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A high resolution global scale groundwater model

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As the world's largest accessible source of freshwater, groundwater plays a vital role in satisfying the basic needs of human society. It serves as a primary source of drinking water and supplies water for agricultural and industrial activities. During times of drought, groundwater storage provides a large natural buffer against water shortage and sustains flows to rivers and wetlands, supporting ecosystem habitats and biodiversity. Yet, the current generation of global scale hydrological models (GHMs) do not include a groundwater flow component, although it is a crucial part of the hydrological cycle. Thus, a realistic physical representation of the groundwater system that allows for the simulation of groundwater head dynamics and lateral flows is essential for GHMs that increasingly run at finer resolution.

In this study we present a global groundwater model with a resolution of 5 arc-minutes (approximately 10 km at the equator) using MODFLOW (McDonald and Harbaugh, 1988). With this global groundwater model we eventually intend to simulate the changes in the groundwater system over time that result from variations in recharge and abstraction.

Aquifer schematization and properties of this groundwater model were developed from available global lithological maps and datasets (Dürr et al., 2005; Gleeson et al., 2010; Hartmann and Moosdorf, 2013), combined with our estimate of aquifer thickness for sedimentary basins. We forced the groundwater model with the output from the global hydrological model PCR-GLOBWB (van Beek et al., 2011), specifically the net groundwater recharge and average surface water levels derived from routed channel discharge. For the parameterization, we relied entirely on available global datasets and did not calibrate the model so that it can equally be expanded to data poor environments. Based on our sensitivity analysis, in which we run the model with various hydrogeological parameter settings, we observed that most variance in groundwater depth is explained by variation in saturated conductivity, and, for the sediment basins, also by variation in recharge. We validated simulated groundwater heads with piezometer heads (available from www.glowasis.eu), resulting in a coefficient of determination for sedimentary basins of 0.92 with regression constant of 0.8. This shows the used method is suitable to build a global groundwater model using best available global information, and estimated water table depths are within acceptable accuracy in many parts of the world.