JWARP> Vol.4 No.7, July 2012

OPEN ACCESS

Calibration of SWAT2009 Using Crop Biomass, Evapotranspiration, and Deep Recharge: Calera Watershed in Zacatecas, Mexico Case Study

PDF (Size:2291KB) PP. 439-450 DOI: 10.4236/jwarp.2012.47051

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ABSTRACT

Groundwater is the main source of water in the semi-arid Calera watershed, located in the State of Zacatecas, Mexico. Due to increasing population, rapid industrial growth, and increased irrigation to meet growing food demand, groundwater extraction in the Calera watershed are exceeding recharge rates. Therefore, development and evaluation of alter-native water management strategies are needed for sustainable development of the region. The Soil and Water Assessment Tool (SWAT) model was selected for this purpose as it has been used to simulate a wide range of agricultural production, the extensive testing and application in diverse watersheds worldwide, and the potential for future linkage of this model to groundwater models. However, crucial flow data which are commonly used for calibrating hydrologic models are not available in this watershed. This paper describes a novel calibration methodology that uses biomass and water balance approach which has potential for calibration of hydrologic models in ungauged or data-scarce watersheds, which are prevalent in many parts of the world. Estimated long-term annual average actual evapotranspiration (AET), and deep aquifer recharge rates and plant biomass values based on the expert knowledge of researchers and managers in the watershed were used as targets for calibration. The model performance was assessed using the Nash-Sutcliffe effi-ciency coefficient (NSE), coefficient of determination (R^2), and percent bias (PBIAS, %) statistics. On average, the calibrated SWAT model yielded annual Nash-Sutcliffe efficiency coefficient values of 0.95, 0.99, and 0.85 for AET, recharge, and biomass, respectively. The coefficient of determination, values for AET, recharge, and biomass were 0.95, 0.94, and 0.99 respectively. The percent bias values of ±2.21%, ±0.18%, and ±0.96% for AET, recharge, and biomass, respectively, indicated that the model reproduced the calibration target values of the three water budget variables within an acceptable value of ± 10.0%. Therefore, it is concluded that the calibrated SWAT model can be used in evaluating alternative water management scenarios for the Calera watershed without further validation. Considering the relative ease in developing calibration data and excellent performance statistics, the calibration methodology proposed in this study may have the potential to be used for ungauged or data-scare agricultural watersheds that are prevalent in many parts of the world.

KEYWORDS

SWAT; Calera Watershed; Scenarios; Recharge; Evapotranspiration; Runoff; Erosion

Cite this paper

J. R. Ávila-Carrasco, F. Mojarro Dávila, D. N. Moriasi, P. H. Gowda, C. Bautista-Capetillo, F. G. Echavarria-Cháirez, J. D. Garbrecht, J. L. Steiner, T. A. Howell, E. T. Kanemasu, A. J. Verser, K. Wagner and J. Hernandez, "Calibration of SWAT2009 Using Crop Biomass, Evapotranspiration, and Deep Recharge: Calera Watershed in Zacatecas, Mexico Case Study," *Journal of Water Resource and Protection*, Vol. 4 No. 7, 2012, pp. 439-450. doi: 10.4236/jwarp.2012.47051.

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