Effect of Nitrogen Oxides on Short Wave Solar Radiation in Atmosphere for Selected Iraqi Stations

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Abstract. It is known that the incoming solar radiation is subject to interaction with the components of the Earth's atmosphere. This reaction is expressed by the mechanisms of absorption, scattering, and reflection. The occurrence of each mechanism depends on the size of the particles about the wavelength of the incoming radiation. The study of the interaction of solar radiation with atmospheric components, including aerosols, has attracted long scientific interest; this interaction is associated with climate change issues. Among the components in the atmosphere, attention was paid to human-derived nitrogen dioxide (NO₂) in the troposphere, as it was found that anthropogenic aerosols play an important role in its interaction with incoming solar radiation. For this reason, the behavior of Nitrogen Oxides gas has been studied with the elements of solar radiation to know the effect of Nitrogen Oxides gas on shortwave solar radiation (Surface net solar radiation (SSR) Surface net solar radiation, clear sky (SSRC) Surface solar radiation downwards (SSRD) TOA incident solar radiation (TISR) Top net solar radiation (TSR)) by using data the European Center for Medium-Range Weather Forecasts (ECMWF) as the monthly mean at the time (midnight) for ten years (2009 - 2018) over selected stations in Iraq (Mosul, Baghdad, Basra).

Keywords: Greenhouse gas, Nitrogen Oxides, Shortwave Solar Radiation, Global Warming, Iraq.

1. Introduction

The sun is a major star in the solar system, it is 4.5 billion years old. The luminosity of the sun increased by about 30%, the rate of ultraviolet radiation decreased and decreased, as the sun's rotation rate became slower and its magnetic activity decreased. It indirectly affects the climate through greenhouse gas concentrations.[1] Solar radiation is electromagnetic radiation that is divided into long wave (thermal) radiation, visible radiation (light), and short wave radiation.[2] Short wave radiation from the sun enters the atmosphere [3]. Where it is affected by the ozone gas that absorbs part of the solar radiation energy (ultraviolet radiation) and then releases thermal energy (longwave radiation)[4]. Where it is affected by atmospheric gases that absorb part of the solar radiation, including nitrogen oxides gas NOx, where nitrogen oxide refers to gaseous nitrogen compounds that consist of combining nitrogen with oxygen under high temperatures, as is the case when fuel is combusted in furnaces or transport and other and the most important of these NO2 nitrogen dioxide compounds[5]. About 70% of nitrogen oxides in the atmosphere are produced from fuel combustion inside cars, and the rest from various industries, power plants and others[6]. Nitrogen oxides, especially nitrogen dioxide, absorb visible solar rays, and when the concentration of nitrogen dioxide in the air reaches 0.25 ppm, it causes a decrease in the range of vision[7]. The effect of nitrogen dioxide on human health varies according to its concentration and exposure period[8].
When its concentration reaches 3 parts per million, the person begins to have an effect, as it causes irritation of the nose and the eye, by irritating the mucous membranes of the respiratory tract, causing lung damage, and causing irritation of the mucous membranes of the eye, and damage to the ozone layer is caused by acid rain[9].

2. Study Stations
Iraq is one of the countries of the Asian continent located in the southwest of the continent, where it is located between longitude (38-49)°E and latitude (28-38)°N, terrain surrounded by northern and northeastern mountain ranges, in the west of the highlands and the center and south of the sedimentary plain. As shown in Table 1 and Figure 1.

3. Data Acquisition and Methodology
The study was conducted for a period of 10 years (2009-2018) to know the behavior of the vertical change of ozone and short-wave solar radiation and analyze the relationship between them, where we chose three stations (Mosul, Baghdad, and Basra) [10].

4. Results and Discussion
4.1. The Monthly Change of Shortwave Solar radiation
The change in short wave solar irradiance in monthly averages is low on January 1 and rises to its highest value on June 6. After that, it drops to its lowest value in the 12th month in December. This difference is due to the axis of rotation of the earth around the sun and because of the oscillation. We also note that its highest value is in Basra station, which is located at low latitudes and decreases with high latitudes, as in Baghdad and Mosul stations. As shown in Figure 2.

| Stations | Longitude(°E) | Latitude(°N) | Sea Level Altitude (Meter) |
|----------|---------------|--------------|---------------------------|
| Mosul    | 43            | 36           | 223                       |
| Baghdad  | 44            | 33           | 34                        |
| Basra    | 47            | 30.5         | 5                         |
4.2. Monthly change of nitrogen oxides
The amount of nitrogen oxides (NOx) gases is higher in the Baghdad station and less in the Mosul station. This is due to human activity resulting from the factories, oil fields and refineries, and car exhaust, where the proportion of nitrogen oxides (NOx) gases is higher in the winter season and less in the summer and that is in the two stations of Mosul and Baghdad while the opposite is at the Basra station. As shown in Figure 3.

Figure 2. The monthly mean of shortwave solar radiation in (Baghdad, Basra, Mosul) Iraq.

Figure 3. The monthly mean of nitrogen oxides in (Baghdad, Basra, Mosul) Iraq.
4.3. The Yearly Change of Shortwave Solar radiation

The change in the values of short wave solar irradiance is greater at lower latitudes and less at higher latitudes as shown in Figure 4.

Figure 4. The yearly mean of shortwave solar radiation in (Baghdad, Basra, Mosul) Iraq.
4.4. The Yearly Change of Nitrogen Oxides
The amount of nitrogen oxides varies during the ten years (2009-2018), as it increases in 2013, decreases in 2015, and returns in 2017. The highest percentage is in Baghdad station. As shown in Figure 5.

![Graph of Nitrogen Oxides](image1)

Figure 5. The yearly mean of nitrogen oxides in (Baghdad, Basra, Mosul) Iraq.

4.5. Analysis of the Monthly Mean of Short wave Solar Radiation with Nitrogen Oxides
The vertical distribution is the weight of the vertical nitrogen oxides (NOx) gases at Baghdad and Mosul stations contrasted in Basra. As shown in Figure 6.
5. Conclusions

- Mathematical and statistical relationships were made to clarify the ratio between ozone and short wave radiation.
- We conclude that the highest value of short wave radiation is located in Basra station, which is located at low latitudes (southern Iraq), and that the lowest value is in Mosul station, which is located at high latitudes in Iraq (northern Iraq). The highest value of short wave solar irradiance is in June and the lowest in December.
- The monthly distribution shows the significant spatial differences of nitrogen oxides over the study area and the seasonal fluctuations that depend on the terrain, weather conditions, and human activity. High concentrations were found mainly at Baghdad Station in January. The minimum values were found during July, especially in Mosul and Basra stations. The large difference in the nitrogen oxide mixing ratio values is due to the different effects, including the variation in meteorological conditions as well as the NOx generation sources.
- The relationship between ozone and radiation is an unstable relationship due to changes in the values of solar irradiance (short wave radiation) and a change in the vertical axis of nitrogen oxides.

Figure 6. Analysis of the monthly rate of short wave solar radiation with nitrogen oxides in (Baghdad, Basra, Mosul) Iraq.
Acknowledgements
An acknowledgment to the European Center Medium Weather Forecasts (ECMWF) on the data used in this study, and we would also like to thanks Mustansiriyah university for providing scientific support to accomplishing this research.

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