

Earth Syst. Dynam. Discuss., referee comment RC1  
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## **Comment on esd-2021-56**

Anonymous Referee #1

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Referee comment on "Inarticulate past: similarity properties of the ice-climate system and their implications for paleo-record attribution" by Mikhail Y. Verbitsky, Earth Syst. Dynam. Discuss., <https://doi.org/10.5194/esd-2021-56-RC1>, 2022

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## **Review on "Incomplete similarity of the ice-climate system" by Mikhail Y. Verbitsky**

General comments:

The author claims to have proved, through the use of dimensional analysis, that the ice-climate system possesses the property of incomplete similarity, concluding from there that a certain event at orbital time-scales could have different causes.

Several aspects are not immediately clear to me:

(1) Definitions for many crucial terms (incomplete similarity among them) are not properly presented in the manuscript and it is, thus, very difficult to follow the logic of the paper and evaluate the potential implications.

(2) The core of the manuscript is the application of dimensional analysis to a simplified model, leading to the derivation of the adimensional parameter  $V$ -number. This has been done already in Verbitsky et al., 2018. I struggle to find what the added value of what is presented here is. In the current manuscript the author just modifies how the  $V$ -number changes in time (the  $V$ -number depends on several model parameters and it is, thus, possible to modify it by changing the values of those parameters in different ways). How is this a substantial knowledge contribution? Seems only an example and not enough material for a new publication.

(3) The author applies dimensional analysis to a 3-equations model of the ice sheets – climate system and makes some conclusions. How does the author then conclude that the real-world ice sheet- climate system also has the incomplete similarity property (whatever definition he is using)? I don't think it is possible to demonstrate, as the author claims, by the arguments shown here that the real-world system has the same a property as the simple model. There is some attempt to discuss this issue in the Conclusions, but the Abstract gives the misleading impression that a demonstration for the real-world case is provided in the paper.

(4) Even if the real-world system would have the incomplete similarity property (again, a concept not clearly defined in the text), which are the "theoretical limits for the use of pale climate proxy records" that the author derives? Is the author implying that proxy records have no value for understanding millennial-scale fluctuations? Even if an event can be produced by several different causes, why does this pose a theoretical limit for the use of proxy records? Which are the "far-reaching implications" that the author says might follow from the present study?

Overall, I find that the manuscript does not provide clear definitions for crucial terms (for example: physical similarity, complete and incomplete similarity) and is, therefore, difficult to read in its current form. Furthermore, given that a dimensional analysis has already been applied to the same (or a very similar) model in Verbitsky et al. 2018, how the material presented here constitutes a substantial new contribution is not at all evident. The differentiation from Verbitsky et al. 2018 must be made clearer and the new contributions highlighted. In its current form, the material here presented seems to be a simple illustration or example ( $V$ -value changing by changing the different model parameters that affect it).

Particular comments:

I find that the introduction section must be substantially reformulated. Clear definitions and notations must be introduced. In addition, the author should clearly state the goal of the manuscript, which is missing in the current version.

Lines 9-10: This sentence is not clear enough for an abstract (and repeats the word similarity 3 times). I would reformulate it and link to the following sentence.

For example: Specifically, we demonstrate that major past events could have been produced by different physical processes and, therefore, the task of disambiguation of the historical paleo-records may be fundamentally difficult, if not impossible" What is it there to disemboque? Please clarify

Lines 13-14: Are you implying that glaciations are independent of orbital forcing? Is this paper implying we cannot forecast events at orbital time-scales? Any proofs?

Lines 21-24: Please cite the work of Willeit et al. (2019).

Willeit, M., Ganopolski, A., Calov, R., & Brovkin, V. (2019). Mid-Pleistocene transition in glacial cycles explained by declining CO<sub>2</sub> and regolith removal. *Science Advances*, 5(4), eaav7337.

Line 34: change super long to extremely long. Also specify what does the author understand by orbital time scales in yrs.

Line 40: remove the word prophetic.

Line 47: asymptotic in which direction? What is the meaning of a parameter to disappear?

Please, clarify, this is not clear.

Lines 48:49: what are the super indices  $m_i$ ,  $n_i$ ,  $q_i$ ? it is not defined. What does it mean  $\pi$  in between brackets? The notation is not understandable, as it is not clearly defined. What's the meaning of conglomerate group?

Line 52: discover? did you prove the real-world system has this property? Or just your

system of equations?

Line 55: what is the definition of conglomerate V-number?

Line 60: You said you already did this in VCV18, why do it again here?

Lines 69-72: Please, provide some extra description of the model.

It is not obvious how terms to the power of  $3/4$  or  $1/4$  appear from the fundamental equations. A brief description of the main assumptions considered in the model derivation would be useful here.

Also, mention if the model has been successfully validated against paleo data, or any indication of its ability to represent the real-life system.

Line 76: what is epsilon? It has units of velocity

Line 78: Are you referring now to the real-world dynamical system or the one of your equations?

Line 88: terrestrial ice sheet mass flux was earlier called snow precipitation rate. Please, use only one name.

Line 93: How is it derived that  $V$  represents that? Which are the positive/negative feedbacks? Below it says: beta is intensity of negative feedbacks, gamma is intensity of positive feedbacks. What is intensity??

Line 95: what is the meaning of slow here?

Line 100: define the Peclet number

Line 104: "This feedback is applied directly to the ice sheet mass balance ( $\gamma\tau\kappa$ )" where is this derived?

Line 105: how is the  $\gamma\tau\kappa$  coefficient derived?

Line 106: what's the meaning of non-idealized?

Line 107: Please explain the meaning of “invoking a global cooling trend”

Line 109: define continentality

Line 112: what does the  $m$  subscript represent?

Figure 1: indicate that x-axis is time (kyr). Please also show the  $S$  time-series in each case.

Line 130: The explanation of which astronomical forcing is used should be mentioned much earlier in the text.

Line 146: “But is incomplete similarity of the global, orbital-scale, climate system real?” I think there is no answer to this question in the manuscript, therefore, you can only focus in your model characteristics.