Impact of Ozone gas on Air Temperature Change in Iraq and Some Surrounding Countries

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Abstract. Iraq faces one of the Middle East's most climate-changing countries, facing many environmental challenges, the most important of which is rising temperatures above normal. The effect of chemical compounds on ozone gas and depletion leads to an increase in the ozone hole and consequently more sunlight reaches the atmosphere. The aim of this research is to study the effect of O3 and its effect on the rate of temperature. The data were obtained from satellites recorded by the European Center for Medium Range Weather Forecast (ECMWF). This study selects Iraq and adjacent areas from latitude 27 to 37 ºN and longitude from 39 to 50 ºE for years (2003-2016), where we studied the behavior of O3 gas concentration and its relationship to air temperature change. Due to the use of correlation coefficient between O3 and temperature, it was found that the relationship was negative in most of the study stations because the weight gas is fluctuating gas, wherein Sulaymaniyah (Iraq) - 0.5, and in Mosul (Iraq) - 0.3, and in Baghdad station -0.2 , while a positive relationship in the southern stations in Basrah station +0.4 and in Nasiriah station +0.3, As in adjacent regions were also positive in Jubail (K.S.A) +0.6, and negative in other neighbor regions.

Keywords. Greenhouse gases, Ozone gas, Temperature, Global warming, Iraq, Neighbor countries.

1. Introduction
Ozone layer absorbs about 90% of the high frequencies of the sun such as ultraviolet rays, which are likely to cause damage to life on Earth [1]. It is located mainly at the bottom of the stratosphere from about 10 km to 50 km above ground, the thickness of the dish varies seasonally and geographically [2]. Therefore, stratospheric ozone plays a major role in physics and atmospheric chemistry, especially the radiation budget. Ozone depletion of the stratosphere was the result of anthropogenic emissions. In recent years, due to the increase in human activity, there has been a significant reduction in ozone concentration, especially in the Antarctic Spring. In many studies based on Earth measurements and various satellites, the ozone concentration is usually less than 10 parts of ozone per million [3] [4]. Ozone is a secondary contaminant and is not normally emitted. Ozone is formed in the atmosphere due to reactions among other pollutants emitted mostly by industries and cars produced by photochemical reactions between VOCs. AL-Salihi, A. M. and Z. M Hassan (2014), conducted a study on the analysis of temporal and spatial pattern of ozone over Iraq and found that the largest of total ozone column amounts occurs systematically over 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 [5]. Hassan, I.A., et al. (2013), presented that ozone concentrations in Jeddah over 365 days in 2012 and the result 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 [6].

2. THE STUDY STATIONS
Iraq is country in Western Asia spanning most of the northwestern end of the Zagros mountain range, the eastern part of the Syrian Desert and the northern part of the Arabian Desert. The desert is in the
southwest and central provinces, along the borders with Saudi Arabia and Jordan and geographically belongs with the Arabian Peninsula. The climate of Iraq is characterized by sub-tropical, continental, arid to semi-arid with dry hot summers and cooler winters. The average annual temperature is varies from 8.5 °C to 49 °C. The summer temperature range is between 16 °C to 49 °C, while winter temperature range is between 8.5 °C to 14 °C. The work was carried with the monthly mean of the years (2003-2016) the O3 and Temperature data taken from the European center medium weather forecasts (ECMWF) [7], specifically model (ERA-interim) [8], this data was taken over Iraq and neighbor regions where chosen for this work located at the latitude SW (27, 37) °N and longitude NE (39, 50) °E with spatial resolution 2*2.5 degree as shown in Figure 1, and Table 1.

Figure 1. All Study stations in Iraq and surrounding countries.

Table 1. Location and Altitude for study stations from north to south.

| Stations          | Longitude (°E) | Latitude (°N) | Altitude above sea level (meter) |
|-------------------|----------------|---------------|----------------------------------|
| Batman (Turkey)    | 41.16          | 37.87         | 601                              |
| Mosul (Iraq)       | 43.15          | 36.31         | 223                              |
| Aleppo (Syria)    | 37.17          | 36.23         | 379                              |
| Sulamaniyah (Iraq)| 45.43          | 35.55         | 882                              |
| Hadithah (Iraq)    | 42.35          | 34.13         | 80                               |
| Baghdad (Iraq)     | 44.43          | 33.30         | 34                               |
| Amman (Jordan)     | 35.98          | 31.98         | 750                              |
| Amarah (Iraq)      | 47.15          | 31.83         | 10                               |
| Ahwaz (Iran)       | 48.66          | 31.33         | 21                               |
| Nasriyah (Iraq)    | 46.26          | 31.02         | 9                                |
| Basrah (Iraq)      | 47.82          | 30.52         | 5                                |
| Jubail (Saudi Arabia) | 49.4        | 28.00         | 7                                |
3. STATISTICAL USED

Choosing spearman (Rho) test from many statistical tests has been selected regression analysis. Using statistical program Sigmaplot to figure out the slope of regression, and p-value simple linear regression [9]. And using sufer13 program to show gas behavior [10].

4. RESULT AND DISCUSSION

4.1. The behavior of monthly mean of O₃ in study stations

Figure 2 shows the behavior of monthly mean of Ozone during period (2003-2016) in study stations, it found that the concentrations of O₃ increase in the winter (December, January and November) and also increase during the spring (March, April, May) the highest value during the winter in November (0.7202ppm) in the city of Batman in Turkey and also note increasing concentrations of ozone in the northern parts of Iraq (Sulaymaniyyah, Mosul) and Western (Hadithah) and in Baghdad, gas concentrations are high for the rest of the world Iraq states, and neighboring regions in the northern hemisphere, either during the spring of the highest concentration of gas in March. The highest concentrations of the ozone gas (0.7377ppm) are also in the city of Batman in Turkey. Gas concentrations are high in the northern and western parts of Iraq, and the concentrations are high in Baghdad. During the summer (June, July, August) (0.6137ppm) and during the fall season (September, October, November), it observe a significant decrease in the concentration of gas in relation to the regions of Iraq Neighboring regions. High concentration of ozone is a direct result of pollution, as the combustion of fossil fuels Fossil fuel and biomass cause the release of some compounds such as nitrogen oxides and other organic compounds that interact with the sun's ozone. This ozone near the Earth's surface is an essential element in the phenomenon of urban smoke which can cause respiratory problems in humans and cause great damage to the plant. Ozone depleting substances, while affecting the ozone layer that could affect the ozone layer, could also affect the global equilibrium of the Earth, as many of these substances are greenhouse gases that contribute to global warming, for example Freon 11 and Freon 12 (the two main components of CFCs that break down the ozone) have a heating capacity greater than 4000 and 8500 respectively on the heating power of carbon dioxide HFCs have been developed to replace CFCs but are also considered strong greenhouse gases.
4.2. The behavior of the total yearly mean of Temperature in study stations

Figure 3, show behavior of the total mean of temperature in study stations. It founded that the highest temperatures are in Baghdad (26.2ºC), and the temperature is high in the southern regions where it is in Basrah (26.8ºC). Also, the temperature is high in Hadithah, western Iraq (25.5ºC) and temperatures are lower in the rest of Iraq, as for the neighboring regions, the highest temperature during the study period is in Amman (Jordan) (27ºC) and is lower in the rest of neighboring regions.

Figure 4, shows the behavior of total average of \( O_3 \), for ozone the highest concentration is in the regions neighboring to Iraq, especially in Aleppo (Syria) where the concentration is (0.6553 ppm) the concentration of gas is also relatively high in Batman (Turkey) where the concentration is (0.6536 ppm). Concentration is also high in the northern regions of Iraq, where it is in Mosul (0.6511 ppm). In Sulamaniyah, northern Iraq is (0.6429 ppm). It is noted that the concentration of gas is high in Hadithah station in western Iraq, the concentration is (0.6379 ppm). In Baghdad concentration is less in than the western region where concentration (0.6363 ppm) and the lowest concentration in the southern regions the lowest value in Jubail (Saudi Arabia) the concentration of gas is (0.5966 ppm).
4.3. The behavior of monthly mean of Temperature in study stations

Figure 5, show the behavior of monthly mean of temperature, during the study (2003-2016) it founded that the highest temperature in the southern stations of Iraq in the August, and the lowest temperature in the January, while in the neighbor stations temperature less than Iraqi stations, just Jubail stations in Saudi Arabia has temperature like the southern stations of Iraq, because it has high concentration of greenhouse gases Jubail was industry region therefore has high pollutions.

4.4. Effect of change in O₃ on temperature for period (2003-2016) in study stations

Figure 6, shows the relationship between the annual ozone rates and the annual temperature of the study period (2003-2016). For Iraq and neighboring regions, it is noted that gas concentrations are increasing in the last years of the study period. Baghdad station, has the highest concentration of gas in 2015, however, the temperature in the city of Baghdad was in 2010 (26.1°C) compared to the concentration of gas (0.6433 ppm), while the maximum temperature in the province of Hadithah in western Iraq 2010 is...
(24.9°C) where the ozone concentration (0.6451 ppm) and the highest gas value in (2015) the concentration of the gas will be (0.6518ppm) and the temperature will reach to (23.5°C).

In the southern regions of Iraq, the concentration of gas is steadily increasing. In architecture, it reaches the highest level in 2015 at a concentration of (0.6354 ppm) and the temperature is (26.9°C), the maximum temperature in 2010 is (27.1°C) compared to the concentration of the ozone gas. In Basrah, the highest temperature in Basrah station is(28.2°C) in 2010 , the concentration of gas is (0.6180 ppm), while in 2015 the temperature was (27.4°C) and the highest concentration of gas (0.6235 ppm), in Nasiriyah station in the south of Iraq the highest temperature is(26.9ºC) in 2010 opposite the concentration  of the gas will be (0.6217ppm) and the degree of tractor (26 °C).

As for the northern parts of Iraq, especially in the city of Mosul, it is noted that there is also a continuous increase in gas concentrations as well as temperatures higher than usual to reach the highest temperature in 2010 (23.4°C), where the concentration of gas this year is (0.6587 ppm). The highest temperature in the year 2010 reaching to (18.3 °C) compared with the concentration of gas which is (0.6503 ppm), the highest temperature in the year 2010, with the concentration of gas (0.6646 ppm) and the corresponding temperature (22.6 °C) But in the years following 2010, gas concentrations rose to their highest values in 2015 with a concentration of gas (0.6548ppm) and temperature (18°C).

The concentration of ozone in Ahwaz (Iran) is highest in 2015 (0.6219 ppm) compared to an annual temperature of (17 °C). The highest temperature in 2010, with a temperature of 17.50 and a gas concentration of 0.6157ppm), and in Batman, Turkey the average temperature is relatively low. The highest temperature in 2010 was (13.2°C) compared to the concentration of gas (0.6635 ppm). In recent years, gas concentrations have been increasing. The concentration of gas in 2015 is 0.6656ppm compared to the average temperature (11.8°C) The ozone will be in 2009 with a concentration of (0.6665 ppm), In Aleppo (Syria), the largest increase in gas concentration was in 2015, with the concentration of the membrane (0.6706ppm) compared to the temperature (19.4°C), but the lack of temperature in 2010, (20.4°C) compared with the concentration of gas (0.6643 ppm). In Jordan, one of Iraq's neighboring regions, the concentration was 0.6391ppm (20.1°C), but the temperature was not determined in Jordan in 2010 (21.6°C) compared to the concentration of the ozone gas (0.6309ppm) Jubil (Saudi Arabia), the concentration of gas in the final phase of the study period in 2015, where the concentration of gas (0.6122ppm) is required temperature (27.3 °C).
4.5. The relationship between $O_3$ and Temperature

Figure 6. The yearly mean of Ozone and Temperature in Iraq and neighbor regions stations.

Figure 7. show the correlation coefficient between the concentrations of ozone and the temperature in Iraq, it was found that the relationship between gas and temperature in most stations is reverse except the stations of Basrah and Nasiriyah, the relationship between the gas concentrations and the temperature is positive, and in neighbor regions stations the correlation coefficient between the concentrations of ozone gas and temperature also found that the relationship between the gas concentrations and the temperature rate is inverse relationship except in the Jubail station in Saudi Arabia, the relationship between them is positive. Where the gas is emitted in areas where fossil fuels are heavily burned and the use of cooling devices and power plants as well as generators and heavy industries produce a high proportion of pollutants that cause the formation of ground ozone, High levels of terrestrial ozone affect breathing, increase asthma in patients with chronic conditions and also affect vegetation.

Table 2. The relationship between $O_3$ and Temperature in study stations for period (2003-2016) by using spearman correlation coefficient

| All stations           | $R$   | Spearman rho          | Simple linear regression | Interpretation of relationship |
|------------------------|-------|-----------------------|--------------------------|--------------------------------|
|                         |       | Correlation degree    | P-value                  |                                |
| Batman(Turkey)          | -0.6  | middle inverse correlation | 0.04                      | linear regression              |
| Mosul(Iraq)             | -0.3  | Low inverse correlation | 0.1                       | Non-linear regression          |
| Aleppo(Syria)           | -0.4  | middle inverse correlation | 0.2                       | Non-linear regression          |
| Sulamaniyah(Iraq)       | -0.5  | middle inverse correlation | 0.1                       | Non-linear regression          |
| Hadithah(Iraq)          | -0.3  | Low inverse correlation | 0.3                       | Non-linear regression          |
| Baghdad(Iraq)           | -0.2  | low inverse correlation | 0.3                       | Non-linear regression          |
| Amman(Jordan)           | -0.2  | low inverse correlation | 0.7                       | Non-linear regression          |
| Amarah(Iraq)            | 0.0   | No correlation         | 0.9                       | Non-linear regression          |
| Ahwaz(Iran)             | -0.2  | low inverse correlation | 0.4                       | Non-linear regression          |
| Nasiriyah(Iraq)         | 0.3   | low positive correlation | 0.3                       | Non-linear regression          |
| Basrah(Iraq)            | 0.4   | middle positive correlation | 0.2                       | Non-linear regression          |
| Jubail(Saudi Arabia)    | 0.6   | middle positive correlation | 0.01                      | linear regression              |
**Figure 7.** The relationship between H$_2$O and Temperature for period (2003-2016) for study stations.

5. CONCLUSIONS

1- The behavior of Ozone found that their concentrations are fluctuating from one year to another and from one season to another due to several factors.

2- The highest correlation coefficient between O$_3$ and temperature in the southern regions of Iraq (Basrah and Nasiriyah) station and in Jubial (KSA).

3- The depletion of the ozone layer by chemical compounds leads to the occurrence of global warming and thus many climate changes.

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