Section 2. Geography

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Droughts and their relationship with some phases of the streamflow regime for Ukrainian rivers

Abstract: The study considers spatial and temporal distribution of droughts in Ukraine at different time scales. The meteorological, agroclimatic and hydrological droughts describes using drought indices PDSI and SPEI for the period of 1950–2012 in the main physiographic zones of Ukraine. Statistical relationship between the SPEI at different time scales and some phases of the river flow in Steppe and Carpathian region has been estimated.

Keywords: drought index, runoff, high- and low-water phase.

Introduction. Territory of Ukraine every vegetation season is exposed the droughts of different intensity and duration. Strong and widespread general drought always accompanied by extended anomalies in the atmospheric circulation such as a blocking, which is lead to development of stationary anticyclones and prolonged deficit of precipitation in the impact region [1].

Monitoring of spatial and temporal distributing of drought has been provided using numerous specialized indices, which based at available data such as precipitation and temperature. Popular and usable drought indices are the Palmer drought severity index (PDSI) and Standardized precipitation-evapotranspiration index (SPEI). A non-rain period is an index, which high frequency and duration often results to drought. This period is defined as a time interval no less than 10 days, during which the amount of precipitation did not exceed 1 millimeter.

The PDSI is a meteorological index was developed to measure intensity, duration and spatial extent of drought. The PDSI values are derived from measurements of precipitation, air temperature, and local available water content of the soil. This index is calculated using the simple water balance equation, when also determined evapotranspiration, soil recharge, runoff and moisture loss from the surface layer [2]. Usually the PDSI values varies between –6.0 and +6.0, the drought conditions are measured by negative values.

The SPEI is a probability index, which is based on precipitation data and potential evapotranspiration data (PET) [3]. In original SPEI database was applied Thornthwaite's method for calculation the PET, which made the index sensitive to the soil moisture content as well as the PDSI.

Intensity of drought can be defined according to negative SPEI values. The SPEI values from –0.99 to 0.00 relate to weakly dry or near normal conditions; values from –1.49 to –1.00 correspond to moderate drought; values from –1.99 to –1.50 correspond to severe drought; values from –2.00 and less relate to extreme dry conditions.

Previous moistening of the territory significantly affects the formation of different phases the streamflow regime of rivers. The spring and rain floods will be accompanied by much greater discharges and the sharp rise in levels if before them was a period of drought. On the other hand, low water flow is directly related to the non-rain period and determined by its duration.

The drought conditions in Ukraine at different time scales has been estimated using the PDSI and SPEI during the second half of the last century and beginning of 21st century. Some characteristics of river runoff in different phases were considered and relationship with the drought indices was analyzed.

Data and methodology. A monthly values of self-calibrated (sc-)PDSI with a step of 0.5 degrees were obtained from CRU (Climatic Research Unit, UK) database [6]. The SPEI data in a regular grid with a step of 0.5 degrees were taken from the Global SPEI database [7], which is based on monthly precipitation and potential evapotranspiration of the CRU data. All indices were averaged over main physiographic zones of Ukraine: Steppe, Forest-and-Steppe, Mixed Forest area (or Poles'e).

For definition of non-rain periods during vegetation seasons the daily station sums of precipitation were analyzed for April-October of 1995–2011.

For the hydrological calculations [4] used the data from of the observation network of the State Hydrometeorological Service of Ukraine for runoff during periods of high and low water for basin of Dniester and Southern Bug River from the start of observations until 2010.

Statistical relationship between the SPEI and runoff parameters was estimated using the Pearson correlation coefficient.

Results and discussion. The analysis of non-rain periods shown that 4–5 episodes in average are observed annually at all stations. Currently the amount of non-rain periods is a few less than climatic, but the duration became longer. The average total duration varies from 43-54 days in the west to 56-64 days in the north and increased to 75–96 days in south and east of country.

According to monthly sc-PDSI extremely dry periods were observed in 2007 and 2009 with the moderate to strong drought during vegetation season. The Steppe appeared the most dry area with the extreme value of sc-PDSI (-6.11) in July, 2007. In 2002 there was the moderate drought from April for July with most intensity in May. In the Forest-and-Steppe area the intensity of droughts usually less severe, but its duration is same as in Steppe. In Poles'e the mild-to-moderate droughts were observed in 1996, 2002 and 2003. Weak droughts were observed in 1996 from April to August and in 1999 from July to October. The frequency of autumn droughts increases in comparing to southern regions. Trends of sc-PDSI shows that aridity of physiographic zones is increased after 2002–2003 years.

The seasonal drought in Ukraine has been described using drought index SPEI at time scale 3 and 7 months. According to the 3-month SPEI during April to June in Ukrainian physiographic areas the dry conditions are prevailed. Spring-summer moderate droughts were observed in 1996, 2003, 2007 and 2012 throughout Ukraine. Spring droughts in those years led to large crop losses of winter wheat and spring barley (10–43 % from the trend). In the area of Mixed Forests were five mainly weak droughts during April-June in 1996, 1999, 2000, 2003 and 2007.

In summer period (during June to August) the drought frequency increasing in Steppe and decreasing in other regions. Moderate summer droughts covered the whole country only in 2007 and 2009 with SPEI equal to –1.13 and –1.00 respectively.

Summer-autumn period (during August to October) characterized by decreasing of drought intensity in all zones. Weak dry conditions were observed in autumn during 1998–2001 and 2005–2010. The anomalous autumn drought with moderate-to-strong intensity was detected in 2011, especially in Poles'e. This case has led to significant crop losses of winter grain crops next year.

On the whole, in Steppe occurred 7–8 droughts in every season during vegetation period. In the Forest-and-Steppe area an amount of spring-summer and summer droughts reduced to 3–4. In Poles'e the temporal distributing of spring-summer droughts differs from south regions.

Using the 7-month SPEI in same period we are identified the most important droughts during vegetation season in 1999, 2007, 2009 and 2012. In Steppe drought in 2007 appeared the most intensive and reached the criteria of strong and extreme in spring and summer. In the Forest-and-Steppe area the most droughty season occurred in 2009, when there was a weak and moderate drought. In 2007 a moderate drought lasted all spring and summer seasons, and in 1999 a moderate summer drought has passed into weak autumn drought. In Poles'e most droughty season observed in 1999, when the mainly weak drought was continued during spring and summer time.

Comparison between indices the SPEI and sc-PDSI shown, that only main drought episode such as 2003, 2007, 2009, 2011 and 2012 clearly identified by all indexes simultaneously.

For hydrological purpose we have analyzed the time series of the SPEI at time scales in 12, 18 and 24 months for a long time period of 1950–2012 in several physiographic zones of Ukraine.

In the Western Steppe 2–3 drought cases were observed in the 1950s and the 1960s. In the 1970s there registered 1 case of severe drought. It is from 1977 to 1983 that a wet period lasted, following which, according to the trend, a long dry period began and has extended till the present time. In the 1990s four drought cases were registered. During the first decade of 21st century three drought cases were observed, in which longest drought of 2006 to 2010 reached extreme values. In the period from 1950 to 1967 a low-water phase was observed in the chronologic setting of the maximum river runoff. Later, with the periodicity of 4–5 years, it gave place to two high-water and one low-water phases, whereupon, since 1980 to the time present, there has been observed a period of low water level on the rivers [5].

For a spring flood the highest closeness of links between SPEI and runoff is reached at the time scale of 3–4 months, and a further increase in the calculation period leads to a steady decrease in the correlation coefficient.

In Carpathian region the time series of the SPEI at scales 12, 18 and 24 months shows that for all points were observed from 12 to 16 episodes of drought with the duration more then one year. The most important dry episodes occurred in region from autumn 1961 to summer 1965, from summer 1971 to summer 1974, from spring 2000 to spring 2005. In these periods hydrological drought reaches up to strong and extreme criteria in some points and years. From summer 1983 to summer 1998 was observed the continuous consecutive period with predominantly moderate dry conditions, when intensity of drought only one station (Golatin) and one time (spring 1997) reach up to extreme value. The main wet periods occurred from autumn 1974 to summer 1983 and from summer 1997 to summer 2002. In first decade of current

century observed the trend to strong increasing the intensity of wet period in mountain station Yasinya and smaller trend west along the Carpathian ridge.

Studies of statistical relationship between the SPEI at different time scales and minimum runoff rivers of Carpathian region showed that degree of significance interrelation depends on the time intervals of the SPEI and months for which they are calculated. Therefore for the winter time the largest value of the correlation coefficients (R) were obtained for March and April (R = 0.4–0.5) and SPEI – 6 and 12 months. For a low flow in summer time the best results were obtained for August, September and October (R = 0.5–0.7) and SPEI – 12 and 18 months.

Conclusions. The review of our investigations shown, that in Ukraine under current climate conditions prevail the spring-summer droughts at all physiographic zones. In summer the drought frequency increasing in Steppe and decreasing in other regions. Autumn period characterized by decreasing of drought intensity everywhere. Severe and extreme droughts occurred mostly in Steppe. In the Forest-and-Steppe area and Poles'e observed only weak and moderate seasonal droughts.

The presence of a significant correlation between the indices of drought and runoff in different periods (floods and low water) shows the possibility of using them for modeling and forecasting the various phases of the water regime of the rivers of Ukraine.

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The influence of the afforestation and swampiness on the design characteristics of the spring flood peak flow in the river Pripyat basin

Abstract: On the basis of the geometric model hydrograph slopeflow and streamflow we offered more sophisticated design scheme, which allows separate categories for factors of floods and freshets. It relies on materials of observations of maximum flood runoff in the basin of Pripyat river.

Keywords: maximum runoff, spring freshet, the layer flow, duration of the slope inflow, design characteristics, afforestation, swampiness.

Introduction

In most cases in the calculation formulas of maximum flow, the adjustments for the afforestation and swampiness are related integraly to the final results. This methodical approach can not account for the degree of influence of these factors inclined flow into separate components. This notice applies to the principal circumstances, as the direction and level of influence of afforestation and swampiness to certain processes of runoff formation can be different and in different modeling combinations can even compensate each other.