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Global groundwater recharge assessment over the last two decades

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Groundwater is the largest global liquid freshwater source and is vital for providing reliable water resources for growing water consumption. To meet an increasing freshwater demand, the groundwater resources have been excessively exploited, which can cause groundwater depletion and its further consequences, such as land subsidence. Groundwater recharge is a major factor for the sustainable management of groundwater abstraction. One of the most uncertain parts of our knowledge of the global scale hydrological cycle is global groundwater recharge. Yet, measuring groundwater recharge requires detailed knowledge of environmental parameters and is observation-intensive. Therefore, we developed a global groundwater recharge model to analyze global groundwater recharge and estimate its spatial and temporal distribution.

The model is a global hydrology grid-based concept implemented in python with a spatial resolution of 0.1°×0.1° and daily temporal resolution. The model comprises three soil layers: topsoil (root zone), subsoil, and aquifer. It simulates the exchange between topsoil and atmosphere performed by meteorological variables, as well as surface runoff, topsoil recharge, soil layers water volume, subsoil recharge, capillary rise from the subsoil to the topsoil, and groundwater recharge. Meteorological and soil properties data from various sources such as ERA5, IMERG, and SoilGrid250m were gathered to build the model and simulate fluxes. The groundwater recharge model applies the water balance budget concept on each soil layer to simulate the daily cell average fluxes values.

With the implementation of the global groundwater recharge model from 2001 to 2020, each global basin's groundwater recharge was calculated. It is estimated that the global average groundwater recharge is 150 mm a^{-1} varying from zero to 1260 mm a^{-1}. Moreover, a linear regression was applied for the decades 2001-2010 and 2011-2020 to evaluate how recharge has changed. An increasing trend in groundwater recharge was identified found in 68% of the world's basins in the period 2001 to 2010. For the period from 2011 to 2020, this percentage has decreased to 48%. Basins with declining recharge show the opposite trend, comprising 32% of the basins in the first period and 52% in the second.

Global groundwater resources status and the possibility of groundwater shortage can be discovered by applying global groundwater recharge model results. An increasing number of river basins show a decreasing trend of groundwater recharge. These outputs provide insight into

uneven global groundwater recharge spatial and temporal distributions and indicate that the groundwater recharge decline in recent years threatens more basins. In addition, the results can be used to identify the regions where groundwater resources are or will be at risk of unsustainability.