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Human-groundwater interactions in a changing environment: modeling stressed global aquifer systems

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Groundwater storages in many of the world’ s major aquifer systems have been declining at an alarming rate. While in-situ measurements and satellite observations provide crucial information on the past changes, hydrological models serve as indispensable tools for attributing the observed changes to climate variability and human actions, and thereby better predicting future dynamics under climate change. Concerted efforts have been made by the hydrologic sciences community over the past decade in better understanding evolving aquifer dynamics in response to climate change and increased groundwater use by humans; however, imperfect or missing groundwater parameterizations in large-scale hydrology models still pose critical challenges in realistically simulating climate-human-groundwater interactions, hindering path forward to sustainable management of groundwater resources. This study presents improved simulations of groundwater flows and storages in the major global aquifer systems using multiple global hydrological models including the Community Land Model version 5 (CLM5). Simulations are conducted at 5km grids over the contiguous United States considering lateral groundwater flow, surface water-groundwater interactions, and aquifer pumping, and at 50km grids globally under simplified settings. Changes in water table depth and terrestrial water storage (TWS) are analyzed and validated using a synthesis of ground- and satellite-based datasets including those from the gravity Recovery and Climate Experiment (GRACE) satellite mission. Results suggest that groundwater depletion in the stressed aquifer systems can be better simulated when lateral flow is represented, especially in models that operate at relatively fine grid sizes (˜5km). Further, results from future projections suggest that TWS in many of the stressed global aquifer systems will reduce under future climate, exacerbating groundwater sustainability issues in many regions.

Keywords: Hydrology, Modeling , Groundwater depletion