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# Multimodel simulation of water flow: uncertainty analysis

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Simulations of soil water flow require measurements of soil hydraulic properties which are particularly difficult at field scale. Laboratory measurements provide hydraulic properties at scales finer than the field scale, whereas pedotransfer functions (PTFs) integrate information on hydraulic properties at larger scales. One way of down-scaling large-scale data is to use several PTFs to generate hydraulic properties with each of the PTFs and to obtain the multimodel prediction of soil water flow by using weighted averages of the simulations results obtained with individual PTFs. Since its introduction, the multimodel prediction has been subject to much debates: whether a multimodel prediction is better than the single best forecast and what is the best method to weigh predictions obtained with the different models. The objective of this work was to evaluate errors and uncertainty of different weighting methods in multimodel prediction of soil water content.

Data on soil water contents were collected at four locations at the USDA-ARS Beltsville OPE3 field site from January to November 2007. The locations were instrumented with Multisensor Capacitance Probes (SEN-TEK) to measure soil water content at depths from 10 to 100 cm with 10 cm increment. Standard meteorological data were measured in the vicinity of the site. Undisturbed soil samples were taken from the same depths to measure soil bulk density (BD), organic carbon content (OC) and soil texture in all locations. Fourteen PTFs, that had been developed from relatively large datasets (>200), were used to calculate soil hydraulic properties for each individual depth from measured BD, OC and soil texture. Thus, 14 sets of hydraulic parameters were obtained for each location. Then we solved the Richards equation with each set of hydraulic parameters for each location. The following multimodel prediction methods were compared in our study: (i) using only the best model; (ii) assigning equal weights to all models; (iii) using the superensemble; (iv) using the superensemble with the singular-value decomposition to find weights; (v) using Bayesian model averaging; and (vi) using information theory. The weighting methods were evaluated in terms of their accuracy and uncertainty (the average error and the standard deviation of errors in reproducing the test data). The multimodel training, i.e., determining the weights, was done with daily water contents using moving windows that were from 30 to 150 d long. All data outside the windows were used to test the model prediction.

Results of simulation revealed several sources of uncertainty in the multimodel approach. The first source of uncertainty included soil BD, OC and texture measured at different locations and used in the PTFs to estimate soil hydraulic properties. Different accuracy was obtained in water content prediction with same PTF, but different soil properties. The second source of uncertainty originated from the PTFs itself. Different PTF qualitatively adequately reproduced observed soil water content at different depths in four locations. This resulted in different PTF weights in the multimodel simulations of water content at different depths and locations. The third source of uncertainty was the start day and length of the model training. Generally, accuracy and uncertainty of prediction increased with increase in length of the model training.

Overall, using PTF ensembles appeared to be a viable approach to soil water flow simulations, though weighting methods can be site specific.