

Review of the manuscript 'The Earth's climate lagged, recurrent and non-linear solar and lunar multi-millennial scale responses: An oceanic hypothesis, evidence, verifications and forecasts' by Jorge Sánchez-Sesma (Independent researcher).

The author presents the 'Lagged & Recurrent Climate Hypothesis' (LRCH), claiming that much of the climate millennial scale variability (with periods between some hundreds of years and a few millennia) is driven by intrinsic solar variability and extreme tides associated with Sun-Earth-Moon orbital coincidences, reoccurring at certain repeated periods. Those extreme tides generate cooling of the sea surface by increased vertical mixing. The lagged response of that forcing in the surface temperature is driven by the Ocean conveyor belt (OCB) with the lag being the 'age of the water' roughly measured by the 'oceanic accumulated distance from the tropical East Pacific'.

The above mechanistic theory is quite simplistic and even not falsifiable according to a fundamental Popper's criterium (<https://en.wikipedia.org/wiki/Falsifiability>) for the validity of scientific theories, The justification of the theory is based on: 1) ad-hoc, physically not well-grounded arguments, generally taken from ancient literature and 2) a set of (non-statistically validated) fitting regressions using over-simplistic linear modulated/lagged models using as predictors extrapolated data by Fourier analysis of the total solar irradiance (TSI) at every 9.5kyr and of the tidal forcing at every 5kyr. The 9.5kyr solar recurrence is misleadingly supported by the same author in Sesma 2016 (SS16 in the manuscript) by a spectral analysis without any statistical significance study analysis of the spectral peaks. That replication (both in the past and future) for a multiple number of Fourier analysis time-series length (9.5 Kyr) is extremely dangerous due to the high dependence of phases of Fourier components from the analysis period. Moreover, the concept of 'age of water' is quite ambiguous because the OCB is a graph with multiple bifurcations, dispersion, stochasticity etc., hence not allowing to estimate the age of water by simple backward cinematics.

The author commits too many methodological and technical flaws in his presentation and discussion of results.

Moreover, the author does not cite or contextualize in his research, related (well supported and methodologically much more advanced) works studying the possible origins of the millennial variability at scales slower than that of Milankovitch forcings. In fact, it is an open discussion, far from being at the end, if the above referred variability comes mostly from the solar/tidal forcing or from the internal slow (not externally forced) variability of the climate system (Soon et al. 2016) or even from magnetic forcing.

The author's belief both in the LRCH and his simplistic model, led him to produce forecasts of the global surface temperature for the next decades, in a clear confrontation and contradiction with the decadal forecasts of the much more sophisticated and physically well-grounded models presented worldwide in the IPCC reports.

Despite the author's recognition in the conclusion of the paper, that his model deserves much more work and physical evaluation, the present work cannot be considered appropriate to be published in the scientific journal ESD.

Next, there are presented some of the major technical and methodological pitfalls of the manuscript:

- 1) Figure 1a is totally inappropriate
- 2) Figs 3a and 3b are not legible. The adapted Fig. 3c is too much stretched and without legibility.
- 3) The model in Eq. (1) of the climate proxy variable, uses the solar proxy variable  $S(t)$  which is supposed itself to be self-similar (with a 9.5kyr period). Therefore, any slower variability with periods larger than 9.5kyr is ignored. The regression score (e.g. MSE) of the fitting is never shown systematically for the tested climatic proxies neither compared against any 95%-expected score of a null-hypothesis model (e.g. an red noise AR1 model). Therefore, the absence of statistical validation is not allowing any attribution arguments of the variability to the tested external forcing.
- 4) Eq. (5) is completely out of the context and add nothing about the tidal forcing particularities.
- 5) The details of models (Section 4) should preferentially be presented in a Table.
- 6) Fig.4 is not clear at all. All panels (except panel b) present two curves which are not explained anywhere, even in the caption. Observed proxy data of some of the time-series does not match perfectly with graphs of the papers from which they were obtained. For instance: a) the Record crbT (green curve of fig 4a) seems to be a degraded representation of data presented in Fig. 2c of Weijers, *et al.*(2007). b) Record jriT (fig. 4b) representing the Northeast Antarctic Peninsula temperature, jriT (Mulvaney et al., 2012) should represent in effect an anomaly (with respect to the period 1961-1990) in the Antarctic James Ross Island, presented in Fig. 3 (black curve) of Mulvaney et al., 2012. The curves don't match.
- 7) The Figs 4d and 5d, supposedly to present the global temperature anomaly do not match. Difference between curves are not explained anywhere.
- 8) Fig. 8a is an appropriate stretched copy-paste figure without any information of the time scale.

- 9) Figs. 8b and 8c presumably showing the contributions of the solar and tidal influences to the global temperature, are not all well explained. The explained variances are not computed and tested against null hypothesis.
- 10) The manuscript is full of confusing acronyms, which are not well defined in the text, like NonRad&NonLinear , TidalNonLin , climate(laggedTSI).
- 11) The description of the tidal contributions in the Discussion section 5, pg. 13 lines 23-34 is quite confusing.
- 12) Figs 10a,b present forecasts of the global temperature up to 4000 cal A.D. The author claims that the use of the NASA's solar system astronomical model represents an independent verification of the model. For instance, the time-series issued from models Trend + mTSI + TidalNonLin (blue line) and Trend + mTSI + TidalNASA (cyan line) appear to be quite different and hence not corroborating the empirical proposed model Trend + mTSI + TidalNonLin.

## References

Soon, Willie; Velasco Herrera, Victor M.; Selvaraj, Kandasamy; Traversi, Rita; Usoskin, Ilya; Chen, Chen-Tung Arthur; Lou, Jiann-Yuh; Kao, Shuh-Ji; Carter, Robert M.; Pipin, Valery; Severi, Mirko; Becagli, Silvia (2014). *A review of Holocene solar-linked climatic variation on centennial to millennial timescales: Physical processes, interpretative frameworks and a new multiple cross-wavelet transform algorithm. Earth-Science Reviews, 134()*, 1–15. doi:10.1016/j.earscirev.2014.03.003