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Evaluating groundwater depletion as computed by a global water model

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When groundwater abstraction occurs faster than its replenishment over a long time and in a large area, the result is an overexploitation or depletion of groundwater. The problem is aggravated in areas where a growing population relies on freshwater resources for an intensive irrigation agriculture that is meant to guarantee food security. Especially in semi-arid and arid regions, the dominant use for groundwater is irrigation, reaching more than 95% of total water use. Therefore, the hot spots for groundwater depletion are the world's major irrigation areas like the central United States, north-western India and north China. Groundwater depletion presents a major threat to securing agricultural productivity and domestic water supply in these parts of the world. Besides, the environmental consequences that accompany the abstraction of groundwater are severe. Within the scientific community there is a common understanding that high-quality data on globally existing groundwater resources are deficient. In order to allow a sustainable management of the world's available groundwater resources, especially in areas under current water stress, the quantification of groundwater depletion is of high importance. WaterGAP (Water – Global Assessment and Prognosis) is a global model of water availability and water use which can serve to estimate the impact of groundwater and surface water withdrawals on groundwater storage. The new WaterGAP version 2.2a was modified to allow for an improved analysis of groundwater storage changes in semi-arid and arid regions. Now, groundwater recharge from surface water bodies is simulated in semi-arid and arid areas. Estimation of net groundwater abstractions was modified with respect of irrigation water use efficiency for groundwater and return flow fractions. In addition, irrigation consumptive use has been set to 70% of optimal irrigation consumptive use, assuming deficit irrigation to prevail in these parts of the world. Based on time series of groundwater storage as computed by WaterGAP, the yearly groundwater depletion rates for the period 1901-2009 have been determined and compared to independent estimates (well observations and GRACE satellite data). So far, the results show that the former WaterGAP standard version overestimates groundwater storage losses considerably in all of the study regions (USA, north-western India, and North China Plain) whereas the improved WaterGAP 2.2a mimics observed groundwater depletion to a high degree.