WATER RESOURCES OF TAJIKISTAN. GLOBAL WARMING OR ANOMALOUS PHENOMENA ON FEDCHENKO GLACIER?

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Abstract: Conducting periodic monitoring of the glaciers of Tajikistan by land expeditions is a rather difficult task and one of the main problems is a big investment. 93% of the territory of Tajikistan is a mountain in which there are more than 8,000 thousand large and small glaciers. And of course it is interesting to follow the emerging new publications in the press and the Internet on the topic of glaciers in Central Asia.

Key words: global warming, glacier ripple, glacier degradation, average air temperature, total precipitation, excessive humidity, microclimate.

Glacial epochs were replaced by interglacial periods when glacier areas significantly decreased. The last period of glaciation, which is also called the Little Ice Age, began in the 13-14 centuries of our era and continues to the present. During this period, five glacial oscillations occurred, during which the glaciers intensified and moved far down the valleys. The maximum of the last glacial activation was observed in the middle of the 19th century. After that, the stage of degradation of glaciers, which are retreating over the past 160 years, began. When the current stage of glacier degradation is over is still unknown. But it is known that it will end with new activation of glaciers and their transgression.

Global warming it has reached the heights of the Pamirs. The white snows of natural glaciers are already clearly receding under the onslaught of a warm temperature background. And now the real question is “how long will the ice reserves in Tajikistan last?” Count is not difficult. There are many climate models for which graphs, tables are actually compiled, scientific materials are written. But what we have now - let's look at the example of our large Fedchenko glacier, which is currently considered difficult to reach and full of mysteries in its thick ice. As it is known, the glacier leaves behind itself “traces”; their composition and structure allow reconstructing past glacial epochs during which the glacier repeatedly came. At present, the mass balance of the glacier is negative, that is, the glacier does not receive enough power to maintain its mass. But the amount of precipitation in the high mountain zone increases, therefore, the glacier nutrition improves. It is highly probable that in the coming years, the glaciers feeding Fedchenko will receive so much snow that their mass balance will become positive.

Conducting periodic monitoring of the glaciers of Tajikistan by land expeditions is a rather difficult task and one of the main problems is a big investment. 93% of the territory of Tajikistan is a mountain in which there are more than 8,000 thousand large and small glaciers. And of course it is interesting to follow the emerging new publications in the press and the Internet on the topic of glaciers in Central Asia. After reading one of the information that appeared in the press (2015), which just makes you wonder if everything is so bad with glaciers in Tajikistan. Back in 2012, Russian scientists, according to satellite images made under the “Hurricane” program, noticed a sharp intensification of the “Bivachny” glacier - this is the left tributary of the Fedchenko glacier. In two years, the “ice wave”, which covered the mountain gorge, advanced four kilometers and reached the Fedchenko glacier. Of particular interest to a small publication is the fact that in all the catalogs it is written: "... the Bivachny glacier never contacted the main body of the Fedchenko glacier, and there is no information about its pulsation ...". The summer period of the glacier movement far exceeds its winter activity. Russian

scientists interested in the fact of the contact of the "ice wave" and whether it will cause a violation of the subglacial hydrological network inside the Fedchenko Glacier.

Watching from space with the help of the latest satellite technology for the movement of glaciers and the state of snow cover has received a large-scale form, but who can confirm or deny this information from Moscow scientists. In August 2015, during the work of the “3rd International Pamir Geophysical Expedition”, conducted a visual observation and filming the place of contact of two glaciers from the window of the helicopter. I observed the real picture: “the mountain gorge connecting the two glaciers was completely covered with a large mass of black ice. The “black tongue”, sliding down the gorge, stretched for 4 km, and really reached the Fedchenko glacier. Part of the “shock” kinetic wave of the Bivachny glacier crawled over 100 meters onto the main body of the Fedchenko glacier. I note that at this time one cannot see the active influence of the Bivachny left glacier flow on the main ice of the Fedchenko glacier.

*** Fedchenko glacier in the center; on the right is the Bivachny glacier**

The slide, movement, of both glaciers occurs without any special incidents. Much melting of the glacier and accumulation of water in spontaneous reservoirs did not occur. ” The predicted event that the ice will be crushed in the main body of the Fedchenko glacier, which will cause a violation of the subglacial hydrological structure, has not been confirmed. This was the first visual expeditionary study that confirmed the movement of the Bivachny glacier.

From the diary of the author.

While on the meteorological station im.Gorbunova, as part of the expedition in the summer of 2015, also noted the changes. In the area of the weather station, there was still a decent mass of snow, which was in no hurry to melt, at least the last five to six years. Its ice structure is noticeable. The Kashal-ayak pass connecting with the glacier of the Academy of Sciences was also covered with a layer of 20-30 cm of snow. On the opposite right side of the

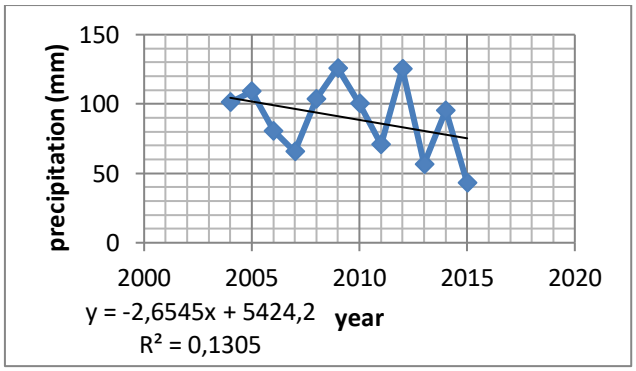
Fedchenko Glacier, small glaciers have also been at the stage of their activity for at least the last five to six years. On the opposite right side of the Fedchenko Glacier, small glaciers have also been at the stage of their activity for at least the last five to six years. This was evident from the "ice waves" that were on the plateau of the glacier, downstream. According to my diary entries, in August, the 80s, ice was already actively melting. On the glacier flowed numerous streams with glacier water, which, connecting, formed a powerful water flow. The glacier itself made sounds of breaking ice. Especially at night, the entire neighborhood around the weather station was filled with the "moan" of breaking ice and the rapid flow of the icy river disappearing in the ice body. Performing glaciological work during this period of time represented an increased level of danger. The melting body of the glacier was a field of ice needles, protruding sharp tips to the top. Small ice lakes hidden from the eyes, there are a lot of them. We had to stop on the route several times. Who fell into the water, was the last in a bundle. Wet clothes were dried on large “ice mushrooms”.

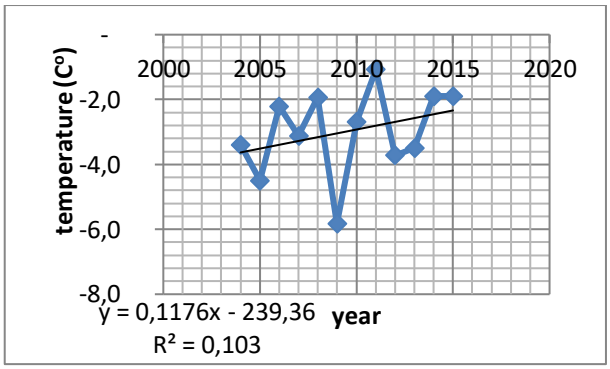
“Ice mushroom” (1984 photo, Fedchenko Glacier, author). * “Ice needles” (photo 1984, Fedchenko Glacier)

Being already at the workplace, in Dushanbe, and looking at numerous footage, I decided to analyze when extensive snow accumulation began in the area of the Fedchenko Glacier, which caused a sharp movement of small glaciers and the Bivachny Glacier itself. According to data from existing meteorological stations, in recent years, it has determined the anomalously cold 2008–2009 winter. Meteorological data from the Gorbunov station (Fedchenko Glacier) do not have their duration and the latest data is dated 1994. I had to use data from meteorological stations located around the Central Pamir. These stations are located in two climatic zones on the territory of Tajikistan - these are “West Pamir” and “East Pamir”. Their climatic conditions are not at all similar to the part of the mountainous Pamir, where large, main reserves of ice (fresh water) are concentrated. But let us return to the meteorological data of those stations that have a period with stable and reliable information.

North GBAO (Gorno-Badakhshan Autonomous Region). The Kara-Kul meteorological station is located in the eastern part of the Pamir Highlands, on the northeast shore of Karakul Lake. The height of the station above sea level is 3930 meters. The climate of Kara-Kul is dry with cold summers and very cold winters, with little precipitation. The average air temperature for the year is -3.7 degrees below zero. The coldest month is January, the average temperature is -17.3 degrees below zero. The recorded absolute minimum temperature was -47 degrees below zero. The warmest month is July, the average air temperature is 8.5 degrees Celsius, and the absolute maximum air temperature was 28 degrees Celsius. The warmest month is July, the average air temperature is +8.5 degrees, and the absolute maximum air temperature was +28 degrees Celsius. The amount of precipitation per year is 82 mm. Plotting performed in two parameters temperature and precipitation:

Meteorological station Kara-Kul (38875).

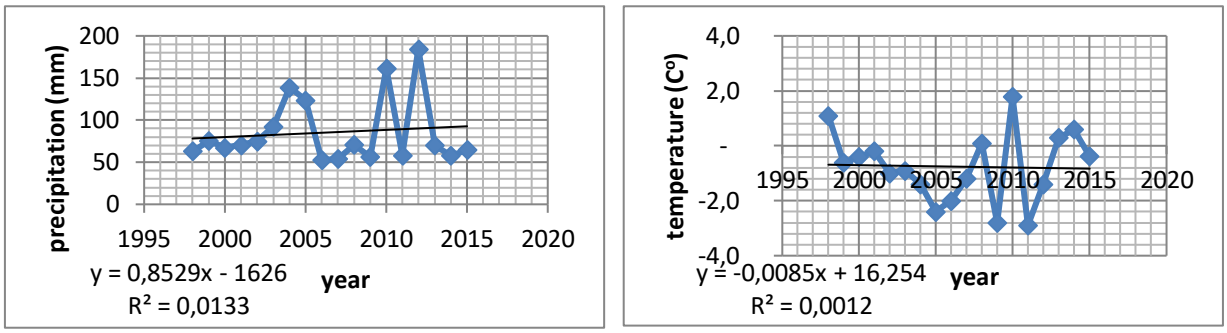




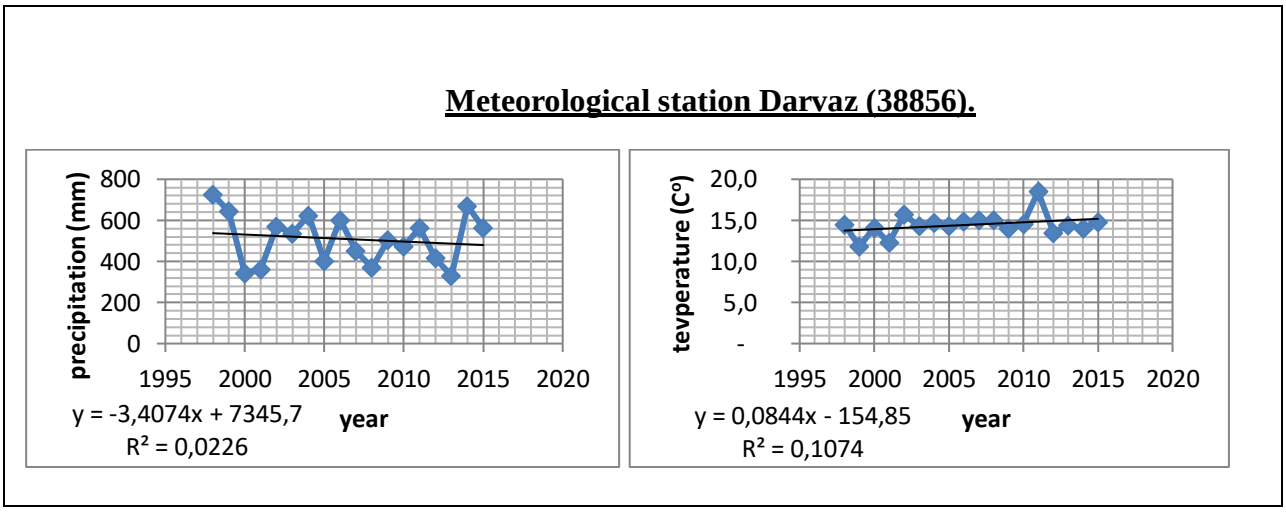
The graphs show that with increasing temperature there is a decrease in precipitation.

East GBAO. Meteorological station Murgab is located in the south-eastern part of the Pamir Highlands, in the valley of the Murgab river. The height of the station above sea level is 3576 meters. The climate is dry with cold summers and very cold winters with little rainfall. The average annual air temperature is -1.4 degrees below zero. The coldest month is January, the average air temperature is -16.9 degrees below zero. The absolute minimum temperature is -39 degrees of frost. The warmest month is July, the average air temperature is 12.6 degrees Celsius, and the absolute maximum air temperature is 33 degrees Celsius. Average annual precipitation is 75 mm. Plotting performed by two parameters of temperature and precipitation. The graphs show that with a general decrease in temperature, an increase in precipitation occurs:

Meteorological station Murghab (38878).



West GBAO. Meteorological station Darvaz. The climate is Darwaz with insufficient moisture, with warm summers and moderately mild winters. The average annual air temperature is 14.1 degrees heat. The average air temperature in the coldest month of January is –0.4 degrees below zero. The average air temperature of the warmest month of August was 28.2 degrees Celsius, and the absolute maximum was 42 degrees Celsius. The annual precipitation is 468 mm. The annual precipitation is characteristic with a maximum in March - April and their almost complete absence in August - September. Plotting performed in two parameters temperature and precipitation:

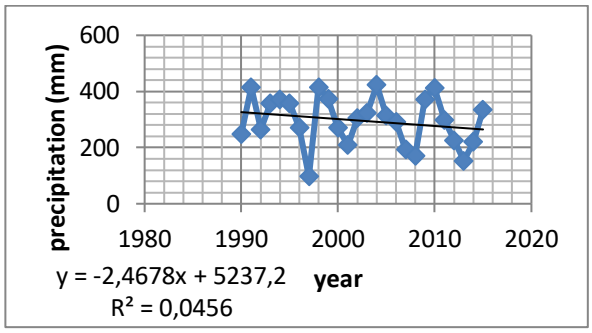


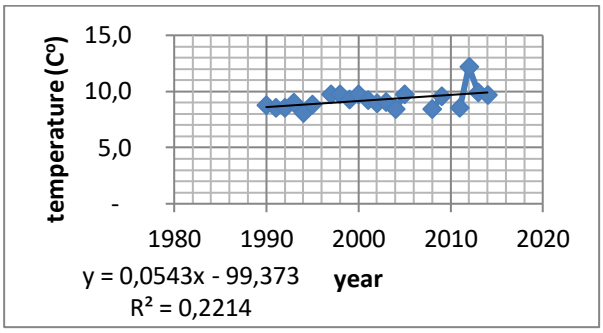
The graphs show that with the total small increase in temperature, the amount of precipitation does not increase, and their amount decreases annually.

Southwest GBAO. Meteorological station Khorog. The height of the weather station is 2075 m above sea level. The climate of Khorog is characterized by moderately warm summers and moderately cold winters. The coldest month is January, the average air temperature is –7.0 degrees Celsius, the warmest month is July, August. The average summer temperature is +22.6 degrees Celsius. The average minimum air temperature in January is -11.7 degrees of frost, but with inflows of large cold air masses it can drop to 20-27 degrees of frost. With an average maximum air temperature in July-August +30.1 degrees Celsius, on the hottest days during the

day, the air warms up to 35 degrees Celsius. Khorog is characterized by a maximum rainfall of 44–53 mm in March-April and a minimum of 4–6 mm in the summer period. The greatest amount of precipitation falls in the cold period November - March and the amount of precipitation per year is 169 mm. Plotting performed in two parameters temperature and precipitation:

Meteorological station Khorog (38954).



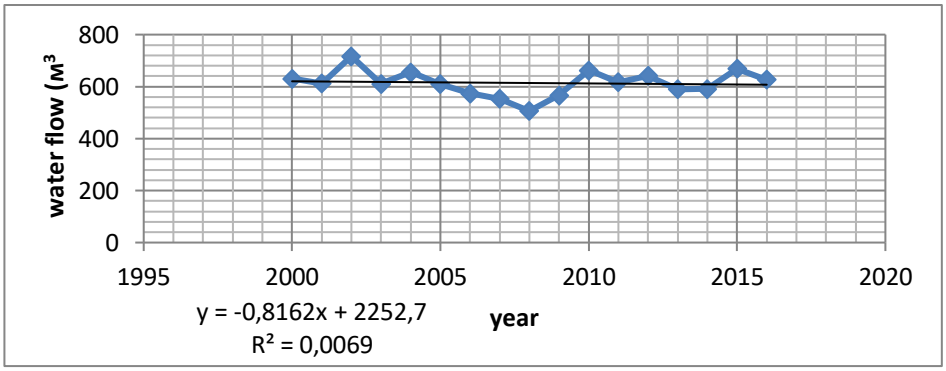


The graphs show that with a general increase in temperature, the amount of precipitation decreases.

The data from meteorological stations located in the east and west, north and south of the Gorno-Badakhshan Autonomous Region showed that the general background of rising temperatures could be assumed to create excessive humidity, which indirectly affected the microclimate of the Central Pamir - Fedchenko glacier basin. The microclimate of the Fedchenko glacier itself is independent of the weather conditions around it. The total number of days, according to meteorological data from the Gorbunov meteorological station of 1984, with precipitation in the form of snow of varying intensity, is 220-240 days per year. And in winter, the maximum rainfall is more than 14 days. The maximum air temperature in August does not exceed 14 degrees Celsius, and in winter it does not fall below -25 degrees Celsius. The movement of ice, in its central part, for the year was 230-250 meters and 150-170 meters along the edges of the glacier. I note that the total width of the glacier in the area of the weather station is 2 kilometers. In 2015, the movement of the glacier, from the visual point of observation, became almost “dead”. Looking at the ice "body" of the Fedchenko glacier, the impression was created that it was "sleeping" covered with a snow blanket. At the same time, the small glaciers of the Fedchenko glacier Basin not only retained their original appearance, but also increased their mass and area.

The ice reserves of all glaciers in Tajikistan are 457 km^3, and fresh water reserves in them are about 400 km^3, which is almost 8 times more than the annual flow of all rivers of Tajikistan.

How did the sharp pulsation of the glaciers of the Fedchenko glacier basin affect the flow of the Vakhsh river during the last years of observation? Let us take for analysis the data of the **Vakhsh-Darband** hydrological observation post, which is located in the area of the Rogun hydropower plant construction Comparing with meteorological data, I note that the abnormally cold period of 2008–09 may have become a certain point of reference. The amount of precipitation during this period was at a minimum level, which of course affected the water level in the river. Even analyzing the hydrological data by months, the picture of the river flow was unchanged, that is, it showed a negative balance.



The graph shows the result of observations of the annual values of water for 2000–2016, in cubic meters, at the hydrological station (17084).

Summing up, I want to make the assumption that the continuing activation of the small glaciers of the glacier basin of the Fedchenko has nevertheless adapted itself to the increasing global warming. The increase in precipitation and the resulting increased humidity in the upper reaches of the Fedchenko Glacier only served as an additional force for small glaciers. Within ten years, the small glaciers of the Fedchenko Glacier Basin are under active development. And they no longer rush to melt and give away water. They turned into actively moving ice.

Future new expeditions and studies will replenish the database on mountain-ice Tajikistan, and the Fedchenko Glacier will reveal to us its secrets that lurk in its thick ice. I think that Nature itself will give us a gift.

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