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THE PAMIR MOUNTAINOUS CLIMATIC FEATURES INFLUENCE ON THE RUNOFF FORMATION OF THE TRANSBOUNDARY PYANJ RIVER TRIBUTARIES

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The results of monitoring the processes of snow cover accumulation on upstream of the Transboundary Pyanj River of the Central Asia are presented. It is found that the formation of the snow cover and the spatial distribution of atmospheric precipitation in the mountain Pamir is mainly determined by the orography of the terrain. The ratio of atmospheric precipitation to the depth of the snow cover is determined by the temperature regime and the altitude of the terrain. The existence of the orography influence on the promotion of air masses in mountain areas contributes to the fact that there is a shift in periods of the snow maximum amount falling out in different climatic zones. Dynamics of changes in climatic conditions of the Vanch river basin for the period 1956-2006 are considered. The hydrograph of the Vanch River in the relevant periods shows a shift in the maximum value of the water flow to the left, indicating an early period of melting snow cover and glaciers on the upstream of the river and a significant increase runoff in the period 1986-2016.

Keywords: Pyanj River, snow cover, orography, Pamir

INTRODUCTION

Data recent decades indicate an increase in reduction of the glaciation and snow cover area in the mountains as the South and North hemisphere of the Earth [1]. It is expected that geographic areas in water cycles of which the hydrology of the melting of glaciers and snow are dominated will be more receptive to climate change, i.e the seasonality of runoff in a river systems [2].

These climatic response of mountain river hydrology combined with potential changes at the surface of the Earth, population growth and existing water shortages can create serious

problems for the mountain regions. Regional climate forecasts IPCC (2007) show that by the end of the XXI century the warming of the Central Asia by 3.7°C with the highest value on the higher terraces is expected, especially on the Tibetan plateau and the Himalayas [3]. The snow accumulation generally grow at increasing altitude due to the combined effect of the prevailing low temperatures and increased frequency of precipitation caused by orographic effects [4]. Data on the distribution of snow depth, density and its water equivalent with high spatial and temporal resolution are needed to verify and / or enter data in the snow drift [5] and snow-flow models [6]. Thus, there is a great need for data on the distribution of snow, mainly to determine the water equivalent of snow. The values of the spatial distribution of water equivalent is important for many stakeholders, for example, to use them as input in a new generation of hydrologic models that predict runoff during snowmelt [7,8,9].

The Vanch river is one of the tributaries of the transboundary Pyanj River that is formed after the confluence of equivalent rivers Kasholyakh and Abdukahor [10]. The formation of the meteorological conditions of the river basin is dominated by entirely the air masses of the Mediterranean and Caspian cyclones. The Vanch river can be considered a representative of river arteries, in the formation of water flow of which groundwater is played an important place dictated by the geological structure and distribution in the basin of permeable rocks. Measurements carried out in 1965 showed that the annual runoff module in the basin of the Geographical society glacier on the upstream of Vanch River (basin area 206 km, the share of glacial runoff 62%) is 15-60 l / km^2 · sec. In the Abdukahor river basin on the upstream of Vanch river (the basin area is 329 km, the share of glacial runoff is 42%) the annual runoff module is 28.4 l / km^2 · sec [11]. The general tendency reduction of glaciers in Central Asia in the last century also covered the glaciers of the Vanch river basin. The processing of satellite images LANDSAT ETM + and TERRA (ASTER) allowed the authors [12,13] to establish that the glacier area of the Vanch River basin for the period 1961-2000 decreased by 23.4%, and throughout the basin of the transboundary Pyanj River by 32.7%.

OBJECT OF RESEARCH

The present work covers the monitoring results of atmospheric precipitation and snow cover of the Transboundary Pyanj rivers upstream. For this the data on depth of snow cover on meteorological stations Khumrogi (N 38°17’ E71°20’), Rushan (N37°57’ E71°33’), Khorog (N37°30’ E71°30’), Irkht (N38°10’ E72°38’), Bulunkul (N37°42’ E72°57’) and Shaymak (N37°32’ E74°49’) of the Pyanj river basin and influence of meteorological condition on formation of Vanch river runoff were used.

RESULT AND DISCUSSION

Feature of the snow depth and precipitation distribution on the height of the terrain in the mountain terraces is shown on the Fig.1. The dependence of the snow cover depth and the amount of precipitation on the altitude of the terrain is not proportional (Fig.1). For example, meteorological station Shaymak located at an altitude of over 3800 m a.s.l on values of precipitation differs little from the values of meteorological station Irkht at the height of 3276 m a. s l. The same can be found at comparing the values of snow depth and precipitation in other meteorological stations. For the meteorological station of Rushan located at an altitude of 1981 m a. s. l the percentage of snow cover to atmospheric precipitation is about 27%, for Shaimak 20%, and for Khumrogi not more than 5%.

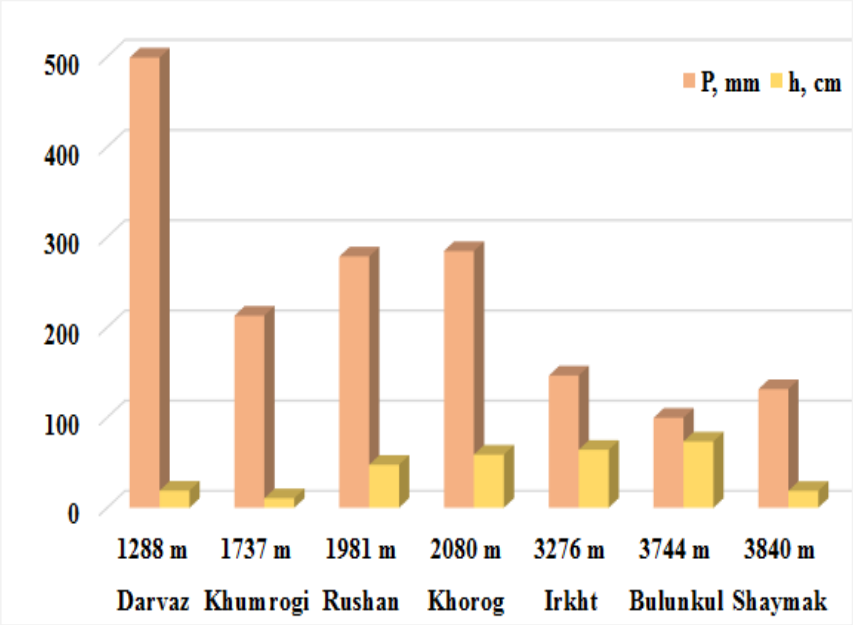

Fig.1. The distribution of atmospheric precipitation (P) and mean annual values of snow cover (h) according to meteostation of the Pyanj river basin

As mentioned [14] spatial heterogeneity of precipitation in mountainous areas is primarily due to the influence of the orography of terrain on the distribution of moist air masses. Average annual temperature at more moderate altitudes (Darvaz) increase occurs with a more tangible rate than on the upper. Therefore, on the meteorological station Darvaz precipitation often falls in the liquid phase and the forming the layer of snow under favorable temperature conditions is characterized by a short lifetime. Vertical gradient of precipitation on the border of South and Central zones of Pamir is about 40 mm per 100 m of uplift suggesting a more humid foothills and the existence of broad basins with open way out West to meet the moist air flow. As move the air flow deep into the mountain region and pass across the ridges, moist air converts moisture to precipitations and becomes dry. The average annual precipitation in the Eastern Pamir insignificantly 40-140 mm with the long-term average of about 76 mm. The rainfall deficit in the Eastern Pamir due to the fact that in the Western Pamir characterized by high mountain ranges (5000 to 6000 m a. s. l) the unloading of humid air with heavy precipitation and passes through the mountain ranges of the Western Pamirs the air becomes dry [14]. In principle, between the periods of the maximum amount of snow in Western, Central climate zones of the Pamir Mountains characterized by rainfall that is more abundant and a dry Eastern climate zone there should be a period of time. This is primarily because dry air mass passes through the mountains must saturate with water vapor. The maximum value of the snow cover at the eastern meteorological stations Bulunkul and Shaimak corresponds to the March (Fig.2).

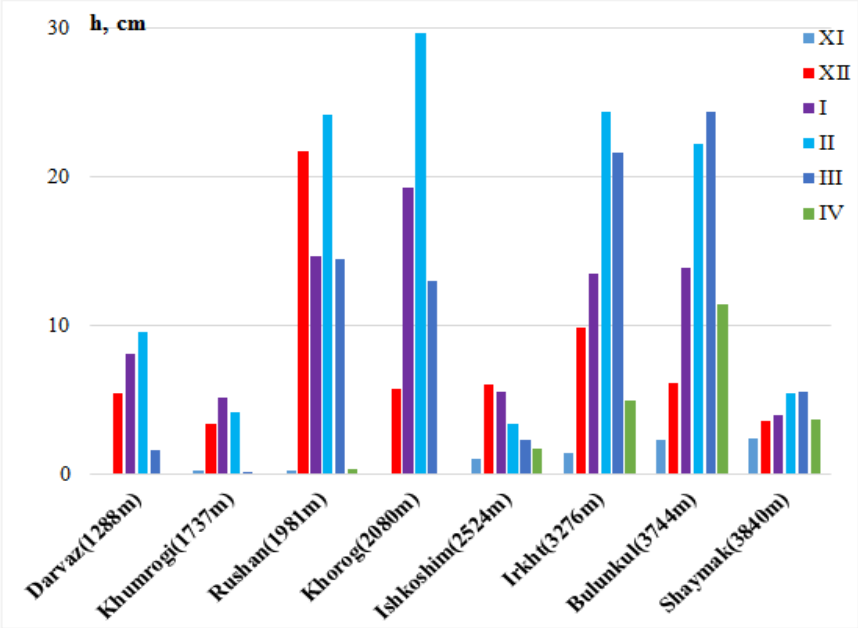

Fig.2. Average monthly of snow cover depth at meteostation of the Pyanj river basin

The appearance of the snow cover maximum depth at the meteorological station Ishkoshim in December probably is due to penetration of air masses from Iran and Afghanistan (Fig.3).

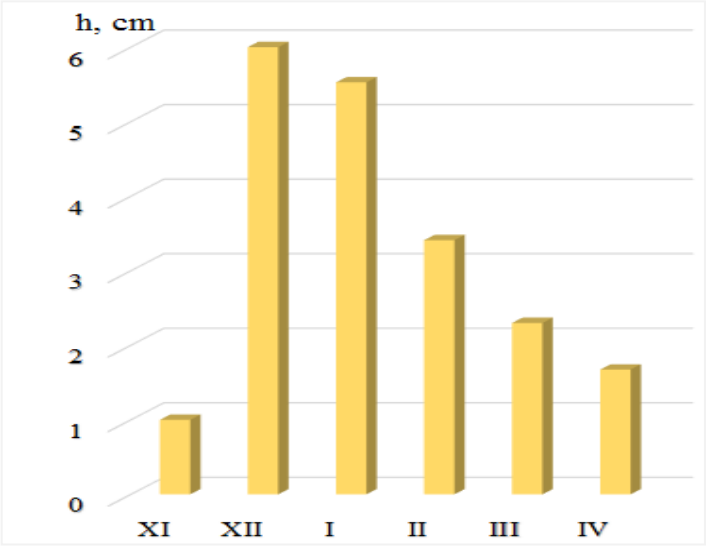

Fig.3. Monthly mean value of snow cover according to Ishkoshim meteostation

At comparing the histograms on the Fig.2, it becomes clear that the Western and Central climate zones (Khorog, Irkht, Rushan and Bulunkul) are characterized by sufficient rainfall and temperature conditions conducive to formation of sufficient snow cover. In the basin of the Gunt River at heights of more than 4300 m a. s. l snow cover (50%) lies from November to March. Given this and the abundant precipitation in the river basin, it is assumed [15] that the snowmelt can make a significant contribution to the water balance and formation of runoff.

The average annual runoff of the Vanch river in relation to the long-term value for the period 1940-2016 is presented on the Fig.4.

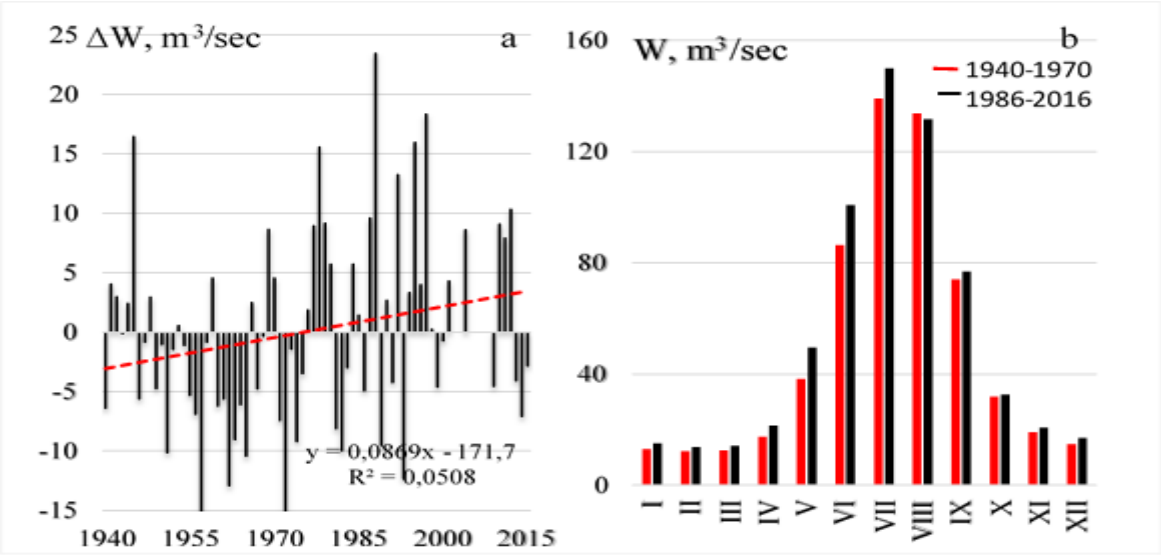

Fig.4. Runoff change of Vanch River in relation to the long-term value for the period 1940-2016 (a) and the hydrograph of the river for the period 1940 - 2016 (b)

In order to determine the influence of the warming factor on the hydrological regime of the Vanch river, a comparison of the changes dynamics in the water flow of the river for the periods 1940-1970 and 1986-2016 are made (Fig. 4a). The hydrograph of the river in two periods (1940-1970, 1986-2016) presented on the Fig. 4 (b).It can be seen that the average monthly value of the water flow of the Vanch river for the period 1986-2016 exceeds the analogous values of the period 1940-1970. The nature of the change in the water flow of the river per two periods indicates the impact of climate change on the state of the ice-snow reserves of the basin on the river upstream. If we take into account the low temperature changes ($3 \cdot 10^{-3}$ °C/year) for considered period, as can be seen from Fig. 5 (a), and the almost constant value of atmospheric precipitation (Fig. 5b), then what factors contribute to the positive development trend of the river runoff.

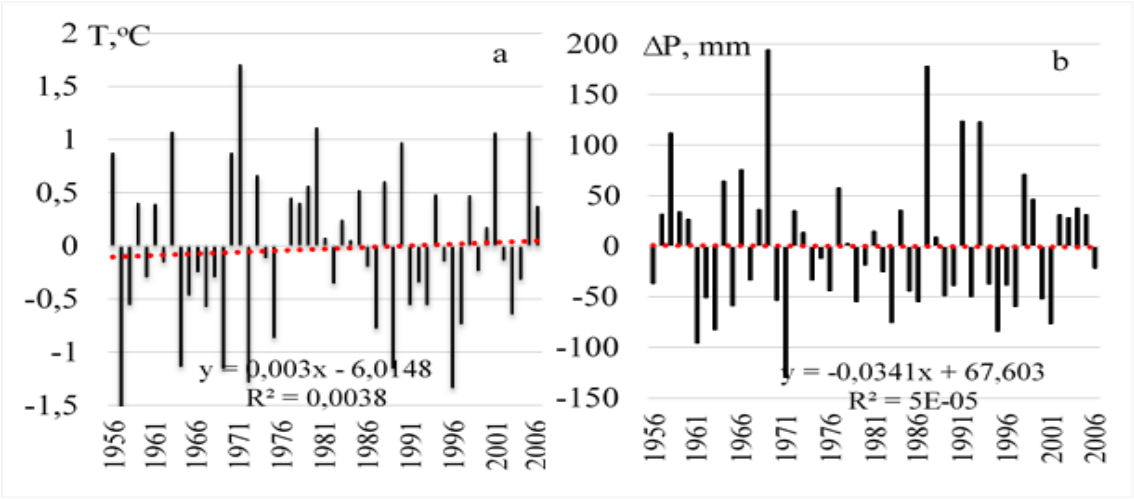

Fig.5. A change of temperature (a) and atmospheric precipitation (b) in relation to the long-term value in the Vanch river basin for the period 1956-2006

To receive an answer to this question, the Vanch River hydrograph is made up in the form shown on the Fig. 6 (a).

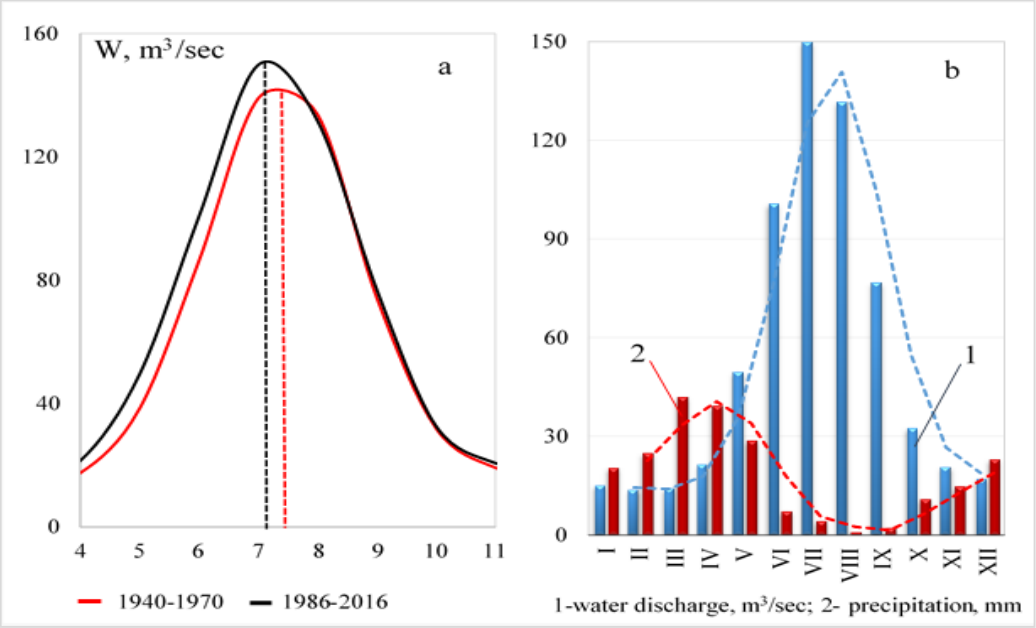

Fig.6. Hydrograph of the Vanch river (a), the average monthly discharge values of the Vanch River and atmospheric precipitation for the period 1940-2016 (b)

It can be seen from the Fig. 6 (a) the maximum of the Vanch river hydrograph for the period 1986-2016 shift to the left. Therefore, the maximum value of the water runoff is observed earlier than the corresponding value of the period 1940-1970. The observed phenomenon can be explained in the framework of the assumption that the source of the river (glacier) is the subject to degradation as a result of warming and is not a dense but loosened structure. For such structures, a small impact is sufficient to effect an aggregate transformation. Based on the obtained results, it can be concluded that the glacial area of the Vanch River upstream is the subject to a significant reduction. In order to establish the type of supply of the Vanch River, it is sufficient to look to the Fig. 6 (b). It can be seen from Fig. 6 (b), the maximum amount of precipitation in the Vanch river basin is March-April but the maximum runoff of the river is July. This means that the Vanch River is characterized by glacier feeding. Naturally, the contribution of seasonal snows to the formation of the river's water flow is not excluded. The value of water flow observing on the Fig. 6 (b) indicates the predominance of the glacial feeding of the river.

CONCLUSION

A spatial heterogeneity of the precipitation and depth of snow cover distribution on the climatic zones of the Pamir - upstream of the Pyanj River due to the orography of the mountainous terrain and feature promotion of air masses are observed. The Western climatic zone compared to the East characterized by rich of precipitation. Expected duration of preservation of a snow cover mainly determined by the temperature regime of the area. It is established that in the Vanch river basin the inflow of the transboundary Pyanj River, the amount of precipitation during the period 1956-2016 remained almost constant, although the temperature trend was characterized by a slight increase. A comparison of the water flow values of the river for the periods 1940-1970 and 1986-2016 revealed its increase for the last period that is associated with the degradation of the ice sheet on the Vanch River upstream. It was observed that during the 50-year period the atmospheric precipitation in the Vanch River basin retained almost unchanged due to the free penetration of moist masses of the Mediterranean and Caucasus cyclones and the influence of the mountainous orography. The influence of climate warming on the runoff is indicated by comparison of water values in two periods 1940-1970 and 1986-2016.

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РУСЛОВЫЕ ДЕФОРМАЦИИ В НИЖНЕМ ТЕЧЕНИИ РЕКИ АМУДАРЬИ

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В статье рассмотрено современное состояние защитно-регуляционных сооружений построенные на пойме реки Амударьи между гидроузлами Туямуюн-Тахиаташ и определены основные задачи исследования.