Mausam, (1983), 34, 1, 117-120

551.515.12 "1980"-12.22"

The western disturbance of 22 December 1980 — A case study

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(Received 7 May 1981)

सार – शरद ऋतु में पूर्व की ओर गमन करने वाली पश्चिमी प्रणालियों (पश्चिमी विक्षोभ या प्रेरित निम्न) से संबंध वर्षा 20° उ० के उत्तर में सामान्यतया सीमित रहती है और जैसे-जैसे प्रणाली आगे चलती जाती है वर्षा पूर्व की ओर खिसकती जाती है। दिसम्बर 1980 की एक विशेष परिस्थिति में वर्षा की सक्रियता अधिक से अधिक 15° तक दक्षिण की ओर विस्तृत होती हुई देखी गई है। सिनाप्टिक अवस्थाएं यह संकेत देती हैं कि पश्चिमी विक्षोभ का अरब सागर पर निम्नदाब वाले क्षेत्र के मिल जाने के कारण संभवतः ऐसा हुआ है। इस प्रणाली के मार्ग के कुछ लक्षण मौसम चार्टों, उपग्रह एवं रेडार से लिए गए छाया चित्रों पर दिखाई पड़ते देखे गए हैं, उन्हें इस शोध पत्र में प्रस्तुत किया गया है।

ABSTRACT. Rainfall associated with eastward moving westerly systems (WD or induced low) in winter, is normally confined to north of 20 deg. N and moves eastward as the system moves. In a specific case during December 1980, the rainfall activity was observed to extend southward as far as 15 deg. N. Synoptic situation suggests that this is probably due to linkage of a western disturbance with a low pressure area over Arabian Sea. Some features observed on weather charts, satellite and radar pictures during the passage of this system, are presented in this paper.

1. Introduction

According to Pisharoty and Desai (1956), western disturbances are defined as"Eastward moving upper air troughs in the subtropical westerlies, often extending down to the lower troposphere of the north Indian latitudes during the winter months". Several workers, Singh (1963, 1979), Datta and Gupta (1967) brought out in their case-studies, the intimate connection of the upper westerly troughs with the intensification and movements of western disturbances over Indo-Pakistan region. These upper tropospheric troughs often give rise to closed cyclonic circulation on the surface or cut-off lows in the mid-tropospheric levels over Iran, Afghanistan, Pakistan and adjoining north India and are responsible for rain/snowfall over these areas. Sometimes, in association with intense western disturbances approaching Indo-Pakistan region, induced lows also develop at somewhat southern latitudes. These also move eastward and cause rain across north west and central parts of India. But between 20-23 December 1980, when such a system in westerlies passed over the country, the rainfall activity extended southward as far as 15 deg. N. In the present paper, synoptic situations responsible for such an extended rainfall activity have been discussed.

Singh (1979) pointed out that the intensification of the upper westerly trough is connected intimately with southward migration of a cold pool of air from the north. This can be noticed prominently at 500 mb level. In view of this, 500 mb charts have been used in the present study. Satellite and radar observations recorded at Colaba, Bombay are also utilised.

2. Synoptic situation

Fig. 1 shows 500 mb constant pressure charts of 20, 21 and 23 December 1980 respectively. The location of the subtropical jet stream axis at 250 mb has been superposed on these charts and shown as a thick line.

From the Fig. 1 (a), it is seen that a westerly trough at 500 mb level was extending roughly along 67 deg. E., north of 15 deg. N at 20/0000 GMT. By 00 GMT of 21st (Fig. 1 b) this upper level trough deepened and formed a 'Cut-off low' over south west Pakistan and adjoining Iran. This 'cut-off low' moved eastward slowly and by 23rd [Fig.1(c)] it started filling up as is evident from rise in contour and temperature values.

A surface low formed over south Pakistan on 20 December 1980 and intensified under the influence of intense upper level westerly trough. At 00 GMT of 22nd it was located over south west Rajasthan and adjoining Gujarat. A trough on the surface from this system was extending to the south off Maharashtra coast and was joining a low pressure area over east central and adjoining south east Arabian Sea (Fig.4). This linkage of

the surface low with low pressure area of Arabian Sea is a less frequent phenomenon. At this time the well marked trough associated with cut-off low in mid tropospheric westerlies extended from north east Afghanistan to east central Arabian Sea roughly along 68 deg. E. Under the influence of this trough the surface low over south west Rajasthan intensified further into a depression centred about 50 km north of Barmer at 1200 GMT of 22nd. On 23 Dec, the system weakened to a well marked low over central part of Rajasthan and subsequently (on 24th) it was seen as a cyclonic circulation over east Rajasthan and neighbourhood. The linkage of induced low with the low in the Arabian Sea seems to have occurred on 21st and became more prominent on 22nd. This linkage might have partly contributed to the intensification of the induced low by providing strong incursion of moisture into it as can be seen from Fig. 5 which shows the wind flow at 0.9 km asl on 21st and 22nd. Due to this mositure incursion there was rain over a wide area as seen from Fig. 6. The 24 hours rainfall recorded at Bombay, Matheran, Bhira and Mahabaleshwar were 2,6,4 and 5 cm respectively.

2. 1. *Satellite and radar observations*

Fig. 2 (a) shows the cloud imagery received on 21 Dec., from the NOAA-6 satellite at APT station, Bombay. There are two distinct cloud masses. The cloud mass marked from A to D is associated with extra tropical system. This cloud mass is elongated almost in a straight line from 27 deg. N, 64 deg. E to 44 deg. N, 83 deg. E having total length about 2000 km. The width at areas marked A, B, C and D is about 500 km and these different regions can be visualised as the developing wave crests expected in the initial stage of an ETC. The other main cloud mass from E to F is attributed to the strong westerly jet stream extending over Jodhpur, Delhi and eastward. The transverse cloud bands are clearly visible towards south of jet stream and indicate that this region is highly turbulent. Table 1 shows the upper wind data recorded at few stations at 00 GMT of 21st. It is seen from the table that vertical wind shears over Ahmedabad, Jodhpur and Delhi roughly along the jet stream, are very much higher as compared to other stations. Large anticyclonic wind shears at 200 mb between Ahmedabad-Bombay and Delhi - Gwalior suggest divergence at this level. The satellite picture of the next day (Fig.2b) shows that the induced low has become well marked.

Fig. 3 shows the radar observations taken on 22 December 1980 with S-band radar at Colaba, Bombay. It is seen that the clouds developed in a narrow belt with orientation from SW to NE direction and were in the region of confluence zone as evident from stream line charts (Fig.5). The clouds were convective type and of well

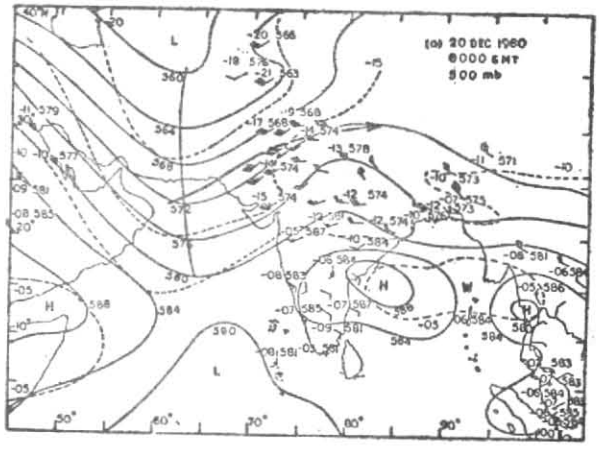

Fig. 1(a). 500 mb chart of 0000 GMT on 20 Dec 1980

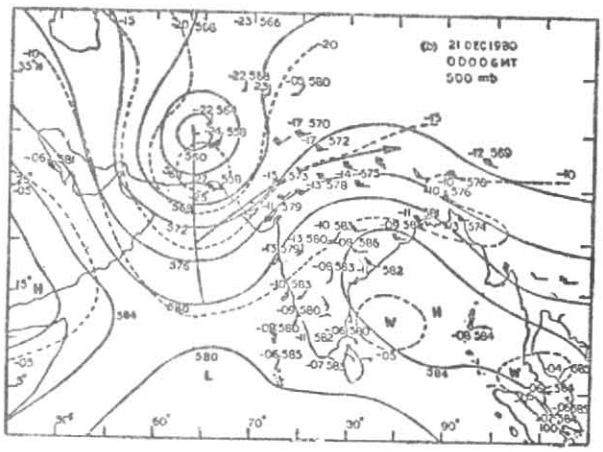

Fig. 1(b). 500 mb chart of 0000 GMT on 21 Dec 1980

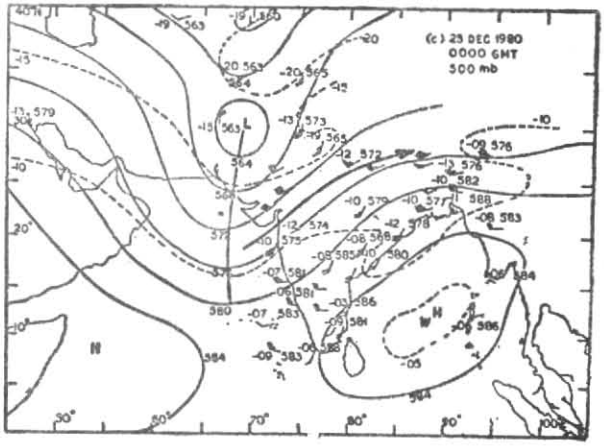

Fig. 1(c). 500 mb chart of 0000 GMT on 23 Dec 1980

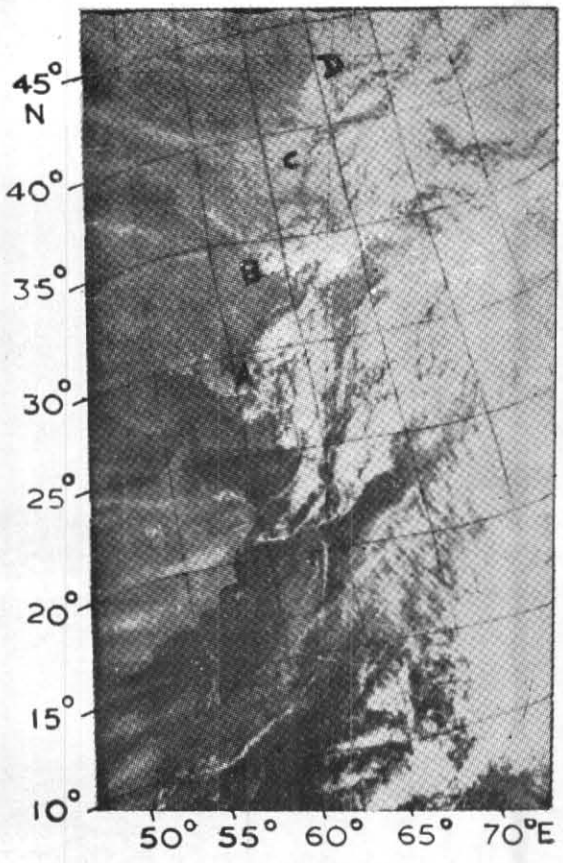

Fig. 2(a). Satellite picture received from NOAA-6 on 21 December 1980

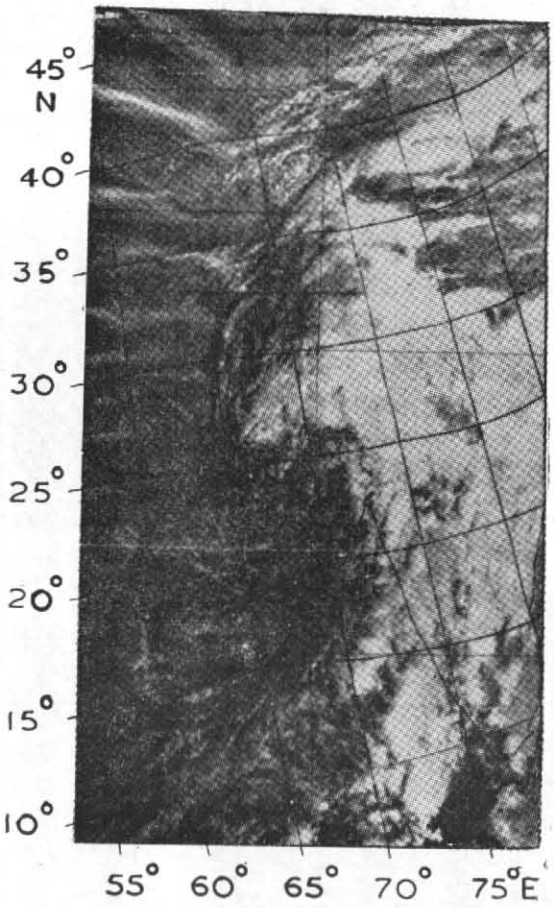

Fig. 2(b). Satellite picture received from NOAA-6 on 22 December 1980

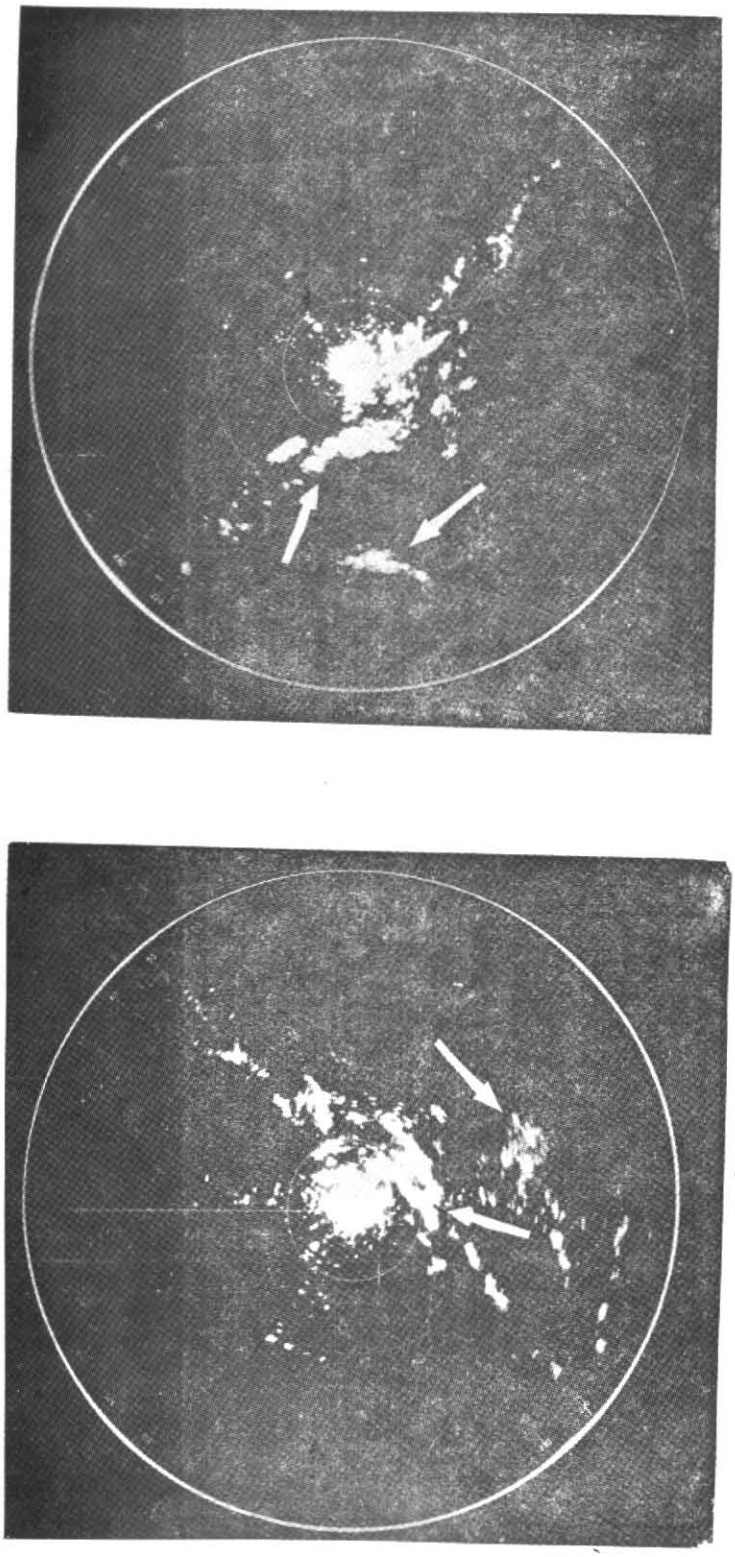

Fig. 3. Radar photographs at : (a) 0614 GMT and (b) 0702 GMT of 22 December 1980

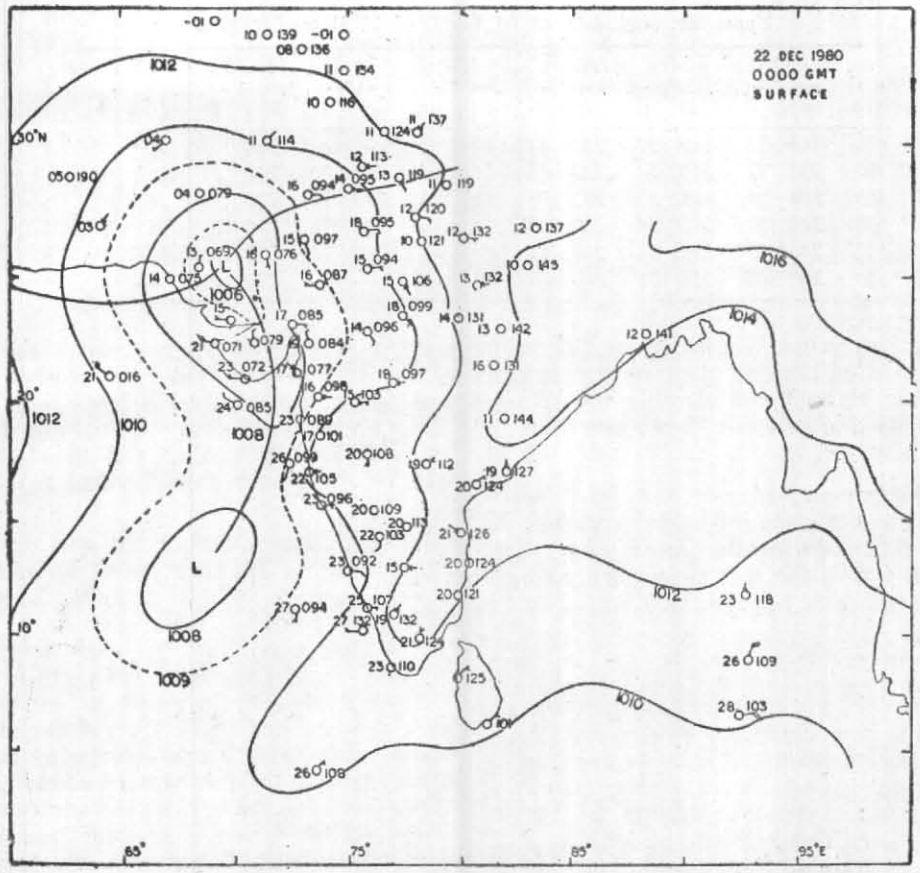

Fig. 4. Surface chart of 0000 GMT on 22 December 1980

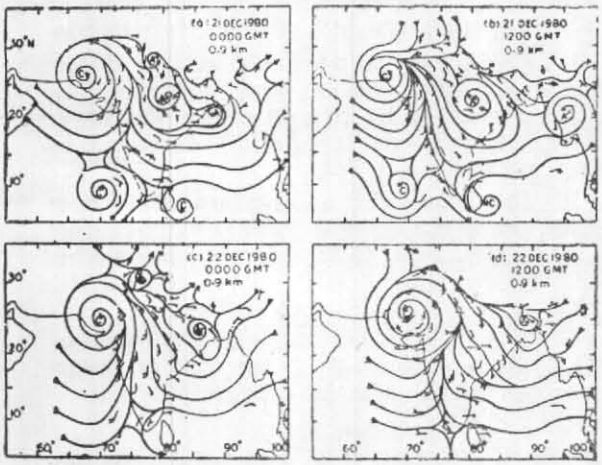

Fig. 5. Stream lines at 0.9 km asl :
(a) 21 Dec 00 GMT
(b) 21 Dec 12 GMT
(c) 22 Dec 00 GMT
(d) 22 Dec 12 GMT

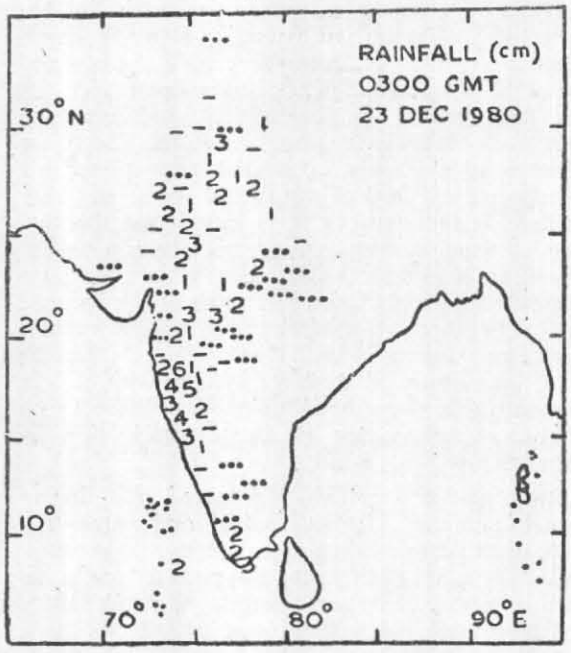

Fig. 6. Rainfall recorded at 03 GMT on 23 Dec 1980

TABLE 1

Upper air wind data at 00 GMT of 21 December 1980

Level (mb)	GOA		BMB		AHM		JDP		GWL		DLH		PTL	
	ddd	ff	ddd	ff	ddd	ff	ddd	ff	ddd	ff	ddd	ff	ddd	ff
400	145	23	210	37	230	41	205	45	—	—	250	45	250	50
300	220	41	220	52	235	56	210	65	260	70	260	55	260	65
250	220	54	195	54	245	109	220	105	270	70	250	95	240	65
200	245	57	210	58	230	103	—	—	240	75	260	125	255	85
150	240	35	215	58	245	81	—	—	240	75	245	60	255	60
100	240	07	235	31	—	—	—	—	—	—	270	45	—	—

developed vertical structure. The heights of clouds tops were about 10 km. Ascent taken at Bombay on 22 December showed considerable increase in latent instability and moisture depth over that of the previous day.

The cloud pattern moved north-eastward as indicated by arrows for some indentifiable clouds. It is noteworthy that during the last 5 years of radar operation, this is the first time when such alignments of cloud cells have been observed in this region.

3. Discussion

During the early winter, *i.e.*, December, southernmost part of the peninsular India gets rainfall from the northeast monsoon and also occasionally with the westward passage of weak disturbance along an active near-equatorial trough of the northern hemisphere. This rainfall is confined to south of 12 deg. N. Rainfall from eastward moving disturbances associated with jet stream is confined to north of latitudes 23 deg. to 25 deg. N (Ramage 1971). There is hardly any rainfall between these two limits.

On 20 December a diffluent trough in the westerlies at 500 mb was extending along 67 deg.E north of 15 deg. N. According to Pisharoty and Desai (1956), such a situation is favourable for the development of secondaries (induced low) over Indo-Pakistan region. Further deepening of these are mainly connected with upper air divergence and feed of warm and moist air from Arabian Sea. Singh (1979) reported that the surface systems develop and decay along with the upper air westerly trough with which they are associated. He concluded that most of the induced lows over west and central India, intensify under such synoptic conditions. However, in the present case, interaction of westerly system with a low pressure area over the Arabian Sea seems to be a contributory factor in the intensification of induced low.

Riehl and Shafer (1944) reported that during winter relatively strong tropical and extra tropical disturbances when approach the same longitude they get linked mutually and intensify. In such a situation upward motion (Ramage 1955, Pisharoty and Desai 1956) east of the southern disturbance, destroys the normal subsidence and brings rain and bad weather in the eastern portion of the two systems. With the delinking of the two systems the bad weather dissipates and normal subsidence returns again. However in the present case, only the northern disturbance (induced low) intensified and the low pressure area of the Arabian Sea drifted eastward over the land.

Pisharoty and Desai (1956) also reported that the interaction between westerly and easterly troughs, during winter months, occurs when there is an in-phase super-position of the two Under these conditions the 'high' to the east of the two troughs reinforce each other and there is a possibility of the moist air of the easterly wave system feeding to the eastern side of the westerly wave and thereby increasing the precipitation capacity of the western disturbance. Our study confirms the conclusion mentioned above except revealing rather unusual case of linkage of a western disturbance with low pressure area over the Arabian Sea.

4. Conclusions

(1) The case shows the linkage of a western disturbance with a low in the lower tropospheric easterlies in the Arabian Sea off west coast of India in winter, which is a rare phenomenon.

(2) The intensification of the western disturbances over south Pakistan and adjoining Rajasthan appears to be connected with the upper tropospheric westerly troughs as envisaged by other workers.

(3) The linkage of the western disturbance with a low in the easterlies which feeds moisture to the former, seems to be a contributory mechanism for the intensification of the western disturbance.

(4) In such a situation rainfall / bad weather extends from tropical low to the western disturbance east of the extended trough line.

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