Deep learning for water level forecasting in the Senegal River Basin: A case study at Bakel Station

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Abstract

The Senegal River experiences significant seasonal fluctuations, particularly between July and November, often leading to flooding that affects agriculture, infrastructure, and communities. More recently, between 1 September and 13 October 2024, the Senegal River basin, affected by extreme rainfall events, experienced one of the most catastrophic floods in its history. During this period, the flood alert level (10 m) at the Bakel station was exceeded three times, with more than 10.8 billion cubic meters of water flowing. This situation caused the river to overflow several kilometers inland, with severe consequences across multiple sectors: more than 55,000 people were affected, and more than 1,600 hectares of agricultural land were flooded, impacting more than 2,660 agricultural producers. Then, today, it remains crucial to develop predictive models to prevent these disasters and strengthen the resilience of local communities, which are already highly vulnerable to the effects of climate change, and the sustainable management of Senegal river basin. It is in this context that this study is being conducted, with the aim of applying advanced technologies such as Artificial Intelligence (AI) and Deep Learning in order to predict extreme water levels in the Senegal River with a view to developing an early warning and decision-making support tool. This study focuses on the Bakel hydrometric station, a key point for monitoring water levels in the basin, and aims to improve water level forecasting using advanced modeling techniques. Over 21,000 daily observations from 1960 to 2018 were analyzed. Traditional statistical models like ARIMA were evaluated alongside deep learning architectures such as LSTM, CNN, DNN, N-BEATS, and NHiTS. The results show that deep learning models significantly outperform classical methods, with N-BEATS achieving the lowest mean absolute error (MAE = 0.0667 m), compared to ARIMA (MAE = 2.3188 m). These findings highlight the potential of deep learning for enhancing flood prediction and guiding sustainable water resource management in the Senegal River basin.

Keywords: Deep learning, water level forecasting, Senegal River, Bakel station, flood prediction, N-BEATS