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Change Of Statistical Characteristics Of Flow With Prolongation Of Observation Series

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Abstract: in the article the changes of statistical characteristics of the river flow in Chirchik and Kashkadarya hydrological regions are considered in the case of lengthening of observation series.
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Key words: river flow, long observation series, short observation series, mean long-term discharge, root-mean-square deviation, coefficient of variation, coefficient of skewness.

Introduction

Further the results of calculations of hydrological and staticstical characteristics for rivers located in Kashkadarya and Chirchik hydrological regions according to V.L. Schults' zoning will be considered.

The conditions of flow formation and hydrological regime of rivers located in the low-mountain areas are peculiar and rather sophisticated for study. For the big and mid-size rivers often it is enough to know climatic flow factors which, according to data of numerous researches (Vladimirov et. al., 1990) and (Iman Mahmoud Elazizy, et. al., 2018) are determined with the elevation of the locality.

For getting reliable hydrological characteristics in the work the actual data are checked for representativeness of series, mean long-term discharge values, root-mean-square deviations, coefficient of variation and coefficient of skewness are calculated (Getu, S. A., 2015).

Preliminary results.

On the base of collected data we assessed the representativeness of the actual series of observations on the annual discharge values. As it is known, the representativeness of series of hydrological observations is determined by relative root-mean-square error of the average value of the series (Vladimirov, 1990) which is estimated by the formula:

$$\sigma_n = \pm \frac{100 * C_v}{\sqrt{n}} \%,$$

where C_v – is coefficient of variation of series for n observation years. The results of calculations are presented in tables 1, 2, 3.

For hydrological calculations the observation period which meets the notion of representativeness is considered to be sufficient. The data which makes it possible to calculate average values of hydrological characteristics within the range of admissible errors are referred to such period. For the mean long-term annual flow such error (σ_n) should not be higher than 5 – 10 %.

Table 1. Hydrological and statistical characteristics of the river flow of Kashkadarya basin (analog – Kashkadarya r. – Varganza vil.)

Gaging stations	Q_{cp}, m^3/s	$Q_{восс}$, m^3/s	C_{vp}	$C_{vв}$	C_{sp}	$C_{sв}$	Q,%	n, years	r	σ,%
Varganza	5,26		0.37		1.17		0	89		3,9
Chirakchi	21,5	22,2	0.49	0.45	1.16	0.99	-3.25	60	0.89	6,3
Khazarnova	12,2		0.25		0.59		0	89	0.80	2,6
Dzhauz	1,30	1,31	0.35	0.31	1.02	0.87	-1.29	57	0.85	4,6
Aksu	9,63	9,40	0.44	0.39	1.48	1.20	2.42	44	0.90	6,6
Ulyan	1,47	1,46	0.37	0.32	0.80	0.68	0.60	47	0.85	5,4
Kattagan	3,93	3,97	0.40	0.36	1.28	1.19	-0.89	68	0.80	4,9
Nushkent	5,18	5,39	0.61	0.45	1.90	1.31	-4.00	30	0.85	*11,1*
Tatar	5,90		0.30		0.74		0	89	0.83	3,2
Ishkent	1,33	1,39	0.46	0.38	1.30	0.87	-4.83	43	0.84	7,0
Chuchaka	0,839	0,883	0.50	0.39	0.71	0.66	-5.17	27	0.86	9,6
Guldara	0,187	0,191	0.33	0.28	-0.15	0.83	-2.32	26	*0.67*	6,5

Gaging stations	**Q_{cp}, m^3/s**	**$Q_{восс}$, m^3/s**	**C_{vp}**	**$C_{vв}$**	**C_{sp}**	**$C_{sв}$**	**Q,%**	**n, years**	**r**	**σ,%**
Kanzhigaly	1,25	1,35	0.54	0.42	1.90	1.23	-8.31	41	0.78	8,4
Lyangar	0,49	0,502	0.68	0.49	1.39	0.96	-2.49	23	0.73	*14,2*
Tal	0,732	0,726	0.58	0.49	2.14	1.48	0.83	36	0.93	9,7
Yartepa	5,99	5,81	0.38	0.41	0.69	1.18	2.99	36	0.85	6,3
Gumbulak	1,35	1,33	0.91	0.79	3.05	2.66	1.22	48	0.85	*13,1*
Bazartepa	3,77	3,88	0.50	0.42	1.43	1.24	-2.86	51	*0.69*	7,0
Urudarya	4,52	4,41	0.30	0.33	0.40	1.11	2.45	37	0.88	4,9
Chambil	2,01	2,21	0.54	0.45	1.41	0.76	-9.60	41	0.95	8,4
Khissarak	12,0	11,5	0.27	0.26	-0.26	0.97	3.67	26	0.86	5,3
Pachkamar	5,35	5,33	0.47	0.43	0.75	1.16	0.49	37	0.76	7,7

Table 2. Hydrological and statistical characteristics of the river flow of Kashkadarya basin (analog – Yakkobagdarya r. – Tatar vil.)

Gaging stations	Q_{cp}, m^3/s	$Q_{восс}$, m^3/s	C_{vp}	$C_{vв}$	C_{sp}	$C_{sв}$	Q,%	n, years	r	σ,%
Varganza	5,26		0,37		1,17		0	89	0,83	3,9
Chirakchi	21,5	22,5	0,49	0,45	1,16	0,92	-4,54	60	0,91	6,3
Khazarnova	12,2		0,25		0,59		0	89	0,81	2,6
Dzhauz	1,30		0,35		1,02			57		4,6
Aksu	9,63	8,60	0,44	0,46	1,48	1,18	9,65	44	0,86	6,6
Ulyan	1,47	1,41	0,37	0,35	0,80	0,67	5,50	47	0,83	5,4
Kattagan	3,93	4,09	0,40	0,36	1,28	1,01	-3,28	68	0,84	4,9
Nushkent	5,18	4,95	0,61	0,54	1,90	1,19	1,80	30	0,88	*11,1*
Tatar	5,90		0,30		0,74			89		3,2
Ishkent	1,33	1,32	0,46	0,40	1,30	0,96	0,64	43	0,84	7,0
Chuchaka	0,839	0,84	0,50	0,43	0,71	0,70	9,60	27	0,80	9,6
Guldara	0,187	0,180	0,33	0,21	-0,15	0,44	3,54	26	0,45	6,5
Kanzhigaly	1,25	1,26	0,54	0,42	1,90	1,67	-1,25	41	0,61	8,4
Lyangar	0,49	0,453	0,68	0,59	1,39	0,90	7,44	23	0,89	*14,2*
Tal	0,732	0,677	0,58	0,52	2,14	2,14	7,55	36	0,81	9,7
Yartepa	5,99	5,24	0,38	0,47	0,69	0,88	12,5	36	0,85	6,3
Gumbulak	1,35	1,53	0,91	0,70	3,05	2,28	-14,6	48	0,84	*13,1*
Bazartepa	3,77	4,06	0,50	0,41	1,43	0,98	-7,72	51	0,78	7,0
Urudarya	4,52	4,09	0,30	0,35	0,40	0,80	9,41	37	0,82	4,9
Chambil	2,01	2,05	0,54	0,46	1,41	0,90	-1,80	41	0,85	8,4
Khissarak	12,0	12,6	0,27	0,24	-0,26	0,46	-5,16	26	0,81	5,3
Pachkamar	5,35	5,75	0,47	0,38	0,75	0,64	-7,51	37	0,71	7,7

Table 3. Hydrological and statistical characteristics of the river flow of Chirchik basin (analog – Ugam r. – Khodjikent vil.)

Gaging stations	Q_{cp}, m^3/s	$Q_{восс}$, m^3/s	C_{vp}	$C_{vв}$	C_{sp}	$C_{sв}$	Q,%	n, years	r	σ,%
Pskem-Mullala	77,0	75,4	0,20	0,19	1,13	1,07	2,12	52	0,85	2.77
Pskem - mouth	81,1	85,1	0,21	0,21	0,43	0,81	1,18	35	0,89	3.55
Sidjak	3,96	3,85	0,31	0,29	0,24	0,63	2,77	43	0,80	4.73
Chatkal - Char	121	128	0,25	0,25	0,22	0,73	-5,83	35	0,89	4.22
Khudaidotsai	105	102	0,35	0,22	0,30	0,46	3,00	52	0,70	4.85
Chimgan	0,298	0,291	0,34	0,32	0,66	0,84	2,11	47	0,71	4.96
Galvasai	0,475	0,446	0,40	0,38	0,51	0,86	6,13	36	0,77	6.67
Aktash	0,388	0,378	0,37	0,36	0,50	0,62	2,55	66	0,77	4.56
Karankul	0,134	0,147	0,66	0,55	1,55	1,06	-9,59	39	0,91	*10.6*
Altynbel	0,384	0,411	0,38	0,34	0,30	0,74	-7,01	19	0,87	8.72
Parkentsai	0,690	0,770	0,45	0,39	0,36	0,88	-11,2	18	0,95	*10.6*
Sumcha	1,54	1,39	0,41	0,37	0,69	1,09	9,92	28	*0,69*	7.75
Bashkyzylsai	1,44	1,54	0,36	0,34	1,01	0,88	-6,41	14	0,84	9.63
Khodjikent	222	230	0,26	0,24	1,44	1,01	-3,96	45	0,95	3.87
Ugam	22.4		0.26		0.88		0	85		2.82

For big rivers of Central Asia (Schults, 1965) estimated that flow values for any 25-year period within the period of 1911 - 1960 differ from the mean long-term value not more that to ± 5 %. However, when analyzing the results of calculations presented in tables 1, 2, 3 it is possible to conclude that in this regard small low-mountain rivers differ from the big ones. If their C_v is more than 0,50 and if observation series period is less than 30 years, then their relative root-mean-square error (σ_n) is higher than 10 %. Only for 32 of 37 investigated rivers (86 %) the observation series satisfy the criterion ($\sigma_n \leq 10$ %), and respectively, they are representative for calculation of hydrological characteristics.

Main results. The main objective of this work is to define the changes of the flow characteristics. Fulfillment of this task is not possible without calculation of the main hydrological characteristics for investigated rivers. In this case three situations can be met:

- calculations with the long (more than 25 – 30 years) observation series;
- calculations with insufficient (short) observation series;
- calculations with the absence of observation data.

Long period observations were carried out only on several small rivers. The number of rivers for which short observation series are available is also limited. For the main bulk of small rivers the data of flow observations are not available at all.

For us it was interesting to find out regular features of changes of hydrological and statistical flow characteristics in case of their prolongation with the use of data obtained for rivers-analogs which were selected with taking into account the following commonly known requirements (Vladimirov et. al., 1990):

- the investigated river and potential river-analog should be as close as possible geographically;
- climatic conditions which determine the formation of river flow should be similar;
- annual flow fluctuations on the compared rivers should be synchronous;
- relief of catchments, soil and hydrogeological conditions in the basins of investigated rivers should not differ too much from each other;
- presence of lakes, marshes, forestation and glaciation of catchments should be close by their relative values, i.e., their influence on annual flow should be almost the same in the investigated basins;
- the catchment areas should not differ from each other more than 10 times for the plain rivers, while in mountains the differences in the mean altitude of catchments should be within 300 m, as usually in this case there is no substantial difference in general flow formation conditions;
- absence of factors which distort the natural river flow significantly;
- the period of joint observations of river flow on the investigated river and river-analog should not be less than 10 years, as this period is enough for manifestation of the common features of their flow formation.

The objective criterion for correctness of selection of the analog point is sufficiently close relationship during the years of one-time observations characterized by correlation coefficient and by relationship between regression coefficient K and its root- mean-square error σ_R, if $r \geq 0,7$ and $K/\sigma_R \geq 2$.

One or several rivers which meet the above mentioned requirements can be taken as analog. Taking into account that the case is related to natural objects, it is not easy to choose the analog.

Basing on all mentioned above, we selected the following rivers as analogs: for Kashkadarya basin they are Kashkadarya r. – Varganza vil. and Yakkobagdarya – Tatar vil., for the rivers of Chirchik river basin it is Ugam r. – Khodjikent vil. materials of observations on investigated rivers were reduced to one period: for Kashkadarya basin 1928 – 2016 years, for Chirchik basin 1932 – 2016 years were taken. Calculations with two analogs for the rivers of Kashkadarya basin are determined by our intention to define the influence of different analogs to changes of characteristics of investigated rivers.

Conclusion

As it was pointed out previously, the results of calculations are presented in tables 1, 2 and 3. After analysis of data presented in these tables the following conclusions can be done:

- coefficients of correlation regarding relationship with Varganza analog are in the range from 0,70 to 0,95 and are regarded as satisfactory. Only for two gauging stations – Guldara and Bazartepa they are in the range from 0,67 to 0,69 respectively;
- coefficients of correlation regarding relationship with Tatar analog are in the range from 0,71 to 0,91 and are satisfactory. Only for two gauging stations – Guldara and Kajigaly they are 0,45 and 0,61, respectively;
- coefficients of correlation regarding relationship with Ugam analog are in the range from 0,70 to 0,95 and are satisfactory. Only for Sumcha r. it is 0,69;

- mean long-term flow for lengthened series with Varganza analog changed as follows: for 11 gaging stations the increase of flow within 0 - 9,60 % is recorded, for 10 gaging stations the decrease of flow within 0,49 - 3,67 % is recorded. All changes are within the range of admissible errors of the flow calculation;

- mean long-term flow for the lengthened series with Tatar analog changed as follows: for 8 gaging stations the increase of flow within 1,25 - 14,6 % is recorded, for 13 gaging stations decrease of flow within 1,80 - 12,5 % is recorded. Almost all changes are within the range of admissible errors of the flow calculations with the exception of Gumbulak (14,6%) and Yartepa (12,5%) gaging stations;

- mean long-term flow for the lengthened series with Ugam analog changed as follows: for 6 gaging stations the increase of flow within 3,96 - 11,2 % is recorded, for 8 gaging stations the decrease of flow within 1,18 до 9,92 % is recorded. All changes are within the range of admissible errors of the flow calculations with the exception of Parkentsai gaging station (11,2 %);

- changes of coefficients of variation C_v in the lengthened series with Varganza analog are: for 18 gaging stations the decrease of values was recorded, for 3 gaging stations the increase of values was recorded;

- changes of coefficients of variation C_v in the lengthened series with Tatar analog are: for 15 gaging stations the decrease of values was recorded, while for 6 gaging stations – the increase of values was recorded;

- changes of coefficients of variation C_v in the lengthened series with Ugam analog are: for 12 gaging stations the decrease of values was recorded, for 2 gaging stations the values were equal;

- changes of coefficients of skewness C_s in the lengthened series with Varganza analog are: for 14 gaging stations decrease of values is recorded, for 7 gaging stations the increase of values was recorded;

- changes of coefficients of skewness C_s in the lengthened series with Tatar analog are: for 13 gaging stations decrease of values was recorded, for 8 gaging stations the increase of values was recorded;

- changes of coefficients of skewness C_s in the lengthened series with Ugam analog are: for 4 gaging stations the decrease of values was recorded, for 10 gaging stations the increase of values was recorded.

From our investigation and calculations it may be concluded that with the proper selection of rivers-analogs the lengthening of series does not affect hydrological and statistical characteristics of the investigated river flow too much.

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