CHAPTER - 10

A mathematical derivation of atmospheric O_3 concentration at Jalpaiguri, its variation and effect on environment

10.1 Introduction

In preceding chapter "Nine", impact of column ozone modification on the environment at subhimalayan area around Jalpaiguri has been analysed. In absence of longperiod ozone data it was not possible to confirm whether ozone concentration around Jalpaiguri is declining year wise.

The column ozone data of Jalpaiguri (26.32°N, 88.46°E) are available only for few months in the "NASA" internet website (Since December 1997), which have been obtained and in the present chapter in order to derive the long period ozone data, a regression analysis has been performed between available ozone data of Jalpaiguri (26.32°N, 88.46°E) and ozone data of DumDum (22.38°N, 88.28°E).

The correlation coefficient between the two variables (ozone data of Jalpaiguri and DumDum) is positive and very high (0.82) which is definitely significant at 5% level. The covariation coefficients are 0.063 and 0.065 respectively. From the scatter diagram between Jalpaiguri ozone data and DumDum ozone data a straight line is obtained and a linear empirical equation from the least square principle has been established to calculate the long period ozone data of subhimalayan Jalpaiguri inorder to investigate the variation of ozone concentration since 1979.

Thinning of atmospheric Ozone layer decreases our planet's natural protection from the harmful solar UV radiation. Farman et.al (1985) found that the values of O_3 concentration over Antarctica were falling during successive years from 1957 to 1984. Since then the environmental scientists have become aware of this depletion of Ozone layer threat. Later the global O_3 assessment made by W.M.O. confirmed that O_3 layer is thinning everywhere throughtout the world (W.M.O. report 25, 1991 and W.M.O. bulletin 41, 1992). It may cause serious health problems and other hazards on earths environment, which has been assessed in papers of the author on Antarctic Ozone sink (Maitra et.al 2000), Arctic Ozone destruction (Maitra et.al 2000) and subhimalayan Ozone variation at Jalpaiguri (Maitra et.al 2000).

Much work has been reported on Ozone variation in Antarctica (Farman et.al. 1985, stolarski et.al. 1991, Logan 1994, Midya et.al. 1996, Maitra et.al 2000) and Arctica (Schoeberl et.al 1990, Manney et.al. 1996, Dessler et.al 1998, Maitra et.al 2000). But so far not many work, have been reported on Tropical / Equatorial region (Ilyas 1986, Maitra et.al 1999) and perhaps the first attempt to work on Ozone concentration variation with meteorological parameters and its impact on environment in subhimalayan region around Jalpaiguri has been made by Maitra et.al (2000).

The formation as well as destruction of atmospheric Ozone and the cause of Ozone depletion and its impact on environment has already been analysed in the earlier chapters.

As the long period O_3 data for Jalpaiguri is not available, so in this chapter an attempt has been made to derive mathematically the O_3 concentration data for a long period at Jalpaiguri, so that the O_3 variation can be studied since 1979. For this a mathematical regression analysis has been performed between O_3 data of DumDum (22.38° N, 38.28° E) and O_3 data of Jalpaiguri (26.32° N, 88.46° E). The O_3 data of DumDum has been obtained from the internet website : http://Jwocky.gsfc.nasa. gov which is available since Nov.'78.

The O_3 data of Jalpaiguri, only for few months are available in the same website (since December 1997) which has been obtained for each day, one by one, by inserting day, month, year, latitude and longitude in the particular windows.

10.2. Analysis, Discussion and Conclusions

10.2.1 Analysis :

A pair of 146 sample of Ozone data has been obtained for DumDum and Jalpaiguri. Their correlation coefficient, mean, median, mode, standard deviation, covariance coefficient etc. are computed, which are shown in table - 10.3.1. It is seen that the pair of O_3 data are well correlated and their covariance coefficients are very close. A scatter diagram (Figure 10.3.1) between the daily O_3 data of Jalpaiguri, and the daily O_3 data of DumDum shows an upward trend in the values of Jalpaiguri O_3 concentration with increase of DumDum O_3 concentration. A linear empirical equation from the least square principle is established. The regression analysis gives following equation :

Jalpaiguri O_3 in D.U. = 52.276 + 0.8073 x DumDum O_3 in D. U. .... (10.2.1.1)

By using the equation - 10.2.1.1, the monthly mean O_3 data for Jalpaiguri has been computed (Table - 10.3.2) to study the variation of Ozone concentration for the period 1979 to 1999 and the seasonal mean values are calculated. (Table 10.3.3). The seasonal variation of O_3 concentration at Jalpaiguri with respect to years are shown in Figure 10.3.2.

10.2.2 Variation of O_3 concentration at Jalpaiguri during 1979 to 1999

The derived data of Ozone concentration of Jalpaiguri by the equation (10.2.1.1) are compared with the available satellite data and the variation found 1% to 2% only (Table 10.3.4). The covariation of observed O_3 data and derived O_3 data at Jalpaiguri are shown in Fig. - 10.3.3. It is seen from table 10.3.2 & table 10.3.3, that the O_3 concentration at Jalpaiguri is maximum in summer and minimum in winter.

Further it is seen from the table - 10.3.3 that in 1979 winter, the seasonal mean O_3 concentration at Jalpaiguri was 263.98 D.U. which decreases to 243.49 D.U. in 1985, the percentage decrease is 7.76%. In 1997 the winter Ozone found as 246.23 D.U. and in 1999 winter, it is found as 249.85 D.U. The percentage decrease with respect to 1979 are 6.72 and 5.35% respectively. On the otherhand in 1979 summer, the seasonal mean O_3 concentration at Jalpaiguri was 283.46 D.U. which found in 1985 as 263.18 D.U., the percentage decrease is 7.15%. In 1982 summer the mean O_3 found as much as 287.55 D.U., so the percentage decrease in 1985 with respect to 1982 found to be 8.5%. Again the mean O_3 concentration in summer 1999 found to be 270.93 D.U., which is a decrease of 5.78% with respect to 1982 summer. It is also recorded a loss of 4 to 4.9% in rainy and autumn season.

The seasonal variation of O_3 concentration at Jalpaiguri with respect to years are shown in Fig. - 10.3.2. It is observed from the figure that the winter ozone concentration at Jalpaiguri is in a declining trend during the period 1979 to 1999. It is also observed that the ozone concentration is minimum in the winter season, on the other hand the ozone concentration is maximum in the summer season, but it is also in a declining trend during the period 1979 to 1999 at Jalpaiguri.

In recent paper of the author on Tropical O_3 deficit at DumDum (Maitra et.al 1999), it has been found an identical result which shows a declining trend in DumDum. Compared to this, Ozone observations in the polar regions reveal the following: In Arctica a 30-50% decrease in lower stratospheric Ozone which means 10-15% decrease in column Ozone (Froidevaux et.al 1994), in Antarctica a 100% decrease over a large region of the lower stratosphere and about 60-70% decrease in column ozone (Hofmann et.al 1994).

Though in comparison with polar region the loss of Ozone concentration at Jalpaiguri is much less, but it is true that O_3 concentration at Jalpaiguri is also declining which may increase the risk of cataract in the eye, malignant melanoma and non melanoma skin cancer and other climactic and environmental hazards if this trend continues.

It is reported by UNEP (1991) that 10% decrease in atmospheric Ozone hasbeen estimated to increase the risk of cataract by 5% per anum, the risk of malignant melanoma may increase 10% and the risk of non malignant melanoma may increase 26%.

10.2.3 Discussion

In the previous paper by the author on subhimalayan total column Ozone variation at Jalpaiguri (Maitra et.al 2000), the following was observed : Ozone depletion may affect seriously the future environment of Jalpaiguri. There are possibilities to have more warm climate. The winter may be shorter, maximum, minimum temperature may rise. Monsoon may have more rainfall and the rainfall distribution pattern may change. But in absence of long period Ozone data of Jalpaiguri it was not possible to confirm whether Ozone concentration at Jalpaiguri shall declining for long period. The results of the present chapter confirm that Ozone is declining (Table 10.3.2 & 10.3.3, Fig. 10.3.2) at Jalpaiguri, it also provide the support in favour of the results found in the previous paper on Jalpaiguri (Maitra et.al 2000).

From the "NASA" internet website :http://jwocky.gsfc.nasa.gov (TOMS, overpass files, For any location) it is possible to retrieve the ozone data for any location, at the 1 degree latitude by 1.25 degree longitude resolution of the gridded ozone data. But it is available for few months only, since December' 1997, and these are not adequate to study the year to year variation. It is proposed that to derive long period ozone data analytically of any place, a long period and observed ozone data set of nearer place may be useful. Accordingly in this chapter the long period ozone data of Dum Dum which was found well correlated with observed short period data (available since December' 1997) of Jalpaiguri has been used to obtain long period data of Jalpaiguri empirically.

By applying this present method of analysis and modifying the equation - 10.2.1.1, it is also possible to compute long period Ozone data of any place of subhimalayan North Bengal, South Bengal, Sikkim, Bihar, UP, Nepal, Bhutan and places of Bangladesh for which observed data are not available for long period, but the latitudes and longitudes are known.

Further regression of winter Ozone concentration of Jalpaiguri with respect to years give another graph (Fig. - 10.3.4) and a linear equation.

Ozone in winter at Jalpaiguri in "x" = 965.14 - 0.3563. "x" 10.2.3.1

Where "x" indicates year.

By using this equation (10.2.3.1), the future Ozone concentration at Jalpaiguri in the season winter can be predicted (Table - 10.3.5) and it is found that in the year 2200, the winter Ozone concentration at Jalpaiguri may drop to 181.28 D.U. (Percentage loss 31.33% with respect to winter O_3 in 1979) if this trend continues. Fig. - 10.3.5 shows the analytically computed winter ozone trend at Jalpaiguri during 1979 - 2200. Where solid lines indicate the winter ozone concentration variation computed by using the equation 10.2.1.1 with respect to DumDum ozone concentration during the period 1979 - 1999 and dotted line indicate the future winter ozone trend predicted by using the equation 10.2.3.1 at Jalpaiguri during the period 1999 - 2200.

As Jalpaiguri is located near the tropic so the solar U.V. radiation penetration is already high throughout the year because of Ozone layer over tropic & equator is thin in comparison with that at poles, so any further depletion of Ozone concentration may increase the dosage of U.V. radiation, which may cause severe harm to the public health as mentioned earlier as well as whole ecosystem.

10.2.4 Conclusions

It is already established that atmospheric Ozone is mainly produced in the stratosphere by the action of solar U.V. radiation (wave length <242 nm) on the monatomic (O) and diatomic (O_2) Oxygen mainly in the equatorial region. The resultant concentration of Ozone depends, at any time on the rate of production and the rate of loss or destruction. The stratospheric Ozone thus produced in the equatorial region, is carried by stratospheric wind towards north and south poles. During winter in the northern hemisphere, the solar radiation falls almost at right angles on the regions between the equator and the tropic of capricorn and obliquely on the regions between the equator and the tropic of cancer, where the region around such as Jalpaiguri is situated. Hence during winter, the net production of Ozone by the solar U.V. rays is expected to be smaller than that during summer. Moreover, the transport of Ozone towards the poles by stratospheric wind contributes to the loss of Ozone at the regions near tropics. This results in minimum Ozone concentration at Jalpaiguri during winter. Besides this loss Ozone by transport, other chemical process involving oxides of nitrogen (used as fertilisers for agricultural work), chloroflurocarbon (used as refrigerants, solvents. etc.) Methyl bromide compounds (used as soil disinfectant) etc. have been found as the cause of destruction of Ozone in the atomosphere, which has been assessed in earlier papers of the author on Arctica (Maitra et.al 2000) and on Antarctica (Maitra et.al 2000).

In this chapter it has been shown that there is a loss of 5.35 to 7.76% in winter ozone, 5.78 to 8.5% is summer ozone, 4 to 4.9% in rainy & autumn season ozone during the period 1979 to 1999 when compared with the corresponding value of 1979. It was also observed that the atmospheric ozone is minimum in winter and maximum in summer at Jalpaiguri. An attempt has been made to predict the future ozone concentration and predicted an expected large loss of 31.33% in the winter of 2200, when compared with the corresponding value of winter of 1979, assuming the present trend of reduction..

Thus it may be concluded that atmospheric Ozone is declining in and around Jalpaiguri, which may cause serious impact on public health as wel as on environment of Jalpaiguri, in near future.

Table - 10.3.1

Statistical relation between the daily value of O_3 concentration at DumDum (22.38° N, 88.28° E) and the daily value of O_3 concentration at Jalpaiguri (26.32° N, 88.46° E)

	O_3 concentration of DumDum	O_3 concentration of Jalpaiguri
1. Mean	254.25	257.53
2. Median	252	258
3. Mode	244	258
4. Standard Deviation	16.47	16.22
5. Minimum	219	226
6. Maximum	289	290
7. Sum	37121	37600
8. Number of Data	146	146
9. Covariance Coefficient	0.0647	0.0630

Correlation coefficient between the daily value of O_3 concentration at DumDum and the daily value of O_3 concentration at Jalpaiguri = 0.82

Table - 10.3.2.

Derived monthly mean O_3 concentration in D.U. at Jalpaiguri (26.32° N, 88.46° E) during 1979 to 1999 by using the equation 10.2.1.1

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1979	261.6	271.3	276.99	285.19	288.22	287.95	283.31	282.86	279.72	272.78	258.72	258.86
1980	250.67	259.39	261.22	269.76	282.16	284.51	283.15	278.82	277.62	270.66	264.78	260.75
1981	261.43	269.01	280.94	288.03	292.08	285.54	283.39	279.49	273.49	269.82	263.81	261.47
1982	260.77	267.33	281.78	289.18	291.72	292.62	285.56	283.77	276.09	268.50	261.76	243.90
1983	252.35	261.04	265.14	272.28	285.50	280.53	277.17	278.65	269.50	265.30	256.97	260.70
1984	265.10	259.78	275.22	278.41	287.82	285.17	279.60	279.75	273.75	261.02	248.9	238.26
1985	245.71	246.50	250.87	259.57	279.10	273.96	278.60	276.35	271.57	266.05	256.4	259.10
1986	253.17	271.1	272.58	283.45	283.53	281.86	278.80	271.92	270.28	266.76	254.09	258.91
1987	256.94	264.65	272.09	284.70	285.26	283.81	282.94	276.48	271.11	264.32	244.88	241.07
1988	251.94	258.40	258.96	271.43	276.68	281.91	277.76	270.78	269.18	262.94	261.57	257.11
1989	258.32	261.60	280.69	284.28	288.95	290.22	286.25	285.63	278.44	272.11	261.54	259.30
1990	251.92	262.56	267.96	274.35	281.68	281.65	283.83	280.77	276.79	269.53	261.09	253.93
1991	257.11	258.42	276.43	279.29	289.62	285.65	286.34	281.26	275.24	269.14	261.31	251.82
1992	252.98	275.16	267.78	274.52	289.87	287.56	280.61	279.66	270.28	261.47	253.9	253.63
1993	252.41	253.98	258.55	276.52	281.10	281.94	269.16	269.86	267.64	259.34	253.63	247.14
1994	259.88	259.25	272.16	273.80	285.66	280.61	280.37	275.96	267.83	263.29	249.47	*
1995	*	*	*	*	*	*	*	*	*	*	*	*
1996	*	*	*	*	*	*	277.61	273.71	269.68	265.27	257.92	242.10
1997	248.10	248.50	263.39	279.68	280.98	281.90	277.40	275.25	272.44	275.63	259.65	254.77
1998	266.96	267.55	273.00	284.79	284.61	281.54 (286.55)	280.31 (284.90)	277.42 (280.08)	278.18 (275.43)	268.69 (269.65)	252.41 (248.07)	249.0 (253.36)
1999	243.25 (245.44)	249.99 (250.76)	254.0 (250.75)	270.37 (273.59)	282.74 (288.46)	279.92	282.58	281.16	277.20	271.26	266.10	264.08

[* Signifies that data are not computed due to lack of DumDum data.
With in ( ) shows the monthly mean values of daily observed data for the period June' 1998 to May' 1999]

Table - 10.3.3

Derived seasonal mean O_3 concentration in D.U. at Jalpaiguri (26.32° N, 88.46° E) during 1979 to 1999

YEAR	WINTER	SUMMER	RAINY	AUTUMN
1979	263.98	283.46	283.46	265.75
1980	256.3	271.04	281.03	267.72
1981	263.73	287.02	280.47	266.82
1982	263.19	287.55	284.51	265.13
1983	253.43	274.31	276.46	261.14
1984	261.86	280.48	279.57	254.96
1985	243.49	263.18	275.12	261.23
1986	261.12	279.85	275.72	260.42
1987	260.17	280.68	278.59	254.6
1988	250.47	269.02	274.91	262.26
1989	259.01	284.65	283.44	266.83
1990	257.93	274.66	280.76	265.31
1991	256.49	281.78	284.42	265.23
1992	259.99	277.39	276.85	257.69
1993	253.34	272.21	272.15	256.49
1994	255.42	277.2	276.19	256.38
1996	*	*	273.67	261.6
1997	246.23	274.68	276.75	267.67
1998	263.09	280.8	281.74	258.86
1999	249.85	270.93	280.22	268.68

(* Signifies that the seasonal mean are not calculated due to lack of monthly data.)

Table - 10.3.4

Comparison between observed "EPTOMS" satellite ozone data and Mathematicaly derived ozone data.

MONTH	YEAR	OBSERVED O_3 DATA	DERIVED O_3 DATA	VARIATION
JUNE	1998	286.55	281.54	1.75%
JULY	1998	284.90	280.31	1.61%
AUG	1998	280.08	277.42	0.94%
SEP	1998	275.43	278.18	0.99%
OCT	1998	269.65	268.69	0.36%
NOV	1998	248.07	252.41	1.72%
DEC	1998	253.36	249.0	1.72%
JAN	1999	245.44	243.25	0.89%
FEB	1999	250.76	249.99	0.31%
MAR	1999	250.75	254.0	1.29%
APR	1999	273.59	270.37	1.17%
MAY	1999	288.46	282.74	1.98%
JUNE	1999	284.0	279.92	1.43%
JULY	1999	286.17	282.58	1.25%

Table - 10.3.5

Future prediction of winter mean value of O_3 concentration at Jalpaiguri assuming continuance of the present trend

Year	O_3 Concentration at Jalpaiguri in D.U.
2025	243.63
2050	234.73
2075	225.81
2100	216.91
2125	208.00
2150	199.10
2175	190.18
2200	181.28

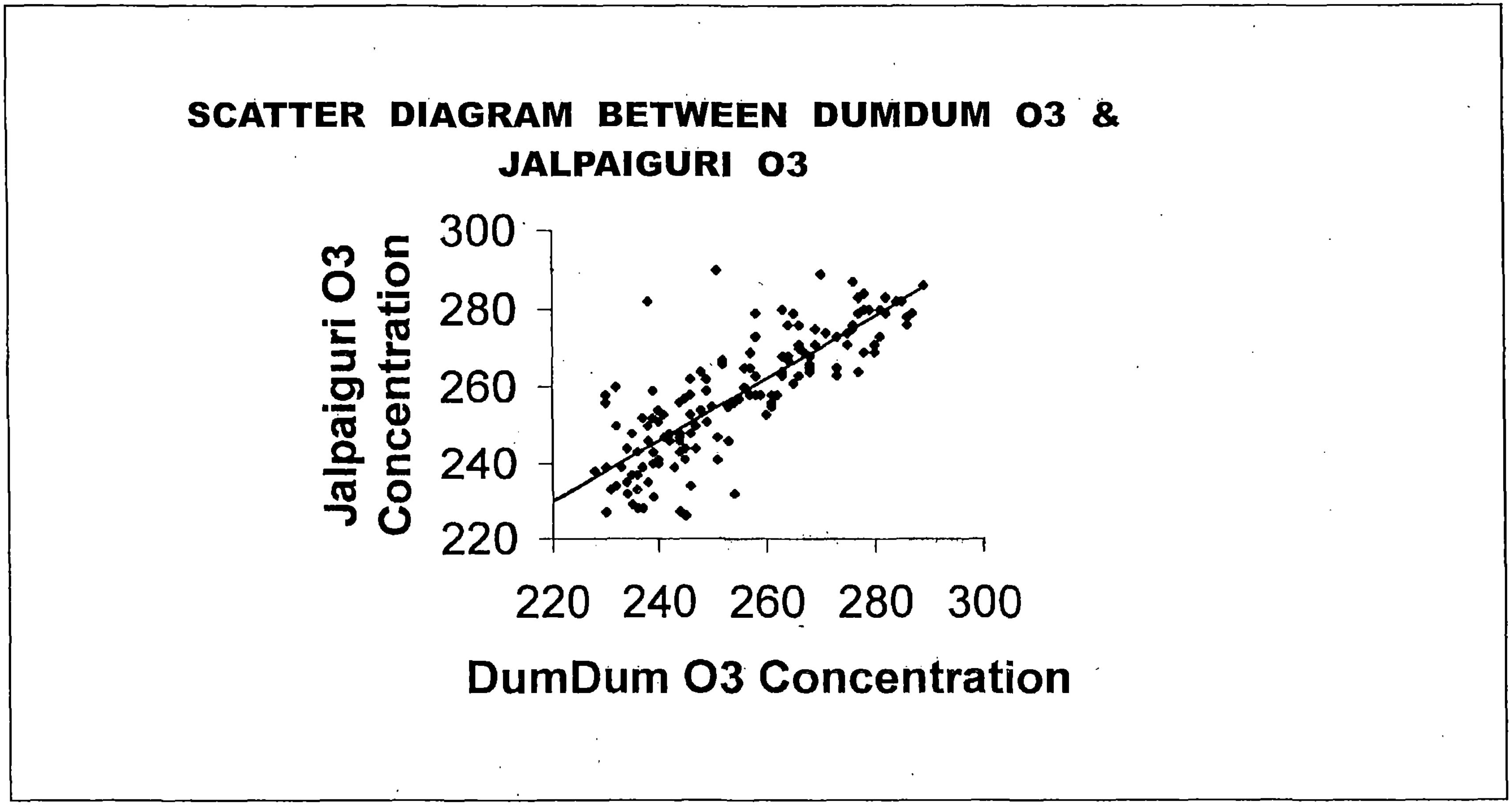
SCATTER DIAGRAM BETWEEN DUMDUM O3 & JALPAIGURI O3
Jalpaiguri O3 Concentration
300
280
260
240
220
220 240 260 280 300
DumDum O3 Concentration

Fig - 10.3.1

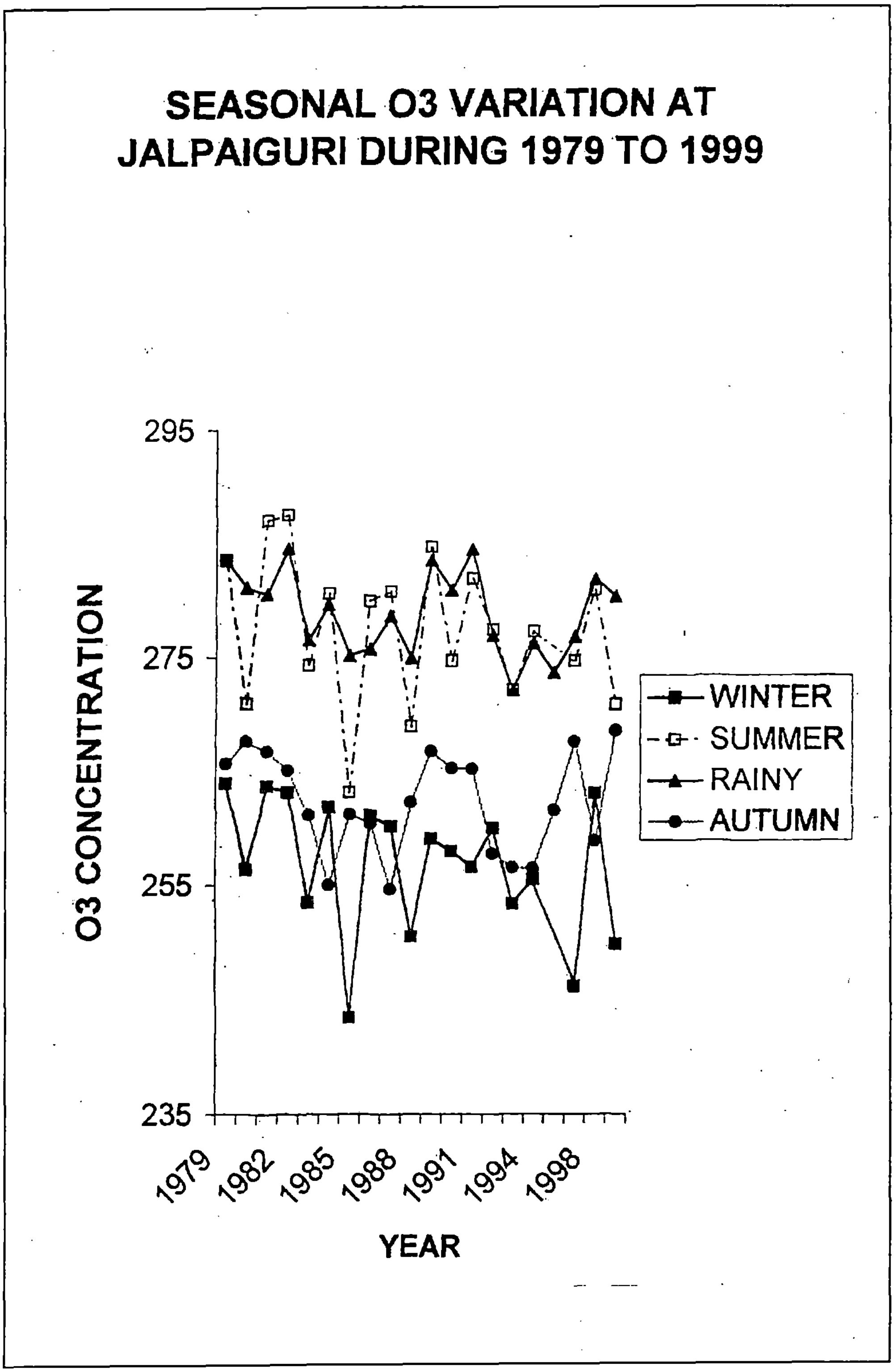
SEASONAL O3 VARIATION AT JALPAIGURI DURING 1979 TO 1999
295
275
255
235
O3 CONCENTRATION
1979
1982
1985
1988
1991
1994
1998
YEAR
WINTER
SUMMER
RAINY
AUTUMN

Fig - 10.3.2

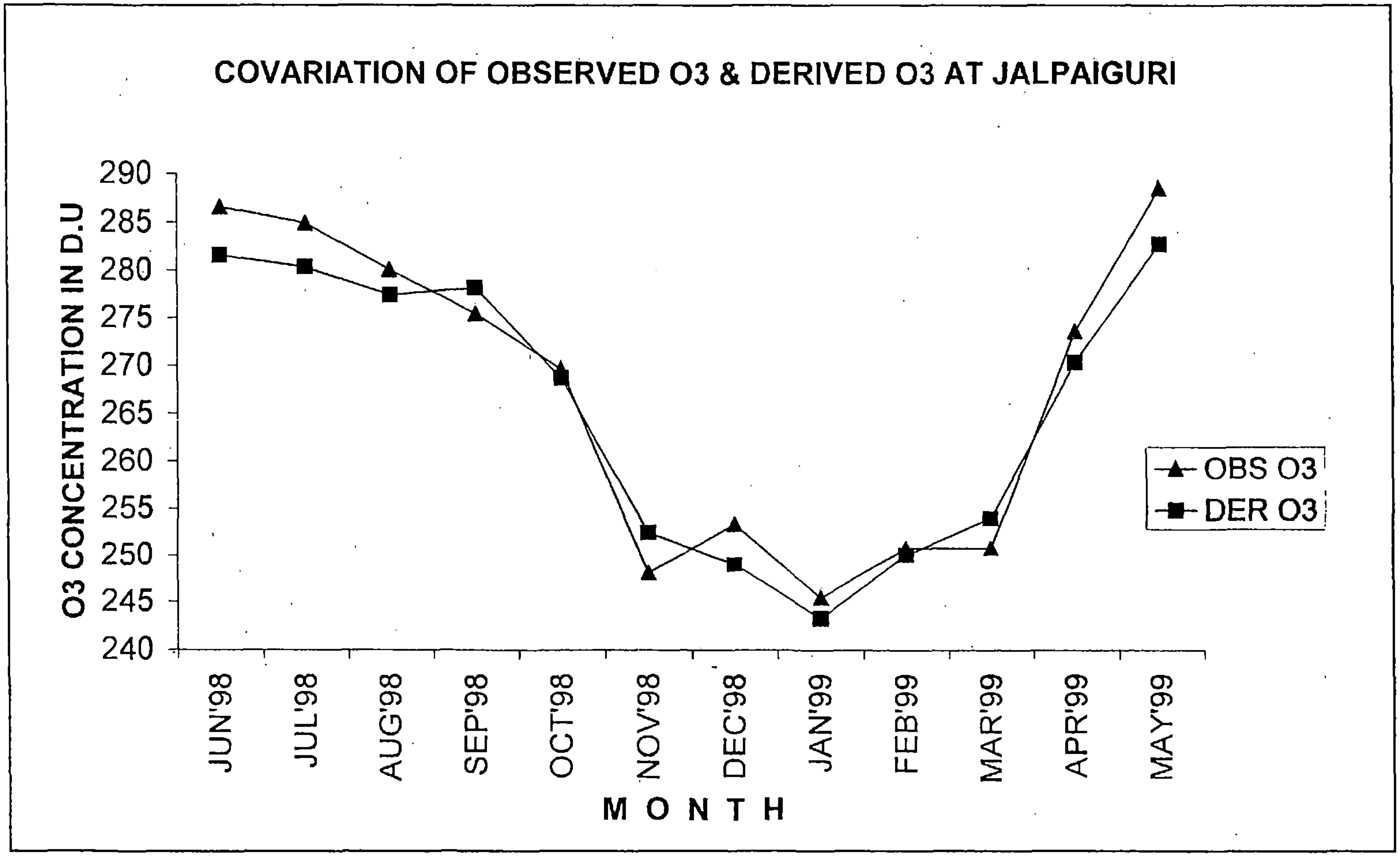
COVARIATION OF OBSERVED O3 & DERIVED O3 AT JALPAIGURI
O3 CONCENTRATION IN D.U
290
285
280
275
270
265
260
255
250
245
240
JUN'98
JUL'98
AUG'98
SEP'98
OCT'98
NOV'98
DEC'98
JAN'99
FEB'99
MAR'99
APR'99
MAY'99
M O N T H
OBS O3
DER O3

Fig - 10.3.3

WINTER O3 VARIATION AT JALPAIGURI WITH YEAR DURING 1979-1999 AND TREND LINE FOR FUTURE PREDICTION

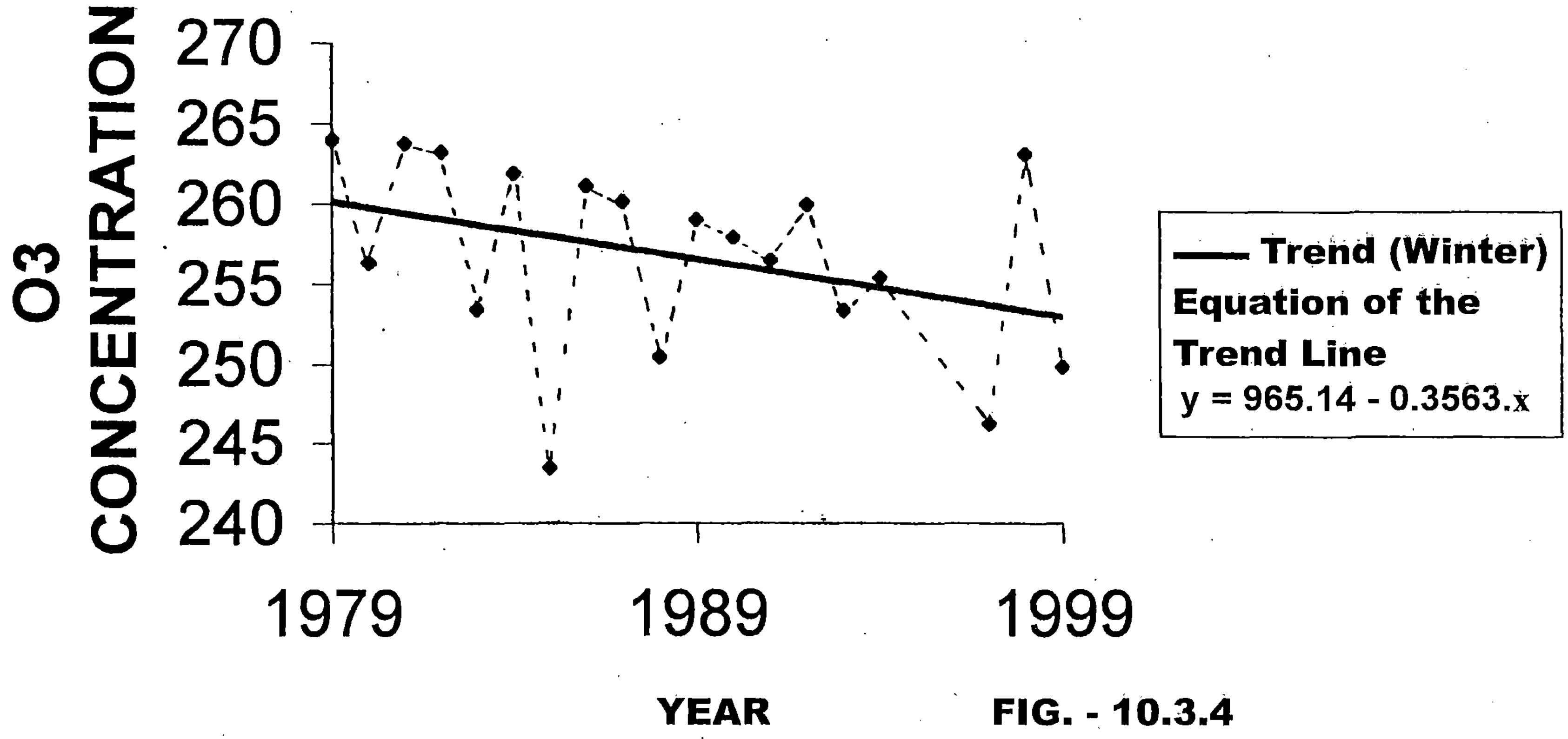

FIG. - 10.3.4

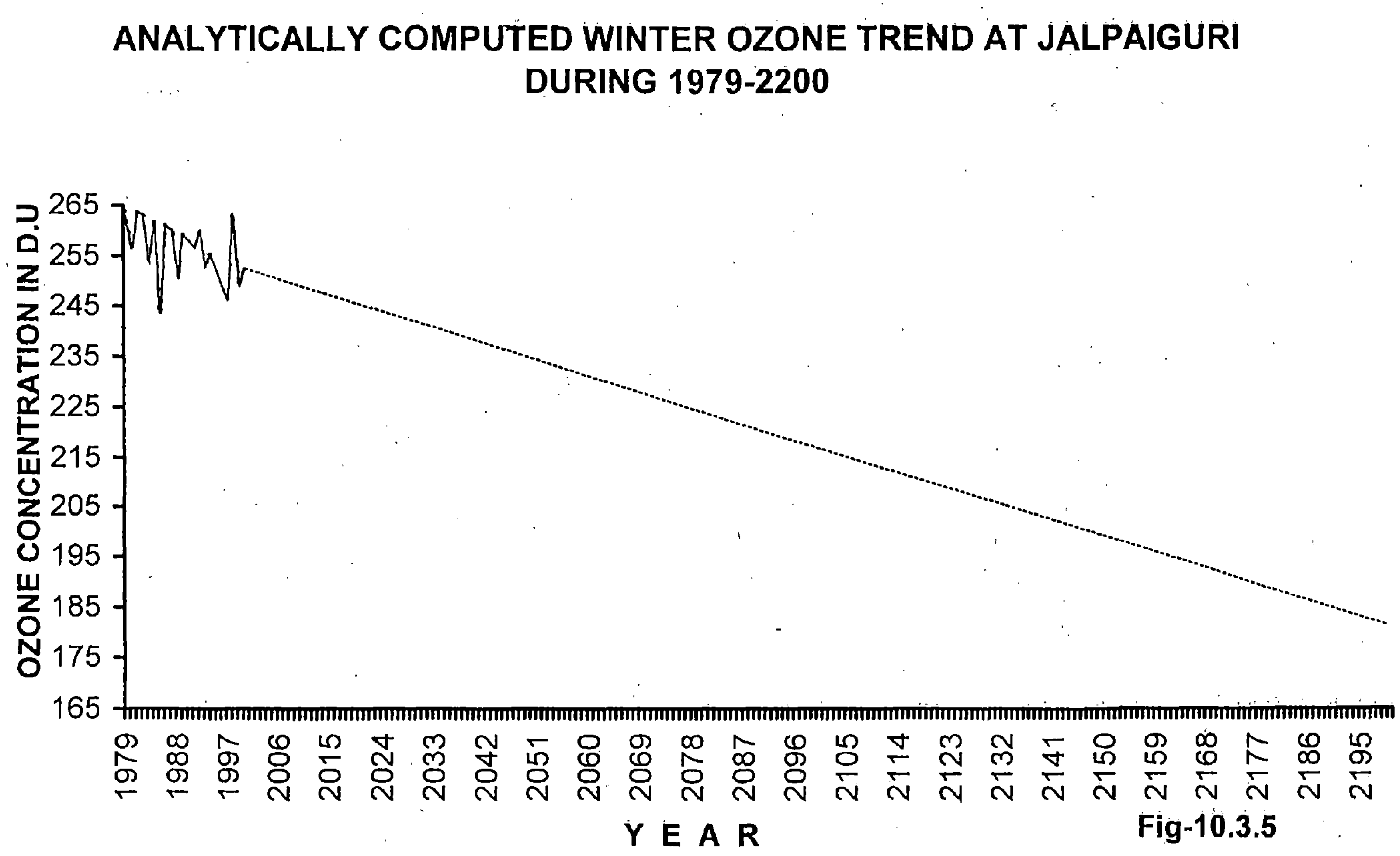
ANALYTICALLY COMPUTED WINTER OZONE TREND AT JALPAIGURI
DURING 1979-2200
OZONE CONCENTRATION IN D.U
265
255
245
235
225
215
205
195
185
175
165
1979
1988
1997
2006
2015
2024
2033
2042
2051
2060
2069
2078
2087
2096
2105
2114
2123
2132
2141
2150
2159
2168
2177
2186
2195
Y E A R

Fig-10.3.5

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