

Earth Syst. Dynam. Discuss., referee comment RC1
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Comment on esd-2021-61

Anonymous Referee #1

Referee comment on "The Pacific Ocean heat engine" by Roger N. Jones and James H. Ricketts, Earth Syst. Dynam. Discuss., <https://doi.org/10.5194/esd-2021-61-RC1>, 2021

The manuscript "The Pacific ocean heat engine" by R. Jones and J. Ricketts (ESD-2021-61) follows from a previous submission by the same authors: "The Pacific Ocean heat engine: global climate's regulator" (ESD-2019-72). It is an in-depth description of the so-called "Pacific Ocean heat engine", a climatological figure acting as a heat pump, delivering heat from a cold reservoir (the tropical Eastern Pacific) towards a warm reservoir (i.e. the Western Pacific, and in particular the warm pool). The heat engine is affected by external forcing and at the same time acts on the way the climate system responds to forcing, in terms of a heat-release mechanism. This is used to explain why the historical warming is better described as a succession of steady states and sudden jumps than as a trend-like behavior. This manuscript is the first of two twin papers, the second one, according to the authors, providing a link between the heat engine and the dynamics of the large-scale circulation.

Overall, I think that the choice of dividing the analysis from the previous paper in two parts has greatly improved the readability of the manuscript. I have also appreciated the fact that a comparison of different methods has been included in order to discuss the network of local and remote impacts of sudden jumps in the features of the heat reservoirs. I still think that, even though it is conceived as a mainly descriptive analysis, aimed at grounding the interpretation of the heat engine mechanism on observational evidences, the take-home message might be conveyed in a more incisive way, clearly distinguishing main results from those that are less relevant.

Provided that the authors take this into account, and address the (few) minor comments stated below, I believe that the manuscript can be accepted for publication.

Specific comments

- l. 32: talking about scaling, I think quite some work has been carried out (also with a focus on energetic matters, e.g. Faranda et al. 2018 JAS) on the scale invariance and multifractal structure of aspects of the atmospheric dynamics (see Lovejoy 2019 book,

for a recent review). It might be suitable to address it explicitly here;

- l. 250: among the fundamental aspects of the climate system related to the concept of efficiency, it is particularly relevant, given its global-scale nature, to mention the Lorenz Energy Cycle, being also often referred to as a heat engine (cfr. Lucarini et al. 2011);
- l. 304-307: I wonder if this period is really needed here;
- l. 335: I think it is not clear to every reader why the distinction between free and forced modes derives from having described the whitening of the time series as we approach the forced regime. Maybe some additional explanation might be helpful here, linking these conclusions to the description above;
- l. 364: I can see no Fig. 9a here. Possibly a mismatch in referencing the figures?
- Figures 9-10: describing the shift timing in the caption, rather than referring to Table S8, might be preferable;
- l. 418: I do not have clear why the description of all these shifting events is needed and why not picking only those that are remarkably different from each other, thus helping to convey the main message;
- ll. 473-474: I think this sentence deserves a bit of rewording;
- ll. 494-495: it might be better explained why the arguments below benefit from the comparison of these two different metrics, and why one needs to take them both into account;
- l. 684: after all the description of the relationship between TEP, TWP and AMO, I am a bit surprised that the authors claim the take-home message is that we have to increase our focus on Pacific-Atlantic linkages, as this is nothing really new to the community. I believe this could be rephrased in a more convincing way;
- l. 733-735: in the end, I found the section on Granger causality very hard to read. In particular, I think the relevant information is somehow hidden in a lot of other features that are barely mentioned and never linked to these conclusions. Authors might want to improve the readability of this section;
- ll. 825-826: this figure of the heat engine as a thermostat, maintaining the system at a somewhat steady state, is really intriguing, and I wonder if it might be related to the relatively stable intensity of the Lorenz Energy Cycle in response to different forcing, despite significant changes in its components (cfr. Lembo et al. 2019, Ma et al. 2021);

Technical corrections

- l. 255: TEP -> TWP;
- l. 265: GSMT -> GMST;
- l. 270: "which some" -> "which in some" (?);
- l. 284: "This only" -> "This is the";
- l. 540: remove "been";
- l. 586: "a" -> "are";
- l. 603: "influence" -> "influenced";
- l. 654: "follow" -> "following";