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Improved reservoir inflow forecasting in the presence of inter-annual variability

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A reliable inflow forecasting is crucial for the adapted operation of any reservoir system in a variable hydrological environment. This is all the more true in situations where competing demands constrain the management of the naturally limited hydrological resource.

Consequently, researchers have been investigating a variety of methods in order to derive inflow predictions for reservoirs worldwide. In addition to physically-based and conceptual rainfall-runoff modeling, data-driven techniques like autoregressive models and artificial neural networks have been applied. Depending on the specific system requirements short-term or long-term weather predictions have been implemented and real-time updating frameworks have been developed. In regions, however, that exhibit a strong variability of the local hydrology and where data availability and data accessibility are major concerns, it remains challenging to establish an operational inflow forecasting of sufficient accuracy and length of the prediction period.

The presented case study focuses on the Itezhi-tezhi reservoir in the Southern African country of Zambia. Itezhi-tezhi is located in a sub-tropical climate with alternating rainy and dry seasons that exhibit a high inter-annual variability. The inflows to the reservoir are mainly determined by the characteristics of the annual rains and its concentration in the approximately 106,000 km^2 large basin of the upper Kafue River. Competing demands constrain the degrees of freedom of dam releases and a flexibilization would require improved reservoir inflow predictions with regard to both accuracy and length of the prediction period.

Two approaches are followed to derive inflow predictions for the Ithezi-thezi reservoir. On the one hand, a conceptual model is investigated that makes combined use of remote-sensing products of soil moisture and precipitation and is calibrated with discharge data at the sub-basin level. On the other hand, a number of artificial neural networks are set up in order to explore the potential of multiple (newly available) remote sensing and ground data products, independently of a preset conceptual model structure. The benefit of including long-term weather forecasts in order to obtain a longer prediction time period is investigated, and seasonal precipitation forecasts are implemented. The prediction skills of existing models are used as benchmarks to assess the quality of the obtained results.