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Influence of dust storms on the climate change
Analysis of Early September 2015 Dust Strom over Iraq

Morwa K. Ibrahim
Department of Atmospheric Science, College of Science, Al-Mustansiriyah University
Baghdad, Iraq

ABSTRACT

Dust storms and suspended dust pose serious environmental problems in south-west Asia and natural hazards in the Middle East region. Major dust storms occur over the Middle East region nearly every spring and summer and cause destructive effects in some countries like Iraq, Saudi Arabia and Iran. Tigris-Euphrates alluvial plain has been recognized as the main dust source in this area. In early September 2015, a storm moved across Iraq towards the Arabian Gulf.

The aim of this study is to investigate this storm based on MODIS satellite images, and meteorological parameters related to the formation and dynamics of dust storms. Maps of Aerosols Index (AI), mean sea level pressure, relative humidity, pressure vertical velocity, and horizontal velocity were analyzed for four days, starting from the day when the storm was initiated, near the Iraq-Syria borders until it reached the Strait of Hormuz inthe Arabian Gulf. On August 31, the storm was detected by the Moderate Resolution Imaging Spectroradiometer (MODIS) on NASA's Terra satellite. Analysis of the meteorological parameters suggested this storm was produced due to the haboobs and Shamal effect.

Key words: Early September 2015 Dust Strom, Iraq, NASA's Terra satellite, climate change.

INTRODUCTION

Iraq is considered one of the region's most vulnerable countries to climate change and it faces a uniqueset of environmental challenges. Rising environmental degradation and increasing frequency andintensity of extreme weather events, especially Sand and Dust Storms, take an enormous toll onsocio-economic life and human development across the region. Dust storms are driven by anorthwest wind called the "Shamal" (means in Arabic language; from the north) that can rip through the Tigrisand Euphrates River valleys of central and southern Iraqat any time of the year, and blow almost constantlythrough June and July. However, in Augustand September it might still blow. Shamal winds can last for several days in a row, strengthening during the dayand weakening at night, and creating devastating duststorms [1].Another mechanism for blowing dust is the Haboobs which are dramaticevents associated with storm fronts and often appear as walls of sand and dust marching across the landscape.But like thunderstorms, haboobs tend to abrupt and short-lived [1].

Since 2003 dust andsand storm in Iraq and surrounded countries were of major concern by research community. Recently, Khalid [2] used TOMS AI data to determine the origin of dust storm sourcesin Iraq. Desouza et al., [3] studied the evolutionary characteristics of a dust storm over Oman on 2February 2008 by analyzing the weather associated with it. They concluded that the weakening of theinversion in the lower troposphere and the formation of a mixed layer due to transfer of horizontalmomentum from upper air towards the surface led to strong surface winds and these strong winds lifted alarge amount of dust particles off the ground, resulting in the dust event under study. Maghrabi [4] investigated the impact of dust storm on meteorological parameters in central Saudi Arabia. Khoshhal et al., [5] explored the recognition and assessment of atmospheric circulation patterns transferring duststorms. They suggested that the temporal and spatial investigation of dust storms shows the interferenceof various factors in their occurrence and expansion. Al-Dabbas et al., [6] studied eight dust storms thatoccurred between December 2008 and March 2009 to determine the dust load of these storms. Al-Jumaily and Ibrahim [7] analyzed and studied the synoptic patterns leading to the formation of dust storms in Iraq. Sissakian et al., [8] discussed the main causes in the development of dust and sand storms in Iraq. They concluded that oneof the main reasons behind the development ofsand and dust storms is the climatic changeswithin the region.. Dehghanpour et al., [9] reported on synoptic analysis of dust systems in Yazd Province of Iran, their results have shown that due to the expansion of low pressure heated air tongue of lower latitudes, entered the Iran from east and caused increased temperature. Mashat and Awad [10] studied the synoptic features of the autumn dust classes in Northern Saudi Arabia, the study showed that the intensity of the vertical motion, the decrease of the static stability over the Arabian Peninsula and its increase over the Mediterranean and Arabian Seas, in addition to the northern shift of the atmospheric systems at 500 hPa, are the main factors affecting the strength of the dust cases.AbdAlKareem [11] analyzed the synoptic situation of a massive dust storm occurred on early July 2009 over Iraq.

Dust storm in the Middle East and south-west Asia is a natural hazard and the Tigris-Euphrates alluvial plain has been recognized as the main dust source in this area. In this study, more than 60 dust storms that occurred during the period 2003-2011 are investigated on the basis of MODIS satellite images, and 12 of the dust storms are selected for synoptic analysis using the NCEP-NCAR Reanalysis Data. The potential dust sources in the Middle East and south-west Asian region (20oE to 80oE, 5oN to 50oN) are analyzed and used in the synoptic analysis. Dust storms in the region can be grouped into two main categories, i.e., the Shamal dust storms and the frontal dust storms. Synoptic systems, associated with the two categories, are distinguished and the frequency of the patterns is identified. For 68% of the Shamal dust storms, a high pressure system is situated between 0oE to 30oE and 27oN to 45oN, and a low pressure system between 50oE to 70^{o}E and 23oN to 43^{o}N. For 86% of the frontal dust storms, a high is located between 51oE to 67oE and 18oN to 33oN and a low between 28^{o}E to 48^{o}E and 32^{o}N to 43^{o}N. Three main patterns for Shamal dust storms are identified, which represent about 60% of the Shamal dust storms. This analysis confirms that the Shamal is related to the anticyclones located over northern Africa to Eastern Europe and the monsoon trough over Iraq, southern Iran, Pakistan and the Indian Subcontinent. The analysis also shows that the main dust sink for the frontal dust storms in Tigris and Euphrates alluvial plain extends from center of Iraq to west and center of Iran and, in most severe cases, to northern Iran and the southern coast of the Caspian Sea.

Meteorological characteristics of dust storms

The climate in the Middle East is mainly affected by four systems: (a) The Siberian anticyclone in winter over central Asia; (b) The Polar anticyclone in summer over east of Europe and Mediterranean Sea; (c) The monsoon cyclones in summer over the India Subcontinent, south and southeast of Iran and southeast of Arabian peninsula; (d) The depressions travelling from north of Africa and south and east of Mediterranean sea across the Middle East and southwest of Asia in the non summer seasons (spring and winter). Summer Shamal and frontal dust storms are the two main kinds of synoptic scale dust storms in this region. Severe dust storms occur in summer and associated with Summer Shamal (for simplicity called Shamal in this study). In non-summer season, frontal dust storm is the most common type. Wilkerson (1991) presented a definition for Summer Shamal and frontal;

(1) Summer Shamal

Shamal (means north in Arabic) dust storm occurs across Iraq, Kuwait, western part of Khuzestan plain and some parts of Arabian Peninsula. It blows almost daily during the summer months from June through September. The summer Shamal travels across central and southern Iraq and picking up dust from Tigris and Euphrates rivers alluvial plain. The synoptic feature that creates the potential for the Shamal is a zone of convergence between the subtropical ridge, extending into the northern Arabian Peninsula and Iraq from the Mediterranean Sea and Monsoon Trough across southern Iran and southern Arabian Peninsula. The zone of convergence is caught between the pressure systems and Zagros Mountains of western Iran. It tends to force an acceleration of the northerly low-level winds across southern Iraq**.**

(2) Frontal dust storm

Frontal dust storms are dynamic synoptic systems that mix the dust in the air and carry it for great distances in non summer seasons. The two main types of frontal dust storms in Tigris and Euphrates rivers alluvial plain are prefrontal and postfrontal dust storm**.**

Mineral dust aerosol is involved in many important processes in Earth’s climate system including radiative forcing nutrient transport, land-use change, and ecosystem health, Dust storms cause soil loss from the dry lands, and worse, they preferentially remove organic matter and the nutrient-rich lightest particles, thereby reducing agricultural productivity. Also the abrasive effect of the storm damages young crop plants. Dust storms also reduced visibility affecting aircraft and road transportation. In addition dust storms also create problems due to complications of breathing in dust.

Dust and environmental change

One environmental consequence of atmospheric dust loadings is their significance for climate through a range of possible influences and mechanisms They may affect air temperatures through the absorption and scattering of solar radiation . Saharan dust modifies short-wave solar radiation transmitted through to the earth’s surface and long-wave infra-red radiation emitted to space. However, the balance between these two ten tendencies whether this creates cooling or warming, and this in turn, depends in part upon such variables as the size distribution of dust particles and their chemical composition. It is also possible that dust may affect climate through its influence on marine primary productivity and there is some evidence that dust may cause ocean cooling. Changes in atmospheric temperatures and in concentrations of potential condensation nu nuclei may affect convectional activity and cloud formation, thereby modifying rainfall amounts.

MARTIAL AND METHODS

In early September 2015, a storm moved across Iraq, Iran,and the Arabian Gulf region. The Moderate Resolution Imaging Spectroradiometer (MODIS) on NASA’s Terra and Agua satellites captured natural-color images of the dust storm on August 31 to September 3, 2015.

[12].These images were used to identify the location and movement of the storm. The Total Ozone Mapping Spectrophotometer (TOMS) aerosol data, which are given in units called the Aaerosolindex (AI) [13],were used to identify the strength of the storm.Daily data of related meteorological parameters for surface and 1000 mb pressure levels provided bythe National Oceanic and Atmospheric Administration (NOAA), US Department of Commerce [14] were used to investigate the meteorological situation of this dust storm.

RESULTS AND DISCUSSION

Figures (1) shows the MODIS images of the dust storm on August 31 to September 3, 2015.The dust event first appeared in the satellite imagery along the Iraq–Syria border on August 31. By the nextday, the storm took on the cyclonic shape. By September 2, the dust cloud reached Kuwait and the northern part of the Arabian Gulf and on September 3, the storm had spread out across the entire basin of the Gulf and reached the strait of Hormuz. Figure 2 gives the AImaps for the storm. The AI reached more than 5.0 on August 31 over the source region of the storm. On the next day, the core region intensified as it moved eastward, the AI was more than 5.5. On September 2, the AI map indicates that the storm has moved southward and spread over a large area. On September 3, the storm started to loss strength, as AI values were less than 3.0. Figure 3 indicates that the storm appears to have been triggered by a surface low-pressure system that movedfrom northwest to southeast during the week. The cyclonic circulation around the center oflow pressure is most obvious in the August 31image. Figure 4 confirms the wind circulation pattern. It is seen that on Aug 31, the surface wind was more than 12 m/s at the center of the low pressure system which is located over north part of Iraq. The circulation pattern of the wind has triggered the dust to be blown from the region close to the Iraq-Syria borders, This area has been confirmed by researchers to be the major source of dust storms in Iraq. On September 1, the wind continued to have the circular pattern. This circular pattern of the wind on these two days made the storm the spiral over north Iraq. The overall movement of the system,during the four days, from the northwest toward the Arabian Gulf also suggest slate-summer Shamal winds.

Figure (5) illustrates the maps of the relative humidity during the four days of the storm. It is obvious that air over the region during that period was dry and the relative humidity barley reached 20% in the northern part of the region. Figure 6 shows the vertical velocity patterns during the storm. It is seen that the region was dominated by low vertical velocity (ranged between -1 to +1, +ve and –ve signs indicate downward and upward motion respectively). This situation may have kept the dust near the ground surface.

Conclusions

The early September 2015 dust storm event occurred over Iraq, Iran, and the Arabian Gulf, was formed by the haboobs and the shamal effect. A surface low-pressure system formed over a major source area of dust has triggered the haboob and strong northwesterly wind (shamal) has spread and transport dust over the region. The dust which has formed over north of Iraqreached the Strait of Hormuz. Dust storms have become more common in Iraq, a result of droughtand human and natural destruction of wetlands in theTigris-Euphrates watersheds.

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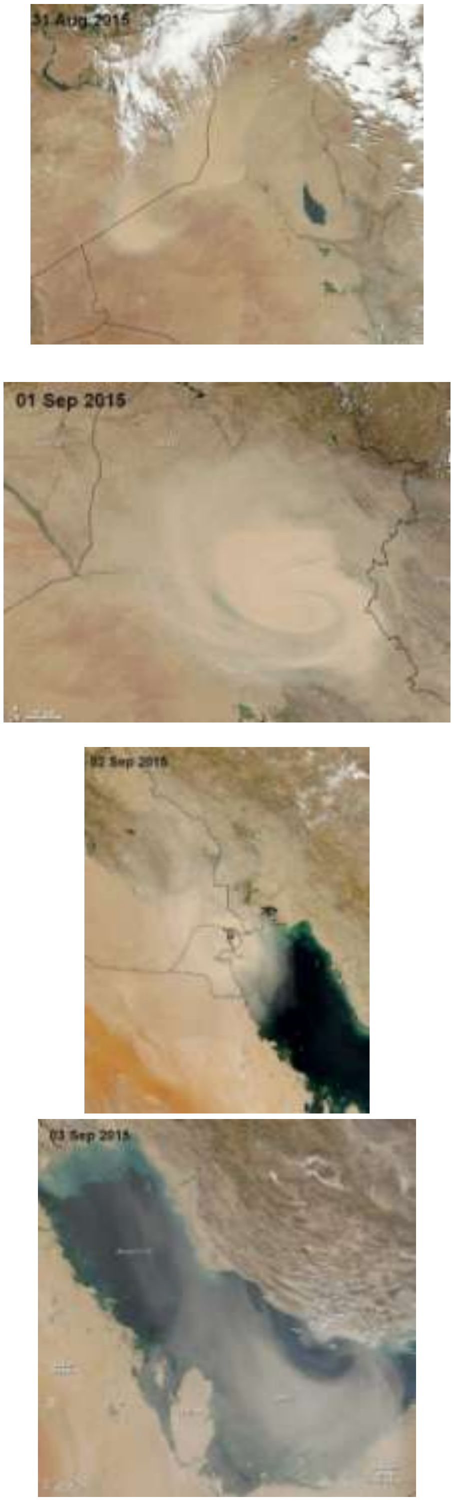

Fig. 1: MODIS images of the dust storm on August 31 to September 3, 2015.

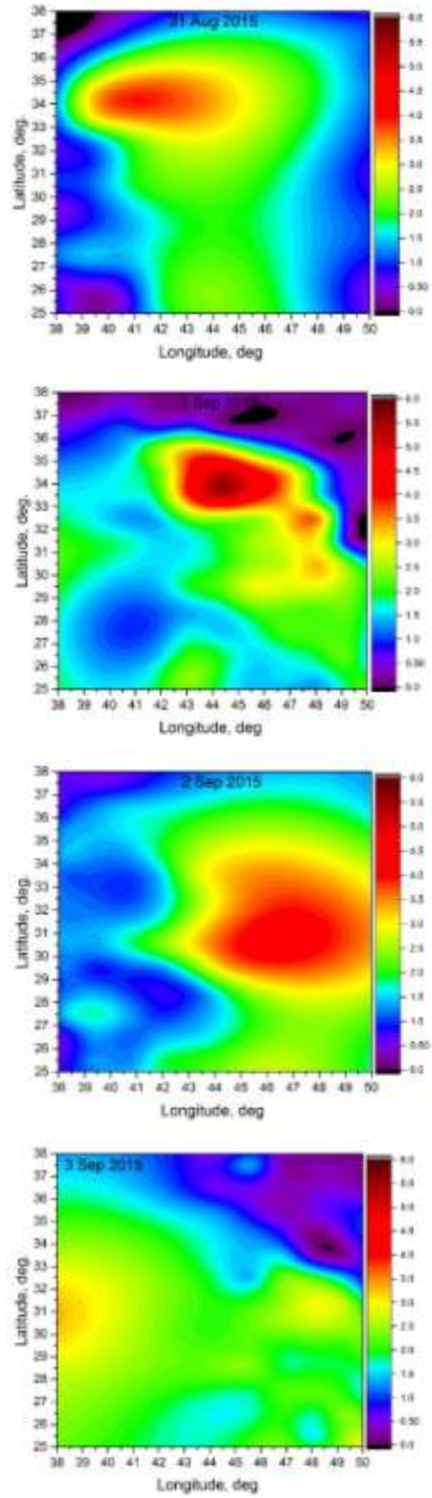

Fig. 2: TOMS aerosols index maps of the 31 Aug – 3 Sep dust storm over Iraq and the Arabian Gulf.

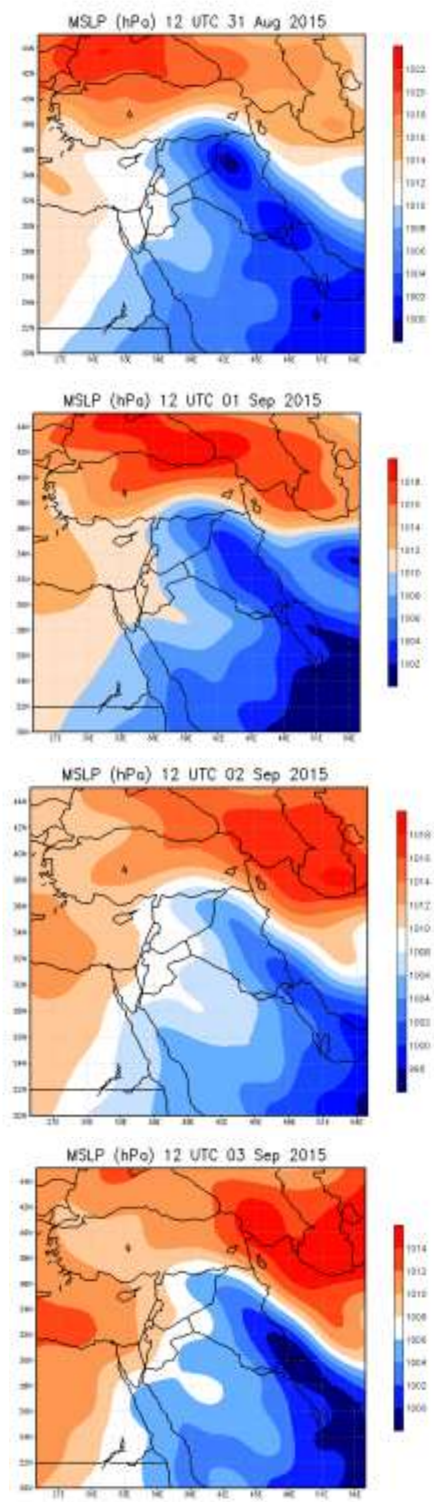

Fig. 3: Mean sea level pressure at 12 UTC on August 31 to September 3, 2015.

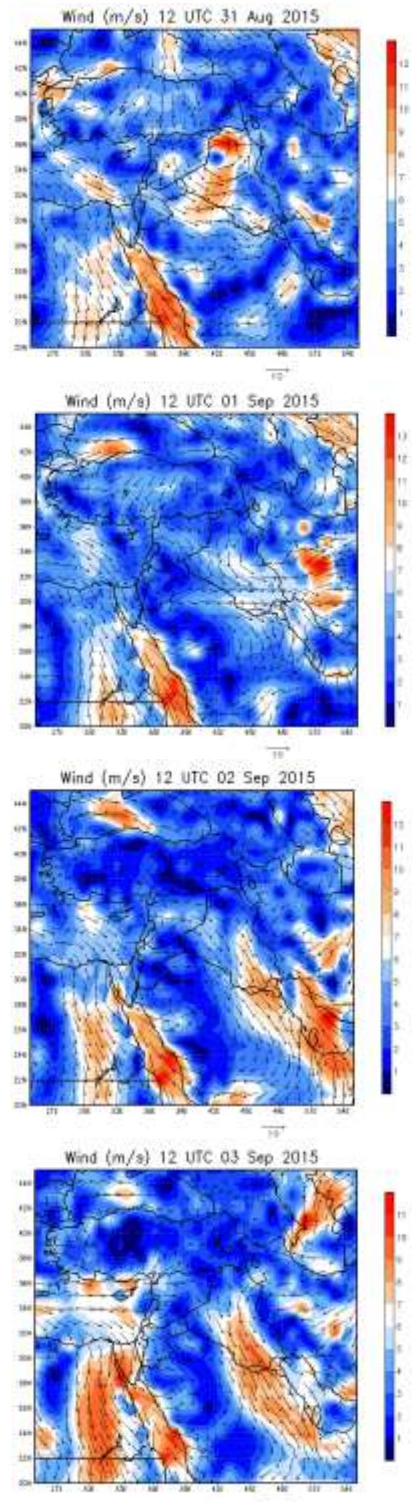

Fig. 4: Surface wind arrows composed on wind speed maps at 12 UTC August 31 to September 3, 2015.

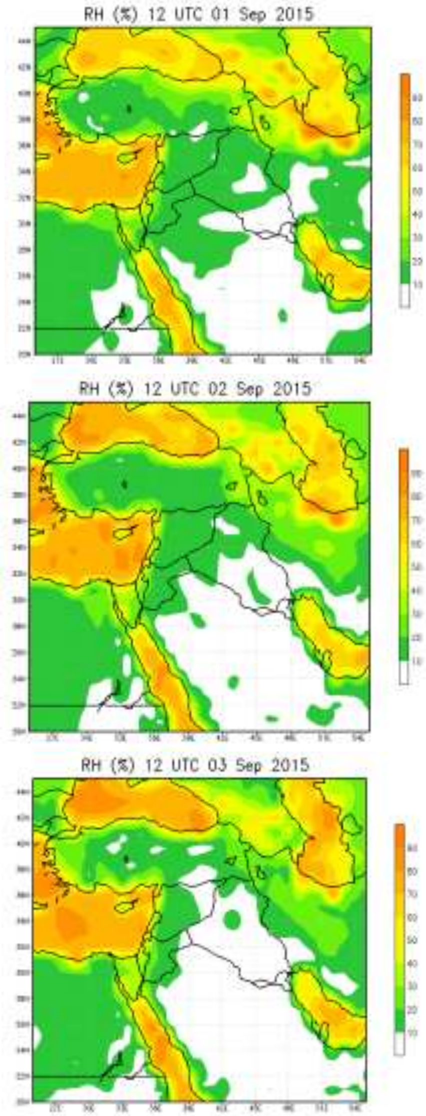

Fig. 5: Relative humidity at 12 UTC August 31 to September 3, 2015.

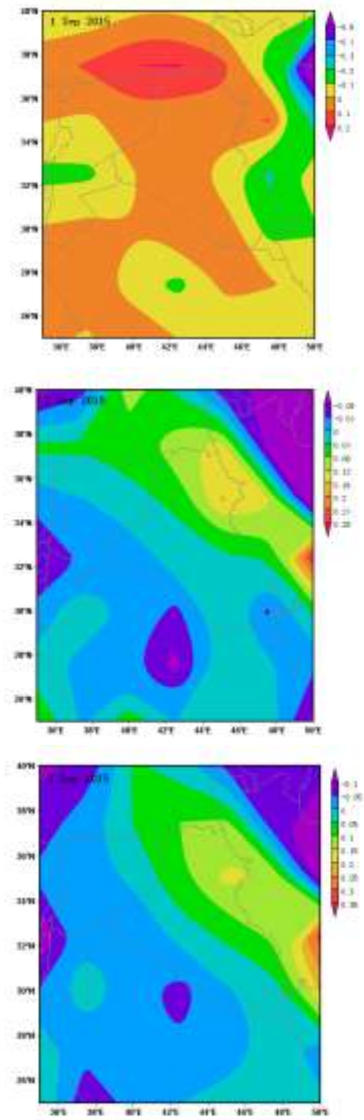

Fig. 6: Pressure vertical velocity (pa/s) at 12 UTC August 31 to September 3, 2015.

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Analysis of Early September 2015 Dust Strom over Iraq

تأثير العواصف الغبارية على تغير المناخ
تحليل العاصفة الغبارية الغبارية على العراق فى اوائل سبتمبر 2015

مروة خليل ابراهيم
قسم علوم فيزياء الغلاف الجوي، كلية العلوم، جامعة المستنصرية
بغداد، العراق

المستخلص

العواصف الغبارية والاتربة المعلقة تمثل أحدى المشاكل البيئية الهامة فى جنوب غرب أسيا وتمثل مخاطر طبيعية فى منطقة الشرق الاوسط. تحدث العواصف الغبارية الكبرى على منطقة الشرق الأوسط خلال شهرى اذار ونيسان كل ربيع والصيف وتتسبب في آثار مدمرة في بعض البلدان مثل العراق والمملكة العربية السعودية وإيران. وقد وجد ان سهل دجلة والفرات هو المصدر الرئيسى للغبار في هذا المنطقة. و في أوائل سبتمبر (ايلول) 2015، تحركت العاصفة الترابية عبر العراق نحو الخليج العربي.

الهدف من هذه الدراسة هو تحليل اسباب وتأثير هذه العاصفة بأستخدام صور الأقمار الصناعية موديس، وبيانات الأرصاد الجوية ذات الصلة والتى تساهم فى تشكيل وديناميكية هذه العواصف الغبارية . وقد امكن من خلال تحليل هذه الصور والخرائط وبيانات الارصاد للضغط ومستوى سطح البحر، والرطوبة النسبية وسرعة الرياح لمدة أربعة أيام، بدءا من اليوم الذي بدأت فيه العاصفة، بالقرب من الحدود العراقية السورية حتى وصلت إلى مضيق هرمز فى الخليج العربي. في 31 آب، تم الكشف عن العاصفة بواسطة (MODIS) على القمر الصناعي تيرا التابع لناسا. ومن الدراسة تم استنتاج اسباب هذه العاصفة والتى نشأت بفعل تاثير رياح الهبوب (haboobs) وتأثير رياح الشمال.