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Interactive comment on "Dynamics of finite causal processes" *by* Kalman Ziha

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Reviewer #2: I strongly sympathize with the research questions that motivated this study, because they are extremely relevant and timely in general physics and in earth system dynamics in particular. The author takes a bold approach to causality that, at ïňĄrst sight, intuitively makes a lot of sense in view of open philosophical discussions that have been going on for a long time.

Submission of this article to ESD was encouraged by enthusiastic aims and scopes of this journal.

Reviewer #2: In my opinion, the fundamental problems are that the theoretical bases are far from being consolidated and the mathematical formulation is far from being fully matured.

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Author: Eqns. 3-5 in Sec. 2.2 follows from the basic relations of ideal feedback amplifier. The article redefines the common terms 'input' and 'output' of ideal feedback amplifier in terms 'cause C' and 'effect E' of continuous infinite causal processes (Fig. 1). The open loop gain is denoted in the article as propensity p, the closed loop gain is q and feedback factor is f. However, this model is not adequate for finite causal processes.

The mathematics of the finite continuous causal processes (Eq. 11-12 of Sec. 3) is not possible without the newly introduced decomposition of basic terms (Eqns. 3-5) into primary effect and interaction (Eq. 6). Decomposition enables the definition of the relation of the interaction term caused by effect of the proportional feedback and the residual causal capacity CU-C (Eq. 12, Fig. 2) instead to the elapsed cause C (Eq. 8, Fig. 1) as it is for infinite processes. The variable rate of sharing of the causal capacity C/(CU-C) at the moment of observation between the elapsed cause C inducing feedback F(C) in the past and the remaining cause (CU-C) (12) in the future, characterizes the influence of the causal finiteness on the causal process or how permanently apply, take or use something physically more of something physically finite. From Eq. 12 directly follows by integration the term for interaction in Eq. 13, the term for overall effect Eq. 15 and the interaction potential Eq. 17. All expressions are easily calculable.

The decomposition (Eq. 6) enlightens also some important features. The two terms: interaction and feedback, colloquially often alternate. In Eq. 6, the article introduces a mathematical distinction between interaction and feedback necessary for understanding of these terms in the manuscript. Interaction is defined as the contribution to the primary effect induced by the feedback affecting the primary cause with intensity i defined in Eq. 4 (Figs. 1 and 2).

The article introduces the mathematical term Eq. 9 in Sec. 2.3, not used in CST for definition of theoretical interaction potential as a measure of how much efforts or works has to be done for progression of a complex continuous causal process. This term is important for assessments of interactions between complex causal processes and their environments.

Appendix A brings forward a general term for derivatives of functions with respect to bounds of finite variables in a concise form based on infinitesimal considerations (Fig. A-1) on constant (Fig. A-2) and quadratic (Fig. A-3) causal relations. Examples of calculus in Appendix A confirm that the mathematical model of finite causal processes provides a unique facility for discovery and estimation of the final causal capacity of observed data.

With all this respect, author believes that the mathematics in the article brings forward new appropriately formulated terms on the only possible and reasonable way. The mathematical model adequately describes the properties of finite causal processes in modified terms of CST useful for applications in system dynamics. It is a novel approach to the concept of finiteness in terms of the control system theory and ideal feedback amplifier for study of general finite causal processes.

Reviewer #2: I cannot recommend this manuscript for publication due to fundamental mathematical and physical concerns (which the other reviewer detailed carefully), especially the unproven validity of the theories and unproven physical reasonability of the formulations.

Author: The finite cause (C) and effect (E) relation (FCE) with ultimate exhaustible finite causal capacity CU exposed in the article are not only philosophical or speculative concepts. The empirical idea of finiteness is also a physical concept per se but not only physical. In physical view particular cause C (e.g. ice melting M) and effect E(C) of C (e.g. ice mass losses L(M)) may be regarded as empirical physical laws of nature dominated by the finiteness of causal capacities CU (such as the total mass MU of ice sheets).

It is also a temporal concept since it relates observable physical processes, such as the interaction between the ice melting M in the past and anticipated ice mass losses

L(MU-M) due to melting of remaining mass of ice sheets MU-M in the future under changing environmental condition.

Due to many complex hardly jointly manageable interrelated causes and effects, this study aims to find out if there are global synthetic measurable theoretically founded quantitative parameters of a general mathematical model appropriate for analysis of complex physical relations of climate change and interactions between ice melting and ice mass losses.

The revised manuscript presents a more detailed description of the physical aspect of the FMLI model based on thermo-dynamical balance in renamed Sec.4.2 Thermal interaction of ice sheets and environment.

The reported acceleration of ice mass losses L[M(T)] (the effect E) alarmed that an growing amount of heat (thermal energy) Q[M(T)] of the climate system (e.g. in GJ) has been transferring to the melting mass M(T) (the cause C) of ice sheets during the observation time T. After achieving the melting temperature and melting of some mass M(T) of ice due to permanent heat flow dQ/dT from environment heat to ice sheets in time T, the further lessening of residual ice mass MU-M(T) together with shrinkage of exposed area of ice sheets is continuing. During melting of surface ice at constant pressure, the temperature gradient of ice sheets supposedly remains approximately constant. Therefore the mean temperature of ice sheet remains nearly constant during the whole melting process in time T. Hence, the heat contents (the enthalpy H, e.g. in GJ) of the mass M(T) of melted ice is H[M(T)] and of the residual mass MU-M(T) of ice sheets is H[MU -M(T)].

The reported ice mass anomaly suggests that the environmental heat Q[M(T)] induces a feedback as in (7) in some proportion i to the heat content H[M(T)] of the mass of melted ice M(T) of the ice sheets in time T is F{Q[M(T)]}=iQ[M(T)]=iH[M(T)].

The mathematical rate of the finite interaction (12) in time T relates the thermodynamical effect of the growing environmental heat Q[M(T)] and the lessening residual heat content H[MU-M(T)] that under before mentioned conditions and assumptions represents the interaction rate of the ice mass losses L[M(T)ïĄİ and ice melting M(T) is dIF[(L,M(T)]/dT=iQ[M(T)]/H[MU -M(T)]=iMt/[MU -M(T)].

Since the last term has the same form with respect to variable M as the interaction rate (12) with respect to variable C of the FCEI, the mathematical model (11-20) may be applied to FMLI problem.

With all this respect, author thinks that the physics of finite causal processes in the article is correctly formulated and that it appropriately explains the relation of global warming and interaction between ice melting and ice mass losses in terms of heat transfer from the climate system and the enthalpy of the ice sheets.

The introduction of finiteness in studies of natural phenomena is important for understanding and analysis of finite processes in earth system dynamics. There are many apparently finite causal processes which might be studied by using coherent mathematical apparatus capable to deal with finiteness.

*Author's opinion is that the article brings forward a novel concept of finiteness in study of natural phenomena and original adequate mathematical model of dynamics of finite causal processes in terms of modified control system theory what is elaborated in more details in the revised manuscript.

*Author also believes that the example 'Climate change and ice melting interaction' in the revised manuscript is properly physically elaborated in terms of thermo-dynamical balance, the underlying concept of finiteness and applied mathematical model of finite causal processes. The results of the numerical calculations are in agreement with systematic collection of observations on ice melting and ice mass losses on Greenland and Antarctica.

*The manuscript fulfils in many aspects the declared aims and scopes of the ESD journal.

*For all this reasons author thinks that the submitted and revised manuscript should be considererd for publishing in order to add impetus to further investigation of finite causal processes of interests in earth system dynamics and elsewhere.

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