NATIONAL ACADEMY OF SCIENCES OF THE KYRGYZ REPUBLIC
INSTITUTE OF WATER PROBLEMS AND HYDROPOWER

Current state and forecast for the water an energy potential of the Kyrgyz Republic

P. A. Satylkanov, Director, Institute of Water Problems and Hydropower, National Academy of Sciences of the Kyrgyz Republic

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Water and energy resources of the KR

1. Current state
2. Assessment
3. Forecast
4. Harnessing

I. Water resources of Kyrgyzstan according to the data of the IWP&HP NAS KR:

- average annual river runoff - 51.9 km³ /year (without secondary, return waters);
- water reserves in glaciers - 390 km³ (85%)
- water reserves in lakes (without Lake Issyk-Kul) - more than 6.2 km³;
- ground (exploitable) water - 10.3 km³.
*Thus, the total water resources of the Kyrgyz Republic amount to approximately **458** km³.*

Most of Kyrgyzstan's river runoff is used for irrigation, while the rest flows to the territories of neighboring countries:
- Kazakhstan - 5.93 km³, of which 50% goes along the riverbeds of Chu, Talas, Kurkureu-Su, Karkyra;
- Uzbekistan - 23.6 km³, of which about 80% flows along the riverbed of Syr Darya;
- Tajikistan - 1.90 km³, of which almost 100% – along the riverbed of Kyzyl-Suu (western);
- to China - 6.99 km³ (100%) – along the rivers of the Tarim River basin.

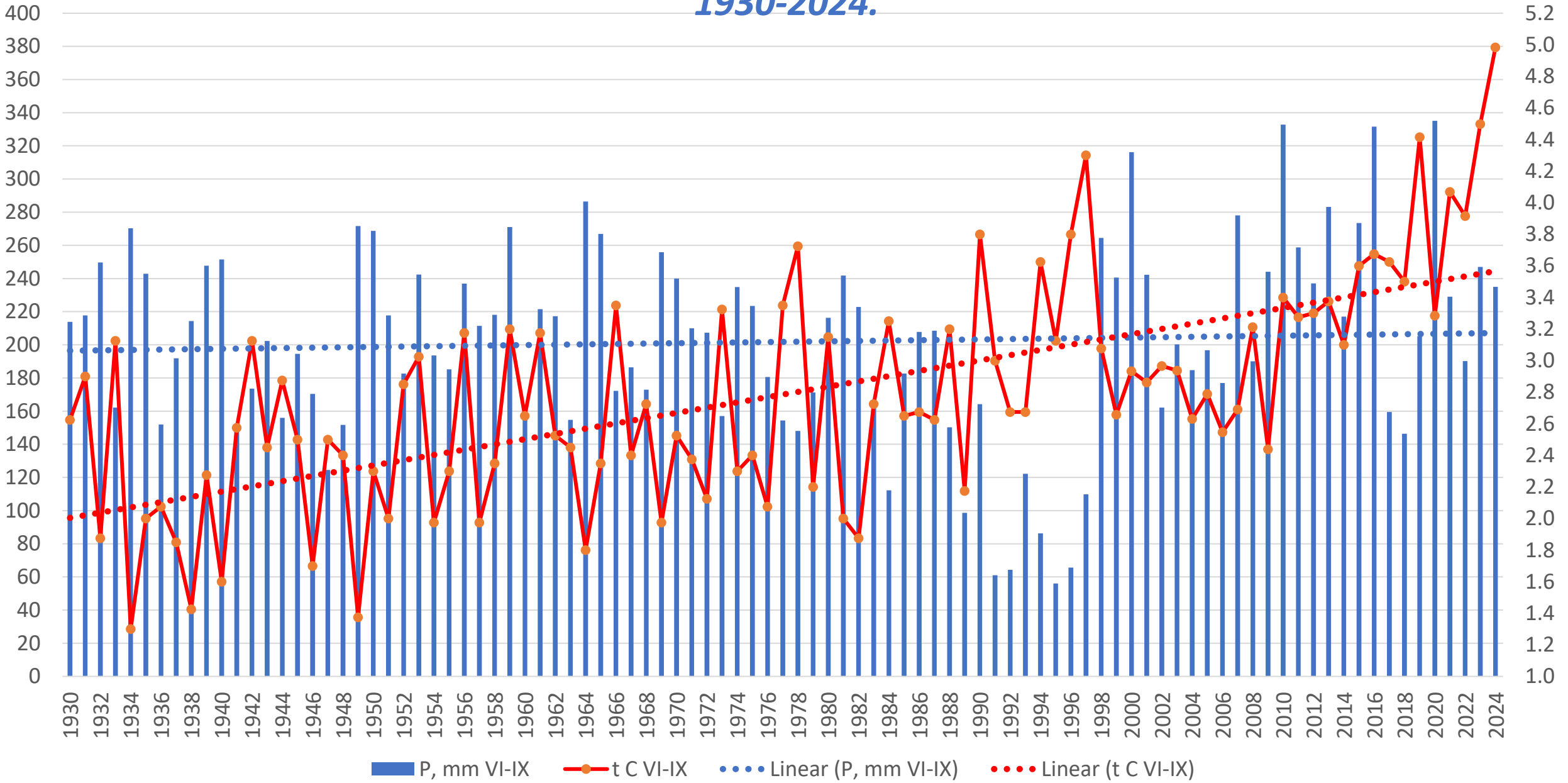
Glaciation of the Kyrgyz Tien Shan and Pamir-Alai Mountains

Change in glaciation of the Kyrgyz Tien Shan and Pamir-Alai, km²:

- ***Late Pleistocene, 13,000 years ago*** — ***60,000***
- ***End of the LIA 1850*** — ***11,500 (-4.35 km2/year)***
- ***1st USSR glacier catalog*** *(1943-1967)* — ***7,944 (-31.8 km2/yr)***
- ***CAIAG*** *(2013-2016)* — ***6,684 (-22.5 km2/year)***

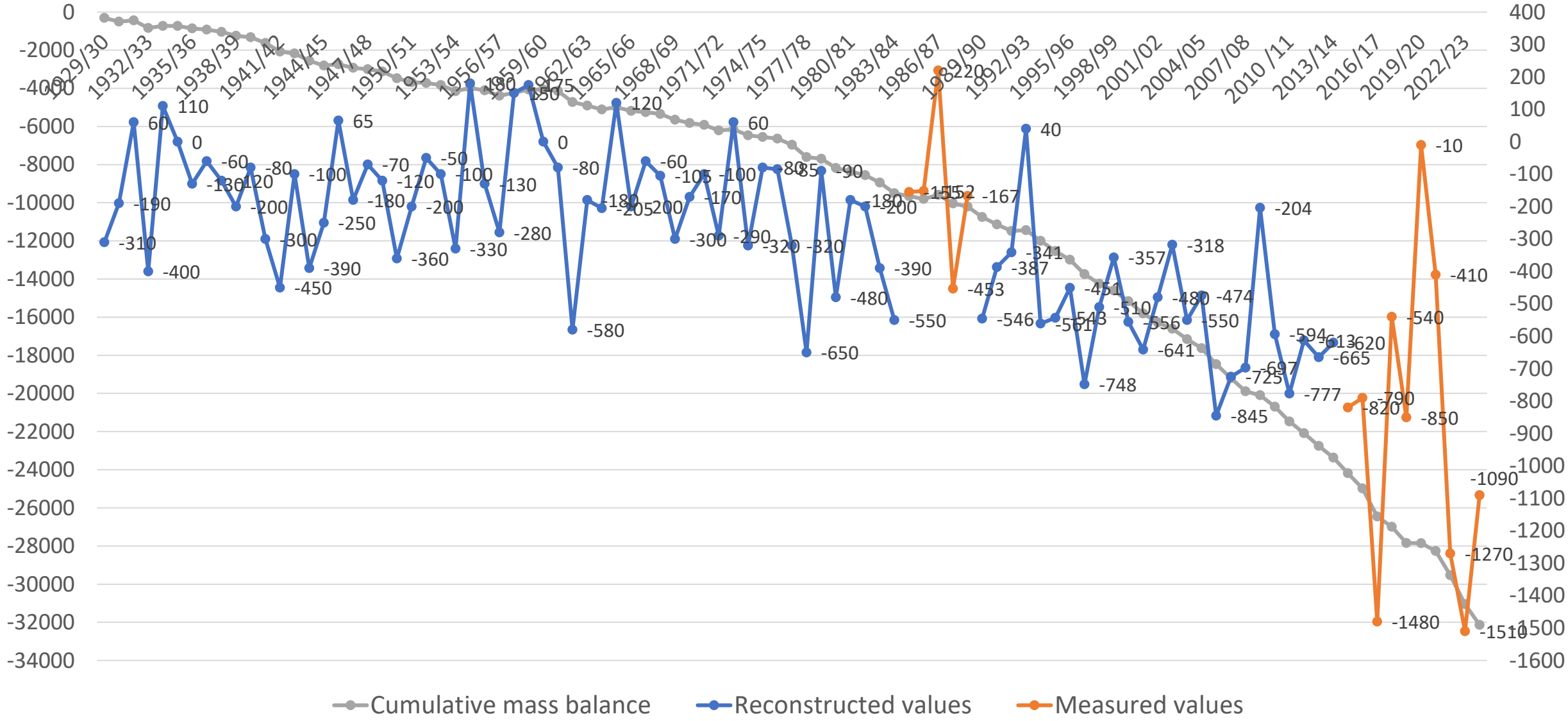
Characteristics	1943-1967 USSR Catalog of Glaciers 1970 Volume 14	2013-2016. Inventory of glaciers of the Kyrgyz Republic
Number of glaciers	8164	9959
Area, km²	7944	6684
Volume, km³	494	390

Mean annual air temperature and precipitation at Tien Shan-Kumtor MS for the period 1930-2024.



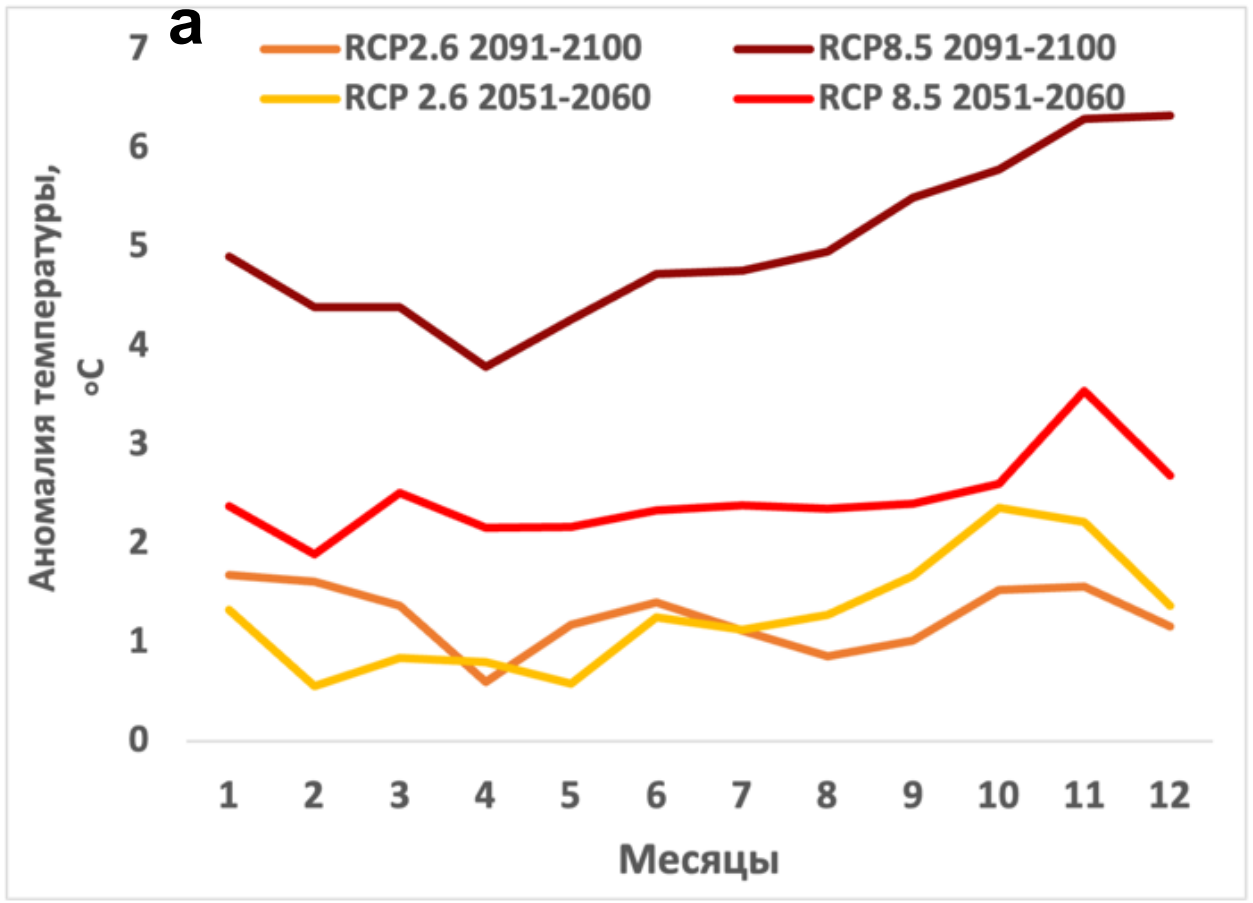
Mass balance of the Sary-Tor glacier for 1930-2024:

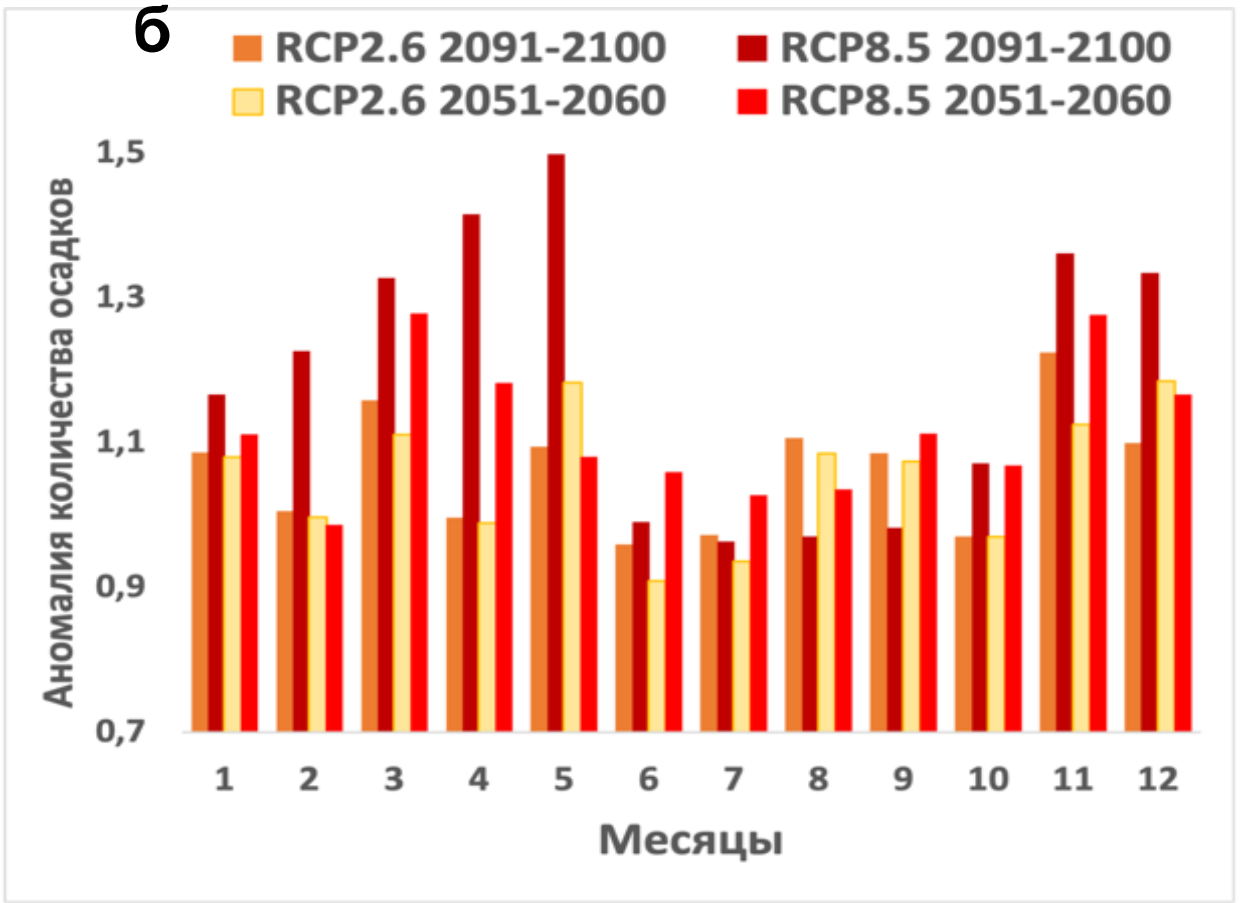
Actual measurements 1984/85-1988/89 (IG RAS) and 2014/15-2023/24 (TSMRC); reconstruction results of 1930/99-1983/84 and 1989/90-2013/14 balance years (MSU, TSMRC)



Regional climate projections using CORDEX mesoscale modeling results

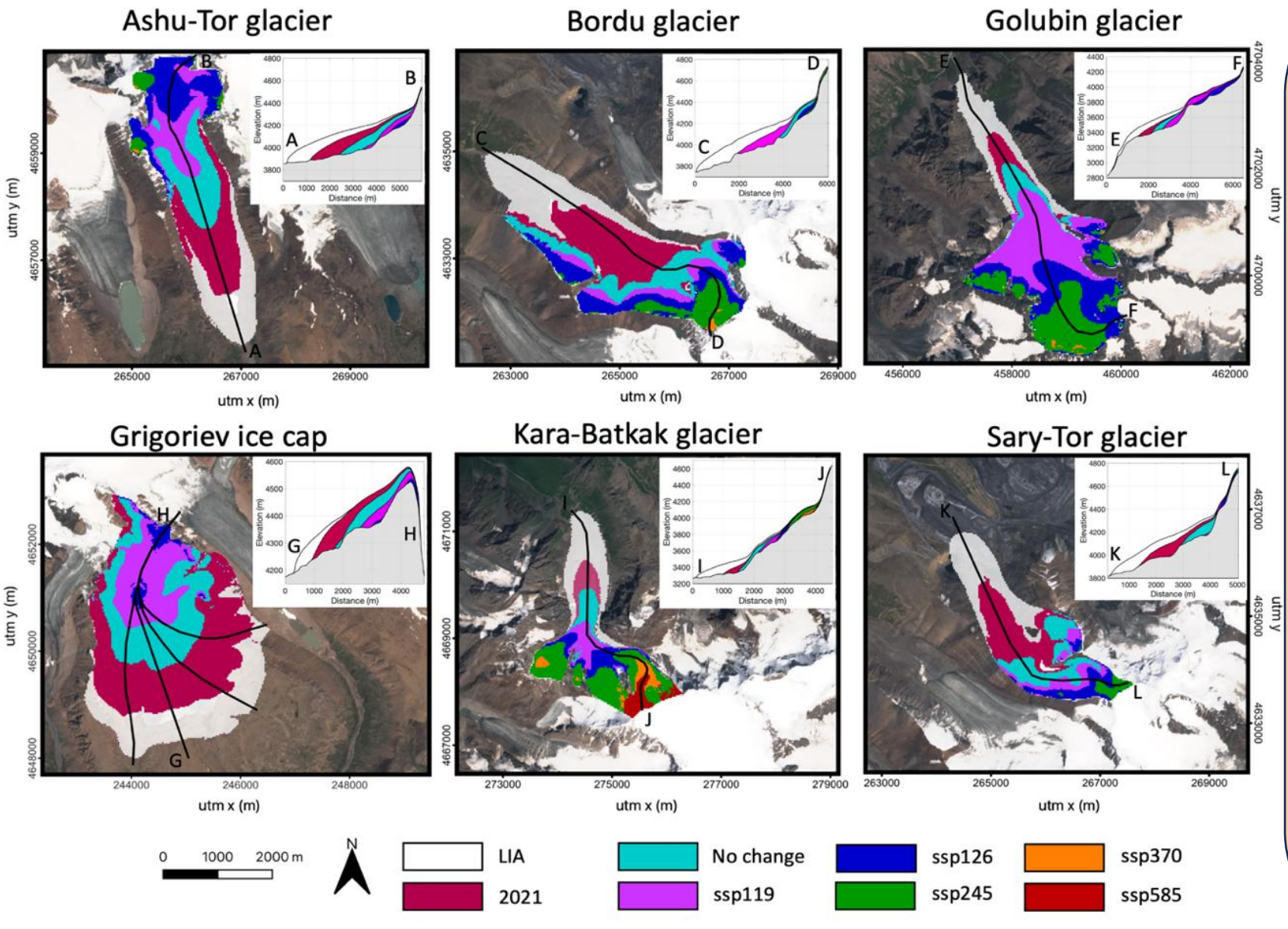
(Coordinated Regional Climate Downscaling Experiment)





(a) annual variations of surface air temperature anomalies, in C degrees, and
(b) precipitation amounts, dimensionless units, for the period 2051-2060 and 2091-2100.
for the whole region - Central and Inner Tien Shan

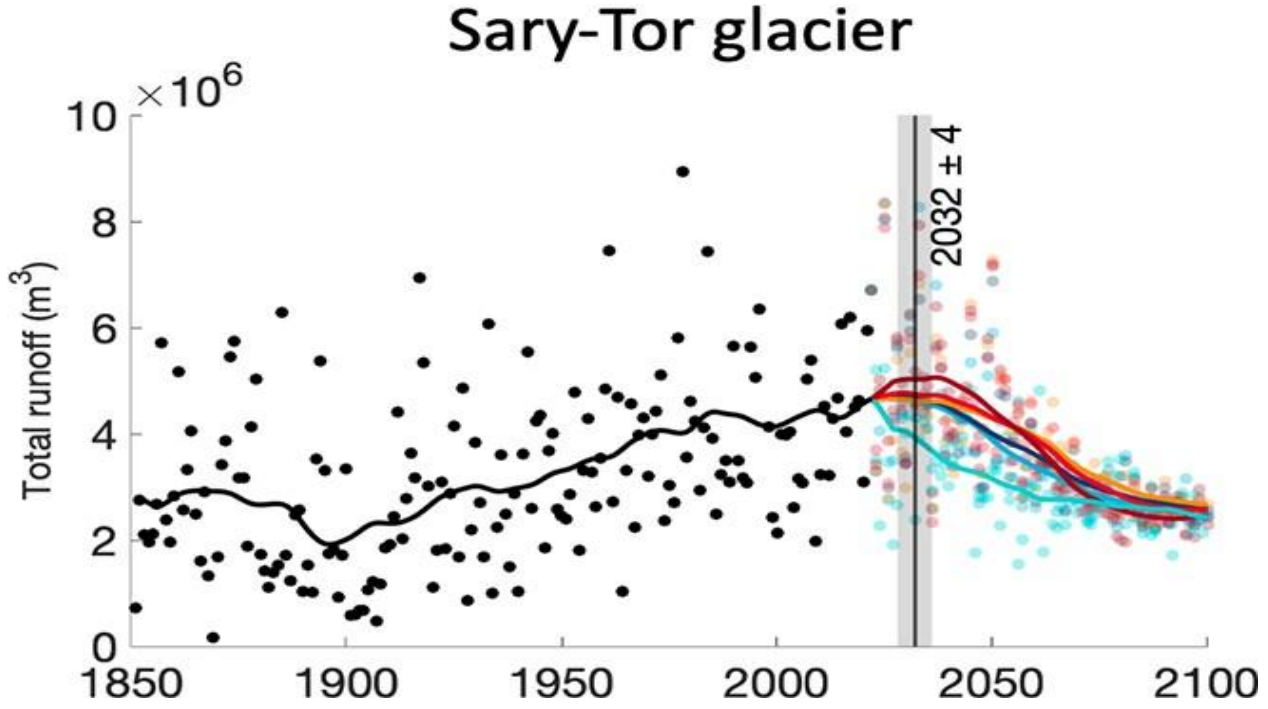
Regional glaciological projections using the results of the MOCAO ensemble (*Model of the General Circulation of the Atmosphere and Ocean*) ***IWP RAS, VUB, TSMRC*** doi.org/10.1017/aog.2023.71

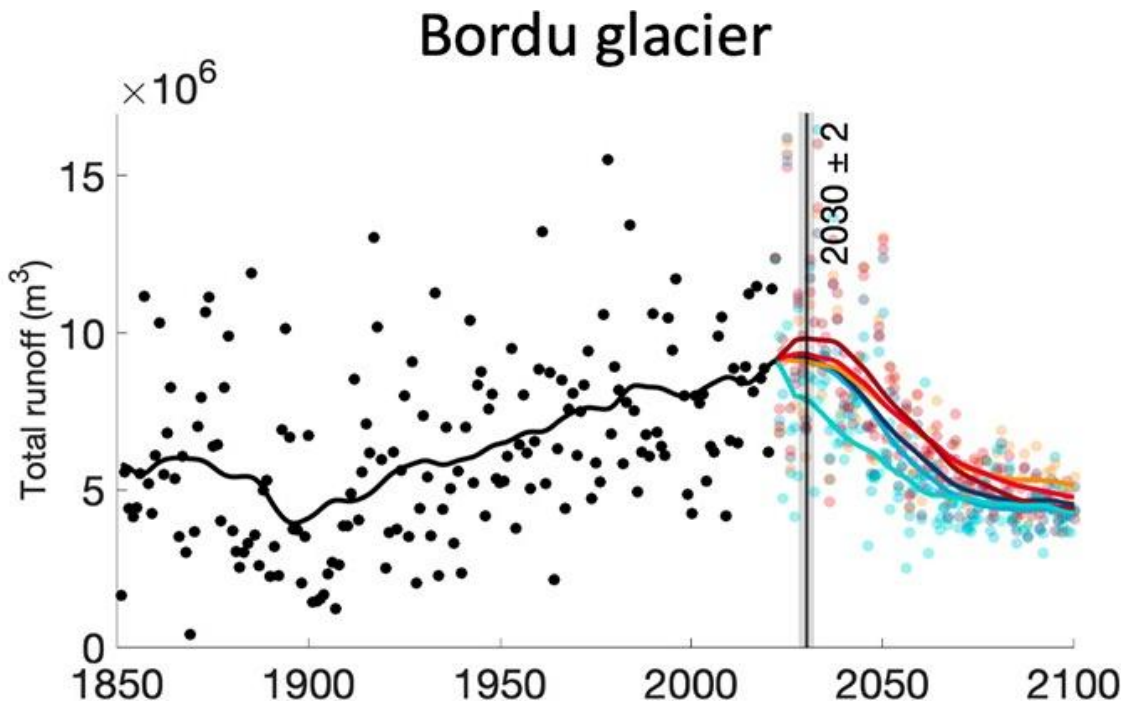


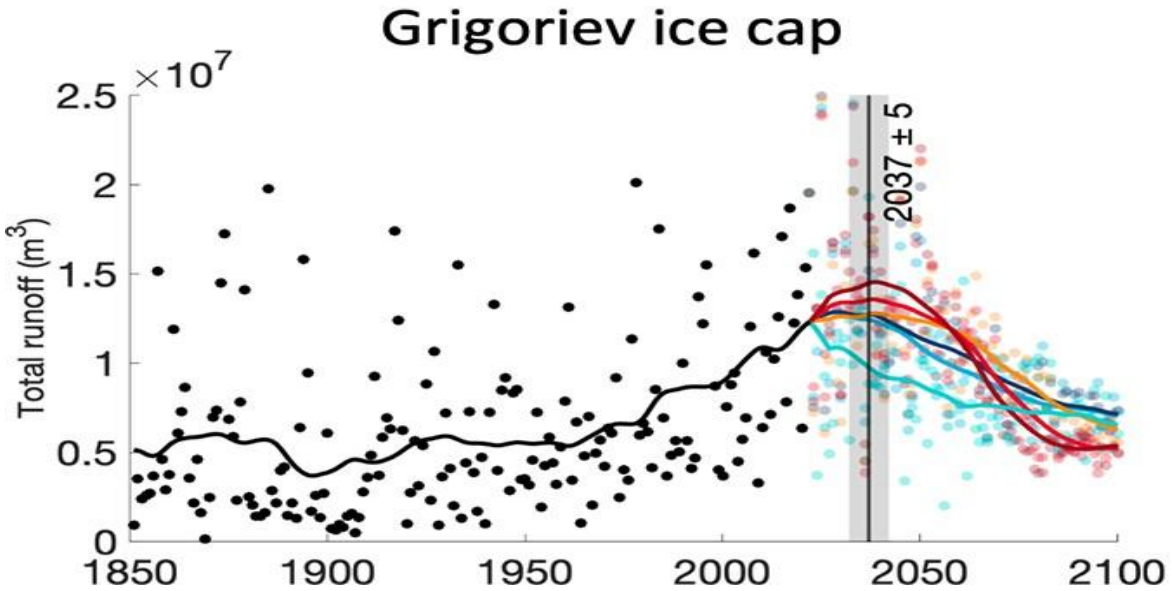
Glacier configuration at the end of the Little Ice Age, in 2021 and in 2100 under different climate scenarios. The inset shows bed profiles along the main centerlines (shown as black lines). Space images from the Sentinel-2 satellite were used as a background.

The area of glaciers of the Inner Tien Shan and Northern Tien Shan in 2100 is much smaller than the present-day one under all scenarios.

Results of glaciological projections https://www.researchgate.net/publication/368920285







Annual total runoff from the original (LIA) glacial area under different climate scenarios.
The dots represent the modeled total runoff for each year and the solid line is a 20-year moving average. The maximum runoff year shown was determined by calculating the average year of the maximum total runoff by SSP1-2.6, SSP2-4.5, SSP3-7.0, and SSP5-8.5, with the gray area corresponding to ± standard deviation from the maximum runoff year.

International research partners

1. ***MSU -*** *Re-evaluation of ice resources in the Kyrgyz Tien Shan and Pamir-Alai taking into account earmarked glaciers (since 2013).*
2. ***Institute of Water Problems of the Russian Academy of Sciences -*** *Model studies of the evolution of glaciers of the Inner Tien Shan (since 2015).*
3. ***Free University, Brussels -*** *Modeling the evolution of Kara-Batkak, Ashuu-Tor, Bordu, and Golubin glaciers, by extrapolation methods (since 2016).*
4. ***Kyoto University, DRPI KU -*** *Simulation of SWE on the Kara-Batkak and Bordu glaciers using the SiBUC model (since 2017).*
5. ***Tibetan Plateau Research Institute, Academy of Sciences of the People's Republic of China -*** *Monitoring the flat-topped Grigoriev Glacier (Arabel River basin) to calculate its mass balance (since 2017).*
6. ***University of Reading, UK -*** *Launch of the Central Asian Mountain Observatory Network (CAMON) within the scope of GEO Mountains (since 2019).*
7. ***University of Fribourg, Switzerland -*** *CROMO-ADAPT project to expand activities to new cryospheric variables and support human resources (since 2022).*
8. ***Laboratory for Spatial Geophysical and Oceanographic Studies (LEGOS), Toulouse -*** *Satellite altimetry of the surface of Lake Issyk-Kul (since 2008).*
9. **Academician N.P. Laverov Federal Research Center for Integrated Arctic Studies, Ural Branch of RAS -** *Application of stable and radioactive isotopes in glaciology, hydrology and hydrogeology.*
10. ***Mountain Communities Research Institute at the University of Central Asia (MCRI UCA)*** *- Development of a Master's program for training specialists in Environmental Science (since 2024).*

II. State order for the “Assessment of water and energy resources of unstudied river basins of the Kyrgyz Republic in the context of climate change” project

More than 20 years ago IWP&HP NAS KR carried out a fundamental assessment of water and energy resources of the Kyrgyz Republic. At present, for the rivers not covered by observations it is possible to use such innovative technologies as mathematical modeling of annual river runoff via geoinformation systems to specify hydrological characteristics and the energy potential of all waterways of the Kyrgyz Republic, assess the state of glaciation of hydrological basins, create a database and visual digital cartographic materials on water and energy resources of the republic’s river basins.

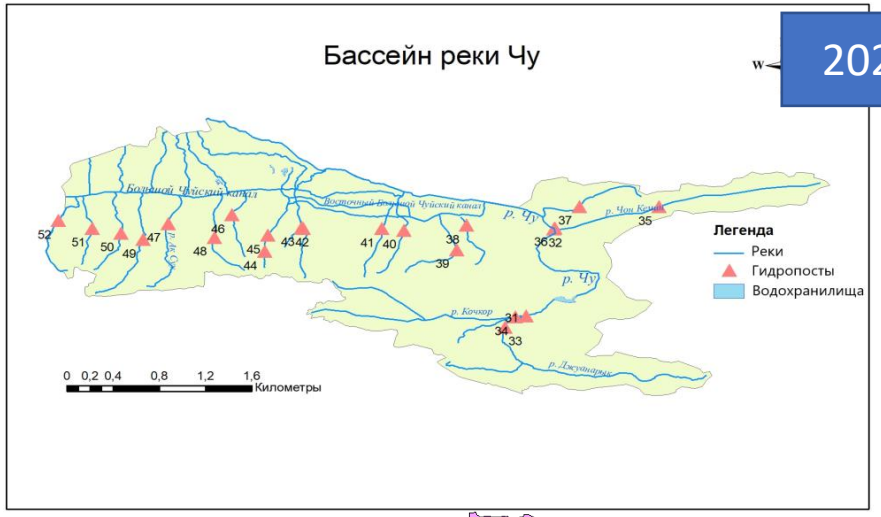
The observational hydrological network of Kyrgyzhydromet provides hydrological data on the main rivers of the Kyrgyz Republic, however, these hydrological observations do not cover all of the numerous rivers in the KR; moreover, there is no assessment of the water content along the entire length of the rivers, since their water content has changed during the present period.

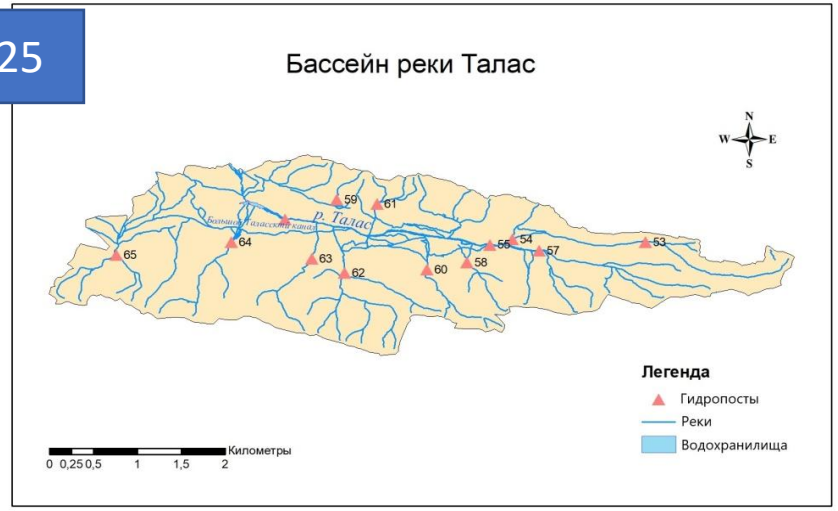
Project implementation:

- *Chu and Talas river basins in 2025;*
- *Naryn River basin in 2026;*
- *Issyk-Kul, Sary-Jaz and Karkyra river basins in 2027;*
- *Tarim, Chatyr-Kul and Amu Darya river basins in 2028;*
- *Syr Darya river basins - northern frame of the Fergana valley and Karadarya river basin in 2029;*
- *Syr Darya river basins - southern frame of the Fergana Valley and Amu Darya in 2030.*

River basins of the Kyrgyz Republic

2025

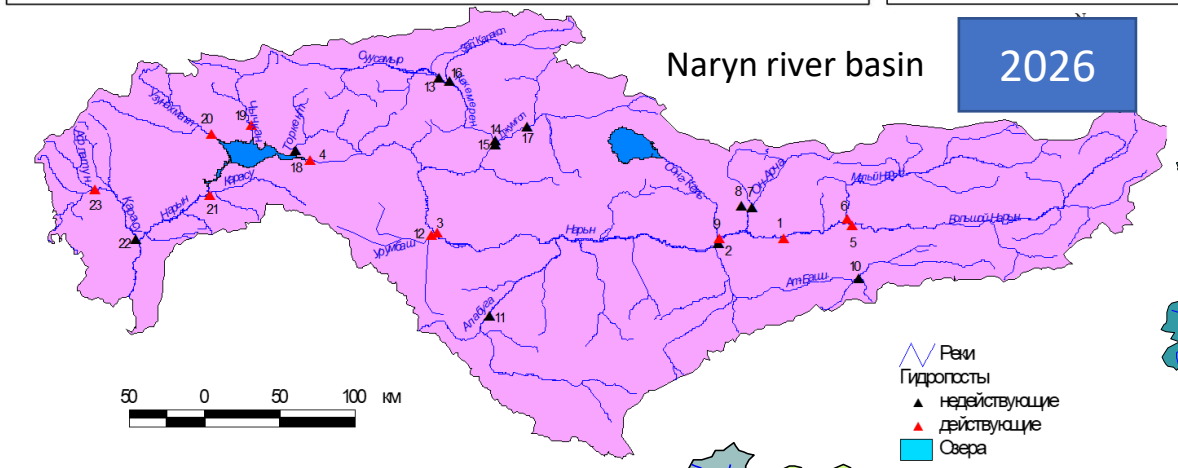


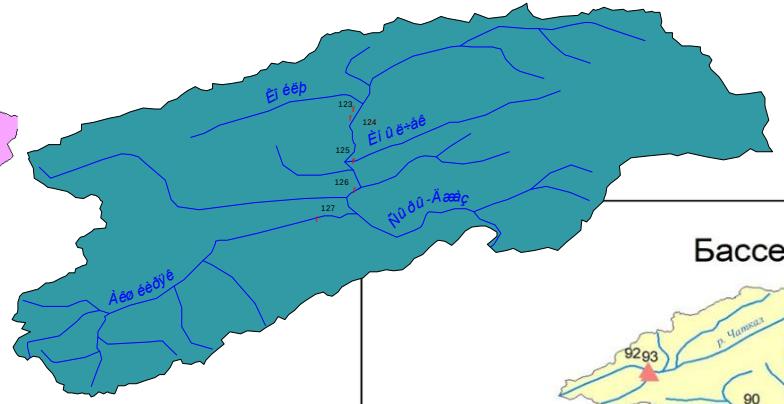


2027

Naryn river basin

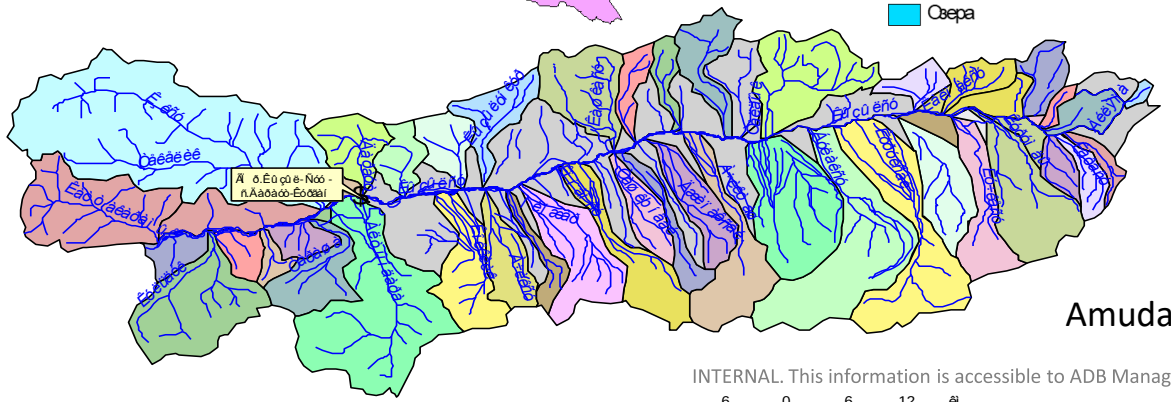
2026





Tarim River basin

2029-2030



Amudarya basin

2028

III. Modeled assessments of future changes in the river runoff characteristics in the Naryn River basin until the end of the 21st century

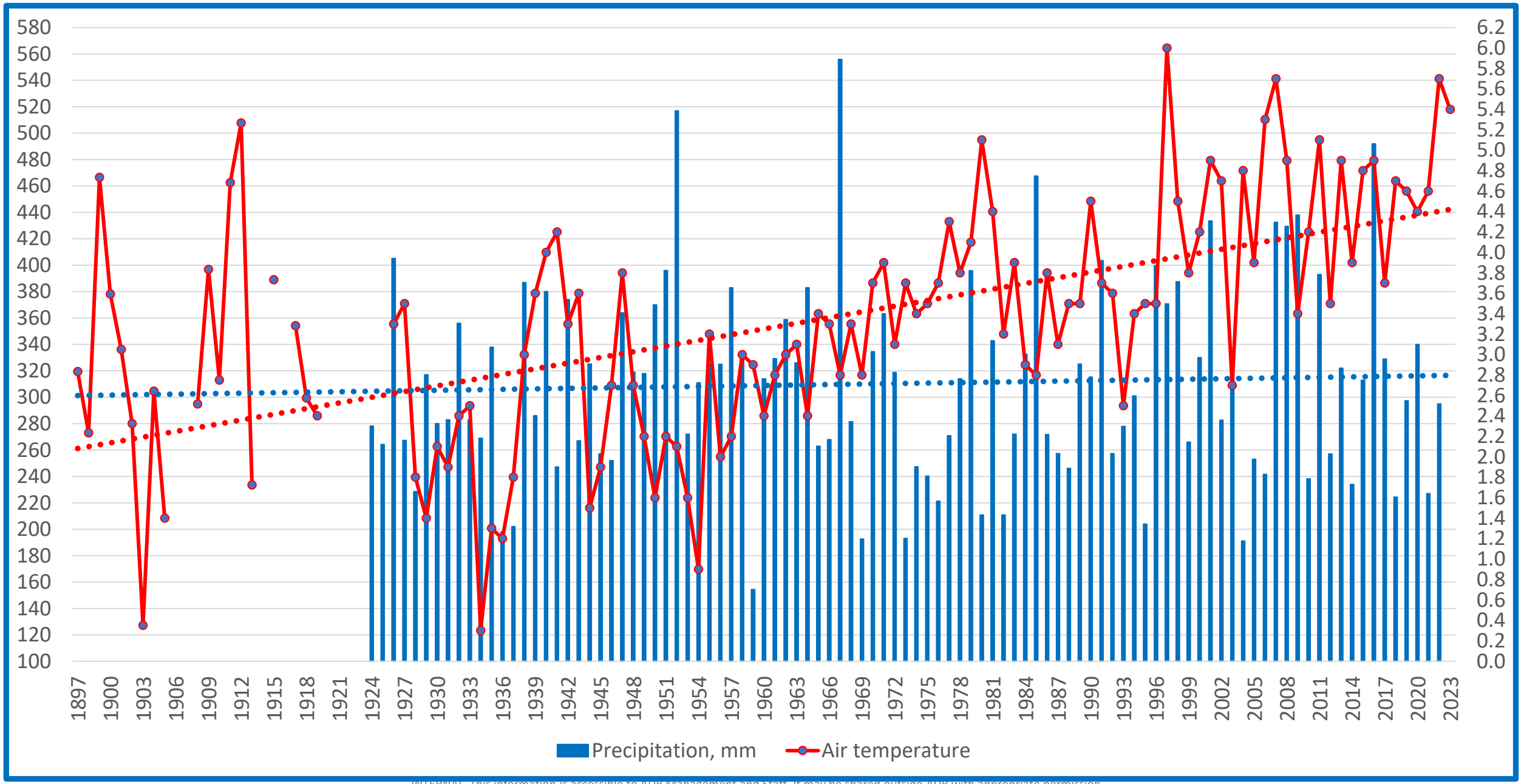
The aim of the project is to obtain projections of changes in the volume and regime of river runoff in the Naryn River basin (in the upper and middle sections until the Toktogul reservoir) under different climatic scenarios and as a result of reduced mountain glaciation. To achieve this goal, it is planned to unite efforts of scientists from different fields – climatologists, glaciologists, hydrologists, and specialists in mathematical modeling.

Objectives

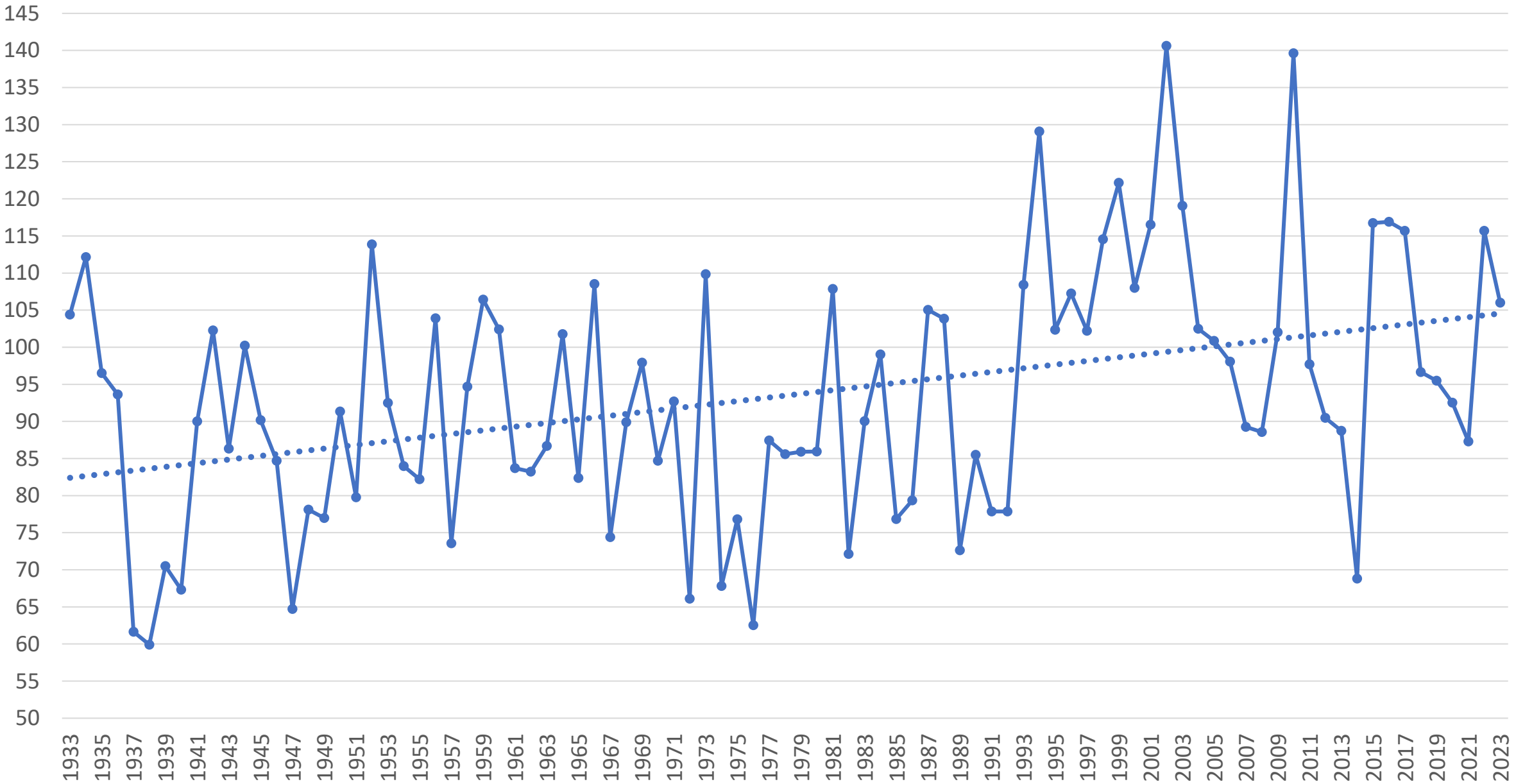
- *To create regional climate projections based on the analysis of multimodel GCM data within the framework of the CMIP6 project and mesoscale climate modeling within the framework of the CORDEX project.*
- *Create glaciological projections based on the climate projections, (i.e., assess changes in glaciation and glacial runoff characteristics) in the Naryn River basin (GGM GloGEMflow-debris).*
- *Using climate and glaciological projections, as well as other data, it is planned to create hydrological projections that reflect the changes in the river runoff in the upper and middle sections of the Naryn River basin.*

The results of the project can be used to make river runoff projections in similar basins with a significant share of glacial feeding.

Average annual air temperature and precipitation in Naryn (Kyrgyzhydromet)



Average annual water flow of Naryn River (Kyrgyzhydromet)



IV. Prospects of the study of potential resources of transboundary rivers

The subject and ultimate goal of studying these rivers should be runoff regulation through the scientific justification for reservoir construction in energy and irrigation modes of their operation.

Project objectives:

1. *Hydrometeorological and glaciological studies in transboundary river basins under climate change conditions.*
2. *Study of hydrological regime, flow components and water balance of rivers.*
3. *Study of engineering-geological and hydro-geological conditions of zones allocated for the construction of water and energy facilities, taking into account stratigraphy, tectonics, lithology, morphology and physico-geological phenomena.*
4. *Expert opinion on the actual environmental situation in the area and assessment of the impact of the construction of new facilities (reservoirs and HPPs) on the environment and population (EIA).*
5. *Development of mutually beneficial measures for the joint use of water and energy resources of transboundary rivers by CA countries.*

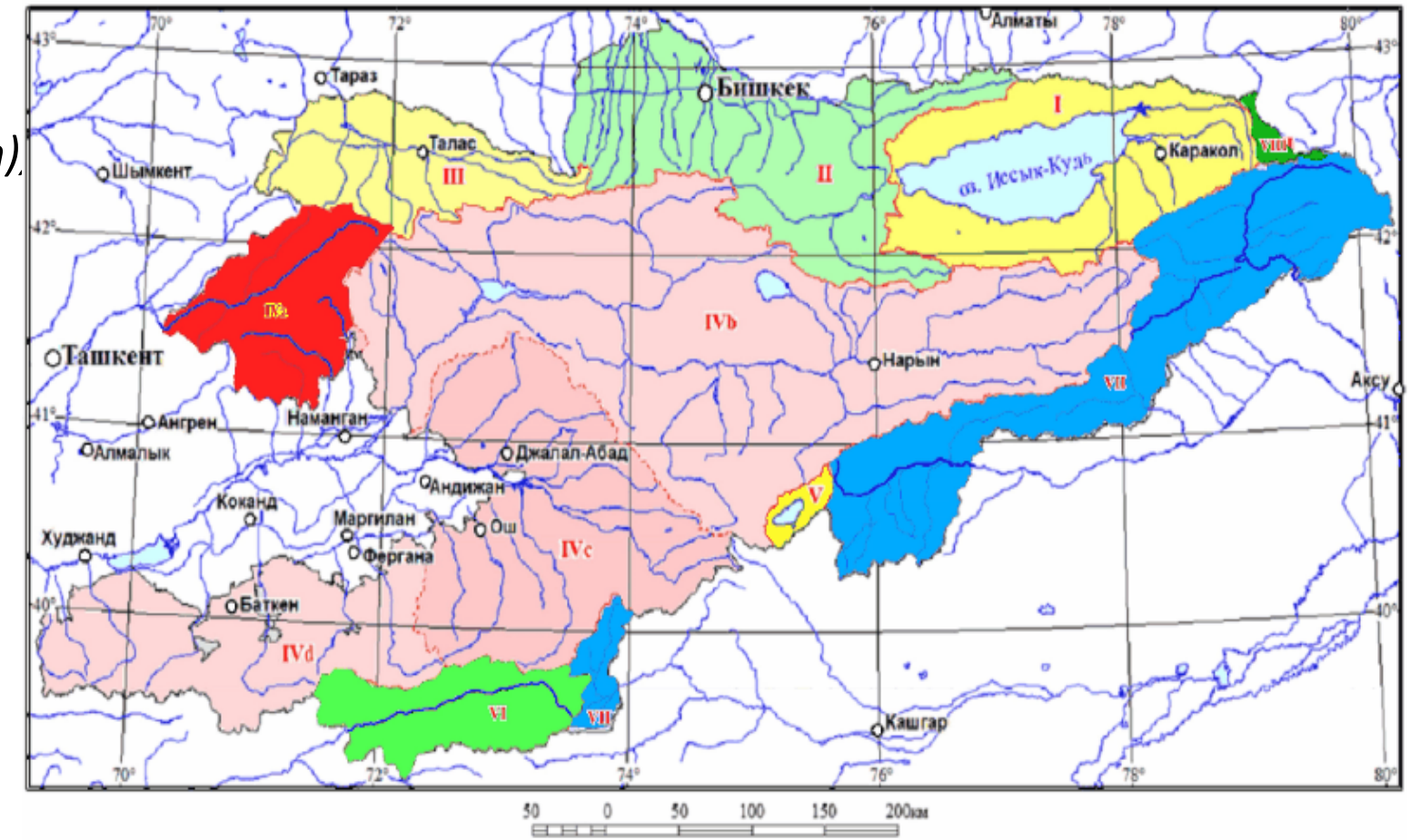
The basins (IVa, VI, VII, VIII) should be the objects of exploration:

("Transboundary waters" means any surface or ground waters that mark, cross or are located on the border between two or more states)

- (VII) Tarim River (total annual flow 7 billion m^3) with tributaries:
  - *i. Sary-Jaz River;*
  - *ii. Uzengi-Kuush River;*
  - *iii. Kakshaal River (Ak-Sai-Mudurum);*
  - *iv. Eastern Kyzyl-Suu.*
- (VI) Western Kyzyl-Suu River

(source of Amu Darya) - 1.6 billion m^3.

- (IVa) Chatkal River - 2 billion m^3.
- (VIII) Karkyra River (0.6 billion m^3).



Utilization of water and energy resources of Kyrgyzstan's transboundary rivers will lead to the following:

1. *Achieving economic sustainability and energy security of the KR by harnessing the hydropower potential of transboundary river runoff formation zones.*
2. *Satisfying the needs of neighboring CA states in irrigation water during the vegetation season by constructing reservoirs in the high-altitude cold border zone of the Kyrgyz Republic.*
3. *Creating infrastructure and jobs for utilizing natural resources of high-altitude zones in the border areas of Tien Shan, Pamir-Alai, and Chatkal.*
4. *Harnessing the transboundary rivers of the Kyrgyz Republic will contribute to the creation of a set of water management and hydropower facilities for power generation, irrigation, flood control and water supply of CA countries, as well as the development of infrastructure in border areas.*

Conclusion

It is necessary to arrange for integrated monitoring by the NAS KR Institutes of environmental, climatic, hydrological and hydrogeological regimes of hard-to-reach transboundary river basins: Sary-Jaz, Uzengi-Kuush, Kakshaal, Eastern Kyzyl-Suu, Western Kyzyl-Suu, Karkyra, and Chatkal, the resources of which are virtually not being used, in order to regulate their flow under the changing climate conditions. This will make it possible to carry out targeted redistribution of water resources in accordance with the water consumption requirements in certain periods and to develop measures for using water and energy resources of the studied river basins.

Therefore, the proposed measures should not be postponed.

THANK YOU FOR YOUR ATTENTION!

r.satylkanov@gmail.com