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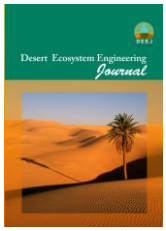

Analysis of Dust Aerosol Optical Depth Changes and Their Frequency in Different Areas of Jazmourian Basin Using Remote Sensing Technology

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Extended Abstract

Introduction: In recent decades, dust phenomena have emerged as one of the most destructive natural hazards in arid and semi-arid regions, profoundly impacting various aspects of life. These regions, characterized by low humidity, sparse vegetation cover, and vulnerable ecosystems, are inherently prone to dust storms. Iran, owing to its geographical position, is no exception and frequently grapples with this phenomenon, primarily driven by factors such as drought, climatic variations, and human activities. Dust storms pose numerous adverse effects on both the environment and the economy, including air pollution, ecosystem degradation, diminished soil fertility, declining agricultural productivity, and escalating healthcare expenses. The occurrence and frequency of dust events in a given area are influenced by a range of factors, including high wind speeds, low relative humidity, exposed soil surfaces, dry land conditions, local and regional weather systems, short-term precipitation deficits, extensive land degradation, prolonged drought periods, land-use changes, and anthropogenic activities. Airborne particles, especially dust, play a vital role in the climate system, affecting both global temperatures and regional weather patterns. Aerosol Optical Depth (AOD) serves as a pivotal parameter for assessing air quality and investigating particulate pollution. It quantifies the extent to which particles in the atmosphere absorb or scatter sunlight, with higher values indicating increased concentrations of suspended particles, including dust. Particularly in arid and semi-arid zones where dust constitutes a major pollutant, AOD proves to be an effective tool for weather monitoring and air quality forecasting. Various methodologies are employed to measure AOD. Ground-based aerosol robotic networks offer precise spectral aerosol data at specific locations but lack comprehensive spatial coverage. Regional models of atmospheric particulate matter analysis are also in use. However, satellite data, with their high revisit frequency and broad spatial scope, facilitate extensive investigations of dust phenomena. Among these, the MODIS (Moderate Resolution Imaging Spectroradiometer) sensors aboard the Terra and Aqua satellites are extensively utilized. The MCD19A2 product, with a spatial resolution of 1 kilometer, is particularly valuable for studying aerosol properties. Its accuracy is enhanced through the combined use of the Deep Blue and Dark Target algorithms, which are specifically designed to measure optical depth and retrieve particulate matter concentrations. In general, analyzing long-term trends in aerosol optical depth and the frequency of dust aerosol events is crucial for identifying vulnerable areas and devising effective mitigation strategies. While data from synoptic stations can be useful for such analyses, their sparse distribution in the Jazmurian basin limits their effectiveness. Hence, remote sensing technologies and satellite-derived products prove instrumental for comprehensive assessments. Accordingly, the primary aim of this study is to analyze the long-term (2001–2022) trends in dust aerosol optical depth and their frequency within

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the sub-basins of the Jazmurian basin, utilizing the MODIS MCD19A2 product. The analysis will be conducted across monthly, seasonal, and annual timescales, employing the Mann-Kendall statistical test to identify significant trends and changes over the two-decade period.

Materials and Methods: In this study, 15 sub-basins of the Jazmurian basin were designated as study areas to monitor variations in air particulate matter concentrations. The aerosol optical depth (AOD) product from the MODIS sensor (MCD19A2) was employed for continuous assessment of dust aerosol depths across these sub-basins. Values of optical depth exceeding 0.5 were considered significant, given their strong correlation with numerous parameters related to dust activity measurement. Data for the MCD19A2 satellite product, with a daily temporal resolution and a spatial resolution of 1 kilometer, were separately downloaded for each sub-basin through the Google Earth Engine platform, covering the period from 2001 to 2022. After extracting events where AOD > 0.5, the average AOD values were calculated at monthly, seasonal, and annual scales. To analyze the trends in temporal variations of dust aerosol optical depth, the Mann-Kendall test was employed. This non-parametric statistical method is widely used in the analysis of meteorological time series. Its advantages include its suitability for data that do not follow a specific statistical distribution and its robustness against the influence of extreme values. The null hypothesis of the Mann-Kendall test indicates the presence of randomness and no trend in the data series, while acceptance of the alternative hypothesis suggests a significant trend exists.

Results and Discussion: The analysis revealed that, at the monthly scale, the lowest and highest frequencies of dust events occurred in October/November and July, respectively. The minimum aerosol optical depth (AOD) values were recorded in October, while the maximum AOD was observed in January/December. Seasonally, the highest aerosol optical depth and dust occurrence frequency were associated with summer and spring, whereas the autumn season exhibited the lowest values. On an annual basis, the lowest frequency of dust events was recorded in 2002 within the Mohammadabad sub-basin, while the highest occurred in 2011 and 2012 in the Hamoun sub-basin. The minimum aerosol concentration was observed in 2002, whereas the maximum levels appeared in 2012, 2016, and 2022. Additionally, it was found that both parameters—dust event frequency and aerosol concentration—showed a decreasing trend in June, which was statistically significant for concentration values in the southeastern regions of the Jazmurian basin. Conversely, most sub-basins exhibited an increasing trend during other months. At the annual scale, over 50% of the sub-basins demonstrated an increasing trend, with this trend being statistically significant in the Rabar, Jiroft, Faryab, Dashtab, and Esfandagheh sub-basins. Seasonally, dust activity also showed an upward trend. The maximum increase in dust event frequency was observed in winter and spring, while the greatest rise in aerosol depth occurred in winter and summer. Given these findings, implementing dust control strategies and adopting improved natural resource management practices are essential—particularly in sub-basins exhibiting significant upward trends—in order to mitigate serious threats to public health and enhance the quality of life for the local population.

Keywords: Aerosol Optical Depth, Wind Erosion, Dust Storm, Land Degradation, Air Quality.