CHAPTER - 6

Arctic O3 Destruction, Cause Investigation and related hazards on Earth's Environment

6.1 Introduction

In the previous four chapters, i,e, chapter "2" to chapter "5", critical analysis has been made to study the cause and impact of Antarctic Ozone hole and result shows that the solar parameters are not responsible for this Antarctic ozone hole. Some man-made pollutants may be responsible for the cause, but the consequences are severe on the earth's environment. The world meteorological organisation (WMO) an international scintific organisation observes the global ozone concentration regularly. According to WMO (1991), (1992), (1994), the atmospheric ozone which protects life on earth is declining not only in the polar regions (Antarctica / Arctica) but also through out the world.

In the present chapter an attempt has been made to investigate the cause of Arctic (North polar) ozone depletion and its impact on environment.

The ozone observations in the Northern polar region were first made by prof. Dobson from Oxford University during 1926 to 1929 at Abisko (68°N), Lerwick (60°N), Spitbergen (78°N). But the systematic ozone observations were started in July 1935 by Dr. Kaare Langlo who Latter became Deputy Secretary of world Meteorological Organisation, Geneva.

Existing evidence shows a 10 to 15% loss of total column ozone in the Arctic region (Froidevaux et.al. 1994). However according to WMO (1992) the loss of column ozone during 1969 and 1986 in Arctica was about 5%, on the other hand WMO (1999) reported an ozone loss of 15 to 25% over Arctica. Therefore it is clear that ozone is declining in the Arctic region, in a much faster way.

It is reported by United Nations Environment programme (UNEP 1991) that 10% decrease in atmospheric ozone has been estimated to increase the risk of cataract by 5% per anum, the risk of malignant melanoma may increase 10% and the risk of nonmalignant melanoma may increase 26%. It can also influence the climatic condition.

In this chapter the ozone data of Arctic station Barrow (71.22° N, 156.30° W) are considered for the period February'79 to August'99 to study the ozone concentration variation for the above mentioned period, to investigate the relative cause of north polar

ozone depletion, the analysis has been performed with the solar U.V. flux for the period February'79 to October'84. In absence of long period solar U.V. data, further analysis has been made with a proxydata of solar U.V. flux (using Solar 10.7 cm. radio flux) for the priod February'79 to July'99.

Recently many investigators have worked on the cause of Arctic Ozone depletion (Schoeberl et.al. 1990 Kerr. 1992a, Kerr. 1992b, Hilsenrath. 1992, Komhyr. et.al. 1994, zurek. et.al. 1996, Manney et.al. 1996, Dessler et.al. 1998 and others). Some investigators also worked on the relation of ozone destruction and U.V. radiation (Summers et.al. 1990, Hood et.al. 1991 & 1992, Reinsel et.al. 1994, Midya et.al. 1996, and others).

In this chapter the ozone data of Arctic Station Barrow (71.22°N, 156.30°W) are considered for the period Feb'79 to Aug'99, obtained from the website *http://jwocky.gsfc.nasa.gov.* tabulated in chapter 1 page 27 and the ozone concentration variations for the above mentioned period are studied. The daily solar U.V. flux values are obtained from NIMBUS 7 Satellite data, published in Solar Geophysical Data book, NOAA, U.S.A. for the period Nov'78 to Oct'84, tabulated in chapter 1 page 32 to 40.

Though the 10.7 cm. solar radio flux is not chemically responsible for ozone destruction or ozone formation, it is well correlated with the value of solar U.V. flux. The calculated correlation coefficient between solar radio flux and solar U.V. flux is positive, very high (0.95) and definitely significant at 5% level. Thus with increase of solar radio flux, the U.V. flux should increase and vice versa. As the solar U.V. data are available for a short period, i.e. Nov'78 to October'84 so the solar radio flux data has been used as the proxydata. So that the covariation study can be made for a reasonably long period at least for one or two solar cycles. In this chapter the study has been done for the period Feb'79 to July'99. The 10.7 cm. solar radio flux daily data are obtained from S.G.D., NOAA, U.S.A., and the recent data are obtained from the internet website *: ftp://ftp.ngdc.noaa.gov.* tabulated in chapter 1, page 57. From the existing theory it is known that U.V. radiation is responsible for atmospheric ozone formation as well as ozone destruction, and atmospheric ozone is also destroyed by man made pollutants. Paul Crutzen (1970) established that nitrogen oxides are responsible for ozone depletion. Harold Johnston (1971) reported that supersonic aircraft which emit nitrogen oxides seriously affect ozone layer. F. Sherwood Rowland and Mario J. Molina (1974) suggested that chloroflurocarbons (CFC's) which are industrial compounds, used as refrigerants, solvents, propellants for spray can, may be responsible for the depletion of atmospheric ozone.

To investigate the relative cause of Arctic ozone depletion in this chapter an attempt has been made to study whether the creator is the killer i,e. whether the solar parameter (U.V. radiation) is responsible for the ozone depletion in this region.

6.2. Analysis, Discussion and Conclusions

6.2.1 Analysis

(i) The daily average values of ozone concentration for the Arctic Station Barrow (71.22°N, 156.30°W) are considered for the period Feb'79 to Aug'99 and from the daily average values, the monthly average values and seasonal average values are calculated to study the covariation.

(ii) The daily average values of solar U.V. flux and solar radio flux data are considered for the period Feb'79 to Oct'84 and Feb'79 to July'99 respectively and from the daily average values, the monthly mean values and seasonal mean values are calculated to study the covariation.

(iii) The correlation coefficients are calculated seasonwise between monthly mean O_3 concentration and monthly mean solar U.V. flux or monthly mean solar radio flux, by using the statistical equation :- 2.2.1.1.

$$\text{Correlation Coefficient} \quad r = \frac{N \Sigma xy - (\Sigma x)(\Sigma y)}{[N(\Sigma x^2) - (\Sigma x)^2]^{1/2} \quad [N(\Sigma y^2) - (\Sigma y)^2]^{1/2}}$$

where "x" is the monthly mean value of solar parameter (U.V. or Radio flux). "y" is the monthly mean value of ozone concentration at Barro in Arctica. "N" is the number of months for which the values of U.V. flux or Radio flux and values of ozone concentration are available for a season.

The calculated correlation coefficients are shown in Table - 6.3.1

6.2.2 Nature of Variation of O_3 concentration at Barrow in Arctica during 1979 to 1999.

In Autumn, 1979, the average ozone concentration was 314.98 D.U. (I.D.U. = 0.01 mm. thickness at S.T.P.) which increased to 323.33 D.U. in 1980 and it is found in 1997 as 296.52 D.U. Since 1980 to 1997 the Autumn time loss of O_3 concentration is 8.35%. In 1998

it has increased significantly. But in August, 1999 (Early Autumn) it is found to be 294.8 D.U. while it was about 321.16 D.U. in August, 1980, so the loss is about 9%. It is also found that the ozone concentration at Barrow is minimum in Autumn.

In spring,1979, the average ozone concentration was 451.07 D.U. which increased to 475.43 D.U. in 1980 and it is found in 1993 as 383.04 D.U. Since 1980 to 1993 the spring time loss of O_3 concentration is 19.36% and in 1997 it is found as 400.21 D.U. Since 1980 to 1997 the spring time ozone loss is 16%. After that the spring time ozone has started increasing in 1999 to reach the value of 452.66 D.U. It is also found that the ozone concentration at Barrow is maximum in Spring.

The covariation of ozone concentration at Barrow with solar parameters are shown in Figs. 6.3.1. & 6.3.2.

6.2.3 Correlation of ozone concentration at Barrow with Solar Parameters

From the correlation Table-6.3.1 the correlation coefficient between monthly mean O_3 concentration during spring and yearly mean O_3 concentration is found to be maximum (0.42) for the period 1979 to 1984 and (0.57) for the period 1979 to 1999. The correlation coefficient during Autumn of the monthly with yearly mean values of the solar U.V. flux and solar radio flux are both found to be maximum (0.97) & (0.96) respectively. The correlation coefficients of monthly mean O_3 concentration with monthly mean solar U.V. flux and monthly mean solar radio flux are also both found to be maximum (0.53) & (0.16) respectively during autumn and the correlation coefficients are definitely significant at 5% level. Thus it may be said that the correlating coefficients of ozone concentration with solar U.V. flux and 10.7 cm. solar radio flux are to a large extent controlled by their Autumn values.

6.2.4 Effects of Pollutants on atmospheric O_3 concentration

The effect of man made pollutants on atmospheric ozone concentration are scrutinised from the available published data.

The chlorofluro carbons (CFCs) are the industrial compounds used in refrigeration, airconditioning etc., which are one of the chief agents of atmospheric ozone destruction. CFCs remained undisturbed and inert in the lower atmosphere for decades and do rise several kilometers up to stratosphere, at altitude of 25km. to 30km. It releases chlorine atoms in

the presence of solar U.V. radiation by dissociation. These chlorine atoms react with ozone and form "ClO" and "O_2" . The "ClO" then becomes part of a chain reaction. As a result of this chain reaction, a single chlorine atom can destroy 100000 molecules of ozone (Rowland and Molina, 1974) or more.

The nitrogen oxides are the other important agent responsible for the stratospheric ozone destruction. The sources are the supersonic aircraft emission in the stratosphere, uses of nitrogenous fertilisers for agricultural work etc. These oxides of nitrogen can destroy stratospheric ozone.

Another ozone destructing agent is water vapour, which occurs naturally in the stratosphere. In presence of solar U.V. rays, water molecules are dissociate in various forms, giving a collection of hydrogen atomes (H), hydroxyl radicals (HO) and hydroperoxyl radicals (HOO) and collectively they are known as HO_x which can destroy ozone (John R. Holum : Wiley-Interscience Publication, U.S.A.).

6.2.5 Impact of ozone depletion on environment

a) Effect on Plants and Crops

There are over 350000 species of crop plants in the world out of which about 3000 are harvested by man and used for food (Miller, 1982).

In general, the effects of U.V. radiation on plants include physiological, biochemical, morphological and anatomical changes, as a result the plant growth and crop yield are affected (Tevini and Teramura, 1989). This effect on plants growth may be influenced by other stresses such as : Food shortage, Water storage, mineral deficiency and increased concentration of CO_2. This increased CO_2 can cause increased greenhouse trapping resulting in tropospheric warming.

b) Effects on Aquatic Life

71% of the earth's surface is covered by sea water, which contribute one third of the global productivity. The living organisms in water can be classified in three group; Nekton (swimmers). Benthos (bottom-dwellers) and Plankton (drifters). Planktons are further classified as : Phytoplankton (plants) and Zooplanktons (animals).

Due to stratospheric O_3 depletion, the increased U.V.- B radiation can have serious effect on these aquatic life (Smith et.al 1980, Bakers and Smith 1982, Worrest 1986, Smith

1989). More than half of the world's population live in Asia and about 40% of these depend on fish for animal protein (Worrest 1986). Any increase of U.V. - B radiation could result in the depletion of fish stock and other aquatic life form also.

A case study has been reported by Geocites which concluded that, due to the adverse effect of O_3 depletion in December 1994 in Bacharcaise Island, out of 1800 Penguin chicks, only ten had survived, the other died of starvation.

In another case study, the Oregon State University has shown the adverse effect on toad and frog repropduction due to ozone depletion (*http://www.geocites.com.*).

c) Effects on Animal

The possible consequences of ozone depletion on animal health are severe. Many animal species develop skin cancer particularly in sparsely haired, light coloured parts of the skin as in the case of cows, goats, sheeps, cats and dogs (Dorn et.al. 1971; Emmett 1973; Nikula 1992). Eye cancer also develop in many species of animals such as cat, dog, sheep swine, horse and particularly in cattle (Russel et.al. 1956; Ley et.al. 1989).

d) Effects on Micro-organism

The effect of excess U.V.- B radiation can influence on "cells" and "viruses", they may be inactive, they may also lose their ability to reproduce (Diffey 1991).

e) Effects on Human

The only beneficial effect of U.V.-B radiation on the skin is synthesis of vitamin D_3 . This vitamin is very much helpful to the bone system and for other health effect. The formation of vitamin D_3 in the skin is self-limiting. That means too much U.V. - B radiation does not lead to the formation of too much vitamin D_3 (Vanderleun et.al. 1993), rather it is very much deleterious to the human health in several ways. It can damage eye cornea (Pitts et.al. 1971: Sliney 1987 : Taylor et.al. 1989), eye lens (opacity of the lens) which is known as Cataract (Taylor et.al. 1988), ratina (Tucker et.al. 1985).

The U.V.-B can damage skin resulting in Photo-aging (dryness, deep wrinkles, sagging, loss of elasticity) (Leyden 1990). Sunburn or erythema is a serious injury to the skin due to the excessive U.V.-B exposure (Diffey 1982). The U.V.-B is most effective, causing skin cancer (Vanderleun et.al. 1993).

The Fact and figures published by the U.S. Environmental Protection

Agency (EPA) are as follow :-

i) There has been an 1,800 percent rise in malignant melanoma since 1930.

ii) One American dies of skin cancer every hour.

iii) One in five Americans develops skin cancer.

iv) People get 80 percent of their life time sun exposure by the age of 18 (EPA 430-K-004-March 1998). 10% decrease in atmospheric ozone has been estimated to increase the risk of cataract 5% per annum. The risk of malignant melanoma has increased by 10% and the risk of nonmelanoma skin cancer by 26% (UNEP - 1991).

f) Effects on Climate

The change of atmospheric ozone concentration can result in increased greenhouse trapping of long wavelength radiatin (Robert M.Mckay et.al. 1997), which may produce global warming and is expected to influence the ocean current. This may alter the distribution of rainfall : weather disturbances, such as hurricanes might become more violent. The other effect of this global warming is rise in sea level caused by melting of ice and thermal expansion of sea water mass, which may submerge many coastal areas and disturb their ecosystems.

Due to global warming, the temperature of the cities will rise, which may increase the heat related illness (Last 1993).

6.2.6 Conclusions

The stratospheric ozone is produced in the equatorial region due to the photo dissociation of oxygen, by the solar U.V. radiation (wavelength less than 242 nm.) (chapman-1930). Stratospheric winds carry ozone towards the poles. There are some differences between both temperatures and circulation patterns over the North Pole (Arctica) and South Pole (Antarctica) and possibly these are the relative causes of different ozone losses. There are many aspects (such as Stratospheric temperature, wind circulation pattern, polar vortex etc.) which are less known in the Arctic region. (WMO 1992).

It is found from the nature of variation of ozone concentration at Barrow that the ozone concentration as well as the ozone loss is maximum in the spring. Since 1980 to 1997, the spring time loss of ozone concentration is 16% which was 19.36% since 1980 to 1993. However WMO Bulletin 2/99 Dtd. 1.9.99 reported that the 1997 spring time ozone deficiency over the northern polar region was 15 to 25%. It is also found that the ozone concentration at Barrow is minimum in the Autumn, which agrees with that of WMO Bull. 41 - (1992).

The correlation coefficient between the solar 10.7 cm. dadio flux and solar U.V. flux is calculated during the period 1979 to 1984 which is very highly positive (0.95) and definitely significant at 5% level.

It is seen from the correlation Table - 6.3.1 the values of correlation coefficients between monthly mean O_3 concentration and monthly mean U.V. or monthly mean solar radio flux are positive, being maximum for Arctic autumn. Even the correlation coefficients between monthly mean U.V. and yearly mean U.V. or between monthly mean solar radio flux and yearly mean solar radio flux are also positive and maximum for Arctic autumn and the calculated correlation coefficients are significant at 5% level. Thus with increase of solar parameters, the O_3 concentration over Arctica should increase and vice versa.

It is also found from the variation study of O_3 concentration during the period 1979 to 1999 that the Autumn values of O_3 concentration are minimum in Arctic Station Barrow.

If Solar radiation, is assumed to be responsible for this declining trend of Autumn ozone concentration in Arctica, then the correlation coefficients between O_3 concentration and solar radiations should have been high negative during Autumn. Contrary to this the results show that most of the correlation coefficients between O_3 concentration and solar radiations are highly positive and significant at 5% level, during Autumn in Arctica.

Thus, it may be concluded that the destruction of O_3 concentration in Arctica is independent of solar parameters and correlation coefficients are mainly controlled by their autumn values. So it may be assumed that the ozone destruction in Arctica may be due to the man made pollutants and O_3 destruction may damage earth's environment severely. Maitra, et.al. (in-press) also indicate that solar radiations are not responsible for O_3 depletion in Antarctica.

Table - 6.3.1

Correlation coefficients between various parameters for different seasons

Barrow (71.22°N, 156.30°W)

	Correlation coefficient between	Autumn (Aug., Sept., Oct.)	Winter (Nov., Dec., Jan., Feb.)	Spring (Mar., Apr.)	Summer (May, June, July)
1.	Monthly mean O_3 Concentration & monthly mean value of U.V. flux (1979 - 1984)	0.53	0.10	-0.02	0.07
2.	Monthly mean value of U.V. flux & yearly mean value of U.V. flux (1979 - 1984)	0.97	0.94	0.94	0.93
3.	Monthly mean O_3 concentration & Yearly mean O_3 concentration (1979 - 1984)	0.33	0.28	0.42	0.047
4.	Monthly mean O_3 concentration & monthly mean value of 10.7 cm. radio flux (1979 - 1999)	0.16	-0.09	0.005	0.03
5.	Monthly mean value of 10.7 cm. radio flux & yearly mean value of 10.7 cm. radio flux (1979 - 1999)	0.96	0.89	0.96	0.96
6.	Monthly mean O_3 concentration & yearly mean O_3 concentration (1979 - 1999)	-0.15	0.34	0.57	0.41

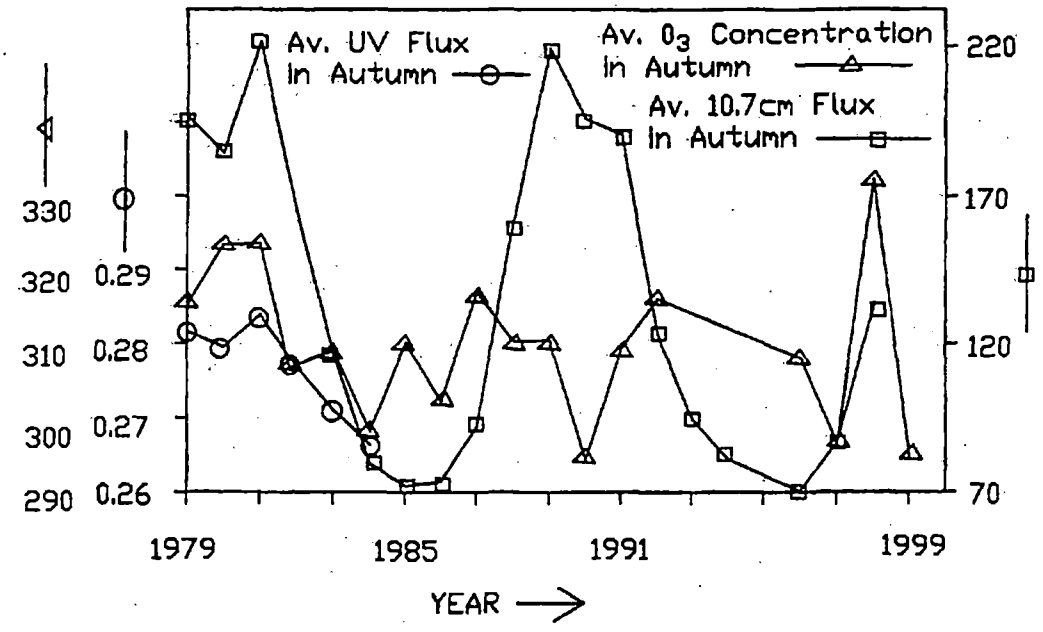

Fig. 6.3.1

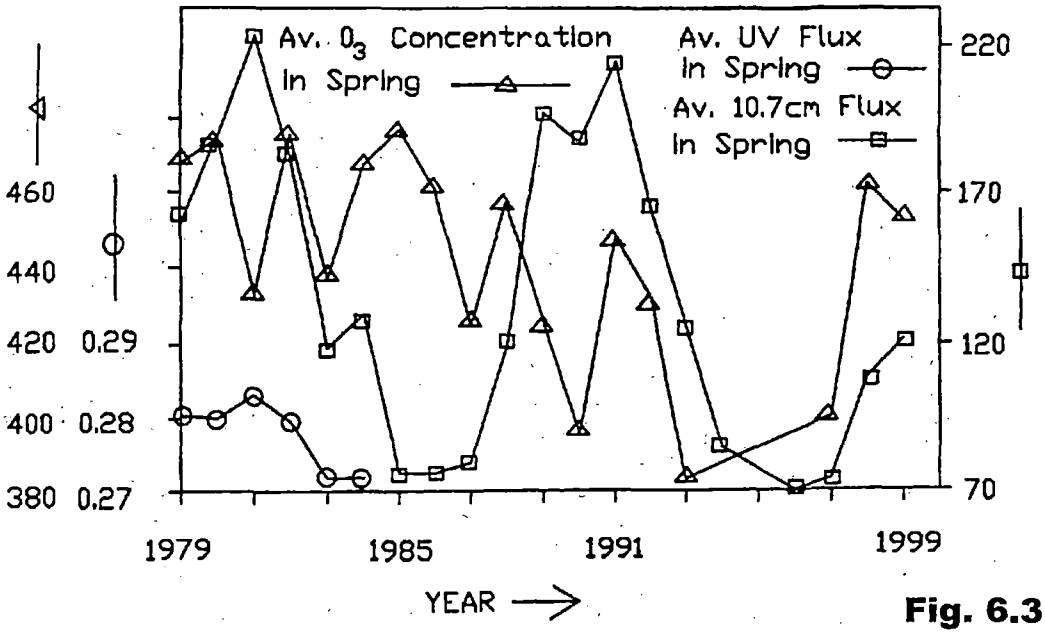

Fig. 6.3.2

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ARCTIC O_3 DESTRUCTION, CAUSE INVESTIGATION AND RELATED HAZARDS ON EARTH'S ENVIRONMENT

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Abstract

To investigate the relative cause of Arctic ozone destruction, correlation coefficients have been computed between ozone concentration of Barrow (71.22ºN, 156.30ºW) with the solar U.V. flux and solar radio flux, for the period Feb'79 to Oct'84 and Feb'79 to July'99 respectively. Also the effect of ozone destruction on earth's environment are scrutinised from the available published standard data and the following interesting results are obtained.

The Arctic ozone destruction is independent of solar parameters, seasonwise correlation coefficients are mainly controlled by their autumn values and atmospheric ozone destruction can damage earth's environment severely.

1. INTRODUCTION

One purpose of this paper is to investigate the relative cause of ozone destruction at Arctic Station Barrow. The other object of this paper is to investigate whether the solar radio flux data can be used in lieu of solar U.V. data, to investigate the cause of ozone destruction.

It is already established that the atmospheric ozone is created by the photo dissociation of "O_2" by the solar U.V. radiation (wave length <242nm.) at an altitude between about 25km. and 100km. Absorption of solar U.V. radiation upto about 320nm. converts the "O_3" back to "O_2" and "O" (Chapman, 1930). So the U.V. radiation is responsible for formation as well as destruction of atomspheric ozonosphere (the thickness of the layer reduced of S.T.P. is small and variable ranging from 1.5mm to 4.5mm., averaging 2.5mm.) which protects the abiotic and biotic environments of the earth from the deleterious effects of solar U.V.–B radiation (280nm. to 320nm.).

The "O_3" observations in the norther polar region were first made by Prof. Dobson from Oxford University during 1926 to 1929 at Abisko (68ºN). Lerwick (60ºN), Spitzbergen (78ºN), but the systematic O_3 observations were started in July, 1935 by Dr. Kaare Langlo who later become Deputy Secretary of World Meteorological Organisation, Geneva.

The global ozone assesment shown that ozone is declining everywhere throughout the world (WMO Report No. 25, 1991 and WMO Bull. No. 41, 1992). Decrease in stratospheric O_3 concentration allows enhanced solar U.V.–B (wavelength range 280nm.—320nm.) which is very much harmful to the biosphere as well as ecosystem.

Many investigators have worked on ozone destruction in polar regions. Ozone depletion is Antarctica (South Pole) has been reported by a number of investigators (Farman et. al. 1985, Stolarski et. al. 1991, Logan 1994, Ghosh and Midya 1994, Midya et. al. 1996). Ozone loss in Arctic region (North Pole) has also been reported by various workers (Schoeberl et. al. 1990, Zurek et. al. 1996, Manney et. al. 1996, Dessler et. al. 1998 and others).

Some investigators also worked on ozone destruction and U.V. radiation (Hood et. al. 1991 & 1992, Reinsel et. al. 1994, Summers et. al. 1990, Midya et. al. 1996).

In this paper, the ozone data of Arctic Station Barrow (71,22ºN, 156.30ºW) are considered for the period Feb'79 to Aug'99 obtained from the website *http://jwocky.gsfc.nasa.gov* and the ozone concentration variations for the above mentioned period are studied. The daily solar U.V. flux values are obtained from NIMBUS 7 Satellite data, published in Solar Geophysical Data book, NOAA, U.S.A. for the period Nov.'78 to Oct'84.

Though the 10.7cm. solar radio flux is not chemically responsible for ozone destruction or ozone

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formation, it is well correlated with the value of solar U.V. flux. The calculated correlation coefficient between solar radio flux and solar U.V. flux is very high (0.95). Thus with increase of solar radio flux, the U.V. flux should increase and vice versa.

As the solar U.V. data are available for a short period, i.e., Nov'78 to October 84, the other object of this paper is to investigate wherher the solar radio flux data can be used in lieu of solar U.V. data. So that the covariation study can be made for a reasonably long period at least for one or two solar cycles, in this paper the study has been done for the period Feb'79 to July'99. The 10.7cm. solar radio flux daily data are obtained from S.G.D., NOAA, U.S.A. and the recent data are obtained from the internet website : *ftp:// ftp.ngdc.noaa.gov.* Form the existing theory it is known that U.V. radiation is responsible for atmospheric ozone formation as well as ozone destruction, and atmospheric ozone is also destroyed by man made pollutants. Paul Crutzen (1970) established that nitrogen oxides are responsible for ozone depletion. Harold Johnston (1971) reported that supersonic aircraft which emit nitrogen oxides seriously affect ozone layer. F.Sherwood Rowland and Mario J. Molina (1974) proposed that chloroflurocarbons (CFC's) which are industrial compounds, used as refrigerants, solvents, propellants for spray cans, can deplete atmospheric ozone; later it has been established by many investigators.

To investigate the relative, cause of global ozone depletion in this paper, an attempt has been made to study whether the creator is the killer. That means whether the solar parameter (U.V. radiation) is responsible for this global ozone depletion.

2. ANALYSIS, DISCUSSION AND CONCLUSIONS

2.1 Analysis

i) The daily average values of ozone concentration for the Arctic Station Barrow (71.22ºN, 156.30ºW) are considered for the period Feb'79 to Aug'99 and from the daily average values, the monthly average values and seasonal average values are calculated to study the covariation.

ii) The daily average values of solar U.V. flux and solar radio flux data are considered for the period Feb'79 to Oct'84 and Feb'79 to July'99 respectively and from the daily average values, the monthly mean values and seasonal mean values are calculated to study the covariation.

iii) The correlation coefficients are calculated seasonwise between monthly mean O_3 concentration and monthly mean solar U.V. flux or monthly mean solar radio flux, by using the statistical equation :–

$$\text{Correlation Coefficient } r = \frac{N\Sigma xy - (\Sigma x)(\Sigma y)}{[N(\Sigma x^2) - (\Sigma x)^2]^{1/2}[N(\Sigma y^2) - (\Sigma y)^2]^{1/2}}$$

where "x" is the monthly mean value of solar parameter (U.V. or Radio flux), "y" is the monthly mean value of ozone concentration at Barro in Arctica. "N" is the number of months for which the values of U.V. flux or Radio flux and values of ozone concentration are available for a season.

The calculated correlation coefficients are shown in Table–1.

Correlation coefficient between various parameters for different seasons.

Barrow (71.22ºN, 156.30ºW)

Correlation coefficient between	Autumn (Aug., Sept., Oct.)	Winter (Nov., Dec., Jan., Feb.,)	Spring (Mar., Apr.)	Summer (May, June, July)
1. Monthly mean O_3 concentration & monthly mean value of U.V. flux (1979–1984)	0.53	0.10	–0.02	0.07
2. Monthly mean value of U.V. flux & yearly mean value of U.V. flux (1979–1984)	0.97	0.94	0.94	0.93
3. Monthly mean O_3 concentration & yearly mean O_3 concentration (1979–1984)	0.33	0.28	0.42	0.047
4. Monthly mean O_3 concentration & monthly mean value of 10.7cm. radio flux radio flux (1979–1999)	0.16	–0.09	0.005	0.03
5. Monthly mean value of 10.7cm. radio flux & yearly mean value of 10.7cm. radio flux (1979–1999)	0.96	0.89	0.96	0.96
6. Monthly mean O_3 concentration & Yearly mean O_3 concentration (1979–1999)	–0.15	0.34	0.57	0.41

Table–1

2.2 Nature of Variation of O_3 concentration at Barrow in Arctica during 1979 to 1999.

In Autumn,1979, the average ozone concentration was 314.98 D.U. (1 D.U. = 0.01mm. thickness at S.T.P.) which increased to 323.33 D.U. in 1980, and it is found

in 1997 as 296.52 D.U. Since 1980 to 1997 the Autumn time loss of O_3 concentration is 8.35%. In 1998 it has increased significantly. But in August, 1999 (Early Autumn) it is found to be 294.8 D.U. while it was about 321.16 D.U. in August 1980, so the loss is about 9%. It is also found that the ozone concentration at Barrow is minimum in Autumn.

In spring, 1979, the average ozone concentration was 451.07 D.U. which increased to 475.43 D.U. in 1980, and it is found in 1993 as 383.04 D.U. Since 1980 to 1993 the spring time loss of O_3 concentration is 19.36% and in 1997 it is found as 400.21 D.U. Since 1980 to 1997 the spring time ozone loss is 16%. After that the spring time ozone has started increasing in 1999 to reach the value of 452.66 D.U. It is also found the ozone concentration at Barrow is maximum in Spring.

The covariation of ozone concentration at Barrow with solar parameters are shown in Figs. 1 & 2

2.3 Correlation of ozone concentration at Barrow with Solar Parameters

From the correlation Table–1, the correlation coefficient between monthly mean O_3 concentration and yearly mean O_3 concentration is found to be maximum (0.42) for the period 1979 to 1984 and (0.57) for the period 1979 to 1999, during spring. The correlation coefficient between the monthly and yearly mean values of the solar U.V. flux and solar radio flux are both found to be maximum (0.97) & (0.96) respectively during Autumn. The correlation coefficients of monthly mean O_3 concentration with monthly mean solar U.V. flux and monthly mean solar radio flux are also both found to be maximum (0.53) & (0.16) respectively during Autumn. Thus we may infer that the correlating coefficients of ozone concentration with solar U.V. flux and 10.7cm. solar radio flux are mainly controlled by their Autumn values.

2.4 Effects of Pollutants on atmospheric O_3 concentration

The effects of man made pollutants on atmospheric ozone concentration are scrutinised from the available publised data.

The chlorofluro carbons (CFCs) are the industrial compounds used in refrigeration, airconditioning etc., which are one of the chief agent of atmospheric ozone destruction. CFCs remained undisturbed and inert in the lower atmosphere for decades and do rise several kilometers up to stratosphere, at altitude of 25km. to 30km. They release chlorine atoms in the presence of solar U.V. radiation. These chlorine atoms react with ozone and form "ClO". and "O_2". The "ClO" becomes part of a chain reaction. As a result of this chain reaction, a single chlorine atom can destroy 100000 molecules of ozone (Rowland and Molina, 1974).

The nitrogen oxides are the other important agent of stratospheric ozone destruction. The sources are the supersonic aircraft emission in the stratosphere, uses of nitrogenous fertilisers for agricultural work etc. These oxides of nitrogen can destroy stratospheric ozone.

Another ozone destructing agent is water vapour, which occurs naturally in the stratosphere. In presence of solar U.V. rays, water molecules are split apart, gives a collection of hydrogen atomes (H), hydroxyl radicals (HO) and hydroperoxyl radicals (HOO) and collectively they are known as HO_x. This can destroy ozone (John R. Holum : Wiley-Interscience Publication, U.S.A.)

2.5 Impact of ozone depletion on environment

a) Effects on Plants and Crops

There are over 350000 species of crop plants in the world out of which about 3000 are hervested by man and used for food (Miller, 1982).

In general, the effects of U.V. radiation on plants include physiological, biochemical, morphological and anatomical changes, as a result the plant growth and crop yield are affected (Tevini and Teramura, 1989). This effect on plants growth may be influenced by other stresses such as : Food shortage, water storage, mineral deficiency and increased concentration of CO_2. This increased CO_2 can cause increased greenhouse trapping resulting in tropospheric warming.

b) Effects on Aquatic Life

71% of the earth's surface is covered by sea water, which contribute one third of the global productivity. The living organisms in water can be classified in three groups; Nekton (swimmers), Benthos (bottom-dwellers) and Plankton (drifters). Planktons are further classified as; Phytoplanton (Plants) and Zooplanktons (animals).

Due to stratospheric O_3 depletion, the increased U.V. –B radiation can have serious effect on these aquatic life (Smith et. al. 1980, Bakers and Smith 1982, Worrest 1986, Smith 1989). More than half of the world's population live in Asia and about 40% of these depend on fish for animal protein (Worrest 1986). Any increase of U.V. –B radiation could result in the depletion of fish stock.

A case study has been reported by Geocites. Due to the adverse effect of O_3 depletion in December,

1994 in Bacharcaise Island, out of 1800 Penguin chicks, only ten had survived, the other died of starvation.

In another case study, the Oregon State University has shown the adverse effect on toad and frog reproduction due to ozone depletion (*http:// www.geocites.cpm).*

c) Effects on Animal

The possible consequences of ozone depletion on animal health are severe. Many animal species develop skin cancer particularly in sparsely haired, light coloured parts of the skin as in the case of cows, goats, sheeps, cats and dogs (Dorn et. al. 1971); Emmett 1973; Nikula 1992). Eye cancer also develop in many species of animals such as cat, dog, sheep, swine, horse and particularly in cattle (Russel et. al. 1956; Ley et. al. 1989).

d) Effects on Micro-organism

The effect of excess U.V. –B radiation can influence on "cells" and "viruses", they may be inactive, they may also lose their ability to reproduce (Diffey 1991).

e) Effects on Human

The only beneficial effect of U.V. –B radiation on the skin is synthesis of vitamin D_3. This vitamin is very much helpful to the bone system and for other health effect. The formation of vitamin D_3 in the skin is self-limiting. That means too much U.V. –B radiation does not lead to the formation of too much vitamin D_3 (Vanderleun et. al. 1993), rather it is very much deleterious to the human health in several ways. It can damage eye cornea (Pitts et. al. 1971; Sliney 1987; Taylor et. al. 1989), eye lens (opacity of the lens) which is known as Cataract (Taylor et. al. 1988), ratina (Tucker et. al. 1985).

The U.V. –B can Damage skin resulting in Photo-aging (dryness, deep wrinkles, sagging, loss of elasticity) (Leyden 1990). Sunburn or erythema is a serious injury to the skin due to the excessive U.V.–B exposure (Diffey 1982). The U.V. –B is most effective causing skin cancer (Vanderleum et. al. 1993).

The fact and figures published by the U.S. Environmental Protection Agency (EPA) are as follows :–

i) There has been an 1,800 percent rise in malignant melanoma since 1930.

ii) One American dies of skin cancer every hour.

iii) One in five Americans develops skin cancer.

iv) People get 80 percent of their life time sun exposure by the age of 18 (EPA 430-K-004-March 1998).

10% decrease in atmospheric ozone has been estimated to increase the risk of cataract by 5% per annum. The risk of malignant melanoma has increased by 10%, and the risk of nonmelanoma skin cancer by 26% (UNEP–1991).

F) Effects on Climate

The change of atmospheric ozone concentration can result in increased greenhouse trapping of long wavelength radiatin (Robert M. Mckay et. al. 1997), which may produce global warming and is expected to influence the ocean current. This may alter the distribution of rainfall; weather disturbances, such as hurricanes might become more violent. The other effect of this global warming is rise in sea level caused by melting of ice and thermal expansion of sea water mass, which may submerge many coastal areas and disturb their ecosystems.

Due to global warming, the temperature of the cities will rise, which may increase the heat related illness (Last 1993).

2.6 Conclusions

The stratospheric ozone is produced in the equatorial region due to the photo dissociation of oxygen, by the solar U.V. radiation (wavelength less than 242nm.). Stratospheric winds carry ozone towards the poles. There are some differences between both temperatures and circulation patterns over the North Pole (Arctica) and South Pole (Antarctica) and possibly these are the relative causes of different ozone losses. There are many aspects which are less known in the Arctic region.

It is found from the nature of variation of ozone concentration at Barrow that the ozone concentration as well as the ozone loss is maximum in the spring. Since 1980 to 1997, the spring time loss of ozone concentration is 16%, which was 19.36% since 1980 to 1993. However WMO Bulletin 2/99 Dtd. 1.9.99 declared that the 1997 spring time ozone deficiency over the northern polar region was 15 to 25%. It is also found that the ozone concentration at Barrow is minimum in the Autumn, which agrees with that of WMO Bull. 41–1992.

The corelation coefficient between the solar 10.7cm. radio flux and solar U.V. flux is calculated which is very high (0.95).

It is seen from the correlation Table–1, the values of correlation coefficients between monthly mean O_3 concentration and monthly mean U.V. or monthly mean solar radio flux are positive, being maximum for Arctic autumn. Even the correlation coefficients between monthly mean U.V. and yearly mean U.V. or between monthly mean solar radio flux and yearly mean solar radio flux are also positive and maximum for Arctic autumn. Thus with increase of solar parameters, the O_3 concentrarion over Arctica should increase and vice versa. But it is found that the autumn values of O_3 concentration of Arctiv Station Barrow is minimum. In our previous paper, it is found that the ozone concentration in tropical station Dum Dum is minimum and the correlations are positive and maximum during tropical late autumn to early winter (Maitra et. al. 1999).

Thus, we may conclude that the 10.7cm. solar radio flux data may be used in lieu of solar U.V. data, and the destruction of O_3 concentration in Arctica is independent of solar parameters and correlation coefficients are mainly controlled by their autumn values. The Ozone destruction in Arctica may be due to the man made pollutants and O_3 destruction may damage earth's environment severely.

The Montreal protocol, 1987 should be amended immediately as per Copenhagen, 1992 for the recovery of the ozone layer (WMO Report 37, 1994).

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LEGEND OF FIGURES

Fig. –1 Seasonal (Autumn) variation of O_3 concentration at Barrow, Solar U.V. flux, Solar Radio flux, during 1979–1999.

Fig. –2 Seasonal (Spring) variation of O_3 concentration at Barrow, Solar U.V. flux, Solar Radio flux, during 1979–1999.

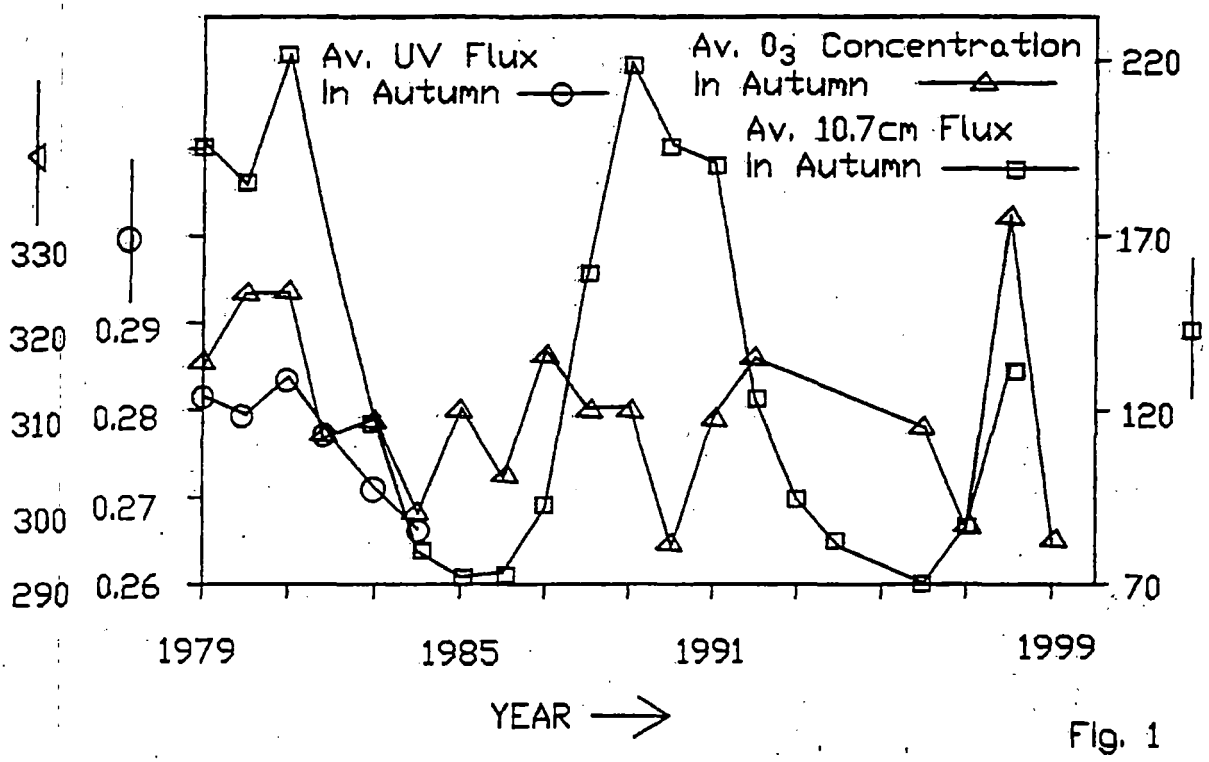
Av. UV Flux
In Autumn
Av. O_3 Concentration
In Autumn
Av. 10.7cm Flux
In Autumn
330
320
310
300
290
0.29
0.28
0.27
0.26
220
170
120
70
1979
1985
1991
1999
YEAR

Fig. 1

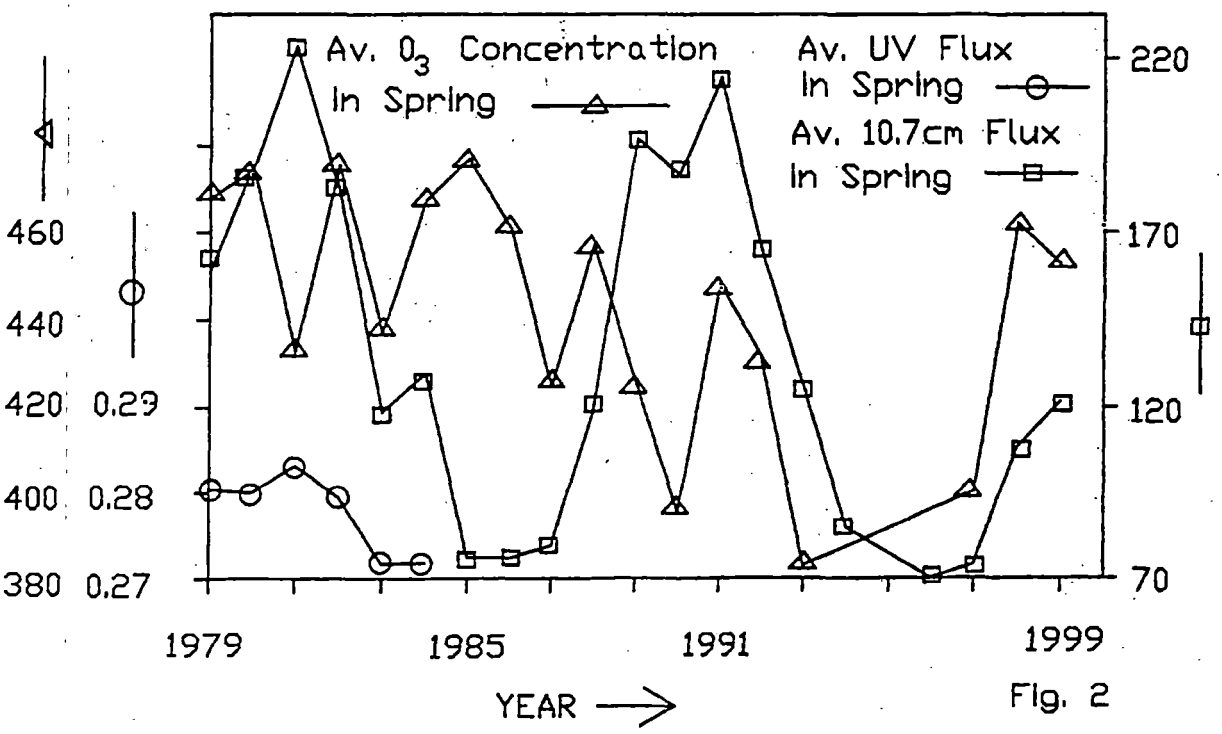
Av. O_3 Concentration
In Spring
Av. UV Flux
In Spring
Av. 10.7cm Flux
In Spring
460
440
420
400
380
0.29
0.28
0.27
220
170
120
70
1979
1985
1991
1999
YEAR

Fig. 2