

**Manuscript Number: nhess-2018-305**

**Response to Reviewers: Point-by-point response to reviewers' comments**

**Reviewer #1:** Overall, the experiment in this paper is useful and the results are also helpful for better drought monitoring in different regions. However, the structure of this paper is not well constructed and there are too many grammar problems which make me hard to read. There are many points that need clarification and major revision. I am not convinced that this paper is suitable to be published in NHSS in the present form. The general and specific comments are outlined below.

**Response to comments:** Thank you for your endorsement of our work, we have revised the manuscript according to your valuable comments. Our point by point responses are presented below.

**\*General Comments:**

**Comment 1:** In this manuscript, the authors mentioned different kinds of drought, “meteorological drought”, “atmospheric drought”, “crop drought”, “soil drought”, “drought in grassland”, “drought”, “high temperatures” (which should be high temperature), “pasture drought” and “soil-pasture drought”, however, the authors never define them. Please add the definitions and the possible effects on grassland before use them.

**Response to comment 1:** The reviewer is correct that the original manuscript needed to go into additional detail on these aspects of the droughts definitions. We have added a new paragraph at the very front of the introduction section in the revised manuscript that goes into more detail as to the droughts definitions. The reviewer is thanked for noting that the original manuscript should have filled in details, which has now been done in Line39-48.

**Comment 2:** The structure of introduction need to be improved. The current introduction missed the definition of different kinds of droughts like “atmospheric drought”, “meteorological drought”, “soil drought”, “grassland drought”. In addition, a detailed introduction of related studies should be added for readers. Finally, the research question(s) is(are) not clear enough.

**Response to comment 2:** A good suggestion by the reviewer. According to your suggestion, we rewrote the introduction section 1(Line39-71), added relevant literature, and explained the research issues in detail.

**Comment 3:** The reviewer notes that additional clarification is needed here. The research area and experimental design area (2.1) were further improved in Line78-104. Add Table 2 to introduce the sample plot distribution map of precipitation control experiment. Figure.1 was deleted because there were more than seven figure in paper.

**Comment 4:** The discussion section is like results or introduction. For example, the section 4.3, I guess your purpose is to prove the higher accuracy of 10 minutes in this study compared with the previous studies with a time scale of 1 day. It is really not convinced with no comparison conducted, no other supported materials. In addition, why the authors discussed/introduced the soil relative humidity here? If you want to discuss the suitability of the soil relative humidity, please give another discussion topic

in another paragraph.

**Response to comment 4:** The reviewer notes some poor language on our part. According to your suggestion, the **discussion section** has been rewritten, see in **Line264-290**.

**Comment 5:** The logic is unclear and the grammar problem is serious. I strongly suggest you (A) engage an active English speaking scientist and/or (B) some professional editing services to improve the English expression of your revised manuscript.

**Response to comment 5:** We like the reviewer's suggested language and have adopted it verbatim in the revised manuscript. We have had the entire manuscript professionally edited by International Science Editing (a language editing company).

**Comment 6:** The paper includes many confusing phrases like "gradient processing", "soil-pasture drought" which make this paper hard to read clearly.

**Response to comment 6:** The reviewer correctly notes that our terminology is not precise here. We have deleted "gradient processing", "soil -pasture" in manuscript.

**\*Specific Comments:**

**Comment 1:** Lines 48-49: Did you mean the underground water level in the "Three Rivers Sources" and "the area around the lake..." are under 2 m? Please provide enough evidence or reword the sentence.

**Response to comment 1:** The reviewer once again points out our use of imprecise language. This has been clarified in the revised manuscript to note that the underground water level of natural grassland in Qinghai Province is deeper than 2 m and the compensation of soil water by groundwater can be neglected in **Line52-53**. The reviewer is thanked for calling our attention to it.

**Comment 2:** Lines 70-71: How can the readers understand the "dynamic" of the drought index? Why call it a "dynamic drought index"? Explain it reasonably.

**Response to comment 2:** The reviewer once again points out our use of imprecise language. Dynamic drought index can reflect the cumulative process of drought. The soil drought intensity(I) reflects the speed at which soil drought conditions develop, while the soil drought degree(D) reflects the existing drought situation in specific, there was detailed introduction in **section 2.2.1(Line103-136)**.

**Comment 3:** Line 74-75: "Since soil moisture in alpine grassland depends on natural precipitation, soil rough directly affects forage yield." All the layers of soil moisture depend on natural precipitation completely? Even for the layers lower than 20 cm? In addition, what's the relationship between the dependence on natural precipitation of soil moisture and the soil drought directly affects forage yield? Is there any indirect factor? Explain it.

**Response to comment 3:** The reviewer once again points out our use of imprecise language. the underground water level of natural grassland in Qinghai Province is deeper than 2 m and the compensation of soil water by groundwater can be neglected. This demonstrates that inadequate soil water is the primary cause of agricultural drought in non-irrigated regions.

**Comment 4:** Line 75: where is the previous studies? Provide them.

**Response to comment 4:** The reviewer notes that additional clarification is needed here.

The statement was modified in **Line56-57**. Add other relative reference.

*Reference:*

*Chen, J. Z., Wang, S., Zhang, L. L., Lü, G. A.: Response of Maize to Progressive Drought and Red Soil's Drought Threshold, Sci. Agric. Sin., 40, 532-539, 2007.*

*Sadras, V. O., Milroy, S. P.: Soil-water thresholds for the responses of leaf expansion and gas exchange-a review, Field. Crop. Res., 47, 253–266, 1996.*

**Comment 5:** Line 77: the use of “few studies” in preference to “no study” implies that there has been some and this needs to be cited here.

**Response to comment 5:** The reviewer once again points out our use of imprecise language. We have deleted the sentences. The sentences was modified in **Line55-57**.

**Comment 6:** Line 79: what are “the abovementioned problems” except the static soil moisture problem?

**Response to comment 6:** The reviewer once again points out our use of imprecise language. We have deleted the sentences. The sentences was modified in **section1**.

**Comment 7:** Lines 81-84: The authors should express these objectives in a better way, as they are not clear enough to read. Such as “the rate of change in soil volumetric moisture content based on simulation tests of precipitation changes...”, “and combined with the soil moisture data”, “to investigate the influences of precipitation and soil moisture on development of drought were”. As mentioned above, how do you define the drought in your study, the deficit of precipitation or the deficit of soil moisture or something else? If you define it as the soil moisture deficiency, then how do you investigate the influences of soil moisture (itself)?

**Response to comment 7:** The reviewer once again points out our use of imprecise language. we re-express the objectives **In Line66-71**.

**Comment 8:** Line 99: The rust-proof iron sheet have 20cm below ground, what's the meaning of the 20-30cm layer and 0-30cm layer?

**Response to comment 8:** The reviewer once again points out our use of imprecise language. a piece of rust-proof iron sheet was inserted into the ground to a depth of 20 cm, while the surface was exposed to a height of 20 cm, it was revised in **Line81-85**. 0-30cm layers equal with the sum of 0-10,10-20,20-30cm layers.

**Comment 9:** Line 108: Why is the average drought intensity? Are there many drought intensities?

**Response to comment 9:** The reviewer once again points out our use of imprecise language. This is a grammatical error, instant of soil drought intensity. there was description in **Line 118-124**.

**Comment 10:** What kind of “reservoir capacity”?

**Response to comment 10:** The reviewer once again points out our use of imprecise language. This is a grammatical error, instant of the remaining transpirable soil water. there was description in **Line184-185**.

**Comment 11:** Line 121: “The surplus available water storages were X ( $x_1, x_2, \dots, x_n$ ) and Y”, What's meaning of the ‘Y’? Define it.

**Comment 12:** Line122: What is the “The regression coefficient (a)”? The same with “the empirical regression parameter” in line 114? If yes, delete it here.

**Response to comment 11-12:** The reviewer is thanked for noting that the reader could

get confused in this paragraph. for a given soil layer, we found that the relationship between the accumulated relative depletion (y) and the remaining transpirable soil water (x) fitted a log-linear model:

$$y=a \ln x+b \quad (7)$$

where a and b are the fitted parameters. In a given soil layer, the daily water depletion is  $w_i$  (mm), the remaining transpirable soil water on the same day is  $x_i$  (mm), and accordingly, the relative depletion,  $r_i$ , is  $w_i / x_i$  (%). On a given day, the accumulated relative depletion is  $y_i=\sum r_i$ . Over the course of soil drying, we obtained two water data sets: (1) the accumulated relative depletion set  $Y = (y_1, y_2, \dots, y_i, \dots, y_n)$ , and (2) the remaining transpirable water set  $X = (x_1, x_2, \dots, x_i, \dots, x_n)$ . There was more description in **Line179-197**.

**Comment 13:** Line 123: The abbreviation D for drought degree is a conflict with the abbreviation of dynamic drought index (D).

**Response to comment 13:** More specifically, the reviewer has noted that the abbreviation D for drought degree is a conflict with the abbreviation of dynamic drought index (D). We have removed the dynamic drought index. The reviewer is thanked for pointing out it was not really necessary and potentially counterproductive.

**Comment 14:** Line 147: “the volumetric soil water content gradient”? And what is the difference between “drought” and “drought events”?

**Response to comment 14:** The reviewer is again thanked for noting our poor language usage. We have deleted “the volumetric soil water content gradient” and “drought events”.

**Comment 15:** Line 159: How should we readers to understand the soil moisture yield? Give enough explanation even with the reference.

**Response to comment 15:** The reviewer is again thanked for noting our poor language usage. We have replaced “the soil moisture” to “the water supply. The language suggested by the reviewer has been adopted verbatim in the revised manuscript, not just here but everywhere we used this term.

**Comment 16:** Line 160-161: The sentence is confusing.

**Response to comment 16:** The reviewer is correct that the language is too casual here. This has been rewritten in the revised manuscript in **Line163-164**.

**Comment 17:** Line 163: “Daily soil water loss generally fluctuated within 0-0.4 mm”, but in Fig3, the Y-axis is “Water loss (%)”? What is the definition of water loss?

**Response to comment 17:** The reviewer is again thanked for noting our poor language usage. 0-0.4 mm is replaced of 0-0.4 %. Water loss is indicated that the water depletion, including evapotranspiration and redistribution, is faster than the rate of water restoration (from the depth below the root zone and precipitation).

**Comment 18:** Line 390~391: Firstly, what’s the meaning of ‘x’ and ‘Y’ in the Regression equation? Secondly, which ‘correlation coefficient’ is used in Table 2?

Pearson, Spearman or Kendall? Thirdly, if the Pearson correlation coefficient is used in Table 2, the two variables are X and Y or  $\ln(X)$  and Y? If the variables are X and Y, the coefficient shouldn’t be 1, if in another situation, the coefficient is -1. Why the correlation coefficient in Table 2 are all 1?

**Response to comment 18:** The reviewer correctly notes that our terminology is not precise here. This sentence has been rewritten in the revised manuscript to clarify our intent. The meaning of 'X' and 'Y' in the Regression equation is water depletion and remained transpirable water cumulative relative water, respectively, it was introduced in Line182-200. The two variables are  $\ln(X)$  and Y. we found that the relationship between the accumulated relative depletion (y) and the remaining transpirable soil water (x) could be well fitted by a log-linear model (**Fig.7**) and Chen et al., (2010, their Fig. 2) draw a similar conclusion(**Fig.8**).

**Comment 19:** Lines 201-202: "This relationship can be described by the logarithmic linear equation  $Y=a\ln X+b$ ", why is the logarithmic linear equation?

**Response to comment 19:** The reviewer correctly notes that our terminology is not precise here. This sentence has been rewritten in the revised manuscript to clarify our intent. The meaning of 'X' and 'Y' in the Regression equation is water depletion and remained transpirable water cumulative relative water, respectively, it was introduced in Line182-200. The two variables are  $\ln(X)$  and Y. we found that the relationship between the accumulated relative depletion (y) and the remaining transpirable soil water (x) could be well fitted by a log-linear model (**Fig.7**) and Chen et al., (2010, their Fig. 2) draw a similar conclusion(**Fig.8**).

**Comment 20:** Lines 209-210: "Pasture cannot normally survive if the level of D stays at 1 for a long time without decreasing", is there any supporting data?

**Response to comment 20:** The reviewer is correct that the language is too casual here. This has been deleted in the revised manuscript.

**Comment 21:** Lines 230-232: Why is the degree threshold 0.36?

**Response to comment 21:** The reviewer is correct that the original manuscript needed to go into additional detail on these aspects of the methodology. A new **Table 4 and Figure 4** have been created and inserted in the revised manuscript that summarizes these computations. We have added a new paragraph at the results section in the revised manuscript in Line **Line232-244** that goes into more detail as to how these thresholds are estimated from the soil relative humidity. The reviewer is thanked for noting that the original manuscript should have filled in some of these steps, which has now been done in the revised manuscript.

**Comment 22:** Line 252: Give the evidence for this sentence.

**Comment 23:** Line 254: expand the research conclusions of other scholars. In addition, other scholars with one citation? Give more accurate citation.

**Comment 24:** Lines 276, 278: How should the authors understand the drought speed? Define it before using it.

**Comment 25:** Lines: 280-281: "D can be calculated easily by testing the soil moisture." There are many vague sentences like this, what is "D"? "testing the soil moisture" for what? The water content or something else?

**Comment 26:** Line 290: what is "the soil-pasture drought"?

**Response to comment 22-26:** The reviewer is again thanked for noting our poor language usage. The **discussion section** has been rewritten, see in **Line265-290**.

**Comment 27:** Line 306: what "slope"?

**Response to comment 27:** The reviewer is thanked for noting our poor language usage. The "slope" is parameter  $a$ .

**Comment 28:** Table 2: I cannot imagine the correlation coefficients for all groups in various soil moisture layers are exactly 1 with just 49 samples for each. It is really exact

a line? In addition, how could you quantify the correlation coefficient between x and Y with an exponent relation? For example,  $Y = -1.028 \ln(x) + 3.2624$  in group 1 for 1-10 cm soil moisture layer. Did you measure the correlation coefficients between  $\ln(x)$  and Y?

**Response to comment 28:** The reviewer correctly notes that our terminology is not precise here. This sentence has been rewritten in the revised manuscript to clarify our intent. The meaning of 'X' and 'Y' in the Regression equation is water depletion and remained transpirable water cumulative relative water, respectively, it was introduced in Line 182-200. The two variables are  $\ln(X)$  and Y. we found that the relationship between the accumulated relative depletion (y) and the remaining transpirable soil water (x) could be well fitted by a log-linear model (Fig.7) and Chen et al., (2010, their Fig. 2) draw a similar conclusion (Fig.8).

**\* Technical Corrections:**

**Comment 1:** I found so many grammar problems. I can find even more than two typos in one sentence. Such as "...At the same time, the moisture gradient among different groups disappeared gradually. The volumetric soil water content gradient in the early period of drought events..." Some specific problems in the first several paragraphs (Not limited to these) are given as follows:

Line 52: The space between "region" and "(Xu et al.,2008;...)" is necessary.

Line 53: "2016).Given";

Line 57: "...Myers et al.,2017) .These"; more than these two...

Line 70: "Chen et al.(2007b),Ma et al.(2017)pointed..." missing spaces

Line 80: "was as follows:(1) to quantify"

Punctuation problems:

Line 54: ["warm and dry." This] in where it should be ["warm and dry". This];

Line 67: "Shi et al(2017)" missed ".";

I suggest the author carefully and rigorously modify the grammar problems sentence by sentence, word by word. You will avoid a lot of typos if you can use the proofreading function of Microsoft word properly.

**Response to comment 1:** The reviewer is again thanked for noting our poor language usage. According your suggestions, we have had the entire manuscript professionally edited by International Science Editing (a language editing company).

**Comment 2:** Line 11: "but" should be "and"?

Lines 15-16: reword the sentence and make it more clearly to authors.

Line 36: Give a more representative abbreviation for the "Dynamic drought index", like DDI or DYDI.

Line 46: Delete "even in".

Lines 47-48: Define "Three 48 Rivers Sources", and what is "the lake"? Did you mean "lake area"? Please check your English expression very carefully.

Lines 53~54: "Given prediction of future climatic changes, the climate in the study area may become 'warm and dry'" Provide some evidence.

Line 70: change "change" as "respond".

**Response to comment 2:** The reviewer is again thanked for noting our poor language usage. The abstract and introduction section has been rewritten.

**Comment 3:** Line 109, 142: No reference 'chen et al.,2017b', maybe 'chen et al.2007b'?

**Response to comment 3:** The reviewer is correct that the language is too casual here.

This has been rewritten in the revised manuscript.

**Comment 4:** Line 124: what's the mean of 'n' and 't' in Expression (2)?

**Response to comment 4:** The reviewer is correct that the language is too casual here. The was corrected in **Expression (3) and (4)**.

**Comment 5:** Line 138: "Results and analysis" or "Results and analyses"?

**Response to comment 5:** The reviewer is again thanked for noting our poor language usage. The language suggested by the reviewer has been adopted verbatim in the revised manuscript.

**Comment 6:** Line 124,191,196: what is the difference between the 'D' in these three expressions?

**Response to comment 6:** More specifically, the reviewer has noted that the abbreviation D for drought degree is a conflict with the abbreviation of dynamic drought index (D). We have removed the dynamic drought index. The reviewer is thanked for pointing out it was not really necessary and potentially counterproductive.

**Comment 7:** Lines 265-266: reword this sentence for clarity.

**Response to comment 7:** The reviewer is correct that the language is too casual here. This has been rewritten in the revised manuscript.

**Comment 8:** Line 275: How to prove that D (drought degree, I guess you mean) can accurately reflect the influences of drought history on the current drought degree and the whole drought process?

**Response to comment 8:** The reviewer is thanked for noting our poor language usage. In order to describe this problem clearly, **the structure of the paper has been adjusted**, some charts have been added to make it more logical. and relevant conclusions have been drawn that the soil drought intensity reflects the speed at which soil drought conditions develop, while the soil drought degree reflects the existing drought situation in specific soil layers. Given a continuous drought without precipitation, a high soil drought intensity would rapidly generate a high soil drought degree. Such changes are indicative of the actual situation of soil drought. According to our preliminary judgment, these two indices were considered reasonable choices to express the drought situation.

\*In summary, the yellow part of the paper is the modified sections. There were significant changes made to the manuscript as regards multiple strike years. The reviewer is thanked for mentioning this suggestion, which has definitely strengthened the manuscript.

**Tiao feng Zhang**