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Earth System Dynamics Discussions

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

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Reviewer #1: This manuscript attempts to apply the concepts of the 'general systems theory' (GST) of Ludwig von Bertalanffy to explain changes of the physical climate, in particular the causal relationship between 'ïňĄnite ice melting' (the cause M) and 'ice mass Losses' (The effect). The 'general systems theory' of Ludwig von Bertalanffy is a holistic, controversial theory, started in 1938, that may qualitatively explain some phenomena in ecology and social sciences but is far from being accepted as a science subjected to veriïňĄcation and falsiïňĄcation.

Author: The 'general systems theory' (GST) of Ludwig von Bertalanffy (1968) is not applied to explain the physical climate in the manuscript. It is mentioned in order to put the concept of finite cause and effect interaction (FCEI) in systemic framework of control system theory (CST). The revised article provides broader description of the

FCEI conceptual platform based on the principles of the control system theory (CST) (Wiener, 1948), of the natural causal process theories (nCPT) (Russell 1948; Salmon 1984), of the circular cumulative causation theory (CCT) (Myrdal, 1957), of the general system theory (GST) (von Bertalanffy, 1968) and particularly of the ideal feedback amplifier (e.g. Kuo and Farid, 2003).

Reviewer #1: Moreover, it presents a simplistic theory of the linear feedback which comes out as a very particular case of the much more general and well-grounded and mathematically funded 'Control system's theory'.

Author: Eqns. 3-5 in Sec. 2.2 follows from the basic relations of ideal feedback amplifier. The article for the purpose of this study 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. This model is not appropriate 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) 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 finiteness on the causal process or how permanently apply, take or use something more of something 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 relations. 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 natural properties of finite causal processes in terms of CST useful for applications in system dynamics. It is a novel approach to the concept of finiteness derived by modification in terms of the control system theory and ideal feedback amplifier for study of general finite causal processes.

Reviewer #1: The application of GST formalism to the relationship between 'Finite ice Melting' and 'ice mass Losses' . . .

Author: The GST formalism is not applied to FMLI relation. The general finite cause (C) and effect (E) relation (FCE) with ultimate exhaustible finite causal capacity CU exposed in the article is not only philosophical or speculative concepts. 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). The empirical idea of finiteness is a physical concept too but not only physical. FMLI 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, the 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.

Reviewer #1: . . .seems therefore inappropriate giving rise to 'vague' concepts without any physical correspondence.

Author: 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 C, 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 is correctly formulated for the purpose of this manuscript and that it appropriately applies the thermo-dynamical 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 to the ice sheets.

Reviewer #1: . . .Examples of that are quoted from the manuscript. 1) 'This study of ïňĄniteness of natural processes recognizes the temporal FCEI (Finite Cause-and-Effect Interaction) empirical concept as a continuous sharing of irreplaceable and restricted overall ultimate causal capacity CU between the observable elapsed effect E in the past and the imperceptible but conceivable forthcoming limited exhaustible cause C beyond the instant of observation in the future. 2) The trans-temporal ïňĄnite interaction implies the empirical link in continuation of the known uninterrupted past and the imaginable but ïňĄnite perpetuating future separated by the instant of observation at the present time' 3) The mathematical model of the FCEI in this study considers a simple intuitive term of the continuous residual causal capacity R(C)=CU-C after spending some primary effect E'(C) (1) of the limited cause C on the expense of the ultimate cause CU.

Author: The first two statements in the manuscript wordily explains the temporal character of the mathematical rate of change E(C)/(CU-C) in the FCEI definition (Eqn. 12) as the ratio between the growing elapsed effect E(C) in the past and the diminishing remaining driving cause (CU-C) with respect to the waste of ultimate causal capacity CU in the future separated by the instant of observation (Fig. 2). The third statement represents the conservation principle between elapsed effect and forthcoming cause which expresses the assumption that a continuous finite causal relation does not change its

properties of propensity to and intensity of interaction during unchanged environmental conditions with respect to wasting of ultimate causal capacity CU over time (Eqns. 11-20).

Reviewer #1: Beyond the above criticisms, the author tries to make millenary climatic predictions (extrapolations) using the simplistic GST relationships, as quoted from the manuscript: 'It is possible to predict by extrapolating the FMLI ice mass loss curve (28) that the melting out of the total mass of ce MU=2.50x106 Gt due to the interaction with climate change under same environmental conditions could happen in the year TM=2850ïĆś70 with 8% uncertainty of ultimate ice mass MU estimation (Figs. 3 and 4). That prediction is totally speculative and cannot be accepted.

Author: The mathematical model of finite causal processes provides analytic parameters based on observed data which allow extrapolations beyond the instant of observation. Following the reviewer's comment the long term predictions are omitted from the revised manuscript. Instead, short term extrapolations to the end of the 21th century are given.

Reviewer #1: Moreover, the author does totally ignore alternative approaches studying the causality in the climatic system (e.g. Granger causality) ...

Author: In the revised manuscript a comment is added why the Granger statistical causality is not used. Granger statistical causality investigates causal dependency between stochastic variables and do not indicate real causality in the deterministic context of the manuscript. Instead of Granger statistical concept of causality, the manuscript focuses on deterministic physical interpretations of work done by environmental effects and inherent physical properties of ice sheets giving the propensity, sensitivity and interaction intensity parameters of the mathematical model by derivatives and integration of the FCEI interaction curves (Eqns. 11-20 and Fig. 2). With respect to the scope and size of the manuscript no statistical analysis is planned.

Reviewer #1: ... and therefore it is not understood in which the manuscript adds new knowledge.

Author: The manuscript presents a novel interdisciplinary approach to system dynamics that conceptualized, modelled and quantified the influence of finiteness of deterministic continuous causal processes with exhaustible causal capacities what was not applied earlier in investigations of Earth mechanisms. The manuscript introduces the finiteness as a physical property inseparable of other physical properties of continuous processes with limited causal capacities. It provides apt mathematical model of finite causal processes with reasonable numerical, geometrical and physical interpretations of the proposed concept. The calculus in the manuscript implies a new general definition of derivatives of functions with respect to bounds of finite variables. The study also uncovers a new application of the mathematical model that makes it possible to discover and to estimate the unknown ultimate causal capacities from relevant information of supposedly finite causal processes beyond the instant of observation. The proposed analytics based on thermo-dynamical balance confirms that the climate system and ice mass anomaly monitored recently on Greenland and Antarctica ice sheets under global interaction of a combination of various component systems, such as the atmosphere, cryosphere, hydrosphere, oceans and human activities may be viewed as finite dynamical causal processes by definition given in the manuscript. Extrapolations suggest dates of beginning of intensive ice melting and possible ice mass losses in the future. The reverse numerical calculation procedure satisfactorily re-estimated the total ice mass of ice sheets from observed data within the suggested limits. The numerical results are in almost perfect agreement with ice mass anomaly data observed on Greenland and Antarctica.

Reviewer #1: Giving the above arguments, the manuscript must be rejected and cannot be accepted to 'Earth System Dynamics' journal.

Author: *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 coher-

ent 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 considered 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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