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Comment on esd-2021-87

Anonymous Referee #1

Referee comment on "ESD Ideas: A Global Warming Scaling Law" by Mikhail Verbitsky and Michael Mann, Earth Syst. Dynam. Discuss., https://doi.org/10.5194/esd-2021-87-RC1, 2021

Review of "A global warming scaling law" by M. Y. Verbitsky and M. E. Mann for consideration in the 'ESD Ideas' section of Earth System Dynamics.

In this manuscript the authors suggest that the evolution of the global temperature is governed by two time scales of positive and negative feedbacks, external forcing strength and evolution, as well as time. Forming non-dimensional groups, time is normalised and an equation for the temperature evolution (2) is derived. Then different cases are discussed where first positive feedbacks dominate, leading to stable climate states, and when positive feedbacks dominate leading to climate instability.

This manuscript is problematic in countless aspects, and I really don't know where to begin, and to end. Although I don't regularly use it, I am familiar with Buckinham's pi-theorem, and feel confident enough to know that if you provide it with a poor hypothesis, then the result will not be more insightful or fundamental. It does make sure the formulation is independent of the units used, but it is not magic.

A guiding principle in the climate sciences is conservation of energy, at least Arrhenius (1896) used it, but probably also earlier studies. Arrhenius realised that studying the energy balance at the top of the atmosphere was a useful starting point and identified forcing from CO2, negative temperature feedback and positive water vapour and surface albedo feedbacks. Not using this as a starting point requires justification.

Typically, it is found that a two-layer formulation of the climate system with a shallow atmosphere+ocean mixed-layer reservoir coupled to a deep ocean provides a good starting point (Hansen et al. 1985), and this type of model is used with slight modification in countless places, and it is well-justified (e.g. Gregory and Forster 2008). Does the here discovered theory in some way predict aspects of climate change that the simple two-layer model does not?

Usually, we would think of feedbacks as dependent on temperature only to first order (e.g. Sherwood et al. 2015). There are modifications to this, for example some feedbacks may change during a transient as the system equilibrates (e.g. Held et al. 2010, Geoffroy et al. 2013), or as the temperature changes (e.g. Bloch-Johnson et al. 2015). But these are higher order effects and the starting point is that the feedback scales with temperature. In their formulation the authors assume that there are negative feedbacks with one time scale and positive feedbacks with another time scale without any justification.

The paper by Steffen et al. (2018) appears to be used as a kind of confirmation of the theory. However, it is well known, and represented by the above mentioned theory, that if the feedback parameter becomes positive one enters an instability and a run-away climate, for instance snow-ball Earth (e.g. Budyko 1969). However, there is no evidence that the hothouse hypothesis of Steffen et al. 2018 is correct as assessed by IPCC AR6.

The other piece of evidence provided is the near linear temperature increase over a select period of time. But that is not proof.

Overall, though, what I find most problematic with this manuscript is that there is no attempt made to connect with relevant studies. A proposed idea can be radically different from whatever is already there, an attempt to reinvent the wheel, if you want. But authors need to do their homework and explain why they did what they did and how that is different and potentially better than existing approaches. It is therefore not possible for me to recommend publication.

Arrhenius, 1896, https://www.rsc.org/images/Arrhenius1896_tcm18-173546.pdf

Bloch-Johnson et al. 2015, http://dx.doi.org/10.1002/2015GL064240

Hansen et al. 1985, https://doi.org/10.1126/science.229.4716.857

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Gregory and Forster, 2008, https://doi.org/10.1029/2008JD010405

Sherwood et al. 2015, http://dx.doi.org/10.1175/BAMS-D-13-00167.1