Identification of the Point Sources of Dust Storms in the Middle East Using Remote Sensing

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Introduction

Dust storms are natural events and are common in the dry land areas. The severe droughts can increase the number of dust storms, particularly during the summer months. Dust storms reduce air quality and may have adverse effects on health, particularly for people who already have breathing-related problems. The most common experienced symptoms during a dust storm are irritation to the eyes and upper airways. The most vulnerable people are infants and young children, the elderly and people with respiratory conditions (e.g. asthma, bronchitis and emphysema) and heart diseases. For these people, exposure to a dust storm may, trigger allergic reactions and asthma attacks, cause serious breathing-related problems, contribute to cardiovascular or heart diseases, contribute to reduced life span. Visibility deteriorates very quickly during a dust storm. Low visibility has important effects on transportation. In these days, dust storm is one of the major environmental disasters in the Middle East. Dust storms happen in the Middle East with very high frequency. According to the mentioned dust storm effects, it is vital to study the dust storms in the Middle East. The first step toward the study ~~on~~ of dust storms is to identify the point sources of dust storms. In addition, it is necessary to find the properties and the characteristics of the point sources and to determine the most important regions in Middle East with high density of point sources. Remote sensing is an appropriate tool for these investigations. Many different dust indices have been developed for the dust identification from remotely sensed images. In this study, a new false color composite method is developed for the identification of the point sources of dust storms in the Middle East using the dust indices. Then, the properties of the point sources are determined and finally, the share of different countries in the dust storm generation is investigated.

Materials and methods:

In this study, MODIS images were utilized as remotely sensed images. MODIS images have been used successfully for dust storms detection. 28 MODIS-Level 1b images from 2008 to 2009 were selected and received from the archive of Iranian Space Agency. The software package for the image processing was ILWIS 3.7 (Integrated Land and Water Information System). The digital number of satellite images converted to the radiance and reflectance data. Then the different famous dust indices were developed using the MODIS images. These indices were BTD_{3132} (Brightness Temperature Difference in band number 31 and 32), BTD_{2931} (Brightness Temperature Difference in band number 31 and 32), NDDI (Normalized Difference Dust Index) and D (Roskovensky and Liou, 2005). Different false color composite maps were generated

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using these Indices, bands 3 and band 4 of MODIS images. Then the performance of different color composite map was evaluated using visual interpretation and the best color composite method for dust enhancement was selected. Then using the selected color composite method, the point sources in 28 MODIS images were identified and after that, all of the identified point sources were combined in GIS environment. Then the share of each country in Middle East in dust storms generation was determined according to the number of point sources in their territories. For determination of the characteristics of the point sources, the point sources map was combined with DEM map, Geological map and NDVI map of Middle East in GIS environment. Finally, we tried to determine the regions with high density of point sources and major role in dust storm generation using the point sources map and IDW (Inverse Distance Weighting) interpolation technique.

Results and Discussion:

The visual interpretation of the generated False Color Composite maps demonstrated that the best combination for dust identification is the utilization of D, BTD_{3132} and NDDI indices as the Red, Green and Blue bands of color composite map, respectively. Using this color composite method, about 420 point sources were extracted from 28 MODIS images and point sources map was generated. The point sources map showed that about 39.2, 23, 14.5, 13.8, 5.7 and 3.7 percent of the point sources of dust storms have been located in Iraq, Syria, Saudi Arabia, Iran, Jordan and Turkey territories, respectively. These results mean that more than 60% of dust storms are generated in Iraq and Syria. Combination of NDVI map with point sources showed that the point sources often have been located in the region with low NDVI values (low vegetation covers). Almost all of the point sources have been located in the planes with low altitude (elevation less than 400 meters). In addition, combination of geological map with the point sources map showed that the surface of the point sources regions often have been covered by non-rigorous soil formations. Therefore, the main characteristics of the dust point sources in Middle East have been determined. To determine the density map of the point sources, the gridded point sources map was interpolated by IDW and an indicator map for density of point sources in the Middle East was generated. The indicator map demonstrated that the main regions of dust storm generation are two regions in western Iraq and eastern Syria.

Conclusions:

MODIS images were very useful for the identification and detection of dust storms. In this study, a new false color composite map was developed for dust storms and point sources detection using the famous dust indices. This color composite was generated by the combination of D, BTD_{3132} and NDDI indices. The point sources of dust storms in the Middle East have been located in the regions with low altitude, low vegetation cover and non-rigorous soil surface. More than 60% of dust storms are generated in Iraq and Syria (especially in the western Iraq and eastern Syria) and transferred to the other parts of the region by the wind. The share of Iran in dust storm generation is about 13.8 %.

Keywords: Dust storm, Point sources, Middle East, MODIS images, False color composite.