherms omitted for clarity), of mean virtual temperature or thickness of a layer containing several changes of lapse rate. See text for explanation.

The temperature at the mid-point R of QS is therefore the mean virtual temperature of the layer p_A to p_C.

As any other straight line through R intersecting the isobars p_A and p_C is an equal area line for the layer p_A to p_C the mean virtual temperature of the layer p_A to p_D

can be obtained by drawing the straight line TV through R and the mid-point of the line CD. TV is an equal area line for the layer p_A to p_D and the temperature at its mid-point U is the mean virtual temperature of the layer.

By proceeding similarly the mean virtual temperature of a layer containing any number of changes of lapse rate of virtual temperature can be found. For example the temperature at X (the mid-point of the straight line WY through U and the mid-point of DE) is the mean virtual temperature of the layer p_A to p_E.

On Commonwealth Bureau of Meteorology aerological diagrams F.160 and F.197 (Skew T - ln p diagrams) the thickness of each standard layer is shown in tens of geopotential feet along a line parallel to and equidistant from the standard pressures bounding the standard layers. The thickness of a layer can then be read off at the intersection of the equal area line obtained as above and the line showing the thickness. For example, if in Fig. 1 the pressures p_A and p_E are 500 and 400 mb respectively, the thickness of the layer is read off at X (since WX = XY) as 5580 geopotential feet to the nearest ten.

Usually there will be no more than two changes in lapse rate of virtual temperature through a standard layer. The geometric determination of thickness can then be made almost as quickly as, and much more accurately than, an estimation by "eye".