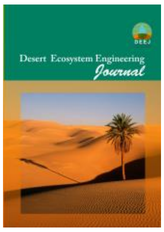
DEEJ (2025) 13 (4) 1-2

University of Kashan

Desert Ecosystem Engineering Journal

Journal homepage: http://deej.kashanu.ac.ir




# A Comparative Analysis of the Performance of Deep Learning Models and Convolutional Neural Networks for Dust Storm Modeling (Case Study: Kermanshah Province)

**Mohammad Ansari Ghojghar**[1]

Received: 09/01/2025 Accepted: 27/04/2024

**Extended abstract**

**Introduction:** Understanding the factors contributing to the occurrence of dust storms, along with awareness of their timing and location, is crucial for managing and mitigating the damage they cause. However, limitations such as scarce resources, high costs, and the time needed for monitoring and analysis often impede effective management. Consequently, the application of deep learning models, artificial intelligence algorithms, and neural networks represents a significant advancement towards the forecasting and integrated management of this destructive climatic phenomenon. This study investigates the results of dust storm modeling using deep learning models and convolutional neural networks across nine synoptic meteorological stations in Kermanshah Province (Qasr-e Shirin, Gilan-e Gharb, Sarpol-e Zahab, Eslamabad-e Gharb, Javanrud, Sararud, Ravansar, Harsin, and Kangavar) over a 40-year statistical period (1981–2020). In this context, two computational models—deep learning and convolutional neural networks—were developed and their performance in predicting the FDSD index was compared. While most studies have focused on modeling the frequency index of dust storms using machine learning models, deep learning approaches have been less commonly utilized. Convolutional Neural Networks, typically employed for image processing and modeling, have been adapted in this research to model dust storms. Furthermore, their performance has been benchmarked against a deep learning model. Accordingly, this research aims to address existing challenges and gaps by examining the performance of deep learning models and Convolutional Neural Networks in dust storm modeling.

**Materials and Methods:** This study investigates the performance of deep learning models and convolutional neural networks in modeling dust storms across nine meteorological stations in Kermanshah Province (Qasr-e Shirin, Gilan-e Gharb, Sarpol-e Zahab, Eslamabad-e Gharb, Javanrud, Sararud, Ravansar, Harsin, and Kangavar) over a 40-year statistical period (1981–2020). For this purpose, hourly horizontal visibility data and the World Meteorological Organization (WMO) present weather codes were utilized. Meteorological phenomena observations are recorded every three hours, totaling eight synoptic reports per day. In these observations, visual weather phenomena are defined according to the WMO's guidelines using 100 codes ranging from 00 to 99. From these 100 codes, 11 specific codes are commonly used to record and report dust storm events at various meteorological stations. Following the WMO definition, a dust storm day is defined as a day when at least one of the eight synoptic reports includes one of the dust-related codes (06, 07, 08, 09, 30, 31, 32, 33, 34, 35, or 98) in the present weather report, provided that the corresponding horizontal visibility is recorded as less than 1000 meters. In this study, a horizontal visibility of less than 1000 meters was consistently used as the criterion for identifying dust storms for all dust-related codes. This approach ensures the accurate detection and classification of dust storm events throughout the study period.

1. Assistant Professor, Department of Rehabilitation of arid and mountainous regions Engineering, Faculty of Natural Resources, University of Tehran, Karaj, Iran Ansari.ghojghar@ut.ac.ir

DOI: 10.22052/deej.2025.256139.1091

**Results and Discussion:** The evaluation metrics R (Pearson correlation coefficient), RMSE (Root Mean Square Error), NS (Nash-Sutcliffe efficiency coefficient), and MAE (Mean Absolute Error) were used to assess and compare the performance of the deep learning model and the convolutional neural network algorithm for dust storm modeling in Kermanshah Province over a 40-year statistical period (1980–2020). The findings from dust storm modeling indicate that at Qasr-e Shirin station, which records the highest seasonal frequency of dust storm days, and Kangavar station, characterized by the lowest seasonal frequency, a clear trend emerges: as the frequency of dusty days' decreases across the studied stations—from Qasr-e Shirin to Kangavar—the accuracy of FDSD index modeling significantly improves. The results reveal statistically significant differences between the models at the 95% and 99% confidence levels. While substantial discrepancies are observed between the outputs of the deep learning (DL) model and the convolutional neural network (CNN), the DL model proves to be the more reliable choice for achieving higher accuracy and enhancing modeling efficiency. Additionally, a t-test comparison of the observed and predicted mean values supports the null hypothesis, validating the equivalence of the observed and predicted time series means for the frequency of dust storm days in Kermanshah Province.

**Conclusion**: Deep learning models, such as deep artificial neural networks, stand out from other methods due to their superior ability to identify patterns and hidden structures within large datasets. In these networks, each layer learns a concept that is refined and expanded upon in subsequent layers, progressively transforming basic concepts into more complex abstract ones. This study aimed to compare the performance of deep learning models and convolutional neural networks for modeling dust storms at nine meteorological stations in Kermanshah Province (Qasr-e Shirin, Gilan-e Gharb, Sarpol-e Zahab, Eslamabad-e Gharb, Javanrud, Sararud, Ravansar, Harsin, and Kangavar) over a 40-year statistical period. The results indicated that the first seasonal combination was selected as the optimal configuration for predicting the FDSD index using both deep learning and CNN models. Both models demonstrated acceptable accuracy and performance in simulating the frequency of dust storm days. However, the DL model, exhibiting higher correlation coefficients and NS values, along with lower RMSE and MAE error estimation metrics, was identified as the optimal model for dust storm modeling in Kermanshah Province. This advanced technology enables more accurate predictions of the timing, intensity, and path of dust storms, playing a fundamental role in reducing human, economic, and environmental damages. Furthermore, the results from these models can serve as an efficient tool in natural resource management—including water, soil, and vegetation—to mitigate the destructive impacts of storms and improve regional planning.

**Keywords**: Forecasting, meta-exploration algorithms, dust storms, DL, FDSD index.