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Hydrological Simulation of River Basins at Different Spatial Scales: 2. Test Results

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Abstract—The results of testing algorithms designed for generalizing the mathematical description of processes and averaging ECOMAG model parameters at scale aggregation during simulation in large river basins are illustrated by the case of simulation of soil moisture field dynamics, snow water equivalent, and runoff hydrographs in the Volga Basin. The calculated fields are compared with data collected by route snow measurements and measurements of available moisture in the monitoring network of agrohydrometeorological stations. The results of numerical experiments were used to study the effects of model grid scaling on the results of simulating the hydrological characteristics and to establish the minimal and maximal sizes of model cells for simulating runoff formation processes.

Keywords: river basin, runoff formation, simulation, scaling, hydrological fields

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MODEL TESTS FOR SMALL WATERSHEDS USING NOPEX EXPERIMENT DATA

In [2], hydrological model ECOMAG (ECOlogical Model for Applied Geophysics) was used to develop algorithms for generalizing the description of processes and assessing moisture exchange parameters when changing the spatial scales of simulation. The first tests and the assessment of the performance of the developed algorithms for small watersheds were based on the materials of international interdisciplinary experiment NOPEX (NOrthern hemisphere climate Processes land-surface EXperiment), whose objectives included the construction and validation of hydrological models at different space and time scales [4]. NOPEX experimental domain, 80 × 100 km in size, lied in Southern Sweden and was typical of the zone of boreal forests. Detailed field studies in the test area were carried out in summer seasons of 1994–1995 at three levels and included ground observations, tall-mast observations, and sounding from airplanes. The obtained dataset was used to evaluate the linear scale of a representative elementary area REA, which, for the given region, was estimated at ~2 km [5], the geophysical parameters for different types of soils and landscapes. Therefore, a regular model grid with a size of 2 × 2 km was used in ECOMAG hydrological model for the NOPEX domain. Clearly, these experiments, detailed as they were, are not enough to specify all parameter models; therefore, some parameters are to be calibrated. A radical distinction from the conventional calibration is that the new variant involves the calibration of the parameters of individual types of landscapes (soils, vegetation, and land use) that occur in the watershed, rather than the parameters of individual partial river basins, as it is commonly made. The specifics of partial river basins are accounted for in the model by the combinations and spatial distribution of different types of soils, vegetation, relief, slopes, river network structure, meteorological conditions, etc. The implementation of such approach enabled successful simulation of soil moisture dynamics and groundwater levels for different types of soils and landscapes (based on the comparison of the calculated values with averaged data of measurements on five elementary experimental watersheds) [5], evaporation dynamics from the entire NOPEX domain (compared with the results obtained by measuring the turbulent fluxes of latent and sensible heat on five tall masts, and data of airplane sounding of NOPEX domain for assessing the weighted mean evaporation fluxes) [3], and runoff hydrographs, calculated by meteorological data on gauged and ungauged river basins (parameter calibration and model verification were carried out in different river basins) [5].

SPATIAL CHEMATIZATION OF WATERSHEDS FOR LARGE RIVER BASINS

The generalization algorithms of the vertical and horizontal moisture exchange in the runoff formation model ECOMAG for large river basins were tested on the Volga Basin. By contrast to the relatively small NOPEX domain, the grid cells for the model of this