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Spatial distribution of the ozone layer and its relationship with temperature and relative humidity over Iraq for the year 2024 using R.S and GIS techniques

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Abstract. The climate of Iraq is one of the most changeable countries in the Middle East, as well as facing many environmental challenges, the most important of which is the high temperature and humidity above normal, and this may cause depletion and increase of the ozone hole, leading to major problems for humanity and other living organisms. The research aims to study the spatial distribution of the ozone layer and its relationship to temperature and relative humidity on Iraq for the year 2024 using GIS technologies, where data were obtained from satellites at 132 stations recorded by the government website (NASA Earth data). The study selected the whole of Iraq from North to South for the year (2024) over four semesters (winter, summer, autumn, spring). I use geographic information systems software to collect, process and analyze spatial data and use the SPSS (Version 26) program in statistical analysis to find out the correlation coefficient and the strength of the relationship between them. After obtaining the results, it was found that in winter the relationship between heat and humidity with ozone and the strength of the relationship is inverse and average, while in summer the ozone rate is low and the correlation relationship is also inverse and strong, and we noticed that in spring the ozone gas rate was high and the correlation relationship is directly and weak with heat and humidity, and in autumn the strength of the correlation feed was inverse and strong. The average strength of the correlation of temperature with ozone was more than humidity throughout the year, with the strength of the correlation of heat with ozone in the summer (0.57 -), in winter (0.58 -), in autumn (0.73-) and in spring (0.11).

1 Introduction

The ozone layer plays a vital role in protecting our planet, absorbing about 90% of harmful rays, as the ozone layer is concentrated in the lower part of the stratosphere [1], at an altitude of 10 to 50 kilometers, the thickness of the ozone layer varies depending on the seasons and geographical location, as it is a protective shield that protects the planet from

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harmful ultraviolet radiation. With the increase in climatic changes, understanding the factors affecting the thickness of this layer has become extremely important. This research aims to study the influence of basic climatic elements, such as specific heat and humidity, on the thickness of the ozone layer, using the latest available technologies in the field of remote sensing and geographic information systems [2]. This research will contribute to enhancing our understanding of the complex interactions between the climate and the ozone layer, helping to develop better strategies for Environmental Protection. Therefore, stratospheric ozone plays a pivotal role in understanding the physical and chemical processes occurring in the atmosphere, studies have well documented the depletion of stratospheric ozone since the seventies of the last century, and this was directly related to human activities. These studies were based on the analysis of aggregate ozone data and ozone characteristic data. Studies conducted in recent years have also shown a sharp decrease in the concentration of ozone over Antarctica during the spring, as a result of human activities. These results were supported by numerous studies based on ground-based measurements and Satellite Data [3]. Studies have shown that the concentration of ozone at ground level is clearly shown by the change of seasons, with the maximum concentration occurring during the spring and low levels during the winter for all the sites studied. Ozone gas also affects the dye used to pollute textiles, and destroys rubber, especially rubber used in the manufacture of automobile tires, the air quality specifications by the US Environmental Protection Agency (EPA) state.

Table 1. The effect of ozone concentration by exposure period.

Ozone concentration in the air ppm	Period of exposure	Influence
0.02	1h	Destruction of substances that include rubber in their composition
0.03	8h	Harmful effects on plants
0.05	1h	Irritation of the nose, throat, dryness of the mucous part of the respiratory tract
0.1	1h	Irritation of the bronchi of the respiratory tract
0.3	(8>)h	Skin irritation
2	2h	Severe cough and chemical changes in the proteins of the lungs
10-5	(1/4)h	Acute inflammation and pulmonary hemorrhage

2 Materials and methods

2.1 Study area

The study included 132 stations in Iraq belonging to the NASA Space Agency from the (Earth data) site [6], where Iraq is located in western Asia, and extends over large parts of the Zagros Mountain range, the Syrian desert and the Arabian Peninsula (Figure (1)). It is characterized by the diversity of its terrain between mountains, plains and deserts, which greatly affects its climate. The climate of Iraq is generally characterized as hot and dry continental, with long hot summers and short cold winters. Temperatures vary greatly between regions, with the highest temperatures recorded in desert areas and the lowest in mountainous areas, and the climate of Iraq is influenced by its diverse geographical location, as it extends over parts of the Zagros Mountain range and the surrounding deserts. While mountainous areas have a relatively mild climate, desert areas suffer from extreme heat and prolonged drought [4].

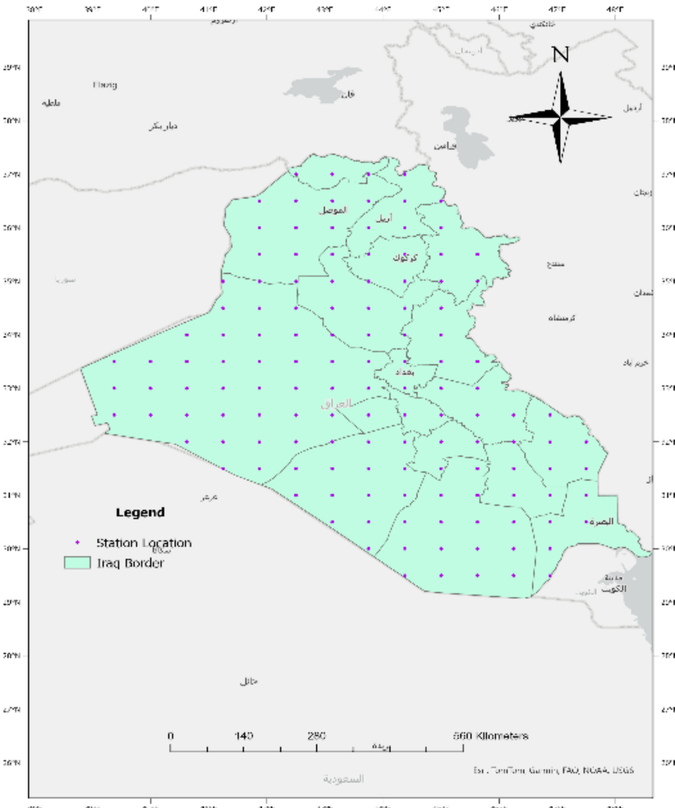

Fig. 1. 132 station sites in Iraq (2024).

2.2 Methodology and data collection

The research focuses on studying the difference in the spatial distribution of ozone gas in Iraq and its relationship with heat and Specific humidity using remote sensing techniques and geographic information systems, where the IDW algorithm was used one of the ArcGIS Pro techniques [5], through which predictive maps were created showing ozone depletion for four seasons and then a statistical analysis was conducted to understand and clarify the relationship between:

1. Acquiring ozone, temperature and Specific humidity data through satellites for the NASA Earth data website [6].

2. The stage of entering and processing ozone, temperature and Specific humidity data in ARC GIS pro by projecting data with their locations in the form of points (point) without relying on latitude and longitude data with Metric accuracy using the program GIS pro. As shown in Figure (2) and Table (1).

Table 2. Sample Virtualization station data for ozone, temperature and specific humidity.

FID	Lon	Lat	Total ozone (Dobson) 2024	Temperature (Kelvin) 2024	Humidity 2024
0	44.38	30	263.509	280.848	0.005628
1	45	30	263.97	282.204	0.005241
2	45.63	30	264.376	283.169	0.004862
3	46.25	30	264.548	282.966	0.0047

Continuation of Table 2.

FID	Lon	Lat	Total ozone (Dobson) 2024	Temperature (Kelvin) 2024	Humidity 2024
4	46.88	30	264.611	282.001	0.004637
5	43.75	30	264.759	280.282	0.005388
6	44.38	30	265.427	281.493	0.004991
7	45	30	265.622	283.239	0.004772
8	45.63	30	265.739	283.329	0.004774
9	46.25	30	265.927	282.38	0.004759
10	46.88	30	266.267	281.762	0.004837
11	43.13	31	268.521	280.118	0.0054
12	43.75	31	267.837	280.637	0.004906
13	44.38	31	267.904	282.634	0.004648
14	45	31	268.234	283.341	0.00469
15	45.63	31	268.335	282.614	0.004887
16	46.25	31	268.279	282.052	0.004936
17	46.88	31	268.249	281.466	0.005108
18	47.5	31	268.751	281.88	0.005165
19	42.5	31	272.642	279.942	0.00552
20	43.13	31	271.54	279.95	0.005358
21	43.75	31	271.267	281.016	0.004814
22	44.38	31	271.53	282.977	0.004688
23	45	31	271.579	282.755	0.004871
24	45.63	31	272.091	281.876	0.005062
25	46.25	31	271.952	281.528	0.004969

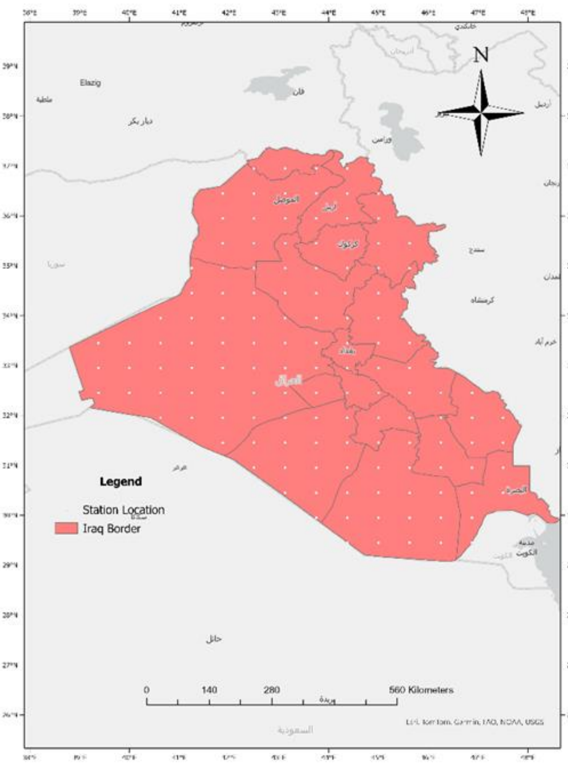

Fig. 2. Virtualization station data for ozone, temperature and specific humidity (2024).

3.The inclusion of the four-month quarterly data (January, April, July, November) representing the four quarters.

4. Using the IDW algorithm within the interpolation completion tools of the Arc GIS pro program to predict the pattern of ozone gas distribution and its relationship to the relative temperature and humidity for a year 2024.

5. Work on the analysis of layers resulting from the application of the algorithm (IDW) To estimate an unknown value at a given point based on known values of other neighboring points [7, 8].

6. Using the statistical program SPSS (Version 26) to understand the type of relationship of climatic elements with ozone gas by using the regression coefficient to clarify the relationship and the strength of the correlation (R-squared) is a statistical measure used in regression analysis to evaluate the quality of the model created. Simply put, R-squared refers to the percentage of variance in the dependent variable that can be explained by the independent variables in the model.

3 Results and discussion

The distribution of ozone gas is associated with many climatic elements, the most important of which are heat and humidity, and the effect varies from season to season, and in the recent period, sensitive devices have been used to monitor the concentration of ozone gas [9, 10]. It turned out that air pollution is not limited to environments only, but extended at regional levels, Where ArcGIS PRO v 0.3 was used in order to model all these variables to predict ozone depletion and influential climatic elements, which is considered one of the variables that cause ozone depletion, and since the aim of the research is to find out the relationship between ozone and climatic elements and their impact, and:

3.1 The behavior of ozone gas distribution at the study stations

Figure (3,4) show the behavior of ozone distribution during the year 2024 at the study stations from NASA data. Which represents the ozone change during four seasons, where it was noted that the ozone percentage is always higher in northern Iraq and begins to decline in the center and then the south, where the standard deviation rate of ozone concentration in the winter was (16.6) Dobson unit in the whole of Iraq, this means that there is a large variation in the thickness of the ozone layer may be the result of natural factors, as for the less concentrated governorates (Muthanna, Basra, Nasiriyah) and the more concentrated governorates (Duhok, Erbil , Nineveh).The standard deviation rate of ozone concentration in the autumn was in the Dobson unit in the whole of Iraq and this indicates the variation of ozone distribution is average compared to other seasons and this is due to the relative stability in weather conditions and the least concentrated governorates are (Muthanna , Basra, Nasiriyah) and the highest concentrated governorates (Nineveh , Dohuk , Erbil), and the standard deviation rate of ozone concentration in the summer (3.6) in the Dobson unit in the whole of Iraq and this indicates the variation of ozone distribution is low compared to this is due to the weather conditions , and the least concentrated governorates are (Muthanna , Najaf , Basra) and the most concentrated governorates (Nineveh , Dohuk , Erbil) , The standard deviation rate of ozone concentration in the spring was (6.81) in the Dobson unit throughout Iraq, and this indicates the variation in the distribution of ozone is average compared to other seasons, and this is due to the relative stability in weather conditions , and the least concentrated governorates are (Karbala , Anbar , Babylon) and the most concentrated governorates (Basra, Muthanna, Duhok).

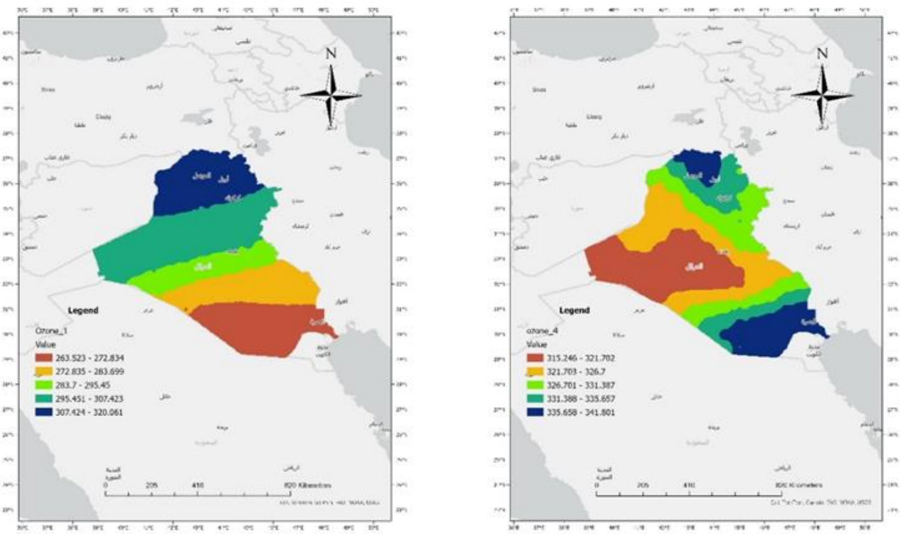

Fig. 3**.** Layer thickness Ozone data for January and April.

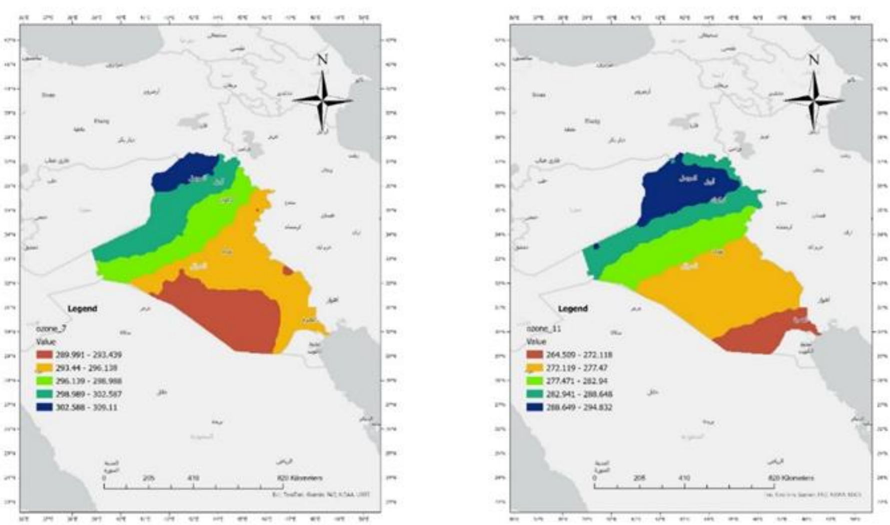

Fig. 4. Layer thickness Ozone data for July and November.

3.2 The behavior of the distribution of temperature and relative humidity at the study stations

The temperature was based on an altitude of 2 meters from the Earth's surface and the relative humidity at an altitude of 10 meters from the Earth's surface, where the highest temperature in the summer was the average rate of (302.03) Kelvin and the average autumn temperature (289.8) Kelvin and spring (287.04) Kelvin and the lowest average temperature in Iraq was in winter at (280.03) Kelvin as shown in Figure (5) and where the relative humidity in summer and spring was higher in southern and central Iraq while in winter and autumn were higher in western Iraq as shown in Table 2,3 and Figure (6). Figures (7-12) show humidity data and temperature/humidity regression coefficient on each season.

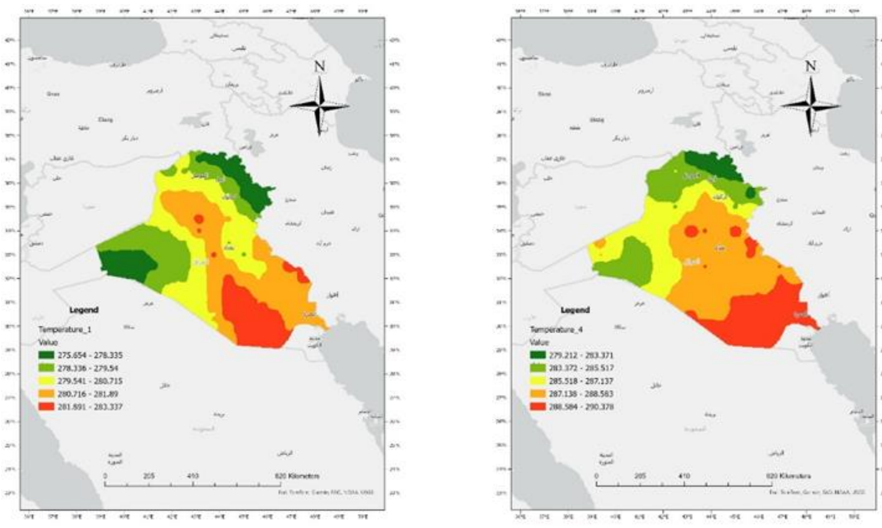

Fig. 5. Temperature data for January and April 2024.

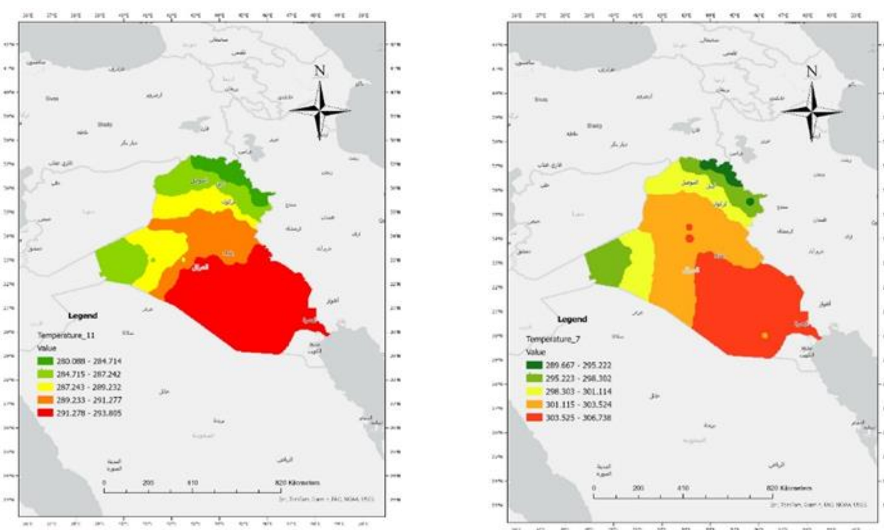

Fig. 6. Temperature data for November and July 2024.

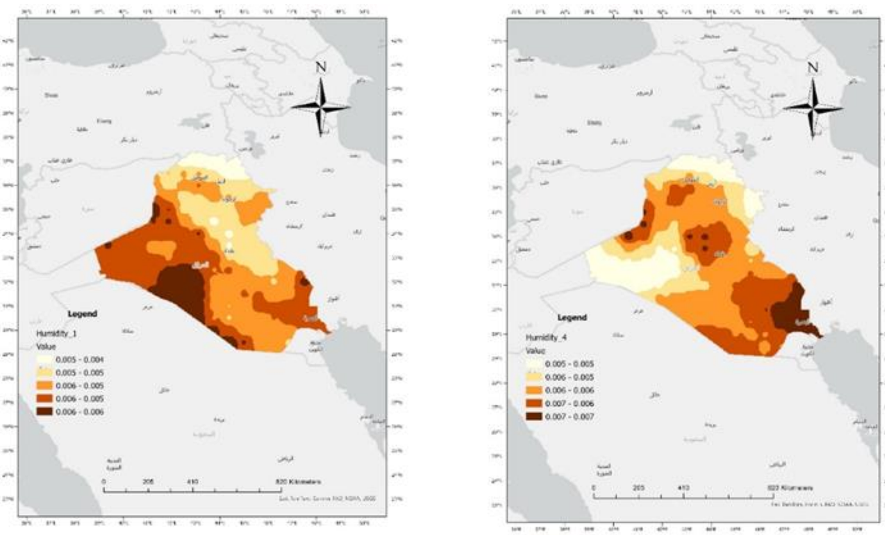

Fig. 7. Specific humidity data for January and April 2024

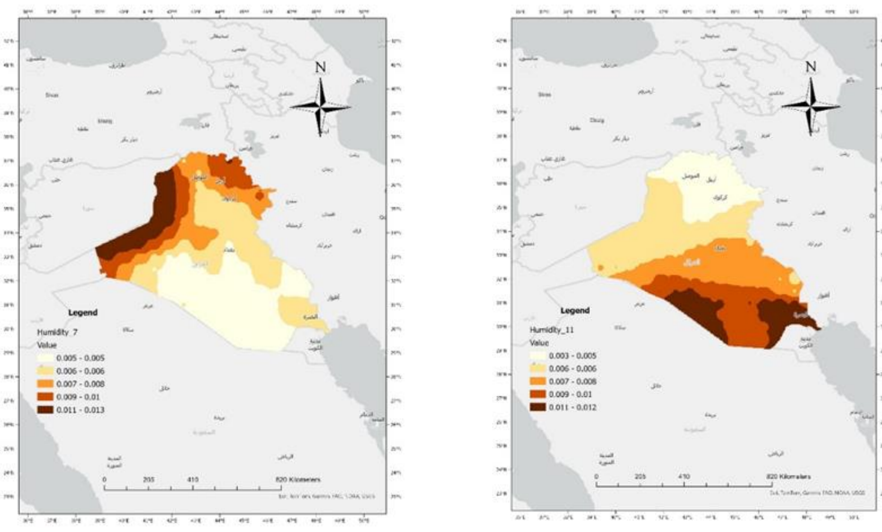

Fig. 8. Specific humidity data for November and July 2024.

3.3 Statistical analysis

Using statistical analysis to find out the strength and type of relationship of the two variables temperature and relative humidity to ozone using statistical tools in the SPSS (Version 26) program shows the following:

Winter: the relationship was the inverse of temperature, humidity and the presence of a strong correlation factor.

Summer: the relationship was inverse to temperature and humidity and the presence of a correlation factor between them.

Spring: the relationship was a function of temperature, humidity and the presence of a weak correlation factor.

Autumn term: the relationship was inverse to temperature, humidity and the presence of a strong correlation factor.

Table 3. A table showing the relationship of the climatic elements of the four seasons with ozone.

Season	Correlation Temperature (2024)	Correlation Humidity (2024)
Winter	-0.5788	-0.384
Summer	-.58.8	0.28
Spring	0.11	0.28
Autumn	-0.73	-0.79

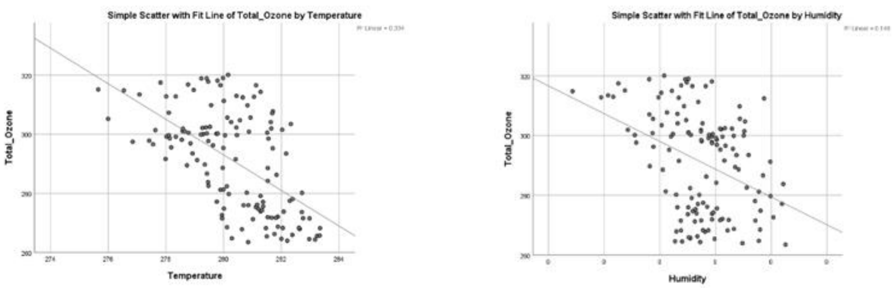

Fig. 9. Winter temperature and humidity regression coefficient (2024).

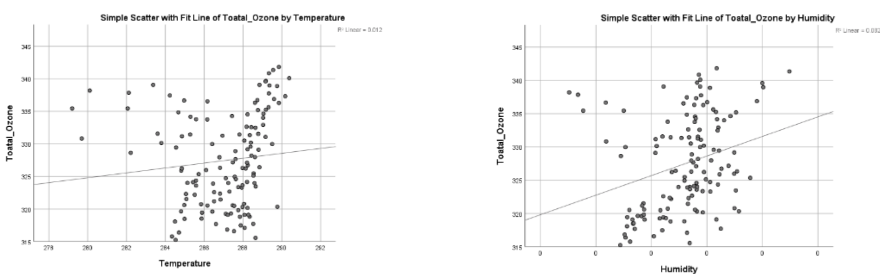

Fig. 10. Spring temperature and humidity regression coefficient (2024).

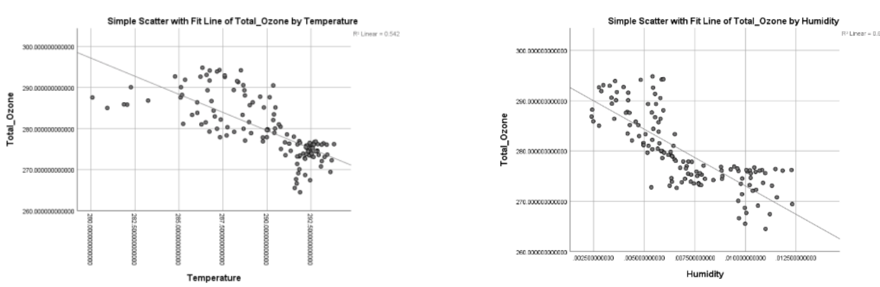

Fig. 11. Autumn temperature and humidity regression coefficient (2024).

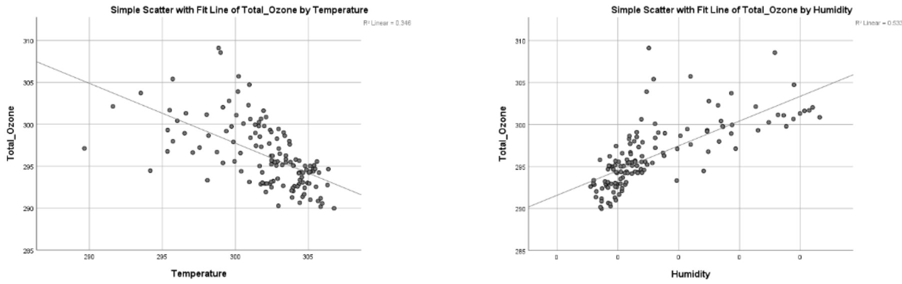

Fig. 12. Summer temperature and humidity regression coefficient (2024).

4 Conclusion

The study showed that the concentration of stratospheric ozone at the ground ozone level is clearly shown by the variability of the four seasons, with the maximum concentration occurring during the spring and a noticeable decrease in summer for all studied sites, which means that high temperature and humidity are responsible for the formation of high ozone concentrations .This study proved that stratospheric ozone values are high during the temperate seasons of ozone gas many climatic influences, and it turned out that these two variables temperature and relative humidity have an important active role and are associated with ozone throughout the seasons, where there is a relationship between the two variables humidity and temperature with ozone gas values, after conducting an analysis. Statistically, it was found that ozone is most concentrated in the spring and least concentrated in the Winter (Spring> Summer> Autumn >Winter).

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