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Climate change influence on maximal runoff rivers of Baltic sea basin within Ukraine

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1. Introduction

The Baltic Sea basin covers about 20% of the territory of Europe, with about 85 million people living on the shores of the Baltic Sea. Within Ukraine, the basin is divided into two parts (the district of the Basin of the Dnister River) and consists of sub basins of the Western Bug and the San. The territory of the Vistula River basin district have the total catchment area of 12892 km2, which makes 2.13% of the territory of Ukraine, is located within two, the Lviv and the Volyn oblasts of Ukraine (Fig 1). Nevertheless, despite the fact that the rivers of the Baltic Sea basin in Ukraine makes rather a small part of the territory, the water resources of the Western Bug River, which are formed in the territory of Ukraine, are further used by the Republic of Poland and Byelorussia. Therefore, the study of the most high-water phases of the water regime in the rivers of the Vistula basin (spring floods and rain floods) is a topical task for further guidelines on the sustainable use of the study area and cross-border cooperation in water management.

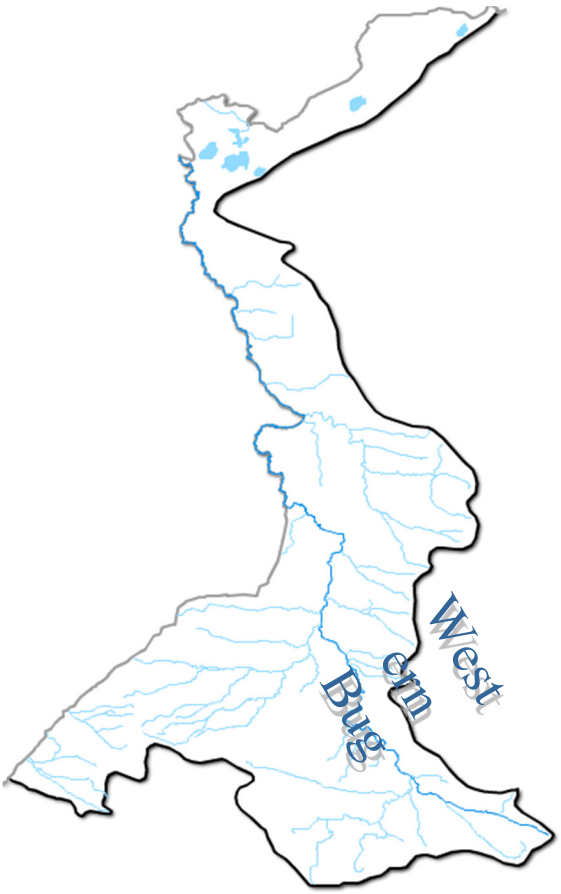

Fig. 1. The scheme of Vistula basin within Ukraine;

On another hand, an analytical review of the normative framework in the field of calculations of maximum runoff showed that despite the vast experience gained by scientists in this issue, the problem is still far from its solution due to the multifactority of the investigated phenomenon and regional features of the forming of maximum runoff on the rivers.

2. Methodology and data

For successful study implementation, was used perennial and modern materials of hydrological and meteorological observations of the state hydrometeorological network, obtained from the regime specialized publications and materials of the Ukrainian Hydrometeorological Center of the State Service of Ukraine for Extreme Situations, which are formed in the ARM-hydro (an automated system for collecting and processing hydrometeorological information for the Ukrainian part of the district in the river basin of Vistula River).

At the Odessa State Ecological University of the Ministry of Education and Science of Ukraine for 85 years there exists and is developed a recognized scientific school of 'Theoretical and Applied Hydrology', recognized in the country and abroad, which studies the processes of formation of floods and spring water with different probability of excess. A scientific school for research into this fundamental scientific problem was created by Prof. A.M. Befani and Prof. N.F. Befani and has been presently developed by Prof. Ye.D. Gopchenko (Gopchenko ,2015), as well as his followers - prof. Zh.R. Shakirzanova (Shakirzanova,2017), Dr. V.A Ovcharuk (Ovcharuk, 2018) and others. Depending on the natural conditions for the formation of river runoff, several theoretical submodels are suggested. It is on their basis of that it is possible to develop a normative base in the field of calculations and forecasting for the maximum runoff of rivers.

In proposed study is in the fact that for the first time in the framework of the original author's model, the procedure for taking account of the probable climate change in determining the maximum water consumption of various probability of excedence is documented methodically. For this purpose, regional coefficients and corrections will be made directly to the snowfall, precipitation and runoff factors for multi-modal climate change data for RCP 4.5 and RCP 8.5 scenarios.

3. Results

For time series of maximum water discharge spring and rain floods at the rivers of study area calculated statistical characteristics of the method of moments and the maximum likelihood.

In the context of regional and global climate change, it is necessary to explore possible trends in the characteristics of the runoff of rivers in its various phases. On the example of the Vistula River, it is shown that the characteristics of the runoff of spring water and rain floods have virtually no significant trends, but it should be noted that at individual stations there is a decrease in the maximum water discharges. The obtained the 1% probability values of

maximum water discharges of spring and rain floods were compared. The discharges Q1% during the spring flood is 27% higher than the maximum discharges of rain floods. Nevertheless, in some cases, discharges of rain floods can to exceed the discharges of spring floods. Thus, the actual task of designing dams at the Vistula river basin is the development of reliable scientific and methodological recommendations for determining the characteristics of the maximum runoff of the rare probability of excess both for spring water and rain floods.

For the plain rivers of Ukraine was implemented of the variant of the calculated method for determining the characteristics of spring flood under climate change. Analyzing the received distribution of "climatic corrections", it should be noted that according to scenario RCP4.5 (model RACMO2, Fig.2a) for the period up to 2050, the forecast for the maximum runoff of spring flood is ambiguous. In particular, in the zone of mixed and broadleaf forests where almost completely situated Vistula basin, the coefficient is vitiated from1.0 to 0.9, that is, virtually no significant change is expected. A slight decrease in the maximal runoff modules of 1% probability of exceeding (by 10-20%) can be expected in the Polissya area.

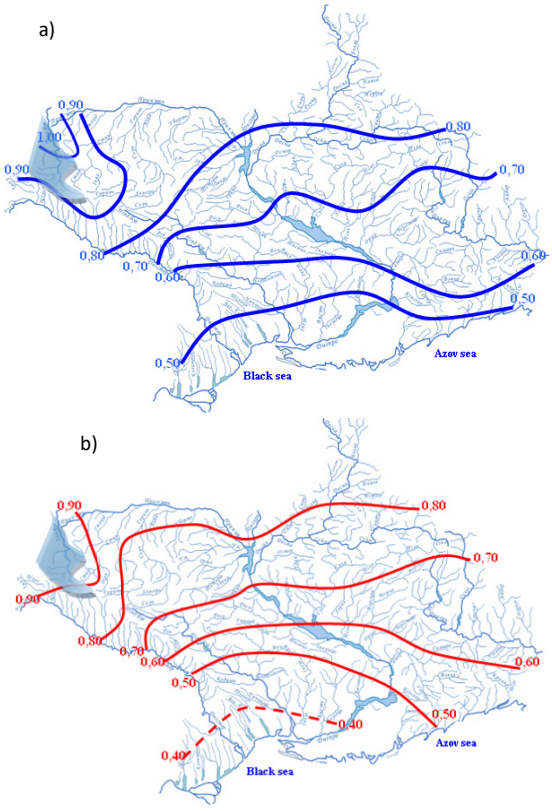

Figure 2. Distribution of the coefficients of influence of climate change on the maximum runoff of spring flood on the plain territory of Ukraine (model RACMO2, scenario RCP4.5 (a) and RCP8.5 (b)) for the period up to 2050, relative to 2010.

From north to south the value of the coefficients decreases, and accordingly the magnitude of the projected decrease in the maximum runoff of spring flood is increased. In general, in the whole territory of forest-steppe zone decrease of runoff are expected by 30-40% during springtime, and most of all (up to 50%) - for the steppe zone rivers. If using the more rigorous RCP8.5 scenario (Fig.2b), most results are similar, but for the Black Sea region, it is forecasted to reduce the runoff of spring flood to 60%. It should be noted here that reducing the flow of spring flood does not mean a corresponding reduction of water resources in general. Most likely, there will be a significant intra-annual redistribution of runoff, that is, due to a reduction in spring runoff, the minimal runoff may increase, as well as will expected the tendency to shift annual highs at earlier dates or increase in the number of cases of winter flood instead of spring flood. Verification of the modified methodic taking into account climate change has shown the possibility of its application for the assessment of changes in water content during the spring flood on the flat rivers of Ukraine, both in the framework of the basic scheme and in the form of separate calculations using climate data as an option for implementing the design scheme under climate change conditions.

4. Conclusions

During development and implementation method for calculation of maximal runoff for Vistula Rivers basin within Ukraine was received such scientific results:

• Description of natural conditions for the formation of the maximum runoff during floods and spring high waters within the Vistula River basin in Ukraine;

• Collection and analysis of information on flooding that occurred in the past and their consequences;

• Creation of a database for the monitoring of water regime (indices of water levels and discharges at hydrological stations) and the meteorological observations (indices of precipitation at meteorological and hydrological stations);

• Provision of scientific and methodological recommendations on the standardization of calculated characteristics of the maximum water discharges and the volumes of spring high water in the Vistula river basins with various probability of excess;

• Generalization of the information on climate change and its consequences in estimates of possible hydrological hazards.

The average accuracy of the calculation in two variants is ± 20.5%, with the accuracy of the initial information ± 21.4%, which allows recommending a technique developed for plan river of Ukraine, including Vistula basin, for practical application

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