Pre-monsoon western disturbances in relation to monsoon rainfall, its advancement over NW India and their trends

A western disturbance (WD) is defined as an eastward-moving extra-tropical upper air trough in the subtropical westerlies, often extending down to the lower atmospheric level of the north Indian latitude during the winter months. Sometimes, these are observed as closed cyclonic circulations at the sea-level. This definition was first put forward by Pisharoty and Desai[1] for WDs in general and subsequently accepted by Rao and Srinivasan[2] for use in India Meteorological Department (IMD). The study by Mooley[3] revealed that even before the onset of monsoon over east Uttar Pradesh, temporary advancement of monsoon current over Punjab, west Uttar Pradesh, Jammu and Kashmir takes place when a WD moves across northwest India. Also, the passage of a WD across north India increases monsoon activity over Punjab and Uttar Pradesh. Chakravorty and Basu[4] found that if the frequencies of formation and movement of depression over the Bay of Bengal in a particular year increase, then the frequencies of WDs in the same year decrease.

Satellite study of WD by Agnihotri and Singh[5] revealed the secondaries of extra-tropical depressions move northeastward from the eastern Mediterranean and are confined in the latitudinal belt 25°N to 35°N. The frequency of WDs abruptly decreases from winter to the pre-monsoon season. Pisharoty and Desai[1], and Das[6] observed that even in the hot weather period of April and May, WDs move across north India.

In the Himalayan region of India, monsoon current progresses from east to west. But the WDs move across north India from west to east, with consequent rise in pressure and cold pool of air in the rear. Though WDs activate monsoon in certain areas of NW India, it is not clear whether the visit of pre-monsoon WDs across north India has any impact on the progress of forthcoming monsoon current towards NW India and its activity. Also, from climate change point of view, trends of the WD frequency in pre-monsoon months and onset dates over north India have not been studied so far. Thus, we have made an attempt to study its relationships with monsoon rainfall over NW India and also with progress of the forthcoming monsoon current towards NW India. The study also aims at finding out the trends of the pre-monsoon frequency of WDs and onset of monsoon over north India from the point of view of climate change.

Here year-wise monsoon rainfall of India, NW India, frequencies of WDs in March–May and onset dates of monsoon over Ganganagar (GGN), New Delhi (DLH), Gorakhpur (GRK), Baghdogra (BGD), Kolkata (KOL) and Guwahati (GHT) were considered for the period 1971–2000. Rainfall data were obtained from the National Data Centre, Pune, and frequency of WD from the Weekly Weather Reports published by the office of DDGM(WF). Year-wise onset dates for different stations were collected from the charts prepared by the office of DDGM(WF).

Statistical technique of Mann–Kendall test as in WMO[7] has been applied to test the significance of trend of frequency of WD, rainfall, onset dates, etc. Linear trend analysis of monthly WD frequen-

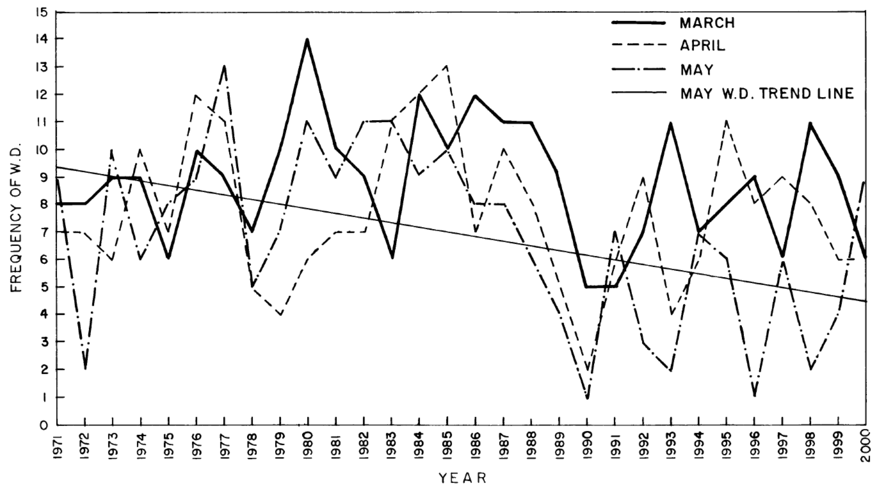

Figure 1. Frequency of western disturbances in pre-monsoon months.

Table 1. Analysis of correlation coefficient (1971–2000)

	Western disturbance frequency			
Onset date	March	April	May	March–May
GGN	0.057	0.344*	0.227	0.303
DLH	– 0.135	0.382*	0.106	0.181
GRK	0.163	0.173	0.134	0.214
GHT	– 0.071	0.224	0.264	0.221
BGD	– 0.086	0.151	0.103	0.093
KOL	– 0.049	0.111	0.060	0.063
Percentage departure NW India rainfall (June–September)	– 0.285	0.061	0.054	– 0.048
Percentage departure All-India rainfall (June–September)	– 0.198	– 0.075	0.092	– 0.056

*Significant at 5% level.

Table 2. Trend analysis

Onset date	Nature of trend	Western disturbance	Nature of trend
GGN	–	March	–
DLH	–	April	–
GRK	Negative*	May	Negative*
GHT	–	March–May	–
BGD	–	NW India rainfall June–September	–
KOL	–	All-India rainfall June–September	–

cies has also been done to obtain the rate of change of frequency.

Figure 1 shows the year-wise frequencies of WDs with the trend line of May WDs. The frequencies of WDs during March–May and in the pre-monsoon season are found to be 9, 8, 7 and 24 respectively, during the period 1971–2000. Results of the analysis of correlation coefficients (CCs) between WD frequencies and onset date are shown in Table 1. CCs between WD frequencies in April and onset dates over New Delhi and Ganganagar are found to be positive and significant, meaning thereby that onset over these places is delayed (or advanced) due to increase (or decrease) in the number of WDs in April.

Trend analysis is shown in Table 2. Both linear trend analysis and Mann–Kendall test show that frequency of May WDs has a significant decreasing trend. The linear trend line for WD frequencies for May (Y_m) is $Y_m = 9.366 - 0.166\ t$, t is the number of years. The number of May WDs is decreasing at the rate of 17 per 100 years.

The Mann–Kendall test confirms that onset date of Gorakhpur (26°45′, 83°12′) has a significant decreasing trend. Onset date for other selected stations does not show any significant trend. The longitude of Gorakhpur roughly passes through the middle of north India. All these considerations indicate that there is a trend for SW monsoon to advance earlier up to the middle of the north India.

Mann–Kendall test shows that no significant trend exists for monsoon rainfall of NW India and for All-India. Thus it seems that observed decreasing trend of WD frequency in May did not influence NW India or All-India rainfall significantly. CCs between May WD frequency, and NW India monsoon and All-India monsoon rainfall are also not significant.

The following are the conclusions of this study: (i) Frequencies of WDs in March–May and pre-monsoon season are found to be 9, 8, 7 and 24 respectively, during the last 30 years; (ii) Frequency of May WDs has a significant decreasing trend, the decrease being 17 per 100 years; (iii) Monsoon is setting in earlier than normal dates over the eastern half of north India; (iv) Monsoon onset over NW India is delayed (or advanced) by increase (or decrease) in the number of WDs in April.

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