The Distributed Regression hydrological Model (DRM)

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ABSTRACT

This paper presents the distributed regression hydrological model (DRM). The DRM is a hybrid model that combines association with hydrological processes and machine learning techniques. It was designed based on the following guiding principles. At first, the model should run relatively fast, meaning it should utilize parallel processing. The selected equations in the model should be associated with physical processes and seek to keep the objective space as smooth as possible. The code should minimize the usage of thresholds and "if sentences" that makes the objective space non-differentiable. Such implementations give gradient-based calibration methods an advantage.

Another guiding principle was that the model should be able to run with only air temperature and precipitation as input. These are commonly used in hydropower and are typically available at daily temporal resolutions. Further, the model should utilize the power of recurrent neural networks (NN) using output from the hydrological calculations as an input to the NN. The model structure in DRM consists of two major parts: HYDMOD and LSTM. The first calculate snow accumulation and melt, infiltration to the soil, evapotranspiration, and runoff in a distributed grid. The sum of the runoff from all grid cells represents the catchment runoff. Secondly, the LSTM-NN is forced with the fluxes and states from the HYDMOD to calculate a modified runoff signal.

Within DRM, a three-step calibration procedure is available. At first, the model runs a discrete Bayesian parameter optimization in the HYDMOD. It starts with many runs selecting the parameter values from uniform distributions. After a certain number of trials (user-specified), it updates the discrete parameter distributions (Bayesian) and starts all over. Furthermore, a one-at-the-time gradient search improves the parameter set further. Finally, the backpropagation algorithm trains the LSTM NN using observed streamflow. Within DRM several objective criteria can be used in the calibration process (MAE, NSE, KGE, and more).

In this research, the DRM model was applied to seventy catchments located in southern Norway. The model was calibrated and validated using many different types of objective criteria. Preliminary results indicate that the DRM model is promising, but further testing and improvement are required.

A detailed description of the DRM model, the data used to test it, and a variety of results will be presented at the conference.

Keywords: hydrology, model, machine learning, physics