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A STUDY OF RADIO REFRACTIVE INDEX AND WIND INDEX ASSOCIATED WITH ONSET OF MONSOON OVER CHANDIGARH

1. The advance intimation of onset of SW monsoon is very useful information all over the country as India's agriculture economy depends upon the south-west monsoon rainfall. The north-west part of the India is the last in the country to receive the monsoon rains. So the arrival of monsoon over this region is very keenly awaited by the farmers and the public. Several studies are available which dealt with the relation between the radio refractive index (RRI) in lower troposphere and wind index associated with the onset of south-west (SW) monsoon. Sharma *et al*. (1993) and Lal (2000) studied the radio refractive index in association with the onset of monsoon over Bombay and Lucknow respectively. In their separate studies they have demonstrated the existence of correlation between the RRI changes in the lower levels and onset of monsoon. Sharma and Prasad (1993) have also shown that the significant changes in zonal wind component give an indication of onset of SW monsoon over Bombay 1-2 weeks in advance. In this study upper air data of RS/RW Patiala is used to correlate

TABLE 1

Fortnightly value of RRI at different levels

	Nm 925	*Nm* 850	*Nm* 700	*Nm* 500	*Nm* 400	*Nm* 925	*Nm* 850	*Nm* 700	*Nm* 500	*Nm* 400
	0000 (UTC)					1200 (UTC)				
May-I*	52.11	43.8	23.93	7.4	3.76	48.77	40.7	25.61	7.53	2.97
May-II*	57.63	43.67	23.29	7.45	3.58	54.45	44.36	22.15	7	3.67
Jun-I	59.84	45.53	27.86	8.63	4.04	58.17	44.72	25.5	8.59	4.27
Jun-II	90.31	70.12	39.47	13.35	5.29	88.91	70.6	36.32	13.71	6.44
Jul-I	106.8	81.34	46.95	14.19	6.89	104.24	79.19	41.57	16.79	6.93
Jul-II	110.18	88.17	46.22	15.87	8.1	106.7	82.98	47.84	17.17	8.08

* I : First fortnight, II : Second fortnight

TABLE 2

Year	Dates when RRI starts rising trend at 850 hPa	Dates when the ZC decreases to 20 kt at 200 hPa	Dates of onset of SW monsoon over the area
1994	20 June 1994 (5)*	17 June 1994 (8)*	25 June 1994
1995	14 June 1995 (26)	26 June 1995 (15)	11 July 1995
1996	4 June 1996 (22)	19 June 1996 (7)	26 June 1996
1997	14 June 1997 (13)	3 July 1997 (–6)	27 June 1997
1998	13 June 1998 (3)	18 June 1998 (–2)	16 June 1998
1999	11 June 1999 (20)	15 June 1999 (5)	20 June 1999

* The figure in paranthesis indicates the lead in number of days with reference to onset of SW-monsoon

the onset of monsoon at Chandigarh and its surrounding area with the radio refractive index value at different levels in the atmosphere and zonal wind index at 300 hPa.

2. Daily upper air data recorded over Patiala for the month of May, June & July at 0000 & 1200 UTC ascent for the years from 1994 to 1999 have been utilized in the present study. The uper air winds at 300 hPa were resolved into its zonal and meridional components and the results for the zonal (westerly) component only have been presented. Further pressure, temperature and humidity were used to calculate the RRI of the atmosphere by using the Bean and Dutton (1966) equation as given below :

$$N = \frac{77.6}{T} * \left(P + \frac{4810\, e}{T} \right) \qquad (1)$$

where pressure (P) and vapour pressure (e) are in hectopascal (hPa), temperature (T) is in degree Kelvin and N is the modified radio refractive index as described by Sharma *et al.* (1993).

Equation (1) represents the contribution of index value due to dry air (Nd) and water vapor (Nm) therefore, it can be written as $N = Nd + Nm$.

In this study the two components Nd and Nm have been computed from the individual ascents recorded at 0000 UTC and 1200 UTC at different levels in the atmosphere. The components of RRI due to dry air (Nd) do not show any fruitful information and therefore results are presents only for the wet components (Nm)

$$i.e. \qquad Nm = \frac{77.6 \times 4810\, e}{T}$$

where e was calculated by using the equation

$$e = \exp\left(1.8099 + \frac{17.27 * Td}{Td + 237.3} \right)$$

where Td is the dew point in degree Celsius.

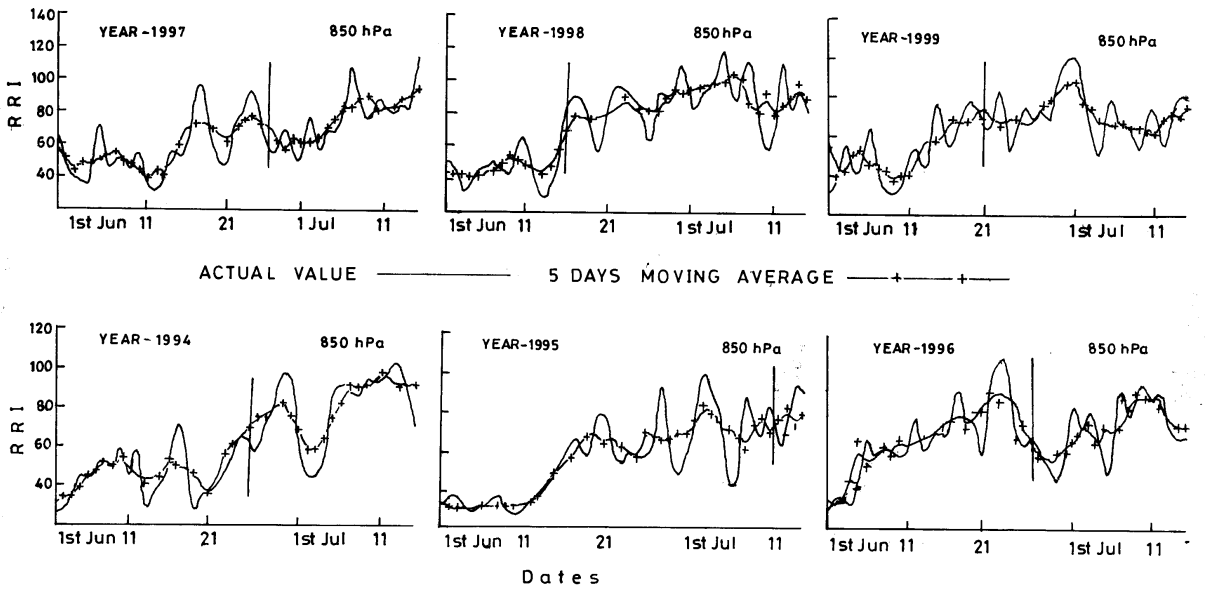

Fig. 1. Actual and 5-days moving average of RRI at 850 hPa

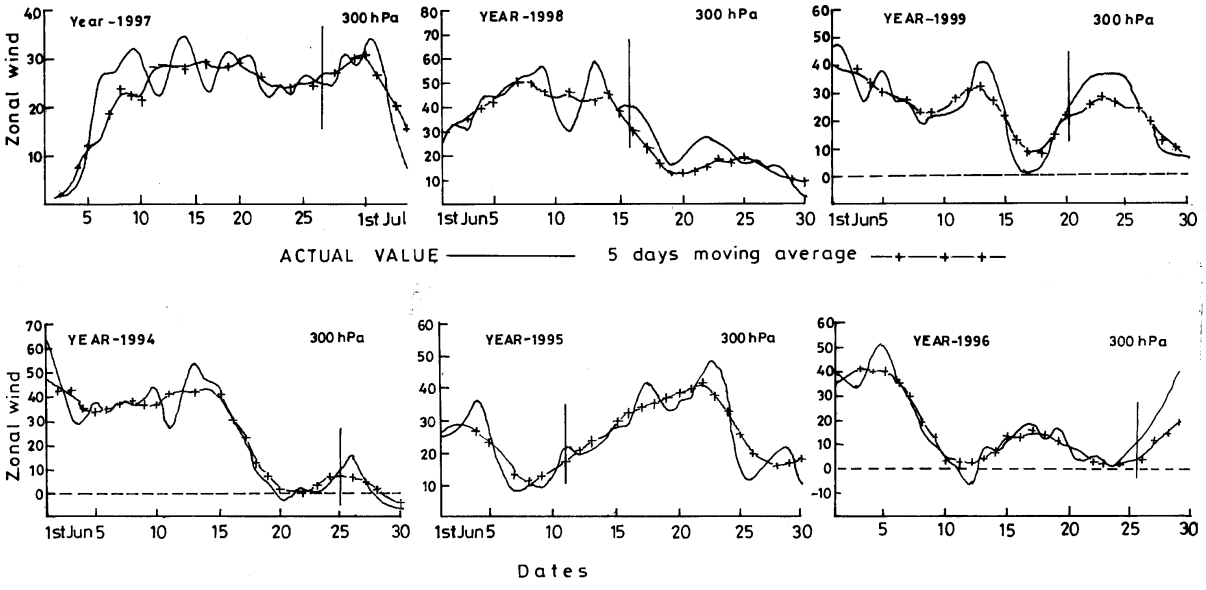

Fig. 2. Actual and 5-days moving average of zonal wind at 300 hPa

The values of *Nm* at 925, 850 hPa, 700 hPa, 500 hPa and 400 hPa levels at 0000UTC and 1200 UTC have been used for preparing the climatology of the RRI. The significant variation of the RRI due to wet components is found only in the lower troposphere. Therefore, the relationships between RRI and monsoon onset have been discussed and presented for 925 hPa and 850 hPa only. Further 5- days moving averages were calculated for these levels to filter out the day-to-day fluctuations.

3.1. Table 1 shows the fortnightly averages of the RRI at different levels for both 0000UTC and 1200 UTC for the

months of May, June and July. The values of RRI at 0000 UTC are higher by 2-4 units than those recorded at 1200 UTC at 925 hPa. This differences in RRI at 0000 UTC and 1200 UTC go on decreasing with the height and becomes negligible at higher levels. The average values of RRI are more of less same from the 1 fortnight of May to the first fortnight of June. It increases by 30 and 26 units at 925 & 850 hPa respectively in the 2 fortnight of June which is the onset period for the SW-monsoon. It again increases by 16 and 9 units in the 1 fortnight of July at these levels and then remain almost the same in the remaining period of monsoon season. This difference also decreases in higher levels.

3.2. Fig. 1 shows the actual values and 5-days moving average of the wet components of the radio refractive index (*Nm*) at 850 hPa levels for the period from 1 June to 15 July at 1200 UTC. This specified period from 1 June to 15 July has selected because during the past 18 years the onset dates of monsoon over Chandigarh and its surrounding areas lay between 15 June to 15 July. The mean values of RRI on the day of onset of monsoon are 91 and 75 units at 925 hPa and 850 hPa level respectively. The vertical line on the curves indicate the onset dates of the monsoon.

In most of the cases sharp rising trend of *Nm* is noticed about one to three weeks in advance before the onset of the monsoon and the value jumped by 35-45 units. The value of *Nm* generally rises from 55 and 45 units at 925 hPa and 850 hPa levels. The average value of RRI on the day of onset of monsoon reached upto 91 and 75 units at 925 hPa and 850 hPa levels respectively. This value remain constant or increased upto certain limits after the onset of monsoon. The dates at which the RRI value starts increasing from its threshold value are listed in Table 2. The table indicates that the values of RRI reach the threshold level about 1 to 3 weeks prior to onset of south-west monsoon over the area.

3.3. The strength of upper air westerlies over northern India is known to decrease considerably just before or at the time of onset of south-west monsoon. The winds at 400, 300 and 200 hPa for the month of June and July were analysed to ascertain whether the reduction in zonal component at these levels could give an advance indication about the onset of south-west monsoon over the area. The trends obtained were similar for all these levels and hence the results are presented only for 300 hPa. The mean monthly value of the zonal component (ZC) for the month of June is 25.3 kt. The average values of ZC during the 1 two weeks of June are 35.2 and 28.1 kt respectively. It further decreases in 21.8 and 16.7 kt in the 3 & last week of the month. The average value of the zonal component on the onset date is 18 kt. Fig. 3 shows the curves of the zonal wind components and its 5-days moving average at 300 hPa level for the month of June at 0000 UTC. It is noticed that the value of zonal component reaches to 20 kt in one to two weeks in advance of the onset of monsoon over the area except in 1997 and 1998.

4. The study shows the existence of a correlation between changes in RRI at 925 hPa and 850 hPa and the zonal wind component at 300 hPa with the onset of the SW monsoon at Chandigarh and its surrounding areas. The index shows significant rising trend about one to three weeks in advance before the onset of the monsoon with a jump of 35-45 units. The zonal wind index shows the decreasing trend before arrival of the monsoon and reaches to 20 kt one to two weeks in advance. These two components *i.e*. RRI and zonal wind index could be used as additional tools to monitor and forecast the advancement of south-west monsoon over the area.

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