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Interactive comment on "Identifying global patterns of stochasticity and nonlinearity in the Earth System" *by* Fernando Arizmendi et al.

Anonymous Referee #2

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In the article "Identifying global patterns of stochasticity and nonlinearity in the Earth System", the authors use two metrics to characterize the properties of air surface temperatures (SAT) in the ERA and the NCEP reanalyses. The authors claim that the distance between the lagged SAT time series and the insolation allows to quantify whether the insolation is the main responsible of local SAT variations. They also suggest that the Shannon entropy is a measure of stochasticity of the SAT time series.

I like the idea of using dynamical metrics to undercover properties of the climate system but I find that the work by Arizmendi et al. does not provide enough elements to support the claims of the authors. I will try to highlight the problems of the manuscript on different levels. I hope that the authors will consider my suggestions to rethink/rewrite their work that, in my opinion, should not be further considered for publication in ESD.

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Discussion paper

1) Methodological problems: everywhere in the manuscript there is confusion between: forcing, physical processes, internal variability, turbulence-uncertainty-stochasticity. I suggest the author to revise the book: “Chaos And Turbulence: An Introduction To Nonlinear Dynamics And Complex Systems” by Paul Manneville, which explain most of those concepts. In particular they write in the introduction that: “... because of the physical processes that govern our climate (ocean and atmospheric processes, solar forcing, vegetation, human activity, etc.)”. In my view, ocean and atmospheric processes are physical processes of the climate system while solar forcing is an external driver that sets the climate system out of equilibrium. Another important point is about the Shannon entropy: I strongly disagree that entropy is a measure of “stochasticity”. The adjective stochastic refers to the random behavior of a system which is not the same as “disordered” in the sense of Shannon. Well-known examples are the class of deterministic chaotic dynamical systems (Lorenz 1963, Rossler, Henon, ...) that have a certain degree of disorder although they have no stochastic components. If the authors really wants to test the stochasticity of the SAT time series, I strongly reccomend to use the results by Rosso, O. A., et al. "Distinguishing noise from chaos." Physical review letters99.15 (2007): 154102. Last but not least, the stochastic behavior observed by the authros could also be due to turbulence: turbulence is different from noise, as the authors know for sure. The authors never comment on the role of turbulence while, especially at the tropics, turbulence is an important player for the atmospheric dynamics.

2) Organization/interpretation of the results: The link between PDF shape, extreme values and Shannon entropy is not shown/explained. The authors make a list of processes that, when the insolation is not linked to the local SAT, should be responsible for the variations of SAT, but they do not provide any analysis or physical justifications of their speculations. In the manuscript, it is claimed that Shannon entropy is good at distinguish ERA from NCEP reanalysis but how this compares to simpler statistical metrics like the difference in the local SAT means, variance, skewness, ...? Why the authors do not provide maps of differences between ERA and NCEP reanalyses? Is it because the datasets are at different resolutions? If the answer is yes, how do

they consider the impact of different grid-sizes on the results? The authors normalize the distances by subtracting the mean and dividing by the variance and claim that this removes all the memory effects. This is false: it removes memory effects up to the second order, but there could be higher order memory effects still hidden in the datasets. Finally, the supplementary information is too short to justify the need for a separate document. I suggest either to expand (for example by comparing the authors' metrics with simpler statistical metrics) or integrate the results in the main text.

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