EGU2011-6337. Investigation on extreme runoff characteristics in major German river basins

Rohini Kumar, Luis Samaniego, and Matthias Zink

UFZ – Helmholtz Centre for Environmental Research, Leipzig, Germany (rohini.kumar@ufz.de)

1. Introduction

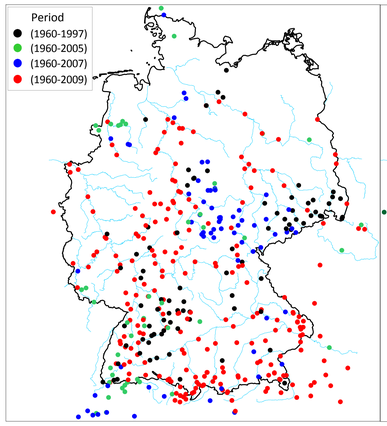
Investigation of extreme runoff characteristics, such as magnitude and frequency of floods and droughts, for analyzing their upward or downward trends has been one of the major research areas in the contemporary hydrology. This is mainly because of the compelling evidence that the anthropogenic disruptions of the environment are significantly modifying the likelihood of occurrence of floods and droughts in a given period. Changes in the behavior of the extreme runoff characteristics may have both socioeconomic and environmental consequences. For instance, during the last decades many river basins in Germany have frequently experienced catastrophic floods and droughts situations leading to enormous losses.

Objective of the study: To identify the possible trends in extreme runoff characteristics in German river basins during last 50 years.

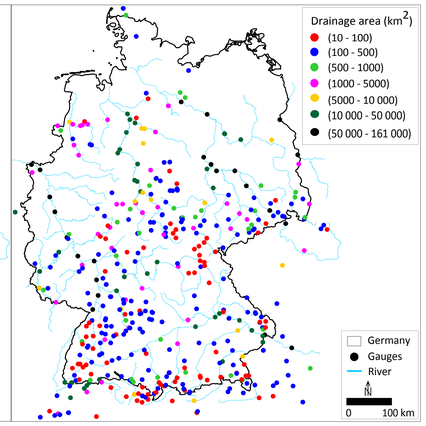
2. Dataset

A daily discharge data of 430 gauging stations with at least 38 years of record starting from 1960 were analyzed in the present study.

Time period map



Drainage area map



3. Trend analysis test

A Mann-Kendall trend test [1, 3] which is a non-parametric, rank based method was used to evaluate the presence of trends in time series data of extreme runoff characteristics, $Q(t)$. The test statistic, Z_S can be given by

$$Z_s = \begin{cases} (S-1)/Var(S) & for \;\; S > 0 \\ 0 & for \;\; S = 0 \\ (S+1)/Var(S) & for \;\; S < 0 \end{cases}$$

where, $S = \sum_{i=1}^{N-1} \sum_{j=i+1}^{N} sign[Q(i) - Q(j)]$, and variance of S, $Var(S)$ is

$$Var(S) = [N(N-1)(2N+5) - \sum_{i=1}^{N} e_i(i)(i-1)(2i+5)]/18$$

Here e_i is the number of ties of extent. The hypothesis of an upward or downward trend cannot be rejected at the α significance level if $|Z_s| > Z_{1-\alpha/2}$, where $Z_{1-\alpha/2}$ is the $(1-\alpha/2)$ quantile of the standard normal distribution.

4. High and low flows characteristics [2]

Extreme runoff characteristics analyzed in this study were estimated from the daily discharge records at each station using the peak over threshold method and the truncation method for high and low flows characteristics, respectively.

High flows characteristics

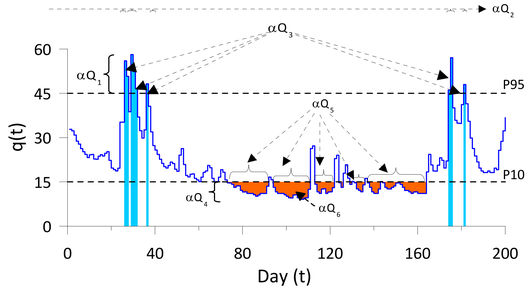
- Specific volume (Q_1)
- Total duration (Q_2)
- Frequency (Q_3)

Low flows characteristics

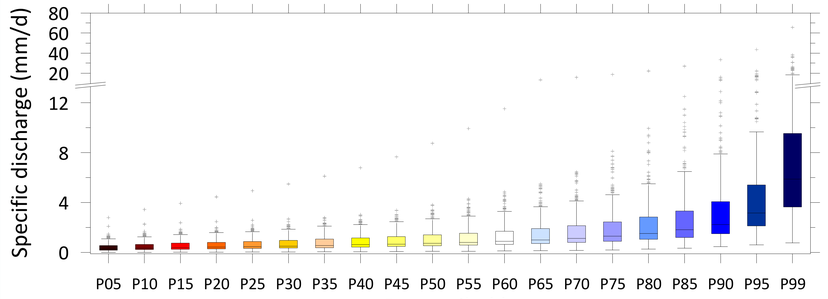
- Cumulative specific deficit (Q_4)
- Drought duration (Q_5)
- Maximum drought intensity (Q_6)

Event specific characteristics

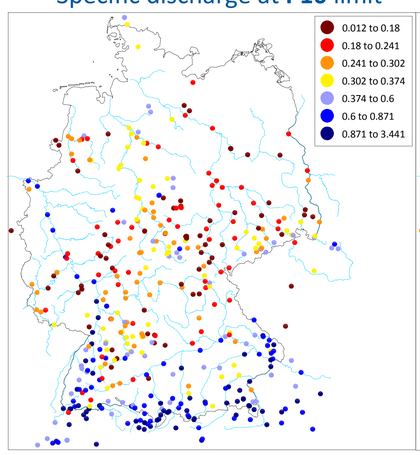
- Specific peak discharge
- Volume of peak flow



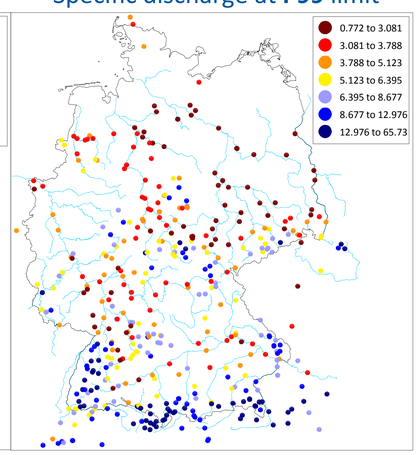
5. Spatial variation of specific discharge at a particular percentile limit



Specific discharge at **P10** limit

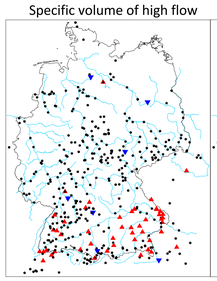


Specific discharge at **P99** limit

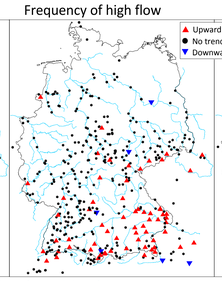


6. Trend analysis results at 5% significance level

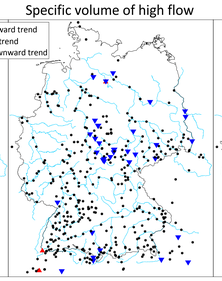
Winter (October - March) — Specific volume of high flow



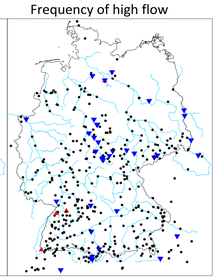
Winter (October - March) — Frequency of high flow



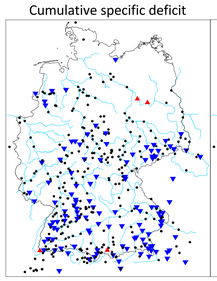
Summer (April - September) — Specific volume of high flow



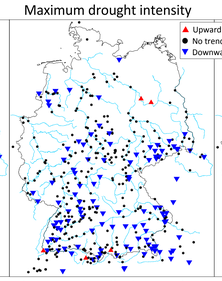
Summer (April - September) — Frequency of high flow



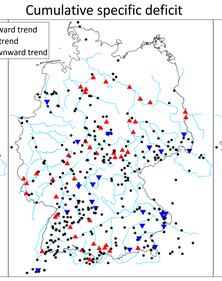
Winter (October - March) — Cumulative specific deficit



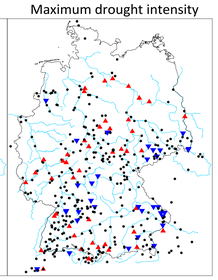
Winter (October - March) — Maximum drought intensity



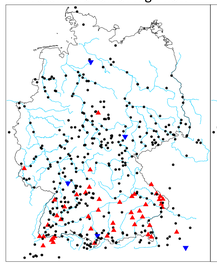
Summer (April - September) — Cumulative specific deficit



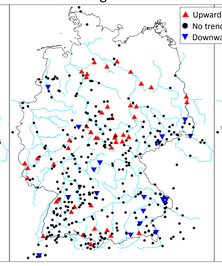
Summer (April - September) — Maximum drought intensity



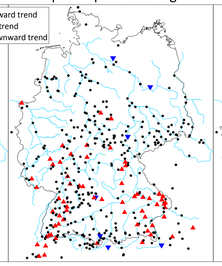
Winter (October - March) — Total duration of high flow



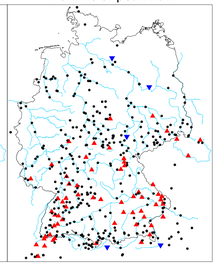
Summer (April - September) — Total drought duration



Annual (October - September) — Specific peak discharge



Annual (October - September) — Volume of peak flow



7. Conclusions and outlook

- An upward trend in the high flow characteristics was found in the southern part of Germany during winter. In contrast, during summer, either downward or no trends in the high flow characteristics was observed.
- Most of the stations showed a downward trend in the low flow characteristics in winter. During summer, some stations in the northern and southern parts of Germany showed a upward trend in the low flow characteristics during the analyzed time period.
- The trend analysis test carried out in the present analysis was based on the assumption of no serial and spatial correlations in an analyzed time series. The validity of this assumption is currently under investigation.

References

[1] M. G. Kendall, "Rank Correlation Methods," *Griffin, London*, 1975.

[2] R. Kumar, L. Samaniego, and S. Attinger, "The effects of spatial discretization and model parameterization on the prediction of extreme runoff characteristics ," *J. Hydrol.*, vol. 392, pp. 54–69, 2010.

[3] H. B. Mann, "Nonparametric tests against trend," *Econometrica*, vol. 13, pp. 245–259, 1945.

HELMHOLTZ CENTRE FOR ENVIRONMENTAL RESEARCH – UFZ