



Enhancing global flood forecasts in Southern Africa using Deep Learning: A user-oriented evaluation for anticipatory actions

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Global hydrological forecasting systems, such as the Global Flood Awareness System (GloFAS), part of the Copernicus Emergency Management Service, are operationally used to inform early warning and early action, particularly in large transboundary river basins and data scarce regions. Humanitarian organizations often integrate these global forecasting systems with local information to assist national mandated agencies in the disaster risk management chain. However, limitations in the skill of global systems restrict their operational adoption and constrain the lead times available for implementing early actions. Recent advances in AI models offer promising solutions to overcome these limitations, by complementing operational physics-based models like GloFAS with hybrid or fully data-driven systems. Despite an increasing number of studies showing the potential of such AI models, there is an urgent need of providing user-oriented evidence of the added value of these solutions in order to increase their operational uptake. Here we explore the application of a deep learning model, based on a Long Short-Term Memory (LSTM) network, to improve the forecasts of GloFAS to support humanitarian anticipatory actions. Different LSTM architectures and loss functions are tested to develop alternative post-processing models of GloFAS, using historical forecasts of river flows, past errors and catchment characteristics as inputs, to improve the prediction of daily streamflows up to a 7-day lead time. The post-processing model is developed with both a single-site and multi-site approach, showing a comparable performance in cross-validation, using streamflow observations as reference. The improvements in skill and value of the flood forecasts of GloFAS are demonstrated for anticipatory actions in Southern Africa (Zambezi River Basin and coastal areas of Mozambique), a region that is highly exposed to frequent tropical cyclones and consequent floods. Using the LSTM-based post-processing, the large biases of GloFAS in this region are substantially reduced and the skillful lead times are extended significantly. We assess the added value of the hybrid forecasts within the framework of the current Red Cross Early Action Protocol for floods in Mozambique, considering user-oriented metrics, including False Alarm Ratios and Hit Rates, and a valuation framework of early actions. Our findings highlight the critical importance of evaluating hybrid forecasting models based on user-oriented criteria and assessing their value to select the most cost-effective solution to support anticipatory actions. Finally, we discuss the potential of our hybrid approach to scale up anticipatory actions in data scarce regions and how ongoing work focusing on post-processing flood hazard maps may further improve forecast value for early actions.