ISSN 2354-9114 (online), ISSN 0024-9521 (print)
Indonesian Journal of Geography Vol 56, No 2 (2024): 335-343
DOI: 10.22146/ijg.93329 website: https://jurnal.ugm.ac.id/ijg

INDONESIAN JOURNAL OF GEOGRAPHY

RESEARCH ARTICLE

Synoptic Conditions at Pressure Different Levels for the Dust Storm of May/ 2022 Over Iraq

Alyaa Matai Hamed[1], **Ebtihal T AL-Khakani***[2]
[1]Department of Geography, College of Education for Girls, Kufa University, al Najaf, Iraq.
[2]Department of Physics, College of Education for Girls, University of Kufa, al Najaf, Iraq.

Received: 2024-01-19
Revised: 2024-06-24
Accepted: 2024-08-17
Published: 2024-08-30

Keywords: Dust Storms, Weather Map, NOAA, ECMWF, Iraq.

Correspondent email: ibtihal.alkhaqani@uo.kufa.edu.iq

Abstract. This study examines the severe dust storm from May 12-16/2022, culminating on May 15, with a comprehensive analysis and explanation. The weather maps from the National Oceanic and Atmospheric Administration (NOAA) and the European Centre for Medium-Range Weather Forecasts (ECMWF) weather maps were used to identify systems and patterns that contributed to the storm's activity, continuity, and tracking as well as maps of pressure compounds and wind vectors in levels 1000 and 850 mbar that appear with the dust state for the same days accompanied by tracking patterns in the middle of the turbosphere 500 mbar to give a comprehensive analytical view of climate conditions at each level of pressure and higher systems supportive of their persistence on the surface. The northwesterly winds are the main factor that carries dust over long distances. The eastern desert in Syria, the Empty Quarter in the Kingdom of Saudi Arabia, the desert of western Iran, and the desert region of western Iraq are among the main sources of dust In its atmosphere. Based on weather maps of the surface and upper levels of storm days, the concentration of dust reached very high levels in Iraq's airspace and surrounding countries, including Egypt, Jordan, Lebanon, Palestine, and Syria. The intensity of the dust gradually decreased as the area was affected by wet westerly winds with relatively low temperatures and a relative increase in wind speeds due to the impact of the study area on the atmospheric decline centered around the Turkish island of Cyprus.

1. Introduction

Comprehensive studies are conducted on various weather phenomena, including dust storms that have increased in frequency and intensity in recent years. In May 2022, one of these storms occurred, causing a decrease in visibility range to less than 1 km due to the dense dust and high wind speeds of 25km/hour. The storm is active in spring, including March, April, and May. Khamsinian thermal depressions accompany a hot air mass from the eastern part of Algeria and the Atlas Mountains heading east towards Libya, Egypt, Jordan, and Iraq (Al-Lami *et al*, 2012, and kutiel, 2003). This results in hot, dry, and dusty winds for 50 days over Egypt, which is why it is called Al-Khamsiniya. The storm caused dense waves of dust over the study area and coincided with a subtropical high on May 12 to 16/ 2022. The region's drought and the expansion of the desert belt in subtropical latitudes also contributed to increasing the intensity of the dust storm.

The arrival of large amounts of dust in Iraq is due to the weakness of the pressure systems that prevailed during the cold season and its withdrawal from the atmosphere represented by the cold Siberian and European highlands. The same applies to air depressions coming from the Mediterranean Sea. This month represents the end of the life of the pressure systems and their decline, in addition to the weakness of India's seasonal thermal system, the beginnings of which are forming during this month (May). The dryness of the soil surface and the decrease in seasonal rainfall in Iraq and its neighboring areas have also contributed to the increasing severity of the dust storms. Countries located in the tropical and subtropical belt in the world, including Iraq, have been interested in studying the phenomenon of dust storms, the frequency of which has increased in recent years due to climate change.

(Ibrahim *et al*, 2013) conducted a study and analysis of the synoptic patterns of dust storms in Iraq using satellite data and the National Centers for Environmental Prediction NCEP to diagnose the comprehensive causes of the emergence and development of dust storms over Iraq. (Mohammed *et al*, 2015) analyzed the synoptic patterns associated with dust events over West Asia during the summer months that resulted from surface low-pressure patterns associated with the Indian monsoon winds over Iran and southeastern Arabia, accompanied by a high-pressure system over the eastern Mediterranean and North Africa. This resulted in strong pressure gradients that caused northwestern winds, which carried dust from arid and semi-arid regions of Syria and Iraq. (Jasim *et al*, 2018) studied the meteorological conditions for the formation of the severe dust storm that struck the Middle East and Iraq due to the dominance of low surface pressure and a series of strong emanations at a pressure level of 850 millibars for the period from September 6-9/ 2015. A study conducted by (Majeed *et al*, 2021) examined the synoptic conditions of a severe dust storm that took place in the last week of October 2017, by using the aerosol index and weather maps, they determined that the storm was caused by an air depression in

northwestern Iraq, accompanied by northwestern winds that blew the dust toward Southern Iraq and Kuwait.

This study came as a continuation of what the researchers began by adopting the analysis of three pressure levels accompanied by maps of Synoptic weather for each level based on NOAA and ECMWF data and maps during May 2022. Therefore, this study aims to determine the importance of pressure patterns at the 500, 850, and 1000 mbar levels in the emergence and continuity, of the dust storm in Iraq, and examine the effect of the direction of the winds on the continuation of consecutive days.

2. Methods

The spatial boundaries of the study are represented by the total area of Iraq, which is geographically located in the southwestern part of the continent of Asia and the northeastern part of the Arab world within the subtropical latitudes between two latitudes (37° 22′-29° 05′) north, and two longitudes (48° 45′ – 38° 45′) east. As for the temporal boundaries, they fall during successive days from May 12 to 16, 2022, to achieve an accurate synoptic analysis of the storm's conditions and causes in the atmosphere's upper and surface layers. Due to Iraq's location, there are six main paths for dust storms dominated by the climate of the Middle East and North Africa, as shown in Map No. (1). The first path originates from the Mediterranean Sea, passing through the island of Cyprus, entering Syria, and then Iraq. The second path originates under the control of the high-pressure system over Eastern Europe. In contrast, the third path comes from the southern Mediterranean or the North African coast, it always hits southern Syria or the northern borders of Jordan and Saudi Arabia, then the Arabian Peninsula and Iraq. As for the fourth path, it originates from North Africa and usually passes through Egypt, north of the Red Sea, and blows towards the southeast of the Kingdom of Saudi Arabia. The fifth path is located in the North African depressions. Finally, the sixth path begins from the Sistan Plain in Iran - Afghanistan, which is dominated by the anticyclone above Middle Asia (International Bank,2019).

Pressure and wind direction data for different regions of Iraq were obtained through the website, https://meteologix.com/om/reanalysis/ecmwf-era5/iraq/sea-level-pressure/20191001-0600z.html.

Then each part of the weather map for the day under study was analyzed and interpreted. The data contained therein was clarified by the scientific analysis of all map symbols, and their effect on the prevailing dust condition on that day was deduced.

3. Results and Discussion

The high and low atmospheric pressure systems of the May 15 dust storm, which was described as red due to the severity and density of the dust in it, will be discussed, along with analyzing the pressure situation for the three days preceding the focus of the storm and observing the day following it, and tracking the extension of the pressure systems and wind vectors that covered the surface of the study area on all those days.

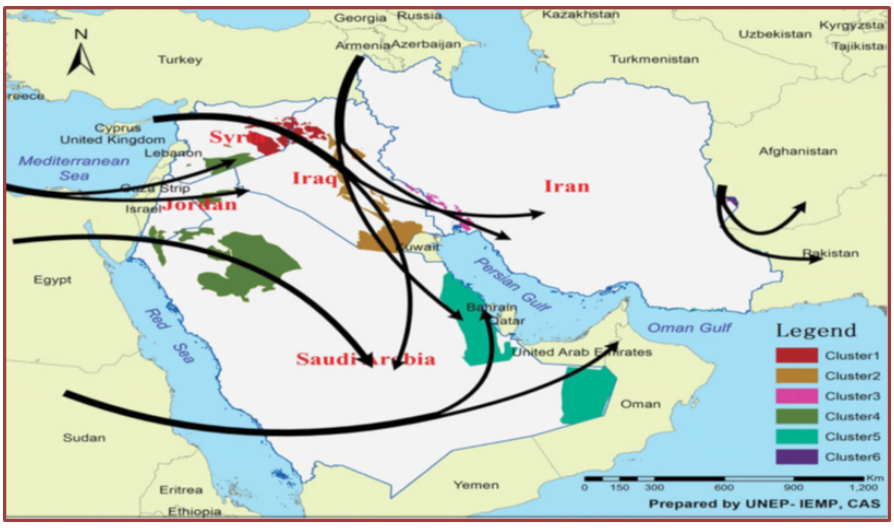
Iraq is exposed to different types of pressure systems throughout the year and the frequency of storms caused by each system differs from the other depending on the differences in the characteristics of each. Low-pressure systems are more capable of causing dust storms than high-pressure systems due to the state of instability that accompanies them. Also, Pressure systems whose extensions dominate for a long period have a greater chance of causing a greater number of storms (Al-Qadi, 2001).

a. Surface pressure systems accompanying the dust storm at the level of 1000 millibars

The Indian monsoon low is the light pressure system that causes dust storm events the most. As for the high-pressure systems, the subtropical high that forms over the African Sahara extends North Africa and the eastern Mediterranean towards Iraq, entering from the northwestern side with increasing speeds of the northern

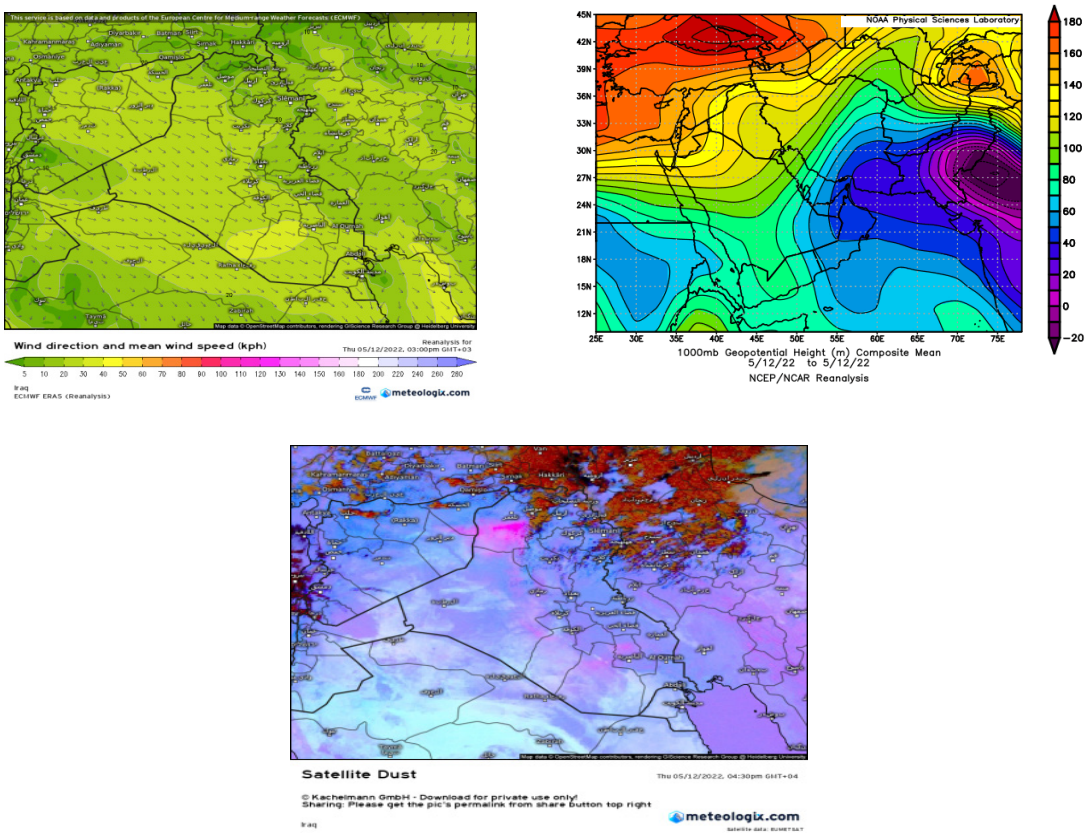
winds are one of the systems causing the effects of the dust storm, as maps (2a-e) indicate the surface systems that prevailed in the days preceding the storm and the day after its occurrence. map (2a) showed the beginning of the advance of the subtropical high to cover the entire study area, accompanied by the composite map of the prevailing northerly and northerly west wind vectors.

Map (2b) shows the deepening of the tropical system in northern Iraq and its increasing closure, creating a great

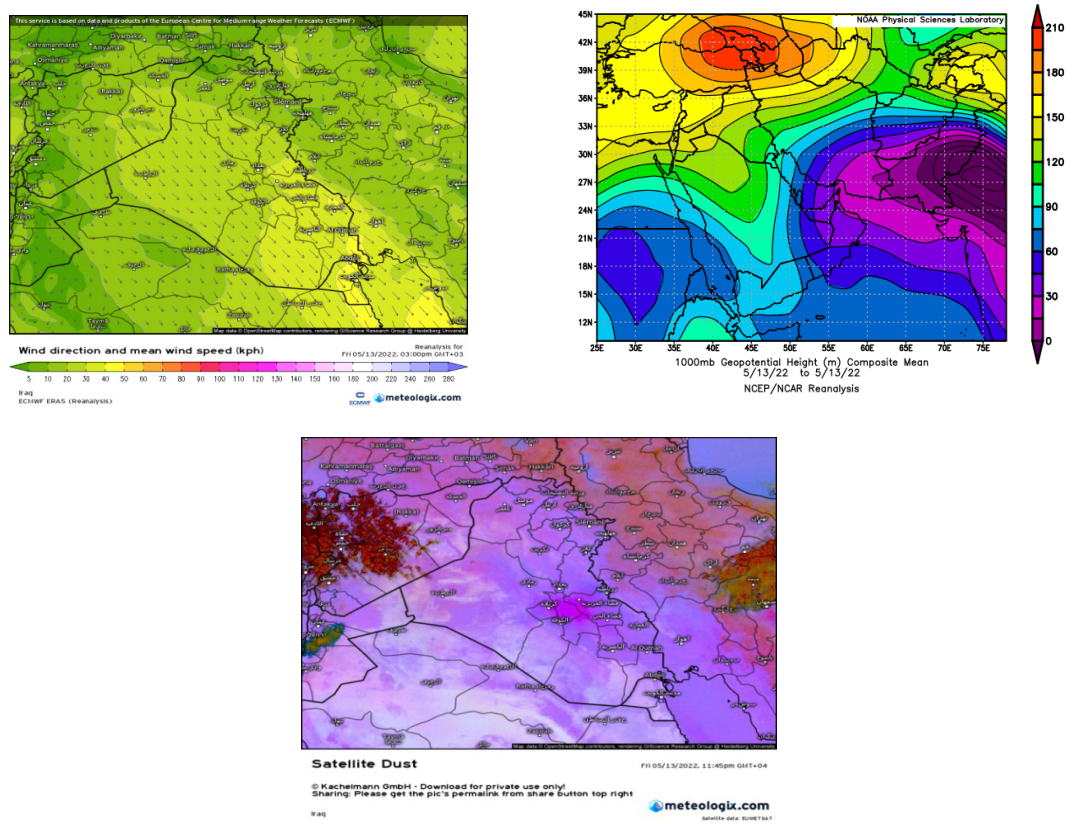


Map (1): Source path of dust storms passing through Iraq. Source: (Cao *et al*, 2015)

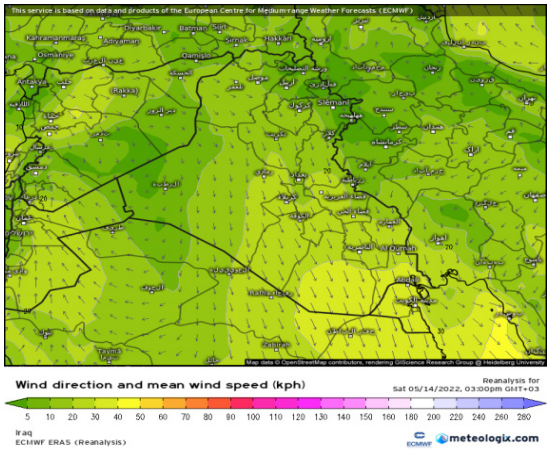
chance for increased wind speed supported by the pressure decline over the Arabian Gulf, creating strong active winds that increase the load currents as a result of the heating process. The map (2c) indicates the development and penetration of the tropical high-pressure center into Northern Iraq, accompanied by the south entry of India's low-pressure system through the Arabian Gulf is causing a sharp step in the pressure on the entire region. Thus, the speed of the westerly winds increased, as well the desertified land and dry soil helped raise sand particles several meters above the surface.

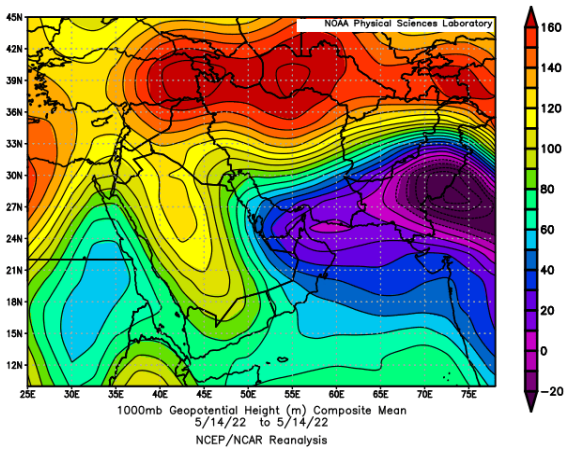


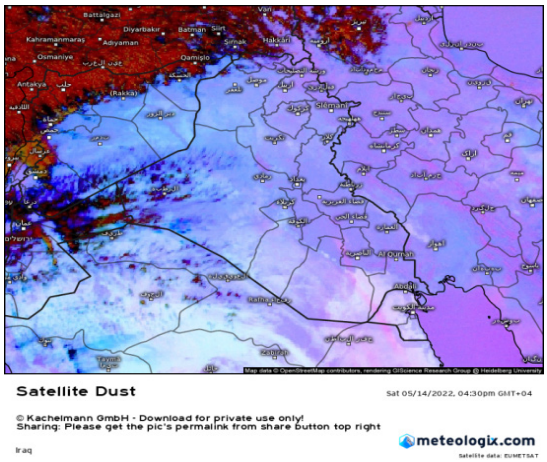
Map (2a): Surface weather map and wind vector for 12-5-2022



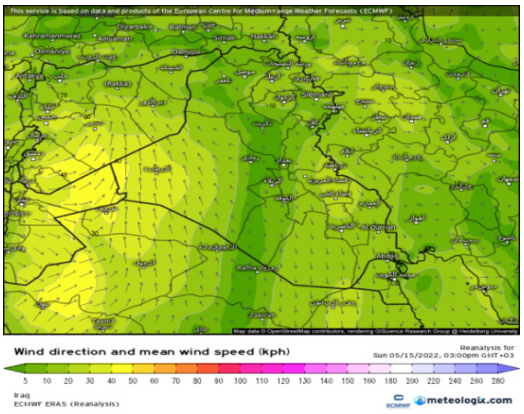
Map (2b): Surface weather map and wind vector for 13-5-2022.

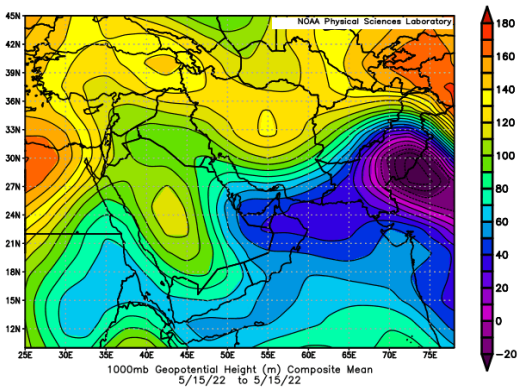


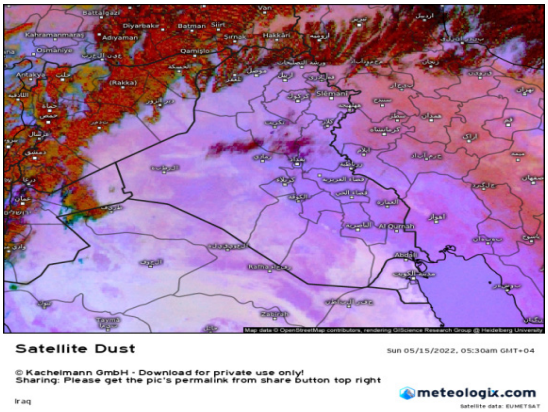




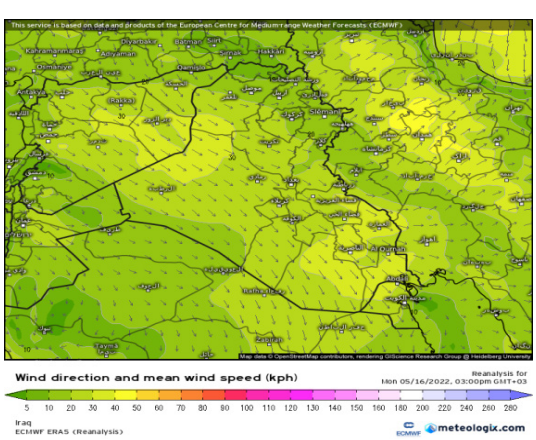
Map (2c): Surface weather map and wind vector for 14-5-2022

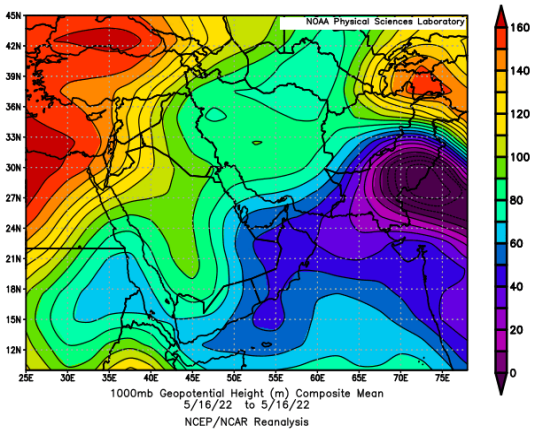


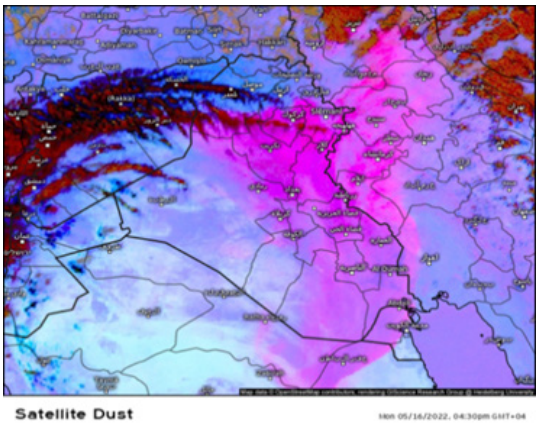




Map (2d): Surface weather map and wind vector for storm day 15-5-2022.







Map (2e): Surface weather map and wind vector for the day following the storm 16-5-2022
Source: Satellites, National Oceanic and Atmospheric Administration- European Center for Medium-Range Forecasting.

Map (2d) shows the beginning of the advance of extensions of the seasonal low system towards southern Iraq in Basra Governorate specifically, with the variation of the wind direction, which became northwest in most parts of Iraq, except for the western part of it, which was dominated by the southwesterly wind direction, and the high pressure receded northward at the Anatolian Plateau. Thus, there was a significant gradient in pressure with increased wind speed, which caused large amounts of dust and sand to rise, as a result, the sky looked red. Vertical speed is an important factor in raising the dust particles upward, and the strong westerly winds work to push the dust toward the east (Al-Jumaily *et al*, 2013).

According to Map (2e), the seasonal decline has been gradually decreasing in strength (remaining shallow and narrow in eastern and southeastern Iraq), its influence weakening. Therefore, the extent of visibility has started to improve in some areas of northern and central Iraq as the storm moved south through the governorates of Misan, Dhi Qar, and Basra, with the continuation of the subtropical high and the sovereignty of north and north-west winds, the prevalence of these winds during the hot months of the year is due to the emergence of India's seasonal system, and the presence of low-pressure over the Arabian Gulf and the concentration of high-pressure areas over the Anatolian-Armenian Plateau (Al-Jizani, 2010), making Iraq a regular passage of these winds which dominated the study area on all the days studied for the storm.

b. The comprehensive analysis of the upper weather maps and the wind vector at 850 mbar level

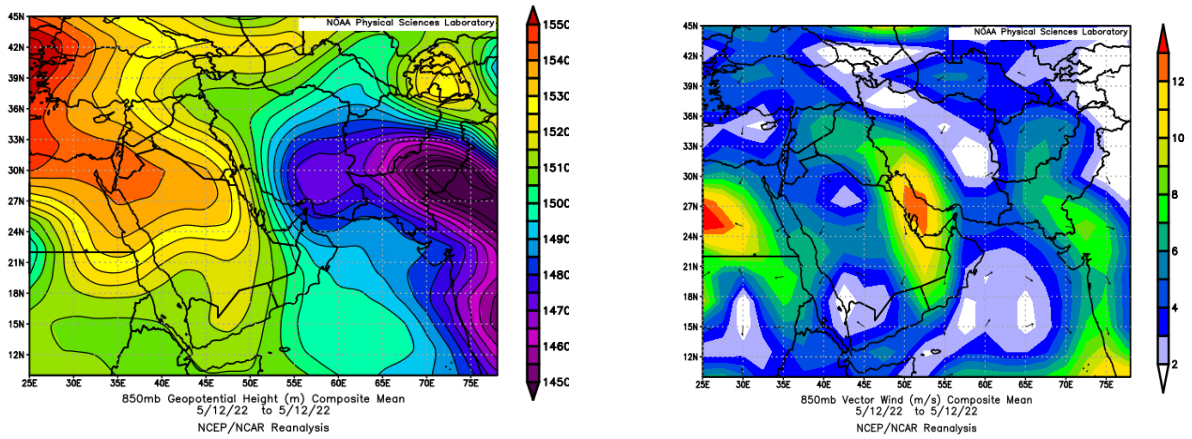
Studying the relationships between climate parameters and geophysical potential heights helps in understanding climate fluctuations and identifying the real causes behind the occurrence of climate phenomena, including dust storms. (Al-khalidi and Stefan, 2017). The average pressure level rise at 850 millibars is approximately 1,500 m. The pressure system may be considered deep if monitored through surface maps and 850 mbar together. On the contrary, they are shallow if monitored through surface maps but do not appear at the 850mbar level to prevail over other types of pressure (Al-Qadi, 2001). The maps (3a-e) indicate the depth of the tropical superficial system, which has appeared strongly and deeply at 850 mbar pressure level.

Map (3a) shows the incursion of suborbital rush into all areas of Iraq with continued wind direction north and north-west, demonstrating the continued escalation of soil and its increasing intensity and density, which is proven by map (3b) through the penetration of sub-tropical elevation secondary centers over western parts of the study area represented by Iraq's western desert, which is the driest, desertified and fragile area in the soil surface.

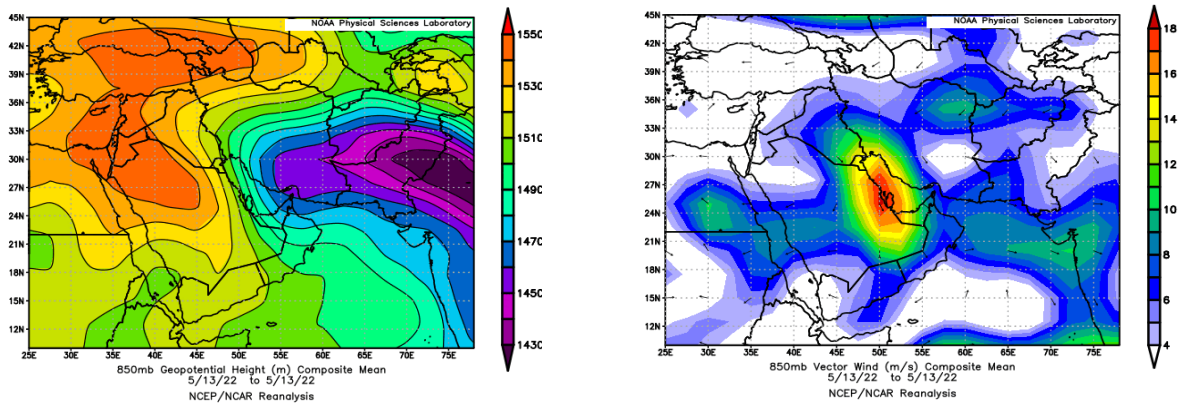
Map (3c) shows a pressure composite map and wind direction towards the northwest, Sissakian mentions that the dust storms are driven by northwesterly winds known as the Shamali that penetrate the Tigris and Euphrates valleys at any time of the year and continue for several consecutive days, intensifying during the day and weakening during the

night (Sissakian *et al*, 2013). It also notes the dominance of the subtropical elevation, African origin over the region with a gradual creep of the Indian seasonal low through the Arabian Gulf.

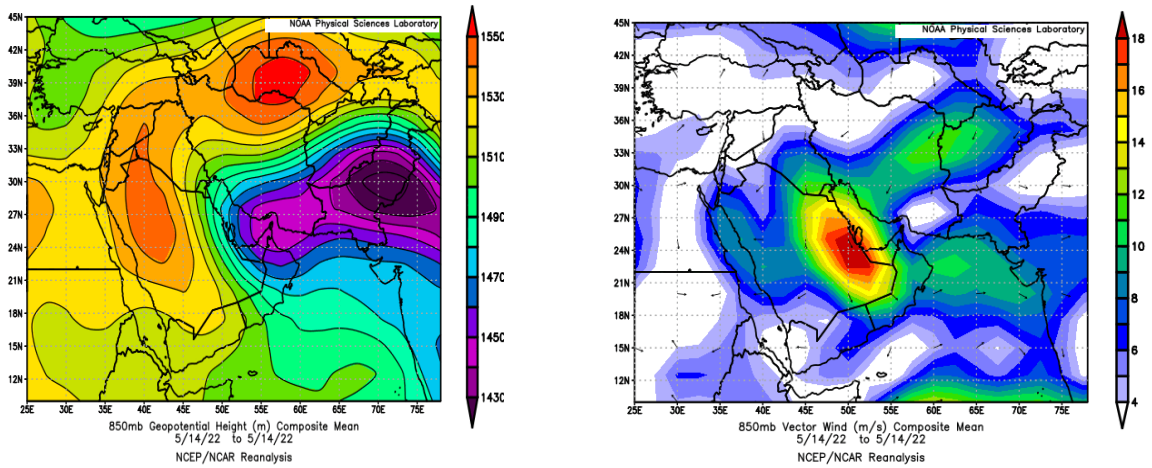
It is also noted from a map (3d) that the wind was in different directions on a dust storm day. Where it took the north and northwest direction in the northern region of Iraq and parts of the central and southern region, while the south and southwest direction included the western parts of it, giving a great opportunity for the influence of the tropical high to penetrate, accompanied by an upper trough that dominated the entire study area. The wind speeds decreased and took one direction to the northwest as demonstrated in a map (3e), with the subtropical high retreating towards the center of southern Iraq and a partial advance of the Indian seasonal low over all areas of the northern Iraqi region. Thus, the storm is shifted to areas without others from Iraq with intensity decreasing.



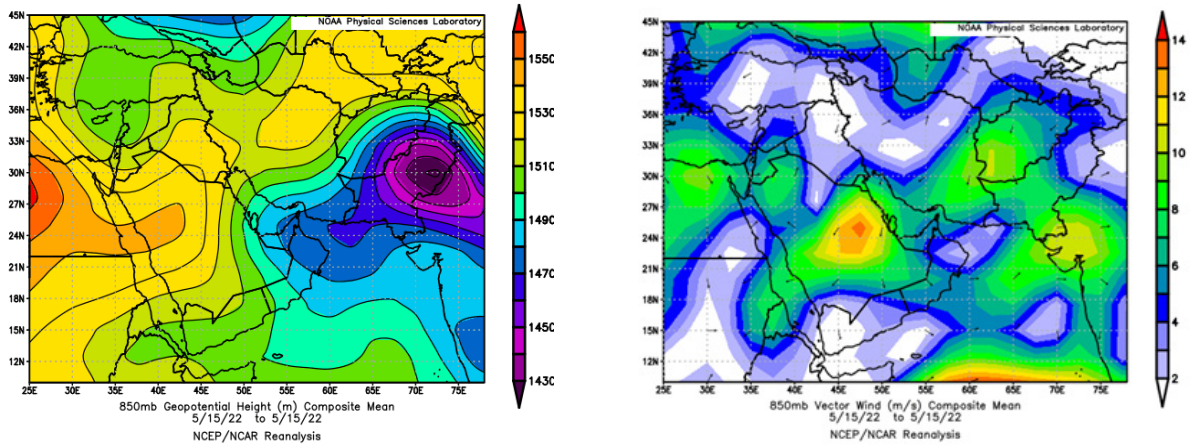
Map (3a): Weather map level of 850 mbar and wind vector for 12-5-2022



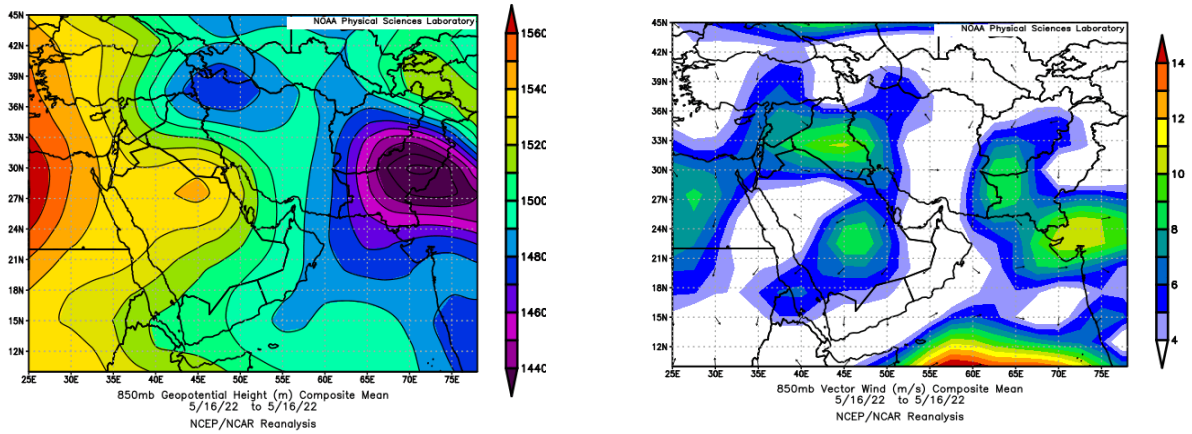
Map (3b): Weather map level of 850 millibars, and wind vector for 13-5-2022



Map(3c): Weather map level of 850 millibars, and wind vector for 14-5-2022



Map (3d): Weather map at 850 millibars and wind vector for 15-5-2022



Map (3e): Weather map level of 850 millibars and wind vector for 16-5-2022.

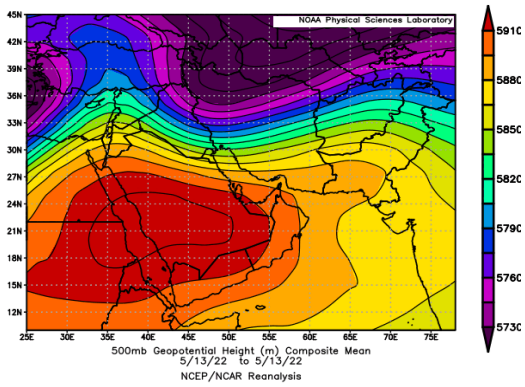
Source: Satellites National Oceanic and Atmospheric Administration- European Center for Medium-Range Forecasting.

c. The comprehensive analysis of the upper weather maps at 500 mbar level

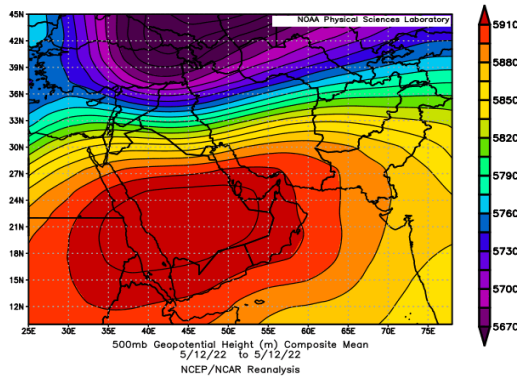
The upper air waves arise due to the difference in heating on the surface, which generates a wave movement known as westerlies that move slowly from west to east, forming Trough and Ridge. This level is located at an altitude of 5500 meters. The researcher demonstrates this by using it in analyzing dust storm days to indicate the type of prevailing and advanced airwaves. Or that penetrated over Iraq during the five days, that is, three days before the studied dust storm and a day after its impact dissipated or diminished, in addition to the main day of the storm, which is May 15, which accompanies the pressure systems in the deep and shallow levels of 1000 and 850 millibars. Maps (4a-e) show the wave sequence of the storm days, as the first day, May 12, witnessed the dominance of transverse waves over the regions of northern and central Iraq due to its affected by the advance of cold polar air trough that meet with waves of the closed upper pattern centered over the Arabian Gulf, the Red Sea, and the Arabian Peninsula as in map (4a), it develops into a dent pattern as it advances over the study area, and (4b) indicated a difference in the direction of the axis of the trough to take the northeast-southwest direction, which paves the way for withdrawal to the eastern and northeastern sides of the study area, which reduces the chance of humid winds blowing.

The map (4c) shows an advance of a warm air ridge from southwestern Iraq towards the central and northern areas. That is consistent with the two surface maps (1c) and (2c), where the subtropical altitude system's control and its role in fueling dust and soil and increased intensity as the northwestern wind accelerates, causing a larger rise in disintegrated soil particles. This promotes the final withdrawal of the trough and the control of the pattern of the ridges, where the ascending axis governs (at left) for ridges on 15 May, as shown in the map (4d), his extensions throughout the study area towards southwest-northeast, with differing pressure and varying speed and wind direction from one area to another, creating atmospheric instability, as illustrated by the map (1d). The ascending arm prepares to troughs withdraw some frontal influences due to ascending air currents, compared to the descending arm, which enhances the process of calming the air currents, and stands in the way of the advance of the air depressions, especially if it coincides with the duration of their remaining high (Schemm *et al*., 2020), this applies to the state of the atmosphere on a map (4d). The synoptic state on the day following the storm witnessed the continued rise of dust in some areas and its expiration in other regions of Iraq, as well as, the concentration of the closed pattern of waves. The upper air wave pattern in southern Iraq changed from the

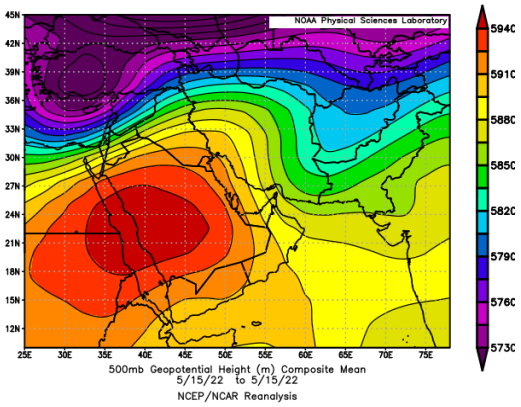
tropical bulge to the transverse wave pattern (4e) with the advancement of air trough in northern Iraq, because the cold air pushes the warm air through the northwestern winds, the latter works to raise sand particles to the top, especially areas of a desert nature. As for the surface with light vegetation and sandy soil that is easy to carry and move, dust gradually pushes from it toward the center and south (Al-Khalidi *et al*, 2021). That is evidenced by the surface map of dust and dust spread (2e), and the rush of dust particles towards the governorates of central and southern Iraq, shown in (pink).



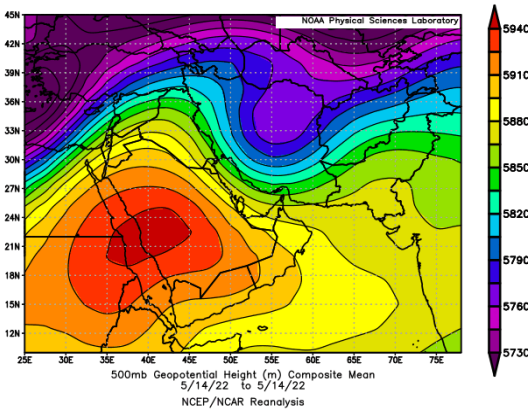
4a) on May 12



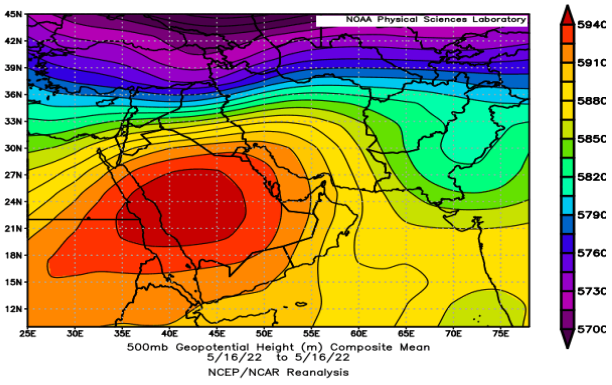
(4b) on May 13



(4c) on May 14



(4d) on May15



(4e) on May16

Map (4): Weather map of upper airwaves at 500 mbar before and after the dust storm

Source: Satellites National Oceanic and Atmospheric Administration- European Center for Medium-Range Forecasting.

The progress of a wet upper trough has reduced the weight of dust and its direction toward decay. Thus, dust storms are increasing during the spring and early summer months due to increased weather disturbances and wind speeds in the eastern and southeastern Mediterranean Sea, especially in the Tigris and Euphrates Basin, as a result of the movement of the Semipolar jet current nucleus to the north and the activity of subtropical high-pressure systems over the Saudi desert, as well as high pressure over Scandinavian countries. The high pressure and temperature gradients over the region encouraged the blowing of northern winds that provoked dust storms arising from surface vortices that caused an intensification of wind speeds over Iraq and the Arabian Gulf (Namdar *et al*, 2018).

It can be said that the main reason for the development of the dust storm and its continuation with varying intensity for

(5) days is the increase in wind speeds that pass over incoherent particles and the decline in rainfall due to climate change and mismanagement of water resources, which contributed to the decrease in vegetation cover, desertification, and drought. As for the higher-pressure levels, we find A deepening of the subtropical high at the level of 850 millibars, supported by the dominance of tropical emanations accompanied by a hot air mass, which caused the storm to persist for consecutive days and to reflect its environmental impacts on all aspects of agricultural, industrial, and economic life and various ecosystems in Iraq.

4. Conclusions

The graduation of pressure in the study area, which is diverse between high subtropical pressure covering the northern parts of the study and low pressure on the Arabic Gulf in the south, plays an important role in the occurrence of the dust storm on 15 May. Therefore, dust storms in Iraq are affected by gradual pressure through northwestern and southwestern winds coming from the deserts of neighboring countries. The alteration of the climate condition at the surface level of 1,000 millibars and the flow of high and low-pressure systems contributed to the effectiveness of a force that gradient pressure, thereby increasing the speed of the wind and its ability to carry dust atoms upward, with a constant northwest wind direction except on the day of storm 15 Mays, which occupied the southwestern direction in the desert region (western Iraq). Analysis of weather maps at the level of 850 millibars demonstrated a deepening of the penetration of the subtropical surge over all regions of Iraq, with the continued direction of the winds north and northwest, which indicates the continued rise of dust and its increasing density and intensity, with the penetration of the secondary centers of the subtropical high in the western parts of the study area, which is the areas are the most arid, decertified, fragile, and disintegrating in the soil surface. The study showed the dominance of airwaves of the type of tropical convexity at the pressure level of 500 millibars as well as the presence of the cut-off pattern, which is originally orbital air rushing from orbit towards southern Iraq, enhancing the relay and strength of the pressure systems at the three levels and stimulating the continuity of the storm for several days with varying intensity and impact in the region.

Acknowledgments

The authors are grateful to the National Oceanic and Atmospheric Administration (NOAA) for providing daily weather maps to facilitate the analysis of atmospheric phenomena.

Conflict of Interest

No potential conflict of interest relevant to this article was reported

References

Al-Jizani, Balsam Shaker Shanishil, northwestern winds in Iraq and their impact on temperature and rainfall, Master's thesis, University of Baghdad, College of Education for Girls, 2010, p. 21.

Al-Jumaily, K. J., & Ibrahim, M. K. (2013). Analysis of the synoptic situation for dust storms in Iraq. Int. J. Energ. Environ, 4(5), 851-858.

Alkhalidi, J., & Stefan, S. (2017). The influence of geopotential height on temperature variability over Iraq. In the EGU General Assembly Conference Abstracts Vol. 19, EGU2017-872.

Al-Khalidi, J., Bakr, D., & Abdullah, A. A. (2021). Synoptic Analysis of Dust Storm in Iraq. Environment Asia, 14(1).

Al-Lami, Huda Abbas, Dust in Iraq, Iraq Metrological Organization, Baghdad, 2012, p. 3.

Al-Qadi Taghreed. (2001) The effect of surface and upper-pressure systems on the formation of dust storms in Iraq, Master's thesis, University of Baghdad, College of Literature, 82-132.

Balsam Sh. A. (2010). Northwestern winds in Iraq and their impact on temperature and rainfall, Master's thesis, University of Baghdad, College of Education for Girls, p. 21.

Cao, H., Amiraslani, F., Liu, J., & Zhou, N. (2015). Identification of dust storm source areas in West Asia using multiple environmental datasets. Science of the Total Environment, 502, 224-235.

Dhuha S. Zaiter, Kais J. Al-Jumaily, Characteristics of Thermal Wind over Iraq, International Journal of Scientific and Research Publications, Volume 6, Issue 5, 2016, P142-143.

European Centre for Medium-Range Weather Forecasts,https://apps.ecmwf.int/datasets/data/interim-full-daily/levtype=sfcdata. https://meteologix.com/om/reanalysis/ecmwf-era5/Iraq/sea-level-pressure/20191001- 0600z.html.

Ibrahim M. K. (2013). Analysis and study of synoptic patterns of dust storms in Iraq using satellite and NCEP data. M.Sc. Thesis. Dept. of Atmospheric Sciences, Al-Mustansiriyah University.

International Bank for Reconstruction and Development, Sand and Dust Storms in the Middle East and North Africa (MENA) Region Sources, Costs, and Solutions, Washington, 2019, p.9.

Jasim, F. H. (2018). Meteorological Analysis of Severe Dust Storm over the Middle East. Al-Mustansiriyah Journal of Science, 29(2), 1-9.

Kutiel Haim F., Dust in the Middle East: Sources of Origin and Their Temporal Characteristics, Environmental Problems Affecting Health, Original Paper, Indoor Built Environ, University of Haifa, 2003, P421.

Majeed, H. T., & Qasim, H. M. (2021). Synoptic Situation of 28-31 October 2017 Severe Dust Storm over Iraq. Al-Mustansiriyah Journal of Science, 32(2).

Mohammed, S. K., Al Fatla, N. M., & Abdul Wahab, S. A. (2015). Analyzing the synoptic patterns associated with dust events over West Asia during the summer months Studies. Journal of Applied Physics, 7, 53-66.

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

National Oceanic and Atmospheric Administration NOAA. https://psl.noaa.gov/cgi-in/data/ composites/print page.pp1.

Schemm, S., Rüdisühli, S., & Sprenger, M. (2020). The life cycle of upper-level troughs and ridges: a novel detection method, climatologies and Lagrangian characteristics. Weather and Climate Dynamics, 1(2), 459-479.

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