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High-level Summer Warmings & Their Possible Association with Monsoon*

B K Mukherjee & Bh V Ramana Murty
Indian Institute of Tropical Meteorology, Poona 411 005

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The stratospheric and mesospheric warmings reported in literature refer to winter and spring periods. Seldom there is mention of the occurrence of such warmings in summer. It is considered that the thermal behaviour of stratosphere and mesosphere over tropical stations in summer may have a bearing, at least on gross scale, on the activity of summer monsoon. With this end in view, the available Soviet rocket data for Thumba (8°32′15″N; 76°51′48″E), of the three summer periods commencing from 1971, are examined. The study revealed the phenomenon of high-level warmings over the station. The behaviour of the monsoon, when such phenomenon occurred, differed from that of the monsoon when it did not occur. Similar feature was also inferred from analysis of radiosonde data. The problem was further examined through analysis of the rocket data of the pre-summer periods. The possibility of such data reflecting the behaviour of the approaching monsoon was indicated.

1. Introduction

Information on temperature changes in the stratosphere/mesosphere is valuable for understanding some aspects of tropospheric events.[1] High-level warmings have been mainly reported from middle and high latitudes during winter and spring.[2-4] But, such reports from tropics, specially in summer, are scanty. Occurrence of the warmings over a tropical station during winter has been recently identified.[5,6] Since the temporal variability of both temperature and wind increases steadily as one proceeds upward above 25 km in summer as well as winter,[7,8] the possibility of occurrence of high-level warmings during summer is not ruled out. In fact, one summer stratospheric warming was reported during July 1958.[9]

As the summer season over a large part of the eastern tropics is associated with a major weather phenomenon, namely, the monsoon, it would be of interest to know whether high-level warmings occur in the tropics during this period and if so, their probable association with the behaviour of the monsoon. With this end in view, the authors have examined the occurrence, if any, of high-level summer warmings over the tropical station, Thumba (8°32′15″N; 76°51′48″E), for which Soviet rocketsonde data are available for three consecutive summers (May-Sep.) during one of which the monsoon was bad over the country. Also, the temperature data of lower levels, as obtained from radiosonde for the same period, for the stations Trivandrum (8°29′N; 76°57′E; 64 m MSL) and Delhi (28°35′N; 77°12′E; 216 m MSL) have been examined. The features noticed in the analysis have been presented.

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2. Data

The rocket and radiosonde data for the period Mar.-Sep. 1971-73, were utilized in the analysis. The pre-summer period, March-April, was also considered in order to know as to what extent the features during this period reflect those during the following summer. The rocket data were available at intervals of, mostly, 7 days. The 1200 GMT radiosonde temperature data relating to 300 mb (upper troposphere) and 50 mb (lower stratosphere) were considered.

Table 1—Cases of Strong and Weak Warming

Date	Height of base and top of warming layer km	Maximum warming	
		Magnitude °C	Height km
(a) Strong warming:			
30 June 1971	55-65	21	57,58
18 Aug. 1971	49-55	21	50,51
25 May 1973	48-54	18	52
4 July 1973	49-60	28	53
16 Aug. 1973	54-63	26	58
(b) Weak warming:			
26 May 1971	50-51	16	51
27 Sept. 1972	52-56	17	54
14 June 1973	50-53	16	52,53

3. Results and Discussion

In the present study, an occasion characterized by a minimum rise in temperature of 15°C over a depth of at least 5 km, from the preceeding sounding, is considered as a case of 'strong warming'. Any occasion associated with the above rise in temperature, but limited to a depth of 5 km, is considered as a case of 'weak warming'. Based on these criteria, the cases of strong and weak warming as identified during summer periods, May to Sept. in the 3 consecutive years, are listed in Table 1. There were 2 cases of strong warming in 1971, 3 cases in 1973 and no case in 1972. As far as weak warming is concerned, there was 1 case during each of the 3 years.

Only one case of strong warming is depicted, for brevity, in Fig. 1. The case relates to warming noted in July 1973. The temperature and wind profiles are given, for various levels, at intervals of 5 km.

Warming occurred in the layer 49 to 60 km. The maximum warming of 26°C occurred at 55 km. There was strong increase in the wind-field in the layer of warming.

3.1 Warmings and Behaviour of Monsoon

The best monsoon year, 1973, was associated with maximum number of cases of strong warming. The worst monsoon year 1972, on the contrary, did not show any case of strong warming. Cases of weak warming occurred, no doubt, in both these years of contrasting monsoon. But in the year of worst monsoon, it occurred after the monsoon had practically withdrawn.

Warming occurred in the month of May both in 1971 and 1973. The onset of the monsoon during these years was either early or normal and the monsoon was good. As data are available only for two launchings separated by an interval of 14 days for the month of May in 1972, no analysis of this nature was possible for 1972.

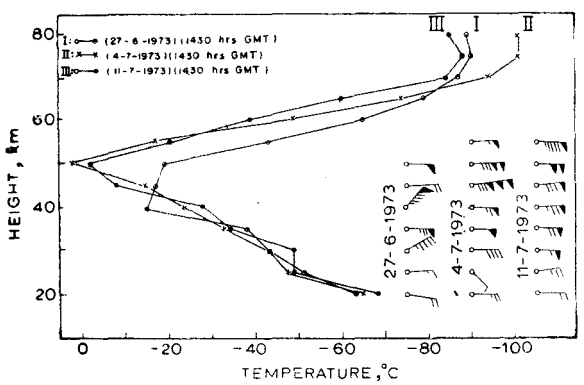

Fig. 1—Temperature and wind profiles in the case of strong summer warming on 4 July 1973 (compare temperatures from I and II between 50 and 60 km)

Table 2—Temperature (°K) at 45 km at Thumba (Trivandrum)

	Mar.	Apr.	May	June	July	Aug.	Sep.
1971	267	268	265	262	263	263	268
1972	269	267	267	266	268	268	266
1973	265	265	261	258	263	257	264

Table 3—Temperature Difference between 20 and 45 km at Thumba (Trivandrum)

	Mar.	Apr.	May	June	July	Aug.	Sep.
1971	58	61	50	48	51	53	54
1972	64	57	57	58	61	60	59
1973	67	59	57	50	56	51	57

Table 4—Temperature Differences between Delhi and Trivandrum

	Mar.	Apr.	May	June	July	Aug.	Sep.
			(a) For 50 mb				
1971	1·4	1·7	1·7	3·4	0·8	3·7	3·7
1972	*	*	4·5	7·2	5·1	4·8	6·9
1973	2·0	6·2	−0·7	1·7	1·3	0·9	2·7
			(b) For 300 mb				
1971	−6·3	−6·1	−2·7	5·7	7·2	7·0	3·2
1972	−9·0	−8·2	−5·0	3·3	8·2	7·2	2·5
1973	−2·2	−2·5	−0·7	4·0	6·8	6·5	4·2

*Data scanty

3.2 Temperature Variations in Stratosphere

The stratopause region is situated around 45 km. The mean temperature at 45 km for each month for the period, Mar.-Sep., is given in Table 2. The stratopause region was coldest during the summer of the best monsoon year, and warmest during the summer of the worst monsoon year. The mean temperature difference between 20 and 45 km levels, in the stratospheric region is given in Table 3. The stratosphere was most stable during summer of the worst monsoon year.

3.3 Meridional Temperature Difference

The temperature differences between Delhi and Trivandrum for 50 mb and of 300 mb, as obtained from radiosonde data, are given in Table 4.

The temperature differences for 50 mb were maximum during the summer of the worst monsoon year. Also, in the same year the temperature differences for 300 mb during the pre-summer period, Mar.-Apr., were maximum but in the opposite direction. The temperature differences for 300 mb during

the pre-summer period of the best monsoon year are minimum.

4. Conclusions

High-level summer warmings have been identified at the tropical station, Thumba. If the features noted from the analysis of data for the three summers of 1971-73 are any indication, the following may be stated :

(i) Good monsoon is associated with strong warmings.

(ii) The commencement of the warmings in summer and the onset of the monsoon appear to be associated.

(iii) Unduly warm stratopause and stable stratosphere are associated with bad monsoon.

(iv) The meridional temperature difference is unduly large in the lower stratosphere when the monsoon is bad.

(v) The meridional temperature difference in the upper troposphere during pre-summer period could be some indicator of the behaviour of the following monsoon.

The possible dynamical features governing the associations as pointed out above have to be investigated.

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