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Climatological aspects of Tehran tropopause

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ABSTRACT. This study is based on 3 years daily observations of upper air of Tehran (35N°) during 1964-66. The author identifies the characteristics of Tehran tropopause and investigates the relationships of some of these characteristics with the temperature and pressure of the surface. The altitude of the tropopause changed between 5·7 and 19·2 km; in 57 per cent of the cases the tropopause altitude was between 10-13 km. Average daily change of tropopause altitude was about 1 km. The fluctuation of the altitude was more in summer than in winter. In 50 per cent of the cases, the tropopause has a mean temperature of —30° with an approximation of 5°C. The average of tropopause pressure was 183 mb. The temperature of the Tehran tropopause in January and July was quite different from that estimated for the Lat. 35°N. There existed a postive correlation between the altitude of tropopause and the surface temperature on the one hand, and a negative correlation between the temperature of tropopause and the surface temperature on the other hand. No significant correlation was found between tropopause pressure and the surface pressures.

1. Introduction

Tropopause is a transitory layer between troposphere and stratosphere. Since no work has been done on Tehran tropopause its nature is not well known yet. The average characteristic factors determined for the tropopause on variosu parallels do not effectively characterize the tropopause of any point on a parallel. The author thus decided on determining the climatological factors of Tehran tropopause and comparing them with the corresponding data obtained on the co-latitude places. These data were obtained from the soundings done by the Upper Air Section of Iranian Meteorological Department (1967) for the years 1964-66 by using Finish-made radio-sondes of Vaisälä type at 12 GMT (or 1530 hr local time) at Mehrabad station (Long. 51°19′ E, Lat. 35°41′N, altitude 1190 m a. s. l.) in Tehran. During the years 1964-66 about 1000 soundings were made from which 200 were indistinguishable, because of waves interference. Tropopause is defined to be located where the lapse rate up to 2 km above it, is less than 2°C per km and the lapse rate for a layer of 1 km below it, is less than 1°C per km.

2. Tropopause altitude

The average altitude of Tehran tropopause is 12.7 km with a standard deviation of 2·5 km. During the three years of study the highest altitude of tropopause was seen on 19 June 1966 which was 19.2 km; the tropopause pressure and temperature on the same day were 70 mb and —75°C, respectively The tropopause was lowest on 19 January 1964 (5·7 km) with pressure and temperature of 470 mb and —40 °C respectively. The range of absolute variation of tropopause altitude is 13·5 km. The annual variation of average monthly altitude of the tropopause had a maximum in July. The height declined through January and February with a minimum in the latter month. Fig. 1 shows the absolute max. and min. as well as the annual variation of average monthly altitude of the tropopause. The range of annual variation in average monthly altitude was 6·6 km and the average annual variation change from one year to another was less than 0.6 km. The average altitude of the tropopause in Tehran was 10.7 km in winter with a standard deviation of 1.2 km The corresponding values in the summer were 16·2 and 1.9 km respectively. The average monthly altitude in January and July were respectively, 10.7 and 17.1 km. Tehse values are different from those obtained by the U.S. Weather Bureau from balloon soundings for the latitude of 35°N (Byers 1959), which were 12.5 km for winter and 14.5 km. for summer. The difference is more than 1.5 km which anticipated as the maximum difference between the average annual height at two points on the same parallel (Polleau and Trochon 1952).

Tropoause altitude in 57 per cent of the soundings was 10–13 km and for 32 per cent of them was more than 13 km, while only 10 per cent of the soundings revealed an altitude of less than 10 km. The altitude frequency distribution of

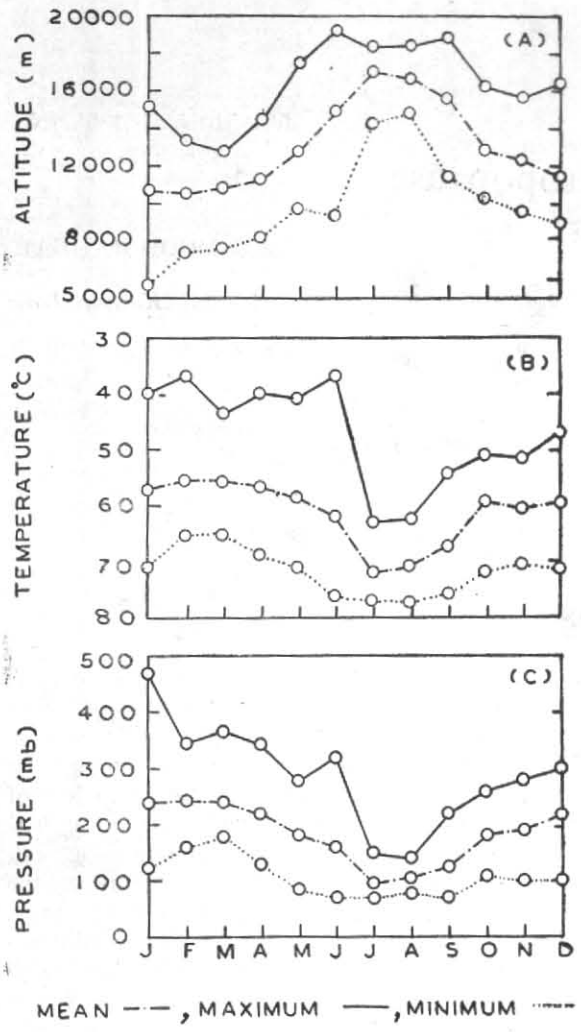

Fig. 1. Annual variation of monthly (A) Altitude, (B) Temperature and (C) Pressure of the tropopause at Tehran

Tehran tropopause for the 3 years is shown in Fig. 2(a). In winter, in 72 per cent of the cases the tropopause altitude was between 10—13 km, and in 1 per cent of the cases it was more than 13 km. However, the tropopause altitude was more than 13 km in 90 per cent of the cases in summer. In 72 per cent of the soundings, the summer altitude was higher than 16 km and only in 1 per cent of soundings it was lower than 10 km. Figs. 2(b) and 2(c) show the frequency distribution of the winter and the summer altitude respectively.

The daily altitude change of tropopause was also studied. Average of these changes was 1007 m and its standard deviation was 1023 m. Although the daily change was less than 1000 m in almost 70 per cent of the times, a change of 6600 m in altitude was sounded on 6 June 1966. The average daily variation of altitude was 936 m in winter and 1010 m in summer. The winter daily variation never reached 5 km; while in summer, in 4 per cent of the cases it was over 5 km. In general, altitude of tropopause in summer had more fluctuation than that of the winter. The standard deviations of daily changes of tropopause altitude and temperature in winter and summer are given in Table 1. Fig. 3 (a—c) shows the frequency distribution of altitude in year, winter and summer respectively.

3. Tropopause temperature

The average tropopause temperature of Tehran was —60°C and its standard deviation was 7·4°C. The minimum and maximum temperatures of the tropopause, which measured, were —77·2°C and —37°C respectively. The first measurement was taken on 31 August 1964 and the latter one on 13 February 1966. The annual variation of the average monthly temperature of the tropopause had a maximum of —55·5°C in February which after a minor reduction during March reached its minimum (—71·8°C) in July. The range of annual variation of average monthly temperature was 16·3°C; but, the average annual change in temperature from one year to another wasl ess than one degree centigrade. Fig. 1(B) shows the annual variation of average monthly temperature at the tropopause. The variation in temperature was similar to the variation of temperature of the medium latitudes. But its range of variation was greater than that of the medium latitudes (Poulleau and Trochon 1952). In winter and summer, the average tropopause temperature of Tehran did not differ greatly from the estimated temperature for the latitude of 35°N, but the average temperatures of January and July were —57°C and —71·8°C respectively; these presented a considerable differences from those estimated for Tehran latitude (Buffaut 1967). In 50 per cent of the cases the tropopause had a mean temperature of—60°C(±5°C) and in about 22 per cent of the cases the temperature was above —55°C. The average temperature of the winter was —55°C. In 14 per cent of the cases the tropopause had a temperature exceeding —55°C and in 1 per cent of the cases the temperature was less than —69°C but in summer the average temperature was —68·7°C and only in 6 per cent of the cases the temperature was above —55°C. In 64 per cent of the cases the summer temperature was less than — 69°C . Fig. 4 (a-c) shows frequency distribution of the tropopause temperature for the year, winter and summer seasons respectively. Daily variation of temperature was on the average

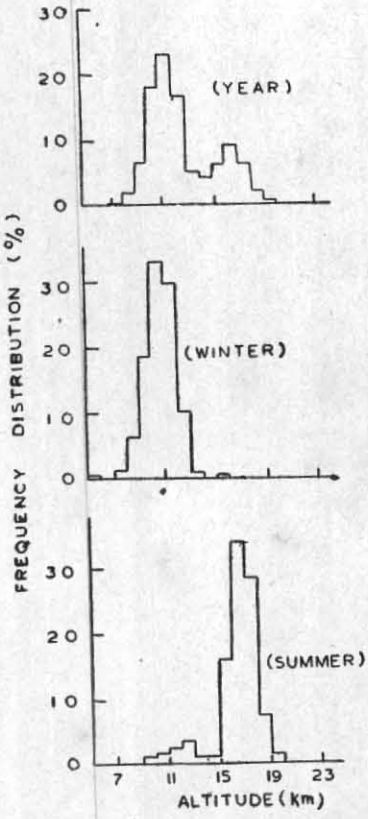

Fig. 2

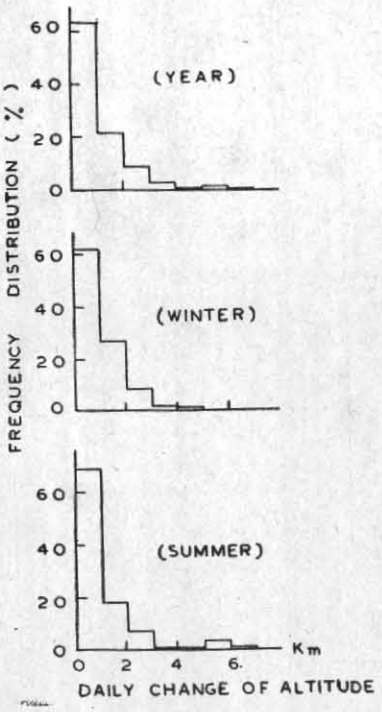

Fig. 3

(*a*) Year (*b*) Winter (*c*) Summer

TABLE 1

	$\overline{H}$ (km)	σH	$\triangle\overline{H}$(m)	$\sigma\triangle H$	$\overline{t}$(°C)	σt	$\triangle t$(°C)	$\sigma\triangle t$
Annual	12·7	2·5	1007	1023	—60	7·4	4	3·9
Winter	10·7	1·2	936	878	—55·9	5·6	4·6	4·1
Summer	16·2	1·9	1010	1261	—68·7	7·1	3·1	4

$\overline{H}$=altitude t=temperature $\triangle H$=daily change of altitude $\triangle t$=daily change of temperature σ=standard deviation

4°C and its standard deviation was 3·9°C, its maximum was recorded to be 24·8 °C. However in about 52 per cent of the cases it was less than 4°C. The daily fluctuation of the tropopause temperature in summer had a shorter range than in winter. In contrast, the daily fluctuation of the tropopause altitude has a shorter range in winter. The average daily temperature variation in winter was 4·6°C and its standard deviation was 4·1°C. These values were 3·1°C and 4°C respectively for summer. In 38 per cent of the cases the daily winter variation of tropopause temperature was less than 2°C; while the daily variation of summer temperature in 54 per cent of the cases was less than 2°C. In the winter, daily variation of the tropopause temperature was, in 27 per cent of the cases more than 8°C; while such summer variation presented 13 per cent of the cases. Fig. 5 (a, b, c) show frequency distribution of daily change of tropopause temperature for year, winter and summer.

4. Tropopause pressure

The tropopause pressure of Tehran was on the average 183 mb. Fig. 1(*c*) shows the annual variation of the average monthly pressure of tropopause. The pressure was maximum in Feburary and minimum (96 mb) in July. The range of annual variation of the average monthly pressure was 148 mb. But the average

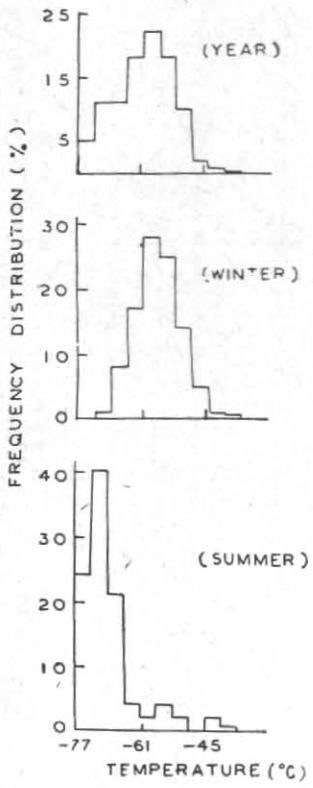

Fig 4.
(*a*) year (*b*) Winter

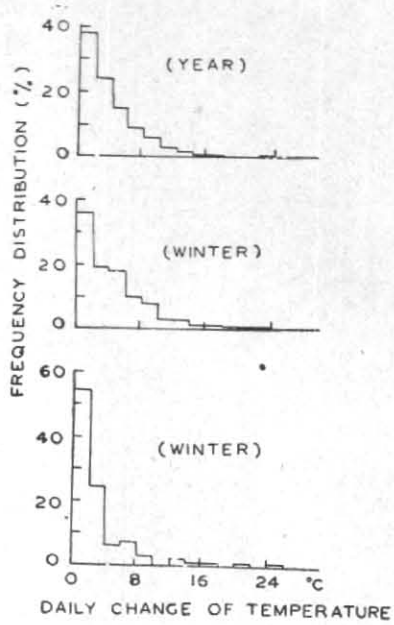

Fig. 5
(*c*) Summer

annual change in successive years was 20 mb. The winter tropopause pressure was 240 mb which reduced to half for summer. The average pressure and temperature of Tehran tropopause in January, April, July and October were similar to those of Nicosia Cyprus, which is 35°N latitude, same as Teheran (Gold *et al.* 1958). The absolute maximum and minimum pressure in the three years of study were 470 and 76 mb respectively.

5. Correlation

Comparison made between the tropopause altitude and temperature with surface temperature shows a significant correlation. The coefficient of correlation between tropopause altitude and the surface temperature was 0·78. The correlation coefficient of the above factors for winter and summer were separately calculated. In winter season relationship between tropopause altitude and surface temperature was higher than those of summer season. The values of these coefficients are 0·15 in summer which reaches to 0·35 in winter. The present calculations show that there is a significant correlation between tropopause temperature and the surface temperature. But the coefficient of correlation was —0·56, less than that of tropopause altitude and surface temperature. The relationship between the summer tropopause temperature and surface temperature exceeded that of the winter. The correlation coefficient was —0·34 for winter and —0·62 for summer and there was no significant correlation between tropopause and surface pressures. Statistical calculation shows that relationship between altitude and temperature of tropopause is more than the tropopause pressure. The absolute variations of daily tropopause altitude indicated a significant correlation at 95 per cent level with the absolute variations of daily tropopause temperature. The coefficient of correlation between these two factors for year winter and summer seassons were 0·62, 0·50 and 0·82 respectively.

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