

Comments on HESS-2019-280: A Skewed perspective of the Indian rainfall-ENSO Relationship

August 22, 2019

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. The methods are based on those published in previous peer-reviewed papers by the authors, and so this paper can be viewed as an application of these methods to a relevant and interesting scientific problem. These tools for higher-order wavelet analysis allow the authors to quantify the nonlinearity of ENSO and indices for the Indian monsoon. The authors conclude from this analysis that ENSO nonlinearity is related to ENSO flavors, and that the apparent changes in the relationship between ENSO and Indian rainfall are also related to ENSO flavors. Finally, the authors use these findings to re-interpret findings by Yun and Timmermann (2018) which suggest that the breakdown of the ENSO-India rainfall relationship is related to shifts in the linearity of the ENSO regime. Specifically, the authors argue that the nonlinear relationship identified by their higher-order wavelet model will have non-Gaussian noise components, potentially confounding the alternative analysis. While this paper is unlikely to be the final word on this debate, it is a clear, well-written, and important contribution to the study of the ENSO-Indian rainfall relationship, and to time series analysis more broadly, and should be published pending minor stylistic edits.

I also note a lack of a data availability policy.¹ Making the code and data used to others would help other researchers apply these methods to other time series.

Specific comments

- L9: It took me a while to understand the similarities and differences between the terms auto-bicoherence, bicoherence, coherence, etc. The auto-bicoherence is defined later, but perhaps a simple table or sentence near the introduction explaining the difference between these different terms would be helpful. (I am flagging this in the abstract but the clarification could happen elsewhere)
- L48: consider rephrasing “investigators”
- LL58-59: there are also concerns about data quality – would be worth at least referencing or discussing them

¹https://www.natural-hazards-and-earth-system-sciences.net/about/data_policy.html

- L95 and beyond: please consider converting from month^{-1} to year^{-1}
- L117: are there possible data quality issues with the rainfall data?
- L135: the formatting here has changed
- L146: are there cases where very small events (say a single month) emerge? If so how are these handled?
- L156: Consider re-wording to continuous wavelet transform of a time series $X = \dots$ as a function of wavelet scale s is given by
- L160: if this transform is commonly used please cite. Are results sensitive to choice of wavelet form or to choice of ω ?
- L188: it would help to be clearer here about what sorts of nonlinearities this analysis can pick up, which sorts of nonlinearities it cannot pick up, and what sorts of nonlinearities have been hypothesized or observed in ENSO time series.
- L200: see above comment regarding distinction between coherence, auto-coherence, etc.
- L464: if there are spatial shifts happening that are related to ENSO, this could potentially complicate some of this analysis correct?
- L545: Consider re-wording “despite how”
- L595: what is your interpretation of the finding that the modes found are not harmonics of 12 months? Given that the seasonal (12 month) cycle is important here and many of the other modes may be coupled to it, it would be useful to explain to the reader why other modes emerge as important.
- L610: this is an important point which the authors should consider emphasizing in the abstract
- Figure 5: consider adding color
- Figure 6: consider plotting the global (average) wavelet spectrum adjacent
- Figure 7: please fix titles
- Figure 8: the figure has gotten clipped at the left margin
- Figure 9: this is the wrong place to bring this up but it would be helpful to add some discussion in the methods section, specifically around hypothesis testing, about what the 5% cumulative area-wise significance means and how to interpret it.
- Figure 11: please clarify why these pairs were chosen

References

Yun, Kyung-Sook and Axel Timmermann (2018). “Decadal Monsoon-ENSO Relationships Reexamined”. *Geophysical Research Letters* 45.4. DOI: 10.1002/2017GL076912.