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Identification of Dust Sources in Iraq Using Meteorological Surface Data and Satellite Data

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Abstract: The research included employment of the meteorological surface data such as surface pressure and wind speed and direction to determine the sources of dust in Iraq through the study and analysis of dust phenomena that strike Iraq in 2011 and at different times of the year. The results showed that Iraq was suffering to No. (18) dust storms in 2011. The highest wind speed recorded at the beginning of the composition of most the dust storms ranged of 6-10 m/s and the lowest wind speed values ranged of 10-14 m/s, while the direction of the wind in No. (14) dust storms were flowed from NW (northwest), only No. (4) dust storms were flowed from southwest SW (southwest), due to the fact that the prevailing wind in Iraq is NW in most days of the year. Atmospheric pressure values recorded for the day of dust storms are ranged of 960-990 millibar, due to the existence Iraq under high pressure system most days of the year. Satellite data of Meteosat 9 are used to determine the sources of dust over Iraq. Used the Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations CALIPSO data to determine the vertical section of the dust, during a dust storm.

Key words: Air pollution, dust, meteorological surface data, satellite data.

1. Introduction

Dust is one of the main features are associated with the climate of the regions, the arid and semi-arid that characterized by the presence of climatic fluctuations cause spiraling of dust, sand and carry them long distances, creating what is called the phenomenon of dust. Dust phenomenon became the important things in the climate of Iraq due to the large frequency and impact it large in the weather, the environment and human health as a result of the drought caused by the lack of rain, which leads to the disintegration of the soil, and thus ease of dust phenomena with a suitable wind speed, in addition to the lack of vegetation [1]. The dust phenomenon means height sand particles from the surface of the earth and spread in the air, causing a decline in the extent of vision. The dust consists generally of three types of particles are sand, silt and clay and it vary in their physical and chemical. The relative density of sand particles is about 2.65 g/cm^3 and mostly consists of granular silica and quartz. The relative density of the clay and silt are about 2.8 g/cm^3 and mostly consists of calcium carbonate. The dust storm is composed of small granules size does not exceed the diameters 100 μm arise with strong wind speed about 8 m/sec or more, and be loaded with dust transported from the soil surface loose in dry areas, where the wind is work to lift the dust to high altitudes and reduce the horizontal vision to less than 1 km and the dust storm front is forward as the high dusty wall reach about 3 km, and tens of kilometers widely [2].

The dust storms are generated results of the turbulence that gets near the earth's surface, which leads to a variation in the measurements of

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atmospheric pressure and temperature, which leads to the generation of up drought air currents bearing dust particles to high altitudes are proportional with the severity of the wind speed, the dryness and the disintegration of the soil surface. Many studies have shown that dust storms impacts significant in all aspects of human life and activities. Mamouri [3] study dust storms in central and southern Iraq, where the region is suffer of large changes due to frequency of the dust storms in all months of the year, although more days in which they occurs are in the spring and summer. The results showed that dust storms have a strong correlation of the wind about 25 km/h. Kutiel [4] discussed the sources of dust in the Middle East that the region was the second place in terms of the vulnerability of dust storms in the world after Sahara in north Africa. The deserts are contributing about 40%-66% of the total dust and dust particles can be passed around 4,000 km away from the source. The observing of dust storms by satellite images depends on the characteristics of the type of sensor and the satellite which holds it. There are many satellites that can be used in the follow-up to configure and track dust storms like the NOAA (national oceanic and atmospheric administration) and the sensor MODIS (moderate imaging spectroradiometer) that is laptop on aqua and terra. MODIS record data as product true color image (true color RGB product) which shows clouds white and color storm painted earthy [5]. The aim of the study:

(1) Use of meteorological surface data such as surface pressure, wind speed and direction through the study, and then analysis some dust storms that stroked Iraq in 2011;

(2) Identify the sources of dust storms in Iraq through the use of satellites Meteosat 9 and CALIPSO data (Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations).

2. Study Area

Iraq is located in the southwestern part of the Asian continent and extends between latitudes 29.5°-37.22° north of the equator and between longitudes 38.45°-48.45°. The site of Iraq in the northern part of the subtropical zone shows that the northwest winds is the most controls of for long periods of the year. The near of Iraq from the tropic of Cancer is reflected on the length of the summer season, which is the longest season in Iraq. The summer season is more imposing their characteristics of climate then the other seasons (spring and autumn) and even Winter, which is a moderate season in the middle section and the southern part of Iraq, which allowed the long draught period where the soil is depleted their moisture, then became dry and the atoms are transported with winds [6]. The most important characteristic of Iraq climate is the large extremism in temperature between day and night, winter and summer. The great disparity is expressed by the extremism climate, which is considering general characteristic for continental climates. The other characteristics of Iraq climate is a drought caused by the lack of rainfall and limited mainly to Winter season and little in the Autumn and Spring, to a lesser extent, the more drought rise in the value of evaporation because of the quantity of high solar radiation falling on the surface especially during the summer season [7].

3. Materials and Methods

The Meteosat 9 is one of the geostationary satellites that takes an image in every hour, also can be detect dust storms specifically using the product dust, which results from the collection of three thermal channels to generate a visual image of the primary colors (red, green and blue). This product allows us to control dust storms in the day and night. The areas that is covered by dust storms in Meteosat 9 seems purple (pink color), while clouds seems bold red color. Iraq shows in the images within the Middle East and East Africa region and it can through these images view areas that formation of dust storms, observation of their track and the affected regions by these storms [8]. The

CALIPSO is one of the polar-orbiting satellites (orbit from pole to pole) and the development by the NASA (National Aeronautical and Space Administration), which is designed to give excellent information on particulate matter (aerosol) in the atmosphere. CALIPSO has the sensor CALIOP (Cloud-Aerosol Lidar With Orthogonal Polarization), which uses wavelengths (532.1064 nm) to measure the properties of scattered light from the particulate matter particularly using a system (Lidar), the system is very effective in the detection of aerosol in the atmosphere, droplets clouds and ice crystals. The work of CALIPSO is send pulses of laser with short wavelengths that penetrates the atmosphere down to the surface of the earth and reflect to it again, where the satellite collect information on the aerosol distribution in the atmosphere. CALIPSO is one of the important tools for monitoring and interpretation of the aerosol effects and clouds in the climate system [9]. The meteorological variables such as pressure surface and the speed and direction of the wind are of the important factors in the formation of dust storms, which provided by the National Center for Environmental Prediction of the US (NASA). Later, these data are reanalysis and compare with Meteosat and CALIPSO satellite images to identify the sources of dust storms in Iraq.

4. Results and Discussion

The results showed in Table 1 that Iraq suffered to No. (18) dust storms in 2011 that beginning in March, and ending in December.

Fig. 1a shows that the highest number of dust storms recorded was five storms in the month of June. The high temperatures in summer (especially in the months of June and July) tend to diurnal differences in wind speed (between the morning and afternoon) has its highest in afternoon, which causing generation of up drought air currents rising to the highest, due to heating the earth surface and carrier with it dust and sand atoms due to dry soil and lack of vegetation, leading to an unstable air and then form of the dust storm.

The results in Fig. 1b show that the highest wind speed that recorded in the beginning of the formation of most of the dust storms over Iraq in 2011 ranged between 6-10 m/sec and the lowest wind speed values ranged between 10-14 m/sec. Which was the wind direction in No. (14) dust storms from the NW (north-west) and only (4) dust storms from the SW (south-west) due to the fact that the prevailing winds

Table 1 Meteorological surface data and dates of dust storms in 2011 over Iraq.

No.	Date	Wind speed (m/sec)	Wind direction	Surface pressure (mb)
1	03/03/2011	9	NW	N
2	03/25/2011	11	NW	980
3	04/03/2011	9	SW	980
4	04/04/2011	8	SW	980
5	04/12/2011	14	NW	960
6	05/04/2011	5	NW	980
7	06/03/2011	8	NW	980
8	06/08/2011	9	NW	960
9	06/09/2011	10	SW	960
10	06/17/2011	8	NW	980
11	06/30/2011	9	NW	980
12	07/16/2011	9	NW	980
13	07/27/2011	8	NW	960
14	08/18/2011	9	NW	980
15	10/13/2011	7	NW	960
16	10/19/2011	8	NW	960
17	11/04/2011	5	SW	990
18	10/12/2011	9	NW	960

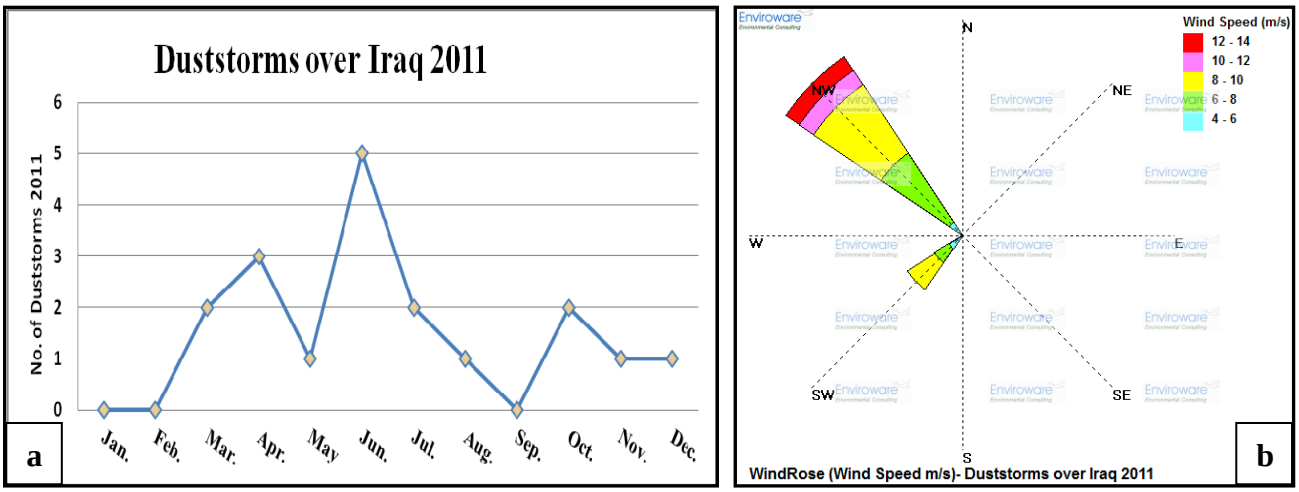

Fig. 1 (a) Number of dust storms over Iraq in 2011; (b) wind rose (wind speed (m/s))—dust storms over Iraq in 2011.

in Iraq is the northwestern in most days of the year. The values of atmospheric pressure that recorded for the days of dust storms study ranged between 960-990 mb, see Table 1, due to the existence Iraq under the high pressure system in most days of the year, leading to a scarcity of rain, dry soil surface and the breakdown of the ease of erosion by wind. The existence Iraq under effects of two pressure systems, the first is the Mediterranean system during the summer, that carrying dust particles comes from the western region depending on the movement of northwestern prevailing wind; The second is Sudanian low pressure system, which carries dust particles from the area of the Arabian Peninsula., due to the movement of air from high pressure to low, more dust storms suffered by Iraq in 2011, which was from the north-west trend prevailing most of year. CALIPSO image captured in 6-17-2011, Fig. 2a indicate to the existence almost of Iraq under the influence a severe dust storm that covered it to a height about 3 km, shown in Fig. 1a, the black circle in this figure is represents location of Iraq by latitude and longitude during the course of CALIPSO scans the area beneath it vertically from north to south (Fig. 1(b)).

The yellow color in Fig. 1b represents the dust which was distinguish by CALIPSO as interpreted by the colors gradating in the right side of the figure, No. (2) and is interpreted 2-dust as key in the lower part of the figure. CALIPSO image that captured in (August 18, 2011), Fig. 2b shows to existence the of some parts of Iraq (elliptical black circle) under the influence of dust storm that reached to height about 2-3 km and the existence of the Arabian Peninsula in southern Iraq under the influence of the same dust storm, due to the Arabian Peninsula desert which feed the dust storm with large amounts of dust and sand.

In Fig. 3, there are No. (8) sources of dust storms recorded in 2011 over Iraq of sum No. (18) dust storms struck across Iraq. The source of dust in Fig. 3 was identified by black circle that represents the beginning of a dust storm formation. The dust appears in these images with pink color if dust lightly as in a storm (09 UTC 13-10-2011), which started from 9 UTC [12 (noon) in Baghdad time]. The most violent dust storms recorded by Meteosat-9 blew from the direction north-west (the direction of the prevailing winds), especially from Aljazeera area (located between the city of Mosul, north of the Euphrates River in Anbar province, leading to the Syrian border), which is one of the main sources of dust in Iraq (storm in 06 UTC 04/04/2011). Fig. 3 shows that there are sources of dust in southern Iraq between the Tigris and Euphrates rivers and the southern desert (storm in 08 UTC 06/17/2011). Also there are more than one source of dust per storm in different places in Iraq, due to the presence of the same reasons of dust storms

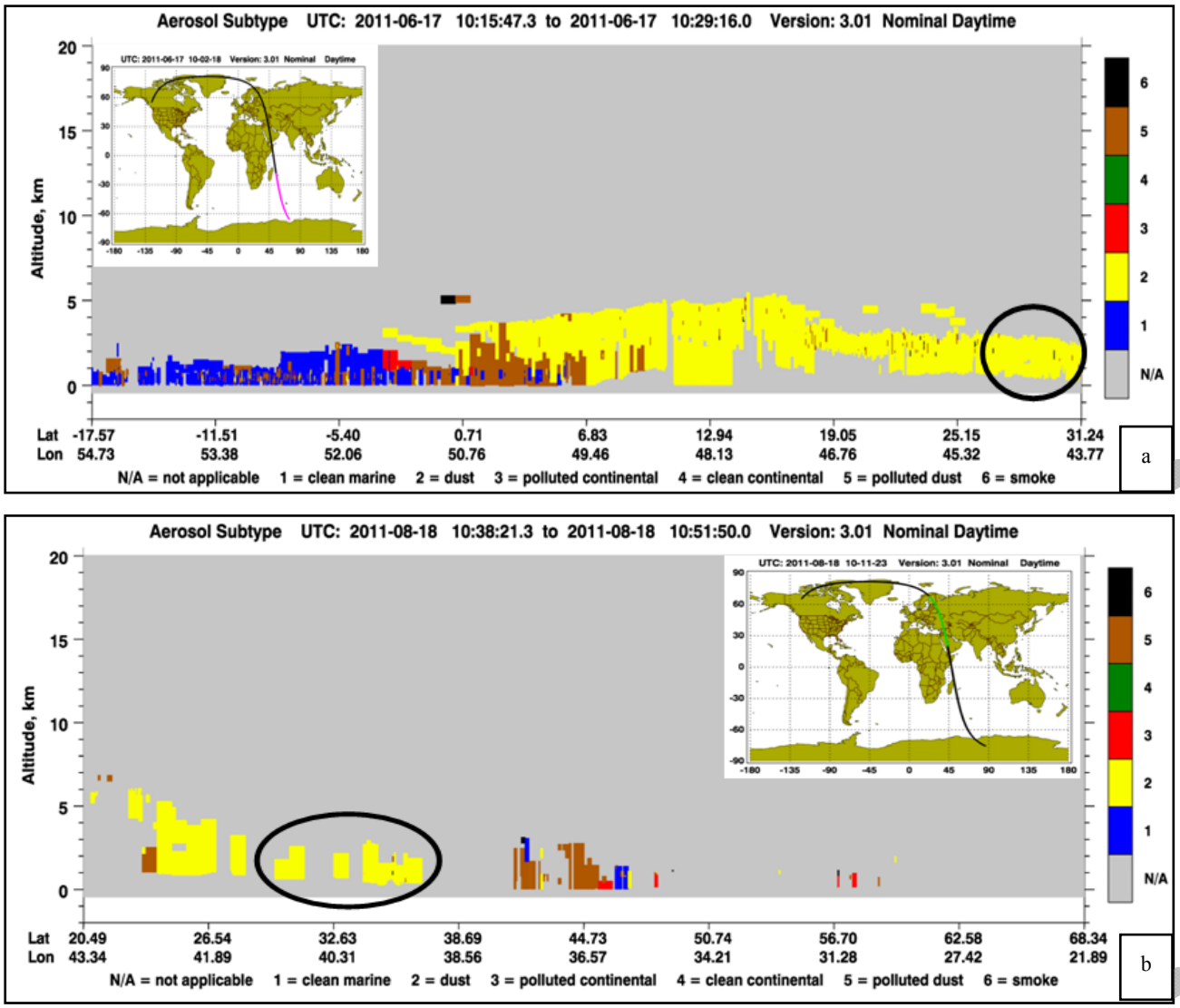

Fig. 2 (a) CALIPSO image captured in (June 17, 2011); (b) CALIPSO image captured in (August 18, 2011).

formation such as disintegration of the soil surface and the presence of suitable wind speed (storm in 09 UTC 04/12/2011). Also the images showed that presence of a source of the dust storm in the northeast in Iraq (storm in 21 UTC 12-10-2011), this is mountainous region that rarely consist dust storm, but because of the scarcity of rainfall for the years past (before 2011), lead to gradually formed a barren area and soils disjointed with a very suitable wind speed (9 m/sec), then led to the formation of a dust storm extended to large areas of central and southern Iraq, parallel to the Iraqi-Iran border, as shown in Fig. 3.

5. Conclusions

(1) The results show that the most violent dust storms is strike Iraq flow from Aljazeera area, because it is a large barren area and which located in the direction of prevailing northwest winds. The results indicated the presence of a source of dust storms in northeastern Iraq, which is one of the rare cases due to the fact that the region is mountainous.

(2) The result indicate the presence is more than one of the source led to dust storm, because of the same reasons to formation of dust storms such as the soil surface disintegration and suitable wind speed in

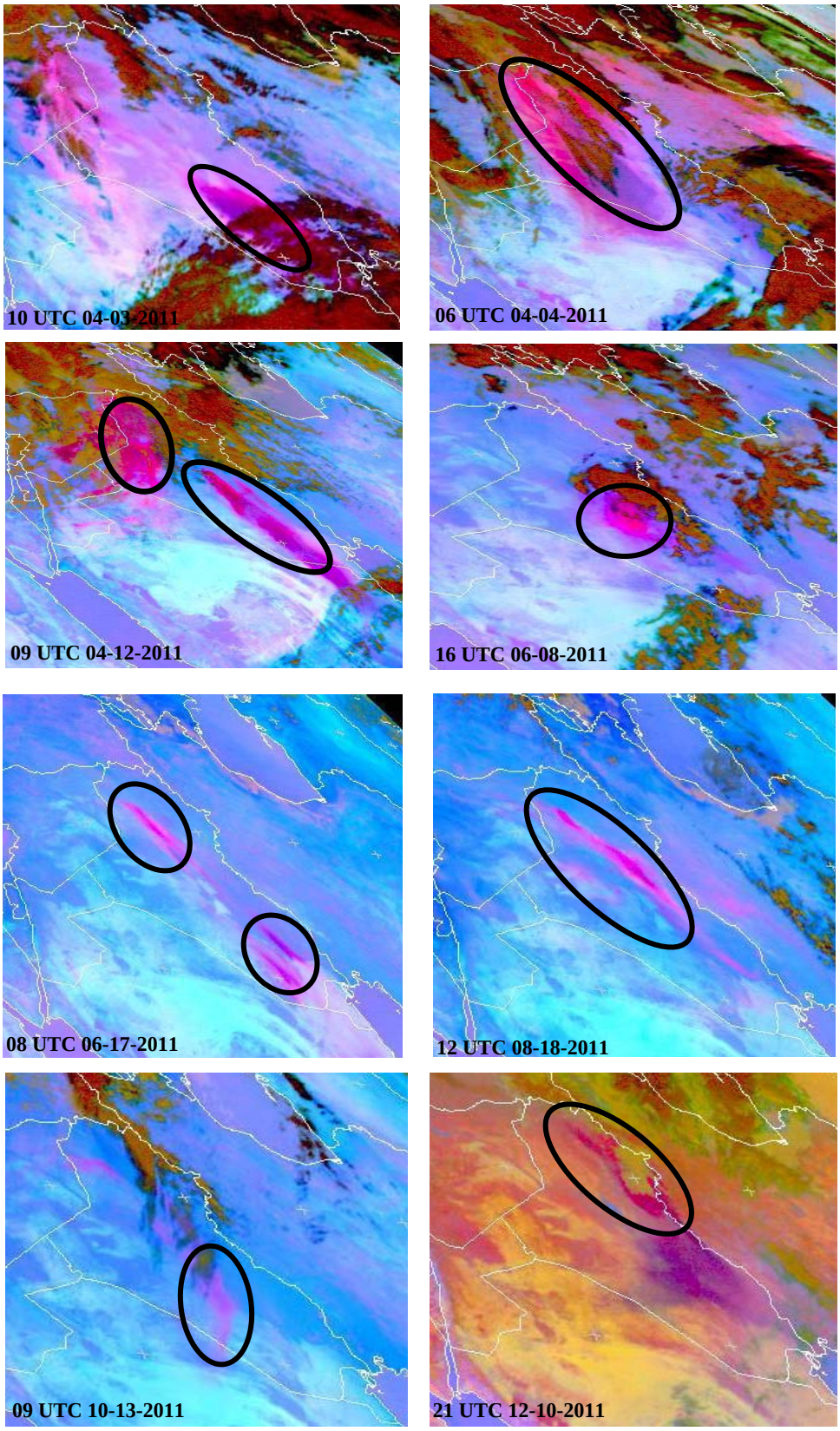

Fig. 3 Dust storm sources captured by Meteosat 9 in 2011 over Iraq.

different parts of Iraq;

(3) The results show the importance of wind speed and direction and surface air pressure in the formation and sustainability of dust storms;

(4) The results indicate the role of Meteosat-9 and CALIPSO in identifying sources of dust and track as well as the appointment of the vertical section of the dust in the atmosphere;

(5) Continues to follow up dust storms because they occur more frequently in recent years in Iraq and they impact on various aspects of life;

(6) Using the modern technologies such as Meteosat and CALIPSO due to availability and easy of information analysis from them and help us to determine the formation of dust storms and follow-up track.

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