Mausam, (1980), 31, 2, 241-246

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Tropospheric structure and jet-streams over the Middle-East in winter

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(*Received* 16 *February* 1979)

ABSTRACT. Jet-streams and some aspects of the upper atmospheric structure over the Middle-East have been studied with the help of January data of four years, i.e., 1975-1978. It was found that there are, in general, two jet cores along 45°E to 50°E south of 45°N, one at 31°N at an altitude of 190mb with core speed of 175kt and the other at 25°N at an altitude of 220 mb and core speed of 150 kt. They are subtropical in nature and are located along and above a subtropical front which is well developed. There is no other jet-core between 31° N and 45° N indicating that the atmosphere in this region is apparently dominated by the tropical/subtropical airmass in winter.

1. Introduction

The knowledge of jet-streams and atmospheric structure over the Middle-East—a centre of growing aviation activity in the eastern hemisphere—is of utmost importance and there have been quite a number of studies of the upper-atmosphere over this region. Recently with the establishment of a satellite telecommunication link between Jeddah and New Delhi (since December 1977) for exchange of meteorological data, upper air observations from this region are readily available. An attempt has been made here to study if these data reveal any additional information regarding the position of the axis of the STJ and the general atmospheric structure over the Middle-East in the winter.

Bannon (1954) utilising the upper air observations of Habbania and Behrein for January 1951, studied the jet-structure over Iraq. He found the jet-stream to be broad and without strong horizontal gradients. Its axis was at about 190 mb, its position about 32°N and the breadth of the region of highest speeds (more than 100 kt) about 800 miles. He, however, notes that Gilchrist (1953) showed the geographical position of the mean jet to be about 30°N. Rieter (1963) observes that over the Middle-East, the sub-tropical jet-stream sometimes assumes a rather stable position. Krishnamurty (1961) carried out the daily upper wind analysis between equator and 45°N around the globe from December 1955 to February 1956 and observed that:

(*i*) The sub-tropical jet is situated close to the 200 mb surface and has a three wave pattern with a ridge over the Mediterranean and the Middle-East. He also noted that these waves are long and quasistanding with little zonal propagation.

(*ii*) Maximum 200 mb wind speeds are situated in the ridges and minimum in the troughs. Over Africa the highest speeds lie between 130 and 180 kt. The position of this core at 45°E is close to the north of 30°N (approx. 31°N).

2. Analysis

In the present study vertical cross-sections were drawn along 45°E on those days of January 1978 on which enough data were available. These yielded 15 vertical cross-sections along 45°E from roughly 15°N to 45°N. The choice of this longitude was due to the fact that a fairly good number of upper air observations were available along this longitude over the Middle-East. Data were taken from the NHAC charts which plots only 850, 700, 500, 300, 250, 200, 100 mb maximum wind and tropopause charts. Data for intermediate levels were interpolated from these observations.

Table 1 gives the position, altitude and maximum speed in the jet-cores observed in these cross-sections. It is seen that on most of the days

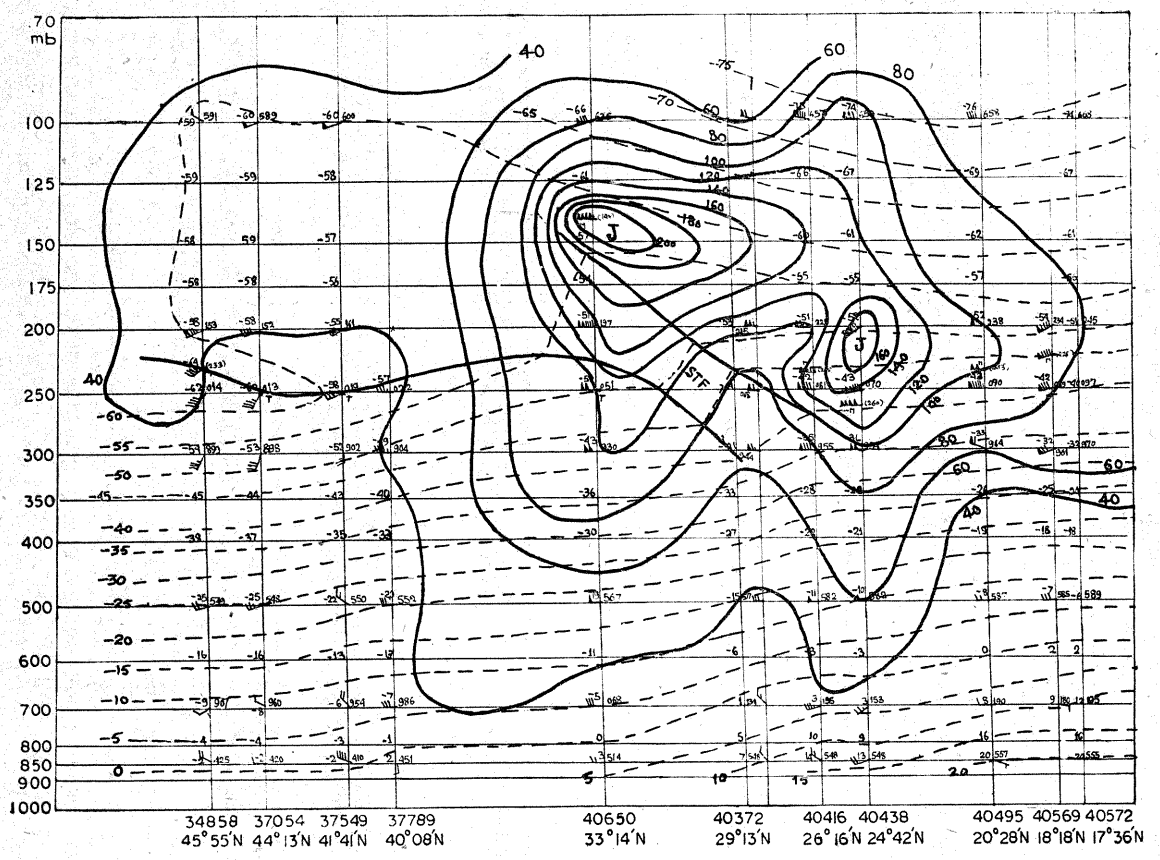

Fig. 1. Vertical cross-section along 45° E on 5 January 1978 at 0000 GMT

there are two well established jet-cores, though on occasions there may be three. It is also seen that north of 35° N only on two days jet-crores were observed. Similarly jet-cores are very few south of 20°N. On the other hand, between 36°N and 20°N there are two jet cores on most of the days. Of these the northern one seems to be more persistent than the southern one. The average position, altitude and core-speed of the northerly branch is roughly 30.9°N, 190 mb and 177 kt whereas that of the southern branch is 25.1°N, 220 mb and 147 kt (Table 1). This shows that there are usually two jet-cores over the Middle-East in the sub-tropical latitudes—one along 31°N at about 190 mb with a core speed of 175 kt and the other at 25°N at 220 mb with a core speed of about 150 kt. occasionally there may be a third one at about 19°N and 240 mb with a speed of about 100 kt. The position of the northern jet, i.e., at 31°N is the same as found by Bannon (1951), Gilchrist (1953) and Krishnamurti (1963). But none has mentioned the southern branch, i.e., at 25°N This may be due to the paucity of observations in this area.

It is interesting that these two jet-cores appear more or less as extensions of the two jet-cores observed over India (Singh 1971 a, b)—one located along 31°N at 200 mb with a speed of 140-150 kt and the other along 23°N at a height of 12.5 km with a core speed of 100 kt.

A study of the cross-sections (Figs. 1 to 4) also show that these jet-streams are of subtropicay type, situated along the above a subtropical front whose base is the extension of middle tropopause from the north, as is the normal case. The middle tropopause is not straight but undulating and is located on the average at 250 mb north of the subtropical front. Below the subtropical front, it slopes downwards and finally vanishes towards the south. It is interesting to note that in all the cross-sections, the middle tropopause predominates. No case of occurrence of polar tropopause has been observed. It appears that this area being ahead of the Mediterranean upper-air trough in winter (Palmen and Newton 1969) is subject to predominently southerly flow bringing in air of subtropical origin whose characteristic tropopause is the middle tropopause. Tropical tropopause was observed in only one cross-section. It appears that the tropical tropopause is located at a higher altitude than 100 mb even in the southerly latitudes of region. The subtropical front is a sloping one decreasing from north to south in height. The

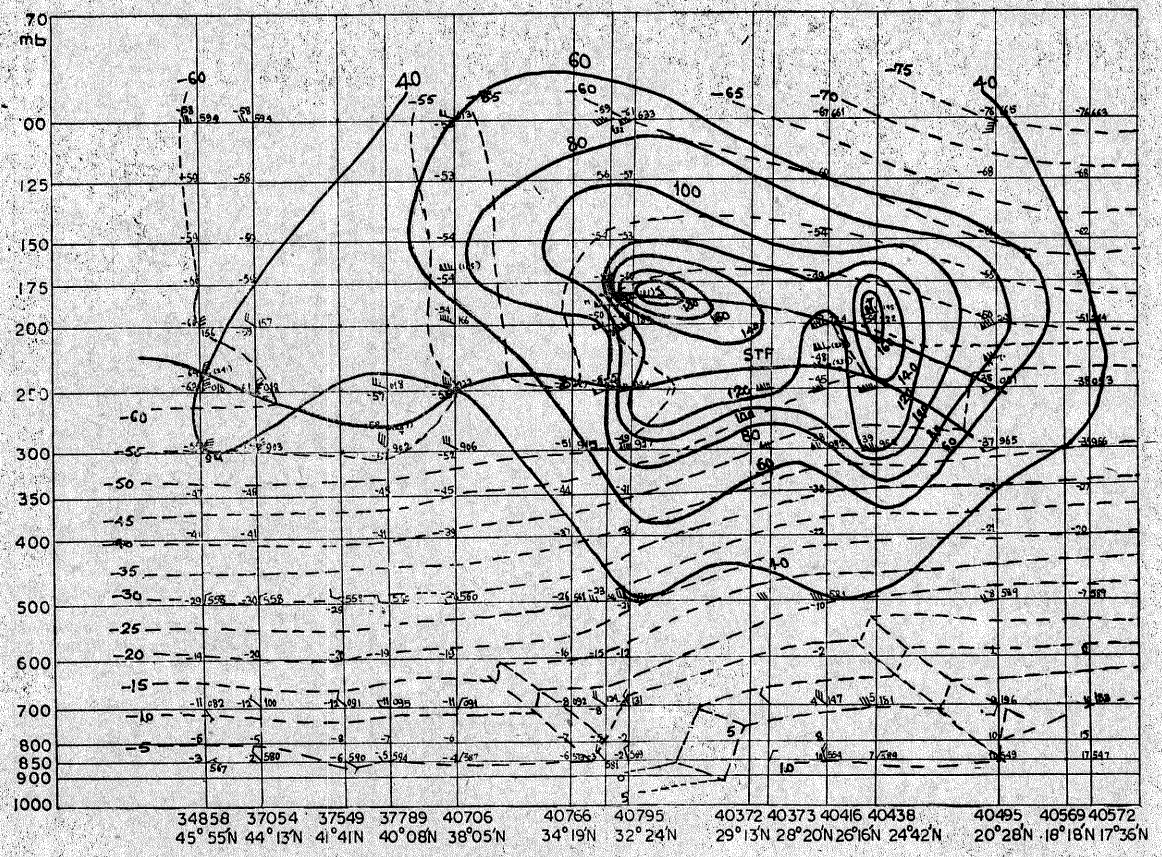

Fig. 2. Vertical cross-section along 45° E on 13 January 1978 at 0000 GMT

TABLE 1

Westerly Jet-streams along 45°E (between 15°N and 45°N) during January 1978

Time of obsn.		Jet Core I			Jet Core II			Jet Core III			Jet Core IV		
Date (Jan 78)	Time (GMT)	Position (°N)	Alt. (mb)	Core speed (kt)	Position (°N)	Alt. (mb)	Core speed (kt)	Position (°N)	Alt. (mb)	Core speed (kt)	Position (°N)	Alt. (mb)	Core speed (kt)
5	0000	—	—	—	33	140	205	25	200	170	—	—	—
6	1200	—	—	—	29	180	140	—	—	—	19	225	120
8	0000	—	—	—	32	170	160	23	140	140	—	—	—
11	1200	—	—	—	31	225	180	—	—	—	—	—	—
13	0000	—	—	—	32	180	180	25	200	160	—	—	—
15	1200	—	—	—	—	—	—	25	175	140	19	250	100
18	1200	41	250	100	—	—	—	25	185	180	18	240	105
21	1200	—	—	—	35	225	160	27	200	140	18	250	70
22	1200	—	—	—	34	225	160	27	260	140	—	—	—
23	1200	—	—	—	29	210	205	24	300	130	—	—	—
24	1200	—	—	—	30	180	180	25	270	130	—	—	—
26	1200	—	—	—	30	200	200	—	—	—	—	—	—
27	1200	—	—	—	28	175	160	—	—	—	—	—	—
29	0000	—	—	—	28	210	150	—	—	—	—	—	—
30	0000	45	275	120	30	150	220	25	270	140	—	—	—
Total		86	525	220	401	2,470	2,300	251	2,200	1,470	74	965	395
Mean		43°	262	110	30.9°	190	177	25.1°	220	147	18.5°	241	99

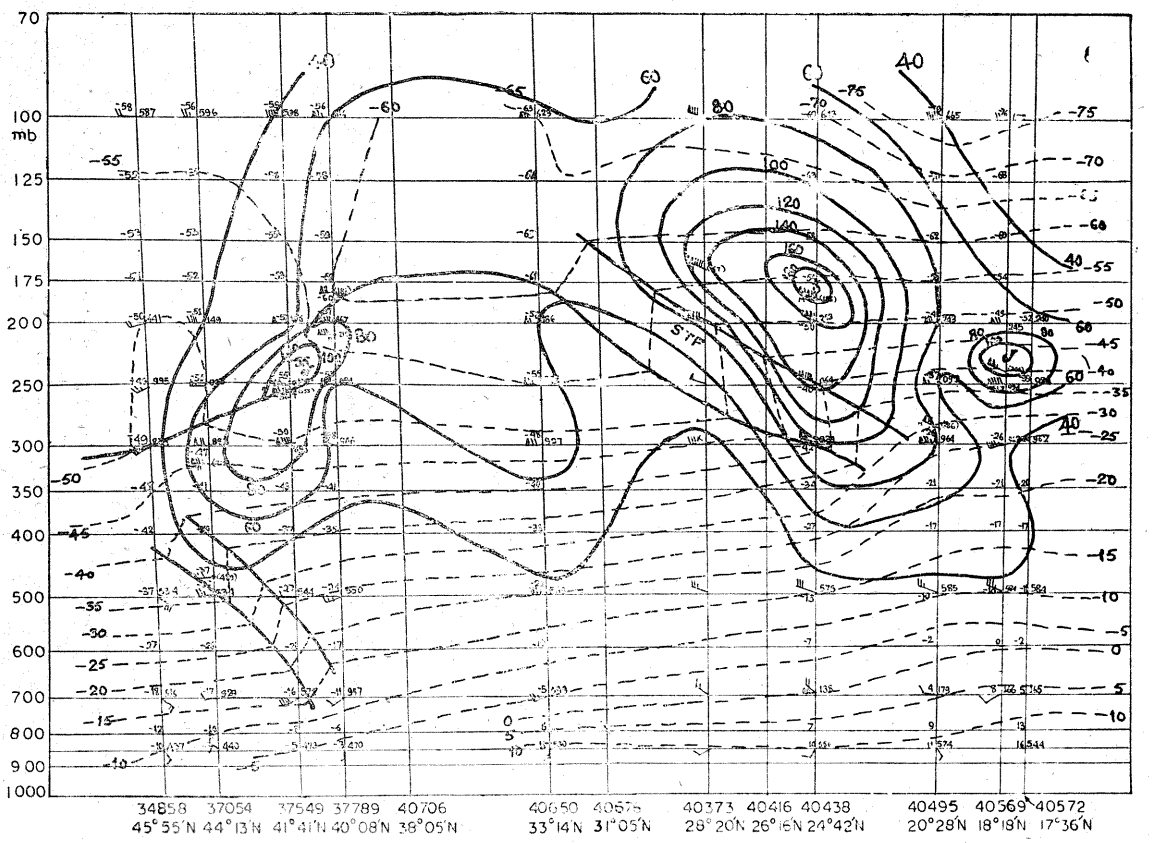

Fig. 3. Vertical cross-section along 45° E on 18 January 1978 at 1200 GMT

TABLE 2

Extent and altitude of subtropical front (Top of inversion)

Date (Jan 78)	Time of Obsn. Time (GMT)	Northern point of top		Southern point of top	
		Position (°N)	Altitude (mb)	Position (°N)	Altitude (mb)
5	0000	33	150	28	270
6	1200	33	165	25	200
8	0000	37	150	22	300
11	1200	32	190	27	225
13	0000	34	185	20	250
15	1200	33	125	18	270
18	1200	31	150	23	300
21	1200	34	190	26	290
22	1200	32	170	25	275
23	1200	36	140	31	230
24	1200	36	200	32	260
26	1200	38	175	33	325
27	1200	34	150	26	275
29	0000	37	135	27	250
30	0000	33	140	30	250
Total		513	2415	393	3970
Mean		34.2°	161	26.2°	265

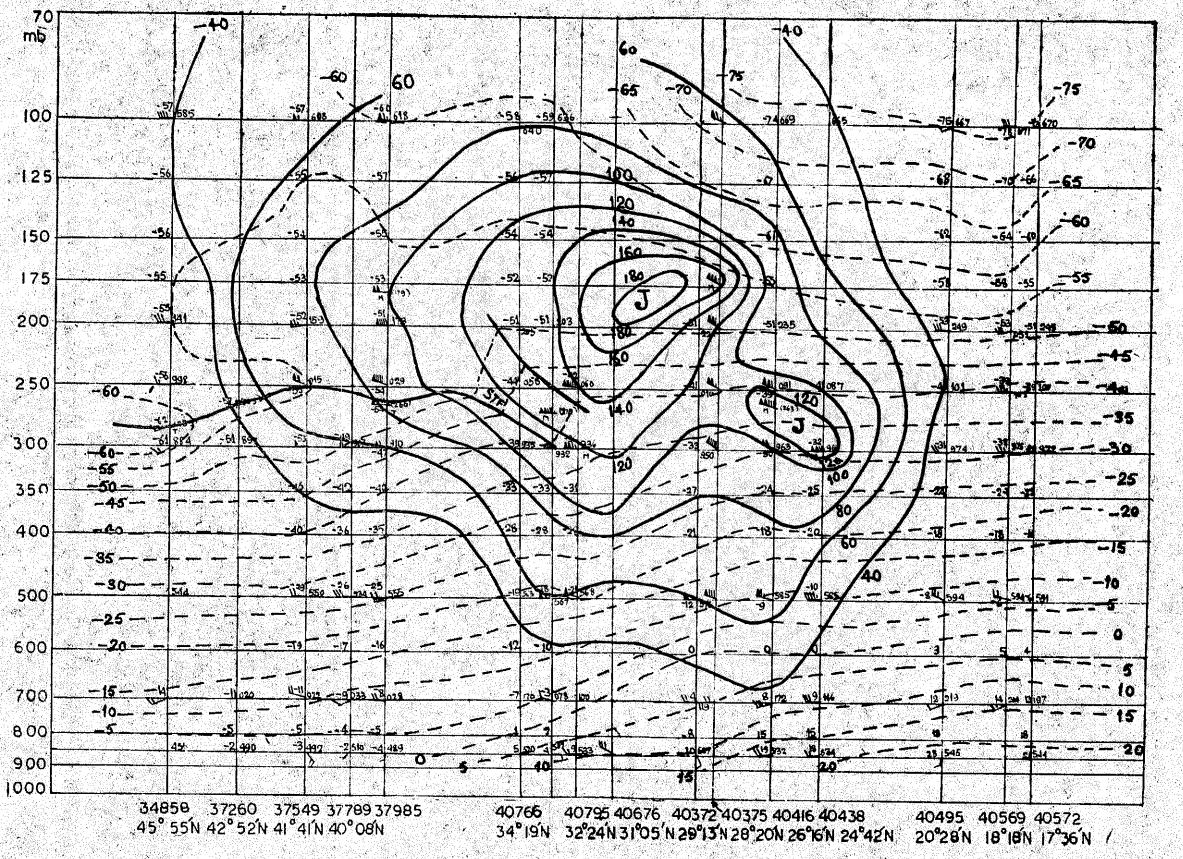

Fig. 4. Vertical cross-section along 45° E on 24 January 1978 at 1200 GMT

extent of the top of the front as well as the altitudes of its two ends are given in Table 2. It can be seen that the top of the front (top of the inversion layer) extends on average from 34° N to 26°N and from 160 mb at its northern most position to 265 mb at its southern end. On most of the days it is quite well developed. The jet-cores lie along and above it, the northern one at a higher level than the southern one as shown earlier (Table 1).

From this study it is inferred that over the Middle-East :

(*i*) There are two cores, in the mean, of the sub-tropical jet-stream in winter. One is located at 31°N at an altitude of 190 mb with an average core-speed of 175 kt and the other at 25 ° N at a height of 220 mb and core speed of 150 kt.

(*ii*) These jets are located above and along a sub-tropical front which is well developed and entends in the mean from 34°N to 26°N and desends from 160 mb at its northern end to 265 mb at its southern end.

(*iii*) The base of this subtropical front is the middle tropopause which is the main tropopause in the entire zone of study, i.e., 15°N-45°N. This tropopause is undulating and is located on the average at 250 mb north of the sub-tropical front.

(*iv*) Tropical tropopause is apparently above 100 mb in the subtropical latitudes and is not seen in most of the cross-sections.

(*v*) Polar tropopause is also not seen indicating that the subtropical/tropical airmass from the south is the dominating airmass in this area in January. It

is because of its location ahead of Mediterranean upper tropospheric trough in the westerlies in winter.

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