

Earth Syst. Dynam. Discuss., referee comment RC2
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Comment on esd-2021-87

Anonymous Referee #2

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-RC2>, 2022

This paper presents an interesting idea to derive a scaling law for global warming based on the physical fundamental physical properties of the climate system and the Buckingham-pi theorem for dimensional analysis. The scaling laws at two extreme conditions of positive or negative feedbacks dominating (complete similarity) are first derived, and then the case of incomplete similarity is discussed. I find this work novel and interesting, and a very good fit for an ESD Idea paper. I have a number of questions and suggestions, mostly about the dimensional analysis part, which I hope the authors address.

- Line 57 and eq 3 (similarly, line 73 and eq 6): it is not clear to me how you can go from $\phi(t/\tau_n, \lambda)$ to $(t/\tau_n)^m$ in eq. (3). In Buckingham-Pi, the function ϕ of some variables can be written as the product of each variable to an unknown power, but it is unclear to me why in eq. 3 there is no λ^q (q being another unknown power) in eq. 3 multiplied by the rest of the terms. This is my main comment/question about the method. Please clarify.

- Line 46: the dimension of ϵ . I guess it is correctly written as $\text{sec}^{-\lambda-1}$, however, it does not appear clearly as far as I see. Please take a look and clarify if possible

- line 53: you may want to change this to "... global temperature response $T/(\epsilon t^{\lambda+1})$ is a function of"

- Also you may want to clarify around line 50 that here there are 6 variables in (1), there are two fundamental dimensions (time and temperature), so Buckingham-pi states that there would be 4 dimensionless (π) groups, as presented on lines 52-53.

- I find the word "dimensionless" just sounding better than "adimensional" but it is up to you which one to use.

- line 99: m should be in the math mode

- line 22: the use of Buckingham-pi theorem in climate science has been rather limited, and the cited paper by Golitsyn is certainly a great example. You may want to also mention some of the recent papers using this approach to study the climate system, e.g.

+Chavas, D.R. and Emanuel, K., 2014. Equilibrium tropical cyclone size in an idealized state of axisymmetric radiative-convective equilibrium. JAS

+Yang, D. and Ingersoll, A.P., 2014. A theory of the MJO horizontal scale. GRL

+Nabizadeh, E., et al. 2019. Size of the atmospheric blocking events: Scaling law and response to climate change. GRL

- line 16: is the word "similarity" in "... in feedbacks similarity parameters" needed?