INTERDISCIPLINARY APPROACHES IN SMALL CATCHMENT HYDROLOGY: MONITORING AND RESEARCH

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The North Atlantic Oscillation impact on hydrological regime in Polish Carpathians

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The impact of the North Atlantic Oscillation was analysed for the following rivers:

- Skawa R. - 835 km^2,
- Dunajec - 4 341 km^2,
- Wisła - 31 846 km^2.

Data sets of river discharges were available for 1951-2000. The linear correlation analysis were used. In many cases, correlation coefficients were very low and were no statistically significant. However, some relationships were identified. For example, significant correlations were obtain for maximum discharge values (tab. 1).

Tab.1. Correlation index between the maximum and minimum discharge and the annual NAO index (R_r) and the winter NAO index (R_z) (bold – $p < 0,01$).

Catchment	Discharge	R_r	R_z
Skawa – Wadowice	Maximum	**-0,39**	-0,11
	Minimum	0,05	0,05
Dunajec – Nowy Sącz	Maximum	**-0,43**	**-0,43**
	Minimum	-0,16	-0,16
Wisła – Sandomierz	Maximum	-0,34	-0,22
	Minimum	0,16	0,29

The meteorological conditions in Poland are influenced by NAO, in particular in winter (Marsz 1999; Marsz, Styszyńska 2001; Wibig 1999). Therefore, it may be posssible a non-directly influence of NAO on river runoff. According to this assumption, analysis of correlation of winter NAO index has been done. The correlation between winter NAO index and mean monthly discharges in winter is significant only in case of Dunajec ($R = 0,38$, $p < 0,01$). Lower correlation deals with winter NAO index and discharges of all rivers in August and Wisła in September (tab. 2).

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Tab. 2. Correlation coefficient between mean monthly discharges and winter NAO index (bold – $p < 0,01$)

Zlewnia	XI	XII	I	II	III	IV	V	VI	VII	VIII	IX	X
Skawa – Wadowice	-0.03	0.18	0.22	0.02	0.01	-0.16	-0.21	-0.09	-0.11	-0.26	-0.19	-0.05
Dunajec – Nowy Sącz	0.05	0.19	**0.38**	0.13	0.21	-0.15	0.13	-0.01	-0.06	-0.25	-0.10	0.05
Wisła – Sandomierz	0.04	0.17	0.21	0.04	-0.12	-0.20	-0.13	-0.14	-0.12	-0.25	-0.24	-0.05

Analysis of correlation between mean monthly NAO index with mean monthly discharges has been done also. There are some correlations between:

- December NAO index and discharges of Skawa in May and September (respectively: R = - 0,37, R = -0,36; $p < 0,05$),
- December NAO index and discharges of Dunajec in May and September (respectively R = -0,32, R = -0,34; $p < 0,05$),
- January NAO index and discharge of Dunajec in January (R = 0,43; $p < 0,01$),
- December NAO index and discharges of Wisła in September (R = -0,36; $p < 0,05$),
- January NAO index and discharges of Wisła in August (R = 0,31; $p < 0,05$),
- March NAO index and disicharges of Wisła in April (R = -0,36; $p < 0,05$).

The relationship between monthly values have not been strong. Therefore, three-months mean values were analysed. The correlation between XI-XII-I-NAO index and discharges of all rivers in the spring (III-IV-V), and discharges of Skawa and Wisła in the summer and autumn, and discharge of Dunajec in winter, are significant. There are also synchronic relationships in the autumn and winter months in Skawa and Dunajec (Fig. 1).

Tab. 3. Correlation coefficient between annual NAO index (R_r) and winter NAO index (R_z) and discharges of Skawa, Dunajec and Wisła (bold – $p < 0,01$) in the epoch E-II (1951-1970)

Discharge	**River**	**R_r**	**R_z**
Year	Skawa	-0,55	-0,32
	Dunajec	-0,32	-0,18
	Wisła	-0,39	-0,24
Summer half-year	Skawa	**-0,64**	-0,33
	Dunajec	-0,40	-0,25
	Wisła	-0,50	-0,33
Winter half-year	Skawa	-0,26	-0,20
	Dunajec	0,03	0,05
	Wisła	0,05	0,08

The NAO conditions in 1951-2000 were very differenciated. There were distinguished a few air-circulation epochs (Marsz, Styszyńska 2001). One of them: the epoch E-II - began in 1930 and finished in 1970, and the next one: epoch-III – began in 1971 and finished in 1995.

There is a significant correlation between annual mean NAO index and annual and summer-half-year discharge of Skawa in the epoch E-II (respectively: R = - 0,55, p < 0,05; R = -0,64, p < 0,01) (tab. 3).

There are some significant correlation in the epoch E-III, but realtionship is not very strong. For example, correaltion between annual NAO index and annual discharges of Wisła and Dunajec is significant (respectively: R = -0,40, R = -0,49; p < 0,05) (tab. 4).

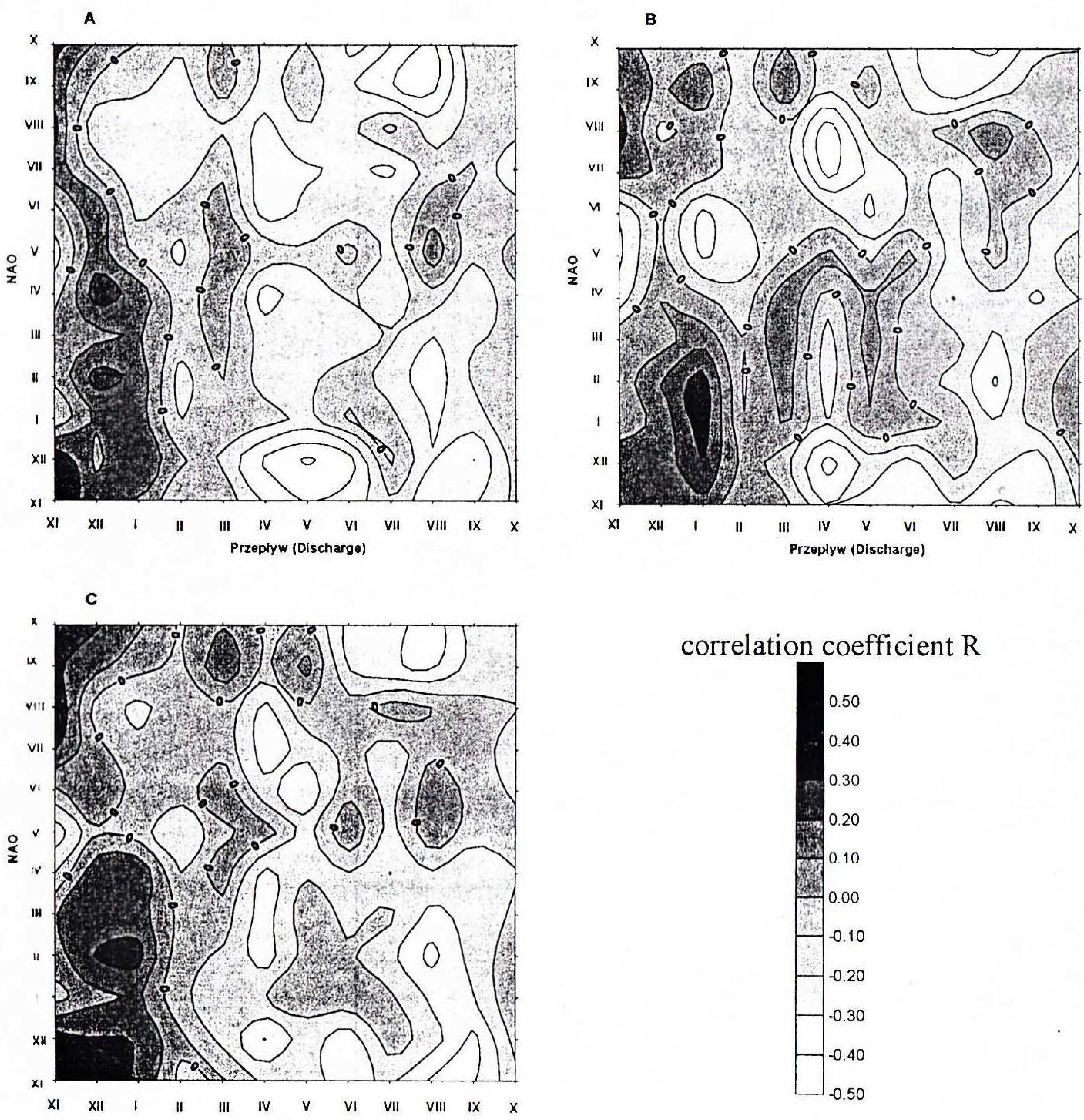

Fig. 1. Correlation between three-mean values of NAO and discharges of Skawa (A), Dunajec (B) and Wisła (C) (month in the figure suits the middle of three counted months)

Tab. 4. Correlation coefficient between annual NAO index (R_r) and winter NAO index (R_z) and discharges of Skawa, Dunajec and Wisła (bold – $p < 0,05$) in the epoch E-III (1971-1995)

Discharge	River	R_r	R_z
Year	Skawa	-0,38	-0,33
	Dunajec	**-0,40**	-0,06
	Wisła	**-0,49**	-0,38
Summer half-year	Skawa	-0,26	-0,23
	Dunajec	-0,26	0,06
	Wisła	-0,34	-0,20
Winter half-year	Skawa	-0,29	-0,25
	Dunajec	-0,28	-0,02
	Wisła	-0,30	-0,35

Final remarks: The NAO influence is stronger in winter: the positive NAO episode in winter are associated with low discharges in the summer and in the beginning of the autumn. There has been stated statistically significant positive correlation between NAO and discharge in January.
There were analysed relationship between three months mean values of discharges and three months mean values of Hurrell's indexes. There were significant correlations between NAO in the Autumn-Winter months and river discharges in the Spring. This delay may be caused by snow-cover ablation process in the Spring.
It may be stated the possibility of improving the runoff forecast of some Polish Carpathian rivers based on the NAO conditions. It is realized that more research into the precipitation phenomena during positive and negative phases of NAO responsible for river runoff responses is required.

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