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Relationship Between Variations Of Flow Of Small Low-Mountain Rivers In Uzbekistan And Climate Changes

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Abstract: in the article the issues of assessment of the climate factors impact on the formation of river flow in the basins of following small low-mountain rivers: Surkhandarya, Zeravshan, Akhangaran and Chirchik are considered. Mean long-term values of precipitation and air temperature are estimated at middle altitudes of studied river basins; with these values the relationships X = f (H) и $t_{ср.год}$ = f (H) were derived for 4 hydrological regions. Relationships are rather close; correlation coefficients are close to one. This made it possible to use them in calculations for estimation of values of the mean long-term precipitation and air temperature values at middle altitudes of studied river basins for the base period. Evaluating forecast of river flow was made in relation to climate changes. For this the climate change scenarios were selected.
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Introduction.

Formulation of A.I.Voyeikov about rivers as about the climatic product, corrected by E.M.Oldekop in regard to the impact of other physiographic factors on river flow is known. This statement of prevailing impact of climate factors on the mean long-term flow is valid only for "closed" basins where watercourses drain precipitation falling on the basin surface completely and which flow down both in surface and ground ways.

This group of basins includes water catchments of all rivers in zone, both with high and low water content. In these basins the annual flow value depends on the mean annual value of precipitation and of evaporation, i.e. hydrometeorological components [7].

Thus, river flow depends mainly on amount of atmospheric precipitation fell on the surface of river basin and on evaporation. Finally, evaporation depends on air temperature. That is, there are two factors which impact river flow in direct way.

Proceeding from this, the relationships between flow changes and climate changes were revealed. Basing on data of numerous literary sources and results of own studies it can be concluded that global warming determined by data of instrumental observations, takes place for sure [1, 4, 5, 8]. Precipitation growth is also being observed.

Currently, assessment of climate change is made basing on analogy principles, with application of empirical-statistical methods, or of general atmospheric circulation model (GACM) [2].

The most reliable instrument for modeling of physical processes which determine climate is three-dimensional numerical models of general atmospheric circulation (MGAC). The advantage of MGAC is that basing on conservation laws, the models take into account physical aspect of processes which make climate simulation and forecasting possible. Its disadvantage is insufficiently adequate simulation of regional climate. Besides, output results of MGAC often are not able even to simulate seasonal structure of modern climate on any regional scale [5].

At present stage for assessment of climate change is proposed to apply system of MAGICC models in the frame of which information about regional structure of climate change obtained with MGAC is generalized with output production of several simple models.

Consequences of climate change for certain regions are rather inexplicit. However, it is evident that they will be a significant trial for ecosystems and human health. That is why the problem of revealing climate changes and assessment of possible changes is important. The need in objective and reliable assessment, especially at regional level is being increased.

Previously we studied variations of annual precipitation totals and mean annual discharge values on rivers and meteorological stations in seven hydrological regions of Uzbekistan. As the third factor which influence river flow is evaporation, or finally, air temperature, we were faced with the task of analysis of relationship between mean annual river flow and precipitation totals and mean annual air temperature values.

Working procedure was as follows:

- mean annual air temperatures were calculated for the middle basin elevations of the studied rivers;
- the values of mean annual river flow and precipitation totals in mm were used;
- relationships of У = f (X, $t_{ср.\ год}$) were derived. Relationships were derived for integral values of mean annual air temperature, taking midpoint of interval of resulted values of mean annual air temperature as integral value;
- at the next stage the need in derivation of relationships between mean long-term precipitation totals and mean long-term annual air temperatures for за reference period arose. They were applied for calculation of precipitation totals and air temperature for the mean basin elevations of studied rivers;
- afterwards we tried to make estimative forecast of the studied rivers flow.

All calculations were performed for each of 14 studied rivers (list of rivers is given in Table 2). In majority of cases correlations between mean annual flow and annual precipitation totals are weak: r ≤ 0,65.

Because of weakness of correlations in У = f (X) relationships, it was decided to graph relationships of three variables (X, У, $t_{ср.\ год}$). Empirical graphs of relationship are proper for use only within limits where they are supported with observation data, as out of these limits the type of relationship can be changed. Nevertheless, the limits of their application can be extended if it is possible to ground preservation of obtained type of relationship line with other values of variables. Thus, it is always expedient to determine limits of application of resulted correlation graph or of its equation [9].

For a number of rivers we constructed nomogram for calculation of mean annual flow level from values of annual precipitation total and mean annual air temperature (Fig.1). In calculations the method of G.A.Alexeev developed for normalization and matching of correlations was used. As particular correlations of У = f (X) and У = f (t) are monotone increasing (first one) and monotone decreasing (second one), then it is quite possible to use the method of G.A.Alexeev. Let's note that annual flow level, annual precipitation total and mean annual air temperature are presented here.

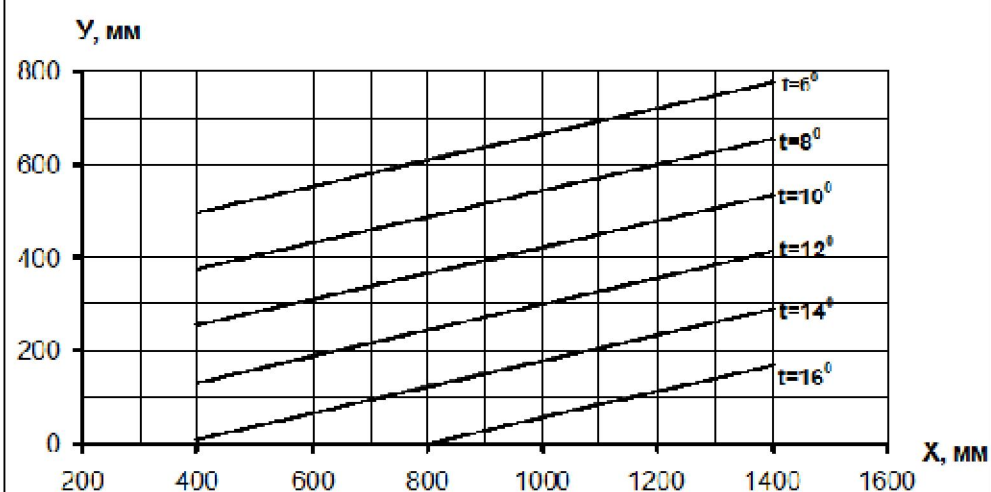

Fig. 1. Nomogram for calculation of mean annual flow layer from values of annual precipitation total and mean annual air temperature

It should be noted that total (summarized) correlation coefficient was rather high (R=0,64) while partial coefficients of correlation are low – 0,60 for correlation between flow and precipitation and -0,59 – for correlation between flow and air temperature.

For calculations it is possible to use nomogram or formula:

$$h_q = 0{,}28 \cdot h_x - 60{,}8 \cdot t + 750,$$

where h_q and h_x – are precipitation layer and flow layer in mm, t – air temperature in ºC.

We were not able to fulfill independent check of calculations because of limited observation data. Results of check on independent material are presented in Table 1. Mean errors (with account of deviation symbol) were ± 0,9 ÷ 57,1 %. As deviations of calculated values of annual flow are very significant, the obtained results can be recommended only for approximate calculations of flow of unexamined rivers.

Table 1. Comparison of actual and calculated layers of small rivers flow

Actual precipitation layer, mm	Calculation flow layer, mm	Calculation error, %
429	425	0,9
399	520	-30,3
234	191	18,5
286	191	33,3
669	625	6,6
887	496	44,1
282	371	-31,4
251	394	-57,1
668	662	0,9
406	532	-31,1
258	398	-54,2
638	602	5,6

For calculation of mean long-term precipitation values and air temperature values at the middle basin elevations of studied rivers the climatic characteristics – mean annual precipitation totals and air temperature for reference period obtained from [3] were used. With these data, for 4 hydrological regions X = f (H) and $t_{ср. год}$ = f (H) correlations were derived. The obtained correlations turned to be close to one. This gives us possibility to use them for calculation of mean long-term values of precipitation and of air temperature at middle basin elevations of studied rivers for reference period.

After getting aforementioned correlations we proceeded with preparation of estimating flow forecast of studied rivers in regard to climate change. For the river flow forecasting it is required to select climate change scenarios.

Scientists of Uzbekistan have done a good deal of work on studies of climate changes. Numerous published works of different authors: V.E. Chub, G.E.Glazyrin, T.Yu.Spektorman, S.P. Nikulina, N.A.Agaltseva, A.V.Pak, L.N.Borovikova, V.O.Usmanov, S.G.Chanysheva, O.I.Subbotina, N.E.Gorelkin and others are dedicated to results of these developmental works. After summarizing results of these works, table of "Expected changes of mean annual air temperatures and annual precipitation totals regarding reference period (1961–1990)" is presented in the Second National Report of the Republic of Uzbekistan on UN Framework Convention on Climate Change [6]. In the table changes of mean annual air temperatures and annual precipitation totals (regarding reference period) calculated with two scenarios – B 2 and A 2 are given for different regions of Uzbekistan for 2030, 2050 and 2080.

Using derived correlations У = f (X, $t_{ср. год}$) and changes of mean annual air temperatures and annual precipitation totals regarding reference period, calculated in [6] for different periods and regions of Uzbekistan, the estimating flow forecast was given for 14 studied small rivers. Calculation results are shown in Table 2.

Table 2. Estimation of mean long-term flow of small low-mountain rivers in accordance with B 2 and A 2 climatic scenarios

River – station	Change of river flow (% of mean long-term value for 1980 – 2007) for climate scenarios			
	B 2		A 2	
	2030	2050	2030	2050
1. Surkhandarya River basin				
Shargun - Chinar	122	122	134	135
Hangaronsai – Baisun	117	117	130	131
2. Zeravshan River basin				
Amankutan – Amankutan	115	116	121	123
Karaagach – Mavlyan	116	119	129	132
Maidan – Almaata	114	119	134	140
3. Akhangaran River basin				
Kyzylcha – Iertash	109	111	119	116
Dzhiblan – Dzhiblan	113	114	118	117
Abdzhaz – Abdzhaz	105	108	117	114
Shaugaz – Karatash	95	97	104	102
4. Chirchik River basin				
Nauvalisai – Sidzhak	109	119	118	116
Yangikurgan-Yangikurgan	114	116	124	122
Chimgan – Chimgan	104	108	113	111
Galvasai – Galvasai	97	99	107	104
Aktash - Aktash	106	107	117	109

In Table 2 it is shown what changes of flow of small low-mountain rivers can be expected in conditions of realization of adopted climatic scenarios. Small water courses are more sensitive to changes of climatic characteristics [3]. The obtained results revealed the following:

- to 2030 according to B 2 Scenario the flow of the majority of studied rivers will increase to 4 –

22 %. In several rivers flow will not changed considerably;

- to 2050 according to the same scenario the flow of small rivers will increase insignificantly in comparison with flow in 2030. The increment will be in the range of 1 - 10 %;

- according to A 2 Scenario flow increase will be higher – to 2030 it will increase to 4 – 34 %, while to 2050 it will increase to 4 – 40 %;

- according to B 2 Scenario flow value will increase or stay unchangeable from 2030 to 2050 in all studied rivers. According to A 2 Scenario, flow in water courses of Surkhandarya River and Zeravshan River basins will increase, while in the basins of Chirchik and Akhangaran rivers it will decrease.

Flow estimation for 2080 is not given as the values of air temperature are out of range of action of $У = f(X, t_{ср.\ год})$ correlations.

Flow estimation with different scenarios is made for small number of small low mountain rivers and for a short time period; however, they reveal the necessity of taking of all possible versions of future flow changes into account.

Main conclusions:

1. In calculations of changes of climatic characteristics in the investigated regions it was revealed that:

- precipitation totals increased at all stations during year. Increment was in the range of 0,11 - 0,91 %/ year. The highest precipitation increase was recorded in the basins of Akhangaran and Chirchik rivers;

- trends of annual and winter precipitation totals in the southern and northern regions are different concerning direction – in the southern regions they increase with height, while in the northern regions the decrease, which is probably explained by different location of stations in regard to direction to direction of moisture-bearing air masses;

- mean annual air temperature increase at all stations, but its increment is different in different elevation zones. Temperature increase is decreased with elevation;

- increase of mean winter air temperature influences change of hydrological characteristics significantly more than change of mean annual temperatures.

2. Mean annual discharge values increase in all studied small low-mountain rivers. Trends of mean annual discharge values tend to decrease with higher elevation of the locality.

3. By empirical correlations of $У = f(X, t_{ср.\ год})$ flow estimation of studied small low-mountain rivers is given for 2030 и 2050 according to B 2 and A 2 scenarios of climate change.

4. Regarding possible changes of the main climatic components – air temperature and precipitation it can be concluded that the increase of maximum discharge in low-mountain rivers is foreseen.

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