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The hydrological model "Hydrograph" – a unified approach to the representation of catchment heterogeneity in different climate and landscape zones

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The problem of heterogeneity of earth surface characteristics is considered to be one of the fundamental challenges of hydrological science. The practical use of any hydrological model is limited if it is not supported by the possibility to generalize and systematize its parameters by different landscape and climate conditions.
Mainly the heterogeneity refers to the model's parameters describing physical properties of soils. However consideration must be given to the fact that the variation of soil properties depends on the areal extent used for their estimating or measuring their values. The evaluation of soil characteristics which have definite physical meaning can be conducted in field and laboratory conditions and the ranges of their values systematized by different soil types are narrow and steady. In contrast, the parameters estimated not individually but in complexes upon the calibration procedures influencing each other often lose physical meaning and usually can not be systematized and transferred to basins without observations.
The appropriate approaches of adequate processes description should be applied to have clear physical sound of all model's parameters.
The hydrological model "Hydrograph" developed by Prof. Yu.B. Vinogradov at the State Hydrological Institute (Saint-Petersburg, Russia) was applied. Being constructed on the basis of a general approach to the description of runoff formation processes, the model covers all types of flows and can be used for simulations at any basin regardless of its landscape type and size. The model algorithm includes the following computation routines: snow accumulation and melting, total evaporation, surface flow and infiltration, soil water dynamics and soil flow, heat dynamics and phase change in soil layers, ground flow formation, slope and channel flow transformation, and flow discharge.
In the framework of the model the basin surface is presented by collection of so called runoff formation complexes (RFC) – areas which have relatively homogeneous conditions of runoff generation. Then the main set of the model's parameters presenting properties of landscape's components are systematized by determined RFCs.
The parameters describe water and physical characteristics of soil (density, porosity, specific heat capacity and conductivity, water holding capacity, filtration coefficient), characteristics of vegetable cover (shadow rate, albedo, evapotranspiration coefficients, interception rate, phenological dates) and nature of slope surface (depression storage, index of snow redistribution over territories).
The results of modelling runoff processes for small-, middle- and large-scale basins will be presented as an example of a successful realization of a single model and one set of model parameters (without change for given types of landscapes). The research was carried out for three different geographical zones: south taiga in the European part of Russia; steppe and arable lands in middle part of Russia; the area of continuous permafrost at north-east part of Russia.