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Seamless reconstruction of global scale hydrologic simulations: challenges and opportunities

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Crucial objective of large-scale hydrologic modeling is to adequately estimate water fluxes and states across different hydroclimatic regions in a spatially consistent and seamless manner. This enables the quantification of hydrologic assessments over large (gauged and ungauged) domains and longer periods. We provide here a synthesis of hydrologic variables at high spatial and temporal resolutions to understand the effects of climate variability on the hydrological response across the Globe. Our synthesis is based on a multi-scale modelling framework, which consists of a well established mesoscale Hydrologic Model (mHM,[1]) featuring the Multiscale Parameter Regionalization (MPR), applied to reconstruct hydrologic fluxes and storages from the beginning of 20th century. Our modelling framework allows for a flexible spatial resolution to incorporate a range of spatially varying datasets. This includes terrain characteristics derived from DEM at 30 m, vegetation and soil textural characteristics at 200 m. Meteorologic forcing data are based on different globally available products being suitable downscaled to 0.1° spatial resolution. The high-resolution hydrologic simulations (0.1°, daily) are carried out on the JUWELS Supercomputing Centre at Jülich [2] with a parallelized model source code having effective scheduling algorithms for tree structured data and hybrid MPI-OpenMP implementations.

The global-scale hydrologic simulations are constrained and evaluated against a range of observed and reference data, which for example consists of (a) streamflow; (b) FLUXNET/FLUXCOM evapotranspiration products; (c) GRACE terrestrial total water storage (TWS) anomaly. We discuss technical limitations and obstacles in implementing the global hydrologic dataset in seamless manner (e.g., finding a compromise set of parameter set across all continents, meaningful delineation of the river network, etc.). Preliminary analysis reveals hotspots of weaker model performance in semi-arid regions than in humid regions. Model performance based on seamless parameterization deteriorates in areas, where water balance closure error is largest. The long-term simulations allow us to identify locations of consistent changes in hydrologic variables responding to long-term climate variability. Finally, we show several examples, where the high-resolution hydrologic simulations can be useful for end-user applications.

1. www.ufz.de/mhm

2. http://www.fz-juelich.de/ias/jsc/juwels