PEER PROJECT

Transboundary water management adaptation in the Amudarya basin to climate change uncertainties

Report

1.3.Data collection and analysis (climate, water and land resources, etc.)

1.3.1 Assessment of climatic scenarios

a) Analysis of REMO climate model (2000 - 2050)

Project coordinator Prof. V.A.Dukhovniy

Responsible for 1.3.1 A.G.Sorokin

Responsible for 1.3.1.a G.Solodkiy

Tashkent 2016

1. Research objective

Collection and analysis of data is a preparatory step for the main task position 2.3 “**Modeling crop water requirements in context of climate change. “**

2. List of data

- Research sites – Planning zones (PZ) receiving water from the Amudarya River – GIS file of PZ.

- Central Asia irrigated area– GIS file

- Data of climate forecast (REMO model)

- Data from earth-based meteorological stations (aeronautical meteorological stations (AMST) from a web-site)

- Rainfall data for research sites

- Groundwater table data for recent 5 years – data for each ten-day period

- List of crops with crop coefficients

- Soil map of research sites, with soil texture

3. Data

a) Planning zones

Tajikistan:

- Lower Kafirnigan
- Upper Kafirnigan
- Pyandj
- Vakhsh

Turkmenistan:

- Akhal
- Tashauz
- Lebap
- Mary

Uzbekistan:

- Bukhara
- Karshi
- Kashkadarya
- Khorezm_1
- North Karakalpakstan
- Surkhandarya

GIS-files of planning zones were taken from SIC's archives.

b) Central Asia irrigated area

GIS-files of Central Asia irrigated area were taken from SIC's archives

c) Meteorological data

It is supposed to make calculations for both historical and future periods of time. As meteorological data we used the output from the REMO model received by SIC ICWC from the Wurzburg University. The model is based on greenhouse gas emission forecast, represents well the general trends but do not consider local specifics of the studied sites. REMO simulated climate data for 2000-2050 were received from the University of Wurzburg (Germany) as part of the CAWA Project. The simulations are daily meteorological data in the nodes of the conditionally-uniform grid with a step of 0.5^o by latitude and longitude.

For data calibration, the ground-based observation data are needed. The data provided by HYDROMET are costly and the network of operational meteorological stations is dispersed. Therefore, for calibration we used aeronautical meteorological stations (AMST). The data for these stations were taken from the site http://gis.ncdc.noaa.gov/map/viewer/. Since the rainfall data observed by AMST are of specific character and cannot be used for our calculation, the needed rainfall data were taken from the site http://climateserv.nsstc.nasa.gov/.

d) Data on groundwater table

Groundwater is presented in the form of ten-day average groundwater table for districts. The data are available only for Uzbekistan. The data cover the period of time 2011 - 2015. **These data were collected by the project expert Ms. G.V.Stulina.**

e) Soil map for the territory related to Uzbekistan

The soil map of a part of the territory of Uzbekistan that covers the studied planning zones is generated in the project. **Materials for digitization were prepared by the project expert Ms. G.V.Stulina, and digitization was made by the project GIS-expert Mr. I.Rusiev.**

f) Crops considered by the project

The list of crops was selected according to statistical reporting on the crops grown in PZs and agreed with the ASBMM model developer.

CropWork	
CropID	**CropName**
11	Maize for grain
20	Winter wheat
37	Cotton
40	Rice
204	Legumes double season
210	Potato double season
222	Beet double season
224	Cucurbits double season
231	Vegetables double season
239	Maize for silage
240	Rice double season
301	Vegetables
302	Orchards
303	Fodder
304	Other crops
1000	Homestead plots

GrName	NewCropID	2
Овощи	301	Potato
Овощи	301	Tomato
Овощи	301	Sugar beet
Овощи	301	Legumes
Овощи	301	Melon
Садовые	302	Table grape
Садовые	302	Orchards
Кормовые	303	Alfalfa
Кормовые	303	Maize for silage
Прочие	304	Sunflower
Прочие	304	Peanut
Прочие	304	Sorghum for grain
Прочие	304	Soybean

Since statistical reporting on agricultural production shows such groups as VEGETABLES, ORCHARDS, FODDER and OTHER CROPS, ten-day values of Кс for these groups of crops were calculated.

For calculation of water requirements of homestead plots, the following rule is applied: **0.45** l/s/ha for growing season (April – September); **0.3** l/s/ha for non-growing season (October-March).

Data sources

1. GIS materials - **SIC's archives**

2. Climate forecast (REMO model) – **Wurzburg University, Germany**

3. Data of aeronautical meteorological stations - **http://gis.ncdc.noaa.gov/map/viewer/, USA**

4. Rainfall data - **http://climateserv.nsstc.nasa.gov/, USA**

5. Crop parameters - **FAO Paper 56 and calibrated coefficients of some crops as derived by the project expert G.V.Stulina.**

ANALYSIS OF CLIMATE CHANGE MODEL OUTPUT

REMO

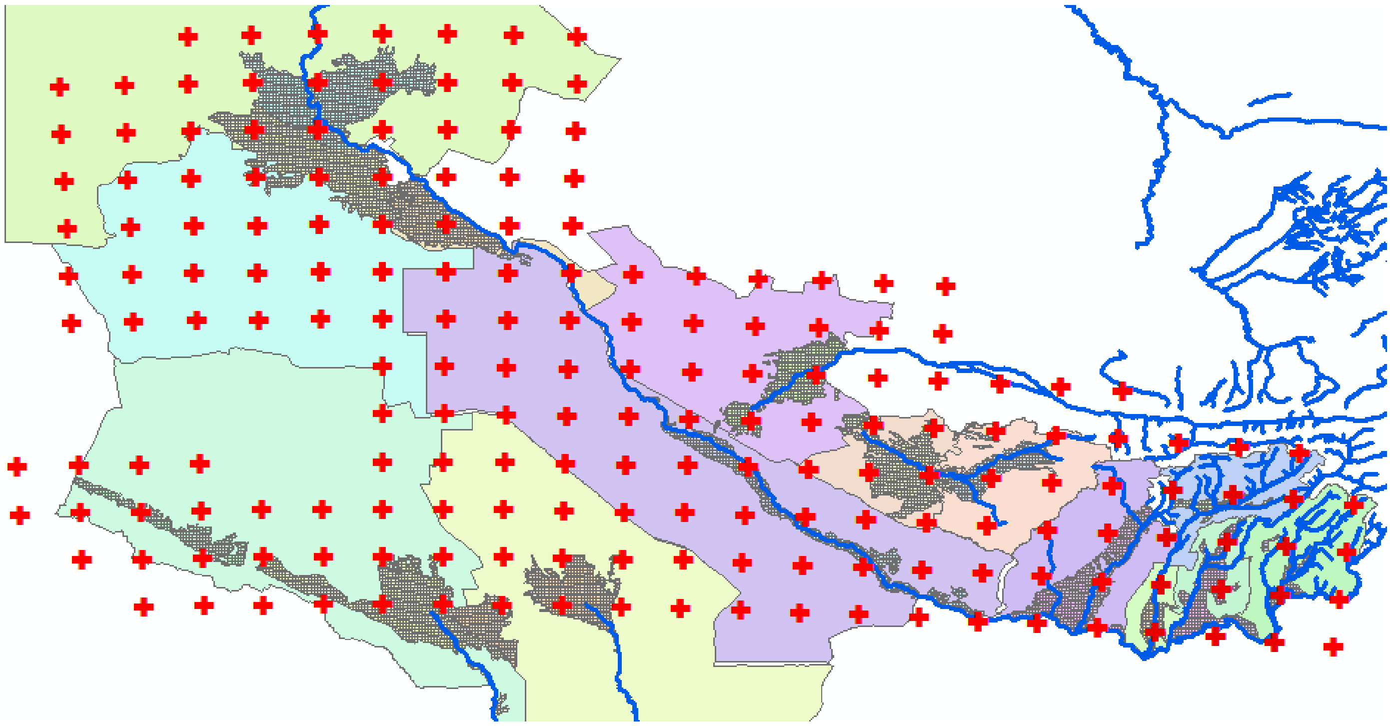


Fig.1

The regional climate model (REMO) with the initial spatial resolution 0.5 ° and the further developed resolution to 0.18 ° was designed for Central Asia to model climate changes in the region for a period by 2100. Given the scenario of future greenhouse gas emissions of the Intergovernmental Panel for Climate Change (IPCC) - SRES-A1B, the REMO model simulates growth in winter temperatures from 1 to 1.5 °C. In mountainous zones, average winter rainfall is expected to increase by 50 - 70 mm.

Figure 1 shows the Planning Zones (PZ) considered in the Project and the nodes of the REMO climatic model, where the model made forecasts of meteorological parameters. The forecast extended to 2100, however, according to the tasks stipulated in the PEER Project, we considered the interval from 2000 to 2050.

The REMO model was approbated in the area of the Fergana Valley for calculation of crop water requirements as part of the CAWA Project.

For project purposes, the nodes were selected that fell into the irrigated area of PZ and were directly adjacent to it. Meteorological parameters in any point of PZ's irrigated area are calculated by interpolation of average weighted, where the weight is the inverse value of distance from the REMO node to calculation point. The only piece that was not covered by REMO nodes was a small southern site of Akhal PZ, for which we had to use extrapolation instead of interpolation.

For the analysis of some climatic parameters three planning zones along the Amudarya River – in its upper, middle, and lower reaches – were selected. These are Kashkadarya PZ, Bukhara PZ, and North Karakalpakstan PZ. The selection criterion was the similarity of natural conditions in PZs, namely plain reach of the river.

Average annual temperatures for all Project planning zones were used for the analysis of dependence of REMO forecast on location of forecast sites, if we move from south to north (i.e. analysis of latitudinal trend).

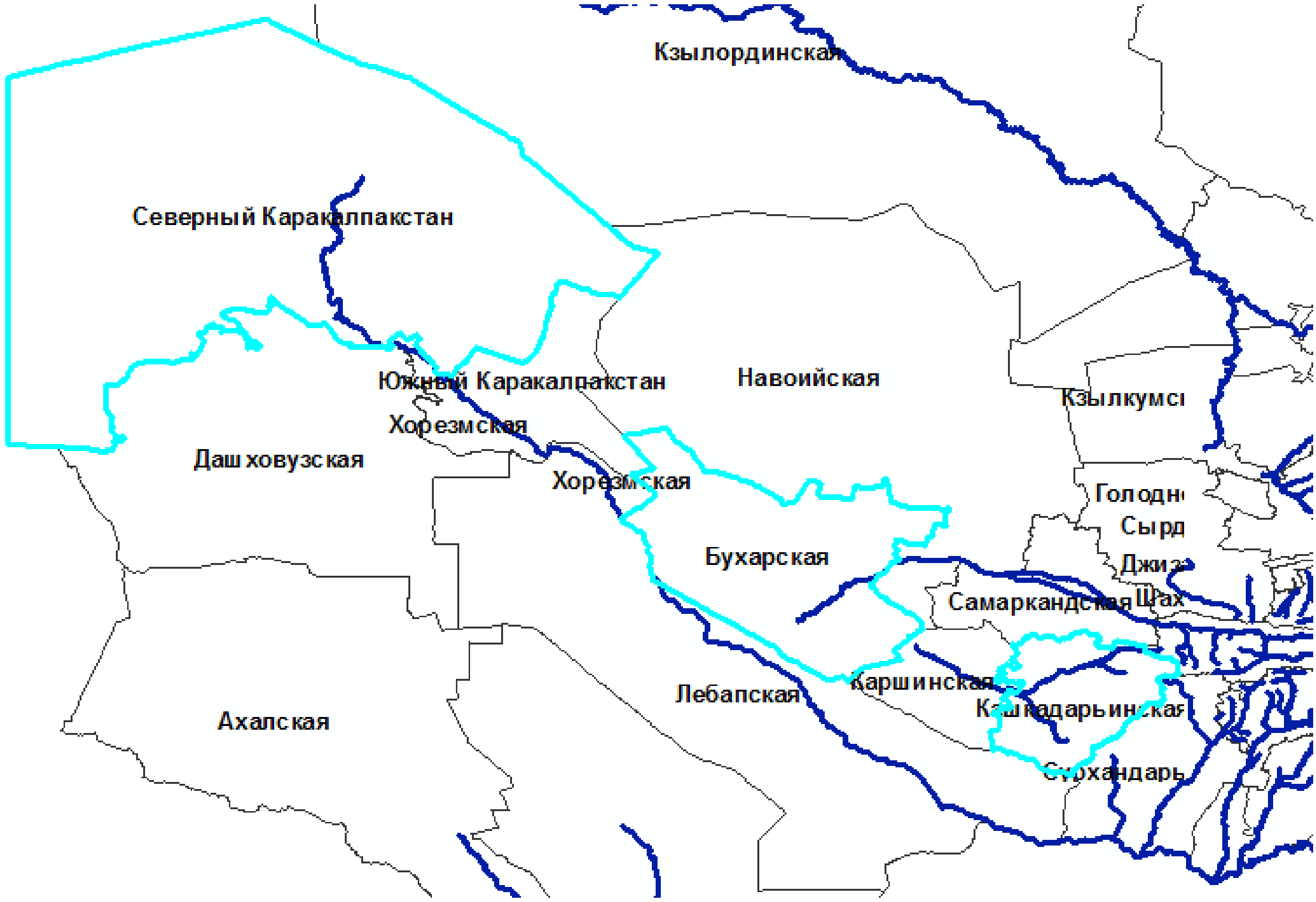


Fig.2

Figure 2 highlights planning zones selected for analysis.

Only irrigated part of land was considered in each PZ. An expert selected in its center a point (control point), for which meteorological parameters were forecasted.

The analysis includes the following:

1. Analysis of all meteorological forecasts and evapotranspiration forecast

2. Latitudinal trends of average annual air temperature

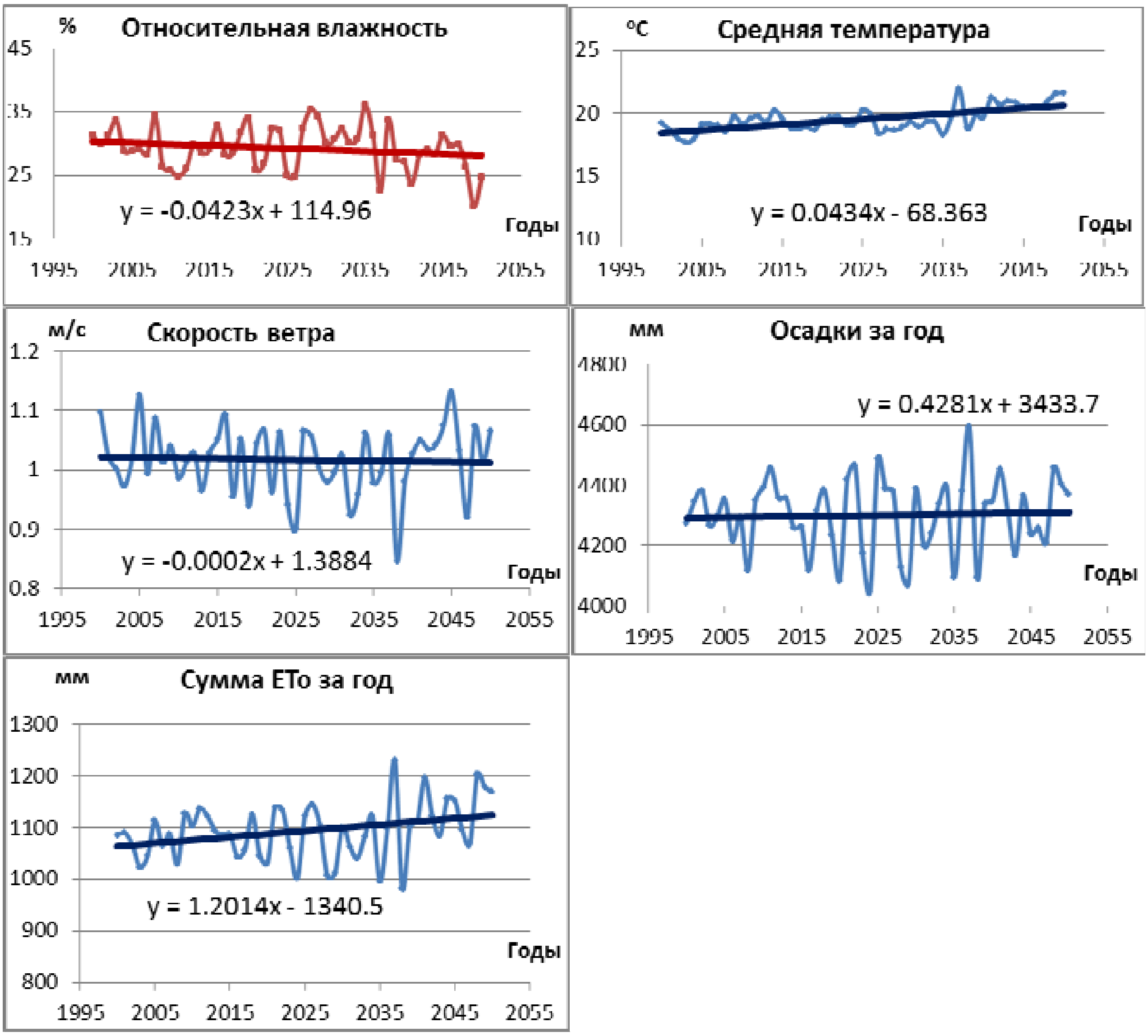
3. Seasonal temperature trends

4. Comparison of model output with the actual data from meteorological stations

Analysis of all meteorological forecasts and evapotranspiration forecast

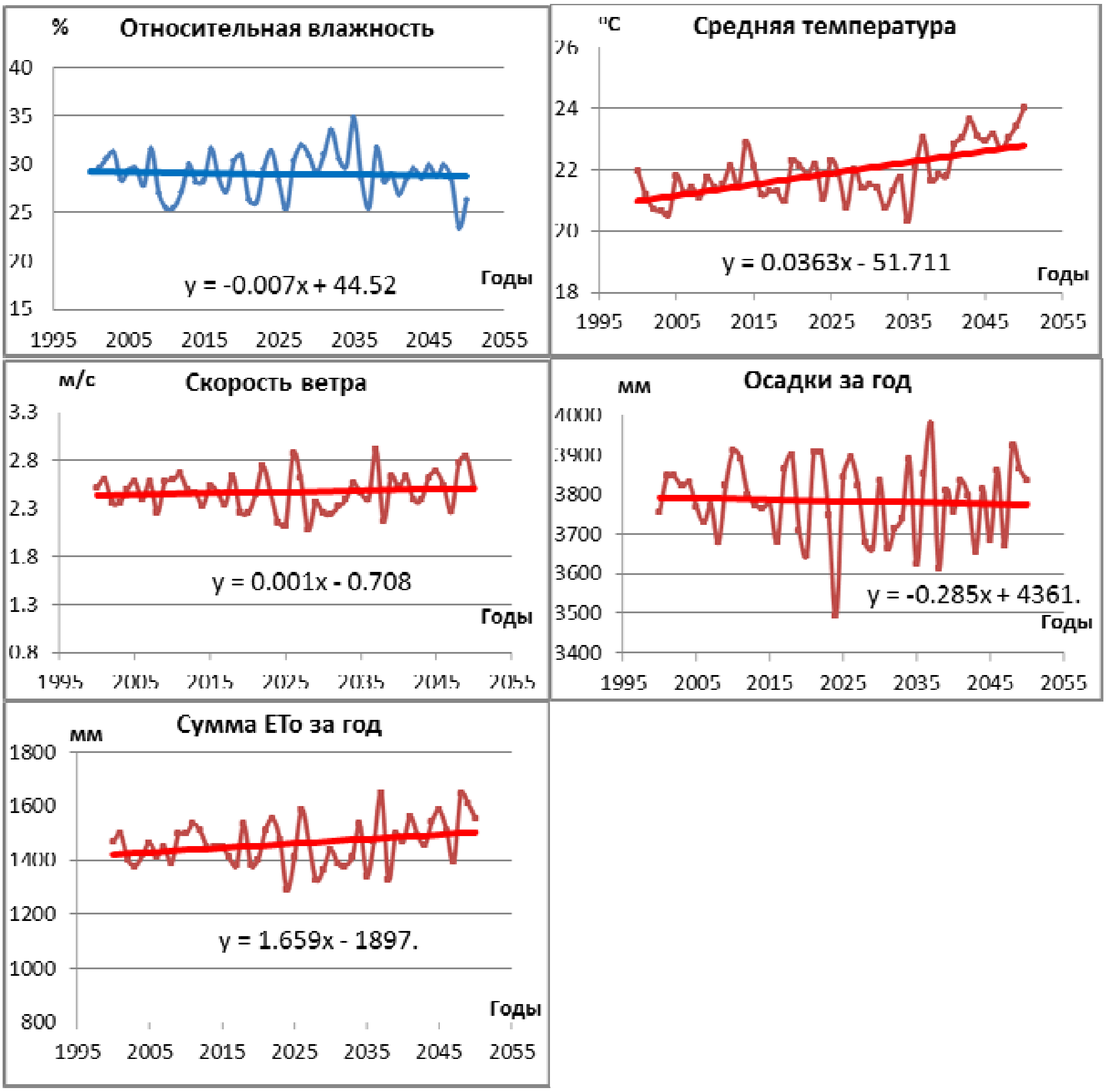
The graphs of annual meteorological parameters and evapotranspiration for selected PZs for the period since 2000 to 2050 are shown below.

Trends of forecast meteorological parameters for Kashkadarya PZ



In Kashkadarya PZ we observe the following trends:
- relative humidity decreases,
- average annual temperature grows,
- virtually no changes in wind speed,
- minor increase of rainfall,
- significant increase of evapotranspiration.

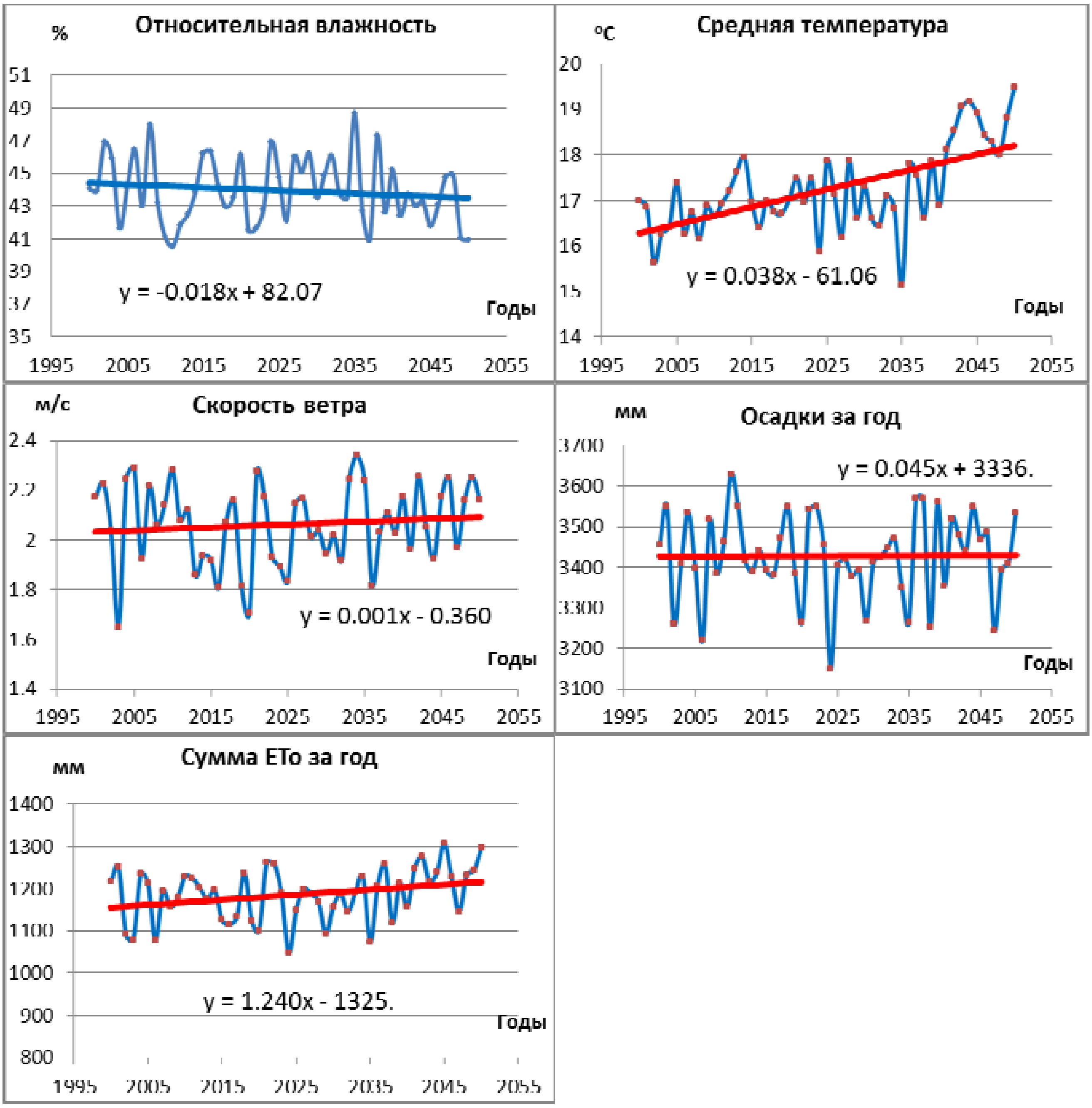
Trends of forecast meteorological parameters for Bukhara PZ



In Bukhara PZ we observe the following trends:

- average annual relative humidity decreases insignificantly,
- average annual temperature grows,
- virtually constant average annual wind speed,
- minor decrease of annual rainfall,
- significant increase of evapotranspiration.

Trends of forecast meteorological parameters for Karakalpakstan PZ

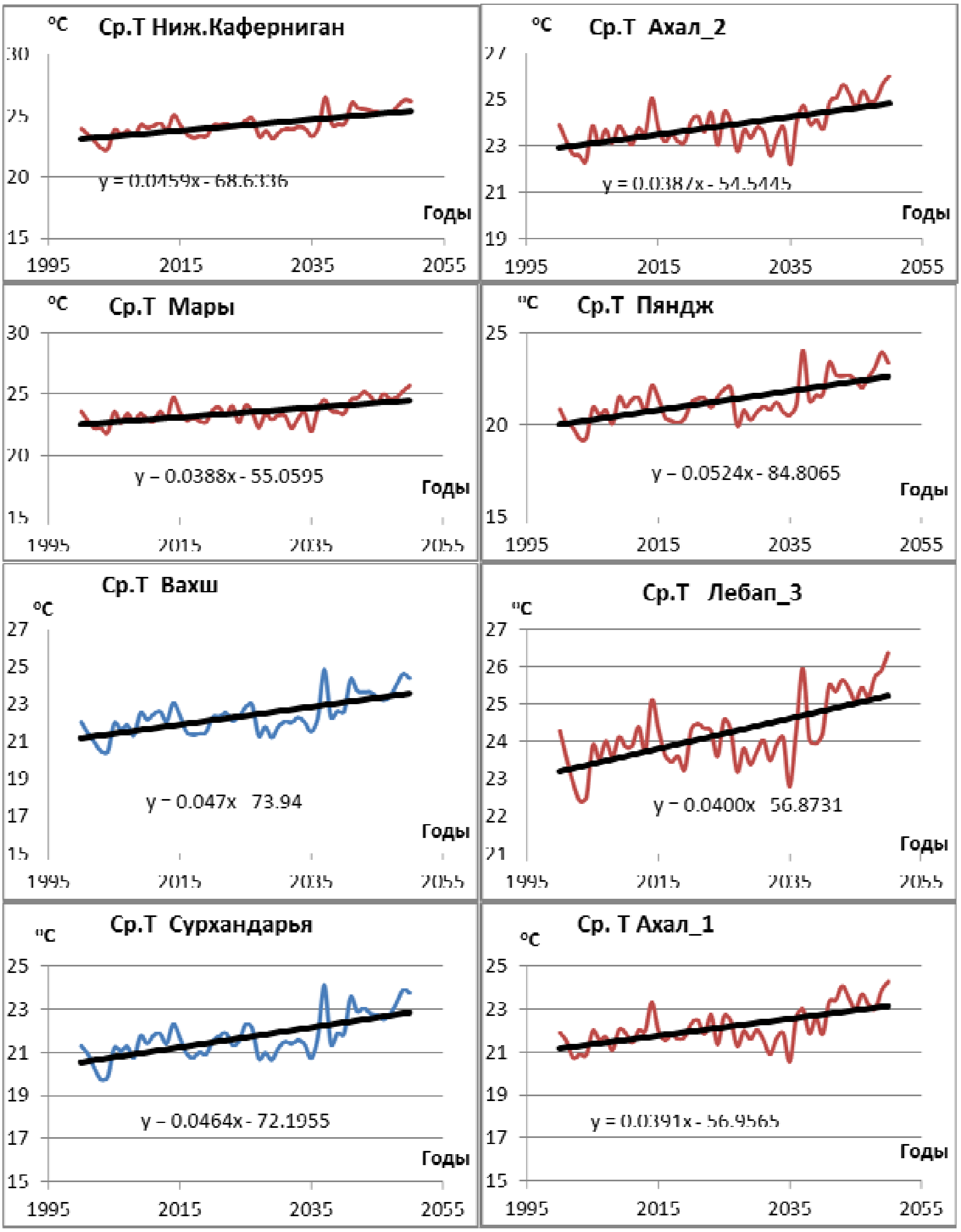


In Karakalpakstan PZ we observe the following trends:
- average annual relative humidity decreases,
- average annual temperature grows significantly,
- minor increase of wind speed,
- slight increase of annual rainfall,
- significant increase of evapotranspiration.

Generally, all PZs will see downward trend of air humidity and upward trend of average annual air temperature. There is insignificant increase of wind speed in all three planning zones. The rainfall trend is downward, while ETo trend is stable positive.

It seems interesting to construct latitudinal trend of forecast parameters.

Latitudinal trends of average annual air temperature

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Ср.Т Верх.Кафкрниган
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y = 0.053x - 93.29
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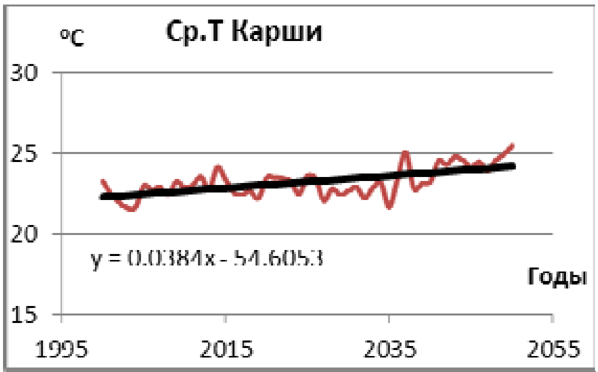
2055


°C
Ср.Т Карши
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25
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15
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Годы
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2055


°C
Ср.Т Кашкадарья
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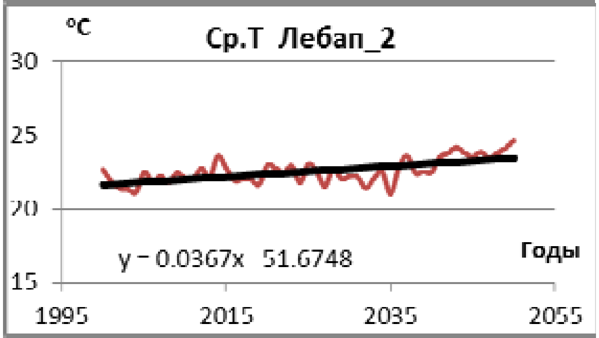
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Ср.Т Лебап_2
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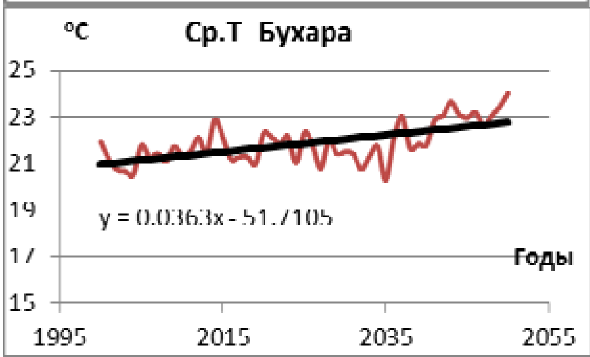
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Ср.Т Бухара
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y = 0.0363x - 51.7105
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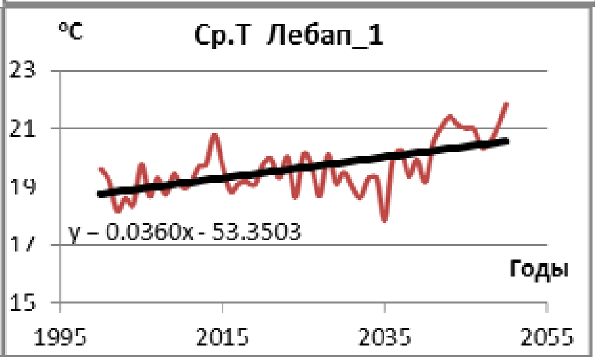
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Ср.Т Лебап_1
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y = 0.0360x - 53.3503
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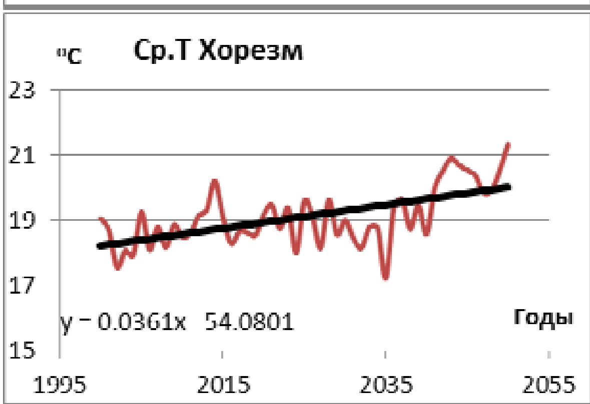
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Ср.Т Хорезм
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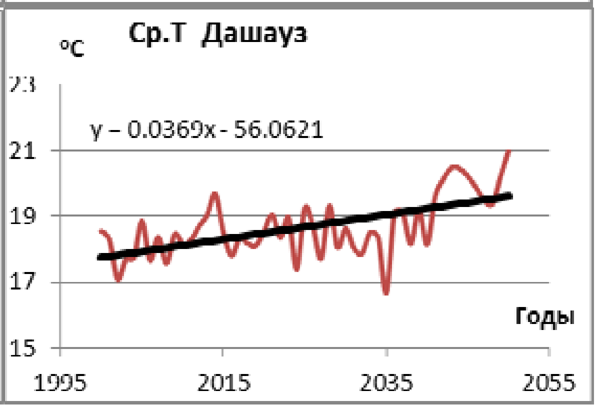
°C
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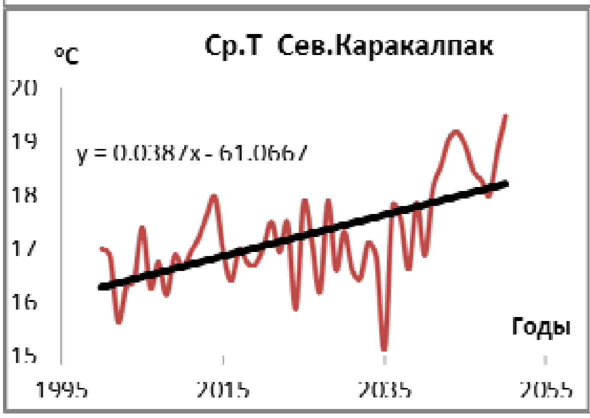
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y = 0.0387x - 61.0667
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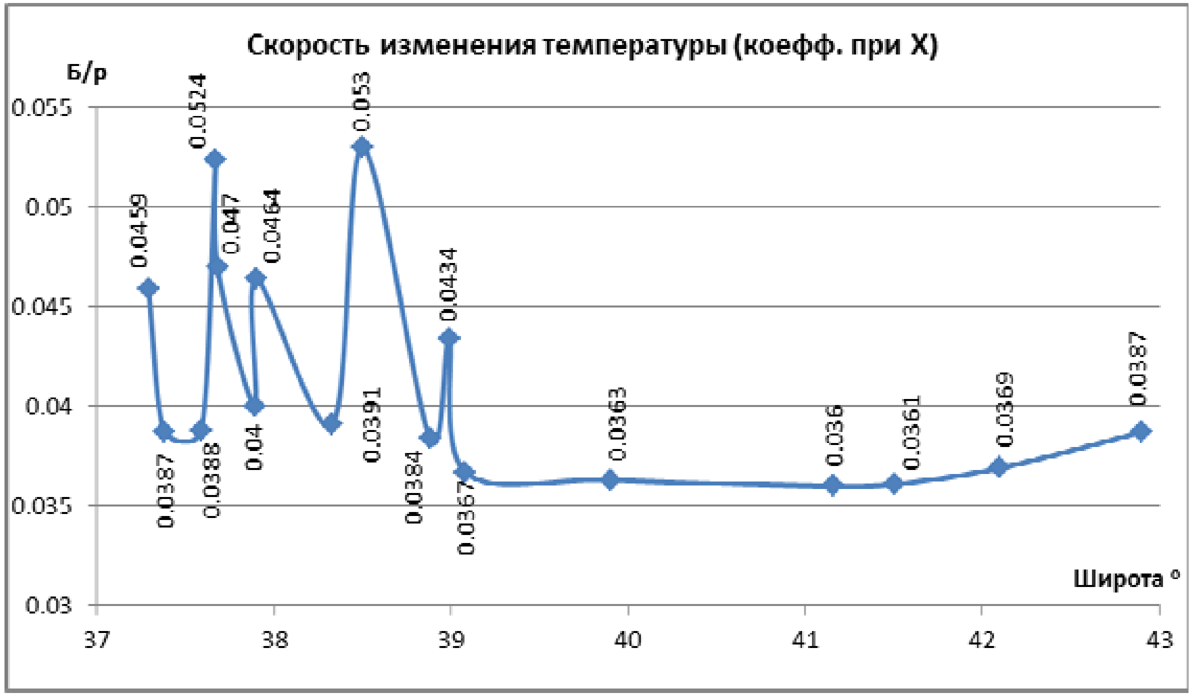
The Table containing latitudes of control points in each PZ and coefficients of **X** in regression equations (trend) for each PZ is given below. Based on this Table, we plotted relationship between the temperature change rate and the latitude.

Planning zone	Latitude	K of X
Lower Kafirnigan	37.29	0.0459
Akhalak_2	37.38	0.0387
Mary	37.59	0.0388
Pyandj	37.67	0.0524
Vakhsh	37.68	0.047
Lebap_3	37.89	0.04
Surkhandarya	37.9	0.0464
Akhalak_1	38.33	0.0391
Upper Kafirnigan	38.5	0.053
Karshi	38.88	0.0384
Kashkadarya	38.99	0.0434
Lebap_2	39.08	0.0367
Bukhara_2	39.9	0.0363
Lebap_1	41.16	0.036
Khorezm	41.51	0.0361
Dashauz	42.1	0.0369
North Karakalpakstan	42.9	0.0387

Increase of average annual temperature over 2000-2050			
Planning zone	**Latitude**	**K of X**	**Div. T**
Lower Kafirnigan	37.29	0.0459	2.30
Akhalak_2	37.38	0.0387	1.94
Mary	37.59	0.0388	1.94
Pyandj	37.67	0.0524	2.62
Vakhsh	37.68	0.0470	2.35
Lebap_3	37.89	0.0400	2.00
Surkhandarya	37.90	0.0464	2.32
Akhalak_1	38.33	0.0391	1.96
Upper Kafirnigan	38.50	0.0530	2.65
Karshi	38.88	0.0384	1.92
Kashkadarya	38.99	0.0434	2.17
Lebap_2	39.08	0.0367	1.84
Bukhara_2	39.90	0.0363	1.82
Lebap_1	41.16	0.0360	1.80
Khorezm	41.51	0.0361	1.81
Dashauz	42.10	0.0369	1.85
North Karakalpakstan	42.90	0.0387	1.94

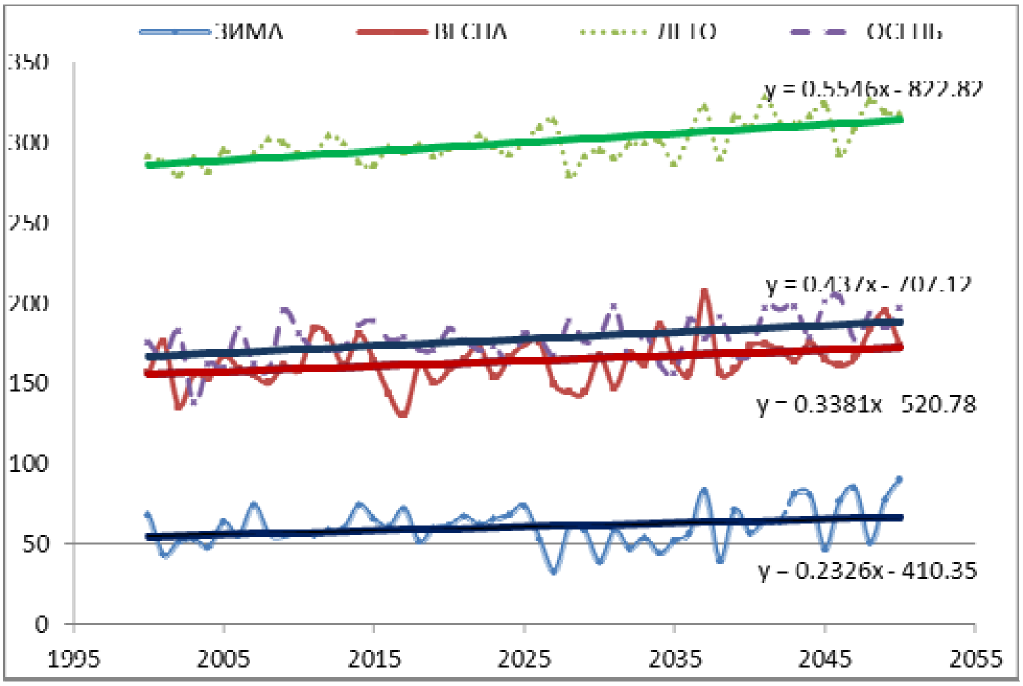


The graph shows that there is no direct dependence of temperature change rate on latitude. However, there is clear influence of mountains. Perhaps, the model takes into account a screening effect of mountain ranges against interventions from north and north-west.

Seasonal temperature trends

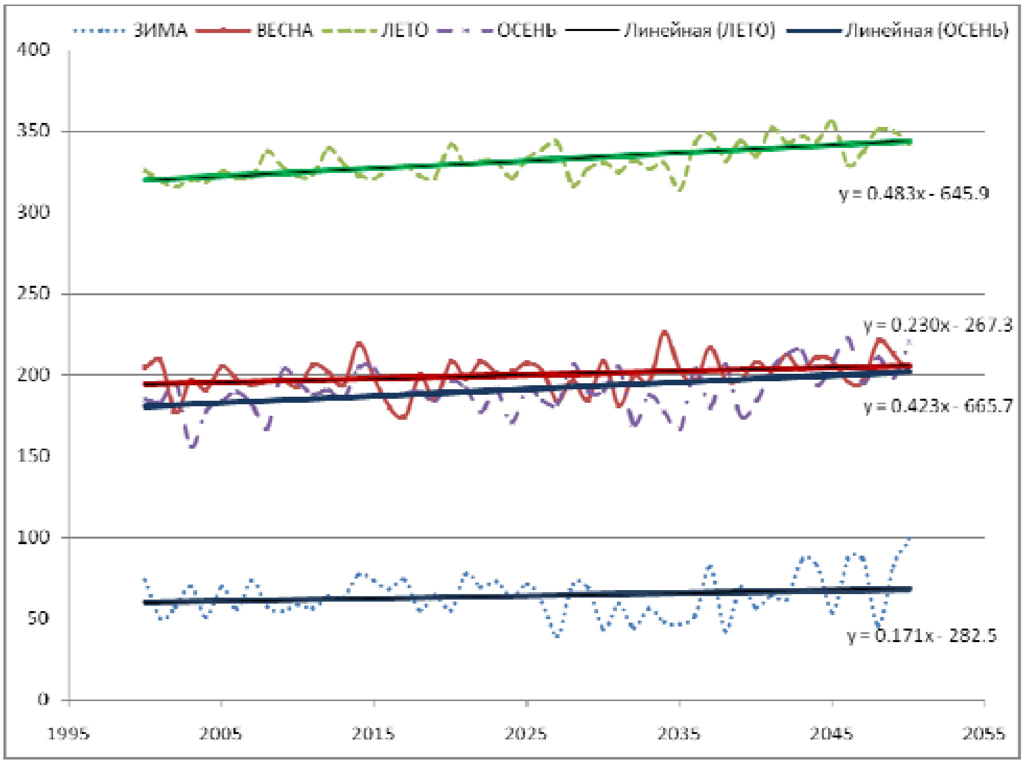
Graphs of air temperature change by season is shown below. The graphs indicate to upward temperature trend in all seasons, but mainly in summer and autumn.

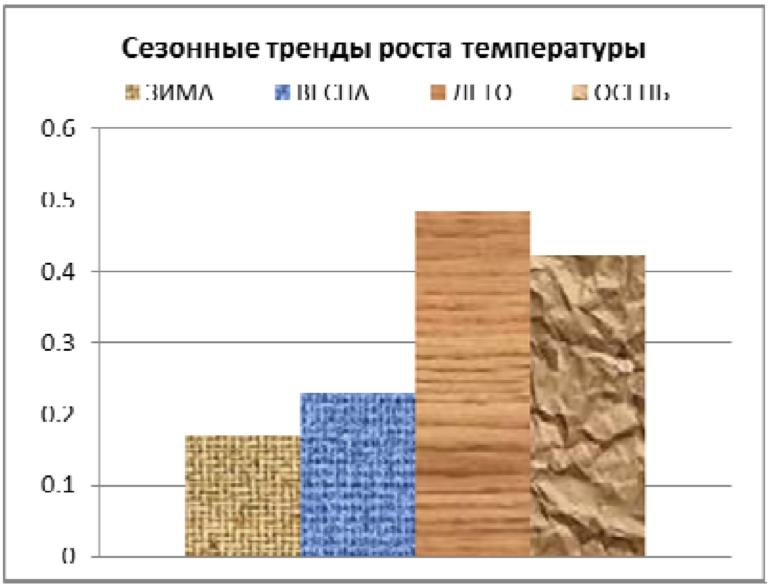
KASHKADARYA



The bar chart shows coefficients of **X** in regression (trend) equations. The rate of average temperature growth in summer in combination with temperature growth in spring and autumn prolongs the growing season of crops.

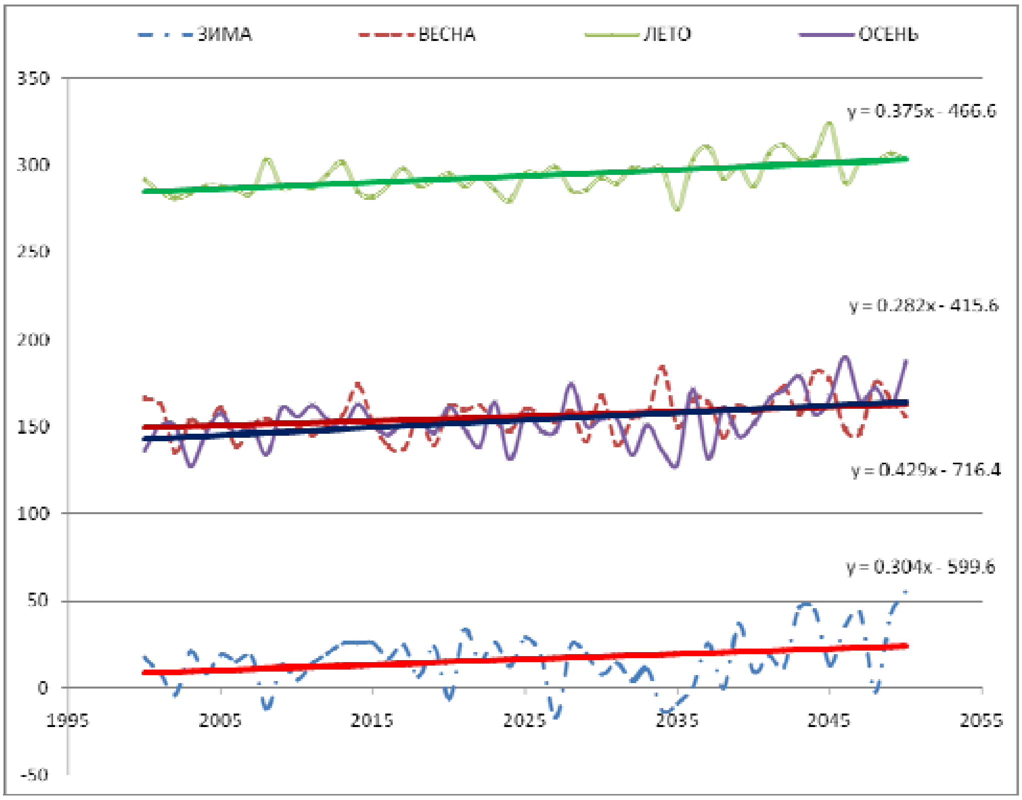
BUKHARA

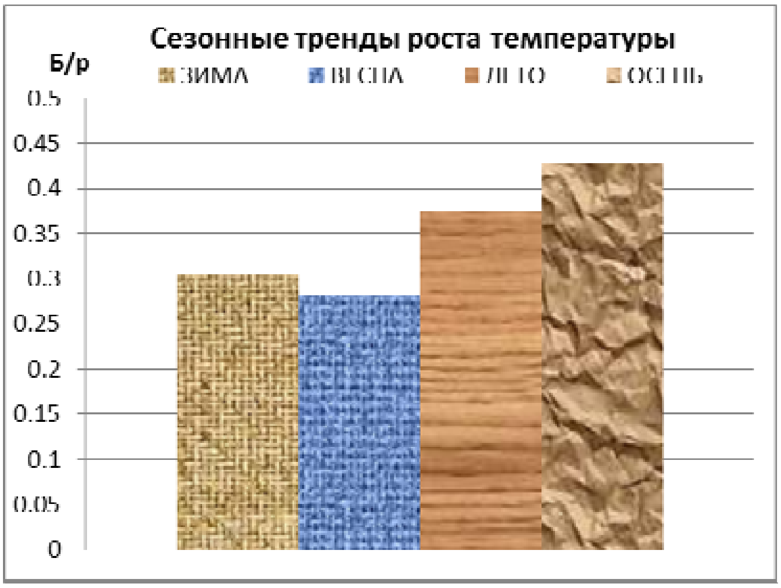




The rate of temperature growth in Bukhara PZ is virtually similar to that in Kashkadarya PZ, although it is slightly lower in absolute values.

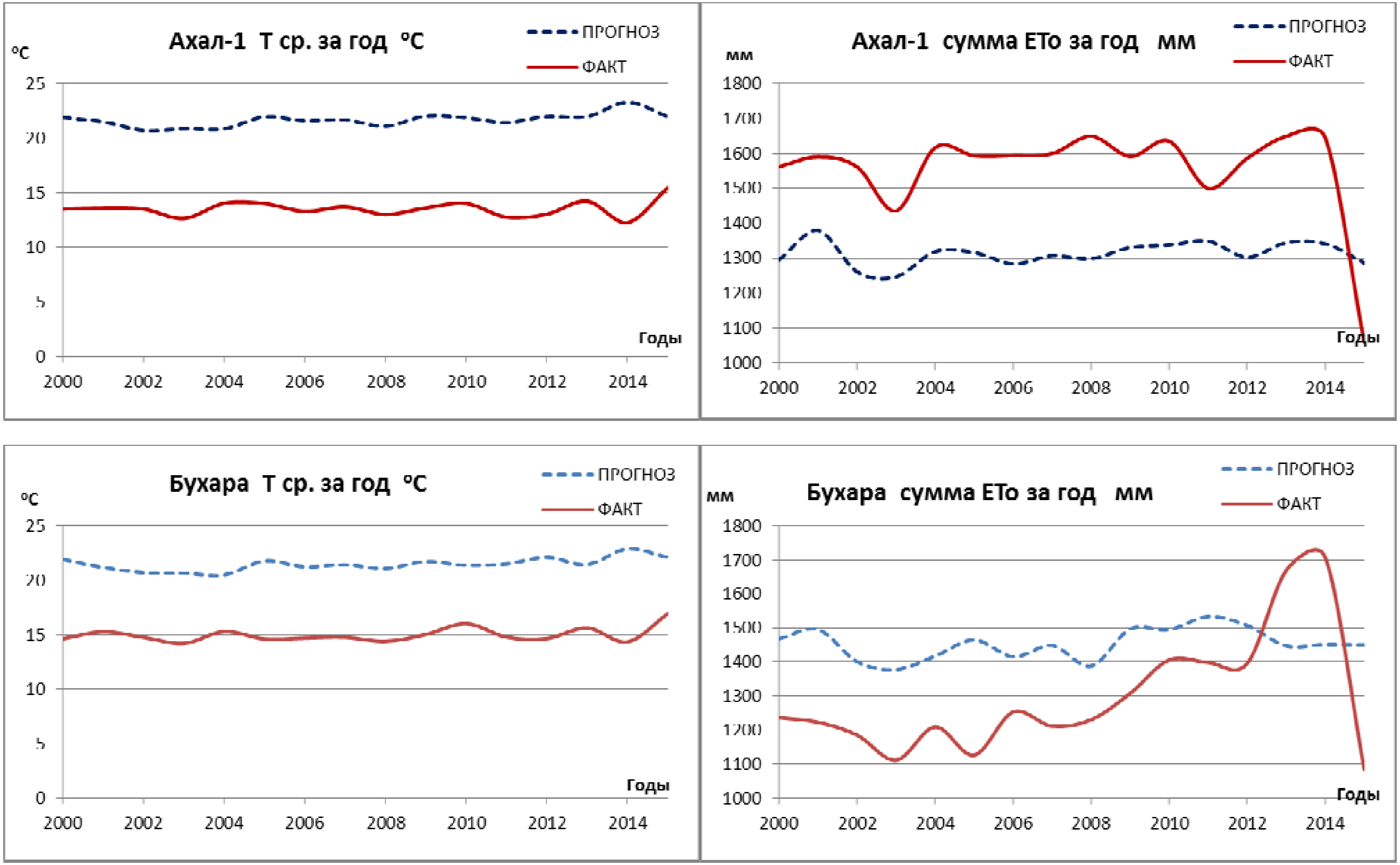
KARAKALPAKSTAN

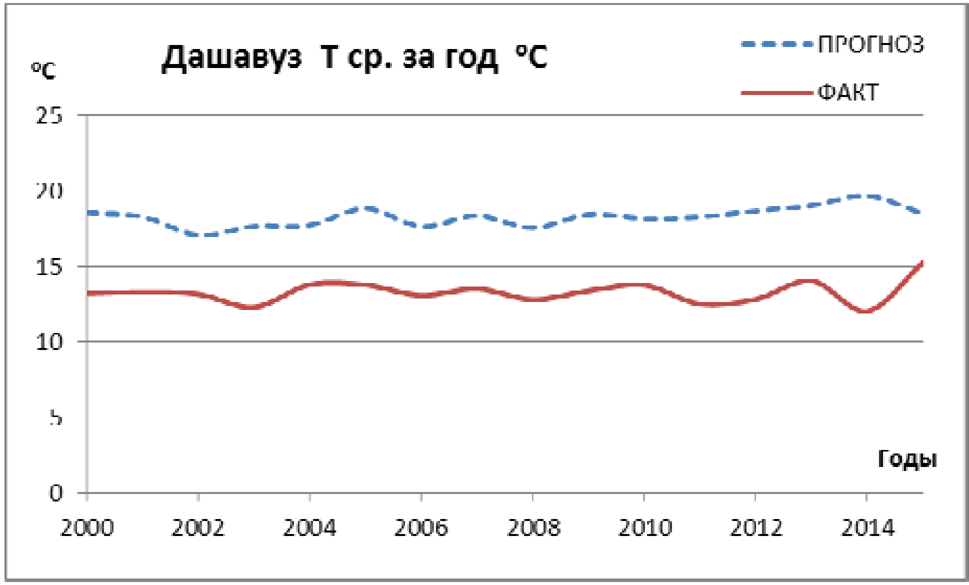




The rates of temperature growth in Karakalpakstan PZ are close for different seasons; however the highest growth takes place in autumn.

Comparison of simulated data with actual data from meteorological stations

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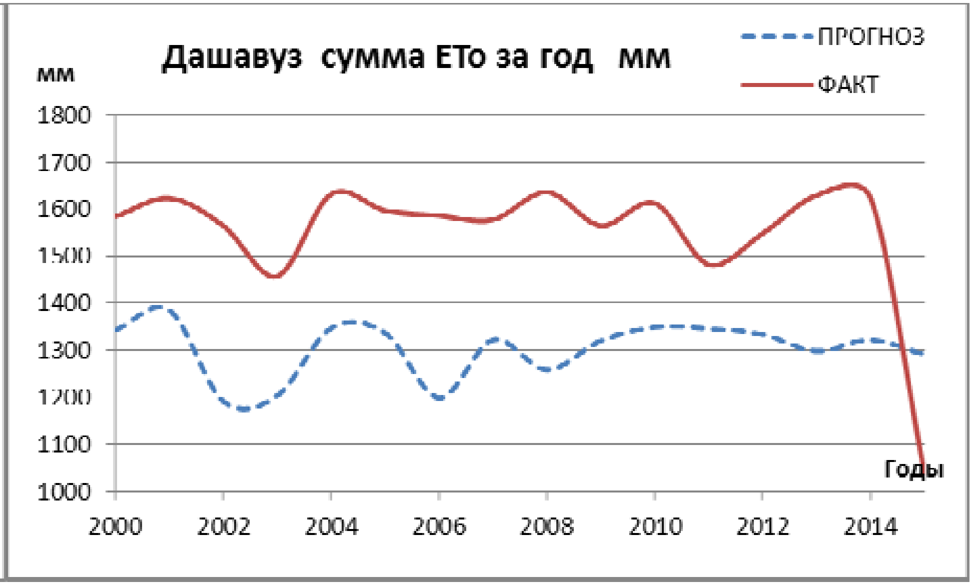
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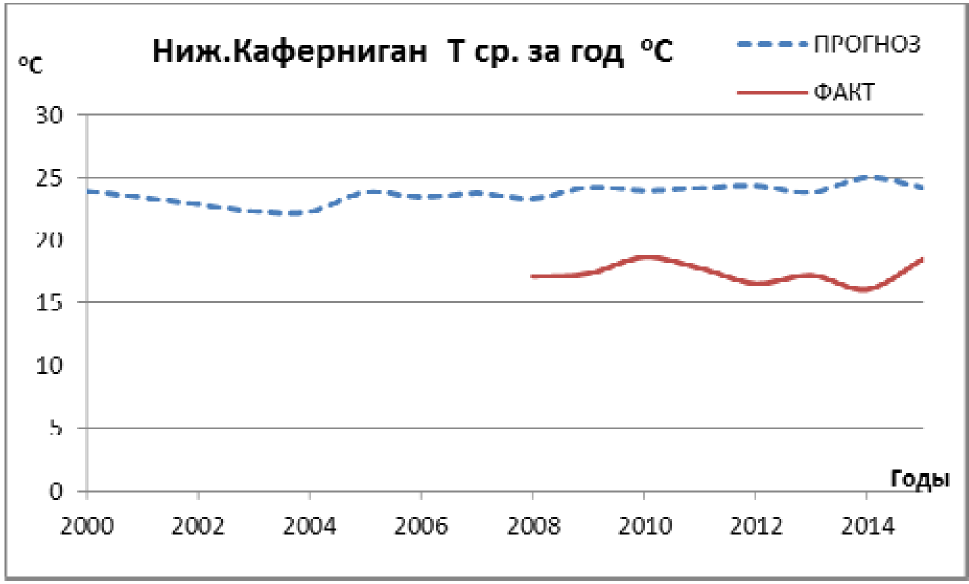
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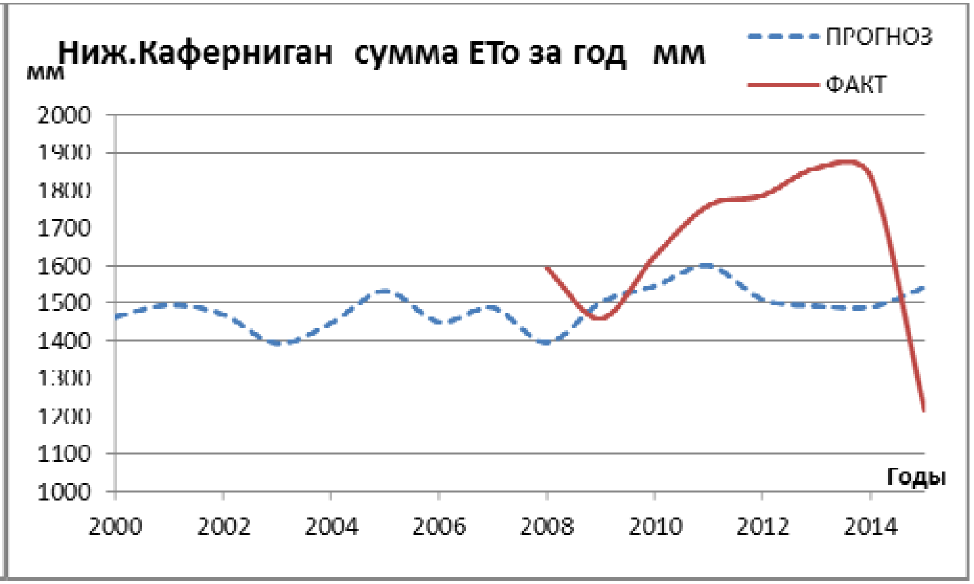
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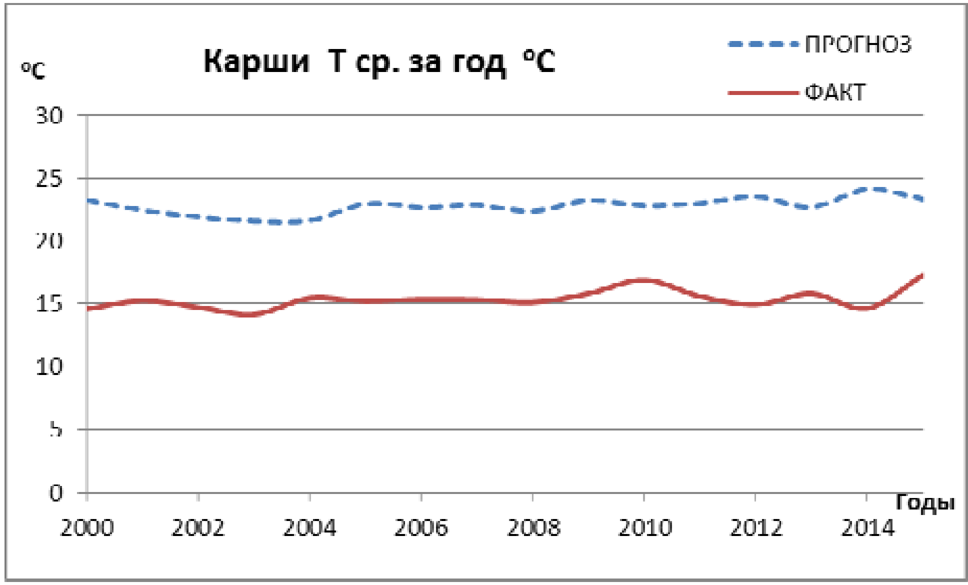
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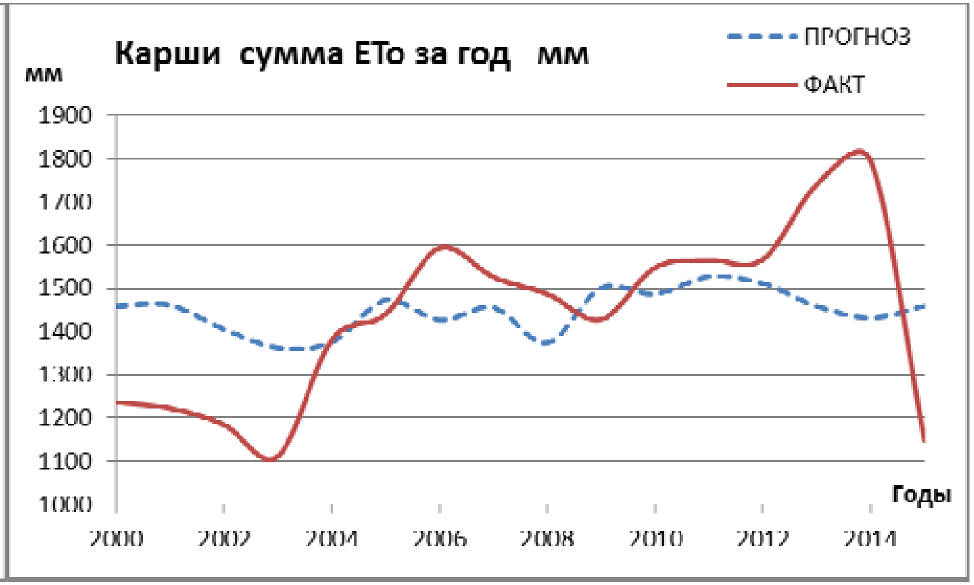
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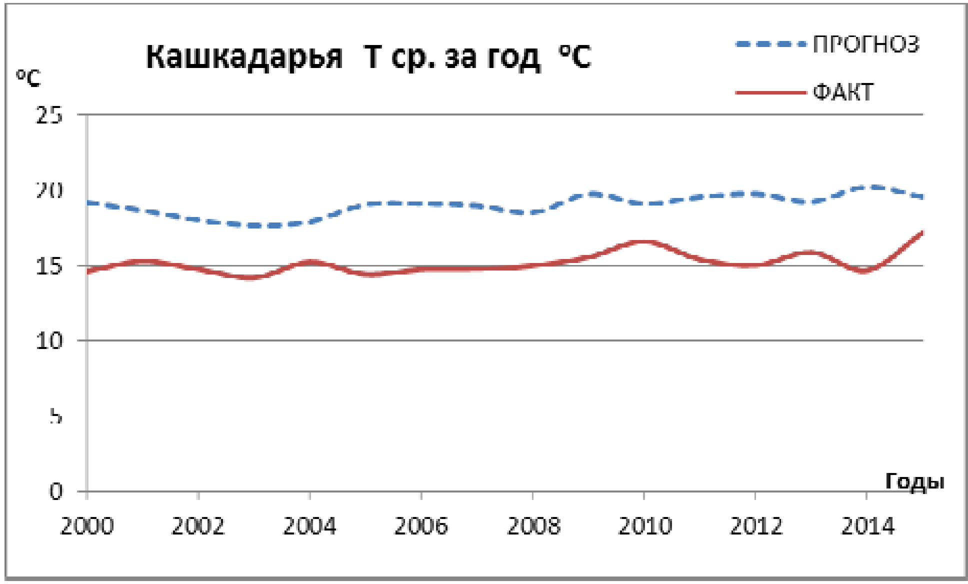
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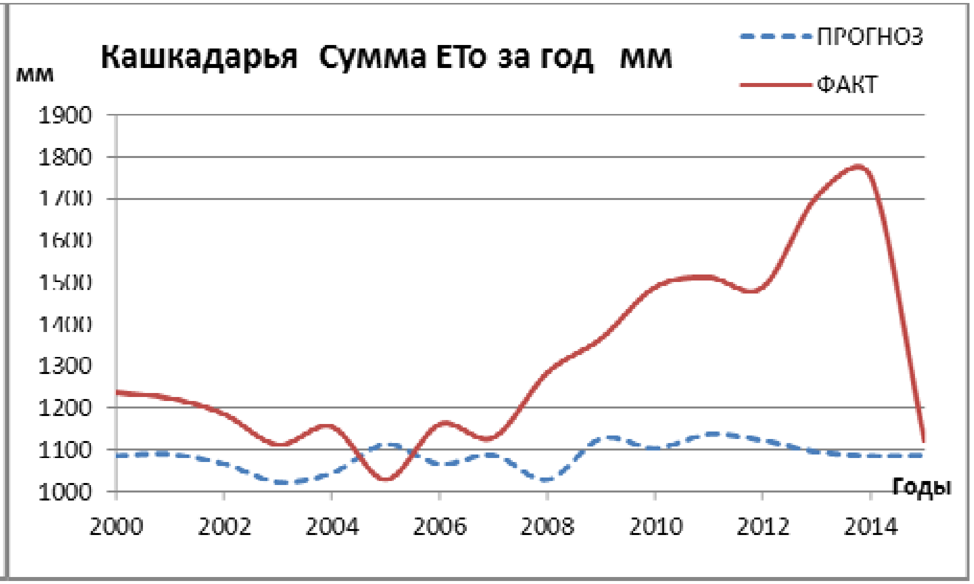
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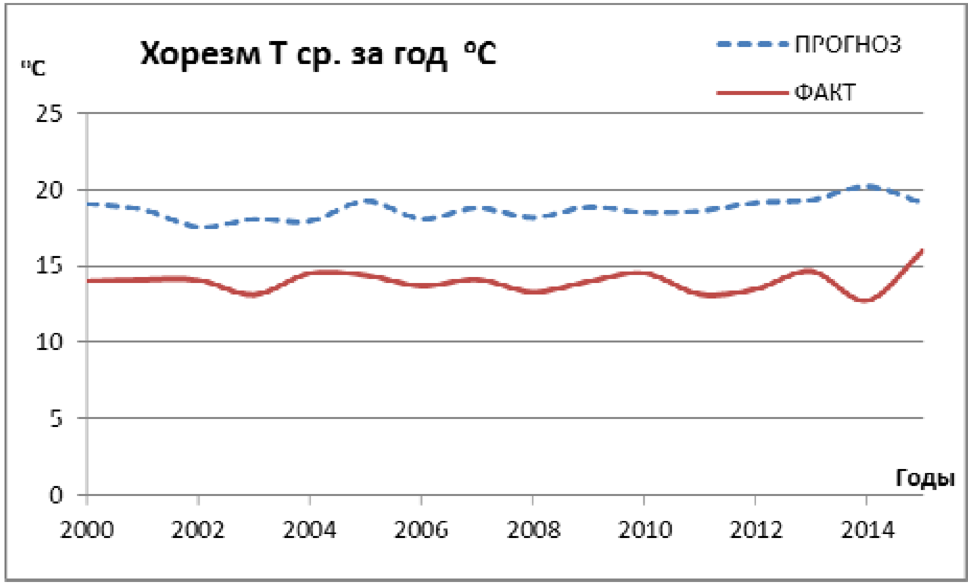
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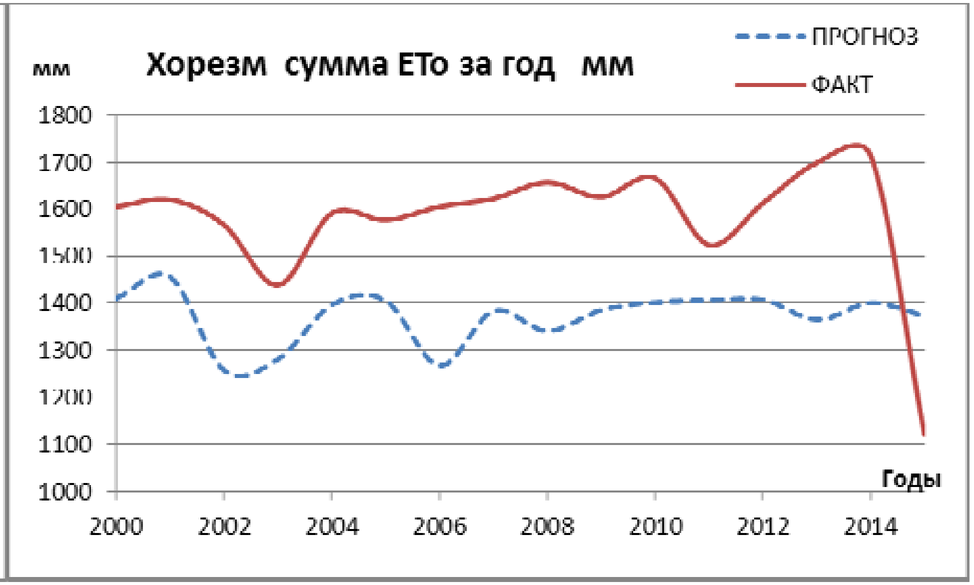
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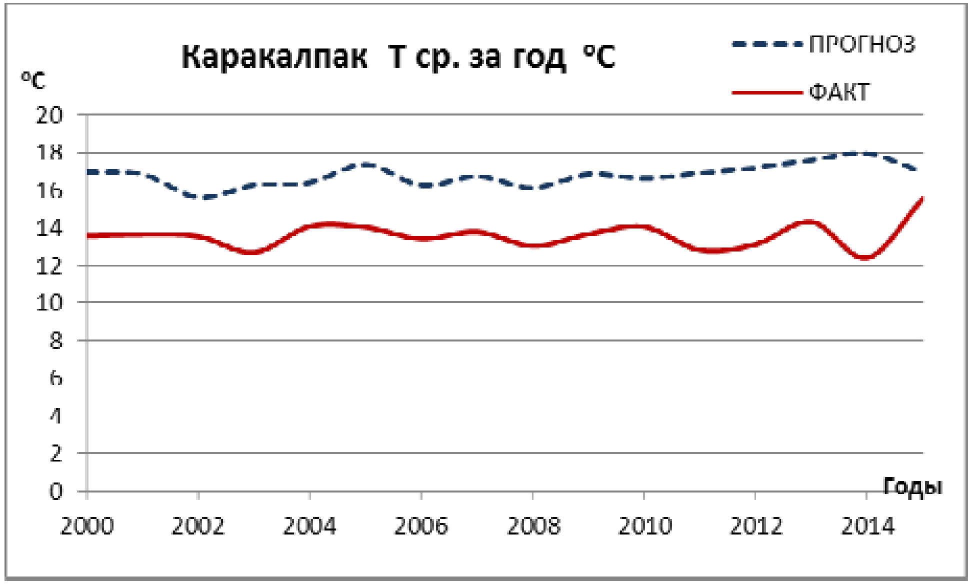
Каракалпак Т ср. за год °С
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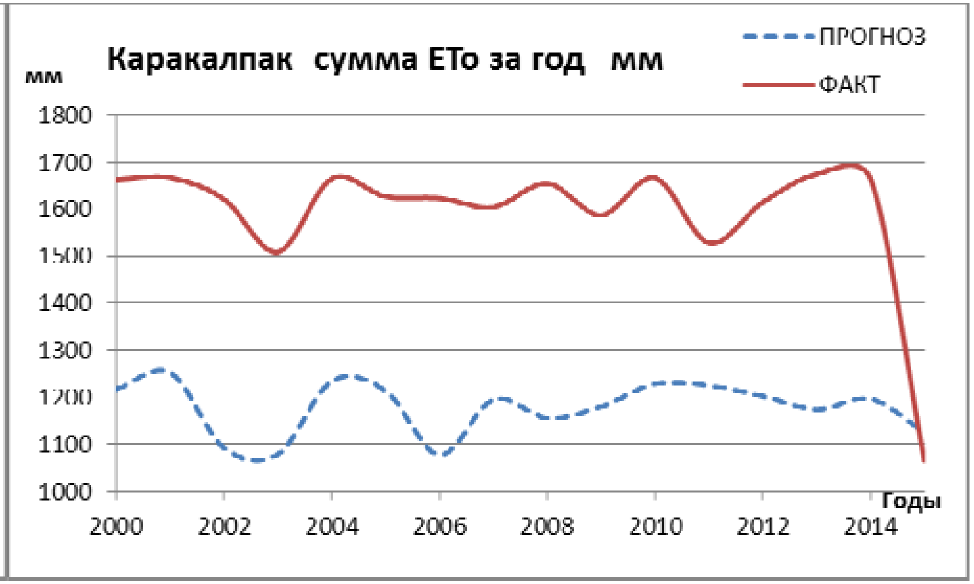
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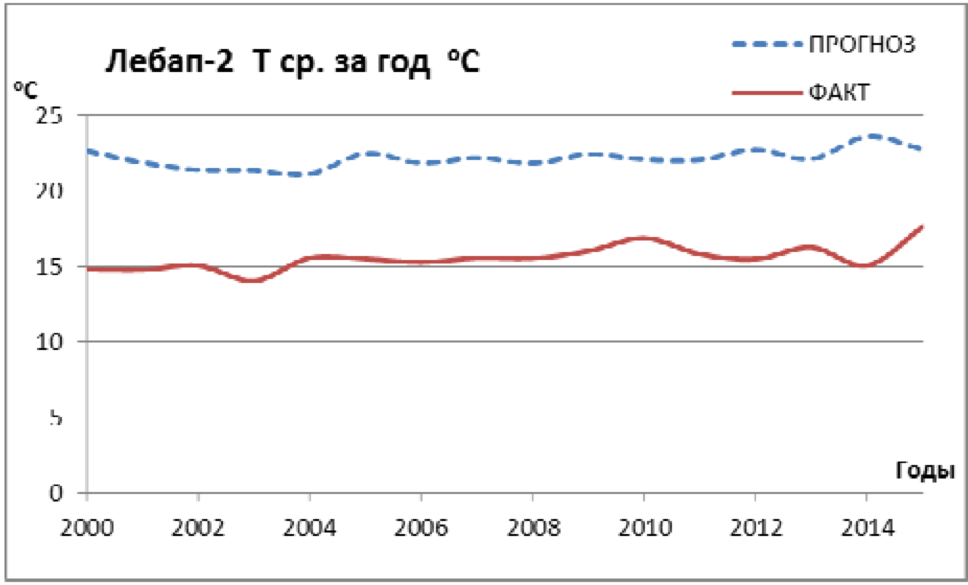
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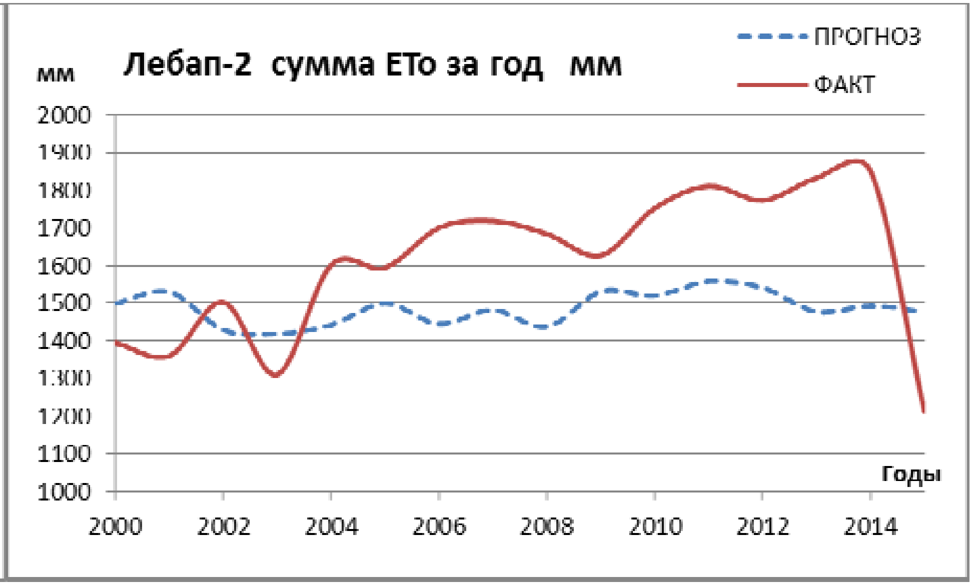
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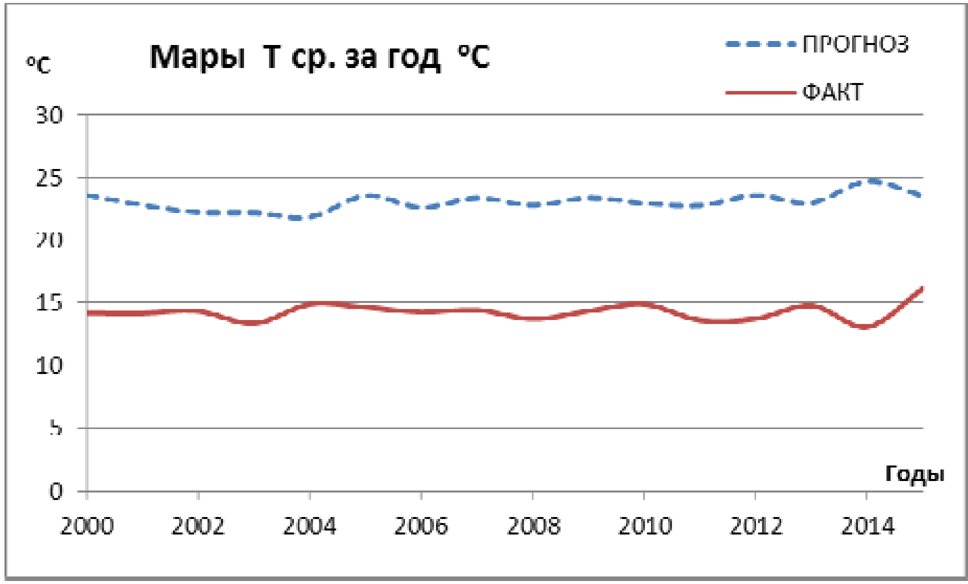
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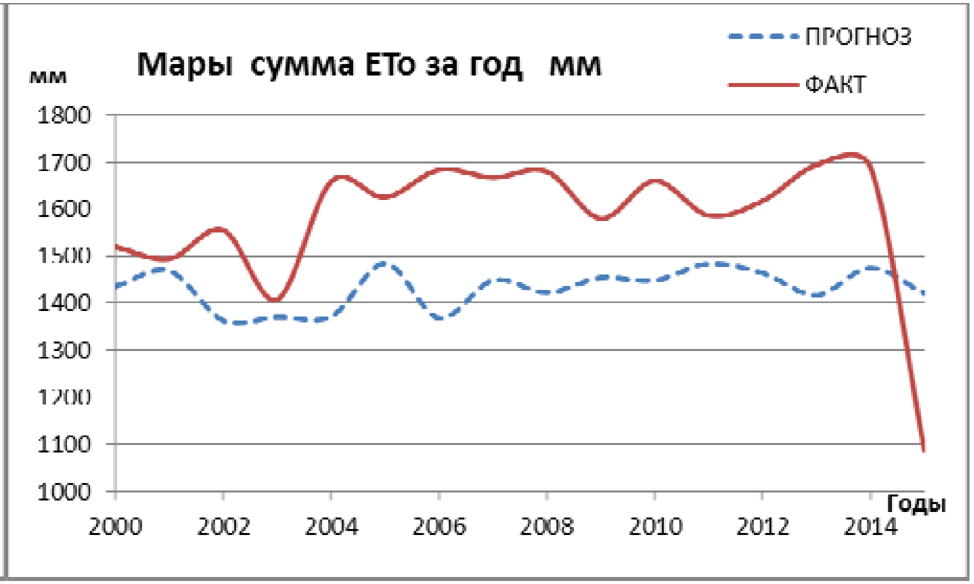
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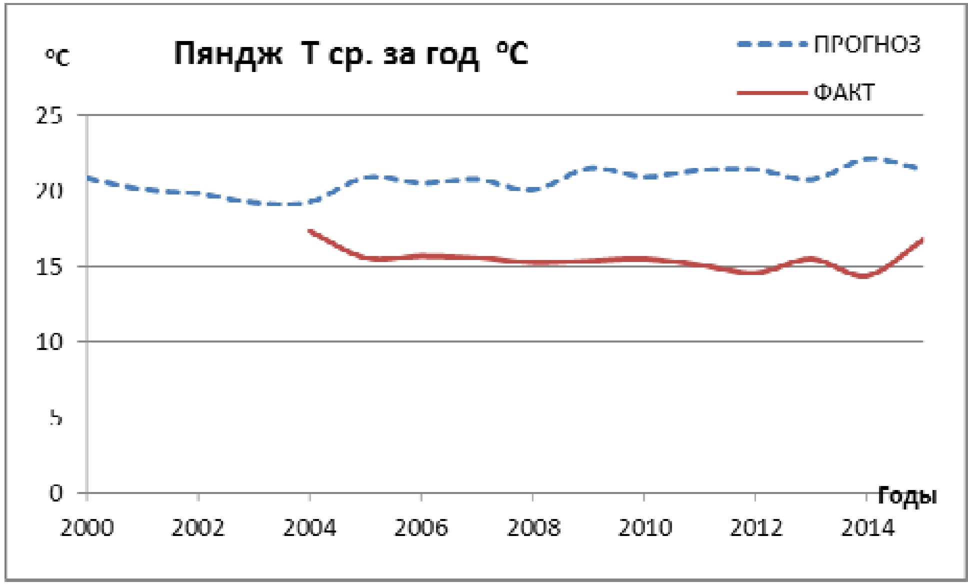
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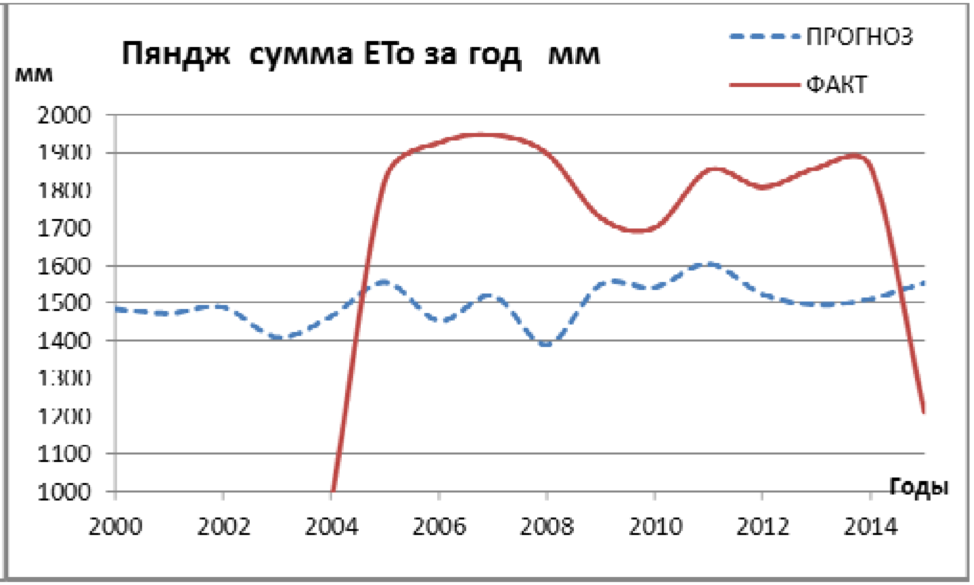
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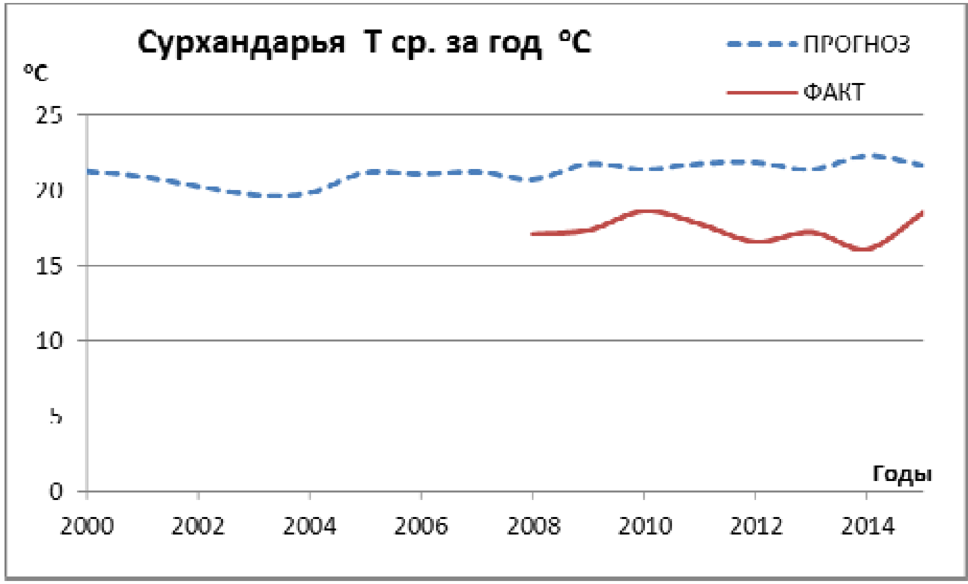
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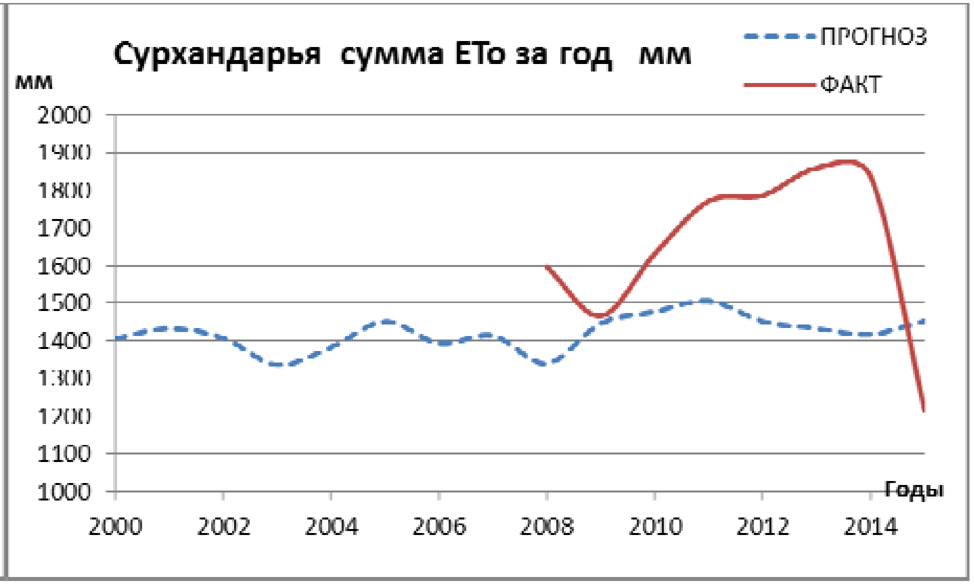
Годы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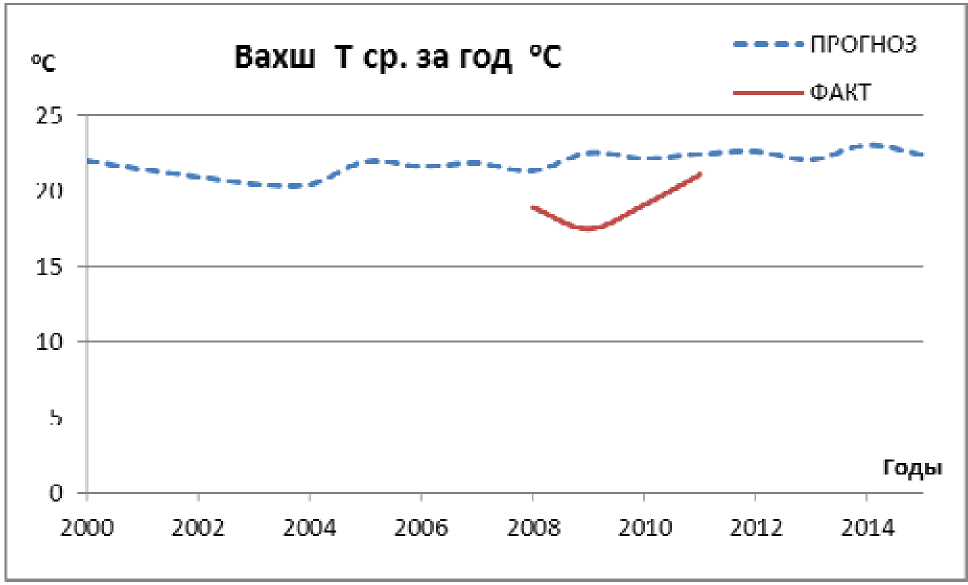
Годы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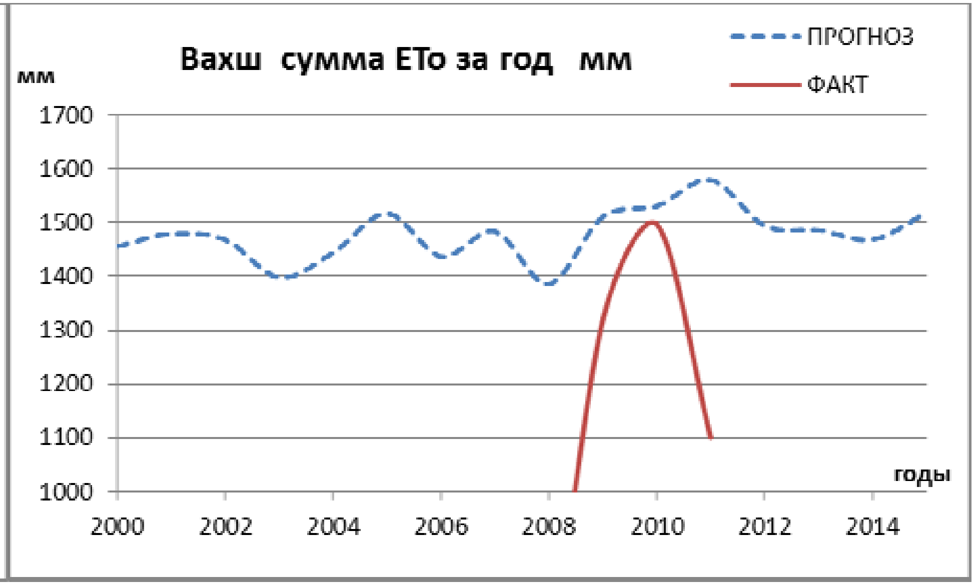
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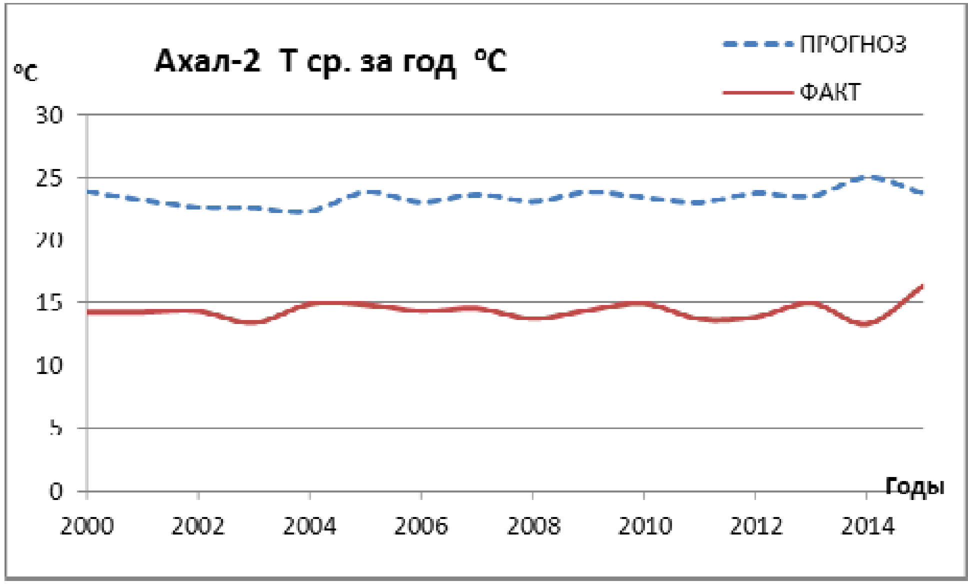
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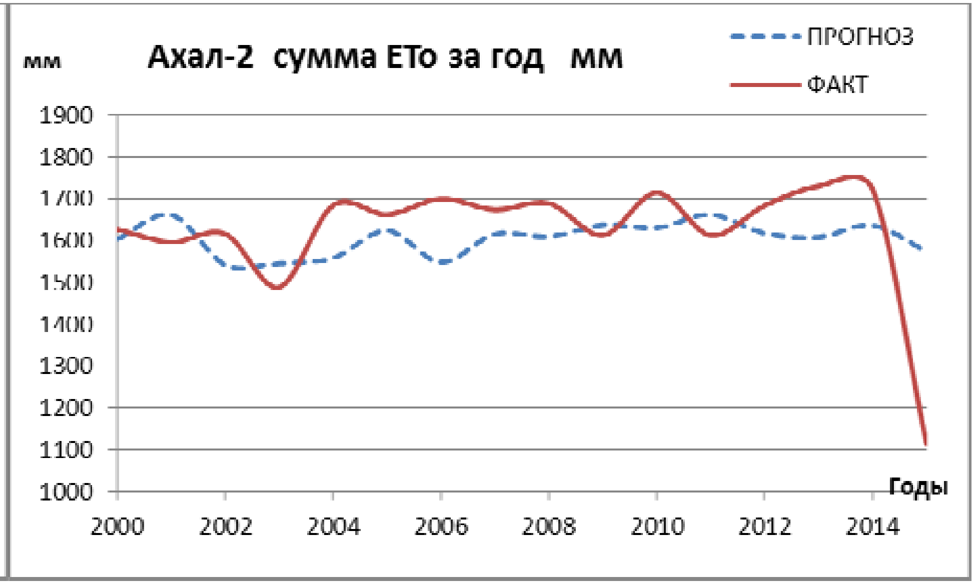
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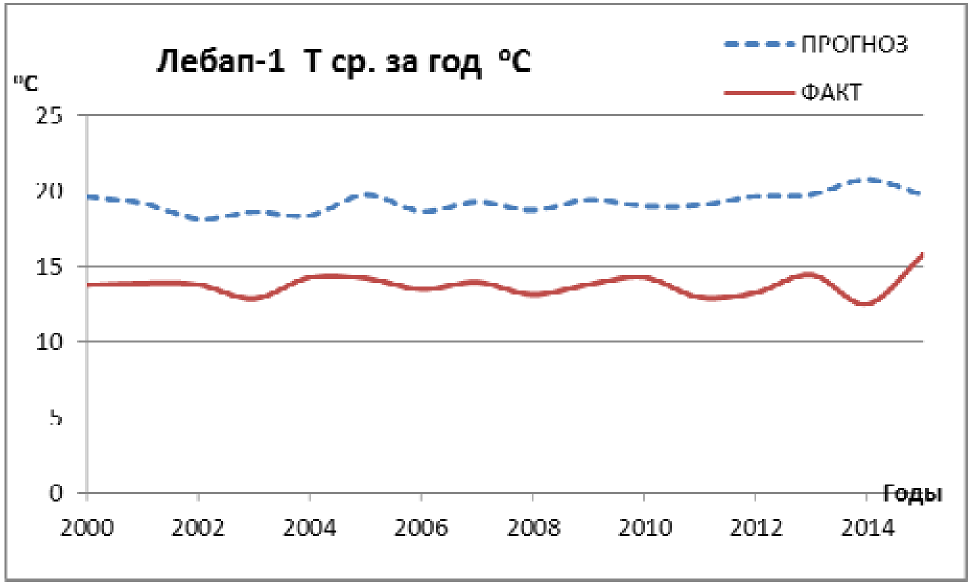
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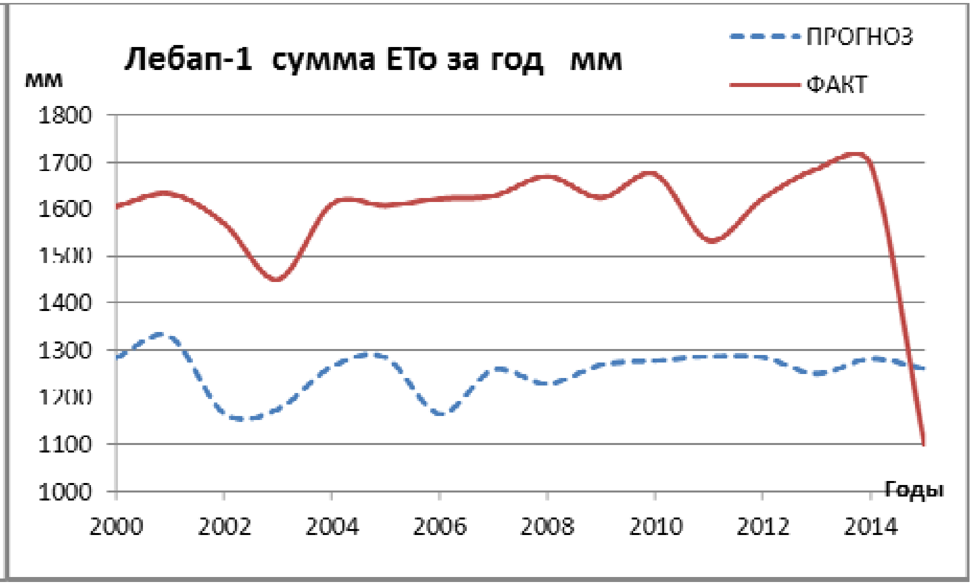
Годы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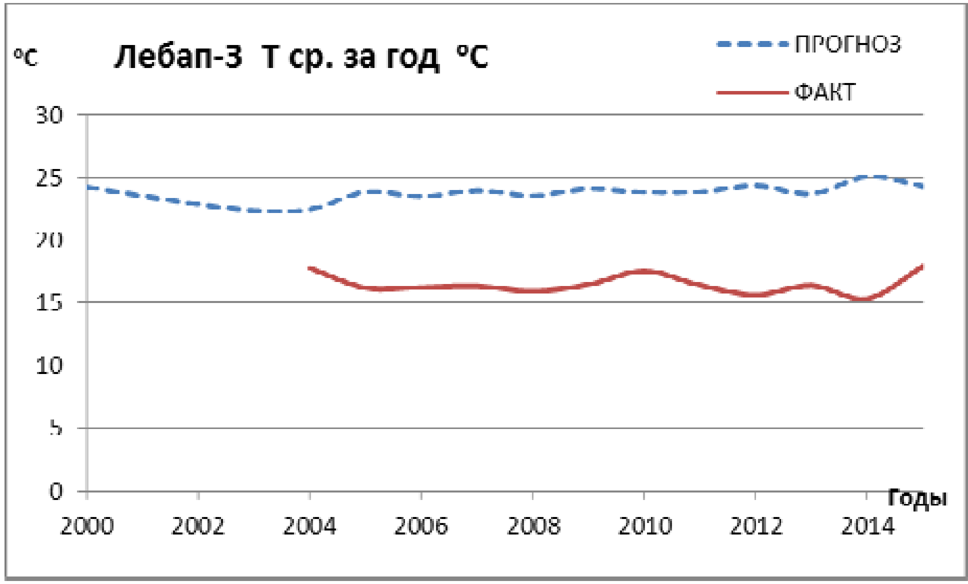
Годы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ФАКТ
°С
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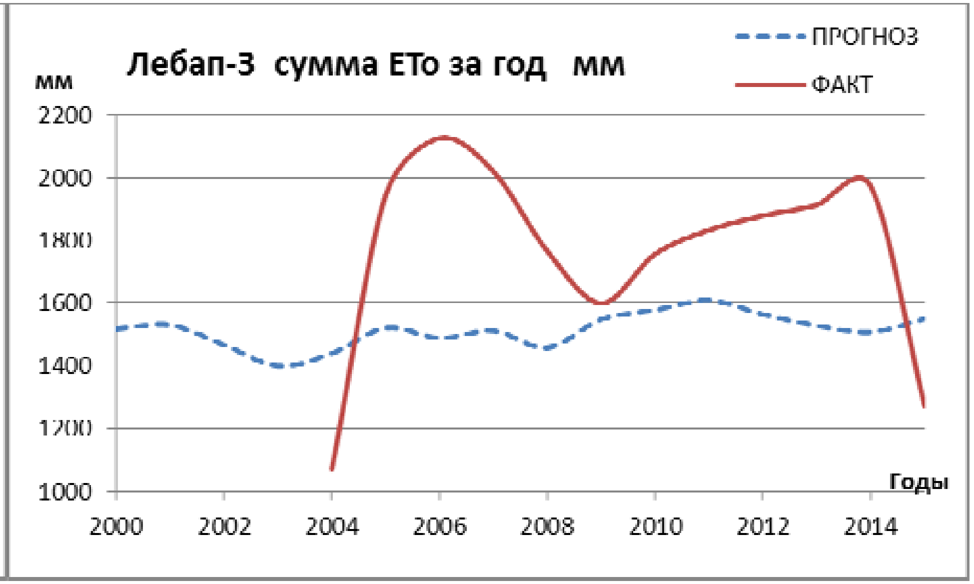
2010
2012
2014
Годы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ФАКТ
мм
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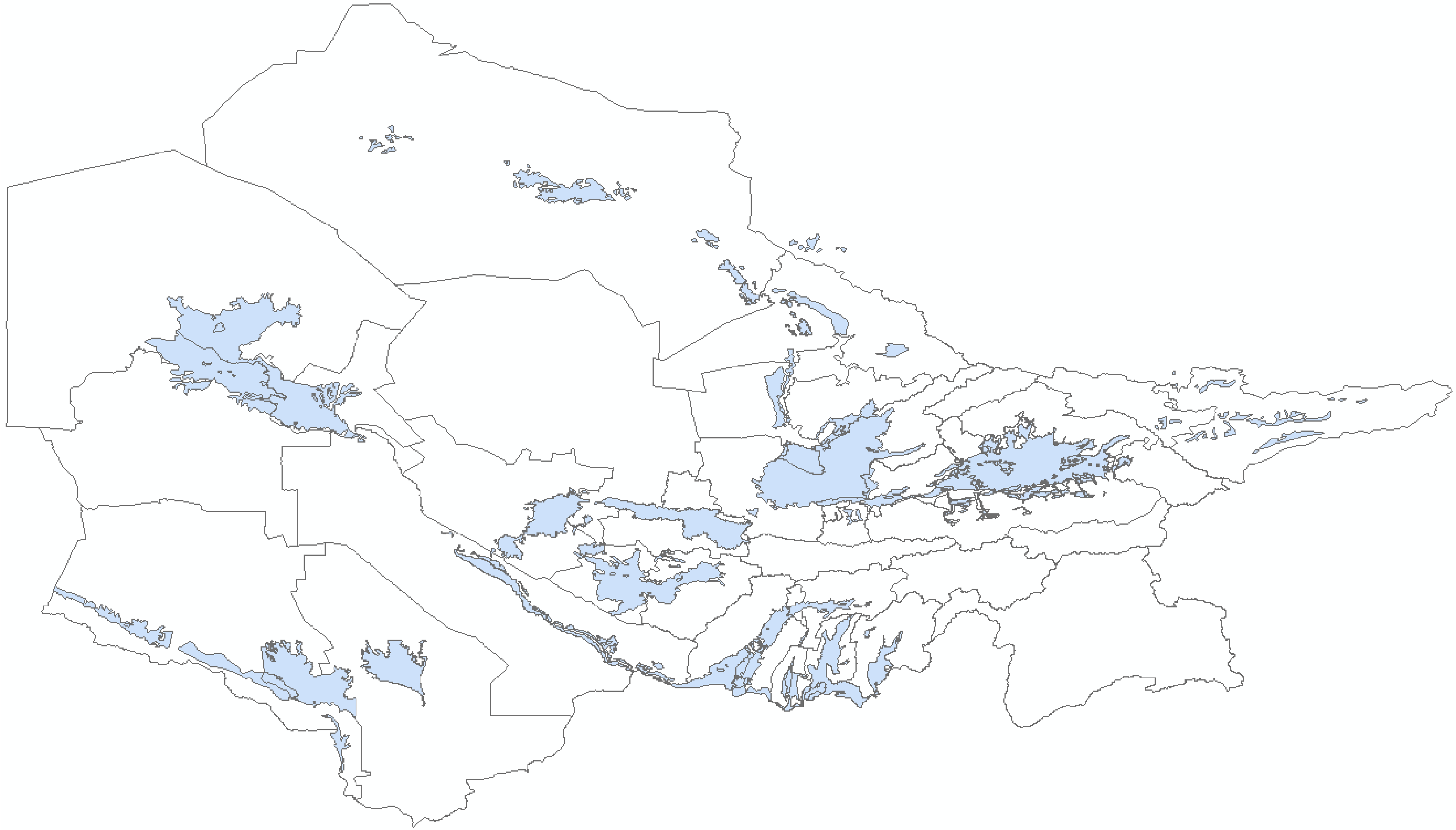
2014
Годы

The above graphs of comparison of average annual temperature and total annual evapotranspiration show that the REMO output is fairly correlated with the ground-based data from aeronautical meteorological stations. This can be used for calibration of the REMO model data when calculating crop water requirements.

ANNEX

CENTRAL ASIA IRRIGATED LAND

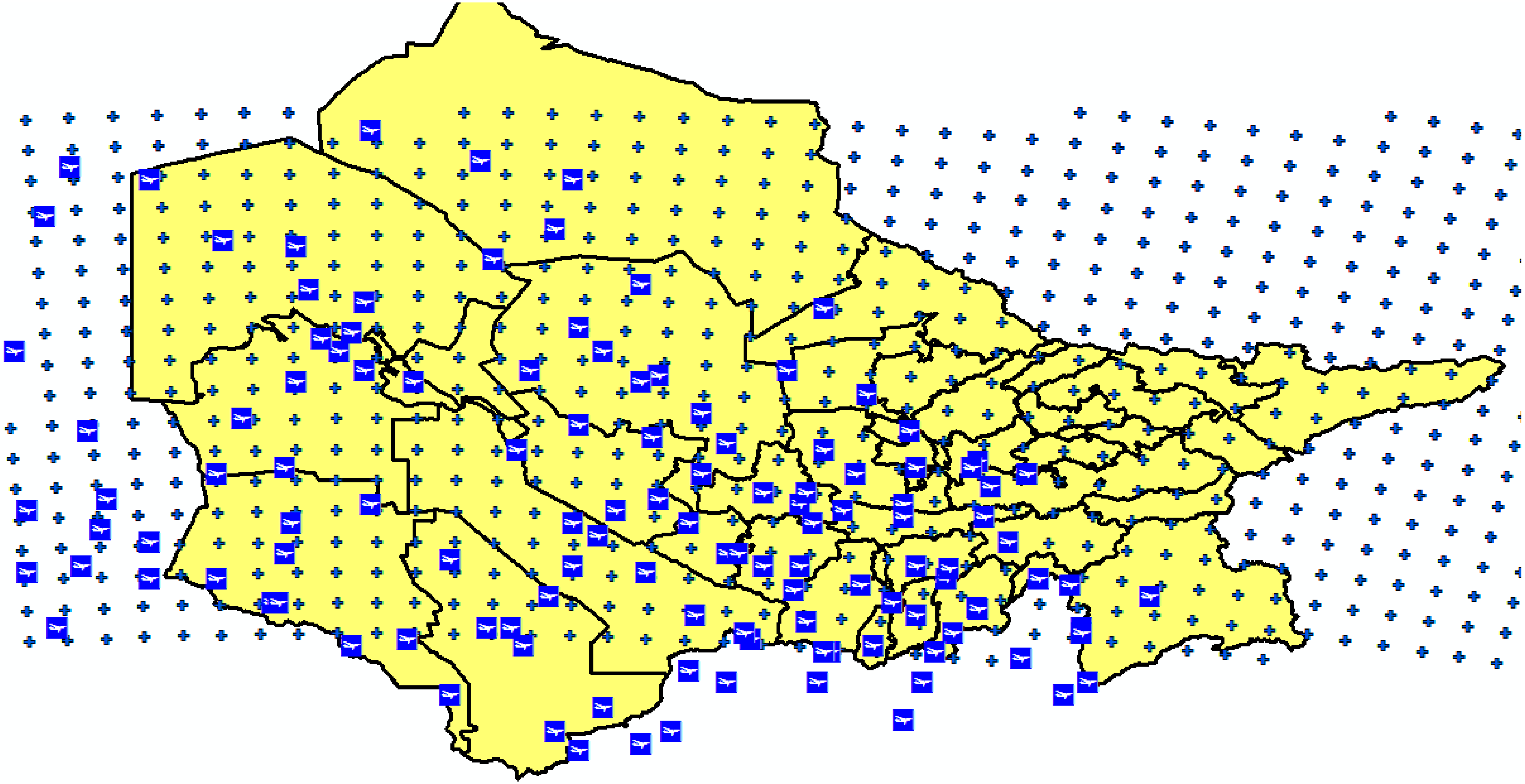


- Irrigated agriculture zones

Uncolored contours – Planning zones

SPATIAL LOCATION OF PEER PROJECT SITES

Annex 2

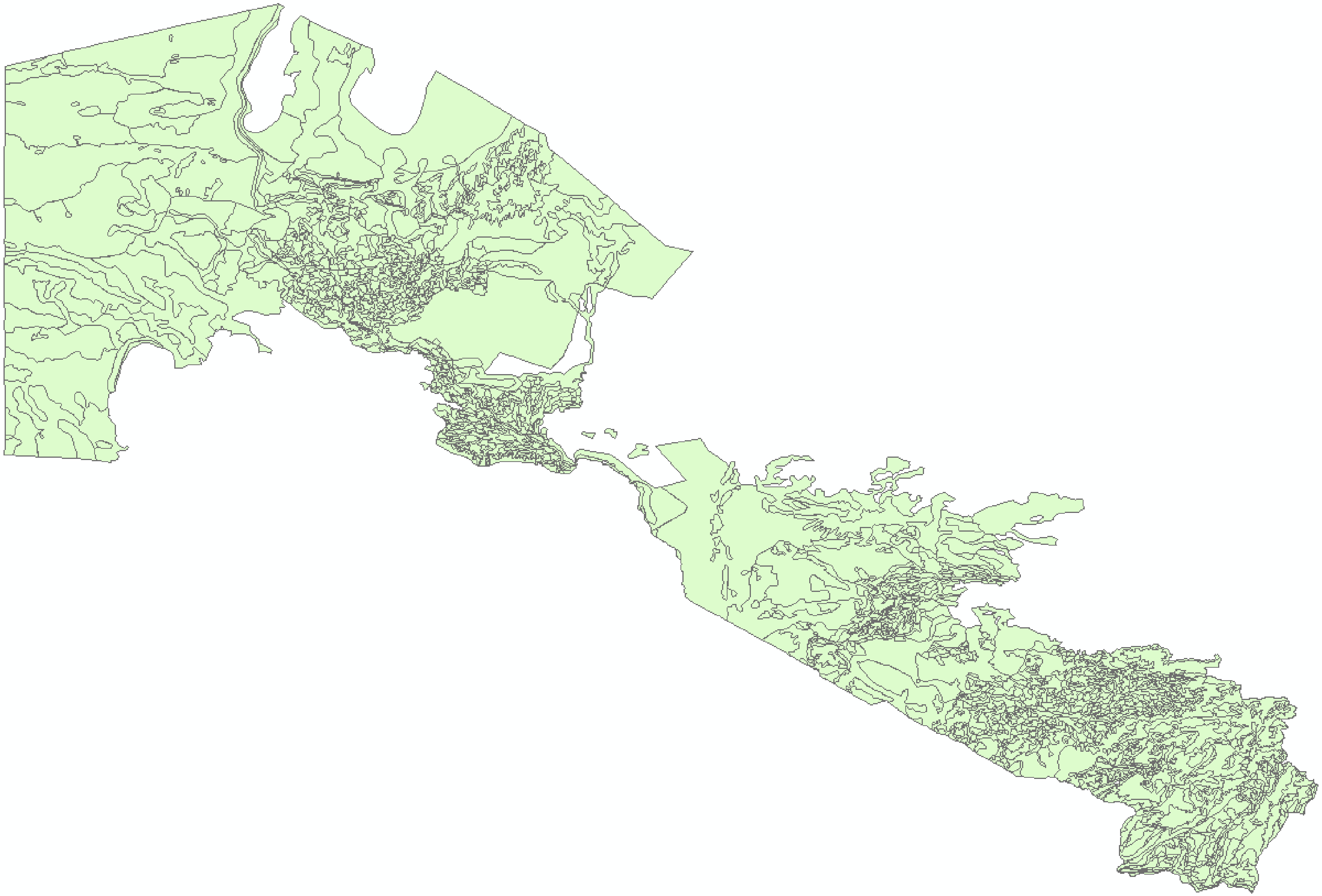


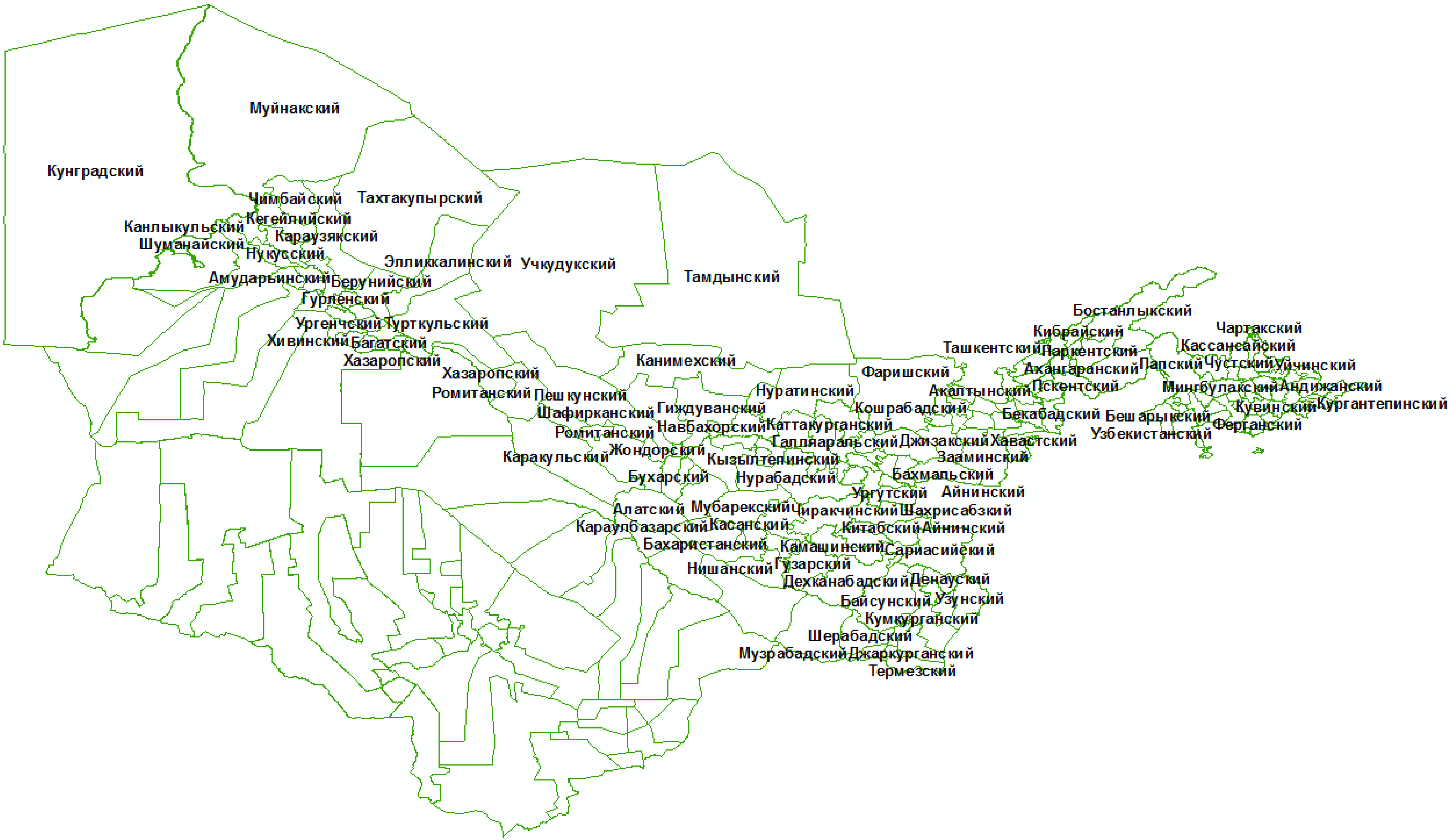
- REMO model nodes

- Aeronautical meteorological stations

- Planning zone contours

FRAGMENT OF SOIL MAP OF THE REPUBLIC OF UZBEKISTAN

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Чимбайский
Тахтакупырский
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Канлыкульский
Караузякский
Шуманайский
Нукусский
Элликкалинский
Учкудукский
Тамдынский
Амударьинский
Берунийский
Гурленский
Ургенчский
Турткульский
Хивинский
Багатский
Хазаропский
Хазаропский
Ромитанский
Пешкунский
Канимехский
Шафирканский
Гиждуванский
Ромитанский
Навбахорский
Каракульский
Жондорский
Бухарский
Нуратинский
Фаришский
Кошрабадский
Каттакурганский
Галляаральский
Джизакский
Хавастский
Кызылтепинский
Нурабадский
Заалминский
Бахмальский
Ургутский
Айнинский
Алатский
Мубарекский
Чиракчинский
Шахрисабзкий
Караулбазарский
Касанский
Китабский
Айнинский
Бахаристанский
Камашинский
Сариасийский
Нишанский
Гузарский
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Денауский
Байсунский
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Кумкурганский
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Музрабадский
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Термезский
Бостанлыкский
Кибрайский
Ташкентский
Паркентский
Ахангаранский
Акалтынский
Пскентский
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Кассансайский
Мингбулакский
Андижанский
Кувинский
Кургантепинский
Бешарыкский
Ферганский
Узбекистанский

FRAGMENT OF DATA ON TEN-DAY GROUNDWATER TABLE OVER 2011-2015

	A	B	C	D	E
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3	1706207	Бухоро	2012	1	2.67
4	1706207	Бухоро	2013	1	2.69
5	1706207	Бухоро	2014	1	2.62
6	1706207	Бухоро	2015	1	2.66
7	1706207	Бухоро	2011	2	2.68
8	1706207	Бухоро	2012	2	2.65
9	1706207	Бухоро	2013	2	2.59
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11	1706207	Бухоро	2015	2	2.64
12	1706207	Бухоро	2011	3	2.61
13	1706207	Бухоро	2012	3	2.60
14	1706207	Бухоро	2013	3	2.58
15	1706207	Бухоро	2014	3	2.49
16	1706207	Бухоро	2015	3	2.61
17	1706207	Бухоро	2011	4	2.51
18	1706207	Бухоро	2012	4	2.56
19	1706207	Бухоро	2013	4	2.50
20	1706207	Бухоро	2014	4	2.45
21	1706207	Бухоро	2015	4	2.43
22	1706207	Бухоро	2011	5	2.44
23	1706207	Бухоро	2012	5	2.53
24	1706207	Бухоро	2013	5	2.47
25	1706207	Бухоро	2014	5	2.52
26	1706207	Бухоро	2015	5	2.42
27	1706207	Бухоро	2011	6	2.44
28	1706207	Бухоро	2012	6	2.50
29	1706207	Бухоро	2013	6	2.48
30	1706207	Бухоро	2014	6	2.52