Response to Referee #1:

The authors would like to thank you for the constructive and thoughtful comments. We have addressed all your suggestions, leading to a much improved and complete manuscript. The following comments are addressed in the sequence as they were asked. We also respond to each point and clarify the corresponding changes adopted in the revised manuscript. The original comments are copied from the report with a **bolded font in black**, and our answers are in blue. Manuscript changes are in ***bold italic***.

Thank you again for your time and effort in reviewing our manuscript.

Yours sincerely

Baoqing Zhang (on behalf of all co-authors)

Reviewer #1

This manuscript introduces a drought product with a multitype and multiscalar drought index, SZI_{snow}. The SZI_{snow} dataset considers a relatively comprehensive extent of the hydrometeorological variables associated with drought development. It uniquely incorporates snow processes in the derivation of a drought index. This consideration is important as global warming has been affecting hydrological processes over the snow-covered regions. The dataset was evaluated across different spatial scales. The result shows the SZI_{snow} has good performance over the snow-covered regions. The dataset was also used to survey the evolution of large drought events with the severity-area-duration method.

The topic of the study is interesting and well fits the scope of the journal, especially for this special issue. The manuscript is well written, logically organized, and the details of the derivation of the SZI_{snow} are easy to follow. The data processing is careful and well documented, and the dataset was friendly to access. However, there are still some concerns that need to be addressed. Thus, I am supportive of the publication after a minor revision to further improve the quality or make it more clear for the readers to understand the results. Below are my suggestions:

Reply: We appreciate the reviewer's positive comments and interest in our work.

General comments

#1 The main improvement in the SZI_{snow} is the consideration of snow related processes, thus it is reasonable that the SZI_{snow} in the snow-covered basins have a better performance than that of SZI as shown in Figure 3. However, I found that both the SZI_{snow} and SZI have a similar performance over the snow-free basins. Please clarify this similar performance.

Reply: We agree with this comment that the SZI_{snow} has a similar performance with the SZI over the snow-free basins. Such similar performance is mainly attributed to the fact

that Psnow, PSM, and PSA values are close to zero over basins at low-latitude and low-altitude snow-free areas, and thus the calculation of SZI_{snow} converges to the snow-free basins. Therefore, the performance of SZI_{snow} and SZI are consistent with each other over snow-free areas.

For the SZI_{snow}:

$$\begin{cases} P = P_{rainfall} + P_{snowfall} \\ Z_{snow} = P - \hat{P}_{snow} \\ \hat{P}_{snow} = \alpha_j PET + \beta_j PR + \gamma_j PRO + \delta_j PSA - \varepsilon_j PL - \varphi_j PSM \end{cases}$$

For the SZI:

$$\begin{cases} Z = P_{rainfall} - \hat{P} \\ \hat{P} = \alpha_j PET + \beta_j PR + \gamma_j PRO - \delta_j PL \end{cases}$$

Following the comments, we will add some information into the discussion section of the revised manuscript to explain why the performance of the SZI_{snow} is similar to that of the SZI in snow-free areas as follows:

Besides the overperformance of the SZI_{snow}, it should be noted that the SZI_{snow} has a similar performance with SZI over the snow-free basins. Such similar performance is mainly owing to the fact that the values of P_{snow}, PSM, and PSA are close to zero over basins at low-latitude and low-altitude (snow-free) areas, leading to the calculation of SZI_{snow} converges to the snow-free basins. Therefore, the performance of SZI_{snow} and SZI are consistent with each other over snow-free areas.

#2 The evaluation of the SZI_{snow} is important compared to current drought indices (for example the scPDSI). Besides the SPI, I think the scPDSI is also a good index to assess the meteorological drought. Thus, it is necessary to evaluate the performance of SZI_{snow} to capture meteorological drought compared with other indices instead of only with SPI. This can help to confirm the robustness of your conclusion.

Reply: Following the comments, in addition to the SPI, we adopted two other mainstream drought indices (SPEI and scPDSI) to compare their performance in monitoring meteorological drought. Figure R1 shows the responses of multiple drought

indices to meteorological drought. As we can see, the performance of SZI_{snow} is prominent and superior to SZI, SPEI, and scPDSI in identifying meteorological drought at multiple temporal scales. This further confirms our prior conclusion.

Following the comments, we will add the following information into section 4.1.1 of the revised manuscript, and Figure R1 will be added as Figure S1 into the supplementary material:

In addition to the SPI, we adopted two other mainstream drought indices (SPEI and scPDSI) to compare their performance in monitoring meteorological drought. As shown in Figure S1, the performance of SZI_{snow} is prominent and superior to SZI, SPEI, and scPDSI in identifying meteorological drought at multiple temporal scales. The selection of reference drought indices did not influence the reliability of our conclusion.

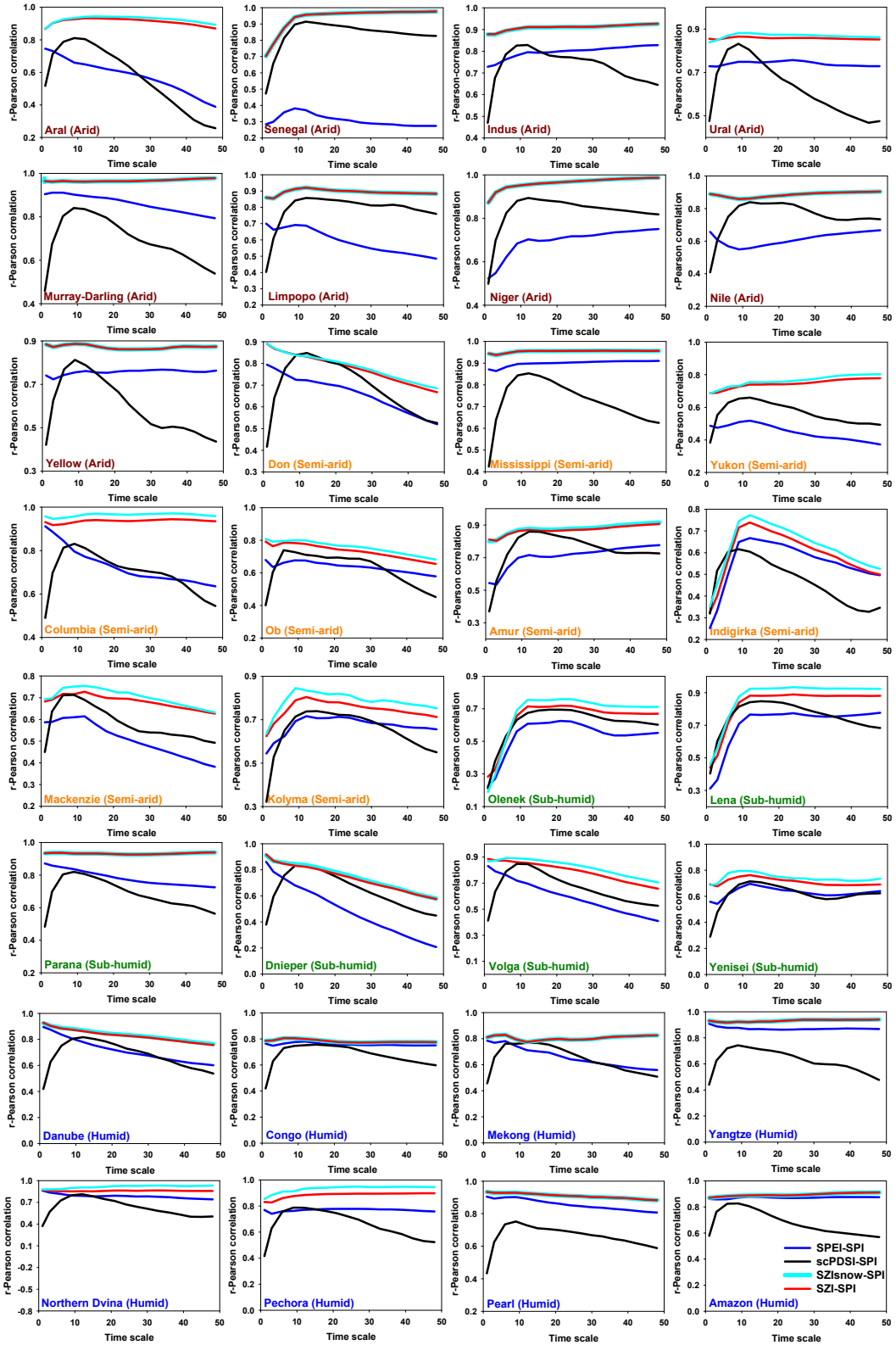

Figure R1. The Pearson correlation coefficients between SPEI and SPI (i.e., SPEI-SPI), scPDSI-SPI, SZI-SPI, and SZI_{snow}-SPI at 1- to 48-month time scales in the selected 32 large basins during 1948–2010. The dominant climate regime of each basin is shown in the parentheses.

Specific comments

#1 Is it possible to include the acronym of your new drought index in the title? Such inclusion can enhance the recognizability of your dataset and facilitate others to cite and employ your dataset.

Reply: The title will be changed to "***A global dataset of standardized moisture anomaly index incorporating snow dynamics (SZI_{snow}) from 1948 to 2010***" in the revised manuscript.

#2 I suggest adding the spatial resolution of your dataset in the Abstract section.

Reply: The spatial resolution of a dataset is essential for the Earth System Science Data journal. The spatial resolution of our proposed dataset is 0.25 degrees. This content will be added in the revised manuscript as follows:

Here, we present a global monthly drought dataset with a spatial resolution of 0.25 ° from 1948 to 2010 based on a multitype and multiscalar drought index, the standardized moisture anomaly index incorporating snow dynamics (SZI_{snow}), driven by systematic fields from an advanced data assimilation system.

#3 The author listed various current drought indices in Figure 1. Please make sure the corresponding references of these indices are supplied in the manuscript.

Reply: Some drought indices in the first row of Figure 1 do not have corresponding references because those indices (e.g., SAI and PHDI) are not mentioned in the main text of the manuscript. Thus, we will add references of these non-mentioned indices in the supplementary material.

#4 Line 38: Correct the "focus" to "focuses".

Reply: This grammar problem will be corrected in the revised manuscript. Such problems have been fixed throughout the revised manuscript.

#5 Line 288: Did the two subplots in Figure S3 have identical contour levels and color bar? If did, please remove one color bar.

Reply: Yes, they did. We have removed one color bar of Figure S3, and the new Figure S3 will be added in the revised supplementary material as follows:

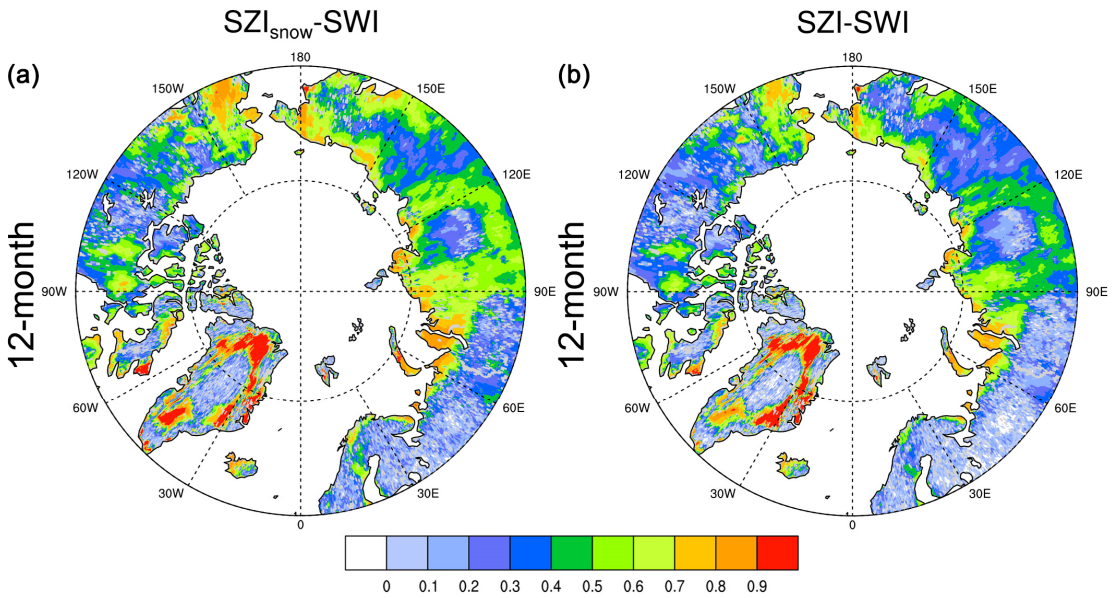

Figure S3. Comparison between the SZI and SZI$_{snow}$ in the context of their performance over the Arctic region. (a) Spatial distribution of the correlation coefficients of the SZI$_{snow}$–SWI over a 12-month timescale. (b) Spatial distribution of the correlation coefficients of the SZI–SWI over a 12-month timescale.

#6 Line 144: Consider adding a comma after the introductory phrase "meanwhile".

Reply: This grammar problem will be corrected in the revised manuscript.

#7 Line 300: What does the shading in the Figure 4d panel mean? It should be clarified in the Figure caption. The inset of the Figure 4d panel seems not clear to me, you can increase the resolution of your figure.

Reply: The shading in Figure 4d denotes the range of correlation coefficients of the SZI$_{snow}$–SWI and SZI–SWI. The upper (lower) boundary is the maximum (minimum)

value. In addition, the original resolution of Figure 4 is 300 dpi, and the new Figure 4 has a resolution of 600 dpi, which makes it clearer. An explanation of the shading will be added into the caption of Figure 4 in the manuscript as follows:

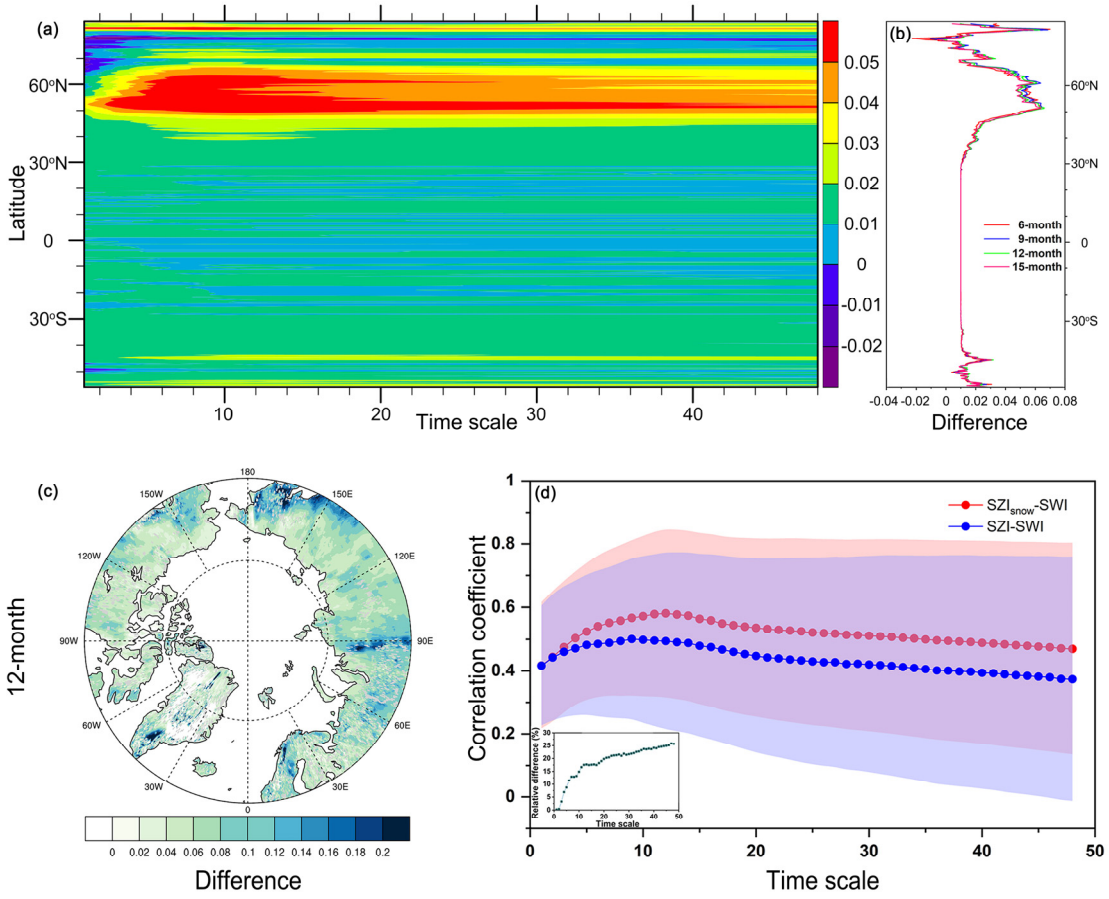

Figure 4: Performance of the SZIsnow over different latitudes (a and b) and specifically over the Arctic region (c and d). Here the differences between the correlation coefficients of the SZIsnow–SWI and those of the SZI–SWI for different timescales were used to 300 compare their performance. (a) The Hovmöller diagram (timescale 60° latitude) shows the differences averaged by latitude from 55°S to 85°N for timescales ranging from 1 to 48 months. (b) Distribution of the difference for specific timescales (6, 9, 12, and 15 months) with changing latitude. (c) Spatial distribution of the differences between the correlation coefficients of the SZIsnow–SWI and those of the SZI–SWI over a 12-month timescale in the Arctic region. (d) Variations of correlation coefficients averaged over the Arctic region for various

temporal scales. The shading denotes the range of correlation coefficients. The upper (lower) boundary is the maximum (minimum) value. The inset shows the change of relative difference (%) for these temporal scales.

#8 Line 315: Did the subplots in the left and middle columns of Figure S3 have identical contour levels and color bar? If did, please remove one color bar.

Reply: Same as comment #5, this comment suggests that we need to remove the identical units in a figure to make it more concise; thus we examined similar problems across all the figures and found Figure 5 has such a problem. We corrected this problem of Figure 5 in the revised manuscript as follows:

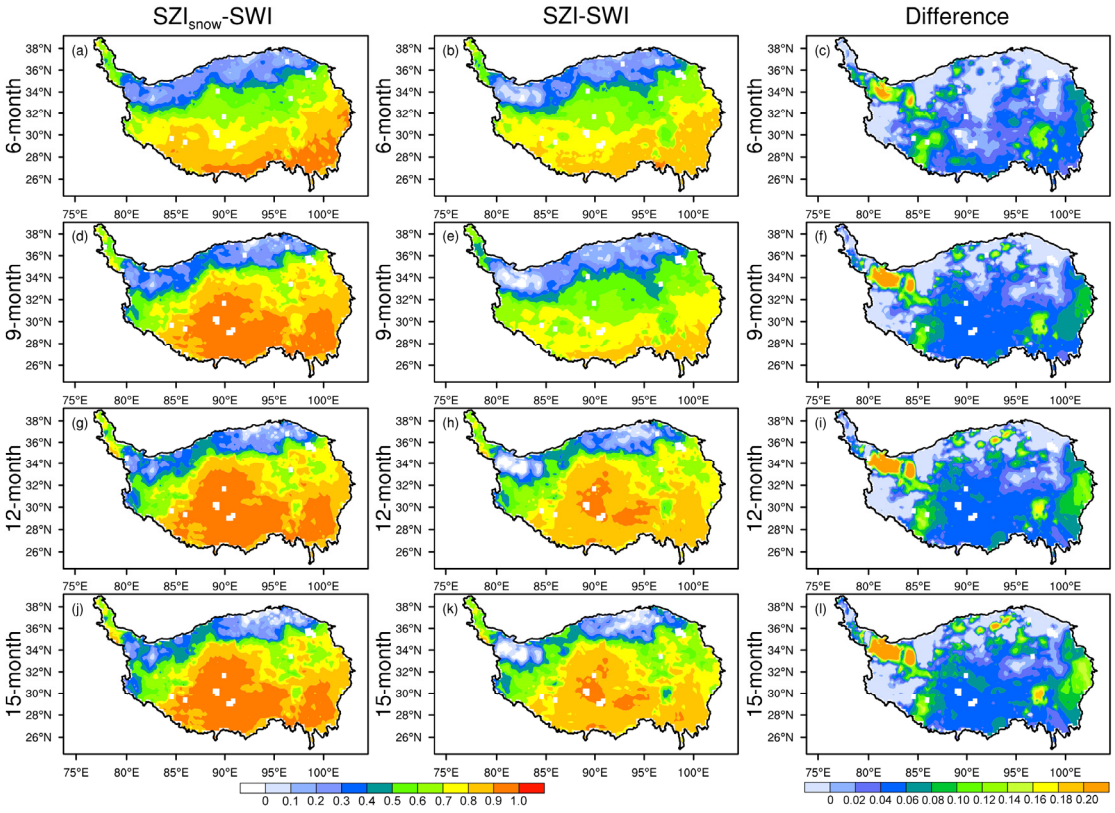

Figure 5: Spatial distribution of correlation coefficients of the SZI$_{snow}$–SWI (left column) and those of the SZI–SWI (middle column), and the differences between the two (right column = left column minus middle column) over the Tibetan Plateau at different timescales (6, 9, 12, and 15 months).

#9 Line 330: Some corner strings (e.g. "a", "b" in panels) are bolded, but some aren't. Please keep the format of these strings consistent across the manuscript.

Reply: We checked and modified the appearance of corner strings throughout the manuscript. As a result, the format of these strings is now consistent across the revised manuscript.

#10 I recommend adding the values of trends in Figure 7 so that the reader can know more information from the figure.

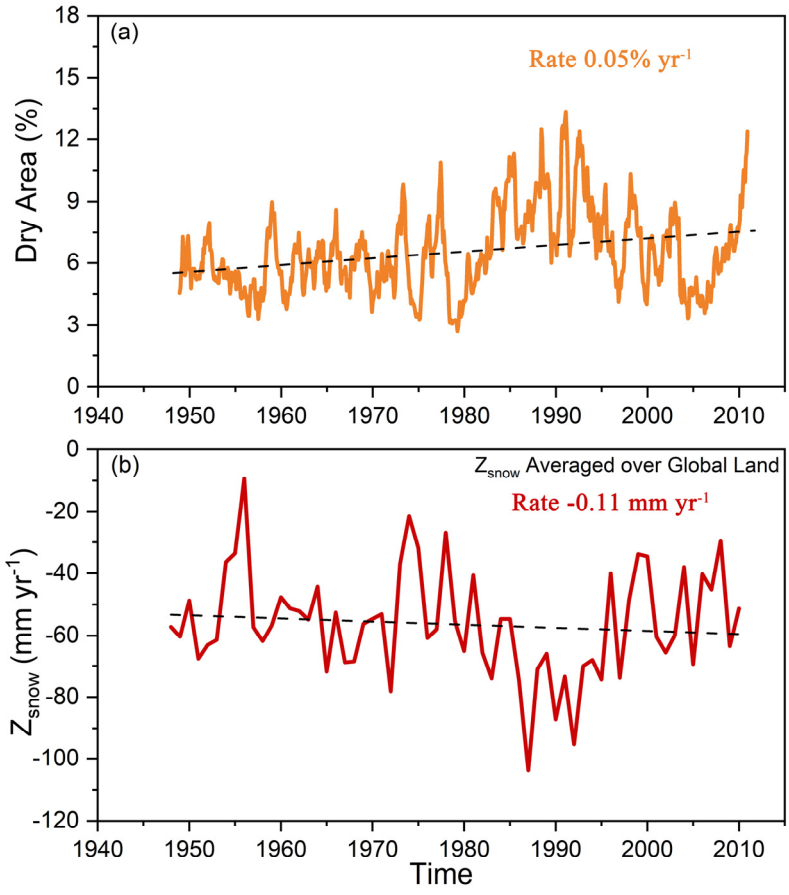

Figure 7: Time series of (a) global dry land area (% yr^{-1}) and (b) Z_{snow} (mm yr^{-1}) between 1948 and 2010. The dry land area was calculated based on the SZI_{snow} at a 12-month timescale. The dashed lines denote the linear trends, and the numbers represent the value of change rate.

#11 Line 352: It is a good way to use a country to describe the area of a drought event. Please add a number to show how large is the size of Guatemala.

Reply: The area of Guatemala is 108,889 km² that will be added in the revised manuscript as follows:

The most spatially extensive drought occurred over Asia in August 2008 (drought lasted from November 2007 to June 2009) and covered an area of approximately 11 million km² (roughly 100 times Guatemala's national territory area of 108,889 km²).

#12 Line 400: The Interdecadal Pacific Oscillation just appears one time, it is not necessary to provide an abbreviation for it. Please correct the same problems throughout the manuscript.

Reply: The abbreviation of the Interdecadal Pacific Oscillation (i.e., IPO) will be removed in the revised manuscript.

Dataset

I downloaded the compressed files including all the files from http://doi.org/10.5281/zenodo.5627369. With the software of "ncdump" and "Panoply", I checked the data files and had no problems to read and visualize the data. All the data is consistent as they were described in the manuscript. Here I give some recommendations to improve the user-friendliness of the proposed dataset.

#1 The compressed file with a suffix of ".zip". Is it possible add an introduction about how to unzip this kind of file?

Reply: The files in the Zenodo repository were compressed by a free and open-source file archiver, 7-Zip, due to its higher compression ratio than other common software. Following the comment, we will add below introduction about how to unzip this kind of file in the Metadata file:

All the files were compressed by the 7-Zip software. The 7-Zip is a free and open-source file archiver and can be downloaded from the URL: https://www.7-zip.org/download.html. After opening the URL, you can choose a suitable install file based on your operating system. The operation of 7-Zip is similar to the standard file archiver.

#2 The SZIsnow datasets have different timescales, thus, months before the timescale are set as missing values. It would be nice to give a clear introduction about the missing values in your dataset.

Reply: Following the comment, we will add below introduction about the missing values of the SZI_{snow} dataset in the Metadata file:

The SZI_{snow} is a multiscalar drought index, and the SZI_{snow} variable in the data file has different timescales. Thus, for a SZI_{snow} variable (len, time, lat, lon) at n months timescale, the first n-1 months (from 1 to n-1) in the SZIsnow variable are missing values.