**--------------------- RESPONSES TO THE COMMENTS ---------------------**

We appreciate the comments and provide our responses below to each comment. You will find your comments in **black** while our responses are given in **blue** and any citation how we suggest to revise the text in the revised manuscript in **red**.

## Reviewer #1:

### General Comments

Drought has been widely evaluated by using different standardized drought indices in the literature. Some studies take the drought indices to develop drought intensity-duration-frequency (IDF) curves as reviewed by the authors in this paper. It is emphasized that the drought indices are dimensionless, and it is therefore difficult to interpret them physically, meaning that precipitation and streamflow deficits cannot be quantified directly from the drought index-based drought IDF curves. This is a true argument. At this point, this paper aims to develop drought IDF curves in terms of precipitation and streamflow deficits to overcome this difficulty. The proposed methodology was applied on two different climatic regions, one from Turkey and another from Germany. The applicability of the IDF curves has been shown by using historical droughts experienced in both regions. Another remarkable result in this study is Table 3 which represents the practical value of IDF curves for various sectors. In my opinion, the deficit-IDF curves developed in this study will be useful tools in establishing proper drought mitigation strategies. Therefore, I recommend publication of the paper after minor revision based on the following specific comments and technical corrections.

**Response:** We are thankful for the clear and constructive comments. We took them all into account in detail and responded each as listed below:

### Specific Comments (in the order they appear in the text)

- Lines 12-13: Revise to clarify the statement "Drought characteristics assigned the same value in index are not necessarily the same in different regions, and in different months of the same region" as it is not clear.

**Response:** We suggest to revise this statement as follows:

**In the text:** Drought severity calculated from the drought index does not necessarily correspond to the same amount of deficit in precipitation or streamflow at different regions and it is different for each month in the same region.

- Line 96: There is no need to emphasize the ratio of the agricultural lands (51%) in Kocher. The paper in not agriculture-oriented and results are not affected by this particular ratio. The previous sentence good enough to state that the catchment has importance for agriculture as it was stated for Seyhan previously in this paragraph.

**Response:** We suggest to remove this sentence from the text in our revised document.

- Lines 135-137: It is known that Gamma distribution is used for SPI but it is advised to make a clear reference to McKee et al. (1993). How did you find that the General Extreme Value (GEV) is the best-fit probability distribution function for the standardized streamflow index (SSI)? Among which distributions?

**Response:** We revised the statement on the Gamma distribution in the text by referencing to McKee et al. (1993). Regarding calculation of SSI, we used the SCI package in R which uses several probability distributions such as Gamma, Generalized Logistic, GEV, Gumbel, Logistic, Lognormal, Normal, Pearson Type 3, and Weibull. We tested all of these distributions on the streamflow data and found the GEV the best-fit probability distribution function after the Anderson-Darling statistical test.

**Suggested revision in the text:** The Gamma probability distribution function is fitted to the precipitation data and transformed to the standard normal distribution with zero mean and unit standard deviation (McKee et al., 1993). Based on the Anderson-Darling statistical test, we found the Generalized Extreme Value (GEV) as the best-fit probability distribution function of the streamflow volume accumulated over a month for the two catchments among several probability distribution functions including Gamma, Generalized Logistic, GEV, Gumbel, Logistic, Lognormal, Normal, Pearson Type 3, and Weibull.

- Line 170: Can you give the name of any other curve tested for establishing functional relationship between the drought indicators and indices?

**Response:** We tested a set of functions among which we choose the logistic curve because it fitted better than others and it was capable to deal with zero precipitation. We revised the text accordingly as follows.

**Suggested revision in the text:**
To establish a functional relationship between the drought indicators and the drought indices, we tested several curves including the second and third order polynomials, exponential, Gompertz and logistic curve. The polynomials, exponential and Gompertz curves were discarded as they produced negative values of precipitation or streamflow, and they could not fit properly to SPI or SSI time series. The logistic curve was selected as the best-fit curve because it provided the highest correlation without producing negative precipitation and streamflow values (Sit and Poulin-Costello, 1994). The logistic function is given by

- Line 183: It is not clear what DId in Eq. 2 is. Please make the statement clear.

**Response:** $DI_d$ represents deficit in the drought indicator. We revised the text by also adding "$DI_d$" in parenthesis to clarify.

**Suggested revision in the text:** The difference between the threshold drought indicator and the critical drought severity is deficit in the drought indicator ($DI_d$), which is either precipitation deficit or streamflow deficit. For each duration and return period, it is calculated by

- Figure 6: The 12-month threshold, which is a constant value over the year is not given in Figure 6. It can be added to Figure 6 as a line or be indicated in the figure caption.

**Response:** We prefer to revise the figure caption as suggested in order not to lose details about the seasonality because of higher values of thresholds at the 12-month timescale.

**In the text:** Figure 6: Precipitation threshold (PTH) and streamflow threshold (STH) corresponding to $SPI_k = 0$ and $SSI_k = 0$ (k = 1, 3, 6 months). Solid lines are for Seyhan and dashed lines for Kocher. The 12-month thresholds are constant values over the year; PTH = 643.88 mm, STH = 333.39 mm for Seyhan; and PTH = 975.57 mm, STH = 356.18 mm for Kocher.

- Lines 243-266: Precipitation threshold and streamflow threshold (in Figure 6) are used in the development of IDF curves (in Figure 5). Thus, I suggest that Figure 6 comes before Figure 5. The text about Figures 5 and 6 needs a thorough check. Please revise your text by considering that Figure 6 tells the story about the within year variability of precipitation and streamflow thresholds and Figure 5 is a tool based on this story. Also, probably because of the disorganization of Figures 5 and 6, I found some statements unclear or redundant: (a) Omit statement 'Comparisons between the …' starting in Line 253. It is a sentence hard to understand and to me again the statement about the drought duration is not true. The second part coming after 'although' is confusing. (b) Revise statement 'Short and more …' starting in Line 257. While revising pay attention to replace 'drought in precipitation deficit' with 'drought in precipitation'. (c) Delete statement 'With the deficit …' starting in Line 262. It reflects an opinion about the IDF curves rather than being result. This is well fit to the Discussion Section (subsection 5.1) where this fact has already been emphasized in Lines 312-314. There is no need to have it here.

**Response:** We agree that we should reorganize this part of the paper by removing redundant sentences.

**Suggested revision:**
4.3 Deficit IDF curves
Precipitation and streamflow thresholds are needed to calculate deficits in precipitation and streamflow, the key elements of the deficit-IDF curves. The thresholds are not constant over the year at 1-, 3- and 6-month timescales (Figure 5).  They change from one month to another and also the value of the thresholds changes notably from precipitation to streamflow. The annual thresholds are constant values as they accumulate the within-year seasonality. The clear seasonal variability of precipitation threshold in Seyhan is not evident in Kocher while the streamflow threshold has a notable seasonality in both catchments. These temporal and spatial variabilities in the thresholds prevent the drought IDF curves from being comparable in time and space. For the sake of comparability of the IDF curves of various timescales at two different catchments, precipitation deficit and streamflow deficit were divided by the respective precipitation threshold (PTH) and streamflow threshold (STH), respectively.

Drought IDF curves of precipitation and streamflow deficits are presented for each month separately at 1-, 3-, and 6-month timescales (Figure 6, Figures A1-A2) while the annual deficits are presented in one single set of IDF curves (Figures A3). Drought IDF curves of precipitation and streamflow deficits show general similarities in the two different climatic regions. In all IDF curves, the precipitation and streamflow deficits decrease linearly as the drought duration increases. The IDF curves are almost parallel to each other for return periods of 5 years and higher. Deficits at the 2-year return period decrease faster, they are therefore separated from other return periods. However, the 2-year return period shows a steeper decrease rate of streamflow deficit in Kocher than in Seyhan and a relatively steeper decrease than the curves for higher return periods. Compared to the precipitation and streamflow thresholds, droughts in precipitation are more intense than in streamflow. In addition, precipitation deficits in summer are less in absolute values than in winter considering the seasonality in the precipitation threshold with higher values in winter than summer. Precipitation deficits are particularly lower during the summer months than the winter months in Seyhan because of the dominant seasonality in the Mediterranean climate while no notable difference was observed between precipitation deficits in summer and winter in Kocher because of the negligible seasonality in precipitation in the humid climate of this catchment. The linear decrease in deficits with increasing drought duration and the faster decay in the 2-year return period for the 3-, 6- and 12-month timescales (Figures A1-A3) are similar to what we obtained at the 1-month timescale (Figure 6).

**Technical Corrections**

- Lines 80-85: So many “we” in this paragraph.

**Response:** We agree to minimize the use of ‘we’ and to revise the paragraph.

**Suggested revision in the text:** The overarching objective is to develop drought IDF curves based on precipitation and streamflow deficits at different timescales and appraise their usefulness in different climates. For this, drought index-derived characteristics are converted into precipitation and streamflow deficits for different cases. For comparison, two catchments are considered in different climatic regions. Hence, the comparison between the regions and among the variables provides the framework of analysis. Specifically, we aim to assess how the deficits vary in the considered study regions and finally explore how deficit IDF curves might be used for different purposes. The study addresses the following research questions:

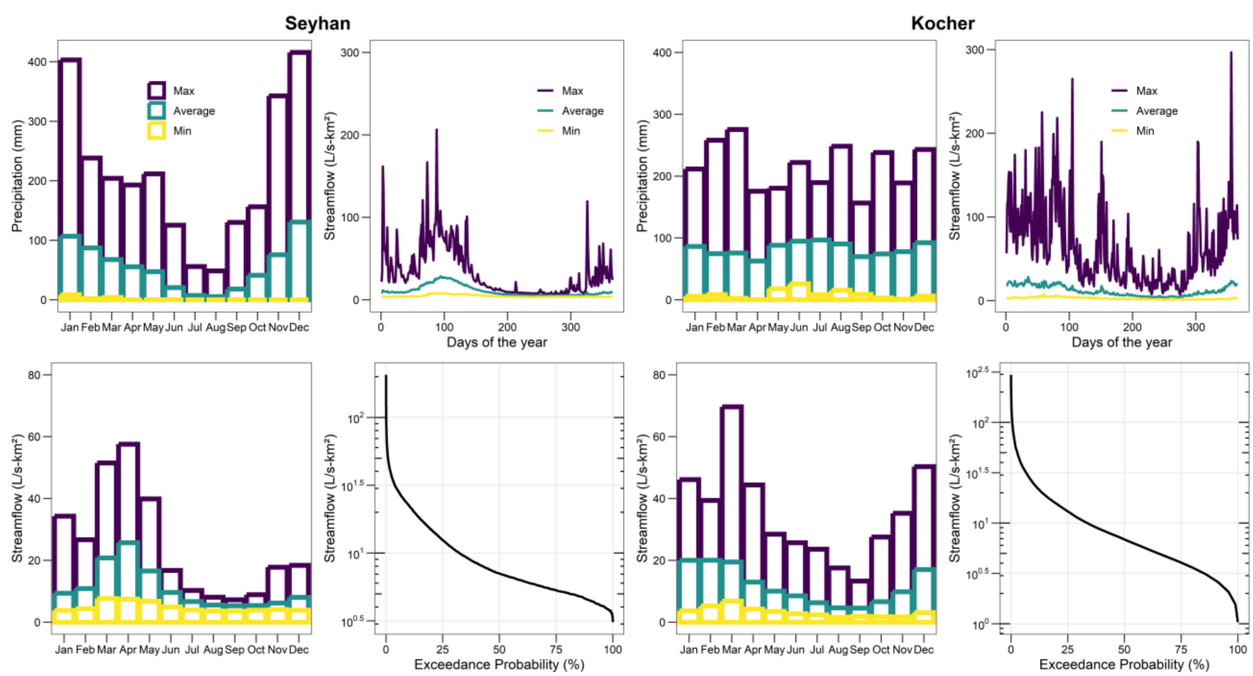
- Line 116 (Caption of Table 1): Put the name of countries in parenthesis as (Turkey) and (Germany) after each catchment to make the table caption self-explanatory.

**Response:** We agree to add the name of countries into the caption of Table 1.

**In the text:** Table 1. Characteristics of selected meteorological and streamflow gauging stations in Seyhan (Turkey) and Kocher (Germany)

- Line 118 (Figure 1): For a better visualization, name of the regions (Seyhan and Kocher) should be centered at the top their group of graphs instead of giving them in the precipitation graph only.

**Response:** We agree to replot Figure 1 by centering name of regions in the graphs.



- Line 177: DIc should be italic.

**Response:** We agree to correct $DI_c$ as Italic. Thank you so much for being so precise.

- Line 225 (Caption of Figure 4): Please add the following sentence to the caption to clarify horizontal axis: 'Horizontal axis indicate SPI and SSI values at the top of each scatter diagram.'

**Response:** We agree to add this sentence to the caption of Figure 4. Thank you for this clarification.

**In the text:** Figure 4. The relation between precipitation as drought indicator and SPI, and streamflow as drought indicator and SSI at 1-, 3-, 6- and 12-month timescales for Seyhan and Kocher. Horizontal axis indicates SPI and SSI values at the top of each scatter diagram.

- Line 257 (end): Make plural as "… intense droughts …"

**Response:** We agree to correct it in the text. Thank you for being so precise.

- Lines 378-380: The footnote is related to Table 3 but there is no "*" in the table. The authors may consider putting it into the Table caption instead of keeping it as a footnote to avoid such confusion.

**Response:** We suggest to move the footnote to the caption of Table 3.

**Revision in the text:** Table 3. Timescale and severity classes of droughts for some specific activities. SM - Short timescale and mild/moderate drought; SS - Short timescale and severe/extreme drought; LM - Long timescale and mild/moderate drought; LS - Long timescale and severe/extreme drought; S: Shorter than 6 months, L: 6 months or longer