Effect of Cloud Cover Types on Solar Radiation Types for Selected Stations in Iraq

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Abstract

The main sources of radiation are solar radiation as incoming short wave (SW) radiation entering the Earth and the longwave radiation (LW) emitted by the Earth's system into space. Absorption of the Sun's radiation heats the Earth's surface, which then warms the air above it. Cloud cover is one of the most important atmospheric factors affecting solar radiation, which plays a major role in the energy budget from cooling and heating. Data are taken by cloud cover types and Sunshine Duration in (Hours), Top Net Solar Radiation for Clear Sky in (W/m^2), Top Solar Radiation in (W/m^2), and Top Incident Solar Radiation in (W/m^2) from satellites recorded by the European Centre for Medium-Range Weather Forecasts (ECMWF). The choice of the period (1979-1983) over Baghdad, Mosul, and Basra stations. Otherwise, we have studied analysis monthly mean of LCC, MCC, HCC, and solar radiation types, as well as the relationship between LCC, MCC, HCC, and solar radiation types. The results showed that the relationship between TCC and Top is inverse for the three stations. Where Basra and Mosul stations represent the highest correlation while Baghdad station and represents the middle correlation. As well as the highest amount of TCC occurred in the winter and spring season. Also the highest cloud cover at the Mosul and the lowest cloud cover at Basra.

Keywords: Cloud cover types, solar radiation types, ECMWF, radiation budget, Iraq.

1. Introduction

Clouds attenuate sunlight by scattering the light when the cloud cover is light to medium and by absorption when the cloud cover is heavy (dense)[1]. The optical depth of the clouds and also the fraction of the sky covered by clouds are important for understanding sunlight transmission[2]. Dense (dark) clouds at low altitudes have an optical depth ranging from ∼50 to 90. Thin and high-altitude clouds have an optical depth ranging from ∼1 to 5 [3]. If the clouds are sufficiently thick, then direct beam radiation is not transmitted to the ground; instead, it is the scattered (diffuse) indirect light that is available. The albedo of clouds covers the range (0.36–0.78). These numbers are associated with the ability of clouds to reflect electromagnetic radiation. But this reflection can come from above or below[4, 5]. When the reflection is sunlight, the clouds cool the Earth[6]. This is a common experience when a cloud comes between the Sun and the person on Earth. However, if the reflection occurs by the underside of the cloud, heat is retained on Earth[7]. This phenomenon is most evident in the deserts when the temperature is high during the day and becomes very cold at night because there are no clouds to retain the daytime heat[8]. The temperature cycle in a desert resembles that of the Moon on the light and dark sides [9, 10].

1.1. Literature Review

Many studies describe the role of the Effect of cloud cover on types of solar radiation for selected stations in Iraq as estimation of solar radiation from cloud cover data of Bangladesh, It was found that it is always better to estimate solar radiation from sunshine duration as it gives the best estimation and accuracy, but if there is no sunshine duration data available for a site, then

solar radiation can be estimated directly from cloud cover data. Estimating sunshine duration first from cloud data to estimate solar radiation introduces more error as it has to go through the modeling stage twice. In case of the need for sunshine duration data only, the estimation from cloud cover is quite helpful. It was also found from the study that for a small country like Bangladesh separating data according to latitude has an insignificant effect[11]. Some research showed that the relationship between low and medium clouds is positive as but the relationship between high clouds is inverse. This is due to the main cause of rain being low and medium clouds but high clouds are not accompanied by rain [12]. Also Studied Study of Absorbance and Emissivity Solar Radiation by Clouds, Aerosols and Some Atmospheric Gases and resulted in The large total cloud during the winter, spring and decrease during the autumn, summer because of the low temperature that acts on the formation of clouds and rain as well as meteorological parameters others[2]. As well as presented the largest amount of Total precipitation occurred on 01/04/2019 (03:00 pm) for Mosul station and 01/04/2019 (03:00 am) for Baghdad station and 28/01/2019 (03:00 pm) for Rutba station while 25/03/2019 (03:00 am) for Basra station [13].

2. Methodology

2.1.The data and study area

Data were taken from the European Center for Medium-range Weather Forecasts (ECMWF) for monthly means of cloud cover types (low, medium, and high) and monthly means of solar radiation types for the (1979-1983) year over three stations (Mosul, Baghdad, and Basra) within the Iraq. where featuring extremely hot, dry summers and mild winters (see Figure 1, and Table 1) [14] [15].

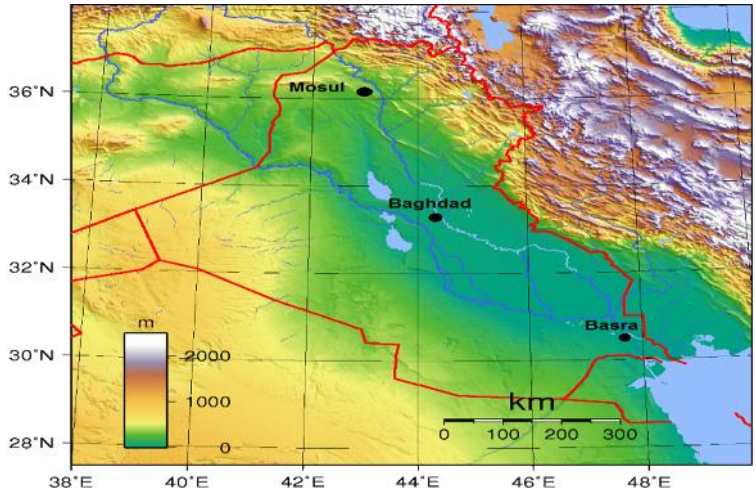


Fig. 1. Locations of the study stations (Mosul, Baghdad, and Basra) in Iraq.

Table 1. Latitude, Longitude, and Elevation over sea level for the study stations (Mosul, Baghdad, and Basra) in Iraq

Study Stations	Latitude in Degree North	Longitude in Degree East	Elevation in Meter
Mosul	36.34º N	43.13º E	223 m
Baghdad	33.33º N	44.38º E	34 m
Basra	30.30º N	47.49º E	5 m

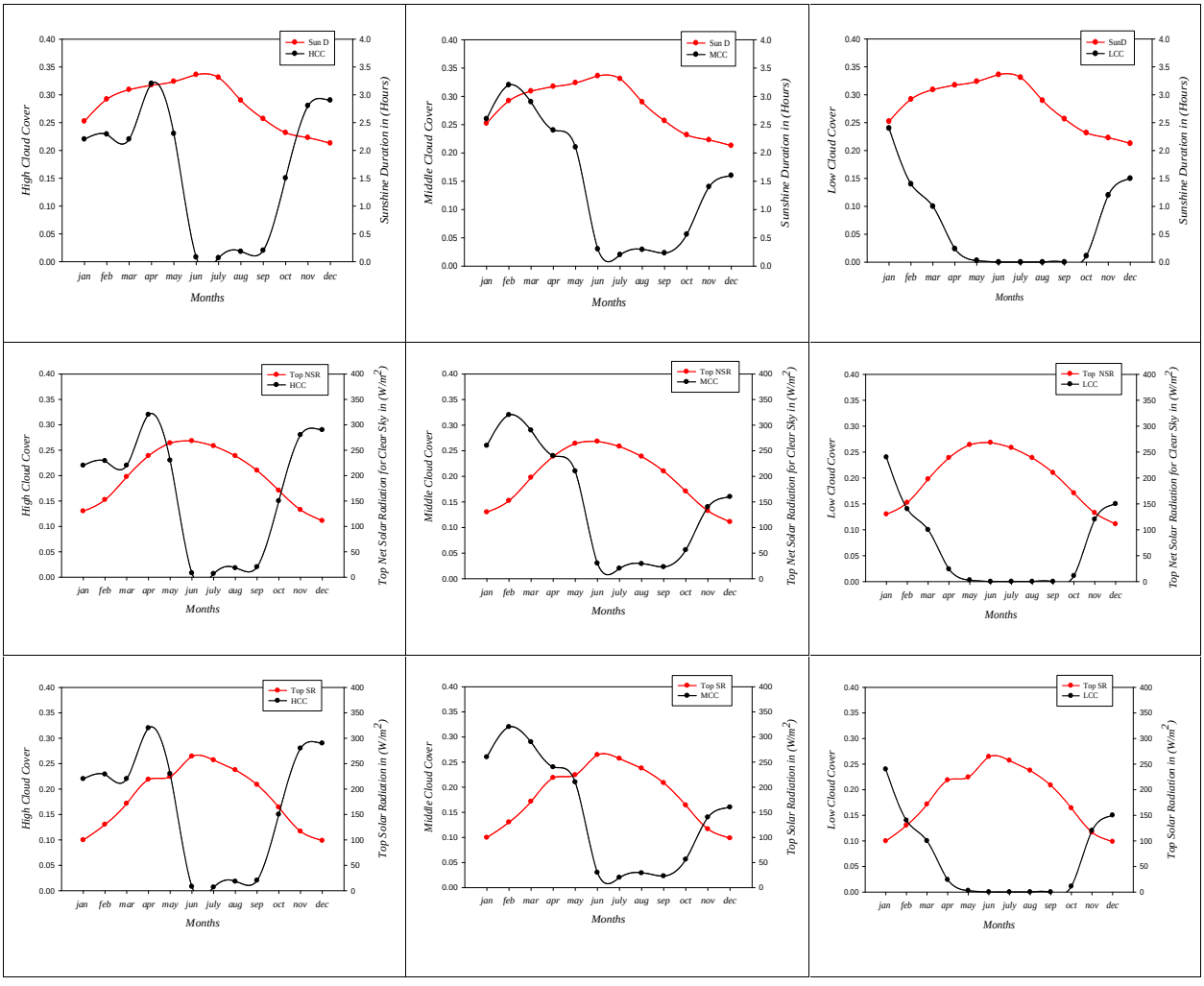
2.2.Statistical Used

Choosing Pearson correlation from several statistical tests has been selected regression analysis[16]. Using statistical program *Sigmaplot (V. 11)* to figure out the slope of the regression (b) and p-value simple linear regression way to detect the relationship between cloud cover types and solar radiation types by simple linear regression (SLR) [17] [18].

3. The Results and Discussion

3.1.The Monthly Mean of Cloud Cover Types and Solar Radiation Types over Mosul Station

Figure 2, and 3, shows The cloud cover (LCC, MCC, and HCC) increase in winter and spring and decreases in autumn and summer (June) because of the low temperature that acts on the formation of clouds and rain as well as meteorological parameters others and nuclei to condense. While solar radiation types are highest in summer and less in winter this is due to the intensity of sunlight, duration of sun brightness, different earth albedo, and earth's rotation the variation of meteorological parameters values, and astronomical factors through the seasons. Where the HCC and sunshine duration was highest.



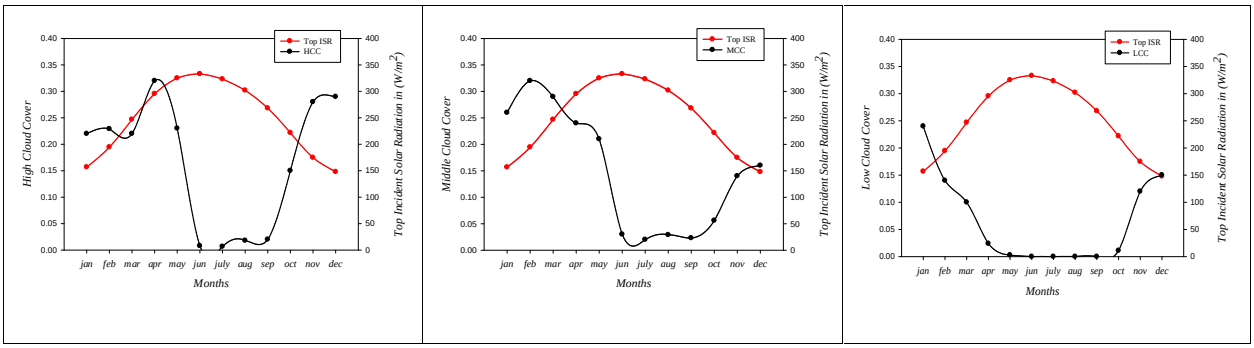


Fig. 2. The monthly mean change of cloud cover types and solar radiation types over Mosul station for the period (1979-1983).

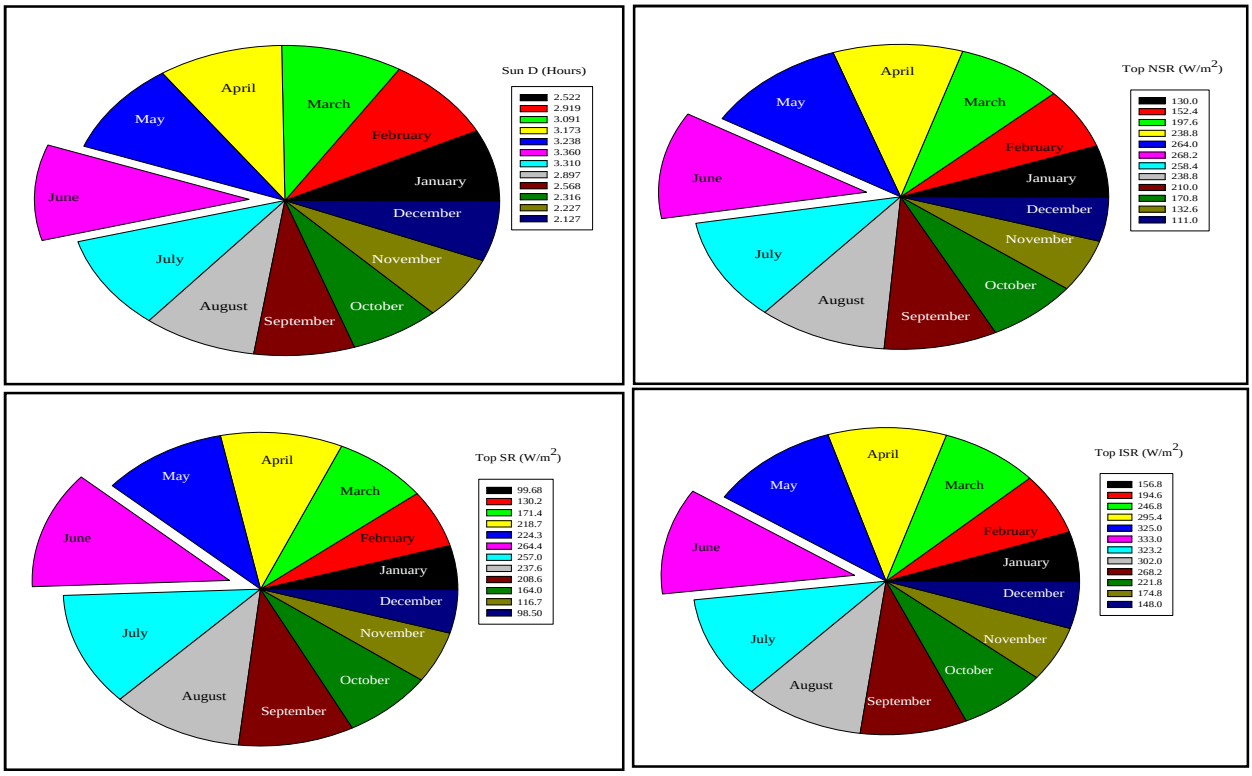


Fig. 3. The highest monthly mean of solar radiation types over Mosul station for the period (1979-1983).

3.2.The Monthly Mean of Cloud Cover (LCC, MCC, and HCC) and Solar Radiation Types over Baghdad Station

Figures 4, and 5, shows The cloud increase (LCC, MCC, and HCC) in winter and spring and decreases in autumn and summer (June) because of the low temperature that acts on the formation of clouds and rain as well as meteorological parameters others and nuclei to condense. While solar radiation types are highest in summer and less in winter this is due to the intensity of sunlight, duration of sun brightness, different earth albedo, and earth's rotation the variation of meteorological parameters values, and astronomical factors through the seasons. Where the HCC and sunshine duration was highest.

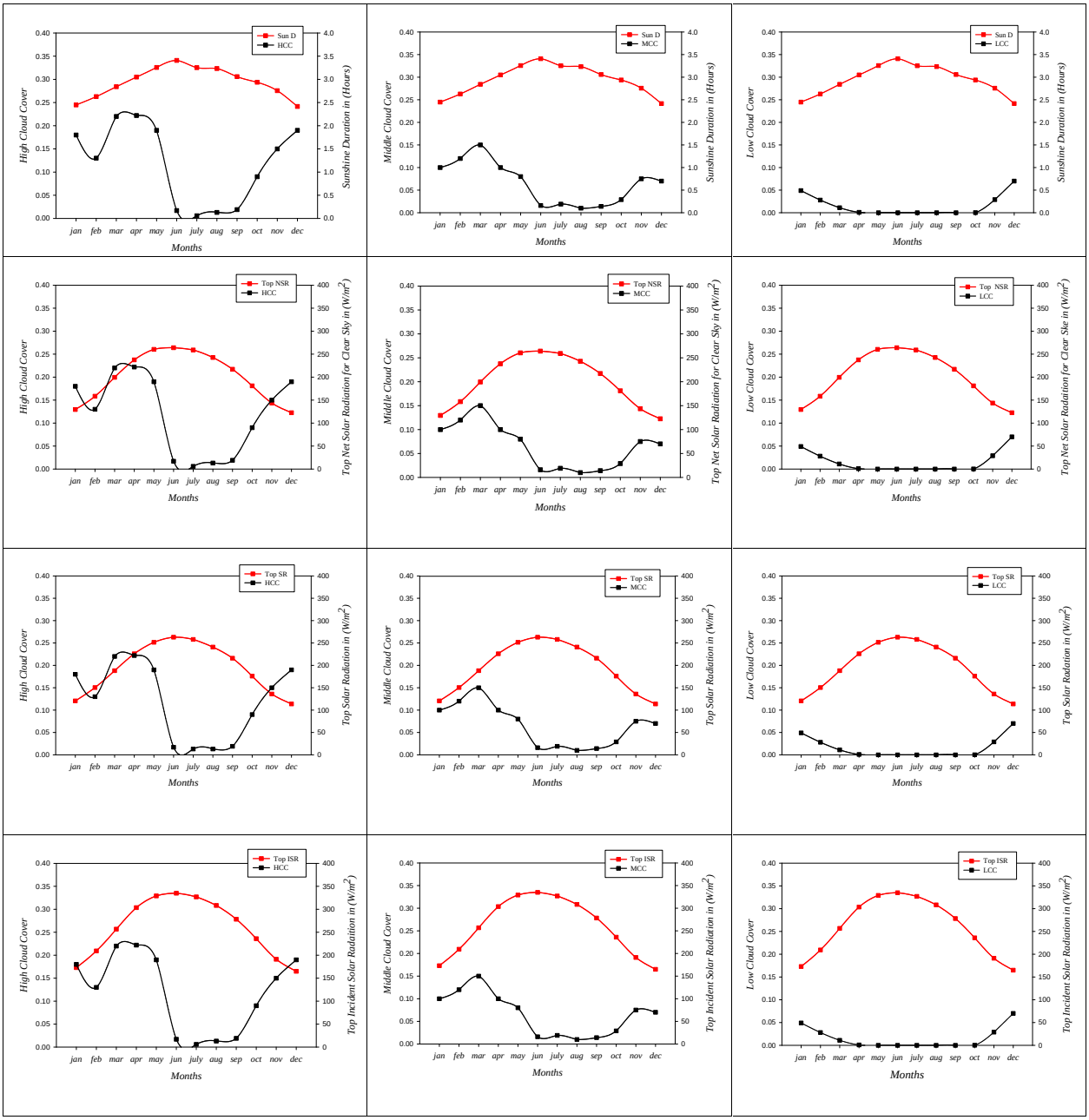


Fig. 4. The monthly mean change of cloud cover types and solar radiation types over Baghdad station for the period (1979-1983).

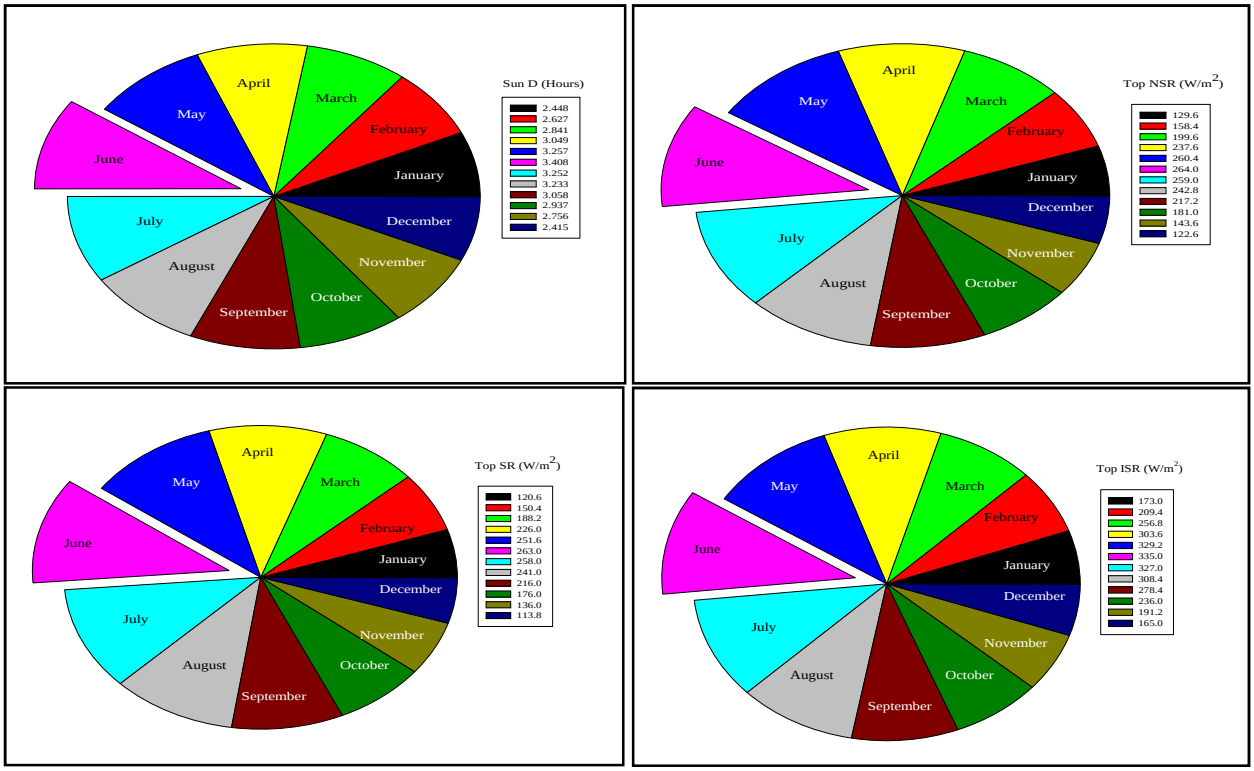


Fig. 5. The highest monthly mean of solar radiation types over Baghdad station for the period (1979-1983).

3.3.The Monthly Mean of Cloud Cover (LCC, MCC, and HCC) and Solar Radiation Types over Basra Station

Figures 6, and 7, shows The cloud increase (LCC, MCC, and HCC) in winter and spring and decreases in autumn and summer (June) because of the low temperature that acts on the formation of clouds and rain as well as meteorological parameters others and nuclei to condense. While solar radiation types are highest in summer and less in winter this is due to the intensity of sunlight, duration of sun brightness, different earth albedo, and earth's rotation the variation of meteorological parameters values, and astronomical factors through the seasons. Where the HCC and sunshine duration was highest.

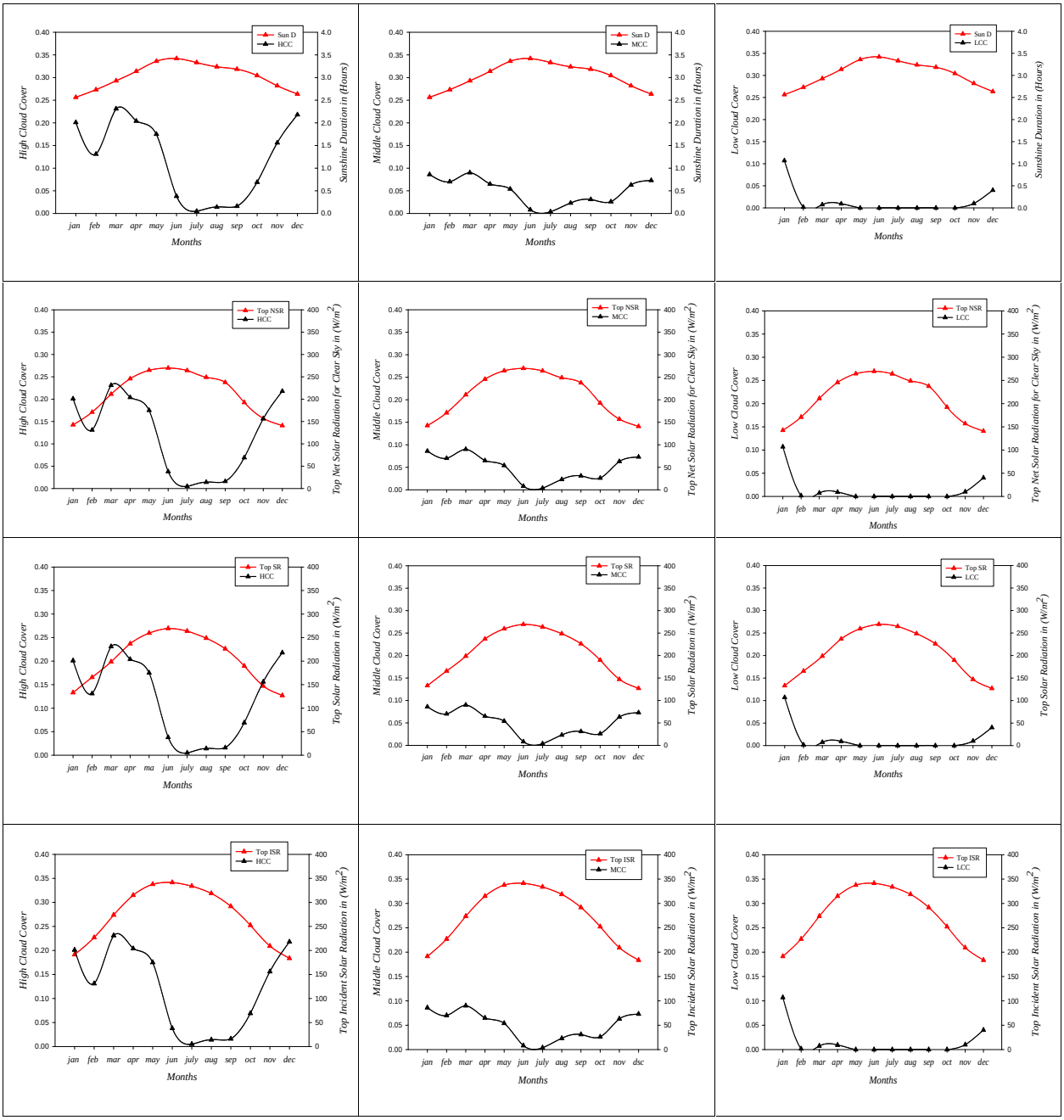


Fig. 6. The monthly mean change of cloud cover types and solar radiation types over Basra station for the period (1979-1983).

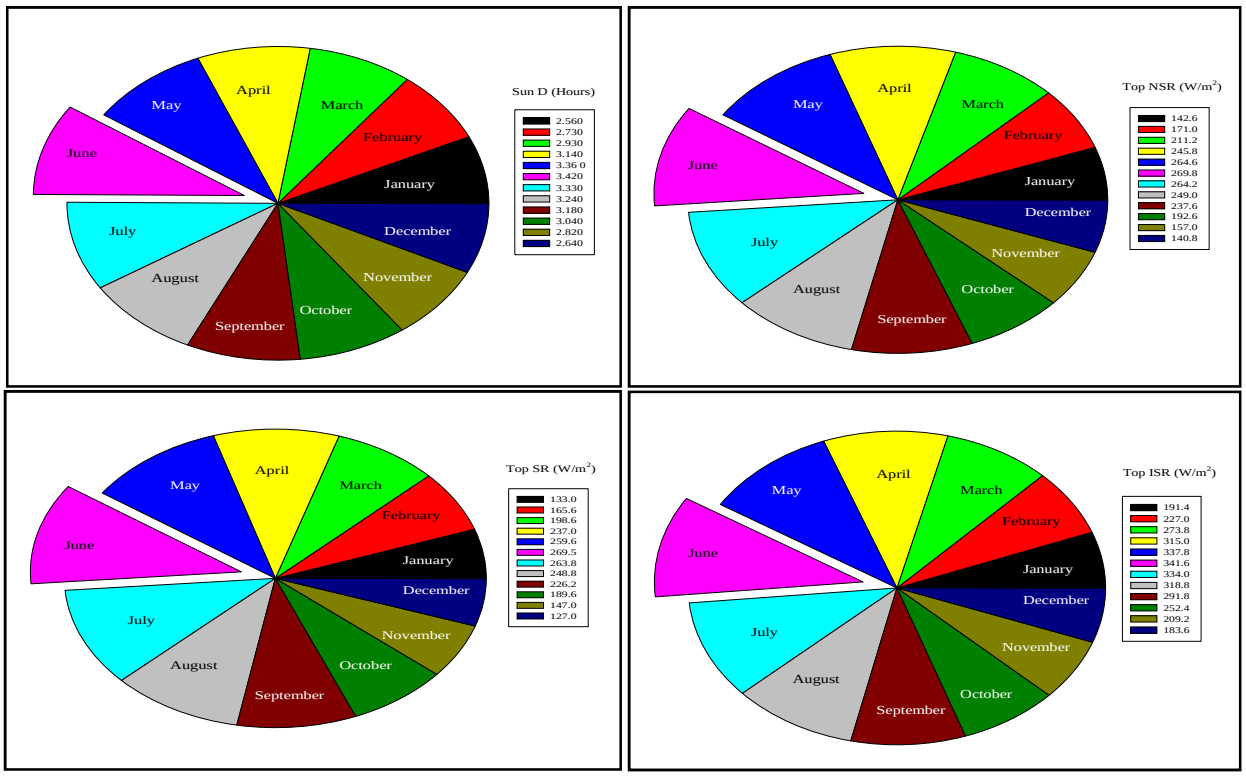
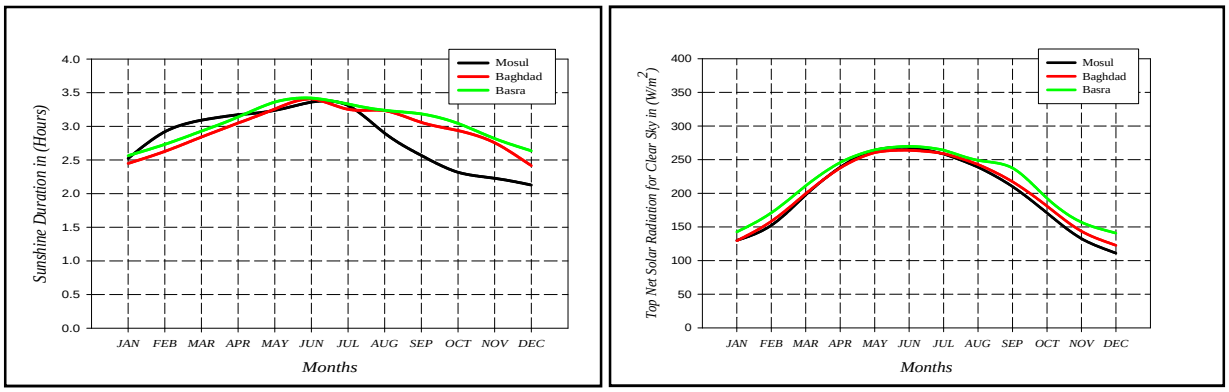


Fig. 7. The highest monthly mean of solar radiation types over Basra station for the period (1979-1983).

3.4. Analysis of the Monthly Mean of solar radiation Types

Figures 8, and 9, show the monthly mean of top solar radiation sunshine data for the period (1979-1983). It was found that the large radiation is Basra station, and the type less of radiation is Mosul station. Because the main source of solar energy is the sun where the intensity of sunlight, duration of sun brightness also incident of angle. All solar radiation is high in summer and be is less in winter at the times because of the variation of meteorological parameters values and astronomical factors through the seasons.



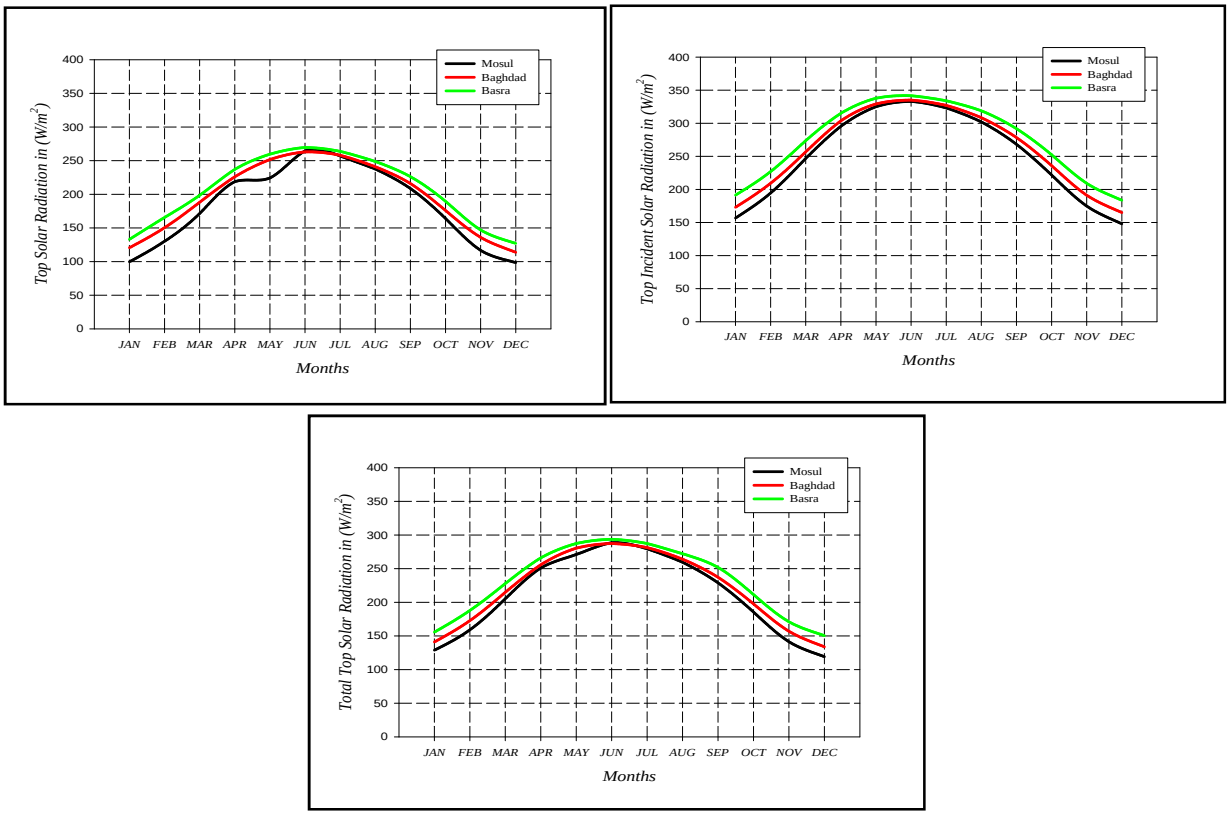
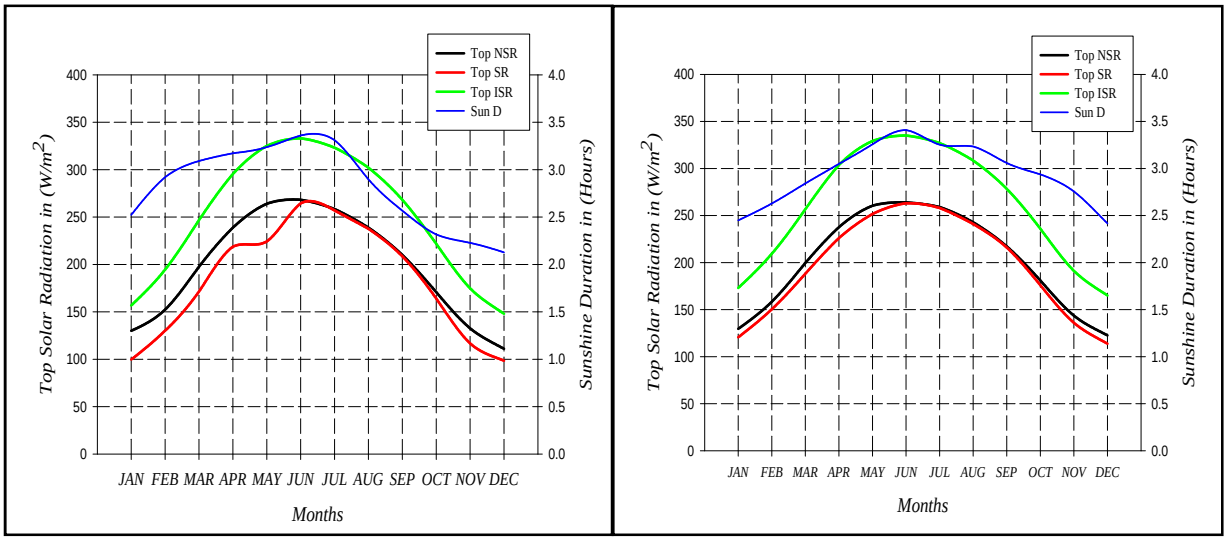


Fig. 8. The monthly mean change of types of solar radiation over study stations (Mosul, Baghdad, and Basra) in Iraq for the period (1979-1983).



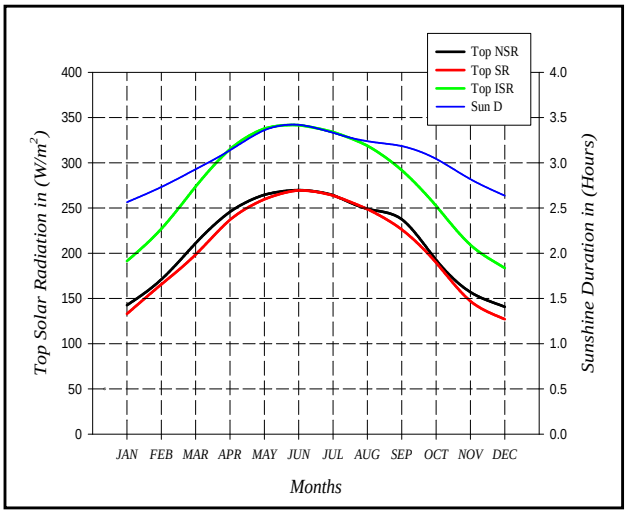
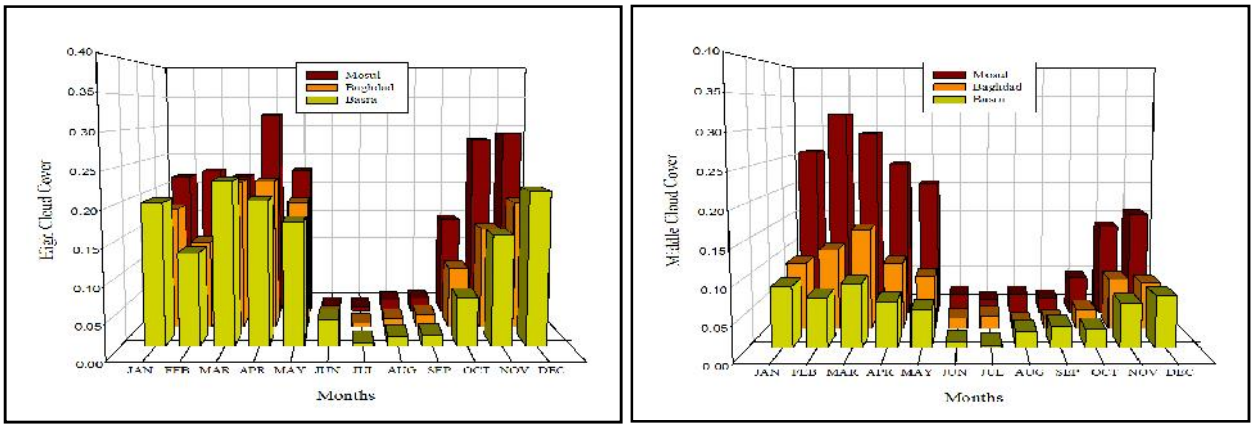


Fig. 9. The monthly mean change of types of solar radiation and sunshine duration for the period (1979-1983).

3.5. Analysis of the Monthly Mean of Cloud Cover Types

Figures 10, and 11, show the monthly mean of cloud cover types (TCC, LCC, MCC, and HCC) for the period (1979-1983). Where it was found that the highest cloud cover at Mosul there is a thicker cloud due to high humidity and low temperature. And lowest cloud cover at Basra, this due to strong radiation, the cloud increase (LCC, MCC, and HCC) in winter and spring and decreases in autumn and summer because of the low temperature that acts on the formation of clouds and rain as well as meteorological parameters others and nuclei to condense. The increase and decrease in cloud cover affect the amount of solar radiation reaching the Earth's surface. The low clouds are not small as in Figure 11, but the reasons are due to the unclear monitoring by the satellite, which monitors the clouds above it. When there is a high and medium cloud cover, it will block the low clouds and therefore low values will be recorded for the low cloud cover during the study period.



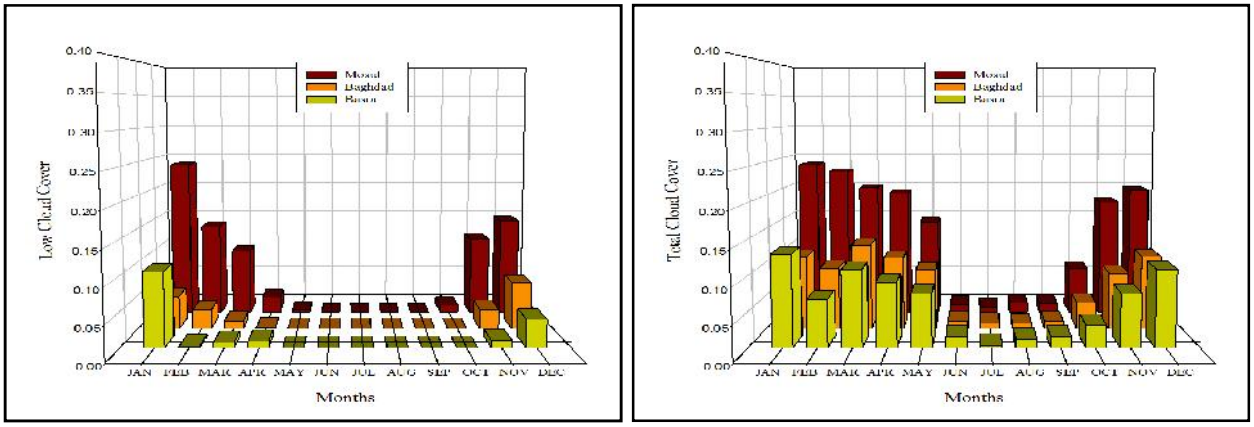


Fig. 10. The monthly mean change of types of cloud cover over study stations (Mosul, Baghdad, and Basra) in Iraq for the period (1979-1983).

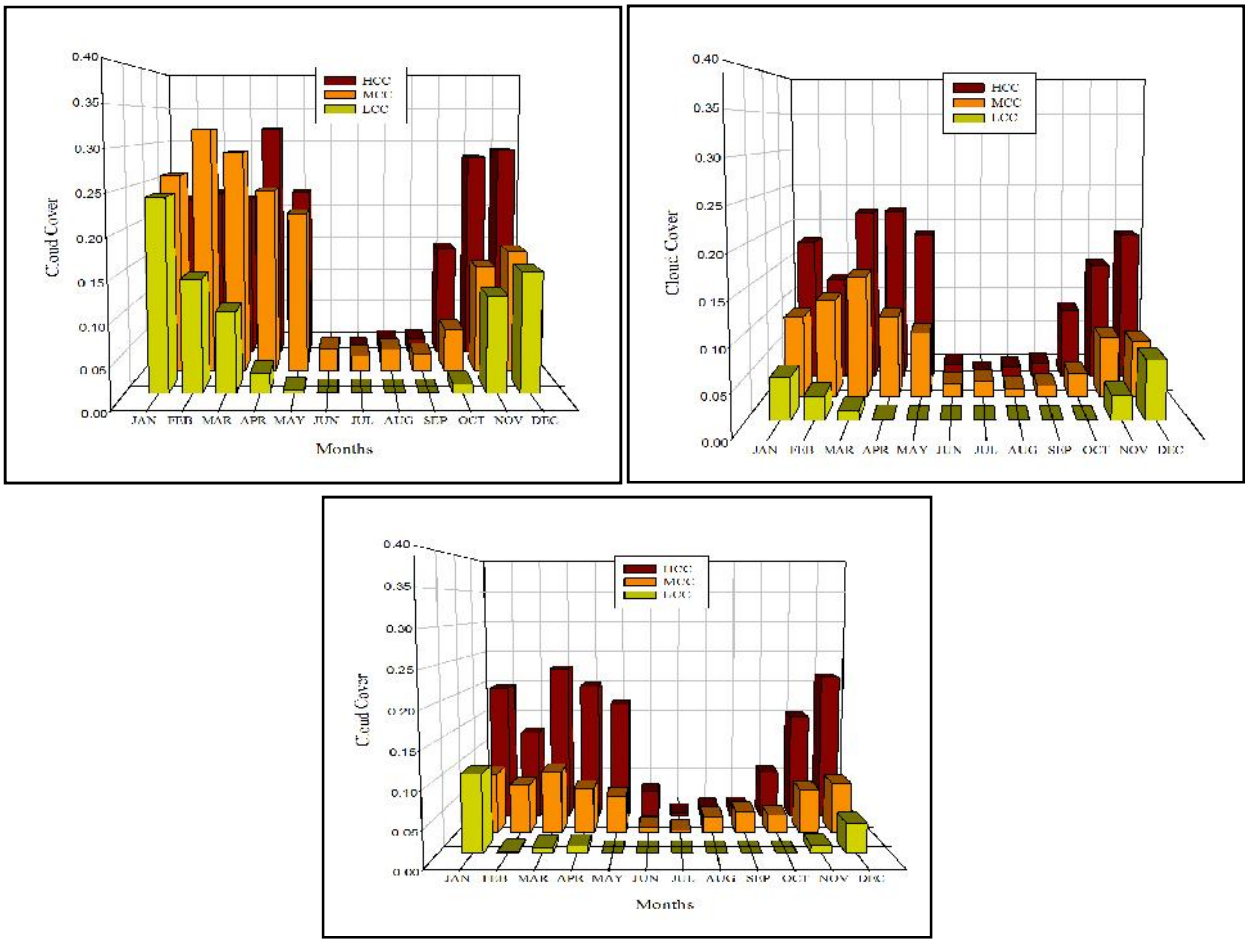


Fig. 11. The monthly mean change of types of cloud cover for the period (1979-1983).

3.6. The Relation between the Monthly Mean of Cloud Cover and Solar Radiation Types over Baghdad, Mosul, and Basra Stations

Figure 12 and Table 1 show the type of relationship and the strength of the correlation between cloud cover types and solar radiation for selected Baghdad, Mosul, and Basra stations. Where the relationship between TCC and solar radiation is inverse in all stations because the increase in cloud cover leads to less solar radiation reaching the surface and less thermal radiation escaping to space and correlation is highest in Mosul and Basra stations.

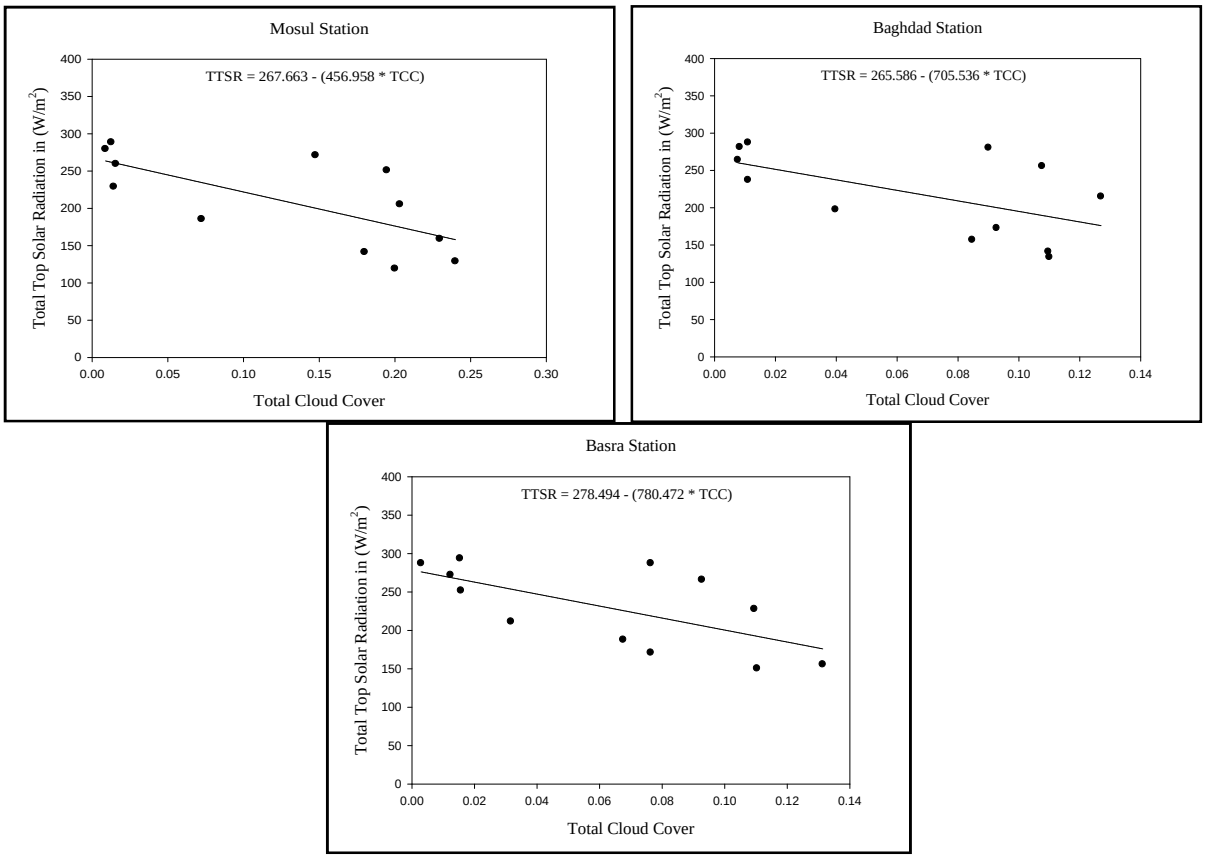


Fig. 12. The relationship between the total cloud cover with total solar radiation over study stations (Mosul, Baghdad, and Basra) in Iraq for the period (1979-1983).

Table 2. Results test of the statistical using (Simple linear regression (SLR) and Pearson correlation) for the relationship between the total cloud cover with total solar radiation over study stations (Mosul, Baghdad, and Basra) in Iraq for the period (1979-1983).

Study Stations	**Simple linear regression**		**Pearson correlation**	
	Slope	**Interpretation**	**r_s**	**Correlation**
Mosul	0.001	Linear	-0.7	High inverse
Baghdad	0.004	Linear	-0.6	Medium inverse
Basra	0.002	Linear	-0.7	High inverse

4. Conclusions

- The cloud increase (LCC, MCC, and HCC) in winter and spring and decreases in autumn and summer (June) because of the variation of meteorological parameters values and astronomical factors through the seasons.
- Where the relationship between TCC and solar radiation is inverse in all stations because the increase in cloud cover leads to less solar radiation reaching the surface and less thermal radiation escaping to space and correlation is highest in Mosul and Basra stations.
- The highest cloud cover at the Mosul there is a thicker cloud due to high humidity and low temperature. And lowest cloud cover at Basra, this due to strong radiation.
- The increase and decrease in cloud cover affect the amount of solar radiation reaching the Earth's surface.

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