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# The Net Effect of Cloud Cover on Carbon Dioxide Concentrations over Baghdad City

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**Abstract.** The Green House Effect nowadays forms one of the major problems and is one of the side effects of technology. This effect is related to the mechanism of exchange of energy of earth with its environment. The $CO_2$ molecules have energy levels in the range of frequencies of the radiation from the earth this will prevent such frequencies from leaving earth, and as a result, affecting a temperature rise. The aim of this research was to analyze the hourly, daily, and monthly behavior of the $CO_2$ concentration, the cloud cover (total, high, medium and low) and find the relationship between the monthly averages of the $CO_2$ concentrations with the total cloud cover, based on the data of the European Centre for Medium-Range Weather Forecasts (ECMWF) for the cloud cover, and the data of the Ministry of the Environment in Iraq for $CO_2$ concentration at three different times (08:00am,

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12:00 pm and 04:00 pm) for the days (15 and 30) of rainy months for the year 2012 of the Wazireya industrial area in Baghdad city. The use of some statistics such as Simple Linear Regression (SLR) and finding P-values, and using Pearson's correlation test to find the strength of the relationship between $CO_2$ concentrations with total cloud cover. It was found that the highest concentration of $CO_2$ was at 08:00 am, the lowest concentration of $CO_2$ was at 04:00 pm, the highest daily of $CO_2$ concentrations was 549 PPM in (30/December), the lowest daily of $CO_2$ concentrations was 252 PPM in (13/September), the highest monthly of $CO_2$ concentrations was in the months (October and December), and the lowest monthly of $CO_2$ concentrations was in January. The lowest low and total cloud cover was found in a month (August and September), and there was a low positive relationship between the monthly of $CO_2$ concentrations and the total cloud cover of the months (January, April, October, November, and December) where the highest correlation in October was +0.36. It was also found that there was a weak inverse relationship in the months (February, March, and May), where the correlation coefficient (-0.08, -0.03, and -0.08) respectively.

**Keywords:** Carbon dioxide, Cloud cover, Global warming, Pearson's correlation, Baghdad.

## 1 INTRODUCTION

Understanding how clouds respond to anthropogenic-induced perturbations of our planet's atmosphere is of paramount importance in determining the impact of the ongoing rise in the air's $CO_2$ content on global climate; for as ( Charlson et al. 2001) have noted, man-made aerosols have a strong influence on cloud albedo, with a global mean forcing estimated to be of the same order (but opposite in sign) as that of greenhouse gases. And because of the great importance of this complex subject, this summary presents a brief review of a number of scientific papers that address various aspects of this crucial issue. ( Ferek et al. 1998) determined that cloud condensation nuclei in the airborne effluents of ships off the west coast of the United States were responsible for producing ship tracks, i.e., brighter and more persistent streaks in the overlying layer of natural and less-reflective cloud, both of which alterations create a cooling influence during daylight hours. Likewise, based on what is known about the properties of the aerosols responsible for jet aircraft contrails, (Meerkotter et al. 1999) suggested that the presence of such contrails tends to cool the earth's surface during daylight hours but warm it at night. And they also noted that aircraft emissions may cause an additional indirect climate forcing by changing the particle size of natural cirrus clouds, concluding that "this indirect forcing may be comparable to the direct forcing due to additional contrail cloud cover. On the other hand, (Boucher 1999) and (Nakanishi et al. 2001) both noted that aircraft-induced increases in high cloud amount may also have a warming effect, although ( Charlson et al. 2001) have contended that the net effect of all anthropogenic produced aerosols averaged over the entire world is one of cooling. Furthermore, they noted that the estimated cooling power of these aerosols, which they said was generally believed to be equivalent to the strength of the warming effect of all anthropogenic greenhouse gases, may actually be too conservative. During this same general time period, (Facchini et al. 1999) studied the effects of atmospheric solutes collected from

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cloud water in the Po Valley of Italy, finding that water vapor was more likely to form on its organic-solute-affected aerosols of lower surface tension as opposed to the less-organic-solute-affected aerosols of the natural environment with their higher surface tension - creating more and smaller (and, therefore, more-highly-reflective) cloud droplets, which, of course, tend to cool the local environment. They also observed that the organic fractions and concentrations of the aerosols they studied were similar to those found in air downwind of other large agricultural/industrial regions, hinting at the likely widespread occurrence of this human-induced cooling influence. Studying this phenomenon several years earlier, (Kulmala et al. 1993) had additionally noted that it is likely that the smaller droplet size will decrease precipitation so that the clouds will have a longer lifetime. In addition, their observation that cloud formation can take place at smaller saturation ratios of water vapor, in the presence of organic-solute-affected aerosols suggests that clouds will be able to format earlier times and in places where they would not otherwise form. In response to this particular type of anthropogenic effluent, therefore, cloud lifetimes expand at both ends of their existence spectrum-they are born earlier and die later (so to speak) and, in imitation of the starship Enterprise, they are able to grow where no clouds have grown before.

The warmer the air, the more water can evaporate: a simple relationship familiar to us from everyday life. Researchers from Germany and the Netherlands have now established that this is not always the case: although an increase in the greenhouse gas $CO_2$ makes the climate warmer, it also allows less water to evaporate. Plants, with their billions of tiny leaf pores, are the cause of this apparent contradiction. They influence the gas and moisture content of the air around them. Using new calculations of an atmospheric model, the researchers found that this sets in motion a cascade of processes, finally resulting in global warming. We wanted to know how the foreseeable rise in $CO_2$ would affect cloud formation in temperate climate zones and what part the vegetation plays in this, says Jordi Vilà-Guerau de Arellano from the University of Wageningen in the Netherlands. Working with colleagues from the Max Planck Institute for Chemistry and Meteorology, the geophysicists made use of, for the first time, a computer model that takes account of the soil, water cycle, atmosphere and growth processes of plants. The model results highlight how local and daily variable processes, through turbulence, can influence the atmosphere on larger scales. The scientists simulated three scenarios for their analysis: a doubling of the $CO_2$ in the atmosphere from the current 0.038% to 0.075%, an increase in the average global temperature by two degrees Celsius and a combination of both. The calculations represent the conditions expected for the year 2100 and compared to 2003 values based on scenarios from the Intergovernmental Panel on Climate Change (IPCC). The researchers established that some land-vegetation-atmosphere exchange processes respond more strongly to increasing $CO_2$ and climate change than others. Doubling the $CO_2$ in the atmosphere actually, starts a cascade of processes beginning with the physiological response of plants to the higher $CO_2$ concentration.

The trigger of the chain of events is that plants regulate the exchange of water vapor and carbon dioxide with the atmosphere by the opening and closing of the leaf pores-the stomata. The cascade starts harmlessly: in the double $CO_2$ scenario, the stomata close earlier since the plants can assimilate the necessary $CO_2$ for photosynthesis more optimally. As a result, less moisture is evaporated by the plants and there is overall less water vapor introduced into the

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atmosphere. Consequently, fewer cumulus clouds are formed, which means that the Earth's surface becomes warmer, as the sun's rays hit it directly and are not reflected by clouds. Then, warmer air creates more turbulence in the atmosphere near the surface, and in consequence, there is more heat and less moisture transported. The earth and the atmosphere thus heat up through the plants' response to the higher $CO_2$ levels. The researchers have thus found another feedback mechanism in the climate system, a self-reinforcing process. This feedback mechanism did not develop in the second scenario, in which the atmosphere only warms by two degrees Celsius without the effect of higher concentrations of the greenhouse gas $CO_2$ on plants. The researchers then simulated a third scenario in which they increased both the $CO_2$ levels and the temperature. Positive effects on cloud formation include the ability of the warmer atmosphere to hold more water or increase the growth of biomass. However, they are only partly able to compensate for the reduction in cloud formation, according to Jordi Vilà. Evaporation will fall by 15%. The atmospheric boundary layer dries out, and fewer clouds form, adds Jos Lelieveld, Director at the Max Planck Institute for Chemistry in Mainz. The study thus shows that diminished evaporation from plants has a direct impact on cloud formation. Chiel van Heerwaarden from the Max Planck Institute for Meteorology emphasizes: The calculations show an important feedback mechanism between the vegetation and physical climate processes. In future, the researchers want to extend their analysis to the Amazon to test the effects of increasing $CO_2$ levels on tropical regions, (Jordi V. G. et al. 2012), see Fig. 1.

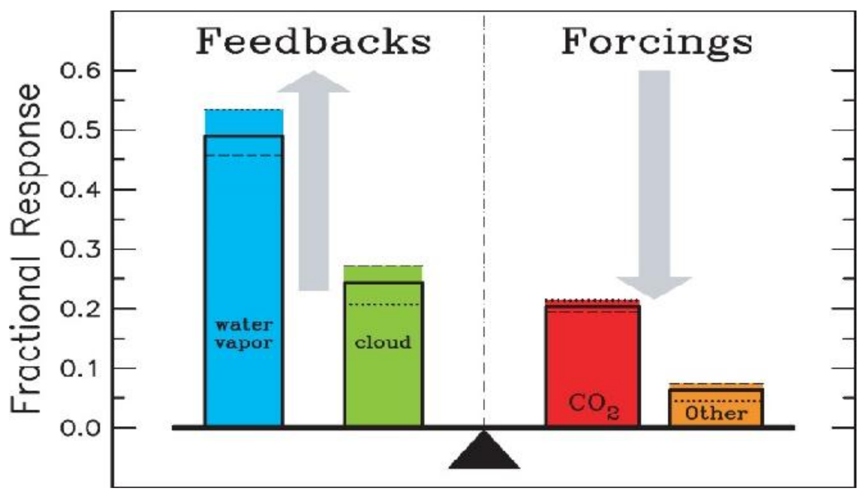


Fig. 1. Various atmospheric components differ in their contributions to the greenhouse effect, some through feedbacks and some through force. Without carbon dioxide and other non-condensing greenhouse gases, water vapor and clouds would be unable to provide the feedback mechanisms that amplify the greenhouse effect, (Kathryn H. 2010).

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## 2 METHODOLOGY

### 2.1 The Statistical Using

**1. Simple Linear Regression (SLR)**

Simple linear regression is the study of the relationship between two variables just to get to the linear relationship (i.e. a straight line equation) between these two variables, a parametric test, which assumes that the data are distributed normally distributed and to find out the gradient value is calculated slope of the regression through the linear equation of the following (Yazdani, M. R. 2011).

$$\bar{Y} = a + b\bar{X} \quad (1)$$

$$b = \frac{\sum_{i=1}^{n} (X_i - \bar{X}) - (Y_i - \bar{Y})}{\sum_{i=1}^{n} (X_i - \bar{X})^2} \quad (2)$$

Where (a) is Steady decline or part of the cross axis ($\bar{Y}$) to the equation of the straight line (Equation 1), and (b) is Slope of the regression.

**2. Probability Value (P-Value)**

Is purely a statistical term, a number is used to assess the statistical measures, which show that the value of the corresponding factor is actually an influential factor or not?

If the (P-Value) less than 0.05, the corresponding factor is an influential factor in the variable that we are trying to study the change. Influential factor has even considered the value of (P-Value) is equal to 0.1, but that increased about 0.1, this factor should be excluded from the model is ineffective, (Mohamed S. 2009).

**3. Person's Correlation Coefficient**

Use Pearson Correlation when:

- Measure the strength of the association between pairs of variables without regard to which variable is dependent or independent.
- Determine if the relationship, if any, between the variables, is a straight line.
- The residuals (distances of the data points from the regression line) are normally distributed with constant variance.

The Pearson Correlation coefficient is the most commonly used correlation coefficient. To predict the value of one variable from another, use Simple or Multiple Linear Regression. If you need to find the correlation of data measured by rank or order, use the nonparametric Spearman Rank Order Correlation. When an assumption is made about the dependency of one variable on another, it affects the computation of the regression line. Reversing the assumption of the variable dependencies results in a different regression line. The Pearson Correlation coefficient does not require the variables to be assigned as independent and dependent. Instead, only the strength of association is measured.

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Pearson Correlation is a parametric test that assumes the residuals (distances of the data points from the regression line) are normally distributed with constant variance, Pearson's correlation coefficient when applied to a sample is commonly represented by the letter r and may be referred to as the sample correlation coefficient or the sample Pearson correlation coefficient. Can obtain a formula for r by substituting estimates of the covariance and variances based on a sample of the formula above. So if we have one dataset $\{x_1,..., x_n\}$ containing n values and another dataset $\{y_1,...,y_n\}$ containing n values then that formula for r is, (Levesque R. 2007):

$$r = \frac{\sum_{i=1}^{n}(x_i - x)(y_i - y)}{\sqrt{\sum_{i=1}^{n}(x_i - x)^2}\sqrt{\sum_{i=1}^{n}(y_i - y)^2}} \quad (3)$$

$$x = \frac{1}{n}\sum_{i=1}^{n} x_i \quad (4)$$

**2.2 The Data and Study Area**

The data used for the Carbon Dioxide ($CO_2$) were obtained from the pollutant measurement station in the Wazireya Industry is followed the Ministry of the Environment of Iraq, and were also used the data for the Total Cloud Cover (TCC), Low Cloud Cover (LCC), Middle Cloud Cover (MCC), and High Cloud Cover (HCC) over Baghdad city from the European Center for Medium-Range Weather Forecasts (ECMWF) Dee, (2011). The hours (08:00 am, 12:00 pm and 04:00 pm) for two days (15 and 30) from every month, in the year 2012. Was chosen the Wazireya area because it is an area of industrial nature and the common name is Wazireya Industrial area. It is characterized by a large presence of laboratories, dying plants and detergents, the presence of the General Company for Battery Industry in Wazireya and the impact of these factories and environmental and healthy plants in the first and second class occupants. Where the field survey was used and found that they suffer from the increase of pollutants in the natural gas harmful to human health, where both the factories and laboratories for the manufacture of dry and liquid batteries with high emission of particles and fumes and Gases harmful to human health despite the presence of filters and filters within the production units as well as the presence of laboratories light and Babylon to produce batteries for various modes of transport, located at the latitude 33°22’06.10”N and longitude 44°23’33.01”E, note that the pollutant measuring station is located at a height of 10 meters above the surface of the earth, see Fig. 2.

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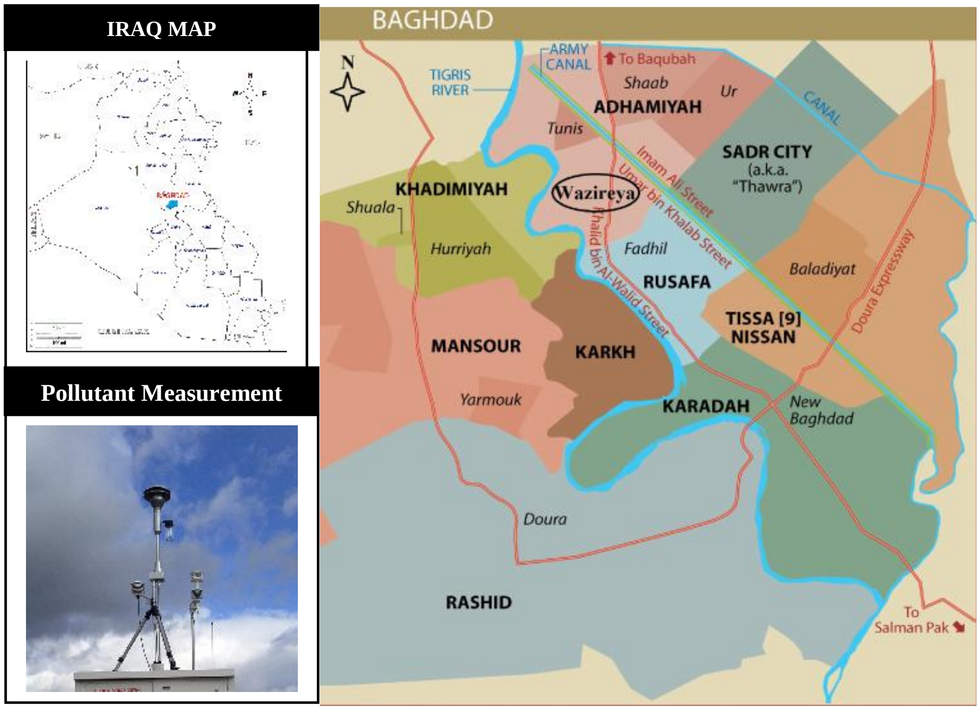


Fig. 2. Study area, Wazireya Industry area in Baghdad city, (Google, 2017).

## 3 RESULTS AND DISCUSSION

In the Fig. 3, shows the behavior or hourly change of the cloud cover (TCC, LCC, MCC, HCC), and gas concentrations $CO_2$ for the study hours of the days (15, 30) represent the middle and end each month in the year 2012 in the Wazireya area of Baghdad city. The hourly values for carbon dioxide concentrations were varied, with the highest gas concentration at the hour 08:00 am in day 30/December/2012 and 30/October/2012, the gas concentration was 549 PPM, and 544 PPM respectively. The lowest concentration of carbon dioxide gas at the hour 04:00 pm in day 30/July/2012 and 30/June/2012, where the concentration of gas recorded 349 PPM and 350 PPM, respectively. As for the behavior of the LCC and TCC, the highest appearance was for the LCC and TCC, which is more apparent than the MCC and HCC, was recorded the highest appearance of LCC and TCC at the hour 08:00 am in day 15/February/2012, where the largest 0.9 (i.e. 8 Octan) Full cloudy day, and also in the days of the months (December, January, March, April and May), the low or no appearance of the LCC, MCC, HCC, and TCC, was in the days of the months (June, July, August, and September). It was found that there was a clear behavior of the cloud cover during the study hours, where the highest appearance was for HCC and LCC and the lowest appearance was MCC and different the appearance of clouds in the middle of the month at the end of the month.

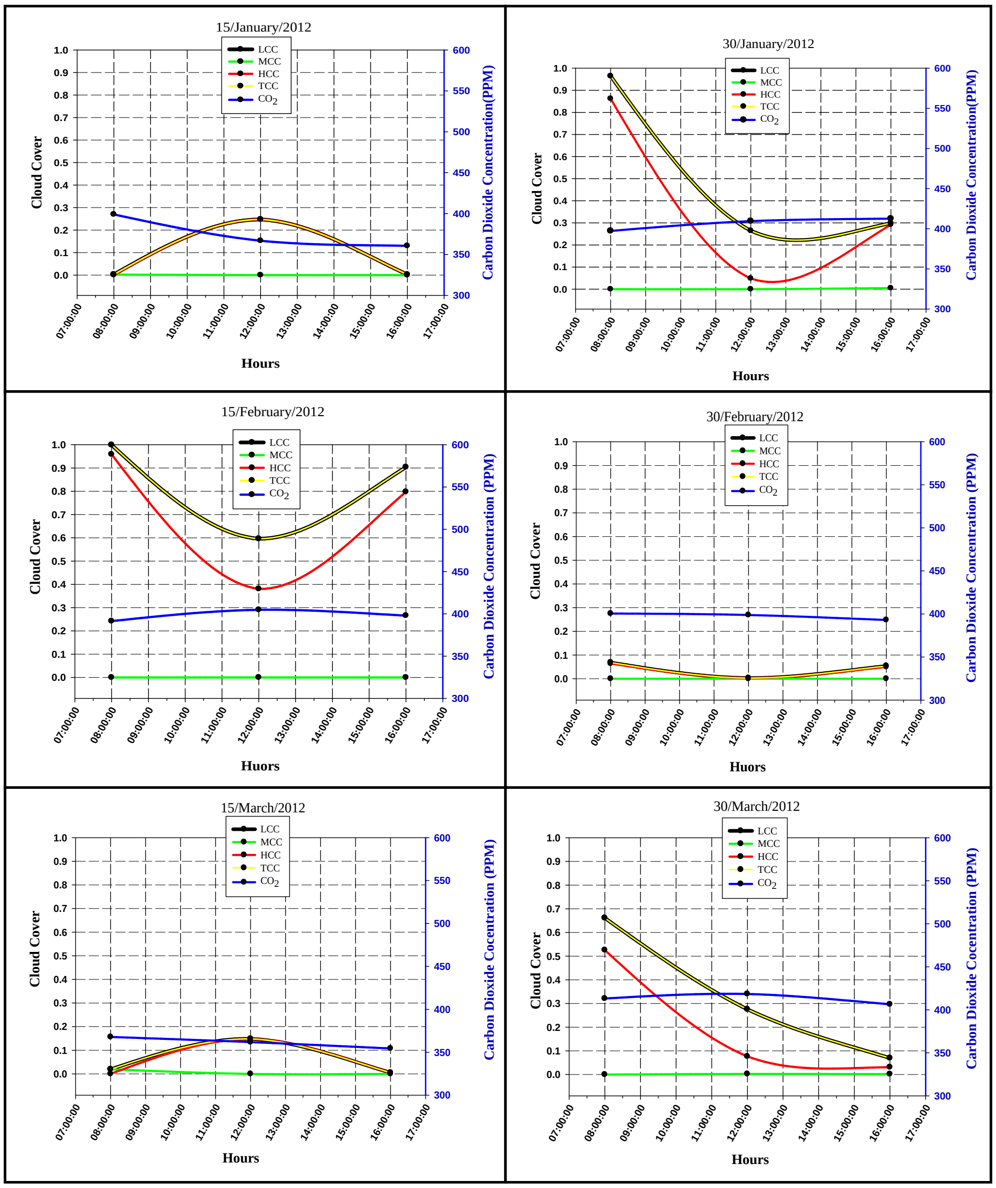


Fig. 3. The hourly change for $CO_2$ concentrations and cloud cover (LCC, MCC, HCC, and TCC) of the days (15 and 30) of each month for the year 2012 in Wazireya area.

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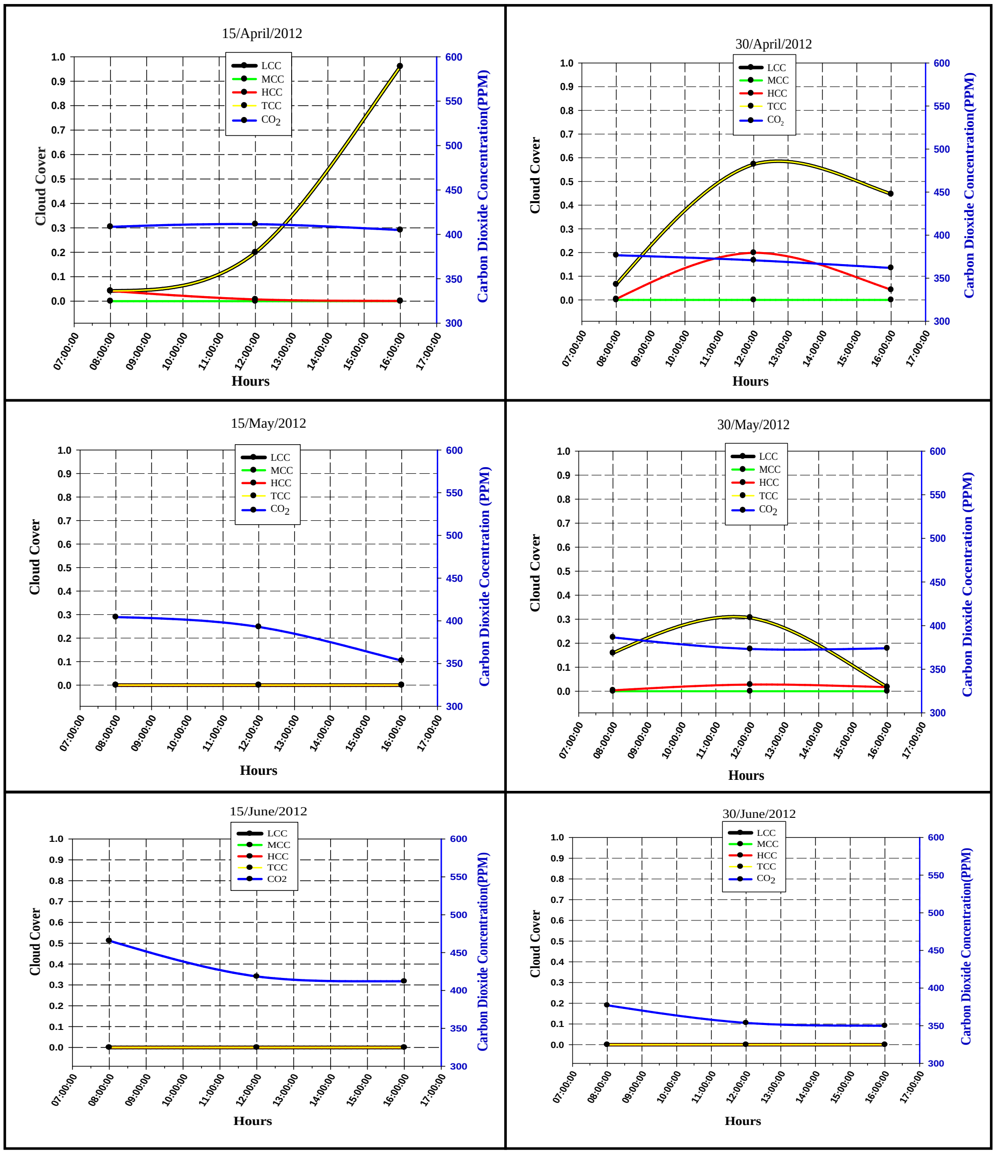


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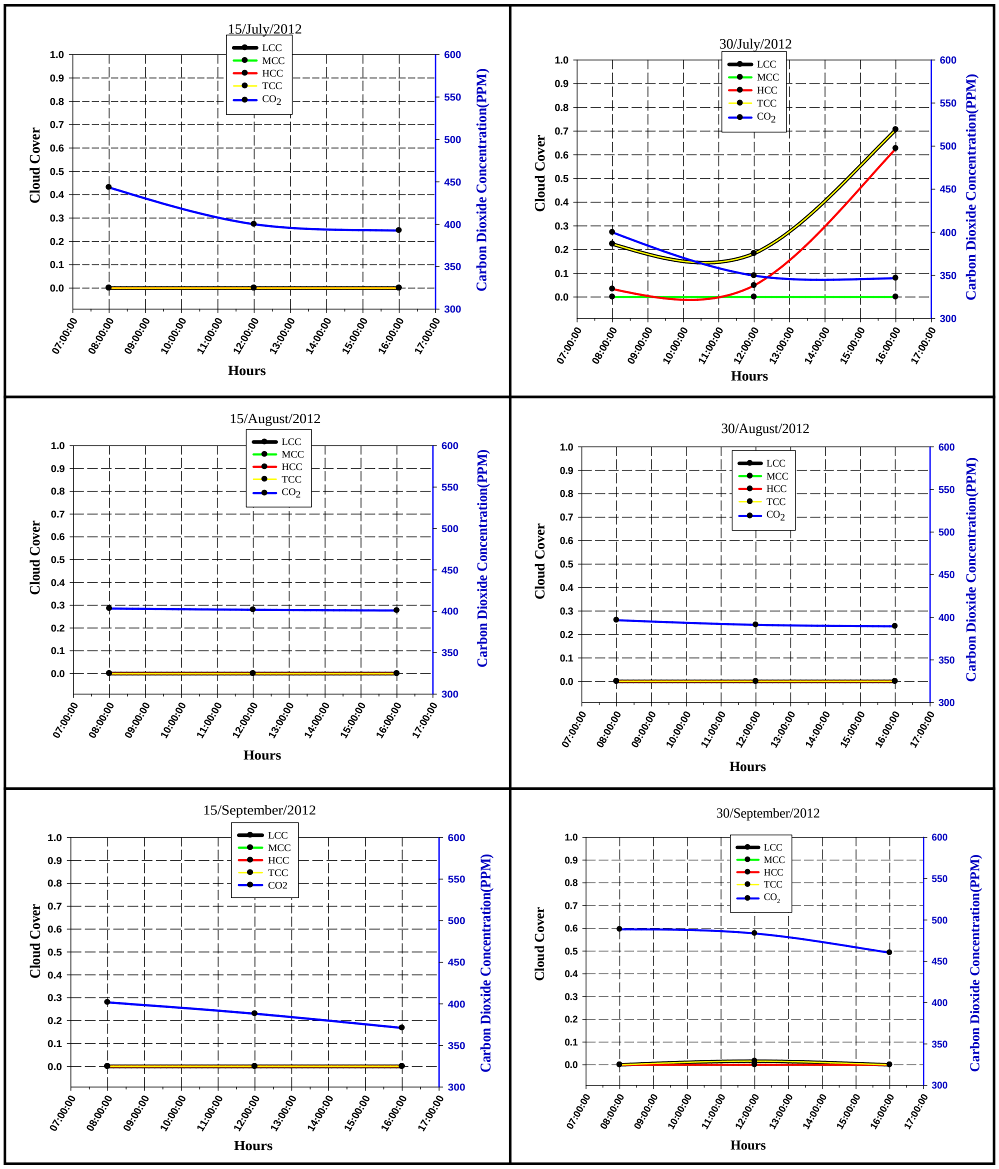


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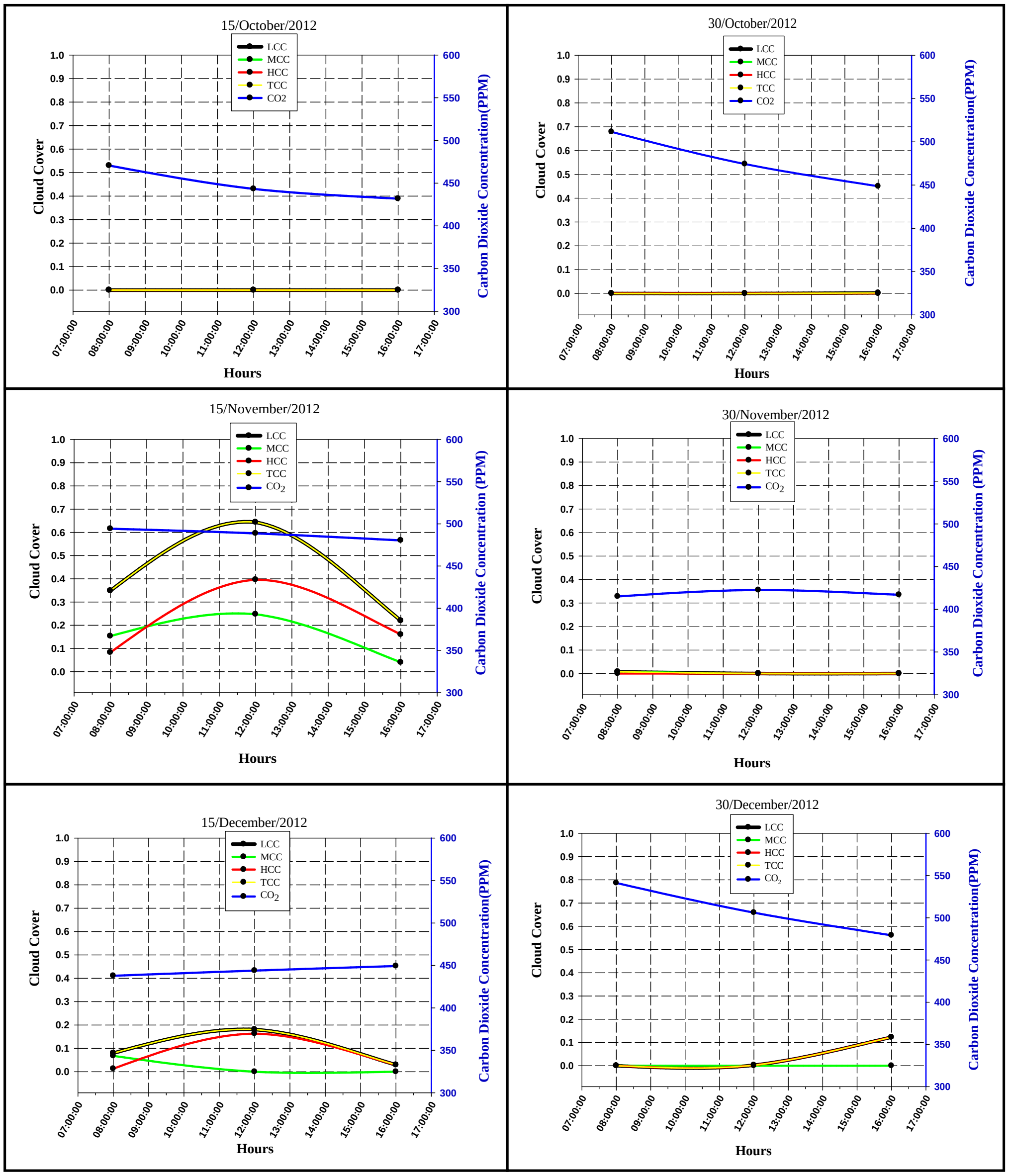


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In the Fig. 4, which shows the daily change of carbon dioxide ($CO_2$) and total cloud cover (TCC) for the year 2012, where the highest daily concentration of gas was 549 PPM of day 30/December and the lowest value of the concentration of gas 252 PPM in the day13/September, the most cloudy appearance was in the days of the month (December, January, and February), the lowest appearance of the clouds were in the days of the months (June, July, and August).

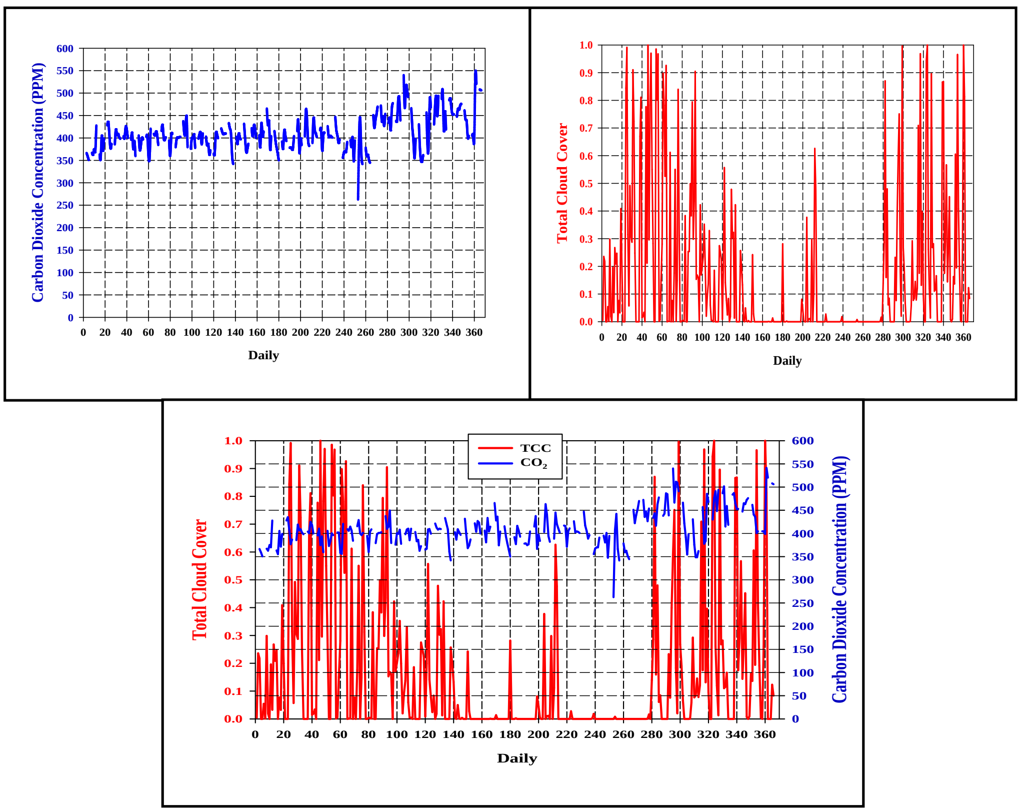


Fig. 4. The daily mean of $CO_2$ concentrations and TCC for the year 2012 in Wazireya area.

In the Fig. 5, shows the behavior of the total monthly average concentration of carbon dioxide and total cloud cover. The highest monthly concentration of gas in October and December, and the lowest monthly concentration of gas in January. The highest appearance for the cloud cover was found in February, and the lowest monthly appearance for the cloud cover was found in July.

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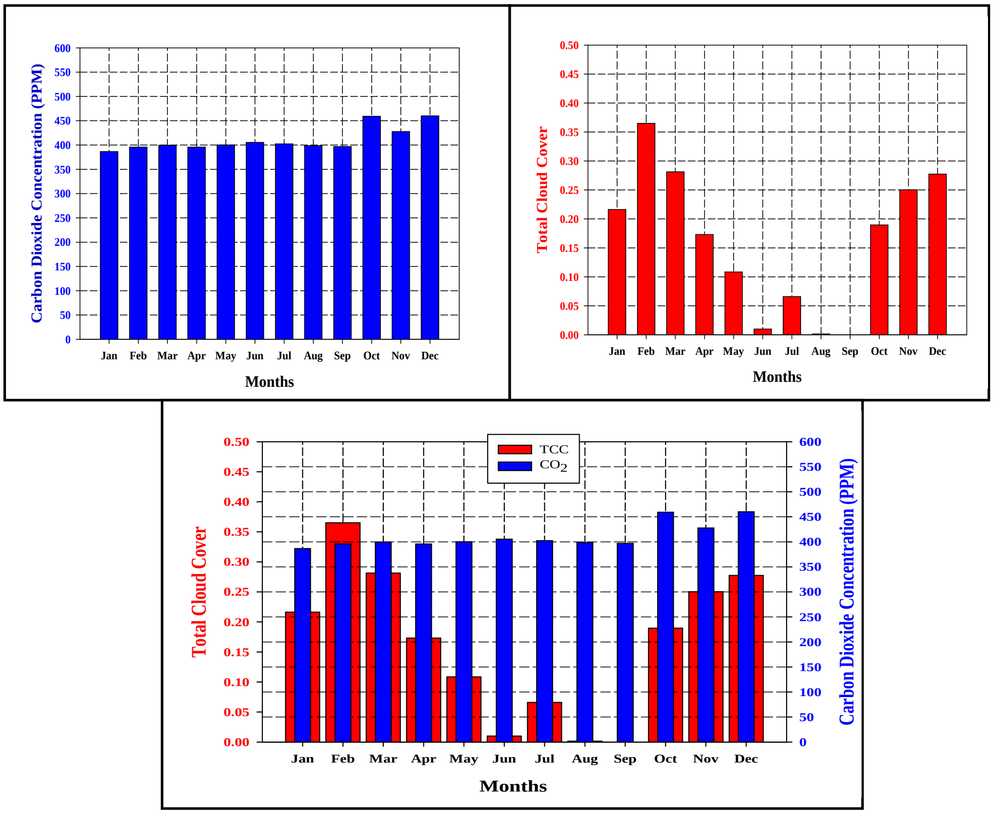


Fig. 5. The monthly mean of $CO_2$ concentrations and TCC for the year 2012 in Wazireya area.

In the Fig. 6, shows the relationship between the total monthly average of the carbon dioxide concentration ($CO_2$) and the total cloud cover (TCC). A low positive relation was found between the concentration of gas and clouds in months (October, November, December, January, and April) and there is a weak inverse relation in the months (February, March, and May) and the non-relationship in the months (June, July, August, and September). This is evident in Table 1, which shows the Pearson's correlation coefficient (r) values and the simple linear regression of P-values. The reason for the positive relationship between clouds and gas concentrations is that the clouds absorb the gas and send it back to the surface of the earth and so the presence of gas is associated with the presence of clouds, and this leads to global warming and then increase atmospheric temperatures.

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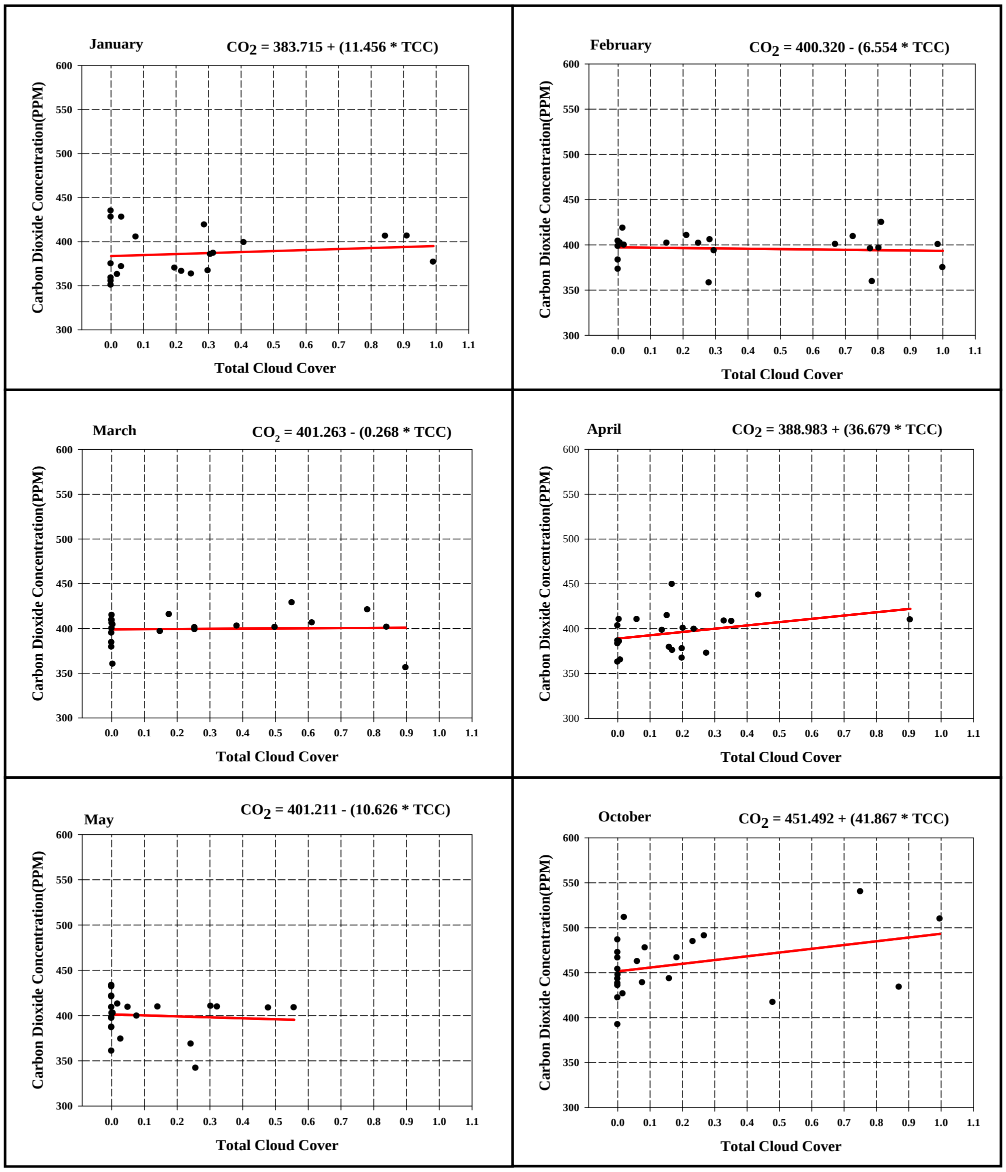


Fig. 6. The relationship between the monthly mean of $CO_2$ concentrations and TCC for the rainy months for the year 2012 in Wazireya area.

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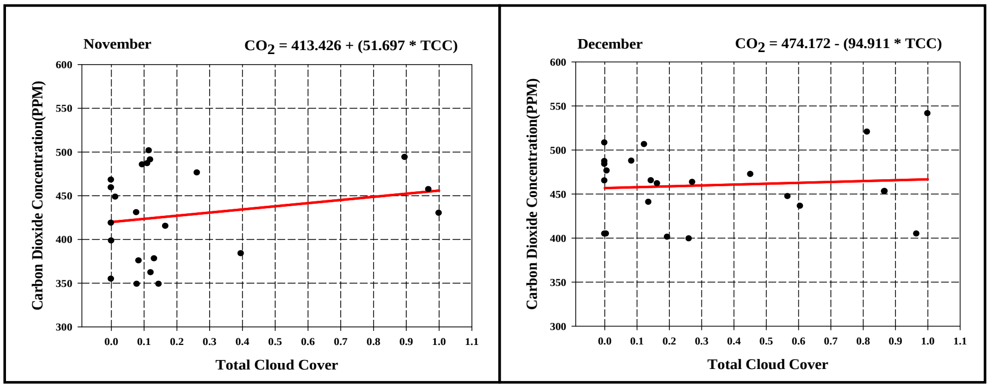


Followed the Fig. 6.

Table 1. Test the strength of the relationship between the monthly mean of $CO_2$ concentrations and TCC for the rainy months for the year 2012 in Wazireya area

| **Months** | **Simple linear regression** | | **Person's correlation** | |
|---|---|---|---|---|
| | P-value | relation | r | correlation |
| January | 0.55 | Non-linear | +0.13 | Positive weak |
| February | 0.72 | Non-linear | -0.08 | Invers weak |
| March | 0.88 | Non-linear | -0.03 | Invers weak |
| April | 0.12 | Non-linear | +0.33 | Positive low |
| May | 0.71 | Non-linear | -0.08 | Invers weak |
| October | 0.08 | Linear | +0.36 | Positive low |
| November | 0.33 | Non-linear | +0.21 | Positive low |
| December | 0.68 | Non-linear | +0.08 | Positive weak |

## 4 CONCLUSIONS

- The highest hourly concentration of carbon dioxide was at hour 08:00 am in day 30/December/2012.
- The lowest hourly concentration of carbon dioxide was at hour 04:00 pm in day 30/July/2012.
- The most appearance of the TCC and LCC was at hour 08:00 am in day 15/February/2012.
- The highest daily concentration of carbon dioxide was in day 30/December/2012.
- The lowest daily concentration of carbon dioxide was in day 13/September/2012.
- The highest appearance of the TCC was in the days of winter and spring months and the lowest or no appearance of TCC was in the summer months.
- The highest monthly concentration of carbon dioxide was in October and December, the lowest monthly concentration of carbon dioxide was in January.
- The most monthly appearance of the TCC was in February and the lowest was in August and September.
- There was a low positive correlation between the monthly mean of carbon dioxide and total cloud cover in months (January, April, October, November, and December).
- There was a weak inverse relationship between the monthly mean of carbon dioxide and total cloud cover in the months (February, March, and May).

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