Materials of Conferences

CONTRADICTIONS IN MODERN CLIMATE THEORY AND THEIR SOLUTION

Vorontsov A., Stepanenko S.
RIHMI-WDC, Obninsk,
e-mail: vorv@meteo.ru vorv10921@gmail.com

The modern climate modeling with general circulation models of the atmosphere and the ocean leads to two contradictions. If we consider the climate in terms of synergy, these contradictions can be eliminated. Shows one of the ways to resolve conflicts through the use of systemic approaches synthesis. Shows the solution for the two scales. Total system can contain about 50 equations (about hundreds of empirical parameters).

Modern theories of a climate we name modeling of a climate by means of models of the general circulation of atmosphere and ocean as now it is considered to be these models the main direction of development of a world science about a climate. We will consider two main contradictions and ways of their permission.

Contradiction 1. On the one hand the climate is understood as not observable fluctuation of a global condition of atmosphere, characteristic which time scale essentially more than characteristic time of synoptic fluctuations [3]. Hence, climatic fields should correspond with fields of synoptic scale as processes net and подсеточного scale. From here follows that at modeling of a climate entry conditions should characterize a climatic field, free (whenever possible) from fluctuations of synoptic scale. On the other hand, in practice initial fields are used the same, as at a weather forecast [1], therefore the decision of system of the equations of circulation of atmosphere and ocean gives only a field of synoptic fluctuations. Procedure of averaging which results in the second contradiction is applied to definition of climatic fields.

Contradiction 2. On the one hand for a long time already have come to a conclusion that the climate changes in time. On the other hand it agree эргодической to a hypothesis a climate it is defined as average value of results of integration (statistical ensemble) for 30 years, i.e. on this interval it is constants. As practice nevertheless demands to estimate climate change climate change is estimated on deviations from a climate that leads to the logic contradiction.

Climate forecasting can't be effective until both specified contradictions will be eliminated. That them to resolve, it is enough to refuse climate definition as statistical ensemble of conditions for 30 years, and to understand a climate as average values on some ensemble of inwardnesses of atmosphere under constant external conditions [3].

This definition leads to climate interpretation as to the usual equilibrium thermodynamic characteristic at which the specified contradictions can't simply arise. Can seem that such definition is not constructive as real atmosphere represents open nonlinear nonequilibrium system for which variable conditions to thermodynamic system in a sense are conditional.

However in many real systems thermodynamic balance is fair for elementary volumes (local balance) [9], i.e. variable conditions (pressure P and temperature T) are functions of spatial coordinates x and time t. If the elementary volume is much more than size of fluctuations values of variables of a condition can be defined by statistical averaging on elementary volume.

At the description of a climate fluctuations are fluctuations of synoptic scale. Their number isn't great, therefore as elementary volume it is necessary to consider atmosphere on all hemisphere that doesn't allow to predict a local climate.

Other way of definition of average values – smoothing of fields. However to solve a problem of smoothing by means of known formal methods of a filtration (for example, stated in [4]), it is impossible, since preconditions of formal methods don't correspond to properties of real atmospheric processes. Consideration of these preconditions is beyond the present article, therefore we will be limited to the remark that if they didn't contradict real processes the filtration problem has been already solved.

Let's consider a method of a filtration of fields from synergetrics positions in terms of the theory of casual processes. The basic concept of this theory is the concept about realization of casual process. Realizations, as it is known, are usual functions. Process name casual only because it is in advance impossible to specify, what will be following realization from set of potentially possible realizations.

Definition of casual process will well be coordinated with concepts of synergetrics, in particular, with concept of dynamic chaos [9]. In the beginning we will consider, in what this conformity on an example фрактальной Kokh's curve [9] consists. It is possible to present each level of a fractal as set of kusochno-linear functions

$$y_{kj}(t_i) = a_{kj}(t_i) + b_{kj}x_{kj}(t_i), \quad (1)$$

$$x_{kj}(t_i) = f(t_i), \quad (2)$$

where x, y – horizontal coordinates; k – number of level of a fractal; j – conditional number of an element of a fractal at the given level, t_i – time. Set of parameters of a «correct» curve of Kokh is usual discrete function. However it is possible will present Kokh's constructed by means of casual unequalateral triangles «the wrong» function. Then we will receive family of linear functions with casual parameters c_{kj}, d_{kj} which with good reason can be considered as casual process. For preservation of linear dependence y from x function f (t_i) shouldn't depend from k, j. Substituting (2) in (1) and summarizing for each k levels on realizations j at everyone t_i, we will receive

$$y_{kj}(t_i) = \alpha_{kj}(t_i) + \beta_{kj}(t)\,\bar{y}_k(t_i), \qquad (3)$$

where (t_i) – a population mean of casual process.

Thus, in фрактальной it is possible to express homogeneous non-stationary casual process to environment through its population mean if set of physically homogeneous realizations is correctly defined.

It is possible to consider atmosphere as фрактальную environment. The climate is level of a fractal of higher order, in comparison with fluctuations of synoptic scale. We will be limited to consideration of these levels (substructures) and we will express their interrelation in the mathematical form.

Let $u(t, x, \xi)$ – a variable field u in t-ty$j$ year, $t = 1, 2, \ldots, m$, ξ day of year, x – horizontal coordinates, $f(x)$ – the function which is not dependent from t, ξ. It is easy to show that if

$$u(t, x, \xi) = a(t, \xi) + b(t, \xi)\, f(x) + \varepsilon(t, x, \xi), \qquad (4)$$

That the invariant $f(x) = \bar{u}(x, \xi)$ is an average long-term field for a day ξ.

In turn a, b it is possible to present parameters in a kind

$$a(t, \xi) = c(t) + d(t)\,\varphi(\xi) + ea(t, \xi), \qquad (5)$$

$$b(t, \xi) = p(t) + q(t)\,\psi(\xi) + eb(t, \xi), \qquad (6)$$

Where $\varphi(\xi)$, $\psi(\xi)$ – a long-term annual course of parameters $a(t, \xi)$, $b(t, \xi)$, accordingly. Summarizing (4)–(6), we will receive

$$u(t, x, \xi) = c(t) + d(t)\,\varphi(\xi) + p(t) f(x, \xi) + q(t)\,\psi(\xi)\, f(x, \xi) + e(t, x, \xi),\ t = 1, 2, \ldots, m, \qquad (7)$$

Where $c(t)$, $d(t)$, $p(t)$, $q(t)$ – the global parameters characterizing change of climatic fields, $e(t, x, \xi)$ – the internal fluctuations reflecting distribution of weather conditions on a hemisphere in each concrete day of year.

It is easy to be convinced that function $E(t, x, \xi) = e2(t, x, \xi)$ has well expressed annual course and a natural component on space. Hence, for $E(t, x, \xi)$, by analogy, it is possible to write down parities

$$E(t,\mathbf{x},\xi) = \omega(t,\mathbf{x}) + h(t,\mathbf{x})\chi(\mathbf{x},\xi) + e(t,\mathbf{x},\xi), \qquad (8)$$

$$\omega(t,\mathbf{x}) = \eta(t) + \mu(t)\psi(\mathbf{x}) + e_{\omega}(t,\mathbf{x}), \qquad (9)$$

$$h(t,\mathbf{x}) = \lambda(t) + \theta(t)\upsilon(\mathbf{x}) + e_{h}(t,\mathbf{x}), \qquad (10)$$

whence

$$E(t, x, \xi) = \eta(t) + \mu(t)\,\psi(x) + \lambda(t)\,\chi(x, \xi) + \theta(t)\,\upsilon(x)\,\chi(x, \xi) + (t, x, \xi),\ t = 1, 2, \ldots, m. \qquad (11)$$

According to classical thermodynamics, macroscopical characteristics of system and its internal fluctuations change is interconnected. Hence, it is possible to write down

$$\Phi[c(t), d(t), p(t), q(t), \eta(t), \mu(t), \lambda(t), \theta(t)] = 0. \qquad (12)$$

Let's write down (11) in the form of

$$E(t,\mathbf{x},\xi) = \hat{E}(t,\mathbf{x},\xi) + e(t,\mathbf{x},\xi),$$

where

$$\hat{E}(t,\mathbf{x},\xi) = \eta(t) + \mu(t)\psi(\mathbf{x}) + \lambda(t)\chi(\mathbf{x},\xi) + \theta(t)\upsilon(\mathbf{x})\chi(\mathbf{x},\xi).$$

Values $e(t,\mathbf{x},\xi)$ is a stationary random process, as all non-stationarity $E(t, x, \xi)$ on time and on space is considered in $\hat{E}(t,\mathbf{x},\xi)$ (record (t, x, ξ) means only that this three-dimensional set). Hence, it is possible to consider that $e(t,\mathbf{x},\xi)$ represents required ensemble of inwardnesses of atmosphere under constant external conditions. Changes of this ensemble (climate fluctuation) are defined by expressions (7), (11).

Knowing Φ on the set horizon of the forecast, it is possible to define a non-stationary component $\hat{E}(t,\mathbf{x},\xi)$. Summarizing with casually chosen steady state $e(\mathrm{t},\mathbf{x},\xi)$, we will receive $E(t, x, \xi)$. For the decision of the primary goal of climatology – the prediction of statistical characteristics of a mode of weather conditions is enough to establish connection between weather conditions and values $E(t, x, \xi)$.

The analysis of the empirical data (air temperature [5, 6], atmospheric pressure [8], fields of radioactive pollution after Chernobyl failure [6]), shows that communication between climatic parameters (12) is nonlinear and has high statistical characteristics (factor of determination more than 90 % at all significant factors). From this it is possible to make two conclusions. First, the climate can't be reduced to simple averaging of weather conditions. The climate not is «average» weather, and represents some structure which, on the one hand, is generated by the internal fluctuations resulting nonequilibrium character of movements in atmosphere. On the other hand, the climate «operates» weather conditions. In other words, the climate and weather are connected among themselves by circular causality.

Important feature of a fractal consists that self-similar structures of different scale represent a single whole in which substructures of the lowest order form substructures of higher order. It is impossible to separate or withdraw one of substructures from the general structure, without destroying thus all structure. From this it follows that for the climate description it is necessary to find empirically interrelation for the greatest possible number of levels of a fractal (this purpose has been formulated still in 1980 [10]). As a matter of fact, it leads to a restoration problem аттрактора on time numbers of supervision. The decision of this problem name also system synthesis [2]. In [7] main principles of system synthesis on an example of modeling of a climate are stated.

Summing up, we can conclude that the method of synthesis system developed thermodynamic approach to equilibrium and no equilibrium processes. Invariants in (7), (11) implicitly characterize the direction and magnitude of flows generated by the potential fields. Parameters of equations (5), (6) are relative indicators of fluxes in the atmosphere – thermodynamic characteristics. When flows of climate fluctuations remains constant, and only their scalar, and with climate change – and change the direction of flows and their inner characteristics.

We examined two related fluctuations of the atmosphere. Full empirical model can contain 40-50 of equations (80-100 empirical parameters). It is incomparably smaller than the hydrodynamic theory of climate change. Therefore, technology forecasting climate can be developed in the near future. The main problem is getting to an array of qualitative data for the hemisphere in increments not exceeding 12 hours.

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