UDK 351: 551.58

O. ISMAILOVA, O. VOLOSHKINA

ANALYSIS OF THE IMPACT OF SOLAR ACTIVITY ON INDICATORS OF CLIMATE CHANGE ON AREAS WITHIN THE DNIESTER RIVER BASIN

Abstract. *Investigated the change of climate in the Carpathian region. The authors evaluated the impact of solar activity on indicators of climate change. Analysis based on data that were obtained from meteorological stations located within the Dniester river basin. Research period is 65 years. The author based on statistics made mathematical analysis of the impact of solar activity on the change of air temperature and amount of precipitation in the region. Mathematical dependence of these quantities, which allows making predictions of future changes in amount of precipitation, depending on the future activity of the sun.*
Keywords: *Wolf numbers, climate change, amount of precipitation, correlation analysis, temperature.*

Introduction

In this study evaluated the impact of solar activity on the main indicators of global climate change. The problem of global climate change is one of the important problems of the modern world.

To investigate was chosen the territory within of the Dniester River basin. Dniester is the largest transboundary river in Western Ukraine and Moldova. The total length of 1380 km of the river, in Ukraine it is 925 km (68%), respectively, within the Dniester Moldovan length is 652 km. Dniester Basin watercatchment area of 72.1 thousand km^2, of which in Ukraine is 52.7 thousand km^2 (73.1%), respectively within Moldova – 19.4 thousand km^2 (26.9%). Taking above mentioned into account, we can see the relative decreasing of Dnister water within territory of Moldova.

Data collection for the study was carried out by Hydrometeorological post located within the above mentioned basin.

This paper studied the influence of solar activity on the change in rainfall and temperature within the territory of the Dniester river basin.

Solar activity characterizes the current solar radiation and its spectral distribution, related electromagnetic phenomena and changes in the characteristics of time sun. Sunspots – a relatively dark areas on the photosphere of the Sun where intense magnetic field inhibits convection plasma and lowers its temperature to 2000 K.

Number sunspot (number Wolf) is investigated for 300 years.

Statistical evaluation of climate change in the region

To assess the climate in the region investigation was chosen two options – rainfall (mm) and average temperature (^{0}C).

Analysis of monitoring data long-term observations of rainfall and temperature for meteorological observation posts drainage basin of the Dniester was done for the period 1945–2009 y.y. Made it possible to detect a gradual increase in both indices as for years, and for individual months.

Based on statistical data, the following conclusions were made that the temperature began to rise in the period from 1988 to 2009. From 1945 to 1988 the temperature is decreased, then increased (1945–1954, 1977–1987 – decreased, 1955–1976 – was increased), but remained almost the same range, after 1988 marked a clear stable increase in temperature on the proposed Hydrometeorological post.

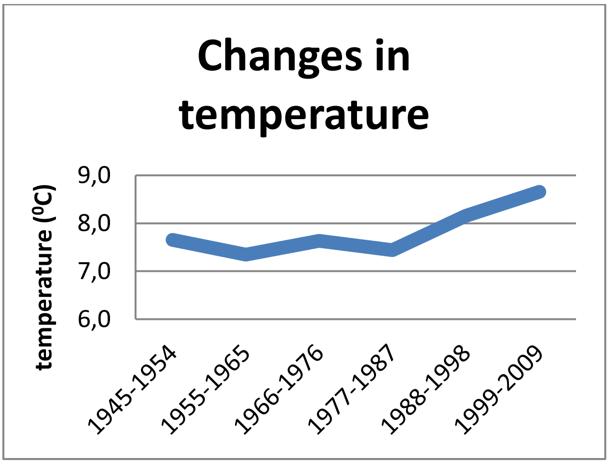

Fig. 1 – Changes in temperature for a long period in the basin of the river Dniester

Also conducting correlation analysis, we could to note that the coefficient of correlation between changes in precipitation and air temperature in the region equal to 0.53.

The impact of solar activity on the change of the temperature and precipitation in the region studied

In a subsequent study determined the impact of Wolf numbers in key indicators of climate change (temperature and rainfall).

It was conducted statistical evaluation depending annual average temperature changes of annual average Wolf numbers for a long period. For answers or solar activity affects the change in air temperature in the region conducted a correlation analysis grouped and not grouped by the data.

The values of the sample correlation coefficient r = 0,16 and correlation relations η_{yx} = 0,19 and η_{xy} = 0,25 point to the low correlation between the studied variables.

Therefore, further divide our time period at intervals of 22 years, corresponding to the cycles of solar activity.

As you can see in the second period rainfall has increased by 38.7 mm compared to the first period, the third – at 67.1 compared with the first and 28.4 mm compared to the second period. That is, you will notice a sharp increase in rainfall over the years. Over the past 22 years the average annual precipitation has increased by an average of 70 mm. The correlation coefficient in this case is quite large and is 0.88.

Table 1 – The average annual temperature, rainfall and Wolf numbers for 22-year periods from 1945 to 2010

Period	The average index – intensive rainfall for the period	The difference between the first and followed by a period, rainfall (mm)	The difference between the second and followed by a period, rainfall (mm)	Average air temperature indicator for the period	The difference between the first and followed by a period, air temperature (^{0}C)	The difference between the second and followed by a period, air temperature (^{0}C)	The average index of Wolf numbers for the period
1945-1966	697,1			7,53			80,41
1967-1988	735,8	+38,7		7,54	+0,01		72,99
1989-2010	764,2	+67,1	28,4	8,45	+0,92	+0,91	61,09

The same applies to the temperature in the second period, an increase of 0,01^{0}C and 0,92^{0}C in the third period. The correlation coefficient in this case is also significant (0.87). Over the past 22 years the average temperature in the region has increased about 1^{0}C.

Grouping according to the statistics cycles of solar activity was able to get an adequate assessment of indicators of climate change. In this case, the correlation coefficients between the air temperature and the Wolf numbers, and between rainfall and Wolf numbers are high enough, -0.59 and -0.7, respectively. The coefficient of correlation of rainfall and temperature in this case is 0.55.

The average temperature has increased in the last two periods in 1989, as annual average and seasonal.

Assessing the dynamics of rainfall, we conclude that the small amount of precipitation in winter is highly likely to give significantly increased rainfall in the spring, summer and fall, compared with periods where winter rainfall was average or high. At the annual average level to say that 11-year period corresponding to the high rainfall indices coincide with a decrease in the average number of Wolf and vice versa.

Analysis of Wolf numbers impact on change in rainfall by means of mathematical modelling

For further detailed analysis was chosen 11-year period from 2000 to 2010 (Fig. 2).

The resulting correlation coefficient has a negative sign and is significant (-0.78). So we have that with increasing numbers of Wolf rainfall decreases and vice versa. Thus, reducing the number of sunspots lead to increased precipitation.

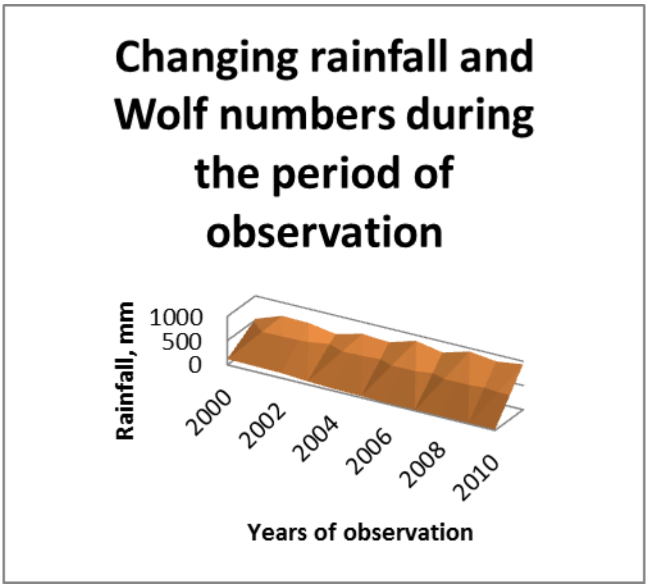

Fig. 2 – Structure of the correlation matrix is depending on the studied parameters and conducted regression analysis

Table 2 – Correlation matrix depending of numbers Wolf and rainfall

	Rainfall	Wolf number
Rainfall	1	
Wolf number	-0,781820335	1

Explore these statistics is based on the regression analysis. Linear position of points on the graph and their relatively small scattering allow direct basis for selecting linear regression model.

After regression analysis were obtained next the following equations:

$$y = 870{,}978-2{,}221x. \quad (1)$$

In this case, the coefficient of determination R^2 = 0,611, the estimated value f = 14,151 statistical significance F and F = 0,004473.

The value of statistics T t_1 = 23,1676, t_2 = 3,7617, significance $P_1 = 2{,}47 * 10^{-9}$, P_2 = 0,004473. Confidence intervals $I_{0,95}$ (1) = (785.933, 956.023) $I_{0,95}$ (2) = = (-3.5567, -0.8854).

Try to find a more accurate model of dependency among the studied polynomial models, was increasing step by step degree polynomial:

The degree polynomial, m	The coefficient of determination, R_m^2
2	0,65
3	0,678
4	0,819
5	0,820

According to the results presented, the most suitable model of study depending polynomial is 4 degrees.

$$y\,(x) = b_0 + xb_1 + x^2\, b_2 + x^3 b_3 + x^4\, b_4. \tag{2}$$

The results

The analysis had shown that the most appropriate model is a polynomial of the fourth degree.

Describing this dependence least squares method, the following characteristics were studied regressive dependence:

Random regression parameters $b_4 = -4{,}243 * 10^{-5}$, $b_3 = 0{,}0096$, $b_2 = -0{,}637$, $b_1 = 9{,}442$, $b_0 = 845{,}8$.

Standard errors of these parameters: $SE_4 = -1{,}9 * 10^{-5}$, $SE_3 = 0{,}00458$, $SE_2 = 0{,}356$, $SE_1 = 9{,}629$, $SE_0 = 65{,}663$.

Coefficient of determination $R^2 = 0{,}82$.

The calculated value f = 6,77 statistics and the number of degrees of freedom denominator of these statistics df = 6.

Polynomial regression equation sample is as follows:

$$y(x) = 845.8{+}9{,}442x{-}0{,}637x^2\ 0{,}0096x^{3-}0{,}000042x^4. \tag{3}$$

The resulting functional relationship lets you forecast for rainfall changes depending on changes in the Wolf numbers.

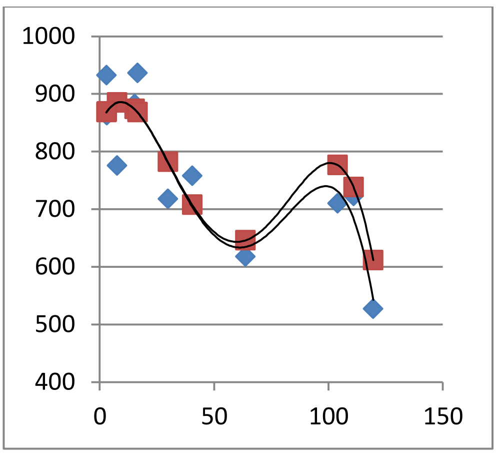

Fig. 3 – Graphic illustration depending statistical and numerical data on rainfall Wolf numbers

Conclusions

Consequently, studies have shown that in this region (the Dniester River basin) rainfall in depends on solar activity. So with increasing sunspot rainfall decreases and vice versa. Also worth noting a sharp increase in temperatures over the past decade.

With the known methods of statistical analysis were obtained functional dependence of these quantities, which allows to make predictions of future changes in rainfall amounts depending on future solar activity.

References

1. Dangerous human-made interference with climate: A GISS modelE study- J. Hansen, M. Sato, R. Ruedy, P. Kharecha, A. Lacis, R. Miller, L. Nazarenko, K. Lo, S. Zhang (Submitted on 16 Oct 2006).
2. Climate simulations for 1880-2003 with GISS model - J. Hansen, M. Sato, R. Ruedy, P. Kharecha, A. Lacis, R. Miller, L. Nazarenko, K. Lo, D. Thresher, N. Unger, M. Yao, S. Zhang (Submitted on 16 Oct 2006 (v1), last revised 12 Apr 2007 (this version, v2)).
3. Оцінка впливу глобальних змін клімату на кількість та нерівномірність опадів у Карпатському регіоні / О.С. Волошкіна, О.В. Цікало // Екологічна безпека та природокористування: Зб. наук. пр. – К., 2012. – Вип. 11. – С. 62–67.

Стаття надійшла до редакції 11.10.2016