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ON THE GROWTH OF INSTABILITY FROM PRECIPITATION

In the growth of convective phenomena, as usually pictured, the energy is provided by the condensation of water vapour from lower layers of moist air[1]. Initial instability, albeit of latent variety, is, according to this picture, a pre-requisite for a non-frontal thunderstorm. Strong vertical up-drafts and the growth of thunderclouds thus precede any precipitation that may be received at the surface. Occasionally, however, one comes across cases when precipitation first commences from the thickening of an upper altostratus layer, and, after the altostratus precipitation has lasted for some time, peals of thunder are heard and larger size rain-drops begin to fall. As this latter type of thunderstorms is not usually accompanied by squalls at the surface, these thunderstorms fall into the category of so called " upper level thunderstorms ". It is possible that, in some at least of these cases, the subsequent growth of instability is due to the incursion of fresh moist air at lower levels, but it is not always possible to trace such an incursion, and this led the author to investigate whether it was not possible for the instability to grow by the evaporation of rain. The figure given below shows that, under favourable conditions, there can be a considerable increase in latent instability due to precipitation.

In the figure, ABCD is the ascent curve and PQRS is the wet bulb curve when the altostratus precipitation commences. The layer CD (or RS) is saturated. At this stage, the positive area corresponding to the lifting of a surface air parcel given by BCY is small and is also less than the negative area given by AB′B. There is thus only a small amount of pseudo latent instability present when the altostratus precipitation commences. As precipitation continues, the air below gets cooled by evaporation of rain water and, after the precipitation has continued sufficiently long, the ascent curve will take the shape A_1B_1QCD. The wet bulb curve, of course, remains unaffected. The positive area corresponding to the lifting of a surface air parcel is now given by $B_1QCYBB'B_1$ which is large and the negative area given by $A_1B''B_1$ is comparatively very little, so that, a considerable amount of real latent instability has developed. Also, the lifting *i.e.*, the "trigger" required for the release of the energy is very little. The lower layers of air are thus now capable of releasing a considerable amount of energy.

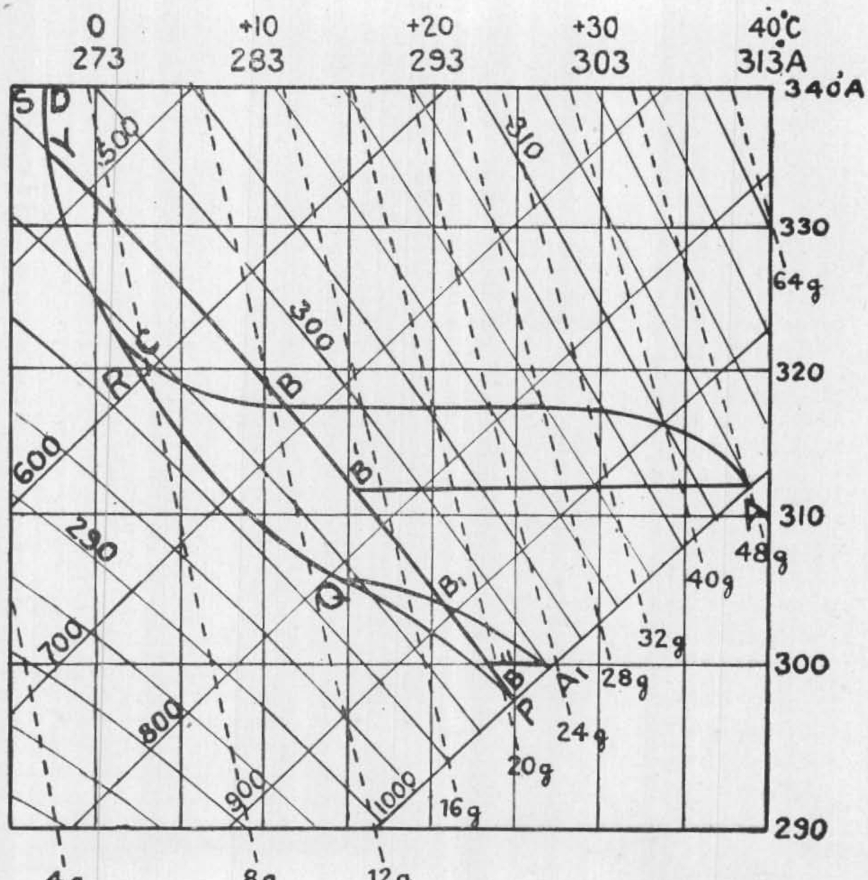

Fig. 1

In the above analysis, we have used the usual parcel method of treatment and have neglected the effect of entrainment of environment air by the rising cloud air. The effect of entrainment of environment air would be to reduce the size of the positive area both before and after the altostratus precipitation[2], but the above conclusion will still remain valid. We have also assumed that altostratus rain does not give rise to any downdrafts which, if present and allowed sufficient time to mix with the environment, will alter the character of the wet bulb curve also, in addition to effecting further change in the ascent curve. The assumption made is, however, fully justified, as downdrafts are caused by localised heavy precipitation only[3] and not by uniform precipitation over a wide area such as one would expect from altostratus cloud.

It will be seen that, by the time a considerable amount of real latent instability has developed and is ready for release, the atmosphere is saturated or nearly so, so that, no appreciable downdraft can result from such thunderstorm, which will thus be characterised by an absence of "air pocket", as also of surface squall, since downdraft is the cause of surface squall in a non-frontal thunderstorm. The other characteristics of this type of thunderstorm would be : little or no fall in surface wet bulb temperature and also no large fall in surface dry bulb temperature, except what occurs due to evaporation cooling before the break of thunderstorm. Conditions favourable for the occurrence of this type of thunderstorms are obviously (1) a thick layer of nearly saturated air from the altostratus level upwards and (2) a markedly dry air with a steep lapse rate below the altostratus level, the lowest layers being convectively unstable. The synoptic situation favourable for the creation of these conditions is a moving system of "Upper Air Low" bringing in an almost saturated air at upper levels, while the air mass below the altostratus level down to the surface is of continental origin and possesses a steep lapse rate. Such a synoptic situation is sometimes provided in northern and central India in late winter and early summer by the travel of extra tropical occluded depressions. Favourable conditions for their occurrence, however, may occasionally develop at other times and in other parts of the country as well.

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REFERENCES

1. Normand, C.W.B., *Quart. J.R. met. Soc.*, **64**, pp. 47-65 (1938).
2. Ray Choudhuri, S.N., *Ind. J. Met. Geophys.*, **1**, 3, pp.248-251 (1950).
3. Byers, Horace R. and Braham, Roscoe R., *J. Met.*, **5**, 3, pp. 71-86 (1948).