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Effect of the temperature variation between Mediterranean Sea and Syrian deserts on the dust storm occurrence in the western half of Iran

Jamil Amanollahi [a,*], Shahram Kaboodvandpour [a,1], Samira Qhavami [a], Bakhtiyar Mohammadi [b,1]

[a] Department of Environmental Sciences, Faculty of Natural Resources, University of Kurdistan, Sanandaj, Iran
[b] Department of Climatology, Faculty of Natural Resources, University of Kurdistan, Sanandaj, Iran

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ABSTRACT

Recent dust storms have caused crises in western Iran, which necessitate the prediction of these storms a few days before their occurrence. This is the first study of its type that analyzes the effect of temperature differences between the Mediterranean Sea surface and Syrian deserts (creation zone of the dusts storms) on the formation of dust storms in the west of Iran. The study also seeks to identify any changes in the atmospheric temperature created by the extreme dust storm of July 5, 2009 in west of Iran (Sanandaj City). In this study, the MODIS images from 2000 to 2008, and particulate matter data of the Sanandaj station from 2008 to 2012 were utilized to identify the dust storm days. The Mediterranean Sea surface temperature data were extracted from NOAA satellites for dust storm days up to four days preceding them. The web site of world weather was used to obtain the temperature of Damascus, Syria station as the selected land station. According to the results, significant differences were acquired between surface temperatures of Damascus station and the Mediterranean Sea in the dust storm days and up to three days before them. As the dust storm days approached, a rising trend was observed in changes of the temperature difference between land and sea. Thermal map analysis of the atmosphere of the Syrian deserts on July 5, 2009 showed significant decrease in the levels of 1000 hPa and 500 hPa but for the days preceding it no significant changes were observed. It can be concluded that the temperature difference between the Mediterranean Sea surface and the Syrian deserts four days before the dust storm occurrences is the important factor in predicting this event.

1. Introduction

Suspended particulate matters (SPMs) in the atmosphere produced by windblown dust has become an environmental crisis in west of Iran. Dust storms occur in arid and semi-arid areas with particulate weather conditions (Natsagdory et al., 2003). The study of dust storm is important because of its effects on chemical characteristics of particulate matter in urban areas (Liu et al., 2014; Cao et al., 2014; Tao et al., 2013), global dispersion of pathogenic microorganisms (Gonzalez-Martin et al., 2014), mortality (Lee et al., 2014; Chan and Ng, 2011), atmospheric nutrient deposition rates (Hartmann et al., 2008), clouds (Posfai et al., 2013; Santos et al., 2013), climate system (Choobari et al, 2014), satellite imagery (Hadjimitsis and Clayton, 2008; Hadjimitsis et al., 2004), cultural heritage monuments (Tzanis et al., 2009, 2011; Varotsos et al., 2009), and the nutrient balance and acidity of soil (Yun et al., 2002; Odabasi and Bagiroz, 2002). In recent decades, dust storm

* Corresponding author at: Department of Environmental Sciences, Faculty of Natural Resources, University of Kurdistan, P.O. Box 416, Pasdaran Street, Sanandaj 66177-15175, Iran. Tel.: +98 871 6627723 25x218; fax: +98 871 6620550.
E-mail addresses: J.amanollahi@uok.ac.ir (J. Amanollahi), s.kaboodvandpour@uok.ac.ir (S. Kaboodvandpour), samiraqhavami@yahoo.com (S. Qhavami), b.mohammadi@uok.ac.ir (B. Mohammadi).
[1] Tel.: +98 9124936595.

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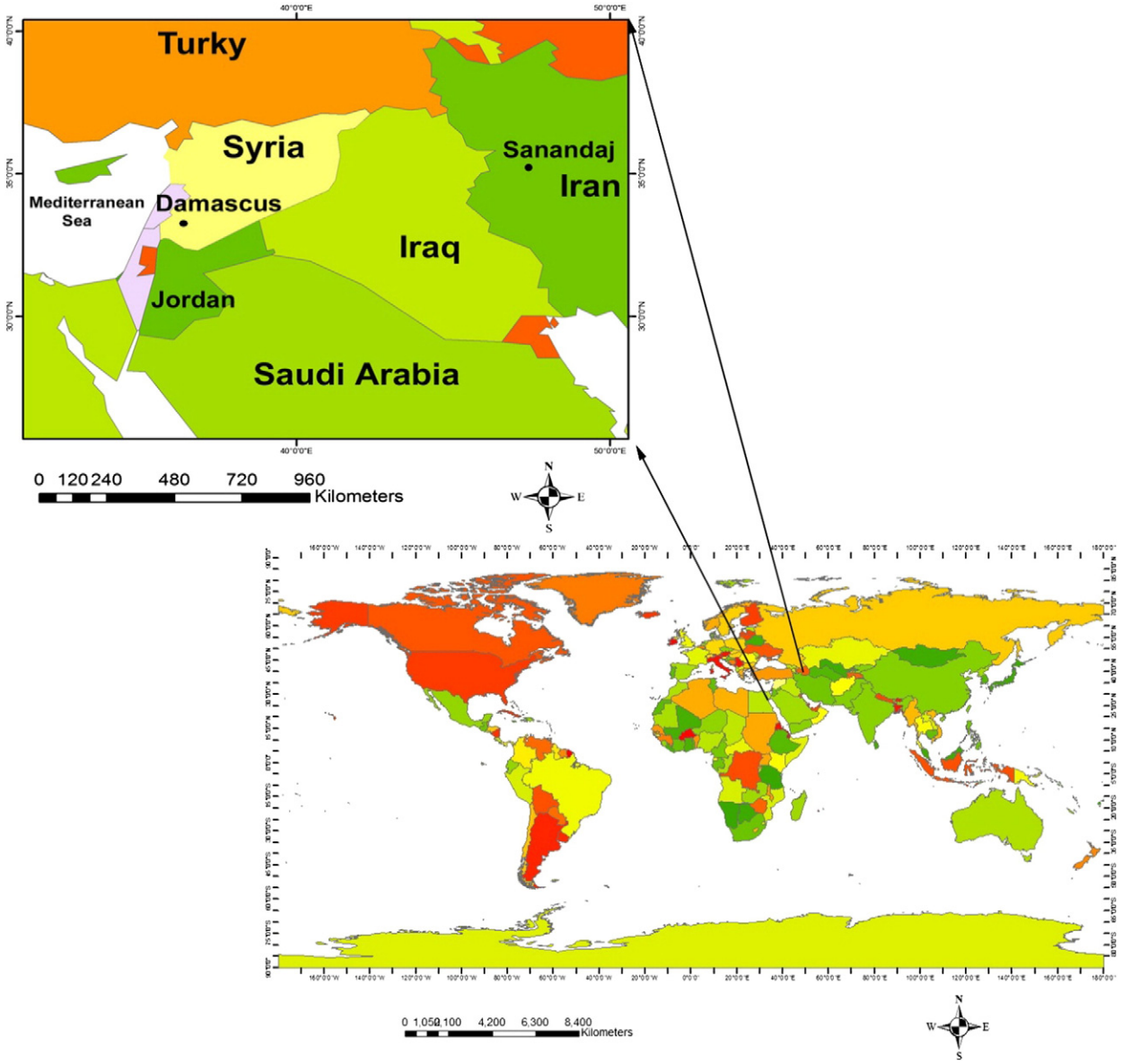

Fig. 1. Study area including Sanandaj City in west of Iran, Damascus ground measurement station in Syria, and Mediterranean Sea surface temperature.

frequency rise in the west of Iran. Amanollahi et al. (2011) used the MODIS natural images to show the dust storm creation zone incoming from the west of Iran. They showed that deserts of eastern Syria and western Iraq are responsible to create most of the dust storms which cause environmental crises in west of Iran. In addition, the Saudi Arabian deserts are the creation zone of the dust storms incoming to south-west of Iran (Amanollahi et al., 2012). Yang et al. (2007) showed that both temperature and precipitation change are the main factors in climate change and important forcing factors for the occurrence of dust storms on a centennial timescale in Northern China. The vegetation cover and land surface temperature changes in the deserts of Syria and Iraq have been reported as the main causes of the dust storms (Amanollahi et al., 2012, 2013). Despite its significance, no valid parameter has been proposed and tested to predict the occurrence of these dust storms. In most studies, sea surface temperature (SST) changes have been offered as the main parameter that affect precipitation range (Nguyen et al., 2007), wind blowing (Yang and Lau, 2004), and climate change (Richard and Smith, 1994). Baldock et al, 2014 tested the accuracy of estimating water temperature from remotely sensed satellite. They showed SST retrieved by satellite is reliable and they were able to estimate the in situ temperature successfully within ± 1 °C, at least 78% of the time. Millana et al. (1995) studied the relationship between sudden rain in the eastern coast of Spain and surface temperature in the Mediterranean Sea. They found that rainfall patterns are related to SST changes from one to two months before the occurrence of sudden rains. Nguyen et al. (2007) investigated the relationship between surface temperature of the Indian as well as the Pacific Oceans and monthly precipitation in the mountains of Vietnam using empirical orthogonal functions. They showed that SST