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A case study of abnormal increase of Ozone over Ahmedabad (23°N) during February 1962

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ABSTRACT. Changes in the total ozone amount and in the vertical distribution of ozone over Ahmedabad, associated with passing western disturbances during February 1962 are considered in this study. Remarkably high values of ozone were recorded in this period. A significant secondary ozone maximum was seen in a layer centred at 150 mb on 17 February when a distinct break in the tropopause was located to the north of Ahmedabad.

1. Introduction

The ozone observational programme at Ahmedabad includes umkehr observations made with a Dobson ozone spectrophotometer for determining the vertical distribution of ozone. The frequency of the umkehr observations is usually increased during December-March, when passing western disturbances cause surges of ozone amount. Some observtions made at Ahmedabad during February 1962 are discussed here.

Two well defined spells of high ozone occurred in this period, raising the monthly mean from 241±13 D.U. (1. D.U.=1 milli atmo-cm) to 262± 13 D.U. On several days during this month the daily means were found to be higher than 280 D.U. In the entire record of ozone observations made at Mt. Abu/Ahmedabad during the last 16 years, 1952-1967, these are the highest ozone values observed in the month of February.

From 3-19 February 1962, 17 daily umkehr observations were available. Using these observations the vertical distributions of ozone were worked out. The results are discussed in the light of the prevailing meteorological conditions.

2. Results and their discussion

Daily values of total ozone amount recorded in February 1962 at four stations situated roughly along 75° east meridian are shown in Fig. 1. The four stations are Alma Ata (43°·6N, 76°·9E) in U.S.S.R., New Delhi (28°·6N, 77°·2E), Ahmedabad (23°·1N, 72°·7E) and Kodaikanal (10°·2N, 77°·5E) in India.

With the first ozone-surge recorded at Ahmedabad on 3 and 4 February 1962, the level of ozone rose to 284 D.U. The spell of high-ozone is seen to have continued up to 11 February at Ahmedabad; while at Delhi, the high ozone values (~310 D.U.) were registered during 2-7 February. In the second fortnight, the Ahmedabad data show a sharp rise on the 17th, raising the ozone value from 256 D.U. on 16 February to 280 D.U. on 17 February, followed by a steady decrease from 19 February upto the month end. The ozone-surges found on 15-16 February in the ozone data for Alma Ata and that on the 18th at New Delhi are sharp and substantial. The ozone decrease observed at these stations on the following days are also quite pronounced. The peak ozone values, in general, show a delay of a few days as we go to lower latitudes.

Using the corrections for multiple scattering as given by Ramanathan and Dave (1957), and following the Method B of computing the ozone amounts in the successive 6-km layers from the ground to 54 km, ozone distributions were worked from the umkehr curves obtained on all the 17 days during 3-19 February 1962. The height-time cross-section constructed from these data is shown in Fig. 2. The contours refer to the layer mean ozone partial pressures expressed in micromillibars, and the ordinate markings show pressure in millibars.

The layer-mean ozone amount in the lower stratosphere was found to increase with the total ozone amount, while the ozone contents above 15-mb level did not show any appreciable or systematic change. There was a small decrease in ozone in the lower troposphere on 9 and 10 February and a small rise at 1-mb level on 16 and 17 February. The ozone amount at about 23-mb level (24-30 km) shows significant increase associated with the ozone surges seen in the total amount (Fig. 1). It may also be noted that the ozone-high at this level is followed by ozone increase at lower levels one or two days later.

Individual daily ozone amounts in different layers observed during 3-19 February as well as the mean ozone distribution based on these 17 days' values are given in Table 1. Quite large

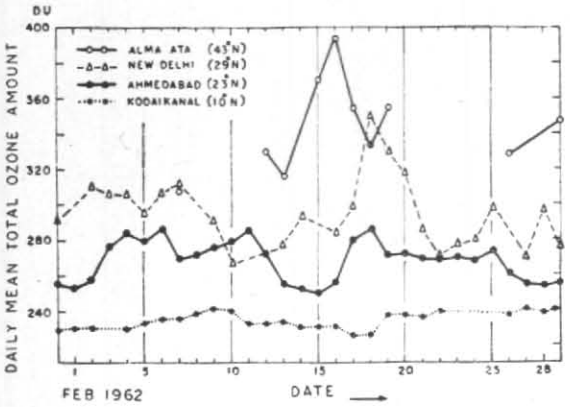

Fig. 1. Total ozone amounts recorded at stations roughly along 75° east meridian during February 1962

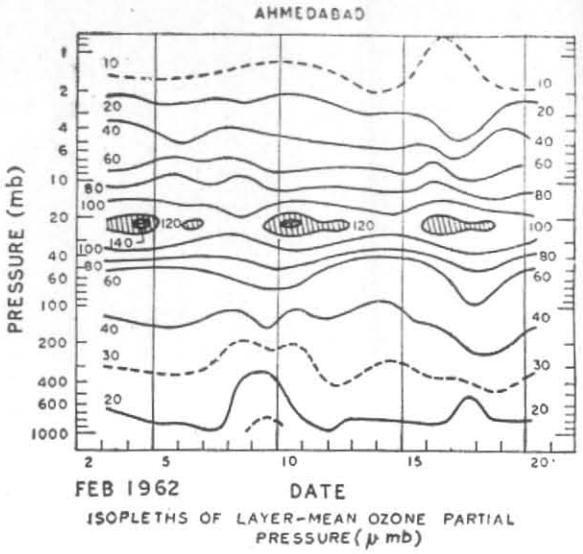

Fig. 2. Time-height cross-section showing changes in ozone distributions in vertical during 3-19 February 1962

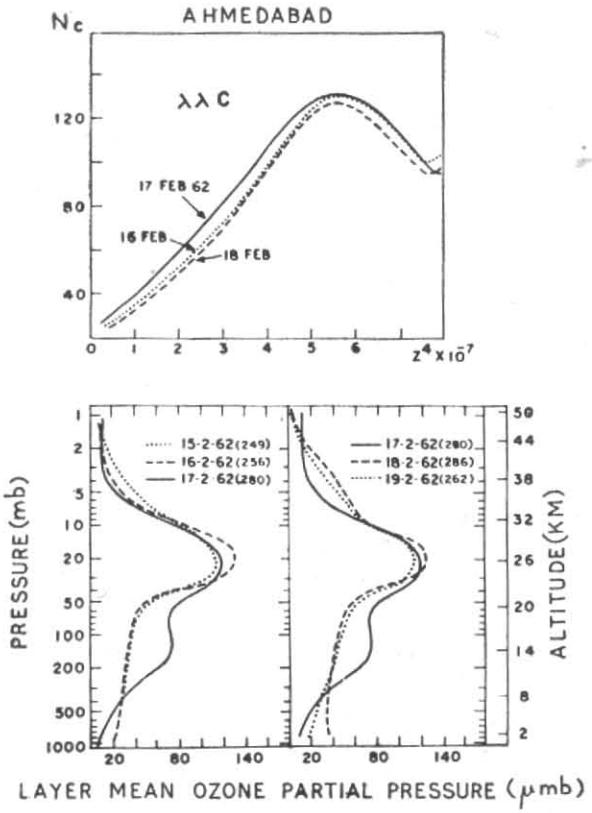

Fig. 3. Umkehr observations (16-18 February 1962) and ozone distribution profiles on individual days, 15-19 February 1962

TABLE 1

Mean and individual vertical distributions of Ozone observed over Ahmedabad during 3-19 February 1962

	Total ozone amount (D.U.)	Layer 1	2	3	4	5	6	7	8	9
		The layer ozone having C.G. at								
		800	360	140	55	21	9	4	1·7	0·9 mb
	Mean for the period	Layer mean ozone partial pressure (μ mb)								
3-19 Feb. 1962	272	21	27	40	56	121	67	35	13	6
		Departures from the mean distribution (μ mb)								
3 Feb 1962	276	—7	2	—3	—2	12	—5	13	0	1
4	284	—7	2	—3	—2	23	—2	10	0	—2
5	279	7	2	2	—2	—8	13	—7	0	—3
6	284	0	2	—3	0	3	4	—2	3	—1
7	269	7	2	—8	5	—11	—2	2	3	—3
8	271	—3	—7	—11	12	—19	10	5	0	—1
9	275	*—12*	—9	2	16	0	—7	5	3	—2
10	279	0	—6	—9	13	19	—6	—2	2	1
11	286	7	2	—3	1	2	4	—3	3	—3
12	272	0	4	—2	—7	3	2	—5	—1	1
13	254	0	2	—3	—15	—8	2	—1	—4	1
14	252	0	—3	—3	—11	—8	—5	—1	—4	1
15	249	0	2	—2	—9	—7	—2	—2	—1	2
16	256	0	2	—6	—13	9	4	*—14*	—1	6
17	280	*—14*	2	*33*	*17*	—3	—5	*—17*	—2	5
18	286	*14*	8	2	—4	3	—5	7	—2	—3
19	269	0	2	7	2	—8	—2	5	—2	—3

day-to-day changes are in evidence here. Though conspicuous day-to-day changes take place mostly in the layers 4 (18-24 km) and 5 (24-30 km) some striking changes are found to occur at other levels also.

The ozone build-up leading to remarkable large total ozone amounts on the 4 February (284 D.U.) and on the 11 February (286 D.U.) seem to be the result of ozone increase in the peak-ozone region and in the lower stratosphere. The event of 16-17 February, however, shows a spectacular re-distribution of ozone even in the troposphere. In Fig. 3 are shown the umkehr data in the upper part, and the ozone distributions on 15-19 February 1962 in the lower part. It will be seen that between 15 and 16 February a major change took place at 20-mb level; the ozone amount increased in the 24 to 30-km layer and decreased in the 36-42 km layer. On 17 February, the distribution shows a secondary ozone maximum at the 150-mb level. The total ozone amount which was 256 D.U. on 16 February became 280 D.U. on 17 February, presumably due to ozone in-flux in the jet stream region associated with a tropopause discontinuity.

The meteorological developments in this period are very interesting. On the 16th morning, a western disturbance lay over Punjab with the secondary trough extending to southeast Rajasthan. On the 17th, the trough had moved to north Madhya Pradesh and on the 18th, there was a deep upper air trough extending over the whole of northwest India from Punjab to north Maharashtra. Fig. 4, after Singh (1964), represents the occurrence of a break in the tropopause near the Ahmedabad latitude on 17 February 1962. An ozone inflow from the stratosphere through the break in the tropopause at about 25°N seems to have been responsible for the ozone increase seen at 150-mb level on the 17 February. It is interesting and somewhat surprising that the wind directions, except at 100 mb at Delhi, came from the southwest. In the next 24 hours the vertical profile underwent a substantial change, the ozone content at 150-mb level came back to its normal strength, the lower-most layer (ground to 6 km) registered a rise in ozone, and the ozone content in 36-42 km layer (with the C.G. at 4-mb level) showed a considerable increase. On 19 February not only the total ozone amount but

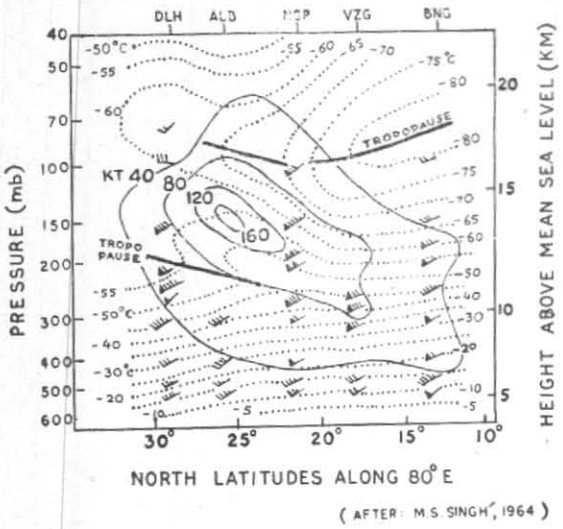

Fig. 4. Vertical cross-section along longitude 80°E on 17 February 1962 (1200 GMT)

also the distribution profile had come back to near-normal conditions.

Following this event, on the morning of 21 February there was an upper air trough in the westerlies extending from west Uttar Pradesh to Telangana, which moved eastwards thereafter. However, no sub-tropical tropopause could be located over Ahmedabad or even to its immediate north on this occasion. The ozone amounts at New Delhi and Ahmedabad on 21 and 22 February did not show any rise as compared to the neighbouring days.

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