# The use of discrimination function in the ice regime forecasts for the rivers of Ukraine

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Introduction. The existing ice regime forecasts provide using of subjective rules and limit of quantity predictors. In modern conditions of science development the mathematical modeling and statistical methods of information which allow to get deeply into physical bases of the hydrometeorological phenomena, and also to define the majority of the factors influencing for these phenomena.

The objective of studying:

- to definite the factors which mostly influence on an ice regime of the Ukrainian rivers;
- to investigate influence degree of global climate changes on the rivers regime.
- To estimate the connection between the changes of atmosphere dynamics and ice-thermal processes on the Ukrainian rivers;
- to use the discrimination function for the hydrological forecasts that allows more thoroughly describing the process of ice formation on the river and getting the scientifically grounded classified rule at the prognosis of the explored phenomenon.

The objects of researches: are the Dniester river at gauge Mogilev - Podol'skiy and the Tiligul river at gauge Berezovka since 1960 till today.

Source data: daily air temperature, decadal water temperature, mean daily stage, mean daily discharge, winter, seasonal, monthly and annual indexes of the North-Atlantic oscillation (NAO). The indexes of the NAO are characterized by changes of pressures at the sea level, which are the most considerable variations of global temperatures and global climate changes, and are also important for characterizing the regional climatic anomalies on the territory of Ukraine. For this reason we explore the influence of the NAO indexes on the dates of first-ice formation at the rivers of Ukraine.

Factorial analysis is used for the definition the factors which mostly influence an ice regime of the Ukrainian rivers:

Table 1 – Factorial loads for the river Dniester

| Variable | First factor | Second factor | Third factor | Fourth factor |
|---|---|---|---|---|
| | 1j | 2j | 3j | 4j |
| Quantity days before 01 October to airs temperature across through 0°C date | 0,1369 | 0,0158 | 0,9454 | -0,0631 |
| Quantity days before 01 October to appearance ice date | 0,0028 | 0,9260 | 0,0225 | -0,0907 |
| Water temperature at day when air temperature across through 0°C | 0,1191 | 0,8074 | -0,4172 | 0,0840 |
| Water temperature at appearance ice date | 0,8410 | -0,2642 | 0,0993 | 0,1553 |
| The sum of negative air temperature before day when air temperature across through 0°C to appearance ice date | 0,0370 | 0,7758 | 0,3698 | 0,3436 |
| The mean daily stage at day when air temperature across through 0°C | -0,2191 | 0,1818 | -0,2206 | 0,8132 |
| The mean daily stage at appearance ice date | -0,7375 | -0,1339 | -0,0912 | 0,0849 |
| NAO index of September | -0,4558 | 0,1006 | -0,3112 | -0,6113 |
| NAO index of October | 0,7847 | -0,3025 | 0,3671 | 0,0807 |
| NAO index of November | 0,8140 | 0,4465 | -0,1391 | 0,0249 |
| NAO index of SON (September - November) | 0,8868 | 0,2049 | 0,0093 | -0,1288 |

Table 2 – Factorial loads for the river Tiligul

| Variable | First factor | Second factor | Third factor | Fourth factor |
|---|---|---|---|---|
| | 1j | 2j | 3j | 4j |
| Quantity days before 01 October to airs temperature across through 0°C date | 0,3579 | -0,7440 | -0,1333 | 0,0194 |
| Quantity days before 01 October to appearance ice date | 0,6296 | -0,5756 | 0,1253 | -0,0755 |
| Water temperature at day when air temperature across through 0°C | 0,1912 | 0,4187 | 0,6595 | 0,2445 |
| Water temperature at appearance ice date | -0,4294 | 0,6333 | 0,1914 | -0,2914 |
| The sum of negative air temperature before day when air temperature across through 0°C to appearance ice date | 0,8565 | -0,1856 | 0,0792 | 0,0367 |
| The mean daily stage at day when air temperature across through 0°C | 0,8674 | 0,1932 | -0,1478 | 0,1759 |
| The mean daily stage at appearance ice date | 0,9328 | 0,1479 | -0,1271 | 0,0942 |
| NAO index of September | 0,1419 | -0,0867 | 0,0145 | 0,9625 |
| NAO index of October | -0,1920 | -0,8089 | 0,1106 | 0,0118 |
| NAO index of November | -0,1372 | 0,0414 | 0,8880 | -0,2295 |
| NAO index SON (September - November) | -0,1715 | -0,5635 | 0,7209 | 0,2454 |

Results:

For the Dniester the input information is described of the fourth factors and the measure of factorization is 81,2%. First factor characterizes the atmospheric processes, its quantity meaning represent NAO indexes. Second factor represent the rivers temperature regime in autumn. Third factor characterizes the cooling processes. Fourth factor describes water content at the day when air temperature across through 0°C.

Results:

For the Tiligul the input information is described of the fourth factors and the measure of factorization is 79%. First factor characterizes the connection between the sum of negative airs temperature and the mean daily stage. Second factor is interpreted as the factor of atmospheric processes influence. It is tight relationship between NAO indexes and water temperature. Third factor characterizes the influence of atmospheric processes in November at ice formation. Fourth factor describes water temperature at the day when air temperature across through 0°C.

Influence of global climate changes on the rivers regime.

Comparative analysis of ice and thermal regime monitoring data of the Dniester and Tiligul rivers for 1981-2006 years with data for the period 1965-1980 years showed that there are significant changes. In recent decades, compared with previous years, the water temperature in the Dniester increased by 2,4ºC (Fig. 1) and by 1°C in the Tiligul. Changing the thermal regime of rivers associated with annual and monthly mean air temperature data and timing of transition the temperatures of air through the critical values in autumn and spring.

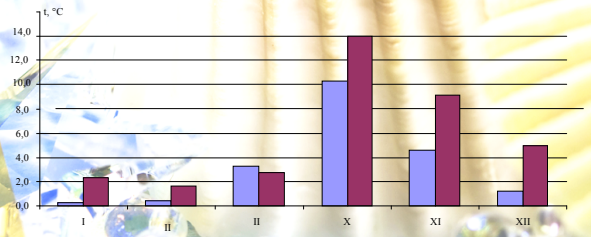


Figure 1 – Water temperature in river Dniester at gauge Mogilev - Podol'skiy
left column - at 1965-1980 years, right - at 1981-2006 years

In the period from 1981 to 2000 time of ice appearance had moved from mid-November - December to the beginning of the year - January, February. At the present stage there is great amplitude of the timing of the first ice appearance and the freeze-up. It is found, that the number of days from the transition temperature through 0ºC until the ice phenomena in recent years has increased: from 2-5 days in the period 1965-1980 up to 25-35 days in period 1981-2006 years. Changes in the dates of the freeze-up affect on their duration. The most significant changes relate to the length of ice cover, which has fallen to 1-2 decades (Fig. 2).

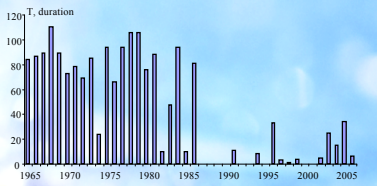


Figure 2 – Duration of ice cover on the Dniester in days

In addition, after 1981, on the Dniester sustained freezing is not observed at all. It is worth emphasizing the fragility of the ice cover on the rivers. It is observed reduction of water content at the Tiligul.

The use of discrimination function for the hydrological forecasts

Based on result of factorial analysis, it was built the discrimination function as rule for the ice regime forecasts

For the Dniester river:

$$F = -6{,}71T_w - 0{,}030H_{i,f} + 0{,}020\sum\theta^- - 0{,}580I_{NAO} + 18{,}4 \qquad (1)$$

For the Tiligul river:

$$F = 1{,}16T_0 + 0{,}02H_{i,f} - 0{,}61\sum\theta^- - 4{,}77 \qquad (2)$$

where Tw – water temperature at appearance ice date; T0 - waters temperature at day when air temperature across through 0°C; $H_{i,f}$ - the mean daily stage at appearance ice date; $\sum\theta^-$ - the sum of negative air temperature before day when air temperature across through 0°C to appearance ice date; $I_{NAO}$ – NAO indexes of SON.

Conclusion:

Research has shown that using the discrimination function allows to take the quality ice regime forecasts and takes into account changes of global climate.