Studying the Effect of Aerosols on Air Temperature in Basra City

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Abstract

In research we study the effect of Aerosols that created in the atmosphere from natural or anthropogenic origin which represent a very large diversity in size and chemical composition. Aerosol has significant environmental, health and climatic effects that affect the balance of earth radiation and the quantity of radiation arrival the Earth's surface, as well as its indirect effect in the process of nucleation and formation of clouds. The variation in the temperature and Aerosol optical depth (AOD) of Basra for the period 2003-2015 was analyzed and then the relationship between them was established using the MODIS sensor for the Aqua satellite. The highest average value of seasonal AOD was recorded in spring and summer, with the maximum values at (0.43-0.46), while the lowest values were (0.33-0.34) in the winter and autumn. The results showed that Diurnal Temperature Range (DTR), maximum, minimum, and mean air temperature are correlated with AOD strongly.

Keywords: Aerosols, Air Temperature, and Aerosol Optical Depth.

دراسة تأثير الهباء على درجة حرارة الهواء في مدينة البصرة

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الخلاصـــة

درس البحث تأثير الهباء المتكون في الغلاف الجوي والناشئ من مصادر مختلفة اما ذات أصل طبيعي او بشري والمتمثلة بالتنوع الكبير جدا في الحجم والتركيب الكيميائي. للهباء الجوي تأثيرات بيئية، صحية ومناخية كبيرة والتي تؤثر على موازنة الاشعاع الارضي وكمية الاشعاع الواصل الى سطح الارض، بالإضافة الى تأثيره المباشر في عمليات التنويه وتكوين الغيوم. تم تحليل التباين في درجة الحرارة والعمق البصري للهباء الجوي (AOD) في مدينة البصرة للفترة 2003 – 2015 ومن ثم ايجاد العلاقة بينهما، باستخدام المتحسس MODIS للقمر لصناعي Aqua. حيث سجلت اعلى قيمة لمتوسط حسابي AOD الموسمية في فصلي الربيع والشتاء، وكانت تتراوح بين (0.43-0.46)، في حين سجلت أدني القيم في فصلي الشتاء والخريف (0.33 – 0.34). من خلال هذه النتائج بين مدى الارتباط القوي بين مدى درجة الحرارة النهارية (DTR) والعظمى والصغرى ومعدل درجة حرارة الهواء مع (AOD).

الكلمات المفتاحية: الهباء الجوي ودرجة حرارة الهواء والعمق البصري للهباء الجوي.

Introduction

Atmospheric aerosols originate various sources from both natural and anthropogenic origins and present a very large diversity of size and chemical composition (Pavese, *et al*., 2016). Since the past twenty years, increased interest in studying aerosols because of them its great health and environmental effects. The increasing Earth's warming has an impact on the extreme climate changes that the global has faced recently (Patz, *et al*., 2014). Warming of the climate system is unequivocal, and since the 1950s, many of the observed changes are unprecedented over decades to millennia. The atmosphere and ocean have warmed, the amounts of snow and ice have diminished, sea level has risen, and the concentrations of greenhouse gases have increased. (Pachauri, *et al*., 2014). Gases Like (CO_2, N_2O, CH_4, O_3 ... etc.), and several factors that influence the equilibrium of terrestrial radiation, including atmospheric aerosols, which have direct or indirect impact through scattering and absorption that affect percentage of radiation received by the ground as a result it will affect the climate. Aerosols globally level contribute to cooling process of Earth, in contrast to effect of greenhouse gases, Air quality changes depending on type of aerosol released, also serious health hazards responsible for increased levels of small particles, so it is necessary to reduce and determine the relative impact of natural and anthropogenic aerosols accurately. The effects of aerosols on global climate change and human health in long term are difficult to assess because of variation in physical, optical and chemical properties (Pöschl, 2005). Suspended particles (Liquid or solid) are classified as aerosols and have an impact on climate (Makkonen, *et al*., 2012), atmospheric chemical (Meskhidze, *et al*., 2005), atmospheric biogeochemical cycles (Hettiyadura, *et al*., 2017), and health in living organisms, especially human (Janssen, *et al*., 1997). Aerosols in atmosphere are classified into human and natural sources, as well as chemical processes in atmosphere that have a role in formation of aerosols, mineral dust, animal and plant debris, volcanic ash and sea spray are among foundations in production of aerosols (Crutzen and Andreae, 1990). atmospheric aerosols are classified into two categories: natural and anthropogenic (Man-made) aerosols. Natural aerosols are produced naturally from volcanoes, sea spray, sand, or wind driven erosion of surface soil. Anthropogenic aerosols are a result of human activities, such as dust from agricultural activities, smoke from burning biomass and fossil fuels, and photochemical induced smog primarily due to vehicle emissions (Muyimbwa, 2016).

This study attempts to achieve two objectives including study the impact of Aerosol Optical Depth (AOD) on temperature. The first of which gives a detailed overview of the temporal analysis of daily, monthly, seasonal, and annual AOD and temperature values over Basra during the period 2003-2015. The second of which investigates the linear and multiple regression analysis between AOD and temperature variables (Mean, Maximum, and Minimum).

Materials and Methods

The data was recorded in Basra, its geographical location in southern Iraq near Arabian Gulf, longitude 47.78°E and latitude 30.57°N degrees, using MODIS aerosol (AOD) data during 12-year period of 2003-2015, This is evident in Figure (1) (Lisle, *et al*., 2011).

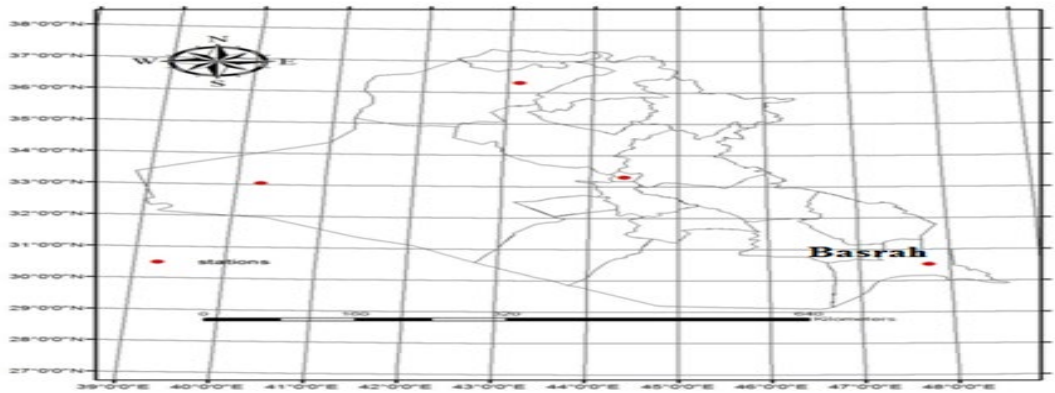

Figure (1) Iraq Map with the City of Basra Illustrated

Physical and Chemical Characterization Size Classification

Atmospheric aerosols are often classified according to their size range or mode. According to the classification, coarse particles generally have a diameter greater than 2.5 μm, below this limit they are referred to as fine aerosols (Yeganeh, *et al*., 2017).

Mineral Dust in the Atmosphere

Mineral dust transported through the atmosphere carries iron-rich minerals that may play a significant role as marine nutrients when deposited into the open ocean. In soil sources, iron is almost insoluble, but its solubility can considerably increase during atmospheric transport. The soluble form of iron is considered a critical parameter for marine bio production (Sholkovitz, *et al*., 2012).

Meteorological Data

Data used in this research is records of previous periods for every day AOD data were obtained from MODIS Satellite, temperatures for period 2003-2015 which included maximum and minimum daily requirements provided by the Iraqi Meteorological and Organization Seismology (IMOS). Data was collected for several years from weather station in Basra. To avoid missing daily data, the study period was chosen for longest possible period according to availability of log data, and data was collected for several years from Basra weather station.

Results and Discussion

In this paper, the characteristics of aerosols in city of Basra were acquired by obtaining MODIS Aqua (AOD) data. Monthly, seasonal, and yearly time differences were analyzed for minimum, maximum and mean air temp., and then analyzed with AOD. Relationship of AOD to temperature in Basra was also studied. Figure (2) depicts time series of AOD daily average.

This data represents a 12-year duration from 2003 - 2015. The total days were 4,290 used with AOD data for analysis. The horizontal black line represents the average of AOD in addition to related standard deviation (AOD) + σ) (0.40 + 0.12 = 0.52) during study period. There are a total of 3,900 days less than 0.52 while 390 days with AOD ≥ 0.52 above horizontal line as we observe in Figure (2).

Monthly and Annual Analysis of AOD and Temperature

A study of relationship of behavior between AOD curve and (Maximum, Minimum and Mean) of air temperature and Diurnal Temperature Range (DTR) temperature, there was a significant relationship and approximately same behavior as shown in Figure (3).

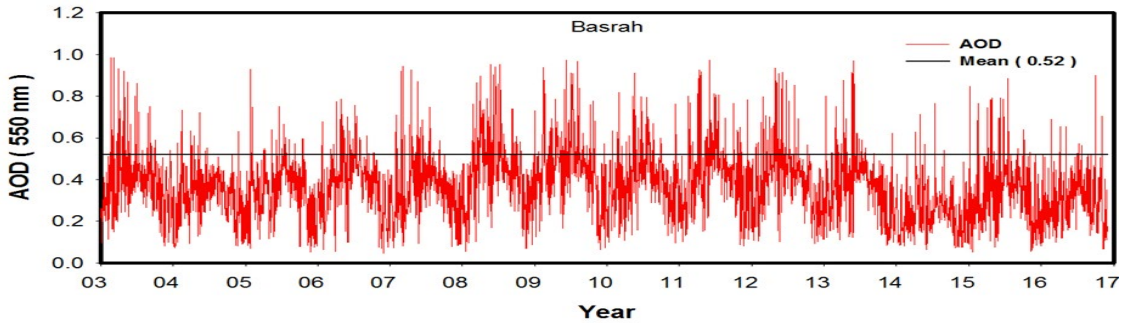

Figure (2) Daily Average of AOD (550 nm) at Basra City During the Period (2003–2015)

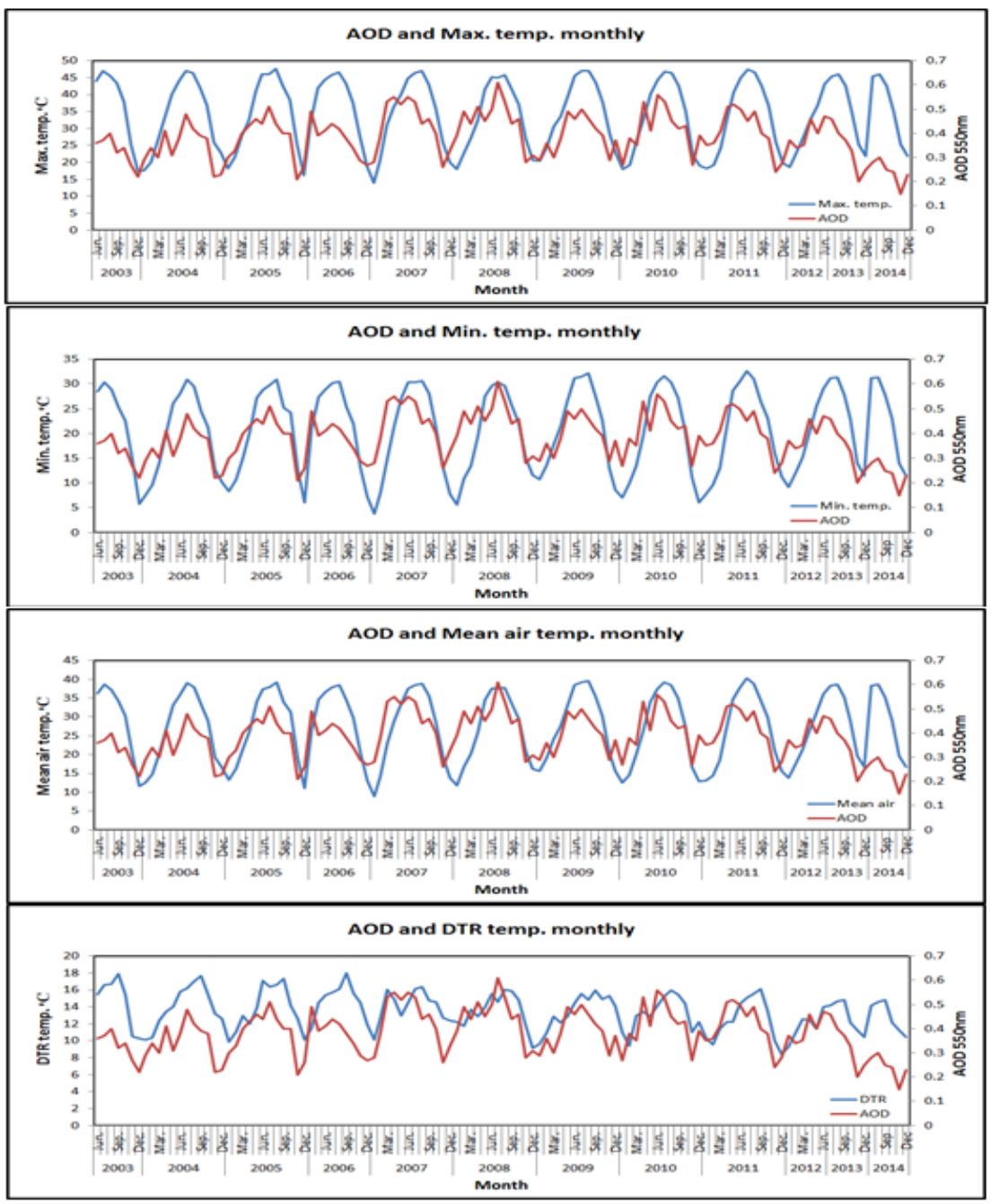

Figure (3) Monthly Averaged Values Variations of AOD and Temperature During (2003 – 2015)

We notice from Figure (4) monthly variation of AOD average, three distinguished peaks were found, the first on February (0.36) the second on April (0.44), and the third in July (0.46). When studying the graph, we notice that monthly averages between (2003-2015) and highest value recorded in July (0.46). Also, AOD distributions are in range of 0.24 to 0.46, represent 65% of total AOD. Curve behaviors AOD There are a significantly correlation between it and (Minimum., Maximum, DTR and Mean Air) temperature. AOD peak rate and (Maximum, Minimum., DTR and mean Air) temp. were observed on July (0.46, 46.34 °C and 30.93 °C), (15.96 °C in August and 38.63 °C in July) correspondingly. Equally, the minimum AOD value was noiced in November (0.24), while the min. value of minimum., maximum., (DTR) and mean air temperature on January were (17.83 °C, 8.05 °C, 9.77 °C and 12.94 °C) respectively, as shown in Figure (5). Also, we notice that AOD and temperature values are in the same direction of variance, decreasing from August to December and increasing from January to July.

Seasonal Analysis of AOD and Temperature

Seasonal mean value from (AOD, minimum, maximum, and DTR) temperature were illustrated in Figure (6), low seasonality mean AOD is about (0.33 – 0.34) was observed on winter. While maximum AOD value was observed through spring and summer and seasonality mean from (0.43 – 0.46) respectively.

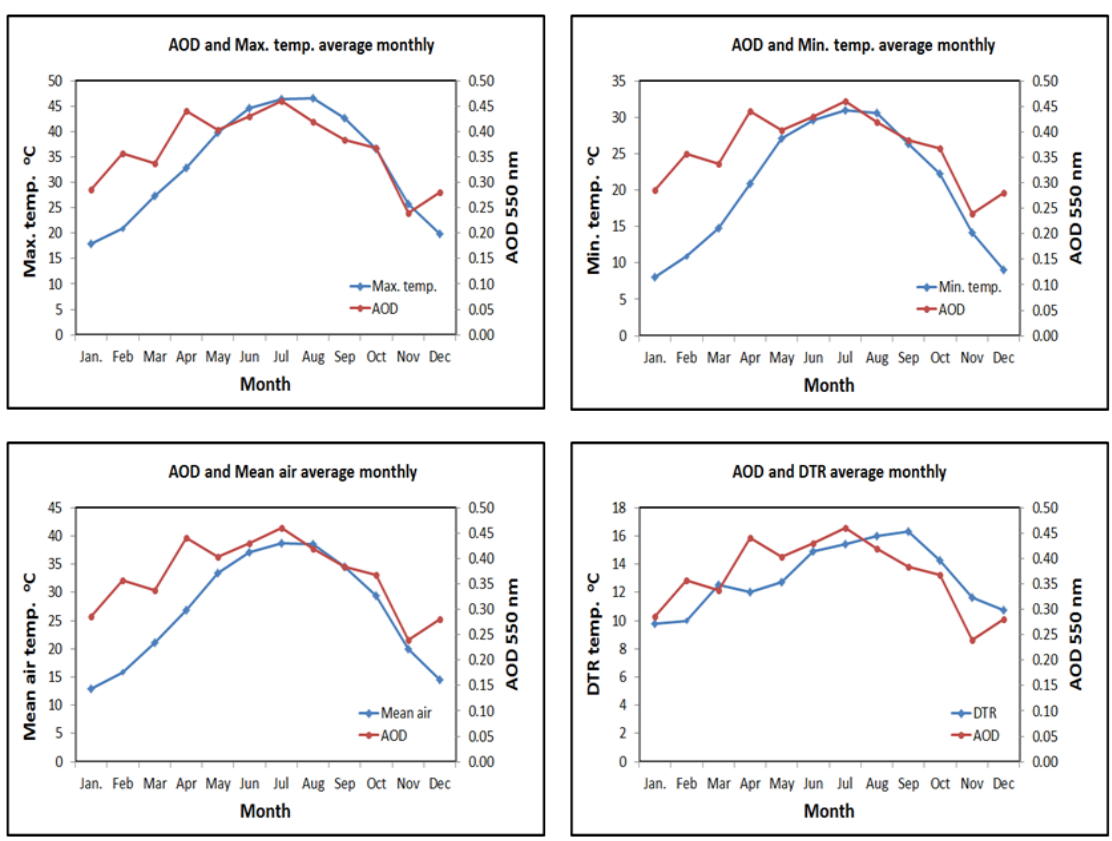

Figure (4) Monthly Means of AOD and Temperature for Period (2003- 2015) for Basra City

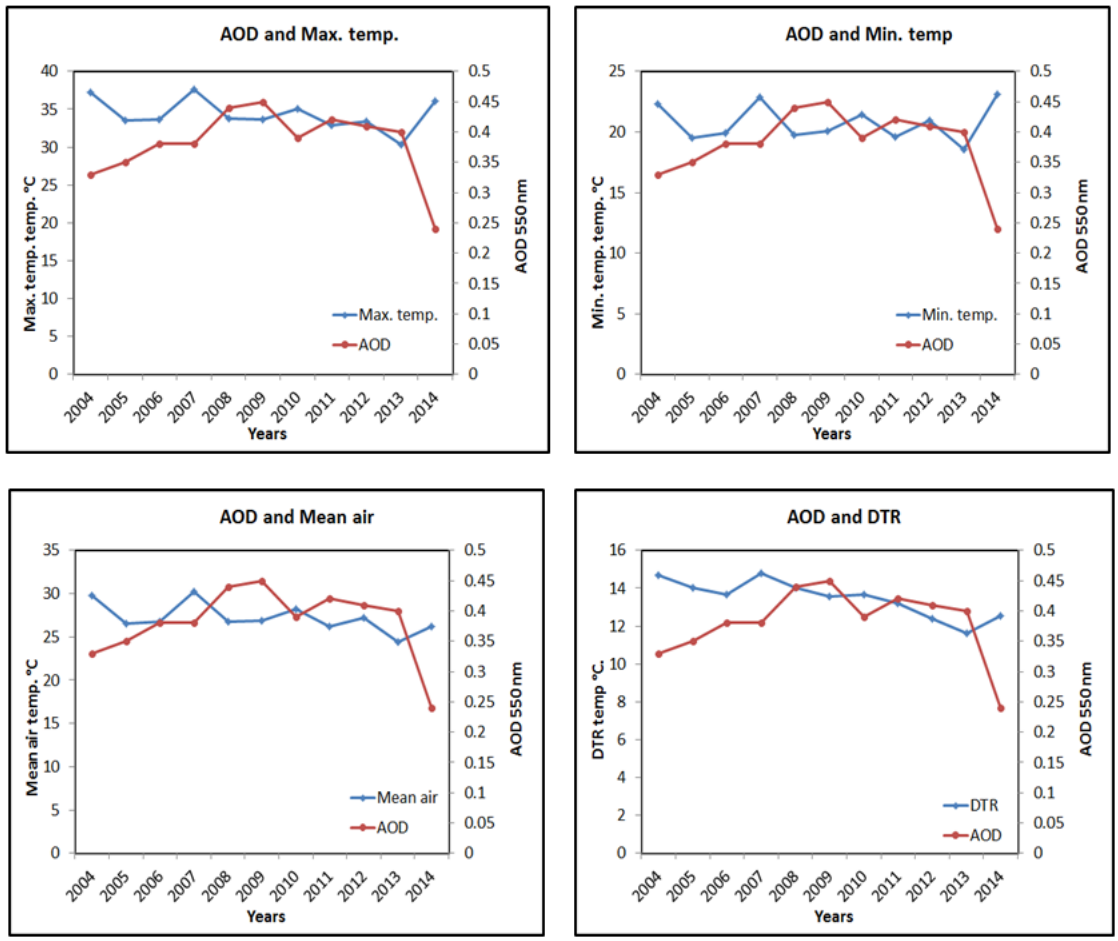

Figure (5) Mean Annual Variations Temperature and AOD During (2003 – 2015)

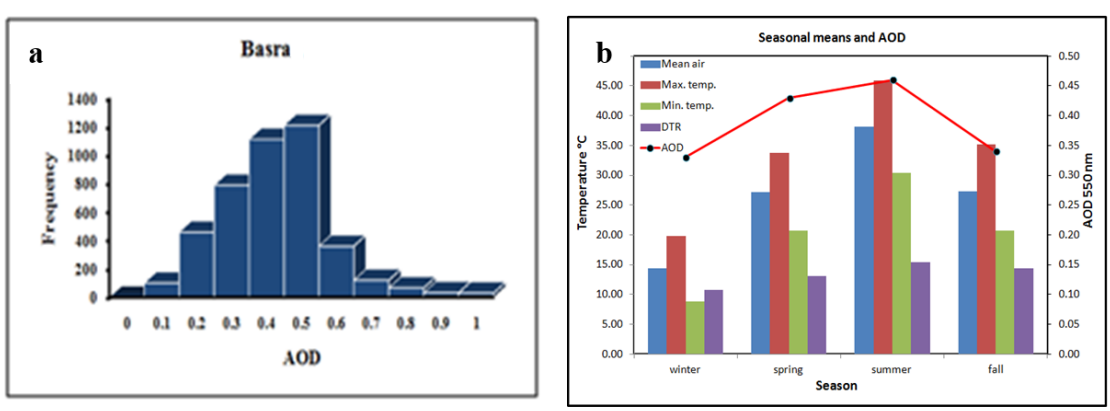

Figure (6) (a) Frequency Distributions and (b) Seasonal Means of AOD and Temperature during the Period (2003 – 2015) for Basra City

The reason for this, arid and semi-arid areas and less rain was the result of drought. Therefore, the increase in wind speed has a great role in moving dust from surface of earth therefore large amounts of aerosols lifted up the height of the boundary layer. Moreover, we notice that the boundary layer height decreases through the winter and thus amount of pollutants decreases, different what we observe through summer season. From Figure (6) we can notice higher value of the maximum and accurate temperature in air and DTR temperature.

Correlation between AOD and Temperature (°C)

The correlation between (Minimum, Maximum and Mean Air) Temp., AOD and DTR of Basra city were well as analyzing, appeared in Figure (7). Correlation for each of DTR and AOD is r = 0.47 whilst for each of AOD with max. Temp. is r = 0.60 whereas for each of AOD and min. temp. r = 0.60, mean air Temp. r= 0.60.

Multiple Regression Analysis between AOD and Temperature

From the previous sections, we conclude that the AOD is correlated to all three variables considered, mean temperature, max. temperature and min. temperature. For further analysis regarding the impact of each of these factors, the multiple linear regression methods to generate the linear regressions equations using monthly data has been done. The regression in terms of β was used to generate the AOD regression equation for data from the entire period in the study area formula is given as follows:

$$AOD=\beta o+\beta mean+\beta max+\beta min$$

Where:
βo is constant of the regression equation.
βmean is the mean temperature constant.
βmax is the max temperature constant.
βmin is the min temperature constant.

The correlation coefficient R obtained from the determination coefficient R2 between AOD and temperature were having positive linear correlations between AOD and the temperature. The correlation coefficient ranging from 0.35 to 0.22, however, in general the relationship between the AOD and (mean, max and min) temperature show a good relationship for the time scale of monthly, however, the high value of correlation was the correlation between AOD and mean temperature (0.35).

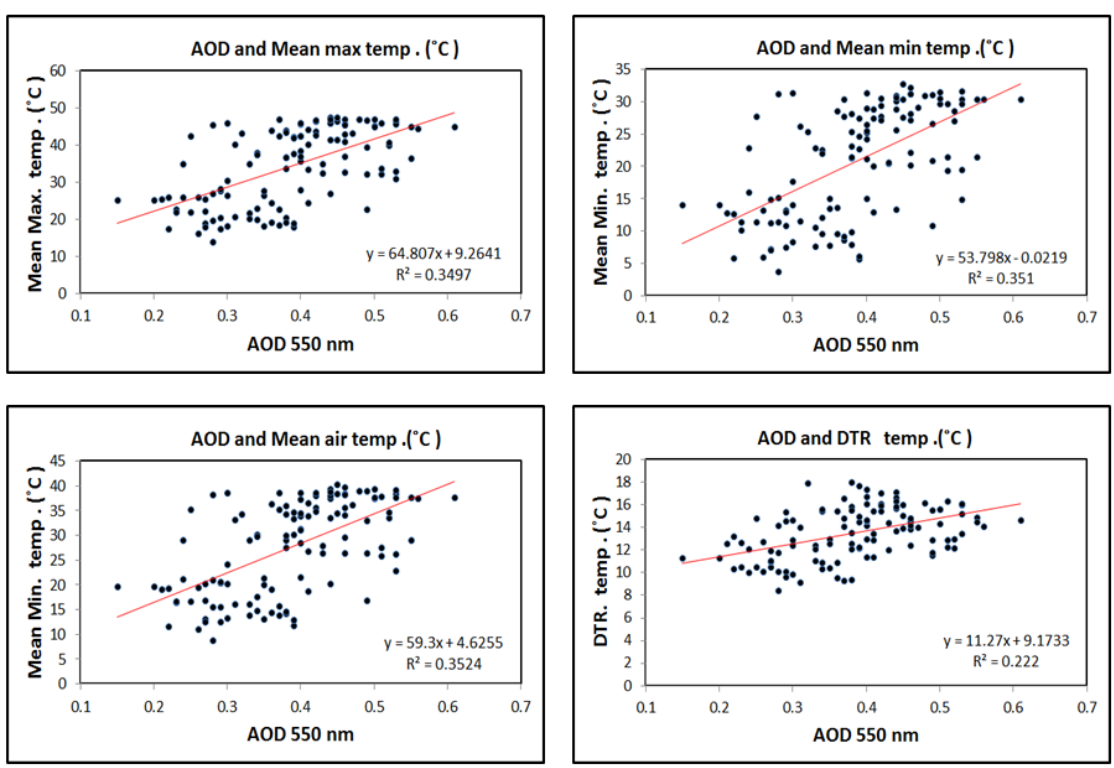

Figure (7) Linear Correlation Monthly to AOD, DTR, Maximum Temperature and Minimum Temperature for Basra City

Table (1) Statistical Analysis for Basra City

Variables	Mean Temp. (°C)	Max Temp. (°C)	Min Temp. (°C)	AOD
Mean Temp. (°C)	1.000	0.969	0.963	0.739
Max Temp. (°C)	0.969	1.000	0.957	0.725
Min Temp. (°C)	0.963	0.957	1.000	0.716
AOD	0.739	0.725	0.716	1.000

The multiple regression analysis conferred a good relationship between AOD and the three selected temperature parameters,

AOD=0.134 + 0.009*Mean + 0.002*Max + 0.00014*Min

Basra city with a correlation coefficient (R = 0.74) show in Table (1).

Conclusions

The climate data for studying area (Basra) for period 2003-2015 was studied in this research. Seasonal and annual fluctuations in aerosols (AOD) and their relationship with temp. (Minimum, Maximum, Average Air and DTR) were observed, while lowest AOD was found during winter and fall. There is a strong correlation between aerosols and temperature, which indicates that aerosols could have a supportable effect on Basra climate.

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