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Why is large sample hydrology important in hydrological forecasting?

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The scientific community has made significant progress towards improving the skill of hydrological forecasts; however, most investigations have normally been conducted at single or in a limited number of catchments. Such an approach is indeed valuable for detailed process investigation and therefore to understand the local conditions that affect forecast skill, but it is limited when it comes to scaling up the underlying hydrometeorological hypotheses. To advance knowledge on the drivers that control the quality and skill of hydrological forecasts, much can be gained by comparative analyses and from the availability of statistically significant samples. Large-scale modelling (at national, continental or global scales) can complement the in-depth knowledge from single catchment modelling by encompassing many river systems that represent a breadth of physiographic and climatic conditions. In addition to large sample sizes which cover a gradient in terms of climatology, scale and hydrological regime, the use of machine learning techniques can contribute to the identification of emerging spatiotemporal patterns leading to forecast skill attribution to different regional physiographic characteristics.

Here, we draw on two seasonal hydrological forecast skill investigations that were conducted at the national and continental scales, providing results for more than 36,000 basins in Sweden and Europe. Due to the large generated samples, we are capable of demonstrating that the quality of seasonal streamflow forecasts can be clustered and regionalized, based on a priori knowledge of the local hydroclimatic conditions. We show that the quality of seasonal streamflow forecasts is linked to physiographic and hydroclimatic descriptors, and that the relative importance of these descriptors varies with initialization month and lead time. In our samples, hydrological similarity, temperature, precipitation, evaporative index, and precipitation forecast biases are strongly linked to the quality of streamflow forecasts. This way, while seasonal river flow can generally be well predicted in river systems with slow hydrological responses, predictability tends to be poor in cold and semiarid climates in which river systems respond immediately to precipitation signals.