Summary

The author is grateful for the constructive comments provided by the reviewers. Substantial modifications have been made to the revised manuscript. The overall length of the manuscript has been reduced by nearly five pages. Some subsections containing redundant information have been deleted. Sentences throughout the manuscript have been simplified and numerous paragraphs have been consolidated. The reduction in text volume allows the cumulative areawise to be better emphasized and also enhances the overall readability of the manuscript. Additionally, the formalization of the persistent homology method enhances the readability of Section 3. Provided below are the reviewer comments in bold text and the responses to the comments.

Reviewer 1

General comments:

1) The manuscript is lengthy and poorly constructed. The linkage between sections and subsections is weak. Some materials have been repeated again and again in the manuscript, making it very boring. Simplification to the manuscript is strongly recommended to enhance its readability.

To reduce the length of the manuscript, subsections 4.2 and 4.3 were deleted, as the material in those subsections was repeated later in the manuscript. The length of the manuscript was also reduced my consolidating numerous paragraphs throughout the manuscript and deleting unimportant information. The overall structure of the manuscript has also been modified. The main changes are in Section 2, which is now Section 4 (see comment 20).

2) The main focus of the manuscript is on the cumulative areawise test. The author should put more effort to highlight it. Including a higher proportion of text for introducing this new test may help. The ratio of the summary of existing significant test to the new test is about 1:1 now. The author is advised to increase the proportion for the new test, at least to a ratio of 1:2.

The author agrees that too much emphasis was placed on the existing procedures. To put more emphasis on the cumulative areawise test, the description of the existing procedures has been shortened. For example, text composing paragraphs on pages 1233 through 1235 have been consolidated and rewritten, which resulted in Section 2 (now Section 4) being much shorter.

3) Some materials do not contribute much to the understanding of the test. It gives a feeling that the author tries to insert everything he knows. The author is suggested to make good use of the citation concept. Readers are expected to refer to previous publications for details of some less important information.

Some materials and corresponding figures have been deleted. For example, panel b of Figure 5 has been deleted, as it was shown in Schulte et al., 2015. The reader is now referred to the paper. The text describing Figure 5a has also been removed. Lines 12-15 defining a hole has been removed, as it was found to contribute nothing to the understanding of the cumulative

areawise test. The details of the geometric test have also been removed. The reader is now referred to Schulte et al., 2015 for more details of the testing procedure.

4) Sentences are tedious. The author should try to keep the sentences simple but precise.

Throughout the manuscript sentences have been simplified and made more precise.

5) The inclusion of four different climatic oscillation indices as examples does not seem necessary. The author should try demonstrating the techniques using one or two examples. Alternatively, the author may also demonstrate the test using other wavelet techniques, e.g. wavelet coherence (also refer to other comments).

The cumulative areawise test is now demonstrated using only the PDO and Nino 3.4 indices.

6) The Nonlinear Processes in Geophysics is a journal for the publication of researchers on nonlinear processes in geophysical applications. Therefore, the geophysical applications should not be only an example.

Physical interpretation of results has been largely excluded from the manuscript. As suggested by Reviewer 2, the main focus of the manuscript should be on the development of the test, not its application. The examples used in the paper are to provide important benchmarks for further application of the new testing procedure.

Specific comments:

1) Page 1228, lines 10-15: The examples used and their results are not the most important message of the paper. The sentences "The new testing procedure was applied . . . was found in the 2-7 year period band for the Nino 3.4 index" is suggested to be removed or simplified to one sentence, e.g. "The new testing procedure is demonstrated by applying to various climatic oscillation indices".

Lines 10-15 have been removed to allow more emphasis on the cumulative areawise test.

2) Page 1228, line 17: First paragraph of introduction does not seem necessary. It contains too much information about wavelet applications. The main focus of this manuscript should be on the significant test. The author should give one or two sentence brief introduction about wavelet and then connect it to the second paragraph.

The first paragraph of Section 1 has been substantially shortened and now contains three sentences.

3) Page 1229, lines 13-14: The sentence "In geophysical applications, for example, red noise is typically chosen as the null hypothesis." can be removed, as this piece of information appears in section 2.2.

Lines 13-14 on page 1229 have been removed.

4) Page 1229, line 19-21: The sentence "Despite the insights gained . . . simply due to multiple testing" can be reformed to "Despite the insights gained from the statistical procedure, Maraun and Kurths (2004) showed that it can lead to many spurious results due to multiple testing."

The suggested change has been adopted.

5) Page 1229, line 23-27: The summary on the areawise test developed by Maraun etal. (2007) can be more precise. The author may refer to the abstract of Manraun et al. (2007).

Lines 23-27 on page 1229 have been made more precise.

6) Page 1229, line 24-27: Please remove the sentence "though dramatically reduce the number of spurious results".

Lines 24-27 on page 1229 have been removed.

7) Page 1230, lines 3-10: This paragraph can be simplified and merge with the precise paragraph. Emphasizing the difference between the areawise test and geometric test should be good enough, as areawise test has just been introduced. The sentence "Like the areawise test, . . . allows patches at different periods to be compared simultaneously" does not seem necessary.

The paragraph corresponding to lines 3-10 has been merged with the previous paragraph. Some text in lines 3-10 has been deleted has as well.

8) Page 1230, line 17: Could real be a better word than present in "In the present case"?

In an effort to shorten the paragraph corresponding to lines 11-28 on page 1230, Line 17 and other lines have been deleted.

9) Page 1230, lines 11-28: This paragraph is supposed to state clearly the objective of the manuscript. However, it is poorly written and the objective is ambiguous. Putting the last few sentences "This test has the important feature that the significance of the wavelet power . . . a consistent statistical construction" at the end of this paragraph does not seem appropriate.

The paragraph corresponding to lines 11-28 on page 1230 has been completely rewritten. The objectives of the paper are now clearly stated at the end of the paragraph. Furthermore, sentence structure has been simplified. The last few sentences "This test has the important feature that the significance of the wavelet power . . . a consistent statistical construction" have been deleted.

10) Page 1231 lines 2-5: The author may consider deleting "including the sensitivity of the geometric test. . . to the development of the new testing procedure"

Lines 2-5 on page 1231 have been deleted.

11) Page 1231 line 11: Why is wavelet analysis under Section 2? It is not a significant test.

The introduction to wavelet analysis has been moved to its own section (now Section 3).

12) Page 1231 lines 12-18: Is there any special reason to include a long paragraph introducing Morlet, Paul and Dog wavelets? It is understood that the cumulative areawise test is demonstrated using different wavelets in section 4, but their results do not seem to be different. The author is advised to pick one for demonstration purpose.

The cumulative areawise test is now applied using only the Morlet wavelet. A paragraph in the conclusion/discussion section has been added that briefly summarizes the results for the other analyzing wavelets. Text corresponding to the discussion of results for the Dog and Paul wavelets has been deleted throughout the manuscript.

13) Page 1231 lines 12-18: The author actually may consider removing the introduction of wavelet analysis. The readers should already have some basic knowledge about wavelet analysis before reading a paper related to its significant test.

The introduction of wavelet analysis is still present in the revised manuscript (now Section 3). The brief introduction will provide a quick review for those familiar with wavelet analysis and useful references for those seeking a better understanding of wavelet analysis. Nevertheless, the introduction section has been substantially shorted.

14) Page 1233 lines 8-9: The sentence "In spectral analysis, . . . against a noise background" can be removed.

Lines 8-9 on page 1233 have been deleted.

15) Page 1234 lines 3-23: This paragraph basically introduces the example and data used. The author should include a section introducing the data used before section 2. Including all these in section 2 makes the manuscript very messy. Please refer to Grinsted et al. (2004).

A subsection describing the data has been added and is now Section 2 of the revised manuscript.

16) Page 1234 line 24: To simplify the manuscript and give it a better structure, the author should consider introduce all existing significant tests first and then demonstrate them all together using one or two example. Some comparisons can be easily made as well.

The existing testing procedures are now introduced first in Section 2 (now Section 4). The application of the tests is now the final subsection of Section 4 in the revised manuscript.

17) Page 1234 line 24: If there is no special reason to include four examples, the author should consider use one or two examples to demonstrate all the significant tests. Actually, using idealized examples may also be a possible way of demonstration.

The techniques is now demonstrated using two examples, one for the PDO index and one for the Nino 3.4 index.

18) Page 1235: Why is areawise test by Maraun et al. (2007) left out in section 2? It is a little bit weird, as the author did introduce it in introduction.

The author agrees. A new subsection (now subsection 4.2) has been included in Section 2 (now Section 4) that describes briefly the areawise test. The geometric test is also mentioned briefly to enhance readability and to decrease the length of the manuscript (see also comment 3).

19) Page 1237 line 4: What is the purpose of including a sensitivity test for geometric test corresponding to different pointwise significant level? Are these results previously been documented? If not, it shouldn't be put in Section 2, which is supposed to be a summary of existing significant tests.

The results of the sensitivity test for the geometric test are presented to quantify the binary problem of the test. The results have been moved to a new section (now Section 5). The inclusion of this section is motivated by how the quantification of the binary problem of the geometric test has not been documented.

20) Pages 1231-1238: The author may consider to reconstruct Section 2 by first give a summary on pointwise test, and then introduce areawise test, with emphasis on its improvement to pointwise test. Further, geometric test may be introduced as a simplified version of areawise test. And then conclude the section with special stress on the binary decision problem suffered by areawise and geometric test and demonstrations of different significant test.

Section 2 (now Section 4) has been reconstructed with the suggested structure as described in the response to comment 16.

21) Page 1241 lines 17-18: It is confusing to refer cumulative areawise test as areawise test, as readers may mess it up with the areawise test developed by Maraun et al. (2007).

The areawise test is now referred to as the cumulative areawise test throughout the manuscript.

Other comments:

In author's previous paper (Schulte et al. 2015), it was mentioned that the geometric test has an advantage of applying to other wavelet applications, e.g. wavelet coherence (Grinsted et al. 2012), partial wavelet coherence and multiple wavelet coherence (Ng and Chan 2012). Is the new cumulative areawise test also applicable to these wavelet applications? If yes, it would be good to include this piece of information in this manuscript as well. Also, the authors may consider demonstrating the cumulative areawise using wavelet coherence, which should be of great interest to many readers.

A paragraph has been added in summary/discussion section (now Section 10) that describes the application of the procedure to wavelet coherence, partial coherence, and multiple coherence.

References:

Grinsted, A., Moore, J. C., and Jevrejeva, S.: Application of the cross wavelet transform and wavelet coherence to geophys- ical time series, Nonlin. Processes Geophys., 11, 561–566, doi:10.5194/npg-11-561-2004, 2004.

Maraun, D., Kurths, J., and Holschneider, M.: Nonstationary Gaussian Processes in Wavelet Domain: Synthesis, Estima- tion, and Significance Testing, Phys. Rev. E, 75, 016707, doi:10.1103/PhysRevE.75.016707, 2007.

Ng, E. K.W. and Chan, J. C. L.: Geophysical Applications of PartialWavelet Coherence and Multiple Wavelet Coherence, J. Atmos. Oceanic Technol., 29, 1845–1853, 2012.

Schulte, J. A., Duffy, C., and Najjar, R. G.: Geometric and topological approaches to significance testing in wavelet analysis, Nonlin. Processes Geophys., 22, 139–156, doi:10.5194/npg-22- 139-2015, 2015.