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Short communication

Relation between the cloud cover and photosynthetically active radiation (PAR) in Baghdad, Iraq

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Clouds cover a major portion of the earth surface and play an important role in the climatic system with their strong effects on atmospheric processes, affecting the radiation budget (Raschke *et al.,* 2005). In crop production, the problem of the influence of production technologies, a variety of conditions and characteristics of land cover on crop yields has not been fully solved. One of the ways to solve these problems is satellite monitoring (Mahmood and Bolotov, 2022). Cloud cover prevents optical instruments from obtaining a clear image of the Earth's surface. Cloud cover limits the capabilities of these systems to provide sufficiently clear images of surfaces with sufficient frequency to monitor these changes (Mahmood, 2022).

The photosynthetically active radiation (PAR) is the portion of the solar radiation spectrum that is usable by plants for photosynthesis. Cloud cover significantly influences the availability and intensity of PAR reaching the Earth's surface. While clouds generally reduce the total incoming solar radiation by scattering and absorbing light, their effect on PAR is complex and can vary depending on cloud type, thickness, and coverage (Pashiardis *et al.,* 2017). Moderate cloud cover can enhance diffuse radiation, which penetrates deeper into plant canopies and can improve overall photosynthetic efficiency, especially in dense vegetation. However, heavy or persistent cloud cover typically leads to a substantial reduction in PAR, potentially limiting photosynthesis and plant growth (Lozano *et al.,* 2022). Thus, understanding the dynamic relationship between cloud cover and PAR is essential for modelling plant productivity, especially in ecosystems or agricultural systems sensitive to light availability. The aim of this study of the relationship between the cloud cover and PAR and in the city of Baghdad.

Baghdad is positioned at 33.33° N latitude and 44.42° E longitude with elevation of 34 m above sea level. Baghdad experiences a hot desert climate characterized by long, extremely hot summers and short, mild winters. In summer, air temperatures often exceed 45 °C, whereas in winter they typically range from 5 to 15 °C. Precipitation is low, with most rainfall occurring between November and March, averaging less than 150 mm annually (Al-Naser and Al-Jiboori, 2025). Annual data for Photosynthetically Active Radiation (PAR) and cloud cover (%) from 2000 to 2020 were obtained from the NASA Prediction of Worldwide Energy Resources (POWER) Project, using the Data Access Viewer and selecting the 'Agroclimatology' community for optimal relevance to vegetation studies. The dataset, focused on Baghdad's geographic coordinates, is satellite-derived and widely recognized for its reliability in long-term climatological assessments. While minor uncertainties may arise under partial cloudiness, aerosol presence, or complex terrain, the data have been validated against ground observations and are considered robust for environmental research (Tayyeh and Mohammed, 2023).

Annual averages of both variables were used to reduce short-term variability and highlight long-term trends. A linear regression model was applied to quantify the relationship between cloud amount (independent variable) and PAR (dependent variable), based on the assumption that increasing cloud cover leads to a decrease in surface-level PAR due to greater attenuation of incoming solar radiation (Li *et al.,* 2002). The regression model was formulated as (Al-Jiboori *et al.,* 2020):

$$PAR=\beta_o+\beta_1*\text{Cloud cover (\%)}$$

where β_0 is the intercept and β_1 is the slope of the regression line, i.e., the rate of change. These values were obtained from the annual

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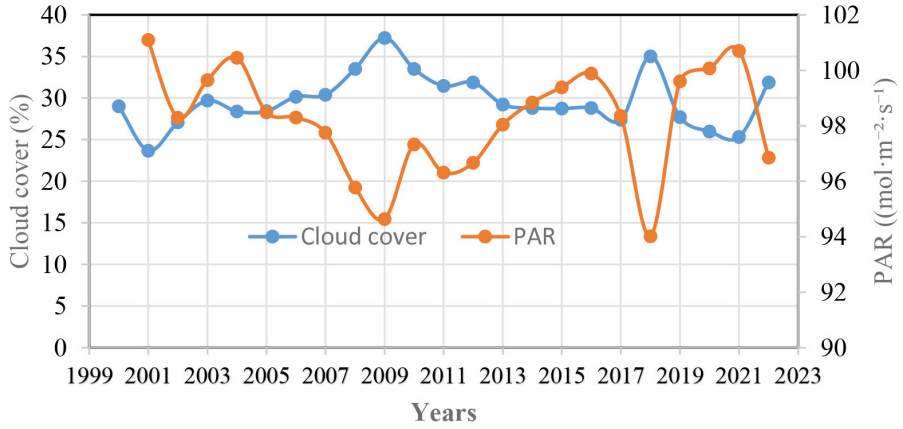

Fig. 1: Annual variation of cloud cover and PAR during 2000-2022 in Baghdad

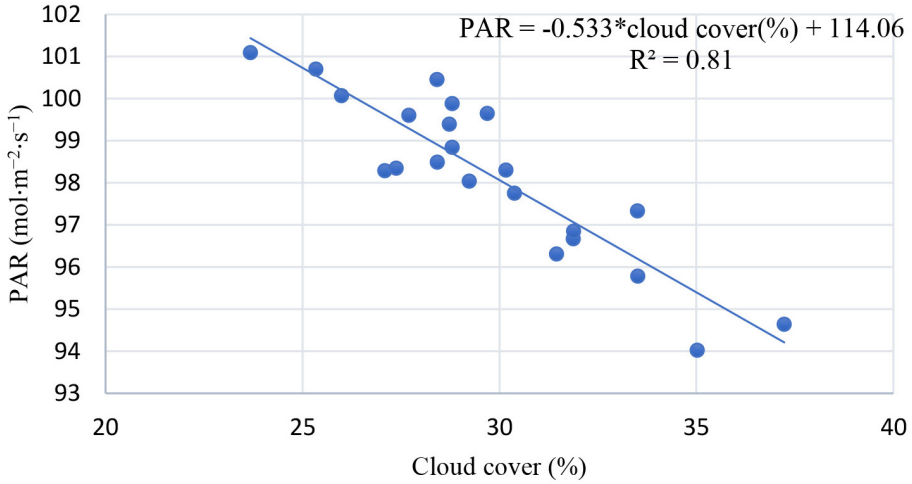

Fig. 2: Relationship between cloud cover and PAR over the period (2000-2022) in Baghdad.

PAR and cloud cover using Origin software. The model's goodness of fit was then assessed using the coefficient of determination (R^2).

The presented graph in Fig. 1 illustrates the annual average values of cloud amount (%) and all-sky surface PAR total over Baghdad for 23 years of the period 2000 to 2022. The highest percentage was estimated at (37.23%) in the year 2009, and its lowest value average (23.68%) in the year 2001, and the climatic indicators of PAR, where its highest value average was (101.9 mol·m^{-2}·s^{-1}) in the year 2001, and its lowest value average (94.02 mol·m^{-2}·s^{-1}) in 2018. Overall, the graph indicates an inverse relationship between cloud cover and PAR across the study period. Years with elevated cloud cover—such as 2009 and 2017—generally correspond to reductions in PAR, while years with reduced cloudiness—such as 2001, 2007, and 2018—exhibit higher PAR values. Notably, a significant decline in PAR is observed in 2018, coinciding with a spike in cloud cover, which supports the conclusion that cloudiness negatively impacts the availability of PAR.

The scatter plot presented in Fig. 2 illustrates the relationship between PAR (mol·m^{-2}·s^{-1}) and cloud amount (%) in an observational dataset. A linear regression line has been fitted to the data, yielding the equation PAR = -0.53*Cloud cover +114.1, with a R^2 of 0.81. This indicates a strong inverse relationship between cloud cover and PAR. For every 1% increase in cloud cover, PAR declines by approximately 0.53 mol·m^{-2}·s^{-1}. The R^2 value of 0.81 suggests that over 80% of the variation in PAR can be explained by changes in cloud cover, signifying a high degree of correlation. This outcome aligns with theoretical expectations, as increased cloudiness typically reduces the amount of solar radiation reaching the Earth's surface, thereby diminishing PAR levels that are crucial for plant photosynthesis and primary productivity.

The results demonstrated a strong inverse relationship between cloud amount and PAR, as confirmed by a linear regression model with a high coefficient of determination (R^2 = 0.81). These findings underscore the critical role of atmospheric conditions in modulating solar radiation at the surface and have implications for ecological modelling, urban climate resilience, and sustainable agriculture in arid environments like Baghdad.

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***Data availability*:** Data will be provided by author on request.

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