

Simulating large-scale groundwater table fluctuations : An application to the Community Water Model (CWATM)

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Groundwater is widely utilized as a valuable water resource, and currently, more than one-quarter of global population heavily relies on groundwater. Recently, many studies report depletion of groundwater resources due to overexploitation, especially in major irrigated areas and highly populated areas, indicating the use is no longer sustainable. The pressure to groundwater resource will increase in future, as it is expected that water demands will increase driven by a growing population and economic development. Climate change will also affect water availability and groundwater recharge. Thus it is an urgent issue to assess and appropriately manage groundwater resource, regarding water and food security and sustainable development. Also, groundwater plays a significant role in the hydrological cycle, and it is indispensable for the ecological and biophysical cycle.

Studies of groundwater dynamics at the global scale are significant in order to understand global environmental issues. They require a better understanding of impacts of changing the climate and anthropogenic activity, such as groundwater pumping and land use change, and feedback to them. Although there are numbers of local or regional studies that discuss groundwater dynamics with models, such as LEAFHYDRO and MODFLOW, however, still only few global models can represent the depletion of groundwater resource. To our knowledge, two hydrological models (PCR-GLOBWB, WaterGAP2.2a) can simulate variability of groundwater storage and two land surface models HiGW-MAT and MATSIRO-GW represents dynamics of groundwater table.

The purpose of this study is to introduce dynamic groundwater scheme into the Community Water Model (CWATM), a global hydrological model, which is able to assess changes in accessibility to groundwater resource and to investigate its impact on water and heat exchange at the surface through soil moisture, simulating the dynamic behavior of groundwater table. As well as the groundwater table, CWATM is going to include water quality module and hydro-economic module to provide a portfolio of economically optimal solutions for future water problems. CWATM is an integrated global hydrological model developed to assess how water availability and water demand will look in future under changing climate and socio-economic condition. Therefore it includes both components and it is designed to run at different scales from local to global. CWATM is open source and a community-driven model. Thus its specification is user-friendly and flexible enough to implement/link new modules.

The dynamic groundwater table scheme is developed as an external module of current CWATM's hydrological module. Originally, it has a groundwater reservoir under three soil layers. The explicit description of groundwater table variabilities enables us to quantify deterioration of accessibility to groundwater resource. Eventually, with hundreds-years long-term simulations, this modeling framework will provide insights of past and future impacts of climate change and anthropogenic activities on the variability of groundwater table, respectively. Taking the accessibility to groundwater resource into account, we will evaluate how effective solutions are to decrease water demand, such as improvement of water use efficiency and better timing of groundwater use to control groundwater table depression. Furthermore, given these solutions, the assessment is going to reveal a time scale to restore depressed

groundwater to its sound state to achieve sustainable water use.

Keywords: Groundwater resource, Groundwater table, Global model, Climate change, Anthropogenic impact