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Investigation of spatial and temporal changes in atmospheric aerosol using aerosol optical depth in Southeastern Iran

Maryam Mirakbari, Zohre Ebrahimi Khusfi

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Abstract

Background and Objective The Aerosol Optical Depth index is one of the most commonly used indicators for assessing air pollution in various regions, especially arid and semi-arid areas. The arid and semi-arid regions are the main sources of dust particles. Due to locating in the arid and semi-arid region, Iran faces dust storms several times over the year, which have caused irreparable environmental and socio-economic damages to different parts of the country. The southeastern of Iran is one of these regions that is affected by dust storms in the first half of the year (early spring to late summer) due to 120-day winds, and large amounts of sand and dust particles enter the atmosphere each year. Therefore, it is important to study the temporal and spatial changes of suspended particles in the atmosphere, of which dust is a major part of aerosols in these regions. In fact, knowing the temporal and spatial changes of suspended particles can be helpful in providing appropriate solutions to reduce the damages caused by these particles.

In this study, due to lack of ground-based aerosol gauge station, aerosol optical depth feature was considered based on the Aerosol Optical Depth (AOD) product of MODIS sensor to monitor and analyze spatial and temporal changes of aerosol concentrations in Iran during a period of 18 years. Annual, monthly and seasonal temporal changes of AOD were investigated using pre-whitening Mann-Kendall trend test.

Materials and Methods The daily MODIS level-4 AOD data have been used in this study. The AOD data were obtained from the earth explorer website USGS in 6570 frames for 2001- 2018 and these data were extracted in NetCDF format with programming in Matlab software as annual, seasonal and monthly time series for 13 synoptic stations in the study area. PM10 concentration data were used to validate the AOD product of MODIS. In order to investigate the temporal and spatial changes of aerosol concentrations. The AOD zoning maps were prepared using inverse distance weighted (IDW) interpolation method based on the mean values of AOD. Based on the IDW method, each point/ station has a local effect that decreases with increasing distance, places close to the measuring point will have more weight. Finally, the temporal trend changes of AOD data were determined using the Mann- Kendall trend test in the different time scales.

M. Mirakbari(✉) [1], Z. Ebrahimi Khusfi [2]

1. PhD. Graduated of Combating Desertification, Faculty of Natural Resources, University of Tehran, Karaj, Iran
2. Assistant Professor, Department of Nature Engineering, Faculty of Natural Resources, University of Jiroft, Jiroft, Iran
e-mail: maryammirakbari@ut.ac.ir

Results and Discussion The results obtained from the validation of AOD data indicated that there was a strong and acceptable relationship between aerosol optical depth and PM10 concentration data at 95% significant level. Therefore, it can be concluded that the AOD data have a good accuracy to investigate and analyze the changes in suspended particles in the atmosphere in the study area. The spatial distribution of AOD in the study area showed that the western and central regions (Kerman, Baft, Sirjan, Rafsanjan) had the lowest concentration of aerosol during the period of 2001- 2018. While, the northeastern, eastern and southern regions (Sistan and Baluchestan province) have been affected by higher concentrations of aerosol. The amounts of AOD have varied from 0.14 to 0.53 in the study period that occurred in the years of 2016 and 2003, respectively. The findings of temporal changes of annual AOD series indicated that the atmosphere suspended particles had the highest amount in the years of 2001, 2003, 2008, 2009 and 2012 at the Zabol, Zahak, Zahedan, Khash and Iranshahr regions, respectively. The seasonal mean AOD had the most concentration in the summer and spring seasons while the autumn and winter had the lowest aerosol concentration. The monthly AOD series showed that the increasing variations of atmosphere suspended particles starts in April and then increases in June and has decreasing changes in July. The results of Mann- Kendall trend test indicated that changes trend of annual aerosol optical depth was decreasing in the most regions except in the Rafsanjan station so that the AOD changes had significant downward trend a 5% level in the Zahedan, Zahak, Zabol, Saravan and Bam stations. The Mann- Kendall statistic of monthly AOD series showed the most frequency of significant trend occurred in May, June, July and October, respectively in the study region. The monthly trend of AOD indicated decreasing changes of aerosol during the study period. As in May, June, July, August, November and February, the concentration of aerosols had a downward trend in the most study stations. The seasonal changes of AOD showed a decreasing trend in aerosols in the summer and spring, while there was an increasing trend in the autumn season.

Conclusion One of the available sources to access the aerosol optical depth data is the MODIS sensor. Based on our findings, there was an acceptable relationship between AOD product of MODIS and PM10 data obtained from ground-based aerosol gauge stations in the study region. The results of this study showed that the annual mean AOD varied from 0.14 to 0.53 which highest and lowest values occurred in the years of 2003 and 2016, respectively. Annual trend of AOD showed the concentration of aerosols was decreasing in most regions. The decreasing trend can be due to the decline of dust events resulted from an increase in vegetation cover in the study area. The monthly and seasonal mean AOD showed the concentration of aerosols had the lowest value during the autumn and winter in November, December, January and February, while in the summer and spring, the aerosols had the highest concentration in May, June and July. However, the temporal changes of monthly and seasonal AOD were decreasing in the most study regions. Generally, our findings showed the western part of the study area, located in Kerman province, had been faced the lower concentration of aerosols than the eastern part, located in Sistan province, during the study period. In general, the declining of aerosol concentrations in some of the study areas could indicate an improvement in air quality in these regions. It seems that the implementation of appropriate executive and management methods in this region, which has been considered by many managers and decision-makers in recent years, have had a significant effect on the reduction of air pollution.

Keywords: Remote sensing, Land degradation, Mann-Kendall test, Arid regions, Air pollution