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# Hyper resolution hydrological modeling: the need and benefit of improving spatial resolutions of global models

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If not addressed and remedied, the unsustainable use of non-renewable groundwater will negatively impact many future generations. To effectively manage global groundwater reserves, we first need accurate estimates of its current availability and how much of this we can feasibly extract. Landscape characteristics have a high impact on local groundwater recharge, groundwater-surface water interactions, and abstractions. It is therefore key to model groundwater at an appropriate spatial resolution so that landscape heterogeneities are captured. Our objective is to enable groundwater modelling at fine spatial (~ 1 km) resolution, with the final aim to assess the physical limits of groundwater withdrawal by providing the first global estimates of fresh groundwater availability (attainable volumes and supply) subject to past human water use. The first step to attaining this objective is the ability to simulate groundwater recharge and surface water levels at 1 km spatial resolution using a global hydrological model. In this study, we aim to tackle this challenge and present the first global case of the PCR-GLOBWB at the 1 km spatial resolution. To do this, we implemented a statistical downscaling routine for meteorological forcing, created a new global 1km land surface parameterization and improved the parallelization of the PCR-GLOBWB model. The meteorological downscaling approach followed here provides outputs that are at a finer resolution than the original meteorological forcing products. This approach relies on Worldclim data to provide realistic sub-grid distributions of precipitation and temperature. In addition, sub-grid distributions of potential reference evaporation were retrieved from the Global Aridity Index and Potential Evapotranspiration Climate Database, which uses Worldclim data to calculate potential reference evaporation following the Penman-Monteith formulation.

We investigate whether these high-resolution meteorological fields, in combination with an improved 1km land surface parameterization, provided improved outcomes by validating against remote sensing observations (soil moisture, total water storage) and local observations of discharge and compare these to simulation at coarser 10 & 50km resolutions. Furthermore, we discuss the computational challenges encountered along the way and outline future directions and opportunities in high-resolution groundwater modelling.