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Hydrologic Modeling in Central Asia

Workshop on Central Asia, “An exploration of climate science in Central Asia – moving towards frontiers of knowledge and action” 4-6 October 2021

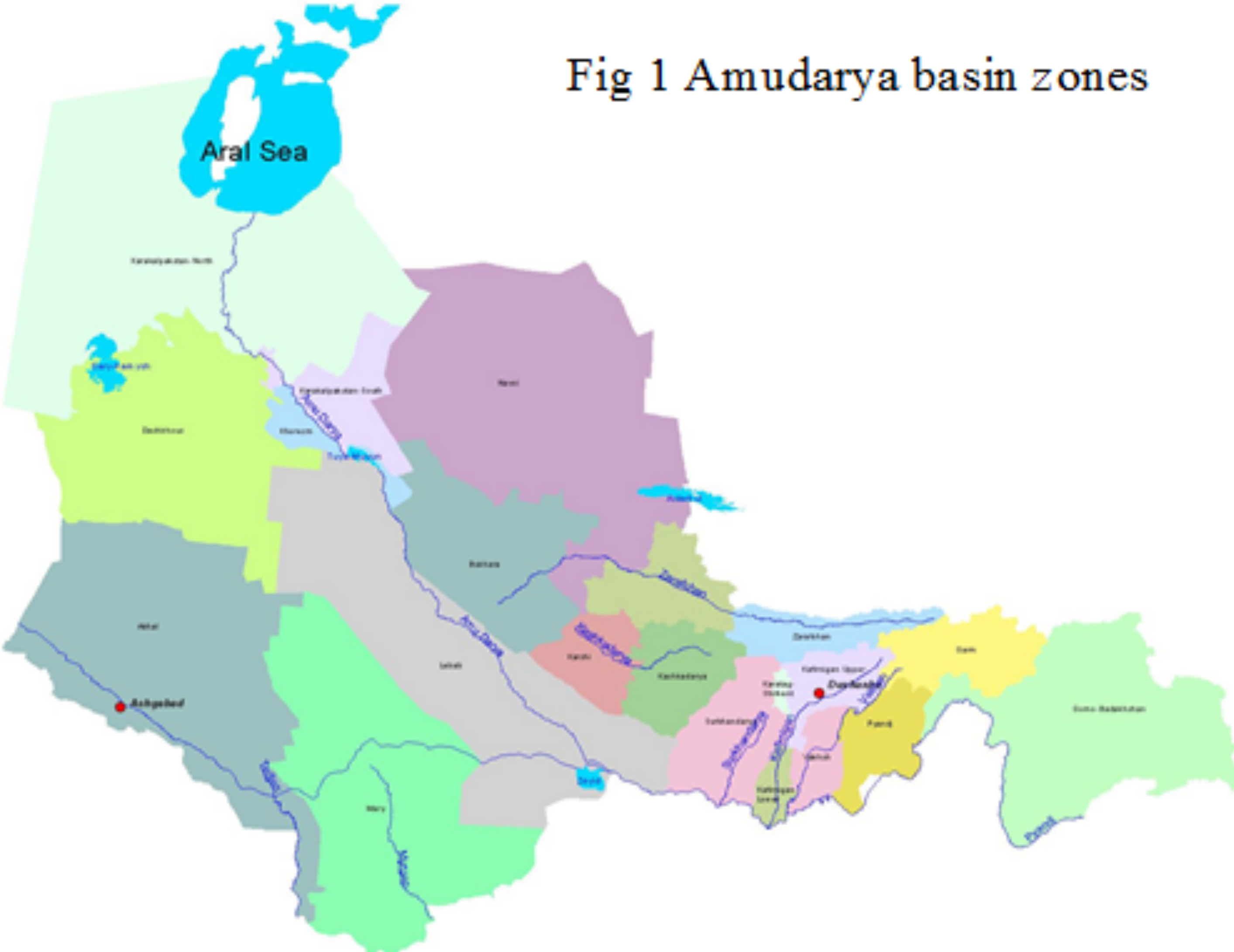
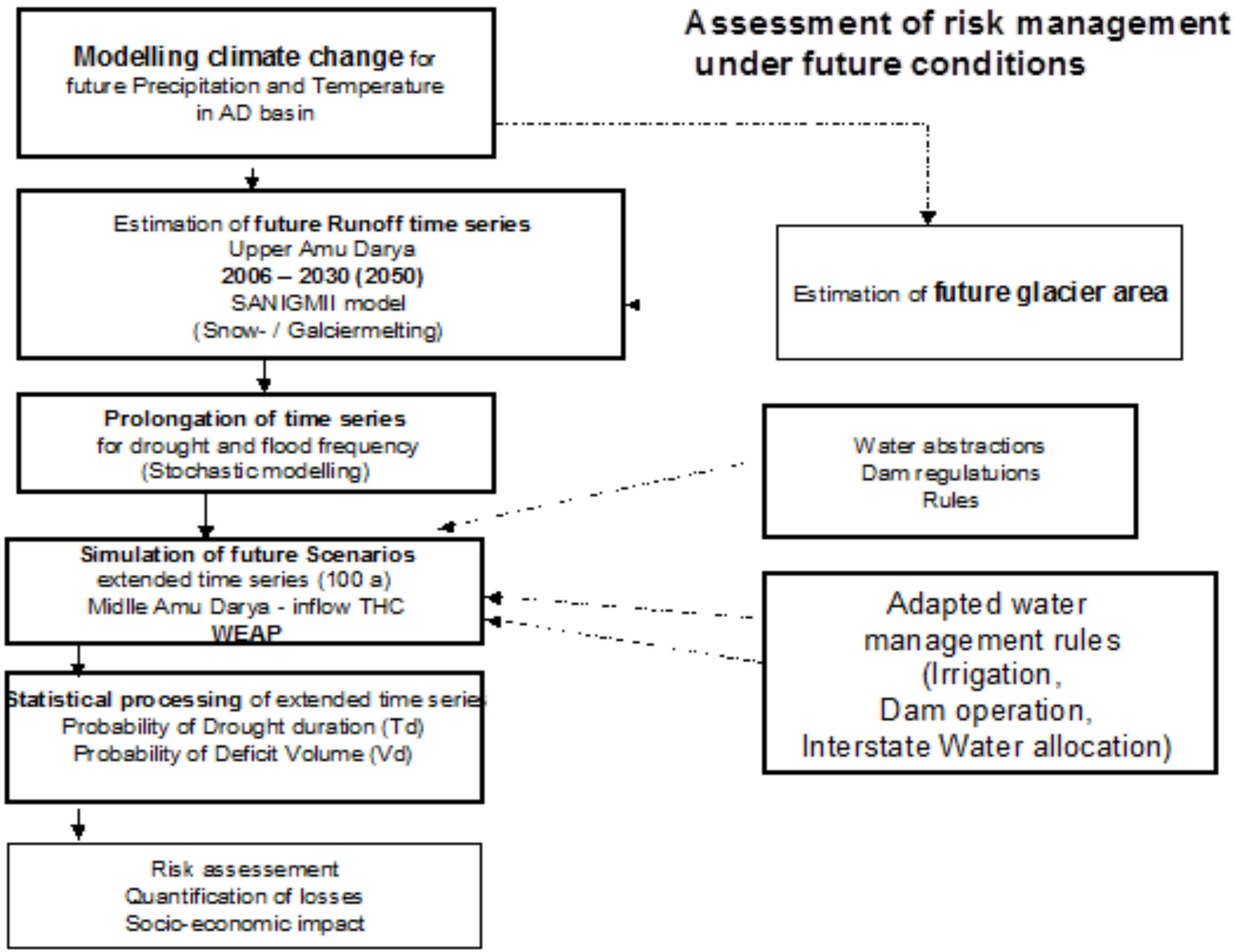
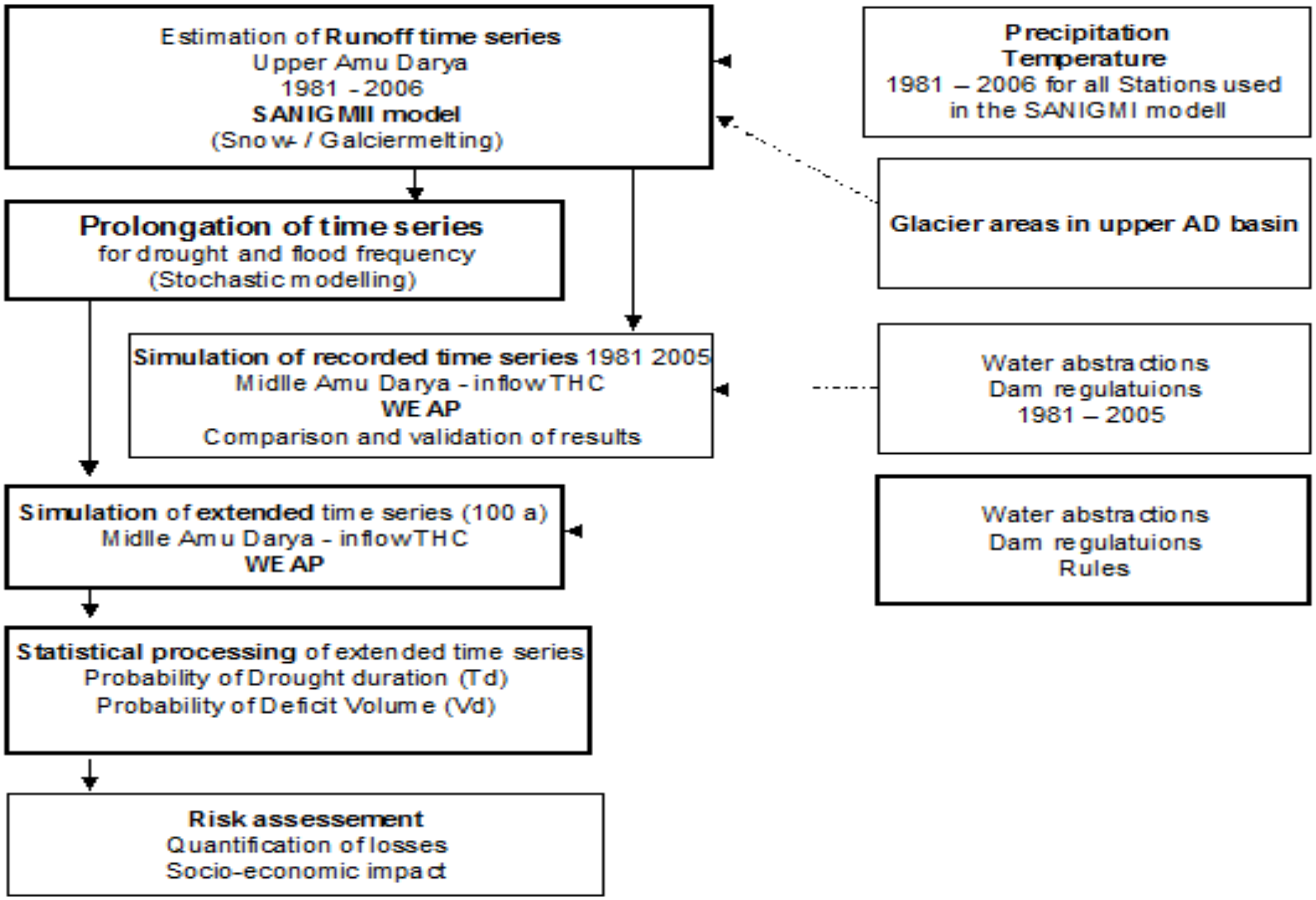


Fig 1 Amudarya basin zones



Assessment of risk management under future conditions
Modelling climate change for future Precipitation and Temperature in AD basin
Estimation of future Runoff time series
Upper Amu Darya
2006 – 2030 (2050)
SANIGMII model
(Snow- / Galciermelting)
Estimation of future glacier area
Prolongation of time series for drought and flood frequency (Stochastic modelling)
Water abstractions
Dam regulatuions
Rules
Simulation of future Scenarios
extended time series (100 a)
Midlle Amu Darya - inflow THC
WEAP
Adapted water management rules (Irrigation, Dam operation, Interstate Water allocation)
Statistical processing of extended time series
Probability of Drought duration (Td)
Probability of Deficit Volume (Vd)
Risk assesement
Quantification of losses
Socio-economic impact

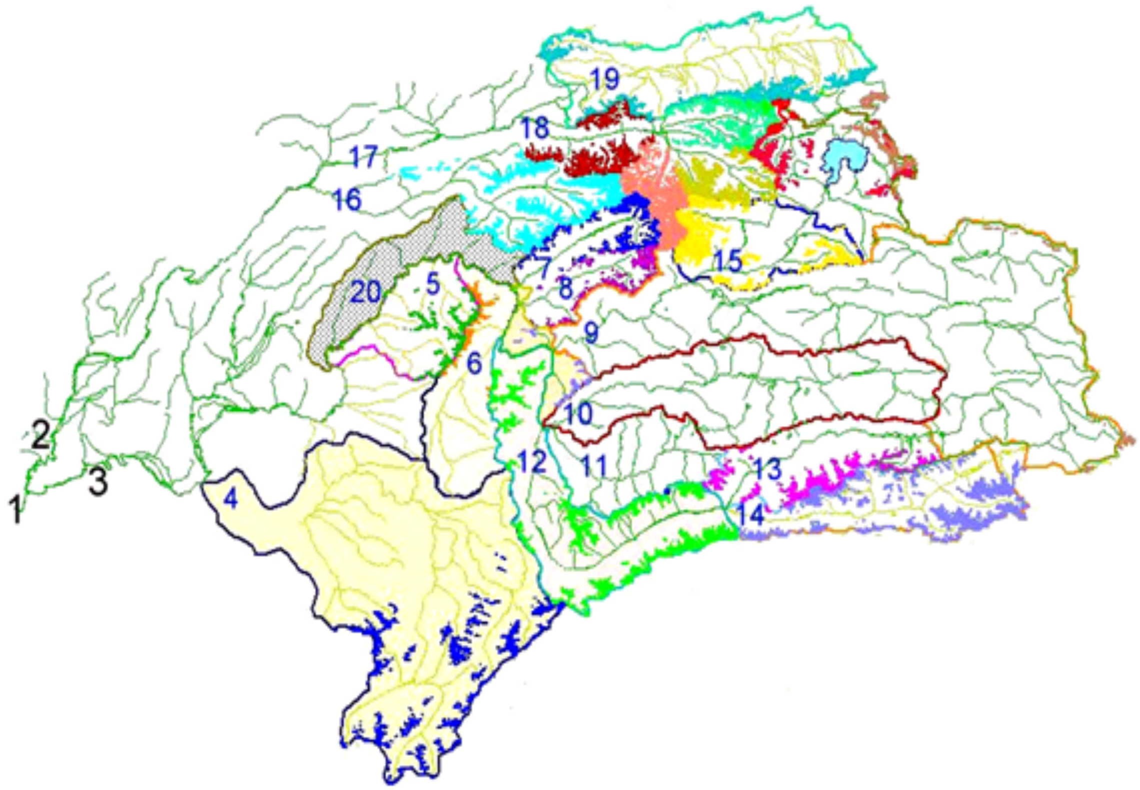
Drought risk assessment for current conditions



Air temperature and precipitation

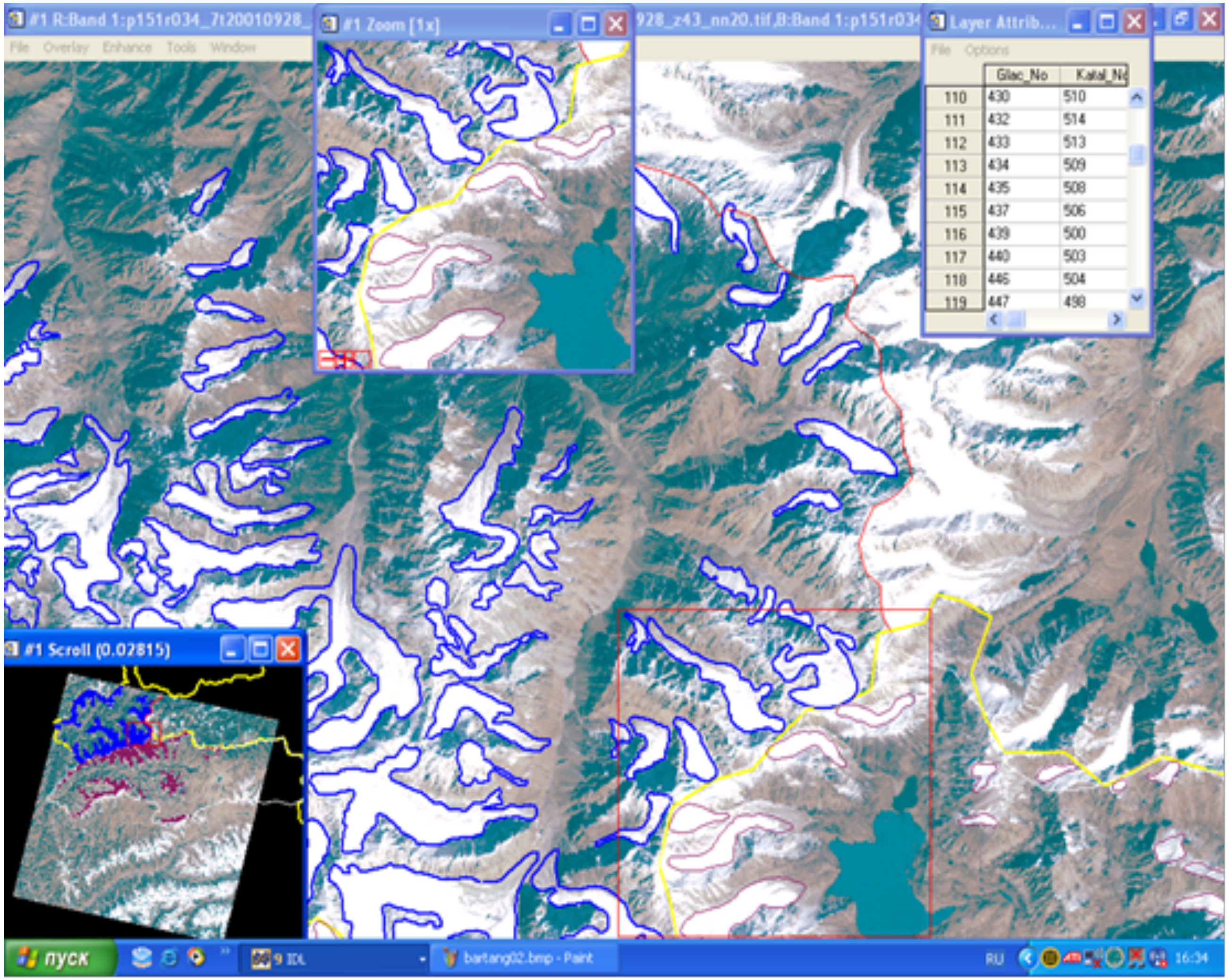
- For approximation of air temperature and precipitation on stations included into calculation model, the grid points of the Tyndall Centre temporal model were chosen. Approximation was made by means of multiple regression analysis using method of analogies.

Glaciological data base

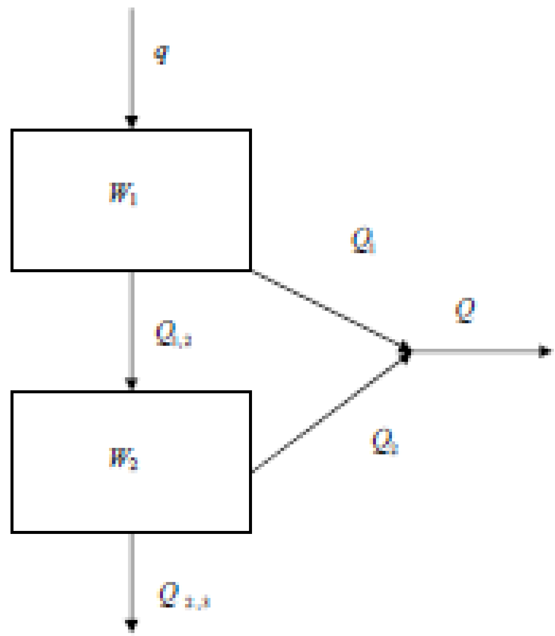


Glaciers in the Upper Amudarya basin. 1 – river Amudarya, 2 – river Vakhsh,
3 – river Pyandj, 4-15 tributaries of the Pyandj river (4 – Kunduz, 5 – Kufab, 6 – Sheva, 7 – Vanch, 8 – Yazgulem, 9 – Bartang and Murgab, 10 – Gunt, 11 – Shahdara, 12 – right and left tributaries of Pyandj downstream the confluence of Pamir and Vahandarya rivers, 13 – Pamir, 14 – Vahandarya, 15 – Kudara), 16-20 are tributaries of Vakhsh river (16 – Obihingou, 17 – Surhob, 18 – Muksu, 19 – western Kyzylsu, 20 – right tributaries of Vakhsh downstream the Vanch river mouth).

Interpretation of borders of the Bartang glaciers in program ENVI v.4.2.



Mathematical modeling of mountain river runoff, (by prof. Yu.M. Denisov)



$$Q_1 = c_1 W_1; \quad Q_2 = c_2 W_2; \quad Q_{1,2} = c_{1,2} W_1; \quad Q_{2,3} = c_{2,3} W_2; \quad Q = Q_1 + Q_2, \tag{45}$$

где q – поступление воды на поверхность бассейна; Q_i – расходы воды из емкостей; W_i – объемы емкостей; c_i – параметры истощения воды из регулирующих емкостей.

Stochastic modeling of the river runoff and meteorological characteristics.

- To estimate reliability of the water utilization system functioning of the Amu-Darya basin, the stochastic model is proposed which allows reproducing of long runoff series in its formation zone. On this stage, the parameters of the runoff distributions of the catchments under investigation correspond with stationary modern climatic conditions. On the next stage, they will be replaced by the new ones, corresponding to modern glaciation and the changed (forecasted) climatic conditions.
- For the imitation modeling, the information from 6 points was taken: 1)Pyandj – Hyrmandzhow, 2) Vakhsh – Komsomolabad, 3) Kafirnigan – Tartki, 4) Surkhondarya – Manguzar, 5) Kunduz – Puli – Kumry, 6) Kokcha – Hodzhagar

The multidimensional modelling

- The algorithm of the multidimensional vector modeling is based on the decomposition of the field along eigenfunctions. It reproduces random variables having the given parameters of one-dimensional distributions, correlation matrix and the first value of the autocorrelation function (it is enough in the Markov approach).

Modeling of monthly values

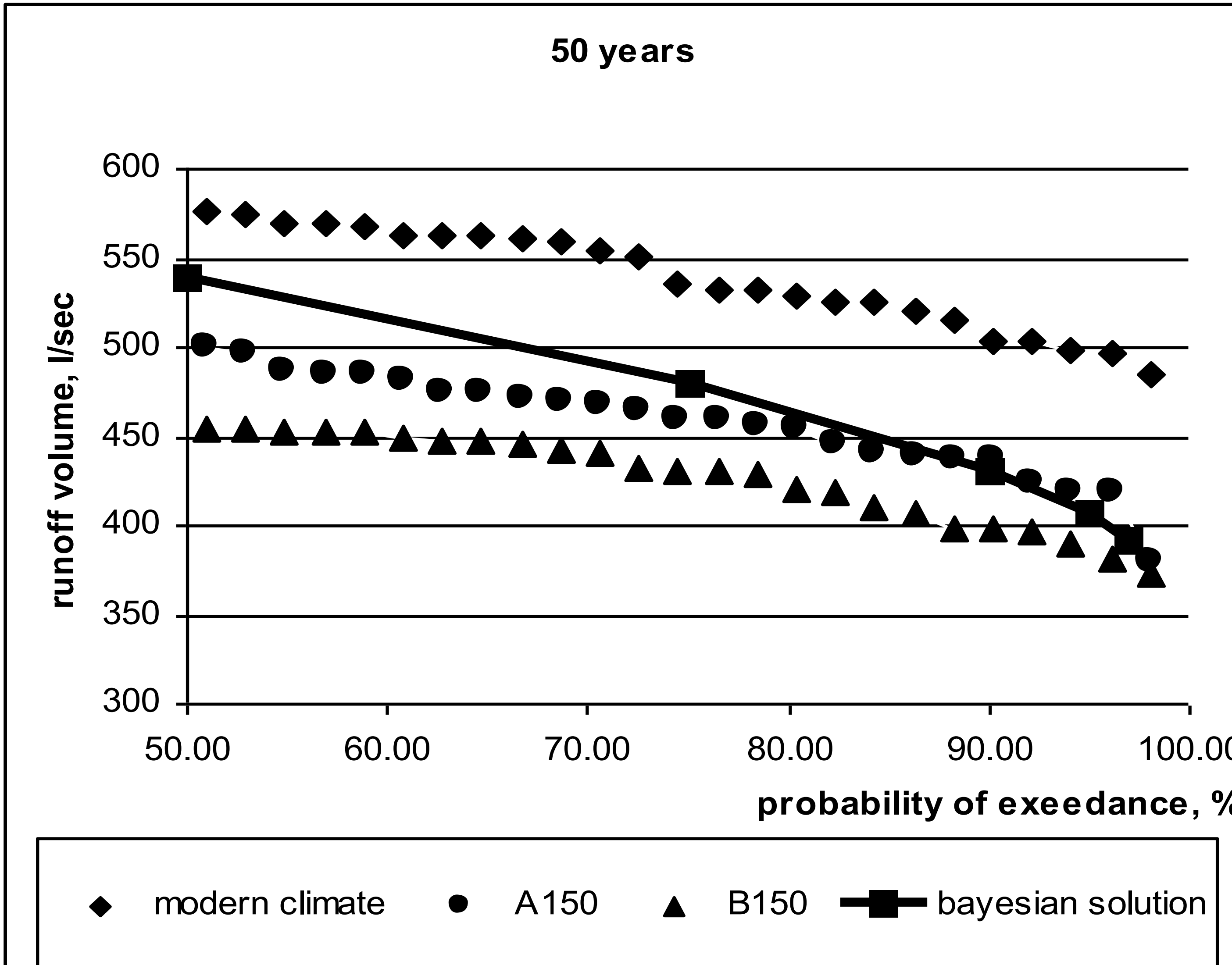
- Modeling of monthly values of precipitation and temperature is executed according to the scheme of the SAR- Model, i.e. the one having the seasonal trend removed. For the model adjustment, matrixes of spatial correlation, autocorrelation functions for each month and the distribution parameters of precipitation and temperature are estimated for the meteorological stations: Garm, Gulcha, Gushary, Hovaling, Fedchenko and Tavyldara.

Bayesian decision for flow evaluation in multiscenario conditions

- Further processing can be continued in two ways. First, we can accept one of values ϑ as estimated parameter, for example, position measure or average of distribution. In some cases, for introduction of reserves into results of calculations, it is possible to assume quantile of a posteriori distribution .
- The second way consists in the construction of forecasted frequency distribution of probabilities of water runoff on the base of the formula of total probability. In that case forecasted frequency is estimated as follows:

$$\pi(x) = \int_{\theta} P(x, \theta) \cdot p(\theta / x) d\theta$$

Distribution function of Vakhsh river runoff under conditions of different climate change scenario



What do you view as the top 2-3 priorities for research to address critical knowledge gaps, and why?

1. Development and adaptation to local conditions of the runoff model taking into account glaciation.
2. Development and optimization of monitoring observation network and open data.
3. Open databases on water consumption.
4. Development of long-term river runoff forecasting methods.

Given current and emerging knowledge, what adaptation responses are the most pressing?

1. Creation of a joint water management system for Amu-Daria and Cyr-Daria.
2. Creation of a joint scientific center on the problem of water resources research, forecasting and management.
3. Attraction of attention and funds of international funds for solving water problems in Central Asia


РАХМАТ!