Geophysical Research Abstracts, Vol. 8, 03421, 2006
SRef-ID: 1607-7962/gra/EGU06-A-03421


# A calibration and uncertainty analysis procedure for large watersheds

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Calibration of hydrologic models for large watersheds is a daunting task because of the uncertainties associated with the conceptual model, driving variables, and model input parameters. The above uncertainties are difficult to quantify, yet they should all be accounted for in the prediction uncertainty. We developed a procedure (SUFI-2) for a combined optimization-uncertainty analysis routine, which quantifies total model uncertainty in the prediction. Conceptually, the calibration begins from large parameter uncertainties, which are decreased in steps. In every step, two criteria quantify the goodness of calibration, 1) the percentage of measured data bracketed by the 95% prediction uncertainty (95PPU) calculated at the 2.5 $(X_L)$ and 97.5 $(X_U)$ percentiles of the cumulative distribution of a measured output variable $(X)$, and 2) the average distance between the $X_U$ and $X_L$ in relation to the standard deviation of the measured data (*R-factor*), which quantifies the degree of the uncertainty. Ideally, the 95PPU should bracket 100% of the measured data with the average distance $(X_U - X_L)$ divided by the standard deviation of the measured data $(\sigma_X)$ less than 1. But in a real situation this is never achieved because of the uncertainties. As all the uncertainties are reflected in the measured output, bracketing this data within the 95PPU captures all the uncertainties. In SUFI-2, all uncertainties are attributed to parameters with the reasoning that a more accurate estimation of the parameter is not possible given all other uncertainties. The combination of the above two measures for both a calibration and a validation data set quantifies the goodness of a calibrated model. The above method was used to calibrate SWAT (Soil and Water Assessment Tool) hydrologic model for a four-million-km$^2$ watershed in West Africa. An initial simultaneous calibration of 68 stations resulted in 80% of the observed monthly runoff values within the 95PPU but also a quite large *R-factor* of 2.98. In subsequent iterations the *R-factor* could be

significantly decreased but only at the cost of less observed discharge values bracketed by the 95PPU. Hence, striking a balance between these two measures provides a final calibration result. Furthermore, an improved calibration will be aspired by elaborating the conceptual model.