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# The benefits of using remotely sensed soil moisture in parameter identification of large-scale hydrological models

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Nowadays large-scale hydrological models are mostly calibrated using observed discharge. Although this may lead to accurate hydrograph estimation, calibration on discharge is restricted to parameters that directly affect discharge. As a result, a large part of the hydrological system that is not directly linked to discharge, in particular the unsaturated zone, remains uncalibrated, or might be modified unrealistically. Soil moisture observations from satellites have the potential to fill this gap, as these provide a direct measurement of the state of the unsaturated zone, and thus are potentially useful in calibrating unsaturated zone model parameters. This is expected to result in a better identification of the complete hydrological system, potentially leading to improved forecasts of the hydrograph as well.

Here we evaluate this added value of remotely sensed soil moisture in calibration of large-scale hydrological models by addressing two research questions: 1) Does calibration on remotely sensed soil moisture lead to an improved identification of hydrological models compared to approaches that calibrate on discharge alone? 2) If this is the case, what is the improvement in the forecasted hydrograph? To answer these questions we use a dual state and parameter ensemble Kalman filter to calibrate the hydrological model LISFLOOD for the Upper-Danube area. Calibration is done with discharge and remotely sensed soil moisture from AMSR-E, SMOS and ASCAT. Estimates and spatial correlation are derived from a previous published study on the quantification of the errors and spatial error structure of microwave remote sensing techniques. Four scenarios are studied, namely, no calibration (expert knowledge), calibration on discharge, calibration on remote sensing data and calibration on both discharge and remote sensing data. Using a split-sample approach, the model is calibrated for a period of 2 years and validated using a validation period of 10 years with the calibrated model parameters.

Results show that calibration with discharge data improves the estimation of groundwater parameters (e.g. groundwater reservoir constant) and routing parameters, compared to a priori estimated values from expert knowledge. On the other hand, calibration with only remotely sensed soil moisture results in a very accurate calibration of parameters related to land surface process (e.g the saturated conductivity), which is not the case for calibration on discharge. Using remotely sensed soil moisture data, routing and groundwater parameters can not be calibrated. This is mainly due to the lack of information from the microwave sensors concerning the routing of the discharge and groundwater levels. Discharge calibration gives a NS of 0.5 for the 10-year validation and a lower overall RMSE compared to the reference run (without calibration). When validation is performed for both discharge and soil moisture the RMSE is reduced by 10-30% for the upstream area compared to the discharge calibration. Downstream, the model performance due to assimilation of remotely sensed soil moisture is not increased or slightly decreased due to the relative importance of the routing and contribution of groundwater. The conclusion is that remotely sensed soil moisture holds potential for calibration of hydrological models especially in upstream areas with sparse discharge observations.