

Vortices embedded in the trough of low pressure off Maharashtra— Goa coasts during the month of July

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ABSTRACT. Two troughs of low pressure are generally noticed over Indian region during the monsoon. One is the monsoon trough over Gangetic plain persisting throughout the monsoon season. The other is of comparatively less pronounced trough persisting off the west coast of India, being most prominent during the month of July.

Vortices embedded in these troughs cause considerable amount of rainfall. While the vortices and low pressure areas associated with the monsoon trough passing over Gangetic plain have been studied extensively, those embedded in the trough off the west coast do not appear to have received enough attention. In this paper the study of latter vortices during the month of July has been conducted. The following conclusions have been arrived at.

(a) These vortices are most prominent in the month of July. They have a tendency to form in series in first half of the month of July, (b) They form just south of Goa, (c) They move generally northwards with an approximate speed of 100 km per day. During second half of the month of July some of them are found to move northwestwards, (d) Heavy rainfall associated with them has the peculiarity that coastal stations get more rain than the Ghats, and (e) There may be an association between the formation of the series of vortices, during first half of July and the existence of an upper air cyclonic circulation between 2.1 and 3.6 km above sea level over Gujarat region and neighbourhood.

1. Introduction

Rainfall during the monsoon is due either to orographic features or synoptic conditions. For the latter some low pressure area or trough is essential. During monsoon months, on the sea level chart, two semi-permanent troughs are seen, one trough over Gangetic Plain generally referred to as the monsoon trough and the other along and off the west coast. Vortices develop and move along both the troughs and cause considerable amount of rainfall. A number of studies have been made on the vortices moving along the monsoon trough axis.

However, the study of vortices along and off the west coast has not received enough attention. The only notable contribution is by George (1956). Rao (1976) in his review of southwest monsoon of India has drawn attention to these vortices and stressed the need for more extensive study of their nature and associated circulation pattern.

West coast of India gets a large amount of rainfall during the monsoon season. This is generally attributed to the orography of the western ghats. It is, however, the experience of the forecasters at Bombay that on a large number of occasions when the coastal stations get very heavy rain the catchment area of hydro-electric project in the Ghat's section do not get such heavy falls; obviously there are other causes for heavy rain besides orography. The off-shore vortices could cause such a distribution of rainfall. The influence of the offshore vortices on the rainfall over Maharashtra-Goa coasts has been studied in this paper.

The trough is often found to exist during the monsoon season and is most prominent in the month of July. George (1956) in his study of off-shore vortices along west coast of India pointed out that such vortices are quite common along the west coast and they are mostly associated with heavy rain. From these two ideas, it was assumed that non-orographic rain over Konkan and Goa was due to the presence of these off-shore vortices.

2. Data

For the purpose of this study, the working charts at Meteorological Office, Colaba, Bombay were consulted. From 1974, bigger scale surface charts (scale 1 : 5000000 at Lat. 20° Mercator Projection) were introduced for operational work and they were very convenient in detecting these vortices. This study was done for the month of July for the three years, 1974 to 1976. For the present study, the month of July was chosen since (i) this is the rainiest month over Konkan, (ii) this is a typical monsoon month and (iii) the trough off west coast is found mostly in the month of July.

3. Results and discussion

The number of vortices formed each year together with their contribution to the rainfall over coastal stations over Maharashtra-Goa coasts is given in Table 1. Coastal stations are arranged in the table latitude-wise from north to south.

During the month of July 1974 seven vortices could be located on the surface chart. During the period of first two weeks of the month, a well-marked trough of low pressure lay off the west coast of India extending from Gujarat coast to Lakshadweep. During this period, a mid-tropospheric cyclonic circulation also existed over Gujarat and neighbourhood on most of the days. Moderate to strong monsoon prevailed over the central Arabian Sea. All these factors were very favourable for vortices to form.

A series of four vortices formed off Goa and moved northwards upto Gujarat coast. These vortices had life span of about five days. A typical case as a vortex is shown in Fig. 1.

The observations of wind, pressure and rainfall are plotted in Fig. 1. It can be seen that as the vortex was moving northwards, the belt of heavy rainfall also moved north.

During the life period of the vortex, coastal stations received more rain than Ghat stations. However, after the vortex moves away or dissipates, the Ghat sections get heavy rainfall, while the rainfall amount decreases over the coastal stations. Fig. 2 shows a typical case of reversal of rainfall distribution after the passage of a vortex.

It may be seen that on 9 July 1974 when the vortex was active and was off Alibag the coastal station near the vortex got heavy rain while the Ghat

stations received only moderate rainfall. On 12 July 1974, when the vortex moved away north-westwards, although the influence of the vortex was still there and coastal stations continued to get heavy rains, the Ghat stations received higher amount of rainfall.

The trough of low pressure off Maharashtra coast became feeble or unimportant during the period 14 July 1974 to 22 July 1974. During this period no heavy rainfall occurred over Maharashtra-Goa coast. A trough of low pressure appeared on 19 July 1974 and extended from Kerala coast to Karnataka coast by 22 July 1974. It further extended to Maharashtra-Goa coasts on 23 July 1974.

Two vortices formed on 23 July 1974, one off Ratnagiri-Harnai and the other off Goa. Both had short life spans of about two days. Heavy to very heavy rain occurred associated with these vortices. Rainfall of the order of 11 cm at Ratnagiri, 13 cm at Harnai and 7 cm at Devgarh were recorded on 23rd. The second vortex moved faster, *i.e.*, about 150 km a day and remained off-shore for about 33 hours, caused heavy rain at Marmagao, which recorded 11 cm on 24th and 8 cm on 25th, while Devgarh and Ratnagiri recorded 6 cm each on 24th.

From satellite pictures it was observed that these vortices moved westwards probably in association with the movement of a low pressure area which was moving westwards across Telangana and adjoining Maharashtra between 25th and 29 July 1974.

The seventh off-shore vortex formed on 30th July off Devgarh moved northwards off Alibag by 2 August 1974 after which it could not be traced. This vortex caused heavy rain, Harnai and Devgarh recording 9 cm of rain each for 24-hr ending at 0830 on 31st.

Similarly during July 1975 four vortices formed and during July 1976 seven vortices formed. Their life span and rate of movement were similar to those that occurred in July 1974. The contribution made by these vortices towards monthly rainfall in respective years can be seen from Table 1.

Miller and Keshavamurthy (1968) pointed out that there may be some association between formation of off-shore vortices and existence of upper air cyclonic circulation at 700 mb over Saurashtra. On the normal chart for the month of July (Meteorological Atlas of IIOE—Ramage and Raman 1972) cyclonic circulation can be observed

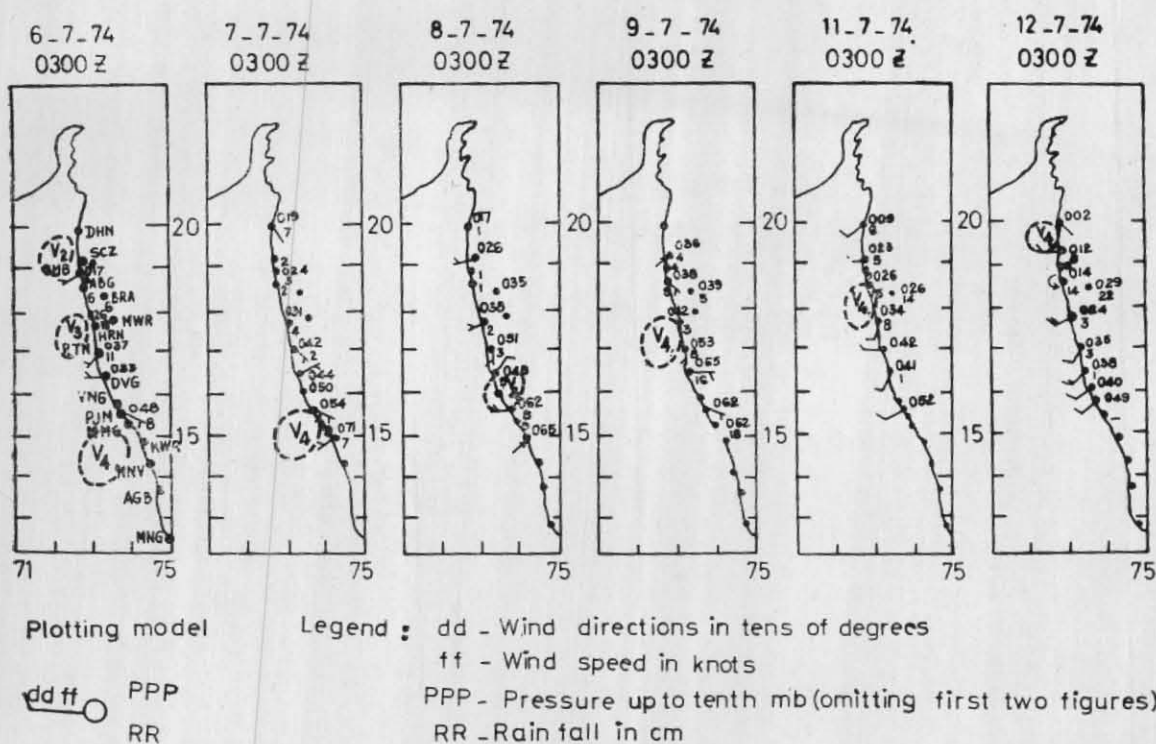


Fig. 1. Sequence of movement of an off-shore vortex

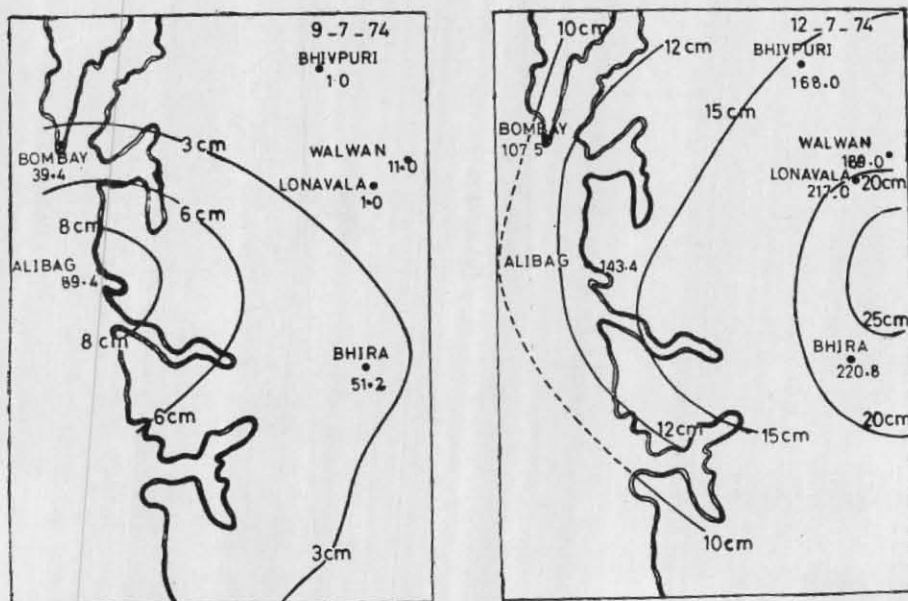


Fig. 2. Reversal of distribution of rainfall after the passage of vortex

over northeast Arabian Sea off Saurashtra at 700 mb. This cyclonic circulation is not present during the month of June and August. It is, therefore, quite likely that there may be some association between cyclonic circulation over and near this place at 700 mb level and existence of

off-shore vortices during the month of July. It is for this reason that we wanted to examine the above mentioned suggestion.

Table 2 shows separately the period when vortices and upper air cyclonic circulation over Gujarat

TABLE I
Percentage of rainfall due to vortices during the month of July

Name of station	July 1974			July 1975			July 1976					
	Rainfall due to vortices (mm)	Monthly total rainfall (mm)	% of rainfall	No. of vortices	Rainfall due to vortices (mm)	Monthly total rainfall (mm)	% of rainfall	No. of vortices	Rainfall due to vortices (mm)	Monthly total rainfall (mm)	% of rainfall	No. of vortices
Dahanu	772.0	989.2	77	4	170.9	381.9	45	2	—	—	—	—
Santacruz	794.0	1106.5	71	3	592.7	835.5	71	2	296.6	842.9	35	1
Colaba	1292.5	1441.3	86	4	629.6	910.2	69	3	276.3	776.0	35	1
Alibag	939.0	1126.0	83	4	564.0	705.8	80	2	293.0	779.2	37	2
Harnai	903.6	1489.9	60	6	643.9	850.8	76	2	497.4	912.6	54	4
Rainagiri	909.0	1160.8	79	7	802.7	1045.0	77	3	751.1	1080.0	69	6
Devgarh	704.8	994.3	71	6	559.6	808.2	69	3	918.2	1322.2	69	7
Panjim	685.8	1126.7	61	4	769.6	1206.1	64	4	678.6	1063.9	63	5

TABLE 2

Association of vortices and upper air circulation

Year	Period of vortex or vortices	No. of vortices during the period	Upper air cyclonic circulation over Gujarat and neighbourhood at 3.1 km above sea level
1974	1 Jul to 13 Jul	4	From 1 Jul to 9 Jul
	23 Jul to 24 Jul	2	Upper air cyclonic circulation absent
	30 Jul to 2 Aug	1	From 28 Jul to the end of month
1975	2 Jul to 9 Jul	2	From 1 Jul to 6 Jul
	28 Jul to end of month	2	Upper air cyclonic circulation absent
1976	1 Jul to 8 Jul	4	From 1 Jul to 8 Jul
	13 Jul to 16 Jul	1	From 14 Jul to 16 Jul
	22 Jul to 26 Jul	2	From 22 Jul to 23 Jul and on 26 Jul

were present simultaneously. It can be seen that during first half of the month of July and more predominantly during first week of July, cyclonic circulation exists over Gujarat. On closer examination, it was seen that upper air cyclonic circulation generally extended over Gujarat from 2.1 km to 3.6 km a.s.l. most predominantly during first half of the month of July.

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DISCUSSION

(Paper presented by K.C. Shah)

K.S. YAJNIK : Was your analysis on the basis of coastal winds ?

AUTHOR : The scale of off-shore vortices is rather small to be obtained by normal synoptic analysis.
