2. Regional climate change scenarios building based on global climatic models outcomes

2.1. Methodological background

According to IEG conclusion global climatic models of general atmosphere and ocean circulation outcomes present most appropriate base for regional scenarios building, which, in turn, serve as a basis for various regional assessments of vulnerability to climate changes. But information received from MGC, as a rule, has low spatial resolution (3 corresponds to 330 km on equator). Such low resolution is main limiting factor for its wide use. In this connection, problem of outcomes interpretation in different regional scales occurs.

One of the simplest ways to spatial detalization of MGC outcomes is interpolation of outcomes on more dense spatial network with further imposing on climatic information of high resolution obtained from instrumental observations. Another approach is hydrodynamic models with high resolution for closed areas called regional climatic models. Another method is method of outcomes statistical interpretation. This method is used for assessment of climate changes impact on agriculture or forestry, water resources, etc. Often these methods are applicable only for specific geographic region. Regional climatic scenarios obtained on base of statistical interpretation suppose conservation of large and mezzo-scale statistical relations in the future.

In given work regional climatic scenarios are built by method of statistical interpretation based on concept of "ideal forecast" described in [9] using gradual linear regression.

2.2. Analysis of existing control running of global climatic models

Criterion for optimal model selection can serve numerical assessment of model capability to reproduce climate of basic period. For this purpose usually compare results of calculations on different models with real climate in grids of latitude-longitude network or interpolate MGC outcomes in coordinates of basic stations [3]. Analysis of such comparison shows that some models within some seasons better reproduce field of temperature, other – field of precipitation, e.g. model capability depends on season and region localization.

We considered control running of some models for state of equilibrium (real climate reproduction under modern CO_2 concentration) [8]. Models outcome for general atmosphere and ocean circulation (data of US National Center of Atmospheric Events (NCAR).

Data bank contains results of air temperature near ground surface modeling (T, (C), precipitation (R, mm/day) in grids of regular network on earth surface for each month under modern CO2 concentration ($1xCO_2$) and doubled one ($2xCO_2$).

Next models are being considered: CCCM – model of Canadian Climatic Center (spatial resolution - 2,22 on latitude and 3,75 on longitude, sensitivity to CO2 doubling - 3,5^{o}C); UKMO – model of Meteorological Bureau, UK (spatial resolution - 2,5 on latitude and 3,75 on longitude sensitivity to CO2 doubling - 3,5^{o}C); GFDL – model of US Laboratory of Geophysical Hydrodynamics (spatial resolution - 2,22 on latitude and 3,75 on longitude, sensitivity to CO_2 doubling – 4,0^{o}C; GISS – model of US Goddard Institute (spatial resolution - 7,83 on latitude and 10,00 on longitude, sensitivity to CO2 doubling - 4,2^{o}C.

Comparison of results show that temperature regime of plane area is better modeled. In mountainous relief there are higher deviations from real data.

With regard for above mentioned, stations were selected located within plane area, control running deviations from basic climatic data were calculated ($1xCO_2$) and interpolated in station coordinates. Analysis of results showed that in this case also modeled temperature differs from real one. Almost all models underestimate average monthly temperature (except summer).

Models CCCM and GFDL give highest deviations from real climate particularly in winter time.

Models UKMO и GISS results are more real. In Table 10 deviations from average temperature for Uzbekistan are presented.

Table 10 | Average deviations of control modeled air temperature from basic climatic norm for plane area of Uzbekistan

Model	Season				Average annual
	Winter	Spring	Summer	Autumn	
CCCM	-9,9	-6,6	0,5	-4,3	-5,1
UKMO	-3,5	-2,1	1,1	0,4	-1,0
GFDL	-9,5	-1,1	1,1	-2,0	-2,9
GISS	0,3	-2,8	-1,5	-0,9	-1,2

Analysis of modeling results for precipitation was carried out with regard for relief peculiarities. For this climatic data was averaged over plane and mountainous area.

Control modeled precipitation for the moment $1xCO_2$ were compared with climatic data of basic period and observation data in grids of network. Analysis shows that data interpolated from grids to station coordinates and observation data are in good compliance but for mountains this difference grows.

Control modeled values variations relatively climatic data are substantial. It is important to note that for stations in mountains inter-model variability for control running during spring months compiles with averaged climatic data. Modeled precipitation exceeds real climatic data.

In Table 11 modeled precipitation values and real climatic data over seasons of a year. Model GISS gives maximum precipitation. In winter it overestimated on average by 1.0 mm/day and in fall – by 0.5 mm/day. Models GFDL and UKMO describe precipitation more realistically for plane area. Good results were obtained under modeled and climatic data averaging over seasons.

Table 11 | Averaged over territory modeled precipitation values (mm/day) and real climatic data for basic period (model climate – data from network grids and observed data (station climate)

Model	Season				Average annual
	Winter	Spring	Summer	Autumn	
Plain					
CCCM	0,62	0,83	0,21	0,26	0,48
UKMO	0,73	0,41	0,00	0,31	0,36
GFDL	0,34	0,52	0,00	0,24	0,27
GISS	1,41	1,08	0,31	0,75	0,88
Model climate	0,53	0,50	0,20	0,23	0,39
Station climate	0,40	0,55	0,09	0,22	0,32
Foothills					
CCCM	1,12	2,13	0,41	0,48	1,04
UKMO	1,72	1,51	0,34	0,93	1,12
GFDL	0,41	1,12	0,64	0,43	0,65
GISS	2,50	1,71	0,62	1,14	1,49
Model climate	0,83	1,18	0,46	0,40	0,71
Station climate	1,33	1,46	0,08	0,53	0,85
Mountains					
CCCM	1,24	2,41	0,89	0,54	1,27
UKMO	2,08	2,46	0,87	1,62	1,51
GFDL	0,54	1,62	1,43	0,78	1,09
GISS	2,27	1,73	1,12	1,14	1,56
Model climate	0,86	1,31	0,50	0,52	0,80
Station climate	1,46	2,40	0,82	1,00	1,42

Seasonal precipitation values computed based on foothill and mountain stations and climatic data for basic periods are also presented in table 10. It worth to note that for foothills and mountains high differences between modeled and real climatic data take place.

When describing climatic fields of precipitation with network grids substantial differences have place increasing in mountains.

UKMO and GFDL models give results closer to real data for plane area. Differences diminish while considering annual values (Table 9). For mountains differences are less that allows use all models for precipitation prediction in mountains.

In conclusion the following can be said:

- model assessments of air temperature variations are underestimated;
- model assessments of precipitation is somewhat overestimated;
- temperature definition uncertainty is less for plane area compared with mountains;
- precipitation definition uncertainty is high for the regions with high natural precipitation variability especially for warm season of the year. Last conclusion is in compliance with precipitation field statistical structure in the Aral Sea basin. Coefficients of precipitation variations are highest for plane part of the basin and diminish in mountains. Thus, model scenarios uncertainty for precipitation is very high for the regions with high precipitation variability, particularly in dry season.

Range of regional climatic scenarios based on abode described results has been built for CO2 concentration doubling in Uzbekistan and adjacent mountains [8]. Diapason of average annual temperature probable changes for models UKMO, GFDL and GISS amounts for 4,4-6,0°C for plane area and 3,4-5,2°C for mountains. Obtained values of expected temperature changes are overestimated due to sulfate aerosol effect not taken into account.

Models UKMO and GFDL give annual precipitation for plane area 90-116% from basic norm and 104-121% for mountains (UKMO, GFDL, GISS).

Scenarios developed for air temperature changes were used as an extreme options while assessing environment and economic sectors vulnerability within UN Framework Convention [12].

Analysis shows that single model of general circulation can't be selected, which describes Uzbekistan climate in best way. For more reliable assessment of probable climatic changes statistical interpretation of results is to be used.

2.3. Selection of optimal MGC outcomes for regional climatic scenarios building for Uzbekistan and adjacent mountainous area

Given work task is to build regional climatic scenarios for the nearest future (by 2025) Described in sub-section 2.2 data are outcomes of models in state of equilibrium permitting obtain temperature and precipitation changes only for hypothetical moment of time when CO2 concentration in the atmosphere is doubled ($2xCO_2$). Thus, these data can't be used for nearest future scenarios. For this models in state of transition are needed. These are more developed models of general atmosphere and ocean circulation allowing evaluation of climatic characteristics change with regard for gas emission (annual green house gas concentration increase).

Taking into account, that our objective is to build scenarios for the nearest future, we take average emission scenario (IS92a) called "business as usual" and average model sensitivity to gas concentration increase.

Analysis of literature and IEG documentation [14, 15, 17] shows possibility to attract modern outcomes for the territory under consideration within system MAGICC/SCENGEN [17]. SCENGEN data base includes outcomes and permits to obtain changes of climatic characteristics in grids of network 5x5 (for period up to 2100 according to various emission scenarios using so called "simple climatic model" (section 1.1) - Models for green house gas effect and climate changes (MAGICC). MAGICC is widely used by IEG as well as system MAGICC/SCENGEN is permanently upgraded and disseminated within UN Convention. That's why outcomes collected in SCENGEN database are appropriate base for regional scenarios building.

It is necessary to analyze climatic models in SCENGEN database and select appropriate for regional scenarios building. For Central Asia model outcomes with resolution 5x5 using SCENGEN database can be obtained. To compare outcomes with observed climatic trends air temperature and precipitation anomalies were selected for central points of two regions with coordinates (between 40-45^o and 60-65^o; 35-40^o and 65-70^o by 2000 (earliest scenario for 1986-2015) and actual deviations from basic norm for 1991-2000 averaged in network scale 5x5, which are observed climatic trends.

It worth to note good compliance of model assessments and actual anomalies for a year as a whole (Fig. 5).

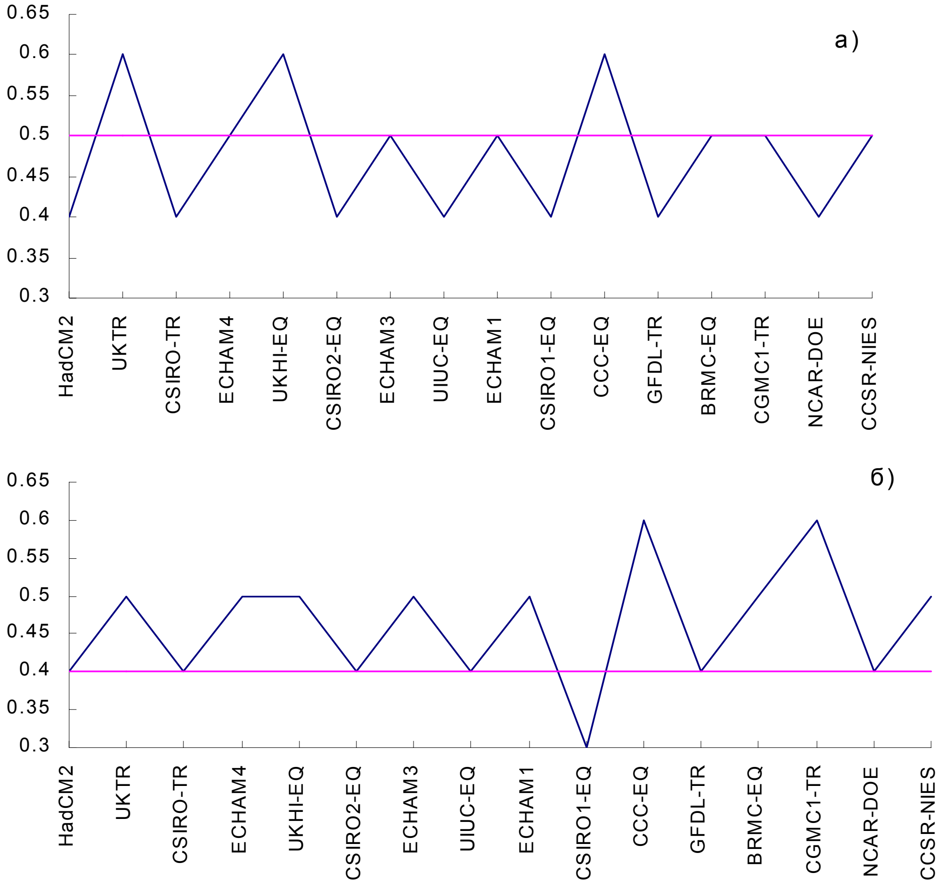
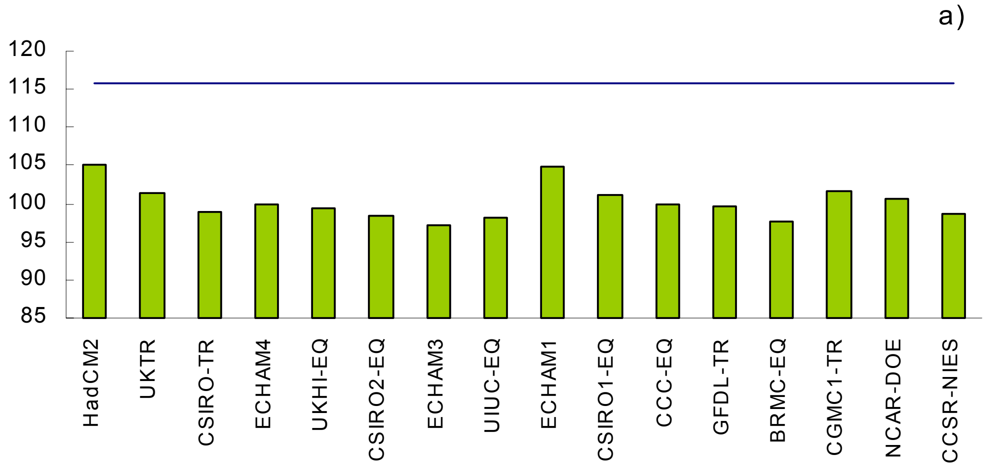


Fig. 5 | Comparison of deviations from basic norm according to various scenarios with actual anomalies of average annual air temperature (^{0}C) for 1991-2000

a - region with coordinates 40-45° latitude and 60-65° longitude
b - region with coordinates 35-40° latitude and 65-70° longitude;
straight line –observed actual values

The same coordination of precipitation scenarios with observed climatic trends is not found due to high spatial and temporal precipitation variability in the region. On Fig. 6 range of probable annual sum of precipitation in percent of 1961-1990 norm over different models under the same conditions for scenario building is shown.



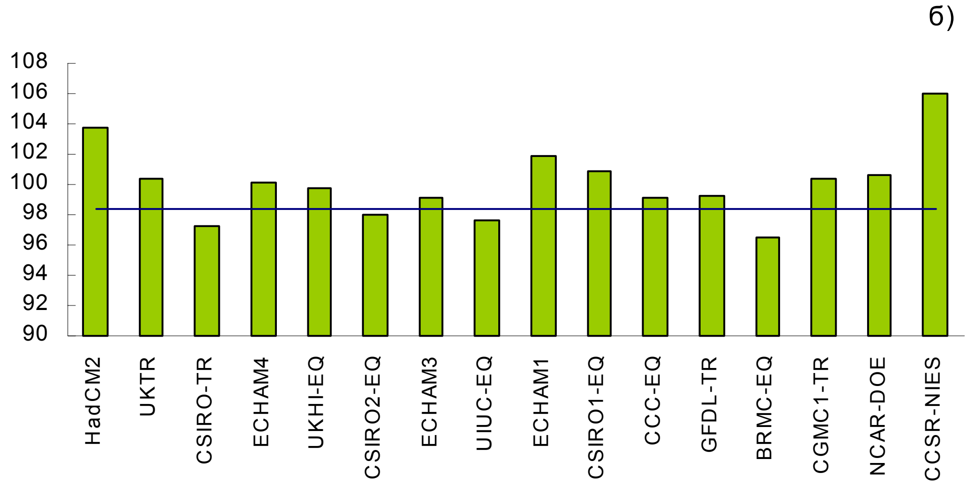


Fig. 6 | Comparison of precipitation sum % from basic norm with average annual temperature for 1991-2000

a - region with coordinates 40-45° latitude and 60-65° longitude
b - region with coordinates 35-40° latitude and 65-70° longitude;
straight line –observed actual values

Analysis of obtained scenarios for the earliest period fro two regions of Uzbekistan and their comparison with observed climatic trends shows that it is difficult to give preference to any model but conclusion can be made: practically all models describe well observed temperature anomalies; calculated precipitation values were lower compared with actual ones.

It is necessary to underline, that strict statistical analysis of precipitation data has been not made. There is high spatial and temporal precipitation variability. That's why statistical meaning of model assessments is lower compared with temperature [14].

Based on IEG documentation [14-17] and analysis results, the following criteria were selected for optimal outcomes:

1. It is necessary to use last available outcomes.

2. It is necessary to use data obtained in state of equilibrium having the same resolution in horizontal direction and level number in the atmosphere and ocean.

3. It is necessary to take into account stratospheric sulfate aerosols effect because according to [11] Central Asia is located within its maximum impact.

Let us consider climate change scenarios in grids of network 5x5 (selected from SCENGEN database by 2020 over 5 models meeting above criteria in points within Uzbekistan and adjacent mountainous area for precipitation (Fig. 7- 9) and air temperature (Fig. 10-12).

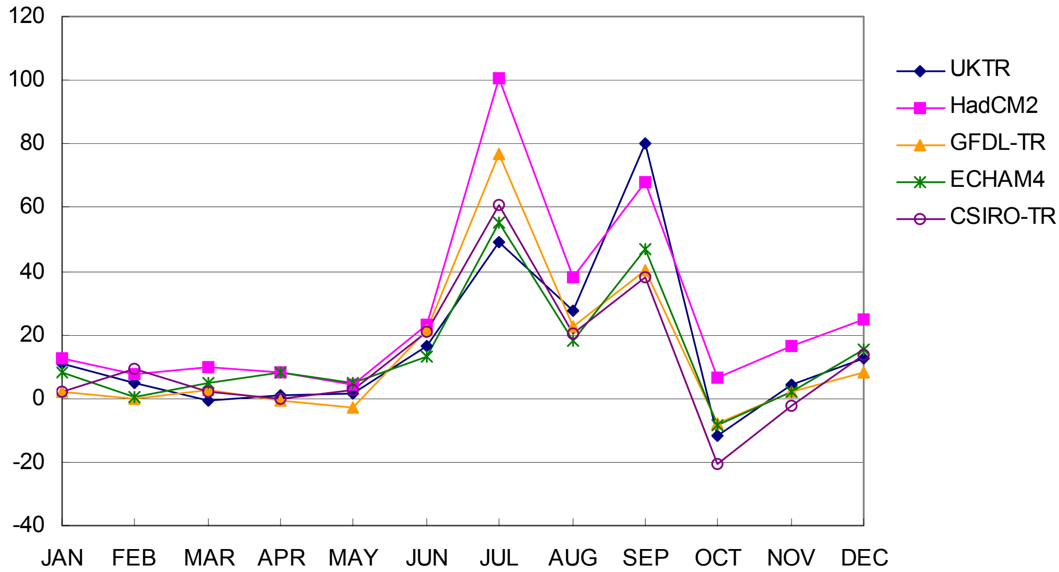


Fig. 7 | Expected monthly sum of precipitation (deviations from basic norm of 1961-1990) by 2020 for the region with coordinates 40-45° and 60-65° (plain)

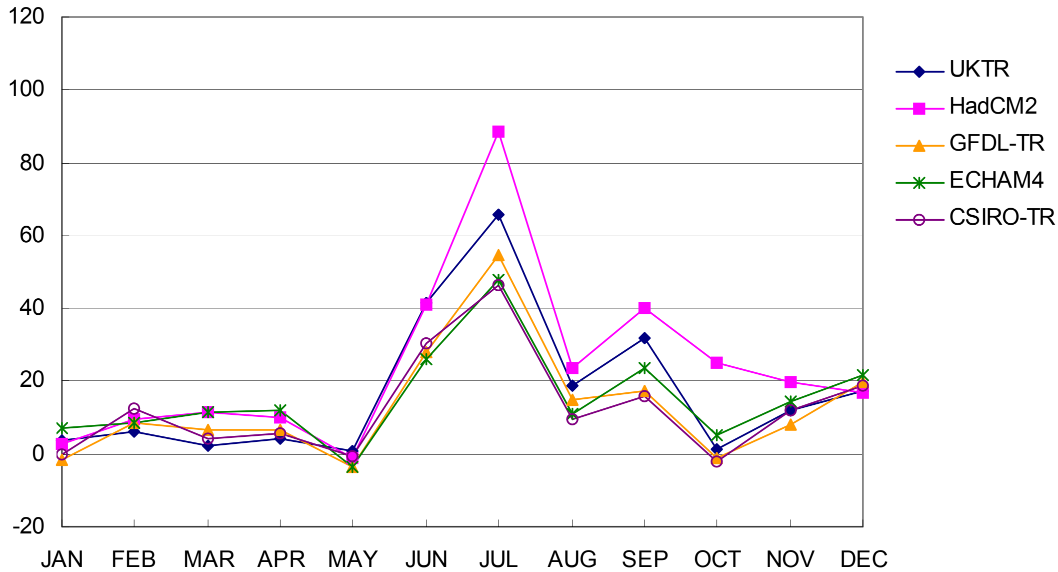


Fig. 8 | Expected monthly sum of precipitation (deviations from basic norm of 1961-1990) by 2020 for the region with coordinates 35-40° and 65-70° (mountains)

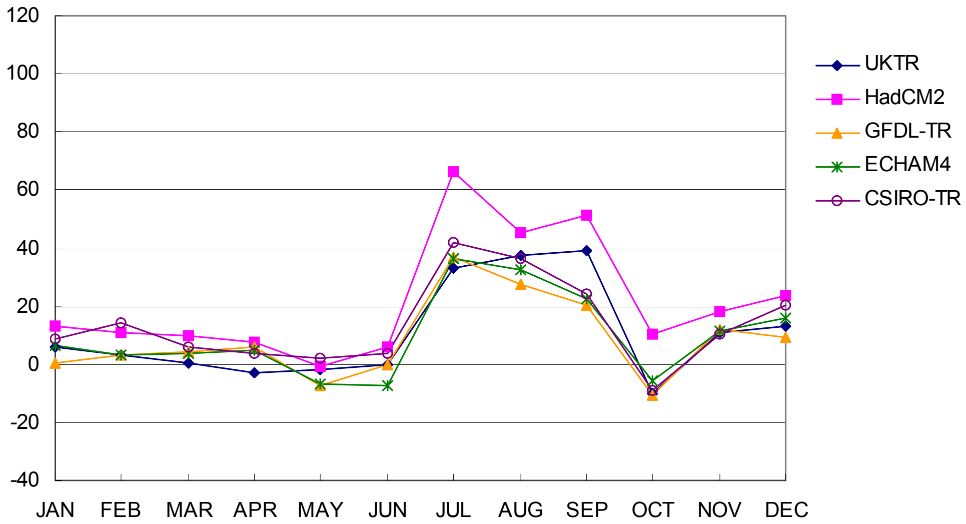


Fig. 9 | Expected monthly sum of precipitation (deviations from basic norm of 1961-1990) by 2020 for the region with coordinates 40-45° and 70-75° (mountains)

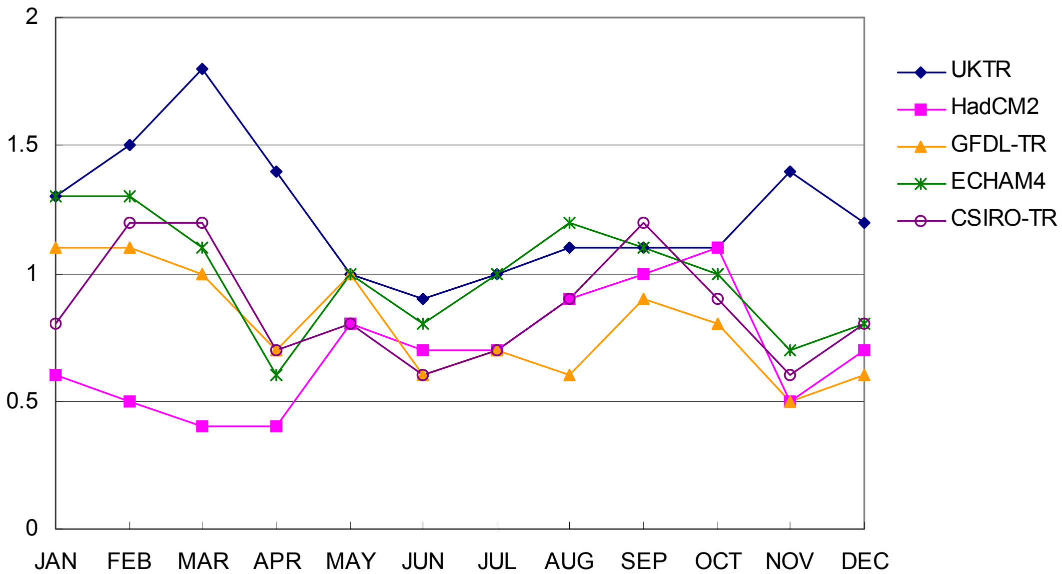


Fig. 10 | Expected average monthly temperature (deviations from basic norm of 1961-1990) by 2020 for the region with coordinates 40-45° and 60-65° (plain)

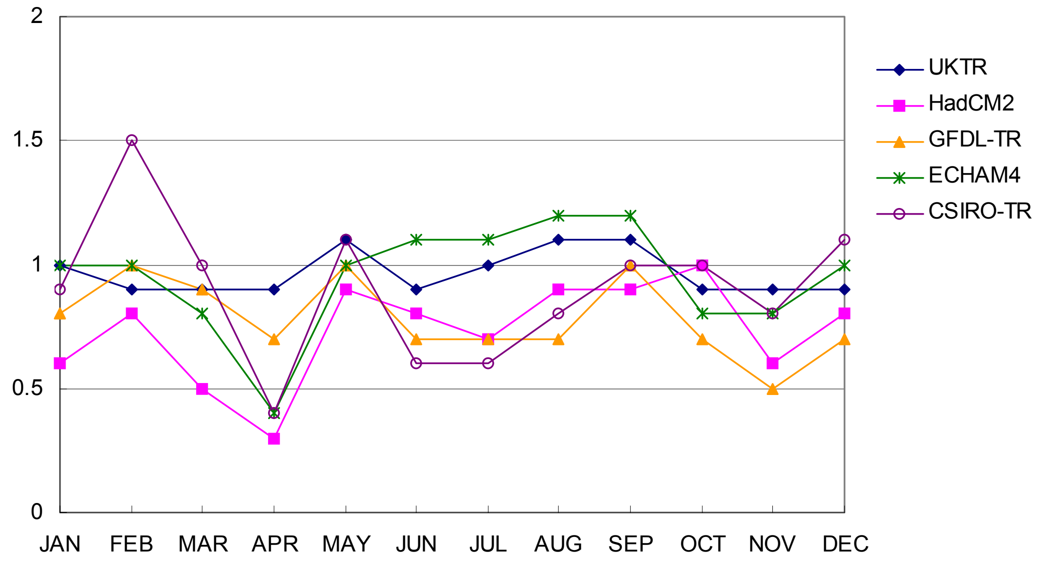


Fig. 11 | Expected average monthly temperature (deviations from basic norm of 1961-1990) by 2020 for the region with coordinates 35-40° and 65-70° (plain)

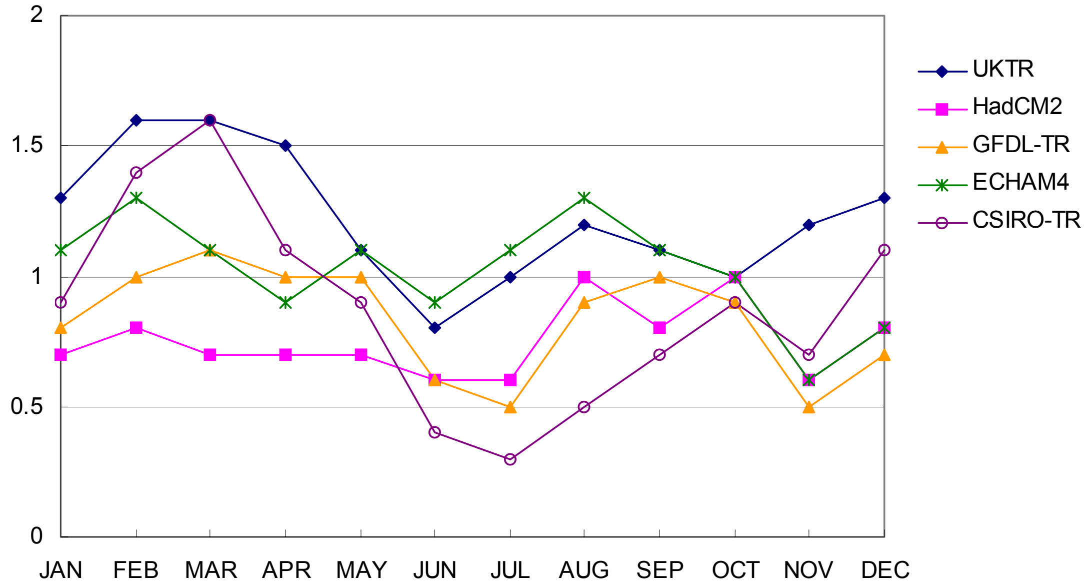


Fig. 12. Expected average monthly temperature (deviations from basic norm of 1961-1990) by 2020 for the region with coordinates 40-45° and 70-75° (plain)

Analysis of graphs shows that all selected MGC give agreed results. Taking into consideration existing uncertainty and necessity to reflect probable range of climatic changes, two models have been selected:

1) HadCM2 (UK, Hadley Centre);

2) ECHAM4 (Germany, Max Planck Institute).

Climatic model ECHAM4 is created based on the model of European Center of Midterm Weather Forecast (ECMWF) and parameterization developed in Hamburg allowing to use this model for climate reproduction and prediction. This model of transition state includes 19 levels in the atmosphere уровней and 11 in the ocean. According to this model data, global warming by 2071-2100 is expected to be 3°C and global precipitation should increase by 1.97% compared with norm of 1961-1990. Besides, softening effect of sulfate aerosols is taken into account.

Climatic model HadCM2 is a version of the model of UK Meteorological Office (UKMO). This is a model of transition state. It includes 19 levels in the atmosphere and 20 in the ocean. In accordance with this model, global temperature increase by 2071-2100 will be 3.1°C and precipitation rise - 5.01% compared with norm of 1961-1990. Softening effect of sulfate aerosols is also taken into account.

2.4. Building scenarios of climate changes in Uzbekistan using method of "ideal forecast" concept's statistical interpretation

Method of MGC outcomes statistical interpretation based on "ideal forecast" concept was used. Main idea of "ideal forecast" is that statistical links are searched from diagnostic data and applied to MGC outcomes. Interpretation quality grows better with model perfection.

Archive of climatic anomalies of monthly resolution in grids of network is used as predictors. They are actual climatic parameters over stations within Uzbekistan and adjacent mountainous area.

Statistical interpretation methodology includes:

- Creation of archive in grids of network based on observation data (anomalies are averaged for vast territory and considered as ideal forecasts of selected MGC); for temperature formula (1) and for precipitation – formula (2) are used.

$$\Delta T_m = \frac{1}{N}\sum_{i=1}^{N}\left(T_i - T_{cp}\right) \qquad (1)$$

$$R_m = \frac{1}{N}\sum_{i=1}^{N}\left(\frac{100R_i}{R_{cp}}\right) \qquad (2)$$

- Building communication equations between averaged anomalies and station data;

- Utilization of built equations for calculation of scenario element over stations using model results in grids as predictors.

Such equations were built for all stations available in archive (Table 12). To build multitude linear regression equation, method of predictors sifting was used. For each station climatic characteristic under consideration field of model outcomes in network grids was a vector-predictor.

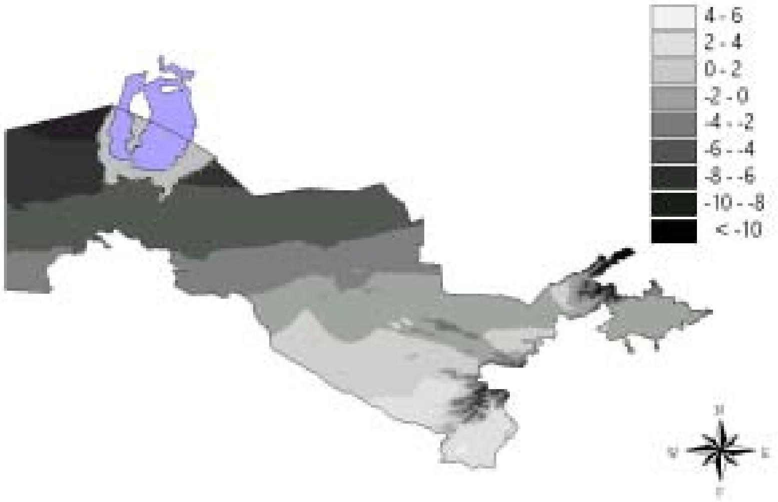
Table 12 | List of basic stations

Uzbekistan			Kyrgyzstan and Tajikistan	
1. Zhaslik	18. Bukhara	35.Yangier	1.Karaкujur	10.Kulyab
2.Karakalpakia	19. Karakul	36.Tashkent	2.Krasny Oktyabr	11.Kurgan-Tyube
3.Chimbai	20. Ayakagitma	37.Tuyabuguz	3.Naryn	12.Khudjant
4.Kungrad	21.Karshi	38.Коkaral	4.Saritash	13.Gorbunov
5.Nukus	22.Guzar	39.Kaunchi	5.Talas	14.Khorog
6.Muinak	23.Dehkanabad	40.Dalverzin	6.Bishkek	
7.Urgench	24.Shahrisyabz	41.Syrdarya	7.Khaidarkan	
8.Khiva	25.Shurchi	42.Pskem	8.Cholpon-Ata	
9. Akbaital	26.Sherabad	43.Dukant	9.Chatkal	
10. Тамды	27.Байсун	44.Oigaing		
11. Buzaubai	28.Denau	45.Коkand		
12.Mashikuduk	29.Termez	46.Feghana		
13. Jingeldi	30.Mingchukur	47.Fedchenko		
14. Samarkand	31.Jizak	48.Andizhan		
15. Kattakurgan	32.Gallyaaral	49.Namangan		
16. Navoy	33.Bogarnoye	50.Pap		
17. Nurata	34.Sanzar			

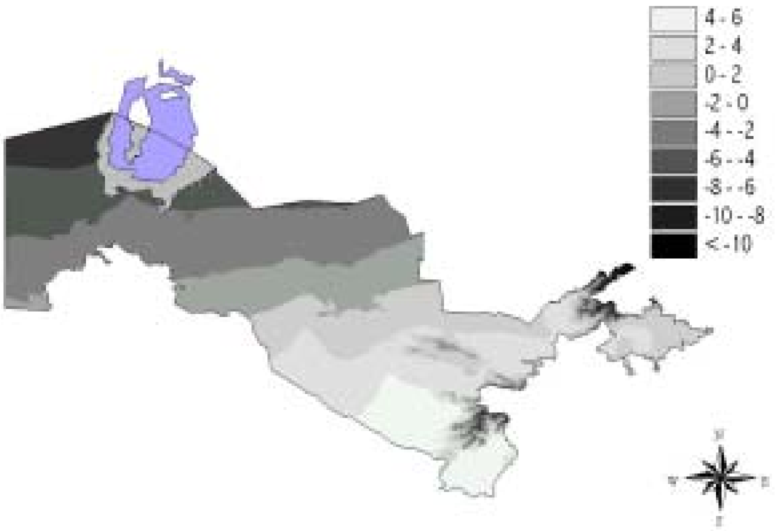
Given methodology allowed to obtain detailed over area scenarios and take into consideration regional peculiarities.

Below, as calculations illustration (Fig. 13) modern basic January norms of average monthly air temperature and its change by 2050 according to scenario IS92a and sulfate aerosols effect (statistical interpretation of model CHAM4 outcomes) are presented. On Fig. 13 temperature gradations shift to the north and new gradation (4-6^{o}C) in southern regions of Uzbekistan appearance in case of selected scenario realization are shown.

Average monthly air temperatures over selected models (HadCM2 and ECHAM4) in anomalies and monthly sums of precipitation in percent of 1961-1990 norm are presented.



(a)



(b)

Fig. 13 | Modern basic norm of average monthly air temperature in January (a) and its expected value by 2050 (b) in accordance with emission scenario IS92a and taking into account sulfate aerosol effect (statistical interpretation of ECHAM4 model outcomes)

Scenarios building for the nearest perspective has been made in accordance with average emission scenario (IS92a) and average model sensitivity to GHG concentration increase in the atmosphere. Calculated values are presented by 30-year average annual values by 2020, e.g. averaged diapason covers period of 2006-2035. Methodology of statistical interpretation allowed to calculate expected changes for 50 stations of Uzbekistan (Tables 13-16) and some stations of adjacent area (Tables 17-20).

Table 13 | Change of average monthly air temperature according to model ECHAM4 by 2020 (deviation from basic norm, 50 stations in Uzbekistan)

Station number	Months											
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
1	1.6	1.5	0.9	0.4	0.9	0.4	0.8	1.2	1.0	0.6	0.4	0.4
2	1.5	1.5	0.6	0.4	1.0	0.4	0.8	0.9	1.0	0.7	0.4	0.4
3	1.5	1.4	0.8	0.5	0.9	0.4	0.6	0.8	1.0	0.9	0.4	0.4
4	1.4	1.5	0.7	0.3	0.7	0.4	0.5	1.0	0.9	0.7	0.4	0.4
5	1.4	1.4	0.7	0.4	0.7	0.4	0.9	0.9	1.2	1.0	0.4	0.4
6	1.4	1.3	1.1	0.3	1.0	0.4	0.5	0.8	1.1	1.1	0.4	0.6
7	1.5	1.7	0.6	0.5	0.9	0.4	0.9	1.1	1.0	0.9	0.4	0.4
8	1.5	1.5	0.6	0.6	0.9	0.5	0.8	1.1	1.2	0.8	0.4	0.5
9	1.6	2.0	0.9	0.6	1.1	0.6	0.6	1.5	1.3	0.9	0.4	0.7
10	1.4	1.9	0.6	0.5	1.0	0.7	1.1	1.2	1.1	0.9	0.4	0.8
11	1.7	1.9	0.6	0.5	1.1	0.7	1.2	1.3	1.2	1.0	0.4	0.5
12	1.6	2.0	0.6	0.4	1.3	0.9	1.1	1.3	1.6	0.9	0.4	0.7
13	1.6	2.0	0.6	0.6	1.1	0.9	1.4	1.5	1.5	1.0	0.4	0.7
14	1.6	1.7	0.6	0.4	0.8	0.5	0.7	1.0	1.2	1.0	0.4	0.8
15	1.5	1.8	0.6	0.4	1.0	0.7	0.9	1.1	0.9	1.0	0.4	0.8
16	1.8	1.6	0.6	0.5	0.9	0.7	1.1	1.0	1.0	0.9	0.4	0.7
17	1.7	1.9	0.8	0.4	1.1	1.1	0.9	1.1	1.2	0.9	0.4	0.9
18	1.6	1.6	0.7	0.6	0.7	0.6	0.8	0.9	0.7	0.8	0.4	0.8
19	1.5	1.7	0.6	0.5	1.0	0.7	1.4	1.6	1.2	0.7	0.4	0.8
20	1.6	1.9	0.6	0.5	1.5	1.0	1.1	1.3	1.5	1.1	0.4	0.9
21	1.5	1.5	0.5	0.2	1.0	0.6	1.2	1.6	1.5	1.0	0.6	0.8
22	1.3	1.4	0.7	0.2	1.2	0.9	0.8	1.0	1.3	1.1	0.6	0.9
23	1.4	1.4	0.5	0.4	0.9	1.0	0.9	1.2	1.4	0.9	0.6	1.0
24	1.4	1.5	0.6	0.3	0.9	1.0	1.0	1.3	1.3	0.9	0.5	0.8
25	1.2	1.4	0.8	0.4	0.8	0.8	0.7	1.0	0.6	0.8	0.4	0.9
26	1.1	1.2	0.6	0.3	1.0	1.0	0.8	1.0	1.2	0.7	0.6	0.9
27	1.4	1.4	0.8	0.3	1.0	0.9	1.4	1.1	1.4	1.0	0.6	1.0
28	1.1	1.4	0.5	0.3	0.8	0.9	0.8	1.0	0.8	0.5	0.4	0.8
29	1.1	1.3	0.6	0.3	0.8	0.9	1.0	1.5	1.5	0.5	0.6	0.8
30	0.9	1.3	0.8	0.4	1.3	1.3	1.7	1.7	1.8	1.2	0.5	0.8
31	1.6	1.9	0.6	0.6	1.1	0.6	1.2	1.0	1.1	1.1	0.5	0.9
32	1.7	1.9	0.6	0.5	1.1	0.5	1.0	1.1	1.2	0.9	0.5	0.8
33	1.7	1.8	0.6	0.5	0.7	0.9	0.8	1.1	1.1	0.7	0.3	0.6
34	1.6	1.9	0.7	0.6	1.0	0.9	0.9	1.2	1.2	1.1	0.5	0.9
35	1.5	1.9	0.7	0.5	0.7	1.1	1.2	1.3	1.4	1.3	0.4	0.6
36	1.6	1.7	0.6	0.5	1.0	0.7	0.7	1.1	0.9	0.8	0.6	0.7
37	1.7	2.0	0.6	0.5	0.8	0.5	0.6	0.9	0.6	0.7	0.3	0.7
38	1.7	2.0	0.6	0.5	1.1	0.5	0.7	1.0	0.8	0.8	0.5	0.7
39	1.7	1.9	0.6	0.5	0.9	0.7	0.7	0.7	0.8	0.7	0.5	0.9
40	1.7	2.0	0.6	0.5	1.0	0.6	0.6	1.0	0.6	0.5	0.5	0.9
41	1.7	2.0	0.6	0.5	1.0	0.5	0.6	0.8	0.8	0.6	0.4	0.8
42	1.2	1.4	0.7	0.6	0.9	0.9	1.4	1.4	1.4	1.2	0.4	0.7
43	1.1	1.3	0.8	0.6	0.9	1.2	1.3	1.3	1.7	1.4	0.9	0.6
44	0.9	1.3	0.8	0.9	1.4	1.0	1.5	1.4	1.6	0.8	0.4	0.7
45	1.4	1.8	0.6	0.6	0.8	0.7	1.0	1.1	0.7	0.7	0.3	0.9
46	1.4	1.6	0.6	0.5	0.8	0.6	0.7	0.7	0.7	0.7	0.3	0.8
47	1.6	1.8	0.6	0.6	0.7	0.8	0.6	0.7	0.9	0.7	0.3	0.7
48	1.5	1.6	0.7	0.5	1.1	0.8	0.8	1.0	0.8	0.9	0.3	0.5
49	1.5	1.8	0.7	0.6	0.8	0.8	0.6	1.0	0.9	0.9	0.5	0.5
50	1.5	1.6	0.7	0.6	0.8	0.6	0.7	0.9	1.0	0.9	0.5	0.8

Table 14 | Change of average monthly air temperature according to model HadCM2 by 2020 (deviation from basic norm, 50 stations in Uzbekistan)

Station number	Months											
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
1	0.7	0.6	0.2	0.2	0.6	0.4	0.4	0.9	0.9	0.8	0.3	0.4
2	0.6	0.4	0.2	0.2	0.7	0.4	0.4	0.7	0.9	0.8	0.3	0.4
3	0.7	0.6	0.2	0.2	0.7	0.4	0.4	0.6	0.8	1.0	0.3	0.4
4	0.6	0.7	0.2	0.2	0.5	0.4	0.4	0.7	0.8	0.8	0.3	0.4
5	0.6	0.6	0.2	0.2	0.5	0.4	0.5	0.6	1.0	1.1	0.3	0.4
6	0.6	0.5	0.3	0.2	0.7	0.4	0.4	0.6	0.8	1.2	0.3	0.4
7	0.8	0.8	0.2	0.3	0.6	0.4	0.6	0.9	0.9	1.1	0.3	0.4
8	0.8	0.8	0.2	0.4	0.8	0.4	0.5	0.9	1.0	1.0	0.3	0.4
9	0.8	0.8	0.2	0.4	0.8	0.5	0.4	1.1	1.0	1.1	0.3	0.5
10	0.7	0.8	0.2	0.3	0.7	0.6	0.7	0.9	1.0	1.0	0.3	0.6
11	0.9	0.8	0.2	0.4	0.9	0.6	0.8	0.9	1.0	1.1	0.3	0.4
12	0.9	0.8	0.2	0.2	1.0	0.7	0.6	0.9	1.3	1.0	0.3	0.6
13	0.9	0.8	0.2	0.4	0.9	0.7	0.9	1.1	1.3	1.1	0.3	0.6
14	0.9	0.8	0.2	0.3	0.6	0.4	0.4	0.8	0.9	1.1	0.3	0.6
15	0.9	0.8	0.2	0.3	0.8	0.5	0.6	0.8	0.6	1.1	0.3	0.6
16	0.9	0.8	0.2	0.3	0.7	0.6	0.6	0.8	0.8	1.1	0.3	0.6
17	0.9	0.8	0.3	0.3	0.9	0.8	0.5	0.8	0.9	1.0	0.3	0.8
18	0.9	0.8	0.2	0.4	0.6	0.4	0.5	0.6	0.6	0.9	0.3	0.7
19	0.9	0.8	0.2	0.4	0.8	0.6	1.0	1.2	0.9	0.8	0.3	0.7
20	0.9	0.8	0.2	0.4	1.2	0.7	0.7	1.0	1.2	1.3	0.3	0.7
21	0.9	1.1	0.3	0.2	0.9	0.5	0.7	1.2	1.2	1.1	0.4	0.7
22	0.8	1.0	0.3	0.2	1.1	0.7	0.5	0.7	1.0	1.3	0.3	0.7
23	0.9	1.1	0.3	0.3	0.8	0.7	0.5	0.9	1.0	1.0	0.3	0.8
24	0.9	1.1	0.3	0.2	0.8	0.7	0.5	0.9	1.0	1.0	0.3	0.7
25	0.8	1.1	0.5	0.3	0.7	0.5	0.4	0.8	0.5	0.9	0.3	0.7
26	0.7	1.0	0.3	0.2	1.0	0.7	0.6	0.8	0.9	0.9	0.4	0.7
27	0.9	1.1	0.4	0.2	0.9	0.6	0.9	0.8	1.2	1.3	0.5	0.8
28	0.7	1.1	0.3	0.2	0.7	0.6	0.5	0.7	0.6	0.7	0.3	0.6
29	0.7	1.1	0.3	0.2	0.7	0.7	0.7	1.2	1.2	0.8	0.4	0.6
30	0.6	1.1	0.5	0.3	1.1	0.9	1.0	1.3	1.3	1.4	0.4	0.7
31	1.0	1.2	0.4	0.5	0.9	0.5	0.9	0.9	0.9	1.2	0.3	0.8
32	1.1	1.2	0.4	0.4	0.7	0.3	0.7	0.9	1.0	1.0	0.3	0.7
33	1.1	1.2	0.4	0.4	0.5	0.6	0.5	0.9	0.9	0.8	0.3	0.6
34	1.0	1.2	0.4	0.4	0.8	0.7	0.5	0.9	0.9	1.2	0.3	0.8
35	1.0	1.2	0.4	0.4	0.5	0.8	0.7	1.0	1.1	1.4	0.3	0.6
36	1.0	1.1	0.4	0.4	0.6	0.5	0.3	0.8	0.7	0.9	0.3	0.6
37	1.0	1.2	0.4	0.4	0.5	0.3	0.3	0.6	0.4	0.9	0.3	0.6
38	1.1	1.2	0.4	0.4	0.8	0.3	0.6	0.9	0.7	0.8	0.3	0.6
39	1.0	1.2	0.4	0.4	0.6	0.5	0.5	0.5	0.7	0.8	0.3	0.8
40	1.1	1.2	0.4	0.4	0.8	0.4	0.4	0.7	0.4	0.7	0.3	0.8
41	1.1	1.2	0.4	0.4	0.7	0.4	0.3	0.6	0.6	0.7	0.3	0.7
42	0.8	0.9	0.4	0.4	0.6	0.6	0.8	1.0	1.1	1.2	0.3	0.7
43	0.7	1.1	0.4	0.5	0.6	0.8	0.7	1.0	1.2	1.5	0.7	0.6
44	0.6	0.9	0.5	0.7	1.0	0.5	0.9	1.1	1.2	0.7	0.3	0.6
45	0.9	1.1	0.4	0.4	0.5	0.4	0.5	0.9	0.6	0.7	0.3	0.8
46	0.9	0.9	0.4	0.4	0.5	0.4	0.4	0.5	0.6	0.8	0.3	0.7
47	1.0	1.1	0.4	0.5	0.4	0.5	0.3	0.5	0.8	0.8	0.3	0.7
48	1.0	0.9	0.4	0.4	0.8	0.5	0.5	0.7	0.6	1.1	0.3	0.5
49	1.0	1.1	0.4	0.5	0.6	0.5	0.3	0.7	0.7	0.9	0.4	0.5
50	0.9	0.9	0.4	0.5	0.5	0.4	0.4	0.7	0.7	1.0	0.4	0.7

Table 15 | Change of precipitation on model ECHAM4 by 2020 (ratio to basic norm %, 50 stations in Uzbekistan)

Station number	Months											
	1	2	3	4	5	6	7	8	9	10	11	12
1	116	128	92	99	100	125	162	117	128	95	85	108
2	108	109	92	103	105	111	131	144	125	119	96	107
3	93	104	98	87	101	126	116	105	133	92	80	97
4	105	112	99	88	101	128	137	93	186	96	87	114
5	97	111	109	92	101	118	136	100	147	91	83	98
6	97	119	89	84	99	115	135	61	116	90	88	106
7	115	124	112	101	106	151	184	100	122	80	104	116
8	114	122	121	100	111	176	158	92	123	83	108	107
9	114	106	115	95	93	125	113	174	112	89	93	114
10	108	99	120	108	105	159	152	100	103	98	111	127
11	106	111	119	102	93	87	128	100	127	80	95	107
12	112	106	115	112	106	130	95	100	106	93	100	124
13	115	109	113	105	101	149	144	100	107	95	101	129
14	102	123	114	112	95	153	141	100	117	94	121	117
15	107	124	121	118	102	151	108	100	121	97	119	127
16	104	111	111	122	104	204	128	100	100	97	109	128
17	105	111	122	116	103	130	137	100	143	95	117	129
18	108	113	115	117	109	100	120	100	100	91	105	132
19	103	111	112	118	105	140	100	100	100	97	103	133
20	109	112	118	113	95	221	103	130	100	102	102	118
21	109	120	120	126	104	102	100	100	91	91	126	120
22	106	114	116	114	93	144	100	100	112	90	129	118
23	104	121	115	113	104	109	100	100	100	96	130	117
24	106	117	120	115	100	147	128	100	110	94	125	118
25	101	113	112	115	115	100	100	100	100	100	121	130
26	104	118	115	109	102	100	100	100	100	99	134	125
27	105	115	117	115	105	177	103	93	104	100	131	117
28	103	116	115	120	108	223	100	100	100	97	120	124
29	102	109	107	106	102	100	100	100	100	100	129	129
30	106	113	110	108	107	131	105	100	97	89	124	117
31	105	115	117	106	93	122	156	129	117	95	130	124
32	102	109	122	108	92	147	141	123	126	94	134	116
33	94	100	109	108	85	87	106	120	91	98	113	100
34	101	115	121	110	93	135	166	102	137	99	125	116
35	103	114	112	106	96	96	130	114	99	92	128	112
36	103	106	123	105	92	142	196	192	121	90	117	114
37	103	112	117	106	90	190	166	100	107	91	128	126
38	102	112	115	106	85	94	128	100	111	91	127	130
39	104	110	118	105	93	128	178	100	130	90	121	122
40	102	111	115	106	91	76	153	118	114	94	126	122
41	103	114	121	109	95	88	144	100	102	91	122	125
42	105	107	116	104	93	101	138	134	117	90	109	114
43	103	109	114	107	92	120	138	160	119	90	120	122
44	103	108	117	104	92	99	143	140	108	91	122	117
45	118	123	117	107	84	115	141	109	110	86	134	132
46	113	110	108	102	87	100	136	121	98	95	147	131
47	111	114	114	106	91	109	127	168	94	93	146	127
48	112	115	117	106	94	110	158	166	104	95	149	131
49	115	123	115	107	92	120	135	134	158	93	143	135
50	114	121	111	107	86	108	136	115	146	87	141	131

Table 16 | Change of precipitation on model HadCM2 by 2020 (ratio to basic norm %, stations in Uzbekistan)

Station number	Months											
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
1	118	96	103	102	131	185	148	124	94	89	104	118
2	116	95	108	105	110	154	152	125	117	99	103	116
3	111	105	88	103	130	164	123	138	96	91	106	111
4	118	107	91	102	136	167	128	185	102	96	116	118
5	118	117	93	99	126	171	120	153	98	95	106	118
6	118	94	86	104	121	143	102	124	89	96	105	118
7	118	119	101	105	136	220	100	140	92	122	125	118
8	118	121	101	113	136	217	136	143	97	125	118	118
9	112	118	96	91	136	135	152	127	103	105	121	112
10	102	121	108	107	136	188	100	122	114	124	130	102
11	118	121	100	92	92	165	100	151	97	107	115	118
12	108	117	108	111	134	122	100	142	107	108	124	108
13	118	120	102	100	136	188	100	127	114	109	132	118
14	118	118	111	98	136	189	100	143	112	128	117	118
15	118	121	116	103	136	137	100	141	116	126	126	118
16	112	112	118	104	136	220	100	100	115	116	124	112
17	115	121	112	103	136	195	100	177	113	123	128	115
18	118	116	113	114	100	145	100	100	106	111	127	118
19	115	114	113	105	136	100	100	100	111	110	131	115
20	116	121	109	95	136	119	152	100	115	110	116	116
21	121	120	121	105	98	100	100	100	104	131	118	121
22	115	118	111	95	138	100	100	134	103	131	117	115
23	121	115	110	106	114	100	100	100	111	131	116	121
24	120	123	112	103	155	171	100	130	107	131	118	120
25	113	111	116	109	100	100	100	100	120	126	122	113
26	120	113	108	109	100	100	100	100	120	131	116	120
27	116	117	113	107	155	121	83	119	115	131	113	116
28	117	114	120	109	155	100	100	100	118	126	118	117
29	110	107	105	106	100	100	100	100	125	131	121	110
30	114	113	107	109	144	167	100	112	105	130	117	114
31	121	121	107	100	116	183	129	153	115	130	129	121
32	116	121	107	100	116	183	141	143	115	130	120	116
33	99	113	107	92	89	133	126	89	106	110	94	99
34	116	121	108	96	116	183	129	149	119	130	120	116
35	119	116	107	99	112	179	120	123	109	130	117	119
36	115	121	107	97	116	183	160	149	107	123	122	115
37	118	121	108	97	116	183	100	134	109	130	131	118
38	119	120	107	92	106	183	100	137	109	130	134	119
39	117	121	106	101	116	183	100	156	108	128	126	117
40	116	121	108	97	88	183	140	145	114	130	127	116
41	120	121	109	104	104	183	100	126	108	129	129	120
42	115	121	108	99	116	158	145	146	102	114	121	115
43	117	121	110	97	116	168	160	149	105	127	129	117
44	117	121	108	97	115	171	150	130	105	130	125	117
45	122	119	112	91	116	153	121	138	109	130	136	122
46	112	111	107	94	116	167	139	123	119	130	134	112
47	118	119	110	100	116	148	160	115	118	130	131	118
48	122	121	110	103	116	183	160	130	121	130	135	122
49	122	121	110	97	116	155	160	167	117	130	136	122
50	122	117	110	94	116	166	125	167	110	130	136	122

For summer months and stations where precipitation is practically not available link equations could not be built. Because of that, expected within scenario values have not been changed and correspond to basic norm 1961-1990 100%).

Table 17 | Changes of average monthly air temperature on model ECHAM4 by 2020 (deviations from basic norm, stations of Tajikistan and Kyrgyzstan)

Station number	Months											
	1	2	3	4	5	6	7	8	9	10	11	12
1	0.9	1.0	0.9	0.6	0.9	0.7	1.0	0.8	1.1	1.1	0.8	0.8
2	0.7	0.7	0.6	0.5	0.7	0.6	0.8	0.9	0.6	0.8	0.7	1.0
3	1.5	1.8	0.9	0.6	1.1	1.1	0.9	0.8	0.8	1.0	0.9	0.9
4	0.8	0.9	0.9	1.0	0.7	1.1	1.0	1.1	1.2	1.2	0.9	0.8
5	1.2	1.8	1.0	0.6	1.3	1.0	0.9	1.2	0.7	1.0	0.9	1.0
6	1.5	1.4	1.0	0.6	1.4	1.3	1.0	1.0	1.3	0.9	0.9	1.2
7	1.1	1.2	1.0	0.6	0.9	1.3	1.3	1.3	1.3	1.1	0.7	1.0
8	0.9	0.7	0.6	0.5	0.9	0.6	0.6	0.7	0.6	0.7	0.5	0.7
9	0.9	1.3	1.7	1.4	0.9	1.0	1.4	1.5	1.2	0.9	0.9	0.9
10	1.0	1.2	0.8	0.4	1.1	1.2	0.7	0.9	1.1	0.8	0.7	1.0
11	1.2	1.0	0.8	0.4	1.1	0.9	0.6	0.8	0.6	0.6	0.7	0.8
12	1.3	1.5	0.9	0.6	1.3	0.9	0.8	0.8	1.0	0.7	0.7	1.1
13	0.8	0.8	0.6	0.5	0.9	1.1	1.1	1.3	1.4	1.0	0.8	0.6
14	1.4	1.5	1.2	0.6	1.2	1.1	1.2	1.0	1.0	0.9	0.8	1.4

Table 18 | Changes of average monthly air temperature on model HadCM2 by 2020 (deviations from basic norm, stations of Tajikistan and Kyrgyzstan)

Station number	Months											
	1	2	3	4	5	6	7	8	9	10	11	12
1	0.5	0.7	0.6	0.4	0.5	0.5	0.6	0.6	0.7	1.0	0.7	0.7
2	0.4	0.4	0.4	0.4	0.4	0.4	0.5	0.7	0.4	0.9	0.5	0.8
3	1.0	0.6	0.6	0.6	0.6	0.6	0.6	0.7	0.5	1.1	0.4	1.0
4	0.6	0.7	0.7	0.7	0.4	0.7	0.6	0.8	0.8	1.1	0.9	0.6
5	0.7	1.0	0.6	0.4	0.9	0.7	0.5	0.8	0.6	1.1	0.8	1.0
6	0.8	0.7	0.5	0.5	1.0	0.9	0.6	0.8	1.0	0.9	0.8	1.2
7	0.7	0.9	0.7	0.5	0.6	0.9	0.7	1.0	0.9	1.2	0.6	0.9
8	0.6	0.4	0.4	0.4	0.6	0.5	0.3	0.5	0.4	0.7	0.5	0.6
9	0.6	0.8	1.0	1.1	0.5	0.7	0.9	1.1	0.9	0.9	0.9	1.0
10	0.6	1.0	0.5	0.3	0.9	0.8	0.4	0.7	0.7	0.9	0.5	0.8
11	0.7	0.8	0.5	0.3	0.9	0.6	0.4	0.6	0.5	0.8	0.5	0.6
12	0.7	0.9	0.5	0.5	0.9	0.6	0.4	0.6	0.8	0.8	0.6	1.0
13	0.5	0.6	0.4	0.3	0.5	0.7	0.6	0.9	0.8	0.9	0.7	0.5
14	0.7	0.9	0.8	0.5	0.8	0.5	0.7	0.7	0.7	0.8	0.7	0.9

Table 19 | Changes of precipitation on model ECHAM4 by 2020 (deviations from basic norm, stations of Tajikistan and Kyrgyzstan)

Station number	Months											
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
1	110	105	109	105	100	103	106	107	111	99	104	105
2	106	95	102	103	103	104	105	103	102	100	102	101
3	110	109	108	105	99	96	117	110	118	107	109	107
4	107	106	104	102	98	105	112	110	103	102	108	121
5	107	97	101	106	93	97	121	123	119	97	106	111
6	104	98	104	103	94	93	118	110	119	97	102	103
7	105	102	109	103	95	94	127	126	118	96	111	116
8	106	101	100	104	102	102	101	107	108	103	103	128
9	105	105	105	101	95	89	131	124	121	94	108	115
10	105	108	109	109	94	110	125	100	132	103	111	116
11	106	110	112	108	94	142	100	100	100	103	113	118
12	107	104	110	100	99	83	135	123	124	95	109	117
13	105	103	104	105	99	110	121	109	106	96	108	116
14	109	109	114	103	92	122	157	100	112	101	119	119

Table 20 | Changes of average monthly air temperature on model HadCM2 by 2020 (deviations from basic norm, stations of Tajikistan and Kyrgyzstan)

Station number	Months											
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
1	109	110	105	99	105	112	110	116	104	106	112	109
2	105	108	105	102	107	111	108	108	104	103	110	105
3	112	111	107	100	101	132	115	128	118	112	114	112
4	107	106	105	98	111	125	115	108	112	112	118	107
5	107	104	107	99	108	169	136	141	108	110	121	107
6	104	108	105	99	100	155	115	134	108	105	113	104
7	107	112	106	100	108	159	136	136	110	115	120	107
8	106	103	103	100	103	105	111	119	116	110	133	106
9	114	113	106	100	96	149	134	146	111	114	126	114
10	109	109	107	98	130	166	100	154	120	114	110	109
11	110	110	107	99	155	100	100	100	124	115	108	110
12	108	112	104	100	102	163	136	154	113	114	121	108
13	107	107	107	100	118	137	111	119	111	111	116	107
14	111	116	106	100	140	196	100	142	130	123	115	111

Thus, let us underline once more that task assigned in this work is to build regional climatic scenarios for the nearest future (by 2025). Described in sub-section 2.2 models data in equilibrium allow receive assessments of temperature and precipitation changes for hypothetical moment of CO_2 concentration doubling in atmosphereв ($2xCO_2$), but we can't use it for scenario. For this purpose models of transition state are needed. Those are more developed models of general atmosphere and ocean circulation. They can serve for receiving climatic characteristics according to set scenario (assuming annual growth of green house gas concentration)

Taking into account, that our objective is scenarios building for nearest future, let us take average scenario of emission (IS92a) or "business as usual" scenario and average model sensitivity to green house gas concentration growth.

Analysis of different sources and IEG documents [14, 15, 17] shows possibility to use modern IAC outcomes for territory under consideration. We used system MAGICC/SCENGEN [17]. MAGICC is widely used by IAC and system MAGICC/SCENGEN is permanently upgraded and circulated within Program of National Message Support of UN Framework Convention. That's why IAC outcomes collected in SCENGEN database are the most appropriate base for regional scenarios building.

Taking into account existing uncertainty and necessity to reflect all range of changes when building regional scenarios, we have select for base two models:

1) HadCM2 (UK, Hadley Centre);

2) ECHAM4 (Germany, Max Planck Institute).

Climatic model ECHAM4 is created on base of the Model of European Centre of midterm forecast (ECMWF) and parametrization developed in Hamburg allowing use this model for climate prediction.

This is model of transition state. It includes 19 levels in the atmosphere and 11 in the ocean. According to this model, global warming on 3C ^{o} and global precipitation growth on 1.97% are expected by 2071-2100 compared with norm (1961-1990). In this option impact of sulfate aerosol is taken into account.

Climatic model HadCM2 is a version of UK Meteorological Office (UKMO)). This is model of transition state. It includes 19 levels in the atmosphere and 20 in the ocean. According to this model, global temperature increase will be 3.1C^{o} and precipitation growth will be 5.01% compared with norm (1961-1990). In this option impact of sulfate aerosol is also taken into account.

Using global models for assessment of the regional climatic changes it is necessary to take into account geographical peculiarities of the regions (relief, water bodies, ground surface, etc.). For this «downscaling» methodology is used (outcomes interpretation in network grids), by which climatic characteristics are transformed to necessary meteorological parameters with needed spatial and temporal resolution.

Scenarios building for nearest future is performed according to average scenario of emission (IS92a) and average sensitivity to green house gas concentration growth. Calculated values present 30-year average values by 2020 (within 2006-2035). Methodology of statistical interpretation based on concept of "ideal forecast" allowed calculate expected changes for 50 stations in Uzbekistan and some stations in adjacent mountains.

Tajikistan and Kyrgyzstan, which are recommended for further calculations.