ISSN 0097-8078, Water Resources, 2018, Vol. 45, Suppl. 1, pp. S90–S101. © Pleiades Publishing, Ltd., 2018.

Validation of a Hydrological Model Intended for Impact Study: Problem Statement and Solution Example for Selenga River Basin

A. N. Gelfan[a, b] and T. D. Millionshchikova[a, *]

[a] *Water Problems Institute, Russian Academy of Sciences, Moscow, 119333 Russia*

[b] *Department of Land Hydrology, Faculty of Geography, Moscow State University, Moscow, 119991 Russia*

**e-mail: tatyana.million@mail.ru*

Received June 19, 2018

Abstract—The study is aimed to evaluate a hydrological simulation model intended for assessing climate change impact. A new test was suggested and applied to evaluate the performance of a physically based model of Selenga River runoff generation. In this test, to calibrate the model, an enhanced Nash–and-Sutcliffe efficiency (NSE) criterion was used, including trend-oriented reference (benchmark) models instead of the simple reference model used in the original NSE criterion. Next, modifications were made in the Differential Split Sample test (DSS-test) of V. Klemeš (1986), focused on differences in the model performance criteria for climatically contrasting periods, and a new statistical measure was proposed to estimate the significance of these differences. After that, model performance was evaluated for four sites within the catchment, three indicators of interest (daily, monthly, and annual discharge series), and the model ability to reproduce the observed trends in annual and seasonal discharge values was assessed. The model proved robust enough to be applied to assessing climate change impact on the annual and monthly runoff in different parts of the Selenga River basin.

Keywords: hydrological modeling, Selenga River Basin, validation, model robustness, impact assessment, crash-test

DOI: 10.1134/S0097807818050354

INTRODUCTION

Predicting the hydrological response to changes in the external impact (for instance, because of climate change) and/or in internal parameters (for instance, because of a change in watershed characteristics) is a traditional problem of terrestrial hydrology. The opportunities to solve these problems with the help of hydrological models developed for unchanged conditions formed the core of major scientific initiatives of The International Association of Hydrological Sciences (IAHS) in the recent two decades. While the previous IAHS decade (2003–2012: Prediction in Ungauged Basins, PUB) was devoted to analyzing the opportunities of "transferring" a hydrological model over space—from gauged basins to ungauged ones, the current IAHS decade (2013–2022: Panta Rhei) is aimed at searching for methods of "transferring" the model over time—into different climate conditions. In both cases, hydrologists have to judge the model performance in the absence of observation data. This paper is devoted to the problem of evaluating a hydrological simulation model intended for assessing climate change impact; more specifically, we will try to answer the question: how should model evaluation be done in the context of climate impact assessment? We emphasize here the difference in the opportunities of evaluation between simulation and forecasting models: the latter can be verified with the use of the available observation data, whereas a simulation model usually cannot be tested directly against some data (the latter, most probably, never be available).

In the following section, before proceeding to the motivation of the paper, its purposes, and the methods used, we concretize the problem statement.

VALIDATION OF A MODEL INTENDED FOR IMPACT ASSESSMENT: PRAGMATIC APPROACH AND "CRASH-TEST" NECESSITIES

"All Models are Wrong, but Some are Useful"
George Box

The validation of a numerical model of an open natural system, considered as evidence of the adequacy of a model for the given system, is impossible. The roots of this statement lie in the widespread direction of contemporary philosophy—the critical rationalism of Karl Popper. In the field of geophysical sciences, the grounds of this statement were first studied in detail in [21], including the problem of "non-