CLIMATE CHANGE IN UKRAINE AND HYDROLOGICAL REGIME OF THE RIVERS

V. I. Vishnevskiy

Central Geophysical Observatory, Kyiv, Ukraine, e-mail: vishnev@i.com.ua

Abstract: Investigations have shown the characteristics of climate change that have significant impact on the hydrological regime of rivers. Changes of hydrological regime of the rivers are as follows: increasing of the annual runoff, the decline in the discharge during the spring flood and increase during dry periods (both winter and summer), the reduced thickness of the ice cover and the ice period phenomena.
Key words: climate change, temperature, precipitation, water runoff

DIE KLIMAVERÄNDERUNGEN IM GEBIET DER UKRAINE UND IHRER EINFLUSS AUF DAS HYDROLOGISCHE FLUSSREGIME

Zusammenfassung: Es sind die wichtigsten klimatischen Charakteristiken untersucht, die den meisten Einfluß auf das hydrologische Regime der Flüße haben. Die wesentlichen Veränderungen des hydrologischen Regimes der Flüße sind Folgenden: die Vergrößerung der mitteljährigen Abflüße, die Rückbildung der Frühlingshochwässer und Abflüßvergrößerung während des Minimalwassers (wie im Winter, als auch im Sommer), die Rückbildung der Eisdecke und der Periode mit den Eiserscheinungen.
Schlüsslworte: Klimaänderungen, Temperatur, Niederschlag, Abfluss

1. Foreword

The purpose of this study is to assess the long-term changes of main climatic characteristics that have the great impact on the hydrological regime of rivers: air temperature, precipitation, the thickness of snow layer, air humidity, wind velocity and so on. The data represent the longest period of observation that covers more than 100 years. Territory under investigation includes Ukraine and the part of Belarus, where the Dnipro river runoff is formed. The data from more than 50 meteorological stations were used for this study. Second stage of the study included the evaluation of changes in hydrological regime of the rivers with the impact of the climate change. For this aim were used data observation on rivers with small anthropogenic impact.

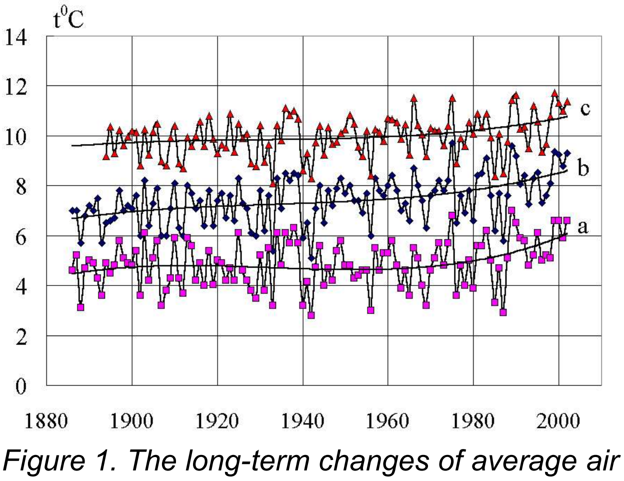

Figure 1. The long-term changes of average air temperature at meteorological stations Gorky (the North of Belarus) (a), Kyiv (the North of Ukraine) (b) and Odesa (the South of Ukraine) (c)

2. Air temperature

For the whole period of observation, started in 1880-th, is observed the increasing of average air temperature. It is 0.7-0.9 ^{0}C for 100 years. The obtained results show that increasing of air temperature on the territory of Ukraine and Belarus is higher than on the Northern hemisphere (fig.1).

The higher increasing of air temperature was noticed during January-March. It makes up about 2 ^{0}C for 100 years. The highest increasing is observed during the last 25-30 years. The increasing of air temperature in January on the North is somewhat larger, than on the South. The air temperature in July practically didn't change. The results obtained show that climate on the researched territory became more even with diminishing differences between the North and the South and between summer and autumn (fig.2).

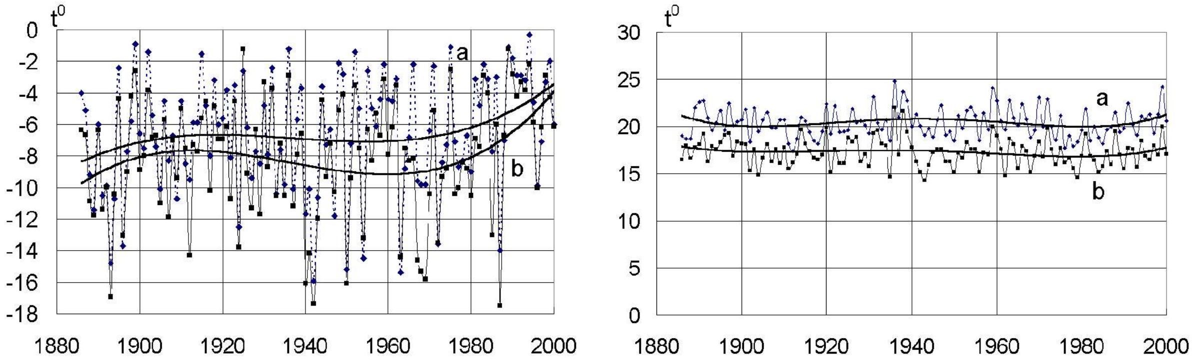

Figure 2. The long-term changes of air temperature in January (on the left) and July (on the right) at meteorological stations Gorky (a) and Poltava (b)

3. Precipitation

During observed period the precipitation on the prevalent part of Ukraine (especially on the South and East) has the tendency for increasing. These changes reach 10-15% for 100 years. At the same time the precipitation on the territory of Belarus became less.

4. Thickness of snow layer

Evaluation of long-term changes of snow layer thickness was carried out for meteorological stations situated on the very North of Ukraine. Data with the largest snow layer thickness during first three months of the year (January-March) were used. The data for December of previous years were not used because snow, formed during this month, as a rule, melts before main period of snow melting.

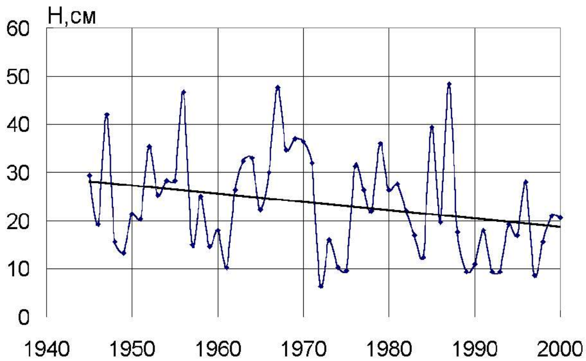

Figure 3. The long-term changes of snow layer thickness at stations, located on the very North of Ukraine

In spite of essential variability of the data it is possible to consider the decreasing of snow layer during last 50-70 years. To some extent it can be explained by the increasing of winter temperature and increasing of frequency of snowmelts during the winter months (fig.3).

The thickest snow layer was observed on the North of Ukraine in 1940-1942, 1967, 1970 and 1987. The snow layer thickness was small in 1972, 1975, 1989 and 1990.

The dimension of snow layer thickness height must influence on the characteristics of spring flood. It is actually observed.

5. Air humidity

The investigation of long-term changes of air humidity was carried out for the warmest period of the year from May to September, when the air humidity is the largest.

The available data show that absolute air humidity has the tendency of increasing. Higher increasing level of air humidity is observed in the East and the South of Ukraine. It is some less in the West (fig.4). In its tern it impacts on the differences in air humidity, that corresponds to the temperature of water. This difference became less.

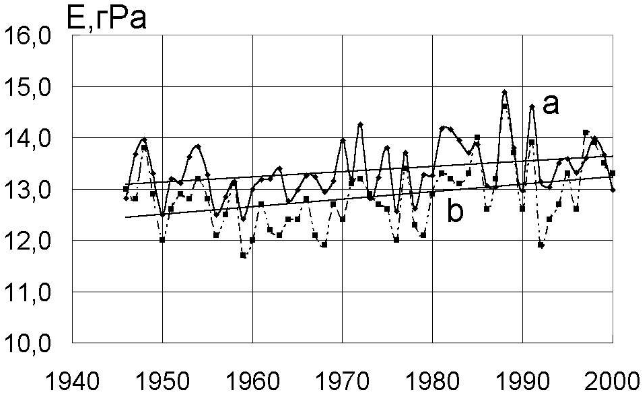

Figure 4.The long-term changes of average air humidity during May-September at meteorological stations Uman' (the central Ukraine) (a) and Poltava (the eastern part of Ukraine) (b)

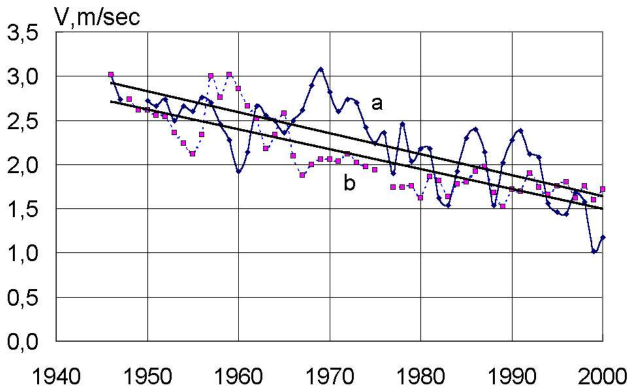

Figure 5. The long-term changes of average wind velocity during May-September at meteorological stations Sarnu (the North of Ukraine) (a) and Lubny (the eastern part of Ukraine) (b)

6. Wind velocity

The changes of wind velocity were investigated for the 5 warmest months from May to September. A fact sheltering of meteorological stations by trees and buildings it was taken into attention. The main result obtained for all meteorological stations is the decreasing of average wind velocity (fig.5).

The same results were obtained by V.Logvinov (1996) for the territory of Belarus.

7. Evaporation from water surface

Among the factors, which influence on the water runoff, the evaporation from water surface should be can mentioned. The area covered by the water bodies in Ukraine gets up to 24500 km^2 or 4.0% of the territory. Swamps and plow districts cover 9400 km^2 or 1.6% of the territory.

The data were obtained from direct measurements with help of device GGI-3000 (3000 – is the area of water surface in square cm). For the analysis of evaporation were used data of measurements from May to September.

The available data show the decreasing of evaporation from the water surface. These changes are comparatively lover in the northern and western parts of Ukraine and higher in the South and the East (fig.6).

The results obtained can be explained by some factors: the increasing of air humidity and the decreasing of wind velocity. The corresponded investigation (Vishnevskiy V.I., 2002) showed that the main factor of these changes is the decreasing of wind velocity.

8. Changes of water balance

The results presented above stipulate the decreasing of evaporation from the river basin. The another factor that can impact on the river runoff is the changes of precipitation.

The lack of direct measurements of evaporation from soil requires to use the parameters calculated from the water balance equation.

The Dnipro river basin near Kyiv city (the area of watershed – 328,000 km^2) was used as the object for investigation. The data about precipitation from 40 meteorological stations (3 – in Russia, 7 – in Belarus and 30 in Ukraine) were used. The investigated period – 1961-1990, climatological data of this is considered as a norm.

The average precipitation in different parts of the river basin are: in the Russian part – 651 mm, the Belarusian – 610 mm and the Ukrainian part – 629 mm.

From the total area of the water shed to Kyiv the area of different parts is equal to 92,900, 118,400 and 116,700 km^2. From these data there can be obtained the volume of water that falls annually on the water shed – 206 km^3. The average precipitation is 628 mm.

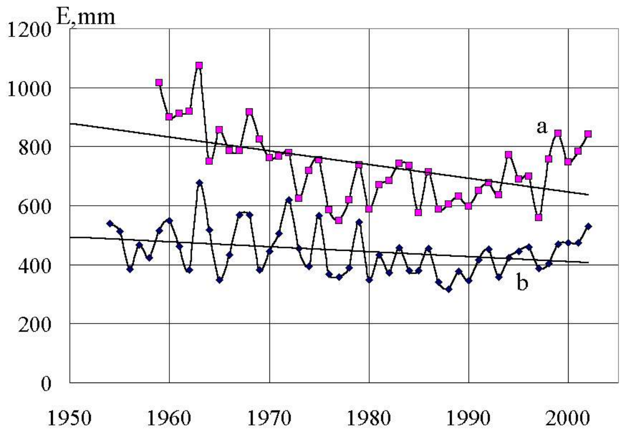

Figure 6. The long-term changes of evaporation from the water surface during May-September at meteorological stations Nova Kahovka (the South of Ukraine) (a) and Pokoshichy (the North of Ukraine) (b)

For the same period the average runoff of the Dnipro river specified on the anthropogenic impact (including water intake for the creation of Kyiv reservoir) is equal to 1440 m^3/s (45.7 km^3).

From these data one could obtain the runoff layer which makes 139 mm. In its tern the evaporation from the water shed is equal to 489 mm, the runoff coefficient – 0.22. The same result was obtained by I.Shiklomanov (1979).

The available data about climate change make it possible to presume that water balance components are not constant. The average precipitation during 1891-1940 is estimated at 666 mm, for the period 1945-2000 – 606 mm.

The average water discharge near Kyiv for these periods turned out to be practically the same – 1390 m^3/s. Taking into account the anthropogenic impact, the natural runoff during the second period is estimated at 1410 m^3/s.

From these data the layer of runoff for 1891-1940 is 134 mm, for 1945-2000 – 136 mm. So, the runoff coefficient is correspondingly equal to 0.20 and 0.22.

The results obtained correspond to those which could be awaited. The climatic change on the territory of Ukraine and Belarus caused the decrease of evaporation from the watershed. Another factor, that must be also mentioned, – the anthropogenic impact (the growth of the urbanization area, the thickening of soil under agricultural activity).

9. Changes of annual runoff

The changes of climate have significantly affected on the hydrological regime of rivers. The main among them is the increase of the annual runoff. The main cause of it is the change of the water balance. With the same precipitation the river runoff has the tendency for increasing. It is caused by the decrease of evaporation from the watershed.

Another important change of the hydrological regime of rivers is the increase of annual discharges of large probability. The annual discharge of 95% probability of the Dnipro river near Kyiv during 1881-1941 was equal to 790 m^3/sec, during 1946-2001 – 925 m^3/sec.

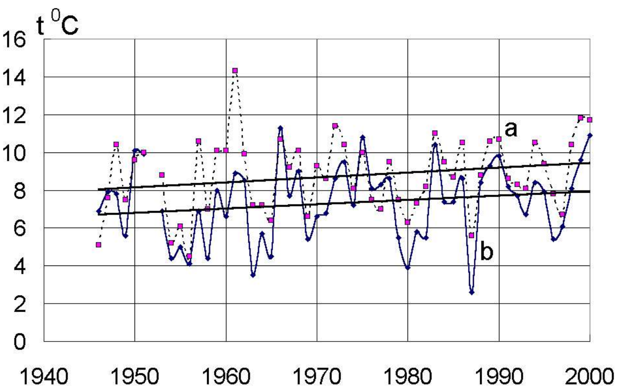

Figure 7. The long-term changes of water temperature in April on the Sluch-Sarnu (a) and the Desna-Chernigiv (b) (both rivers are located in the North of Ukraine)

10. Changes of inner distribution of water runoff

The climate changes impact the inner distribution of water runoff. Discharges during the spring flood decrease and during dry periods (both winter and summer) increase. As a result the inner distribution of runoff has become more even.

11. Changes of water temperature

The climatic changes also influenced on some other elements of hydrological regime of rivers. During the last decades the tendency of the increasing of the water temperature during spring months is observed. On the North of Ukraine, where the changes are larger, the increasing of temperature during April (period – 1946-2001) is equal to 1.0 ^{0}C. In the South (including the Danube river near its mouth) the increasing of the water temperature for the same period makes up 0.3-0.5 ^{0}C (fig.7).

12. Changes of ice regime

The increasing of the air temperature during winter caused the essential changes of ice cover thickness and the duration of period with ice phenomena. The average thickness of the ice cover, observed in winter, during 1980-2001 became almost two times less in comparison with the previous period. The main cause of it is the essential dimension of the sum of negative temperatures of the air. Nowadays the largest thickness of ice is observed 10-20 days earlier than some decades ago. The essential changes, caused by the increasing of the air temperature, stipulated also the dimension of the period with ice phenomena (especially with ice cover) (fig.8).

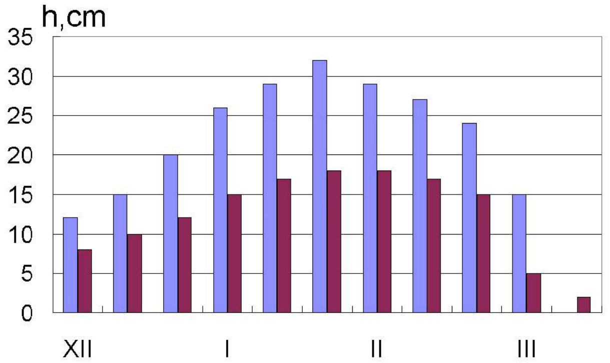

Figure 8. The ice cover thickness on the Sluch river–Sarnu (the North of Ukraine): left columns in 1945-1975, right – in 1981-2001

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