

Clustering-Based Deep Learning for Improved Streamflow Prediction in Poorly Gauged Moroccan Mountain Catchments (Oral)

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ABSTRACT

Accurate streamflow prediction in mountainous and poorly gauged basins remains a major challenge due to limited observations and high hydro-climatic variability. This study aims to enhance streamflow prediction in such data-scarce environments by combining basin clustering with deep learning models to identify robust and transferable predictive configurations across similar catchments.

The proposed approach relies on hydro-climatic and remote sensing data, including precipitation, temperature, and snow cover variables, to train three deep learning models: Long Short-Term Memory (LSTM), Gated Recurrent Unit (GRU), and one-dimensional Convolutional Neural Network (1D-CNN). Sub-basins were grouped into three clusters based on their physical and climatic similarities, enabling the identification of shared hydrological behavior and facilitating model transfer between basins. Model performance was evaluated using Kling–Gupta Efficiency (KGE), Nash–Sutcliffe Efficiency (NSE), correlation coefficient (R), Root Mean Square Error (RMSE), and Mean Absolute Error (MAE).

The results show that recurrent neural network models significantly outperform convolutional approaches in predicting daily streamflow. LSTM and GRU achieved median correlation values exceeding 0.6 during training, with KGE and NSE values above 0.5 in several basins. Although performance decreased during validation and testing, these models maintained relatively stable behavior compared to 1D-CNN, which showed lower correlation values (often below 0.4) and higher variability. The LSTM model demonstrated the highest stability across clusters, while GRU showed better adaptability in more heterogeneous basins. Error metrics further support these findings, with RMSE values below 10 and MAE below 6 during training, but increasing during testing in more complex basins, where RMSE exceeded 20 and MAE surpassed 7. In some cases, negative NSE values and KGE as low as -0.3 were observed, highlighting the difficulty of prediction in poorly gauged environments.

Overall, the results demonstrate that combining clustering with recurrent deep learning models improves the reliability and transferability of streamflow prediction in poorly gauged mountainous basins, providing a practical framework for water resource management under data limitations.

Keywords: Streamflow prediction; Poorly gauged basins; Deep learning; Clustering