Investigating the Influence of Cosmic Rays on Ozone Layer Depletion at Beijing, China

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Abstract: In the present study monthly and annually data of ozone depth and cosmic rays (CRs) intensity at China Beijing during the period of 1984-2010 have been analyzed to investigate the effects of cosmic rays intensity on ozone layer depletion (OLD). This communication implements statistical analysis on the data sets for the specified period mentioned above. The analyses exhibit that mean monthly variation of cosmic rays intensity increases. Our investigation claims that in the month of May (1984-2010) changes occurred in the decrease the ozone depth due to the increase in cosmic rays intensity .This sort of study confirms cosmic rays influence on the ozone layer depletion.

Keywords: Cosmic rays, Ozone depletion, Climate change.

INTRODUCTION

Cosmic rays are atomic nuclei (mostly composed by proton & electrons), high frequency, and high energy particles [1,2]. Cosmic rays are an essential part of the universe. Their origin is interrelated with dynamics of star formation, stellar evolution, and supernova explosion and to the state and conditions of the interstellar matter in the galaxy [3]. The study of cosmic rays originated approximately in 1900 because of observation of balloon experiment. Cosmic Rays investigated first time by V. Hess in 1912 and discovered that high penetrating radiations are coming from outer space. Later they are termed as cosmic rays.

Cosmic rays (CR) have strong biological and Climatic effects. CR is the main source of ionization on atmosphere and increase low latitude cloud, increase planetary albedo. Cosmic rays also increase production of oxides of nitrogen (NO, NO2) and oxides of hydrogen (OH) on earth biosphere thus enhance destruction of OLD, reducing sunlight, reducing potential global cooling. The effects on global climate change and increase UV radiation flux at surface of earth due to OLD` [4,5]. In 2001, Lu and Sunche indicate that the action of cosmic rays on polar stratospheric clouds (PSC) effects rapidly destruction of Chlorofluorocarbons (CFC) and HCL. This show a new path to enhance " Ozone Hole''. They further suggested that Ozone loss strongly correlated with cosmic rays ionization-rate variation with altitude and solar cycle. Since Ozone depletion causes an increase in the solar UV-flux because of the reduced absorption, where as the radiation flux in the range decreases due to larger absorption by $NO_{2,}$ thus the opacity of the atmosphere changes, which leads to green house effect and alterations in the temperature and geo potential heights. There is causing a disturbance in the atmospheric circulation [6].

It is also known that cosmic rays create devastation in computers because they affect persistent performance of electronic logic memories and affect memory failure or error in computers [7,8]. Since Cosmic rays are relatively high-energy particles that influence highly on earth atmosphere and induced diverse effect. After 1937 Street and Stevenson discover the neon particle in cosmic rays. In 1982 Stekido and Elliot give correct explanation of cosmic rays that how ionized atom i.e. cosmic rays from outer space hitting the atmosphere. That is why cosmic rays become one of the most important problems in experimental as well as theoretical astrophysics. Observations of [4,9] reported a (3-4) % variation of global cloud cover during the recent solar cycle is effectively correlated with cosmic ray flux and inversely correlated with solar activity.

In 2009, the highest flux of galactic cosmic rays during the whole history of the regular monitoring of cosmic rays in the atmosphere measured. The flux of CR with E > 0.2 GeV was about 20% higher than maximum flux observed in 1995 [10,11]. A new research of 2009 by Q. B. Lu, clearly showing a strong correlation between Cosmic rays and Ozone Depletion,

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particularly ozone content over Antarctica and consequences point out strong evidence of physical mechanism that CR-driven electron reaction of halogenated molecule leads significant role to effect the ozone hole. Further, this mechanism indicates extreme ozone content in 2008-2009 and probably another maximum in 2019-2020.

In general, a cosmic ray certainly plays a significant role in the atmospheric ion chemistry, leading to ozone depletion and to the green house effect. Cosmic rays affect the increase of atmospheric pressure Cosmic rays also effect on the global electric circuit.

DATA AND METHOD OF ANALYSIS

Monthly and annual ozone depth data sets (1984-2010) taken from the Chinese Academy of sciences Institute of Atmospheric Physics at Beijing China, where Dobson Spectrophotometers were installed under supervision of World Meteorological Organization. Cosmic rays data were recorded at Beijing where super neutron monitor (18-MN-64) situated in the outer edge of Beijing (40.08N, 116.260E) with altitude 47 m, Center for Space Science and Applied Research, Chinese academy of science and taken from World Data Centre for Cosmic rays (WDC) [13].

In atmospheric science, especially in the field of meteorology and astrophysics, various techniques of statistical analysis are used. Current study expresses exploratory data analysis (EDA). EDA is widely used in statistical analysis to explore time series analysis, regression analysis etc. It expose in regression or correlation to establish a cause and effect relationship between two variables. For computational technique, we have used Minitab soft wares as statistical tool [14,15].

RESULTS AND DISCUSSION

The monthly averages of Cosmic Rays intensity illustrated against the stratosphere Ozone to represent their dependence or interaction over each other. This is because cosmic rays play a key role in annual and monthly variation of ozone. When the cosmic rays enter in the atmospheric region, they ionize the nitrogen and oxygen and produce nitrogen oxides compounds, which are responsible for Ozone destruction. The model equation of given observations for (n = 324) taken as

$$CR_{(China)} = 1715 + 0.780\, O_{3\,(China)} \ldots \quad (1)$$

Where, b_o = 1715, (parameter value of intercept), b_1 = 0.780, (parameter value of slop), this indicates that the parametric value of slope is positive so Cosmic rays increase ozone thickness increases. Here R^2 is 8.5% and R^2 (adj) = 8.3% .This indicates only 8.5% of variation is explained by this regression model.

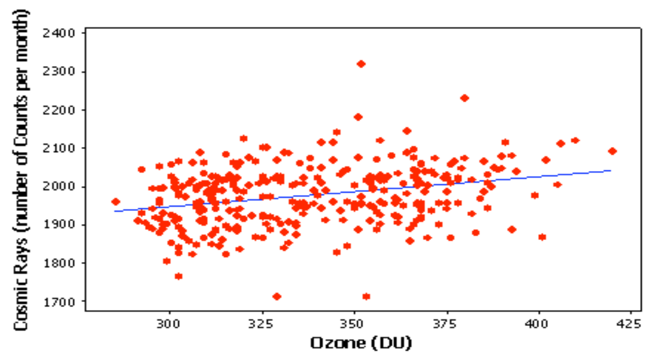

Figure 1: Monthly mean variation of CR of China with China Ozone for period 1984-2010.

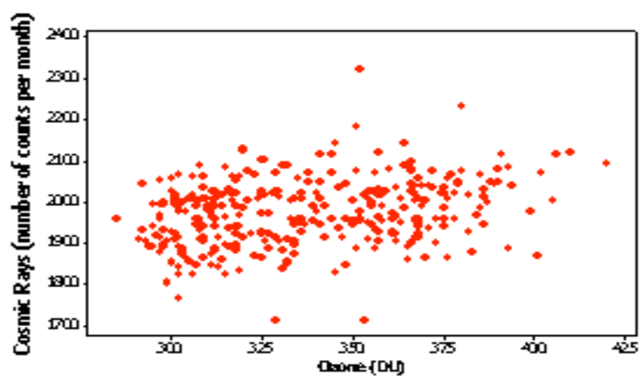

Figure 2: Scatter Plot of monthly mean of Ozone vs Cosmic Rays of china for period 1984-2010.

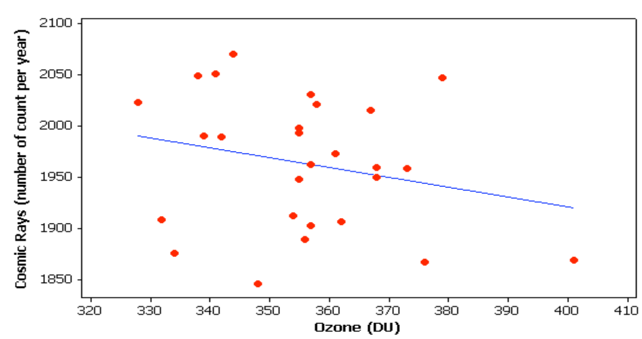

Figure 3: Comparison of China Cosmic rays and Ozone for month of May in each year from 1984-2010.

The regression coefficient b_1 = 0.780 is well considerable because the P-value < 0.05 at 95% level of significance for confidence interval.

For F-Test, the observed F-value is 30.07 is highly significant because its P-value is 0.00. Hence, the above equation (1) may be a meaningful linear model.

The scatter plot of cosmic rays and ozone, is shown between two variables in Figure **2** and is estimated as r = 0.291. Here, ozone depth positively correlated with cosmic rays intensity (95% significance level). This shows that a weak relationship is exhibited between cosmic rays intensity and ozone depth.

The data shows a temporal correlation between the annual mean O_3 and CR intensity. Figure **4** shows clearly establish the correlation of O_3 depletion with CR intensity. Percentage variation of Ozone depletion shows inversely with the CR intensity. This Observation provides evidence of the time correlation between CR intensity and O_3 depletion. Figure **3** shows negative correlation in month of May from 1984-2010. Model equation for the month of may shown as

$$CR_{(c)} = 2077 - 0.394\, O_{3(C)} \;\ldots\ldots \qquad (2)$$

Where, value of slop is negative (b_1 = - 0.394) which describes in the month of May at China region the Ozone thickness is decreased when cosmic rays are increased.

In this study we have compared ozone depth and Cosmic rays intensity of China with time. Figure **5** compares monthly mean variation of ozone depth and cosmic rays intensity with time and Figure **6** shows comparison of annual mean variation of CR intensity and annual mean Ozone depth of China during the period 1984-2010 which shows that cosmic rays increases at Beijing China due to increase of Ozone depth.

CONCLUSION

From the above discussions, we have found that the model equation (1) shows linearity between cosmic rays and ozone depth in China region. We have

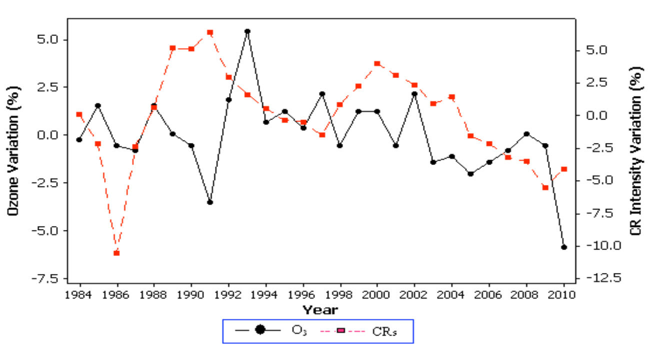

Figure 4: Comparison of mean percent variation of CR intensity and annual mean Ozone depth of China during the period 1984-2010.The CR data were taken from World Data Centre for Cosmic rays (WDC) while ozone data were obtained from World Meteorological Organization (WMO).

obtained a coefficient of determination R^2 = 8.4% between monthly mean cosmic rays intensity and ozone depth of China Beijing. It indicates that only 8.4% explained by regression model. We are also able to find a negative correlation in the month of May as in equation (2). Therefore during month of May for each yearfrom 1984-2010 the ozone depletes with increase of cosmic rays intensity. At last, evidence of our quantitative treatment shows increasing trend of monthly mean variation and only month of May shows decreasing trend at Beijing China.

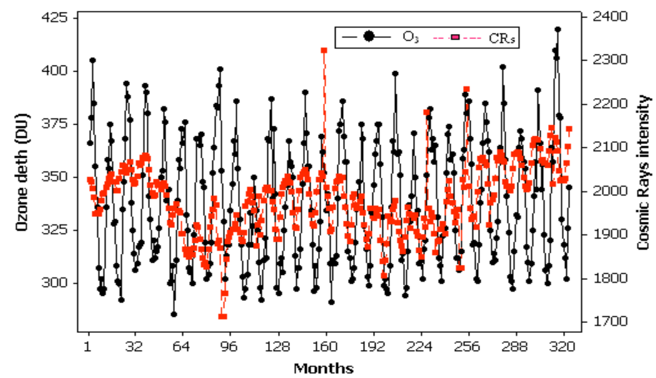

Figure 5: Comparison of monthly mean variation of CR intensity and monthly mean Ozone depth of China during the period 1984-2010. The CR data were taken from World Data Centre for Cosmic rays (WDC) while ozone data were obtained from World Meteorological Organization (WMO).

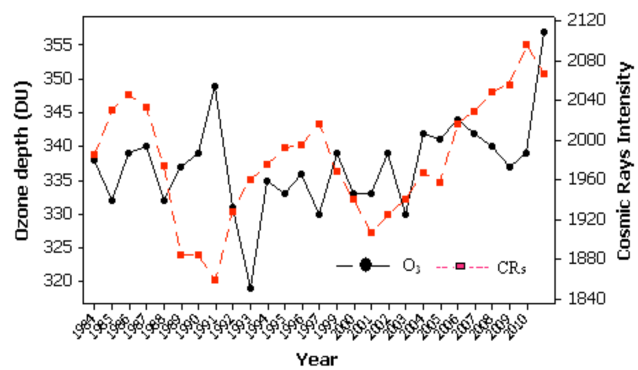

Figure 6: Comparison of mean variation of CR intensity and annual mean Ozone depth of China during the period 1984-2010. The CR data were taken from World Data Centre for Cosmic rays (WDC) while ozone data were obtained from World Meteorological Organization (WMO).

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