Results of the 50 year ground-based measurements in comparison with satellite remote sensing of two prominent dust emission sources located in Iran

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ABSTRACT

Mineral dusts, as the most important type of aerosols, play an important role in climate forcing and terribly affect human health, living in the vicinity of large persistent emission sources; especially located in the arid or hyper arid regions of Middle Eastern countries like Iran. In this paper, we systematically examine the TOMS satellite absorbing aerosol product (AI) over a 25-year period (1979–2004) for the evidence of local persistent dust sources, and simultaneously evaluate the most related synoptical parameters to dust emission derived from data records of more than 150 synoptical weather stations located all around the country. We also study two local prominent emission sources based on recent evaluation results, the first one is Sistan basin which is located between Iran and Afghanistan at ~31°N,61.5°E and the second are border wetlands which are located between Iran and Iraq at 31°N, ~ 46.5°E. Evaluations include the 50 year ground-based measurements in comparison with satellite remote sensing results based on data from MODerate Resolution Imaging Spectrometer (MODIS) on the Aqua satellite. Compared to ground-based measurements, satellite imagery, due to their large spatial coverage and reliable repeated measurements, provide us another important tool to monitor mineral dusts and their prominent emission sources.

Keywords: Iran, aerosols, mineral dust, TOMS, MODIS, synoptical parameters

1. INTRODUCTION

There is increasing interest in the atmospheric transport of mineral dusts and monitoring their paths to find the associated hot spots where emitting large quantities of the particles into the atmosphere. Actually monitoring mineral dusts and anthropogenic aerosols (biomass burning smoke, industrial pollution) has gained renewed attention because they influence cloud properties, alter the radiation budget of the earth-atmosphere system, affect atmospheric circulation patterns and cause changes in surface temperature and precipitation (Kaufman et al., 2002).

While a lot of progress has been made in characterizing the importance of mineral dusts in global-scale processes, there has been less progress in identifying the main prominent sources of large-scale dusts, the environmental processes that affect dust generation in local scale, and the meteorological factors that affect the subsequent transport.

The results of many field programs have identified specific types of environments that seem to be sources of mineral dusts. Similarly, many studies have characterized dust generation on a micrometeorological scale. These have shown that dust mobilization is extremely sensitive to a wide range of factors, including the composition of the soils, their moisture content, the condition of the surface, and wind velocity (Gillette, 1981, 1999).

Besides the above, there are some other related synoptical parameters to the intensity of dust emission, such as temperature, number of dusty days and visibility below 2 kilometres, that can be used in local scale studies of mapping dust sources.

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Although point measurements are generally well calibrated, and have tremendous potential for examining aerosol-related climate issues, they are limited in space, and are inadequate to provide material for study large spatial scales, especially when the pollution comes from sources outside the country like border sites.

Remote sensing is another useful method in above situations for monitoring dust propagation in the atmosphere. Total Ozone Mapping Spectrometer (TOMS) yielded data that can be used to map the distribution of absorbing aerosols which are largely comprised of black carbon, emitted primarily from biomass burning regions, and mineral dust, most commonly emitted from sources in arid regions but also from occasional volcanic eruptions (Herman et al., 1997; Torres et al., 1998).

Because TOMS measurements are made in the ultraviolet (UV) spectrum and the UV albedo of continental surfaces is low and relatively invariant, TOMS can readily detect absorbing aerosols over land surfaces as well as water. With TOMS one can clearly observe the occurrence of large dust events over the continents and subsequently follow the movement of large-scale plumes over the oceans (Herman et al., 1997).

The MODerate Resolution Imaging Spectrometer (MODIS) instrument is another useful sensor designed to fly on the Earth Orbiting System (EOS) AM and PM platforms, with a daily global coverage. It is dedicated to perform measurements in the solar to thermal infrared spectrum region from 0.415 to 14.235 mm (Salomon son et al., 1989). The spectral domain of interest is covered by three of the four focal planes, the visible (VIS from 0.412 to 0.551 mm), the near infrared (NIR from 0.650 to 0.940 mm), and the short-wavelength/medium wavelength infrared (SWIR/MWIR from 1.240 to 4.565 mm). The spectral stability is expected to be better than 2 nm and the instantaneous field of view varies between 250 and 500 m (Kaufman and Tanré, 1998).

A valuable data sets from the MODIS (on the Aqua satellite) provide an unprecedented opportunity to monitor aerosol events and examine the role of aerosols in the earth atmosphere system. One of the important and common aerosol parameter retrieved from satellite sensors like MODIS, is Aerosol Optical Thickness (AOT) that is the degree to which aerosols prevent the transmission of light. The aerosol optical depth or optical thickness (τ) is defined as the integrated extinction coefficient over a vertical column of unit cross section. Extinction coefficient is the fractional depletion of radiance per unit path length (also called attenuation especially in reference to radar frequencies).Aerosol Angstrom Exponent (AAE) based on 0.47 and 0.67 μm aerosol optical thickness (over land) is another approximate measure of aerosol particle size that can be estimated from aerosol optical depths measured at two different wavelengths. Besides Aerosol Angstrom Exponent, higher quantities of aerosol Mass Concentration (MC) also be used as a reliable approximation to identify dust emission sources.

In a general way based on the aerosol measurements from satellite products in comparison with ground based measurements from climatic and synoptic weather stations near the study areas, and general knowledge of these regions (land use, agricultural practices, etc) we can have reliable judgments about land-atmosphere interface processes like dust emission and propagation.

In this paper, we systematically examine the TOMS satellite absorbing aerosol product (AI) over a 25-year period (1979–2004) for evidence of local persistent dust sources and simultaneously evaluate the most related synoptical parameters to dust emission, such as temperature, wind velocity, number of dusty days and visibility derived from data records of more than 150 synoptical weather stations located all around the country.Also, we explore the potential of using the MODIS AOT,AAE and MC products over a 3-year period (2002-2004) to find approximate location of prominent dust emission sources in Iran-Iraq border wetlands.

Local identification of major sources will enable us to focus on critical regions and to characterize emission rates in response to environmental conditions. With such knowledge we will be better able to improve global dust models and to assess the effects of climate change on emissions in the future.

2. CHARACTERIZATION OF THE STUDY AREA

The largest and most persistent sources are located in the Northern Hemisphere, mainly in a broad “dust belt” that extends from the west coast of North Africa, over the Middle East, Central and South Asia, to China. There is remarkably little large-scale dust activity outside this region (Prospero et al., 2002).Dust sources, regardless of size or strength, can usually be associated with topographical lows located in arid regions with annual rainfall under 200–250 mm.

Iran is one of the countries which is located in the arid to semiarid region, with annual rainfall between 224–275 mm and has remarkable dust emission sources which are one of the most prominent ones in the dust belt shown in Figure 1.

Although the source regions themselves are arid or hyper arid, the action of water is evident from the presence of ephemeral streams, rivers, lakes, and playas. Most major sources have been intermittently flooded as evidenced by deep alluvial deposits. Historical records of dust storms in Iran show that during the past decade dust storms have increased in intensity especially in the south eastern part of the country. Population growth and a need for more food, increase to land use changes and decrease soil productivity which leads farm lands being more abandoned. Besides these activities, natural desertification processes and climate changes increase dust sources.

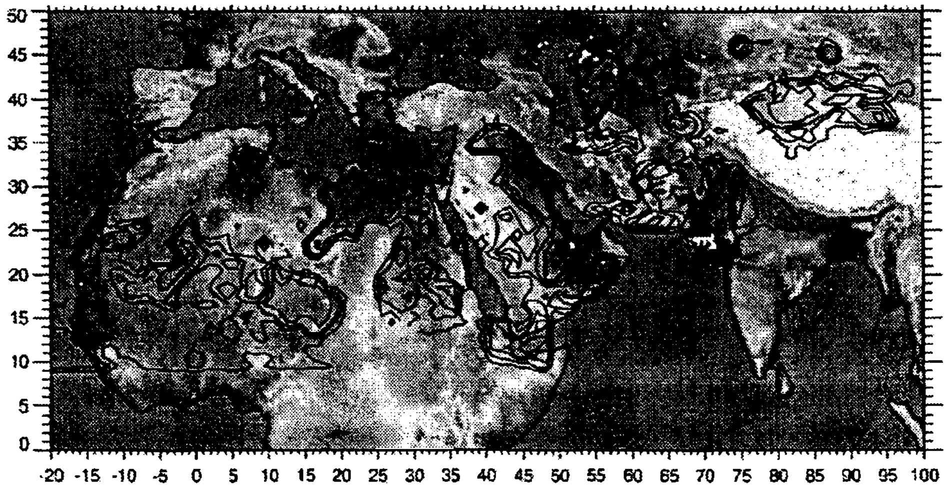


Fig. 1. Dust sources in the global dust belt and their association with topographic relief (Prospero et al., 2002).

3. SYNOPTICAL DATA AND ANALYSES METHODS

To have a general evaluation about the whole country, we systematically evaluate the most related synoptical parameters to dust emission, such as temperature, wind velocity, number of dusty days and visibility below 2 kilometers, derived from data records of more than 150 synoptical weather stations located all around the country.

Synoptical analyses of the parameters should be performed based on climatic clustering of the synoptical stations which is shown in Figure 2 by different colors. For the assessment of spatial and regional trends of synoptical parameters, we applied two common trend detection methods, Mann-Kendall and Spearman's Rho tests, to the synoptical time series collected at the number of individual stations which has been active for at least the 15 year duration in data measuring, so climatic changes are properly considered in time series analyses.

The test results (such as trend direction and significance level) are then mapped and interpreted in terms of their spatial distribution. Mapped results for monthly number of dusty days and measured at 51 stations monthly days, with visibility below 2 kilometers measured at 60 stations in the country between 1951 and 2000 appear in Figure 2 as an example. The information depicted on the maps include, for each sampling site, an identifier, a trend direction, and the trend significance level. The site identifier is presented as a four-digit alphanumeric code. The trend detection is depicted by a triangle, pointing upward for an increasing trend and downward for a decreasing trend. A green solid circle is used to denote a site having no trend. The significance of the trend is illustrated by the colour of the triangle. Similarly, some other synoptical parameters were tested and mapped individually to have general spatial and regional assessments.

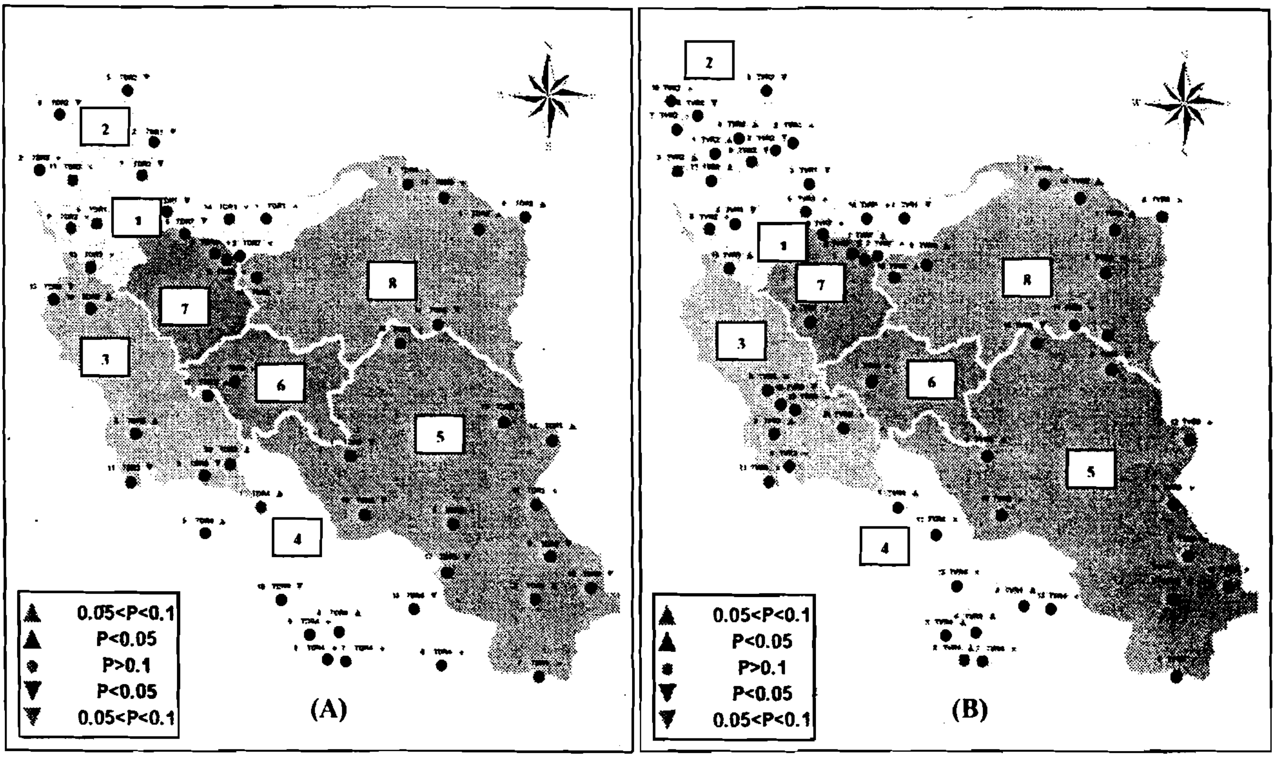


Fig. 2. (A). Monthly number of dusty days trend results based on Mann-Kendall test index. (B). Monthly days with visibility below 2 kilometers trend results based on Mann-Kendall test index. (The significance level is denoted by P).

4. COUNTRY SCALE REMOTE SENSING ANALYSES

We also systematically examined the TOMS absorbing aerosol product (AI) over a 25-year period (1979–2004) except the years 1994 and 1995, for evidence of persistent dust sources. The TOMS data show that on a global country scale the dominant sources of mineral dusts are mainly located in the natural borders between Iran and neighbouring countries like Iraq, Afghanistan and Pakistan. Besides the mentioned regions, there are some dust sources in the large intermountain basin south of the Alborz Mountains which are stretched to the central deserts consisting largely of salt flats. TOMS also shows that there are large seasonal changes in dust distribution patterns and that these patterns often display a characteristic geometry. Although these patterns may change seasonally, sometimes disappearing during some seasons, they appear year after year. A cursory examination of maps reveals that the geometry of the TOMS aerosol distributions over specific regions can often be associated with geomorphologic features, in particular, topographical lows in arid or semiarid regions.

Dust activity, is visible over much of the country for about half of the year. Activity is often low during the winter, grows strong in March–April, and increases to a maximum in May, June and July when much of the country is covered with dust. The dust maximum observed by TOMS matches the monthly occurrence of dust storms as reported by meteorological stations. We also identified and characterized major dust source regions on the basis of the appearance of persistent spatial-temporal patterns in the TOMS aerosol distribution.

There are two well defined active areas, most clearly seen all the year. One extends along the eastern side of the country and located at the tail end of a large closed inland basin, in one of the driest regions of the world, and a second are marshes straddling the west borders with Iraq. These two regions also stand out in both the TOMS AI and the monthly related synoptical parameters. This information coupled with a knowledge about local environments enables us to identify those characteristics that are important for dust generation.

5. IRAN MAIN DUST EMISSION SOURCES

Based on recent studies, one of the main dust source areas is located immediately to the south of the Caspian Sea in a large intermountain basin south of the Alborz Mountains; the source extends from Tehran (35.6_°N, 51.3_°E) eastward to ~ 60_°E. As Tehran is one of the most air polluted cities in the world with considerable aerosol production which are largely comprised of black carbon (i.e., soot), emitted primarily from biomass burning, making an objective distinction between aerosol derived from biomass burning and that from dust sources has some difficulties. Within the basin is the Dasht-e-Kavir desert (48,000 km2), which appears to consist largely of salt flats (Gill, 1996) and particularly centred over the western part of the basin (in the region close to Tehran) where there are many large drainage channels and a number of ephemeral lakes and marshes, including a large intermittent salt lake, Daryacheh-ye Namak (1807 km^2).

Another considerable dust activity can be seen along the coast of the Persian Gulf and the Arabian Sea of Iran and Pakistan, on the southern flanks of the mountain chain that parallels the coast. There is one particularly active source in a small intermountain valley centred at 27.5_°N, 59_°E. At the centre of this valley is a large salt/dry lake (Hamun-e-Jaz Murian, 1087 km2). The fact that so many of these sources in this region can be associated with salt/dry lakes suggests that the lakes themselves are important sources of dust. Many of the sources in the Iran-Afghanistan-Pakistan region contribute to the very high dust concentrations observed over the northern Arabian Sea (Tindale and Pease, 1999).

The two other prominent cluster of sources which were mentioned before shown in Figure 4, are the border ones with the former being the Sistan basin centred at ~31_°N, 61.5_°E, which is characterized by widespread ephemeral lakes and swamps, and makes the natural border between Iran and Afghanistan and will be discussed at the next part. The latter one are Al-Howizeh/Al-Azim marshes straddling the Iran-Iraq border.

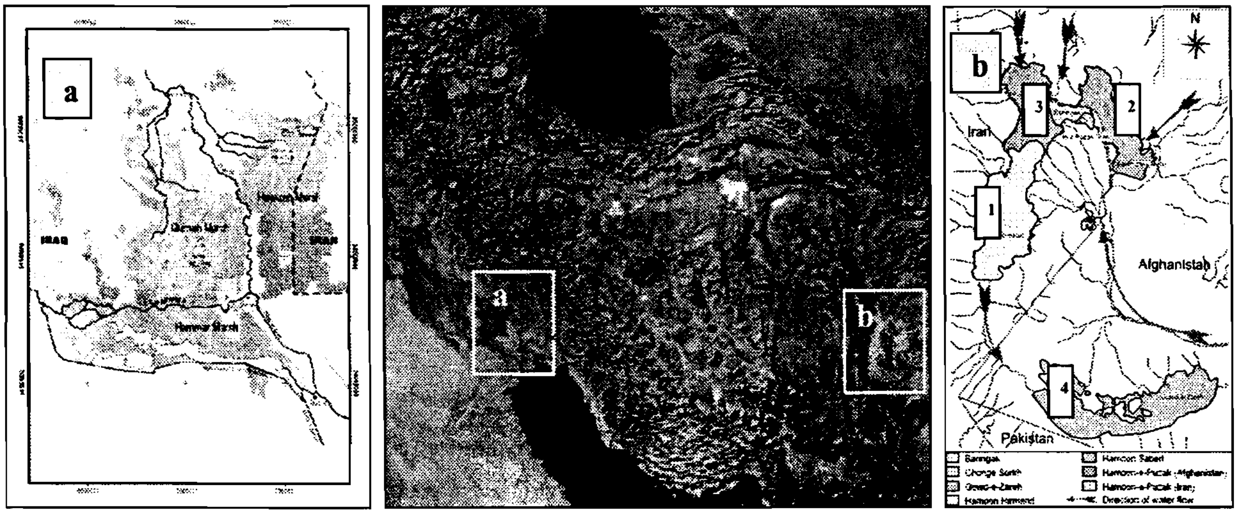


Fig. 3. Prominent mineral dust sources in Iran. (a) Sistan basin and hamuns, subdivision of the Hamuns with the main directions of water flow . (UNEP report, History of Environmental Change in the Sistan Basin Based on Satellite Image Analysis: 1976-2005), (b) Al-Howizeh/Al-Azim marshes.

5.1 Sistan basin characterization

The Sistan area is located at the tail end of a large closed inland basin, in one of the driest regions of the world. It is comprised of three geographical sub-units:

- The upper plain of the inland delta of the Helmand (Hirmand) river, which is mostly drained and used for agriculture;
- The wetlands (Hamuns) covering the lower delta plain;
- A hyper-saline lake (Gowd-e-Zareh) in the lowest part of the basin, which collects the overspill from the wetlands and – in case of extreme floods – from the Helmand River. There is no outflow from this terminal lake; water is lost from Gowd-e-Zareh only by evaporation (Zolta'n Vekerdy and Remco Dost, 2006)

The Helmand River comprises the largest watershed in the Sistan basin, but other smaller rivers also feed the Hamuns, which are, from an environmental perspective, the most important parts of the Sistan area. The basin receives much runoff from the Sistan Mountains to the west in Iran and the eastern mountains in Afghanistan. The basin is characterized by widespread ephemeral lakes and swamps; and many salt/dry lakes in the norther parts.

Often huge dust plumes emerge from three of the largest hamuns, Hamun-e-Saberi (31.5_°N, 61.3_°E), Hamun-e-Puzak (31.5_°N, 61.7_°E), and Daryacheh-ye-Hamun (31.7_°N, 61.1_°E) and from the Gowd-e-Zareh depression a little farther to the south (29.8_°N, 61.8_°E).This is shown by many satellite images. Zabol, a city located in the midst of these salt/dry lakes, reports 81 dust storms per year (Middleton, 1986b). In some years, dust activity is also seen in an intermountain basin to the south in Baluchistan, Pakistan; within this basin, there is a large dry lake (the Hamun-i-Mashkel, 1950 km^2; 28.2_°N, 63.0_°E), which is another prominent source of dusts.

5.1.1 The hamun system

The Hamuns constitute an integral system that can be divided into sub-units connected to each other at high water levels, and disconnected at low water levels. Some of the sub-units receive direct inflow from rivers; others get water only from neighbouring sub-units.The political boundary between Iran and Afghanistan splits the Hamun system, further complicating management possibilities in the area. Ninety percent of the watershed is located in Afghanistan and practically all of the wetlands' water sources originate there. The Iranian part is desert, and produces runoff only in rare cases of significant local rainfall. The Hamuns are classified as freshwater wetlands, although in cases of long water stagnation, not only is salt dissolved from the soil, but the water's salt concentration is increased through evaporation. Another source of salt is the saline return drainage from irrigation schemes.The Hamuns are very shallow. Local experts were interviewed in January 2005 to estimate the volume of water stored in the lakes at maximum water stage. Table 1 summarizes these estimates.

Table. 1. Volume estimated by local experts for the highest water stages. The listing numbers are referred to the figure 3 (b).

	Units	Average depth (m)	Area (km^2)	Volume (million m^3)
1	Hamun Hirmand	2	2388.8	4777.5
2	Hamun-e-Puzak (Afghanistan)	3	1453.4	4360.3
2	Hamun-e-Puzak (Iran)	2	61.0	122.0
3	Hamun Saberi	3	1161.5	3484.5
	Total		5346	13025.6
4	Gowd-e-Zareh	10	2417.5	24174.9

As mentioned before, the Hamuns are very shallow and have a very considerable tendency to convert into dry lands. It is a fact that a large part of this region can be associated with salt/dry lakes due to the high rate of evaporation and a considerable sedimentation process due to Helmand River inflow. When these Hamuns are converted into dry lands in the arid months of the year (From April to September), the playa and tiny sediments are exposed to the atmosphere. Simultaneously, some intense low-level jets like the Sistan-120 day wind (Lavar wind), generated by the interaction between low pressure regions and high pressure ones, blow over the basin dominantly in the north-east to south-west direction. The velocity of these jets can be reached about 110 to 120 km/hr. As the plain delta is subjected to these enormous winds, they are immediately degraded. Lake deposits are generally very fine-grained, and as lakes dry up, they leave salt deposits. The salty soils inhibit plant growth, which further contributes to dust availability. So, it is a fact that the lakes themselves are important sources of dust. Many of the dust storms in these regions are quite intense; and are relatively considerable compared to those in other regions around the world.

5.1.2 A comparison between synoptical parameters and TOMS Aerosol Index (AI)

The TOMS satellite data show that on a global scale the dominant sources of mineral dust are mainly located in the vicinity of salt/dry lakes or large basins of internal drainage which are assumed to be very prone sources and there are large seasonal changes in dust distribution patterns which often display a characteristic geometry. A comparison of the TOMS satellite aerosol index (AI) with measured synoptical parameters by Zabol synoptical station, which is one of the most active dust emission sources in the world, shows a very reliable level of consistency. As the temperature rises in the arid months, the rate of evaporation due to aridity and high temperature would be affected and intensifies the seasonal lakes and wetlands to dry out. So, when the generated storms due to climatic interaction of different terrains pass the region, the very tiny salt deposits and fine silts, which mainly form the bed of the wetlands, are emitted to the atmosphere and often create very intensive dust storms like the one which is shown in Figure 4 (B).

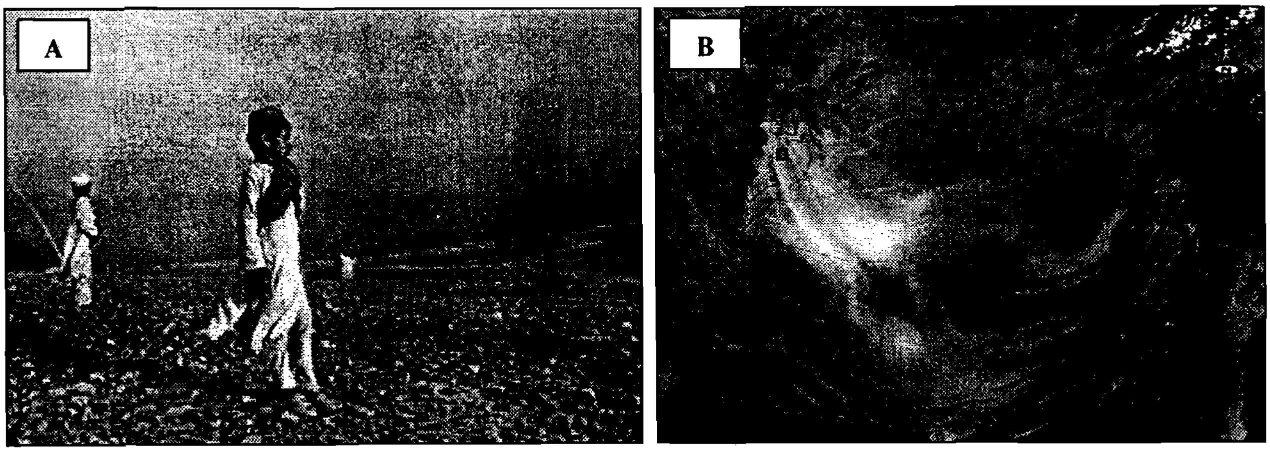


Fig. 4. (A), A dust storm due to Sistan 120 day winds at Zabol city, the city which is located at the center of the Hamuns (The red square in (B) shows the location of the Zabol city).(B), Wind-blown sand originating from the lakebed of the Hamuns, Captured in MODIS (Terra) image on 1 September 2004. Several satellite images show that sand plumes can cross the Persian Gulf and reach the Arabian Peninsula.

So, we can logically assume that the salt/dry lakes or large basins of internal drainage, are the most prominent dust sources. Having a comparison between temperature, wind velocity and monthly number of dusty days approved the mentioned assumption. From Figure 5 we can actually realise the level of consistency of the relations between each of the synoptical data and TOMS Aerosol Index (AI). Regardless of the zero ones, the higher AI is corresponded to the higher value of each synoptical parameters. Besides, Figure 6 illustrates the phenomenon, the higher temperature, the more intensive winds and also the more monthly number of dusty days.

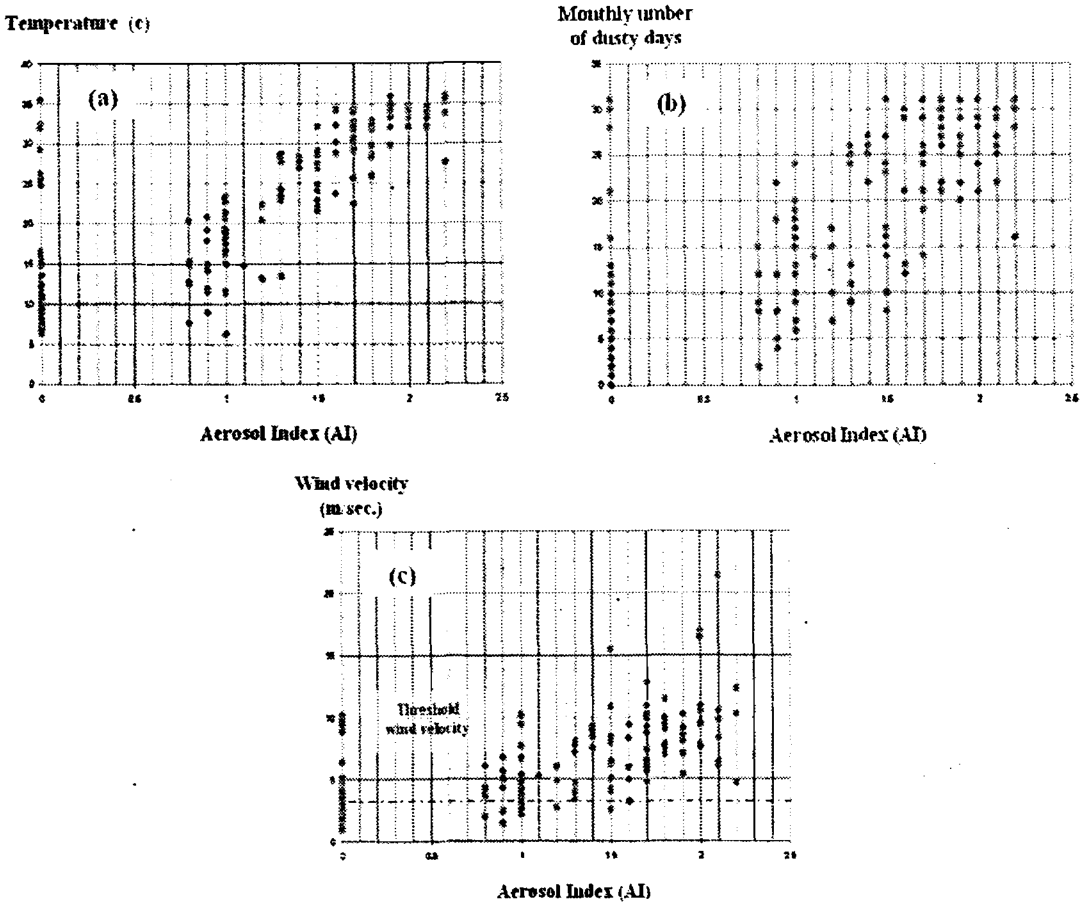


Fig. 5. A comparison between measured synoptical parameters recorded by Zabol synoptical station which is the nearest station to the hamuns, with TOMS Aerosol Index (AI). (To be continued at next page.)

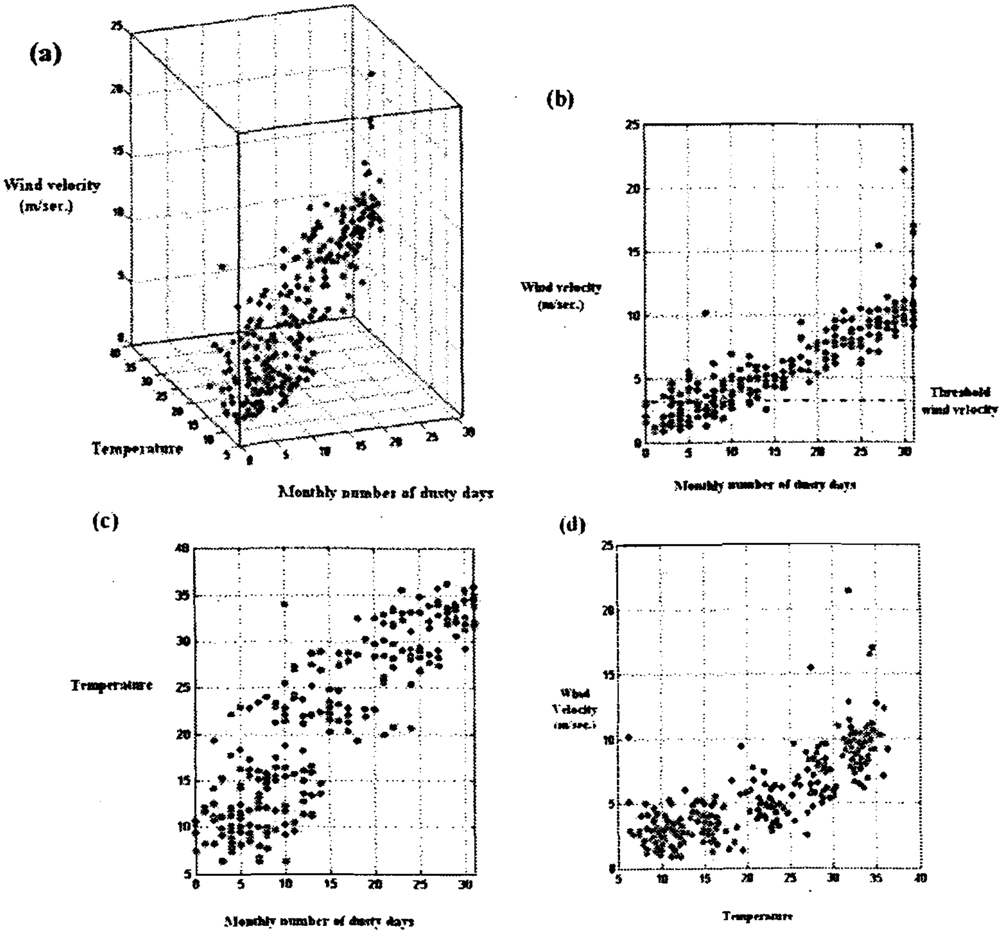


Fig. 6. A comparison between measured synoptical parameters recorded by Zabol synoptical station.

5.2 Iran-Iraq border marshlands characterization

The wetlands comprise a system of shallow lakes and marshes which, in the mid-twentieth century, occupied an area of between 15,000-20,000km^2 (Figure 3 (a)). Situated predominately within southern Iraq to the north of Basra (30-33°N, 45-47°E), this wetland complex is constructed upon a naturally poorly drained, low-lying, very low-gradient Quaternary alluvial plain (Larsen and Evans, 1978; Sanlaville, 1989).

The climate of the region is arid and the annual rainfall of 100-150mm is greatly exceeded by the evaporative demand which reaches 3400mm per annum (Alex, 1985). The main marsh area has developed on two large, flat, active fan-deltas nourished by distributaries and over bank floods of the Rivers Tigris and Euphrates, both of which rise in the highlands of eastern Turkey. The marshlands lie at the downstream margin of this international river basin, where the two rivers join to form the Arvanad river (Shatt al Arab) waterway before discharging into the Persian Gulf 90km south of Basra. The drainage area of this combined basin exceeds 915,000km^2 and extends over five countries; Turkey, Syria, Iran, Iraq and to a lesser extent, Saudia Arabia. The regime of the Tigris and Euphrates is strongly seasonal, reflecting high winter rainfall and spring snowmelt in their highland headwaters. Contributions to runoff are highly variable across the basin and over 85% and 50% of the flow of the Euphrates and Tigris respectively, originates in Turkey. The winter rains and spring snowmelt give rise to an annual flood which peaks downstream in southern Iraq during April and May and is main source of recharge to the wetlands. Water levels within the marshes respond sensitively to this hydrological regime and Salim (1962) reports typical depths within the marshes fluctuating between 0.5-3.5m,although depths of up to 6m have been recorded in some of the major permanent lakes (AMAR, 1994). This flood cycle can more generally be interpreted as the key driver of wetland dynamics, as recharge to the marshes depends non-linearly on river stage (level), and is primarily maintained by the high spring flows. Upstream river engineering projects, in particular dam construction, which disrupt this flood cycle by regulating and distributing discharge more evenly may therefore, be expected to have a major impact on the marshlands.

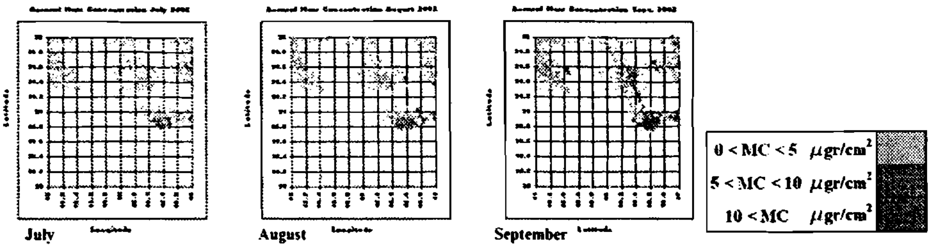
For their greater part, the marshes are covered by natural wetland vegetation, dominated by reed (Phragmites australis) and reedmace (Typha angustifolia).Phragmites dominates the permanent areas of the marsh while Typha is more common in peripheral areas with seasonally variable water levels (Evans, this volume). Extensive permanent lakes used to be common within the marshes, including the 120 km long Lake Hammar, which was the largest lake in the Lower Euphrates basin. Along the fringes of the marshes where irrigation water is available, rice is cultivated on small bunded parcels of land and barley on higher areas.(AMAR, 2001)

The entire wetland complex is often considered as three individual marshes, incorporating the Hammar, Howizeh and the Central or Qurnah Marshes (Figure 3(a)). The Hammar marsh lies to the south of the Euphrates and to the west of the Arvanad river. Historically, this wetland was dominated by Lake Hammar, and is fed from the west by the Euphrates. The Qurnah marsh lies directly north of the Hammar marsh and receives flows from the west and south via the Euphrates but also from distributaries of the Tigris to the north and east. Prior to recent river diversion schemes (see discussion) the Qurnah marshes also received floodwaters along their eastern limit from the Tigris. The Howizeh marsh, straddles the Iran-Iraq border and receives its influx from the north via the Nahr al Musharrah, a left bank tributary of the Tigris, and to a lesser extent along its western margin from the Tigris itself. The Howizeh is also fed from Iran in the east, by the rivers Kharkeh, Dwairoj and Teab. (AMAR, 2001)

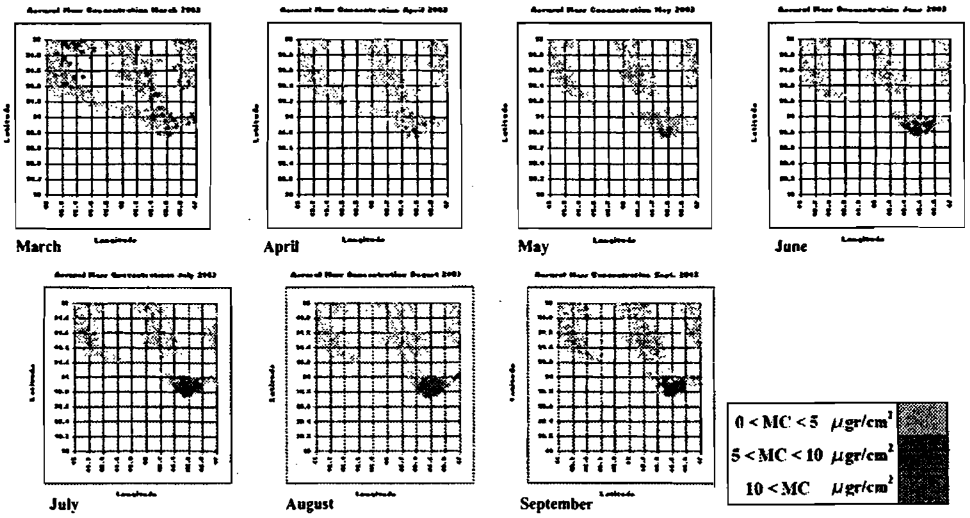
5.2.1 Spatial and temporal remote sensing of marshes based on MODIS products

The application of remotely sensed image analysis in wetland ecology is a well established methodology, and has been used extensively in the environmental planning process to provide baseline and environmental change data where sensitive wetlands are at risk from local and upstream changes to their feeder catchments (Federal Interagency Committee for Wetland Delineation, 1989).

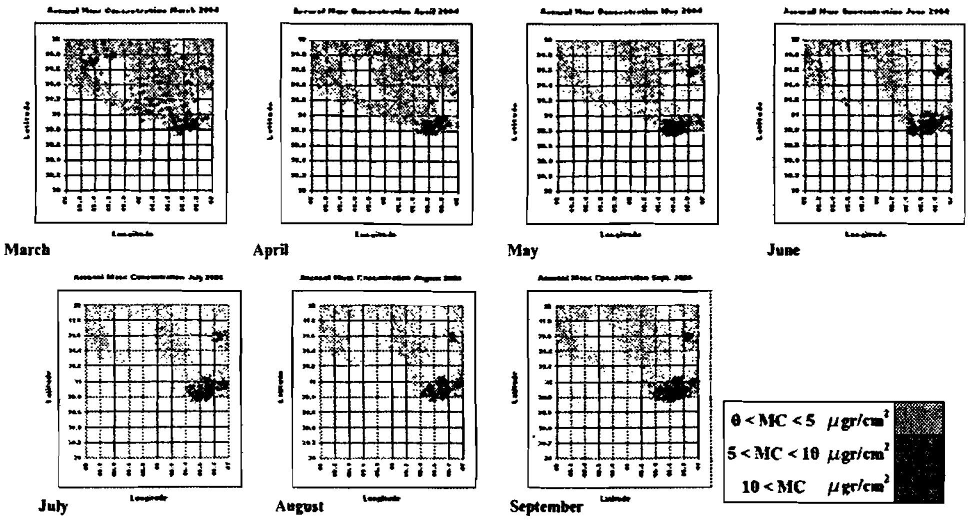
Here we explore the potential of using the MODIS AOT,AAE and MC products over a 3-year period (2002-2004) to find approximate location of prominent dust emission sources in Iran-Iraq border wetlands.



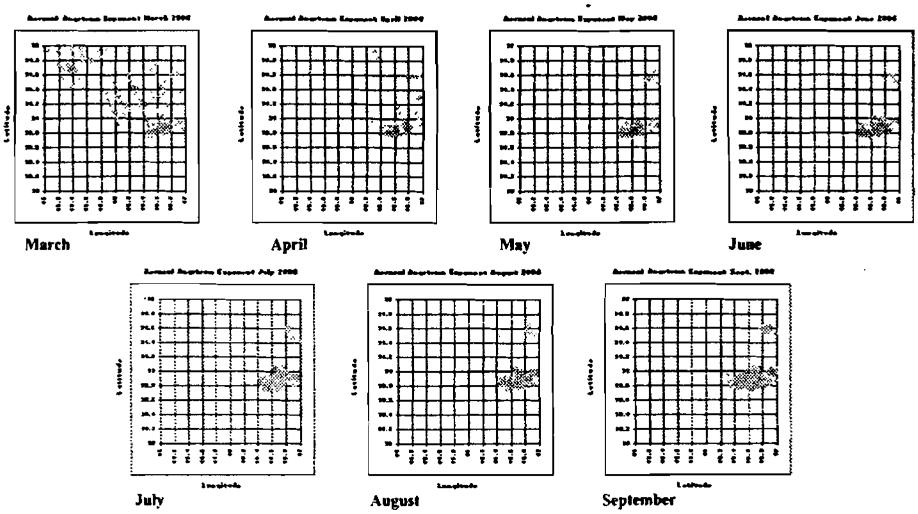
(A) Aerosol Mass Concentration of the year 2002 for the region (30-32°N, 45-47°E)



(B) Aerosol Mass Concentration of the year 2003 for the region (30-32°N, 45-47°E)



(C) Aerosol Mass Concentration of the year 2004 for the region (30-32°N, 45-47°E)



(D) Aerosol Angstrom Exponent of the year 2004 for the region (30-32°N, 45-47°E)

Fig. 7. (A,B,C) A comparison between satellite derived Aerosol Mass Concentration distribution plots for the selected region over the dry months of the period of years 2002-2004,(D) satellite derived Aerosol Angstrom Exponent distribution plots for the selected region over the year 2004.

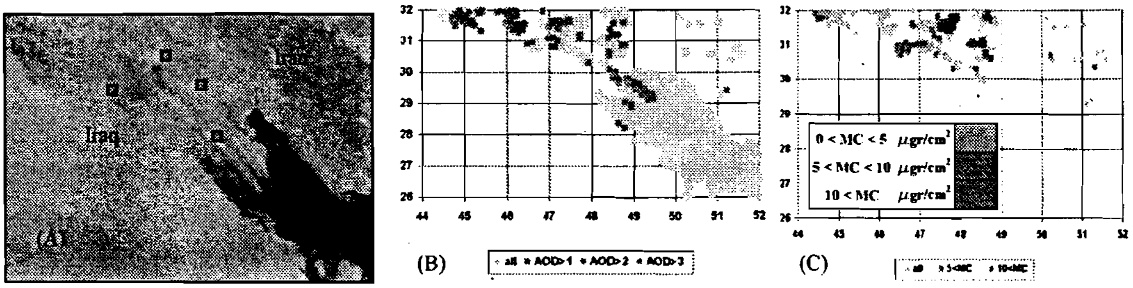


Fig. 8. (A) Traced locations which are supposed to be dust emission sources from (B) and (C). (B,C) A comparison between satellite derived Aerosol Optical Thickness (~ Aerosol Optical Depth) distribution plots and satellite derived Aerosol Mass Concentration distribution plots for the selected region (26-32°N, 44-52°E) during the severe dust storm at September 2004.

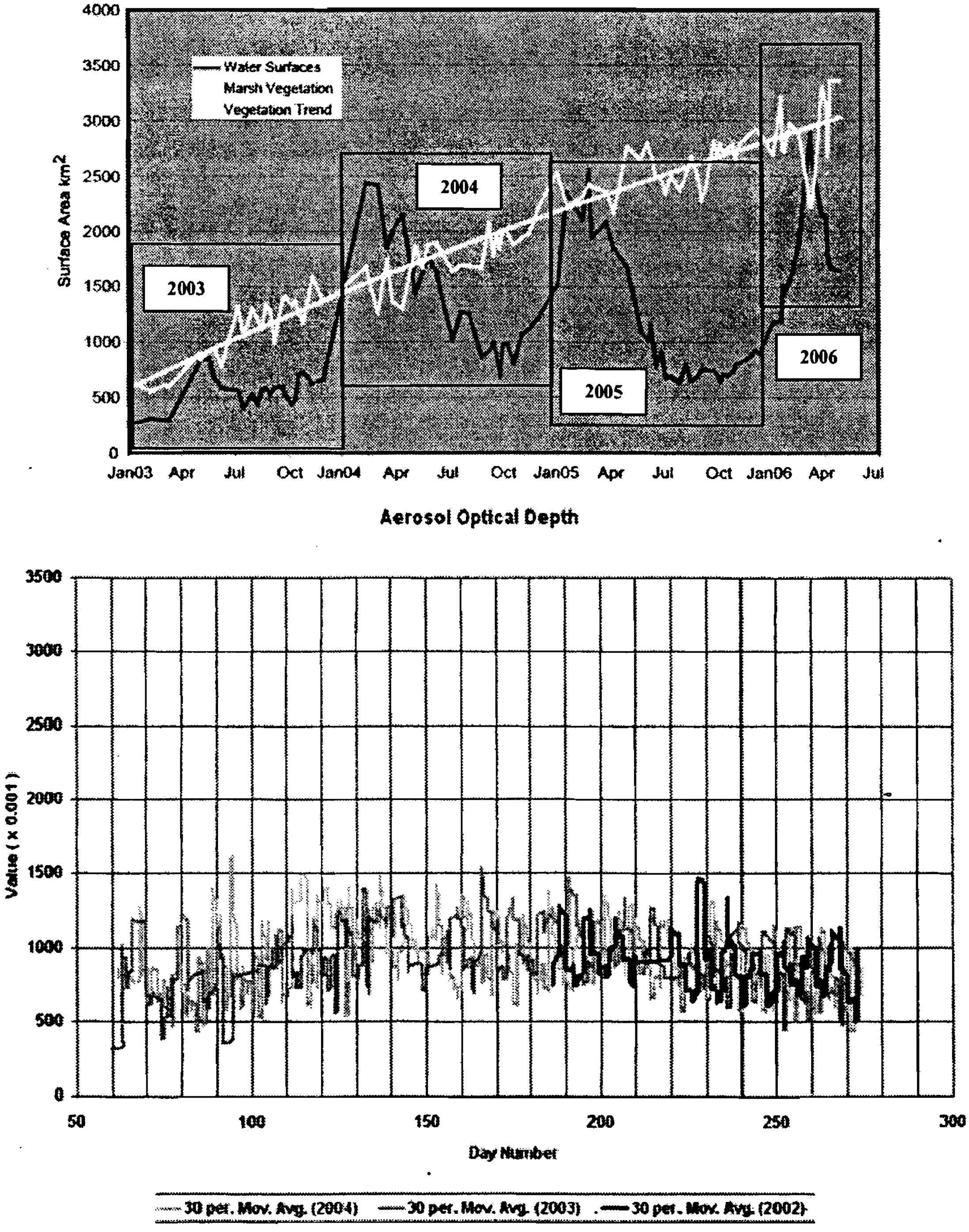


Fig. 9. (A) Evolution of marsh vegetation and water surface from January 2003 throughout spring 2006. The vegetation increase, as estimated by the trend line, is of the order of 800 km^2 per year. Oscillations on graphs are partly due to variations in satellite image quality and classification artifacts. (UNEP website-Iraqi Marshlands Observation System (IMOS)), (B) Moving average plot of Aerosol Optical Depth of the years 2002 , 2003 and 2004 for the study area.

When we plot the corresponding locations of each point in the selected area which has a meaningful measurements of the satellite derived AOT, we can find the estimated physical shape of the aerosol plume over the study area and if we clustering the corresponding magnitude of each location by different colours, we can approach to the main origin of the dust plume location. But by plotting the corresponding locations of each point ,which has a meaningful measurements of the satellite derived AAE and AMC simultaneously, we can validate our estimation and have a better evaluation about the dust activity of the area. Through comparison between the spatial plots which are shown in Figure 7(A,B,C),we can find a number of points which have a significant aerosol mass concentration value during recent three years (2002-2004).The red points are the ones which have the aerosol mass concentration about 10-20 μgr/cm^2 and actually the ones which are more frequent than the others. As a comparison between AAE corresponding locations distribution plots and the locations associated with the points that have AMC value greater than 5 μgr/cm^2, we find them the same.(Figure 7(D)).So, plotting AAE corresponding locations would give us a reliable estimation about dust emission sources in the study area. During a very dense dust storm occurred at September 2004, we find the estimated dust emission sources of the storm by this method and relocate them on the true-colour image of the Terra satellite. The hot spots are actually located at the Iran-Iraq border marshes (Figure 8).

Having a temporal plot of satellite derived AOT product of the years 2003-2004 (Figure 9(B)), and compare it with temporal diagram of marsh vegetation and water surface (Figure 9(A)), would make dewatering as one of the main reason of dust activity in the study area.This recent pattern of dewatering has been forced by a combination of off-site and on-site water supply and river diversion schemes. Assessing the relative balance of these two sets of influences is difficult given the limited hydrometric data context. It is clear, however, that as with any hydrological problem, a consensus regarding the nature of the problem, its causes, and future needs must be reached by all the major riparian states of the river basin before secure environmental management can be formulated and executed. It is also clear that localized river management has undoubtedly played a major part in the controlling the recent timeline of change. While the motives underlying many of these schemes remain the subject of significant political debate and scrutiny, their localized impact is comparatively incontrovertible.

REFERENCES

1. N. Diffenbaugh, , J.S. Pal , R.J. Trapp and F. Giorgi, "Fine-scale processes regulate the response of extreme events to global climate change,"(2005).
2. D. A. Gillette, "A qualitative geophysical explanation for “hot spot” dust emitting source regions," Contrib. Atmos. Phys., Vol. 72, pp. 67–77 (1999).
3. Gillette, D. A., "Production of dust that may be carried great distances, in Desert Dust: Origin, Characteristics, and Effect on Man", Spec. Pap. Geol. Soc. Am.,Vol. 86,pp.11–26. (1981).
4. J. R. Herman, , and E. A.Celarier, "Earth surface reflectivity climatology at 340–380 nm from TOMS data," J. Geophys. Res., Vol. 102, No. 28, pp. 3–12. (1997).
5. J. R. Herman, P. K. Bhartia, O. Torres, C. Hsu , C. Seftor and E. Celarier , "Global distribution of UV-absorbing aerosols from Nimbus-7/TOMS data ," J. Geophys. Res., Vol. 102, No. 16, pp. 911,922. (1997).
6. L. Herrmann, , K. Stahr, and R. Jahn, "The importance of source region identification and their properties for soil derived dust: The case of Harmattan dust sources for eastern West Africa," Contrib. Atmos. Phys., Vol. 72, pp.141–150. (1999).
7. R. L. Miller and I. Tegen, "Climate response to soil dust aerosols," J., Clim., Vol. 11, pp. 3247–3267. (1998).
8. J. M. Prospero, "Saharan dust transport over the North Atlantic Ocean and Mediterranean: An overview, in The Impact of Desert Dust Across the Mediterranean," edited by S. Guerzoni and R. Chester, pp. 133–151. (1996)
9. J. M. Prospero, P. Ginoux, O. Torres, S.E. Nicholson and T.E. Gill,"Environmental characterization of global sources of atmospheric soil dust identified with the Nimbus 7 Total Ozone Spectrometer (TOMS) Absorbing Aerosol Product," J., Geophysics, Vol. 40, pp. 2-1,2-31. (2002).
10. M. Reheis ," Dust deposition downwind of Owens (dry) Lake, 1991–1994: Preliminary findings," J. Geophys. Res., Vol. 102, No. 25. (1997)
11. O. Torres, P.K. Bhartia, , J. R. Herman, Z. Ahmad, and J. Gleason,"Derivation of aerosol properties from a satellite measurements of backscattered ultraviolet radiation: Theoretical basis," J. Geophys. Res., Vol. 103, No. 17, 099–17,110. (1998).
12. O. Torres, P.K. Bhartia, Herman, A. Syniuk, P. Ginoux, and B. Holben, "A long term record of aerosol optical depth from TOMS observations and comparison to AERONET measurements,"J. Atm. Sci., Vol. 59, 398-413. (2002).
13. Z. Vekerdy and R. Dost, "History of Environmental Change in the Sistan Basin Based on Satellite Image Analysis:1976 – 2005,"UNEP Post-Conflict Branch Geneva. (2006).
14. P. Clark and S. Magee," The Iraqi Marshlands A human and environmental study," The AMAR International charitable foundation.(2001).