Abstract

Sustainable utilization of water resources requires that the components of water balance and water fluxes are accurately estimated at different locations in the entire landscape. Over the last few decades, a great stride is made on developing physically-based and distributed-parameter hydrological models, which are capable of generating area-wise and hydrologic process-wise outputs over a watershed. Distributed-parameter models are generally implemented by discretizing the watershed into hydrological response units (HRUs), solving the physically-based governing non-linear hydrological equations for each zone, and aggregating the outputs. The present study shows that soil hydraulic properties such as water retention characteristics and saturated hydraulic conductivity (K_s) may be effectively used to discretize a watershed. For discretization of watershed into hydrologically-similar zones, surface maps of hydraulic properties were prepared, which were obtained by linking pedotransfer functions (PTFs) with surface map of basic soil properties. Point PTF of K_s and parametric PTFs of van Genuchten water retention parameters were developed from a small soil database generated from the Dengei Pahad micro-watershed (DPMW), which is located in the Western Catchment of the Chilika Lake in Orissa, India. This study also shows that robust PTFs may be developed from a limited number of soil samples with sufficient variability in soil properties. Spectrotransfer functions were also developed in this study for estimating soil hydraulic properties using spectral reflectance data collected over visible, near-infrared, and shortwave infrared regions of electromagnetic spectrum. Evaluation of different spatial interpolation method showed that REML-EBLUP (residual maximum likelihood estimation of covariance parameters followed by empirically best linear unbiased prediction) approach is most suitable method for spatial interpolation of soil properties in a watershed-scale with fewer data. Fuzzy logic-based inference system was shown to effectively classify hydraulic properties into distinct hydrological classes. These hydrological classes were used to discretize the DPMW into hydrologically-similar zones or HRUs. Simulations with distributed parameter model SWAT showed that hydraulic property-based hydrologic classes may be a comprehensive way to define hydrologically-similar zones or the HRUs.

Keywords: Pedotransfer functions, Spectrotransfer functions, REML-EBLUP, Fuzzy logic, Hydrologic response units, Spatial interpolation, Runoff