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WATER RESOURCES AND THE REGIME OF WATER BODIES

Physically Based Modeling of Many-Year Dynamics of Daily Streamflow and Snow Water Equivalent in the Lena R. Basin

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Abstract—The applicability of a procedure, developed previously for evaluating runoff hydrographs of northern rivers, to the largest Russian river—the Lena—which flows under severe conditions of the Northeastern Siberia, is examined. The procedure is based on the land surface model SWAP in combination with input data derived from global databases of land surface parameters and meteorological forcing data derived from observations at meteorological stations located in the basins of the rivers or near them. Also studied was the ability of the model SWAP to reproduce the many-year dynamics of the values of snow water equivalent averaged over the Lena basin and their distribution over the basin area.

Keywords: river runoff hydrograph, snow cover formation, interaction between land surface and the atmosphere, physically based modeling, global databases, Lena R. basin

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INTRODUCTION

This article pursues a series of publications devoted to simulating the formation of water balance components (primarily, runoff) in the basins of northern rivers of the Russian Federation (RF) [1, 5–7, 9, 10, 18, 19]. The importance of this line of studies, which has been substantiated in this series, is associated with the creation of a more accurate tool for solving hydrological problems and the development of a method for scenario forecasting variations in water balance components in the river basins on RF northern slope [3, 9, 20].

According to most scenarios of climate changes, the territory of the northern regions of RF will experience the most significant changes. Thus, IPCC reports [21–23] estimate the air temperature increments in the northern part of the Northern Hemisphere by the late XXI century at 3–5°C, and an increase in precipitation at 15%. At the same time, this region attracts ever-growing attention because of the considerable reserves of fossil fuel on its shelf. In addition, this region features the wide diversity of water resources, including the largest rivers in the world. Therefore, the issue of the hydrological regime of the basins of northern rivers under current conditions and its variations under possible climate changes is of extreme importance and requires sufficiently accurate procedures for evaluating the many-year dynamics of water resources in the northern Russian rivers for both the present time and the nearest decades.

The authors' studies [5–7, 9, 10, 18, 19] use a method for simulating the dynamics of water resource components of northern rivers (for both the present and the future) based on their physically based land surface model SWAP (Soil Water–Atmospher–Plants). This method has demonstrated a good quality in reproducing the runoff of northern RF rivers and other characteristics of the hydrological regime of their basins for the present time, allowing us to expect that the dynamics of water balance components will be adequately reproduced for the nearest decades, given forecasts of the dynamics of meteorological elements. In the development of scenario forecasting of meteorological elements, the authors used various IPCC-scenarios of climate changes.

This article is aimed to analyze the potentialities of SWAP model in reproducing the dynamics of hydrological characteristics for the basin of the largest Russian river—the Lena. This river has been the focus of several studies devoted to conceptual [12] and physically based [25] modeling of Lena R. runoff, as well as modeling, combining the features of hydrological modeling and land surface modeling [28]. As mentioned above, the objective of this study was to examine the potentiality of reproducing water balance components of the Lena R. by the SWAP model, which has been used for hydrological calculations for nearly all large rivers of RF northern slope with the perspective of scenario forecasting the changes of water balance