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Article

Impact of the Air Temperature on Dust Storm in Middle and Southern Iraq

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Abstract: Dust storms (DS) are a part of the climatic phenomenon in most semi-arid regions worldwide. The environment of DS is characterized by the suspension and transport of fine particles of dust in the atmosphere. The association between air temperature (AT) and visibility was investigated. AT data came from the ERA-5, the fifth version of ECMWF, as hourly data for the Iraq region period (2008-2022). The second data came from the Iraqi Meteorological Organization and Seismology, where visibility is available for most of Iraq for the same time cases. The results were shown for both cases through mid-DS, where visibility was (300m), and AT increased by more than 10 OKs, the opposite relationship between AT and visibility. Analyzed of DS point to the AT decreased before visibility by a quarter wave of DS, AT considered a significant function for DS genesis. The track of DS attacked Baghdad first, then transferred to Najaf and Nasiriya, which took two hours. DS became dispersions after decreased AT and clear visibility to declare the end of DS.

Keywords: Dust storm, Air temperature, Visibility, Iraq

1. Introduction

Dust Phenomena is A component of atmospheric particulate matter; the phenomenon consists of at least four elements: suspended dust, rising dust, and dust storms [1]. An unstable atmospheric condition relationship with temperature causes Rising dust When wind speeds reach between 25-75 km/h [2]; as for convection current, small particles with diameters less than 63 micrometers that are dry and can reduce horizontal visibility, sometimes up to 4 kilometers, Called Suspended dust that remains in the air for extended periods due to its lightweight nature [3]. Dust storms characterized by the suspension and transport of fine particles of dust and debris in the atmosphere.

These events significantly impact various aspects of the environment, including geomorphology, climatology, ecology, and human activities [4]. The emergence of dust storms is caused by intense surface heating; the air above the ground becomes heated and creates variations in pressure, leading to the upward movement of air in a convective manner. Consequently, dust is stirred up, and sand particles are lifted to higher levels corresponding to the strength of the winds and the dryness of the soil [5], the majority of dust storms engage reasons of their occurrence, including climatic factor like insufficient rainfall regions that generally receive with increasing in the number of dry and hot days throughout the year [6]. Human activity such as extensive farming in unplanned areas,

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poor management of grassland, deforestation, and expansion of arid lands without vegetation cover [7], loose soil nature including dry gypsum and calcareous soils, where the organic matter content in these soils is low, around 1%, and the soil content of calcium carbonate exceeds 10%, negatively affecting the stability of the structure and makes them exposed to wind erosion [8], and one of the important reasons for handle the dust storm as a manifestation of climate changes is global warming that increase in temperature on Earth, where decrease in water quantity and rainfall [9].

Iraq is regarded as fertile land for dust storms, especially in the central and southern regions, because of its topography as a part of the larger desert (Rub' al Khali) and the Syrian Desert, prevailing weather patterns, arid to semi-arid conditions, which are conducive to the movement of dry air masses, such as the Shamal winds from the northwest, can transport dust and sand particles from these desert regions into Iraq [10]. A study conducted in China examined the severity of sand and dust storms. Using the current track and the direction of the horizontal surface wind, five main sources of SDS transportation were identified. One-third of sand dust storms have durations more than two hours due to winds of 10–17 m/s [11]. The occurrence of dust storms is directly related to wind speed and inversely related to rainfall, according to researchers in China (2016) who examined the divergence of dust storms with atmospheric conditions from 1983 to 2013. During that time, dust storms became more often, peaking at 29% in the spring [12]. A study conducted by Al-Khalidi et al., 2021 examined the synoptic analysis of dust storms in Iraq. The researchers found that dust storms of the frontal type tend to occur more frequently in the spring compared to the summer. The primary factor responsible for transporting dust long distances is the northwest wind [13]. Drought intensity increased across all weather stations and there was a correlation with elevated dust storm occurrences from 1981 to 2010, according to a study by Ali Sahib (2018) that examined the spatial distribution of dust phenomena in central and southern Iraq. In central Iraq and other dry and semiarid locations, wind speed is also associated with dust storms [14]. The dust storms of October 2017 were endured by Husam T. Majeed and Hawraa Majid Qasim. On the first day of the dust storm, two ridges existed in north Iran, and the storm developed above the dust source region. As the storm continued on its second day, the second one moved forward from Egypt [15]. There was a strong relationship between the Z-Score Index (ZSI), the Standardised Precipitation Index (SPI), and the Percentage of Precipitation Anomaly (PPA) in the study. In terms of drought vulnerability, the three indicators for the most recent period showed that northern Iraq was the least affected [16]. Dust storms and the amount of suspended and ascending dust particles were shown to have increased throughout the analysed time, according to another study. The average number of dust storms detected over the period was compared to the frequency of occurrence over the last five years. A noteworthy finding from the study is the downward trend line for water years, which indicates a clear decrease in yearly precipitation throughout the years. Trend line analysis, on the other hand, showed that yearly average air temperatures had been steadily rising [17]. Dust storms' effects on the temperature of the troposphere were investigated by Nazarov and Abdullaev. This was accomplished by measuring the impact of dust on air cooling and a reduction in the diurnal temperature difference during a dust storm that occurred in November 2007 in Dushanbe, Tajikistan.

Additionally, data on how dust in the air affects air temperature in arid zones was given. It was established what the crucial aerosol concentration value is for switching between the greenhouse and anti-greenhouse effects [18].

2. Materials and Methods

Difficulty obtaining direct observational data for dust storms in the atmosphere has led to a heavy reliance on scientific research in atmospheric sciences. This research includes data from Era5, the fifth generation ECMWF reanalysis for the global climate and weather for the past eight decades. Reanalysis combines model data with observations. Data is

available from 1940 onwards. Data from the Iraqi Meteorological Organization was used to assess the impact of temperature on dust storms. Values of visibility range and temperature were collected by determining the coordinates of selected cities in Iraq (Baghdad, Najaf, and Nasiriyah) during the days of dust storm occurrence for the years 2008 and 2022. We used SigmaPlot to plot these values, and we watched satellite images from the same storm days. The geography, culture, and history of Iraq have all been profoundly impacted by the country's position and climate. Syria, Turkey, Iran, Kuwait, Saudi Arabia, Jordan, and Jordan are some of Iraq's Middle Eastern neighbors. Because of its central position near the Persian Gulf and important maritime routes, it plays a pivotal role in regional politics and economics. Iraq's varied landscWe used SigmaPlot to plot these values, and we watched satellite images from the same storm days. The geography, culture, and history of Iraq have all been profoundly impacted by the country's position and climate. Syria, Turkey, Iran, Kuwait, Saudi Arabia, Jordan, and Jordan are some of Iraq's Middle Eastern neighbors. Because of its central position near the Persian Gulf and important maritime routes, it plays a pivotal role in regional politics and economics. Iraq's varied landscape varies from hilly northern sections to flat southern plains and deserts. The rivers Tigris and Euphrates provide irrigation, hydroelectric power, and transportation with freshwater as they flow through the middle and southern regions of the country. The geography and culture of Iraq owe a great deal to the influence of these rivers. Hot summers and relatively mild winters characterize Iraq's mostly desert climate. Dust storms and extremely hot weather (above 50°C) are summertime hazards that can reduce crop yields and endanger human health are varies from hilly northern sections to flat southern plains and deserts. The rivers Tigris and Euphrates provide irrigation, hydroelectric power, and transportation with freshwater as they flow through the middle and southern regions of the country. The geography and culture of Iraq owe a great deal to the influence of these rivers. Hot summers and relatively mild winters characterize Iraq's mostly desert climate. Dust storms and extremely hot weather (above 50°C) are summertime hazards that can reduce crop yields and endanger human health [17]. This study was conducted based on the selection of three cities in Iraq (Baghdad, Nasiriyah, and Najaf), Figure 1, as indicated in Table 1. These locations were distinguished by their geographical variation in distance, proximity to water bodies, and elevation above sea level.

Table 1. The study areas' longitude, latitude, and elevation

Station name	Longitude	latitude	Elevation
Baghdad	44.4	33.3	31.7
Najaf	31.95	44.32	53
Nasiryia	31.02	46.23	5

Figure 1. The map illustrates the main study areas

3. Results and Discussion

This study analyses the dust storm on the day of its occurrence, the day before, and the day after. The temperature falls 6 degrees below normal and keeps falling until it hits 298 degrees. During the day, it quickly climbs to 7 degrees. The trend of the temperature remains consistent from the start to the finish of the storm, Figure 2, for Baghdad. For the dust outbreaks in 2008 and 2022, the starting and ending temperatures were the same, reaching 304 k. This pattern persisted throughout the years. The blanket effect, the impact of long-wave radiation on daytime temperatures, provides an explanation for this observed phenomena. Figure 2 shows that visibility dropped to 300 m in the first quarter. At regular intervals, there is a cycle of storm activity, with the intensity increasing during the day and decreasing throughout the night. Figure 2 shows that whereas daytime visibility and temperature were directly linked, at night they were inversely proportional. The temperature changes in Baghdad, Nasiriyah, and Najaf follow this pattern.

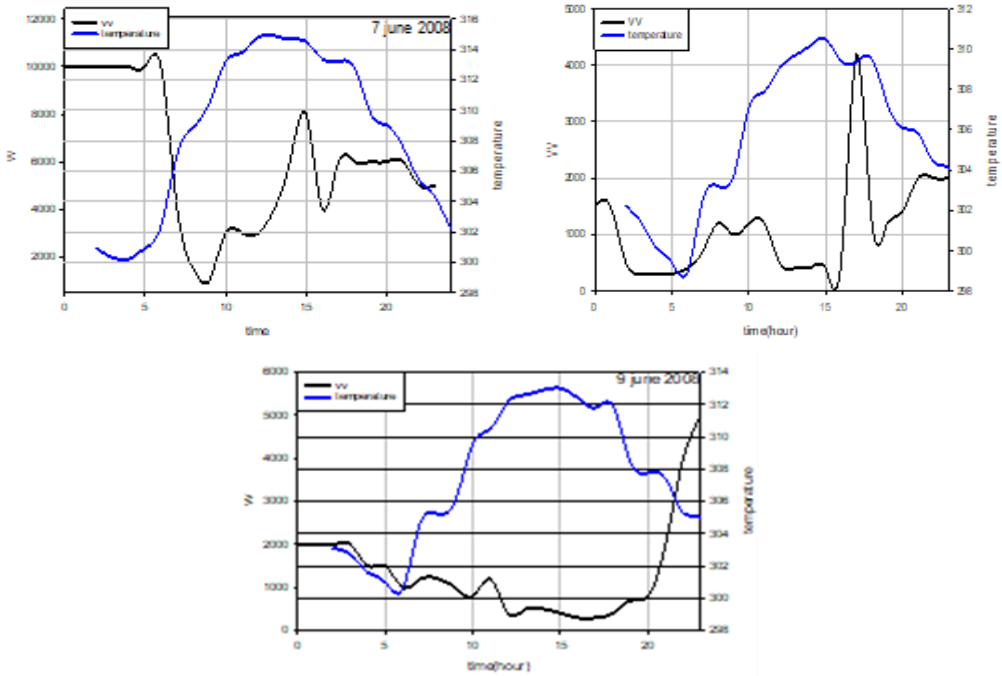

Figure 2. The temperature changes with the visibility range during dust storm hours in Baghdad

As shown in Figure 3, the high temperature was 312 k at 3 pm, while the low was 302 k at 6 am. At the height of the storm, nevertheless, there is a temperature-visibility phase difference of 180 degrees (Figure 3). Looking at Figures 2c and 3b, we can see that Baghdad and Nasiriyah are involved in a thermal exchange phenomenon, with Baghdad's temperature dropping a quarter of a wave before Nasiriyah. The course of the dust storm was traced as it moved into neighbouring provinces using satellite surveillance [7, 8]. Specifically, there was a noticeable gap between stations, as seen in the case of Nasiriyah compared to Baghdad.

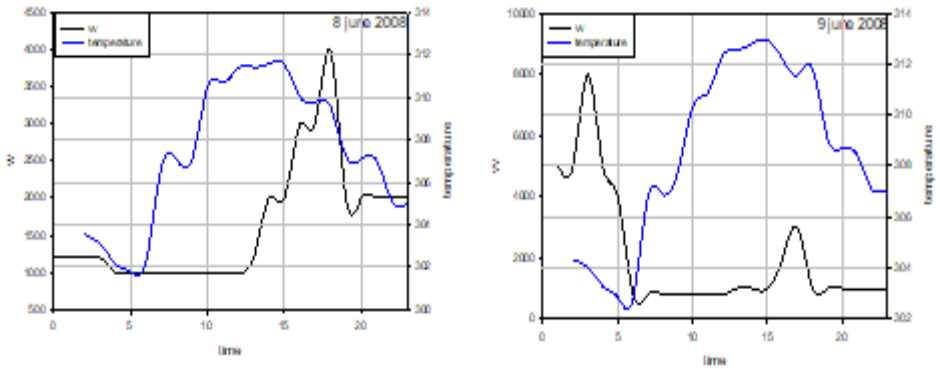

Figure 3. The temperature changes with the visibility range during dust storm hours in Nasiryia

The combination of Najaf's high temperatures, poor visibility, and hilly terrain led to the formation of dust storms. In addition, the sandstone terrain and lack of proximity to bodies of water like rivers and lakes result in an exceptionally active dust storm in Najaf, Baghdad, and Nasiriya.

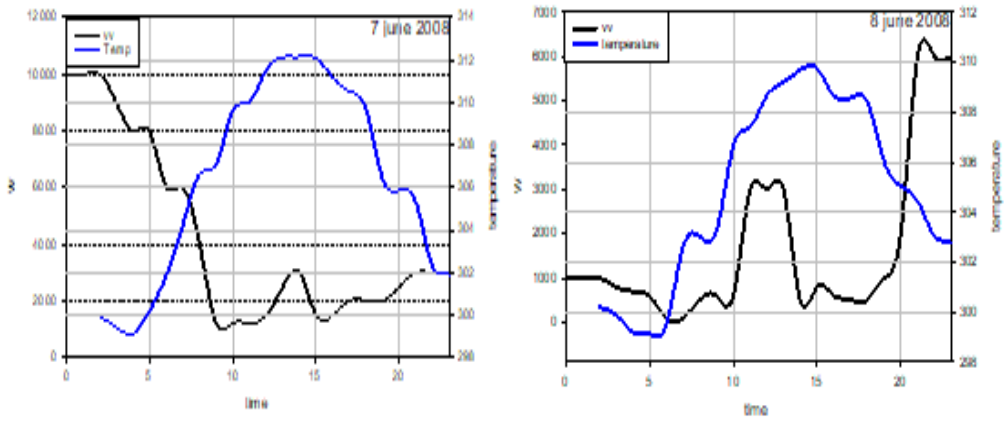

Figure 4. The temperature changes with the visibility range during dust storm hours in Najaf

It is clear that temperature is more sensitive to the beginning of the storm than visibility is when comparing the behaviour of visibility and temperature between 2008 and 2022; this is particularly true in the early stages before the storm reaches maturity (Figures 2, 3, and 4 with Figures 5 and 6 show a delay in Nasiriya). In the early phases of a storm's development, around half a wave before visibility, temperatures drop. In contrast, the storm in 2022 will only last for a single day, and

its duration will be cut in half. However, as shown in Figure 7, it maintains the same characteristics as the dust storm that occurred in 2008.

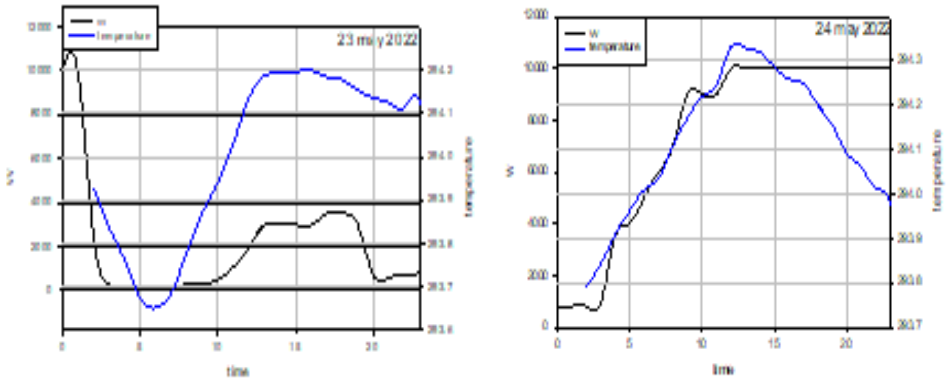

Figure 5. The temperature changes with the visibility range during dust storm hours in Bagdad (23 May 2022)

Previous research has focused on visibility as an established signal, and this observation further supports the importance of temperature fall as a critical storm occurrence predictor; however, visibility does not have easy feedback due to the boundary layer's structure.

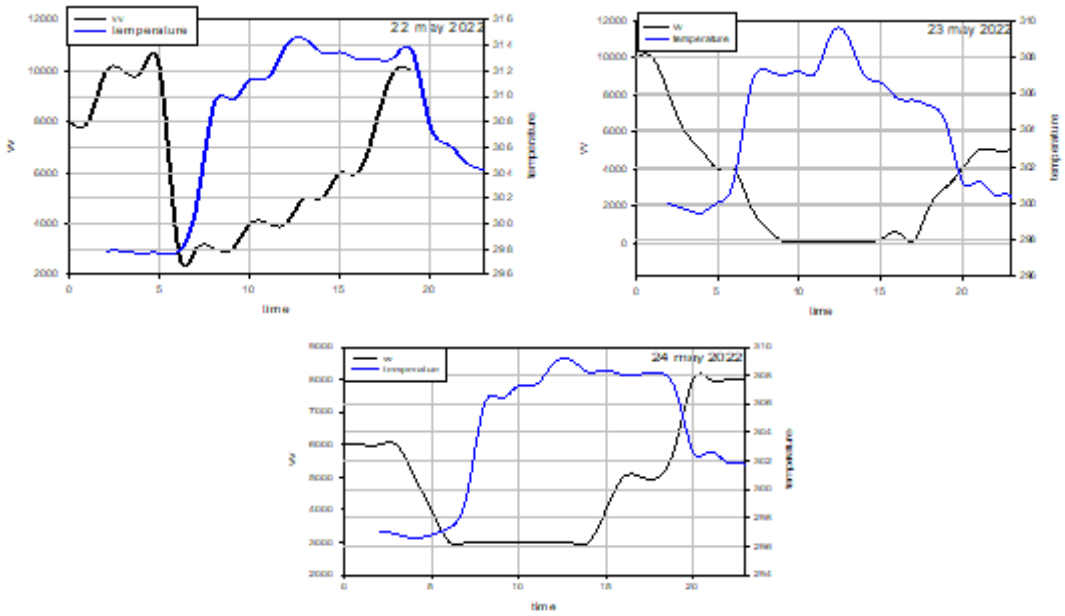

Figure 6. The temperature changes with the visibility range during dust storm hours in Nasiriya (23 May 2022)

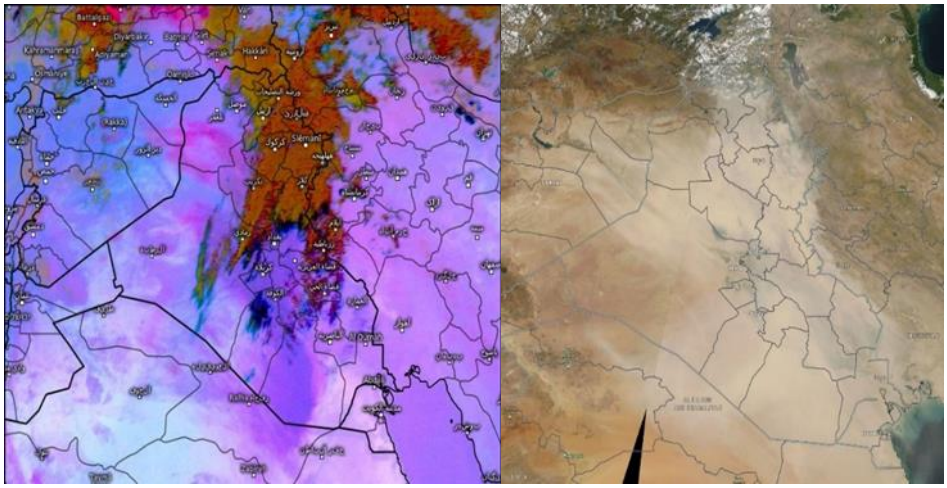

Figure 7. Dust storm at 11 am on 8 June 2008, and Dust storm at 11 am on 23 May 2022

4. Conclusion

Understanding the origins and development of the dust storm is made easier by the study's explanation of the correlation between visibility and temperature. By the way, the dust storm actually started on June 7, 2008. Also, starting on the 8th of the month, the temperature falls 6 degrees below average and keeps going down until it hits 298 degrees. Within the course of a typical day, it climbs seven degrees in a matter of minutes. During these days, there was an inverse relationship between visibility and temperature; this was most noticeable in Nasiriya and Najaf on June 8th. Up until the third day, the storm's behaviour remained unchanged. The 180-degree phase was the difference between temperature and visibility. When it's daylight, the correlation between temperature and visibility is straightforward, but when it's nighttime, it's the opposite. It was difficult to evaluate the visibility, but the temperature changed quickly. Also, for two hours, Baghdad and Nasiriyah experienced a heat exchange event. Although it had the same dust storm conditions as in 2008, the storm in 2022 lasted only one day, which is deemed shorter. Last but not least, dust storms were thought to affect temperature.

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