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Improving Sub-Seasonal Hydrological Forecasts in Switzerland: An Exploratory Study of Post-Processing Techniques by Using Machine Learning and Weather Regime Diagnostics

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Across the globe, there has been an increasing interest in improving the predictability of weekly to monthly (sub-seasonal) hydro-meteorological forecasts as they play a valuable role in medium- to long-term planning in many sectors such as agriculture, navigation, hydro-power production, and hazard warnings. A Precipitation-Runoff-Evapotranspiration HRU model (PREVAH) has been previously set up with raw metrological forcing of 51 ensemble members and 32 days lead time taken from the operational European Centre for Medium-Range Weather Forecasts (ECMWF) extended-range forecast. The PREVAH model is used to generate hydrological forecasts for the study area, which consists of 300 catchments covering approximately the entire area of Switzerland. The primary goal of this study is to improve the quality of the categorical forecast of weekly mean total discharge in a catchment laying in the lower, normal, or upper tercile of the climatological distribution at a monthly horizon. Therefore, we explore the approach to post-process PREVAH outputs using machine learning algorithm Gaussian process. Weather regime (WR) data, based on 500 hPa geopotential height in the Atlantic-European region are used as an added feature to further enhance the post-processing performance.

By comparing the overall accuracy and the ranked probability skill score of the post-processed forecasts with the ones of raw forecasts we show that the proposed post-processing techniques are able to improve the forecast skill. The degree of improvement varies by catchment, lead time and variable. The benefit of the added WR data is not consistent across the study area but most promising in high altitude catchments with steep slopes. Among the seven types of WRs, the majority of the corrections are observed when either a European blocking or a Scandinavian blocking is forecasted as the dominant weather regime. By applying a “best practice” to each individual catchment, that is the processing technique with the highest accuracy among the different proposed techniques, a median accuracy of 0.65 (improved from a value of 0.53 with no processing technique) can be achieved at 4-week lead time. Due to the small data size, the conclusions should be considered preliminary, but this study highlights the potential of improving the skill of sub-seasonal hydro-meteorological forecasts utilizing weather regime data and

machine learning in a real-time deployable setup.