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## SOME THERMODYNAMIC IMPLICATIONS OF MICROBURST FORECASTING OVER MADRAS AIRPORT

1. The extraordinary growth of the air transport has necessitated the need for precise and accurate nowcasting of short lived convective activity. One such very short lived convective phonomenon, the microburst which was first described by Fujita (1985) is attributed to be the cause of some of the major aircrashes. The temporal and spatial scale of the microbursts make the detection almost impossible. However, this scale also happens to be the most important from the point of view of aviation during landing and take off phases.

2. Inspite of the sophisticated Doppler radar techniques and various special experiments etc., the quantitative assessment of microburst impact still appears to be lacking. It is more so in countries like India, where such instrumentation facility is still at the preliminary stage only. Hence, in the absence of such specific facility one has to seek recourse to conventional observations and try to obtain some qualitative assessment, using parameters like thermodynamic stability, vertical wind profile and mesoscale temperature structure, etc. One such obvious method is the utilisation of upper air baloonsondes and study the thermodynamic structure of the microburst days. Atkins and Wakimoto (1991) had made some such studies based on 1986 MIST (Microburst and Severe Thunderstorm) experiment conducted in Northern Alabama and brought out certain distinct and different characteristics of microbursts when compared either to general thunderstorm days without microburst or the other ordinary non-thunderstorm days.

2.1. The aim of the present study is to find out whether such similar characteristics are seen with respect to microbursts over the Madras airport in India and to study the general environmental conditions that could favour microbursts.

3. Though microburst instances are not frequent at Madras, study has been made earlier listing out possible instances of microbursts over Madras airport over a 50-year period by Jayanthi *et al.* (1995). Out of the cases listed, some typical four days of clear cut microburst instances were taken for this study. To compare these with other non-microburst days, two typical thunderstorm (TS) days without microbursts and two clear non - convective days were considered. Details of comparison are given in the Table 1.

3.1. The morning 0000 UTC and afternoon 1200 UTC soundings launched from the airport Meteorological Office at Madras on these days were the main data base for analysing the thermodynamic characteristics, like the vertical profiles of the equivalent potential temperatures, potential buoyant energy (PBE), George *k* Index, vertical wind shear, Bulk Richardson Number, etc.

**TABLE 1**

**Thermodynamic characteristics**

| Type of activity | Date | At 1200 UTC | | | | |
|---|---|---|---|---|---|---|
| | | $\theta_e$ max | | $\theta_e$ min | | $\Delta\theta_e$ |
| | | Level (hPa) | $\theta_e$(°K) | Level (hPa) | $\theta_e$(°K) | |
| Micro | 24 Jun 1984 | Surface | 350 | 645 | 323 | 27 |
| Burst | 3 Jun 1986 | 820 | 362 | 600 | 327 | 35 |
| | 30 Aug 1986 | Surface | 358 | 543 | 327 | 31 |
| | 8 Oct 1986 | 960 | 360 | 600 | 331 | 29 |
| | 21Sep1987 | 805 | 369 | 500 | 335 | 34 |
| TS | 19 Jul 1986 | Surface | 348 | 475 | 338 | 10 |
| With no micro burst | 23 Sep1986 | 825 | 345 | 600 | 332 | 13 |
| No | 27 Jun 1984 | 970 | 354 | 630 | 330 | 24 |
| TS | 30 Jul 1986 | Surface | 338 | 700 | 327 | 11 |

4. Examination of the morning T-$\phi$ grams on all the microburst days indicates clear pronounced low level inversion below 900 hPa of thickness ranging from 45 to 80 hPa. Figs.1(a-c) give the vertical temperature profile of 3 days representing microburst day, mere TS day and an ordinary day respectively. It is seen that on the microburst day, there is clear indication of low level inversion. On the other hand, the soundings on mere TS days indicate more stability and lower levels have more mixing than on microburst days.

4.1. As surface heating continues, this inversion is replaced by dry adiabatic sub-cloud layer extending from surface to 900 hPa. Further, the levels above the 500 hPa are usually dry as seen again from Fig.1(a). Carcena and Maier (1987) have also documented the existence and the potential importance of mid-level dry air in an environment that produces strong microbursts.

4.2.(a) Even as early as in 1938 for Bengal norwesters, Desai and Mull (1938) have used '$\theta_e$', the equivalent potential temperature, as the tracer to determine the source region of the down draft under adiabatic process in which no mixing or ice processes occur.

(b) In the present study also the vertical profile of $\theta_e$ are studied. The afternoon thermodynamic diagrams indicate, that the microburst environments are potentially unstable from the surface to mid-levels and the minimum $\theta_e$ is typically located between 600 and 500 hPa. This low mid-level '$\theta_e$' is responsible for promoting strong microbursts, evaporative cooling and production of large negative buoyancy. The analysis pertaining to non-microburst convectively active thunderstorm days indicates no such distinct difference. The comparison of these verses microburst days is given in Table 1. The existence of such minimum value of '$\theta_e$' in an environment producing wet microbursts has also been documented by Atkin and Wakimoto (1991).

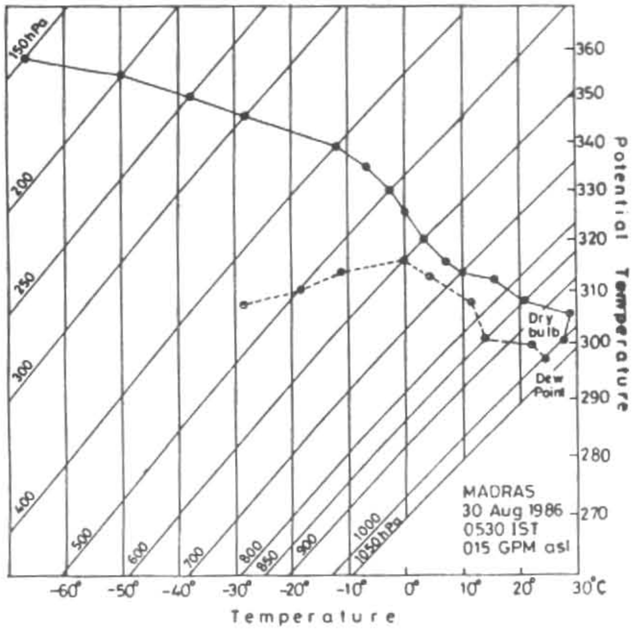



Fig. 1(a). Temperature profile for a microburst day

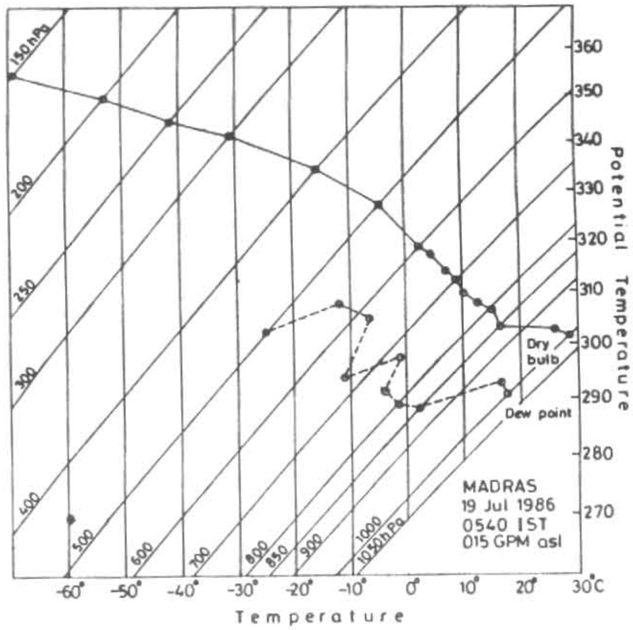



Fig. 1 (b). Temperature profile for a non-microburst day

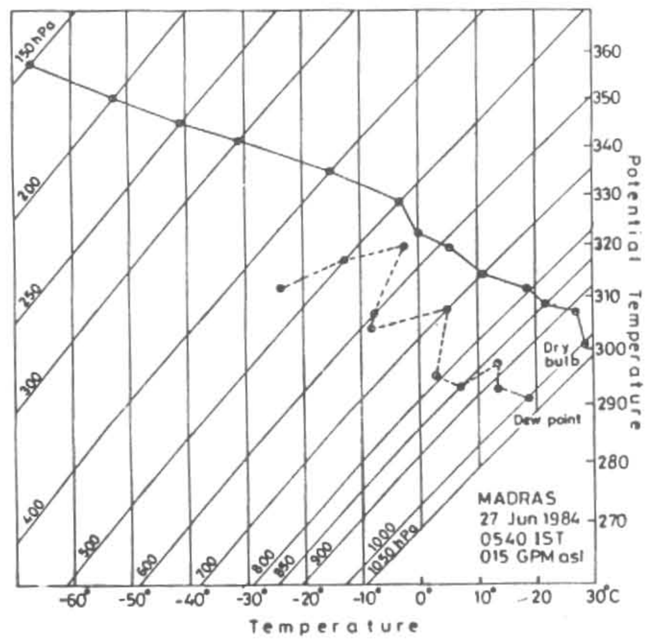



Fig. 1 (c). Temperature profile for a non convective day

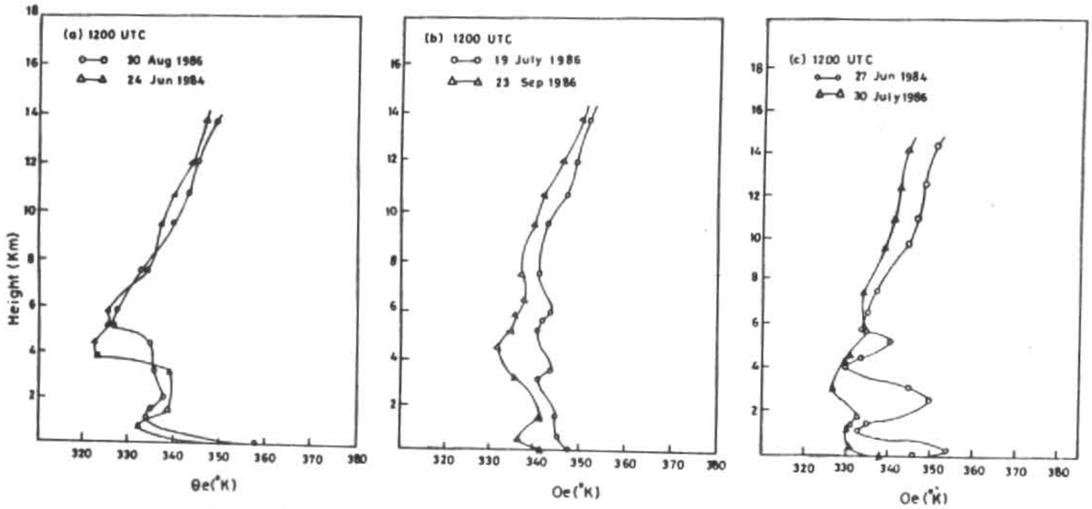
(c) Figs.2 (a-c) give the $\theta_e$ profiles for typical days in case of microburst days, TS days and null days for 1200 UTC radiosonde. The $\Delta\theta e$ in microburst days indicate much higher values ranging from 27° to 35° K. These values are similar to that reported in case of MIST experiment of Albama which indicated $\Delta\theta e$ values ranging between 21° and 39°K. While $\Delta\theta_e$ in case of TS without microburst days is found to be much less than 13°K. However, there are instances when even on null days high values of $\Delta\theta e$ greater than 27° K are reported. These higher values of $\Delta\theta e$ on null days indicate that stability is not the only factor that produces microburst but lifting mechanism should also be present to produce the same. As explained by Atkins and Wakimoto (1991), if convection had developed on any of such days, microburst would have certainly occurred. Also, the comparative analysis of morning and evening ascents indicates higher values of $\Delta\theta_e$ in the afternoon than in the morning.

**TABLE 2**

**Values of PBE(J/kg) for 1200 UTC**

| Type of activity | Date | PBE(J/kg) |
|---|---|---|
| Microburst | 24 Jun 1984 | 1113 |
| | 3 Jun 1986 | 2266 |
| | 30 Aug 1986 | 3899 |
| | 8 Oct 1986 | 3323 |
| | 21 Sep 1987 | 2098 |
| TS with no | 19 Jul 1986 | 685 |
| Microburst | 23 Sep 1986 | 874 |
| Null days | 27 Jun 1984 | 116 |
| | 30 Jul 1986 | 261 |

(d) Thus there exists a distinct difference in $\Delta\theta e$ value between microburst days and mere thunderstorm days and we can infer that there should be some threshold value for $\Delta\theta_e$ which would distinguish a microburst day from an ordinary thunderstorm day. As indicated in the analysis since $\Delta\theta_e$ values on all the microburst days were greater than 27°K the minimum threshold value can be taken as 27°K as far as Madras is concerned.




**Figs. 2 (a -c).** Vertical $\theta_e$ profile of (a) microburst days (b) non-microburst days (c) non-convective days

(e) However, due to very few number of cases, this needs further testing over a large number of days before arriving at a more accurate threshold value of $\Delta\theta_e$ as a reliable predicter.

4.3. To further examine the difference between microburst *versus* non-microburst conditions, the other important thermodynamic parameter, *viz.*, PBE (potential buoyant energy) for 1200 UTC radiosonde data is also considered, which measures directly the potential vigour of the downdraft and boundary layer out flow. As is well known, PBE is the work done per unit mass on the environment by a buoyant air parcel as it rises level of free convection (LFC) to its equilibrium level (EL) indicating positive area on an energy conserved thermodynamic diagram as calculated below:

$$\text{PBE} = \int_{\text{LFC}}^{\text{EL}} \frac{g\,(\theta_p - \theta_e)}{\theta_e}\, dz \qquad (1)$$

Where $\theta_p$ and $\theta_e$ are the potential temperatures of the parcel and the environment, respectively and the values are indicated in Table 2. It is seen that microburst days have higher PBE when compared to other days.

4.4. The values of vertical wind shear, bulk Richardson number and George $K$ index were computed for all the cases considered to find out any characteristic distinction between microburst, non-microburst and non-convective days. However, no clear distinction could be obtained from the values so computed.

5. From the foregoing it is seen that there are certain distinct features as mainly depicted by the afternoon radiosonde ascents which differentiate a microburst day from any other day. One important thumb rule is that whenever there is morning inversion and if in the afternoon the $\Delta\theta e$ value exceeds 27° and PBE value greater than 1000 J/K, the forecaster can expect microburst.

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