DETERMINISTIC-STOCHASTIC MODELING OF HYDROLOGICAL EXTREMES IN SMALL BASINS

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This paper contains the results of deterministic-stochastic modeling for small basins situated in different physical and geographical zones of Russia. Utilization of deterministic models of runoff formation in conjunction with stochastic weather models allow us using the Monte-Carlo method to reproduce different reactions of hydrological system to a multitude of possible meteorological influences practically unlimited number of times necessary to obtain probabilistic characteristics of river runoff extremes.

These investigations were carried out on the basis of deterministic-stochastic modeling system (DSMS) developed in the State Hydrological Institute (GGI) under the guidance of Professor Yury B. Vinogradov (St Petersburg, Russia). The features and advantages of this model consist in the principle of universality that is possibility of using basins of different sizes existing in any physical and geographic conditions.

DSMS consists of two elements: deterministic model of runoff formation processes "Hydrograph" and Stochastic Weather Model (SMP).

The model "Hydrograph" is physically-based modeling system with distributed input and parameters. It is oriented to the simplest meteorological network information with the simultaneous application of methods enhancing it (daily data on precipitation depth and duration, moisture deficit and temperature). The parameter distribution is assumed as being spatial as well as vertical. Spatial distribution is over the basin area and represented as orderly system of representative points. Vertical distribution is along depth taken into account as soil layers each representing a unique combination of specific litho -, pedo-, and phyto-logic indices.

Model parameters represent water and physical characteristics of soil and vegetable cover, features of hydrographic network, nature of slope and channel runoff transformation. The model output consists in continuous daily runoff hydrograph and distributed variable states reflecting temperature, water, phase regimes of soil and snow cover for the specified time intervals.

SMP provides input simulation information for model "Hydrograph". This model reproduces a flow of random numbers that correspond to consecutive sequences of diurnal precipitations, average daily temperatures and moisture deficits in different points of river basins taking into account time and space correlations of meteorological elements and features of their annual course.

To meet the study objective ten watersheds representing different landscape characteristics within the territory of the former USSR have been chosen (Figure 1). The watershed selection is summarized in tab. 1.

In this extended abstract, the main stages of deterministic-stochastic modeling and results obtained for one (due to text size limitation) basin under investigation (Timpton at Nagorniy – # 6 at Figure 1 and Table 1).

1. Selection and analysis of existing meteorological and hydrological observations.
2. Initial data analysis and first assessment of the model parameters:

- Vegetation properties: shadow effects, albedo, evapotranspiration, etc.
- Soil: maximum water capacity, filtration coefficient, density, porosity, heat transfer, heat capacity.
- Surface parameters: surface flow retaining capacity, etc.
- Groundwater parameters: distribution of incoming water content between modeling groundwater layers.

3. Preparation of data and parameters for modeling procedure (input meteorological data, control hydrologic characteristics, watershed characteristics, and landscape parameters of runoff formation).
4. Deterministic modeling procedure with the limited parameters adjustment (Figure 2).
5. Evaluation of Stochastic Model of Weather parameters.
6. Generation of meteorological values sequences by the Stochastic Model of Weather.
7. Imitation of runoff formation processes by deterministic model "Hydrograph".
8. Calculation of the coordinates of distribution curves of annual, monthly, daily, maximal and minimal discharges (Figure 3).

Utilization of the described method for the adopted series of basins allowed us to obtain good results. In such a way, features of Deterministic Stochastic System developed in GGI for dynamical and stochastic modeling and obtaining distribution curves of extreme characteristics of runoff are shown.

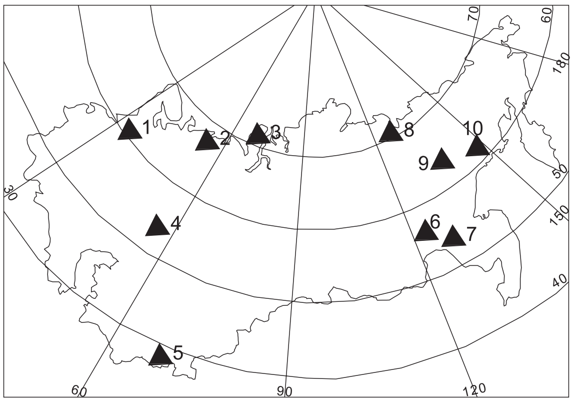

Figure 1. Study area with location of small basins

Table 1. Description of watersheds used in the study: the basin number is coordinated with Figure 1

No	River; outlet	Area, km^2	Geographical location		Landscapes
1	Manga; Manga	243	Karelia, the Onega Lake basin		European boreal forests
2	Nyashenniy; Kotkino	16.1	Arhangelsk district; northern European part of Russia		Tundra
3	Pyasedey-Yaha; 27 km from mouth	113.6	Yamal Peninsula coast		Tundra
4	Tanalyk; Samarskoye	1750	Bashkiria, South Ural foothills		Steppe
5	Varzob; Dagana	1270	The Kafirnigan and Amudarya rivers basin; Central Asia		Mountains
6	Timpton; Nagorniy	613	The Stanovoy Range	East Siberia	Mountainous larch taiga
7	Kataryk; Toko	40.2	The Stanovoy Range		Mountainous southern taiga, swamps
8	Ebytiem; Ebytiem	1000	The Lena river mouth area		Mountainous tundra headwaters and taiga downstream
9	Suntar; the Saharynya river mouth	7680	The headstreams of Indigirka river, the Suntar-Hayata Range		Alluvial rocks, mountainous tundra, sparse larch forest
10	Tenke; 2.2 km from Nilkoba river mouth	1820	The headstreams of Kolyma river		Mountainous tundra and taiga

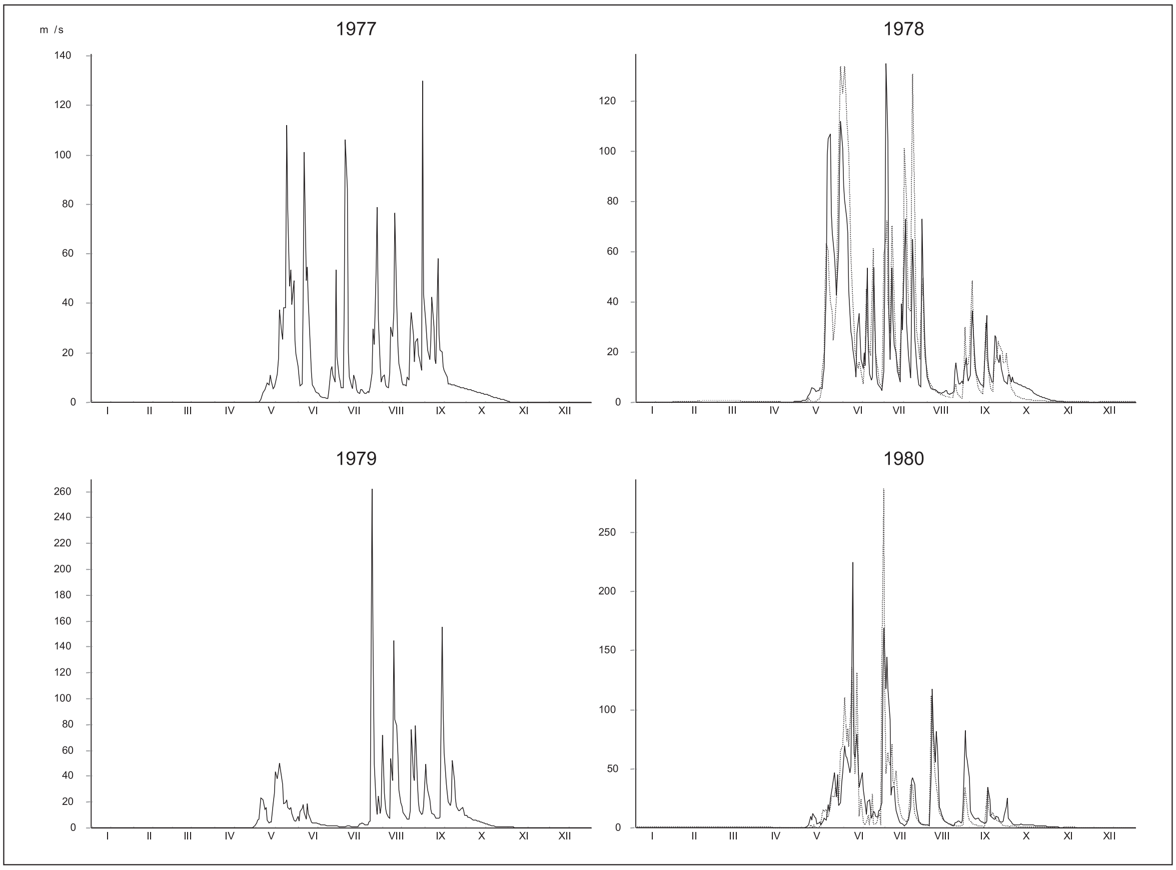

Figure 2. Observed (solid line) versus simulated (dotted line) hydrographs, Timpton at Nagorniy, F = 613 km^2, 1977-1980

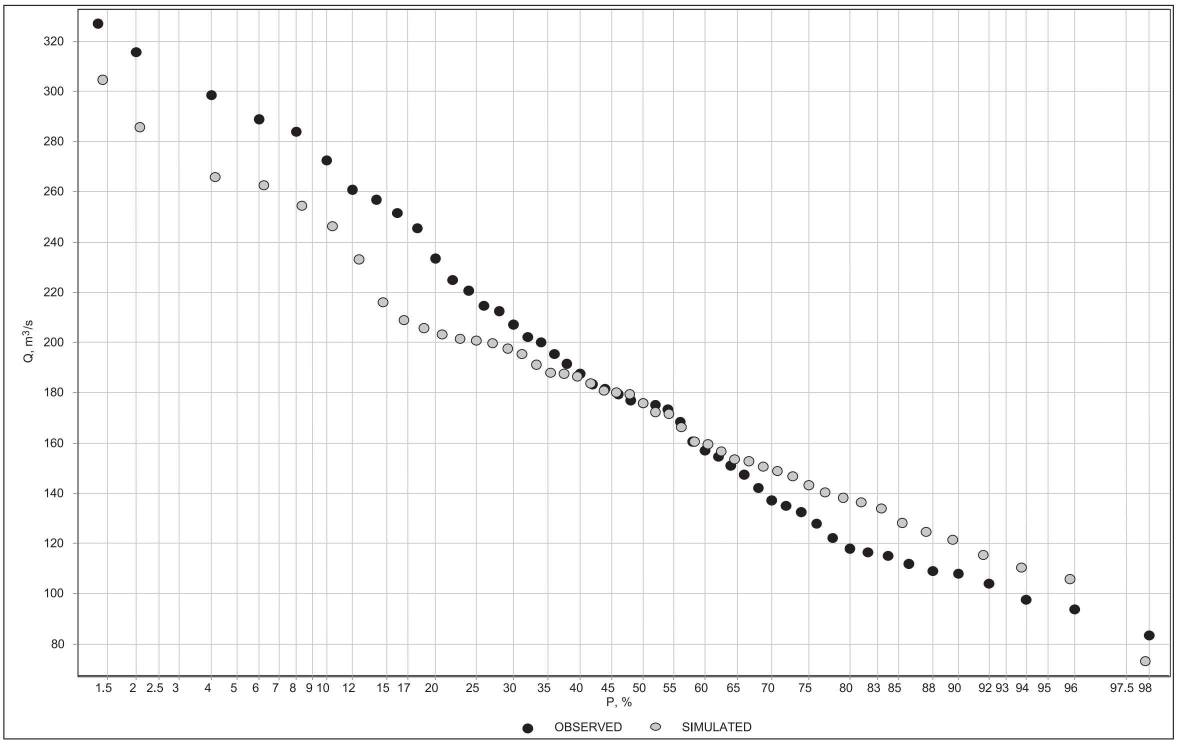

Figure 3. Observed versus simulated empirical distribution curves of maximum floods, Timpton at Nagorniy, F = 613 km^2