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Development of runoff generation models in the former USSR and Russia: a historical overview

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ABSTRACT

The paper presents a historical overview of the development of hydrological models in the former USSR and Russia since the 1930s. An overwhelming number of hydrological papers were published in Russian, and they are not sufficiently well known to the world hydrological community. The purpose of the review is to fill the gap and present the main achievements, some of which were pioneering for their time. The period under consideration is divided into three sub-periods. Pre-computer, the 1930–1950s were associated, first of all, with the development of models of unsteady water flow in river channels and linear flood-routing models; in the 1960–1980s, many theoretical and practical foundations for modelling the processes of the hydrological cycle and the formation of river runoff were developed; and in the Russian era, following 1991, several notable advancements in the considered field were also made.

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1 Introduction

The purpose of our paper is to acquaint readers with the achievements of the Soviet–Russian school of mathematical modelling of hydrological processes in river catchments. The review covers a period of almost a century, starting in the 1930s. With a few exceptions, the majority of Soviet-era notable works were published in Russian and they remain mostly unknown to the international community. Meanwhile, among the achievements there were pioneering ones for their time, which, albeit not having much effect on hydrological evolution, are nonetheless a part of hydrology's global history. Bringing this dimly lit side of hydrological history into the light was our main motivation for writing this review.

Before we begin, let us make a few remarks to clarify the subject and the logic of the review. We consider only achievements in the field of modelling of catchment-scale runoff generation processes. Numerous studies conducted in the USSR and Russia and related to the development of models of water quality, water erosion and sediment transport, river ice, water management, etc. are not included in the review.

Only studies that presented original mathematical models created by Soviet and Russian hydrologists or described the application of such models, mostly by their developers, to solve research and engineering problems are considered.

Many well-known Soviet experts in the field of modelling hydrological processes continued successful scientific careers in other countries. The review presents the results obtained during their work in the USSR only.

As a rule, results that were published only in Russian are reviewed in more detail. If the results of some of these studies were subsequently supplemented by the author(s) and described in another paper published later in English, we provide both Russian and later English references.

Some Russian-language papers published in the 1960s and 1970s were subsequently translated into English, particularly within the framework of the Israel Program for Scientific Translations. In such cases, we indicate both sources: the original (Russian-language) and its translation.

A guideline for how to access some hard-to-find but valuable publications of the Soviet period is presented in Supplementary Material.

The last two remarks are related to the issues resulting from the isolation of Soviet science, primarily in the 1930–1950s. Soviet scientists, having very limited access to international publications, sometimes independently achieved results previously obtained by their foreign colleagues. We include these results as independent achievements of Soviet hydrology, but indicate the priority known to us today. The isolation of the USSR also contributed to the formation of specific hydrological terminology, which does not always correspond to that accepted in Western science. In cases where the essence of a term is not obvious from its context, we try to indicate its connection with a term more familiar to international readers.

2 1930s–1950s: pre-computer period

The Soviet Union experienced rapid industrial growth in the 1930s, which was matched by a rise in hydraulic engineering and hydropower development. In this regard, significant improvements in hydrological prediction and forecasting

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