Synoptic Analysis of 3-5 July 2009 Severe Dust Storm in Iraq

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Abstract- Dust storms are a common atmospheric phenomenon in Iraq especially during spring and summer months. Their frequency of occurrence has increased drastically in the last decade and it is increasing continuously due to many factors including urbanization in areas previously devoted to agriculture, drought, military operations that remove sandy pavements that would otherwise cap dust, and upstream dams on the Tigris and Euphrates Rivers that reduce the water available to Iraq. The aim of this work is to analyze the synoptic situation of a massive dust storm occurred on the first week of July 2009 and covered most of Iraq. TOMS aerosols index and weather maps for three days from 3rd of July to 5th were used for this purpose. Results indicated that the storm was typically caused by Shamal wind. Results also showed patterns of upward surface vertical velocity, downward 850 hPa level vertical velocity, and northwesterly horizontal wind on both pressure levels. The horizontal wind was strongest on 3rd of July and was weakening and shifting eastwards on the following days. It is believed that such patterns may have caused the severity and persistence of the storm.

Index Terms- Dust storm, MODIS, TOMS AI, Synoptic

I. INTRODUCTION

Dust phenomenon is an important natural disaster that has been highly considered by many researchers to study their sources, movement direction, and consequences of its expansion as well as its control. Environmental impacts of dust storms, reported in the literature include reduced soil fertility and damage to crops, a reduction of solar radiation and in consequence the efficiency of solar devices, damage to telecommunications and mechanical systems, dirt, air pollution, increase of respiratory diseases and so on [1]. 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. Since 2003 dust storms in Iraq and surrounded countries were of major concern by research community. Kutiel and Furman [2] studied the spatial and temporal characteristics of dust storms in the Middle East by an analysis of the visibility reduction in that region. Anderson [3] has analyzed the impact of 25-27 March 2003 dust storm on military operation. Bartlett [4] used an imperial analysis to forecast dust storms for Al Udeid air base in Qatar. He concluded that seasonal patterns and dust storm type offers operators within the region a quick synopsis of possible dust prone periods and duration of events. Khalid [5] used TOMS AI data to determine the origin of dust storm sources in Iraq. Maghrabi [6] investigated the impact of dust storm on meteorological parameters in central Saudi Arabia. Al-Dabbas et al., [7] studied eight dust storms that occurred between December 2008 and March 2009 to determine the dust load of these storms. Al-Jumaily and Ibrahim [8] analyzed several dust storms in Iraq. They concluded that The most important reason of the occurrence of dust storms in Iraq is the passage of a low-pressure system over Iran they carry cool air from that region towards warmer region or warmer air of areas like eastern Syria and Iraq. Hamidi et al., [9] analyzed synoptic situation of dust storms in the Middle East. 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. Dehghanpour et al., [10] 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 [11] 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.

II. MATERAILS AND METHOD

In this work satellite images of dust storms were used to determine the source and location of storm. These images were captured by the Moderate Resolution Imaging Spectroradiometer (MODIS) on board Aqua and Terra satellites which are operated by the National Aeronautics and Space Administration (NASA). The Total Ozone Mapping Spectrophotometer (TOMS) aerosol measurements were employed for evaluating the strength of storm. These measurements are available in terms of the aerosol index. The Aerosol Index (AI) is defined as the difference between the observations and model calculations from a pure molecular atmosphere with the same surface reflectivity and measurement conditions. Sea level pressure, surface wind, 850 hPa vertical wind and horizontal wind were obtained from the European Center for Medium Range Weather Forecast (ECMWF) for the days of storms. The surface vertical wind

maps were obtained from the National Center for Environmental Predication (NCEP). AI and meteorological data were plotted for the same areas over which the dust storm were blowing in order to determine the synoptic patterns associated with them during the three days period.

III. RESULTS AND DISCUSSION

Severe dust storm swept Iraq on the period 3-5 July 2009 and moved into Iran. Figure 1 shows the images captured by the (MODIS) on NASA's Terra and Aqua satellites. The image of 3 July 2009 (Figure 1a) shows that the storm was blown from northwestern region of Iraq, near the borders with Syria. This area is believed to be the one of the major sources of dust storms in Iraq. The dust takes on a strangely textured appearance: a combination of small bumps and curving waves. By the time MODIS acquired this image, the dust storm had persisted over Iraq for several days. On the next day, the dust storm spread toward the east and southeast, over Iran and the Gulf (Figure 1b). Over much of Iraq, including Baghdad, the dust is thick enough to completely obscure the view of the land surface below. To the east and southeast, the dust is thin enough to show shadowy land and ocean surfaces beneath, although dust is very thick along the southern coast of Iran. On 5 July 2009, MODIS image (Figure 1c) indicates that in some places the dust was only a veil, and the landscape below is recognizable. Parts of the Tigris and Euphrates Rivers are visible. In other places, however, the dust is a thick blanket, completely blocking the ground from view. The city of Baghdad was hidden.

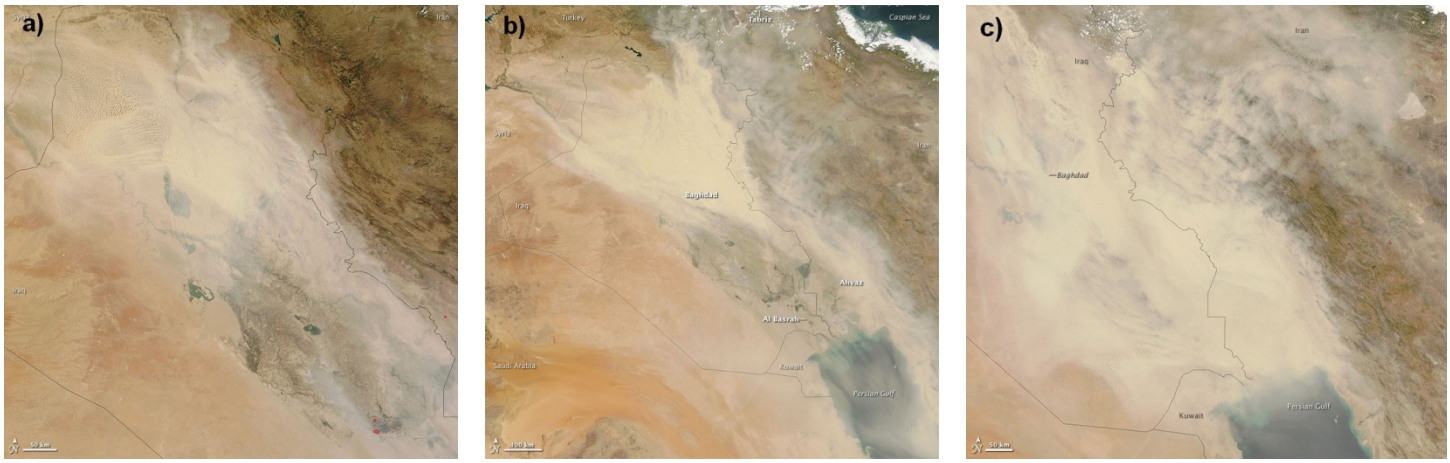

Figure 1: MODIS images for a) 3 July, b) 4 July, and c) 5 July 2009 dust storm..

Figure 2 gives the TOMS AI for the three days. 3 July 2009 shows an interesting pattern of concentric circles with values of AI reaching more than 5.5 the center of the storm, which was located just over the northwestern region of Iraq. On the following day, the AI data indicates that the center of the storm slightly moved eastward and thick dust extended to cover most of Iraq (AI greater than 3). On 5 July 2009, the AI data illustrates that the storm was still covering all Iraq but its thickset part was covering the southeastern region and parts of southwestern regions of Iran.

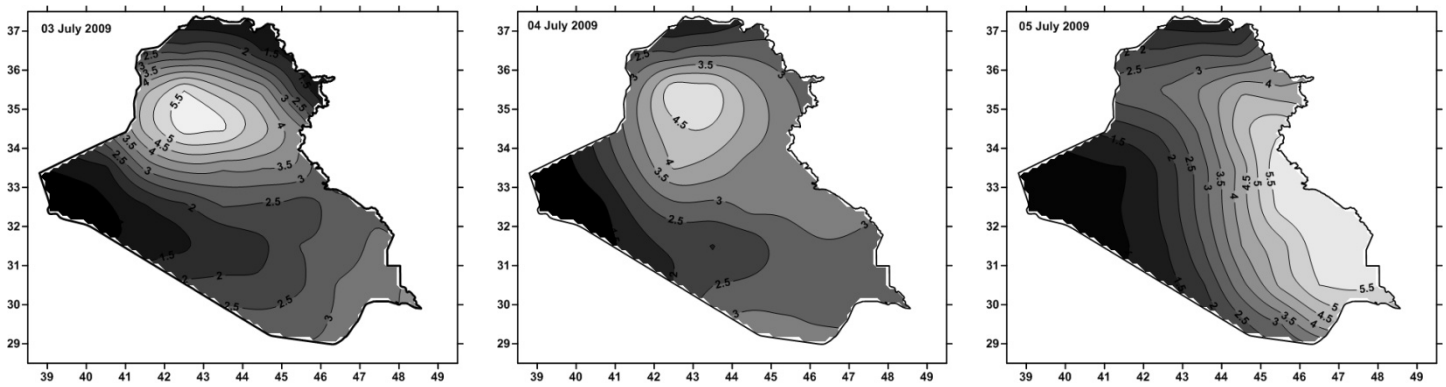

Figure 2: TOMS AI for 3-5 July, 2009 dust storm.

Figure 3 shows the synoptic daily maps of mean sea level pressure (shaded) and surface wind (arrows) for the three days of the storm. It is seen that the area was dominated by a low-pressure system. The center of this low pressure system extended form the Gulf to north of Iraq. Dynamically, low-pressure system is produced by counterclockwise spin in the northern hemisphere. As a results the surface wind was northwesterly. On 3 July, the wind was relatively stronger than its value on the following days, which caused the lift of dust form the source area. On the following days the wind becomes slower with a shift towards east. This situation may have caused the persistence of dust over Iraq for three consecutive days. This synoptic situation of a typical situation for the Shamal wind. Shamal wind is a northwesterly wind blowing over Iraq, Saudi Arabia and Kuwait. This weather effect occurs anywhere from once to several times a year, mostly in summer but sometimes in winter. The resulting wind typically creates large sandstorms that impact these countries. The surface vertical velocity maps, shown in Figure 4, indicates that the area was dominated by negative values of vertical velocity. Negative vertical velocity is produced by ascending motion of air. Figure 5 gives the 850 hPa maps of the vertical wind (shaded) and horizontal wind (arrows). It is clear that on the 850 hPa level (which is about 1.5 km above the ground), the vertical wind was positive (downward motion) over the area of the dust storm. On 3 July the vertical wind map shows two regions of relatively high values and one of these areas is just above the core of the dust storm. The horizontal wind was strong westerly on 3 July and became weaker on 4 July and on July 5 it was shifted eastward.

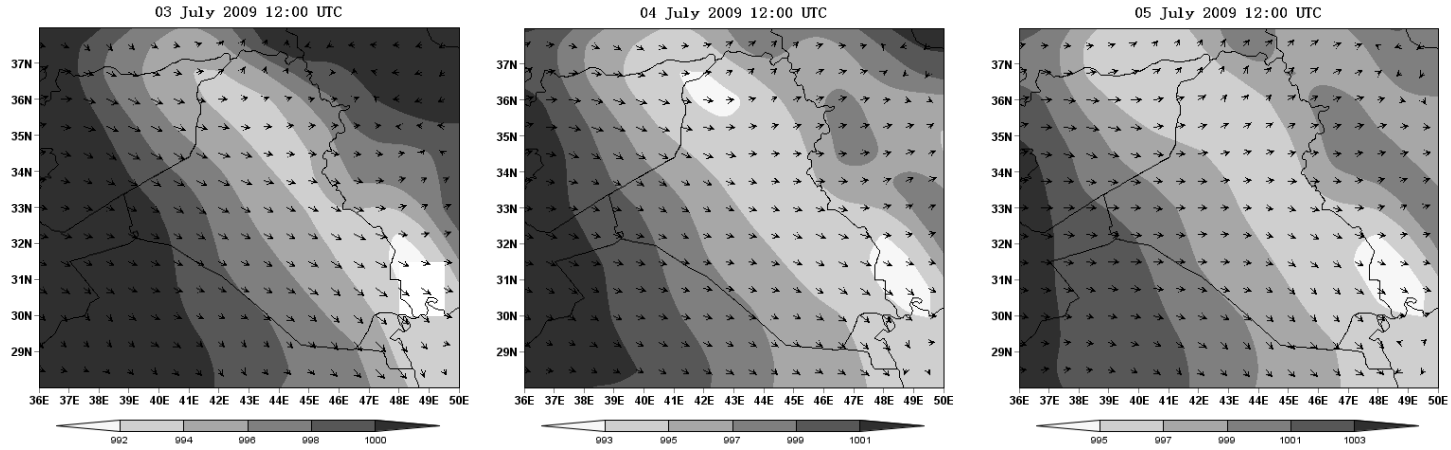

Figure 3: Surface level pressure (shaded) and surface wind (arrows) for 3-5 July 2009.

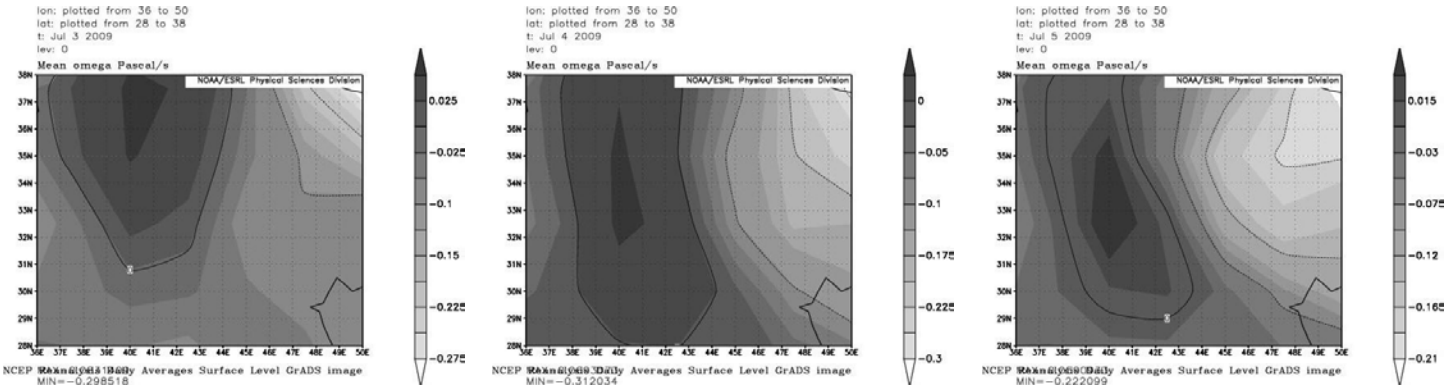

Figure 4: Surface vertical wind for 3-5 July 2009.

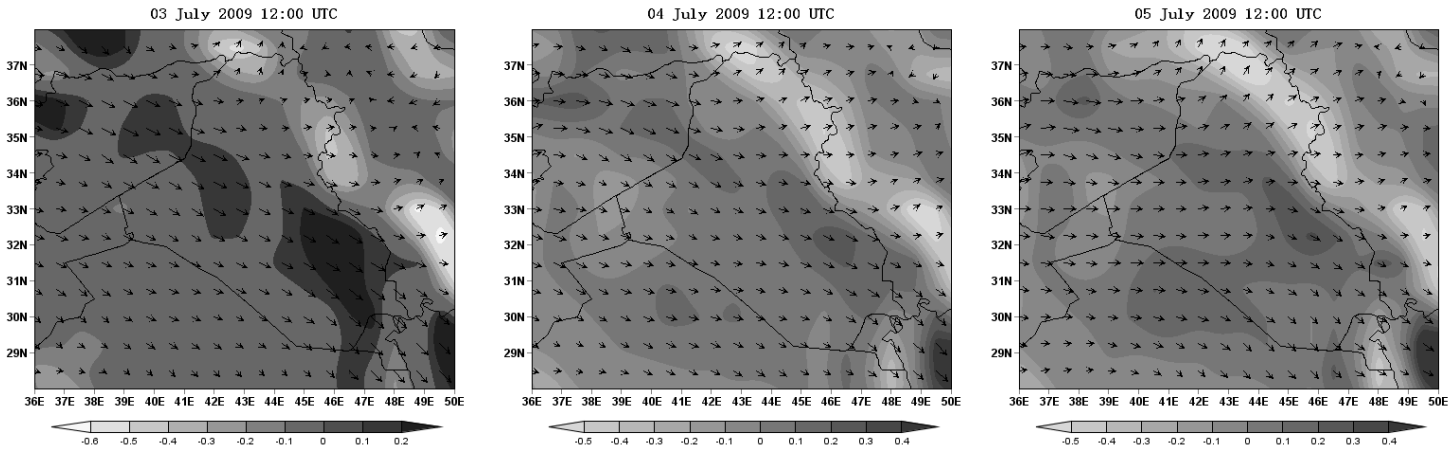

Figure 5: 850 hPa level vertical wind pressure (shaded) and horizontal wind (arrows) for 3-5 July 2009.

IV. CONCLUSION

The dust storm which has raged through Iraq in the first week of July 2009 was considered to be the worst in living memory. Analysis of surface weather maps indicated that this storm was initiated by Shamal. Although Shamals have long occurred in this region and caused frequent dust storm, other factors may have contributed to a severity and life time of such storm. Analysis of synoptic patterns suggested that upward motion at the surface, downward motion at 850 hPa and weakening northwesterly surface wind may have caused the storm to be sever and covered most of Iraq for three consecutive days.

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