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RECYCLING

AIR POLLUTION AND CLIMATE CHANGE

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DROUGHTS IN KAZAKHSTAN

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ABSTRACT

One of the main and most important features of the weather in Kazakhstan is the air temperature, which significantly affects for energy, agriculture, etc. Particular interest are the significant temperature anomaly, which is related to many dangerous phenomena. These include, first of all, severe drought, excessive moisture, which if not take the necessary protective measures, often bring huge losses in various sectors of economic activity.There is no any single universal index to characterize the conditions of atmospheric aridity. The article as indicators of changes in aridity/moisture in the area it is proposed to use the Ped Index (Si).It includes the main factors necessary for the formation of the phenomenon under study: air temperature (T) andthe amount of rainfall (R), the author suggested not to take the values T and R but their anomaly (ΔT and ΔR).

Drought occurs when there is a combination of a large anomaly fields: $\Delta T >> 0$ and $\Delta R << 0$. The formation of a drought will occur in the area where it will be the largest in magnitude. We can know about the intensity of atmospheric drought on the value of S: the more Si, the phenomenon is stronger, and vice versa. By the intensity the drought can be divided into three classes: weak (Si = 1,0–2,0), average (Si = 2,0–3,0) and strong ($Si \geq 3,0$).

The materials of 1960-2014 for 30 meteorological stations, relatively evenly located on the territory of Kazakhstan, were studied to determine the degree of aridity of the summer season in Kazakhstan.The duration of atmospheric drought of different intensity by months was studied. The frequency of occurrence in a single month is much bigger than two, but it's even smaller in three and four. Protracted drought, which is observed continuously in two or three months in a row, is a very rare phenomenon.The spatial extent of droughts was investigated across regions: Western, Northern, Eastern, Central and Southern. The most of the dry months were observed in Northern, Eastern and Southern regions.The dynamics of atmospheric ariditywere analyzed– the trend component is missing in most parts of the territory.

Keywords: drought, temperature, precipitation, aridity index, duration and extent of drought.

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INTRODUCTION

One of the main and most important features of the weather in Kazakhstan is the air temperature, which significantly affects for energy, agriculture, etc. The most interesting are the significant temperature anomalies in all over the world, which are related to many dangerous phenomena. These include, first of all, severe drought, excessive moisture, which bring huge losses in various sectors of economic activity, if we will not take the necessary protective measures [1-3].

The main branch of agriculture of Kazakhstan is grain farming. In recent years, the overall cereal crops occupy more than 80 % of the cultivated area of crops, which productivity largely depends on weather conditions of a particular year [4].

MATERIALS AND METHODS

The materials of 1960-2014. for 30 meteorological stations, relatively evenly located on the territory of Kazakhstan, were studied to determine the degree of aridity of the summer season in Kazakhstan

There is no any single universal index to characterize the conditions of atmospheric aridity [5]. The article as indicators of changes in aridity/moisture in the area it is proposed to use the Ped Index (Si) [6]. It includes the main factors necessary for the formation of the phenomenon under study: air temperature (T) and the amount of rainfall (R), the author suggested not to take the values T and R but their anomaly (ΔT and ΔR):

$$Si = \frac{\Delta T}{\sigma_T} - \frac{\Delta R}{\sigma_R},$$

where σ_T, σ_R – the average quadratic deviations ΔT and ΔR.

The formation of a drought will occur in the area where it will be the largest in magnitude. We can know about the intensity of atmospheric drought on the value of Si: the more Si, the phenomenon is stronger, and vice versa. By the intensity the drought can be divided into three classes: weak (Si = 1,0–2,0), average (Si = 2,0–3,0) and strong (Si ≥ 3,0).The most dangerous for agricultural production is the atmospheric spring drought during which the developing the roots of plants is occuring. With a weak root system, but the strong transpiration, the plant dies even when the moisture reserves in the soil that it is unable to use. Summer droughts, especially in the second half of the season, are less dangerous. Therefore, with the same total figures for the vegetation period the effect may be different (for the harvest) depending on when there was a great drought in the first or second part of this period. So the description of the drought through Si is necessary to produce taking into account the time [6].

RESULTS

Unlike other criteria, the Si index does not estimate the degree of arid climate, but characterizes the actual drought, which can be characterized by the intensity, duration and coverage of the territory.

On April, the maximum values of Si are equal to an average of 3.0, with a large focus of highest values recorded in the central (3.1–3.7), in the east (3.3–3.9) and in the south (3.3-4.1) regions. In May, the field of the Simax parameter changed significantly, its average value is 2.8. At this time several centers of maximum Si values are noted: in

the north of the republic (3.6-4.4), in the south (3.4-3.7) and in the southeast (3.2-3.9). In June, July and August the average value of Simax is 3.0-3.2, with the maximum value in July (7.6 - Kainar).The most intense atmospheric droughts in June are observed in the western, northern and southern regions; in July – in the south; in August – in the western and northern. In September, there is a slight decrease in the intensity of atmospheric aridity, the average value of Si max is 2.1, and the maximum value is 4.0. The repeatability of droughts of different intensities is not the same. A weak phenomenon is more common, the average is less frequent, and a strong one is very rare (less than 5%). Extreme values of Simax reach large values (4.1-7.6), and can be in different months of the warm period.

Table 1 – The spatial extent of droughts of different intensity in Kazakhstan

Year	Region of Kazakhstan				
	W	N	C	S	E
April					
1961			*	*	*
1962	*	*			
1967		*	*		*
1970			*	*	
1975		**	**	**	
1977	*	*	**	**	*
1982			*	**	*
1983	*	*	*	**	*
1988	*	*	*	*	*
1991	*	*	*	*	*
1995	**	**	**	**	
1997		**	***	**	
2000	*	*	**	***	*
2007		*			
Total:	7/100	11/100	12/100	11/100	8/100
*	6/86	8/72	7/58	4/36	8/100
**	1/14	3/28	4/33	6/55	
***			1/8	1/9	
June					
1963		**			
1965		*			
1974				*	*
1975	**	*			
1976		*			
1977	**	**	**	**	**
1982		*	*		**
1985			*	*	
1988	**	**			
1990		*	**	**	*
1991	**	**	**		*
1994		*	**	*	*
1996		*			
1997		*			
1998	**	*	*		*
2008			*	**	*
Total:	5/100	13/100	8/100	6/100	8/100
*		9/69	4/50	3/50	6/75
**	5/100	4/31	4/50	3/50	2/25
***					

Year	Region of Kazakhstan				
	W	N	C	S	E
May					
1961	*	*	**	**	
1962		*			
1965		*	*	**	*
1968	**	*			
1974	*	*	**	*	**
1976			*	*	*
1977	*	*	**	*	
1980	*	*			
1982			*	*	*
1991	*	**	*	**	*
1999			*		**
2001		**	**		
2004	*	*			
2008			**	**	
Total:	7/100	10/100	10/100	8/100	6/100
*	6/86	8/80	5/50	4/50	4/67
**	1/14	2/20	5/50	4/50	2/33
***					
July					
1962	**	*	*	**	*
1963				*	*
1965		**	**	**	**
1966		*			
1974		*	**	**	**
1975	**	*	*	**	*
1980	*	*	*	**	
1981		*	*	**	
1983	*	**	**	**	*
1984	***	*	*	***	
1987			*		*
1989		**			
1996		*		*	*
1997			*	**	*
1998	**	**	**	*	*
2000				**	*
2005				***	
2008	*	*			
Total:	7/100	13/100	12/100	14/100	11/100
*	3/43	9/69	8/67	3/21	9/81
**	3/43	4/31	4/33	9/65	2/19
***	1/14			2/14	

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Table1 continuation

	August					September					
1962				**	*	1966		*	**		**
1966	*	*				1971	***	***	**		*
1968			*		*	1975		*			
1976	***	**	**	**	*	1978		**	**		*
1981	*	***				1980		*	*		*
1983		*	*	**	*	1982		*			
1984			**	**	*	1990			*		*
1987			*	**	*	1997		*	**		**
1988		*				2002			*	*	
1989		*	*	*	*	2003		*			
1995	*	*	*	*		2007	*	*	*	*	
1997		*									
1998		***	**	*	**						
1999	**	*	**	*	*						
2000			*	**	*						
2002			**	*							
2003	*										
2006			*	**							
2007			*	*							
2008	**	*	**	**							
Total:	7/100	11/100	14/100	14/100	10/100	Total:	2/100	9/100	8/100	2/100	6/100
*	4/57	8/73	8/57	6/43	9/90	*	1/50	7/78	4/50	2/100	4/67
**	3/43	1/9	6//43	8/57	1/10	**		1/11	4/50		2/33
***		2/18				***	1/50	1/11			

Regions of Kazakhstan:
W - Western, N - northern, C - central, S - southern, E - eastern.
The intensity of the drought: * - weak, ** - average, *** - strong

The duration of atmospheric drought of different intensity by months was studied. The frequency of occurrence in a single month is much bigger than two, but it's even smaller in three and four. The probability of a drought in two consecutive months is 4-6%, only in the southern region it increases to 10%. The probability of a drought for three consecutive months is about the same (3-6%). So, the protracted drought, which is continuously observed in two three months in a row, is very rare.

The analysis showed, that $Si \geq 3$ never passes into adjacent months in the same gradation. As a rule, after such droughts calculations show $Si \leq 2$ that demonstrates weakening of the phenomenon over time. The similar tendency is observed for $Si \geq 2$, but such state ($Si \geq 2$) can remain in adjacent months. The most important parameter characterizing the drought is the coverage of this phenomenon. In this work, droughts of varying intensity have been considered covering most of the territory under consideration.

It is interesting to clarify the relationship between the parameter of atmospheric aridity on the Ped Index (Si) with the productivity of cereals. The value of a particular indicator characterizing hydrometeorological conditions for the development of agricultural crops is determined primarily by its relationship to the productivity. The results of drought estimates for the Si parameter confirmed average and severe droughts (1975, 1984, 1991 and 1998), almost all droughts in Kostanai. Akmola and Pavloda regions, identified by the yield of grain crops,

Figure 1 shows the distribution of the aridity on the Ped Index across Kazakhsta from April to September 2008. The analysis of the dynamics of atmospheric aridity is scientific and practical interest.The example of the Akmola region shows the tenden of the temporal variation of the aridity parameter (Si) for the warm period from 196

2014 (Figure 2).

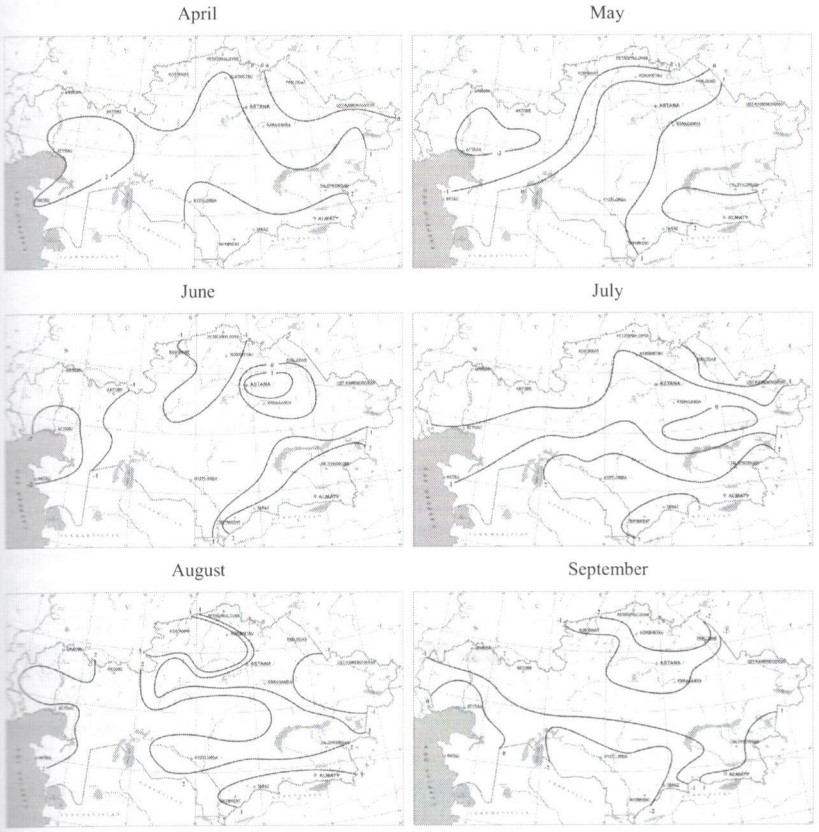

Figure 1 – Distribution of the aridity Ped Index on the territory of Kazakhstan from April to September 2008

Positive trends are observed in May, August and September, in all other months of the warm period the trend component is absent. A similar analysis was conducted for all regions of Kazakhstan, weak positive trends are observed in August-September in most of the territory under consideration.In the work, histograms of the distribution of the parameter Si by stations and regions for the months of the warm semester were constructed. For illustration Figure 3 shows us the histograms of the distribution of the Ped Index in the Akmola region from April to September.

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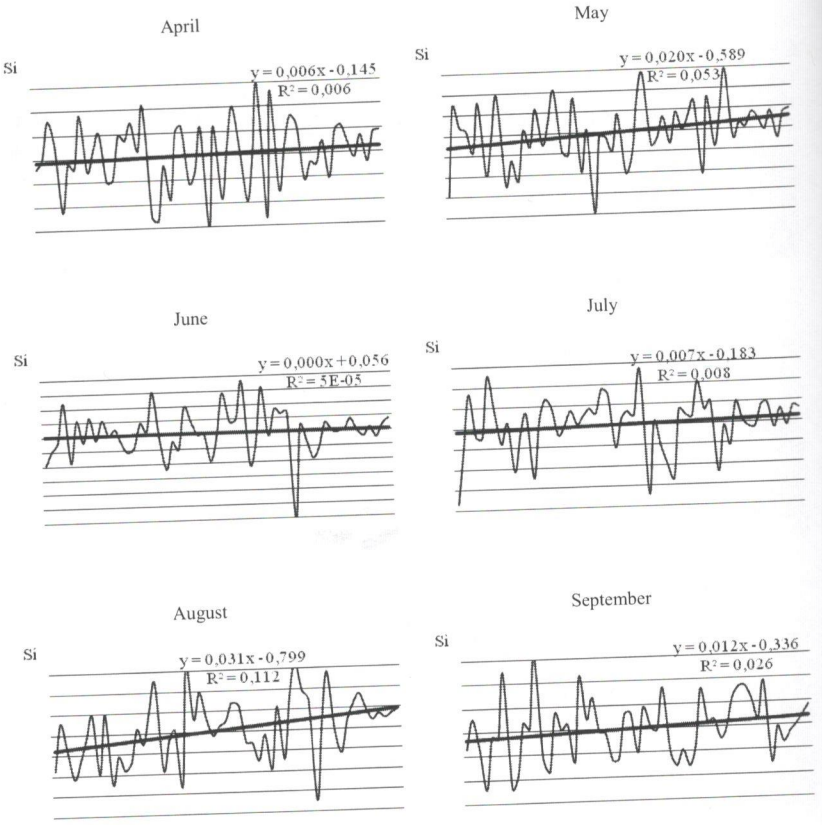

Figure 2 –Dynamics of the atmospheric aridity index in the Akmola region from April to September

According to Figure 3, in the Akmola region, the values of the parameter Si> 1 in all months of the warm period are noted in 14-36% of cases. Strong droughts with Si> 3 are rare and occur in 3-5% of cases. The value of the index of Si < -1 is observed in 16-27% of cases, and strong humidification of Si < -3 only in 3% of cases.

DISCUSSION

Most of the territory of the Republic of Kazakhstan, located in arid and semi-arid zones, is vulnerable to the observed climatic changes.

There is no single universal index to characterize the conditions of aridity / moistening. The list of indices used in world practice is quite wide [5-12], you can

indicate some of them that are used in Kazakhstan: Moistening coefficient (the relation of an amount of precipitation and evaporability) which allows to judge moisture supply based on the ratio of heat and moisture reaching this land area.

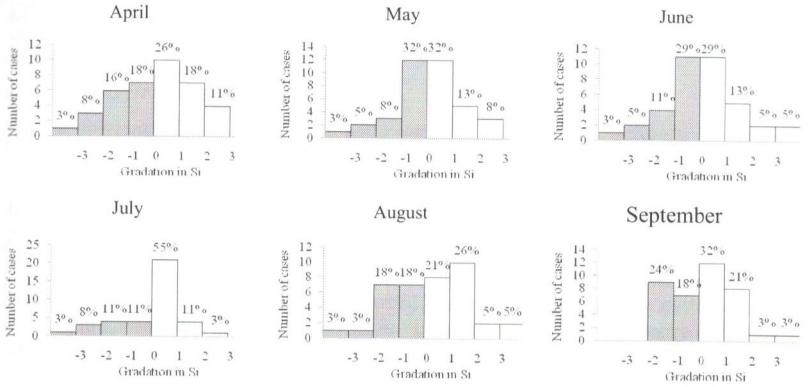

Figure 3 –Histograms of the distribution on the Ped index in the Akmola region from April to September

– Selyaninov Hydrothermal Coefficient (SHC) – Integral index of the hydrothermal regime, taking into account heat and moisture and used as an indicator of the moisture content of the vegetation cover [4].

– Standardized precipitation index (SPI) – Is recommended by the World Meteorological Organization for use by all national hydrometeorological services to assess humidification conditions. SPI is developed on the basis of the provision that the deficit of rainfall has a different effect on the surface and underground runoff of natural waters, snow cover and soil moisture [1].

– Palmer Drought Severity Index (PDSI) – Is based on the use of available meteorological data (air temperature and precipitation), as well as local constants characterizing the moisture capacity of the soil. On the basis of these input values, using the simplified scheme of moisture transfer in soil, the real and potential values of evapotranspiration are determined, which are determined by the Torntveit method [7].

– Ped Index (Si) [6] - Using Ped Index in this study allows us to characterize the drought in terms of intensity, time of onset, duration and place of origin.

CONCLUSION

The climatic features of atmospheric aridity in Kazakhstan with the help of Ped Index are considered, calculated for April-September 1960-2014, which describes the actual drought, characterized by the intensity, duration and coverage of the territory. The repeatability of droughts of different intensity is always different. A weak phenomenon is more common, the average is less frequent, and a strong one is very rare (less than 5%).Repeatability of initial values is diverse and depends on the region. The probability $Si \geq 3$ is about 4 % for the whole territory of Kazakhstan, while in the North it around

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8% in the West about 5% in the South around 3 % in Eastern and Central about 1 %, i.e. severe drought observed not often. Probability Si ≥2 is much more and is about 20-25%.The analysis of the dynamics of atmospheric aridity in grain-bearing regions of Kazakhstan for the spring-summer period for 1971-2008. It shows that in the territory under consideration there is no significant trend towards an increase in atmospheric aridity.

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