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Author: CHEN Xiang-Dong, LIANG Xu, XIA Jun and SHE Dun-Xian

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Impact of Lower Boundary Condition of Richards' Equation on Water, Energy, and Soil Carbon Based on Coupling Land-surface Model and Biogeochemical Model

CHEN Xiang-Dong[1,2,*], LIANG Xu[3], XIA Jun[4] and SHE Dun-Xian[4]

[1]*China Institution of Water Resources and Hydropower Research , Beijing 100036 (China)*
[2]*State Key Laboratory of Simulation and Regulation of Water Cycle in River Basin, IWHR, Beijing 100036 (China)*
[3]*Department of Civil and Environmental Engineering, University of Pittsburgh, Pittsburgh 15261 (USA)*
[4] *State Key Laboratory of Water Resources and Hydropower Engineering Science, Wuhan University, Wuhan 430072 (China)*
[*] Corresponding author. E-mail: Chenxdw@iwhr.com

ABSTRACT

Soil moisture has a significant influence on the water, energy, and carbon biogeochemical cycles. A numerical method for solving Richards' equation is usually used for simulating soil moisture. The selection of the lower boundary condition for Richards' equation will further affect the simulation results for the soil moisture, water cycle, energy balance, and carbon biogeochemical processes. In this paper, the soil water movement dynamic sub-model of a hydrologically based land surface model, the variable infiltration capacity model (VIC), is modified using the finite difference method (FDM) to solve a mixed-form Richards equation. In addition, the VIC model is coupled with a terrestrial biogeochemical model, the Carnegie Ames Stanford Approach model of carbon, nitrogen and phosphorus (CASACNP). The no-flux boundary and free-drainage boundary are selected to investigate their impact on simulations of the water, energy, and soil carbon cycles based on the coupling model. The no-flux boundary and free-drainage boundary had different influences on the water, energy, and soil carbon simulations. The water and energy simulations were more sensitive and the soil carbon simulation was less sensitive to the free-drainage boundary than to the no-flux boundary. The free-drainage boundary could result in lower soil moisture, evaporation, runoff, and heterotrophic respiration and higher surface soil temperature, sensible heat flux, and soil carbon. The impact of the lower boundary condition on a simulation would be greater with an increase in the soil permeability. In the silt loam soil case, the evaporation, runoff, and soil respiration of the free-drainage boundary are smaller by nearly 16%, 13%, and 1% compared to those of the no-flux boundary, respectively.

Key words: Lower boundary condition, Soil moisture, Richards' equation, Water and energy balance, Soil carbon

INTRODUCTION

Soil moisture is the amount of water stored in the unsaturated zone. It connects the surface water and groundwater and is an essential element in the water cycle. In addition, it is a source of transpiration and bare soil evaporation. Soil moisture also plays a key role in the energy balance through its impact on the partitioning of the incoming energy to the latent and sensible heat fluxes (Sonia *et al.*, 2010) and interacts very closely with the climate system. Soil moisture also has a strong impact on the terrestrial carbon