

Responses to Review

General comments

1. This is a revised version of an article appeared in HESSD; it is acknowledged that the authors have put a considerable effort to respond to reviewers' comments and revise their manuscript accordingly; yet, a number of corrections are still required, which are listed in the specific comments section below.

Ans.) We responded all comments in detail and revised as the reviewer had proposed.

2. As for the originality of the paper, in my previous review I was stating: “(1) the severity-duration-frequency (SDF) curve for drought analysis has been proposed by Dalezios et al. (2000); (2) those researchers have used the GEV distribution as the authors of the current paper do; (3) since drought is a slowly developing phenomenon it needs to be analyzed only at coarse time scales (e.g., greater than a month); as a result, daily deficit is of no practical use in drought analysis; (4) a direct consequence of the previous statement is that the use of the proposed MDF curve is not expected to contribute to drought analysis; (5) the approaches used to determine thresholds are known.” The authors responded successfully to all the above. They think that the use of the desired yield threshold is an original element in their work. In my view, this contribution is marginal due to the fact that the use of the desired yield implies some anthropogenic intervention on the natural hydrological system, which, according to Tsakiris et al. (2013), is not related to drought but to another form of water scarcity, namely water shortage; but this leads to invalidating the concept of socioeconomic drought and I will not insist on this. In my view, the main contribution of the paper is the comparative application on the study area of various approaches regarding threshold definition, i.e., its contribution on the knowledge of droughts in the study region through using various threshold methods; of course results on more basins and climatic zones would greatly raise the value of the research presented.

Ans.) We agreed with your point. Therefore, we revised abstracts and conclusions to include the comparative application on the study area regarding four threshold level methods. Also we added the future study (more applications) in the last paragraph of the conclusions.

3. Since the Magnitude-Duration-Frequency Curves have been removed from the manuscript, it is suggested to modify the title to read “Development of Streamflow Drought Severity-Duration-Frequency Curves Using the Threshold Level Method”.

Ans.) We revised the title the reviewer had proposed.

4. English has to be further improved.

Ans.) We used the commercial English editing service as follows:



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Development of Streamflow Drought Severity- and Magnitude-Duration-Frequency Curves Using the Threshold Level Method

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5. The manuscript still has a number of serious weaknesses which are given in the specific comment section below.

Ans.) We revised all weaknesses you had pointed out. You can check all the following questions and responses.

6. In view of the above and the specific comments below, the manuscript cannot be accepted for publication in its present form; after major revision it has the potential to be published as a contribution to knowledge of the hydrology of a specific area with a marginal contribution at the methodological level.

Specific comments

1. L 16: General statements such as “which can significantly affect the streamflow drought severity” should be avoided in the Abstract; if the selected thresholds are effectively tested and found to significantly affect the streamflow drought severity, this should be clearly said.

Ans.) We removed the general statements the reviewer pointed out.

2. L 16 -17: The phrase “The four threshold levels utilized” presupposes that readers know that the threshold levels are four in number; it is suggested to remove “The” to read “Four threshold levels ...”.

Ans.) We removed “the”.

3. L 30: The Abstract is left unfinished; no information on the validation of the proposed approach is provided.

Ans.) We tried to include meaningful information in the abstract. The revised and added sentences are as follow

As a result, the durations and severities from the desired yield threshold level were completely different from those for the fixed, monthly and daily levels. That is, the desired yield threshold can identify streamflow droughts using the total water deficit to the hydrological and socioeconomic targets, while the fixed, monthly, and daily streamflow thresholds derive the deficiencies or anomalies from the average of historical streamflow. Based on individual frequency analyses, SDF curves for four thresholds were developed to quantify the relation among severities, durations, and frequencies. SDF curves from fixed, daily, and monthly thresholds have comparatively short durations because the annual maximum durations vary from 30 to 96 days while those from the desired yield have much longer durations until 270 days. For the additional analysis, the return period-duration curve was also derived to quantify the extent to drought duration. These curves can be an effective tool for identifying streamflow droughts using severities, durations, and frequencies.

4. L 36 -37: The definition “A drought implies a period of time when the supply of water cannot meet its typical demand” is too narrow and suitable only for the socioeconomic drought; it is suggested to remove it so as to avoid confusion.

Ans.) We removed the sentence.

5. L 37: The statement “Rainfall deficiencies of sufficient magnitude over prolonged durations” is incomplete when dealing with drought phenomena; the spatial dimension is critical; please consider saying “Rainfall deficiencies of sufficient magnitude over prolonged durations and extended areas”; then a comment will be necessary to justify the fact that the areal dimension is omitted.

Ans.) We revised the sentence the reviewer had proposed.

6. L 58 -62: The definition of the hydrological drought is copied from the Introduction of the paper by Nalbantis and Tsakiris (2009); this requires putting the text within quotation marks and italicizing it; since the number of such quotations within an article cannot be large, these are used only when necessary; while the authors effectively apply this rule later, in lines 72-73, they avoid doing this here and in other cases.

Ans.) We used quotations at this section because this part is related to the definition of “hydrological drought. We used three quotation marks for the entire manuscript. Three isn’t too large.

7. L 62-66: The same holds for this phrase which is taken from Tsakiris et al. (2013); it is assumed that the editor can electronically locate all these cases; then it is up to the authors to choose those quotations that are absolutely necessary; the remaining text from other papers should be removed or condensed and rephrased so as to avoid using quotations.

Ans.) We didn't use quotations at this time. Instead, we rephrased the sentence.

8. L 83: The term "to the variable method" is meaningless; please consider changing it.

Ans.) We changed the sentence as follows:

Therefore, Kjeldsen et al. (2000) applied three variable threshold level methods employing seasonal, monthly and daily streamflows.

9. L 90: The reader will wonder about the need to plot drought iso-severity curves; a brief comment is necessary or the whole phrase should be removed.

Ans.) We rewrite the paragraph including the reason why SDF curve should be developed as follows:

There has been a growing need for new planning and design of natural resources and environment based on the above mentioned scientific trends. For design purposes, IDF curves have been used for a long time to synthesize the design storm. Therefore, many studies have integrated drought severity and duration based on multivariate theory (Bonaccorso et al., 2003; González and Valdés, 2003; Mishra et al., 2009; Song and Singh, 2010a, b; De Michele et al., 2013). This, however, cannot fully explain droughts without any consideration of frequency, which has resulted in the development of drought iso-severity curves for certain return periods and durations for design purposes.

10. L 140: The expression "will be studied in the future" is incomprehensible in this context.

Ans.) We deleted the sentence to avoid the misunderstanding.

11. L 152: I presume that the authors meant "percentile from the FDC".

Ans.) We rewrite the relevant sentences to clearly explain as follows:

The fixed threshold level in this study is the 70th percentile value (Q_{70}) of the flow duration curve (FDC), which is compiled using all the available daily streamflows, and the monthly threshold level is the monthly-varying Q_{70} s of each month's FDC. The daily variable threshold is the Q_{70} of the FDC obtained from the antecedent 365 daily streamflows.

12. L 155-156: A verb is missing in the phrase “Specifically, 70% is the percentage of time that the streamflow Q70 is exceeded”.

Ans.) We deleted this sentence for clear description.

13. L 159: I presume that by “where to apply” the authors meant “whether to apply”.

Ans.) You are correct. We revised it.

14. L 166-167: The argument “because droughts in the region of interest have never been studied” is unclear in this context; please explain better.

Ans.) The previous sentence isn’t correct. So, we revised as follows:

This study used daily streamflow data, and the various time resolutions (30, 60, 90, 120, 150, 180, 210, 240 and 270 days) were selected to check the temporal characteristics.

15. L 179: The terms “hydrological and socioeconomic demands” induce confusion and need to be defined or removed.

Ans.) We removed the phrase to avoid the confusion.

16. L 197 – 200: Symbols $f(\cdot)$ and $F(\cdot)$ are left undefined.

Ans.) We defined symbols $f(x)$ and $F(x)$.

17. L 213: Modify to read “result from the rainfall frequency analysis”.

18. L 218: The term “return period” is known needs no definition.

Ans.) We removed the definition of “return period”.

19. L 251: Is it forest land already mentioned in line 249? If yes, please make the necessary corrections; otherwise, please explain.

Ans.) The description is repeated. We deleted the description.

20. L 255: It is suggested to remove qualifiers such as “serious” for droughts to avoid confusion with drought class names.

Ans.) We changed with “large”.

21. L 291 – 293: In this phrase two sentences begin with “because” which is generally avoided due to the confusion it creates.

Ans.) We removed the second “because”.

22. L 300 – 301: In the phrase “the correlation coefficients were calculated” the correlated variables are not named.

Ans.) We clarified the phrase as follows:

the correlation coefficients between water deficits from four different threshold levels

23. L 312: The title fails to be fully informative since the probability distribution function is not linked to any variable.

Ans.) We changed with “identification if probability density function”.

24. L 321: The statement “distributions that use more than three parameters are required” creates confusion since distributions appearing later include three parameters; please consider amending this.

Ans.) Three is correct. So we deleted “more than”.

25. L 324-325: What do the authors mean by “This corresponds to Dalezios et al. (2000) for the PDSI and Yoo et al. (2008) for the SPI.”?

Ans.) We deleted this sentence to avoid readers’ confusion.

26. L 339: What is the “difference ratio”?

Ans.) “difference ratio” is wrong. We changed with “severity difference”.

27. L 349-353: This material is unsuitable for a “Results” section and should be found in a “Methodology” section; also, comments on results may be added which are missing now.

Ans.) We moved the section to “introduction” instead of “Methodology” because this material showed the reason why drought durations should be included to this study.

28. L 361-385: The whole conclusion section needs to be rewritten; as is, it corresponds to a summary rather than a conclusion section; it is therefore suggested to rename the section into “Summary and conclusions”; in the summary part of the section methodological details should be avoided, which is not the case with the current form of the section; last, the conclusion part needs to be enhanced.

Ans.) We deleted the first three sentences in the 2nd paragraph describing the methodology. Also, to enhance the conclusions and summarize our findings, we rewrote the section “summary and conclusions” excluding future study as follows:

This study developed a useful concept to describe the characteristics of streamflow droughts using threshold level methods. The SDF curves for streamflow droughts were developed to quantify a specific volume based on a specific duration and frequency. This study compared the SDF curves of four threshold level methods: fixed, monthly, daily, and desired-yield levels for water use. In addition,

the duration-frequency curves for four thresholds were used to derive the relationship between the drought duration and the drought frequency. This study used the severity, which represents the total water deficit for specific durations. From this study, we can make the following conclusions:

1) The daily threshold levels significantly fluctuated because of the natural streamflow variations for the antecedent 365 days and were the largest threshold level because a summer period (June, July, and August) was considered. The desired-yield level was larger than the fixed, monthly, and daily thresholds. This phenomenon occurred during the winter in Korea; thus,, both the water demand and natural runoff during the winter (December, January, and February) were notably small.

2) The durations and severities from the desired-yield threshold level were completely different from those for the fixed, monthly and daily levels. In other words, the desired-yield threshold can identify streamflow droughts using the total water deficit to the hydrological and socioeconomic targets, whereas the fixed, monthly, and daily streamflow thresholds derive the deficiencies or anomalies from the average of historical streamflow.

3) The GEV distribution for a representative probability distribution was selected for the streamflow drought severities because most observations are appropriate for the GEV.

4) The severities increased with increasing duration and frequency. However, these values were notably different because the four threshold level approaches defined the streamflow drought differently. The SDF curves from the fixed, daily, and monthly thresholds were calculated using comparatively short durations because the annual maximum durations vary from 30 to 96 days. However, the SDF curve from the desired-yield levels shows the water deficits for longer durations of 30~270 days. In addition, the water deficits from the desired-yield levels are significantly higher than those from the others even in the same duration.

5) For the SDF curve of the desired-yield threshold, when the duration increases, the severity differences among return periods significantly increase. Therefore, because the streamflow drought severity should be more crucial when the drought continues for a longer period, the frequency of long droughts should be approached with caution.

6) Duration-frequency curves for four threshold levels were also developed to quantify the streamflow drought duration. Similar to the SDF curves, the desired-yield level had much longer durations for the other three thresholds.

7) In the end, the drought identification techniques based on the general threshold levels cannot reflect the socioeconomic drought in terms of water supply and demand. Therefore, the two-way approaches that are categorized by the time periods (fixed, monthly, and daily) for hydrological drought and the desired-yield threshold for socioeconomic drought should be separately included to identify specific drought characteristics.