LETTER TO THE EDITOR

Cyclogenesis in the Bay of Bengal and the Arabian Sea

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The normal temperature charts for July for 200 mb produced by Rao & Desai (1970) do not appear to be appropriate for the study of the warm pools mentioned by Mowla (1968) since the effects of the Tibetan Plateau obscured the real position of the warm areas due to the formation of warm pools, in their 200 mb normal temperature charts. Rao & Desai admit that "Ram Krishnan probably did not consider effect of the Tibetan Plateau on the temperature distribution". Ram Krishnan's normal isotherms for 200 mb for July should, therefore, be preferred for this study. Thus substantial modification might be necessary in the normal temperature charts of 200 mb level for July produced by Rao & Desai (1970) in order that the statistical result of the warm pools might be well reflected in their charts. Depressions developed even on land below the warm areas as may be noticed from Fig. 1*b* of Mowla.

Table 1 given by Rao & Desai shows that temperature rose from August 18 to 20, fell on August 21, rose on August 22, remained steady from 22nd to 23rd and finally fell on 24th.

A glance at the above table and Fig. 1 given below would show that temperature for 200 mb on August 21 at 0000Z for Calcutta was most probably −41°C and not −48°C as reported. The steady rise of the temperatures is also shown in the Figure.

The daily rise in 0000Z temperature from 18th to 22nd was 5°C, 4°C and (for last 2 days) 5°C respectively, showing it was most probably 3°C and 2°C for 21st and 22nd, thus −41°C for 0000Z of 21st. This also explains how the temperature of the warm pool on August 21 was shown as −40°C in Table 2 of Mowla (1968). Similarly the fall in 1200Z temperatures from 18th was 1°C daily up to 23rd, showing −42°C and −43°C as probable temperatures for 20th and 21st respectively.

The above correction also appeared necessary while drawing isotherms for 0000Z of 200 mb level for August 21. Calcutta did not record 1200Z temperature for levels above 600 mb on 20th.

Though temperatures at 200 mb level above Calcutta at 1200Z fell by 4°C from August 18 to 22, the same rose by 14°C at 0000Z during the same period. The cooling was, however, less than one-third of the warming.

The 200 mb temperatures of Calcutta thus rose steadily at 0000Z from August 18 to 22, remained steady up to 23rd and then fell on 24th.

The fall from 23rd to 24th was due to the shift of the warm pool after formation of the depression on 22nd.

Table 1 shows that during the day, the temperature gap from 0000Z to 1200Z decreased everyday from 18th to 21st and then reversed up to 23rd. During the night also the temperature gap from 1200Z of the day to 0000Z of the following day decreased from 18th/19th night to, probably, 20th/21st night and then reversed up to 22nd/23rd night. The mean temperatures (after correction) rose steadily from August 18 to 22 and then fell from 23rd onwards. It is, therefore, difficult to accept the remarks of Rao & Desai that there was no regular and persistent development of a warm pool at 200 mb before the formation of the depression on August 22, 1964. The mean temperatures definitely rose everyday from August 18 to 22 when cyclogenesis occurred and then started falling from 23rd onwards due to the shift of the warm pool.

Table 2 of Mowla (1968) was given to show that warm pools were present on both days. If the warm pool on one day was warmer o

Table 1. *200 mb temperature (degrees centigrade) for Calcutta, August 1964*

Date	At 0000Z	At 1200Z	Mean 0000Z & 1200Z	Change 0000Z–1200Z	Change 1200Z–0000Z next day
18	−53°C	−40°C	−46.5°C	13	
19	−48°C	−41°C	−44.5°C	7	−8
20	−44°C	(−42°C)	(−43°C)	(2)	−3
21	−48°C	−48°C	−48°C	0	(1)[a]
	−41°C[a]	(−43°C)[a]	(−42°C)[a]	(−2)[a]	−
22	−39°C	−44°C	−41.5°C	−5	+9
					(+4)[a]
23	−39°C	−45°C	−42°C	−6	+5
24	−45°C	−41°C	−43°C	+4	0

[a] *After correction.* ( ) *Probable figures.*

cooler than that of the previous day, this might also indicate how the cyclogenesis was changing.

From the survey of various views presented by Rao & Desai, it is apparent that (i) they probably suggest that unsettled conditions moving westwards led to the formation of the depression of August 22. But "for a tropical storm to form and persist, the upper outflow above the surface disturbance must exceed the compensating inflow at the surface so that central pressure falls sufficiently to transform the surface disturbance into a vigorous energy producing circulation" (Ramage, 1959); (ii) the distribution of temperature at 200 mb shown in Fig. 1 of Rao & Desai's letter could not explain winds of Calcutta for 200 mb from 18th to 24th; (iii) Desai apparently contradicts his first findings (1968) on the cause–effect relationship of pressure system movement at 200 mb level with the development at the surface in his second paper (1969); (iv) the hitherto prevailing idea regarding fall of temperature in the rear of the trough moving in the westerlies in the middle and upper troposphere during months of June–September would, according to Rao & Desai, require modification in view of the I.Met.D. charts (1968) for July of normal temperatures for 500 mb and 300 mb and 200 mb produced by Rao & Desai. This indicates the need to modify these charts rather than the hitherto prevailing idea; (v) Ramawamy (1962, 1969) sees disappearances of monsoon troughs at surface due to westerly troughs in the middle and upper troposphere, but (vi) Changraney (1966) and Desai (1967) found evidence of accentuations of monsoon troughs due to movement of the troughs in the westerlies.

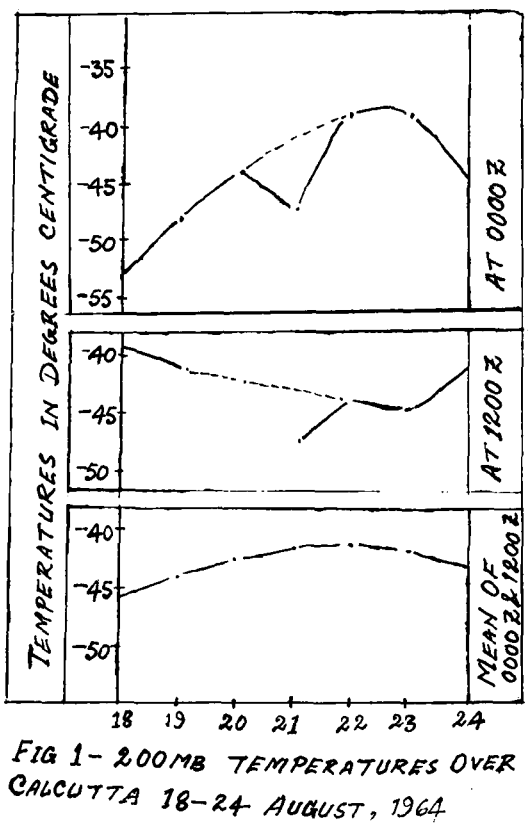

FIG 1 - 200 MB TEMPERATURES OVER CALCUTTA 18-24 AUGUST, 1964

Fig. 1. 200 mb temperatures over Calcutta, August 18–24, 1964

The survey neither proves nor disproves conclusively any one theory on the genesis of the monsoon depressions.

No doubt the pressure pattern developing in

the lower troposphere represents integrated effects of various factors and not of any individual factor. Mowla did not try to prove the contrary.

"The upper tropospheric part of the monsoon circulation over Bay of Bengal and over the Arabian Sea is persistently divergent east of the Indian peninsula and persistently convergent west of the peninsula.

"Upper divergence over the Bay of Bengal is strongest in summer at the height of the monsoon. Despite this, excessive vertical wind shear between the lower and upper branches of the monsoon tends to inhibit hurricane development. The upper convergence and the strong vertical wind shear of the monsoon circulation over the Arabian Sea ensure that no hurricane ever forms in the Arabian Sea during summer" (Ramage, 1959).

The movements of the cold troughs in the westerlies across north India on 18th and 19th and of a cold trough in the easterlies on the 19th found by Mowla was probably a situation Reihl (1954) thought might supply the starting mechanism for cyclogenesis to develop tropical storms. Sawyer also placed initiating events in the high tropospheric layer between 300 mb and the tropopause. Sadler (1967) believes tropical vortices originate in the directional shear zones of the trough system rather than in the easterly flow and penetrate downwards to surface to form tropical storms.

Concluding remarks

It is therefore difficult to appreciate why Rao & Desai should not accept Mowla's conclusions about development of warm pools at 200 mb level, before the depression forms at sea level below them.

The normal temperature charts of July for 200 mb level of Rao & Desai need modifications to facilitate such studies.

REFERENCES

Mowla, K. G. 1968. *Tellus 20*, 151–162.
Ramage, C. S. 1959. *J. Meteor. 16*, 227, 230 & 232.
Rao, Y. P. & Desai, B. N. 1970. *Tellus 22*, 4.
Reihl, H. 1954. *Tropical meteorology*, pp. 332–4. McGraw-Hill, New York.
Sadler, J. C. 1967. *Proc. Working Panel Trop. Dyna. Meteor.*, 45, 71.