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The PCR-GLOBWB global hydrological reanalysis product

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Accurate and long time series of hydrological data are important for understanding land surface water and energy budgets in many parts of the world, as well as for improving real-time hydrological monitoring and climate change anticipation. The ultimate goal of the present work is to produce a multi-decadal “land surface hydrological reanalysis” dataset with retrospective and updated hydrological states and fluxes that are constrained to available in-situ river discharge measurements.

Here we use PCR-GLOBWB (van Beek et al., 2011), which is a large-scale hydrological model intended for global to regional studies. PCR-GLOBWB provides a grid-based representation of terrestrial hydrology with a typical spatial resolution of approximately 50×50 km (currently 0.5° globally) on a daily basis. For each grid cell, PCR-GLOBWB simulates moisture storage in two vertically stacked soil layers as well as the water exchange between the soil and the atmosphere and the underlying groundwater reservoir. Exchange to the atmosphere comprises precipitation, evaporation and transpiration, as well as snow accumulation and melt, which are all simulated by considering vegetation phenology and sub-grid variations of elevation, land cover and soil saturation distribution. The model includes improved schemes for runoff-infiltration partitioning, interflow, groundwater recharge and baseflow, as well as river routing of discharge. It also dynamically simulates water storage in reservoirs, water demand and the withdrawal, allocation and consumptive use of surface water and groundwater resources.

By embedding the PCR-GLOBWB model in an Ensemble Kalman Filter framework, we calibrate the model parameters based on the discharge observations from the Global Runoff Data Centre. The parameters calibrated are related to snow accumulation and melt, runoff-infiltration partitioning, groundwater recharge, channel discharge and baseflow processes, as well as pre-factors to correct forcing precipitation fields with consideration of local topographic and orographic effects.

Results show that the model parameters can be successfully calibrated, while corrections to the forcing precipitation fields are substantial. Topography has the largest impact on the corrected precipitation and globally the precipitation is reduced by 3%. The calibrated model output is compared to the reference run of PCR-GLOBWB before calibration showing significant improvement in simulation of the global terrestrial water cycle. The RMSE is reduced by 10% on average, leading to improved discharge simulations, especially under base flow situations.

The main outcome of this work is a 1960-2010 global reanalysis dataset that includes extensive daily hydrological components, such as precipitation, evaporation and transpiration, snow, soil moisture, groundwater storage and discharge. This reanalysis product may be used for understanding land surface memory processes, initializing regional studies and operational forecasts, as well as evaluating and improving our understanding of spatio-temporal variation of meteorological and hydrological processes. Moreover, The PCR-GLOBWB data assimilation framework developed in this work can also be extended by including more observational data, including remotely sensed data reflecting the distribution of energy and water (e.g., heat fluxes and soil moisture storage).