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Detection of Sand Dust Storm on MODIS Images Processing

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ABSTRACT

Over the past decade, dust storms have increased in Iran. Remote control for spatial and temporal coverage, can provide a valuable source for the study of dust. In this study, levels of dust on the surface of the Golestan province in July 2013, using spectrophotometric sensor data imaging radiometer moderate resolution (MODIS) were estimated. For this purpose, according to the difference between the 13.2 micrometer signal band and 0.469 micrometer band that distincts between the sand dust storms (SDS) and clouds of ice or water, to make a good show and also the normalized differential dust index (NDDI), was used to estimate the amounts of sand and dust storms. To determine the dust aircraft and ground brightness temperature of (BT) 31 MODIS bands (28. 11-78.10 micrometers) were studied. The results showed more dust in the north and some parts of east and south region has higher values. Maximum dust in the barren land (0.336) and the lowest amount of dust in the agricultural lands (0.112) and forest (0.158) was observed. The numerical values of dust in the water bodies were negative.

INTRODUCTION

Dust phenomenon is a complex process that affects earth and the atmosphere interactions, primarily by high winds and forming dry weather conditions in wastelands (Mei & Xiushan 2008). The dust affects the amount of radiation as a result of climate change due to scattering and absorption behaviour, which in turn influences the atmosphere (Haunget al. 2007). Remote sensing for spatial and temporal coverage, can provide a valuable resource for dust study (Zhao et al. 2010, Li et al. 2011). In the past decade, coinciding with the development of ground-based measurements and remote sensing dust, to eliminate restrictions and better use of measurement results, methods were developed. Cakmur et al. (2006) investigated the dust emissions by using the optical depth of aerosols, and dust density in the global model was optimized. On a regional scale (Ku & Park 2011), by using the least squares method of Bayesian, density difference between the amount of particulate matter less than 10 μm as measured by the method, and the model can be minimized.

Spectral indices based on the characteristics of dust on areas of visible, near infrared and thermal infrared, provide lot of information about the characteristics of dust (Tao et al. 2005). More methods in combination of multispectral bands (the reflectance spectra of the sun and in the temperature range) are applied. For example Qu et al. (2006) used Normalized Difference Dust Index (NDDI) that a normalized ratio of 1.2 micron band and the blue band to identify dust storm and monitoring of changes in humidity caused by dust. On the other hand, 31 and 32MODIS bands in the thermal infrared windows are small enough to be absorbed by other gases from the atmosphere. Dust emissions are higher in the band of 32 in comparison to the band of 31. So to extract the particles, brightness and temperature difference (BTD) between the two bands can be used (Badarinath et al. 2010, Haung et al. 2007). In this research, we explain a new index by MODIS channels centered near 0.469 and 2.13 μm for Golestan Province of Iran for dust detection. We also discuss the index threshold to distinguish the thick airborne dust storm from the surface features.

MATERIALS AND METHODS

The area of study: The study area is located in northeast of Iran (Fig. 1), between latitudes 36°30' to 38°10' N and the longitudes 53°50' to 56°20' E and covers an area of approximately 21400 km^2. Altitude varies from about -40m to 3800m above sea level. The climate is temperate with the annual average temperature of 16.88°C and mean annual precipitation of 454 mm. The Golestan province is a major agricultural centre, but includes substantive forest cover, residential areas, bare lands, rangelands and aquatic ecosystems of all sizes and densities. The reason for choosing this province is its environmental sensitivity to destructive activities.

Dust: To estimate the amount of dust in Golestan province in July 2013, the dust index normalized difference (NDDI) was used, which can be calculated as follows (Qu et al. 2006):

Analysis of spectral properties of dust: Various indicators based on their spectral characteristics are recommended. The spectral properties of sand indicate that sand dust storm signals (SDS) using the difference between the micrometer band signal, that is 2.13 and 0.469 micrometer band, where the signal levels are low, can be calculated. These differences, distinctions between dust storms and sand, water or ice clouds could be well determined. Because of this high distinction, using SDS, NDDI can be calculated.

$$NDDI = (\rho 2.13\mu m - \rho 0.469\mu m)/(\rho 2.13\mu m + \rho 0.469\mu m)$$

$\rho 2.13\mu m$, $\rho 0.469\mu m$ to the high reflectivity of the atmosphere (TOA) for bands is 2.13 and 0.469 micrometer.

To check capabilities of NDDI to predict SDS, 9 of the SDS have been studied in Golestan province and the average NDDI dust cloud and earth surfaces were analysed. NDDI clouds due to the high reflectivity of the low reflectivity band 0.469 microns and 2.13 microns was negative in the band (NDDI <0.0). NDDI terrain was less than 0.28, while the amount of dust NDDI for pixels more than 28/0 in Golestan province.

So this shows that SDS can effectively separating NDDI from the clouds water or ice and terrain (except sand and dust of the earth) with a threshold 0.28 in Golestan province. To determine the dust aircraft and the ground, brightness temperature (BT) 31 MODIS bands (28 11.28-10.78 micrometers) were studied. Dust aircraft compared with ground-based dust and sand were cooler. By investigating the BT of band 31, SDS can be separated from the dust and sand ground. BT in the study area with the 275k threshold for detecting dust or sand aircraft and the ground was used. Thermal method greatly reduces the loss of error.

RESULTS

Spatial distribution of dust in Golestan province in 2013 is shown in Fig. 2. As can be seen, the maximum and minimum amount of dust in 2013 is 0.35195 and -0.80077 respectively. The amount of dust in the north, some parts of east and barren-land of south of Golestan province is higher than other areas. The lowest amount of dust can be seen in western areas near the Caspian Sea. Table 1 shows the amount of dust based on the main land-use classes of Golestan province. Maximum amount of dust was seen in barren lands (0.336) and minimum amount was seen in agriculture and forest areas (0.133 and 0.158 respectively). The numerical values of dust in the water bodies were negative (Table 1).

DISCUSSION AND CONCLUSION

Our study showed that maximum amount of dust was in barren-land (0.336) and minimum amount was in the agriculture (0.112) and forest areas (0.158). Shafiezadeh et al. (2011) suggest that over the past decade dust storm have increased in Iran. They claimed that some factors such as population growth and the need to provide food, water and habitat leads to drastic changes in land use and land cover, so they conclude that destructive human activities, natural process of desertification and climate change have increased dust sources in recent years. The study results of Tatarko et al. (2013) also showed that the degradation of pastures with disturbance of surface soil have a greater impact on dust emissions than other land management systems. In addition, political and economic pressure on land-use management through the effect on wind erosion and dust storm can have significant local and regional consequences.

In the case of high dust amount in the barren lands of the study area, it can be stated that dust emissions can be influenced by climate (by changing dust generation by wind speed and soil moisture) and land-uses. Vegetation usually reduces dust emissions through increasing the stability and moisture of surface soil (Bhattachan et al. 2013). The destruction and loss of vegetation cover due to climate change and land use changes cause increase in dust emissions. Human activities also play an important role in generating new dust sources.

Table 1: Quantities of dust in each of the uses of Golestan in 2013.

Standard deviation	Mean	Maximum	Minimum	Type of use
0.04	-0.435	-0.141	-0.800	Water zone
0.031	0.241	0.288	0.183	Residential
0.045	0.263	0.309	0.170	Pastures
0.018	0.158	0.182	0.085	Jungle
0.020	0.336	0.351	0.233	Barren lands
0.01	0.112	0.186	0.052	Agriculture
0.02733	0.1125	0.1985	0.0205	Average

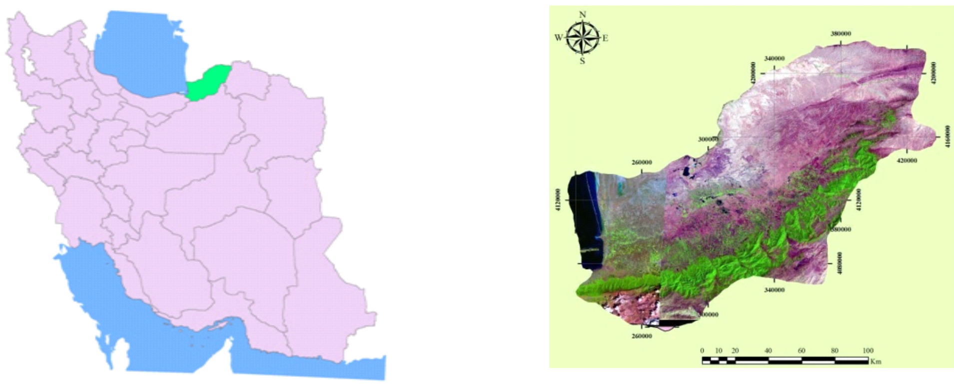

Fig. 1: Location of the study area in Iran.

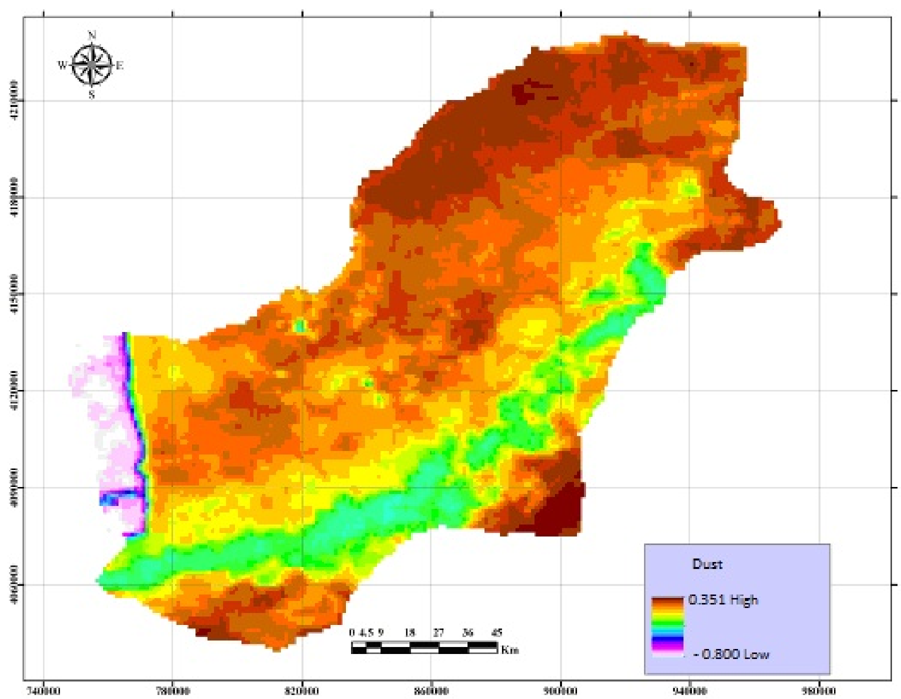

Fig. 2: The spatial distribution of dust in Golestan province in 2013.

Now the main question of researchers is about the contribution of human activities in generation of new dust areas. Yoshioka et al. (2006) concluded that human activities in North Africa have a smaller share (25-0 percent) in the generation of dust. These results have been confirmed by Ginoux et al. (2012) who studied the dust generation using MODIS data. Their results showed that 25 percent of the daily dust emission at the global level occur as a result of human activities.

However, many challenges about potential of different land-uses on dust emission, new sources of dust formation and the share of land use changes and climate change still remains unclear.

It is an extremely complex mechanism of dust formation, which depends on local weather system, short-term rainfall, soil moisture and extent of deforestation, increase long-term drought, land use and land cover change, and other human activities (Qu et al. 2006).

The reason of the negative numerical amount of dust in the water bodies could be due to the high reflectivity of these land uses in band 0.469 μm and low reflectivity in band 2.13 μm (Qu et al. 2006). In this regard, it can be stated that the study about the effects of dust on climate need information about optical properties and particle size of dust. Thus, to better understand the modelling of these effects, the first step is to investigate the optical properties and particle size of dust.

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