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Modeling of reservoir operation in UNH global hydrological model

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Climate is changing and river flow is an integrated characteristic reflecting numerous environmental processes and their changes aggregated over large areas. Anthropogenic impacts on the river flow, however, can significantly exceed the changes associated with climate variability. Besides of irrigation, reservoirs and dams are one of major anthropogenic factor affecting streamflow. They distort hydrological regime of many rivers by trapping of freshwater runoff, modifying timing of river discharge and increasing the evaporation rate. Thus, reservoirs is an integral part of the global hydrological system and their impacts on rivers have to be taken into account for better quantification and understanding of hydrological changes.
We developed a new technique, which was incorporated into WBM-TrANS model (Water Balance Model-Transport from Anthropogenic and Natural Systems) to simulate river routing through large reservoirs and natural lakes based on information available from freely accessible databases such as GRanD (the Global Reservoir and Dam database) or NID (National Inventory of Dams for US). Different formulations were applied for unregulated spillway dams and lakes, and for 4 types of regulated reservoirs, which were subdivided based on main purpose including generic (multipurpose), hydropower generation, irrigation and water supply, and flood control. We also incorporated rules for reservoir fill up and draining at the times of construction and decommission based on available data.
The model were tested for many reservoirs of different size and types located in various climatic conditions using several gridded meteorological data sets as model input and observed daily and monthly discharge data from GRDC (Global Runoff Data Center), USGS Water Data (US Geological Survey), and UNH archives. The best results with Nash–Sutcliffe model efficiency coefficient in the range of 0.5-0.9 were obtained for temperate zone of Northern Hemisphere where most of large reservoirs designed for hydropower generation, water supply and flood control. Less reliable results were observed for Africa and dry areas of Asia and America. There are several possible causes of large uncertainties in discharge simulations for these areas including: accuracy of observational data, model underestimation of extensive water use and greater uncertainties of used climatic data in these regions due to sparser observational network. In general the applied approach for streamflow routing through reservoirs and large natural lakes has significantly improved simulated discharge estimates.