

Earth Syst. Dynam. Discuss., referee comment RC2
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Comment on esd-2021-61

Anonymous Referee #2

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-RC2>, 2021

The manuscript "The Pacific Ocean heat engine" by Jones and Ricketts addresses the role of the Western Pacific warm pool as a heat supplier to the globe, of which heat is transported from the eastern tropical Pacific. This supply occurred as stepladder-like rather than gradual warming during the observational period. (The importance of step-like warming is already reported in 2017 by the authors.) It also argues the shifts are related to longer variability such as PDO and AMO. The reviewer thinks this is a good storyline to explain the global warming hiatus where rather stable conditions are maintained. The abstract reads very well by pointing to this interesting result and the reviewer was keen to read the manuscript. However, the ways of presentation in the text (analysis, figures, and description) are not well structured. The reviewer has to admit that it was quite difficult to read the manuscript as the text is too descriptive, figures are not adequately shown, and figures captions do not explain clearly what is shown. It requires concise writing and succinct figures with clear representation. Also, further analysis to support the changes of heat is required as suggested below.

Here are some specific aspects that may help to revise the manuscript.

- SST changes include some aspects of heat transport in the climate system. However, it is difficult to conclude only from the SST (and air temperature) relationship between different locations to argue a rather bold statement of defining 'heat engine'. In certain areas. Although SST can be an indication of heat distribution, it is quite a noisy variable to specifically link heat move in the climate system. The authors even argue a mechanism of heat transport and dissipation, which is not analyzed at all. In addition to the SST, heat content (at least upper 700 m where observational (or reanalysis) data is available) and ocean-atmosphere heat exchange need to be analyzed. Particularly, heat content changes by ocean advection and net surface heat fluxes will be useful.
- All analyses are based on time series. Except for the global mean temperature, the choice of areas for calculating time series is subject to change the results, and having too many indices makes the comparison difficult as it is presented. It is also difficult to rationalize the movement of heat without seeing spatial distribution. A suggestion is

showing spatial maps of temperature differences that occurred due to step-like changes. As there are many step-like changes (each case can be called ensemble member), the ensemble mean of those cases must show a stronger signal over the TWP. If any roles of PDO and AMO are important, some features reminiscent of the modes can be seen in the ensemble mean or in some cases with time delay. Spatial patterns of individual cases will also be useful, e.g. relative role of different climate modes, e.g. PDO, AMO. Similar analysis can be done also with the heat content and surface heat fluxes data as suggested above.

- Years of the shift (step-like change) need to be consistent and marked on all relevant analyses. The years should be defined by global mean temperature because the main message of the manuscript is for global temperature changes. Many other years of shift based on different indexes (e.g. TWP and TEP) are introduced to track the sources of changes. However, as this is not compared with the years of global shifts, it is difficult to follow the arguments.
- Term 'steady-state regime' seems not correct as changes are happening also on a shorter time scale. A suggestion would be rephrasing the term or give a specific definition to be used in this paper.
- Defining free and forced modes and how those years are defined need to be given.
- Most of the figure captions do not include a detailed explanation and it is virtually impossible to reproduce or objectively understand the analysis. For example, Figure 1 and related text do not explain how the periods for trends and shifts are not chosen.
- Section 2.4: It is too lengthy and better to be incorporated into the introduction by reducing the text. In line 227, please also check whether winds turn east really during El Niño. It will be eastward anomalously.
- Section 3.2/3.3: As pointed above, a spatial map of SST (or surface air temperature) during the individual shift cases will help to support the role of individual factors used. Figs. 9-13: It looks the choice of factors is subjectively chosen for each shift. To be objective, authors may find ways to combine Section 3.2 and 3.3 and use PDO, AMO to link the TWP and TEP. I suggest excluding AMOC as no direct observations of AMOC are available for the whole period of the analysis. The AMOC index used here is a reconstruction from SST, and which can be projected already by AMO.
- Section 3.4: I have to admit that it is quite difficult to follow the argument. It is quite descriptive and the figures are quite complicated even without labeling of x- and y-axis in the figures.
- Line 25: Accompanying paper is not cited.