Dear Referee,

We appreciate your interest to our article and your comments. We reply on the comments as follows:

(1) **Referee.** In figure 4, the abrupt changes occurred in different locations of the oceans at the same time. Please discuss possible mechanism about them. Are there some teleconnections between them or just a casual one?

Authors. Actually, it is a question about the standard of the abrupt change. In present manuscript, the method is based on the percentile threshold method, and this is a relatively standard. Thus, when an abrupt change in one grid is detected, it means that the difference between the two states before and after the abrupt change of this moment has the biggest amplitude by comparing with the other moment. Taking fig. A3 for example, we know that both the two series have two abrupt changes in moment t1 and t2 respectively. However, when we detect the abrupt change by setting a standard, only one abrupt change can be considered as a real abrupt change. The amplitude of the abrupt change should be bigger than any others. Then, it is in moment t1 for grid 1 and it is in moment t2 for grid 2. Therefore, when the abrupt changes of different grids are detected, the abrupt change moments of two adjacent points could be different. It is inferred that the longer the time sequence, the more disperse the abrupt change space will be.

There could be some teleconnections between the abrupt changes occurring in different locations at the same time, because they are likely to be driven by the same force. It's complex and difficult to explain the mechanism. Before that, it has to dig out how the different standard effect on the detection of abrupt change. When all the real abrupt changes are obtained, it is easy to know how the abrupt change transforming from one place to another in dynamics. However, in present manuscript, we just did some basic research about the transition process, proposing a special quantitative relationship. The relationship will be used to study the physical mechanism of abrupt change by climate model.

(2) **Referee.** Since the parameter χ is a function of α and β, χ becomes a constant if set α=0.2, β=0.8. Why?

Authors. This issue was discussed in the previous paper(Yan et al, 2015). α and β represent two points($A(X_\alpha,t_\alpha)$, $B(X_\beta,t_\beta)$) of the transition process, respectively (as shown in fig. A1), then α, $\beta \in (0,1)$. According to the function as mentioned in line 15, page 3, the location parameter χ can be expressed by α and β. As shown in fig. A2, it is found that parameter χ is almost constant when the values of α and β are within a certain range. Therefore, we think that that parameter χ is approximately constant.

(3)**Referee.** The word "and" should be removed in the author list.

Authors. We are going to correct this mistake.

(4)**Referee.** Formula (3): The word "section1, section2, section3" may be replaced by "stage 1, stage2, stage3" or "domain1, domain2, doman3"?

Authors. The words "section1, section2, section3" will be replaced by "stage 1, stage2, stage3".

Appendix：

Figures

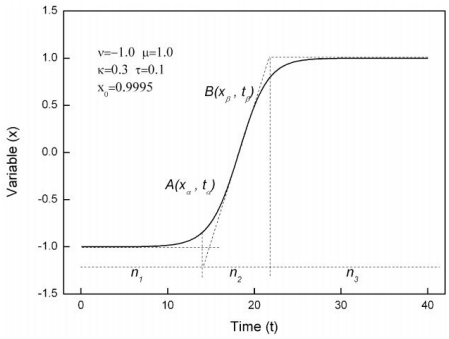

Fig. A1. The transition process of abrupt change with two points. (according to reference [1])

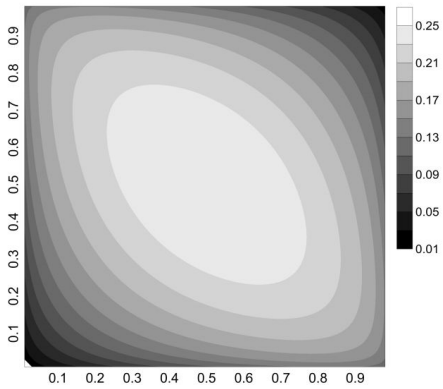

Fig. A2. The relationship parameter χ and parameters α, β, where the x axis is parameter α, the y axis is parameter β and the contour is parameter χ. (according to reference [1])

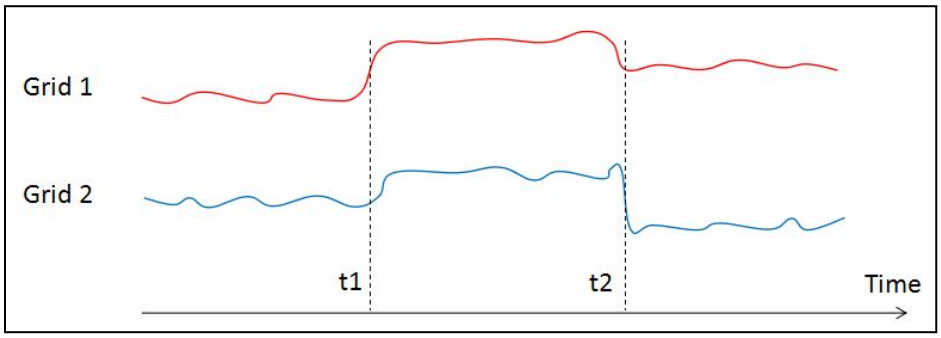

Fig. A3. To detect the abrupt change of different grids.

Reference

[1] Yan P. C., Feng G. .L, Hou W., 2015: A novel method for analyzing the process of abrupt climate change. Nonlin. Processes Geophys. 22, 249–258, doi,10.5194/npg-22-249-2015