EnvironmentAsia
The international journal by the Thai Society of Higher Education Institutes on Environment

EnvironmentAsia 14(1) 2021 13-22
DOI 10.14456/ea.2021.2
ISSN 1906-1714; ONLINE ISSN: 2586-8861

Synoptic Analysis of Dust Storm in Iraq

Jasim Al-Khalidi[1*], Dher Bakr[1] and Abdullah A. Abdullah[2]

[1]*Department of Physics, Faculty of Sciences, University of Diyala, Diyala, Iraq*
[2]*Pharmacy collage, Baghdad University, Baghdad, Iraq*

Corresponding Author: jasimkhalel77@yahoo.com *
Received: July 25, 2020; Revised: September 2, 2020; Accepted: September 21, 2020

Abstract

In this study, the synoptic analysis of dust storm for spring and summertime in Iraq were investigated. The images for dust provided by NASA are used to emphasize the dust storm days, while the composite maps of wind vector and geopotential 850hPa are mapped to investigate the pressure and wind direction patterns appearing with the dust condition in the same days. Spring has more dust frequency than summertime, especially in May. The frontal type of dust storm is dominant on spring, the cold air pushes the warm air that picking up the sand to the air through the vertical wind, but the southwestern high-speed wind and drought condition were controlled on the dust in summer. The northwestern wind is the main factor that carries the dust for long-distance. The eastern desert of Syria, Rub Alkhali in Saudi Arabia, the western area of Iran and the area between Tigris and Euphrates rivers are the main sources for dust in Iraq.

Keywords: Dust storms; Iraq region; Geopotential height; Storms frequency; Shamal mechanism; Drought.

1. Introduction

According to the World Meteorological Organization (WMO) definition, the dust storm is a natural risk that influences different regions on the earth. The large deserts and riverbed residue consider huge sources for the dust storms in the Middle East countries including Iraq (Alam *et al.,* 2014; Gharibzadeh *et al.,* 2017). The dust storms have different forms and types, the frontal, shamal (north), and convective are the major types of storms, the shamal type is dominant on the Iraq dust storms (Wilderson, 1991).The type of Iraq climate is subtropical semi-arid (Alkhalidi *et al.,* 2017). The sandy western desert covers ~ 60% from the total area of Iraq, the fine particles of dust originating from the plain area between Tigris and Euphrates rivers (Figure.1) considered important local sources for the sand storms in Iraq. The regional sources represented in the eastern desert of Syria, the Rub Alkhali desert in Saudi Arabia to the south of Iraq and the western part of Iran are contributing to the dust storm in Iraq (Hamidi *et al.,* 2013). The dust storms increased in the last decade due to the drought (Sissakian *et al.,* 2013), military activities in the region, especially after the first Gulf War in 1991, contributed in large wide in dust storms frequency in the region (Wilderson, 1991). The wind speed (> 4 m/s) and relative humidity (< 25%) play threshold roles in generating and transport the dust storms in semi-arid climate regions (Csavina *et al.,* 2014). The dust storm occurs when a big cold air mass passes through a dry and sandy soil. The shamal and strong western winds from Iran and Syria, respectively, pushing the cold air that passes through infertility soil and desert area of Iraq picking up the dust to the area between Tigris and Euphrates and to southern Iraq, Kuwait, and Iran (Wilderson, 1991). The vertical velocity is an important factor in lifting the dust upward in Iraq (Al-Jumaily and Ibrahim, 2013).

In addition, lifting threshold, settling threshold, and particle size are important factors to lift the particles and staying in the atmosphere (Bagnold, 2012; Kalu, 1979).

Many studies identify the relationship between meteorological factors and dust storms. The gradient pressure mode forms the frontal system which controls the directions and speed of the wind which dominate on the dust storm over Iraq region (Al - Jumaily and Ibrahim, 2013). For Baghdad, Hai, Diwaniya, and Nasiriya meteorological stations in Iraq the dust storms are associated with drought index that increases significantly for 2008 to 2012 time period, the monthly wind speeds have a considerable relationship with the dust storms frequency for the previous four stations for the 1970-2012 time period (Al Ameri *et al.,* 2019). The main sources of dust storm on southwestern Iran region are the central and southern areas of Iraq (Javadian *et al.,* 2019). In the Sahel region the relationship between the dust storm and rainfall was studied by (Hui *et al.,* 2008) they found that the dust storms are associated with drought in western Africa. Namdari *et al* (2018) found a significant correlation between monthly data of the aerosol optical depth and meteorological parameters (temperature and precipitation) in two deserts area (Saudi Arabia and Iraq- Syria) in the Middle East region for the 2000-2015 time period. Kanniah and Yaso (2010) studied the relationship between aerosol optical depth and some meteorological parameters (temperature, humidity, and radiation) by using regression map in Malaysia, they investigate that the dust storms decrease in the wet months. The dust storms activity enhance in the spring and summer on most of the Middle East countries (Shao, 2008). The frontal modes control in spring dust storms and bringing the dust particles from permanent dust area in Saudi Arabia to the north of Iraq and northwestern Iran, while, the shamal mechanism is dominant in summer dust storms from the dusty area in Syria through the northwest-southeast path to Iraq (Nabavi *et al.,* 2016). The drought of soil due to the dam constructions and urbanization decreasing the humidity of the soil and increases their fragmentation which causes the dust storms in the Middle East (Hamidi *et al.,* 2013). The active cyclones (cold fronts) dominate on the climate of the Middle East region in winter, these fronts correlated with the subtropical jet stream and characterize with huge dust storms (Alpert and Ziv, 1989). The dominant factors in the dust transport to the Persian Gulf are the location of high - low - pressure patterns and the northwest wind formation over Iraq area (Hassan *et al.,* 2019). The dust storm causes many risks for human health and environmental activities in Iraq, it increasing asthma attacks numbers due to closed the bronchial tubes and decreasing the human ability to struggle diseases (Al-Dabbas *et al.,* 2012).

In this vital study, 2012 year is selected to investigate the synoptic condition of the dust storm in Iraq, this year is one of the dustiest years in Iraq, the Iraq daily dust storm frequency for this year at spring and summertime at selective days are emphasized. These two seasons consider the major time for dust in Iraq. The synoptic conditions of the pressure and wind at geopotential 850hPa that appearing with the same days of dust storms were also, investigated.

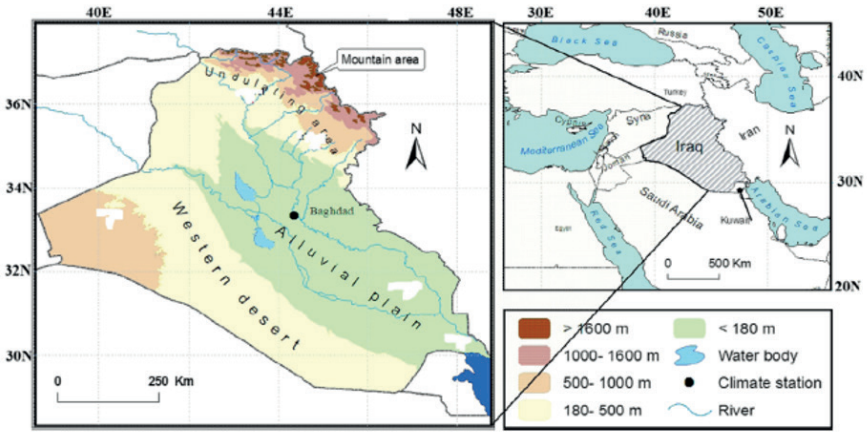

Figure 1. Regional and geographical map for Iraq (Alkalidi *et al.,* 2018)

2. Data and Methodology

The images of the daily dust storm for the selective days provided by the Earth Observing System Data and Information System (EOSDIS) (Winker, 2016) are used to investigate the daily dust storm of Iraq for spring and summer in 2012, The EOSDIS offers the daily states of the dust storms on the global scale, we are focusing the Iraqi dust storm images through snipping the images over the Iraqi region for the selective days on the spring and summertime. The (EOSDIS) is a key application from NASA that deals with the Earth science data from different sources, it gives the ability to control, capture and presses the data. The composite maps of pressure and wind at geopotential 850hPa are used to investigate the pressure modes and wind vectors which accompanying to the dust storms for selective days over Iraqi region, the composite map is a good tool to calculate the arithmetic mean for above/below for a given data set. The re-analysis data provided by the Physical Sciences Division from NOAA (Kalnay *et al.,* 1996), the Physical Sciences Division provide the daily composite map for many climatological parameters including the geopotential height and wind vector for many regions scale, we are choosing the geopotential height for 850hPa and wind vectors for the Middle East region scale for the selective days. We used the data of 850hPa to avoid the influence of orography. We presented the synoptic case for the two consecutive days in one map.

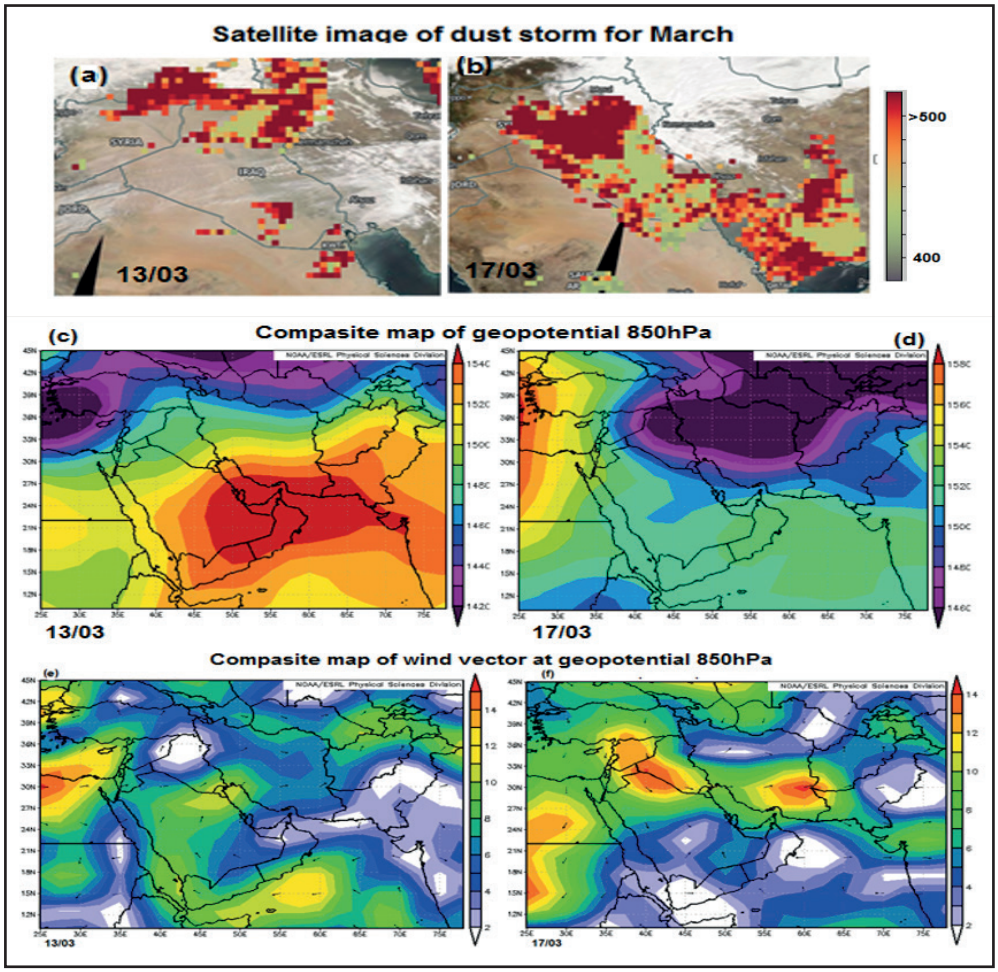

Figure 2. Satellite image of dust storm (a, b), composite map of pressure and wind vector at 850hPa (c, d, e, f) for days (13, 17) of march 2012 respectively.

3. Results

3.1 Synoptic study of Dust storm on 13, 17 March

The satellite image and composite maps of pressure and wind are used to investigate the synoptic condition of dust storms for selective days in Iraq. On the 13 of March, a dust storm can be observed concentrated in the northern and southern parts of Iraq (Figure 2a) originating in the desert area of Syria and Saudi Arabia respectively. Moreover, the low pressure over the Mediterranean area bring the cold condition through the northwestern wind toward Iraq region, the cold air pushes the hot air in front of it causing raising the dust from the western desert of Syria to Iraqi region, also, the southwestern wind brings the dust from the Rub Alkhali desert in Saudi Arabia to the south of Iraq and Arab Gulf region (Figure 2c, e). In the second day (17/3), the dust storm extended to cover the most area of Iraq and part of the Arab Gulf (Figure 2b, d, f). The polar front brings the cold air from the north to Iraq through the strong north wind (14 m/sec) which drives the cold air to the sand area in the west and the region between Tigris and Euphrates rivers that extend over the most area of Iraq that causes a huge dust storm over Iraq.

3.2 Synoptic study of Dust storm on 19, 29 April

For selective days the dust storms case are investigated through the satellite image and composite maps of pressure in Iraq. On the first dusty day (19 April), the sand lifting over the western area of Iraq (Figure 3a), the western

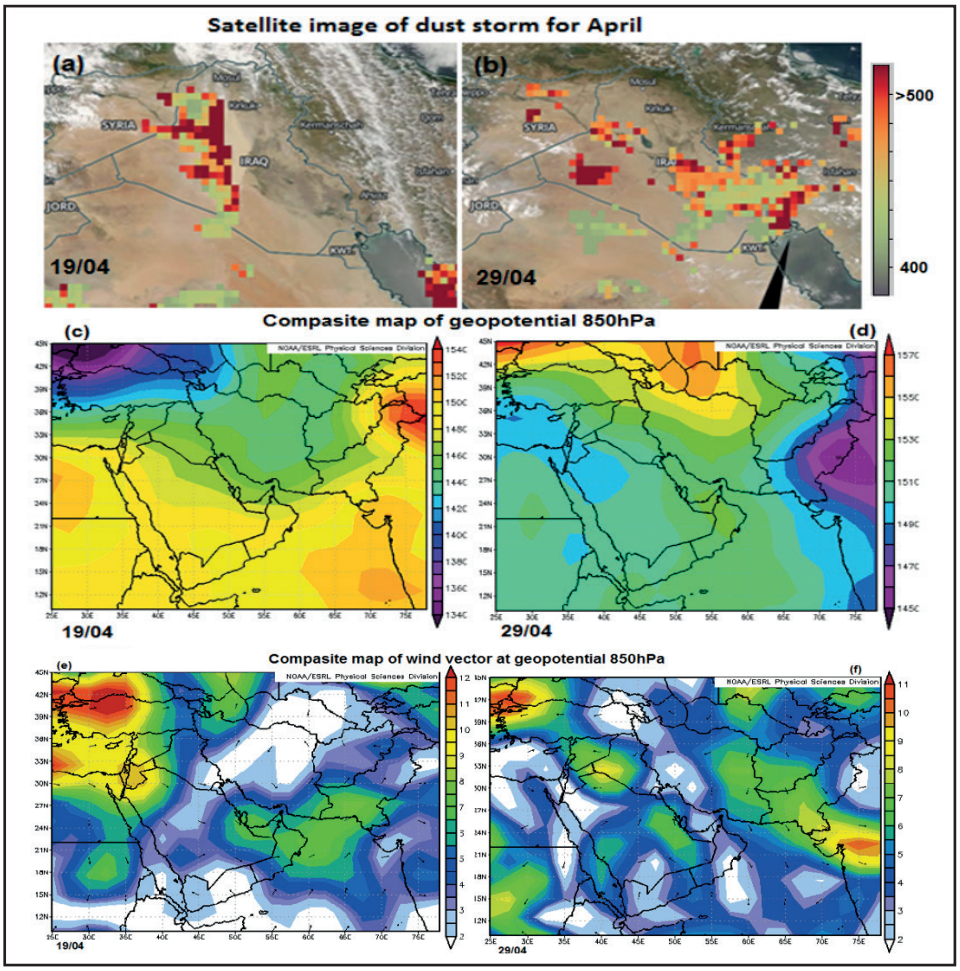

Figure 3. Satellite image of dust storm (a, b), composite map of pressure and wind vector at 850hPa (c, d, e, f) for days (19, 29) of April 2012 respectively.

wind bring the dust sand from the desert region in Syria to the neighboring region of Iraq. The gradient pressure is small, therefore the wind value is a small also (Figure 3c, e). On the 29 April, the northwestern wind from the desert of Syria via the western desert of Iraq and the area between Tigris and Euphrates picking up the dust to middle and southern area of Iraq (Figure 3b, d). The wind in the second case is more than in the first (Figure 3f).

3.3 Synoptic study of Dust storm on 2, 11, 20, 24 May

May is characterized by an increase in the occurrence of dust storms, it has four significant storms. This month is recorded a rise in temperatures, less humidity and precipitation and therefore increasing on dust frequency, most of these storms covered a large area of Iraq and sometimes the storm stays two days consecutively (Figure 4, 5, 6a, b, c, d). In the second day of May, the storm covers a large area in the middle and south of Iraq, the low pressure over Syria and Jordon bring the cold air to Iraq through the western wind, the cold air picking the hot air over infertility land (the area between Tigris and Euphrates) causing lifting the dust on the air. On 11 May the dust covers most of the Iraqi area specially the eastern region along the border with Iran, the northwestern cold wind from Syria via the Iraqi region bring the cold air to Iraqi infertility raising the grain of sand on the air, in this case, the gradient pressure dominates in the dust storm. On 20 May, the dust centered on a large area of Syria, Jordon, Iraq, Iran and part of Arab Gulf, the gradient pressure controls on this storm via the cold northwestern wind influence by the low-pressure condition originating over the Mediterranean Sea. On 24 May, the dust storm covers a large part of Iraqi area, the gradient pressure over the region bring the cold air over the Iraq area through the northwestern wind. The infertile land makes a better condition for lifting the sand in the air.

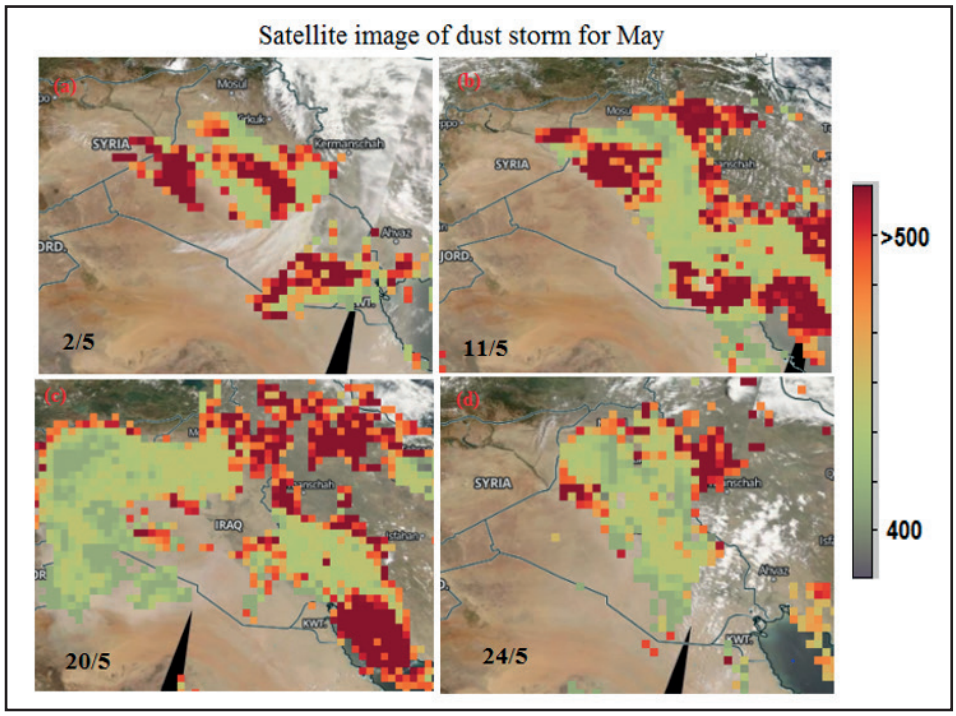

Figure 4. Satellite image of dust storms (a, b, c, and d) for days (2, 11, 20, and 24) of May 2012 respectively.

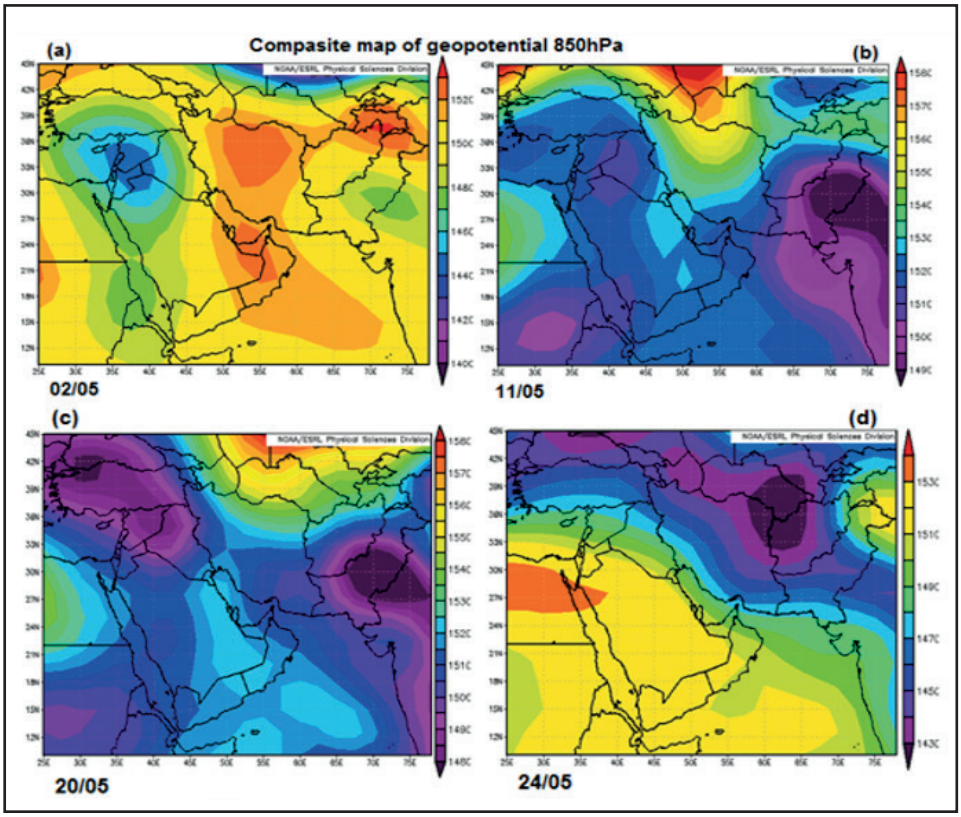

Figure 5. Composite map of geopotential height 850hPa (a, b, c, d) for days (2, 11, 20, 24) of May 2012 respectively.

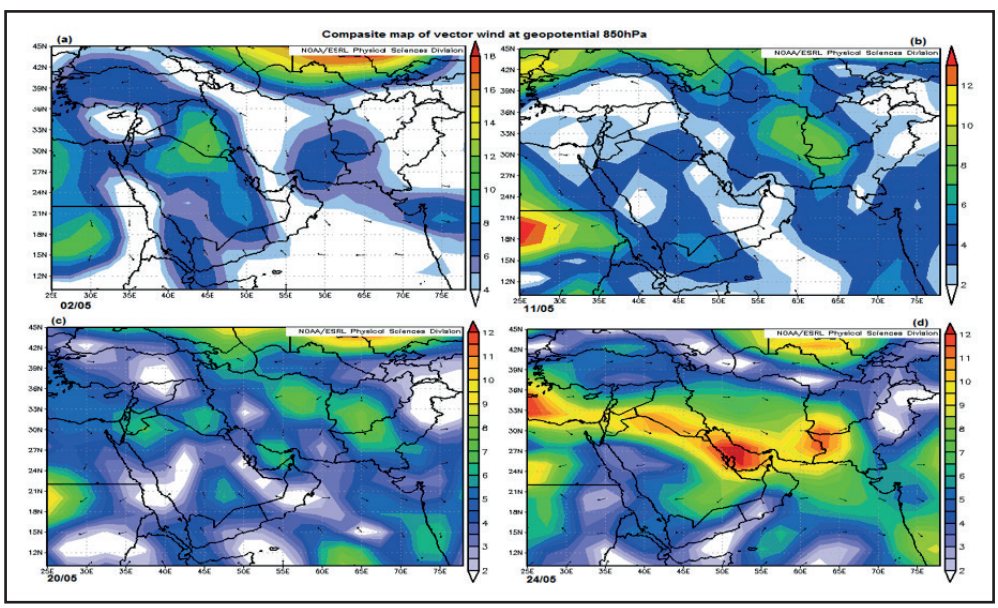

Figure 6. Composite map of wind vector at geopotential height 850hPa (a, b, c, d) for days (2, 11, 20, 24) of May 2012 respectively.

3.4 Synoptic study of Dust storm on 18, 19 June

The summer season in Iraq characterized by hot temperature and very little rain showers. On 18-19/06 the sand storm centered on the areas between the Tigris and Euphrates and the easternly area with the border of Iran (Fig. 7a, b). The Indian high pressure controls on the region (Alkhalidi *et al.,* 2017) with the southwestern wind (Figure 7c, d). The drought is the main causing of the dust frequency in summer, these storms move in the southeastern direction of Iraq and turn into the storm the next day in the southeastern part. The two days storms have the same meteorological conditions, they relies on their transition on a combination of factors including the properties of the specific layer and the change of weather elements in addition to wind speed. The increase in the degrees of the temperature is working to sustain the storm of dust and an increase in the amount of dust. The accelerated wind in the case of increased temperature can work to increase dust storms to carry minute long distances.

3.5 Synoptic study of Dust storm on 5, 7 July

On 5-7 July the sand storm centered on the area between the Tigris and Euphrates, the area of Kuwait and a small area from border of Iran (Figure 8 a, b). The drought is the main causing of the dust frequency in this month. The Indian high-pressure system controlled on these storms and influenced its staying two days in the Iraq region (Figure 8c, d). The southwesterly wind brings the hot air from the south and pass through a soft area that causes raising the sand from the soil and staying on the air (Figure 8e, f). The drought, in turn, works on a decrease or lack of vegetation cover in those areas. The lack of vegetation is a primary cause of soil erosion and its transmission by wind and its transformation into dust storms that move from the northwestern part to the southeastern part of Iraq.

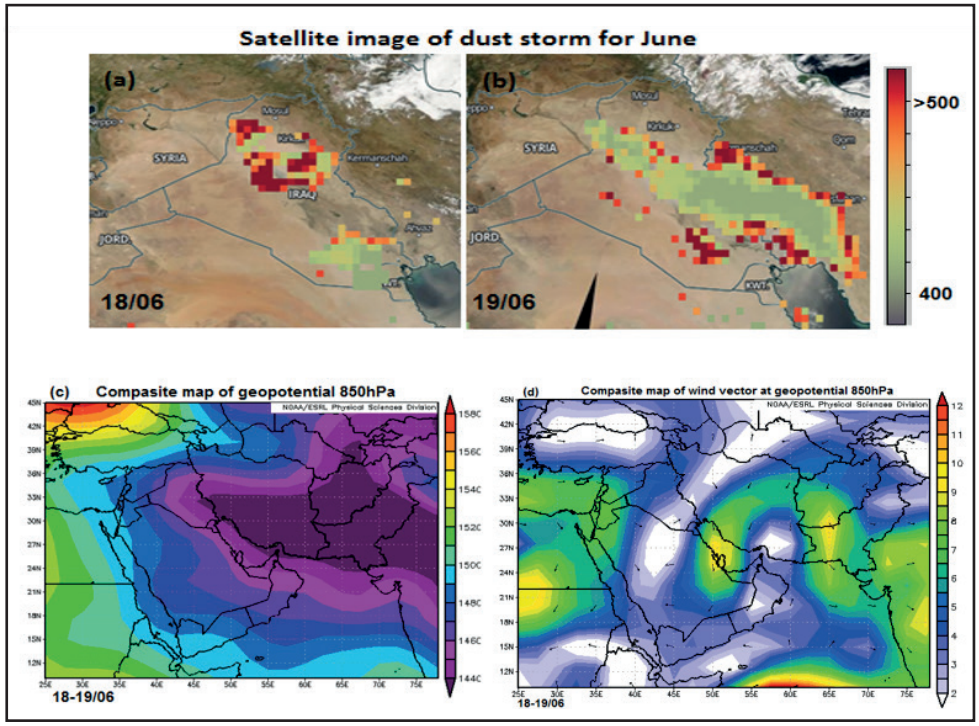

Figure 7. Satellite image of dust storm (a, b), composite map of geopotential height and wind vector at 850hPa (c and d) for days (18 and 19) of June 2012 respectively.

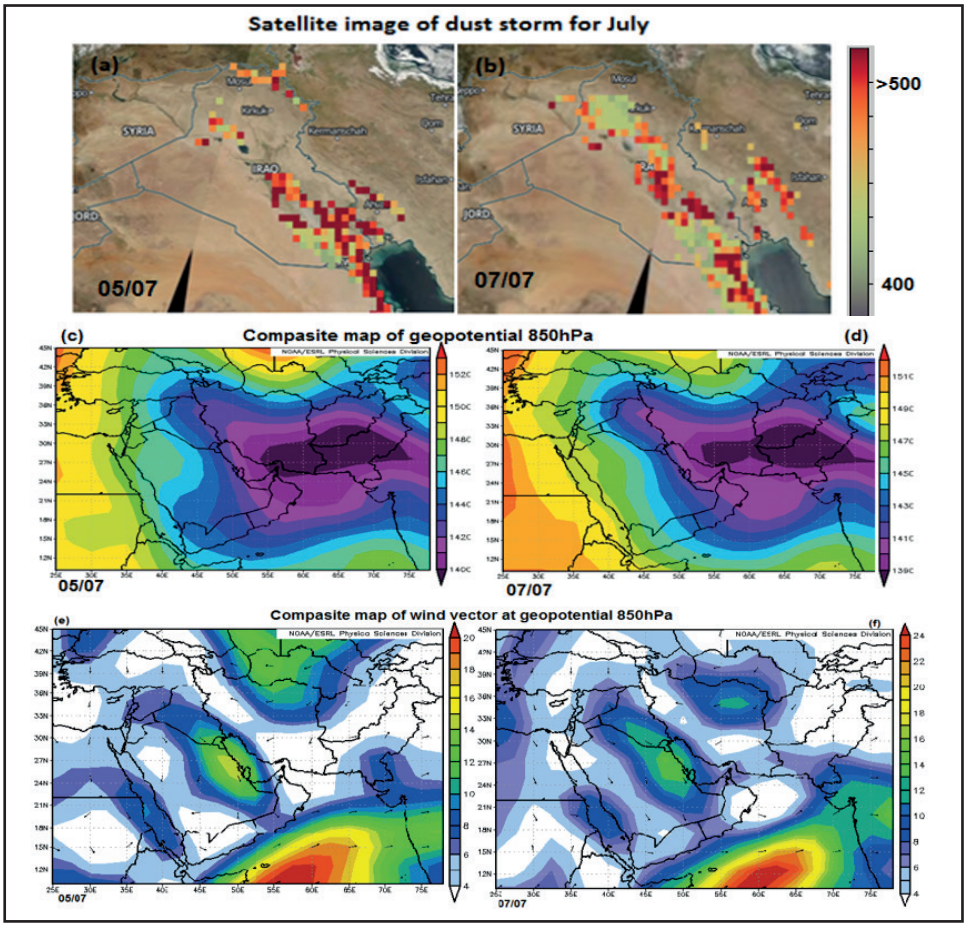

Figure 8. Satellite image of dust storm (a, b), composite map of geopotential height and wind vector at 850hPa (c, d, e, and f) for days (05, 07) of July 2012 respectively.

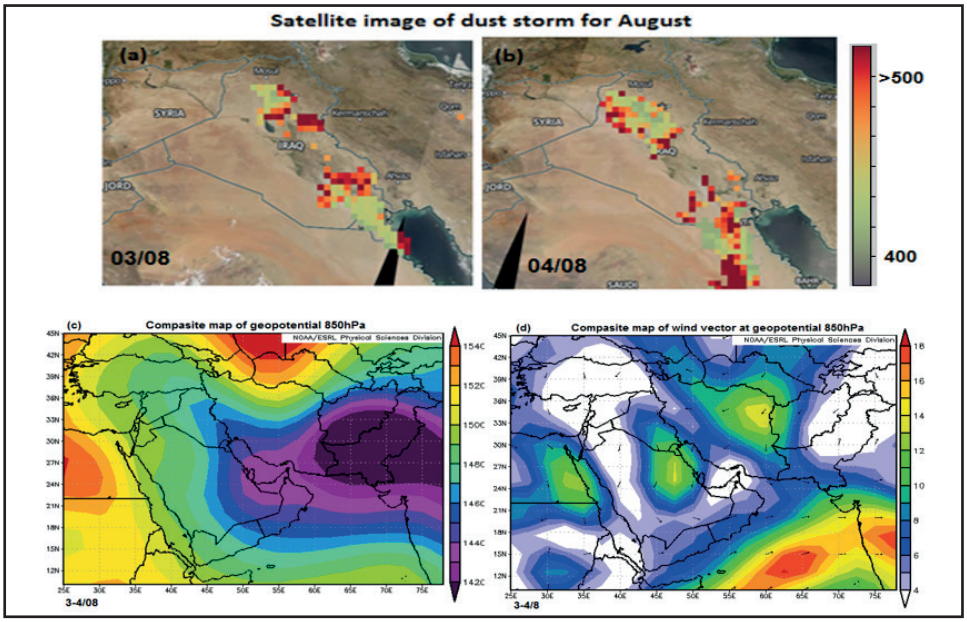

Figure 9. Satellite image of dust storm (a, b), composite map of geopotential height and wind vector at 850hPa (c, d) for days (3, 4) of August 2012 respectively.

3.6 Synoptic study of Dust storm on 3, 4 August

The August is the drier month on summer. The dust storm on the 3-4 August were originated in the southeastern and extend to the northwestern part of the country and continues with two days in a row (Figure 9a, b). The increase in drought, summer temperature condition and decrease in the amount of drought of the irrigational rivers, these factors collectively cause the emergence and development of the dust storm and enhance the dust storm to works large. The Indian high pressure and southwestern wind is dominant on the cases of summer (Figure 9c, d).

4. Conclusions

In this study, the results provide a new perspective on the synoptic patterns of the dust storms on spring and summer, the important factors that impact on the dust are also investigated in Iraq. The main conclusions of this study are summarized as follows;

- The dust storms covered a huge area of Iraq in the springtime, especially in May (Figure 2, 3, 4, 5, 6).
- The summer season has fewer sand storms and staying two consecutive days (Figure 7, 8, 9).
- The pressure gradient and low - pressure condition play an important role in the occurrence of the dust storm in spring.
- The drought condition is the dominant factor in the dust storm in the summertime.
- The sand deserts in Syria, Saudi Arabia, Iran and the area between the Tigris and Euphrates are the major sources for the dust storm in Iraq.
- The northwestern and southwestern winds are considered a dominant factor in dust transfer.

The spring and summer are the major time to occurrence the dust in Iraq, similar study by (Shao, 2008) confirm that the main time for dust in the Middle East region including Iraq is the spring and summertime.

According to the spring climatological condition, a clear change occurs in the atmospheric elements from day to another, where it clarifies the great difference in temperature and precipitation, this difference in the atmospheric elements works on a change in the physical properties of the soil, which makes the soil more disintegrating and easy to carry and move, Also, the wind speed increases the dust state and it is one of the important factors in the emergence and excitation of dust storms, especially with the absence of precipitation, with all these climatological factors, the north and frontal dust storm is the main types of storms in spring time This result is similar to the finding of Wilderson (1991).

The dust storms that arise in Iraq are urged in areas of semi - desert nature and surface with semi - sandy soil easy to carry by the wind in addition to the lack of vegetation in those areas, due to this condition, the cold air pushes the hot air via the northwestern wind, and because the hot air is lighter than the cold, the warm air picking up the sand and lifting it to the air causing the dust. Identical studies by (Wilderson, 1991; Al - Jumaily and Ibrahim, 2013) investigated that the cold air and vertical wind play an important role in occurrence the dust in Iraq respectively. The eastern desert of Syria, the Rub Alkhali in Saudi Arabia, the western desert in Iran and the area between Tigris and Euphrates are the main sources that provide Iraq by the dust particles, the study of (Hamidi *et al.,* 2013) has the same sources of dust storm impact on Iraq region.

The main conclusion is that the Iraq dust storms are influenced by the gradient pressure condition through the northwestern wind and southwestern wind from the neighboring desert countries.

Acknowledgments

The authors are grateful to the EOSDIS and the Physical Sciences Division for providing the data and analysis.

Conflicts of Interest

The authors declare no conflict of interest.

References

Al Ameri ID, Briant RM, Engels S. Drought severity and increased dust storm frequency in the Middle East: a case study from the Tigris–Euphrates alluvial plain, central Iraq. Weather 2018; 74(12): 416-426.

Alam K, Trautmann T, Blaschke T, Subhan F. Changes in aerosol optical properties due to dust storms in the Middle East and Southwest Asia. Remote Sensing of Environment 2014; 143: 216-227.

Al-Dabbas MA, Abbas MA, Al-Khafaji RM. Dust storms loads analyses—Iraq. Arabian Journal of Geosciences 2012; 5(1): 121-131.

Al-Jumaily KJ, Ibrahim, MK. Analysis of synoptic situation for dust storms in Iraq. International Journal of energy and environment 2013; 4(5): 851-858.

Al-Khalidi J, Dima M, Vaideanu P, Stefan S. North Atlantic and Indian Ocean links with Iraq climate. Atmosphere 2017; 8(12): 235.

Al-Khalidi J, Dima M, Stefan S. Large-scale modes impact on Iraq climate variability. Theoretical and Applied Climatology 2018; 133(1-2): 179-190.

Alpert P, Ziv B. The Sharav cyclone: observations and some theoretical considerations. Journal of Geophysical Research. Atmospheres 1989; 94(D15): 18495-18514.

Bagnold RA. The Physics of Blown Sand and Desert Dunes; Courier Corporation: Morrow, NY, USA, 2012.

Csavina J, Field J, Félix O, Corral-Avitia, AY, Sáez AE, Betterton EA. Effect of wind speed and relative humidity on atmospheric dust concentrations in semi-arid climates. Science of the Total Environment 2014; 487: 82-90.

Gharibzadeh M, Alam K, Bidokhti AA, Abedini Y, Masoumi A. Radiative effects and optical properties of aerosol during two dust events in 2013 over Zanjan, Iran. Aerosol and Air Quality Research 2017; 17: 888-898.

Hamidi M, Kavianpour MR, Shao Y. Synoptic analysis of dust storms in the Middle East. Asia-Pacific Journal of Atmospheric Sciences 2013; 49(3): 279-286.

Hassan EM, Fatahi E, Khan MK, Noori F. The effect of wind direction on dust transfer toward the Persian Gulf. Journal of Air Pollution and Health 2019; 4(1): 33-52.

Hui WJ, Cook BI, Ravi S, Fuentes JD, D'Odorico P. Dust-rainfall feedbacks in the West African Sahel. Water Resources Research 2008; 44(5): 230-242.

Javadian, M; Behrangi, A; Sorooshian, A. Impact of drought on dust storms: case study over Southwest Iran. Environmental Research Letters 2019; 14(12): 124- 137.

Kalnay E, Kanamitsu M, Kistler R, Collins W, Deaven D, Gandin L, ... Zhu Y. The NCEP/NCAR 40-year reanalysis project. Bulletin of the American meteorological Society 1996; 77(3): 437-472.

Kalu A. The African dust plume: its characteristics and propagation across West Africa in winter. Saharan dust 1979; 12: 95-118

Kanniah KD, Yaso N. Preliminary analysis of the spatial and temporal patterns of aerosols and their impact on climate in Malaysia using MODIS satellite data. International Archives of the Photogrammetry, Remote Sensing and Spatial Information Science 2010; 38(8): 386-391.

Nabavi SO, Haimberger L, Samimi C. Climatology of dust distribution over West Asia from homogenized remote sensing data. Aeolian Research 2016; 21: 93-107.

Namdari S, Karimi N, Sorooshian A, Mohammadi G, Sehatkashani, S. Impacts of climate and synoptic fluctuations on dust storm activity over the Middle East. Atmospheric environment 2018; 173: 265-276.

Sissakian V, Al-Ansari N, Knutsson S. Sand and dust storm events in Iraq. Journal of Natural Science, 2013; 5(10): 1084-1094.

Shalaby A, Rappenglueck B, Eltahir EA. The climatology of dust aerosol over the Arabian Peninsula. Atmospheric Chemistry and Physics Discussions 2015; 15(2): 1523-1571.

Shao Y. Physics and modelling of wind erosion. Kluwer Academic Publishers, Dordrecht, Boston, London. 2008.

Wilderson WD. Dust and sand forecasting in Iraq and adjoining countries, Tech. Note AWS/In-91/001, Air Weather Service, Scott Air Force Base, Illinois, USA. 1991.

Winker D, Calispo L. Standard HDF File-Version 4.10 [Data set]. NASA Langley Research Center Atmospheric Science Data Center DAAC 2016.