

14. Estimability analysis of hydraulic properties parameters from measurements at a bare field lysimeter: optimization and validation

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Abstract:

Experiments at the lysimeter scale are developing since lysimeter is considered as an intermediate scale between laboratory and field scales. Accurate hydraulic parameters are required for the modeling of water flow and solute transport through the vadose zone. Such parameters measured at the bench scale may be not representative for the field scale. Inverse method is increasingly used to determine these parameters from different data. However, problems concerning the non-uniqueness of such optimized parameters still exist. They can be partly solved if additional and more accurate measurements are included in the objective function. The information content of data appears to be much more important than the amount of data used for model calibration. As a matter of fact, the only focus on subsets where the model is most sensitive to changes in the unknown parameters can improve the quality of inverse solution. Thus, the sensitivity of model parameters, information content of different measurements and correlation between different parameters before parameter calibration need to be assessed.

Our objectives were to (i) evaluate the effect of van Genuchten parameters on four hourly and daily output predictions (pressure head, water content, cumulative bottom flow, cumulative evaporation) in the bare field lysimeter via sensitivity analysis, (ii) investigate the information content of 4 types of measurements to the parameter optimization, (iii) optimize the hydraulic parameters from daily measurements with different scenarios and valid the model by using the optimized parameters.

The lysimeter (2 m depth x 1 m²) was located in the experimental station of the GISFI (French Scientific Interest Group on Industrial Wastelands, www.gisfi.fr) in Homécourt, France (49°14'N, 5°59'E) and was exposed to natural atmospheric conditions. A one-dimensional numerical flow model, HYDRUS-1D, was used. Sensitivity analysis was performed by using sensitivity coefficients, which quantified how model predictions were affected by changes in parameter values. Estimability analysis was based on sequentially calculating a sensitivity coefficient matrix to classify parameter estimability.

Sensitivity analysis result showed that for both hourly and daily output predictions, pressure heads were the most sensitive to the hydraulic parameters. In almost all cases, n and \hat{I}_s parameters were the most influential parameters, \hat{I}_r parameter was least influential. Estimability analysis results indicated that hourly data contained less information than daily data; for both of them pressure heads had the most information content. The combination between daily pressure heads and water contents increased parameter estimability. When daily pressure heads and water contents were simultaneously included in the objective function, \hat{I}_r , \hat{I}_s and n were successfully estimated, but optimized parameters \hat{I}_\pm and K_s showed high uncertainties because of narrow pressure heads and water contents. Accounting for soil heterogeneity slightly improved the calibration quality and the model validation.

Keywords: Lysimeter, sensitivity analysis, estimability analysis, optimization, HYDRUS-1D

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