

Interactive comment on “Reconstructing coupled time series in climate systems by machine learning” by Yu Huang et al.

Anonymous Referee #1

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This manuscript investigates the potentialities of reconstructing time series using machine learning (ML) techniques. This approach is applied on a set of simple systems, and then applied to the interaction between the Tropical surface temperature and the Northern extra-tropical surface temperature. Different configurations of the machine learning approaches are explored, the reservoir computing, the long short-term memory, but also a simplified version of the latter and back-propagation. The authors use the correlation (for linear systems) and the convergent cross mapping (for nonlinear systems), CCM, as tools to evaluate the ability of the machine learning approaches to reproduce the original time series. Although I find the idea of putting in parallel the CCM with the ability of reconstructing time series based on ML very interesting, the description of the tools and the results is confusing, the presentation is quite poor and

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many details on the approaches used are missing.

My first main point is the confusion present in the notation of input/output and the notion of directional dependence. Let me clarify my point by considering Table 2 in which the results for the Lorenz 3-variable system are displayed. The first column indicates the input of the ML approach (also indicated $a(t)$), the second the output of the ML (also indicated $b(t)$), while the fourth represents the CCM dependence. The later, as defined at lines 291-297, has high values if $b(t)$ influence $a(t)$. So according to that table if $b(t)$ is influencing $a(t)$ I should get good results of fitting from $a(t)$ to $b(t)$. I am really confused with this claim. I have the same problem with the other tables, and in particular with Table 4 which is even more confusing when related with the discussion in the text. In the table it is indicated that TSAT influences strongly NHSAT but then the ML modelling is done from NHSAT to TSAT. This is what is claimed at lines 463-464, while in the conclusion it is said (line 542) that the TSAT is mainly influencing the NHSAT. I hope this is just a matter of confused notation but I am not sure and I strongly recommend the authors to revisit carefully their notations and interpretation carefully.

A second important concern is the way the ML is used. In Figure 2 there are three parts but it seems to me that the ML system is composed of the two first ones, the third one being the application of the optimized system to new input data. So It should be worth to split both and also to clarify the details of the Machine Learning underlying structure, number of nodes, number of layers (if any)... Details on the different ML systems used are necessary. A detailed description is also missing for the CCM method.

These two main problems prevent me to recommend publication of this manuscript at this stage although the main question addressed is very interesting (CCM vs ML). A considerable effort of clarification and rewriting is necessary.

More specific points:

Line 54: What does mean “wile physics of systems is suggested for consideration”? Please rephrase.

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Lines 57-58. You probably meant that: sensitivity to initial conditions is a property of the underlying system giving rise to the climate time series. Chaos theory is a framework in which this type of dynamics can be described. Please rephrase.

Line 67. What is nonlinear correlation? I think that this is not an appropriate terminology. Please revisit your manuscript with that in mind.

Line 72. You speak about “trajectories”. Maybe this is more “relationships”.

Line 87. “hided”?

Line 111. “learnt” should probably be “reconstructed”

Line 115. “learnt” is probably “estimated” or “inferred”.

Figure 1. Why putting the training after the testing? It does not look natural (and also confusing).

Lines 175-178. Quite confusing. Please clarify the way prediction is done. I think that the presentation of the ML approach should be completely revisited.

Line 191. Why using this measure and why 0.1 is a good threshold? These should be detailed.

Line 212. Runge-Kutta integral? What does it mean? Maybe “integrator”?

Section 2.4.2. Please give more details on the way average is done, and whether the seasonality is removed and how? This also open the question on how the parameters of the ML are changing as a function of the season. There is not enough details on how the datasets are handled.

Lines 295-296. Sugihara (1994). This reference does not exist in the reference list. What is “empirical dynamics model? Much more information is needed on the way it is used. Embedding dimension and so on.

Line 302. What is “unstable local correlation”. What is this?

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Table 2. As already mentioned in my main comment, very confusing. Please modify.

Figure 6. Some typos in titles. Also where is panel (d)? Is it (c)?

Table 3 and Fig 6. Why not using a multivariate CCM to compare with the ML fitting with multiple predictors?

Lines 536-543. Really confusing. What is influencing what? TSAT or NHSAT?

I have also noted many typographical errors, and the manuscript will benefit for a careful reading by the authors and by an English native speaker to rephrase some sentences.

Interactive comment on Earth Syst. Dynam. Discuss., <https://doi.org/10.5194/esd-2019-63>, 2019.

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