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Spatial and temporal estimation of global groundwater withdrawal and depletion

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The extent of water withdrawal and its increase is a growing concern as population continues to grow and climate change affects the water cycle. Global water withdrawal grew by about 20% per decade during 1960-2000, and water scarcity is a significant condition for 1-2 billion people worldwide. Groundwater is an attractive source of freshwater consisting about one third of the global water withdrawals, and its use has increased in recent decades relative to surface water. There are reports of groundwater depletion in several areas such as Northern India, North East China and the central U.S.. However, in most of the reported areas, the whole picture of the current state is often not known. Moreover, there is a possibility that groundwater depletion has been occurring in areas that we do not even know about, as water table is inherently hidden underground. In order to grasp the global picture of groundwater withdrawals and to assess future global water resources, it is necessary to comprehend the past and current withdrawal trends and distribution. However, consistent data on global groundwater withdrawals are very difficult to come by. While physically based models are useful to fill data gaps, their estimates of groundwater withdrawal vary significantly among studies. In this study, we estimated total and groundwater withdrawal for 1960-2000 in grid scale (1.0 degree) primarily based on statistical data. In order for our estimates to have good agreement with country scale statistical data, we collected data from a wide range of database and literature and prepared a country scale time series withdrawal database. By combining our results of groundwater withdrawal with groundwater recharge, we estimated groundwater depletion (nonrenewable groundwater withdrawal).

First, total water withdrawal for each sector was estimated by downscaling country statistics using proxies such as irrigation water demand simulated by a global water resources model, infrastructure area and population for the agricultural, industrial and domestic sector, respectively. Groundwater withdrawal was also estimated based on country scale statistics collected from a wide range of database and literature. Then, we separated the country scale groundwater withdrawal into each sector using sectoral ratio of groundwater withdrawal from statistical data, and then distributed each of them using the estimated total water withdrawal as a proxy for each sector. Finally, groundwater depletion was estimated by subtracting simulated groundwater recharge from groundwater withdrawal. Groundwater recharge is simulated by a global-scale land surface model coupled with a groundwater model.

Validation of the estimated groundwater withdrawal in USA and India for specific years showed relatively good correlation. Compared to previous studies, our estimated groundwater depletion showed higher values in Southern India, Turkey, Spain, Morocco and Northern Algeria. With these results, we aim to contribute to revealing the global picture of groundwater resources and its sustainability.

Keywords: groundwater withdrawal, groundwater depletion, H08 model, MATSIRO