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Global-scale modeling of groundwater recharge and water table depth using a LSM with groundwater representation

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Traditionally, global-scale land surface models (LSMs) mainly focused on energy balance at land surface, often simplifying runoff scheme while largely neglecting the groundwater process. But, explicit representation of groundwater process is necessary in models for proper estimation of groundwater resources in current and future climate conditions. In this study, an explicit shallow groundwater representation was integrated into a LSM, Minimal Advanced Treatments of Surface Interaction and Runoff (MATSIRO). The model with groundwater representation was then applied in global-scale to estimate the major groundwater resources related variables namely, groundwater recharge and water table depth (WTD).

The global terrestrial mean annual groundwater recharge is estimated to be around 31,500 km3 yr-1. It is larger than previous estimations (around 15, 000 km3 yr-1) by Doll and Fiedler (2008) and Wada et al. (2010). In both previous model-based estimates, the model parameters were explicitly calibrated to match the river discharge in various river basins, ignoring the physical process of moisture flow in soil and actual soil moisture condition. Also, if the water table is in equilibrium condition, long-term mean groundwater recharge should be of similar magnitude to long-term mean base runoff. The recharge estimated in this study is much closer to multi-model ensemble mean base runoff (30200 km3 yr-1) from second phase of Global Soil Wetness Project (GSWP-2). On the spatial context, humid regions have the largest groundwater recharge. Quantitatively, Amazon and Congo river basins contribute around 20 % of global groundwater recharge and the estimation of this study is much larger in these regions compared to previous estimates of groundwater recharge. The recharge is low for arid and semi-arid regions mainly because of small precipitation input, high evaporative loss, and strong upward capillary flux from groundwater reservoir to unsaturated soil zone.

Similarly, WTD has been estimated in global scale. Climate and soil characteristics are found to be major controlling factors for large-scale mean WTD. Simulated WTD is shallow in regions with either large infiltration, which is governed by climatic condition, or poor drainage condition, which is governed by soil characteristics. The WTD is deeper for dry regions whereas it is shallow for humid regions. However, further heterogeneity in WTD is provided by soil type, for e.g., grid cells with loamy soil (large permeability) have deeper WTD than the regions with clay (low permeability).

キーワード: Global, Land surface model, Groundwater recharge, Water table depth
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