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Low flows along the Vistula River (and more) – some preliminary results of the Chinese-Polish HUMDROUGHT project

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ABSTRACT

The Chinese-Polish project HUMDROUGHT is focused on drought risk, hazard and vulnerability assessment in the context of two main triggers which may influence drought severity and duration: (1) climatic variability and change and (2) human impacts on landscape, land use and land cover, water resources and their management. Two river catchments were selected as the case studies: the Huai River in China and the River Vistula in Poland. Although the project is focused on the risk of drought in the future, this cannot be done without identifying droughts and their determinants in the historic period basing on the existing multi-source data.

The aim of the paper is to present the preliminary results of carried out multi-faceted analysis of low flows along the Vistula River, their magnitude, timing, the multiannual variability and identification of climatic drivers and human impacts on low flows. Due to the hydrological regime in Poland (Poland is located in the transitional climate zone) the research was performed with reference to seasonal (winter and summer) and annual discharge data. The hydrological year in Poland lasts from November 1 of the previous year to October 31, and it is divided into the winter (November-April) and summer (May-October) seasons.

The research was performed for 15 hydrological stations along the Vistula River course in the observation period 1951-2018 (68 years). It was focused on: timing of lowest annual flows and the most sever hydrological droughts, simultaneous assessment of trends in the mean value and standard deviation of the lowest seasonal flow, trends in the lowest seasonal flows (Mann test, Sneyers, 1990) and of trend in frequency of flows lower than mean seasonal minimum flow (Lang's test, Lang et al. 1999, Zieliński, 2009). Mean annual discharge was examined by mass curve technique in the oblique coordinates showing wet and dry periods within the seasonal and yearly observations. The monthly Standardized Runoff Index SRI series were analyzed as well.

Spring floods from snowmelt pose a significant threat to the Polish territory. The largest and most extensive snowmelt floods commonly occur in the north-eastern Poland but they are also significant in the whole country. The decrease in their size and frequency could be beneficial for reduction of the risk and losses. However, intensive melting of snow presents not only a threat of flooding, but also a chance for considerable supplementation of soil moisture and groundwater resources to the condition, which may alleviate shortages of rainfall in the coming months. That is why a complex study of winter runoff seemed to be important in the context of drought in summer season and hence the complex analysis was carried out by quantifying different aspects of hydrological regime change in winter season along the Vistula River.

The following flow characteristics were analyzed:

1. Magnitude and duration of floods

1.1. Winter maxima Q_{max}

1.2. Number of days with flow above the specified threshold (e.g. flow corresponding to alarm level)

2. Magnitude and duration of low flows

2.1. Winter minima Q_{min}

2.2. Duration of flow below the specified threshold (e.g. ecological flow)

2.3. D-characteristic of low flows dynamics (QdF modelling)

2.4. *Frequency (β) of winters without flow below the specified threshold (DqF modelling)*

3. Timing

3.1. *Time of maxima and minima in winter*

3.2. *Centroid location on the time axis in winter*

3.3. *Median of time i.e. time value which divides the winter runoff on halves*

4. Winter discharge

4.1. *Runoff volume*

4.2. *Standardized daily discharge range*

5. Concentration of winter runoff

5.1. *Moment of inertia of winter hydrograph about the axis passing through the centroid with respect to time (corresponding to variance and consequently standard deviation) as a de-concentration measure with respect to centroid location*

5.2. *Coefficient of skewness with respect to time (Cs)*

5.3. *Gini index of concentration (Gini, 1936)*

The research is currently executed and results will be available in the coming months. The study will be finished by the end of April and the aim is to present the main results at the 6th IAHR Europe Congress in Warsaw.

The next stage of the analysis will involve the assimilation and analysis of data on the main tributaries of the Vistula, precipitation amount and snowpack depth and more detailed data on water management in retention reservoirs, water abstraction for municipal purposes and irrigation from surface and ground water, water abstraction for industry and the discharge of mining water together with inter-catchment transfers and sewage discharge. And all these for quantify the separation the contributions of climate change and human activities to hydrological drought severity and duration assessment (e.g. Jiang S et al., 2019, Wu and Miao, 2018).

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