

Is it a drought or only a fluctuation in precipitation patterns? - drought reconnaissance in Poland

Renata ROMANOWICZ¹, Emilia KARAMUZ², Urszula SOMOROWSKA³, Tesfaye SENBETA⁴, Jarosław NAPIÓRKOWSKI⁵

^{1,2,4,5} Institute of Geophysics Polish Academy of Sciences, Poland

email: romanowicz@igf.edu.pl

email: emilia_karamuz@igf.edu.pl

email: tsenbeta@igf.edu.pl

email: j.napiorkowski@igf.edu.pl

³ University of Warsaw, Faculty of Geography and Regional Studies, Department of Hydrology, Poland

email: usomorow@uw.edu.pl

ABSTRACT

The process of propagation of drought from meteorological to hydrological is studied using the Vistula Basin in Poland. Scientists predict that rising average global temperatures and rising anthropopressure will have an increasing impact on hydrological phenomena. The aim of this study is to present the history of drought events and find the similarities and differences that characterize the origins, development and ending of drought events based on historical hydro-meteorological observations. The study is based on the analysis of temporal and spatial variability of a number of standardized drought indices and a comparison of their sensitivity to physio-climatic characteristics in Poland. As a result, the factors affecting temporal and spatial drought variability - with particular emphasis on the interaction between the variability induced by natural processes and human interaction are identified.

1. Introduction

Drought events are difficult to define before they are over. The decrease of precipitation over a longer periods of time provides conditions that may lead to drought but there are also other factors that affect drought occurrence and its dynamics. It is very complex phenomenon in the sense that many factors have influence on drought conditions and those factors are inter-related. There are complicated feedbacks influencing the development of drought both in time and space. For example, decrease of precipitation over a cultivated area causes the need for irrigation systems to be employed. The water is pumped from the available surface water resources and groundwater. In turn, those resources are depleted and their depletion deepens the deficits of natural water resources in the area. This is an example of local feedback mechanism. Unfortunately there are also global feedback mechanisms which are acting over the areas of thousands of kilometers (e.g. Amazon rainforest). In Poland there is a growing concern of drought occurring with varying intensity over many regions in the last decades. Following a number of studies, it is evident that drought signals are increasing and becoming widespread (Somorowska, 2016; Tokarczyk and Szalinska, 2014). In Poland, investigations conducted in semi-natural catchments have proved that river regimes have undergone pronounced changes in the period from 1981 to 2016 (Piniewski et al., 2018). Decreases in river flow occurred in the northern part of the country and increases were usually present in the southern part, while in the central part, no significant trends were found. In spite of a vast literature on the changes in temperature and precipitation patterns in Poland, there is a lack of an integral assessment of temporal and spatial occurrences of drought events in the River Vistula basin in the last 50 years. This study addresses transformation of changes in low flow conditions along the River Vistula.

2. Methods

The study applies a number of different approaches to understand how the climate and human induced changes are inflicting flow patterns in the River Vistula. We analyze the baseflow changes along the river and the variability of elasticity index for the consecutive gauging stations along the main channel. The derived annual balance models for each gauging station are used to test changes of water balance conditions along the river. The static relationships between water levels observed at the gauging stations are examined through an analysis of differences between normalized water level quantiles along the river channel (Karamuz et al.,

2015). This “quantile difference” approach is applied to separate human induced and natural changes. The standardized precipitation and runoff coefficients are also derived for each subbasement to analyze the temporal variability of those indices and their inter-dependence.

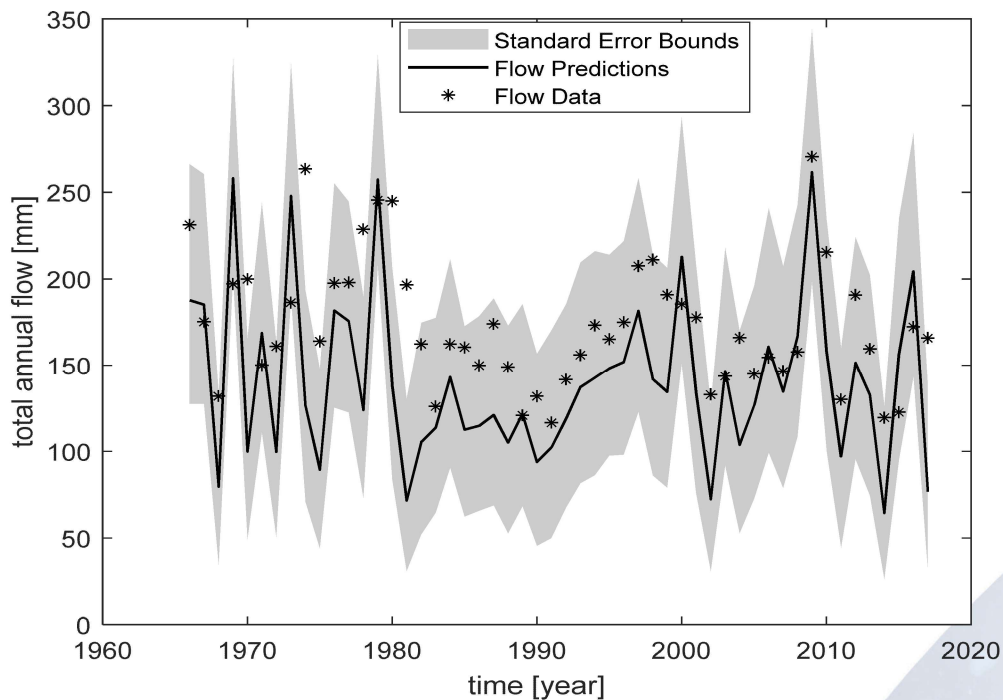


Fig. 1. Balance model simulations for the Vistula catchment at Tczew.

Figure 1 presents the results of simulations of a simple, annual Budyko-based water balance model for the downstream gauging station at Tczew. The model was calibrated on a part of the available flow observations. Flow simulations are shown by a thick black line, observations are presented as black dots. The shaded area presents standard 0.96 error bounds. There are periods of years which show large discrepancy between the modelled and observed flow indicating potential influence of other than climatic factors.

3. Conclusions

The study gives a summary of ongoing changes in low flow conditions along the River Vistula, trying to separate climatic and human-induced changes.

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