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Technique for the long-term projections of water balance components for northern river basins of Russia

Yeugeniy Gusev (1) and Olga Nasonova (2)

(1) The Institute of Water Problems, Moscow, Russian Federation (sowaso@yandex.ru), (2) The Institute of Water Problems, Moscow, Russian Federation (nasonova@aqua.laser.ru)

The goal of the present work is a development of a technique for a long-term projection of changes in water resources of northern rivers of Russia caused by climate change. The technique is based on the land surface model SWAP and information on the land surface parameters taken from global data sets. SWAP is a physically-based model. A good accuracy of simulating different characteristics of the water and energy regimes under different conditions and on different spatial scales was confirmed by numerous validation of the model against measured data. As a result, it was concluded that SWAP can be a good tool for simulation of water balance components for various river basins both for the current climatic conditions and for the future ones.

The northern river basins of Russia are covered with a sparse network of meteorological stations and poorly provided with land surface parameters. The latter was overcome by application of global data sets on land surface characteristics. Evidently, that direct application of such information leads to a low accuracy of model simulations. To improve the quality of river runoff modeling the main land surface parameters were calibrated using the SCE-UA algorithm and river runoff measurements. Optimization of model parameters has significantly improved the agreement between measured and simulated streamflow of northern rivers. The Nash-Satcliffe efficiency for the modeled daily streamflow varied from 0.70 to 0.85 and the absolute bias values reached 1-10 %. That allowed us to use the SWAP model for hydrological projections.

In order to make sure that the land surface parameters, obtained for the modern period, remain valid in projection periods, the following investigation was carried out. For the Northern Dvina River, model transposability in time under contracted climate conditions was analyzed. In so doing, model calibration and validation was performed for contrasted climatic conditions in terms of temperature and precipitation. Thus, model parameters were calibrated for five dry and cold years, while their validation was carried out for seven humid and warm years. Good results of model validation allowed us to conclude that the SWAP model and the global data sets on land surface parameters can be used for hydrological projections for a number of northern rivers of Russia (the Onega, the Northern Dvina, the Olenek and the Indigirka) up to 2060-2070's.

Four SRES climate change scenarios were chosen for generating climate change projections by an ensemble of 16 General Circulation Models with a high spatial resolution. The projections represented increments of monthly values of meteorological characteristics. Then temporal downscaling was used for creating 3-hour meteorological time series to drive the SWAP model. Model simulations up to 2060 have shown, that in the European part of Russia river runoff will slightly decrease, but evapotranspiration will significantly increase. As to the chosen Siberian rivers, both evaporation (greatly) and streamflow (to a less extent) will increase.