

Summary

The authors appreciate the additional comments and suggestions, which have been incorporated in the revised manuscript. The only large change to the manuscript was the removal of the local auto-bicoherence results for the Nino 3 and Nino 3.4 indices. Changes to the manuscript are highlighted in green and deletions are highlighted in red. Page and line numbers correspond to the tracked version of the manuscript. Reviewer responses are in bold text and our response are in plain text.

Reviewer 1

The purpose of this paper is to apply novel methods for bivariate, nonlinear wavelet analysis to understand whether apparent changes in the relationship between indices for ENSO and the Indian Monsoon represent fundamental changes in their relationship. Since the previous submission, the authors have thoughtfully responded to all my comments. I recommend this paper for publication in HESS, pending very minor corrections.

- **providing a link to the R software is helpful – I suggest either archiving the particular version of the software used for this code on a repository like Zenodo that generates a permanent DOI, and/or including the code for the online supporting information with this article**

The authors appreciate the suggestions for the possible places to post the software. The code will be posted online in a repository if the manuscript is accepted.

- **the distinction between “linear coherence” and bicoherence is helpful**
- **wording and formatting comments were addressed and the overall organization of the manuscript was streamlined**
- **clarification of the types of nonlinearities that the analysis can identify is useful**
- **figures are improved**
- **response to questions about the quality of rainfall and ENSO data is reasonable. The authors should note that this analysis neglects uncertainties in the data themselves, but since the objective is to demonstrate the wavelet method, addressing uncertainties in SST reconstructions should not be a priority**
- **discussion of the choice of Morlet wavelet with $\omega = 6$ is reasonable**

The document needs some copy editing – this is beyond the scope of this review although

Extensive copy editing was applied to the revised manuscript.

some comments are provided for the abstract:

L10 “temporally changes” should be “changes in time”

“temporally changes” has been changed to “changes in time” on Line 10.

L11 “changing nonlinear characteristics” is a bit unclear – specify

“changing nonlinear characteristics” has been changed to “skewness” on Line 11 to be more specific.

L16 “India sub-continent” should be “Indian”

“India sub-continent” has been changed to “Indian” on Line 16.

Reviewer 2

GENERAL COMMENTS

The manuscript has been significantly improved, but there are some points where it could still be improved for more clarity and readability. My comments are given below and some examples that the authors could consider to make the paper more understandable to readers.

COMMENT: In Introduction, the prediction of South Asian Monsoon using ENSO is problematic given their complex relationship in time domain and frequency domain. However, there have been new studies accounting for differences in spectral attributes which improve prediction performance using wavelet analysis. For example,

Jiang, Z., Sharma, A., & Johnson, F. (2020). Refining Predictor Spectral Representation Using Wavelet Theory for Improved Natural System Modeling. Water Resources Research, 56(3), e2019WR026962. doi:10.1029/2019wr026962

Authors may want to have a look and include some discussion in Introduction as a possible means of improving their assessment further through the latest refinements in wavelet methodology.

We appreciate the reference to this relevant paper. We have added a brief discussion about the paper on Page 9 Line 65.

COMMENT1: The way to compute monthly anomaly = monthly – monthly climatology over a baseline period, so given different base period in most cases it won't be uniformly up or down. **Authors must have misunderstood something referring to Line 421-423:**

“To remove the influence of the annual cycle, the time series was converted into anomaly time series by subtracting the 1871-2016 long-term mean for each month from the individual monthly values.”

We appreciate the clarification regarding the chosen base period. However, we still feel it is best to use long-term means because it makes it easier to compare recent El Niño events to others that have occurred in the past.

COMMENT2: Authors focus on the skewness, but throughout there is not clear definition or quantification of skewness you used in this work. Only a paragraph discussion is given in the introduction (Line 370 to 382). I would suggest adding a description in the Method section.

The mathematical definition of skewness is now included in the methods section of the revised manuscript on Pages 4-5 Line 175-180.

COMMENT3: Section 4.2, you probably mess up with figure captions. Figure 4 shows the correlation while Figure 5 gives skewness. Same in Section 4.3. Also, I would suggest authors combine section 4.1 and 4.2 since they both discussed the relationship between the correlation and skewness.

We appreciate the identification of the errors in the figure captions, which have been corrected in the revised manuscript. The authors agree that Sections 4.1 and 4.2 can be combined. The two sections are now combined and section numbers throughout the manuscript have been adjusted accordingly.

COMMENT4: Section 4.3, I would suggest authors keep the x-axis labels of Figure 4 and 5 consistent with Figure 6 and 7. So readers can easily refer to each other. Also, the auto-bicoherence of Niño 3 and 3.4 are not shown in the main context or supporting information. However, one entire paragraph is discussed about this. I would suggest authors to add the results of Niño3 and 3.4 to both Figure 7 and 8.

X labels for all figures have been standardized to help readers refer to plots. For consistency, the results for Niño 3 and Niño 3.4 are not shown to help the reader focus on the results for Niño 1+2 and Niño 4 indices. We decided to make this change because other sections do not show results for the Niño 3 and Niño 3.4 indices. The one exception is for Section 4.5 because the Niño 3.4 index findings in the full auto-bicoherence spectrum are needed to make the spatial auto-bicoherence plots. The paragraph discussing the Niño 3 and Niño 3.4 index local auto-bicoherence results was deleted, though some discussion of the results was moved to the discussion section.

COMMENT5: Section 4.4, the second paragraph is talking about Figure 8 not Figure 10 (There are many other places in the manuscript, e.g. Section 4.5). This might be due to the review

process, but authors need to read through the paper and make sure the content and figure are associated with each other.

Figure references have been corrected throughout the manuscript.

COMMENT6: Figure 12-15 now are not discussed in the revised manuscript, so it can be removed. Even though Table 1 is included in the end, it is not cited or discussed anywhere in the main context. A discussion should be added to clarify the difference among them.

The authors are unsure how to address this comment because the revised manuscript contains 13 figures. Table 1 is cited in the methods section (e.g. Line 151 Page 4) and descriptions to the methods are provided in the main text and Table 1.

SPECIFIC POINTS:

1. Line 396: keep the numbering format consistent. 1) -> (1)

Formatting has been corrected throughout the manuscript.

2. Where is abbreviation AIR in Data section?

The abbreviation is located on Page 3 Line 119.

3. Line 454: 3.1 Wavelet Analysis and hereafter

It is unclear to the authors what change is suggested.

4. Line 464: Readers are referred to...

The word "is" was changed to "are".

5. Line 588: Eq. (12)

The equation number was corrected but was adjusted because of the addition of the skewness equation.

6. Line 517: should be $B_{\text{local}}(s_1, s_1)$?

Texted has been change to $B_{\text{local}}(s_1, s_1)$. Note that the notation has been changed to B_n to make equations easier to read.

7. Line 526: should be $\phi_n(s_1, s_1)$?

Text has been changed to $\phi_n(s_1, s_1)$

8. Line 629: small capital $w_F(t)$

Notation is now consistent throughout the text. Capitalization was used because that is what is used in the equations.

9. Figure 3: ylab: Nino 1+2

Axis label was corrected.

10. Line 688: it should be Nino 4 time series?

Because of line number discrepancies between the revised manuscript and those reported in this review, we could not find the suggested change. A careful reading of the manuscript did not identify any such error though.

11. Line 713: should it be (Figure 4a and 4b)

Because of line number discrepancies between the revised manuscript and those reported in this review, we could find the suggested change.

12. Figure 10 and 11: The ylab is from 20N to 20S.

The axis labels have been corrected.

13. Line 1117: The R software link missing. These methods...

The link is provided on Page 12 Line 521 of the revised manuscript.