A chance to “cure” local climate systems and reconcile humanity with Nature

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Abstract. Sustainable development becomes illusive when the observed reality demonstrates extraordinary oscillations beyond habitual seasonal patterns. Sound estimations on climate destabilizations and their negative consequences as well as attempts to return to desirable seasons remain endless disputable until the uncertainties and oddities of local climate dynamics remain unclear. Per se, the clarification requires a physical meaning of the so-called interannual variability. At the same time, valid evidence to such point can be achieved only if there is a dynamical system describing local climate dynamics in both weather and climate terms simultaneously. Nothing success to satisfy this requirement existed before the rule of modes was discovered in 2014 (Kolokolov & Monovskaya) by the processing of temperature observations under the hypothesis that a local climate system represents a solar energy converter obeyed the astronomic-based hysteresis control with double synchronization. After, this hypothesis was verified completely and developed into the regulatory theory of local climate dynamics to analyze nonlinear stationary and nonstationary processes taking into account regularities of bifurcation scenarios and regulatory responses. The paper focuses on the aspects of this theory connecting with seasonal evolution rapidly and individually developing in local climate due to anthropogenic destruction of ecosystem equilibrium. In other words, Nature is the Great Dictator demanding from men to obey undeviatingly physical laws, among which “controlled chaos” and “democratic reforms” are absent. In practical application, it means that local climate systems need urgently careful cure to slow down global ecosystem collapse and to get a chance to reconcile humanity with Nature. The paper seems to be interesting to responsible researchers and practitioners oriented to efficient work to hold back from the destructive-for-human-activities transition towards a novel global climate.

1. Introduction
Sustainable development of human activities directly and crucially depends on climate changes in spite of variety and power of contemporary technologies. The majority of prognostic estimations on climate changes continue to follow the traditional averaging concept on regional/global tendencies of essential climate variables and aggregative energy characteristics, for example [1-7]. Let us comment this concept in application to annual temperature variation (Fig.1a). From an unbiased practical view on applicability, the following question appears inevitably: a climate scale (upper horizontal part in Fig.1a) corresponds to desirable predictive horizons (one or several decades), however desirable predictive details relate to local daily means estimated for no more than 10-14 days (lower horizontal part in Fig.1a); correspondingly, the sequential averaging from days to year leads to information losses and a prognostic tendency is built in this context (for example, Fig.1b); so, how should the information
losses be restored? To the present, well-grounded scientific doubts about enough validity of such tendencies are collected, for example [8-13].

In other words, climate systems demonstrate phenomena which are originally beyond the scope of the theoretical basis of the conventional protocols, for example [14-17], used traditionally to meteorological data acquisition and processing. The corresponding errors convert to climate norms widely used in practice (especially, such errors influence negatively on middle-term and long-term projects); next, resources are squandered but avalanche-like rise of damages occur; meanwhile, a waste of time to organize activity oriented to keep from dangerous climate-related scenarios is irreplaceable. That is why there is the insistent need to return to the problem statement without ill-wresting simplifications or/and exclusions of incomprehensible-to-the-conventional-climate-theory phenomena. In this sense, the so-called interannual variability, for example [8, 11, 18-20], remains the principal obstacle to understand everything required to prevent the most serious negative consequences due to developing climate changes. The variability is detected over the last thousands, for example [21-22], and there are valid physical arguments for the conclusion that such phenomena personify local dynamics stabilization under the astronomic regulation, for example [11, 23-24].

In particular, the most reliable meteorological observations show the interannual variability over the last 150 years at least (for example, Fig.2a), where main signs are simply-visualized by compressing/stretching annual seasonal cycles (for example, Fig.2b) with “dancing” of temperature extremes about their conditional centerlines (for example, Fig.2c). In this connection, strictly speaking, classical climate norms/tendencies are originally incorrect in mathematical sense due to insufficient confirmations to the hypothesis on the normal distribution, for example [9-11]. So, lawful questions appear to climate forecasts based on such results. Attempts to reform the classical statistical theory without proofs concerning physical meaning of such reforms, for example [25-31], conflict with other fundamental theories (for example, with the bifurcation theory, with the control theory, and
so on, section 2) and seem inexpedient due to the problem remains unresolved (section 3). Meanwhile, there are enough physical confirmations that it is a point of specific dynamics, for example [11, 32-34], and, correspondingly, the classical statistical theory does not need reforming.

Clear explanation on the interannual variability by dynamical systems were impossible before the so-called rule of modes (for example, Fig.2d) was discovered physically-based by processing temperature observations, for example [23], from the concept that a local climate system represents a solar energy converter under the astronomically forced hysteresis control with double synchronization (i.e. under the so-called HDS-control). Then the fragmentation in an annual warming-cooling cycle from one temperature minimum to the next one (i.e. AWCC-unit denoted by violet in Fig.2e) was substituted for the calendar one in annual temperature variation from one the 1st January to the next one (i.e. ATV-unit denoted by gray in Fig.2b) in order to correlate with the HDS-control meaning. Next, AWCC-characteristics were established (for example, Fig.2e, dmin- and dmax-values denote time coordinates of the temperature minimum and maximum correspondingly, k denotes a relative duration of a warming stage, and so on) and mass of the observations were analyzed concerning existence/absence of features inherent to the HDS-dynamics only. As a result, the rule of the modes personified the first of these features.

Namely (Fig.2d), the majority of dmin-values with k > 0.5 are on the left from the majority of dmin-values with k < 0.5; the majority of dmax-values with k > 0.5 are on the right from the majority of dmax-values with k < 0.5. In other words, the interannual variability is associated with bimodality identified two times per year (in winter and in summer) when temperature extremes are grouped around two time locations in relation to the corresponding centerlines (i.e. around C\text{dmin}- and C\text{dmax}-locations in Fig.2c). After, three other HDS-features in the form of functional regularities of the interannual variability (the so-called KP-, KT- and KA-regularities) were physically-based confirmed and, finally, bifurcation diagrams to show evolitional properties in local climate dynamics were first built, for example [23-24]. Currently, the HDS-hypothesis is verified completely, for example [11, 32-34], and is developed into the regulatory theory of local climate dynamics. Fundamentals of this theory are briefly commented in section 2. Here let us illustrate several points important to analyze individual seasonal evolution in local climate instead of uniform global warming.

Let us mention that the formula “similar event occurs N times per N years” can not explain why local weather abnormalities overload seasonal course over the last 10-15 years. In other words, some transitional stage occurred when deep regularities of local dynamics personified into outwardly observed evident abnormalities, for example [34]. Since climate states before and after are quite clear distinct then there is a question: is this change qualitative or quantitative? Thus, a field of discussion supposes qualitative changes (i.e. bifurcations) and nonstationary states (i.e. transients, multiple attractors, and so on). So, three principal demands should be satisfied. First, a conceptual model of a local climate system should be proposed in the form of a dynamical system in order a transient from one attractive steady state to other one or a return to the initial state can be described completely (i.e. with daily resolution over decades). Second, the bifurcation theory should be used to analyze soundly changes of attractive steady states (i.e. a bifurcation picture of potentialities). Third, it is necessary to ground which of theories should be used to analyze soundly nonstationary states taking into account peculiarities of the proposed dynamical system.

The classic Lorenz model, for example [35], was the first physically-based dynamical model of local climate to describe conceptually evolution for a short time interval under the corresponding strict restrictions. From the experience concerning practical applications of this mode, this time interval is estimated from several hours up to several days (i.e. in weather terms), for example [36], due to the so-called butterfly effect, for example [37]. In other words, the Lorenz model demonstrates that nonlinear dynamics is inevitable for local climate, however quasi-periodic solutions are inadmissible from the restrictions on the consistency, for example [38]. After the passed years, the physical restrictions associated originally with the Lorenz model were take out of the considerations; and attention
becomes focused on the system of differential equations only. As a result, the so-called Lorenz-like models represent abstract mathematical objects to generate a variety of nonlinear solutions, for example [39-43]. Such solutions could be used in cryptography, for example [42-43], but have nothing relation to climate dynamics really observed, for example [11].

Figure 2. Variation of factual locations of temperature maximums and minimums (a); a fragment of temperature time series with examples of annual warming-cooling cycles compressed and stretched in relation to one calendar year (b); comments to visible signs of interannual variability (c); visualization of the rule of modes on the basis of the processing the data of temperature observations (d) and characteristics of a warming-cooling cycle used in this connection (e).
To widen time interval and to keep considering details, let us pay attention to common features revealed by analysis of different climate-related data in middle-term and long-term scales, namely: to signs of astronomic synchronization, for example [44-46], and hysteresis properties, for example [47-49]. In other words, such signs indicate that a conceptual model of local climate dynamics should include a hysteresis regulator providing the synchronized annual temperature course with extremely wide variation of local dynamics parameters over a globe. Possible variants of such regulator are essentially restricted by several circumstances. Namely, per se, a climate system realizes energy conversion, for example [5, 13, 50]; from the engineering experience, the most efficient energy conversion systems are controlled by pulse modes, for example [32, 51]; and it seems to be evident to assume that Nature applies one of such modes. At the same time, from the bifurcation analysis, specific properties of nonlinear dynamics are determined by a kind of regulation most of all, for example [52-54]. Thus, the regulatory law is proper if features of dynamics under this regulation confirm the features of local climate factually observed including the known oddities.

Such confirmations occur for the conceptual model under the hysteresis control with double synchronization only, for example [11, 23-24, 32-34, 55-57]. These facts pioneer the way for constructive and unbiased discussions and present a wide spectrum of abilities to involve experience from the bifurcation and control theories to answer the interesting questions concerning dynamics evolution during stationary and nonstationary states. The regulatory theory of local climate dynamics, for example [11], was formed from analytical results of the investigations made in this direction. Currently, this theory allows to visualize a general attractive structure of the phase space to reconstruct in its context latent and realized routes of annual seasonal cycles taking into account peculiarities of local climate dynamics under the HDS-control, for example [32-34, 55-57]. Section 2 concerns briefly the basic points of the theory; section 3 focuses on the bilateral relations between natural and anthropogenic factors; section 4 summarizes the discussion.

2. Theories and Data
In accordance with the regulatory theory of local climate dynamics, for example [11, 32-34], a local climate system is considered as a solar energy converter under the HDS-control realized by the astronomic forcing. Here computer-based and physically-based investigations concerning evolutionary and regulatory features of nonlinear dynamics are carried out in accordance with the bifurcation and control theories correspondingly. Nonstationary components of bifurcation scenarios are detailed from the theory of dynamics forecasting specialized for systems with variable structures (the so-called BF-analytics, for example [57]). Let us comment briefly the general points of this research context illustrated by the processing the open-access meteorological data retrieved from the official web site of the Russian Research Institute of Hydro-Meteorological Information – World Data Center [58].

In bifurcation theory terms, characteristic properties of nonlinear dynamics depend mainly on the kind of a pulse control, for example [52]. In particular, the HDS-law establishes the natural competition between the amplitude quantization restricted by a hysteresis \((H)\) and the time quantization caused by the double synchronization shifted in \(T_S/2\)-period, where \(T_S\) is a synchronization period, for example [11, 23, 32]. Mathematically, the HDS-law is formalized by the commutation function \((K_F)\):

\[
K_F(t) = \begin{cases} 
1, & \varepsilon(t) > H/2 \\
0, & \varepsilon(t) < -H/2 \\
0 \rightarrow 1, & t = jT_S \text{ or } \varepsilon(t) = H/2 \\
1 \rightarrow 0, & t = (j+0.5)T_S \text{ or } \varepsilon(t) = -H/2 
\end{cases}
\]  

(1)

where \(j=0,1,2,\ldots\); \(\varepsilon\) is a control error. Thus, phase trajectories are sewed by passes through surfaces (numerated by 1, 2, 3, and 4 in Fig.3a), and three elementary processes with \(T_S\)-periodicity and
different orders of the passes through sewing surfaces (3243-, 242-, and 2143-solutions, Fig.3a) are dominating in dynamics (with H/H_{crit} > 1, on the right of white solid line in Fig.3b).

Figure 3. Time-temperature relations between the elementary processes in the HDS-law context (a); the main parametrical plan to HDS-dynamics regularities (b) accompanied by zoom-in fragments; signs of interannual variability (c) and the rule of modes (d) in association with the relationship caused by the HDS-law; diagrams to “breathing” periodicity during transitions between elementary processes (e); a gallery of examples to ATV- and AWCC-units (f).
Specific relations between these three dominating processes (Fig.3a) lead to unexampled features of the HDS-dynamics. Namely, since alternations between these processes (i.e. border-collision bifurcations) do not lead to changes in the periodicity then the preset synchronization is not lost with extremely wide variation of internal and external parameters. In control theory terms, such dynamics means that the operating stability and performance are guaranteed absolutely (i.e. with any duty cycle) at the expense of bifurcations (i.e. at the expense of the circumstances originally prevented by traditional design). The unique advance of this paradoxical engineering solution was physically verified by its first industrial application in the control system for the first-in-USSR high-speed railway train ER200 (the railway line Moscow – St. Petersburg), for example [32]. So, no wonder that Nature's engineering uses long ago such advantage for the energy conversion control in local climate dynamics, at least there are enough verification arguments to this conclusion, starting from the fact that HDS-features correspond completely with the ones of the interannual variability under the assumption that $T_S$ is equal to one year, for example [11, 23-24, 32-34].

Understanding the local dynamics supposes matter-of-fact description of interannual variability. From the HDS-control, the description is guided by a relative duration of a warming stage ($k$) during year (i.e. during $T_S$-period, Fig.3a). In other words, the geometrical profiles of annual temperature cycles are divided into three groups. Namely (Fig.3a), annual maximums of 3243-solutions are shifted to the right and thus $k>0.5$; so, such solutions are denoted as $R$-process (i.e. right-processes). Similarly, 242-solutions with $k=0.5$ are denoted as $C$-process (central-process), and 2142-solutions with $k<0.5$ are denoted as $L$-process (left-process). Then alternations between the elementary processes look like outwardly a chaotic-like manner, however nothing changes in periodicity occur; at the same time, extremums of annual temperature variation “dance” about two centerlines quite definitely in accordance with 2- and 4-sewing surfaces (Fig.3c in comparison with Fig.3a). In general, results of processing of temperature time series demonstrate undoubtedly that features of HDS-dynamics agree clearly with the features of interannual variability observed in local climate, for example, recent summary to this conclusion is in [11].

Let us concern two of them to comment the mentioned “dancing” of temperature extremes (Fig.2c,d) with “breathing” periodicity (Fig.2c,e). The positional relations between $R$, $L$, $C$-processes agree completely with the rule of modes, namely (Fig.3d in comparison with Fig.2d): the mathematical expectation of a temperature minimum of $R$-processes ($M_{d_{\text{min}}^{k<0.5}}$) is on the left from the one of $L$-process ($M_{d_{\text{min}}^{k>0.5}}$); and the mathematical expectation of a temperature maximum of $L$-process ($M_{d_{\text{max}}^{k>0.5}}$) is on the left from the one of $R$-process ($M_{d_{\text{max}}^{k<0.5}}$). The rule of modes in the function form was denoted as KD-regularity in [11, 23-24]. Strictly speaking, the interannual variability is mathematically identified as multimodality revealed by calculations of the climate norm, where bimodality dominates by the rest, for example [11]. From the HDS-law interpretation, it means that bimodality indicates components inherent for steady-states (Fig.3a,c,d). Other kinds of multimodality are variable and indicate components of nonstationary states obeyed the KP-regularity first shown in [23] in a functional form of the rule of “breathing” periodicity (Fig.3e), namely: $p$-values (i.e. AWCC-cycle duration, Fig.2e) with $k<0.5$ are in general smaller than the ones with $k>0.5$ because of the asymmetry of passes permitted/forbidden by the HDS-law (Fig.3a).

So, temperature observations can be built into the HDS-law coordinate system from the phase space by means of KD- and KP-regularities. This physically-grounded tie dictates the corresponding units to describe the dynamics, namely: the HDS-law supposes annual warming–cooling cycles instead of the calendar terms of annual temperature variation (i.e. AWCC-units Fig.2e instead of ATV-units Fig.2b). Thus (Fig.3f), AWCC-units are unified by a geometrical profile in accordance with similar physical events (from one temperature minimum to the next one) and have variable beginning and duration; ATV-units are unified by a calendar year (from one the 1st January to the next one) and have essentially variable geometrical profiles. On the basis of the AWCC-units, four functional regularities of the interannual variability (the so-called KD-, KP-, KT-, and KA-regularities) were discovered and bifurcation diagrams to show intermittency were first built, for example [23-24]. Translations to AWCC-units pioneer understanding the physical meaning and
features of the interannual variability (“dancing extremums” and “breathing periodicity”, Fig.2), for example [11, 32-34, 55-56], which are unexplained in ATV-units till now.

Summarily, the HDS-law determines qualitatively and quantitatively positional regularities in time and temperature between RLC-processes in their ensemble context. The physical meaning and research abilities based on RLC-ensembles are essentially different from the ones based on statistical ensembles using to simulate nature-climate processes, for example [25-31], where the following two differences are fundamental. First, RLC-ensemble represents a self-consistent system of functional regularities (but not only statistical distributions) logically following from the HDS-law, as a result of which all the potentialities of local steady states (including the latent ones never realized before) are reconstructible by processing meteorological observations (i.e. by processing essentially incomplete mass of factually realized particular cases). These potentialities are personified in the parametrical space by regularities of evolutionary scenarios with necessary zoom-in (i.e. by domains of steady-states onto a general parametrical map, for example Fig.3b), in the phase space by time and temperature details of these scenarios (i.e. by an ensemble of attractive phase volumes, for example Fig.4c,d), as well as in other special spaces to show necessary views (for example, Fig.4a). “Statistical ensembles”, for example [25-31], are not principally intended to analyze evolutionary scenarios and to show completely potentialities of local climate dynamics (for example, Fig.4e).

Second, the statistical concept cannot be principally used to analyze responses on disturbances because of these responses are realized by transients and, correspondingly, nonstationary processes appear. Meanwhile, the regulatory theory of local climate dynamics provides naturally investigations of nonstationary processes from the control quality view (for example, Fig.4a) as well as from the specialized view on evolutionary scenarios in systems with variable structures, for example [57]. So, both direction and rate of bifurcation and regulatory tendencies become identified uninterruptedly and conflict-freely, for example [11, 32-34, 55-56]. As a result, it was revealed that nonstationary processes dominate in the local dynamics over the last 150 years at least, for example [32, 34]; just equal periodicity of quite close elementary processes provided outward similarity of local weather patterns until recently. These circumstances become evident when the observed temperature time series are connected with classical meaning of the stability and performance through the coordinate translations described by Fig.3a,c,d.

3. Results

Since the features typical for HDS-dynamics only are completely confirmed in dynamics observed in local climate systems in different quasi-homogeneous regions then the HDS-hypothesis is verified and conflict-free cooperation between fundamentals of bifurcation, statistical and control theories is established, for example [11, 32-34]. In particular, taking into account the main bifurcation plan (for example, Fig.3b), it was determined that the H/H_{crit}-range covering cases observed in Russian territory locates enough far from H/H_{crit}=1 (approximately from 1.1 to 2) that excludes principally T_{S-periodicity loss} in the near future at least. The corresponding k-range for stationary states is concentrated about 0.45...0.6. Thus, various nonlinearities can occur in the climate dynamics similar to HDS-dynamics observed in technical systems, namely: zones of combined processes between neighbor parametrical domains (for example, primary zoom-in to Fig.3b), zones of multiple attractors with overlapping the neighbor domains (for example, secondary zoom-in to Fig.3b), and so on. However, all these cases suppose alternating elementary processes and serve subsidiary strengthening for energy conversion constancy with T_{S-periodicity}. In other words, in steady-state terms, alternating elementary processes will form a behavioral manner outwardly resembling intermittency.

Yes, the notion of intermittency contains several nonlinear phenomena, each of which is extremely capricious even separately; however, the observed climate transformations are not connected with the loss of the constancy of the periodicity because of the border-collision bifurcations realized by closely related elementary processes continue to keep annual warming-cooling repetitions. In other words, in interannual meaning (i.e. in climate terms, Fig.1a), interannual variability is not a recently appearing reason (for example, Fig.2a) leading to the climate changes and nothing principal bifurcation changes
in local climate occur over the last 150 years at least. But something in the current climate really transforms. What is it? In fact, principal transformations occur in seasonal patterns. In other words, it is a point of destructions of habitual weather patterns within annual seasonal cycles (i.e. in weather terms, Fig.1a). Such statement is impossible to considerations neither in the classical “climate” no in the classical “weather”. Moreover, the interesting field of the research is, strictly speaking, beyond the limits of the classical bifurcation analysis due to nonstationary processes. To clarify the research statement, nonstationary and stationary stages in temperature observations should be separated. However, nothing comments to this fundamental item exist in the context of the majority of climate estimations, for example [1-7, 12-22, 25-31].

At the same, the regulatory theory of local climate dynamics allows to turn to the experience of the control theory to analyze responses on disturbing impacts. Namely, $T_{AV}$-constancy in general validates the ability to analyze nonstationary behaviors in deviations from a steady state averaged per a synchronization period (hereafter, $T_{AV}$), so, a classic control error ($\varepsilon_{classic}$) means the following:

$$\varepsilon_{classic} = 100 \cdot \frac{(T_{REF} - T_{AV})}{T_{AV}}$$

(2)

However, due to evident HDS-dynamics features, such $\varepsilon_{classic}$-tendency will lead to imperfect considerations, namely: usually, the reference value ($T_{REF}$) is more than a steady state averaged per a synchronization period ($T_{AV}$); however, the HDS-law supposes two-side $T_{AV}$-dispositions (Fig.3a) and annual temperature cycles pass above and/or below zero (for example, Fig.1c). In this connection, the relative deviation from the temperature reference ($\varepsilon_{AWCC}$) is introduced:

$$\varepsilon_{AWCC} = 100 \cdot \frac{(T_{AV} - T_{REF})}{H}$$

(3)

Thus, a tendency of $T_{AV}$-deviations from $T_{REF}$ (i.e. $\varepsilon_{AWCC}$-tendency) is brined to conformity as with the physical meaning of the HDS-control as with the physical meaning of the control performance used for typical pulse control. So, engineering experience can be attracted to get clear analytical conclusions on the control quality for various local climate systems, for example [32, 34].

Let us comment results of such translation by an example of a typical $\varepsilon_{AWCC}$-tendency (Fig.4a) built in accordance with the Eq.3. Most of all, such translation visualizes limits of stationary and nonstationary stages (denoted by I, III and II, IV correspondingly in Fig.4a). In this connection, endless debates on what is a common window to determine local climate norms become closed because of real physical verification to this assumption is absent. Why? Because a common interval, within which stationary stages occur for all the local climate systems, is absent; strictly speaking, each local regulatory response (i.e. a nonstationary stage) is realized in its individual manner, duration, and intensity. In particular, a classical window of years 1961-1990 covers three heterogeneous intervals in Fig.4a. At the same time, the common property consists in the following: nonstationary stages amount usually several decades and prevail in dynamics over the last decades, for example [32, 34]. So, traditional “climate norms”, for example [14-17], as well as novel norms shifted more and more towards the year 2020 (for example, [14, 59-60]) will say nothing valid.

Taking into account the mentioned consideration, the regulatory theory of local climate dynamics analyzes seasonal patterns in the context, which is differ from the traditional one. Let us consider several illustrative examples starting from the $\varepsilon_{AWCC}$-tendency in Fig.4a. Here the resultant regulatory course becomes apparent from one stage of homogeneous dynamics to the next one, where each of the stages can be detailed separately (in contrast to traditional estimations, for example Fig.1b). In particular, nonlinear effects leading to dangerous consequences are interesting. For example, two intervals circled in Fig.4a during a transient (the stage II) demonstrate a “hovering effect”, when annual means (i.e. $T_{AV}$-values) are temporary stabilized; however, the stabilization is abruptly (in several years) destroyed with significant $T_{AV}$-developing (for example, $T_{AV}$-acceleration after year 1925 and $T_{AV}$-droop after years 1950, Fig.4a). Here the physical reason relates to structural changes within
RLC-ensemble and, in general, such changes can be well-monitored and even forecasted, for example [34]. But, outwardly, T\textsubscript{av}-stabilization is observed and nothing preparations to further dangerous events (abrupt T\textsubscript{av}-acceleration/drop) occur. Let us mention that “hovering effects” are expected in climate dynamics from the engineering experience; meanwhile, there are effects, which are unexampled from the engineering. Let us clarify the last.

Any regulator is intended to stabilize and minimize a control error; and any HDS-regulator attracts structural changes (i.e. border-collision bifurcations) to realize these purposes. At the same time, local climate dynamics demonstrates adaptive behaviors known in the HDS-practice as the so-called reference adaptation, for example [32-34, 55-56]. Per se, such adaptation leads to the following: the initial (non-adapted) phase trajectories of R- and L-processes (painted blue and red in Fig.3a,4b) are shifted upward and downward C-process correspondingly (painted by cyan and magenta in Fig.4b correspondingly). However, climate dynamics is formed under too frequent perpetual vibrations of initial conditions and parameters (usually, hundred times per year – i.e. hundred times per a synchronization period) that is not considered in engineering. In other words, it means the following: each elementary process becomes associated with a phase cloud consisting of a set of closely situated stable and unstable attractors, for example [33-34, 55-56]. As a result, R- and L-processes coexist under two modes (without/with reference adaptation) and each RLC-ensemble consists of five attractive phase clouds (for example, red, magenta, cyan, blue and black clouds in Fig.4c,d).

Such clouds can be widen/compressed and change their positional relationship with parametric variation (for example, non-adapted R- and L-clouds in Fig.4c are essentially closer to the adapted ones than in Fig.4d). Each annual temperature route is driven through potentialities provided by a cloud structure (for example, examples of such routes are shown by green dots in Fig.4c,d), where the following should be taken into account: from physical laws, any regulation supposes attention to bilateral relations between parameters and phase variables, for example [57]. In other words, usually, it is analyzed how parameters can influence on phase variables; but phase variables can also influence on parameters, especially, about bifurcation boundaries (i.e. during essentially nonlinear fragments of parameter-variable dependencies). The HDS-dynamics represents “bifurcation dynamics” (per se, it is a point of the dynamics within/about supersaturated bifurcation zones), where such bilateral relations create additional alternative routes in the phase space at the expense of widen and/or complicated domains of multiple attractors. It is crucial because of the second distinction between natural and artificial HDS-controlled systems, namely: a climate system is inseparably linked with flora and fauna, living cycles of which depend essentially from weather conditions.

So, each local ecosystem is considered in terms of local climate, landscape, flora/fauna, and so on; so, the bilateral relations between parameters and phase variables mean that, yes, weather conditions in a seasonal course influence on vitality of species but results of their vital functions influence on this seasonal course, for example [61-62]. From the regulatory theory of local climate dynamics, it means that life cycles of different species within an ecosystem and between several ecosystems are adjusted with each other by iterative search of optimal moments of seasonal “switches” from one attractive phase cloud to other one in order to stabilize the corresponding bilateral relations between living and lifeless ecosystem components, where united astronomical HDS-regulator held together all the relations. So, usually, two additional (in comparison with the basic HDS-algorithm, Eq.1) switches per year appear during seasonal transitions from-winter-to-summer and from-summer-to-winter (for example, green circles in Fig.4c). Thus, well-repeated time-and-temperature seasonal patterns are formed, where annual seasonal patterns seem to be preferable; however, other variants (two and more years long) are possible and are known in biology.
Figure 4. $\varepsilon_{AWCC}$-tendency built for (day,T)-plan in Fig.1c (a); RLC-ensemble supplemented with adapted versions of $L$- and $R$-processes (b); reconstructions of phase clouds of $R$-, $L$-, and $C$-processes made for the beginning and end of the 20-th century (c) and (d) correspondingly; sub-domains of “well-adjusted climate” and “changeable climate” in terms of RLC-ensemble in comparison with the statistical estimations of available temperature potentialities (e).

In general, external edges of non-adapted $L$- and $R$-clouds restrict a phase domain of each RLC-ensemble (RLC-domain), within which all the weather temperature limits physically available in dynamics of the corresponding climate system are caught (for example, deep-green dotted contour in Fig.4e). And each RLC-domain can be divided into sub-domains of “well-adjusted climate” and...
“changeable climate” - denoted by deep-green and rose hatching correspondingly in Fig.4e, where white points denote the observed daily means. Such division demonstrates that there comes a wintry time when life comes to a standstill and a stabilizing support providing by local flora/fauna is weakened; correspondingly, values of daily means shift more and more from the sub-domain of “well-adjusted climate” towards the sub-domain of “changeable climate”. A new life is started during spring and temperature daily means return back. The RLC-domain can be compared with the result of the statistical estimations made for the same sampling (denoted by red and blue wavy lines in Fig.4e) to illustrate the scope of local dynamics potentialities latent from the traditional view. In other words, results of traditional processing cannot cover all the facts (for example, zoom-in fragments to Fig.4c), and variants of “statistical ensembles”, for example [25-31] cannot cardinaly improve this situation.

Let us illustrate how RLC-ensemble restores climate-weather vertical (Fig.1a) throughout seasonal cause-and-effect relations considered with daily resolution. Let us use the traditional «seasonal template» consisting of four regular parts in three calendar months (Fig.1a, central part). Then at least three synchronizations of events are necessary since a “calendar day” can belong to one of five attractive clouds (for example, A-section in Fig.4d) and personify different physical meaning. So, the conformity between “calendar days” in the sequence of “seasonal ranges” (Fig.5a,b) and, after, between versions of “seasonal ranges” in temperature terms (Fig.5c) should be restored to visualize appearing temperature differences with daily details. In particular, results of such synchronization shown that -13…-8°C range (light green horizontal in Fig.5c) should disappear during one and a half month starting from the begin of April (light green vertical in Fig.5a,b). The corresponding filtration made for the original (day,T)-plan (Fig.1c) confirms this expectation, namely (Fig.5d): the mentioned range during the mentioned period (i.e. between 90th and 130th days starting from the 1st January) really practically disappeared about year 1966 (i.e. on the right on the white line, Fig.5d).

**Figure 5.** Synchronizations of “calendar days” in the sequence of “seasonal ranges” reconstructed for the beginning and end of the 20-th century (a) and (b) correspondingly; synchronizations of “seasonal ranges” in temperature terms (c); results of the filtration made for the original (day,T)-plan in Fig.1c (d).
4. Concluding discussion
The problem situation about the topic on “climate changes and weather disasters” develops within the interdisciplinary field and needs to resolve the conflict-of-conceptions between essentially different systems, namely: there is Nature and its physical laws, which are impossible to change but it is possible to live in harmony with them; there are artificial systems restricted by physical laws, technological abilities and available resources but more and more stimulated by irresponsible requests; there are subjective value scales (cultural, social, economical, and so on), which can vary and even become far from reality. Nevertheless, the problem situation demands unbiased scientific investigations beyond stereotypes, beyond prescriptions, and so on; and such investigation should be aimed most of all to reveal a physical law, in accordance with which regularities of interannual variability are formed.

Then cause-and-effect relations from “weather” to “climate” and vice versa could be determined for each local climate system; otherwise, it seems to be impossible not only to estimate soundly the future but also to describe correctly the observed local climate evolution. Clear explanations to the interannual variability were impossible before the so-called rule of modes was discovered and physically-based verified in 2014, for example [23], from the concept that a local climate system represents a solar energy converter under the astronomically forced hysteresis control with double synchronization (i.e. under the HDS-control). The corresponding HDS-law determines a set of potentially available variants of seasonal patterns, alternations of which provide characteristic features of «dancing» (time/temperature oscillating) temperature extremes and «breathing» (compressing/stretching) annual seasonal cycles with keeping-in-general annual periodicity.

So, each local climate system demonstrates not only nonlinear but also piece-wise dynamics with too peculiar properties, that is why it was so hard to catch the fundamental reason of the interannual variability. Moreover, local climate is formed with circumstances, which are unexampled from the experience of nonlinear dynamics in relation to control systems with variable structures. Namely, first, too frequent perpetual vibrations of initial conditions and parameters (usually, hundred times per year – i.e. hundred times per a synchronization period) occur. So, the dynamics is reconstructed by a set of potentially available behavioral vacancies (the so-called attractive cloud ensemble, for example [33-34, 55-56]), time-and-temperature relations between which are determined by the HDS-law. Second, a climate system is inseparably linked with flora and fauna, living cycles of which depend essentially from weather conditions. As a result, two additional switches per year appear during seasonal transitions from-winter-to-summer and vice versa.

In this connection, the bilateral relations between parameters and phase variables become crucial, namely: weather conditions in a seasonal course influence on vitality of species as well as results of vital functions of the species influence on the repetition of this seasonal course. In terms of the regulatory theory of local climate dynamics, it means that life cycles of different species within an ecosystem and between several ecosystems are adjusted with each other by iterative search of optimal moments of seasonal “switches” from one attractive phase cloud to other one in order to stabilize the bilateral relations between living and lifeless ecosystem components hold together by united astronomical HDS-regulator. The adjustable unit of local reference adaptation personifies the mechanism of this search, for example [32]. Thus, the main reason of the climate changes consists in the following: irresponsible human activities lead to corrosion of adjusted relations between living and lifeless components within and between ecosystems.

A local climate system realizes adjusting from own individual peculiarities, including both beginning and duration of each of stationary stages. That is why the traditional approach to determine local climate norms in the context of the common unified time window is not originally intended to describe soundly local climate changes. Individual local peculiarities are already distinguishable, for example [24], even within the regions considered as quasi-homogeneous ones until now, for example [1-2]. At present, it is possible to demonstrate that evolutionary and regulatory features of nonlinear dynamics in accordance with the bifurcation and control theories can be identified and forecasted, for
example [34, 55]; and there are not principal scientific obstacles to simulate how dynamical processes in local climate systems could influence each other.

Meanwhile, the joint action of individual, regional and global factors led to the beginning of synchronized climate changes in different time and space scales (the corresponding signs are identified about the 80-the of the 20-th century, for example [32, 34]). Taking into account the experience of historical precedents, for example [5, 12, 61-62], natural processes of local ecosystem restorations are estimated about one or several hundreds and the destructive-for-human-activities transient towards a novel global climate seem to be very long (500 and more years long). In other words, Nature is the Great Dictator demanding from men to obey undeviatingly physical laws, among which “controlled chaos” and “democratic reforms” are absent. Is there a chance to “cure” local climate systems and to reconcile humanity with Nature? Perhaps, such chance will appear if destroyed ecosystem complexes will be recovered at least in order to slow down the “flywheel” accelerating climate changes.

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