

## Unusual high total ozone over New Delhi on 25 March 1990 — A case study

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**सार**— 25 मार्च 1990 को नई दिल्ली में 373 डॉबसन एकक के मूल्य वाले एक असामान्य उच्च कुल ओजोन का प्रेक्षण किया गया। क्षोभ सीमा विच्छेद से क्षोभ मंडल में समताप मंडलीय ओजोन का रिसाव लक्षित किया गया है। यह 300 मि. दार स्तर पर 20° उ. अक्ष. 82° पू. देशान्तर उत्तर के साथ-साथ मध्य क्षोभमंडलीय पश्चिमी हवाओं की द्रोणी से भी संबंधित है।

**ABSTRACT.** An unusual high total ozone value of 373 Dobson unit was observed over New Delhi on 25 March 1990. It is attributed to the leakage of stratospheric ozone into troposphere through tropopause break in association with a trough in mid-tropospheric westerlies with its axis lying along 82° E longitude north of 20° N, at 300 hPa level.

**Key words** — Anti-cyclone, Trough in westerlies, Sub-tropical jet stream.

### 1. Introduction

Ozone is formed mainly at height of 30 km or more in lower latitudes and transported from this source region of tropical stratosphere to a reservoir region in the middle stratosphere of high latitudes. Simultaneously in northern hemisphere, a back transport from north to south within the lower stratosphere takes place, causing an increase of ozone in the lower stratosphere of middle latitudes. The higher troposphere of the tropics is supplied with ozone from the lower stratosphere of middle latitudes through the tropopause break.

Ramanathan (1954) had shown that significant variations in total ozone occur over New Delhi, Mount Abu, and Ahmedabad during December to April when western disturbances associated with trough in westerlies at 9 km are active over north India. The rise of ozone takes place when the northwesterly winds are replacing the southwesterlies, but once the north westerlies get settled, the ozone amount begins to fall. The increase of ozone over north India in winter is associated with the formation of a double tropopause over north India and leakage of middle latitudes stratospheric air into the north Indian troposphere.

A series of ozone soundings were made at New Delhi by Mani *et al.* (1973, 1976) to study the changes in the vertical distribution of atmospheric ozone associated with western disturbances. The study shows that with the approach of upper tropospheric trough and the simultaneous lowering of the tropopause, there is an increased influx in shallow layers of middle latitudes ozone rich air through break in the tropopause, replacing the sub-tropical ozone poor air over the station.

In the present paper, an unusual high value of total ozone of 373 DU observed over New Delhi on 25 March 1990 has been discussed with the help of prevailing synoptic conditions.

### 2. Observations

#### 2.1. Total ozone

Total ozone, *i.e.*, the amount of ozone contained in vertical column of air extending from the ground to the top of the atmosphere at a place, is measured at Indian network stations by Dobson Ozone Spectrophotometer. Maxima of daily total ozone observed in the month of March for the years 1960 to 1990 over New Delhi is shown in Fig. 1. The figure shows that the highest daily total ozone so far observed was 373 DU on 25 March 1990. The next lower daily total ozone 362 DU was observed on 25 March 1979, 8 March 1980 and 25 March 1982. Fig. 2 shows day to day variation of total ozone over New Delhi from 22 to 28 March 1990. Over New Delhi, total ozone was 296 DU on 23 March. Next day it was 325 DU and increased to 373 DU on 25 March. It decreased to 355 DU next day and came down to 296 DU on 28 March.

Variation of day to day total ozone over Varanasi from 22 to 28 March 1990 is also shown in Fig. 2. The trend of variation of daily total ozone at Varanasi is similar to New Delhi, having maximum value of 339 DU on 25 March.

#### 2.2. Upper air cyclonic circulation and the trough in westerlies, 23-27 March 1990

In the morning of 23 March 1990, an upper air cyclonic circulation extending up to 2.1 km a.s.l. lay over north

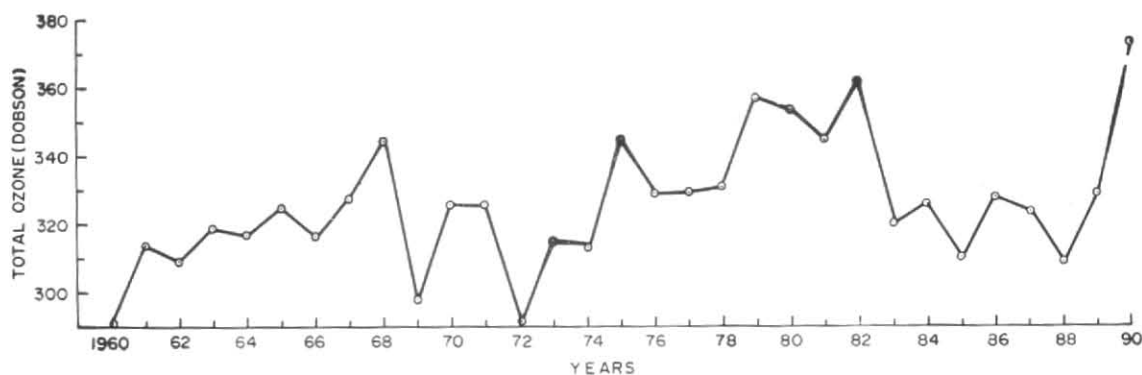


Fig. 1. Maximum daily total ozone in the month of March for years 1960-1990 over New Delhi

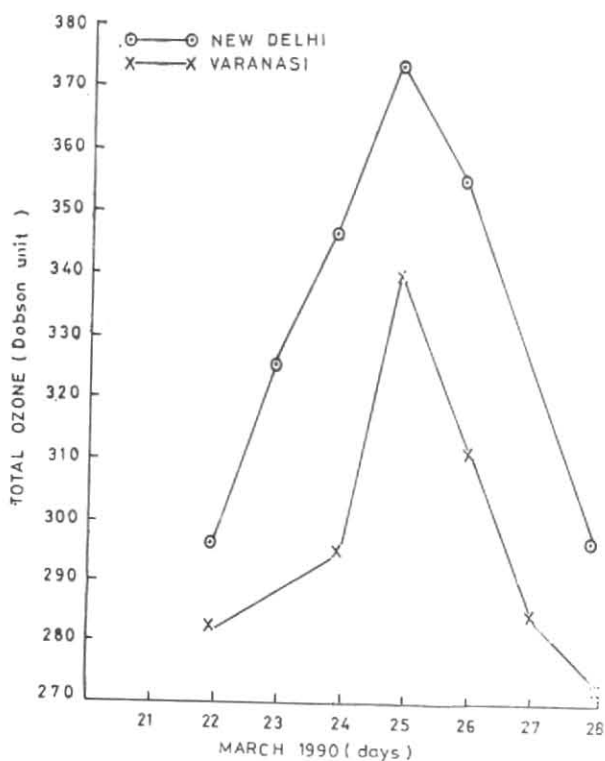


Fig. 2. Day-to-day variation of total ozone over New Delhi and Varanasi, 22-28 March 1990

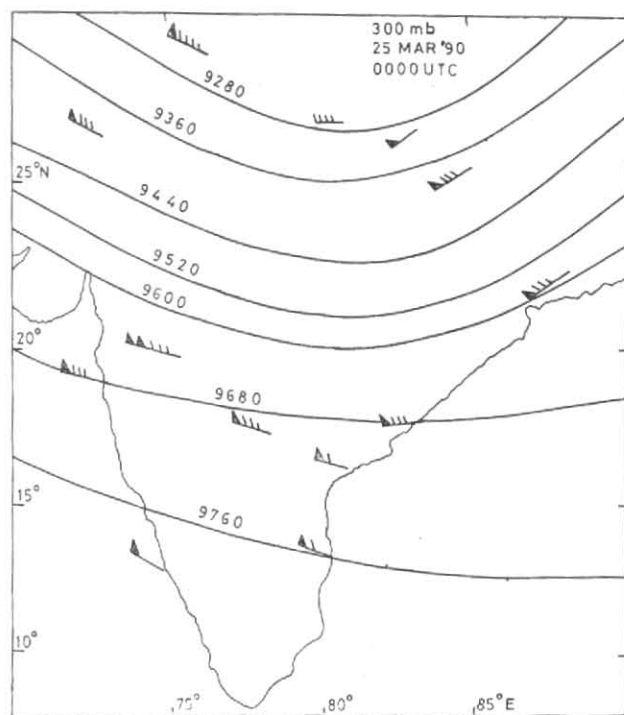


Fig. 3. 300 hPa height contours — 25 March 1990 (00 UT)

Haryana and adjoining northwest Uttar Pradesh. A trough from this system was running southwestwards to southwest Rajasthan between 0.9 & 3.1 km. A trough in the mid and upper tropospheric westerlies with its axis at 300 hPa level lay roughly along 73° E north of Lat. 26° N. In the evening, cyclonic circulation moved southwestwards across hills of west Uttar Pradesh and the trough in the westerlies was lying along Long. 74° E. On 24 March 1990, cyclonic circulation moved away across hills of west Uttar Pradesh while trough in westerlies persisted. On 25 March the trough in westerlies moved eastwards and lay along Long. 82° E north 20° N (Fig. 3). On 26 March it further moved eastwards and was running from Bihar to west central Bay on 27 March.

### 2.3. Upper air winds at 300 hPa

Upper air winds at 300 hPa over New Delhi for 23-27 March 1990 are given in Table 1.

### 2.4. Tropopause break

Over New Delhi, on 24 March morning tropical tropopause was at 109 hPa and extra-tropical tropopause at 237 hPa. In the evening these two tropopause were at 112 and 178 hPa respectively. On 25 March morning tropical tropopause came down to 165 hPa and extra-tropical tropopause at 267 hPa while in the evening the values were 182 and 265 hPa respectively. The tropical tropopause rose to 98.9 hPa and other one to 218 hPa on 26 morning.

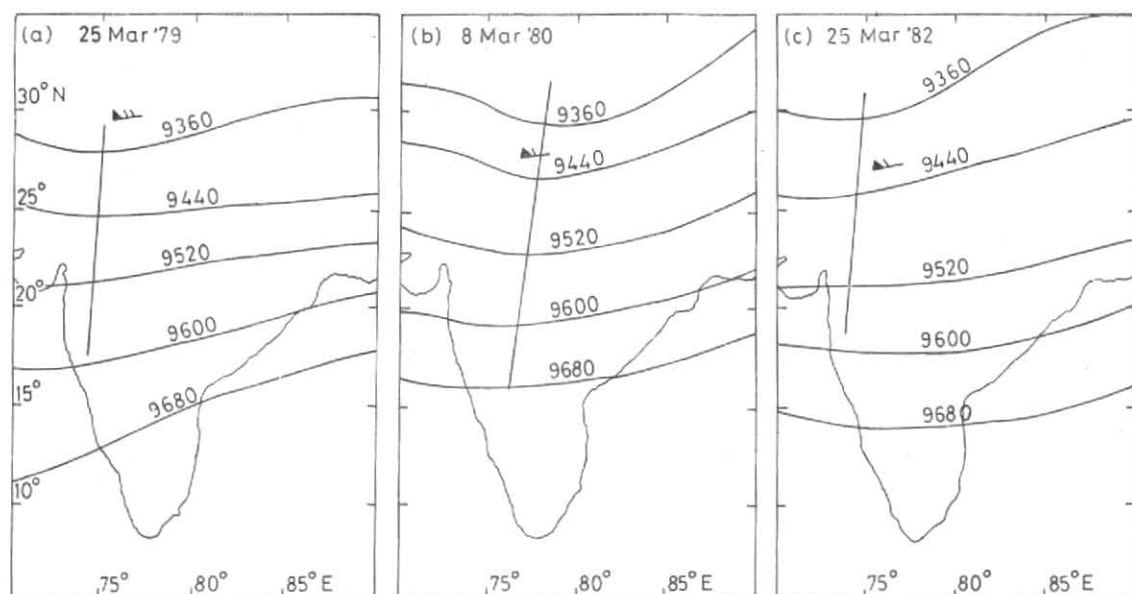


Fig. 4. 300 hPa height contours — 25 March 1979, 8 March 1980 and 25 March 1982 (00 UT)

### 3. Discussion

Upper air features of 25 March 1990 when total ozone maxima of 373 DU was observed at New Delhi, are presented under paras 2.2, 2.3 and 2.4. On 25 March 1979, 8 March 1980 and 25 March 1982 the days when total ozone maximas though of lesser amplitude of 362 DU observed, the similar features as observed on 25 March 1990 were present. On these days also western disturbance was active over north India. The associated trough in westerlies was lying with its axis along 75° E on 25 March 1979, along 76° E on 8 March 1980 and along 78° E on 25 March 1982, north of 20° N at 300 hPa level (Fig. 4), as compared to axis position along 82° E longitude on 25 March 1990. Over New Delhi, winds at 300 hPa level were 265/70, 260/60 and 265/55 on 25 March 1979, 8 March 1980 and 25 March 1982 respectively as compared to 300/47

on 25 March 1990. Sub-tropical westerly jet was present on all these four days, north of 20° N along the contour lines, at 300 hPa level chart. Over New Delhi tropical tropopause was lowered to 120 hPa on 25 March 1979, on 25 March 1980 it was not reported while it was at 90 hPa on 25 March 1982, as compared to 182 hPa on 25 March 1990. Middle latitude tropopause was at 305 hPa on 8 March 1980 and at 243 hPa on 25 March 1982. On 25 March 1979 it was not reported while on 25 March 1990 middle latitude tropopause was at 265 hPa.

Presence of trough in westerlies and of sub-tropical jet stream, lowering of tropical tropopause/break in tropopause are the favourable features for stratospheric tropospheric exchange and these were present on all these four days 25 March 1979, 8 March 1980, 25 March 1982 and 25 March 1990. But lowering of tropical tropopause down to 182 hPa and comparatively eastward position of trough, *i. e.*, 82° E on 25 March 1990 are more favourable for unusual increase of total ozone to 373 DU over New Delhi. The levels at which this surge of ozone took place, could not be identified because due to technical reasons both the Umkehr as well as ozone sonde observations could not be taken at New Delhi on 25 March 1990. However, earlier studies (Mani *et al.* 1973, Mani and Sreedharan 1973) have shown that surge of ozone takes place in lower stratospheric and upper tropospheric levels.

Long period (1960-90) average value for the month of March for New Delhi is 292 DU. So there is 28%

TABLE 1  
Delhi winds at 300 hPa constant pressure chart,  
23-27 March 1990

Date	00 UT		12 UT	
	Wind direction (deg)	Wind speed (kt)	Wind direction (deg)	Wind speed (kt)
23 March 1990	265	92	265	89
24 March 1990	260	74	290	72
25 March 1990	300	47	290	67
26 March 1990	285	74	280	72
27 March 1990	275	90	280	83

increase in total ozone on 25 March 1990. Although monthly mean maximum in total ozone seasonal variation over New Delhi comes in May/June, large day to day variation and daily maxima occur during January to April.

#### 4. Conclusion

An unusual high total ozone 373 DU over New Delhi on 25 March 1990 was owing to the leakage of stratospheric ozone into troposphere through tropopause break in association with trough in mid upper troposphere lying with its axis along Long.  $82^{\circ}$  E north of Lat.  $20^{\circ}$  N at 300 hPa.

However, the pathway of leakage of ozone could not be identified due to absence of vertical ozone profile during this period either by Umkehr or by balloon

borne ozone sounding. In future, measurements will be attempted during similar synoptic conditions to study this feature in detail.

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