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An ECOMAG-based Regional Hydrological Model for the Mackenzie River basin

Yury Motovilov, Andrey Kalugin, and Alexander Gelfan
Water Problems Institute of Russian Academy of Sciences, Moscow, Russian Federation (motol49@yandex.ru)

A physically-based distributed model of runoff generation has been developed for the Mackenzie River basin (the catchment area is 1 660 000 km2). The model is based on the ECOMAG (ECOlogical Model for Applied Geophysics) hydrological modeling platform and describes processes of interception of rainfall/snowfall by the canopy, snow accumulation and melt, soil freezing and thawing, water infiltration into unfrozen and frozen soil, evapotranspiration, thermal and water regime of soil, overland, subsurface and ground flow, flow routing through a channel network accounting for flow regulation by lakes and reservoirs. The governing model's equations are derived from integration of the basic hydro- and thermodynamics equations of water and heat vertical transfer in snowpack, frozen/unfrozen soil, horizontal water flow under and over catchment slopes, etc. The Mackenzie basin's schematization was performed on the basis of the global DEM data (1-km resolution) from the HYDRO1K database of the U.S. Geological Survey. Most of the model parameters are physically meaningful and derived through the global datasets of the basin characteristics: FAO/IIASA Harmonized World Soil Database, USGS EROS Global Land Cover Characteristics project, etc. The 0.50.5 WATCH reanalysis daily precipitation, air temperature and air humidity data were used as the model input for the period of 1971-2002. The daily discharge data provided by the Water Survey of Canada for 10 streamflow gauges, which are located at the Mackenzie River and the main tributaries (Peel River, Great Bear River, Liard River, Slave River and Athabasca River), were used for calibration (1991-2001) and validation (1971-1990) of the model. The gauges' catchment areas vary from 70600 km2 (Peel River above Fort Mopherson) to 1 660 000 km2 (Mackenzie River at Arctic Red River). The model demonstrated satisfactory performance in terms of Nash-and Sutcliffe efficiency (NSE(daily) [U+F0B3] 0.60 and NSE(monthly) [U+F0B3] 0.70) and percent bias (PBIAS [U+F0A3] 15%) for 8 gauges of 10. Weaker results were obtained for Great Bear River at outlet of Great Bear Lake and Peace River at Peace Point. Possibilities of a model approach for the construction of mean annual hydrological fields (maps) using meteorological data for the large river basins are shown. Spatial fields of the 32-year mean annual runoff and evaporation (1971-2002) for the Mackenzie River basin were simulated by the distributed model and the corresponding maps were compared with that provided by Hydrological Atlas of Canada (1972) for 30-year period (1941-1970). Analysis of fields conformity is made and possible sources of errors are discussed.