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Constraining a semi-distributed, conceptual hydrological model on evaporation - a case study for the Kulpawn River Basin, Ghana

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Hydrological models are typically calibrated on stream flow observations. However, such data are frequently not available. In addition, in many parts of the world not stream flow, but rather evaporation and transpiration are the largest fluxes from hydrological systems. Nevertheless, models trained to evaporation data are rare and typically rely on evaporation estimates that were themselves also derived from models, thereby considerably reducing the robustness of such approaches. In this study, we test the power of alternative approaches to constrain semi-distributed, conceptual models with information on evaporation in the absence of stream flow data. By gradually increasing the constraining information, the analysis is designed in a stepwise way. Both, the models and the relevance of the added information are evaluated for each step.

As a first step, a large set of random parameter sets from uniform prior distributions is generated. Subsequently, parameter sets that cannot produce model outputs that satisfy the added constraints are discarded. The information content of these constraints will be gradually increased by making use of the Budyko framework: (1) the model has to reproduce the long-term average actual evaporation of the system, as indicated by the position in the Budyko framework, (2) the model, similarly, has to reproduce the long-term average seasonal variations of actual evaporation, (3) the model has to reproduce the temporal variations of evaporation, e.g. differences between 5-year mean evaporation of different periods, as indicated by different positions in the Budyko framework. As a last step, the model's temporal dynamics in the root zone moisture content are constrained by comparing it to time series of the NDII (Normalized Difference Infrared Index), which has recently been shown to be a close proxy for plant available water in the root zone and, thus, for transpiration rates (Sriwongsitanon et al., 2015). The value of the information content of these different constraints to reduce model uncertainty for reproducing the hydrological response of catchments is assessed by comparing the model results of the individual stages to actually observed discharge data in the study catchment.