---------- 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 #2:

General Comments

The manuscript presents a methodology for development of intensity-duration-frequency (IDF) curves based on the frequency analysis of severity of the critical (the most severe) droughts of different fixed durations based on two non-dimensional indices, SPI and SSI, and their consequent transformation into corresponding dimensional quantities, deficits of precipitation and streamflow. In this way, final IDF curves are easier to interpret in various contexts in which drought analysis is needed.

The overall presentation of the methodology in the paper is clear, with a minor shortcoming that I describe as the first specific comment. The motivation for proposing this methodology is laid out well. The part of the discussion related to the potential for the use of the IDF curves provides an excellent overview. In my opinion, the discussion and conclusion sections in the paper lacks two aspects that I describe as the second and the third specific comment.

I find that the proposed approach, which considers different fixed drought durations, provides a more rigorous structural description of droughts than other approaches where duration is treated as an additional variable. I therefore commend the authors on devising this methodology.

Overall, I propose minor revision of the manuscript in accordance with the comments below.

Response: We are thankful for the clear and constructive comments. We took them all into account in detail and respond to each below:

Specific comments

1. Description of Step 4 of the methodology (around L170) lacks specification of data used in developing logistic regression between SPI/SSI and precipitation/streamflow. Is this based only on the critical droughts or on all droughts? What was the time scale of precipitation/streamflow used in the regression analysis (matching the time scale of SPI/SSI or something more general, like annual precipitation)? I suggest that this is precisely described so that the methodology can be fully comprehended and potentially replicated for other sites by other authors.

Response: We agree to revise this sentence to make it clear. Each month in the time series has a drought indicator (precipitation or streamflow) accumulated at 1-, 3-, 6-, and 12-month timescales and the corresponding drought index (SPI or SSI) at the same timescales. Regression equations were developed between the drought indicators and the indices for each timescale separately by using all indicators and indices. Due to the periodicity, the regression equations were fitted separately for each month of the year; 12 regression equations were obtained for 1-, 3-, 6-month timescales, and one regression equation for 12-month timescale. We suggest to insert this information as in the statement below to come after Equation (1) at the end of paragraph explaining Step 4 of the methodology (around Line 170).

Suggested revision in the text:

$$f(x) = \frac{\alpha}{1+be^{-cx}} \quad (1)$$

in which x is the drought index, and a, b and c are parameters. Each month in the time series has a drought indicator (precipitation or streamflow) accumulated at 1-, 3-, 6-, and 12-month timescales and the corresponding drought index (SPI or SSI) at the same timescales. Regression equations were developed between the drought indicators and indices by using their all values. Owing to periodicity (seasonality), the relation changes from month to month for timescales shorter than a year; 12 regression equations were obtained for 1-, 3-, 6-month timescales, and one regression equation was obtained for the 12-month timescale.

2. The methodology builds on droughts defined using the thresholds SPI = 0 and SSI = 0. However, specific areas for which the droughts need to be analysed may require different types of thresholds. For example, in agriculture, different crops have different water requirements in terms of precipitation. How would your methodology fit to that type of thresholds? Furthermore, can the proposed methodology be easily adapted to other indices than SPI and SSI?

Response: The methodology is flexible to use with different threshold and it can be adopted to other indices**.** We suggest to add following statement to discuss the threshold issue and the extension of the methodology to other drought indices as commented.

Suggested revision in the text: Deficit IDF curves can be applied to quantify the frequency of drought events and characterize the droughts by their intensity and duration at different timescales. The threshold level is also important to consider in the IDF curves which is taken as the level corresponding to SPI = 0 and SSI = 0 in this study. By doing so, we considered to take all drought classes (extreme, severe, moderate, and mild drought) of McKee et al. (1993) in the methodology which is flexible to use with any other threshold. The methodology can also be adapted to other drought indices than SPI and SSI. It is possible to choose a lower threshold level to exclude mild droughts for which a new set of IDF curves will be obtained as the IDF curves are threshold-dependent.

3. In my opinion, the conclusions lack a brief overview of open questions and potential for further research. These open questions could be regional IDF curves, estimation at ungauged sites etc.

Response: We agree to extend final sentences in the conclusion section by adding open questions and potential future research.

Suggested replacement/addition of the last two sentences in the Conclusion: Deficit IDF curves can be applied to quantify the frequency of drought events and characterize droughts by their intensity and duration at different timescales. The application here was limited to a few examples regarding indices, timescales, and thresholds for station-based precipitation and streamflow deficits of droughts. The deficit IDF curve approach of this study can also be adapted to drought indices other than SPI or SSI, and to threshold levels corresponding to different situations in terms of severity or even to impact-specific thresholds. How transferable the approach is to other indices and thresholds and also to other climates and hydrological regimes than the examples used here remains to be tested in order to assess the range of applicability.

Further work might also explore the extension of station-based drought IDF curves to develop regional curves for a possible use at ungauged basins.

Minor comments and technical corrections

L72-74: Sentence starting with “Because…” is unclear or unfinished. Please revise.

Response: We found that this sentence interrupted smooth reading of the paragraph. We suggest to move this sentence to the beginning of its paragraph in Line 67 (after omitting the word ‘Because’) to read as follows:

Suggested revision in the text: Meteorological and hydrological droughts correspond to temporal anomalies changing also spatially from one catchment to another and they are characterized based on long-term conditions, which are related to climatic and environmental factors (Vicente-Serrano et al., 2013; van Loon, 2015). Therefore, the same value of a drought index corresponds to different deficits in different regions. The non-dimensionality of drought indices comes at the expense of physical non-interpretability, i.e. most drought indices cannot be read quantitatively as actual precipitation and streamflow deficits. In climates with high seasonal variation (i.e., Mediterranean climate), the difference between deficits varies greatly in each month while this difference may be lower in regions with low seasonality (i.e., humid climate). Determination of precipitation and streamflow deficits is a challenge when the common drought indices are used. Thus, any non-dimensional drought severity or intensity derived from index series might insufficiently represent the actual water availability for water management under drought conditions.

L113: Replace “likely to observe” with “likely to be observed”.

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

L153: Remove “for each year” from this sentence. Frequency analysis is done for the series of annual maximum severities, but not for each year.

Response: We agree to remove it in the text. Thank you for this correction.

L175: Please check this part: “drought INDICATORS were converted to precipitation and streamflow deficits using the relation between the drought indicators and indices”. Looks like the first “indicators” should be replaced by “indices”.

Response: Yes, it is a mistyped word. We will change ‘indicators’ with ‘indices’ in the text. Thank you so much for the careful correction.

L319: Section 5.2 heading is incomplete: “… in different climatic” what? (maybe conditions?)

Response: We agree to complete the heading as ‘different climatic conditions’ in the text.

L393: I suggest replacing “variability” with “temporal variability” (since one could also possibly discuss spatial variability of droughts).

Response: We agree to specify the variability by adding ‘temporal’. Thank you for being so precise.