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A more active role for groundwater in the land water cycle

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How much precipitation recharges groundwaters varies enormously across Earth's surface, but recharge rates are uncertain because field observations are sparse and modeled global estimates remain largely unvalidated. Here we show that annual recharge is predictable as a simple function of climatic aridity — the ratio of long-term potential evapotranspiration to precipitation — using a global synthesis of measured recharge of 5237 sites across six continents. We use this relationship to estimate long-term recharge globally outside of permafrost regions. Our estimates double previous global hydrological model estimates and are more consistent with empirical field observations. These revised higher estimates of global groundwater recharge imply that groundwater contributes more actively to evapotranspiration and streamflow than previously represented in global water cycle depictions or global hydrological and Earth system models. In addition, we quantify the sensitivity of groundwater recharge to changes in aridity using the empirical relationship between groundwater recharge rates and climatic aridity. This analysis indicates that recharge is most sensitive to climate aridity in mesic regions, where changes in the replenishment of aquifers will be amplified relative to projected changes in precipitation. Global hydrological models seem to underestimate changes in recharge with climate aridity. Thus, the impacts of climatic changes on the replenishment of Earth's largest liquid freshwater stores may be larger than previously anticipated.