

SPATIAL DISTRIBUTION OF CLIMATIC INDEXES ON THE TERRITORY OF FOREST-STEPPE AND STEPPE OF THE LEFT-BANK UKRAINE

С. І. Решетченко, В. Г. Клименко, Н. І. Черкашина, В. В. Машкіна. ПРОСТОРОВИЙ РОЗПОДІЛ КЛІМАТИЧНИХ ПОКАЗНИКІВ НА ТЕРИТОРІЇ ЛІСОСТЕПУ ТА СТЕПУ ЛІВОБЕРЕЖНОЇ УКРАЇНИ. У статті розглядаються особливості розподілу середньомісячної температури повітря, місячної кількості опадів та середньомісячного приземного атмосферного тиску на території лісостепу і степу лівобережної України впродовж року. За допомогою кластерного аналізу були визначені закономірності просторової зміни кліматичних показників впродовж року за період 1951-2000 рр. Встановлено, що зміни часових рядів кліматичних показників формуються під впливом великомасштабних атмосферних процесів і мають свої варіації впродовж сезонів. Також досліджується вплив Північної Атлантики на кліматичні умови досліджуваної території, який максимально відчувається у осінньо-зимовий період. Статистичний аналіз температурних рядів дозволив визначити подальшу тенденцію зміни температурного режиму Харківської області за період 2001-2014 рр., що характеризується зростанням температури повітря. Отримані результати уточнюють інформацію про просторово-часові зміни основних кліматичних показників на регіональному рівні.

Ключові слова: температура повітря, атмосферні опади, атмосферний тиск, кластерний аналіз, статистичний аналіз.

С. И. Решетченко, В. Г. Клименко, Н. И. Черкашина, В. В. Машкина. ПРОСТРАНСТВЕННОЕ РАСПРЕДЕЛЕНИЕ КЛИМАТИЧЕСКИХ ПОКАЗАТЕЛЕЙ НА ТЕРРИТОРИИ ЛЕСОСТЕПИ И СТЕПИ ЛЕВОБЕРЕЖНОЙ УКРАИНЫ. В статье рассматриваются особенности распределения среднемесячной температуры воздуха, месячной суммы осадков и среднемесячного приземного атмосферного давления на территории лесостепи и степи левобережной Украины в течение года. Определено, что изменения временных рядов климатических показателей формируются под действием крупномасштабных атмосферных процессов и имеют свои вариации в течение сезонов. С использованием кластерного анализа были определены закономерности пространственного изменения климатических показателей в течение года за период 1951-2000 гг. Также исследуется влияние Северной Атлантики на климатические условия изучаемой территории, которое максимально значимо имеет в осенне-зимний период. Статистический анализ температурных рядов позволил определить дальнейшую тенденцию изменения температурного режима Харьковской области в период 2001-2014 гг., что характеризуется увеличением значений температуры воздуха. Полученные результаты уточняют информацию о пространственно-временных изменениях климатических показателей на региональном уровне.

Ключевые слова: температура воздуха, атмосферные осадки, атмосферное давление, кластерный анализ, статистический анализ.

Formulation of the problem. Changes in meteorological values indicate unsteady temperature conditions of both the global and regional climatic systems [1-4, 11-14]. It has been determined that sharp fluctuations in the average daily air temperature can be accompanied by dangerous elemental hydrometeorological phenomena: squalls, hail, tornados and thunderstorms. The study of regional law of the climatic indexes distribution in the conditions of global warming will allow to define the features of atmospheric processes that form the anomalies of temperature, to specify factors of impact that will improve methods of short-term and long-term forecasts in the future.

Analysis of recent research and publications. The main results of the global climate studies are in the report of the Intergovernmental Panel on Climate Change at the United Nations and WMO [10], as well as in a number of papers [7-9]. Analysis of climatic parameters on the territory of Ukraine was carried out by many researchers [1-3, 6, 15-16, 18, 20-21]. They consider temperature and humidity conditions, as well as the synoptic conditions of their formation. Further study of the climate of Ukraine, as a component of the global climate, will identify

features and rate of change of meteorological parameters.

The purpose of the article. The statistical methods of long-term prognoses allow to calculate meteorological processes, to build the statistical models of meteorological values and phenomena. By means of cluster and component analyses climatic fields of average monthly air temperature values, monthly rainfalls and atmospheric pressure have been studied at 38 stations for the year in the second half of the last century. The cluster analysis is an heuristic algorithm based on the Euclidean distances determined with predetermined threshold values. This method is called "Universal iterative adaptive method of cluster analysis (UAIMKA), which examines the components of the vectors characterizing the physical state of the atmosphere [19]. Initial information was introduced by matrix $X = \{X_{ij}\}_{nm}$, composed of n-series vectors with capacity m, characterizing the statistical series of volume $m = 50$ of 38 points (n), which can be clustered.

Taking into account that the meteorological fields are formed under the action of atmospheric processes of different scale, the method of component analysis allows the make parameterization of

these climatic fields' data. They are expressed by a few uncorrelated parameters, linearly connected with the components of a random vector and contain basic information about the change [5]. This method (the method of expanding the fields on the natural orthogonal functions (NOF) allows to "compress" the initial information, analyzing it, and it has been applied to the temporal rows of monthly average air temperature, precipitation, surface pressure considered during the year for the period from 1951 to 2000.

Presentation of the main material. Cluster analysis characterizes the same type of districts on temperature conditions, moisture regime and atmospheric pressure within the limits of forest-steppe and steppe of the left-bank Ukraine.

Fig. 1 shows as an example, districting of the territory on the values of atmospheric pressure for

the central months of the seasons (January, April, July and October). A winter period is characterized by the presence of three districts: north (I), south (III) and southeast (II). Northern district embraces the territory of Chernihiv, Sumy, Poltava, Kyiv and partly Kharkiv regions. In a December-January period, it extends to the borders of Zaporizhzhya, Dnipropetrovsk and Luhansk regions. In February the south-eastern district activates to the limits of Luhansk and Donetsk regions. In spring characteristic is distribution into the territory of northern district. The southeast is mainly within the limits of Luhansk region, and in May it is replaced by the southern one.

In summer the third district activates on the territory of Luhansk and of Donetsk regions. In July northern district broadens on the large area of the examined territory (up to borders of Zaporizhzhya

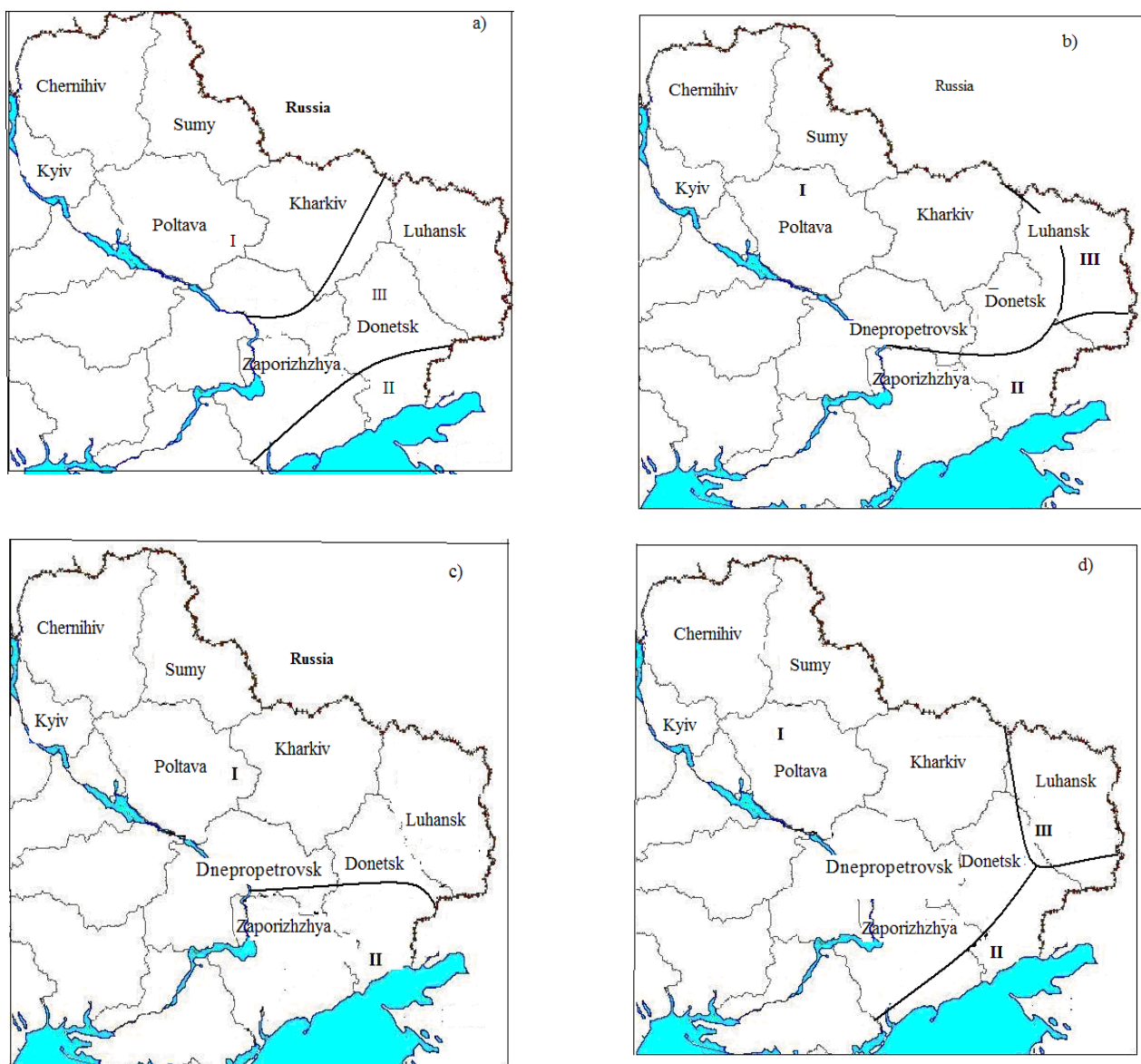


Fig. 1. Classification of the territory on air temperature, precipitation and atmospheric pressure (a- January, b- April, c- July, d- October)

and Donetsk regions).

In autumn there is leveling of the climatic field of atmospheric pressure: northern district embraces almost all the territory of forest-steppe and steppe, displacing the southern to the coast of the Azov sea. Within the limits of Luhansk and Donetsk regions the south-eastern district recommences.

Analysis of the average monthly values of air temperature on the presented territory have shown two main districts in an autumn-winter period: northern and southern, the border between them passes on the line of the north-west of Luhansk region, the north of Donetsk and the south of Dnipropetrovsk regions. It takes place near the barometric axis of Vovchuk, which is defined by atmospheric circulation. In a spring-summer period when the main value has the feature of laying surface, in forest-steppe and steppe of the left-bank Ukraine a local district is formed on the territory of the Azov-Donetsk ridge.

Distribution of atmospheric precipitation is complicated on the territory as it is formed under the influence of circulation factors where regional circulation is examined as a component of general circulation. Thus, the change in the amount of precipitation on the territory takes place differently. Atmospheric precipitation substantially changes in time. During the research there have been selected three districts (northern, central, southern) that have mainly latitudinal location. Northern region is located in Chernihiv, Sumy, Poltava and Kiev regions, the central – in Dnepropetrovsk, Kharkov, Lugansk, on the north of Donetsk and Zaporizhzhya regions, southern – on the coast of the Azov Sea. A more homogeneous climatic precipitation field is in autumn and winter.

In a spring-summer period local districts reflecting local orographic features of the territory are determined. Significant changes in the precipitation field are marked in a spring period under the action of general and regional factors of atmospheric circulation.

Thus, in the forest-steppe and steppe zone of the left-bank Ukraine a cluster analysis has defined three basic districts with general temperature and water-moisture descriptions and similar distribution of the surface pressure. In a fall-winter period these climatic fields have a clear structure that confirms the impact of global atmospheric processes on their formation.

A component analysis defined main components corresponding to the large structure features of the climatic fields of air temperature, precipitation and atmospheric pressure (table 1). According to table 1, the average monthly temperature of air is characterized by the first main component that has 80-93% of total dispersion of this field in all seasons of year. The climatic field of atmospheric pressure

has 85% of total dispersion in an autumn-winter-spring period, in summer - 70%. Field of precipitation is characterized by two main components described as 64-76% of total dispersion of the field in February-April, September-November and December periods (table 1). In May-August for consideration of the field of atmospheric precipitation it is necessary to take into account three main components that have more than 50% dispersions of the precipitation field. As is known, the first main components characterize the features of large atmospheric processes that influence the climatic fields formation over the prospected territory.

The second and the third principal components are the processes of a smaller scale, small-scale fluctuations, noise, which can be observed because of errors in the measurements and data processing. The analysis of the field of the first own vector of the correlation matrix of atmospheric pressure for a year on this territory determines two districts: the first is located within the limits of Chernihiv, Kyiv, Poltava, Sumy and partly Kharkiv regions; the second is on the territory of Dnipropetrovsk, Zaporizhzhya, Luhansk regions. During winter they change their configuration due to the changes of atmospheric circulation.

In January, the southern district narrows but in February it occupies the area of the south-eastern part of Luhansk region. The first district is formed under the influence of western transfer where western, north-western winds bringing significant atmospheric precipitation prevail. Another district is under the influence of eastern, north-eastern winds bringing dry air. The location of the first district has a meridional location, and the second one has a latitudinal location. Thus, at the end of winter the prevailing part of the territory is under the influence of cyclonic activity of North Atlantic.

The location of districts changes in spring. In March the central district broadens in the north-eastern direction. The area of northern district diminishes, the southern district spreads to the borders of Poltava and Kharkiv regions. In summer there are local district within the north-east of Luhansk region and south-west of Dnipropetrovsk, Zaporizhzhya regions. In autumn under the influence of the atmospheric circulation above the Azov - Black and the Mediterranean seas aquatoria additional districts are formed. By October, the climatic fields of atmospheric pressure stabilize on the studied territory.

The fields of the first own vector of correlation matrix of average air temperature confirm two pre-existed districts: northern and southern, their division takes place on the line Kharkov-Dnepropetrovsk. In winter there are local districts on the east of Sumy and the northeast of Luhansk regions. The climatic field of air temperature is per-

Main components of air temperature, precipitation and atmospheric pressure

Month	Amount of main components	Air temperature		Precipitation		Atmospheric pressure	
		λ_i	$\sigma_{z_i}^2, \%$	λ_i	$\sigma_{z_i}^2, \%$	λ_i	$\sigma_{z_i}^2, \%$
01	1	33,97	91,82	28,42	74,78	33,98	88,0
02	1	32,91	88,94	21,76	57,26	34,26	89,0
	2	-	-	4,47	11,76	-	-
03	1	34,35	92,84	21,10	55,53	33,50	87,0
	2	-	-	4,82	12,69	-	-
04	1	34,24	92,54	18,02	47,42	31,77	85,0
	2	-	-	6,26	16,46	-	-
05	1	33,73	91,15	14,96	39,36	30,9	82,0
	2	-	-	5,50	14,48	-	-
	3	-	-	2,03	5,34	-	--
06	1	34,42	93,01	16,25	42,75	28,02	70,0
	2	-	-	3,30	8,68	-	-
	3	-	-	1,74	4,58	-	-
07	1	31,52	85,20	14,69	38,64	27,11	68,0
	2	-	-	4,28	11,25	-	-
	3	-	-	2,21	5,81	-	-
08	1	31,32	84,66	13,25	34,86	26,07	67,95
	2	-	-	5,58	14,69	-	-
	3	-	-	2,13	5,60	-	-
09	1	33,44	90,37	20,08	52,83	29,65	69,37
	2	-	-	4,94	12,99	-	-
10	1	32,80	88,65	23,18	60,99	32,19	86,25
	2	-	-	3,31	8,70	-	-
11	1	32,11	86,78	21,71	57,14	34,31	89,21
	2	-	-	7,11	18,72	-	-
12	1	32,70	88,37	21,71	57,13	33,37	88,68
	2	-	-	6,32	16,63	-	-

manent in spring. Northern district broadens into the territory. In summer a local district activates on the east of Sumy, Kharkiv, and Luhansk regions. In August due to the increased process over the water area of the Azov and Black Seas the southern district spreads to the northeast, covering almost all the territory of Kharkiv and Luhansk regions. In autumn under the influence of atmospheric circulation northern district activates on the greater part of the prospected territory.

The analysis of the fields of the first own vectors of correlation precipitation matrix specifies on two districts. In winter they change. The first district has meridional direction and western cyclonic influence. Its area diminishes in spring. The southern district activates. In summer local districts appear on the north-eastern and south-western territory. In au-

tumn during the activation of atmospheric processes there are insignificant districts on the south of the prospected territory.

Thus, under the influence of atmospheric circulation, solar radiation throughout the year there is a transformation of the surface pressure field, temperature and moisture characteristics in forest-steppe and steppe zone of the left-bank Ukraine, which must be considered when forecasting the dynamics of regional climate changes.

Conclusion. The research has allowed to specify the same type of areas on temperature and humidity characteristics and the distribution of atmospheric pressure by the actual data in the forest steppe and steppe zone of the left-bank Ukraine. The component analysis has revealed the factors of main climatic fields of the territory formation. On the exam-

ple of Kharkov region a trend in the increase in surface air temperature, which is ahead of global growth has been determined.

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