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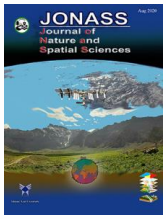

Original Article

Analysis of dust changes using satellite images in Giovanni NASA and Sentinel-5P in Google Earth Engine in western Iran

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ABSTRACT

Background and objective: Dust is one of the most important destructive climatic phenomena that cause great damage to human health and the environment every year. In Iran, due to having a 23% share of dust storms in the world and the transfer of dust from Iraq and Saudi Arabia, it is necessary to study it. Dust storms in Iran during the last few years have been a serious crisis in the western and south-western provinces of the country, including Khuzestan province, and have had dangerous consequences in the fields of environment, health, and economy.

Materials and methods: This study examines the changes in the dust during the last 40 years (1980-2020) in the western and south-western regions of Iran and Iran's neighbours (Kuwait, east and southeast of Iraq, and northern Saudi Arabia). And its relationship to wind stress and vegetation has been investigated using MERRA-2 satellite imagery and model maps from the Giovanni site. Dust monitoring from June 2018 to February 2021 has also been analysed through Google Earth Engine, a specialized web-based remote sensing system.

Results and conclusion: The results show that during the 40 years under study, especially from 2020 to 2010, the volume of dust and wind stress in the study area has increased significantly. Also, dust, vegetation, wind stress have had related changes over 40 years, so that wind stress is directly related to the amount of dust and increases its effects. Also, in areas with more vegetation, there is less dust.

1. Introduction

Dust is a climate-atmospheric disaster that affects various aspects of human life. The occurrence of dust in arid and semi-arid regions is much greater and the living conditions in many arid and semi-arid regions of Asia have been significantly affected (Middletonet, et al., 2019; Sokolik et al., 2020). Iran is located in a region with an arid climate and more than 30% of its area covers arid and semi-arid regions (Modarres, 2008). Studies show that this phenomenon is one of the most destructive and common phenomena in arid regions of Iran and the world that can have harmful effects on human life and other living organisms (Omidvar and Omidi, 2013). Studies on the frequency of dusty days in the country

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show that the central regions of Iran have the dustiest days. Due to the proximity of the western and southwestern regions of the country to the large deserts of neighboring countries, dusty days in these regions are significant and have increased in recent years. Most dust storms occur in this area in summer and spring (Kutiel and Furman, 2003; He et al. 2020; He et al. 2021).

Statistics of the Meteorological Organization of Iran show that the average of dusty days during the last 50 years in the cities of Ahvaz, Abadan, Bushehr, and Kermanshah have been on average 75, 76, 68, and 27 days during the year, respectively. According to the researchers, dust storms are the cause of acute respiratory diseases, asthma, allergies, asthma, and water pollution (Achudume and Oladipo, 2009). A dust storm is a complex process that is influenced by the interactions of atmospheric systems and is basically caused by conditions such as high wind speed, bare soil, and dry air. One of the main causes of this phenomenon is relatively strong winds on deserts with favorable conditions for creating dust (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 levels of the atmosphere. Suspended particles, depending on the size of their diameter in the layers, are arranged from bottom to top, respectively, and then move with the air currents in those levels, covering large areas (Akhlaq et al., 2012). According to the definition of the World Meteorological Organization (WMO), the occurrence of dust in terms of horizontal visibility to four categories 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, vegetation composition, and wind speed (Prospero et al., 2002).

The results of these studies showed that with increasing dust emission, surface properties such as vegetation and soil moisture have decreased. In 2005, Verossaki and Mikami examined recent dust events and their relationship to wind levels in East Asia. The results showed that with increasing wind stress and decreasing vegetation in dust harvesting areas in East Asia, the number of occurrences of dust has increased. During the years of drought, vegetation decreased and the intensity of dust increased significantly (Pourhashemi et al., 2015). Due to the increase of dust in recent years in the study area, it is necessary to consider this phenomenon and other factors such as vegetation and wind flow in this area. The objective is the analysis of dust changes using satellite images in Giovanni NASA and Sentinel 5P in Google Earth Engine in western Iran.

2. Materials and methods

In this research, the library method has been used and the required data on dust, wind, and vegetation have been extracted from NASA's Giovanni website (at https://giovanni.gsfc.nasa.gov/giovanni/) and in the form of a map is provided. Dust monitoring has also been analyzed from June 2018 to February 2021 through Google Earth Engine (GEE), a specialized web-based remote sensing system using Sentinel 5p satellite imagery.

Giovanni is a free application for online data modeling, providing researchers with advanced capabilities for exploring and analyzing data using satellite imagery. With the ability to visualize and analyze via the World Wide Web, Giovanni accelerates the multi-step process of data discovery, data acquisition, data management, and ultimately data analysis in the investigation of geophysical events and processes with remote sensing data (Berrick et al., 2009).

Launched in late 2010, Google Earth Engine is a powerful remote sensing tool for extracting useful information from satellite imagery, providing more advanced opportunities for Earth observation studies (Kumar and, Mutanga 2018). The Google Earth system is a cloud-based platform engine for planet-scale geospatial analysis that demonstrates Google's extensive computing capabilities in a variety of high-impact areas, including deforestation, drought, disease, food security, water management, and monitoring. Provides climate and environmental protection, etc. on various scales (from local to global

scale) (Gorelick et al., 2017). The scope of research, as shown in Fig. 1, is the western and southwest regions of Iran and Iran's neighbors (Kuwait, eastern and southeast Iraq and northern Saudi Arabia) is with geographical coordinates of 40˚E, 27˚N, 54˚E, 34˚ N.

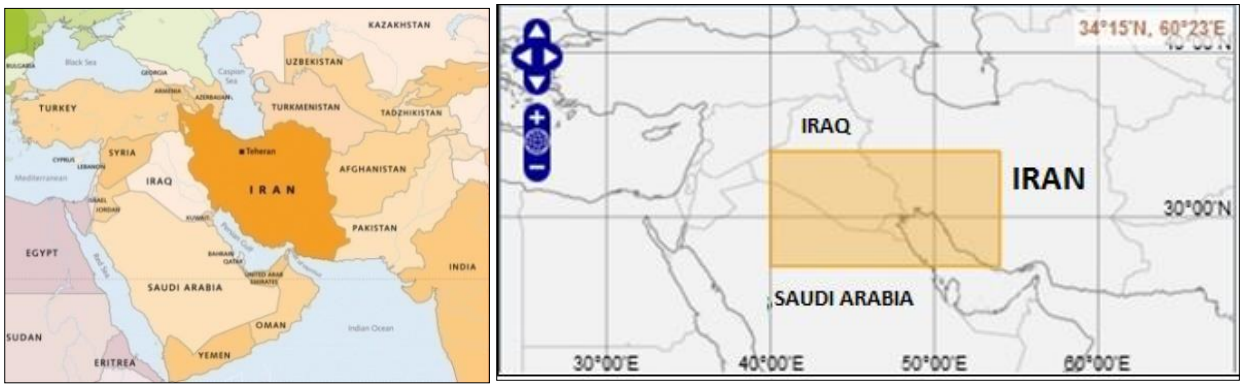


Fig. 1- Research study area (taken from the site Giovanni)

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;

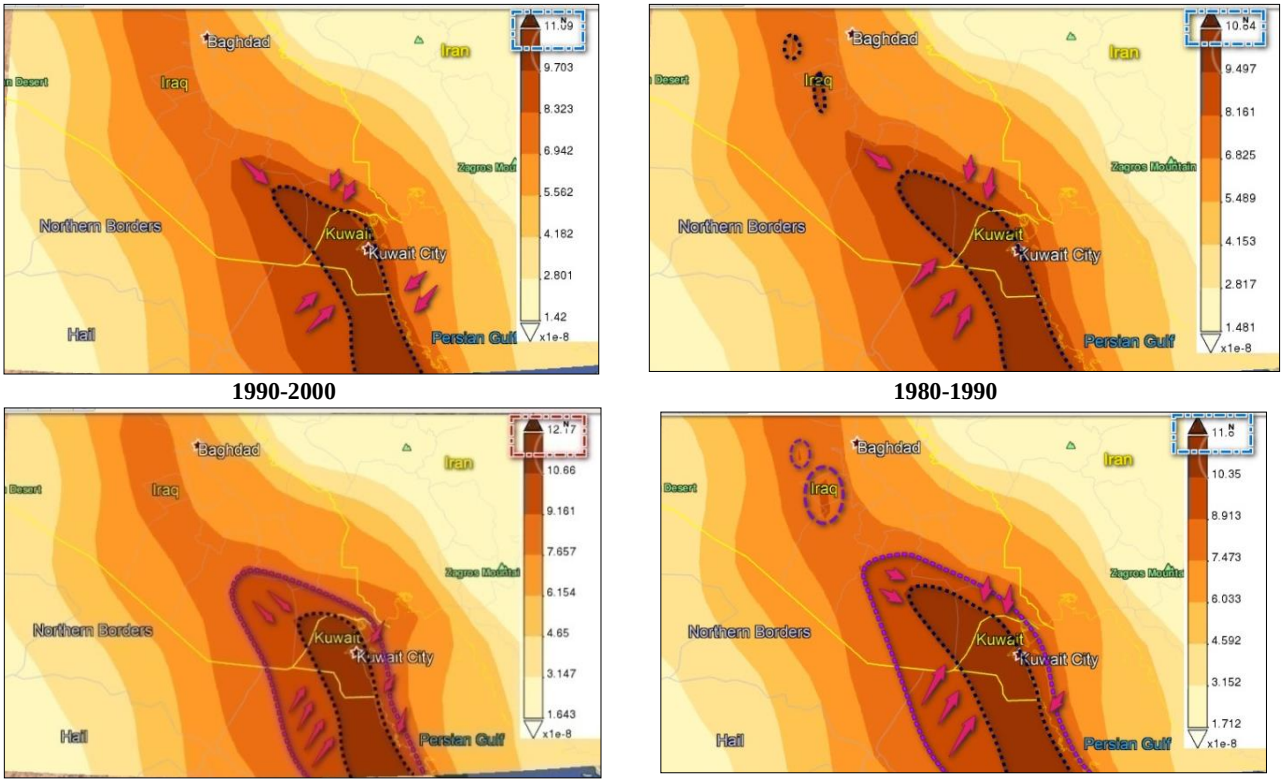
- Variable used for dust; Time Averaged Map of Dust Surface Mass Concentration monthly 0.5 x 0.625 deg Usage
- Variable for wind stress; Time Averaged Map of Eastward surface stress monthly 0.5 x 0.625 deg
- Variable used for vegetation; Time Averaged Map of Greenness fraction monthly 0.5 x 0.625 deg

3. Results and Discussion

Equations To study the changes in the dust during the last 40 years (1980-2020) in the western and southwest regions of Iran and Iran's neighbors (Kuwait, eastern and southeast Iraq, and northern Saudi Arabia) and communication It is prepared with wind and vegetation using satellite images and modeled maps from NASA's Giovanni site and is presented below.

3.1. Dust

Dust change maps show that the highest volume of dust is related to Kuwait, the southern regions of Iraq, and northeast Saudi Arabia, and in the study area in Iran, the highest volume of dust is related to Khuzestan province. According to the following figures, the intensity and volume of dust has increased during the last 40 years, especially in the mentioned areas, and has also increased significantly from 2010 to 2020. (Fig. 2)



1990-2000 **1980-1990**

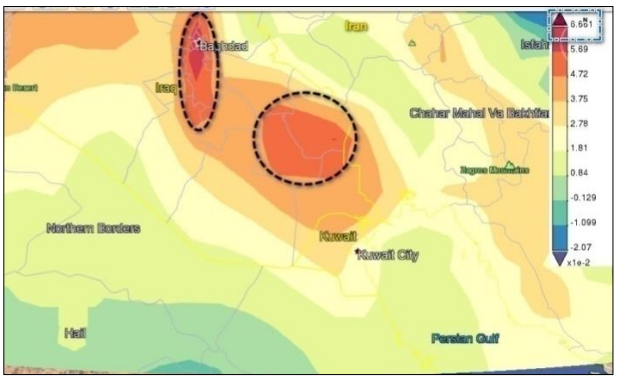
2010-2020 **2000-2010**

Fig. 2 - Map of dust changes in the study area during the last 40 years (1980-2020) in ten-year periods (taken from the site (Giovanni)

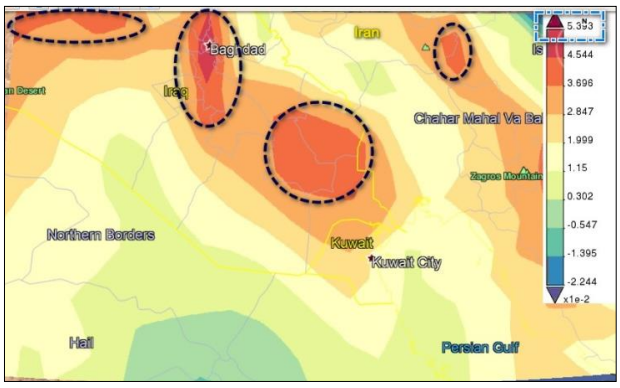
As it is clear from the above maps, dust enters Iran from neighboring countries (Iraq, Kuwait, and Saudi Arabia), and in the study area in Iran, it is most concentrated in Khuzestan province and by dealing with forests, Zagros Mountains, and effects. It decreases. One of the most important reasons for the release of fine dust is the de-wetting in Iraq, which has caused fine soil particles to rise from the surface of the lagoons. In recent years, due to droughts and events in Iraq, new areas have been added to the source of dust and the intensity of dust has greatly increased.

3.2. Wind stress

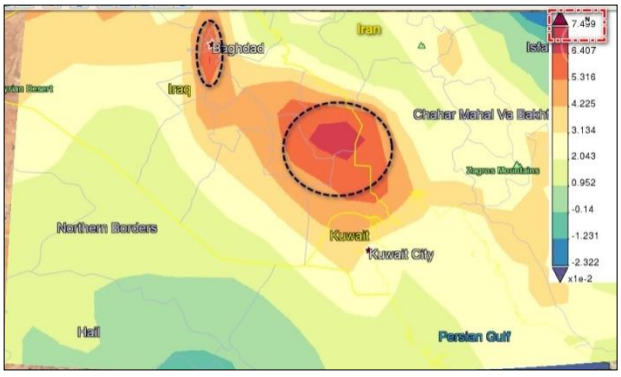
Maps related to wind stress changes show that the highest wind stress is related to the northern and eastern regions of Iraq and the Khuzestan province of Iran. According to the following figures, wind stress has increased during the last 40 years, especially in the above-mentioned areas, and has also increased significantly from 2010 to 2020. (Fig. 3)



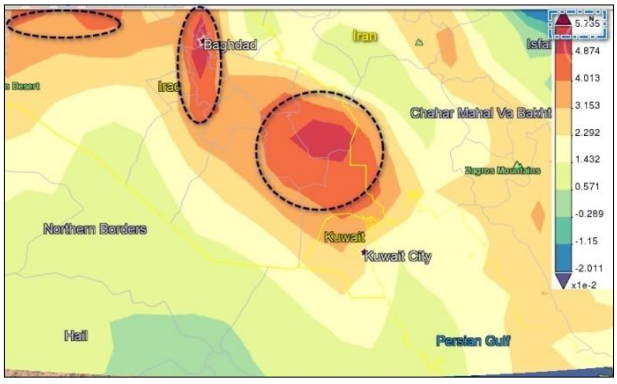
1990-2000



1980-1990



2010-2020



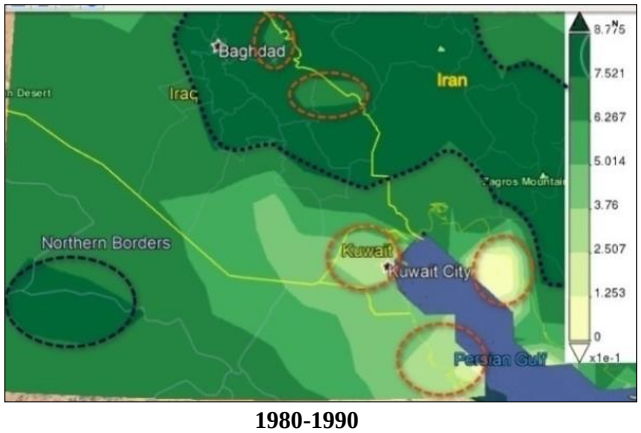
2000-2010

Fig. 3- Map of wind stress changes in the study area during the last 40 years (1980-2020) in ten-year periods (taken from the site (Giovanni)

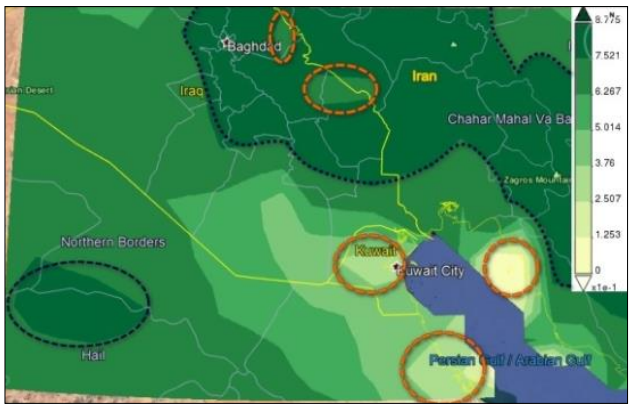
3.3. Vegetation

Examination of vegetation maps shows that this factor is almost constant and no significant changes are observed and there is the highest volume of vegetation in the forest areas of Zagros, eastern Iraq. (Fig. 4)

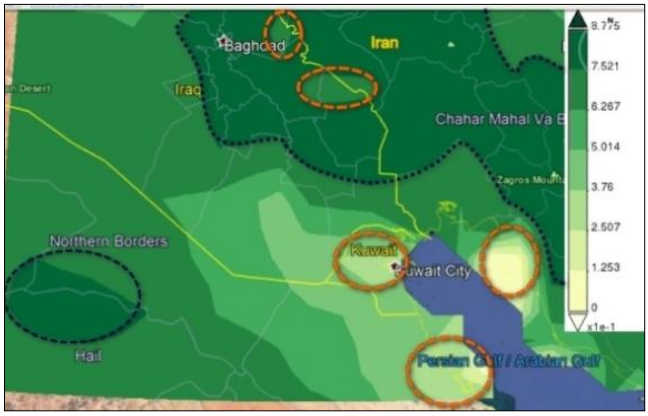
1990-2000



1980-1990



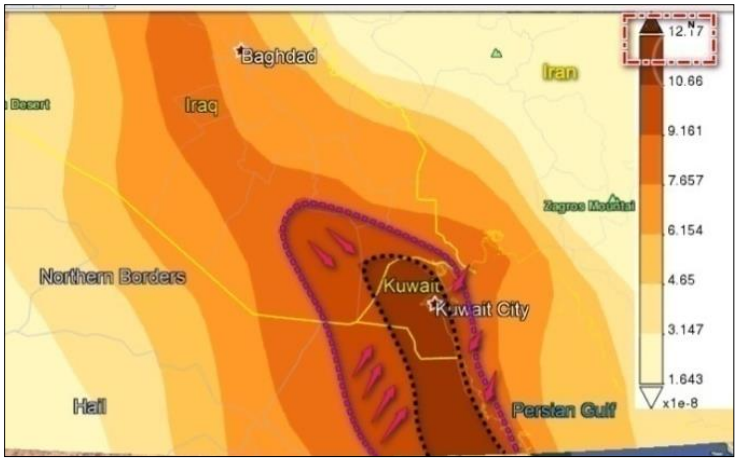
2010-2020



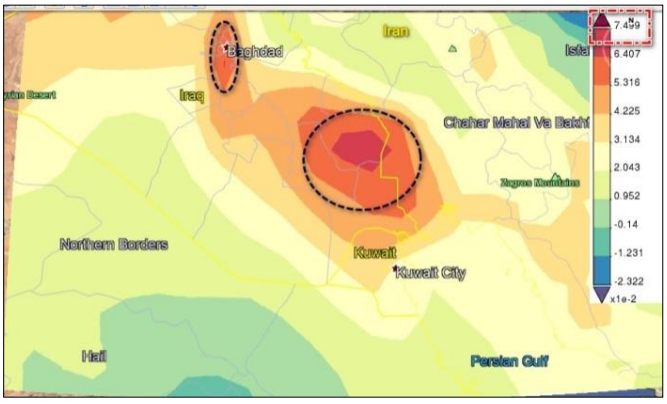
2000-2010

Fig. 4 - Map of vegetation changes in the study area during the last 40 years (1980-2020) in the form of ten-year periods (taken from the site (Giovanni)

Study of dust, wind stress, and vegetation together, considering that the increase in dust volume and wind stress in the period of 2010-2020 shows a significant relationship between them. (Fig. 5)



Map of dust changes in the years 2010-2020

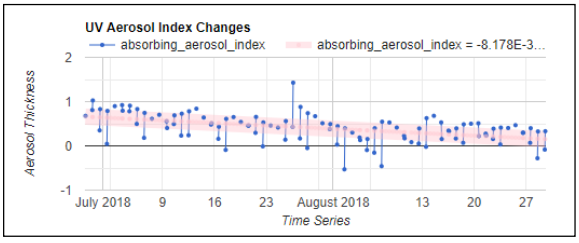


Map of vegetation changes in the years 2010-2020 **Map of wind stress changes in the years 2010-2020**

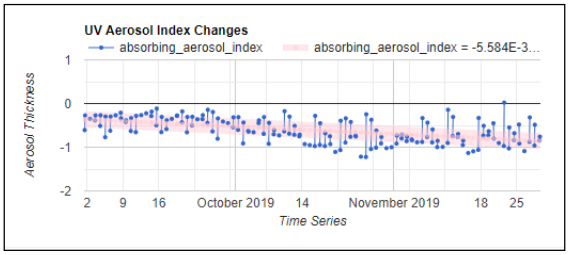
Fig. 5 - Dust, wind stress and vegetation maps in the years 2010-2020

Leading studies show that dust, vegetation, wind flow, and stress have been associated with changes over 40 years, so that wind flow and stress are directly related to the amount of dust and increase its effects. Also, in areas with more vegetation, there is less dust, so that the green factor or vegetation in the area acts as a preventive factor and can reduce the destructive and harmful effects of dust. Rising dust during these years is an environmental and human warning that decision-makers must strive to preserve the environment and vegetation and reduce environmental pollution.

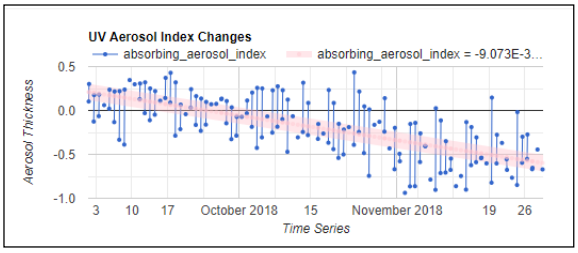
Other sources of information and software used in the timely monitoring of climate change and weather conditions include the Google Earth Engine, a specialized remote sensing system under the Google Earth Web Engine. As you can see, Fig. 6 shows the dust monitoring in Google Earth Engine on an annual basis from June 2018 to February 2021, from which it can be seen that the dust phenomenon is analyzed over a period of time. Taken in the study area, decreased. The results of this study were consistent with other studies such as (Jamali et al. 2021; Jamali et al. 2020; Jamali and Ghorbani Kalkhajeh 2019; Parsasyrat and Jamali 2015).



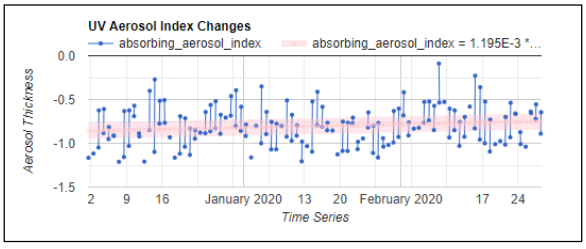
(summer) 2018/06/01 to 2018/08/30



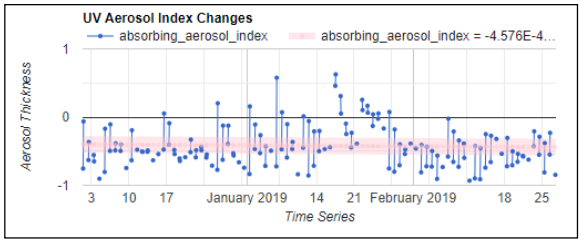
(fall) 2019/09/01 to 2019/11/30



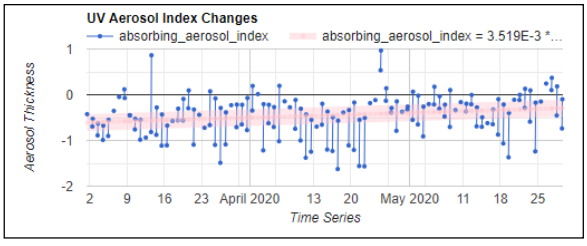
(fall) 2018/09/01 to 2018/11/30



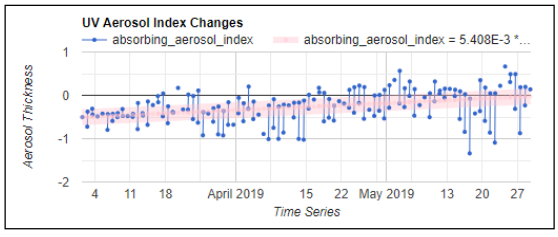
(winter) 2019/12/01 to 2020/02/29

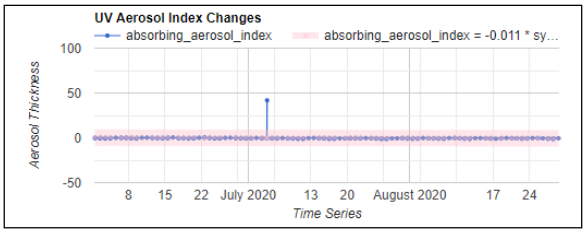


(winter) 2018/12/01 to 2019/02/28

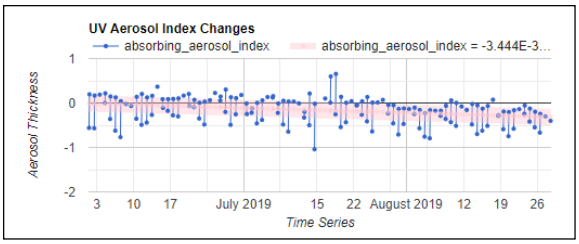


(Spring) 2020/03/01 to 2020/05/30

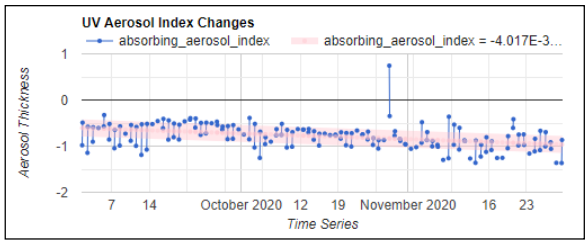




(Spring) 2019/03/01 to 2019/05/30

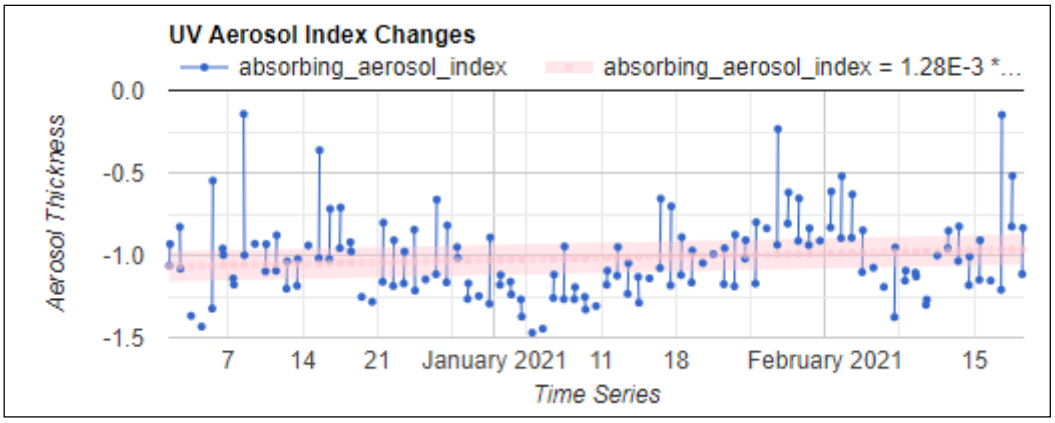


(summer) 2020/06/01 to 2020/08/30



(summer) 2019/06/01 to 2019/08/29

(fall) 2020/09/01 to 2020/11/30



(winter) 2020/12/01 to 2021/02/20

Fig. 6 - Chart of dust changes in the study area on a quarterly basis and quarterly periods from 2018/06/01 to 2021/02/20 (Maps taken from Google Earth Engine site)

4. Conclusions and suggestions

All Dust storms affect environmental cycles and cause climate change, so examining dust conditions can help to understand how climate change; Therefore, the ability to detect and detect dust and predict it is important. The phenomenon of dust is actually 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 sections of society.

In expressing the result of this study, it should be said that during the 40 years under study (1980-1980), especially from 2010 to 2020, the volume of dust and wind stress in the study area has increased significantly. Also, considering the significant relationship between pollen, dust, vegetation and wind flow, and stress in the study area (Fig. 5), it can be concluded that vegetation has an indirect relationship with the amount of dust in the case area. It has been studied and also the climatic factor of wind intensifies the effects of dust in the region. Therefore, it can be concluded that increasing vegetation in this area can reduce the harmful effects of dust and also reduce the amount of dust. Therefore, the results of this study also confirm the results of the research of researchers such as Gillette et al., Reynolds et al., Washington et al., Mahwald et al., Bryant et al., Abdoli et al., And Rusaki and Mikami. So that with the increase of wind stress and decrease of vegetation, the occurrence of dust has increased. In this regard, based on Fig. 6, which analyzed the dust phenomenon during the last three years and in quarterly periods, it was found that this phenomenon has decreased, which can be generally mentioned that effective measures Environmental measures have been taken to reduce dust in the study area.

As suggested by planners and decision-makers, they can stabilize sand by methods such as preserving and rehabilitating forests and pastures with the participation of local communities, organizations, and related bodies, conducting watershed and aquifer management operations, creating green space belts around cities, and maintaining and expanding urban green space. Through planting and mulching, use of artificial rain, prevention of drying of the region's wetlands, development of a regional agreement between the related countries on dust control, etc. to reduce the destructive effects of the environment and human health caused by the round phenomenon and dust the area to take an effective step.

Declarations

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Conflict of Interest /Competing interests (None)

Availability of Data and Material (Data are available when requested)

Code availability (Yes, in GEE https://code.earthengine.google.com)

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