551. 553. 21 : 551. 513 : 551. 524. 7

A NOTE ON THE MERIDIONAL TEMPERATURE GRADIENTS IN THE UPPER STRATOSPHERE AT BALASORE DURING MONSOON OF 1979

Meteorological rocket sounding wind data from the Indian station Balasore (21 deg. 31 Lat.) on 4, 6 and 11 July and 1, 3 and 8 August 1979 are used to derive the meridional temperature gradients at different heights. From the wind data it is found that there is a layer of large vertical wind shear in the upper stratosphere which fluctuates in height on different days. The vertical wind shear increased and, therefore, the south-north temperature gradient increased to about 20 deg. C to 30 deg. C per 100 km in the 45 to 50 km layer at Balasore, before the formation and intensification of two monsoon depressions in the northeast Bay of Bengal.

2. It is valid to apply the equations of motion used in the troposphere upto 70 km or so (Chapman 1954). Hence the thermal wind equation can be safely used to derive the horizontal temperature gradient from the vertical wind shear. The equation we have used in the x, y, z co-ordinate system is :

$$\left(\frac{\partial T}{\partial y}\right)_z = \frac{f}{R} \quad \frac{u(z_1) - u(z_0)}{\ln(z_1/z_0)}$$

where, $z_1 > z > z_0$

The left hand side represents the meridional temperature gradient at height z km; $u(z)$ is the zonal wind at height z; f is the coriolis parameter and R is the gas constant for dry air.

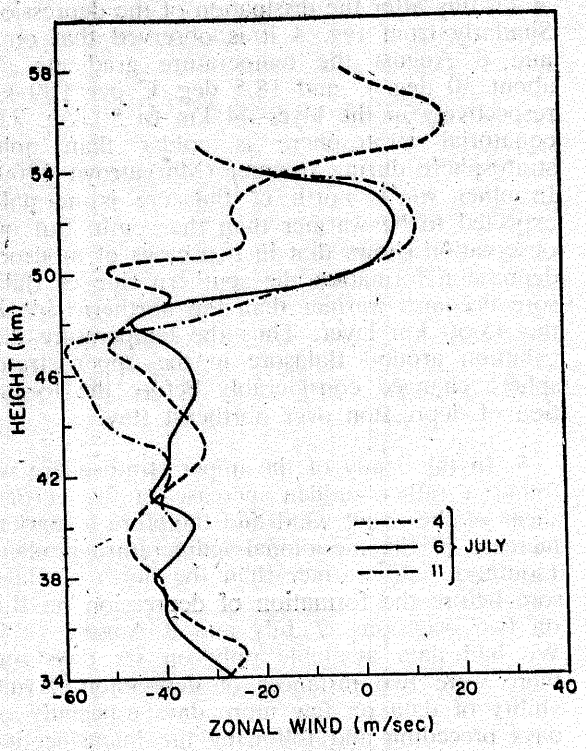

Fig. 1. Zonal wind (m/sec) *vs* height (km) on 4, 6 & 11 July 1979

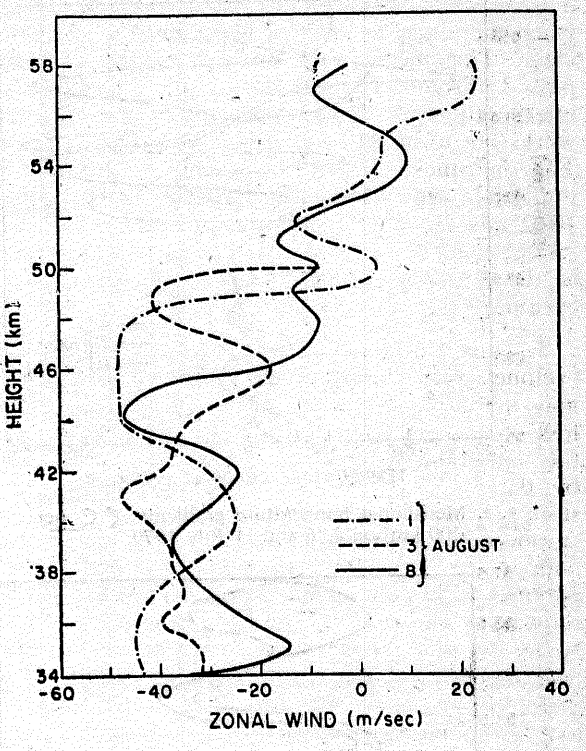

Fig. 2. Zonal wind (m/sec) *vs* height (Km) on 1, 3 and 8 August 1979

When there is decrease of temperature towards the north the south-north temparature gradient is taken to be positive.

3. A monsoon depression formed on 7 July 1979 in northwest Bay moved westwards and crossed north Orissa coast near Paradeep on 8 July. Similarly another depression formed on 6 August in northeast Bay, moved westwards and intensified into deep depression (DD) by evening and into a severe cyclonic storm (SCS) on 7 August. On 8th it moved westwards, crossed north Orissa coast near Balasore and lay centred close to Rourkela. Considering the vertical distribution of zonal wind in the layer 48 km to 54 km in Fig. 1 it is observed that on 4 and 6 July (before the formation of depression), the wind is westerly, about 11 m/sec and 7 m/sec respectively at 51.5 km and on 11 July it is about 25 m/sec easterly at the same height. Similarly from Fig. 2 in the layer 48 km to 54 km it is clear that on 1 August the wind changes from 48 m/sec easterly at 48 km to 4 m/sec westerly at 50 km. On 3rd the easterly wind becomes weaker than on 1st and and on 8 August it is 10 m/sec westerly at 54 km. Apparently on both occasions of depression formation the easterly winds in the upper stratosphere become weak and are replaced by westerly wind. In the case of July data, the largest vertical shear has occurred in the layer 47-52 km on 4 and 6 July and between 50-55 km on 11 July. Similarly in Fig. 2 the layer of very large positive shear has fluctuated between 41 to 50 km on different days. Thus there is the presence of a layer of large vertical wind shear in the upper stratosphere which changes its height on different days between about 45-55 km. However, in the layer 45 km to 50 km the vertical wind shear is increased before the formation of both the depressions. To compare the situation with that in the troposphere it may be noted that decrease of vertical shear in the upper troposphere at the time of formation of monsoon disturbances has been documented by Keshavamurty *et al.* (1978 a) and before the formation of monsoon depressions by Raman *et al.* (1978).

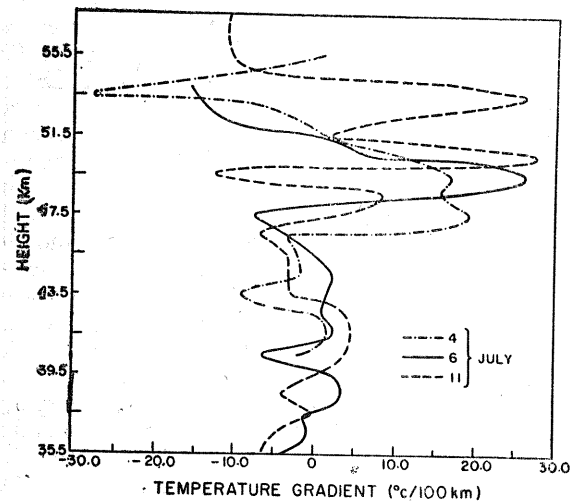

Fig. 3. Meridional temperature gradients (° C per 100 km) on 4, 6 and 11 July 1979

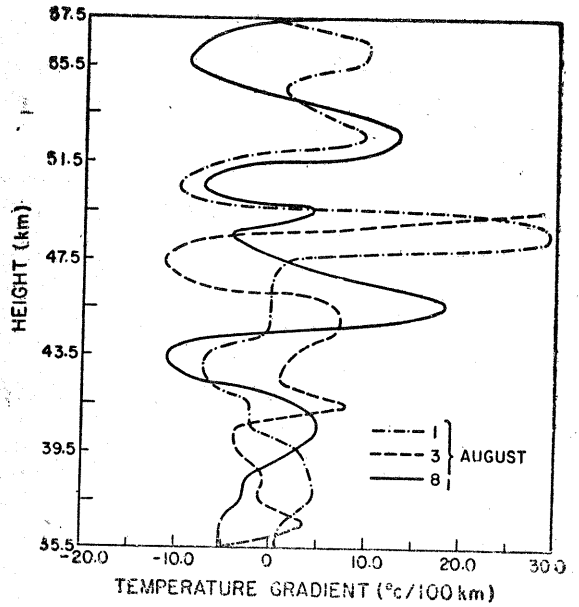

Fig. 4. Meridional temperature gradients (°C per 100 km) on 1, 3 and 8 August 1979

4. Before the formation of 6 July depression, on 4th and 6th the south-north temperature gradients are 20 deg. C and about 27 deg. C per 100 km respectively in the layer 46 km to 50 km (Fig. 3). At the same height the temperature gradient is about — 13 deg. C/100 km on at 11 July after the dissipation of the depression. Similarly from Fig. 4 it is observed that on 3 and 8 August the temperature gradients are about 30 deg. C and 18.5 deg. C per 100 km respectively in the layer 44 km to 50 km. The equatorial stratosphere is colder than polar stratosphere during summer (Murgatroyd 1969). In other words north of Balasore is normally expected to be warmer than the south. But our observation shows that in two cases of monsoon depression formation the southern side of Balasore becomes warmer than the northern side in the 45-50 km layer. Thus the temperature distribution around Balasore in the upper stratosphere changed considerably before the formation of depression over northeast Bay.

5. In this study of the upper stratosphere we found a rather sudden increase in the vertical shear of the zonal wind and therefore a marked increase of the meridional temperature gradient (southern side warmer than the north at Balasore before the formation of depression on Bay on two occasions, 7 July and 8 August 1979. We had data available only on six days and there were two instances of depression. Availability of data on few more days especially on days preceding and following the intensification of depression would help in studying the evolution of the vertical wind shear and temperature gradient in the upper stratosphere.

6. The author wishes to thank Prof. P. R. Pisharoty for suggesting the problem and to Dr. V. Satyan for useful discussions. Thanks are also due to Mr. S. P. Saxena for making available the *Indian Daily Weather Reports*.

References

Chapman, S., 1954, Conference on motions in the upper atmosphere, U.G.G.I. News Letter No. 6.

Keshavamurthy, R. N., Asnani, G. C., Pillai, P. V. and Das, S. K., 1978(a), Some studies of the growth of monsoon disturbances, *Proc. Indian Acadm. Sci.*, **87A**, (E and P Sciences), 3, 61-75.

Murgatroyd, R. J., 1969, *The structure aud dynamics of the stratosphere*, The Global Circulation of the atmosphere, G. A. Corby, Ed., London, Roy. met. Soc., 159-195.

Raman, C. R. V., Rao, Y. P., Subramanian, S. K. and Sheikh, Z. E., 1978, Wind Shear in a monsoon depression, *Nature*, **276**, 51-53.

S. K. DASH

Physical Research Laboratory, Ahmedabad
6 May 1980