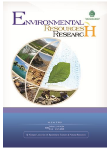

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Short Communication

The effect of drought in the source area of dust storms on vegetation change (case study: western parts of Iran)

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Abstract
Water scarcity is one of the factors limiting plant growth and development. More than one third of the global terrestrial ecosystems is located in arid and semi-arid regions. The most important limiting factor for plant growth is water shortage. Drought could significantly change the natural vegetation cover. Rainfall reduction in Iraq, Turkey and Syria has reduced vegetation cover so that dust storms have increased. Therefore, these areas have a high potential to increase dust particles in the environment. To investigate the temporal changes of vegetation, we focused on the source of dust particles between Tigris and Euphrates rivers and some parts of the west bank of these rivers in Iraq. The Normalized Difference Vegetation Index (NDVI) was used. In addition, the standard precipitation index was calculated to assess drought events in the region. The results show that the vegetation and rainfall indexes are inversely correlated in the study area.

Keywords: Dust Storm, Drought, Vegetation

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Introduction

In recent decades, the dust phenomenon, as an environmental problem, has affected the life in the Middle East. In fact, dust storms are considered an important environmental challenge in Iran (Rezazadeh and Azmi, 2013). Water scarcity is one of the factors limiting plant growth and development. Many physiological processes such as the total amount of chlorophyll fluorescence highly depend on water availability (Barker and Ressenquist, 2004). More than two-third of Iraq and one third of the world are arid and semi-arid struggling with water stresses which is the most important limiting factor in agricultural and natural ecosystems (Ghasryany, 1992). In Iran, particularly in western provinces, dust particles mainly originate from Iraq (Bartyna *et al.*, 2013; Partow, 2013). After determining dust origin area, the prevailing environmental factors as well as human activities were evaluated in the area (Partow, 2013). The most significant factor is vegetation removal causing intense dust storms (Gu *et al.*, 2003). Intense dust storms are the most important environmental problems in arid and semi-arid regions (Darvishi Blorani, 2011). The main sources of aerosols are deserts, spreading across the world, mainly in Asia and Africa. Solid particles in the atmosphere originating from the deserts can be blown away across the world. As mentioned above, the total amount of rainfall below the global average in desert areas causes drought and consequently aerosol events. Continuous drought events besides war conflicts have led to drying of wetlands and marshlands and destruction of lakes in arid regions such as Syria, central and south-west Iraq. Furthermore, the decreasing trend of vegetation cover in Iran, Syria, and Iraq has accelerated dust storms in the region (Darvishi Blorani, 2011). Low soil moisture as a result of rainfall shortage, overuse of water resources, as well as vegetation loss has accelerated wind erosion in these parts of the world. Higher wind erosion increases dust storms (Efati Kellermi *et al.*, 2011). Overall, dust storms closely correlate with regional weather conditions, including rain, wind, and temperature (Nickling and Brazel, 1984). Dust storms occur in areas characterized by low soil moisture and vegetation cover. The intensity and frequency of dust storms negatively correlates with rainfall. A strong correlation between dust and drought aerosol events has been suggested (Prospero *et al.*, 2002). In recent years, drought events have caused a sharp reduction in vegetation cover and an increase in soil erosion (Tahmasebi Birgany *et al.*, 2009). In addition, water shortage prevents chlorophyll formation (Sarmadniya and Kochaki, 1994; Saeidian, 1996). As suggested in previous studies, with the increase of drought stress, root to shoot ratio could also increase (Bagheri Najaf Abadi, 1999; Saeidian, 1996). There is also a simple and direct relationship between the atmosphere and human caused desertification and climate fluctuation (Mc Common, 1997). This is evident in southern and northern China as solid dust particles make the southern and northern areas completely different in terms of climate. In fact, some human activities such as stock grazing have caused forest degradation in northern China exacerbating dust storms. Temperature and precipitation significantly affect the severity of dust storms. During hot days, soil surface particles shrink due to the direct solar radiation effects and are consequently blown away more quickly. Moreover, human induced climate changes in recent years have caused an increase in aerosols worldwide. The intensified drought conditions have caused higher aerosol amounts in Afghanistan and India. This is also the same in East Africa and partially in Canada (western and central areas) due to the circulation of hot and cold aerosols (Menon *et al.*, 2008). Overall, seasonal and annual variations in climatic conditions influence dust particle concentrations (Ried and Coathor, 2003). In this study, we set our goal as assessing the relationship between natural land vegetation and drought in Iraq.

Materials and method

This study is focused on aerosol sources of dust particles between Tigris and Euphrates rivers in Iraq. On the whole, 23 out of 40 cases were investigated to determine dust resources in these areas, including agricultural areas in Turkey and Syria border, Ceylanpinar, and northern and eastern areas of Abolkamal city. The main focus was aerosols in the northwest of Iraq and eastern Syria. To study the temporal variability of desertification and drought events, vegetation and drought indices, including Normalized Difference Vegetation Index (NDVI) and Standard Precipitation Index (SPI) were used. Vegetation indices were introduced to evaluate vegetation density change in NDVI index according to plant reflection properties and the properties of near infrared bands. This was conducted considering phenology of vegetation, climatic conditions, and germination stage (Tucker, 1979). In this research, bands 3 and 7 of MODIS sensor were used for preparation of NDVI maps. This index can be calculated as follows:

NDVI=(NIR-RED)/(NIR+RED)

The SPI index was also used to assess droughts and wet periods in the area of origin in 2002 and 2009, comparing rainfall variation diagram (Moradi and Tolabi, 2011).

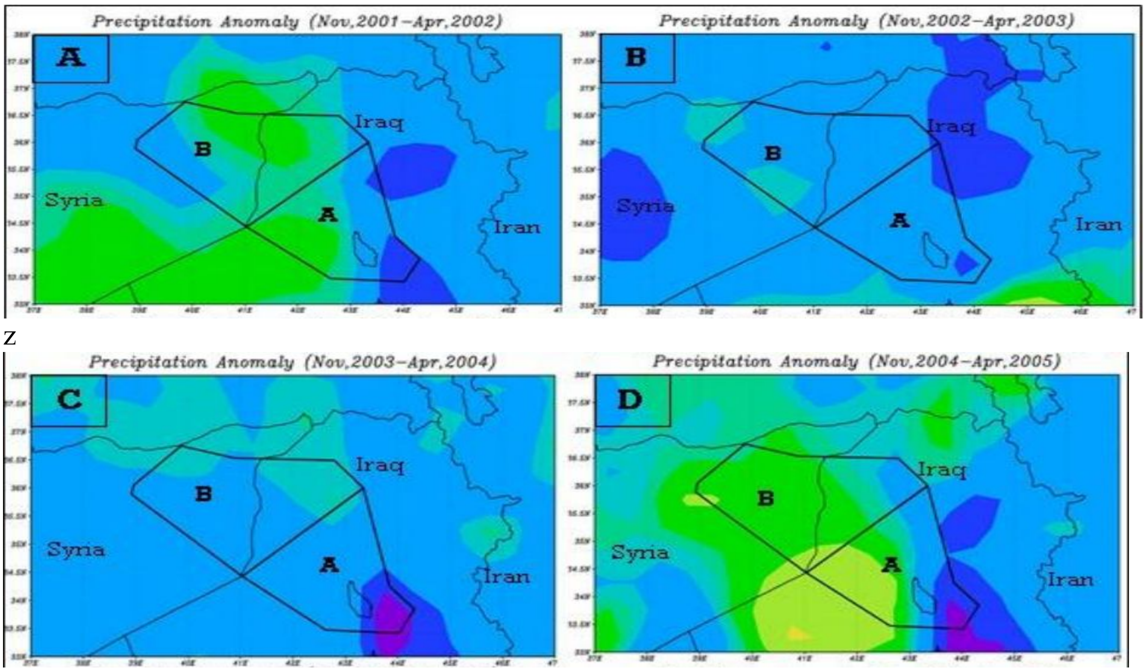
Results and discussion

The reduction in water resource availability in both surface and subsurface layers of the study area destroyed not only natural vegetation cover but also agricultural productivity, consequently causing economic and social ripples and developing new dust sources. Previous research (Trigo *et al.*, 2010.; Gibson, 2012) and monitoring environmental data support the fact that the main cluster core has caused severe drought events in Iraq and Syria during the last decade, especially in 2007 and 2008. The cluster core precipitation data are presented in Figure (1) as a percentage fraction of the precipitation mean for the period from November 2000 to April 2002 in the first drought period observed in 2002 – 2002. In fact, the average rainfall decreased by 20% and in some areas even by 40% (Figure A-1) However, the situation was totally different in 2003 and 2004, with a higher precipitation amount compared to the regional average (Figure B,C-1). Considering stifling dust storm swept from Iraq, Turkey, and Syria to the west of Iran in 2002 – 2004, a mild and local drought event followed by two subsequently wet years could be a reason. In 2005, a widespread drought event, affected the main cluster core area, causing a sharp precipitation decrease by almost 40% (Figure D-1). Overall, the 2005 drought event was much more severe and the amount of precipitation was lower compared with 2002, covering a large area in the region. Assessing precipitation fluctuation and dust storm events were clearly interrelated in the study cluster (Figure E-1). In fact, only one dust storm event was observed in 2006, when the precipitation amount was above average in the region (Trigo *et al.*, 2010). Despite 2006, a severe dust storm was observed in 2009, a year with the lowest precipitation amount since 1940. In 2007, decrease in precipitation amount by 20 - 40% caused the early signs of drought across the region, (Figure F-1), and consequently two dust storm events occurred in the west of Iran and its surroundings. The most evident decrease in precipitation amount occurred from November 2007 to April 2008 as shown in Figure G-1. Furthermore, a sharp 50 – 90 percent decrease in the amount of mean precipitation was observed in the region (Iraq, Turkey, Syria) from 2006 to 2007. This drought event continued with lower intensity in 2009 (Trigo *et al.*, 2010). (Figure A-1).

Furthermore, cyclone circulation frequency was monitored to determine the average surface pressure of Iraq as one of the affected parameters by atmospheric cyclone circulation. Normally, a higher surface pressure during the cold season (November to April) is expected in the middle latitude due to the low surface temperature. However, if low pressure cyclone circulation runs straight across the region, the pressure will marginally drop. The average surface pressure during the cold period (coinciding with the drought event) was higher in Iraq and its surroundings from 2007 to 2009. In other words, higher surface pressure and lower precipitation were evident during these years due to the low frequency of cyclonic circulations. On the other hand, higher (almost above average) cyclonic circulation in 2003 and 2006 enhanced the amount of precipitation and consequently decreased dust storm events in the region. Overall, dust storm events in Iraq and its neighbors were at their maximum when cyclonic frequency and rainfall events dropped, causing severe drought during the summer. In addition, local drought events in southeast Iraq, Turkey, Syria, and the rest of Iraq (e.g. during 2002, 2005, and 2008) as well as low surface flow suppressed vegetation growth causing a series of severe dust storms in recent years (Darvishi Blorani, 2013). Vegetation cover is one of the main resources of biosphere, efficiently absorbing aerosol and dust particles (Gu *et al.*, 2003). In fact, dust is a destructive element influencing photosynthesis process, stomatal conductance, leaf development, and consequently suppressing plant growth and productivity (Abdi Karamvand, 2011). In fact, lower vegetation cover could motivate dust storm events, posing a negative impact on plant growth.

Conclusion

Vegetation cover could influence drought severity and intensity in the study area. The decreasing trend of vegetation cover, intense human activities such as dam construction in Turkey as well as long-term sanctions on Syria and Iraq have accelerated dust sweeping and therefore the desertification process. Hence, these countries (Iraq, Turkey and Syria) could be considered as the main focus areas of dust, particularly affecting western provinces of Iran.



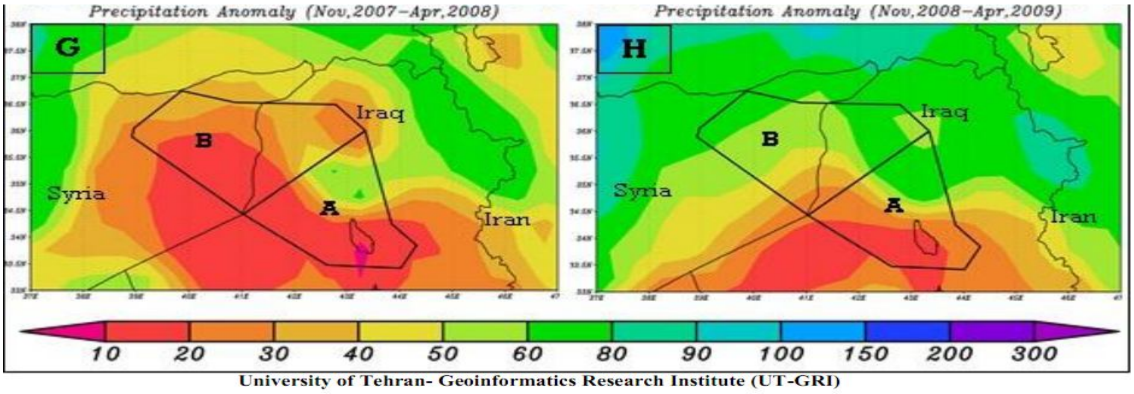


Figure 1. The cluster core data, changes in mean annual precipitation (percent) for the period November to April are drawn (Tehran University Research Center for Geo-Informatics)

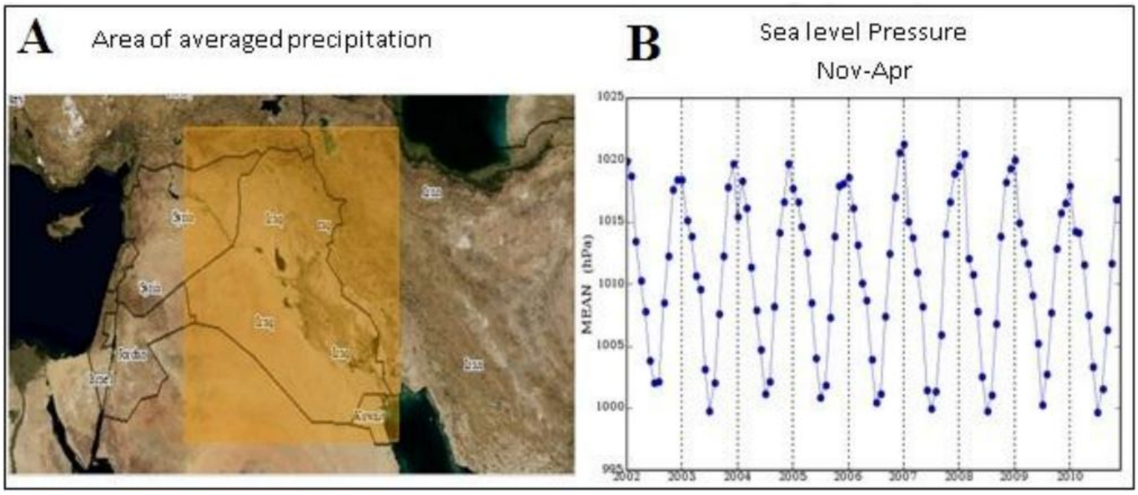


Figure 2. The amount of precipitation and surface pressure (B) in Iraq and the neighboring regions (Tehran University Research Center for Geo-Informatics)

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