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Global-scale high-resolution (∼1 km) modelling of mean, maximum and minimum annual streamflow

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Quantifying mean, maximum and minimum annual flow (AF) of rivers at ungauged sites is essential for a number of applications, including assessments of global water supply, ecosystem integrity and water footprints. AF metrics can be quantified with spatially explicit process-based models, which might be overly time-consuming and data-intensive for this purpose, or with empirical regression models that predict AF metrics based on climate and catchment characteristics. Yet, so far, regression models have mostly been developed at a regional scale and the extent to which they can be extrapolated to other regions is not known. We developed global-scale regression models that quantify mean, maximum and minimum AF as function of catchment area and catchment-averaged slope, elevation, and mean, maximum and minimum annual precipitation and air temperature. We then used these models to obtain global 30 arc-seconds (∼ 1 km) maps of mean, maximum and minimum AF for each year from 1960 through 2015, based on a newly developed hydrologically conditioned digital elevation model. We calibrated our regression models based on observations of discharge and catchment characteristics from about 4,000 catchments worldwide, ranging from 10^0 to 10^6 km^2 in size, and validated them against independent measurements as well as the output of a number of process-based global hydrological models (GHMs). The variance explained by our regression models ranged up to 90% and the performance of the models compared well with the performance of existing GHMs. Yet, our AF maps provide a level of spatial detail that cannot yet be achieved by current GHMs.