Hydrol. Earth Syst. Sci. Discuss., 2, S1399–S1405, 2005
www.copernicus.org/EGU/hess/hessd/2/S1399/
European Geosciences Union

Hydrology and Earth System Sciences Discussions

Interactive comment on "A global evaluation of streamflow drought characteristics" *by* A. K. Fleig et al.

A. K. Fleig et al.

Received and published: 13 February 2006

Author Comment

We want to thank the anonymous referee very much for his positive response to our article and his valuable comments. Please find below our response to the comments regarding the content of the article. Technical comments will be accounted for in the revised text and are only mentioned here in case we do not agree completely.

Referee #1: "The paper is interesting and the scientific content is generally good, whereas the presentation could be improved. It is not always easy to distinguish between reviewed methods and the methodology of this study. In particular chapter 3 could be structured more clearly in this sense. The title "A global evaluation of streamflow drought characteristics" reflects the content of the paper well. However, the criteria for this evaluation should be presented more explicitly (e.g. in abstract and at the end

of the introduction)."

- The paper will be revised presenting more clearly what is a review of methods and what is the methodology of this study.

- The evaluation criteria will be stated more explicitly. They were:

1. objectivity: what kind of decisions have to be made by the user of the method;

2. data requirements: can the method deal with missing data; have any other data considerations to be made;

3. reasonableness: can the selected drought events be considered 'true' drought events for all series, e.g. are all major historical events represented, and do the selected events all represent droughts;

4. robustness with respect to different streamflow regimes: are the results comparable for different kinds of streams;

5. suitability for a frequency analysis: is the obtained drought series independent and identically distributed.

Aspects 1 and 2 were evaluated based on theoretical considerations. Aspect 3 was studied based on a visual inspection of the drought time series with respect to the discharge series. Aspect 4 is the evaluation of aspect 3 for different streamflow regimes. Aspect 5 was evaluated based on statistical tests and exploratory data analysis.

Referee #1: "It is argued that a kind of pooling is necessary when deriving drought characteristics from daily discharge series, and the pooling parameters are optimal when the average DC are not sensitive to a change of the pooling parameters. I guess that a discussion of the reasons of minor droughts is necessary to underlay this thesis. Pooling generally adulterates the statistical distribution of DCs, and this adulteration is different for different hydrological settings, as it can be seen from Figure 6 and Figure 7 of this paper. The influence is again much larger on alternative characteristics such

HESSD

2, S1399–S1405, 2005

as variance, maximum or minimum of drought duration, which are not subject to this paper. In this light, the justification of pooling might be to filter out artificial influences on the low flow regime. Then pooling parameters could be chosen depending on the time scale of the perturbations at a specific river. E.g. the interevent time criterion tc could be set to 2 days for measurement errors of daily discharges, and 7 days for perturbations from weekly storage schemes. The value/necessity of pooling should not be mixed up with the exclusion of minor droughts within the Frequency Analysis since both analyses are independent and different criteria for removing minor droughts are used for the frequency analysis."

- We agree that pooling and the exclusion of minor droughts should not be mixed up, and we believe that we have dealt with and presented these two aspects separately in the paper. Pooling is necessary due to short excess periods and mutually dependent droughts as stated in the 1st paragraph on page 2435. In this paragraph it will be added that independence of subsequent drought events is required for example for a frequency analysis of extreme events. Pooling is not a tool to remove minor droughts. The only pooling procedure presented in this study that also removes minor droughts (as an unintended but positive byproduct) is the moving average procedure. Short excess periods can be caused by short rainfall. However, such short excess periods can often not be considered to end a severe drought. As mentioned by the referee, they could also be due to artificial influences. However, this is likely not the case for the series used in this study as they were selected to represent natural conditions. Pooling is further necessary in order to cope with the different responses of catchments to climatic conditions in a regional study. For example in a slowly responding groundwater-fed catchment a short rainfall event during a prolonged dry period will lead to a much smaller rise in streamflow as compared to a fast responding catchment. In a fast responding catchment streamflow is much more probable to exceed the threshold level during or after a short wet period.

- We agree that pooling affects drought characteristics. However, we see pooling as

HESSD

2, S1399–S1405, 2005

a necessary element in the definition of drought from a daily time series. In case of defining drought based on the threshold level method the definition of drought consists of the chosen threshold level, the used pooling procedure, the parameter values of the pooling criteria, the criteria to exclude minor droughts and the parameter values for the criteria to exclude minor droughts. This point of view will be stated in the revised text along with the discussion of the subjectivity of defining drought (see also: response to first comment by Dr. Cancelliere).

Referee #1: “Page 2428, line 5: Abstract "...streamflow drought characteristics are evaluated based on their application to daily streamflow series from a wide range of hydrological regimes." Add evaluation criteria.”

- See above (reply to the first comment by referee #1).

Referee #1: “Page 2429, Chapter 1 Introduction: It is not clear from the presentation (1) what is the scientific basis of the study (precedent studies of Tallaksen et al.), (2) which questions have not been addressed by precedent studies, and (3) which of these questions are addressed in the study at hand. I suggest modifying the introduction in this sense.”

- The introduction will be revised to better present the state of the art and the new topics addressed in this study.

Referee #1: “Page 2429, line 28: "Thus some standardisation of drought characteristics is preferable,..." Could be more explicit, why and which standardisation?”

- We agree that this use of the term “standardization” can cause some confusion. It is rather meant that some harmonization in the use of drought characteristics would be preferable. Due to the lack of an unique standard definition, the definition of drought is still subjective and a large number of different characteristics are used to describe and quantify droughts. However, in order to study the spatial aspects of drought the definition and identification of drought events have to be consistent throughout large re-

HESSD

2, S1399–S1405, 2005

gions. Thus, a standard procedure has to be identified, which is capable to characterize droughts under different hydroclimatological conditions. The text will be rephrased to state this objective more clearly.

Referee #1: “Page 2430, line19: "A more detailed discussion of 20 low flow characteristics is given by Fleig (2004)." Give more details or skip.”

- This sentence will be skipped.

Referee #1: “Page 2431, line 10: "In order to allow some standardisation of streamflow drought characteristics the applicability of three pooling procedures..." The meaning of this sentence is not clear for me. Same paragraph: Make clear that the aim of the paper is not to present novel methods, but to evaluate existing methods. Present the evaluation criteria.

- The paragraph will be rephrased and the term “standardization” will be avoided (see above: comment to page 2429, line 28).

- The objective of the paper to evaluate existing methods will be presented more clearly and the evaluation criteria will be listed (see above: first comment by referee #1).

Referee #1: “Page 2434: Chapter 3 - Threshold level method: Please say explicitly what the aim of this section is, a review of methods, or a presentation of the methods used in this study. The limits between literature and the methodology of this study should be crystal clear.”

- We agree and will revise these sections accordingly.

Referee #1: “Page 2424, lines 13-22: Are there objective reasons for the proposed thresholds?”

- Yes, a percentile of the flow duration curve is chosen as threshold level as it results in the same percentage of days with discharge below the threshold level for all streams. With the threshold level method it can be studied how these days are distributed in time.

HESSD

2, S1399–S1405, 2005

The specific percentiles, Q90 and Q70, are chosen for two reasons. 1) They are chosen to represent the range of commonly used threshold levels for perennial streams. In general, threshold levels are chosen either to represent a certain water demand or to represent the boundary between normal streamflow conditions and unusually low streamflow. Thus, a range of different thresholds corresponding to low streamflows are applied in practice. 2) The choice of threshold level influences both the number of events and the presence of multi-year droughts in the obtained drought series. When focus is on within-year droughts neither a large amount of multi-year droughts nor a large number of years without any droughts should be included in the series (Tallaksen et al., 1997). The threshold level has to be chosen as a compromise between these two features. Based on the experience from previous studies (Tallaksen et al., 1997; Hisdal et al., 2002; Engeland et al., 2004) a value in the range Q90 to Q70 is considered reasonable as threshold levels for most perennial streams. For intermittent streams the threshold levels have to be higher as the percentiles Q90 and Q70 often equal zero. The threshold levels for intermittent streams were chosen to represent various threshold levels which have been applied earlier for intermittent streams (e.g. Woo and Tarhule, 1994; Tate and Freeman, 2000). These reasons for the choice of threshold level will be included in the revised text.

Referee #1: "Page 2438, line 9: How are fixed seasons defined?"

- See page 2438 lines 9-13: "For frost influenced catchments Hisdal et al. (2001) specified fixed seasons and defined the summer as the period with mean monthly temperature above the freezing point. In case of an annual snow-melt flood, the start of the summer season was defined to be at the end of the flood period to avoid that very high flow values influence the seasonal threshold level." In the revised text it will be made clear that this is the definition applied also in this study.

Referee #1: "Page 2444, line 5-16: I guess it should be added that pooling always adulterates drought characteristics, and this adulteration is different for different hydrological settings / regimes (see Figure 6). But if daily discharge time series suffer

HESSD

2, S1399–S1405, 2005

from artificial influences, pooling is an appropriate and recommended way to get more realistic drought characteristics."

- As commented on earlier we consider pooling to be a necessary element in a consistent definition of drought applicable at the regional level (see above: second comment by referee #1).

Additionally included references

Hisdal, H., Tallaksen, L.M and Frigessi, A.: Handling non-extreme events in extreme value modelling of streamflow droughts, in: FRIEND 2002 - Regional Hydrology: Bridging the Gap between Research and Practice, IAHS Publ. no. 274, 281–288, 2002.

Interactive comment on Hydrology and Earth System Sciences Discussions, 2, 2427, 2005.