551.510.52 : 551.58(54)

Large scale convection over central parts of India in relation to 'Sub Tropical Jet Stream Wave'

D. R. SWAMINATHAN

Main Meteorological Office, Madras

(Revised paper received 31 August 1968)

ABSTRACT. Large scale convection over central parts of India during 17-19 February 1962 was found to be associated with strong upper tropospheric divergence in a sinusoidal type of 'Sub-Tropical Jet Stream Wave', augmented by the southeastward movement of 'Jet Maximum' from central India to coastal Andhra Pradesh. Mean sea level situations or lower tropospheric flow patterns alone did not give conclusive or significant clue to subsequent large scale convective developments.

1. Introduction

A large number of stations in east Madhya Pradesh and adjoining areas recorded thunderstorms on the mornings of 18 and 19 February 1962. Nagpur airport recorded squalls also on 17 and 18 February, while Begumpet airport recorded on 18 February a series of 3 squalls from north, northeast and south, a rather unusual and very rare development. Hailstorms causing slight damage to standing crops were reported from Pachmarhi and Umaria on 17 February, Garhakota (Sagar District) on 18 February and Katol (Nagpur District) and Patnagarh (Orissa) on 19 February. According to press reports, the damage to life and property at Patnagarh (Orissa) was considerable.

In this context, the synoptic situations associated with these vigorous convective phenomena were examined.

2. Low and high level situations during 17-19 February 1962

A western disturbance moved away across Rajasthan and Punjab on 15 and 16 February. It induced a low pressure area over east Rajasthan on 17 February and over extreme west Madhya Pradesh on 18 February with associated upper air trough line at 1500 m a.s.l. running southwards upto Yeotmal (Vidarbha) on 17 February and upto Bangalore on 18 February. They became unimportant later.

During this period, the entire sub-continent of India and Pakistan, excluding extreme south Peninsula, was under the grip of a 'Sub-Tropical Jet Stream Wave' which moved across Karachi (67°E) by morning of 17 February, across Jodhpur, Ahmedabad and Bombay (72°-73°E) by morning of 18 February, across New Delhi and Nagpur (77°-79°E) by evening of same day and across Allahabad and Visakhapatnam (82-83°E) by morning of 19 February, covering an average of 8 degrees longitude per day (Fig. 1). Moreover, a number of stations recorded wind maximum exceeding 100 kt generally between 11 and 12-km level (Table 1), which confirms Reiter's (1963) statement that the 'Sub Tropical Jet Stream' reaches its maximum intensity at 12 km.

3. Analysis

(1) *Sea level features on 17 and 18 February 1962 and subsequent convective weather development* — The sea level isobaric features at 03 GMT on 17 and 18 February, with 'weather remarks' (in symbols) of convective development of thunderstorms, rain, etc that occurred during the subsequent 24 hr are shown in Figs. 2 and 3 respectively.

One low over Delhi-Gwalior-Jaipur area on 17 February and two lows, one over extreme west Madhya Pradesh and the other along Maharashtra coast on 18 February may be seen. Such lows during pre-monsoon months, March-May, were found by Ramaswamy (1956) to have no significant association with subsequent convective developments over or near them. In this study also, convective weather developed on a large scale in areas far away from the lows while fair weather prevailed over and near them, showing thereby that formation and dissipation of surface lows at sea level even in the cold weather month of February may not necessarily indicate subsequent convective weather developments.

(2) *Lower tropospheric flow patterns on 17 and 18 February 1962 and subsequent convective weather development* — Upper winds, stream lines and trough lines at 1·5-km level at 00 GMT on 17 and 18 February with the weather development during subsequent 24 hr (same symbols as shown in Figs. 2 and 3), may be seen in Figs. 4 and 5 respectively.

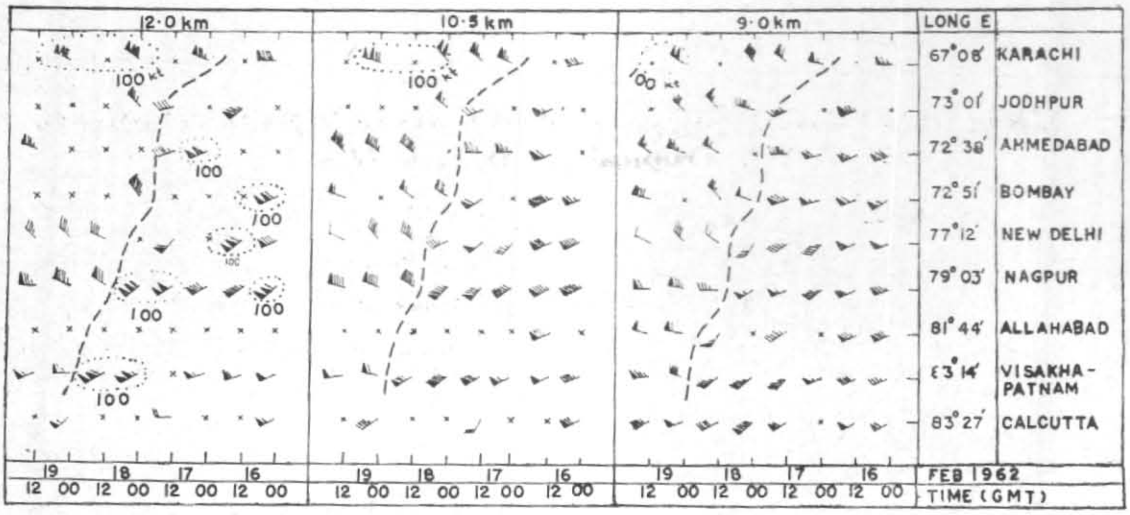


Fig. 1. Upper winds over selected stations between Long. 67° and 88°E

– – – – – –Trough line, ...Isotachs, Wind speed in knots

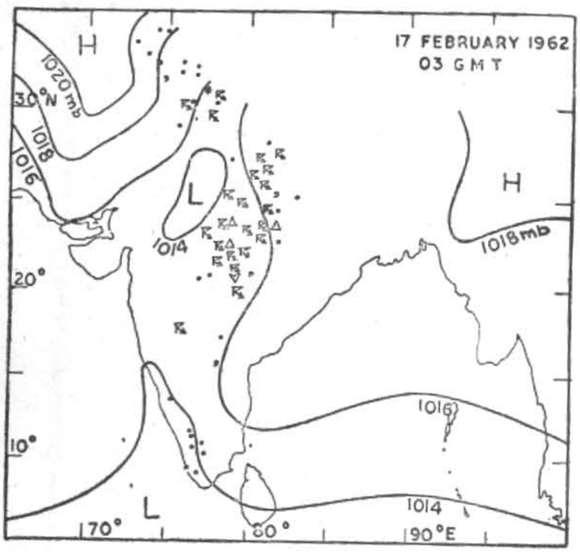


Fig. 2. Sea level isobaric chart and development of large scale convection during subsequent 24 hours

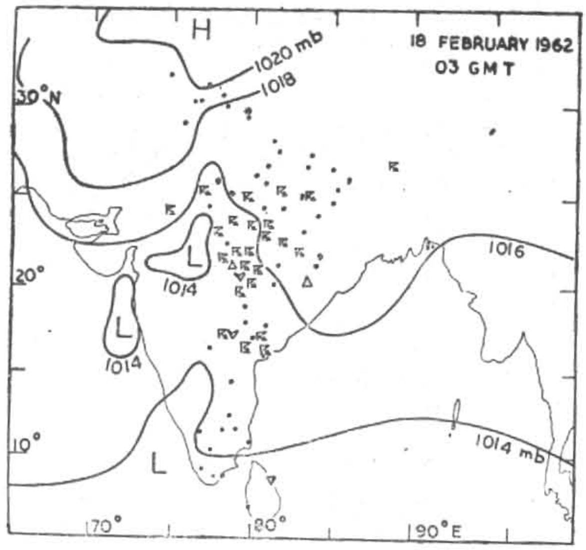
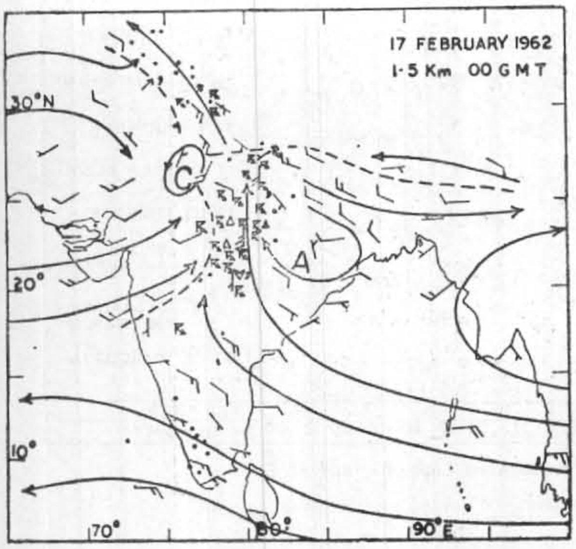


Fig. 3. Sea level isobaric chart and development of large scale convection during subsequent 24 hours

The trough lines bear a close resemblance with those of the normal sea level pattern for pre-monsoon months described by Ramaswamy (1956).

Convective weather developed on a large scale only in the moisture laden southerlies (as seen by the increase of dew point) even at places quite far away from the trough lines associated with these systems as found by Ramaswamy for pre-monsoon months. Koteswaram and Srinivasan (1958) have also mentioned that 'straight southerlies' with superimposed high level divergence over them, are favourable for setting off thunderstorms. In Hyderabad-Gannavaram area the southeasterlies of 17 February veered to southerlies by 18 February with subsequent weather development, suggesting that velocity convergence in the southerlies in the lower troposphere may have contributed to the development of convection.

Again on the morning of 19 February (Fig. 5) the area of weather development extended eastwards roughly upto 86°E, even over areas where the stream lines show an 'anticyclonic curl' (Fig. 3) and hence with no obvious or apparent agency for lower tropospheric convergence. Ramaswamy also found similar occurrence over the same areas and concluded that no significant clue is



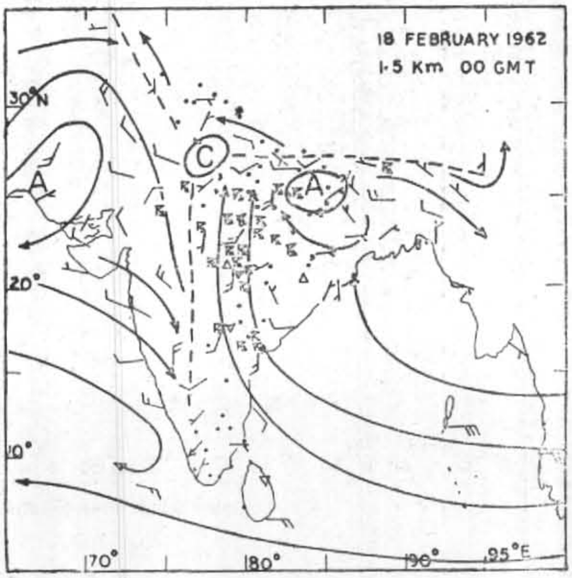


Fig. 4. 17 February 1962

Fig. 5. 18 February 1962

Figs. 4 & 5. Upper winds and stream lines at 1·5 km of 00 GMT and development of large scale convection during subsequent 24 hours

— — — Trough C — Cyclonic A — Anticyclonic

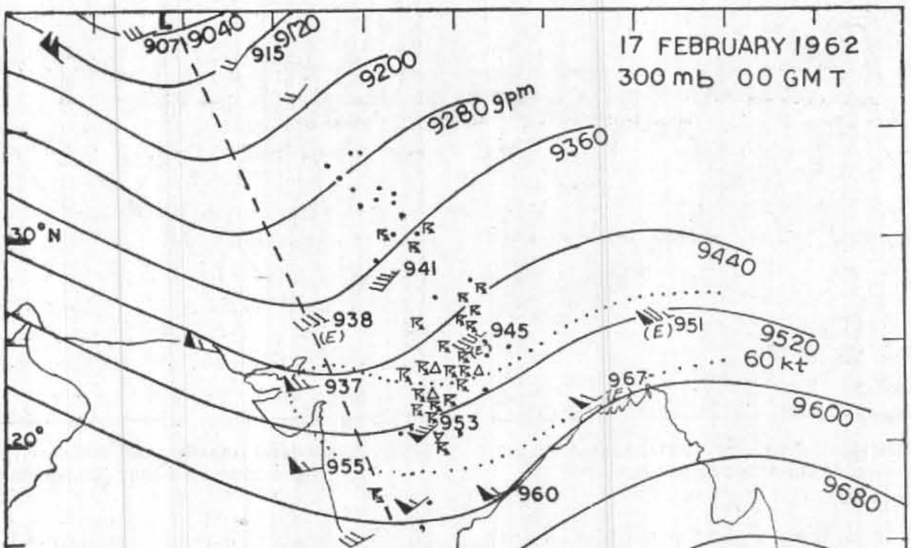


Fig. 6. 300-mb contour chart at 00 Z on 17 Feb 1962, winds at 9·0 km and development of large scale convection during subsequent 24 hours

— — — — Trough L — Low H — High

.........., Isotachs E — Evening winds

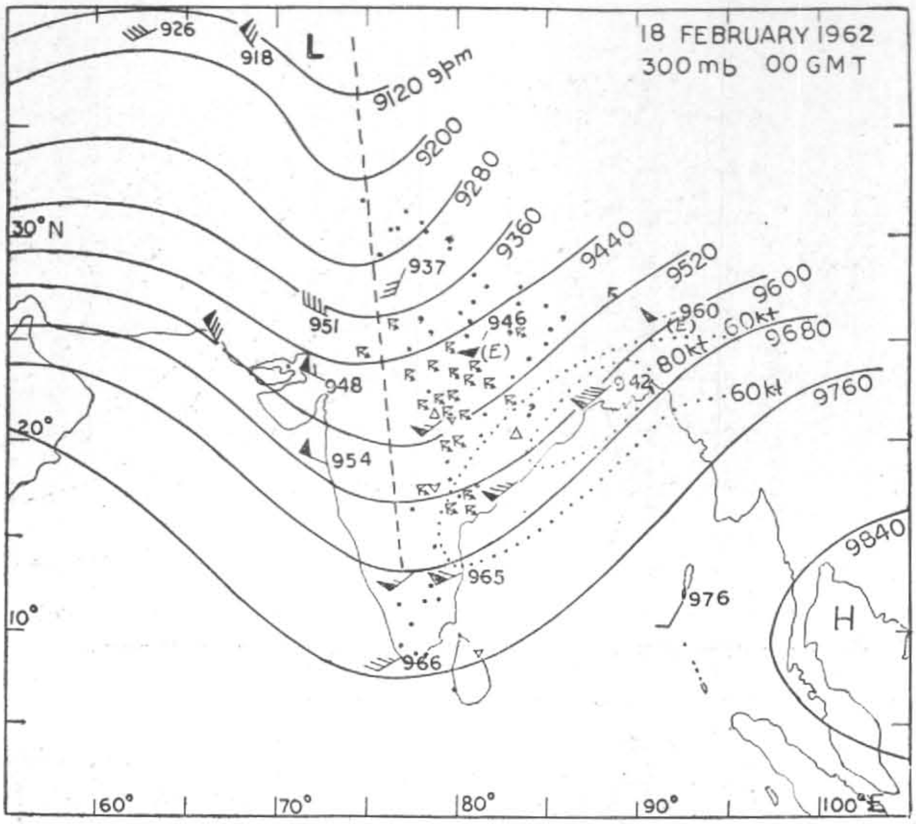


Fig. 7. 300-mb contour chart at 00Z on 18 Feb 1962, winds at 9·0 km and development of large scale convection during subsequent 24 hours

– – – – –Trough L — Low H — High E — Evening winds . . . . .Isotachs

shown by the lower tropospheric flow pattern alone to locate areas of subsequent convective weather development.

Rainfall north of 30°N and west of 80°E was in association with the western disturbance which moved as an upper air trough, augmented, of course, by orography and high level divergence associated with upper tropospheric trough.

(3) *Upper tropospheric contour patterns on 17 and 18 February 1962 and subsequent convective weather development* — The 300-mb contour charts for 00 GMT on 17 and 18 February with convective weather developments during subsequent 24 hrs (same symbols as in Figs. 2 and 3) are shown in Figs. 6 and 7 respectively.

It may be seen that the 'Sub-Tropical Jet Stream Wave' closely resembled the sinusoidal wave-type described by Ramaswamy (1956) with generally uniform shear and sinusoidal variation in curvature. The shear effect is more evident on 18 February.

Convective weather developed ahead of the Jet Stream Wave only over areas where the rate of change of curvature of the sinusoidal wave pattern was maximum.

On the morning of 18 February, the Jet Stream strengthened considerably and the trough line moved eastwards and extended southwards also with subsequent convective weather developments extending eastwards upto about 86°E where the lower tropospheric flow pattern was even anticyclonically curving.

Moreover, an embedded Jet Maximum of 109 to 123 kt ahead of the trough line of the Jet Stream wave passed over Nagpur on 17-18 February (Fig. 8). It is well known that 'the left front quadrant and the right rear quadrant of a Jet Maximum are areas of strong high level divergence'. Hence more severe weather occurred over extensive areas to the north and east of Nagpur due to the augmentation of the general field of divergence by additional divergence in the left exit and right entrance of the Jet Maximum.

On 18 February a Jet Maximum of 123 kt passed over Visakhapatnam (Table 1) and thunderstorms occurred over the Begumpet-Gannavaram area apparently in association with the southward movement of the Jet Maximum.

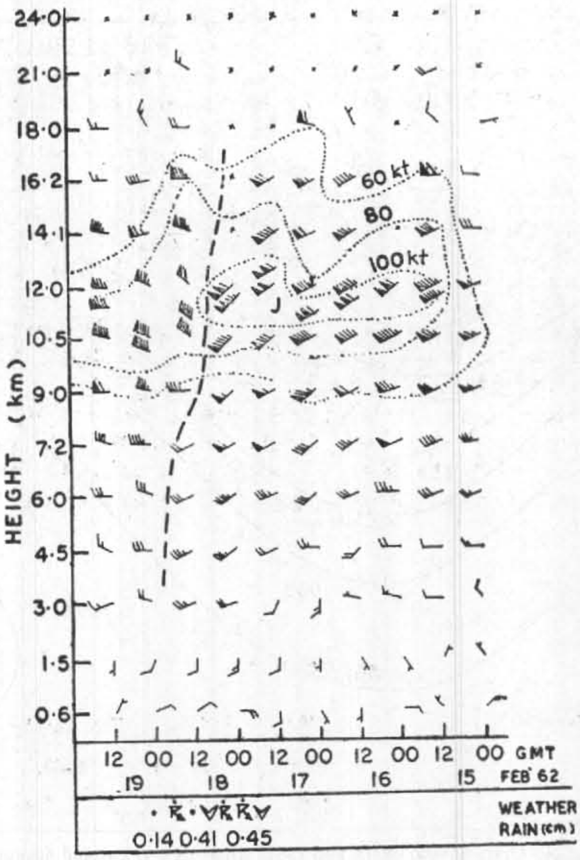


Fig. 8. Vertical time-section of winds over Nagpur during 15-19 Feb 1962

— — — — —Trough line ....Isotach (knots)

J—Jet Maximum, Wind speed in knots

TABLE 1

Maximum wind of 100 kt and more during 16 - 19 February 1962

Date (1962)	Morning (0000 GMT) Station	Height (km)	Direction (Deg)	Speed (kt)	Evening (1200 GMT) Station	Height (km)	Direction (Deg)	Speed (kt)
16 Feb	Allahabad	09·91	250	103	Gauhati	9·34	270	101
	Bombay	12·66	250	150	Bombay	10·85	250	115
	Nagpur	12·00	230	109	Nagpur	11·45	240	109
					New Delhi	12·10	230	108
17 Feb	Ahmedabad	12·16	250	106	Gauhati	9·82	220	099
	Nagpur	11·10	250	109	Nagpur	12·42	240	108
18 Feb	Bombay	11·10	330	104	Ahmedabad	9·76	330	104
	Visakhapatnam	12·08	250	123	Gauhati	11·15	240	120
	Nagpur	11·59	220	123	Visakhapatnam	12·40	250	121
19 Feb	Ahmedabad	11·76	310	135	Gauhati	11·78	240	101
	Visakhapatnam	17·41	270	102				

To the north of 30°N and west of 80°E, convective activity resulted mostly in precipitation since high level divergence over those areas with upper tropospheric winds of only about 40 kt should be much less than over central parts with Nagpur recording 75 kt at the same level.

4. Conclusions

1. The convective developments were far more associated with 300-mb contour patterns than with the sea level situations or lower tropospheric flow patterns.

2. Precipitation, even in areas far away from lower tropospheric trough lines and also in areas with 'anticyclonic curl' of stream lines near their vicinity was scanty which confirmed that high level divergence played a greater role in the subsequent development of convective phenomena.

3. Mean sea level situations or lower tropospheric flow patterns did not give conclusive or significant clues of subsequent large scale convective weather development.

4. Convective weather developments recorded over extensive areas on the morning of 19 February indicated that greater the general intensity of the Sub-Tropical Jet Stream Wave, more extensive was the area of subsequent convective activity.

5. Large scale convective phenomena over central parts of India during 17-19 February 1962 were associated with strong upper tropospheric divergence in a sinusoidal type of 'Sub-Tropical Jet Stream Wave' augmented by southeastward movement of a Jet Maximum across Vidarbha and neighbouring areas.

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