SEASONAL AND MULTIANNUAL VARIABILITY OF DROUGHT STREAMFLOW DEFICIT IN SMALL LOWLAND CATCHMENTS

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Most components of river regime demonstrate variability in seasonal and multiannual scale. It also concerns such characteristics which are connected with shortage of water resources. Low flows and droughts play important role in river flow regime because they are significantly connected with basic water resources. Their extremes indicate limitations in water and spatial management. Origin of this phenomenon is not fully identified because of many indirect factors which impact is considerably stretched in time. Therefore multiannual analyses in year and seasonal step may by very useful both from scientific and practical point of view.

The term of hydrological drought and low flow period is well-known in the field of hydrology. However, various methods define this phenomenon in different ways. One of them is based on threshold level. A period which is set below the established limit is selected as runoff deficit. Its two basic parameters are: low flow duration and deficit volume. The threshold can be chosen in a conventional (connected with water management) or a statistical way, which is represented by two methodological approaches. The first assumes that the threshold should derive from a flow duration curve such as the percentile Q_{70} or Q_{90} (Hisdal at al., 2004). The second one takes the minimum annual daily discharge to a calculation of: SNQ (mean minimum runoff), WNQ (maximum runoff out of the minimums) or ZNQ (median minimum runoff) (Ozga-Zielińska, 1990).

Studied area is placed in central part of Poland. There were selected 11 water-gauges closing small and middle autochthonous catchments (Table1). All of them are situated inside Warta, Pilica and Bzura river basin.

Basic calculations were made on daily discharge series from the period 1951 – 2000, measured by Institute Meteorology and Water Management. To estimate streamflow deficit the threshold method was applied, where,

Table 1. Studied catchments

River	Water-gauge	Catchment Area [km^2]	River Basin
Niesób	Kuźnica Skakawska	246	Warta
Łasica	Władysławów	363	Bzura
Ołobok	Ołobok	447	Warta
Oleśnica	Niechmirów	591	Warta
Wolbórka	Zawada	616	Pilica
Mogilnica	Konojad	663	Warta
Utrata	Krubice	704	Bzura
Grabia	Grabno	810	Warta
Czarna Maleniecka	Dąbrowa	941	Pilica
Drzewiczka	Odrzywół	1004	Pilica
Rawka	Kęszyce	1190	Bzura

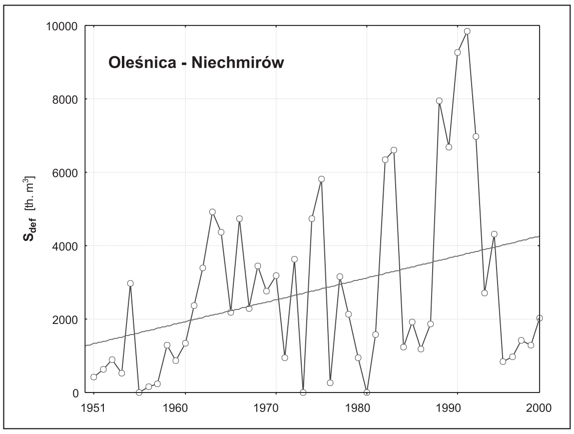

Figure 1. Course of annual streamflow deficit volume (1951-2000) and its trend

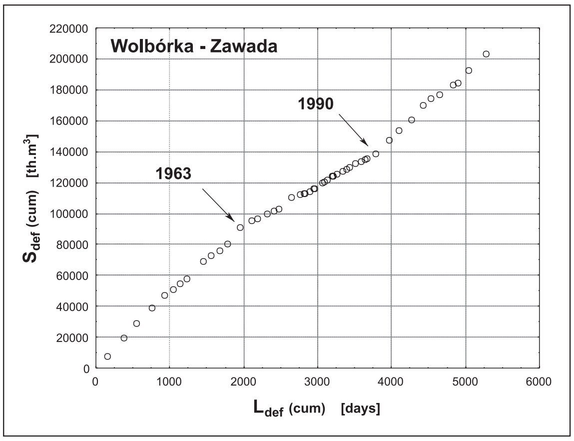

Figure 2. Double mass curve (1951-2000) L_{def} (cum) – cumulated annual number of days with streamflow deficit, S_{def} (cum) – cumulated annual streamflow deficit volume

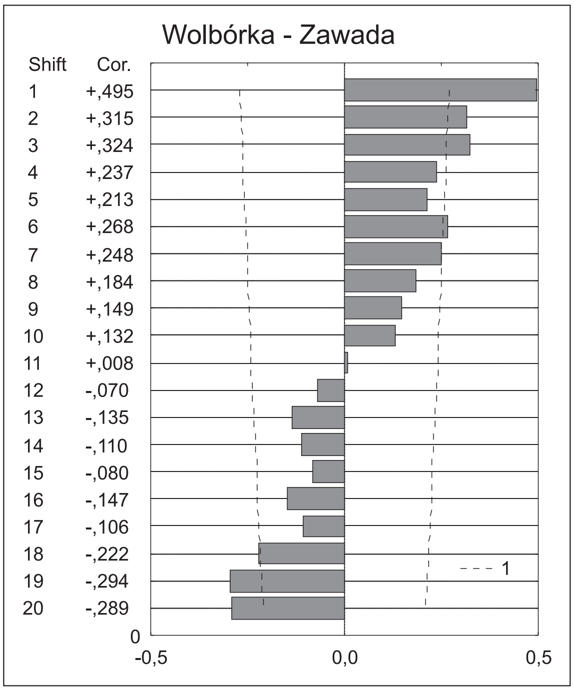

Figure 3. Autocorrelation of annual streamflow deficit volume in successive shifts (1951-2000). 1 – confidence interval

as a significant limitation level, the percentile Q_{70} from flow duration curve was accepted. As a result, for each month, there were calculate two basic parameters: monthly sum of streamflow deficit volume and number of days with streamflow deficit.

Variability of annual streamflow deficit volume was analyzed on the base of variation coefficient. Time tendency was estimated by a linear trend equation, its statistical significance and error of estimation (Figure 1). There was also a trial of dividing investigated period into segments with weak and severe drought episodes and its influence on estimated trend significance. Homogeneity of conditions determining streamflow deficit was investigated by using double mass curve (Figure 2). It shows relationship between cumulated variable of annual streamflow deficit and cumulated variable of annual number of days with streamflow deficit. Breaks which appeared on the curve indicated changes in relations between conditions determining this process. Interesting results gave the analysis of streamflow shortage inertia which was made on the base of autocorrelation. First autocorrelation coefficient (shift=1, 1 year in this case) allowed to identify pocket of information about low flow forming which is transmitted year by year. Furthermore, functions of autocorrelation in successive shifts were analyzed (Figure 3). As a result some types of them were identified as well as they helped to verify previously proposed theses on multiannual fluctuations of streamflow deficit.

Seasonal variability of streamflow deficit was estimated on the base of Markham (1970) indices. Level of irregularity of annual deficit volume distribution as well as its concentration time was calculated on the base angular characteristics. In original version it was used to precipitation analyses, however, it was also adopted to total and groundwater runoff (Bartnik, Tomaszewski, 2006; Jokiel, Bartnik, 2001; Tomaszewski, 2001, 2007). Both characteristics refer to vector analysis (Figure 4). Each of the 12 months is represented by vector whose length is determined by monthly streamflow deficit volume, and its angle depends on midpoint position of the month in relation to the beginning of the year. The length of the resultant vector in relation to the sum of the 12 vectors

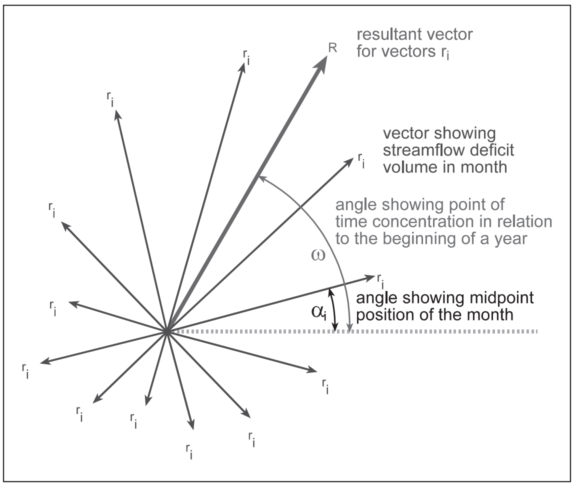

Figure 4. Idea of Markham procedure

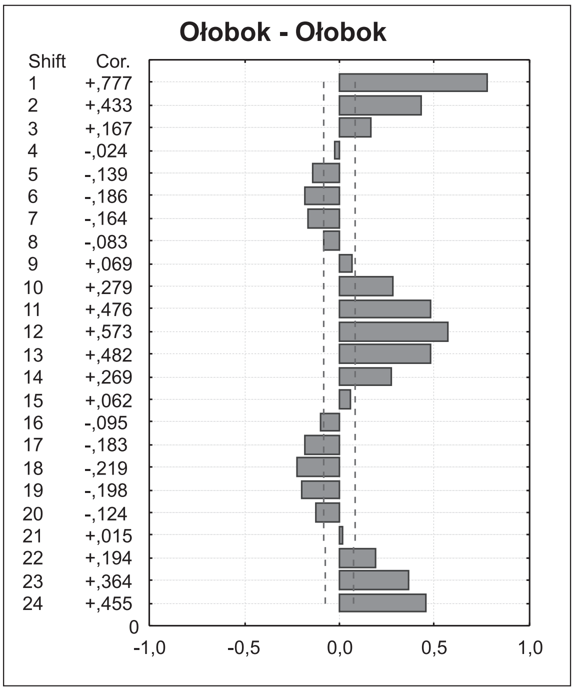

Figure 5. Autocorrelation of monthly streamflow deficit volume in successive shifts (1951-2000)

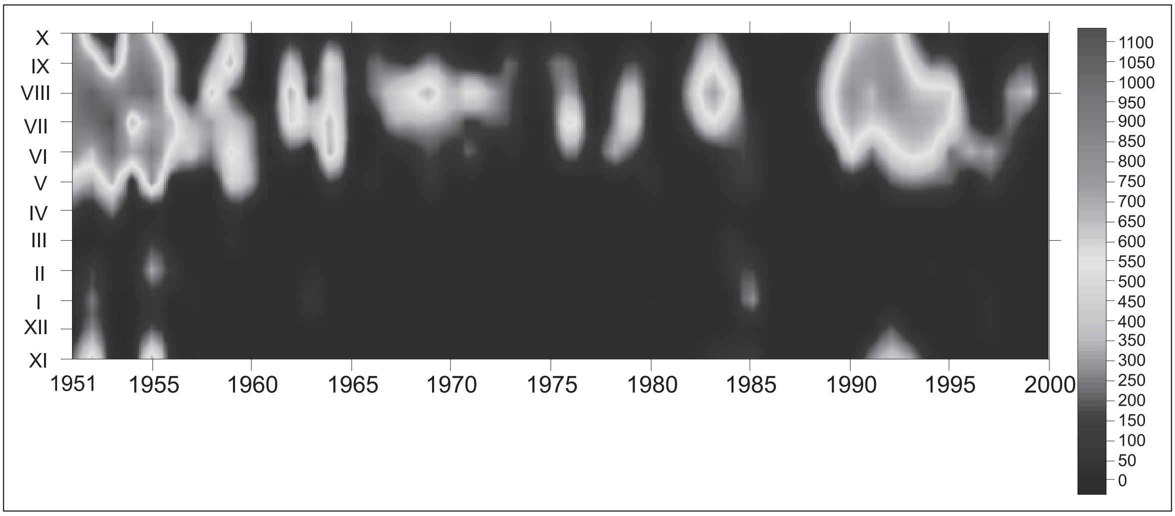

Figure 6. The annual and long-term courses of monthly streamflow deficit volume [th.m^3] (Niesób – Kuźnica Skakawska)

defines streamflow deficit seasonality index (SI). Second characteristic, i.e., time concentration index (TCI), is represented by the angle of the resultant vector and shows the day (or month) of a year of streamflow deficit concentration. As a result typical time and level of water shortage concentration as well as their multiannual variability and tendency was estimated.

The question of inertia was also examined in seasonal (monthly) scale. Analyses of autocorrelograms in successive shifts allowed to identify seasonal cycles (Figure 5). Finally, the complex analysis of seasonal and multiannual variability of streamflow deficit was made on the base of an isopleth diagram (Figure 6). After comparative analysis it was possible to draw some conclusions about local or regional conditions determining low flow episodes in investigated group of catchments.

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