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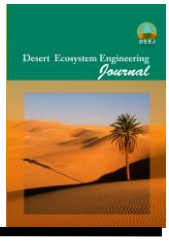

Investigating and Classifying Temporal-Spatial Characteristics of Iran's Annual Precipitation Using Maximal Overlap Discrete Wavelet Transform and Multiscale Entropy

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Extended Abstract

Introduction: Assessing precipitation alterations in a large area like Iran is required for the identification of those areas that are more vulnerable to changes in precipitation patterns, considering the fact that such changes may significantly influence water availability, agriculture, and other sectors that are dependent on water resources . On the other hand, understanding the spatial variability of precipitation patterns can help develop purposive strategies, including drought or flood management in specific regions. Moreover, as severe weather events such as floods and droughts can devastate communities and their infrastructure, such an understanding can inform decisions made concerning disaster risk reduction efforts. Therefore, assessing precipitation variations is essential for the effective management of water resources and the reduction of disaster risks.

Materials and methods: This study suggests a new method for analyzing precipitation properties in Iran, using a mixture of Maximal Overlap Discrete Wavelet Transform (MODWT) and Multiscale Entropy (MDE) techniques. This approach allows for a more detailed and accurate assessment of the spatial and temporal characteristics of precipitation properties, preparing the ground for the development of appropriate strategies for different regions in Iran. To this end, annual precipitation data collected from fifty Iranian synoptic stations for 1980-2020 were analyzed. Then, after classifying the precipitation data into different subseries, the concept of entropy was used to measure precipitation variability. Moreover, MDE values were used as input data for clustering purposes, followed by the calculation of internal evaluation criteria to be used for the determination of the optimal number of clusters and the most suitable clustering method calculated.

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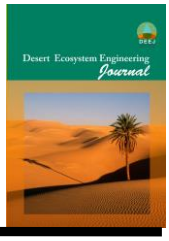

Results: The variations and trends of the precipitation data can be identified through the analysis of partial coefficients D1-D4 and the approximation coefficient. Accordingly, while the smaller partial sub-categories indicate more rapid variations at higher frequencies, the greater partial coefficients show more moderate variations at lower frequencies. Moreover, the approximation coefficient reveals the slightest variations at low frequencies in annual time series. The study's results suggested that northern and northwestern Iranian regions that are primarily characterized by rainy, cold, and in some cases semi-arid climates experienced the greatest variations in terms of annual precipitation. On the other hand, the eastern and southern parts of Iran, which are mostly dry areas, experienced more moderate variations in annual precipitation rates. Therefore, according to the results found in this study, it could be argued that northern and northwestern Iran enjoy more precipitation variability than other parts of the country. Furthermore, the D3 sub-category (eight years) was found to have the greatest variations in terms of MWE. On the other hand, based on the values of Sci, DBi, and CH index, the k-means clustering method performed better than SOM (Sci=0.41, DBi= 1.22, and CH= 14.58). Finally, fifty Iranian synoptic stations were categorized into four clusters based on the MWE index, with Chabahar, Shahrud, Abadan, and Zanjan being selected as core clusters.

Discussion and Conclusion: The current study proposed a methodology for analyzing and zoning Iran's annual precipitation based on the multiscale entropy method, considering the fact that the period and trend of the annual time series could be identified via the analysis of the precipitation series. Following the analysis of the collected data, this study used the multiscale entropy method to record precipitation variability in each synoptic station. On the other hand, the determination of SOM and k-means input data based on MWE values helped reduce the input data, leading to an increase in the accuracy of the zoning method and the selection of the homogenous clusters based on the proposed methodology. The results of the study indicated that generally, the K-means method offered more homogeneous areas than the SOM method. Moreover, the homogeneous distribution of annual precipitation variations obtained based on the K-means-derived clusters confirmed the positive performance of the methodology proposed in this study, which involves the identification of hydrologic uncertainty and temporal-spatial variations of precipitation in those stations related to a specific cluster. The methodology seeks to create distinct clusters of stations that share common features. This approach can provide insights into the spatial variability of hydrological processes and help improve water resource management by identifying areas susceptible to hydrological extremes such as floods or droughts. Some studies have already been conducted on the spatial clustering of precipitation stations in Iran using different methods, including the application of geographical proximity or precipitation rate as criteria for clustering. However, the method used in the current study involved clustering based on similarity in hydrological uncertainty and temporal-spatial complexity, which is consistent with the findings of Roshangar and Alizadeh (2019), and Roshangar et al. (2019). Identifying hydrologically homogeneous regions and their associated precipitation characteristics can significantly enhance the effective management of water resources in terms of adapting to climate change, preventing damage to water environments, and mitigating the impact of climate-related disasters. Therefore, the proposed methodology for spatial clustering of synoptic stations could be useful in managing water resources and all precipitation-related sectors and variables such as runoff and soil moisture. However, this study faced some limitations such as the small number of synoptic stations and the short length of the statistical period. Therefore, it is recommended that the methodology be applied to more stations at more varied time scales.

Keywords: Clustering, Discrete Wavelet Transform, Entropy, Iran, Maximal Overlap, Precipitation.

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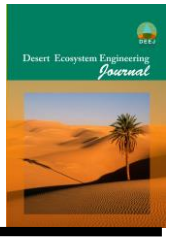

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