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High maximum temperatures on the north Konkan coast

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1. Introduction

A study of spells of hot weather during summer over the city of Bombay (Colaba) for the period 1878—1955 has been reported by Natarajan (1956). The present study carried out some time before the study reported by Natarajan relates to the occurrence of hot spells over the north Konkan coast represented by Colaba, Alibag and Ratnagiri during the pre-monsoon as well as the post monsoon period.

In the north Konkan coast the maximum temperatures exhibit *two peaks*, one before the onset of the southwest monsoon and the other after the end of the monsoon. The clearing of the skies after the cessation of the rains leads to a rise of day temperature, which begins to fall again only with the approach of the winter. The second maximum after the monsoon occurs in October-November both in the mean daily as well as in the mean monthly maximum temperature. It is interesting, however, to note that the principal pre-monsoon maximum of the mean monthly maximum temperature as well as the highest temperature of the year are both recorded usually in March and *not in May*.

In marked contrast to this the annual march of the maximum temperature along the north coastal Andhra Pradesh exhibits only a *single* peak in May-June, both in the mean daily maximum temperature as well as in the mean monthly maximum temperature. The highest maximum temperature of the year is also recorded in May or June. This is a result of the dry hot westerly winds which blow across the north of the Peninsula in this season. The continuation of rains in October-November (the retreating monsoon rains), prevents any rise of temperature after the end of the southwest monsoon proper.

2. Data

Table 1 gives the maximum temperature data for the two coasts. Mean of the three observatories, Colaba, Alibag and Ratnagiri gives the data for the north Konkan coast while the mean of the four observatories, Gopalpur, Calingapatnam, Vizagapatnam and Cocanada gives the data for the north coastal Andhra Pradesh. In order to examine further the anomaly of the earlier occurrence of the maximum value of mean monthly maximum temperature, frequency values giving the months in which the highest maximum temperature of each year was recorded at the three north Konkan stations, Colaba, Alibag and Ratnagiri were prepared and are given in Table 2. It will be seen that maximum temperatures exceeding 99°F have occurred at all the stations mostly in March and sometimes in April or even in February.

A tabulation of the maximum temperatures recorded each day in the ten year period, 1930-1939, at the 3 observatories gives the following frequencies of occurrence for the 12 months (Table 3).

It will be seen that at all the stations maximum temperatures exceeding 99°F have occurred only in March. Temperatures of 95° to 99°F are more frequent in March than in April or May at Bombay and Ratnagiri while at Alibag, March and April

TABLE 1

Maximum temperature (°F)—1940 Normals

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1. NORTH KONKAN COAST (*Colaba, Alibag and Ratnagiri*)												
Mean daily maximum	84·2	83·7	86·2	88·5	90·1	86·4	84·5	84·1	84·3	88·5	89·5	86·8
Mean monthly maximum	90·4	90·6	93·3	92·6	92·9	92·0	87·4	86·6	87·5	94·5	93·7	91·9
Highest maximum	98	101	102	100	100	99	96	91	95	99	99	97
2. NORTH CIRCARS COAST (*Gopalpur, Calingapatam, Vizagapatam and Cocanada*)												
Mean daily maximum	81·0	84·7	89·1	91·6	93·9	92·8	89·2	89·1	89·1	87·9	83·7	80·5
Mean monthly maximum	86·0	90·4	94·5	96·2	100·6	101·5	95·9	93·3	94·0	92·8	87·9	84·0
Highest maximum	93	100	102	109	116	117	107	100	100	99	93	90

have about equal frequencies and May considerably less. Another fact brought out by this table is that frequencies of temperature of this range, *i.e.*, 95° to 99°F are greatest at all the three stations in October, while at Ratnagiri, November has also a large frequency. Adding up only the larger of the frequencies of individual temperatures in May, it is found that at Bombay temperatures of 89° to 93°F have a frequency of 298 while at Alibag and Ratnagiri, temperatures of 87° to 91°F have frequencies of 283 and 295 respectively. This is in conformity with the higher mean daily maximum temperature at Bombay than at Alibag and Ratnagiri in this month.

It is well known that the main cause of high maximum temperature at a coastal station is the delay in the setting in of the sea breeze owing to the continuation of the nocturnal land breeze beyond its usual time, apparently due to its reinforcement by frequently occurring synoptic situations. Hence the explanation for the earlier occurrence of the highest maximum of the year on the north Konkan coast is to be sought in the general climatic and weather situations which reinforce or weaken the land breeze in the different months. During May, the hottest month, the heat low over upper India is associated with westerly to northwesterly winds in the west of the country. On the Konkan coast winds are westerly throughout the day and the only effect of the nocturnal cooling of the land is a slight weakening of the wind from the sea. Hence although the maximum is usually high in this month there is very little chance of any appreciable rise above the usual range. In the month of March, on the other hand, pressure is more or less uniform over the greater part of the country. The sea breeze sets in at about 10 A.M. and continues late into the night. The land breeze which sets in in the early morning hours lasts upto 9 A.M.; it does not exceed the strength of a light breeze. Skies are clear or lightly clouded and rainfall is rare. The upper air circulation shows a weak northeasterly wind at 1 km which becomes westerly to southwesterly at greater heights with no appreciable change in strength. The development of a 'high' over northwest India with an anticyclonic circulation round it is a weather

TABLE 2

Frequencies of occurrence of the highest maximum temperature (°F) of the year in different months

Month	93	94	95	96	97	98	99	100	101	102	103	104	105
						1. COLABA (1891—1955)							
Jan	..	..	..	..	..	..	..	..	..	..	..	..	..
Feb	..	..	..	..	1	..	..	..	1	..	..	..	..
Mar	..	2	2	2	2	..	..	3	2	..	1	..	..
Apr	3	..	2	2	1	..	2	1	..	..	..	..	1
May	1	4	3	2	..	..	..	..	..	..	..	..	..
Jun	3	6	7	..	..	..	1	..	..	..	..	..	..
Jul	..	..	..	..	..	..	..	..	..	..	..	..	..
Aug	..	..	..	..	..	..	..	..	..	..	..	..	..
Sep	..	..	..	..	..	..	..	..	..	..	..	..	..
Oct	1	1	1	2	1	..	..	..	..	..	..	..	..
Nov	..	1	1	1	1	..	..	..	..	..	..	..	..
Dec	..	..	..	..	..	..	..	..	..	..	..	..	..
						2. ALIBAG (1930—1955)							
Jan	..	..	..	..	..	..	..	..	..	..	..	..	..
Feb	1	..	..	1	2	..	..	1	..	..	..	..	..
Mar	..	1	..	1	1	..	..	..	2	2	1	..	..
Apr	..	..	..	1	1	..	..	..	1	..	1	1	..
May	..	1	..	..	..	1	..	..	..	..	..	..	..
Jun	..	..	..	..	..	..	..	..	..	..	..	..	..
Jul	..	..	..	..	..	..	..	..	..	..	..	..	..
Aug	..	..	..	..	..	..	..	..	..	..	..	..	..
Sep	..	..	..	..	..	..	..	..	..	..	..	..	..
Oct	..	..	..	1	4	..	..	..	..	..	..	..	..
Nov	..	..	1	..	..	..	..	..	..	..	..	..	..
Dec	..	..	..	..	..	..	..	..	..	..	..	..	..
						3. RATNAGIRI (1891—1945, 1951—1955) with HARNAI (1946—1950)							
Jan	..	..	1	1	..	1	..	..	..	..	..	..	..
Feb	..	..	1	..	4	1	..	..	2	..	..	..	..
Mar	..	..	..	1	1	2	4	3	2	1	..	1	..
Apr	..	1	2	1	2	..	..	..	..	..	..	..	..
May	..	..	..	1	..	..	..	..	..	..	..	..	..
Jun	..	..	..	..	..	..	..	..	..	..	..	..	..
Jul	..	1	..	..	..	..	..	..	..	..	..	..	..
Aug	..	..	..	..	..	..	..	..	..	..	..	..	..
Sep	..	..	..	..	..	..	..	..	..	..	..	..	..
Oct	1	..	2	4	5	5	1	..	..	..	..	..	..
Nov	..	1	3	3	3	..	3	..	..	..	..	..	..
Dec	..	..	..	..	..	..	..	..	..	..	..	..	..

TABLE 3

Frequencies of occurrence of maximum temperature (°F), 1930-1939

Month	75—79	80—84	85—89	90—94	95—99	100 and over
			1. COLABA			
Jan	38	138	95	38	..	..
Feb	21	167	71	22	1	..
Mar	1	62	208	26	10	3
Apr	..	1	148	150	1	..
May	..	..	26	282	2	..
Jun	2	41	118	138	1	..
Jul	2	80	214	14	..	..
Aug	5	80	224	1	..	..
Sep	5	53	236	6	..	..
Oct	3	21	150	110	26	..
Nov	4	20	110	164	2	..
Dec	13	63	166	68	..	..
			2. ALIBAG			
Jan	37	192	74	7	..	..
Feb	28	187	53	12	2	..
Mar	..	121	151	27	7	4
Apr	..	20	225	47	8	..
May	..	..	220	88	2	..
Jun	3	53	181	63	..	..
Jul	2	151	157	..	..	..
Aug	4	199	106	1	..	..
Sep	6	121	169	4	..	..
Oct	1	40	166	81	22	..
Nov	5	32	162	94	7	..
Dec	8	124	145	33	..	..
			3. RATNAGIRI			
Jan	18	85	105	98	4	..
Feb	8	164	78	26	6	..
Mar	..	76	206	19	5	4
Apr	..	5	252	42	1	..
May	..	..	208	101	1	..
Jun	9	93	158	40	..	..
Jul	14	216	80	..	..	..
Aug	10	260	40	..	..	..
Sep	13	234	51	2	..	..
Oct	2	76	131	73	28	..
Nov	2	17	84	180	17	..
Dec	1	50	118	140	1	..

TABLE 4

Contemporary departures of maximum temperature at Kathiawar, Gujarat and Konkan coasts

Date	VERAVAL		SURAT		COLABA		ALIBAG		RATNAGIRI	
	Max. temp. °F	Dep. from normal	Max. temp. °F	Dep. from normal	Max. temp. °F	Dep. from normal	Max. temp. °F	Dep. from normal	Max. temp. °F	Dep. from normal
15-3-1933	101	+15	105	+ 8	100	+11	101	+15	100	+13
10-3-1935	92	+ 7	100	+ 4	101	+16	100	+15	99	+12
12-3-1936	100	+15	105	+ 9	101	+16	102	+17	100	+13
14-3-1946	102	+17	107	+11	99	+14	96	+11	99	+12
1-3-1949	86	+ 3	102	+ 9	99	+15	97	+12	90	+ 7
19-3-1952	90	+ 4	105	+ 8	100	+14	88	+ 2	86	+ 1
18-4-1955	104	+18	108	+ 8	105	+16	104	+16	89	— 1

situation occurring in the rear of a "western disturbance" frequently during March and occasionally in April. Such a situation serves to strengthen the easterly component of the land wind and thereby obstruct and delay the onset of the sea breeze. Two typical spells of hot day in March over the Kathiawar-Konkan coast along with the thermograms of Alibag is described in detail below.

8—11 March 1953

During this period, pressures were higher than usual over northern India and lower than usual over the Peninsula, a situation frequently met with during winter. This pressure distribution resulted in north-easterly to easterly winds over central Maharashtra and the Konkan upto about 2 km. High maximum temperature were recorded on all these days on the north Konkan coast as well as on the Gujarat-Saurashtra coast (see Table 4).

The thermograms of Alibag for the two days 9-10 and 10-11 March 1935 are shown in Figs. 1 and 2. On the 9th, temperature rose till about 1115 A.M. to about 96°F when the sea breeze made an attempt to set in. The fluctuations of both the D.B. and the W.B. curves show that it had to battle with the land breeze before it could establish itself, although at the first onset the D.B. temperature fell sharply by 10°F. The fluctuations of the curve between 1 A.M. and 5 A.M. of the 10th indicate small rises of D.B. temperature with sudden spurts of warmer, probably descending air.

The thermogram of the 10-11th indicate that the temperature rose steadily till 1 P.M. to 100°F, when the onset of the sea breeze brought it down by nearly 10 degrees in as many minutes. The trace for the early morning of the 11th is even more interesting than that of the previous morning. While the W.B. curve showed a slow but steady decline in the early morning hours, the D.B. curve showed a rise of 2 to 3 degrees, three times during the night, *viz.*, between 2 A.M. and 3 A.M., between 4 A.M. and 5 A.M. and just before 6 A.M. These rises indicate the arrival of warmer air at these times.

12 March 1936

This was another day of high maximum temperature on the north Konkan coast under the influence of a well marked anti-cyclone over northwest India. Upper winds were mainly easterly upto 3 km over central Maharashtra and the Konkan on the 12th morning, the winds being moderate to strong below 2 km. The thermograms of

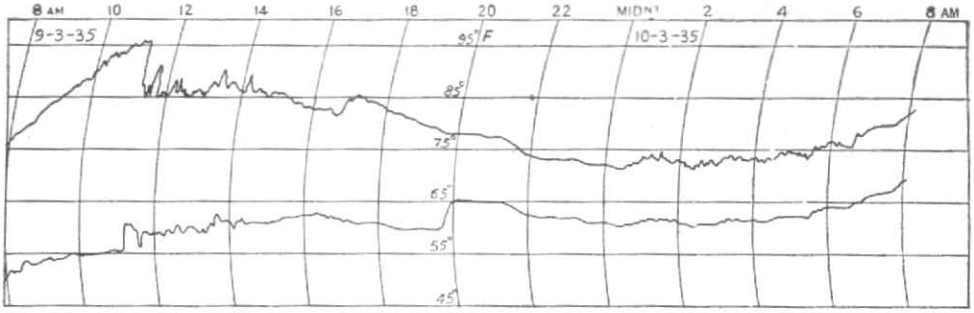

Fig. 1

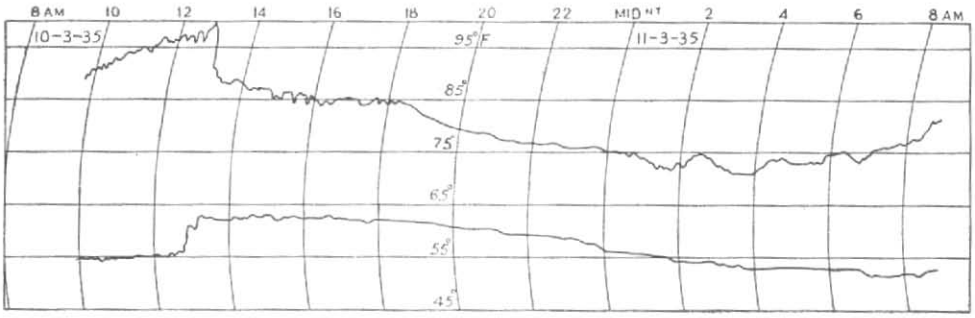

Fig. 2

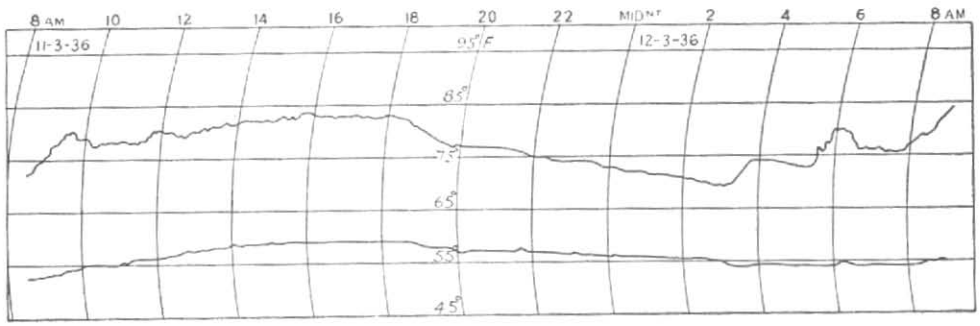

Fig. 3 (a)

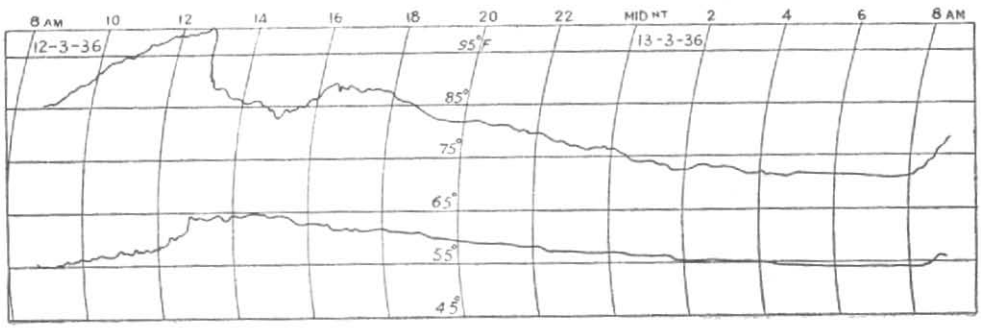

Fig. 3 (b)

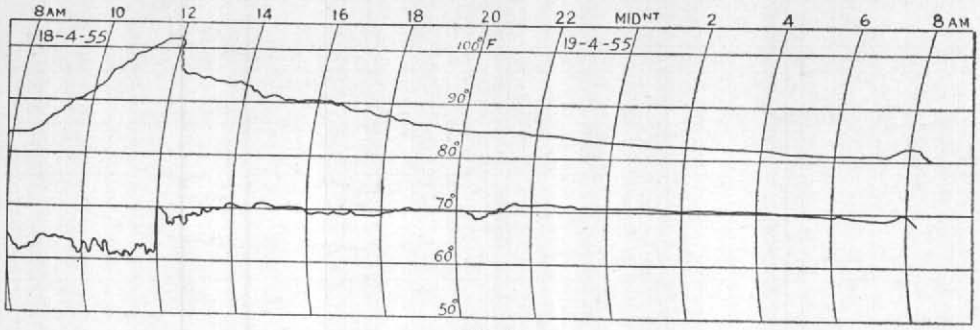

Fig. 4

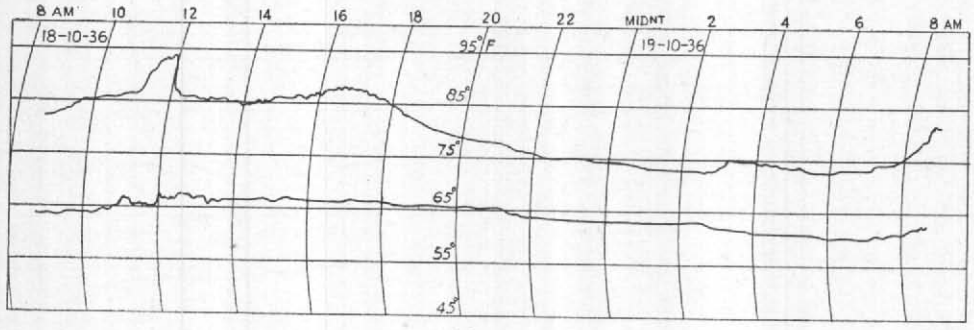

Fig. 5

Alibag for the 12th (midnight of 11—12th to 1800 hrs of 12th)—Figs. 3(a) and 3(b)—are interesting; Fig. 3(a) shows two rises of D.B. temperature in the early morning hours, a rise of 5°F between 3-20 A.M. and 3-40 A.M. and another rise of 7°F between 5-25 A.M. and 5-55 A.M., indicating the arrival of warmer descending air in two waves at the station. After sunrise there is a steady rise of D.B. temperature to 100°F at 1 P.M. (Fig. 3b) when the delayed sea breeze causes a sharp fall of 11°F. The subsequent march of the D.B. temperature on the chart indicates probably a weakening and failure of the sea breeze after 3 P.M.

18 April 1955

The severe heat wave that occurred on 18 April 1955 over Bombay when the maximum temperature at Colaba shot up to 105°F, has been described by Natarajan (1956). On the morning in question, the upper wind at 1 km over Bombay had an easterly component of 17 knots instead of the normal westerly component of 2 knots, while Poona for the same height and hour had an easterly component of 30 knots instead of the normal westerly component of 2 knots.

The thermograms of Colaba for 18th (0800 to 1800 hrs local time) show clearly the setting in of the sea breeze at 12 noon, a couple of hours after the usual time (Fig. 4).

3. Rise of maximum temperature in October-November

October, a month of transition from the southwest to the northeast monsoon conditions, is again a period of very little pressure gradients over the country. A 'high' is just beginning to appear in northwest India with indications of a low pressure area developing over the Bay of Bengal. The surface winds over the Konkan coast are generally from westnorthwest in the afternoon and veer to northeast to east in the night and early morning. The upper winds over the Konkan and central Maharashtra are light to moderate,

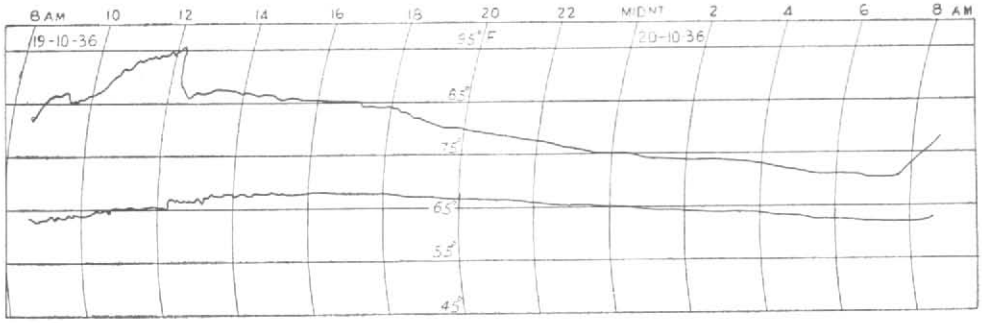

Fig. 6

mainly northeasterly upto 4 km. The development of any weather situation which intensifies the 'high' in northwest India or gives rise to a 'low' in the east Arabian Sea will strengthen the easterlies over the Konkan and central Maharashtra, delay the onset of the sea breeze along the Konkan coast and thereby cause high maximum temperatures on the north Konkan coast.

The number of occasions when maximum temperature rose in the months of October-November at Colaba, Alibag and Ratnagiri may be seen from Table 3. Such a rise during this period is peculiar in itself although the magnitude of the excess over normal is not as marked as in March-April. Figs. 5 and 6 (thermograms of Alibag from 0900 to 1800 hrs of 18 and 19 October 1936) give two instances of abnormally high maximum temperatures during October.

4. Subsidence along the Konkan and Kathiawar coasts

Natarajan (1956) has stated that the adiabatic descent of the easterly winds down the Western Ghats can lead to a warming of the air along the Konkan coast by as much as 4°F thereby contributing about a fourth of the abnormal departure of 16°F, observed at Bombay (Colaba). However, the Kathiawar and the Gujarat coasts also occasionally experience equally large departures, contemporary with the Konkan coast *vide* Table 4.

Orographic subsidence cannot make any contribution to the abnormal heating along the Kathiawar and Gujarat coasts as there are no hills immediately to the east. But there can be a general non-orographic subsidence, over this area, associated with the synoptic situation producing abnormal easterly components in the winds upto 1 or 2 km above sea level over this part of India in March-April as well as in October-November. On these occasions the dryness of the soil behind the Kathiawar-Gujarat coast, compared to the vegetation covered soil of the Konkan and the Western Ghats, may also contribute some extra heating of the easterly air. Such a differential heating may, to some extent, compensate the orographic subsidence down the Western Ghats.

Although no direct evidence of descent of air down the ghats can be had from the max. temperature data alone, certain pulses of rise of temperature at night (somewhat in the nature of Föhn wind) shown by the thermograms of Alibag are clearly evident. On some occasions a differential fall or rise of D.B. and W.B. curves indicate the arrival of drier air perhaps by descent.

5. Acknowledgement

I am indebted to the records of the India Meteorological Department for the data utilised in this paper, and am thankful to the Director of the Colaba and Alibag Observatories for the loan of the thermograms reproduced here.

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