CHAPTER - 3

Cause of South Polar O_3 Depletion and Hazards on Ecology

3.1 Introduction

From the existing theory it is known that solar ultraviolet radiation is responsible for atmospheric ozone formation as well as ozone destruction, some evidence suggests that it is also destroyed by manmade pollutants. In this chapter, to investigate the cause of south polar (Antarctic) ozone depletion, an attempt has been made to study whether the creator is the killer, i,e whether the solar U.V. radiation is itself responsible for this atmospheric O_3 depletion. To do so a linear regression analysis has been performed between the daily value of the solar flux and daily relative sunspot number. The linear regression analysis on least square principle shows two components of solar U.V. flux for a month, one is variable component and other is basic component, which are associated with solar activity and steady background solar radiations respectively.

For analysis the ozone concentration of Halleybay (73.5° S, 26.7°W) and Syowa (69° S, 39.58° E) at different locations in Antarctica are considered.

The thinning of ozone layer in the south pole was reported by Farman. et.al. (1985) and watson. (1989) But it spreads over "Chile", "Argentina", "New Zealand" and Australia within very short period (Solomon. 1990), though the decrease in ozone concentration was very ilttle in 1970s (McElory et.al.). The atmospheric ozone depletion intensify the solar U.V. penetration to the earth's environment which may create many problems.

About 120 years ago in 1880 a Danish Physician "Nicls Finsen" started experiment about the effect of sunlight on skin. He discovered that the "chemical rays" (solar U.V. radiation) can damage the skin, may cause sunburn and inflammation although it can treat some infectious disease such as small pox (Finsen. 1901 a) and Tuberculosis of the skin (Finsen. 1901 b). However increased dosage of solar ultraviolet radiation (mainly U.V. - B) can cause skin cancer (Urbach. 1969 Swanbeck. et.al. 1971, Larko. et.al. 1982). The over exposure to UV-B causes sunburn and long term exposure can lead to loss of elasticity as well as photoaging of skin (Young. 1990, Leyden. 1990, Kligman and Kligman. 1986, Bissett. et.al. 1989, Fourtainer and Berrebi. 1989).

However many investigators worked on the relation between solar activity and Global ozone change. Observational evidence shows an upward trend in solar U.V. radiation with the increase in sunspot number (Heath and Thekae Kara 1977). In this chapter sunspot number and solar U.V. data are obtained from NOAA internet website ftp://ftp.ngdc.noaa.gov/STP/SOLAR_DATA, also available in Solar Geophysical Data Book, tabulated in chapter 1 Page 32 to 40, 64 to 69.

The ozone data for Halleybay in Antarctica are obtained from the internet website http://jwocky.gsfc.nasa.gov. and the ozone data for Syowa in Antarctica are obtained from the internet website http.://www.tor.ec.gc.ca which are tabulated in page 26 respectively.

3.2. Analysis, Discussion and Conclusions

3.2.1. Analysis

The observation made by Heath and Thekaekara (1977) found that the U.V. radiation increases with the increase of relative sunspot number. Hence a linear regression relation between the daily value of the solar U.V. flux and daily relative sunspot number on least square principle shows two components of solar U.V. flux for a month-one is variable component (UV_v) directly proportional to the relative sunspot number and the other called basic component (UV_b) independent of the relative sunspot number. Let the equation of the straight line between sunspot number and solar U.V. flux be

$$Y = mx + c \quad \ldots\ldots\ldots\ldots \text{(i)}$$

Then from the least square principle

$$\Sigma y = m\Sigma x + nc \quad \ldots\ldots\ldots\ldots \text{(ii)}$$

$$\text{and } \Sigma xy = m\Sigma x^2 + c\Sigma x \quad \ldots\ldots\ldots\ldots \text{(iii)}$$

$$\text{Let } \Delta = \begin{vmatrix} \Sigma x & n \\ \Sigma x^2 & \Sigma x \end{vmatrix} = \text{Determinant of the system.}$$

$$\therefore c = \frac{\begin{vmatrix} \Sigma x & \Sigma y \\ \Sigma x^2 & \Sigma xy \end{vmatrix}}{\Delta}$$

$$\therefore \text{Basic component } (UV_b) = \frac{(\Sigma x)\ (\Sigma xy) - (\Sigma y)\ (\Sigma x^2)}{(\Sigma x)^2 - n\Sigma x^2} \quad \ldots\ldots\ldots\ldots 3.2.1.1.$$

and

$$\text{Variable component } (UV_v) = \frac{\Sigma y}{n} - UV_b \quad \ldots\ldots\ldots\ldots 3.2.1.2.$$

Each of two components of the solar U.V. flux is computed for every month for the year 1979 to 1984 using the equations - 3.2.1.1. and 3.2.1.2.

3.2.2 Correlation between each of two components of solar U.V. flux & O_3 concentration of Antarctica Survey Stations Halley Bay & Syowa

The monthly mean values (variable or basic component) of solar U.V. flux are computed by using the equations 3.2.1.1. and 3.2.1.2. The available monthly mean values of O_3 concentration during the period 1978 to 1984 for Halley Bay and Syowa in Antarctica are considered to find the correlation coefficient between each of the two components of solar U.V. flux and ozone concentration for different seasons during above mentioned period. The calculated correlation coefficients are given in Table 3.3.1 and Table 3.3.2

It is found from the correlation table that the correlation coefficients between each of two components of solar U.V. flux and O_3 concentration are mainly controlled by their spring values.

Correlation coefficients are calculated of monthly mean values of O_3 concentration at Halleybay or Syowa with yearly mean values of O_3 concentration for the seasons of winter (May, June, July, August), spring (September, October), summer (November, December, January) and autumn (February, March, April). It is found from the correlation Table - 3.3.1. & Table - 3.3.2. that the correlation coefficients become maximum (0.65) & (0.77) respectively for the spring and both are significant at 5% level.

The correlation coefficients are calculated between monthly mean values of O_3 concentration of Halleybay and monthly mean values of variable component of solar U.V. flux and is positive and maximum (0.56) for spring. The correlation coefficient between monthly mean values of O_3 concentration and monthly mean values of basic component of the solar U.V. flux is maximum (0.62) during spring. Also the correlation coefficients between monthly mean O_3 concentration and yearly mean variable component or basic component of solar U.V. flux (0.68) and (0.72) respectively and are positive and maximum during spring and all of these correlation coefficients are significant at 5% level.

Variations of Antarctic O_3 concentration at Halley Bay and variable and basic components of U.V. flux with year for the months of August, September & October during period 1979 to 1984 are shown in fig. 3.3.1.

Variations of O_3 concentration at Syowa and variable and basic components of U.V. flux with year for the season spring during the period 1979 to 1984 are shown in fig. 3.3.2.

Also the correlation coefficients are calculated between monthly mean values of O_3 concentration of Syowa and monthly mean values of variable component of solar U.V. flux found to be positive and significant (0.35) for spring. The correlation coefficient between monthly mean O_3 concentration and monthly mean values of basic component of the solar U.V. flux is positive and maximum (0.62) during spring. Also the correlation coefficients between monthly mean O_3 concentration and yearly mean variable component or basic component of solar U.V. flux (0.62 and 0.58) are positive and maximum during spring. All the calculated coefficients during spring are significant at 5% level, but the correlation coefficient between monthly mean value O_3 concentration at Syowa and the monthly mean vlues of variable component of solar U.V. flux during spring is found to be not significant at 5% level.

Thus it may be inferred that O_3 concentration and components of solar U.V. flux are mainly controlled by their spring values. This observation agrees with Midya et.al (1996), who found the O_3 concentration and U.V. radiation (not divided into basic and variable components) to be mainly controlled by their October (spring) values, in Antarctica.

3.2.3. <u>Conclusions</u>

It is seen from the correlation Table 3.3.1 & Table 3.3.2 the values of correlation coefficients between monthly mean ozone concentration and basic and variable components of solar U.V. radiation are positive and maximum for Antarctic spring and most of the correlation coefficients are significant at 5% level. Thus, with increase of variable and basic components of solar U.V. flux, the ozone concentration should increase and vice versa. However, Faman et.al. (1985) found that the spring values of O_3 concentration over Antarctica were falling during successive years from 1957 to 1984. If solar U.V. radiation would have been responsible for this declining trend of spring values of ozone concentration, then the correlation coefficients between O_3 concentration and solar U.V. flux should have been highly negative in spring. But result shows that most of the correlation coefficients between ozone concentration and components of solar flux are highly positive and significant at 5% level during Antarctic spring.

Thus it may be concluded that the variable or basic components of solar U.V. radiation which are associated respectively with solar activity and steady background solar radiation may not be responsible for the Antarctic ozone depletion, although this O_3 depletion can affect earth's environment and ecology in several ways.

Table - 3.3.1

Correlation coefficient between various parameters for different seasons.

Halley Bay (73.5°S, 26.7°W)

	Correlation Coefficient Between	Winter (May, June, July, August)	Spring (Sept., Oct.)	Summer (Nov., Dec., Jan.)	Autumn (Feb., Mar., Apr.)
1.	Monthly mean O_3 and monthly mean UV_v (1979 - 1984)	*	0.56	0.18	0.25
2.	Monthly mean O_3 and yearly mean UV_b (1979 - 1984)	*	0.62	0.09	0.10
3.	Monthly mean O_3 and yearly mean UV_v (1979 - 1984)	*	0.68	0.36	0.12
4.	Monthly mean O_3 and yearly mean UV_b (1979 - 1984)	*	0.72	0.33	0.04
5.	Monthly mean O_3 and yearly mean O_3 (1979 - 1984)	*	0.65	0.49	0.40

** Signifies that correlation coefficients are not calculated due to insufficient data*

Table - 3.3.2
Correlation coefficient between various parameters for different seasons.
Syowa (69°S, 39.58°E)

	Correlation Coefficient Between	Winter (May, June, July, August)	Spring (Sept., Oct.)	Summer (Nov., Dec., Jan.)	Autumn (Feb., Mar., Apr.)
1.	Monthly mean O_3 and monthly mean UV_v (1979 - 1984)	0.39	0.35	0.14	0.40
2.	Monthly mean O_3 and monthly mean UV_b (1979 - 1984)	-0.10	0.62	0.13	0.23
3.	Monthly mean O_3 and yearly mean UV_v (1979 - 1984)	0.24	0.62	0.14	0.41
4.	Monthly mean O_3 and yearly mean UV_b (1979 - 1984)	0.24	-0.58	0.12	0.48
5.	Monthly mean O_3 and yearly mean O_3 (1979 - 1984)	0.26	0.77	0.31	0.21

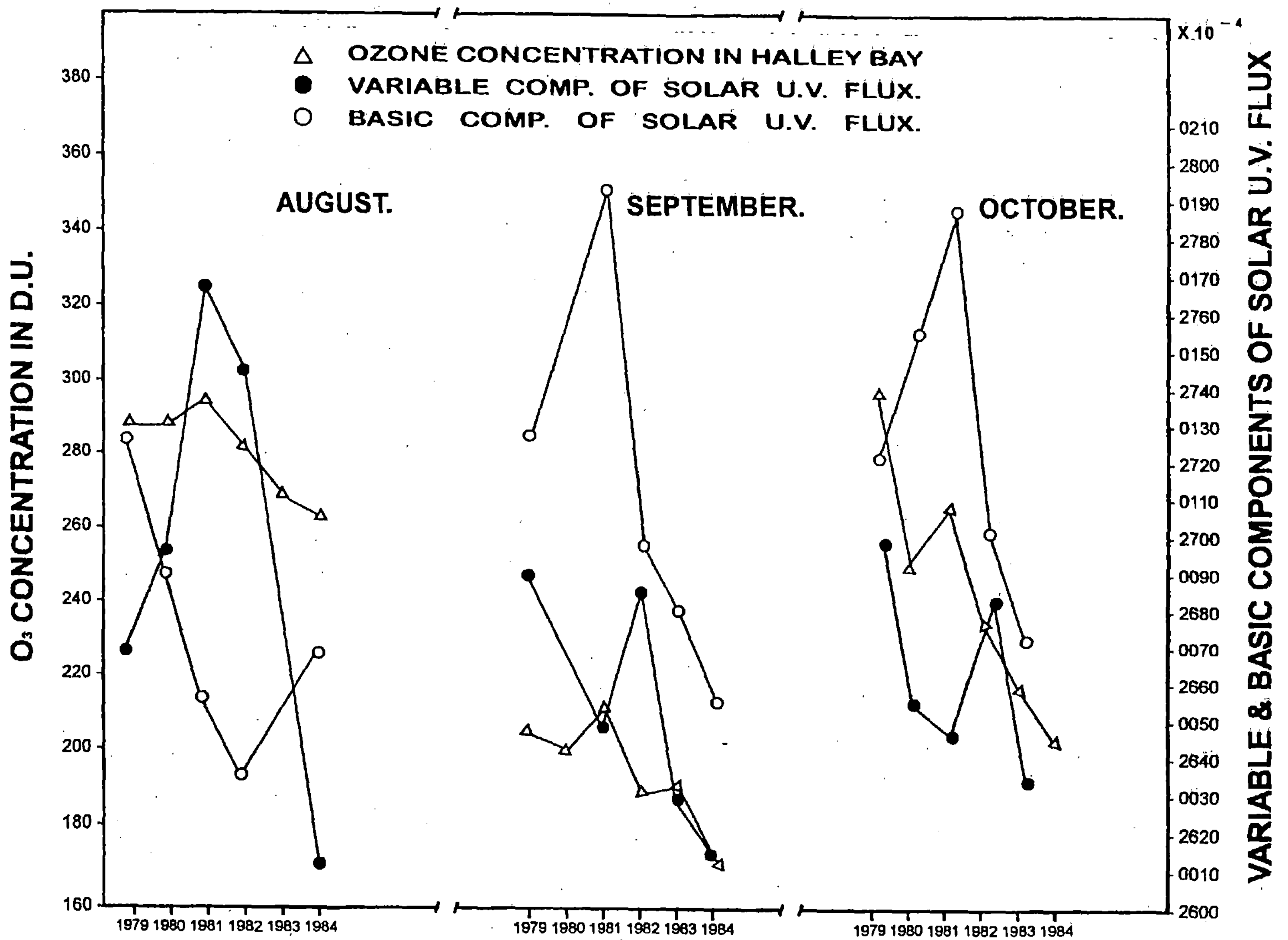

FIG - 3.3.1

Variations of Antarctic O3 concentration at Halleybay and variable and basic components of U.V. flux with year for the months of August, September & October during period 1979 to 1984.

O3 COVARIATION AT SYOWA WITH U.Vv. & U.Vb. IN SPRING DURING 1979 TO 1984.

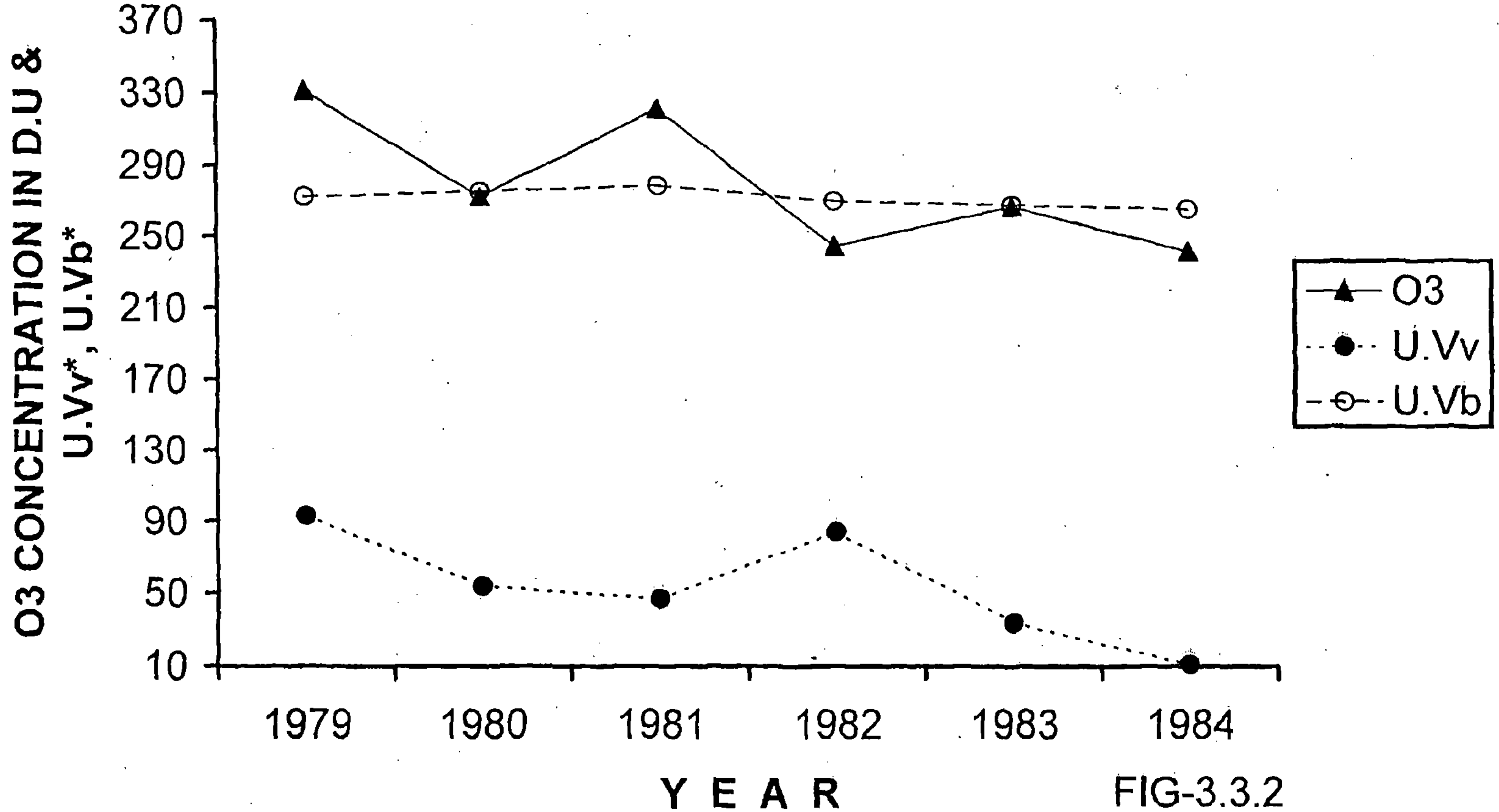

FIG-3.3.2

* Range of UVv = 11 X 10^{-4} to 93 x 10^{-4}

* Range of UVb = 265.4 X 10^{-3} to 278.9 X 10^{3}

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PO&DI JALPAIGURI(WB) 735101

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