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Nonlinear Processes in Geophysics
Discussions

Interactive comment on "A method to predict the uncompleted climate transition process" *by* Pengcheng Yan et al.

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REPLY to RC2

Dear reviewer,

Thanks for the comments, we modify the manuscript according to the comments and reply them one by one as follows. More details are included in the supplement for the plain text can not display the entire reply especially the symbols.

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General comments

1. The abstract needs to be made more clear. The phrase "more details of climate

change" is too broad and does not explain what exactly is being addressed by the methods presented in the paper. The PDO is also not explained, nor its relation to climate change.

REPLY: We rewrite the abstract as follows, and we add more explanation about the PDO.

"Climate change is expressed as a climate system transiting from the initial state to a new state in a short time. The period between the initial state and the new state is defined as transition process, which is the key to connect the two states. By using a piecewise function, the transition process is expressed approximately (Mudelsee, 2000). However, the dynamic processes are not included in the piecewise function. Thus, we had proposed a method to study the transition process by using a continuous function. In this manuscript, the method is developed to predict the unfinished transition process based on the dynamic characteristics of the continuous function. We introduce this method in details and apply it to predict end moment and end state of one unfinished transition process of the Pacific Decadal Oscillation (PDO) time sequence, which is a long-lived El Niño-like pattern of Pacific climate variability (Barnett et al, 1999). This method reveals a new relationship during the transition process, which explores a nonlinear relationship between the linear trend and the amplitude (difference) between the initial state and the end state. Since the transition process begins, the initial state and the linear trend are estimated. Then, according to the relationship, the end states and end moment of the unfinished transition process is predicted. The results of either the ideal experiments or the PDO index show good prediction."

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2. There is not enough introduction to the methods section before discussing the details of time series analysis.

REPLY: In this manuscript, we develop a new method to predict the end state and end moment of a uncompleted transition process based on the detection method of

transition process. The detection method had been published in our previous papers as follows. Thus, we rewrite this part about the method in this edition of the manuscript. More details about the prediction method are added. Also, we introduce more about the ideal experiments in section 2.2.

Yan PC, Feng GL, Hou W, Wu H Statistical characteristics on decadal abrupt change process of time sequence in 500 hPa temperature field. Chinese Journal of Atmospheric Sciences 2014; 38 (5): 861−873

Yan PC, Feng GL, Hou W. A novel method for analyzing the process of abrupt climate change. Nonlinear Processes in Geophysics 2015; 22:249-258, doi: 10.5194/npg-22-249-2015

Yan PC, Hou W, Feng GL Transition process of abrupt climate change based on global sea surface temperature over the past century, Nonlinear Processes in Geophysics 2016; 23:115–126, doi:10.5194/npg-23-115-2016

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3. The mathematical notation is inconsistent and unclear.

Variable k appears to be often interchanged with κ

Parameter k is referred to as both a stability (Fig. 10 and Section 3.3) and instability parameter (Fig. 10).

μ is never formally introduced and is potentially being exchanged with u.

REPLY: Stability parameter k should be instability parameter. We corrected this mistake. The other two mistakes are also corrected.

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4. There is terminology that is used but not defined.

continued process (pg 1, line 12)

the filtering process (pg 2, line 16)

ramp function (pg 2, line 24)

crush (pg 4, line 21)

percentile threshold (pg 11, line 21)

augmented abrupt change (pg 11, line 28)

REPLY: We correct all above mistakes in manuscript one by one. More details are as follows:

continued process (pg 1, line 12)

The wrong description is moved.

the filtering process (pg 2, line 16)

”filtering” is replaced by “transition”

ramp function (pg 2, line 24)

The ramp function means piecewise function according to Mudelsee’s work. This mistake is corrected.

crush (pg 4, line 21)

It means that the system will be crushed. A reference is added.

percentile threshold (pg 11, line 21)

A reference is added.

augmented abrupt change (pg 11, line 28)

We rewrite this paragraph, and the mistake is corrected.

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5. There is inconsistency between Section 2.2 and Section 3. In Section 2.2 it is stated that the parameter k cannot be obtained from the data (with no explanation as to why), so it is fixed a priori. In Section 3 the parameter k has been estimated from a time series, but again with no explanation as to how one would estimate this.

REPLY: In section 2.2, the ideal time sequence only have one abrupt change, which means that we have no way to obtain the parameter k because that there is no more other climate changes. While in section 3, the PDO index have several abrupt changes, and parameter k is obtained by counting these changes. We rewrite this paragraph in the manuscript as follows.

" It has to be noticed that in this ideal time sequence there is just one abrupt change, which means that we have no way to obtain the parameter k by counting many changes. Thus parameter k is given directly, and the prediction of the end state (moment) is drawn in figure 5b, 5c and 5d. For the entire ime sequence, there are 500 moments as shown in figure 5a. In figure 5b, only 240 moments are given, and the other moments are unknown. Then, we obtain parameters v and h by regression method. Then, Parameter u is calculated with Eq(8) since parameter k is given. The blue line represent the prediction result. The transition process would be ended in moment 342 with the end state value 2.92. In figure 5c, the end moment and end state are predicted 356 and 2.65 respectively when the time sequence is given 250 moments. In figure 5d, the time sequence is given 260 moments, and the end moment and end state are predicted 359, 2.58 respectively. The ideal experiments predict the end moment and end state of transition process successfully. The results also show that the longer the transition process experience, the more accurate the prediction."

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6. In Section 3.1 it is stated "When the length of the sub-sequence is 20 years and 30 years, there is only one peak in the distribution of k values: : :" (pg 10, lines 21-24). This seems strange, as there are said to be multiple peaks for a smaller subsequence (10

years), a single peak for 20 and 30, and then multiple peaks for larger subsequences. I would assume there would be a more continuous relationship. This is not discussed why this is not the case. Also, a quantitative measure is not specified of what defines a peak.

REPLY: The description in this part was not right. We rewrite this part about the values of parameter k. Parameter k characterizes the stability of the system during climate change. If it is detected to be large, the system is not stable. The ideal time sequences are shown in our previous work as follows. The evolution of the system expressed by the logistic model with different stability parameters: (a) the system reaches to the stable states with a different initial variable when parameter k = $\pm$0.01; (b) the system becomes bifurcated when the parameter k = 105; (c) the system becomes chaotic when the parameter k = 135. However, we can not identify the value of parameter directly, but we can find its threshold. Thus, in section 3.1 of this manuscript, we obtain parameter k by counting the climate changes of the PDO index.

By referring: Yan PC, Feng GL, Hou W. A novel method for analyzing the process of abrupt climate change. Nonlinear Processes in Geophysics 2015; 22:249-258, doi: 10.5194/npg-22-249-2015

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7. The motivation for Section 3.2 is absent and it is not obvious how this section relates to the overall goal of Section 3.

REPLY: In section 3.1, we obtain the parameter k, and in section 3.2, we obtain the parameters v, h. More explanation as follows in the first paragraph of section 3 is added. We also rewrite the first paragraph of section 3.2.

"During the following research, a transition process starting from 2011 is studied. According to the prediction method, several parameters have to be determined in advance. We determine parameter k firstly."

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8. “Abrupt change” appears to be used synonymously with “transition process” in Section 3.2 and this does not seem consistent with the rest of the paper. Please maintain the same terminology for clarity.

REPLY: We check all the manuscript, and change inconsistent description.

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9. The final paragraph of Section 3.2 (pg 12, lines 10-24) discusses three abrupt changes. The previous paragraph discussed four. There is much confusion as to what abrupt change events are being discussed throughout this paragraph.

REPLY: We correct this mistake and give more explanation in section 3.2.

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10. The lengths of the subsequences mentioned in Section 3.2 do not match the

numbers on the colour bar in Fig 9. It is therefore not clear what Fig 9 is showing.

REPLY: We add more explanation about figure 9 in section 3.2. In figure 9, the transition process starting from 1976 should not be shown. It is corrected now. Only the transition process starting from 2007 and 2011 are stated.

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11. There is no discussion as to which abrupt change detection (year 2007 or 2011) is correct, which leads to a lack of motivation for studying only the 2011 event. It needs to be more clearly explained why the 2011 event is chosen for the prediction experiment.

REPLY: Both of the climate changes starting from 2007 and 2011 are right. When the sub-sequence are set as different lengths, which means we test the climate change in different time scale, the start moments of climate changes might be different. In this manuscript, only the climate change starting from 2011 is studied for testing the

prediction method. More explanation is added in section 3.

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12. The “variation situation of parameter μ” (pg 13, lines 6-7) was never introduced nor explained.

REPLY: This is a mistake. It is corrected to be “u”.

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13. The “prediction result” (pg 13, lines 13-14) was not specified. Additionally, it is not clear which prediction is being shown in Fig. 11.

REPLY: We rewrite this paragraph as follows in the manuscript. More explanation about the prediction in figure 11 is included.

“In figure 11, the PDO time sequence is displayed as black line. The period during 2006$\sim$2011 is detected as the initial state, and a transition process is increasing from this initial state. It is not able to be known whether the increasing process has been completed or not. Based on the linear regression method, the initial state and the linear trend are obtained and shown as purple dash lines. Then by the method proposed in section 2.2, the end state of transition process are obtained with Eq(8), and it is marked as green dash line.. Unlike the uncompleted transition process of ideal experiment, the transition process has completed in 2015 since we detected the PDO change in 2016. This transition process started from 2011, and end in 2015. The initial moment and the end moment are marked as black dash lines. However, we are still not sure whether the PDO complete this transition process or not for it it appears at the end of the sequence. As we all know, many statistical methods are not accurate for the detecting both ends of the sequence. Thus, the real PDO sequence during 2016$\sim$2017 is added to the end of the PDO time sequence. The PDO value from 2015 to 2017 is almost unchanged, which is consistent with the predicted result.”

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14. Conclusion needs to be expanded upon much more.

REPLY: We rewrite the conclusion and discussion, and all three following mistakes are corrected now.

The sentence “The abrupt change with smaller time scales has a continuous process, and the abrupt change with larger time scales becomes abrupt change point.” (pg 14, lines 8-10) is not easily understandable and alludes to material that does not appear to have been discussed in the paper.

The phrase “a detected abrupt change beginning in 2011 appears relatively close to the end of the 115-year sequence, and it is difficult to identify by using other methods” (pg 14, line 11-13) was not previously discussed in the manuscript. Please expand on why the abrupt change is difficult to identify through other methods.

There is not enough evidence in the manuscript to support the claim “The findings increases the possibility of resolving the problem associated with difficult processing at the end of a time sequence” (pg 14, lines 14-16). Please add discussion of the problem of difficult processing at the end of a time sequence.

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Specific comments

1. pg 1, line 14 - Change “self” to “itself”

REPLY: This mistake is corrected.

2. pg 1, line 15 - Add full reference to paper on PDO

REPLY: The reference is added.

3. pg 1, line 16 - Remove “And” from beginning of sentence

REPLY: This mistake is corrected.

4. pg 2, lines 4-6 - Add references for each of the fields mentioned

REPLY: Two references are added.

5. pg 2, line 6 - Change “famous” to “observed”

REPLY: This mistake is corrected.

6. pg 2, line 8 - Add reference for “Thom’s research”

REPLY: The reference is added.

7. pg 2, line 8 - Remove “And” from beginning of sentence

REPLY: This mistake is corrected.

8. pg 2, line 24 - “Ramp Function” does not need to be capitalised

REPLY: This mistake is corrected.

9. pg 2, line 26 - “Non-linear Function” and “Ramp Function” do not need to be capitalised

REPLY: This mistake is corrected.

10. pg 2, line 29 - Remove “Besides” from beginning of sentence

REPLY: This mistake is corrected.

11. pg 3, line 1 - Change “got reach to” to “reached”

REPLY: This mistake is corrected.

12. pg 3, line 3-4 - Capitalise “decadal oscillation”

REPLY: This mistake is corrected.

13. pg 3, line 4 - Move reference to end of sentence

REPLY: The reference is moved..

14. pg 3, line 5 - Remove “has”

REPLY: This mistake is corrected.

15. pg 3, line 20 - Change “change” to “changes”

REPLY: This mistake is corrected.

16. pg 3, line 22 - Change “more short” to “shorter”

REPLY: This mistake is corrected.

17. pg 3, line 24 - Change “change” to “changes”

REPLY: This mistake is corrected.

18. pg 4, eq 1 - Add punctuation to equations (including all subsequent equations in paper)

REPLY: This mistake is corrected.

19. pg 4, lines 7-8 - The sentence starting “The population changed: : :” is not clear.

REPLY: This mistake is corrected.

20. pg 5, line 5 - Change “would” to “could”

REPLY: This mistake is corrected.

21. pg 8, line 11 - Change “which” to “that”

REPLY: This mistake is corrected.

22. pg 8, lines 20-21 - Please write out the equation for the logistic model with noise

REPLY: The equation is added.

23. pg 8, lines 21-22 - Please specify the difference between the “three uncompleted changes”. Is the same noise realisation used but for different lengths of trajectories?

REPLY: An entire time sequence with 500 moments is shown in figure 5a and three

other lengths of time sequences are shown in figures 5b, 5c and 5d respectively. More explanation is added in title of figure 5.

24. pg 8, lines 27-29 - The sentence starting with “The results show: : :” is not clear.

REPLY: More explanation is added in manuscript.

25. pg 10, line 9 - Add “of the largest peak” after “The k value”

REPLY: It is added.

26. pg 10, line 10 - Change “are distributed in the” to “also have”

REPLY: This mistake is corrected.

27. pg 10, line 26 - Please quantify what is meant by “tiny”

REPLY: We rewrite this sentence as:

It is difficult to detect an abrupt change with huge amplitude if the abrupt change takes almost no time.

28. pg 11, lines 1-5 - Percentages of what?

REPLY: Percentages of all k values.We correct this mistake.

29. pg 11, line 8 - Add “in the PDO” after “abrupt changes”

REPLY: This mistake is corrected.

30. pg 11, line 10 - Add “the” before “two”

REPLY: This mistake is corrected.

31. pg 11, line 13 - Write out the set of sub-sequence lengths in words

REPLY: We rewrite this sentences in the manuscript.

32. pg 13, line 1 - Remove “after the abrupt change”

REPLY: This mistake is corrected.

33. pg 13, line 9 - Remove the “a” after each year in the brackets

REPLY: This mistake is corrected.

34. pg 13, line 23 - Remove “the” before “uncompleted” and change “process” to “processes”

REPLY: These mistakes are corrected.

35. pg 13, line 24 - Remove “the” before “ideal”

REPLY: This mistake is corrected.

36. pg 13, line 26 - Remove “started

REPLY: This mistake is corrected.

Please also note the supplement to this comment:
https://www.nonlin-processes-geophys-discuss.net/npg-2020-2/npg-2020-2-AC2-supplement.pdf

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Interactive comment on Nonlin. Processes Geophys. Discuss., https://doi.org/10.5194/npg-2020-2, 2020.

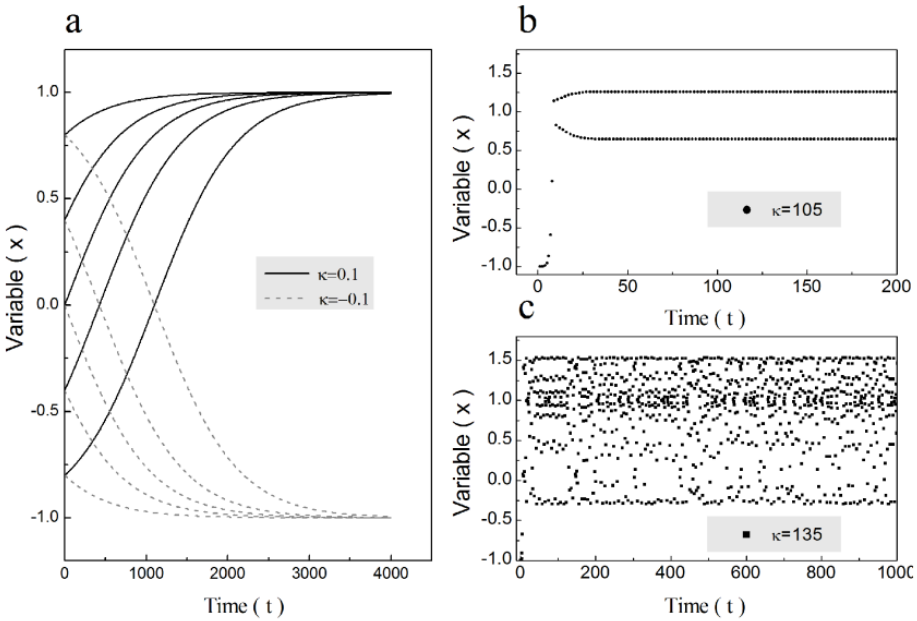

Fig. 1. Figure for question 6