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Analysis of Dust Storm Intensity over Baghdad City

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ABSTRACT: ***Background:*** *Semi-arid regions of the world experience diverse climates and weather events, including dust storms. These storms suspend and transport particles in the atmosphere.* ***Objective:*** *The Iraqi Meteorological Organization and Seismology (IOM) is a key data source for researchers studying these dynamics, offering visibility data for Baghdad from several years (2005, 2008, 2009, 2011, 2018, 2022). Baghdad's data is also included in the ERA-5 dataset from the European Centre for Medium-Range Weather Forecasts (ECMWF), which provides precise hourly air temperature data at 2 meters above ground level.* ***Methods:*** *The study investigates the correlation between air temperature and dust storm severity in semi-arid regions, particularly during storm waves, which can constitute up to half of a storm's duration. The severity of dust storms, influenced by temperature variations, is crucial in understanding storm characteristics.* ***Results:*** *The findings underscore the significance of air temperature in understanding dust storms' behavior, aiding in refining forecasting models and emergency planning in vulnerable areas. The detailed spatial and temporal data from the study provide a foundation for in-depth research into the complexities of dust storms.* ***Conclusions:*** *By analyzing visibility and temperature records, the study emphasizes the role of climatic factors in shaping dust storm behavior in semi-arid regions.*

KEYWORDS: *Intensity; Dust storm; Temperature; Baghdad; ERA-5*

INTRODUCTION

Dust storms have a variety of implications on agricultural production, human health, the biogeochemical cycle, and radioactive forcing [1]. can carry over thousands of kilometers and cover vast areas [2]. At the same time, some unfavorable circumstances, such as population pressure rise, reclamation of arable land, and climate change, may damage the ecological environment and increase the frequency of dust storms [3]. When the horizontal vision at the ground is less than 2km in a dusty environment and the instantaneous wind speed is greater than 10 m s1, a dust storm is recorded [4]. According to various research, Temperature variations in temperature have an impact on dust storm intensity, hence the temperature effect in the visibility range and optical characteristic of the atmosphere [5]. JUGDER DULAM estimated that dust storms would begin anywhere between 12 and 36 hours in the future. Display a prediction accuracy of between 72.2 and 79.9 percent using the data used to generate the equations (dependent variables), and 67.1 - 72.0 percent using data that is unrelated to the development of the equations [6]. The frequency of sand-dust storms throughout the period 1960-2000 has been mapped out by the China State Meteorological Bureau. Its occurrence is most valuable in sandy and dry loess regions, and least valuable in high mountain regions [7]. Chinese studies The trend in DSI was for the period 1980-2007 According to the spatiotemporal distribution, they found four patterns of change in DSI over the period, which is a significantly declining trend, has increasing trend, remained a constant, double peak [8]. To effectively minimize DSI in northern China, the Great Green Wall (GGW) program adopted the Dust Storm Intensity Scale (DSI) in 1978.

The DSI takes into account the frequency, visibility, and duration of dust occurrences [9]. Vegetation index dropped by between 24.9% and 8.6% in four different areas. The association between changes in vegetation cover and variance in DSI was shown to weaken from the sub-humid temperate region to the dry temperate zone when Minghong integrated land surface data with DSI data using multiple regression [10]. The study of dust storms occurs frequently in arid Central Asia and greatly affects regions environment, as well as the global climate. Temperature controls wind speed and then dust storm intensity, the lower the temperature higher the intensity of dust storms, and vice versa [11]. When researcher Saadi Aood compared dust from a dust storm to dust found in the city of Baghdad, he discovered the local dust was significantly more polluted [12]. According to Iraqi researchers, the dust storm's trajectories are determined by winds in the depression system [13]. Dust storms are thought to be caused by drought, Nedham and Ahmed S. Hassan have determined the greatest indication for researching drought index to be the percentage of precipitation anomaly (PPA) [14]. Ali M. AL-Salihi analyzes Aerosol Index (AI) data from January 2003 to December 2013 for all of Iraq and neighboring regions (27.5°-38.5°N, 38°-49.25°E) with a spatial accuracy of 0.25° 0.25° [15], [16].

MATERIALS AND METHODS

The discipline of atmospheric sciences has come to rely heavily on scientific study because it is challenging to collect direct observational data about dust storms in the atmosphere. The Fifth generation ECMWF reanalysis for the past eight decades of the world's climate and weather is used in this study. Reanalysis integrates model data with observations. Data has been accessible starting in 1940 [17], [18]. Additionally, information from the Iraqi Meteorological Organization is used to gauge how intense dust storms are. By locating Baghdad's coordinates on the day of a dust storm's occurrence for the years 2005, 2008, 2009, 2011, 2018, and 2022, values for the visibility range and temperature were gathered to calculate the intensity of dust storm and plotted by the SigmaPlot program version14. Some nations frequently experience sand and dust storms (SDS) due to their geographic location. Iraq is regrettably one of those nations where dust storms can occur and continue for days. Summers in Iraq are typically hot and dusty. The central and southern Iraqi river valleys of the Tigris and Euphrates are vulnerable to throughout the year dust storms. Baghdad was selected for this study because it is located in the geographic center of Iraq at longitude 33.5 and latitude 44.5 [19], [20].

RESULTS AND DISCUSSION

The research on dust storms revealed a critical need to understand the intensity of dust storms due to their impact on several aspects of life. This study relied on an equation to calculate the intensity of the dust storm:

$$I = \frac{T}{V \times D}, \tag{1}$$

where I: intensity of dust storm, T: air temperature, D: duration of the dust storm.

Dust storm intensity is directly related to temperature, as is the case in the majority of the cases analyzed. The storm's intensity during the day corresponds to the rise in temperature. The dust storm's behavior in terms of intensity was depending on time, taking three hours. As a result, the storm is characterized in terms of weather rather than climate. This necessitates analyzing the sort of storm on an hourly rather than daily basis because the intensity characterizes the storm to us. Figure 1 shows how the dust storm's intensity rose progressively until it peaked at 50 degrees during the first quarter of the wave, In the last quarter of the dust storm, the intensity value returned to zero.

In 2008, the storm's intensity continued for three hours since it exceeded 30 degrees in June and zero degrees at its beginning and finish Figure 2.

At the beginning of the spring of 2009 Figure 3, The dust storm reached its peak, reaching 45 degrees, its intensity lasted two hours, and it was inside the third quarter of the wave, continuing to decline to its lowest value of 10 in the fourth quarter.

The stability of the temperature beyond the range of visibility is responsible for the decrease in the intensity values to 10 in the storm for the year 2011, as shown in Figure 4. The first peak of intensity at 5 am reaches 45 degrees and the second peak at 7 p.m. due to the drop in visibility range since there is an inverse relation between the intensity of the storm and the visibility range. This is in contrast to the morning when visibility range values vary.

At first, the 2018 storm was quite mild, but the intensity of the dust storm quickly picked up between 9 a.m. and 5 p.m., coinciding with the rising and falling temperatures that characterize the storm's wave, as shown in Figure 5.

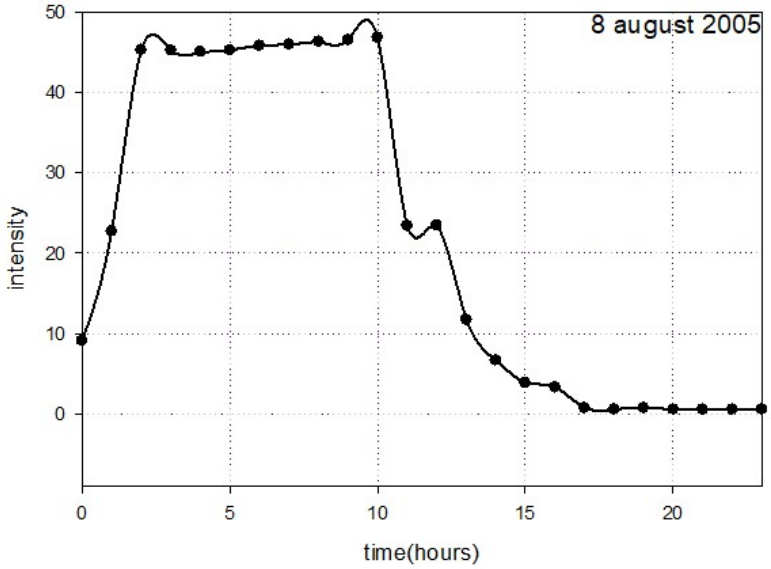

Figure 1. time series of intensity for hourly dust storm 2005

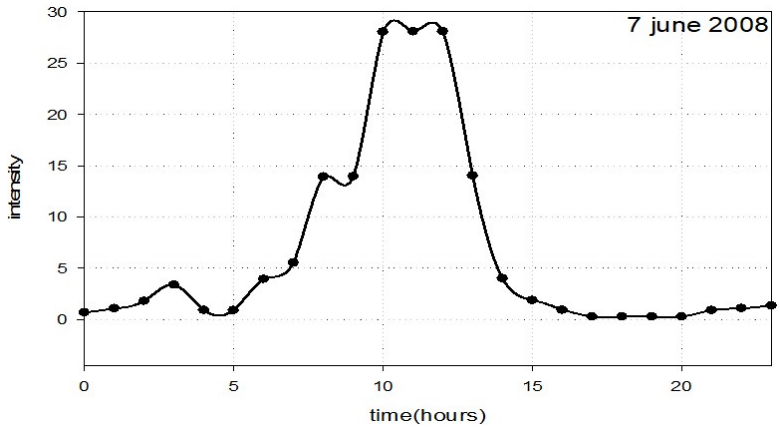

Figure 2. time series of intensity for hourly dust storm 2008

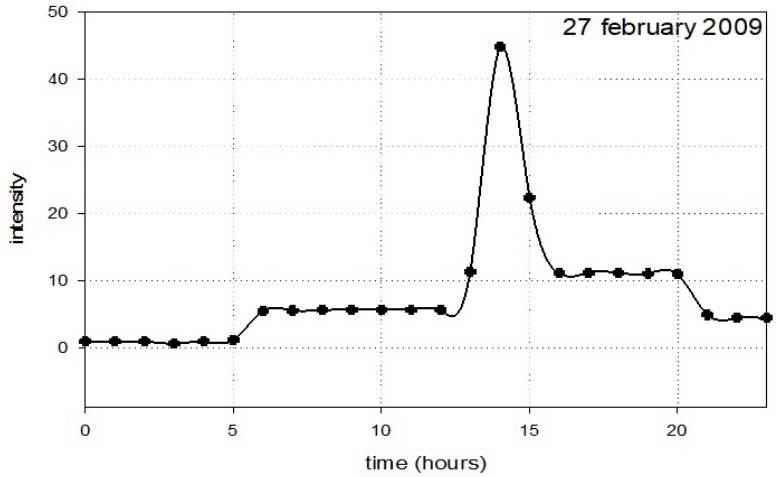

Figure 3. time series of intensity for hourly dust storm 2009

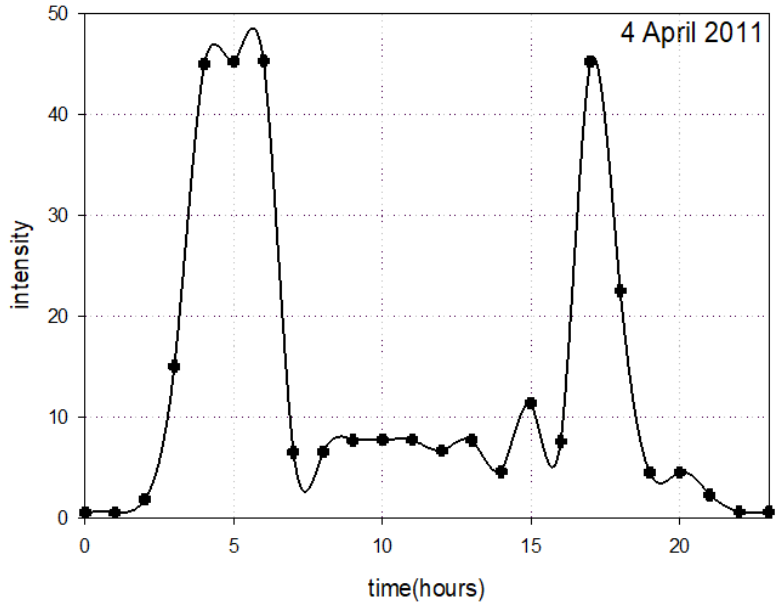

Figure 4. Time series of intensity for hourly dust storm 2011

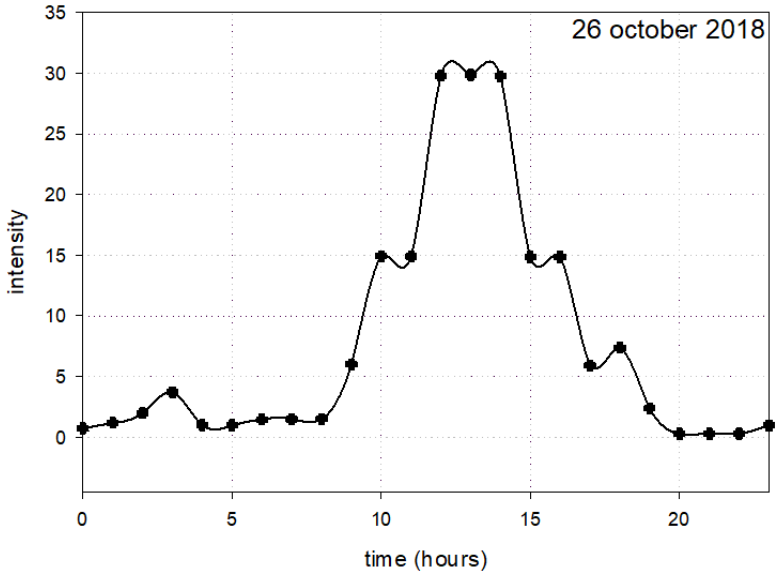

Figure 5. Time series of intensity for hourly dust storm 2018

Here, the entry factor of the decline in visibility is highly essential in increasing the intensity of the dust storm, and then reducing it to near zero, whereas in 2022 the intensity of the storm peaked in the early morning (3 a.m. – 9 a.m.), as shown in Figure 6.

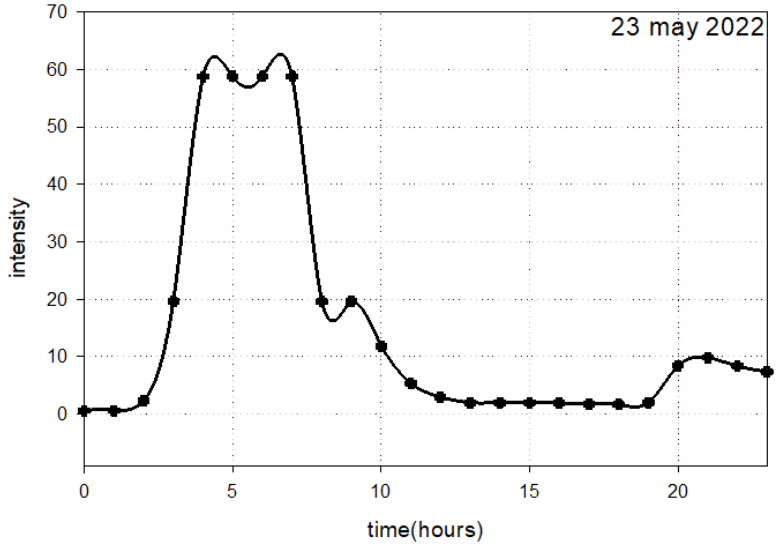

Figure 6. Time series of intensity for hourly dust storm 2022

There are four instances of dust storms where the storm's intensity value is near 50 degrees, only two instances where it is close to 30 degrees, and three instances where the storm's intensity is high and peaks between 10 a.m. and 3 p.m. Regarding the years 2005 and 2022, the storm intensity peaked between 5 and 10 in the morning, and we see in the all chosen cases, the storm intensity declines or even disappears in the evening. analyzing the data reveals that the dust storm intensifies to its maximum throughout the afternoon as air temperatures increase. In four of the six cases, the storm intensity was concentrated in half of the storm wave. where Three of the six cases demonstrated that storm intensity was focused in the early third of the storm wave. The findings revealed that there was one instance where the storm's intensity was focused in the storm wave's second third. The study demonstrated that storm intensity is an excellent predictor of storm degradation, which explains why dust storms exhibit a sequential behavior rather than a continuous one.

By dividing the total duration of a dust storm by the peak, Table 1 reveals that in four of the six cases, the peak of the storm remains constant.

Table 1. The values of the peak duration of a dust storm and the duration in an hour

The date	Peak duration (hour)	The duration of SDS (hour)
8/8/2005	8	15
7/6/2008	3	10
27/2/2009	1	15
4/4/2011	4	15
26/10/2018	3	10
23/5/2022	4	9

CONCLUSION

The intensity of a storm is the most important aspect in classifying them; it is used as an index for identifying the storm's stage and establishing a link between dust storms and other meteorological factors like temperature and visibility. It's important to use weather-related terms instead of climatic ones. This importance of intensity makes hourly rather than daily study necessary for understanding dust storms. In contrast to popular belief, dust storms do not occur in one continuous wave but have separate phases. The intensity of a dust storm provides important information about the stage of development it is in. This statistic is crucial because it reveals information about the relationship between dust storms and other aspects of the weather, such as temperature and visibility. The qualities of the storm are better captured by using language associated with that weather. When looking at the effects of the storm hour by hour instead of over a day, a more accurate picture emerges. By their very nature, dust storms do not develop in a continuous, sequential fashion. Instead, they have a sequential pattern, evolving through clearly defined phases. The sequential nature of this feature highlights the value of constant storm intensity monitoring to scientists and meteorologists. By monitoring the storm for an hour, its multiple phases may be better identified and analyzed. This focal point on intensity is useful in meteorology for forecasting the storm's path and potential damage. The hourly method provides greater detail, allowing for the identification of subtle changes in the storm's behavior. Through studying dust storms, scientists can learn more about the complex dynamics at play by identifying patterns and correlations between the intensity of the storm and other meteorological variables. An understanding of the complexity of a dust storm can be gained by gauging its severity. Researchers get useful information for forecasting models, improving measures, and expanding our understanding of these weather phenomena by focusing on the storm's progression on an hourly basis. A deeper understanding of dust storms and their complex relationship with meteorological parameters can be attained using this sophisticated approach, which is based on weather-specific vocabulary and rigorous hourly data.

SUPPLEMENTARY MATERIAL

None.

AUTHOR CONTRIBUTIONS

Asmaa K. Hammoodi: Writing, editing, and visualization. Ahmed S. Hassan: Supervised and contributed to the interpretation of the results. Jasim H. Kadhum: Supervised the study.

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None.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available at: https://www.ecmwf.int/en/research /climate-reanalysis.

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CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

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