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Simulation of possible scenarios of precipitation on river basin of water reservoir with considerate of climatic change.

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Abstract.

At the moment, it is generally accepted that global climate warming takes place. This process leads to increased precipitation in many regions, since warm air can contain more moisture and a higher temperature also accelerates the hydrological cycle, which should contribute to the increased precipitation and evaporation. Such hypothesis has to confirm for every region, since there are exceptions. Accordingly, the hypothesis checked in respect to precipitation of Moscow Meteorological station, which has observation during 135 years. It was defined, that precipitation amount of last decades is differed significantly from previous years, therefore, special method of Monte-Carlo was tested for precipitation simulation with discreteness of ten day periods according to data observations for the last 30 years, which represents more really today climatic situation. Such scenarios are needed for modeling of water reservoirs operation. The test results were enough satisfactory.

1 Introduction

Usually water reservoir operation is made on the base of water balance equation with discreteness 10 days. The values of such equation are calculated on the data base for the long time series. During last decades is observed a change of different climatic characteristics in different of regions, in particularity precipitations [1,3,4,5,6 and others], which are an element of water balance and has very significant influence on runoff to water reservoir. There are 10 water reservoirs on the territory of Moscow region. Accordingly, there is need to simulate precipitation according to last time of series which has more short duration but more reality. We must take to consideration a big amount of different

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scenarios of precipitation both for annual values and for the internal year intervals. Accordingly, main purpose of the scientific work is the checking of the method for simulation artificial rows of precipitation according to climatic changes. The next problems were decided: determination of statistical parameters and trends according to data observation for the precipitation; assessment of statistical parameters for the time series of observations; simulation of artificial rows of precipitation according to climatic changes; check of the method for simulation artificial rows of precipitation. The method Monte Carlo (variant of fragments) [3,7,8,9] was used for simulation of precipitation on territory of Moscow region.

2 Methods and materials

Research has been prepared on the base of long time series data of meteorological observation on the meteorological observatory by name Mixelson of Russian Agrarian Academy [4]. The observatory has observatory 135 years of observations and can serve for enough objective evaluation of climate change. Other meteorological stations of Moscow region have not long time observations. Analysis has been made in respect to precipitation. Trend of annual precipitation is represented on Figure 1.

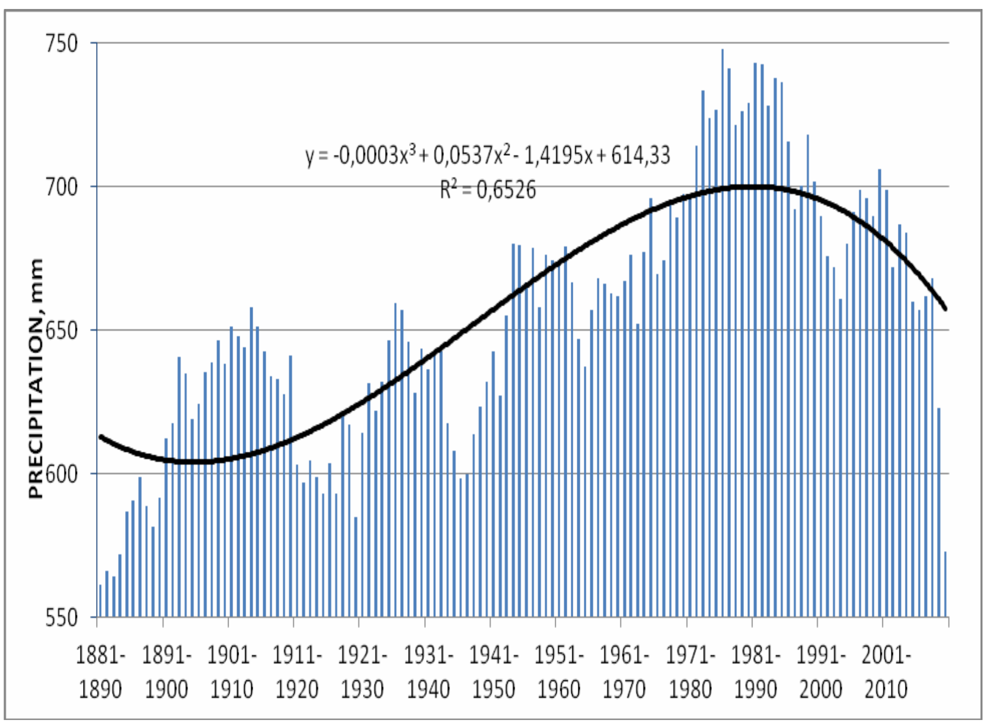

Figure 1: Trend of annual precipitation according to observation of observatory

We can't see of a constant trend of annual precipitation, however, it is clear that over the last 30 years the average precipitation was more in the period before that. So, statistical parameters of precipitation have changed during last decades due to climatic changes in the region of Moscow system water reservoir. However, recently a series of observations (3 decades) makes it possible to accurately calculate basic statistical characteristics, but they do not contain various combinations (scenarios) of precipitation in the annual and the internal value of the year. It is therefore necessary artificial simulation of long time series (about 1000 years) to obtain them. The main statistic characteristics of the artificial long-time series should not differ substantially from similar characteristics of time series data for the last 30 years. The Fragment way of Monte-Caro method [3,7,8,9] uses twice modeling. At first, the ranks of annual precipitation were modeled by method Monte Carlo. Then within each year – the ten day values of precipitation were modeled with help of fragments, which were selected randomly (Monte Carlo method was used again). Each fragment is represented by a set of 36 coefficients (36 for ten days' period) in a year. Every coefficient is ratio of ten days' precipitation to annual precipitation. The differences of statistical characteristics (mean, variation) between new artificial series and the original series must not be exceeding the statistical errors of row of 30 years, which is calculated on the basis of time series data according to formulas [2]:

$$E = \frac{Cv}{\sqrt{N}} \times 100\% \quad (1)$$

$$E_{Cv} = \frac{1}{(N + 4C_v^2)} \sqrt{\frac{N(1 + C_v^2)}{2}} \quad (2)$$

Then the artificial long time series of the ten days of precipitation were modeling. During of modeling process - number "m" of fragment is chosen with help casual value, which is modeled according to special program. Accordingly, number "m" is equal-probable value among all umbers of fragments. So, artificial long time series (1000 years) relative to precipitation were imulated with discreetness decade (10 days).

3 Result and discussion

The checking of the obtained artificial series was done by comparison of the statistical characteristics respect to observed values (Table 1).

Their differences (Delta) were evaluated with respect to the errors (E) that have been calculated by the formulas (2) and (3). Analysis of table 1 has showed that the simulated artificial long time series almost have not differences in respect to average values. Majority of differences between variation coefficients of observed and simulated precipitations do not exceed statistical errors calculated on the base of observed data for the last decades, but there are exceptions.

A comparison of statistical characteristics of precipitation in annual and ten days' intervals allows us to conclude that the simulated series is virtually adequate relative to observed data and can be used to evaluate the probability of occurrence of the dry periods.

So, the obtained artificial long time series gave possibility to evaluate probability of the appearance of the several consecutive dry periods, when precipitation is not more 10 mm or is equal zero. For example, for the month of June probability of precipitation less 10 mm equal 0.07 or 7%. Accordingly, probability of the appearance of the 20 dry days consecutive without precipitation is 0,03 or 3%.

Basic statistical characteristics of precipitation of the Moscow region for the last 30 years differ significantly from those same characteristics in the last 100 years.

The Monte Carlo method on the way "fragment" to simulate precipitation gave satisfactory results and the possibility to take consideration of different scenarios with respect to the combination of dry and wet periods

Table 1: Comparison of statistical characteristics of observed and simulated ranks

Month.	Decade	$E_{average}$ %	Delta, %	Ec_v%	Delta %
January	1	10,72	3,85	14,3	5,88
	2	11,63	6,36	14,5	8,54
	3	10,16	3,57	14,2	4,62
February	1	12,79	1,39	14,8	14,87
	2	11,70	4,137	14,5	5,80
	3	13,76	5,18	15,0	18,65
March	1	13,15	8,79	14,9	4,15
	2	14,74	5,75	15,3	10,91
	3	12,87	4,48	14,8	10,74
April	1	16,66	1,90	15,7	13,30
	2	16,96	2,92	15,8	16,39
	3	14,70	8,08	15,3	29,52
May	1	14,70	6,53	15,3	8,95
	2	18,65	2,01	16,2	1,47
	3	16,07	2,60	15,6	11,72
June	1	15,35	6,93	15,4	24,64
	2	11,88	6,77	14,6	1,16
	3	12,80	3,58	14,8	18,35
July	1	15,96	6,93	15,6	26,84
	2	18,16	9,96	16,1	5,21
	3	16,92	0,90	15,8	10,33
August	1	15,53	7,68	15,5	14,78
	2	15,18	7,73	15,4	9,45
	3	13,37	2,97	14,9	4,4907
September	1	14,50	0,69	15,2	23,8
	2	15,36	9,35	15,4	2,92
	3	15,45	1,18	15,4	0,472
October	1	17,50	2,05	15,9	10,39
	2	13,04	3,26	14,9	6,11
	3	12,72	3,51	14,8	10,27
November	1	11,13	2,94	14,4	8,24
	2	10,38	0,44	14,2	6,90
	3	12,35	0,58	14,7	7,28
December	1	15,41	2,98	15,4	10,87
	2	13,40	7,34	14,9	12,0
	3	11,75	3,49	14,6	12,0

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