

Synoptic Situation of 28-31 October 2017 Severe Dust Storm over Iraq

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ABSTRACT

The phenomenon of dust storms occurs in areas that are characterized by drought, and lack of rainfalls. There are many such areas around the world, including the Middle East in general and large parts of Iraq in particular. In the last week of October 2017, a severe dust storm occurred over Iraq and lasted for four days, the aim of this work was to investigate the synoptic situation of this severe storm using remote sensing data. Data include daily true-color images, Aerosols Index (AI), surface weather maps, and 850 Mb weather maps. These data were analyzed for the four days of the storm (28-31 Oct 2017). The results showed that the storm was triggered on the 28th of October over the northwestern part of Iraq. The weather maps revealed that the cause, development, and transport of this storm were caused by a low-pressure system. This system was developed just over the source area of dust on the first day of the storm, and two ridges in which one has existed over the north of Iran and the second advanced from Egypt during the second day of the storm. The pattern of the trough and two ridges on the second and third day caused the storm to halt over central and southwestern areas of Iraq and the northern border of Saudi Arabia with Iraq. On the fourth day, the storm was moved by the northwesterly wind towards the south of Iraq and Kuwait.

KEYWORDS: Synoptic; Dust; Aerosols; MODIS; Iraq.

الخلاصة

تحدث ظاهرة العواصف الترابية في المناطق التي تتميز بالجفاف ونقص الأمطار. هناك العديد من هذه المناطق حول العالم، بما في ذلك الشرق الأوسط بشكل عام وأجزاء كبيرة من العراق بشكل خاص. في الأسبوع الأخير من أكتوبر ٢٠١٧ حدثت عاصفة ترابية شديدة فوق العراق واستمرت لمدة أربعة أيام، الهدف من هذا البحث هو دراسة الوضع السينوبيتيكي لتلك العاصفة الشديدة باستخدام بيانات الاستشعار عن بعد. وتتضمنت البيانات صورًا يومية بالوان حقيقية، ومؤشر الهباء الجوي (AI)، وخرائط الطقس السطحية وخرائط الطقس ٨٥٠ مليبار. تم تحليل هذه البيانات لمدة الأربعة أيام التي حدثت فيها العاصفة من ٢٨ إلى ٣١ تشرين الأول ٢٠١٧. أظهرت النتائج أن العاصفة هبت في يوم ٢٨ فوق الجزء الشمالي الغربي من العراق. ودلت خرائط الطقس أن سبب تكون هذه العاصفة وتطورها وانتقالها هو وجود منخفض جوي وقد تطور هذا المنخفض خلال اليوم الأول فوق أحد المصادر الرئيسية للغبار في العراق. كما تواجد نتوئين مرتفعين جوبيين أحدهما تواجد شمال إيران والثاني تقدم من مصر خلال اليوم الثاني من العاصفة. وقد تسبب نمط انبعاج المنخفض الجوي والنتوئين خلال اليومين الثاني والثالث في انتشار العاصفة فوق المناطق الوسطى والجنوبية الغربية من العراق والحدود الشمالية للمملكة العربية السعودية مع العراق. وفي اليوم الرابع، تحركت العاصفة بفعل الرياح الشمالية الغربية باتجاه جنوب العراق والكويت.

INTRODUCTION

The phenomenon of dust storms occurs in areas that are characterized by drought, low rainfall. Large such areas are found around the globe including large areas including the Middle East general and large parts of Iraq in particular. The solids suspended particles in the atmosphere are generally dust or sand and are usually lifted upwards by the wind from areas of loose soil, and wind can transport them from their origin to other places at hundreds and

even thousands kilometers [1]. Dust storms have many environmental impacts including the increase of respiratory diseases [2]. reduction in solar radiation and consequently reducing the efficiency of solar devices, reduced soil fertility and damage to crops [3], damages to mechanical and telecommunications systems [4], and so on. In the Middle East dust storms occur during any time of the year but mostly during spring and summer seasons [5][6]. Over the past

decade, there has been an increasing trend in the annual number of dust storms; this led numerous research works on verity topics concerning these storms including the dynamic and synoptic situations. Mashat and Awad (2010) investigated the dynamic and synoptic situations leading to the 24-27 March 2003 [7]. Al-Jumaily and Ibrahim (2013) [8] reported on the synoptic situation of several dust storms in Iraq and suggested that the main cause for the occurrence of dust storms in Iraq was a low-pressure system usually passes over Iran. Hamidi *et al.* (2013) [9], in their research on the synoptic situation of dust storms in the Middle East, confirm that the Shamal winds are responsible for the majority of dust storms in Iraq particularly during summer and sometimes during winter. Dehghanpour *et al.*, (2014) [10] analyzed the synoptic situation of dust systems in Yazd Province of Iran, they indicated that these systems were due to the expansion of a low pressure entered Iran from the east and caused increased. Mashat and Awad (2015) [11] studied the synoptic characteristics of the autumn dust storms in Northern Saudi Arabia, they suggested that the main factors affecting these storms were the vertical motion and the decrease of the static stability over the Arabian Peninsula. Namdari *et al.*, (2017) [12] studied the impact of climate and synoptic fluctuations of dust storms in the Middle East. They indicted that turbulence plays an important role in intensifying the surface winds. Beegum *et al.* (2018) [13] simulated and analyzed synoptic scale dust storms over the Arabian Peninsula. They concluded that extreme dust events reduce the horizontal visibility to near-zero values and co-occurred with the production of extremely high dust deposition flux. Hasseb (2018) [14] analyzed the meteorological conditions of a severe dust storm during the period 6-9 September 2015 over seven Middle East countries including Iraq and showed that two thermal convection lows were responsible of lifting dust from source areas of dust in the region. Albarakat and Lakshmi (2019) [15] monitored dust storms in Iraq using satellite data to assess the development and spread of dust storms over different parts of the country. Mashat *et al.*

(2020) [16] investigated the dynamic and synoptic situations of spring dust storms over northern Saudi Arabia. They analyzed both frontal systems and shamal systems and found that during the development of the dust event pressure and temperature gradient were increasing over the northern Arabian Peninsula and the maximum wind shifted eastwards. The aim of this work was investigating the synoptic situation during a severe dust storm that occurred over Iraq during the period 28-31 October 2017.

Study Area and Data Sources

Iraq, with an area of about 437,072 km², is located approximately between 29°N and 38°N in latitude and between 38°E and 49°E in longitude. Figure 1 shows an elevation map of Iraq. It is seen that Iraq's topography can be divided into four distinct regions: the mountain area in the north and northeast part of the country; the alluvial plains which extends from the central and southeastern areas of the country; an upland which extends from northwest to southwest of the country; and high deserts in the west. The last two parts of Iraq are the major sources of dust storms that occur during any time of the year but mostly during summer season [17].

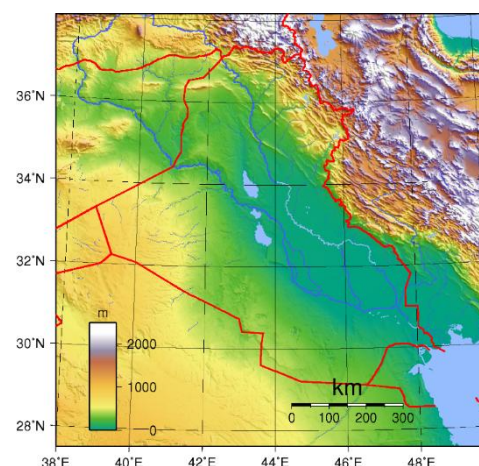


Figure 1. Study area. <http://www.diva-gis.org>.

The climate of Iraq is mainly arid and semi-arid, except in the north and northeast areas where the Mediterranean climate prevails. The average annual precipitation in Iraq is about 215 mm. Precipitation only falls during the period from October to May [18]. Temperature

may reach 50 °C during summer months in the central and southern parts and below freezing during winter in the north and mountain areas [19]. In this work, true color images of the dust storms during the four days period were obtained from the Moderate Resolution Imaging Spectroradiometer (MODIS). MODIS is a key instrument aboard Aqua and Terra Satellites operated by NASA [20]. Data of the Aerosols Index (AI) were acquired from the Ozone monitoring Instrument (OMI) aboard NASA's Aura satellite [21]. Meteorological variables during the storm period were obtained from the European Center for Medium-Range Weather Forecasts (ECMWF) reanalysis data with 10×10 resolution [22]. The variables include mean sea level pressure, surface horizontal wind, 850 mb vertical pressure velocity and 850 mb horizontal wind. Analysis was carried out with the Grid Analysis and Display System (GrADS). GrADS is an interactive desktop tool that is used for easy access, manipulation, and visualization of earth science data [23].

RESULTS AND DISCUSSION

Figure 2 shows true color images of the storm during the four days (28-31 Oct 2017). It is seen that during the first day the storm has started on the northwestern border region with Syria. This area is considered as one of the major source of dust [24]. The presence of the cloud sheet just north of the storm suggests that the storm was a post frontal type. During the following day the dust storm became intensified and moved towards southwest and entered to Saudi Arabia. On the third day, the storm has changed direction and spread northward back to Iraq. The storm has covered most the southeastern, central, and northwestern parts of Iraq. It is notable that the dust was lying underneath the clouds over the northwestern area. On the fourth day, the storm changed direction again and headed to the south. The image of this last day shows that the dust was covering Iraq, Kuwait, western coastal area of Iran, and northern part of the Arabian Gulf.

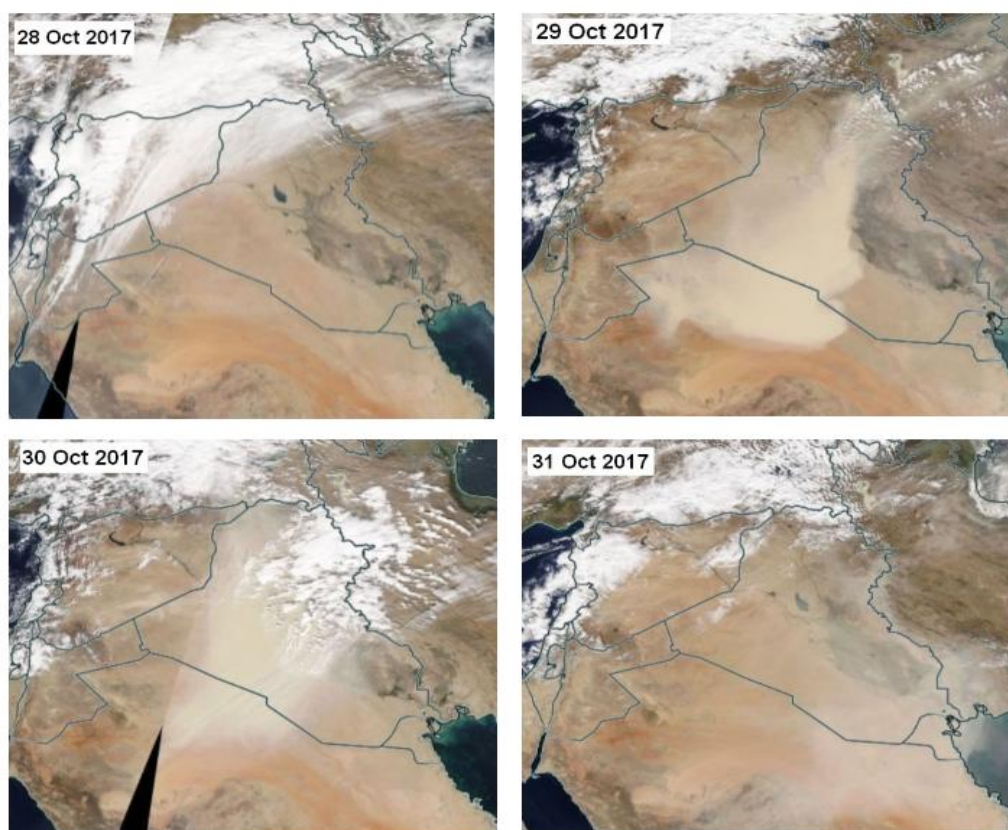


Figure 2. MODIS true color images of dust storms over Iraq and surrounded regions on 28-31 October 2017.

Figure 3 gives the analysis of the AI. Unfortunately, the AI data covering the study area were available for two days of the storm (29th and 30th Oct). It is clear during the second day, the AI reached high values (>3) over large area of the storm and the maximum

AI (>3.5) has occurred over a small area just west of the two lakes Therthar (in the north) and Razaza (in the south). On the fourth day, AI values were greater than 3.5 covered large areas in south Iraq, entire Kuwait, and northeastern part of Saudi Arabia.

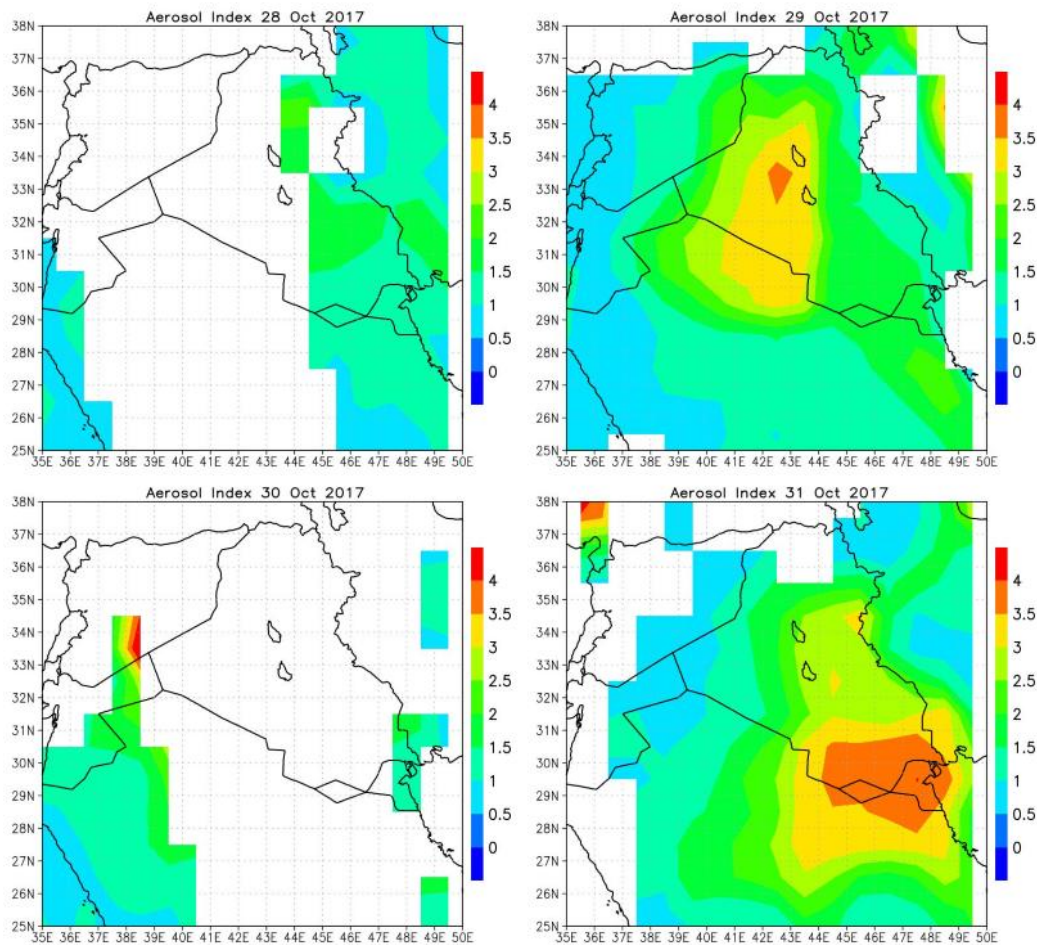


Figure 3. Aerosol index over Iraq and surrounded regions on 28-31 October 2017.

Figure 4 illustrates the surface weather patterns during the four days of the storm. It is obvious that on 28th Oct there was a low pressure system and its center was located just above the source area of dust. The wind was circulating counterclockwise around the center of that low; such the wind was southerly and south easterly on the right side of the low and northerly and south westerly on the left side. The non-geostrophic wind was strong (> 9 m/s) all over the east side of the low pressure system and slower on the west side. This pattern of wind has lifted dust from underneath earth surface and triggering the dust storm. On the same day, there was a ridge over Iran and it seems that it did not affect the formation of the dust storm.

On the second day, the low pressure system has just moved towards northwest towards Europe and a second ridge was approaching the area from the west. The existence of two ridges around the dust storm resulted in strong southerly wind on the east of Iraq and a slower northerly wind over the west part where the storm was located. This slower northerly wind has caused the dust to travel south towards Saudi Arabia. On the third day, a strong westerly wind pushed the dust eastwards and a slower southerly wind just east of the storm pushes the dust northwards. On the last day, the wind was shifted to be northerly on the east part of Iraq and was relatively strong in the south. This wind pattern has helped

transporting the dust towards Kuwait, south western Iran, and the Arabian Gulf. Figure 5 shows the maps of the vertical pressure velocity (omega) and the horizontal velocity at 850 mb pressure level. Negative omega indicates upwards motion while positive values mean downward motion. On the first day, the omega was strongly negative (about -0.8 pa/s) above the dust source area, this might have help lifting dust upwards by sucking air

from level below the 850 mb level. On the remaining days of the dust storm, omega was positive in areas above the dust storm, meaning that air movement from the 850 mb level towards the surface keeps dust close to the ground. The patterns of the horizontal wind at 850 mb level during the four days of the storm have contributed to the shift and movements of the storm.

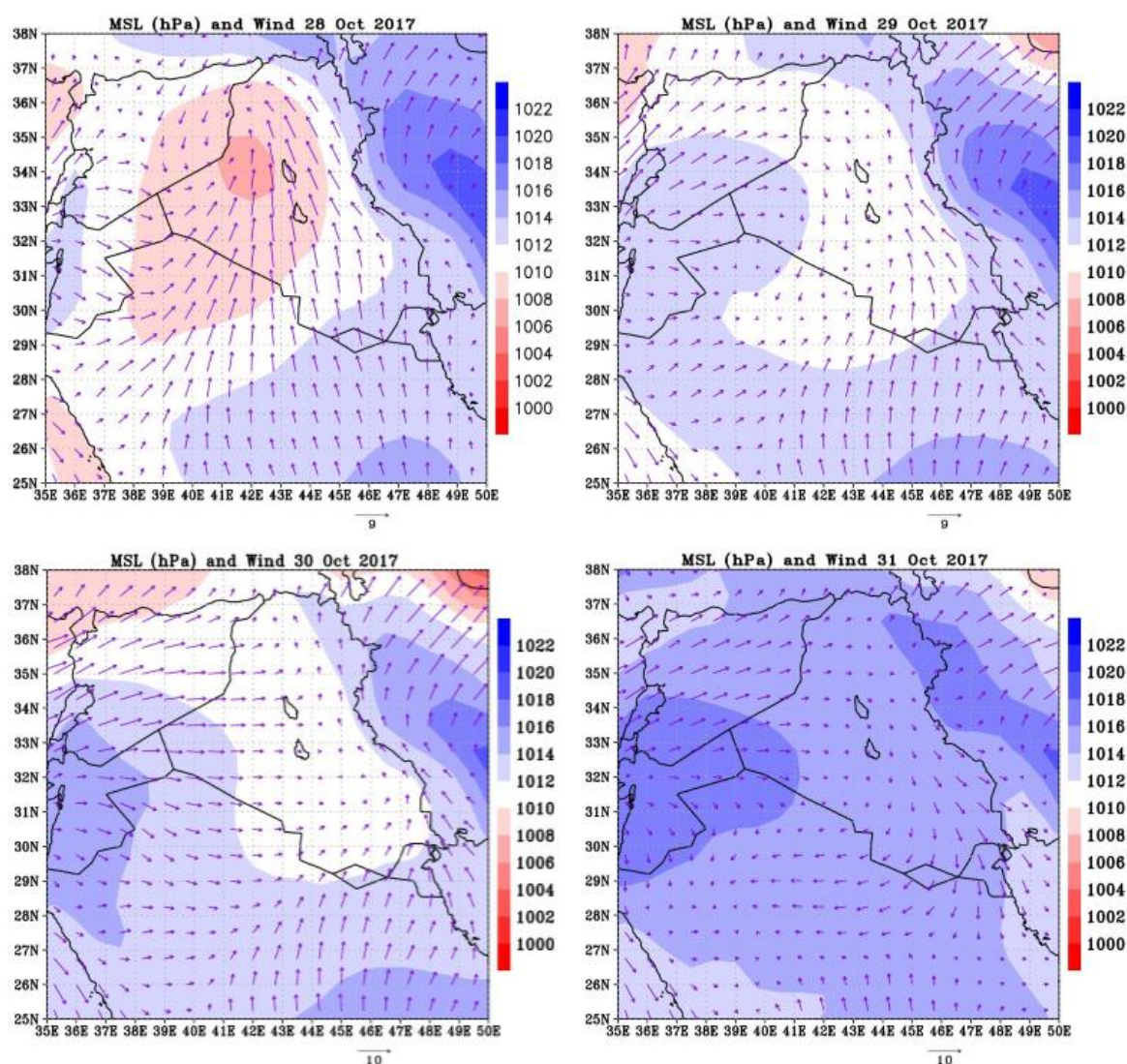


Figure 4. Mean seal level pressure (mb) and wind vectors over Iraq and surrounded regions on 28-31 October 2017.

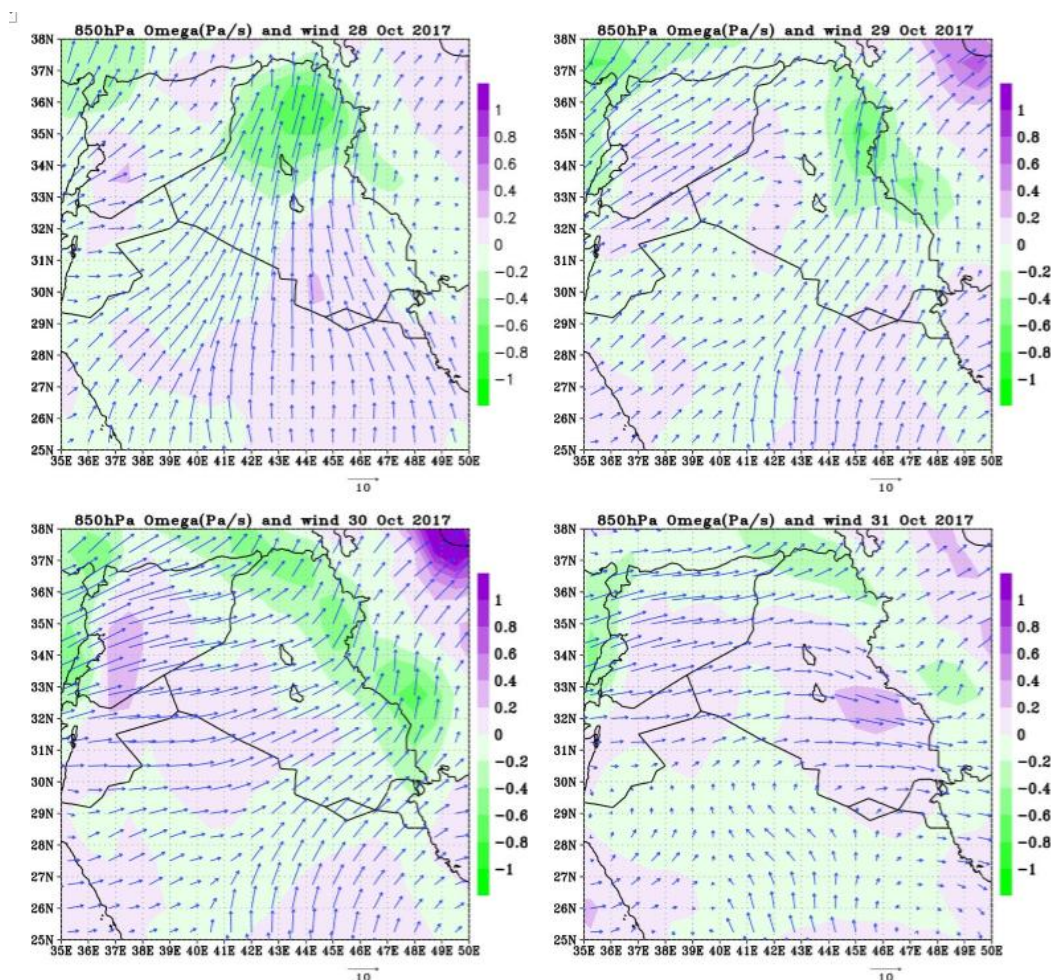


Figure 5. 850 mb vertical velocity (Pa/s) and horizontal wind vectors over Iraq and surrounded regions on 28-31 October 2017.

CONCLUSION

On 28th of Oct 2017 a severe dust storm blew over Iraq and surrounded countries. The storm lasted four consecutive days. This work aimed at analyzing the synoptic situation during the period of the storm. Results showed that the storm was triggered by a low pressure system which happened to be located just over one of the major source areas of dust in Iraq. On the first day, the northerly wind transported the dust southwards but the wind was shifted to the north and caused the storm to move northwards during the second and third days. The main cause of this shifting was the two ridges that existed on both east and west side of the dust storm during these two days. On the fourth day winds calmed down in most of the study area except in the south of Iraq where wind was strong and northerly and transported the dust southwards towards Kuwait and the Arabian Gulf. The pattern of the vertical pressure velocity on the 850 mb pressure level also played a role in

behavior of the storm. The movement of air at that level was upwards over the dust source area on the first day which contributed to lifting dust from ground and the air motion during the remaining days was downwards so the dust was kept close to the ground on these days.

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