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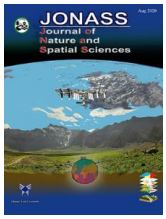

Case Study

Dust time series analysis using long-term monthly images of MERRA2 satellites and Sentinel5 images in Google Earth Engine

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ABSTRACT

Background and objective: The dust phenomenon is one of the important climatic hazards in arid and semi-arid regions of the world, which causes human and financial losses to humans. In recent decades, due to long-term droughts, the incidence of dust has increased. Considering that Iran is one of the centers affected by particulate matter and the damage caused by this phenomenon affects our country, special attention should be paid to the issue of increasing particulate matter. The purpose of this study is to investigate changes in the dust, vegetation density, and wind conditions in the geographical region of south and southeast of Iran and its neighbors, Afghanistan and Pakistan.
Materials and methods: Through NASA Giovanni online modeling and the use of MERRA-2 satellite imagery to study dust and wind stress and the MODIS-Terra satellite to study vegetation. During the last 40 years and 4 10-year periods from 1980 to 2020, the state of dust and wind stress was examined. Vegetation has also been studied over the past 20 years and 10-year periods from 2000 to 2020. Dust monitoring from June 2018 to February 2021 was also analyzed using Google Earth Engine (GEE), a web-based remote sensing system, using long-term monthly images of Sentinel5 satellites.
Results and conclusion: The results show that with increasing the amount of dust, the percentage of vegetation, increases, and decrease in wind stress. Although plants and wind have had a good trend in these years, this increase in dust can be due to lower water levels and increased dust collection sites as a result of not observing the water level of wetlands.

1. Introduction

The planet Earth has been in great danger since its inception. In recent years, a series of natural hazards have occurred around the world, among which, a group resulting from the interventions of atmospheric elements, have caused extensive human and financial damage in various regions. In some parts of the world, especially in the Middle East, dust storms are phenomena that have a high frequency (Karimi Ahmadabad and Shokoohi Razi, 2011: 114). Dust storms are a complex process that is

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influenced by the interactions of atmospheric systems and is mainly caused by conditions such as high wind speed, bare soil, and dry air (Mei et al., 2008). Dust storms are important atmospheric phenomena that have very important effects on environmental, health, and economic and social activities due to the entry of suspended particles of dust and dust into the atmosphere (Babaei et al., 2017: 105). One of the main causes of this phenomenon is relatively strong winds on deserts with favorable conditions for dust generation (Koohestani et al., 2019; Fenta et al., 2020). These factors, along with the upward movement of air from atmospheric systems, provide vertical transport of suspended dust particles to higher atmospheric levels. Suspended particles, depending on the size of their diameter in the layers, are placed from bottom to top, respectively, and then move with the air currents in those levels, covering large areas (Akhlaq et al., 2012). Wind erosion dust is a major challenge in arid and semi-arid regions, exacerbated by climate change in recent years (Adib et al., 2018). On the other hand, recognizing the impact of annual dust storms on vegetation can be considered as a prerequisite for programs related to comprehensive watershed management in dust storm-prone areas, including wetlands (Kazeminia 2016; Sashik Kumar et al., 2017; Jamali and Ghorbani Kalkhajeh 2020). According to the definition of the World Meteorological Organization (WMO), the occurrence of dust in terms of horizontal visibility to four levels of weak dust or horizontal visibility less than 10 km, moderate dust with visibility between 1 to 10 km, a severe storm with visibility between 200 to 1000 meters and very severe storms with visibility of fewer than 200 meters are divided (Tan et al., 2014). The probability of dust spreading at a position from the ground depends on several factors including soil composition, soil moisture content, vegetation composition, and wind speed (Ginoux et al., 2002). Dust as one of the stressors plays an important role in the incidence of disease in plants. Hence extensive studies in the field of evaluation. These analyses can help to city governor and mayor for preventing of dunes offense toward the city. Today's primary policy is using vegetation cover and biological controlling by the government (Jamali et al., 2018).

The interaction of dust and vegetation phenomena has been done in Iran and the world, among which the following can be mentioned:

Qian et al. (2004) studied dust storms and concluded that barren lands have a high potential for dust formation. In general, in addition to environmental conditions, climate and vegetation, soil erosion also plays an important role in the occurrence of this phenomenon (Qian & et al., 2004). In another study, Reynolds et al. (2007) studied the relationship between dust emissions and vegetation. Their results showed that with increasing dust emission, surface properties such as vegetation and soil moisture decreased (Reynolds RL et al., 2007). Kurosaki and Mikami studied the occurrence of dust and its relationship with wind levels in East Asia in 2005. During this study, they concluded that increasing wind speed and decreasing vegetation in the region has increased the number of occurrences of dust (Kurosaki and Mikami, 2005). Kim et al.'s 2008 study of dust in Japan showed that the incidence of dust in the region decreased between 1965 and 2004 (Kim et al., 2008). Also in 2009, Sharma et al. Used satellite observations to investigate the occurrence of heavy dust in northeastern India and its relationship to meteorological conditions on March 17, 2009. During this study, they concluded that two months before the occurrence of dust in the region, the weather conditions were dry and without rain. Also, winds have occurred at very high speeds in the region (Sharma et al., 2009). Parsasyrat, and Jamali (2015) study of The Effects of Impermeable Surfaces on the Flooding Possibility in ZarrinShahr, Isfahan Municipal Watershed showed that the Vegetation helps to transfer water to the surface of the earth slowly and the impediment it makes against the flow of water increases the absorption level of the soil. Thus, vegetation has a significant impact on the runoff of the watersheds. Changing the type or density of vegetation can reduce or increase destructive floods or runoffs (Parsasyrat, and Jamali, 2015).

Also, in Iran, research has been conducted on the relationship between the occurrence of dust storms and the impact on vegetation.

Mirzaei studies in 2013 by studying the effect of fine dust on the spectral behavior of strategic plants showed that among the studied indices, the PVI index had the highest correlation (R2 = 0.74) and NDVI spectral index (R2 = 0.65) had the lowest correlation with the number of Shows days with dust (Mirzaei, 2013). In 2016, Pourhashemi et al. Studied the effect of vegetation on the occurrence of dust in Khorasan Razavi province between 2004 and 2013. The results obtained in this study showed that the number of occurrences of dust is related to the distribution of vegetation and the decrease in vegetation increases the number of occurrences of dust in the region (Pourhashemi et al., 2016).

The study of the relationship between vegetation and droughts with the occurrence of dust is of particular importance. The purpose of this study is to investigate the effect of vegetation and wind stress on the occurrence of dust phenomena and to prepare the zoning of the occurrence of dust in the south and southeast of the country during the last 40 years (1980-2020 AD) in 10-year periods.

2. Materials and methods

The main purpose of this study is to investigate the role of dust on land cover and wind stress (velocity) for the study area. For this purpose, NASA Giovanni online modeling method has been used. The study area in the south and southeast of Iran, which is adjacent to Afghanistan and Pakistan, has a latitude of 24 ° to 32 ° and longitude of 54 ° to 70 ° (Figure 1). The climate of the study area has an arid and semi-arid climate. Changes in land cover vegetation in the region and wind stress status during the last 40 years (1980-2020 AD) in 10-year periods were studied. By examining the changes in vegetation and wind stress in the study area, the negative effects of dust can be observed.

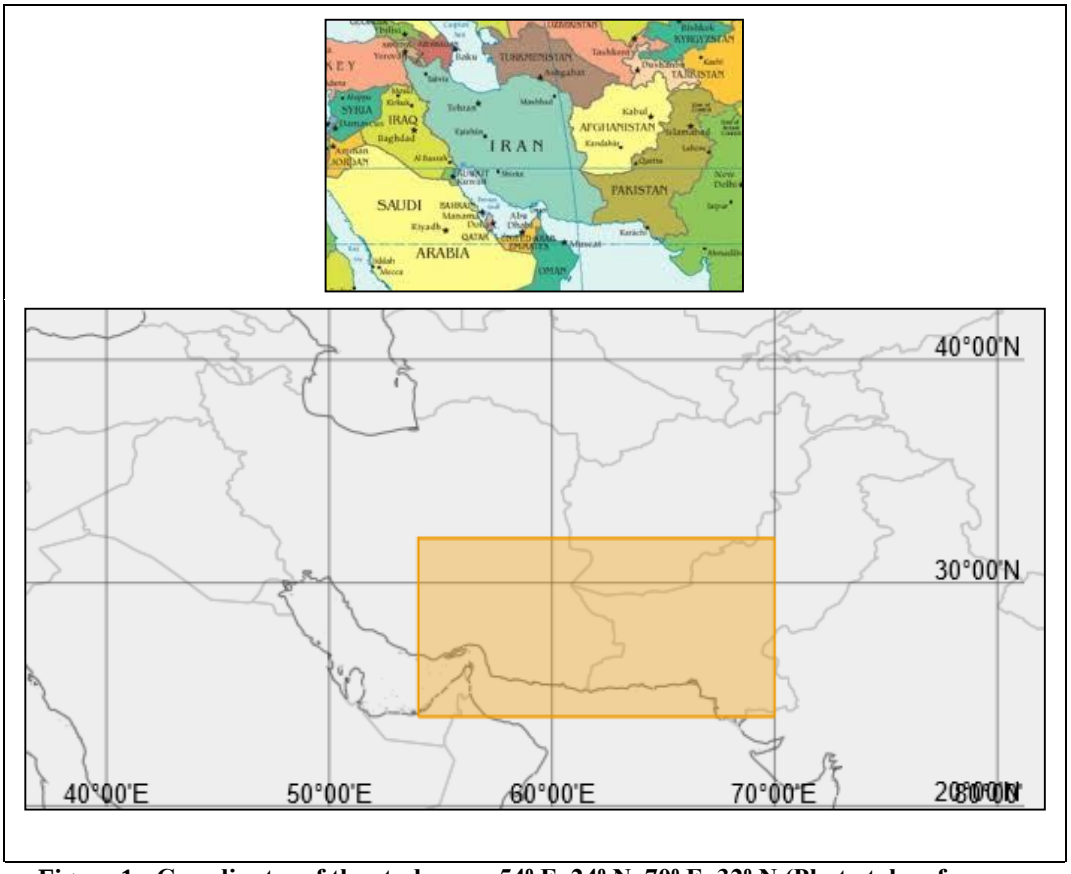


Figure 1 - Coordinates of the study area 54º E, 24º N, 70º E, 32º N (Photo taken from NASA Giovanni site)

In this study, the Giovanni NASA online modeling site was used to investigate the occurrence of dust in the specified geographical area during the last 40 years (1980-2020). The variables used in Giovanni NASA for dust, vegetation, and wind stress are as follows;

- Variable used for dust; Time Averaged Map of Dust Surface Mass Concentration monthly 0.5 x 0.625 deg,

- the variable used for vegetation; Time Averaged Map of CMG 0.05 Deg Monthly EVI monthly 0.05 deg,
- the variable used for wind tension; Time Averaged Map of Northward surface stress monthly 0.5 x 0.625 deg.

3. Results and Discussion

The satellite used to plot the dust situation in the study area is the MERRA-2 satellite. Based on the results of modeling output diagrams for dust, it was found that the vegetation status of the land surface and wind speed (wind stress) in the studied areas are related to the phenomenon of dust. Thus, as can be seen from the diagrams of 10-year periods of dust during the last 40 years in the region, it is clear that the dust situation in the last decade (2010-2020 AD) is an increasing trend compared to the period. Previous vegetation and wind stress have decreased (Figure 2).

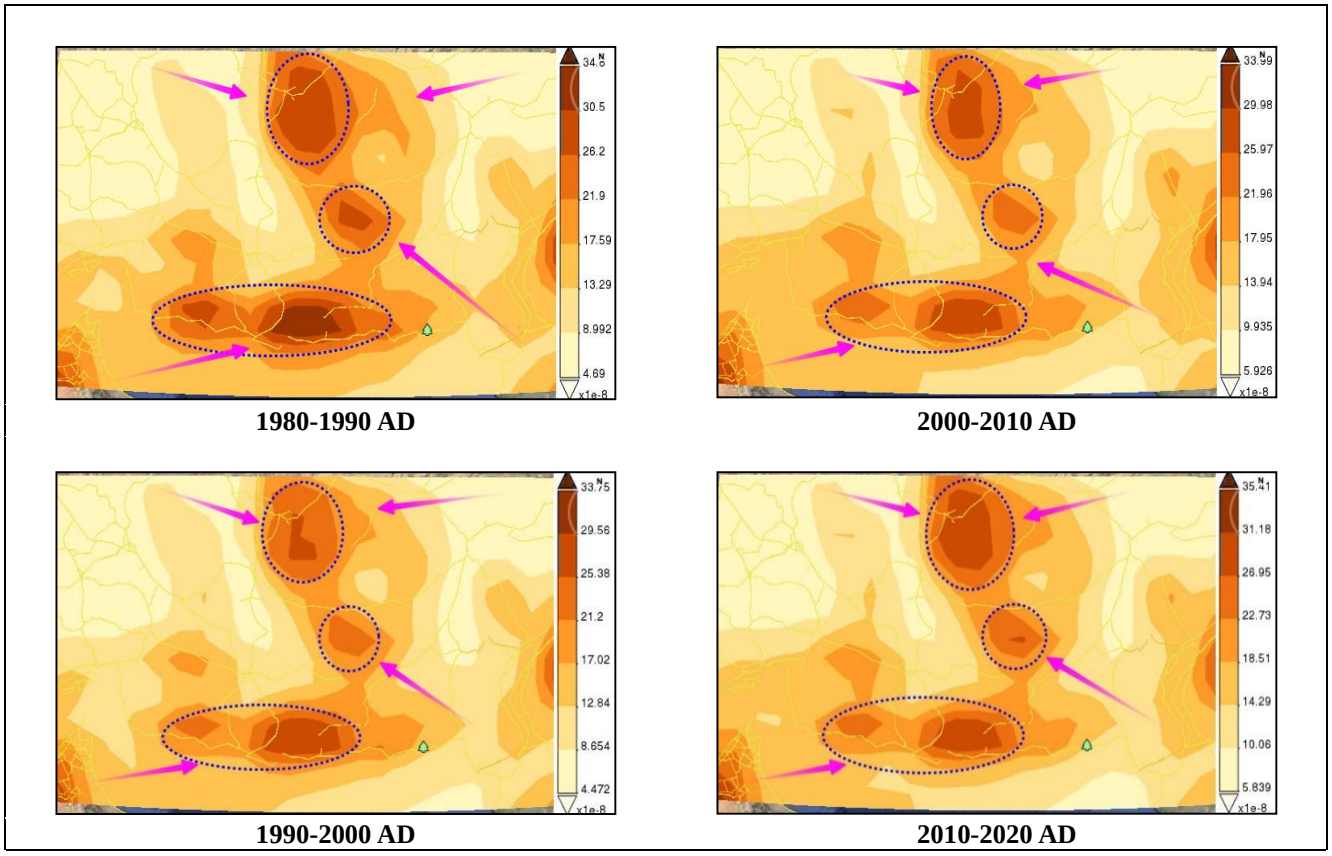


Figure 2 - Dust map in the study area during the last 40 years (1980-2020 AD) in ten-year periods

3.1. Vegetation (EVI)

MODIS-Terra satellite images have been used to determine the vegetation index of the study area. In the output of this type of modeling using the satellite (Jamali and Ghorbani Kalkhajeh 2019) used in this paper, the vegetation surface images are displayed in a period of 20 years (2000-2020 AD) and 10-year periods. Based on the outputs of this model, it was found that the vegetation status in the last decade (2010-2020) was not much different from the previous decade (2000-2010) (Figure 3). In this regard, it is noted that

the status of dust particles in the desired geographical area and this period of 20 years, has increased (Figure 1).

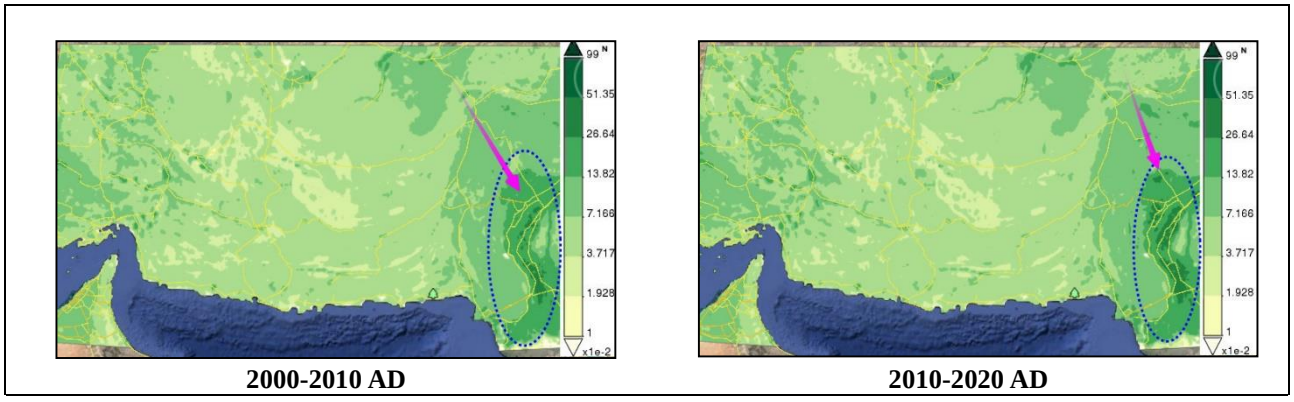
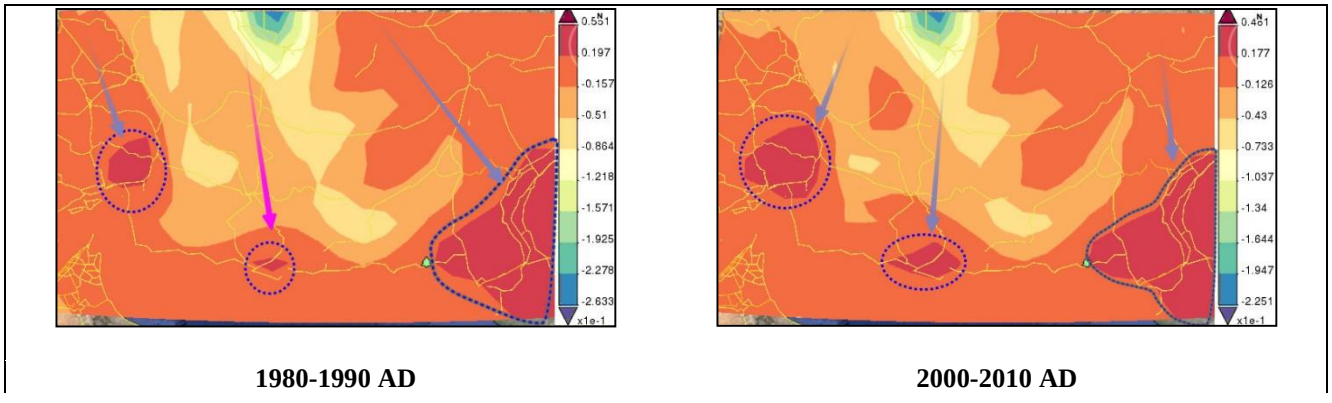


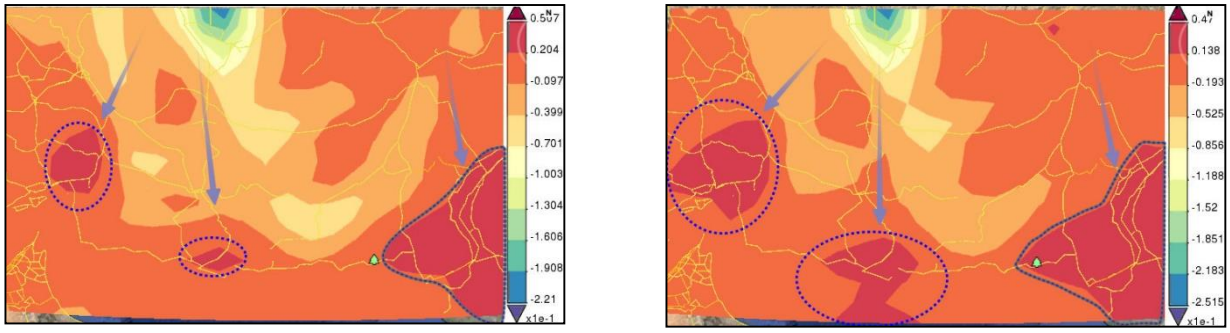
Figure 3 - Vegetation map in the study area during the last 20 years (2000-2020 AD) in ten-year periods

3.2. Tension wind

MERRA-2 satellite imagery has been used to determine the wind stress situation in the study area. According to the output of this type of modeling using the satellite used in this paper, wind stress images during the last 40 years (1980-2020 AD) and in 10-year periods have been displayed. Based on the outputs of this modeling, it was found that the wind stress state had a decreasing trend (Figure 4). Therefore, to investigate the relationship between wind stress and dust during the period of this research, it can be concluded that according to the dust maps that during the last 40 years, the incidence of dust has been increasing, and the trend Wind stress has decreased over these 40 years.

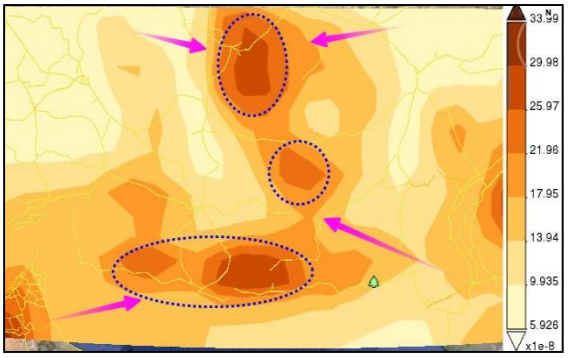
Considering the comparisons made between the vegetation condition and wind stress compared to the dust phenomenon conditions in the last two decades (2000-2020 AD), it can be concluded that the dust situation has increased in these two decades. In this regard, diagrams of dust status, vegetation, and wind stress during the years 2000-2000 and 2010-2020 are shown in Figures 5 and 6.



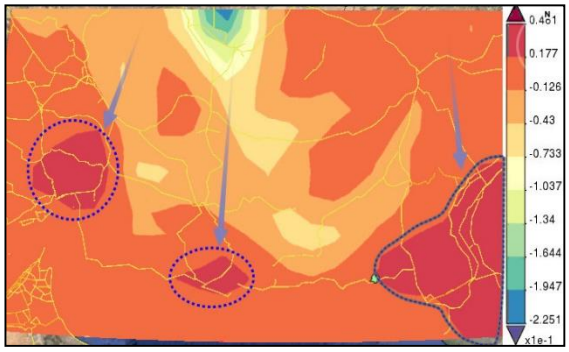


1990-2000 AD **2010-2020 AD**

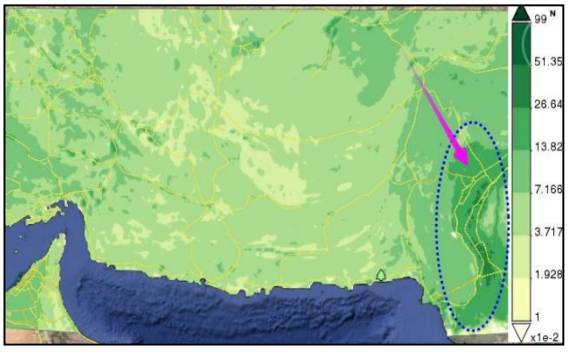
Figure 4 - Wind stress map in the study area during the last 40 years (1980-2020 AD) in ten-year periods



Dust map from 2000-2010



Wind stress map from 2000-2010



Vegetation map from 2000-2010

Figure 5 - Dust, vegetation and wind maps for the years 2000-2010

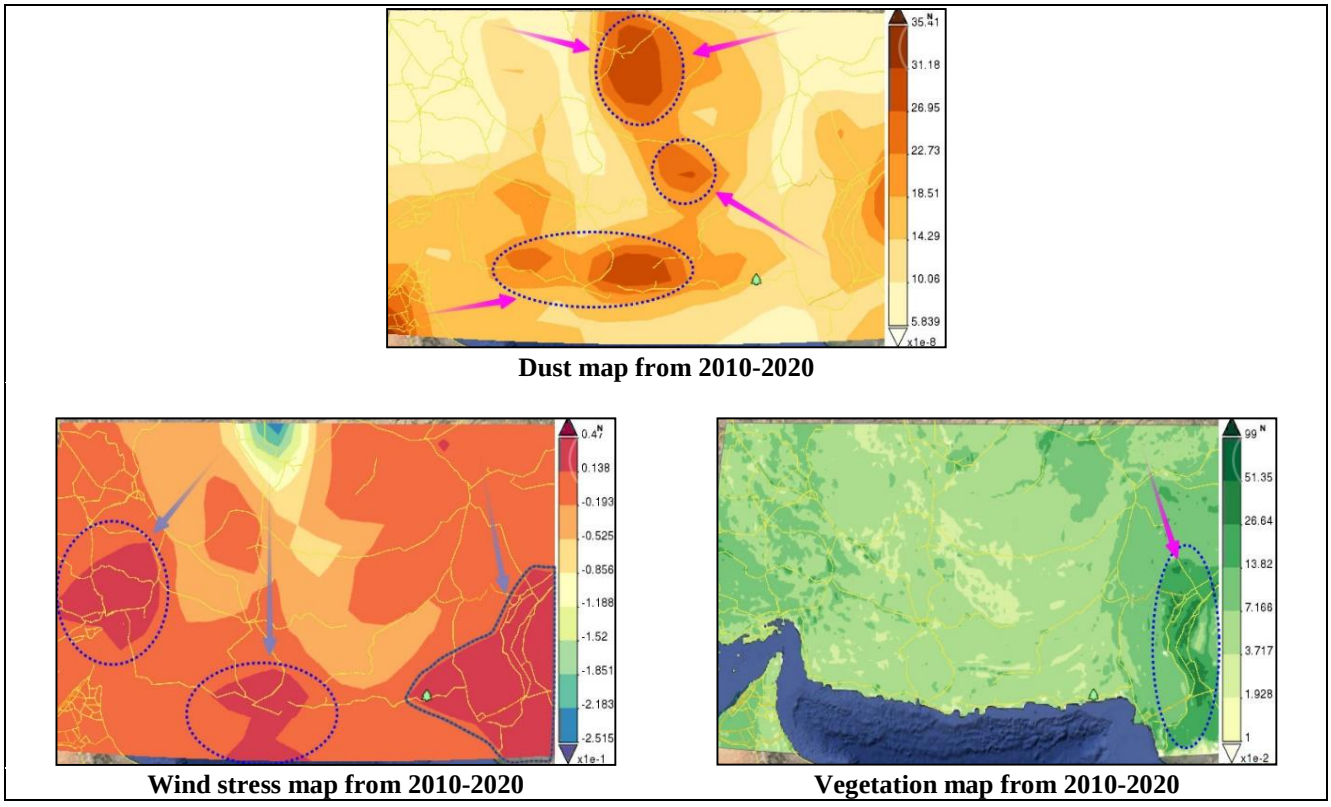
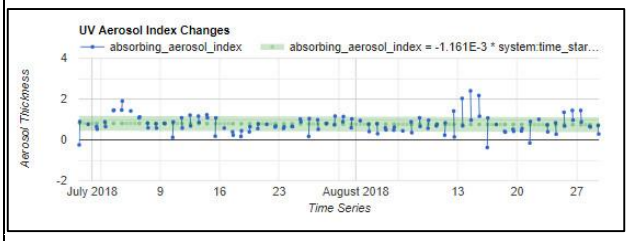


Figure 6- Dust, vegetation and wind maps for the years 2010-2020

Today, the science of remote sensing is changing a fundamental paradigm in which one- or two-image interpretation approaches pave the way for a wide range of data-rich applications. These improvements have been facilitated by the online satellite image processing system (GEE) (Majidi and Ahmad, 1: 2018). Google Earth Engine is a computing platform recently published by Google for petabyte-scale scientific analysis and visualization of terrestrial data. Using a dedicated high-performance computing infrastructure allows researchers to easily and quickly access more than 30 years of free and public data archiving for global remote sensing applications. In this way, many limitations related to data loading, storage, and processing are easily removed (Nascetti et al., 2017). Google Earth Engine, a specialized remote sensing system under the web (GEE), is one of the information resources and software used in time monitoring of climate change and weather conditions. Using this system, many satellite image processing processes Have made it easier in recent years. As shown in Figure 7, the dust monitoring in Google Earth Engine is three years from June 2018 to February 2021, it can be seen from these images that the dust phenomenon has decreased during the period analyzed in the study area. In this regard, the access code to Google Earth Engine in the study area is the following address:

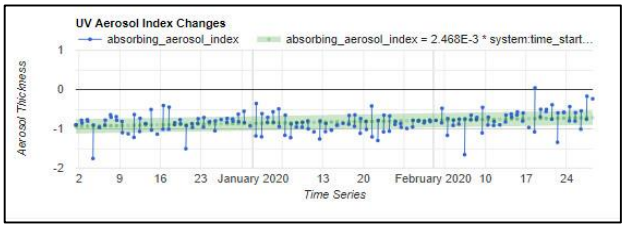
https://code.earthengine.google.com/1d2984ab7d4ffd68de07577d727713a1 taken quarterly and quarterly using long-term monthly images of Sentinel5 satellites in the Google Earth Engine.



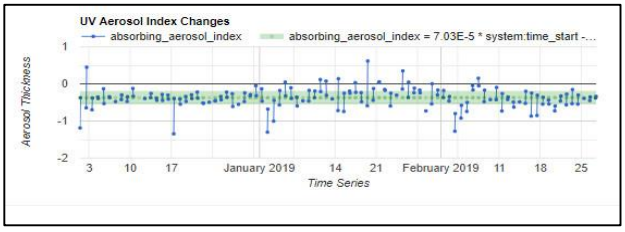
01/06/2018 to 30/08/2018 (Summer season)

01/09/2019 to 30/11/2019 (Autumn season)

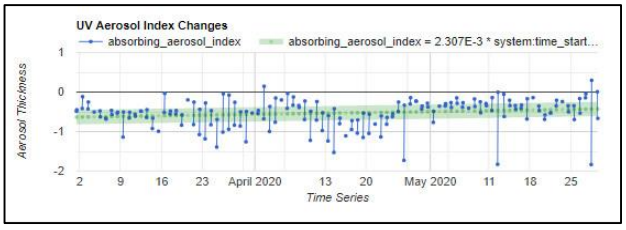
01/09/2018 to 30/11/2018 (Autumn season)



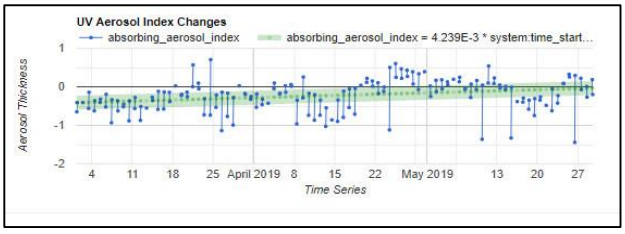
01/12/2019 to 29/02/2020 (Winter season)



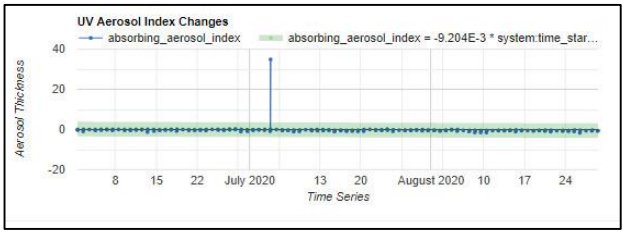
01/12/2018 to 28/02/2019 (Winter season)



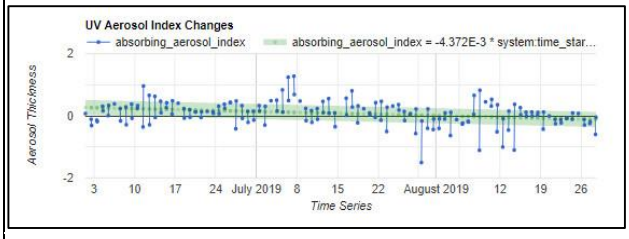
01/03/2020 to 30/05/2020 (Spring season)



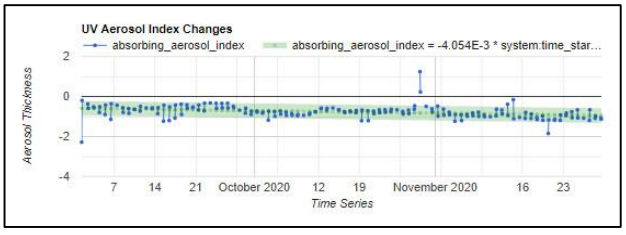
01/03/2019 to 30/05/2019 (Spring season)



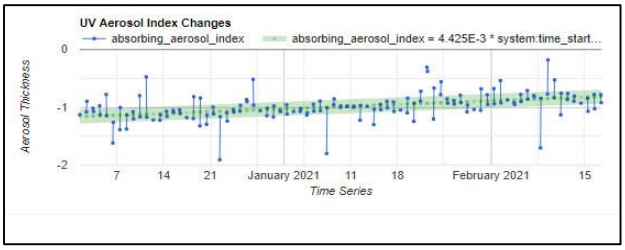
01/03/2019 to 30/05/2019 (Spring season)



01/06/2019 to 29/08/2019 (Summer season)



01/09/2020 to 30/11/2020 (Autumn season)



01/12/2020 to 20/02/2021 (Winter season)

Figure 7 - Chart of dust changes in the study area seasonally and quarterly periods from 01/06/2018 to 20/02/2021 (Maps taken from Google Earth Engine site)

4. Conclusions and suggestions

Dust storms affect environmental cycles and cause climate change, so examining dust conditions can help you understand how climate change; Therefore, the ability to detect and detect dust and predict it is important. The phenomenon of dust is a type of air pollution, which has irreversible effects on all aspects of human life. Therefore, one of the most important consequences of climate change in recent years is the dust situation, which has directly and indirectly affected different parts of society.

The results showed that in recent years in the study area (south and southeast of the country) the occurrence of dust has increased. Also in the last decade of research (2010-2020), the highest occurrence of dust occurred in the study area. The results showed that the occurrence of dust reacts to the state of vegetation and wind stress. According to Figure 2, which has increased dust in the last decade (2010-2020), vegetation is almost constant in these two decades (Figure 3), and wind stress (Figure 4) has decreased in the last decade. Vegetation acts as a barrier to the movement of dust particles and stops them from moving. The results indicate that the condition of the vegetation surface is related to the number of occurrences of dust so that with the increase of vegetation, the occurrence of dust will decrease. In this regard, and based on Figure 7, the dust phenomenon was analyzed during the last three years in quarterly periods, it turned out that this phenomenon has decreased, in general, it can be pointed out that effective environmental measures have been taken to reduce dust in the study area.

In this regard, a proposal to reduce dust and increase the level of vegetation is presented:

1- Planting tree species resistant to drought, heat, cold, and dust, such as hawthorn tree species, juniper.
2- By applying for management programs in rangeland areas, the dust phenomenon can be controlled as much as possible.
3- Since one of the causes of drought is the occurrence of dust, it is recommended to use artificial rain.
4- Planning to prevent the drying of wetlands in the region is emphasized.
5. Establishing a regional pact between related countries to combat the dust phenomenon can be effective.

Declarations

Funding Information (Private funding by authors, or funding's ID)
Conflict of Interest /Competing interests (None)
Availability of Data and Material (Data are available when requested)
Code availability (GEE code)

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