

## **Toward a seamless sub-seasonal to seasonal prediction system for the Blue Nile Basin [Abstract]**

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## Toward a Seamless Sub-Seasonal to Seasonal Prediction System for the Blue Nile Basin

Rebecca Wiegels<sup>1</sup>, Christian Chwala<sup>1</sup>, Julius Polz<sup>1</sup>, Luca Glawion<sup>1</sup>, Christof Lorenz<sup>1</sup>, **Jan N. Weber<sup>1</sup>**, Yasir Hageltom<sup>1</sup>, Windmanagda Sawadogo<sup>1</sup>, Tanja C. Schober<sup>1</sup>, Selina Janner<sup>1</sup>, Morteza Zargar<sup>3</sup>, Axel Bronstert<sup>3</sup>, and Harald Kunstmann<sup>1,2,4</sup>

<sup>1</sup>Institute of Meteorology and Climate Research, Karlsruhe Institute of Technology, Campus Alpin, Garmisch-Partenkirchen, Germany

<sup>2</sup>Institute of Geography, University of Augsburg, Augsburg, Germany

<sup>3</sup>Institute of Environmental Science and Geography, University of Potsdam, Campus Golm, Potsdam-Golm, Germany

<sup>4</sup>Center for Climate Resilience, University of Augsburg, Augsburg, Germany

The Blue Nile Basin, located in the Greater Horn of Africa, is highly vulnerable to climate variability, where hydrometeorological extremes have severe socio-economic consequences. Reliable prediction on sub-seasonal to seasonal (S2S) timescales is therefore critical for preparedness in sectors such as agriculture, water and dam management. However, S2S prediction in the region remains particularly challenging due to complex orography, the influence of large water bodies, various climate zones, and the interaction of multiple large-scale circulation modes, including ENSO, the Indian Ocean Dipole, and the Madden-Julian Oscillation.

While global forecasting systems provide valuable large-scale climate information, their direct application at regional scale is limited. In heterogeneous regions such as the Blue Nile Basin, global products are often insufficient in spatial resolution and show systematic biases that reduce their usability for regional and sector-specific applications. This requires targeted post-processing to correct errors and regionally enhance the forecasts.

In this study, we evaluate state-of-the-art seasonal and sub-seasonal forecasting products from the ECMWF, focusing on the SEAS5 seasonal forecasting system (lead times up to 215 days) and the ECMWF sub-seasonal range forecasts (lead times up to 46 days). Forecast skill is assessed against ERA5 and ERA5-Land reanalyses, as well as a composite observational dataset combining satellite and station measurements (CHIRPS). To enhance the raw forecasts, we apply an established statistical post-processing technique, namely bias correction and spatial disaggregation (BCSD), alongside advanced deep learning approaches. The latter include Seasonal AFNO-based models and ProS2St, which has previously been developed and tested at global scale within the ECMWF AI Weather Quest Challenge.

Our results demonstrate that post-processing methods significantly improve raw forecast performance over the Blue Nile Basin. Despite these improvements, outperforming climatology remains challenging for meteorological variables alone. However, we show that when the

enhanced forecasts are used as input for subsequent impact models, such as hydrological models, they provide added value compared to climatological forcing.

This work highlights the potential of regionally enhanced meteorological forecasts as a foundation for sub-seasonal to seasonal prediction systems. By coupling post-processed meteorological forecasts with hydrological and crop models, we enable S2S forecasts that support improved decision-making in specific sectors. The focused evaluation of S2S forecasting products and post-processing methods for the Blue Nile Basin, together with their integration into downstream impact models, represents a novel contribution toward operational and application-oriented prediction systems in the region.