Response to comments of Anonymous Referees

Our responses to the referee's comments are shown below in blue, with the reviewer's comments shown as normal text.

Response to comments of Anonymous Referee #1 at the round1

Overall assessments:

The manuscript illustrates a prediction model of seasonal droughts based on atmospheric/oceanic standard anomalies (SA). In particular, the model is based on synchronous relationship between SPI3 and 90-day accumulated SA anomalies.

Although the paper addresses an interesting topic within the scope of the journal, by proposing a novel methodology, I believe it cannot be published in its current form. My main criticisms are related to the fact that the proposed methods are poorly described or are unclear in several parts of the manuscript.

RESPONSE:

Thank you for your feedback about this manuscript. Actually, the synchronous predictor-SPI3 statistical relationship forced by dynamical products, together with process prediction, are new and valuable attempt in the field of drought prediction. Besides, the process prediction model performs well at predicting seasonal drought development, despite its weakness in predicting drought severity. It is also an important result. As a whole, the paper actually addresses an important topic with a novel methodology.

Since it is a complete drought process prediction model, the procedure of model construction contains adequate but necessary information. Although we tried our best to illustrate it, the original manuscript still lack clarity. With comments you and Referee#2 made, we have realized the problems to solve. Large amounts of work are being conducted to improve it, especially in the structure of the manuscript. In the potentially revised version, we will give up the expression pattern of methodology and result section. Instead, we will choose the "theme-workstep" pattern for clarity, which is the comment Referee#1 made. By doing so, the continuity between the steps could be easier to follow. For example, a flow diagram map of model construction will be inserted in the end of the Introduction section. Accordingly, a brief but general introduction about the sequential procedures will also be given. Sections and sub-sections will be adjusted, following the sequential procedures of model construction. Additionally, brief but necessary

text description, tables and figures will be added in the feasible position. Basically, we hope the quality of the manuscript will be improved as much as possible, and it can be more readable and easily understood.

Major comments:

- in Section 3.1,

details on SPI computation (which seems to be different from the approach originally proposed by McKee et al., 1993) are lacking;

RESPONSE:

Thank you for pointing out this problem. We will add a flow chart to illustrate the steps of calculating SPI3 updated everyday in detail. Besides, we have also made text description clear and simple. The revised text description and flow chart are shown as follows: "*SPI3 was used as the drought index for seasonal drought recognition and prediction in this study, and the period for SPI3 calculation is 1979–2014. Traditionally, the SPI3 set is moving in the sense that each month a new value is determined from the previous 3 months (McKee and Kleist, 1993). To obtain seasonal drought processes at the one-day timescale, we chose to update SPI3 everyday, which was also recommended by the World Metrological Organization (2012). Compared with the traditional method, the essential difference is that the interval for SPI3 calculation has been extended from 12 months to 365 days, while the moving window has changed from one month to one day. However, no changes happen to relevant mathematic procedures. Specified illustrations and details about how to calculate SPI3 updated everyday are shown as Fig. 2.*"

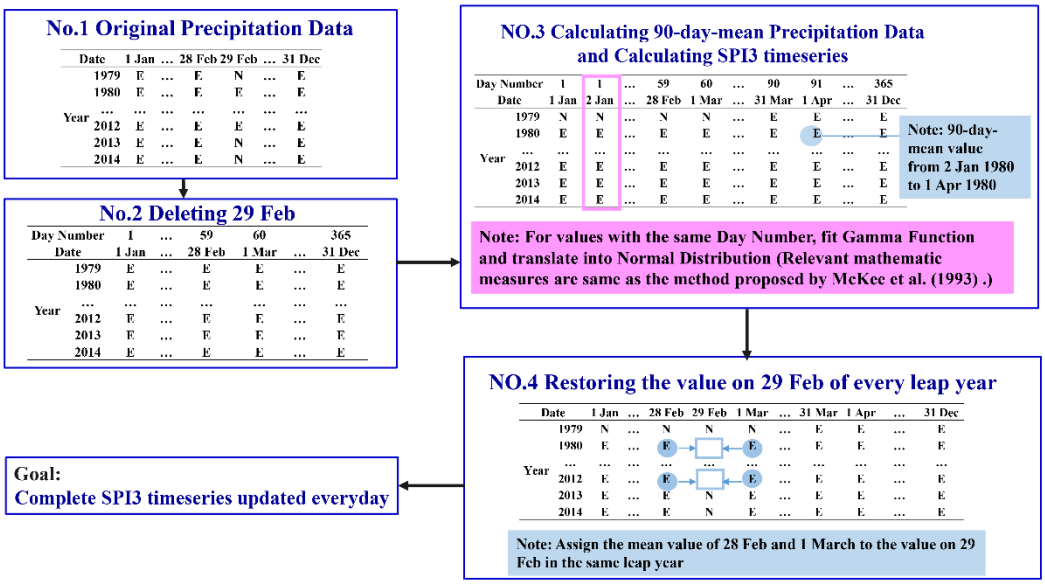

Figure 2. Illustration of calculating SPI3 updated everyday. The letter "E" represents value existence, while the letter "N" represents no relevant data.

- in Section 3.2,

division of drought processes is rather obscure. Why do you need to split years in dry/wet periods? SPI is computed on a 90-day period, but some of the identified spells (see table 2) cover a shorter period. How do you deal with this issue? What do you mean with initial-segment days (see lines 125-129)? Figure 3 is unintelligible.

RESPONSE:

Thank for your valuable and advisable feedback, which help me realize the problems and make the description clearer. Corresponding responses are organized as follows:

(1) Why to split years into dry/wet periods

RESPONSE: Essentially, it serves the following step of predictor construction, in which drought-related atmospheric/oceanic anomalies within the same dry/wet spells are extracted and used for anomaly-based predictor construction. The main reason is that drought-related circulation patterns during different dry/wet periods are different. As illustrated in Lines 108-111 in the original version, one complete drought process usually goes through one or several dry/wet spells. Different dry/wet spells usually correspond to

various precipitation characteristics and circulation patterns. Therefore, it is appropriate to divide drought processes into different segments and assign these segments into different dry/wet spells.

(2) "SPI is computed on a 90-day period, but some of the identified spells (see table 2) cover a shorter period."

RESPONSE: Actually, connections among timescale of SPI3, drought processes and dry/wet spells need to be illustrated indeed. SPI is computed on a 90-day period (SPI3), used to identify seasonal (90-day timescale) drought processes. Dry/wet spells are used to split identified complete drought processes. However, timescale of SPI3 and dry/wet spells have no relationship with each other. We think that the cause of confusion lies in the originally implicit description about SPI3 calculation and its application in seasonal drought process identification. In the potentially revised version, the explicit description and two feasible sketch maps will be provided.

(3) the expression of initial-segment days

RESPONSE: Initial segments are actually the split drought process segments according to dry/wet spells, which are used to compute Intersection Proportion (IP). The previous description about these two terms are confusing. In the revised paper, we will replace "Herein, IP is the proportion of initial-segment days in days of involved spells." with the new expression "*Herein, IP is the proportion of initial segments accounting for relevant dry/wet spells, and the initial segments (e.g., D1, D3 and D4 in Fig. 6) refer to parts of one drought process split by dry/wet spells*". Additionally, relevant sketch maps will be provided for clarity.

(4) Figure 3 is unintelligible

RESPONSE: The original expression is implicit and unintelligible indeed. We think two places need to be revised. On one hand, it lacks calculation expression of IP[0] and IP[-1]. In the revised version, we will take the processes going through two dry/wet spells as an examples, and add the simple information of IP[0] and IP[-1] calculation. On the other hand, the original sketch maps about processes going through more than two dry/wet spells lack the information before assignment. In the revised version, this problem will be solved. The revised figure is shown as follows.

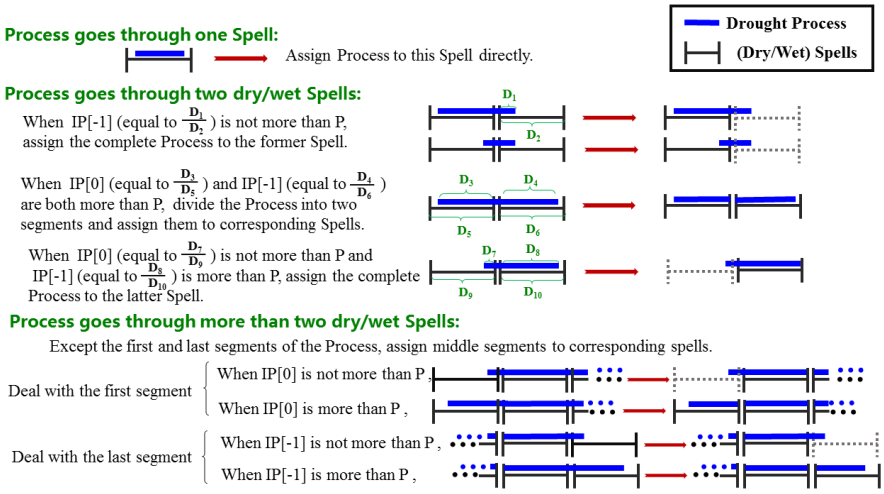

Figure 1. Process-split rules of one drought process according to dry/wet spells. IP represents Intersection Proportion, while P refers to critical Proportion. The terms "IP[0]" and "IP[-1]" express IP of the start and end segments respectively.

- in Section 3.6,

the description of the angle comparison approach is rather messy. Please clarify and check the correctness of mathematical notations (i.e. subscripts of the angles). What is R2 in Table 3 and how is it calculated?

RESPONSE:

Actually, the implicit description of the angle comparison approach is also pointed out in the comments Referee#2 made. In the potentially revised version, we will transform the original text into three sub issues. They are namely "how to describe drought development", "general classifications of drought outlook" and "how to calculate angles and conduct angle-based drought outlook". By doing so, we hope that it can be explicit and easily understood.

We have checked mathematical notations (i.e. subscripts of the angles). Currently, we have found a mathematical notation in the caption of original Table 3. We have changed "α_i is greater than critical angle α_{2i}" into "α_i is greater than critical angle α_{3i}". Besides, the original description about mathematical notations is confusing indeed. In the revised version, it has been clarified in the sub issue of "how to calculate angles and conduct angle-based drought outlook".

Finally, R2 represents the ratio of specific days in the period of the predicted prospective 46–90 days. These specific days meet the criteria that α_i is greater than critical angle α_{3i}. It is dividing selected specific

days by 45 (the 46th - 90th day) days, which can be found in the definition of R2. Illustration about R2 can be found in the caption of original Table 3.

- in Section 4.1,

115 please add further information on the content of Table 5.

[Supplementary comment: I guess that Table 5 is coherent with Table 1 (drought classification) and Table 2 (division of annual period). What is unclear to me is the division of drought process (initial segment days?) illustrated at lines 125-129 and in Figure 3 and its application.]

RESPONSE:

120 Thank you for this feedback. Actually, results in original Table 5 follow the division rules in original Figure 3 and the dry/wet spells in original Table 2. However, it is incoherent with original Table 1. (Table 1 is used to assign dry/wet grades to every daily SPI3 value of an identified complete drought process. It will be further illustrated in the potentially major version.)

We have to admit that the original division rules itself (original Figure 3) are actually confusing. In the

125 potential revision, we will add a new figure (Figure 7.) as an intermediate result of drought process division. Additionally, detailed but necessary labels will be inserted into the feasible positions in original Figure 3, which help people understand the process division rules. The following figure is the intermediate sketch map.

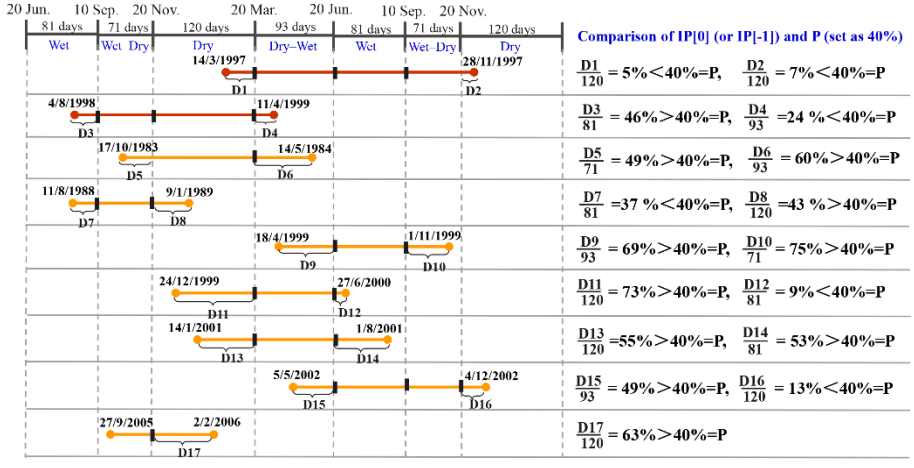

Figure 2. Comparison results of P, "IP[0]" and "IP[-1]" of drought processes during 1979–2008 in North China. The start dates of these drought processes have been shifted 90 days in advance. IP represents Intersection Proportion, while P refers to critical Proportion. The terms "IP[0]" and "IP[-1]" express IP of the start and end segments respectively, when a drought process is divided into two segments.

- in Section 4.3,

the model calibration procedure is also ambiguous What is F in Table 7? Please provide a list of the initial 43 predictors and the selected ones.

RESPONSE:

Actually, in original Table 7, F represents values of the constructed F-test statistic in the final stepwise regression, while $F_{\alpha=0.05}$ refer to F-test critical values at 5% significance level. Considering F and $F_{\alpha=0.05}$ are included in the details of procedures, we tend to delete these two columns of F and $F_{\alpha=0.05}$ in original Table 7 in the potentially revised version.

Besides, a list of the initial 43 predictors and the selected ones will be shown in the potentially revised version. Since all the initial 43 predictors are shown, we will also add the information of predictor construction in the 200 hPa HGT field into the manuscript. Accordingly, the first leading EOF modes of SA for 200 hPa HGT will also be shown.

- in Section 4.4,

the synchronous stepwise-regression relationship should be described in-depth.

[I suggest to better clarify:

- the structure of the multiple regression models (linear or not?);
- the explained variables

(the first PCs of SA predictors reported in Table 6?) and which criterion is used

to select the most significant ones;

- how the calibration and validation periods have been chosen (see Table 7) and which of them is finally applied.]

RESPONSE:

Thank you for pointing out this problem about clarity. Stepwise regression is also multiple and linear. Essentially, stepwise regression selects a best subset of explanatory variables used for model construction

while all the explanatory variables are used to build multiple linear regression model. Additionally, positive and negative pattern areas on the first leading EOF modes are used to build SA predictors in our study. SA predictors reported in original Table 6 is actually explanatory variables, instead of the first PCs (Principal Component) of SA predictors.

The general description about criterion used to select the most significant ones (Afifi and Azen, 1972) is as follows. "The technique of stepwise regression which selects a best subset according to the following procedure: The first step selects the single variable which best predicts Y. The second step finds the variable which best predicts Y given the first variable entered. In the steps that follow, either: (a) a variable is entered which best improved the prediction of Y given all the variables entered from the previous steps; or (b) a variable is removed from the set of predictors if its predictive ability falls below a given level. The process is terminated when no further variable improves the prediction of Y".

However, these aforementioned information is detailed. Considering large amounts of information this manuscript contains, we tend to give a brief but important introduction about the structure, explanatory variables and criterion of stepwise regression in the potentially revised version. Additionally, the citation of the introduction about stepwise regression (Afifi and Azen, 1972) will be also provided.

References:

Afifi, A. A., and Azen, S. P.: Statistical analysis: a computer oriented approach, Academic press, 1972.

In terms of selection approaches of calibration and validation periods, two reasons are responsible for it. First, we want to examine model performance on the 2009/2010 Southwest China drought. Therefore, the end of the first calibration period is 31 December 2008. Second, consistent with the drought prediction year by year, the calibration period is running and extended to the day before the new year. For example, the seasonal drought prediction model calibrated from 1 Jan 1983 to 31 Dec 2011, is used for everyday initial prediction time in the whole year of 2012. When it comes to every initial drought prediction in the year of 2013, the corresponding drought model is calibrated from 1 Jan 1983 to 31 Dec 2012. Accordingly, every SPI3 value in original Fig.9 and original Fig.10 is simulated or predicted, using the drought prediction model with corresponding calibration period. We think the original description in original

section 4.3 is unclear and confusing. In the potentially revised version, we will make a brief but necessary explanation about the selection of calibration.

Overall, the lack of clarity in the methodology makes difficult to verify the quality of the derived results.

RESPONSE:

Thank you for pointing out the lack of clarity. Actually, large amounts of revision work is being conducted to improve it. For example, a general flow diagram of model construction will be provided at the end part of the Introduction section, aiming at a brief instruction about sub-sections. Besides, the original Figure 3 will also be readable, by means of adding some necessary labels. As an important revision designed for the potentially revised version, **general introduction to the sequential procedures of model construction** is as follows:

(1) Descriptive texts in the end of the Introduction section

"*Considering that the conceptual model proposed consists of several important parts, a brief but general introduction about sequential procedures are shown (Fig. 1), prior to specified illustration from sect. 3 to sect. 8. In sect. 3, historical extreme and severe historical drought processes will be identified with 3-month SPI updated everyday (SPI3). Identified drought processes usually go through one or several dry/wet spells, in which precipitation deficit characteristics and circulation patterns varies. Therefore, process-split rules according to dry/wet spells in sect. 4 are designed to assign drought process segments to different dry/wet spells. Meanwhile, gridded values in the fields of 200 hPa/500 hPa HGT and SST are transformed into gridded values of Standardized Anomalies (SA) in sect. 5. Basically, maps of atmospheric/oceanic SA during drought process segments within the same dry/wet spells are the important inputs of predictor construction. After Empirical Orthogonal Function (EOF) analysis are conducted on these SA-based maps, the first leading EOF modes are used to build up predictors (sect. 5). Further, synchronous statistical relationship between SA-based predictors and SPI3 are calibrated with the method of stepwise regression in sect. 6. The National Centers for Environmental Prediction / National Center for Atmospheric Research (NCEP/NCAR) Reanalysis datasets and the NCEP Climate Forecast System Version 2 (CFSv2) operationally forecasted datasets are used to force the synchronous*

statistical relationship, respectively. Simulated and predicted 90-day prospective SPI3 time series are output of sect. 7. With the help of angle-based rules of drought outlook, simulated and predicted SPI3 time series are transformed to five kinds of drought outlook, which are easily accessible to end water managers."

(2) General flow chart

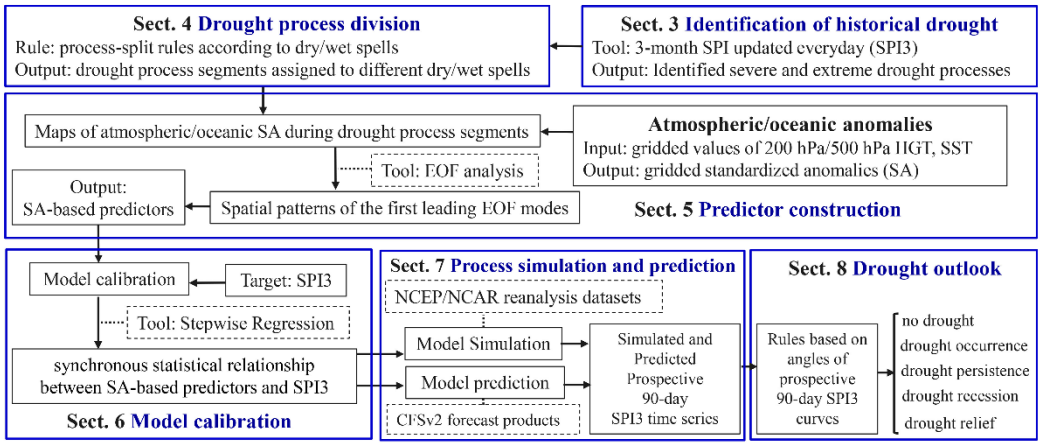

Figure 3. Brief introduction about sequential procedures of the drought prediction model construction

(3) Section assignments

7.2 Drought processes simulated by the NCEP/NCAR reanalysis datasets

7.3 Drought Processes predicted by the CFSv2 forecast datasets

8 Drought outlook

8.1 Angle-based rules

8.2 Simulated and predicted results

Finally, I would also suggest the authors to revise the language of the manuscript in order to make it more fluid and comprehensible.

RESPONSE:

Thank you for this comment. We have followed almost all the comments, and this manuscript is being revised as much as possible by ourselves. Once finished, we will further invite professional editors at Editage, a division of Cactus Communications to revise it and improve the language quality. We try our best to make this manuscript more fluid, readable and comprehensible.