Supplement of Hydrol. Earth Syst. Sci., 25, 3991–4023, 2021
https://doi.org/10.5194/hess-25-3991-2021-supplement

Hydrology and Earth System Sciences
Open Access

Supplement of

Streamflow drought: implication of drought definitions and its application for drought forecasting

Samuel J. Sutanto and Henny A. J. Van Lanen

Correspondence to: Samuel J. Sutanto (s.j.sutanto@uu.nl)

In the supplementary material, we present, in addition to the detailed temporal drought analysis (Section 3.1.2), the drought characteristics of the four selected rivers over the entire period (1990-2018) using different drought identification approaches (Supplementary Table S1 and Table S2). Table S1 shows that number of FTD droughts is almost equal in the Rhine and Danube, or lower in the Ebro River than those of VTD droughts (up to 30% for Ebro). When monthly data are used as an alternative of daily data, then we see the opposite (Table S2), that is, number of VTM droughts of four rivers is equal (Ebro), or lower than those of FTM droughts (up to 20% for Vuoksi). The Vouksi River that is located in a cold climate (Dfc) has a substantially lower number of droughts than the three other rivers according to all identification approaches (Table S1 and S2). The average drought duration is negatively correlated with the number of droughts, implying that duration of FTD droughts is longer than of VTD droughts. The difference in duration between FTD and VTD droughts for the Rhine and Danube is small, due to almost equal number of drought occurrences, and this difference is larger for the Ebro and Vuoksi. However, the negative correlation between the number of drought occurrence and duration is less apparent for the VTM and FTM droughts, except for the Vouksi River. In this river, the FTM approach identifies a slightly higher number of drought occurrences but it has a somewhat shorter drought duration (~7%) than the VTM. The number of drought occurrences and average duration obtained with the SSI-1 method are mostly close to both the VTM and FTM method, except the duration of the SSI-1 drought in the Vouksi River, which is about 20-25% longer than the droughts obtained with the monthly threshold methods (Table S2). Clearly, rivers in wetter climates (Rhine and Danube) have larger deficit volumes than in dryer climates (Ebro). In the Rhine and Danube, deficit volumes of the FTD and FTM methods are slightly higher than of the VTD and VTM methods (up to about 10%). In the Ebro, we see the opposite, i.e. the VTD and VTM methods yield higher deficit volumes than the FTD and FTM methods (~10-20%). Drought timing does not show a clear pattern among the different approaches, which means that droughts start in different months. However, when using the VTM approach drought mostly start in winter or spring in all rivers (except Vuoksi), and in summer or autumn when applying the FTM approach (Table S2). SSI-1 drought does not follow VTM or FTM droughts in terms of timing (Table S2).

Supplementary Table S1. Streamflow drought characteristics derived from daily streamflow data using the VTD and the FTD approaches for the selected locations in the four rivers (Fig. 1) and hydrologic years 1991 to 2018. N stands for number of occurrence, T stands for timing (start month), D stands for average duration (day), and DV stands for average deficit volume in million m^3

No	River	Drought characteristics							
		VTD				FTD			
		N	T	D	DV	N	T	D	DV
1	Rhine	54	12	35.9	786.9M	53	9	37.9	867.9M
2	Danube	63	3	31.6	628.8M	58	12	35	707.6M
3	Vuoksi	20	3	95.1	440.3M	17	6	122.5	572.4M
4	Ebro	49	10	43.3	227.6M	37	8	53.4	205.6M

Supplementary Table S2. Streamflow drought characteristics derived from monthly streamflow data using the VTM, the FTM, and the SSI-1 approaches for the selected locations in the four rivers and hydrologic years 1991 to 2018. See Table 3 for drought characteristic abbreviations. The unit for drought duration is month

No	River	Drought characteristics										
		VTM				FTM				SSI-1		
		N	T	D	DV	N	T	D	DV	N	T	D
1	Rhine	29	3	1.9	1,380M	33	9	1.9	1,392M	32	7	1.8
2	Danube	29	2	1.9	1,098M	34	11	1.9	1,159M	32	2	1.8
3	Vuoksi	12	6	4.7	669.3M	15	3	4.4	630.3M	12	1	6
4	Ebro	32	5	1.8	296.7M	32	8	2.1	246.9M	31	9	2.1

Obviously, the drought characteristics obtained for individual rivers over the period 1990-2018 may deviate from the general pattern, as reported in Section 3.1.1, because the drought analysis of a specific river only involves streamflow generation upstream of the river grid cell that has been selected to represent the river. The generic pattern is based upon many more points, i.e. for the humid continental climate (Dfb) the average characteristics are derived from over 11,000 grid cells.