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

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There are two major driving forces affecting the water cycle and consequently the riverine hydrologic regimes: climate (variability and change) and human activity. For quantifying their effects on hydrological regime the long term data are indispensable. The hydrological data from 15 hydrologic stations situated along the Vistula course in the period 1951-2018 were used in this study.

It is commonly recognized that the main feature of hydrological regime of Polish rivers is a sequential occurrence of wet and dry lasting 1 to a dozen years. The differences between mean annual flows during series of wet and dry years are large and statistically significant. Another important feature of the hydrological regime of Polish rivers is the seasonality of the runoff associated with the occurrence of cool and warm season within a hydrological year. The seasonal characteristics of flow differ, so their statistical properties ought to be analysed separately. In the social but also researchers' perception the climate changes are more accentuated in winter season i.e. November – April.

The following flow characteristics were analyzed:

Magnitude and duration of floods: *Seasonal daily flow maxima Q_{max},*
Number of days with flow above the specified threshold (e.g. alarm flow)

Magnitude and duration of low flows: *Seasonal daily flow minima Q_{min},*
Duration of flow below the specified threshold (e.g. ecological flow)

Timing: *Time of maxima and minima, Centroid location on the time axis*
Median of time i.e. time value which divides the winter runoff on halves

Seasonal discharge: *Runoff volume*

Concentration of seasonal runoff: *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, Gini index of concentration*

Results of the Mann test (uF) for trend in winter season daily flow;
light blue – negative uF value; dark blue significant negative trend;
light orange – positive uF value; dark orange significant positive trend

Subject of the analysis→	Floods		Low flows		Timing				Runoff	Concentration	
Stations on the Vistula↓	Magnitude	Duration	Magnitude	Duration	Time of max	Time of min	Centroid	Median	Volume	Inertia	Gini
Skoczów	0,281	0,768	2,377	-1,837	-1,080	-1,577	-1,429	-1,636	1,567	-0,116	-0,519
Goczałkowice	-1,228	-1,911	0,212	-0,963	-1,323	0,116	-1,101	-0,948	0,318	0,286	-1,884
Jawiszowice	-1,906	-2,234	1,149	-0,831	-0,561	0,360	-1,080	-1,165	0,318	0,805	-2,191
Nowy Bieruń	-1,366	-1,461	3,652	-2,985	-1,053	0,005	-1,323	-1,313	0,678	0,985	-2,371
Jagodniki	-2,123	-1,884	1,355	-1,080	-0,884	-0,614	-1,366	-1,239	-1,016	0,328	-2,340
Szczucin	-1,122	-1,678	2,297	-1,683	-0,910	0,159	-1,207	-0,921	0,445	0,381	-1,810
Sandomierz	-1,985	-2,207	3,197	-2,070	-1,159	0,360	-1,355	-1,186	0,381	0,582	-1,959
Zawichost	-2,414	-2,536	2,101	-2,149	-0,937	-0,651	-1,249	-1,112	-0,688	0,889	-2,128
Annopol	-2,080	-2,006	1,435	-1,313	-0,937	-0,492	-1,122	-1,064	-0,476	0,847	-1,937
Puławy	-1,969	-1,858	1,842	-1,265	-0,551	0,291	-1,038	-0,879	-0,466	0,709	-1,789
Dęblin	-1,884	-1,683	1,551	-1,514	-0,884	-0,074	-1,207	-1,143	-0,434	0,498	-2,064
Warszawa	-1,805	-1,694	2,281	-3,547	-1,276	0,143	-1,323	-1,292	0,064	0,392	-2,573
Kępa Polska	-2,467	-2,117	2,075	-2,456	-0,836	-0,773	-1,355	-1,726	0,349	-0,953	-3,134
Toruń	-2,604	-2,234	1,329	-1,546	-0,879	-1,710	-1,376	-1,535	-0,169	-0,836	-3,134
Tczew	-1,937	-1,450	1,604	-1,752	-0,672	-1,689	-1,450	-1,530	0,148	-0,942	-2,901
Tributaries with observation period 1951-2018											
Iłownica/Czechowice-Dziedzice	-1,207	-1,339	-0,074	-0,228	-1,837	1,159	-1,461	-1,450	-0,752	0,582	0,116
Przemsza/Jeleń	-3,626	-2,774	0,884	-0,556	-0,900	-0,492	-0,646	-1,085	-0,730	-0,625	-3,218
Soła/Oświęcim	-1,281	-1,625	0,572	0,333	-1,424	-0,138	-1,704	-1,498	0,275	-0,116	-0,720
Skawa/Wadowice	0,397	0,551	0,069	-0,233	-1,313	-0,593	-0,434	0,212	1,143	0,222	0,826
Nida/Pińczów	-3,372	-3,017	1,371	-0,937	0,159	-1,302	-0,392	-0,423	-1,239	1,260	-2,795
San/Radomyśl	-1,985	-2,086	4,769	-4,176	1,138	-1,313	-0,783	-0,900	0,900	0,741	-3,621
Wieprz/Kośmin	-1,731	-1,043	3,637	-2,726	-0,270	0,021	-1,292	-1,794	1,673	-0,191	-3,038
Pilica/Białobrzegi	-3,997	-3,102	2,154	-1,736	-1,244	-0,482	-1,122	-1,217	-0,603	1,090	-3,684
Biebrza/Osowiec	-1,239	-1,133	3,854	-3,541	-2,345	-1,408	-1,429	-2,424	2,361	-3,705	-3,113
Bug/Wyszków	-2,493	-2,430	3,330	-3,001	-0,492	-1,307	-2,033	-2,488	0,423	-0,360	-3,705
Skrwa(prawa)/Parzeń	-0,577	-0,503	0,275	-0,159	-0,995	-2,149	-0,222	-0,985	0,180	-1,355	-0,540
Drwęca/Elgiszewo	0,164	0,101	0,259	-0,958	-0,566	-1,519	-0,212	-0,021	0,434	-1,980	-0,625

Conclusions: 1. The winter maxima generaly decrease while the minima increase. 2. The number of days above the average maximum flow and the number below the average minimum flow decreases. 3. In the most cases the daily maxima occur faster, however the shift is no-significant. 4. The same for the centroid location and the median flow. 5. Gini index of concentration reveals significant decrease in concentration (so bigger uniformity) of fows in the most part of cases.

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