TELECONNECTIONS OF AO, NAO, SO, AND QBO WITH INTERANNUAL STREAMFLOW FLUCTUATION IN THE HRON BASIN

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The aim of the paper is to analyse a possible teleconnection of AO (Arctic Oscillation), SO (Southern Oscillation), PDO (Pacific Decade Oscillation), NAO (North Atlantic Oscillation) and QBO (Quasi Biennial Oscillation) phenomena with long-term streamflow fluctuation in Hron River basin (Central Slovakia). The spectral analysis shows that for the series of AO, NAO, SO, and PDO indexes we can identify the ca 2.4-; 3.6-; 7.8-; 14-; 21-; 30- and 36-yr cycles. The coincident cycles were found in the monthly discharge time series from the Hron basin (period 1931–2000) using combined periodogram method. As these periods were found in almost all discharge series analysed within very different geographical zones, it can be considered as the general regularity on the earth. The regularity is related to general oceanic and atmospheric circulation, part of which are also the SO, AO, PDO and NAO phenomena.

KEY WORDS: Long-term Streamflow Fluctuation, Spectral Analysis, Teleconnection, Discharge, AO, NAO, SO, QBO.


Cieľom predloženej štúdie je analýza možných telekonekcií Arktickej oscilácie (AO), Južnej oscilácie (SO), Tichomorskej dekádnej oscilácie (PDO), Severoatlantickej oscilácie (NAO) a Kvázi dvojročnej oscilácie (QBO) s viacročnými cyklami priemerných ročných prietokov v povodi rieky Hron (stredné Slovensko). Spektrálnou analýzou časových radov AO, NAO, SO, a PDO indexov boli nájdené nasledujúce viacročné cykly kolísania indexov: ca 2,4; 3,6; 7,8; 14; 21; 30 a 36 rokov. Metódou kombinovaného periodogramu boli nájdené zhodné cykly kolísania viacročných suchých a mokrých období i v mesačných prietokových radoch z povodia Hrona (1930–2000). Keďže tieto periódy boli nájdené vo všetkých prietokových radoch z rôznych geografických zón, môžu byť považované za všeobecný jav na Zemi. Toto pravidelné opakovanie mokrých a suchých období súvisí so všeobecnou cirkuláciou oceánov a atmosféry, súčasťou ktorých sú i SO, AO, PDO, NAO a QBO javy.

KLÚČOVÉ SLOVÁ: viacročné kolísanie odtoku, spektrálna analýza, telekonekcia, prietoky, AO, NAO, SO, QBO.

1. Introduction

Interannual discharge series fluctuations have their natural origin. Apart from it river discharge may have changed due to a range of human activities. Dams and artificial reservoirs dramatically change the natural flow regime. Nowadays main problem of hydrology and design support for water projects connects with climate change and its impact on hydrological characteristics as observed as well as designed. According to Lobanov & Lobanova (2004), there are three main stages of this problem:

i) how to extract a climate variability and climate change from complex hydrological records;
ii) how to assess the contribution of climate change and its significance for the point and area scale;
iii) how to use the detected climate change for computation of design hydrological characteristics.

Currently to the climate change problems of the long-term streamflow trends a number of studies was published all over the world. For example,
a special section of Hydrological Sciences Journal in February 2004 dealt with the issue of detecting changes in hydrological data. Authors Kundzewicz & Robson (2004), Sheng & Pilon (2004), and Xiong & Guo (2004) focused on detecting changes in hydrological long-time series. In Radziejewski & Kundzewicz (2004) a new concept of visualisation of the comprehensive change detection is demonstrated. In Burn et al. (2004) the trends in the Liard River (northern Canada) were investigated using Mann-Kendall test. They showed that the observed trends are related to both, trends in meteorological data and a large-scale oceanic and atmospheric process. In Slovakia, Hlavcova et al. (1999) studied the possible impact of climate change upon streamflow regime and analysed the unfavourable decreasing streamflow trend in 1981–1995. Kostka & Holko (2000) studied the impact of climate changes to hydrological regime in small mountainous basin. Halmova (2000) studied the water changes of storage in reservoirs under climate change. Pekarova & Miklanek (2004) analysed long-term course of 27 discharge series from the database of National Climate Programme SR (period 1931–2000). Regardless the fact that they showed the decrease of discharge in South Slovakia in decade 1982–1993, they emphasize from the long-term point of view the necessity to identify hidden periods in the long-term series. As mentioned in Pekarova (2003) and Pekarova et al. (2003), it is necessary to come out from sufficiently long-time discharge series because of possible confusion between long-term trend and variability.

The variability of streamflow results from the global system of oceanic streams, the global circulation of the atmosphere, and the transport of moisture (precipitation). In recent few years many scientists have studied relationships between the atmospheric phenomena (as Arctic Oscillation (AO), Southern Oscillation (SO), Pacific Decade Oscillation (PDO) and North Atlantic Oscillation (NAO)) and some hydroclimatic characteristics (as total precipitation, air temperature, discharge, snow and ice cover, flood risk, see levels series, or coral oxygen isotope records, dendrochronological series etc).

E.g., Compagnucci et al. (2000) employed a wavelet filter for removing the strong annual wave in the Atuel river streamflow data to analyze for other wavelength phenomena and to examine the influence of the ENSO events.

Jevrejeva & Moore (2001) and Jevrejeva et al. (2003) studied variability in time series of ice conditions in the Baltic Sea within the context of North Atlantic Oscillation (NAO) and Arctic Oscillation (AO) winter indices using the Singular Spectrum Analysis (SSA) and wavelet approach. According these authors cross-wavelet power for the time series indicates that the times of largest variance in ice conditions are in excellent agreement with significant power in the AO at 2.2–3.5-, 5.7–7.8-, and 12–20-yr periods, similar patterns are also seen with the Southern Oscillation Index (SOI) and Nino-3 sea surface temperature (Nino-3) series. Wavelet coherence shows in-phase linkages between the 2.2–7.8- and 12–20-yr period signals in both, tropical and Arctic atmospheric circulation and also with ice conditions in the Baltic Sea.

In Kiem et al. (2003) the variability of flood risk across New South Wales (Australia) is analyzed with respect to the observed modulation of ENSO event magnitude. This is achieved through the use of a simple index of regional flood risk. The results indicate that cold ENSO events (La Nina) are the dominant drivers of elevated flood risk. An analysis of multi-decadal modulation of flood risk is achieved using the inter-decadal Pacific Oscillation (IPO) index. The analysis reveals that IPO modulation of ENSO events leads to multi-decadal epochs of elevated flood risk, however this modulation appears to affect not only the magnitude of individual ENSO events, but also the frequency of their occurrence. These results have marked implications for achieving robust flood frequency analysis as well as providing a strong example of the role of natural climate variability.

Anctil & Coulibaly (2003) described the local interannual variability in southern Québec streamflow based on wavelet analysis, and to identify plausible climatic teleconnections that could explain these local variations. The span of available observations, 1938–2000, allows depicting the variance for periods up to about 12 yr. The most striking feature, in the 2–3-yr band, in the 3–6-yr band, and the 6–12-yr band is dominated by white noise and is not considered further – is a net distinction between the timing of the interannual variability in local western and eastern streamflows, which may be linked to the local climatology. This opens up the opportunity to construct two regional time series using principal component (PC) analysis. Then, for each band, linear relationships are sought between the regional streamflow and five selected climatic indices: the Pacific–North America (PNA), the North Atlantic Oscillation (NAO), the Northern Hemisphere annular mode (NAM), the Baffin Island–
West Atlantic (BWA) and the sea surface temperature anomalies over the Niño-3 region (ENSO-3).

Turkes & Erlat (2003) and Uvo (2003) studied teleconnection of NAO variability with precipitation variability in Turkey, and in Northern Europe, resp.

Felis et al. (2000) studied a 245-yr coral oxygen isotope record from the northern Red Sea in bi-monthly resolution. A similar to 70-yr oscillation of probably North Atlantic origin dominates the coral time series. Interannual to interdecadal variability is correlated with instrumental indices of the North Atlantic Oscillation (NAO), the El Nino-Southern Oscillation (ENSO), and North Pacific climate variability. The results suggest that these modes contributed consistently to Middle East climate variability since at least 1750, preferentially at a period of similar to 5.7 years.

Tardif et al. (2003) studied variations in periodicities of the radial growth response of black ash exposed to yearly spring flooding in relation to hydrological fluctuations at Lake Duparquet in northwestern Québec. They detected about 3.5-, 3.75-, and 7.5-yr periodicities in all the dendrochronological series. According to authors, the 3.75- and 7.5-yr components are harmonics of a 15-yr periodicity.

In this study we try:
1. to identify an interannual variability analysis of AO (Arctic Oscillation), NAO (North Atlantic Oscillation), PDO (Pacific Decade Oscillation) and QBO (Quasi Biennial Oscillation) phenomena by combined periodogram method;
2. to perform an interannual variability analysis of discharge time series in the Hron River basin;
3. and to find teleconnection between AO, NAO, SO, PDO, and QBO phenomena with long-term streamflow dynamics in the Hron River basin.

The mountainous Hron River basin (Central Slovakia) was chosen due to its relatively natural conditions uninfluenced by man activity (especially in the upper part of the basin).

2. Interannual variability analysis of AO, NAO, PDO, SO and QBO phenomena

2.1 Material

North Atlantic Oscillation Index

North Atlantic Oscillation is one of the major modes of atmospheric circulation variability of the Northern Hemisphere over the middle and high latitudes. According to Hurrell et al. (2003), the NAO refers to swings in the atmospheric sea level pressure difference between the Arctic and sub-tropical Atlantic that are associated with changes in the mean wind speed and direction. There exist several time series of NAO Indexes (NAOI), e.g. according to Stephenson et al. (2000) (Azory-Reykjavik), according to Hurrell (2000) (Lisbon-Reykjavik), or according to Jones et al. (1997) (Gibraltar-Island). In this study, for forecast purposes, the winter NOAI time series (December – March) according to Jones et al. (1997) are used (period 1825–2002). Dickson et al. (2000) or Kodera and Kuroda (2003) suggest, that NAO is the regional manifestation of a larger-scale (hemispheric) mode of variability known as the Arctic Oscillation.

Arctic Oscillation Index

Arctic Oscillation (AO) Index (AOI) is defined as the normalized difference in zonal-averaged sea level pressure anomalies between 35°N and 65°N, and it is a measure of hemispheric-wide fluctuations in air mass between zones of high and low pressure anomalies centered around these two latitudes of Northern Hemisphere. The AOI captures an optimal representation of the temporal-spatial features of the AO, and the latitudinal zones centered at 35°N and 65°N are denoted as annular belts of action for the AO. The longest AOI time series exhibits a major source of low-frequency variability in the Northern Hemispheric climate. We used the winter AOI according to Thompson (www.atmos.colostate.edu/ao/) for period 1899–2002.

Pacific Decadal Oscillation Index

Pacific Decadal Oscillation (PDO) is defined as leading anomalies of mean November through March sea surface temperatures for the Pacific Ocean to the north of 20°N latitude (Mitchell, 2004). Positive values of PDOI indicate months of above normal SSTs along the west coast of the North and Central America and on the equator and below normal SSTs in the central and western north Pacific at about the latitude of Japan. Fluctuations in this pattern are dominated by variability on decadal time scales. We used the data according to Mitchell, (2004).

Southern Oscillation Index

The SO (Southern Oscillation) pattern represents large-scale fluctuation of ocean temperatures, rainfall, atmospheric circulation, vertical motion and air
pressure across the tropical Pacific. El Nino episodes (also called Pacific warm episodes or ENSO) and La Nina episodes (also called Pacific cold episodes) represent opposite extremes of the SO cycle (Gershunov et al., 2001).

Quasi-Biennial Oscillation Index
Quasi-Biennial Oscillation Index (QBOI) represents variability in equatorial lower stratospheric zonal wind. The values for period 1953–2001 were provided by Naujokat (1986) and Marquardt & Naujokat (1997). This index is the concatenation of values at Canton Island (3S, 172W) for Jan 1953–Aug 1967; Maledives (1S, 73E) for Sept 1967–Dec 1975; and Singapore (1N, 104 E) for Jan 1976–Sep 2001.

2.2 Spectral Analysis

Time series analysis includes many useful methods to identify periodicity in time series, e.g. Maximum Entropy Spectrum Analysis (MESA), Power Spectrum Analysis (PSA), Singular Spectrum Analysis (SSA), Empirical Orthogonal Functions Method (EOFs)/Fourier Analysis (FA), Autocorrelation Analysis (AC), Method of Main Components (MMC), etc. (Nobre & Shukla, 1996; Jevrejeva & Moore, 2001; Rao & Hamed, 2003; Liritzis & Fairbridge, 2003; Van Gelder et al., 2000; Prochazka et al., 2001). In this study we used both, combined periodogram method described by Pekarova et al. (2003) and AC method to identify interannual dynamics pattern of AO, NAO, PDO, SO as well as QBO phenomena.

In Fig. 1 there are the filtered (double 48-months moving averages) month indexes of the AO, NAO, and SO phenomena between 1900 and 2002. The circles indicate the about 28-yrs periods of El Niño occurrence. The graph below represents course of monthly QBO index for period 1953–2000.

Fig. 1. The filtered monthly indexes of the AO, NAO, and SO phenomena between 1900 and 2002. Course of the monthly QBO index, period 1953–2000.

The autocorrelograms of SOI and NAOI are on Fig. 2a). The cyclicity of both indexes is more evident if we plot the 3-years moving averages of the autocorrelation coefficients (Fig. 2b). SOI shows the 6–7-yr cycle, the NAOI 7–8-yr cycle. The autocorrelogram of yearly values is not very suitable for identification periodicities because it works in one year steps only. For the accurate calculation of the lengths of the periodicities we use the combined periodogram method.

On the Fig. 3 the combined periodograms of mentioned indexes are presented. In QBOI time series a significant 28-month (ca 2.4-yr) periodicity was found. This period occurs in both, AOI and SOI time series. In the AOI time series all periods are presented. Similarly, in the NAOI time series there exists a significant 7.8-yr period, presented in the AO series.

Fourier analysis shows, that all periods found in all other indexes are presented in the AOI time series. It means, the AO pattern covers variability of all mentioned oscillations around the North Hemisphere.

3. Interannual variability analysis of discharge time series

Statistical analysis of the streamflow oscillations depends on availability of long-term data series. In Slovakia there exist four 100-year discharge time series, namely Danube at Bratislava station, Morava: at Moravsky Jan, Vah: at Sala, and Bodrog: at Streda n. Bodrogom station. Systematic measurements of water levels in Hron river basin (Central Slovakia) started after 1930.

In order to identify long-term variability (wet and dry periods dynamics) of discharge in the Hron basin, eight monthly discharge time series were collected. The data series were obtained from the SHMI archive. Basic hydrological characteristics of analysed discharge series are given in Tab. 1.

Our goal is to identify periods of long-term dry and wet conditions occurred in the Hron basin. For this purpose, the standardised monthly average discharge time series was computed according to the formula:

$$Y_t = \frac{y_t - \bar{y}}{\sigma_y},$$  \hspace{1cm} (1)

where

- $\bar{y}$ – mean of the analysed series,
- $\sigma_y$ – standard deviation of the analysed series,
- $Y_t$ – element of the standardised series.

Then the standardized data were filtered by double MA-filter from 84 terms. On the Fig. 4 the course of the filtered monthly standardized discharge time series are presented. From the figure it follows, that after 1965 the variance of series is lower. The discharge series of Bystra brook before 1965 are probably influenced by systematic errors, there-
Fig. 3. The combined periodograms of AO, PDO, NAO, SO and QBO indexes.
Obr. 3. Kombinované periodogramy AO, PDO, NAO, SO a QBO indexov.
Teleconnections of AO, NAO, SO, and QBO with interannual streamflow fluctuation in the Hron basin

Table 1. Basic hydrological characteristics of yearly discharge, period of observation (1931–2000); $A$ – area [km$^2$], $Q$ – average annual discharge [m$^3$/s], $qa$ – mean annual specific yield [l s$^{-1}$ km$^{-2}$], $cs$ – coefficient of asymmetry, $cv$ – coefficient of variation, min/max – minimal/maximal mean multiannual discharge [m$^3$/s].

<table>
<thead>
<tr>
<th>River</th>
<th>Station</th>
<th>A</th>
<th>Rkm</th>
<th>a.s.l</th>
<th>$Q$</th>
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<th>cs</th>
<th>cv</th>
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<td>D. Lehota</td>
<td>53</td>
<td>2.7</td>
<td>495</td>
<td>1.4</td>
<td>26.3</td>
<td>0.82</td>
<td>0.24</td>
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<td>Bystrá</td>
<td>36</td>
<td>7</td>
<td>573</td>
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<td>Mýto p. Ž. Štiavnička</td>
<td>47.1</td>
<td>2.9</td>
<td>616</td>
<td>1.1</td>
<td>22.9</td>
<td>-0.05</td>
<td>0.24</td>
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<td>1.6</td>
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<tr>
<td>6950</td>
<td>Hron</td>
<td>83.7</td>
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<td>733</td>
<td>1.4</td>
<td>17.3</td>
<td>0.94</td>
<td>0.32</td>
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<td>582</td>
<td>223</td>
<td>490</td>
<td>7.7</td>
<td>13.2</td>
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<td>7045</td>
<td>Č. Hron</td>
<td>239</td>
<td>2.4</td>
<td>480</td>
<td>3.0</td>
<td>12.4</td>
<td>0.34</td>
<td>0.32</td>
<td>1.05</td>
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</tr>
<tr>
<td>7160</td>
<td>Hron</td>
<td>1766</td>
<td>175</td>
<td>334</td>
<td>26.5</td>
<td>15.0</td>
<td>0.46</td>
<td>0.26</td>
<td>12.49</td>
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<td>7290</td>
<td>Hron</td>
<td>3821</td>
<td>93.9</td>
<td>194</td>
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<td>0.44</td>
<td>0.28</td>
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</tr>
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Thus, this station was removed from statistical analysis.

On the Figs. 4–6, the extreme dry period 1982–1994 is presented on monthly (Fig. 4 and 5) runoff and on average annual discharge time series (Fig. 6) from period 1931–2000. As follows from the Fig. 6, (course of 10-yr moving averages of coefficients of variation $c_v$), the dry periods are characterized by lower variability of discharge time series.

On Fig. 7, the combined periodograms of yearly discharge are drawn. In discharge time series, the periods of 2.4-; 3.6-; 5-; 7-; 9-; 13.5-22-; and 33-yrs were found.

Fig. 4. Course of the filtered monthly standardized discharge time series. Double MA-filter from 84 terms. Comparison of input data.

Obr. 4. Priebeh filtrovaných priemerných mesačných prietokov. Dvojnásobný MA filter z 84 členov. Porovnanie vstupných údajov – grafická kontrola.

Fig. 5. Course of the filtered monthly specific runoff \([\text{l s}^{-1} \text{ km}^2]\), double MA-filter from 84 terms. Identification of dry and wet period, as well as of long-term trend.

Obr. 5. Priebeh filtrovaných priemerných mesačných špecifických odtokov \([\text{l s}^{-1} \text{ km}^2]\), dvojnásobný MA filter z 84 členov. Identifikácia suchých a mokrých období, ako aj dlhodoboého trendu.
Fig. 6. Course of average annual discharge time series $Q_a$ (left), (differences from 5-yr moving averages values), course of 10-yr moving averages of coefficient of variation $cv$ and symmetry $cs$, a) Vajskovsky brook, b) Hron: Brehy.

Obr. 6. Priebeh priemerných ročných prietokov $Q_a$ (vľavo), (rozdiely v porovnaní s 5-ročnými kĺzavými priemermi), priebehy 10-ročných kĺzavých priemerov koeficientov variácie $cv$ a symetrie $cs$.

Fig. 7. The combined periodograms of discharge time series (1931–2000).

4. Teleconnection AO, NAO, SO, PDO and QBO phenomena with long-term streamflow fluctuation in Hron River basin

In this part the teleconnection of some atmospheric phenomena with long-term discharge fluctuation is studied in relatively uninfluenced mountainous basin in the Central Slovakia.

The cross-correlations of the Southern Oscillation Index (SOI) and mean annual discharge of the Hron River shows, that there exists a 3–4 years shift between these time series. Therefore, for following analysis, we used winter SOI data series with 3 years shift (SOIw-3). In Tab. 2, correlation matrix coefficients of annual discharge time series from selected sites in the Hron basin and winter indexes of AO, SO and NAO phenomena are presented. There is a direct relationship between discharge and SOIw-3, and an indirect relationship between the discharge series and AOw, as well as NAOw. The average annual Hron River discharge is lower during higher AO and NAOI periods.

Based on AOIw and SOIw-3 the relationship (2) for simple estimation of average annual discharge in Hron: Brehy station in the current year was derived. The multiple coefficient of correlation was 0.68. In Tab. 3 other statistical characteristics of estimated parameters are presented.

\[ Q_a = 46.84 - 7.5 \text{AOIw} + 0.209 \text{SOIw-3}, \]  
where \( Q_a \) – annual discharge in Hron: Brehy.

On the Fig. 8a), the combined periodogram of Hron: Brehy yearly discharge is presented and on Fig. 8b) there is the autocorrelogram of monthly adjusted discharge (12-monthly seasonality was removed from raw data). On the basis of the previous analyses we suppose that the 28-month period in the discharge time series is connected to the QBO cycle. While all the periods 3.65-; 7–8–; 14-; 21-; 30- and 36-yr are connected to the AO phenomenon, only some of them are connected to the NAO and SO phenomena.

5. Conclusions

In the study, the teleconnection of AO, SO, NAO, and QBO on the interannual streamflow cycles in Hron basin (Central Europe) was found. The ca 2.4-; 3.6–; 7.8–; 14–; 21–; 30– and 36-yr periods of SOI, NAOI, AOI time series were identified by AC and the combined periodogram. Such periods were found also in most of the analysed discharge series.

The mutual teleconnection of the temperature, discharge, precipitation, ice cover, see level, dendrochronological and other time series and AO,
Fig. 8. Combined periodogram of yearly discharge (top), Hron River at Brehy station, 1931–2000. Calculated values of the autocorrelation function and 95% confidence intervals for monthly adjusted discharge (12-monthly seasonality was removed) below.

NAO, PDO, SO is sufficiently proved, now. There must be a reason for why lengths of the found interannual cycles coincide in all analyzed time series all over the world. They have probably an identical origin. Unfortunately, the source of this interannual cyclicity is unknown, yet.

As a source of these cycles, the fluctuations of solar activity (known 11- and 22-yrs cycles of sunspot numbers) was discussed in a lot of studies, e.g. Palus et al. (2000) showed that there is a weak interaction of gravity and solar activity. On the other hand, Garric & Huber (2003) considered, there is no compelling reason to invoke solar cycles as a cause of quasi-decadal (QD) variability in paleoclimatic records. Important results were obtained by Charvatova & Strestik (1995). Authors employed the inertial motion of the Sun around the barycentre of the Solar System as the base in searching for possible influence of the Solar System as a whole on climatic processes, especially on the changes in surface air temperature. Charvatova (2000) explained a solar activity cycle of about 2400 years by solar inertial motion. She described the 178.7-year basic cycle of solar motion. The longer cycle, over an 8000 year interval, is found to average 2402.2 years. This corresponds to the Jupiter/Heliocentre/Barycentre alignments (9.8855-yr x 243). Similarly, Esper et al. (2002), Vasiliev & Dergachev (2002), or Liritzis & Fairbridge (2003) showed, the multiannual cycles have probably their origin in terrestrial motion of the Earth in the Space. In the next research it will be necessary to take into account also the impact of the natural variability of the climate on the hydrological cycle.

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TELEKONEKCIA AO, NAO, SO A QBO S VIACROČNÝMI FLUKTUÁCIAMI PRIETOKOV V POVODÍ HRONA

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Štúdia analyzovala možné telekonekcie Arktickej oscilácie (AO), Južnej oscilácie (SO), Tichomorskej dekádnej oscilácie (PDO), Severoatlantickej oscilácie (NAO) a Kvázi dvojročnej oscilácie (QBO) s viacročnými cyklami suchých a mokrých období (vyjadrených priemernými ročnými prietokmi) v povodi rieky Hron (stredné Slovensko). Speciálnej analýzou časových radov AO, NAO, SO, a PDO indexov boli nájdené tieto viacročné cykly kolísania spomenutých javov: ca 2,4; 3,6; 7,8; 14; 21; 30 a 36 rokov. Metódou kombinovanej periodogramu boli nájdené zhodné cykly kolísania viacročných suchých a mokrých období i v mesačných prietokových radoch z povodia Hronu (1930–2000). Keďže tieto periódy boli nájdené vo všetkých prietokových radoch z rôznych geografických zón, môžu byť považované za všeobecný jav na Zemi. Toto pravidelné opakovanie mokrých a suchých období súvisí so všeobecnou cirkulácou oceánov a atmosféry, súčasťou ktorých sú i SO, AO, PDO, NAO a QBO javy.