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Study on interface and frame structure of SWAT and MODFLOW models coupling

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Abstract: In recent years, water resources are increasingly affecting the global development of environment and economy. The temporal and spatial changes of water resources are directly dependent on the cognition of hydrological cycle laws. Watershed is the basic unit of natural water circulation, the basic system of water resources development and utilization, water environment preservation, water resources allocation and utilization. Based on the determination of the standard period of hydrological variation, the restoration of the natural runoff under the impact of human activities by the use of hydrological model through hydrology simulations, the quantitative evaluation of the impact of climate changes and human activities on watershed water sources variation and the obtainment of responding regularity and mechanism of watershed water circulation to climate changes and human activities are hotspots of the present hydrology research. The most widely used hydrological models are SWAT and MODFLOW. SWAT is the acronym for soil and water assessment tool, a watershed scale model developed by USDA Agricultural Research Service (ARS). SWAT was developed to simulate the quality and quantity of surface water and groundwater, predict the impact of land management practices on water, sediment and agriculture chemical yields in large complex watersheds with varying soils, land use and management conditions over long periods of time. The model is physically based, computationally efficient, and capable of continuous simulation over long time periods. The limitation of SWAT is its semi-distributed characteristics, which is the sub-watersheds divided in the model have distributed characteristics, and the hydrologic response units (HRUs) subdivided in the sub-watersheds do not have distributed characteristics. In order to improve the accuracy of the model simulations, especially the accuracy of daily/monthly average simulation in the plain areas with complex features of topography, substrate and groundwater withdrawal over short periods of time, each hydrologic response unit (HRU) needs the information that reflects spatial distribution, such as runoff curve number, characteristic parameters of soil water content, crop type, suppression factor of moisture under different irrigations, groundwater level and permeability, to veritably reflect states of interaction between surface water and groundwater. MODFLOW is a modular three-dimensional finite-difference ground-water flow model developed by USGS for numerical simulation of groundwater flow in porous media. The model is physically based, and capable of reflecting spatial characteristics and movement of groundwater. The limitation of MODFLOW is its running dependence on the input of some specified conditions for tributary flow, recharge, evaporation and water uses. The model lacks a means of specifying these conditions in terms of hydrologic processes at the watershed's surface and in the soil profile. MODFLOW is designed to treat specified conditions as parameters to be determined by calibration. The accuracy of groundwater simulations is higher only when the value of these calibrated parameters corresponds to reality. However, it is very difficult. Therefore, when SWAT is used for watershed hydrological simulations, it is very necessary to couple SWAT with MODFLOW to form SWAT-MODFLOW model that keeps the advantages of the two models and realizes the appropriate quantitative analysis of watershed hydrological processes. The concrete process is that the recharge values of HRU from SWAT are assigned to MODFLOW, the groundwater flow values of cell between river and aquifer from MODFLOW are returned to SWAT, and then the temporal and spatial characteristics of watershed can be revealed reasonably. Because the smallest computational units of SWAT and MODFLOW are hydrologic response units (HRUs) and cells respectively, the conversion between HRU and CELL, that is the interface of SWAT and MODFLOW models coupling, must be implemented first in the SWAT and MODFLOW models coupling. Currently, the HRU-CELL conversion method under AVSWAT2000 has been described in relative literatures, but the method has been implemented only in the small watershed of about 200 square kilometers. There are not applied case studies in the large watershed which covers an area

of more than 10000 square kilometers when the computing time of simulation will be of importance, and the HRU-CELL conversion method under ArcSWAT2005 that is the premium edition of AVSWAT2000 has not been involved. Therefore, an HRU-CELL conversion method applicable for large watersheds under ArcSWAT2005 and the frame structure of SWAT-MODFLOW coupled model are given. The HRU-CELL conversion method is applied to the co-simulation of surface water and groundwater of Hun-River and Taizi-River Basin, the area of which is 27327 square kilometers and the effectiveness of the SWAT-MODFLOW coupled model in the water cycle simulations of large watersheds is verified to lay the foundation for the quantitative evaluation of the impact of climate changes and human activities on watershed water sources variation and the obtainment of responding regularity and mechanism of watershed water circulation to climate changes and human activities.

Key words: SWAT; MODFLOW; HRU-CELL conversion; interface; frame structure