The Influence of Solar Radiation on Ozone Column Weight over Baghdad City

Wedyan G. Nassif, Osama T. Al-Taai*, Zainab M. Abbood

Department of Atmospheric Science, College of Science, Mustansiriyah University, Baghdad, Iraq.

*E-mail: osamaaltaai77@uomustansiriyah.edu.iq

Abstract. The ozone layer is part of the atmosphere surrounding Earth. This layer, like anything natural, depends on the balance in its quantitative components, but in front of human aspirations that reach the level of destruction. Make these chemicals a factor in destroying and destroying the ozone layer. Ozone is found naturally in the stratosphere due to a series of interactions between partial oxygenation and atoms. The methods used in the study depend on the monthly and yearly average Ozone (O3), Incident Solar Radiation (ISR) and Temperature (T) taken from the European Mediterranean Weather Forecast (ECMWF) during the period (2014-2018) for the Baghdad region. The largest ozone value was recorded in March and April, and the lowest in September and October. The highest value of Incident Solar Radiation was recorded during June and July and the lowest value in January and December, while the highest value of temperature was during July and August, and the lowest value in January and December. As for seasonal analysis, it was observed that ozone was high during spring and low during summer and Incident Solar Radiation (ISR) and T were observed high in summer and less in winter. In addition, the binding strength of ozone (O3) with ISR was positive and O3 with T inverse.

Keywords. Ozone, Incident Solar Radiation, Temperatures, ECMWF, Baghdad.

1. Introduction

The atmosphere protects life on earth by absorbing ultraviolet solar radiation and reducing temperature extremes between day and night. The gases that account for the remaining 0.1% are all called trace gases. They include ozone (O3: 0%-7 * 10-6%), methane (CH4: 0.0001745%), nitrous oxide (N2O: 0.00005%), nitrous dioxides (NO2: 2*10-6) [1]. O3 is a secondary pollutant and is not normally emitted, O3 is formed in the atmosphere due to reactions among other pollutants mostly emitted by industries and cars that are produced by photochemical reactions between volatile, Organic compounds (VOCS) and nitrogen oxides (NOx) under sunlight (VOCS) and (NOx), they are called together as ozone precursors. O3 precursors can be both human and natural resources. Automotive exhaust, industrial emissions, fuel station and chemical solvents. Where ozone is a trace gas and has an important effect on weather and climate regulation in terms of surface temperature. Ozone is of two types are Tropospheric ozone is caused by the human pollutants, and stratospheric ozone formed by optical decomposition of molecular oxygen (at wavelength less than 242nm) [2]. Ozone gas is a layer in the earth's atmosphere that has relatively high concentrations. There is only about 10% of the atmospheric ozone in the troposphere layer either as natural gas or as polluted act as a greenhouse gas and the 90 % is found as a belt at the bottom of the stratosphere at a height of (15-35) km from the earth surface the thickness of the dish varies seasonally and geographically [3].
The amount of ozone in the atmosphere varies substantially from day to day, varies with season, height, latitude and depend on atmospheric variables and its residence time in the atmosphere is relatively short [4]. In addition, the lower column O₃ is much smaller in the tropics than those at middle and high latitudes [5]. Where Ozone absorbs solar radiation in the ultraviolet and visible region of the spectrum and Ozone can absorb the thermal infrared radiation of the earth atmosphere system [6]. Ozone absorbs 100% of solar radiation with a wavelength less than 0.29 μm [7]. A small amount of ultraviolet radiation penetrates the atmosphere and reaches the earth's surface there a narrow absorption band at a wavelength of 9.6 μm within the infrared range. Ozone is the main cause of global warming [8]. Where global warming is the process of radiation exchange between the atmosphere and its contents of gases and suspended substances. The atmosphere allows solar radiation to travel to Earth, but at the same time, terrestrial thermal radiation traps heat [5]. There are several researchers who conducted studies the Influence of solar radiation on ozone concentration weight concentrations over selected areas in Iraq. Where Hassan, (2013) [9] presented that ozone concentrations in Jeddah over 365 days in 2012 and the results showed that the peak of the ozone concentration cycle occurs at midday and the lowest concentration occurs at midnight which is due to the formation of optical ozone. Conducted a study on the analysis of temporal and spatial patterns of ozone over Iraq and found that the largest of total ozone column amounts occurs systematically over the northern regions during winter. Whereas in spring and early summer months the maximum values of total ozone column directed to the northwestern regions of the country. Abdulhussein, (2017) [10] studied of outgoing long wave radiation over Iraq using AIRS data, concluded there is temporal variation represented by the lower values of OLR during winter than summer because of the variation of meteorological parameters values and astronomical factors through the seasons such as the cloudy sky, or decrease in temperature in winter. Aboodd, (2019) [11] studied of Absorbance and Emissivity Solar Radiation by Clouds, Aerosols and Some Atmospheric Gases concluded there is Ozone the greatest value in winter-spring and less in summer-autumn at the times (00:00 am, 12:00 pm) and ozone relationship with solar radiation (SW-LW) is positive and inverse with albedo. The research aims to study the effect of solar radiation on ozone concentration weight concentrations in selected stations from Iraq for the period (2014-2018). All data is provided by the European Center, which contains reliable data.

2. Materials and Methods

2.1. Data source and study station

The work was performed using monthly data on Ozone (O₃), Incident Solar Radiation (ISR) and Temperature (T) taken from the European Center for Medium-Range Weather Forecasts (ECMWF) [12]. This data was converted into annual and seasonal rates to show seasonal effect. The data was processed by MATLAB and drawn by SigmaPlot. The map of Iraq was drawn using the GIS program as shown the Baghdad station at longitude (44.45°E) and latitude (33.24°N) see Figure 1.
2.2. Statistical Used

2.2.1. Simple Linear Regression (SLR)

Several available statistical operations were performed where the Sigmaplot program was used to calculate the slope value and the value of P by a simple linear regression method (SLR) in order to predict the relationship between precipitation and wind speed? SLR is the study of the relationship between two variables to arrive at a linear relationship between these two variables, where the data is supposed to be distributed naturally [13]. To find the value of the slope, the slope is calculated from the following equation [14]:

\[ y = a + bx \]  
\[ b = \frac{\sum_{i=1}^{n}(x_i - \bar{x})(y_i - \bar{y})}{\sum_{i=1}^{n}(x_i - \bar{x})^2} \]

Where: (b) is the slope and the slope of the straight line is shown, (a) is constant and shows the value of the line unit division, the equivalent. (1) [15].

As for the probabilistic value, the value of P is a statistical term, which is a number or number used to evaluate statistics, a value that appears if the factor actually affects or not?

After converting data from NC file format to (TXT file), FORTRAN language (a multi-use programming language and after isolating and filtering data for each region separately in the form of (TXT file)) is used through which the calculations are performed. Then using the program Sigmaplot, which is a set of scientific programs for charts and data analysis through which to draw the time series charts for each introverted variable and find the relationship between each variable and O3 to calculate the slope value and the value of the value of P [16].

2.2.2. Pearson’s Correlation Coefficient (r)

The Pearson test is the instantaneous correlation matrix which is a series of scatter graphs that draw correlations between all possible combinations of variables. The first row of the array represents the first set of variables or the first column of data, the second row of the array represents the second set of variables or the second data column, and the third row of the array represents the third set of variables or the third data column. The graphs of x and y data correspond to the column and row in the graph in the array. For example, the x data for the graphs in the first row of the matrix are taken from the first column of the tested data, and the y data is taken from the first column of the tested data. The x data for the graphs in the second row of the matrix are taken from the second column of the tested data, and the y data is taken from the second column of the tested data. The y data for the graphs in the third row of the matrix are taken from the third column of the tested data, etc.

The number of rows of the graph in the array is equal to the number of columns of data being tested [17]. The Pearson correlation coefficient (r) is used to measure the strength of the linear correlation between two variables, where r = 1 means perfect positive correlation and r = -1 means ideal negative correlation. So, for example, you can use this test to find out if the height and weight of people are related. Pearson correlation test requirements [18]:

- Scale of measurement should be interval or ratio.
- Variables should be approximately normally distributed.
- The association should be linear.
- There should be no outliers in the data.
2.2.3. Relationship between both Celsius and Kelvin

There is a constant relationship between both Celsius and Kelvin. Once a constant number is added to Celsius or the “centenary”, the Kelvin is obtained, and when this number of Kelvin is subtracted, the Celsius is obtained, and this number is “273”, and this can be illustrated by the equation the following mathematics: degree [19].

\[ r = \frac{\sum_{i=1}^{n}(x_i-\bar{x})(y_i-\bar{y})}{\sqrt{\sum_{i=1}^{n}(x_i-\bar{x})^2} \sqrt{\sum_{i=1}^{n}(y_i-\bar{y})^2}} \]  

(3)

3. Results and Discussion

3.1. Behavior Analysis the Monthly Mean of Ozone and Incident Solar Radiation and Temperature over Baghdad Station

In Figure 2, shows monthly mean of O3, ISR and T over Baghdad station, where observed O3 was high during months March and April and less in September and October this due to meteorological parameters, climate changes and location in the atmosphere. Gases concentrations are always high near its sources and decreases when increasing the distance or height from these sources. While observed ISR was high during months June and July and less in January and December but observed T was high during months July and August and less in January and December. This is due to astronomical factors such as the solar constant, the distance between the Earth and the sun, the inclination of the sun, latitude and length of day.
Figure 2. The Total Monthly Mean of O3, ISR and Temperature for a period (2014-2018) over Baghdad Station.

3.2. Analysis the Season Mean of Ozone and Incident Solar Radiation and Temperature over Baghdad Station

In Figure 3, shows monthly mean of O3, ISR and T over Baghdad station, where O3 observed was high during spring and less in summer season this due to because of the transfer of stratospheric ozone from the equator to the north. As soon as the pole approaches, it beings to descend with increasing amount. The presence of slow streams in winter redistributes air from the tropics to the regions above tropics. While observed ISR and T was high during summer and less in winter season this due to astronomical and meteorological parameters.

![Graph 1](image1)

![Graph 2](image2)

![Graph 3](image3)

Figure 3. The Analysis Behavior of the Seasonally Mean of O3, ISR and T data for a period (2014-2018) over Baghdad Station.

3.3. Behavior Analysis the Seasonally and yearly Mean of O3 and ISR T over Baghdad Station

In Figure 4, shows monthly mean of O3, ISR and T over Baghdad station, where observed O3 was high during Spring and less in summer season this due to ozone distribution for several factors, including the interaction of the dioxin element with sunlight, which varies with different seasons, regions and wind directions and its storms, causing the ozone density to vary from season to season. While observed ISR and T was high during summer and less in winter season this due to astronomical and meteorological parameters. Where 2017 year was the highest concentration of ozone and temperature while solar radiation was high 2016-2017, this is due to natural and human activities.
3.4. Relationship between The Monthly Mean 5 years of O3, ISR and T over Baghdad station

In Figure 5 and table 1, shows the relationship of \( O_3 \) with ISR is positive and the relationship of \( O_3 \) with T is inverse. In addition, the relationship of T with ISR is positive. It was found that the highest positive correlation coefficient is 0.9 between (ISR with T) that represents high correlation. This due to ozone formed by optical decomposition of molecular oxygen (at wavelength less than 242nm) where solar radiation is the main cause of increased ozone. Ozone absorbs solar radiation as a shield that reduces the temperature. Global warming is a danger of resulted of the ozone hole. Where stratospheric ozone
regulates the atmosphere's temperature, called good ozone. The ozone in the troposphere is called bad ozone, because it is close to the surface of the earth and interacts strongly with other molecules and thus endangers life.

When there is a hole in the ozone layer, the solar radiation will arrive to the earth, the ultraviolet rays with them penetrate to the surface. Where the surface absorbs the radiation reaching it and heats it up, and sends its heat to the atmosphere in the form of long-wave radiation. Therefore, the air near the surface of the earth absorbs it, so the heat is retained and atmosphere does not allow it to penetrate up and re-transmit it to the earth, which makes the surface earth temperature increase.

![Figure 5. The Relationship between the monthly Mean of O3, ISR and T over Baghdad station](image)

**Table 1.** The relationship between O3, ISR and T for the monthly mean 5 years over Baghdad station.

| Relationship   | Spearman rho | Linear regression | Simple            |
|----------------|--------------|-------------------|-------------------|
|                | r            | Correlation degree| P-value           |
| ISR vs. O3     | +0.2         | Low positive correlation | 0.985      |
| T vs. O3       | -0.2         | Low inverse correlation | 0.001      |
| ISR vs. T      | +0.9         | Very high positive correlation | 0.001 |

4. Conclusions
- The figures showed O3 was high during months March and April and less in September and October While ISR was high during months June and July and less in January and December but observed T was high during months July and August and less in January and December.
- From monthly mean of O3, ISR and T over Baghdad station, resulted O3 was high during Spring and less in summer season while observed ISR and T was high during summer and less in winter.
- So resulted 2017 year was the highest concentration of ozone and temperature while solar radiation was high 2016-2017, this is due to natural and human activities.
The relationship of O₃ with ISR is positive and the relationship of O₃ with T is inverse. In addition, the relationship of T with ISR is positive.

It was found that the highest positive correlation coefficient is 0.9 between (ISR with T) that represents high correlation.

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