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# Using remote sensing derived evapotranspiration data to calibrate a distributed hydrological SWAT model in the semi-arid Punjab region of Pakistan

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A SWAT (Soil & Water Assessment Tool) model is applied in the semi-arid Punjab region in Pakistan. The physically based hydrological model is set up to simulate hydrological processes and water resources demands under future land use, climate change and irrigation management scenarios. To guarantee a reliable prediction capability, detailed focus is laid on the calibration procedure of the model.
The study deals with the following calibration challenges: i. lack of reliable calibration/validation data to assess model uncertainty, ii. need for alternative and spatially distributed data sets to overcome data uncertainty and iii. difficulty to accurately model a highly managed system with a physically based hydrological model. In our study area field observations are rare and the entirely human controlled irrigation system renders central calibration parameters (e.g. runoff/curve number) unsuitable, as it can't be assumed that they represent the natural behavior of the hydrological system. From evapotranspiration (ET) however, principal hydrological processes can still be inferred. Usman et al. (2015) derived satellite based monthly ET data for our study area based on SEBAL (Surface Energy Balance Algorithm) and created an ET data set which we use in this study to calibrate our SWAT model. The model is adapted to the local characteristics of this human controlled system and incorporates detailed information on plant physiognomy and irrigation practices, hence simulating ET to a high degree of accuracy.
The initial model performance is evaluated with respect to the SEBAL results using correlation coefficients, RMSE, and Kling Gupta Efficiencies. Particular focus is laid on the spatial patterns, investigating the potential of a spatially differentiated parameterization with respect to ET instead of just using spatially uniform calibration data. Using the SEBAL-ET product we calibrate the model for the time period 2009-2010 using a dynamically dimensioned global search algorithm (DDS; Tolson and Shoemaker, 2007) as well as Sequential Uncertainty Fitting (SUFI) implemented in the SWAT-CUP software, to minimize RMSE. The model improvement after the calibration procedure is finally evaluated based on the previously chosen evaluation criteria for the time period 2011-2012.
The study reveals the potential of calibrating SWAT model parameters of a highly human controlled system using satellite derived ET data. Nevertheless the results also show the limitations of this approach, especially during months with poor quality of remotely sensed ET data (i.e. monsoon period). Although, SEBAL has proved to provide reasonable estimates for ET, we suggest a site-specific verification with additional in-situ data on the surface energy balance. The outlook of the work, presents an experimental design of in-situ measurements using a portable set of sensors in order to refine the ET estimates and hence the calibration results of our hydrological model.