Interactive comment on
"Multi-scale event synchronization analysis for unraveling climate processes: A wavelet-based approach" by

A. Agarwal et al.

Reviewer #2

Reply to the Review Comments

We would like to thank the reviewers for reviewing our manuscript, and for their constructive comments and useful suggestions for further improvement. We have revised our manuscript, taking into consideration all the review comments. During the revision, we have also made further changes, facilitated by a fresh reading. Here, we respond to the specific review comments. In what follows, Page numbers and Line Numbers correspond to those in the clean version.

General comments:

Reviewer 2:
In my opinion, the manuscript is interesting and well written. The proposed approach is novel and original because it provides a new view in the use of ES method, increasing potentiality of this method in the investigation of climate processes. I also think that the subject of the manuscript is interesting for the Jnp's readers. For this reason, I recommend the manuscript for the publication on JNP. I just would like to suggest to the authors few modifications in order to make more accessible the subject also to readers who are not familiar with Wavelet and Event synchronization approaches. Although these suggestions have been put also into the comments of the pdf file in attachment, I summarize them in the following:

Author's Response: We thank the reviewer for his/her overall positive evaluation of the manuscript. All the comments of the reviewer have been responded to and the required changes have been made in the manuscript.

a) The description of the methodological link between Multiresolution decomposition of signals and Event synchronization could be explained in more detail. Section 2.1 Discrete wavelet transform, in my opinion, should be rewritten more clearly, probably using a less generic formalism and adding a more explicative figure than figure 1 of the multiresolution decomposition.
Author's Response: We thank the reviewer for pointing out this critical issue. In the revised version we have given a detailed figure (Fig. 3) explaining the methodological link between multiresolution decomposition of signal and synchronization.

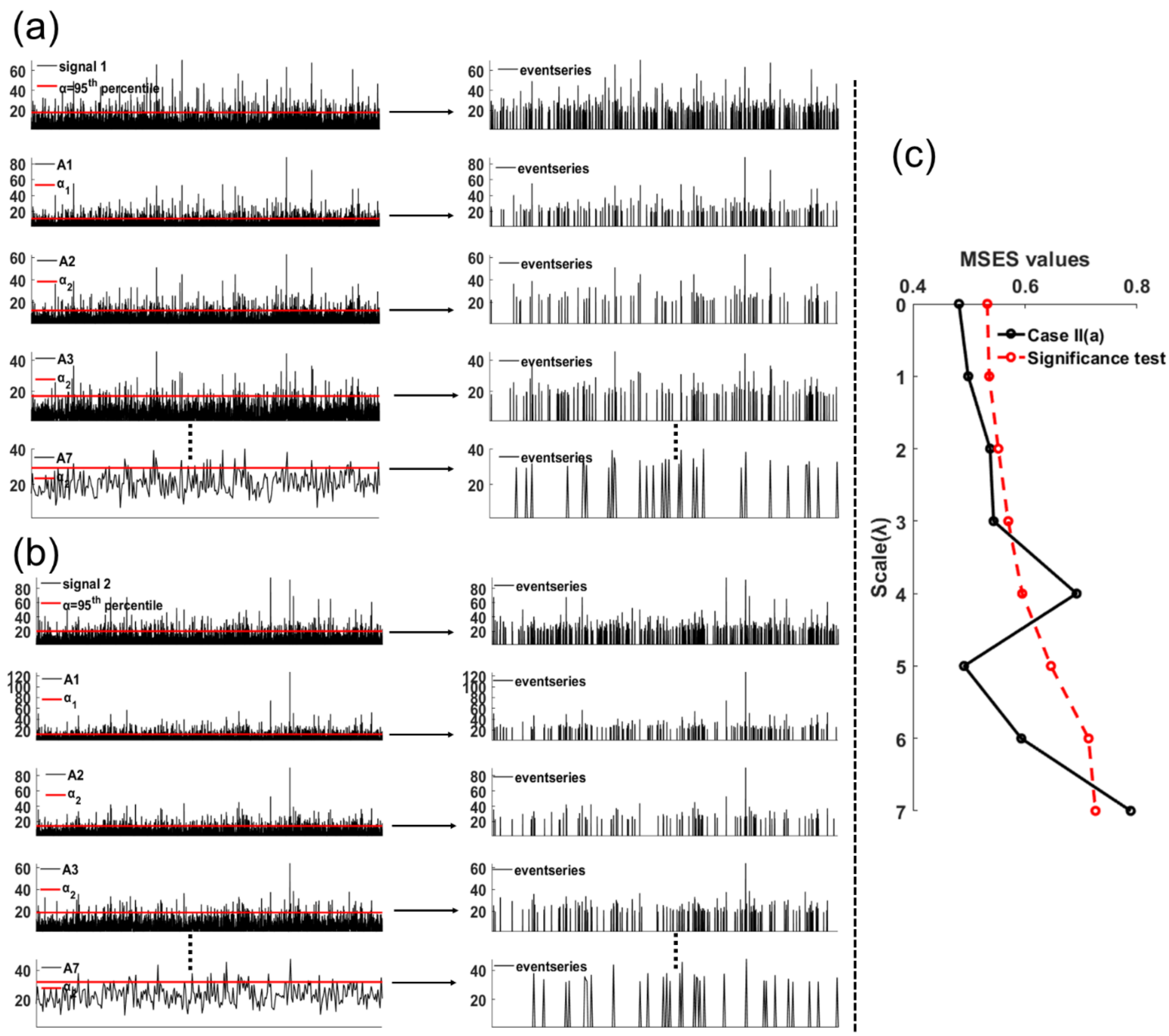

Figure 3 Multiscale event synchronization (MSES) stepwise methodology. (a) Signal 1 and its decomposed component along with corresponding event series after applying the (95th percentile) threshold. (b) Same for signal 2. (c) Event synchronization values corresponding to each scale.

The authors feel that section 2.1, giving the mathematical basis of MSES, is needed for clear understanding. However, the authors have accommodated all other suggestions.

b) How the continuous signals at the different scales have been converted to binary vectors in order to apply ES is just mentioned, but what thresholds have been used and why is never written in the manuscript;

Author's Response: We apologize that we have not been exact enough at this place. In the revised version we have now included details of this procedure to ensure the reproducibility. <u>The threshold chosen for converting a timeseries into event series has been mentioned in the text (page 5, line number 9) and Fig. 3.</u>

c) There are some parts of 'Section 4 Results' that should be developed in more detail, especially, the results concerning not stationary time series IIIa and IIIb. More discussion about the capability of the approach to treat with non-stationary time series and to capture emerging scales would enhance the paper contents.

   What are the differences between this approach and the multi-wavelet approach by Hu and Si (2016)? Since the papers use the same synthetic time series should be interesting to compare the two different approaches, their advantages, and limitations.

Author's Response: We thank the reviewer for demanding a necessary explanation that definitely would increase the understanding and readability of the paper. In the revised version we have extended the discussion on the case III which is as follows:

"Case III(a) is used as an analogue of dynamics and features of natural processes (Table 1). Its WPS (Figure 4 Panel III) shows non-stationary, time-dependent features at higher scales $2 \leq \lambda \leq 6$*. ES values at lower scales* $\lambda \leq 1$ *are below the significance level, revealing that the two signals are not synchronized (Figure 8a). The ES for the signal components of the larger time scales reveals significant synchronization up to scale 6, which is expected because of the common features (scale 2 to scale 6) in S1 and S2. After scale* $\lambda = 6$*, the MSES value drops below the significance level as the features responsible for synchronization are removed in form of the details component during decomposition. Results from this case show the wavelet's ability in capturing the underlying multiple non-stationarities that are common in both the time series which otherwise go unnoticed using ES at the observation scale."*

"The similar case III(b) is used to investigate the behavior of MSES in a scale-emerging process in a non-stationary regime (Table 1). As the wavelet spectrum of the signal reveals, only features at scales 5 and 6 are present (Figure 4 Panel IV). The corresponding MSES values are significant only at those scales (Figure 8b), revealing the synchronization at scales 5 and 6. This case illustrates that MSES reveals only the relevant timescales and does not mix them with the observation scale. In reality, there may be situations where the causative events act only at certain time scales and remain unconnected at other time scales. Under such situations MSES is useful to unravel the relevant scale emerging relationships."

Even though we have used some of the synthetic time series of Hu and Si(2016), the aim of the latter was to propose a method to determine the proportion of the variance of a response variable that is explained by predictor variables, at a specific scale and location (spatially or temporally). In contrast, our work deals with analyzing the synchronization between two variable at different scales. Therefore, we feel that the comparison between the results from both studies may not be meaningful.

d) The quality of the figures should be improved: 1. Figure 1 has distorted axes. Font size should be increased. 2. Figure 2 Font size should be increased 3. Figure 5, 6,7,8,9 have distorted axes. E.g. they are squeezed or elongated.

Author’s Response: In the revised manuscript Figure 1 has been removed and the required information on the methodology has been provided in Figure 2. All other figures have been improved to the required quality.

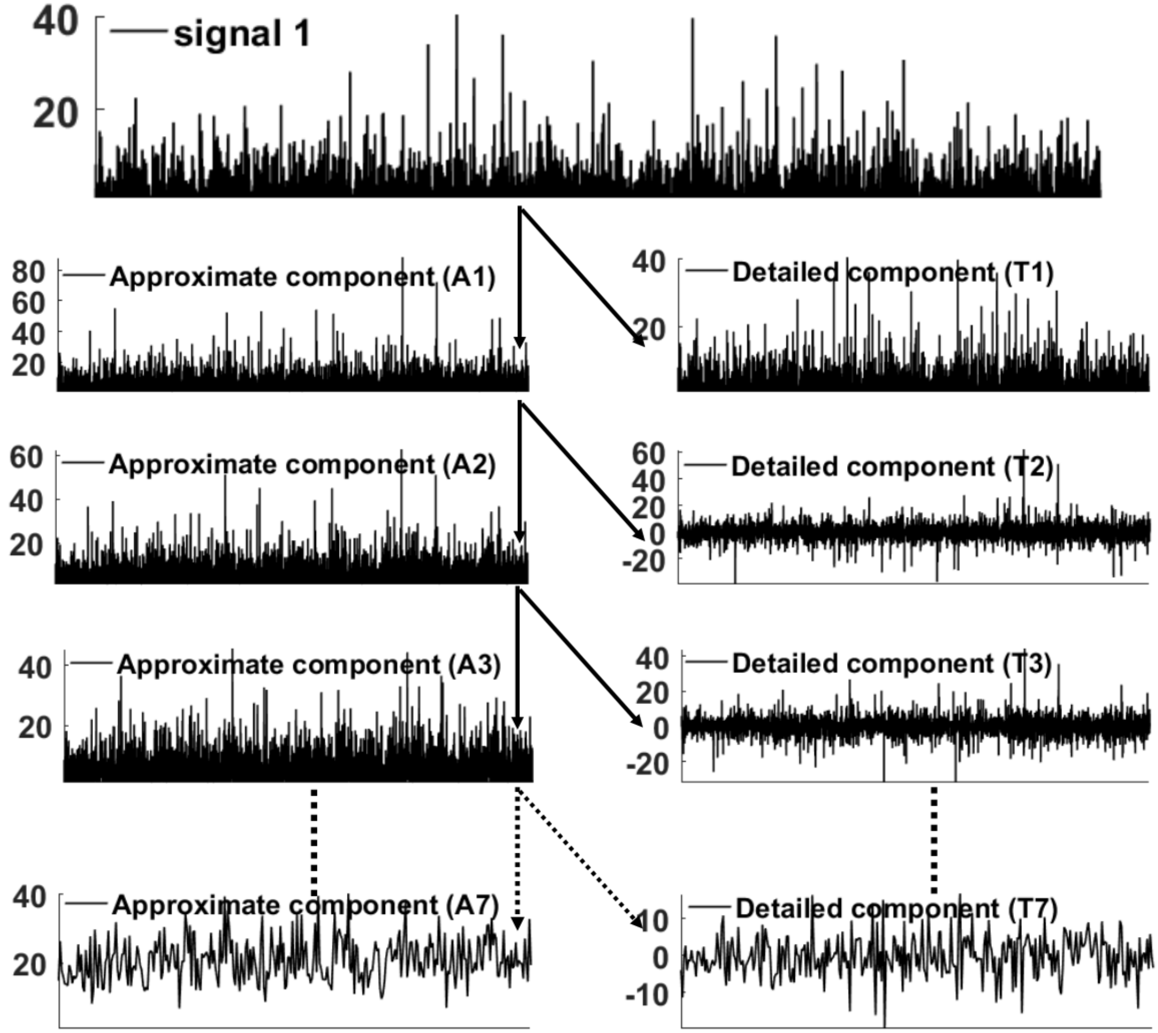

Figure 1 Scheme of Multi-Scale decomposition of signal using discrete wavelet transformation (DWT). The relationship between signal, approximate component and detailed component is shown.