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Impact of Wind Speed and Direction on Low Cloud Cover over Baghdad City

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Abstract

Clouds are one of the best evidences for the continuous movement of the Earth's atmosphere, and they play a major role in the Earth's climate through their influence on the balance of solar radiation. Part of the falling solar radiation causes the heating of the Earth's surface. The statistical methods used in this study depend on the daily, monthly and seasonal mean of Low Cloud Cover (LCC), Wind Speed (WS), and Wind Direction (WD), with data taken from the European Center for Medium Range Weather Forecasts (ECMWF) for the year 2018 at the times of 00.00 am, and 12.00 pm over Baghdad Station. The highest values of low cloud cover were recorded during December, January and February, while wind speed was low. The highest values of wind speed were found during June and July at 12:00 pm. As for the seasonal analysis, it was noted that the LCC was high during winter and autumn. The relationship between wind speed and low cloud cover was also found to be inverse; the higher the wind speed, the lower the cloud cover.

Keywords: low cloud cover; wind speed; wind direction; ECMWF; Baghdad
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1. Introduction

Clouds are a collection of huge numbers of small droplets. There are about one hundred drops per cubic centimeter [1]. Clouds are formed when air cools and its temperature drop below the dew point and then water vapor condensation occurs. The cloud formation occurs in two ways. First, if the rise is slow, clouds that are predominant form the stratum shape. Second, if the rise is rapid, clouds of a cumulative shape tend to form [2]. Movement of clouds can be horizontal or vertical and does not remain in the places of their formation due to the movement of the air masses and wind directions. The movement of air currents is up and down and is affected by thermal changes and the resulting low or high pressures. Wind movement is from high pressure areas to low pressure areas, and winds moves clouds and clouds transfer the characteristics of the area passing over them from temperatures and humidity to other areas [3]. So, the direction of the wind is one of the main factors that determine the nature of clouds in terms of temperature, amount of moisture, height, and sometimes the shape and appearance of clouds [4]. Clouds have an important impact on the climate because they are source of rain and snow that fall on the surface of the earth [5]. The cooling and

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heating depend on the height, thickness and water content of clouds. Clouds are classified according to their height and shape, and clouds are divided into three levels:

1) Low-rise clouds consist of drops of liquid water except for a period of cold winter storms and at an altitude of 2 km.

2) Medium-height clouds consist of water droplets, ice crystals or a mixture of the two, and are found in the middle levels of the troposphere; they form at an altitude between 2-6 km.

3) High-altitude clouds consist of snow crystals, and are at a freezing temperature and at a height of 6 km [6].

There are many studies that show the relationship between wind speed and direction of clouds in the city of Baghdad. Clouds play an important role in climate change, in predicting local weather or in the provision of flight safety. In the case of flight safety, the most important parameters are the height of the cloud base and the amount of cloud cover [7]. Using the T-Φ gram model over Baghdad, the calculation of absorption and heat radiation emission by cloud cover clarify the positive relationship between cloud water content and absorption; as the water content in the cloud increased, there was greater absorption. The relationship between the saturated vapor density in the cloud and the emissivity is also positive because an increase in the saturated vapor density in the cloud leads to a greater emission [8]. Some research has shown that the absorption of solar radiation by clouds, aerosols, and some atmospheric gases are affected by the composition of the atmosphere, location, season, and meteorological parameters (temperature, pressure, relative humidity, wind speed, wind direction, rain, and wavelength) as these factors can be very important in terms of volume of cooling and heating (surface and air) [9]. Abd [10] studied the frequency of winds in Iraq with its eight main directions and its relationship to the frequency of high, medium and low winds. It was concluded that wind directions have an effect on the formation of clouds and their types in the transitional seasons and the quality of the prevailing trends in each region.

The research aims to study the relationship between low cloud cover, wind speed, and wind direction at selected stations over Iraq for a whole year (2018).

2. Materials and Methods

2.1 The study aera

The work was carried out using daily data on Wind Speed (WS). Wind Direction (WD) and Low Cloud Cover (LCC) taken from the European Center for Medium Range Weather Forecasts (ECMWF) for Baghdad city (Lat. 33.24ºN, Long. 44.45ºE) [11]. This data was converted to monthly rates to show seasonally effects. The data were processed by MAT-LAB and drawn through the new version of SigmaPlot and Organics program [12]. Iraq map was drawn using a Geographical Information System (GIS) program, as shown in Figure 1.

2.2 Statistical analysis

2.2.1 Simple linear regression (SLR)

Simple linear regression is a statistical method that allows us to summarize and study the relationships between two continuous (quantitative) variables [13]. The basic concept and procedures for simple linear regression are according to the following equations [14]:

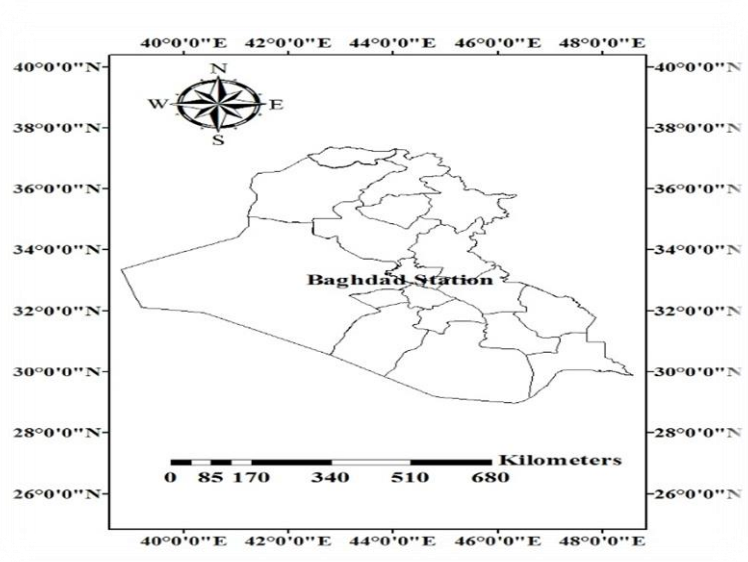

Figure 1. Baghdad city in Iraq

$$\bar{Y} = a + bx \tag{1}$$

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

where b is the slope, and a is constant value.

2.2.2 Pearson's correlation coefficient ®

Pearson's correlation coefficient is a very useful statistical formula that measures the strength between variables and relationships. In the field of statistics, this formula is often referred to as the Pearson R test when performing a statistical test between two variables, and it is a good idea to perform a Pearson correlation value to determine how strong this relationship is between these two variables. The Pearson correlation coefficient r is used to measure the strength of the linear correlation between two variables; as r = 1 means full positive correlation and r = -1 means perfect negative correlation [15].

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

3. Results and Discussion

3.1 The daily mean behavior of LCC, WS, and WD for Baghdad station

The daily means of LCC, WS and WD for Baghdad station, was observed at the times of 00:00 am and 12:00 pm. LCC was high during February, November and December while wind speed was

high during March and October at the time 00:00 am, wind speed was high during June and July at the time of 12:00 pm. Wind direction was high during July and August at the times of 00:00 am, and 12:00 pm. This was due to meteorological factors, pressure systems, astronomical factors through the seasons and surface nature. Low and high cloud cover affects the velocity of wind speed while reaching the Earth's surface as well as the effect on wind direction (Figure 2).

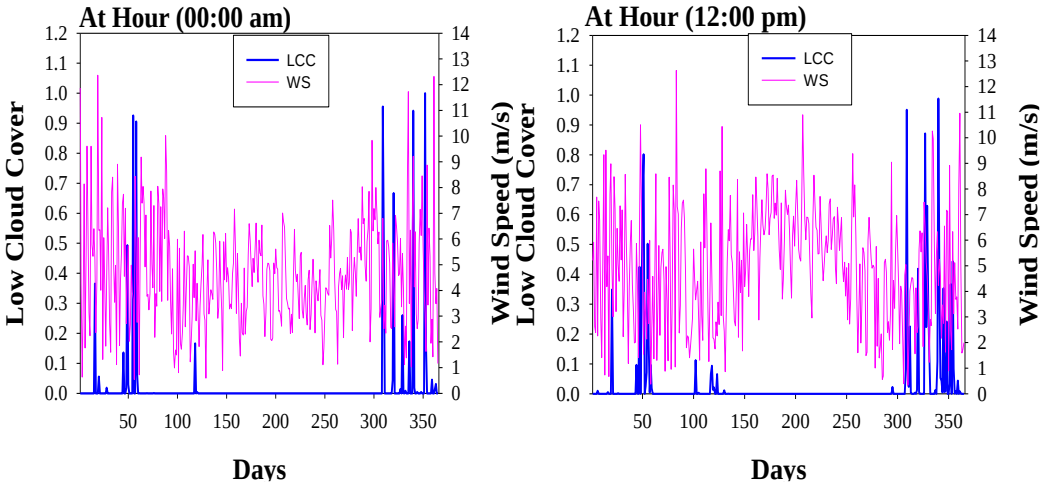

Figure 2. Behavior of the daily means of LCC, WS and WD for Bagdad station

3.2 Analysis of the daily means of wind direction for Baghdad station

Figure 3 shows that the wind is blowing from any direction, but the wind speed at 00.00am is faster than at 12.00pm. As for the direction, it changes more at 12.00 noon. The prevailing wind is the northwest wind, and the wind speed is greater than 5m/s. The wind direction is one of the main factors determining the nature of clouds in terms of temperature, height, and sometimes the shape of the clouds and their external appearance.

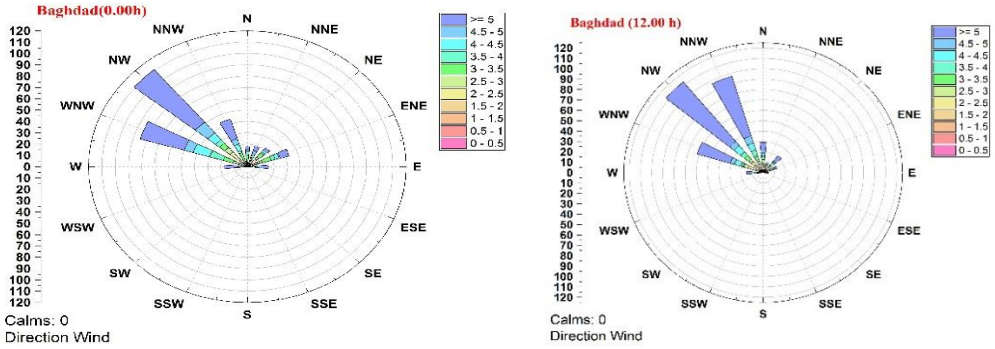

Figure 3. The analysis of the daily mean of winds (speed and direction) for Bagdad station

3.3 The relationship between the daily mean of LCC and WS for Baghdad station

Figure 4 and Table 1 present the type of relationship and the strength of the correlation between LCC and wind speed, LCC, and wind direction for Baghdad station at the times of 00:00 am and 12:00 pm over the year 2018. The relationship between LCC with wind speed and with wind direction is inverse because an increase in wind speed leads to a decrease in LCC, which is formed near the surface of the earth. The cooling and heating of the surface depends on the height, thickness and water content of the clouds. That is why the relationship between clouds and meteorological factors, especially speed and wind direction, is a very important relationship at all the time

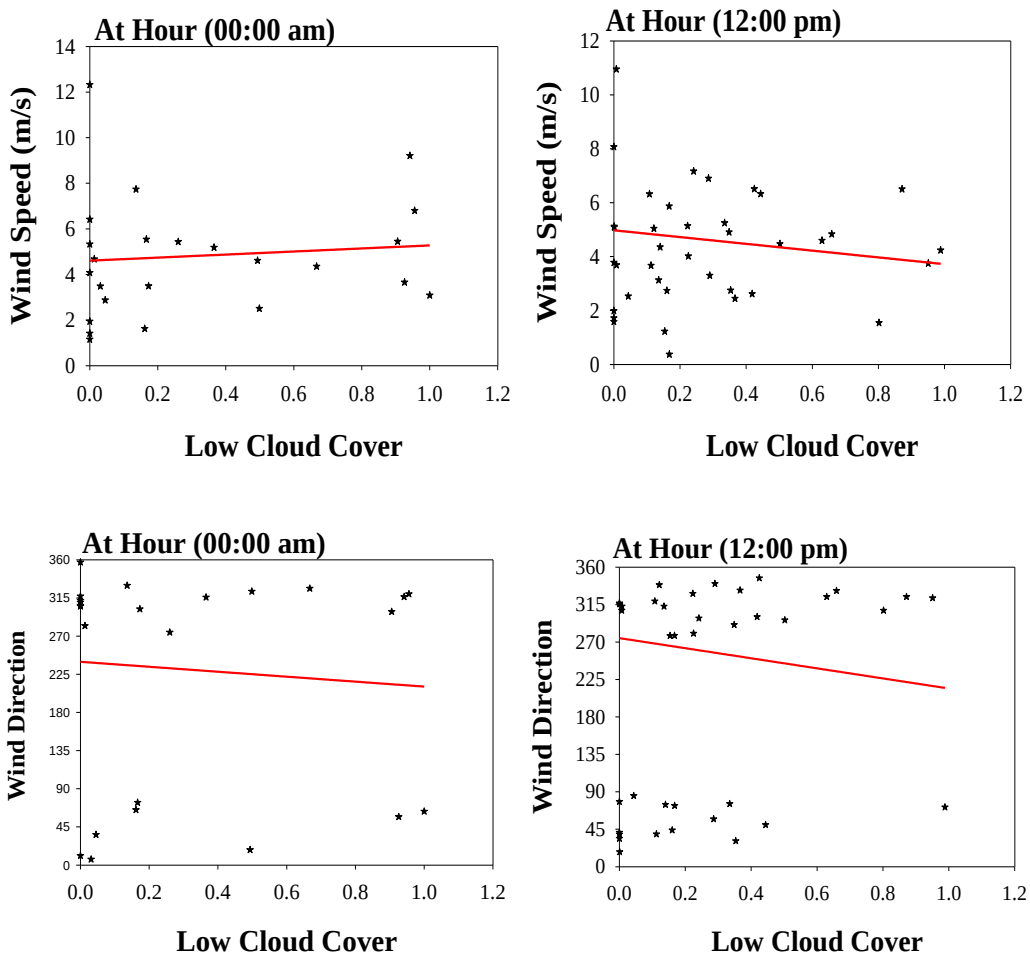

Figure 4. The relationship between the daily means of (LCC and WS), (LCC and WD) for Baghdad station

Table 1. Relationship and the strength of correlation coefficient between the daily means of (LCC and WS), (LCC and WD) at the times of 00:00 am -12:00 pm for Baghdad station

Relationship	Pearson's Test		Simple Linear Regression	
	r	Correlation	P-value	Interpretation
LCC vs. WS at 00:00 am	-0.1	Low inverse	0.001	**Linear**
LCC vs. WS at 12:00 pm	-0.2	Low inverse	0.002	**Linear**
LCC vs. WD at 00:00 am	-0.1	Low inverse	0.001	**Linear**
LCC vs. WD at 12:00 pm	-0.2	Low inverse	0.003	**Linear**

3.4 The monthly mean of LCC, WS and WD for Baghdad station

Figures 5 and 6 show the monthly means of LCC, WS and WD for Baghdad station. LCC was high during the months of December, January and February while speed and wind direction through these months was low due to various meteorological factors, which include low temperatures, high humidity, low solar radiation and low wind speed and wind direction. These conditions led to the formation of many low clouds such as cumulus, stratus, stratocumulus and cumulonimbus. While LCC was low during the months of June, July and August, speed and wind direction was high due to various meteorological factors including high temperatures, low humidity, high solar radiation, high speed and wind direction. These conditions led to the formation of many high clouds such as cirrus, cirrostratus and cirrocumulus. Low and high cloud cover affects the velocity of wind speed reaching the Earth's surface and consequently affects the wind direction.

3.5 The seasonal mean of LCC, WS, and WD for Baghdad station

Figures 7 and 8 show the seasonally means of LCC, WS and WD for Baghdad station as observed at 00:00 am -12:00 pm. LCC was high during winter and autumn while wind speed was high during winter and autumn at 00:00 am, but wind speed was high during summer at 12:00 pm. Wind direction was high during summer season at the times of 00:00 am-12:00 pm. This was due to meteorological factors, pressure systems and surface nature.

4. Conclusions

The relationship between LCC with wind speed and with wind direction was inverse as the higher the wind speed, the lower the LCC. LCC was high during December, January, February. The wind speed was high during the months of June and July at 12:00 pm which led to the absence of the formation of low clouds during these months. The wind speed was high during the summer at 12:00 pm and the wind direction was high during the summer season. This was due to the intensity of the solar radiation, which worked to heat the Earth's surface, and hence causing the air near the surface to warm, which in turn led to an increase in air moving in an upwards direction and an increase in wind speed. The increase and decrease in cloud cover affects the velocity of wind speed reaching the Earth's surface and consequently affects wind direction.

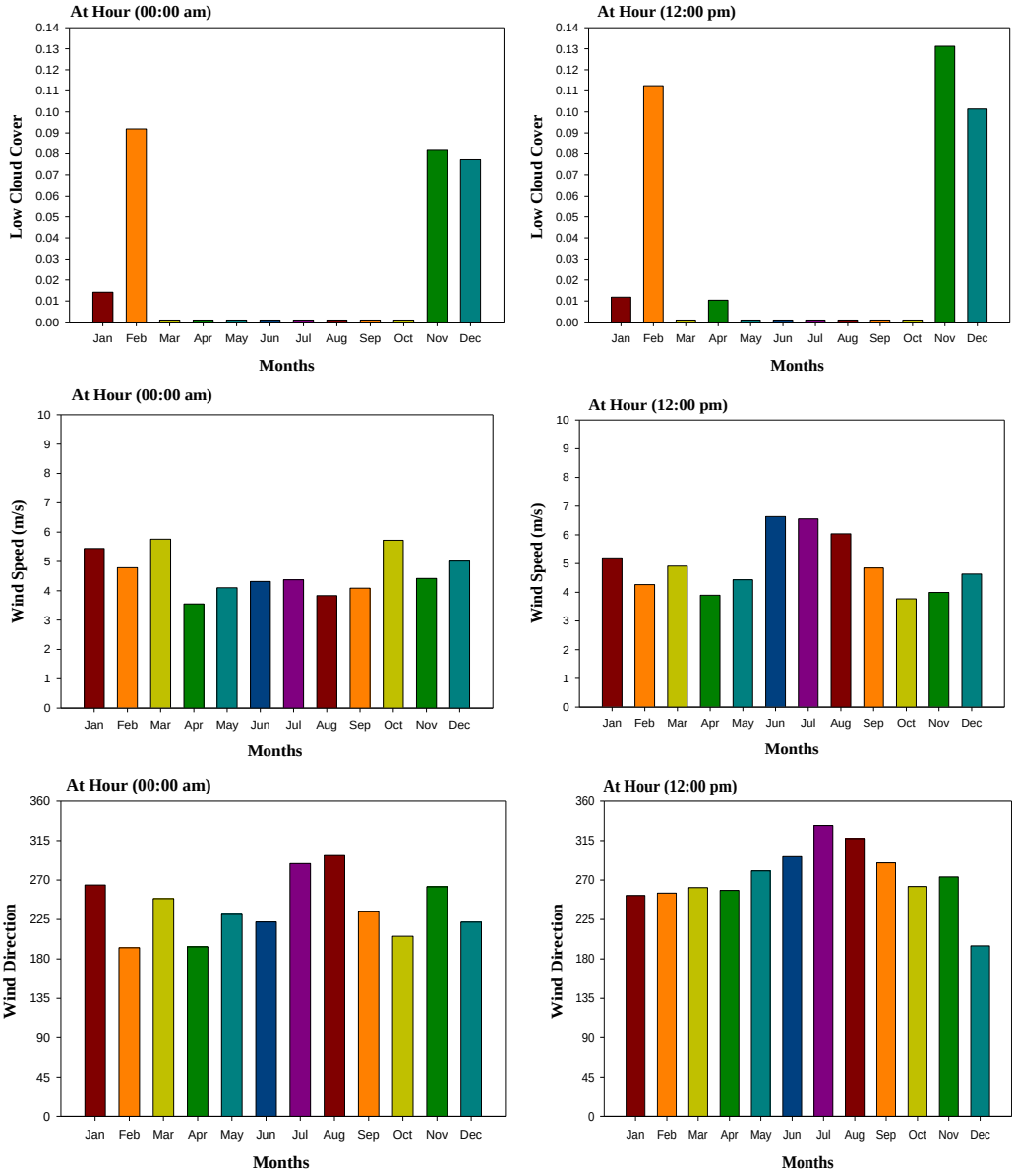

Figure 5. The monthly means of LCC, WS and WD at the times of 00:00 am -12:00 pm for Baghdad station

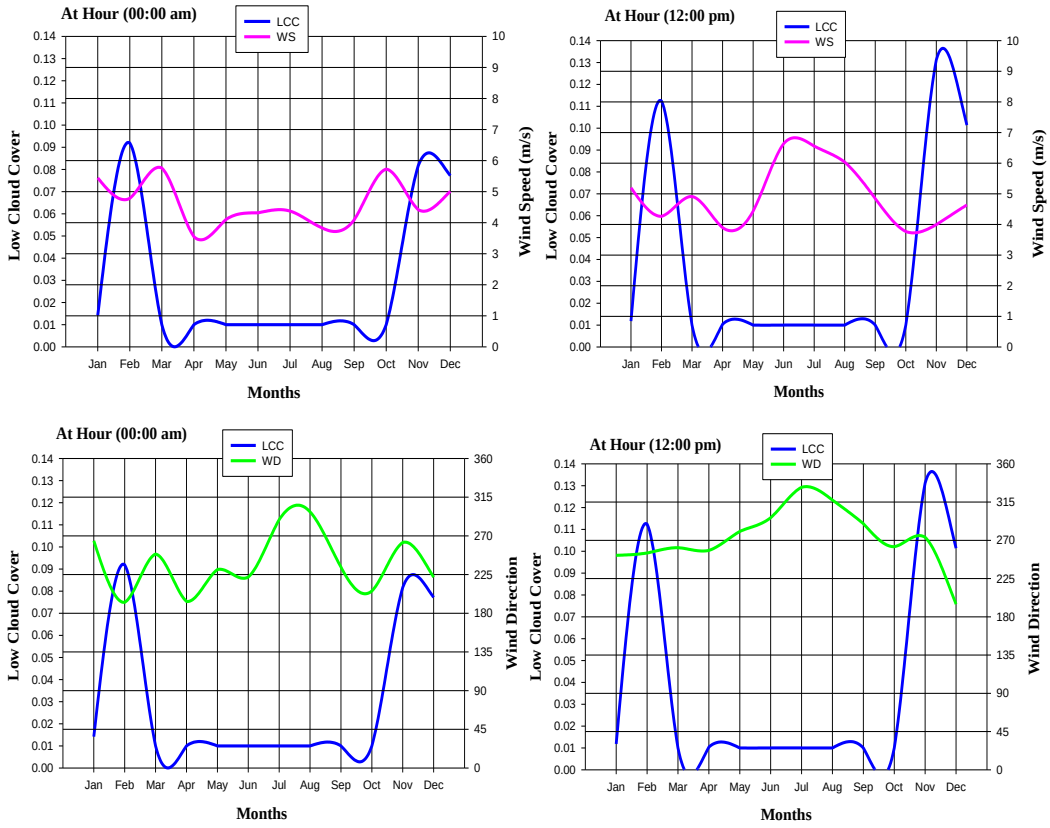

Figure 6. The monthly changes of (LCC and WS), (LCC and WD) at the times of 00:00 am -12:00 pm for Baghdad station

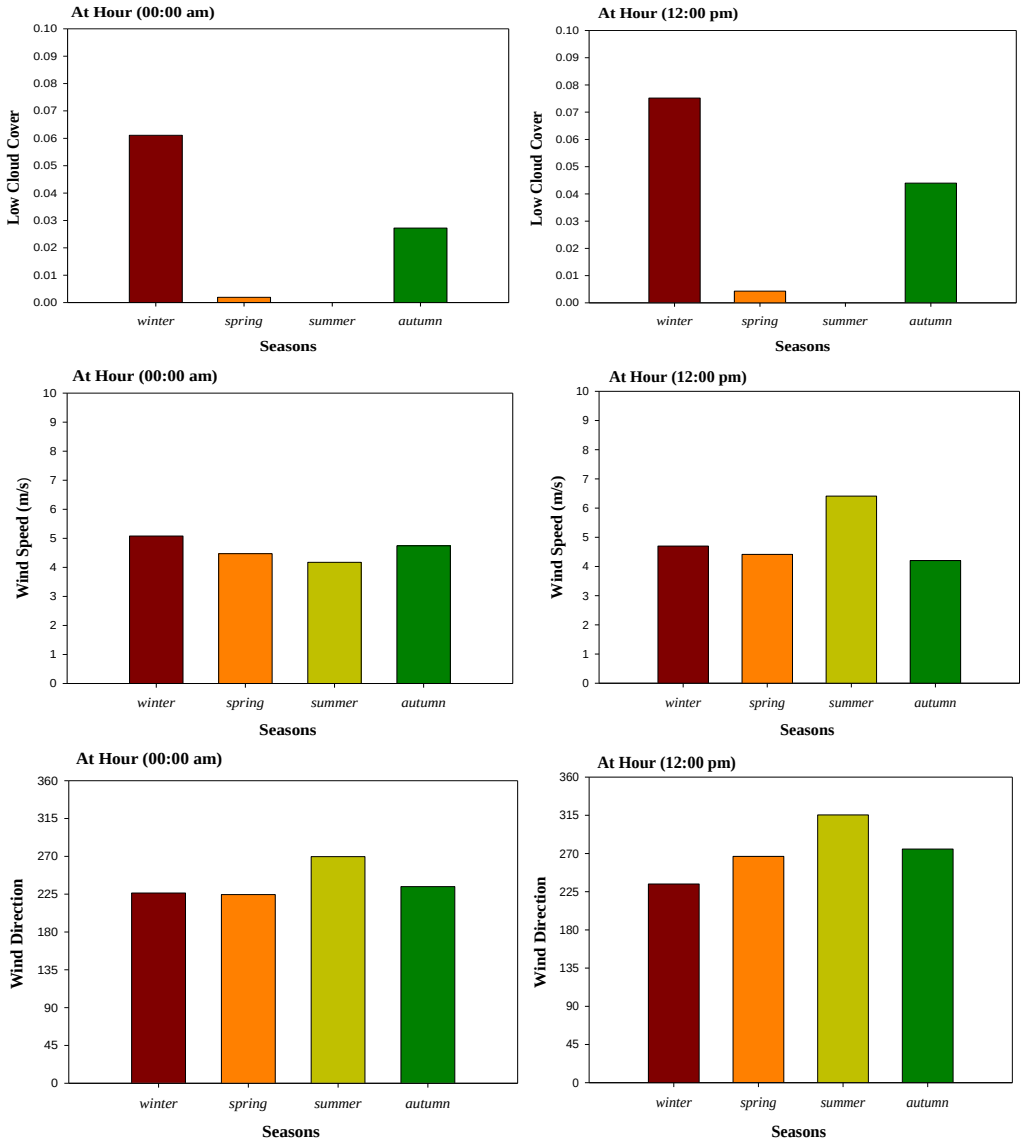

Figure 7. The seasonally means of LCC, WS and WD at 00:00 am -12:00 pm for Baghdad station

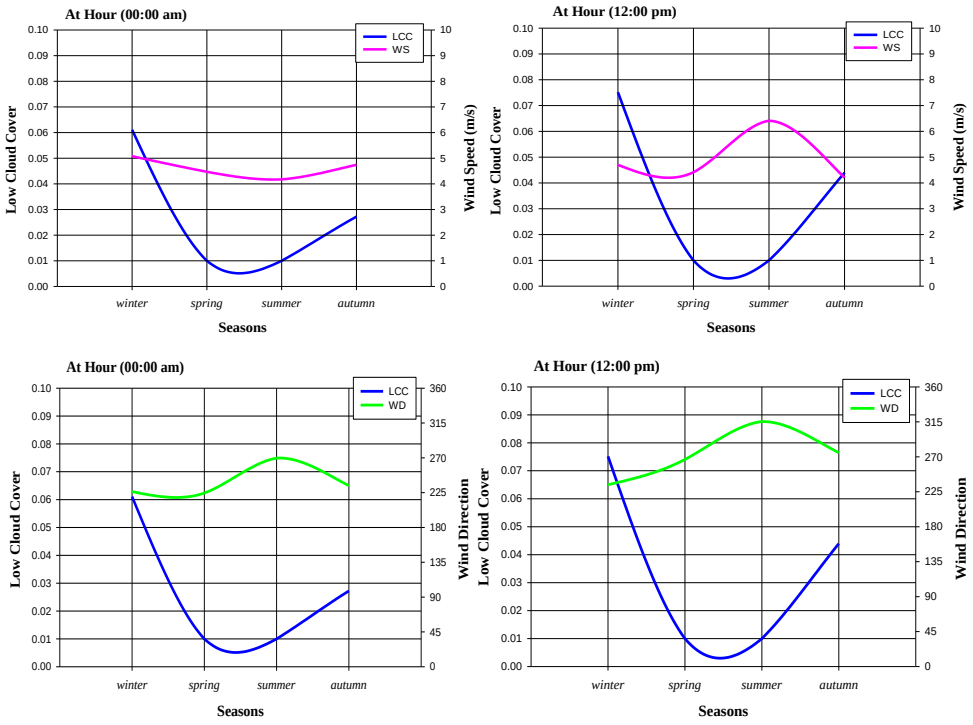

Figure 8. The seasonally change of (LCC and WS), (LCC and WD) at 00:00 am -12:00 pm for Baghdad station

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