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В ежегодном издании Научного общества Тетис представлены статьи по теоретическим и прикладным вопросам географии, ГИС и космического зондирования. Издание рассчитано на географов, экологов, студентов и географов широкого профиля.

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Introduction

The heavy growth of the population, industry and agriculture in the twentieth century, especially in its second half, have reduced in sharp growth of anthropogenic loads on natural environment of the Aral region and to disastrous impoverishment of water resources. The ecological crisis, which basic sources are negative manufactured activities, strongly demands search of the measures compensatory negative consequences. As show theoretical studies and location observations, the processes of a change of state of natural-climatic environment of region tend to the long-lived latent periods, education of new systems of interaction, and are capable to accumulate huge power. Most the strong influence of an anthropogenic factor is supervised in the most saturated by life low layer of biosphere near to a demarcation of a dry land, water reservoirs and atmosphere. High movement and instability of the natural climatic processes defining the vital parameters for the human existence define this sphere.

The problem of an evaluation of the most probable physical-climatic consequences of anthropogenic loads for elaboration of optimal water using strategies in arid zones is aim in this elaboration. Realization of the given purpose of scientific probes is carried out through serial stages of an approaching to the solution of the main task:

I. Detail study of regularities of interaction a component of natural-climatic environment in vivo;
II. Secretion of the influences irrelevant with these processes, and their time-space analysis;
III. Forecast of possible changes of natural-climatic environment for different scenarios of economic activities and selection of optimal solutions.

The analysis of main routes in scientific geographical probes shows, that now the main centre of gravity falls at study the delicate interactions of a climate and a underlying terrain, which determine their local features and on scales are commensurable with the modern influence of human activity. The method of classification of temperature-humidifying parameters of a climate is applied for detection and a quantitative assessment of such regularities on types of landscape.

Classification of climatic indexes

General principles

Basis of landscape classification temperature-humidifying parameters was the concept about close correlation of the natural environment and a climate. Its major principles are found out in the certain interrelation of landscapes and a climate both as natural-climatic zones, and as mountain high-altitude zones. That idea has been realized by the way numerous indexes and precipitation-evaporation ratios, dryness and aridity, which at a semiempirical level established the quantitative correlations between thermal and humidifying characteristics.

One more basis of now researching has become submission about the climatic characteristics as about some spectrum of more simple parameters specified by the causes of a miscellaneous scale: global, regional, and local. At such approach, each component is isolated from statistically representative extract of climatic parameters, the statistical analysis of its interrelations with elements of a underlying terrain is executed and verified on availability synergetic interrelation between them implements. Then decisive algorithms are made.

With this purpose the climatic database on 4300 meteorological stations of Asia, Africa and Europe in ranges gathered and parsed:

- from 5 degrees of Southern latitude up to 80 degrees of Northern latitude;
- from 18 degrees of Western longitude up to 150 degrees of Eastern longitude;
- from -150 up to 5023 m above sea level.

Main criteria at its integration was availability of most full enumeration of the basic types of the underlying terrain conforming to him of volume and quality of climatic indexes and concomitant landscape information.

For study the main water-balance parameters - an air temperature, precipitations and evaporation for the seasons have been elected:

- Winter (XII-II months);

- Spring (III-V months);
- Summer (VI-VIII months);
- Autumn (IX-XI months);
- Average annual.

Method of classification

The analysis of heat-balance equation, which describes a condition of a underlying terrain,

$$R + P + L^* E + B = 0,$$

where

R - radiation balance;

P - turbulent heat exchange between an active surface and air;

L - specific heat of evaporation (condensation);

E - quantity of evaporated (condensed) water;

B - heat exchange between an active surface and subjacent substrates.

The analysis shows, that the component of heat input on vaporization and condensation plays very large role and it is the most volatile parameter of an equation both on a mark, and on an absolute value. In conditions more or less homogeneous radiation modes given component also determines a diversification of local climates. At the conforming organization of the analysis has appeared possible quantitatively to evaluate influence of costs of transmission of latent heat on distribution of temperatures of ground air. Therefore essentially an important point of probe were optimal grading of types of a underlying terrain on degrees of their humidity and correct selection of background type of a underlying terrain, concerning which in consequent temperature deviations, were determined.

For different types of a underlying terrain in the capacity of categorizing values of hydrothermal parameters of a climate – precipitation-evaporation ratio of Mezentsev [1] and aridity index of De Martonn [2], which were modified for the taking into account of altitude influence. After corrective action, assumption formulas have a following view:

1) Mezentsev modified precipitation-evaporation ratio [3]:

$$\mathrm{K}_y = \frac{W_i \cdot e^{-0,343 \cdot \frac{Hi}{Ti}}}{0.2 \cdot \sum t_{+10°C} + 306},$$

where

W_i – sum of precipitations for year, *(mm)*;

H_i – altitude of meteostations above sea level, (*m)*;

T_i – average annual temperature of a layer of air in the interval from *0* up to H_i в in absolute degrees;

$\sum t_{+10°C}$ – sum of air temperature above +10 °C.

2) Modified aridity index of De Martonn [3]:

$$I_a = \frac{W_i}{t^* + 10^\circ C},$$

where

$$t^* = 235 * \lg \frac{E_i}{6.1} \Big/ \left(7.45 - \lg \frac{E_i}{6.1}\right), \qquad (1)$$

where

t^* – efficient air temperature in Celsius degrees for altitude – H_i,;

W_i – sum of precipitations for year *(sm)*;

E_i – average annual evaporability *(mm)* for altitude– H_i .

By results of cluster analysis are determined seven of significant discriminating between themselves groups of climatic conditioned gradations of humidifying for types of a underlying terrain (Table 1).

Table 1. Hydrothermal coefficients for types of vegetation

Gradations of humidifying on groups of underlying terrain types	K_y			I_a		
	min	max	avrg	min	max	avrg
1 Desert	0.0	0.2	0.1	0.0	2.2	0.7
2 Semidesert	0.2	0.5	0.3	0.8	3.2	1.5
3 Savannah, dry steppe	0.3	0.7	0.4	1.5	4.7	2.5
4 Meadow-steppe, forest-steppe, forest-meadow-steppe, including mountain	0.4	0.9	0.6	2.3	5.7	3.9
5 Meadow-bush, dry deciduous forests of subtropical and tropical zones, including mountain	0.5	0.9	0.7	2.3	5.8	3.9
6 Conifers and deciduous forests of a moderate belt, a meadow and tundra, a wood and bushes of a subtropical zones, the wet ever-green forests of tropical zone, the mountain conifers, coniferous and broadleaved woods of tropical zone	0.7	6.4	1.4	3.6	42.1	7.6
7 Glacial surfaces in the ablation zone	0.92	4.39	2.12	5.46	28.86	11.80

The calculated values of the modified hydrothermal coefficients are characterized by high mutual correlation r=0,94 and arithmetic means I_a/K_y=5,6. Standard deviation of their relation is equal σ=±0,32.

Air temperature

For the first time the method of landscape-climatic classification had been applied by the writer at the impact analysis of a underlying terrain on distribution of thermal parameters of climate [3]. At such approach, the air temperature was considered as an integral parameter of a spectrum of interacting factors: latitude, altitude, zonal, azonal and anthropogenic, which has the development in different types of vegetation and soil and influence of water surfaces.

The visual analysis for distributions of air temperatures on longitude, latitude and altitude shows (Figure 1, Figure 2, Figure 3) that the latitude factor is master (Figure 2).

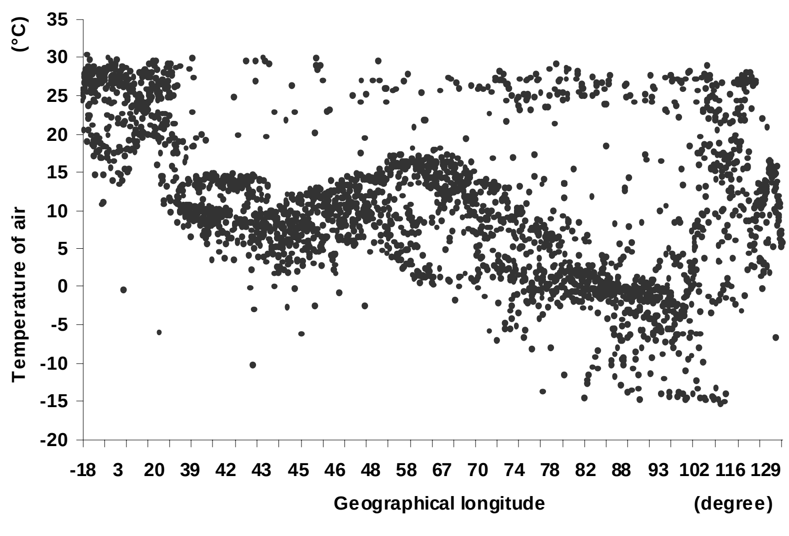

Figure 1. Distribution of average annual air temperatures on longitude

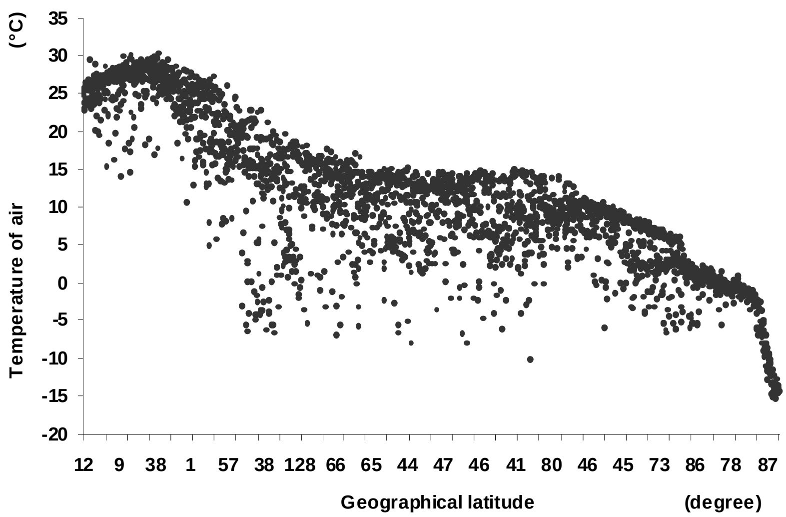

Figure 2. Distribution of average annual air temperatures on latitude.

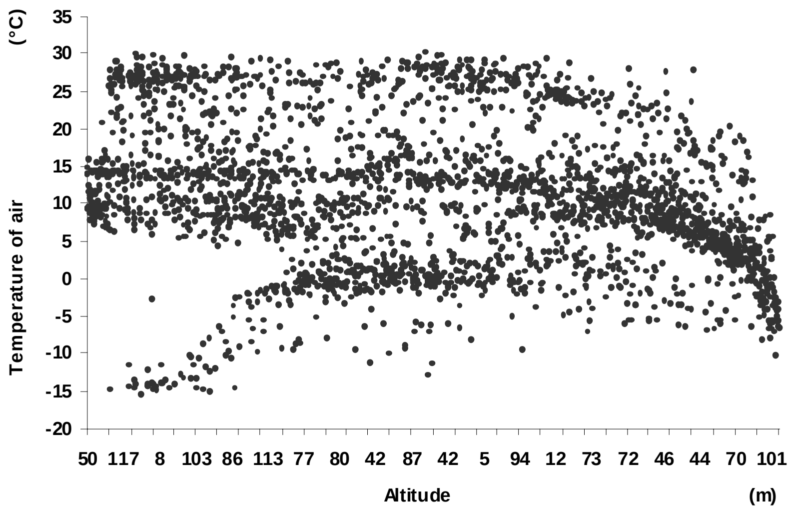

Figure 3. Distribution of annual air temperatures on altitude.

The large dispersion of a natural latitude trend at $\sigma = \pm 5.7°\boldsymbol{C}$ does not allow to use available data for calculations. Therefore, their preselection executed.

For a quantitative assessment of influence of the latitude factor in the capacity of background values of temperatures in smoothing landforms for arid types of vegetation, not complicated by additional influences are adopted. Such conditions are defined not only the least values of hydrothermal coefficients, but also the least variability. A background latitudinal distribution for the meteorological stations located in a flat land for arid types of vegetation on seasons have been approximated by polynomial regressions (Figure 4) with elimination of the values, which are not falling in a range $\pm 2\sigma_l$. Standard deviations of approximating have limit $\sigma_l = \pm 1.1$ ч ± 1.4°C.

The evaluation of seasonal distributions of air temperatures on altitude was realized under following scheme:

- for calculation of an equation the meteorological stations located in smoothing forms of a mountain relief - intermountain walleyes and intermountain depressions of arid types of vegetation were involved;
- altitude trends were calculated for air temperatures with the eliminated designed background latitudinal distributions.

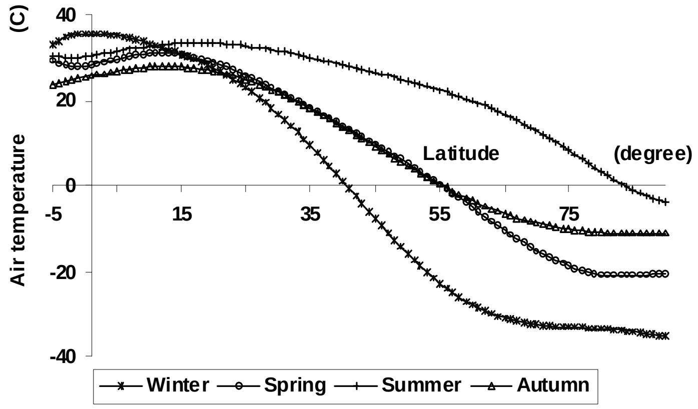

Figure 4. Calculated of background distribution seasonal for air temperatures on geographic latitude.

The extrapolation of trends for altitude more than 5000 m by formula is executed:

$$T_i=(H_e-H_{abs})*t_e+T_f,$$

where

H_e - altitude in zone of extrapolation;

H_{abs} - altitude of high part of empirical zone dependence;

t_e - constant value of altitude thermal gradient in the upper range of the diagram;

T_f - background value of air temperature fitted on latitude on high part of an empirical zone dependence, equal 5000 *m*.

Background distributions of "residual" seasonal temperatures of air on altitude are approximated by polynomial regresses (Figure 5) for standard deviation $\sigma_a = \pm0.7 \div \pm1.1$°C.

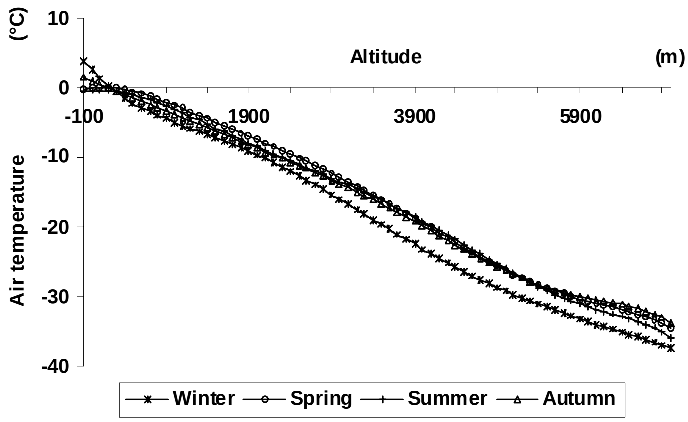

Figure 5. Calculated background distribution of seasonal air temperatures on altitude.

For the count of influence of a relief on a temperature regime all diversity is shown to two types, grouped on altitude tiers:

1. Smoothing relief - plains, poorly inclined piedmont plains, intermountain valleys and depressions of all altitude tiers and mountain plateau;
2. Broken relief - mountains ridge, tops, picks, and passes, slopes, bottoms of narrow mountain valleys.

After elimination of influence of latitude and altitude of value of "residual" temperatures, grouped on gradations of humidifying, are subjected to complex dispersion analysis.

Comprehensive analysis of seasonal temperature parameters on the meteorological stations, not entered in parameters climatic conditioned types of landscape, has allowed supplementing available relations intrazonal and/or anthropogenic factors, and the factor of influence of water surfaces.

Results have shown absence of the composite synergetic interactions and have been interpreted as hierarchically organized regularities connecting a seasonal temperature regime with elements of a underlying terrain.

Codification of elements for underlying terrain formed on the basis of grading types of vegetations, soils (Table 2,Table 3 , Table 4, Table 5, Table 6, Table 7) and grading of types of relief (Table 8):

In more detail, technology of codification of types of a underlying terrain is described in activities [3, 4].

Table 2. Climatic conditioned types of vegetation.

Codes	Description of types of vegetation
100000	Deserts
200000	Semi deserts
300000	Savannas
320000	Dry steps
350000	Meadow–steps
400000	Forest–steps
450000	Mountain forest–meadow–steps
500000	Meadow–bushes, including mountain
550000	Dry fall–of–leaf woods of subtropical and tropical zones
600000	Coniferous woods of temperate zone, including taiga
650000	Fall–of–leaf woods of temperate zone
700000	Meadows, including alpine, tundra, including mountain
750000	Woods and bushes of a subtropical zone
800000	Raining woods of a tropical zone
850000	Mountain coniferous–leaf and coniferous woods of a tropical zone
890000	Glacial surfaces in the ablation zone

Azonal types of a surface are submitted intrazonal and anthropogenic changed types of vegetation and influence of water surface.

Table 3. Anthropogenic changed types of landscapes.

Codes	Description of types of landscapes
0	Is absent
3200	Cereal crops (wheat, rye, oats)
3500	Corn, sunflower, fruits and berries, vegetables and fodder grass
7000	Cotton, sugar beet, melons and gourds
8700	Rice
9400	Inhabited localities
9600	Average cities
9800	Large cities

Table 4. Intrazonal types of soils.

Codes	Type of soils
0	Is absent
11000	Takyr
32000	Meadow dried salty soils, alluvial-meadow dried salty soils, takyric solonchak
35000	Meadow-brown soils, meadow salty soils, alluvial-meadow salty soils, meadow-swampy dried salty soils, usual solonchak, meadow solonchak, seaside solonchak, march solonchak, secondary solonchak
55000	Alluvial forest-meadow dried soils
70000	Meadow-swampy salty soils, swampy salty dried soils, alluvial swampy dried salty soils, seaside swampy dried soils
75000	Alluvial forest-meadow soils, alluvial meadow-swampy soils
35000	alluvial meadow-swampy dried salty soils
86000	Swampy salty soils, alluvial swampy soils, seaside swampy soils, shor solonchak

Table 5. Influence of water surfaces.

Codes	Description of types of vegetation
0	Is absent
100	Zone of the minimal influence of reservoirs
200	Zone of average influence of reservoirs
300	Zone of the maximal influence of reservoirs (shores of seas and lakes)
400	Water surface of reservoirs, lakes and seas (off shore).
500	Water surface of reservoirs, lakes and seas (far off shore).

Table 6. Intrazonal types of vegetation.

Codes	Description of types of vegetation
0	Is absent
10000	Deserts
11000	Takyrs
20000	Semideserts
30000	Savannas
32000	Dry steps
35000	Meadow–steps, solonchaks
40000	Forest–steps
45000	Mountain forest–meadow–steps
50000	Meadow–bushes, including mountain
55000	Dry fall–of–leaf woods of subtropical and tropical zones, tugay drained forests
60000	Coniferous woods of temperate zone, including taiga
65000	Fall–of–leaf woods of temperate zone
70000	Meadows, including alpine, meadow-marsh, march solonchaks, tundra, including mountain
75000	Woods and bushes of a subtropical zone, tugay forests
80000	Raining woods of a tropical zone, marshes
85000	Mountain coniferous–leaf and coniferous woods of a tropical zone
86000	Marshes, shor solonchaks
89000	Glacial surfaces in the ablation zone
90000	Glacial drifts, slide-rocks
91000	Rocks

For natural complexes of Syrdarya River basin, it has been developed the system of codification submitted below soils with using of the data soil mapping for the purpose of modelling.

Table 7. Anthropogenic changed types of soils.

Codes	Type of soils
3200	Brown desert irrigated soils, takyr-like irrigated soils
3500	Meadow irrigated soils
8700	Rice-swampy soils

Natural complexes can have the complex structure submitted by types of the spreading surface of the different order of hierarchy. Depending on a level of an enclosure calculation of codes for climatic caused and intrazonal types of vegetation or types soils is carried out under the general scheme:

$$COD_I = ((100 - Q2 - \ldots QN)*a + Q2*b+\ldots +QN*n)/100*N,$$

where

Q – value of percentage of type soils in n-th an investment;

a – code of belonging of type soils the first level of an investment;

b – code of belonging of type soils the second level of an investment;

n – code of belonging of type soils the n-th level of an investment;

N – amount of nonzero (absent) values of types soils.

Table 8. Types of relief.

Codes	Description of types relief on high-altitude tiers	Range of altitude (m)
SMOOTHING RELIEF:		
10	Plain *(incline 0 – 6°, exceeding of altitude 0 – 30m)*	0-600
5000	Foothill some slanting plains *(incline 7 – 12°, exceeding of altitude 0 – 50m)*	0-900
Intermountain depressions *(incline 0 – 10°, exceeding of altitude 0 –50m)*:		
100	Intermountain depressions of the bottom tier	0-1200
105	Intermountain valleys of the bottom tier	0-1200
200	Intermountain depressions of an average tier	1201-3000
205	Intermountain valleys of an average tier	1201-3000
300	Intermountain depressions of the top tier	> 3000
305	Intermountain valleys of the top tier	> 3000
BROKEN RELIEF *(incline > 15°)*:		
6000	Low-mountainous a relief, including small hills (*exceeding of altitude 50 – 200m)*	0-1200
7000	Middle-mountainous deeply broken relief of 1-st subtier (*exceeding of altitude 400 –*	1201-1600
7050	Middle-mountainous smoothed relief of 2-nd subtier (*exceeding of altitude 200 – 600m)*	1601-3000
8000	High-mountainous deeply broken periglacial relief (*exceeding of altitude 400 – 1500m)*	3001-4000
8050	High-mountainous middle broken glacial relief (*exceeding of altitude 200 – 800m)*	> 4000

If calculated value of COD_I is not equal to one of tabulated values it is accepted equal to the nearest tabulated value.

Influence of water surface pays off from a coastal line under formulas:

1. For the seas and oceans

$$COD_{500} = -0.04*(L + W),$$
$$COD_{400} = -0.02*(L + W),$$
$$COD_{200} = 0.04*(L + W),$$
$$COD_{100} = 0.12*(L + W),$$

Limiting distance for COD_{100} no more than 200 km from a coastal line.

2. For lakes

$$Cod_{200} = 0.10*(L + W),$$
$$Cod_{100} = 0.25*(L + W),$$

Limiting distance for Cod_{100} no more than 10 km from a coastal line.

3. For the rivers and channels

$$cod_{200} = 1.5*W,$$
$$cod_{100} = 4.0*W,$$

where
L – length of a reservoir;
W – width of a reservoir.
Limiting distance for cod_{100} no more than 3 km from a coastal line.

Quantitative assessments of distributions in a dispersion complex have formed the basis for argument of regularities between the revealed components of underlying terrain and residual values of temperature parameters. As a matter of convenience, their submissions and visualization were presented one-dimensional projections of arithmetic averages studied performances for each factor at a locked position of all remaining. Values of temperatures for conditions of ultraarid type of vegetation and smoothing relief are determined in the capacity of reference point. They are accepted equal to zero, and values on other gradations of all factors are shown as deviation from these of values of reference points.

The contribution of climatic conditioned types of vegetation in a seasonal thermal mode has appeared highest of all a component of underlying terrain (Figure 6) and concedes only to influence of the latitude and altitude factor. Standard deviations of approximating lay within the limits $\sigma_{cl} = \pm 0.5 \div \pm 0.9$°C.

The contribution ruggedness of relief in a thermal mode on seasons (Figure 7) shows small relative reduction of temperatures in a broken relief in comparison with smoothing relief. It reflects condition of atmosphere circulation in a mountainous country, which promotes the best ventilation of mountain slopes and to generation of adiabatic processes in intermountain reductions.

Corrections for types of relief are defined by smalls values at the high significance and consequently they stability influence on distribution of temperature parameters in a mountainous territories. Standard deviations on seasons $\sigma_{tr} = \pm 0.3 \div \pm 0.6°C$.

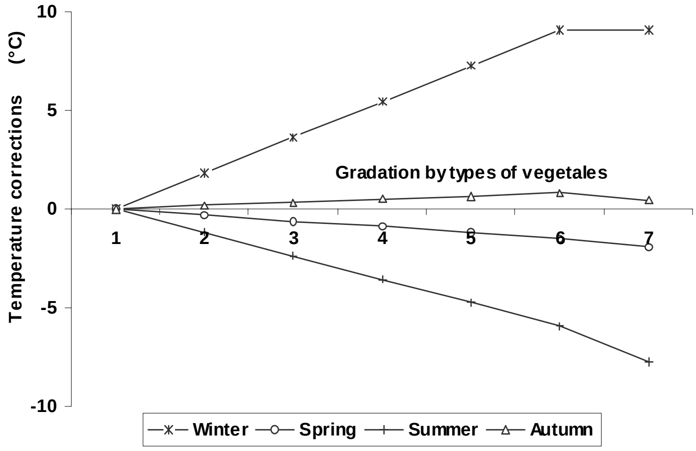

Figure 6. Influence the climatic caused types of humidifying on distribution of temperatures of air. (Symbols see Table 2)

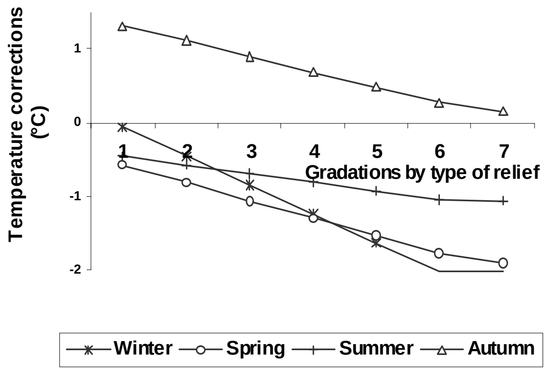

Figure 7. Influence of brokenness relief on distribution of air temperatures (Symbols see Table 8).

The temperature values, which are not including in, a confidence interval of climatic conditioned, have been interpreted as influence intrazonal, anthropogenic factors and influence of water surfaces. Their contribution is determined as deviations of thermal parameters from conforming climatic conditioned types of humidifying.

For an evaluation of relations following classification on gradations intrazonal and/or anthropogenically conditioned humidifying has been developed:

1. climatic conditioned type of vegetation;
2. solonchaks and takyrs;
3. intrazonal deserts;
4. intrazonal semideserts;
5. intrazonal dry steppes and/or crops;
6. intrazonal meadow-steppes and/or fodder grasses;
7. intrazonal meadow-bushes, bottomland forests and/or cottony fields;
8. intrazonal marshes, bogs, and/or rice fields;
9. cities.

Integrated trends of intrazonal and anthropogenic influence on thermal mode are shown below (Figure 8, Figure 9)

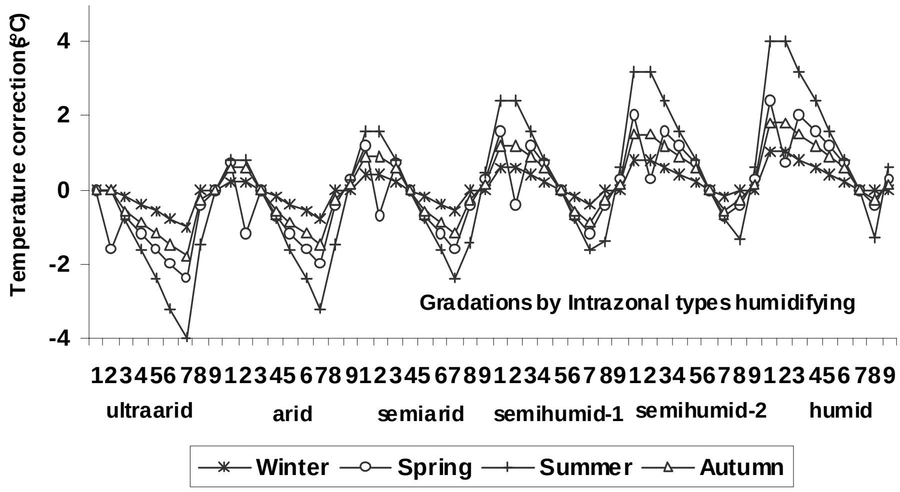

Figure 8. Influence of intrazonal types of a underlying terrain on seasonal air temperatures (Symbols see Table 2.).

Standard deviations of approximating have limits $\sigma_{in} = \pm0.5 \div \pm0.9$°C.

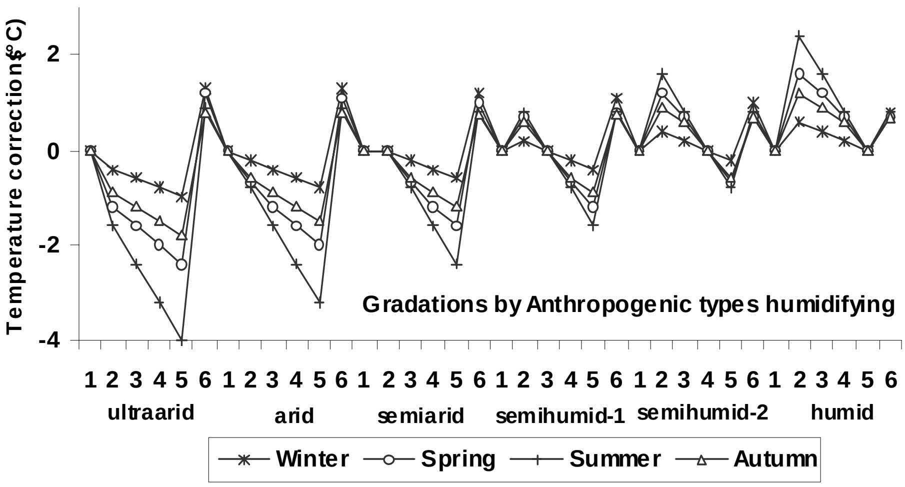

Figure 9. Influence of anthropogenically changed types of a underlying terrain on seasonal air temperatures (Symbols see Table 2).

Standard deviations of approximating have limits $\sigma_{an} = \pm0.8 \div \pm1.1$°C.

For an evaluation of influence of water surface of lakes and seas on formation of seasonal temperatures of a meteorological station are assorted on a degree of their remoteness from water reservoirs, which is determined in each concrete event at data analysis of neighbouring meteorological stations (Figure 10):

1. climatic conditioned zone of vegetation (zero line on the regime);
2. zone of minimum influence of water reservoirs;
3. zone of resistant influence of water reservoirs;
4. zone of maximum influence of water reservoirs;
5. water surface of lakes and seas.

Influence of water surface on a thermal mode shows accumulative effect of water on a background of climatic conditioned types of underlying terrain. With reference to the winter season, given conclusions are corrected only for areas, where at this time of year there are ice-free water spaces. In the same place, where water reservoirs are covered with ice, in accordance with increase of width of a fast ice the temperature effect "moving aside" a coastline show. Thus, ice is a barrier interfering active heat exchange between water and air and essentially smoothes temperature influence of reservoirs.

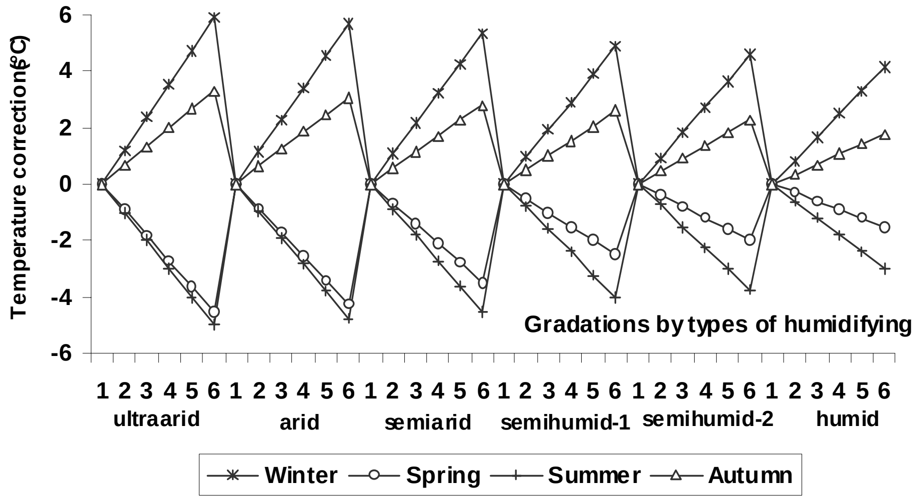

Figure 10. Influence of water surfaces of surface on seasonal air temperatures (Symbols see Table 2).

Standard deviations of approximating have limits $\sigma_{an} = \pm 0.4 \div \pm 0.7°C$.

Summarizing standard deviation of an evaluation of a spacing of seasonal air temperatures is designed by formula:

$$\sigma_r = \frac{\sum_i^k \sigma_i}{k} = \pm 1.3 \div 2.1°C$$
,

where

σ_I - partial standard deviations under analyzed factors;

k - number of partial standard deviations

They are equal for seasons: Winter = ±2.1°C; Spring = ±1.3°C; Summer = ±1.6°C; Autumn = ±1.4°C.

Precipitations

Precipitations are the most volatile climatic index, which hardly depends not only on conditions of common moisture transport, but also from local features of orography (Figure 11, Figure 12, Figure 13).

At the visual analysis of different distributions for the precipitations obtained on meteorological stations of database it is visible, that only in distribution of precipitations on latitude some tendency complicated with influences of the higher order is tracked (Figure 12).

The method of landscape grading has been applied for reduction of general high variability of precipitations on latitude. The essence of it comprised in following.

- For an evaluation of distribution of dispersions all latitude range has been split on intervals by step of 5 degrees, on which statistical parameters estimated.
- Because of a trace amount of meteorological stations on the interval, more than 60 degrees of northern latitude here have been adopted step, equal 10 degrees of geographic latitude.
- From the analysis of two stations with extremely high values of an annual precipitation have been eliminated: Cherrapunji - 10902 mm/year and Debundza - 9655 mm/year. It has been conditioned, that too the trace amount of basic data in this range of values of a precipitations has not allowed making safety enough conclusions.

The method of cluster analysis had been determined types of vegetation with statistically significant distinctions in a latitudinal distribution of annual precipitations. Data with close values have been grouped for five types of humidifying:

1. ultraarid;
2. arid;
3. semiarid;
4. semihumid;
5. humid.

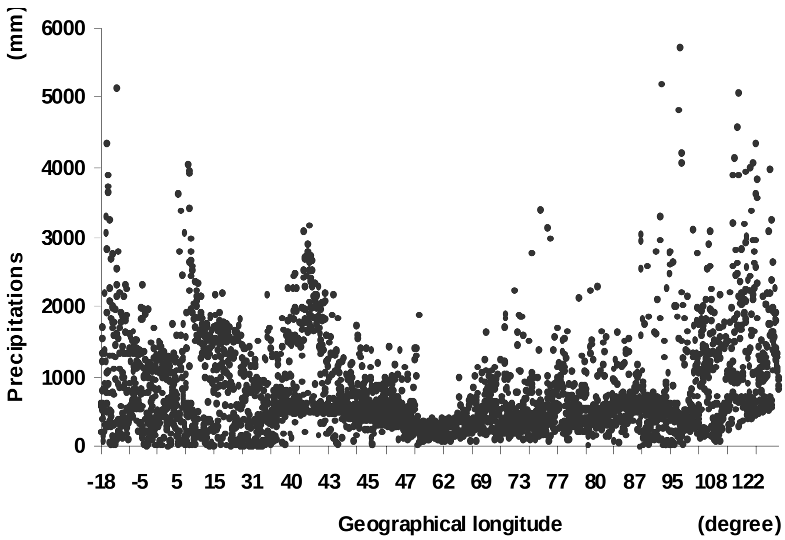

Figure 11. Distribution of annual precipitations on longitude.

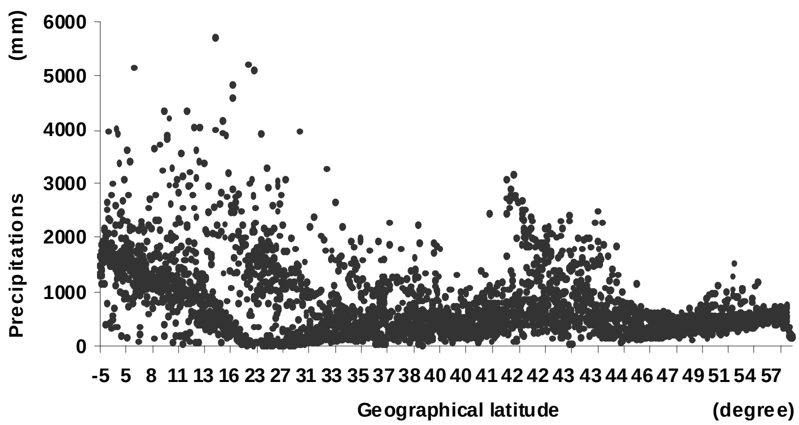

Figure 12. Distribution of annual precipitations on latitude.

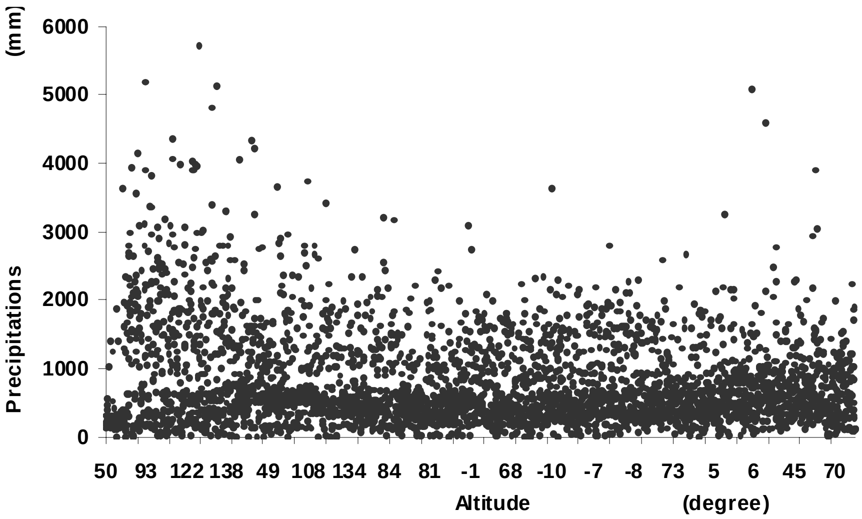

Figure 13. Distribution of annual precipitations on altitude.

Comparison of parameters of mixed distribution of precipitations (Figure 12) and categorized distributions is shown below (Figure 14).

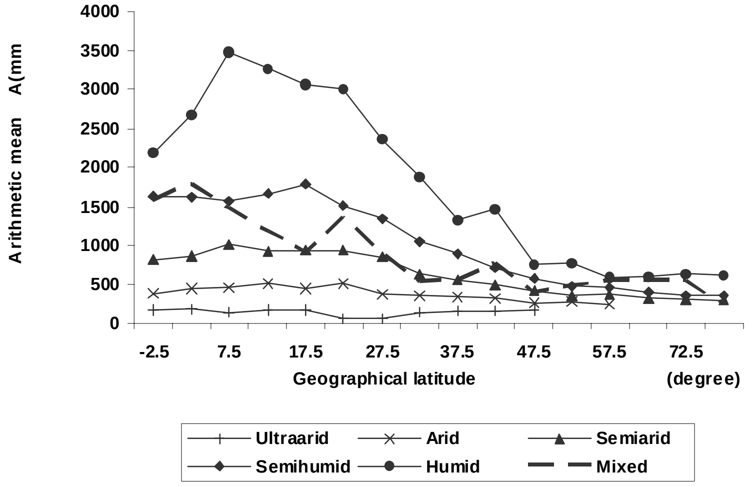

Figure 14. .Distributions of arithmetic means of values of annual precipitations on latitude and types of humidifying.

The cluster analysis has revealed significant difference for distribution of precipitations (Fisher's ratio test more than 99 %) as between undivided distribution of precipitations and classifying types of climatic conditioned humidifying (Figure 14). Standard deviations for mixed distribution of precipitations almost always is more, than even for most changeable precipitations of humid type and is much greater, than for remaining types (Figure 15).

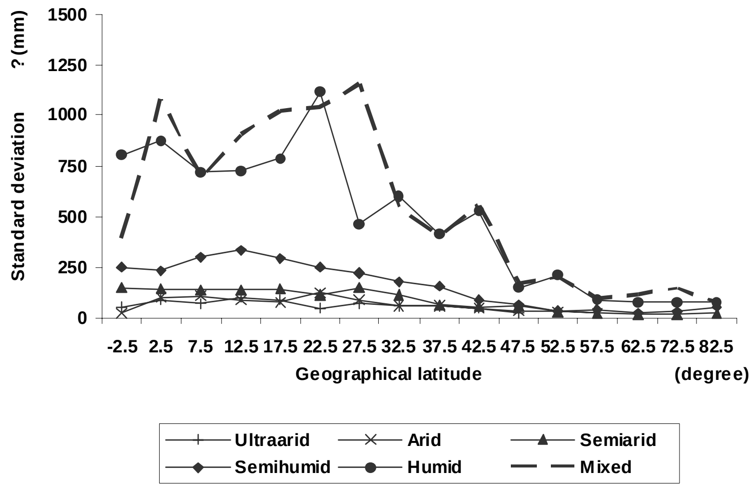

Figure 15. Distributions of standard deviations for annual precipitations on latitude and types of humidifying.

The analysis of relations of standard deviations to average values of precipitations demonstrates the considerable reduction of dispersion after grading precipitations for types humidifying (Figure 16).

Comparison of trend on latitude classifying precipitations with mixed distribution shows, that average values of mixed distribution reflect relative weight of each type of humidifying in the given latitude interval.

By results of grouping of polynomial trends of relation of precipitations from geographic latitude have been designed (Figure 17).

For assessment of influence of altitude on distribution of precipitations, grouped for types of humidifying, the technique of evaluation of "residual" values, which well itself has built up a reputation for analogous researches of temperature trends, has been applied**.** For this purpose all altitude range has been split on intervals by of 300 meters step, on which statistical parameters - arithmetic means estimated, standard deviations and confidence intervals.

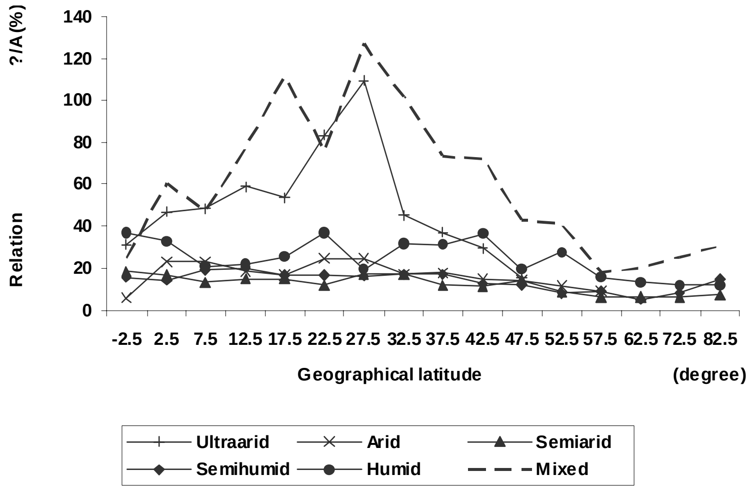

Figure 16. Relations of standard deviation to arithmetic mean annual precipitations on latitude and types of humidifying.

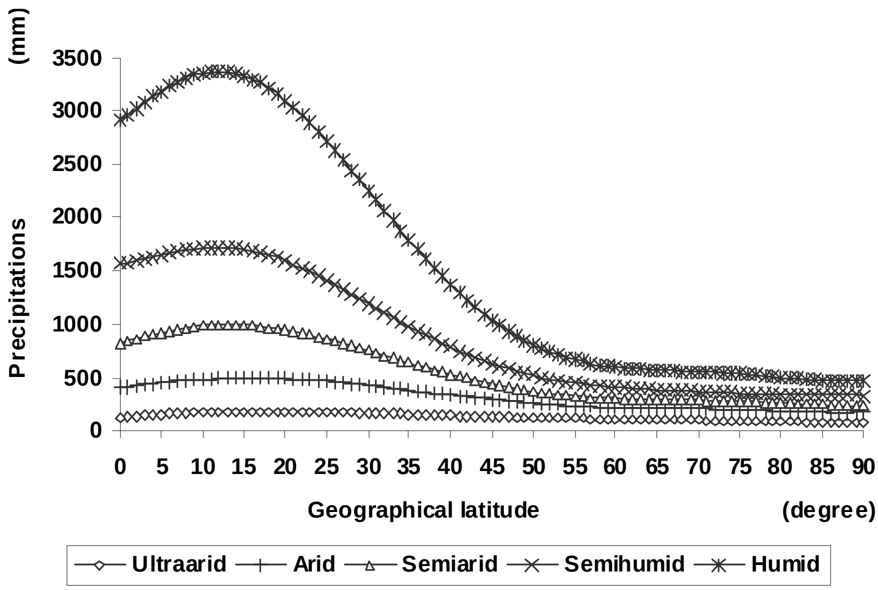

Figure 17. Calculated background distribution of annual precipitations on geographical latitude.

Results of dispersion analysis of distribution of residual values of precipitations on altitude are shown by charts of arithmetic means for each group of types of vegetation and concomitant ranges of confidence intervals ±95 % (Figure 18).

The analysis of results for each group and between them shows absence of something significant trends. The absolute majority of deviations from zero line are conditioned by local features of position of meteorological stations and cannot be confidently interpreted as change of an amount of precipitation for increase of altitude.

At first sight, such conclusion contradicts the stable submissions about character of change of precipitations on an altitude. But if to take into consideration the fact, that altitude zonality of vegetation types for mountain terrains is everywhere defined by changeover from less humidified landscapes to more humidified in direction from bottom to ridges of mountains obtained outcomes will be agreed the conventional submissions. After fulfilment of landscape grading distribution of precipitations the factor of influence of altitude on their distribution has not vanished, and acts in mediated view through altitude zonality of vegetation types. Thus, finds the argument for high territorial variability of distribution of precipitations on altitude defined as direct functional linkage is solved. For each concrete terrain trend of precipitations on altitude is much more safely determined on an elevation profile landscape on altitude tiers.

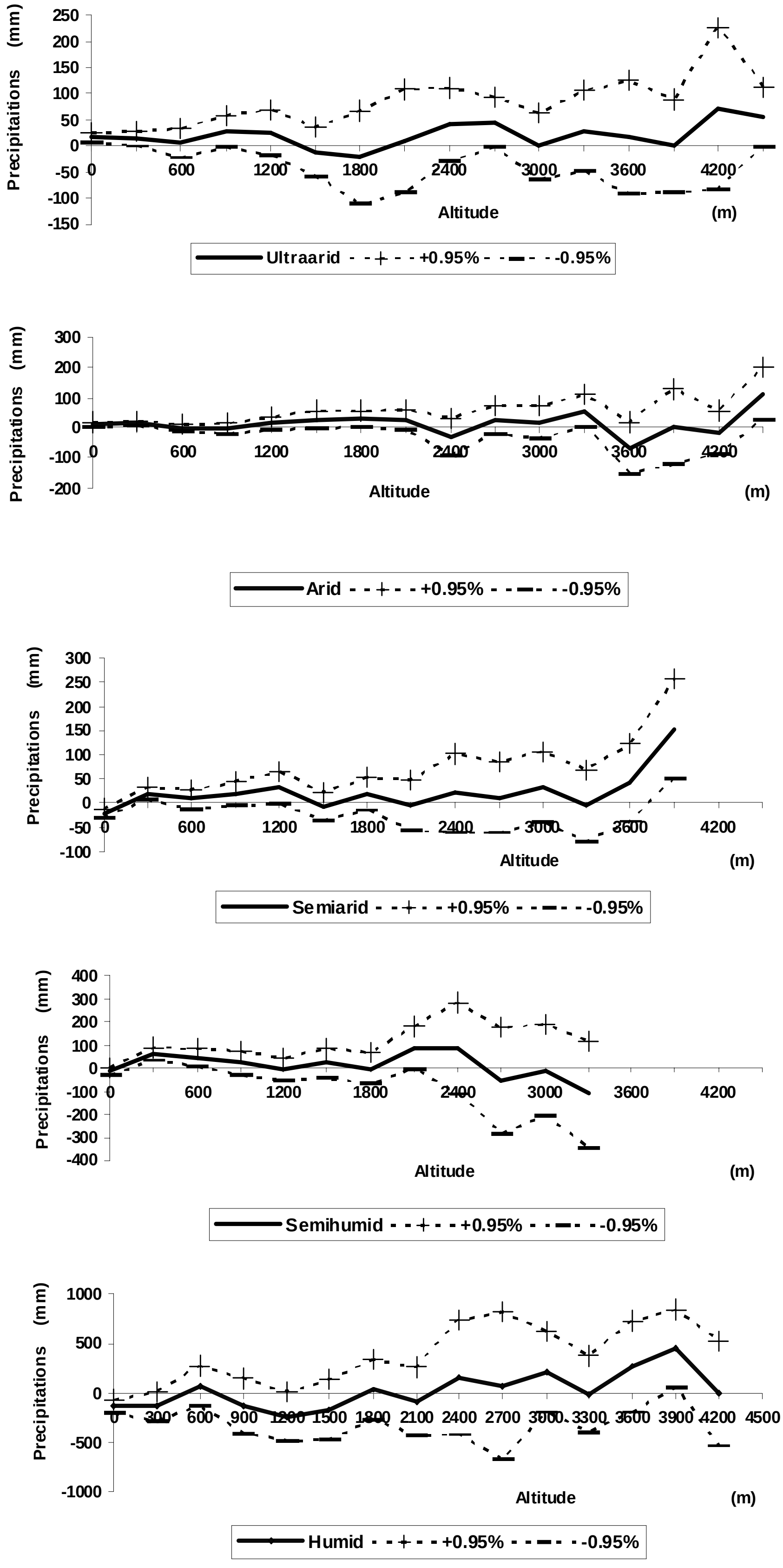

Figure 18. Distribution of average arithmetic values of annual precipitations on altitude and types of humidifying.

Depend on landscape diversification of the investigated areas it is possible to receive more detail outcomes for the leeward and upwind slopes, solar and shaded surfaces. Therefore, for climatic conditioned precipitations one general supposition is accepted. Range of deviations from calculated values is interpreted as area of resistant existence of those or other types of landscapes. Relations of residual variances to their average values are interpreted as index of openness to moisture transport, relating to the given group of types of landscapes. Ranges of relative oscillations of an index of openness for precipitations, grouped for types of vegetation, change in limits:

1. ultraarid – I=10 ÷ 162%;
2. arid – I=70 ÷ 125%;
3. semiarid – I=73 ÷ 123%;
4. semihumid – I=75 ÷ 135%;
5. humid – I=70 ÷ 220%.

Groups of humidifying, since arid up to semi humid type, are defined inclusively by marginal values of range of existence in limits ±25 ÷ ±35 % of change of precipitations. For marginal types of humidifying, it is possible to explain high values of range of existence by the following causes. On the one hand, it explains low values statistically a normal distribution of precipitations for ultraarid zone and availability in deserts of terrains with almost full absence of precipitations. On the other hand, it is practically not limited high bound of precipitations for over moisten landscapes.

The attention low-level relative intersection of ranges of precipitations for adjacent groups of humidifying for the limits pays to itself 3 ÷ 6 %. It is the indirect argument verifying the suppositions about acceptable variations of values of precipitations for maintenance of resistant existence of those or other groups of vegetation types, having common temperature-humidifying parameters. Transition zones for biological communities usually have much smaller dimensions as contrasted to ranges of steady existence of species.

Those conclusions are right only for climatic conditioned types of landscapes as their formation directly depends on moisture coming with precipitations. The dominating role in formation intrazonal and anthropogenically changed landscapes is played with the water component not linked with precipitations. Therefore, in the given activity for such landscapes distribution of precipitations is accepted to equal values of ambient climatic conditioned background.

Testing calculations on meteorological stations have show following. In case not account index of openness of terrain to moisture transport under condition of correct definition of landscape surrounding of each object relation of amounts of deflection of entries $\Delta_i = W_i - W_c$ to measured values of precipitations – W_i lay within the limits $100*\Delta_i/W_i = \pm 7 \div \pm 27\%$. Account of values of an index openness of terrain to moisture transport increases accuracy of a forecast up to $100*\Delta_i/W_i = \pm 3 \div \pm 14\%$.

Evaporation

In the basis of landscape, grading evaporation outcomes of investigations of A.R. Konstantinov have been fixed [6]. The first doubtless dignity of those researches is development of computational algorithms, based on easily gauged and widespread climatic characteristics – air temperatures and water vapour pressure. The second dignity of the recognized regularities was a good coherence of profiles of vaporization and the conforming profiles of precipitations. It expressed that at realization of control calculations has not been founded statistically significant excesses of the calculated values of evaporation above precipitations.

Imperfection of investigations of A.R. Konstantinov is the poor universality of working algorithms. Failure to take account of influences of barometric pressure and landscape diversification has caused the underestimated values of computational vaporization in mountains.

Analysis of parameters for meteorological stations, on which values of climatic indexes initial relations, have been obtained and has shown, that all of them are located in altitude range 0 ÷ 600 m. above sea level and dated, basically, to semidesert-steppe landscapes. Therefore, the procedure of updating of working algorithms was executed in two stages.

- At the first stage correction for the count of influence of an altitude through changing of a measured air temperature by efficient temperature with use of the *formula 1* was executed. It has improved on the average on 26 % an approaching of computational vaporization to substantial values, which have been received with use of the lysimeter. Besides publishing errors of values of vaporization in initial data have been corrected and polynomial smoothing trends executed.
- At the second stage detailed analyse of landscape surrounding of meteorological stations, which were used by A.R. Konstantinov for investigations, has been made.

After fulfilment of identification procedure and grouping of stations for types of humidifying has appeared possible to calculate the trend of correlation evaporation rates from soil and snow for the basic types of humidifying:

1. ultraarid – K=0.9;
2. arid – K=1.3;
3. semiarid – K=1.6;
4. semihumid – K=1.8;
5. humid – K=2.2.

A.R. Konstantinov obtained relations of evaporation to air temperature and water vapour pressure from water for special evaporating pool. At transition to the large water spaces it had been offered the improving coefficient *K=1.3 ÷ 2.2*. Test calculations for water reservoirs of Central Asia have shown that the most acceptable is the value of coefficient *K=1.95.*

The repaired and corrected trends of evaporation have been interpolated by cubic splines to scale 10:1 of an initial step. In result relations of evaporation to air temperature and water vapour pressure from soil, snow and water, which are submitted by like families of curves, are obtained. Actuarially they can be presented as the composite three-dimensional surfaces (Figure 19, Figure 20, Figure 21).

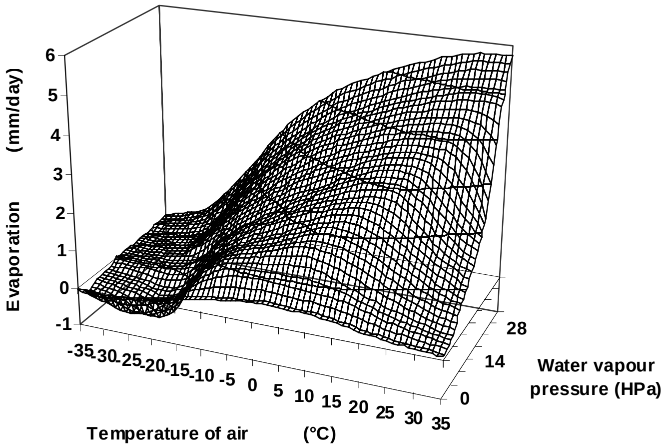

Figure 19. Dependence of evaporation from ground for effective air temperature and pressure water pair.

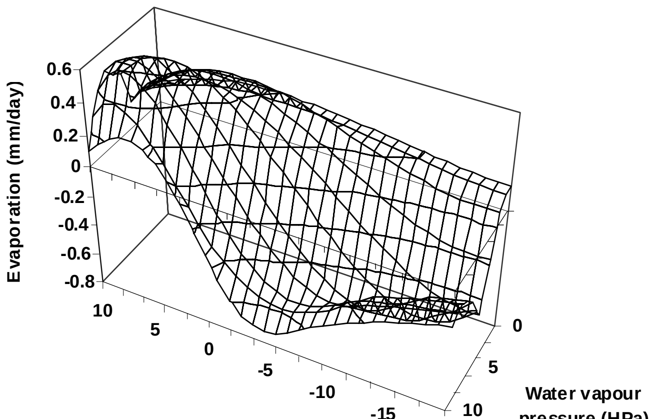

Figure 20. Dependence of evaporation from snow for effective air temperature and pressure water pair.

Necessary input data for calculation of values of vaporization are calculated as follows.

The air temperature is determined on a technique described in paragraph **Air temperature**.

Water vapour pressure is considered as the functional two-dimensional relation to altitude and latitude. The spacing distribution of water vapour pressure for each season is determined by statistical methods based on data analysis on meteorological stations under following scheme:

- partial distributions of water vapour pressure on altitude for separate latitude circles are appreciated by step of 10 degrees, which have been approximated by polynomial regressions;

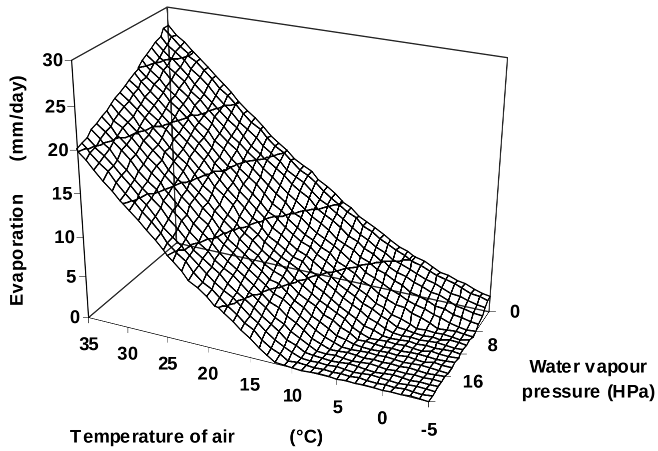

Figure 21. Dependence of evaporation from ground for effective air temperature and pressure water pair.

- for each season, the obtained family of trends have been subjected regression cross-analysis by results, of which surfaces of complex relations of water vapour pressure from altitude and latitude, are constructed (Figure 22, Figure 23, Figure 24, Figure 25).

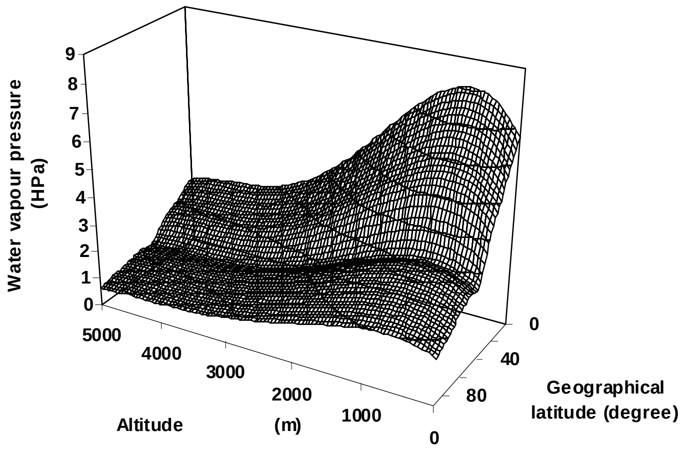

Figure 22. Trends of water vapour pressure on altitude and latitude for Winter.

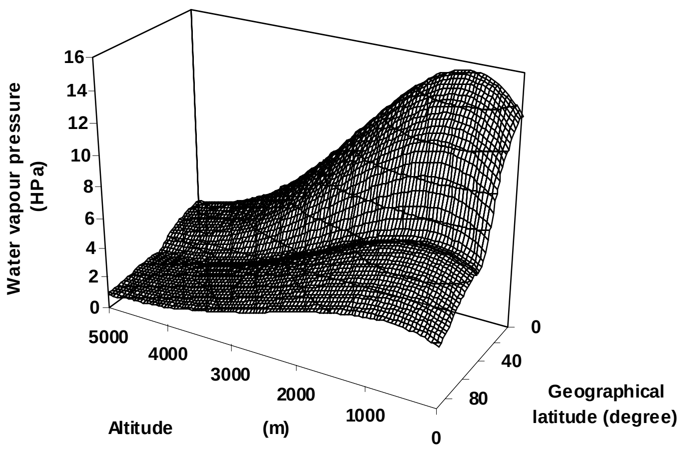

Figure 23. Trends of water vapour pressure on altitude and latitude for Spring.

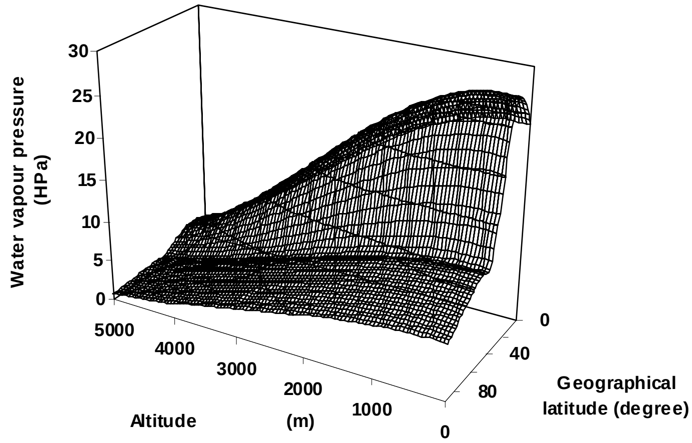

Figure 24. Trends of water vapour pressure on altitude and latitude for Summer.

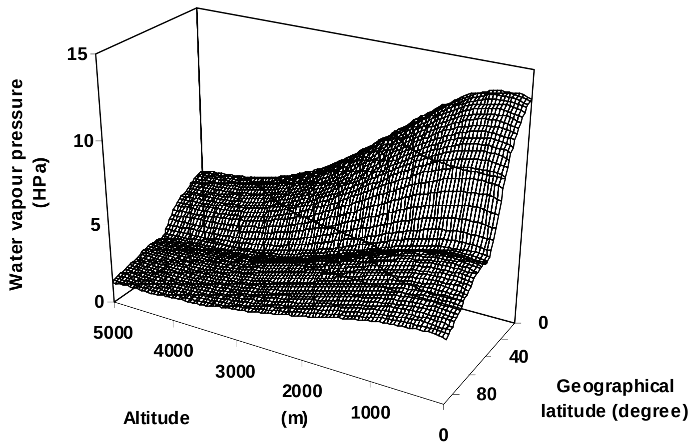

Figure 25. Trends of water vapour pressure on altitude and latitude for Autumn.

Evaporation is a calculated value and the direct assessment of certainty of its definition is inconvenient in a mass scale. Therefore following indirect methods of definition of certainty of values of vaporization were applied:

1. comparison of calculated value of water balance for local river basins and values of a river inflow on hydroposts;
2. the interdiction for significant excess of the calculated values of evaporation above values of precipitations on forecasting points.

The first method of evaluation is universal but not comprehensive while the second method does not usable to intrazonal, anthropogenic changed landscapes and water surfaces.

Testing calculations on local river basins have shown that differences between entries of a water balance and values of undisturbed river inflow lay within the limits 3.3 ÷ 8.2 %.

Share of calculated values of the evaporation on meteorological stations, which superior values of precipitations for ultraarid climatic conditioned zone, does not exceed 15 % from total number and 6 % for meteorological stations located in arid climatic conditioned zone. Thus, values of the overstated values of evaporation have no more than 19 % from precipitations values for these zones. It is not supervised not only excesses of the designed evaporation above of recorded precipitations for more humidified climatic zones and mountain tiers, but also their equalities.

Resume

- Method of landscape classification allows on the unified methodological to execute basis comprehensive analysis of correlation of climatic performances and underlying terrain, quantitative assessment of such important parameters, as air temperature, precipitations, evaporation, and also value of a water balance derivative of them for any time interval (month, season, year and decade).

- Doubtless dignity of the landscape-climatic approach is possibility of using in the analysis easily available and the most mass in measurement of recorded natural-climatic data.
- Landscape classification of evaporation is equitable only for natural evaporating systems: water reservoirs, ground, snow and transpiration of vegetation. The technogenic desiccations conditioned by activity mining and a manufacturing industry, together with municipal sector, have no clearly expressed connections within the framework of the given investigation system.
- At observance of requests of correct definition of landscape surrounding and aerographical characteristics reliability of definition of studied climatic indexes makes:
- standard deviation of an evaluation of a spacing of seasonal air temperatures have limit $\sigma_{an} = \pm 1.3 \div \pm 2.1$°C, and for seasons: Winter = ±2.1°C; Spring = ±1.3°C; Summer = ±1.6°C; Autumn = ±1.4°C;
- relation of amounts of deflection of calculated to measured values of precipitations have limit $100 * \Delta_i / W_i = \pm 3 \div \pm 14\%$;
- indirect assessment of calculation reliability of evaporation through comparison of a difference between precipitations and evaporation with measured data on hydroposts for local basins with not anthropogenic changed river inflow is determined over the range 3.3 ÷ 8.2%.
- Formulas, relations and schemes of solutions are composed counting upon fast and their convenient adaptation in modelling systems of time-space mapping of climatic indexes and for the solution of engineering hydrodynamic problems.

Climatic model

The meso-climatic model of interaction of underlying terrain and temperature-humidifying characteristics is intended for the spatial-temporal analysis and a prediction of the most probable distribution of climatic parameters for flat and mountain territories for seasons: Winter (XII-II months), Spring (III-V months), Summer (VI-VIII months), an Autumn (IX-XI months) and Year.

The model is developed based on the landscape-climatic approach in an estimation of temperature-humidifying characteristics. Each climatic component is considered as certain integrated parameter of a spectrum of cooperating factors: latitude, altitude, zonal, azonal and anthropogenic, which has the manifestations in various types of vegetation and soils. Decision algorithms are constructed using of original soil-landscape classification of modelled climatic characteristics (Table 2, Table 8).

Structure of model and algorithms

The structure of model consists of the following mainframes (Figure 26):

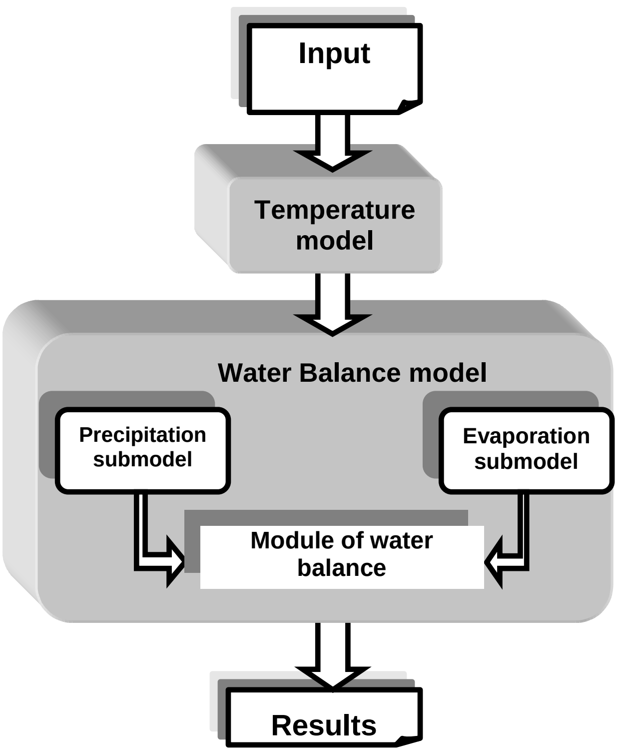

Figure 26. Block diagram of meso-climatic model.

Model allows receiving the following results, suitable for spatial mapping:

1. Seasonal changes of air temperatures, caused by influence of underlying terrain (*°C*);
2. Seasonal and annual distributions of air temperatures (*°C*);
3. Seasonal and annual distributions of precipitations (*mm*);
4. Seasonal and annual distributions of evaporation (*mm*);
5. Seasonal and annual balance between precipitations and evaporation (*mm*);
6. Seasonal and annual distributions of volumes of precipitated water from the elementary platforms (*m3*);
7. Seasonal and annual distributions of volumes of evaporated water from the elementary platforms (*m3*);
8. Seasonal and annual distributions of balance between volumes of precipitated and evaporated water from the elementary platforms (*m3*).

Above-listed parameters the model allows to obtain the summarizing values of water balance, distribution of the elementary platforms with the given characteristics of underlying terrain and grid files on each of predicted climatic parameters for visualization of the received results.

The model is supplied with the adjuster of a local temperature background whom allows to arrange model for concrete area, and also a regulator of amount of dropping out precipitations, which allows to receive not only long-term average water-balance characteristics, but also for separate years.

Algorithms of calculation of climatic parameters are elaborated based on the analysis of initial given meteorological stations of Asia, Europe and Africa.

Input data

Indata - Initial matrix including:

Indata (:,1) – Identical number
Indata (:,2) – Altitude (*m*);
Indata (:,3) – Latitude (*degrees, decimal*) / (km*);*
Indata (:,4) – Longitude (*degree, decimal*) / (*km*);
Indata (:,5) – Geographical azimuth (*degrees*);
Indata (:,6) – Skew of slope (*degrees*);
Indata (:,7) – Codes of types relief;
Indata (:,8) – Codes of the climatic caused types of vegetation;
Indata (:,9) – Codes of the intrazonal types of vegetation;
Indata (:,10) – Codes of the anthropogenic changed types of vegetation;
Indata(:,11) – Codes of influence of water reservoirs;
Indata (:,12) – Real square of elementary platform around of a calculation point *(км2)*
Indata (:,13) – Index of an openness to humid transfer (%)
Indata (:,14) – Share of Winter precipitations from annual (%);
Indata (:,15) – Share of Spring precipitations from annual (%);
Indata (:,16) – Share of Summer precipitations from annual (%);
Indata (:,17) – Share of Autumn precipitations from annual (%);
Indata (:,18) – Identification number of a local river basing;
Indata (:,19) – Corrections of regional background air temperatures for Winter (°C);
Indata (:,20) – Corrections of regional background air temperatures for Spring (°C);
Indata (:,21) – Corrections of regional background air temperatures for Summer (°C);
Indata (:,22) – Corrections of regional background air temperatures for Autumn (°C);
Indata (:,23) – Corrections for changes of annual precipitations (%).

Input modelling parameters should be unequivocally determined without misses of their values in initial matrixes of the data and attributes.

Air temperature model

The model solves tasks of an spatial-temporary prediction of temperature parameters of investigated territory based on the revealed connections between properties of underlying terrain and a thermal regime based on the following algorithm:

$$t_i=(t_{Lat} + t_{Alt} + t_{lnd})*k_{tas} + \Delta t_{ll} + \varepsilon, \qquad (2)$$

where

t_{lat} – trend of the temperature parameter on latitude for plains with deserted types of vegetation;

t_{alt} – trend of the temperature parameter on altitude corrected on latitude for plains with deserted types of vegetation;

t_{lnd} – temperature contribution of underlying terrain (3);
k_{tas} – adjusting multiplier for a angle of standing of the sun, an azimuth and skew of slope (4);
Δt_{ll} – adjusting correction for a local temperature background;
ε – error of modelling.

The background trend of temperatures on latitude is calculated under the formula:

$$t_{Lat} = \sum_{k=0}^{n} a_k * Lat_i$$

where
a_k – coefficient of approximating polynomial. The vector of polynomial coefficients is given in formulas of algorithm;
Lat_i – current value of latitude (*degrees, decimal or kilometres*);
i – number of a forecasting point;
k – current exponent of approximating polynomial;
n – maximal exponent of approximating polynomial.

The background trend of temperatures on altitude is calculated under the formula:

$$t_{Alt} = \sum_{k=0}^{n} a_k * Alt_i,$$

where
a_k – coefficient of approximating polynomial. The vector of polynomial coefficients is given in formulas of algorithm;
Alt_i – current value of altitude (*meters*);
i – number of a forecasting point;
k – current exponent of approximating polynomial;
n – maximal exponent of approximating polynomial.

The contribution of underlying terrain to a temperature regime may be separated into of its simpler components:

$$t_{lnd}=\Delta t_{cl}+\Delta t_{br}+\Delta t_{ia}+\Delta t_{wt}\ , \tag{3}$$

where
Δt_{cl} – climatic the caused types of vegetation in a smoothing relief;
Δt_{br} – correction on type of relief;
Δt_{ia} – correction on intrazonal and/or anthropogenic influence for climatic the caused types of vegetation;
Δt_{wt} – correction on influence of water objects.

Adjusting correction for an angle of standing of the sun, an azimuth and skew of slope pays off under the formula:

$$K_{azsk}=cos(Lat_i)*k_{as}*kc_a, \tag{4}$$

where
$kc_a= -cos(Az_i)$.
if $kc_a<=0,$ $k_{as}=sin(kk_a),$ else $k_{as}=sin(kk_s)$.
if $Tilt-Skew_i>=Skew_i,$ $kk_s=Skew_i,$ else $kk_s=2*Tilt-Skew_i$.

$$Tilt=sin(30*(mn-3))*23.5+90-Lat_i,$$

where
$Tilt$ – angle of standing the sun (*degrees from horizon*);
m_n – number of month (middle month of season) for year (*1 - 12*);
Lat_i – current value of latitude (*degrees, decimal or kilometres*).
Az_i – geographical azimuth for forecasting point (*degrees*);
$Skew_i$ – skew of slope around forecasting point (*degrees from horizon*).

Adjusting correction for a local temperature background is not strictly obligatory. It is accepted to the equal regular mistake received as a result of preliminary modelling of temperatures of neighbouring meteorological stations, and is entered with same sign.

Result of modelling are forecasted values of seasonal changes of the temperatures (3), caused by influence of underlying terrain, and air temperatures for seasons and year (2).

In detail principles, a technique and reliability of an estimation of interaction of underlying terrain and a thermal regime it is submitted in works [3, 4, 5].

The structure of temperature model can be presented in the following kind (Figure 27):

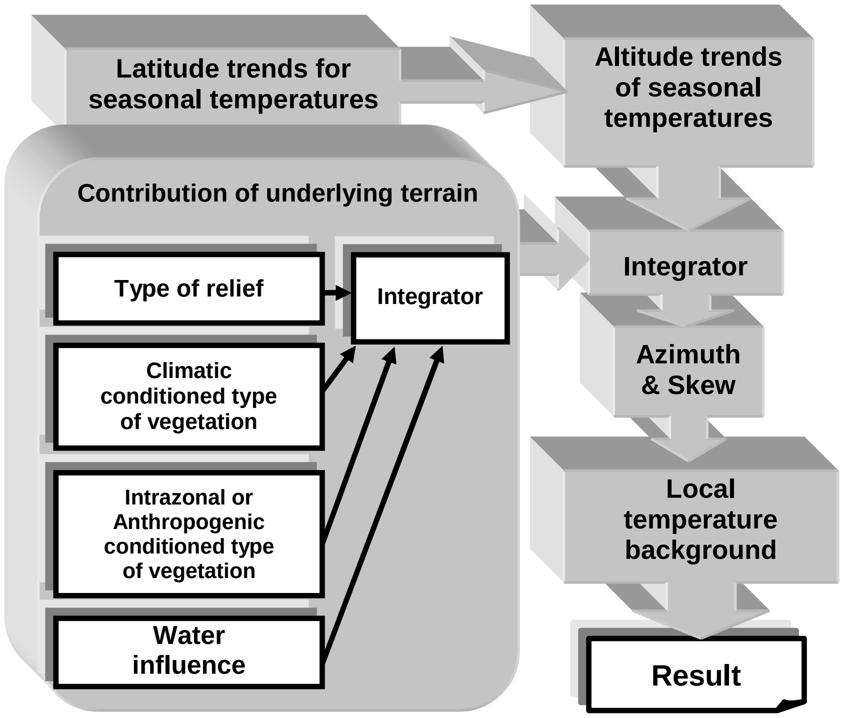

Figure 27. Block diagram of temperature model.

Water balance model

Water balance model consists of two submodels of precipitations, evaporation and the water balance block. From temperature model as the input data, it receives the designed values of air temperatures.

Precipitation submodel

Submodel of precipitations realizes the following sequence of procedures:

Estimation of distribution of precipitations for year on latitude for various groups of types of vegetation;

Correction of distribution of precipitations for year by additional algorithms of calculation of an openness of territory for precipitations transfer and shares of seasonal precipitations;

Calculation of precipitations (*mm*);

Calculation of volumes of precipitations from elementary platforms (*m3*).

Background distribution of precipitations on latitude for each group of types of vegetation is calculated under the formula:

$$Prc_i^0 = \sum_{k=0}^{n} a_k * Lat_i, \qquad (5)$$

where

a_k – coefficient of approximating polynomial;

Lat_i – current value of latitude (*degrees, decimal or kilometres*).

i – number of a forecasting point;

k – current exponent of approximating polynomial;

n – maximal exponent of approximating polynomial.

Correction of background distribution of precipitations by index for openness of terrain to precipitations transport is calculated under the formula:

$$Prc_i = Prc_i^0 * \frac{Index_i}{100} * \frac{\Delta Prc_i}{100}$$

where

i – number of a forecasting point;

Prc_i – corrected values of annual precipitations (*mm);*

$Index_i$ – index for openness of terrain to moisture transport *(%).*

ΔPrc_i – local changings of annual precipitations (*%*);

Calculation of seasonal precipitations is calculated under the formula:

$$Prc_i^j = \frac{Prc_i * Share_i^S}{100}$$

where

j – number of season (month);

Prc^j_i – corrected values of annual precipitations (*mm)*;

$Share^s_i$ – seasonal share of precipitations from year volume *(%/year).*

The volume of water seasonal and year precipitations (m^3) from each real elementary platform is equal:

$$VolPrc^j_i = Prc^j_i * S_i, \qquad (6)$$

where

S_i – real area of an elementary platform (*km2*);

where

$$S_i = \frac{S_i^0}{\cos Skew_i}, \qquad (7)$$

Result of modelling are forecasting values of spatial distribution of precipitations for elementary platforms (5), and their volumes for seasons and year (6).

The structure of submodel of precipitations can be presented in the following kind (***Figure 28***):

Evaporation submodel

The model solves tasks of an existential prediction of evaporation in investigated territory based on the revealed connections between properties of underlying terrain on algorithm of A.R. Konstantinov [6]. Its distinctive feature is the original design procedure of vertical gradients of humidity and temperatures as functions from humidity and temperatures at height of 2.0 m that considerably reduces requirements to selection of the initial data and simplifies calculations. To other advantages, it is necessary to relate universality of the decision algorithm and independent from local climatic conditions.

As a result of the transformations executed by A.R. Konstantinov, the formula for calculation of intensity of evaporation finally it is submitted as:

$$E_i = \frac{0.076 * \gamma * \alpha_e * u_f}{lg \frac{200}{z_0^1} * lg \frac{1000}{z_0^1}} * (e_0 - e_{2.0}) \quad mm/hour,$$

where

e_0 – air humidity on ground;

$e_{2.0}$ – air humidity at height of *2 m*.

γ – correction factor describing difference of natural profiles of meteorological elements from logarithmic;

$$\gamma = \frac{1}{\sqrt[4]{1-Ri_{1.0}}}$$

where

$Ri_{1.0}$ – Richardson number at height above ground *1m*;

$$Ri_{1.0} = -0.08 * \frac{lg^2 \frac{1000}{z_0^1}}{lg \frac{200}{z_0^1}} * \frac{T_o - T_{2.0}}{u_f^2},$$

where

u_f – function of a vertical profile of a wind speed measured on meteorological stations;

z^1_0 – height $z_{1.0}=1.0\ m$;

T_0 – air temperature on ground in Kelvin degrees;

$T_{2.0}$ – air temperature in Kelvin degrees at height - *2 m*.

$$\alpha_e = 1+0.72 \left(\sqrt{1-28 \left(\frac{z_0}{z_{00}} \right) * Ri_{1.0}} - 1 \right),$$

where

α_e – function of humidity of air measured on meteorological stations;

z_{00} – dimensional factor $z_{00}=1m$

By results of A.R. Konstantinov calculations matrixes of functional dependences of evaporation from snow, ground and water in recalculation on other dimension - mm/day, which have lain in a basis of algorithm of a submodel, were made.

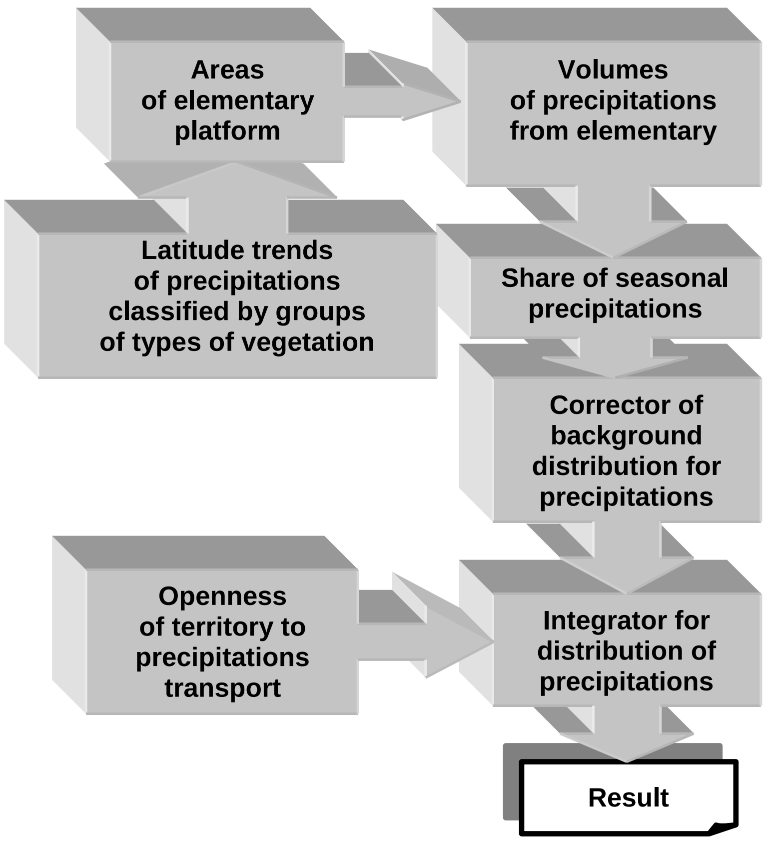

Figure 28. Block diagram of precipitations submodel.

Unfortunately, initial matrixes of the given distributions appeared are incomplete and designed for conditions of a flat relief. Therefore the developer of climatic model executed updating of initial matrixes with calculation of additional values, characteristic for area of research and with passing correction of publishing mistakes. The corrected and added settlement dependences of evaporation on air temperature and pressure water pair have the big resolution on the order and cover practically all range temperature-humidifying characteristics.

Besides formula Hann-Kuzmin [7] was used for correction of size of water vapour pressure on altitude:

$$E_i = E_t * 10^a,$$

where

a – empirically determined factor connecting change of water pair pressure on altitude:

$a=1/6.3\div2/6.3$ – for continental areas of Asia (P.P. Kuzmin, Y.Y. Grechanichenko);

$a=1/5$ – for free atmosphere (Hann).

Evaporation for snow of ground and water calculates pressure water pair under the formula:

$$E^{Alt} = \sum_{k=0}^{n} a_{ki} * Alt_i, \quad (8)$$

where

a_k – coefficient of approximating polynomial.;

Alt_i – current value of altitude (*meters*);

i – number of a forecasting point;

k – current exponent of approximating polynomial;

n – maximal exponent of approximating polynomial.

The background trend of water vapour pressure on latitude is calculated under the formula:

$$E_i^{Lat} = \sum_{k=0}^{n} a_k * Lat_i, \quad (9)$$

where

a_k – coefficient of approximating polynomial;

Lat_i – current value of latitude (*degrees, decimal or kilometres*).

i – number of a forecasting point;

k – current exponent of approximating polynomial;

n – maximal exponent of approximating polynomial.

Then, it is carried out procedure of a choice of the appropriate matrix of evaporation (snow, ground or water) with use of the input data of a temperature regime and is calculated evaporation.

$$Evp^j{}_i = f(E^{Alt}{}_i, E^{Lat}{}_i, t_i)$$

Seasonal evaporation in a water layer *(mm)* is calculated on the basis of the corrected data under the formula:

$$Evp^j{}_i = Evp^j{}_i * K_{azs}, \quad (10)$$

where

K_{azs} – correction for angle of sun standing, azimuth and skew of slope (4);

The volume of seasonal evaporation *(m^3)* is calculated under the formula.

$$VolEvp^j{}_i = Evp^j{}_i * S^j{}_i, \quad (11)$$

where

$S^j{}_i$ – real area of elementary platform (km^2) (7).

Result of modelling is forecasting values of spatial distribution of evaporation for elementary platforms (10) and their volumes for seasons and year (11).

The structure of a submodel of evaporation can be presented in the following kind (Figure 29):

1.2.4.3 Module of water balance

Module of water balance carries out for correction and calculation of water balance on seasons and year for elementary platforms. Besides, for separate local river basin total values of precipitations, evaporations and water balance are calculated.

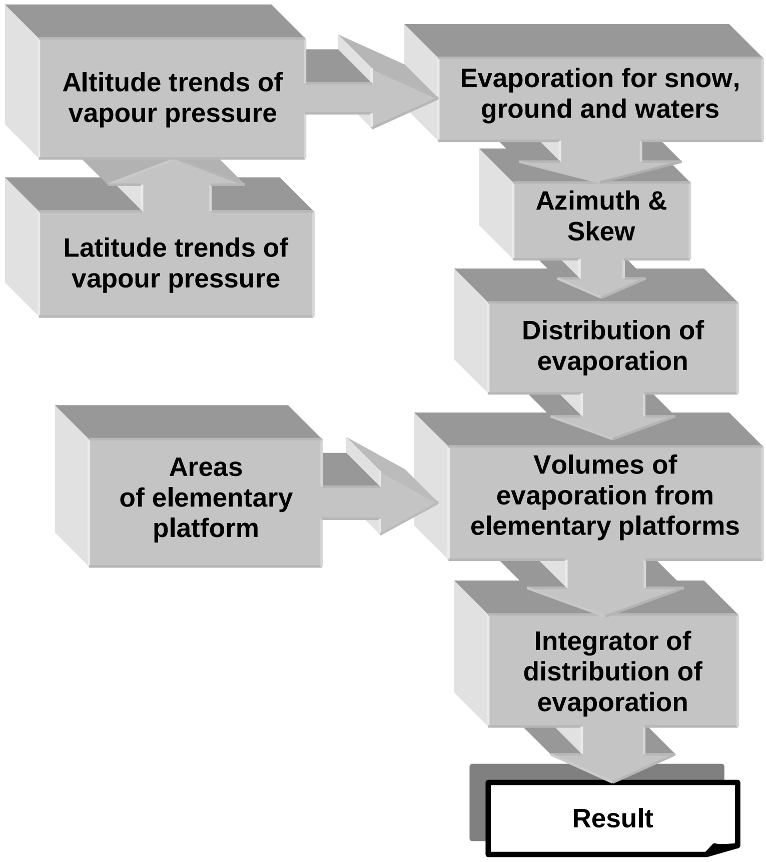

Figure 29. Block diagram of evaporation submodel.

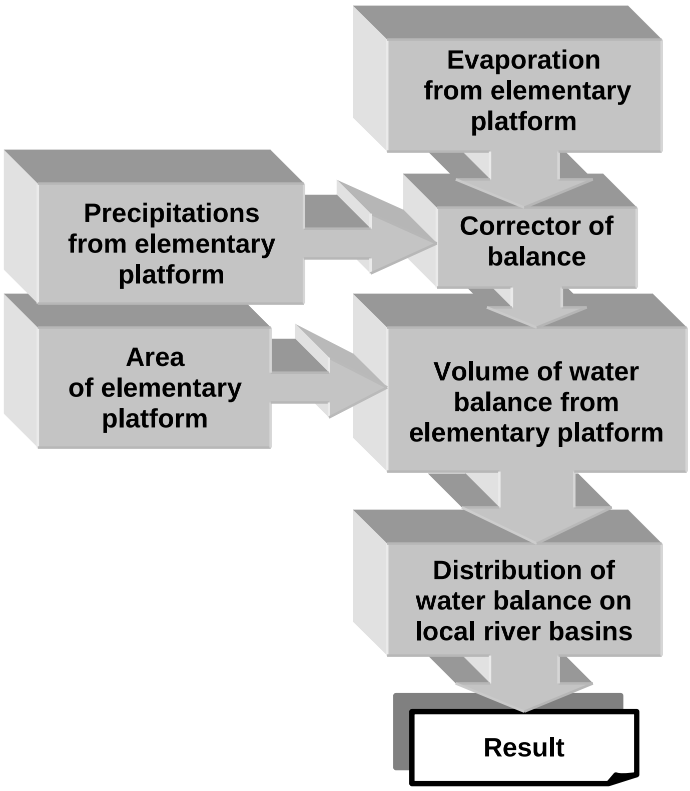

Figure 30. Block diagram of water balance module.

Calculation of water balance in a water layer *(mm)* is executed under the scheme of computing systems with previous memory:

$$Bln^j_i = Bln^{j-1}_i + Prc^j_i - Evp^j_i,$$

where

Bln^{j-1}_i – water balance in a water layer *(mm);*

Correction of water balance is fulfilled only for plants with climatic conditioned by groups of vegetable types on the following requirement:

if $Bln^j_i < 0$ $Evp^j_{i,} = Prc^j_i$ and $VolEvp^j_{i,} = VolPrc^j_i$

The essence of correction will be that for climatic conditioned types of humidification the aggregate volume of evaporated water cannot be more than volume of water falling out in precipitations. The volume water balance for a water layer *(mm)* of calculated points is equal:

$$VolBln^j_i = Bln^j_i * S^j_{i,}$$

where

S^j_i – real area of elementary platform (km^2) (7).

Result is forecasting values of spatial distribution of water balance in a water layer *(mm)* and volumes of water balance *(m^3)*.

The structure of module of water balance can be presented in the following kind (Figure 30):

Output data

Output data are submitted by matrixes ***- Output u BsnWtrBlnc:***

Output(:,1) - Changing of temperature for Winter (*°C*)
Output(:,2) - Changing of temperature for Spring (*°C*)
Output(:,3) - Changing of temperature for Summer (*°C*)
Output(:,4) - Changing of temperature for Autumn (*°C*)
Output(:,5) - Full temperature for Winter (*°C*)
Output(:,6) - Full temperature for Spring (*°C*)
Output(:,7) - Full temperature for Summer (*°C*)
Output(:,8) - Full temperature for Autumn (*°C*)
Output(:,9) - Full temperature for Year (*°C*)
Output(:,10) - Precipitations for Winter (*mm*)
Output(:,11) - Precipitations for Spring (*mm*)
Output(:,12) - Precipitations for Summer (*mm*)
Output(:,13) - Precipitations for Autumn (*mm*)
Output(:,14) - Precipitations for Year (*mm*)
Output(:,15) - Evaporation for Winter (*mm*)
Output(:,16) - Evaporation for Spring (*mm*)
Output(:,17) - Evaporation for Summer (*mm*)
Output(:,18) - Evaporation for Autumn (*mm*)
Output(:,19) - Evaporation for Year (*mm*)
Output(:,20) - Water balance for Winter (*mm*)
Output(:,21) - Water balance for Spring (*mm*)
Output(:,22) - Water balance for Summer (*mm*)
Output(:,23) - Water balance for Autumn (*mm*)
Output(:,24) - Water balance for Year (*mm*)
Output(:,25) - Volume of precipitating water for Winter from elementary platforms (*m3*)
Output(:,26) - Volume of precipitating water for Spring from elementary platforms (*m3*)
Output(:,27) - Volume of precipitating water for Summer from elementary platforms (*m3*)
Output(:,28) - Volume of precipitating water for Autumn from elementary platforms (*m3*)
Output(:,29) - Volume of precipitating water for Year from elementary platforms (*m3*)
Output(:,30) - Volume of evaporating water for Winter from elementary platforms (*m3*)
Output(:,31) - Volume of evaporating water for Spring from elementary platforms (*m3*)
Output(:,32) - Volume of evaporating water for Summer from elementary platforms (*m3*)
Output(:,33) - Volume of evaporating water for Autumn from elementary platforms (*m3*)

Output(:,34) - Volume of evaporating water for Year from elementary platforms (*m3*)
Output(:,35) - Volume of water balance for Winter from elementary platforms (*m3*)
Output(:,36) - Volume of water balance for Spring from elementary platforms (*m3*)
Output(:,37) - Volume of water balance for Summer from elementary platforms (*m3*)
Output(:,38) - Volume of water balance for Autumn from elementary platforms (*m3*)
Output(:,39) - Volume of water balance for Year from elementary platforms (*m3*)

BsnWtrBlnc – Water balance for local river basins, including:
BsnWtrBlnc(1,:) – First local river basin (m^3);
BsnWtrBlnc(2,:) - Second local river basin (m^3);
. . . . ;
BsnWtrBlnc(n,:) – Last local river basin (m^3).

Structure of output matrix for local water balance – *BsnWtrBlnc* is following:

1. Identification number of a local basin;
2. Sum of precipitations of a local basin for Winter (m^3);
3. Sum of precipitations of a local basin for Spring (m^3);
4. Sum of precipitations of a local basin for Summer (m^3);
5. Sum of precipitations of a local basin for Autumn (m^3);
6. Sum of precipitations of a local basin for Year (m^3);
7. Sum of evaporation of a local basin for Winter (m^3);
8. Sum of evaporation of a local basin for Spring (m^3);
9. Sum of evaporation of a local basin for Summer (m^3);
10. Sum of evaporation of a local basin for Autumn (m^3);
11. Sum of evaporation of a local basin for Year (m^3);
12. Sum of water balance of a local basin for Winter (m^3);
13. Sum of water balance of a local basin for Spring (m^3);
14. Sum of water balance of a local basin for Summer (m^3);
15. Sum of water balance of a local basin for Autumn (m^3);
16. Sum of water balance of a local basin for Year (m^3).

Presence in target given identification numbers and geographical coordinates allows to create on their basis of a database, and also it is easy to adapt climatic parameters in geoinformation systems (GIS) and others electronic mapping makers.

Resume

- Meso-climatic model constructed on principles of landscape classification of temperature-humidifying parameters is intended for a quantitative estimation of natural of climatic forming processes and does not estimate direct manufactured influence on a climate.
- The model allows obtaining settlement parameters with a high degree of existential detailed elaboration.
- Modern high-speed algorithms of matrix operations of modelling are realized. It is allows to process great volumes of the entrance information for comprehensible time and with comprehensible accuracy.
- The achieved accuracy of modelling in a combination to opportunities of flexible adjustment for local conditions of formation of climatic background allows using model for the decision of tasks of practical water use.
- Results of modelling are convenient for visualization and easily adapt in databases;
- The structure of model supposes its further development for more detailed estimation of intraannual changes of climatic parameters for modelling of natural systems.

Analysis of reliability of results

Approbation of the landscape-climatic approach for estimation of water balance norms was produced for mountain terrain of northeast Tien-Shan (China). Outcomes of modeling are introduced below (Table 9).

In full, the landscape-climatic modelling was executed by step of 30 sec of geographical coordinates (the dimension of cells ≈ *1*1 km*) for Syrdarya River basin with inclusion in accounts of Aral Sea aquatory. Climatic indexes are calculated for the period up to the middle of 60 years of XX century (standard), the decade of 70 years, the decade of 80 years and for the changes, which have occurred between these periods.

Matching of results of model operation and the previous scientific researches [8] reveal incompleteness of them assessments of distribution of climatic characteristics in region. It expresses in a volume, that precedent cartographical materials reflect a situation only in a mountain part of Syrdarya basin, not doing the complete regional description of climatic processes for all territory. Evaluation procedures of a water regime for linear objects were applied to an evaluation of module of inflow of a flat part of basin - the rivers and channels, or local - lakes and water reservoirs, on which it is rather difficult to make one-valued spatial conclusions. Therefore, for matching quality of model operation those areas of Syrdarya basin have been elected, for which there were maps of like climatic parameters (Figure 31, Figure 32, Figure 33, Figure 34).

Table 9 Calculated values of annual precipitations, evaporation and water balance of headstream the Ili River in matching with the measured values of a river flow.

River basin	Water balance *(km^3)*					River Inflow *(km^3)*	Difference *(%)*
	Winter	Spring	Summer	Autumn	YEAR		
Kash - Precipitations	1.577	2.383	1.599	1.457	7.143		
Kash - Evaporation	0.289	0.532	1.485	0.562	2.864		
Kash – Water balance	*1.287*	*1.855*	*0.114*	*0.889*	*4.137*	*4.080*	*1.38*
Kyunes - Precipitations	1.585	1.600	1.679	0.979	4.746		
Kyunes - Evaporation	0.328	0.473	1.290	0.554	2.388		
Kyunes - Water balance	*0.738*	*1.129*	*0.390*	*0.425*	*2.324*	*2.200*	*5.34*
Tekes - Precipitations	1.575	5.421	8.521	3.536	18.656		
Tekes - Evaporation	1.938	1.629	5.996	1.892	10.694		
Tekes - Water balance	*0.413*	*3.413*	*2.526*	*1.643*	*7.996*	*8.260*	*-3.30*
Water balance of Ili River for hydropost Jamadu					*14.458*	*14.540*	*-0.57*

The comparative analysis of various techniques shows, that at application of the landscape-climatic approach realized in the above described model, spacing of precipitations and a water balance (analogy of module of inflow) have more contrast view. The range of values variations for climatic indexes will essentially increase, attaining a difference - 30 %.

Modelled map of distribution of precipitations (Figure 32) at matching with the previous outcomes (Figure 31) reflects features of precipitations accumulation in a mountainous territories, which are conditioned by an exposition, skew of slopes and an openness to moisture transport in more details. These discrepancies show the more brightly, than discrepancies of types of the vegetation covering mountain slopes are more contrast.

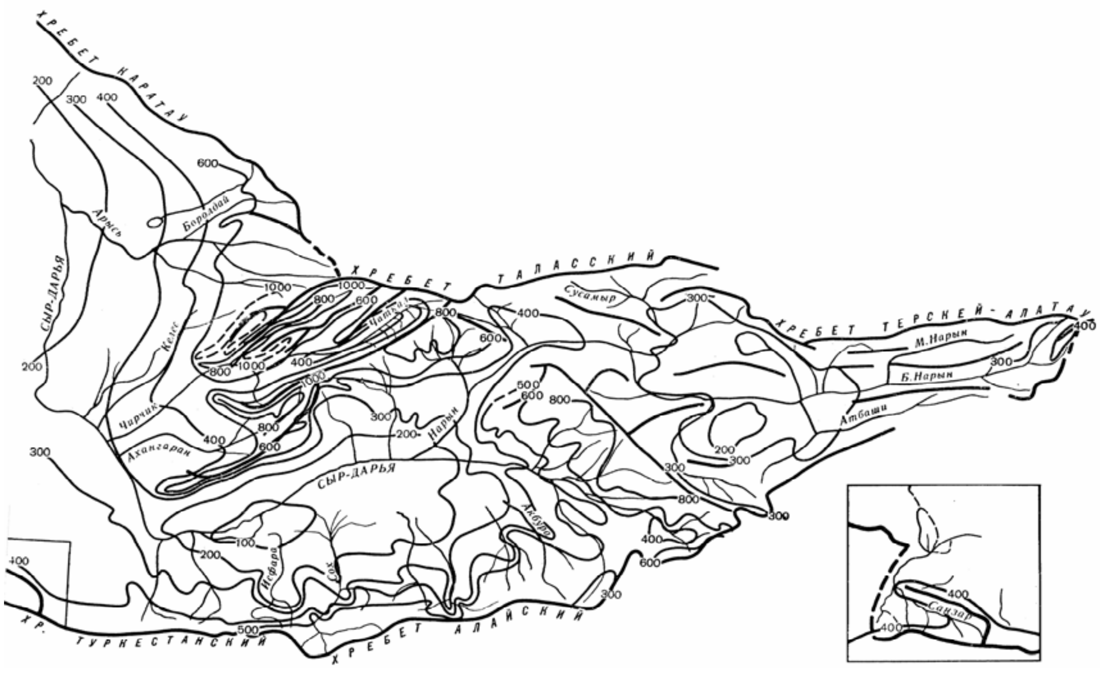

Figure 31. Distribution of precipitations for Year (mm). Source of the data [8].

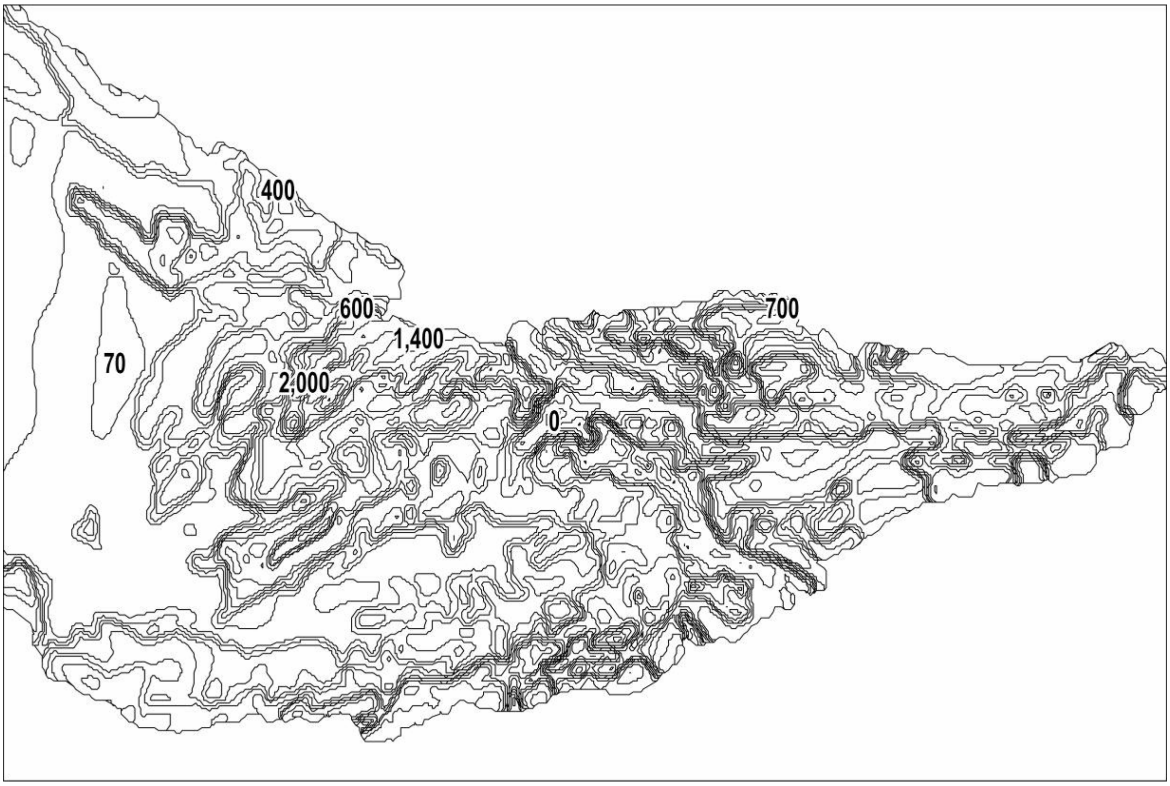

Figure 32. Distribution of precipitations for year (mm). Source of the data is Water balance modeling.

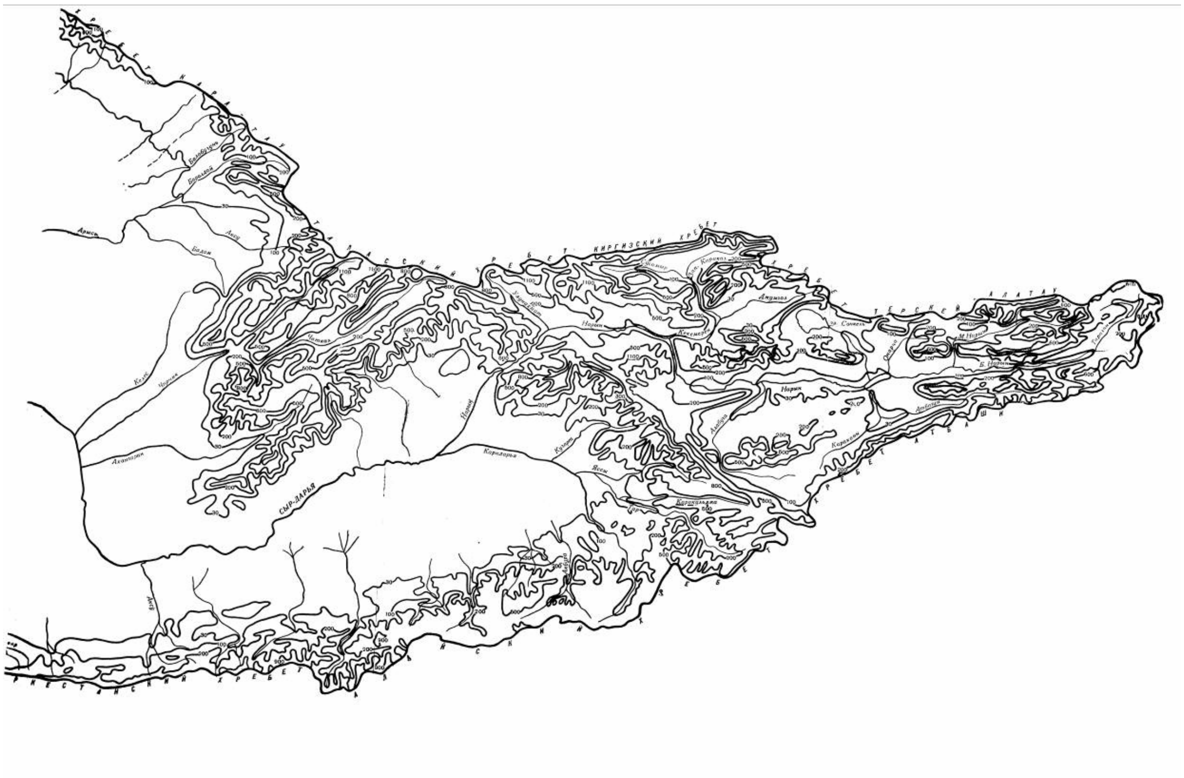

Figure 33. Distribution of module of inflow for Year (mm). Source of the data [8].

The map of a water balance contains the information in the integrated form about precipitations and evaporation, which is presented as function of air temperature, orientations, skew of slopes, and altitude. The combination of the given dependences realized in working algorithms of climatic model, have allowed to receive more legible picture of a spacing distribution for water balance (Figure 34). At the same time, it is visible, that at a map compilation of module of inflow, its authors were guided by predominary local dependences of distribution of a rated parameter on altitude (Figure 33). Therefore, in a mountain broken relief isolines for modulus of inflow move paralleled of isohypses and for smoothing relief they simply miss, because isohypses are practically absence. It, a known degree, explains the cause of absence of a map for module of inflow for whole Syrdarya basin.

Landscape-climatic mapping of water balance is based on more complex and thin dependences, which in various combinations enable to estimate continuously on territory climatic parameters, its components, as in mountain, and flat area.

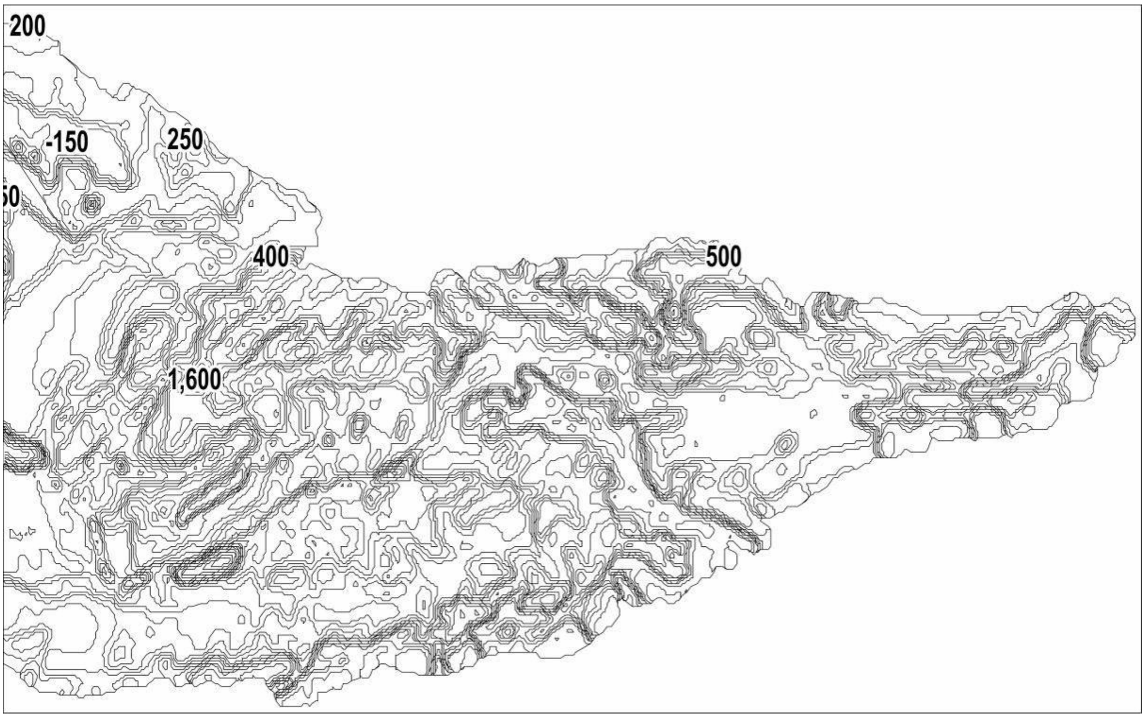

Figure 34. Distribution of water balance for Year (mm).

Conclusion

The landscape-climatic approach to estimation temperature-humidifying parameters is based on principles of stratification of set influencing of the climate forming factors on a series of simple and statistically authentic components, which confidently correlate with natural factors indicators, and reconstruction on the basis of the founded connections of quantitative characteristics of climatic parameters. Thus a critical requirement is not the weight separate influential ingredient in a complex, but a consistency and an exactitude of grouping exposition them of character space. The given approach does not claim for strict scientific description of thermodynamic processes of interaction of atmosphere and underlying terrain. The used procedure reveals statistically significant quantitative connections between explored climatic indexes and their connatural indicators.

By results of the analysis of partial dependences the hypermatrix of the most probable state of climatic indexes for the relevant geographical environment, geometries of a landforms and types of a underlying terrain is built. The step of clusterization of modelling algorithms is picked such that the computing exactitude matched to a representativeness of input data. The method of modelling operation for climatic indexes on their connatural indicators allows bypassing challenges of effect of fast local heterogeneities of heat exchange of an atmosphere and a underlying terrain, which render big effect on forming of a local climate.

For elaboration of simulative algorithms large analyzable database of the climatic and connatural data, which reflects the greatest possible spectrum of state of explored parameters and responses of an environment, is very important. Such unwieldy and single procedure of classification is completely cancelled by the relative simplicity of preparation of input data for practical calculations and a high-speed evaluation.

The methodology and structure of landscape-climatic modelling operation determines a sphere of its application in climatology and hydrology. Minimum stable time step is one month; minimum admissible spatial scale is determined by variety of connatural indicators.

All algorithms are invariant over the range geographical coordinates from 15° Southern latitude till 85° Northern latitude; from 20° Western longitude till 180° Eastern longitude. It allows calculating space distribution of climatic indexes in flat and mountain terrains of this part of a Globe.

The complex tasks of spatial-temporary allocation of precipitations and evaporation within the framework of landscape-climatic method with comprehensible reliability of modelling are solved. Precipitations are characterized by very high territorial variability, especially in mountain regions. Most of known formulas for calculation of evaporation from underlying terrain have a restricted diapason for spatial application and insufficiently completely take into account effect of geometry of landforms, air pressure and humidity. It was possible to solve and this problem at a comprehensible level of reliability in the given researching. In outcome, the possibility has appeared to estimate water resources of terrain through potential water balance. After realization of preliminary procedures of detailing, the given method can be applied to a solution of some engineering hydrological tasks.

Perspectives of the landscape-climatic approach for estimation of a thermal regime are not restricted only to air temperatures. The methodology admits dilation of a spectrum of modelling for such temperature performances, as the sum of air temperatures for the given intervals and soil temperatures.

In structure of model operations all investigated climatic indexes - temperature, precipitations and evaporation are interdependent by a principle of a feedback also compound the continuous whole of climatic processes.

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Резюме

Гречаниченко Ю. **Ландшафтно-климатическое моделирование**

В статье рассматриваются методические аспекты пространственно-временного моделирования климатических показателей в условиях недостаточного обеспечения климатическими данными наблюдений. Предложен и обоснован ландшафтно-климатический подход к оценке температур, осадков, испарения и производного от них водного баланса, как для равнин, так и для горных территорий. Данный подход основан на принципах расслоения совокупности климатообразующих факторов на серию простых и статистически достоверных составляющих, которые уверенно коррелируют с природными факторами - индикаторами, и реконструкцией на основе выявленных связей количественных характеристик климатических параметров.

Разработанная классификация температурно-влажностных показателей по типам подстилающей поверхности позволила создать рабочие алгоритмы для количественной оценки и предсказания температур воздуха, осадков, испарения и водного баланса на основе анализа орографических, ландшафтных и/или почвенных исходных данных. Приведены основные формулы, блок - схемы и оценка достоверности рабочих алгоритмов модели пространственно-временного предсказания климатических показателей.

Тестирование модели проведено на примере горных районов бассейнов рек Или и Сырдарья, результаты тестирования приводятся в настоящей статье. Работа климатической модели на реальных данных показала, что она может быть использована для решения задач климатологии, а также для оценки состояния и перспектив практического водопользования в речных бассейнах.