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# Simulation of large-scale soil water systems using groundwater data and satellite based soil moisture

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Complex concepts for the physically correct depiction of dominant processes in the hydrosphere are increasingly at the forefront of hydrological modelling. Many scientific issues in hydrological modelling demand for additional system variables besides a simulation of runoff only, such as groundwater recharge or soil moisture conditions. Models that include soil water simulations are either very simplified or require a high number of parameters. Against this backdrop there is a heightened demand of observations to be used to calibrate the model. A reasonable integration of groundwater data or remote sensing data in calibration procedures as well as the identifiability of physically plausible sets of parameters is subject to research in the field of hydrology. Since this data is often combined with conceptual models, the given interfaces are not suitable for such demands. Furthermore, the application of automated optimisation procedures is generally associated with conceptual models, whose (fast) computing times allow many iterations of the optimisation in an acceptable time frame.
One of the main aims of this study is to reduce the discrepancy between scientific and practical applications in the field of hydrological modelling. Therefore, the soil model DYVESOM (DYnamic VEgetation SOil Model) was developed as one of the primary components of the hydrological modelling system PANTA RHEI. DYVESOMs structure provides the required interfaces for the calibrations made at runoff, satellite based soil moisture and groundwater level. The model considers spatial and temporal differentiated feedback of the development of the vegetation on the soil system. In addition, small scale heterogeneities of soil properties (subgrid-variability) are parameterized by variation of van Genuchten parameters depending on distribution functions. Different sets of parameters are operated simultaneously while interacting with each other. The developed soil model is innovative regarding concept, interfaces, and parameterisation.
The demand for an automated optimisation procedure arises through the multi-variable examination of the system and its new complexity. A pioneering lexicographical strategy of optimisation was developed, using the model interfaces connected to modern data types. The employed strategy is easy to use, can be transferred to other model areas and does not require high computing times. The new strategy converges in less than 100 iterations. Established algorithms, like SCE-UA, were used by comparison. They need 500-2000 iterations.
Taking runoff, soil moisture and groundwater levels as objectives, the calibration with the help of the lexicographical calibration strategy showed the following results:
- For different model areas it is possible to fit the simulated runoff very well to the observation ($R^2 \sim 0.9$).
- Internal system variables like soil moisture and groundwater levels are plausibly simulated and are of high quality as well ($R^2 \sim 0.8$).
- During winter season a significant improvement of the quality of the simulated runoff is achieved, compared to calibrations without the objectives of soil moisture and groundwater level. This shows that the involvement of additional observation sources leads to a much higher plausibility of internal system behaviour.
- Parameters that were achieved by the lexicographical calibration strategy are more plausible compared to results of the SCE-UA algorithm.