Journal of Engineering and Sustainable Development

Vol. 23, No.02, March 2019
ISSN 2520-0917
https://doi.org/10.31272/jeasd.23.2.2

TEMPORAL AND SPATIAL ASSESSMENTS OF CARBON MONOXIDE COLUMNS OVER IRAQ USING ECMWF DATASET

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Abstract :Carbon monoxide (CO) is the poisonous gas of a potential health hazard. Since the continuous measurements of this unsafe gas are not available in Iraq, this research is an attempt to study the distribution of columns gas over Iraq. The data which used in this study is Total Column of Carbon Monoxide (TCCO) in unit kilogram per square meter from European Centre for Medium-Range Weather Forecasts (ECMWF). Data are representative of all Iraqi areas and the surrounding regions. The study area consists of 961 grid points. MATLAB program was used to calculate and plot spatial analysis data. The analyzed data of the southern and the middle parts of Iraq (Baghdad and Basra) were in consistence with the general seasonal cycle of TCCO in the Northern Hemisphere. They exhibit a significant enhancement in winter and spring and small values of TCCO in summer. The typical seasonal TCCO variations over the Rutba station are less noticeable, where there is an obvious decrease in TCCO in all seasons. This remarkable feature suggests that the Mosul and Rutba stations may be blanketed by regional pollution, while Basra area (South Baghdad and Iraq region) may be influenced by TCCO plumes transported either vertically or horizontally, which can be considered industry region or from biomass burning.

Keywords: *Total Carbon Monoxide Columns TCCO, Air pollution, Environment, ECMWF Dataset.*

1. Introduction

The monoxide gas CO, is a pollutant gas emitted into the troposphere due to incomplete combustion processes, chemical production and photochemical oxidation of CH_4 and non-methane hydrocarbons [1,2]. Global direct emissions of CO are dominated by relatively stable anthropogenic emissions (500–600 Tg yr−1) and by biomass burning with significant inter-annual variability (300–600 Tg yr−1) [3,4].

The main sink of CO is oxidation by hydroxide ion which lasts two months mean lifetime. Because of this relatively short lifetime, CO is not homogeneous in the troposphere [5].

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Carbon oxide has a poisonous effect on a human health. CO molecules pass easily into the bloodstream and ruin the red blood cells [6]. Deadly CO concentrations relates to amounts greater than 1000 parts per million (ppm) by volume [7]. Since it is not irritating and has no color, odor, or taste, humans cannot distinguish it and need suitable detection devices. This makes CO among the many issues in the focus of interest of scientists and environment and health management officials. Many studies dealt with National Ambient Air Quality Standards (NAAQS) that estimate the acceptable limits of CO exposure. In 1985, EPA (Environmental Protection Agency) rescinded the secondary standard for CO, but retained two primary standards: 9 ppm about (10 mg/m^3) as average of eight-hour and 35 ppm about (40 mg/m^3) as average of one hour. The NAAQS for CO are designed to keep CO-Hemoglobin levels below 2% in the blood of the healthy children and adults. Additionally, in relating to greenhouse effect, it was found that CO is a vital indirect greenhouse gas that may affect the global climate [8]. Also, CO can be considered as a useful means to trace the tropospheric transport processes and plumes [9].

NASA's Terra satellite with the aid of measurements of pollution in the troposphere (MOPITT) instrument offers good monitoring of CO in the troposphere in record starting from 2000 up to now. These records allow for more investigations on the variability of tropospheric CO air quality [10].

Our study aims to address the general features of the overall column CO loading over Iraq using ECMWF data from 2003 to 2013. The major source contributions of CO and their impacts on temporal and spatial variability will be examined through the use of ECMWF that used Moderate Resolution Imaging Spectrora Diometer (MODIS) sensors.

2. Data and location

Air pollutant concentrations can be expressed either as part per million (ppm) or as milligrams per cubic meter (mg/m^3). In this study the selected data represented by the total column of carbon monoxide by Kilogram or gram $/m^2$ units. The collected data covered all Iraqi cities as a grid of nine hundred and sixty-one points which fall within the latitudes (25^o-40^o) N and longitudes (35^o- 50^o) E, with a uniform grid interval of 0.5 degree latitudes-longitudes (≈25 kilometers) (see Fig. 1). Time period of study extended from 1st January 2003 to 31th December 2013 with intervals of three hours (00, 03, 06, 09,12,15,18 and 21) UTC (time universal coordinate). Total Column of Carbon monoxide (TCCO) data were taken from European Centre for Medium-Range Weather Forecasts (ECMWF) [11].

In this paper, the TCCO data were taken from MACC project model operated by ECMWF to study the TCCO patterns over Iraq. The work was divided into two parts temporal analysis and spatial analysis. The temporal analysis represents the temperate trend of TCCO (from 2003-2014) in selected locations in Iraq as follows (Mosul, Basra, Rutba and Baghdad). The spatial analysis represents the mean spatial distribution of hourly, monthly and seasonally maximum and minimum values of TCCO over Iraq and nearby surroundings.

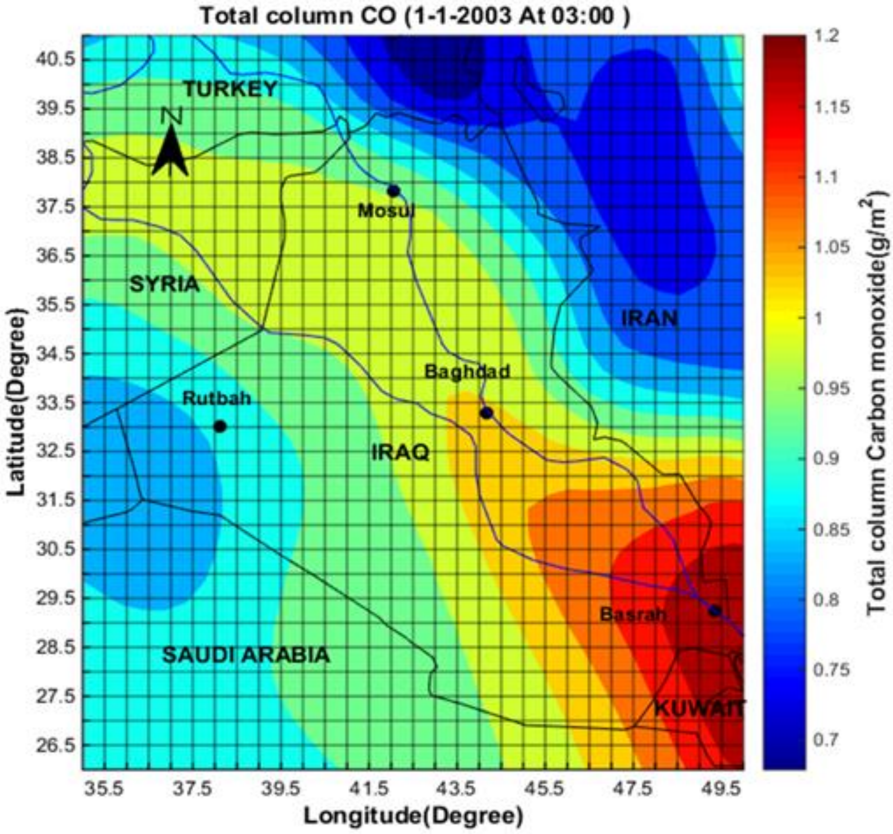

Figure 1:CO distribution for Iraq at 03:00AM on 1 Jan 2003.

3. Results and Discussion

3.1 Hourly Temporal Variability of TCCO

Hourly time series of TCCO data is analyzed at four locations in Iraq: Baghdad (44.5^0-33.5^0), Mosul (43.15^0-36.31^0), Basra (48^0-30.5^0) and Rutba (44.5^0-33^0). From the analysis of hourly TCCO data at three hour increments (00.00-21.00) UTC, it was found that all stations have a waveform behavior in Winter (Dec., Jan., and Feb.) and Autumn (Sep., Oct., and Nov) as shown in Fig. 2. In the other months there was a significant increase of TCCO data (Spring and Summer). From these hourly data, we noted that the maximum TCCO value of January month at Basra station was 1.46 gm/m^2 while the minimum value in January at Mosel station was 0.5 gm/m^2. The largest value of dispersion data about the mean value of TCCO was in Mosel station where the standard deviation was 0.00925 gm/m^2 of January month. Generally, there was a decreasing in TCCO through ten years in all study stations, which is clear from linear fitting data. The large decreasing was in Mosul station -9.0x105 gm/m^2 for every year. The total decreasing through the period 2003-2013 was -0.00174, -0.00174, -0.00192 and -0.00173 for Baghdad, Basra, Mosul and Rutba, respectively, this may belong to the reduction of the industrial activities during this period. These may affect indirectly on the concentration of CO in troposphere as it discussed in the next section.

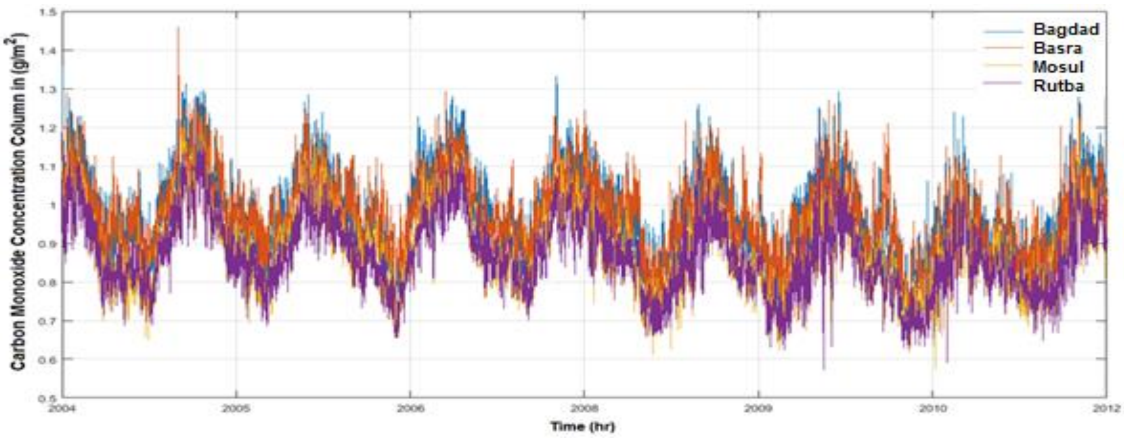

Figure 2: Hourly TCCO concentration in mg/m^2 through the period 2003-2012 over Iraqi provinces Baghdad, Basra, Mosul and Rutba.

3.2 Hourly spatial variability of TCCO

Fig. 3 shows the spatial of maximum hourly distribution of TCCO for the study area or each three-hour period from 00:00 to 21:00 UTC from 2003 to 2013. A MATLAB program was written to analyze and plot the NetCDF (A special meteorological data file format) (Network Common Data Form) data file as contour line graph. From this analysis, it was able to extract maximum and minimum values of monthly and seasonally TCCO data with respect to longitudes and latitudes. It can notice that, the high values of TCCO were localized at the middle and the south parts of Iraq during 00:00, 03:00 and 06:00 UTC (night). On the other hand, the values at 09:00, 12:00 and 15:00 UTC were variable especially at the urban area like Baghdad city (see Fig. 3, and Fig. 4). The high values of TCCO were constant at approximately 1.4741, 1.5167 and 1.533 (g/m^2) at 09:00, 12:00 and 15:00 UTC, respectively. Most permanent high values in this zone were due to the local effects of pollution especially in Baghdad which contains a lot of crowded traffics industrial activities in Iraq.

The south part of Iraq is considered as the second world's oil reservoirs and the Basra oil exports constitute about 80% of the Iraq total. Thus, Basra kept the level of TCCO values high relative to the other regions in Iraq after Baghdad, the capital. The middle south and northwest regions are considered as a hot spot of TCCO. These regions are low in height above sea level and usually have high air temperature with a northwest prevailing, low wind speeds. This make TCCO mostly have high values in the maximum and minimum analysis. Fig. 4 shows that there is a high coincidence in TCCO values between the south and the middle parts which is clear at 06:00, 09:00, and 21:00 UTC in Basra and south-west of Baghdad (see Fig. 4 (c) and 4 (d)). In the latter case, the large values of TCCO may be caused by the vehicle exhaust gases and the power plants [12].

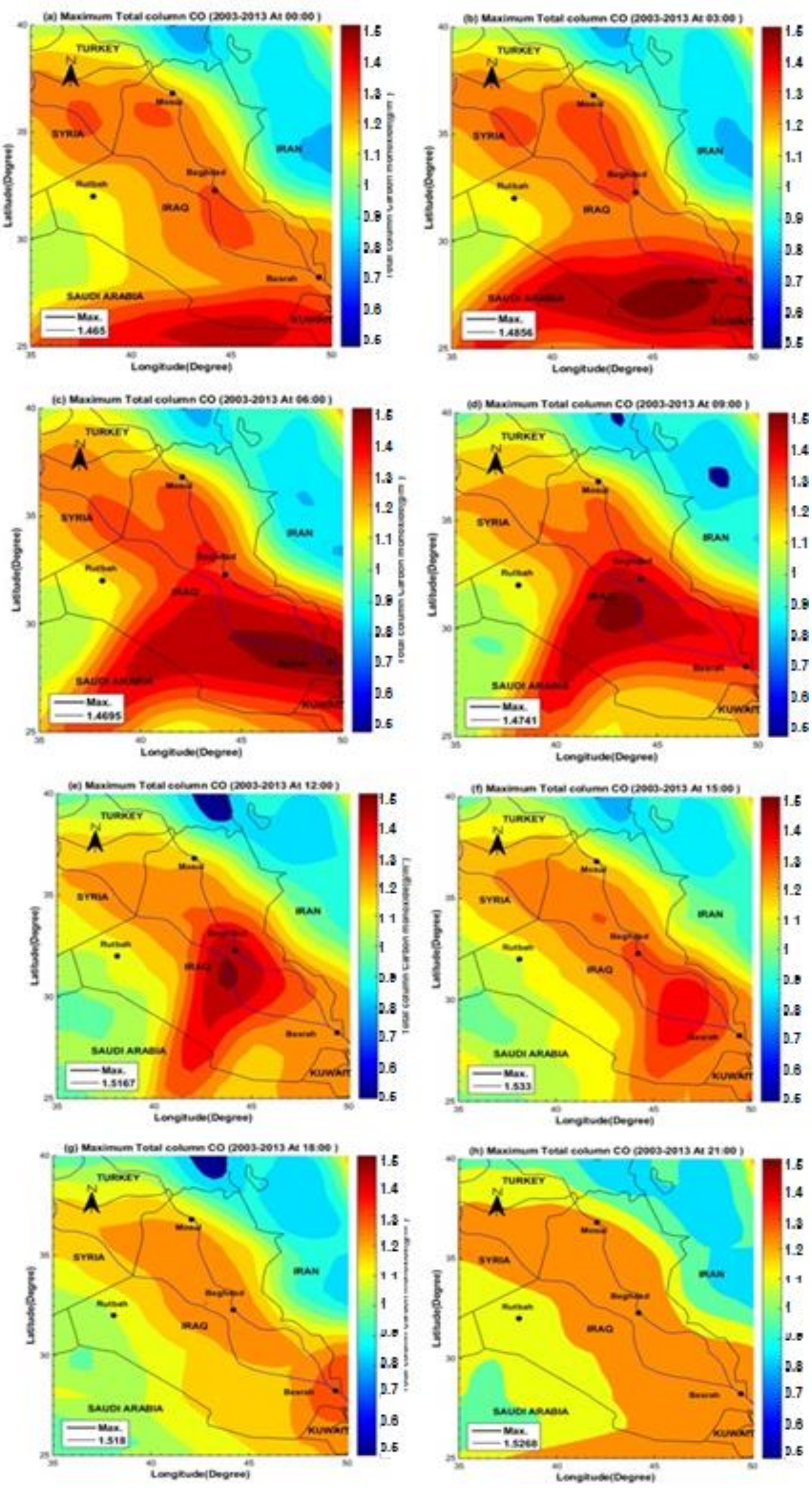

Figure 3: (a), (b), (c), (d) (e), (f), (g) and (h) are the maximum hourly spatial variation of TCCO over Iraq and area surrounded it (00:00, 03:00, 06:00 to 09:00) and (12:00, 15:00, 18:00 to 21:00) from the year 2003-2013.

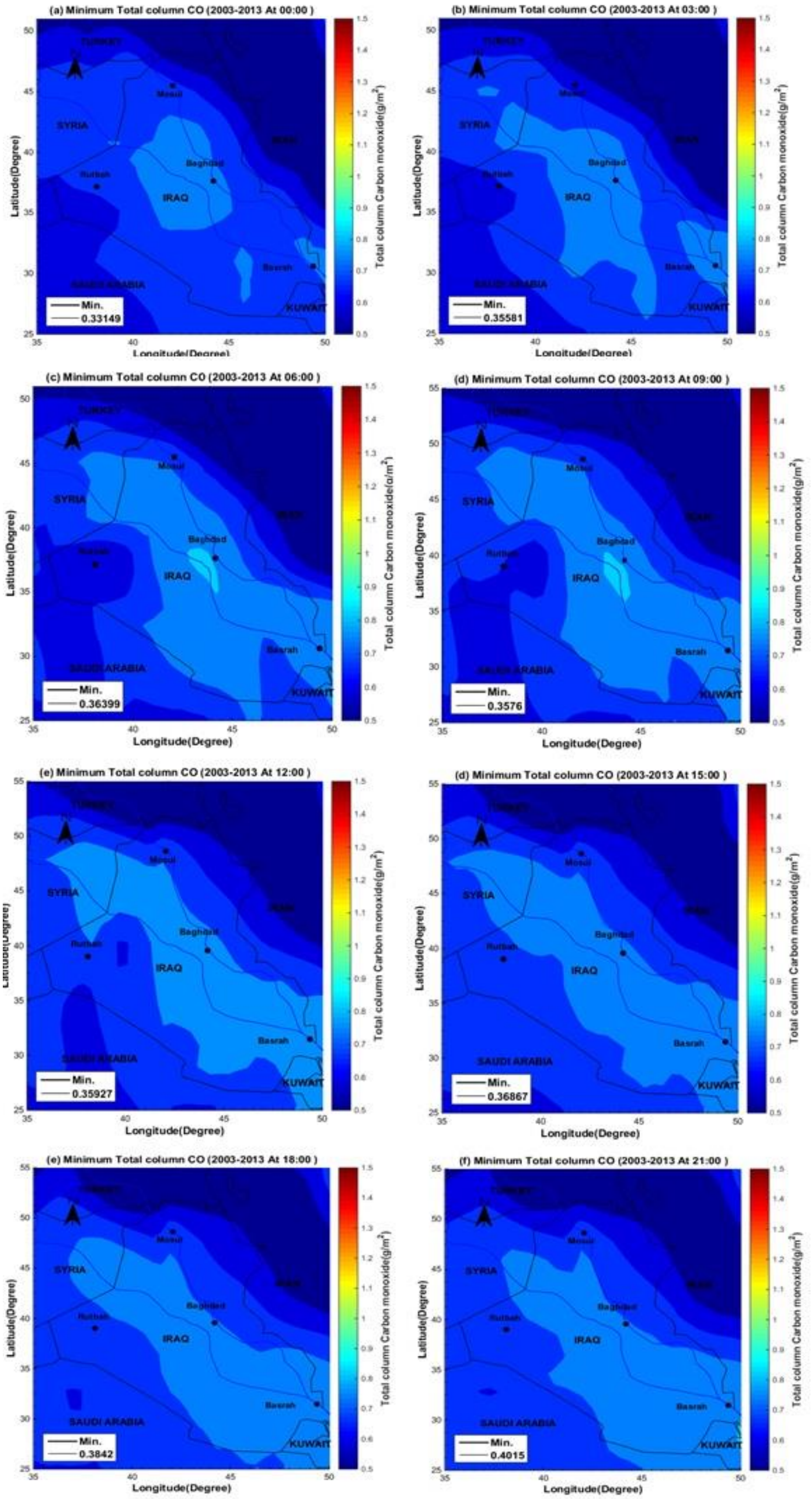

Figure 4: (a), (b), (c), (d), (e), (f), (g) and (h) are minimum hourly spatial variation of TCCO over Iraq and area surrounded it (06:00, 09:00, 12:00, 15:00, 18:00 to 21:00) from the year 2003-2013.

3.3 Temporal and Spatial Monthly and Seasonal Variability of TCCO

MATLAB program was also applied to extract the temporal and the spatial, monthly and seasonally average of TCCO during 10 years. Fig. (5) shows monthly averages at the grid points of Baghdad, Basra, Mosul and Rutba. Baghdad has the largest values in months November, December, January, February, March, and April (Fig. 6 for Winter time and Fig. 7a).

The situation is different at July, August, September and October where Basra has higher record than Baghdad and the other stations (See Fig. 5, Fig. 6, Fig. 7c). On the other hand, Mosul generally has larger TCCO values than Rutba but the mean values become nearly equal at months May, June, September, and October (Fig. 5, and Fig. 7c). These latter two stations are high above sea level and far from the anthropogenic activities.

The data are distributed over a grid of a spatial resolution of $0.50^o \times 0.50^o$ latitude-longitude (see Fig. 7). The highest contour values for TCCO are at Spring season ($1.067 g/m^2$). This mean seasonal value is less than the monthly values at February, March, and April, which are (1.094, 1.109, 1.08) g/m^2 respectively.

At Winter time (Fig. 5) TCCO emissions persist for several weeks after the emissions themselves have ceased, causing high TCCO concentrations to be detected in early Spring where the seasonal cycle of TCCO loading is driven primarily by the balance of emissions and photochemical production, as well as destruction by the hydroxyl radical (OH) during the Summer months under conditions of high solar illumination, OH is produced mainly through O_3 photolysis and subsequent reaction with H_2O, which accounts for strongest sink of TCCO in Summer.

Thus the main TCCO loss is caused by OH oxidation, followed by dry deposition as shown in Fig. 7 and Fig. 8 (Summer and Autumn seasons) (0.846, 0.779) g/m^2 these mean seasonal value account lowest monthly values at (Sep., Oct. and Nov.) respectively (0.796, 0.752, 0.791) g/m^2.

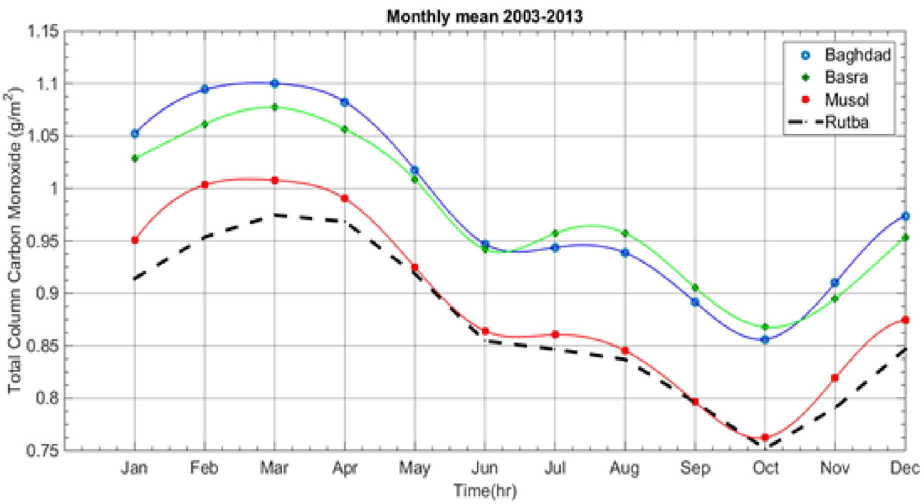

Figure 5: Mean monthly TCCO over stations of Baghdad, Basra, Rutba and Musol from period 2003 – 2013.

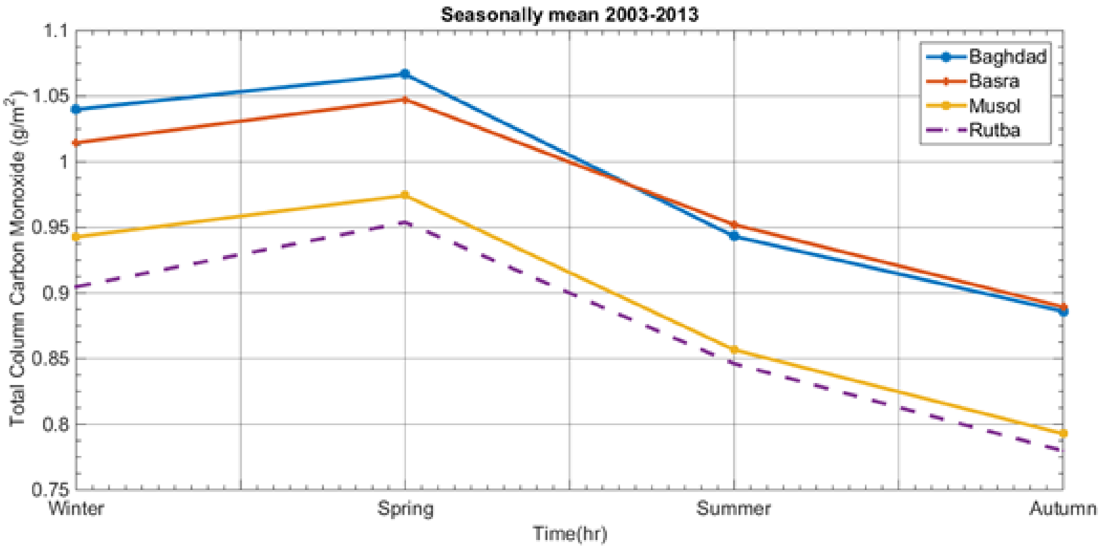

Figure 6: Mean seasonal TCCO over stations of Baghdad, Basra, Rutba and Musol from period 2003 – 2013.

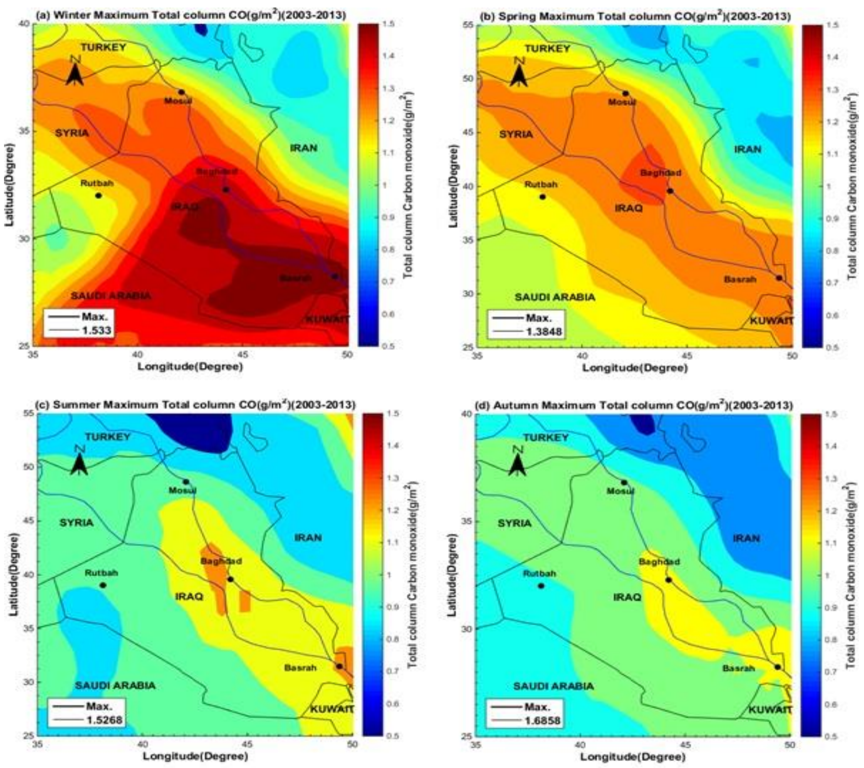

Figure 7: (a), (b), (c) and (d) are seasonal maximum hourly spatial variation of TCCO over Iraq and area surrounded it (Winter, Spring, Summer and Autumn) from the year 2003-2013.

The maximum seasonal spatial TCCO values are concentrated over most of Iraq area at Winter and Spring. The reason of these values was already explained in the above paragraph. The minimum seasonal spatial TCCO in the same season stayed high at the middle and the south of Iraq as seen in Fig. (8) that present mean values of TCCO at station Baghdad (middle part) and Basra station (south part). In Autumn and Winter, the minimum TCCO values are nearly equal in spite of there are some zones have high contours line for TCCO in the south and middle parts (see Fig. 8).

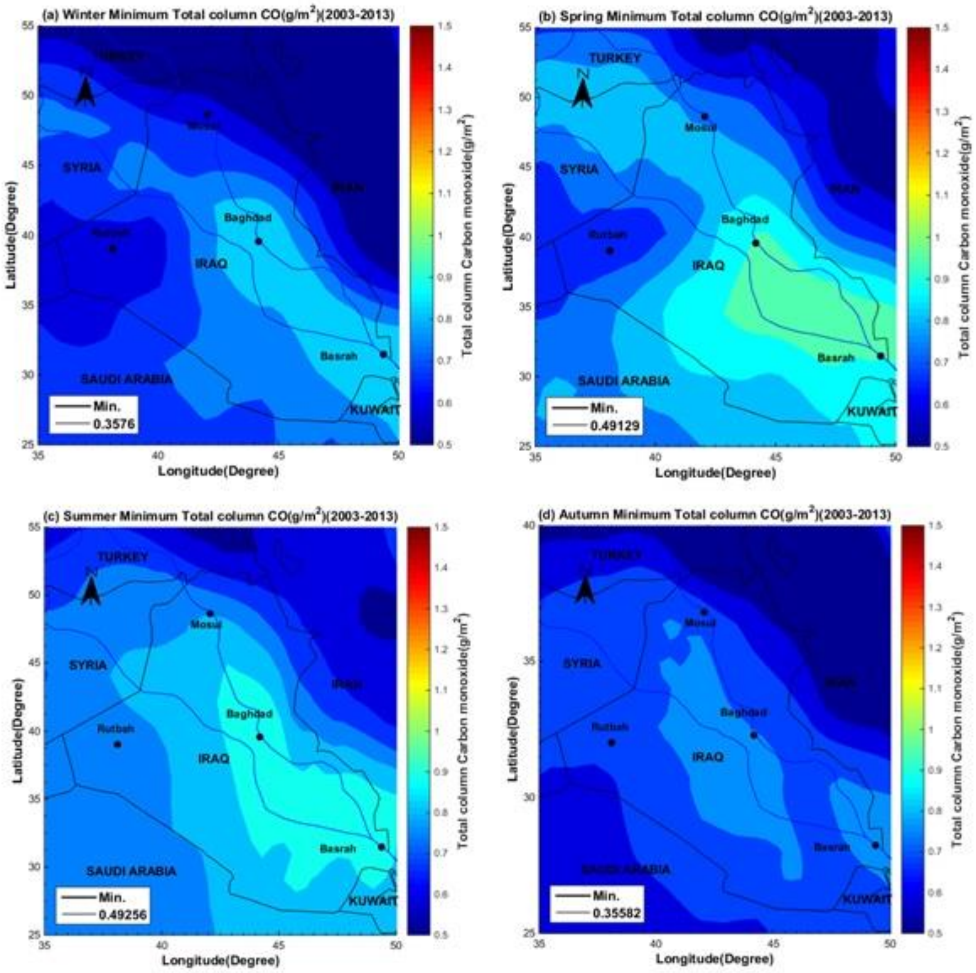

Figure 8: (a), (b), (c) and (d) are seasonal minimum hourly spatial variation of TCCO over Iraq and area surrounded it (Winter, Spring, Summer and Autumn) from the year 2003-2013.

4. Conclusions

1. The analyzed data total column of carbon monoxide (TCCO) of the southern and the middle parts of Iraq (Baghdad and Basra) were in consistence with the general seasonal cycle of TCCO in the Northern Hemisphere. They exhibit a significant enhancement in winter and spring and small values of TCCO in summer.
2. The typical seasonal TCCO variations over the Rutba station are less noticeable, where there is an obvious decrease in TCCO in all seasons.
3. The above remarkable feature suggests that the Mosul and the Rutba stations may be blanketed by regional pollution, while Basra area may be influenced by TCCO plumes transported either vertically or horizontally, which can be considered industry region or from biomass burning.

5. References

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